Optimal Distributed Generation Allocation and Sizing Using Genetic and Ant Colony Algorithms

Yousef Y. Zakaria\textsuperscript{1}, R. A. Swief\textsuperscript{2}, Noha H. El-Amary\textsuperscript{1}, Amr M. Ibrahim\textsuperscript{2}

\textsuperscript{1}Power and Machines \textsuperscript{1}Engineering Department, Faculty of Engineering, Arab Academy for Science, Technology, and Maritime Transport, Cairo, Egypt.

\textsuperscript{2}Electrical Power and Machines \textsuperscript{1}Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

E-mail: Yousef.a.elec@gmail.com

Abstract. Distributed generators (DG) which installed into distribution network to face the increasing of load demand. DG can used to enhance power generation systems and improve distribution network efficiency. However, the distributed generators units' implementation at not convenient position and sizing can lead to negative impacts such as a growing in power losses and invasion of system constraints. Because the rising of demand in energy. The appropriate placement and sizing of DG's units is a credible solution to much problems in distribution system, for example power loss reduction and voltage regulation. The allocation of distributed generators into the distribution network can significantly impact in the transmission and distribution systems. Therefore, a method, which can identify an optimum DG location and size, is necessary. In this paper, Genetic Algorithm (GA) and Ant colony Algorithm (ACO) optimization techniques are proposed to find optimal sizing and location for distributed generation in electrical networks. The objective function of the work relies upon a linearized model to compute the active power losses as a function of power supplied from the generators. This strategy based on a strong coupling between active power and power flow taking into consideration the voltage angles. With the end goal to exhibit the adequacy of the proposed method, the proposed strategy is applied on IEEE 57-bus standard systems. Different maximum penetration level capacity of DG units and various possible places of DG units among several types of DG (active, reactive or active and reactive power) are considered. Results show that the optimization tools employing GA and ACO are effective in reducing active power losses by finding the optimal placement and sizing of DG units.

1. Introduction

Distributed Generation (DG) offers a huge number of environmental and financial benefits, in addition to guarantee a reasonable limit development in distribution systems with enhanced productivity and reliability. However, these points of interest can't be completely misused if inappropriate siting and sizing of DGs are determined. The integration of DG units into distribution networks, including sizing and placements, has pulled vast interest during the most recent 15 years. The issue of choosing the optimal conductor for a real radial distribution system in Egypt is investigated utilizing an ongoing meta-heuristic algorithm, known as slap swarm enhancement [1]. An enhancement strategy dependent on the Genetic Algorithm (GA) related
to the Power Flow (PF) technique is utilized to enhance the Distribution Network (DN) performance and to distinguish the best location and size of the DG's [2]. A comprehensive study considering the effect of integration of customer owned DG on the arranging of active network management (ANM) plans and maximum DG penetration limits is examined [3]. In [4], a simple methodology is presented to obtain the optimal location and sizing of DG units using genetic algorithm (GA) method. Comparison of optimal DG location applying Particle Swarm Optimization (PSO) and GA for minimum real power loss in radial distribution system is explored [5]. In [6], a data driven technique based on the distributional robust optimization is utilized to determine the maximum penetration level of distributed generation (DG) for active distribution networks (ADNs). Optimal location and sizing of DG’s using Backtracking Search Algorithm (BSA) in IEEE 33-bus distribution system are investigated [7]. Many other researchers are utilized meta-heuristic algorithms and powerful analytic methodologies to find the optimal sizing of DG. Some of these algorithms and methodologies are; New Particle Swarm Optimization (NPSO) [8], flower pollination algorithm (MFPA) [9], real option analysis [10], Simulated Annealing (SA) [11], a hybrid method by adding optimal power injections to the power distribution systems to reduce power loss [12], Index Vector Method (IVM) approach [13], Artificial Bee Colony (ABC) optimization algorithm [14], Distribution System Reconfiguration (DSR) [15], Genetic Algorithm (GA) [16], utilizing evolutionary algorithms in meshed network [17] and finally some analytical approaches are employed for finding the optimal location of the DGs [18,19]. In this paper, two optimization algorithms have been developed to find the optimal DG’s sizing and siting depends on power losses. These algorithms are Ant Colony Algorithm (ACO) [20] and Genetic Algorithm (GA) [21]. The suggested algorithms have the ability to solve effectively large-scale linear and nonlinear problems. The classification of this paper is as follows: Section 2 gives brief information about GA and ACO. The formulation of methodology is given in Section 3. Section 4 presents the case study on the IEEE-57 bus, test network. In conclusion, derivation is summed up in Section 5.

2. The Proposed Algorithms

2.1. Ant Colony Algorithm

Ant colony algorithm derived from the method of finding food in real ant. The process of the ant colony optimization algorithm controls the scheduling of three steps; the first step forms a basis in creating a pheromone trail. In the second step, each ant put forward a complete solution to the problem according to the probability state transition rule. The state transition rule depends primarily on the state of pheromone. The third step updates the quantity of pheromone. The update rule for pheromone is applied in two stages. The first is the evaporation stage where a fraction of the pheromone evaporates, and then there is an enhanced phase that increases the amount of pheromone on the road with high-quality solutions. This process is repeated until the stop gauge is reached. Several different methods have been proposed to translate the above principles into a computational procedure to solve the optimization problem. Figure.1 shows the flowchart of the proposed ant colony optimization techniques [20].
3. Problem Formulation

The primary point of this search is to investigate the dependable execution of the network in the wake of putting the DG ideally at a reasonable site. Since the motivation behind DG is to diminish the complete real power wastage and enhancement the voltage, the establishment of DG units at non-ideal spots may not give precise outcomes, which will be increase the system losses. Anyway, losses cannot be totally evacuated, however they can be pushed down to a satisfactory worth. Since the effect of distributed generators on system execution dependent on system working conditions and the kind of the distributed generators, it is essential to utilize a some solution in the planning and operation to arrive at solution for the best execution. The primary target is to decrease the overall active power loss in the grid with DG, which expressed as follows [5]:

Minimization of

\[ f = \sum_{i=1}^{N} P_{\text{Lossi}} \]  \hspace{1cm} (1)

With DG Subject to real power constraints given by:

\[ \sum_{j=1}^{N} P_{\text{DGj}} = \sum_{j=1}^{N} P_{\text{Dj}} + P_{L} \]  \hspace{1cm} (2)
The inequality constraints on $P_{DGj}$ of DG given by:

$$P_{DGj}^{min} \leq P_{DGj} \leq P_{DGj}^{max}$$  \hspace{1cm} (3)$$

The inequality constraints on $Q_{DGj}$ of DG given by:

$$Q_{DGj}^{min} \leq Q_{DGj} \leq Q_{DGj}^{max}$$  \hspace{1cm} (4)$$

The inequality constraints on $P_{DGj}$ and $Q_{DGj}$ of DG with constant power factor given by:

$$P \cdot F_j = \cos \theta_j$$  \hspace{1cm} (5)$$

$$\tan^{-1} \theta_j = \frac{Q_{Lj}}{P_{Lj}}$$  \hspace{1cm} (6)$$

The $Q_{DGj}$ given by:

$$Q_{DGj} = \tan^{-1} \theta_j \times P_{DGj}$$  \hspace{1cm} (7)$$

where \( f \) is the complete loss of the grid, \( P_{lossi} \) is the real power losses at bus \( i \), \( P_{Gj} \) is the real power injected at bus \( J \), \( PL \) is the overall real network losses, \( P_{Dj} \) is the full needed of power, \( P_{DGj} \) is the active power generation from DG, \( Q_{DGj} \) is the injected Q from the DG, \( P_{DGj}^{min} \) and \( P_{DGj}^{max} \) are the lower and upper P generation boundaries at \( i \) bus for DG values, \( Q_{DGj}^{min} \) and \( Q_{DGj}^{max} \) are the lower and upper Q generation boundaries at \( i \) bus for DG input, \( P \cdot F_j \) is the power factor of bus \( i \), \( P_{Lj} \) is the active power load at bus \( i \), \( Q_{Lj} \) is the reactive power load at bus \( j \), \( \theta_j \) the angle between \( P_{L} \) and \( Q_{L} \) at bus \( j \), (8):

$$Of = 1 - \sum_{i=1}^{N} v(j)$$  \hspace{1cm} (8)$$

\( Of \) = main Function in expression of all buses voltages and \( v(j) \) is the bus \( j \) voltage in the grid. The GA and ACO techniques are utilized for the optimal location and sizing of the DG, taking into consideration the lower power losses. The techniques works to no further minimization of system losses founded, taking into consideration the limitations.

### 4. Case Study and Results

The suggested optimization algorithms have been imitated in MATLAB and applied for IEEE 57 bus system. To check the viability and proficiency of the GA and ACO strategies, applied to IEEE 57-bus system. In this paper, minimization of the active power loss and enhancement in the voltage are counted as main functions. The proposed method is applied to an IEEE 57-bus system with the all P load is 1238MW and Q load is 334.02 MVAR. The active P losses are 36.65 MW and Q losses are 175.5 MVAR when calculated using load flow for the base case. Bus one selected as slack bus, from economical case we assume 1000 LE is the tariff per one MW power loss.

#### 4.1 Case 1:3.9% Penetration Level
The proposed methods are applied to IEEE 57-bus system with 3.9% of load penetration level, 3.9% of active power and reactive power load are 48.3 MW and 13.03 MVAR. With 36.65 MW active power losses and 175.5 MVAR reactive power losses. Table 1 represents the comparison of power losses without DGs and with adding active power DGs, reactive power DGs and active reactive power DGs with constant power factor of bus with respect to its load, using GA and ACO. Figure 3 represents the comparison of average voltage profile of IEEE 57-bus without DGs and with implementing active power DGs, reactive power DGs and active reactive power DGs with constant power factor of bus with respect to its load, using GA and ACO. For this case, two active power DG units are optimally sized and placed using ACO technique; the size and location of each DG are given in table 1. Show that in figure 3 the best solution for maximum average voltage profile is; three active and reactive power DG units are optimally sized and placed using GA technique; the size and location of each DG are given in table 1.

4.2 Case 2: 5.9% Penetration Level
The proposed methods are applied to IEEE 57-bus system with 5.9% of load penetration level, 5.9% of active power and reactive power load are 73.05 MW and 19.71 MVAR. With 36.65 MW active power losses and 175.5 MVAR reactive power losses. Table 2 represents the comparison of power losses without DGs and with adding active power DGs, reactive power DGs and active reactive power DGs with constant power factor of bus with respect to its load, using GA and ACO. Figure 4 represents the comparison of average voltage profile of IEEE 57-bus without DGs and with implementing active power DGs, reactive power DGs and active reactive power DGs with constant power factor of bus with respect to its load, using GA and ACO. For this case, two active power DG units are optimally sized and placed using ACO technique; the size and location of each DG are given in table 2. Show that in figure 4 the best solution for maximum average voltage profile is; three active and reactive power DG units are optimally sized and placed using ACO technique; the size and location of each DG are given in table 2.

4.3 Case 3: 30% Penetration Level
The proposed methods are applied to IEEE 57-bus system with 8.9% of load penetration level, 8.9% of active power and reactive power load are 110.2 MW and 29.73 MVAR. With 36.65 MW active power losses and 175.5 MVAR reactive power losses. Table 3 represents the comparison of power losses without DGs and with adding active power DGs, reactive power DGs and active reactive power DGs with constant power factor of bus with respect to its load, using GA and ACO. Figure 5 represents the comparison of average voltage profile of IEEE 57-bus without DGs and with implementing active power DGs, reactive power DGs and active reactive power DGs with constant power factor of bus with respect to its load, using GA and ACO. For this case, three active and reactive power DG units are optimally sized and placed using ACO technique; the size and location of each DG are given in table 3. Show that in figure 5, the best solution for maximum average voltage profile is; two active and reactive power DG units are optimally sized and placed using ACO technique; the size and location of each DG are given in table 3.
### Table 1. DG Placement by GA and ACO for 57-Bus System (3.9% penetration)

| Techniques | DG Types | Implemented DG Schedule | DGs (MW) | DGs (MVAR) | Ploss (MW) | Cost Loss (LE) | Cost&P Loss Reduction (%) |
|------------|----------|-------------------------|---------|-----------|-----------|--------------|--------------------------|
| GA         | P        | BUS 30 56               | 48.31   | 0.0       | 29.941    | 29941        | 18.3                     |
|            | Q        | BUS 7 34                | 0.0     | 13.034    | 35.925    | 35925        | 1.973                    |
|            | P & Q    | BUS 30 42               | 48.31   | 28.17     | 28.476    | 28476        | 22.3                     |
| ACO        | P        | BUS 31 56               | 48.4    | 0.0       | 29.935    | 29935        | 18.32                    |
|            | Q        | BUS 24 53               | 0.0     | 12.5      | 35.9      | 35900        | 2.04                     |
|            | P & Q    | BUS 50 35               | 48.3    | 24.15     | 28.415    | 28415        | 22.5                     |
| GA         | P        | BUS 20 23 35            | 50.5    | 0.0       | 30.046    | 30046        | 18.014                   |
|            | Q        | BUS 28 31 35            | 0.0     | 10.2      | 36.181    | 36181        | 1.3                      |
|            | P & Q    | BUS 30 42 35            | 48.4    | 25.45     | 28.147    | 28147        | 23.2                     |
| ACO        | P        | BUS 32 53 56            | 48.3    | 0.0       | 28.561    | 28561        | 22.1                     |
|            | Q        | BUS 32 52 57            | 0.0     | 13.2      | 35.912    | 35912        | 2.01                     |
|            | P & Q    | BUS 42 31 57            | 48.3    | 24.9      | 28.367    | 28367        | 22.6                     |

### Table 2. DG Placement by GA and ACO for 57-Bus System (5.9% penetration)

| Techniques | DG Types | Implemented DG Schedule | DGs (MW) | DGs (MVAR) | Ploss (MW) | Cost Loss (LE) | Cost&P Loss Reduction (%) |
|------------|----------|-------------------------|---------|-----------|-----------|--------------|--------------------------|
| GA         | P        | BUS 30 56               | 48.31   | 0.0       | 29.941    | 29941        | 18.3                     |
|            | Q        | BUS 7 34                | 0.0     | 13.034    | 35.925    | 35925        | 1.973                    |
|            | P & Q    | BUS 30 42               | 48.31   | 28.17     | 28.476    | 28476        | 22.3                     |
| ACO        | P        | BUS 31 56               | 48.4    | 0.0       | 29.935    | 29935        | 18.32                    |
|            | Q        | BUS 24 53               | 0.0     | 12.5      | 35.9      | 35900        | 2.04                     |
|            | P & Q    | BUS 50 35               | 48.3    | 24.15     | 28.415    | 28415        | 22.5                     |
| Techniques | DG Types | Implemented DG Schedule | DGs (MW) | DGs (MVAR) | Ploss (MW) | Cost Loss (LE) | Cost&P Loss Reduction (%) |
|------------|----------|-------------------------|----------|-----------|----------|----------------|--------------------------|
| GA | P | BUS | 38 | 53 | 73.1 | 0.0 | 27.827 | 27827 | 24.1 |
| | | Size (MW) | 57.8 | 15.3 | | | | | |
| | Q | BUS | 35 | 53 | 0.0 | 18.724 | 35.565 | 35565 | 2.96 |
| | | Size (MVAR) | 13.1 | 5.624 | | | | | |
| | P & Q | BUS | 38 | 53 | 73.7 | 36.85 | 25.916 | 25916 | 29.3 |
| | | Size (MW) | 56.2 | 17.5 | | | | | |
| | | Size (MVAR) | 28.1 | 8.75 | | | | | |
| ACO | P | BUS | 30 | 55 | 73.06 | 0.0 | 27.678 | 27678 | 24.5 |
| | | Size (MW) | 36.53 | 36.53 | | | | | |
| | Q | BUS | 35 | 53 | 0.0 | 19.5 | 35.594 | 35594 | 2.9 |
| | | Size (MVAR) | 9.6 | 9.9 | | | | | |
| | P & Q | BUS | 38 | 53 | 73.7 | 36.9 | 26.01 | 26010 | 29.03 |
| | | Size (MW) | 50 | 23.7 | | | | | |
| | | Size (MVAR) | 25 | 11.9 | | | | | |
| GA | P | BUS | 22 | 32 | 53 | 73.02 | 0.0 | 27.633 | 27633 | 24.6 |
| | | Size (MW) | 48.42 | 11.3 | | | | | |
| | Q | BUS | 2 | 5 | 36 | 3.6 | 2.4 | 15 | 0.0 | 21 | 35.756 | 35756 | 2.43 |
| | | Size (MVAR) | 3.6 | 2.4 | | | | | |
| | P & Q | BUS | 35 | 50 | 30 | 21.42 | 28.43 | 23.2 | 73.05 | 36.54 | 25.555 | 25555 | 30.3 |
| | | Size (MW) | 10.71 | 14.23 | | | | | |
| | | Size (MVAR) | | | | | | | | | | | | |
| ACO | P | BUS | 38 | 53 | 56 | 73.06 | 0.0 | 27.482 | 27482 | 25.01 |
| | | Size (MW) | 50 | 11.53 | | | | | |
| | Q | BUS | 6 | 25 | 36 | 0.7 | 3.7 | 15.53 | 0.0 | 19.93 | 35.628 | 35628 | 2.8 |
| | | Size (MVAR) | | | | | | | | | | | | |
| | P & Q | BUS | 53 | 25 | 56 | 73.8 | 31.92 | 25.621 | 25621 | 30.1 |
| | | Size (MW) | 24.6 | 24.6 | | | | | |
| | | Size (MVAR) | 12.3 | 12.5 | 7.12 | | | | | |
Table 3. DG Placement by GA and ACO for 57-Bus System (8.9% penetration)

| Techniques | DG Types | Implemented DG Schedule | DGs (MW) | DGs (MVAR) | Ploss (MW) | Cost Loss (LE) | Cost&P Loss Reduction (%) |
|------------|----------|-------------------------|----------|------------|------------|----------------|--------------------------|
|            |          |                         |          |            |            |                |                          |
| GA         | P        | BUS 10 31               | 91.04 19.2 | 0.0 29.8 35.468 | 35468 | 0            |
|            | Q        | BUS 30 35               | 14 15.8   | 3.22      |
|            | P & Q    | BUS 23 56               | 79.22 31  | 110.22 35.41 24.2 | 24200 | 33.97      |
| ACO        | P        | BUS 22 51               | 55.1 55.1 | 0.0 29.73 34.904 | 34904 | 4.8         |
|            | Q        | BUS 34 54               | 9.73 20   | 0.0 29.73 34.904 | 34904 | 4.8         |
|            | P & Q    | BUS 30 47               | 55.1 55.1 | 34.6      |
|            |          |                         | 27.55 40.1 |            |            |            |                          |
| GA         | P        | BUS 34 38 51           | 24.62 24.54 60.94 | 110.1 0.0 23.588 | 23588 | 35.64      |
|            | Q        | BUS 25 26 36           | 11.4 3.412 14.7 | 0.0 29.512 35.413 | 35413 | 3.4         |
|            | P & Q    | BUS 38 16 14           | 76.6 14.02 19.58 | 110.2 49.8 23.868 | 23868 | 34.9        |
| ACO        | P        | BUS 38 40 51           | 10.5 1 10.5 | 36.73 36.73 36.73 | 110.2 47.61 23.507 | 23507 | 35.9        |
|            | Q        | BUS 56 53 55           | 10.2 10.2 10.81 | 36.73 36.73 36.73 | 110.2 47.61 23.507 | 23507 | 35.9        |
|            | P & Q    | BUS 53 32 51           | 18.4 18.4 10.81 |            |            |            |                          |
By observing the Tables 1-3 we conclude that maximum power loss reduction for case I occurs when buses 31, 42 and 57 receive the following three active and reactive DGs of size 20 MW and 10 MVAR, 20 MW and 21.4 MVAR, 8.3 MW and 2.5 MVAR respectively using ACO technique, while in case II it occurs when buses 30, 35 and 50 receive the following three active and reactive DGs of size 23.2 MW and 11.6 MVAR, 21.42 MW and 10.71 MVAR, 28.43 MW and 14.23 MVAR respectively using GA technique and for case 3 it occurs when buses 32, 51
and 53 receive the following three active and reactive DGs of size 36.73 MW and 18.4 MVAR, 36.73 MW and 10.81 MVAR, 36.73 MW and 18.4 MVAR respectively using ACO technique. In addition, the histograms illustrated in figures 3-5 indicate that the optimum average voltage for the IEEE 57-bus for case 1 occurs when active and reactive two DGs are fed to bus 30 and 42 where the first bus receives a power of size 31.5 MW and 17.75 MVAR while the second bus receives a power of 16.81 MW and 10.48 MVAR, using GA technique, while for case 2 it occurs when buses 30, 35 and 50 receive the following three active and reactive DGs of size 23 MW and 11.6 MVAR, 21.42 MW and 10.71 MVAR, 28.43 MW and 14.23 MVAR respectively using GA technique and for case 3 it occurs when buses 30 and 47 receive two active and reactive DGs of size 55.1 MW and 27.55 MVAR, 55.1 MW and 40.1 MVAR, respectively using ACO technique.

5. Conclusion
In perspective of consistently expanding load demand in the power sector, distributed generators are playing an extremely indispensable role to improve the execution of the system by diminishing the Plosses and improving the system voltage. Finding the optimal sizing and locations of DGs are high substantial for the electrical grid reliability. This paper presents two heuristic methods; GA and ACO. The suggested algorithms are used to find the optimal DG's sizing and siting depends on power losses. To validate the proposed techniques, IEEE-57 bus systems are examined and the conclusion gained are compared. The outcomes are organized and the voltage improvement is demonstrated graphically. Decreasing in active power losses and enhancement in voltage profile can be noticed. The results demonstrated that the implementation of DG based on ACO is exceedingly viable in reduction total losses of P and voltage are compared using genetic algorithm

References

[1] Ismael, S., Abdel Aleem, S., Abdelaziz, A., & Zobaa, A. (2018). Practical Considerations for Optimal Conductor Reinforcement and Hosting Capacity Enhancement in Radial Distribution Systems. *IEEE Access*, 6, 27268-27277.

[2] Alhamali, A., Farrag, M., Bevan, G., & Hepburn, D. (2017). Determination of optimal site and capacity of DG systems in distribution network based on genetic algorithm. 2017 52Nd International Universities Power Engineering Conference (UPEC).

[3] Alkaabi, S., Zeineldin, H., & Khadkikar, V. (2018). Adaptive planning approach for customer DG installations in smart distribution networks. *IET Renewable Power Generation*, 12(1), 81-89.

[4] Saad, M., El-Ghany, H., & Azmy, A. (2017). Optimal DG deployment to improve voltage stability margin considering load variation. 2017 Nineteenth International Middle East Power Systems Conference (MEPCON).

[5] Uniyal, A., & Kumar, A. (2016). Comparison of optimal DG placement using CSA, GSA, PSO and GA for minimum real power loss in radial distribution system. 2016 IEEE 6Th International Conference On Power Systems (ICPS).

[6] Chen, X., Wu, W., Zhang, B., & Lin, C. (2017). Data-Driven DG Capacity Assessment Method for Active Distribution Networks. *IEEE Transactions On Power Systems*, 32(5), 3946-3957.

[7] Kanth, D., Reddy, N., & Reddy, R. (2017). Optimal placement & sizing of DG's using backtracking search algorithm in IEEE 33-bus distribution system. 2017 International Conference On Computing Methodologies And Communication (ICCMC).

[8] Kumari, R., Kumar, G., Nagaraju, S., & Jain, M. (2017). Optimal sizing of distributed generation using particle swarm optimization. 2017 International Conference On Intelligent...
Computing, Instrumentation And Control Technologies (ICICICT).

[9] Oda, E., & Abdelsalam, A. (2017). Optimal DGs allocation in distribution networks using modified flower pollination algorithm. *2017 Nineteenth International Middle East Power Systems Conference (MEPCON)*.

[10] Zou, B., Wang, J., & Wen, F. (2017). Optimal investment strategies for distributed generation in distribution networks with real option analysis. IET Generation, Transmission & Distribution, 11(3), 804-813.

[11] Mitra, J., Vallem, M., & Singh, C. (2016). Optimal Deployment of Distributed Generation Using a Reliability Criterion. IEEE Transactions On Industry Applications, 52(3), 1989-1997.

[12] Prasanna, K., Jain, A., & Kumar, R. (2017). Optimal distributed generation placement using hybrid technique. 2017 IEEE PES Asia-Pacific Power And Energy Engineering Conference (APPEEC).

[13] Sarfaraz, S., Bansal, A., & Singh, S. (2016). Optimal allocation and sizing of distributed generation for power loss reduction. International Conference & Workshop On Electronics & Telecommunication Engineering (ICWET 2016).

[14] Dixit, M., Kundu, P., & Jariwala, H. (2016). Optimal placement and sizing of DG in Distribution system using Artificial Bee Colony Algorithm. 2016 IEEE 6Th International Conference On Power Systems (ICPS).

[15] Abbasi, F., & Hosseini, S. (2016). Optimal DG allocation and sizing in presence of storage systems considering network configuration effects in distribution systems. IET Generation, Transmission & Distribution, 10(3), 617-624.

[16] Ameri, A., Nichita, C., Riouch, T., & El-Bachtiri, R. (2015). Genetic algorithm for optimal sizing and location of multiple distributed generations in electrical network. 2015 Modern Electric Power Systems (MEPS).

[17] Kumar, D., Tianyi, H., Srinivasan, D., Reindl, T., & Shenoy, U. (2015). Optimal distributed generation allocation using evolutionary algorithms in meshed network. 2015 IEEE Innovative Smart Grid Technologies - Asia (ISGT ASIA).

[18] Gopiya Naik, S., Khatod, D., & Sharma, M. (2015). Analytical approach for optimal siting and sizing of distributed generation in radial distribution networks. IET Generation, Transmission & Distribution, 9(3), 209-220.

[19] Elsaiah, S., Benidris, M., & Mitra, J. (2014). Analytical approach for placement and sizing of distributed generation on distribution systems. IET Generation, Transmission & Distribution, 8(6), 1039-1049.

[20] Falaghi, H., & Haghfam, M. (2007). ACO Based Algorithm for Distributed Generation Sources Allocation and Sizing in Distribution Systems. 2007 IEEE Lausanne Power Tech.

[21] Ugrani, F., & Karatepe, E. (2012). Genetic algorithm for weight assignment in optimum planning of multiple distributed generations to minimize energy losses. 2012 International Symposium On Innovations In Intelligent Systems And Applications.