Environmental Economic Power Dispatch Using Bat Algorithm with Generalized Fly and Evolutionary Boundary Constraint Handling Scheme

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ABSTRACT
This article intends to resolve the evolving environmental economic power dispatching problem (EED) using an enhanced version of the bat algorithm (BA) which is the Bat Algorithm with Generalized Fly (BAG). A good solution based on the Evolutionary Boundary Constraint Handling Scheme rather than the well-known absorbing technique and a good choice of the bi-objective function are provided to maintain the advantages of such algorithms on this problem. In the first stage, an individual economic power dispatch problem is considered by minimizing the fuel cost and taking into account the maximum pollutant emission. In the second stage and after weighting soft constraints satisfaction maximization and hard constraints abuse penalties, the proposed approach of the bi-objective environmental and economic load dispatch was built on a pareto function. The approach was tested on a thermal power plant with 10 generators and an IEEE30 power system of 6 generators. The results on the two datasets compared to those of other methods show that the proposed technique yields better cost and pollutant emissions.

KEYWORDS
Bat Algorithm With Generalized, Bat Algorithm (BA), Environment, Evolutionary Boundary Constraint Handling Scheme, Fuel Cost, Pollutant Emission, Power Dispatch, Walk Algorithm (BAG)

1. INTRODUCTION
Nowadays, with an increase in the need for electrical energy in every field of life, power systems planning optimization are making considerable interest in terms of how to get cheap fuel cost when dispatching electrical energy. Otherwise, the increasing public awareness of environmental protection makes the minimization of atmospheric pollutant emissions of thermal power plants, one of the most important issues of the power dispatching. In the literature, economic power dispatch problem (ED) is usually refers to control the committed generator output in order to minimize the total fuel cost while satisfying the power demand and other constraints. Whereas, Environmental power dispatch aims to minimize the pollutant emission. The power dispatch problem can also be handled as a multi-purpose optimization problem with contradictory and non-commensurable objectives.

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Traditionally, the focus of power system dispatch has been always on minimizing either the cost or the pollutant emission but rarely both of them.

Wenyuan (1987) established a successive linear programming model with penalty terms for solving real-time economic active power dispatch with security. Granelli and Montagna (2000) presented a procedure for handling real power transmission constraints on branch flows and inter-area exchanges to supplement the classic economic dispatch (ED) formulation. A sequential quadratic programming (SQP) method was employed to solve the resulting non-linear programming problem. Shafie-khah et al. (2011) combined with a modified Branch-and-Bound with Quadratic Programming for solving the non-convex security constraint unit commitment (SCUC) problem in power systems. The emission was considered as a constraint. Jizhong Zhu et al. (2001) presented a nonlinear convex network flow programming (NLCNFP) model and algorithm for solving the security-constrained multi-area economic dispatch problem by using a combined method of quadratic programming and network flow programming.

But the last years have witnessed a huge growth in multi-objective power dispatch optimization. In (Ahlam et al., 2016), authors were concerned by wind power uncertainty incorporating energy storage system and demand side management in the multi-objective problem. To reduce carbon price and pollutant emission in power dispatch, Abdirahman Mohamed Abdilahi et al. (2017) used metaheuristics. Haiping et al. (2017) resolved dynamic economic emission load dispatch considering plug-in electric vehicles charging using a biogeography base approach. In (Rizk et al., 2017), authors presented a parallel hurricane optimization algorithm to secure emission/economic load dispatch solution and a Taguchi method was detailed. Collective neurodynamic multi-objective optimization was proposed in (Wang et al., 2017) taking into account valve point effect in microgrid. Shaabani et al. (2017) combined the heat and power economic/emission dispatch problems. They used stochastics techniques.

Many researchers have attempted to solve power scheduling problems using conventional techniques. Zehar and Sayah (2008) applied successive linear programming technique is proposed on the Algerian 59-bus power system multi objective dispatch. Mohsen Nemati et al. (2017) used genetic algorithms and integer linear programming. Azizipanah-Abarghoee et al. (2016) proposed a probabilistic unit commitment problem with incentive-based demand response and high level of wind power. They proposed a new chance-constrained method with an iterative economic dispatch correction. Esmaeily et al. (2017) used mixed-integer linear programming for economic thermal power scheduling. Zhong-kai Feng et al. (2017) applied on a Chinese economic hydropower system an improved discrete differential dynamic programming with orthogonal experimental design. Belsnes et al. (2016) presented a model for operational stochastic short-term hydropower scheduling, taking into account the uncertainty in future prices and inflow using stochastic successive linear programming. In (Yibo Jiang et al., 2017), the authors were interested by the day-ahead stochastic economic dispatch of wind integrated power system. They proposed an operation optimization model.

Most of researchers have tended to focus on conventional methods rather than intelligent methods. Besides, few of researchers used metaheuristics and particularly evolutionary computation-based approach. (Gherbi et al., 2016) combined economic/environmental dispatch using Firefly algorithm and Bat algorithm. Cuckoo optimization was used in (Mellal et al., 2015) to solve combined heat and power economic dispatch problem. Dinu Calin Secui (2017) investigated a symbiotic organism search algorithm for large-scale multi-area economic/emission dispatch taking into account valve-point effect and transmission losses. Authors in (Jaybarathi et al., 2016) included crossover and mutation to the grey wolf optimizer for solving economic dispatch problems with prohibited operating zones, valve point loading effect and ramp rate limit constraints have been solved. Narang et al. (2017) described an integrated approach that embeds civilized swarm optimization and Powell’s pattern search to optimize economic dispatch (ED) of combined heat and power dispatch problem. They used Wilcoxon signed rank is performed to test results. Nemati et al. (2018) proposed an improved
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