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Slime Mould Optimization Algorithm for optimal location and sizing of distributed generations

Abstract: - In this paper, a new meta-heuristic slime mould algorithm (SMA) is developed for both location and size of distributed generation (DG) units. Total real power losses minimization is considered as a main objective considering DG units' allocation and voltage profile kept within the acceptable limits. The main concept of the SMA algorithm is motivated by natural slime mould movement to search for its food as an objective. This approach works on a weighted positive and negative feedback-based bio-oscillator, to generate a network of nourishing veins of various diameters, to search its food resources selecting the optimal route. IEEE-30-bus test and 57-bus test systems are applied via implemented approach to achieve the optimized results. Both DG units' allocation based SMA, and biogeography-based optimization (BBO) approaches simulated results are compared. The comparison illustrates the better optimization and efficacy of the implemented technique in terms of improvement in total installed capacity of DG units, optimal solution, and fast convergence rate.

Keywords: Distributed Generation; Active Power Losses; Voltage Profile; Slime Mould Algorithm; Biogeography-Based Optimization; Convergence Rate.

I. INTRODUCTION

Nowadays, various kinds of distributed generation units, such as solar photovoltaic generation (PVDG) are in distributed power systems, because of steady progress in DG technical advancements [1]. The purpose of DG placement in power network is to satisfy and fulfil the power requirement of the consumers during power transmission and distribution from one location to another. Efficiency of the system reduces because of line losses and voltage deviation level, which leads to low power quality, higher cost, and scarcity of power supply [2]. Placement of DG units sorts out the problems mentioned by installing extra power units to the power line. The DG unit must be installed at optimum capacity and in an optimum location to achieve its maximum efficiency. Conversely, inappropriate location and random capacity of the installed DG unit can cause unpredicted problems, such as power loss, voltage stability, high system losses, sometime even complete power failure [3]. For the load flow computation general power flow approaches for example, due to high resistance (R) and reactance (X) ratio of radial distribution systems, fast decoupled power flow (FDPF) and Newton Raphson (NR) cannot be used [4].

So, various algorithms are developed depending on the system topology, such as loop impedance algorithm [5], forward & backward sweep approach [6], bus voltage to path current and current injection matrix algorithm for the power flow estimation [7].

Previous research has stated that unsuitable capacity and placement may cause a rise in network losses as compared to the system losses without DG unit [8]. Power services in the underdeveloped countries are facing problems, such as high-power loss and low voltage profile. By optimal capacity and placement of DG unit, the services take benefit of decrease in the system loss, enhancement of voltage deviation and progress in consistency of the supply [9]. Many researchers have developed various techniques to measure the optimal size and identify the optimal site of the DG units by analytical expressions [10]. The methodology and the analytical statement are expressed by the specific loss formula. Excluding the quality and better reliability of the system, voltage profile enhancement, voltage regulation improvement and thermal capacity reduction are also the successive outcomes [11].

In [12] a combined effective method has been suggested, such as loss sensitivity factor method and losses based simulated annealing approach to determine optimum capacity and suitable site for DG source. In [13] also sensitivity factor is applied to find suitable location and a total power losses minimization based analytical algorithm, without Jacobian matrix, is used to calculate optimal capacity of DG unit. In [14] a sensitivity-based technique is applied to find the optimum location in a distributed power system with real power loss minimization as a main objective.

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Genetic algorithm (GA) was developed to obtain optimal size and location of DG units for a unity power factor system based on power improvement and loss reduction [15]. Furthermore, GA can calculate non-derivative, dimensionless and discrete problems. It also can achieve optimum values in real time; however, random solutions and slow convergence is its main drawback [24]. In [16] an optimization algorithm called ant colony algorithm is designed for DG unites. The algorithm optimizes the location and rating of the installed DG sources to enhance the energy system reliability. The key disadvantage of the algorithm is its delayed steady state or convergence for optimal solution. Another optimization approach is named particle swarm optimization (PSO) algorithm. The main objective of the method is to improve the voltage profile and reduce power losses of the system [17][18][19][20]. Furthermore, a Particle swarm optimization (PSO) algorithm developed for DG units' size and location in power system for the best efficiency. The algorithm is divided into two stages, such as particle location and velocity measurement with less memory and simulation duration. However, the main disadvantage of the algorithm is its partial optimization after simulation [22]. To further improve the results of PSO and GA algorithms in terms of allocation of DG units of power network, a hybrid approach is designed to enhance the system voltage profile and minimize the network losses [21]. In [23] an optimization approach named Shuffled frog algorithm (SFA) is implemented to optimize the capacity and site of the DGs in the power system. The SFA approach can solve the various optimization problems, such as non-differentiable optimization issues, multi-mode problem and complex mathematical numerical. The method uses idea of a leaping population in simulation. But the technique fails because of premature results and slow convergence. In [25] Bacterial foraging optimization method (BFOM) is implemented for different cases of power system issues. The approach can find the promising area of the solution space. But developers found this technique complex. Therefore, designers decided to find an easy method to enhance convergence rate of the algorithm. As mentioned earlier in [21], a hybrid optimization method of PSO and GA algorithms form enhancement of DGs allocation. Another combined approach called hybridization of Monte Carlo simulation and swarm-based optimization algorithm (IPSO) is formulated to improve size & location of solar powered DG units based on power losses and voltage profile improvement [26]. In [27] a biogeography-based optimization (BBO) approach recently developed to enhance allocation of solar panels as DG units to optimize the system losses and voltage profile. All the above reviewed optimization algorithms designed for DG sources in power system effectively. But the discussed techniques have some drawbacks, such as slow convergence time, economical prospective and effective only in small-scale power systems.

Recently, a meta-heuristic optimization algorithm named Slime mould algorithm (SMA) was developed by Li, Shimin. The developer applied natural slime mould movement idea in the algorithm to search its food [28]. The algorithm fundamentally estimates positive and negative feedback based on applied weights. The feedback is used for biological oscillators in the slim mould to generate the varied sizes of nourishing veins in searching for food as a basic objective.

This searching food approach of the slim mould is suggested and used by the author to implement an optimization algorithm. The simulation results of SMA algorithm can prove the effective outcomes in terms of improved exploration and exploitation. The algorithm gives optimistic statistical results, because of better balance between its exploration and exploitation.

In this research, SMA algorithm is designed for optimal size and location of DG sources in power systems, considering active power loss optimization a main goal, to overcome the drawbacks in the above literature review. Main advantages of this algorithm are, such as less iterations, fast convergence rate and mature optimal solution, as compared to the above discussed DG based optimization algorithms. The proposed SMA algorithm applied on IEEE 30-bus and IEEE 57-bus test systems. The simulated results of the developed method are also validated against obtained outcomes of Biogeographical-based Optimization (BBO) algorithm, considering DG allocation.

Main contributions of this article are summarized as follows: A newly developed optimization technique designed to search best location and optimal capacity of DG sources in a single run; mathematical formulas with associated limitations are applied based on sources properties; power losses of the entire system can be reduced with improved voltage profile; Finally, optimized results of the developed algorithm are matched with the outcomes of the DG units allocation based BBO method.

The research paper is arranged as follows: Mathematical expressions with related constraints of the key objective function are given in Section 2. A summarized note of SMA optimization method is defined in Section 3. DG units' allocation based SMA algorithm implementation with flowchart showed in Section 4. Results with discussion are mentioned in Section 5. Lastly, the conclusion of the article is mentioned in Section 6.

II. PROBLEM FORMULATION

In this article, the key goal function optimizes the total active power losses (TPL_{DG}) through DG units' integration, since TPL_{DG} is a major factor for economic performance of power systems. Total active power losses (TPL) before placement of DG units is calculated using the following formula [29]:

$$TPL = \sum_{n=1}^{Nbr} I_n^2 R_n \tag{1}$$

Where R and I_n denotes resistance and branch current of the n^{th} power line, respectively. Mathematical expression of total real power losses after DG sources installation is given below: [29]:

$$min \ \ TPL_{DG} \ = \sum_{n=1}^{Nbr} I_{nDG}^2 R_n \tag{2}$$

Where I_{nDG} is the branch current after placement of DG unit.
The constraints of the objective function as follow [27]:

Power balance constraints:

$$\sum_{i=2}^{Nbr} P_{DG,i} \leq \sum_{i=2}^{Nbr} P_{,i} \leq \sum_{i=1}^{n} I_{nDG}^2 R_{n,i,i+1} 1 \tag{3}$$

Voltage constraints:

$$V^{min} \leq |V_i| \leq V^{max} \ \ i = 1, \ldots\ldots, N_{bus} \tag{4}$$

Where V^{min} shows Minimum and V^{max} represents Maximum range of the system voltage. IEC Std. 50160 kept higher limits to 0.9 p.u and lower limits to 1.1 p.u for the medium and low voltage distribution systems, respectively. The $|V_i|$ denotes the voltage value in root mean square (RMS) of the i^{th}bus. The inequality constraints shall keep the active power of a particular DG unit to be within a specific range, also the total size of DG units shouldn't be allowed to cross the demands. These constraints can be described by the following inequalities [27]:

$$P_{DG}^{min} \leq \ P_{DG,i} \ \leq P_{DG}^{max} \tag{5}$$

$$\sum_{i=1}^{NDG} P_{DG,i} \leq \sum_{i=1}^{NLoad} P_{Load,i} \tag{6}$$

Where $P_{DG,i}$ and $P_{Load,i}$ are the i^{th} DG unit injected power and load demand in the distribution system, respectively.

III. THE OVERVIEW OF SLIME MOULD ALGORITHM

Slime mould is an organism that lives in a humid and cool environment. Plasmodium is the main dynamic and active stage of the organism, to find its nutrition. In this phase, an organic substance called slime mould searches food in the surrounding area. The slime mould spreads itself into a fan-shaped during its movement with interconnected network of venous [30]. Because of its unique design and characteristic, it can find foods sources located at various locations at the same time through interconnected venous network. The idea of its movement and strategy of searching food is applied in the slime mould algorithm (SMA). The method is designed by Li, Shimin and the details of the approach is given in [28]. Three main steps of the SMA approach are given in mathematical form, approach food, wrapped food and grabbed food.

A. Approach Food

To indicate the slime mould's approaching movement, the following mathematical expression imitates its behavior in mathematical form:

$$\underset{\boldsymbol{x(t+1)}}{\longrightarrow} = \begin{cases} \underset{\boldsymbol{x_b(t)}}{\longrightarrow} + \underset{\boldsymbol{vb}}{\rightarrow} . \left(\underset{\boldsymbol{w}}{\rightarrow} . \underset{\boldsymbol{x_A(t)}}{\longrightarrow} - \underset{\boldsymbol{x_B(t)}}{\longrightarrow} \right), r < p \\ \underset{\boldsymbol{vc}}{\rightarrow} . \underset{\boldsymbol{x(t+1)}}{\longrightarrow}, r \geq p \end{cases} \tag{7}$$

Where $\underset{\boldsymbol{vb}}{\rightarrow}$ indicated as a parameter with lower and upper ranges of $[-g, g]$, and the parameter $\underset{\boldsymbol{vc}}{\rightarrow}$ decreases linearly from upper range to lower range, such as $[1, 0]$. Current iteration of the approach is represented by t, currently searched highest odor level is denoted by the $\underset{\boldsymbol{x_b}}{\rightarrow}$ and the slime mould location indicated by $\underset{\boldsymbol{x}}{\rightarrow}$. Two specifics random values are elected from the mould as represented by $\underset{\boldsymbol{x_A}}{\rightarrow}$ and $\underset{\boldsymbol{x_B}}{\rightarrow}$. Furthermore, $\underset{\boldsymbol{w}}{\rightarrow}$ denotes the weighting factor of the slime mould.

Where p is mathematically formulated as follows:

$$p = \tanh|l(i) - BO| \qquad i \in 1,2 \dots., n \tag{8}$$

The fitness of the factor $\underset{\boldsymbol{x}}{\rightarrow}$ is represented by $l(i)$ and BO shows the optimal fitness found after all iterations.

In addition, the factor $\underset{\boldsymbol{vb}}{\rightarrow}$ is expended by formula as follows:

$$\underset{vb}{\rightarrow} = [-g, g] \tag{9}$$

$$g = arc\tanh(-\left(\frac{t}{\max -t}\right) + 1) \tag{10}$$

The factor $\underset{\boldsymbol{w}}{\rightarrow}$ is expanded in the following list:

$$\underset{w(OdorIindex(l))}{\xrightarrow{\hspace{6em}}} = \begin{cases} 1 + r.log.\left(\frac{bF-l(i)}{bF-wF} + 1\right), \ condition \\ 1 + r.log.\left(\frac{bF-l(i)}{bF-wF} + 1\right). \ \ others \end{cases} \tag{11}$$

$$odorIndex = sort(l) \tag{12}$$

Where first half of the population is ranked by $l(i)$ to represent the specific $conditio$n. Maximum iteration is represented by max $\_t$ and the random variables in the range of $[0, 1]$ is denoted by r. Likewise, bF and wF are the best and worse finesses achieved in the ongoing iteration process and the sorted fitness values are denoted by OdoreIndex.

B. Wrap Food

The updated location of slime mould is mathematically expressed as follows:

$$\underset{x^*}{\rightarrow} = \begin{cases} rand.(U^b - L^b) + L^b, \ rand < z \\ \underset{\boldsymbol{x_b(t)}}{\xrightarrow{\hspace{2em}}} + \underset{\boldsymbol{vb}}{\rightarrow}.\left(\underset{\boldsymbol{w}}{\rightarrow}.\underset{\boldsymbol{x_A(t)}}{\xrightarrow{\hspace{2em}}} - \underset{\boldsymbol{x_B(t)}}{\xrightarrow{\hspace{2em}}}\right), \ r < p \\ \underset{\boldsymbol{vb}}{\rightarrow}.\underset{\boldsymbol{x(t+1)}}{\xrightarrow{\hspace{2em}}}, \ r \geq p \end{cases} \tag{13}$$

Where U^b and L^b represents the higher and lower limits of feasible region, r and *rand* represent the non-deterministic value between 1 and 0, respectively.

IV. THE SMA ALGORITHM DEVELOPMENT CONSIDERING OPTIMAL DG UNIT ALLOCATION ISSUE

In this section, the applied steps of the proposed SMA method to optimally allocate DG has been demonstrated as below:

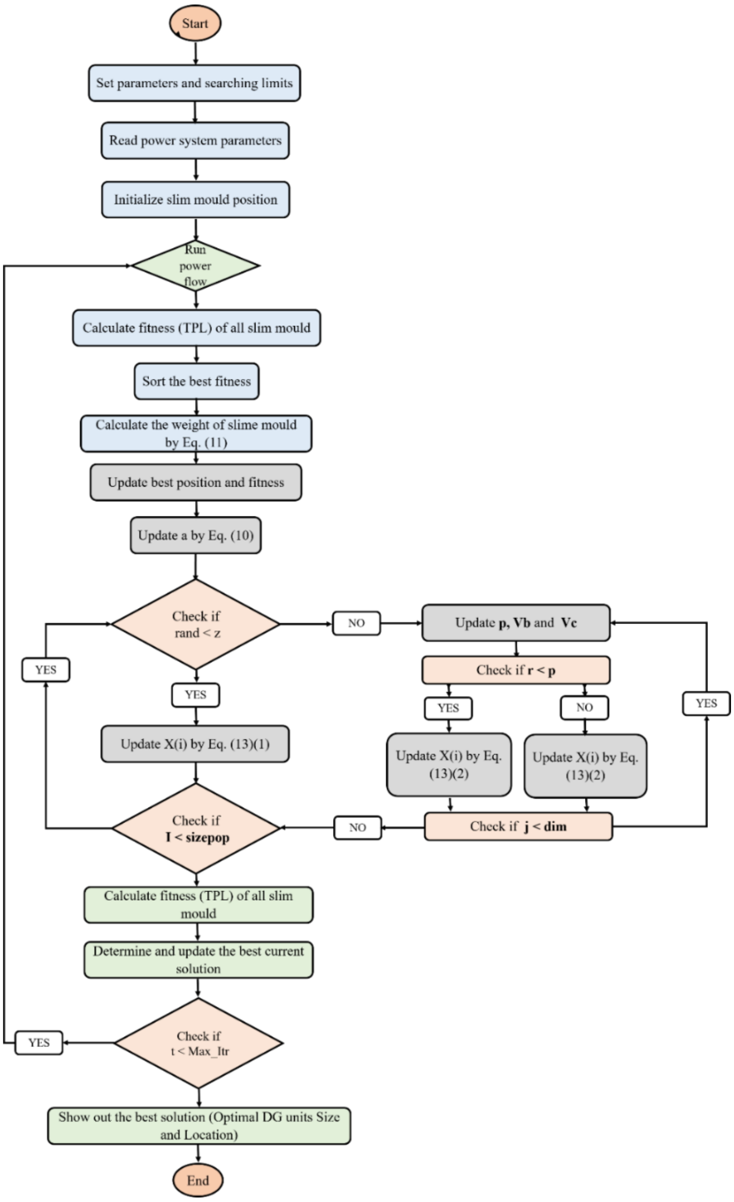


Fig. a. The flowchart shows implementation of the SMA optimization process based on optimal DG units' allocation.

Step 1: Set the parameters, such as popsize, $Max\_iteraition$; upper and lower bound limits of transmission lines and DG units.

Step 2: Read basic power flow data. For example, active and reactive power boundaries, voltage boundaries of generator buses, generators data, starting parameters of effective power, capacitive reactance, and winding ratio of the tap-changing transformers.

real and reactive power limits, generators data, voltage limits of generator buses, initial values of active power, reactive power of capacitors and turn ratios of the tap-controlled transformers.

Step 3: Initialize location of the slime mould, such as x_i (i = 1,2, …, n).

Step 4: Execute the load flow and compute the value of fitness (TPL) of all slime mould and then sort the best fitness value.

Step 5: Compute the weight w of slime mould using Eq (11), to update the best fitness x_b and its position.

Step 6: Update vc, vb and p during every search part according to Eq. (13).

Step 7: Execute the load flow and compute the value of fitness (TPL) of all slime mould.

Step 8: Define and update the existing best position.

Step 9: Check the maximum iteration, if reached the maximum iteration then print the best solutions of optimal size and location DG.

V. RESULTS AND DISCUSSION

The suggested SMA approach has been verified on IEEE-30 bus and IEEE-57 bus test networks to demonstrate its efficiency. Initial parameters are kept the same for both applied IEEE test networks, using the suggested approach. The modeling of the power flow and design SMA algorithm were coded in MATLAB software to solve the optimal DG unit allocation problems.

A. IEEE-30 Bus Test Network Results

The IEEE-30 bus test network has been modelled using the suggested SMA approach, where the test system values, and associated data are given in [31]. The system consists of 6 generators, installed at 1st, 2nd, 5th, 8th, 11th, and 13th locations of the test system. There are 24 buses, 41 transmission lines with total active power loads of 283.40 MW and reactive power load of 126.200 MVAr. The total active power loss minimization was the main objective function, to find the optimal capacity and location of one, two, and three DG units in the network. The installation of DG units at more than three locations proved to be inefficient to reduce power losses [32].

IEEE-30 bus system results for one, two and three DGs units' allocation:

Total effective or real power loss minimization is taken as a goal function, based on optimal capacity and location of one, two, and three DG units by using SMA algorithm. The results achieved using the proposed SMA technique are compared with those acquired using the BBO algorithm.

The graph in Fig 1a depicts that the proposed SMA algorithm needs 15 iterations while the BBO method requires around seven iterations to reach the optimum solution for single DG unit. In addition, the proposed algorithm needs around twenty iterations only, for three DG units as shown in Fig 2c. Over and above that, the results of the IEEE-30 bus test system for one, two, and three DG units have been compared considering SMA and BBO algorithms as shown in Table 1, Table 2, and Table 3.

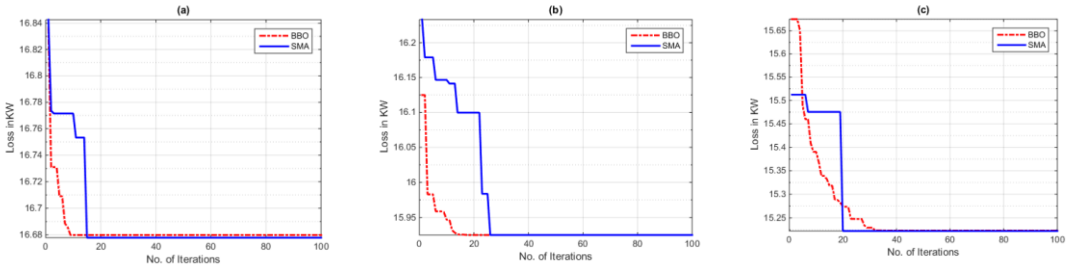
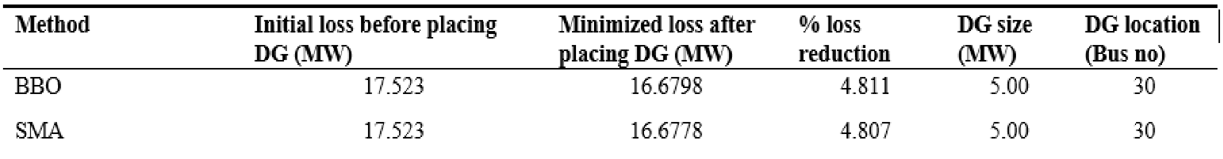


Fig. 1. Illustrates power losses versus iterations of single (a), dual (b) and triple (c) DG sources based on IEEE 30-bus model.

Considering single DG unit, the obtained percentage of loss minimization is 4.807 % based on the SMA algorithm. The optimal capacity of the installed DG unit at 30th bus is 5 MW. The system losses have been minimized to 16.6778 MW from initial loss (base case) of 17.523 MW. Simulated and analyzed results of both algorithms based on single DG units are mentioned in Table 1. The percentage of loss minimization has increased to 9.1027 % with the installation of two DG units, considering the proposed SMA technique as compared to the result of 9.1025 % obtained from applying the BBO algorithm, as shown in Table 2. The optimal sizes of two installed DG units are 4.9315 MW and 4.9315 MW on 29th and 5th with considering the findings of the suggested SMA approach analyzed with the BBO method of 5 MW capacity of each DG unit on 5th and 30th bus. The total losses have been minimized to 15.9250 MW based on the results of the suggested algorithm, in term of initial losses (base Case) of 17.523 MW. To sum up, in the consideration of total losses and total installed capacity of DG units, both are improved to 15.9250 MW and 9.8788 MVA respectively, whereas the proposed technique is analyzed with the results of the BBO method.

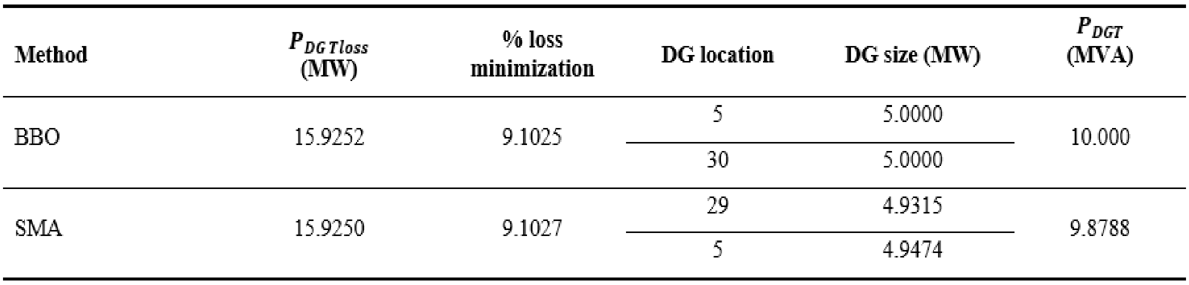
Table.1 Results comparison using IEEE-30 bus system after 1 DG installation.



Method	Initial loss before placing DG (MW)	Minimized loss after placing DG (MW)	% loss reduction	DG size (MW)	DG location (Bus no)
BBO	17.523	16.6798	4.811	5.00	30
SMA	17.523	16.6778	4.807	5.00	30

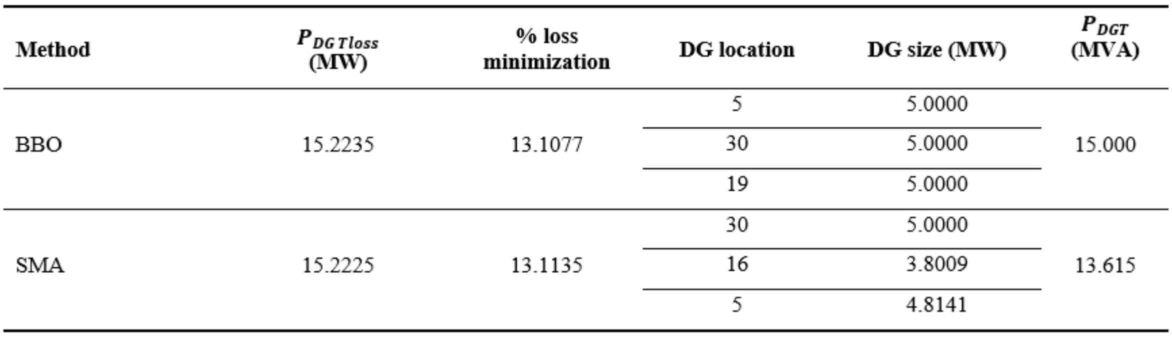
Moreover, **Table 3** shows that the percentage of losses reduction has further improved to 13.1135 %, by allocation three DG units because of SMA algorithm. The optimal capacities of the connected three DG units are 5 MW, 3.8 MW, and 4.8 MW at 30th, 16th, and 5th, respectively, using the proposed SMA method. However, based on BBO method, the optimum sizes of the three installed DG units are 5 MW at each bus of 5th, 30th and 19th. On the other hand, the voltage profiles of the IEEE 30-bus test network not having DG, and having one, two and three DG units are illustrated in **Fig 2**.

Table 2. Results comparison after 2 DG sources installation using IEEE-30 bus system.



Method	$P_{DGTloss}$ (MW)	% loss minimization	DG location	DG size (MW)	P_{DGT} (MVA)
BBO	15.9252	9.1025	5	5.0000	10.000
			30	5.0000	
SMA	15.9250	9.1027	29	4.9315	9.8788
			5	4.9474	

Table 3. Comparison of triple DG sources results considering IEEE-30 bus test system.



Method	$P_{DGTloss}$ (MW)	% loss minimization	DG location	DG size (MW)	P_{DGT} (MVA)
BBO	15.2235	13.1077	5	5.0000	15.000
			30	5.0000	
			19	5.0000	
SMA	15.2225	13.1135	30	5.0000	13.615
			16	3.8009	
			5	4.8141	

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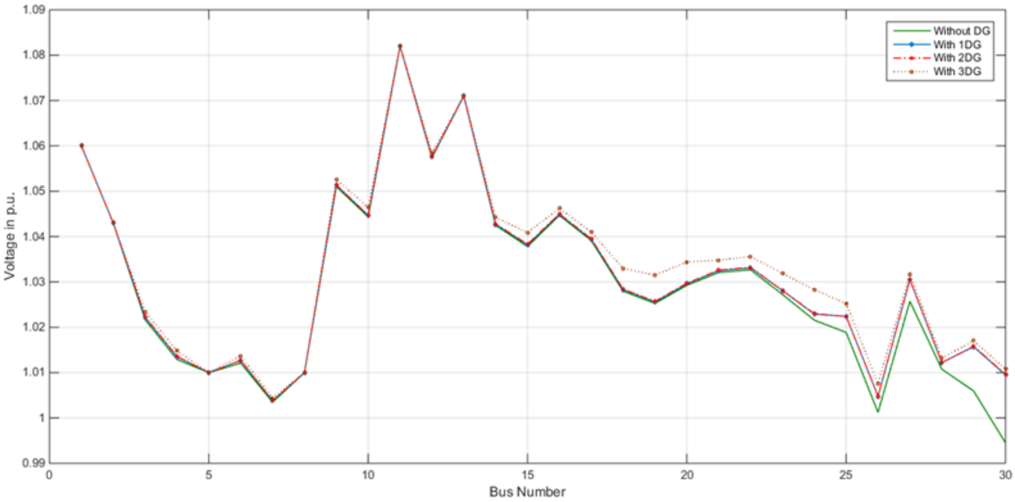


Fig. 2. Voltage profile of the IEEE-30 bus network before and after installation of DG unit

B. IEEE-57 Bus Test Network Results

The IEEE-57 bus test network has been modelled using the suggested SMA approach. The test system, parameters and associated data are given in [33]. The network has 7 generators installed on the 1st, 2nd, 3rd, 6th, 8th, 9th, and 12th buses. The network consists of 78 transmission lines with a total peak load of 1250.8 MW and overall generation capacity of 1975.88 MW. The objective function based on the total active power losses as main objective, and that to optimally allocate of one, two and three DG units in the system using the proposed SMA algorithm. It is important to mention that, the installation of DG units at more than three locations is proved to be inefficient in power losses minimization [32].

The IEEE-57 bus system results in one, two and three DG installations:

In this section, the real power dissipation minimization is evaluated as a goal function to optimize size and location of DG units based on the suggested SMA approach. It is noted from **Fig 3a**, that the suggested SMA method requires around 5 iterations, while the BBO technique requires forty-four iterations to reach the optimal solution in considering one DG unit case. In two, and three DG units' cases, the proposed technique needs about 24 and 10 iterations, respectively. Where the BBO technique requires 80 and 84 iterations to obtain the optimal result, as shown in **Fig 3b** and **Fig 3c**.

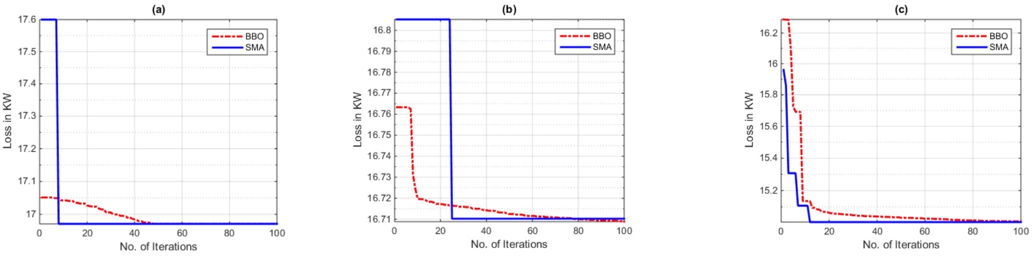


Fig. 3. shows power losses versus iterations of single (a), duel (b) and triple(c) DG sources using IEEE 30-bus system.

The results obtained of the SMA algorithm are also matched with simulated results of the BBO method, based on IEEE-57 bus test system for all the above DG unit cases, as mentioned in **Table 4**, **Table 5** and **Table 6**. For the one DG unit case, both approaches have remarkably close results, as shown in Table **4**. The loss reduction percentage has been improved to 41.26 % through the placement of two DG units, based on the SMA technique, the results are close compared to obtain from BBO algorithm, as shown in **Table 5**. Optimal capacity of the located DG units are 4.0638 MW and 3.4177 MW at buses 12th and 51st respectively, considering results of the proposed SMA algorithm. However, installed capacity of both DG units are 4.5753 MW and 5.000 MW at buses 53 and 12 respectively, based on the BBO approach. In addition, the total loss has been reduced to 16.7102 MW based on the results of the proposed SMA approach, which compared with the BBO method, in terms of initial loss (Base Case) of 28.453MW. In summary, with account of total installed DG units' capacity, the value has been improved to 7.4815MVA when applying the SMA technique compared with 9.5753 MVA obtained from BBO method.

Furthermore, **Table 6** demonstrates that the percentage of loss minimization has been further enhanced to 47.2568 %, as consequence of the installation of three DG units using SMA method. The optimal capacities of the located three DG units are 4.7570 MW, 4.8330 MW, and 3.1932 MW at buses 9, 16, and 35, respectively. Total active power loss minimization is improved to 15.0070 MW, when the proposed SMA method was applied compared to 15.0117 MW obtained from result BBO method.

Table.4 Results comparison using IEEE-57 bus network after 1 DG installation.

Method	Initial loss before placing DG (MW)	Minimized loss after placing DG (MW)	% loss reduction	DG size (MW)	DG location (Bus no)
BBO	28.453	16.9713	40.3468	5.00	12
SMA	28.453	16.9711	40.3470	5.00	12

Table 5. Results comparison after 2 DG sources installation using IEEE-57 bus system.

Method	$P_{DG\,Tloss}$ **(MW)**	**% loss minimization**	**DG location**	**DG size (MW)**	P_{DGT} **(MVA)**
BBO	16.7089	41.2693	53	4.5753	9.5753
			12	5.0000	
SMA	16.7102	41.2646	12	4.0638	7.4815
			51	3.4177	

The base voltage profiles of the IEEE-57 bus test system with one, two and three DG units are depicted in **Fig 4**. After installation of DG units, the voltage profiles of all cases are closed compared to voltage profiles of the base case. Therefore, the proposed SMA approach has been proved to have better efficiency over BBO method in terms of real power loss reduction and total installed capacity.

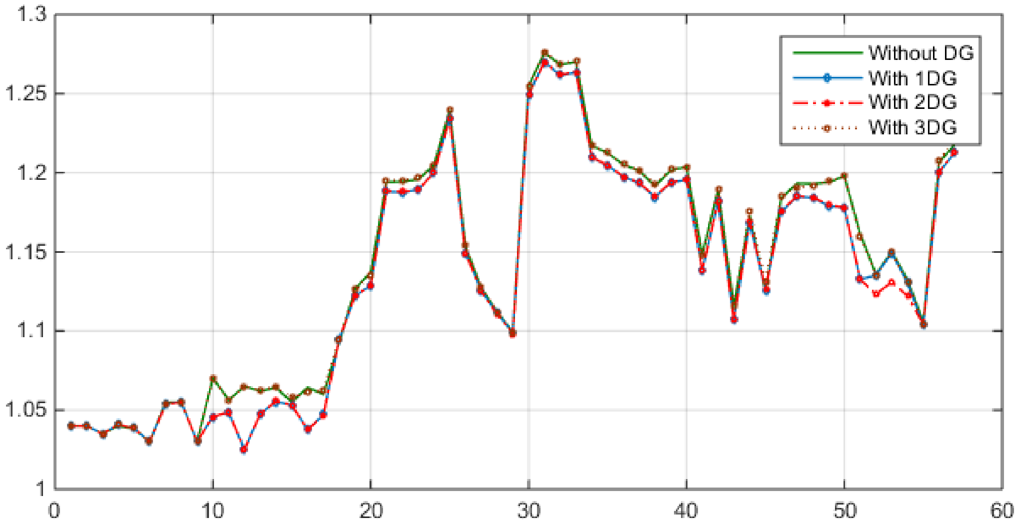
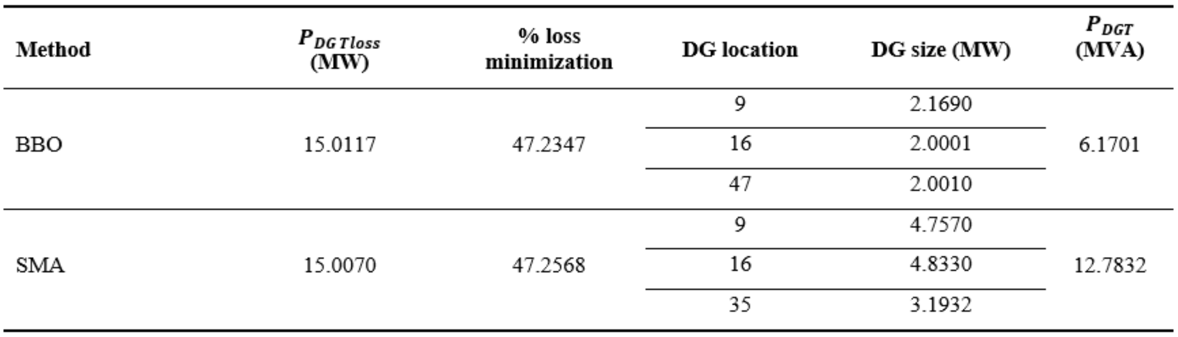


Fig. 4. Voltage profile of the IEEE-57 bus system before and after installation of DG units.

Table 6. Comparison of triple DG sources results applied on IEEE 57-bus test network.



Method	$P_{DG\,Tloss}$ (MW)	% loss minimization	DG location	DG size (MW)	P_{DGT} (MVA)
BBO	15.0117	47.2347	9	2.1690	6.1701
			16	2.0001	
			47	2.0010	
SMA	15.0070	47.2568	9	4.7570	12.7832
			16	4.8330	
			35	3.1932	

VI. CONCLUSIONS

In this article, a newly developed, effective SMA algorithm has been implemented for allocation of DG unites based on total losses minimization, in distribution system. Two test networks, like IEEE 30 and IEEE 57 buses have been applied to demonstrate the feasibility of the proposed approach. One another meta-heuristic method called biogeography-based algorithm (BBO) has also been applied for comparison purpose. It has been observed from comparison of both algorithms that total power losses and total installed DG unit capacity have been improved by using the SMA technique. The proposed SMA approach needs less iteration in most cases as compared to the BBO method for optimal solution. Voltage profiles of all cases are the same before and after allocation of DG units to the system. To sum up, required iterations, total active power loss, percentage loss minimization, and installed capacity have been improved by application of the SMA algorithm. So, it proves the effectiveness and applicability of the suggested SMA method in terms of searching optimal capacity and location of DG units in distribution system.

ACKNOWLEDGMENT

We are submitting a manuscript of a research article for consideration of publication in the Journal of Electrical systems. The manuscript is entitled “Slime Mould Optimization Algorithm for optimal location and sizing of distributed generations.” It has not been published elsewhere, and it has not been submitted simultaneously for publication elsewhere. We know of no conflict of interest associated with this publication, and there has been significant financial support for this work that could have influenced its outcome, As Corresponding Author, I confirm that the manuscript has been read and approved for submission by all the named authors.

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