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

Summary report on results and experiences from pilot projects in

Sweden, Finland, Austria and Spain

Final report

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PILOT PROJECTS FINAL REPORT

WP6

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SQUARE

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Preface

This report is part of the work carried out within the SQUARE project (EIE/07/093/SI2.466701), which stands for A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings. The project is co-funded by the European Commission, and supported by its programme Intelligent Energy Europe (IEE). The SQUARE project aims to assure energy-efficient retrofitting of social housing, with a good indoor environment, in a systematic and controlled way.

The partners of the SQUARE project are:

- AEE Institute for Sustainable Technologies, Austria
- EAP Energy Agency of Plovdiv, Bulgaria
- TKK Helsinki University of Technology, Finland
- Trecodome, The Netherlands
- TTA Trama Tecno Ambiental S.L, Spain
- Poma Arquitectura S.L., Spain
- SP Technical Research Institute of Sweden, Sweden
- AB Alingsåshem, Sweden

Summary

This report is a summary of the national reports prepared by the four organizations that have been following up one pilot project in each country regarding energy efficient and improved indoor environment renovation of existing residential buildings.

The aim of this report is provide a review of the four pilot projects renovated during the last three years in Sweden, Finland, Austria and Spain, focused in two main areas:

- the implementation of the Square's Quality Assurance System during the development of each pilot project, and
- the technical solutions applied in each pilot project adapted to each building conditions and climate.

The Swedish pilot project was selected because of its condition of typical multi-family housing structure in Sweden, representative for the Swedish "million homes program" built in the sixties and seventies, most of them public residential buildings, so feasible concepts for renovation have a great potential for multiplication. The other reason was that the housing organization Alingsåshem had far-reaching ambitions for this large renovation project. The Swedish pilot project comprises the retrofitting of 50 out of the 300 multifamily apartments in Brogården, Alingsås. SP has been acting as a technical partner to Alingsåshem during the planning and construction work.

The pilot project in Spain has been conducted in a smaller development, but very representative as a basis for replication at a larger scale. Usually in Spain, the development is conducted under a private scheme and the renovated apartments are sold at the end of the renovation works. The pilot project is a 4 storey building, 100 years old, located in the city of Barcelona (Sant Joan de Malta Street).

The Austrian pilot project was selected due to its high representativeness of the typical social housing structures of Austria. The building stock of 3-4 stored multifamily–houses built in suburban areas or small-towns in the 1950s, 1960s and 1970s is very large. The feasible solution-with prefabricated façade elements for renovation have a great potential for replication. The Austrian pilot project comprises the retrofitting of 6 multifamily apartment buildings in Graz, with a total of 204 flats.

The Finnish project was selected because its owner, the North Finland Student House Foundation (PSOAS), has established some very demanding target requirements for energy use after renovation. These are taken from a voluntary standard for passive houses recently developed in German and adopted to the climate in North Finland. The main focus of the SQUARE activities in Pohjankaleva is the assessment of Finnish QA tools already in operation and how they can be integrated with the new essential SQUARE procedures. The building is a student house in Oulu. It was built in 1970 and partially renovated in 1993. Its technical condition is still relatively good.

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1 Introduction

1.1 Objectives and target buildings

The Pilot Projects main objectives were to:

- apply 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 typical multifamily building in each country
- achieve a high performance on energy use and indoor environment

The objective was that target buildings were representatives of the particular building stock of each country, in terms of several factors:

- Age and size of existing residential building stock
- Multifamily building size
- Suitable for replication

In Sweden, the “million homes program” consists of approximately 600.000 dwellings in multifamily houses, built in the sixties and seventies. Out of the total number of apartments in multifamily houses, public residential buildings account for around 60 %. The majority of existing residential buildings are thus managed under lease schemes (by housing associations or similar organisations), but privately owned flats and houses are becoming more and more common.

Hence, the pilot project in Sweden is being conducted in a publicly owned housing complex, so as to serve as a basis for replication at a larger scale. However, as private apartment owners in Sweden normally manages renovation of building shell and installations in a common effort, the pilot project will also be useful in that particular environment.

The situation in Spain is very different. 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 is usually carried out by the same community of users/owners of the block or development. During the last 25 years much of the public residential stock has been privatized, usually sold 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 only area within the building sector that will maintain a certain activity in the short and medium term given the general financial context.

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.

Austria is very similar to Sweden, more than 50 % of all dwellings are owned by public associations or municipalities. It is common to have a couple of them in suburban areas like Dieselweg, the Austrian pilot project, as well as in small towns. An important aim is to raise the renovation rate in Austria – that is also one of the objectives, when Dieselweg uses prefabricated facade-modules for the renovation.

In Finland, the production of social apartment buildings was highest in the beginning of 1970's. The Finnish pilot building is typical student building built during 1960's and 70's. The average room size is small which increases renovation costs per square meter due to high building services installation cost.

The production levels of private condos were highest in 1974 and in 1988. The construction technology is quite same as in social apartment buildings. It is easy to adapt experiences from social housing in to condo's. The management of condo's is less professional and the decision making process in condo's is difficult and time consuming.

The target buildings

Sweden

The Swedish Brogården pilot project consists of 16 three storey buildings including 299 flats, of the similar type of construction built between 1971 and 1973, and located in the vicinity of the city of Alingsås. The main characteristics of the target buildings were:

- Forty year old buildings with a need for an integral renovation
- High replication potential of the developed renovation model
- Property management organization with the aim to go far beyond the actual energy regulations

The buildings have problems with frost damages brick facades, draughty apartments, thermal bridges, damaged balcony slabs and moisture damaged concrete ground slabs. The municipal housing association, AB Alingsåshem intends to retrofit the buildings to **passive house standard**. This will be achieved by supplementary insulation of the building envelope, additional air-tightening the building envelope, changing to super-insulated windows and installing high efficient air-to-air heat recovery.

Austria

The Austrian renovation project „Dieselweg" was selected as SQUARE pilot project due to the following reasons:

- It represents the typical social housing structures of Austria
- The building owner´s policy is oriented on quality assurance and has an intention to realize innovative concepts.

The building stock has 3-4 stores. The area is suburban (can be compared with the situation of small towns in Austria) and the buildings were built in the 1950s, 1960s and 1970s. These building structures are found in a great number in Austria. Therefore feasible solution-sets have a great potential of multiplication. Since the time of construction no improvement measures had been carried out in these buildings.

Spain

At the beginning of the Square project, has proved very difficult to find a candidate for a pilot project. It was not possible to engage public administrations or private developer with a large project of renovation to be developed within the SQUARE time scope.

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.

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. Pilot projects buildings before renovation (Brogarden, Barcelona, Finland and Graz, clockwise order)

Finland

The Finnish renovation project "Pohjankaleva" was selected as SQUARE pilot project primarily because the building owner's policy is oriented on quality assurance and has an intention to realize innovative concepts.

The building is a student house in Oulu for 128 rooms with shared WC, bathroom and kitchen for students. It has been built in 1970 and partially renovated in 1993.

The main reason for renovation is the number of un-rent rooms which have been increasing during last years and was before renovation already 20 %.

1.2 Scope and limits

In the following section, the pilot projects are described in terms of objectives and limits with each renovation etc.

Pilot project	Sweden	Findland	Austria	Spain
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Target buildings	■ 40 years old buildings with a need for an integral renovation ■ High replication potential of the developed renovation model ■ Property management organization with the aim to go far beyond the actual energy regulations	■ Student house ■ Improve the quality and comfort of the apartments ■ Renovate the services	■ 3-4 stores ■ Built in 1950's and 70's ■ Suburban area ■ It represents the typical social housing structures of Austria ■ The building owner´s policy is based on quality assurance and has an intention to realize innovative concepts.	■ 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
Objectives	■ High performance renovation: passive house standard ■ To improve air quality, thermal comfort and moisture control ■ To improve accessibility for elderly and disabled ■ To increase heterogeneity in apartment size and better accessibility for families.	■ High performance renovation: Class C in the Finnish Indoor Air Classification. ■ New introduction of ventilation systems.	■ High performance renovation: passive house standard. ■ Renewal of the building services. ■ Introduction of ventilation systems. ■ To establish new, innovative and economic procedures to improve renovation quality. ■ To reach an user acceptance for high-performance renovation. ■ To establish more awareness within housing associations for sustainable and energy-efficient renovations.	■ High energy performance retrofitting ■ Preserve as much as possible the existing structure (walls, floors, roof, staircase, etc.) ■ 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.
Limits	■ Preserve social networks among tenants ■ Long term stable rent levels ■ Impression of the exterior facades were to be maintained in terms of colour and texture ■ Facades are to be kept plain without screen roofs or similar attachments in order to maintain the original impression ■ Rents were to be kept within certain limits which set a roof for the available renovation budget. In this context, the apartments at ground level were renovated into new built standard, resulting in comparably high rent levels.	■ outdoor design temperature -32 ºC.	■ No additional measures inside the building (except elevators). ■ No additional measures inside the apartments except the ventilation devices, the integration of balconies and replacement of windows.	■ Old building in very bad conditions, grave structural deficiencies. ■ Private developer (Residencial Sardana S.A.) with the wish to renovate and sell the apartments. It will not manage the apartments after the hand-over to the new owners. ■ The size of the the pilot project is limited to the 6 apartments.

1.3 Background

The following table is a technical description of the pilot building.

Pilot project	Sweden	Findland	Austria	Spain
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Construction year	1971-1973	1970	1952- 1959 - 1970	ca 1890
Number of apartments	299	Student house	204	6
Number of bloks	6	1	6	1
Construction materials	Concrete frame, infill walls facing balconies, brick facade, concrete floor structure, concrete loft ceiling beams, rafter with strut of wood and tar paper on top. The facades have a cladding of a sheet material	Aerated concrete, concrete floor structure, concrete roof. No balconies.	Brick walls, concrete floor and top ceilings without insulation, wooden windows of very poor performance	Brik and stone walls, wood beams, wood windows of very bad performance,non-insulated flat roof and external walls
General systems	District heating (incl. domestic hot water), electricity, water and sewer	District heating (incl. domestic hot water), electricity, water and sewer	Heating and hot water from electricity and old fossil fuel boilers	Individual electric hot water and heating system
Initial buildng state	Low insulation, non performant ventilation	Partially renovated in 1993, relatively good technical condition of the building, low confort, high exhaust air flow rates.	High energy consumption, low indoor environment quality	Structural damages, obsolte services, high energy demand, low comfort
Ownership	Alingsåshem /Public Housing company	Public student housing company (PSOAS North Finland Student Home Foundation)	GIWOG / Public Housing Association	Residencial Sardana /Private developer
Developer	Alingsåshem /Public Housing company	Public student housing company (PSOAS North Finland Student Home Foundation)	GIWOG / Public Housing Association	Residencial Sardana /Private developer
Renovation period	2007-2010 (3 bloks)	2009-2011	2007 - 2010	2007 - 2010

2 QA system Methods and accomplishment

2.1 General QA strategy

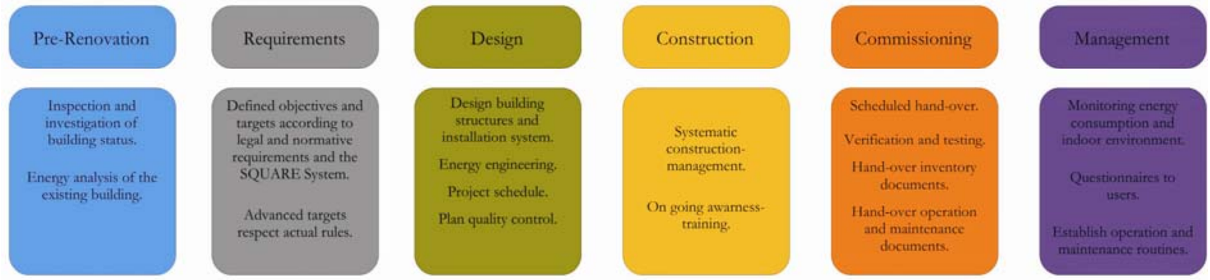
The Square QA system is not only a pioneer quality assurance system for building renovation projects on energy and indoor environment aspects; it is also a new management experience for many of the different pilot project partners in each country. For this reason, the procedures involved in the Square QA system have been implemented gradually, integrating them into the usual management procedures of a building renovation work. Usually the social housing association /company or equivalent organization have coordinated the QA implementation.

The objectives were to test:

- the advantages derived of the QA implementation
- the time required for the document management
- the difficulties to implement the QA guidelines between the pilot project partners
- the QA system adaptation to specific country requirements, rules, kind of ownership, etc.,

during the renovation project of each pilot project.

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



Picture 2. Overview of the main steps in the SQUARE QA system

The following tables summarize the main aspects of the SQUARE QA system that have been worked on in each pilot project:

2.2 Establishing pre-renovation conditions

Pilot project	**Sweden**	**Finland**	**Austria**	**Spain**
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Pre-renovation	■ Getting in contact with the Tenants. ■ Involving the tenants in the renovation process. ■ Thorough Primary Inspection (TPI) of the buildings.	Tenant surveys: IAQ-problems, prorization of individual needs like private WC and bathroom.	■ Getting in contact and building up the cooperation between partners for the project group – everybody in this team has been approved to develop innovative concepts. ■ All necessary steps to set up a pilot project were prepared. ■ A project team for the planning was established. ■ The office “Hohensinn Architektur ZT GmbH” was assigned to do the primary investigation (similar to the TPI) – an analysis of the building structure and the weak points. ■ The technical office of Mr. Aschauer was assigned to elaborate the first energy analysis.	■ Analysis of the pre-renovation conditions has been focused on structural aspects. ■ The TPI was developped on the building, analyzing the transmittance of the façades, basement floor and roof. ■ Energy simulation carried out on a reference building created by the LIDER software.

2.3 Formulation of requirements and targets prior to renovation

Pilot project		Sweden	Finland	Austria	Spain
Town		Brogården, Alingsås	Oulu	Graz	Barcelona
Requirements	on the energy efficiency	■ To keep total energy needs at 92 kWh/m^2.	■ To reach passive house standard level which in northern Finland is 30 kWh/m^2 per year for heating energy (domestic hot water 25 kWh/m^2). ■ To keep total energy (heating + electricity + domestic electricity) needs at 127 kWh/m^2.	■ To reduce the energy demand for space heating about 90 %. ■ To keep total heating energy needs at 10 kWh/m^2 per year. ■ To reduce the running costs for hot water generation. ■ To eliminate construction damages and thermal bridges. ■ To use solar thermal systems for hot water generation and heating.	■ Better global U-value (< 1 W/m^{2o}C). ■ Better performance of thermal generation (>100% boiler performance). ■ Better performance of the ventilation system (>90% performance of heat air recovery). ■ At least B level energy certificate (total heating energy needs < 25 kWh/m^2).
Requirements	on the indoor environment	■ To verify a confortable indoor environment by making building simulations. ■ To fulfill the requirements in P-marked indoor environment.	■ To verify a confortable indoor environment by making building simulations.	■ Installation of single room ventilation fans with integrated heat-recovery to get adequate air quality. ■ To install a centralised heating system – partly based on renewable energy sources. ■ To increase the living space. ■ To get barrier-free access to all flats by installation of passenger lifts per each building.	■ Air renovation regulated by CO_2 sensors. ■ Air renovation programated in function of the use of the apartments. ■ Low emissions paints and furniture. ■ Installation of individuals ventilation fans with integrated heat-recovery to get adequate air quality.
Requirements	others	■ To permit the individual control of energy use and indoor climate. ■ Easy to operate techniques. ■ Small maintenance needs through conscious choice of material. ■ Long-term stable rent levels. ■ Better accessibility for elderly and disabled people. ■ Meeting places for tenants. ■ Preserving the cultural heritage value of the buildings.		■ All occupants should remain in their flats during the construction works. ■ The occupant's comfort has to be improved (increased indoor living quality). ■ The living quality within the quarter has to be upgraded (increased outdoor living quality).	

2.4 Design

Pilot project	Sweden	Finland	Austria	Spain
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Design	■ Determination of the daylight factor. ■ New design of the wall construction to guarantee U-values, moisture safety,… ■ Energy engineering and general systems deign. ■ Design of the ventilation system.	■ Simple energy analyse (www.motiva.fi). ■ Simple condition survey. ■ Plumbing and water systems. ■ Indoor air and ventilation	■ 3D–on-site measurement of building façade (laser scanning). ■ Design of the entire building structure by “Hohensinn Architektur ZT GmbH”, HVAC - Engineering consulted by the AEE INTEC. ■ Drafts for solution-sets for the façade and roof modules. ■ Energy engineering by the technical office Aschauer. ■ Development of the pre-fabricated module by the technical office “gap-solution”. ■ Applying the building permit. ■ Approval of the detailed composition of the modules by the building physician, consulted by the AEE INTEC. ■ Design of the detailed drawings, consulted by the AEE INTEC. ■ Tendering procedure and placing of orders.	■ 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.

2.5 Training

Pilot project	Sweden	Findland	Austria	Spain
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Training	■ Training and information to the contractors. ■ Training and information to tenants. ■ Presentation of the technical systems and practical arrangements in the new apartments to the tenants.	■ Maintenance handbook (mandatory in Finland). ■ Guidelines for how to build a clean ventilation system. ■ Guidelines for how to clean building before occupancy.	■ Training and information to the contractors. ■ Training and information to tenants. ■ Presentation and awareness rising for the coming monitoring procedure.	■ Training and information to the contractors. ■ Training and information to tenants. ■ Permanent training during the technical work visits (weekly)

2.6 Site management and follow-up during work stage

Pilot project	Sweden	Findland	Austria	Spain
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Construction	■ Job planning. ■ Testing of air tightness. ■ Moisture control.	■ Moisture control during construction work. ■ Dust control during construction work.	■ Regularly site consultation meetings. ■ Systematic communication structures. ■ Regularly on-site inspections of the different experts – each responsible for his defined department. ■ Inspection and approval of the prototypes of the pre-fabricated modules in the fabrication hall. ■ Production of the single modules according to the on-site measurements and detailed drawings.	■ 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.

2.7 Commissioning and user's information

Pilot project	**Sweden**	**Finland**	**Austria**	**Spain**
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Commissioning	There will be no final inspection by the end of the project. A control program for "quality critical measures" is maintained by the main contractor and by the subcontractors.	■ Measurements of air tightness, thermal bridges and thermal comfort measurements after renovation. ■ Measurements of ventilation rates and carbon dioxide levels.	■ Commissioning a Blower Door Test. ■ Checked the assessment of the thermal envelope.	■ 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.

2.8 Performance assessment, monitoring and management

Pilot project	**Sweden**	**Finland**	**Austria**	**Spain**
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Performance assessment Monitoring	■ Follow up on indoor environment. ■ Follow up on energy use.	■ Energy certification Simple (Annually) Detailed (Between 10 years)	■ Follow up of the energy flows.	■ Follow up of the electricity, gas and heat consumptions by specific meters.

3 Lessons learned from the QA system implementation

Pilot project	**Sweden**	**Findland**	**Austria**	**Spain**
Town	Brogården, Alingsås	Oulu	Graz	Barcelona
Identified success factors in the implementation work	■ Form of contract used: partner contracting which involved new ways of working and new possibilities. ■ High investment of the main contractor. ■ Evaluation and adaptation of untraditional working methods and new technical solutions ■ Use of the feed back to the SQUARE project. ■ Definition and integration of relevant requirements on indoor environment and energy use in the system. ■ Assessment and adjustment of Alingsåshem's existing QA system.	■ Use of the existing finnish QA system.	■ Tenants remaining in their apartments. ■ Tenants informed from the beginning. ■ Use of new (prototypes) renovation technologies. ■ Design of a new shape of the building.■ Short construction works.	■ A design team that unites experience and complementary skills and great interest in the concept Square has formed. ■ Close relationship between developer, architects, engineers, installers, building workers, etc... ■ Adaptation of the procedure to the circumstances of the project. ■ Priority given to conservation than to the demolition. ■ Most of the structures has been preserved. ■ Construction methods compatible with the existing have been used. ■ Energy improvements bring economical added value to the apartments for sale.
Identified barriers or difficulties in the implementation work	■ Adding daily burden to the service personel. ■ Lack of skilled project leaders. ■ Lack of integration of the local manager in the design phase. ■ Sub contractors often lack understanding about the importance of quality assurance. ■ Difficulty to record the findings in a database. ■ The QA system was not used as intended in all parts during the initial work: feedback is lacking.		■ Difficult selection of the right technical solution (especially within the HVAC –systems) ■ Financial aspect: raise of rents because the improvement costs but compensated because of the reduction of the energy running costs.	■ Lack of continuity of the building developer because apartments are for sale. ■ Lack of companies engaged in the management of residential buildings thermal plants.

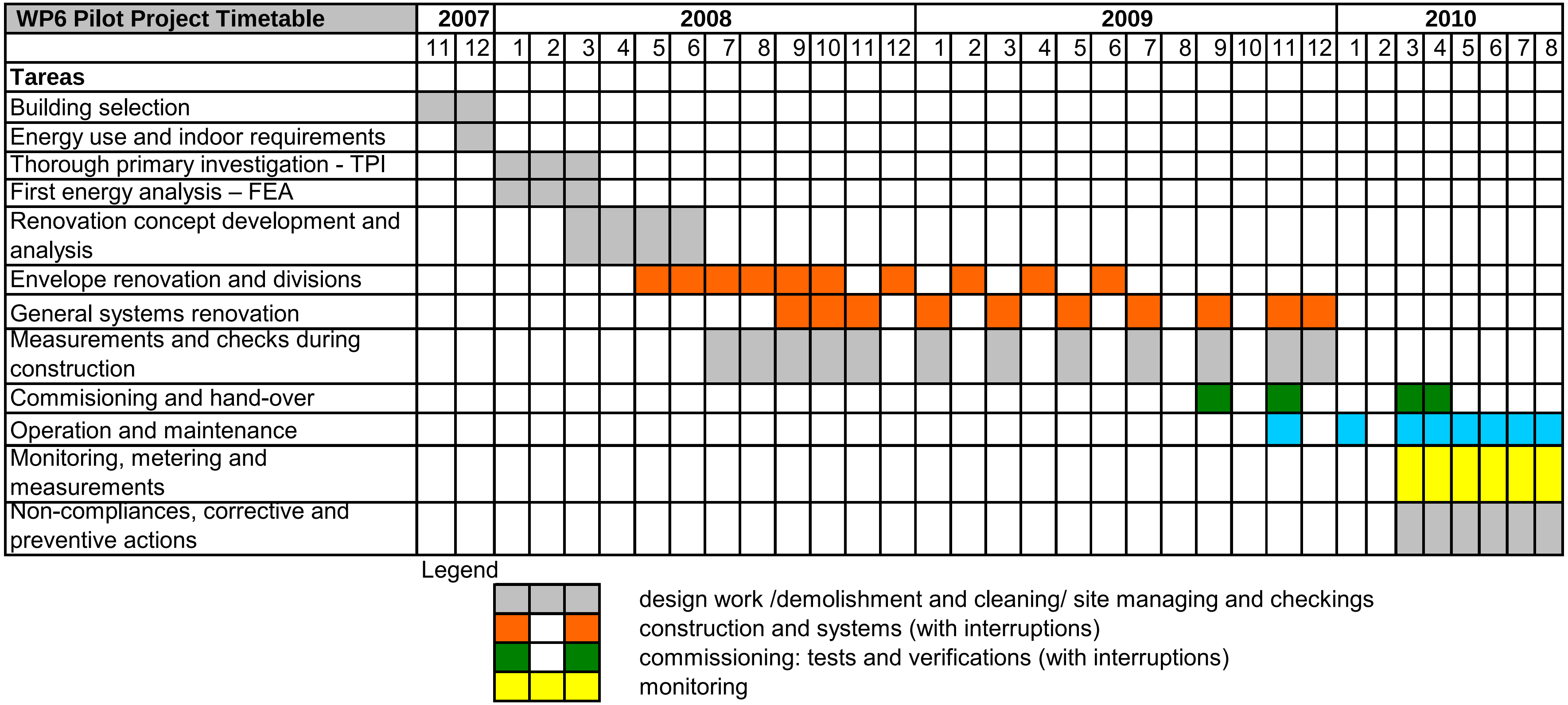
4 Final Project Schedule

Sweden

Pilot project Timetable	Before the Square projekt started					2007		2008												2009												2010					
						11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Activities																																					
Building selection																																					
Requirements on energy use and indoor environment																																					
Thorough primary inspection (TPI)																																					
First energy analysis (FEA)																																					
Renovation concept development and analysis																																					
Procurement and contracting																																					
Official start meeting and training																																					
Demolishion of facade and in-filled walls												D										E			F												
Building envelope renovation works															D								E			F											
General installations and systems																D								E			F										
Measurements and controls																																					
Commissioning and hand-over																				D										E			F				
Moving in building D, E and F																					D										E			F			
Operation and maintenance																																					
Follow up on indoor environment																																	DE				
Monitoring, metering and measurements																																					
Non-compliances, corrective and preventive actions																																					

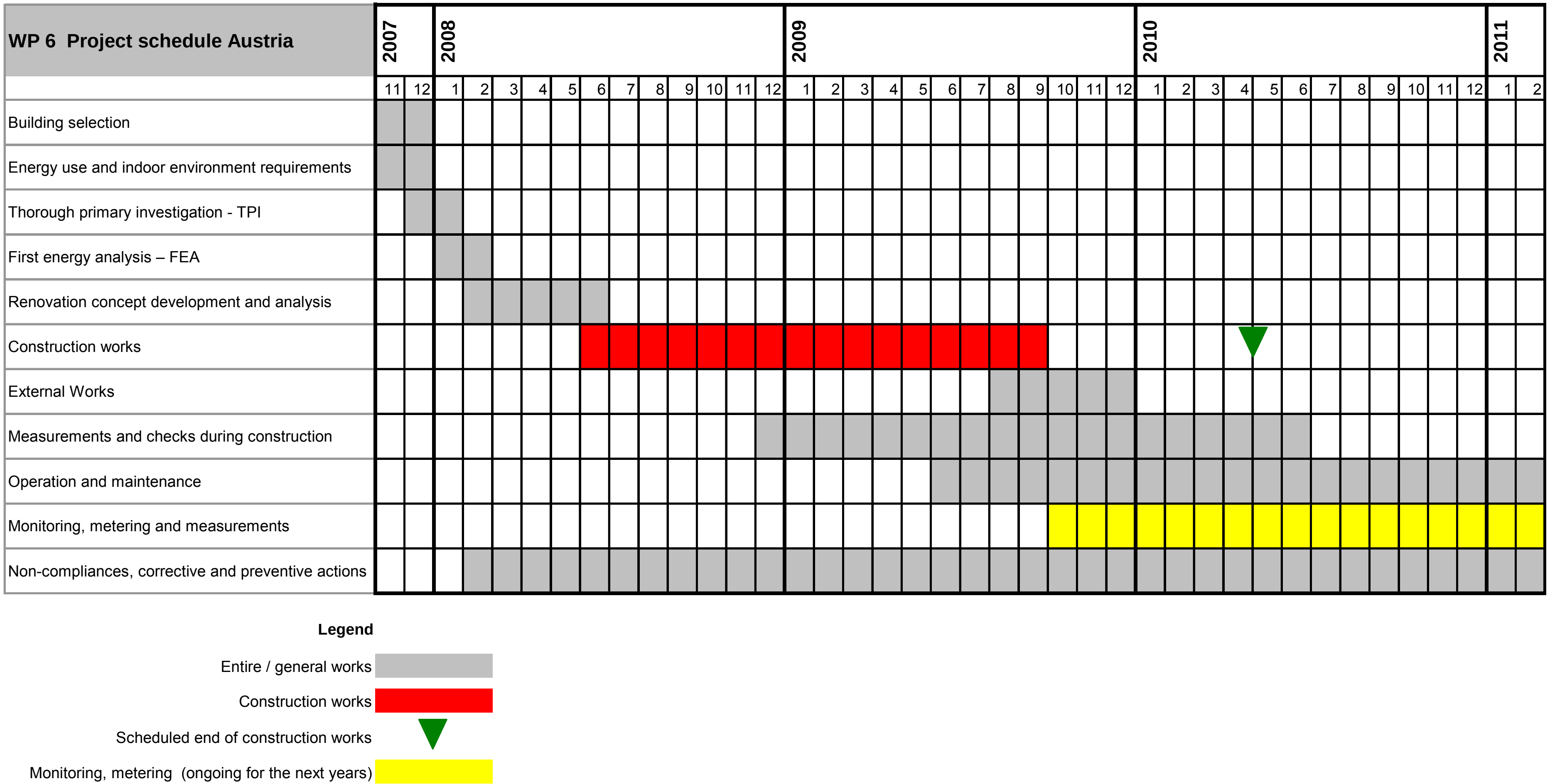
Picture 3: Swedish project schedule

Spain



Picture 4: Spanish project schedule

Austria



Picture 5: Austrian project schedule

Finland

	Year
	Month
Building selection	2008/3
Energy use and indoor environment requirements	2008/9
Thorough primary investigation - TPI	2007
First energy analysis – FEA	2008
Renovation concept development and analysis	2008(1-12)
Envelope renovation	2010/8-
General systems renovation	2010/9-
Measurements and checks during construction	2011(1-6)
Operation and maintenance	2011/8-
Monitoring, metering and measurements	2011/7-
Non-compliances, corrective and preventive actions. Warranty period 24 months	2011-2013

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

Annexes from the national WP6 reports.

Technical description of pilot project

A.1 The building structure before renovation

A.1.1 Windows, wall and roof insulation

The residential area Brogården in Alingsås with 299 apartments build between the years 1971 to 1973 and is part of the Swedish "million homes program". The building type is *slab blocks* with tree floors and no lifts. The buildings are placed in groups around pedestrian precinct yards. The slab blocks were built of in situ concrete as gables and interior sheer walls and light fill in walls units of wood, insulation and gypsum boards. Three different ground constructions can be found; concrete slab on ground without insulation, cellar with shelter and crawlspace. Some parts of the building have moisture damages in the slab on ground. The *façade* material is yellow brick, which is severely damaged by frost. The facades facing the balconies have a cladding of a sheet material. The *roof* is low tilted roofs with short shoulders, covered by under-felt. The windows is 3-panes with a U-value of 2,0 W/m^2, K and the doors have a U-value of 2,5 W/m^2, K. The balcony slabs are an extension of the load bearing concrete frame which means that there are thermal bridges to the floor inside the apartments. The balcony slabs also have damages due to carbonation.

A.1.2 Heating and ventilation

The buildings are heated with a traditional heating system consisting of hydronic radiators and have a central ventilation system without heat recovery. The apartments are draughty most probably due to air leakages in the building envelope.

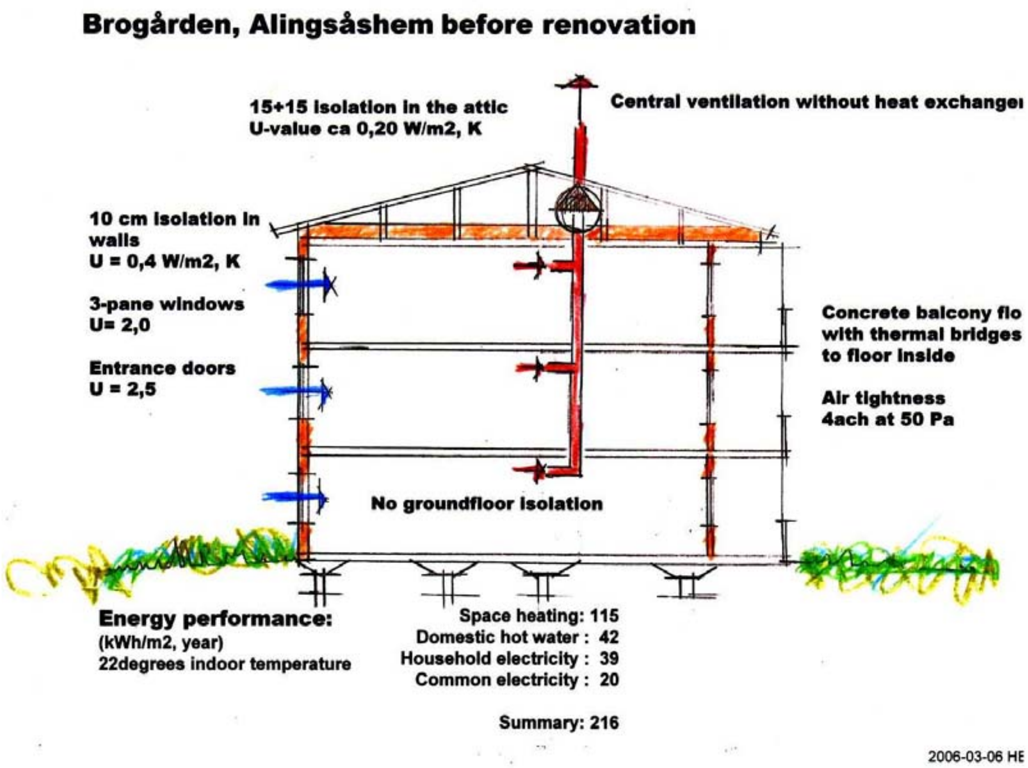


Figure 35 Building envelope and installations pre renovation. Illustration by Hans Eek.

A.2 The building structure after renovation

A.2.1 New construction materials

The existing low tilted roof of tongued and grooved wooden boards has been reserved. Additional insulation of approximately 50 cm has been placed in the attic. The beams of the roof and eaves have been extended to cover the new thicker façade. The in situ concrete framework has been preserved. The old in fill walls are removed and replaced with new in fill walls of steel studs and in total 440 mm insulation, which gives a total thickness of 520 mm. The old balconies are encased in the building envelope and made part of the living room. New self-supporting balconies are placed outside the façade. The facade is covered by screen bricks in a yellow shade. New 3-pane windows with an U-value of 0,9 W/m^2, (opening window) och 0,8 W/m^2, °C (non opening window). The infill walls are covered by fiber cement panel boards. A layer of EPDM rubber has been laid on the existing slab on ground as a moisture barrier. On top of that is 10-12 cm expanded cellular plastics board, a screed and fiber board floor. The cellar vault is insulated in the buildings with cellar.

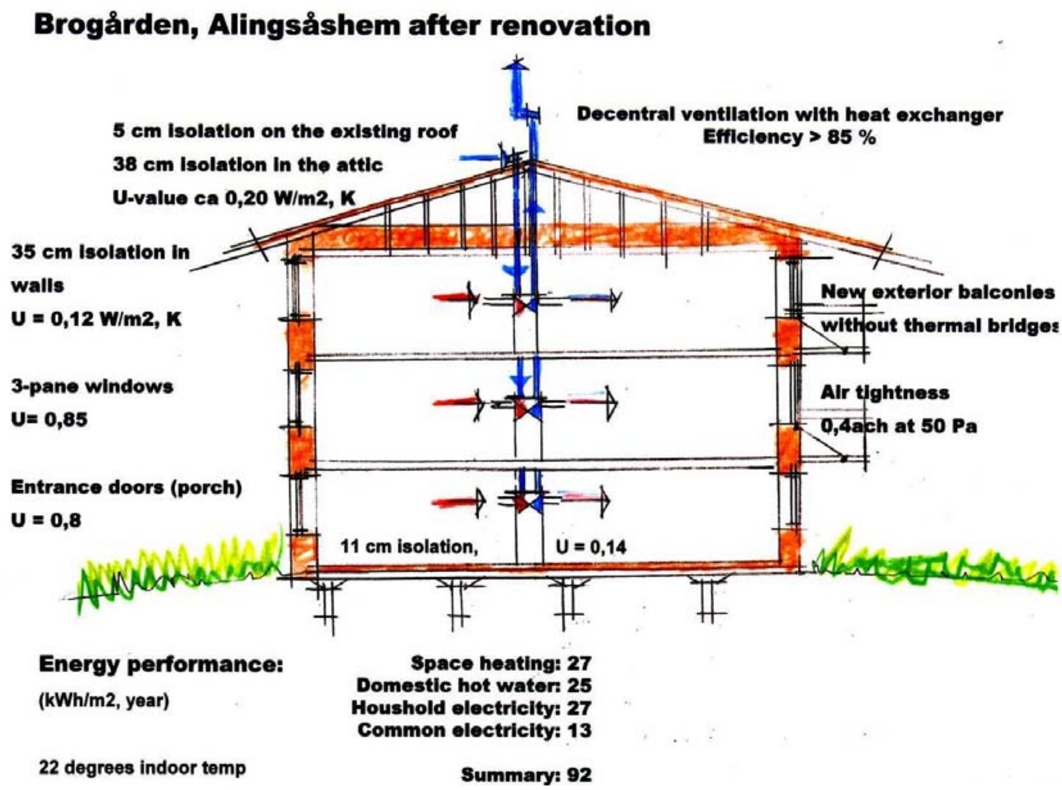


Figure 36 Building envelope and installations after renovation. Illustration by Hans Eek.

A.2.2 New heat, hot water and ventilation system

In the first building D, an air treatment unit (REC Temovex 250S-EC) was installed in each apartment. The air is supplied through a mesh in the outer wall behind the façade and the exhaust air is transported via shafts to the roof. The air treatment unit is placed in the bathroom which was enlarged to make room for the unit. It is complemented with a hydraulic heating coil that will be activated at very low outdoor temperatures. In the summertime tap water will be heated by solar panels and in the wintertime the tap water will be heated by district heating, and so will the hydraulic heating coils. The unit has a user friendly maneuver board which can be adjusted by the tenants. The filters are change by the care takers.

The ventilation solution is building E and F, is a central aggregate for heating and ventilation serving all apartments as well as common space. In case of fire, the supply air is forced and the exhaust air is throttled to avoid spreading of smoke and gases to apartments close. Kitchen fans are installed on existing network of canals emerging on the top of the roof.

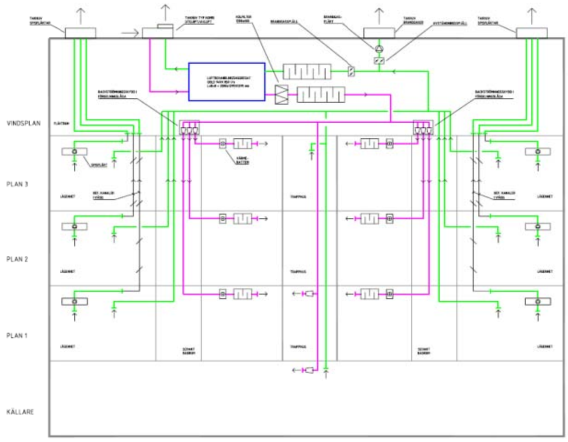


Figure 37 Designed ventilation system for the buildings with central ventilation, building E and F.

Figure 38 Air treatment system unit for a single apartment, used in building D.

A.2.3 Electricity

All electric installations are new and the apartments are provided with tele/IT communication circuit. The entrées are provided with hall telephone and permit system.

A.2.4 Metering and monitoring equipments

All supplied energy will be measured individually in each apartment in terms of electricity, hot water and heat. The supplied heat from district heating will be measured for each staircase since this is very low. The extra heat supply is maximized to 10 days per year.

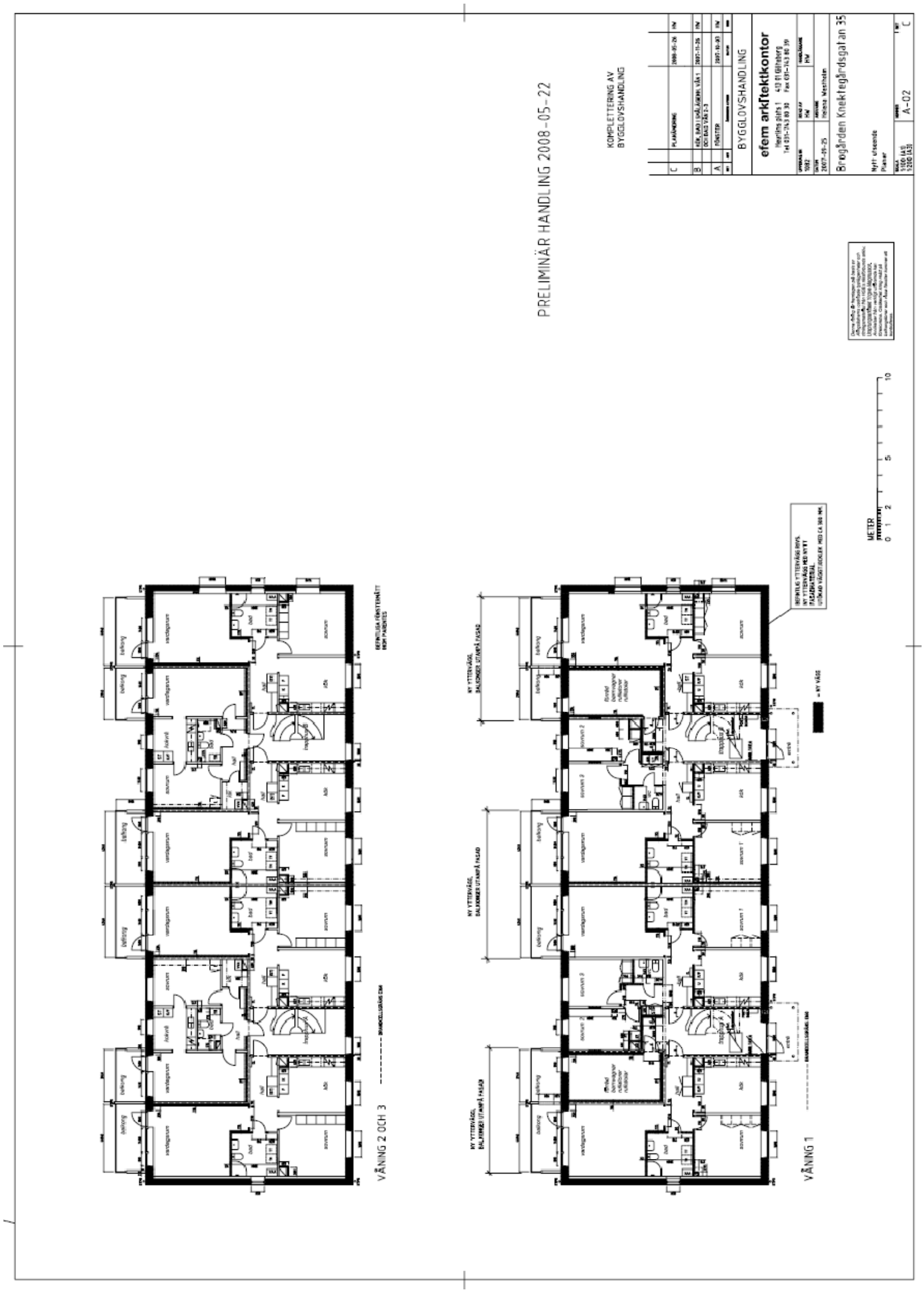


Figure 39 Plans of building D.

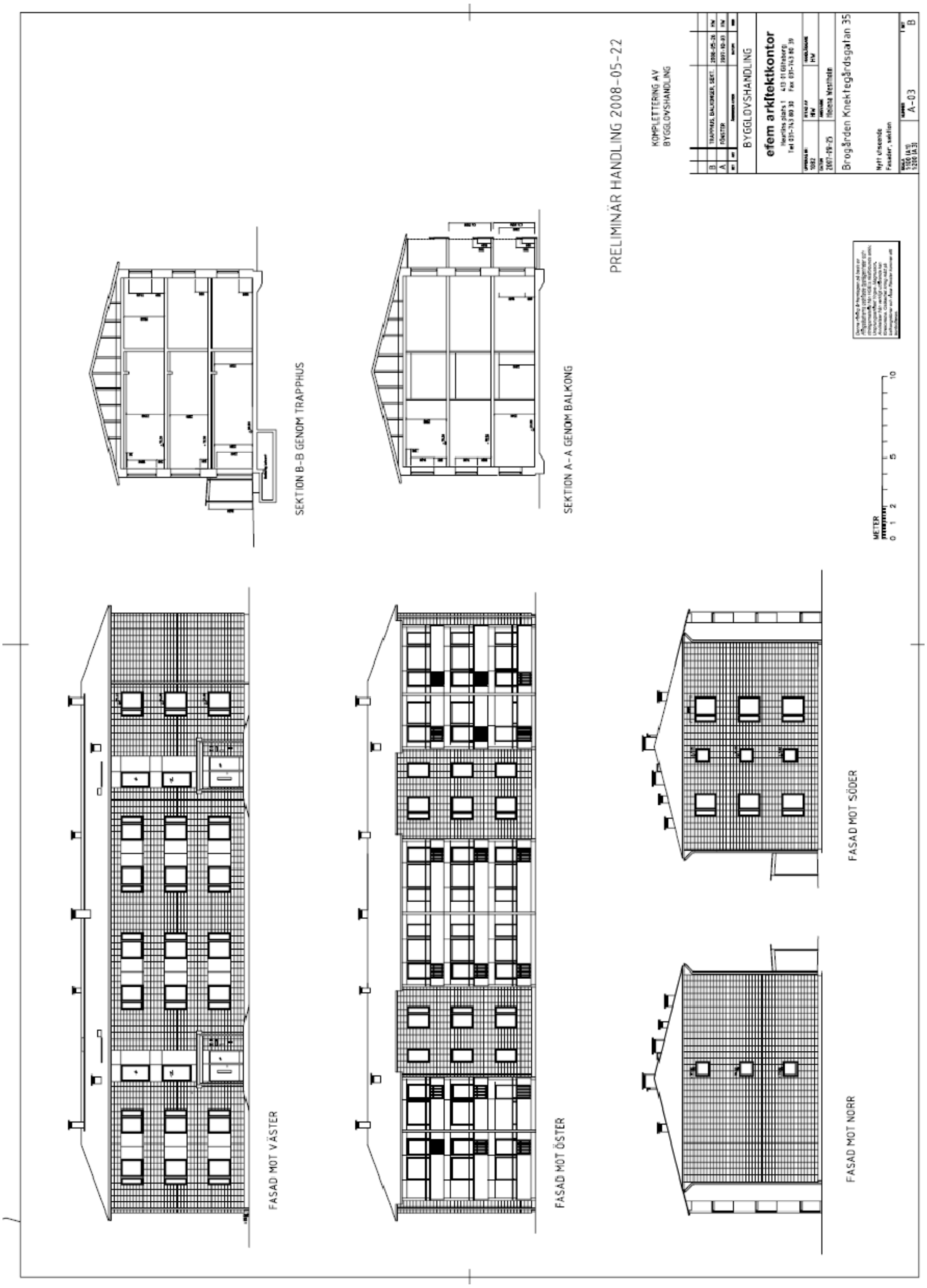


Figure 40 Facade sketches for building D.

Annex 2 – Technical Annex: Description of the Austrian Pilot Project

Residential area Dieselweg, Graz

Owner: GIWOG
Gemeinnützige Industrie Wohnungs AG
Architect: Architekturbüro
Hohensinn ZT GmbH
General Contractor: gap-solution GmbH
Energy concept: ESA-Energie Systeme
Aschauer GmbH
Report: AEE INTEC
Location: A-8041 Graz
Date: 2010

Key technologies

- Passive solar façade "climate wall concept"
- Heat supply with a high solar coverage + new kind of storage technology
- Heating- and hot water supply system between the façade and existing wall
- Decentralized ventilation system with heat recovery
- Controll and remote maintenance via internet
- Pre-fabrication of all facade components

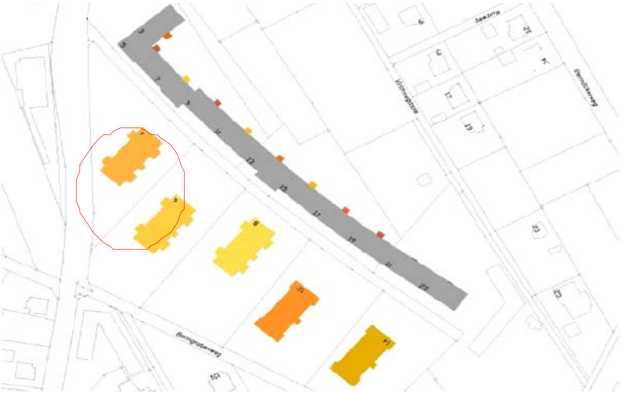
The residential area Dieselweg comprises five single buildings and one long building row. One single building – Dieselweg No. 4 was chosen as representative for all others.

Background

Building before renovation:

- 16 Apartments
- Exterior walls, floor and roof without insulation
- Windows in need of rehabilitation
- Heat supply: 13% solid fuel, 33% oil, 54% electricity
- Power based hot water generation
- Low comfort
- High operating costs

Picture A1: View of building before renovation [source: GIWOG]



Picture A2: Site plan showing the entire area and location of building "Dieselweg 4" [source: Hohensinn ZT GmbH]

Building before renovation

Location	Dieselweg 4, Graz
Altitude	345 m
Heating degree days	3.499 Kd
Year of construction	1959
Number of apartments	16
Heated floor area	1.091,6 m²
Total heating energy (incl. hot water)	200.855 kWh/a
Spec. heating energy consumption	184 kWh/(m²a)
Installed heating capacity	71,83 kW
Spec. Heating capacity	65,8 W/m²

Figure 3: Typical floor plan of building [source: Hohensinn ZT GmbH]

2

Renovation concept

Figure 4: View on renovated building [source: GIWOG]

Design data for renovated building

Year of renovation 2008-2009
Number of apartments 16
Heated floor area 1589,4 m²
Total heating energy (incl. hot water) 15.258 kWh/a
Spec. heating energy consumption 9,6 kWh/(m²a)
Heating energy savings (174,4 kWh/m².a) 95 %
Installed heating capacity 11,13 kW
Spec. Heating capacity 7,0 W/m²
Current consumption (without heating) 34.031 kWh/a
Spec. current consumption 21,4 kWh/(m²a)

Figure A5: Pre-fabricated façade module with integrated window [source: AEE INTEC]

The goals of the renovation strategy and the therefore used technologies were:

Goals:

• 91% reduction of the energy demand for heating

• Reduction of the costs for the hot water generation from ca. 0,40€/m² living area and month to ca. 0,10€/m² living area and month

• 89% reduction of the CO_2-emissions

• Increase of property value

• Improvement of the indoor environment quality

Technologies: see page 4

Figure 6: Floor plan changes of renovated building [source: Hohensinn ZT GmbH]

Renovation design details

Façade Solutions

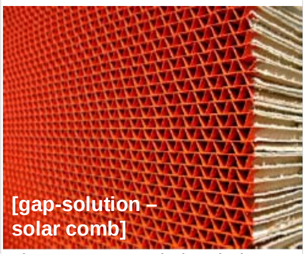


Figure A9: Façade insulation

- „To insulate with sunlight“
→ Special solarcomb construction (cellulose) converts light into heat (warm zone in the winter/ shading in the summer)
→ Rear-ventilated glass panels protect the solarcomb construction from weather and mechanical damage
- Increase of the surface temperature → improvement of the indoor environment quality
- High acoustical absorption
- Solarcomb construction can be painted in every color

Figure A10: Mounting procedure

Pre-fabricated modules:

- The joint formation is designed horizontally
- One joint at the level of the ceiling
- One joint on the upper line of the window
- Each module is matched on the lower one

Advantages of the renovation concept

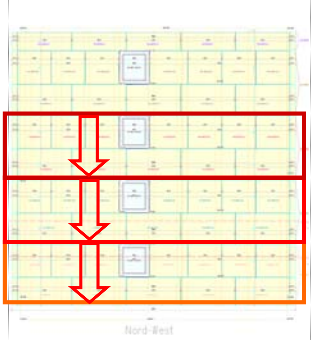


Figure A11: construction principle

- Energy performance = passive house standard
- Project management based on QA
- Improvement of indoor and outdoor environment
- Smart and quick construction procedure on-site
- Occupants are less disturbed during the construction phase
- The existing static system keeps unaffected
- Thermal bridges were eliminated determined by the system
- High quality because of the pre-fabrication in the fabrication hall
- Weather-independent fabrication
- Best quality assurance of produced modules in the fabrication hall
- Smart and short-time construction sites
- Dry mortar less construction
- Separable and particularly reusable components

Construction process

Development of pre- fabricated modules :

• 3D – on-site measurement of building façade

• Development of the pre-fabricated module by "gap – solution"

• Approval of the detailed composition of the modules by the building physician, consulted by AEE INTEC

• Design of each module and all detailed drawings (window-connections, plinth-weathering, angles,..)

• Approval of the detailed drawings, consulted by AEE INTEC

Figure A12-A15: mounting steps

Pre-fabrication on works :

• "Solar comb - system" pre-existing from "gap-solution"

• Fabrication hall of carpentry "KULMER BAU"

• Approval on works by building physician, architect, client

• The single modules are produced according to the on-site measurement and plans

Preparation before mounting :

• Installation of the elevator's construction

• Installation of electricity cables

• Bore – holes for ventilation – pipes

• Installation of heating supply for exterior walls

• Installation of equalization plane

• Mounting of sheet steel angles <bearing at the splint-weathering>

• Mounting of rock wool between post and mullion construction

• Mounting of vapour-proof barriers

• Cutting-off roof-overhang

Mounting and fitting the single modules :

• The pre-fabricated modules are brought by a truck and trailer on-site.

• Afterwards they are lifted by a truck-mounted crane to the building's façade.

• Two additional mobile-cranes are positioned on each side

• Assembly operators on these cranes are helping during the fitting procedure.

6

Summary

At this showcase project (GIWOG) for the high-quality renovation of a large-volume residential building to a passive house, the heating costs could be noticeably reduced (ca. 90%). With the usage of alternative energy sources, e.g. solar modules, the CO_2 emissions could also be reduced. Thereby highest possible pre-fabricated and large-scale façade modules with integrated components for the building services were used. In this way an essential increase of the comfort and an improvement of the indoor environment quality could be achieved.

Figure 16-17: view of the renovated building

Practical Experience

Our reconstruction project in Graz, Dieselweg is remarkable for many reasons: All 204 flats were rented before and throughout all the construction time. The room heating was based on electricity, oil and coal. There were no elevators and a majority of senior inhabitants. The buildings were in a very poor condition according their age. Aiming a sustained, global technical solution – passive house standard, sustainable energy based heating, barrier free access, healthy room climate - we had to provide a perfect financial solution too, to convince the inhabitants to accept all the interference and disturbances. Supported by the Austrian system of public housing aid and additional aid of research funds and a special aid provided by the governor of environmental affairs of Styria, Manfred Wegscheider, in connection with the non-profit status of GIWOG we found a fit solution, in order to keep up the social low rental fees combined with a amortization of investments within reasonable time. We achieved affordable sustainability. The evaluation of the first results makes us confident, that we can keep our promises, given as well to our customers, as to the aiding institutions and our shareholders.

Georg Pilarz
(CEO) GIWOG AG

Annex 3 – Technical Annex: Description of the Spanish Pilot Project

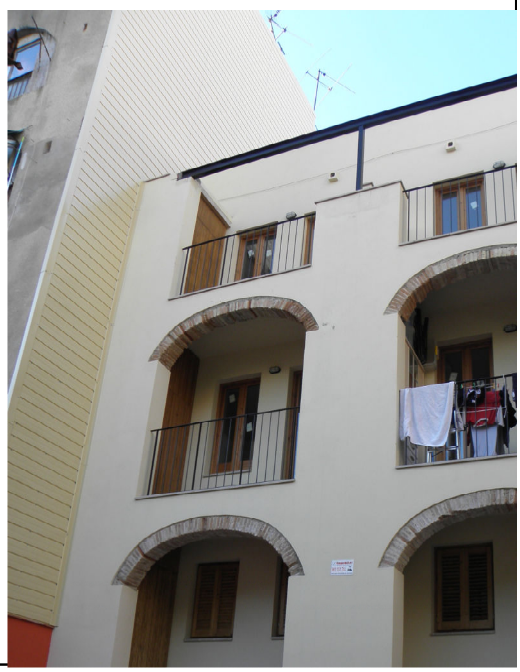
A Annex 1 – Technical Annex: Description of the Pilot Project

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



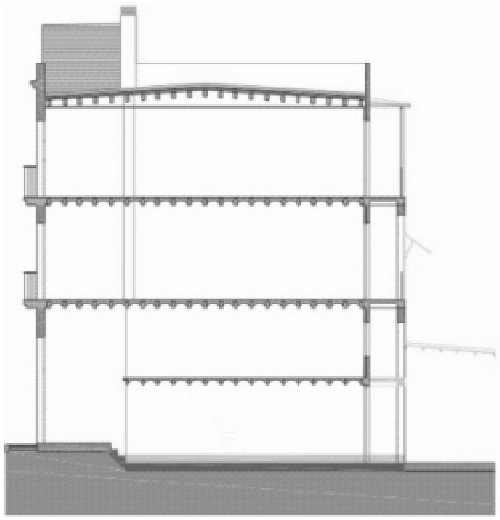
Background

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

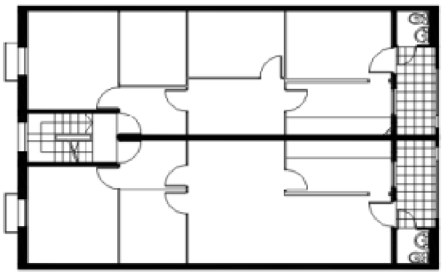
Picture: Building aerial view

Picture: Building main facade

Building before renovation:
Location: Sant Joan de Malta Steet, Barcelona, Spain.
Heating degree days : 1.732
Year of construction: around 1890.
Number of apartments: 6.
Heated floor area: 324 m².
Total heating energy: no data from formers tenants



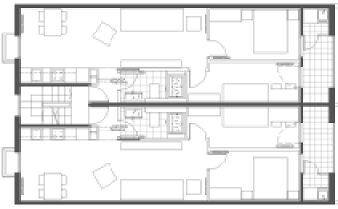
Picture: Former cross-section of the buiolding



Picture: Former floor plan of the building

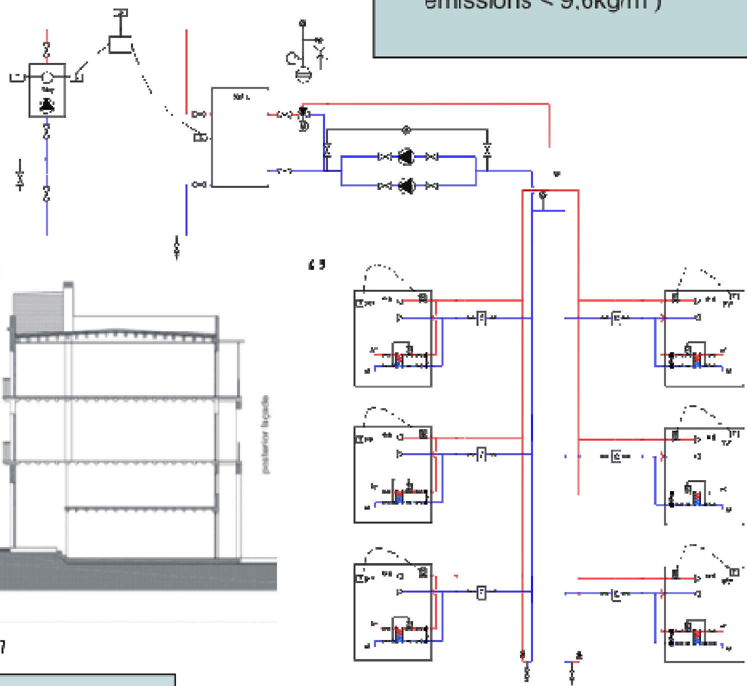
Renovation energy concept ½

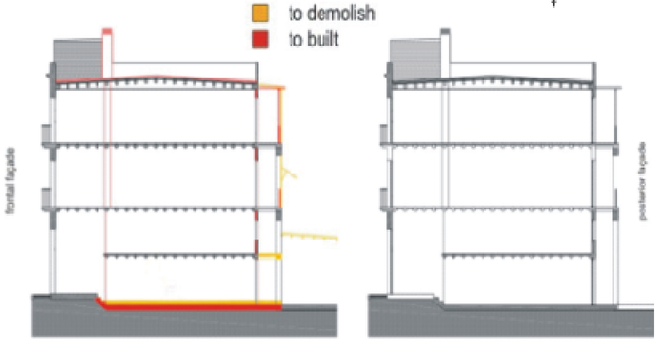
The goals of the renovation startegy were:
- better global U-value (< 1 W/m²°C)
- better performance of thermal generation (>100% boiler performance)
- better performance of the ventilation system (>90% performance of heat air recovery)
- better quality of indoor environment
- at least B energy certificate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



Picture: Renovated floor plan

Picture: Space heating and hot water production system hydraulic scheme





Picture: Renovated cross-section

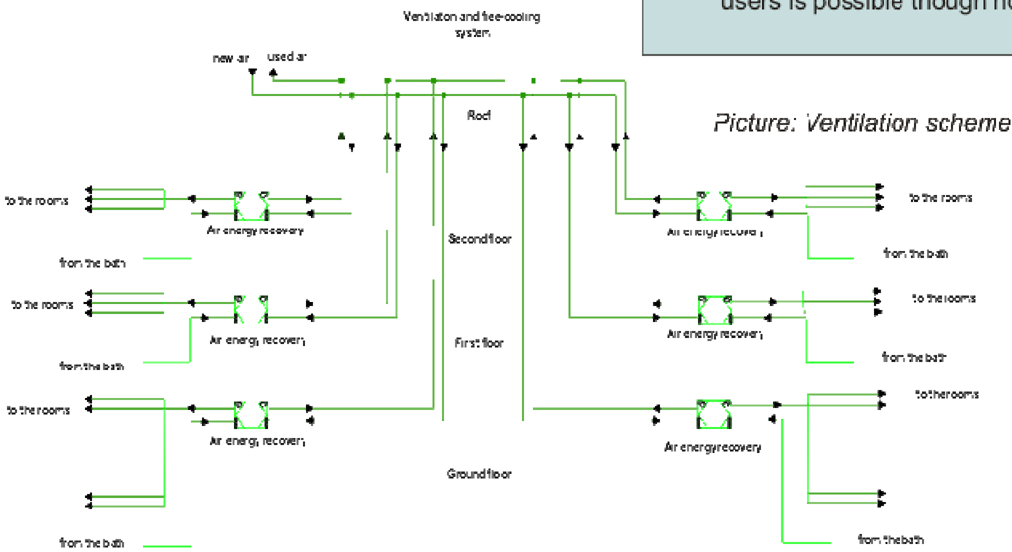
Collective heating and hot water production:
- Centralized heat production
- Highly efficient boiler
- Instantaneous heat exchanger
- Heated floor area: 324 m²
- Installed heating capacity: 76kW
- Spec. Heating capacity: 235W/m²
- Total estimated space heating energy : 8.175 kWh/a
- No solar installation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

Picture: Hot water tank, thermal energy meter, condensation boiler

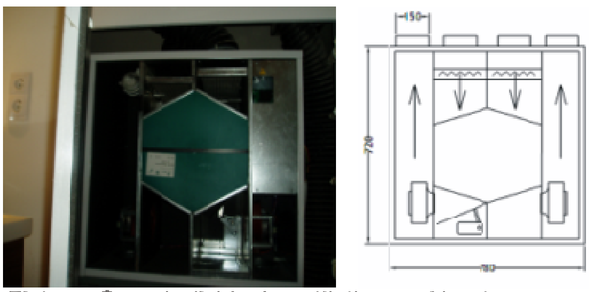
Renovation energy concept 2/2

Picture: 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.



Picture: Ventilation scheme



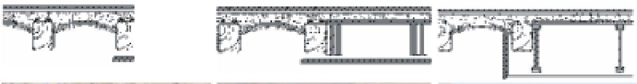
Picture: Open individual ventilation and heat recovery equipment

Picture: Rainwater harvesting

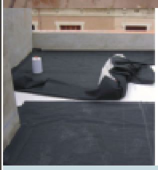
Rain water collection:
- 2 tanks of 1000l each.
- rainwater supply by gravity.

Construction progress


- Demolishment and preventive works.
- Construction of the new sewer.




- Reinforcement the existing beams.
- Installation of new timber beams.



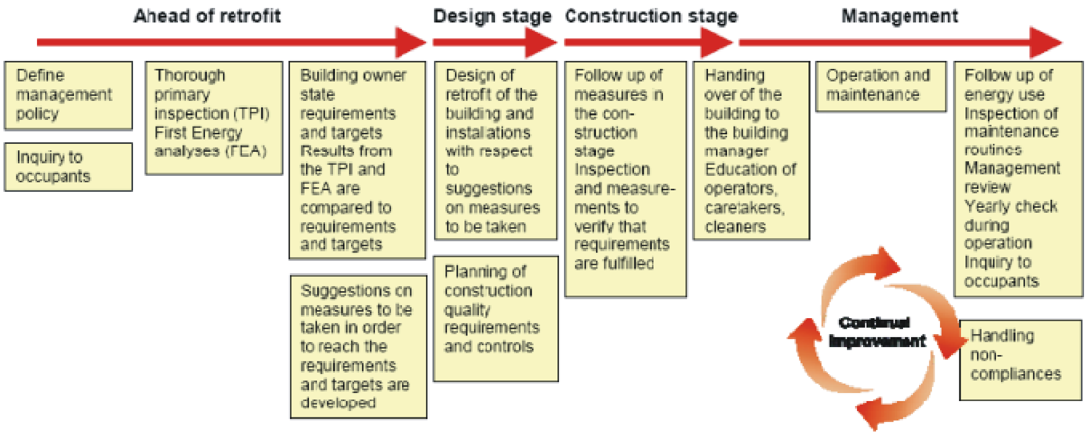
- Step the capillary moisture from the basement.
- Realisation of a waterproof and vented roof.
- Pose of the facade and internal walls´ insulation.


- 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.

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

Certificación Energética de Edificios Indicador kgCO2/m²	Edificio Objeto	Edificio Referencia

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.

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

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