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Energy performance of an existing office building in the northern part of Italy: Retrofitting actions and economic assessment

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ABSTRACT

In recent years, the interest of the scientific community towards building energy performance has become more evident in order to meet the National and European Directives. In this context, retrofits that result in improved building energy performance are widely investigated. The paper presents a comparative analysis of two different and complementary strategies to enhance the energy performance of an existing tertiary building located in Bologna, Italy. The first retrofit action is to reduce the heat transfer by transmission (i.e. use of low-emissivity glass) and the second one is to decrease the ventilation losses (i.e. installation of a heat recovery system). Then a third case has been investigated: it contemplates simultaneously both the solutions of windows replacement and installing a ventilation recovery system. Potential energy savings were calculated by means of dynamic simulation assisted by Trnsys energy simulation tool. Finally, an evaluation of the simple payback time and the net present value was performed in order to investigate global cost assessment. The window replacement option in the analyzed building office proved to be absolutely unprofitable, even if it would appear as the first and simplest action to be performed. On the contrary, the installation of a total energy recovery system resulted in sensible reduction of energy consumption and at the same time generated good values of NPV with reference to all the three different analyzed variation of the cost of energy.

1. Introduction

The building sector accounts for around 40% of energy demand in the European Union and 32% in the world (Khatib, 2012). Member States of the European Union are required to implement energy efficiency measures for buildings under two Energy Performance Building Directives: Directive 2002/91/EC (European Parliament, 2002) and Directive2010/31/EU (European Parliament, 2010),shortly EPBD and EPBD recasting. While the first directive was more focused on methodologies and new buildings, the second is giving more importance to the existing buildings not only when subject to major renovation but also when building technical elements and/or technical systems are retrofitted or replaced. After the EPBD and the EPBD recasting entered into force, member states have shown an increased interest in interventions aimed to obtain energy saving in existing buildings. This resulted in an explicit article on building renovation in the Energy Efficiency Directive 2012/27/EU (European Parliament, 2012). The above mentioned EU Directives came into effect in Italy through the Legislative Decree no. 192/2005 (Legislative Decree, 2005) and no. 311/2006 (Legislative Decree, 2006). Therefore building energy retrofitting is a key-strategy to achieve tangible results in reducing energy consumption, but such opportunity has to be managed carefully (Mazzarella, 2015; Mauro et al., 2015).

A multi-stage methodology has been developed in Mauro et al., 2015 in order to investigate the implementation of energy actions for the retrofitting of buildings. The effect of these actions on primary energy consumption and global cost are explored in order to meet two main objectives: cost optimality and evaluation of effectiveness regarding the current policies of invectives. For demonstration, a case study of an existing office building located in South Italy has been presented by means of SLABE methodology, “Simulation based-large-scale uncertainty/sensitivity Analysis of Building Energy performance”. Ref. Chenari, Carrilho and Gameiro da Silva (2016) recounts a review of scientific research and reports, as well as regulations and standards, which evaluated, investigated and reported the development of energy-efficient methods for ventilation in buildings. The analysis carried out in Ref. Ciampi, Rosato, Scorpio and Sibilio (2015) is applied to an existing office building supposed in five different countries (among which Italy); the evaluation tool consisted of a new energy cost optimization procedure based on a sequential-search optimization technique. In Ref.

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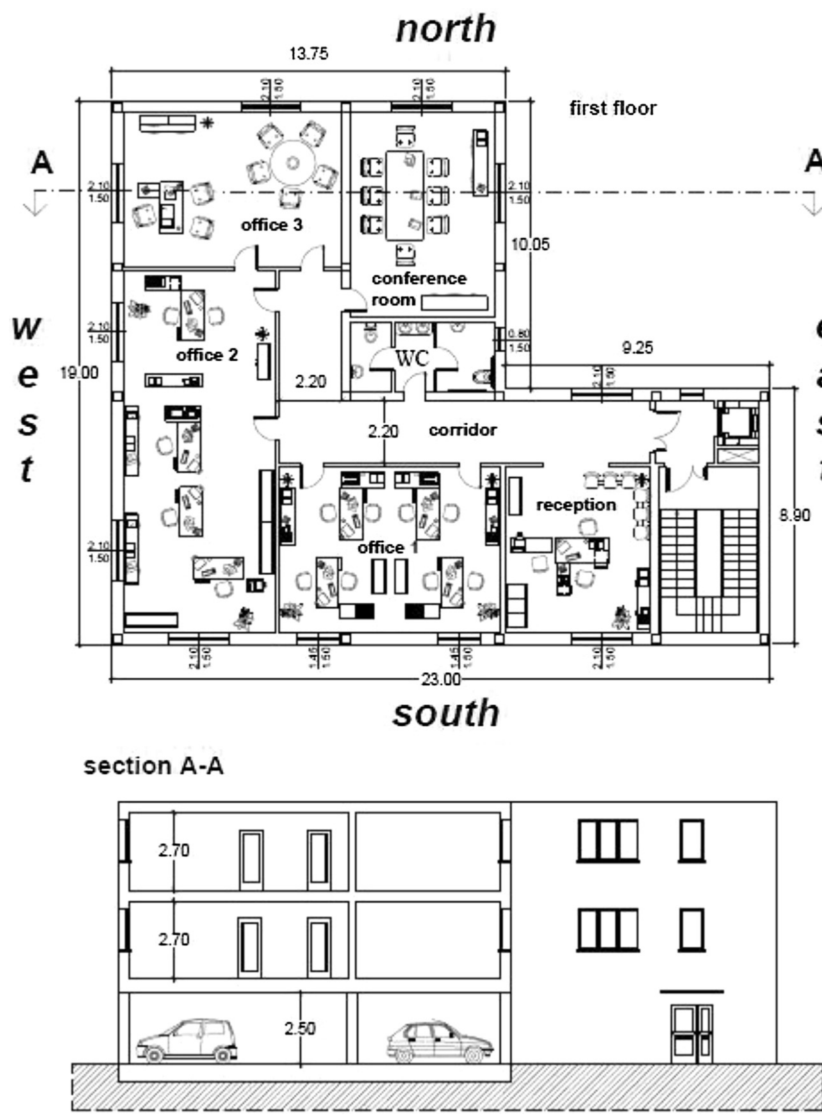

Fig. 1. Plant and section of the office block.

Aste, Caputo, Buzzetti and Fattore (2016), the monitoring and analysis process is presented referring to the case of Lombardy Region (northern part of Italy) that provided subsidies in order to test innovative design approach and technologies of great impact within the topic of energy efficiency in buildings.

In the present work, a numerical study regarding an existing office building has been carried out developing some retrofitting solutions. The paper presents a comparative analysis of two different and complementary strategies to enhance the energy performance of an existing building located in Bologna, Italy. The first retrofit action is to reduce the heat transfer by transmission (i.e. use of low-emissivity glass) and the second one is to decrease the ventilation losses (i.e. installation of a heat recovery system). Then a third case has been investigated: it contemplates simultaneously both the solutions of windows replacement and installing a ventilation recovery system. The simulations were conducted by means of the Trnsys commercial code dividing the building office under investigation in 16 zones and a simulation time step of 15 min. Trnsys (Solar Energy Laboratory, 2012) is an extensible simulation environment for the transient simulation of energy systems including multizone buildings. It is used to validate new energy concepts, design and simulation of buildings and their equipment, including control strategies, occupant behavior, and alternative energy systems (wind, solar, photovoltaic, hydrogen systems, etc.).

2. Description of the building under investigation

The numerical model has been applied to an office building, located in Bologna (Italy). The construction, shown in Fig. 1, is a three-storey building having heated offices on the first and second floor and parking lots on the ground floor (not heated). The heat loss surface area of conditioned space is 1110 m^2, whilst the net heated volume is 1440 m^3; the total area of the building facade is 500 m^2 and the windows area 70 m^2, it means that the ratio of transparent to total envelope surface for vertical walls is 14%. The total net floor area of the two offices (heated area) is 534 m^2; each floor is composed by one reception, three offices, a conference room, a corridor and a toilet. Table 1 illustrates the surface of the main heated rooms as well as the net floor area of the entire office.

Table 2 highlights the characteristics of the building envelope (between the heated offices and the unheated spaces).

The heating and humidification system is composed by the following fundamental components: a boiler powered by natural gas as generation subsystem, a net of pipes as distribution subsystem and fan coils as emission subsystem. It is supposed to operate 14 h