

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-based unit commitment problem, dynamic programming, particle swarm optimization.

I. NOMENCLATURE

a_i, b_i, c_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_i	Profit of GENCOs.
P_{it}	Power generation of i^{th} thermal unit at hour t .
$P_i^{\text{max}}, P_i^{\text{min}}$	Max/Min generation of i^{th} thermal unit.
R_{it}	Reserve generation of i^{th} thermal unit at hour t .
R_i	Revenue of GENCOs.
SR_{it}	Spinning reserve requirements at hour t .
SC_{it}	Startup cost of i^{th} thermal unit at hour t .
$T_{\text{down}}, T_{\text{on}}$	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.
$T_{\text{on}}/T_{\text{down}}$	Minimum up and down time of i^{th} thermal unit.
U_{it}	Schedule state of i^{th} thermal unit for hour t .
$\mathcal{S}_t$	Forecasted spot price at hour t .
$\mathcal{R}_t$	Forecasted reserve price at hour t .
ζ	Probability of the reserve.

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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, it 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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Table of Contents Matlab Code For Pso Based Unit Commitment

1. Understanding the eBook Matlab Code For Pso Based Unit Commitment
 - The Rise of Digital Reading Matlab Code For Pso Based Unit Commitment
 - Advantages of eBooks Over Traditional Books
2. Identifying Matlab Code For Pso Based Unit Commitment
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Matlab Code For Pso Based Unit Commitment
 - User-Friendly Interface
4. Exploring eBook Recommendations from Matlab Code For Pso Based Unit Commitment
 - Personalized Recommendations
 - Matlab Code For Pso Based Unit Commitment User Reviews and Ratings
 - Matlab Code For Pso Based Unit Commitment and Bestseller Lists
5. Accessing Matlab Code For Pso Based Unit Commitment Free and Paid eBooks
 - Matlab Code For Pso Based Unit Commitment Public Domain eBooks
 - Matlab Code For Pso Based Unit Commitment eBook Subscription Services
 - Matlab Code For Pso Based Unit Commitment Budget-Friendly Options

6. Navigating Matlab Code For Pso Based Unit Commitment eBook Formats
 - ePub, PDF, MOBI, and More
 - Matlab Code For Pso Based Unit Commitment Compatibility with Devices
 - Matlab Code For Pso Based Unit Commitment Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Matlab Code For Pso Based Unit Commitment
 - Highlighting and Note-Taking Matlab Code For Pso Based Unit Commitment
 - Interactive Elements Matlab Code For Pso Based Unit Commitment
8. Staying Engaged with Matlab Code For Pso Based Unit Commitment
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Matlab Code For Pso Based Unit Commitment
9. Balancing eBooks and Physical Books Matlab Code For Pso Based Unit Commitment
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Matlab Code For Pso Based Unit Commitment
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Matlab Code For Pso Based Unit Commitment
 - Setting Reading Goals Matlab Code For Pso Based Unit Commitment
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Matlab Code For Pso Based Unit Commitment
 - Fact-Checking eBook Content of Matlab Code For Pso Based Unit Commitment
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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