



Economic Load Dispatch using IYSGA

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Abstract:

The Economic Load Dispatch (ELD) problem is a pivotal aspect of power system management, focusing on the efficient allocation of power generation among various units to meet the demand while minimizing costs. This research paper presents an Improved Yellow Saddle Goat Fish Algorithm (IYSGA) based method for resolving ELD issues. The key objective of proposed IYSGA method is to reduce error between demanded and generated load along with its unit cost. This objective is accomplished by using YSGA whose

exploration ability is improved by exploring ability of Grasshopper Optimization Algorithm (GOA). By implementing IYSGA in given ELD problem, the convergence rate, exploring ability and solution quality is enhanced. The fitness function is determined by IYSGA in terms of error and cost reduction, which should be as minimum as possible. The simulations are performed on standardized IEEE bus system with 3-unit and 6-units to meet load demand of 850MW to 1263MW respectively. The experimental simulations conducted provide evidence that the proposed approach met the load demand with zero error. Furthermore, proposed method attained best cost of \$8197.633 and \$15,285.7055 for the 3-unit and 6-unit generation unit. These outcomes underscore the robustness and superiority of the proposed method in addressing the Economic Load Dispatch (ELD) problem, emphasizing its capacity to optimize power generation with unparalleled precision and cost-effectiveness.

Keywords: *Economic Load Dispatch, Multi-objective, Power systems, Optimization, Yellow Saddle Goat Fish Algorithm.*

Introduction

The continuous growth of the global economy is driving up the consumption of traditional fossil fuels and the need for energy (Zou, et al., 2016). The growing contradiction between energy scarcity and economic expansion necessitates a reduction in energy costs per GDP unit if the global economy is to grow sustainably. Since, electricity is one of the major economic and energy sectors that needs huge amount of fossil fuels for its operation and hence, will depend more and more on renewable energy (Wadim, et

al., 2021). To ensure smooth and reliable operation in electricity industry, lower prices for energy and emissions of harmful substances are essential (Hussein, 2022). Ensuring electric power systems are of the greatest quality and simultaneously economically feasible requires optimising the system's building costs. However, the economic dispatch (ED) problem in power networks represents the anticipated amount of demand which must be distributed amongst the electricity producers in order to provide the lowest feasible operational cost (Nikmehr, et al.,



2015). Optimisation of these systems must minimise the goal function while maintaining an appropriate and acceptable level of system efficiency. Since scheduling producing unit activities is its main objective, it aims to achieve the highest efficiency at the lowest possible operation cost, which means that customers will pay less for energy and the service provider may make money in the market for energy. Because of this, most people agree that ED is an important aspect of the power structure management and operation. The generated electrical power has to satisfy changing load requirements while feeding the load in real time as it cannot be stored in a bulk unit. To meet the demand in real time, multiple generating units would be required.

In an ideal situation, it is desirable to provide power to the demand side at the lowest feasible cost. However, ELD problems are considered as core power system problems. Its basic objective is to Minimize the total production cost of the thermal power station whilst adhering to equity and inequality requirements (Ali, 2021). In some scenarios, the limitations of the transmission system are overlooked when dispatching loads economically. The main goal of this method is not to determine which producing unit should be switched on or off, rather it depicts the fast way to determine the most profitable way to run and produce units under a given set of generating and transmission constraints. Traditionally, some researchers thought that cost curves of generator are monotonic and continuous, however, it turned out to be false assumption which resulted in revenue loss. Numerous conventional techniques, such as the Newton-Raphson approach, the lambda iteration strategy, the linear programming technique, and the dynamic programming technique, have been developed to handle ELD concerns (Rahman, et al., 2021). The economic load scheduling problem means minimising a given cost function under various constraints and is given by below equations.

$$\min\{\sum_{i=1}^{n_G} C_i (P_{Gi})\}$$

$$P_{Gi} \min \leq P_{Gi} \leq P_{Gi} \max \quad (1)$$

$$P_{ij} \leq P_{ij}M \quad (2)$$

$$\sum P_{Gi} = PD + PL \quad (3)$$

where generally $C_i P_{Gi}$ is quadratic curve;

$$C_i P_{Gi} = a_i + b_i P_{Gi} + c_i P_{Gi}^2 \quad (4)$$

Here a_i , b_i , and c_i stand for the known coefficients. The constraints given in equation (1), (2), and (3) clearly correspond to generating limitations, the line power flow limit, and active power balancing, correspondingly (Sahni, et al., 2021).

The problem of ELD problem in power systems have been solved in past few years by using optimization algorithms (Deb, et al., 2021). Optimisation techniques are essential because the cost functions associated with every producing unit are often nonlinear and quadratic, making it difficult to navigate the solution space and find the optimal values of power production. These techniques are highly effective in controlling complex, multi-unit, large-scale systems as well as play a significant role in satisfying various equality and inequality constraints. Unit-specific electrical output restrictions or the power balance constraint are the two constraints in ELD that ensure that generated power meets demanded power demand. Moreover, these constraints are integral components of the ELD problem, guiding the optimization process to adhere to operational limitations and maintain grid reliability. These techniques also make it easier to perform sensitivity analyses, which look into how different parameters like ramp rate limits and transmission restrictions impact the optimal answer. Generally, optimisation techniques are crucial tools for successfully and economically handling the challenging ELD problem in power systems (Al-Betar, et al., 2023). The core of energy distribution, a common issue in electrical system functioning, is the effort of regulating thermal generators for a predefined peak load while battling several operational and physical constraints. In addition, ED is a single-objective

optimisation problem whose goal is to dispatch electricity as inexpensively as possible without breaking any limits. Nevertheless, whenever an emission target is added, ED becomes a multi-objective issue with the goal of minimising cost and emission while abiding by limitations. This kind of multi-objective problem is known as combined economic emission dispatch, or CEED. The complex, nonlinear, and computationally demanding architecture of electrical systems creates functional obstacles for both CEED and ED, diminishing the efficacy of MGs. Due to their mathematical complexity, optimisation methods are a great option for tackling and proving their validity. A few common ELD techniques are described in the section that follows.

The remaining sections of this paper are categorized as; Section 2 reviews different optimization based ELD approaches proposed in past, followed up by problem statement. Section 3 discusses proposed work and its step wise methodology. Section 4 explains the results obtained for proposed approach on IEEE bus system in terms of power and cost and finally conclusion of paper is written in Section 5.

Literature Review

Over the past few years, a diverse range of methodologies has been explored to enhance the efficiency and accuracy of power system operations. Researchers have delved into the application of nature-inspired algorithms, such as Particle Swarm Optimization (PSO), and GOA, GWO and others to address the intricate challenges posed by ELD. Some of these methods are discussed here. Wulandhari, et al. [10], utilized bat method for reducing the overall generating price from thermal power plants. In comparison to the real cost, the experiment findings indicated that the Bat method could save around 1.23%, whereas the Firefly algorithm could only save 0.12%. Moreover, R. Ghanizadeh et al. (2019), proposed ELD approach based on Teaching-Learning-Based Optimization (TLBO). To assess the effectiveness of the suggested approach, they take into account the economic load dispatch for

a network consisting of six power plant units. The usefulness of the suggested method was demonstrated by comparing the outcomes of simulations with those of other algorithms, indicating that the suggested approach could be a dependable solution for ELD difficulties. Yasin et al., (2018), introduced the Multi-objective Cuckoo Search Algorithm (MOCSA) to address the ELD issue. The primary objective of the ELD was to fulfill network equality and inequality requirements by selecting the committed producing unit's output in order to satisfy load demand at the lowest possible operational cost. By means of a comparison with other methods like Multi-objective Genetic Algorithm (MOGA) and Multi-objective Particle Swarm Optimization (MOPSO), the efficacy of MOCSA's performances was demonstrated with regard to fitness values. Furthermore, U K Gupta et al. (2014), demonstrated the use of the GA approach to solve an ELD issue related to thermal generators. On three and six generator systems, the suggested approach has been put into practice. It was the lossless scheme that was being examined here. When compared to standard methodologies, the findings produced demonstrated a considerable enhancement in generator fuel cost while meeting different equality and inequality restrictions. Also addressed non-linear issues associated with ELD by employing TLBO. The convergence ratio-optimal solution to the non-linear issue was contacted by TLBO given the limitations of voltages, actual power, transformer tapping, and reactive energy, shunt capacitor, etc. (Kaur et al., 2017). In order to meet operational restrictions at the same time, the ELD's goal was to distribute the entire loss in transmission and the entire load demand across power plants. This research proposed a way to increase the ELD's efficiency responsiveness via the use of fuzzy logic optimization and genetic method techniques. S Harminder et al. (2016), presented multiverse optimization (MVO) approach as a solution to the ELD issue. Furthermore, this research concluded with a comparison of the ELD problem-solving outcomes from MVO with other renowned current methodologies, demonstrating the superiority of MVO over other approaches. L Daniel et al. (2019),

proposed Ant Lion Optimization (ALO) technique for solving ELD issues in power systems. In order to solve the ELD, this suggested solution was evaluated with 3, 6, and 20 units. Findings indicated that the method provided an accurate solution for ELD issues and good convergence characteristics. Moreover, Y Kun, et al. (2022) enhanced whale optimization algorithm (IWOA) was the basis of a unique approach to the ELD problem, and its optimization efficacy in ELDP was thoroughly assessed. To increase the method's rate of convergence, the adaptive nonlinear inertia weight was included. To enhance the method's convergence, a restricted mutation method was suggested. When there were more than eight activated units, IWOA's computation accuracy outperformed WOA's. Furthermore, Fu. C et al. (2020) suggested the use of the Improved Bird Swarm Algorithm (IBSA). To further improve the unpredictability, the Levy flight method was introduced to the group between providers and the needy. Moreover, two systems, including six and fifteen units, accordingly, were used to verify the efficacy of IBSA. Additionally, Nabihah Ahmad et al. (2019), an effective optimization method based on a genetic algorithm approach was used in this research to tackle the ELD problem. Six generators in a 315 MW, 330 megawatts (MW), and 342 MW IEEE-30 bus systems were used in the simulation, which accounts for losses. Moreover, the outcomes were then examined and contrasted in relation to the operational expenses in this article. The bus system's fuel costs were contrasted when the load demand was 450 MW and losses were taken into account. To increase the system's reliability and invalidity, power loss and running costs were both crucial components of the system architecture.

It is observed that over the past few years, an ample number of optimization algorithms have been presented by various researchers to solve the ELD issue. However, there are still a number of issues associated with these methods that hinder their efficient working. One of the major limitations of conventional approaches is their slow convergence rate and tendency to get trapped in local minima. Moreover, the

exploration and exploitation abilities of majority of these optimization algorithms were not balanced specifically when dealing with complex and multi-objective optimization problems. Keeping these limitations in mind, the need for developing an effective and cost-effective method arises that can solve above mentioned issues.

Proposed Work

With the aim to overcome the limitations of conventional ELD approaches, a cost-effective and reliable method namely as, Improved YSGA is proposed in this paper. The proposed approach basically has two objectives of error reduction and cost reduction. By implementing the proposed improved YSGA approach, we tried to reduce the error between the demanded load and generated load. However, satisfying the demanded load criteria only is not considered as effective and hence, we devised our second objective of reducing cost as well. To achieve these objectives, standard YSGA is improved with exploration ability of GOA. The motivation behind adopting YSGA for ELD issue lies in its unique capacity to explore the entire search space with two searching agents i.e., Chaser and Blocker. The Chaser fish is tasked with locating the prey, while the Blocker fish ensures the prey's containment. This distinct hunting behavior enables YSGA to generate optimized outcomes by its boosting accuracy and convergence rates compared to alternative optimization algorithms. Despite YSGA's efficacy, there might be a possibility where it may not uncover an optimal solution during its zone changing process. To address this, the exploration phase of YSGA is enhanced by integrating the searching ability of the GOA. The synergistic collaboration between YSGA and GOA strengthens the algorithm's ability to explore the solution space comprehensively, overcoming potential limitations in the exploration process. The improved YSGA algorithm subsequently evaluates the fitness function, which, in our case, encompasses both error and cost reduction considerations. The fitness value that aligns with the ability to satisfy the current load demand while minimizing costs is meticulously selected. This selected fitness

value is then implemented in a real power system, thereby offering a pragmatic and efficient solution to the Economic Load Dispatch problem. The detailed working of Improved YSGA method is explained in subsequent Methodology Section of this paper.

Methodology

Before discussing the step wise working of proposed improved YSGA method, it is important to mention that transmission losses and other constraints of power units are ignored in proposed work. Also, the working flow remains same for 3 unit and 6 unit power systems except their power generation limits and cost characteristics.

Step 1

The very first step of proposed work is to gather information regarding power systems containing different power generating units along with their least and maximum generating capacity. As mentioned earlier, we are dealing with two systems of 3-unit and 6 unit, therefore, details of both systems are explained separately in this part.

For 3 Unit System

The system is examined on IEEE bus system which comprises of three generating units, denoted by “P1, P2 and P3” to satisfy the demanded load of 850MW. The min and max

generation ability of each power unit is mentioned in Table 1.

Table 1. Power Generation Capacity of 3 Unit Generators

Parameter	P1	P2	P3
Min	100MW	100MW	50MW
Max	600MW	400MW	200MW

Based on this generation capacity, the values of unit generation “ P_i ” is generated by using the quadratic input-output method whose equation is given in equation 5 and values in Table 2.

$$F_i(P_i) = a_i P_i^2 + b_i P_i + c_i \quad (5)$$

Table 2. Input-Output Cost Characteristics

Parameter	P1	P2	P3
a_i	0.001562	0.00194	0.00482
b_i	7.92	7.85	7.97
c_i	561	310	78

For 6-Unit System

In the same manner, the min and max generation ability of 6 generating units (P1, P2, P3, P4, P5 and P6) operated on IEEE-30 bus system is attained along with their unit cost. The details of costing and capacity are given in Table 3.

Table 3. Unit cost and Capacity Characteristics of 6 Unit Generators

Unit	P_i^{min}	P_i^{max}	α_i (\$)	β_i (\$/MW)	γ_i (\$/MW ²)
P1	100	500	240	7.0	0.0070
P2	50	200	200	10.0	0.0095
P3	80	300	220	8.5	0.0090
P4	50	150	200	11.0	0.0090
P5	50	200	220	10.5	0.00080
P6	50	120	190	12.0	0.0075

Step 2

In the next step, different parameters of Improved YSGA method are initialized to streamline the optimization process for current problem. The value of some basic parameters

including population size, iterations, dimension and others are given in Table 4, along with their specified values. The population size in this case defines the information of power system gathered in previous step.

Table 4. Initialization Parameters of Improved YSGA

S.no	Parameter	Values
1	Population Size	20
2	Iterations	50
3	Dim	3
4	Clusters	4
5	Min Exploration Factor	0.1
6	Max exploration factor	1

Step 3

After initialization, the fitness value is calculated for every particle which in our case is error reduction between demanded load and generated load and cost. The fitness function in proposed method for error and cost is evaluated using equation 6 and 7 respectively.

$$Fitness = P_d \sum_{i=1}^N P_i \quad (6)$$

Wherein, P_d depicts the demanded load, N depicts the number of units and P_i depicts the power generated by individual unit.

$$Cost = \sum_{i=1}^N F_i P_i \quad (7)$$

In this context, F_i and P_i denote the functions utilized for calculating the cost for each unit, respectively and can be calculated by using equation (8).

$$F_i P_i = [a_i P_i^2 + b_i P_i + c_i + |e_i \sin(f_i(P_i^{min} - P_i))|] \quad (8)$$

Wherein, coefficients like a_i, b_i, c_i and e_i, f_i depicts smooth and non-smooth coefficients belong to unit “i” and sine function denotes its impact of valve-point load obtained waves in heat-rate.

Step 4

Following this, the global best solution (Φ_{best}) is determined based on the fitness achieved in

previous step. Subsequently, the entire population (P) is divided into four clusters using k-means clustering algorithm. Within each cluster, a chaser fish φ_i and blocker fish φ_g are identified to initiate the process of searching for solutions.

Step 5

In the next step of proposed work, hunting and blocking mechanism of chaser and blocker fishes are implemented by using equation 9 and 10 respectively.

$$\varphi_i^{t+1} = \varphi_i^t + \alpha \oplus Levy(\beta) \quad (8)$$

$$0 < \beta \leq 2 \text{ and } \alpha = 1$$

$$\varphi_i^{t+1} = D_g * e^{b\rho} * Cos2\pi\rho + \varphi_i \quad (9)$$

Again, the fitness value for each fish is calculated by using the equations given in step 3.

Step 6

Next, if blocker fish got the best fitness value than chaser, roles are exchanged which means current chaser fish assumes role of blocker and current blocker becomes chaser fish. Nevertheless, in case if chaser has got best fitness compared to global best, then global best value is subsequently updated.

Step 7

If the fitness of the Chaser fish fails to show improvement, a counter is incremented until a predefined limit is reached. This iterative process is executed until the value of 'q' is less than λ . Once the limit is exceeded, a zone change is initiated, indicating lack of further solutions in the given search space. In such instances, the global exploration factor is updated using the GOA's Equation 11.

$$P_i^d = c \left(\sum_{i=1}^N c \frac{Ub_d - lb_d}{2} S(|P_j^d - P_i^d|) \frac{P_j - P_i}{a_{ij}} \right) + \hat{T}_d \quad (11)$$

Step 8

The procedure is iteratively conducted for a predetermined number of iterations, capturing, and retaining the best fitness value attained. This fitness value serves as an indicator of an optimal or sub-optimal solution to ELD problem, ensuring the satisfaction of the demanded load at a minimized cost. Subsequently, leveraging this fitness value, the outcomes are derived in the form of power and cost that are discussed in coming up sections.

Results and Discussion

The performance of proposed improved YSGA is tested on two IEEE testing beds having 3 and 6 generating units and load demand of 850MW and 1263MW respectively. The proposed method tends to solve the ELD problem with improved YSGA for 3 units generators and 6-unit generators. The detailed analysis of results obtained for both units in terms of power generation and cost are discussed below.

3 Unit System

The 3 units generator ability to satisfy the load demand of 850MW is tested on standard IEEE bus system. To begin with, performance of proposed improved YSGA approach is tested in terms of its power generation ability for 3-unit system that is executed 5 times. The analytical comparison graph for power generated by three units “P1, P2 and P3” are shown in Figure 1. From the given graph, it is observed that average value of power generated by P1 is 367MW, highest of other two generators i.e., P2 and P3. Nevertheless, the P2 also generated an average power of 351.8MW whereas, P3 generated power of 131.2 MW to satisfy the load demand of 850MW.

Furthermore, as cost is an important factor in solving the ELD problem in power systems. Therefore, we have also analyzed the cost characteristics of proposed method for different executions. The simulating graph is displayed in figure 2. Through this graph, it is observed that

least cost of 8197.633 \$/h is attained during Exec 3 for meeting the load demand of 850MW. Also, the highest cost of 8218.866 \$/h is attained for Exec 1 for meeting the given load demand. On an average, the cost of generated power came out to be 8205.787 \$/h. The specific value of power generated and cost for each execution is shown in Table 5.

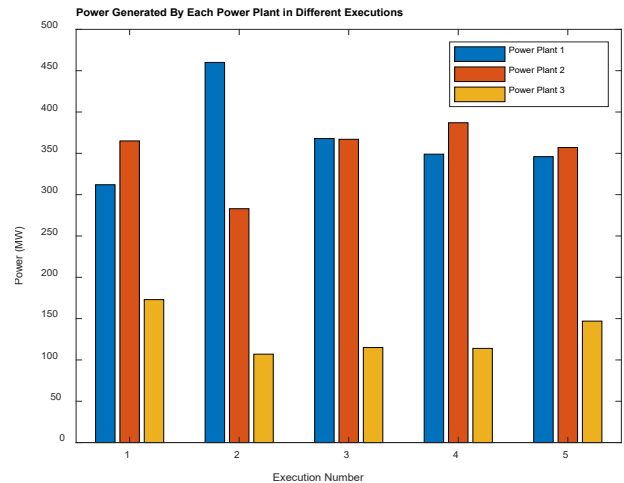


Figure 1. Analysis of Power Generated by 3 Units by Improved YSGA

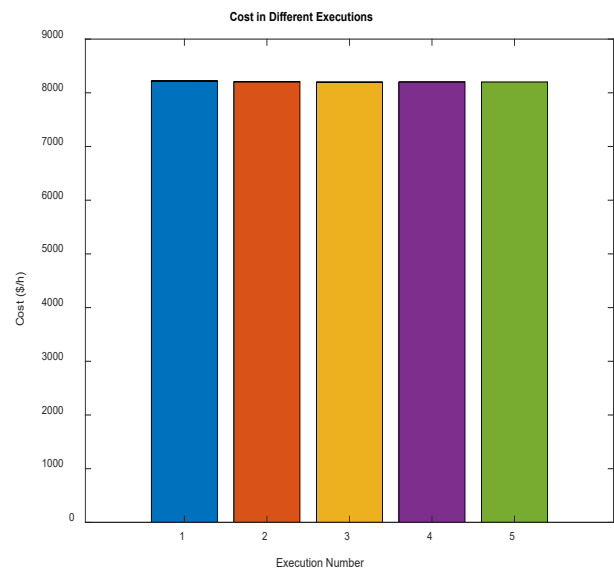


Figure 2. Analysis of Cost for 3 Units by Improved YSGA

Table 5. Power, Cost and Error Analysis by Improved YSGA for 3 Generating Units

Execution	P1	P2	P3	Cost (\$/h)	Error
'Exec 1'	312	365	173	8218.866	0
'Exec 2'	460	283	107	8207.616	0
'Exec 3'	368	367	115	8197.633	0
'Exec 4'	349	387	114	8203.056	0
'Exec 5'	346	357	147	8201.763	0
Mean	367	351.8	131.2	8205.787	0

Furthermore, in order to prove that proposed method is more cost effective than other previous models, we have compared them with traditional models in terms of best cost whose graph is shown in Figure 3. According to the presented graph, nearly every standard method SCABHC, SCA, BHC, BGWO, FCASOSQP, HCAISO, HCPSO, HCPSOSQP, MDE, NDS, NUHS, QIPSO, SDE, and THS, showed a cost of 8234.07 dollars per hour, except GAPSSQP that has best cost of 8234.1 dollars per hour. However, this is not the case in proposed method that obtains a significantly lower best cost of 8197.633 to demonstrate the higher degree of efficacy in locating a more economical solution in contrast to the other algorithms in the comparison. Table 6 displays the precise best power cost values for the various algorithms.

Table 6. Comparative Analysis of Best Cost

Algorithms	Best Cost
'SCABHC'	8234.07
'SCA'	8234.07
'BHC'	8234.07
'BGWO'	8234.07
'FCASOSQP'	8234.07
'GAPSSQP'	8234.1
'HCAISO'	8234.07
'HCPSO'	8234.07
'HCPSOSQP'	8234.07
'MDE'	8234.07
'NDS'	8234.07
'NSS'	8234.08
'NUHS'	8234.07
'QIPSO'	8234.07
'SDE'	8234.07
'THS'	8234.07
'Proposed'	8197.633448

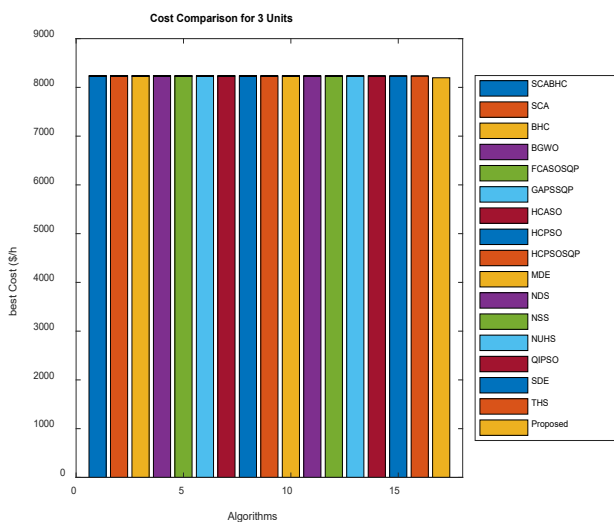


Figure 3. Comparison of Cost for 3 Units for 5 Executions

6 Unit System

Likewise, the optimized power generation ability of proposed improved YSGA is also examined for 6-unit system for 5 executions, which needs to fulfill the load demand of 1263MW. Specifically for this case, IEEE-30 bus system is considered containing 6 units with 26 buses and 46 transmission lines. The power generation analysis for different executions in this case is shown in Figure 4. The given graph clearly depicts that unit-1 “P1” produces an average power of 463.4MW which is highest among all other power units. Similarly, P2, P3, P4, P5 and P6 units produced an average power of 169.2MW, 270.2MW, 111.8MW, 173.6MW and 74.8MW respectively. The specific value of power generated by each unit in each execution is recorded in Table 7.

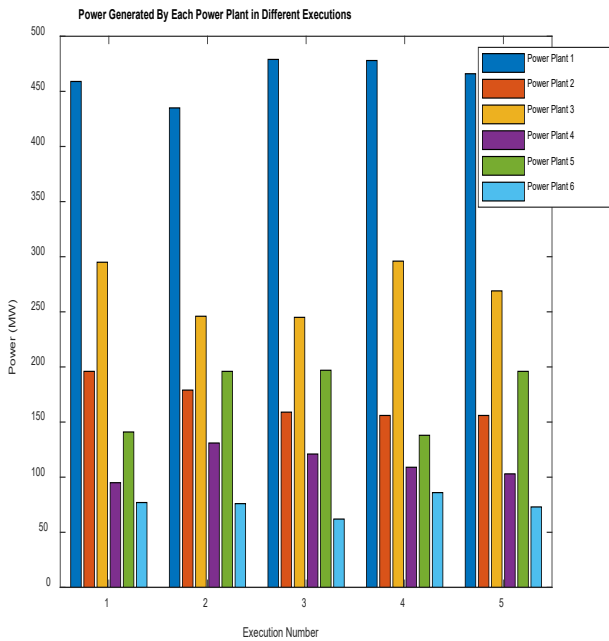


Figure 4. Analysis of Power Generated for 6 Units by Improved YSGA

Moreover, we have also analyzed the cost characteristics of proposed improved YSGA model for 6-unit system under 5 executions. The analytical graph obtained for the same is shown in figure 5.

While examining the provided graph, we note that the proposed method demonstrates a range of costs across different executions. Specifically, it achieves its lowest cost of \$15,285.71 per hour during 'Exec2' and incurs the highest cost of \$15,307.55 per hour during 'Exec1.'

Additionally, the costs for 'Exec3,' 'Exec4,' and 'Exec5' are recorded as \$15,296.558/h, \$15,305.88/h, and \$15,290.81/h, respectively. When considering the average cost, the power units P1, P2, P3, P4, P5, and P6 contribute to an overall average cost of \$15,297.33/h. This analysis illuminates the varying cost dynamics of the proposed improved YSGA model across different execution scenarios and power units. The specific values of cost in each execution is depicted in Table 7. The table clearly showcases that for execution the given load demand is satisfied without errors, and overall costs are also relatively low.

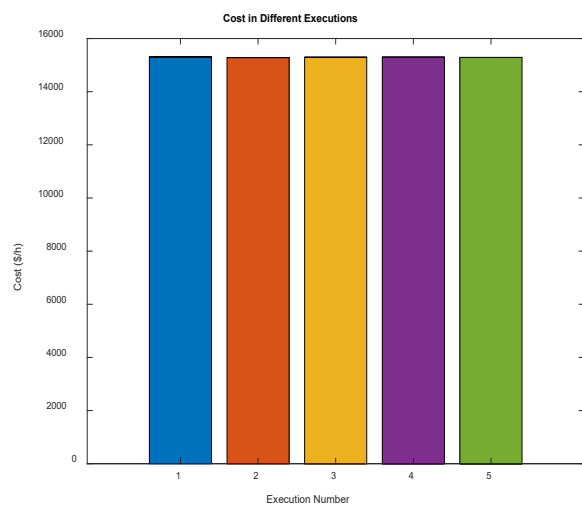


Figure 5. Analysis of Cost by 6 Units by Improved YSGA

Table 7. Power, Cost and Error Analysis by Improved YSGA for 6 Units and 5 Executions

Execution	P 1	P2	P3	P4	P5	P6	Cost (\$/h)	Error
'Exec 1'	459	196	295	95	141	77	15307.68	0
'Exec 2'	435	179	246	131	196	76	15285.71	0
'Exec 3'	479	159	245	121	197	62	15296.55	0
'Exec 4'	478	156	296	109	138	86	15305.88	0
'Exec 5'	466	156	269	103	196	73	15290.81	0
Mean	463.4	169.2	270.2	111.8	173.6	74.8	15297.33	0

In addition to this, the performance of proposed method is also compared with conventional methods in terms of their best cost generation ability for satisfying the load demand of

1263MW. The comparative graph attained for the same is shown in Figure 6. Upon examination of the provided graph, it becomes evident that the proposed model distinguishes

itself as highly efficient through considerably lower best cost of \$15,285.7055 per hour. In contrast, other algorithms such as SCABHC, BBO, CPSO, HBF, IGWO, IHSI, IPSO, NPSO, NPSOLRS, PSO, PSOLRS, PVHS, SOHPSO exhibit best cost values within the range of \$15,442.2 to \$15,459 per hour. These findings underscore the distinct advantage achieved by the Proposed algorithm, positioning it as a standout performer compared to the other algorithms considered in the analysis. Table 8 showcasing the comparison of best costs for each method.

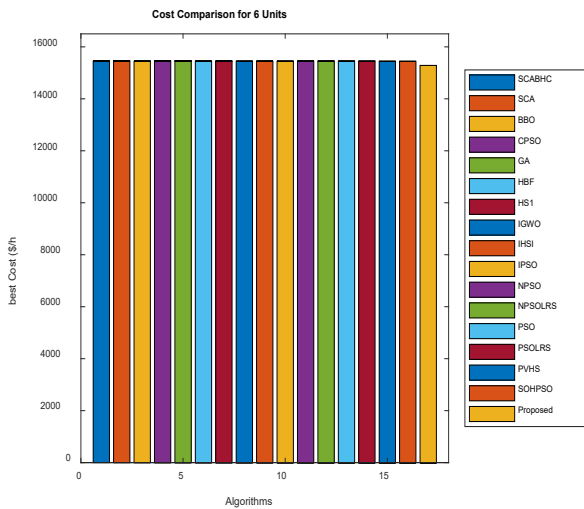


Figure 6. Comparative Analysis of Best Cost by 6 Generating Units

Table 8. Comparative analysis of best cost for 6 generating Units

Algorithms	Best Cost
'SCABHC'	15444.3
'SCA'	15461.47
'BBO'	15443.1
'CPSO'	15447
'GA'	15459
'HBF'	15443.82
'HS1'	15447.5
'IGWO'	15442.2
'IHSI'	15445.64
'IPSO'	15444
'NPSO'	15450
'NPSOLRS'	15450
'PSO'	15450
'PSOLRS'	15450

'PVHS'	15444.96
'SOHPSO'	15446
'Proposed'	15285.7055

From the above graphs and tables, it is evident that the proposed improved YSGA method outperforms other optimization techniques in effectively optimizing power units to meet the given load demand at minimal costs. The outcome obtained for 3-unit and 6-unit generators suggests that proposed improved YSGA method successfully strikes an optimal balance between power generation units, ensuring an economically viable solution that not only meets the load demand requirements but also does so with cost-effectiveness in mind.

Conclusion

This paper presents an effective solution to the ELD problem faced in power systems by using Improved YSGA optimization algorithm. The simulation of #-Unit generator system and 6-Unit generator system is tested on IEEE bus systems to determine their power generation and cost characteristics. In the context of a 3-unit system, it is evident that the P1 system exhibits the highest average power generation at 367 MW, surpassing P2 and P3, which generate 351.8 MW and 131.2 MW, respectively. The average cost incurred to meet a load demand of 850 MW is determined to be \$8205.787 per hour. Notably, the proposed method achieves a best cost of \$8197.633 for the 3-unit system which is less than other methods. Similarly, in the case of a 6-unit generator system, the proposed improved YSGA yields average power outputs of 463.4 MW, 169.2 MW, 270.2 MW, 111.8 MW, 173.6 MW, and 74.8 MW for P1, P2, P3, P4, P5, and P6, respectively. The corresponding average cost in this model is \$15,297.3 per hour for meeting the load demand of 1263MW. Furthermore, the proposed method achieves least the best cost of \$15,285.7055 for the 6-unit system to prove its supremacy over other methods. Additionally, the error between the demanded load and the generated load is zero for both scenarios, underscoring the superior performance of the proposed approach.

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