International Conference on Advance Studies in Engineering and Sciences
Sri Satya Sai University of Technology and Medical Sciences , Sehore (M.P.) ICASES-17
2nd December 2017, www.conferenceworld.in ISBN: 978-93-86171-83-2

Literature Review of Economic Load Dispatch Problem in Electrical Power System using Modern Soft Computing

AMIT BHARDWAJ

PhD Research Scholar, Electrical Engineering,

Sri Satya Sai University of Technology & Medical Sciences, MP

ABSTRACT

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. The Economic Load Dispatch (ELD) problem is the most significant problem of optimization in forecasting the generation amongst thermal generating units in power system.

I.INTRODUCTION

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.

The purpose of economic dispatch is to determine the optimal power generation of the units participating in supplying the load. The sum of the total power generation should equal to the load demand at the station. In a simplified case, the transmission losses are neglected. This makes the task of solution procedure easier. In actual practice, the transmission losses are to be considered. The inclusion of transmission losses makes the task of economic dispatch more complicated. A different solution procedure is to be employed to arrive at the solution.

II.STATEMENT OF THE PROBLEM

Economic dispatch, by definition is an on-line function, carried out after every 15-30 minutes or on request in Power Control Centers. It is defined as the process of calculating the power generation of the generating units in the system in such a way that the total system demand is supplied most economically. The current study is to analyze the economic Load Dispatch problem and to implement an Effective Modern Soft Computing Algorithm (EMSCA) for Economic Load Dispatch (ELD) problems in power system in order to obtain optimal economic dispatch with minimum generation cost.

It is the standard industrial practice that the fuel cost of generator is represented by polynomial for economic dispatch computation (EDC). The key issue is to determine the degree and the coefficients such that the error between the polynomial and test data is sufficiently low. Traditionally, in the EDC, the cost function for each generator is approximately represented by a quadratic function which is convex in nature.

III.DEFINITIONS AND EXPLANATION TERMS

Electrical Power Industry

Electrical power industry is changing quickly and under the present commercial burden determining the optimal approaches to meet the demand for electricity, for a specific planning horizon is one of the most important concerns. These days chief challenge is to fulfill the consumer's demand for power at minimum cost. Any given power system consisting of many generating stations, having their own characteristic operating parameters, are used to meet the total consumer demand.

Economic load dispatch problem

Economic load dispatch problem can be defined as allocating loads to plants or generators for minimum cost while satisfying various operational constraints. The generators are to be scheduled in such a way that generators with minimum cost are used as much as possible. In addition the growing public consciousness of environmental protection has enforced the utilities to adapt their operational policies to decrease the pollution and atmospheric emissions.

IV.SIGNIFICANCE OF THE STUDY

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 (SOx), Nitrogen Oxide (NOx) and

Carbon Oxide (COx) 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.

Power systems operation combines a highly non-linear and computationally difficult environment with a need for optimality. The economic operation and planning of power system are ranked high amongst the major tasks in the power generation. Power economic dispatch (ED) is necessary and vital step in power system operational planning and has always occupied an important position in the electric power industry.

V.LITERATURE REVIEW

One of the first attempts to combine the UC problem and the economic dispatch problem is made by Birge and Takriti [1]. In their work they handle the stochasticity of load by using multi-stage stochastic programming techniques. They approximate the nonlinear subproblems to their linear equivalents and solve these to attain a lower bound on the solution. Then they employ heuristic rules to derive a feasible solution. To combine these two different time horizon problems, they utilize match-up scheduling.

Theofanis et al. [2], developed firefly algorithm for the application of multi-objective problem of economic load dispatch with emission constraints. Further, the proposed method was applied for several load demand wherein they slightly modified the firefly algorithm in a 700 MW and 500 MW load demands to reduce the difference in the initial solutions. The results clearly showed the efficiency and effectiveness of the firefly algorithm over other stochastic nature inspired algorithms.

Xin she Yang et. al. [3], proposed a novel approach to determine the optimal solution of economic load dispatch problem utilizing the firefly algorithm taking into account the non linear characteristics of power system viz. valve point loading effect, ramp rate limits and prohibited operating zones considering for three, thirteen and forty generating units. The FA results its robustness and effectiveness to solve complex optimization problem.

Sulaiman et. al. [4], have proposed a paper on economic load dispatch problem solution by using the meta-heuristic firefly algorithm technique. They used 26 bus systems to show the effectiveness of firefly algorithm. Later on the FA result was compared with the continuous genetic algorithm and lambda iteration method for the cost minimization showing that FA is more robust and consistent.

Amoli et al. [5] presented the application of firefly algorithm to solve economic load dispatch with cubical and quadratic equation of fuel cost functions. Also they have compared the simulation results with genetic algorithm, modified Particle Swarm Optimization (PSO), pattern search, dynamic programming and improved genetic algorithm with multiplier updating techniques. The simulation were carried out on 1400 MW load, and it was concluded that the FA works more efficiently than other mentioned methods in terms of better optimal solution while fulfilling the equality and inequality constraints.

Swarnkar [6] proposed the approach to solve economic load dispatch with reduced power losses using firefly algorithm, The author also introduced the Biogeography-Based Optimization (BBO) algorithm to solve the described problem. The effectiveness and the efficiency of the firefly algorithm was later compared with GA, PSO, Artificial Bee Colony optimization (ABC), BBO and Bacterial Foraging Algorithm (BFA) and other optimization techniques. BBO was found to be more capable for obtaining better quality solutions with higher computational efficiency and stable convergence characteristic. Latifa et al [7], showed the efficiency and the feasibility of the firefly meet algorithm to resolve economic load dispatch problem with pollutant emission reduction. The proposed method was tested on IEEE 14 bus test system and on two thermal plant units. In one of the test cases the transmission loss and the pollutant emission were neglected, finally the results were compared with the PSO, to demonstrate the efficiency and the robustness of the firefly algorithm with lesser average CPU time.

Reddy et al. [8] proposed a novel method of economic load dispatch using the firefly algorithm which was then applied to various test systems and result were compared with the lambda iteration method. The 3 and 6 unit test system were used for testing and the results revealed that the firefly algorithm gave more reliable optimal solution than the lambda iteration method.

Rao et al. [9] proposed a comparative study of the Big Bang- Big Crunch (BB-BC) and firefly algorithm for solving the economic load dispatch problem. To test the effectiveness and quality if optimization method simulations were carried out on the ward hale 6 bus and modified IEEE 30 bus system networks were revealed that the firefly optimization gives optimal, fast and reliable solutions than the BB-BC optimization method.

Abedinia et al. [10] proposed a method to solve multi objective environmental economic dispatch using firefly algorithm technique. The Multi Objective Firefly Algorithm (MOFA) was validated and tested on the IEEE 30 bus and IEEE 118 bus test system and results were compared with other optimization techniques like Non-dominating Sorting Genetic Algorithm (NSGA), Niched Pareto Genetic Algorithm (NPGA) and Strength Pareto Evolutionary Algorithm (SPEA) which revealed that the MOFA gave lower cost with higher efficiency.

In an another paper of Sulaiman et al [11], economic load dispatch problem was resolved with the Modified Firefly Algorithm (MFA) including practical operation constraints such as ramp rate limit, prohibited operating zones and generating limits. To demonstrate the effectiveness and the feasibility of MFA two well known test systems were evaluated and compared with other recently developed ELD problem solution techniques. Results revealed that the method found more economical solutions than those determined by other techniques.

Taher et al [12], proposed a new fast Self Adaptive Modified Firefly Algorithm (SAMFA) to solve the Reserve Constraint Dynamic Economic Dispatch (RCDED) where the self adaptive tuning parameter tuning and mutation strategy were utilized. In order to evaluate the proposed method, it was implemented and tested on four cases: 5, 10 30 and 100 units system and it was found that SAMFA converged towards more better optimal solution with higher computational efficiency and accuracy.

Mimoun Younes et al. [13] proposed an approach to solve the economic load dispatch including renewable energy using firefly algorithm. Solar and wind power were included as the sources of renewable energy, They had considered the emission constraints to reduce the emission pollution. The proposed method was tested on a

10 unit system and The inclusion of renewable power to the system reduces the generator fuel cost as well as the emission of pollutants in the environment.

Palaniyappan et al. [14] proposed a computational approach to solve economic load dispatch with reduction of CO2 emission in thermal plant using firefly algorithm. It was concluded from the simulation of the six generating system that the proposed method reduce the global warming by minimization of fuel consumption. Higher accuracy and lesser computational time of the method described its superiority to the existing Meta heuristic algorithms.

Subramanian et al. [15] proposed an efficient and reliable firefly algorithm to solve economic load dispatch problem. The proposed method was applied on six generating system and the results were compared with the other population based techniques like simulated annealing, genetic algorithm, differential evolution, particle swarm optimization, artificial bee colony optimization and biogeography- based optimization techniques. This method showed its higher quality of solutions with better computational efficiency and stable convergence characteristics.

Weixun Ge [16] proposed a new approach to solve ramp rate constrained unit commitment (RUC) problem by improving the method of PSO, namely improved priority list and enhanced particle swarm optimization (IPL-EPSO). The IPL-EPSO proposed in this paper is a combination of improved priority list (IPL) and enhanced particle swarm optimization (EPSO), which decomposes UC problem into two sub-optimization problems and solves them respectively.

Christober and Asir Rajan presented a new approach to solve the short term unit commitment problem using an Evolutionary Programming Based Simulated Annealing Method with cooling and banking constraints. The objective of this paper was to find the generation scheduling such that the total operating cost can be minimized, when subjected to a variety of constraints [17].

Christober Asir Rajan et al. [18] proposed new Neural Based Tabu Search (NBTS) - based algorithm for the unit commitment problem. The objective of this paper was to find the generation scheduling such that the total operating cost can be minimized, when subjected to a variety of constraints.

Subramanian et al [19], presented the method to solve the economic load dispatch using the modified firefly algorithm for IEEE 3, 6, 13 and 15 generator test case systems. Later the results were compared with the GA, DE, PSO, ABC, BBO and BFO techniques. From the simulation it was found that the MFA gave better results of total cost minimization as compared with the other mentioned algorithms.

Chandrasekaran et al [20], proposed a new approach to solve the unit commitment problem using the Binary Real Coded Firefly Algorithm (BRCFF). The proposed BRCFF algorithm was validated on the test system viz. 3, 12, 17, 26, and 38 unit systems. The tanh function and the sigmoid functions were introduced to improve the flipping probability of the binary variables, Thereby increasing the quality of solution and reducing computational time. The proposed method was found more efficient and gave the more promising results as compared to other techniques.

Mimoun Younes [21] proposed a novel hybrid Firefly Algorithm – Ant Colony optimization (FA-ACO) for economic load dispatch approach, where he had clubbed the robustness of ACO with the convergence speed of the FA to create a new hybrid algorithm. The ACO was used for the global search while FA was used for the local search. The method was tested on modified IEEE 30 bus test system. Later the outcomes are compared with the other techniques like PSO, tabu search, improved evolutionary programming, DE, EP and non-linear programming. Case study reported that the proposed method was easy to apply, robust, having fast computational speed and require less number of iterations.

VI.METHODOLOGIES TO SOLVE ECONOMIC LOAD DISPATCH PROBLEM

The Unit Commitment is the essential and vital step in power system operational planning. In addition to the ED objective, environmental concern that arises from the emission produced by fossil fuel electric power plants becomes a major problem to be addressed.
Now methods for solving this ELD problem are discussed below:

Lambda Iteration: In Lambda iteration method lambda is the variable introduced in solving constraint optimization problem and is called Lagrange multiplier [1]. It is important to note that lambda can be solved at hand by solving systems of equation. Since all the inequality constraints to be satisfied in each trial the equations are solved by the iterative method. This method has used equal increment cost criterion for systems without transmission losses and penalty factors B matrix for considering the losses.

Gradient Search Method: This method works on the principle that the minimum of a function, f(x), can be found by a series of steps that always take us in a downward direction. In this method the fuel cost function is chosen to be of quadratic form. However, the fuel cost function becomes more nonlinear when valve point loading effects are included.

Newton Method: Newton's method goes a step beyond the simple gradient method and tries to solve the economic dispatch by observing that the aim is to always drive the gradient of function to zero. Generally, Newton's method will solve for the correction that is much closer to the minimum generation cost in one cost in one step than would the gradient method.

Linear Programming: Linear programming (LP) is a technique for optimization of a linear objective function subject to linear equality and linear in-equality constraints. Informally, linear programming determines the way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model and given some list of requirements represented by linear equations. A linear programming method will find a point in the optimization surface where this function has the smallest (or largest) value. Such points may not exist, but if they do, searching through the optimization surface vertices is guaranteed to find at least one of them.

Base Point and Participation Factor: This method assumes that the economic dispatch problem has to be solved repeatedly by moving the generators from one economically optimum schedule to another as the load changes by a reasonably small amount. It is started from a given schedule called the base point. Next assumes a load change and investigates how much each generating unit needs to be moved in order that the new load served at the most economic operating point.

VII.PROPOSED METHODOLOGIES

Evolutionary Programming (EP), Simulated Annealing (SA), Tabu Search (TS)

Although the heuristic methods do not always guarantee discovering globally optimal solutions in finite time, they often provide a fast and reasonable solution. EP can be a quite powerful evolutionary approach; however, it is rather slow converging to a near optimum for some problems. Both SA and TS can be quite useful in solving complex reliability optimization problems; however, SA is very time consuming, and cannot be utilized easily to tune the control parameters of the annealing schedule. TS is difficult in defining effective memory structures and strategies which are problem dependent.

Dynamic Programming (DP)

When cost functions are no-convex equal incremental cost methodology cannot be applied. Under such circumstances, there is a way to find an optimum dispatch which use dynamic programming method. In dynamic Programming is an optimization technique that transforms a maximization (or minimization) problem involving n decision variables into n problems having only one decision variable each. This is done by defining a sequence of Value functions V1, V2…..Vn , with an argument y representing the state of the system. The definition of Vi(y) is the maximum obtainable if decisions 1, 2 ...I are available and the state of the system is y. The function V1 is easy to find. For I=2,...n, Vi at any state y is calculated from Vi -1 by maximizing, over the I-th decision a simple function (usually the sum) of the gain of decision i and the function Vi -1 at the new state of the system if this decision is made. Since Vi -1 has already been calculated, for the needed states, the above operation yields Vi for all the needed states. Finally, Vn at the initial state of the system is the value of the optimal solution. The optimal values of the decision variables can be recovered, one by one, by tracking back the calculations already performed.

Hopfield Neural Network (HNN)

Hopfield introduced in 1982[4] and 1984[5], the Hopfield neural networks have been used in many different applications. The important property of the Hopfield neural network is the decrease in energy by finite amount whenever there is any change in inputs. Thus, the Hopfield neural network can be used for optimization. Tank and Hopfield [13] described how several optimization problem can be rapidly solved by highly interconnected networks of a simple analog processor, which is an implementation of the Hopfield neural network. Park and others [6] presented the economic load dispatch for piecewise quadratic cost functions using the Hopfield neural network. The results of this method were compared very well with those of the numerical method in a hierarchical approach. King and Others [12] applied the Hopfield neural network in the economic and environmental dispatching of electric power systems. These applications, however, involved a large number of iterations and often shown oscillations during transients. This suggests a need for improvement in convergence through an adaptive approach, such as the adaptive learning rate method developed by Ku and Lee [2] for a diagonal recurrent neural network.

Genetic Algorithm (GA), Differential Evolution (DE)

GA ensures colony evolves and solutions change continually; however, sometimes it lacks a strong capacity of producing better offspring and causes slow convergence near global optimum, sometimes may be trapped into local optimum. Due to the premature convergence of GA, its performance degrades and its search capability reduces. Price and Storn [8] invented differential evolution (DE). It involves three basic operations, e.g., mutation, crossover, and selection, in order to reach an optimal solution. DE has been found to yield better and faster solution, satisfying all the constraints, both for uni-modal and multi-modal system, using its different crossover strategies. But when system complexity and size increases, DE method is unable to map its entire unknown variables together in a better way. In DE all variables are changed together during the crossover operation. The individual variable is not tuned separately. So in starting stage, the solutions moves very fast towards the optimal point but at later stage when fine tuning operation is required, DE fails to give better performance.

Particle Swarm Optimization (PSO)

In the mid 1990s, Kennedy and Eberhart invented PSO [10]. In PSO there are only a few parameters to be adjusted, which make PSO more attractive. Simple concept, easy implementation, robustness and computational efficiency are the main advantages of the PSO algorithm. A closer examination on the operation of the algorithm indicates that once inside the optimum region, the algorithm progresses slowly due to its inability to adjust the velocity step size to continue the search at a finer grain. So for multi-modal function, particles sometimes fail to reach global optimal point. When compared with other methods, the PSO is computationally inexpensive in terms of memory and speed. The most attractive features of PSO could be summarized as: simple concept, easy implementation, fast computation, and robust search ability. Artificial Immune System (AIS) Artificial Immune System (AIS) [11] is another population based or network-based soft computing technique in the field of optimization that has been successfully implemented in various power system optimization problems.

Bacterial Foraging Algorithm (BFA)

Inspired from the mechanism of the survival of bacteria, e.g., E. coli, an optimization algorithm, called Bacterial Foraging Algorithm (BFA) [7], has been developed. Chemotaxis, reproduction and dispersion are the three processes with the help of which global searching capability of this algorithm has been achieved. These properties have helped BFA to be applied successfully in several kinds of power system optimization problems. But constraints satisfaction creates little trouble in BFA.

Quantum-inspired Evolutionary Algorithm (QEAs)

The quantum-inspired evolutionary algorithms (QEAs) [9], is then proposed, are based on the concepts and principles of quantum computing, which can strike the right balance between exploration and exploitation more easily when compared with conventional EAs. Meanwhile, the QEAs can explore the search space with a smaller number of individuals and exploit global solution within a short span of time. In the research of the QEAs and PSO, quantum-inspired particle swarm optimization (QPSO) is proposed. Two main definitions used in the QEAs are introduced: quantum bit and quantum rotation gate. Quantum bit is used as probabilistic representation of particles, defined as the smallest information unit. A string of quantum bits consists of a quantum bit individual. Also, quantum rotation gate is defined as an implementation to drive individuals toward better solutions and eventually find global optimum.

Snake Algorithm

Snake Algorithm is demonstrated to overcome the drawbacks of traditional snake/ contour algorithms for contour tracking of multiple objects more effectively and efficiently. The experimental results of the tests carried out have proved that the proposed method is robust, effective and accurate in terms of finding the boundary solutions of multiple objects.

IX.CONCLUSION

Economic load dispatch (ELD) is a process of finding optimal generation scheduling of available generators in an interconnected power system to meet the demand of the system, at lowest possible cost, while satisfying various operational constraints on the system. More just, the soft computing method has received supplementary concentration and was used in a quantity of successful and sensible applications. Here, an attempt will be made to find out the minimum cost by using different algorithm techniques using the data of some generating units. In this work, data will be taken such as the loss coefficients with the max-min power limit and cost function. All the methods will be executed in MATLAB environment.

REFERENCES

[1]. JR Birge, S Takriti, “A stochastic model for the unit commitment problem”, E Long -IEEE Transactions on Power Systems, 1996.

[2]. Apostolopoulos T. and Valchos A., “Application of Firefly Algorithm for Solving the Economic Emission Load Dispatch Problem”, International Journal of Combitronics, volume 2011. 23 pages, doi:10.1155/2011/523806.

[3]. Yang X. S., Hosseini S. S. Sadat, Gandomi A. H., “Firefly Algorithm for Solving NonConvex Economic Dispatch Problem With Valve Point Loading Effect”, Applied Soft Computing, vol. 12, issue 3, pp 1180-1186, March 2012.

[4]. Sulaiman M.H., Mustafa M.W., Zakaria Z.N, Aliman O. and Rahim A. S. R., "Firefly Algorithm Technique for Solving Economic Dispatch Problem", IEEE International Power Engineering and optimization conference, Malaysia, 6-7, , pp. 90-95, June, 2012.

[5]. Amoli N.A., Jadid S., Shayanfar H. A., Barzipour F., "Solving Economic Dispatch Problem With Cubic Fuel Cost Function by Firefly Algorithm", ICTPE conference on Technical Physical Problems of Power Engineering , vol. 1, pp 1-5, 2012.

[6]. Swarnkar K.K., AS.P, "Economic load Dispatch Problem with Reduce Power losses using Firefly Algorithm", Journal of Advanced computer science and technology, vol. 1, pp 42-56, 2012.

[7]. Dekhici L., Belkadi K., Lamosi B. P., " Firefly Algorithm for Economic Power Dispatching With Pollutants Emission", Imformatica Economica, vol. 16, issue 2, pp 45 57, 2012.

[8]. Reddy S. and Reddy M. D., "Economic Load Dispatch Using Firefly Algorithm", International Journal of Engineering Research and Application, vol. 2, issue 4, pp. 2325 2330, July 2012.

[9]. Rao C.V. G.K. and Yesuratnam G., "Big Bang And Big Crunch And Firefly Algorithm Application And Comparison To Optimal Power Flow With Continuous And Discrete Control Variables", International Journal On Electrical Engineering And Informatics, vol. 4, issue 4, pp. 575-583, December 2012.

[10]. Abedinia O., Amjady N., Naderi M.S., "Multi-objective Environmental/Economic Dispatch using firefly technique," 11th International Conference on Environment and Electrical Engineering (EEEIC), 18-25 May 2012, pp. 461-466, 2012.

[11]. Sulaiman M. H., Daniyal H., Mustafa M. W., " Modified Firefly Algorithm In Solving Economic Dispatch Problem With Practical Constraints", IEEE International Conference on Power and Energy, PECon, Kota Kinabalu, Malaysia, pp. 157- 161, 2012.

[12]. Niknam T., Azizipanah A., Roosta R., "Reserve Constrained Dynamic Economic Dispatch: A New Fast Self-Adaptive Modified Firefly Algorithm", Systems Journal, vol.6, no.4, pp. 635- 646, December 2012.

[13]. Younes Mimoun , "Environmental/Economic power Dispatch Problem/ Renewable Energy Using Firefly Algorithm", International Conference on Environmental, Energy, Ecosystem and Development, pp 170-176, 2013.

[14]. Palaniyappan S. and Anbalagan P., " A Nature Inspired Algorithm for Reduction Of CO2 Emission In Thermal Power Station", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 2, issue 9, pp. 4516-4522, September 2013.

[15]. Subramanian R. and Thanushkodi K., "An Efficient Firefly Algorithm To Solve Economic Dispatch Problems", International Journal of Soft Computing And Engineering, vol. 2, issue 1, pp 52-55, March 2013.

[16]. Chitra Y., "Multi-Area Unit Commitment and Economic Dispatch with Market Operation Components", Arlington, May 2006.

[17]. Christober C. and Asir R., "An Evolutionary Programming Based Simulated Annealing Method for Unit Commitment Problem with Cooling - Banking Constraints", 2004.