Original Article

Proposing Optimal Price of Distributed Generation Sources with the Aim of Increasing Profits Using ALO Algorithm

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ABSTRACT

Distribution of generation resources in distribution systems has several advantages, including reducing losses, improving voltage profiles, reducing pollution, and increasing system reliability. However, one of the most important points regarding the placement of these resources in distribution networks is economic issues and the return on investment and the increase in profits from the placement of these resources. On the other hand, due to the privatization of power systems, other distribution networks will not necessarily own the distributed generation resources. Therefore, despite choosing the location of scattered production resources by the owners of scattered production resources and pricing their production power, the selection of purchasing power from each of the scattered production units or the national electricity system is done by the distribution network operator. It will be planned for supply. Thus, the owners of scattered production resources must choose the location and price of the production capacity of their resources in such a way that their profit is maximized and at the same time the amount of payment paid by the network operator is minimized. Therefore, in this paper, the issue of location and optimal pricing of distributed products is considered to increase the profit of the owner of scattered production resources provided that the distribution company pays the minimum payment cost and the method used to solve this problem is the ant-optimization algorithm. It is inspired by the ant's milk hunting mechanism and is a powerful optimization algorithm.

Introduction

In recent decades, the restructuring of the electricity industry, as well as the privatization of this industry, has been discussed and implemented in some countries. During this time, the electricity industry has undergone fundamental changes in terms of management and ownership due to increased efficiency and encouragement of investors, so that to create a competitive environment, its various sectors, including production, transfer, and distribution, are independent.

Also, factors such as environmental pollution, problems with the construction of new transmission lines, and technological advances in economizing the construction of small-scale production units are compared with large-scale

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production units, showing a rise in the use of small production units called DG, mainly to distribution networks, which do not require transmission lines [1-5]. DG has many benefits for the distribution system, including reducing losses, reducing peak load, reducing line density, providing ancillary services, improving power quality and reliability, reducing uninterruptible power supply, and delaying costs [6-9]. It provides different types of DGs to compensate for active and reactive power to reduce active losses in the secondary distribution system using the PSO algorithm [10-12]. The optimal power factor is intended to minimize power loss. The results obtained by PSO have been confirmed using an analytical approach. The analytical approach of each shin evaluates the system for finding the optimal solution and is, therefore, suitable for finding the location and size of DG in a small system. In this paper, in addition to reducing line losses, the size of DGs is reduced and voltage constraints are observed. Using the firewall algorithm, the optimal size and location of scattered production is determined [13-15]. In this study, the objective function is to maximize profits. In the proposed method, DG generators are of two types, photovoltaic and CHP. CHP is modeled as a voltage control node and photovoltaic panels are modeled as generators distributed in constant power mode. The method presented in this paper is simulated in the MATLAB environment and on IEEE 37-bus system. The results show the high efficiency of the algorithm provided in solving this problem. A way to ensure the dispersion of indestructible dispersed production units in the distribution system for economic recovery was provided [16-19]. The cost of installation and the operating cost of scattered production versus the amount of reliability is optimized as "willingness to pay" to customers to prevent power outages. Therefore, the main purpose of this article is to determine the optimal combination between scattered production units for installation. In this study, the genetic algorithm was used for optimization and the system studied was the IEEE 33-bus system. A framework for integrating geographic information systems (GIS) and mathematical optimization to obtain the optimal location and size of the PV unit for the next two decades has been proposed. A GIS module has been developed to find suitable roofs and panel capacity according to the amount of solar radiation, slope, and height. Then, an optimization module was used to maximize the long-term net profit of PV facilities due to different investment costs, inverter replacement, and maintenance operations [20].

In this paper, the problem of locating and optimizing the optimal distribution of scattered products to increase the profit of the owner of scattered products will be solved provided that the distribution company pays the minimum cost and the method used to solve this problem follows the algorithm optimization algorithm.

Ant Lion Optimization Algorithm (ALO)

The ant lion optimization algorithm (ALO) mimics the ant-hunting mechanism in nature [21, 22]. The five main steps in prey hunting are accidental walking of ants, trapping, trapping ants in the trap, catching prey, and rebuilding the trap. This algorithm can yield very competitive results in terms of avoiding local optimality and convergence.

ALO Algorithm Operators

The ALO algorithm mimics the interaction between ants and ants. To model such interactions, ants need to move in the search space, and the ant lion is allowed to hunt them using traps and become more adaptable. Since ants move randomly while searching for food in nature, a random walking method for modeling ants' movement is selected as follows:

$$X(t) = [0, cumsum(2r(t_1)-1), cumsum(2r(t_2)-1), \ldots, cumsum(2r(t_n)-1)] \quad (1)$$

Where cumsum calculates the sum of the sums, n is the maximum number of repetitions, t indicates the random walking step (repetition in this study), and r (t) is a random function defined as follows:

$$r(t)=\begin{cases}1 \ if \ \ rand > 0.5 \\ 0 \ if \ \ rand \le 0.5\end{cases} \quad (2)$$

Where t indicates the random walking step (repetition in this method), and *rand* is a random number generated with a uniform distribution in the range [0, 1]. The position of the ants during storage is stored in the following matrix:

$$M_{ant}=\begin{pmatrix} A_{1,1} & A_{1,2} & \cdots & \cdots & A_{1,d} \\ A_{2,1} & A_{2,2} & \cdots & \cdots & A_{2,d} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_{n,1} & A_{n,2} & \cdots & \cdots & A_{n,d} \end{pmatrix} \quad (3)$$

It should be noted that ants are similar to particles in PSO or people in GA. The position of an ant refers to the parameters for a particular answer. The M_{Ant} matrix is intended to store the position of all ants, variables of all responses, during optimization. To evaluate each ant, a fitness function, target, is used during optimization, and the matrix below stores the fitness function of all ants.

$$M_{OA}=\begin{pmatrix} f([A_{1,1} & A_{1,2} & \cdots & \cdots & A_{1,d}]) \\ f([A_{2,1} & A_{2,2} & \cdots & \cdots & A_{2,d}]) \\ & & \vdots & \vdots & \\ f([A_{n,1} & A_{n,2} & \cdots & \cdots & A_{n,d}]) \end{pmatrix} \quad (4)$$

Where M_{OA} is the matrix of each ant's storage reserve, $A_{i,j}$ shows the value of the variable j (dimension) of the *i-th* mouse, n is the number of ants, and f is a function of the target. In addition, ants are thought to be hiding in search areas. The following matrix is used to store the position and values of their fit.

$$M_{ant}=\begin{pmatrix} AL_{1,1} & AL_{1,2} & \cdots & \cdots & AL_{1,d} \\ AL_{2,1} & AL_{2,2} & \cdots & \cdots & AL_{2,d} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ AL_{n,1} & AL_{n,2} & \cdots & \cdots & AL_{n,d} \end{pmatrix} \quad (5)$$

$$M_{ant}=\begin{pmatrix} f([AL_{1,1} & AL_{1,2} & \cdots & \cdots & AL_{1,d}]) \\ f([AL_{2,1} & AL_{2,2} & \cdots & \cdots & AL_{2,d}]) \\ & & \vdots & \vdots & \\ f([AL_{n,1} & AL_{n,2} & \cdots & \cdots & AL_{n,d}]) \end{pmatrix} \quad (6)$$

The $M_{Antlion}$ matrix stores the value of each valve, $A_{Li,j}$ indicates the value of the variable j (dimension) of the valve i, the number of valves and the number of variables (dimension).

Simulated System Information

To demonstrate the effectiveness of the proposed method, several tests have been performed with two distribution systems, 34 and 85 buses. Figure 1 shows the distribution system of 34-bus. This system is similar to IEEE's 34-bus radial distribution system topology. Line information and bus information are also given in the tables [23]. Figure 2 shows the configuration of the 85-bus system. Line information and bus information are also given in the following tables [24].

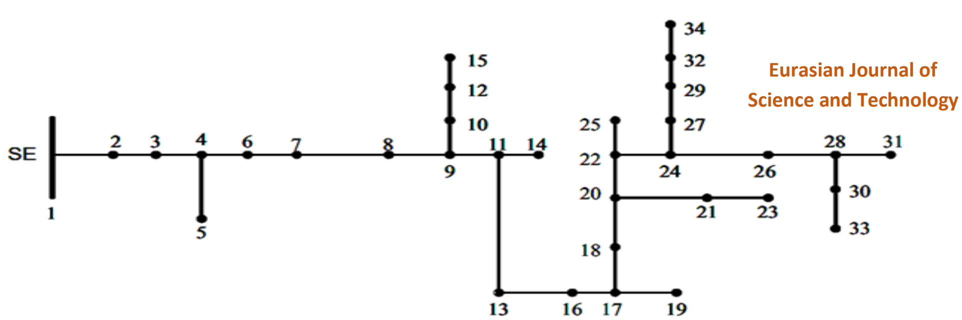

Figure 1 34-Bus radial system diagram

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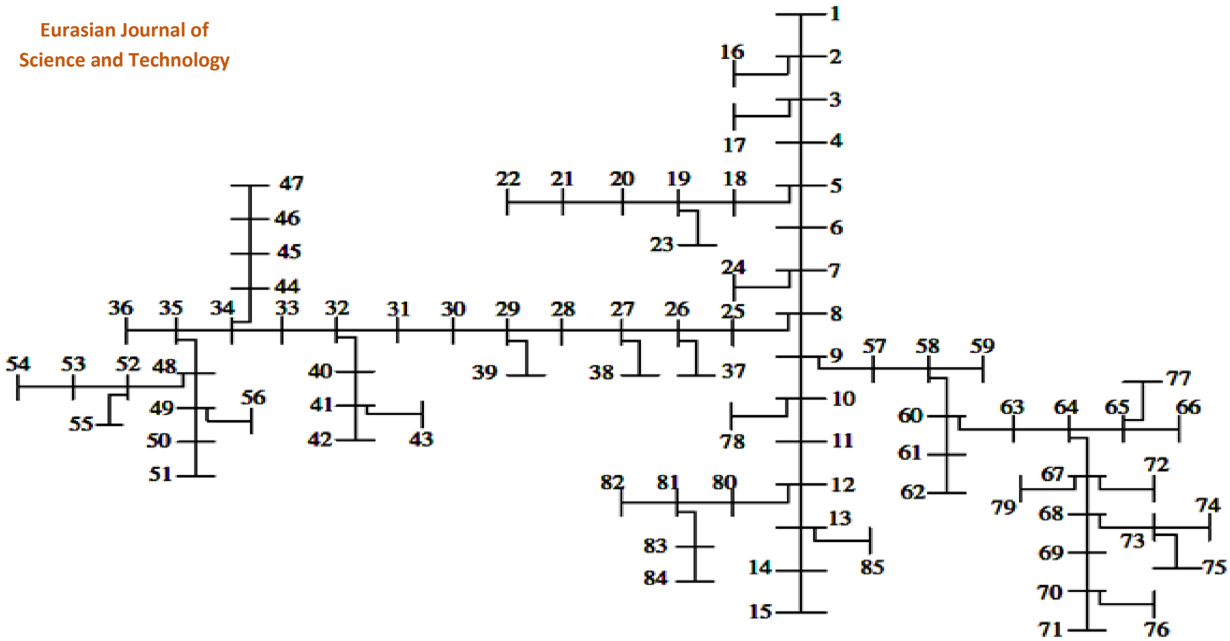

Figure 2. 85-Bus radial system diagram

Analysis of Simulation Results

In Tables 1 to 3, the simulation results for the 34-bus radial system are presented and compared with the results of the paper [25]. A comparison between the total DisCo payment for the different scenarios obtained by ALO and paper [25] is presented in Table 1. Table 2 shows the total energy loss in percentage. Table 4 presents the simulation results for the 85-bus radial system and compares them with the results of the paper [25].

Table 1 Simulation results for a 34-bus with 2 DG units

	Algorithm	Buses	Price(€/MWh)	Profit(€)
Scenario A	ALO	29, 22	75.3, 71	145254.7
	GA[12]	29, 32	68.7, 73.2	127135.99
Scenario B	ALO	26, 29	81.6, 72.8	250567
	GA[12]	27, 29	73.6, 78.2	213634.50
Scenario C	ALO	28, 29	86.5, 87.8	435663.3
	GA[12]	24, 29	81.1, 82.9	367482.31

Table 1 shows that for all three scenarios, the results obtained by the ALO algorithm were better so that for scenario A is 14.25%, for scenario B is 17.28%, and for the scenario, C is 18.55%, profit increases compared with that of this paper [25].

Table 2 Simulation results for a 34-bus with 3 DG units

	Algorithm	Buses	Price(€/MWh)	Profit(€)
Scenario A	ALO	13, 24, 29	72.3, 71, 73.2	195230
	GA[12]	29, 27, 23	71.8, 68.7, 71.7	177554.25
Scenario B	ALO	29, 26 22	83.1, 81.7, 72.7	341132.3
	GA[12]	32,23,24	76.6, 76.4, 79.7	301015.50
Scenario C	ALO	29, 23, 26	78.5, 82.3, 84.3	600645.7
	GA[12]	27, 28,20	79.1, 78.9, 80.6	519933.80

Table 2 shows that for all three scenarios, the results obtained by the ALO algorithm were better, so for scenario A it is 9.95%, for scenario B by 13.32% and the scenario C by 15.52% increase profit derived from the paper [25-27].

Table 3 Simulation results for a 34-bus system with 4 DG units

	Algorithm	Buses	Price(€/MWh)	Profit(€)
Scenario A	ALO	22, 15, 4, 18	71, 70.5, 70.4, 73.3	239818
	GA[12]	29, 18, 30, 28	71.1, 70.3, 70.8, 68.6	222066
Scenario B	ALO	23, 29, 24, 16	80.5, 79.2, 75, 71.4	431904.3
	GA[12]	29, 13, 12, 24	76.6, 68.8, 70.8, 72.4	379969.52
Scenario C	ALO	27, 26, 11, 24	80.7, 81.9, 77.8, 78.4	744206
	GA[12]	27, 30, 24, 21	79.1, 78.6, 78.4, 78.1	655844.01

Table 3 shows that for all three scenarios, the results obtained by the ALO algorithm were better, so for scenario A by 7.99%, for scenario B by 13.66%, and for the scenario C by 13.47%, profit growth was obtained compared with that of this paper [25].

Table 4 Simulation results for 85 bus system with 3 DG units

Algorithm	DG power factor	Buses	Price(€/MWh)	Profit(€)
	0.9 leading	19, 85, 34	66.9, 69.2, 69.8	215417.6
ALO	1	26, 32, 63	67.6, 67.9, 67.9	251150.2
	0.9 lagging	32, 2, 60	66.8, 65, 66.8	264481.5
GA[12]	-	32, 4, 18	65.6, 65.7, 65.6	204900.95

Table 4 shows that when the DG power factor is 0.90 lagging, i.e., DGs, in addition to generating active power, produce reactive power, the profit is greater than when working with power factor 1. And when leading works, i.e., DGs use reactive power to generate active power, they make the least profit. The profit generated by ALO was better than that of GA.

Conclusion

DG has many benefits for the distribution system, including reducing losses, reducing peak load, reducing line density, providing ancillary services, improving power quality and reliability, reducing uninterruptible power supply, and delaying costs. Increasing the number of DGs in the network indicates an increase in the cost of installing and maintaining DGs. By determining the optimal number of DGs, it is possible to create a balance between cost and improve technical parameters in terms of the process of deploying distributed generation resources; therefore, from the company's perspective, it is desirable to install distributed products in areas that bring the most benefits to the network, giving the most efficiency in the field of network operator activities and responsibilities. In this paper, the problem of locating and optimizing the optimal distribution of scattered products to increase profits will be solved provided that the distribution company pays the minimum cost and the method used to solve this problem will be the algorithm optimization algorithm, which is inspired by the behavior of the valve. It is a powerful optimization algorithm. The proposed method for determining the optimal location and size of DG was applied to two systems of radius distribution of 34 and 85 buses. For the 34-bus radius system, three different scenarios with low, medium and high loads were considered, and for each scenario, the number of DG units was considered in three modes: 2 units, 3 units and 4 units. Comparing the results, we found that the profit from installing DG and its pricing by ALO algorithm was higher than that of GA. Also, increasing the number of DGs has always increased profits. As for the total payment of DisCOs and energy losses, it is not possible to say which algorithm performed better. In the 85 bass radial system simulation, one scenario was considered, but three power coefficients for the DGs were considered in three different simulations. In this simulation, it was found that although losses are reduced by DG and the total payment of DisCOs is reduced, when the power factor is pre-phase and DG produces reactive power in addition to active power, the lowest profit is obtained when the power factor is after the phase. Comparing the two algorithms, GA and ALO, we found that ALO was more profitable, but GA was less likely to suffer losses and lower overall DisCO payments. However, given the DG owner's solution to this problem, the ALO response is more favorable than the GA response.

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