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Energy retrofit of historic buildings in the Mediterranean area: the case of the Palaeontology Museum of Naples

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Abstract

This paper aims to identify some optimal system solutions for the energy refurbishment of a specific historic building, through energy simulations in dynamic conditions performed with a suitable software. The analysis is carried out by the evaluation of energy requirements of the building, in terms of both primary and electric energy. The hypotheses of intervention regard only the air conditioning system components and take into account the existing architectural constraints. The case study refers to the Palaeontology Museum of Naples (Southern Italy), whose rooms are currently in a historic building located in the ancient centre of the city.

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Keywords: Historic buildings; Case study; Energy refurbishment; HVAC systems; Simulation software.

1. Introduction

Nowadays, one of the main topics of discussion regards the energy consumption, as well as the related natural resources exploitation and pollutants emissions.

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In Europe, the greatest impact on the total energy requirements is given by the building sector, which is responsible of about 40% of the final energy consumption.

The EU-27 reports that in Europe there are 160 million buildings, but only 1-1.5% of them can be considered new buildings and about 14% date back to before 1919 [1]. Therefore, most of the buildings present poor energy performance and consequently high energy consumptions and relevant pollutant emissions. This implies that it is necessary to plain and carry out suitable energy retrofit measures of existing buildings, by applying various techniques.

It has been demonstrated [2,3,4] that it is possible to obtain satisfactory energy requirement reductions even by simply applying some innovative and non-invasive surface finishes.

Other researches [5] have instead addressed the problem of thermal bridges, which in the specific case were treated with insulating vacuum panels.

Some authors [6] have shown, specifically for office buildings, a suitable way to identify an effective thermal insulation for Mediterranean climates, both technically and economically.

A category of existing buildings characterized by high energy consumption is represented by historic buildings. For them, energy retrofit actions are more complicated because of architectural and artistic constrains that often oblige to preserve the integrity of the buildings. In Italy, there are many historic buildings, which are currently used for different functions, both in the public sector, such as offices and universities, and as private residences. With reference to this category of buildings, some authors [7] have evaluated the benefits produced by innovative integrated systems, which do not spoil the aesthetic appearance of the building, such as special tiles with high insulation properties. In the perspective of a sustainable future, it has been evaluated [8] the contribution obtained with the green retrofit applied on historic buildings.

Some research papers refer to real historic buildings. A historic building located in Benevento (Southern Italy), "Palazzo Bosco Lucarelli", administrative headquarter of the Engineering Faculty of the University of Sannio, was examined by some authors [9,10] using a multidisciplinary approach to optimise both the structural behaviour under seismic action and energy retrofit measures.

Another building in the city of Benevento, "ex-INPS" building, has been analysed to determine the correct approach to be adopted for the energy renovation of a historic building [11]. The innovative "cost-optimal" approach has been applied for energy retrofit of Palazzo Penne, a fifteenth century building located in Naples [12].

In Franco et al. [13], the best solutions to achieve high energy performance in view of a possible re-use of the building have been analysed for the "Albergo dei poveri", an abandoned building sited in Genoa (Northern Italy); also the possibility of including energy production systems from renewable sources has been considered.

This paper analyses the energy refurbishment of a historic building used as a museum, for which there is an increased degree of difficulty due to the nature of the elements contained in these structures: sometimes, the artworks exhibited in museums require specific temperature-humidity conditions for their preservation, and not always such conditions are compatible with the occupant thermal comfort.

In Bellia et al. [14] the best thermal conditions for the artworks conservation in the exhibition halls have been analysed. Through a multidisciplinary approach, in [15] suitable guidelines for simultaneously obtaining optimal conservation, energy efficiency and human comfort in museum buildings have been proposed.

Some research studies have also been carried out on real museums. With reference to the "Salone dei 500", a museum hall located in the "Palazzo Vecchio" in Florence, in Balocco and Grazzini [16] the authors verified the possibility to reach the ideal thermo-hygrometric conditions using mobile platforms with integrated radiant panels.

In Rota et al. [17], the authors in collaboration with the "Musei Senesi" Foundation have defined solutions to improve the museum energy efficiency with both active and passive systems.

In this paper, a real historic building, used as Palaeontology Museum of Naples (Southern Italy), is analysed to improve the indoor thermal-hygrometric conditions and reduce energy consumption of the air conditioning systems. To this aim, a software tool is used to carry out building energy performance simulations in dynamic conditions. Some possible different modifications of the air conditioning systems are analysed to minimize the energy requirement. The existing architectural constraints do not allow the energetic improvement of the building envelope.