International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

OPTIMIZATION OF UNIT COMMITMENT PROBLEM USING CLASSICAL SOFT COMPUTING TECHNIQUE (PSO)

Sanjeev Kumar[1], Harkamal Deep Singh[2]

[1]M.Tech. Research Scholar, Department of EEE, IKGPTU University, Punjab
[2]Assistant professor, Department of EEE, IKGPTU University, Punjab

---***---

Abstract: *In electrical power system network of transmission and distribution, unit commitment is a complicated decision-making process, which link to the arrangement of generators over a desire of time periods to satisfy power system load demand (industrial and agriculture), operational constraints and system reliability. A classical soft computing (particle swarm optimization) is a technique used to apply for the search space of a given problem to discover out the parameters required to max. or min. a particular objective. This research paper presents the way out to short term (one day) unit commitment of thermal electrical power System using PSO Algorithm.*

Keywords: *Unit Commitment problem (UCP), Particle Swarm Optimization (PSO).*

I. INTRODUCTION

The unit commitment problem finds out hourly start-up and shut down schedule as well as power output for the generating units over an assured time period. The optimization schedule of units minimizes the total operational cost while satisfying all system constraints and load demand of generating units. In a Unit Commitment Problem, the main aim is to get the minimum total operating cost by a accurate scheduling of the units ON/OFF status of the generators subject to the power system and physical constraints. For a short-term (one day) unit commitment problem such as daily or hourly arrangement of generators, the units operator needs to run the model in real-time. The operator should have instant right to use to information concerning which generators should be operated when emergency situations came up or how to-do list around planned maintenance of generating units. Modern Soft Computing Techniques Particle Swarm Optimization is applied to solve the unit commitment problem.

II. PROBLEM FORMULATION

Unit commitment is a multifarious decision making process because of the many constraints that must not be desecrated when finding optimal or close to optimal commitment schedules. Mathematically, the Unit Commitment Problem is a mixed-integer, non-linear, combinatorial optimization problem. The optimal solution of above complex UCP in power system can be obtained by classical soft computing global search techniques. The objective function of the short term thermal Unit Commitment Problem is combination of the fuel cost, start-up cost and shut-down cost of the generating units and mathematically can be expressed as [1]:

$$Cost_{NH} = \sum_{h=1}^{H}\sum_{i=1}^{NG}[FC_i(P_{ih})*U_{ih} + STUC_{ih}*(1-U_{i(h-1)})*U_{ih} + SDC_{ih}*(1-U_{ih})*U_{i(h-1)}] \quad (1)$$

Where,

$Cost_{NH}$ is the total operating cost over the scheduled horizon

$FC_i(P_{ih})$ is the fuel cost function of units

$U_{i(h-1)}$ is the ON/OFF status of i^{th} unit at $(h-1)^{th}$ hour.

U_{ih} is the ON/OFF status of i^{th} unit at h^{th} hour.

U is the decision matrix of the U_{ih} variable. for i=1,2,3,........NG.

P_{ih} is the generation output of i^{th} unit at h^{th} hour.

$STUC_{ih}$ is the start-up cost of the i^{th} generating unit at h^{th} hour.

SDC_{ih} is the shut-down cost of the i^{th} generating unit at the h^{th} hour.

NG is the number of thermal generating units

$U_{ih} \in \{0,1\}$ and $U_{i(h-1)} \in \{0,1\}$

H is the number of hours in the study of time horizon.
(for Short-Term unit Commitment, H is generally taken as 8-12 Hours or one day. For general unit commitment scheduling H is taken as 24 hours and for long term unit commitment, Time horizon H may be taken as one week , one month, three month, six month or one year duration.

(a) Fuel Cost, $FC_i(P_{ih})$

The fuel cost function of the thermal unit $FC_i(P_{ih})$ is expressed as a quadratic equation:

$$FC(P_{ih}) = \sum_{i=1}^{NG}(a_i P_{ih}^2 + b_i P_{ih} + c_i) \qquad \$/hrs. \quad (2)$$

Where, a_i (\$/MW²h), b_i (\$/MWh) and c_i (\$/h) are fuel consumption coefficients of i[th] unit.

(b) Start-up cost, $STUC_{ih}$

Startup cost is warmth-dependent. Startup cost is the cost concerned in bringing the thermal generators unit online. Startup cost is expressed as a function of the no. of hours the generating units has been shut down. Mathematically, the start-up cost can be represented as a step function:

$$STUC_{ih} = \begin{cases} HSC_i, & if \quad MDT_i \le DT_i < (MDT_i + CSH_i) \\ CSC_i, & if\ DT_i > (MDT_i + CSH_i) \end{cases}$$

where, DTi is shut down duration, MDTi is Minimum down time, HSCi is Hot start up cost, CSCi is Cold start up cost and CSHi is Cold start hour of ith unit.

(c) Shut down cost , SDC_{ih}

Shut down costs are defined as a fixed amount for each unit/shutdown. The typical value of the shut down cost is zero in the standard systems. This cost is considered as a fixed cost.

III. PARTICLE SWARM OPTIMIZATION

PSO is a swarm-based intelligence algorithm subjective by the social behavior of animals such as a flock of birds finding a food source or a school of fish protecting them-self from a marauder. It is classical soft computing technique first described by James Kennedy and Russell C. Eberhart in 1995. They found the idea from two separate concepts, idea of swarm intelligence based off the surveillance of swarming habits by certain kinds of animals (such as fish & birds) and field of evolutionary computation.

A particle in this technique is analogous to a bird or fish flying through a search (problem) space. The movement of each particle is co-ordinate by a velocity which has both magnitude and direction. Each particle (unit) position at any instance of time is influenced by its best position and the position of the best particle in a problem space. The performance of a constituent part is measured by a fitness value, which is problem precise.

IV. MATHEMATICS INVOLVED IN PSO

The Particle Swarm Optimization algorithm works by separately maintaining a no. of candidate (particle) solutions in the search space. For the period of each iteration of the algorithm, each particle solution is considered by the objective function being optimized, determining fitness of that solution. Each candidates solution can be consideration of as particle 'flying' through the fitness landscape finding the max./min. of the objective function. At the start, the PSO The PSO algorithm just use to calculate its candidate solutions, and operates upon the resultant fitness values. Each particle sustains its position, collected of the candidate solution and its calculated fitness, and its velocity. In addition, it considered the best fitness value it has completed thus far during the operation of the algorithm, referred to as the individual best fitness, and candidate solution that achieved this fitness, referred to as the individual best position or individual best candidate solution. At last, the algorithm keeps the best fitness value achieved among all particles in the swarm, called the global best fitness and candidate solution that achieved this fitness called the global best candidate solution or global best position. Fitness evaluation is performed by supplying the candidate solution to the objective function. Individual and global best fitnesses and positions are updated by comparing the recently evaluated fitnesses against the previous individual and global best fitnesses, and replacing the best fitnesses and positions as needed. The position and velocity update step is responsible for optimization capability of algorithm. The velocity of each particle in swarm is updated using the following equation:

$$V_i^{(u+1)} = w * V_{ij}^{(u)} + C_1 * R_1 \left(Pb^u{}_{ij} - P^u{}_{ij} \right) + C_2 * R_2 \left(G^u{}_J - P^u{}_{ij} \right) \left(i = 1,2...NP;\ j = 1,2...NG \right) \quad (3)$$

$$P^{u+1}{}_{ij} = P^u{}_{ij} + V_i^{u+1} \quad (4)$$

P is the current position of j^{th} member of i^{th} particle at u^{th} iteration

C_1, C_2 are the acceleration constants

w is the weighing function or inertia weight factor
NP is the number of particles in a group
NG is the number of members in a particle
R_1, R_2 is random number between 0 and 1

The velocity is generally limited to a certain maximum value. PSO using Eq.(3) is called the *gbest* model. The particles in the swarm are accelerated to new positions by adding new Velocities to their present positions. The new velocities are calculated using Eq.(5) and new positions of the particles are updated using Eq. (6).

$$V_i^{new} = w * V_{ij} + C_1 R_1 \left(Pb^{best}{}_{ij} - P_{ij} \right) + C_2 R_2 \left(G^{best}{}_J - P_{ij} \right) \left(i = 1,2...NP;\ j = 1,2...NG \right) \quad (5)$$

$$P^{new}{}_{ij} = P_{ij} + V_i^{new} \quad (6)$$

Suitable selection of inertia weight 'ω' is used to provide a balance between global and local explorations, which requires less iterations, on an average, to find a sufficiently optimal solutions.

The inertia weight w is set according to the following equation,

$$W = W_{\max} - \left[\frac{W_{\max} - W_{\min}}{ITER_{\max}}\right] * ITER \qquad (7)$$

Where
$IT^{\max}$ is the maximum number of iterations(generation) and IT is the current number of iterations.
The maximum and minimum velocity limit in the j^{th} dimension is computed as:

$$V_j^{\max} = \frac{P_j^{\max} - P_j^{\min}}{\alpha} \quad and \quad V_j^{\min} = \frac{P_j^{\max} - P_j^{\min}}{\alpha} \qquad (8)$$

Where α is the chosen number of intervals in the j^{th} dimension.

PSO Algorithm and Flow Chart: figure 1
The PSO algorithm have just three steps, which are repeated in anticipation of some stopping condition is meet up.
1. Evaluate the fitness of each particle
2. Update individual and global best fitness and positions
3. Update velocity and position of each particle

V. FLOW CHART OF PROPOSED PSO ALGORITHM

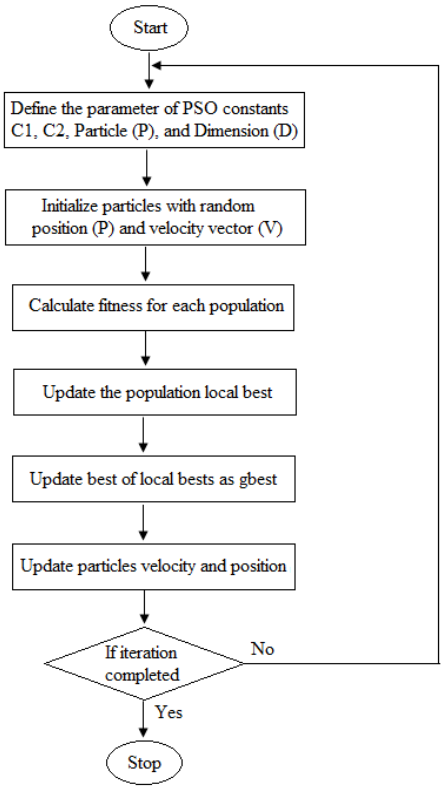

Figure-1: Flow chart of proposed PSO.

VI. ALGORITHM FOR STUCP USING PSO

The search procedure for calculating the optimal generation quantity of each unit is summarized as follows:

1. In the ELD problems the number of online generating units is the 'dimension' of this problem. The particles are randomly generated between the maximum and the minimum operating limits of the generators and represented using Eq. (3).
2. To each individual of the population calculate the dependent unit output from the power balance.
3. Calculate the evaluation value of each particle P_{gi} in the population using the evaluation function.
4. Compare each particle's evaluation value with its *pbest*. The best evaluation value among them *pbest* is identified as *gbest*.
5. Modify the Velocity of each particle by using the Equation (5)
6. Check the velocity constraints of the members of each particle from the following conditions :

$$f \;\; V_{ij}^{r+1} > V_J \;,\; then \; V_{ij}^{r+1} = V_j^{\max}$$
$$if \;\; V_{ij}^{r+1} < V_J \;,\; then \; V_{ij}^{r+1} = V_j^{\min}$$
$$where \; V_j^{\min} = -0.5 P_j^{\min}$$
$$where \; V_j^{\max} = +0.5 P_j^{\max}$$

7. Modify the position of each particle using the Eq. (4). P_{ij}^{u+1} must satisfy the constraints, P_{ij}^{u+1} must be modified towards the nearest margin of the feasible solution.
7. If the evaluation value of each particle is better than previous *pbest*, the current value is set to be *pbest*. If the best *pbest* is better than *gbest*, the best *pbest* is set to be *gbest*.
8. If the number of iterations reaches the maximum, then go to step 10. Otherwise, goto step 2.
10. The individual that generates the latest *gbest* is the optimal generation power of each unit with the minimum total generation cost.

VII. TEST SYSTEMS, RESULTS AND DISCUSSION:

In order to show the effectiveness of the Proposed PSO Algorithm for STUCP, two different types of test systems have been taken into consideration:

1. The first test system consists of Six Generating units has been taken from IEEE 30-Bus System with a time varying load demand for one day.
2. The second test system consists of Ten Generating Units Model and load data for one day.

The corresponding results has been obtained using Particle Swarm optimization Technique using Population Size=50 and Maximum Iteration=50. The Flow chart for Single Area Unit Commitment Problem using PSO is shown in Figure-1.

The MATLAB Simulation software 7.12.0 (R2011a) is used to obtain the corresponding results.

Table-I: IEEE 30 bus system characteristics 6 Unit Model

UNITS	P_{max}	P_{min}	A Rs	B Rs.	C Rs	MU_i	MD_i	H_{cost} Rs	C_{cost} Rs	C_{hour}	IniState
Unit1	200	50	0.00375	2	0	1	1	70	176	2	1
Unit2	80	20	0.0175	1.7	0	2	2	74	187	1	-3
Unit3	50	15	0.0625	1	0	1	1	50	113	1	-2
Unit4	35	10	0.00834	3.25	0	1	2	110	267	1	-3
Unit5	30	10	0.025	3	0	2	1	72	180	1	-2
Unit6	40	12	0.025	3	0	1	1	40	113	1	-2

Table-II: Load Demand data for 6 Unit Model

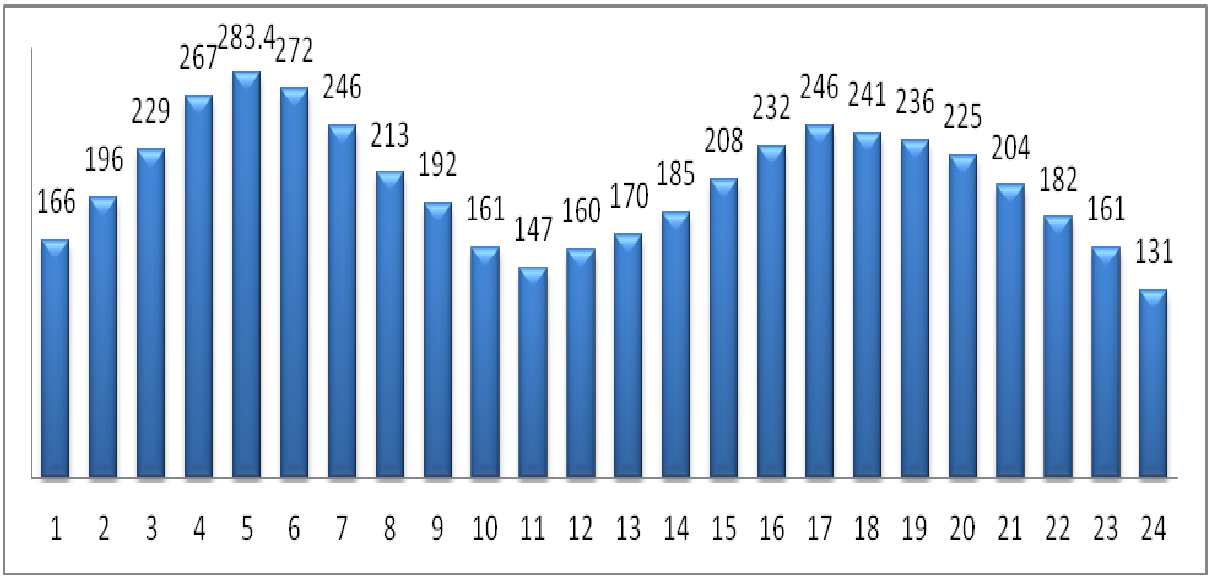

Table-III: Results for 30-Bus System 6 unit Using PSO

Load Demand (MW)	U1	U2	U3	U4	U5	U6
166	166	0	0	0	0	0
196	146	0	50	0	0	0
229	167	0	50	0	0	12
267	137	80	50	0	0	0
283.4	153	80	50	0	0	0
272	142	80	50	0	0	0
246	166	80	0	0	0	0
213	133	80	0	0	0	0

192	112	80	0	0	0	0
161	161	0	0	0	0	0
147	147	0	0	0	0	0
160	160	0	0	0	0	0
170	170	0	0	0	0	0
185	105	80	0	0	0	0
208	128	80	0	0	0	0
232	152	80	0	0	0	0
246	166	80	0	0	0	0
241	161	80	0	0	0	0
236	156	80	0	0	0	0
225	145	80	0	0	0	0
204	124	80	0	0	0	0
182	102	80	0	0	0	0
161	161	0	0	0	0	0
131	131	0	0	0	0	0
TOTAL COST					13423 ($)	

Table-IV: Generating Unit characteristics-10 Unit Model

UNITS	P_{max}	P_{min}	A Rs	B Rs.	C Rs	MU_i	MD_i	H_{cost} Rs	C_{cost} Rs	C_{hour}	IniState
Unit1	455	150	1000	16.19	0.00048	8	8	4500	9000	5	8
Unit2	455	150	970	17.26	0.00031	8	8	5000	10000	5	8
Unit3	130	20	700	16.6	0.002	5	5	550	1100	4	-5
Unit4	130	20	680	16.5	0.00211	5	5	560	1120	4	-5
Unit5	162	25	450	19.7	0.00398	6	6	900	1800	4	-6
Unit6	80	20	370	22.26	0.00712	3	3	170	340	2	-3
Unit7	85	25	480	27.74	0.00079	3	3	260	520	2	-3
Unit8	55	10	660	25.92	0.00413	1	1	30	60	0	-1
Unit9	55	10	665	27.27	0.00222	1	1	30	60	0	-1
Unit10	55	10	670	27.79	0.00173	1	1	30	60	0	-1

Table-V: Load Demand data for 10 Unit Model

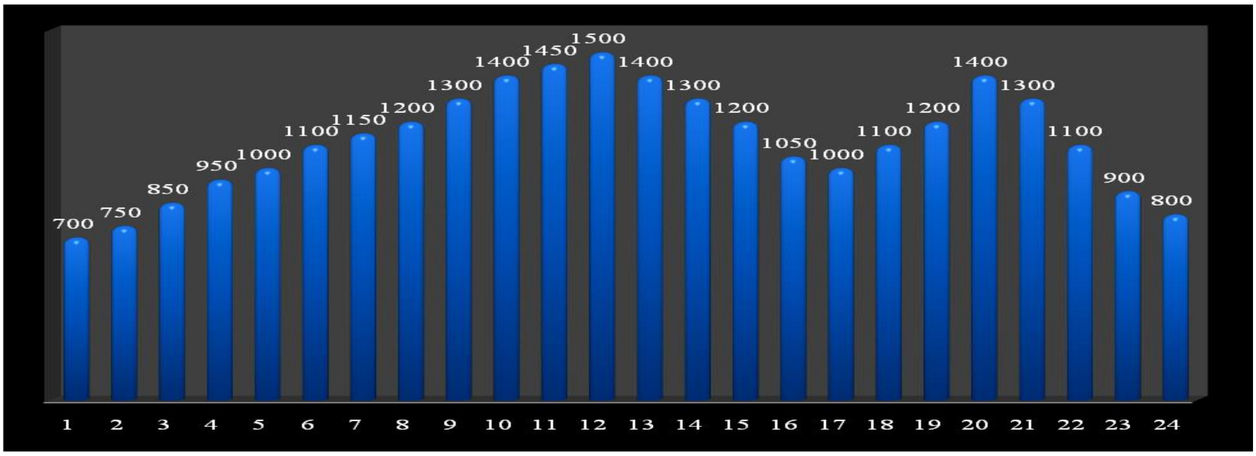

Table-VI: Results of 10 unit System Using PSO

Load Demand (MW)	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
700	455	245	0	0	0	0	0	0	0	0
750	455	295	0	0	0	0	0	0	0	0
850	455	370	0	0	0	0	25	0	0	0
950	455	450	0	0	0	20	25	0	0	0
1000	455	370	0	130	0	20	25	0	0	0
1100	255	455	0	130	0	20	25	0	0	0
1150	455	455	0	130	40	20	0	0	0	0
1200	455	410	130	130	25	0	0	0	0	0
1300	455	455	130	130	30	0	0	0	0	0
1400	455	355	130	130	110	0	0	10	10	0
1450	455	355	130	130	162	33	25	10	10	0
1500	455	355	130	130	162	73	25	10	10	0
1400	455	355	130	130	162	80	25	43	10	10
1300	455	355	130	130	162	33	25	10	0	0
1200	455	455	130	130	30	0	0	0	0	0
1050	455	310	130	130	25	0	0	0	0	0
1000	455	260	130	130	25	0	0	0	0	0
1100	455	335	130	130	25	0	25	0	0	0
1200	455	415	130	130	25	20	25	0	0	0
1400	455	455	130	130	162	33	25	10	0	0
1300	455	455	130	130	100	20	0	0	10	0
1100	455	360	130	130	25	0	0	0	0	0
900	455	420	0	0	25	0	0	0	0	0
800	455	345	0	0	0	0	0	0	0	0
TOTAL COST					5,67,330.56 ($)					

Table VII: Comparison of Results for ACO and proposed Method

S.NO	METHOD	TOTAL COST($)
1	FUZZY	571893.00
2	ACO	568815.38
3	PSO	567330.56

VIII. Conclusion

In this paper, researchers have presented the solution of Short Term Unit Commitment Problem using Particle Swarm Optimization Algorithm. The results for standard IEEE Bus system consisting of 6 Generating units has been successfully evaluated using PSO. Proposed method result is compared with ACO technique 10 unit system.

IX. Future Scope

(1) Particle Swarm Optimization is based on the intelligence. It can be applied into both scientific research and engineering purpose use.

(2) Particle Swarm Optimization has no overlapping and mutation calculation. The search can be carried out by the velocity of the particle. During the development of several generations, only the most optimist particle can transmit information on to the other particles, and the speed of the researching is very fast.

(3)The calculation in Particle Swarm Optimization is very simple. Compared with the other developing calculations, it occupies the bigger optimization ability and it can be completed easily.

(4) Particle Swarm Optimization adopts the real number code, and it is decided directly by the solution. The number of the dimension is equal to the constant of the solution.

REFERENCES

[1] Dimitris N. Simopoulos, Stavroula D. Kavatza, and Costas D. Vournas"Unit Commitment by an Enhanced Simulated Annealing Algorithm"IEEE Transactions on Power Systems, Vol.21, No. 1 Year: feb. 2006, pp. 68 – 76.

[2] Shantanu Chakraborty,Tomonobu Senjyu, Atsushi Yona,Ahmed Yousuf Saber and Toshihisa Funabashi, "Generation Scheduling of Thermal Units Integrated with Wind-Battery System Using a Fuzzy Modified Differential Evolution", Year 2009 , pp. 1-6

[3] Morteza Eslamian, Seyed Hossein Hosseinian, and Behrooz Vahidi "Bacterial Foraging-Based Solution to the Unit-Commitment Problem " IEEE Transactions on Power Systems,Vol.24, No.3 Year Aug. 2009, pp. 1478-1488.

[4] Yare Y., Venayagamoorthy G. K., and Saber A. Y., "Economic Dispatch of a Differential Evolution Based Generator Maintenance Scheduling of a Power System", IEEE Transactions on Power Systems,Vol. 12 July 2009, pp. 1-8.

[5] Chung, C.Y.,Han Yu and Kit Po Wong"An Advanced Quantum-Inspired Evolutionary Algorithm for Unit Commitment" IEEE Transactions on Power Systems,Vol. 26, Year 2011, pp. 847 – 854

[6] Manisha Govardhan , Ranjit Roy "An application of Differential Evolution technique on Unit Commitment Problem using Priority List Approach"IEEE Transactions on Power Systems,Vol 14 .Dec.2012, pp. 858 – 863

[6] Nicola Pedroni, and Yan-Fu Li, 'A Memetic Evolutionary Multi-Objective Optimization Method for Environmental Power Unit Commitment " IEEE Transactions on Power Systems,Vol 28, Year 2013 ,pp. 2660 – 2669

[7] Ranjit Roy et.al. "An application of Differential Evolution technique on Unit Commitment Problem using Priority List Approach" IEEE Transactions on Power Systems, Dec.2013 pp.858-863

[8] Divya Mathur "New Methodology BBO for Solving Different Economic Dispatch Problems"International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 1, January 2013

[9]Vikram Kumar Kamboj and S.K. Bath "Mathematical Formulation of Scalar and Multi-Objective Unit Commitment Problem Considering System and Physical Constraints"NCACCNES, February 2014, pp 245-250

[10] tao ding and rui bo, "big-m based miqp method for economic dispatch with disjoint prohibited zonesIEEE Transactions on power systems, vol. 29, no. 2, march 2014 pp 976-977

[11] M. S. P. Subathra et. al. "A Hybrid With Cross-Entropy Method and Sequential Quadratic Programming to Solve Economic Load Dispatch Problem" Year 2014, pp 1 – 14.

[12] *David Naso and* Ali Davoudi "A Distributed Auction-Based Algorithm for the Nonconvex Economic Dispatch problem" IEEE Transactions on industrial informatics, vol. 10, no. 2, may 2014 pp 1124-1132