

Unit Commitment in Electrical Power System- A Literature Review

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Abstract--This paper brings out the studies of generation scheduling problem in an electrical power system. This paper presents some general reviews of research and developments in the field of unit commitment based on published articles and web-sites. Here, it is set about to perform a comprehensive survey of research work made in the domain of Unit Commitment using various techniques. This may be a helpful tool for the researchers, scientists or investigators working in the area of unit commitment.

Keywords - Unit Commitment Problem (UCP); Dynamic Programming (DP); Lagrangian Relaxation (LR), Demand.

I. INTRODUCTION

IN the modernistic age of the power system operation, one of the most stimulating interest is to decide which electrical generating units should run in each period so as to satisfy a varying demand for electricity. The problem is interesting because in a typical electrical system there are a variety of units available for generating electricity, and each unit has its own characteristics [1]. Such type of decisions and actions are made under the section Unit Commitment.

Unit Commitment problem (UCP) brings up the task of finding an optimal schedule, and a production level, for each generating unit over a given period of time. The unit commitment decision indicates which generating units are to be in use at each point in time over a scheduling horizon [2,3]. An important criterion in power system operation is to meet the load demand at least possible fuel cost using an amalgamate of different power plants. For such kind of problems, the load requirements, reserve requirements and the constraints of the generating units must be taken into considerations. Solving such type of problem may be computationally expensive in large electrical power systems [3,4].

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Furthermore, in order to supply high quality electric power to customers in a fastened and economical manner, thermal unit commitment is considered to be one of the best available options. The planning of the committed generating units generally for a time period of 1 or 2 days to 2 weeks split down in a periods of 1 hour. The committed units should satisfy the forecasted system load and reserve requirements, at minimal operating cost, subject to a large set of other system, technological and environmental constraints [4]. Also, the available and committed generating units should be able to supply the peak demands as well as the seasonal demands. At one extreme, a nuclear power unit can provide electricity at a very low incremental cost for each additional megawatt hour of energy, but it has both a high cost of starting up again once it has been shut down and it takes awhile to bring it back up to full power. A typical nuclear unit may be shut down only in the Spring or Autumn, when there is very little heating or air-conditioning demand, so demand is lowest. At the other extreme, a gas turbine generator can be started up in a few minutes. However, its incremental cost per megawatt hour is much more expensive [1, 5]. Similarly, the limited amount of hydro-electric energy stored in the dams and the system reservoirs may not prove to be sufficient to respond to high demands. Therefore, costly thermal generating-units are often used to make up for the supply shortage [6]. Since generators cannot instantly turn on and produce power, unit commitment must be planned in advance so that enough generation is always available to handle system demand with an adequate reserve margin in the event that generators or transmission lines go out or load demand increases [7]. The start up and shut down processes are considered in the post-processing step performed after the UC calculation [8]. In case of the worse load forecast, the deviation of the conventional UC solution can be overcome with the lower load level and the more hourly reserve requirements[9]. Several conventional methods are available to solve the UCP. But all these methods need the exact mathematical model of the system and there may be a chance of bog down at the local optimum [10].

II. METHODOLOGIES USED

- a. Priority List Method
- b. Dynamic Programming
- c. Lagrangian Relaxation
- d. Genetic Algorithms
- e. Simulated Annealing
- f. Particle Swarm Optimization
- g. Tabu-Search Method
- h. Fuzzy Logic Algorithm
- i. Evolutionary Programming

a. *Priority List Method*

The simplest unit commitment solution is to list all combinations of units on and off, as well as the corresponding total cost to create a rank list, and then make the decision according to the rank table. This method is called the priority list [11]. The generation of initial solution is important, particularly, for the UC problem. The initial solution is usually generated at random. However this technique is difficult to get a feasible solution for the UC problem with many constraints, resulting in the quality of solution obtained being unsatisfactory [12-14]. The priority list method is an efficient method to overcome this problem. This method is simple and requires short computing time and small computer memory [15]. However, the UC solution obtained from the priority list method may not be the optimal schedule because start-up cost and ramp rate constraints are not included in determining the priority commitment order and AFLC does not adequately reflect the operating cost of generating units when they do not operate at the full load [16-18].

Yang Tingfang and T. O. Ting proposed a methodological priority list method which is simple and more efficient than conventional priority list method and incorporates more intelligent strategy with priority list as the backbone. The solutions obtained by Methodology Priority List method are deterministic [15-21]. The simplicity of the MPL and fast calculation of ED leads to a methodological and competent method in comparison with conventional method [22].

Burns et al. proposed a dynamic priority list that varies with the system demand [23].

b. *Dynamic Programming Method*

The dynamic programming algorithm (DP) has proven to be one of the successful approaches to unit commitment. Due to the enumerative nature of the method, dynamic programming suffers from a long processing time that expands exponentially with the size of the problem, and soon reaches a level that is practically impossible to compute. Therefore, in practice many heuristic strategies have been introduced to limit the dynamic search for a large system [24]. In 1991, Z. Ouyang and S. M. Shahidehpour proposed the DP-TC algorithm and employed various heuristic strategies in the paper. Finally, experimental results are presented which support the methodology by utilizing a much smaller execution time while preserving the quality of the optimization. In [25], a large scale scheduling problem is decomposed into a series of overlap ping sub-problems, and each sub-problem is solved by dynamic programming. One of the algorithm proposed in [26, 27], known as DP-SC, uses a strict priority list search sequence to reduce the possible combinations at every stage. Another method by the same authors employs a fixed search window to truncate the priority list, in which only the truncated combinations are evaluated. This method, known as DP-TC, performs much better than DP-SC as an optimizer; however it requires a much longer processing time.

c. *Lagrangian Relaxation*

LR has been successfully applied to the complex UC problem including various hard constraints (e.g. ramp rate constraints, minimum up and down time, etc.) [28]. However, ramping constraints in UC problem required enlarging state spaces dramatically for dynamic programming to solve each unit subproblem [29]. The total number of states was the sum of number of down states, number of ramp up states, number of up states, and number of ramp down states [30].

M. Bavafa et. al proposed a hybrid Lagrangian relaxation with evolutionary programming and quadratic programming (LREQP) for ramp rate constrained unit commitment (RUC) problem [28].

Xiaohong Guan et. al proposed that Lagrangian relaxation (LR) is one of the most successful approaches [31-34]. One of the most obvious advantages of the Lagrangian relaxation method is its quantitative measure of the solution quality since the cost of the dual function is a lower bound on the cost of the primal problem. For UC problems, the duality gap, the relative difference between the feasible cost and the dual cost is rather small, often with (1-2)% . This accuracy was considered sufficient for industrial applications before the emergence of wholesale competitive energy markets [35-39]. Weeraya Poommalee et. al (2008) obtained the unit commitment considering security-constrained optimal power flow (UC-SCOPF) by using Lagrangian relaxation with genetic algorithm (LRGA) [40].

d. *Genetic Algorithms*

Genetic Algorithms (GAS), whose search is based on natural evolution, are promising techniques for solving the difficult UC problem. GAS can inherently deal with inequality constraints imposed on the control variables, such as power limits, ramping rate and spinning reserve constraints [41].

Gwo-Ching Liao and Ta-Peng Tsao (2002) presented a new approach, 'the hybrid genetic algorithm/fuzzy system and Tabu Search for short-term thermal generating unit commitment. He discussed four improvement plans for the GA. The four improvements include: a). The improvement about regulate scale of fitness function, b). The improvement in the selection

items and reproduction strategy, c). The crossover ratio and mutation ratio are from the fixed value change to be determined using fuzzy system method, d). Importing the best local search method into the algorithm [42].

Li Maojun and Tong Tiaosheng proposed a Gene Complementary Genetic Algorithm for Unit Commitment and constructed three kinds of genetic operators. The results of experiment show that the algorithm proposed in this paper is available for the UCP [43].

S. Jalilzadeh and Y. Pirhayati presented (2009) an Improved Genetic Algorithm (IGA) for UCP with lowest cost. A modified approach to the solution of unit commitment problem using genetic algorithms is proposed in this paper. Improvement in cost and quality of solution is obtained [44].

In order to obtain a near optimal solution in low computational time and storage requirements, with respect to all specified

constraints, Alma Ademovic et al.(2010) presented a Genetic Algorithm using real-coded chromosomes in opposite to the more commonly used binary coded scheme[45].

e. *Simulated Annealing*

Simulated Annealing (SA) is a recent optimization technique, proposed by Kirkpatrick, Gelatt and Vecchi in 1983 [46], which simulate the annealing of metals. Annealing refers to the slow procedure of gradually cooling a metal, until it reaches its “freezing” point, where the energy of the system has acquired the globally minimal value [47].

D. Simopoulos and G. Contaxis (2004) proposed some new rules concerning the cooling schedule and the random generation of the initial solution of the system. The results obtained in system studies show the effectiveness of the proposed model and indicate the need for further work in this area [48].

Dimitris N. Simopoulos et al. presented an enhanced SA algorithm for the solution of the short-term UC problem. The algorithm uses a simple cooling schedule, while an effective approach for the random generation of the initial solution is implemented [49].

Ana Viana et al. (2001) proposed a resolution approach based on Simulated Annealing. The interest of developing code with modular programming languages like C++ has also been enlightened. Two coding schemes (a binary and an integer one) were presented, and a particular attention was given to neighborhood structures and searching strategies [50].

C. Christofer and Asir Rajan (2004) 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 [51].

f. *Particle Swarm Optimization*

P. Sriyanyong, and Y. H. Song (2005), proposed Particle Swarm Optimization (PSO) combined with Lagrange Relaxation method (LR) for solving UCP. The proposed approach employs PSO algorithm for optimal settings of Lagrangian multipliers. The feasibility of the proposed method is demonstrated for four and ten unit systems, respectively [52].

Wei Xiong et al. (2008) presented a new strategy to produce particle, which all of them are feasible solution, enhanced the convergence speed, and applied multi particle swarm to parallel arithmetic, escaped the local optimum solution. The simulation results show that the presented method is more efficient than genetic algorithm, which could obtain the global optimum solution more probably [53].

Yun Won Jeong et al. (2009) presented a new Binary Particle Swarm Optimization-based approach for solving the UC problems. To enhance the performance of the conventional BPSO, this paper proposes a quantum-inspired BPSO (QBPSO) which is based on the concept and principles of

quantum computing such as a quantum bit and superposition of states [54].

Weixun Ge (2010) 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-EPSON). The IPL-EPSON proposed in this paper is a combination of improved priority list (IPL) and enhanced particle swarm optimization (EPSON), which decomposes UC problem into two sub-optimization problems and solves them respectively [55].

g. *Tabu-Search Method*

The Tabu Search (TS) algorithm [7] is mainly used for solving combinatorial optimization problems. It is an iterative search algorithm, characterized by the use of a flexible memory. It is able to eliminate local minima and to search areas beyond a local minimum. The TS method is also mainly used to solve simplified OPF problems such as unit commitment and reactive optimization problems.

C. Christofer Asir Rajan et al. (2002) 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. The results show an improvement in the quality of obtained solutions compared with previous results. The successful implementation presented in this paper highlights the importance of NBTS approach as a powerful tool for solving difficult combinatorial optimization problems [56]. The same authors in 2003 developed an improved version of NBTS approach. They were able to find good UC schedules and their hypothesis was moved beyond doubt by the case study under consideration. It was shown that the results obtained from the proposed method were far superior to those obtained from conventional methods [57]. Borghetti et. al. in [58] suggested that, to explore all of the feasible solution space, the meta-heuristic algorithm should occasionally accept the worse solution than the current one because the exploration of their neighborhood may lead to a better region and a better result. Once there is no better solution in the neighborhood of the current one, the Tabu search is terminated. There is no guarantee that the Tabu search will yield the global optimal result especially with large systems.

h. *Fuzzy Logic Algorithm*

Seyedrasoul Saneifard et al. (1997) proposed that Fuzzy logic is a mathematical theory which encompasses the idea of vagueness when defining a concept or a meaning. In this paper, no attempt has been made to determine the optimality or the degree of optimality that can be obtained using fuzzy logic. The primary objective has been the demonstration that if the process of unit commitment can be described linguistically then such linguistic descriptions can be translated to a solution that yields similar results compared to dynamic programming [59].

D. P. Kadam et al. (2009) described the application of fuzzy logic algorithm for determining short term commitment of thermal units in electrical power generation. The results obtained from fuzzy logic based approach were compared with the priority list method solution to unit commitment problem. The comparison fuzzy logic based approach were powerful tools for solving such highly non-linear, multi constrained optimization problems in electrical power systems. This paper attempts to find the best schedule from a set of good feasible commitment decisions [10].

Bo Wang et al. (2011) used the fuzzy variable to more accurately describe the future power load while the fuzzy Value at Risk is employed as a technique to evaluate the power demand and reserve for each period. To handle the improved unit commitment problem, they proposed a local convergence averse binary particle swarm optimization (LCA-PSO), which overperforms existing algorithms [60].

i. Evolutionary Programming

H. Chen et al. (2002) presented a conjunctive co evolutionary algorithm for unit commitment. The proposed algorithm is a denotation of the conventional evolutionary programming which appears to have considerable potential for formulating and solving more complex problems by precisely modeling the convolution of cooperating species [61].

C. Christober Asir Rajan et. al (2004) used Evolutionary Programming (EP) method in conjunction with the Tabu search method. As indicated in the paper, the EP algorithm has also proved to be an efficient tool for solving the important economic dispatch problem for units with “non smooth” fuel cost functions. Such functions may be included in the proposed EP search for practical problem solving. The main advantage of the proposed algorithm is speed. The EPTS approach avoids entrapping in local optimum solutions. Also, disadvantages of huge memory sizes required by the SA method are eliminated [62].

C. Christober Asir Rajan (2006) presented a new approach to solve the short-term unit commitment problem using An Evolutionary Programming Based Tabu search Method with cooling and banking constraints. The objective of this paper was to find the generation scheduling such that the total operating cost could be minimized, when subjected to a variety of constraints [63].

III. CONCLUSIONS

This paper presents an introductory concept of various methodologies used to solve Unit Commitment Problem in Power System along with literature review of research work on unit commitment Problem. The paper may help the new researchers expeditiously with a brief idea of Power System Unit Commitment and various paper studied may give a quick approach to the new researchers.

IV. BIOGRAPHIES

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