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Original article

The energy performance improvement of historic buildings and their environmental sustainability assessment

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ABSTRACT

The changes in present world oblige the scientific community working on Cultural Heritage to face every day more urgent challenges of “sustainability”. This concept refers to a very broad horizon, touching various spheres: cultural, economic, social, environmental, before the purely technical and energetic ones; the terms deal, in fact, with a sustainable process of conservation, renovation, reuse and management of historical architecture, where the assessment methods could play a key role, even in the early stage process. The assessment of the environmental sustainability of historical buildings may help to recognize potential ways of enhancement. This is the main content of the article, showing results of a multi-disciplinary research on a representative case study, the huge historical complex of the *Albergo dei Poveri* of Genoa (XVII–XIX Century), which will be completely restored and reused as a university campus. To highlight the increasing value of a smart renovation, the sustainability of the energy solutions has been analysed verifying how a good rating can be obtained, within the early design process, in the energy performance sectors. The outcomes allow to show that better results can be reached in the environmental sustainability certification by means of added actions not strictly needed, but allowed. A proposal of a methodological approach to the sustainability evaluation for historic building renovation is the main result of the investigation. A relevant step of the assessment is represented by the comparison of the obtained scores with calculated reference scores that do not correspond to the absolute maximum values. This approach helps to individuate the fields in which higher global scores can be reached by planning smart renovation actions. The results allow also to highlight some aspects of the procedure application that can be improved for a more appropriate use of sustainability rating systems for this particular kind of heritage.

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1. Research aims

The research deals with the application of sustainability assessment procedures on historic buildings, to highlight how their smart energy renovation can fit also the sustainability principles, and how the assessment of the environmental sustainability of historical buildings, in an early stage of the energy improvement design, may help to recognize potential ways of enhancement.

This approach is new in the field of conservation, restoration, and reuse of Cultural Heritage, as it is not subdued to laws or regulations to limit their energy consumption or to control the renovation process and material sustainability.

Even if a new rating system for the historic buildings has been introduced in 2013, showing the increasing interest on these buildings, it does not appear suitable for an early stage of the refurbishment project. Therefore, the sustainability procedure, indicated by regional legislations for the other building typologies, has been chosen for the application to a large historic monumental complex.

Taking into account the preservation, the constraints, and the respect of the historic value, some actions to reduce energy needs have been considered and evaluated in terms of sustainability. These actions, here referred specifically to the case study, represent a set of general interventions in the management process of historical architecture.

The present investigation deepens some preliminary results [1], and outlines a proposal of a methodological approach to the sustainability evaluation for the historic building conservation and renovation.

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2. Introduction

Sustainability and *Heritage* represent two terms that more and more frequently are put beside, as Cultural Heritage, tangible and intangible, is not only seen, nowadays, as a product of a specific site or society, but is strictly linked to the general principles of sustainable growth, in a larger perspective opened also by international entities.

Nevertheless, numerous conflicts emerge while considering traditional architecture as an occasion for the future sustainable growth. Cultural Heritage may be seen a repository of valuable reusable resources and their integrated conservation can extend the active life in reasonable future economic conditions. However, historical architectures are at the same time non-renewable resources and, therefore, the interventions should be able to cope with specific conflicts of interests, so that the achievement of new requirements for modernisation do not alter intrinsic values of the historical heritage.

The concept of sustainability here proposed, with particular reference to the process of conservation and management of Cultural Heritage, refers to a very broad horizon, touching various spheres: cultural, economic, social, environmental, before the purely technical and energetic one. It is not just a simple matter for economic or social sciences, neither a purely investigation on suitable technical answers to questions concerning ecological footprint, energy efficiency, environmental behaviour of industrial products or building techniques. It is a crucial question for every human activity, even concerning the destiny of our inheritance.

The relation between *Sustainability* and *Heritage* is often reduced to the mere energy efficiency of the buildings, simplifying a complex problem into the exclusive item of energy saving. Consequently, technical innovation remains still largely a process of the application of products and technologies. This often leads to a greater emphasis on the technical components that do not correspond to effective cultural advancement. Neither do they improve the capacity to assimilate and modify the technology to achieve higher long-term objectives [2].

As an example, even if the contribution to reduce energy consumption may be not significant [3], the growing interest given to the energy efficiency could increase also the attention to renewable energy adoption in historical contexts and valuable landscape. The support of renewable energy sources is often difficult to be considered, as their impact on the ancient structures may be not allowed, even if, in some cases, also photovoltaic systems have been incorporated in old structures [4], effectively supporting the energy-efficiency improvement [5].

Guidelines for improving the energy performance of historic buildings are the subject of a new European Standard [6] “aiming at facilitating the sustainable management of these buildings by integrating measures for energy improvements and reduction of greenhouse gas emissions with the adequate conservation of the buildings”, by means of a systematic approach, that anyway “does not presuppose a need for energy improvements in all historic buildings”. The common interest to give the same regulation for all the European historic buildings demonstrates the particular attention on this problem and the importance of a shared procedure for selecting appropriate measures to improve the energy performance.

The environmental sustainability of historic buildings is evidently becoming a new challenge: many researchers were asking how to best sustainably preserve this part of our cultural heritage, in the absence of any standard approach [7]. In the last years, in the field of the building sustainability, the lack of standard methods by which to assess the historic buildings is slowly coming to a resolution.

Within this framework, the assessment of environmental sustainability of historical buildings, in an early stage of the energy improvement design, may help to recognize potential ways of enhancement. This approach is specifically the aim of this work, which methodology consists in the application of the more suitable assessment method (after a comparative investigation among several ones) and which main results consist in the critical discussion of outputs, opening to new horizons in the planning procedure that, until now, do not consider at all this specific aspect. This specific application followed a general feasibility study on the whole architectural complex, aimed to identify the best and more compatible intervention (passive and active), even including a new plant system in co- and tri-generation.

The United States Environmental Protection Agency considers the preservation of historic buildings as an important part of a smart growth approach [8]. The International Code Council, a non-profit U.S. organisation born in 1994 to provide codes regarding safety and performance of the built environment, indicates means for the preservation of historic buildings subduced to repair, alteration, relocation and change of occupancy, in a specific chapter of its International Existing Building Code [9].

In Europe, after the national transposition of the European Directive 2002/91/EC on the building energy performance, some local governments have given indications on an appropriate balance between building conservation and measures to improve energy efficiency in historic buildings [10].

The Green Building Council, one of the international organizations that promote sustainability protocols, is developing the GBC Historic Building™, a new rating system to combine the criteria of the International LEED® standards and the specific needs of the historic buildings restoration [11].

Researches on the integration between the energy retrofit of historic buildings and the urban sustainability goals are the subject of the 3ENCULT (Efficient ENergy for EU Cultural Heritage) European Project, finalised to develop a comprehensive, strategic, integrated and effective approach to best utilize these buildings as vehicles for sustainable development at local community level [12]. Other European research projects regard the sustainable refurbishment of old cities, even if often “old” buildings refer to representative constructions, dated before 1945, not necessarily protected by heritage legislation (i.e. the EFFESUS project, “Energy Efficiency for EU Historic Districts’ Sustainability”).

3. Methodology

The Environmental Sustainability protocols are promoted by international organizations such as USGBC, BREEAM, iiSBE etc.

The US Green Building Council (USGBC) has, as its purpose, the promotion, and the development of a comprehensive approach to sustainability, giving recognition to virtuous performances in key areas of human and environmental health. Its methodology, LEED, is a system of certification of buildings, born on a voluntary basis and applied in more than 140 countries worldwide [13] in five fields: Building Design and Construction, Interior Design and Construction, Building Operations and Maintenance, Neighbourhood Development and Homes.

The Green Building Council promotes the LEED methods in Italy through GBC-Italia that has recently realized the GBC Historic Buildings procedure for the environmental sustainability assessment of historic buildings, mainly built for the Italian historic heritage, but with wider international potential application [14,15]. Two specific criteria are considered: the Historical Value and the Design Innovation to satisfy the need to apply principles of sustainability also to architectural conservation, maintenance, or renovation. The certification process involves new figures as a

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