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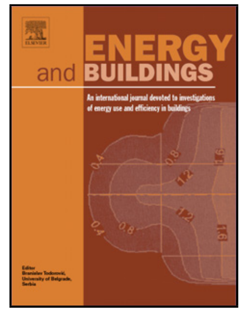

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Author: Facundo Bre Víctor D. Fachinotti

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A computational multi-objective optimization method to improve energy efficiency and thermal comfort in dwellings

Facundo Bre[a,b], Víctor D. Fachinotti[a]

[a] *Centro de Investigación de Métodos Computacionales (CIMEC), UNL, CONICET, Predio "Dr. Alberto Cassano", Colectora Ruta Nacional 168 s/n, 3000, Santa Fe, Argentina*
[b] *Grupo de Investigación en Mecánica Computacional y Estructuras (GIMCE), Facultad Regional Concepción del Uruguay (FRCU), Universidad Tecnológica Nacional (UTN), 3260, Concepción del Uruguay, Argentina*

Abstract

In the last years, multi-objective optimization techniques became into one of the main challenges of the buildings energy efficiency area. The objective of this paper is to develop and validate a computational code for multi-objective buildings performance optimization by linking an evolutionary algorithm and a building simulation software in a powerful cluster. A sophisticated version of the multi-objective Non-dominated Sorting Genetic Algorithm-II (NSGA-II) was implemented in Python code to determine the optimal building design, which allows working with categorical and discrete variables, and the objectives were evaluated using the building energy simulation software EnergyPlus. NSGA-II was implemented to run in a high-performance cluster for the parallel computing of the fitness of each population (set of possible designs). In this work, the strengths of the proposed method were demonstrated by its application to the optimal design of a typical single-family house, located in the Argentine Littoral region. This house has some rooms conditioned only by natural ventilation, and other rooms with natural ventilation supplemented by mechanical air-conditioning (hybrid ventilation). The most influential design variables like roof types, external and internal wall types, solar orientation, solar absorptance, size, type, and windows shading of this house among others were studied in two complex cases of 10^8 and 10^{16} possibilities to obtain the best trade-off (Pareto front) between heating and cooling performance. Finally, a decision-making method was applied to select one configuration of the Pareto front. Optimal simulation results for the study cases indicated that is possible to improve up to 95% the thermal comfort in naturally ventilated rooms and up to 82% energy performance in air-conditioned rooms of the building with respect to the original configuration by using a design that takes simultaneous advantage of passive strategies like thermal inertia and natural ventilation. The methodology was proved to give a robust and powerful tool to design efficient dwellings reducing the optimization time from almost 12 days to 4,4h.

Keywords: Multi-objective optimization, NSGA-II, Energy consumption, Thermal comfort, Hybrid ventilation, High-performance cluster application

1. Introduction

Today, Argentine electricity sector faces an emergency state since the operation reserve under extreme weather conditions is less than 5% of the available power, while the thermoelectric power plants (providing more than