Application and comparison of optimization technique of economic dispatch with the General Algebraic Modeling System

Manoj Kumar Solanki[1], Himmat Singh[2]

[1,2]*Department of Electrical Engineering,*
Madhav Institute of Technology and Science, Gwalior (M.P.) India.

solankimanoj323@gmail.com

Abstract-- **The objective of Economic Dispatch is to determine an optimal of power output. To obtain the demand at minimum cost while satisfying the constraints. For simplicity, the cost function for each unit in the ED problems has been approximately represented by a single quadratic function and is solved using mathematical programming techniques. ELD has the objective of generation allocation to the power unit generators such that the total fuel cost is minimized and all operating constraints are satisfied. Generally economic dispatch is solved without accounting to transmission constraints, however, in deregulated power system environment Economic load dispatch (ELD) has the objective of generation allocation to the power generators such that the total fuel cost is minimized and all operating constraints are satisfied. A number of traditional methods are using for solving ED and other power system problems. During the last decade soft computing methods like PSO proposed, Evolutionary Strategy and GA method have been increasingly proposed for complex optimization problems. This paper proposes GAMS technique in which premature convergence is avoided by tuning the parameters for enhanced global and local search. This paper reviews and comparisons the performance of the PSO, GA and Evolutionary algorithm variants with conventional solver GAMS for economic load dispatch on two standard test systems 15-units and 40-units power system is included for validate the results.**

Keywords— **Non-linear Optimization, Modelling Language, Economic load dispatch, ramp rate limits, prohibiting zones, GAMS.**

1. INTRODUCTION

Generally power system optimization problems including economic dispatch (ED) have nonlinear characteristics with heavy equality and inequality constraints. Economic dispatch is one of the most important problems to be solved in the operation and planning of power system utilities tries to achieve high operating efficiency to produce cheap electricity. Competition exists in the electrical industry in generation and in the marketing of electricity. The operating cost of a power pool can be reduced if the areas with more economic units generate larger power than their load, and export the left-over power to other areas with more pricey units. The benefits thus gained will depend on several factors like the characteristics of a pool, the policies adopted by utilities, types of interconnections, tie-line limits and load distribution in different areas. Therefore, transmission capacity constraints in production cost analysis are important issues in the operation and planning of electric power systems. Soft computing based approaches are also becoming very popular. Although these methods do not always guarantee global best solutions, they often achieve a fast and near global optimal solution. Recently covariance matrix adapted evolutionary strategy has been proposed problems. Large dimension problems are difficult to optimize using soft computing methods, as these techniques take a long time to converge; on the other hand, traditional methods like the GAMS solver computes the best result almost instantaneously. There has been exceptional growth in mathematical programming techniques and development of computer codes to solve large scale optimization models over the past four to five decades. There has also been remarkable development in relational database for improved data organization and transformation capabilities. A number of efficient modeling languages have been developed which makes use of both the development in improved database management and mathematical programming techniques. One of the most popular and flexible languages among these is the General Algebraic Modeling System (GAMS) [1]. GAMS component was originally developed through a World Bank funded study in 1988. Resulting solutions are inaccurate and cause revenue losses. This assumption is not valid for practical generators because the cost functions of generators have discontinuities and higher order non-linearities due to valve point loading [2, 3], prohibited operating zones, and ramp rate limits of generators. This paper compare two test cases with PSO method and GA method. The performance is compared and validated by GAMS (General Algebraic Modeling System) software for standard two test systems.

2. GENERAL ALGEBRAIC MODELING SYSTEM

The General Algebraic Modeling System (GAMS) is particularly considered for modeling linear, nonlinear and mixed integer optimization problems[4]. The system is particularly very advantageous with large, complex problems. GAMS allows the user to deliberate on the modeling problem by making the setup simple. GAMS is especially useful for the conducting large, complex, one-of-a-kind problems which may require many revisions to establish an exact model. The user can change the formulation quickly and easily, and can even change from one solver to another. Similarly the use can easily convert from linear to nonlinear optimization option with little trouble. GAMS main window shown in the fig-1.

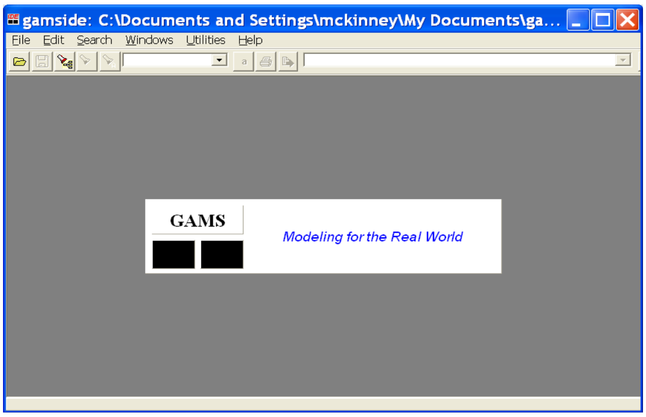

Fig.1: GAMS main window

The optimization solvers, in GAMS modeling system solves the different problems of linear, nonlinear and mixed integer optimization problems. The block diagram of optimization is shown in fig-2.

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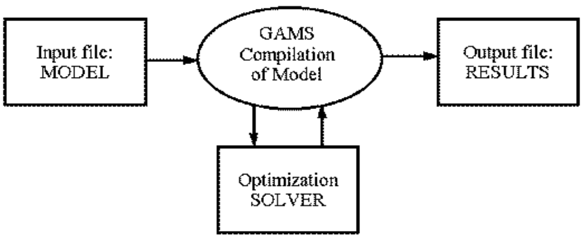

Fig.2: Optimization solver

Using the tools show in the table-1, recently use of GAMS are using the different area show in the table-2. The fundamental structure of a mathematical model coded in GAMS has the components: sets, data variable, equation, model and output. The tool kit in GAMS gives algorithms for each category of problem. The data presentation in GAMS can be done in its most elemental from using tables, columns etc. There are standard IF-ELSE, WHILE, LOOP, exception handling logic available which gives the inherent flexibility to use GAMS almost like any programming language while retaining the basic advantages. Exceptional debugging features exist for quick and effective identification of errors. GAMS also has the unique feature of providing a common language that can make use of a variety of solvers.

Table -1: Structure of GAMS model [4]

Sets: Declaration and assignment of members e.g. (buses, generators, lines etc.)
Dates in the form of scalars, parameters and tables: Declaration and assignment of values e.g. (generator ratings, costs, line parameters, MW and MVA loads etc.)
Declaration variables: Declaration and assignment of types. Bounds, initial values e.g.(generation level, line flow, load bus voltages, tap setting etc.)
Equations: Declarations and definition e.g.(load flow constraints, voltage limit, generation limits on MW and MWA cost function etc.)
Model and solve statements: Declaration and assignments of appropriate solver e.g. (model OPF, solve OPF)

Table -2: GAMS is using the different Areas [5, 6].

Agriculture	Applied general equilibrium
Chemical engineering	Economic development
Economics	Energy
Environmental Economics	Engineering
Finance	Forestry
International Trade	Military
Macro Economics	Physics
Management Science	Mathematics

3. ECONOMIC LOAD DISPATCH

The objective of the economic dispatch problem is to determine the generated powers P_i of units for a total load of P_D so that the total fuel cost, F_T for the N number of generating units is minimized subject to the power balance constraint and unit upper and lower operating limits [7]. The objective is

$$MinF_T = \sum_{i=1}^{N} F_i(P_i) \qquad \text{... (1)}$$

Where F_i is total fuel cost for the i^{th} generator (in \$/h) which is defined by,

$$F_i(P_i) = (a_i P_i^2 + b_i P_i + c_i)\$/MWh \quad \text{... (2)}$$

Where a_i, b_i and c_i are fuel-cost coefficients of the i^{th} unit.

$$P_i^{\min} \le P_i \le P_i^{\max} \qquad i = 1,2,..., N \quad \text{... (3)}$$

For a given total real load PD the system loss Pl is a function of active power generation at each generating unit. To calculate system losses, methods based on penalty factors and constant loss formula coefficients or B-coefficients are in use. The latter is adopted in this paper as per which transmission losses are expressed as

$$P_L = \sum_{i=1}^{n} \sum_{j=1}^{n} P_i B_{ij} P_j + \sum_{i=1}^{n} B_{i0} P_i + B_{00} \quad \text{... (4)}$$

3.1 Generator ramp rate limits. [8].

When the generator ramp rate limits (rrl) are considered, the operating limits are customized as follows:

$$\max(P_i^{\min}, P_i^0 - DR_i) \leqslant P_i \leqslant \min(P_i^{\max}, P_i^0 + UR_i) \quad \text{... (5)}$$

3.2 Prohibited operating zones. [9].

The cost curves of practical generators are discontinuous as whole of the unit operating range is not always available for allocation. In other words, the generating units have poz due to some faults in the machines or their accessories such as pumps or boilers etc. A unit with prohibited operating zones has discontinuous input-output characteristics. This feature can be included in the ELD formulation as follows:

$$P_i \in \begin{cases} P_i^{\min} \le P_i \le P_{i1}^L \\ P_{ik-1}^U \le P_i \le P_{ik}^L \\ P_{izi}^U \le P_i \le P_i^{\max} \end{cases} \quad \text{... (6)}$$

Here z_i are the number of prohibited zones in i^{th} generator curve, k is the index of prohibited zone of i^{th} generator, P^L_{ik} is the lower limit of k^{th} prohibited zone, and is the upper limit of k^{th} prohibited zone of i^{th} generator.

4. RESULTS AND DISCUSSIONS

The performance of traditional optimization approach using the NLP minimization module of GAMS has been compared with GA and PSO for two test cases and complexity levels as described below. Simulations were carried out using GAMS with system configuration dual core, processor and 2GB RAM.

4.1 Description of the test cases

The performance of conventional optimization approach using the NLP minimization module of GAMS has been compared GA and PSO and its variants for two test cases.

Test case 1: This system has 15-generating units supplying a total load of 2630 MW. Transmission losses are also considered while minimizing cost function given by eq. (1) subject to constraints given by (2). The fuel-cost characteristics are given in Table-11(appendix).

Test case 2: The coefficient of fuel cost and maximum and minimum power limits for 40-generating unit are given in table-13(appendix). Transmission losses are neglecting while minimizing cost function given by eq. (1) subject to constraints given by (2). The power demand is to be 8550(MW). The comparisons to GA and PSO with GAMS are shown in table-6. The results corresponding are detailed in table-7.

TEST STUDY-1

15- Units test system:

This system comprises of 15-generating units and the input data of 15-generator system loss coefficients of generating unit shown in Table-10(appendix). Here, the total demand for the system is set to 2630 MW and fuel coefficients, maximum and minimum power limits are given in table-11(appendix). The obtained results for the 15-generator system using the GAMS and the results are compared with those from PSO and GA, in finding a global optimal solution presented in the Table-3.

Table-3: Comparison of best result for the test case-1(PD=2630)

All Unit(MW)	GA [16, 18]	PSO Method [16, 17]	GAMS
P1	415.31	455.00	455.000
P2	359.72	380.00	380.000
P3	104.42	130.00	130.000
P4	74.98	130.00	130.000
P5	380.28	170.00	170.000
P6	426.79	460.00	460.000
P7	341.32	430.00	430.000
P8	124.79	60.00	69.601
P9	133.14	71.05	60.234
P10	89.26	159.85	160.000
P11	60.06	80.00	80.000
P12	50.00	80.00	80.000
P13	38.77	25.00	25.000
P14	41.94	15.00	15.000
P15	22.64	15.00	15.000
Load(MW)	**2630**	**2630**	**2630**
Total Loss(MW)	**38.28**	**30.908**	**29.835**
Total Cost($/h)	**33113.00**	**32780.00**	**32695.214**

Effect of load variation for 15-units system

Load change from the base case 2300 MW to 2900 MW for test case-1, with increases in the load the optimal cost was found to increases, it was found that the system did not convergence above 2900 MW. It can be seen from table-4. For the demand 2630MW the best result $32695.214 shown above in the table-3.

Table-4: Results of optimal dispatch with changing load for test case-1

S No.	Load (MW)	Cost ($/h)	Loss (MW)	CPU Time (S)	Violation(MW)
1	2300	29040.380	20.161	0.062	0.0010
2	2400	30098.141	21.809	0.062	0.0000
3	2500	31185.294	23.433	0.062	0.0000
4	2600	32336.219	27.977	0.062	0.0000
5	2700	33547.066	35.239	0.172	0.0000
6	2800	34808.135	40.484	0.094	0.0000
7	2900	35781.286	41.809	0.062	26..809
8	3000	**Infeasible**			

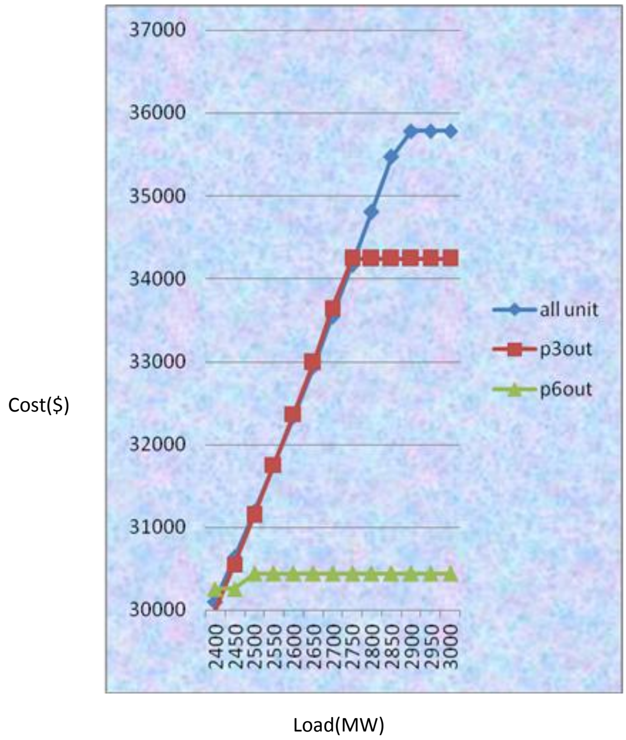

Fig-3: Graph for Gen-3 outage, Gen-6 outage and all unit running cases for different loads

Effect of Generator Outage contingency:

In practical power system operation, power generators often become faulty and are not available. In this paper each generator is considered out of service one by one for load demand of 2630MW for test case-1, comparison of best results of one by one generator outage can be seen from table-9(appendix), it can be seen that outage of gen-3 maximum cost ($32740.418) was computed and least operational cost ($30441.594) was found for outage of gen-6. Comparison of best results of all unit running, gen-3 outage and gen-6 outage for different loads are shows in table-5.

Table-5: Comparison of best results of all unit running, gen-3 outage and gen-6 outage for different loads.

S No.	LOAD	All unit(cost)	P_{3out}(cost)	P_{6out}(cost)
1	2400	30098.141	29973.620	30257.480
2	2450	30636.348	30552.287	30257.480
3	2500	31185.294	31148.604	30441.594
4	2550	31751.068	31753.697	30441.594
5	2600	32336.219	32367.3331	30441.594
6	2650	32936.515	32991.062	30441.594
7	2700	33547.066	33646.103	30441.594
8	2750	34168.579	34244.256	30441.594
9	2800	34808.135	34244.256	30441.594
10	2850	35467.952	34244.256	30441.594
11	2900	35781.286	34244.256	30441.594
12	**Infeasible**			

TEST STUDY-2

40-units test system:

The coefficient of fuel cost and maximum and minimum power limits are given in table-13(appendix). The power demand is to be 8550 (MW). The comparisons of best results to GA and PSO with GAMS are shown in table-6. The detailed corresponding to results is shown in table-7, the comparison of best results of at 8550MW shown in table-6.

Table-6: Comparative results for 40-units system

Output	PSO[16,17]	GA[12,16]	GAMS
Load(MW)	8550	8551.32	8850
Cost($/h)	121430	135070	115247
Time(S)	12.30	2.00	0.16

Table-7: the best results in details for test study-2 (PD=8550MW)

S. No.	Unit Output	GAMS
1	P_1(MW)	69.351
2	P_2(MW)	120.00
3	P_3(MW)	190.00
4	P_4(MW)	33.381
5	P_5(MW)	31.208
6	P_6(MW)	140.00
7	P_7(MW)	300.00
8	P_8(MW)	300.00
9	P_9(MW)	300.00
10	P_{10}(MW)	130.00
11	P_{11}(MW)	94.00
12	P_{12}(MW)	94.00
13	P_{13}(MW)	125.00
14	P_{14}(MW)	250.545
15	P_{15}(MW)	243.778
16	P_{16}(MW)	243.778
17	P_{17}(MW)	243.778
18	P_{18}(MW)	500.00
19	P_{19}(MW)	500.00
20	P_{20}(MW)	550.00
21	P_{21}(MW)	550.00
22	P_{22}(MW)	550.00
23	P_{23}(MW)	550.00
24	P24(MW)	550.00
25	P25(MW)	550.00
26	P26(MW)	550.00
27	P27(MW)	550.00
28	P28(MW)	10.00
29	P29(MW)	10.00
30	P30(MW)	10.00
31	P31(MW)	20.00
32	P32(MW)	20.00
33	P33(MW)	20.00
34	P34(MW)	20.00
35	P35(MW)	18.00
36	P36(MW)	18.00
37	P37(MW)	20.00
38	P38(MW)	25.00
39	P39(MW)	25.00
40	P40(MW)	25.00
41	**Total Cost($/h**	**115247**
42	**CPU Time(S)**	**0.16**

Effect of load variation for 40 unit system:

Load was changed from the base case 8000 MW to 13000 MW for test study-2; with increase in load the optimal cost was found to increase. It was found that the system did not convergence for 11600MW and more loads. It can be seen from Table-8, and best result found $115247 shown in detailed in the table-7. Results of optimal dispatch with changing load is shown in table-8.

Table-8: Results of optimal dispatch with changing load

S. No.	Load(MW)	Cost($/h)	CPU Time(S)
1	8000	108760	0.016
2	8500	114619	0.015
3	8550	115246	0.017
4	9000	121243	0.016
5	10000	135986	0.0176
6	10500	143924	0.015
7	11000	156053	0.017
8	11500	191155	0.016
9	11600	199272	0.016
10	12000	199272	0.016
11	13000	**Infeasible**	

5. CONCLUSIONS

The performance of PSO variants was compared with traditional NLP solver GAMS for economic dispatch problem of four test cases. The following conclusions were drawn.

Soft computing techniques like the GAMS use arbitrary operators for achieving the most favourable result therefore in every fresh tryout; these methods join to different solutions near the global best solution. The conventional NLP algorithm like the GAMS uses mathematical operations to achieve the best solution so they are always consistent and join to the unique global minimum solution.
Soft computing techniques however are becoming popular for non-convex, multimodal, discontinuous optimization problem for which conventional methods cannot provide solution. The time taken by soft computing techniques is quite outsized as compared to GAMS. The time requirement increases enormously with problem difficulty (like the inclusion of losses) and with increase in problem size. No such matter is there with GAMS.

APPENDIX

Table-9: Results of optimal dispatch with generator outage contingency (test case-1 PD=2630)

S.No.	All Unit	P_1out	P_2out	P_3out	P_4out	P_5out	P_6out	P_7out	P_8out	P_9out	P_{10}out	P_{11}out	P_{12}out	P_{13}out	P_{14}out	P_{15}out
1	455.000	0.00	455.000	455.000	455.000	455.000	455.000	455.000	455.000	455.000	455.000	455.000	455.000	455.000	455.000	455.000
2	380.000	380.000	0.00	380.000	380.000	380.000	380.000	380.000	380.000	380.000	380.000	380.000	380.000	380.000	380.000	380.000
3	130.000	130.000	130.000	0.00	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000
4	130.000	130.000	130.000	130.000	0.00	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000	130.000
5	170.000	170.000	170.000	170.000	170.000	0.00	170.000	170.000	170.000	170.000	170.000	170.000	170.000	170.000	170.000	170.000
6	460.000	460.000	460.000	460.000	460.000	460.000	0.00	460.000	460.000	460.000	460.000	460.000	460.000	460.000	460.000	460.000
7	430.000	430.000	430.000	430.000	430.000	430.000	430.000	0.00	430.000	430.000	430.000	430.000	430.000	430.000	430.000	430.000
8	69.601	160.000	160.000	148.908	160.000	160.000	160.000	160.000	0.00	130.628	160.000	121.524	122.638	82.197	78.660	77.327
9	60.234	85.000	85.000	85.000	85.000	85.000	85.000	85.000	85.000	0.00	85.000	85.000	85.000	74.326	67.156	68.905
10	160.000	160.000	160.000	160.000	160.000	160.000	160.000	160.000	160.000	160.000	0.00	160.000	160.000	160.000	160.000	160.000
11	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	0.00	80.000	80.000	80.000	80.000
12	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	0.00	80.00	80.00	80.00
13	25.000	85.000	85.000	25.000	25.000	28.967	85.000	85.000	25.000	25.000	25.000	25.000	25.000	0.00	25.00	25.00
14	15.000	55.000	55.000	44.702	29.246	54.641	55.000	55.000	49.286	15.000	50.607	15.735	21.254	15.000	0.00	15.00
15	15.000	55.000	55.000	18.589	20.201	36.512	55.000	55.000	24.322	15.000	25.564	23.308	18.008	15.000	15.00	0.00
COST($)	**32695.214**	**30452.885**	**31304.861**	**32740.418**	**32696.847**	**32568.757**	**30441.594**	**30951.982**	**32503.674**	**32532.305**	**32645.440**	**32648.817**	**32629.527**	**32443.569**	**32384.439**	**32370.149**
LOSS(MW)	**29.835**	**36.386**	**35.699**	**37.199**	**34.446**	**40.119**	**41.488**	**34.410**	**28.609**	**30.628**	**31.171**	**35.567**	**36.900**	**31.523**	**30.816**	**31.232**

Table-10: B-loss coefficients of 15-generating unit

	1.4	1.2	0.7	-0.1	-0.3	-0.1	-0.1	-0.1	-0.3	-0.5	-0.3	-0.2	0.4	0.3	-0.1
	1.2	1.5	1.3	0.0	-0.5	-0.2	0.0	0.1	-0.2	-0.4	-0.4	0.0	0.4	1.0	-0.2
	0.7	1.3	7.6	-0.1	-1.3	-0.9	-0.1	0.0	-0.8	-1.2	-1.7	0.0	-2.6	11,1	-2.8
	-0.1	0.0	-0.1	3.4	-0.7	-0.4	1.1	5.0	2.9	3.2	-1.1	0.0	0.1	0.1	-2.6
	-0.3	-0.5	-1.3	-0.7	9.0	1.4	-0.3	-1.2	-1.o	-1.3	0.7	-0.2	-0.2	-2.4	-0.3
	-0.1	-0.2	-0.9	-0.4	1.4	1.6	0.0	-0.6	-0.5	-0.8	1.1	-0.1	-0.2	-1.7	0.3
	-0.1	0.0	-01.1	1.1	-0.3	0.0	1.5	1.7	1.5	0.9	-0.5	0.7	0.0	-0.2	-0.8
B_{ij}= 10^{-3}.	-0.1	0.1	0.0	5.0	-1.2	-0.6	1.7	16.8	8.2	7.9	-2.3	-3.6	0.1	0.5	-7.8
	-0.3	-0.2	-0.8	2.9	-1.0	-0.5	1.5	8.2	12.9	11.6	-2.1	-2.5	0.7	-1.2	-7.2
	-0.5	-0.4	-0.2	3.2	-1.3	-0.8	0.9	7.9	11.6	20.0	-2.7	-3,4	0.9	-1.1	-8.8
	-0.3	-0.4	-1.7	-1.1	0.7	1.1	-0.5	-2.3	-2.1	-2.7	14.0	0.1	0.4	-3.8	16.8
	-0.2	0.0	0.0	0.0	-0.2	-0.1	0.7	-3.6	-2.5	-3.4	0.1	5.4	-0.1	-0.4	2.8
	0.4	0.4	-2.6	0.1	-0.2	-0.2	0.0	0.1	0.7	0.9	0.4	-0.1	10.3	-10.1	2.8
	0.3	1.0	11.1	0.1	-2.4	-1.7	-0.2	0.5	-1.2	-1.1	-3.8	0.4	-10.1	57.8	-9.4
	-0.1	-0.2	-2.8	-2.6	-0.3	0.3	-0.8	-7.8	-7.2	-8.8	16.8	2.8	2.8	-9.4	128.3
B_{i0}=10^{-3}.	-0.1	-0.2	2.8	-0.1	0.1	-0.3	-0.2	-0.2	0.6	3.9	-1.7	0.0	-3.2	6.7	-6.4
B_{00}=	0.0055														

Table-11: cost coefficients of 15-generating unit.

Unit	P_i^{max}	P_i^{min}	a_i	b_i	c_i
1	455	150	0.000299	10.1	671
2	455	150	0.000183	10.2	574
3	130	20	0.001126	8.8	374
4	130	20	0.001126	8.8	374
5	470	150	0.000205	10.4	461
6	460	135	0.000301	10.1	630
7	465	135	0.000364	9.8	548
8	300	60	0.000338	11.2	227
9	162	25	0.000807	11.2	173
10	160	25	0.001203	10.7	175
11	80	20	0.003586	10.2	186
12	80	20	0.005513	9.9	230
13	85	25	0.000371	13.1	225
14	55	15	0.001929	12.1	309
15	55	15	0.004447	12.4	323

Table-12: data for the 15-unit of ramp rate limits and prohibited zones.

Unit	P_i^0	UR_i	DR_i	Prohibited zones
1	400	80		
2	300	80		[185 255] [305 335] [420 450]
3	105	130		
4	100	130		
5	90	80		[180 200] [305 335] [390 420]
6	400	80		[230 255] [365 395] [430 455]
7	350	80		
8	95	65		
9	105	60		
10	110	60		
11	60	80		
12	40	80		[30 40] [55 65]
13	30	80		
14	20	55		
15	20	55		

Table-13: Characteristics of the cost and generation constraints for the 40-generating unit

S. No.	P_{max}	P_{min}	a_i	b_i	c_i
1	80	40	0.03073	8.336	170.44
2	120	60	0.02028	7.0706	309.54
3	190	80	0.00942	8.1817	369.03
4	42	24	0.08482	6.9467	135.19
5	42	26	0.09693	6.5595	222.33
6	140	68	0.01142	8.0543	287.71
7	300	110	0.00492	8.0323	391.98
8	300	135	0.00573	6.999	455.76
9	300	135	0.00605	6.602	722.82
10	300	130	0.00515	12.908	635.2
11	375	94	0.00569	12.986	654.69
12	375	94	0.00421	12.796	913.4
13	500	125	0.00752	12.501	1760.4
14	500	125	0.00708	8.8412	1728.3
15	500	125	0.00708	9.1575	1728.3
16	500	125	0.00708	9.1575	1728.3
17	500	125	0.00708	9.1575	1728.3
18	500	220	0.00313	7.9691	647.85
19	500	220	0.00313	7.955	649.83
20	550	242	0.00313	7.9691	649.83
21	550	242	0.00313	7.9691	649.83
22	550	254	0.00298	6.6313	785.96
23	550	254	0.00298	6.6313	785.96
24	550	254	0.00284	6.6611	794.53
25	550	254	0.00284	6.6611	794.53
26	550	254	0.00277	7.1032	801.32
27	550	254	0.00277	7.1032	801.32
28	150	10	0.52124	3.3353	1055.1
29	150	10	0.52124	3.3353	1055.1
30	150	10	0.52124	3.3353	1055.1
31	70	20	0.25098	13.052	1207.8
32	70	20	0.16766	21.887	810.79
33	70	20	0.2635	10.244	1247.7
34	70	20	0.30575	8.3707	1219.2
35	60	18	0.18362	26.258	641.43
36	60	18	0.32563	9.6956	1112.8
37	60	20	0.33722	7.1633	1044.4
38	60	25	0.23915	16.339	832.24
39	60	25	0.23915	16.339	834.24
40	60	25	0.23915	16.339	1035.2

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