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Impacts of Plug-in Electric Vehicles and Renewable Energy Source on Unit Commitment Problem using Cat Mouse Based Optimization A lgorithm

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Abstract

Objectives: The main objective of this paper is to solve the Cost Based Unit Commitment (CBIC) problem considering Renewable Energy Sources (RES) and Plug-in Electric vehicles (PEVs). The proposed problem minimizes the total operating of the interconnected system. **Methods:** A novel and recently developed successful optimization tool of Cat and Mouse Based Optimizer (CMBO) is proposed for optimal solution of Cost Based UC problem. The proposed CMBO approach is having two groups such as Cat group and Mice group for searching the global optimal solution with less computational time. It contains two phases like Cat's movement towards Mice and Mice escape to a safe place is effectively updating the new position of Cat and Mice to easily reaching the best solutions. The control parameter of CMBO is number of agents is 50, number of variables is 10 and maximum number of iteration is 500. MATLAB 14.0 platform is utilized for the projected problem. **Findings:** The method tested on standard IEEE-39 bus system (10 generators and 24 hour) with an equivalent PEV and Wind farm. The CMBO approach minimize the total operating cost with various test cases. The outcomes such as UC schedule, Real power output of thermal, wind and PEV units, fuel cost, startup cost and total operating cost of the interconnected system are numerically and graphically reported. The total operating cost is 4.11 % minimized when compared with base case approach and 0.73 % reduced than the other existing method viz. Parallel UCs-RP method. **Novelty:** The CMBO is recently developed powerful optimizer and parameter free algorithm, so easily reaches the global optimal solutions. The obtained simulated results are compared with other mathematical and intelligent computational approaches for proving the efficiency and performance of the proposed CNBO technique.

Keywords: Unit Commitment; Plugin Electric Vehicles; Renewable Energy Sources; Cost minimization; Cat and Mouse Based Optimizer

1 Introduction

Unit Commitment (UC) problem plays a vital role in ensuring the reliable and efficient operation of power systems, as it determines the commitment and dispatch of power generation resources over a specified time horizon[1]. The UC is a critical component of the operation and scheduling of electric power systems. It involves determining the optimal schedule and committed status of power generation units to meet the forecasted load demand at the minimum operating cost while satisfying various operational constraints.

The integration of renewable energy sources and Plug-In Electric Vehicles (PEVs) is to engage in recreation, an important role for the effective planning, operation and control of modern electric power system networks. The PEVs are operated in the both charging and discharging mode that is vehicle to gird (V2G) and gird to vehicle (G2V), so the demand of the system is varied. The overall operational cost of integrated power systems is minimized by considering the RES and PEVs[1]. The few researchers only inveterate the impacts of PEVs and RES are interconnected to thermal plants for reducing the overall operating cost of the system. The proposed CMBO approach is having more ability to optimize the UC problem then the existing approaches of GA, PSO, and ABC etc. The GA, PSO, and ABC are only single mode of searching operators but proposed CMBO provide the two groups like Cat group and Mice group for searching the global optimal solution with less computational time.

The main contribution of the proposed problem is to minimize the total operating cost of the interconnected power system by optimal unit commitment process. The proposed thermal generators are interconnected with an equivalent wind and PEVs for minimizing the total operating cost of the system. The proposed CMBO approach is effectively optimizes the variables of interconnected system to achieve the optimal solutions.

The researchers developed various mathematical and intelligent computational techniques for solution of UC problem considering renewable energy sources and PEVs to obtain the minimum operational and fuel cost of thermal power plants. Mixed-Integer Non-Linear Programming (MINLP) has been implemented for the solution of UC problem[2]. This work integrated the wind generation uncertainties, reserve generation and plug in electric vehicles. The results have been displayed with different test cases for charging and discharging of PEVs, Here, the comparative study of fuel cost is not properly displayed.

Nandi, A., & Kamboj, V. K[3] applied an Intensify Harris Hawks Optimizer (IHHO) for solution of the UC problem to determine the impact of battery electric vehicles, hybrid electric vehicles and plug in electric vehicles. The simulated generation cost of thermal with renewable units was carried out for 5 % and 10% of spinning reserve with winter and summer period. Qun Niu et al[4] applied binary covariance matrix adaption evolution strategy (BCMAES) and dubbed BCMAES for solution of same problem. The problem considering RES and PEVs to minimizes the fuel cost and emissions.

Enhanced-interval linear programming[5] has been proposed to find the optimal power scheduling projected test system. The scheduling integrated thermal, wind, solar, and EV power units. This approach evaluates the total operating cost considering the charging and discharging cost of the PEVs. Dinesh Dhawale et al[6] applied Chaotic Slime Mould Optimizer considering wind and electric vehicles. The methodology optimizes the thermal and wind power in both V2G and G2V mode of operation of EVs. The results have been compared with other evolutionary approaches to justify the performance of projected method. Ona Egbue et al[7] developed a unit commitment model for a V2G system connected to a smart power grid. This model simultaneously charge/discharge of the PEVs to obtain the minimized operational cost of smart gird. Water Wave Optimization approach[8] has been implemented in the same smart gird system. This work considers the PHEVs to minimize the environmental emission of transportation sector.

Adraktas, P and Dagoumas, A developed various UC models[9] to determine the minimum operating cost of the thermal plant. Here, impact of renewable energy sources and PEVs on UC problem for reducing fuel cost was analyzed. A benchmark IEEE RTS 96 test system has been considered to get optimal solutions using various intelligent approaches. Madzharov, D et al[10] proposed UC problem with large numbers of EVs and PHEVs using MILP approach. Mainly the authors determine the operational cost by integrating more number of EVs and PHEVs units in the projected test system. When addition of 10% of EVs, the fuel cost of thermal plant 1% is increased. Zhile Yang et al[11] developed a comprehensive frame work for solution of Economic UC problem using Multi-zone sampling method. Here, thermal plant integrated with wind, solar and PEVs to reduce the operational cost of the hybrid system. The simulation results have been analyzed with different scenarios in renewable power production and demand side organization of disputing of PEVs load.

A variant of Differential Evolution, aided by heuristic repair mechanisms, Priority Lists and advanced State-of-the-Art constraint handling techniques[12] has been applied to optimize the PEVs charging to minimize the total operating cost of the tests system. Obtained results have been compared to display the performance of the hybrid approach. The problem has been analyzed by Niu, Q et al[13] using improved harmony search algorithm Chaotic Zebra Optimization Algorithm[14] has been applied that optimizes the economical charging and discharging of PEVs and thermal and wind generation to reduce the cost. Here 10, 20 and 40 generating unit test system was analyzed in terms of best, worst and average values. Dhawale, P. G et al[15] solved the security constrained unit commitment for hybrid power systems and integrating the renewable energy and plug-in electric vehicles. The chaotic arithmetic optimization algorithm has been implemented for different test cases.

This article addresses the important optimization problem of unit commitment frame work using a new and presently developed optimization tool of Cat and Mouse based Optimization (CMBO) algorithm. The total operational cost of the system is minimized by allowing for the wind units and charging and discharging modes of PEVs.

The organization of this paper is summarized as follows.

- Section 2 proposes the solution methodology and it includes overview of CMBO approach and implementation of CMBO algorithm for UC problem.
- Section 3 provides the mathematical formulation of UC problem considering the wind units and charging and discharging modes of PEVs. It modeled as optimization problem considering several system and unit constraints.
- Section 4 gives the numerical example of standard IEE test system and simulation results with different cases,
- Section 5 outlines the conclusions of the paper.

2 Methodology

2.1 Cat and Mouse Based Optimization Algorithm

In this section, the philosophy of the Cat and Mouse Based Optimization (CMBO) algorithm is detailed and its mathematical representation is discussed. It will be very much useful for solving the optimization problems[16,17]. The CMBO is modeled by adopting population based theory which is formulated by the motivation from the actions of cat's attacking behavior on mouse and escaping method of mouse from cat. The algorithm search agents are split into two groups of cats and mice which analyze the search space by making random movements.

The population of the algorithm is determined using a matrix called the population matrix in Equation (1). Each member of the population is a vector whose values determine the variables of the problem.

$$X=\begin{bmatrix} X_1 \\ \vdots \\ X_i \\ \vdots \\ X_N \end{bmatrix}_{N\times m} = \begin{bmatrix} X_{1,1} & \cdots & X_{1,d} & \cdots & X_{1,m} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{i,1} & \cdots & X_{i,d} & \cdots & X_{i,m} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{N,1} & \cdots & X_{N,d} & \cdots & X_{N,m} \end{bmatrix}_{N\times m} \tag{1}$$

Where X is the population matrix of CMBO, X_i is the ith search agent, $X_{i,d}$ is the value for the dth problem variable obtained by the ith search agent, *N* is the number of population members, and *m* is the number of problem variables.

As pointed out, the exact value of the problem variables are calculated by the every member of the population. Hence, for an individual member of the population, a value is assigned for the objective function. The derived values of the objective function are specified by a vector in Equation (2).

$$F=\begin{bmatrix} F_1 \\ \vdots \\ XF_i \\ \vdots \\ F_N \end{bmatrix}_{N\times 1} \tag{2}$$

Here, F will be the vector of the particular objective function and F_1 provides the value of the objective function for the ith search agent.

Depending upon the values attained from the objective function, the individual members of the population are arranged from the best member with the minimum value of the objective function to the worst member of the population with maximum value of the objective function. The organized population matrix along with organized objective function are computed using Equations (3) and (4).

$$X^s=\begin{bmatrix} X_1^S \\ \vdots \\ X_i^S \\ \vdots \\ X_N^S \end{bmatrix}_{N\times m} = \begin{bmatrix} X_{1,1}^S & \cdots & X_{1,d}^S & \cdots & X_{1,m}^S \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{i,1}^S & \cdots & X_{i,d}^S & \cdots & X_{i,m}^S \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{N,1}^S & \cdots & X_{N,d}^S & \cdots & X_{N,m}^S \end{bmatrix}_{N\times m} \tag{3}$$

$$F^S = \begin{bmatrix} F_1^S & min(F) \\ \vdots & \vdots \\ F_N^S & max(F) \end{bmatrix}_{N\times 1} \tag{4}$$

The population matrix has two groups of cats and mice in the suggested CMBO algorithm. In this CMBO, it is presumed that half of the population members have given better values for the objective function which compose the population of mice and the other half of the population members which provides lower values for the objective function establishes the population of cats. According to this method, the population of cats and mice are resolved using Equations (5) and (6) respectively.

$$M = \begin{bmatrix} M_1 = X_1^S \\ \vdots \\ M_i = X_i^S \\ \vdots \\ M_{N_m} = X_N^S \end{bmatrix}_{N\times m} = \begin{bmatrix} X_{1,1}^S & \cdots & X_{1,d}^S & \cdots & X_{1,m}^S \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{i,1}^S & \cdots & X_{i,d}^S & \cdots & X_{i,m}^S \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{N,1}^S & \cdots & X_{N,d}^S & \cdots & X_{N,m}^S \end{bmatrix}_{N\times m} \tag{5}$$

$$C = \begin{bmatrix} C_1 = X_{N_m+1}^S \\ \vdots \\ C_j = X_{N_m+j}^S \\ \vdots \\ C_{N_c} = X_{N_m+N_c}^S \end{bmatrix}_{N\times m} = \begin{bmatrix} X_{N_m+1,1}^S & \cdots & X_{N_m+1,d}^S & \cdots & X_{N_m+1,m}^S \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{N_m+j,1}^S & \cdots & X_{N_m+j,d}^S & \cdots & X_{N_m+j,m}^S \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ X_{N_m+N_c,1}^S & \cdots & X_{N_m+N_c,d}^S & \cdots & X_{N_m+N_c,m}^S \end{bmatrix}_{N_c\times m} \tag{6}$$

Here M indicates the matrix of mice population, M_i is the Jth mouse, C_j gives the matrix of cats population, N_c shows the number of count of cats, and C_j is the ith cat.

In order to keep the search factor updated, in the initial phase, the change in population of cat is devised using the instinctive behavior of cats and its activity towards mice. This sequence of the updating of the proposed CMBO is mathematically formulated by the Equations (7), (8) and (9).

$$C_j^{new} : C_{j,d}^{new} = C_{j,d} + r\times\left(m_{k,d} - I\times C_{j,d}\right) \;\&\; j = 1 : N_c,\, d = 1 : m,\, k \in 1 : N_m, \tag{7}$$

$$I = round\ (1 + rand), \tag{8}$$

$$C_j = \begin{cases} C_j^{new}, & \left| F_j^{c,new} < F_j^c \right. , \\ C_j, & |else \end{cases} \tag{9}$$

Here, C_j^{new} is the new status of the jth cat, $C_{j,d}^{new}$ is the new value for the dth problem variable obtained by the jth cat, *r* is a random number in interval [0,1], $m_{k,d}$ is the dth dimension of the kth mouse, $F_j^{c,new}$ is the objective function value based on new status of the jth cat.

During the second phase of the CMBO, mouse's ability to flee to safe haven is modeled. In this algorithm, it is pretended that there will be a random haven for each and every mouse and mice may take asylum in those havens. The places of the havens are the search space which is randomly created based on patterning the positions of different members of the proposed algorithm.

$$H_i : h_{i,d} = x_{l,d} \,\&\, i = 1 : N_m,\, d = 1 : m,\, l \in 1 : N, \tag{10}$$

$$\begin{aligned} &M_i^{new} : M_{i,d}^{new} = m_{i,d} + r\times\left(h_{i,d} - I\times m_{i,d}\right) \times sign\left(F_i^m - F_i^H\right) \\ &\&\ j = 1 : N_c,\, d = 1 : m,\, k \in 1 : N_m, \end{aligned} \tag{11}$$

$$M_i = \begin{cases} M_i^{new}, & |F_i^{m,new} < F_j^m \\ M_i, & |else \end{cases}, \quad (12)$$

Hence, H_i the haven of i[th] mouse and F_i^H is the value of objective function, M_i^{new} is the present and new status of the i[th] mouse and F_i denotes the value of objective function.

Once all the members of the algorithm are updated, the algorithm moves to the next stage of iteration through Equations (5), (6), (7), (8), (9), (10), (11) and (12) and the iterations of the algorithm continues till the final condition is satisfied. The algorithm stands conclude its execution based on specified number of iteration or by mentioning curtail allowable error between the final solutions during the process of iteration. Also, certain period of time may be fixed for stopping the execution of the algorithm. After the completion of successful iterations and complete implementation of all algorithmic procedures, the CMBO provides the best global optimal solution.

2.2 Problem Formulation

The objective function of the unit commitment problem [15,18,19] is to minimize the total production cost and is mathematically formulated as:

2.2.1 Objective function

$$minJeco = \sum_{t=1}^{T} \sum_{j=1}^{n} \left[C_j \left(P_{j,t} \right) .U_{j,t} + SU_{j,t}. \left(1 - U_{j,t-1} \right) .U_{j,t} \right] \quad (13)$$

- ***Fuel Cost***

The quadratic approximation is the most widely used by the researchers, which is basically a convex shaped function. The curve is the operating fuel cost equation for unit i and is mathematically represented as:

$$C_j \left(P_{j,t} \right) = a_j + b_j.P_{j,t} + c_j.P_{j,t}^2 \quad (14)$$

- ***Start up cost***

Start up cost is warmth-dependent. Mathematically it is represented as a step function:

$$SU_{j,t} = \begin{cases} SU_{H,j}, & if\, MDT_j \leq TOFF_{j,t} \leq MDT_j + T_{cold,j} \\ SU_{C,j}, & if\, TOFF_{j,t} > MDT_j + T_{cold,j} \end{cases} \quad \$/MW \quad (15)$$

- ***Shut down cost***

The typical value of the shut down cost is zero in the standard systems. This cost is considered as a fixed cost.

$$SD.U_{it} = KP_{it} \qquad \$/h \quad (16)$$

2.2.2 Constraints

In association with the objective function, the UCs-RP problem also considers the limitations of thermal units, RGs and power interaction of PEVs.

- ***Generation limit Constraints***

Generation limit is the maximum and minimum power generation of each unit shown as,

$$u_{j,t}.P_{j,min} \leq P_{j,t} \leq u_{j,t}.P_{j,max} \quad (17)$$

Where $P_{j,min}$ and $P_{j,max}$ are the minimum and maximum power limits respectively.

- ***Power Balance constraints***

In the PEV-UC problem, the sum of thermal unit generations and RGs should meet the power demand and PEVs power as shown below,

$$\sum_{j=1}^{n} P_{j,t}.u_{j,t} + P_{wind,r,t} + P_{solar,r,t} = P_{D,t} + P_{PEV,t} \tag{18}$$

- ***Spinning reserve limit***

The spinning reserve of power system aims to provide fast response to compensate the deviations between real and predictive demands. Considering the RGs and PEVs, the new reserve limit is modeled as follows,

$$\sum_{j=1}^{n} P_{j,max}.u_{j,t} + P_{wind,r,t} + P_{solar,r,t} \geq P_{D,t} + SR_t + P_{PEV,t} \tag{19}$$

- ***Minimum up/down time limit***

Thermal power has minimum up and down time limit as shown,

$$u_{j,t} = \begin{cases} 1,\ if\ 1 \leq TON_{j,t-1} < MUT_j \\ 0,\ if\ 1 \leq TOFF_{j,t-1} < MUT_j \\ 0\ or\ 1,\quad otherwise \end{cases} \tag{20}$$

Where the unit is required to turn on or off within minimum periods.

- ***Renewable generation limit***

$$P_{WInd,r,t} \leq P_{WInd,max} \tag{21}$$

$$P_{Solar,r,t} \leq P_{Solar,max} \tag{22}$$

- ***Charging / discharging power limit***

$$\sum_{t=1}^{T} P_{PEV,t} \leq P_{EV,total} \tag{23}$$

$$P_{EVD,t,max} \leq P_{PEV,t} \leq P_{EVC,t,max} \tag{24}$$

2.3 Implementation of Proposed CMBO Algorithm for UC problem

The step by step procedure for PEVs and RES constrained UC problem using CMBO algorithm has been explained by the following steps.

1. Read the thermal, PEVs and RES data such as market price, load and reserve demand, cost coefficients of thermal units, start-up/shut-down cost of thermal units, operating limits of wind and thermal units, cut-in, rated and cut-out speed, fixed and operating cost of wind units.
2. Initialize the CMBO parameters: like population size (N), number of variables, random number and maximum number of iterations.
3. Generate population for both Cat and Mouse. Using the equation (5) and (6).
4. Set Count i = 1 and Time interval t=1
5. Determine the best and feasible UC schedule PEVs for charging and discharging mode, wind and thermal units for the given forecasted load demand and reserve demand using CMBO algorithm.
6. Optimize the power generation of wind generation, charging and discharging of PEVs and power generation of thermal units.

7. Compute the fuel cost, startup cost and total operating cost of interconnected power system.
8. Check, whether all constraints and various forecasted load of hybrid electric systems are satisfied. If yes go to step 13 otherwise go to next step.
9. Set count i = I + 1
10. Call CMBO algorithm and determine fitness value of each populations (Minimum operating cost)
11. Compute best UC schedule, charging and discharging power of PEVs, steam power dispatch, Reserve power allocation, wind power dispatch, total operating cost of proposed hybrid system.
12. Check, whether all intervals are over. If yes go to next step otherwise go to step 4.
13. Check, whether the optimal solution is reached. If yes go to next step else go to step 3.
14. Save the best solutions & Print the results and STOP.

3 Results and Discussion

In this section, simulate the Unit commitment problem using MATLAB platform and obtained results are discussed. The performance and optimization quality of proposed CMBO is analyzed using standard IEEE-39 test system (10 Unit 24 Hour Test System) and considering PEVs and RES. Generator data of steam plants, operating limits, system demand for 234 hours are taken from reference[11]. The wind velocity, cut-in and cut-out speed of the wind turbine, date of PEVs are adopted from reference[7].

The ten thermal units are integrated with a wind power generating plant with large scale unit and PEVs for 24 h power system. The wind data taken from[20] and it is the forecasting data of an on-shore 85 MW wind farm in Northern Ireland power system. Hourly data from one typical day in January, April, July and October has been selected representing scenarios in the seasons of winter, spring, summer and autumn are shown in reference[11]. Locating in the west coast of Europe in the Atlantic Ocean, the island of Ireland endures high wind and frequent raining during the autumn and winter while lower wind in the spring and summer.

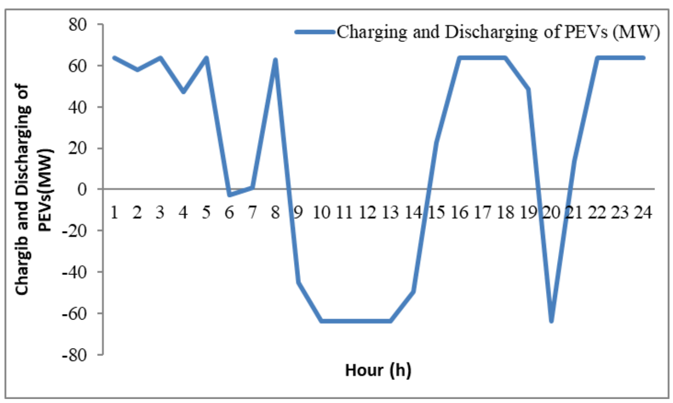

Fig 1. Charging and Discharging of PEVs

In this work, 50,000 PEVs are unspecified to be integrated in the 10-unit power system, and the daily average travelling distance and expected power demand of a PEV are 32.88 miles and 8.22 kW h respectively. The predicted hourly power demands are also shown in the study[12]. In addition, the total Power necessity P_{exp} is 411 MW and expected to be met by power generation. The G2V and V2G models are also considered in the case studies. The data of wind farm and PEVs are given in refinance[11].

The proposed CMBO algorithm is effectively determines the optimal solution of renewable energy and PEVs integrated 10 unit 24 hour test system. The methodology initially computes the maximum available power generation of wind and PEVs units. The PEVs are operated in both charging and discharging mode, so the original power demand will be increased in the charging mode (G2V) and decreased in the discharging mode (V2G). The charging and discharging power of PEVs unit is graphically displayed in Figure 1. The sum of generated wind and PEVs powers are subtracted from the load demand, the remaining power only generated by thermal units. The algorithm find the most economical she dulling plan for wind and PEVs integrated test system. Here, generator 6, 7, 8 and 9 are entirely de-committed for 24 hours. Generator 10 only one hour generates the power

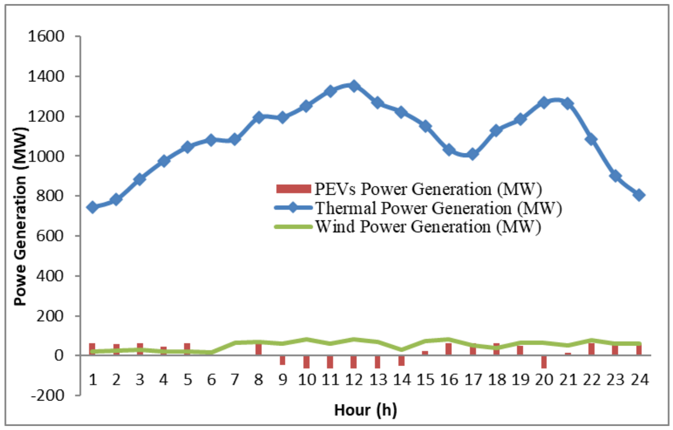

Fig 2. Power generation of thermal, PEVs and Wind units

for meeting the power demand. The Power generation of 10 Thermal Units with a PEV and Wind farm is graphically reported in Figure 2.

Table 1. Simulation results of 10 Thermal Units with a PEV and Wind farm

Hour (h)	Startup cost ($)	Fuel Cost ($)	Total cost ($)
1	0	14410.79	14410.79
2	0	15100.59	15100.59
3	0	16898.47	16898.47
4	1120	19102.3	20222.3
5	0	19535.39	19535.39
6	1800	21479.95	23279.95
7	1100	22136.13	23236.13
8	0	24018.09	24018.09
9	0	24355.65	24355.65
10	340	25456	25796
11	0	26745.32	26745.32
12	60	28091.47	28091.47
13	0	25718.81	25718.81
14	0	24812.37	24812.37
15	0	23275.06	23275.06
16	0	21207.47	21207.47
17	0	20829.84	20829.84
18	0	22948.71	22948.71
19	0	24220.91	24220.91
20	0	25554.9	25554.9
21	0	25422.28	25422.28
22	0	21678.72	21678.72
23	0	17201.06	17201.06
24	0	15482.29	15482.29
Total ($)	4420	525682.56	**530102.56**

The cat and mouse group searching operators are effectively searching the optimal power generation of all committed units and to minimize the total operating cost of integrated generating system. The simulation results of 10 Thermal Units with a PEV and Wind farm is reported in Table 1. This table describes the hourly start-up cost, fuel cost and total operating cost system.

Table 2. Comparison of total cost of proposed with existing method for various case studies

Various Case Studies	CMBO (proposed Method)			Parallel UCsRP method [11]		
	Best ($)	Worst ($)	Average ($)	Best ($)	Worst ($)	Average ($)
UC only (Case 1)	552847.33	552892.56	552860.42	563937	563937	563937
UC + PEVs charging (Case 2)	560068.68	560095.20	560072.50	571158	571164	571160
UC + PEVs charging / discharging (Case 3)	554482.50	554499.50	554487.50	565572	566065	565711
UC + PEVs charging / discharging + Wind units (Case 4)	530102.56	53011336	530106.29	533961	533998	533970

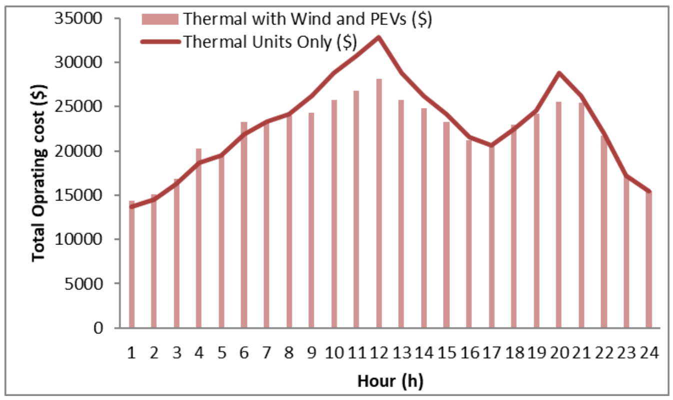

Fig 3. Caparison of total operating cost of thermal units with and without wind and PEVs

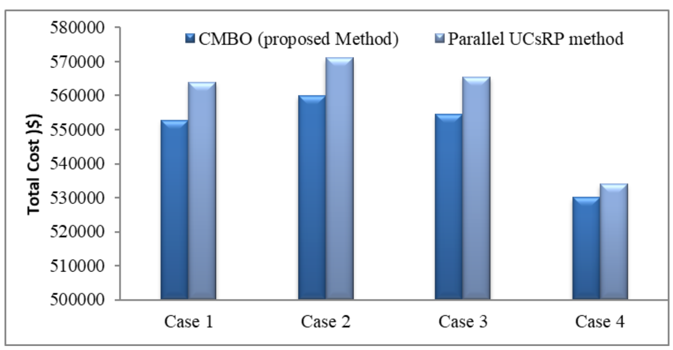

Fig 4. Caparison of total operating cost of proposed with Parallel UCs-RP method

The total start-up cost, total fuel cost and total operating cost is $ 4420, $525682.56 and $530102.56 respectively. Caparison of total operating cost of thermal units with and without wind farm and PEVs is shown in Figure 3. Comparison of total cost of proposed with existing method for various case studies is shown in Table 2. This table describes the best, worst and average cost of proposed with existing method meth0d of Parallel UCsRP. It is also graphically displayed in Figure 4. From the Figure 4, the case 4 that is thermal units with RES and PEV is efficiently minimizing the total operating cost of the integrated power system.

4 Conclusion

In this research work, a method based on CMBO approach has been proposed to find the best solution for the Wind and PEVs interconnected UC problem for minimizing their total operational cost. The essential optimal solutions are obtained by properly allocations and commitment of thermal units, maximum utilization wind power generation and optimal charging and discharging of PEVs in a various load demand with 24 hour time period. The projected technique has been implemented on the IEEE 39-bus test system with a wind and PEV units. The simulated results such as optimal UC schedule, optimal power production, and wind power, charging and discharging power of PEVs are displayed. The total operating cost is 4.11 % minimized when compared with base case approach and 0.73 % reduced than the other existing method viz. parallel UCs–RP method From the comparison, the proposed algorithm effectively minimizes the total operational cost of interconnected power system. The proposed CMBO is a parameter less optimization approach and it contains two groups of searching agents such as Cat group and Mice group. The two searching agents easily reach the global optimal solution (More accuracy solutions) with less program execution time. The existing algorithm of GA, PSO and ABC etc. have more number of control parameters with a single searching operator, so it takes more time for achieving the best solutions. These algorithms (GA, PSO and ABC etc.) may yield premature results with local optimal solutions based on the selection of its control parameters It is recommended that the proposed CMBO algorithm is one of the best meta-heuristic approaches for solution complex, multi objective nonlinear security constrained UC, profit maximization of GENCOs problems.

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