

# **Design and Analysis of Genetic Algorithm to Solve Economic Load Dispatch Problem in the Power System**

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**ABSTRACT:** In this paper, an efficient and practical real-coded genetic algorithm (GAs) has been proposed for solving the economic load dispatch(ELD) problem. The objective is to minimize the total generation fuel cost and keep the power flows within the security limits. For each problem of optimization in genetic algorithms (GAs) there are a large number of possible encodings. The efficiency of the GAs is increased as there is no need to convert chromosomes to the binary type, less memory is required. There is no loss in precision. The proposed technique improves the quality of the solution and speed of convergence of the algorithm. The Coding are written and executed the values are plotted in graph for different values of MW loading.

**KEYWORDS:** Economic Load Dispatch, Fuel cost, Genetic Algorithm, MW loading

## **I.INTRODUCTION**

Improve the reliability and efficiency of power systems, new communication technologies, and distributed energy Sources, and demand response programs have been introduced. These efforts are mainly motivated by the increasing Costs of fossil fuels, environmental changes, and energy security concerns coupled with investments in wind and solar generation to replace conventional CO<sub>2</sub>-emitting energy sources. The increased flexibility of the power system results in a higher level of complexity for economic dispatch (ED) problems.

Real-time dispatch is, in general, computed in two stages. In the first stage, a unit commitment (UC) problem is solved to select generating units to meet the expected load during each hour. In the second stage, an ED problem is solved to compute the power outputs of the committed units for meeting the load. This ED decision takes place minutes to hours ahead of the time of implementation.

Recent work has explored UC for planning purposes to accommodate generation/load forecasting uncertainties, mostly based on standard commercial solvers. However, the location-based marginal prices (LMPs) are found by solving the corresponding ED problem with fixed unit commitment decisions.

## **II. SCOPE**

The economic dispatch (ED) problem is one of the most important operational functions of the modern energy management system. The purpose of the ED is to find the optimum generation among the existing units, such that the total generation cost is minimized while simultaneously satisfying the power balance equations and various other constraints in the system. The literature of the ED problem and its solution methods are surveyed. However, it is realized that the conventional techniques become very complicated when dealing with increasingly complex dispatch problems, and are further limited by their lack of robustness and efficiency in a number of practical applications.

Recently, a global optimization technique known as GAs which is a kind of the probabilistic heuristic algorithm has been studied to solve the power optimization problems. The GAs may find the several sub-optimum solutions within a

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realistic computation time. The efficiency and the robustness of the proposed GAs are demonstrated by test functions. Then the GAs with simulated non uniform arithmetic crossover, elitism and a non uniform mutation are applied to ED problem.

## III. CHALLENGES IN MEETING POWER DEMAND

The main objective of Economic load dispatch of electric power generation is to schedule the committed generating units output so as to meet the load demand at minimum operating cost, while satisfying all the unit and the system equality and inequality constraints. For the purpose of economic dispatch studies, online generators are represented by functions that relates their production cost to their power output. Quadratic cost functions are used to model generator in order to simplify the mathematical formulation of the problem and to allow many of the conventional optimization technique to be used.

## IV. OPTIMIZATION TECHNIQUE FOR THE ECONOMIC DISPATCH IN POWER SYSTEM OPERATION

The optimal economic operation of their electric networks while considering the challenges of increasing fuel costs and increasing demand for electricity. The dynamic economic dispatch (DED) occupies important place in a power system's operation and control. It aims to determine the optimal power outputs of on-line generating units in order to meet the load demand and reducing the fuel cost. The nonlinear and non convex characteristics are more common in the DED problem. Therefore, obtaining a optimal solution presents a challenge. In the proposed system, genetic algorithm(GA) – a recently introduced population-based technique – is utilized to solve the DED problem. We demonstrate 3 units and 6 units generating system for simulate the maximize power output and minimize the fuel cost.

### 4.1.1 NEED FOR ECONOMIC LOAD DISPATCH

#### 1. Planning for Tomorrow's Dispatch

- i. Scheduling generating units for each hour of the next day's dispatch
  - a. Based on forecast load for the next day
  - b. Select generating units to be running and available for dispatch the next day (operating day)
- ii. Recognize each generating unit's operating limit, including its:
- iii. Ramp rate (how quickly the generator's output can be changed)
- iv. Maximum and minimum generation levels
- v. Minimum amount of time the generator must run
  - a. Minimum amount of time the generator must stay off once turned off

#### 2. Recognize generating unit characteristics, including:

- i. Cost of generating,
- ii. Its variable operating costs (fuel and non-fuel),
- iii. Variable cost of environmental compliance,
- iv. Start-up costs,

#### 3. Reliability Assessment.

#### 4. Dispatching the Power System Today.

### 4.1.2 OVER VIEW OF ECONOMIC LOAD DISPATCH

Economic dispatch is the short-term determination of the optimal output of a number of [electrical generation](#) facilities, to meet the system load, at the lowest possible cost, while serving power to the public in a robust and reliable manner. The Economic Dispatch Problem is solved by specialized computer software which should honor the operational and system constraints of the available resources and corresponding transmission capabilities. This is defined as "the operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities.

### 4.1.3 Solution methods for Economic load dispatch

Some of the algorithms are given below, they are,

1. Artificial neural networks

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2. Genetic algorithms
3. Evolutionary algorithms
4. Particle swarm optimization
5. Ant colony optimization
6. Fuzzy logic
7. Other biological systems.

## 4.1.5 Algorithm Used In Proposed System

The algorithm used here is the Genetic algorithm(GA) is well-known stochastic methods of global optimization based on the evolution theory of Darwin. They have successfully been applied in different real-world applications. With this proposed technique we will reduce the fuel cost and losses.

## V. GENETIC ALGORITHM

### 5.1.1 Introduction

GA was originally developed for solving unconstrained problems. Recently, many variants of GAs have been developed for solving constrained nonlinear programming. Most of these methods were based on penalty formulations that transform (1) into an unconstrained function  $F_m(PG, rk)$  (6), consisting of a sum of the objective and the constraints weighted by penalties, and use GAs to minimize  $F_m(PG, rk)$ . GAs, unlike strict mathematical methods, have the apparent ability to adapt to non linear ties and discontinuities commonly found in power systems.

The basic idea behind GAs is to mathematically imitate the evolution process of nature. The algorithms are based on the evaluation of a set of solutions, called population. The population is treated with genetic operations. At the iteration  $i$  the population  $X_i$  consist of a number of  $N$  individual's  $x_j$ , that is, solutions, where  $N$  is called a population size. The population is initialized by randomly generated individuals.

The individuals can be encoded using either binary or real numbers. We use the latter because of their popularity. Each individual  $x_j = (x_1, \dots, x_n)$  is a vector of variables. Each variable is a real number. The suitability of an individual is determined by the value of the objective function, to be called a fitness function.

A new population is generated by the genetic operations selection, crossover and mutation. Parents are chosen by selection and new off springs are produced with crossover and mutation. All these operations include randomness. The success of the optimization process is improved by elitism where the best individuals of the old population are copied as such to the next population.

### 5.1.2 Optimization with GA

For each problem of optimization in GAs there are a large number of possible encodings. Although binary representation is usually applied to power optimization problems, in this letter we use a GA switch is a modified GAs employing real valued vectors for representation of the chromosomes. The use of real valued representation in the GAs has a number of advantages in numerical function optimization over binary encoding.

The efficiency of the GAs is increased as there is no need to convert chromosomes to the binary type, less memory is required, there is no loss in precision by discretization to binary or other values, and there is greater freedom to use different genetic operators.

For the real valued representation, the  $k$ -th Chromosome  $C_k$  can be defined as follows

$$C_k = [P_{k1}, P_{k2}, \dots, P_{kn}] \quad k=1, 2, \dots, \text{popsize}$$

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Where pop size means population size and  $P_{ki}$  is the generation power of the  $i$ -th unit at  $k$ -th chromosome. Reproduction involves the creation of new offspring from the mating of two selected parents or mating pairs. It is thought that the crossover operator is mainly responsible for the global search property of the GA. A non-uniform arithmetic crossover operator was introduced into the GAs.

### 5.1.3 Economic load dispatch with GA

The economic dispatch problem, which is used to minimize the cost of production of real power, can generally be stated as follows:

Economic load dispatch problem is allocating loads to plants for minimum cost while meeting the constraints. It is formulated as an optimization problem of minimizing the total fuel cost of all committed plant while meeting the demand and losses. The variants of the problems are numerous which model the objective and the constraints in different ways.

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

$$\text{Minimize } \sum_{i=1}^n F_i(P_i) \quad \dots\dots(1)$$

$F_i(P_i)$  is the fuel cost equation of the 'i'th plant. It is the variation of fuel cost (\$ or Rs) with generated power (MW). Normally it is expressed as continuous quadratic equation.

$$F_{ij}(P_i) = a_i P_i^2 + b_i P_i + c_i, \quad P_i^{\min} \leq P_i \leq P_i^{\max} \quad \dots\dots(2)$$

The total generation should meet the total demand and transmission loss. The transmission loss can be determined from either  $B_{mn}$  coefficients or power flow.

$$\sum_{i=1}^n P_i = D + P_l \quad \dots\dots(3)$$

$$P_l = \sum_i^n \sum_j^n B_{ij} P_i P_j \quad \dots\dots(4)$$

GAs is a probabilistic search technique, which generates the initial parent vectors distributed uniformly in intervals within the limits and obtains global optimum solution over number of iterations. The implementation of GAs is given below. The initial population is generated after satisfying the equation. The elements of parent vectors ( $PG_i$ ) are the real power outputs of generating units distributed uniformly between their minimum and maximum limits.

The fitness function is used to transform the cost function value into a measure of relative fitness. The fitness function is given in equation.

1. Select a reference plant. For better convergence chose a plant which has maximum capacity and range. In this program It is considered as plant 1. The reference plant allocation is fixed by the equations (A3&A4).
2. Convert the constrained optimization problem as an unconstrained problem by penalty function method.

Minimize

$$\sum_{i=1}^n F_i(P_i) + 1000 * \text{abs}(\sum_{i=1}^n P_i - D - \sum_{i=1}^n \sum_{j=1}^n B_{ij} P_i P_j) \quad \dots\dots(5)$$

3. The allocation minimum fuel cost and transmission losses can be determined

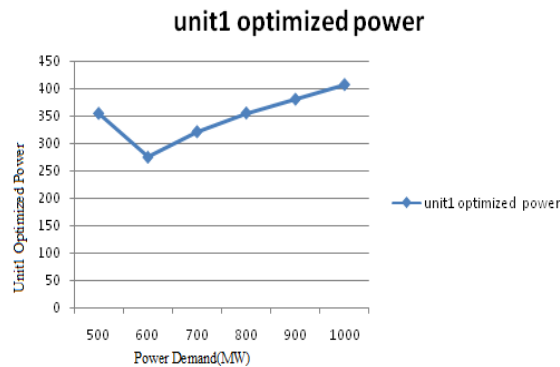
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*Table 5.1.3 Genetic algorithm optimization*

POWER DEMAND	UNIT1 OPTIMIZED POWER
500	354.3868
600	274.4185
700	320.9227
800	355.078
900	380.207
1000	406.8564



*Fig 5.1.3 Graph for Genetic algorithm optimization*

### 5.1.4 Algorithm for GA

Step 1

Input the value of load demand, power demand and the values of cost coefficients,  $a_i$ ,  $b_i$ ,  $c_i$  where  $i=1, 2, \dots, n$ .

Step 2

Input the values of  $B_{mn}$  coefficients in the non linear equation

Step 3

Update the loss coefficients and find the total demand and the incremental fuel cost.

Step 4

Assume  $P_i = 0$  for  $i = 1, 2, \dots, n$

Step 5

Fix the limit for generating plant and solve equation iteratively for  $P_i$ 's.

Step 6

Check if test unit 1 converges to load demand at its limit. Similarly check the conversion of the other plants.

Step 7

Check if power balance equation is satisfied and find fuel cost and emission when all the 6 test units are converged.

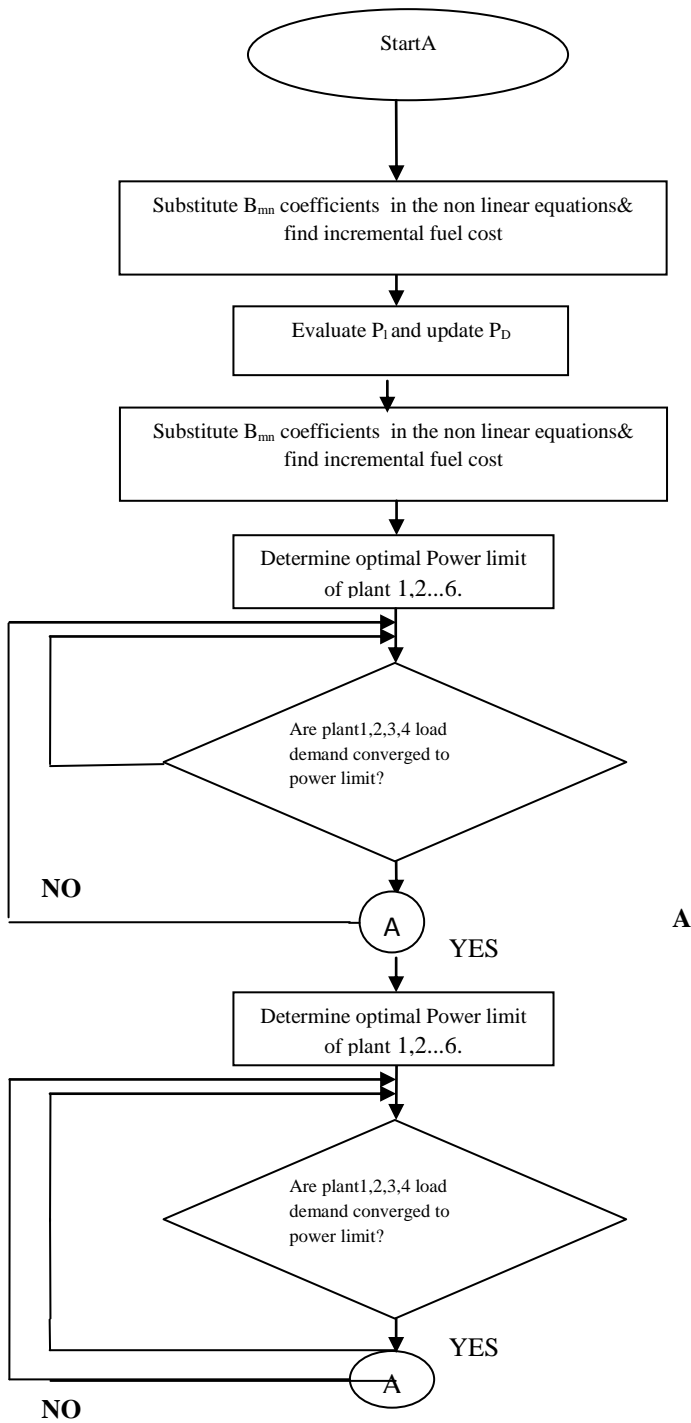
The above said steps are explained in following flowchart

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## 5.1.5 Flowchart for GA



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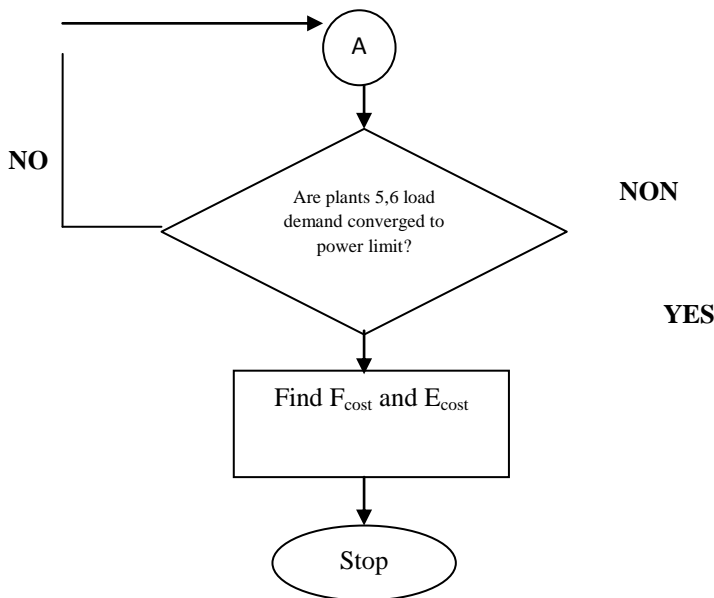


Fig 5.1.5 Flow chart for ELD using GA

## VI SIMULATION AND RESULT

### 6.1 PROBLEM FORMULATION

The ED problem may be expressed by minimizing the fuel cost of generator units under constraints. Depending on load variations, the output of generators has to be changed to meet the balance between loads and generation of a power system. The power system model consists of n generating units already connected to the system.

The ED problem can be expressed as:

$$\text{Min} \sum_{i=1}^{NG} F_i(P_{Gi})$$

$$F_i(P_{Gi}) = (a_i + b_i P_{Gi} + c_i P_{Gi}^2)$$

Where,

- ai, bi and ci are the cost coefficients of the it generator.
- NG is the number of generators including the slack bus.
- PGi is the real power output of the i-th generator (MW).
- Fi(PGi) is the operating cost of unit i ( \$/h).

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## 6.2 CONSTRAINTS

Subjects to the following constraints,

$$P_{Gi}^{\min} \leq P_{Gi} \leq P_{Gi}^{\max} \quad \text{for } i=1, \dots, NG$$

$$\sum_{i=1}^{NG} P_{Gi} - D - P_L = 0$$

Where

$$P_L = \sum_{i=1}^N \sum_{j=1}^N P_{Gi} B_{ij} P_{Gj} + \sum_{i=1}^N B_{0i} P_{Gi} + B_{00}$$

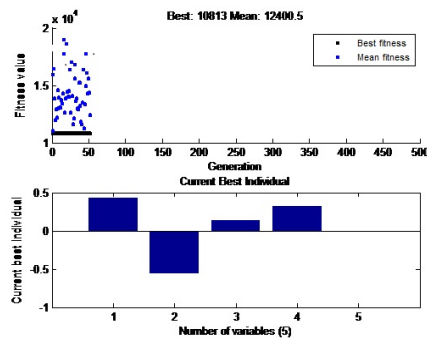
- D : total demand (MW)
- $P_L$  : transmission losses (MW)
- $P_{Gi}^{\max}$  : maximum generation output of the i-th generator
- $P_{Gi}^{\min}$  : minimum generation output of the i-th generator
- B : coefficients of transmission losses

GAs is a general stochastic optimization algorithm that was originally developed for solving unconstrained problems. By applying an exterior penalty function we transform a constrained non-linear ED problem into an unconstrained problem

### 6.6.2 Input datas

1. Loss co-efficients.
2. Data matrix(Fuel cost co-efficient( $a_i$ ,  $b_i$  and  $c_i$ ) and plant limits).  
 $a_i$  = measure of losses in the system.  
 $b_i$  = represents the fuel cost.  
 $c_i$  = includes salary and wages, interests and depreciation.
3. Load demand(D).

### 6.6.3 Simulation results



F =  
1.0813e+04



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P1 =  
386.3605 116.8379 201.3102 64.3634 99.1567 50.4517

P1 =  
18.4805

## VIII. CONCLUSION

In this paper, an approach based on a genetic algorithm has been successfully presented and applied to the generation cost in electric power network to obtain the optimum solution of economic dispatch (ED). Operators are used in LAGRANGIAN to generate a set of solutions for this problem. LAGRANGIAN method is most useful for large power systems, it LAGRANGIAN ve well results and it is much faster and more effective than iterative method. Methods are compared for solving an economic dispatch problem with two generators. Test results have shown GA algorithm can provide highly optimal solutions and reduces the computation time than those with the iterative method. An advantage of the GA solution is the flexibility it provides in modeling both time dependent and coupling constants [10]. Another advantage of the GA approach is the ease with which it can handle arbitrary kinds of constraints and objectives.

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