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# **Economic Load Dispatch with the Help of Artificial Bee Colony Technique**

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**ABSTRACT:** The economical load dispatch acts a critical function in the functioning of power system and several frameworks by using different techniques have been used to solve these problem. Various traditional methods, such as lambda-iteration and the gradient techniques are employed to determine the best solution for non-linear problem. Recently, the soft computing methods such as GA, PSO, SA and DE have received more attention and were used in a number successful and practical application. In this dissertation a modern heuristic approach Artificial Bee Colony (ABC) is presented to solve economic load dispatch problem. The feasibility of the Artificial Bee Colony algorithm, tested on different Test Cases like, consisting 3 and 6 generating unit systems with transmission losses using MATLAB. At last comparison is made with results available in various literatures using other existing relevant approaches. Observational results support the claim of technique of method over other existing methods in terms of robustness, fast convergence and most especially its optimal search behavior.

**KEYWORDS:** Economic Load Dispatch (ELD), Artificial Bee Colony (ABC), Soft Computing Techniques, Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Simulated Annealing (SA), Differential Evolution (DE), Convex Fuel Cost Characteristics, MATLAB Simulation, Optimal Search Behavior.

## **I. INTRODUCTION**

Since an engineer is always perturbed with the expenses of products and services, the efficient optimum economic functioning and strategizing of electric power generation system have always occupied an important position in the electric power sector. With large interconnection of the electric networks, the energy crisis in the world and continuous increase in cost, it is very essential to reduce the generating cost of the electric energy. A saving in the operation of the system of a small percent represents a significant reduction in operating cost as well as in the quantity of fuel consumption. The traditional issue is the economic load dispatch of generating systems to achieve minimum operating cost.

This issue has shifted somewhat due to growing public worry for environmental issues, leading economic dispatch to now encompass the management of systems aimed at reducing pollutants, conserving different types of fuel and ensuring minimal costs. Moreover this singular goal of economic dispatch can no longer be regarded in isolation because of the environmental issues arising from the emission produced by fossil-fueled electric power plants. Economic and environmental dispatch constitutes a multi-objective challenge. There is a need to expand the limited economic optimization problem to incorporate constraints on system operation to make sure the security of the system, thereby preventing the collapse of the system due to unexpected conditions. However closely associated with this economic dispatch problem is the problem of the proper assurance of any selection of units out of a total unit to serve the estimated load demands in an 'optimal' manner. For the purpose of optimum economic operation of this large-scale system, modern system theory and optimization methods are being applied with the considerable cost reduction.

## **II. PROBLEM FORMULATION**

Artificial Bee Colony Algorithm (ABC) [11-14] is an optimization algorithm based on the intelligent foraging behavior of honey bee swarm, proposed by Dervis Karaboga in 2005. It is as simple and uses only common control parameters such as colony size and maximum cycle number. ABC serves as an optimization tool that employs a population-based

search methodology. In this framework, individuals known as food positions are iteratively adjusted by artificial bees over time. The primary objective of the bees is to locate food sources that yield a high quantity of nectar, ultimately identifying the source with the maximum nectar content. Within the ABC system, artificial bees navigate a multidimensional search space. Certain bees, categorized as employed and onlooker bees, select food sources based on their own experiences and those of their nest mates, subsequently modifying their positions. In contrast, scout bees randomly explore food sources without relying on prior experience. When a scout discovers a new source with a nectar amount greater than that stored in memory, it records the new location and discards the previous one. The foraging process initiates with scout bees dispatched to identify promising flower patches, moving randomly between them. Throughout the harvesting season, the colony maintains its exploration efforts, designating a portion of the population to remain as scout bees.

When they return to the hive, those scout bees that found a patch with better quality than the certain quality threshold (measured as a combination of some ingredients, such as sugar content) accumulate their nectar and go to perform a dance known as the waggle dance on the dance floor.

This dance plays a crucial role in the communication within the colony, conveying three key pieces of information about a flower patch: its direction, the distance from the hive, and its quality rating or fitness. Such information enables the colony to direct its bees to flower patches with precision, eliminating the need for guides or maps. Each bee's understanding of the external environment is derived exclusively from the waggle dance. This dance allows the colony to assess the relative value of various patches based on both the quality of the food available and the energy required for its collection. Following the waggle dance performed inside the hive, the dancer, known as the scout bee, returns to the flower patch accompanied by follower bees that had been waiting in the hive. A greater number of follower bees are dispatched to the more promising patches, facilitating the colony's ability to gather food swiftly and effectively.

Thus, ABC system combines local search methods, carried out by employed and onlooker bees, with global search methods, govern by onlookers and scouts, trying to balance exploration and exploitation process.

In the ABC model, the colony is composed of three distinct groups of bees: employed bees, onlookers, and scout bees. It is posited that there is a single artificial employed bee corresponding to each food source. Consequently, the number of food sources available in proximity to the hive matches the number of employed bees within the colony. Employed bees visit their designated food sources and return to the hive to perform a dance in that area. When an employed bee abandons its food source, it transitions into a scout bee and begins the search for a new food source. Onlookers select the food sources based on the dance performances by the employed bees. The main steps of the algorithm are given below:

In this algorithm, the position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. The number of the employed bees (N) or the onlooker bees is equal to the number of solutions in the population. The following steps describe how ABC algorithms applied to the problem under consideration.

**Step 1: Input data**

Line data, bus data and generator cost coefficients and generation limits for each unit are read.

**Step 2: Initialization of parameter setup**

There are few control parameters used in the ABC algorithm, i.e. the size of colony, the number of employed bees, number of maximum, and the value of limit are initialized.

**Step 3: Initialization of population with random solutions** In this step, an initial population of N solution is generated randomly, where N denotes the size of the employed bees, which is equal to the number of food source positions. Each solution  $x_i$  ( $i = 1, 2, \dots, N$ ) is represented by a D-dimensional vector, where D is the number of parameters to be optimized and each parameter is real coded.

**Step 4: Evaluation of Fitness of the population** Evaluate the fitness value of each individual in the colony using.

$$\text{Fitness} = A [1 - \% \text{Cost}] + B [1 - \% \text{Error}]$$

Where A, B are the weighting coefficients,

$$Error = \left| \sum_{i=1}^N P_i - P_D - P_L \right|$$

$$\%cost = \frac{String\ cost - Min\ cost}{Max\ cost - Min\ cost}$$

$$\%Error = \frac{Stringerror - Minerror}{Maxerror - Minerror}$$

Where,

- String cost: the individual string's cost of generation.
- Min cost: the minimum value of the objective function within the population.
- Max cost: the maximum value of objective function within the population.
- String error: individual error of string's to meet the power balance constraint.
- Min error: the minimum error of constraint within the population.
- Max error: the maximum error of constraint within the population.

**Step 5:** Tempering of position by employed bees. An employed bee makes a revision on the position in her memory on the basis of local information (visual information) and evaluates the nectar amount of the new source. In order to produce a seeker food position from the old one in memory, the ABC uses

$$V_{ij} = X_{Kj} + \phi_{ij}(X_{ij} - X_{Kj})$$

Where  $k \in \{1, 2, \dots, N\}$  and  $j \in \{1, 2, \dots, D\}$  are arbitrarily chosen indicators. Although  $K$  is determined arbitrarily, it has to differ from  $i$ .  $\phi_{ij}$  is a random number between  $[0, 1]$ . It directs the production of the neighboring food sources around and shows the comparison of two food positions visually by a bee.  $V_{ij}$  is produced after each candidate source position and make comparison of its performance with that of its old one. It is change with the old one in the memory If the new food has better nectar than the old one. On the contrary, the old one is preserve in the memory.

**Step 6:** The neighborhood search Bees that have the highest fitness are chosen as selected bees and the sites visited by the selected bees are chosen for neighborhood search site.

**Step 7:** For chosen sites and assess fitness value the recruitment of onlooker bees.

$$P_i = \frac{f_i t_i}{\sum_{n=1}^N f_i t_n}$$

Where the fitness value of the solution  $I$  is  $f_i t_i$  which is proportionate to the nectar amount of the food source in the position  $i$  and the number of food sources is  $N$ . The number of employed bees and the number of food source is equal.

**Step 8:** Modification of position by onlookers.

As in the case of the employed bee, the onlooker produces a revision on the position which is stored in its memory and inspects the nectar amount of the candidate source. If the new food has equal or better nectar than the old one, it is replaced with the old source in the memory. Otherwise, no change in the memory.

**Step 9:** Abandon sources exploited by the bees.

The food source is abandoned by its employed bee if the new solution of a food source is not improved by a predetermined number of trials. The number of trials for supplying a food source is equal to the value of 'limit' which

is a very important control parameter in ABC algorithm. The “limit” value generally varies from 0.1 N\*D to N\*D. Assume that the dumped source is  $X_{ij}$  and  $j \in \{1,2,\dots,D\}$  then the scout discovers a new food source to be substitute with  $X_{ij}$ . This operation can be defined as in

$$X_i^j = X_{\min}^j + rand(0,1) * (X_{\max}^j - X_{\min}^j)$$

Where  $X_{\min}^j$  and  $X_{\max}^j$  are the minimum and maximum limits of the parameter to be optimized.

**Step 10:** Retain the best solution attain so far.

**Step 11:** Terminate the process if the termination criteria is satisfied. Else, go to step 5

In presented ABC population based algorithm, a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution represented by the position of a food source.

A colony of honey bees can expand itself over long distances (up to 14 km) and in multiple directions concurrently to exploit a large number of food sources. In principle, flower patches collected with less effort and have huge amounts of nectar or pollen should be visited by more bees, whereas patches with less nectar or pollen should receive fewer bees. The increase in the number of scouts uplift the inspection as the increase of onlookers on a food source increases the manipulation. Each of the trial was sustained numerous times with different arbitrary seeds. The mean function values of the best solutions establish by the algorithms for different confines have been recorded.

### III. TEST RESULTS AND ANALYSIS

To access the feasibility of the Artificial Bee Colony algorithm, it has been applied to solve the different types of economic dispatch problems. Test Case1, Test Case 2 consists of Three and six generating unit system with emission and losses which is tested on different load demands. Test Case3 considers IEEE30 bus consisting 6 generating unit systems with transmission losses. Test case 4 and Test case 5 consists of 18 and 15 generating unit system having convex fuel cost characteristics without transmission losses. All these simulation are done on MATLAB environment.

#### Test case 1: Three generating units system

The three generating units considered are having different characteristic. Their Fuel cost coefficient are given in table1

Table: 1 Fuel cost coefficient for Three Generating units system

unit	Fuel cost coefficient			P <sub>Gmin</sub> (MW)	P <sub>Gmax</sub> (MW)
	a <sub>i</sub>	b <sub>i</sub>	c <sub>i</sub>		
G1	0.03546	38.30553	1243.53110	35	210
G2	0.02111	36.32782	1658.56960	130	325
G3	0.01799	38.27041	1356.65920	125	315

According to the constraints considered in this work among inequality constraints only active power constraints are constraints are considered. There operating limit of maximum and minimum power are also different. The unit operating ranges are same for both cost function and emission function which are given in tables. Their emission function characteristics are given in table is shown below. Which are basically presented in environmentally [4].

Table: 2 NO<sub>x</sub> emission equation in kg/h are given below in

unit	Emission coefficient			P <sub>Gmin</sub> (MW)	P <sub>Gmax</sub> (MW)
	d <sub>i</sub>	e <sub>i</sub>	f <sub>i</sub>		
G1	0.0068	–	40.2669	35	210
	3	0.5455	0		
G2	0.0046	–	42.8955	130	325
	1	0.5116	3		
G3	0.0046	–	42.8955	125	315
	1	0.5116	3		

The transmission line losses can be calculated by knowing the loss coefficient. The B<sub>mn</sub> loss coefficient matrix is given by,

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

The convergence tendency of proposed ABC based strategy for power demand of 400MW, 500MW and 700 MW is plotted in figure: 1, figure: 2 and figure: 3. it shows that the technique converges in relatively fewer cycles thereby possessing good convergence property and resulting in low operating cost.

The Parameter for ABC algorithm considered here are:  
Number colony size N=20; Food-Number=N/2; and limit=50.

Table: 3 shows the summarized result of CEED problem for load demand of 400MW, 500MW and 700MW are obtained by the proposed ABC algorithm with stopping criteria based on maximum-generation=100.

Form Table: 3, it is clear that ABC algorithm gives optimum result in terms of minimum fuel cost, emission level and the total operating cost.

Table: 4 gives the best optimum power output of generators for CEED problem using ABC algorithm for load demand 400MW, 500MW and 700MW

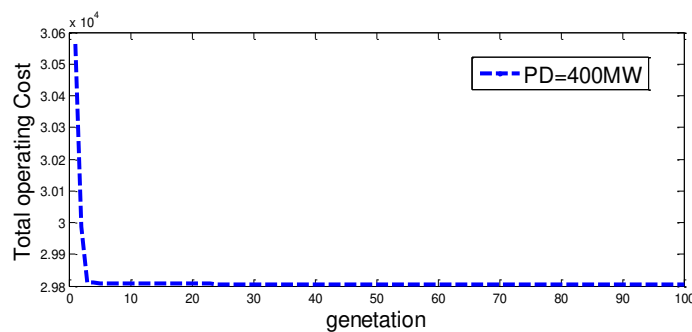


Figure: 1 convergence of Three generating units system for PD=400 MW

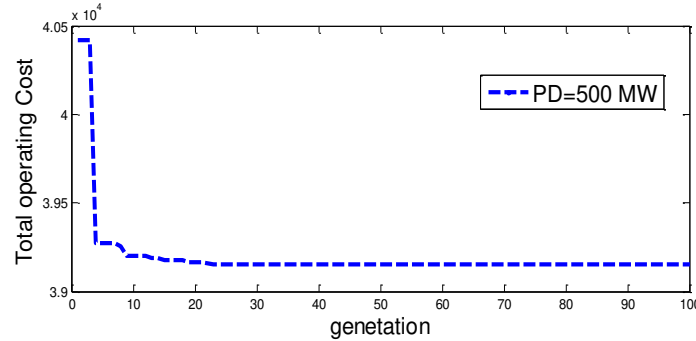


Figure: 2 convergence of Three generating units system for PD=500MW

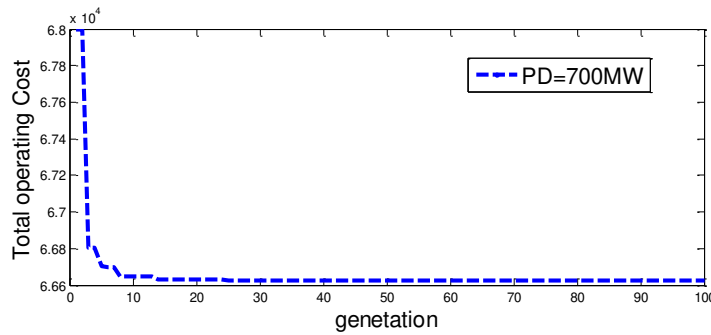


Figure: 3 convergence of Three generating units system for PD=700MW

Table: 3 Comparison of test results for Three Generating units system

PD (MW)	Performance	H (Rs/kg)	Conventional method [21]	SGA[21]	RGA[21]	Proposed ABC
400	Fuel cost Rs/hr	44.788	20898.83	20883.54	20801.8	20838
	Emission Kg/hr		201.5	201.35	201.21	200.2211
	PL, MW		7.41	7.69	7.39	7.5681
	Total Cost, Rs/hr		29922	29820	29812	29804.2
500	Fuel cost Rs/hr	44.788	25486.64	25474.56	25491.6	25495
	Emission Kg/hr		312.0	311.89	311.33	311.1553
	PL, MW		11.88	11.80	11.70	11.6937
	Total Cost, Rs/hr		39458	39441	39433	39428.3
700	Fuel cost Rs/hr	47.82	35485.05	35478.44	35471.48	35464
	Emission Kg/hr		652.55	652.04	651.60	651.5775
	PL, MW		23.37	23.29	23.28	23.3664
	Total Cost, Rs/hr		66690	66659	66631	66622.5

Table: 4 Optimum Power dispatch Results by Proposed method for three units system

PD MW	P1 MW	P2 MW	P3 MW	Escape Time (second)
400	102.5422	153.7333	151.1370	1.895377
500	128.8241	192.5837	190.2859	2.340603
700	182.6011	271.2813	269.4840	3.770030

**Test case 2: Six generating units system**

The six generating units considered are having different characteristic. Their cost function characteristics are given in the table 5 shown,

The constraints considered in this work among inequality constraints only active power constraints are constraints are considered. Their operating limit of maximum and minimum power are also different. The unit operating ranges are same for both cost function and emission function which are in table 5.

The convergence tendency of proposed ABC based strategy for power demand of 500MW and 900 MW is plotted in figure: 4 and figure: 5. it shows that the technique converges in relatively fewer cycles thereby possessing good convergence property and resulting in low operating cost.

The Parameter for ABC algorithm considered here are:

Number of colony size  $N=20$ ; Food-Number= $N/2$ ; and limit= $50$ .

Their emission function characteristics are given in table 6 is shown below, which are make the effect on the generation fuel cost, effective fuel cost will be rise due presence of  $NO_x$ .

Table: 5 Fuel cost coefficient for six generating unit system

unit	Fuel cost coefficient			$P_{Gmin}$ (MW)	$P_{Gmax}$ (MW)
	$a_i$	$b_i$	$c_i$		
G1	0.15247	38.53973	756.79886	10	125
G2	0.10587	46.15916	451.32513	20	150
G3	0.02803	40.39655	1049.99770	35	225
G4	0.03546	38.30552	1243.53110	35	210
G5	0.02111	36.32782	1658.55960	130	325
G6	0.01799	38.27041	1356.65920	125	325



$B_{mn}$  loss coefficient matrix in the order of  $10^{-4}$  is given as:

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

These are the B loss coefficient and are also called as transmission loss. Transmission loss are presented in power system which make effect on the generating fuel cost

Table: 6 NO<sub>x</sub> emission equation in kg/h are given below in

unit	Emission coefficient			P <sub>Gmin</sub> (MW)	P <sub>Gmax</sub> (MW)
	di	ei	fi		
G1	0.00419	0.32767	13.85932	10	125
G2	0.00419	0.32767	13.85932	20	150
G3	0.00683	- 0.54551	40.26690	35	225
G4	0.00683	- 0.54551	40.26690	35	210
G5	0.00461	- 0.51116	42.89553	130	325
G6	0.00461	- 0.51116	42.89553	125	325

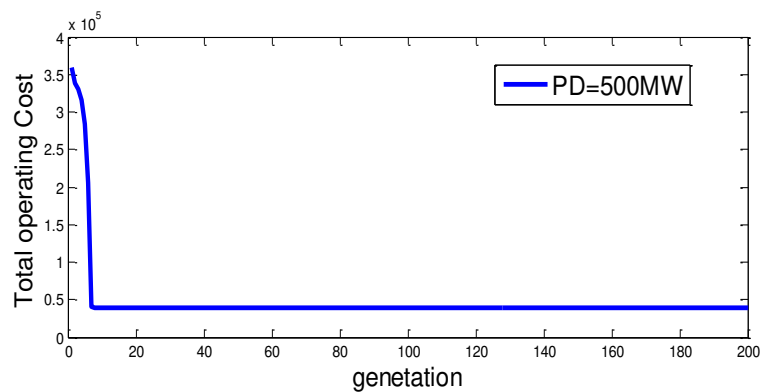


Figure: 4 convergence of six generating unit system for PD=500MW

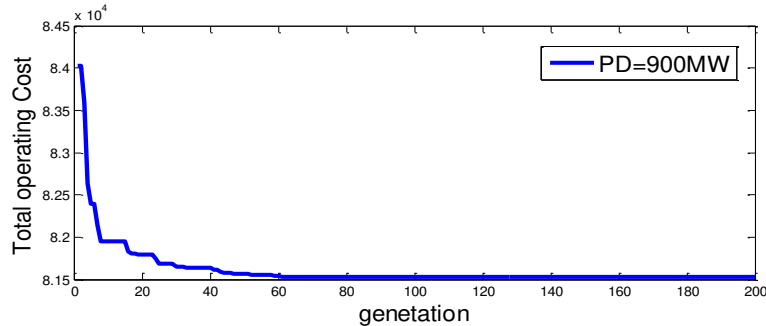


Figure: 5 convergence of six generating unit system for PD=900MW

Table: 7 Generating units' results by ABC Approach for six unit system

PD (MW)	P1 (MW)	P2 (MW)	P3 (MW)	P4 (MW)	P5 (MW)	P6 (MW)
500	33.2772	26.8596	89.8963	90.4832	135.6435	132.7744
900	92.3185	98.3707	150.1997	148.5549	220.4051	218.1615

#### IV. CONCLUSIONS

Economic load dispatch in electric power sector is an important task, as it is required to supply the power at the minimum cost which aids in profit-making. As the efficiency of newly added generating units are more than the previous units the economic load dispatch has to be efficiently solved for minimizing the cost of the generated power.

A new optimization of artificial bee colony (ABC) algorithm has been proposed. In order to prove the effectiveness of algorithm it is applied to five different test cases. Case 1 consisting three units system, Case 2 consists of six generating units. The results obtained by proposed method were compared to those obtained in various literatures. The comparison shows that ABC algorithm performs better than reported methods in efficient manner. The ABC algorithm has superior features, including quality of solution, stable convergence characteristics and good computational efficiency. Therefore, this results shows that ABC optimization is a promising technique for solving complicated problems in power system.

#### REFERENCES

1. A.J. Wood and B.F. Wollenberg, Power Generation, Operation, and Control, John Wiley and Sons., New York (1984).
2. P. Aravindhbabu and K.R. Nayar, Economic dispatch based on optimal lambda using radial basis function network, *Elect. Power Energy Syst.*, **24** (2002), pp. 551–556.
3. B.H. Chowdhury and S. Rahman, A review of recent advances in economic dispatch, *IEEE Trans. Power Syst.*, **5** (4) (1990), pp. 1248–1259.
4. M. Muslu, "Economic dispatch with environmental considerations: tradeoff curves and emission reduction rates", *Electric Power Syst. Res.* 71 no. 2, 2004, pp 153–158.
5. D.C. Walters and G.B. Sheble, Genetic algorithm solution of economic dispatch with valve point loading, *IEEE Trans. Power Syst.*, **8** (August (3)) (1993), pp. 1325–1332.
6. J. Tippayachai, W. Ongsakul and I. Ngamroo, Parallel micro genetic algorithm for constrained economic dispatch, *IEEE Trans. Power Syst.*, **17** (August (3)) (2003), pp. 790–797.
7. N. Sinha, R. Chakrabarti and P.K. Chattopadhyay, Evolutionary programming techniques for economic load dispatch, *IEEE Evol. Comput.*, **7** (February (1)) (2003), pp. 83–94.

8. H.T. Yang, P.C. Yang and C.L. Huang, Evolutionary programming based economic dispatch for units with nonsmooth fuel cost functions, *IEEE Trans. Power Syst.*, **11** (February (1)) (1996), pp. 112–118.
9. A.J. Wood and B.F. Wollenberg, *Power Generation, Operation, and Control* (2nd ed.), Wiley, New York (1996).
10. W.M. Lin, F.S. Cheng and M.T. Tsay, An improved Tabu search for economic dispatch with multiple minima, *IEEE Trans. Power Syst.*, **17** (February (1)) (2002), pp. 108–112.
11. D. Karaboga, B. Basturk, “On The Performance Of Artificial Bee Colony (ABC) Algorithm,” *Applied Soft Computing*, volume 8, Issue 1, January 2008, pp- 687-697 .
12. Dervis Karaboga, Bahriye Akay, “A comparative study of artificial bee colony algorithm,” *App. Mathematics and computation*, Elsevier, pp.108-132,2009.
13. A. Immanuel Selva kumar, K. Dhanushkodi, J.Jaya Kumar, C. Kumar Charlie Pual, “Particle swarm optimization solution to emission and economic dispatch problem ,” *IEEE Conference Tencon*, paper ID-075 Oct.2003
14. W. Ongsakul and T. Tantimaporn, “ Optimal powers flow by improved evolutionary programming,” *Elect. Power Comp. and Syst*, Vol. 34, 2006, pp. 79-95.
15. J. Yuryevich, K. P. Wong, “Evolutionary Programming Based Optimal Power Flow Algorithm,” *IEEE Transaction on power Systems*, Vol. 14, No. 4, November 1999.
16. Y. Labbi , D. Ben Attous, “A Hybrid GA-PS Method to solve the economic Load Dispatch problem,” *Jouranal of Theoreticaland appliedInformation Technology*, Vol.15,No.1, pp.61-68,2009
17. Ioannis G. Damousis, Anastasios G. Bakirtzis and Petros S. Dokopoulos, “Netwok- Constrained Economic Dispatch Using Real-Coded Genetic Algorithm,” *IEEE Trans. Power Syst.*, volume 18, No.1, pp. 198–205, Feb 2003.



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