A review of voltage and reactive power control algorithms in medium voltage distribution networks

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Abstract. Current power network was built in mind that there will be mostly one-way power transmission, but as there is increasing penetration of distributed generation (DG), power network evolves and changes. Thereof old control strategies and algorithms used in power distribution do not fully utilize ever evolving power network in ensuring minimum active power loses, best distribution power generation for optimal voltage and frequency control. The main objective of this paper is review and comparison of heuristic algorithms in medium-voltage (MV) distribution networks with high distributed generation (DG) penetration. The specific goal is integrating reviewed algorithms in distributor power network control to minimise power loss, control active and reactive power flow between transmission and distribution power networks and utilization of current power network structure with growing number distributed generation penetration and thus minimizing required cost for its upgrade. Due to complexity of different power network structures and control methods used in managing it, algorithms are reviewed used in ensuring fast and reliable calculations by guaranteeing as minimum active power loss as possible and by improving power system performance over existing centralised as well as decentralised control methods. For both control methods distributed generators requires to be endowed with communication capabilities, as it is effective in driving the voltages within the admissible intervals and, additionally, it exploits the cooperation among the distributed generators and controllers to reach power network objectives of minimal power loss, voltage stability as mentioned before.

1. Introduction

As the world is dealing with climate change, carbon dioxide-generating energy sources have been classified as detrimental to the atmosphere, and green energy sources as a potential energy source has gained more attention. A agreement has been achieved, laying the foundations for tackling environmental challenges effectively and paving the way for more ambitious problems. As a result, implementing policies to improve energy conservation and alternative energy (such as solar energy) would significantly shorten the time required to meet net greenhouse gas emissions goals. However, the scarcity of renewable energy has resulted in additional technological and economic issues, limiting its appeal. Renewable energy plants, on the other hand, require unique areas where resources are typically available, as opposed to traditional power plants. This condition necessitates the development of a mathematical optimization method to aid in the planning and decision-making process, especially in terms of the scale and location of renewable energy sources (RES) platforms. Utility companies have created distributed generator (DG) to stimulate competition and generate flexibility in the clean energy industry in order to reduce the cost of large-scale construction. Indeed, in a liberalized
electricity market, the number of generators related to power distribution will grow, particularly in terms of size and location. The CEOs of green energy firms are streamlined and they have a significant effect on reducing technological challenges associated with renewable energy incorporation (such as energy waste). According to records, inadequate estimation of the position and scale of DG would result in increased network losses [1], [2]. The optimum location and scale of DG will not only minimize errors in the electrical grid, but will also improve network voltage and efficiency because it will dictate the maximum level of RES DG that can be connected to the grid. Also, with the ongoing development in materials and energy system control technologies, the cost of RES DG is expected to fall and so ease DG integration in in power network. In comparison to massive traditional power plants, the reduced scale reduces construction time. Furthermore, DG can be used as a backup solution in the event of an emergency and provides the device's islanding feature. Their benefit is that there is less construction, the current systems can be modified, allowing the electricity grid to be transformed from centralized to decentralized.

There is increasing global interest in the use of device optimization strategies to deploy DG RES: more than half of all research undertaken in developing countries (such as Europe) is currently under investigation. However, developing countries like China, Iran, and India conduct roughly 30% of all studies. The emphasis on developed and emerging countries derives from international pressure on policies and incentives to minimize carbon dioxide emissions and encourage the use of renewable energy. The decision has been made to view green energy as a feasible alternative to conventional energy sources in order to satisfy rising domestic demand while still ensuring national security and protection. Among the numerous advantages of installing DG RES, studies have shown that as system losses rise, utilities can face new difficulties, owing to a lack of utility development. The utility companies can solve the problem using applied optimization technology.

2. Drivers and challenges of distributed generation growth
This segment provides an overview of the various factors that have contributed to the increasing interest in DG implementation, with an emphasis on DGs from RES. This article would focus on the real context of the change to more aggressive power system maintenance and smart grid implementation. A summary of the obstacles to be resolved will also be included.

2.1. Definitions
A distributed generator (DG) is an energy generating source that is connected to a power grid. DG are typically connected to distribution networks, but using International Council on Large Electric Systems (CIGRE) definitions, its power is specified as up to 50-100 MW [3], of which some countries can approve DG development only if it is connected to a transmission network. Using the Electric Power Research Institute (EPRI) definition, DG power ranges from a few kilowatts to 50 MW [4].

2.2. Drivers
It is no secret that the power network was built without considering the impact of human action on global temperature, and that humans would need to evolve and transition power production to one created by renewable energy. Due to atmosphere change at an accelerated pace, the race has already begun with a single goal in mind: to generate electricity with the smallest possible carbon footprint. Renewable energy sources (RES) come into play since the electricity generated does not contain carbon, and the carbon is only emitted in the manufacturing and assembly of renewable energy resources, but its footprint is just a fraction of the footprint of traditional power resources as compared to generating fuel.

2.3. Challenges
While there are several benefits and reasons supporting the extension of DG, fast integration of DG may also trigger economic and technological issues. The following are some of the most pressing issues confronting DG. The first is that within a certain voltage spectrum, grid current has shifted from
unidirectional to bidirectional. As a result, the successful deployment of the DG unit would have an effect on network reliability and electrical device efficiency. As a result, the selection of DG installation capability is influenced not just by the expense and benefits of each technology, but also by the optimum position and scale, which can greatly minimize overall system loss [5]. This is one of the issues with DG installation. The competition in the conventional non-liberalized power structure is typically distinguished by a vertically integrated monopoly. Investment in DG is compensated by the increased competition brought on by new prospects.

3. Power network models objectives and constrains

This segment covers the steps and causes that must be precisely coordinated when planning real estate. Power flow models, general objective features, limits, and involuntary data sets are also worth investigating.

3.1. Power flow models

The fundamental element of network control is energy flow. Methods of energy transfer vary from optimum power flow (OPF) to continuous power flow (CPF) to probabilistic power flow (PPF) (PPF, etc.). The power failure conditions, on the other hand, are determined by the form of generator source. For instance, consider the energy moment of a diesel generator. Provide energy through PV or WT. Similarly, if it is single-phase or three-phase, the structure of the energy distribution can shift. Figure 1 [6] depicts the design diagram of the single-phase power supply.

![Figure 1. Design diagram of the single-phase power supply [6].](image)

3.2. Common objectives functions

In fact, the objective function is a digital restriction created to replicate the system’s properties. The most well-known aim of ideal switching is to reduce real energy loss, which is accompanied by improving voltage stability, improving voltage distribution and minimizing costs and increasing profits.

3.2.1. Power loss minimization. Power grid outages are almost unavoidable, but efforts to mitigate them cannot be overestimated. This objective is regarded as an optimal combined target, and it is mostly used as the primary target for solving calculations (such as voltage curves). Kirchhoff’s rule, which states that introducing the number of the results of each transmission will fix the loss issue in the whole power grid, can affect power loss. Excess energy is inefficient in terms of money.

3.2.2. Voltage stability improvement. Voltage reliability is an important element in distribution network load control. Power outages may be caused by sudden voltage surges or variations. Uncompensated obtained power, unfortunately, may also trigger voltage instability [6], especially in microgrids with limited range. The Voltage Stability Index (VSI) is a network stability and bandwidth measurement tool that can only be used to address issues when designing traffic networks. Rejection
methods, on the other hand, are seen in just a few techniques [7]. Line stability index (Lmn), line stability index (Lp), current line stability index (NLSI), line voltage stability index (LVSI), voltage stability index (FVSI), and overvoltage proximity indicator are all part of the proposed technologies (long time). To coordinate repeated networks, the word VSI has been paired with meta-heuristic calculations.

3.2.3. Load variance minimization. A mixture of electric cars will help to achieve this aim. Given the stacking system of electric cars, it is critical to ensure a fair charging schedule for electric vehicles. If this target is achieved, power outages can be limited. Based on its position, the average goal load shift is determined. In theory, this aim can also take into account dumping and smoothing costs in order to increase network performance. Changes in load can increase network efficiency (not related to VSI)[8]. This objective is linked to the advent of electric cars. Given how electric vehicles interact with one another, a realistic strategy would minimize network volatility. The perfect retreat will help save resources.

3.2.4. Peak load shaving. Peak load shaving is a valuable objective of V2G efficiency, since it allows you to fulfill performance expectations by using usable resources rather than stretching frame boundaries.

3.2.5. Cost minimization. The financial aspect of the optimal mix should take compatibility and approval into account. If such an idea does not exist, a significant portion of the programs will not be finished. As a result, the costs of carrying out an optimal pooling of DG unit programs must be kept to a minimum. Most studies calculate the absolute costs as the amount of the DG unit's production costs and operation and service costs [9],[10].

3.2.6. Operating profit maximization. Investing in upgrading the electricity grid could result in a profit for investors. For example, when developing an electric vehicle, the aggregator should have an appealing benefit expense compared to the profit. With this in mind, partners in joint venture growth must expect a predictable return [9].

3.3. Constraints

Investing in upgrading the energy structure can provide financial backers with returns. For example, if you use EV booking, the aggregator's benefit should have low charging costs [9].

3.3.1. Bus voltage limits. To keep the network stable, the bus voltage cap is used. Each bus is required to provide an allowable voltage for the power supply of a DG or EV device, with a maximum deviation of 5%. The highest permissible variation in certain situations is 10%.

3.3.2. Bus capacity limits. The bus capacity limit is used to change the bus's overall allowed load. This limitation mostly extends to EV charging, where multiple EVs may only be charged from a single bus. This inequality cap must be equal to or less than the total amount of electric vehicles attached to the same bus plus the aggregate of traditional electric vehicles (residential or commercial vehicles).

3.3.3. DG penetration limit. The overall nominal performance of the deployed DG units is proportional to the DG penetration limit (such as PV and WT). Electric vehicle intrusion is often
limited, whether gradual measures are permitted [11] or the full amount of intrusions is used, as in [12].

3.3.4. Power flow balance. The power flow balance ensures that the combined reactive and responsive power of the network equals the amount of the active and reactive power flowing from the DG unit, the substation, and the power network's active and reactive losses.

3.4. Non-arbitrary data-set
The active and reactive power of the buses, as well as the resistance and reactance of the branches linking the buses, was used to optimize the dimensioning and positioning of power supply units and power electronics. These parameters influence critical goal functions including power failure, voltage profile, and voltage. The IEEE dataset is a benchmark for solving size and position issues, and it was chosen as a high priority in the analysis for this study. Passages from the literature have also been considered. Climate, human behaviour, and other factors may also have an impact on other necessary data such as demand, PV output, and electricity prices. These variables may cause inconsistencies in the results. As a result, various models for dealing with such cases have been created. While recent studies in the literature have taken complexities into consideration, this research focuses solely on the optimization mechanism that employs metaheuristic algorithms in a single objective or multi-objective context.

4. Algorithms used in power network

4.1. Algorithm classification
The key issues with renewable energy are uncertainty and variability, especially in terms of the availability of wind, solar, and hydro power resources. Energy-related approaches, such as standard and intelligent search methods, are also included in the literature. In most cases, the DG bandwidth is modeled as a nonlinear mathematical optimization challenge. Determine some objective limits and functions first. Optimization technology aids decision-making by producing the best option or collection of best solutions, or producing output variables from a set of reduced initial input variables. Many optimization approaches have been proposed in the literature to date in attempt to solve these models. These approaches are classified as heuristic methods, empirical methods, gradient and second-order methods, and iterative methods, as seen in Fig. 2. This paper is being focused only on heuristic methods.

There are two kinds of optimization approaches based on the objective function: single-objective methods and multi-criteria methods. The most popular aim of the analysis is to minimize electrical device failure. Other strategies, too, are aimed at lowering overall costs. In reality, the various objectives of the optimization dilemma would inevitably lead to some form of conflict, since no one approach will satisfy all of the needs. The maximum growth in DG capability would clash not only with the increase in production line depletion, but also with the potential increase in investment costs and public interest in lowering carbon dioxide emissions [13]. Multiple target functions are normally minimized or expanded concurrently in optimization problems with multiple conditions [14].

The weighted sum approach, in which a multi-criteria problem is translated into a single objective problem using a fixed weight, is one of the most commonly applied techniques for solving multi-criteria optimization problems. The weighted sum system has several drawbacks due to its nature. On the one side, the weighted sum procedure cannot be used to solve non-convex problems and additional goals cannot be added. The suggested solution, on the other side, is limited to a range of weights (priority) chosen for the objective purpose.

4.2. Heuristic methods
Many meta-heuristic algorithms are built on the idea of a characterized agent or group of agents that work without human intervention to accomplish an objective or set of objectives. For large complex problem solving heuristic methods often help by reducing calculation time and producing good enough results. Since there is a lot of new heuristic algorithms being invented, classification of these methods becomes significant in comparing one to another. Methology on how to heuristic methods work is inspired by the world around us. Due to that, meta-heuristic optimization algorithms can be divided into five categories from which 3 are physics, evolution and swarm inspired techniques, other 2 categories come from combining algorithms. For classification of different meta-heuristic algorithms see figure 3.

4.2.1. Evolutionary-based algorithms. For optimal solutions, these evolutionary based heuristic algorithms employ Darwinian evolution and natural selection theory. GA, Differential Evolution (DE), and Evolution Strategy are examples of this type (ES). A generation, like the evolutionary mechanism, may consist of parents and children who inherit the characteristics of their parents. Selection, crossover, and mutation are the three main operators used by evolutionary algorithms. The crossover operator manages the mating mechanism to produce offspring, while the selection operator requires two parents. Finally, the mutation operator is often used to create stronger pupils. Many different forms of study have used evolutionary algorithms to optimize the integration of electrical units, such as in [14], [15], [16], [17], [18].

The genetic algorithm [14] provides the best knowledge for studying the trend. It updates the power flow response to optimally position the capacitor bank in the distribution line's critical region. Saudi Electricity Company (SEC) placed it through its paces. Consider [20] the ideal BESS solution for the ideal transportation company in the Virtual Power Plant in this direction (VPP). Genetic algorithms have been used to reduce the energy loss and power instability induced by photovoltaic systems, taking into account the susceptibility of impact and the characteristics of load growth.

The developer [15] increased the objective of reducing power loss in the ideal capacitor location in the uneven transportation frame by using an enhanced GA. GA has been evaluated on IEEE 4, 123, and 85 transmission feeders and is primarily used to approximate ideal transmission response efficiency. In [16], preferably weigh and place the BESS device in the grid photovoltaic system's circulating frame using a BA-based two-stage piping system. The aim is to minimize voltage variations generated by PV module control by supplying active power and BESS units in the event of a power loss. Compare the suggested equation to other meta-heuristic estimates for prediction, assembly period, and calculation time.

![Figure 2. Classification of different methodologies to solve DGs placement and sizing problem [19].](image-url)
Figure 3. Classification of different meta heuristic algorithms [14].

[21] DE operations generate objective and contrast vectors, which are then used to generate pre-vectors by standard EA managers (such as Hybrid and Transformable). [22] Using isolated and continuous variables In [22], DE was used to determine the optimal area, scale, and output parameters of the DG system in the required influencing organization in order to minimize energy loss. The differential search algorithm (DSA) is used in [23] to increase the absolute power failure, voltage divergence, and overall workload in the transmission network by comparative calculations. In comparison to AG, the final outcome may be obtained by improving DSA.

For the optimal allocation and calculation of DG and D-STATCOM units in the allocation network, the modified Shuffled Frog Leaping Algorithm (MSFLA) algorithm is proposed [23]. The aim is to reduce failure in the distribution string in order to enhance voltage reliability and effect efficiency. This measurement was checked and compared to the GA calculation in the IEEE 33 transmission. MSFLA is observed to produce fewer GD and STATCOM bandwidth than GA. MSFLA also increases stress distribution more effectively than GA. MSFLA has also been extended to the energy framework of dashboards in high-performance delivery companies by the authors of [24]. DG and BESS been paired for the best switches and priorities. [25] developed a GA-based simplification approach to simplify the mixture of DG, STATCOM, PHEV, and FACTS blocks and reduce total real energy usage in the delivery organization. In GA calculates each chromosome's health score based on the status of each transport intensity. The measurement is performed in the IEEE 37 Transport Dispersion Organization, assuming that the block alignment of DG, STATCOM, and PHEV will conduct real and responsive maintenance on the improved strength and power factor of the extended frame. Other prototype cars can be used to validate the current standard. As a result, different simulations may be run to boost the model.

Coercion is a significant component of the ideal union dilemma. As a result, the management is a significant issue. The majority of study has focused on computational approaches that effectively solve the issue. GA, on the other hand, will successfully solve this dilemma. The Penalty-Free Genetic Algorithm (PFGA), which deals with restrictions and exclusions, was developed in [17]. In the capacitor circuit, choose the direction of the penalty limit and measurement challenge. Since the opportunity or desire to be disciplined for breaching prohibitions is restricted, it is necessary to procure two chromosomes to deal with the conditions: if two chromosomes do not violate the requirements, choose one chromosome depending on its suitability; if both chromosomes do not
violates the requirements, choose a chromosome. If one of the chromosomes follows the order, the other chromosome is chosen to go on with the measurement. And, since both chromosomes break the constraints, the chromosome with the lowest harm score is chosen. To pick the nearest quality of another chromosome, PGFA employs single-point mixing and unequal likelihood rounds. The greatest praise is always reserved for the first class of the next cycle, regardless of dialect. This loop eliminates the ambiguity that can occur by using total restrictions in the transformation planner. PFGA is used to minimize control and energy loss and has been studied on transport frames 18, 68, and 141.

In [26], neither the hybrid manager nor the exchange manager are able to correctly allocate the BESS block. They employed a dual boss who selected rewards depending on the qualities of the two subordinates. This technique finds a good compromise between exploring and abusing high-quality environments. Your transition planner employs a heterogeneous method focused on loops and polynomial probability transformations. Since, unlike [17], the amount of extraction is determined by the mass number, one output extraction is assumed for each chromosome, thus extending the conversion period increases measurement time. [27] Formalized paraphrase To accelerate power loss and voltage drift, normal distribution crossover (NDC) is used to produce new chromosomes. It has been discovered that NDC-based GA calculations are quicker than PSO and PSO-GA calculations.

In transportation organisations, GA efficiency has been tailored for perfect BESS connections [18]. OPF technology controls BESS reserves and reduces network errors, while GA has the potential to boost net present value (NPV). This saves time and reduces the amount of age ranges needed to tackle the perfect coordination dilemma. It has previously been evaluated on the IEEE 33 bus platform and in previous GA races. The findings indicate that by shortening the measurement period, the amount of GA ages can be increased.

4.2.2. Swarm-based algorithms. This type of algorithm is focused on simulating the interaction of groups of animals (referred to as quest agents or particles) in order to accomplish a shared target. The parameter added to the simulation has the greatest effect on the algorithm’s efficiency. To boost voltage reliability and mitigate power loss, the optimum integration of electrical units has been refined and modified, and parameters have been reduced, resulting in improved overall network efficiency. Some experiments have also altered the algorithm engine to improve computational performance. [28] considered the charge delivery scheme, and numerous PSO topologies were suggested to improve capacitor positioning. It generates random numbers using Gaussian and Cauchy probability distributions rather than a uniform probability distribution. The diffusion function is extended alternately to the social and cognitive elements, yielding fifteen different types of PSO mechanisms.

The GA and Taboo search algorithms are used to evaluate all PSO groups. Changing the social variable of PSO will obviously increase the algorithm’s efficiency as compared to other permutations. They have a tendency to collide so much. To stop this setback, In [29] suggested an enhanced PSO to attain the lowest power and generation costs while incorporating renewable energy into the distribution network. The location of the particles is modified by a rivalry mechanism applied to randomly chosen pairs of particles, rather than by their personal and global best output [29]. The PSO algorithm is used in [30] to evaluate the optimum location and size of the DG block while also taking into account the estimation of the harmonic power flow of various harmonics dependent on the nonlinear load in the 31-bus distribution network. The key constraint in terms of units, pollution, and fuel is maintaining a reasonable degree of harmonic distortion. In [31], he suggested an enhanced PSO for optimum parallel capacitor usage and scale in radial distribution systems. The algorithm is applied by lowering the high current induced by the voltage decrease, thus decreasing real power loss and lowering the capacitor cost. According to estimates, as comparison to the PSO implementation, the proposed PSO implementation has a lower capacitor expense [32]. Similarly, in [33], PSO is used to solve the objective function to find the best location and scale of capacitor banks in a delivery network of 10, 33, and 69 buses. The aim is to minimize the lack of active and reactive power while saving the most money for the distribution business. Another consideration is to incorporate a feature to inflict line losses to ensure minimum voltage interference.
[34] suggested an artificial bee colony (ABC) system for optimizing the delivery of dispersed BESS blocks in the distribution network, which enhanced by removing power loss, voltage drift, and linear load. According to studies, this algorithm outperforms PSO in terms of reducing real output loss. The BESS device is optimally inserted into the microgrid in [35] to input and consume real resources as electricity rates adjust. Improve the voltage curve and the voltage reliability of the microgrid to reduce power loss. The scale of the study can be broadened by running the algorithm through its paces on a test bus grid and contrasting it to other algorithms. PSO was suggested in [36] to maximize the scale and position of capacitors in the delivery network in order to minimize real electricity loss and economic costs. The algorithm was tested on 34 and 85 bus networks, and its performance was compared to that of WOA.

Any scholars concentrate mostly on the benefits of these two algorithms. In [37], for example, there are two group-based meta-heuristics: Bat Algorithm (BA) and Cuckoo Search (CS). The analogy was rendered in order to solve the issue of determining the ideal size and position of the capacitor. In the 34 and 85 bus networks, the target is to minimize real output loss while maximizing network savings. It is discovered that although CS outperforms the consistency of the BA solution, its convergence speed is slower than that of the Swar algorithm.

The arbitrary specification of parameters is one of the key drawbacks of community algorithms. Incorrect parameter settings can trigger premature convergence [38], which can result in local optimized outcomes. Finding an easy way to limit or remove parameter changes as far as possible is a basic trick. This idea was investigated in [39], which established a symbiotic chaotic organism (CSOS) search algorithm with less parameters to locate and decide the size of the DG unit in the distribution network. A disorderly vector is added in place of parameters to render it less vulnerable to the effects of local optima. In terms of convergence, the algorithm outperforms the initial SOS on 33, 69, and 118 RDS buses. The Hybrid Grey Wolf optimizer was created by the creator of [40]. Other than the population scale, no other parameters need to be adjusted for this optimizer. This algorithm is used to solve the issue of determining the optimal RG to allocate in the delivery network in order to reduce active and reactive power losses. The DG unit's height, power factor on each bus, and bus voltage are all within the acceptable range.

Meta-heuristic algorithms, such as WOA, ALO, and JAYA, have been designed to address the realization of a wide number of parameters. [41] used an ALO-based optimization strategy to position fixed shunt capacitors in the power distribution system optimally thus minimizing overall power. ALO is often used in [42] to optimize the placement of simultaneous capacitors in the delivery network when optimizing goal functions like energy loss and stress conditions. ALO has been tested in IEEE bus networks 33 and 69. To achieve the optimal flow in the existing renewable energy delivery network, use the JAYA algorithm [43]. The most difficult integration challenge [44]. In [45], WOA was used to optimize the size and position of capacitors in RDN. Developed to mitigate energy loss, increase the voltage curve, and reduce costs. WOA was tested on IEEE 34 and 85 bus systems and contrasted to other meta-heuristic algorithms such as PSO and BFOA. [46] investigated the strongest incorporation result of BESS and PV-DG blocks in various scenarios. In comparison to PSO and FA, WOA is added to a 25-bus network to reduce overall energy loss. The output of WOA and PSO is considerably higher than that of FA, with WOA doing marginally better than PSO.

Other algorithms, such as [47], which uses the discrete ray search algorithm (DLSA) to optimize the location of the capacitor, have also been applied to the optimal integration issue. Inside the windmill. The suggested target is to reduce administrative expenses while mitigating electricity waste. Contrast DLSA with the GA and the Discrete Harmony Search Algorithm (DHSA). The moth algorithm (MFA) has been used to maximize the scale and placement of the capacitor bank delivery network since [48]. To minimize the deficit, an iterative algorithm is used to solve the energy flux. Simultaneously, the responsive and reactive load curves are simulated at 15-minute intervals.

[49] Formalized paraphrase Implemented a Flower Pollination Algorithm (FPA) focused on a thick-tailed probability distribution to find the best global approach that can minimize the overall cost of installed capacitors thus determining the best capacitor size power network. The Butterfly Search
Algorithm (MSA) employs the Levy Flight approach in a related manner and has suggested [50] to change the bus voltage while positioning and calculating DG units in the distribution network.

4.2.3. **Physics-inspired algorithms.** These equations mimic the functions of actual miracles, which may be technological breakthroughs, human collaboration, or some other distinguishing occurrence. This classification can be assigned to population-based calculations to develop, especially in terms of composition. Instead of a vast number of quest experts, a search specialist may be included in material science equations to engage in the search space to locate answers, and vice versa. An Improved Harmony Algorithm (IHA) is suggested in [51] for ideal capacitor calculation in transportation organizations, where the power loss index (PLI) distinguishes the feasible transportation methods for the ideal capacitor installation. This measure was checked with 69 transmissions and contrasted to others including PSO, ABC, DE, and HSA. The expanded organisation found the stochastic principle of electric cars and the dubious energy performance of PV-DG systems in [52]. Use the Gravity Search Algorithm (GSA) layering problem to maximize the advantages of the PV portfolio while limiting annual energy loss. Display the electric car's battery to change the charging level at each level and charge/discharge level. The hypothetical region and scale of the PV-DG device are built on the first layer, taking into account the charge/release potential of electric vehicles, and an ideal area is formed on the next step. Load and post the results profile. HSA is another successful meta-heuristic approach built on an elegant sound mix. This approach can be found in [53] and [54] for a detailed review of its usefulness in improving energy structure. In [55], an improved HSA was developed for the optimal combination of units in the circulation organisation to reduce overall labor expense. These algorithms mimic the behavior of physical processes such as chemical reactions, human experiences, or findings of some natural occurrence. Distribute the system and evaluate it to other algorithms (such as PSO, ABC, DE, and HSA). [52] investigates the randomness of electric cars and the effect of instability on the success of PV-DG systems in the delivery network. The Gravity Search Algorithm (GSA) is a two-step problem designed to optimize the advantages of photovoltaic incorporation while minimizing annual energy loss. The battery of an electric vehicle has been modeled, and the state of charge at each stage and charge/discharge state can be changed. To reduce overall cost of ownership, Advanced HSA will better incorporate the drive into the power delivery network. In [56], HSA hybridizes with FA, as will be addressed in the following segment.

4.2.4. **Hybrid algorithms.** A hybrid algorithm is an algorithm that combines two or more meta-heuristic algorithms. Algorithms may be merged to solve the whole optimization problem in a single algorithm, or they cannot be combined to solve separate sub-problems. Any instances of implementation can be found in literary works. A hybrid algorithm was proposed in [57] to reconfigure the distributor feeder via ESS, DG, and solar PV to maximize capacitor distribution. To achieve minimized power loss and decreased voltage drift, improved PSO and MSFLA were used in conjunction with VSI technology. Since the whole thing is split into two sections, each algorithm will solve the same problem. Then, IPSOMSFLA selects the best health attribute again and again until the full amount of iterations is achieved. This algorithm, according to sources, will have greater voltage stability and lower running costs than previous algorithms. Taking complexity into account, a hybrid PSO-GA algorithm was suggested in [58] to optimally position the energy storage device in the wind farm network. Designed to reduce maintenance costs and greenhouse pollution while improving voltage deflection. The algorithm was put through its paces on a grid of 30 IEEE buses. According to studies, PSO-GA outperforms GSA in all goals excluding voltage suppression. [59] optimizes and allocates DG units throughout the delivery network using GA and Intelligent Water Drops (IWD). By defining applicant buses, VSI is used to minimize real power loss. IWD computes fitness values, thus GA operators build a new generation of chromosomes. The hybrid algorithm was evaluated on a device with 33 buses and 69 buses, and it demonstrated excellent computation time that increased linearly with the amount of DG blocks.
In [60], the aim room created a hybrid algorithm (including community optimization and TBLO) to increase network reliability while allocating charging stations to the IEEE33 bus network. Voltage stability metrics, efficiency measures, and power failure indicators are also part of network stability. CSO and TLBO combine explicitly to accelerate convergence and reduce the risk of premature convergence. The INV parameters in CSO-TLBO, like those in CSO, are user-definable and must be modified appropriately to prevent local optimum solutions. According to sources, CSO-TLBO has a quicker convergence speed than the evolutionary general decomposition algorithm (MOEA/D) and NSGA-II, but the computation period is longer.

The author [56] combined HSA and FA (CHSFA) by lowering running costs and increasing delivery network sales to increase distribution network business revenues. To cope with the volatility of load demand, a rigorous paradigm has been applied that employs deterministic methods rather than probabilistic methods based on confidence intervals or forecasts based on historical evidence. CHSFA employs the HSA engine to locate the harmony of the best goal value in memory, and the FA engine to display the random value. To get the right answer, repeat this step again. CHSFA has been measured on 38 bus delivery networks and is stated to have a higher convergence pace than HSA. Although there is no study comparing calculation times, it is estimated that CHSFA would take longer to calculate than HSA due to its complicated mechanism.

[61] created a hybrid DE and Harmony Search (DEHS) algorithm to find the best place for multiple STATCOMs in an IEEE 30 mesh bus network. The DE mutation operator is widely used in this analysis to locate the best answer in the harmonic memory without modifying the HSA search engine. The opposing theory is to shorten the quest method and hence the convergence period. DEHS, as an HSA, raises the network stability index. It also has a higher convergence rate than HSA.

[62] combines a number of evolutionary algorithms, including GA, DE, and the Pareto Force Evolutionary Algorithm (SPEA-II), to incorporate RES units (solar and wind energy), capacitor banks, and electric cars into the delivery network all at once. The algorithm employs a vector cross feature to choose between three mutation strategies at random. The aim is to increase voltage efficiency while lowering gas pollution and installation costs.

4.2.5. Combined techniques. This group, in relation to cross-computer grouping, is a hybrid of two distinct enhancement methods. Scientific/metaheuristic and numerical/metaheuristic methods are included in the simulations. Both techniques should be used to reduce the sophistication of the optimal electrical device combination and solve the undeniable degree of simplex estimation. They are often the first stage in the process of upgrading the newly redesigned model. Calculations are typically paired with different methods of changing output systems to improve productivity. [63] investigated the optimal location and height of the ESS and PV-DG blocks in the distribution network. The region of the GD block was determined using an in-depth effect study of 33 buses and a fire spread model. Reduce power outages and boost power efficiency.

The power loss reduction factor and enhanced optimization of the multi-purpose golden ratio was used in [64] to optimally distribute and scale capacitors and STATCOMs in a different power distribution network. IEEE 69 and 118 bus systems were allocated to restrict output loss, react to impact assumptions, and increase voltage curves. The authors of [65] suggested an ABC-PSO hybrid approach that can smoothly quantify the load flow based on the load flow to minimize energy loss and increase voltage distribution during the monitoring phase. The Loss Sensitivity Factor (LSF) approach is used to classify vehicles that are vulnerable to loss of control and then pick the ideal capacitor set using a soft-tap frame. The hybrid ABC-PSO algorithm is used for capacitor ranking and estimation. 34 RDN hubs were checked. Similarly, in [66], a half-calculated HSAABC was built to increase the size and position of capacitors in RDN when taking into account various load models. PLI, VSI, and LSF were introduced to measure the overall company's power loss, discern lower voltage quality on the hub, and identify high dynamic impulse loss on the hub under a specified capacitor condition. In a 69-bus device with varying loads, an MFA-based algorithm was designed to optimally quantify capacitors in order to minimize energy loss. Since the output of LSF ALO is similar to defined and
calculated preferably in [67], an inexhaustible DG should be used on a separate microgrid. The suggested equations were tested on the RDS 69 bus and contrasted to other calculations, demonstrating that the total energy deficit was minimized and the net reserve was increased. [68] adds VSI to the LSF method to optimally position the capacitor in the delivery organization. The fluffy symmetric technique improves the estimation of enhanced bacterial absorption (IBFOA). The most rigorous approaches for limiting power loss and improving voltage reliability have been applied and validated in an enterprise of 33, 69, and 141 hubs.

When arranging the cycle, the maker of [69] sacrificed the perfect condenser region and condenser height. The LSF procedure was used in this case to choose opposing conveyors for capacitor placement in order to achieve GSA for ideal capacitor calculation. In the chosen truck. The FPA equation is used to optimally calculate the size of the capacitor, with the primary goal of limiting real power usage. The effects of the calculations are analyzed in the 10, 33, and 69 bus systems.

[70] suggested a BA enhancement strategy to limit the ratio of energy average interest to energy expense in a multi-level improvement scheme. The architecture employs phased curve programming to merge power demand reservations, ESS blocks, and PV-based DG blocks for households. The turbulence relationship is linked to the bee settlement miscalculation in [71]. This perfect condition is ideal for BESS transportation in the PV and WT IEEE 33 bus system organisation. The aim is to reduce power loss and voltage drift while also expanding the linear stack.

5. Conclusion

Since the beginning of power network, it has always evolved and now it is facing yet again new changes, this time due to increasing penetration of distributed generation. Due to power network complexity and growing number of uncertainties current control strategies and algorithms need to be updated to ensure minimum active power loses, best distribution power generation for optimal voltage and frequency control.

The usage of meta-heuristic algorithms to solve the optimum integration problem and its complex realization to solve the objective function problem was discussed in this paper. Evolutionary algorithms, swarm-based algorithms, physical algorithms, hybrid algorithms, and combined algorithms have all been commonly debated and known as metaheuristic algorithms. In the literature, each of these definitions has been explored in depth using descriptions of program modes, judgment variables, and objective functions. Since the process of optimum integration is dependent on achieving several objectives, researchers may make additional choices, such as selecting the best yet correct answer. Furthermore, depending on the network circumstance, the simultaneous integration and management of uncertainties in the delivery network may significantly complicate the model. Ensuring that algorithms are properly integrated into the system requires the system to be adapted for rapid management and monitoring. The selection of the most appropriate algorithm for medium voltage power network management depends on the network management structure. Thus, the use of different control algorithms like in hybrid and combined techniques in medium voltage power network may help making them more universal, easier to manage and more resilient to upcoming network changes.

In the future, proposed work on the subject of optimum incorporation into the distribution network could be needed. For example, the development of new meta-heuristic algorithms necessitates minimal user interaction; the development of the optimal number of parameters; the development of a hybrid algorithm with fast convergence and short calculation time; the development of a better support method for the selection of candidate buses for the best position of the electrical unit in the distribution network; and the development of a better support method for the selection of candidate buses for the best position of the electrical unit in the distribution network.

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