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Seagull Optimization Algorithm For Constrained Dynamic Load Dispatch

Dr.Sudhir Sharma[1],Shivani Mehta[2],Rahul[3]
Department of Electrical Engineering, D.A.V.I.E.T., Jalandhar, Punjab, India[1, 2, 3]
Associate Professor, sudhir.abc@gmail.com[1]
Assistant Professor, shivanimehta7@gmail.com [2]
Student, Master of Technology, rahulkhinder@gmail.com[3]

ABSTRACT
This paper present seagull optimization algorithm to solve constrained dynamic load dispatch (ELD) problem. Seagull Optimization algorithm (SOA) is a new meta-heuristic inspired by seagull. The leadership hierarchy and hunting mechanism of the seagull is mimicked in SOA. The objective of ELD problem is to minimize the total generation cost while fulfilling the different constraints, when the required load of power system is being supplied. The proposed technique is implemented on two different test systems for solving the ELD with various load demands. To show the effectiveness of SOA to solve ELD problem results were compared with other existing techniques.

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I. INTRODUCTION

The economic load dispatch is a vital problem to reduce the operating cost of generating system. With the increasing in population a slight twist is taken to deal with environmental matters, now it is implemented for the dispatch of systems to decrease pollutants and to save different kind of fuels, as well as achieve low cost for operation . Moreover there is a need enlarge finite economic optimization is problem integrate constraints on system operation to verify system security, thereby preventing the failure of system during the unpredicted circumstance. Although closely related with this economic dispatch problem is the proper responsibility of any array of units out of a total array of units to provide the unpredicted needs of load in a perfect manner.

However the problem of the proper commitment of any array of units out of a total array of units to serve the expected load demands in an ‘optimal’ manner is closely associated with this economic dispatch problem. Modern system theory and optimization techniques are being implemented with expectation of operation cost reduction for the optimum economic operation of large scale system.[5] [3] like unit commitment, Load Forecasting, Available Transfer Capability (ATC) calculation, Security Analysis, Scheduling of fuel purchase etc,the economic load dispatch (ELD) is a necessary function in advance power system. It is found in a bibliographical survey on ELD methods that wide range of numerical optimization techniques have been working to approach the ELD problem.

Conventionally ELD is solved by using mathematical programming based on optimization techniques that are lambda iteration, gradient method etc. The linear cost functions are more analytical with economic load dispatch. Lambda iteration, gradient method can solve simple ELD calculations but they are not sufficient for real applications in deregulated market.

There a number of methods among them genetic algorithm implemented to resolve the real time problem of solving the economic load dispatch issue. However, some issues are resolves by Evolutionary algorithm and some other techniques such as tabu search are used to resolve the problem. Also Artificial neural network are employed solve the optimization problem. Although different masses implemented swarm behavior to the problem of optimum dispatch, as well as unit commitment problem for general purpose; although they possess. ELD accurate methods can be amended with respect to reduce randomness. Because of valve point loading effect, prohibited operating zones and ramp rate limits the input output characteristics are illogical, whereas the cost curve of thermal generating units are design as trouble free. Major steam turbines generators possess the number of valves with them the power balance should be continue. Apart from that there is some range of generating units where the operation is difficult to run that regions are prohibited operating zones (POZ). After that, operating spans for connected online units is opposed by their ramp rate limits. The amount of either increase or decrease of output power of generating units is finite in a range to keep thermal changes in the turbine between safe ranges and to shun shortening of life. That is way ramp rate constraints made regular ED problem to Dynamic Economic Dispatch (DED) problem. It makes more difficult to solve the ED problem due to occurrence of these nonlinearities in practical generator operations

PROBLEM FORMULATION

as quadratic equation in terms of power generated as shown below:

$FC = a*P^2+b*P+c$ Where "FC" Is fuel cost In Economic load dispatch the objective is to find out the generation

Our objective is to minimize this fuel cost. We can extend this problem to time span of 24 hours with each hour having different load demand then above equation can be modified as : Fuel Cost $\sum_{i=1}^{24} \sum_{i=1}^{N} a_i P_i^2 + b_i P_i + c_i$

This is called dynamic load dispatch where load demand is changing with time.

The Fuel cost for the generator can be expressed of generator generating power "P"and "a, b&c" are fuel cost coefficients.

If there is N number of generators committed, then load demand can be divided among them economically for which overall Fuel cost equation can be written like this:

Fuel Cost $\sum_{i=1}^{N} FC(P_i) = \sum_{i=1}^{N} ai\ P_i^2 + b_i P_i + c_i$

as to fulfill load demand with minimum operating costs while for.

LINEAR CONSTRAINTS

Generation capacity constraint

For normal system operations, real power output of each generator is within its lower and upper limits as follows,

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

Power balance constraint

$$\sum_{i=1}^{n} Pgi = P_d + P_L \qquad P_L = \sum_{i=1}^{n} P_{gi} B_{ij} P_{gj} + \sum_{i=1}^{n} B_0 P_{gi} + B_{00}$$

P_d is Power demand & P_L is power losses which are calculated with

NON-LINEARCONSTRAINTS

The actual characteristics of generators are drawn by considering the non-linear constraints. These characteristics exhibit higher order non-linearity and discontinuities. Thus, the ELD problem becomes a complex non-convex optimization problem [26].
Generator ramp rate limits

Prohibited operating zones

Valve point loading effects

DELD CONSIDERING VALVE POIN TLOADING EFFECTS

To control every generators output power, the power plant employs several valves. The valve point loading effect occurs when each steam admission valve in a turbine starts to open, thus producing a rippling effect on the cost curve.

$$F_T = \sum_{i=1}^{n} a_i P_i^2 + b_i P_i + c_i + |e_i \times sin\{f_i \times Pgimin - Pgi$$

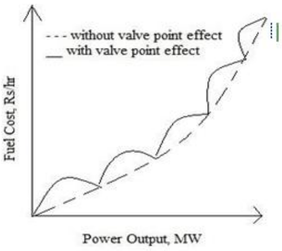
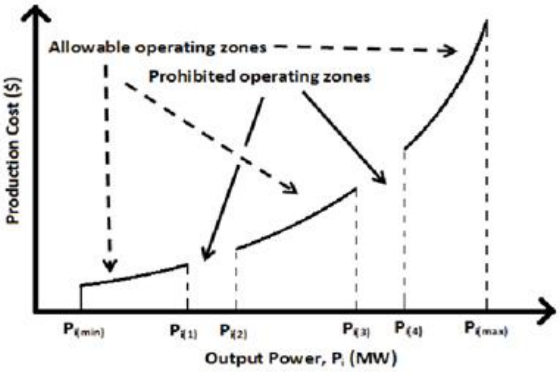


Figure 1: Fuel cost curve under valve point loading [2

POZ: PROHIBITED OPERATING ZONES

The prohibited operating zones (POZ) are due to steam valve operation or vibration in shaft bearing. The feasible operating zones of the *j*th generator can be described as follows:

$$P_j \in \begin{cases} P_j^{\min} \le P_j \le P_{j,1}^{l}, \\ P_{j,k-1}^{u} \le P_j \le P_{j,k}^{l}, \\ P_{j,n_j-1}^{u} \le P_j \le P_j^{\max}, \\ k = 2, 3, \ldots, n_j, j = 1, 2, \ldots, N_g, \end{cases}$$



GENERATING UNIT RAMP RATE LIMIT

Ramp rates are the maximum rates specified for each unit at which the power output of a unit can be increased (ramp up rate) or decreased (ramp down rate) in a time interval.Violation of generation ramp rates will shorten the life of the rotor and therefore has to be satisfied in a practical system operation where the generation changes with demand.

Increase in generation limited by:

$$P_j - P_j^0 \le \mathrm{UR}_j.$$

Decrease in generation limited by:

$$P_j^0 - P_j \le \mathrm{DR}_j,$$

SEAGULL OPTIMIZATION ALGORITHM

The main inspiration of this algorithm is the migration and attacking behaviors of a seagull in nature. These behaviors are mathematically modeled and implemented to emphasize exploration and exploitation in a given search space.Generally, seagulls live in colonies. They use their intelligence to find and attack the prey. The most important thing about the seagulls is their migrating and attacking behaviors.

Migration is defined as the seasonal movement of seagulls from one place to another to find the richest and most abundant food sources that will provide adequate energy.

The mathematical models of migration and attacking the prey are discussed. During migration, the algorithm simulates how the group of seagulls move towards one position to another.

In this phase, a seagull should satisfy three conditions:•

Avoiding the collisions: To avoid the collision between neighbors (i.e., other seagulls), an additional variable A is employed for the calculation of new search agent position **Cs= Ps(x) * A**

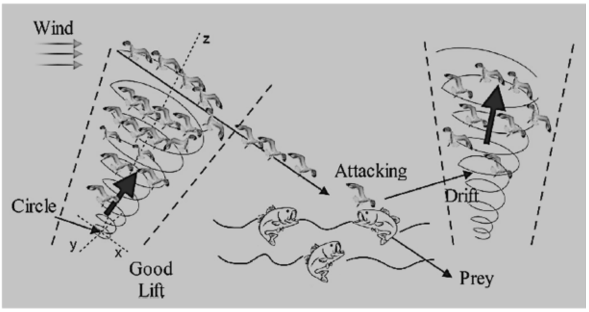
where → Cs represents the position of search agent which does not collide with other search agent, → Ps representsthe current position of search agent, x indicates the current iteration, and A represents the movement behavior of search agent in a given search space.

A = fc − (x × (fc/Maxiteration))

where: x = 0, 1, 2, . . . , Maxiteration

where fc is introduced to control the frequency of employing variable A which is linearly decreased from fc to 0. In this work, the value of fc is set to 2.

The mathematical models of migration and attacking the prey are discussed.



Movement towards best neighbor's direction: After avoiding the collision between neighbors, the search agents are move towards the direction of best neighbor.$\vec{M}s = B \times (\vec{P}bs(x) - \vec{P}s(x))$

Where $\vec{M}s$ represents the positions of search agent $\vec{P}s$ towards the best fit search agent $\vec{P}bs$ (i.e., fittest seagull). The behavior of B is randomized which is responsible for proper balancing between exploration and exploitation. B is calculated as:

$B = 2 \times A2 \times rd$

Whererd is a random number lies in the range of [0, 1].

Remain close to the best search agent: Lastly, the search agent can update its position with respect to best search agent

which is$\vec{D}s = | \vec{C}s + \vec{M}s |$ (9)

where $\vec{D}s$ represents the distance between the search agent and best fit search agent (i.e., best seagull whose fitness value is less).

Attacking (exploitation): The exploitation intends to exploit the history and experience of the search process. Seagulls can change the angle of attack continuously as well as speed during migration. They maintain their altitude using their wings and weight. While attacking the prey, the spiral movement behavior occurs in the air.

This behavior in x, y, and z planes is described as follows.

$x' = r \times \cos(k) \quad y' = r \times \sin(k)$ (11)

$z' = r \times k \qquad r = u \times ekv$ (13)

where r is the radius of each turn of the spiral, k is a random number in range $[0 \le k \le 2\pi]$. u and v are constants to define the spiral shape, and e is the base of the natural logarithm. The updated position of search agent is calculated using

$\vec{P}s(x) = (\vec{D}s \times x' \times y' \times z') + \vec{P}bs(x)$

Where $\vec{P}s(x)$ saves the best solution and updates the position of other search agents.

II. RESULTS& DISCUSSIONS

I. To develop improved Seagull optimization algorithm and test it on different benchmark functions

We propose an improved version of existing Seagull optimization algorithm (SOA) algorithm by hybridizing it with very popular Simulated Annealing (SA) technique. The improved version of SOA i.e., SOA-SA is tested on 7 unimodal and 6 multimodal mathematical benchmark functions.

Table.1. Unimodal benchmark functions

Function	**Range**	**D**	**Fmin**
F1(y)=$\sum_{i=1}^{n} y_i^2$	[-100,100]	30	0
F2(y)=$\sum_{i=1}^{n} \lvert y_i \rvert + \prod_{i=1}^{n} \lvert y_i \rvert$	[-10,100]	30	0
F3(y)=$\sum_{i=1}^{n} \left(\sum_{j-1}^{i} y_j\right)^2$	[-100,100]	30	0
F4(y)=$max_i[\lvert y_i \rvert, 1 \leq i \leq n]$	[-100,100]	30	0
F5(y)=$\sum_{i=1}^{n-1}\{100(y_{i+1} - y_i^2)^2 + (y_i - 1)^2\}$	[-30,30]	30	0
F6(y)=$\sum_{i=1}^{n}(y_i + 0.5)^2$	[-100,100]	30	0
F7(y)=$\sum_{i=1}^{n} iy_i^4 + random(0,1)$	[-1.28,1.28]	30	0

Table2. Results of unimodal functions

Function	Algorithm Indices	Best	Mean	Worst	SD
F1	SOA	0.110779817	0.746756719	2.534267812	0.58502583
	SOA-SA	1.07839E-05	0.001576762	0.005725766	0.00137021
F2	SOA	0.011673452	0.075060759	0.164691666	0.040868653
	SOA-SA	0.010644108	0.039424795	0.176544123	0.030688028
F3	SOA	30.52998405	431.5223201	2863.753184	573.7172456
	SOA-SA	0.026822791	0.52869091	1.712109355	0.487791764
F4	SOA	3.545836655	29.01469614	58.94006852	17.17509757
	SOA-SA	0.063681634	0.65315192	1.051202987	0.409513315
F5	SOA	55.04436402	134.5095516	366.2038492	69.66607059
	SOA-SA	49.14327665	57.48281624	94.79618104	12.87523543
F6	SOA	8.07275827	10.1397504	13.23078448	1.228610122
	SOA-SA	6.43669126	7.948462439	8.897852611	0.612310281
F7	SOA	0.006624057	0.023238814	0.068475206	0.014057079
	SOA-SA	0.00588943	0.017197091	0.059897611	0.011538813

Table.3. Multimodal benchmark functions

Function	**Range**	**D**	**Fmin**
F8(y)=$\sum_{i=1}^{n} -y_i \sin\left(\sqrt{\lvert y_i \rvert}\right)$	[-500,500]	30	-12569.5
F9(y)=$\sum_{i=1}^{n}[y_i^{\,2} - 10\cos(2\pi y_i) + 10]$	[-5.12,5.12]	30	0
F10(y)=$-20\exp\left(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^{\,2}}\right)$ $-exp\left(\frac{1}{n}\sum_{i=1}^{n}\cos(2\pi y_i)\right) + 20 + e$	[-32,32]	30	0
F11(y)=$\frac{1}{4000}\sum_{i=1}^{n} y_i^{\,2} - \prod_{i=1}^{n} cos\left(\frac{y_i}{\sqrt{i}}\right) + 1$	[-600,600]	30	0
F12(y)=$\frac{\pi}{n}\{10sin(\pi x_1) + \sum_{i=1}^{n-1}(x_i - 1)^2[1 + 10sin^2(\pi x_{i+1})] +$ $(x_n - 1)^2\} + \sum_{i=1}^{n} u(y_i, 10, 100, 4)$ $x_i = 1 + \frac{y_i + 1}{4}$ $u(y_i, k, a, m) = \begin{cases} k(y_i - a)^m ; & y_i > a \\ 0 ; & -a < y_i < a \\ k(-y_i - a)^m ; & y_i < -a \end{cases}$	[-50,50]	30	0
F13(y)= $0.1\{sin^2(3\pi y_1) + \sum_{i=1}^{n}(y_i - 1)^2[1 + sin^2(3\pi y_i + 1)] +$ $(y_n - 1)^2[1 + sin^2(2\pi y_n)]\} + \sum_{i=1}^{n} u(y_i, 5, 100, 4)$	[-50,50]	30	0

Table.4. Results Multimodal functions

Function	Algorithm Indices	Best	Mean	Worst	SD
F8	SOA	-8447.060922	-6451.780027	-5026.913047	735.516645
	SOA-SA	-8111.825005	-6348.609559	-4738.18943	848.1032139
F9	SOA	0.202601057	50.84227146	244.5738547	49.70055641
	SOA-SA	11.02544925	16.90354503	21.22731315	2.082191673
F10	SOA	19.96270162	19.96506269	19.96676885	0.00089607
	SOA-SA	0.00236171	0.074018366	1.858043432	0.337023723
F11	SOA	0.231338079	0.558354151	0.981242844	0.206992061
	SOA-SA	1.76886E-05	0.000153612	0.000717345	0.000160556
F12	SOA	0.670848459	1.21123851	2.269241919	0.433390526
	SOA-SA	0.39632695	0.647401138	0.927014066	0.13948411
F13	SOA	4.60562975	6.548824221	17.56561032	2.44157647
	SOA-SA	0.9747431	1.376777755	1.626064102	0.158161527

To solve single-objective optimum generation dispatch for different IEEE test case systems

II. **Six unit system-** The improved SOA is tested on IEEE 30 bus 6 generator system for economic load dispatch problem with power demand of 700 MW. The power losses are calculated using krons loss formula

Table A.2 Cost Coefficients and power limits of six unit

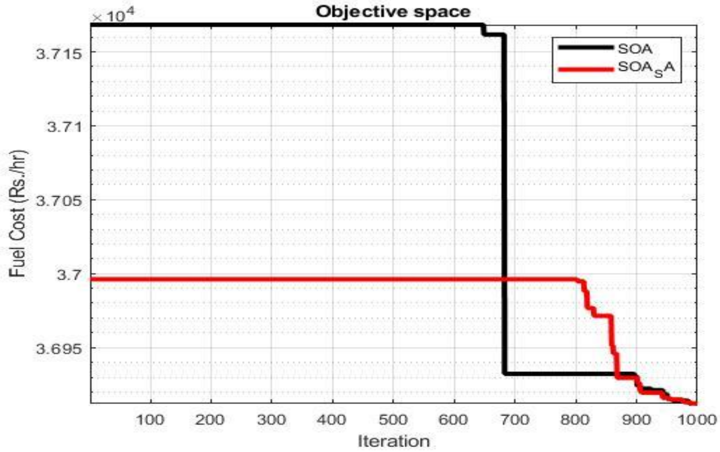
Unit	a_i	b_i	c_i	Pmin	Pmax
1	0.15240	38.53973	756.79886	10	125
2	0.10587	46.15916	451.32513	10	150
3	0.02803	40.39655	1049.9977	35	225
4	0.03546	38.30553	1243.5311	35	210
5	0.02111	36.32782	1658.5596	130	325
6	0.01799	38.27041	1356.6592	125	315

The B_{in} loss coefficient matrix is given by

$$B_{mn} = \begin{bmatrix} 0.000014 & 0.000017 & 0.000015 & 0.000019 & 0.000026 & 0.000022 \\ 0.000017 & 0.000060 & 0.000013 & 0.000016 & 0.000015 & 0.000020 \\ 0.000015 & 0.000013 & 0.000065 & 0.000017 & 0.000024 & 0.000019 \\ 0.000019 & 0.000016 & 0.000017 & 0.000072 & 0.000030 & 0.000025 \\ 0.000026 & 0.000015 & 0.000024 & 0.000030 & 0.000069 & 0.000032 \\ 0.000022 & 0.000020 & 0.000019 & 0.000025 & 0.000032 & 0.000085 \end{bmatrix}$$

Algorithm	Total_Cost	G1	G2	G3	G4	G5	G6	Power_loss
SOA	36912.30	28.23	10.26	118.15	118.97	230.70	213.13	19.44
SOA_SA	36912.18	28.65	10.00	119.50	118.71	230.42	212.13	19.41

LI Method	QP[28]	PSO[28]	CSA[27]	SOA	SOA-SA
36946.4	36914.01	36912.16	36912.2	36912.30	36912.18



III. FORTY SYSTEM WITH VALVE LOADING EFFECT

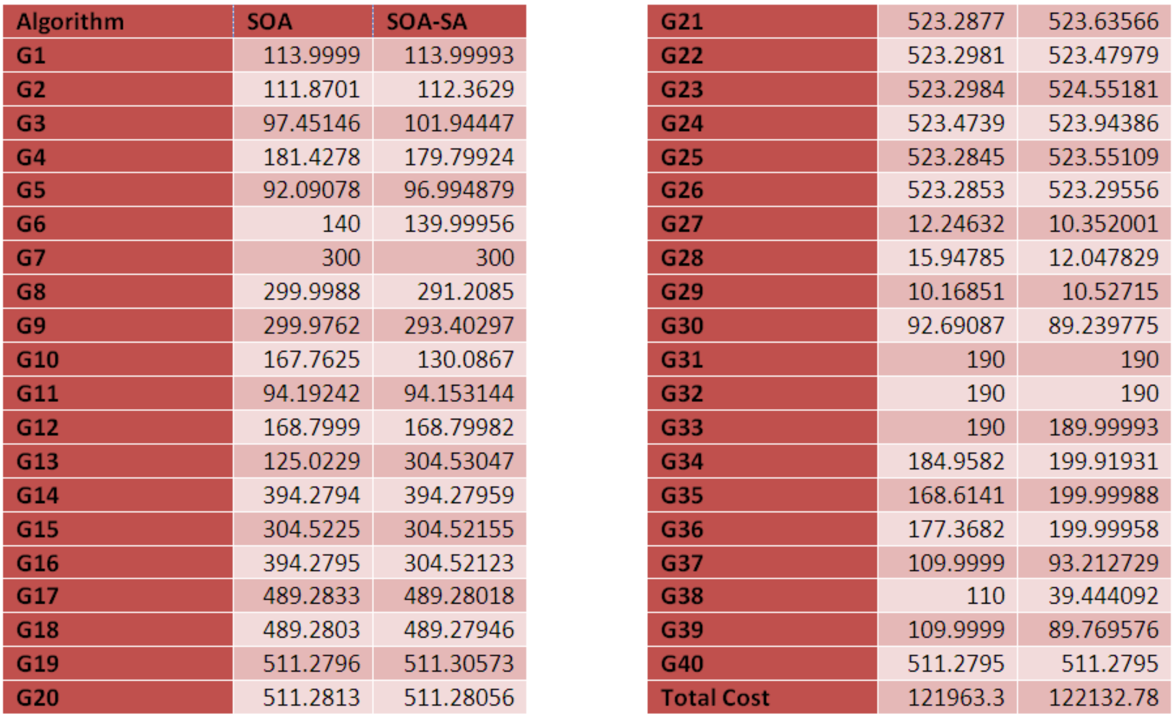
The improved SOA is tested on 40 generator system with valve loading effects for economic load dispatch problem with power demand of 10500 MW. The transmission losses are neglected in this system.

Table: Cost Coefficients and power limits of 40 units

Unit	a_i	b_i	c_i	e_i	f_i	Pmin	Pmax
1	0.00690	6.73	94.705	100	0.084	36	114
2	0.00690	6.73	94.705	100	0.084	36	114
3	0.02028	7.07	309.540	100	0.084	60	120
4	0.00942	8.18	369.030	150	0.063	80	190
5	0.01140	5.35	148.890	120	0.077	47	97
6	0.01142	8.05	222.330	100	0.084	68	140
7	0.00357	8.03	287.710	200	0.042	110	300
8	0.00492	6.99	391.980	200	0.042	135	300
9	0.00573	6.60	455.760	200	0.042	135	300
10	0.00605	12.9	722.820	200	0.042	130	300
11	0.00515	12.9	635.200	200	0.042	94	375
12	0.00569	12.8	654.690	200	0.042	94	375
13	0.00421	12.5	913.400	300	0.035	125	500
14	0.00752	8.84	1760.400	300	0.035	125	500
15	0.00752	8.84	1760.400	300	0.035	125	500
16	0.00752	8.84	1760.400	300	0.035	125	500
17	0.00313	7.97	647.850	300	0.035	220	500
18	0.00313	7.95	649.690	300	0.035	220	500
19	0.00313	7.97	647.830	300	0.035	242	550
20	0.00313	7.97	647.810	300	0.035	242	550
21	0.00298	6.63	785.960	300	0.035	254	550
22	0.00298	6.63	785.960	300	0.035	254	550
23	0.00284	6.66	794.530	300	0.035	254	550
24	0.00284	6.66	794.530	300	0.035	254	550
25	0.00277	7.10	801.320	300	0.035	254	550
26	0.00277	7.10	801.320	300	0.035	254	550
27	0.52124	3.33	1055.100	120	0.077	10	150

28	0.52124	3.33	1055.100	120	0.077	10	150
29	0.52124	3.33	1055.100	120	0.077	10	150
30	0.01140	5.35	148.890	120	0.077	47	97
31	0.00160	6.43	222.920	150	0.063	60	190
32	0.00160	6.43	222.920	150	0.063	60	190
33	0.00160	6.43	222.920	150	0.063	60	190
34	0.00010	8.95	107.870	200	0.042	90	200
35	0.00010	8.62	116.580	200	0.042	90	200
36	0.00010	8.62	116.580	200	0.042	90	200
37	0.01610	5.88	307.450	80	0.098	25	110
38	0.01610	5.88	307.450	80	0.098	25	110
39	0.01610	5.88	307.450	80	0.098	25	110
40	0.00313	7.97	647.830	300	0.035	242	550

Table : Power dispatch for 40-unit system with 10,500 MW load demand

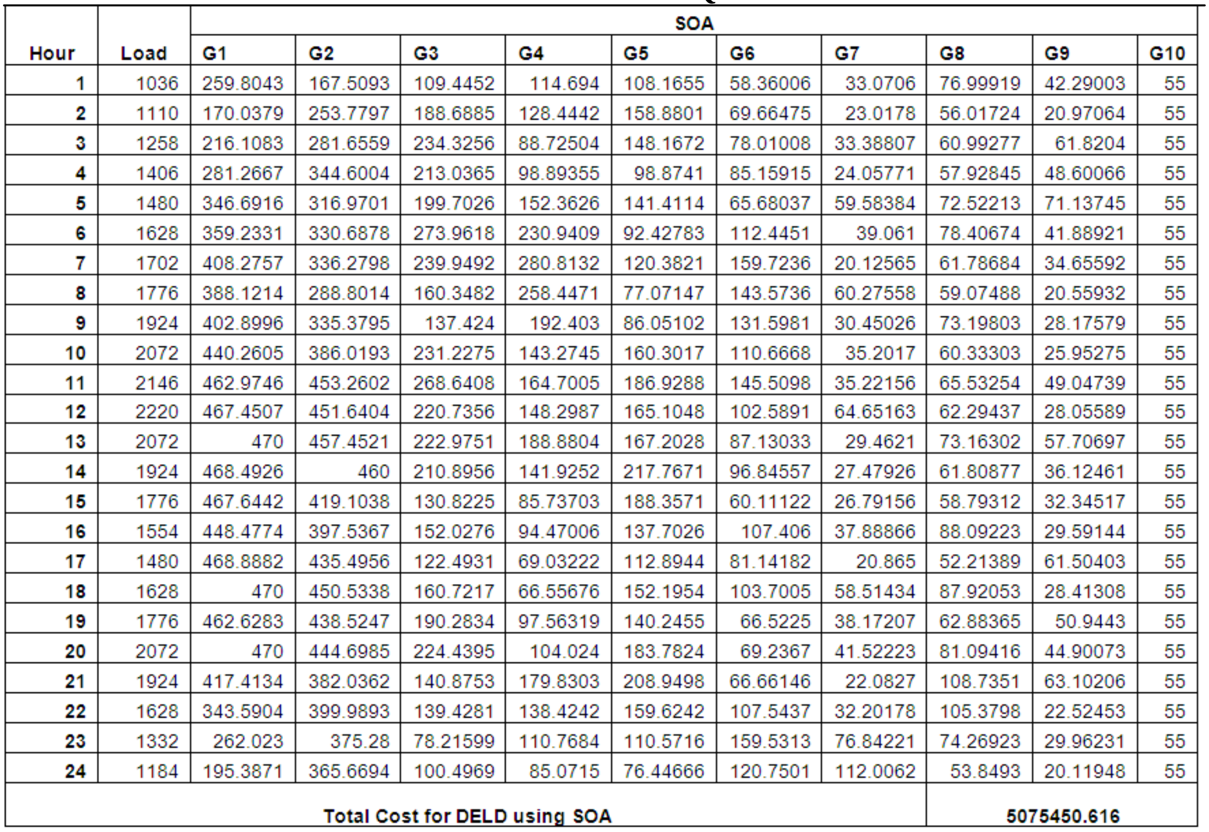


Algorithm	SOA	SOA-SA
G1	113.9999	113.99993
G2	111.8701	112.3629
G3	97.45146	101.94447
G4	181.4278	179.79924
G5	92.09078	96.994879
G6	140	139.99956
G7	300	300
G8	299.9988	291.2085
G9	299.9762	293.40297
G10	167.7625	130.0867
G11	94.19242	94.153144
G12	168.7999	168.79982
G13	125.0229	304.53047
G14	394.2794	394.27959
G15	304.5225	304.52155
G16	394.2795	304.52123
G17	489.2833	489.28018
G18	489.2803	489.27946
G19	511.2796	511.30573
G20	511.2813	511.28056
G21	523.2877	523.63566
G22	523.2981	523.47979
G23	523.2984	524.55181
G24	523.4739	523.94386
G25	523.2845	523.55109
G26	523.2853	523.29556
G27	12.24632	10.352001
G28	15.94785	12.047829
G29	10.16851	10.52715
G30	92.69087	89.239775
G31	190	190
G32	190	190
G33	190	189.99993
G34	184.9582	199.91931
G35	168.6141	199.99988
G36	177.3682	199.99958
G37	109.9999	93.212729
G38	110	39.444092
G39	109.9999	89.769576
G40	511.2795	511.2795
Total Cost	121963.3	122132.78

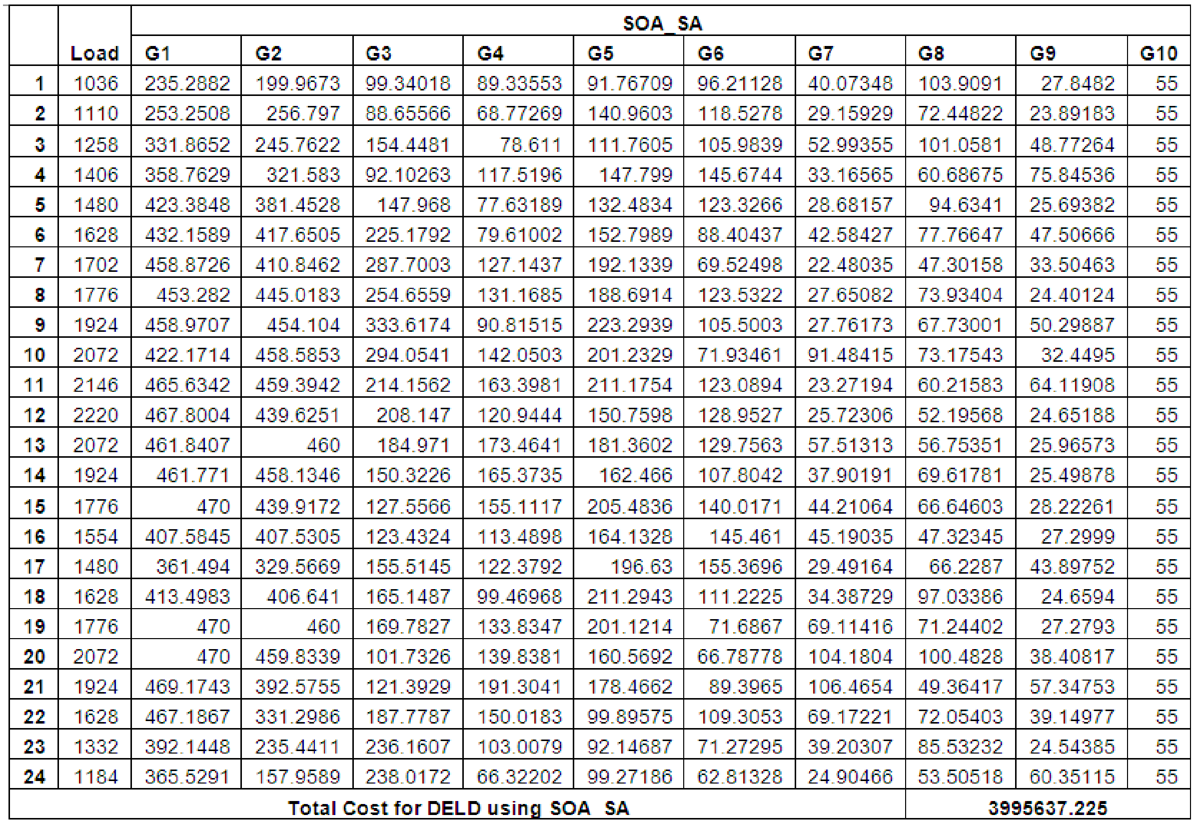
Table : Comparison of fuel cost with other techniques for 40-Unit system

Method	Minimum Cost ($/ h)	Average Cost ($/ h)	Maximum Cost ($/ h)
HGPSO [25]	124797.13	126855.70	NA
SPSO [25]	124350.40	126074.40	NA
PSO [24]	123930.45	124154.49	NA
CEP [26]	123488.29	124793.48	126902.89
HGAPSO [25]	122780.00	124575.70	NA
FEP [26]	122679.71	124119.37	127245.59
MFEP [26]	122647.57	123489.74	124356.47
IFEP [26]	122624.35	123382.00	125740.63
EP-SQP [24]	122323.97	122379.63	NA
HPSOM [25]	122112.40	124350.87	NA
PSO-SQP [24]	122094.67	122245.25	NA
SOA	122132.78	12332.98	124675.15
SOA-SA	121963.3	122731.45	124287.47

IV. TO COMPARE THE RESULTS OBTAINED BY PROPOSED TECHNIQUE WITH OTHER TECHNIQUES.



Hour	Load	SOA									
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
1	1036	259.8043	167.5093	109.4452	114.694	108.1655	58.36006	33.0706	76.99919	42.29003	55
2	1110	170.0379	253.7797	188.6885	128.4442	158.8801	69.66475	23.0178	56.01724	20.97064	55
3	1258	216.1083	281.6559	234.3256	88.72504	148.1672	78.01008	33.38807	60.99277	61.8204	55
4	1406	281.2667	344.6004	213.0365	98.89355	98.8741	85.15915	24.05771	57.92845	48.60066	55
5	1480	346.6916	316.9701	199.7026	152.3626	141.4114	65.68037	59.58384	72.52213	71.13745	55
6	1628	359.2331	330.6878	273.9618	230.9409	92.42783	112.4451	39.061	78.40674	41.88921	55
7	1702	408.2757	336.2798	239.9492	280.8132	120.3821	159.7236	20.12565	61.78684	34.65592	55
8	1776	388.1214	288.8014	160.3482	258.4471	77.07147	143.5736	60.27558	59.07488	20.55932	55
9	1924	402.8996	335.3795	137.424	192.403	86.05102	131.5981	30.45026	73.19803	28.17579	55
10	2072	440.2605	386.0193	231.2275	143.2745	160.3017	110.6668	35.2017	60.33303	25.95275	55
11	2146	462.9746	453.2602	268.6408	164.7005	186.9288	145.5098	35.22156	65.53254	49.04739	55
12	2220	467.4507	451.6404	220.7356	148.2987	165.1048	102.5891	64.65163	62.29437	28.05589	55
13	2072	470	457.4521	222.9751	188.8804	167.2028	87.13033	29.4621	73.16302	57.70697	55
14	1924	468.4926	460	210.8956	141.9252	217.7671	96.84557	27.47926	61.80877	36.12461	55
15	1776	467.6442	419.1038	130.8225	85.73703	188.3571	60.11122	26.79156	58.79312	32.34517	55
16	1554	448.4774	397.5367	152.0276	94.47006	137.7026	107.406	37.88866	88.09223	29.59144	55
17	1480	468.8882	435.4956	122.4931	69.03222	112.8944	81.14182	20.865	52.21389	61.50403	55
18	1628	470	450.5338	160.7217	66.55676	152.1954	103.7005	58.51434	87.92053	28.41308	55
19	1776	462.6283	438.5247	190.2834	97.56319	140.2455	66.5225	38.17207	62.88365	50.9443	55
20	2072	470	444.6985	224.4395	104.024	183.7824	69.2367	41.52223	81.09416	44.90073	55
21	1924	417.4134	382.0362	140.8753	179.8303	208.9498	66.66146	22.0827	108.7351	63.10206	55
22	1628	343.5904	399.9893	139.4281	138.4242	159.6242	107.5437	32.20178	105.3798	22.52453	55
23	1332	262.023	375.28	78.21599	110.7684	110.5716	159.5313	76.84221	74.26923	29.96231	55
24	1184	195.3871	365.6694	100.4969	85.0715	76.44666	120.7501	112.0062	53.8493	20.11948	55
Total Cost for DELD using SOA									5075450.616		



	Load	SOA_SA									
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
1	1036	235.2882	199.9673	99.34018	89.33553	91.76709	96.21128	40.07348	103.9091	27.8482	55
2	1110	253.2508	256.797	88.65566	68.77269	140.9603	118.5278	29.15929	72.44822	23.89183	55
3	1258	331.8652	245.7622	154.4481	78.611	111.7605	105.9839	52.99355	101.0581	48.77264	55
4	1406	358.7629	321.583	92.10263	117.5196	147.799	145.6744	33.16565	60.68675	75.84536	55
5	1480	423.3848	381.4528	147.968	77.63189	132.4834	123.3266	28.68157	94.6341	25.69382	55
6	1628	432.1589	417.6505	225.1792	79.61002	152.7989	88.40437	42.58427	77.76647	47.50666	55
7	1702	458.8726	410.8462	287.7003	127.1437	192.1339	69.52498	22.48035	47.30158	33.50463	55
8	1776	453.282	445.0183	254.6559	131.1685	188.6914	123.5322	27.65082	73.93404	24.40124	55
9	1924	458.9707	454.104	333.6174	90.81515	223.2939	105.5003	27.76173	67.73001	50.29887	55
10	2072	422.1714	458.5853	294.0541	142.0503	201.2329	71.93461	91.48415	73.17543	32.4495	55
11	2146	465.6342	459.3942	214.1562	163.3981	211.1754	123.0894	23.27194	60.21583	64.11908	55
12	2220	467.8004	439.6251	208.147	120.9444	150.7598	128.9527	25.72306	52.19568	24.65188	55
13	2072	461.8407	460	184.971	173.4641	181.3602	129.7563	57.51313	56.75351	25.96573	55
14	1924	461.771	458.1346	150.3226	165.3735	162.466	107.8042	37.90191	69.61781	25.49878	55
15	1776	470	439.9172	127.5566	155.1117	205.4836	140.0171	44.21064	66.64603	28.22261	55
16	1554	407.5845	407.5305	123.4324	113.4898	164.1328	145.461	45.19035	47.32345	27.2999	55
17	1480	361.494	329.5669	155.5145	122.3792	196.63	155.3696	29.49164	66.2287	43.89752	55
18	1628	413.4983	406.641	165.1487	99.46968	211.2943	111.2225	34.38729	97.03386	24.6594	55
19	1776	470	460	169.7827	133.8347	201.1214	71.6867	69.11416	71.24402	27.2793	55
20	2072	470	459.8339	101.7326	139.8381	160.5692	66.78778	104.1804	100.4828	38.40817	55
21	1924	469.1743	392.5755	121.3929	191.3041	178.4662	89.3965	106.4654	49.36417	57.34753	55
22	1628	467.1867	331.2986	187.7787	150.0183	99.89575	109.3053	69.17221	72.05403	39.14977	55
23	1332	392.1448	235.4411	236.1607	103.0079	92.14687	71.27295	39.20307	85.53232	24.54385	55
24	1184	365.5291	157.9589	238.0172	66.32202	99.27186	62.81328	24.90466	53.50518	60.35115	55
Total Cost for DELD using SOA_SA									3995637.225		

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