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HVAC solutions for energy retrofitted hotel in Mediterranean area

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Abstract

To meet the European targets for achieving high-performing buildings, the refurbishment of the existing building stock and, in particular, of historical buildings represents a great challenge.
The research aims at identifying the most energy-effective HVAC configuration for retrofitting historical hotels in Mediterranean area, where the objective is to minimize the consumptions for both space heating and cooling. A Reference Building for an historical hotel was simulated in five Mediterranean cities and different HVAC solutions were assessed, using EnergyPlus software coupled with tools specifically set to emulate the energy behaviour of certain HVAC technologies, aiming to highlight the most efficient alternative.

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Keywords: energy retrofit; energy efficiency measures; HVAC systems design; hotels; Mediterranean climate.

1. Introduction

Energy security and climate changing make it necessary to improve the global energy performance, especially in the

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construction sector, where the high levels of energy consumption and greenhouse gas (GHG) emissions are a strong challenge. In this context, European Commission's Roadmap established that GHG emissions in buildings must be reduced by around 90% by 2050 compared to 1990 levels [1]. The most immediate and effective way of achieving this target is through a combination of cutting energy demand through increased energy efficiency of the buildings and systems and a wider deployment of renewable technologies.

Consequently, European legislation set out a cross-sectional framework of ambitious targets for achieving high-energy performances in buildings. The recast of the Directive on the Energy Performance of Buildings (EPBD) defined that all new buildings will be nearly zero-energy buildings by the end of 2020; this represents a real step-change to the current way of designing the building, from both architectural perspective and technical systems side, including HVAC. Furthermore, the EPBD Recast strengthened the focus on existing buildings, considering the low annual growth rate of new constructions, mainly due to the consequences that the financial crisis had on the construction sector. Moreover, a large share of European buildings stock was built before 1960s, when there were few or no energy efficiency requirements and only a small part of these was subject to energy retrofits [2]. Since surely the oldest part of the buildings contributes greatly to the high-energy consumption in the sector, it is evident that the largest energy saving potential is associated with existing buildings.

Nevertheless, the wide variety of existing buildings, which may differ in age, dimensions and location, does not allow having a unique approach to the problem. Another particular case is the one of historical buildings, which must be dealt case-by-case [3]. Historical buildings can be defined as buildings having important artistic value and historic significance. Therefore, retrofit interventions must be carefully defined and designed for the existence of historical or architectural constraints, with attention to maintain their historic physical integrity. In this sense, planning authorities and other organizations may restrict the type of renovation that can be undertaken. However, historical buildings cannot be excluded from energy renovations: according to the Building Performance Institute of Europe, "there will always be some energy efficiency measures that can be applied, even if it is not a total renovation" [2]. The problem of refurbishment of historical buildings is also due to the lack of defined European plans. Indeed, generally, special national or local laws protect historical buildings and any retrofit action must get permission from the local planning authority, which typically consults the national Cultural Heritage agency. Accordingly, any energy retrofit must be authorized by these competent authorities, which aim to preserve the existing identity of the building [3], often requiring the use of existing materials in the retrofit and the preservation of the external building envelope.

The increasing interest toward historical buildings and their energy issues led many researchers to develop and propose retrofit actions able to combine architectural heritage and energy efficiency. Ciulla et al. [4] express the need to find the most applicable retrofit actions and understand whether these retrofit plans are effectively able of reducing the energy needs of historical buildings. Currently, this theme is absolutely challenging for architects, engineers and owners. The present paper fits in perfectly with this challenge, analyzing which are the possible efficiency measures that can be implemented in existing historical hotels in Mediterranean area. This area presents a rich cultural and historical heritage, in line with the objectives of the research field. Furthermore, the Mediterranean region is one of the most visited tourist destination areas in the world and this justifies the choice of the hotels as case study for the research. The analysis of energy consumption of accommodation structures is a topical issue, since the United Nations General Assembly approved the adoption of 2017 as the International Year of Sustainable Tourism for Development [5]. In the non-residential sector, hotels are ones of the most energy-intensive buildings, since these structures must provide services to guests and guarantee their internal comfort. Coming to numbers, in 2005 the contribute of tourism sector was estimated to 5% of global CO_2 emissions and the breakdown among sub-sectors highlights that the accommodation sector causes more than 20% of the total emissions, ranking third behind plane and cars transports [6]. Nevertheless, in the accommodation sector the high GHG emissions permit high potential for improvement, representing an interesting research topic.

Furthermore, the issue of building energy performance in Southern Europe and in Mediterranean climates is taking on increasing prominence in recent times. Indeed, it is well known that in the European framework the issue of low consumption buildings was initially addressed in the Northern countries, where the control of thermal loads in heating periods is fundamental and where the external climate conditions make the free cooling with external air possible. On the contrary, in Mediterranean area, the great design challenge is to minimize the energy consumption for both heating and cooling; depending on climate areas and conditions, these loads can be comparable or the cooling needs in summer may prevail. Consequently, the scenarios to face are extremely different, based on climate conditions; in the countries