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Influence of envelope design in the optimization of the energy performance of a multi-family building

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Abstract

In Europe, the recast of the Directive on the Energy Performance of Building and the consequent Zero Energy Buildings objective that has to be reached for all new buildings by 2020, lead designers to re-think building design as a complex optimization problem aimed at identifying the most effective strategies to improve building performance. These strategies can help reducing not only the climate change effect, but also the risk of energy poverty for low-income households.

This work is intended to apply a simulation-based optimization methodology for optimizing the energy performance of a multi-family building for social housing. The method combines the use of TRNSYS® with GenOpt®. A typical floor of a real case study was modeled and the impacts of the variation of several design parameters on the heating and cooling demand were assessed. The optimization lead to reduce the primary energy demand of a floor by 36%. The resulted differences in performance and energy rating between flats were analyzed.

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Keywords: simulation-based optimization; multi-family building; social housing; TRNSYS; GenOpt; particle swarm; sensitivity analysis; flats

1. Introduction

In Europe, the adoption of the recast of the Directive on the Energy Performance of Building [1] pushed Member States to establish new regulations with new minimum energy performance requirements. In the residential sector, improving the energy efficiency of new and existing multi-family buildings also constitutes a challenge for working

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against the risk of energy poverty for low-income households. In fact, it has been proved that financial problems may oblige people to consume less energy, leading to the incomplete satisfaction of their needs [2]. As reported in [3], it can be observed that during the financial crisis of 2007– 2012 in Europe, the energy consumption of residential buildings has decreased by 4%, while in countries with a deeper economic problem like Portugal, Slovakia and Ireland the corresponding decrease was 16%, 22% and 22% respectively. A recent study in Italy, estimates that between 5% and 20% of households was in energy poverty in 2012 [4].
Associated to this problem, it is important to consider also one of the possible effects of the climate change that may contribute in reducing heating needs, but increasing the summer cooling requirements of buildings. Within a more comprehensive approach towards the implementation of economic sustainability principles, it emerges the importance of considering the effect of the design strategies in the total energy demand of multi-family buildings and their related operational costs, even more so if addressed to low-income households. The use of tools able to evaluate and optimize the building energy performance by analyzing a great number of different design configurations is emerging as a powerful method for supporting this design process [5].

1.1. Scope of the work

The aim of the work is to apply a simulation-based optimization methodology, defined in [6] for a detached house and in [7] for a school classroom, to assess the potential reduction of the primary energy demand for heating and cooling of a multi-family building for social housing in Italy. The optimization process focuses on energy efficiency measures able to reduce the primary energy demand for heating and cooling of each flat. With the addition of the primary energy demand for DHW and ventilation fans, the work also evaluates the potential reduction of the primary energy demand for heating, cooling, DHW and ventilation fans (that will be named as “total” hereinafter) due to the optimization process. Lighting is not considered according to the Italian legislation on energy rating of residential building.

2. Case study

In order to study a multi-family building that is representative of recent social housing intervention in Italy, a real building located in Cremona was selected. Because of its features that are recurrent in similar buildings throughout Italy, the analysis can be potentially replicated in other Italian contexts.

It has a C shaped plan around a common inner courtyard. Each block has different number of storeys. The building has a concrete structure and a well-insulated envelope. External wall is made of bricks (30cm) and external thermal insulation (10 cm) with a U-value equal to 0.26 W/m^2K. Transparent surfaces are double low-e glass windows with metal frame, having U-value equal to 1.45 W/m^2K and a solar factor equal to 0.59. Some windows are shaded by external loggias, a typical feature of the Italian architecture.

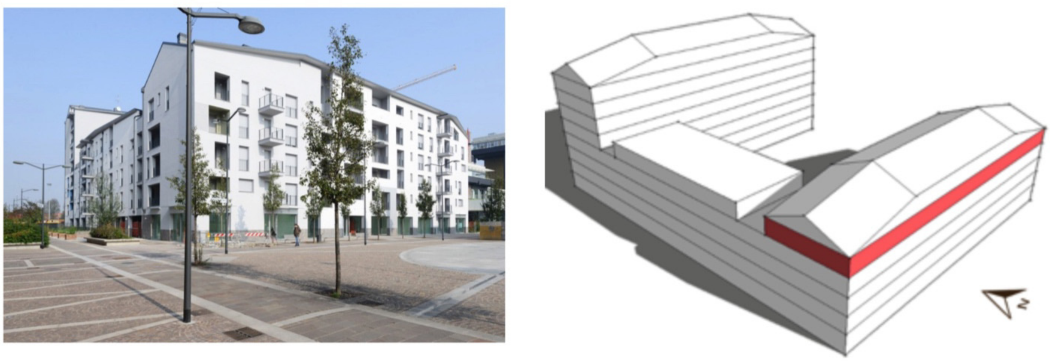

Fig. 1. The multi-family building, in red is the case study floor.