

## **An Analysis of Stochastic Wind Power Approach for Economic Load Dispatch Optimization Using Genetic Algorithm**

**Muhammad Muneeb Khan<sup>1</sup>, Muhammad Aamir Shafi<sup>2</sup>, Muhammad Saad Khan Khosa<sup>3</sup>**

<sup>1</sup>Department of Electrical and Computer Engineering, COMSATS University Islamabad, Wah Campus, Pakistan

<sup>2</sup>Department of Electrical and Computer Engineering, COMSATS University Islamabad, Islamabad, Pakistan

<sup>3</sup>Department of Electrical Engineering, The Islamia University of Bahawalpur, Bahawalpur, Pakistan

### **Abstract**

Due to the continuous development of electrical and electronic products in the market, the need for power is growing quickly. Also, as the population increases, the need for electricity rises and this creates a task for load management. This primary task has been moved to enhance performance, cost reduction of the solution to make it optimal, and development of a dependable and effective system to meet the need for electricity. Both conventional and non-conventional generation methods are required to supply the growing electricity demand. With time rapid changes incur in energy systems because conventional sources are depleting as time goes on and becoming expensive whereas the demand for electricity and generation must be balanced to ensure the stability of the power system.

The most effective solution is chosen using the economical load dispatch strategy for generation units in terms of power output and operational fuel costs. The main goal of this article is to create a cost-effective solution for wind power plants. A genetic algorithm (GA) is proposed to ensure an optimization strategy. This method is mostly focused on the use of the state-of-the-art tool MATLAB but on introducing genetic operators. The basic principle of the Genetic Algorithm (GA) is that all generators can provide the required electric power supply at the lowest possible fuel cost while maintaining system limits in range. Two separate test systems, the first one with separate thermal generators which are six in number, and the other is a wind power unit; were used for the simulation purpose. The concept and layout of the methodology that employs the genetic algorithm as an optimization tool are discussed in this work.

**Keywords:** Genetic algorithm, Economic Load dispatch, Optimization Method, Fuel Economy, Economic dispatch, Unit Commitment, Renewable power generation, Economic dispatch of Wind power.

Email: [muneebkhan@isp.edu.pk](mailto:muneebkhan@isp.edu.pk)

## 1. Introduction

A major problem in the power system is the challenge of economic load dispatch the practice of assigning generation levels to produce units to transmit power to the system load and make it cost-effective is known as economic load dispatch (ELD). It is indeed essential to lower fuel prices and make our system more affordable in the connected power system. Utilizing renewable energy sources has a lot of benefits, clean energy provides considerably more advantages because renewable energy is environmentally friendly.

Today, the developing sector helps to improve electric networks, increase energy access in underdeveloped countries, and lower energy costs. All of these elements have combined to a remarkable increase in renewable energy awareness, therefore at present, wind power is establishing new records for electricity generation in power systems. There is a strong need and demand for such an algorithm that is capable of utilizing green power production with thermal power plants for power management [1]-[2].

So, there is a strong need to research on optimization of economic load dispatch different ideas by which we can manage load with minimum cost. Need to develop such type of advanced algorithms that can share the load between thermal power plants and renewable energy resources to make the system more economical. Algorithm that can take decisions according to the demand of load and maximum use of renewable energy resources.

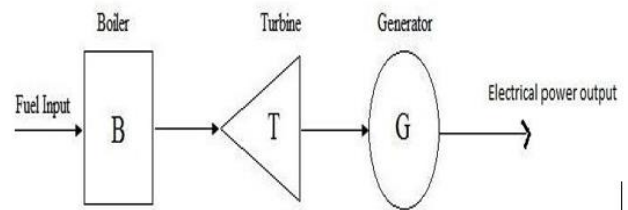
Many attempts have been made to overcome the problem of economic load dispatch including various types of constraints and numerous objectives have been applied through different mathematical programming methods and optimization techniques. These traditional techniques are (the Newton-Raphson technique method of the lambda iteration, factor method, and gradient method). It is found that these

conventional methods become complex when they deal with economic dispatch issues [3]-[4]-[5]. For this, it is crucial to create an efficient algorithm with a defined structure. Recently, an optimization technique which is known as a genetic algorithm, this algorithm is a probabilistic predictive algorithm.

The main part of the system is to minimize the cost and take the information from the thermal power plant and wind power then synchronize both systems. According to the demand of the load genetic algorithm decides to provide either the thermal power plant or renewable wind source to the load. Alternatively, independent sources of renewable energy or both share the load to minimize the cost.

The plan for this output uses renewable energy from multiple generators in the system to meet the requirements for low operating costs. As this research's goal is to reduce system load costs overall while taking into account all practical constraints. This problem is more complex when the renewable energy wind turbine is synchronized with these power units and the wind turbine is attached parallel to these power units.

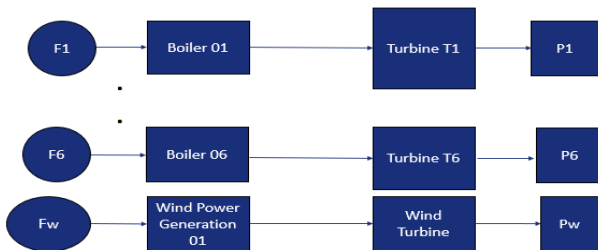
We know that the nature of wind is variable, thus this issue is resolved to maximize the economic load dispatch by lowering the cost of fuel using these measures. Therefore, we employed the most recent programming technique to reduce the running cost of the generator to decrease these operational costs. The basic design of a power plant that converts energy is depicted in Figure 1.



**FIGURE 1. Model for thermal generator**

The basic notion includes a boiler that produces steam from water, which is then fed into a steam turbine and a generator. Fuel is the main element in the thermal power plant coal or other source is supplied to the boiler which converts the water into super-heated steam which uses coal as a fuel, then this extremely super-heated steam is delivered to a turbine and whose shaft is connected to the output of a generator and power is obtained as the shaft moves. The cost of operating a steam power plant, which includes things like fuel costs that are rising daily and maintenance costs, is what determines how well it runs.

In power plants, different parallel generator with different capacity is attached to full fill the demands of load as shown in the figure. The generators are connected in parallel whereas the diagram also shows how many parallel boiler parts are connected. To meet the demands of the load, every generator, each with a varied capacity, is coupled to a common bus bar. As mentioned, a parallel generator is attached to meet the energy demand for the least amount of cost while providing reliable electricity that satisfies all constraints.



**FIGURE 2. A simple model for a wind turbine with thermal generators**

**II. Fuel Cost Function**

The power plant has a huge number of various generators connected in a ring system, each with a varied capacity. Our primary goal is to reduce the cost of fuel, which is managed by altering the input of fuel to obtain variable output power from these power units [6]. Because these power units are built at high maintenance costs and high investment, the cost of fuel is therefore also high. The quadratic function shown below is considered a generator cost function.

$$y = \sum (q_i0 + q_i1x_i + q_i2x_i^2) \dots\dots\dots 1$$

All generating units share the same input and output properties, which is referred to as a generating unit attribute. We are aware that each generator has distinct input/output characteristics in a real-world scenario, thus the load dispersion will be equal. Due to the variable input-output characteristics of each generator, each has a unique operational cost [13]. Additionally, not all plants are situated next to the load side; some are; however, other plants are farther away from it therefore each generating unit has its expenses as a result. Because ELD is a different merit-based technique with the set limits of the generator [8]-[9]. This sort of power supply satisfies the load demand at the lowest possible fuel cost, making economic load dispatch in the power system a significant problem to tackle.

**III. Economic Load Dispatch Integrated Wind Turbine (Model)**

To lower the cost of fuel for wind turbines and generators, an economic load dispatch for power systems model has been developed. The generator and electrical system are synchronized., (ELD) the problem becomes more complicated when the power system connects with renewable energy [10]. Nevertheless, because renewable energy sources like solar and wind, and coal are used, it is more difficult because of their intermittent nature.,. In this article, we'll build a model of a heat generator and a wind turbine as shown in the power schematic design [11].

The quadratic cost function is applied. The cost function and fuel economy are related, as has already been stated. When multiple sources are related, such as gas, wind, and so on, the cost function should be quadratic. This paper incorporates the stated strategy. In this research, the approach is applied to a single energy problem, although it can be used for a variety of fuel problems. The constraints play a significant

role in the cost function for wind turbines as well as the equality and inequality functions.

$$y = \sum q_i 0 + q_i 1 x_i + q_i 2 x_i^2 \dots \dots \dots 2$$

turbi

$$x_{min}, i \leq x_i \leq x_{max}, i \dots \dots \dots 4$$

In nature, wind fluctuates and is not steady. Typically, we see changes in wind value and wind speed every minute. We need a solution for this issue because the wind is unpredictable by nature, hence the probabilistic approach is the best. Having taken because of its stochastic nature, wind speed is considered a random variable. The probability distribution of wind speed can be described by the Weibull distribution.

The CDF of Weibull distribution is given.

$$(v) = 1 - \exp[-(vc)k] \dots \dots \dots 5$$

K= shape parameter

C=scale parameter

$$(v) = (vc)k - 1 \exp[-(vc)k] \dots \dots \dots 6$$

Due to the vary in nature, we used the Expected value of wind

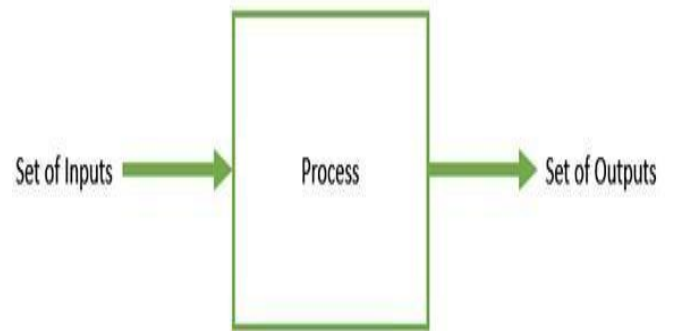
$$E(w) + \sum_{i=1}^n x_i = Pd \dots \dots \dots 7$$

Where E(w) is the expected value of the wind

**IV. Genetic Algorithm**

A quest optimization approach built on the principles of Genetics and Random Selection is known as the Genetic Algorithm (GA). The genetic algorithm is also leveraged to find strategies that are close to optimal for challenging tasks that would take ages to solve [12]. It is commonly utilized in both research

and machine learning for optimization issues. Making something (such as a design, system, or decision) entirely ideal, functioning, and providing a superior solution is the process of optimization. Any optimization process has a set of inputs and outputs. The ideal solution relies on the issue at hand and changes from problem to problem. To maximize or minimize one or more objective functions to change the input parameters is known as "maximizing" or "minimization" in mathematics.



**FIGURE 3. Block Diagram**

The entire collection of potential outcomes or quantities that the inputs could take to develop the search space. The goal of optimization is to identify the point or group of points in the parameter space that provide the optimum and effective result, or the best choice in this search area.

The Genetic Algorithm has three major types of operators to find out the global optimum solution.

- selection
- cross over
- Mutation

**A. SELECTION**

The process of choosing parents for the following generation, who will pair and recombine to produce offspring, is known as parent selection. It's a crucial aspect in the selection process that the fittest person will

likely be chosen. Fitness is defined as a person's aptitude for the resources available inside a specific source [14]. The selection operator's main goal is to choose the best person and to eliminate the weak solution from the population while maintaining the size of the population constant. There are numerous methods for choosing the best strategy depending on one's degree of fitness.

**B. CROSS OVER**

In a genetic algorithm, cross-over is the most significant element. The operator crossover involves swapping one or more parts of two parents to deliver a new offspring. Crossover occurs when the sequences of two chromosomes are swapped [15-16]. There are several methods for resolving these chromosomes

**C. MUTATION**

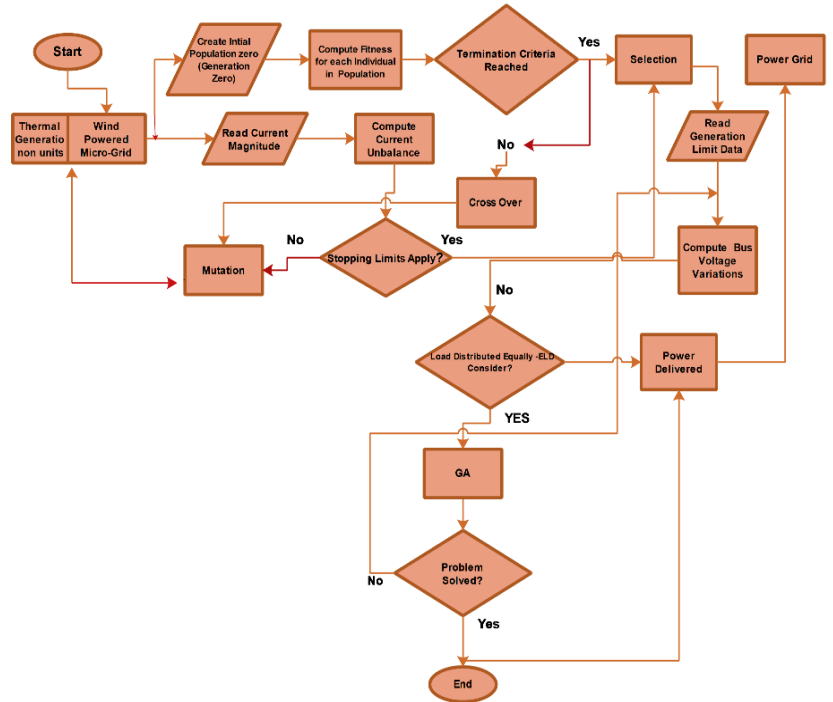
The random modification of a single solution's component pieces broadens the population's diversity and offers a means of eluding a local optimum. Sets of input and output.

**D. FLOW CHART.**

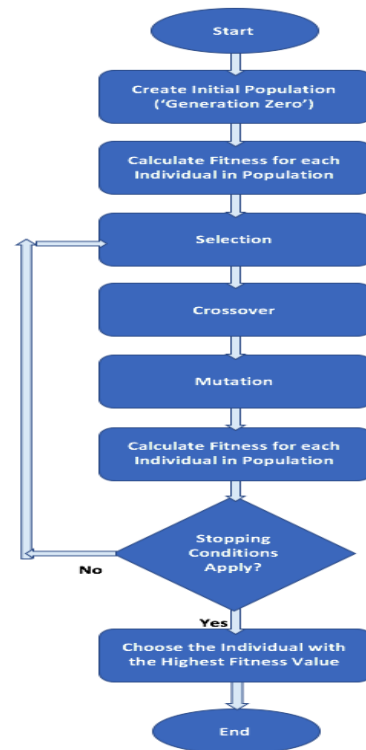
Data reading, cost function, maximum permissible iteration, total population, crossover probability, mutation probability, wind parameters, and voltage variations are included.

Without the support of the purpose or fitness landscape data, both crossover and mutation are present. Either way, elitism also known as selection of the fittest uses the fitness landscape to guide choice and search behavior in the selection process [17]-[18]. What is chosen and how solutions are chosen are determined by the algorithm and the values of the objective function. In light of this,

selecting cross-over, selection, or mutation imposes the following restrictions. A system-wide algorithm and a GA algorithm are two



employed. As shown, **FIGURE 4. System-Wide Algorithm**



**FIGURE 5. Genetic Algorithm**

Step 1: In the first step it will start initializing the population and the loop for maximum iteration.

Step 2: Every iteration includes an analysis of the previous population, the optimal solution's output is kept, and the outcome is compared to the previous iteration [19]-[20]. It will either keep it or throw it away if this is the best option.

Step 3: The reproduction step GA operator is used in this phase to organize the tournament, select the two parents at random, and compare them. More chances to advance to the next round exist for the fittest solution.

Step 4: Cross-over is performed now with two parents to form a new offspring, which is called the child because the one-point cross-over is carried out here. If there is no cross-over, the children are a straight replica of their parents and the system will carry out the mutation. If the outcome is the same as the previous 30 iterations, print the results and put an end to the procedure.

Step 5: Utilizing the algorithm, computational performance is carried out to send a signal to the bus by comparing the magnitudes of the current or voltage for load variations. If the process goes well, it will be finished; if not, the cycle will be repeated.

Step 6: Set restrictions are endorsed within the system, so when the particular criteria are met, the genetic algorithm produces the optimal decision and which increases the system's efficiency.

**V. RESULTS AND DISCUSSIONS**

In this paper, the economic load dispatch problem-(ELD) is solved by implementing the genetic algorithm. The results of the simulation are discussed. The software which is used is MATLAB. Table 4.1 consists of generator parameters where  $q_{i2}$ ,  $q_{i1}$ , and  $q_{i0}$  are the coefficient of this generator. Table 4.2 consists of limits that play an important role these limits define inequality and equality

constraints for each generator.

**TABLE 4. I**  
**Generator coefficient parameters**

Sr No	Generator	Values
1	X opt1	0.3257
2	X opt2	0.4715
3	X opt3	0.8097
4	X opt4	1.4194
5	X opt5	1.2243
6	X opt6	0.5416

Table 4.1 shows the maximum and minimum limits for each generator. The minimum and maximum limits for the reach generator are given in the table.  $x_1, x_2, x_3, x_4, x_5, x_6$  represent generator minimum and maximum limits of generation. Equations 4.1 and 4.2 as shown below, these equations explain the cost function. In this paper, we have taken all variables as per unit and taken a base value of 100 MVA.

Cost Function:

$$y = \sum_{i=1}^n q_{i0} + q_{i1}x_i + q_{i2}x_i^2 \dots\dots 8$$

Power demand

$$\sum_{i=1}^n x_i = Pd \dots\dots\dots 9$$

**TABLE 4.2**

Limits of the generators

Limits	Minimum	Maximum
$x_1$	0.02	0.5
$x_2$	0.03	0.7
$x_3$	0.05	1.2
$x_4$	0.06	1.5
$x_5$	0.05	1.3
$x_6$	0.07	0.7

We've selected three distinct power demands for this study. Power demands of 4.8 per unit demand, 5.0 per unit demand, and 5.2 per unit demand will be discussed. For these power requirements, we've picked

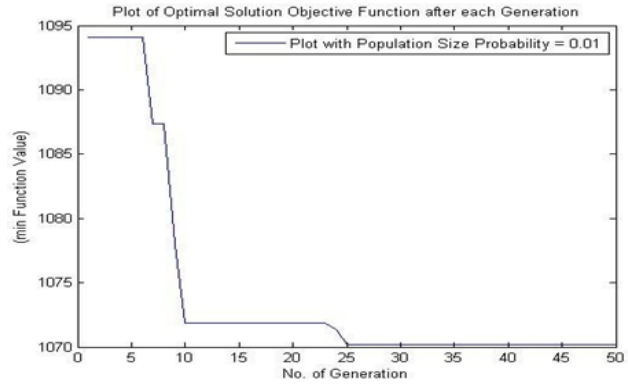
a maximum population size of 50, which comes from generator constraints. Selection is done using a genetic algorithm, and we've taken 50 iterations by generation. For the first scenario, the six generators were taken. Demand for this case as a whole is 4.8 per unit. The maximum number of iterations required to achieve the best outcome in this scenario for the genetic algorithm is 50. Cross-over and mutation probabilities are 0.01 and 0.9, respectively. The best result is displayed in Table 4.3 of the results.

**TABLE 4.3**

<b>Generat or index</b>	<b>qi2</b>	<b>qi1</b>	<b>qi0</b>
1	100	200	10
2	120	150	10
3	40	180	20
4	60	100	10
5	40	180	20
6	100	150	10

The optimal solution for economic load dispatch power demand is 4.8 per unit. The best ideal values for each generator are listed in the table above because they provide the greatest way to meet the demand for electricity while spending the least amount possible. These are each generator's base costs according to the genetic algorithm. In MATLAB, a graph is plotted based on these variables to determine the ideal cost.

According to Graph, the genetic algorithm's best cost was generated at 1070.2. The iteration to determine the ideal price at which the power demand is 4.8 cents per unit includes the number of generations represented.



**FIGURE 6. Fuel cost during iteration for power demand 4.8 per unit**

For the second situation, a set of six generators was used as well. There is a 5.0 per unit total demand in this instance and we have chosen a population size of 50 for the entire population with 50 iterations. Cross-over and mutation are taken as having a probability of (0.9 and 0.1). The table of the generator displays the best values that can be found. The outcome is presented in Fig 6. The ideal cost that is obtained is 1132.3.

FIGURE 7. Fuel cost during iteration for power demand 5.0 per unit

The top-optimal readings for each generator in Test 2 of the thermal generator, where there is a 5 per unit power requirement, are listed in the preceding table as the best way to meet that need.

**TABLE 4.5**  
The optimal solution of ELD Pd=5.

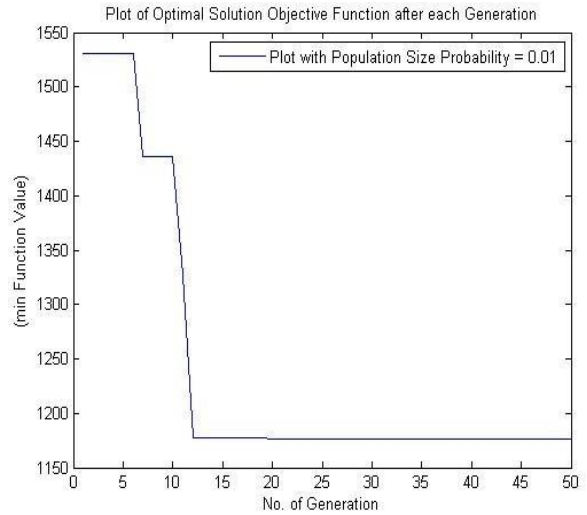
Sr No	Generator	Values
1	X opt1	0.325
2	X opt2	0.5914
3	X opt3	1.0182
4	X opt4	1.2649
5	X opt5	1.2412
6	X opt6	0.5286

Now the set of six generators is taken in the third and final scenario. In this situation, there is an overall power demand of 5.2 power units. We utilized 50 iterations to obtain our findings, and the population size is 50. Therefore, in this circumstance, the likelihood of cross-over and mutation is (0.9,0.1). The genetic algorithm's lowest costs for this generator are as follows. A graph is created in MATLAB. The ideal values, as determined by this case, are listed in the table and the output generation values for the 5.2 per unit demand are shown by X opt1, X opt2, X opt3, X opt4, X opt5, and X opt6.

**TABLE 4.6**  
The optimal solution of ELD Pd =5.2

Sr No	Generator	values
1	X opt1	0.4176
2	X opt2	0.5657
3	X opt3	1.0749
4	X opt4	1.3993
5	X opt5	1.1972
6	X opt6	0.5474

**FIGURE 8. Fuel cost during iteration for power demand 5.0 per unit**



**VI. CONCLUSION**

To determine the most advantageous choice for economical load dispatch, the article uses the genetic algorithm method with both traditional generation systems and wind turbines. Wind power is one of the constraint sets that is solved using a stochastic method. Because the load in large power systems fluctuates, it is impossible to design a general strategy that can manage the load dispatch in that circumstance by load demand. The genetic algorithm is a heuristics method that operates in parallel to quickly and efficiently identify the best answer throughout the entire structure. In this study, the genetic algorithm is applied to six generators plus a wind turbine to the respective cases. Even in situations when the thermal turbine's generated power is constrained, we were able to identify the best option for each situation. As a result, this metaheuristic optimization technique can be used to find the best solution for ELD.

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