Profit-Based Unit Commitment Problem Using PSO with Modified Dynamic Programming

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***Abstract*- This paper proposes a hybrid approach utilizing particle swarm optimization along with dynamic programming to solve unit commitment problem based on the profit under the deregulated power market. In the deregulated market, power and reserve prices are important factors in the decision process for unit commitment scheduling and offer freedom to utilities to schedule their generators to produce less than predicted load as well as reserve to maximize their profit. To solve the profit based unit commitment problem (PBUCP), the model is divided into exterior and interior dependent sub problems, which are discrete and continuous, respectively. The proposed model helps GENCOs to make a decision, how much power and reserve that must be put up for sale in the market, and how to schedule generators in order to receive the maximum profit. GENCOs with 3 and 10 generating units are used to demonstrate the effectiveness of the proposed approach.**

***Index Terms* - Competitive environment, profit-base unit commitment problem, dynamic programming, particle swarm optimization.**

I. NOMENCLATURE

a_i, b_i, λ_i	Cost coefficients of the i^{th} generating unit.
D_t	System load demand at hour t.
F_{Cost}	Fuel cost or production cost of units.
N	Number of thermal units.
P_F	Profit of GENCOs.
P_{it}	Power generation of i^{th} thermal unit at hour t.
P_i^{max}, P_i^{min}	Max/Min generation of i^{th} thermal unit.
R_{it}	Reserve generation of i^{th} thermal unit at hour t.
R_F	Revenue of GENCOs.
SR_t	Spinning reserve requirements at hour t.
SC_{it}	Startup cost of i^{th} thermal unit at hour t.
$t_{OFF,it}/t_{ON,it}$	Time period that i^{th} thermal unit has been continuously down and up till period t.
T	Number of time interval (hours).
T_C	Total cost over the scheduling horizon.
$T_{ON,i}/T_{OFF,i}$	Minimum up and down time of i^{th} thermal unit.
U_{it}	Schedule state of i^{th} thermal unit for hour t.
$\mathfrak{I}_t$	Forecasted spot price at hour t.
$\mathfrak{R}_t$	Forecasted reserve price at hour t.
ζ	Probability of the reserve.

Authors acknowledge with thanks the partial financial support provided by the Department of Science and Technology (DST), New Delhi, India, under project no. DST/EE/20100127, to carry out the present research work.
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II. INTRODUCTION

DAILY generation scheduling is a critical task in modern energy management systems. The main task of unit commitment problem (UCP) is to find the ON/OFF status of the generating units to meet the forecasted demand, over a short-term period, meeting all kinds of system and unit constraints to minimize total cost. Restructuring of power system has resulted in market-based competition to utilities by creating an open market environment and bringing changes in operation, planning and controlling of the traditional power system [1-2]. Hence, the objective function of minimum production cost is changed to profit maximization. Deregulation in power sector increases the efficiency of electricity production and distribution. It also plays a key role in lowering prices, with higher quality and reliability by allowing customers to choose their supplier. In deregulated market, power and reserve prices are important factors in decision making process for unit commitment scheduling, because the profit of GENCOs depend on revenue and production cost. Therefore, its offers freedom to utilities to schedule their generators to produce less than predicted load and reserve in the market which can produce maximum revenue with minimum production cost in order to maximize their overall profit.

To solve PBUCP, several methods have been proposed, such as priority list (PL) [3], dynamic programming (DP) [4], Lagrangian relaxation (LR) approach [5], Muller method (MM) [6], etc. These methods are known as classical or numerical optimization techniques. Although, these methods are generally fast and simple, but most of them suffer from numerical convergence and solution quality problems. Some stochastic search methods such as genetic algorithm (GA) [7], particle swarm optimization (PSO) [8-9], artificial bee colony (ABC) [10], evolutionary programming (EP) [11], simulated annealing (SA) [12], etc. can successfully handle complex nonlinear constraints and provide high-quality solutions, but these methods suffer from the dimensionality problem. Later, efforts have been made to develop hybrid techniques, such as LR with GA (LR-GA) [13], LR with EP (LR-EP) [14], LR with PSO (LR-PSO) [15], Tabu search based hybrid technique (TS-IRP) [16], etc., for better and faster optimum results to overcome these problems. Some other intelligent techniques, such as selective enumerative method with dynamic programming [17], multi-agent system (MAS) [18], new multi-agent approach [19-20] etc. also have been used to solve PBUCP effectively.

Compared to other evolutionary techniques, the characteristic of the PSO is simple to implement to find a number of high

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