SQUARE – A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

WP6 -National Pilot Project SPAIN

Final report

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SQUARE

SQUARE - A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

SPANISH PILOT PROJECT REPORT

WP6

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March 2010

SQUARE

Coordinated by

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Table of contents

1 Introduction

1.1 Objectives and target buildings

The number of public residential buildings in Spain is only a small fraction of the total stock. The most usual are private residential buildings inhabited by their own owners. Furthermore, the majority of existing residential buildings are not managed under lease schemes (by social housing associations or similar organisations), but privately owned and its management are usually made by the community of users/owners of the block or development. During the lasts 25 years much of the public residential stock has been privatized, usually to the former tenants.

More than 50% of existing residential buildings were constructed before any compulsory thermal rule exists. Thus, the retrofitting of this huge stock is urgent and probably the sole working area for the nearly death Spanish construction sector (2008…).

The actual retrofitting projects in Spain are scarce and the renovation intensity is low usually, focused on installing accessibility improving solutions (like elevators), roof water proofing, façade consolidation, painting and, sometimes, thermal insulation.

At the start of the Square project, to found a candidate for a pilot project has proved very difficult. There were not public administrations or private developer with a large project of renovation to be developed in short time

At last, the pilot project in Spain is being conducted in a not large private development, but representative enough to serve as a basis for replication at a larger scale.

Thus, even if the pilot project in Spain is not as large as others pilot project, it has important positive aspects:

- It's conducted under a small private development scheme
- The developer has a wide commitment to apply the QA methodology and achieve the planned results on energy and indoor environment quality
- The developer has a close relationship with the architects team POMA, partner of the Square project, and with a high interest of testing new methodology and technical solutions applied to building renovation
- Being a private development will serve as a basis for replication at a larger scale as the private property in the most usual at Spain

The Pilot Project main objectives were:

- test the Square QA system during the different phases of a renovation project
- involve different organizations, developer, architects, energy engineering company, builders, system installers, users.., with a new renovation methodology of quality assurance on energy efficiency and indoor environment
- renovate a model of multifamily building very usual at historical centres of towns and villages
- achieve a high performance degree on energy use and indoor quality

The development consists of a 4 storey building, located in the city of Barcelona (Sant Joan de Malta Street). The main characteristics of the target building were:

- existing building with a need for an integral renovation
- high replication potential of the building renovation model
- developer organisation with the aim to go beyond the actual energy regulations

Picture 1. Building state before renovation

1.2 Scope and limits

The old building was in very bad general condition, without permanent tenants. Some parts have grave structural deficiencies and the general systems were completely obsolete.

The building was bought by a private developer (Residencial Sardana S.A.) with the aim to renovate it completely and sell the apartments.

The global renovation of the building included the following aspects:

a. High energy performance retrofitting through a extensive renovation of:

- Existing structure: floors, roof, internal divisions
- Thermal renovation of the building envelope: insulation, new windows and doors
- Renovation of all the building services, including specific new systems (e.g. forced ventilation, regulation, monitoring)

b. Preserve as much as possible the existing structure (walls, floors, roof, staircase, etc.) in order to reduce the building renovation cost and its renovation ecological footprint

c. Choose constructive methods compatible with the old ones and apply modern solutions when the old structures were in bad state.

The size of the pilot project is limited to the 6 apartments of the building block.

The developer, as a private company, will not manage the apartments after the hand-over to the new owners. The pilot project organizations, however, will be involved with the users in order to establish a managing scheme with the owner's community and maintenance companies.

2 Background

2.1 The location

The aerial photographs show the location of the building. The renovated building is located in the old centre of the Clot neighbourhood, at the east of Barcelona, Spain.

Picture 2. Location of the building

2.2 The building

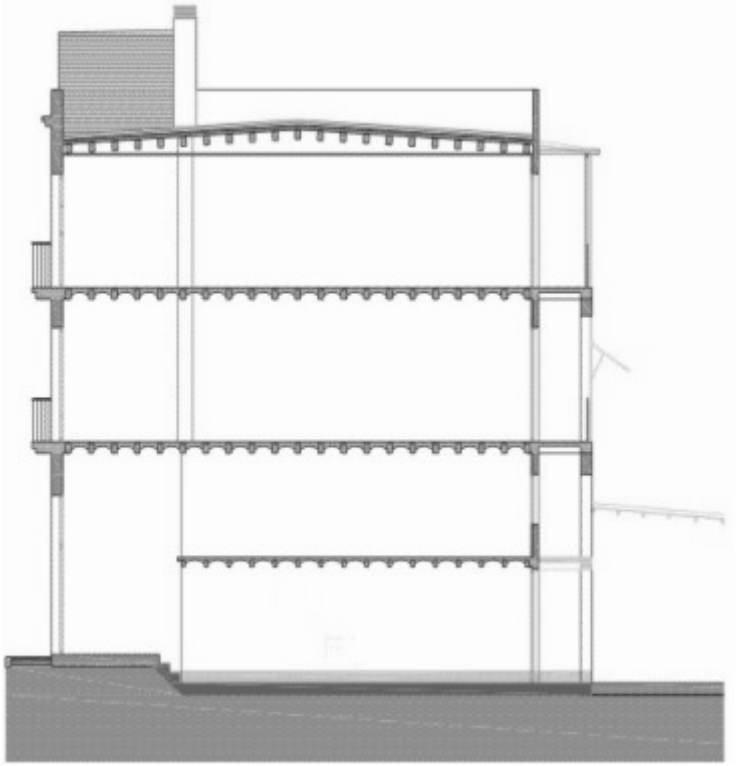
The pilot project is a renovation of a private building, developed by the company Residencial Sardana S.A, who is also in charge of the architectural design.

The project was initiated in 2007 and the first work (internal demolishing) began in January 2008.

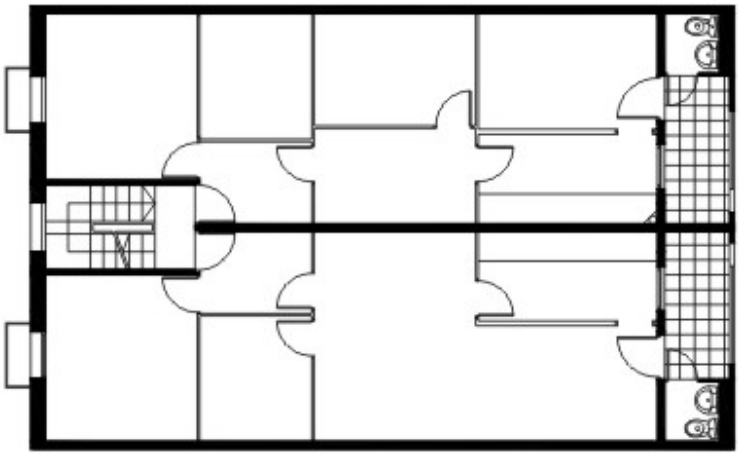
Pilot Project Building Block	**Initial state**
Address	Sant Joan de Malta street. Barcelona
Number apartments	6
Year of construction	Around 1890
Materials	Brick and stone (walls), wood (beams), flat tiles (roof)
Orientation	45º SW

General systems	Electricity, water and sewer
Situation	Block with two external façades and two dividing walls
Ownership	Private (Residencial Sardana as a developer)

Table: Initial state



Picture 3. Cross-section of the building initial state



Picture 4. Ground plan of the building initial state

3 QA system management

3.1 The developer and technical partners

The developer is a little residential construction company, which main activity is to buy old buildings and renovate it completely. It's experience in high performance buildings was poor, but it's interest on it increase with the proposal to participate at the Square project.

The developer and its partner's role during the Square QA system application is likely a social housing organisation during the first part of the renovation project.. However, when the flats are for sale, post hand-over phase of these the current organization will cease to manage the building

In the Spanish pilot, the participant organisations are:

- Residencial Sardana: building owner and developer
- POMA: responsible for the architecture design. During the renovation work, POMA also carries out the site management, and quality control checking.
- TTA: consultant in energy, indoor environment quality and general systems. TTA also carries out the site management on the above mentioned areas.
- Subcontractors: responsible for specific works, coordinated by POMA

3.2 QA-General policy of the builder

Before launching the Square pilot project, the builder's quality policy related primarily to comply with building regulations and quality control of the execution of work through site visits, sample analysis and testing during the commissioning. The collaboration between POMA Architecture and Trama Tecnoambiental in previous projects (before pilot project) introduced new concepts of energy efficiency and renewable energy use in the architectural design. With the completion of the Square pilot project, the developer have expanded it's energy goals and implemented management procedures and quality assurance for the new projects.

4 Methods and accomplishment

4.1 General QA strategy

The Square QA system is not only a pioneer quality assurance system for building renovation projects on energy and indoor environment aspects, it is also a new management experience for all the Spanish Pilot Project partners. The procedures involved in the Square QA system have been implemented gradually, integrating them into the usual management procedures of a building renovation work. TTA has coordinated the QA implementation.

The objective is to test:

- the advantages derived of the QA implementation
- the time required for the document management
- the difficulties to implant the QA guidelines between the pilot project partners
- the QA system adaptation to specific Spanish requirements

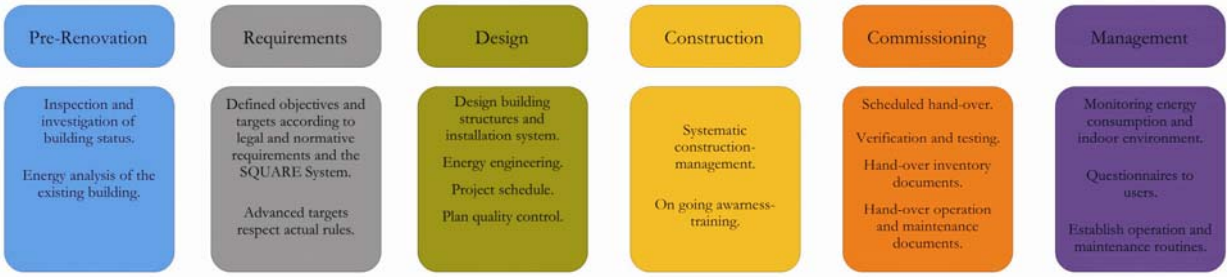
The QA system implementation on Spanish pilot project has focused mainly on the definition of targets to be reached, and the project adaptation in order to fulfil them.

The assumption of the changes by all the project partners (architects, engineers, installers, building workers, etc.) has required several meetings, reasoned discussions during the site management visits and teaching on the proposed new technologies.

Since the renovation project began some months before the Square WP6, the pilot project in Spain is ahead of schedule with respect to the implementation of the Square QA system.

Even though the initial phases of the pilot project were carried out before the Square QA system was available, many equivalent actions have been implemented and documented according to the directions given in the QA system, as described below.

The general strategy for the renovation process follows the structure of the SQUARE- QA-system, summarized at the following picture.



Picture 5. *Overview of SQUARE QA system*

4.2 Establishing pre-renovation conditions

The old building was in very bad general condition, without permanent tenants. Hence, the analysis of the pre-renovation conditions has been focused on structural aspects, while other pre-renovation procedures, like residents' questionnaires, TPI and FEA, were not completely applicable.

The TPI was developed on the original building, analyzing the transmittance of the façades, basement floor and roof. Identifying the needs of insulation of the building envelope, analyzing sun availability on the overtures and the roof, measuring the presence of moisture by capillary difussion of the ground floor and walls, etc. Identifying the conservation status of the structural elements was also done.

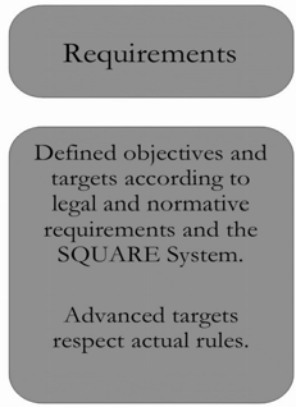
The absence of energy use data of the old building, an energy simulation was carried out on a reference building created by the LIDER software, according to the CTE

The following table summarizes the pre-renovation situation and the targets.

ENVELOPE	U before retrofit (W/m2ºC)	U after retrofit (W/m2ºC)
external north	1,70	0,50
external south	1,70	0,50
dividing wall east	1,70	1,70
dividing wall west	1,70	1,70
roof	2,00	0,30
basement floor	2,70	0,30
wall touching stairs	2,00	0,80
windows	4,20	2,60
internal walls	2,00	2,00
internal floors	2,70	2,00
	Uglobal before retrofit (W/m2ºC)	Uglobal after retrofit (W/m2ºC)
	2,10	0,92

Table. Initial and target U-values

4.3 Formulation of requirements and targets prior to renovation



POMA and TTA defined the values for the main thermal and indoor environment quality parameters. Most of them are current requirements set in recent building regulations (CTE and RITE). Further -more strict- requirements were also introduced as part of the pilot project added value, like a high performance ventilation system.

The initial targets to achieve were:

- to improve the global U-value (< 1 W/m2ºC)

- to improve the performance of thermal generation (>100% boiler performance)

- to improve the performance of the ventilation system (>90% performance of heat air recovery)

- to improve the quality of indoor environment

- to achieve at least B energy certificate

-

Picture 6. Proposals for better energy efficiency and indoor environment quality

4.4 Design

- New drawings of the existing building (POMA)
- New interior distribution design (POMA)
- Architectonic solutions for damaged areas (POMA)
- Energy engineering and general systems design (TTA)
- Design of the detailed drawings by both TTA and POMA.

The initial architectural project has given priority to the reinforcement of existing structures, redesign of internal distributions, and maintenance of the original construction methodology and materials. The adopted structure renovation criteria were:

- No overload vertical structure.
- Avoid new loads on the existent structure
- Compatibility of the materials and technologies introduced with the existent ones.

In order to reduce the environmental impact of the whole renovation and indirectly improve the thermal performance, the project previewed:

- Reutilisation of the most part of the structure.
- Preservation of the mass of the existing walls
- Selection of wood as a material with zero CO2 emissions
- Avoidance of unnecessary divisions to facilitate natural crossed ventilation

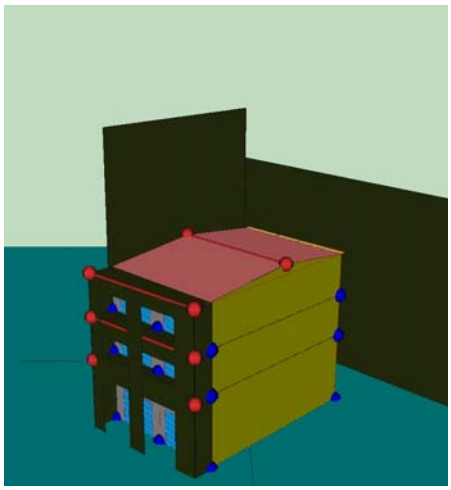
However, few additional thermal and energy efficient solutions were introduced in this first version project. The project revision carried out by TTA made several proposals in order to improve the energy efficiency and the indoor environment quality. The most relevant proposals were to:

- exterior thermal insulation on the main façade
- internal walls insulation surrounding not heated spaces, and the basement floor
- vented roof
- correction of thermal bridges
- introduce a collective heating system (instead of individual boilers in each flat) and collective hot water generation
- introduce high efficiency boiler (condensation)
- introduce hot water and heating metering (each apartment)

- centralise ventilation (roof air entrance and evacuation) with individual thermal recovery from renovated air flow
- introduce free cooling for intermediate seasons
- improve air tightness using windows without permanent venting
- avoid the capillary moisture from the basement
- prevent eventual flow of radon from basement
- introduce continuous monitoring of energy performance
- encourage of energy-awareness behaviour by users by means of individual temperature control in each apartment, supported by electricity and heat consumption meters.
- rainwater collection

The reformulated project has been tested with official software in order to verify the accomplishment of Spanish Building Energy requirements (CTE) and later to calculate its Energy Certificate. The target was to reach at least the level B.
The Certificate will be issued after the renovation is completed. Targets are to keep heating needs below 25 kWh/m2, and emissions from thermal consumption (heating, cooling and HW) below 9,4 kg CO2/m2 .

Certificación Energética de Edificios Indicador kgCO2/m²	Edificio Objeto	Edificio Referencia
<5,9 A 5,9-9,6 B 9,6-14,9 C 14,9-22,9 D >22,9 E F G	9,4 B	20,6 D
Demanda calefacción kWh/m²	C 25,2	D 42,8
Demanda refrigeración kWh/m²	B 4,1	C 5,4
Emisiones CO2 calefacción kgCO2/m²	C 5,3	E 13,7
Emisiones CO2 refrigeración kgCO2/m²	C 1,5	D 2,0
Emisiones CO2 ACS kgCO2/m²	A 2,6	D 4,9



4.5 Training

The contractor's commitment with the initial requirements has been guaranteed by preliminary meetings and documents about the technical solutions adopted for this project. A permanent training during the technical work visits (weekly) has been carried out focused to the starting of a new work, or to new contractors.

4.6 Site management and follow-up during work stage

The construction site management has been implemented according to the usual system established in Spain, and include regular on site visits both architects and system engineers:

- Regularly on site meetings with contractors and technical visits
- Documented instructions and decisions
- Communication between work direction and contractors
- Weekly on-site visit and inspections of each responsible of working area

As additional information to the project work control book, work sheets have been developed for each site mangement visit. They specify the topics covered during the inspection of work, the person responsible of each subject, the decisions taken, the required additional documentation and the work scheduled for the week. Emphasis on instructions that relate to requirements on energy use and indoor environment has been done. The work sheet was sent to all the personal involved on the work and serves as a script for the next work visit.

The construction works were carried out by the following sequence:

- Demolition works: with on site waste selection
- Structural repair : roof, apartments roofs, internal divisions
- New sanitary drains and waterproof basement
- Thermal insulation: façades, basement,
- Internal divisions, ceilings, floors, windows
- General systems and energy installations

4.7 Commissioning and user's information

The objectives of the commissioning are to:

- check than the requirements are fulfilled.
- verify the installations performance
- correct the inconfotmities
- recieve documents, user's manuals and warranties from the contractors and equipment supplyers

Picture 1: Ventilation system commissionig:

The commissioning of the new systems has been the most important part of the final work management. The new building structures, insulation, window joints, etc., has been inspected and cheeked when they were carried out, but the thermal (heating and hot water) and ventilation installations, have had to be commissioned at the end of all building renovation works.

Thermal installations commissioning tasks has been:

- hydraulic tight test
- boiler start up
- temperature regulation adjustments
- variable speed pump regulation
- distribution circuit balance
- checking heat exchangers performance
- thermal meters verification
- hot water temperature at each apartment
- heating regulation at each apartment

Ventilation commissioning tasks has been:

- Ducts testing
- Verify temperature and air quality sensors

Picture 2: Open individual ventilation and heat recovery equipment

- Programming the daily or weekly ventilation schedule

All apartments are equipped with a ventilation unit, (with filters, fans, heat exchanger and regulation device with display). This system is very innovative in Spain and no new apartment user has been seen it before. So, it's very important to explain them how the system works, and the need to change the old behaviour about ventilation in order to improve its thermal performance, and indoor air quality.

Each apartment ventilation system has been commissioned and a user's manual has been given to the new flat owner.

Picture 3: Ventilation equipments: air quality control display (left) and heat exchanger for thermal recovery at the bathroom (right)

4.8 Performance assessment, monitoring and management

Management

Monitoring energy consumption and indoor environment

Questionnaires to tenants

Establish operation and maintenance routines

In order to know the real energy consumption of the building and each apartment, several meters will be used:

- electricity consumption: individual meter

- gas consumption: only one gas meter (the collective gas boiler is the unique gas consumption

- heat consumption: both hot water and space heating are measured by a thermal meter

Also the water consumption will be measured and monitored

The energy use will be completely metered and the data will be gathered by a user data sheet (individual electric use, thermal use, water consumption). The thermal meter data will be gathered also by a bus system and centralized. The individual consumption rate will be used to bill the energy cost at each user.

The compiled data will be useful for the energy consumption evaluation, the thermal performance monitoring of the building and the real effectiveness of the measures applied during the retrofitting work.

A complement of the energy data is the user's opinion about thermal comfort, temperatures, air quality, odours, humidity, management of the ventilation system, etc., by means of an annual questionnaire.

The building systems maintenance will be contracted by the owner's community, but the routines, frequencies, and mandatory revisions will be organized by the developer technical team (POMA and TTA)

5 Lessons learned from the QA system implementation

The QA system implementation on Spanish pilot project has focused mainly on the definition of targets to be reached and the project adaptation in order to fulfil them. The assumption of the changes by all the project partners (architects, engineers, installers, building workers, etc.) has required several meetings, reasoned discussions during the site management visits and teaching on the proposed new technologies.

The second part has focused on the checking of the quality of the building work (structure, envelope, etc.), general systems (piping, air ducts, heating, ventilation, etc.). The next steps has focused on the commissioning of general systems, the adjustments of thermal and ventilation systems, and the operational phase.

During this process the QA system has been introduced gradually, at first involving the technical staff of the companies (developers, architects, engineers) and later the building company workers and it subcontractors. The reduced dimension of the building project, and consequently the number of persons involved, has simplified a lot the process.

Some of the lessons learned have been:

- Even if no member of the companies participating in the project had used before a QA system in a building work, there was not rejection when the system was introduced, but interest.
  - Due to the small size of the building work, QA management fell mainly on a few people. The number of companies and individuals involved in the work was small so that simplified the process of implementing the QA system.

  - It has been necessary to adapt the procedure to the circumstances of the project:: as the absence of tenants at the beginning of the work, emphasis on the management of the structural works and services, determine an ambitious quality objectives regardless of the values of existing regulations or standards, etc.

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  - Another lesson has been the need to adapt the implementation of the Square's QA system to the management structure of a construction company / developer, with a short temporal involvement on the renovated building in comparison with a social housing association
  - The documents management has been simplified. We selected the most suitable for each phase of the project and they were introduced sequentially
  - The contractors for specific jobs were informed prior to engagement about the implementation of a QA system in the works, about the objectives were to be attained and the also the obligations regarding the management of procedures

5.1 Identified success factors in the implementation work

The pilot project developed under the Square project has allowed to show a rather unique rehabilitation model within the usual constructive model in Spain. The highlights would be:

- Has given priority to conservation than the demolition
- Most of the structures has been preserved
- Construction methods compatible with the existing have been used

- A design team that unites experience and complementary skills and great interest in the concept Square has formed
- The saved costs in structure (through conservation of the existing) has been invested in energy efficiency improvements and indoor environmental quality equipments
- Huge progress has been made regarding the energy performance level required in the current building regulations
- The improvements have brought added value to the apartments that have speeded up its sale respect other promotions.
- Adaptation of the Square QA system to a developer company and the commitment of the developer company to use the QA system when the following projects

5.2 Identified barriers or difficulties in the implementation work

Probably, the most important barrier to a successful QA system in a renovation project of residential buildings is the lack of continuity of the building developer because the apartments are for sell. So, the post-renovation period couldn't be managed by the developer.

The management of the operation period should be done by the homeowners association, the first year with the support of the pilot project participants (developer and technical team -architecture and engineering offices)

Lack of companies engaged in the management of residential buildings thermal plants

5.3 Dissemination potential within the organisation and within the national scope for relevant stakeholders

The SQUARE project's Spanish partners have focused its dissemination efforts to relevant stakeholders on the residential buildings renovation: mainly the architects collective and the builder associations, in order to raise awareness between these collectives. Therefore a series of presentations were held at the following events:

STEP 2015. *Forum of experiences and reflections about incorporation of generic sustainability skills and social commitment to the new curriculum ETSAV.*
Organization: University of Architecture of Barcelona. etsab-etsav
Number of assistants: between 25-35 people
Date: 22/06/2009
Place: University of Architecture Vallès (Barcelona)

Enhancement program for housing rehabilitation of buildings
Organization: COAC. (Official College of Architects of Catalonia).
Number of assistants: 30 people.
Date: 1/03/2010

Place: SERT School (Barcelona)

Sustainable building, neighbourhood revitalization and refurbishment
Organization: GBCE (Green Building Council Spain)
Madrid. 28- 30 April 2010

Workshop with architects: Presentation of the Square's QA system and three pilot projects.

Organization: COAC. (Official College of Architects of Catalonia).
Place: Escola Sert
Number of assistants: between 30 people
Date: 8/4/2010

Picture 4: SQUARE presentation at the Sert School cours: "How to improve sustainability at the existing buildings", 1 march 10 – Presentation Oriol Muntaner (Source: POMA)

Also, some technical visits to the Pilot Project in Barcelona, and TV recording, were held:

Picture 5: Architects association visit (30/December/2009) (Source:TTA)

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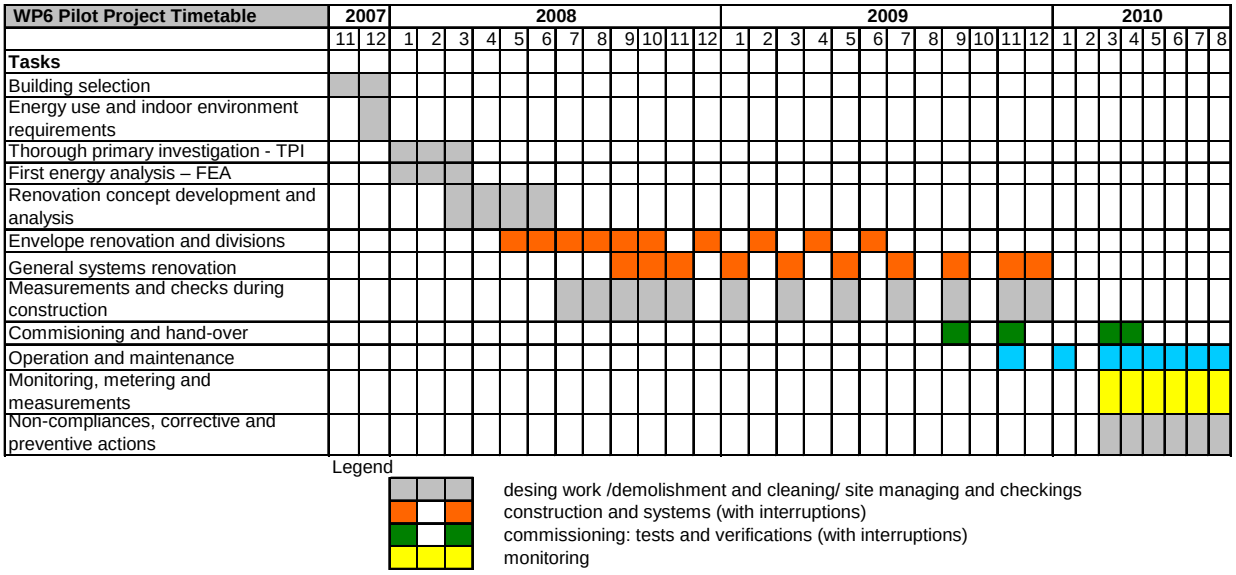
Picture 20. Regional Public TV station (TV3) recording images and interviews at the Barcelona's Pilot Project (Source. Poma A.)

6 Final Project Schedule

The project timetable shows the steps from the planning to the construction and the monitoring.

The intense economic crisis greatly affected the construction sector since middle 2008. The financial problems and demand retraction forced the developer to slow the work process. Finally, during the second 2009 semester most of the apartments were near finished. Some of them were already inhabited during the fisrt months of 2010.



Picture 6: Project schedule

A Annex 1 – Technical Annex: Description of the Pilot Project

Sant Joan de Malta Pilot project, Barcelona, Spain

Owner: Residencial Sardana
Architect: POMA Arquitectura
General contractor: Residencial Sardana
Energy concept: TRAMA TECNOAMBIENTAL
Location: Sant Joan de Malta street, Barcelona
Construction period: 2007-2010*

* *The long time of construction is due to the deep building sector crisis, the crash of credit and the drop of apartment demand.*

Key Technologies:

- Strenghtened thermal insulation and correction of thermal bridges
- Centralised ventilation (roof air entrance and evacuation) with individual energy recovery from renovated air flow
- Vented roof
- Highly efficient boilers (condensation)
- Free cooling
- Continuous monitoring of energy performance

A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

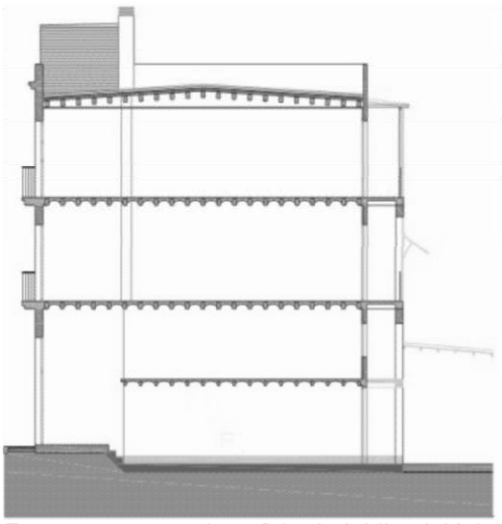
SQUARE

Background

Building before the renovation:
- 6 apartements
- Exterior walls, floor and roof without insulation
- Windows in very bad state
- Low confort,
- No heating system
- High operation costs
- Structural damages

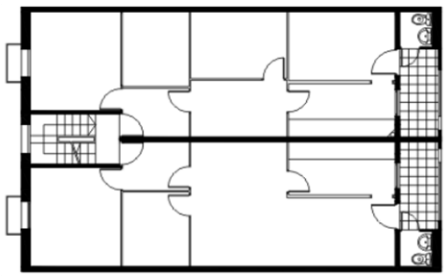
Building aerial view

Building main facade



Former cross-section of the buiolding initial state

Location: Old centre of the Clot neighbourhood
Heating degree days : 1.732
Year of construction: around 1890.
Heated floor area: 324 m^2.
Total heating energy: no data from formers tenants



Former floor plan of the building

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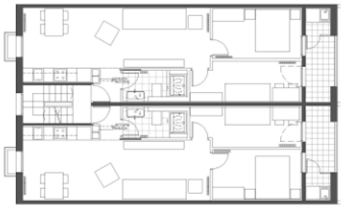
POMAARQUITECTURA

tta Trama TecnoAmbiental

Renovation energy concept ½

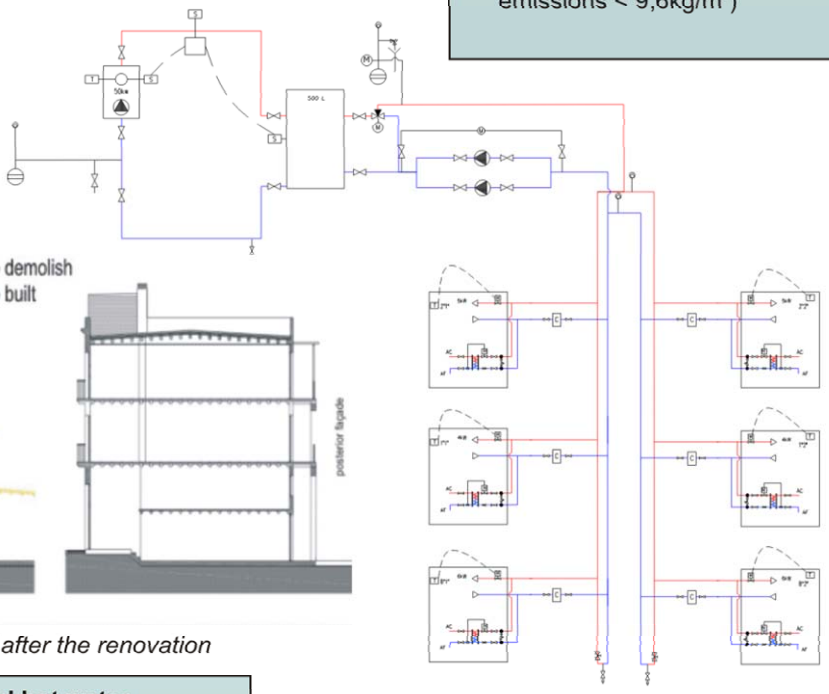


Renovated floor plan

The goals of the renovation startegy were:

- better global U-value (< 1 W/m²°C)
- better performance of thermal generation (>100% boiler performance)
- better performance of the ventilation system (>90% performance of heat air recovery)
- better quality of indoor environment
- at least B energy certificate (Co_2 emissions < 9,6kg/m²)

Space heating and hot water production system hydraulic scheme



Cross-section before and after the renovation

Collective heating and hot water production:

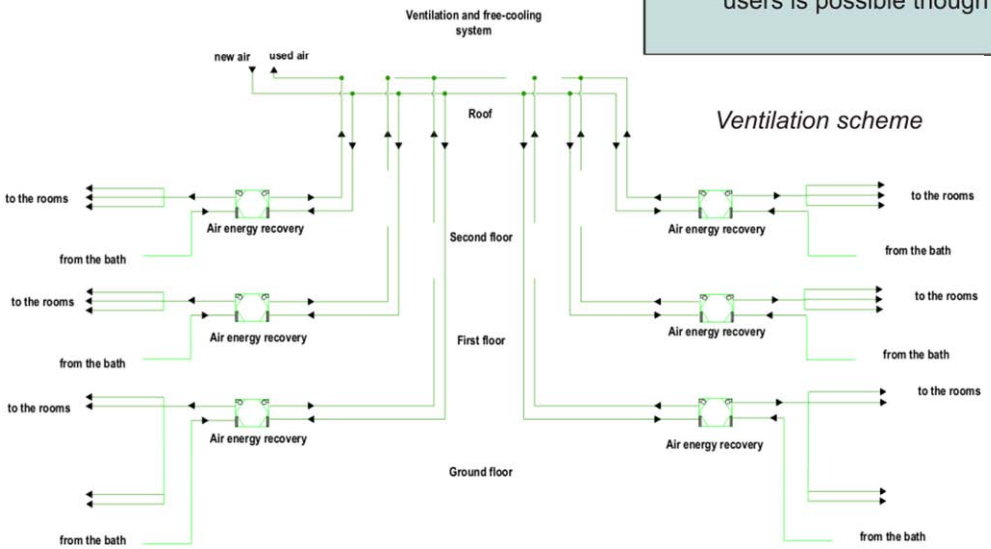
- Centralized heat production
- Highly efficient boiler
- Instantaneous heat exchanger
- Heated floor area: 324 m²
- Installed heating capacity: 76kW
- Spec. Heating capacity: 235W/m²
- Total estimated space heating energy : 8.175 kWh/a
- No solar installation because of the shadow on the roof.

Hot water tank, thermal energy meter and condensation boiler

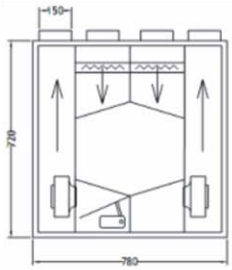
Renovation energy concept 2/2

Ventilation concept

Centralised ventilation:
- roof air entrance and evacuation
- individual energy recovery from renovated air flow
- Air energy recovery unit:
  - High efficiency >90%
  - Free cooling bypass
  - 1 unit per apartment
- Natural crossed ventilation controlled by the users is possible though not recommended.



Ventilation scheme



Opened individual ventilation and heat recovery equipment

Rainwater harvesting

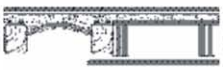
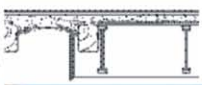
Rain water collection:
- 2 tanks of 1000l each.
- rainwater supply by gravity.

A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

SQUARE

Construction progress










- Demolishment and preventive works.
- Construction of the new sewer.
- Reinforcement the existing beams.
- Installation of new timber beams.
- Step the capillary moisture from the basement.
- Realisation of a waterproof and vented roof.
- Pose of the facade and internal walls´ insulation.
- Improvement of the air tightness: Use of new windows: wood frame, 4 -9- 5 double glazing.
- Installation of the rainwater harvesting sytem. The ground floor dwellings uses rain water for the garden.

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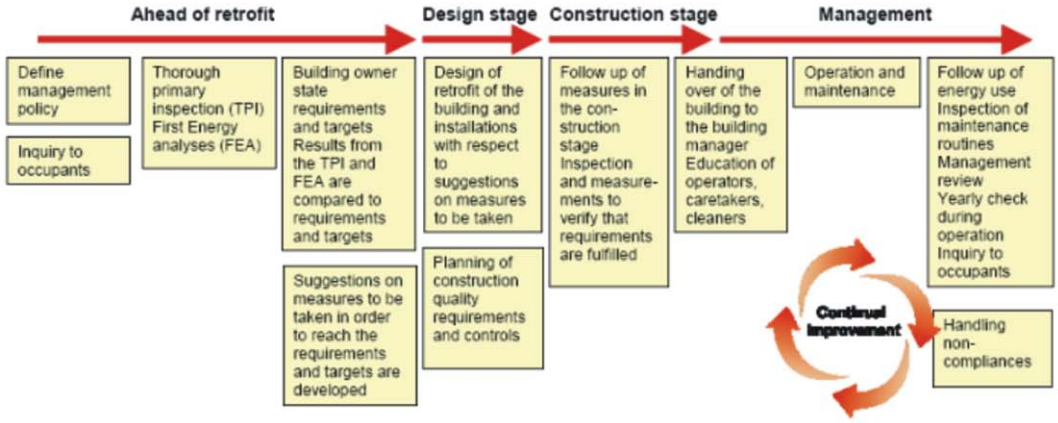
Summary

Project organisation:



The reformulated project has been tested with official software in order to verify the accomplishment of Spanish Building Energy requirements (CTE) and later to calculate its Energy Certificate

Demanda calefacción kWh/m²	C 25,2	D 42,8
Demanda refrigeración kWh/m²	B 4,1	C 5,4
Emisiones CO2 calefacción kgCO2/m²	C 5,3	E 13,7
Emisiones CO2 refrigeración kgCO2/m²	C 1,5	D 2,0
Emisiones CO2 ACS kgCO2/m²	A 2,6	D 4,9

Simulation by LIDER and Energy Certificate by CALENER

Success experience:

- Avoid complete demolishment of an old and damaged building.
- Building full renovation, preserving most of its structure.
- Preserve the building image and its integration on an ancient neighbourhood.
- Introduce actual mandatory rules on thermal demand.
- High performance ventilation system.
- High performance of the heating and hot water production system.
- Continuous monitoring of the energy performance.

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