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Towards a systematic approach for energy refurbishment of historical buildings. The case study of Albergo dei Poveri in Genoa, Italy

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SUMMARY

The article deals with the main problems arising during the sustainable renovation process and energy refurbishment of historical architecture. In particular, it focuses on the feasibility study for a huge historical listed building, aiming at its progressive and complete re-utilization as university campus, respectful of the many cultural values of which it is the depository. The complex of the 'Albergo dei Poveri' was built in Genoa between the late seventeenth century and the middle of the nineteenth century, as a monumental structure for charitable purposes. Given its size and location in the heart of the city, it still represents an important urban structure and a great opportunity for urban renewal, even though it is actually almost completely abandoned. Main aim of the research is the definition, from a methodological and technical point of view, of feasibility studies in order to submit the historical monumental heritage to a process of 'energy efficiency' and 'energy production', even recurring to the most suitable technologies supplied by renewable energies. In this paper, a preliminiary approach and general criteria for the building refurbishment, in relation to the architectural and historical commitments, are presented.

1. Introduction

Numerous conflicts emerge while considering traditional architecture as an occasion and object of experimentation, as historical buildings are at all non-renewable resources and therefore the interventions should be able to cope with antithetic interests, so that the achievement of new requirements for modernisation do not alter intrinsic historical values.

The preservation of historical heritage and the enhancement of its energy performance represent, in fact, a combination that is often seen as in conflict. The delay with which the Cultural Heritage sector as a whole faces today the theme at the base of this item is due, of course, to many different reasons. The specificity of historical architectural heritage, the reasons for its safeguard and conservation, procedures and regulations have taken technological innovation away from the concept of architectural restoration, both at the academic and professional level and public action.

Recent research experiences, as well as the growing interest by experts in conservation to the issues of energy efficiency, and the ability to insert renewable energy sources in historical contexts and valuable landscape are, hopefully, rapidly reversing the point of view, and enriching the prospects of action. Experts in Cultural Heritage preservation, in fact, are facing the subject of environmental technologies more slowly than others, and can play a key role in bringing the debate and the research out from a purely and reductively technicism. Restorators, working together with experts in building energy efficiency, can introduce a serious awareness of the many implications that the issues raised are for the present and future human living environment, placing in the foreground, in addition to energy saving, heritage protection and safeguard and suggesting the search for new forms of compatibility between conservation and innovation.

The energy renovation of historical buildings is, in fact, subdued to the same restrictions as repairs, additions, physical alterations, needed to allow their reuse. Each action must be approved by the Cultural Heritage official body that guarantee the protection of the historical features.

On the one hand, actions are needed for renewal or replacement of windows, insulation of external walls, floors and roofs, to reduce energy consumption, on the other hand, the same design practice and criteria that apply to newer buildings cannot be adopted in all cases.

The requirement of management expenses reduction must be balanced by the need to maintain an acceptable indoor comfort, considering all the different aspects of the IEQ (indoor environmental quality), that are influenced by the design solutions [1,2].

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Due to the increasing needs to find the best methods for the renovation of historical buildings, some researches suggest procedures based on the analyses of indicators to take into account historical, architectural, but also economic, social and other elements with the application of multi-criteria decision-making methods [3].

However, the local context characteristics, needs and limitations make their application very difficult in a generalized way.

2. Methodology

Following these considerations, it is even necessary to loose some of the technical bonds, in order to overcome the segmentation of competences, which up until now have been at play in this sector, moving from inter-disciplinarity to trans-disciplinarity and adopting a real holistic attitude, not reduced to mere intuition or imponderable expertise of the single researcher.

The management of any restoration/renovation process of existing buildings and especially of large monumental complexes, in fact, poses evident and difficult challenges as compared to new constructions.

The research project focuses on the historical buildings of the city of Genoa, UNESCO heritage, and it intends to propose a model, exportable to other urban contexts, both for the definition of a methodological framework and for the technical content that it intends to develop.

The experimentation in course on the complex of the 'Albergo dei Poveri' of Genoa, chosen as a representative case study, offers many opportunities for reflections, as it can be considered as a resource rather than a mere and difficult (or un-solvable) problem.

The work aims at defining a strategic plan for the complete reuse of the case study, based on a clear vision of its future as a fundamental part of the town, so that its recovery would be a great operation of cultural and planning importance.

For dimensions, location and importance that the complex will play at the urban level, as well as for the many topics of research and experimentation that it offers, especially in trans-disciplinary relationships, the study can become paradigmatic for other experiences. In fact, the expected results from the research program will certainly be a model or a kind of "best- practice" potentially replicable in other similar urban contexts.

Specifically, taking into account the experience of the local academic scientists and designers involved and the proposals of some recent researches, the study on the energy performance enhancement of the historical architecture has been organised in the following steps [4–6].

Step 1. Site analysis on the historical complex chosen as case study: environmental, morphological and constructive features. Data acquisition and collection (recurring to GIS and BIM technology) to perform calculation of its energy behaviour and enhancement.

Step 2. Building energy modelling and validation of the calculation: energy audit and identification of energy demand for its future use (in the actual state). Validation of the model through comparison with the real energy consumption of a small part of the complex already restored and in use.

Step 3. Smart management of historical architecture by the way of the energy performance enhancement: identification of the most suitable technologies for thermal insulation, compatible with the safeguard of historic values, and calculation of energy gains. This process leads to define guidelines for future possibile interventions, highlighting, since early stages, the real problems linked to technical feasibility.

Step 4. Analysis of efficient power generation solutions: evaluation of the possibility to install co- and tri-generation systems along with others powered from renewable sources aiming at an autonomous energy production and consumption, then adding, for the first time, the historical–monumental heritage in a wider system of intelligent networks at the service of the local University.

The importance of energy modelling for post-occupancy analyses has been significantly increased by the Energy Performance Building Directive recast (EPBD 2010/31/EU [7]), which remarks that buildings account for more than one third of total European annual energy consumption. Therefore, the importance of refurbishment has been growing in relation to the potential energy saving of existing constructions, which can be obtained through appropriate Energy Conservation Measures (ECM).

Simulations can reproduce more or less accurately the actual behaviour of buildings, and allow evaluating the real effectiveness of different ECM; therefore, they are a strategic tool for the renovation design process.

The quasi steady state approaches provide for quite reliable results with a simplified model in a short time and with a sustainable use of resources (economical and time-consuming). Therefore, they could be worthy applied during the preliminary phase of the refurbishment project, to assess the energy saving of ECM and to select the more effective ones.

In the following, the preliminary studies on the energy restoration feasibility are considered referring to the four steps and first considerations are presented. They will be more deeply analysed in a further development of the study.

3. Step 1 – Site analysis of the case study

Following the desire to create a place of universal charity for the city of Genoa, in the early decades of the seventeenth century the noble Emanuele Brignole decided the foundation of a new 'reclusory' based on the segregation of poor and diseased people, divided for sex, age, social status and physical health. In this place, also thought to ensure a better control and internal order, compulsory work was intended as an instrument of spiritual salvation and, at the same time, self-sustenance.

This was the genesis of the design and construction of the Albergo dei Poveri in the Carbonara valley. Its architectural features and its organizational structure reflect the ideas of Genoese politics and welfarists, mainly those of Emanuele Brignole, who, from the date of August 27th 1656, when the contract for the new building was signed, dedicated his entire life and his capital to create the Albergo.

The choice of the site was effective: it was located between old and new city-wall system, a place that appeared morphologically very steep and therefore unattractive for real estate speculation, with the presence of water (Rio Carbonara, a little river that discharged water in the harbor) and fresh air. Last, but not least, the ground was made up of rocky land from which artisans could obtain building material, reducing significantly the cost of construction.

The soil of the little valley was thus a source of water supply and of products of the cultivation of the land, contributing to the livelihood of the patients, an economy that today we might call 'zero kilometre'. The most important figures who worked on the project were, according to some sources, the architect Stefano Scaniglia, Gio Battista Ghiso and the director of the works, Geronimo Gandolfo [8].

The most important steps of the construction of the Albergo date between 1656, year of the complete acquisition of land, and 1696 during which the east and north wings were completed. The building was ended in 1832 with the construction of the west wing, reduced in comparison to the original project (Figs. 1–3).

The monumental complex occupies a total surface of about 60,000 m^2 and has a plant and a volume partly differing from the first project, due to a series of economic, technical and operational