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Economic Dispatch with Integrated Wind-Thermal using Particle Swarm Optimization

R Saravanan[1], S Subramanian[1], V Dharmalingam,[2] S Ganesan[1]
[1]Deaprtment of Mechcnial Engineering, Annamalai University, Chidambaram, Annamalainagar, Tamil Nadu
[2]Pandian Saraswathi Yadav Engineering College, Sivagangai , Tamil Nadu, India

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Abstract
The Economic dispatch is an important optimization task in power system. Thermal power plants are the major electrical energy producers. Need for renewable energy occurs due to the extinction of fossil fuels. Hence, it is necessary to operate these renewable plants with the thermal plants. In India, especially in Tamilnadu, Wind is the renewable plant which is widely available. The problem with the wind plant is its unpredictability.Hence, better wind thermal coordination economic dispatch method is necessary to integrate wind power reliably and efficiently. In this paper, Particle swarm optimization (PSO) technique is utilized to coordinate the wind and thermal generation dispatch and to minimize the total production cost. Ten units of thermal system incorporating wind power plant is utilized for numerical simulation. Different simulations with and without wind power production are simulated. Simulation result shows the effectiveness of wind power generation in reducing total fuel cost when compared with the genetic algorithm.

1. Introduction

The evolution of new energy sources for electric power generation is to meet the increasing demand or load and the rapid increase in fuel cost. Generally, there are two type of energy sources are available to produce or generate electricity. 1. Conventional energy source like thermal, petroleum, natural gas and nuclear sources of energy. 2. Non-conventional energy sources and they are solar, wind, tidal, hydro, biomass and geothermal energy sources.

The unit commitment and economic dispatch problems are used to calculate the generation cost with respect to the fuel consumption depend upon the demand. The generation cost reduced by maintaining the generation scheduling constraints with varies critical load condition.

The generation scheduling constraints will vary from one utility unit to other unit with respect to the type of combination of energy sources in the particular generating station. When the availability of energy source which is used to produce electricity increases, the fuel consumption decreases and so the generation cost will also decrease with respect to the load.

The impacts of wind, hydro and thermal power generation are modelled by increasing the reserve requirements and the hydro power generation relates to the availability of water level in the reservoir. The generated power in wind and hydro units are depending on the availability of wind speed and the amount of water. So it is difficult to produce power to meet the demand. Thus integrating conventional and non-conventional unit results in enough power production in all conditions. Economic Dispatch is an important optimization task in power system. It is the process of allocating generation among the committed units such that the constraints imposed are satisfied and the energy requirements are minimized. More just, the soft computing method has received supplementary concentration and was used in a quantity of successful and sensible applications. Here, an attempt has been made to find out the minimum cost by using Particle Swarm Optimization (PSO) Algorithm using the data of ten thermal generating units and two wind units. Since wind power does not consume fossil fuel, the government has regulated in its renewable energy law that the power grid should buy all electricity produced by renewable energy plant. Thereafter, adoption and variation of high penetration wind power will have notable impact to economic dispatch of power system. Recently, metaheuristic methods are widely in use for the optimization applications and found to be more efficient than the conventional methods. This project focuses on the problems associated with the economic dispatch of the system with thermal and wind units integrated. The optimized dispatch is to be obtained using the particle swarm optimization technique and the result is analysed by comparing with that of conventional method and using Particle swarm optimization.

***Corresponding Author,**
E-mail address: jajivarghese@gmail.com; Phone:+91- 09968009210

2.Problem Formulation

The main objective of this paper is to reduce the operating cost by properly allocating the Power generated by the thermal units as well as the wind units.

The objective fnction is,

$C = \Sigma C_i(P_{gi})$; for i=1,2,....,n (1)

where, $C_i(P_{gi})$ is the cost of ith generating unit

C is the total operating cost

subject to the constraints

$\Sigma P_i - P_d - P_l = 0$; for i=1,2,....,n (2)

$P_{gi}^{min} \le P_i \le P_{gi}^{max}$

P_i is the Power generation of ith unit

P_d is the total load demand

The operating cost of ith thermal unit is given by,

$C_i(P_{gi}) = a_i + b_i P_{gi} + c_i P_{gi}^2$ (3)

The wind power is allotted based on the constraints

Wind generation fluctuation constraints:

if $P_{wt}(t-1) \le P_{wt}(t)$,$P_{wt}(t) - P_{wt}(t-1) \le TDR(t)$

if $P_{wt}(t-1) \ge P_{wt}(t)$,$P_{wt}(t-1) - P_{wt}(t) \le TUR(t)$ (4)

Total available wind generation

$P_{wt}(t) = \Sigma P_{wt,j}(t)$, for j=1,2,...., NW (5)

Total actual wind generation limit:

$0 \le P_{wt}(t) \le P_{wt}(t)$

3. Particle Swarm Optimization

Particle swarm optimization is one of the metaheuristic optimization methods. It has te advantages of Simple concept, Easy implementation, Computationally efficient etc.

When any optimization process is applied to the ED problem some constraints are considered. In this work two different constraints are considered. Among them the equality constraint is summation of all the generating power must be equal to the load demand and the inequality constraint is the powers generated must be within the limit of maximum and minimum active power of each unit. The sequential steps of the proposed PSO method are given below.

- Initialize the Fitness Function ie. Total cost function from the individual cost function of the various generating stations.

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- Initialize the PSO parameters Population size, C_1, C_2, W_{max}, W_{min}, error gradient etc.
- Input the Fuel cost Functions, MW limits of the generating stations along with the total power demand.
- At the first step of the execution of the program a large no(equal to the population size) of vectors of active power satisfying the MW limits are randomly allocated.
- For each vector of active power the value of the fitness function is calculated. All values obtained in an iteration are compared to obtain Pbest.

  $V_i(k+1)=\omega*V_i(k)+c_1*random_1()*(pbest_i-P_i(k))+c_2*random_2()*(gbest-P_i(k))$
- At each iteration all values of the whole population till then are compared to obtain the Gbest.

  $P_i(k+1) = P_i(k) + V_i(k+1)$
- At each step error gradient is checked and the value of Gbest is plotted till it comes within the pre-specified range.
- This final value of Gbest is the minimum cost and the active power vector represents the economic load dispatch solution.

Units	Pmax	Pmin	a($/MWh)	b($/MWh)	c($/h)	d($/h)	e($/h)
1	470	150	0.00043	21.60	958.20	450	0.041
2	460	135	0.00063	21.05	1313.6	600	0.036
3	340	73	0.00039	20.81	604.97	320	0.028
4	300	60	0.00070	23.90	471.60	260	0.052
5	243	73	0.00079	21.62	480.29	280	0.063
6	160	57	0.00056	17.87	601.75	310	0.048
7	130	20	0.000211	16.51	502.70	300	0.086
8	120	47	0.00480	23.23	639.40	340	0.082
9	80	20	0.10908	19.58	455.60	270	0.098
10	55	55	0.00951	22.54	692.40	380	0.094

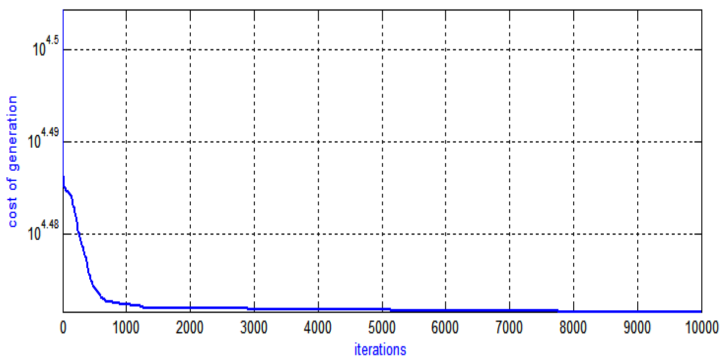
4. Results And Discussions

The system contains ten conventional thermal generation units and the demand of the system is divided into 12 months interval for the whole day. The data of the ten thermal units are listed in Table 1. The load demand and wind power generation for each hour are listed in Table 2. Economic dispatch is calculated using particle swarm optimization algorithm with and without wind generation.

Table 1: Test Data for Ten Unit System

Table:2 Load pattern and wind farm output

Month	Load Demand	Pwind11	Pwind12
1	1036	72	0.12
2	1110	106	0.11
3	1258	113	0.10
4	1406	103	0.10
5	1480	139	0.10
6	1628	116	0.11
7	1702	122	0.10
8	1776	88	0.13
9	1924	42.1	0.10
10	2072	57.1	0.09
11	2146	44	0.13
12	2220	65.2	0.10



Hour	1	2	3	4	5	6	7	8	9	10	Pwind1	Pwind2	Demand
1	150.00	135.00	133.88	60.00	73.00	160.00	130.00	47.00	20.00	55.00	72.00	0.12	1036
2	150.00	135.00	173.89	60.00	73.00	160.00	130.00	47.00	20.00	55.00	106.00	0.11	1110.00
3	150.00	135.00	314.90	60.00	73.00	160.00	130.00	47.00	20.00	55.00	113.00	0.10	1258.00
4	150.00	267.90	340.00	60.00	73.00	160.00	130.00	47.00	20.00	55.00	103.00	0.10	1406.00
5	150.00	305.90	340.00	60.00	73.00	160.00	130.00	47.00	20.00	55.00	139.00	0.10	1480.00
6	160.57	460.00	340.00	60.00	79.32	160.00	130.00	47.00	20.00	55.00	116.00	0.11	1628.00
7	212.81	460.00	340.00	60.00	95.09	160.00	130.00	47.00	20.00	55.00	122.00	0.10	1702.00
8	285.25	460.00	340.00	60.00	130.62	160.00	130.00	47.00	20.00	55.00	88.00	0.13	1776.00
9	410.64	460.00	340.00	60.00	199.16	160.00	130.00	47.00	20.00	55.00	42.10	0.10	1924.00
10	470.00	460.00	340.00	60.00	243.00	160.00	130.00	76.72	20.09	55.00	57.10	0.09	2072.00
11	470.00	460.00	340.00	134.52	243.00	160.00	130.00	88.70	20.64	55.00	44.00	0.13	2146.00
12	470.00	460.00	340.00	180.13	243.00	160.00	130.00	95.45	20.92	55.00	65.40	0.10	2220.00

The table 4 describes that the operational cost reduces with the coordination of the wind power plant with the thermal power plant. In the above table, the cost of generation of the case with wind power is found to be comparatively lower than that of the case without wind power.

	GENETIC ALGORITHM	PARTICLE SWARM OPTIMIZATION
Cost of generation without wind power generation ($/Month)	1064814.34	1009985.32
Cost of generation with wind power generation ($/Month)	1026048.84	976085.46

V. CONCULSION

In this paper, the formulation and implementation of solution methods to obtain the solution of Economic Dispatch problem using Particle swarm optimization is carried out successfully for coordinated thermal and wind power generation. The cost of the best solution without wind power generation is 1009985 ($/day) while the cost for best solution with wind power generation 976085.46 ($/day). The profit by using wind energy is 33899.86 ($/day). The simulations for with/without wind power production shows that the total system operating costs and consumption of fossil fuel can be reduced notably by utilizing wind power generation.

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