THE ENERGY AND ENVIRONMENTAL REQUALIFICATION OF POST-WAR HOUSING: PROBLEMATICS AND INNOVATIVE SOLUTIONS FOR THE BUILDING ENVELOPE

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Summary

Since a large part of European building stock – which was made before the 70's in the absence of specific rules with regard to the energy performance of building envelope – has serious weaknesses concerning comfort and healthy indoor air, the field of investigation research, based on a cooperation agreement between the DASTEC Department of Reggio Calabria, and the OTB Delft, is aimed at the study of housing built from 1945 to 1970. The choice was determined by the substantial presence of buildings of that period in the two national contexts taken into account – in Italy it represents 36.8 % of the total and in the Netherlands the 27 % (Dol, Haffner, 2010) – and by the awareness that these buildings present many problems related to poor performances of the technical and constructive elements. Furthermore, it is useful to underline that the new building activities are a decreasing percentage in the actions of transformation of European cities, compared to a progressive increase of the existing buildings renovation, which has become the driving force for the construction sector. Recently residential investment has collapsed in some countries at the same time as, or immediately before, the onset of the financial and economic crisis (Andrews, D., A. Caldera Sánchez and Å. Johansson, 2011). The Working Group "Sustainable Construction Methods and Techniques", of the Architects' Council of Europe, meeting in Brussels in 2003, affirmed that *"it is much harder implementing the sustainable renovation than the sustainable new building and, moreover, that the scientific research hasn't been appropriately addressed towards the definition of guidelines and tools for sustainable renovation"*. In recent years, there has been an increasing interest in the improvement of the quality of the housing stock that do not meet the modern preferences of urban households and do not have sufficient level of quality. Consequently to the pressing need of requalificating the public and private residential stock, it should be noted that despite it is absolutely necessary to launch the appropriate renovation actions, the current tools of both technical and procedural kind are totally insufficient and/or inadequate in almost all European reality (Van der Bos, Meijer, 2005).

Keywords: Energy retrofit, indoor air quality, building envelope

1 Performance characteristics of post-war housing

1.1 The residential buildings and the demographic boom of the post-war period

The period of construction of buildings is a very important data for the assessment of residential heritage because it allows to define the technical and structural characteristics and the relative levels of thermal-physical performances. However, the quality level is also closely related to the possible recovery activities that buildings have undergone over the years. The significant population growth that occurred in the post-war period led to an exceptional increase in the buildings production, especially the residential ones: the need to respond quickly to the pressing and growing housing needs caused, in those years, the proliferation of buildings that satisfied demands of purely quantitative kind, with little attention to the levels of overall quality of construction. The residential buildings built in that period are characterized by poor quality construction techniques that result in considerable loss of heat, thermal bridges, moisture from condensation, mold problems, air and water infiltrations. In particular, it emphasizes the low level of performance of the building envelope, characterized by elements and technological systems with high thermal transmittance, both as regards the opaque surfaces that those transparent, as well as by heat losses due also to the large presence of thermal bridges. The data on the levels of energy consumption relating to the buildings show, on the basis of the reference values of the thermal transmittance of the materials of which is made the building envelope, that the constructions of the '60s, for example, are much more inadequate than those of the previous decades, from the point of view of the thermal insulation (BPIE, 2011). Such poor energy performances are also due to the lack of specific rules: in fact, these were a consequence of the 1973's oil crisis. In fact the data analyzed (**Fig. 1**) show that the components of the building envelope carried out before the introduction of such rules are characterized by a very high U-Values (Eurima, 2005).

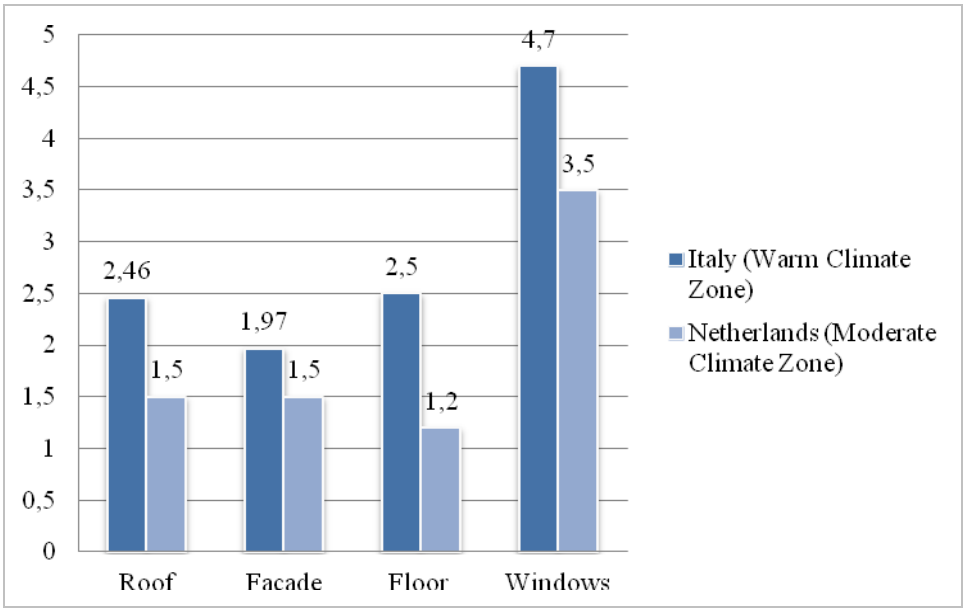

Fig. 1 *U-values in W/m²K of building components before 1975*

1.2 Final energy consumption in residential buildings

In the last twenty years, there has been a gradual increase in energy consumption of European buildings, accounting for about 40% of the total consumption of primary energy. It must be pointed out that a large part of the European building stock was built before the 70's, in the absence of specific rules with regard to thermal insulation of the envelope and its energy efficiency and it also presents serious weaknesses concerning comfort and safety conditions of the indoor environment. The dwellings, which account the 75 % of the existing buildings, cause the majority of energy consumption in this sector: in 2009, accounted for 68 % of total final energy consumption in buildings (BPIE, 2011) and 27 % of total energy consumption. The energy consumption for heating in winter and cooling in summer is the most significant component of total consumption of housing and it varies according to the design features of the buildings, to the performance levels of the technical elements of the building envelope and to the reference climate region.

The figure (**Fig. 2**) compares the data on final energy consumption of Italian and Dutch dwellings, in relation to the different types of fuels used, their percentages and trends in the last two decades. In Europe, the Netherlands is the country with the highest percentage of natural gas consumption of the dwellings (73 % in 2008) and a very limited consumption of oil, in Italy, instead, in the period between 1998 and 2008 , there was a reduction in the consumption of petroleum products and an increase in the use of natural gas and of renewable energy sources (Eurostat, 2009).

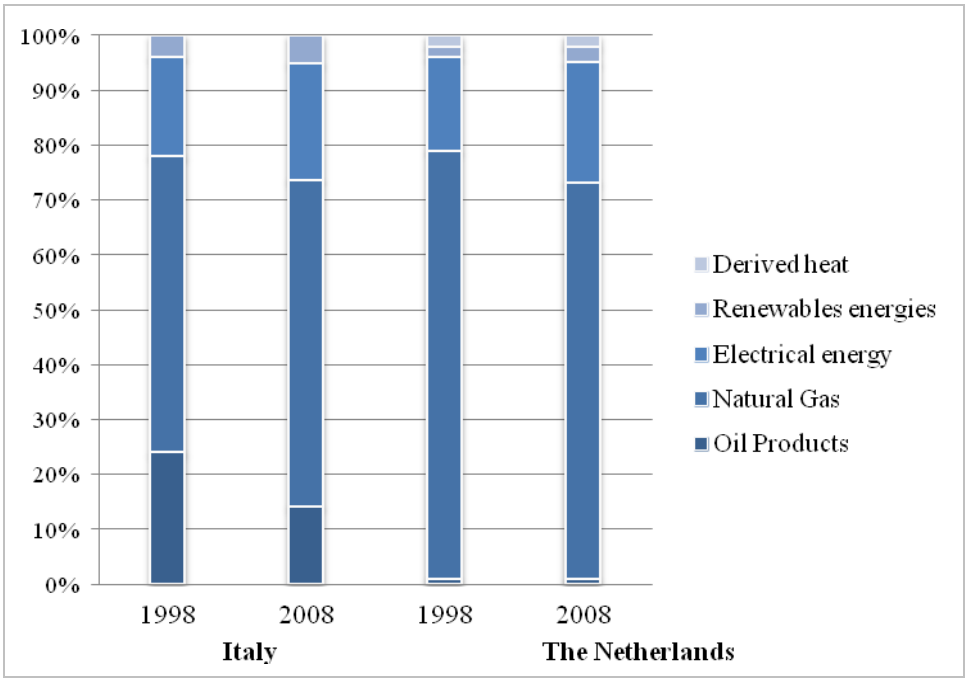

Fig. 2 *Final energy consumption in households, by fuel*

2 The requalification of the building envelope

2.1 The control of the building envelope performances

The performance of the existing buildings are related to a series of factors such as the material and technical characteristics of the building envelope components, the efficiency of heating and air conditioning, climate conditions and user behavior (BPIE, 2011). The building envelope is the frontier element between indoor and outdoor environments: it adjusts the flows of energy, the relationship between the building and the environmental system and establishes its forms of environmental and energy control.

The energy consumption for heating, which is the preponderant part of the total consumption, is connected to the heat balance of the buildings, namely the heat losses through the building envelope elements, ventilation and air infiltration and to the heat gains through the radiation solar (Itard L., Meijer F., Vrins E., Hoiting H., 2008). In some cases, the deterioration of the materials and the absence of appropriate maintenance actions aggravate the problems of thermal inertia of the building envelope with consequent increase of energy consumption for heating and cooling the indoor environment.

In relation to the energy issue, it is estimated that for the management of buildings with inadequate levels of energy performances requests a very high consumption, which could be reduced as much as 50 % through appropriate renovation interventions.

At the European level, the Energy Performance of Buildings Directive (EPBD, 2002/91/EC) defines, among other things, the minimum requirements about energy return of already existing buildings subject to important renovations. The Directive has been recast in 2010 (EPBD recast, 2010/31/EU) with more ambitious provisions.

The Art. 7 of the "Directive 2010/31/EU on the energy performance of buildings" related to the existing building, defines that *"Member States shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements so far as this is technically, functionally and economically feasible. Member States shall in addition take the necessary measures to ensure that when a building element that forms part of the building envelope and has a significant impact on the energy performance of the building envelope, is retrofitted or replaced, the energy performance of the building element meets minimum energy performance requirements".*

2.2 The innovative solutions for the building envelope.

The overall quality of a building is related, above all, to the technological characteristics of the building envelope which is "complex functional element" that has the task of ensuring an effective balance between indoor and outdoor environments. The overall quality of a building is related, above all, to the technological characteristics of the building envelope which is "complex functional element" that has the task of ensuring an effective balance between indoor and outdoor.

In recent decades, the evolution of technology has led to the progressive changes in the structure of the material of the building envelope, increasing performance and complexity, giving to designers a wider range of possibilities in the constructive choices. Although the possible technical solutions that can be applied in case of redevelopment are very numerous and also extremely innovative and flexible, the designer has to confront both with a series of recommendations regarding the fulfillment of the complex regulatory

system that imposes indispensable constraints and both with the level of adaptability of the technological solutions with the existing buildings.

The majority of modern buildings is characterized not only by low levels of energy performance and by the presence of a high technological degradation but even by a large "manipulability" that prefigures numerous scenarios of intervention both from a technical and formal profile, unlike of the historical architectures in which the building renovation is limited by constraints of cultural and historical importance. Such freedom to change the original structures orients the choice towards interventions that enhance the formal and expressive qualities of products and systems, including those of innovative type, aimed not only to implement the energy performance of the building but also to improve the architectural appearance.

Since the energy and environmental performances are related to the heat balance of buildings the redevelopment of the existing buildings is often achieved by the juxtaposition and/or replacement of functional layers concerning the external walls. The "recladding", a new discipline, is oriented to meet the characteristics of each requalification intervention, regarding the conditions of the existing buildings, of the available budget, but, above all, with respect to the performance targets. In particular, there is a type of strategy called "re-fitting", aimed at the improvement of the energy performance through the partial replacement of non-appropriate elements or the juxtaposition of systems such as brise--soleil, photovoltaic panels and so on. In this context, also, there are numerous initiatives of study and research about the ventilated facade hybrid solar collection: the evolution of the ventilated wall, from an element of passive control to an active system for capturing and converting solar radiation, capable not only of improve the interior comfort but also to convert solar energy into electricity and heat.

2.3 A case-study: Poptahof in the Netherlands

In the Netherlands it is possible to individualize a lot of residential buildings which have undergone energy requalification. Among these, Poptahof is a social neighbourhood, built in 1964 in Delft: the urban renewal programme consists in the demolition of some buildings and in the refurbishment of the eleven-storey blocks.

The strategies applied are of "replacement" type: it was done the demolition of existing facades because, due to the cold climate and the high energy demand for heating, it was necessary to replace them with technological solutions that would ensure thermal transmittance values such as to ensure the achievement of energy standards more ambitious than those provided for new dwellings.

The strategies for building renovation of Poptahof have taken into account seasonal differences in the Dutch climate: in winter it is necessary to reduce energy demand for heating, moreover sky is often cloudy and passive solar gains are of poor usefulness; in summer the indoor overheating must be avoided. The specific goals are the following:

- energy requalification of 200 apartments in order to achieve the national standards set for new dwellings;
- installation of a 10 kWp PV system on the southern façade of one refurbishment apartment building (**Fig.3**);
- replacement and implementation of the heat distribution system;
- connection of the heating systems, at low temperature, to the district heating infrastructure of recovery of the residual industrial heat.

Fig. 3 *PV system on the southern façade of a apartment building in Poptahof*

3 Conclusions

Although it is difficult to outline the scenario of this century, given the numerous internal and external variables related to economic and political scenarios, it can be assumed, however, that the renovation will continue to grow to meet the needs of improving the quality of a big part of the building stock. It follows that the renovation of the housing stock, especially those related to energy retrofit, as well as ensure the standards imposed by the current reference standards, should take into account aspects related to indoor air quality, both in terms of elimination of the degradation factors and in terms of utilization of materials and technical solutions capable of ensuring healthy indoor environments.

The current innovation in the sector of the building envelope is oriented towards the implementation of systems and components that offer a wide range in terms of performance, functionality and aesthetics. The re-cladding, applied to existing buildings, is emerging as an intervention strategy quickly, economically viable and that guarantees high performance standards.

References

[1] AA.VV., (2007), The image project new tools for neighbourhood regeneration 2004 to 2007, Schiedam, Delft.

[2] Andrews, D., A. Caldera Sánchez and Å. Johansson (2011), “Housing Markets and Structural Policies in OECD Countries”, OECD Economics Department Working Papers, No. 836, OECD Publishing. http://dx.doi.org/10.1787/5kgk8t2k9vf3-en.

[3] BPIE, Buildings Performance Institute Europe, (2011), *Europe's buildings under the microscope*.

[4] Dol, K., Haffner, M. (2010), *Housing Statistics in the European Union 2010*, OTB Research Institute for the Built Environment, Delft University of Technology.

[5] Laure Itard, Frits Meijer, Evert Vrins & Harry Hoiting, (2008), "Building Renovation and Modernisation in Europe: State of the art review" ERABUILD.

[6] Van der Bos, A., Meijer, F. (2005), "Existing housing stock: how to improve the building quality?", Proceedings of the 4TH Triennial International Conference Rethinking and Revitalizing Construction Safety, Health, Environment and Quality, Port Elizabeth, pp. 528–543.

[7] Zappa A., (2011), "*È tempo di re-cladding*" in Costruire n. 339 – Settembre 2011".