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Deploy energy-efficient technologies in the restoration of a traditional building in the historical center of Catania (Italy).

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Abstract

The policy about energy efficiency of buildings, including minimum energy requirements and energy performance certificate (EPC), have to be also applied to existing buildings in the case of energy retrofit. In this paper, the possible strategies that can be used to reduce the energy needs of traditional massive buildings, that are widespread in the old town of the Mediterranean cities, have been investigated. To this aim, this study evaluates the energy consumption of a massive building placed in Catania city, called "La Casa del Portuale", which was recently refurbished with the aim to host two local administrative centers. The energy needs of this building was evaluated through computer simulation both in the heating and cooling period, on a yearly basis. The activities research were developed analyzing different refurbishment solutions suitable to improve the thermal performance of most traditional buildings without adversely affecting their fabric and character. Therefore, the feasibility comparison has been performed between the examined refurbishment solutions. The results of the proposed research , considering the diffusion of this typology of buildings, could be assumed as reference to a significant portion of the traditional real estate.

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1. Introduction

The BLUE Map scenario is predicated on strong policies to accelerate energy R&D, deploy energy efficient and low/zero-carbon energy technologies and put a value on CO_2 abatement.

Fifty percent of the buildings sector energy savings in the BLUE Map scenario [1] come from space and water heating, cooling and ventilation. Most buildings have long life spans, meaning that more than half of the current global building stock will still be standing in 2050. In this context, it is fundamental identify practical solutions for energy efficiency renovation of historic and traditional building stock. Historic buildings are the trademark of numerous European cities, historic centers are a living symbol of the rich cultural heritage of our cities. Thereby, they are precious and need to be protected. Restoration projects have to allow the buildings to continue to function in terms of maintaining ventilation and moisture permeability, whilst retaining historic character and minimizing the visual impact of the changes. Therefore

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a restoration project must be seen as an opportunity to make use of traditional construction systems as a tool for revitalizing and conserving historical city centers, and for promoting a new building model with sustainability as the centerpiece of architectural restoration [2]. The criterion of sustainability, as part of the restoration project should be pursued with moderation and prudence, to avoid excessive invasiveness. Therefore, it is appropriate to proceed with broad freedom in the replacement and renovation of the building elements, while more caution should be given when the modification of the elements of the factory as a whole and in the morphology of the spaces. Anyway, freedom of expression should be commensurate both with the needs dependent on the intended use and the other to the aesthetic, which must always be at the center of the design.

Mediterranean traditional building envelopes have good thermal inertia, but given their poor thermal insulation, they are usually exhibit high thermal losses. Several studies have investigated the energy performance of heritage building [3], [4]. Reducing buildings' energy consumptions is a task that has guided several researchers for continuously improve the energy refurbishment strategies and to develop adequate simulation tools [5], [6]. Other interesting theme is the exploitation of renewable energy sources (RES) in the built environment [7], [8] and their building integration. In this study, two targeted actions were evaluated: one action on the building envelope and the other one focused on the air conditioning system. The first action is focused on the upgrade of the thermal insulation of the building envelope with the aim to reduce both of the energy demand for heating and cooling. The second action is based on the renovation and the optimizations of the current energy production systems with the goal to increase its overall efficiency. Subsequently the financial analysis of the technological solutions designed was evaluated in order to assess which of them is the most effective.

2. Methodology

The energy uses that have to be considered in assessing the energy performance of the building are those related to heating (H), cooling (C), production of hot water (W), ventilation (V) and lighting (L). Electricity for household appliances is not included in the current scope of the EPDB [9].

The energy consumption will be normalized with reference to the net surface or the net volume of the building; a year is the period of time to be used to make all the energy balances. As concerns renewable energy sources (RE), only on-site contributions can be considered.

Finally, specific primary energy (PE) is the indicator used for making the balance between energy uses and renewable energy production.

As a consequence, the following expression holds:

$$PE = \sum_{year}(PE_H + PE_W + PE_C + PE_V - PE_{RE}) \quad (1)$$

The result of Equation (1) shall not be positive in order to center the target of Net-ZEB buildings. PE can be expressed both in ($kWh \cdot m^{-3} \cdot y^{-1}$) or ($kWh \cdot m^{-2} \cdot y^{-1}$), if the net heating volume (V_n) or the net heated surface is used (S_n). Q_H and Q_W are the annual thermal energy demand respectively for space heating and heat water production (kWh) while Q_C is the annual cooling energy demand (kWh).

The other terms are calculated as follows:

$$PE_H = Q_H/\eta_H \cdot V_n \quad (2)$$

$$PE_W = Q_W/\eta_W \cdot V_n \quad (3)$$

$$PE_C = Q_C/V_n \quad (4)$$

η_H = annual fuel utilization efficiency of the thermal energy plant for space heating (%)
η_W = annual fuel utilization efficiency of the thermal energy plant for heat water production (%)

Specifically, η_H and η_W are respectively the ratio of the annual thermal energy demand for space heating or for heat water production, compared to the total annual fossil fuel energy consumed by a furnace or