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Optimization of Economic Load Dispatch with Unit Commitment on Multi Machine

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ABSTRACT

Economic load dispatch (ELD) and Unit Commitment (UC) are significant research applications in power systems that optimize the total production cost of the predicted load demand. The UC problem determines a turn-on and turn-off schedule for a given combination of generating units, thus satisfying a set of dynamic operational constraints. ELD optimizes the operation cost for all scheduled generating units with respect to the load demands of customers. The first phase in this project is to economically schedule the distribution of generating units using Gauss seidal and the second phase is to determine optimal load distribution for the scheduled units using dynamic programming method is applied to select and choose the combination of generating units that commit and de-commit during each hour. These pre-committed schedules are optimized by dynamic programming method thus producing a global optimum solution with feasible and effective solution quality, minimal cost and time and higher precision. The effectiveness of the proposed techniques is investigated on two test systems consisting of five generating units and the experiments are carried out using MATLAB R2010b software. Experimental results prove that the proposed method is capable of yielding higher quality solution including mathematical simplicity, fast convergence, diversity maintenance, robustness and scalability for the complex ELD-UC problem.

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1. INTRODUCTION

The Economic Load Dispatch (ELD) and Unit Commitment (UC) are well known problems in the power industry and have the potential to save millions of rupees per year in fuel and related costs. This problem is a complex decision-making process and it is difficult to develop any rigorous mathematical optimization methods capable of solving the ELD- UC problem for any real-size system. Also, multiple constraints should be imposed which must not be violated while finding the optimal or near-optimal solution. Hence, classical methods like Gauss seidal method solving practical ELD- UC problems. Nature and Bio-inspired techniques are successful nowadays due to their inherent capability of processing a population of potential solution simultaneously, which allows them to perform an extensive search space thus arriving at an optimal solution. The Economic Load Dispatch and Unit Commitment problems. The UC problem determines a turn-on and turn-off schedule for a given combination of generating units, thus satisfying a set of dynamic operational constraints using GS. ELD optimizes the operation cost for all scheduled generating units with respect to the load demands of customers using Gauss seidal. The proposed algorithm is evaluated in terms of total fuel cost, execution time, mean cost, robustness and algorithmic efficiency. The significance of this approach is to obtain a least cost solution for the ELD- UC problem. The paper is organized as follows: The mathematical formulation of the ELD -UC problems along with the constraints are given in Section 3. The implementation of Gauss Seidal for solving the problem under consideration is delineated in Section 4.fault analysis is section.5 and section 6 consists of UC optimization problem for turning a unit on/off which is solved by Dynamic Programing Method including Priorty List concept. Experimental results for the test systems are discussed in Section 7. Section 8. Draws the concluding remarks and future expansions of this work.

2. NOMENCLATURE :

ai, bi , ci Fuel cost coefficients unit i
Shi : Hot start cost in Rs
Sci : Cold start cost in Rs
c–s : hour Cold start hour in hours
MUi : Minimum up time in hours
MDi : Minimum down time in hours
N : Number of generating units
Pi max : Maximum output power of unit i in MW
Pi min : Minimum output power of unit i in MW
Pit : Power produced by unit i in time t
PGi : Power generation of the plant i in MW
PDt : Power demand at hour t in MW
PRt : Spinning reserve requirement at hour t in MW
Rs Rupees ini state Initial status of the unit in hours
SDi : Shut down cost in Rs
STi : Start up cost in Rs
CCF : Composite cost function h hour MW Mega Watt i Index of generating units (i = 1 ,2,….,N)
Xi on (t) : Duration of continuously ON of unit i in hour t
Xi off (t): Duration of continuously OFF of unit i in hour t
λ : Incremental production cost

3. MATHEMATICAL FORMULATION

The ideal method of solving the generator scheduling problem involves an exhaustive trial of all the possible solutions and then choosing the best amongst these solutions. This straightforward method would test all combinations of units that can supply load and reserve requirements. The combination that has the least operating cost is taken as the optimal schedule. This enumerative process is guaranteed to find the optimal solution but the solution must be obtained within a time that makes it useful for the intended purpose. Even when the problem is highly constrained, the efficiency of the solution is poor except for the simplest of cases The generator scheduling problem involves the determination of the start up/shut down times and the power output levels of all the generating units at each time step, over a specified scheduling period *T*, so that the total start up, shut down and running costs are minimized subject to system and unit constraints. The major component of the operating cost for thermal units is the power production cost of the committed units that is conventionally taken in a quadratic form. The fuel cost, FCi per unit in any given time interval is a function of the generator power output as given in Equ. 1.

$$F_T = \sum_{i=1}^{n} F_i\,(P_i) = \sum_{i=1}^{n} a_i + b_i P_i + c_i P_i^2 \quad \frac{Rs}{hr} \tag{1}$$

where i a , i b , i c represents unit cost coefficients, and Pi is the unit power output.
The start-up cost (SC) depends upon the down time of the unit, which can vary from maximum value, when the unit is started from cold state, to a much smaller value, if the unit was turned off recently. The start-up cost calculation depends also on the treatment method for the thermal unit during down time periods. It can be represented by an exponential cost curve as shown in Equ. 2

$$SC_i = \sigma_i + \delta_i^* \left\{1 - exp\left(\frac{-Toff}{\tau_i}\right)\right\} \tag{2}$$

where σi is the hot start up cost, δi the cold start up cost, τi the unit cooling time constant and Toff, is the time at which the unit has been turned off. The total production cost, FT for the scheduling period is the sum of the running cost, start up cost and shut down cost for all the units is as shown in Equ. 3

$$F_T = \sum_{t=1}^{T} \sum_{i=1}^{N} FC_{i,t} + SC_{i,t} + SD_{i,t} \tag{3}$$

where N is the number of generating units and T is the number of different load demands for which the commitment has to be estimated. The shut down cost, SD is usually a constant value for each unit. The overall objective is to minimize FT subject to a number of constraints as follows:

(i) System hourly power balance is given in Equ. 4, where the total power generated must supply the load demand (PD) and system losses (PL).

$$\sum_{i=1}^{N} P_i\, u_i - (P_D + P_L) = 0 \tag{4}$$

(ii) Hourly spinning reserve requirements (R) must be met. This is mathematically represented using

$$\sum_{i=1}^{N} P_i^{max}\, u_i - (P_D + P_L) = R$$

(iii) Unit rated minimum and maximum capacities must not be violated. The power allocated to each unit should be within their minimum and maximum generating capacity as shown in Equ

$$P_i^{min} \leq P_i \leq P_i^{max}$$

(iv) The initial states of each generating unit at themstart of the scheduling period must be taken in to account.

(v) Minimum up/down (*MUT/MDT*) time limits of units must not be violated. This is expressed in

$$\left(T_{t-1,i}^{on} - MUT_i\right)^* \left(u_{t-1,i} - u_{t,i}\right) \geq 0$$

$$\left(T_{t-1,i}^{off} - MDT_i\right)^* \left(u_{t,i} - u_{t-1,i}\right) \geq 0$$

where Toff / Ton is the unit off / on time, while t,i u denotes the unit off / on [0,1] status. The principal objective of the economic load dispatch problem is to find a set of active power delivered by the committed generators to satisfy the required demand subject to the unit technical limits at the lowest production cost. The optimization of the. ELD problem is formulated in terms of the fuel cost
Expressed as,

$$F_T = \sum_{i=1}^{n} F_i\,(P_i) = \sum_{i=1}^{n} a_i + b_i P_i + c_i P_i^2 \quad Rs/hr$$

Subject to the equality constraint,

$$F_T = \sum_{i=1}^{N} P_i = P_D + P_L$$

Subject to the inequality constraint,

$$P_i^{min} \leq P_i \leq P_i^{max}$$

4. SOLVING ELD-UC USING GAUSS SEIDAL AND DYNAMING PROGRAMMING METHOD

Optimization technique was used to solve the economic load dispatch problem. In this case, the cost function for each generator has been approximately represented by a single quadratic function and is solved using mathematical programming based optimization techniques such as gauss seidal method which is an iterative algorithm for solving a set of non-linear algebraic equation. It was one of the methods used in load flow studies where a solution of vector is assumed and one of the equations is used to obtain the revised value of a particular variable and the solution of vector is immediately updated in respect of this variable. The process is then repeated for all the variable thereby completing one iteration the iteration process is repeated till the solution vector converges within prescribed accuracy. In GAUSS-SEIDEL algorithm, equation is utilized to find the final bus voltages using successive step of iterations, where

$$V_K^{i+1} = \frac{1}{Y_{KK}}\left[\frac{P_K + jQ_K}{V_K^*} - \left(\sum_{n=1}^{K=1} Y_{kn} V_n^{i+1} + \sum_{n=k+1}^{N} Y_{KN} V_n^{i}\right)\right]$$

5. FAULT ANALYSIS:

Fault in a circuit is any failure which interferes with the normal flow of current. Most of the faults on the power system lead to a short-circuit condition. When such a condition occurs, a heavy current (called short-circuit current) flows through the equipment, causing considerable damage to the equipment and interruption of service to the consumers. The fault current that flows depends on the equivalent Thevenin voltage, and the equivalent impedance at the fault terminals and the fault impedance, as illustrated in Figure 1.

$$I_{FAULT} = \frac{V_{TH}}{Z_{TH} + Z_f}$$

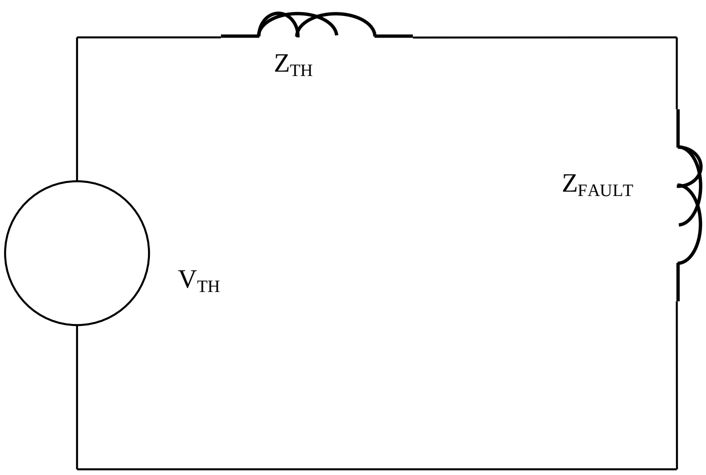

Figure 1. Equivalent impedance at the fault terminals and the fault impedance

Three-phase faults are called symmetrical faults which give rise to symmetrical currents (i.e. equal fault currents in the lines with 120 degree displacement). Other types of transmission-line faults (line to ground, line to line and double line to ground faults) cause an imbalance between the phases, and so they are called unsymmetrical faults. In this paper, a three – phase balanced fault occurs on bus – and the system is then unbalanced. The voltage magnitude and the phase angle at all the system buses are changed due to the fault and these values are then updated and are used to carry out the economic load dispatch analysis

6. DYNAMIC PROGRAMMING METHOD

This method is applicable to a wide class of problems and through this method the optimum combination of units to use without calculating the cost of all possible combinations can be found. The essence of dynamic programming is that the problem of finding the optimum outputs of the various units for a given load is replaced by the problem of finding the optimum outputs of the various units for all the loads between the minimum and maximum capacity of the units Suppose there are N thermal units and the time horizon is T. The unit commitment problem is to determine the commitment and generation levels of all units over the period T so that the total generation cost is minimized. Itis formulated as a mixed-integer optimization problem in which the generating units are assigned priority depending upon their AFLC (Average Full Load Cost).This method is considered to be one of the simplest method of unit commitment scheduling. Unit with the least value of AFLC is assigned the top most priority and the rest according to the increasing value of AFLC. This method is primarily based on the principle that unit with the least value of AFLC should be loaded to the maximum level and the unit with the least value should be lightly loaded as this may fetch more economical unit commitment solution. The value of AFLC is calculated as follows:

$$AFLCi = \frac{A_i+(B_i*P_{imax})+(C_i*P_{imax}^2)}{P_{imax}}$$

Following steps are followed for having unit commitment through Priority List Method –

- According to the AFLC value, arrange each generator in increasing order of their AFLC values. Generator with least value is given the highest priority.

- Now according to the total demand ‘D’, select how many generators required to fetch the given demand i.e. $\sum P_{macx}$ of how many generators from top are giving the required Demand.

- If number ‘n’comes out to be one, than entire generation from that priority 1 unit.

- If ‘n’comes out to be two, than through exhaustive technique checking which combination of power distribution between the two units is fetching the most optimized result.

- If ‘n’is coming greater than two, than all the generators from 1 to (n-2) will be loaded to their full capacity. The power left after loading these (n-2) generators will be distributed between the two left generators and through exhaustive technique, we will find the most optimized way to distribute the remaining power between these two units.

7. EXPERIMENTAL RESULTS

Experimental analysis is carried out with the goal of verifying or establishing the accuracy of a hypothesis. In this section, the simulation results of the proposed hybrid algorithms to optimize the Economic Load Dispatch (ELD) and Unit Commitment (UC) problem is discussed. The main objective of ELD-UC problem is to obtain minimum cost solution while satisfying various equality and inequality constraints. The effectiveness of the proposed algorithm is tested on a six unit 14 bus system .The costs incurred by each unit, fuel cost per hour, total and mean fuel costs per day, total execution time, mean time and algorithmic efficiency are evaluated.

8. FIVE UNIT TEST SYSTEM

The second case study consists of a Five- unit test system. The input data includes the generator limits, fuel cost coefficients, transmission loss matrix and load profile for 24 hours. The minimum generating capacity of the system is 25 MW and the maximum generating capacity is 770 MW. The load profile and the generator input data is given in Bus data Table 1 Line data Table 2 generator Real Power Limit Table 3 Cost function Table 4 and Unit Commitment input data Table 6 and Result Analysis Table 5 and Table 7 respectively. The minimum power demand requirement is 240 MW and the maximum demand is 740 MW

Table 1. Economic Load Dispatch Input Data Bus Data

BUS NO	BUS CODE	VOLTAGE (V)	ANGLE (δ)	PL (MW)	QL (MVAR)	PG (MW)	QG MVAR)	QMIN (MVAR)	QMAX (MVAR)	STATIC (MVAR)
1	1	1.06	0	0	0	0	0	0	0	0
2	2	1.045	0	50	60	79	0	40	50	0
3	2	1.014	0	131.88	26.6	80	0	60	40	0
4	2	1.02	0	66.92	10.0	100	0	80	90	0
5	2	1..01	0	13.64	2.24	120	0	30	70	0
6	0	1.00	0	15.68	10.5	0	0	-6	24	0
7	0	1.00	0	20	30.0	0	0	0	0	0
8	0	1.00	0	20	10.0	0	0	-6	24	0
9	0	1.00	0	41.3	23.24	0	0	0	0	0
10	0	1.00	0	22.6	8.12	0	0	0	0	0
11	0	1.00	0	4.9	2.252	0	0	0	0	0
12	0	1.00	0	8.54	2.24	0	0	0	0	0
13	0	1.00	0	19.9	8.12	0	0	0	0	0
14	0	1.00	0	20.86	7.00	0	0	0	0	0

Table 2. Line Data

BUS FROM	BUS TO	R (P.U)	X (P.U)	½ B_{sh} (P.U)	TAP SETTING VALUE
1	2	0.01938	0.05917	0.0264	1
1	8	0.04698	0.019797	0.0219	1
2	3	0.05811	0.17632	0.0187	1
2	6	0.5403	0.22304	0.0246	1
2	8	0.5695	0.17103	0.017	1
3	6	0.06701	0.04211	0.0173	1
6	7	0.01035	0.25202	0.0064	1
6	4	0.02330	0.20112	0.01230	0.912
7	9	0.06780	0.17015	0.001450	0.932
7	8	0.69870	0.55618	0.05600	0.978
8	5	0.01230	0.11001	0.0076	1
8	9	0.02340	0.0845	0.0110	1
9	10	0.03181	0.1989	0.090	1
9	14	0.09498	0.2551	0.03400	1
10	11	0.12291	0.13027	0.0120	1
11	4	0.066615	0.27038	0.040	1
4	12	0.12711	0.19207	0.0700	1
4	13	0.08205	0.19988	0.01110	1
12	13	0.22092	0.17388	0.0770	1
13	14	0.17093	0.34802	0.0230	1

WITH CAPACITOR												
SNO.	C6	C8	C13	P1(MW)	P2(MW)	P3(MW)	P4(MW)	P5(MW)	Λ(RS/MW)	LOSS	COST(RS/H)
1	5	6	8	165.4332	113.1396	80.0000	62.1532	25.00	484.3012	12.513	253248.31
	10	8	5	165.8282	112.4814	80.0000	62.2169	25.00	484.2387	12.276	253153.34
	15	10	12	165.8287	112.4800	80.0000	63.8500	25.00	484.2014	12.17	25293.20

Table 3. Generator Real Power Limit

GENERATOR	MIN(MW)	MAX(MW)
1	120	300
2	100	200
3	80	100
4	50	90
5	25	80

Table 4. Generator Cost Function

	GENERATOR COST FUNCTION ($C_i = A + BP_i + CP_i^2$)		
GENERATOR	A	B	C
1	160	6.0	0.003
2	180	6.1	0.005
3	200	6.3	0.008
4	220	6.5	0.001
5	250	6.7	0.0025

Table 5. Result Analysis

WITHOUT CAPACITOR									
SNO.	CAPACITOR	P1(MW)	P2(MW)	P3(MW)	P4(MW)	P5(MW)	Λ(RS/MW)	LOSS	COST(RS/H)
1	0	165.6334	112.5637	80.0000	63.1709	25.0000	485.7886	13.146	253571.0

FAULT WITHOUT CAPACITOR										
SNO.	FAULT	CAPACITOR	P1(MW)	P2(MW)	P3(MW)	P4(MW)	P5(MW)	Λ(RS/MW)	LOSS	COST(RS/H)
1	4+5i	0	165.464	112.870	80.00	62.7073	25.00	485.774	12.824	255409.96

FAULT WITH SHUNT CAPACITOR										
SNO.	FAULT	CAPACITOR	P1(MW)	P2(MW)	P3(MW)	P4(MW)	P5(MW)	Λ(RS/MW)	LOSS	COST(RS/H)
1	4+5i	5	165.3975	112.6960	80.00	63.0072	25.00	485.8481	12.773	254247.20
		10	165.6706	112.7400	80.00	62.5210	25.00	485.1620	12.566	253350.08
		15	165.8829	112.8820	80.00	62.0689	25.00	485.9650	12.3022	25285.02

Table 6. Unit Commitment Input Data

INPUT DATA	P1	P2	P3	P4	P5
P_{MIN}	120	100	80	50	25
P_{MAX}	300	200	100	90	80
Coef a	160	180	200	220	250
Coef b	6.0	6.1	6.3	6.5	6.7
Coef c	0.003	0.005	0.008	0.01	0.025
MINIMUM UP TIME	2	3	4	5	6
MINIMUM DOWN TIME	2	3	4	1	2
NO LOAD COST	16800	24000	33600	46080	49920
START UP COLD COST	19200	33600	40320	21120	26880
START UP HOT COST	14400	24000	33600	17280	19200
SHUT_DOWN COST	11520	15360	19200	14400	7680
FUEL_COST	192.00	192.00	192.00	192.00	192.00
RAMP-UP	50	80	100	80	30
RAMP-DOWN	75	120	150	120	50
COLD START TIME	4	5	5	1	2

HOURLY RESULTS:

Hour	Demand	Tot.Gen	Min MW	Max MW	ST-UP Cost	Prod.Cost	F-Cost	State	Units ON/OFF
0	-	-	375	770	0	0	0	5	1 1 1 1 1
1	250	250	145	380	48960	174336	223296	2	1 0 0 0 1
2	300	300	145	380	0	197856	421152	2	1 0 0 0 1
3	325	325	145	380	0	209616	630768	2	1 0 0 0 1
4	400	400	195	470	21120	298368	950256	3	1 0 0 1 1
5	450	450	195	470	0	324845	1275101	3	1 0 0 1 1
6	650	650	375	770	73920	532090	1881110	5	1 1 1 1 1
7	700	700	375	770	0	566170	2447280	5	1 1 1 1 1
8	720	720	375	770	0	579802	3027082	5	1 1 1 1 1
9	650	650	375	770	0	532090	3559171	5	1 1 1 1 1
10	550	550	375	770	0	479136	4038307	5	1 1 1 1 1
11	500	500	375	770	0	455616	4493923	5	1 1 1 1 1
12	650	650	375	770	0	544762	5038685	5	1 1 1 1 1
13	680	680	375	770	0	554650	5593334	5	1 1 1 1 1
14	740	740	375	770	0	593434	6186768	5	1 1 1 1 1
15	620	620	295	670	19200	463450	6669418	4	1 1 0 1 1
16	540	540	295	670	0	410822	7080240	4	1 1 0 1 1
17	420	420	195	470	15360	307776	7403376	3	1 0 0 1 1
18	400	400	195	470	0	298368	7701744	3	1 0 0 1 1
19	390	390	195	470	0	293664	7995408	3	1 0 0 1 1
20	350	350	145	380	14400	221376	8231184	2	1 0 0 0 1
21	320	320	145	380	0	207264	8438448	2	1 0 0 0 1
22	300	300	145	380	0	197856	8636304	2	1 0 0 0 1
23	280	280	145	380	0	188448	8824752	2	1 0 0 0 1
24	240	240	145	380	0	169632	8994384	2	1 0 0 0 1

Table 7. Hourly Basis Result

HOUR: 1 DEMAND: 250.0 MW F-COST: Rs 223296.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	170.0	120.0	300.0	0.0	96768.0
2	0	0.0	0.0	0.0	15360.0	0.0
3	0	0.0	0.0	0.0	19200.0	0.0
4	0	0.0	0.0	0.0	14400.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	250.0	145.0	380.0	48960.0	174336.0

HOUR: 2 DEMAND: 300.0 MW F-COST: Rs 421152.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	220.0	120.0	300.0	0.0	120288.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	300.0	145.0	380.0	0.0	197856.0

HOUR: 3 DEMAND: 325.0 MW F-COST: Rs 630768.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	245.0	120.0	300.0	0.0	132048.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	325.0	145.0	380.0	0.0	209616.0

HOUR: 4 DEMAND: 400.0 MW F-COST: Rs 950256.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	270.0	120.0	300.0	0.0	143808.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	1	50.0	50.0	90.0	21120.0	76992.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	3	400.0	195.0	470.0	21120.0	298368.0

HOUR: 5 DEMAND: 450.0 MW F-COST: Rs 1275100.8

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	1	70.0	50.0	90.0	0.0	89356.8
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	3	450.0	195.0	470.0	0.0	324844.8

HOUR: 6 DEMAND: 650.0 MW F-COST: Rs 1881110.4

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	1	100.0	100.0	200.0	33600.0	92160.0
3	1	80.0	80.0	100.0	40320.0	102720.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	650.0	375.0	770.0	73920.0	532089.6

HOUR: 7 DEMAND: 700.0 MW F-COST: Rs 2447280.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	1	150.0	100.0	200.0	0.0	126240.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	700.0	375.0	770.0	0.0	566169.6

HOUR: 8 DEMAND: 720.0 MW F-COST: Rs 3027081.6

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	1	170.0	100.0	200.0	0.0	139872.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	720.0	375.0	770.0	0.0	579801.6

HOUR: 9 DEMAND: 650.0 MW F-COST: Rs 3559171.2

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	1	100.0	100.0	200.0	0.0	92160.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	650.0	375.0	770.0	0.0	532089.6

HOUR: 10 DEMAND: 550.0 MW F-COST: Rs 4038307.2

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	240.0	120.0	300.0	0.0	129696.0
2	1	100.0	100.0	200.0	0.0	92160.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	50.0	50.0	90.0	0.0	76992.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	550.0	375.0	770.0	0.0	479136.0

HOUR: 11 DEMAND: 500.0 MW F-COST: Rs 4493923.2

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	190.0	120.0	300.0	0.0	106176.0
2	1	100.0	100.0	200.0	0.0	92160.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	50.0	50.0	90.0	0.0	76992.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	500.0	375.0	770.0	0.0	455616.0

HOUR: 12 DEMAND: 650.0 MW F-COST: Rs 5038684.8

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	240.0	120.0	300.0	0.0	129696.0
2	1	160.0	100.0	200.0	0.0	133056.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	650.0	375.0	770.0	0.0	544761.6

HOUR: 13 DEMAND: 680.0 MW F-COST: Rs 5593334.4

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	290.0	120.0	300.0	0.0	153216.0
2	1	140.0	100.0	200.0	0.0	119424.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	680.0	375.0	770.0	0.0	554649.6

HOUR: 14 DEMAND: 740.0 MW F-COST: Rs 6186768.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	1	190.0	100.0	200.0	0.0	153504.0
3	1	80.0	80.0	100.0	0.0	102720.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	5	740.0	375.0	770.0	0.0	593433.6

HOUR: 15 DEMAND: 620.0 MW F-COST: Rs 6669417.6

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	1	150.0	100.0	200.0	0.0	126240.0
3	0	0.0	0.0	0.0	19200.0	0.0
4	1	90.0	50.0	90.0	0.0	101721.6
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	4	620.0	295.0	670.0	19200.0	463449.6

HOUR: 16 DEMAND: 540.0 MW F-COST: Rs 7080240.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	300.0	120.0	300.0	0.0	157920.0
2	1	100.0	100.0	200.0	0.0	92160.0
3	0	0.0	0.0	0.0	0.0	0.0
4	1	60.0	50.0	90.0	0.0	83174.4
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	4	540.0	295.0	670.0	0.0	410822.4

HOUR: 17 DEMAND: 420.0 MW F-COST: Rs 7403376.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	290.0	120.0	300.0	0.0	153216.0
2	0	0.0	0.0	0.0	15360.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	1	50.0	50.0	90.0	0.0	76992.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	3	420.0	195.0	470.0	15360.0	307776.0

HOUR: 18 DEMAND: 400.0 MW F-COST: Rs 7701744.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	270.0	120.0	300.0	0.0	143808.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	1	50.0	50.0	90.0	0.0	76992.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	3	400.0	195.0	470.0	0.0	298368.0

HOUR: 19 DEMAND: 390.0 MW F-COST: Rs 7995408.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	260.0	120.0	300.0	0.0	139104.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	1	50.0	50.0	90.0	0.0	76992.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	3	390.0	195.0	470.0	0.0	293664.0

HOUR: 20 DEMAND: 350.0 MW F-COST: Rs 8231184.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	270.0	120.0	300.0	0.0	143808.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	14400.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	350.0	145.0	380.0	14400.0	221376.0

HOUR: 21 DEMAND: 320.0 MW F-COST: Rs 8438448.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	240.0	120.0	300.0	0.0	129696.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	320.0	145.0	380.0	0.0	207264.0

HOUR: 22 DEMAND: 300.0 MW F-COST: Rs 8636304.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	220.0	120.0	300.0	0.0	120288.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	300.0	145.0	380.0	0.0	197856.0

HOUR: 23 DEMAND: 280.0 MW F-COST: Rs 8824752.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	200.0	120.0	300.0	0.0	110880.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	280.0	145.0	380.0	0.0	188448.0

HOUR: 24 DEMAND: 240.0 MW F-COST: Rs 8994384.0

UNITS	ON/OFF	GENERATION	MIN MW	MAX MW	ST-UP Cost	PROD.COST
1	1	160.0	120.0	300.0	0.0	92064.0
2	0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0
5	1	80.0	25.0	80.0	0.0	77568.0
TOTAL:	2	240.0	145.0	380.0	0.0	169632.0

9. CONCLUSION

Economic Load Dispatch (ELD) and Unit Commitment (UC) problem has a significant influence on secure and economic operation of power system. Optimal commitment scheduling and dispatching can save huge amount of costs to electric utilities thus improving reliability of operation. This paper presents a novel approach based on Gauss Seidal and Dynamic programming method for solving the Economic Load Dispatch and Unit commitment problem. From the experimental results obtained, it can be seen that GS-Dynamic technique provides optimal solution in terms of total fuel cost, execution time and algorithmic efficiency. In future, efforts will be taken to impose complex real time constraints to the ELD-UC problem that include spinning reserves, emission constraint and network security on the ELD-UC problem. This application can also be solved using new optimization techniques like PSO, Genetic Algorithm

REFERENCES

[1] Pang C.K., Sheble G.B., and Albuyeh, "Evaluation of Dynamic Programming Based Methods and Multiple Area Representation for Thermal Unit Commitments", *IEEE* Transactions on PAS-100, no. 3, pp. 1212-1218, March 1981.
[2] C. E. Lin, S. T. Chen, and C. L. Huang, "A direct Newton-Raphson economic dispatch," *IEEE* Trans. on Power Systems, vol. 7, no. 3, pp.1149-1154, 1992.
[3] G.P.Granelli, P.Marannino, M.Montagna, and A.Silvestri, "Fast and Efficient Gradient Projection Algorithm for Dynamic Generation Dispatching", *IEEE* Transactions on Generation, Transmission, Distribution, vol.136, no. 5, pp.295-302, Sep. 1989.
[4] Xiaohong Guan, Peter B. Luh, and Lan Zhang "Nonlinear Approximation Method in Lagrangian Relaxation-Based Algorithms for Hydrothermal Scheduling ", *IEEE* Transactions on Power Systems, vol. 10, no. 2, pp. 772-778, May 1995.
[5] K.S.Hindi and M.R.Ab Ghani, "Dynamic Economic Dispatch for Large Scale Power Systems: A Lagrangian Relaxation Approach," Electrical Power Systems Research, vol. 13, no. 1, pp. 51-56, 1991.
[6] K. P. Wong and J. Yuryevich, "Evolutionary programming based algorithm for Environmentally-constrained economic dispatch," *IEEE* Trans.Power Syst., vol. 13, pp. 301–306, May 1998.
[7] Khamsawang, S., Booseng, C. and Pothiya, S., "Solving the economic dispatch problem with Tabu search algorithm," *IEEE* Int. Conf. on Ind. Technology, vol. 1, pp. 108-112, 2002.
[8] Zhuang F. and Galiana F.D., "Unit Commitment by Simulated Annealing," *IEEE* Transactions. on Power Systems, vol. 5, no.1, pp. 311-318, 1990.
[9] Roa C.A-Sepulveda, Herrera M., Pavez-Lazo. B, Knight U.G., Coonick A.H., "Economic Dispatch using fuzzy decision trees", Electric Power Systems Research 66 (2003) 115_/122, Dec 2002.
[10] R. Storn, K.V. Price. "Differential evolution a simple and efficient heuristic for global optimization over continuous spaces." J. Global Optimization vol.11, no. 4, 341–359, 1997.
[11] K.V. Price, R.M. Storn, J.A. Lampinen. Differential Evolution: A Practical Approach to Global Optimization. Berlin, Heidelberg: Springer, 2005.
[12] Iba, N. Nomana and H. "Differential evolution for economic load dispatch problems." Elect. Power Syst. Res. vol.78, no. 3, 1322–1331, 2008.
[13] S.-K. Wang, J.-P. Chiou and C.-W. Liu. "Nonsmooth/ non-convex economic dispatch by a novel hybrid differential evolution algorithm." IET Gen., Transm. Distrib. vol. 1, no. 5, 793– 803, 2007.