Residential Cogeneration System: A Multiobjective Optimization Design

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Abstract
The Combined Heat and Power (CHP), which is known as Cogeneration, is the simultaneous production of thermal and electric energies. This methodology allows the use of energy by optimizing the primary energy conversion into useful forms of energy, distributing the energy production and minimizing energy distribution losses. The Cogeneration has been increasingly implemented in industry units of large and medium dimension. Nowadays, in Portugal and in all Europe, the small scale CHP for domestic use is still in development being a paramount solution for energy systems located in urban areas.

The main objective of this paper is to design a small domestic unit of cogeneration in a pilot scale unit (<6 kWe), for single household applications. The unit is based on a micro gas-turbine and includes an internal pre-heater (typical of these types of small-scale units) and the usual HRSG (Heat Recuperator Steam Generator).

Firstly, the problem was formulated as a minimization problem. The objective function was defined as the total annual cost of operation of the system, subject to physics and thermodynamics restrictions, similar to that used in the design and optimization of large industrial cogeneration systems, the CGAM problem [1]. Despite difficulties in obtaining data for some of the components cost-equations, the model proved to be an invaluable guidance tool for the optimal design of this type of energy systems [2]. In this paper, the optimization of the adapted CGAM system has been formulated using a multiobjective approach.

The objectives have been defined as the maximum utility demands and the minimization of the annual total cost of the operation. The true Pareto-optimal solutions are found with a multiobjective genetic algorithm that employs an efficient variable encoding scheme and some problem-specific mutation and crossover operators. The information gained from the Pareto-optimal solution set is shown for all non-dominated solutions, from which the final decision can be made considering appropriate scenarios.

Keywords: Genetic algorithms, Micro-cogeneration, Multi-disciplinary project, Thermo-economic optimization.

References