# A REVIEW ON TECHNIQUES FOR COMBINED ECONOMIC EMISSION DISPATCH PROBLEMS

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***Abstract:*** The most important issue in power systems is the problem of optimization of economic dispatch (ED). ED's problem in energy systems is that the power output is planned in such a way as to minimize operating costs and at the same time to meet demands for load, power operating limits and maintain stability for each dedicated generator. In large power systems, this problem becomes more complex as it is difficult to find the best solution because it is non-linear and has an optimal local number. ED researchers are proposing various techniques. The main goal of ED techniques is to minimize overall emission costs. This survey is intended to help researcher and scientists to develop better CEED optimization techniques in energy systems.

***Index Terms*** **- Economic Dispatch, Emission Dispatch, Combined Economic Emission Dispatch, Genetic Algorithm, PSO**

## I. INTRODUCTION

Power systems have become enormous and complicated in recent years. One of the major concerns of electricity generation companies is the problem of adapting the best solution to meet the varying demand for electricity. Economic charging is a key function in the operation; organization and scheduling of electrical power systems **[**1, 2]. In the performance of the power shipment, economics, consistency and stability are the important factors. The main purpose of ED in general is to minimize the overall cost of production while retaining the necessary equality and inequality restrictions. Several researchers have proposed different techniques due to emerging technology.

Economic and emissions problem needs to be solving in real time. The conventional way of operating electricity systems is to minimize operational expenses while maintaining system constraints [3][4]. In dispatch approaches, both economic factors and emission reductions should be taken into account [5]. Although several existing techniques have been used to solve economic and carbon emission problems, the associated consignment programmes, as the system load changes, must be re-run when the real time dispatch is not satisfied.

Recently, energy sources used to produce mechanical power are fossil fuels, used on the rotor shaft of production units. That causes a large number of carbon dioxide, sulfur dioxide and emissions of nitrogen oxides that cause air pollution. The control of environmental pollution caused by fossil-fired units and the implementation of environmental regulations has received a high degree of attention. This environmental pollution scenario must also be taken into consideration in the ED optimization technique today. However, only the operation of minimum environmental impacts is not feasible because of the system's higher cost of production. Otherwise the operation of the power system cannot meet the emission requirements at a minimum of total production costs. Consequently it is necessary to consider economic dispatch, emission dispatch or combined economic and emission shipment. A good power management policy is necessary to choose the best approach among the three. Various traditional approaches for optimization are employed for the solution to various economic shipment issues as well as unit commitment problems [6]. These approaches are well-known for the economical thermal dispatches of generators (e.g. lambda iteration, linear programming, non-linear programming, quadratic programming and interior point procedure).

More recently, several researchers also proposed improved optimization and smart search techniques such as genetic, evolutionary programming, particle swarm optimization, etc**.** [7, 8]. ED problem with GA requires many generations if a large number of units are present in the power generation system. Combined economic and emission dispatch were proposed, reducing both fuel and total emissions simultaneously. The existing transmission systems are increasingly stressed by the current environmental and economic factors. Modern, non-linear power systems are highly interconnected with a broad geographical distribution. This requires the optimization under few practical constraints of a complex objective function. The optimization of the network power system means, therefore, that objectives can be maximized or minimized under certain restrictions. Different researchers therefore developed various approaches for the stabilization of power systems due to the importance of the ED of the

power system and its effect on the environment. This paper analyzes the different current approaches to ED power system optimization.

**II. LITERATURE SURVEY**

Mulralidharan et al.,[3] proposed a novel dynamic programming, the main aim of this approach is to combine costs, emissions and losses and also to ensure that emission restricted and loss restricted delivery is a parallel economic dispatch. This approach replaces conventional optimization approaches by a new approach to dynamic programming (DP). It is a new recursive technique to recognize a reduction in production costs, with restricted emissions and lower losses. DP is a mathematical approach to optimizing multi-stage decision-making [9, 10]. A final operational condition with minimum cost of production at a low emission rate and maintaining stability leads to a multi-target problem that this approach is successfully implemented.

The new Genetic Algorithms technique based on the crossover similarity to solve the CEED problem for power systems was proposed in Ugur Guvenc, et al. [11]. Children are created in the proposed technique by using similitude measurements between mother and father chromosomes. The technology proposed was tested on the problems of dispatching economic emission loads by six and eleven generators. It is apparent from the experimental results that the technique proposed is highly effective in solving CEED issues in greater quality.

Effective and best-efficient operations of power-generating systems in the electricity industry have always been considered important. This requires the allocation of the total charge between the generating units available to minimize the total operating cost. This problem has recently become a twist as the public interest has increased in environmental issues, and economic dispatch now includes the dispatch of pollutants reduction systems at the same time that minimum costs are achieved. Lakshmi Devi et al.[12] suggests a lambda based technique that uses Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) techniques to solve the CEED problem with the generator power limits in mind. The approach proposed determines the optimal global or almost global solution for the CEED problem. CEED's main objective is to simultaneously reduce operating fuel costs and emissions while maintaining demand for load and operating constraints. A modified price penalty factor method is used to convert that multi-objective CEED problem into a single objective function. Three generating units are tested for the proposed approach.In an acceptable time the PSO method has proved to provide accurate and feasible solutions.

Lakhwinder Singh et al. [13] discuss the issue of the Economic Emission Dispatch (EED) that concerns the planning of thermal energy generation units in real and reactive power. For each non-inferior solution, the formulated EED problem is solved by weighing technique, allowing explicit trade-off between objective levels. The technique of decision-making is used to determine the schedule of the generation. For the purposes of accessing the band of indifference, the Cardinal Priority Ranking (CPR) of the objectives will interact with the decision maker. In the functional space the cardinal priority classification is built and transformed into the decision-making place, so the priority ranking of the goals relates preferences of the decision maker to non-inferior solutions by means of standardized weights. Regression analysis is carried out in order to determine a "best" compromised solution between cardinal priority ranking and simulated weights. The loss coefficients and transmission losses are analyzed for decoupled load flow. The validity of the proposed method is demonstrated by the 3-generator IEEE 11-bus system.

T. Ratniyomchai et al., [14] suggested that the combined economic and emission dispatch issues should be resolved. With due respect for fuel cost and total emissions, the main objective of the combined problem can be expressed. The PSO is one of the most effective smart search techniques to solve the economic load shipment. PSO is used to demonstrate its importance in this approach. With the aid of price penalty factor h, both economic problems and emission shipment issues are combined and transformed into a single objective role [9, 10]. On the basis of efficient PSO, the converted objective function is minimized. The simulation test uses a three-unit thermal power plant. Appropriate shipments can be found efficiently in relation to economic or emission goals.

Global warming has recently been a major concern worldwide. The increase of air pollution and carbon dioxide pollution from thermal energy stations is mainly attributable to global warming. This global warming problem should be resolved with the necessary steps. This paper addresses the problem of economic shipment, including the shipping of emissions-reduction systems and minimum fuel costs. Concurrent optimization of the fuel costs and emission control are contradictory in the combined economic dispatch (CEED). Economic emission control (CEED) with the help of the price penalty factor (PPF) the bio-objective CEED can be changed into a single optimization problem. Gonggui Chen et al**.** [15] presented a novel technique called the CEED

restricted reserve based Shuffled Frog Leaping Algorithm (SFLA). The algorithm is presented in the paper to solve the reserve-restricted CEED problem. A 15-unit system assesses the performance of the technique proposed. The result of the assessment shows that the technique proposed is effective and practical.

With the aid of Improved Harmony Search (IHS), Ravikumar Pandi et al**.** [16] proposed a new technology for optimizing the displacement of economic power. The technique presented is easy to handle the various constraints of equality and inequality of the power dispatch problem in order to find the best solution. The technology is applied for a single area and four-area system, consist of 16 units with and without Prohibited Operating Zones (POZ) for the purposes of proving their efficiency. The results are compared to other related conventional techniques. The result of the presented technique ensures that the algorithms are robust and efficient compared to the other reported techniques

The new classical PSO (PSO), namely, the new PSO (NPSO), to solve non-convex economic problems of shipments was presented in Selvakumar et al.[17]. The results demonstrate that the method proposed is highly effective in consistently providing solutions to Nonconvex ED issues.

Park et al. proposed an approach to enhance the optimization of particulate swarming (IPSO) to resolve non-convex ED issues in [18]. In view of valve points that are prohibited in operating zones, limit ratings and losses of transmission network, the proposed IPSO algorithms have successfully been applied to Nonconvex ED problems. The results show clearly that an efficient optimizer that provides satisfactory solutions to Nonconvex ED problems for proposed framework.

In order to resolve ED problems involving non-smooth / no convex costs, Niknam et al. [19] presented a new evolutional algorithm based on a combination of Adaptive PSO (APSO) and Mutation Operator, called new adaptive PSO [NAPSO]. In APSO, during the optimization process, acceleration factors are co-evolved with particles and inertia weight is tuned based upon a fluid system. The proposed algorithm has superior robustness, reduced computational effort and is usable for large and practical systems, as shown by numerical results.

In order to resolve difficult mixed optimization challenges, such as Nonconvex and discontinuous economic dispatch (ED), Jadoun et al. [20] introduced a PSO (Parcel Swam Optimization) for large-scale thermal plant systems. On a 13-generatorand40-generator system the proposed algorithm is tested. The PSO offer a better search area exploration and exploitation and therefore produces better quality solutions than traditional PSO or other stochastic methods.

The use of bio-inspired Artificial Bee Colony (ABC) optimization in order to limit the problem of economic freight dispatch was presented by Nayak et al. in [21]. Use of several nonlinear features such as limits on the ramp rate and forbidden working zones to model practical generator operation. Compared with other algorithms, the proposed approach produced results comparable or better, and solutions obtained have superior solution quality for satisfying the objective.

In order to prove the effectiveness of the algorithm, Mallikarjuna et al. [22] presented new BAT units for the cost saving of three and five generating units. The findings were compared to those obtained by lambda method of iteration, GA, PSO, APSO and ABC, using the proposed procedure. The comparison shows that the BAT algorithm works better than above. The BAT algorithm has superior features such as solution quality, stable convergence features and good computer efficiency.

In Reddy et al. [23], the proposed bat algorithm provides the optimum economic charge dispatch (ELD) solution. Here Bat algorithms are used to optimize operating costs for a thermal power plant. Numeric results show that a good convergence property and better solution quality than PSOs and methods reported in recent literature are presented in the proposed method. The main advantage of the proposed technology is its simple implementation and can be achieved with less computational effort nearly the global optimum solution. The system was tested on 3 and 6 units to illustrate the efficacy of the proposed method.

A search-algorithm (CSA), which considers generator and system characteristically including valve-point effects, multiple fuels, prohibited areas, spin-reserve and power loss (SED) for the solving of non-convex economic discharge (NCD) was presented in Vo. et al., [24]. Various non-convex ED problems have been tested for the effectiveness of the proposed method. The results of testing showed that less costly solutions can be found in the proposed approach than many other literature reports. The proposed CSA is therefore a promising way to resolve the practical problems of non-convex ED.

Vaisakh et al. [25] presented the Bacterial forage PSO-DE (BPSO-DE) algorithm through the integration of the Non-smooth Non-Convex Dynamic Economic Dispatch (DED) Bacterial Foraging Optimization Algorithm (BFOA), Particle Swarm Optimization (PSO) and Non-Smooth Dynamic Economic Dispatch (NSED). The efficiency of this proposed method shall be

considered in the form of 3-and7-unit systems for static economic transmission, 26-bus, 6-generator and IEEE 39-bus10-unit New England test systems.

Wong et al. [26] proposed an algorithm based on SA to solve the problem of multi-objective dispatcher optimization. In the problem formulation, in addition to fuel and environmental costs, safety requirements for the all-thermal system have been taken into account. Consistent weighting factors in the pollutant emission objective function have been increased to represent the environmental objective. The efficacy of the method was demonstrated with a single test system that mainly concerned security of supply and neglected losses in power transmission.

The two algorithms suggested were basically a combination of GA and SA techniques. Tsoi et al. [27] the total emissions of different pollutants were combined into a single objective using relative weighting factors before the commercialized curves were obtained between the overall fuel cost and the emissions. There were 3 pollutants in a 10-unit all-thermal emission system; NOx, $SO_2$ and $CO_2$ were used to prove the performance of the two hybrid algorithms. In addition, the simulation results considered the impact of fuel types and, consequently, heat-rate characteristics of generators.

In Xu et al., in [28] a GA had been proposed, which was converted into a single target using the weighing method, for the multi-objective if optimization problem in question. The aim of the economic emissions was considered as a matter of concern about system stability and power exchange.

Srinivasan et al. in [29] introduced a heuristic genetic evolutionary algorithm for solving the problem of bi-criteria optimization. The approach was developed for the development of economical solutions in Pareto, from which anyone can be selected based on pre-defined preferences. To evaluate the performance of the algorithm, three different thermal generation systems were used. Results were given in the form of trade-off curves to determine emission levels in line with the Pareto front and the corresponding costs.

Security issues were regarded in Das et al. in [30] as the third goal in the multi-objective dispatch problem. In order to select the algorithm the applied GA was hybridized using an SA technique. In addition to some statistical data on the convergence property, two standard systems have been used to test the proposed hybrid Algorithm, and a Pareto optimal solution set has been produced as trade-off curves. However, there was no information on the time of the computer although the reduction of search time was mentioned as one of the algorithm's advantages.

Abido et al. [31] proposed a non-dominated, GA-based sorting approach to address the problem of multi-target economic emission dispatch. To prevent premature convergence and generate a well spread Pareto front series of solutions; a diversity-preserving technique was utilized. Testing the algorithm with an all-thermal 6-generator system for transmission losses and valve point effects has been performed. The performance and results of the proposed algorithm were compared with those obtained with the superiority of the proposed algorithm by other methods.

In order to solve the environmental / economic problem of dispatch, Rughooputh et al. [32] propose to use an elitist, multiple objective, evolutionary algorithms. The elitism algorithm has been integrated so that over generations the health of the best solution would not deteriorate. Elite parents have been used to enhance offspring quality and convergence. GA convergence. As a result, Pareto frontal solutions have been improved in their diversity. Fuzzy logic was used in order to provide a tool for the decision-maker to select a point from the Pareto Solution System.

In Kumarappan et al., [33] the GA proposed to solve the economical-emission dispatch of the all-thermal generation system was hybridized with a taboo search algorithm. The authors aimed to integrate both algorithms with a view to minimizing the probability that the hybrid algorithm will get stuck in local minimum requirements and improving convergence.

A comparative study was presented in Abido et al. in [34] among three methods used to resolve the problem based on evolution.. To conclude, the Pareto evolutionary algorithm has been reported to have the best time of calculation and better management of the multi-objective problem.

In 2006, Chiang et al. [35] presented an AG equipped with an operator for evolutionary guidance and migration. A multiplier update technique was used to avoid deformation of the increased Lagrange function. Use the β restriction technology to produce the optimal Pareto solutions, the multi-target optimization problem with the economic emission was formulated. To show the efficiency of the proposed approach, the results were shown in the commercialization curve of a Pareto solution set for an all-

thermal6-generator test system. It was found that, in comparison with the standard GA, the method proposed required relatively less CPU time.

Bharathi et al., 2007[36] presented a comparative study to solve the issue of emission dispatch by applying two evolution-based algorithms. Genetic and ant-colony research algorithms were submitted, implemented and compared to the standard Lambda iteration process to solve the multi-objective problem. The selection of Roulette wheels and the crossover of two points have been used in GA but premature convergence has been observed, although its performance is better than the Lambda iteration method.

In Zio et al. in [37], two methods had been integrated into a multi-objective GA-based technique in view of the decision makers ' objectives of seeking the optimum solution in Pareto. The first was a weighted Pareto procedure and the other was the so-called GA. The operator's preferences were expressed by numerical weights with this algorithm, thus extending the concept of Pareto dominance through the inclusion of the chromosome replacement step of the algorithm. In addition, the shape of the dominant region was changed according to the preferred linear trade functions.

In Wang et al. [38] the algorithm is proposed and implemented for electrical power delivery with a view to both economic and environmental issues, a multiple objective particle swarm optimization(FMOPSO). Comparing its performance to other methods, including WA and developmental multi-target optimization algorithms, demonstrates the effectiveness of the proposed approach. All simulations are carried out on the basis of a standard test power system. Many problems such as non-linear generator characteristics, limiting ramp rates and a prohibited operating zone for actual power system operations are not taken into account in this optimization.

. In Wang et al. in [39], both deterministic and stochastic models were first drawn up, followed by the development of an improved PSO approach that addresses the dispatch of economic loads while at the same time considering the effects on the environment. The efficacy of the proposed approach is examined through comparative studies. First of all, the proposed PSO approach is compared with other approaches, including weighted aggregation and evolutionary optimization. On the basis of the proposed PSO the impacts on the results of power delivery from various problem formulations are then investigated and analyzed, including stochastic and deterministic models.

Hemamalini et al**.** [40] introduced a PSO technique to solve the problem of economic emissions shipment in view of the non-smoothness of thermal generating unit valve-load impacts. Each objective function according to its importance was assigned various weighting factors. The one-objective function was then formulated in a method of weighting to represent the conflicting aims. The results of simulations were presented in terms of best costs and the respective release of emissions without providing any trade-off curves for the optimal Pareto domain. The algorithm's performance was comparable to the performance of other evolutionary algorithms and, although there was no evidence, it showed comparable results and very less computational time.

In Al-Awami et al. [41] incorporated wind power into the multi-objective optimization problem of economic emissions. A multi-target PSO algorithm has been employed to determine the optimal solution for Pareto. Two thermal units and two wind farms constituted the test system used to validate the proposed algorithm. A set of optimum solutions were developed from Pareto and the effects of different operating conditions on these solutions were studied, such as load levels and cost confident values.

A novel technique was proposed and applied to an optimized environment / economic power dispatch problem for multi-objective particle swarm (MOPSO) in Abido et al. [42]. The proposed technique MOPSO presents a multi-target version of the conventional technique PSO and uses its efficiency to resolve problems of multi-target optimization. Concurring fuel expenses and environmental impact targets have been formulated as a combined economic emission dispatch (CEED) problem. The results show that the proposed MOPSO technology has the potential and efficiency to solve multi-objective CEED problems and produce multiple solutions in one simulation run. The diversity of non-dominated solutions derived from the proposed MOPSO technique and their well-distribution were also demonstrated. The results of the simulation also demonstrate the superiority, in the diversity and quality of Pareto-optimal solutions, of the technology proposed by MOPSO.

The Particle Swarm Optimization Algorithm was presented by Gupta et al. [43] to solve the economic power transfer of the pollution controlled electricity system. In one function, the fuel costs and emissions are combined with a weighting factor. PSO's main advantage over other modern heuristics is flexibility modeling, reliable and rapid convergence, less calculation time than other methods. PSO only needs to adjust a few parameters that make it attractive in terms of implementation. A feasible

IEEE 30-bus system is shown for the proposed algorithm. The findings indicate that the proposed algorithm is effective in resolving optimal power flow (OPF) problems that take into account the nonlinear features of power systems with different objectives. PSO can produce a solution of efficient quality with more stable convergence features than genetic algorithms.

Niknam et al. [44] presented a multi-objective optimum energy flow (OPF) optimization method (IPSO). The multi-objective OPF is based on the objective functions cost, voltage stabilization, loss and emission impacts. To improve the search capacity for the proposed algorithm, a new mutation is applied. To illustrate the application of the proposed problem, the 30-bus IEEE test system is introduced. The results obtained are compared with those in the literature and the superiority of the approach proposed is shown over other methods.

Summaries of work on environmental and economic deployments were submitted by Talaq et al. [45]. The summary includes a number of techniques for reducing atmospheric emissions from electric power generation. Minimum emission and fuel transfer are included among the techniques. Fuel change is either changed to another type of fuel, or the sulfur content of the fuel decreases. Total or ground levels (ground level concentration) emissions are to be reduced. Lastly, the location of power stations and weather conditions depend on and therefore air diffusion modeling is needed.

Zhao et al. [46] proposed that hidden curves be taken into account by market participants and presented a dynamic, hidden, economic model of dispatch. This model aims to determine the levels of economic generation and demand in a competitive electricity market, in order to maximize profits in line with all operational limitations and with the reform of the power sector. Furthermore, a PSO method was proposed to resolve the bid-based dynamic financial dispatch problem. The PSO algorithm has been shown to have superior characteristics including a solution with high quality, stable convergence and good calculation efficiency.

## III. PROBLEMS AND DIRECTIONS

In the literature, several traditional approaches to optimization have been proposed to solve ECED. The conventional approaches to resolve the problem of economic dispatch, such as lambda-iteration and gradient approach, require generator unit input-output curves. However, because of the working zones of the approaches these curves do not increase monotonically. The conventional delivery algorithms are therefore not able to use this non-linear cost function directly to optimize it. The Emissions-Economic Dispatch (EED) problem was addressed in most conventional techniques, given that a system was only loaded by one condition. Most traditional methods failed to address the impact of different loading conditions on the shape of the optimal set in Pareto.

The cost function for every generator is roughly represented by a single quadratic function in the classical economic dispatch problem. However, due to the restrictions of power system and emission, the characteristics of generating units are highly nonlinear.

. Recently, advanced heuristic techniques such as non-genetic algorithm (NG), evolutionary programming (EP) and taboo search (TS) have been utilized to find an ideal solution to simple ED globally or almost globally. Techniques of optimization provide the ED problem with a better solution. Better optimization methods can be used, especially if procedures are too complex to analyze using conventional methods, to deliver promising results.

## IV. CONCLUSION

Dispatch problem of economic and emissions is combined and transformed into a single objective function. Based on efficient partition swarm optimization (PSO), the converted objective function was minimized. The results showed that appropriate dispatch sets could be efficiently identified in relation to economic or emission objectives.

In order to minimize operating costs, while maintaining the stability and consistency of the systems, and to improve efficiency, the existing techniques for economic and emission dispatch are analyzed in this review. In this paper, major studies of ED technology of the power system, such as NN, fuzzy logic, genetic algorithms, Cuckoo search and other literature optimizing techniques are presented. The new innovation on the efficient stabilization approaches of the power system can be based on these conventional stabilization techniques.

This review is undertaken to explore and analyze the existing Economic and emission Dispatch techniques present in the literature which is very much required to minimize the operating cost while maintaining system stability and consistency and provide better performance. This paper present major studies of power system ED techniques, such as NN, fuzzy logic, Genetic Algorithm and other optimization techniques which is available in the literature. These conventional power system stabilization

techniques form the basis for the new innovation of the effective power system stabilization approaches. The majority of ED approaches in the literature cannot be used directly to optimize this non-linear cost function. The merits of the PSO algorithm, by contrast, convinced and encouraged diverse researchers to use the algorithm to solve the power system control stabilization problem. In addition, in conventional approaches the cost function for each generator was represented by approximately one quadratic function. It is obvious from the literature that PSO performs better than other conventional technology. For the significant performance of the power system, other modern optimization techniques such as Ant Colony Optimization (ACO), cuckoo search may be applied.

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