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Energy functional retrofitting of historic residential buildings: the case study of the historic center of Perugia

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Abstract

The built heritage is characterized by an average low energy performance, but it is often excluded from studies and retrofit scenarios. In Italy, as in Europe, the building sector is the most energy consuming and pollutant. Italy accounts for 40% of the European historical heritage, which is not concerned by the building performance legislation. The description and the analysis of the residential building stock is the object of this work, presenting an overview of the historical typologies built since the XII century. The case study is the entire historic center of Perugia. A major step was to choose a qualitative methodology that combined together four main approaches in order to categorize the all ancient buildings in the old town: (1) historical documentation and municipal documental information (2) in situ investigation; (3) surveys to the occupants; and (4) infrared thermography. The first approach allowed to identify five typological archetypes while the subsequent steps allowed to define sub-typologies relatively to energy performance. The knowledge of the characters of the old manufactured buildings is crucial to improve the energy efficiency of the built heritage.

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1. Introduction

The building sector shows a large potential for saving energy. Buildings use around the 40% of total EU energy consumption and generate almost 36% of greenhouse gases in Europe [1, 2].

Since we must find a way that can help to decarbonize the environment through the minimization of the energy consumption, the great challenge seems to be the retrofit of the existing buildings. In Italy approximately 70% of the buildings (data based on ISTAT Census 2001) were built before the release in

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1976 of the first law establishing limits for the energy consumption in building sector [3] [4]. Moreover, around 85% of this stock consists of buildings continuously occupied, indicating the large potential in energy conservation for residential sector.

In order to improve the building's efficiency, the European Commission launched the first Directive on building Energy Performance - 2002/91/EC - shortly named as EPBD [5] and transposed and implemented in Italy by the Legislative Decree 192/2005 [6]. Since this first Directive took greater account of the new buildings, which are a minor part compared to the built stock, it has been launched the second Directive - 2010/31/UE - [7] implemented in Italy one year later with the Law 90/2013 [8]. The provisions of this law do not apply to all buildings that fall under the regulations of Part Two and Article 136, paragraph 1, letters b) and c) of Legislative Decree 22 January 2004 n. 42 of the Code of cultural heritage and landscape (Article 3, paragraph 3) [9]. This means all Italian historical centers are in derogation from law. In some cases in order to protect the aesthetic-historical value of the worth constructions technological measures for retrofitting are not applied or when applied they might be inappropriate and undermine the cultural heritage preservation.

In response to this conflict, the present study aims to develop a methodology which classify the historic stock constructed until the second World War, and therefore mainly pre-industrial. The methodology aims to estimate the energy performance of buildings in order to simulate suitable refurbishment scenarios in a future study. The research had two different target: the primary objective was to carry out an overview on general and recurrent typological archetypes at district level. The second target is focused on the energy categorization of the archetypes in sub-typologies that already received energy refurbishment measures in the recent years.

It will be shown which are the single best technologies eligible for the energy efficiency of ancient buildings without compromising their historical, artistic, architectural value, with the aim of simulating suitable - even if basic - recovery scenarios.

Many studies have debated the method for evaluating the energy performance of a built settlement and considered strategies with the aim to improve the energy efficiency of heritage building stocks. Fracastoro and Serraino [10] focused their work on Italian realty and proposed an analytical procedure for the "Statistical Distribution of Residential Buildings" (E-SDOB), applicable at regional or national scale. Hrabovszky-Horvath et al. [11] based their bottom-up methodology in order to simplify building type upon a non-real building documentation.

Fabrizi et al [12] have integrated GIS with geometrical census data and with a cadastre of a numbered certification reported on the SACE DATABASE, in order to perform study and simulation on the whole tissue of the historic city center of Ferrara.

Far fewer are the studies dedicated to address the issue of the retrofit in built heritage. This is due to a mismatch. In fact, all buildings that have turned 50 are classified as historic [13]. Not all the historical buildings, however, have an aesthetic, historical or architectural prominence: they are classified as historical only due to the factor's age.

This paper basically differs from those aforementioned for because only pre-industrial buildings were considered and was used a mix of top – down and bottom – up methodology. General real data of old urban tissue detected from the technical Department of municipality were summed up in five main typologies. The survey revealed that the total number of residential buildings in the historic center of Perugia is 1,889. In the following section the analysis of architectonic typologies of the historic city center of Perugia, concerning the preliminary phase about data retrieval, the energy inventory's executive phase [14] of the entire building stock will be discussed.

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