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Smart Energy Building Strategy in Social Housing: A Case of the Basque Region

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Abstract

The regional government of the Basque Country has established a double objective for social housing buildings: to supply free heating in the new constructions and to achieve a cost-optimal refurbishment solution for the existing buildings. It is analyzed the improvement of the energy performance of social housing buildings during the last decade. The analysis includes new buildings and renovations of existing residential buildings.

The initial stage of new buildings implemented some renewable energy systems, such as Combined Heat and Power units, solar thermal panels. The second stage reduced the heating demand by demand controlled ventilation and combined conventional systems with Ground Source Heat Pumps or Trombe walls. The present stage has achieved a Zero Energy Building and expects to improve the minimum comfort levels for tenants. It is explained how has been achieved the optimal system operation and the contribution of each system to the final zero energy balance.

The renovation of existing residential buildings is analyzed by the results of the main grant programs that have been applied in the last 3 years to more than 1000 dwellings. These grants demanded a reduction of at least 50% of heating consumption and a verification through 3 years monitoring.

To conclude, several improvement possibilities will be demonstrated and some additional ideas will be suggested for future social housing projects.

Keywords – social housing; zero energy building; refurbishment; active facade; building monitoring; housing policy.

1. Introduction

Social housing represents one of the most vulnerable social sectors regarding the energy poverty. Some years ago, the regional government of the Basque Country planned a strategy to find out how to reduce the energy consumption in social housing buildings.

One of the main lines of work of the Basque Government has been to increase the energy efficiency in buildings [1]. In the case of Social Housing, the Department of Employment and Social Policies was the organization that drove the improvement of these buildings [2]. The measures taken by this Department tried to overpass the minimum requirements of current regulations, making a step forward with local regulations. These additional requirements for social Housing buildings demanded a higher energy performance and at the same time to implement some innovative solutions, in comparison with current Spanish energy regulations such as the Technical Code of Construction (Código Técnico de la Edificación CTE) [3]. Therefore, the policy of the Basque Government for social housing evolved with a dual objective: on the one hand, build more energy efficient social dwellings, and on the other hand, reduce the costs of production and maintenance of heating and domestic hot water (DHW) as much as possible.

These objectives were applied in new construction projects which provided a good opportunity to improve the knowledge among public professionals and local construction companies. At the same time, this approach was used to assess the maintenance operations and the renovation of existing Social Housing stock. This way, the Social Housing stock was analyzed and the main possibilities to steadily improve their energy performance were detected.

Nevertheless, the international challenge to mitigate Climate Change provoked the recent regulations for EU (like the EPBD, Directive 2010/31/EU) [4]. In 2013, a new Spanish regulation was promulgated (CTE DB-HE-2013) [5] to adapt the European requirements. During the upcoming years, before the expected nearly Zero Energy Building (nZEB) will become mandatory by 2020 (2018 in the case of Public buildings), a new EPBD II Directive will be defined. Consequently, we can state that the European energy efficiency requirements increased faster than the local regulation measures. However, all these recent changes have highlighted the crucial need of improving the energy performance of public buildings.

During this recent period of new regulations and challenges, the Basque Government relied on the Thermal Area of the Laboratory for the Quality Control of Buildings (Laboratorio de Control de Calidad en la Edificación del Gobierno Vasco), in order to analyze the Social Housing requirements and suggest future actions. It is worth remembering that the Thermal Area was created in 2005, by an agreement between the Department of Housing of the Basque regional government and researchers of the University of the Basque Country UPV/EHU, mostly from the Department of Thermal

Engineering. Thus, the Thermal Area was familiar with the building stock and due to its connection with the international research it could introduce newer technologies into local construction sector.

Regarding to the building features, it is necessary to keep in mind that Social Housing is a specific typology with unique characteristics and some limitations. The size of the dwellings is adjusted to the minimum requirements of liveability. The residents of social houses are often families or individuals of low income, which affects greatly the energy use and heating, which is often below adequate comfort levels in order to reduce their bills. Moreover, in the case of Social Housing, the impact of highly insulated building goes beyond the thermal comfort, because it also reduces pathology risks in dwellings. A well insulated building keeps the structural elements and the envelope temperate and stable, and so it prevents the appearing of pathologies related with deficient heating or lack of ventilation. Accordingly, the reduction of utility costs and the increase of thermal insulation are the key factors for the real use of these dwellings.

The present study presents the experience gathered in recently built and renovated Social Housing buildings in the Basque region. A set of cases will be explained in further chapters in order to show the considerable transformation carried out during last decade in Basque Social and Public Housing buildings. The aim of this work is to identify the difficulties faced to improve the energy performance of Social Housing buildings, and to show the solutions tested during the last decade in the Basque region.

2. Strategy for the New Construction Buildings

Regarding the new construction Social Housing buildings, the progress has been considerable between 2006 and 2016. This development is explained through the SH cases built during three stages: origin, renewable energies implementation and nZEB optimization.

2.1. The Origin and Background

The first Spanish regulation that demanded a minimum level of thermal insulation was promulgated in 1979 (NBE CTE-79). The first Energy Performance of Buildings Directive (Directive 2002/91/EC, EPBD) was transposed in 2006 with some improvements: higher levels of thermal insulation and a minimum amount of solar thermal panels to cover at least 30% of the DHW.

As a result, the expected energy performance was slightly improved to fulfill the prescriptions by the implementation of some solar thermal panels and the addition of 3-4 cm of thermal insulation. In multifamily buildings the systems were centralized with gas boilers and DHW tanks to improve their performance. There are no monitoring data of this period.

During this stage (2005 - 2009), despite the fact that a considerable amount of residential buildings were financed by a public sector, only several of them can be considered as SH buildings due to their purpose to serve low income tenants. One of the first SH cases consisted of a small building with 12 social dwellings in Iruña de Oca, a small town in the South and inner part of Basque region. Their heating and DHW were provided by a collective gas boiler of 65 kW of nominal power and 5 solar thermal arrays, which contributed with slightly more than the 30% of the DHW.

The next case was bigger, with a couple of high rise buildings with 53 social dwellings that were located in Hernani, a warmer town near the Atlantic sea. With two gas boilers of a nominal power of 100 kW each one, and 8 solar arrays to fulfill the solar contribution to DHW.

The last case was another high rise multi-family building in Ermua with 57 social dwellings, 3 gas boilers of a nominal power of 90kW each one and 8 solar thermal panels.

2.2. Implementation of Renewable Energies

This stage was strongly influenced by the economic crisis in Spain and Europe. The Basque Government decided that the costs should be lower for SH buildings and invested in more efficient systems. Besides, the experience gathered on solar thermal systems was really poor, with low real performance, high maintenance costs and tenants dissatisfaction. Thus, the Basque SH program shifted to other renewable energy alternatives and reinforced the collaboration with UPV/EHU University and LCCE.

In 2012 a new project was finished in Donostia-San Sebastián, in the Atlantic coast and near the France border. The project consisted of a multi-family high rise building with 34 dwellings, 3 Ground Source Heat Pumps to provide heating and DHW with a nominal power of 900 kW, and a considerable contribution of renewable electricity power provided by 288 solar Photo Voltaic (PV) arrays on the roof. The electricity power is directly supplying the GSHP, the mechanical ventilation system (MVS) of homes and the lighting of the underground parking.

Another recent case has implemented various generators with an operational strategy to achieve the optimal global performance. The 79 SH were built in Vitoria-Gasteiz, in a cold-temperate area in the inner part of the Basque region, it combined three condensing boilers of 654 kW of total nominal power, with the contribution of a Combined Heat and Power unit (CHP) that supplies up to 12.5 kW thermal and 5.5 kW electricity power.

Recently, an ambitious project analyzed the cost, energy performance and indoor comfort differences between regulation standards and non-conventional buildings. These two twin buildings with the same orientation and size were constructed in Durango: The first building was a private housing block equipped with conventional systems, and the second one contained 26 SH equipped with GSHP, boilers, Trombe walls and sun protections. Figure 1 shows both buildings which are currently monitored.

The data are being analyzed by the designers (ONEKA, RENER) and it is expected to have a final report in following months of 2016.

Fig. 1 26 social housing, twin private housing buildings and a Trombe wall detail.

2.3. Present and Future Steps

The last project was finished by the end of 2015 in Portugalete, and it has become the first nZEB public housing of the Basque Government. It is formed by 3 buildings with 5 floors, 32 dwellings of 2325 m^2 in total. They are similar in size, geometry, thermal envelope features and sun orientation. Figure 2 shows the similar southern façades along the slope of the plot. The building commissioning has recently started with several performance tests and verifications. The first tenants will move in before the summer of 2016.

Fig. 2 First nZEB public housing of the Basque Government, Portugalete.

The original SH project was incorporated in a FP7 European Project named SMARTBUILD and increased the possibilities to develop new improvements. The original aim of the project was to compare three different facades and their passive potential. However, the original project was improved with new active facades, as a consequence of to the collaboration with the university research group of the LCCE. Thus, the southern facades included:

- Ventilated façade as a traditional construction element,
- Trombe wall connected to the ventilation system by a heat exchanger that preheats the fresh air
- A cladding with high absorptivity, named Solar Wall, which provides a warm air source to HP, increasing their seasonal performance from 4.41 up to 4.92

Additionally, there are 88 PV panels with 255Wp of nominal power that supply power for the lighting of public areas and the MVS of dwellings. This way, the tenants may perceive considerable reductions for their lighting and ventilation costs. Actually, the rest of produced power is redirected to the HP to supply "Free Heating" for all the tenants, without any energy cost. Further details will be explained in the performance analysis.

As aforementioned, all the experience gathered in design, operation and the monitored results of previous projects was useful to improve the passive elements to a cost-optimal level and combine the active systems within the thermal envelope. The building presents a very low heating demand of 17,7 kWh/m2y plus 7,07 kWh/m^{2}y related DHW demand. According to the simulation results, the project is a Net Zero Energy Building, with all the primary energy consumption compensated with renewable or high efficiency technologies (PV, CHP and renewable HP). The Figure 3 shows the results.

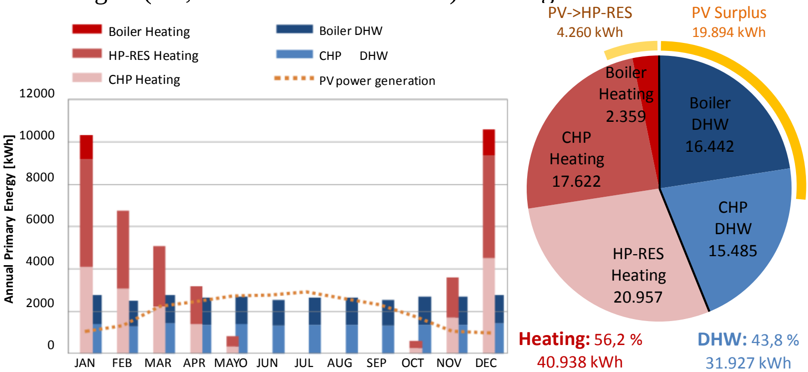

Fig. 3 Annual performance and monthly results of the nZEB Portugalete Social Housing.

The building and all the systems are monitored by a control and management software that is open to main stakeholders (tenants, owner, utility managers) and facilitates useful information (instant and cumulated parameters), as shown in Figure 3. This software can adjust and improve every system operation to the real energy use, and show the performance and usage of each service.

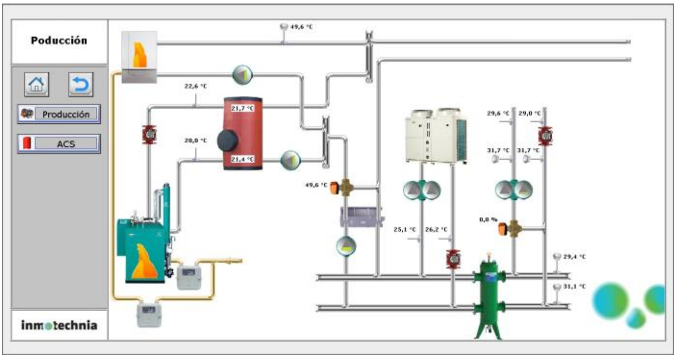

Fig. 4 System operation software interface in Portugalete nZEB Social Housing.

This case has been a hard challenge for all administration levels to find the optimal solutions and to develop a closer control in design, construction and commissioning, starting from previous experiences. The implementation of “Free Heating” concept has been a major achievement, and it will be implemented in the upcoming SH projects.

3. Strategy for the Renovation of Existing Buildings

The public housing building stock of Basque administration is large and includes several categories of dwellings (public, social, protected, etc) oriented to assorted tenant classes. Most of them were built long ago and present low thermal performances. The replacement of windows has been done along most of the cases, as an easy way of improving the indoor comfort. However, a further renovation of these buildings is usually a complex process that can become disturbing for the residents. In general, each case is analyzed individually and big interventions of systems or envelope are only conducted when the maintenance demands so.

Apart from the aforementioned renovation of the public building stock, the Basque Government has traditionally released funding programs to promote private housing renovations. In 2012 these funding programs evolved deeply into a holistic approach to achieve high performance and demanded building monitoring, in order to verify the results. This first call “REVIVE” [6] contributed with up to the 50% of the cost of thermal and accessibility improvements, for those who reach fully the present building regulations. It was mandatory to monitor heating, indoor air temperature and relative humidity in all feasible dwellings for a period of 3 years. Table 2 and Figure 4 show the variety of cases.

Table 1. Main features of REVIVE projects.

Town	Dwell. Nr.	Mon. T,RH, Heating	Mon. T,RH	Thermal Insulation System
Eibar	8	7	1	Vent. Clad., MW
Zarautz	16	19	0	Vent. Clad., MW
Arrigorriaga	37	21	16	Vent. Clad., MW
Vitoria-Gasteiz	30	26	4	Vent. Clad., MW
Bilbao	110	30	70	Loose-fill cellulose, ETICS EPS
Arrasate	120	79	7	ETICS EPS

Fig. 5 REVIVE projects of Zarautz (left), Arrasate (center) and Vitoria-Gasteiz (right).

After obtaining the results by the previous program, another funding program was launched in 2013. This “RENOVE” program [7] raised the budget and improved the energy requirements for the projects conducted between 2013 and 2016. Table 3 shows the main features of the cases funded by the end of 2014. The following call of 2015 was recently approved for 466 dwellings, for that reason there is no detail of the cases yet.

Table 2. Main features of RENOVE 2014 projects.

Town	Dwell. Num.	Thermal Insul. System	Accesibility	Systems
Vitoria-Gasteiz	18	Vent. Clad., MW	New Elev. Out.	No mod.
Amurrio	30	Vent. Clad., MW	New Elev. Out.	No mod.
Amurrio II	20	Vent. Clad., MW	New Elev. Out.	Ind. Boilers
Bilbao	10	ETICS, EPS	New Elev. Ins.	Ind. Boilers
Bilbao II	96	Vent. Clad., MW	Elev. Upgrade	No mod.
Bilbao III	96	Vent. Clad., MW	Elev. Upgrade	No mod.
Bailbao IV	118	ETICS, EPS	Elev. Upgrade	Gas C. Boil.
Portugalete	43	ETICS, EPS	Stairs fixed	Gas C. Boil.

Portugalete II	51	ETICS, EPS	Stairs fixed	Gas C. Boil.
Leioa	42	Vent. Clad. + loose fill	Not necessary	No mod.
Oñati	42	Vent. Clad., MW	New Elev. Out.	No mod.
Donostia	6	ETICS, EPS	New Elev. Out.	No mod.
Zarautz	16	Vent. Clad., MW	New Elev. Ins.	No mod.
Bergara	12	ETICS, EPS	New Elev. Ins.	No mod.
Eibar	58	Vent. Clad. + ETICS, EPS	Not necessary	Solar thermal panels
Donostia II	66	ETICS, EPS	Stairs fixed	No mod.

The first RENOVE projects were finished in the summer of 2015 and the renovation works of the second call are going to end during 2016. The monitoring results of the first winter are being registered now by the engineering teams of each case and delivered to the LCCE to verify the obtained improvement. The preliminary analyses have been very positive. Figure 6 shows a deep renovated building which has reduced approximately the 83% of the original heating demand of 160,4 kWh/m^2. The monitored heating demand is 26,7 kWh/m^2 for an average indoor temperature of 20ºC.

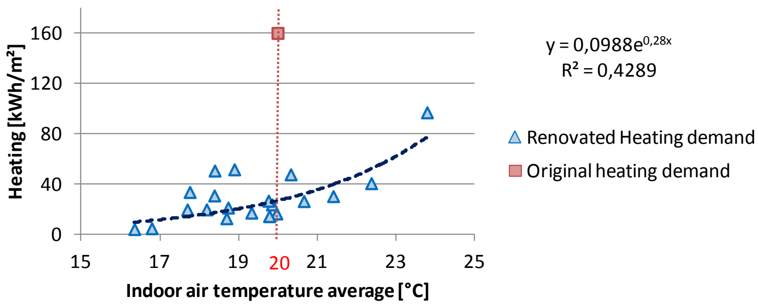

Fig. 6 Heating demand of dwellings in a deep renovation multifamily building, RENOVE.

As we have seen in the previous case, the user behavior in residential buildings affects greatly to the heating consumption, and this impact should be also considered into future renovation programs. Future analysis of this behavior will be done to consider the observed real use of dwellings in simulation models and adjust the optimal performance to reality. This database of the best practices will be used in citizen training programs.

Conclusions

Regarding the new SH buildings, it has been demonstrated how a Net Zero Energy Social Housing Building can be achieved with affordable costs.

Three main issues were acknowledged: the design of thermal envelope and thermal bridging, the combination of mature technologies to find out the optimal performance of the building, and the analysis of local climatology to discover which systems are better for each location.

These statements will be checked by monitoring the houses during the following months, once the first tenants move in. The real performance of each system will be examined in detail, under real living conditions.

According to the existing residential buildings and refurbishment programs, some findings are remarkable:

- The obliged monitoring has induced a better control in the construction site and it has also raised the concern of inhabitants about their energy use.
- Information screens installed in many homes open a new line of work, where further analysis and evaluations are expected.
- A high level of discomfort has been detected in many refurbished buildings, additional studies will be conducted to fix or mitigate this effect.

The information gathered in more than 450 monitored dwellings from different calls (280 REVIVE, 113 + 72 RENOVE) will provide reliable information about heating and energy use at homes, as the baseline to improve the requirements in future calls.

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