Quality Assurance System for Energy Efficient Retrofitting of Multifamily Buildings

Intelligent Energy Europe

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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, supported by its Programme Intelligent Energy Europe (IEE). The SQUARE project aims to assure energy efficient retrofitting of social housing with 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, Netherlands
- TTA Trama Tecno Ambiental S.L, Spain
- Poma Arquitectura S.L., Spain
- SP Technical Research Institute of Sweden, Sweden
- AB Alingsåshem, Sweden

Author: Kristina Mjörnell (SP)

Co-authors: Peter Kovacs (SP), Armin Knotzer and Sonja Geier (AEE INTEC), Liyana Adjarova and Nina Raycheva (EAP), Chiel Boonstra (Trecodome), Jari Palonen and Jarek Kurnitski (TKK), Jaume Serrasolses (TTA), Jordi Espar and Oriol Muntané (POMA), Anders Kyrkander and Ing-Marie Odegren (AB Alingsåshem).

Layout: Carolina Hiller (SP)

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1 The SQUARE project

Within the SQUARE project a general quality assurance (QA) system to ensure energy efficient retrofitting of multifamily buildings with good indoor environment has been developed. The QA system is a very useful tool to enable your organization to retrofit a large number of apartments in a systematic and controlled way, and harvesting the great potential for improvements.

1.1 Description of the project

This report is a summary report of the main results from the SQUARE project – A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings. SQUARE is a European co-operation project for development and implementation of a quality assurance (QA) system in the retrofitting process. The aim is to assure energy efficient retrofitting of multifamily housing with good indoor environment in a systematic and controlled way. The SQUARE project started in November 2007 and ended in April 2010. The work has been conducted in work packages concentrating on different core areas. The main task was to adjust an existing QA system to the retrofitting process and to implement this QA system in the retrofitting process in four pilot projects. Other important issues dealt with were the potential for energy efficient retrofit of the existing building stock, non technical barriers for energy efficient retrofit and strategies to overcome these barriers, technical solutions for energy efficient retrofit, for installations as well as for the building envelope, suitable for multifamily buildings For further information on the project or on reports and other tools produced in the project see: www.iee-square.eu.

1.2 The project consortium

Project-coordination:

- Kristina Mjörnell, SP Technical research institute of Sweden (SE)

FINLAND

- TKK Helsinki University of Technology

NETHERLANDS

- Trecodome

AUSTRIA

- AEE Institute for Sustainable Technologies

BULGARIA

- EAP Energy Agency of Plovdiv

Figure 1 Project partners: The consortium consists of organisations from six European countries

The consortium was established with the objectives to provide a multidisciplinary group, represented by key actors representing public and private housing associations or companies (AB Alingsåshem, Trecodome and POMAA), technical consultant and architect (TTA and POMAA), technical institutes and a university (SP, Aalto and AEE INTEC). The consortium has the ability to identify national conditions, find energy potentials and ways of adopting and introducing a QA system in the process of retrofitting social housing. Furthermore, by applying the QA system in several pilot projects in countries with different conditions gives the maximum of experience exchange and dissemination of good examples. The fact that northern and southern as well as eastern parts of Europe are represented in the project will give a much wider validity to the results compared to what would have been the case in national projects.

1.3 Financial support

The SQUARE project has been supported by the Intelligent Energy Europe (IEE) program of the European Union promoting energy efficiency and renewable. More details on the program can be found at: http://ec.europa.eu/energy/intelligent/index_en.html.

1.4 Target groups

Important target groups are:

- Companies owning social housing. These may be non-profit community-owned companies or privately owned companies
- Private owners of flats and co-operative flats in multifamily housing. In Spain, for example, most apartments are privately owned. The inhabitants of these apartments are an important target group, since they make the decisions on refurbishment and retrofitting measures
- Consultants working with renovation and retrofitting of multifamily housing involving energy improvement measures
- Contractors and suppliers involved in retrofitting multifamily housing
- Tenants renting flats in multifamily housing and neighbourhood representatives
- Representatives from municipalities dealing with planning and construction of multifamily housing
- National authorities will have an interest in issues related to investments and subsidies for energy efficient retrofitting of multifamily housing

Read more…
… about the SQUARE project at www.iee-square.eu

2 The energy saving potential of the European multifamily housing stock

A substantial part of the social housing stock in Europe, mainly built in the 60's and 70's, is in great need of major renovations. This provides the owners with an opportunity and challenge to invest in cost-effective energy measures that also ensures a good indoor environment.

2.1 Age distribution of the multifamily housing stock

In Austria the production of new blocks of flats were highest between 1961 and 1970 and between 1971 and 1980. One third of multifamily buildings have been built before 1945. In Finland production of dwellings was highest during the 1970's. During 1960's and 1980's production levels were also higher than normal. In Spain production levels have been high between 1960 and the last 1970. A second peak was also produced during 2000's (real state bubble). In Sweden, 265 000 apartments were built between 1946 and 1960 and between 1960 and 1975, 830 000 new apartments were built. Since 1975 production of new apartments has been in same level as before 1945. From Bulgaria we did not have any statistic.

Figure 2 Multifamily housing complex in Brogården built 1963-1973, Alingsås, Sweden.

Figure 3 Social housing complex in Barcelona, Spain.

2.2 How many are already refurbished?

In, Austria 43 % of the dwellings built between 1945 and 1980 has been renovated. The total number of dwellings, that still have to be retrofitted, is 876 113. They are divided into 562 391 private one-family-houses, 187 620 owner-occupied dwellings, 87 358 municipal dwellings and 38 744 dwellings of non-profit housing companies.

Though financial retrofit grants were increased in the recent years, the number of retrofit actions decreased. While in the middle of the 90ies about 85 000 retrofit actions were registered, in 1997 there were only 70 000. Particularly in the field of multi-family-buildings the number of completed retrofit measures is regressive. In Finland approximately one third of social apartments have been renovated (plumbing system, ventilation system, windows, façade and balcony, electrical installation, elevators (installation of elevator), kitchen and bathroom. No special energy saving renovation actions have been made. Especially renovation of plumbing system, hot and cold water system is increasing. Increased renovation costs and lack of workers limits the renovation volume.

In Spain the renovation volume of protected dwellings has been about 50 000 dwellings per year, usually with structural and accessibility retrofitting.

In Sweden it was estimated that in the year 2002 only 13 % of the social housing built 1961 – 1975 has been renovated. The actual refurbishment volume is about 1.5% of the building stock per year. 95% of the buildings built from 1961 to 1975 need refurbishment. From these buildings, the multifamily buildings have the highest need of renovation. The needed actions are; exchange of pipes, electrical installation, facades and roofs, windows, balcony, ventilation and elevators.

In Bulgaria there are more than 80 000 multifamily buildings with about 700 000 residential units. Many of them are in need for renovation. Up till now, 27 multifamily buildings have been renovated and 27 is undergoing renovation. About 97% of the dwellings are privately owned and the rest 3% of the dwellings are owned by state institutions or municipalities. This creates problems in the decision making process preceding a renovation. The energy use in multifamily housing in Bulgaria is 170 kWh/m^2 up to more than 200 kWh/m^2 per year.

2.3 What is the estimated cost for retrofit per year?

The Austrian retrofit volume is estimated to a cost of 1.4 milliards €. Retrofit activities are initiated by the introduction of financial retrofit grants. Within the time period of 1994 to 2002, the expenses for the retrofit of residential buildings increased from 520 million € to 630 million €. In average the retrofit measures are promoted by 22% of the retrofit costs through financial retrofit grants.

In Finland it has been estimated that retrofit volume in blocks of flats in will 1400 million Euros per year in 2010. Buildings built in the 1960's and the 70's will be the most costly building groups. Both age groups use 30 % of renovation costs. Buildings built before 1960 use 20 % of the total investment costs and buildings built in 1980.s use 15 % of the total investment costs.

2.4 The potential for energy efficiency

The energy efficient potential for multifamily buildings is at least 50 % in most countries. In mid 1990's Finland were some experimental projects dealing with low-energy renovation. Even 60% reduction of heating (hot tap water excluded) energy was possible. In Austria typical energy performances before retrofit in buildings built 1960-1980 are 100-150 up to 210 kWh/m²a, with an energy saving potential of 50-90 %.

Fulfilment of the rules on building thermal retrofitting in Spain would produce an important reduction of energy consumption in the existing residential building. In Spain, improvement of the building envelope could reduce the energy use dramatically. There is an example of a retrofitted building in Barcelona that reduces its energy demand for heating about 60% by adding external insulation on roof and external walls and change of windows.

In Bulgaria almost all dwellings needs renovation.

For Swedish multifamily buildings, the estimated total energy use for the buildings from the Swedish "million homes program", including household electricity, is estimate to 9.5 TWh/y. On an average the specific energy use is about 210 kWh/(m^2 year). The estimated total energy use and saving potential for different measures are given below.

Table 1 Energy use and saving potentials

Energy usage	Energy use today (TWh)	Saving potential (TWh)
Better insulated windows	1.5 – 2.0	0.5 – 1.0
Insulation of the rest of the envelope	1.0 – 1.5	0.5 – 1.0
Air tightness	0.5 – 1.0	0.5
Ventilation	2.0 – 2.5	1.5 – 2.0
Sanitary hot water	1.5 – 2.0	0.5 – 1.0
Losses in heating system	0.5 – 1.0	0.5
House hold electricity	1.0 – 1.5	0.0 – 0.5
Total	**8.5 – 10.5**	**4.0 – 5.5**

The summary of the European residential building stock and its energy and indoor environmental performance is given in table 2 below.

Table 2 Average energy saving potential of residential building stock (Reference: Energy improvement measures and their effect on indoor environment, available at www.iee-square.eu.)

Country	Energy demand for heating (kWh/m^2a) before retrofit	Energy saving potential (%)
Austria	210	50 – 60
Bulgaria	> 170	40
Finland	> 170	50
Spain	55 to 100	60
Sweden	210	50 – 60

Read more…

…..in the report *Survey of national Conditions, part 2, Overview of potentials and estimated costs for energy savings in retrofitting of social housing*, available at www.iee-square.eu.

3 Non-technical barriers and strategies for energy efficient retrofitting

Why don't we retrofit the entire existing building stock to be energy efficient buildings with good indoor environment now? It is not that easy. In order to do that a number of barriers have to be overcome, mostly non-technical barriers regarding economy, subsidies, regulations but also behavior, attitude and culture in organizations and among users. The stakeholders suggest a number of strategies such as legislation, package-solutions, good examples, training, individual metering etc to overcome these barriers.

3.1 Non-technical barriers in general

There are many non-technical barriers that have to be overcome in order to get energy efficient retrofitting and operation of multifamily housing. One barrier is the attitude in the construction industry and the scepticism to new building and energy system concepts. A way to involve the designers and contractors in the retrofitting process may be to introduce incitements that stimulate the actors to do one's very best. The purpose is to get a win-win concept and to stimulate the actors to further improve the quality of their work. Another barrier may be the owners' lack of knowledge and experience. The owner of the building must have sufficient qualifications to make functional requirements in the building process and follow up that these are met. One way to inspire the actors is to demonstrate by good examples and forming networks for exchanging experience from design, construction and operation of energy efficient social housing.

The energy consumption of a building depends not only on the quality of the building and the technical installations but also on the behaviour of the tenants. There are many ways to inspire the tenants to reduce their use of energy to a minimum. One way is to design the energy system in such a way that it is adapted to the different degree of motivation of the tenants to reduce the energy consumption. First it is important to survey the profile of residents and their view of the different energy saving schemes. Based on the results of the survey, a number of activities can be proposed. Therefore it is important to involve the tenants early in the retrofitting process to get their opinions on different energy saving solutions. Another important activity is information about how to choose and use energy consuming equipment in the households.

In the following the main non-technical barriers for different stakeholder groups are described. The stakeholder groups were: Owners/developers/investors, tenants and building managers. The non-technical barriers for different stakeholder groups have been generalized and grouped into the following areas: Legislative, financial, organizational, and institutional barriers. Also strategies to overcome the non-technical barriers for different stakeholder groups have been suggested based on analyses from each SQUARE partner's national work interviewing stakeholders and focus groups and previous work done in other projects involving technical barriers.

3.2 Non-technical barriers for owners/developers/investors and strategies to overcome these

Main legislative barriers	Strategies to overcome legislative barriers
• Lack of requirements on energy efficiency in some regulations for existing buildings.	• Formulate compulsory requirements for existing buildings in line with new buildings in order to synchronize with EU targets that encourage low energy use, particularly in Sweden.
• Lack of skilled experts in the fields of EPBD.	• Training of experts in the fields of EPBD.
• The national legislation provides opportunity for partial or only "cosmetic" measures seen as standard-raising measures, and consequently allow a rise in the rent.	• There is necessity of additional texts into national legislation for restriction the opportunity for partial retrofitting existing buildings or only "cosmetic" renovation without energy measures.

Main financial barriers and barriers related to tax initiatives	Strategies to overcome financial barriers and barriers related to tax initiatives
• Short-term thinking/high investment costs/long payback period.	• "The timing" of the implementation of energy measures. • Development of guidelines for energy measures integration into concrete organisations renovation/maintenance plan. • Checking a "package solution", where more profitable measures cover less profitable ones. The less, or non-, profitable measures are included as it is seen as public/housing companies responsibility to the society to decrease their energy use.
• High costs of realization of the retrofitting project.	• Retrofitting projects or energy efficiency measures should substantially decrease the energy use and at the same time be economically acceptable. • Promotion of energy saving initiatives by housing owners through changing tax regulations, terms of loans, maintenance fees, etc.
• Insufficient clear rules to apply existing forms of subsidies and loans to owners/developers.	• The sizes of subsidies need to be in proportion to the payback period of energy saving measures. Measures with long pay back period should be afflicted with larger subsidies. • Subsidies should be concentrated to provide incentive for more than single actions. • Subsidies are one the way to reach 50% energy reduction by 2050.
• Not used to comprehensive actions.	• Promotion of the local economy benefits from comprehensive retrofit of buildings.

Main organizational/behavioural barriers	**Strategies to overcome organizational/behavioural barriers**
• In daily practice energy issues are not treated in an integrated way and difficulties in understanding the cost-benefit balance and foreseen energy cost increase.	• Information among owners/developers/investors for better understanding the relation between investments, energy performance, CO_2 performance, renovation plus maintenance, and quality of building stock and living conditions.
• Slow/lack of "translation" of interest and concern for environmental/climate/energy issues among owners into actions.	• Organization of meetings where experiences can be exchanged among different companies.

Main organizational/institutional barriers	**Strategies to overcome organizational/institutional barriers**
• Lack of technical/renovation solutions available - renovation projects can be difficult because unknown construction of building.	• Completion of all minor measures such as adjustments of heating and ventilation systems, then the major measures. • Mechanical ventilation with heat exchanger is necessary to be included in a renovation project in order to be able to reach the EU targets of lowering energy use in buildings.
• Evaluation (follow-up) on the impact of specific energy efficient measures is very difficult to do in a correct way.	• Implementation of tests in few apartments before renovating larger parts of the building stock. • Needs of understanding that whole building process is important: Needs-design–construction–follow up. • Collection of experiences of follow-ups in data base.
• Lack of quality in building process by the reason of: - no responsibility aspects, - lack of competence in the building industry and of clients, - previous experiences are not utilised	• The roles in building process must be well defined (with clear responsibilities). • Needs of actually state requirements on energy efficiency. • Promotion and utilising of previous experiences in order to learn from mistakes. • System "thinking" is needed when considering different measures. • Initiatives of clients.
• Fewer drivers within real estate companies-/developers/investors.	• Elaboration of suitable national models in order to integrate investors into retrofitting process and work out on standard cost-benefit analyses. • Public authorities' promotions of trainings for the staff of the building sector are very important to close information deficits.
• Lack of owners' associations as legal organized groups in new member states.	• Municipal initiatives to help creating the public housing associations-owners associations, registered as legal unities.

3.3 Main non-technical barriers for tenants and strategies to overcome these

Main legislative barriers	Strategy to overcome legislative barriers
• No definition of the tenants' responsibilities in national legislations.	• Updating national legislations in regards to tenants' responsibilities in energy efficient retrofitting process.
• No clear definition in national laws for criteria for rent increase.	• Updating national legislations in regards to definition for criteria for rent when retrofitting existing buildings to energy efficiency buildings.

Financial barriers	Strategy to overcome financial barriers
• Continuous increases of rents • Tenants are lower-income stakeholder group and find it difficult to access bank loans.	• Offering state subsidies to eliminate social disadvantages and to get thermally comfortable dwellings, although those people have little income.

Organizational/behavioural barriers	Strategies to overcome organizational/behavioural barriers
• Slow/lack of "translation" of interest and concern for environmental/climate/energy issues among tenants into actions.	• To disseminate informational material about energy saving actions. • To provide information about a certain measure that has been taken in order to "maintain" the benefits of the measure.
• The energy savings is not priority for many tenants.	• Spreading of good practices to inform the tenants/end-users.

Organizational/institutional barriers	Strategies to overcome organizational/institutional barriers
• Lack of motivation of the tenants/end-users.	• Signing rental agreements with the occupants to actually pay for their individual consumption. • To split energy metering regarding electricity is an easy measure. Separate metering for domestic hot water in new buildings. • Individual metering and payment should be considered as good way to visualize the consumption - the tenants association can be used to spread information.
• Lack or insufficiency of tenants' associations.	• Municipal initiatives for creation representative organizations of the tenants or tenants associations.

3.4 Main non-technical barriers for building management and strategies to overcome these

Main legislative barriers	Strategy to overcome legislative barriers
• The measures suggested in the certification protocol (in regards to EPBD) are not compulsory but could be an input to the maintenance plan. As long as the measures are voluntary, it is not certain that the measures will be implemented.	• Incorporation of suggested energy efficient measures into maintenance plans.
• The deadlines for the EU targets are too far in the future (year 2020 and 2050).	• EU targets that also encourage those who already have a low energy use and that are closer in time.

Main financial barriers and barriers related to tax initiatives	Strategies to overcome financial barriers and barriers related to tax initiatives
• Short-term thinking/ long payback period/high investment costs.	• Implementation of energy measures within organization's maintenance/renovation plan. • Creation of a model database of different possible energy saving solutions with different payback periods. • Companies should start with implementing measures with payback periods of 0-3 years. Highlight more clearly that money can be saved by investing in energy saving measures. • Desired characteristics of subsidies: - "The right timing" of subsidies, i.e. the right subsidy at the right time for a specific company. - It has to coincide with the maintenance plan. - The sizes of subsidies must be in proportion to the payback periods of the energy saving measures. • Highlight positive "side effects" of energy measures, e.g. better indoor climate – i.e. present to boards of housing co-operatives that they get more than energy efficiency for their invested money. • Financial benefits, such as tax abatements and deduction of value-added taxes (VAT) for measures that contribute to lower energy use (that have a decreased impact on climate changes) could be discussed and introduced.

Main organizational/behavioural barriers	Strategies to overcome organizational/behavioural barriers
• Slow/lack of "translation" of interest and concern for environmental/climate/energy issues among members of housing co-operatives into actions. Lack of separate metering.	• Individual metering and payment, especially regarding domestic hot water are considered to be a good way to visualize the consumption. • Dissemination of information materials for energy saving actions to the residents although there are some doubts about their impact on the actual behaviour of occupants. • To arrange education/courses for (board) members of housing co-operatives in general as well as a specified comprehensive, well substantiated, presentation materials, including balanced cost calculations/savings, to motivate housing co-operatives.

Main organizational/institutional barriers	Strategies to overcome organizational/institutional barriers
• The long term maintenance programs within social housing associations do not exist or not include the long term energy strategies.	• The costs of good energy effective retrofitting can become affordable, when they are part of a maintenance program. Technically and financially it is necessary to combine renovation and energy.
• Lack of technical/renovation solutions available and good examples.	• Produce an "energy program" for an organization. Energy issues are then recognized as a prioritized issue. • Produce standardized industrial solutions, which could lower the costs because the buildings in need of renovation are similar. • Important suggestions for the building management phase are (including the handover of the building): - Consider easy and simple improvements. - Try to motivate the end-users (here members/occupants of housing co-operatives) to take their responsibility by increasing their awareness (organise trade fairs and courses). Have internet forum for board members where to inform them about the latest in the energy and environmental fields. - Sell energy services. - Sell energy certification. - Important to measure and follow-up energy use of buildings. • Visit good practices and products existing on the market. Showing how solutions/techniques work in market before promoting them to building owners.
• Lack of necessary knowledge among board members of housing co-operatives/organizations who make decisions.	• Promotion of independent consulting. Public authorities should make technical courses for board members of housing co-operatives.

Read more…

…..in the report *Methods to break non-technical barriers in the energy saving retrofitting process*, available at www.iee-square.eu.

4 Technical measures for energy efficient retrofit

The energy use of a building depends both on the building envelope and on the building services systems which, in their turn, affect the indoor environment. Concentrating excessively on either good indoor environment or energy efficiency might cause mutually negative effects, and it is important to avoid this.

4.1 Energy efficiency in buildings

Energy use in and by a building has the most important environmental impact during the building's life, and is therefore the most important to reduce. New emphasis on energy conservation has added new demands for energy improvements as well. The energy use of a building depends both on the building envelope and on the building services systems which, in their turn, affect the indoor environment. Concentrating excessively on either good indoor environment or energy efficiency might cause mutually negative effects, and it is important to avoid this.

In the following a number of energy efficient solutions suitable for retrofitting of multifamily housing in several countries are described. The energy efficient solutions have been sorted out by evaluating the energy improvement potential in different types of buildings in different climates requiring heating and/or cooling, see Table 3 and 4. An investigation of the influence of energy efficiency measures on the indoor environment in different types of buildings has also been done.

Table 3 Characteristics of the three different European climates used for specifying energy improvement measures of buildings' retrofit. (Reference: Energy improvement measures and their effect on indoor environment, available at www.iee-square.eu.)

Climate/ Characteristics	Warm	Temperate	Cool
Lowest standard outside temperature during heating period (°C)	0 to -10	-10 to -16	-12 to -25
Outside average temperature during heating period (°C)	+8 to +10	+2 to +4	+2 to -10
Outside average temperature during summer (°C)	+20 to +24	+17 to +22	+10 to +16
Heating degree days 20/12 (K.d)	1 200 - 3 000	3 000 - 4 500	4 500 - 7 000
Solar radiation (kWh/m²a)	1 200 - 1 500	1 000 - 1 200	Up to 1 000

Table 4 Values of indoor environment parameters due to different climates. (Reference: Energy improvement measures and their effect on indoor environment, available at www.iee-square.eu.)

Climate	Warm	Temperate	Cool
Room temperature Winter/Summer (°C)	21/<26	20/<26	20/<26
Ventilation rate (ach) *or*	0.35 - 0.4	≥ 0.3	0.2 - 0.35
CO_2-concentration (ppm)	<1 000	800	900 - 1 000

Examples of the most relevant energy improvement measures, easily usable for our target groups are presented. It is very important to give a quick and feasible overview. The decision was not to go in details regarding different types of buildings or different building traditions and resources, but to make evident, what kind of measures are really important both for the building renovation and operation regarding energy efficiency and indoor environment (thermal comfort, air quality, etc). The measures have been selected with reference to the building stock of the period 1960 to 1980, since all over Europe this was the period with the highest building activity, setting up buildings with the highest energy demand.

4.2 Priority measures suitable for different climates

Although there are different energy and (re)source relevant "levels" of measures, one small package of measures is typical for each climate regarding heating and cooling. The following figure aims to give a very brief view on the essential measures.

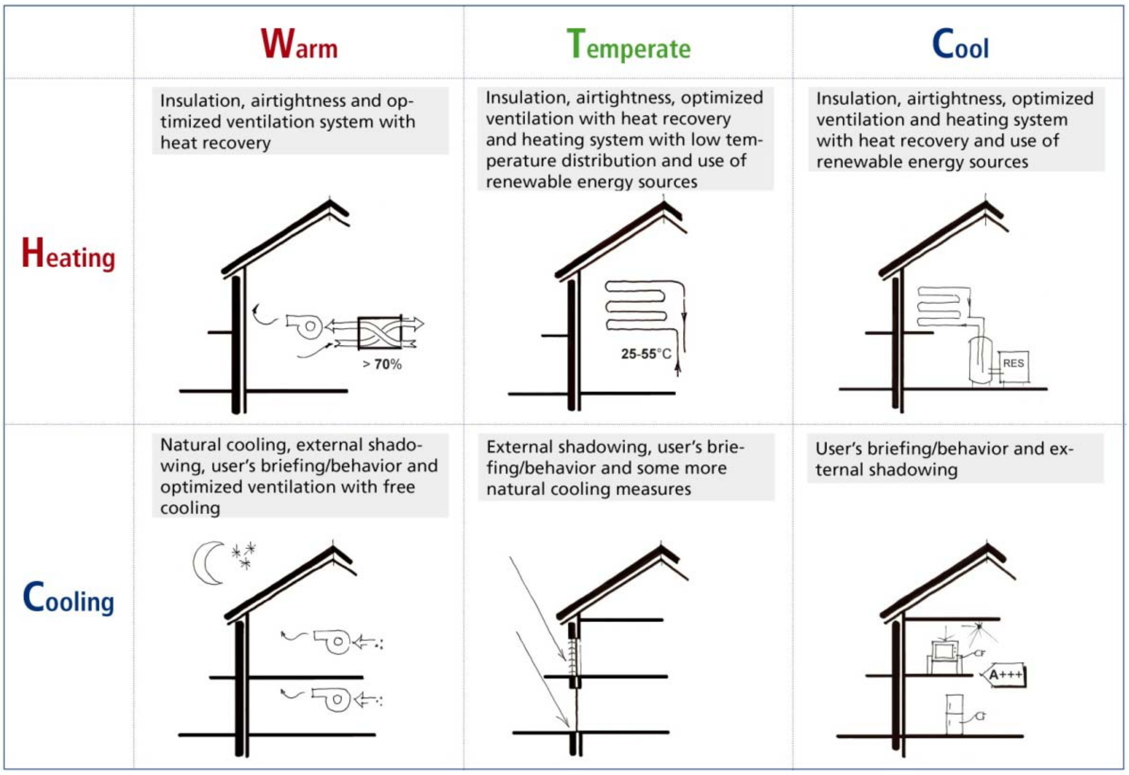

Figure 4 Most relevant energy efficient measures for heating and cooling of renovated residential buildings in three European climates. (Reference: Energy improvement measures and their effect on indoor environment, available at www.iee-square.eu.)

Complete exterior insulation

In all climates we have the need for insulated buildings. The thickness of the layer is ranging from 5 cm in the South to 40 cm in the North part of Europe. Before adding additional insulation it is crucial to investigate building components (ground, exterior walls, roof) thoroughly for analysing existing moisture damages or possible risk of moisture damages due to change of construction. If there are existing damages these should be taken care of immediately.

For building physical reasons the insulation layer should be positioned at the exterior side of the load bearing structure. Hereafter it is easier to avoid thermal bridges, to cover window frames with insulation, to keep heat storage mass and humidity buffer of the building components inside the thermal building shell. Interior insulation is mainly used for historic buildings, but it is more difficult to manage the building physical challenges there.

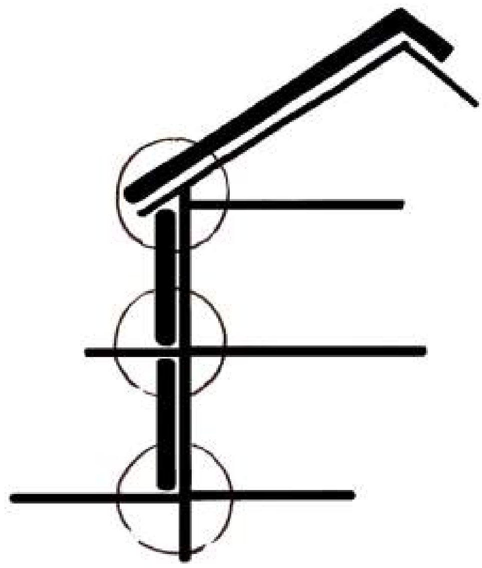

Figure 5 ***Three points of a building where you have to take care of thermal bridges. (Source: AEE INTEC)***

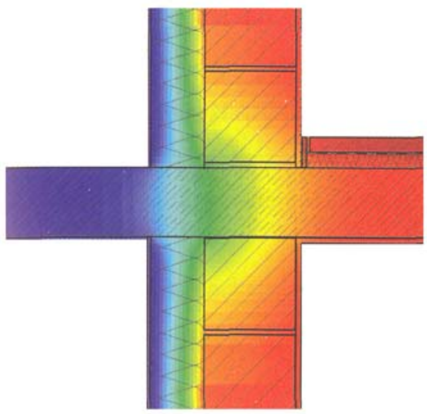

Figure 6 ***"Cooling rip"-effect of not completely insulated thermal bridge "balcony". (Source: AEE INTEC)***

Influence on energy efficiency

The impact on energy efficiency is that exterior insulation reduces heat transmission losses and avoids thermal bridges.

Influence on indoor environment

The influence on indoor environment is an improved thermal comfort because of increased temperatures of the inner surface of the building (components). It avoids damage of building components and mould caused by condensate through thermal bridges. Heat storage mass is effectively keeping heat or cool, only if the insulation layer is situated at the exterior of a building.

Thermal optimized windows and doors

In all European climates we have the need for better insulated glazing, windows and doors. This is very important for the temperate and cool climates, but also getting more common in the warm climates. Not only the value of insulation of windows and doors itself is very important to improve the energy efficiency of buildings, but also the fixing of them into the cladding – the exterior insulation layer should cover a big part of the window frame (on site) to make it more heat protected and the joints more draught-proofed, etc. Impact on energy efficiency

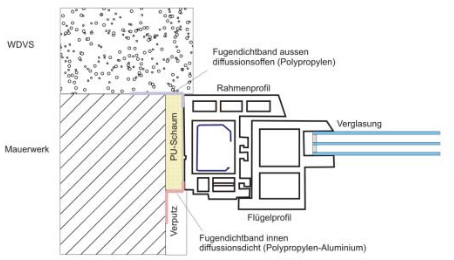

Figure 7 Thermal insulation of window joint. (Source: Wikipedia)

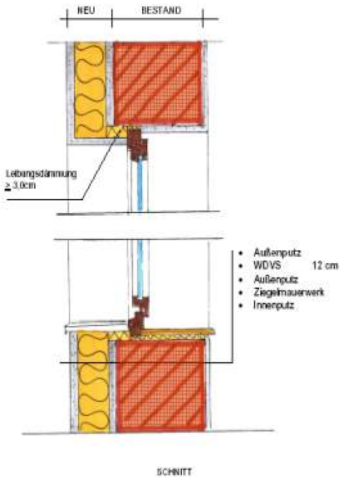

Figure 8 Well fixed insulated window. (Source. AEE INTEC)

Influence on energy efficiency

Thermal optimized windows, doors and other transparent building components reduce heat transmission losses and gain "passive" solar energy.

Influence on indoor environment

Insulated windows and doors lower the energy input from glazing during summer; in some cases it is worth to downsize the glazing area to reduce transmission losses during heating period and overheating during summer.

Air tightness

In all European but mainly in cold and temperate climates, we have the need for an airtight building envelope. The most important thing is to decide where the airtight envelope will be situated (inner side of the exterior wall or between old and new façade, etc.) and how are windows, doors and building breaches integrated into that airtight envelope.

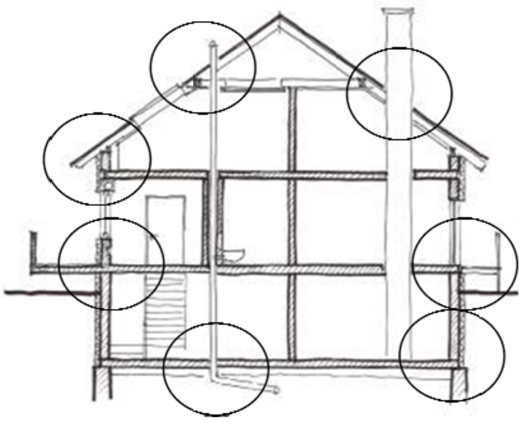

Figure 9 Joints and connections have to be air tight. (Source: AEE INTEC)

Figure 10 Making the attic airtight at Dieselweg, Graz. (Source: AEE INTEC)

Influence on energy efficiency

Airtight building shell reduces infiltration and ventilation heat losses and avoids losses of heating up cool inner surfaces caused by draught.

Influence on indoor environment

Air tightness avoids damage of building components and mould caused by condensate through leaks. Air tightness increases thermal comfort because it lowers the air velocity especially near windows, doors and other typical draughty points.

External solar shading

This measure is necessary to keep indoor thermal comfort during warm season. Of course it is important in warm climates, but the importance for temperate and even cool climates is noticeably increasing. There are various reasons for that like higher inner heat load (technical equipment, lighting), big window areas without countable shading possibility, etc.

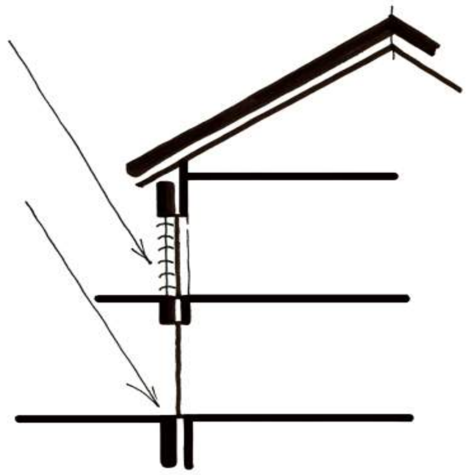

Figure 11 External solar shading reduces cooling demand. (Source: AEE INTEC)

Figure 12 External solar shading reduces cooling demand. (Source: AEE INTEC)

Influence on energy efficiency

External solar shading reduces cooling demand, thus lowers need for cooling devices. It lowers the current demand if daylight is used for lighting, see Figure 12, but may sometime increase the current demand by using artificial light.

Influence on indoor environment

Combined daylight use reduces power consumption for artificial lighting. If all blinds are closed without directing daylight into the rooms, more current might be needed. External solar shading protects residents from glare and reflection.

Natural cooling

In warm European climates vented roof and light coloured roof and façade is very useful to protect the building from heat. Natural cross ventilation and night free-cooling, combined with external insulation and interior heat storage mass, are used to hold suitable indoor climate during summer season also in temperate climates.

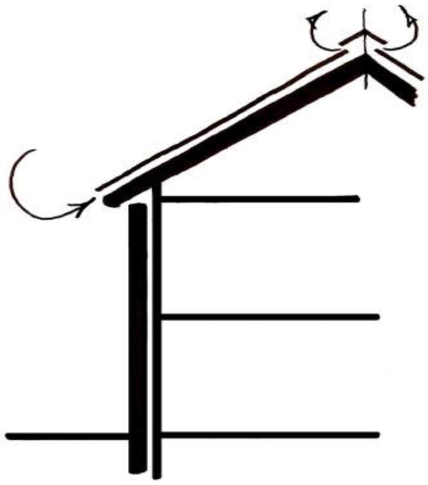

***Figure 13** Vented roof and light coloured roof and façade is very useful to protect the building from heat (Source: AEE INTEC)*

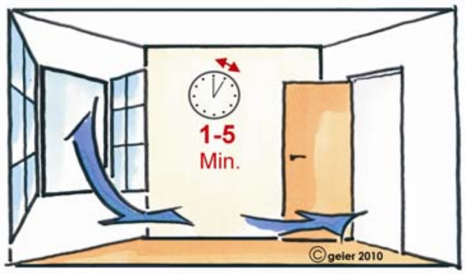

***Figure 14** Night cross ventilation is one way to keep a good indoor climate during summer season. (Source: AEE INTEC)*

Influence on energy efficiency

Natural cooling facilities of buildings reduce cooling demand.
It should be an exception or much better not be necessary to use active cooling systems in residential buildings.

Influence on indoor environment

Light facade (exterior insulated or vented) and vented roof prevent material fatigue and damages because they reflect or reradiate most of the solar energy. Natural cross ventilation is an alternative to the mechanical ventilation system during the warm season, mostly used to cool down thermal mass during the night. So the heat storage mass helps to cool down the indoor air during summer and to keep rooms warm during winter.

User's briefing and user's behavior

Every retrofit process of residential buildings is first of all a technical and organisational effort, but also a social and communicational one, guiding residents (the users) to energy improvement and high indoor environment during the use and the operation of the building(s). The users' understanding of the actions during and the use of the building after renovation is very important for a comprehensive performance of the process. It is very important to give residents tools and information so that they can learn what they are dealing with (building services, electricity demands of different devices, ventilation system, etc.). We speak about energy efficiency, so let's include user's interests and problems.

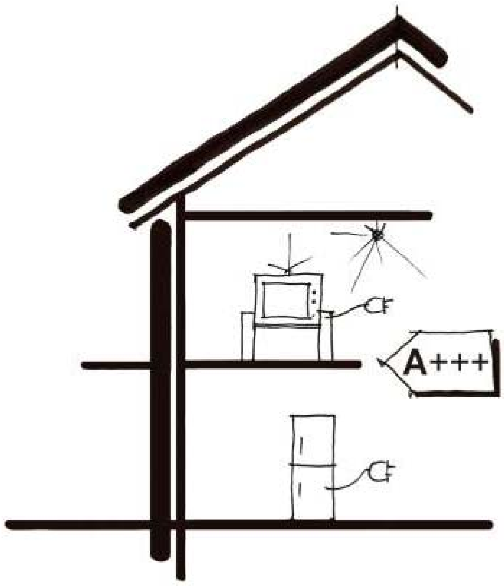

Figure 15 Users behaviour and choice of appliances affects the energy use. (Source: AEE INTEC)

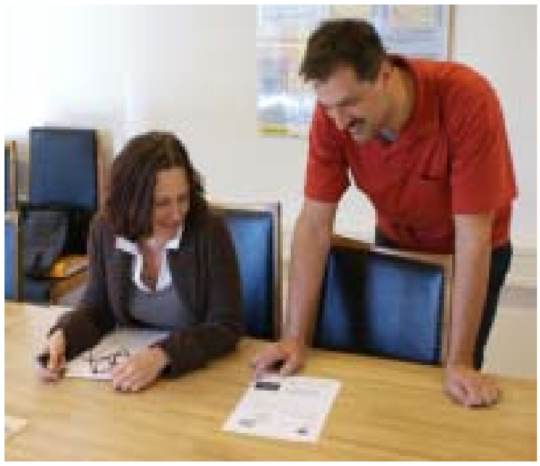

Figure 16 Communication with occupants. (Source: AEE INTEC)

Influence on energy efficiency

Information and communication (indirectly) decrease final energy use of the residents when being aware of technical equipment, services and maintenance. This helps to "optimize" internal energy gains.

Influence on indoor environment

User's briefings raise awareness of the retrofit and operational needs of an existing building. If the users change traditional behaviour in dealing with new ventilation and heating systems or current devices they contribute to the public attitude of energy saving households. User's briefings contribute to an active contact between the housing association/housing owner and its tenants.

Optimized heating system

In cold and temperate climates there should be a very clear aim to minimize the heat losses of the heating system, wherever this is possible. Insulated heat pipes, low temperature (heat) grid, right dimensioned heat generation (heat load), latest boiler and heat storage technology, use of condensing boilers are examples that lead to an optimized performance of the heating system.

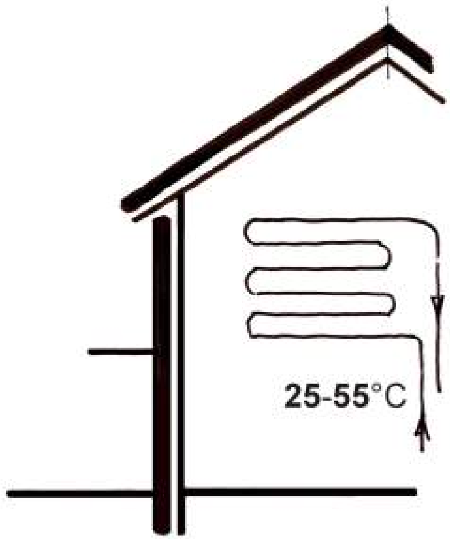

Figure 17 Low temperature distribution. (Source: AEE INTEC)

Figure 18 Wall heating system. (Source: natürlich bauen GmbH)

Influence on energy efficiency

An optimized heating system reduces energy consumption for heating.

Influence on indoor environment

The coefficient of performance of low temperature energy generation such as solar thermal energy is much better by using radiant floor heating or wall heating systems. Even in winter it is possible to get 40° or 50°C of flow temperature from solar collectors, but not high temperatures like 60° or 70°C. These systems yield high indoor thermal comfort through heat radiation instead of heat convection.

Use of renewable energy sources

In all European climates we should increase the share of renewable energy sources. Except deep geothermal energy, they all have its origin in the sun. In cooler climates it will be better to use water and biomass like wood, more than solar thermal and photovoltaic energy which is mainly used in warm and temperate climates. Wind, biomass like biogas and deep geothermal energy can be used in all climates, only if there is local supply. To know about the local sources for decentralized energy generation is crucial to get independent from fossil fuels, to force the local economy and to reduce greenhouse gas emissions for long term perspective.

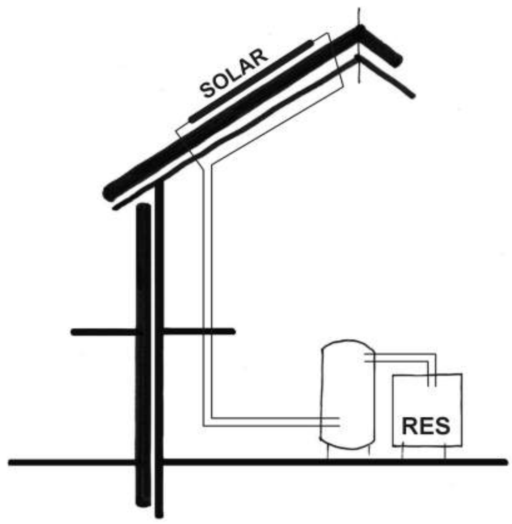

Figure 19 Renewable energy use with storage possibilities. (Source: AEE INTEC)

Figure 20 Solar thermal façade collectors at Dieselweg, Graz. (Source: AEE INTEC)

Energy from heat pumps such as ground coupled, water-water or air to water can only be considered as renewable energy if the current which is used for the operation of the heat pump comes out of ecological energy sources like wind, biomass, water or deep geothermal energy.

Influence on energy efficiency

Renewable energy sources replace fossil fuels and -energy sources, and lower the primary energy consumption.

Influence on indoor environment

The use of efficient renewable energy technology is crucial to decrease GHG-emissions and to increase regional added value. At a very subjective level: It is much more comfort to “feel” the sun heating water for the shower or to look at a wood fire place than smelling fuel oil out of the cellar.

Optimized heating control system

The best heating control system is the one that offers the right amount of heat at the right place and the right time! So every single room should have its own heating circuit or ventilation vent in order to control it separately. A high quality control system is every time connected with the outside temperature, the room temperature and the boiler or the flow temperature of the heating system. New future linked systems like individual (smart) metering are able to control even single devices or parts of the system, and make them run when it is favourable both for energy supply times and the users' budget.

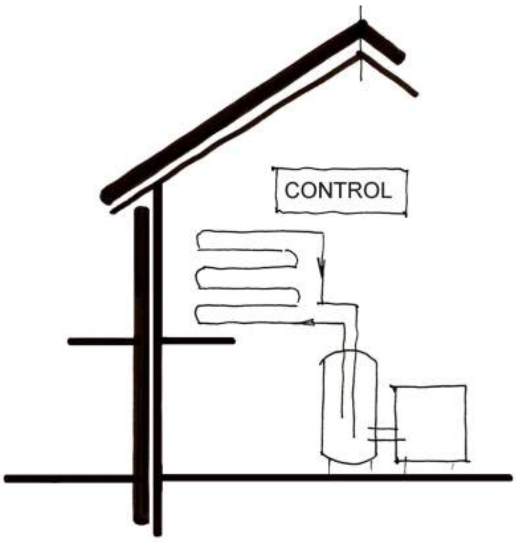

***Figure 21** It is important to have a well planned control system for the heating system. (Source: AEE INTEC)*

***Figure 22** Display for the apartments ventilation units with heat exchanger. (Source: SP)*

Influence on energy use

An optimized heating control system reduces energy consumption for heating by strongly raising the annual use efficiency of the supply system.

Influence on indoor environment

The control system raises thermal comfort by optimizing the time of heat supply inside the different parts of a dwelling. It avoids overheating (particularly in south situated rooms) and the cool down of adverse situated rooms.

Optimized ventilation system

A well planned and carefully installed ventilation system is the best assurance for high indoor air quality. In all European climates there is the need for an excellent ventilation system that runs hygienically and energetically satisfying. For energy efficiency the ventilation system uses heat recovery by applying an air heat exchanger. In cool and temperate climate it is common to use a ground-air heat exchanger in addition to the heat recovery to pre-warm the outside air.

In warm but also in temperate climates it is common to use the ventilation for cooling down rooms during the hot season: The rooms are supplied with the "cooler" outside air usually at night (free-cooling), because they are heated up by inner loads. In this case the heat recovery is turned off the cooler air comes in via air-bypass.

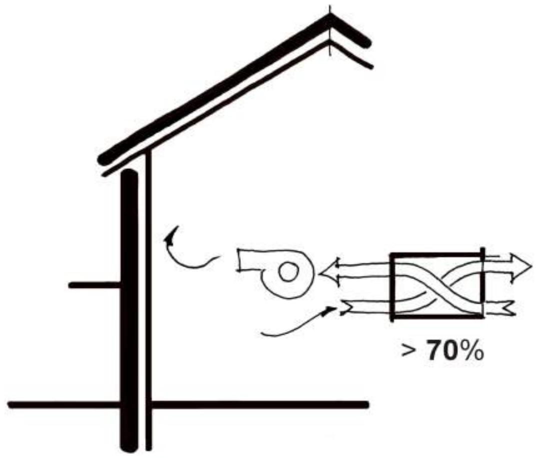

Figure 23 Ventilation system with heat recovery. (Source: AEE INTEC)

Figure 24 Ventilation device with integrated heat recovery. (Source: AEE INTEC)

Influence on energy use

If the ventilation system is equipped with heat recovery, it reduces heat losses. Ventilation such as free-cooling helps to reduce the cooling demand, especially in warm climates if there is relatively high heat storage mass.

Influence on indoor environment

The controlled, mechanical ventilation system raises indoor comfort by constant change of air. It avoids construction damages concerning condensation and moist building components, offers possibilities to filter out allergy germs, pollen and air pollutants. If the indoor air gets too dry caused by the ventilation system during cold season, humidity recovery or plants can solve this problem.

Read more
…..in the report *Energy improvement measures and their effect on indoor environment*, available at www.iee-square.eu.

5 A Quality Assurance system for energy efficient retrofitting

To achieve the intended results of a retrofit requires knowledge, continuity and communication. This can be assured by a quality assurance (QA) system describing a systematic and controlled way of working both in the retrofitting process as well as in the operation and maintenance phase.

5.1 Why use a Quality Assurance system?

An important part of the energy efficiency improvement potential lies in the existing residential building stock. If we are to achieve significant reductions of energy use in existing buildings, it is important to perform future large-scale retrofitting of buildings in a systematic and controlled manner. When retrofitting a building many aspects must be taken into account, such as local resources, costs, building traditions, legislation and financing. These aspects will have an impact on decision-making and on the outcome of the retrofit, which will differ from case to case, and so there are no universal solutions. However, to achieve the intended results of the retrofit requires knowledge, continuity and communication. This can be assured by a quality assurance (QA) system that describes a systematic and controlled way of working. A QA system should cover both the retrofitting process and maintenance, since experience shows that a successful energy improvement retrofit will be permanent only if use of the building is guided by effective routines and continuous capacity building of all parties involved.

One example of such a quality assurance system is a system for indoor environment quality assurance that has been developed in Sweden and successfully applied in a number of buildings over the last ten years [1]. This QA system has recently been extended to include energy use [2, 3]. It is based on Swedish Standard SS 62 77 50 [4], for energy management systems for organisations, and works in a similar way to ISO 14 001 (Environmental management) and EN 16001 (Energy management). This system has been extended and matched to the needs of the building sector, and is now ready to be applied in retrofitting of buildings in different European countries.

5.2 Purpose of a Quality Assurance system

How well targets for energy use and good indoor environment conditions are met in the user stage depends largely on the success of the retrofitting process. Procedures for preparations, planning and monitoring the retrofitting process provide excellent help for ensuring quality and achieving good results.

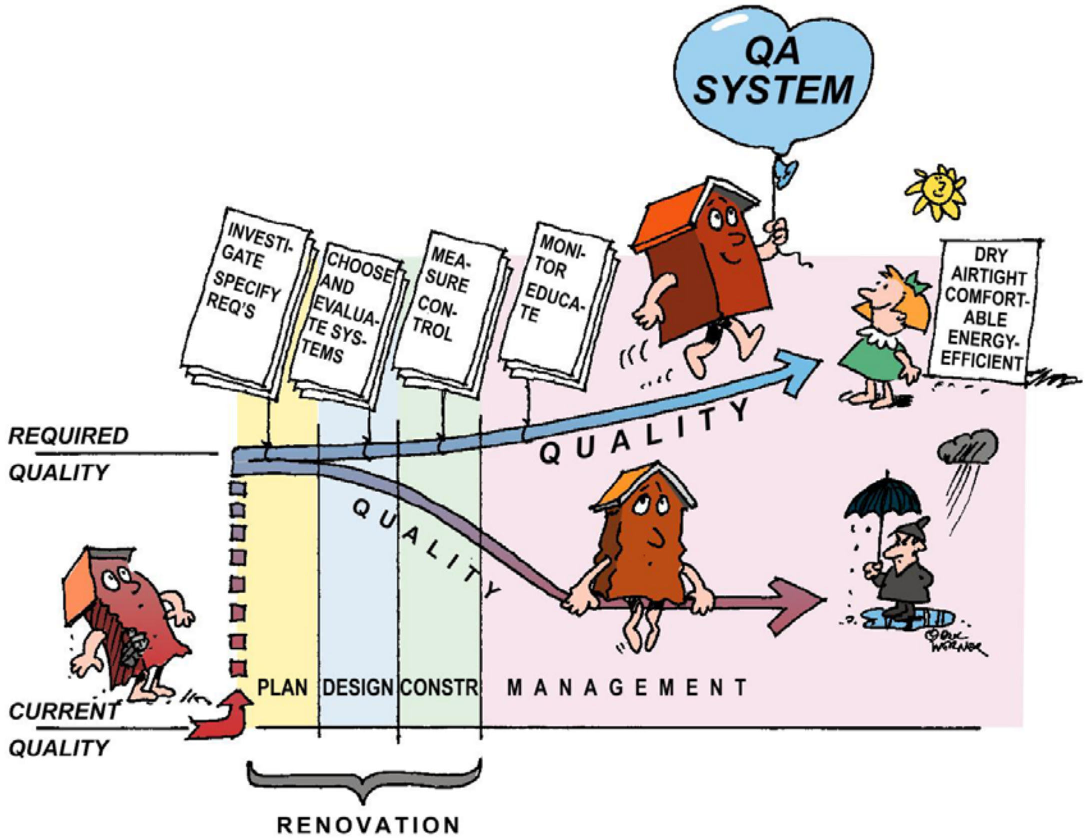

Figure 25 Achieving the required level of indoor environment and energy performance is more likely by applying a QA system in the retrofitting process from planning to facility management. (Source: Eric Werner, Tecknaren AB)

The purpose of introducing a quality assurance system for indoor environment and energy use in the retrofitting process of social housing is to assure organization, routines, responsibility and resources to maintain the indoor environment and energy use performance according to pre defined requirements and targets. The purpose is also to revise the targets with a certain periodicity and in case of changes in management or operation conditions. The system is applicable to all types of social housing that is to be retrofitted and updated to present-day requirements concerning their indoor environment and energy use. Each country has a unique stock of social housing with different needs of renovation. The QA system could be adopted by all countries to suit their particular conditions since it is flexible in terms of organization, requirements and end energy-efficient solutions by concentrating primarily on a systematic way of working. It is a very good base for other countries to start out from to develop their own versions adapted to their conditions, such as regulations, building traditions and climate.

5.3 Essential elements of the Quality Assurance system

The overall objective of the quality assurance system is to ascertain that all predefined requirements on indoor environment and energy use performance are reached, i.e. that none of them is reached on too high expense of another. The essential elements of the process are illustrated in Figure 26. It is based on a policy for retrofit actions, indoor environment and energy use defined by the organization. Two main parts can be distinguished in the process:

- The part associated with the management/supervision of the process of retrofitting the building.
- The part associated with the management of the retrofitted building.

Quality assurance in the first part focuses on a thorough pre-study of the conditions prior to renovation, on formulation of requirements and targets to be integrated in the design process and on description and analysis of the different measures that can be applied in order to reach the targets. Careful definition of the requirements on the monitoring systems for indoor environment and energy use of the building after it has been taken into use is very important for a successful implementation of the second part of the process.

Another essential part of the work is formulation of the specific requirements that applies to the retrofit process itself and definition of how they shall be verified during the renovation. Examples are requirements on air tightness, moisture content and choice of building materials where control may be difficult to perform or rectification could become very expensive, once the renovation is finalized. Supervision of the design and construction by the organization or its representative will be required in order to assure that unconventional quality requirements associated with the co-optimization of indoor environment and energy use are actually being fulfilled.

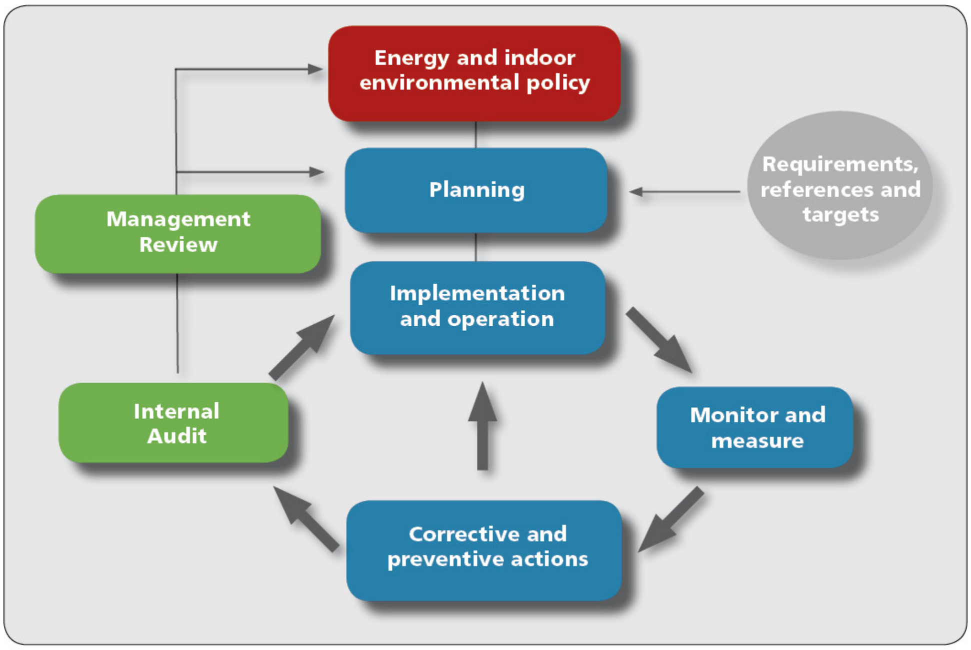

Figure 26 Energy and indoor environment QA system model.

6 The Quality Assurance system used in the retrofitting process

For a Quality Assurance system to be applicable to and effective for a specific project it needs to be customised to the particular procedures and activities of the organisation concerned. All stages from initial planning to operation of the retrofitted building are covered by the quality assurance system.

6.1 Overall description

The quality assurance system itself is described in the report *Quality assurance system for improvement of Indoor Environment and Energy Performance when Retrofitting Multifamily Houses*. However, for the system to be applicable to, and effective for, a specific project, it needs to be customised to the particular procedures and activities of the organisation concerned. In concrete terms, this means that the organisation must, either by means of its own efforts or by bringing in an external consultant, construct the quality assurance system, draw up the necessary procedures and documents, as well as to anchor the system in the organisation. Therefore, a guidance to help the organization to implement the quality assurance system has been produced, *A guide to quality assurance for improvement of indoor environment and energy performance when retrofitting multifamily houses*. The following is a brief description of the practical implication of using the QA system in practice.

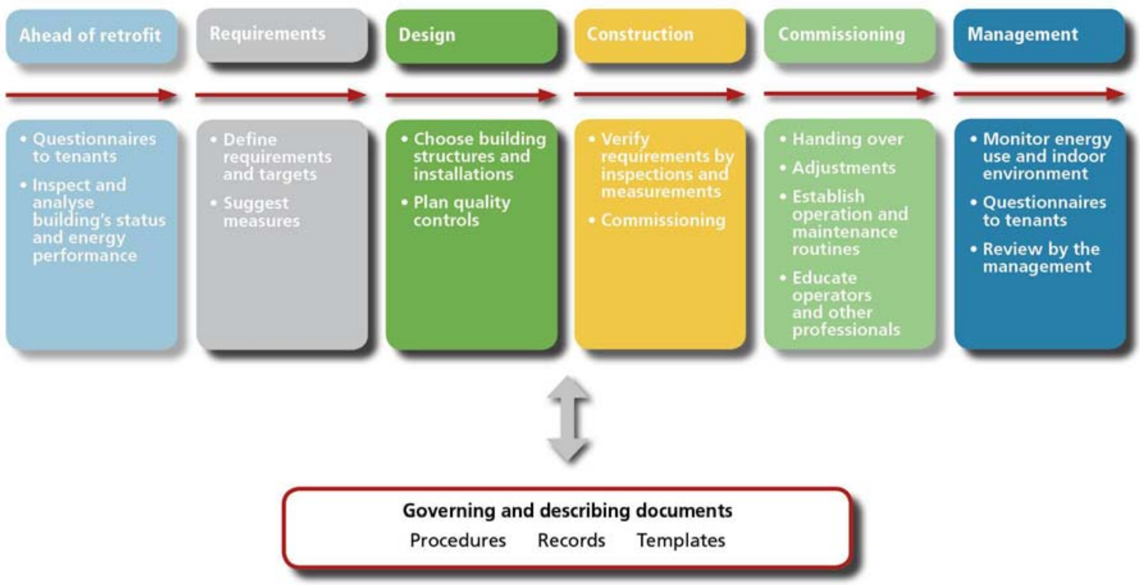

Figure 27 The six stages from initial idea to operation of newly renovated buildings that are covered by the SQUARE QA system.

The quality assurance in the second part, the operation stage, functions more as a conventional QA system. Continuous monitoring of essential parameters and repetitive reviews of policy and target fulfilment are used to maintain or improve the quality of services and the performance of the systems.

The procedures, document control, plans for improvements in energy efficiency and indoor environment and presentation of results as used in these rules follow the same logic structure as set out in SS 62 77 50 and EN16001.

6.2 Ahead of retrofit

The first thing to do is to establish pre-retrofitting conditions of the building. A physical evaluation of the indoor environment, and metering of energy use, is needed as a starting point for deciding on the aims of the renovation. This investigation consists of a Thorough Primary Inspection (TPI) and a First Energy Analysis (FEA). The results from these two will provide the basis for planning the retrofitting work and future operation of the buildings. In addition, before the retrofitting process starts, a questionnaire investigation of the residents' views of indoor environment conditions should be carried out.

Residents' questionnaires

It must be possible to verify all function requirements by means of measurements: in addition, the occupants' or residents' views on the indoor environment must be checked which can suitably be done by means of a questionnaire. The purpose of the questionnaire is to obtain the occupants' views on thermal comfort, air quality, noise, lighting and daylight conditions. The reasons for complaints picked up by the questionnaire survey must always be investigated. Although the proportion of those complaining may be less than the 20 % that is regarded as acceptable, the developer must investigate to find out whether the complaints might be due to damage to the building structure, poor ventilation etc. The questionnaire surveys should be carried out at least every five years. To ensure that they are an effective part of the quality assurance system, they must be carried out carefully, concentrating on important aspects, in order to deliver unambiguous results that can easily be aggregated. It is worthwhile using professional services to prepare these questionnaires, or to use an existing, proven questionnaire.

The thorough primary inspection

It is important to carry out a thorough primary inspection before the work starts, in order to ascertain the state of the building, the building services systems and the existing indoor environment conditions. This involves a survey and inspection of the building as a whole, and also of a number of individual apartments. It can be carried out on a single building, or on a group of buildings having similar technical features and status, together with similar heating and ventilation systems.

A range of measurements is required in order to check whether the indoor environment meets the conditions specified by public authorities or by the developer or administrator. This involves inspection of walls, floors and roofs, measuring moisture, odours, mildew, bacteria and radon. Ventilation systems must be checked to see whether they are providing adequate ventilation rates and not generating too high noise levels. In apartments, noise levels from sources such as traffic must also be checked. The inspection must be carried out in a sufficient number of apartments to ensure that the results are representative of the entire stock. Defects and poor performance found by the inspection form the basis of the renovation plan drawn up before starting the work.

The inspection investigates whether the building and its indoor environment meet the requirements specified by the authorities or by the developer in the following areas:

- Thermal comfort
- Air quality
- Moisture
- Noise
- Light
- Radon
- Domestic hot water quality and temperature

A thorough primary inspection must be carried out by a person or group of persons possessing the necessary theoretical and measurement knowledge, with experience of earlier inspections and measurements. The necessary competence should be supported by documented training and reference objects. All instruments must be calibrated.

Figure 28 Building inventory (Source: Peter Friedl).

Figure 29 Inventory of installations (Source: AEE INTEC).

First energy analysis

Carry out a first energy analysis (FEA) before planning the retrofit of apartment buildings in which energy performance is to be quality-assured. The purpose is to provide material which not only shows how performance requirements set by public authorities and/or the developer are being fulfilled, but which also provides material for allowing the costs of various measures, and their effects or savings, to be calculated.

A FEA consists of a presentation of a survey of the building or building stock, with details of the relevant energy status and performance. The survey can involve examination of drawings, performance monitoring programmes, supervisory systems and other documentation, such as design material from earlier renovations. In addition, it includes inspection of the condition of energy-related services and parts of the building, interviews with operating and maintenance personnel and possibly of additional measurements as required. As far as possible, carry out the first energy analysis at the same time as the basic first inspection, when aspects such as visual inspection and interviews with personnel are being carried out.

After renovation, complement the results from the survey with relevant technical data from the renovation to provide a basis for those parts of the quality system dealing with operation and maintenance of the buildings and building services systems.

6.3 Dialogue and cooperation with tenants and users

The higher the requirements for indoor environment conditions and energy performance, the more important it is that the organisation can communicate its requirements and targets. Correctly used, the quality assurance system will be an important element of this communication by clearly expressing requirements and targets, responsibilities and authorities, and by helping to concentrate the work on important parts of the processes.

Figure 30 Building Information about plans and achievements through newsletters (Source: AB Alingsåshem)

Figure 31 Inventory Stakeholder meetings for information sharing and decision making are two ways of encouraging tenants to take an active part in the process. (Source: AB Alingsåshem)

6.4 Formulation of requirements and targets prior to renovation

How can the purchaser best be assisted in formulating clear, quantifiable and achievable targets and requirements?

The pre-renovation requirements also apply during the user stage, although in the longer term they require appropriate input from operation and maintenance personnel in order to ensure that they are fulfilled.

The developer decides on the performance requirements for the indoor environment and energy use. All requirements must be accompanied by suggestions for appropriate methods for determining their achievement, and of indication of who is responsible for ensuring that the requirement is fulfilled. In this respect it is also desirable to define requirements on measuring equipment that is to be included in e.g. HVAC units or heating systems in order to enable control and follow up of the energy performance.

In order to ensure that all the defects and faults identified in the TFI or FEA are dealt with, the necessary work must be included in the project planning and renovation work. The organisation must decide on what measures are to be carried out, such as:

- Dealing with moisture damage.
- Retrofitting of insulation to the building envelope in order to reduce transmission losses through foundation, walls and roofs.
- Insulation or cladding of structural parts that are acting as thermal bridges, e.g. balconies.
- Measures to improve air tightness.
- Replacement of windows to reduce transmission losses and improve air tightness.
- Reduction of ventilation heat losses (heat recovery, dealing with involuntary air leaks)
- Improving the indoor environment through filtration and improved distribution of supply air
- Replacement of inefficient and/or CO_2 emitting energy supply by efficient supply based on renewable energy
- Continuous monitoring of energy performance
- Encouragement of energy-aware behaviour on the part of users by means of individual temperature control, supported by electricity and heat (hot water) meters in each apartment.

The European Union will in the coming years through the Energy using products Directive 2005/32/EC and the Energy labelling Directive 92/75/EEC define requirements and consumer guiding labels on many energy using and energy related products. This will also support the developer in defining requirements prior to renovation. Furthermore, it is expected that the pressure on manufacturers and suppliers for more efficient products will increase.

While awaiting the common European labelling schemes and efficiency requirements, the organisation planning for a retrofit of its buildings can get valuable information about performance and quality from the business organisations in Europe representing essential products related to improved energy efficiency and use of renewable energy.

Requirements on indoor environment

An example of a requirement can be that of air tightness of the climate screen, expressed as maximum permissible air leakage measured in l/s, m^2 when subjected to a test pressure difference of 50 Pa. Verify the requirement by measurements made during the construction stage after the airtight layer has been applied but before applying internal wall cladding sheets, in order to be able to identify any sources of leakage. The air tightness must then also be measured in the same way when the work is completed.

Another example of requirements can be that of protection against moisture at the workplace, expressed by the requirement that materials and structures must be protected against moisture and precipitation during the construction period.

A third example of a requirement can be that of the lighting conditions in residential apartments after renovation, expressed as luminous intensity in various parts of the apartment, in stairwells and entrance lobbies, and that at least 80 % of the tenants must be satisfied, which can be measured during future questionnaire surveys.

A fourth example can relate to thermal comfort, expressed not only in quantifiable terms such as floor temperatures, temperature gradients, operative temperatures and maximum air velocities, but also in the form of the proportion of satisfied occupants and tenants.

All formulated requirements must be possible to verify by means of measurements or in some other way.

Requirements on energy performance

Energy performance requirements can be expressed in the form of function requirements, such as 'Maximum power of 10 W/m^2 for heating' or energy requirements 'Maximum 45 kWh/m^2 for heating', complemented with the applicable boundary conditions. Function requirements are preferable, rather than more detailed requirements, as they permit greater freedom for the designer to choose appropriate system solutions. Requirements should include not only energy for heating purposes (including electricity for domestic purposes), but also energy for domestic hot water production.

Demanding requirements for energy performance also increase the pressure for quality of workmanship of the building construction and for the quality and performance of building services systems. There can therefore sometimes be justification for complementing function requirements with additional requirements for specific components. It may also be worth while specifying third-party inspection of products involving new technical developments, in order to avoid suffering from teething troubles.

All requirements formulated in respect of final energy use must be quantifiable by means of measurements and/or calculations.

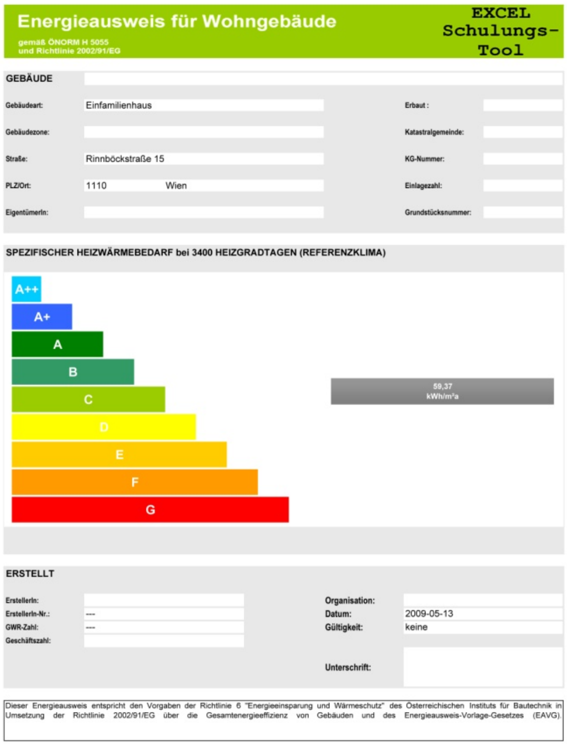

Figure 32 Example of a requirement and declaration of energy performance of a building. (Source: Energy performance certification is from the "Excel- Education - Tool" made by "Dr. Christian Pöhn, MA 39 VFA" July 2008, http://www.oib.or.at/ 2009-05-13)

6.5 Follow-up of requirements in the planning stage

Planning of the renovation work should include the requirements in respect of energy use and indoor environment conditions, as well as the results from the thorough primary inspection and the first energy analysis. It can be advisable to review the requirements when the retrofitting programme has been formulated, in order to decide whether they are practical in the light of the planned work.

It is important that the specified requirements and the procedures for following up their achievement are clear when negotiating with architects, consultants, contractors, installation contractors and suppliers. Unclear requirements can result in misunderstandings and high costs at later stages.

6.6 Follow-up of requirements in the design stage

It is important that the choice of designs, technical systems and functions should be settled at an early stage. The various specialists must work together and concentrate on the building as a whole, instead of on individual parts, right from the design stage. During the design work, it is important to monitor that the requirements in respect of energy use and the indoor environment will be achieved using the proposed structures and systems. This can suitably be done at design meetings, bringing together all the designers. In some cases, it may be necessary to hold special meetings, discussing more specific solutions needed to meet such aspects as requirements for thermal comfort, air tightness, protection against damp etc.

IT tools such as IDA, BV2, ENORM, WUFI and Heat are available for calculating thermal comfort, future energy use and moisture conditions. A list of internationally available programs is available at www.rosh-project.eu/products_tools_aatk_a1.php.

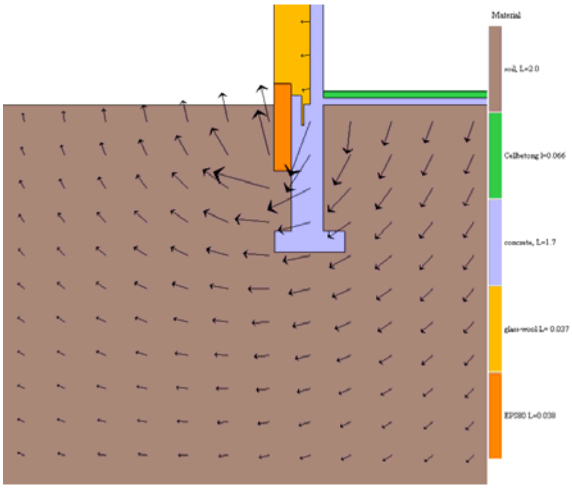

Figure 33 Calculated heat losses through the gable foundation. (Source: WSP)

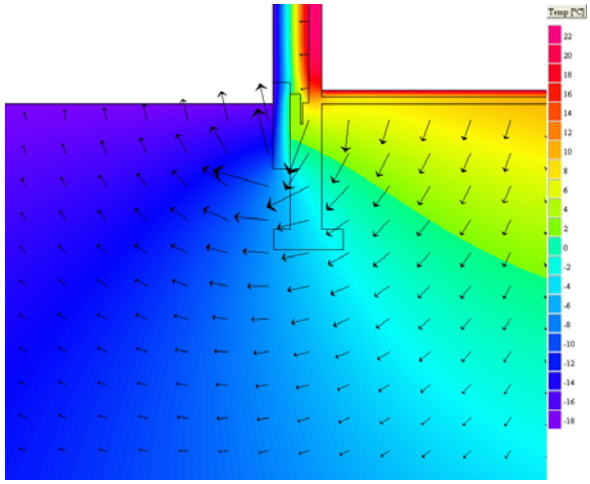

Figure 34 Calculated temperatures through the gable foundation. (Source: WSP)

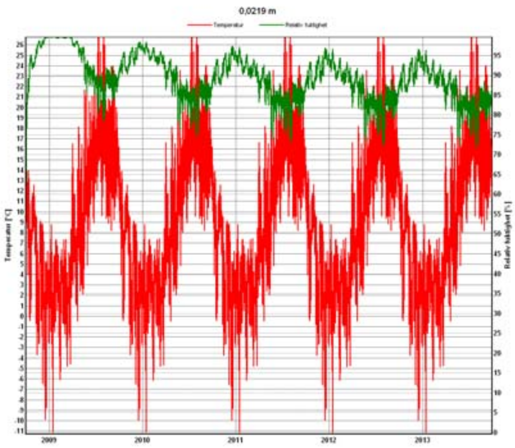

Figure 35 Screen shot from moisture and temperature calculations with the WUFI software. Wall construction with mineral wool insulation. (Source: SP)

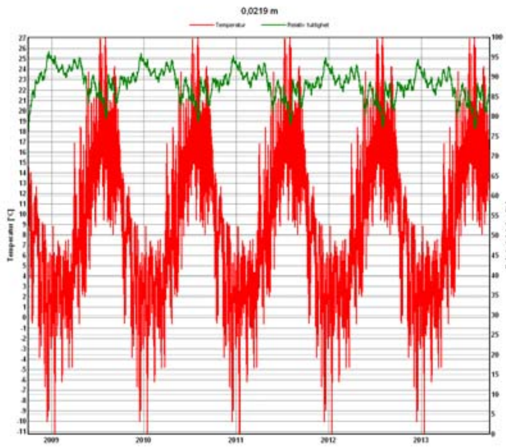

Figure 36 Screen shot from moisture and temperature calculations with the WUFI software. Wall construction with polystyrene insulation. (Source: SP)

The results from the design work are the building documents, consisting of design solutions, details, choice of systems, technical descriptions etc., as needed for production. Documents must also indicate the inspections and verified measurements that must be carried out during the building stage.

6.7 Follow-up of requirements during the construction work stage

At the start of the construction work stage, it is appropriate for the developer to hold an information meeting with the designers and contractors, to inform them of the measures selected during the design stage in order to ensure fulfilment of the requirements. This also provides an opportunity for the contractors to put forward their views on the designs and technical systems. If possible, allow the building contractor to be involved in late stages of the design, in order to be able to put forward views on the design and systems that can be included in the documents.

Figure 37 A well prepared start up meeting involving the housing organisation and all contractors is important for achieving a common view on the work ahead. Regular meetings for sharing experiences and discussing upcoming problems are essential. (Source: AB Alingsåshem)

Figure 38 Joint meetings with designers and contractors during the design and construction processes (Source: AB Alingsåshem)

Figure 39 Inspection rounds with all contractors and well defined control programs during the construction processes. (Source: TTA Trama Tecno Ambiental S.L.)

The contractor works in accordance with the requirements of the documents, performing the inspections and confirmatory measurements specified in the documents and which are required to be carried out during the work stage. The contractor prepares material for operating and maintenance instructions for building services systems, cleaning of sumps, cleaning procedures and methods for service claddings etc.

Figure 40 Moisture rounds at the building site. (Source: SP)

Figure 41 Weather protection to keep the building site dry. (Source: SP)

When the work is completed, make confirmatory measurements in order to ensure that the specified requirements have been fulfilled.

Figure 42 Testing the air tightness of a wall during the construction stage in order to verify air tightness. (Source: AEE INTEC)

Figure 43 An example of an air tight solution of a window opening. (Source: SP)

6.8 Follow-up requirements in the commissioning stage

There is a common agreement among building management professionals about the importance of the commissioning process as a powerful tool for ensuring the fulfilment of requirements on indoor environment and energy performance.

Figure 44 The commissioning process reaches from construction and into the management phase.

There is no absolute definition of the word "commissioning" and the process is hardly separable from the construction and management stages. On the contrary, commissioning and handover is a process that should be a bridge between the two and therefore it should be in operation during both stages. It should NOT be limited to a short period of time in between the two stages as in the case of a traditional final inspection when handing over the building.

IEA ECBCS Annex 40 "Commissioning of Building HVAC Systems for Improving Energy Performance" [7], one of the major international projects in the field, defines commissioning as:

"Clarifying building system performance requirements set by the owner, auditing different judgments and actions by the commissioning related parties in order to realize the performance, writing necessary and sufficient documentation, and verifying that the system enables proper operation and maintenance through functional performance testing. Commissioning should be applied through the whole life of the building."

The last sentence may sound as an impossible task but it applies to the fact that during the whole life of a building, several major changes in the building envelope and in the installations will take place. Following these changes commissioning should ensure that the changes have been well integrated with the whole system i.e. that adjustments in other systems that may be required as a result are actually carried out.

Some of the recommendations and tools delivered by Annex 40 are also adapted for the quality assurances system developed and used in the SQUARE project. It will be up to each organization to choose the components and build their own commissioning procedures on the basis of this information.

We would nevertheless like to point out a few important issues to consider when doing this:

- Continuous monitoring of energy performance
- The main objective of the commissioning is to verify that "what was ordered has been delivered" through optimum co-functioning of the building and its' technical systems'.
- A project's technical result should never be approved on the basis of a conventional final inspection only. On the contrary, the commissioning process should ideally reach over at least a one year period in order to exhibit all types of operating conditions for the building and its systems and to allow for adjustments and repeated check ups.

- For optimum results, commissioning should be carried out by representatives of the building contractor and the building manager in close cooperation.
- The commissioning should focus on the HVAC systems, the domestic hot water systems including circulation lines and on control systems.

Further, according to Annex 40 "The primary obstacles that impede the adoption of commissioning as a routine process for all buildings are clearly lack of awareness, lack of time and too high costs. Hence, efforts for improvement should consider how new tools, methods and organizations can increase the awareness of commissioning, decrease the cost and demonstrate the benefits obtained by performing commissioning."

6.9 Follow-up requirement in the management stage

Handing over of the building

When handing over the building, it is appropriate for the contractors to go through the building with the developer, pointing out critical designs, structures and details, demonstrating how systems work, how they need to be looked after, and how they are adjusted. It is also important that operating and care instructions should be gone through, and that the developer is familiar with the associated procedures.

Some aspects can be checked and monitored in connection to inspection rounds: examples include inspection of particularly moisture-exposed parts, checking for odours, checking that water is not collecting on roofs or ground surfaces, checking that cleaning and lighting of public areas are satisfactory, and so on. Temperatures, energy use, energy flows, electricity and domestic hot water can most suitably be monitored by computerised supervision of the entire building and/or of each individual apartment. Experience indicates that this makes it easier to save energy without sacrificing comfort, and also provides more rapid indication of operational problems, helping to repay the investment more quickly. In this context, look-ahead control can also be something to consider. It is advisable to hold meetings with operational staff regularly in order to discuss and deal with any problems or suggestions for improvements that have been picked up by inspection rounds or operational supervision.

***Figure 45** Installations check-up during inspection rounds. (Source: AEE INTEC)*

***Figure 46** Involving the tenants early in the renovation process also makes the follow up more effective. (Source: SP)*

The building owner should also arrange meetings in order to hear residents' views on the indoor environment in their apartments and in public areas. Occupants' views can also be collected by the regular questionnaire surveys and from reporting of complaints. A tenants or occupants' representative should also be involved in the regular operational meetings and inspection rounds. There must be a procedure for dealing with complaints concerning the indoor environment.

Figure 47 Measuring the operative temperature in an apartment in Brogården, Sweden. (Source: SP)

Figure 48 Measuring the air velocity in an apartment in Brogården, Sweden. (Source: SP)

Deal with departures from requirements, such as complaints or shortcomings and faults, at regular meetings with the developer's organisation during the management reviews, when decisions are made concerning action to be taken in order to fulfil the requirements. Reliable measurements of a range of parameters constitute an important part of the quality assurance of renovation projects and of subsequent building operation. This requires appropriate levels of competence on the part of those making the measurements, and on the quality and calibration of the equipment used. In addition, the choice of measurement methods and references for the measurements is often decisive for the end results. As far as possible, apply international, European or national standards.

Measurements during the work stage (moisture, air tightness, ventilation air flow rates) are first and foremost the responsibility of the building contractor and any subcontractors specified by the purchaser. The purchaser checks the results of these measurements and may complement them with additional sample measurements. Such measurements may be made by the purchaser's own personnel if they have the necessary training and equipment, although it can also be useful to arrange for an independent third party to make such check measurements.

More extensive measurements will be required in existing/completed buildings: not only individual measurements or indoor climate conditions, those associated with adjustment of ventilation, heating and cooling systems (noise, light, ventilation air flow rates, thermal comfort, draughts, pressure differences, thermography), but also those forming part of the continuous operational monitoring (domestic hot water temperature, space heating water supply temperatures, supply and exhaust air temperatures and energy use by space heating, domestic hot water and electric power systems). As previously mentioned, it is strongly recommended that these latter measurements should be carried out by computerised supervisory systems.

The work of making check measurements and operational supervisory measurements during the in-use stage of the building, involving data acquisition, processing, presentation of statistics etc., can be carried out either (partly or wholly) by the organisation itself or by a subcontractor for the work. There is no general preference here: instead, each individual organisation should make the choice based on its own circumstances.

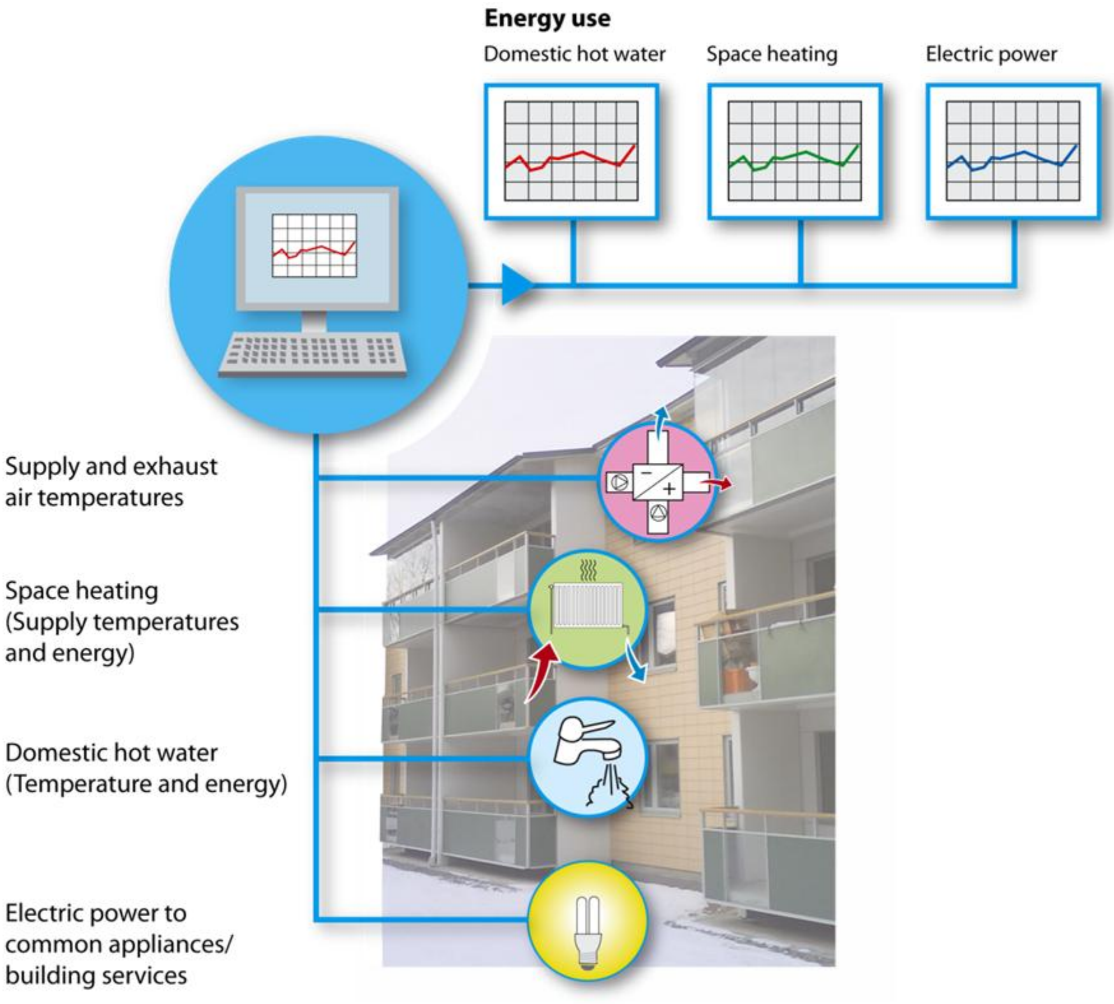

Figure 49 Illustration of computerized supervisory or building management systems (BEMS). (Source: SP)

Read more…

…..in the reports *Quality assurance system for improvement of Indoor Environment and Energy Performance when retrofitting Multifamily Houses* and *A Guide to Quality Assurance for improvement of indoor environment and energy performance when retrofitting multifamily houses*, available at www.iee-square.eu.

7 Implementation of the QA system in pilot projects

Nothing is as instructive as building good examples where advanced technology is used to achieve efficient energy use and good indoor environment. The quality assurance system has been implemented in the retrofitting process in four pilot projects. Experiences and results from these projects are used to exemplify the benefits of using a QA system in the retrofitting process.

7.1 The purpose with the pilot projects

Nothing is as instructive as building good examples where advanced technology is used to achieve efficient energy use and high comfort with good architecture. The QA system for efficient energy use and improved indoor environment has been applied in pilot projects involving retrofitting and renovation of social housing. These pilot projects have been selected for the reason that they represent typical social housing structures in the participating countries and are planning retrofitting initiatives which are supposed to be implemented in the years of the project duration anyway. The added value of taking part in the SQUARE project will mean for them to push the standard of refurbishment to more ambitious targets and to receive methodologically correct and valuable information thanks to the QA system to be applied. Experiences from design, construction and operation of these pilot projects will be discussed, summarized, evaluated and disseminated among the partners and to other target groups. The evaluation should illustrate both what has been functioning well and what areas need more research and development. Communication with tenants is a very important part of the evaluation that can give valuable information. Evaluation of the pilot projects and dissemination of results and experiences is a very important task. In addition, the tenants, developers, consultants, contractors participating in the pilot projects have got an opportunity of education and advancement regarding energy efficiency and indoor environment.

7.2 Pilot project Brogården, Alingsås – Sweden

Before retrofit

After retrofit

GENERAL INFORMATION	
Location/town	Brogården, Alingsås, Sweden
Year of construction	1971-1973
Number of apartments	299
Number of buildings	16
Construction materials	Concrete frame, infill walls facing balconies, brick facade, concrete floor structure, concrete loft ceiling beams, rafter with studs of wood and tar paper on top. The facades have either a brick façade or boards
General systems	District heating (incl. domestic hot water), electricity, water and sewer
Initial building state	Draught, bad insulation, low ventilation
Ownership	AB Alingsåshem /Public Housing company
Developer	AB Alingsåshem /Public Housing company
Renovation period	2007-2010 (3 buildings)
Structural retrofit	Renovation of existing structure: floors, roof, internal divisions
Envelope retrofit	Insulation, air tightness, windows, new façade material
Services retrofit	Forced ventilation with energy recovery
Control retrofit	Individual control of energy use and indoor climate
TARGET BUILDING AND OBJECTIVES	
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
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.

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.
IMPLEMENTATION OF THE QA SYSTEM	
Pre-renovation conditions	• Getting in contact with the tenants. • Involving the tenants in the renovation process. • Technical inspection of buildings
Req. on the energy efficiency	• To keep total energy needs at 92 kWh/m^2
Req. on the indoor environment	• To fulfil the requirements of P-marked indoor environment • To verify a comfortable indoor environment by making building simulations.
Other requirements	• 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.
Design	• New drawings of the building to make lighter, determination of the daylight factor. • New design of the wall construction to guarantee U-values, moisture safety. • Energy engineering and general systems design. • Design of the ventilation system.
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.
Construction	• Job planning. • Testing of air tightness. • Moisture control.
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.
Performance assessment and monitoring	• Follow up on indoor environment. • Follow up on energy use.

Identified success factors in the implementation work	• Form of contract used: partner contracting which involved new ways of working and new possibilities. • High level of involvement 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 of the existing system
Identified barriers or difficulties in the implementation work	• Adding daily burden to the service personnel. • Lack of skilled project leaders. • Bad integration of the local manager in the design phase. • Sub contractors often lack understanding about the importance of quality assurance. • Difficult 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.

TECHNICAL STATUS	**Before retrofit**	**After retrofit**
Utility		
Space heating (kWh/m²)	115	27
Water heating (kWh/m²)	42	25
Domestic electricity (kWh/m²)	39	27
Common appliances electricity (kWh/m²)	20	13
Total demand (kWh/m²)	216	92
Envelope		
External walls (W/m²°C)	0.4	0.15
Windows (W/m²°C)	2	0.85
Roof (W/m²°C)	0,3	0.12
Air tightness (1/h)	n.a.	0.25

7.3 Pilot project Dieselweg, Graz - Austria

Before retrofit

After retrofit

GENERAL INFORMATION	
Location/town	Dieselweg, Graz
Year of construction	1952, 1959, 1970
Number of apartments	204
Number of buildings	6
Construction materials	Brick façades, concrete floor, roof and walls without insulation, wood windows of very bad performance
General systems	Heating and hot water system from electricity and old fossil fuel boilers
Initial building state	High energy consumption, low indoor environment quality
Ownership	GIWOG / Public Housing Association
Developer	GIWOG / Public Housing Association
Renovation period	2007 – 2010
Structural retrofit	• Passive solar façade. • Enlargement of living surface and elevators. • All the renovation works made from the external side.
Envelope retrofit	• Pre-fabrication of all new façades. • High performance external insulation.
Services retrofit	• Ventilation with Individual heat recovery. • Heat supply by solar energy and renewable fuel. • Heating supply system between de new and the existing façade.
Control retrofit	
TARGET BUILDING AND OBJECTIVES	
Target buildings	• 3-4 stores • Built in 1970's • Suburban area • 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.

Objectives	• High performance renovation: passive house standard. • Renewal of the building services. • New introduction of ventilation systems. • To establish new, innovative and economical renovation procedures to improve renovation quality. • To reach a user acceptance for high-performance renovation. • To establish more awareness within housing associations for sustainable and energy-efficient renovations.
Limits	• 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.
IMPLEMENTATION OF THE QA SYSTEM	
Pre-renovation conditions	• Getting in contact and building up the cooperation between partners for the project group – everybody in this group 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.
Req. on the energy efficiency	• To reduce the energy demand for space heating about 90 %. • To keep total energy needs at 30 kWh/m² per year. • To keep total heating energy needs at 10 kWh/m² per year. • To reduce the running costs for hot water generation. • To eliminate construction damages and thermal bridges.
Req. on the indoor environment	• Installation of single room ventilation fans with integrated heat-recovery to get adequate air quality. • To install a centralised heating system – based on renewable energy sources. • To use solar thermal systems for hot water generation. • To increase the living space. • To get barrier-free access to all flats by installation of passenger lifts per each building.
Other requirements	• 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).
Design	• 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. • 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.
Training	• Training and information to the contractors. • Training and information to tenants. • Presentation and awareness rising for the coming monitoring procedure.
Construction	• 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.
Commissioning	• Commissioning a Blower Door Test. • Checked the assessment of the thermal envelope.
Performance assessment and monitoring	• Follow up of the energy flows.
Identified success factors in the implementation work	• Tenants remaining in their apartments. • Tenants informed from the beginning. • Use of new (prototypes) renovation technologies. • Design of a new shape of the building.
Identified barriers or difficulties in the implementation work	• 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.

TECHNICAL STATUS	Before retrofit	After retrofit
Utility		
Space heating (kWh/m²)	184	9.6
Water heating (kWh/m²)		
Domestic electricity (kWh/m²)		24.1
Common appliances electricity (kWh/m²)		
Total demand (kWh/m²)		
Envelope		
External walls (W/m²°C)	1.28	0.2
Windows (W/m²°C)	2	0.85
Roof (W/m²°C)	1,5	0,2
Air tightness (1/h)	n.a.	0,6

7.4 Pilot project Sant Joan Malta, Barcelona – Spain

Before retrofit

After retrofit

GENERAL INFORMATION	
Location/town	Sant Joan de Malta, Barcelona
Year of construction	ca 1890
Number of apartments	6
Number of buildings	1
Construction materials	Brick and stone walls, wood beams, wood windows of very bad performance, non-insulated flat roof and external walls.
General systems	Individual electric hot water and heating system
Initial building state	Structural damages, obsolete services, high energy demand, low comfort
Ownership	Residencial Sardana (Private developer)
Developer	Residencial Sardana (Private developer)
Renovation period	2007 – 2010
Structural retrofit	Partial renovation of existing structure: floors, roof, wood beams, internal divisions Preserve as much as possible the existing structure (walls, floors, roof, staircase, etc.) in order to reduce the building renovation cost and its renovation
Envelope retrofit	Choose constructive methods compatible with the old ones and apply modern solutions when the old structures were in bad state
Services retrofit	Renovation of all the building services, Forced ventilation with energy recovery in each flat, possibility of free cooling, Centralized gas heating, and hot water

Control retrofit	Thermal regulation, individual meters and global monitoring Every flat can meter the consumption of: • Heat: heating and hot water • Electric energy • Water In the building there is one gas meter. The gas bill would be divided proportionally to the individual consumption.
TARGET BUILDING AND OBJECTIVES	
Target buildings	• 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 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	• 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 pilot project is limited to the 6 apartments.
IMPLEMENTATION OF THE QA SYSTEM	
Pre-renovation conditions	• Analysis of the pre-renovation conditions has been focused on structural aspects. • The TPI was developed 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.
Req. on the energy efficiency	• Better global U-value (< 1 W/m²ºC). • 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/m²).
Req. on the indoor environment	• Air renovation regulated by CO_2 sensors. • Air renovation programmed in function of the use of the apartments. • Low emissions paints and furniture.

Other requirements	The project revision carried out by TTA made several proposals in order to improve the energy efficiency and the indoor environment quality. • Consider the external thermal insulation on the main façade to keep the wall mass to storage energy. • Insulate the internal walls surrounding not heated spaces, and the basement floor • Consider a vented roof • Correct thermal bridges and the capillary moisture from the ground. • 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 energy recovery from renovated air flow • Introduce free cooling And POMA added some global architectural and sustainable targets: • No over loading vertical structure. • Not subjecting existent structure (walls) to new efforts. • Compatible construction solutions with existent. • Election of the wood as a material that has low emissions of CO_2.
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.
Training	• Training and information to the contractors. • Training and information to tenants. • Permanent training during the technical work visits (weekly).
Construction	• 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.
Commissioning	• Check that the requirements are fulfilled. • Verify the installations performance. • Correct the in-conformities. • Receive documents, user's manuals and warranties from the contractors and equipment suppliers.
Performance assessment and monitoring	• Follow up of the electricity, gas and heat consumptions by specific meters.

Identified success factors in the implementation work	• 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 rather than to demolition. • Most of the structures have 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	• Lack of continuity of the building developer because apartments are for sale. • Lack of companies engaged in the management of residential buildings thermal plants.

TECHNICAL STATUS	Before retrofit	After retrofit
Utility		
Space heating (kWh/m²)	no data	25.1
Water heating (kWh/m²)	no data	
Domestic electricity (kWh/m²)	no data	
Common appliances electricity (kWh/m²)	no data	
Total demand (kWh/m²)	no data	
Envelope		
External walls (W/m²°C)	1.7	0.5
Windows (W/m²°C)	4.2	2.6
Roof (W/m²°C)	2	0.3
Air tightness (1/h)		Class 4

7.5 Pilot project Pohjankaleva student house, Oulu – Finland

Before retrofit

After retrofit

GENERAL INFORMATION	
Location/town	Oulu
Year of construction	1970
Number of apartments	Student Homes
Number of buildings	1
Construction materials	Aerated concrete, concrete floor structure, concrete roof. No balconies.
General systems	District heating (incl. domestic hot water), electricity, water and sewer
Initial building state	Partially renovated in 1993, relatively good technical condition of the building, low comfort, high exhaust air flow rates.
Ownership	Public student housing company (PSOAS North Finland Student Home Foundation)
Developer	Public student housing company (PSOAS North Finland Student Home Foundation)
Renovation period	2009-2011
Structural retrofit	Renovation of existing structure: floors, roof, internal divisions
Envelope retrofit	Insulation, air tightness, windows, new façade material
Services retrofit	Forced ventilation with energy recovery
Control retrofit	
TARGET BUILDING AND OBJECTIVES	
Target buildings	• Student house • Improve the quality and comfort of the apartments • Renovate the services
Objectives	• High performance renovation: Class C in the Finnish Indoor Air Classification. • New introduction of ventilation systems.
Limits	• Outdoor design temperature -32 °C.

IMPLEMENTATION OF THE QA SYSTEM	
Pre-renovation conditions	
Req. on the energy efficiency	• To reach passive house standard level which in northern Finland is 30 kWh/m² per year for heating energy (domestic hot water 25 kWh/m²). • To keep total energy (heating + electricity + domestic electricity) needs at 127 kWh/m².
Req. on the indoor environment	• To verify a comfortable indoor environment by making building simulations.
Other requirements	• Simple energy analyse (www.motiva.fi). • Simple condition survey. • Plumbing and water systems. • Indoor air and ventilation.
Design	• Maintenance handbook (mandatory in Finland)
Training	• Moisture control during construction work • Dust control during construction work
Construction	• Measurements of air tightness, thermal bridges and thermal comfort measurements after renovation. • Measurements of ventilation rates and carbon dioxide levels.
Commissioning	• Energy certification Annual Between 10 years
Performance assessment and monitoring	• To reach passive house standard level which in northern Finland is 30 kWh/m² per year for heating energy (domestic hot water 25 kWh/m²). • To keep total energy (heating + electricity + domestic electricity) needs at 127 kWh/m².
Identified success factors in the implementation work	• Use of the existing Finnish QA system.
Identified barriers or difficulties in the implementation work	

TECHNICAL STATUS	Before retrofit	After retrofit****
Utility		
Space heating (kWh/m²)	140	25
Water heating (kWh/m²)	30*	35***
Domestic electricity (kWh/m²)	50	67**
Common appliances electricity (kWh/m²)		
Total demand (kWh/m²)	220	127
Envelope		
External walls (W/m²°C)	0.4	0.15
Windows (W/m²°C)	2	0.85
Roof (W/m²°C)	0.3	0.12
Air tightness (1/h)	n.a.	0.25

* Decreased number of tenants
** Increased number private appliances
*** Private showers instead of shared can increase use of showers
**** Estimated values

Read more…

…..in the reports "National pilot project, Sweden", "National pilot project, Austria", National pilot project, Spain" National pilot project, Finland" and "Summary report on all pilot projects" available at www.iee-square.eu.

8 Success stories and lessons learnt

Many companies have a quality assurance system but it is only when it is well implemented in the routines and used in the daily work that it has an effect. Therefore, it is better to start with a limited scope and expand the system than to do the opposite. A high level of ambition has upturned many QA systems.

8.1 Success stories

More ambitious targets at Dieselweg

The SQUARE project pushed the standard of refurbishment to more ambitious targets and received presentable renovated buildings with the demonstration project "Dieselweg". The success is founded in the new renovation technology and the shape and sight of the buildings. QA applied in renovation procedures are thought to be costly in terms of work and effort. But the advantages of implementing a QA system are visible by realised projects. So the Dieselweg is a good example to show the potential within renovation procedures.

Experiences from design, construction and operation of these pilot projects were discussed, summarized, evaluated and disseminated among the SQUARE partners and to other target groups. A lot of interested parties and experts visited the "Dieselweg". But also the tenants are satisfied, that they could remain in their apartments. A lot of them watched all construction processes on-site with great interest. And after finished works they have a very good picture in front of them:

Figure 50 The last part of the long building row is owned by different owners. They did not want to join the renovation – so their building remained as before. Even the space heating is like it was before; everybody has to care for himself/herself (Source: AEE INTEC).

So it is QA which helps new renovation strategies to be implemented successfully for both – builders and users. Additionally QA supports smartly renovation processes. Of course the time-span and the effort for preparing and planning is bigger than usual – but in the end it helps to save time.

The financial aspect can be solved easily if it is considered in the earliest stage of the process. It is necessary to raise the rents if the flat-standard is raised. The GIWOG calculated, that the rent had to be raised about 30 to 40 € (per one 60m²-flat). The calculation is resulting from the increment of 1.46 € per square meter for the fee covering the maintenance and improvement-costs. But the occupants could be convinced to vote for the renovation, because the running costs will decrease about 100 € per month. This calculation is effecting an economy of about 60 – 70 € per flat.

It is necessary to consider such financial matters and to inform the tenants from the beginning. But most important – in the end the promises of reduced costs had to be kept by the builder. Therefore the importance of a good quality assurance during the whole process is obviously.

Partner contracting at Brogården

One success factor identified in the Swedish pilot project in Brogården is the form of contract used, partner contracting which involved new ways of working and new possibilities. One objective of this form of cooperation is to get experience back to the organization. An example often stated by the responsible project leader at the contractor is “to improve quality the building process should be treated as a football team with 97% training and 3 % match instead of the opposite which is the case today”.

Figure 51 Workshop and information meeting with all participants to agree on common goals and working methods. (Source: Skanska AB)

Figure 52 The partner organization has worked a lot with team building activities. (Source: Skanska AB)

The main contractor Skanska has worked a lot to build a team. Example of team building activities are; eating in a big common canteen, having a common start meeting common targets were formulated, make awareness who the customer is (the “customer” is visible in the process, “has a face”), introduce and work with safety routines. An open minded atmosphere and a forgiving mentality also bring the team closer together and give higher quality in the end. It should be acceptable to tell about mistakes, to question has other peoples work and to come with own suggestions. The partner organisation thus led to a good platform to build on in the following phases. Evaluation and adaptation of untraditional working methods and new technical solutions has been made throughout the earlier phases and experience is passed on to next phase. This has been extremely successful in terms of quality improvements as well as in time- and cost savings.

Added value compared to other apartments in Barcelona

The implementation of the SQUARE QA system in the Spanish pilot project has offered the possibility to the developer to:

- Establish an ambitious energy policy.
- Adopt a tool to plan and organize the targets, the construction stage and the management.
- Improve the monitoring of the construction process and the metered parameters
- More efficient and systematic construction control and commissioning.
- More complicity between the actors: builders - technical – property (developer).
- Generate detailed information about maintenance, management and operation to new owners.
- Offer a high quality dwelling without increase of prices.
- Be able to sell (because of the improvements compared to others) in a moment that the market is completely frozen (66% of the apartments has been sold in few months after the building renovation at the end of 2009 when the selling rate in the region was at its lowest level, as can be seen at the figure 54).

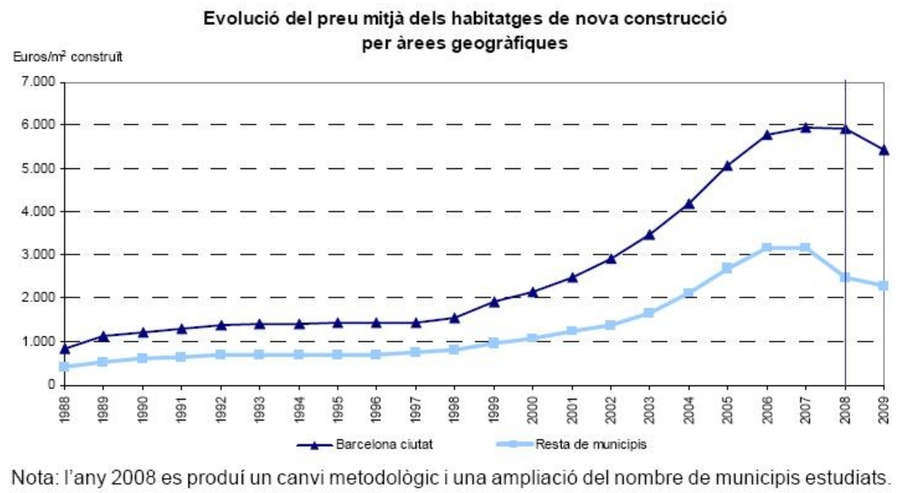

Figure 53 New dwelling price evolution between 1988-2009, in Barcelona (dark blue) and the rest of Catalan municipalities (clear blue), €/m2.

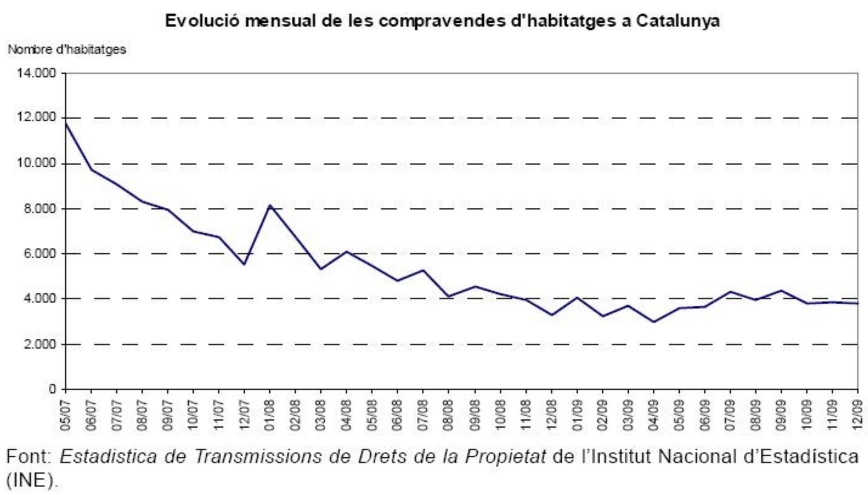

Figure 54 Sold dwelling evolution between 05/2007-12/2009, in Catalonia.

Implementation of the Square system in Orbit hart of England, UK

The SQUARE group has during the action cooperated with the Treco group. TRECO (Transnational ECO Network) was started in 2004 as one of the first private European initiatives to improve energy efficiency and energy effectiveness in housing. TRECO is a project/cooperation actively involving their members, a group of international stakeholders in housing. Each partner has identified a project (new construction, regeneration, renovation or technique) for which the knowledge, labour and materials are to be sourced according to principles of sustainability and which is intended to achieve an output of higher than usual standards of energy efficiency. This may involve measures to reduce the energy demand or the installation of efficient technology or even both. Innovation plays a part in the project but the most important objective is to achieve replicable solutions and a wider use of the lessons learnt. Throughout the SQUARE project, common workshops have been hold with the TRECO network, which has not only resulted in active feedback from TRECO partners on the SQUARE method, but also in the uptake of the essence of SQUARE by TRECO members.

The first example of uptake is in the United Kingdom, where Orbit Heart of England has made an effort to interpret and include the SQUARE approach in daily routines of this organisation. Orbit Heart of England is part of the Orbit group, a UK based social housing provider owning and managing over 33,000 units. Orbit Heart of England is developing an approach to tackle fuel poverty through energy efficiency measures in their stock, and basing the measures on passive renovation technologies. Orbit is in the process of developing pilot demonstration projects in different house types which do reflect their full housing stock. Orbit Heart of England did accept the serious lesson from SQUARE that an integrated approach, covering all phases of a project life is needed to achieve the necessary quality. Orbit has developed a series of documents to start the process of implementing the SQUARE method within their organisation.

Application of the TES prefabricated facade system in Roosendaal

The second example of uptake is in The Netherlands, where Aramis Alleewonen is developing a large passive renovation project in the area called Kroeven in Roosendaal. Social housing provider Allee Wonen owns 19,000 properties in Roosendaal and Breda, The Netherlands. In Roosendaal, in 1960 a large scale residential development was built in an area called De Kroeven, which mainly consists of identical single family houses.

Figure 55 De Kroeven in Roosendaal, NL.

After 40 years of use, and only gradual improvements and normal maintenance, Allee Wonen decided to upgrade and redesign the area. Also the tenants had expressed interest in an energy efficient renovation. Whereas Allee Wonen had learned about the passive house concept as part of her involvement in the European Treco network for social housing providers, Allee Wonen and the tenants developed a shared interest in low energy renovation. The full upgrade of Kroeven consists of 370 single family houses, of which 246 will be renovated and 124 units will be newly constructed, replacing about 100 existing houses. Two architect firms and energy consultants have been appointed to develop different approaches to passive renovation, and to ensure a variety in architectural and technical solutions, whilst aiming at the same low energy demand for space heating and domestic hot water. The renovation will be carried out in such a way that the tenants shall stay in their houses. This requires a fast and non-intrusive renovation process.

Approach 1 resulted in two test houses, demonstrating how the houses can be insulated using 200 mm external EPS insulation and a plastered facade, passive house window frames and triple glazing, and prefabricated timber roof elements, filled with 350 mm cellulose insulation.
From 2010 to 2012 this approach will be implemented in 112 houses.

Figure 56 Test house with external EPS insulation and plaster and prefabricated timber roof.

Figure 57 Test house with timber frame elements with cellulose insulation and prefabricated timber roof.

Approach 2 resulted in one test house demonstrating the how the houses can be insulated using a new 350 mm timber frame element with cellulose insulation, with triple glazed passive house window frames, and again prefabricated timber roof elements, filled with 350 mm insulation. The external façade cladding is natural slates. From 2010 to 2012 this approach will be implemented in 134 houses.

Figure 55 New compact heat and ventilation system.

Figure 56 Prefabricated facade system used in Roosendaal.

In both cases the heating, ventilation and domestic hot water system will be upgraded using new compact systems, which include per house a mechanical heat recovery system, a 200 litre storage tank, connected to a solar collector array, with a backup by a small condensing gas boiler.

The renovation approach results in a heat demand of less than 25 kWh/m2, compared to an original energy use for space heating of 150 kWh/m2.

The lessons from SQUARE have been taken by including a thorough energy approach throughout the design process, and assessing design decisions with precise PHPP energy calculations in order to achieve passive renovation targets. During the project execution full attention is given to quality control, for instance by using blower-door tests for all units just before completion. Aramis Alleewonen has used an integrated approach involving all departments of their organisation, and working with tenants to develop the project. Aramis Alleewonen manages the project execution by external contractors, and will remain to be the future owner. Aramis Alleewonen has given a financial guarantee about reduced energy costs against the increased rent level. Therefore there will be an evaluation process during the first years after completion.

8.2 Identified barriers for implementing a QA system

Reluctant to add more to the daily burden

Renovation of the building stock is an exception in the daily work of a housing association. Most of the work is carried out in everyday processes; maintenance, renting out and operation of the building. From an economic point of view as few activities as possible is preferable, to let the investments made create a mild trickle of pay back. Improvements, efficiency increase and lubrication of processes are made within the existing framework. Most of the routines needed and used on a regular basis are handling complaints, support tenants and overall control of the buildings and its systems. Implementing routines for an activity used as seldom as large scale renovation risk to be out of date already next time they are needed. It is of great importance that added routines are seen as useful in the everyday operation of the buildings, to integrate them thoroughly in the maintenance and service routines the staff are used to handle, and to make the parts of the QA that are used more seldom clear and simple.

During the initial work it was recognised that Alingsåshem's existing QA system was not being used as intended in all parts. More specifically, this means that most of the regularly occurring procedures and routines described in the system are being applied in practice in the everyday work but the feedback to the system is lacking. Thus, the potential for continual improvement and capacity building in the organisation is not being utilised to its full extent.

The integration in the operational procedures means getting the service personnel to gather and register data, and performing new controls. Having limited time for their tasks they are understandingly reluctant to add more to the daily burden. In the first meetings this was the dominating approach to implementation, it was seen as yet more work with abstract value. However, working through the documents item by item on several meetings, and discussing the value of each in an open manner lead to an understanding. Seeing that this work, such as measuring moisture in the attic, looking for humidity between the glasses of the windows, odour or any other signs of damages when performing their ordinary control, has a greater meaning for economy, health and strategic decision-making created an acceptance and even enthusiasm among the operating personnel.

Recording the findings in a database to make them easily accessible for future use is another task that has been seen as unnecessary and complicated. The staff have hand held computers for this, but they have not been using them, rather sticking to the pen and paper. During the discussions this issue was lifted from time to time, and some acceptance was gained.

Do not start from a very ambitious level

A general conclusion from this is that the QA system should have a limited scope to start with and then be extended bit by bit, rather than starting from a very ambitious level, in order to come into full practice.

Lack of training for all actors

The local manager from Skanska means that the requirements for indoor environment could have been more integrated in the design phase. This was not clear from Alingsåshems' side. Skanska have had a strong focus on the energy targets. Proportionately, quite short time was spent on the energy and passive house issues during design.

The local manager at Skanska means that the sub contractors have no routines for setting up quality control plans. They have minor understanding for delimitation to other sub contractors. The sub contractors often lack understanding about the importance of quality assurance in general. It's essential that they understand the importance of quality in the design. They should also, for the benefit of the entire renovation project, start to put their work in a larger perspective than what they do today.

One reason for these barriers could be a lack of skilled project leaders. One part of the solution could be dedicated trainings and accreditations for building passive houses: One for project leaders, one for carpenters and one for HVAC designers.

Lack of continuity of the building developer

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.

Difficult with new technical solutions

One identified difficulty is the selection of the right technical solution (especially within the HVAC –systems). It was a very intensive process to find an appropriate solution. The difficulty is the innovative component – there are few experiences with new concepts. So first it is hard to convince a builder, a stakeholder and tenants to trust in new technologies. Even the best QA system can not prevent from a long and difficult commissioning phase – but we need ambitious builders and tenants daring to go new ways.

8.3 Lessons learnt

Select the most suitable documents for each phase

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.
- 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.

Easier to understand if the QA activities are shown in practice

The SQUARE activities in the Swedish pilot project involved practical QA activities such as measurements, investigations, inquiries etc. as well as "desktop work" more directly related to the QA system implementation. Examples of performed practical activities are:

- measurements of moisture content in existing structures
- measurements of air tightness and thermal comfort measurements after renovation
- questionnaires to tenants

The QA in the construction process is considered to be well managed in this project, mainly as a result of Alingsåshem's procedures for choosing their contractors. Therefore, the focus of the implementation has been on the preparatory and operational phases. More specifically it has been focusing on:

- Assessment of the existing system, taking into account the previous experiences of Alingsåshem. This is done in order to improve the usefulness and applicability of existing as well as new (SQUARE QA) procedures. This way the feed back to the SQUARE project will also be enhanced, as long term experience from the application of our QA system is very limited until date.
- Definition and integration of relevant requirements on indoor environment and energy use in the system.
- Integration of procedures and templates for the TPI and FEA.
- Review of procedures and templates for the building management phase, in particular with respect to follow up on energy use.
- Review of the "capacity building potential" of the QA system i.e. the systems' ability to bring on the experiences from one renovation project to the next one.

Do not keep QA routines in one or two key persons' minds

Many times during the work with the QA system this conflict between the practical work and the need of gathering comprehensive data has been evident. To convince the staff why they should go through all that work to register what they already know on a personal level, is a long term process which we were not able to conclude during the project, but the attitude has slowly changed. '

The lesson learned is that each work task has to be meaningful, and the context understood, not by some people administering the QA-system, but by all. You must also understand that you are a part of an organization, that will move on without you, and that it is the organization that needs the knowledge on what work has been done, and what should be done next period of time. It is not good enough that this knowledge is kept in the minds of one or two key persons in the organization.

Read more…
…..in the report *National pilot project reports*, available at www.iee-square.eu.

9 Dissemination activities

A project designed to introduce techniques to enhance and improve efficient use and energy and good indoor environment and improve is not successful until the results is disseminated and used by many people and thus affect the way stakeholders work. Only then will we see the effect of reduced energy use and improved indoor environment.

9.1 Workshops together with the TRECO group

The work in SQUARE has continously been presented and discussed with people from TRECO network. TRECO is a network of European social housing organisations exchanging the implementation of building sustainability in practice by following pilot demonstration projects and discussing selected issues and themes. The purpose of the joint workshops is to discuss methods and exchange experience from introduction of the QA system for energy use and improved indoor environment, as well as methods to communicate and disseminate result from this work. The workshops provided an opportunity for partners with technical background and partners with practical experience from pilot projects and associated partners (TRECO) from social housing companies, to meet in creative discussions and exchange experience.

Figure 60 The SQUARE and the TRECO group.

The SQUARE Treco meetings have been arranged with:

- A common discussion workshop
- A common project site visit

The topics for the workshops were:

- Workshop 1 - Alingsås local workshop in Alingsås - introduction to SQUARE and passive house
- Workshop 2 - Amsterdam - introduction to SQUARE and TRECO
- Workshop 3 - Oulu - What are the needs for quality management systems, outline SQUARE system
- Workshop 4 – Gleisdorf - Ins and outs of SQUARE system - feedback from Treco partners
- Workshop 5 – Barcelona - Experiences with SQUARE-system
- Workshop 6 – Sofia - Implementation routes for SQUARE-system

Figure 61 Site visit in Graz. (Source: SP)

Figure 57 Site visit to Bijlmer area, the largest renovation in The Netherlands. (Source: SP)

9.2 National workshops

National workshops have been arranged in each country. The aim of these workshops was to present the QA system to national/local stakeholders and show examples of implementation of the system in the renovation process. Some of the national workshops were arranged together with other closely allied projects.

9.3 Presentation at seminars and conferences

The QA system and example of implementation in the pilot projects have been presented at a number of national and international workshops, seminars and conferences: ökosan'07 and '09 in Graz and Nordic Passive house conference in Gothenburg and in Aarhus, SHSC - Social Housing Services Corporation, 19 May 2009, Toronto, IBPC, international building physics conference in Istanbul and International Conference SB10mad in Madrid.

9.4 Articles in journals

The QA system and example of implementation in the pilot projects have been presented in a number of articles in popular science articles.


Kvalitetssäkring av innemiljö och energianvändning vid renovering av miljonprogrammets bostäder

Energibesparing i miljonprogrammet

SQUARE Qualitätssicherungssystem für thermische Gebäudesanierung

Wärmeschutz mit Qualität

Figure 63 Examples of popular science articles presenting the QA system developed in Square.

9.5 Newsletter

Four issues of a newsletter have been sent out to 350 subscribers in Europe.

Figure 64 Newsletters has been distributed to 350 subscribers in Europe.

9.6 Website

A website was set up and updated during the time of the project. All public reports, newsletters and presentations produced during the project are available at the website.

Figure 15 An external web site was set up and used to disseminate latest news and useful tool such as reports, information and presentation material.

9.7 Information material

Information material in form of brochures and power point presentations has been developed.

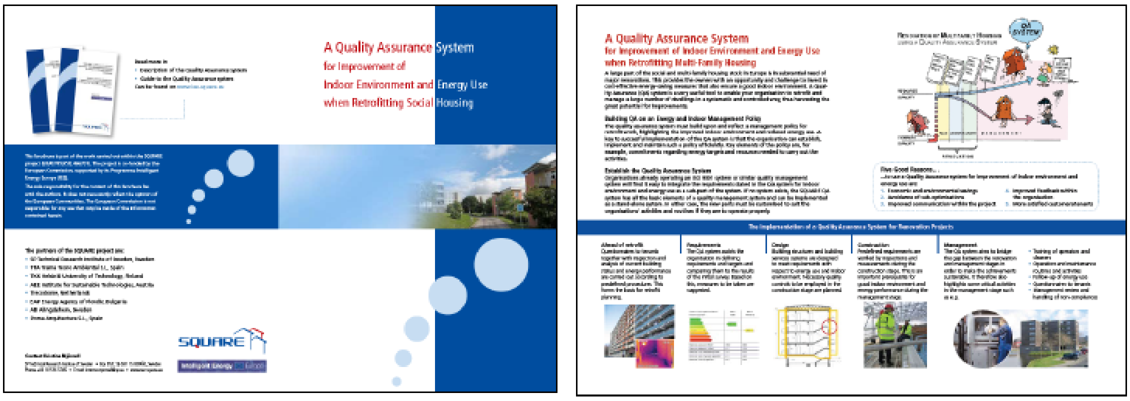

Figure 66 Brochure presenting the basic outlines of the QA system.

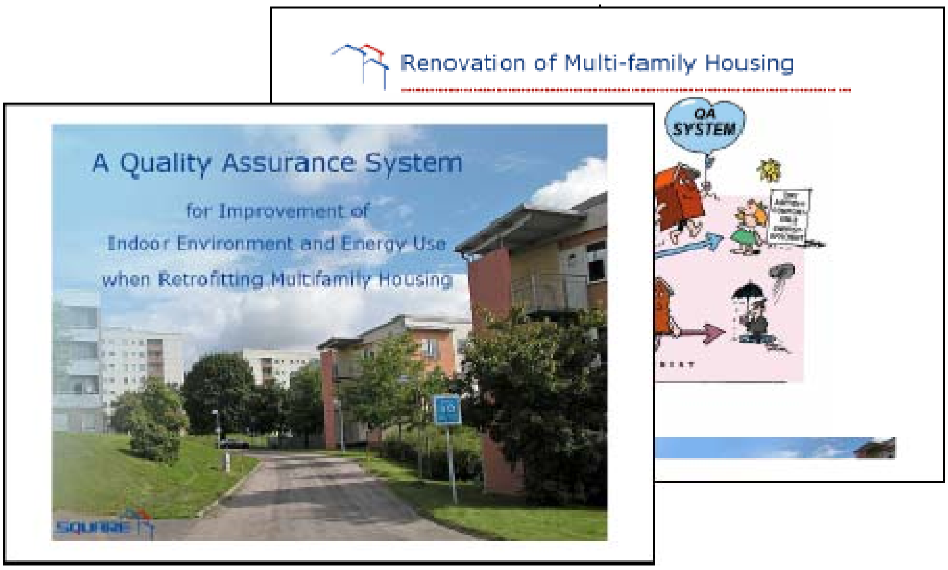

Figure 67 Power point presentation of the QA system.

9.8 SQUARE at TV

The Spanish project was presented at the Spanish TV.

Figure 68 Interview with Jordi Espar from Poma Arqitectura. (Source: Poma Arqitectura)

Figure 69 The Spanish pilot project on TV. (Source: Poma Arqitectura)

9.9 Dissemination of knowledge on a broader front

Training for passive house builders has started in Sweden

So far, new construction as well as renovation aiming at very low energy use.
A training and certification initiative related to energy efficient buildings in general and passive houses in particular was recently launched in Sweden. Three main stakeholder groups are addressed:

- Carpenters
- HVAC installers
- Site managers

The training provides practical knowledge related to the tendering, the design and construction as well as to the liability period. It is addressing experienced builders with an interest in energy efficient buildings trying to achieve higher quality and improved control and security with respect to energy performance and to requirement- and responsibility related issues.

> **Read more…**
> **…..in the presentations from national pilot projects, available at www.iee-square.eu.**

10 Summary

A quality assurance system for improved indoor environment and reduced energy use has been adapted to the renovation process with special focus on multifamily housing. Practical guidelines have been developed to support the owners and managers implementing the QA system in their renovation projects.

10.1 Summary

The aim with this project is to assure energy efficient retrofitting of multifamily housing with good indoor environment, in a systematic and controlled way. To achieve this, a quality assurance (QA) system for retrofitting and maintenance has been adopted to conditions in several European countries and implemented in four pilot projects in Austria, Spain, Sweden and Finland. The QA system supports decision-making and ensures that the most suitable energy efficient retrofitting measures are chosen for each case. The QA system has be spread in several European countries by the use in pilot projects and in other renovation projects. The experiences from have been used to improve the QA system. The pilot projects act as good examples to inspire and encourage other multifamily housing owners and housing associations to carry through energy efficient retrofitting projects. The main conclusions from the project are that every organisation must find its own way to implement an effective QA system. It is better to start out with a modest ambition and increase it later than vice versa. If the organisation has an existing management system such as ISO 9001 or similar in place, the best thing is to integrate the new indoor environment and energy use aspects in the existing system and not create parallel QA systems. Quality assurance is definitely an essential tool in the common efforts for improving the energy efficiency in the European building stock and this seems to be acknowledged by most parties, but as already mentioned the full practical implementation of a QA system is often difficult. Routines are carried out but documented feedback to the system, essential for the further improvement of the processes, is often missing. Far reaching improvements in the energy efficiency during renovation most often requires thorough actions on the building envelope. But due to the high costs, this is not done unless the outer facade is damaged and need to be replaced. Effectively, this means the many large renovation projects will only reach part of the way in improving the energy efficiency, compared to the potential. Therefore good examples are needed to encourage other buildings owners to do energy effective retrofitting resulting in low energy use and good indoor environment. A number of dissemination activities have been carried out in the project in order to spread knowledge and experience to owners, contractors, consultants, national authorities, municipalities, tenants etc. on local, national and international level.

References

External references

[1] SPCR 114 Certifieringsregler för P-märkning avseende innemiljö, SP Technical Research Institute of Sweden. In Swedish.

[2] Wahlström Å., Ekstrand-Tobin A., 2005, Quality assurance of indoor environment and energy use. Proceeding of the 7th Symposium on Building Physics in the Nordic Countries, page 1041- 1048, Reykjavik, June 13-15.

[3] SPCR 114E, 2007, Certification rules for P-marking of the indoor environment and energy use, SP Technical Research Institute of Sweden.

[4] Swedish Standard SS 62 77 50, Energy management system –specification, SIS Swedish Standards Institute, 2003.

[5] ISO 14 001 Standard for Environmental management system.

[6] EN 16001 Energy management standard

[7] IEA ECBCS Annex 40 "Commissioning of Building HVAC Systems for Improving Energy Performance".

Reports produced within the Square project

- Overview on existing QA systems for energy efficient renovation with improved environment. (in English)
- Overview of potentials and estimated costs for energy savings in retrofitting of social housing. (in English)
- Methods to break non technical barriers in the energy saving retrofitting process. (In English)
- Quality Assurance System for Improvement of Indoor Environment and Energy Use when Retrofitting Social Housing. Annex 1 adapted to specific conditions in different countries. (In English, Swedish, Austrian (German), Spanish, Finish, Bulgarian).
- A Guide to Quality Assurance for Improvement of Indoor Environment and Energy Performance when retrofitting Multifamily Houses. (In English).
- Energy Improvement Measures and their effect on Indoor Environment. (In English, Swedish, German, Finish, Bulgarian and Spanish).
- Report on the results and experiences from national pilot projects. (In English, Swedish, German, Finish and Spanish).
- Summary report on all pilot projects showing good examples for other countries. (In English, Swedish, Spanish, Finish, German).
- Information material (slide show and brochure) from the pilot projects.

- Handouts from workshops in Alingsås in November 2008, in Amsterdam in March 2008, in Oulu in September 2008 and in Graz in March 2009, in Barcelona in September 2009 and in Sofia in March, 2010.
- Information material about the QA system. (One slide show and one brochure). (In English, Swedish, Spanish, Finish, German).
- Project website www.iee-square.eu.
- Project fact sheet.
- Project presentation (slide show) was.

Useful links

- For ventilation technologies and products the major organisation is Eurovent: www.eurovent-association.eu/web/eurovent/web/index.asp
- For solar heating and cooling technologies and products the major organisation is the European Solar Thermal Industry Federation, ESTIF: www.estif.org
- For solar heating and cooling technologies and products the major organisation is the European Solar Thermal Industry Federation, ESTIF: www.estif.org
- For Solar PV in Europe, it's the European Photovoltaic Industry Association, EPIA: www.epia.org
- The major information resource in Europe on heat pump technologies is the IEA related Heat Pump Centre: www.heatpumpcentre.org
- The European insulation manufacturers association, EURIMA: www.eurima.org
- Scandinavian initiative on Energy and Quality rated windows, the so called "EQ Window": www.energifonster.nu
- ByggaF method for moisture safety in the building process. It includes checklists and procedures for appropriate design, and can be downloaded cost-free from: www.fuktcentrum.se
- Cost-free web-based resource for developers, helping them to formulate their requirements in terms of energy use and indoor environment conditions: www.energilotsen.nu

The SQUARE consortium consists of organisations from six European countries:

AUSTRIA
AEE Institute for Sustainable Technologies

BULGARIA
EAP Energy Agency of Plovdiv

FINLAND
TKK Helsinki University of Technology

NETHERLANDS
Trecodome

SPAIN
TTA Trama Tecno Ambiental S.L

Poma Arquitectura S.L.

SWEDEN
SP Technical research institute of Sweden

AB Alingsåshem

SQUARE - A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings
Coordinated by
SP Technical Research Institute of Sweden
Box 857, SE-501 15 BORÅS, Sweden
www.iee-square.eu