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ARTICLE

# TO SOLVE ECONOMIC DISPATCH PROBLEM USING COOPERATIVE PARTICLE SWARM OPTIMIZATION ALGORITHM

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## ABSTRACT

*An efficient Cooperative Particle Swarm Optimization (CPSO) algorithm is used to solve the Economic Dispatch (ED) problem in power systems. Generally, PSO technique helps to explore the search space very efficient and effectively. The presented CPSO algorithm is very effective to solving the constraints and the objective function of ED problems in power systems. The results of proposed algorithm are compared with existing algorithms like Genetic algorithm, Tabu search technique and evolutionary programming approaches. The experimental result indicates the proposed CPSO technique was really capable to achieve higher quality solutions in ED problems.*

**KEY WORDS**
*Economic Dispatch (ED), Cooperative Particle Swarm Optimization (CPSO), Power system, Evolutionary Programming, Genetic Algorithm.*

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## INTRODUCTION

Economic dispatch (ED) problem is one of the popular and most important and basic essential issues in power system operation. In nature optimization problems are very interesting and their characteristics (both complex and nonlinear) have satisfying constraints (equality and inequality). In recent world, there are so many mathematical approaches used, such as Tabu search method, genetic algorithm, Particle swarm optimization (PSO), Ant colony optimization (ACO), and simulated annealing. The swarm intelligence based PSO algorithm is very powerful and produce optimal solutions to global optimal solutions in power system problems in optimization [1].

The Economic Dispatch (ED) problem is previously discussed in various different techniques includes conventional methods, lambda iteration method, gradient method, base point technique and participation factors method [2, 3, 4, 5]. The main aim of optimization concept and their objective is used to minimize the overall generation cost of units, and also satisfying constraints with help of mathematical modeling and used optimization techniques. The ED problem main objective is to find out an optimal combination of power productivity to meet the customer requirement (demand) at minimum cost, at the same time satisfying the constraints also. For ease, the ED problem each unit cost function has been approximately stand for single quadratic function and solved by use of mathematical techniques [6]. In general mathematical methods need some derivative information of the cost function. The generating units of input and output characteristics are non-convex due to their prohibited operating zones, multi-fuel effects and valve point loadings etc.Dynamic programming (DP) technique is used to solve the ED problems with valve-point modeling have been presented by [2, 3]. This dynamic programming method is difficult to solve the dimensionality to become extremely large, and thus it requires huge computational efforts.

Particle Swarm Optimization (PSO) algorithm is one of the most powerful algorithms in modern heuristic world, this algorithm is suitable to solve simple and also large scale non-convex optimization problems. PSO algorithm is developed by Eberhart and kennedy based on the idea of analogy of swarm of bird and fish schooling [7]. The PSO technique imitate swarm individuals behavior and to maximize the species survivals. In PSO technique, each individual makes his own decision using their own and neighbors experience together [8]. This algorithm is basically a population based search algorithm, and searches a space by parallel with the help of group of particles moving across in a multidimensional search space. Each individual particle are stochastically moving toward the position of current best velocity of each individual particle, and their own previous best performance value and also the neighbors previous best performance value [9].

The important and most powerful advantage of PSO algorithm is very simple in concept, implementation is easy, minimum number of parameters is used, robustness in nature, computational efficiency is very high compared to other mathematical models and other heuristic based optimization methods. The searching capabilities of PSO algorithm is good and it may get trapped in local minimum while managing heavily constrained problems due to the limited global/local searching capabilities [10, 11].

In early years, Genetic Algorithm (GA) or Simulated annealing (SA) techniques are comes under global optimization technique. A probabilistic heuristic algorithm is used to solve successfully in a power optimization problems such as feeder configuration & capacitor placement in a distributed system [12-15]. Compared to simulated annealing technique the GA method is usually fast, for the reason that GA generally has a parallel search technique. Due to their natural genetic operations, global optimization has high potential and GA techniques have great effect in solving ED problems. Using GA technique lot of changes done in the ED problems like ramp rate limits, network losses and valve point zone are also considered.

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Authors walters and Sheble is used a GA technique to solve the ED problem for valve-point discontinuities that employed unit output as encoded in parameter of chromosome [16]. Chen and Chang also presented a same general GA method to solve ED problems in a system incremented cost as encoded parameter can include the ramp rate limits, network losses and valve-point zone [17]. Fung et al. presented a GA method incorporating with Tabu search (TS) and Simulated Annealing (SA) methods that employed the generators output as encoded parameter [18]. Yalcinoz et al. used an efficient GA technique in the real coded representation scheme, generally the GA technique have crossover (arithmetic), mutation and elitism in GA is used to solve more efficiently for ED problems in a high quality solution obtain with less computation time period [19].

This paper presented a PSO based approach to solve the Economic Dispatch (ED) problems with heavy constraints. To overcome existing issues, made some changes and combining techniques in a sequence. Additionally, the crossover technique is proposed to improve the solution quality without scarifying the efficiency of computational time. The main aim of this paper is to solve ED problems in an existing CPSO technique [21].

## ECONOMIC DISPATCH PROBLEM

In modern world a good business practice is one which minimizes the production cost at the same time without sacrificing the quality. In power system generations has different number of power plants and each power plant system has different number of generating units. At any time, the total load system will met in the generating units in different power plants system. To determine the Economic Dispatch problem control the power output of each power plant system and generating unit of each power system unit within power plant system, which is used to minimize the total cost of fuel required to serve the system load.
The main objective of Economic Dispatch (ED) problem is to minimize the total generation cost and also satisfies the equality and inequality constraints, to meet the power system load demand. The ED problem is to find the each power system have the real power generation such as the objective function (i.e., overall production cost function) as defined by the equation 1.

$$C_t = \sum_{i \in I}^{m} F_i(P_i) \qquad (1)$$

The transmission losses is a major factor to transmitted power in long distances and affect the optimum best dispatch of generation. One common thing they include to express an effect of transmission loss in an overall transmission loss of the power output generators with the help of quadratic function. The simplest representation of the quadratic equation 2 is

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

Where

$C_t$ - Overall generation cost;

$F_i$ - Generator i[th] Cost function;

$a_i$ ,$b_i$, $c_i$ - three cost coefficients of generator i;

$P_i$ - Generator i[th] Electrical output;

$i$ - Set value for all generators.

The overall generation cost is minimizing, the overall generation cost should be equal to total number of system demand and transmission network loss. In this work network loss is not considered, cost function is detailed description is listed. It is minimum subject to the constraints are represented equation 3

$$\sum_{i \in I}^{m} P_i = P_D \qquad (3)$$

Where $P_D$ is the overall system demand. Subject to constraints, number of generations is equal to overall demand plus their respective losses, i.e, equation 4 is shown below

$$\sum_{i \in I}^{m} P_i = P_D + P_L \qquad (4)$$

Where the $P_D$ represents the overall system is load and $P_L$ is the total transmission network loss. The power output of each generator unit should be within its minimum and maximum limits. Here they satisfying the inequality constraints are expressed in the way as follows equation 5

$$P_i, min \le P_i \le P_i, max \qquad (5)$$

Where $P_i, min$ and $P_i, max$ both represented as minimum and maximum output of generator i respectively.

## OVERVIEW OF PARTICLE SWARM OPTIMIZATION

In the year 1995, the PSO algorithm was first introduced by Kennedy and Eberhart [7], this concept is admirable by social behavior of swarm individuals (each particle) such as bird flocking and fish schooling. The PSO provides a population based search technique, each individual represented as particles and each particle move in a multidimensional search space. In a given search space each individual particle adjust its own position according to its own experience of particle, and their neighboring experience of other particle to their best position.

Let us assume the n- dimensional search space, the position (particle co-ordinates) and their velocity of individual (particle j) are represented as $V_j = (v_{j1}, \dots, v_{jn})$ and $X_j = (x_{j1}, \dots, x_{jn})$ vectors in the PSO algorithm. the j[th] individual particle previous best position is $Pbest_j = (x_{j1}^{Pbest}, \dots, x_{jn}^{Pbest})$ stored in $Pbest_j$. The best particle value among all the particle in the group of individual and its global best value is updated in $Gbest_j = (x_{j1}^{Gbest}, \dots, x_{jn}^{Gbest})$. The each particle position and velocity is modified, and calculated by best velocity and their distance from $Pbest_{jn}$ to $Gbest_{jn}$ as described in the following formulas 6, 7 and 8:

$$V_{jn}^{i+1} = w.V_{jn}^{i} + c_1 * rand() * (pbest_{jn} - x_{jn}^{i}) + c_2 * rand() * (gbest_n - x_{jn}^{i}) \quad (6)$$

$$x_{jn}^{i+1} = x_{jn}^{i} + V_{jn}^{i+1}, j = 1, 2, \dots, m \quad (7)$$

$$n = 1, 2, \dots l \quad (8)$$

Where

$m$ - Total number of individual in a group

$I$ - Total number of members in a individual (Particle)

$i$ - Iterations of pointer (generations)

$w$ - Inertia weight component

$c_1, c_2$ - Constant (Acceleration constant)

$rand()$ - Random uniform value, Range between [0, 1]

$V_j^i$ - Individual j[th] velocity at iteration i

$x_j^i$ - Individual j[th] current position at iteration i.

The presented above equations demonstrated the searching mechanism of PSO algorithm using position and their velocity of each individual.

## COOPERATIVE PSO FOR ED PROBLEMS

In this sector, a Cooperative PSO algorithm is presented to derive Economic Dispatch (ED) problems in power system. Here both the constraints of equality and inequality are also satisfied with the help of this technique to solve ED problems. Especially, the multidimensional search space is used to increase the convergence speed and the each individual search point is devised. The CPSO algorithm can be presented as follows:

### Procedure of CPSO

Step 1: Random initialization

Initialize random position of all individuals $X^{sl} = (x_1^{sl}, x_2^{sl}, \dots, x_m^{sl})$ of slave swarm of size $m^{sl} = m$.

Initialize randomly the position of all individuals $X^{ma} = (x_1^{ma}, x_2^{ma}, \dots, x_m^{ma})$ of master swarm of size $m^{ma} = m$.

Initialize randomly the velocity of all individuals $V^{sl} = (v_1^{sl}, v_2^{sl}, \dots, v_m^{sl})$ of slave swarm.

Initialize randomly the velocity of all individuals $V^{ma} = (v_1^{ma}, v_2^{ma}, \dots, v_m^{ma})$ of master swarm.

Evaluate the fitness value of $X^{sl}$ and $X^{ma}$.

Set $X^{ma}$ to be $pbest^{ma} = (pbest_1^{ma}, pbest_2^{ma}, \dots, pbest_m^{ma})$ for each individual of the master swarm.

Set the particle with best fitness to be $gbest$.

Set the particle with best fitness of slave swarm to be $gbest^{sl}$.

Set generation i = 0.

Step 2: Reproduction and loop updating

Step 2.1: Slave swarm update

for i = 1 : m

for j = 1: N

Update the velocity $v_i^{sl}$ of individual $x_i^{sl}$ using the below equations.

$$v_{ij}^{sl}(k+1) \leftarrow c_1^{sl} r_1 (1 - r_2)(x_{tj}^{sl}(k) - x_{ij}^{sl}(k)) + c_2^{sl}(1 - r_1) r_2 (gbest_j(k) - x_{ij}^{sl}(k))$$

$$v_{ij}^{sl} \leftarrow \min(v_{ij\,max}^{sl}, \max(v_{ij\,min}^{sl}, v_{ij}^{sl}))$$

Update the position of individual $x_i^{sl}$ using the below equation

$$x_{ij}^{sl}(k+1) \leftarrow x_{ij}^{sl}(k+1) + v_{ij}^{sl}(k)$$

If $x_{ij}^{sl} > x_{ij\,max}^{sl}$, set $x_{ij}^{sl} \leftarrow x_{ij\,max}^{sl}, v_{ij}^{sl} \leftarrow v_{ij}^{sl}$;

If $x_{ij}^{sl} < x_{ij\,min}^{sl}$, set $x_{ij}^{sl} \leftarrow x_{ij\,min}^{sl}, v_{ij}^{sl} \leftarrow v_{ij}^{sl}$.

End for
End for
Update $gbest^{sl}$.
Step 2.2: Master swarm Update
for i = 1 : m
for j = 1: N
Update the velocity $v_i^{ma}$ of individual $x_i^{ma}$ using the following equations.

$$v_{ij}^{ma}(k+1) \leftarrow w^{ma}.v_{ij}^{ma}(k) + c_1^{ma} r_1 (1-r_2)(1-r_3)\left(pbest_{ij}^{ma}(k) - x_{ij}^{ma}(k)\right) + c_2^{ma} r_2 (1-r_1)(1 - r_3\left(gbest_j^{ma}(k) - x_{ij}^{ma}(k)\right) + c_3^{ma} r_3 (1-r_1)(1-r_2)(gbest_j(k) - x_{ij}^{ma}(k))$$

$$v_{ij}^{ma} \leftarrow \min\left(v_{ij\,max}^{ma}, \max\left(v_{ij\,min}^{ma}, v_{ij}^{ma}\right)\right)$$

Update the position of individual $x_i^{ma}$ using the following equation

$$x_{ij}^{ma}(k+1) \leftarrow x_{ij}^{ma}(k) + v_{ij}^{ma}(k+1)$$

If $x_{ij}^{ma} > x_{ij\,max}^{ma}$, set $x_{ij}^{ma} \leftarrow x_{ij\,max}^{ma}, v_{ij}^{ma} \leftarrow v_{ij}^{ma}$;
If $x_{ij}^{ma} < x_{ij\,min}^{ma}$, set $x_{ij}^{ma} \leftarrow x_{ij\,min}^{ma}, v_{ij}^{ma} \leftarrow v_{ij}^{ma}$.
End for
End for
Update $pbest_i^{ma}$
End for
Update $gbest$.
Set $k = k + 1$.
Step 3: if not met termination condition, go to step , otherwise end CPSO

Generally, simultaneously handle two tasks are very difficult for swarm, and these improved methods to make a fast convergence speed and distribution of diversity among the individuals. In this mechanism the new CPSO is introduced and two swarm techniques are used, one is slave swarm and another one is master swarm (the two swarms are used instead of previous swarms) [21]. The slave swarm only first focal point on exploiting the search interval to ignore trapping into local optima and to retain the diversity of individuals.

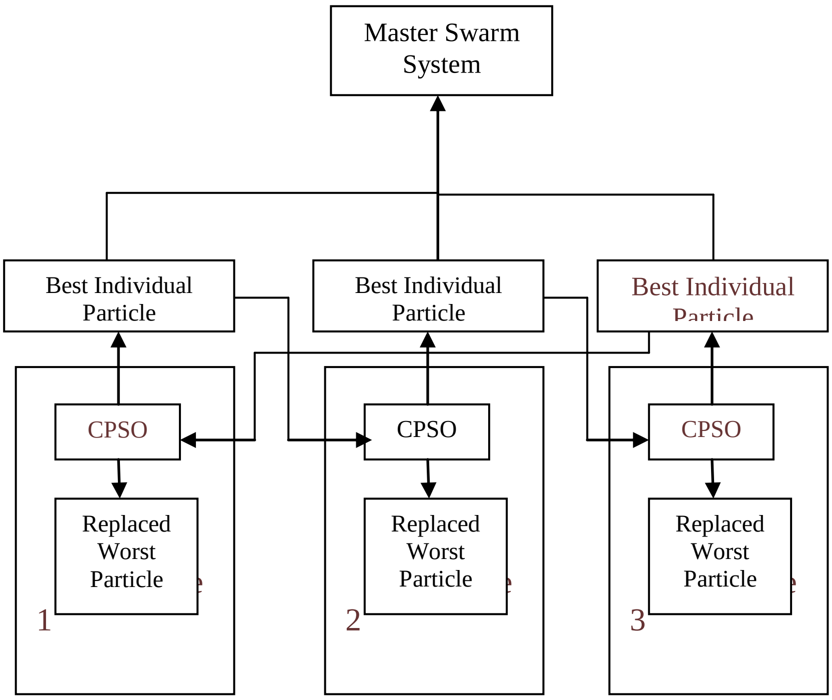


**Fig.1:** The working procedure of CPSO.

The CPSO algorithm was mainly utilized to establish the best optimal generation power of each unit that was present at the specific period, and thus minimizing the total cost generation. Generally the PSO techniques have three components used; they are namely inertial weight, cognitive parameters, and social parameters. The inertial weight element reproduces the inertial behavior of birds flying previous direction.

The two parameter used, cognitive used to maintain the birds memory in best previous position and social is used to maintain best position among the individuals (the parallel interaction between the swarms). In the dynamic search space where the best optimal solution is required, each individual in the swarm is moved from the optimal point by adding together a velocity with its position. Based on the mathematical model the velocity update equation 9 is

$$v_{ij}(k+1) = c_1 r_1 (pbest_{tj}(k) - x_{ij}(k)) + c_2 r_2 (gbest_j(k) - x_{ij}(k)) \quad (9)$$

For high level convergence speed, the presented method is used to update the velocity of the individuals[32-35], the equation 10 reprsented below.

$$v_{ij}(k+1) = c_1 r_1 \left(x_{tj}(k) - x_{ij}(k)\right) + c_2 r_2 (gbest_j(k) - x_{ij}(k)) \quad (10)$$

The [Fig. 1] represents the overall working flow of CPSO algorithm, here the swarm master maintains the slave swarms best particle value and again sends the best value to slave swarm 1 to slave swarm2 like that. The strategy represented in this to balance exploitation and exploration of presented approach.

## RESULTS AND DISCUSSION

An efficiency to assess the proposed CPSO algorithm is developed and used in ED problems; the main objective function is also compared with their specific constraints. Here three benchmark test systems are taken, they are 6-units, 20-units, and 38-units are considered. The setting of parameter constraints is same for all the test systems and maximum number of iterations is excluded.
The power systems have the reasonable B loss coefficients matrix value and that was working to represent transmission loss and their constraints. The code was implemented in Matlab language and executed in the personal computer.

### Test System 1: Six unit system

The Test case system contains six benchmark units. The overall system load is 1263 MW. In the six unit power generator outputs, such as listed P1, P2, P3, P4, P5 and P6 are randomly generated. The data input are taken from six generating unit system [29]. The proposed methods of the CPSO and their other comparing algorithms best solutions are described in [Table 1]. The [Table 1] results are compared with SA [28], TS [28], PSO [28], GA [30], and NPSO – LRS [31]. The [Table 1] listed the statistical values

**Table 1:** Best solution of six unit system

| Method | Min (S/hr) | Mean (S/hr) | Max (S/hr) | TFE | Time (sec.) | Standard Deviation |
|---|---|---|---|---|---|---|
| SA | 15461.1 | 15488.98 | 15545.5 | NA | 50.36 | 28.367 |
| TS | 15454.89 | 15472.56 | 15498.05 | NA | 20.55 | 13.719 |
| PSO | 15450.14 | 15465.83 | 15491.71 | 100,000 | 6.82 | 10.15 |
| GA | 15459 | 15469 | 15524 | 20,000 | 41.58 | 0.057 |
| NPSO-LRS | 15450 | 15454 | 15492 | 20,000 | 14.89 | 0.002 |
| CPSO | 15443.2 | 15458 | 15490 | 20,000 | 14.12 | 0.0018 |

The [Table 1] observed values for Minimum, Mean for optimal solution to generate the six unit system. The standard deviation results of the proposed system are 0.0018. Compared to other existing taken algorithms the results are shown in the above table.

### Test System 2: Twenty unit system

The data input for twenty generating units system is taken from [24]. The [Table 2] listed a detailed test system unit of 20 generators; the load demand value is 2500 MW. The results are compared with BBO [25], LI [26], HM [26], PSO [27], and IPSO [27].

**Table 2:** Best solution of twenty unit system

| Unit Number | BBO | LI | HM | PSO | IPSO | CPSO |
|---|---|---|---|---|---|---|
| P1 | 513.09 | 512.78 | 512.78 | 270.2587 | 483.1617 | 221.6283 |
| P2 | 173.35 | 169.10 | 169.10 | 184.0766 | 127.9918 | 118.5223 |
| P3 | 126.92 | 126.89 | 126.89 | 50 | 58.93857 | 50 |

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|---|---|---|---|---|---|---|
| P4 | 103.33 | 102.87 | 102.87 | 70.93799 | 63.08068 | 91.75936 |
| P5 | 113.77 | 113.64 | 113.68 | 61.38516 | 101.6452 | 64.39798 |
| P6 | 73.07 | 73.57 | 73.57 | 20 | 53.40166 | 20 |
| P7 | 114.98 | 115.29 | 115.29 | 118.0858 | 120.7673 | 118.1018 |
| P8 | 116.42 | 116.40 | 116.40 | 50 | 50 | 50 |
| P9 | 100.69 | 100.41 | 100.41 | 147.2164 | 70.47716 | 155.5842 |
| P10 | 100.00 | 106.03 | 106.03 | 80.26374 | 40.14163 | 62.84119 |
| P11 | 148.98 | 150.24 | 150.24 | 241.0485 | 238.8903 | 261.1216 |
| P12 | 294.02 | 292.76 | 292.76 | 400.8137 | 434.4287 | 422.8988 |
| P13 | 119.58 | 119.12 | 119.12 | 96.81035 | 113.1663 | 97.7352 |
| P14 | 30.55 | 30.83 | 30.83 | 93.79342 | 80.23303 | 88.89034 |
| P15 | 116.45 | 115.81 | 115.81 | 62.45174 | 104.5378 | 77.67747 |
| P16 | 36.23 | 36.25 | 36.25 | 38.51789 | 44.24926 | 33.31954 |
| P17 | 66.86 | 66.86 | 66.86 | 33.0497 | 57.2506 | 30 |
| P18 | 88.55 | 87.97 | 87.97 | 30 | 56.86099 | 41.80909 |
| P19 | 100.98 | 100.80 | 100.80 | 87.68055 | 54.10037 | 85.5325 |
| P20 | 54.27 | 54.31 | 54.31 | 34.15818 | 30 | 30 |
| Total Generation (MW) | 2592.10 | 2591.97 | 2591.97 | 2170.548 | 2383.323 | 2121.82 |
| Total Transmission Loss (MW) | 92.10 | 91.97 | 91.97 | 329.4517 | 116.6769 | 378.18 |
| Total Generation cost (S/h) | 62456.78 | 62456.64 | 62456.63 | 60213 | 60221.96 | 60199.45 |

### Test System 3: Thirty Eight unit system

The CPSO algorithm is applied to Economic Dispatch problems, here 38 generators unit system with cost and transmission loss. The [Table 3] listed the detailed test system values of 38 generator system unit. The data input values are taken from [21] and load demand is 6000 MW. The results are compared with DE/BBO [22], BBO [22], PSO-TVAC [23], NEW-PSO [23] and EP-EPSO [21].

**Table 3:** Best solution of thirty eight unit system

| Unit Number | DE/BBO | BBO | PSO-TVAC | NEW-PSO | EP-EPSO | CPSO |
|---|---|---|---|---|---|---|
| P1 | 426.60606 | 422.230586 | 443.659 | 550 | 318.0777 | 497.4661 |
| P2 | 426.606054 | 422.117933 | 342.956 | 512.263 | 475.117 | 324.1907 |
| P3 | 429.663164 | 435.779411 | 433.117 | 485.733 | 399.1265 | 326.988 |
| P4 | 429.663181 | 445.48195 | 500 | 391.083 | 500 | 500 |
| P5 | 429.663193 | 428.475752 | 410.539 | 443.846 | 500 | 327.0108 |
| P6 | 429.663164 | 428.649254 | 492.864 | 358.398 | 500 | 326.5769 |
| P7 | 429.663185 | 428.119288 | 409.483 | 415.729 | 500 | 327.4176 |
| P8 | 429.663168 | 429.900663 | 446.079 | 320.816 | 500 | 327.0777 |
| P9 | 114 | 115.904947 | 119.566 | 115.347 | 114 | 114 |
| P10 | 114 | 114.115368 | 137.274 | 204.422 | 132.7826 | 114 |
| P11 | 119.768 | 115.418662 | 138.933 | 114 | 114 | 114 |
| P12 | 127.0728 | 127.511404 | 155.401 | 249.197 | 114 | 114 |
| P13 | 110 | 110.000948 | 121.719 | 118.886 | 110 | 110 |
| P14 | 90 | 90.0217671 | 90.924 | 102.802 | 90 | 90 |
| P15 | 82 | 82 | 97.941 | 89.039 | 82 | 82 |
| P16 | 120 | 120.038496 | 128.106 | 120 | 120 | 120 |
| P17 | 159.598 | 160.303835 | 189.108 | 156.562 | 141.9435 | 147.1996 |
| P18 | 65 | 65.0001141 | 65 | 84.265 | 65 | 65.00002 |
| P19 | 65 | 65.000137 | 65 | 65.041 | 65 | 65 |
| P20 | 272 | 271.999591 | 267.422 | 151.104 | 120 | 272 |
| P21 | 272 | 271.872268 | 221.383 | 226.344 | 272 | 272 |
| P22 | 260 | 259.732054 | 130.804 | 209.298 | 260 | 260 |
| P23 | 130.648618 | 125.993076 | 124.269 | 85.719 | 80 | 96.77796 |
| P24 | 10 | 10.4134771 | 11.535 | 10 | 10 | 10 |
| P25 | 113.305034 | 109.417723 | 77.103 | 60 | 92.9577 | 85.36166 |
| P26 | 88.0669159 | 89.3772664 | 55.018 | 90.489 | 55 | 72.1951 |
| P27 | 37.5051018 | 36.4110655 | 75 | 39.67 | 35 | 35 |
| P28 | 20 | 20.009888 | 21.682 | 20 | 20 | 21.19425 |
| P29 | 20 | 20.0089554 | 29.829 | 20.985 | 20 | 20 |
| P30 | 20 | 20 | 20.326 | 22.81 | 20 | 20 |
| P31 | 20 | 20 | 20 | 20 | 20 | 20 |
| P32 | 20 | 20.0033959 | 21.84 | 20.416 | 20 | 20 |
| P33 | 25 | 25.0066586 | 25.62 | 25 | 25 | 25 |
| P34 | 18 | 18.0222107 | 24.261 | 21.319 | 18 | 18 |

| | | | | | | |
|---|---|---|---|---|---|---|
| P35 | 8 | 8.0000426 | 9.667 | 9.122 | 8 | 8 |
| P36 | 25 | 25.006066 | 25 | 25.184 | 25 | 25 |
| P37 | 21.782 | 22.0005641 | 31.642 | 20 | 38 | 20 |
| P38 | 21.0621792 | 20.6076309 | 29.935 | 25.104 | 20 | 20 |
| Total Cost | 9,417,235.79 | 9,417,633.64 | 9,500,448.31 | 9,596,448.31 | 9,387,925.50 | 9013940 |

## CONCLUSION

A presented CPSO algorithm technique is used to solve the Economic Dispatch (ED) problems. The CPSO algorithm had an adjustment in a position update strategy is added in the PSO framework to achieve the solutions and satisfying the constraints (both equality and inequality). With the help of multi dimensional search space, the CPSO technique is increase the convergence speed, and also the high probability constraints of ED problems cost function is satisfied with the help of global solution value. The taken benchmark sample systems are used to compare the existing algorithms with the presented proposed algorithms. These test systems are 6-units, 20-units, 38-units system.

### CONFLICT OF INTEREST
There is no conflict of interest.

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None

### FINANCIAL DISCLOSURE
None

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