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Optimal Location and Sizing of Distributed Generation Using Artificial Bee Colony and JAYA Algorithms

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ABSTRACT

The rapid increase in energy demand, environmental concerns, and the necessity for efficient utilization of energy resources highlight the importance of distributed generation (DG) systems. Optimal positioning and sizing of DG units play a critical role in reducing power losses, improving voltage profiles, and increasing system reliability. This study evaluates the performance of the Artificial Bee Colony (ABC) and JAYA algorithms for solving the optimal DG location and sizing problem on an IEEE 33-bus distribution system. The results show that the JAYA algorithm provides superior performance in reducing power losses, achieving a 73.00% reduction in active power loss and a 68.77% reduction in reactive power loss in the DG3 scenario. The minimum bus voltage improved from 0.902 p.u. (base case) to 0.979 p.u. with the JAYA algorithm. The ABC algorithm, on the other hand, was more effective in improving the voltage profile, reaching 0.969 p.u. in the DG3 scenario. Moreover, the JAYA algorithm achieved a faster convergence rate and lower computational time compared to the ABC algorithm. These findings indicate that a hybrid approach combining both algorithms may lead to further improvements in DG optimization. This study aims to contribute to the effective planning and implementation of distributed generation units in modern power systems.

Yapay Arı Kolonisi ve JAYA Algoritmaları Kullanarak Dağıtık Üretimin Optimal Yerleşimi ve Boyutlandırılması

ÖZ

Enerji talebindeki hızlı artış, çevresel kaygılar ve enerji kaynaklarının verimli kullanılması gerekliliği, dağıtık üretim (DG) sistemlerinin önemini vurgulamaktadır. DG ünitelerinin optimum konumlandırılması ve boyutlandırılması, güç kayıplarının azaltılmasında, gerilim profillerinin iyileştirilmesinde ve sistem güvenilirliğinin artırılmasında kritik bir rol oynamaktadır. Bu çalışma, bir IEEE 33-bus dağıtım sisteminde optimum DG konumu ve boyutlandırma problemini çözmek için Yapay Arı Kolonisi (ABC) ve JAYA algoritmalarının performansını değerlendirmektedir. Sonuçlar, JAYA algoritmasının güç kayıplarını azaltmada üstün performans sağladığını ve DG3 senaryosunda aktif güç kaybında %73,00 ve reaktif güç kaybında %68,77 azalma elde ettiğini göstermektedir. Minimum bara gerilimi JAYA algoritması ile 0,902 p.u.'dan (baz durum) 0,979 p.u.'ya yükselmiştir. ABC algoritması ise gerilim profilini iyileştirmede daha etkili olmuş ve DG3 senaryosunda 0,969 p.u. değerine ulaşmıştır. Ayrıca, JAYA algoritması ABC algoritmasına kıyasla daha hızlı bir yakınsama oranı ve daha düşük hesaplama süresi elde etmiştir. Bu bulgular, her iki algoritmayı birleştiren hibrit bir yaklaşımın DG optimizasyonunda daha fazla iyileştirmeye yol açabileceğini göstermektedir. Bu çalışma, modern güç sistemlerinde dağıtık üretim birimlerinin etkin bir şekilde planlanmasına ve uygulanmasına katkıda bulunmayı amaçlamaktadır.

Anahtar Kelimeler: Dağıtık Üretim (DG), Optimal Yerleşim, Yapay Arı Kolonisi (ABC), JAYA Algoritması, Güç Kaybı Azaltma

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1. Introduction

Today, increasing energy demand, environmental concerns, and the need for efficient use of energy resources have necessitated the adoption of innovative approaches in energy generation and distribution systems. In this context, DG has emerged as an important solution that aims to shift energy generation from centralized systems to smaller and more localized energy sources. DG systems can be defined as small-scale power generation within the distribution system [1]. Distributed generation systems have the potential to reduce energy losses and improve system reliability and efficiency [2-4]. However, the effective integration of these systems requires correct siting and sizing decisions [5]. Improper placement and sizing of DGs can lead to excessive power losses, voltage ripples, and increased costs [6].

The optimal placement and sizing of DGs require balancing multiple objectives such as reducing energy generation costs, minimizing power losses, improving voltage profiles, and enhancing system reliability. To maximize the benefits of DGs, single/multi-objective target functions should be established. Therefore, such multi-objective optimization problems necessitate the use of robust and flexible optimization methods [7-9]. When determining these objective functions, the constraints and limitations must be well-defined to ensure maximum system benefit.

DG systems are flexible in utilizing renewable energy sources such as solar, wind, hydro, biomass, and geothermal, as well as conventional energy sources like gas turbines, microturbines, fuel cells, and internal combustion engines [10]. For efficient allocation of DGs in distribution networks, minimization of power losses is very important. Various optimization techniques are also used to minimize power loss. Genetic Algorithm (GA) [11], Artificial Neural Networks (ANN) [12], Particle Swarm Optimization (PSO) [13] have been widely used to achieve this goal. Moreover, determining the optimal location of the DGs is a critical issue that needs careful consideration, and various methods have been proposed to address it. In the literature, continuous power flow (CPF) analysis has been used to calculate the sensitivity of each bus and determine the optimal DG placement [14]. Weak Bus Sensitivity Index (WBSI) is proposed using CPF to identify suitable locations for DG integration [15]. Moreover, PSO and GA are used to determine the optimal size and location of DGs [16]. Voltage Sensitivity Index (VSI) is used to identify the weakest bus in the system [17]. Furthermore, the optimal allocation and sizing of DGs in distribution networks are performed to minimize power losses and improve voltage stability. Three VSI and PSO are used in this process: Direct Voltage Stability Index (DVSI), Fast Voltage Stability Index (FVSI), and Line Quality Factor (LQF) [18].

In the IEEE 69-bus distribution system, studies aimed at optimizing the allocation and sizing of DGs to reduce total active power losses and improve the voltage stability index have been presented using PSO and Bat Algorithm (BA) [19]. The Grey Wolf Optimizer (GWO), Whale Optimization Algorithm (WOA), and PSO have been applied to the IEEE 33-bus and IEEE 69-bus test systems to reduce power losses and improve voltage profiles [20]. Moreover, a hybrid model based on PSO and Chaotic Frog Leaping Algorithm (PSO-CFL) has been proposed to minimize power losses and enhance voltage profile quality. This study developed a PSO-CFL based algorithm to determine the optimal DG location and size, analyzing its performance on IEEE 33-bus and IEEE 69-bus radial distribution systems [21]. Additionally, optimization techniques such as Biogeography-Based Optimization (BBO), GWO, Salp Swarm Algorithm (SSA), WOA, and Moth Flame Optimization (MFO) have been proposed to solve the sizing and allocation problems of DGs in the IEEE 33-bus, IEEE 69-bus, and other distribution systems while reducing energy losses [22]. To find the optimal size and location of different types of DGs and optimally reconfigure the grid, continuous and binary PSO algorithms (CBPSO) have been recommended. These methods have been applied to the IEEE 33-bus and IEEE 69-bus distribution networks to reduce power losses and improve voltage profiles [23].

In the IEEE 33-bus distribution network, GA, Harmony Search Algorithm (HSA), and improved HSA have been proposed to determine optimal DG locations and improve voltage profiles [24]. Furthermore, a new methodology is applied to minimize power losses through optimal reconfiguration and placement of DGs in

IEEE 33-bus and IEEE 69-bus test radial distribution systems. Three optimization algorithms, PSO, GA, and Blue Whale Optimization (BWO) were used to achieve these objectives [25]. The optimal dimensioning and placement of distributed generators in the 7-33-71 bus power systems have been achieved by the application of a high convergence optimization algorithm [26]. The artificial rabbit optimization technique was employed in radial distribution systems to enhance the voltage stability index, facilitating the calculation of optimal locations and sizes of DGs [27]. To determine the optimum DG allocation in IEEE 14-30 bus systems, Garra Rufa optimization was used to reduce active power loss and increase the voltage index, thus realizing location and size allocation [28]. Finally, a fine-tuned PSO-based approach is proposed to optimize the placement and sizing of various types of DGs in IEEE 33-bus, IEEE 69-bus, and real-world radial distribution networks in Malaysia [29].

The location and size of DGs must be carefully considered when assessing the installation, cost, and impact of a distribution system. Incorrect selection of DG location and size can cause more harm than benefit, leading to significant power losses and instability in the distribution network. That is, incorrect location and size can lead to significant power losses and instability in the distribution network. In distribution systems, power flows from the grid supply point to the load. This can result in large power losses.

This study aims to address the problem of optimal placement and sizing of distributed generation (DG) systems by evaluating the performance of the Artificial Bee Colony (ABC) and JAYA algorithms. The main objectives of the study are to minimize power losses, improve voltage profiles, and enhance system reliability. The analyses conducted on the IEEE 33-bus distribution system compare both algorithms in terms of convergence speed, power loss reduction, voltage improvement capability, and computation time. The obtained results indicate that the JAYA algorithm achieves faster convergence and more effective reduction of active/reactive power losses. On the other hand, the ABC algorithm proves to be more successful in improving voltage profiles. This study aims to contribute to the efficient planning and implementation of distributed generation units in modern power systems.

The manuscript is organized as follows: Section 2 defines the mathematical formulation and objective functions for the optimal placement and sizing problem of DGs. Section 3 introduces the proposed algorithms. Analysis results, comparisons, and literature discussions are presented in Section 4. Finally, Section 5 concludes the study.

2. Formulatıon of The Problem

To determine the optimum location and size of DGs in distribution systems, the objective functions of minimizing active power losses and reducing voltage deviation are determined within various constraints and limitations.

2.1.Power loss minimization

To minimize the total power loss in distribution systems, it is formulated as in Eq. 1.

$$f_1(x) = P_{Loss} = \sum_{i=1}^{N} R_i |I_i|^2 \quad (1)$$

Where, $f_1(x)$ is the power loss objective function, N is the number of buses, R_i is the resistance of bus i. and I_i is the current of bus i.

2.2. Voltage deviation

To minimize the voltage deviation value in distribution systems, it is formulated as in Eq. 2.

$$f_2(x) = VD = \sum_{i=1}^{N} |V_i - 1| \quad (2)$$

Where, $f_2(x)$ is the voltage deviation objective function, V_i is the voltage at bus i.

2.3. Objective function

The objective function for the optimum location and size of DGs in the distribution system, which is the sum of the power loss reduction and voltage deviation value, is given in Eq. 3.

$$f_{(x)} = \omega f_1(x) + (1 - \omega) f_2(x) \quad (3)$$

Here, $f_{(x)}$ is the objective function for the optimal location and size, ω is chosen as the weight factor. The weighting factor is determined according to the needs of the system and can be adjusted by the operator. For example, if the power loss in a distribution system is high, the value of ω can be kept high. If voltage fluctuations are a major problem, ω can be selected at low values. In this way, system performance is optimized by producing solutions suitable for different network conditions and operating strategies.

2.3.1. Equality constraints

The equality constraints are based on the balance principle. The power flow equations corresponding to both the active and reactive power balance equations are defined mathematically as Eqs. 4 and 5:

$$P_{Gi} - P_{Di} - V_i \sum_{j=1}^{N} V_j \left[G_{ij} \cos(\delta_i - \delta_j) + B_{ij} \sin(\delta_i - \delta_j) \right] = 0 \quad (4)$$

$$Q_{Gi} - Q_{Di} - V_i \sum_{j=1}^{N} V_j \left[G_{ij} \sin(\delta_i - \delta_j) + B_{ij} \cos(\delta_i - \delta_j) \right] = 0 \quad (5)$$

Here, P_{Gi} is the active power produced by the generators at bus i. P_{Di}, the active power demand at bus i. Q_{Gi} is the reactive power produced by the generators at bus i. Q_{Di}, the active power demand at bus i. G_{ij} and B_{ij} are the conductance and susceptance values of the transmission line between the i. and j. buses.

2.3.2. Inequality constraints

The voltage value of each busbar must be maintained within the limits in Eq. 6. In the study, V_{min} and V_{max} values are taken as 0.95 and 1.05 p.u, respectively.

$$V_{min} \leq V \leq V_{max} \quad (6)$$

The maximum operating limits of the DGs are defined in Eq. 7.

$$P_i \leq P_i^{max} \quad (7)$$

Here, P_i^{max} is the maximum operating limit of the DGs. In the study, P_i^{max} is chosen as 5 MW.

3. Optimization Algorithms

3.1. Artificial bee colony algorithm (ABC)

The ABC algorithm [30] is an optimization method inspired by the foraging behavior of honeybees, developed to solve complex optimization problems. Figure 1 visually illustrates the foraging process of bees. Bees are generally categorized into three main groups: worker bees, onlooker bees, and scout bees. Worker bees are primarily tasked with searching for abundant food sources, functioning as onlooker bees during this process.

After gathering information from high-quality food sources, worker bees perform a waggle dance to guide other bees to the optimal food source. Subsequently, scout bees combine the information received from onlooker bees with the probabilities of nectar sources to select a new food source, then initiate a search in a new area, similar to onlooker bees. If the newly found food source offers a better solution, it replaces the current solution. This cycle continues throughout the solution process until the best solution is identified based on fitness value or error rate [31].

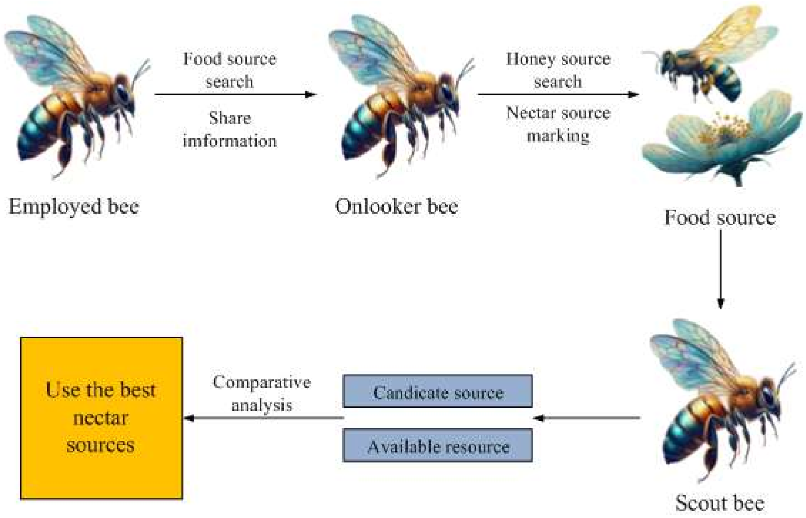

Figure 1. Food foraging and information sharing process of bees

The pseudo-code sequence of the ABC algorithm used for optimal location and sizing of DGs is given below.

ABC_ALGORITHM()
1. Load IEEE 33-bus system data
2. Initialize candidate solutions randomly (each solution represents DG location and capacity)
3. Define colony size and number of iterations
FOR
iteration = 1 TO Maximum_Iterations DO
 # Employed Bees Phase
FOR i = 1 TO Number_of_Food_Sources DO
4. Select a random neighbor solution (between i and k)
5. Generate a new DG location and capacity:
*New_Solution = Current_Solution + φ * (Current_Solution - Neighbor_Solution)*
6. Evaluate the fitness of the new solution:
f_new = CALCULATE_OBJECTIVE_FUNCTION(New_Solution)
7. If f_new is better, update the current solution
8. Otherwise, increase the abandonment counter
ENDFOR
 # Onlooker Bees Phase
9. Compute selection probabilities based on solution fitness
10. Select a solution randomly and generate a new solution
11. Evaluate the new solution's fitness and update if it is better
 # Scout Bees Phase
12. Replace abandoned solutions with new random ones
13. Update the best solution and record iteration progress
ENDFOR
14. Return the optimal DG locations and capacities

(1) Worker Bees; this process consists of two main stages. The first stage, the initialization phase, accepts each food source as a feasible solution and randomly initializes the parameters of this solution. Each feasible

solution is then evaluated by substituting its parameters into the objective function, and the resulting function values are assessed using the fitness function, defined as Eq. 8:

$$fitness = \begin{cases} 1/(1+f_i\,, & f_i \geq 0 \\ 1+abs(f_i, & f_i < 0 \end{cases} \quad (8)$$

Here, f_i represents the function value for each feasible solution.

The second sub-stage involves a crossover mutation where the j. dimension of each feasible solution is modified using a randomly generated neighbor solution in the j. dimension. This is expressed by Eq. 9:

$$V_{ij} = x_{ij} + \varphi_{ij}(x_{ij} - x_{kj}) \quad (9)$$

Here, V_{ij} represents the valid solution obtained after the crossover mutation. x_{ij} represents the j. dimension solution of the i. valid solution, while x_{kj} represents the j. dimension solution of the k. valid solution, which is the neighbor of the i. solution. φ_{ij} is a random number. After the crossover-mutation stage, the fitness value will be calculated according to Eq. 8. This value will be compared with the initial fitness value in the initial stage, and if the post-mutation value is better, the parameters of the valid solution will be updated with the post-mutation parameters.

(2) Onlooker Bees; onlooker bees evaluate all information returned by worker bees and select a set of solutions from this information. The probability of selecting a solution (p_i) is calculated using Eq. 10:

$$p_i = \frac{fitness_i}{\sum_{i=1}^{SN} fitness_i} \quad (10)$$

Here, $fitness_i$ represents the fitness value of each feasible solution. SN denotes the number of feasible solutions, which equals the number of available food sources. At this stage, a random number between 0 and 1 is compared with the probability of each solution. If the random number is smaller, it is used as a criterion to determine whether the corresponding food source improves the objective function. If the improvement is insignificant or the random number exceeds the probability value, the crossover mutation process is performed as per Eq. 9.

(3) Scout Bees; if a feasible solution does not converge within a specified number of crossover mutations, it is considered invalid, and a new solution is randomly generated for recalculation.

3.1. JAYA algorithm

The JAYA algorithm, proposed by Rao (2016), is a population-based global optimization method [32]. The fundamental principle of the algorithm is that each solution should consistently move towards the optimal solution within a population while simultaneously moving away from inferior solutions. A key advantage of this algorithm is its simplicity, as it relies solely on a single equation without requiring parameter adjustments to find the optimal solution [33]. In conclusion, the JAYA algorithm is considered more intuitive and distinct compared to other metaheuristic algorithms [34]. The position update equation of the JAYA algorithm is expressed in Eq. 11 [35].

$$X'_{k,j} = X_{k,j} + r_1 \times \left(Best_j - \left|X_{k,j}\right|\right) - r_2 \times \left(worst_j - \left|X_{k,j}\right|\right) \quad (11)$$

In the equation given above, $k = 1,2, \dots, N$ is the index of the candidate solution, $j = 1,2, \dots, D$ is the relevant dimension of the problem, $Best_j$ is the best solution for the population, $worst_j$ is the worst solution in the population. r_1 and r_2 represent a random value generated between [0,1]. The pseudo-code sequence of the JAYA algorithm used for optimal location and sizing of DGs is given below.

```
JAYA_ALGORITHM()
1. Load IEEE 33-bus system data
2. Initialize population randomly (each solution represents DG location and capacity)
3. Define number of particles and number of iterations
FOR iteration = 1 TO Maximum_Iterations DO
  4. Identify the best and worst solutions in the population
  FOR i = 1 TO Population_Size DO
    5. Generate two random factors (r1, r2)
    6. Compute the new solution using:
      New_Solution = Current_Solution + r1 * (Best_Solution - Current_Solution)
                     - r2 * (Current_Solution - Worst_Solution)
    7. Evaluate the fitness of the new solution:
      f_new = CALCULATE_OBJECTIVE_FUNCTION(New_Solution)
    8. If f_new is better, update the current solution
  ENDFOR
  9. Update the best solution and record iteration progress
ENDFOR
10. Return the optimal DG locations and capacities
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4. Simulations and Results

In this study, the analysis of optimal sizing and placement of DG was carried out using the IEEE 33-bus distribution system. The ABC and JAYA algorithms were employed to perform these analyses. The total active power of the IEEE 33-bus power system was taken as 3.72 MW, and the total reactive power was taken as 2.3 MVAr [36]. The single-line diagram of the IEEE 33-bus system is shown in Figure 2. All analyses were conducted on a PC with an Intel Core(TM) i7-2620 2.7GHz processor and 8 GB RAM (64-bit) using MATLAB R2017b.

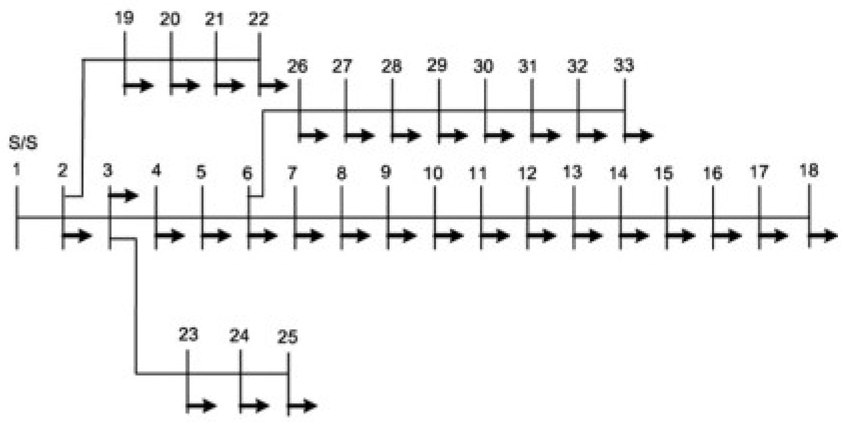

Figure 2. Single-line diagram of the IEEE 33-bus distribution network

The objective functions of the IEEE 33-bus power system were to minimize active power losses and reduce voltage deviations to achieve optimal DG sizing and placement. The ABC and JAYA algorithms were utilized to determine the optimal size and location based on these objective functions. Analyses were conducted for three cases based on the number of DGs:

- Sizing and placement of a single DG (DG1)
- Sizing and placement of two DGs (DG2)
- Sizing and placement of three DGs (DG3)

In the base case without DGs, total active and reactive power losses and bus voltage values were calculated using the Newton-Raphson power flow method. The values obtained for the base case were then compared in detail with those obtained for DG1, DG2, and DG3 cases using the ABC and JAYA algorithms.

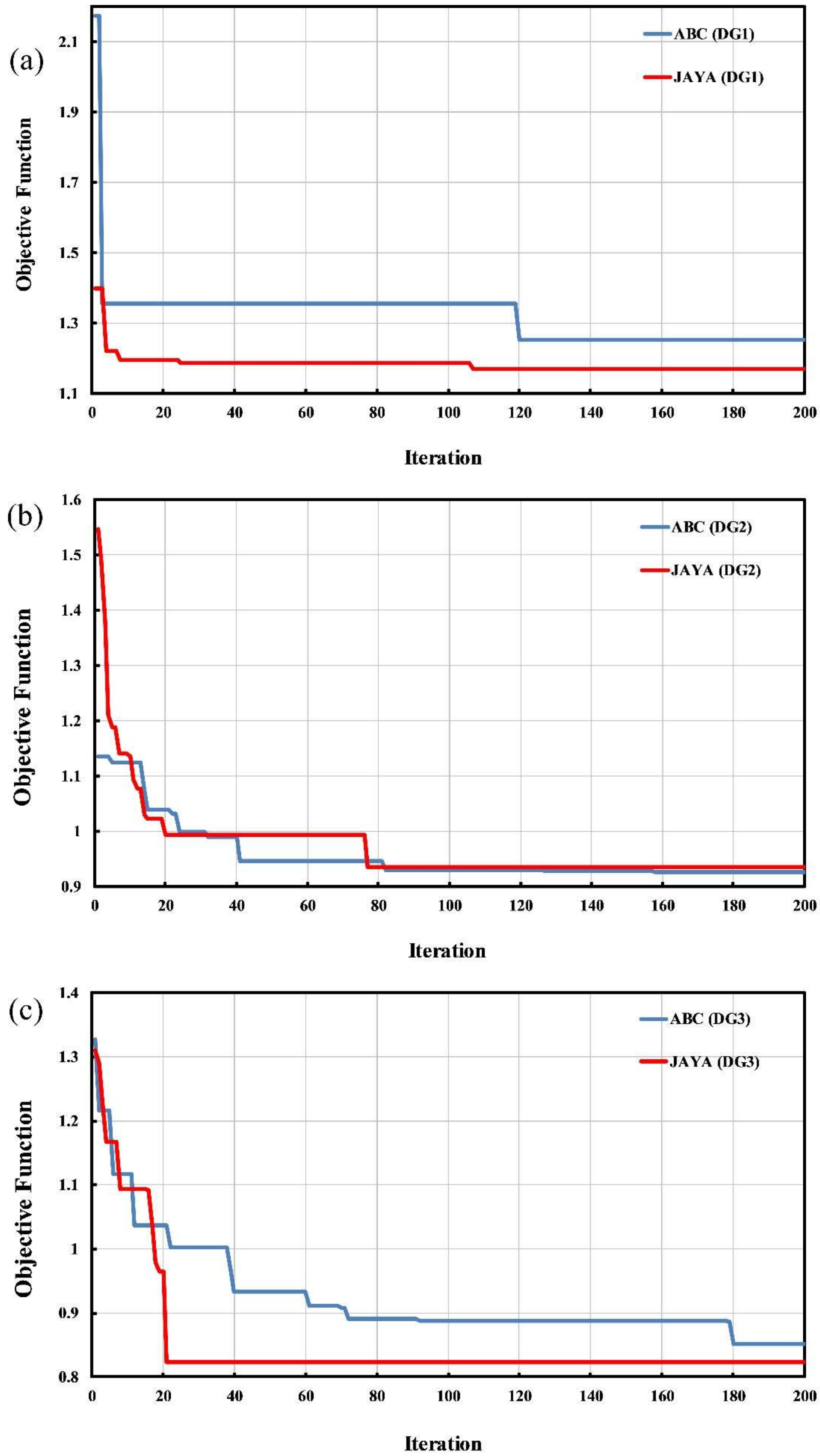

Figure 3. Convergence graphs of the algorithms based on objective functions (a) DG1, (b) DG2, (c) DG3

Figure 3 presents the convergence graphs of ABC and JAYA algorithms for three cases. Both algorithms were run for 200 iterations to determine the optimum size and location of DGs concerning their objective functions. As shown in Figure 3, the JAYA algorithm showed faster convergence than the ABC algorithm in all three cases. JAYA algorithm achieved 4.26%, 16.46%, and 24.32% lower objective function values compared to ABC in DG1, DG2, and DG3 cases, respectively. When more DG units were placed, the objective function decreased to lower values and the system became more efficient.

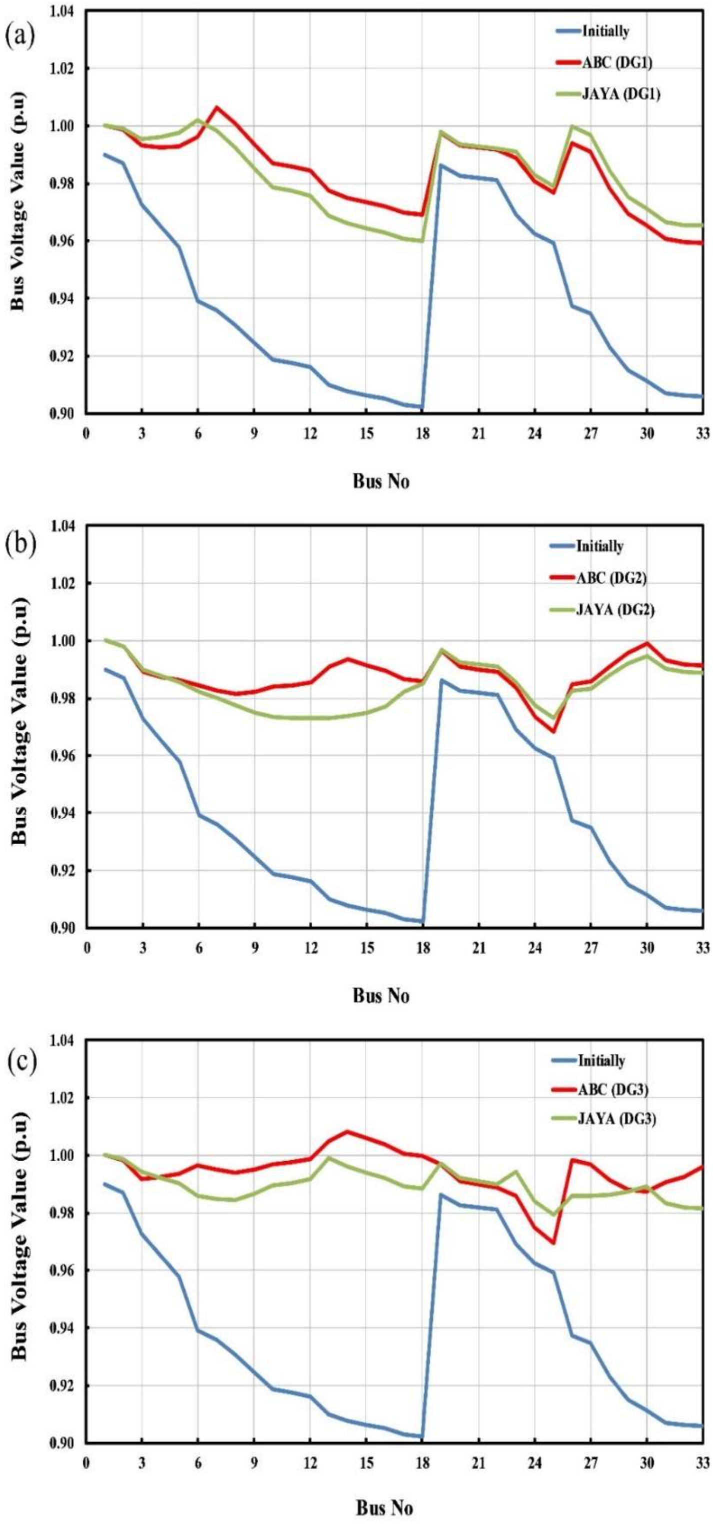

Figure 4. Voltage profiles of the algorithms (a) DG1, (b) DG2, (c) DG3

Figure 4 shows the bus voltage profiles for the base case, DG1, DG2, and DG3 scenarios calculated using the ABC and JAYA algorithms. The results indicate that both algorithms successfully maintained the bus voltage values within the specified limits of 0.95–1.1 p.u. In terms of voltage profile improvement, the ABC algorithm is more successful compared to the JAYA algorithm. However, it has been observed that as the number of DGs in the power system increases, the improvement in bus voltage values also increases.

As seen in Figure 4 and Table 1, the lowest bus voltage in the base case was calculated as 0.902 p.u. (Bus 18). With the ABC algorithm, this value increased to 0.959 p.u. in the DG1 scenario, 0.968 p.u. in the DG2 scenario, and 0.969 p.u. in the DG3 scenario. In the JAYA algorithm, the lowest voltage values were calculated as 0.956 p.u., 0.973 p.u., and 0.979 p.u., respectively. The highest improvement was achieved with the JAYA algorithm in the DG3 scenario, reaching a value of 0.979 p.u.

With the reduction in voltage deviations, a more balanced voltage profile has been established in the system. In particular, the ABC algorithm has been more effective in providing a more homogeneous improvement in low-voltage buses, while the JAYA algorithm has been more effective in raising the minimum voltage level. This situation offers a significant advantage in terms of increasing system stability and improving energy quality.

Table 1. Analysis results for the IEEE 33-bus power system under DG1, DG2, and DG3 scenarios

	Without DG	DG1		DG2		DG3	
Analysis	**Initially**	**ABC**	**JAYA**	**ABC**	**JAYA**	**ABC**	**JAYA**
Active Power Loss (KW)	0.207	0.094	0.090	0.079	0.066	0.074	0.056
Reactive Power Loss (KVAr)	0.138	0.076	0.071	0.057	0.047	0.058	0.043
Active Power Reduction (%)		54.33	56.48	61.55	67.92	64.24	73.00
Reactive Power Reduction (%)		45.21	48.36	58.98	66.03	58.30	68.77
DG1 Size (MW) and Location		3.235, 7	3.768, 6	1.367, 14	1.931, 30	1.215, 33	1.557, 23
DG2 Size (MW) and Location				2.271, 30	2.485, 18	1.489, 14	1.542, 13
DG3 Size (MW) and Location						2.097, 26	1.817, 30
Minimum Voltage (p.u.) and Location	0.902, 18	0.959, 33	0.956, 18	0.968, 25	0.973, 12	0.969, 25	0.979, 25
VD (p.u.)	2.047	0.548	0.570	0.392	0.521	0.237	0.344
Time (sn)		664.9	241.6	1261.6	842.6	1942.7	570.7

As shown in Table 1, the inclusion of DGs reduced both active and reactive power losses compared to the base case. The JAYA algorithm achieved greater reductions in active and reactive power losses in all cases compared to the ABC algorithm. For the DG1 case, the JAYA algorithm reduced active and reactive power losses by 56.48% and 48.36%, respectively. For the DG3 case, these reductions were 73.00% and 68.77%, respectively. These results indicate that increasing the number of DGs decreases power losses. Regarding computation time, the JAYA algorithm outperformed the ABC algorithm.

Table 2. Comparison of ABC and JAYA algorithms with other methods

Algorithm	DG1 Location (Bus No)	DG1 DG Size (MW)	DG1 Active Power Loss (MW)	DG2 Location (Bus No)	DG2 DG Size (MW)	DG2 Active Power Loss (MW)	DG3 Location (Bus No)	DG3 DG Size (MW)	DG3 Active Power Loss (MW)
	7	3.2350	0.0944	14	1.3670	0.0795	33	1.2150	0.0739
ABC				30	2.2710		14	1.4890	
							26	2.0970	
	6	3.7680	0.0900	30	1.9310	0.0663	23	1.5570	0.0558
JAYA				18	2.4850		13	1.5420	
							30	1.8170	
	6	2.5775	0.1050	6	1.9707	0.0899	6	1.7569	0.0792
ABC [37]				15	0.5757		15	0.5757	
							25	0.7826	
	6	2.5752	0.1039	14	0.7876	0.0962	10	1.0491	0.0760
PSO-CFA [38]				29	1.2487		25	0.8786	
							33	0.8049	
	6	2.5753	0.1039	13	0.8464	0.0859	14	0.7547	0.0714
ACO-ABC [39]				30	1.1588		24	1.0999	
							30	1.0714	
	6	3.1335	0.1102	6	3.1335	0.1057	6	2.1642	0.0828
PSO [40]				16	0.3651		16	0.3651	
							25	0.7386	

Table 2 presents the comparison of the developed ABC and JAYA algorithms on IEEE 33 busbar power systems in the literature in terms of the location, size of the DG, and the total active power losses on the system according to the cases of DG1, DG2, and DG3. It is seen that the developed algorithms give better results in terms of reducing active power losses compared to other algorithms studied in the literature.

5. Conclusion

In this study, the problem of optimal location and sizing of DG systems is analyzed using ABC and JAYA algorithms. The optimization process is focused on the objectives of minimizing active power losses and reducing voltage deviations. Simulations performed on an IEEE 33-bus power system showed that both algorithms effectively optimize the specified objective functions. The results show that the JAYA algorithm exhibits superior performance in reducing active and reactive power losses due to its faster convergence. On the other hand, the ABC algorithm is found to be more effective in terms of improving voltage profiles. Moreover, increasing the number of distributed generation units significantly reduced system losses and improved voltage stability for both algorithms. The results of the study support the applicability of the JAYA algorithm in large-scale distribution systems due to its simple structure and fast computability. On the other hand, the ABC algorithm is found to provide an effective solution in terms of voltage profile improvement. Accordingly, it is considered that a hybrid approach combining both algorithms can achieve superior results. The proposed optimization methods provide important contributions to the effective planning and implementation of DG systems within the scope of engineering and academic research. Future studies can focus on the development of optimization processes for different test systems and the integration of renewable energy sources.

Conflict of Interest Statement

The authors declare that there is no conflict of interest

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