Egyptian Vulture Optimization For Combined Economic and Emission Dispatch New Meta- heuristic Algorithm

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Abstract: *Presently, No more possible to use fossil fuels to generate energy, according to its influences on all life forms, for this reason recent studies of combined economic and emissions dispatch It became concerned as well as cost reduction to other parameters emissions, losses, to keep the environmental balance.*

Searchers use many processes to simulate the nature to achieve those objectives; this paper presents a recent method of Egyptian Vulture Optimization Algorithm (EVOA) for multi-objectives optimization problem in power system.

The Egyptian vulture needs during feeding to bird's eggs, which are protected with solid covers, the Egyptian vulture made many attempts using throwing gravels before succeeding in breaking egg's cover by changing –randomly- in every attempt the throwing angle and/or the throwing force.

EVOA is among the most effective methods, easy to applied and able to search near total optimum solutions.

Key words: *Egyptian Vulture, Optimization, Emission, Dispatch, New Meta- heuristic Algorithm*

1. Introduction

It is known that power generators using fossil fuels to produce electricity, which is produced from burning emission of gas polluted air by unanimity of scientific organizations which is considered as the major emitters of gases like carbon dioxide(CO_2), sulfur dioxide (SO_2) and nitrogen oxide (NO_x) into the atmosphere[1].

So it was imperative for the companies of energy production to change power generation strategy where proceeded to methods to reduce the level of emissions and cost, among them:

Particle Biogeography Based Optimization (BBO) [1], Differential Evolution (DE), Swarm Optimization (PSO) [2,3], Genetic Algorithm (GA) [4], Multi-Objective Evolutionary Algorithms (MOEA) , Refined Genetic Algorithm (RGA), Non-Dominated Sorting Genetic Algorithm (NSGA-II) [5-9],Artificial Bee Colony (ABC) [10], ABC-PSO Simple Recursive Approach, (SRA) [11], Gravitational Search Algorithm (GSA) [12-14]. Here, a new meta-heuristic technique Egyptian Vulture Optimization [15-21] is implemented to solve multi-objective CEED problem.

The aim of Egyptian Vultures suggested is to solve combined economic and emissions dispatch problems and present its effectiveness using three, six and ten generating units test systems. The result shows that the suggested methodology can reliably handle complex multi-objective optimization problem in strong and effective way.

In this paper we include for the first time the method Egyptian Vulture Optimization Algorithm in dispatching emission gas, we obtain very satisfactory results (emission , cost, total cost, P_L) compared with results of previous studies relied on other methods

2. Mathematical formulation of the problem [22-30]:

The statement of the problem is to minimize two functions multi-objective interpreting the cost of fuel for the production of electrical energy and the rate of gas emission to the environment associated with this production.

The objective function of the economic cost of production is presented in the following form:

$$F_i(P_{gi}) = c_i + b_i P_{gi} + a_i P_{gi}^2 \qquad (1)$$

where a_i, b_i and c_i are the coefficients of own cost for each unit of production of electrical energy. The objective function of gas emission at the time of the production is the following:

where (f_i, e_i, d_i) are the coefficient emission characteristics attached to each group of production.

$$E_i(P_{gi}) = f_i + e_i P_{gi} + d_i P_{gi}^2 \qquad (2)$$

The functions to minimize can be described in the following manner:

$$E_i(P_{gi}) = f_i + e_i P_{gi} + d_i P_{gi}^2 \qquad (3)$$

Under the following constraints:

$$\sum_{i}^{ng} P_{gi} - P_{ch} - P_L = 0 \qquad (4)$$

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \qquad (5)$$

Expression of the loss of transmission as a function of the generated power is given by[31,36]:

$$P_L = \sum_{i=1}^{ng}\sum_{j=1}^{ng} P_{ig} B_{ij} P_{jg} \qquad (6)$$

where B_{ij} is the constant called the losses coefficient.
F: function of total cost.
F_i: cost function of the unit of production i.
E: A function of emission rate of the total gas.
E_i: function of the emission rates of the production unit
n_g: number of generators of production.
P_{gi}: active power produced by the unit i.
P_L: total losses active in transmission.
The factor H_i of hybridization is exposed as follow [14]:

$$H_i = \left[\sum_{i}^{ng} F_i(P_{ig\max})\right] / \left[\sum_{i=1}^{ng} E_i(P_{ig\max})\right] \qquad (7)$$

$$H_i = \frac{\left[\sum_{i}^{ng} F_i(c_i + bP_{gi\max} + a_i P^2_{ig\max})\right]}{\left[\sum_{i=1}^{ng} E_i(f_i + e_i P_{gimax} + diP^2_{ig\max})\right]} \qquad (8)$$

The functions to minimize can be described in the following manner:

$$\text{Min}\left[f(P_{gi}) = \sum_{i}^{ng} F_i(P_{gi}) + H_i \sum_{i=1}^{ng} E_i(P_{gi}) \right] \qquad (9)$$

$$\text{Min}\left[\begin{array}{l} f(P_{gi}) = \sum_{i}^{ng} F_i(c_i + b_i P_{gi} + a_i P^2_{gi}) \\ + H_i \sum_{i=1}^{ng} E_i(f_i + e_i P_{gi} + d_i P^2_{gi}) \end{array}\right] RS/H \qquad (10)$$

3. Description of EVOA [33].

The **EVOA is a** new member in the family of Meta-Heuristics, this method of some given phases, using representation by illustrations and explications. The two principal actions of the Egyptian Vulture, which are taken into account here or by preference to turn over into algorithm, are the throwing of gravel and the capacity of turn round and round objects with twigs.

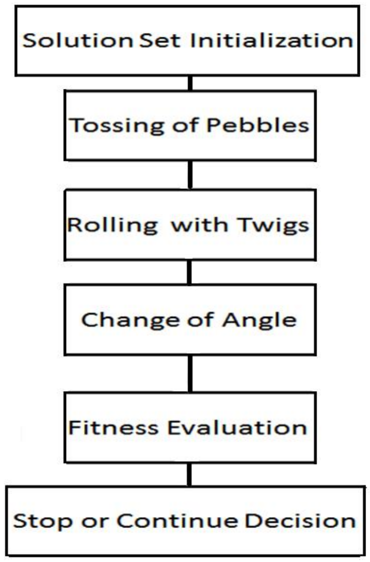

Fig.1. **EVOA's** organizational chart

The nature has developed many methods to protect it balance and elements, the Egyptian vulture is one of these elements, needs during feeding to bird's eggs, which are protected with solid covers, the Egyptian vulture made many attempts using throwing gravels before succeeding in breaking egg's cover by changing –randomly- in every attempt the throwing angle and/or the throwing force. The EVOA process is applied to minimize gas emissions in the electric power stations. Figure 1, illustrate the EVOA's organizational chart [15].

3.1 A simplified explanation of the EVOA:

Phase 1: Initiation
Phase 2: Take randomly the maximum possible of value n which Achieve the condition
Phase 3: validation of value n in Function F

$$P_{igmin} \le P_{ig} \le P_{ig\max}$$

Phase 4: Classification of solutions from the minimum till maximum
Phase 5: Take a certain Percentage xi of solutions
Phase 6: Creation of proximity solutions obtains from phase 5
Phase 7: Validation of solutions obtains from phase 6
Phase 8: Classification of solutions obtains from phase 6 from the minimum till maximum
Phase 9: The phases 5, 6, 7 and 8 are repeated till the end of iterations
Remark:

$$\text{if } P_i \le P_{\min} \text{so } P_i = P_{\min}$$
$$P_i \ge P_{\max} \text{so } P_i = P_{\max}$$

n: number of solutions
x_i: Percentage of a number of solutions
P_{ig}: number of generators
$P_{ig\,min}$: minimum power generates
$P_{ig\,max}$: maximum power generates

4. SIMULATION RESULTS

Experimentally, In order to evaluate the efficacy of EVOA, it utilizes a system composed firstly of three units, and the process is repeated with six units, and finally with ten units. The process proposed to perform Matlab to obtain solutions.

APPLICATION 1:

The application of the EVOA has been made on an IEEE network of three generators of production; they have a cost function of fuel and a function of emission of exhaust gas to this production. The parameters related by the system composed of three units are indicated in the table 1 and table 2 below:

Table 1
Data of three generators of production

unit	**Fuel cost coefficient**			P_{gmin}	P_{gmax}
	a_i	b_i	c_i	*(MW)*	*(MW)*
G_1	0.03546	38.30553	1243.53110	35	210
G_2	0.02111	36.32782	1656.56960	130	325
G_3	0.01799	38.27041	1356.65920	125	315

Table 2
Emission coefficients of three generators of production

unit	Emission coefficient			P_{gmin}	P_{gmax}
	di	*ei*	*fi*	(MW)	(MW)
G1	*0.00683*	*-0.5455*	*40.26669*	*35*	*210*
G2	*0.00461*	*-0.5116*	*42.89553*	*130*	*325*
G3	*0.00461*	*-0.5116*	*42.89553*	*125*	*315*

The transmission line losses coefficient of three generators of production:

$$Bmn = \begin{bmatrix} 0.000070 & 0.000025 & 0.000030 \\ 0.000030 & 0.000069 & 0.000032 \\ 0.000025 & 0.000032 & 0.000080 \end{bmatrix}$$

Table 3, contains an optimum simulation's results of generating system of three units given by EVOA for charge demand 400MW.

Table 3
System of three units simulated by EVOA and four other processes P_{ch}=400MW

P_{Ch} (MW)	**400MW**		
Performance	**PL (MW)**	**Fuel cost(RS/hr)**	**Emission (Kg/hr)**
PSPSO[14]	7.412	20837.605	**200.230**
PSO[25]	NR	20838.313	**201.5**
GA[25]	NR	20839.146	**201.35**
CS [35]	7.41434	20837.4857	**200.23984**
GA [38]	7.41324	20840.1	**200.256**
PSO [38]	7.41173	20838.3	**200.221**
FPA[39]	7.4126	20838.1	**200.2238**
Proposed EVOA	7.3490	20837.2961	**200.2075**

The table 3 presented an optimum simulation results of EAOA (emission, Fuel cost, total cost, losses) compared with simulation results of PSPSO[14],PSO[25], GA[25], CS[35], GA [38], PSO [38] and FPA[39] where the charge is modified as follows: P_{ch}=400MW.The results obtained by EVOA are satisfactory when compared with four other processes.

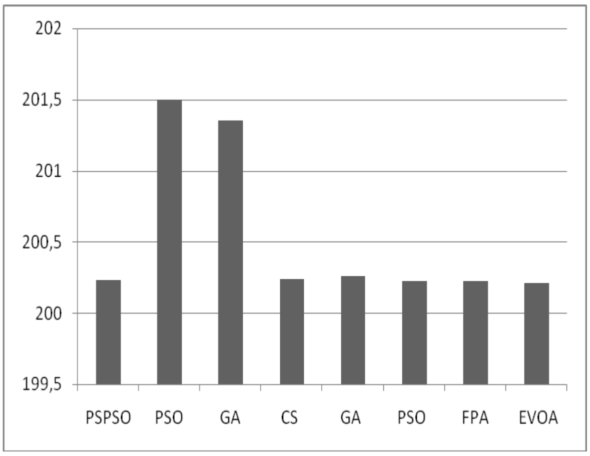

Fig.2. Illustration of emission by FPA, PSO, GA, CS, GA, PSO, PSPSO and EVOA of three generators of production P_{ch}=400MMW.

Variations of fuel cost in terms of number of iterations with EVOA for power demand of 400MW are plotted in figure 5, the proposed EVOA reduces the cost of electrical power generate.

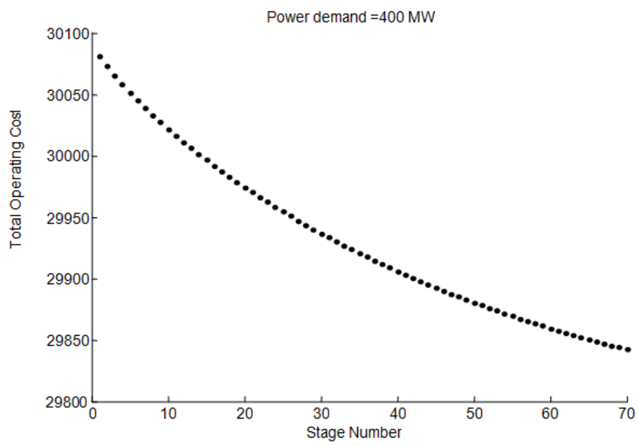

Fig. 5. Convergence of three generating unit system for P_{ch}=400MW

Table 4, contains an optimum simulation's results of generating system of three units given by EVOA for charge demand 550MW and 700MW.

Table 4
System of three units simulated by EVOA and four other process P_{ch}=550MWand 700MW.

P_{Ch} (MW)	Performance	PSPSO [14]	PSO [25]	GA [25]	CS [35]	Proposed EVOA
550	Fuel cost (RS/hr)	27904.35	27907.31	27905.10	27903.980	27903.48
	Emission (Kg/hr)	**381.210**	**384.361**	**383.614**	**381.21735**	**381.17**
	PL(MW)	14.214	NR	NR	14.21671	14.181
700	Fuel cost (RS/hr)	35463.66	35467.06	35465.94	35463.579	35461.605
	Emission (Kg/hr)	**651.585**	**653.504**	**653.267**	**651.58841**	**651.4962**
	PL(MW)	23.638	NR	NR	23.36862	23.3069

NR means not reported in the refereed literature.

The table 4 presented an optimum simulation results of EAOA (emission, Fuel cost, total cost, losses) compared with simulation results of PSPSO[14],PSO[25], GA[25], and CS[35], where the charge is modified as follows: P_{ch}=550MW and P_{ch}=700MW.The results obtained by EVOA are satisfactory when compared with four other processes.

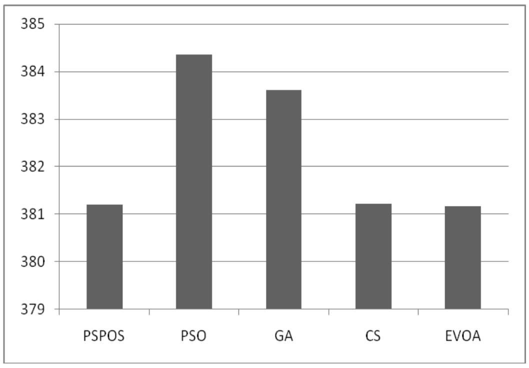

Fig .3. Illustration of emission by CS, GA, PSO, PSPSO and EVOA of three generators of production P_{ch}=550MMW

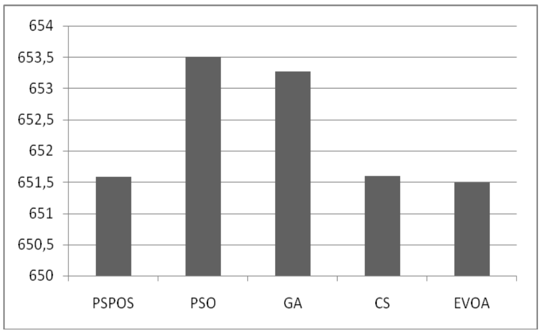

Fig.4. Illustration of emission by CS, GA, PSO, PSPSO and EVOA of three generators of production Pch=700MMW.

Table 5
Optimal results of generating system of three units given by EVOA

Unit Power Output(MW)	Load Demand (MW) 400	550	700
P1	102,565123	142,20785	182,527169
P2	153,881829	211,26185	271,555809
P3	150,945308	210,72572	269,237824
Fuel cost ($/hr)	**20837.2961**	**25496.204**	**35464.72440**
Emission (kg/hr)	**200.207537**	**381.17844**	**651.464731**
PL(MW)	**7.34903**	**14.18162**	**23.2950046**
Total cost(Rs/hr)	**29808.3291**	**44982.714**	**64654,8247**

Variations of fuel cost in terms of number of iterations with EVOA for power demand of 550MW and 700 MW are plotted in figure 6 and figure 7,the proposed EVOA reduces the cost of electrical power generate .

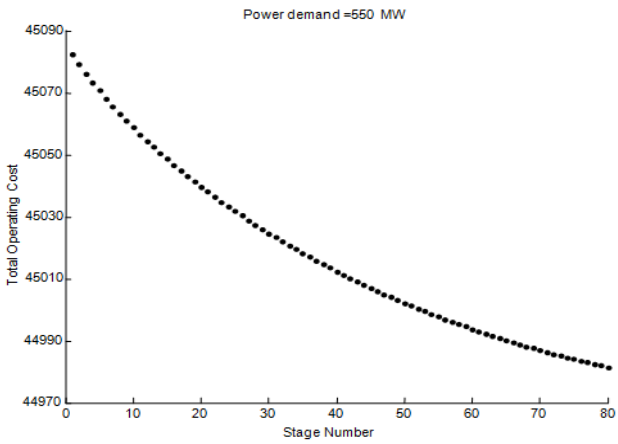

Fig. 6. Convergence of three generating unit system for P_{ch}=550MW

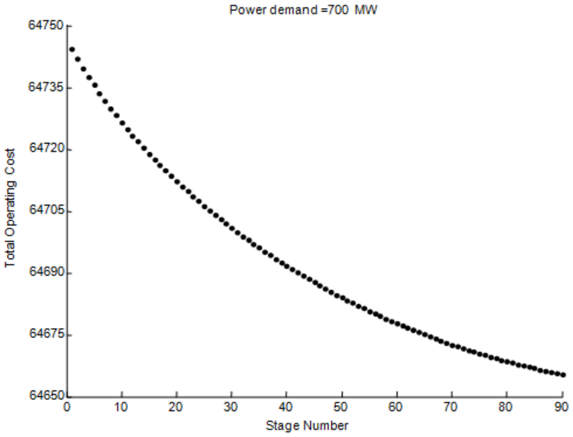

Figure7**.** Convergence of three generating unit system for P_{ch}=700MW

APPLICATION 2:

The application of the EVOA has been made on an IEEE network of six generators of production; they have a cost function of fuel and a function of emission of exhaust gas to this production. The parameters related by the system composed of six units are indicated in the table 5 and table 6 below:

Table 6
Data of six generators of production.

unit	Fuel cost coefficient			P_{gmin}	P_{gmax}
	a_i	b_i	c_i	(MW)	(MW)
G_1	0.1527	38.53973	756.7986	10	125
G_2	0.1057	46.15916	451.3253	20	150
G_3	0.0283	40.39655	1049.531	35	225
G_4	0.0356	38.30552	1243.531	35	210
G_5	0.0211	36.32782	1658.556	130	325
G_6	0.0179	38.27041	1356.652	125	325

Table 7
Emission coefficients of six generators of production.

unit	Fuel cost coefficient			P_{Gmin}	P_{Gmax}
	d_i	e_i	f_i	(MW)	(MW)
G_1	*0.00419*	*0.32767*	*13.85932*	*10*	*125*
G_2	*0.00419*	*0.32767*	*13.85932*	*20*	*150*
G_3	*0.00683*	*-0.54551*	*40.26690*	*35*	*225*
G_4	*0.00683*	*-0.54551*	*40.26690*	*35*	*210*
G_5	*0.00461*	*-0.51116*	*42.89553*	*130*	*325*
G_6	*0.00461*	*-0.51116*	*42.89553*	*125*	*325*

The transmission line losses coefficient of six generators of production:

$$B_{mn=}\begin{bmatrix} 1.40 & 0.17 & 0.15 & 0.19 & 0.26 & 0.22 \\ 0.17 & 0.60 & 0.13 & 0.16 & 0.15 & 0.20 \\ 0.15 & 0.13 & 0.65 & 0.17 & 0.24 & 0.19 \\ 0.19 & 0.16 & 0.17 & 0.71 & 0.30 & 0.25 \\ 0.26 & 0.15 & 0.24 & 0.30 & 0.69 & 0.32 \\ 0.22 & 0.20 & 0.19 & 0.25 & 0.32 & 0.85 \end{bmatrix}$$

The table 8 presented an optimum simulation results of EAOA (emission, Fuel cost, total cost, losses) compared with simulation results of FA[37],BA[37]and HYB[37], where the charge is modified as follows: P_{ch}=700MW, Pch=800MW, P_{ch}=900MW and P_{ch}=1000MW.The results obtained by EVOA are satisfactory when compared with four other processes.

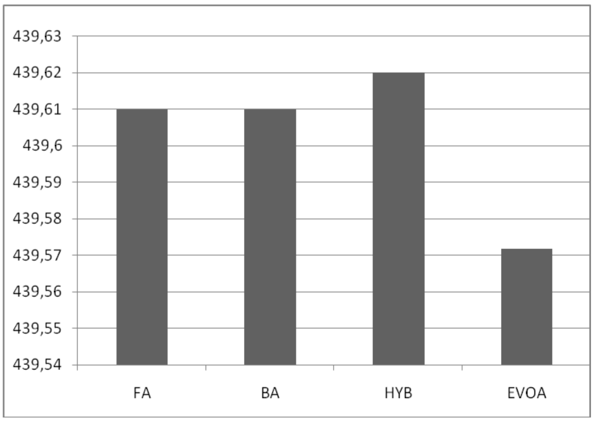

Fig. 8. Illustration of emission by HYB, BA, FA and EVOA of six generators of production P_{ch}=700MMW.

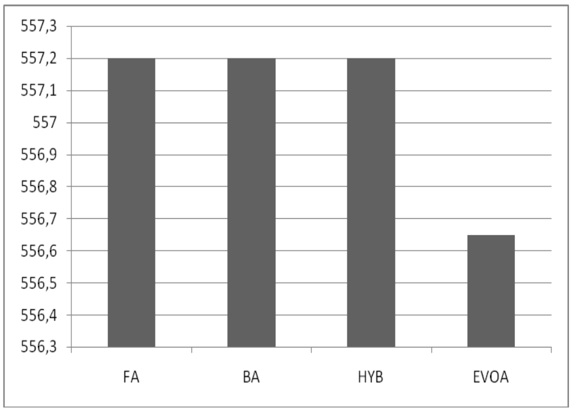

Fig.9. Illustration of emission by HYB, BA, FA and EVOA of six generators of production P_{ch}=800MMW.

Table 8
System of six units simulated by EVOA and four other processes.

P_{ch} (MW)	Performance	FA [37]	BA [37]	HYB [37]	Proposed EVOA
	Total cost (Rs/hr)	571910.01	571900.01	571900.01	56562,8311
	Emission (Kg/hr)	**439.61**	**439.61**	**439.62**	**439.5717**
700	PL(MW)	17.0566	17.0566	17.0569	16.6541
	Fuel cost (RS/hr)	37500.93	37500.84	37500.48	37575.3967
	Total cost (Rs/hr)	67740.26	67740.26	67740.26	66947,9599
	Emission (Kg/hr)	**557.20**	**557.20**	**557.20**	**556.6477**
800	PL(MW)	22.1890	22.1888	22.1888	22,0381
	Fuel cost (RS/hr)	42784.41	42784.52	42784.36	42921.7857
	Total cost (Rs/hr)	81529.09	81529.09	81529.09	78287,7016
	Emission (Kg/hr)	**693.79**	**693.78**	**693.79**	**692.9526**
900	PL(MW)	28.0098	28.0094	28.0095	27,555114
	Fuel cost (RS/hr)	4850.59	4850.77	4850.54	4835.18115
	Total cost (Rs/hr)	94846.36	94846.36	94846.36	90925,2363
	Emission (Kg/hr)	**851.53**	**851.53**	**851.53**	**850.8578**
1000	PL(MW)	34.6112	34.6113	34.6113	33,7630
	Fuel cost (RS/hr)	54124.28	54124.12	54124.13	54119.7598

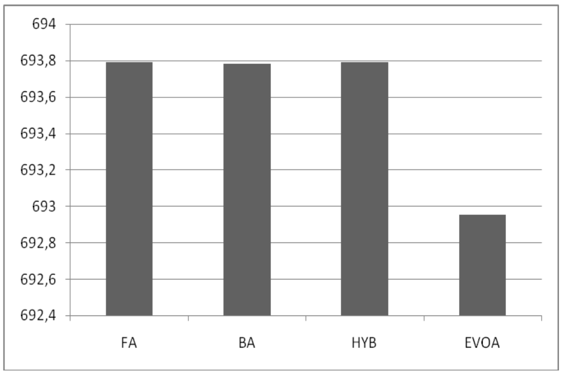

Fig .10. Illustration of emission by HYB, BA, FA and EVOA of six generators of production P_{ch}=900MMW.

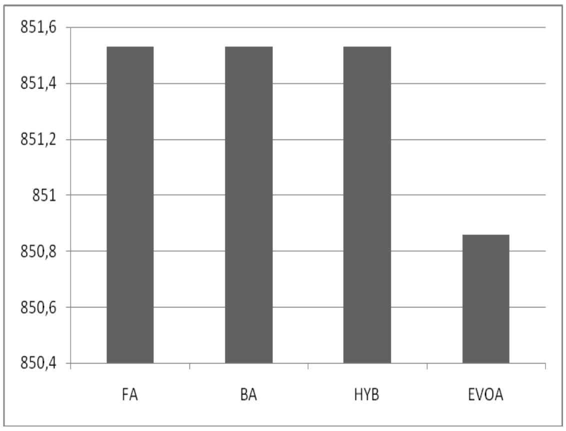

Fig.11. Illustration of emission by HYB, BA, FA and EVOA of six generators of production P_{ch}=1000MMW

Table 9, contains an optimum simulation results of the generating system of six units given by EVOA for charge demand 700MW, 800MW, 900MW and 1000MW.

Table 9
Optimal results of the generating system of six units given by EVOA

Unit Power Output (MW)	Load Demand (MW) 700	800	900	1000
P_1	61,06496	84,9087278	95,0104039	110,6735
P_2	71,08263	76,6526063	97,8276776	115,0069
P_3	113,6715	138,506233	149,214881	169,8053
P_4	106,9277	139,38355	140,743799	151,3749
P_5	186,5580	181,496879	222,664986	237,5525
P_6	177,3492	201,090978	222,093367	249,3497
Total cost(Rs/hr)	**56562,8311**	**66947,9599**	**78287,7016**	**90925,2363**
Fuel cost ($/hr)	**37575.3967**	**42921.7857**	**48351.8115**	**54119.7598**
Emission (kg/hr)	**439.5717**	**556.6477**	**48351.8115**	**850.8578**
P_L(MW)	**16.6541**	**22,0381**	**27,5552**	**33,7630**
T(s)	9.071	10.470	11.670	11.915

An approach based on EVOA has been presented and applied to the function of the cost of fuel and the function of emission in a network of electrical energy. The problem has been formulated as a problem multi objective with objectives to optimize the cost of fuel for the production and the rate of impact on the environment. The EVOA has therefore well given satisfactory results.

Variations of fuel cost in terms of number of iterations with EVOA for power demand of 700MW, 800 MW, 900 MW and 1000MW are plotted in Figure 12, Figure 13, Figure 14 and Figure 15, the proposed EVOA reduce the cost of electrical power generate

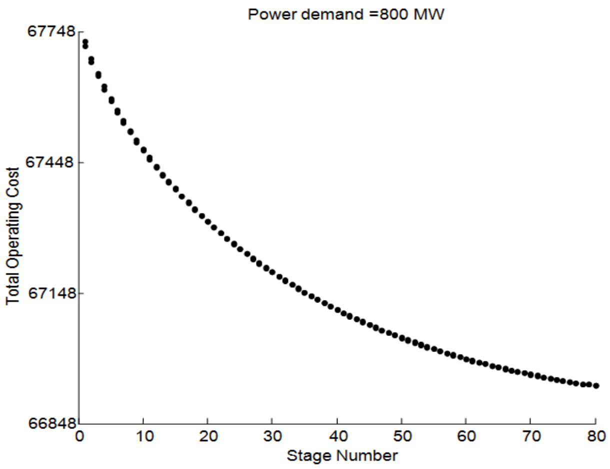

Fig .13. Convergence of six generating unit system for P_{ch}=800MW.

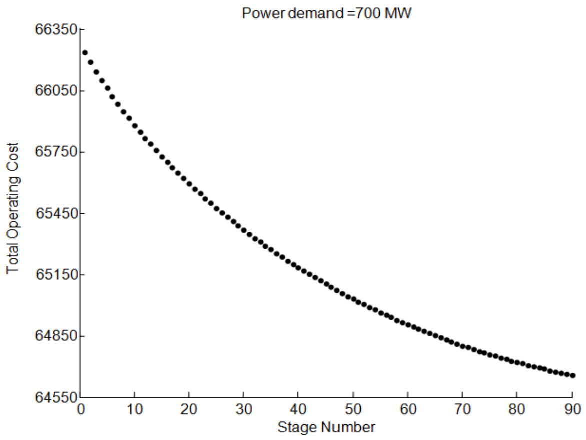

Fig .12. Convergence of six generating unit system for Pch=700MW

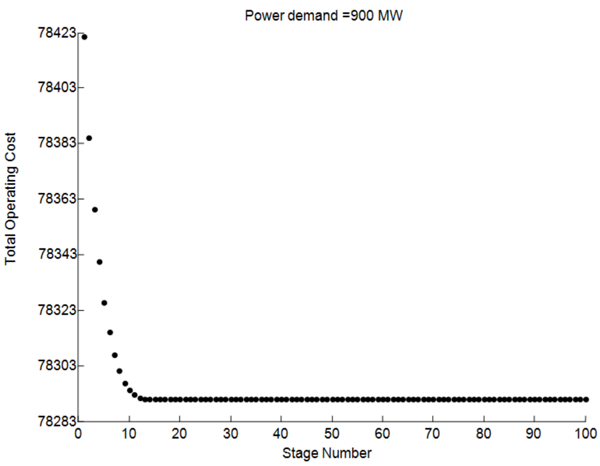

Fig .14. Convergence of six generating unit system for P_{ch}=900MW

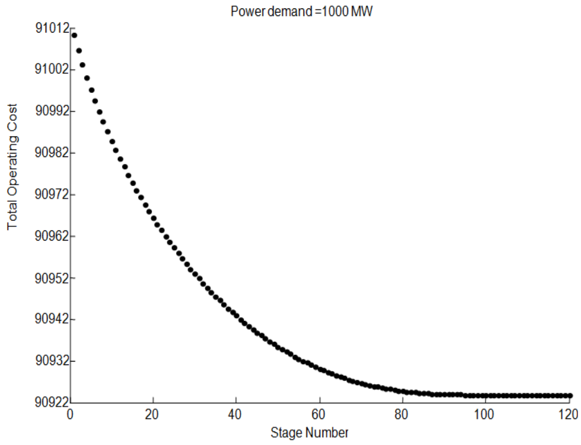

Fig.15. Convergence of six generating unit system for P_{ch}=1000MW

APPLICATION 3:

The application of the EVOA has been made on an IEEE network of ten generators of production; they have a cost function of fuel and a function of emission of exhaust gas to this production. The parameters related by the system composed of ten units are indicated in the table 9 and table 10 below:

Table 10
Data of ten generators of production.

unit	Fuel cost coefficient			P_{gmin}	P_{gmax}
	ai	*bi*	*ci*	(MW)	(MW)
G1	*0.12951*	*40.5407*	*1000.403*	*10*	*55*
G2	*0.10908*	*39.5804*	*950.606*	*20*	*80*
G3	*0.12511*	*36.5104*	*900.705*	*47*	*120*
G4	*0.12111*	*39.5104*	*800.705*	*20*	*130*
G5	*0.15247*	*38.539*	*756.799*	*50*	*160*
G6	*0.10587*	*46.1592*	*451.325*	*70*	*240*
G7	*0.03546*	*38.3055*	*1243.531*	*60*	*300*
G8	*0.02803*	*40.3965*	*1049.998*	*70*	*340*
G9	*0.02111*	*36.3278*	*1658.569*	*135*	*470*
G10	*0.01799*	*38.2704*	*1356.659*	*150*	*470*

Table 11
Emission coefficients of ten generators of production.

unit	Fuel cost coefficient			$P_{g\,min}$	$P_{g\,max}$
	***d*i**	***e*i**	***f*i**	*(MW)*	*(MW)*
G_1	0.04702	-3.9864	360.0012	10	55
G_2	0.04652	-3.9524	350.0056	20	80
G_3	0.04652	-3.9023	330.0056	47	120
G_4	0.4652	-3.9023	330.0056	20	130
G_5	0.0042	0.3277	13.8593	50	160
G_6	0.0042	0.3277	13.8593	70	240
G_7	0.0068	-0.5455	40.2669	60	300
G_8	0.0068	-0.5455	40.2669	70	340
G_9	0.0046	-0.5112	42.8955	135	470
G_{10}	0.0046	-0.5112	42.8955	150	470

The transmission line losses coefficient of ten generators of production:

$$B_{mn} = 0.0001*\begin{bmatrix} 0.49 & 0.14 & 0.15 & 0.15 & 0.16 & 0.17 & 0.17 & 0.18 & 0.19 & 0.20 \\ 0.14 & 0.45 & 0.16 & 0.16 & 0.17 & 0.15 & 0.15 & 0.16 & 0.18 & 0.18 \\ 0.15 & 0.16 & 0.39 & 0.10 & 0.12 & 0.12 & 0.14 & 0.14 & 0.16 & 0.16 \\ 0.15 & 0.16 & 0.10 & 0.40 & 0.14 & 0.10 & 0.11 & 0.12 & 0.14 & 0.15 \\ 0.16 & 0.17 & 0.12 & 0.14 & 0.35 & 0.11 & 0.13 & 0.13 & 0.15 & 0.16 \\ 0.17 & 0.15 & 0.12 & 0.10 & 0.11 & 0.36 & 0.12 & 0.12 & 0.14 & 0.15 \\ 0.17 & 0.15 & 0.14 & 0.11 & 0.13 & 0.12 & 0.38 & 0.16 & 0.16 & 0.18 \\ 0.18 & 0.16 & 0.14 & 0.12 & 0.13 & 0.12 & 0.16 & 0.40 & 0.15 & 0.16 \\ 0.19 & 0.18 & 0.16 & 0.14 & 0.15 & 0.14 & 0.16 & 0.15 & 0.42 & 0.19 \\ 0.20 & 0.18 & 0.16 & 0.15 & 0.16 & 0.15 & 0.18 & 0.16 & 0.19 & 0.44 \end{bmatrix}$$

Table 12. System of ten units simulated by EVOA and four other processes.

Unit Power Output (MW)	**NSGA-II [40]**	**RCCRO [41]**	**MODE [42]**	**ABC_PSO [43]**	**EMOCA [44]**	**MODE [45]**	**GSA [46]**	**EVOA**
P_1	51.9515	55.0000	54.9487	55	55	54.9487	54.9992	48.0212
P_2	67.2584	80.0000	74.5821	80	80	74.5821	79.9586	63.1488
P_3	73.6879	85.6453	79.4294	81.14	83.5594	79.4294	79.4341	105.289
P_4	91.3554	84.1259	80.6875	84.216	84.6031	80.6875	85.0000	77.9493
P_5	134.052	136.503	136.855	138.3377	146.563	136.8551	142.1063	86.1894
P_6	174.950	155.580	172.6393	167.5086	169.248	172.6393	166.5670	188.189
P_7	289.435	300.000	283.823	296.8338	300	283.8233	292.8749	296.503
P_8	314.055	316.674	316.3407	311.5824	317.349	316.3407	313.2387	336.046
P_9	455.697	434.125	448.592	420.3363	412.918	448.5923	441.1775	426.875
P_{10}	431.805	436.572	436.428	449.1598	434.313	436.4287	428.6306	454.823
Fuel cost ($/hr)	**113540**	**113355.7**	**113484**	**113420**	**113445**	**113480**	**113490**	**112983.8**
Emission (kg/hr)	**4130.2**	**4121.06**	**4124.9**	**4120.1**	**4113.98**	**4124.90**	**4111.4**	**4111.39**
PL(MW)	**NR**	**NR**	**84.33**	**84.1736**	**83.56**	**NR**	**83.9869**	**83.0359**
T(s)	**NR**	**NR**	**3.82**	**NR**	**2.90**	**3.82**	**NR**	**15.069**

NR means not reported in the refereed literature.

The table 12 present an optimum simulation results of EVOA CEED compared with simulation results of NSGA-II [40], RCCRO [41], MODE[42] ABC_PSO [43], EMOCA[44],MODE[45] and GSA [46] where the charge is modified as follows: P_{ch}=2000MW.The results obtained by EVOA are satisfactory when compared with other processes Figure 16.

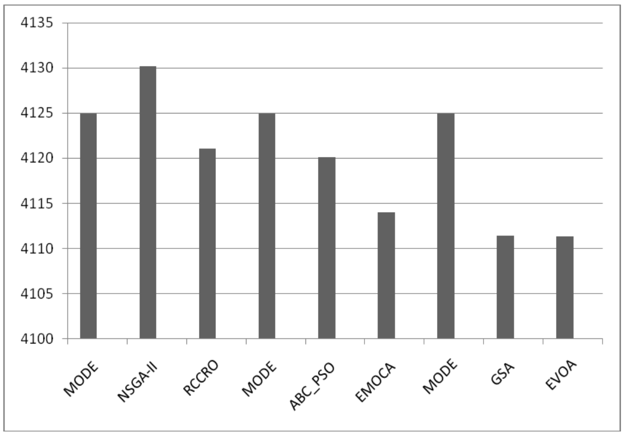

Fig.16. Illustration of CEED by EVOA and other processes in application 3.

Variations of fuel cost in terms of number of iterations with EVOA for power demand of 2000MW are plotted in figure17 the proposed EVOA reduces the cost of electrical power generate.

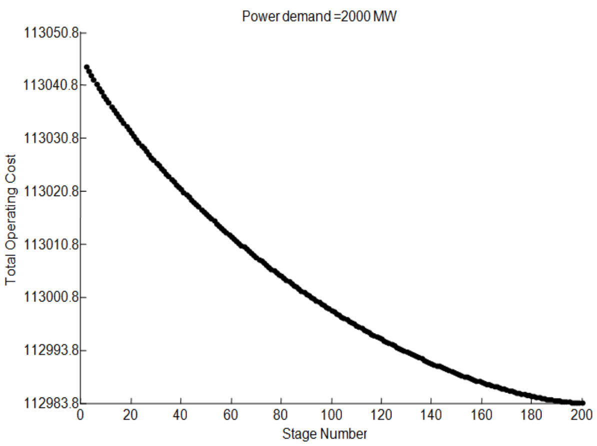

Fig. 17. Convergence of ten generating unit system for P_{ch}=2000MW

Table 13, contains an optimum simulation results of the generating system of ten units given by EVOA for charge demand 1100MW, 1400 MW and 1700MW

Table 13.
Optimal results of the generating system of ten units given by EVOA

Unit Power Output (MW)	Load Demand (MW)		
	1100	1400	1700
P_1	54,1329	51,3393	48,8251
P_2	48,3049	73,3870	52,6199
P_3	61,8698	72,4786	62,7911
P_4	20	20,5377	20,2999
P_5	135,8292	75,0618	152,1661
P_6	92,4619	115,6240	199,8725
P_7	173,2468	206,4850	192,0777
P_8	163,5811	218,3653	246,6841
P_9	204,9682	263,2107	362,4260
P_{10}	169,4741	344,3621	421,6672
Total cost ($/hr)	**118305,38**	**150714,429**	**190958,797**
Fuel cost ($/hr)	**62101.3531**	**76670.2227**	**96941.8475**
Emission (kg/hr)	**1972.8357**	**2599.7466**	**3280.2416**
PL(MW)	**23,8695**	**40,8521**	**59,4298**
T(s)	**8.231 s**	**10.124**	**12.312**

The EVOA has therefore well given satisfactory results. This demonstrates that it is much faster and more efficient than similar techniques in dealing with the problems of multi- objective optimization.

Variations of fuel cost in terms of number of iterations with EVOA for power demand of 1100MW ,1400 MW and 1700 MW are plotted in Figure 18, Figure 19, Figure 20 and Figure 19, the proposed EVOA reduce the cost of electrical power generate

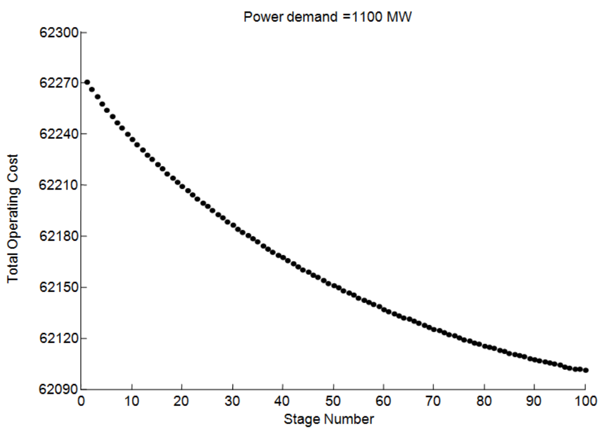

Fig .18. Convergence of ten generating unit system for P_{ch}=1100MW

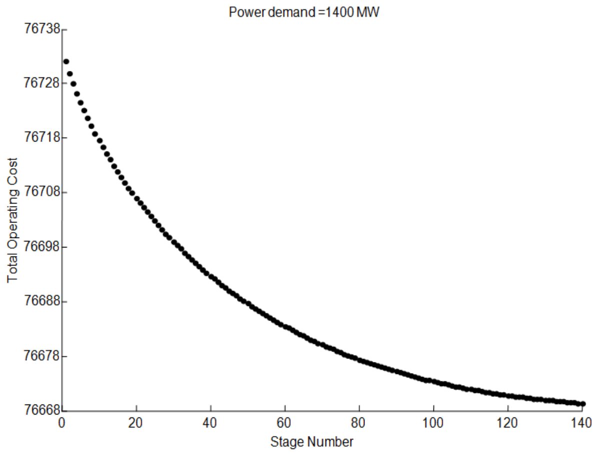

Fig.19. Convergence of ten generating unit system for P_{ch}=1400MW

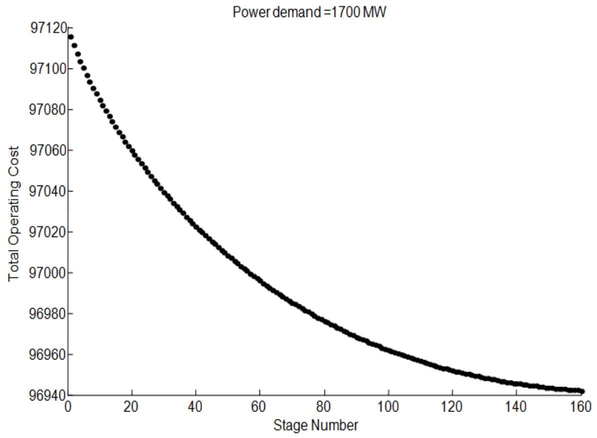

Fig.20. Convergence of ten generating unit system for P_{ch}=1700MW.

1. The simplified generalized term taken in this paper distinctly confers optimal generation scheduling of thermal units for the determined charge request without necessity of repeated steps. As a consequence, the counting of the total generation cost will be an easier task.
2. The suggested procedure needs a less number of repetitions for convergence after including transmission losses in the economic power dispatch problem.
3. The suggested EVOA procedure can be realized for large-scale systems.
4. The suggested procedure gives the optimal solution with less computational effort.

5. Conclusion

Egyptian Vulture Optimization Algorithm (EVOA), is a new optimization suggested by this paper in the domain of Combined Economic and Emission Dispatch. So as to show the efficiency of EVOA using three, six and ten generating units test systems.

The method of Egyptian Vulture Optimization Algorithm, is included for the first time in dispatching emission gas, we obtained very satisfactory results (emission, cost, total cost, PL) compared with results of previous studies relied on other methods .As of PSPSO, PSO, GA,CS, GA , PSO, FPA, BA, HYB ,FA NSGA-II , RCCRO, MODE ABC_PSO , EMOCA, MODE and GSA. EVOA is the most effective methods, easy to applied and able to search near total optimum solutions.

So, this result proves that EVOA optimization is a reliable technique for solving Combined Economic and Emission Dispatch problem

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