A literature Survey on Well-known Algorithms of Optimum Power Flow

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Abstract. One of the most often researched non-linear optimization issues is the optimal power flow (OPF) problem. The performance of electricity production, transmission, and distribution must be improved under a variety of system needs and control restrictions in general (OPF). The compositions of OPFs and the methods used to apply them are quite diverse. Furthermore, as a result of recent power markets and the absorption of renewable resources, the character of OPF is evolving. Various OPF formulations have been dealt with using a variety of classical and meta-heuristic methods throughout the last three decades. This survey explores both traditional and intelligent OPF approaches to provide a strong background for the present status of OPF formulations and solutions approaches. The survey covers all of the optimization approaches that researchers have used to (OPF), with a focus on the advantages and disadvantages of each method for both traditional and intelligent OPF methods.

Keywords: Optimal Power Flow (OPF), classical Optimization methods, metaheuristic algorithm Optimization.

1 Introduction

Since Carpentier initially published a paper in 1962, the optimal power flow (OPF) problem has been one of the most extensively studied problems in power system operation. The goal of OPF formulation is to arrive at a steady-state solution that reduces generating costs, system losses, or optimizes societal welfare or system utilization, among other things while maintaining acceptable performance of the system active and reactive power constraints on generators, line flow limitations, and a maximum output of different compensating devices...etc. The generic OPF problem is a large-scale, non-convex, nonlinear optimization problem with both continuous and discrete control variables. Several OPF formulations have been created to solve specific examples of the problems, each with its own set of assumptions and choices of objective functions, system limitations, and controls. Generally, the OPF approach is frequently applied to several industrial applications such as restricted economic dispatch and voltage control problems [1]. In this survey, the OPF methods are broadly classified as conventional and intelligent methods. Solution methodologies can broadly be categorized into two groups: classical methods; several traditional methods used for solving OPF problems such as the Newtonian technique grid flow programming, linear programming, nonlinear programming, quadratic programming, and the interior point method. As the main shortcoming, these traditional methods are not suitable for large and difficult OPF problems. Because the

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optimization framework is non-linear and multimedia in nature, these approaches may become trapped in local solutions. Traditional approaches are based on diverse mathematical programming frameworks and are used to answer a variety of sizes of OPF issues in order to meet the requirements of various objective functions, application types, and constraint natures. Traditional methods are inadequate for dealing with qualitative constraints. These approaches have weak convergence, can only identify one optimum solution in a single simulation run, become excessively slow when the number of variables grows big, and are computationally expensive when addressing a large system.. Intelligent methods; many meta-heuristic methods were used to solve OPF such as genetic algorithm (GA), particle swarm optimization (PSO), artificial neural network (ANN), bee colony optimization (BCO), differential evolution (DE), grey wolf optimizer (GWO), shuffled frog-leaping (SFL) and fuzzy logic (FL) method. Recently, to overcome the shortcomings of conventional methods, many intelligence optimization techniques based on various concepts such as evolutionary inspired algorithms, human-inspired algorithms, and naturally inspired algorithms were implemented to solve the OPF formulation. The main advantages of meta-heuristic optimization techniques are that they are relatively flexible in dealing with different qualitative constraints. As a result, they are well suited for solving multi-objective optimization problems. In most cases, they could also find the global optimal solution. It also has learning capability, is fast in convergence, and is suitable for non-linear modeling. However, there are some drawbacks such as high dimensionality and the selection of training methods [2]. In this article, the form of a table is used to review the scientific contributions of each method with its advantages and disadvantages. Also, a summary to review the conclusions is given.

2 Optimal Power Flow Methods

The traditional and modern optimization techniques that have been used to solve the OPF problem are depicted in Fig 1.

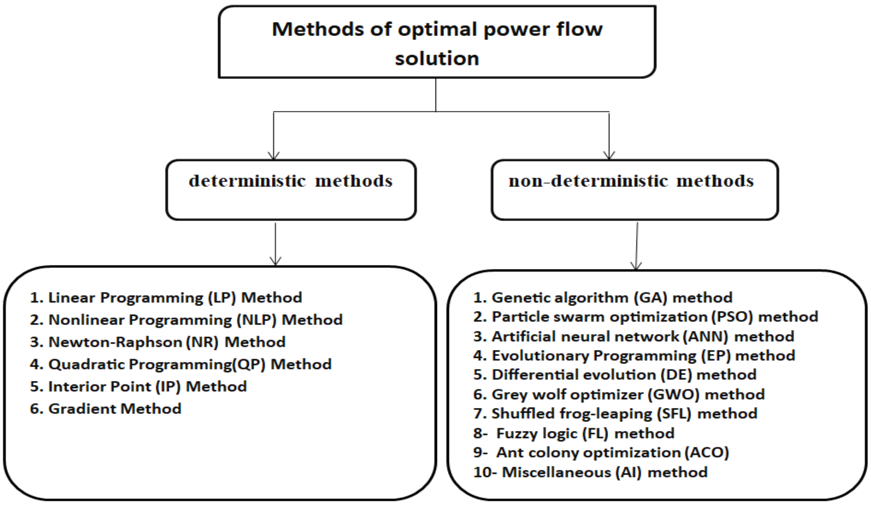

Fig. 1. Optimal Power Flow Solution Methods.

2.1 Classical Methods (Deterministic Methods)

2.1.1 Linear Programming (LP) Method

Several academics have used linear programming to tackle many problems involving optimal power flow. Linear programming formulation necessitates the linearization of the goal function as well as nonnegative variable constraints. Several nonlinear power system optimization issues are linearized using various linear programming-based methodologies [3]. In Table 1, the most important scientific contributions in this field were explained:-

Table 1. The LP approaches are used for solving the OPF problem.

Ref. No.	year	objective function	system	Scientific contribution
[4]	1996	the optimal cost and benefit.	14 bus system	provided a recursive linear programming-based method for reducing line losses and determining the best capacitor allocation in a distribution system.
[5]	2001	transmission losses and generator reactive outputs	the French, Portuguese, and Moroccan systems.	The method proposed is an iterative approach in which the objective function and constraints are linearized in each iteration. A set of tangent cuts is also used to represent the objective function..
[6]	2003	determines the number, position, and settings of phase shifters in a network. maximize system load ability	the IEEE 24-, 118-, and 300-bus systems, a 904-bus network	A recent mixed-integer linear programming (MILP) method was used.
[7]	1992	cost optimization	5-bus system	For optimum power flow, a linear programming-based optimization approach was presented.
[8]	2014	generation cost, P loss.	Iraqi 24 bus (400 kV) test system.	Linear Programming to cover the target fitness and constraints in each iteration.

In summary, we find that linear programming has several advantages and disadvantages which are mentioned briefly as follows:

Advantages:

1. The LP approach can easily deal with nonlinearity constraints.
2. It is effective in dealing with inequalities and it has a good convergence characteristic.
3. Efficiently handles local constraints.
4. It is capable of incorporating contingency constraints.

Disadvantages:

1. It suffers a lack of accuracy. Also, it is trapped in local minima.
2. Although LP approaches are quick and dependable, they have several drawbacks due to piecewise linear cost assumptions.

2.1.2 Nonlinear Programming (NLP) Method

Nonlinear programming (NLP) is a technique for solving problems with nonlinear goal and constraint functions. The fundamental benefit of NLP formulation for (OPF) is also that they correctly reflect the behavior of power systems. (NLP) techniques employ the reduced gradient technique with the Lagrange multiplier or the penalty function optimization method (2). In Table 2, the most important scientific contributions in this field were explained:

Table 2. The NLP approaches are used for solving the OPF problem.

Ref. No.	year	objective function	system	Scientific contribution
[9]	2001	Losses and cost	IEEE 30-bus system	Applied a new nonlinear convex programming (NLCNFP) model.
[10]	2006	maximize the system load ability	IEEE 24-bus	In the deregulated energy markets, a new method is applied to find the best number and position of TCSCs utilising a mixed-integer non-linear programming methodology.
[11]	2004	minimize active losses and load stability	from 30,57,118,300 to 2098 buses system	presents and compares the computational performance of smooth, non-smooth, and Jacobian smoothing nonlinear complementarity (NC) methods for solving nonlinear (OPF) problems.
[12]	2002	the total cost of VArs committed or the overall cost associated with the VAr requirement	the IEEE-I 18 bus system	The characteristics of optimal power flows (OPFs) based on linear programming (LP) and nonlinear programming (NLP) are examined.
[13]	1970	reduction in computer time, storage requirements	the IEEE 14, 30, 57, and 118bus systems	provides a decomposition methodology that may be combined with the Fletcher-Powell method to broaden the nonlinear programming method's application to huge systems.

In summary, we find that nonlinear programming has several outcomes as follows:

Advantages:

1. When compared to linear programming, the nonlinear programming (NLP) method is more accurate since it may be used for nonlinear objective functions and constraints.
2. Can be applied to large-scale problems.

Disadvantage:

1. some components of the system are not considered.

2.1.3 Quadratic Programming (QP) method

With a quadratic objective function and linear constraints, it is a type of nonlinear programming. In power systems, quadratic programming-based optimization is used to keep a specified voltage profile, maximise power flow, and lower generating costs [1]. In Table 3, the most important scientific contributions in this field were explained:-

Table 3. The QP approaches are used for solving the OPF problem.

Ref. No.	year	objective function	system	Scientific contribution
[14]	1989	Voltage deviation, cost, and losses	A 39-bus system	A generalized optimal power system flow problem has been formulated using a quadratic form of power systems. The (OPF) method is built with the feasibility, convergence, and optimality requirements in mind.
[15]	1998	Losses with many elements including reactive power.	the IEEE 30 and 278 bus systems	The method of successive quadratic programming (SQP) was used to develop a reactive power optimization model. The focus of this study is on the mathematical elements of reactive power optimization using the successive QP approach.
[16]	2000	total generation and transmission losses	the CIGRE system and the Italian EHV system	For security-constrained economic dispatch, dual sequential quadratic programming was recommended. By minimising transmission constraints and subsequently punishing constraint violations, the dual quadratic technique is utilised to produce a dual viable starting point. It features a quick calculating time and good precision.
[17]	2003	voltage stability and minimum reactive cost	the IEEE 14-bus system.	For competitive marketplaces, a method is proposed that integrates cost and voltage stability analysis using an OPF formulation.
[18]	2005	calculations of line flows and real losses	the CIGRE 63-bus system and Italian EHV network.	proposed SCOPF (security-constrained optimal power flow) to find the best UPFC and TCPAR settings and operation modes. The HP (Han-Powell) algorithm was used to find the solution to the OPF.

In summary, we find that QP could be summarized by:

Advantages:

1. In many cases, conditioned and divergent systems are solvable.
2. When compared to other recognized approaches, the accuracy of the QP approach is significantly better.
3. It has fast convergence characteristic.

Disadvantage:

1. Obtaining solutions to quadratic programming problems in reliable performance of approximating QP problems is difficult.

2.1.4 Interior Point (IP) Method

It's a novel method for computing large-scale linear programming problems quickly. Because it enhances search directions only within the limitations of the possible space, it is referred to as an internal technique. Interior Point Methods (IPMs) are a type of scaling approach that uses projections to solve linear and nonlinear optimization problems [3]. In Table 4, the most important scientific contributions in this field were explained:

Table 4. The IP approaches are used for solving the OPF problem.

Ref. No.	year	objective function	system	Scientific contribution
[19]	2002	fuel cost and power loss minimization	IEEE 14 and 57 buses standard test systems	presented an independent OPF methodology with IPBCM approach.
[20]	2001	cost and loss minimization	The IEEE 30 and 118 buses	For optimum power flow problems, new versions of interior-point techniques were introduced. A mixture of two approaches, affine-scaling and centralization, is used to get the optimal answer.
[21]	2005	generation cost and active power losses.	Nordic32 system , IEEE118 and IEEE300 systems	Two interior point (IP) based methods were compared to address various OPF issues: the infeasible 1 pure primal-dual method and the infeasible primal-dual predictor-corrector approach.
[22]	2006	Time, iterations, and power losses	IEEE Test Systems with various buses	A new transformer model is applied by ideal case and load impedance.
[23]	2020	the MSE-loss and total energy cost	The energy price data	The Linear Programming relaxation was given a log-barrier term, which makes it twice differentiable and is the usual procedure in Linear Programming when employing interior point methods.

In summary, we find that IP has unique outcomes such as:

Advantages:

1. It is one of the most effective algorithms available.
2. high accuracy, high convergence speed and reliability.

Disadvantages:

1. Due to the starting and ending conditions, there is a constraint.
2. If the step size is selected incorrectly, the solution is infeasible.

Finally, the disadvantages of traditional approaches might be summarized as three main drawbacks:

1. The optimum solution cannot be obtained and are frequently stuck at a local optimum.

2. All of these approaches are predicated on the assumption of objective function properties in which some of its elements are not attainable.
3. With discrete variables like transformer taps, none of these techniques can be used. It is observed that intelligent techniques are suitable methods to overcome the above drawbacks.

2.2 Artificial Intelligence (AI) Methods (Non-Deterministic Methods)

Intelligent search has become a widely used methodology. Several non-deterministic optimization approaches were discovered to address the global search methods in supporting the deterministic optimization algorithms. Many of these methods, such as the genetic algorithm, particle swarm optimization, artificial neural network, evolutionary programming, differential evolution, grey wolf optimizer, shuffling frog-leaping, fuzzy logic (FL) method, and ant colony optimization, have been utilised to tackle OPF problems. We will briefly mention the scientific contributions made by researchers to some of the methods above:

2.2.1 Genetic Algorithms

The genetic algorithm (GA) works with the problem parameters encoded binary string rather than the system's real parameters. GA employs an iterative process in which each iteration step three genetic factors (selection, crossover, and mutation) are applied to enhance the new selection of populations [3]. In Table 5, the most important scientific contributions in this field were explained:

Table 5. The GA approaches are used for solving the OPF problem.

Ref. No.	year	objective function	system	Scientific contribution
[24]	2005	fuel cost, P losses, and computing time	the electrical network in western Algeria	The Lagrange approach was used to construct a genetic algorithm solution in this paper.
[25]	2007	fuel cost, P losses	the modified IEEE 57 bus test system	To deal with OPF, a hybrid method is applied such as GA and mat power including the both active and reactive power dispatching.
[26]	2010	fuel cost, P losses and voltage stability enhancement	IEEE 30 bus system	The DQLF method is applied that is combined with an enhanced genetic algorithm to solve the OPF problem.
[27]	2014	minimization of cost, P losses, and emission	IEEE 30-bus test system	considers fuel cost and emission functions and proposes a solution to the severely constrained multi-objective involving competing objectives.
[28]	2018	fuel cost, P losses	two test systems, 15 benchmark functions	designs and suggests a real-coded genetic algorithm that is more efficient.

In conclusion, we discover that GA has a number of advantages and downsides, which are briefly listed below:

Advantages:

1. GA avoids the trap of local optimality, they can deliver a globally optimal solution.
2. GA can solve non-smooth, non-continuous, and non-convex problems.
3. Changeable, with the ability to create a large number of solutions and a fast convergence.

Disadvantages:

1. GA are stochastic algorithms which means that the solution isn't always optimal.
2. With increasing chromosomal length the run period and accuracy of the solution decrease.
3. Once the system model goes bigger, the GA might lead to a waste of computing efforts.

2.2.2 Particle Swarm Optimization (PSO) Method

PSO is a population-based stochastic optimization method. It is a natural phenomena like as bird flocks and fish schools that occur in socially organised colonies. PSO employs a crew of individuals to scour the search space for promising regions [3]. In Table 6, the most important scientific contributions in this field were explained :

Table 6. The person approaches are used for solving the OPF problem.

Ref .No.	year	objective function	system	Scientific contribution
[29]	2002	fuel cost, voltage deviation, and voltage stability	standard IEEE 30-bus test systems	For the best position of OPF problem control variables, the PSO method is utilised.
[30]	2013	fuel cost, P losses	IEEE 14 and 30 bus test systems.	To identify the lowest generation cost values, this innovative approach adds PSO to the Newton Raphson method.
[31]	2015	Fuel cost, P Losses, and L-index	standard IEEE 30-bus test system	Particle Swarm Optimization (PSO) was used to tackle the optimization problem for the FACTS device's power injection model.
[32]	2020	Cost ($/h) , P loss (MW) , VD and L max	standard IEEE 30 and 57 bus test systems	A multi-objective hybrid firefly and PSO (MOHFPSO) was developed for various multi-objective optimal power flow (MOOPF) challenges.
[33]	2020	Fuel cost, P Losses, VD and L-index	tested for IEEE 9 and 30 bus systems	The reactive power is solved using the PSO method and the MATPOWER 6.0 toolbox.

In summary, PSO could be briefly summarized by:

Advantages:

1. Capable of solving non-convex optimization problems on a large scale, such as OPF.
2. Simple concept, simple implementation, relative control parameter robustness, computing efficiency, and fast convergence speed.
3. Flexibility in balancing global and local search space exploration.

Disadvantage:

1. Slow convergence in detailed search stage (local search capability is limited).

2.2.3 Ant Colony Optimization (ACO) Method

It is based on ant foraging and the creation of a trail utilising pheromone communication. ACO is distinguished by using a probabilistic model to provide optimum solutions at hand [34]**.** In Table 7, the most important scientific contributions in this field were explained:

Table 7. The ACO approaches are used for solving the OPF problem.

Ref .No.	year	objective function	system	Scientific contribution
[35]	2004	Generating cost, Total cost	A universal moment generating function (UMGF) , three and ten generating units	A suggested ant colony optimization method with stochastic disruption activity (RPACO) with randomised technique towards the Unit commitment (UC) with stochastic spinning reserve calculation.
[36]	2013	the voltage stability	WSCC 9-bus test system.	The voltage stability margin feature was introduced and put into the load target function of an OPF using an ACS method.
[37]	2016	the total fuel cost and ecological emission	an IEEE 30 and 118 bus test system	The ideal power flow with ecological emission is resolved using an enhanced ant colony optimization technique.
[38]	2020	Power losses and Cost	the IEEE 30 and the IEEE 57 bus test cases	shows the use of mixed-integer AC optimization for power grid.
[39]	2020	fuel cost, p losses and voltage deviation	the IEEE-30 bus system	OPF is also solved using AC with single target function based on constraints.

In summary, we find that ACO has several advantages and disadvantages which are mentioned briefly as follows:

Advantages:

1. Intelligent search, global optimization, dependability, and positive feedback are all features.

2. Has the ability to compete with other optimization techniques.
3. The computational operators of the ACO algorithm are simple, with no crossover or mutation, resulting in low memory and calculation costs.
4. ACO is a gene selection that has the benefit of being able to be combined with other algorithms.

Disadvantages:

1. The convergence rate is very slow.
2. Over time, the pheromone gets overpowered.
3. It is simple to fall in the local optimal.
4. Theoretical analysis is difficult [40].

2.2.4 Fuzzy Logic (FL) Method

Fuzzy logic is based on fuzzy set theory, which deals with approximate rather than precise reasoning. It is utilised to solve the problem of load flow, resulting in a significant reduction in processing time. To express inexact relationships FL theory is a easy and appropriate tool [41]. In Table 8, the most important scientific contributions in this field were explained:

Table 8. The FL approaches are used for solving the OPF problem.

Ref. No.	year	objective function	system	Scientific contribution
[42]	1992	cost of energy generation	very small system the 6 bus/6 branch network	presented a fuzzy model to describe load and generation uncertainty as fuzzy numbers.
[43]	1997	operating cost and correction times	14-bus system	the creation of fuzzy membership functions and their objectives using a mechanism for expressing the tolerance parameters required.
[44]	2004	percentage Real and Reactive power curtailment and per unit generation cost	modified IEEE 30 bus test system	An effective and practical mixture model for overcrowding management for active and reactive power transactions has been created in the deregulated fuzzy environment of the power system.
[45]	2010	Fuel cost and emissions	the IEEE 14-bus system	the use of a fuzzy model to obtain a Pareto curve that reflects the (tradeoff) between two competing objectives.
[46]	2013	voltage deviations and Network Constraints	thestandardIEEE30-bustestsystem	introduce a new controller architecture that uses AFLC and SFLC techniques to regulate VAR flow in the power system network. A simulation software is used to introduce and test an adaptive fuzzy set.

In summary, we find that FL has several outcomes such as:

Advantages:

1. As a result, a fuzzy multi-objective approach like this is appealing for such problems in terms of cost and emissions.
2. Ease of use and flexibility, as well as a lower cost of development.
3. Is capable of modeling nonlinear functions of any complexity.
4. Has the ability to deal with data that is inaccurate or incomplete.

Disadvantages:

1- A large number of calculations are required on account of the matrix.
2- When large-scale networks exist, a straightforward implementation of these approaches becomes inefficient resulting in increased memory requirements and computational time [41].

2.2.5 Differential Evolution (DE) Method

DE is a direct random search technique that is based on a population. To get from a random starting population to a final solution, it combines simple arithmetic operators with the conventional evolutionary operators of crossover, mutation, and selection. It uses a greedy strategy rather than a stochastic method to solve the problem [3]. In Table 9, the most important scientific contributions in this field were explained:

Table 9. The DE approaches are used for solving the OPF problem.

Ref .No.	year	objective function	system	Scientific contribution
[47]	2007	the total fuel cost and P losses	two test systems	Proposes improved DE approaches for tackling the problem of economic load dispatch.
[48]	2008	fuel cost and transmission losses	6-bus and IEEE 30 bus systems	MDE technique to achieve optimal power flow (OPF).
[49]	2012	fuel cost, P losses, and L-index	IEEE 30 and 118 bus systems	provides a multi-objective differential evolution-based method for OPF.
[50]	2018	cost, power loss emission, voltage deviation and stability	IEEE 30, 57 and 118 bus systems	This research assesses the performance of appropriate CH, SF, SP, and joint of two of these.
[51]	2020	fuel cost, P losses, Vd, the emission, and the generation and emission cost	IEEE30-bus test system	A self-adaptive penalty constraint handling system with improved adaptive differential evolution (JADE).

In conclusion, we discover that DE offers a number of benefits and drawbacks, which are briefly discussed below:

Advantages:

1. When evaluated, it outperformed search heuristics.
2. It is a simple and effective evolutionary approach for optimising continuous-space functions.
3. The DE algorithm is a method for dealing with objective functions that are non-differentiable, non-linear, and multimodal.
4. It can search at random, requires fewer parameters to set is fast, and can be utilised to solve high-dimensional difficult optimization problems.

Disadvantages:

1. The DE has a number of drawbacks, including lengthy operations, stagnation, and poor searchability.
2. Takes into account recent times of unstable convergence and the ease with which a regional optimum could be reached [52].

1.2.6 Grey Wolf Optimizer (GWO) Method

heuristics method is applied by GWO, which helps us understand Gray wolf hunting technique and leadership structure. Omega wolves are preceded by scoffed kappa and lambda wolves, whereas alpha wolves make decisions, beta wolves help alpha wolves, delta wolves are the lowest, and sneered kappa and lambda wolves are the highest [3]. Table 10 summarises the most significant scientific achievements in this field:

Table 10. The GWO approaches are used for solving the OPF problem.

Ref .No.	year	objective function	system	Scientific contribution
[53]	2015	the total transmission loss, and voltage deviation	IEEE 30 and 118 bus systems	Best control elements are updated by GWO such as generator voltages, tap changing transformer ratios, and the number of reactive compensation devices.
[54]	2016	cost, Emission, total generation (MW), and percentage of losses	IEEE 30 bus system	Modifications to the exploration-exploitation balance in the original GWO algorithms, which search the solution space with a random localization, have been suggested for high-quality solutions.
[55]	2017	P loss (MW) and total cost	IEEE 30-bus test system.	The method is used to address the optimal power flow (OPF) problem in a system incorporating wind farms in order to reduce power grid losses and power production costs.
[56]	2018	quadratic fuel cost, P loss, L-index, and Vd	IEEE 30-bus.	The DGWO algorithm is proposed to improve this optimizer's search capabilities (DGWO).
[57]	2020	fuel cost, P losses, and L-index and Vd	IEEE 30 bus.	ORPD problems are computed using a unique nature-inspired metaheuristic optimization approach based on the Grey Wolf Optimization (GWO) algorithm.

In conclusion, we discover that GWO offers a number of benefits and drawbacks, which are briefly listed below:

Advantages:

1. Its ability to solve OPF problems in both single- and multi-objective optimization domains.
2. Due to its basic structure, it is straightforward to apply.
3. Requirements for storage and computation are reduced.
4. Convergence occurs faster since the search space is always shrinking and there are fewer choice criteria.
5. It is the capacity to avoid local minima and govern algorithm performance with only two control parameters, resulting in increased stability and robustness [58].

Disadvantages:

1. There is a lack of precision in solving problems.
2. Inadequate local search capability.
3. A slow rate of convergence [59].

1.2.7 Shuffled Frog- Leaping (SFLA) Method

To find a globally optimal solution, SFLA employs a heuristic search based on the evolution of memes carried by individuals and global information flow. It combines the advantages of PSM's local search tool with the concept of combining data from several local searches to arrive at a global solution (3)**.** In Table 11, the most important scientific contributions in this field were explained:

Table 11. The SFLA approaches are used for solving the OPF problem.

Ref .No.	year	objective function	system	Scientific contribution
[60]	2011	total cost	standard IEEE -30bus system	Proposed a new way for distributing the power optimal distribution based on a shuffling frog jumping algorithm.
[61]	2017	total loss, total cost, and the Vd	IEEE 33 and 69 bus test systems	For optimal DG placement in the distribution system, the shuffled frog leaping algorithm (SFLA) is used.
[62]	2018	P loss	the IEEE33 node distribution system	A reconfiguration algorithm for a distribution network based on an improved shuffling frog leaping algorithm was developed using molecular dynamics theory and cloud simulation theory.
[63]	2021	P loss	standard IEEE 14,300 bus test system	The best frog information is used to augment the local search in each iteration of the proposed Advanced Frog Leaping Algorithm (EFLA).

In summary, we find that SFLA has some unique operational outcome in terms of

Advantages:

1. It adds the benefits of PSM's local search tool with the idea of merging data from multiple local searches to get a global solution.

Disadvantage:

1. Slow convergence, It's easy to get caught up in the local best answer, which leads to premature convergence.

Traditional methodologies are not always adequate and cannot guarantee a global solution since OPF issues are multimodal, nonlinear, or non-convex; therefore many heuristic methods were applied. By looking at the past studies stated above, the benefits of new optimization approaches may be summarized as follows:

1. These techniques can be used in systems of various sizes are available.
2. High dependability in obtaining the optimum solutions in a single simulation run.
3. These techniques rarely resulted in local minimum solutions.
4. When compared to traditional methods, these techniques converge quickly to the optimum solution.
5. Suitable in solving multi-objective optimization problems.
6. Able to handle various qualitative constraints.

3 CONCLUSION

This study examines a variety of optimization techniques for tackling OPF issues, including both classic and intelligent approaches. Even if classical methods have made significant progress, they still have drawbacks. For example, due to the relatively limited ability to handle real-world large-scale power system problems so mathematical formulations must be simplified to obtain solutions. Some needed linearization and differentiability may become entangled at a locally optimal. have poor convergence are ineffective in dealing with qualitative constraints and will be very slow if there are a lot of variables. But the main benefit of artificial intelligence approaches is their adaptability in organizing different qualitative constraints. The optimum solution can be performed using AI approaches in one computation. In the vast majority global solution can be approached. In this survey, the benefits and drawbacks of artificial intelligence methods were discussed. Also in this Paper, various popular techniques in optimum power flow researchers' contributions to each methodology have been presented clearly and concisely.

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