Combined Heat and Power Dispatch using Hybrid Genetic Algorithm and Biogeography-based Optimization

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ABSTRACT
This paper explores the performance of biogeography-based optimization (BBO) algorithm for solving combined heat and power dispatch (CHPD) or cogeneration problem of power system. BBO is a type of evolutionary algorithm which is based on the theory of biogeography and is inspired by the two concepts, namely migration of species between “islands” via flotsam, wind, flying, swimming, etc. and mutation. To improve the convergence property and solution quality, blended crossover strategy of genetic algorithm (GA) is integrated with conventional BBO algorithm in this study. The effect of valve-point in cost function is considered by adding an absolute sinusoidal term with the conventional polynomial cost function. The potential of the proposed BBO and GA based BBO (GABBO) algorithms are assessed by means of an extensive comparative study of the solutions obtained for small and medium CHPD problems of power systems. To show the priority of the proposed algorithm, comparative studies are carried out to examine the effectiveness of the proposed BBO and GABBO approaches over evolutionary programming (EP), differential evolution (DE), particle swarm optimization (PSO) and time varying acceleration coefficients PSO (TVAC-PSO reported in the literature. The experimental results and comparison with other algorithms demonstrate that the proposed GABBO algorithm can be a proficient substitute lying on solving combined heat and power dispatch problems.

KEYWORDS
Biogeography, Cogeneration, Combined Heat and Power Dispatch, Evolutionary Algorithms, Genetic Algorithm, Migration, Mutation

1. INTRODUCTION
With sharp the rise in energy demand and resulting increased pollution, the issues of energy conservation and green power gained much attention to the researchers. Cogeneration or combined heat and power technology proves to be a promising alternative with its greater conversion efficiency than traditional generation method as it harnesses heat that would otherwise be wasted. Cogeneration is a sequential generation of two different forms of useful energy from a single primary energy source such as natural gas, typically electrical and thermal energy. The heat production capacity of most co-generation units depends on the power generated, and vice versa. The mutual dependency of multiple demand and heat–power capacity of those units introduces complexities in the integration of co-generation units into the economic dispatch (ED) problem.

Although a lot of works (Rooijers, & Amerongen, 1994; Guo, Henwood, & Ooijen, 1996; Song, Chou, & Stonham, 1999; Wong, & Algie, 2002; Su, & Chiang, 2004; Vasebi, Fesanghary, & Bathae, 2007; Piperagkas, Anastasiadis, & Hatzigiyyriou, 2011; Sudhakaran, & Slochanal, 2003;
Hosseini, Jafarnejad, Behrooz, & Gandomi, 2011) have been done in the field of cogeneration stating the objective of ED is to schedule the outputs of the online generating units so that the fuel cost of generation can be minimized, while simultaneously satisfying all system equality and inequality constraints.

Non-linear optimization methods, such as dual and quadratic programming (QP) (Rooijers, & Amerongen, 1994), lagrangian relaxation (Sashirekha, Pasupuleti, Moin, & Tan, 2013), gradient descent approaches, Lagrangian relaxation (LR) (Guo, Henwood, & Ooijen, 1996), were applied for solving combined heat power economic dispatch (CHPED) problem. However, these methods cannot handle non-convex fuel cost function of the generating units.

The advent of stochastic search algorithms has provided alternative approaches for solving CHPED problem. Improved ant colony search algorithm (ACO) (Song, Chou, & Stonham, 1999), evolutionary programming (EP) (Wong, & Algie, 2002), genetic algorithm (GA) (Su, & Chiang, 2004), harmonic search algorithm (HSA) (Vasebi, Fesanghary, & Bathaeae, 2007), particle swarm optimization (PSO) (Piperagkas, Anastasiadis, & Hatziargyriou, 2011), multi-objective PSO (MOPSO) (Wang, & Singh, 2008), self-adaptive real-coded genetic algorithm (SRCGA) (Subbaraj, Rengaraj, & Salivahanan, 2009), tabu search (TS) (Sudhakaran, & Slochanal, 2003), artificial immune algorithm (AIA) (Basu, 2012), direct search approach (DSA) (Hosseini, Jafarnejad, Behrooz, & Gandomi, 2011; Chen, Lee, Jan, & Lu 2012), harmony-genetic based heuristic approach (HGBHA) (Huang, & Lin, 2013), multi-objective CHPED algorithm (Niknam, Azizipanah-Abarghoee, Roosta, & Amiri, 2012), pareto based 0-self adaptive gravitational search algorithm (0-SAGSA) (Niknam, Bornapour, & Gheisari, 2013) were successfully applied to solve CHPED problem in the recent past. In (Geem, & Cho, 2012) a novel technique was proposed to consider the non-convex heat–power feasible region in the CHPED problem more accurately. Very recently, Haghrah et al. presented a real coded genetic algorithm with improved Muhlenbein mutation (RCGA-IMM) for solving CHPED of four different power systems problem. A comparatively new gravitational search algorithm to solve the non-convex combined heat and power economic dispatch problems was presented by Beigvanda et al. (Beigvanda, Abdi, & Scala, 2016). A cuckoo search algorithm (CSA) for solving CHPED problem considering valve-point loading effects on fuel cost function of power generation units and electrical power losses in transmission systems was successfully implemented by Nguyen & Vo (Nguyen & Vo 2016). A crisscross optimization (CSO) algorithm was implemented by Meng (Meng, Mei, Yin, Peng, & Guo, 2015) to solve the large scale CHPED problem. Basu, in his recent endeavor presented an opposition-based group optimization (OGSO) (Basu, 2015) to solve non-smooth non-convex CHPED problem. Grey wolf optimization (GWO) algorithm to solve CHPD problems of three different Standard test systems containing 4, 7, 11 and 24 units was successfully applied by Jayakumar et al. (Jayakumar, Subramanian, Ganesan, & Elanchezhian, 2016). Abdollahi et al. recently implemented An efficient decomposition-based optimization (DSO) (Abdollahi, Wang, & Lahdelma, 2016) method to optimize the hourly combined heat and power (CHP) production of multiple area power systems. However, the researchers found some drawbacks in the aforesaid methods. The PSO algorithm is highly susceptible to the initial value of weighting factor of the cognitive and social components, and weighting strategy of the velocity vector. The search ability of DE is highly determined by mutation factor (F) and crossover rate (CR). The algorithmic control parameters of CSA are the scale factor and mutation probability rate. Improper selection may lead to instability of power system.

The main drawback of most of these algorithm is the slow convergence towards the optimal solution. Moreover, the performance of most of the aforesaid techniques depends on the input parameters of the algorithms. If these are not properly defined, the algorithm may trap into local optimum value. From the literature survey, it may be observed that there is still scope to work with new optimization technique to solve CHPED problem.

Biogeography-based optimization (BBO) introduced by Simon et al. (Simon, 2008) is relatively a new, much simpler and more robust optimization algorithm compared to the many other well popular optimization methods proposed by past scholars. This inspires the authors to implement
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