Energy rehabilitation of social housing for rent, as demonstrator in the LIFE "New4Old" Project

Abstract: *The main goal of the cofounded by the European Commission LIFE Project, New4Old (LIFE10 ENV/ES/439), is to define the most appropriate method and the best available practice in social housing rehabilitation with energy and environmental sustainability criteria, as well as to apply innovative technologies in the fight against climate change through an efficient use of resources and energy. The institutions involved in the Project are the Technological Centre AITEMIN, Madrid Polytechnic University (UPM), Portugal Technological Centre for Ceramics and Glass (CTCV) and the Zaragoza City Housing Society (SMZV).*

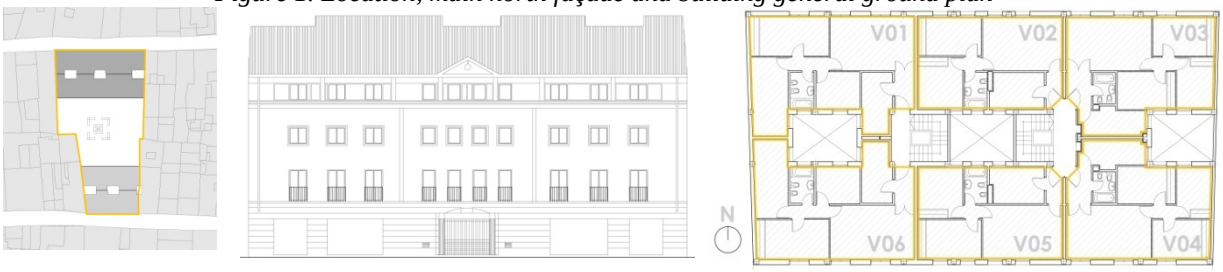
The demonstrator project consists in the energy rehabilitation of a rental social housing building located in Zaragoza's historic quarter, according to the conclusions and strategies developed for the LIFE project. In actions taken in households of this nature passive design strategies are essential due to the limited income of owners, who often cannot afford energy bills. Therefore, the proposed actions will help improve the building's passive performance and reach a higher thermal comfort, without increasing the economic cost linked to energy consumption.

Keywords: Energy retrofitting, Energy Efficiency, Passive Design, Social Housing, Climate Change

Background and building characteristics

The LIFE Project New4Old (LIFE10 ENV/ES/439) intends to prove that it is possible to design an energy retrofitting methodology for the most inefficient dwellings, from the energy point of view, in order to reduce the effects of climate change. The case study is a building block owned by the Zaragoza City Housing Society, built in the early 90's. It is a block between two buildings located in Zaragoza's historic quarter, with two façades. The main one faces north and the south façade is oriented to a large courtyard, which separates this block from another of the same development set, and it contains three light wells of around 3 x 4 m. It is a four storey building, with dwellings in the upper three floors and commercial spaces in the ground floor. The dwellings face north or south and many of the rooms open up to the light wells.

Figure 1. Location, main north façade and building general ground plan



Social dwellings for rent means that users have a low income profile, and thus the working method to define the improvement measures to apply in the building pays particular attention to the existing terms of use of the dwellings and to the possibility of incorporating passive design strategies, which improve inside comfort without increasing the cost associated to energy consumption. Due to the condition of rental housing, with continuous change of users,

the selected solutions are self-regulating, so that successive neighbours do not need to learn how to use any device.

Environment conditions. Climate change projections

Actions taken with energy and environmental sustainability criteria, intended to obtain long term results, ought to take into account the modifications of climate conditions in a relatively near future, due to the effect of climate change. In the case of Spain, the impact of these modifications can be significant if forecasts made are met. Studies of the phenomenon of climate change (Olcina Cantos, 2009) predict that summer conditions for inland cities, such as Zaragoza[1], will be modified by the increase of temperatures and reduction of precipitations. Both issues, especially the first one, involve changes in energy interchange between the building and its outside, and thus, in its inside comfort conditions. Differences in today's climate conditions and those expected for 2050 for Zaragoza may be observed in the following climograms:

Figure 2. Comparative Olgyay bioclimatic chart for Zaragoza. Period 1971-2050

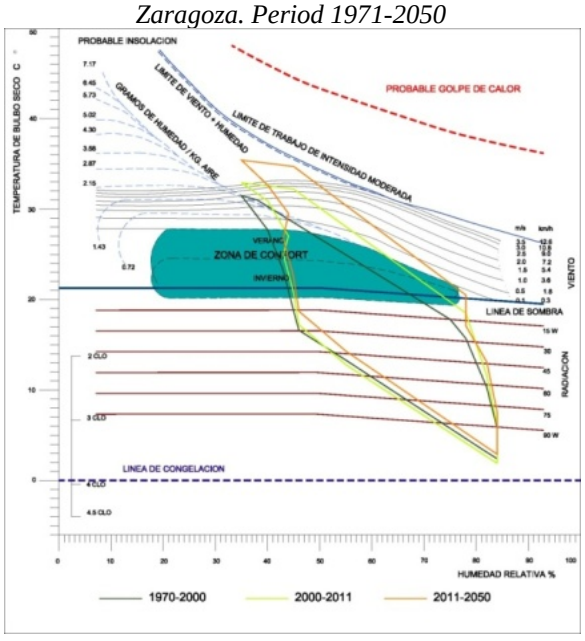
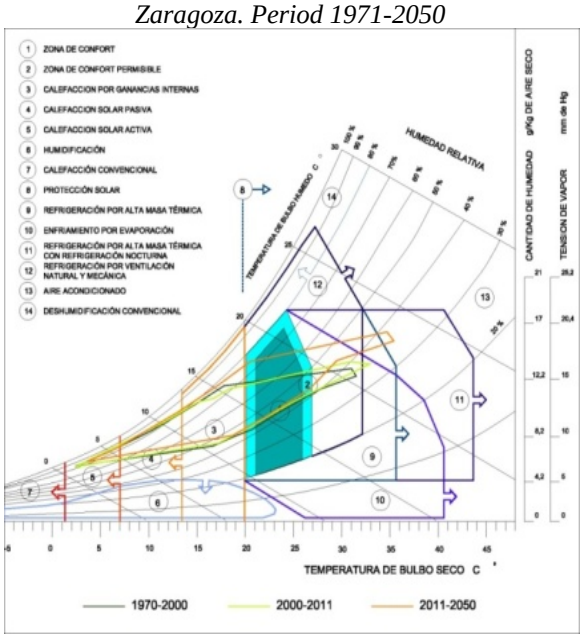


Figure 3. Comparative Givoni bioclimatic chart for Zaragoza. Period 1971-2050



Annual areas have been represented in these charts with average temperature and humidity data of maximum and minimum records. The blue line represents 1971 data and the orange one corresponds with expectations for 2050.

Projections of temperature changes expected for Zaragoza until 2050 show a tendency in the increase of maximum temperatures in most months. This means that ventilation needs and moisture contribution will increase, reaching extreme situations during the warmest times. Those months entering comfort areas in their central hours will expand and solar radiation contribution will still be necessary during the coldest months.

[1] With a continentalized Mediterranean climate, of warm summers and a strong thermal oscillation, which occurs not only between seasons, but also throughout the day.

In the relatively near term, the number of days in which it is necessary to consider summer strategies gradually increases. Regarding the measures to apply on existing buildings, it will be necessary to consider that, although energy consumption on heating will get reduced, those related to cooling will increase. Therefore summer strategies become particularly important in order to reach comfort and reduce energy consumption through passive systems, such as solar protection, high thermic mass and night ventilation.

In addition to the climate change phenomenon, any urban intervention should consider the heat island phenomenon. In the case of Zaragoza it is particularly worth highlighting the study made by Cuadrat Prats, Vicente-Serrano & Saz Sánchez (2005), where its conclusions point out the importance of considering adjustment actions to the overheating conditions, due to the fact that they are already necessary and will be even more significant in the near future, not only because of the climate forecast evolution, but also because of the heat island phenomenon. In our case study, due to the location of the building in the historic quarter, with high urban density, the increase of the temperatures will be higher than in other less dense areas. During the summer season, this situation will get even worse, due to the SE prevailing wind. On the other hand, the usual overheating and traffic pollution effect in the nearest streets of the building will not be so significant, because of traffic restrictions in the location area, although it will be important for the city as a whole.

The climate analysis and the will to raise passive design measures on the building, make necessary a study of the solar incidence and the ventilation, as well as of the conditioning factors due to its particular location in the historic quarter of Zaragoza's urban fabric. The good dimensions of the courtyard and the height of the opposite building at the other side of it, guarantee four hours of solar incidence in the south façade, even in January, the most extreme month. However, the north façade will always be in shadow. Natural ventilation possibilities may be reduced because of the orientation and the high density of the urban fabric, but eased because of the dimensions, orientation and shape of the courtyard and the chimney effect of the light wells in the building.

Involvement of users in the building's characterization

Household users answered a survey created together with SMZV social services, in order to evaluate their comfort conditions throughout the year, as well as to get to know which improvement measures they considered a priority and their particular economic situation to cope with the building's heating and air conditioning costs. The aim was to identify users' perception of inside comfort and habitability conditions, as well as the economic capacity to cope with associated energy costs.

Survey results show that there are some differences between users of north facing dwellings and those of south oriented homes. Many of them, especially those north oriented dwellings, show an underheating problem during the winter season. In the summer season all south facing dwellings show an overheating situation. 74% of respondents consider they spend too much in energy and 86% use some strategy to try to save energy. 43% of users do not turn on

the heating, because they cannot afford it. 71% of south facing dwellings have some cooling system (mostly ventilators) versus 37% of dwellings facing north. In general, users found that getting warmer in winter and cooler in summer are the most important measures.

Proposed measures for the building's energy rehabilitation

According to the characterization of the building and the conclusions of a previous research (Luxán, Vázquez, Gómez, Román, Barbero 2009) the following improvement measures were proposed[2]:

1. *Thermal envelope improvements*

The thermal performance of the building's envelope was improved in order to reduce energy demand, although, unlike other buildings of the historic quarter, the construction of this building took place under CT-79 building thermal regulations. In addition, the heating performance was higher as the requirements, because of the radiant electric floor heating system, that improved the element's transmittance, according to the electricity company regulations when contracting the service.

2. *Solar shading in south façade*

In order to improve inside comfort conditions during the warmest months, an outside solar shading system was proposed. This strategy was necessary according to the Zaragoza climatic study and 2050 projection climograms. This is a horizontal fixed sunscreen along the whole façade, with tilted blades that act as sun control, allowing sunlight radiation during the coldest months, but protecting the façade during the warmest ones.

Figure 4. South façade after intervention. Noon June

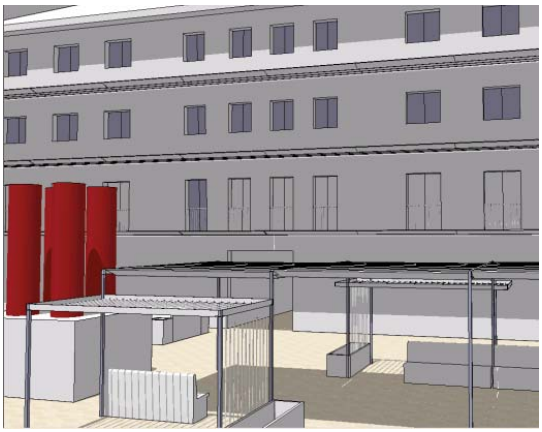
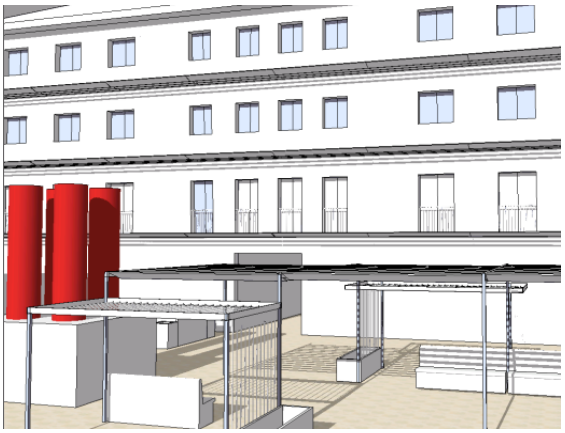


Figure 5. South façade after intervention. Noon December



3. *Hybrid solar system for DHW and electricity production*

Currently these dwellings use boilers for hot water production. In order to reduce energy consumption a solar system will be installed for DHW production. The kind of selected solar panels is a hybrid one, in order to produce hot water as well as electricity.

[2] The budget limit for the working construction was up to 358.000 €

4. *Courtyard environmental conditioning*

The existing courtyard is an interesting space as an open air common area for the neighbours' enjoyment, as well as to help dwellings' conditioning. Currently, the lack of shadow and the distribution of furniture, make both difficult. A pergola was designed in order to provide solar protection, minimizing ground and air overheating during the warmest months. In addition, the benches have been rearranged in more comfortable spots of the courtyard throughout the year, and plants have been placed to raise relative humidity.

5. *Lighting*

70% of dwellings' rooms and building's common spaces get light through the light wells. In order to improve the natural lighting of the lower areas and stays open to them, a solar conduit will be installed in each one of them, bringing natural light to rooms where it is currently inadequate. In addition, presence detectors will be installed in all common spaces of the building.

6. *Heating system*

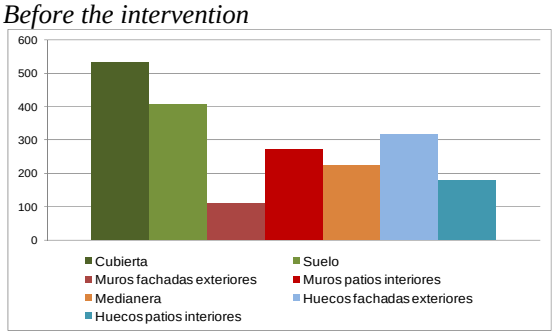
In order to raise passive heating possibilities, a prototype device has been developed to be installed in the south façade. It is a small mechanism consisting of a flat steel plate recruiter placed horizontally under the blades. Inside this recruiter flows an antifreeze fluid, which gets warm during winter months, due to incident solar radiation on the tilted blades. During summer, blades shade the device. This element is connected to a transmitter inside, designed to warm up one of the dwelling's rooms.

Energy evaluation before and after the intervention

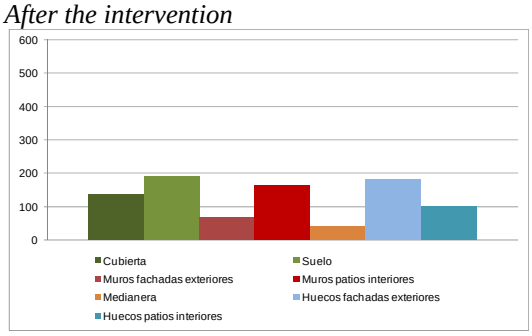
As can be seen, all measures proposed act on passive aspects of the building, without interfering in the heating installation itself. The reason is that, for those users who currently cannot afford the heating system, the fact that it is an electric one does not mean any extra monthly cost. Any other heating system, although more efficient, would mean a new contract with a fixed monthly cost. However, improvements in the building's envelope involve an important reduction of energy demand, as can be seen in the following charts:

Figure 6. Distribution of losses through the building's envelope before and after the intervention

Before the intervention



After the intervention



Finally, consumption evaluation was carried out through the energy performance certificate of the building with the Ce3 software. The letter obtained was E and the corresponding values

are shown in the following charts, showing that the highest consumption comes from heating needs.

Table 1. Building's energy performance qualification before the intervention

	Heating	**Cooling**	**DHW**	**Total**
Energy demand (kWh/m^2)	86,49	10,38	13,08	109,95
Final energy consumption (kWh/m^2)	142,18	5,28	16,35	163,81
Primary energy consumption (kWh/m^2)	143,60	13,78	42,68	200,06
CO_2 emissions (kgCO_2/m^2)	29,00	3,43	10,61	43,04

Considering the proposed measures for the building's rehabilitation, the qualification obtained would be C, with the following demand and consumption values:

Table 2. Building's energy performance qualification after the intervention

	Heating	**Cooling**	**DHW**	**Total**
Energy demand (kWh/m^2)	23,97	7,66	13,08	44,71
Reduction in demand percentage regarding initial situation (%)	72,29	26,20	0,00	59,34
Primary energy consumption (kWh/m^2)	34,51	11,76	10,90	57,18
Savings in primary energy percentage regarding initial situation (%)	75,97	14,66	74,46	71,42

Reduction in demand after applying the proposed measures reach a value of more than 70% on heating and around 25% on cooling. For DHW, reduction in energy consumption can go up to 75%.

Conclusions

The initial conditions study of the housing building in Zaragoza and its surrounding has allowed the definition of various rehabilitation measures, according to the characteristics and need of users. These measures intend to reach a higher thermal comfort for the neighbours, without increasing consumption economic cost. For this reason, actions proposed on the building will help improve its passive performance, avoiding complex active systems with high maintenance costs. The only action on the envelope, improving insulation and solar protection of windows in the south façade, allows a consumption reduction of up to 70%, regarding the initial situation. These savings allow the building to step from an E energy qualification up to a C.

As we have seen, passive strategies are very important when acting on social housing, especially that on social dwellings for rent, where some tenants living with very limited incomes are suffering a fuel poverty situation. In this regard, the intervention on the building's envelope is longer lasting and more economic to maintain, with less consumption costs for the user as changing air conditioning systems in the dwellings, and consequently, more adequate in situations such as the one described.

Neighbours taking part in the characterization phase of the project brought to light the amount of users who cannot afford either heating or cooling. Hence the relevance of this work, which intends to adapt the rehabilitation proposals to the existing urban, climatic and social conditions of this sort of buildings.

Currently the LIFE New4Old project is underway. The document was finished on July 2013, working construction has already begun and is expected to be finished during the second semester of 2014. Monitoring the building before and after the intervention will allow the evaluation of the effectiveness and the scope of the embraced measures.

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