Application of Intelligent Optimization Algorithms on Economic Dispatch Problem

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***Abstract*— Nowadays, in power system operation and control, applications of optimization techniques in economic dispatch are essential during the competitiveness and demand accretion for electrical power in the market. On the other hand, engineers are concerned with the cost of products and services using artificial intelligent optimization in the efficient optimum economic in most the industry operation and planning. This paper presents an investigation of studies related to various algorithms Used to find solutions for economical sending processing; the period considered is 2019-2023. This is done to avoid any repetition of previous studies which were published prior to 2011. Also, the survey of economic dispatch methods solution is divided into three categories according to the optimization method, which are: (i) Basic methods, (ii) Modified methods, and (iii) Hybrid methods.**

Keywords—basic methods, modified methods, hybrid methods, economic dispatch, literature review

I. INTRODUCTION

Economic Dispatch (ED) refers to the process of determining the generation output of generating units and stations respectively so as to meet the total system load fully and economically profitably. This paper provides a broad overview of the current state of ED. The reviewed papers in this study were articles published in high-quality journals and conferences within the period of 2019 to 2023. At last year's many authors proposed and used many optimization algorithms to solve economic dispatch problem. For the purpose of obtaining optimum solution for economic dispatch problem authors proposed and used only original algorithms classifying here basic methods. Obtain better results of economic dispatch problem, researchers modified these original algorithms, which classified in this paper as modified methods. Last the authors combined two or three original or modified algorithms together in order to get best solution with fast convergence iterations, these combined algorithms classified here as hybrid methods Numerous methods were in use prior

The composer showed Prabhujit and others with him as in the work. [1] The researchers arrived at a solution to the problem of distributing economic power using the Competitive Swarm Optimization (CSO) technique.

The PSO method stimulated the development of the CSO algorithm, but there are a number of problems, the most important of which is the CSO problem is that it does not contain and does not retain the best memory, and what it has personally and is best globally for updating swarms. The description of CSO is a dual competitive mode in that the losing particle is updated based on the position of the winning particle while the winning particle is accepted directly into the next population. This method is also used to discover the generations of different factory units, which leads to any clear increase in reducing the total price of fuel while maintaining total demand and losses. The CSO algorithm outperforms PSO and several state-of-the-art heuristics in dealing with the ED problem based on experimental studies.

Subapriya, et al. [2] introduced Butterfly optimization algorithm to find solution of ED problem, which is described by BOA. The results of BOA were calculated based on six generating units test system. The performance of BOA is in contrast with PSO and genetic algorithm performance.

Mohapatra et al. [3] reported the discovery of the best solution for a hybrid thermal power plant with solar PV and renewable wind using the Dragonfly Algorithm (DFA) at the lowest cost. The ED problem is optimized using the swarming behavior of dragonflies. The proposed DFA was used to find the solution to the objective function, which is then compared to the performance of other algorithms like Ant Lion Optimizer, Crow Search Algorithm, Biogeography-Based Optimization, PSO, etc. The proposed approach achieved better solutions In aspects related to costs effectiveness and execution time. Four test systems were evaluated to validate the efficiency standards of the proposed DFA.

To overcome the ED problem, Venkatraj et al. [4] created a new optimization technique called Rao algorithm for the determination of the lowest cost. Some studies also demonstrated the performance of the proposed method, which used different systems with 3 and 6 generating units. The suggested Rao algorithm was implemented in MATLAB platform and used to determine the lowest cost for various power demands. It was then compared to many other existing methods, such as GA, PSO, the lambda iteration method, and the ALO methodology, where it was found that they produce superior performance with low computational load.

To handle the dynamic ED problem of wind power systems, Chen et al. [5] suggested a modified antipredator PSO (MAPSO) algorithm that incorporates the social avoidance inertia weight speed update formula. The distance of the global worst particle from the other particles determines the size of inertia weight in this approach. The suggested algorithm was tested on a variety of benchmark functions and models of power grid systems; the performance was compared to those obtained using previous algorithms to prove its efficacy and superiority.

As researchers Malik et al. have found in the work. [6] They solved the ED problem using a modified whale optimization algorithm, which is flexible and effective in determining the global optimum. Which leads to a greater enhancement of the final fitness values, as this technique includes the proposed technique of mutations and sequential quadratic programming. It also explained that simulation studies were conducted on test systems consisting of 3, 6, and 15 units to determine the effectiveness of these methods, to prove the results achieved, and to prove their effectiveness.

As for the researchers Naystani and others, as in work No. [7], they proposed a unique and new optimization technique based on PSO to benefit from it to solve non-convex and non-linear ED problems in the hybrid system, which is characterized by the combination of heat and energy. The proposed method is called Advanced Modified PSO (AMPSO), where the traditional PSO is used to update one-third of the population while the rest is updated randomly using variable boundaries. Taguchi's method was used to determine the parameters required to improve the efficiency of the algorithm. The optimization problem considered is nonlinear and non-convex ED, which includes the effects of steam valves and energy losses. The proposed algorithm was evaluated on a variety of systems, and the results were compared with several well-known methods and approaches created by other scientists. Compared with new existing methods, the results show the superiority of the proposed AMPSO.

II. The Problem

The ED has been solved by Naveen et al. [8] The researchers used Modified Competitive Swarm Optimizer (MCSO) which is based on PSO. However, with this new algorithm they came to the conclusion that this method does not keep a record of a personal best position or a global best position when updating particles. This technique has been used to identify different generating units in a generating station that can minimize the total fuel cost, total demand and losses. Also the results

The trial showed better performance of MCSO compared to PSO in dealing with the problem of erectile dysfunction.

Chansareewittaya et al. [9] developed a new updated algorithm called the Bee Algorithm / Adaptive Tabu Search BA/ATS for solving ED problem in which the key changes are the inclusion of negative values in the BA basic equation and the integration of Adaptive Tabu Search (ATS) into BA. In this algorithm, each generator's operation is restricted by constraints. The results showed that the overall operation costs while utilizing the suggested algorithm were better compared to the use of other comparative algorithms, thereby indicating that the modified hybrid BA/ATS algorithm can efficiently solve the ED problem.

The ED problem was solved by Hussein [10] using the IEEE system, which consist of 30-Bus to estimate the performance of the proposed technique.

III. Hybrid Methods

Takeang, et al. [11] describe a multiple hybrid approach (MHLSA) for solving ED problems with smooth cost function features; this new method combines lambda iteration and SA methods. Load demand and transmission loss were the considered ED constraints in this approach. The suggested MHLSA technique is a mix of the lambda iteration and simulated annealing approaches that adds several search mechanisms to improve efficiency. On a single personal microcomputer, a single lambda iteration and the SA (HLSA) hybrid algorithm are implemented sequentially. There are also introduced several ways for enhancing search operations, including the hybrid approach, multiple searches, and the possibility of multiple adaptive searches. Researchers Zheng et al. [12] introduced a hybrid invasive weed optimization (HIWO) strategy that combines GA and invasive weed optimization algorithms to address ED issues in electric power systems. As the new suggested technique uses this IWO method as a fundamental optimizer to explore the solution space, later on, GA-specific crossings and mutations are created to greatly enhance the IWO optimization capability. Furthermore, the suggested approach incorporates a proficient strategy for repairing unfeasible solutions by addressing various physical limitations. To confirm the accuracy and efficiency of the suggested method, six ED queries with varying numbers of power system units are calculated and contrasted with other current algorithms.

Li Ping and colleagues (SG-QPSO) [13] The researchers improved and put out a fresh approach to tackling the quantum behavior of the distribution. By iteratively decreasing the Gaussian probability distribution around each particle's learning tendency point, SG-QPSO initially maintains a strong global search capacity and gradually enhances its local search capability. Through the improvement of QPSO's limited local search functionality, SG-QPSO can tackle ED problems at different stages. Three different energy regimes with various nonlinear properties (POZ, slope rate limits, and nonsmooth cost functions) were used to evaluate the SG-QPSO approach against other existing methods for convergence, flexibility, and quality of solution. Khamsen, et al. [14] present hybrid method combines incremental cost rates and bee colony optimization for handling non-smooth cost function ED problem. The methods were separated into two categories: incremental cost rates were employed for the identification of the initial solution while BCO was used to find the best solution. Among the factors that affect E ower losses, generator practical operation constraints, and load demand constraints are all factors that affect economic dispatch. The suggested algorithm was compared to PSO, CSA, BA, FA, and BCA in three case studies with 3, 6, and 13 generator units.

Chen and colleagues [15] presented a novel hybrid technique that combines ICA and PSO methods to get the best solution that is both practical and takes valve loading effects into account for non-convex ED situations. The suggested method made use of the benefits of both methods. A range of test systems were used to evaluate the proposed ICA-PSO-based hybrid methodology, and it was contrasted with some of the most current approaches. Furthermore, a large-scale multi-area ED issue was solved using the suggested method, with the aim of lowering the overall fuel cost while satisfying tie-line capacity restrictions, power balancing constraints, and producing limits in every region.

Sahoo, et al. [16] applied a novel hybridization of dragonfly algorithm with pattern search algorithm to solve ED problem. The ED problem behaves as anon-convex, non-linear, non-smooth problem with the implementation of practical constraints such as ramp rate limits and like valve-point loading effect. The suggested method was validated on 6 different benchmark functions and implemented on 4 different nonlinear testbeds. The efficiency of the suggested strategy for schedule generation and estimation was demonstrated by its application to the ED problem.

Barun, et al. [17, 18] introduced hybrid grasshopper optimization algorithm (GOA) with oppositional based learning (OBL). To solve the ED problem in the most efficient way, a new approach called Oppositional-based learning grasshopper optimization algorithm (OBLGOA) was tested on two ED systems (6-unit and 10-unit) for wind-based and conventional energy systems. The proposed OBLGOA was tested for performance via comparison with traditional GOA and other recently proposed meta-heuristics in the literature. In an islanded reconfigurable microgrid, a novel operation management strategy (OMS) for complicated power scheduling the next day is proposed in this work. Renewable distributed generators (RDGs) such as solar and wind turbines provide the microgrid's energy source. In the meanwhile, there are two fuel cell units and two microturbine units that function as dispatchable distributed generators (DDG) [19]. An essential instrument for the safe and effective operation of power systems is power flow analysis, or PF. There isn't a slack bus that allows an isolated microgrid (IMG) with just local distributed generators (DGs) to operate at a steady frequency. As a result, the Y bus bus admittance matrix is not fixed [20].

IV. CONCLUSION

This paper presents a comprehensive survey of articles addressing various ED algorithms. The study spans the years 2019 to 2023. Economic dispatch evolutionary algorithms are classified into three categories, and the reviewed articles are categorized into these categories (Basic, Modified, and Hybrid methods). This review attempted to add as many content descriptions as possible to capture the crucial and distinctive characteristics of each article. Interactions between publications by the same authors over time or between similar works by other authors were also presented to the possible extent within the confines of a single paper. This work is not concerned with evaluation and comparison the relative performance of the currently existing algorithms, but to offer a better view of what is currently available so that a generation dispatch researcher can be properly guided in discovering the existing problems and seeking solutions. This survey clearly demonstrates that ED has gotten a lot of attention in the previous few years. This tendency, we believe, will continue as long as better processors and more efficient optimization methods are implemented. It is true that several scholars have designed and implemented more accurate and efficient algorithms since 2019 to 2023, however, the main difference between these methods is their convergence. Some authors take traditional method which here classified as basic method and use it in new cases studies , another authors made some modification on these basic methods to get good results, and other last group of authors made combine of two or even three algorithms for making hybrid methods in order to get a perfect results, but the search for new method is not stop , many author created new algorithms like chive Imperialist Competition Algorithm (ICA), seeker optimization algorithm, Tabu Search (TS), Others have used the Crow Search Algorithm (CSA), Ant Lion Optimization (ALO), Flower Pollination Algorithm, Moth-Flame Optimization (MFO), Competitive Swarm Optimization (CSO), Butterfly optimization technique, Dragonfly Algorithm, and RAO algorithm. Cuckoo Search (CS) Algorithm and Crow Search Algorithm are two examples of these algorithms.

TABLE I. THE COMPARISON BETWEEN ALGORITHMS OF ED

Basic	Modified	Hybrid
Imperialist Competition Algorithm (ICA).	Modified Differential Evolution Based Solution	Lbest-Particle Swarm Optimization with Dynamically Varying Sub-swarms' (LPSO-DVS).
Seeker Optimization Algorithm	Modified Ant Colony Optimization algorithm (MACO)	Particle Swarm Optimization (PSO) Bacterial Foraging Algorithm (BFA)
Genetic Algorithm (GA)	Modification Bat Algorithm	PSO and Simulated Annealing (SA)
Tabu Search (TS).	Modified Particle Swarm Optimization	Particle Swarm Optimization (PSO) and Genetic Algorithms (GA)
Differential Search (DS)	Modified Version of the Social Spider Algorithm	Genetic algorithm (GA) and micro-genetic algorithm (MGA),
Cuckoo Search (CS) Algorithm	Modified Symbiotic Organisms Search (MSOS)	harmony search (HS) algorithm and interior point method (IPM)
Simulated Annealing (SA)	Modified Teaching-Learning-Based Optimization	Evolutionary Programming (EP) and Particle Swarm Optimization (PSO) algorithm
Pattern Search Technique	Chaotic Modified Imperialist Competitive algorithm (CMICA)	Ant Colony Optimization (ACO), Artificial Bee Colony (ABC) and Harmonic Search (HS) algorithms
Game theory application Invasive weed optimization	modified sine cosine optimization (MSCO)	Hybrid Lamda and Bee Colony Optimization (HLBCO)
	Modified Jaya Optimization Algorithm (MJOA)	Particle Swarm Optimization (PSO)and gray wolf optimization
Crow Search Algorithm (CSA)	Modified Cuckoo Search (CS)	JAYA and TLBO algorithms
ant lion optimization (ALO)	Modified Genetic Algorithm	Artificial Immune System (AIS) and Evolutionary Programming (EP).
Flower Pollination Algorithm	Modified Artificial Bee Colony Optimization	Lambda Iteration and Simulated Annealing (MHLSA)

Basic	Modified	Hybrid
Moth-Flame Optimization (MFO)	A modified Antipredator Particle Swarm Optimization (MAPSO)	invasive weed optimization (IWO) algorithm and genetic algorithm (GA)
competitive swarm optimization (CSO)	Modified Whales Optimization Algorithm	Gaussian distribution quantum-behaved optimization (SG-QPSO)
Butterfly optimization technique	Advanced Modified PSO (AMPSO),	Incremental cost rates and bee colony optimization
Dragonfly Algorithm	Modified competitive swarm optimizer (MCSO)	Imperialist competitive algorithm (ICA) and particle swarm optimization (PSO)
Rao algorithm	Bee Algorithm (BA) and integrating adaptive tabu search (ATS)	Dragonfly algorithm with pattern search algorithm
Bat Algorithm	Modified Firefly Algorithm	Grasshopper optimization algorithm (GOA) with oppositional based learning (OBL)

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