OPTIMIZATION IN ECONOMIC LOAD DISPATCH WITH SECURITY CONSTRAINTS

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Abstract—**Optimization of power scheduling for dynamically varying demand in real time considering constraints like transmission line capabilities, availability of conventional and renewable power sources, change of reliability index, serving critical and forecasted loads, optimization of losses, storage capacity. The scheduling is made considering practical security aspects like line and generator outages. Deep dive analysis is made on demand side management and suggestions are proposed. Dynamic economic load dispatch problem has been modeled as inequality constrained optimization problem. The evolutionary programming is applied to optimize the solution.**

***Index Terms*—Economic Load Dispatch, Particle Swarm Optimization, Genetic Algorithm, Distributed Generation.**

I. INTRODUCTION

Now a days due to interconnection of all the various electrical networks, energy crisis in the world and continuous rising prices, it is now very much in need to reduce the operating cost of electric energy. The main aim of todays electrical utility is to provide electrical power in a reliable way and in a possible low cost. Electrical Energy cannot be stored, but it can be generated form available sources be it conventional resources or Renewable energy sources. Transmission system is used for delivery of bulk power for a considerable distance and distribution system is used for local delivery of power. Since now a days there are so many sources of energy be it coal, oil or gas, water, solar energy, wind power, the choice of what resource should be taken, is taken in the basis of mostly economic expenditure, then other conditions are kept in mind such as Technical and Geographical.

Economic Load Dispatch in Generating units is one of the very few problems in Power system Operation. The new wave of implementing more and more renewable energy sources makes this problem even more important now a day. The main aim of Economic Load Dispatch Problem is to define the production cost of each plant so that the total cost of generation and transmission is as minimum as possible for a specific amount of load. Some factors have to be taken into account such as the generating Plant characteristics, the fuel used, heat rate of the fuel, water reserved for hydrothermal, the transmission losses etc.

II. BACKGROUND AND MOTIVATION

A. *Economic Load Dispatch*

As we have mentioned earlier, Economic Load Dispatch is one of the main problem now a days in our power system where dispatching the load in an economic way carries a great significance in present times power system where reducing the operating and generation cost is the most significant work to be look after.

B. *Thermal Scheduling*

Scheduling on plants in thermal generation carries a great significance. Thermal power plants have to take into account the fuel cost. In present days with the increase of Load Demand, it is very much necessary to operate the generating stations in a economical way. So it is very much essential to reduce the cost of the generation. The optimum scheduling of generating plants plays a very big role in reducing the total cost. In thermal plants the main cost is of Fossil fuel. So in thermal scheduling our aim is to minimize the fuel cost to supply the load demand, considering the constraints.

C. *Hydrothermal scheduling*

In the present age when there are large system set up of Hydro and Thermal Power system are already existing, the idea of integrating the two power stations together cannot be ruled out looking at the economic aspect of the same. The main idea behind the integrated operation is utilization of all the available energy sources in an optimal economical way to give the customers an uninterrupted supply. In a very interesting case, the cost of operation in Thermal Power plants is high but the capital cost is low, whereas in the case of hydro, it is the opposite. The operational cost is low but the capital cost is high. So it is rather economical as well as convenient to have both the plant in the same grid. Hydro Plant can be started quickly and it has a fast response time. But thermal power plant is slow in response. Mainly the thermal plant can be preferred for base load plant and hydro electric will be as peak load plant. For Hydrothermal Scheduling, it is very much essential to use the total amount of water available to the fullest. In hydro power for consumption charge will be fixed as there is no fuel cost, regardless to the amount of power generated. So we can get the minimum overall cost can be achieved by exploiting the hydro power to the maximum. Few things that should be kept in mind is number of hydro stations, their location and their characteristics.

D. *Wind based generation*

In the present scenario wind power has been one of the most preferred renewable energy sources in the world. Wind energy currently generates only 1% of all the electricity, but the share of it is growing rapidly. Globally, the longterm technical potential of wind energy is believed to be five times total current global energy production. In Denmark the share of wind power production has already gone up to 19% of the total energy generation. We can say it is the fastest growing renewable energy source. Wind power is one of the cleanest sources of energy as there are no chances of spreading pollution. With the growing energy demand in the world its very necessary to keep a balance between both normal conventional source of energy as well as Renewable energy source.

III. PROBLEM FORMULATION

here are different constraints in Economic Load Dispatch problem, mainly equality Constraints and Inequality Constraints. The objective function has to be minimized based on these constraints. Transmission loss plays a major role in this optimum dispatch of generation. The basic formula for optimization can be stated as to,

$$minimize, F(P_{gi}) = \sum_{i=1}^{NG} F_i(P_{gi})$$

$$subjected.to \sum_{i=1}^{NG} P_{gi} = P_D \qquad (1)$$

$$P^{gi}{}_{\min} \le P_{gi} \le P_{gi}{}^{\min}$$

Where P_{gi} is real power generation, PD is the real power demand, P_{gmin} is the lower limit of the power generation.

P_{gmax} is the higher limit of the power generation $F_i(P_{gi})$ is the operating fuel cost of the i^{th} plant.

The fuel cost is given by a quadratic equation,

$$Fi(P_{gi}^2) = aiP_{gi}^2 + b_iP_{gi} + ciRs/h \qquad (2)$$

IV. PARTICLE SWARM OPTIMIZATION

It is one of the very few methods that are available and have been developed to solve optimization problem such as Economic Load dispatch problem. The basic concept of PSO lies in accelerating each particle toward its pbest and the gbest locations, with a random weighted acceleration at each time step. The two things considered for particle swarm optimization is Pbest, and Gbest. In PSO, a swarm of n individuals communicate either directly or indirectly with one another search directions (gradients). Each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle.

Application of PSO in Power System are Economic Load Dispatch, Power System

Reliability, State Estimation, Load Flow and Power Flow and Power System Identification and Control.

V. GENETIC ALGORITHM

It is a method that mimics the natural selection process of nature. It is one of those methods used as a solution to optimizing problems. It is one of those methods belonging to Evolutionary algorithms, which generate its solution using the natural evolution such as mutation, crossover etc. In a genetic algorithm, a Population of candidate solutions is evaluated as towards a better solution. Each candidate solution will have a set of properties (chromosomes) which can be mutated. Normally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. At first many numbers of random solutions are generated from a given initial population. The population size depends on the nature of the problem, but generally it contains several hundreds or thousands of possible solutions. Traditionally, the population is generated randomly which allows a full range of possible solutions.

Genetic Algorithm problems have five main components,

- A genetic representation for potential solution to the problem; solution coding.
- To create an initial population of potential solutions;
  Initialization.
- Fitness function
- Genetic operators that alter the composition of children, Genetic operators.
- Values of different parameters that are used for using the problem with GA.

The main usage of Genetic Algorithm is for getting an optimized solution for a given problem. Same as in for Power system also, aim is to get the optimum solution. In power system one of the main criteria is to dispatch the load in an economical way, so for that we need to get the optimum solution on which price we can dispatch the load to the customer. Thats why Genetic Algorithm is used.

VI. DISTRIBUTED GENERATION

In present world it is very much needed for the power system to be very user friendly and for that distributed generation, which is also known as decentralized generation, is very much needed. Because in this present times, most of the power plants as thermal, nuclear or coal fired power plants are all of centralized generation type and sometimes it needs to be transmitted to a long distance which creates a problem when there is a problem in the line that affects the whole system. But as of distributed generation, it is located near the consumer place where the serve the load as it is decentralized, making it more flexible and not prone to face the failures if any problem happens in the neighborhood. The distributed generation uses mainly renewable energy resources.

VII. RESULTS

The sample problem was considered for different type of generation. The economic load dispatch is done using GA and PSO algorithm.[2]

VIII. CONCLUSION

The economic load dispatch problem has been simulated for different types of generation like wind, hydrothermal, thermal as well as IEEE-30 bus system using genetic and partical swarm optimization. The comparative study has been made with respect to consistency of optimal solution and simulation time. It has been observed that PSO gives better consistency

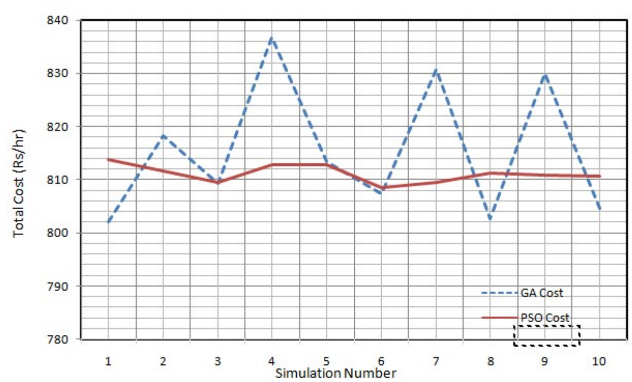

Fig. 1. Consistency of optimal cost using PSO algorithm and GA algorithm in IEEE-30 bus system

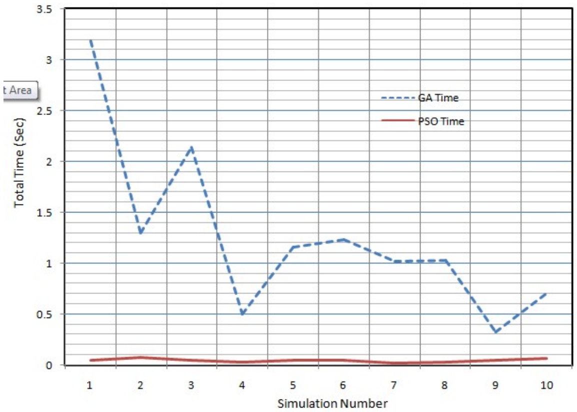

Fig. 2. Simulation time taken by PSO algorithm and GA algorithm for IEEE30 bus system

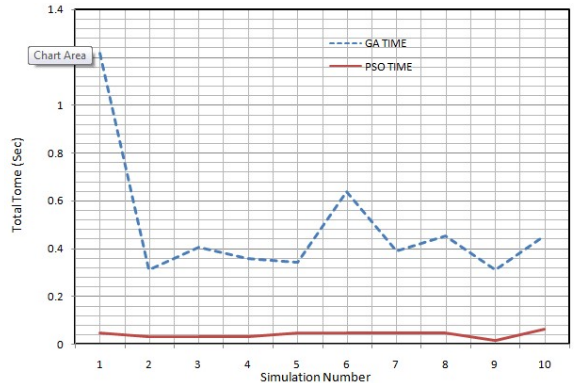

Fig. 5. Simulation time taken by PSO algorithm and GA algorithm for thermal generation

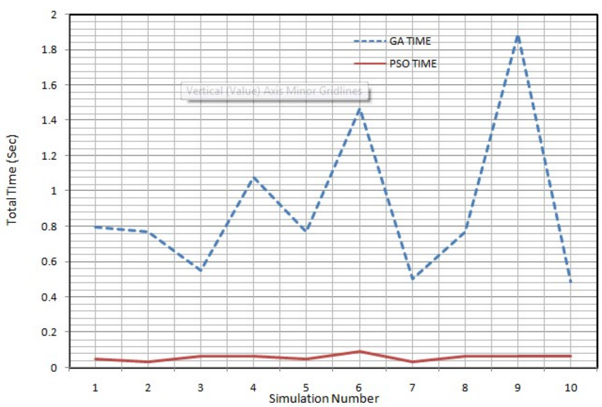

Fig. 3. Consistency of optimal cost using PSO algorithm and GA algorithm in hydrothermal generation

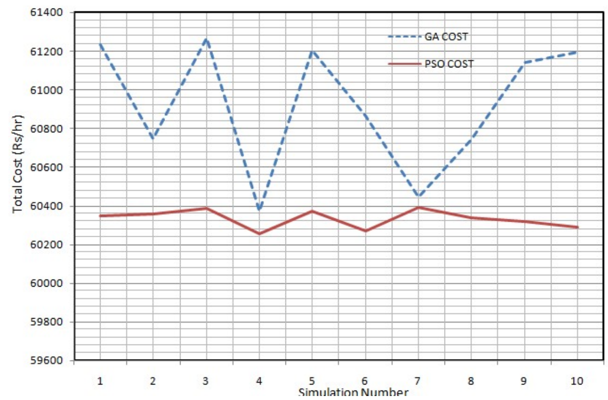

Fig. 6. Consistency of optimal cost using PSO algorithm and GA algorithm in wind generation

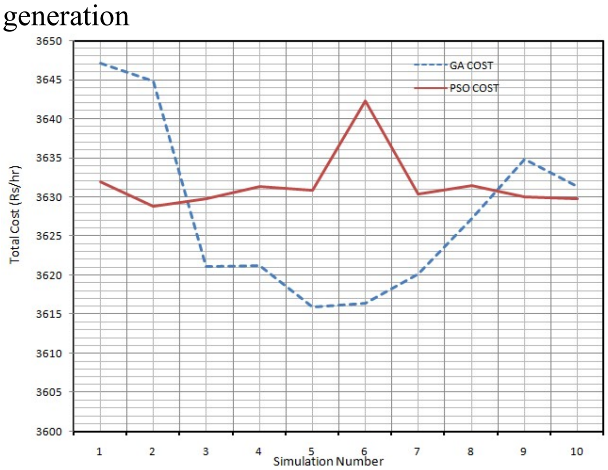

Fig. 4. Consistency of optimal cost using PSO algorithm and GA algorithm in thermal generation

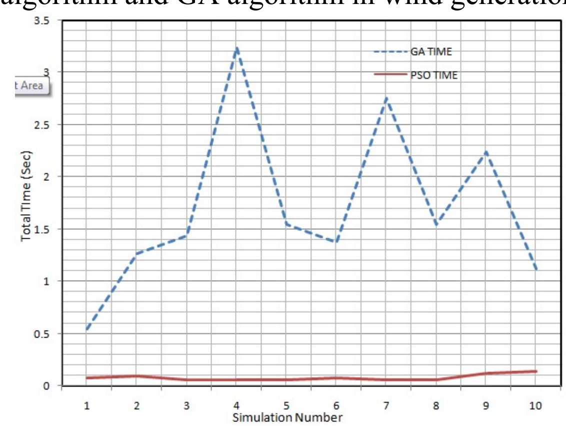

Fig. 7. Simulation time taken by PSO algorithm and GA algorithm for wind generation

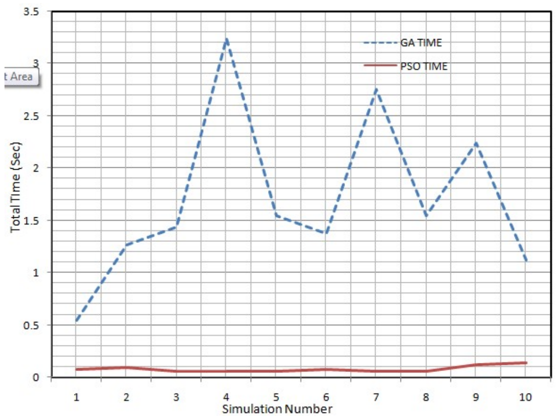

Fig. 8. Simulation time taken by PSO algorithm and GA algorithm for wind generation

	P1	P2	P3	P4
GA	187.5416	154.6825	215	14.40933
PSO	222.8415	121.2677	206.3063	12.25443
GA	171.951	170	215	12.05497
PSO	234.85	129.6718	182.1369	11.4813
GA	170.1678	170	215	13.26017
PSO	239.691	118.6862	189.7223	10.13045

Fig. 9. Simulation time taken by PSO algorithm and GA algorithm for wind generation

	P1	P2	P3
GA	169.2242	45.68567	100
PSO	191.009	47.72342	74.00755
GA	207.9703	24.51265	82.18814
PSO	188.0822	50.15988	74.21794
GA	184.0009	71.15463	57.41803
PSO	190.5246	46.46327	75.54208

Fig. 10. Simulation time taken by PSO algorithm and GA algorithm for wind generation

	P1	*P2*	*P3*
GA	175.1879	48.4664	21.94559
PSO	202.0029	34.31468	19.54208
GA	167.5313	29.53974	19.86533
PSO	185.531	43.1274	20.32467
GA	164.8007	44.79349	19.55504
PSO	187.7028	48.20544	15.76577

Fig. 11. Simulation time taken by PSO algorithm and GA algorithm for wind generation

P4	*P5*	*P6*
21.41068	11.4499	14.17757
10.91632	11.02748	14.62658
30.82075	13.89978	29.84902
11.63676	15.74007	16.1601
16.63857	24.46285	21.53492
17.01052	10.93732	12.61814

Fig. 12. Simulation time taken by PSO algorithm and GA algorithm for wind generationand takes lesser time than genetic algorithm. The local and global optima is converging very fast in PSO compared to the fluctuating response of GA. The detailed study made considering the different parameters which affects the cost characteristics. Line and generator outage constraints were considered for IEEE-30 bus system and the stress on the transmission line, increase in the transmission loss and the non-reliability has been studied.

Line Outage	Overloading factor
No outage	1.339
1-2	1.971
6-7	1.412
2-4	1.222
6-8	1.431
14-15	1.339

Fig. 13. Line Outage and its impact on transmission line

Generator Outage	Overloading factor
No outage	1.339
2	1.608
3	1
4	1.166
5	1.332
6	1.364

Fig. 14. Generator Outage and its impact on transmission line

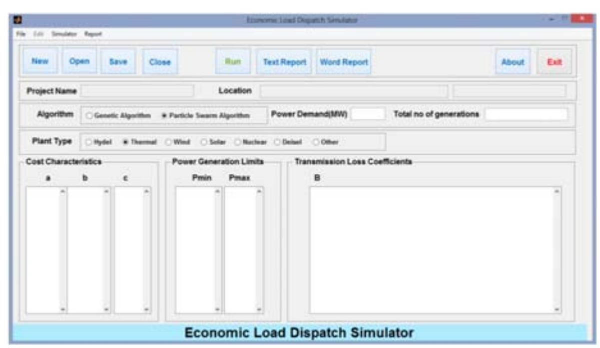

Fig. 15. ELD Simulator

APPENDIX A SIMULATOR

The tool is developed to simulate PSO and GA for economic load dispatch problem to different types of generations.

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