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# A Comparitive Study of Economic Load Dispatch Problems Using Classical method and Artificial Intelligence Method

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**ABSTRACT**: Economic load dispatch (ELD) is a sub problem of the optimal power flow (OPF) having the objective of fuel cost minimization. The fuel cost equation of a thermal plant is generally expressed as continuous quadratic equation. In real situations the fuel cost equations can be discontinuous. Recent advancements in artificial intelligence especially in evolutionary algorithms have enabled much efficient way to solve the constrained optimization problems in various fields of engineering. In this paper we applied Genetic Algorithm (GA) technique to a 6-generator test system having continuous fuel cost equations. Results are compared to conventional Newton-Raphson method to show the superiority of the proposed computational intelligence technique.

**KEYWORDS:** Economic Load Dispatch (ELD), Fuel Cost, Genetic Algorithm (GA), Newton Rapshon (N-R).

## I.INTRODUCTION

In order to maintain a better economy and reliability of the power system, economic load dispatch is one of the best options for generating companies as the main task for them is to ensure that the electrical energy requirement from the customer is served while minimizing the cost of power generation. Hence, for economic operation of the system, the total demand must be optimally shared among all the generating units with an objective to minimize the total generation cost while satisfying operational constraints on system. Economic load dispatch (ELD) is a process of allocating the optimal combination of generation to all generating units in the power system so that the total generation cost of system is minimized, while satisfying the load demand and system equality and inequality constraints.

This paper addresses the use of Genetic Algorithm to solve ELD problem with power balance equation as the equality constraint and limits on the active power generations of the units as the inequality constraints. The proposed algorithm is applied on 6 generating unit system to find optimal allocation of generation on each generating unit and results are compared with Newton-Raphson methods.

Over the last two decades, a large number of research papers have appeared in the area of Economic Load Dispatch Problems (ELD).various optimization techniques have found to solve economic load dispatch problems.
**Kumar Sushil and Naresh R**. proposed an efficient optimization technique based on genetic algorithm for solution of economic load dispatch problem with continuous and non smooth cost function and various constraints being considered. The effectiveness proposed algorithm has been demonstrated on different system considering transmission loss in thermal power plant.

**Dhillon** et. al formulated the problem as multiobjective one. They considered objectives such as operating cost, minimal emission and minimal transmission losses in thermal power dispatch systems, considering uncertainties and inaccuracies in system data. The validity and effectiveness of the method was demonstrated by analyzing a 6-generator case.

**C.Ardil** et.al define Economic load dispatch is the process of allocating generation levels to the generating units in the mix, so that system load is supplied entirely and most economically.

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**Chen po-Hung & chan hong** this paper proposed a genetic approach for solving the economic dispatch problem in large scale system. A new coding technique for solving the ELD solution is developed in this paper.

**Bouzboudja Hamid, chaker abdelkar and Alali Ahmed** proposed about the economic load dispatch using the real coded genetic algorithm (RCGA).The use of real valued representation in the Gas gives number of advantages in numerical function optimization over binary encoding, the efficiency of GAs is increased as there is no need to convert chromosomes to the binary type, less memory is required.

**Hadi saadat presented** The components of the cost that fall under the category of dispatching procedures are the costs of the fuel burnt in the fossil plant because nuclear plants tend to be operated at constant output levels and hydro plants have essentially no variable operating costs.

## II. PROBLEM STATEMENT

The basic economic dispatch problem can described mathematically as a minimization of problem of minimizing the total fuel cost of all committed plants subject to the constraints.

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

Subject to the constraints

$$\sum_{i=1}^{N} P_i - P_D - P_L \qquad (2)$$

$$P_{imin} \leq P_i \leq P_{imax},\ i=1, 2\ldots N \qquad (3)$$

Where
F = Total operating cost
N = Number of generating units
$P_i$ = Power output of i th generating unit
$F_i$ ($P_i$) = Fuel cost function of i th
Generating unit
$P_D$ = Total load demand
$P_L$ = Total losses
$P_{i\,min}$ = Minimum output power limit of i th generating unit
$P_{i\,max}$ = Maximum output power limit of i th generating unit

The total fuel cost is to be minimized subject to the constraints. The transmission loss can be determined form $B_{mn}$ coefficients. The conditions for optimality can be obtained by using Lagrangian multipliers method and Kuhn tucker conditions as follows:

$$2a_iP_i+b_i=\lambda(1-2\sum_{J=1}^{N}(B_{ij}),i=1,2\ldots N \qquad (4)$$

## III. GENETIC ALGORITHM

Genetic Algorithm (GA) was first introduced by john Holland of Michigan university in1970's.The GA is a stochastic global search method that mimics the metaphor of natural biological evolution such as selection, crossover, and mutation. The artificial principal is the Darwinians survival of fittest principal and genetic operation is abstracted from nature form a robust mechanism that is very effective at finding optimal solutions to complex real world problems.

**The process of GA follows this pattern:**

1) An initial population of a random solution is created.

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2) Each member of the population is assigned a fitness value based on its evaluation against the current problem.
3) Solution with highest fitness value is most likely to parent new solutions during reproduction.
4) The new solution set replaces the old, a generation is completed and the process Continues at step (2).

**GA FLOW CHARTS:-**
**STEP1**: CREATE A RANDOM INITIAL STATE: An initial population is created from a random selection of solutions .this is unlike the situation for symbolic AI system, where the initial state in a problem is already given.
**STEP2**: EVALUATE FITNESS: A value for fitness is assigned to each solution depending on how close it actually is solving the problem. These solutions are not to be confused with answers of the problem; think of them as possible characteristics that the system would imply in order to reach the answer.
**STEP3**: REPRODUE (AND CHILDREN MUTATE): Those chromosomes with a higher fitness value are more likely to reproduce offspring .The offspring is a product of the father and mother, whose composition consists of a combination of genes from the two This process is known as crossing over .
**STEP 4**: NEXT GENERATION: If the new generation contains solution that produces an output that is a close enough or equal to the desired answer then the problem has been solved. If this is not the case, then the new generation will go through the same process as their parents did. This will continue until a solution is reached.

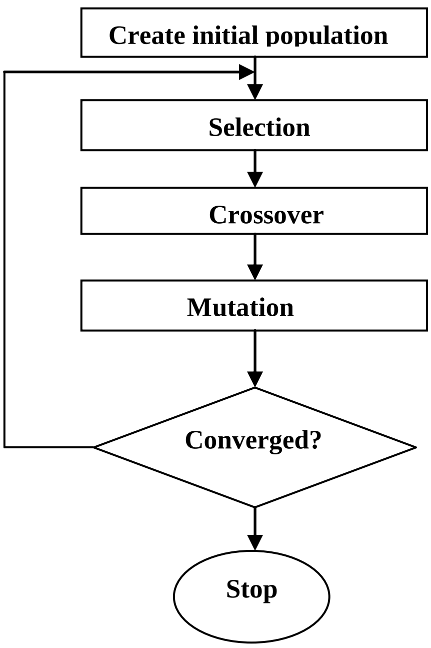


Fig. 1 GA Flow Chart

## IV. NEWTON-RAPHSON METHOD

The Newton-Raphson method is widely used for solving non-linear equations. It transforms the original non-linear problem into a sequence of linear problems whose solutions approach the solutions of the original problem.

Let G=F(x,y) be an equation where the variables x and y are the function of arguments of F. G is a specified quantity. If F is non-linear in nature there may not be a direct solution to get the values of x and y for a particular value of G. in such cases, we take an initial estimate of x and y and iteratively solve for the real values of x and y until the difference is the specified value of G and the calculated value of F(using the estimates of x and y) i.e. ΔF is less than a tolerance value. The procedure is as follows. Let the initial estimate of x and y bex0and y0 respectively. The variables are expressed in polar coordinates. It has quadratic convergence characteristics. The numbers of iterations are independent of the size of the system.

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## V. RESULT AND DISCUSSION

The system consists of 26 bus, 6 units, and the demand of the system was divided into 10 small intervals. Generating units' data are given in Table I. The cost function coefficients along with minimum and maximum generation capacity for each fuel option are given in Table III. Table IV, shows the optimal generators' power outputs for each hour including their corresponding fuel costs using Newton-Raphson and GA method.

Genetic algorithm and Newton-Raphson method have been successfully introduced to obtain the optimum solution of Economic Load Dispatch. Power system has large variation in load from time to time and it is not possible to have the load dispatch for every possible load demand as there is no general procedure for finding out optimum solution of economic load dispatch. This is where GA plays an important role to find out optimum solution in a fraction of second.

TABLE I SPECIFICATION FOR SIX GENERATORS SYSTEM

| UNITS | a ($/MW$^2$h) | b ($/MW$^2$h) | C ($/MW$^2$h) | $P_{min}$ (MW) | $P_{max}$ (MW) |
|---|---|---|---|---|---|
| 1 | 0.007 | 7 | 240 | 100 | 500 |
| 2 | 0.0095 | 10 | 200 | 50 | 200 |
| 3 | 0.009 | 8.5 | 220 | 80 | 300 |
| 4 | 0.009 | 11 | 200 | 50 | 150 |
| 5 | 0.008 | 10.5 | 220 | 50 | 200 |
| 6 | 0.0075 | 12 | 120 | 50 | 120 |

TABLE II RESULT OF GENETIC ALGORITHM (GA) METHOD

| U/T | 810 | 860 | 1000 | 1010 | 1160 | 1280 | 990 | 920 | 820 | 930 |
|---|---|---|---|---|---|---|---|---|---|---|
| $P_{g1}$ | 361.1143 | 374.0533 | 409.8882 | 406.8345 | 448.6909 | 477.4125 | 410.6790 | 385.2231 | 360.0986 | 391.4168 |
| $P_{g2}$ | 99.0671 | 110.1149 | 133.8607 | 137.1959 | 168.2350 | 184.2606 | 132.9407 | 123.1186 | 101.4944 | 120.7264 |
| $P_{g3}$ | 181.9378 | 196.7755 | 224.1064 | 223.1745 | 250.1647 | 270.2602 | 215.6856 | 205.1412 | 185.4289 | 205.1412 |
| $P_{g4}$ | 56.5843 | 60.5112 | 86.3175 | 92.3093 | 111.7225 | 131.8515 | 86.9381 | 67.7902 | 54.8294 | 73.9916 |
| $P_{g5}$ | 75.8918 | 84.9491 | 117.0570 | 123.8342 | 147.1150 | 167.9006 | 116.3266 | 107.5690 | 83.1968 | 108.4608 |
| $P_{g6}$ | 50.0664 | 50.3180 | 52.0454 | 50.5533 | 66.1956 | 88.2097 | 50.1155 | 50.6681 | 50.1142 | 50.1756 |
| Total Cost $ | 96827.0 | 10306.0 | 12111.0 | 12243.0 | 14277.0 | 15969.0 | 11979.0 | 11069.0 | 98061.0 | 11198.0 |

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TABLE III RESULTS OF NEWTON-RAPHSON (N-R) METHOD

| U/T | 810 | 860 | 1000 | 1010 | 1160 | 1280 | 990 | 920 | 820 | 930 |
|---|---|---|---|---|---|---|---|---|---|---|
| $P_{g1}$ | 364.9021 | 378.5274 | 414.0844 | 416.3495 | 450.5165 | 484.1922 | 411.8209 | 394.9424 | 367.6232 | 397.6851 |
| $P_{g2}$ | 97.5072 | 106.4641 | 129.7567 | 131.2346 | 153.4519 | 174.6590 | 128.2793 | 117.2248 | 99.2978 | 119.0196 |
| $P_{g3}$ | 135.0157 | 141.4467 | 158.7316 | 159.7907 | 175.5540 | 187.2872 | 157.6715 | 149.1029 | 136.3056 | 150.3724 |
| $P_{g4}$ | 69.6570 | 80.4834 | 109.3247 | 111.1442 | 138.6040 | 150.0000 | 107.5066 | 93.5288 | 71.8190 | 95.7088 |
| $P_{g5}$ | 106.1659 | 117.6799 | 147.5998 | 149.5032 | 178.1541 | 200.0000 | 145.6973 | 131.5278 | 108.4668 | 133.8390 |
| $P_{g6}$ | 50.0000 | 50.0000 | 59.1527 | 60.9111 | 87.2507 | 111.7392 | 57.3940 | 50.0000 | 50.0000 | 50.0000 |
| Total Cost $/h | 9767.04 | 10386.15 | 12172.65 | 12302.97 | 14298.35 | 15951.48 | 12042.66 | 11142.44 | 9890.05 | 11269.91 |

TABLE IV COMPARISON OF GA AND N-R METHOD

| LOAD | 810 | 860 | 1000 | 1010 | 1160 | 1280 | 990 | 920 | 820 | 930 |
|---|---|---|---|---|---|---|---|---|---|---|
| N-R METHOD | 9767.04 | 10386.15 | 12172.65 | 12302.97 | 14298.35 | 15951.48 | 12042.66 | 11142.44 | 9890.05 | 11269.91 |
| GA | 96827.0 | 10306.0 | 12111.0 | 12243.0 | 14277.0 | 15969.0 | 11979.0 | 11069.0 | 9806.0 | 11198.0 |

## VI.CONCLUSION

Genetic algorithm and Newton-Raphson methods have been successfully introduced to obtain the optimum solution of Economic Load Dispatch. Power system has large variation in load from time to time and it is not possible to have the load dispatch for every possible load demand as there is no general procedure for finding out optimum solution of economic load dispatch. This is where GA plays an important role to find out optimum solution in a fraction of second.

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