VARIABILITY AND MODULARITY FOR ENVELOPE RETROFITTING STRATEGIES: A COMPARATIVE EVALUATION OF THE ENERGY PERFORMANCE FOR MULTIPLE DESIGN AND TECHNICAL SOLUTIONS

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Summary

Energy efficiency in housing is more than a technical problem, since the quality of dwellings deeply influences the identity of a city or neighbourhood. Nowadays a greater attention is given to energy conservation, efficiency in buildings and sustainable design, which also result in the increasing need for technological solutions able to generate energy--efficient improvement in the existing building stock.

The energy building retrofitting strategy here proposed aims at tackling the problem of energy retrofitting, by a combination of innovative instruments and tools.

The methodology framework is based on the comparative analysis on the performance of multiple envelope solutions that have been tested and combined in different building types in the case study of a large urban district, the Corticella neighbourhood in the north of Bologna. This on going experimental project involves social participation of dwellers in the retrofitting activities; the Architecture Department of Bologna University is working together with the Department of Sociology and Building Physics to set up a direct and active cooperation looking for socio-sustainable solution that can also determine an effective improvement in the energy performance of the buildings' envelopes. Several design options have been studied for the existing buildings, proposing a structure for expansion and adds-on to be added in different time and space, according to the different users' needs or requirements, exploring the potential links between technologies and urban dwellers in particular contexts of use [1]. The "Abacus" of possible technologies represents a potential innovative tool collecting all the different design options and determining, for each option, the evaluation in terms of energy performance improvement, cost estimations, cost-benefit analysis, social preferences' indicators. Keeping into account the high degree of variability of the different contexts and buildings asking for energy renovation, it is suggested to apply a different, integrated approach; the here proposed design research study suggests a multiple and modular system allowing customised and tailored solutions, which would ensure a higher level of adaptability, durability and efficiency. Notably, some of Europe's leading innovation Nations have included user-driven innovation as a way of providing innovative products and services that correspond better to user needs [2]. Thus, the proposed methodology intends to incorporate in the design process specificities of both building type and users' needs, searching for the solution that best fit within the specific

social and environmental context (tailored *retrofitting*), by neglecting the use of universal and over imposed solutions and accepting the variability and indeterminacy of flexibility and adaptability, in a longer term retrofitting scenarios.

Keywords: retrofitting, energy efficiency, building rennovation, sustainability, adaptability

1 Introduction

Energy efficiency in housing is more than a technical problem. The sort, quality and the variety of dwellings define for a great part the identity of a city or neighbourhood. In other terms, building energy retrofitting may represent a great opportunity for a formal revision of existing buildings, by addressing different issues and improving the built environment.

Within the frame of social housing sector, many experiences have highlighted the coincidence between low quality and high-energy management costs, often associated to the deterioration of both buildings and urban contexts [3]. Thus, promoting energy improvement measures for social housing is an urgent and challenging objective [4]. The opportunity for interventions to reduce energy costs must also be considered in terms of renovation and valorisation of buildings, which are corresponding key benefits. In fact, operating a mere energy retrofitting on individual residential units or building blocks in urban contexts in severe degradation conditions may imply a depreciation of the same retrofitting actions; in other terms, it can be said that energy retrofitting in the context of social housing has a strong influence on the quality of the built environment that can not be ignored since they have the potential of a key added value in terms of social, technical and economical feasibility [2]. The necessary integration between the need for retrofitting and the opportunity to assume a wider rehabilitation process scenario have found a pilot experiment in the energy retrofit design of the public residential district in Corticella PEEP (Bologna); within this urban context a reference building has been used to test and compare four possible energy retrofit options. For each residential unit, the analysis of the possible conversions and the consequent impact of each solution have been performed.

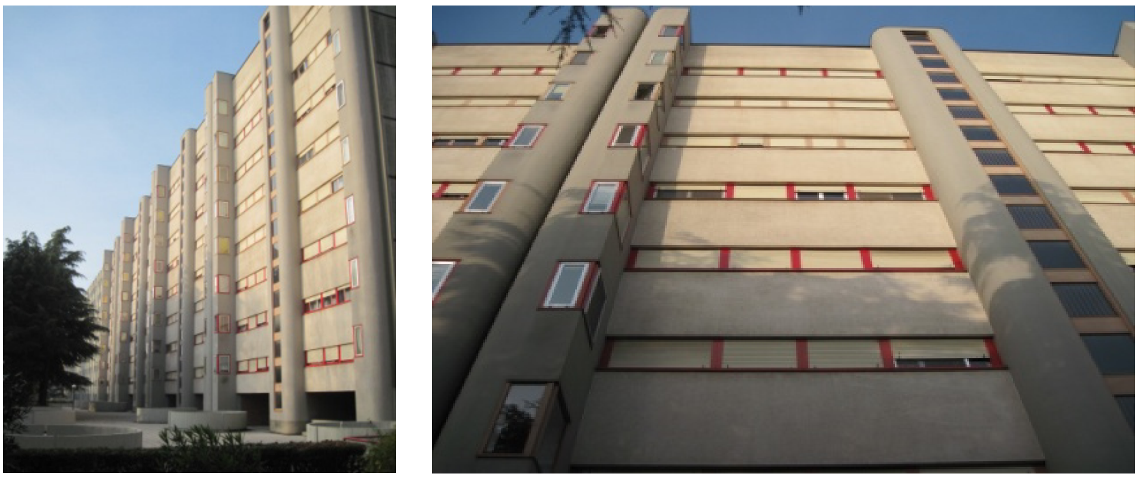

Fig. 1 *The reference building in the Corticella urban district*

2 The energy retrofit design

In brief, the proposed retrofitting options for south oriented facades contemplate: (1) standard insulation of opaque walls and windows replacement, (2) addition of a loggia, (3) construction of a sunspace, (4) new closed and insulated adds-on (extra room).

As far as the north orientation concerns, the types of intervention consider the following two possibilities: (1) standard insulation opaque walls (initial U value = 2,137 [W/m²°K] designed U value = 0,22 [W/m²°K]) and windows replacement, (2) closure of the existing lodge. The energy retrofitting scenarios have proved to be unsustainable economically, with high pay-back times which vary from 8–9 years (standard insulation, fig. 3) to 25 years (Fig. 4, 5). The effective transformation of the building in more complex scenarios, however, has suggested the possibility to promote further changes in volume increase, to reduce pay back times of energy retrofitting options. For this reason, in the last phase of the design process eight additional flats as a roof extension on the existing building have been inserted as further option to compensate high costs of all the considered scenarios in the retrofitting of the building (Fig. 6).

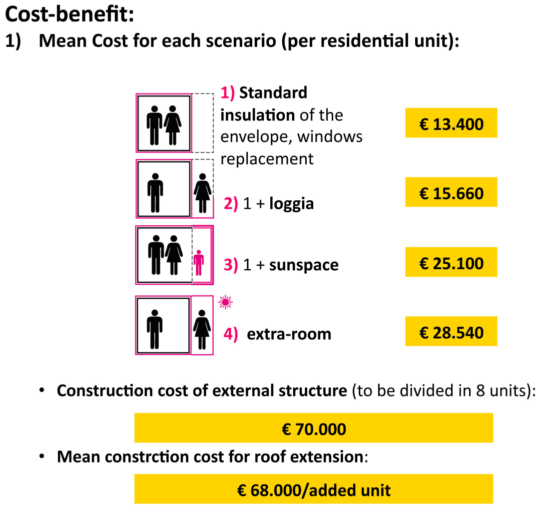

Fig. 2 *Cost analysis for each different option in the energy retrofit of the reference building*

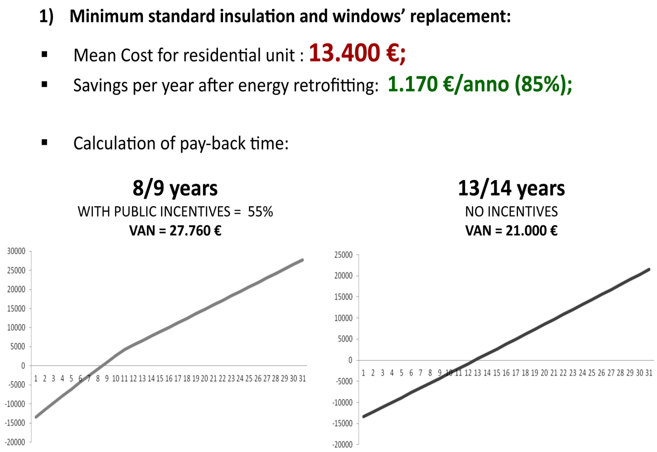

Fig. 3 *Cost-benefit analysis for standard insulation*

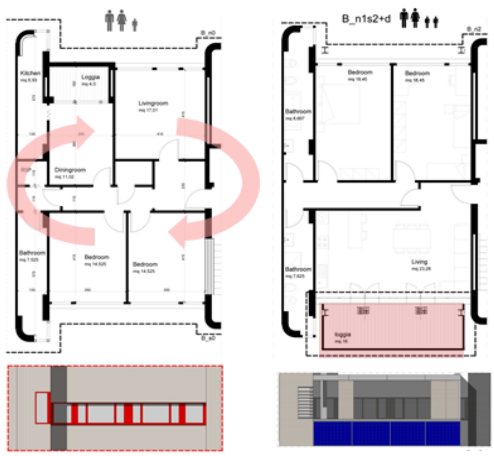

Fig. 4 *Addition of a loggia (option 2) as one of the possible options in the south façade of a residential unit*

The technical feasibility of the roof extension can take advantage of the wooden construction techniques, statically compatible to the lightness requirements for new structure to be added in existing pre-fabricated concrete building block.

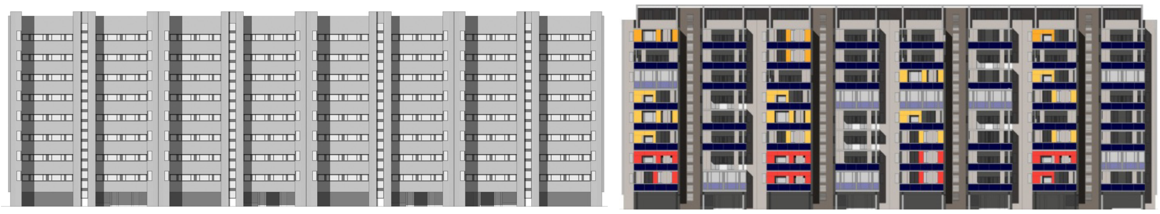

Fig. 5 *South façade before and after the retrofit*

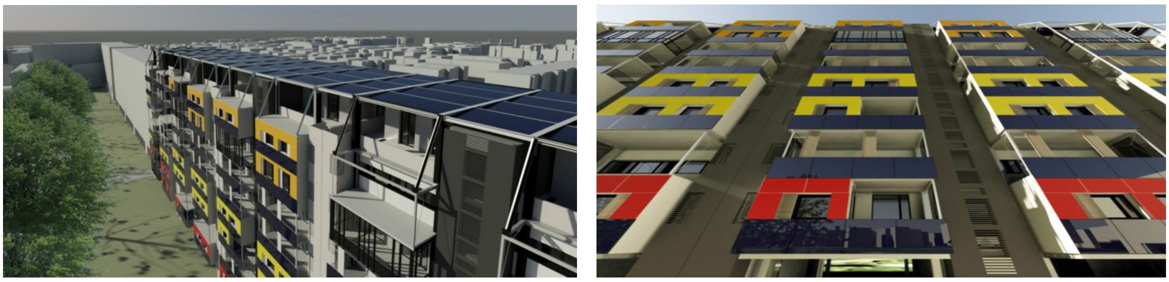

Fig. 6 *Roof extension (left) and adds-on (right) in the south façade of the building after renovation*

3 Conclusions

The proposed design study and the performed technical-economical evaluation demonstrate that energy efficiency in residential urban complex can be considered as an extraordinary opportunity to restore environmental, social and urban quality. The techno-economical feasibility assessment, the proper identification of the types of intervention and their combination in possible scenarios must be investigated and estimated on a case-by-case basis, with an effective and interdisciplinary design approach integrating in a whole system the socio-technical aspects into the feasibility study of economical and architectural issues.

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