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Review Of Various Optimization Algorithms For Single And Multi Objective Economic Load Dispatch Problem

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ABSTRACT

Nature-inspired algorithms are among the most powerful algorithms for optimization. This paper intends to provide review of various optimization algorithms for single and multi objective economic load dispatch problem. We will compare the different algorithm with one another. Finally we will discuss conclusion and future scope of these different optimization algorithms.

1.1 INTRODUCTION

The electric power industry is being relentlessly pressured by governments, politicians, large industries, and investors to privatize, restructure, and deregulate. Before deregulation, most elements of the power industry, such as power generation, bulk power sales, capital expenditures, and investment decisions, were heavily regulated. Some of these regulations were at the state level, and some at the national level. Thus new deregulation in the power industry meant new challenges and huge changes. However, despite changes in different structures, market rules, and uncertainties, the underlying requirements for power system operations to be secure, economical, and reliable remain the same. Electrical power plays a pivotal role in the modern world to satisfy various needs. It is therefore very important that the electrical power generated is transmitted and distributed efficiently in order to satisfy the power requirement.

1.2 ECONOMIC LOAD DISPATCH AND ENVIRONMENT

The Economic Load Dispatch (ELD) problem is the most significant problem of optimization in forecasting the generation amongst thermal generating units in power system. The ELD problem is to plan the output power for each devoted generating unit such that the cost of operation is minimized along with matching power operating limits, load demand and fulfilling diverse system limitations. The ELD problem is a significant problem in the operation of thermal/hydro generating station. It is considered an optimization problem, and is defined for minimized total generation cost, subject to various non-linear and linear constraints, in order to meet the power demand. The ELD problem is classified in two different ways, as convex ELD problem and non-convex ELD problem. The convex ELD problem is modeled by considering the objective function as minimizing the generator cost functions considering linear limitations/constraints. In the non-convex ELD problem the non-linear limitations/constraints are considered beside linear limitations while reducing cost function. The linear constraints, that is the generation capacity and power balance leads the ELD problem as approximate, simplified problem and the characteristics curve is assumed to be piecewise linear. A more precise and accurate problem is modeled by having the non-linear constraints such as prohibited operating zones, valve point effects and ramp rate limits. The problem of ELD is usually multimodal, discontinuous and highly nonlinear. Although the cost curve of thermal generating units are generally modeled as a smooth curve, the input-output characteristics are nonlinear by nature because of valve-point loading effects, Prohibited Operating Zones (POZ), ramp rate limits and so on. Large steam turbine generators normally have multiple valves in steam turbines. These valves are opened and closed to keep the real power balance. However, this effect produces the

ripples in the cost function. This effect is known as valve-point loading effect. Ignoring of valve-point effects leads to inaccurate generation dispatch. Besides this, the generating units may have definite range where operation is abandoned due to the physical limitations of mechanical components. Such restricted regions 2 of loading are commonly known as prohibited operating zones(POZ). When a generating unit has POZ, its operating region breaks into remote sub-regions, thus forming a non-convex decision space. Furthermore, the operating range for online units is restricted by their ramp rate limits. To keep thermal changes in the turbine inside safe limits and to avoid shortening of life, the rate of increase or decrease of power output of generating units is limited within a range. Such ramp rate constraint makes the conventional ED problem as a Dynamic Economic Dispatch (DED) problem. The presence of these nonlinearities in practical generator operation makes solving the ED problem more challenging. In addition to the ED objective, environmental concern that arises from the emission output by coal based power plants becomes a major problem to be addressed. In India, two third of the electrical power generated is from coal based power stations. The generation of electricity from coal releases several contaminants, like Sulphur Oxide (SO_x), Nitrogen Oxide (NO_x) and Carbon Oxide (CO_x) in atmosphere. This causes negative effects to human health and the quality of life. It also causes damage to vegetation, acid rain, reducing visibility and global warming. The detrimental influence to environment by discharge of gases from coal based power plants can be diminished by scheduling of appropriate load to each generator. But this may cause rise in the operating cost of generators. So, it is vital to discover out a solution which gives neutral result between emission and cost. This can be attained by Combined Economic Emission Dispatch problem.

1.3 ELECTRIC POWER SYSTEM NETWORKS

Electricity is a key commodity in modern societies. It not only powers our laptops and televisions, but it also provides us many of the basic items needed for living comfortably, e.g., heating, cooling and lighting, and facilitates economic growth. In fact, it is so ingrained in our way of life that many of us take it for granted. The reality is that the wide-spread availability of this commodity and its accessible cost are the result of the workings of one of man's most complex creations: electric power grids. These systems, which are also known as electric power networks, are collections of power generating sources and power consuming elements, or loads, interconnected through transmission lines, transformers and ancillary equipment [1-2]. They can cover wide geographical regions and include tens of thousands of components [3]. Electrically, they are typically balanced three-phase voltage systems. That is, each section of the network has three conductors, and each one carries a voltage sinusoid of equal magnitude and frequency, but having a phase difference of 120◦ [4]. These systems are expected to work around the clock transporting electricity from the various locations where it is generated, e.g., power plants, to the locations where it is consumed, e.g., houses, factories, and shopping malls. They must be both efficient and reliable. When a failure occurs, the consequences can be catastrophic. For example, the 31-hour blackout that occurred in North America in 2003 was estimated to have affected around 50 million people and cost between 4 to 6 billion dollars [5-6]. Consequently, significant resources are invested by governments and other organizations in order to improve the hardware and software used by these complex systems as well as the technical skills of its workforce.

1.4 NUMERICAL OPTIMIZATION IN POWER SYSTEM

Numerical optimization plays a key role in almost every aspect of the operation and planning of electric power networks. Its applications cover times frames ranging from seconds to years. In recent years, various evolutionary, heuristic and meta-heuristics optimization algorithms have been developed simulating natural phenomena such as: Genetic Algorithm (GA) , Ant Colony Optimization (ACO), Particle Swarm Optimization, Simulating Annealing (SA) , Gravitational Local Search (GLSA), Big-Bang Big-Crunch (BBBC), Gravitational Search Algorithm (GSA), Curved Space Optimization (CSO), Charged System Search (CSS), Central Force Optimization (CFO), Artificial Chemical Reaction Optimization Algorithm (ACROA) , Black Hole (BH) algorithm, Ray Optimization Algorithm (ROA), Small-World Optimization Algorithm (SWOA) , Galaxy-based Search Algorithm (GbSA) , Shuffled Frog Leaping Algorithm (SFLA), Snake Algorithm, Biogeography-Based Optimization, Marriage in Honey Bees Optimization algorithm (MBO), Artificial Fish-Swarm Algorithm (AFSA), Termite Algorithm (TA), Wasp Swarm Algorithm (WSA), Monkey Search Algorithm (MSA), Bee Collecting Pollen Algorithm (BCPA) , Cuckoo Search Algorithm (CSA), Dolphin Partner Optimization (DPO),

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Firefly Algorithm, Krill Herd (KH) algorithm , Fruit fly Optimization Algorithm (FOA) and Distributed BBO [30]. Out of these heuristics evolutionary search algorithm, some of these are used to solve ELDP, Combined Economic Load Dispatch Problem (CELDP), Dynamic Economic Dispatch Problem (DEDP) and Combined Economic Emission Dispatch (CEED) and are reported in numerous literatures as: Evolutionary Programming, Particle Swarm Optimization, Genetic Algorithm, Improved Genetic Algorithm , Adaptive PSO and Chaotic PSO, Cardinal Priority Ranking-based Decision-making, Gravitational Search Algorithm, Biogeography-based Optimization, Intelligent Water Drop Algorithm, Hybrid Harmony Search Algorithm. Although no optimization algorithm can perform general enough to solve all optimizations problems, each optimization algorithm have their own advantages and disadvantages. The No-Free Lunch (NFL) theorem for optimization allows researchers to propose new algorithms or improve the current algorithms because it logically proves that there is no optimization algorithm for solving all optimization problems. This theorem applies to both single-objective and multi-objective optimization techniques. Although the current algorithms in the literature are able to solve a variety of problems, according to the NFL theorem, they are not able to solve all optimization problems. Thus, In an effort to solve single and multi-objective economic load dispatch problem of electric power system, Dragonfly algorithm (DA) and moth flame optimizer (MFO) algorithms are proposed in the succeeding chapters. The proposed are implemented with the hope to better solve single and multi-objective economic load dispatch problem of electric power system. .

This segment consists literature review of varied optimization algorithms that square measure utilized in solving Economic load dispatch problem by the researchers within the space of power system. The literature review of various optimization algorithms for single and multi objective economic load dispatch problem is made public below:

Ching-Tzong Su et.al. (2000) [5]**:** In this paper a brand new approach with Hopfield modeling framework is employed for economic dispatch problem of power systems. The economic dispatch problem is resolved by the use of Hopfield model; energy function composing power mate, total fuel cost and the line losses is outlined. This approach provides accurate solutions and quick conversion compared with the typical lambda-iteration methodology.

Attaviriyanupap P.et.al. (2002) [6]**:** In this paper a brand new hybrid methodology used for solving Dynamic economic dispatch. The projected method is developed in such a method that an easy evolutionary programming (EP) is apply base level search, which will give a wonderful way to the worldwide best region, and a local search serial quadratic programming (SQP) is use as a wonderful modification to make a decision the most effective answer. A ten-unit test system with non smooth fuel price function is used to indicate the potency of the projected methodology compare with those acquire from EP and SQP alone.

Lee G.Z. (2003) [7]**:** In this paper Particle swarm optimization technique can be used for handling the ELD problem. The ELDP is fixed with the ramp rate restrictions and prohibited operating area for practical generators. The performance of the PSO is weighed against the GA method in conditions of the answer quality and computation performance.

Abido (2003) [8]: In this paper environmental/economic power dispatch problem is solved by use of Strength Pareto evolutionary rule (SPEA). In this approach, diversity-preserving mechanism is working to defeat the first convergence and search bias downside. A hierarchical bunch is mandatory to provide the selection creator with a manageable and representative Pareto best set. The projected methodology is compare with classical method.

NidulS.et.al. (2003) [9]**:** This paper present evolutionary programming technique is used for resolving the economic load dispatch problem. In this work 3, 13 and 14 unit check system with valve point loading impact is used in Economic load dispatch.

Rahman et.al. *(2004)* [26]: This paper proposed application of Artificial Immune System by using colonel choice principle to unravel ELD problem. The total generation cost is taken into account as associate degree objective function and described because the affinity measure. The antibodies with affinity measure are made by genetic evolution. Before implementing the algorithm, few adaptations were made: there is no specific substance to be recognized, but associate degree objective function is to be optimized; all the antibodies are to

be designated for cloning; the range of cloned generated by the antibodies are equal. The algorithm is tested on binary and real range illustration.

TabatabaeiN.M.et.al. (2005) [27]: This paper presents a new approach for solving ELD problem considering the returning cost exploitation Hopfield Neural Network (HNN) model. In this approach two energy functions are introduced. The first energy function accommodates mismatch power, total fuel cost and transmission line losses. Each term of this function is increased by a coefficient issue that represents the relative importance of those terms. The other energy function composed of total fuel cost and losses power cost. Our purpose is to minimize these two functions and therefore the results shows that finding ELD drawback with this approach yield additional saving cost.

VictoireT.A.A.et.al. (2005) [28]**:** This paper presents a deterministically guided particle swarm optimization (DGPSO) rule to solve the dynamic economic dispatch downside (DEDP) of generating units considering the valve-point effects. The cost function of the generating units exhibits the non-convex characteristics, as the valve-point effects are sculptural and obligatory as corrected sinusoid elements within the price function.

HouY.H.et.al. (2005) [29]: This paper presents a new versatile optimization algorithmic rule referred to as modified particle swarm optimization algorithmic rule (MPSO) for finding the economic dispatch (ED) problem of power systems. This algorithm is used to unravel the difficult, non-convex, nonlinear economic dispatch issues. Several factors such as, valve-point effects of fuel cost functions, transmission capacity constraints, and system stability constraints are thought-about in the computation models. Numerical results show that the proposed technique is possible and economical.

Lung C.C. (2005) [32]**:** This paper presented Associate in Nursing improved genetic algorithmic rule for resolution economic load dispatch issues of generating units with multiple fuels and valve-point effects. The proposed algorithmic rule adds the superior genetic rule and multiplier factor change. To demonstrate the advantages of the projected algorithmic rule, it was applied to check ED issues with initial example considering multiple fuels, second example considering valve-point effects, and third example considering together multiple fuels and valve-point effects.

Mishra D.et.al. (2006) [35]: In this paper, we present stability analysis for an OR-neuron primarily based Hopfield neural network. We explore the risk of implementing higher order Hopfield neural network for finding economic load dispatch drawback subjected to equality and difference constraints. The proposed approach is helpful for higher order value perform similarly. We solved and mentioned illustrative examples in order to depict the quality of the projected methodology.

Santos Coelho L.et.al. et.al. (2007) [49]: This paper discusses the use of the optimization procedures supported artificial immune network theory. The optimization approaches primarily based on artificial immune network square measure valid for a check system consisting of thirteen thermal units whose progressive fuel cost function takes under consideration the valve-point loading effects.

Sudhakaran M.et.al. (2007) [50]**:** This paper presents an economical and reliable Particle Swarm optimization (PSO) technique for the Economic load dispatch (ELD) issues. The proposed rule is applied for the ELD of 3 unit & six unit thermal plant systems and extended to 3 plant system within which one plant is combined cycle co-generation plant. The comparison of results shows that the proposed PSO technique was so capable of getting higher quality solutions expeditiously for ELD issues at intervals less computation time.

MusirinI.et.al. (2008) [51]**:** This paper presents the economic power dispatch problems resolved using ant Colony optimization (ACO) technique. ACO is a meta-heuristic approach for solving laborious combinatorial optimization issues. In this study, the projected technique was tested exploitation the normal IEEE 26-Bus RTS and therefore the results discovered that the proposed technique has the benefit in achieving optimum answer for addressing the issues.

SayahS.et.al. (2008) [53]: This paper reports on an evolutionary algorithmic rule primarily based methodology for finding the economic load dispatch (ELD) downside. The IEEE 30 bus check system was used for testing and validation purposes. The results obtained demonstrate the effectiveness of the proposed technique for finding the economic load dispatch downside.

Lakshmi D.A.et.al. (2008) [55]**:** In this paper Combined Economic and Emission Dispatch problem has been resolved exploiting Genetic algorithmic rule and Particle Swarm optimization. The goal of CEED is to reduce the in operation fuel value and emissions at identical time whereas fulfilling load demand and operational limitations. This multi-objective drawback is modified into one objective problem victimization worth penalty issue technique.

Santos Coelho L.et.al. (2008) [61]**:** This work presents the use of mixing of PSO, Gaussian likelihood distribution functions and/or chaotic sequences. In this context, this paper proposes improved PSO approaches for solving EDPs that takes into account nonlinear generator options like ramp-rate limits and prohibited operational zones within the power grid operation. The PSO and its variants are valid for 2 check systems consisting of fifteen and twenty thermal generation units. The proposed combined methodology outperforms different trendy metaheuristic optimization techniques reported in the recent literature in finding for the 2 constrained EDPs case studies.

KumariM.S.et.al. (2009) [64]**:** This paper presents a Fast Genetic algorithmic rule (FGA) approach for resolution Economic Load Dispatch (ELD) downside. This feature of the algorithm is enticing once applied to ELD of giant systems. The results have been demonstrated for ELD of normal three generator, 6 generator, 20 generator and thirty eight generator systems with and while not thought of transmission system losses. In all the cases the Fast GA shows reliable convergence. The final results obtained using quick GA are compared with standard GA and located to be encouraging.

Abido (2009) [66]: In this paper Multi-objective Particle Swarm Optimization MOPSO method by red scribing the global best entities in multi-objective optimization area. The clustering algorithm is used to achieve the magnitude of the Pareto-optimal set & fuzzy tactic is used to excerpt the best conciliation solution amid minimum cost & less emission. This method is found effectual over another multi-objective method in terms of the superiority of the attained Pareto-optimal solutions.

Kumar K.S.et.al. (2008) [68]**:** In this paper economic load dispatch with valve-point effects has been solved victimisation four custom-made versions of PSO. The diverse PSO techniques square measure Self-Adaptive Particle Swarm Optimization; New PSO and Chaotic PSO. Among the different PSO techniques, it is found that Self-Adaptive PSO is superior to other PSO techniques in terms of improved answer, convergence speed, execution time and robustness however it has additional untimely convergence.

Singh L.et.al. (2009) [69]**:** In this paper economic emission load dispatch problem has been resolved using cardinal priority ranking base higher cognitive process. Weighting technique is used to unravel EED to provide non-inferior solutions that permits clear trade-offs between goal levels for every non-inferior solution.

Chaturvedi K.T.et.al. (2009) [70]: This effort on PSO with time changing acceleration factor for non-convex economic dispatch to govern the local & global exploration& to evade early convergence in the classical PSO.

Roy P.K.et.al. (2009) [72]: This paper boons Biogeography-Based Optimization (BBO) method for resolving constrained economic dispatch problems in the power system. Numerous nonlinear features of generators, like valve point loading, ramp rate limits, prohibited zone, & multiple fuels cost functions are deliberated. Two Economic Load Dispatch (ELD) problems with diversefeatures are applied &equated its solution superiority & calculation efficiency to Genetic algorithm (GA), Particle swarm optimization (PSO), &additional optimization methods. The simulation results display that the suggested algorithm outdoes earlier optimization approaches.

Park J.B.et.al. (2010) [73]: This paper offers an effectual method for resolving economic dispatch (ED) problems with non-convex cost functions by means of an improved particle swarm optimization (IPSO). The suggested IPSO is smeared to three different non-convex ED problems with valve-point effects, prohibited operating zones with ramp rate limits as well as transmission network losses& multi-fuels with valve-point effects. Furthermore, it is smeared to the large-scale power system of Korea. Similarly, the results are equated with those of the state-of-the-art approaches.

Basu M. (2011) [77]: This paper recommends artificial immune system centered on the clonal choice principle for resolving dynamic economic dispatch problem. The results attained from the suggested algorithm are equated with those attained from particle swarm optimization & evolutionary programming. From mathematical results, it is bring into being that the suggested artificial immune system centered method is capable to deliver

healthier answer than particle swarm optimization & evolutionary programming in relations of minimum cost & calculation period.

Bhattacharya A.et.al. (2010) [78]**:** This paper recommends biogeography-based optimization to resolve non-convex & convex economic dispatch problems of the power system.To display the benefits of BBO, it is smeared to four dissimilar test systems for resolving economic dispatch problems for 6, 10, 20 & 40 generating units.

Bhattacharya A.et.al. (2010) [79]**:** This article represents a BBO method to resolve EELD of thermal generators of the power systems. Diverse emission elements (NO_x, SO_x, & CO_x) are measured for event reading. This procedure has been smeared for resolving EELD for 3 & 6 generator structures with valve point effects.

Selvi V.et.al. (2010) [80]**:** This paper emphasis on the proportional investigation of most fruitful approaches of optimization methods motivated by Swarm Intelligence (SI): Ant Colony Optimization (ACO) & Particle Swarm Optimization (PSO). An intricate proportional investigation is conceded out to give these procedures with fitness allocation, pointing to examine whether this progresses performance which can be employed in the evolutionary processes.

SasikalaJ.et.al. (2010) [81]: This paper tries to cultivate a novel SA centered improved method with a solitary choice mutable to resolve the EED problem. The attitude includes the outline of a novel choice mutable through a far-sighted mathematical alteration of the relation amid the choice mutable& the optimum generations. It therefore harvests a decrease in the quantity of problem variables &subsidizes to credibly boost the performance of the present heuristic approaches. The viability of the projected approach is assessed over two test systems & the results are equated with the accessible approaches to highpoint its appropriateness for online solicitations.

Duman S.et.al. (2010) [83]**:** In this paper a novel meta- heuristic algorithm named Gravitational Search Algorithm has been recommended to resolve economic load dispatch considering valve point effects. The recommended algorithm has been verified on diverse test systems.

Rao S. (2011) [84]**:** In this paper the economic load dispatch problem has been resolved by means of smart water drop algorithm. In demand to validate the effectiveness of the projected technique has been verified on 6 generating unit & 20 generating unit test systems captivating into account the valve point-point loading effects.

Pandi V.R.et.al. (2011) [86]**:** In this paper the dynamic economic load dispatch problem has been resolved by means of the hybrid harmony search algorithm with swarm intellect. In this effort the HS process has been crossbred with PSO for a healthier convergence of the projected process. The performance of the process was tested above numerous benchmark test systems with 5 units, 10 units & 30 units.

Shaw B.et.al. (2011) [87]: This article grants an effectual method for solving economic load dispatch (ELD) problems in diverse test power systems by means of a new seeker optimization algorithm (SOA) In this paper, four test systems of the ELD problems are resolved by accepting the SOA. An evaluation of obtained simulation results by accepting the SOA is carried out with those issued in the current literatures.

Shaw B.et.al. (2011) [88]: This paper presents Seeker optimization algorithm (SOA) for resolving the economic load dispatch (ELD) problem. The efficacy of the procedure is verified on two large-scale test power systems to resolve the ED problems. The results attained by the SOA are associated to the other diverse algorithms issued in the current literatures to inaugurate its preeminence.

Sreenivasan G.et.al. (2011) [89]: This paper grants particle swarm optimization method to resolve the DELD problem for the purpose of the global or near global optimum dispatch solution. To exemplify the efficacy of the projected method, three test systems containing of 5,10 & 15 generating units, with amalgamation of load balance constraints, operating limits, valve point loading, ramp constraints & network losses are measured & verified. The comparison of mathematical results is demonstrates the performance & applicability of the suggested technique.

Yang Xin-She (2012) [90]**:** In this paper firefly algorithm has been applied to solve economic load dispatch problem considering different constraints such as generation restrictions, ramp rate limits, prohibited operating zones, transmission loss, and nonlinear cost functions. The proposed algorithm was solved for 4 different test

systems, the results of this study show that the FA is able to find more cost-effective loads than those determined by other methods.

Bhattacharya A.et.al. (2011) [91]: This paper grants grouping of differential evolution (DE) & biogeography-based optimization (BBO) process to resolve composite economic emission load dispatch (EELD) problems of thermal generators of the power systems. The benefits of the suggested procedure, is that it has been smeared for resolving multi-objective EELD problems in a 3-generator system with NO_x & SOx emission, in a 6-generators system bearing in mind NO_x emission, in a 6-generator system addressing together valve-point loading & NO_x emission. The recent suggestion is to initiate healthier in terms of superiority of the cooperating & discrete solution attained.

Tankasala G.R. (2012) [93]**:** This paper presents ABC is the best method to reach the near Global optimal solution but at the cost of high computational time. However good choice of the number of iterations, population size, Employed and unemployed bees results in fast computational ABC.

VishwakarmaK.K.et.al. (2012) [94]**:** This paper grants Simulated Annealing (SA) process for optimization encouraged by the method of annealing in thermodynamics to resolve economic load dispatch (ELD) problems. The suggested approach is bring into being to deliver optimum results while operational with operating constraints in the ELD & valve point loadings effects. In order to demonstrate the heftiness of the process it is explored on four diverse standard test cases containing of 3, 13, 40 generating unit system with valve point effect & a Crete Island system of 18 thermal generating units having convex fuel cost features.

Soni S.K.et.al. (2012) [95]: This work presents DEA (Differential Evolution Algorithm) for multi-objective emission constrained economic power dispatch problem. The search space is explored by randomly choosing the initial candidate solutions and using mutation, crossover and selection operators. The technique is found simple having compact structure and high convergence characteristics.

Agrawal N.et.al. (2012) [96]:This paper grants an effectual & dependable biogeography–based optimization (BBO) algorithm to resolve mutually convex & non-convex Economic load dispatch problem (ELD) with Ramp rate limit of the thermal power plants. This paper boons an application of the BBO process to economic load dispatch problem with ramp rate limit for 13 and 18 generator test case systems. Economic load dispatch problems are pragmatic & equated its answer superiority & calculation efficacy to Genetic algorithm (GA) &additional optimization methods. The simulation results demonstrate that the suggested algorithm outdoes preceding optimization approaches**.**

Murugan R.et.al. (2012) [97]: This paper suggests a Modified Artificial Bee Colony algorithm (MABC). The performance of the suggested algorithm (MABC) is smeared to & tested on ieee-6 unit & IEEE- 13 unit systems. The results of the suggested process are equated with that attained by the elementary (ABC) algorithm, lambda - iteration technique to verify the legitimacy & efficacy of the suggested algorithm.

Hardiansyah.et.al. (2012) [98]**:** This paper grants an operational & dependable particle swarm optimization (PSO) method for the economic load dispatch problem**.** The results have been verified for ELD of standard 3-generator & 6-generator systems with & without deliberation of transmission losses. The suggested method is comparatively modest, dependable, effectual & appropriate for real-world application.

Swain R.K. (2012) [99]**:** In this paper economic load dispatch problem has been solved using gravitational search algorithm. Tests were performed over various systems with different number of generating units and comparisons are performed with other common approaches. The results proved the strength, fast convergence and skill of proposed methodology over other existing technique.

Rajasomashekar S.et.al. (2012) [100]**:** In this paper finest cooperation solution of EED problem has been bring into being by means of biogeography based optimization. The straight forward hint is to produce an improved objective function that delivers the similar implication to mutually emission cost & fuel cost constituents. The performance is tested through three test systems & the simulation results are offered to display the legitimacy & efficacy of the technique for real-world applications.

Manteaw E.D.at. (2012) [101]**:** This paper suggests Artificial Bee Colony (ABC) & Particle Swarm Optimization (PSO). A amalgam manufactured from these two processes is cast-off on the 30-bus 6 generator

IEEE test system. The results are equated with ABC, Fuzzy Controlled Genetic Algorithm (FCGA) & Non Sorting Genetic Algorithm (NSGA-II) &initiate to be operative on the joint economic & emission dispatch problem.

GuvencU.et.al. (2012) [103]**:**In this paper, the Gravitational Search Algorithm has been castoff to discover the solution for CEED problems. The CEED problem is designed as a multi-objective problem by captivating into deliberation the fuel cost & emissions of generators. The multi-objective optimization problem is changed to a single objective problem by means of a price penalty factor. The gravitational search algorithm has been smeared on four dissimilar test cases. To check the efficacy of the suggested process has been equated with other prevailing processes in the literature.

Ravi C.N.et.al. (2013) [104]**:** In this paper differential evolution method is suggested to resolve the mutual economic emission dispatch problem for standard IEEE30 bus power system taking 6 thermal generating units.

BasuM. (2013) [105]**:** In this paper, ABCO (Artificial bee colony optimization) has been effectively applied to resolve MAED problems. The efficacy of the suggested technique is explained by means of three diverse test systems & the test results are matched with the results attained from DE, EP & RCGA. It is understood from the evaluation that the suggested ABCO has the capability to unite to a healthier superiority solution than DE, EP & RCGA.

Subramanian R.et.al. (2013) [106]: This paper suggested an effectual & dependable firefly algorithm to resolve economic load dispatch problem. The suggested technique was smeared on six generating system & the results were equated with the other population centred methods like simulated annealing, genetic algorithm, differential evolution, particle swarm optimization, artificial bee colony optimization and biogeography- based optimization methods. This technique exhibited its greater superiority of solutions with heal their calculation efficacy & steady convergence features.

Rama P.D.et.al. (2013)[109]: This paper suggested applications of bacterial scavenging& firefly optimization algorithms to resolve economic load dispatch counting valve point loading. The suggested techniques were verified on 3 & 13 generator systems, for load demand of 850 MW, 900 MW & 1800 MW with addition & elimination of valve point loading effect. The results attained from bacterial scavenging optimization algorithm were extra controlling than FA in terms of efficacy, correctness and swiftness.

Singh N.et.al (2013) [110]: In this paper suggested a novel Particle swarm optimization with moderate random search. Particle swarm optimization with a moderate-random-search strategy called MRPSO, increases the capability of particles to discover the solution places further efficiently & upsurges their convergence rates. In this paper the power & helpfulness of the MRPSO algorithm is verified through its application to three & six generator systems with valve point loading effect & ramp rate limit constraints.

GargeyaM.A.et.al .(2013)[112]: In this scheme, Economic Load Dispatch (ELD) of real power generation is well-thought-out. To resolve economic load dispatch, two of intellectually exploration approaches are considered, explicitly, genetic algorithm & pattern search approaches. Equality constraint is fulfilled by penalty tactic technique. Economic load dispatch resolved for three distinctive test cases of 5 generator, 13-generator & 40-generator cases.

Tiwari S.et.al. (2013) [113]**:** In this paper, particle swarm optimization can be an effectual substitute to resolve large scale non linear optimization problems. In both circumstances for loss involved& loss deserted it uses very less iteration for Classical PSO technique to store the optimal answer.

GopalkrishanR.et.al. (2013) [115]**:**This paper suggests an effectual & dependable method for mutual fuel cost economic optimization & emission dispatch by means of the Modified Ant Colony Optimization algorithm (MACO) to harvest better optimum solution.

NiknamT.et.al. (2012) [117]:In this paper a new phase named “modified phase” based on a self-adaptive learning mechanism is added to the algorithm to improve the process of knowledge learning among the learners and accordingly generate promising candidate solutions. The proposed framework is applied to 5-, 10-, 30-, 40-, and 140-unit test systems in order to evaluate its efficiency and feasibility.

Effatnejad R.et.al. (2013) [118]**:** In this paper, ACO method is moderately able of attaining advanced superiority solution. The Suggested ACO is equated with other, such as DE-OBL, ABC, DE, and ACO-OPF & GA. It is clear that, the suggested method can be an appropriate technique for medium-scale system an ant colony optimization technique can provide a finest result.

Hardiansyah (2013) [120]**:** In this paper, a novel optimization of artificial bee colony (ABC) algorithm has been effectively presented to attain the optimal solution of economic load dispatch problem. Three test cases comprising of 3-unit, 6-unit & 15-unit system have been verified& the results are matched with orthodox technique& GA. The evaluation displays that ABC algorithm achieves superior than above stated approaches.

Jain J.et.al. (2013) [121]: This paper grants a biogeography-based optimization (BBO) algorithm to resolve Economic Load Dispatch (ELD) problem with generator constraints in power plants. The determination of this paper is to discover out the benefits of application of the evolutionary computing method& BBO in specific to the economic load dispatch problem. This method is fulfilled in MATLAB environment.

Adriane B.S.et.al (2013) [122]**:** In this paper Cuckoo Search (CS) Algorithm has been smeared to resolve economic load dispatch problem for two dissimilar test systems. The evaluation of attained simulation results by means of the Cuckoo Search is conceded out contrary to six other swarm centered intellect processes: Bacterial Foraging Optimization, Harmony search, Shuffled Frog Leaping Algorithm, Particle Swarm Optimization, Artificial Bee Colony, &Firefly Algorithm. The efficacy of each swarm centered intellect process is smeared on a test system containing of 3 generators & other comprising 6 generators.

Dubey H.M.et.al. (2013) [123]**:** This paper offered a novel algorithm PSOGSA (hybrid of PSO and GSA) to resolve economic load dispatch. This algorithm conglomerates the societal philosophy feature in PSO with the local exploration capability of GSA. The attained results are matched with recently described approaches. The judgment established the efficacy & heftiness of the algorithm above other prevailing methods.

Allairani A.et.al. **(2013)** [125]: This paper suggested a technique of solution of firefly algorithm for solution of economic load dispatch with emission constraints in numerous generation plants. The suggested technique was applied & verified on 3, 6 and 12 generating test systems. The results attained were equated with the artificial bee colony & particle swarm optimization methods& it was bring into being that the FA fuel cost was fewer than the stated processes. Furthermore the superiority of the solutions in addition to the convergence rate was discovered to be greater than that of additional methods& provides hopeful method for resolving ELD problem.

Younes M. (2013) [126] : This paper suggested a new hybrid Firefly Algorithm – Ant Colony optimization (FA-ACO) for economic load dispatch method, where he had battered the heftiness of ACO with the convergence swiftness of the FA to produce a novel hybrid process. The ACO was castoff for the global exploration while FA was used for the local exploration. The technique was verified on improved IEEE 30 bus test system. Well along the results are equated with the other methods like PSO, tabu search, improved evolutionary programming, DE, EP & non-linear programming. Case study described that the suggested technique was simple to smear, strong, having profligate computational swiftness & necessitate fewer amount of reiterations.

WangLing (2013) [127]**:** In this paper, differential evolution & harmony search are crossbred together to form differential harmony search algorithm which is smeared to resolve economic load dispatch problem. In the differential harmony search, the pitch tuning procedure is used laterally with the diverse alteration procedure to develop the exploitation ability of harmony search, & both the pitch tuning& the memory deliberation are castoff to develop the exploration ability of evolution search. Simulation results &evaluations with the other prevailing algorithms displayed the heftiness & efficacy of the suggested process.

HosseinnezhadV.et.al. (2013) [128]: This paper grants a h-particle swarm optimization (h-PSO) centered algorithm to resolve constrained economic load dispatch (ELD) problems of thermal plants. The performance of suggested process has been verified on systems owning 6, 13, 15, & 40 generating units linking variable mark of intricacy. The verdicts sustain that the technique outdoes the prevailing methods in relations of solution superiority& computational efficacy & can be an encouraging substitute method for resolving the ELD problems in real-world power system.

Xiong G.et.al. (2013) [130]: In this paper, a multi-strategy collaborative biogeography-based optimization (MsEBBO) centered technique for ED problems is suggested. The performance of MsEBBO is verified on four ED problems with dissimilar intricacies. Experimental results & judgments with other lately scribed ED solution approaches approve that MsEBBO is able of yielding a decent equilibrium amid exploration & exploitation, & attaining modest solution superiority. Furthermore, the understanding of MsEBBO to deviations in population size is examined as well.

Dr. VisaliN.et.al. (2013) [132]**:** This paper covenants with optimum generation scheduling in thermal power plant by means of differential evolution programming technique. The Economic Dispatch (ED) is to minimize the operating fuel cost while sustaining the load demand & operational constraints. The examination is conceded out with ignoring transmission losses & the results are offered. This paper resolves sample test system of six generator system & 15 generator systems for numerous load demands deserting transmission losses.

MallikarjunaB.et.al. (2014) [133]**:** This paper suggests application of BAT algorithm for resolving economic load dispatch problem. The results of the estimated BAT method are matched with that of other methods such as lambda iteration, GA, PSO, APSO, ABC & basic principle. For each the case, the estimated algorithmic program outdoes the responded scribed for the prevailing algorithms. Furthermore, the capable results show the resoluteness, rapid convergence &effectiveness of the estimated method.

Jiang S. et.al. (2014) [134]**:** This paper boon a new amalgam method to the solution of optimal power generation for EELD problems by means of HPSO–GSA method. The suggested algorithm delivers an exciting mixture of PSO-GSA &accepts co-evolutionary method to appraise its particle location in the swarm with the collaboration of PSO & GSA. The EELD problems on five test systems comprising diverse constraints are resolved by the HPSO–GSA to evaluate the optimization performance of the suggested hybrid method. The results attained approve the probable efficacy of the recommended method matched to PSO, GSA & other algorithms available in the latest state-of-the art literatures for the solution of the EELD problems.

Kaur A.et.al. (2014) [135]**:** In this paper genetic algorithm is able of optimizing any manner of difficulties regardless of load demand. The results argued are attained after substantial decrease in Fuel Cost of Generators &pleases each & every constraint. The system well-thought-out here is the lossless system. The results attained display a momentous hatchment in generator fuel cost while at the similar time satiating ferrous equity & inequity constraints.

Sahoo S.et.al. (2014) [138]**:** This paper presents an evolutionary algorithm named as Cuckoo Search algorithm applied to non-convex economic load dispatch problems. In comparison with the solution quality and execution time obtained by five test systems, for six, fifteen, forty, one hundred and forty and three hundred and twenty unit power system .Cuckoo Search algorithm is converging better than PSO and GA and also provides cheapest generation schedule, thus making it quite an efficient algorithm and less time consuming for online applications as well.

KumarS.et.al. (2014) [140]**:** This paper defines gravitational search algorithm for resolving the non convex Economic load Dispatch (ELD) problem. In this paper, gravitational search algorithm (GSA) centered on rule of gravity & mass interface is projected. This projected method has been tried on 3, 38 test systems. Simulation results of projected method are matched with some renowned heuristic search approaches. The attained results confirm the efficacy of the projected technique with least computational period in resolving numerous nonlinear functions.

Belkacem M.et.al. (2014) [141]**:** This paper boons an improved artificial bee colony (IABC) optimization technique to resolving real-world economic dispatch captivating into account the nonlinear generator attributes such as valve-point loading effects. It is detected that the suggested alternative centered ABC is able to refine the solution of large economic dispatch bearing in mind real-world generator constraints.

Hardiansyah et.al. (2014) [142]: This paper boons an effectual simulated annealing (SA) algorithm with a sole decision variable to resolve the economic load dispatch (ELD) problems. The suggested SA algorithm offered here is smeared to two case studies, which investigate power systems taking three, & six generating units. The results resolute by the suggested methodology are matched to those bring into being by orthodox quadratic programming (QP) & genetic algorithm (GA).

Kherfane R.L.et.al (2014) [143]**:** This paper offered a novel hybrid GA-MGA to resolve the economic load dispatch problem. The GA is smeared to find the global best while the MGA is castoff to explore the local best. The problem is specified by bearing in mind the accumulation of wind power into the power system. The suggested process is smeared to 30 buses & on a western part of the Algerian power network. The attained results are matched with additional prevailing processes in literature.

SahuG.et.al. (2014) [144]**:** In this paper, smeared GA to the generation cost in electric power network to attain the optimal solution of Economic Load Dispatch (ELD). GA can deliver exceedingly optimal solutions & decreases the calculation time than those with the iterative technique. A benefit of the GA solution is the plasticity it delivers in modeling together time dependent & coupling constants. Additional benefit of the GA method is the comfort with which it can grip random kind of constraints & objective.

Upadhyay N.D.et.al. (2014) [145]**:** In this paper, biogeography-based optimization (BBO) process to resolve both convex & non-convex economic load dispatch (ELD) problems of thermal plants. The biogeography based optimization (BBO) algorithm has the capability to discover the superior class solution & has superior convergence attributes& computational efficacy. It is vibrant from the results attained by diverse judgments' that the suggested BBO technique has decent convergence attributes& can evade the inadequacy of early convergence of other optimization methods to attain heal their superiority solution, so these approaches converge to diverse solutions.

RastgouA.et.al. (2014) [146]**:** This paper suggested an effectual estimate for non-convex ED bearing in mind the valve-point effects &grants a solution by approximation centered mean squared error (MSE) on non-convex objective function of this problem in order to govern the feasible optimum solution. The suggested practice is smeared on diverse test systems &matched with the greatest of the current approaches. Attained results approve that the suggested method is able of attaining advanced superiority solution proficiently, specifically in large scale power systems.

Dogan A.et.al. (2014) [147]**:** In this paper artificial bee colony algorithm with dynamic population size has been suggested to resolve mutual economic emission dispatch problem which is transformed into solitary objective optimization problem

Phuong T.N.et.al. (2014) [150]**:** In this paper, a Cuckoo Search Algorithm is suggested for resolving EELD problem with quadratic fuel function. The efficacy of the suggested technique is verified on a number of cases of dispatch & loads. The attained results from Cuckoo Search Algorithm are matched to those from other prevailing approaches in the literature. The judgment result has displayed that the suggested algorithm is a very proficient technique for resolving EELD problem.

Calian S.D.et.al. (2014) [151]**:** This paper offered a reformed harmony search algorithm for resolving the economic dispatch problem bearing in mind valve point effects. The reformed harmony search algorithm is based on harmony search algorithm, but an original harmony is attained by implanting a few qualities from artificial bee colony algorithm. The efficacy of suggested algorithm is verified in contrast to two systems comprising of 6 & 38 thermal power generating units.

Wang M. Q.et.al. (2014) [152]**:**In this paper a mixed integer quadratic programming (MIQP) is suggested to resolve the dynamic economic dispatch (DED) with valve-point effect (VPE) where the non-linear & non-smooth cost instigated by VPE is piecewise liberalized. In this paper the multi-step technique, the warm start method& the range limitation arrangement are united with the MIQP. The optimization procedure can then halt the convergence stagnancy & the calculation efficacy can be significantly enhanced. When the system loss is measured, the loss formula is piecewise liberalized. The efficacy of the suggested technique is verified by seven cases & the results are matched with those attained by the preceding published techniques.

Sukumar M.et.al. (2014) [153]**:** This paper grants an innovative optimization method GSO to resolve an optimization problem mutual Economic & Emission Dispatch (CEED) for Optimal Power Flow (OPF). The results of the GSO to resolve CEED are verified with 3 unit generator power system & they are satisfactory. GSO-CEED results are also matched with the renowned swarm intelligence method, Particle Swarm Optimization (PSO) to resolve the efficacy of algorithm.

Singh S.P.et. al. (2014) [154]**:** In this paper, GA can offer more precise results with profligate convergence attributes& is higher to LIM. GA shows an imperative part to discover out the optimal solution in a segment of second. It is bring into being that GA is giving superior results than LIM. i.e. GA verifies itself as profligate algorithm &produces true optimal generations of mutually operating costs & transmission line losses of the power system.

Wong L. I.et.al. (2014) [155]**:** This paper suggests a novel meta-heuristic so-called Grey Wolf Optimizer (GWO) which stimulated by grey wolves (Canes lupus). This algorithm is then benchmarked on 20 generating units in economic dispatch, & the results are superior than additional algorithms stated in current literature.

Jie Lin.et.al. (2015) [156]**:** This work boons an intellectual particle swarm optimization for economic dispatch with valve-point effect. The direct search algorithm is castoff to modify & define the ultimate global optimum solution at little computational expenditure. Mathematical trials validate that the suggested method bids advanced superiority solutions than do numerous prevailing methods.

Singh N.et.al.(2015) [157]**:** In this paper, fuel cost & the environmental emission functions are well-thought-out & expressed as a multi objective economic load dispatch problem. For attaining the solution of multi objective economic load dispatch problem a novel PSO so-called moderate random search PSO was used. MRPSO improves the capability of particles to discover in the search areas more efficiently & upsurges their convergence rates. The suggested algorithm is verified for the IEEE 30 bus test systems. The results attained by MRPSO algorithm display that it is efficient &successful.

Deshpande P.et.al. (2015) [158]**:** This paper castoff particle swarm optimization methods for solution of economic load dispatch problem with ramp rate constraints. For the analysis of the suggested PSO is intriguing data of 6 generating unit system of IEEE standard bus system. In this effort the power &practicality of the PSO algorithm is verified through its application for six generator systems with constraints.

Reddy D. P.et.al. (2015) [159]**:** This paper suggests application of Firefly algorithm for resolving economic load dispatch problem with valve point effect. The suggested method has been observed & verified with the mathematical results of economic load dispatch problems with three & five generating units with valve point loading deprived of bearing in mind prohibited operating zones & ramp rate limits. The results of the suggested Firefly algorithm are matched with that of numerous other methods for example lambda iteration and ABC.

Dr.Sharma.et.al. (2015) [160]**:** In this paper the grey wolf optimization (GWO) is used to resolve convex economic load dispatch (ELD) problem. The benefit of GWO algorithm is its easiness, dependability & efficacy for real-world applications.

Kamboj V. K. et.al. (2015) [166]**:** This paper offered the solution of non-convex & dynamic ELDP of electric power system. The performance of GWO algorithm is verified for small-, medium& large-scale power plants. GWO has been effectively applied to resolve diverse ELD problems; GWO is very profligate as likened to lambda iteration method, Particle Swarm Optimization (PSO) algorithm, Genetic Algorithm (GA), Biogeography-Based Optimization (BBO), Differential Evolution (DE) Algorithm, pattern search algorithm, NN-EPSO, FEP, CEP, IFEP & MFEP for small& medium-scale power Systems. GWO has the capability to congregate to a healthier superiority near-optimum solution.

BoonthienthongM.et.al. (2015) [167]: This paper offered simulated annealing processto resolve the economic load dispatch (ELD) problems. The performance of the advancedprocedure is verified by power system test cases system with 6 generation units. The results designate the applicability of the suggested technique to the real-world economic load dispatch problem.

NischalM.M.et.al. (2015) [168]**:** This paper boons Ant lion optimization (ALO) method to resolve optimal load dispatch problem. The suggested method is employed on 3, 6 & 20 unit test system for resolving the OLD. Mathematical results display that the suggested technique has decent convergence attribute &superior in class of solution than additional algorithms stated in current literature.

Tran C. D. et.al. (2015) [169]**:** This paper boon the Cuckoo Search Algorithm (CSA) castoff for economic load dispatch problem. The suggested CSA approaches are verified on two systems with numerous load cases &attained results are matched to other techniques. The result evaluations have revealed that the suggested

approaches are exceedingly effectual for resolving ELD problem with multiple fuel options and/nor valve point effect.

MirjaliliS.et.al. (2015) [170]: In this paper a new nature-motivated optimization exemplar is suggested so-called Moth-Flame Optimization (MFO) algorithm. The key motivation of this optimizer is the course-plotting technique of moths in nature named transverse orientation. Moths fly in night by upholding a stable angle with respect to the moon, a very effectual contrivance for drifting in a straightforward streak for elongated distances. Though, these extravagant insects are surrounded in an unusable/lethal spiral trail nearby artificial lights. This paper arithmetically models this conduct to achieve optimization. The MFO algorithm is matched with other renowned nature-motivated processes on 29 benchmark & 7 real engineering problems. The numerical results on the benchmark functions show that this algorithm is capable to deliver very encouraging& useful results.

Conclusion and future scope

The survey of existing literature reveals that various numerical optimization techniques have been employed to approach the solution of Economic Load Dispatch Problem. Also, it has been observed that appreciable efforts have been made to solve the economic load dispatch problem using different methodologies, but each method have some pros and cons., which are mentioned below:

1. Numerical Technique fails when the size or dimensions of the problem, large computational time and complexity in programming.
2. The mixed integer programming methods for solving the economic load dispatch problem fail when the participation of number of units increases because they require a large memory and suffer from great computational delay.
3. Particle swarm optimization (PSO) has simple concept, easy implementation, relative robustness to control parameters and computational efficiency ; although it has numerous advantages, it get trapped in a local minimum, when handling heavily constrained problems due to the limited local/global searching capabilities.
4. The Lagrangian relaxation (LR) approach fails to obtain solution feasibility and solution quality of problems and becomes complex if the number of units is more.
5. The branch and bound (BB) method employs a linear function to represent fuel cost and start-up cost and obtains lower and upper bounds. The difficulty of this method is the exponential growth in the execution time for systems of a large practical size.
6. An expert system (ES) algorithm rectifies the complexity in calculations and saves computation time. But it faces the problem whether the new schedule is differing from schedule in database.
7. The fuzzy theory method using fuzzy set solves the forecasted load schedules error, but it suffers from complexity.
8. The Hopfield neural network technique considers more constraints, but it may suffer from numerical convergence due to its training process.
9. The simulated annealing (SA) and Tabu search (TS) are powerful, general-purpose stochastic optimization technique, which can theoretically converge asymptotically to a global optimum solution with probability one. But it takes much time to reach the near-global minimum.
10. Gravitational search algorithm has the advantages to explore better optimized results, but due to the cumulative effect of the fitness function on mass, masses get heavier and heavier over the course of iteration. This causes masses to remain in close proximity and neutralize the gravitational forces of each other in later iterations, preventing them from rapidly exploiting the optimum. Therefore, increasing effect of the cost function on mass, masses get greater over the course of iteration and search process and convergence becomes slow.

Also, no considerable efforts are made to solve single and multi-Objective economic load dispatch

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