# A Chaotic Firefly Algorithm Framework for Non-Convex Economic Dispatch Problem

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**Abstract**

The aim of economic dispatch (ED) problem is to provide an efficient utilization of energy resources to produce economic and secure operating conditions for the planning and operation of a power system. ED is formed as a nonlinear optimization problem with conflicting objectives and it is subjected to both inequality and equality constraints. An efficient improvement of firefly algorithm (FA), a powerful metaheuristic method, has been introduced in this paper. FA is a bio-inspired optimization algorithm that is inspired by flashing patterns and behaviour of fireflies in nature, it has been introduced for solving non-convex economic dispatch problem due to valve-point effects. The proposed chaotic firefly algorithm (CFA) improvement is done by incorporating the chaos approach to FA algorithm for raising the global convergence speed and for enhancing its performance. The results show clearly the superiority of CFA in searching for the best cost value results when compared with well-known metaheuristic search algorithms.

**Keywords:** firefly algorithm; chaotic maps; economic dispatch; valve-point effect

*Received*: Dec, 29, 2016

**To cite this article:**
Bachir Bentouati, Saliha Chettih, Ragab El-Sehiemy, "A Chaotic Firefly Algorithm Framework for Non-Convex Economic Dispatch Problem" in *Electrotehnica, Electronica, Automatica (EEA)*, 2017, vol. 60, no. 1, pp. 172-179, ISSN 1582-5175.

## 1. Introduction

In the last decades, planning and operation of modern power systems were more complex as result of the quick development of electricity demand, integration of networks and movement toward open markets in electricity around the world. The fundamentals of economic dispatch (ED) problem provides an optimum utilization of electrical power systems to produce economic and secure operating conditions for the planning and operation of a power system. Traditional ED has provided a tool to achieve such a task and has its first treaty as the cost of fuel only. Later, several technical and environmental targets were fused into the ED issue with the traditional economic objectives [1].

To optimize the objective functions, which include cost, the ED issue is dependent on two sorts of operational limitations. These limitations are recognized as equality and inequality constraints. The ED issue is a non-convex optimization problem, which requires huge computational effort if a large power system is considered. Essentially, the problem of ED is considered as static and non-linear that is the major operational functions of the innovative energy management framework. The approach of ED has gained more relevance in view of the increased availability of control devices and energy prices since its beginning point has demonstrated its efficiency in managing various issues.

Recently, different techniques were explored in the literature to unravel the ED problem, which had been studied for over 20 years and many algorithms had been created to solve it. Various conventional optimization methods [1] were produced to tackle the ED problem as lambda-iteration method, gradient-method, linear-programming-method and Newton's method. Conventional programming techniques are fast and reliable but often fail to have the best solution for solving highly complex non-linear objective function. While applying the classical mathematical techniques, a generating unit of the fuel cost trademark is assumed to be smooth and to possess convex functions. These techniques are sensitive towards initial solutions and may fail due to initial improper values of variables. The practical power systems are difficult to solve using these classical mathematical techniques as result of their nonlinear attributes of limited operating zones, valve-point effects, and piecewise quadratic cost functions. Therefore, an efficient strategy is highly required to deal with the non-convex, non-linear, and multi-modular power system problems. The drawbacks associated with these classical methods prompted the evolution of various artificial intelligence (AI) methods and their application to solve a practical ED problem.

Although in general AI methods do not ensure the global ideal solution, they can produce feasible sub-optimal solutions with less computational time. Several AI techniques, like genetic algorithms (GAs) [2], particle swarm optimization (PSO) [2], differential evolution (DE) [3], cuckoo search (CS) [4], bat algorithm (BA) [5], teacher-learner-based-optimization (TLBO) [6], harmony search (HS) [7], artificial bee colony (ABC) [2], grey wolf optimizer (GWO) [2], biogeography-based optimization (BBO) [8], and flower pollination algorithm (FPA) [9] are documented in the literature for solving practical ED problem. Some attempts reported the use of hybrid approaches for solving ED problems, such as hybrid differential evolution with BBO [10], hybrid swarm intelligence based harmony search algorithm [11], hybrid genetic algorithm approach in view of differential evolution [12] and PSO embedded evolutionary programming technique [13], etc., to find the