Optimizations Algorithms and Methods for Distributed Generation Systems: A Review

Saifee Kanjetawala[1]; Dr. Samir H. Patel[2]; Dr. Dattesh Y. Joshi[3]

[1]Research Scholar, Electrical Engineering Department, Krishna School of Emerging Technology and Applied Research (KSET), KPGU, Vadodara (Gujarat), India.

[2]Associate Professor, Electrical Engineering Department, Krishna School of Emerging Technology and Applied Research (KSET), KPGU, Vadodara (Gujarat), India.

[3]Associate Professor, Electrical Engineering Department, Krishna School of Diploma Studies (KSDS), KPGU, Vadodara (Gujarat), India

ABSTRACT: Reconfiguring the distribution system and installing distributed generation (DG) are two methods that minimise installed distributed generation (DG) costs and greenhouse gas emissions while reducing real and reactive power loss, improving voltage profile, enhancing power system stability, and security of the system. Additionally, it reduces the system's operating costs and enhances service performance in both typical and extraordinary circumstances. The installation of DGs in less than ideal places within the electrical distribution system, however, will have detrimental effects on system voltage changes and overall power loss. Therefore, the best method for determining the placement and size of DG must be devised. Several analytical, conventional, meta-heuristic, and intelligent strategies have been used to solve this problem in recent years. The fundamental goal of optimal distributed generation placement (ODGP) is to put DG in the best location and size possible while adhering to a number of limitations. The most important factors in designing electrical distribution systems are the switches' ideal placement and the safety measures. Switching devices are essential for network reconfiguration and DG installation in a distribution system. In this study, ODGP presents a comprehensive evaluation based on recently published studies in network reconfiguration.

Keywords: Distributed generation, Optimal DG placement, Optimization techniques, Artificial intelligence computational techniques, Renewable energy sources.

Abbreviations: ANM, Active Network Management; ABC, Artificial Bee Colony; BA, Bat Algorithm; BFA, Brute Force Algorithm; BFOA, Bacterial Foraging Optimization Algorithm; BSOA, Backtracking Search Optimization Algorithm; CS, Cuckoo Search; DG, Distributed Generation; DS, Distribution System; DGA, Distributed Generation Allocation; DGP, Distributed Generation Planning; DSDR, Distribution System Dynamic Reconfiguration; DP, Dynamic Programming; DA, Dragonfly Algorithm; EA, Evolutionary Algorithm; FFM, Firefly Method; GA, Genetic Algorithm; HS, Harmony Search; ICA, Imperialist Competitive Algorithm; IWO, Invasive Weed Optimization Algorithm; LP, Linear Programming; MINLP, Mixed Integer Nonlinear Programming; NLP. Nonlinear Programming; NSGA, Non-dominated Sorting Genetic Algorithm; ODGP, Optimal Distributed Generation Placement; OO, Ordinal Optimization; OPF, Optimal Power Flow; PSO, Particle Swarm Optimization; PGSA, Plant Growth Simulation Algorithm, SQP, Sequential Quadratic Programming; SA, Simulated Annealing; TS, Tabu Search.

I. INTRODUCTION

Interest in the use of renewable energy sources for the production of electrical power has been sparked by recent developments in the utilization of non-conventional/renewable energy sources, its approaches towards diverse applications in connection with the methodology, and changes. Assets connected to renewable energy sources have recently been successfully integrated into electrical power systems all over the world, with DGs being the one that has been extensively adopted in the particular distribution system (DS). Depending on the characteristics of the DG units and the loads, the electric power system organizers and controllers get benefits from integrating DG units in the distribution networks. Additionally, it will depend on the circuit configuration and local renewable energy assets. If all of the DGs assets are the right size and in the right place, the system is improved. Even Nevertheless, there are some advantages to the distribution system's incorporation of renewable energy sources.

DGs are facing various challenges in the DS due to the unpredictable nature of the system. The most critical concern when integrating DGs with DS is to maintain the power quality and system stability.

Distributed generation (DG) is a term used to describe the production of electricity at a small scale using alternative energy sources primarily at the distribution level for delivery to customers. When electricity is transmitted over long distances in a distribution system, a significant amount of power gets lost in the form of heat due to high current flow. According to research, 71% of the total power losses in the power system is accounted for in a distribution system, with transmission and sub-transmission lines contributing 29% of the losses.

A few issues related to DG incorporating in distributed systems are a power loss, variations in voltage profile, service reliability, restoration and system stability have been overviewed in [3-6]. DG installation in the distribution system affects the practical features of the entire network and create a problem towards the electricity market worldwide [7].

Power losses can be reduced in the system through the network reconfiguration strategies or techniques. Mainly, the distribution feeder reconfiguration technique can be conveniently utilized for system planning and real-time controlling and operation. Network reconfiguration in an electrical distribution system incorporates design and maintenance, which is required to identify the suitable structure, by changing switch positions inside the network [8]. Interconnection to neighborhood plants is considered to be another strategy to reduce the total power loss for instance (mini-hydropower generating plants, wind turbine power plants, solar power plants and biomass energy plants) [9].

The literature on the various research work shows that the use of renewable energy sources can minimize carbon contamination or pollution by 61% rather than from traditional electrical power generation plants by 2040 [10]. Installing DGs in distribution system leads to improved load balance, improves voltage profile, energy efficiency and reliability when it is appropriately sized and placed optimally. Optimal distributed generation placement is defined as the most appropriate place for the installation of DG. Unacceptable DG size results in an increased total power loss. Therefore, optimal sizing and location of the DGs reduce the power loss by keeping the system stable [11].

The Distributed Generation Planning (DGP) is also known as Distributed Generation Allocation (DGA). The optimization techniques used for optimal DGP are Analytical techniques, numerical methods, society inspired algorithms, nature-inspired techniques etc. In past research works published, authors have taken a single objective function, to find the optimal DG allocation problem in such way to minimize system power losses [12-14], voltage profile enhancement [15- 16], reduction of reactive power [17], DG size enlargement [18-19] and economy-oriented objectives [20-21].

In connection with this, a few review papers have published which are considering the network reconfiguration, ODGP, the optimal location of switching devices to solve service restoration problems in [22-24]. In continuation, the voltage sensitivity technique has implemented to maximize the accommodation capacity of the photovoltaic system provided for low voltage gridsin [22]. Another method has been proposed in [23] based on the active power flow management, that leads to help for DG incorporation improvement. Another method knows as the Active Network Management (ANM), which comprises of multiple system-level strategies for better placement of DGs have presented [25-27].

Recent meta-heuristic algorithms have been implemented for solving DG placement problems such as Bacterial Foraging Optimization Algorithm (BFOA), Stud Krill herd Algorithm, Harmony Search Algorithm (HSA) [28-30], Grey wolf optimizer [29, 30]. Another concept knows as Greedy algorithm has implemented for solving a weighted set cover issue, in which the nearby available minimum number of critical switches have recognized for enhancing the restoration capability of a distribution system considering DG placement [33]. In the distribution system dynamic reconfiguration

II. DG DEFINITION

Distributed Generation is a mini power generating a system to provide a small amount of energy to the customer loads through a utility electrical distribution system, defined in [36]. Some of the standard definitions of DG defined by the international organization has described [37-39].

Benefits of DG. As the rate of electricity consumption by consumers is becoming increasing rapidly, due to this integration of DGs in the radial distribution system isexpanding. New technological improvement in DGs design has contributed to the generation of energy at low cost, emission and high efficiency. In [40], the application of DGs in a modern electrical power system has been introduced to fulfil the requirements of customer load demand continuously by checking the reliability and quality of the supply. The development in design and manufacturing of DG unit's apparatuses, continuous variations in load pattern and uncertainty of available fuels have created opportunities for theutilizing renewable/ non-conventional energy resources to generate power as per consumer's load demand balance. Some of the advantages of DG installation are described in Table 1 [41-42] below.

Table 1: Distributed generation (DG) advantages [41].

Parameters	Advantages
Economic benefits	– Less maintenance and operation cost. – Cost of fuel consumption is less withrenewable DG. – Purchase of right of way cost is less. – Equipment cost of purchasing is less.
Environmental benefits	– Environmentally friendly. – Reduce the maximum amount of greenhouse gas pollutant. – Less land requires to install renewable DG unit.
Technical benefits	– Improve the reliability of the electricalpower system. – Reduction of Peak load demands. – Voltage profile and quality can be improved. – Better voltage regulation and fewer voltage flickers. – Reactive power can be control quickly, and losses in line are less. – Improve the overall efficiency of thesystem. – Reserve capacity power can be reduced. – Enhance the security of power utilities and critical loads.

Types and Methodologies of Distributed Generation: Generally, DG methodologies have classified into two types, namely renewable energy and non-renewable energy resources. The below Table 2 shows the types of DG methodologies and the DG methodologies with their characteristics [43-46].

III. DISTRIBUTED GENERATION

DG is termed as a mini generating unit from kW to MW and also an energy storage device which is located/placed near to customer loads, distribution substations and transmission substations in terms of distributed energy resources.

Significance of ODGP. To construct a reliable electricaldistribution network, DG plays a vital role in the future upcoming grids. To minimize the impact of power stations on economic and environmental conditions, DG such as renewable energy sources, diesel generator and energy storage devices is a better choice. DGs placement can minimize transmission, the distribution cost of generation and provide a way to consume energy under the peak load conditions and increase the reliability of the system. To achieve maximum benefit from DGs, the optimum sizing and location should be planned carefully, considering different criteria like climatic conditions and availability of resources [47]. DGs integration has an impact on the operating condition and reliability of the distribution system. If the DG is placed inappropriate, cause an increase in power loss and instability of the system. Therefore, the appropriate placement of DGs enhance the system power quality, improves system voltage profile, minimize harmonics and system losses. DG scheduling and planning is a significant issue for distributing real & reactive power to the electrical distribution system. Some DG planning methods are (a) size only (b) location (c) size and location (d) size, location and numbers and (e) size, location, number andtype.

Table 2: DG Technologies/Methodologies [43-46].

Different DG Technologies/Methodologies					
Renewable DG Technologies				Non-Renewable DG Technologies	
Contents	Wind energy	Photovoltaic	Fuel cell	Gas turbine	Reciprocating Engines
% efficiency	35-45	10-36	35-55	20-45	Diesel :35-45
Fuel used	Wind	Sun radiation	Methanol & Hydrogen	Natural gas & kerosene	Diesel, Bio-Diesel, Bío-gas.
Capacity range	0.2 MW- 4 MW	1kW-10kW	10kW-1MW	2MW-20MW	Diesel:15kW-10MW
CO_2 Emission(g/Kwh)	No emission	No emission	400-500	500-650	Diesel:600-650
Applications	Industrial and commercial application, Domestic Applications	Household, Industrial, Transportation, Communication and power generation.	Domestic & army applications, Transportation sector.	Reserve power generation, Transportation sector and commercial sector.	Standby and combined heat generation.
Advantages	No emission, Low Operation & Maintenance costs, low environmental impact.	No emission, Low Operation & Maintenance costs, less impact on environmental.	Compact, Low Operation & Maintenance costs, more efficiency, reliability and low emissions	Low Operation & Maintenance costs, low emission, high operating speed.	Capital Cost is low, high efficiency and reliability.
Disadvantages	Noise pollution and Telephone interference	Electromagnetic Field-effect, loss of natural environment and biodiversity loss.	High Installation Cost.	Low Efficiency & High Capital Cost.	More noise, High maintenance cost.

The main advantages of ODGP are:

- Minimize active and reactive power loss
- Reduces power system fluctuations
- Enhance available electrical power transfer capacity
- Improves power system reliability and security
- Maximize power system load ability.
- Enhance the stability of system, voltage, frequency and stability of rotor angle
- Minimize conjunction of the line power and
- Increase the range of operation of the system.

Effects of DG. The impacts of DG have classified as follow: Environmental, Economic and Technical impacts. Due depletion of fossil fuels, an increase in pollution and changes in climate condition has origin the power generation through renewable sources. According to the literature published by many researchers, academic persons, 75% of the pollution in the environment around the world has generated due to fuel-burning [48-50]. By implementing recent DG technologies like renewable energy sources to generate power can reduce the emission of carbon content particle releasing into the atmosphere. The large thermal power generating station release a large portion of greenhouse gases into the atmosphere, which are primary contributors to global warming [51].

Some of DG technologies which do not consume fossil fuels such as wind energy, solar photovoltaic system and hydropower plant can reduce the greenhouse gases to the maximum. The economic benefits which the utilities obtain by shifting to DG integration are reduced in fuel cost, reservation of power storage, up gradation of the generation, maximization of the protection for critical loads, minimization of operating cost during peak hours and minimization of the maintenances and operation cost [52]. The technical problems which occur in the distribution system, when DG is placed in an inappropriate location are real and reactive power losses, excess energy, voltage variation and unstable reliability in system operation [53-55].

Selected Objectives for ODGP. Generally, the main goal concerning ODGP is to minimize total power losses in the power system. Other objectives like voltage profile improvement, current reduction in delicate lines, the reactive power loss minimization and network MVA capacity increment have been considered as fitness functions for optimization. The primary optimization objectives for ODGP are shown in Fig. 1.

Number of DGs. Dependent on DGs connected to the distribution system, the ODGP problem is classified as:

- Single DG
- Multiple DGs installation.

Load Variable Levels. The different types of load/stack variable levels modelled in DG location are as follows: single stack, multi-stack and time-dependent stacks, etc., distributed along buses/lines.

Constraints. The majority constraints considered in the design of ODGP are as follows:

- Bus voltage, voltage drop limits,
- Line, transformer overloading, capacity limit,
- Total harmonic voltage distortion limit,
- Short-circuit level limit,
- Reliability constraints, e.g., SAIDI, SAIFI.
- Power generation limits,
- Budget limit, Power flow equality constraints and

– DG penetration limit. he variables

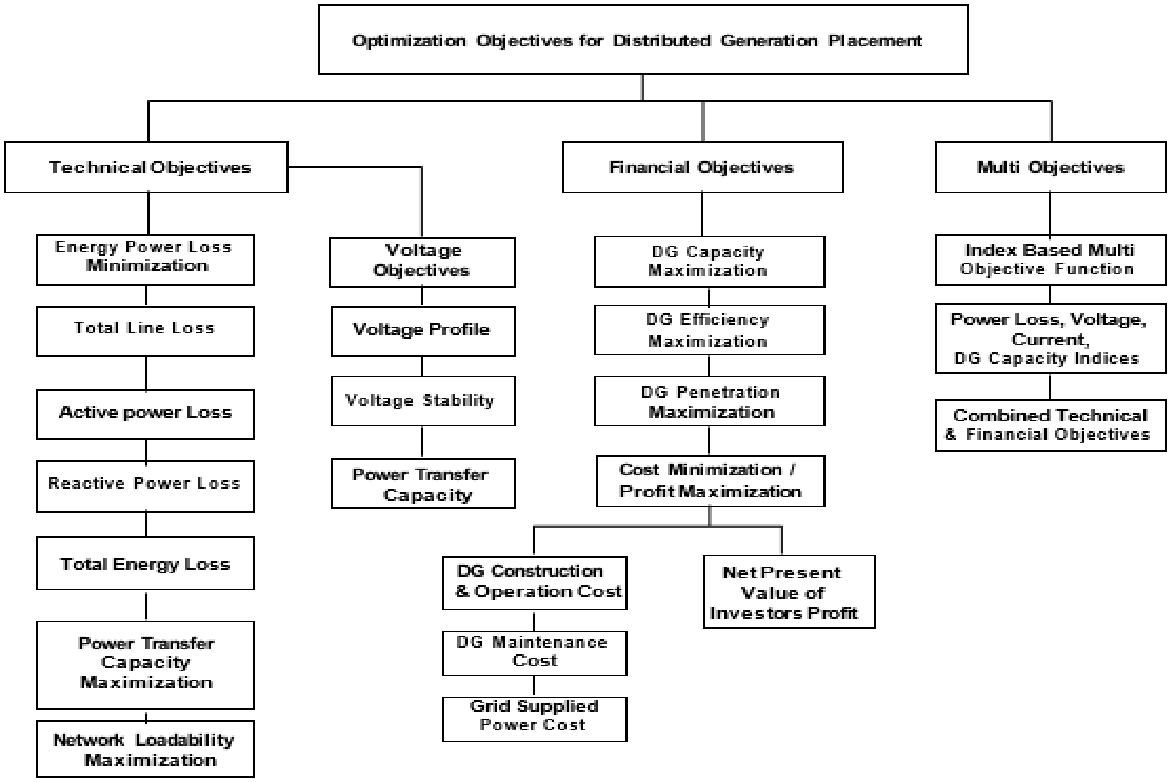

Fig. 1. Objectives in distributed generation placement/allocation.

Comprehensive Algorithm for ODGP. The Comprehensive algorithm for ODGP in the distribution system is explained as [56]:

Step 1: Initialize the system data.
Step 2: Execute the power flow analysis.
Step 3: Estimate bus voltage, system losses and short circuit current at the bus.
Step 4: Check if constraints satisfy or not.
Step 5: If satisfies initialize weight factor, and evaluate the objective function.

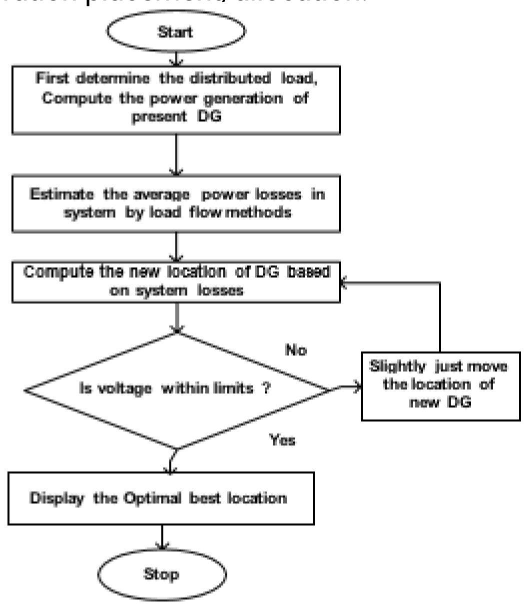

Fig. 2. ODGP in radial distribution system.

Step 6: Incorporate required optimization method to optimize the objective function.
Step 7: Else estimate the new position and sizing and go to step 2.
Step 8: Check if the solution is the best fit for objective function or not?
Step 9: Yes, means calculate indices values or not means go to step 7.

Step 10: Analysis of the weight factor and print the best- fit position and size for DG placement, otherwise go to step7.

The flowchart used for determining ODGP in a radial distribution system is depicted in Fig. 2.

IV. OPTIMIZATION METHODS AND ALGORITHMS

Several methods have been implemented for ODGP in the electrical distribution system areas [57, 58]:

1. Analytical Optimization Methods.
2. Numerical Methods.
3. Modern Higher-Level Algorithms.
4. Nature Inspired Techniques
5. Other Technique for Future use.

The most commonly used optimization methods andalgorithms for ODGP are summarized in Fig. 3.

Analytical Optimization Methods. Analytical optimization methods have implemented based on the 2/3 rule concept. In this concept a 2/3 size of DG, which is having a received generation at 2/3 span of the line connected to a network. This rule is applicable mostly for loads having a uniform distribution. Two analytical methods have proposed by C. Wang and Nehrir foroptimum location of DG in the system considering fixed size [59]:

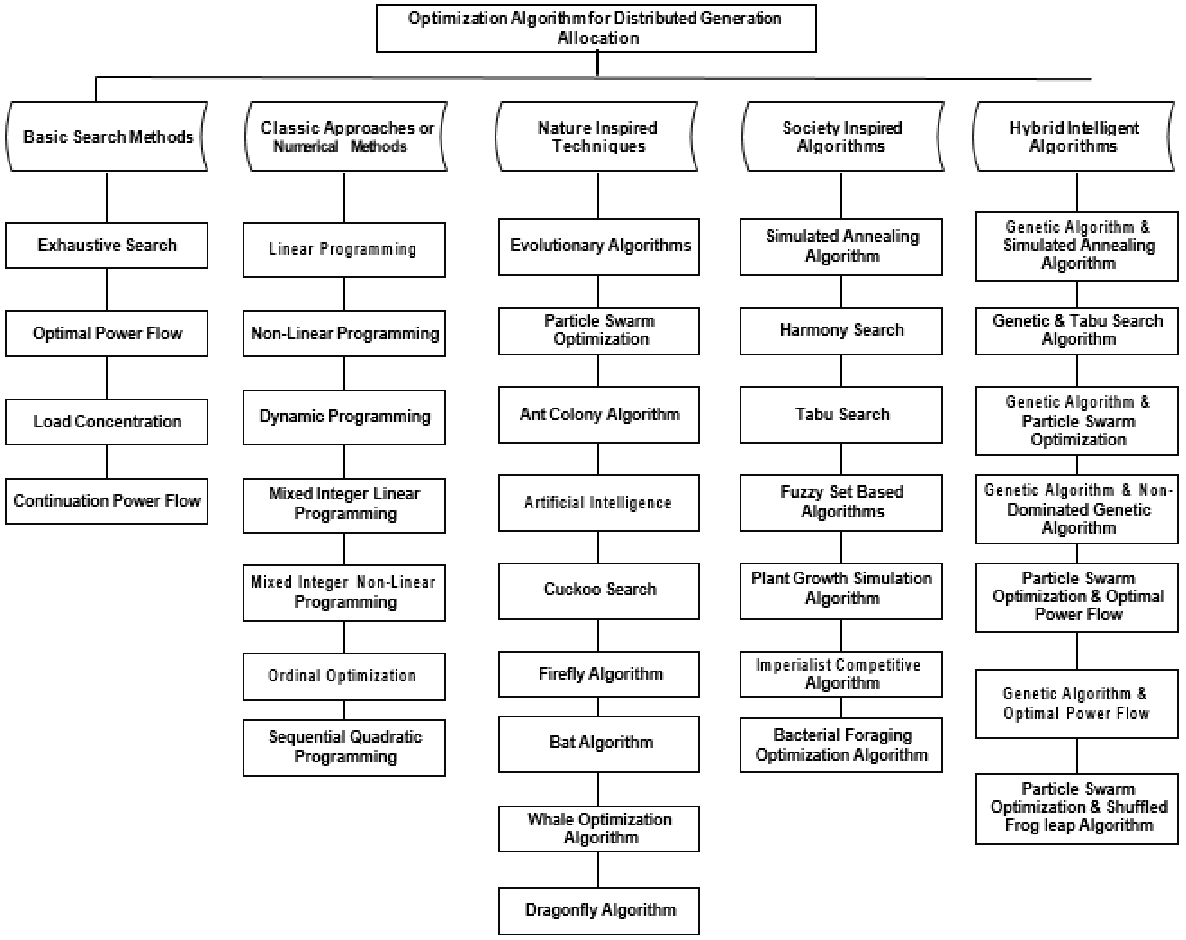

Fig. 3. Different optimization algorithms for optimal distributed generation placement.

The primary method is valid to radial and the other to a meshed electrical distribution system. Another analytical method has been proposed for ODGP based on “exact loss formula” by Acharya [60].

Gözel has introduced a technique for ODGP using loss sensitivity factor depending on the equivalent current injection process [61]. Another method has been suggested [62] for obtaining the optimal location/placement of multiple DGs, including “Kalman filter algorithm” to define their size. A set of regular expressions has developed for finding the optimum size,including different types of DGs power factor to reduce the system power losses [63, 64].

(a)*Eigen Value-Based Technique:* To analysis, the stability condition of the electrical power system Eigen value-based technique is utilized. Stability places a vital role in the effective operation of the electrical system under loaded condition [65].

(b)*Sensitivity Based Method:* This method has implemented based on the variation of one variable value, which in turn affects the desired value of a variable. As per the literature review, the authors have proposed the sensitivity-based method considering loss minimization for ODGP in the electrical distribution system [66-68].

(c) *Index Method:* This method has implemented depending on the theory of variation of constraint value from an actual value. This method is mainly used for reliability determination, as proposed [69].

Numerical Methods. Some of the underlying numerical methods used for ODGP are:

(a)*Gradient Search Method:* This method has proposed by authors for the ODGP in meshed networks, including constraints related to fault outages/levels in the system [70, 71].

(b) ***Sequential Quadratic Programming (SQP):*** SQP is proposed for resolving ODGP models considering different constraints involving fault level scenarios [72].

(c) ***Linear Programming (LP):*** Linear programming method is mainly utilized for constructing ODGP models, aiming to attain maximum distributed generation penetration in distribution system [73].

(d) ***Nonlinear Programming (NLP):*** This method has been used for placement of minimum number DG in both distribution system, i.e. radial system and meshed system, with an objective improving voltage stability of system [74]. NLP methods are also used to construct and solve deterministic models, which are used for the ODGP formulation considering AC optimal power flow [75]. MINLP is also a method used for ODGP to reduce system power loss and to enhance voltage stability limits [76].

(e) ***Dynamic Programming (DP):*** This method has been implemented to resolve an ODGP design with an objective function to maximize the distribution network operator profit by considering different load conditions [77].

(f) ***Ordinal Optimization (OO):*** An Ordinal Optimization technique is employed for obtaining the ODGP by considering the trade-off among loss minimization and for capacity maximization of DG [78].

(g) ***Exhaustive Search:*** Exhaustive Search technique has been used for analyzing the behavior of load demand concerning time-dependent and generation in the system; once a DG is placed in a large distribution system. This search method is used for ODGP with an objective function to maximize the reliability of a system for a particular DG size [79].

(h) ***Optimal Power Flow (OPF):*** A constraint nonlinear optimization method have been used mostly to solve many problems raised in power system related to reliability of supply, DG placement, voltage profile improvement and minimization of power losses. These OPF methods are basic search methods utilized by researchers for ODGP in distribution system [80, 81].

(i) ***Mixed Integer Non-Linear Programming (MINLP):*** This technique is formed on a combination of linear and nonlinear programming, mixed-integer linear and nonlinear programming methods, depending on the required problem defined for ODGP. MINLP can be applicable for different functions like discrete, continuous variables and non-linear. The technique provides an accurate, reliable solution for multi-objectiveproblems [82, 83].

(j) ***Continuous Power Flow Method:*** This technique has been well known for solving the non-linear equation of the system. By using this technique, voltage collapse in the system can be computed by using the system load flow equation. If the matrix has value as zero, then it is represented as a voltage collapse condition. A method has proposed in [84] to identify a sensitive bus to place a DG in the system.

Modern Higher-Level Algorithms. Due to stochastic nature in power generation by renewable energy sources, the proper placement, sizing & location of DGs in the distribution system play a pivotal role. Many socially inspired algorithms have been integrated with different heuristic solvers for solving DG placement in the system. For solve the ODGP optimization problem, many conventional optimization methods, advanced hybrid algorithm combine with fuzzy algorithms have been implemented by researchers in the literature survey.

(a) ***Simulated Annealing (SA):*** This algorithm has been implemented by Kirkpatrick, Gelatt and Vecchi in the year 1983, based on a random search method, to evaluate huge combinatorial optimization issues. Limitation of this algorithm possibilities of getting entrapped in the local minima when tolerating and rejecting new results. This algorithm have an initial random solution for the defined problem, later updating one component of the solution iteratively towards the goal, to obtain the best solution for the considered optimization problem. This technique is formulated for ODGP depending on objective function to minimize power loss and improvement of voltage profile [85].

(b) ***Harmony Search (HS):*** Zong Woo Geem have introduced the algorithm in the year 2001 [86]. The harmony search algorithm is a metaheuristic algorithm formed based on music and inspired by music harmony combining different sounds from a visual point of view. This technique has formulated for ODGP depending on the objective function to minimize the power loss [87]. The flowchart for the harmony search algorithm is depicted in below Fig. 4.

(c) ***Tabu Search:*** This algorithm have been first introduced by Glover and McMillan in the year 1986, for computing optimization problem based on the performance of the human memory. To obtain a better solution within a smaller number of iterations for combinatorial problems, the tabu search algorithm ispreferred more. This technique provides an accurate, reliable solution in less time for multi-objective problems considering both ODGP and location of reactive power sources [88]. The flowchart for the algorithm is shown in below Fig. 5.

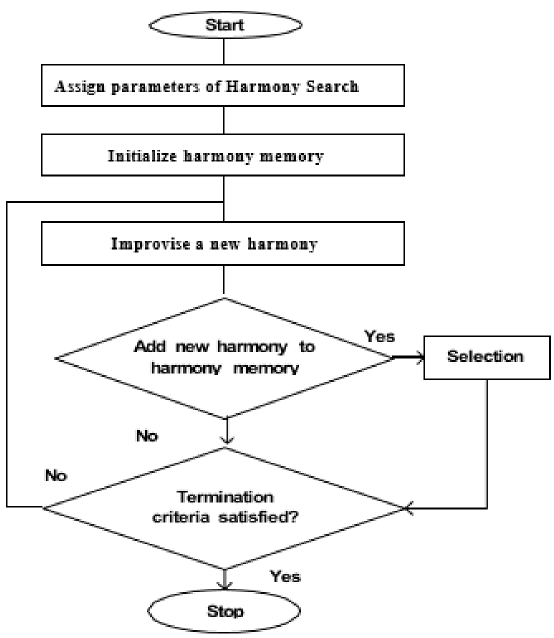

Fig. 4. Harmony search algorithm flowchart.

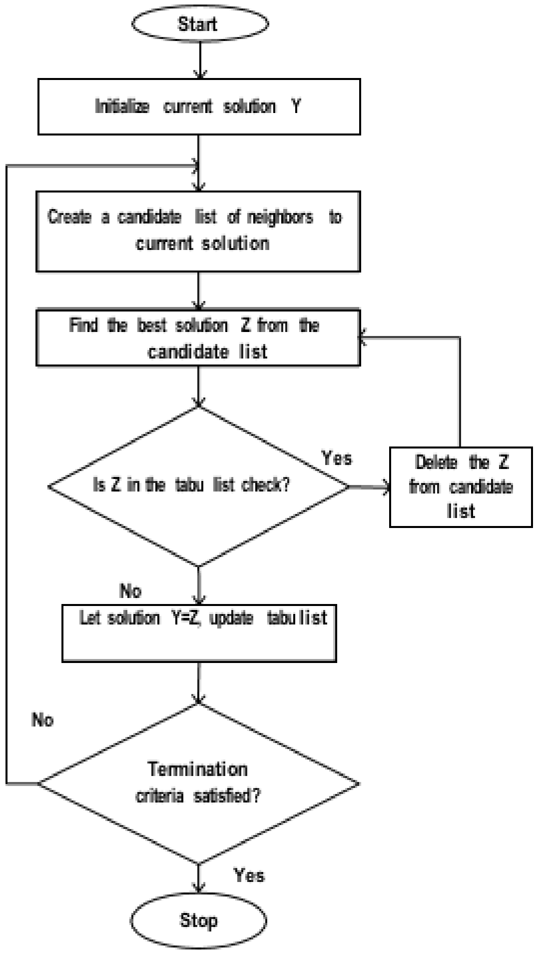

Fig. 5. Tabu search algorithm flowchart.

(d) Fuzzy Base Algorithms: Fuzzy based algorithms are effective tools for assessing the stochastic nature of systems, modeling, and planning [90]. Fuzzy is used in a two-stage approach that has been implemented for ODGP to determine the ODGP. The ABC algorithm was then used to determine the size of the DGs while taking loss reduction into account [91].

(e) The Plant Growth Simulation Algorithm (PGSA): When determining an appropriate value, the Plant Growth Simulation Algorithm (PGSA) is a rapid method that doesn't require further parameter tuning. The placement of a capacitor in a radial distribution system and ODGP both use this technique [92, 93].

(f) Imperialist Competitive Algorithm (ICA): One of the evolutionary algorithms starts with the basic population and divides it into several monarchs and colonies as imperialists. In comparison to other methods for stage-based computation of ODGP, our strategy is more appropriate, effective, and accurate [94].

(g) The BA (Bat Algorithm): The reverberation area characteristics of bats with varying loudness and vibration rates of release were the basis for Yangin's 2010 algorithmic proposal. By utilizing the Bat algorithm, ODGP in the radial distribution system was proposed in [95]. Fig. 6 depicts the flowchart for the Bat algorithm.

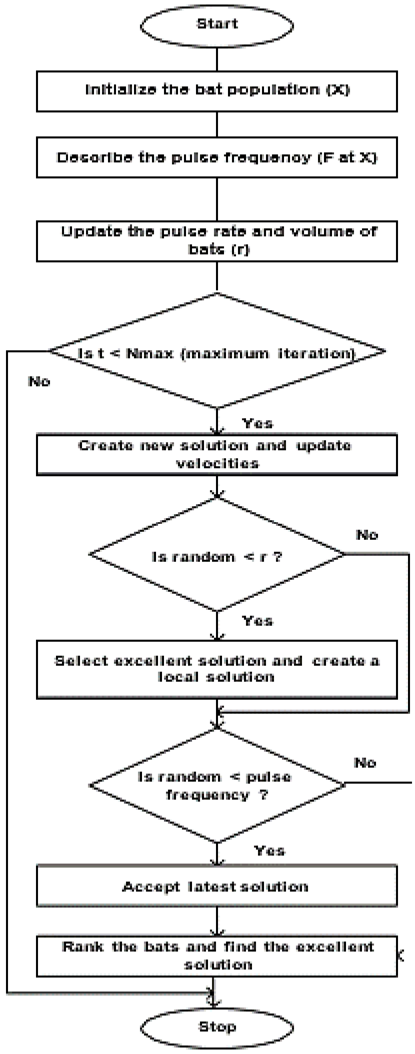

Fig. 6. Bat algorithm flowchart.

(h) Brute Force Algorithm: BFA is a safe algorithm for solving issues. This approach involves computing solutions for each contender in turn and determining whether or not they satisfy the problem description. By observing how far the other algorithm's results deviate from the real results computed using the BFA that Mena and Garca (2015) [96] recommended, it will be easier to assess how well the other algorithm is being implemented.

(i) The Bacterial Foraging Optimization Algorithm: Swarm optimization, computational intelligence, and metaheuristics are three fields in which BFOA falls. This method takes its cues from bacteria's chemotaxis behavior, which involves tracking precise signals by observing chemical gradients in the surrounding environment. The algorithm's method of processing information involves allowing cells to stochastically and collectively swarm in the direction of optima [97]. For ODGP in the radial distribution system, BFOA has been proposed, uses an objective function to reduce line losses while taking into account different limitations [98].

(j) Invasive Weed Optimization Algorithm (IWO): In 2006, Mehrabian and Caro Lucas introduced the IWO method, which is based on the stochastic optimization algorithm and is motivated by the behavior of weeds. This algorithm was used to determine the ideal size and location of the DG using a strategy for integrating power loss reduction and loss sensitivity factors. It has been suggested to use a multi-objective approach for ODGP in the distribution network with several load models [99].

(k) Backtracking Search Optimization method (BSOA): BSOA is a recently suggested evolutionary method that can be used to find a solution to problems involving complex numerical optimization functions, nonlinear functions, and non-differential functions. This approach is utilized for many statistical procedures more easily, quickly, and effectively [100-102].

Logic was influenced by nature. The following are a few methods used by researchers who were inspired by nature: Dragonfly Algorithm, Genetic Algorithm, Particle Swarm Optimization, Bee Colony Optimization Algorithm, and Evolutionary Algorithm the algorithms for "whale optimization," "ant-colony optimization," "cuckoo search optimization," and "firefly optimization."

(a) Evolutionary Algorithms: An evolutionary algorithm is a general population-based meta-heuristic algorithm that is used to develop solutions to problems based on natural selections (recombination, mutation, selection, reproduction, etc.). This algorithm was created in order to find the best solution to a given problem. It is based on a natural phenomenon. Generally speaking, the first stage in the algorithm's necessary phases is creating the initial population of people at random (first generation). The next phase is to discover potential solutions and update them in accordance with the plan to make them better. The third phase entails repeating the second step until the convergence criteria have been satisfied in order to identify the best solution to the described problem under consideration. This method has been put forth. in order to enhance the system voltage profile and minimize power loss, the position and size of the DGs were optimized [103].

(b) Genetic Algorithm: This optimization algorithm that mimics the natural processes of evolution and transformation is known as a genetic algorithm (GA). In order to find a globally optimal solution to big optimization problems, GA is typically used. Because GA is simple to model and comprehend, it has been used in the optimization of DG placement and position, business purposes, and for sophisticated machine learning ideas. The multi-objective cost function is used to construct GA for determining the ODGP while taking into account variables like the cost of DGs, active power loss, and reliability indices like SAIDI and SAIFI [104]. The Non-dominated Sorting Genetic Algorithm-II (NSGA-II) is an upgraded version of GA that has been utilized in distribution systems for dynamic reconfiguration [105], taking into account a multi-objective function that aims to reduce operating system costs while maximizing system reliability. By factoring in the time sequence characteristics of the load and distributed generator output, an improved NSGA has been presented for ODGP in the radial distribution system [106]. Fig. 7 below displays the flowchart for the genetic algorithm.

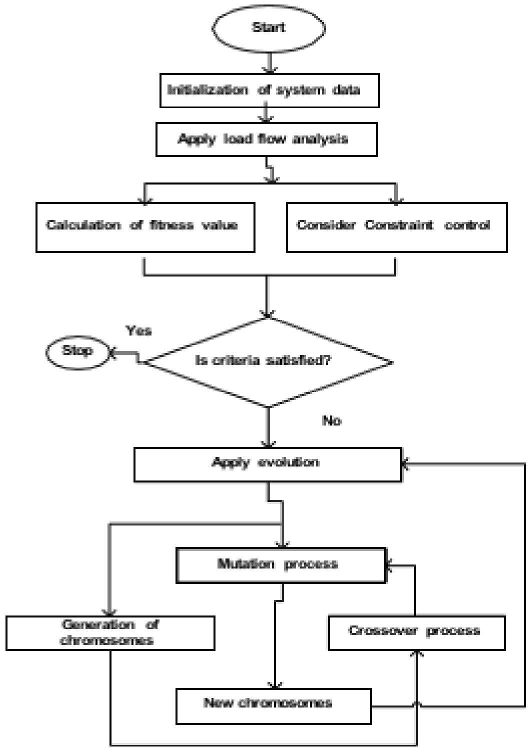

Fig. 7. Genetic algorithm flowchart.

(c) Particle Swarm Optimization (PSO): Developed by James Kennedy and Russell Eberhart in 1995, the PSO algorithm is regarded as a robust, stochastic optimization method based on the movement and intelligence of swarms. The PSO algorithm primarily simulates population dynamics and mimics the social behavior of bird flocks or fish schools. Every available person in the entire population is seen in this context as being designated as a particle. Further assumed to be moving in time-domain steps within the multi-dimensional search space [107]. The new location of the particle has been determined in relation to its existing location, the best state as experienced by the particle itself (Individual Best), and the best state as experienced by the particle's immediate neighbors (Global Best) [108].

For optimization problems operating under various load situations, PSO method has been implemented for obtaining the Pbest value and Gbest value [109]. The concept of PSO is employed for determining the best placement and DG size for integrating renewable energy sources in radial and multi-phased DS under unbalanced conditions [110]. In order to reduce losses, the researchers employed the PSO method to locate the ODGP and size several DGs in DS. Voltage profile improvement in DS has been achieved using hybrid PSO and HBMO algorithms [111,112]. Fig. 8 below depicts the PSO algorithm's flowchart.

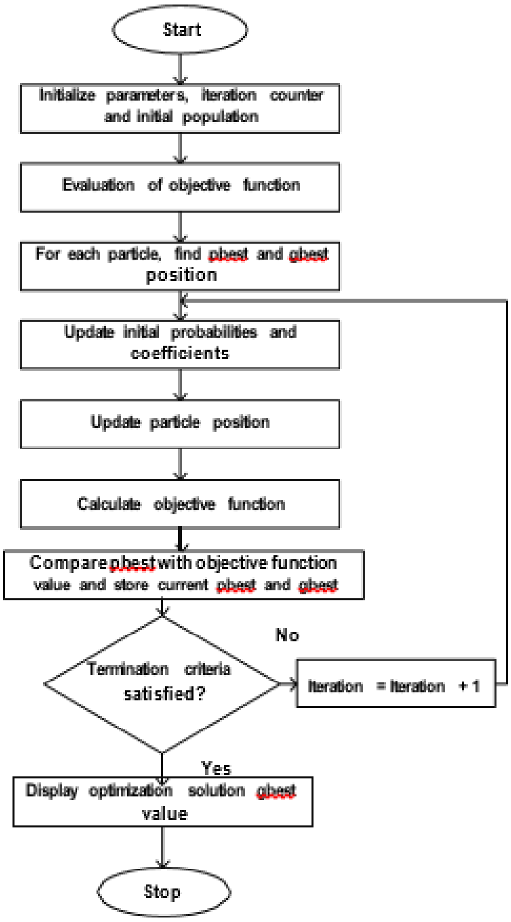

Fig. 8. PSO Algorithm flowchart

(d) Dragonfly Algorithm (DA): Developed by Mirjalili in 2015, the DA is based on the dragonflies' static and intellectual behavior as well as their swarm intelligence, which is depicted in nature.

DA have applied to find an ideal unit size of DGs age to further develop voltage guideline, profile, soundness and power misfortune decrease as well concerning the financial advantages [113]. The flowchart for the Dragonfly calculation is displayed in Fig. 9.

(e) Whale Optimization Algorithm (WAO): Whale Optimization Algorithm have been carried out to track down the ideal size and area of DGs, to assess multi objective capabilities in light of the framework all out power misfortune minimization, improvement in voltage profile and the decrease in working expense in thought with correspondence and imbalance imperatives [114].

(f) Ant Colony Optimization Algorithm (ACO): ACO algorithm have been carried out in light of the way of behaving of the social bug (subterranean insect) for finding the briefest course for their food needs [115]. These intern help to figure out the chance of taking care of enhancement issues simply by utilizing the reenactment devices [116]. The Subterranean insect settlement framework is a superior form of ACO, which further gives better recreation brings about different designing issues [117].

Thus, ACS have been applied for distinguishing the ideal area of the fixed recloser switch and the place of ODGP, to improve the dependability of the DS.

The flowchart for the Ant colony optimization algorithm is portrayed in Fig. 10.

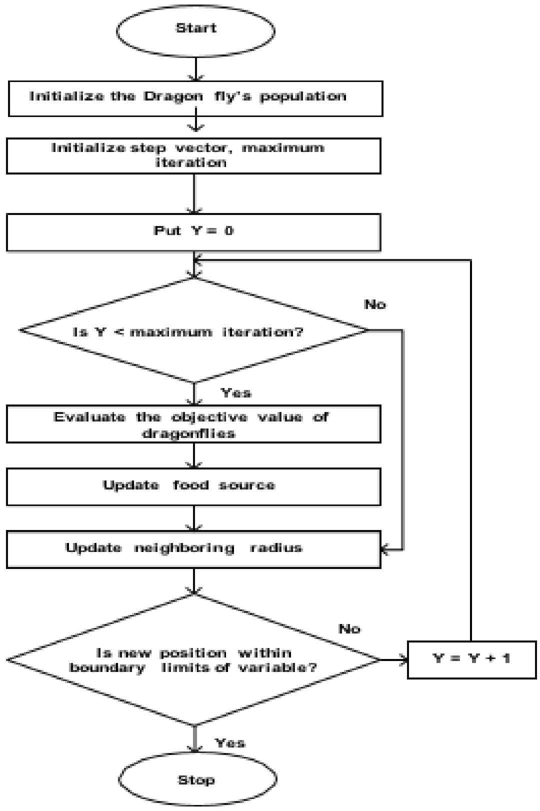

Fig. 9. Dragonfly Algorithm flowchart

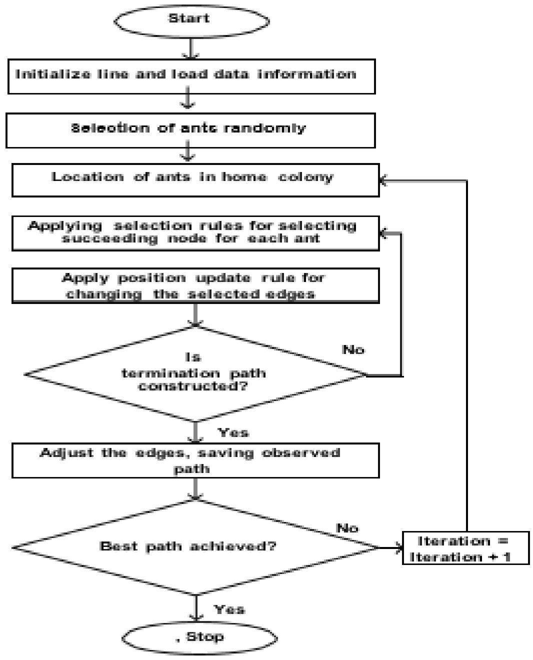

Fig. 10. Ant colony optimization Algorithm flowchart

(g) Artificial Bee Colony (ABC): Karaboga (2005) [118] have utilized ABC algorithm in view of the savvy conduct of the bumble bee bugs/swarm for tracking down ideal worth.

The adequate settlement size, number of emphases and the variable constraints has viewed as the basic control boundaries in ABC. These boundaries need to characterize at first by the concerned client of the calculation. Toward the early phases ABC calculation have really used for tackling the mathematical based optimization issues [118]. Later the use of calculation has delayed to different applications, for example, the issues connected with compelled, unconstrained and, surprisingly, a few combinatorial issues [119-120]. Since the algorithm enjoys explicit benefits like strength, basic and adaptable in tackling issues has made to involve this calculation something else for taking care of the optimization issues. ABC is essentially managing the position changes made by the honey bees in the home for the decision of food sources, concerning their own as well as their nest mate's contribution. Likewise, in a given complex hunt space, the counterfeit honey bee can move along with other existing honey bees in the home. Subsequently, the huge models considered in ABC concentrate just with two control boundaries which can be suitably tuned as related with the GA and PSO algorithms. As a general rule, the ABC optimization algorithm is successfully used for investigating the transient way of behaving of the network interconnected DGs [121]. The flowchart for the Fake Honey Bee State calculation is displayed in underneath Fig. 11.

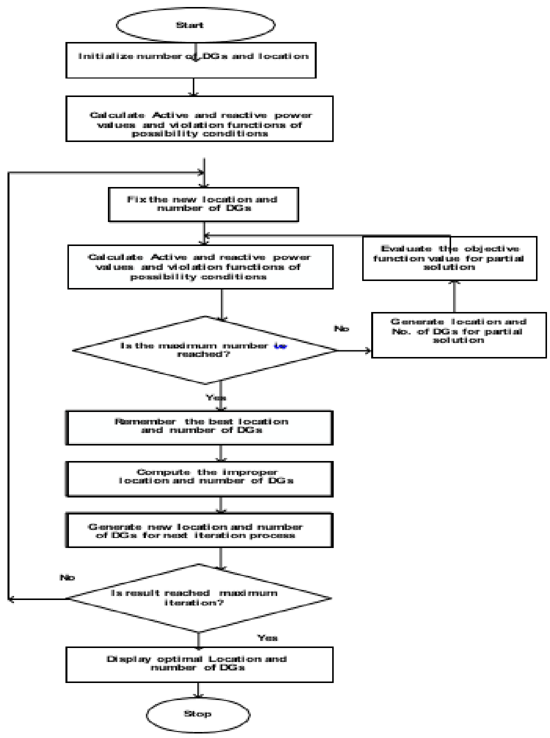

Fig. 11. Artificial Bee Colony Algorithm flowchart

(h) Cuckoo Search (CS): The Cuckoo Search Optimization (CSO) have been carried out in 2009 in view of enlivened by the parasitic egg-laying of the cuckoo species in the other host bird's home [122,123]. For better execution and keeping away from caught in nearby extremums, a piece of the new age ought to be created haphazardly and far enough from the most recent best arrangement. The CSO have carried out for the incorporation of biomass and sun powered warm DGA, taking into account misfortune minimization and voltage profile improvement [124]. Moravej and Akhlaghi involved CSO for voltage profile improvement, which is finished by utilizing two guideline and variety files, and power misfortune decrease for ODGP [125].

(i) Firefly Method (FFM): The Firefly Algorithm is a multitude information in view of the stochastic hunt strategy. FFM can be used for enhancement and to seek after promising regions called an answer space. The algorithm is animated by the peculiarity of blast firecrackers and sparkles made inside a space around the firecrackers overhead.

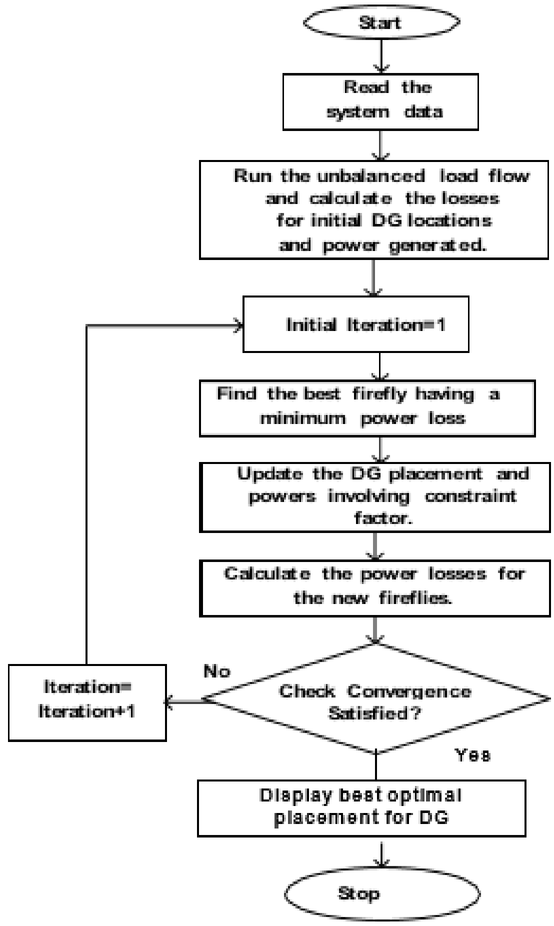

Fig. 12. Firefly Algorithm flowchart

The algorithm figures out how to assign properties between firecracker swarms while entering for arrangements reliably. The Firefly technique is propelled by the ideal model of the fireflies blazing way of behaving. For the most part, the blazing is being finished to draw in different fireflies. This strategy comprises of three fundamental principles, as follows [126], first fireflies in the populace are of similar orientation every one of them can be appealing to others towards it. Then, the brilliance and thusly, the allure decline with distance increment. At last, the firefly's brilliance has gotten from the idea of the goal capability search space. The brilliance of a firefly commits its engaging quality, and the more splendid one pulls the less splendid one. The two significant testing issues in FFM are appeal and light force variety detailing. The FFM have been carried out for ODGP meaning to limit the dynamic and responsive power misfortunes, voltage profile improvement for different models of burdens, line current, level of a short out, and all out ingested clear influence of the organization [127]. The flowchart for the firefly algorithm is displayed in Fig. 12.

(j) Hybrid Intelligent Algorithms: Hybrid Intelligent Algorithms (HIAs) is known as a mix of various AI strategies working in equal or flowed mode to take care of an optimization issue. A portion of the different blend of existing meta-heuristic strategies for ODGP, including Genetic-Tabu search (GATS) (GATS) in [128], Genetic-Particle Swarm Optimization (GAPSO) in [129] the flowchart is portrayed in Fig. 13, Genetic-Optimal Power Flow (GAOPF) in [129] and the Grasshopper Optimization Algorithm (GOA) and Cuckoo Search (CS) method in Fig. 14. Merit-based correlation between various enhancement strategies are talked about in Table 3 underneath, and Examination of AI techniques for measuring and area of DG in the appropriation framework are examined in Table 4.

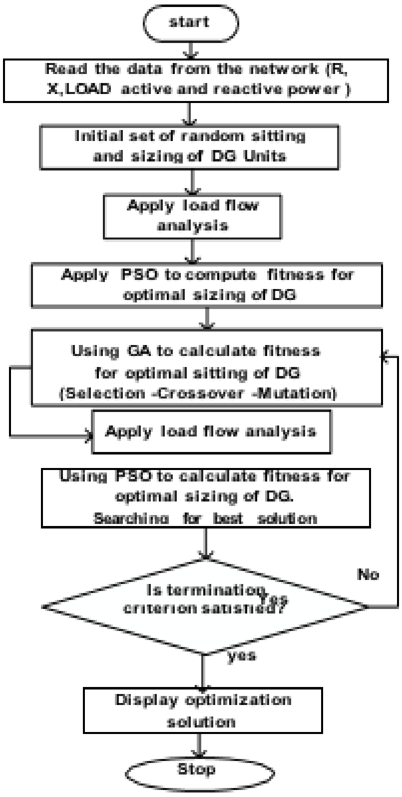

Fig. 13. Genetic-Particle Swarm Optimization (GAPSO)

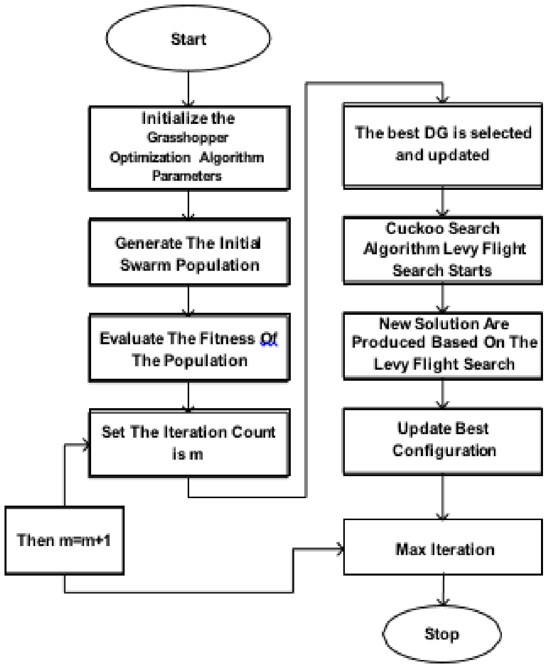

Fig. 14. Grasshopper Optimization Algorithm (GOA) and Cuckoo Search (CS) technique

Table 3: Merit-based comparison between different optimization techniques.

S. No.	Goals	Methods	Advantages	Disadvantages	References
1.	Minimize total system power losses.	Analytical Based Methods	curate and efficient method.	More time is required for the complex system.	59,60, 61,63.
2.	Reduction of system losses as a single objective.	Kalman filter algorithm	Complexity is less	sults obtained are Inaccurate.	62
		Sensitivity Based method	duction in Search space and losses.	Probability distribution require more information.	67,68, 69
		Artificial Bee Colony Optimization	Results obtained for global optimization are excellent.	More dependent on control parameters linked to the algorithm, less efficiency.	118,119, 120,121
		Particle Swarm Optimization.	The optimal method to place DG in the distribution system.	For a large number of functions in the system, it provides an unfortunate result.	107,108, 109,110

3.	Losses minimization and voltage profile improvement.	Continuous Power Flow method	More efficient, effective, robust and capable to increase the penetration level of DG in the system.	To analysis the voltage stability of the system more information required.	84
		Plant growth Simulation Algorithm	No external crossover and on rate information is required.	The quality solution cannot be obtained.	92,93
		Particle Swarm Optimization.	The optimal method to place DG in distribution system easily, a high degree of accuracy.	For a large number of functions in the system, it provides an inefficient result.	111,112
		Backtracking Search Optimization Algorithm	Provide good result for global optimization.	Crossover strategy is non-uniformly followed; only one direction is allocated for each candidate based on random strategy.	100,101, 102
		Bat Algorithm	Efficiency, accuracy is more when compared to other algorithms.	By adjusting parameters values, the convergence rate is more affected.	95
		Bacterial Foraging Optimization Algorithm	More convergence, efficient and accurate than PSO, GA algorithms.	Problem arises in global optimization	97,98
		Genetic algorithm combined with optimal power flow and sensitivity analysis method.	Efficient and large for complex systems, required less computation time. Transmission losses are reduced more effectively.	Computation of mathematical formulae is more difficult, involved more parameters.	80,81,66, 67,69,105
4.	Improvement in voltage profile as one objective function.	Harmony Search (HS)	Have the capability to handle both continuous and discontinuous functions. Provide proper global search.	Local convergence speed is slow.	86,87
5.	Reduction of system losses and cost.	Brute Force Algorithm	Required less time to get an optimal solution and search space is also less.	Effectiveness suffered and not applied for optimization.	96
		Particle Swarm Optimization.	Most optimal method to place DG in distribution system easily, a high degree of accuracy.	For a large number of functions in the system, it provides an inefficient result.	112
6.	Reduction of system losses and cost, improvement of voltage profile and system load-ability.	Hybrid algorithms.	A high degree of accuracy, capable of handling all types of loads as DG penetration rate increases and provide accurate location and size of DGs.	Challenging arises in selecting the best solution for DG location. More time is required for computation.	128,129

Table 4: Comparison of Analytical and Intelligent techniques of sizing and location of DG in distributionsystem.

S. No.	Analytical technique	Nature Inspired Techniques
1.	An analytical method is well suited for finding out local maxima and minima value of both continuous and differentiable functions.	The intelligent optimization technique is suited for finding out local and global optimum solution for constrained, discontinuous and non-differential functions.
2.	These methods provide accurate optimum solution and time taken for computing is less, and it is not easy to implement.	These methods provide optimum near-optimum solution and time taken for simulation is more, and it is easy to implement.
3.	In this method, the optimization function have to be differentiable.	In this method, optimization function need not be differentiable.
4.	These methods are not suitable for large system and complex problems, and convergence problem does not exist in this method.	These methods are suitable for large system and complex problems, and premature convergence problem does exist in this method.
5.	These methods during modelling involve a set of nonlinearequations that might be difficult to compute.	These methods have no such types of difficulty faced during the modelling process.

V. CONCLUSION

This paper presents a total depiction of the new works distributed in DG position and organization reconfiguration thinking about DGs. Incorporating DGs inside the organization further develop the power framework security, unwavering quality, framework power factor, framework voltage profile, load-capacity is an upgrade, further develop soundness of the framework and furthermore power move limit of the framework. The most often involved procedure for the arrangement of the ODGP issue is the hereditary calculation, concordance search algorithm, PSO, artificial bee colony, cuckoo search, bat algorithm, tabu search, firefly algorithm, whale optimization algorithm, gray wolf optimizer, bacterial foraging optimization algorithm and hybridheuristics algorithm and AI techniques. At last, it is reasoned that the AI techniques are more desirable over DG arranging in DS. Mixture optimization methods yield improved brings about DG anticipating huge scope in power system.

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REFERENCES

[1]. Singh, B., & Mishra, D. K. (2018). A survey on enhancement of power system performances by optimally placed DG in distribution networks. *Energy Reports*, *4*, 129-158.

[2]. Sulaima, M. F., Mohd Fadhlan, M., Jali, M. H., Daud, W., Bukhari, W. M., & Baharom, M. F. (2014). A comparative study of optimization methods for 33kV distribution network feeder reconfiguration. *International Journal of Applied Engineering Research*, *9*(9), 1169-1182.

[3]. Barker, P. P., & De Mello, R. W. (2000). Determining the impact of distributed generation on power systems. I. Radial distribution systems. In *2000 Power Engineering Society Summer Meeting (Cat. No. 00CH37134)*, *3*, 1645-1656.

[4]. Edwards, F. V., Dudgeon, G. J. W., McDonald, J. R., & Leithead, W. E. (2000). Dynamics of distribution networks with distributed generation. In *2000 Power Engineering Society Summer Meeting (Cat. No. 00CH37134)*, *IEEE*, *2*,1032-1037

[5]. Joos, G., Ooi, B. T., McGillis, D., Galiana, F. D., & Marceau, R. (2000). The potential of distributed generation to provide ancillary services. In *2000 power engineering societysummer meeting (cat. no. 00ch37134)*, IEEE, 3, 1762-1767.

[6]. Walling, R. A., Saint, R., Dugan, R. C., Burke, J., & Kojovic, L. A. (2008). Summary of distributed resources impact on power delivery systems. *IEEE Transactions on power delivery*, *23*(3), 1636-1644.

[7]. Ault, G. W., & McDonald, J. R. (2000). Planning for distributed generation within distribution networks in restructured electricity markets. *IEEE Power Engineering Review*, *20*(2), 52-54.

[8]. Rau, N. S., & Wan, Y. H. (1994). Optimum location of resources in distributed planning. *IEEE Transactions on Power systems*, *9*(4), 2014-2020.

[9]. Moosavian, S. M., Modiri-Delshad, M., Rahim, N. A., & Selvaraj, J. (2013). Imperialistic competition algorithm: Novel advanced approach to optimal sizing of hybrid power system. *Journal of Renewable and Sustainable Energy*, *5*(5), 053-141.

[10]. Javanmardi, O., Nasri, M., & Sadeghkhani, I. (2012). Investigation of distributed generation effects on the voltage profile and power losses in distribution systems. *Adv. Electr. Eng. Syst*, *1*(2), 74-77.

[11]. Capitanescu, F., Ochoa, L. F., Margossian, H., & Hatziargyriou, N. D. (2014). Assessing the potential of network reconfiguration to improve distributed generation hosting capacity in active distribution systems. *IEEE Transactions on Power Systems*, *30*(1), 346-356.

[12]. Viral, R., & Khatod, D. K. (2012). Optimal planning of distributed generation systems in distribution system: A review. *Renewable and Sustainable Energy Reviews*, *16*(7), 5146-5165.

[13]. Khatod, D. K., Pant, V., & Sharma, J. (2012). Evolutionary programming based optimal placement of renewable distributed generators. *IEEE Transactions on Power systems*, *28*(2), 683-695.

[14]. Kang, Q., Zhou, M., An, J., & Wu, Q. (2012). Swarm intelligence approaches to optimal power flow problem with distributed generator failures in power networks. *IEEE Transactions on Automation Science and Engineering*, *10*(2), 343-353.

[15]. Muttaqi, K. M., Le, A. D., Negnevitsky, M., & Ledwich, G. (2014). An algebraic approach for determination of DG parameters to support voltage profiles in radial distributionnetworks. *IEEE transactions on smart grid*, *5*(3), 1351-1360.

[16]. Al Abri, R. S., El-Saadany, E. F., & Atwa, Y. M. (2012). Optimal placement and sizing method to improve the voltage stability margin in a distribution system using distributed generation. *IEEE transactions on power systems*, *28*(1), 326-334.
[17]. Popović, D. H., Greatbanks, J. A., Begović, M., & Pregelj, A. (2005). Placement of distributed generators and reclosers for distribution network security and reliability. *International Journal of Electrical Power & Energy Systems*, *27*(5-6), 398- 408.
[18]. Ochoa, L. F., Dent, C. J., & Harrison, G. P. (2009). Distribution network capacity assessment: Variable DG and active networks. *IEEE Transactions on Power Systems*, *25*(1), 87-95.
[19]. Pandi, V. R., Zeineldin, H. H., & Xiao, W. (2012). Determining optimal location and size of distributed generationresources considering harmonic and protection coordination limits. *IEEE transactions on power systems*, *28*(2), 1245-1254.
[20]. Phonrattanasak, P., Miyatake, M., & Sakamoto, O. (2013).Optimal location and sizing of solar farm on japan east powersystem using multiobjective bees algorithm. In *2013 IEEEEnergytech* ,1-6.
[21]. Ameli, A., Bahrami, S., Khazaeli, F., & Haghifam, M. R. (2014). A multiobjective particle swarm optimization for sizing and placement of DGs from DG owner's and distribution company's viewpoints. *IEEE Transactions on power delivery*, *29*(4), 1831-1840.
[22]. Eltawil, M. A., & Zhao, Z. (2010). Grid-connected photovoltaic power systems: Technical and potential problems—A review. *Renewable and sustainable energy reviews*, *14*(1), 112-129.
[23]. Singh, B., & Sharma, J., (2017). A review on distributed generation planning. *Renewable and Sustainable Energy Reviews*, *76*, 529-544.
[24]. Adefarati, T., & Bansal, R. C. (2016). Integration of renewable distributed generators into the distribution system: a review. *IET Renewable Power Generation*, *10*(7),873-884.
[25]. Santos, S. F., Fitiwi, D. Z., Shafie-Khah, M., Bizuayehu, A. W., Cabrita, C. M., & Catalão, J. P. (2016). New multistage and stochastic mathematical model for maximizing RES hosting capacity—Part I: Problem formulation. *IEEE Transactions on Sustainable Energy*, *8*(1), 304-319.
[26]. Santos, S. F., Fitiwi, D. Z., Shafie-khah, M., Bizuayehu, A. W., Cabrita, C. M., & Catalão, J. P. (2016). New multi-stage and stochastic mathematical model for maximizing RES hosting capacity—Part II: Numerical results. *IEEE Transactionson Sustainable Energy*, *8*(1), 320-330.
[27]. Chen, X., Hou, Y., & Hui, S. R. (2016). Distributed control of multiple electric springs for voltage control in microgrid. *IEEETransactions on Smart Grid*, *8*(3), 1350-1359.
[28].Arandian, B., Hooshmand, R. A., & Gholipour, E. (2014). Decreasing activity cost of a distribution system company by reconfiguration and power generation control of DGs based on shuffled frog leaping algorithm. *International Journal of Electrical Power & Energy Systems*, *61*, 48-55.
[29]. Chithra Devi, S. A., Lakshminarasimman, L., & Balamurugan, R. (2017). Stud Krill herd Algorithm for multiple DG placement and sizing in a radial distribution system. *Engineering Science and Technology, an International Journal*, *20*(2), 748-759.
[30]. Rao, R. S., Ravindra, K., Satish, K., & Narasimham, S. V. L. (2012). Power loss minimization in distribution system using network reconfiguration in the presence of distributed generation. *IEEE transactions on power systems*, *28*(1), 317- 325.
[31]. Chen, K., Wu, W., Zhang, B., Djokic, S., & Harrison, G. P. (2015). A method to evaluate total supply capability of distribution systems considering network reconfiguration and daily load curves. *IEEE Transactions on Power systems*, *31*(3),2096-2104.
[32]. Carvalho, P. M. S., Ferreira, L. A. F. M., & Da Silva, A. C. (2005). A decomposition approach to optimal remote-controlled switch allocation in distribution systems. *IEEE Transactions on Power Delivery*, *20*(2), 1031-1036.
[33]. Xu, Y., Liu, C. C., Schneider, K. P., & Ton, D. T. (2015). Placement of remote-controlled switches to enhance distribution system restoration capability. *IEEE Transactions onPower Systems*, *31*(2), 1139-1150.
[34]. Li, Z., Jazebi, S., & De Leon, F., (2016). Determination of the optimal switching frequency for distribution system reconfiguration. *IEEE Transactions on Power Delivery*, *32*(4), 2060-2069.
[35]. Chen, C. S., & Cho, M. Y. (1993). Energy loss reduction by critical switches. *IEEE Transactions on Power Delivery*, *8*(3),1246-1253.
[36]. Gonzalez-Longatt, F. M. (2007). Impact of distributed generation over power losses on distribution system. In *9th International conference on electrical power quality and utilization*, 45-55.
[37]. Fraser, P. (2002). Distributed generation in liberalised electricity markets. In *Second international symposium on distributed generation: power system and market aspect,* 1-12.
[38].Abdelaziz, A. Y., Ali, E. S., & Elazim, S. A. (2016). Optimal sizing and locations of capacitors in radial distribution systems via flower pollination optimization algorithm and power loss index. *Engineering Science and Technology, an International Journal*, *19*(1), 610-618.
[39]. Sanjay, R., Jayabarathi, T., Raghunathan, T., Ramesh, V., & Mithulananthan, N. (2017). Optimal allocation of distributed generation using hybrid grey wolf optimizer. *IEEE Access*, *5*, 14807-14818.
[40]. El-Khattam, W., & Salama, M. M. (2004). Distributed generation technologies, definitions and benefits. *Electric power systems research*, *71*(2), 119-128.
[41]. Momoh, J. A., Meliopoulos, S., & Saint, R. (2012). Centralized and distributed generated power systems-a comparison approach. *Future grid initiative white paper*, 1-10.
[42]. The potential benefits of distributed generation and the rate related issues that may impede its expansion, ReportUnder Section 1817 of the Energy Policy Act of 2005, http://energy.gov/oe/downloads/potential-benefits-distributed- generation-and-rate-related-issues-may impede its, accessedJune 2015.
[43]. International renewable energy agency, Renewable power generation costs in 2014, http://www.irena.org/documentdownloads/publications/re_techn ologies_cost_analysis hydropower.pdf, accessed May 2015.
[44]. Narbel, P. A., Hansen, J. P., & Lien, J. R. (2014). *Energytechnologies and economics*. Springer,170-180.
[45]. de Oliveira, E. J., Rosseti, G. J., de Oliveira, L. W., Gomes, F. V., & Peres, W. (2014). New algorithm for reconfiguration and operating procedures in electric distribution systems. *International Journal of Electrical Power & Energy Systems*, *57*, 129-134.
[46]. Islam, F. R., & Mamun, K. A. (2017). Possibilities and challenges of implementing renewable energy in the light of PESTLE & SWOT analyses for island countries. In *Smart Energy Grid Design for Island Countries* ,1-19. Springer, Cham.
[47]. Georgilakis, P. S., & Hatziargyriou, N. D. (2013). Optimal distributed generation placement in power distribution networks: models, methods, and future research. *IEEE Transactions on power systems*, *28*(3), 3420-3428.
[48]. Buchholz, B. M., & Boese, C. (2003). The impact of dispersed power generation in distribution systems. In *CIGRE/IEEE PES International Symposium Quality and Security of Electric Power Delivery Systems, 2003. CIGRE/PES 2003, IEEE,* 198-203.
[49]. Wang, D. T. C., Ochoa, L. F., & Harrison, G. P. (2009). DG impact on investment deferral: Network planning and security of supply. *IEEE Transactions on Power Systems*, *25*(2), 1134-1141.
[50]. Delfanti, M., Falabretti, D., & Merlo, M. (2013). Dispersed generation impact on distribution network

losses. *ElectricPower Systems Research*, *97*, 10-18.

[51]. Gomez-Gonzalez, M., Ruiz-Rodriguez, F. J., & Jurado, F.(2014). Probabilistic optimal allocation of biomass fueled gas engine in unbalanced radial systems with metaheuristic techniques. *Electric Power Systems Research*, *108*, 35-42.

[52]. Chiradeja, P., & Ramakumar, R. (2004). An approach to quantify the technical benefits of distributed generation. *IEEETransactions on energy conversion*, *19*(4), 764-773.

[53]. Ghosh, S., Ghoshal, S. P., & Ghosh, S. (2009). Two analytical approaches for optimal placement of distributed generation unit in power systems. In *2009 International Conference on Power Systems*, IEEE,1-6.

[54]. Sheng, W., Liu, K. Y., Liu, Y., Meng, X., & Li, Y. (2014). Optimal placement and sizing of distributed generation via an improved nondominated sorting genetic algorithm II. *IEEE Transactions on Power Delivery*, *30*(2), 569-578.

[55]. Liu, Y., Li, Y., Liu, K. Y., & Sheng, W., (2013). Optimal placement and sizing of distributed generation in distribution power system based on multi-objective harmony search algorithm. In *2013 6th IEEE Conference on Robotics, Automation and Mechatronics (RAM)*, IEEE, 168-173.

[56]. Hosseini, S. A., Madahi, S. S. K., Razavi, F., Karami, M., & Ghadimi, A. A. (2013). Optimal sizing and siting distributed generation resources using a multiobjective algorithm. *Turkish Journal of Electrical Engineering & Computer Sciences*, *21*(3), 825-850.

[57]. Singh, B., Mukherjee, V., & Tiwari, P. (2015). A survey on impact assessment of DG and FACTS controllers in power systems. *Renewable and Sustainable Energy Reviews*, *42*, 846-882.

[58]. LIANG, Y. W., HU, Z. J., & CHEN, Y. P. (2003). A survey of distributed generation and its application in power system [J]. *Power System Technology*, *12*(27), 72-77.

[59]. Wang, C., & Nehrir, M. H. (2004). Analytical approaches for optimal placement of distributed generation sources in power systems. *IEEE Transactions on Power systems*, *19*(4), 2068-2076.

[60]. Acharya, N., Mahat, P., & Mithulananthan, N. (2006). An analytical approach for DG allocation in primary distribution network. *International Journal of Electrical Power & Energy Systems*, *28*(10), 669-678.

[61]. Gözel, T., & Hocaoglu, M. H. (2009). An analytical method for the sizing and siting of distributed generators in radial systems. *Electric power systems research*, *79*(6), 912-918.

[62]. Kumar, P. K. (2013). Selection of optimal location and size of multiple distributed generations by using kalman filteralgorithm. *Int. J. Eng. Res. Appl.*, *4*, 1708-1729.

[63]. Hung, D. Q., Mithulananthan, N., & Bansal, R. C. (2010). Analytical expressions for DG allocation in primary distribution networks. *IEEE Transactions on energy conversion*, *25*(3), 814-820.

[64]. Hazem, N., Elshahed, M. A., & Osman, Z. H. (2017). Optimal placement of dispatchable and non-dispatchable distributed generation of different technologies. In *2017 Nineteenth International Middle East Power Systems Conference (MEPCON)*, IEEE,1023-1030.

[65]. Hung, D. Q., Mithulananthan, N., & Lee, K. Y. (2014). Optimal placement of dispatchable and nondispatchable renewable DG units in distribution networks for minimizing energy loss. *International Journal of Electrical Power & Energy Systems*, *55*, 179-186.

[66]. De Souza, A. R. R., Fernandes, T. S. P., Aoki, A. R., Sans, M. R., Oening, A. P., Marcilio, D. C., & Omori, J. S. (2013). Sensitivity analysis to connect distributed generation. *International Journal of Electrical Power & Energy Systems*, *46*, 145-152.

[67]. Naik, S. G., Khatod, D. K., & Sharma, M. P. (2013). Optimal allocation of combined DG and capacitor for real power loss minimization in distribution networks. *International Journal of Electrical Power & Energy Systems*, *53*, 967-973.

[68]. Sambaiah, K. S., & Jayabarathi, T. (2020). Loss minimization techniques for optimal operation and planning of distribution systems: A review of different methodologies. *International Transactions on Electrical Energy Systems*, *30*(2), 122-130.

[69]. Raoofat, M., & Malekpour, A. R. (2011). Optimal allocation of distributed generations and remote controllable switches to improve the network performance considering operation strategy of distributed generations. *Electric Power Components and Systems*, *39*(16), 1809-1827.

[70]. Gandomkar, M., Vakilian, M., & Ehsan, M. (2005). A genetic–based tabu search algorithm for optimal DG allocation in distribution networks. *Electric Power Components and Systems*, *33*(12), 1351-1362.

[71]. Vovos, P. N., & Bialek, J. W. (2005). Direct incorporation of fault level constraints in optimal power flow as a tool for network capacity analysis. *IEEE Transactions on Power Systems*, *20*(4), 2125-2134.

[72]. AlHajri, M. F., AlRashidi, M. R., & El-Hawary, M. E. (2010). Improved sequential quadratic programming approach for optimal distribution generation deployments via stability and sensitivity analyses. *Electric Power Components andSystems*, *38*(14), 1595-1614.

[73]. Keane, A., & O'Malley, M. (2007). Optimal utilization of distribution networks for energy harvesting. *IEEE Transactions on Power Systems*, *22*(1), 467-475.

[74]. Darfoun, M. A., & El-Hawary, M. E. (2015). Multi-objective optimization approach for optimal distributed generation sizing and placement. *Electric Power Components and Systems*, *43*(7), 828-836.

[75]. Ochoa, L. F., & Harrison, G. P. (2010). Minimizing energy losses: Optimal accommodation and smart operation of renewable distributed generation. *IEEE Transactions on Power Systems*, *26*(1), 198-205.

[76]. Al Abri, R. S., El-Saadany, E. F., & Atwa, Y. M. (2012). Optimal placement and sizing method to improve the voltage stability margin in a distribution system using distributed generation. *IEEE transactions on power systems*, *28*(1), 326- 334.

[77]. Khalesi, N., Rezaei, N., & Haghifam, M. R. (2011). DG allocation with application of dynamic programming for loss reduction and reliability improvement. *International Journal of Electrical Power & Energy Systems*, *33*(2), 288-295.

[78]. Jabr, R. A., & Pal, B. C. (2009). Ordinal optimisation approach for locating and sizing of distributed generation. *IET generation, transmission & distribution*, *3*(8), 713-723.

[79]. Khan, H., & Choudhry, M. A. (2010). Implementation of Distributed Generation (IDG) algorithm for performance enhancement of distribution feeder under extreme load growth. *International Journal of Electrical Power & Energy Systems*, *32*(9), 985-997.

[80]. Harrison, G. P., Piccolo, A., Siano, P., & Wallace, A. R. (2008). Hybrid GA and OPF evaluation of network capacity for distributed generation connections. *Electric Power Systems Research*, *78*(3), 392-398.

[81]. Leeton, U., Uthitsunthorn, D., Kwannetr, U., Sinsuphun,N., & Kulworawanichpong, T., (2010). Power loss minimization using optimal power flow based on particle swarm optimization. In *ECTI-CON2010: The 2010 ECTI International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology* , IEEE, 440- 444.

[82]. Atwa, Y. M., & El-Saadany, E. F. (2011). Probabilistic approach for optimal allocation of wind-based distributed generation in distribution systems. *IET Renewable Power Generation*, *5*(1), 79-88.

[83]. Zou, K., Agalgaonkar, A. P., Muttaqi, K. M., & Perera, S. (2011). Distribution system planning with incorporating DG reactive capability and system uncertainties. *IEEE Transactionson Sustainable Energy*, *3*(1), 112-123.

[84]. Hemdan, N. G., & Kurrat, M. (2011). Efficient integration of distributed generation for meeting the increased load demand. *International Journal of Electrical Power & Energy Systems*, *33*(9), 1572-1583.

[85]. EL-Sayed, S. K. (2017). Optimal Location and Sizing of Distributed Generation for Minimizing Power Loss Using Simulated Annealing Algorithm. *Journal of Electrical and Electronic Engineering*, *5*(3), 104-112.
[86]. Geem, Z. W., Kim, J. H., & Loganathan, G. V. (2001). A new heuristic optimization algorithm: harmony search. *simulation*, *76*(2), 60-68.
[87]. Haghighat, H. (2015). Energy loss reduction by optimal distributed generation allocation in distribution systems. *International Transactions on Electrical Energy Systems*, *25*(9), 1673-1684.
[88]. Aman, M. M., Jasmon, G. B., Mokhlis, H., & Bakar, A. H.
A. (2012). Optimal placement and sizing of a DG based on a new power stability index and line losses. *International Journal of Electrical Power & Energy Systems*, *43*(1), 1296-1304.
[89]. Maciel, R. S., & Padilha-Feltrin, A. (2009). Distributedgeneration impact evaluation using a multi-objective Tabu Search. In *2009 15th International Conference on Intelligent System Applications to Power Systems*, IEEE,1-5.
[90]. Singh, H., Gupta, M. M., Meitzler, T., Hou, Z. G., Garg, K. K., Solo, A. M., & Zadeh, L. A. (2013). Real-life applications of fuzzy logic. Advances in Fuzzy Systems, 2013.
[91]. Padma Lalitha, M., Veera Reddy, V. C., & Sivarami Reddy, N. (2010). Application of fuzzy and ABC algorithm for DG placement for minimum loss in radial distribution system. *Iranian Journal of Electrical and Electronic Engineering*, *6*(4), 248-257.
[92]. Singh, B., & Gyanish, B. J. (2018). Impact assessment of DG in distribution systems from minimization of total real powerloss viewpoint by using optimal power flow algorithms. *Energy Reports*, *4*, 407-417.
[93]. Prabha, D. R., & Jayabarathi, T. (2014). Determining the optimal location and sizing of distributed generation unit using plant Growth simulation algorithm in a radial distribution network. *WSEAS Trans. Syst.*, *13*, 543-550.
[94].Moradi, M. H., Zeinalzadeh, A., Mohammadi, Y., & Abedini,
M. (2014). An efficient hybrid method for solving the optimal sitting and sizing problem of DG and shunt capacitor banks simultaneously based on imperialist competitive algorithm and genetic algorithm. *International Journal of Electrical Power & Energy Systems*, *54*, 101-111.
[95]. Remha, S., Chettih, S., & Arif, S. (2018). A Novel Multi-Objective Bat Algorithm for Optimal Placement and Sizing of Distributed Generation in Radial Distributed Systems. *Advances in Electrical and Electronic Engineering*, *15*(5), 736-746.
[96]. Mena, A. J. G., & García, J. A. M. (2015). An efficient approach for the siting and sizing problem of distributed generation. *International Journal of Electrical Power & Energy Systems*, *69*, 167-172.
[97]. Muller, S. D., Marchetto, J., Airaghi, S., & Kournoutsakos,
P. (2002). Optimization based on bacterial chemotaxis. *IEEE transactions on Evolutionary Computation*, *6*(1), 16-29.
[98]. Kowsalya, M. (2014). Optimal size and siting of multiple distributed generators in distribution system using bacterial foraging optimization. *Swarm and Evolutionary computation*, *15*, 58-65.
[99]. Prabha, D. R., and Jayabarathi, T. (2016). Optimal placement and sizing of distributed generating units in distributed networks by invasive weed optimization algorithm. Ain shams Engineering Journal, 7(2), 683-694.
[100]. El-Fergany, A. (2015). Optimal allocation of multi-type distributed generators using backtracking search optimization algorithm. International Journal of Electrical Power & Energy Systems, 64, 1197-1205.
[101]. Civicioglu, P. (2013). Backtracking search optimization algorithm for numerical optimization problems. *Applied Mathematics and computation*, *219*(15), 8121-8144.
[102]. Wang, H., Hu, Z., Sun, Y., Su, Q., & Xia, X. (2018). Modified backtracking search optimization algorithm inspired bysimulated annealing for constrained engineering optimization problems. *Computational intelligence and neuroscience*, *5*(4), 54-61.
[103]. Syahputra, R., Wiyagi, R. O., Suripto, S., & Soesanti, I. (2017). Optimization of Distribution Network Configuration Using Evolutionary Algorithm Approach. *International Journal of Applied Engineering Research*, *12*(16), 6192-6200.
[104]. Bhattacharya, M., & Das, D. (2016). Multi-objective placement and sizing of DGs in distribution network using genetic algorithm. In *2016 National Power Systems Conference (NPSC)*, IEEE,1-6.
[105]. Sheng, W., Liu, K. Y., Liu, Y., Meng, X., & Li, Y. (2014). Optimal placement and sizing of distributed generation via an improved nondominated sorting genetic algorithm II. *IEEE Transactions on Power Delivery*, *30*(2), 569-578.
[106]. Liu, K. Y., Sheng, W., Liu, Y., Meng, X., & Liu, Y. (2015). Optimal sitting and sizing of DGs in distribution system considering time sequence characteristics of loads and DGs. *International Journal of Electrical Power & Energy Systems*, *69*, 430-440.
[107]. Poli, R., Kennedy, J., & Blackwell, T. (2007). Particle swarm optimization. *Swarm intelligence*, *1*(1), 33-57.
[108]. Del Valle, Y., Venayagamoorthy, G. K., Mohagheghi, S., Hernandez, J. C., & Harley, R. G. (2008). Particle swarm optimization: basic concepts, variants and applications in power systems. *IEEE Transactions on evolutionary computation*, *12*(2), 171-195.
[109]. Tawfeek, T. S., Ahmed, A. H., & Hasan, S. (2018). Analytical and particle swarm optimization algorithms foroptimal allocation of four different distributed generation typesin radial distribution networks. *Energy Procedia*, *153*, 86-94.
[110]. El-Zonkoly, A. M. (2011). Optimal placement of multi-distributed generation units including different load modelsusing particle swarm optimisation. *IET generation, transmission& distribution*, *5*(7), 760-771.
[111]. Prakash, D. B., & Lakshminarayana, C. (2016). Multiple DG placements in distribution system for power loss reduction using PSO Algorithm. *Procedia technology*, *25*, 785-792.
[112]. Afzalan, M., & Taghikhani, M. A. (2012). Placement andsizing of DG using PSO&HBMO Algorithms in radial distributionnetworks. *I.J. Intelligent Systems and Applications*, *10*, 43-49.
[113]. Suresh, M. C. V., & Belwin, E. J. (2018). Optimal DGplacement for benefit maximization in distribution networks byusing Dragonfly algorithm. *Renewables: Wind, Water, andSolar*, *5*(1), 4-14.
[114]. Prakash, D. B., & Lakshminarayana, C. (2018). Multiple DG placements in radial distribution system for multi objectives using Whale Optimization Algorithm. *Alexandria engineering journal*, *57*(4), 2797-2806.
[115]. Dorigo, M., & Di Caro, G. (1999). Ant colony optimization: a new meta-heuristic. In *Proceedings of the 1999 congress on evolutionary computation-CEC99 (Cat. No. 99TH8406)*, IEEE, *2*, 1470-1477.
[116]. Dorigo, M., & Blum, C. (2005). Ant colony optimization theory: A survey. *Theoretical computer science*, *344*(2-3), 243- 278.
[117]. Chu, S. C., Roddick, J. F., & Pan, J. S. (2004). Ant
colony system with communication strategies. *Information Sciences*, *167*(1-4), 63-76.
[118]. Karaboga, D. (2005). *An idea based on honey bee swarm for numerical optimization*,Technical report-tr06, Erciyes university, engineering faculty, computer engineeringdepartment,1-10.
[119]. Karaboga, D., & Basturk, B. (2007). Artificial bee colony (ABC) optimization algorithm for solving constrained optimization problems. In *International fuzzy systems association world congress*, Springer, Berlin,

Heidelberg, 789- 798.
[120]. Karaboga, D., & Akay, B. (2009). A comparative study of artificial bee colony algorithm. *Applied mathematics and computation*, *214*(1), 108-132.
[121]. Chatterjee, A., Ghoshal, S. P., & Mukherjee, V. (2010). Artificial bee colony algorithm for transient performance augmentation of grid connected distributed generation. In *International Conference on Swarm, Evolutionary, and Memetic Computing,* Springer, Berlin, Heidelberg, 559-566. [122]. Yang, X. S., & Deb, S. (2009). Cuckoo search via Lévy flights. In *2009 World congress on nature & biologicallyinspired computing (NaBIC)*, IEEE, 210-214.
[123].Yuvaraj, T., Ravi, K., & Devabalaji, K. R. (2017). Optimal allocation of DG and DSTATCOM in radial distribution system using cuckoo search optimization algorithm. *Modelling and Simulation in Engineering*, *8,* 88-98.
[124]. Noroozian, R., & Molaei, S. (2012). Determining the optimal placement and capacity of DG in intelligent distribution networks under uncertainty demands by COA. In *Iranian Conference on Smart Grids*, IEEE,1-8.
[125]. Moravej, Z., & Akhlaghi, A. (2013). A novel approach based on cuckoo search for DG allocation in distribution network. *International Journal of Electrical Power & Energy Systems*, *44*(1), 672-679.
[126]. Yang, X. S. (2010). Firefly algorithm, stochastic test functions and design optimisation. *arXiv preprint arXiv,*1003- 1409.
[127]. Saravanamutthukumaran, S., & Kumarappan, N. (2012). Sizing and siting of distribution generator for different loads using firefly algorithm. In *IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM-2012)*, IEEE, 800-803.
[128]. Gandomkar, M., Vakilian, M., & Ehsan, M. (2005). A genetic–based tabu search algorithm for optimal DG allocation in distribution networks. *Electric Power Components and Systems*, *33*(12), 1351-1362.
[129]. Moradi, M. H., & Abedini, M. (2012). A combination of genetic algorithm and particle swarm optimization for optimal distributed generation location and sizing in distribution systems with fuzzy optimal theory. *International Journal of Green Energy*, *9*(7), 641-660.