Rainha Dona Leonor neighborhood, Porto

Project summary

Energy concept

Although energy consumption were not the main concern in the engagement of the renovation process, a global intervention had to comply with current thermal regulation, thus providing a significant improvement in the energy performance of the building envelope, the installation of new heating/cooling and DHW systems and also the use of RES.

Background for renovation

This is a social neighborhood built in 1953 that reached a profound state of degradation. A deep renovation or demolition were the possible actions to take towards this neighborhood. The final decision was to renovate it and the approved project aimed to:

- Renovate the buildings that have reached a profound state of physical degradation
- Improve comfort conditions of dwellings that were built 60 years ago and were never upgraded
- Recover the neighborhood's image maintaining architectural and urban original characteristics
- Increase the dwellings area, adjusting it to todays people's life patterns
- Refresh of the neighborhoods surroundings taking advantage of its urban context

Site:	**Porto, Portugal**
Altitude:	76 m
Heating degree days:	1610 (base temp. 20ºC)
Owner:	Domus Social
Architect:	Inês Lobo Arquitectos, Lda.

Contact Person:	**Domus Social, Porto**
Important dates:	Originally built in 1953 Renovation started in 2009 Renovation completed in 2014
Date completed:	7th May 2014

Building description /typology

- Neighborhood with 150 dwelling that will be reduced to 90 after complete renovation
- Multifamily building, with concrete structure, brick walls and light weight slabs
- Originally built in 1953
- Gross heated area of the selected building: 123.60 m² (2 dwellings)
- Gross heated of the total renovated neighborhood: Approx.. 5000m²

General view of selected building before renovation (left) and after the renovation (right)

Building envelope, heating, ventilation, cooling and lighting systems before the energy renovation

Description of building (building situation, building system, renovation needs, renovation options)

This neighborhood is a social housing complex with several two floors buildings with variations in the area and the number of bedrooms. It also has 3 apartment blocks, but the renovation intervention taking place includes only the two floor multifamily buildings.

Building envelope

The building has a concrete structure with single brick walls. It did not had any insulation in the exterior wall, roof or floor. The roof is made of fiber cement sheets with a wooden structure and a lightweight ceiling slab. The windows frames were made of wood and the windows used to have a single glass with external plastic blinds. The box for the blinds was placed outside the wall.

Heating, ventilation, cooling and lighting systems before retrofit

There was not a heating or cooling system installed. Occasionally it was used an electric heater or portable fan coils, that each user has acquired. The domestic hot water was supplied by individual electric heaters with storage tank and the ventilation was made by natural means.

Rainha Dona Leonor neighbourhood urban context

Building before renovation

Element	U-Value before renovation W/m²K
Exterior walls	1.69 (first floor) 1.38 (ground floor)
Window	3.40 (with external blinds)
Glass	Solar factor - 0.88
Roof	U value - 2.62 W/m²°C

Energy renovation features

Energy saving concept

The main purpose of the intervention was to improve the livability of the dwellings and simultaneously restore consistency and homogeneity to the neighborhood by subtracting the illegally constructed elements, restoring the original volumes.

The main targets were:

- Renovate the buildings due to its deep degradation state
- Adapt the living areas to modern standards once the original dwellings were very small
- Improve the comfort inside the dwellings
- Renovate the outdoor areas such as playgrounds and circulation areas

Technologies:

- Exterior walls insulation
- Roof insulation
- Introduction of double glazing windows
- Day lighting improvement with bigger windows in the living room
- Efficient heating and cooling systems
- Solar thermal system for DHW

Building

- Wall: External insulation and wall renovation with 60mm of EPS covered by reinforced plaster;
- Roof: Insulation with 50mm XPS panels;
- Windows: Wooden frames + double glazing with 4mm and 6mm

Systems

- HVAC: Multi-split air conditioning system with a coefficient of performance (COP) of 4,1 for heating and energy efficiency ratio (EER) of 3,50 for cooling, on each flat.
- Lighting: Improved daylighting with larger windows.
- Renewables: 3m^2 of solar panels for DHW, per flat.
- DHW: New electric heater with storage tank

Element	U-Value before renovation W/m^{2}K	U-Value after renovation W/m^{2}K	After renovation
Exterior walls	1.38 / 1.69	0.45 / 0.48	60mm EPS insulation
Windows	3.40	2.90	Double glass and wood
Roof	2.62	0.64	50 mm XPS insulation

Above and right: Buildings after renovation

Energy Savings, CO_2 reductions and Life Cycle Costs

	Before renovation (calculated)	After renovation (calculated)	Reduction
Heating Needs (kWh/m².a)	119.70	68.55	43%
Cooling Needs (kWh/m².a)	6.49	7.86	-21%
DHW Needs (kWh/m².a) (considering the reduction from the use of solar thermal panels)	37.09	27.13	27%
Non renewable primary energy consumption for heating, cooling and DHW (kWh/m².a)	413,75	127,21	70%
Total annual electricity consumption (kWh/a)	20 456	6 289	70%
Energy Cost for calculated life time of 30 years (€)	85 580	27 221	70%
Carbon Emissions (TONeqCO²/a)	18.92	6.02	70%

Calculated energy savings:

Energy needs reduction due to the improvement of the envelope and control of infiltrations: 49.78 kWh/m².a
Solar thermal contribution: 9.96 kWh/m².a
Primary energy savings: 286.54 kWh/m².a
Total carbon emissions reduction:
12.9 ToneqCO_2.a

Global evaluation

"Within the municipality housing stock, Rainha Dona Leonor, by the deep renovation work that has been submitted, passed from Group I (very poor condition and / or low level of comfort) to Group V (good condition), becoming the best social neighbourhood of Porto, with comfort and liveability conditions superior to newly built neighbourhoods like Monte São João and Parceria e Antunes."

Rui Rio, Porto Mayor

Costs	EUR	EUR/m²
Total Life Cycle Costs (NPV)	225 609€	1825€/m²
Total Investment	165 340€	1338€/m²
Investment in renewables	6 987€	57€/m²
Investment in systems	16 092€	130€/m²
Energy costs	27 221€	220€/m²
Maintenance costs	33 048€	267€/m²

Building during the renovation process

Building after the renovation process

Overall improvements, experiences and lessons learned

Energy

Potential annual savings of 35417 kWh/a of primary energy in each building.

Indoor climate

Reduction of losses through walls, roof and windows;

Reduction of the thermal bridges allowing to eliminate related condensation problems;

Upgrade of the building energy performance. The standard energy performance for new buildings in Portugal has been achieved;

Control of indoor temperature and humidity without relevant energy costs.

Economics

These renovations were supported by the municipality, who owns and runs these neighborhoods allowing a significant increase of the rents.

Potential energy costs for heating, cooling and DHW have been reduced by almost 70%.

Decision process – barriers that were overcome

The lack of financing to carry out the works at once;

Strong discussion whether the best solution was to renovate or to demolish and transfer tenants to other buildings;

The need to have the buildings vacant to carry out the renovation works.

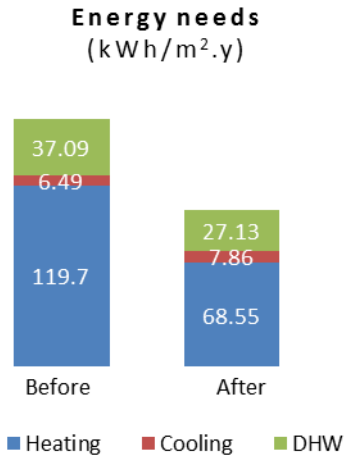
Non-energy benefits

Aesthetical improvement, returning the dignity and identity of the neighbourhood, reducing the social housing stigma;

Better living conditions with more space and more qualified living spaces;

Improved thermal comfort conditions with users now able to heat indoor spaces and keep the interior environment within healthy and comfortable temperatures;

Improved natural lighting with larger glazing areas in living room.



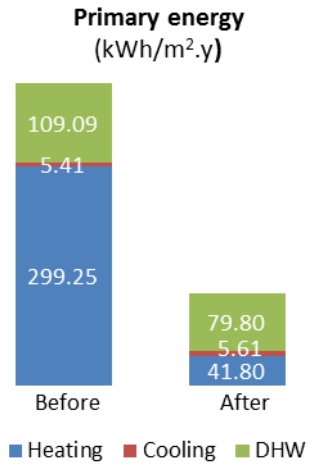
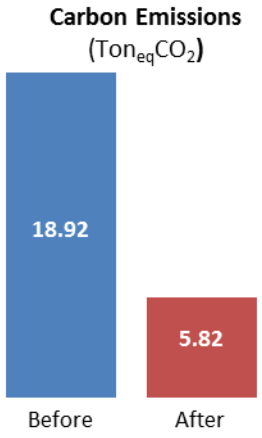


Figure above on the left shows the energy needs for heating, cooling and DHW before and after the renovation works calculated in accordance with the Portuguese thermal codes, which consider the comfort indoor temperatures of 20ºC in winter and 25ºC in summer.

Figure above on the right shows the non renewable primary energy use for heating, cooling and DHW, before and after the building renovation.

Figure on the right shows the carbon emissions before and after the building renovation related to the non renewable primary energy use.



General data

With this renovation process, the city hall achieved two main goals: return the confidence to the neighborhood and improve the living conditions of the local population.

Additionally, the potential reduction of the non renewable primary energy consumptions is about 70%.

The overall improvement of the neighborhood allowed to transform this neighborhood into the best social neighborhood of Porto city according to the evaluation of the municipality, with comfort and livability conditions much better than other recently built neighborhoods.

Front facade of the renovated buildings

Back facade of the renovated buildings

Acknowledgments

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