Rainha Dona Leonor neighbourhood, Porto (Portugal)

Country: **Portugal**

Name of city/municipality: **Porto**

Title of case study: Rainha Dona Leonor, Porto

Year and duration of the renovation: 2009-2014

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Link(s) to further project related information / publications, etc.:
https://www.covenantofmayors.eu/IMG/pdf/Porto.pdf
http://iea-annex56.org/Groups/GroupItemID6/13.PT.pdf
http://www.ilobo.pt/ines_lobo_arquitectos_lda/01023_Rainha_D._Leonor_Social_Housing_Quarter.html

Schematic figure or aerial overview

Figure 1. Schematic view of Rainha Dona Leonor neighbourhood. Source: "Google Maps".

Introduction and description of the situation before the renovation

Rainha Dona Leonor neighbourhood consists of 150 multifamily dwellings originally built in 1953. The buildings, with a concrete structure, non-insulated envelope with brick walls, lightweight slabs, and single glazed wood frame windows, had never been upgraded, which led to a profound state of degradation of the neighbourhood. Additionally, there were several buildings that had elements added illegally, such as small exterior storage units and other changes to the original façades.

During the planning phase of the renovation intervention, the municipality had to decide whether to deep renovate or demolish the buildings. The decision to renovate was made in 2009 and the plans included reducing the total number of dwellings from 150 to 90. The objective was to increase the average area of the housing units. About 5’000 m^2 of the gross heated area was renovated, and the renovation works were completed in 2014.

At the time of the renovation intervention, the neighbourhood was a social housing complex composed of eighteen two floors buildings and three apartment blocks. As part of the overall neighbourhood intervention (and the financing operation of the renovation), the three apartments blocks were demolished and replaced by new buildings (including a private non-social housing residential building).

Initially, energy efficiency was not central to the renovation intervention, which aimed to improve the liveability of the dwellings and to restore consistency and homogeneity to the buildings and exterior spaces.

There was not any heating or cooling system installed. Occupants used individual electric heaters or portable fan coils in their houses. Individual electric heaters with storage tank supplied the domestic hot water.

Figure 2. Image of the building before and after the intervention.

Description of the renovation goal

The main driver for the renovation works was to improve the deep state of physical degradation of the buildings. Additional drivers included recovering the neighbourhood's image maintaining the original architectural and urban features, increasing the dwellings area and adjusting it to the actual living standards. There were also concerns regarding the maintenance of neighbourhood architectural image and characteristics.

The main concern of the renovation decision was not related to the reduction of energy needs. However, due to the depth of the renovation intervention, it had to comply with the thermal requirements imposed by national regulations. Therefore, the building envelope had to be significantly improved in terms of energy performance. Measures, such as exterior wall and roof insulation, as well as double glazing windows, were taken as a way to address poor thermal comfort and thermal bridges issues, which were responsible for severe condensation problems. In addition, new heating and cooling systems were put into place, as well as renewable energy supply sources.

Description of the renovation concept

The renovation included improvements at the building envelope insulation. Exterior wall and roof insulation were added, as well as double glazing windows. For the external walls, 60 mm thick expanded polystyrene (EPS) panels were used. For the roof insulation, 50 mm extruded polystyrene (XPS) panels were used. Windows were replaced by wooden frames and double glazing with 4 mm and 6 mm panes (Table 1). New energy-efficient heating and cooling systems were installed as a 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, with a solar thermal system for domestic hot water (3 m^2 per flat).

Renovation measures resulted in a reduction of 12.9 tons of annual CO_2 emissions and a yearly primary energy savings of 286.54 kWh/m^2. In particular, the improvement of the building envelope and airtightness control allowed for an annual reduction in energy needs of 49.78 kWh/m^2a. The uptake of renewable energy by using solar thermal panels for domestic hot water (DHW) additionally contributes with 9.96 kWh/m^2 per year for the neighbourhood's energy needs reduction.

Even though rents were increased in Rainha Dona Leonor following the renovation, this could be offset by a decrease of about 70% in energy costs for the residents.

Table 1. Measures implemented in the renovation intervention regarding building envelope.

Element	U-Value (W/m^2.°C) before renovation	U-Value (W/m^2.°C) after renovation	Material used
Exterior Walls	1.38/1.69	0.45/0.48	60 mm EPS insulation
Windows	3.40	2.90	Double glazing with wood frame
Roof	2.62	0.64	50 mm XPS insulation

The main involved stakeholder was Domus Social, which is the municipal company whose purpose is to manage the municipal public housing stock (including social housing), maintenance and conservation of all real estate, equipment and municipal infrastructures.

Project Fact Box (I)

General information

Parameter	unit	before renovation	after renovation
Urban scale of area:	m²	19’700	19’700
Population in the area:	-	n.a.	n.a.
Number of buildings in the area	-	150	90
Heated floor area of all (renovated) buildings	m²	5’000	5’000
Building mix in the area:			
Single family homes (SFH)	% of heated floor area of all buildings		
Multi-family homes (MFH) - up to three stories and / or 8 flats		95	95
Apartment blocks (AB) - more than 8 flats			
Schools		5	5
Office buildings			
Production hall, industrial building			
other (please specify)			
Consumer mix in the area:			
Small consumers: SFH + MFH – < 80 MWh/a	in % of annual heat demand	97	97
Medium consumers: AB, schools, etc. – 80-800 MWh/a		3	3
Large consumers: industrial consumers, hospitals, etc. > 800 MWh/a		0	0
Property situation of buildings:			
private	% of heated floor area		
public		100	100
Property situation of energy supply system (district heating):			
private	% of heated floor area	n.a.	n.a.
public		n.a.	n.a.

Project Fact Box (II)

Specific information on energy demand and supply:

Parameter	unit	before renovation	after renovation
heating demand (calculated)	kWh/m^{2}a	**119**	**69**
domestic hot water demand (calculated)	kWh/m^{2}a	37	27
cooling demand (calculated)	kWh/m^{2}a	6.5	8
electricity demand (calculated)	kWh/m^{2}a	n.a.	n.a.
heating consumption (measured)	kWh/m^{2}a	n.a.	n.a.
domestic hot water consumption (calculated)	kWh/m^{2}a	413.75	127.21
cooling consumption (measured)	kWh/m^{2}a		
electricity consumption (measured)	kWh/a	20’456	6’289
(Thermal) energy supply technologies:			
decentralized oil or gas boilers	% of heated floor area	-	-
decentralized biomass boilers		-	-
decentralized heat pumps		-	-
centralized (district heating)		-	-
other*: electric heaters*		*100*	-
other*: Multisplit AVAC*		-	*100*
renewable energy generation on-site:			
solar thermal collector area	m²	0	540
photovoltaics	kWp	0	0
other (please specify)	kW	0	0

Financial issues:

Parameter	unit	before renovation	after renovation
total investment costs of the renovation	Euro/m^2	-	1’338
- building envelope renovation costs	Euro/m^2	-	n.a.
- heating/cooling supply costs	Euro/m^2	-	130
- renewable energy production costs	Euro/m^2	-	57
LCC available	yes / no	no	no

Description of the technical highlight(s) and innovative approach(es)

The combination of building envelope measures with the chosen heating, cooling and DHW systems led to considerable energy demand reductions, which in the social housing context are quite significant. The heating needs were reduced by 43%, which evidences the effectiveness of the measures implemented for the improvement of the building envelope. The cooling system installed also improved the indoor living conditions during summer. The measures adopted in renovation led to an increase in housing rents but this increase was offset by potential energy savings for heating, cooling and DHW, which were reduced by 70%, enabling users to heat indoor spaces and keep the interior environment within healthy and comfortable temperatures at a significantly lower cost.

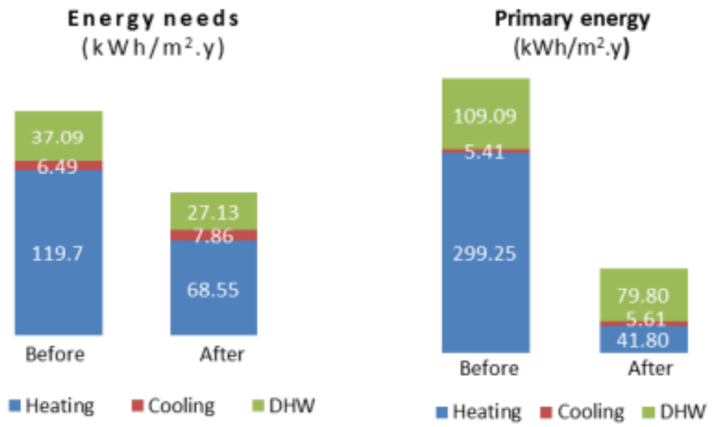

Figure 3. Energy needs for heating, cooling and DHW before and after renovation and non-renewable primary energy use for heating, cooling and DHW. Source: [https://www.covenantofmayors.eu/IMG/pdf/Porto.pdf.](https://www.covenantofmayors.eu/IMG/pdf/Porto.pdf)

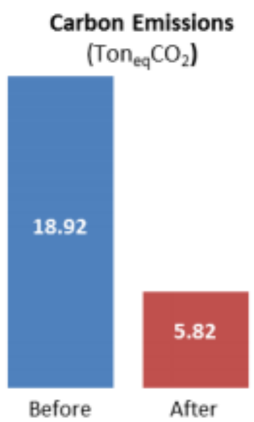

Figure 4. Carbon emissions before and after the building renovation related to the non-renewable primary energy use. Source: [https://www.covenantofmayors.eu/IMG/pdf/Porto.pdf.](https://www.covenantofmayors.eu/IMG/pdf/Porto.pdf)

An innovative approach adopted in this project is related to the financing of the neighbourhood overall intervention. Initially, the municipality intended to support the costs of renovating the two-floor buildings but found it very difficult. As a way to promote private investment, a public tender was held by the municipality to find a developer who would demolish the three apartment blocks and build “high-end social housing” buildings, as well as a private-owned residential building that would be put on the regular market. The financing model took advantage of the prime location (and economic value) of the neighbourhood land, which is close to the centre of the city of Porto and has generous Douro river views. The contract with the developer included several obligations dedicated to protecting the investment that had to be made in the social housing neighbourhood. For example, the developer could only start with the private-owned residential building construction after all the interventions regarding the social housing project were concluded. The approach (finalized in 2018) allowed the neighbourhood to be renovated and expanded by introducing new social housing (20 dwellings) that meets current energy and thermal requirements, keeping residents in the same location, and housing new residents at no costs for the municipality. The new four-storey buildings have 70 new dwellings (from one bedroom to four bedrooms apartments) (*Figure 5*).

Figure 5. View of the new buildings on Rainha Dona Leonor neighbourhood. Source: https://www.engenhariaeconstrucao.com/.

Decision and design process

General / organizational issues:

The project was initiated to respond to a high level of deterioration of the buildings.

The main stakeholders involved in the buildings renovation were:
Domus Social (municipality social housing company)
Inês Lobo Architects
AdEPorto - Agência de Energia do Porto (municipal energy agency)

The main stakeholders involved in the new construction were:
Domus Social (municipality social housing company)
AYTHYA – Investimentos Imobiliários, Lda (real estate development company).

Barriers to the project included:

1) the need to comply with the norms: although energy renovation was not the focus of the intervention, the intervention had to comply with thermal requirements imposed by national regulations, which increased complexity;
2) the preliminary lack of financing to complete the necessary renovation works;
3) the discussion on whether the best solution was to renovate or to demolish;
4) the temporary transfer of tenants to other buildings because of the need to have the buildings vacant to carry out the renovation works.

Stakeholders' role and motivation

Main stakeholder	Specify which organization(s) was (were) involved	Role (Decision maker, influencer, technical advisor, delivery)	Driver/motivation
Policy actors (municipality department, government body, innovation agency, etc.)	Domus Social (municipality social housing company)	Owner/Decision maker	High level of building deterioration
Users/ investors (individual owner, housing association, building managers, asset manager, project developer)	Domus Social (municipality social housing company) AYTHYA (real estate development company)	Owner/Decision maker Investor	a) improvements of the profound state of physical degradation of the buildings b) recover the neighbourhood's image maintaining architectural and urban original characteristics c)Increase the dwellings area, adjusting it to today's people's life patterns
District-related actors (Community/occupants organizations, etc.)	There weren't any of them involved	-	-
Energy network solution suppliers (Distributor system operator, energy supply company, energy agency, ESCO, renewable energy companies)	There weren't any of them involved	-	-
Renovation solution suppliers (Planning and construction parties, urban planners, architects, design team general contractors, products suppliers, ESCO, contractor, energy monitoring, facility manager, installation provider, one-stop-shop, etc.)	Inês Lobo Architects AdEPorto - Agência de Energia do Porto (municipal energy agency)	Influencer/Technical advisor, delivery	
Other intermediaries (public bodies, trade organizations, NGO's, consultancies, research institutes)	There weren't any of them involved	-	-

Design approach:

The main purposes of the intervention were to improve the indoor quality of the dwellings and simultaneously restore consistency and homogeneity of the neighbourhood, subtracting the illegally added elements and restoring the original building volumes.

The main targets were:
- to recover the neighbourhood architectural image;
- to renovate the buildings due to their deep degradation state;
- to adapt the living areas to modern living standards, since the original dwellings were very small;
- to improve indoor comfort;
- to renovate outdoor areas such as playgrounds and circulation areas.

The technologies included in the intervention were the following:
- exterior wall insulation;
- roof insulation;
- double glazing windows;
- daylighting improvement with bigger windows in the living room;
- energy-efficient heating and cooling systems;
- solar thermal system for DHW.

The measures concerning the building envelope were:
- wall: External insulation and wall renovation with 60mm of EPS covered with reinforced plaster;
- Roof: Insulation with 50mm XPS panels;
- Windows: Wooden frames + double glazing with 4mm and 6mm panes.

The measures concerning the building systems were:
- HVAC: Multi-split air conditioning system with a coefficient of performance (COP) of 4.1 for heating and energy ratio (EER) of 3.50 for cooling, on each flat;
- lighting: Improved daylighting with larger windows;
- renewables: 3 m^2 of solar panels for DHW per flat;
- DHW: New electric heater with a storage tank.

Main challenges in the design phase consisted of the decision-making process regarding the intervention to be made. Demolition was also considered as an alternative to the renovation intervention.

Technical issues:

The major constraint regarding technical issues consisted of the lack of infrastructure that allowed for the implementation of heating and cooling equipment without affecting the aesthetic of the buildings.

Financing issues:

Private investors made the most significant investment in the neighbourhood renovation interventions. The municipality designed and implemented a financing model that allowed a private investor to retain a part of the neighbourhood's land and promote a new real estate development, in exchange for being responsible for the renovation and construction of a new social housing building. There were delays regarding the public tender and contracting that caused constraints to the initial planning for the neighbourhood renovation, especially due to the complexity of the financing operation.

Even though rents were reported to be higher after the renovation works, this rent increase is expected to be offset by a reduction of about 70% in energy costs for the residents of the renovated dwellings.

Management issues:

The main challenge regarding the project management consisted of the need to move the residents to other locations to carry out the renovation works.

Policy framework conditions:

Although there was no intention to perform an energy renovation at the beginning of the renovation process, it should be noticed that thermal regulations and energy standards requirements, and in particular the compliance with the Decree-Law 118/2013 requirements, were key to obtaining energy reductions.

Lessons learned

The technical measures implemented during the renovation process allowed for significant energy savings and carbon emissions reductions. The intervention also made possible to achieve a higher quality in indoor comfort conditions, which is quite important in the context of social housing.

Identified bottlenecks include the preliminary lack of financing for completing the necessary renovation works and the need to move tenants to other buildings to carry out the renovation works.

Rents were increased as a consequence of the intervention, which has been contested by the residents, despite the expected savings in energy consumptions.

In addition to the buildings´ renovation intervention, it was foreseen that a part of the neighbourhood would be demolished, and a privately-owned residential building would be constructed to finance additional social housing. This model was implemented and completed in 2018 by a private promoter that was chosen through an international public tender. Besides the obvious promotion of social inclusion, the model can be considered as an innovative business model to finance new social housing and renovate existing neighbourhoods. However, it is dependent on several contextual conditions (e.g. attractiveness of the location or available space).

There is significant potential for transferability and replicability of the lessons learned in this project for other municipalities and governance structures, namely regarding the opportunity for the combination of social inclusion and improvement of energy efficiency measures.