Economic Load Dispatch by Improved Drone Optimization Technique

Manish Kashyap, Achala Jain, Vinita Swarnakar

Abstract: In this paper, the ELD problem is resolved via ABC (Artificial BEE Colony) technique. The major goal of this study is to use the IDO method to present very efficient & reliable approach for solving ED problem in Power system. The suggested approach is used to solve a variety of non-convex ED issues, including banned operating zones with ramp rate constraints. This problem is described as an optimization of the objective function and minimization of the overall operating cost while gratifying all allied constraints, accompanied by the lowest down & up time limitations, startup cost, and spinning reserve. A six generators scheduling problem is discussed, along with its formulation, representation, and simulation result.

Keywords: Artificial BEE Colony (ABC), Improved Drone Optimization (IDO), Economic Load Dispatch/ Economic Dispatch (ED), Unit Commitment (UC), Artificial Intelligence (AI).

I. INTRODUCTION

Unit commitment (UC) is an iterative method which is used to calculate the operating itinerary of generating units at every hour course with fluctuating loads under diverse constraints & conditions. Emissions & depletion of non-renewable inside the global climate are growing quickly; as a result, non-traditional energy sources are being engaged in power system circuitry to address industrial, environmental, economic & societal demands. To address the need, an alternate renewable energy source, wind energy generation, has been implemented. In the fourth quarter of 2021, our country's wind energy capacity surpassed 26% of the total installed base. In India, roughly 151.4 Giga-watts of renewable energy capacity is built as of 31st December 2021. With discharged gravity fuels, forms of energy are employed in the electrical system network to fulfill global environmental change, financial, ecological, contemporary, and social scale requirements. Wind energy production has evolved into a viable substitute source of energy for conventional assets. Wind power perforation have expanded in the last decennium, and advancement and re need strategies capture the arrangement system of a current design, technique, and usable conventions because of its consistency and eccentricities. Different strategies, such as advanced unit commitment, controlling wind fluctuations using pumped-storage hydro, and improved ancillary service procurement, can be used to accommodate wind management inconstancy. To satisfy demand at a cheaper cost, we must devise an optimization problem that decides which wind turbines should be engaged and/or shut down during a certain time period. It's referred to as a Unit Commitment optimization challenge. When each and every generating unit along with the wind-power are committed, the least generation cost is attained. Various technologies are employed to board the changeability of the wind power generation, including changing wind power variants with pumped-storage hydro, improved auxiliary service acquisition, and enhanced propelled unit responsibility. Progressively, a variety of optimization problems are used to meet the requirement at a reduced cost, which decides which generating station should be implemented & which one to cease production throughout the specified time frame. This forecasting model may determine the accurate forecasting model required by the wind power system for committing wind power.

Unit commitment to non-conventional sources of energy and hydro energy systems is important in the power system since the issue is mostly determined by the operating costs of the generation units. As a result of the vagueness in the wind energy system, the Unit Commitment problem is more difficult. As a result, multi-objective optimization is defined as a uncertainty with problems. To address wind power fluctuation, several technologies such as wind power balancing and improved unit commitment are applied.

Various approaches, including the genetic algorithm, Swarm optimization, bacterial forage, ant colony optimization, and gravitational search algorithm, can be applied. The advantages of genetic algorithms include the ease with which mathematical and financial issues may be calculated. However, it has drawbacks, such as the inability to always provide a precise answer. Dynamic applications can benefit from ant colony optimization. Positive feedback contributes to the speedy identification of good remedy. The restrictions, such as convergence, are assured, but the time to convergence is unknown. Moreover, the preceding research solely focused on thermal and hydro generating; the incorporation of vagueness in wind power is hardly described in literatures. However, the functioning of smart grids frequently necessitates balancing competing objectives including such cost, possibility of loss, and environmental effect owing to gas emissions.

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II. REVIEW CRITERIA

Meeting load power at least costing of fuel utilizing most favorite mix of various power plants is an important requirement in operating power system. Furthermore, one of the finest accessible solutions for supplying electric power to clients secure & cost-effective manner is thermal unit commitment. As a result, it is widely acknowledged that optimal UC of thermal systems results in significant cost savings for electric utilities. The difficulty of calculating the schedule of producing units under operating limits and device is known as unit commitment. The solution is derived using the conventional dynamic programming method after discussing the concept of unit commitment. The unit commitment problem has been solved using an algorithm named ABC technique, which is a population-based global search and optimization technique. The efficiency of the following algorithms were tested on different systems with units of 3 &4 and the total running cost has been compared (Vinod Puri, Nitin Narang, 2012).

The unit commitment problem, which may be theoretically stated as a larger scale nonlinear mixed-integer minimization problem with no accurate solution approach, is an essential optimization job in planning the operational power system daily. The answer to the issue can only be determined by comprehensive enumeration, which typically results in excessively long computing times for realistic power systems. For the unit commitment issue,
3 Particle Swarm Optimization methods were illustrated: Binary Particle Swarm Optimization, Improved binary Particle Swarm Optimization, and Particle Swarm Optimization with Lagrangian relaxation. In overall, the benchmark data sets and technique demonstrated that the suggested Particle Swarm Optimization algorithms are capable of efficiently producing standard quality solutions in tackling unit commitment issues. Some of the most appealing properties of ABC algorithms in tackling UC problems are their fast numerical convergence and ease of implementation. Furthermore, the suggested ABC algorithms are simply extendable to tackle novel profit-based unit commitment problems in a competitive setting. (Sirote Khunkitti , Neville R. Watson, Rongrit Chatthaworn, Suttichai Premrudeepreechacharn and Apirat Siritaratiwat, 2019)

A novel strategy based on branch-and-bound techniques is provided for tackling the unit commitment problem. The technique takes into account time-based start-up costs, demand & reserve restrictions, as well as minimum up and down time limits. It is not necessary to rank the units in order of priority. A probabilistic reserve restriction can be added to the procedure. The preliminary computational findings are provided. This study describes a novel method to unit commitment that is based on bound & branch approaches. The stop & start times, as well as the unit generation levels, are the decision factors. It has been demonstrated that the method may be expanded to include a probabilistic reserve restriction that takes into account the impacts of random unit induced outages and uncertain demand on reserve.(T. Cohen, Miki Yoshimura,1983)

Production of winds fluctuates over short time intervals, which is balanced by altering thermal plant generation to match demand. Because thermal ramp rates are restricted, higher fluctuation in wind production as wind penetration rises can raise system running costs due to the requirement for additional thermal operating reserves. Traditional deterministic modeling approaches fall short of completely accounting for these additional expenditures. In the face of variable wind generation, we offer a stochastic dynamic programming (SDP) method to unit commitment and dispatch, reducing operating costs by making optimum unit commitment, dispatch, and storage decisions. **(**Jeremy J. Hargreaves, Benjamin F. Hobbs,2012**)**.

III. MATHEMATICAL FORMULATION

The objective of the unit commitment issue is to reduce overall operating expenses over the scheduling horizon while adhering to a set of system and unit limitations. The production cost is considered to be, pc_i is a quad function for output of generator power, P_i, at any given time interval.

$$F_i(P_i) = a_i + b_iP_i + c_iP_i^2$$

Where a_i, b_i & c_i are unit cost coefficient. The cost of starting a generator is determined by how long the unit has been turned off before starting, *Toff*. The startup cost *SCi* is supposed to be an exponential cost curve at any given moment.

$$SCi = \delta i + \sigma i\{1 - e^{\frac{-Toff}{Ti}}\}$$

Where δi = hot start-up cost, σi = cold start-up cost & Ti = the cooling time constant.
For the time period T, Overall operating costs, OC_T is sum of production & start-up cost.

$$OC_T = \sum_{t=1}^{T}\sum_{i=1}^{N} PC_{i,t}U_{i,t} + SC_{i,t}(1 - U_{i,t-1})U_{i,t}$$

Where $U_{i,t}$= binary variable, shows the ON/OFF condition of the unit *i* at the time *t*,
$U_{i,t}$=1, if unit i is committed at time t, otherwise 0.

IV. METHODOLOGY

A. Particle Swarm Optimization Algorithm:

- Startup the swarm, p(t) of particles such that the position x_i (t**)** of each particles. P(t) is random within the hyperspace, with t=0
- Determine the *pbest* by evaluating the fitness function for each particle.
- Compare the particle's fitness rating with its *pbest* for each individual particle. Set this value as the *pbest* and the current particles position x_i as p_i, if the current value is higher than the *pbest* value, the current value is preferred.
- Determine which particle has the highest fitness value. The fitness function's value is designated as *gbest*, while its position is designated as g_b.
- All of the particles' velocities and locations should be updated as,

$$u_i^{(t)} = u + M_1 \times rand \times (p_{pbesti} - p_i^{(t)}) + M_2 \times rand \times (p_{gbest} - p_i^{(t)})$$

Where, M1 & M2 : Random Variables

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B. Proposed Method

- Create a particle population *pi* and other factors. Typically, each particle is created at random within a given range.

$P_{i,min} \leq P_i \leq P_{i,max}$

Here *pi* is i^{th} unit in the power system.

- Initialize the population size, starting and ultimate inertia weights, particle random velocity, acceleration constant, maximum generation, Lagrange's multiplier (λi) and other parameters.
- Using the fitness function or the cost function, calculate each individual's fitness in the population .

$$OC_T = \sum_{t=1}^{T}\sum_{i=1}^{N} PC_{i,t}U_{i,t} + SC_{i,t}(1 - U_{i,t-1})U_{i,t}$$

Where *PCi,t* is presented as

$$F_i(P_i) = a_i + b_iP_i + c_iP_i^2$$

With similarity constraint as

$$\sum_{i=1}^{n} P_i = P_D$$

Where P_i = i^{th} generators and P_D = load or demand.

And dissimilarity constraints as

$$P_{i,min} \leq P_i \leq P_{i,max}$$

- Compare each fitness value of each individual to the *pbest*. *gbest* best fitness value among *pbest*.
- Individual velocity *vid* of each p_i should be changed as follow

$$u_i^{(t)} = u + M_1 \times rand \times (p_{pbesti} - p_i^{(t)}) + M_2 \times rand \times (p_{gbest} - p_i^{(t)})$$

- Modify the individual's position *pi* as

$$p_i^{(t)} = p_i^{(t-1)} + p_i^{(t)}$$

Where i= i^{th} unit & t= time (in hr).

- The current value is set to *ppbest* if each individual's evaluation rating is higher than the previous *ppbest.* The value is set to *pgbest*, if the best *ppbest* is better than *pgbest.*
- Modify the λ and α for each equality and Inequality constraint. For Inequality Constraint

$$\alpha = \max(inequality\ constrant, -\lambda(\text{iter}-1)/(2 \times r))$$

$$\lambda(iter) = \lambda(\text{iter}-1) + (2 \times r \times \alpha)$$

For equality Constraint

$$\alpha = \max(inequality\ constraint, -\lambda(\text{iter}-1)/(2 \times r))$$

- If the no. of units are found running minimize the fitness function using the particle swarm optimization.
- Go to step k if the number of iterations approaches its limit. If not, proceed to step c.
- The individual who generates the most is the unit's optimal generating power with the lowest cost of total generation.

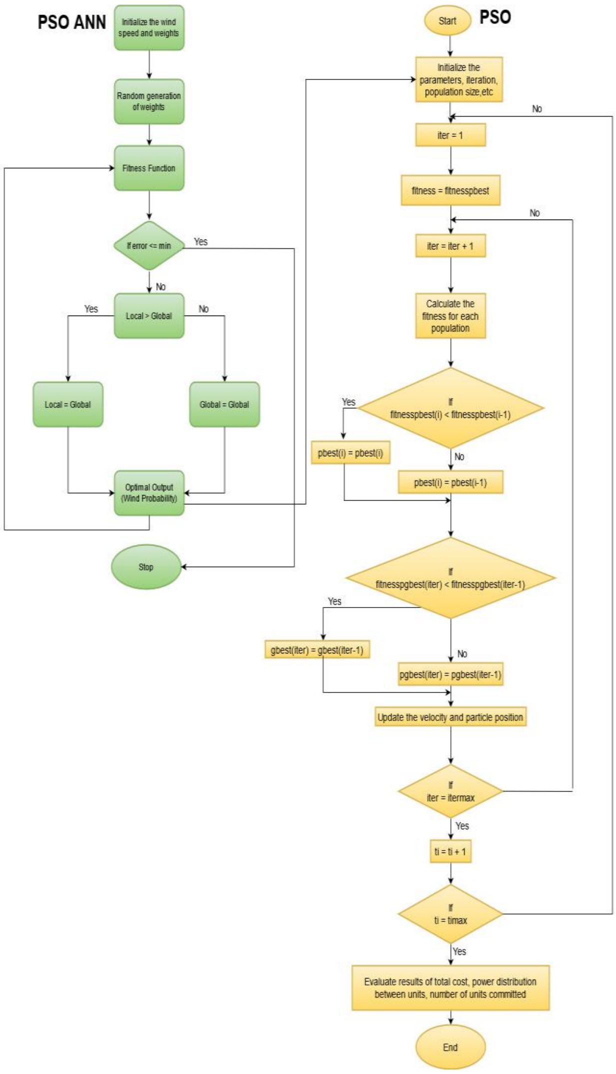

Fig.- ED using PSO

V. RESULT AND DISCUSSION

Results of many tested philosophies are presented in this section & are contrasted with one another. To determine the practicality of the various procedures, an examination of the various techniques was conducted alongside the MATLAB/play operating level. With the help of the suggested strategies & emission dreams are separately restrained. A six unit generation framework is used, and results are compared with some different methods.

Unit	a_i	b_i	c_i	P_{min}	P_{max}
1	0.001562	7.92	561	100	600
2	0.001940	7.85	310	100	400
3	0.004820	7.97	78	50	200
4	0.001390	7.06	500	140	590
5	0.001840	7.46	295	110	440
6	0.001840	7.46	295	110	440

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Table- I: Comparison Table

Method	Load (MW)	Unit 1 (MW)	Unit 2 (MW)	Unit 3 (MW)	Unit 4 (MW)	Unit 5 (MW)	Unit 6 (MW)	Total cost (Rs)
CGA	800	109.17	104.08	52.04	305.05	114.83	114.83	642000.762
QCGA	800	104.89	104.89	51.74	314.18	113.16	113.16	641855.719
BeeOA	800	100	100	50	305.63	122.19	122.19	641549.258
Proposed	**800**	**101.86**	**100.32**	**50.69**	**302.75**	**122.19**	**122.19**	**621958.328**
CGA	1200	142.55	117.80	58.90	515.20	182.78	182.78	896281.845
QCGA	1200	131.50	129.05	52.08	494.08	200.61	200.61	895212.739
BeeOA	1200	123.76	117.68	50	448.42	230.06	230.06	894982.698
Proposed	**1200**	**124**	**117.08**	**51.84**	**451.08**	**228**	**228**	**892563.986**
CGA	1800	222.42	190.73	95.36	555.63	367.92	367.92	1293614.119
QCGA	1800	250.49	215.43	109.92	572.84	325.66	325.66	1293364.583
BeeOA	1800	247.99	217.719	75.18	588.04	335.52	335.53	129856.1534
Proposed	**1800**	**248**	**216.89**	**77.89**	**587.22**	**335.54**	**334.46**	**128992.576**

VI. CONCLUSION

In this paper different methods were compared with proposed method. The optimal unit commitment of thermal system is well understood to result in significant electrical utility cost saving. The difficulty of calculating the schedule of producing units under device and operating limits is known as unit commitment. The solution is derived using the conventional method after discussing the concept of unit commitment. The issue of Economic Load Dispatch is been resolved by applying an algorithms acquired from the IDO technique, which is a population based global search & optimization tactic. The efficiency of the above mentioned algorithms has been certified on various systems with different number of units and the total cost has been compared.

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