# Optimized Economic Dispatch in Multi-Area Systems Using Modified PSO

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**Abstract.** Optimizing the placement of power generation capacity across several regions to satisfy demand while lowering costs and abiding by operational restrictions is the main goal of the Multi-Area Economic Dispatch (MAED) problem. Traditional optimization methods often struggle with the complexities of multi-area systems, necessitating advanced techniques such as Integrated Particle Swarm Optimization (IPSO). This study introduces an enhanced version of PSO, IPSO, which incorporates adaptive parameter adjustments, diversity preservation mechanisms, and problem- specific operators to address the challenges of MAED. The usefulness of the suggested IPSO approach in solving large- scale, non- convex MAED issues is demonstrated through testing on a system with 40 generators. According to the results, IPSO is a potential tool for power system optimization since it performs better than traditional techniques in terms of robustness, computing efficiency, and solution quality

*Keywords—— Power Systems, Optimization Algorithms, Multi-Area Systems, Fuel Cost Minimization,*

## INTRODUCTION

This When The Economic Dispatch (ED) problem is a critical challenge in power system optimization, particularly in interconnected multi-area systems. While reducing expenses and abiding by operational restrictions such gearbox limits, environmental laws, and generator capacities, efficient ED guarantees the best possible allocation of generation resources among areas to satisfy demand.

Traditional optimization techniques, including gradient-based methods and evolutionary algorithms, often fall short when applied to multi-area systems due to their high-dimensional, non-linear, and non-convex nature. Because of its ease of use and efficiency in resolving intricate optimization issues, particle swarm optimization, or PSO, has grown in prominence. However, standard PSO algorithms face limitations such as premature convergence, lack of diversity, and poor handling of constraints in multi-area systems. An Improved PSO (IPSO) method, which combines adaptive parameter tuning, diversity maintenance techniques, and problem-specific operators designed for MAED, is projected in this paper to address these problems.

The IPSO algorithm dynamically adjusts parameters such as inertia power and acceleration factors to balance exploration and exploitation, ensuring faster convergence and higher solution quality. This is how the paper is structured: In Section II, we examine the current literature on PSO and its different variations for economic dispatch. Section III introduces the projected IPSO algorithm, and Section IV covers the results and evaluates the performance. Finally, Section V wraps up the study and gives a summary of possible future research paths.

# REVIEW OF LITERATURE

Before Wu et al. (2014) propose an Improved Particle Swarm Optimization (IPSO) algorithm to address the Economic Dispatch Problem (EDP) with non-convex cost functions, particularly concentrating on the impact of key point compression. The IPSO algorithm introduces two key modifications: (1) a position update mechanism that initially relies on individual particle experiences and later shifts to global best experiences, and (2) a mutation operator to enhance maintaining demographic variety and avoiding untimely convergence. The algorithm is tested on benchmark EDPs with valve-point effects, and the results demonstrate that IPSO outperforms traditional PSO and other metaheuristic algorithms regarding velocity of convergence and solution standard. The mutation operator effectively maintains diversity, enabling the algorithm to escape local optima and achieve near-global solutions. The study concludes that IPSO is a robust and efficient method for solving complex EDPs with non-convex cost functions. Finds IPSO achieves superior solution quality and convergence compared to traditional PSO., The mutation operator enhances diversity and prevents premature convergence. The algorithm is effective in handling non-convex cost functions with valve-point effects [1].

Kumar et al. (2014) present three improved PSO algorithms (IPSO-A, IPSO-B, and IPSO-C) for solving the Economic Load Dispatch (ELD) problem. These algorithms combine inertia weight and constriction factor techniques to enhance the performance of conventional PSO. The study evaluates the algorithms on IEEE 5, 14, and 30 bus systems, conducting 20 independent experiments for each algorithm. Results show that the proposed IPSO algorithms achieve lower operating costs and more consistent solutions compared to traditional PSO. The algorithms also demonstrate robustness in handling non-linear constraints and high-dimensional search spaces. The study highlights the importance of balancing exploration and exploitation in PSO to achieve optimal solutions for ELD problems. IPSO-states that , IPSO-B, and IPSO-C outperform traditional PSO in terms of cost minimization. The algorithms exhibit consistent performance across multiple test systems. Combining inertia weight and constriction factor improves convergence and solution quality. [2].

Chiang (2012) introduces an IPSO algorithm tailored for Power Economic Dispatch (PED) problems with prohibited operating zones (POZs). The algorithm incorporates a migration mechanism and accelerated functionality to enhance search efficiency. It also employs a multiplier update (MU) method to handle equality and inequality constraints effectively. The proposed IPSO-MU algorithm is tested on a real-world case study, and its performance is compared with other optimization methods. Results indicate that IPSO-MU achieves better solutions with lower computational effort, particularly for non-convex fuel cost functions. The study concludes that the integration of IPSO and MU simplifies implementation and improves efficiency in solving PED problems with POZs. Concluded that IPSO-MU effectively handles non-convex fuel cost functions and POZs. The algorithm [3].

Othman et al. (2012) propose a hybrid PSO algorithm that combines evolutionary techniques for particle initialization to improve the performance of PSO in solving the Economic Dispatch Problem (EDP). The algorithm uses an evolutionary approach to generate an initial population of particles, ensuring better diversity and coverage of the search space. The study evaluates the algorithm on standard test systems and compares its performance with traditional PSO. Results show that the hybrid approach achieves faster convergence and better solution quality, particularly in handling non-linear constraints and non-convex cost functions. The study emphasizes the importance of effective initialization in enhancing the performance of PSO for EDP .Find that Evolutionary initialization improves diversity and search space coverage. The hybrid PSO algorithm achieves faster convergence and better [4]. Pandit (2011) develops an IPSO algorithm to address non-convex static and dynamic economic dispatch problems. The algorithm incorporates a velocity reset mechanism to prevent premature convergence and a parameter automation technique to balance local and global search. The study tests the algorithm on five standard test systems and compares its performance with existing

methods. Results demonstrate that IPSO achieves superior solutions with reduced computational effort, particularly for non-convex and multimodal functions. The study concludes that IPSO is a robust and efficient method for solving complex economic dispatch problems. Summarize IPSO

effectively handles non- convex and multimodal functions The velocity reset [5].

Park et al. (2010) propose an IPSO framework to solve non-convex economic dispatch problems with complex constraints. The framework incorporates chaotic sequences, linearly decreasing inertia weights, and crossover

operations to enhance exploration and exploitation. The algorithm is tested on three non-convex ED problems, including valve-point effects, ramp rate limits, and prohibited operating zones. Results show that IPSO achieves better solution quality and convergence compared to traditional PSO and other state-of-the-art methods. The study highlights the effectiveness of IPSO in handling non-convex and heavily constrained ED problems. Find that IPSO achieves superior solution quality for non-convex ED problems. Chaotic sequences and crossover operations enhance exploration and exploitation. The algorithm effectively handles complex constraints and non-convex cost [6].

Lala et al. (2010) propose an IPSO algorithm for solving the Unit Commitment Problem (UCP). The algorithm incorporates problem-specific heuristics to handle constraints and improve solution quality. The study demonstrates the effectiveness of IPSO in achieving optimal unit commitment schedules with reduced computational effort. The algorithm is tested on standard test systems, and results show that it outperforms traditional PSO and other optimization methods in terms of cost minimization and constraint handling. Concluded that IPSO achieves optimal unit commitment schedules with reduced computational effort. Problem-specific heuristics improve constraint handling and solution quality. The algorithm outperforms traditional PSO and other optimization methods.[7].

Neyestani et al. (2010) propose a modified PSO algorithm to solve economic dispatch problems with non- smooth cost functions. The algorithm incorporates a mutation operator to enhance diversity and prevent premature convergence. The study evaluates the algorithm on standard test systems and compares its performance with traditional PSO. Results show that the modified PSO achieves better solution quality and convergence, particularly for non-smooth cost functions. The study concludes that the mutation operator is effective in maintaining diversity and improving solution quality. Finding that The modified PSO achieves better solution quality for non-smooth cost functions .The mutation operator enhances diversity and prevents premature convergence. The algorithm outperforms traditional PSO in terms of convergence and solution quality.[8]

Chopra et al. (2021) propose a hybrid PSO algorithm combining simplex search and PSO to solve environmentally constrained economic dispatch problems. The algorithm is tested on real-world scenarios, and results show that it achieves better solutions compared to traditional PSO and other optimization methods. The study highlights the effectiveness of the hybrid approach in handling complex constraints and achieving optimal solutions. concluded The hybrid PSO algorithm achieves superior solutions for constrained economic dispatch. The simplex search enhances the performance of PSO. The algorithm effectively handles environmental constraints and achieves optimal solutions.[10]

Abbas et al. (2017) provide a comprehensive survey of PSO and its variants for solving economic dispatch problems. The study reviews the challenges posed by non-convex cost functions and operational constraints and highlights the need for hybrid PSO approaches to improve computational efficiency. The survey concludes that PSO is a powerful tool for solving economic dispatch problems but requires further enhancements to handle the complexities of modern power systems. PSO is effective for solving economic dispatch problems but has limitations. Hybrid PSO approaches improve computational efficiency and solution quality. Further research is needed to address the challenges of non- convex cost functions and operational constraints. [9]

## METHODOLOGY

Mutation operators and crowding-based selection are incorporated to preserve solution diversity and prevent premature convergence. Problem-Specific Operators: Customized heuristics are introduced to handle constraints such as transmission line limits, reserve requirements, and renewable energy integration uncertainties. The algorithm is implemented in MATLAB and tested on a 40-generator system with six interconnecting tie-lines. The population's size is set at fifty, and the algorithm runs for a maximum of 1500 iterations (RAM).

# RESULTS AND DISCUSSION

The Finding the ideal number for ks depends heavily on the experiments conducted on this system. The intended results were obtained by testing PSO with ks values increasing in steps of 0.05 and ranging from 0.05 to 0.25.

Interestingly, the system achieved the minimum standard deviation (STD) and the ideal average fuel cost when ks was adjusted to 0.10. Consequently, ks = 0.10 was chosen for additional simulations. Following the implementation of the suggested IPSO method, the system's performance was assessed across 100 trials, as shown in Table 1. The findings unequivocally show that IPSO uses computing resources significantly more efficiently than alternative approaches. To better understand the effects of the modifications made to the PSO control equation, the variants were separated into four distinct sections. 'a' represents the conventional PSO.'b': Refers to 'a' with exponential adjustments to the inertia weight. 'c': Builds on 'b' by incorporating previous experience into the cognitive component. 'd': Represents the final proposed Improved PSO (IPSO). These categories help demonstrate how each modification contributes to the overall performance of the algorithm.
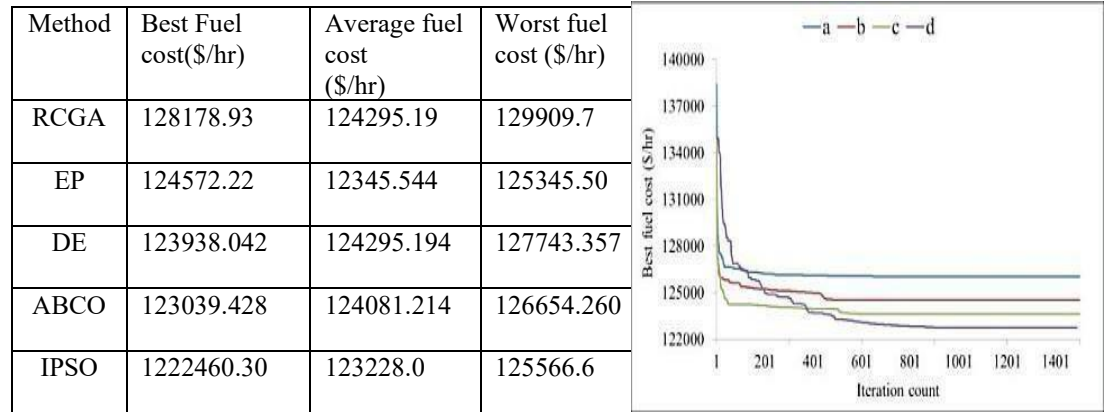
| Method | Best Fuel cost($/hr) | Average fuel cost ($/hr) | Worst fuel cost ($/hr) |
|--------|----------------------|--------------------------|------------------------|
| RCGA   | 128178.93            | 124295.19                | 129909.7               |
| EP     | 124572.22            | 12345.544                | 125345.50              |
| DE     | 123938.042           | 124295.194               | 127743.357             |
| ABCO   | 123039.428           | 124081.214               | 126654.260             |
| IPSO   | 1222460.30           | 123228.0                 | 125566.6               |

*TABLE I. COMPARING FUEL COST*



*FIG 1: Convergence feature for best fuel cost*

By progressively avoiding local optima, Figure 1 shows how modifying the motion volume, cognitively element, and community factor in the fundamental PSO control equation improves convergence. From the figure, it is clear that the initial convergence patterns are relatively consistent across all variations, except for IPSO. This highlights the importance of the constriction factor added to the social component of a particle's velocity, which plays a key role in improving convergence in IPSO. further reinforces this observation. The graphic reveals that particles struggle to identify promising regions in the initial state when IPSO is applied independently. This suggests that careful exploration of the search space during these initial stages is crucial, ultimately leading to higher- quality solutions. IPSO outperforms conventional PSO techniques by striking a balance between exploration and exploitation.

## CONCLUSION

The In order to solve the difficult MAED problem in a large-scale test generating system with a variety of operating limitations, the practicality of the suggested approach has currently been examined. The application results demonstrate the efficacy of the suggested strategy and its ability to stay out of local minima. The analysis of application outcomes demonstrates that the suggested approach can generate higher-quality solutions and is more computationally efficient than other tried-and-true methods. It is noteworthy that the suggested IPSO eliminates the need for any extra methods to prevent local entrapment and limits the particle velocity using an empirical formula, hence shrinking the search space. Furthermore, it is unaffected by the initial state of the particle.

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