Literature Review- Profit Based Unit Commitment Problems

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Abstract - This survey paper enlightens recent research in the area of Profit Based Unit Commitment Problem in electrical power system. The research papers published in the indexed journals and proceedings in the broad area of Profit Based UnitCommitment are addressed and presented in a hierarchical methodology. A detailed survey is done in the sphere of Profit Based UnitCommitment for finding different classical, hybrid and non-hybrid methods by means of which PBUC problems can be solved effectively. It will be quite helpful to the scientists, investigators or researchers to be employed in this area.

***Key Words*:** Profit Based Unit Commitment, LiteratureSurvey, Independent System Operator, Particle Swarm Optimization

1.INTRODUCTION

GENCOs offer their services to energy and reserve markets depending upon the generator availability and this is referred as Profit Based Unit Commitment (PBUC). This PBUC problem determines how much energy and reserve should be offered in deregulated power market to achieve the maximum profit. The objective of generating companies (GENCOs) is to maximize their profit.

In today's competitive scenario, GENCOs are no longer bound to serve the given demand in the open electricity market. The problems under a deregulated environment are more complex and competitive than traditional problems. GENCOs solve economic dispatch and UC not to minimize the total production cost as before, but for maximizing their own profit. Many evolutionary programming models were developed in the literature for Profit-Based UC [1].GENCOs can now consider a schedule that produces less than the predicted load demand but creates a maximum profit [2]. In the deregulated power markets, the generators are scheduledto maximize their profit. While committing the units, it is not necessary to satisfy the power demand. Independent System Operator (ISO) takes the responsibility to monitor the operation of power system. The PBUC evaluates power and reserve which can be offered in the market to get the maximum profit. [3]. Deregulated power industry creates a competitive open market situation to get better performance and optimal operation of existing electric industry [4, 5]. In the electricity markets, GENCOs are operated to exploit their profit simultaneously minimize the environmental emissions. Here, it's not essential to meet the demand. So, GENCOs has a different objective than that of conventional UC and is referred as Profit Based UC (PBUC) [6].

The power sectors all over the globe underwent restructuring and deregulation and hence the Unit Commitment (UC) problem has taken a new form called "Profit Based Unit Commitment (PBUC)". The objective of the traditional unit commitment problem is to minimize the total production cost while satisfying all the system constraints. However, in a deregulated environment, the traditional unit commitment objective needs to be changed to profit based unit commitment which is a combinatorial optimization problem in which the generation company's (GENCO's) objective is to maximize the profit and minimize the effort [7]. Due to the inclusion of constraints such as prohibited operating zones, ramp rate limits, line flow constraints and emission limitations, these problems become highly nonlinear and hence may not be solved by conventional optimization tools. The power engineers need special optimization tools to analyze and optimize the above nonlinear power system optimization problems. This paper focuses on providing a clear review of the latest techniques both classical and Intelligent techniques to discuss PBUC problems.

2. LITERATURE REVIEW ON PROFIT BASED UNIT COMMITMENT PROBLEM

Classical Optimization Techniques: The conventional optimization techniques addressed for solving PBUC problem are explained as follows:

Mixed Integer Programming and Dynamic Programming Methods: Tao Li & Mahammad [8] suggested Mixed Integer Programming (MIP) method to solve Price Based Unit Commitment (PBUC) problem. The proposed method was applied to a PBUC solution for a generating company (GENCO) with thermal, combined-cycle, cascaded-hydro, and pumped- storage units. The PBUC solution by utilizing MIP was compared with that of Lagrangian-relaxation (LR) method. Test results on the modified IEEE-118 bus test system show the efficiency of MIP formulation and advantages of the MIP method for solving the PBUC problem.

Mixed Integer Linear Programming Method: Smajo et al [9] presented a Mixed Integer Linear Programming (MILP) method for solving unit commitment problem in a deregulated environment. The proposed method allows precise modeling of non-convex variable cost, non-linear startup cost, ramp-rate limits and minimum up and minimum down time constraints. The effectiveness of the proposed method was tested on 15-unit test system.

Lagrangian Relaxation Method: Takayuki & Isamu [10] proposed a Lagrangian Relaxation (LR) method for solving PBUC problem. This article develops a stochastic programming model which incorporates power trading. A stochastic integer programming model was proposed in which the objective was to maximize expected profits. In this model, ON/OFF decisions for each generator are made in the first stage. The approach to solving the problem is based on Lagrangian relaxation and dynamic programming methods.

Evolutionary Computing Methods: The evolutionary computing techniques available in the literature for solving the PBUC problems are discussed as follows:

Particle Swarm Optimization: Jacob Ragled et al [11] reported the application of PSO to solve the PBUC problem under a deregulated environment considering generation, spinning reserve, non-spinning reserve and system constraints. This paper presents a new approach of GENCOs profit based unit commitment using the PSO technique in a day ahead competitive electricity market. The PBUC problem was solved using various PSO techniques such as chaotic PSO (CPSO), new PSO (NPSO) and dispersed PSO (DPSO) on IEEE-30 bus test system with 6 units as an individual GENCO. The results obtained are quite encouraging and useful in a deregulated power market.

Sam Harrison &Sreerengaraja[12] investigated the application of swarm intelligence to the solution of PBUC problems with emission limitations. In this paper, two incompatible objectives are taken in to consideration - one is maximizing profit and the other is minimizing emission. The binary PSO is used to solve the PBUC problem and real-valued PSO (RPSO) is used to solve the economic dispatch which is a sub problem of PBUC. A 6 and 11 generating unit test systems were taken and the proposed algorithm was applied to solve it for the PBUC with emission limitations. From the comparison of results, the capability of the proposed algorithm was demonstrated in the aspects of solution quality and computational efficiency.

Xiaohui et al[13] prescribed an Improved discrete binary Particle Swarm Optimization (IPSO) to solve PBUC problem. In this IPSO method, the position of particles (x_2) can take on values of 0 or 1 only and the velocity (v_i) will determine a probability threshold. Then the proposed approach was tested on 10 units with a forecasted spot price for 24-hour period. Then the results were compared with a hybrid approach (LR-EP). The result showed that the profit using the IPSO approach was 0.2% more than that of the hybrid method between LR and EP.

Evolutionary Programming: Padmini et al [14] suggested an EvolutionaryProgramming based hydro -thermal commitment scheduling problem of maximizing the profit of GENCOS considering the effect of reserve in a deregulated energy market. The proposed method was applied to hydrothermal scheduling for 3 thermal and 4 hydro units test system.

Genetic Algorithm: Ritcher&Sheble[15] used a Genetic Algorithm (GA) to solve PBUC in the competitive environment. In this proposed method, the authors made accessible a PBUC formulation which considers the softer demand constraint and allocates fixed and transitional costs to the scheduled hours. The proposed GA method was validated on 2 units 14 hours case and 10 units 48-hour case. Senthil Kumar & Mohan [16] formulated GA for solving security constrained unit commitment problem in which the line flow limit violations have been properly handled by GA.

Muller Method: Chandram et al [17] used the Muller Method (MM) for solving PBUC problem. The proposed method was implemented in two stages. In the first step the determination of the units to be committed was obtained through Non- Linear Programming (NLP) method and the economic dispatch was solved by the proposed muller method. The main advantage of this method is diminishing the computation time through the initial allocation.

Shuffled Frog Leaf Algorithm: Venkatesan &Sanavullah [18]presented Shuffled Frog Leaf Algorithm (SFLA) to solve the PBUC problem in a deregulated market with emission limitation. The twin objective function is formulated as a maximization of profit and a minimization of the emission output of the thermal units. The effectiveness of the algorithm was validated on the IEEE -39 buses with 10-unit test system.

Sample Average Approximation Method: Qianfan Wang et al [19] proposed the Sample Average Approximation (SAA) method to solve the PBUC problem in a deregulated power market in which chance constraints to ensure wind power utilization was incorporated. The problem has a two stage stochastic optimization problem with the first stage decision includes UC and quantity of electricity submitted to day-ahead market and second stage decision include generation dispatch, actual usage of wind power and the amount of energy imbalance between day-ahead and real time markets. The SAA algorithm gives a solution in which the sensitivity of the total profit as the requirement of wind power utilization changes.

Memetic Algorithm: Dionisios et al [20] suggested a new Memetic Algorithm (MA) approach for solving the price based unit commitment problem. The main contributions of the proposed method are (i) an innovative two-level tournament selection (ii) a new multiple window crossover (iii) a novel window in window mutation operator (iv) an innovative local search scheme called elite mutation (v) new population initialization algorithm that is specific to PBUC problem and (vi) new PBUC test systems including ramp up and ramp down constraints so as to provide new PBUC benchmarks for future research. The proposed memetic algorithm was applied to 4, 10, 60 and 110 units and the results showed that in every case examined the proposed MA converged to higher profit PBUC schedules than the GA, SA and the LR methods.

Hybrid Methods: The hybrid methods addressed in the literature for solving PBUC problem are as follows:

LR-EP Method: Pathom et al[21] investigated a hybrid method (LR-EP) to solve the PBUC problem. The proposed algorithm for helping GENCOs decides as to how much power and reserve should be sold in energy and ancillary markets in order to receive the maximum profit. Based on forecast data, PBUC is solved by considering power and reserve generation simultaneously. In the proposed hybrid method, EP is used to update Lagrange multipliers in the traditional LR method. Two reserve payment methods were simulated using 3 and 10 unit systems and the results obtained were compared with the traditional Unit Commitment (UC) method.

LR-PSO Method: Rampriya& Mahadevan [22] suggested the LR-PSO method to solve scheduling of generating units and maximizing the profit of GENCOs under deregulated environment. The purpose of PSO used to update the Lagrangian multipliers in an effective manner so that it can handle various constraints and provides a faster solution. The comprehensive search property of PSO was included in this method thereby improving the performance of the traditional LR method. The proposed hybrid method was tested on 3-unit 12 hours data and the results were compared to LR-gradient search, muller method and LR-EP methods.

LR-FA Method: Rampriya et al [23] suggested the hybrid method (LR-FA) to solve PBUC problems in a restructured power system. In this hybrid approach, the performance of the Ttraditional LR method was improved by FA. The proposed hybrid method generates a feasible unit commitment schedule, and total profit gained by GENCOs. The algorithm was tested on a 10 unit 24-hourly data and the results were compared with the other methods.

Artificial Immune System based GA: Lakshmi &Vasantharathna[24] presented a hybrid Artificial Immune System (AIS) based GA algorithm to solve the PBUC problem. The proposed hybrid method was developed during the adaptive search inspired by the Artificial Immune System and GA to carry out profit maximization of generation companies. The proposed algorithm was tested on 3, 10 and 36 units and the results were compared with the other methods.

3. CONCLUSION

This literature review covers the various algorithms both conventional and Intelligent techniques used to analyze the Profit Based Unit Commitment Problem. The merits and limitations of each research paper isdiscussed and highlighted. This paper will be the guiding force for the researchers working in the area of PBUC problems.

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