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

WP6 -National Pilot Project Sweden

Final report

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SQUARE

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

Final report from the Swedish pilot project Brogården

Internal report

Work Package 6. Application of the QA system in pilot projects

Deliverable D6:1. Report on the results and experiences from pilot project

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Preface

This internal 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

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Summary

The QA system for efficient energy use and improved indoor environment is applied in national pilot projects involving retrofitting and renovation of social housing or multifamily houses.

The Swedish pilot project was selected because it represents typical multifamily housing structures in Sweden and because the housing organization Alingsåshem had far reaching ambitions for this large renovation project. The building stock of 3-4 storey multifamily houses built in suburban areas or small-towns in the period 1961 to 1975 amounts to almost one million apartments. Feasible concepts for renovation have a great potential for multiplication which has already been demonstrated within the pilot project.

The Swedish pilot project comprises the retrofitting of 50 out of the 300 multifamily apartments in Brogården, Alingsås. SP has been acting as a technical partner to Alingsåshem during the planning and construction work. The report describes the organisation of the renovation project, its contents and target values and how the SQUARE QA system has been introduced and implemented in the housing organization.

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. The main contractor Skanska has worked a lot to build a team and the project has been managed through a partnering agreement between them and Alingsåshem. This led to a good platform to build on in the work that followed the first phase where one building containing 16 apartments was renovated. 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.

A general conclusion from the work 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. Another experience was that the organizations' policies and targets for increased energy efficiency needed to be more directly formulated and better integrated in the organization if the goal of a 50% reduced energy use by 2050 shall be reached.

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1 Introduction

1.1 Objectives and target buildings

The Swedish "million homes program" consists of approximately 600 000 dwellings in multifamily houses, built in the sixties and seventies. Out of the total number of apartments in multifamily houses, public residential buildings account for around 60 %. The majority of existing residential buildings are thus managed under lease schemes (by housing associations or similar organisations), but privately owned flats and houses are becoming more and more common.

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

The pilot project consists of 16 three storey buildings including 300 flats, located in the vicinity of the city of Alingsås. The main characteristics of the target buildings were:

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

The Swedish pilot project Brogården is a social housing area consisting of 299 apartments of the similar type of construction built between 1971 and 1973, Figure 2. The buildings have problems with frost damages brick facades, draughty apartments, thermal bridges, damaged balcony slabs and moisture damaged concrete ground slabs. The municipal housing association, AB Alingsåshem intends to retrofit the buildings to passive house standard. This will be achieved by supplementary insulation of the building envelope, additional air-tightening the building envelope, changing to super-insulated windows and installing high efficient air-to-air heat recovery. The project is carried out in partner contracting between Alingsåshem (owner), Skanska Housing (contractor), Alingsås Rör (piping), Elteknik (electricity), Bravida (ventilation), Skanska Mark (landscaping) and Sandå måleri (painting) and will go on for five years.

Figure 1 The Swedish pilot project Brogården before renovation.

1.2 Scope and limits

The renovation of the selected building included the following aspects:

- Structural: floors, roof, internal divisions
- Building shell: insulation, air tightness, windows, new façade material
- Sound proofing (increasingly important as the building shell becomes air tight and heavily insulated)
- Services: all building services with a particular focus on ventilation heat recovery
- Accessibility for disabled residents and visitors

The target requirements for energy use after renovation are very demanding, in level with a voluntary standard for passive houses recently developed in Sweden. The indoor environment requirements are equally demanding, in accordance with the example in Appendix 1a of SQUARE's quality assurance system.

Due to the fact that the renovation of Brogården will continue stepwise until 2011 and involves a great deal of learning for all involved parties, there is no definite timeline for the whole project. However, the SQUARE project will follow initial investigations, planning and design, construction, delivery and operation in the first two stages of the renovation project, incorporating some 30 dwellings.

The scope of the Brogården project was:

- Retrofit into passive house standard and increasing the share of renewable energy
- Improved air quality, thermal comfort and moisture control
- Improved accessibility for elderly and disabled

- Increased heterogeneity in apartment size and better accessibility for families
- Individual control of energy use and indoor climate
- Easy to operate techniques
- Preserved social networks among tenants
- Long term stable rent levels
- Conscious choice of materials and components
- User involvement in the renovation process
- Stepwise renovation program and a long term partnering contract with common targets and open cost accounting. This made it possible to use experience for continuous improvement of the building process, including reduced costs.

Limitations of the project were:

- 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.

2 Background

2.1 Swedish old multifamily buildings in general

During the period of the "million homes program", 1005 614 apartments and single family houses were built in Sweden. Today, about one sixth of the Swedish population live in multifamily houses built in the period 1961 to 1975. In the 1970s, Sweden enters an economic recession and the demand for new apartments was decreasing. The immigration and moving into towns were also decreasing. All of a sudden, there were empty apartments and the construction of multifamily housing decreased dramatically.

The most common types of buildings were the *slab blocks* with three or four floors. Houses with up to three floors did not require lift. The slab blocks were placed in groups around pedestrian precinct yards or in parallel grouping. The slab blocks were usually built of in situ concrete as gables and interior sheer walls and light curtain walls. The ground is a slab on ground without insulation. Some of the slab block had fill in walls of prefabricated facade units of wood, which made the production fast and rational.

2.2 The location

In the first step eighteen apartments in building D are retrofitted. Experience from this part will be continuously transferred to the process of retrofitting the remaining 282 apartments. The second phase was building E and F. The whole project is expected to be finalized in 2012 whereas the first part will be ready in early 2009.

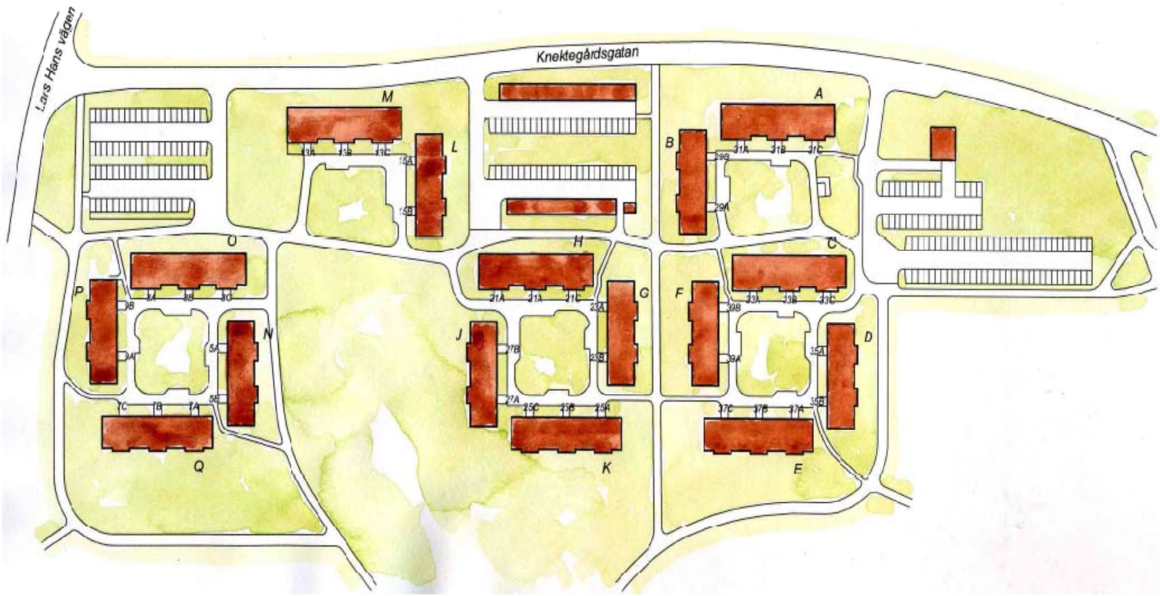

Figure 2 Plan over the Brogården. Phase 1: House D, phase 2: House E, F, phase 3: House A, B and C

2.3 Building structure

The pilot project is a renovation of an entire multifamily housing complex, incorporating 299 apartments. The main contractor is the Swedish/ multinational construction company Skanska and there are eight sub contractors working on design and construction in different sub works.

The project started in 2006. The first stage (16 flats) began with demolishing works in early 2008 and the renovation was finalized February 2009.

Table 1 Initial state at Brogården

Pilot Project Building Blocks	**Initial state**
Address	Brogården, Alingsås
Number of apartments	299
Year of construction	1971-73
Materials	Concrete frame, infill walls facing balconies, brick facade, concrete floor structure, concrete loft ceiling beams, rafter with strut of wood and tar paper on top
General systems	District heating (incl. domestic hot water), electricity, water and sewer
Ownership	Public housing company (SQUARE partner Alingsåshem)

For further details about the buildings, see Appendix A.

3 QA System management

3.1 The housing association Alingsåshem AB

Alingsåshem is owned by the municipality of Alingsås, as a part of the group AB Alingsås Rådhus, where the local energy company Alingsås Energi and the managers of public institutions as schools and health care clinics are also included. In the directives from the owner it is stated that the three stakeholders must cooperate for the benefit of all. This means that strategies and actions taken in one of the organizations affects the others, and that the changing needs due to the development of Alingsåshem's building stock must be met by Alingsås Energi. The board of Alingsåshem is selected by the local government and the directives and policies are given as a result of a political process.

The directives from the owner state that Alingsåshem must

- Provide an attractive, safe and pleasant environment for the tenants
- Provide a wide and attractive range of dwellings
- Provide accessibility for all and contribute to integration of different groups in society
- Be active in development of energy efficient solutions for housing.
- Be active in the realization of the local governments' vision for Alingsås.

In practice this means that Alingsåshem for instance has a policy to always try the passive house solution for each new development or larger renovation, and that partnering with contractors and planners is chosen as a method to ensure efficient cooperation between stakeholders. See chapter 6 for more details about directive and policies.

The company has 32 employees, who administer 3400 apartments. The annual turnover is approximately 19 million Euros, and the level of new developments is about 50 new apartments per annum.

Partnering is an important strategy for Alingsåshems development. Long term contracts with open books and continuous evaluation and improvements, not just between projects, but in ongoing work ensure knowledge and control during the process, and lead to better understanding of the buildings during operational phase. In Brogården there is a partner group consisting of all contractors and most of the planners involved, and experiences are being noted and registered on recurrent meetings, and are used in planning the following steps of the renovation.

One of the core values of Alingsåshem is the importance of personal meetings with the tenants, and they and their organizations have been involved in the project since the first sketches. Monthly open meetings have been held to collect opinions and demands and to avoid misunderstandings. There are several positive outcomes from this work, from planning of the work site itself, to strategies for rent levels and disposition of tenants within the area to maintain social relations and networks.

In future projects, the housing association Alingsåshem AB intends to work according to a planning model which, to a greater extent than today, addresses the needs of the tenants. By working from a tenants' perspective, the tree dimensions of sustainable living (economical, ecological and social) can be integrated. The model will help to move focus from the building and apartment itself (in a production perspective) to the experience of living in the apartment (tenant perspective), and the context in which people spend their lives. Good apartments/housing is not a guarantee for good living.

The proposed planning model emerges from a multicultural and global thinking. The process starts with mapping out the different needs of the tenants. One example to create a common picture of the tenants' needs in the residential area is to use a tool to categorize them into different residential typologies. The other is to describe a number of sustainable residential areas to present concrete solutions on how to integrate the three dimensions, the economical, the ecological and the social perspective.

The planning model will bring about a "common language" understandable for all actors involved; those who live in the residential area, work with overall city planning, municipalities, authorities, architects, design engineers, consultants, contractors and operators.

3.2 Existing policy and QA system of the housing association

Alingsåshem already had a QA system consisting of instructions and checklists for different activities. The principal achievement of the SQUARE project has been to integrate the SQUARE QA system for energy efficiency and indoor environment in the existing framework. Checklists that are recurrently used when tenants are moving out, at annual inventories etc has been changed to also address issues relevant to indoor environment and energy use, and to make the data collected available for analysis.

The document that defines the criteria for new developments and renovation projects, "The Building Manual", has been updated to address energy and indoor environment in a more thorough way, and new documents and routines have been added to the process web, which is the basis of process control in Alingsåshem. The work is ongoing and the result so far is:

- A guide to support the organization in all stages of the renovation process
- Changes and added information in existing documents and databases
- New documents on indoor climate and energy, and the early stages of renovation
- A template for compilation of existing data, generating a checklist of found deficiencies
- A template for distinct energy targets for each project

- Proposal of new and more distinct policies on energy and indoor climate.
- Updated managing documents

The objective of the implementation work has been to update the existing QA to support a more efficient work on indoor climate and energy performance. These areas are traditionally not followed up to the same extent as other properties of the buildings, but are of great importance for the wellbeing and economy of the inhabitants, as to the image and environmental impact of the company and its activities. This update will give at better overview and control from the earliest stages, and simplify decision making and planning.

The operation policy of Alingsåshem states that their clients' varying needs of housing, to be experienced as attractive, safe and pleasant, is in the focus of the organisations' activities. They are also striving to contribute to a sustainable society. This is manifested by:

- Getting to know present and future clients through personal meetings
- Assuring the quality of all activities by adequate knowledge, experience and suitability
- Economizing resources and giving the customer the opportunity to take own responsibility for the use of resources
- Working with continual improvements and having a positive approach to development in order to meet the customers' needs etc.

In the owners directive for Alingsåshem it is stated that the organization shall apply a holistic approach to quality, work environment, global environment and economy. Alingsåshem has three certifications in operation since several years, namely an ISO 9001 certification (Financial management) an ISO 14001 certification (Environment) and an AFS 2001 certification (work environment).

The housing association Alingsåshem AB has been operating for more than 30 years and administrative routines are continuously being further developed. The documentation and process control of Alingsåshem is divided in several non compatible IT-systems. These systems are well functioning in themselves, and have been considered sufficient for the management. The division into different systems is not a problem in the daily work, since each function knows where to find the data needed for their tasks. The staff are used to these systems, and a lot of effort has been put in to them, which is the reason we chose to add to them rather than building an altogether new system, in spite of the obvious difficulties.

In brief, the organisation is operating the following IT-based systems in their work:

1. Process web: Governing documents including check lists, building manual, routines etc.
2. Project web (Windows Sharepoint): All documents related to an ongoing renovation project

3. Redok: Conventional tree-structure located on own server where all records are filed e.g. results from inspections, filled in check lists etc.
4. FINCE: Archive for drawings. This is where the drawings from e.g. Brogårdens' project web will end up once the renovation project is ready.
5. ESS-200 (Vitec) Stand alone system for collection and compilation of energy statistcs from Alingsåshems buildings
6. Fast-2. Registration of complaints, service reports, apartment maintenance operations, contracts etc.

This situation is not very well suited to support the SQUARE QA approach, promoting a "one package solution". The whole chain from the first idea on a renovation project to the long term engagement from tenants and a thorough follow up- and maintenance work from the housing owner should thus ideally be covered by one well integrated tool. Splitting the administrative resources on six different IT-platforms that in principle do not communicate with each other is not in line with this idea.

One conclusion from our work is that this situation is familiar to most organizations and a major challenge for reaching an efficient QA system is therefore to achieve a well integrated IT-platform that can handle "the whole package". (A basic assumption is that an extensive IT-support is a prerequisite for making this kind of QA system work in a modern housing organisation aiming for highly energy efficient buildings with a good indoor environment.)

A general concept in the building business that promotes this kind of thinking is referred to as BIM or Building information modeling. BIM is defined as "covering geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components (for example manufacturers' details). BIM can be used to demonstrate the entire building life cycle, including the processes of construction and facility operation. Quantities and shared properties of materials can be extracted easily. Scopes of work can be isolated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities."

Main challenges *for the SQUARE project* in the implementation of the QA system at Alingsåshem has been e.g.:

- To get a good overview of the different administrative systems
- To identify essential routines from the SQUARE QA system that are already in efficient use in the organization
- To suggest complementary routines to be integrated in the existing system and
- To suggest modifications to some ineffective existing routines in order to make the whole system better aligned to the overall SQUARE QA approach

A “building manual” containing overall requirements for design, construction and management is part of Alingsåshem’s process web and this document has been the focus for the SQUARE QA system implementation.

3.3 Organization chart of the housing association

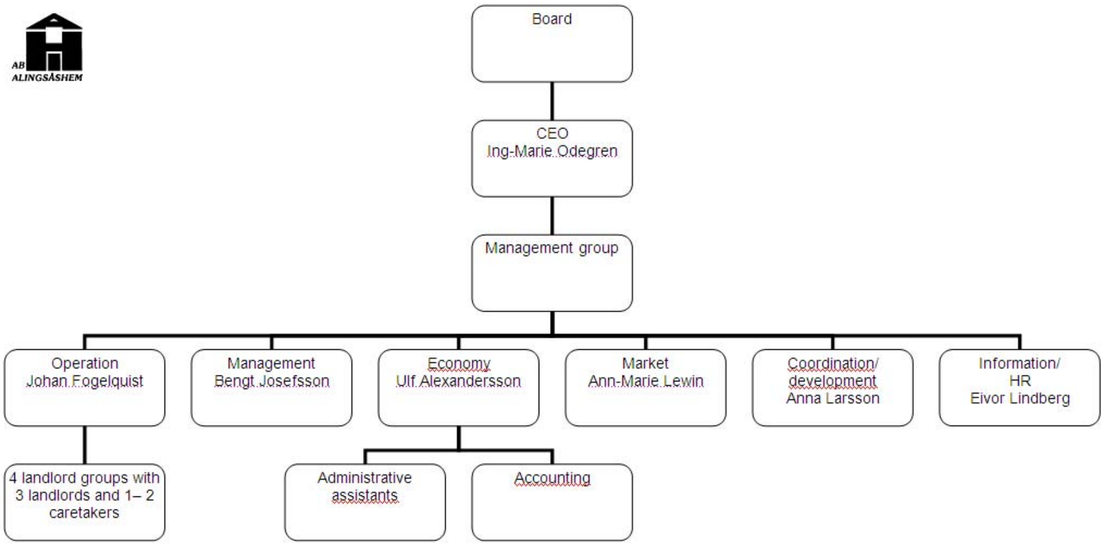

Figure 3 Organizational structure of the housing organization Alingsåshem

The board consists of local politicians. Board meetings are held six times per year. The Management group of Alingsåshem consists of the CEO and heads of economy, operation, management, information, staff administration and coordinator. Administration staff takes care of market, letting, billing, economy, information and coordination. The concierge teams are responsible for one housing area each. Complaints, service and cleaning are their main tasks.

Figure 4 Process structure as shown in the existing QA system of Alingsåshem

3.4 Project organization

3.4.1 Stakeholder groups

SP coordinates the SQUARE QA system implementation at Brogården and focuses on Alingsåshem's work with QA and on amendments of its existing QA system. Other stakeholders mentioned below are mainly addressed in joint efforts with Alingsåshem. The status of the main participating groups, organisations and companies with respect to QA are the following:

- The tenants are the main target group of all QA efforts of Alingsåshem. Therefore, they are involved in the renovation process and in the management of the buildings in a number of different ways.
- Alingsåshem as a housing association are quite experienced with building renovation and management and they have their own QA system for operation since more than five years. At present, the framework of their QA system is being transferred to a new IT platform.
- The main contractor Skanska is a very large construction company with long experience from building construction and renovation. Their team at Brogården is very dedicated and interested in solving upcoming challenges related to the extraordinary requirements. They have their own QA system and own experts to consult e.g. in moisture and air tightness related issues.
- Another important stakeholder group is the subcontractors. Alingsåshem have signed a "partnering agreement" with Skanska and the four major subcontractors in an effort to further improve the quality of the renovation project

Table 2 The housing organization and its consultants and contractors

Stakeholder organization	Stakeholder name
Housing association (owner)	AB Alingsåshem
Architect	Efem arkitekter (Phase 1&2), Creacon (Remaining phases)
Construction design engineer	WSP
HVAC design engineer	Andersson & Hultmark
Partner contractor	Skanska Hus
Landscape architect	Skanska Mark
Sub contractor HVAC	Bravida and Alingsås rör
Electricity design engineer	Picon
Sub contractor Electricity	Elteknik
Sub contractor Landscaping	Skanska Mark
Sub contractor Painter	Sandå

3.4.2 Cooperative partners for the QA system implementation

The main contractor Skanska had a well functioning QA system in use since the start of the project. Furthermore, Alingsåshem has relied on Skanska's own routines for quality control trough the partnering contract (which was already made up when the SQUARE project started). This situation was basically very favorable for Alingsåshem, who was "in good hands" with Skanska as their main contractor. For the SQUARE project however, this meant that the options for working actively in the design and construction stages of the project was rather limited compared to what it would have been with a less tight project team and divided contracting with Alingsåshem as the sovereign leader of the project.

3.4.3 Tendering process

In the tendering procedure, interviews were held with all contractors and sub contractors involved in the building process to inquire them about engagement, values, quality conscious etc. A main contractor and subcontractors were selected and engaged in long term partnering contract with common targets and an open cost accounting. Before starting the renovation, the consortium held an information meeting and education for all parties involved, to give information of the background and development of the project as well as to get a common educational level, foundation of values and common targets. The intention is to get an open climate that will encourage questions, suggest improvements and personal responsibility.

The procurement of the main contractor Skanska was evaluated based on 20% cost, 80% quality and organization i.e. no technical requirements were used at this stage.

Skanska and Alingsåshem now have a long time partnering contract with common targets and open cost accounting.

4 Methods and accomplishment

4.1 General QA strategy

As the renovation project owner, Alingsåshem, was already operating a quality management system, several of the procedures and routines described in the SQUARE QA system were in use before the SQUARE project and thus applied as the renovation project was initiated. SQUARE inputs therefore focused on an assessment of the existing system and on the integration of a number of additional documents considered to be particularly relevant with respect to efficient use of energy and good indoor environment. These new documents were mainly taken from the SQUARE QA system and tailored in order to harmonise with the needs of Alingsåshem. The strategy is further described in the following.

The overall goal of the activity was fourfold:

1. To closely follow the main steps of the renovation process and on to building management in order to assure that requirements on indoor environment and energy use are fulfilled

2. To take active part in the development of Alingsåshems' existing QA system, thus improving its usefulness as a tool in the everyday work and for capacity building of the organisation

3. To have the essential SQUARE QA system procedures for assuring good indoor environment and efficient use of energy effectively integrated in Alingsåshems' existing QA system

4. To bring back generally applicable experiences from Brogården to the SQUARE QA system

Since the renovation of the first phase of the project began some months before the SQUARE work package 6 started, the pilot project at that time was ahead of schedule with respect to the implementation of the SQUARE QA system. The procurement documents for the first stage included the requirements for P-marking of indoor environment, which are the basis for the requirements in Appendix A. When the second phase started in autumn 2008, the SQUARE QA system was in place from the start.

The Appendix A requirements on indoor environment are thus intended to function as a governing document for the renovation process. With respect to requirements on energy use, a newly developed voluntary standard for passive houses is applied and has been integrated in Alingsåshems' QA system as part of the SQUARE activities.

When a project is initiated it should be assessed in terms of extent, economy, possible problems to handle etc. A report template used for assessing a project at an early stage of the process is available on the process web. Here the assessor is guided to data stored from the different IT systems supporting him to make a qualified estimation based only on desk work.

In the next step, after a decision is made to carry on with the project, the investigation is complemented with interviews with tenants, technical inventories of the buildings and other investigations not covered by the regular control system. At this stage, a careful specification is made of the requirements concerning for example energy and environmental aspects. This report forms the basis for the design of the renovation.

A template has been developed for how the supporting documents for decision making by the board should be drawn up. This template is based on the SQUARE QA system and the document called ”template for damage survey in multifamily buildings” from Boverkets (The National Board of Housing, Building and Planning) survey of the energy use, technical status and indoor environment of the Swedish building stock, BETSI. The document 5.2.1 ”Surveyable pre-study” in the Process web is under revision. The pre-study also comprise interviews with tenants and the results are incorporated in the report. The result from the pre study should give a good picture of the technical status of the building as well as the indoor environment and also give suggestions on renovation measures for improvements.

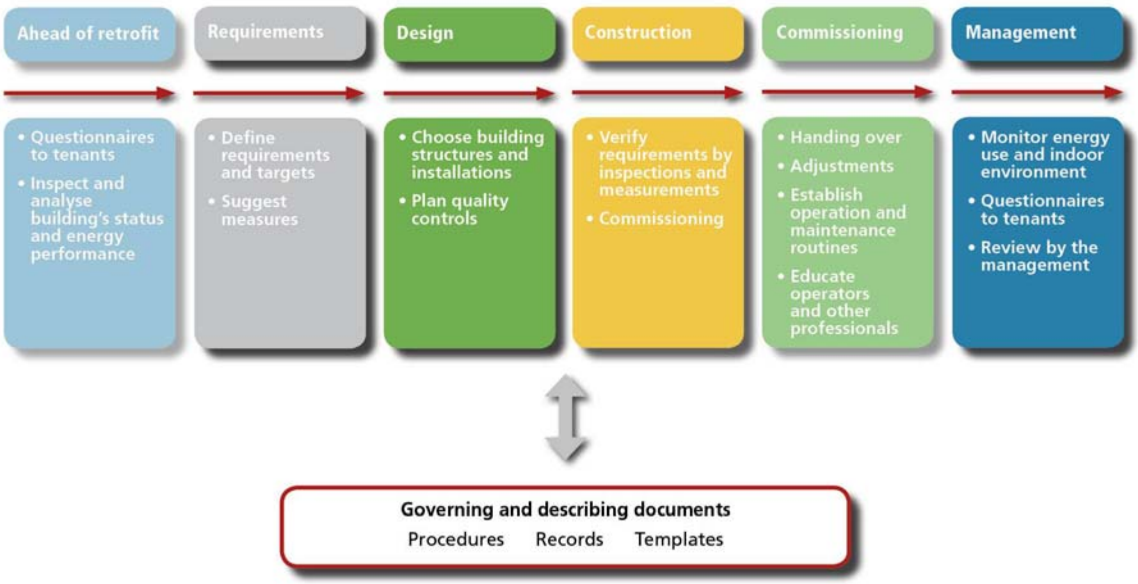

Figure 5 The six stages from initial idea to operation of newly renovated buildings that are covered by the SQUARE QA system

It was suggested to Alingsåshem to develop a simple system of codes for specific complaint and findings in order to simplify future follow up and preparation of pre-renovation studies. The same goes for the suggestion to use the compulsory “moving out inventories” as a resource for the organizations’ long term quality work. Due to time constraints however, it has not been possible to implement these proposals yet even though they were very positively received by the organization management.

4.2 Establishing pre-renovation conditions ahead of retrofit

The first thing to do ahead of a major retrofit is to communicate with the tenants. In phase one and two in Brogården, the tenants' opinion about the indoor environment in their apartments was communicated at tenants' meetings and through complaints from certain tenants. In phase three a questionnaire was sent out to around 60 tenants ahead of retrofit. The result from the questionnaire should be used as input to the design and construction phase and also as a benchmark when the indoor environment is followed up after renovation. No questionnaire was sent out to tenants before renovation of phase one and two but as well after renovation as for following up of the indoor environment. At the same time about 50 questionnaires were sent out to apartments not yet renovated and the results will serve as a bench mark and starting point for further renovation phases. The questionnaire used in Brogården is based on a questionnaires developed by Andersson K. (Andersson K, 1998.) Even though questionnaires to the tenants were not used in the first and second phase, complaints and general feedback from tenants has been recorded in Brogården since several years which provided similar information. The tenants were also involved in the renovation process through other means, e.g. through information meetings, newsletters and information via the local TV network.

The building status in Brogårdens' phase 1 and 2 was determined by means of an investigation similar to the one described in the SQUARE TPI (thorough primary inspection). SP contributed to these investigations by performing air tightness and moisture measurements and by bringing some expertise on these and similar issues into the project.

Several "surprises" occurred during the demolition which resulted in an extended program for the renovation. This was mainly caused by parts of wood and steel buried in the concrete construction thus forming thermal bridges or potential mould hazards. Furthermore uncertainty concerning the moisture barrier and air tightness in existing walls once the demolition had started led to the decision to tear them down as well.

Thanks to the high quality documentation (drawings etc.) describing the existing buildings it was determined at an early stage that reinforcements in the existing concrete floors were highly optimized, making new perforations (for vent ducts) essentially impossible. Without these drawings, this might have come as a very unpleasant surprise.

In order to increase the chances for a successful renovation this kind of surprises could be dealt with in either of two ways:

- A more thorough TPI may have revealed the problems
- More likely, some surprises will always occur during demolition works and therefore, contracts and budgets should take it into account somehow. Otherwise there is an obvious risk that requirements on either energy efficiency or indoor environment will not be met. The following tables summarize the pre-renovation situation and the targets.

Table 3 Initial and target U-values

Envelope	U before retrofit (W/m²°C)	U after retrofit (W/m²°C)
External walls	0,4	0,15
Windows	2,0	0,85
Roof	0,3	0,12
Floor	n.a.	0,25

Table 4 Initial and target energy demand

Utility	Energy demand before retrofit (kWh/ m²)	Energy demand after retrofit (kWh/ m²)
Space heating	115	27
Water heating	42	25
Domestic electricity	39	27
Common appliances electricity	20	13
Total demand	216	92

At an early stage, a first thorough inspection was made to localize shortcomings in the building and problems with the indoor environment. The investigation showed that the apartments were draughty, there were moisture problems in the slab on ground floor, the façade was in very bad condition and the balconies acted as cold bridges.

Figure 6 The brick façade was damaged by frost and had to be torn down.

Figure 7 The ground slab had moisture damages that had to be taken care of.

4.3 Formulation of requirements and targets prior to renovation

4.3.1 Targets for energy efficiency and indoor environment

The municipal housing association, Alingsåshem, have established some very demanding target requirements for energy use after renovation. These are taken from a voluntary standard for passive houses recently developed in Sweden and Brogården is the first major renovation project where they are applied. The indoor environment requirements are equally demanding, in accordance with the example in Appendix 1a of SQUARE's quality assurance system. In both cases (energy and indoor environment) the requirements are, on the whole, more strict than Swedish legally binding requirements and so are the majority of the individual requirements.

Considerations of accessibility – i.e. designing technical and physical installations with the needs of disabled residents and visitors in mind – have also received high priority in planning the conversion/renovation work however this is not within the scope of the SQUARE project activities.

Due to the very strict requirements and targets, the estimated renovation cost was very high. Alingsåshem and their main contractor therefore also considered a budget for complete demolition and rebuilding before the decision on renovation was taken. This was however even more expensive, so the renovation was decided to be realized.

The basic outline of the QA system was introduced in this project in the planning stage. The housing association decided that the buildings should fulfill the requirements in the Swedish QA system P-marked indoor environment, SPCR 114 including thermal comfort, air quality, moisture control, acoustic environment, air exchange rates, low emission construction materials, surface finish, paints, etc.

The housing association also had the ambition to reduce the energy use by renovating the buildings to passive house standard and increasing share of renewables for example solar thermal.

The target is to keep total energy needs at 92 kWh/m^2. Regarding CO_2 emissions related to energy use, no quantitative requirements have been set but the organisation has a general commitment to reduce these emissions. The energy requirements have been verified by means of building simulations prior to renovation. Provided the energy targets are actually reached, the building will reach the top level Swedish official rating with a good margin. A certificate related to the compulsory energy declaration of buildings will be issued after the renovation is completed.

In order to guarantee a good indoor environment, thermal comfort requirements have been equally verified through building simulations and they will also be verified through detailed measurements as part of the SQUARE activities by the end of the project.

4.3.2 Other requirements

Furthermore, Alingsåshem have set a number of other requirements such as:

- Individual control of energy use and indoor climate
- Easy to operate techniques
- Small maintenance needs through conscious choice of material
- Long-term stable rent levels
- Better accessibility for elderly and disabled people
- Meeting places for tenants

4.4 Implementation and follow up of requirements in the design process

In the design phase, the architect and design engineer started to work out technical solutions for the building that should meet the requirements.

The architect looked for available windows that fulfilled the requirements in terms of U-value, daylight factor, heat transfer, availability of opening window and non opening windows, cleaning, appearance, size, price etc. Different manufactures were evaluated and the most suitable was chosen.

The starting point in the first building was to keep the old wall. Therefore, the size and placing of the windows were kept the same as in the existing building. This was not changed even when the walls were decided to be exchanged to new ones. However, the placing is functional for furnishing of the apartments. To keep the original window appearance could also be favorable from an esthetic and cultural heritage point of view.

However, a few new windows have been put into staircases and entrees for inlet of daylight.

The entrance halls were made wider, lighter and nicer by moving out the door section to the façade. New doors were chosen with a much better U-value than before.

For preserving the cultural heritage value of the buildings, the vertical coloured passages were kept at balcony fronts and window sections. The eaves were extended to keep the same appearance even with a much thicker façade. The roofs were covered with black felt to keep the same appearance. The façade were kept yellow with vertical colored passages of green.

Figure 8 Appearance of the new entrees.

Figure 9 The vertical colored passages were kept at balcony fronts.

The design engineer designed the wall construction since they had the full responsibility (economically as well as guarantee for U-values, moisture safety etc).

The design engineer also did energy balance calculations of the whole building with different measures in order to find optimum combinations of (energy efficient) improvement measures. They did heat balance calculations to find the best solution for insulation foundation. It is almost impossible to avoid heat transfer through the concrete gable foundation beam since it becomes a cold flanged beam transferring heat into the ground. 25 % of the heat losses in the gable apartment occur at the gable foundation beam. The results from the calculations show that at cold outdoor temperatures the floor temperature can be as low as 16°C in the bathroom in the gable apartment.

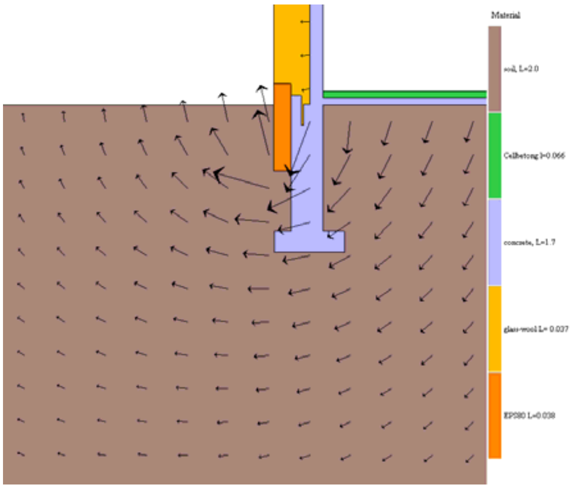

Figure 10 Heat losses through the gable foundation.

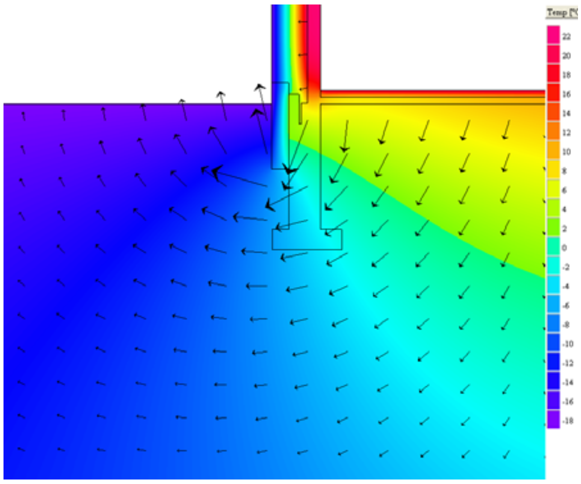

Figure 11 Temperature picture of heat losses.

The design engineer also did moisture calculations of additional insulated roof, walls and slab on ground to check that the critical moisture levels were not exceeded after measures.

The HVAC engineer Andersson & Hultmark, designed the ventilation to fulfill required air flow rates. Architect, design engineers and HVAC engineers worked close together and juggle around optional solution of placing of shafts, ventilation duct and floor-to-ceiling height until the most optimal was found. The result was horizontal ventilation ducts with lowering of the ceiling from 2,50 to 2,10 in bathrooms and hall to have room for intersecting ducts.. This was a critical point of the design.

The architect chose all surface materials. The old parquet had to be removed and replaced by new since the living room was extended with a few square meters from the balcony.

Walls separating apartments were covered with additional insulation and boards to get a better noise insulation. This resulted in new linoleum floors in the bedrooms as well.

The painter chose the type of paint. No checking of emissions from building materials has been done, but no unusual materials have been used.

The suggested measures were:

- New walls instead of additional insulation on existing walls
- Highly improved air tightness of the building envelope
- New windows, new doors
- New heating and ventilation system including efficient heat recovery
- Old balconies are included in the living room space and new are built outside

- Larger bathrooms
- Better accessibility (lifts are installed to reach 60 % of the apartments)
- Individual metering
- New façade material with air gap behind

During the design phase, Alingsåshem and later also the contractor had following up meetings with the designers and also planning of quality controls.

4.5 Training and information

4.5.1 Training and information to contractors

One day, before construction started, was dedicated for energy training for all project participants. There have also been recurrent information meetings every forth Friday at the building site, where for example the SQUARE project has been presented. Other topics have been focusing on tenants, fire protection, ventilation solutions, lean production and planning of land use and landscaping. New training opportunities are planned for phase 3. Building contractor continually supplies information to employees on quality targets.

Figure 12 At the beginning of the project a one day information meeting was held with all participants in order to agree on common goals and working methods.

Figure 13 The partner organization has worked a lot with team building activities.

Figure 14 The project organization has several following up meetings during the building process.

Figure 15 The local manager provides the workers with updated information at the notice board.

4.5.2 Information to tenants

Alingsåshem has been working a lot with information to the tenants, both with the newsletter, Brogårdsbladet and the web site; www.alingsashem.se. There have also been frequent information meetings with tenants. A representative from the tenants has participated in design meetings.

Figure 16 A special newsletter, Brogårds-bladet, was distributed to the tenants.

Figure 17 Meeting with tenants during the building process.

4.5.3 Show case apartment

Before the construction phase started, Alingåshem put in order a show apartment to give the tenants the opportunity to examine the technical systems and practical arrangements in the new apartments. The show apartment has also been used for site visits, for project meetings and meetings with tenants. When the renovation of the first building started, a new show apartment was put in order in the first building and when it was finished the show apartment was put in order in the second renovated building.

Figure 18 In the show apartment the tenants can look at the optional colour schemes and materials to choose from.

Figure 19 The sign explains that this is the supply air duct for pre heated and filtrated, fresh air.

4.6 Implementation and follow up requirements in the construction phase

4.6.1 Job planning

A number of different activities have been carried out in order to increase the quality of the work. One example is job planning before critical elements such as air-tightness and verification with test pressure loading. Skanska has been working with job planning before every critical element. In the beginning of the project the job planning was only verbal but lately they have started to make it in writing and distribute it to all participants involved. This will also help to pass on good experience to the next phase. The new way of working with documented job planning will be evaluated by the organization.

The contractor has also set up an experience bank (in the form of an excel sheet). This bank is used in discussions about good and bad experiences after each work phase.

Another example is that Skanska built up a prototype of the new in-filled wall elements to see that the solutions for air tightness, connections and joints were well thought out and were easy to perform in full scale, see Figure 20.

There has been much focus on the air tightness in the construction process. A concrete example is the information leaflet saying ”Do not cut or destroy the plastic foil. It must be unbroken to enable mounting of windows and the air tight layer“, taped at surfaces around the building site to remind the workers of the importance of the air tight layer, Figure 21.

Figure 20 A prototype of the light in-filled walls was build before building at large scale.

Figure 21 The workers were reminded of the importance of the air tight layer everywhere.

4.6.2 Testing of air tightness

The function requirements have been followed up in the construction phase. For example, Skanska tested the air tightness of every apartment during construction phase. In October 2008, SP made a blower door test according to EN13829:2000 of one apartment (8077) in the first renovated building to verify the measuring method used by Skanska, Figure 23. The apartment was under renovation and the air tight layer was competed but internal surfaces were not yet finished. The measurements were made at 50 Pa negative pressure. The results from the measured air leakage was 12,4 l/s between apartment and outdoor, 12,7 l/s between apartment and staircase and 12,5 l/s between apartment and staircase at 50 Pa positive pressure. The air leakage measured by Skanska was 12,3 l/s so the agreement was good.

Figure 22 An example of an air tight solution of a window opening.

Figure 23 The air tightness of the building envelope was verified using blower door test.

4.6.3 Moisture control

The moisture control is part of the extended self inspection. Some of the routines are described in the following: Receiving inspections are made for all material delivered. Building material is stored at pallets with tarpaulins or in the building beneath weather protection protected from precipitation. In case the material got wet it was torn down. Wood was used only at very few places in the construction. Steel studs were principally used in the in-filled walls. Wood material from the original form work, left in the concrete walls and slab, has been removed to avoid risk of mould growth and rot.

Measurements of moisture content in the tongued and grooved board in the attic were made during the beginning of the users phase to see that the moisture levels were not critical with respect to mould growth. Predicted drying times has been calculated for the topping concrete casted on the slab on ground. A fast drying mortar has been used in the wet areas. A complete wether protection was erected before demolition to protect the whole building from precipitation. All moisture control measures were documented in the day work sheet.

Figure 24 Moisture rounds at the building site.

Figure 25 The contracted used weather protection in order to have a dry building site.

4.7 Commissioning and handing over of the building

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. The contractors thereafter give a guarantee for the building and its functions for five years.

The SQUARE approach is to run the commissioning process during at least one year after delivery of the completed building in order to be able to study the building in operation during all foreseeable conditions. To our opinion the approach used in this project could be questioned from the fact that it will not be possible to access this information without careful follow up on energy use statistics. It will thus be up to the building owner to do this in order to disclose any malfunctions or deficiencies during the warranty period.

Education of cleaners and maintenance staff in Brogården will not be managed differently after the renovation compared to before. There has been introduction to the building technology used and to new equipment e.g. the heat recovery units. The relevant building manual's checklists have also been updated and interior materials have been carefully chosen with respect to low emission considerations, but apart from this no special measures have been taken with respect to the tough requirements on the buildings.

In terms of users' briefings at the time of moving in to the newly renovated apartments, every tenant got 2 hours of carpenter assistance for mounting of shelves etc in order to avoid perforation of the air tight layer. Furthermore, a one hour general introduction to the apartments' installations was given to each tenant at the time of moving in. According to Alingsåshem however, the tenants on this occasion were not really able to digest this info. At the time of SPs follow up interviews with the tenants, several claimed that no such introduction had been given and were uncertain about the operation of the heat recovery units etc. The showcase apartment has been kept open one evening per week also after moving in, in order to give tenants further opportunities for asking questions.

4.8 Performance assessment, monitoring and management

4.8.1 Follow up on indoor environment

When the renovation was finished functional requirements like thermal comfort, ventilation, light, acoustic environment have been verified with measurements. The indoor environment has been checked with questionnaires to tenants and inspection and measurements in a few apartments in the buildings.

The questionnaire was sent out to tenants in renovated apartments in building 35 and 37 as well as in apartments in not yet renovated buildings as a comparison. The tenants were also offered technical measurements in their apartment and also to participate in an interviewed in connection to that. Technical measurements and interviews were made in six apartments. The technical measurements were made to investigate how well the buildings fulfill the technical requirements for a good indoor environment. A number of parameters were measured; air temperature, floor temperature, surface temperatures at outer wall, relative humidity and moisture content, exhaust air flow rate, temperature and velocity of supply air, pressure difference over the building envelope, domestic hot water temperature and moisture indication in wet areas. In two of the apartments, thorough measurements of thermal comfort (operative temperature) were made.

4.8.1.1 Results from questionnaires

The result from the study is not statistically significant since it is only based on 57 questionnaires. Therefore it is important not to over interpret differences between the different buildings. The tenants in building 35 are more dissatisfied than the tenants in building 37 in general. The reason for that could be due to a poorer indoor environment but also due to more sensitive people. It must be taken into account that the results are based on a small number of persons and the fact that two persons living in the same apartment may result in considerable differences. This is why it might be more correct to compare the results from not yet renovated apartment with the results from the renovated apartments in building 35 and 37 together.
The results show that the air quality in general is somewhat better in the renovated apartments.

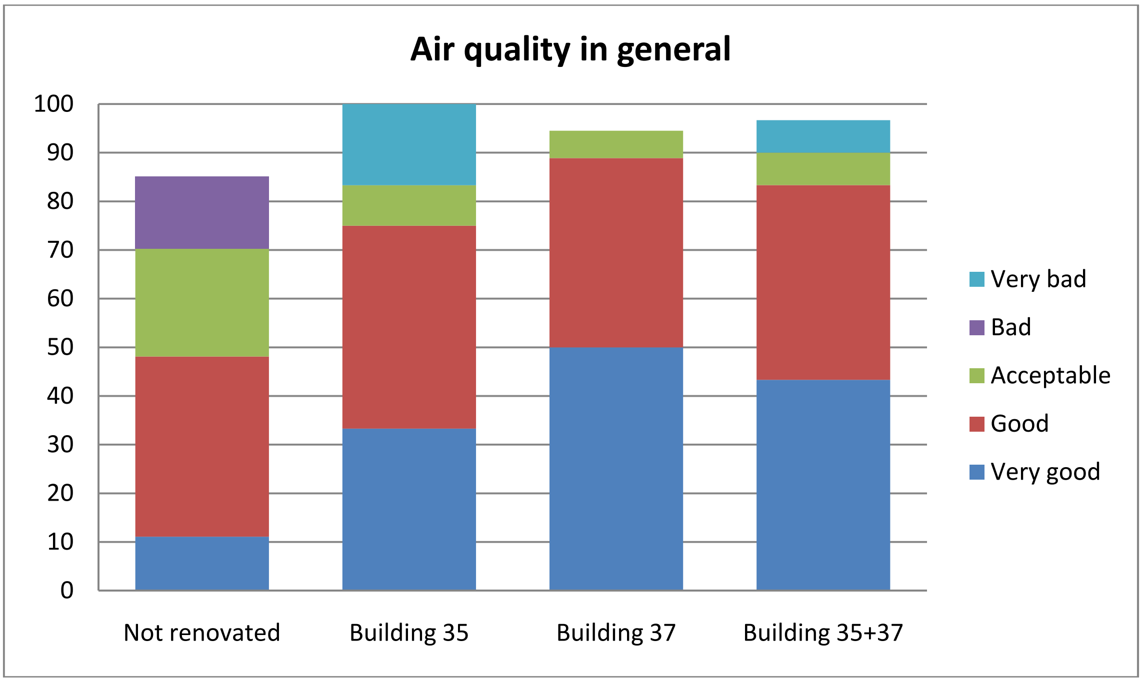

Figure 26 Tenants opinion about the air quality in general.

Above all, there are fewer complaints on spreading of own smell of cooking inside the renovated apartments, which most likely is due to insertion of a kitchen fan. However, in building 37 there are quite many complaints of smell from neighbors' cooking. This may be due to dispersion of smell in the central ventilation aggregates in building 37 whereas building 35 have single ventilation units in each apartment.

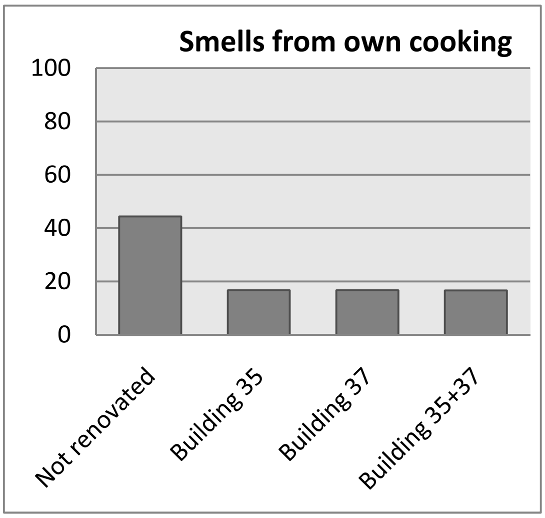

Figure 27 Tenants complaining at smell from own cooking spreading inside their own apartment.

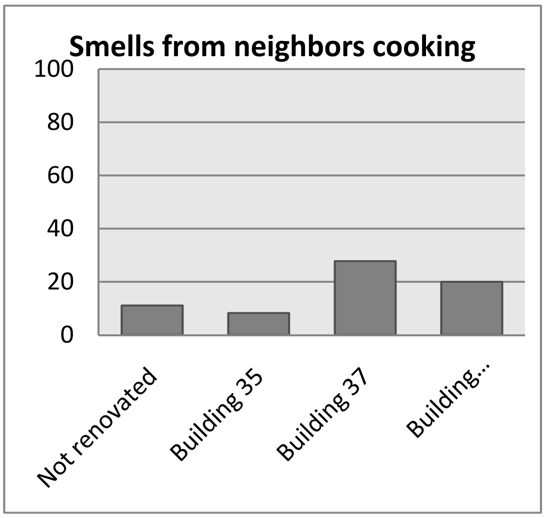

Figure 28 Tenants complaining at smell from neighbors cooking.

Draught is a larger problem in the not yet renovated apartments which is not strange since much effort has been made making the apartments air tight. A tight building envelope also decreases the noise from outside and so do thicker windows. On the other hand the tenants in the renovated buildings have more problems with noise from installations. This is most likely due to the mechanical ventilation but also due to the fact that if they have less noise from outside they experience the noise from installations stronger. The tenants in renovated buildings have had problems with high temperature levels during the summer period. It must however be noted that the tenants in building 37 moved in December and haven't yet stayed in the apartment during the summer period.

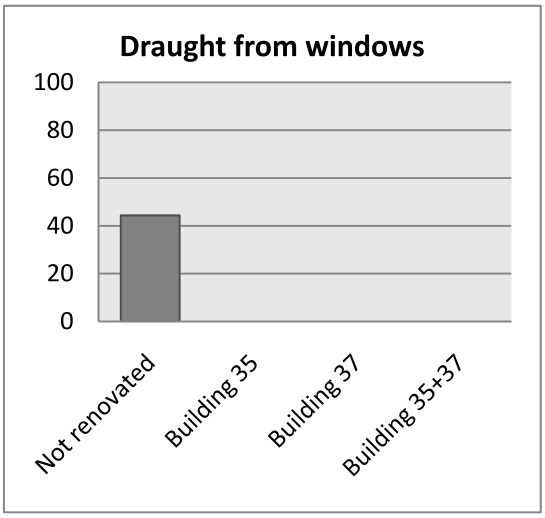

Figure 29 Tenants complaining at draught from windows.

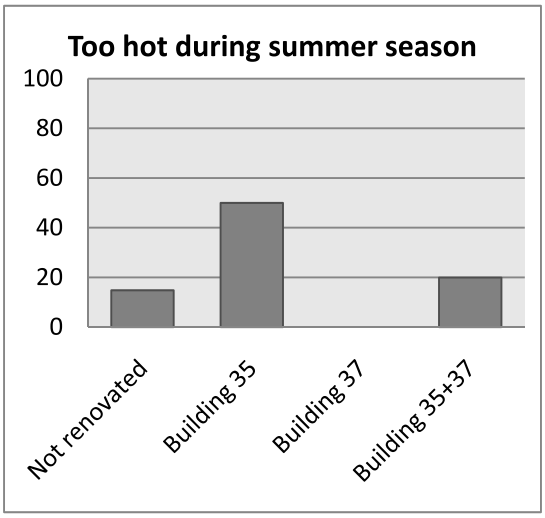

Figure 30 Tenants complaining at high temperatures during the hot summer periods.

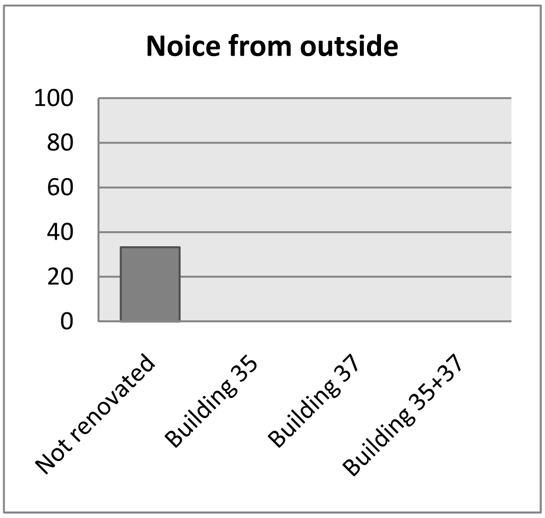

Figure 31 Tenants complaining at noise from outside

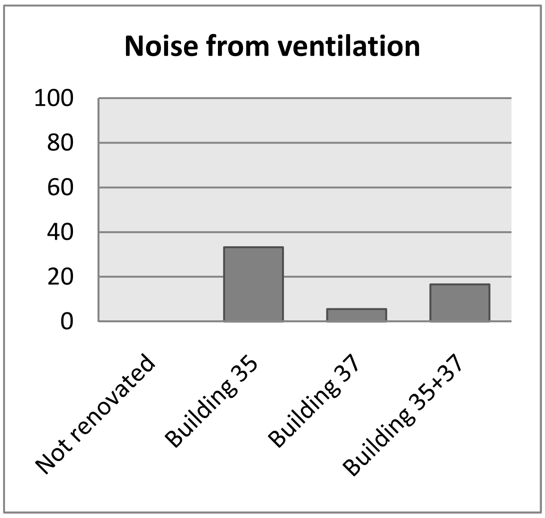

Figure 32 Tenants complaining at noise from installations.

4.8.1.2 Results from technical measurements

The technical measurements show that the renovated buildings have a good indoor environment performance. The measured values fulfill the requirements on indoor environment in BBR (Swedish building regulations). The technical measurements show that the air was quite dry in all apartments (17-22 % RH) but this is expected at such low outdoor temperatures (-5 to 2 °C). In one of the renovated apartments a positive pressure was measured instead of the desired negative pressure. I two of the apartments it took several minutes for the tap hot water to reach the desired value of 50 °C to avoid the risk of Legionnaires diseases.

4.8.1.3 Results from interviews

Six interviews were carry through in total, three with tenants living in building 35 and three with tenants living in building 37.
The results from the interviews confirm in many ways the results from the questionnaires.
One example is that the tenants both in building 35 and 37 thought the air quality and temperature was good and even in general but tenants in building 35 have had problems with the temperatures when it was cold outside and problems and had experienced very high temperatures during the summer period. One reason for this could be that there are no venetian blinds to block the sun. It is up to the tenant to install. Since the tenants in building 37 had not lived there during the summer period, this question was not relevant for them.

Quite a few raise the problem with noise from neighbors, mainly caused by music and TV, as well as impact sound from children running above. A reason could be that noise from outside have toned down and by that noise from apartment to apartment become more distinct.

Tenants in building 37 complain about smell from neighbors' cooking at several occasions.

4.8.2 Follow up on energy use

The energy use has been measured and analyzed during operation of the first building in the Brogården pilot project, before and after the renovation. At the time of reporting (April 2010), the renovated building had been in operation since February 2009. During the renovation process Alingsåshem have reviewed and changed their strategy on how to work with their future Energy monitoring and analysis. They are thus still in charge of the measurement systems but collection and compilation of measurement data is now done by the local municipal energy company Alingsås Energi. Analysis is still done by Alingsåshems' own staff. Due to a mistake by an installer who left a valve closed, no heat was available in the buildings before the beginning of October, thus complete heat measurements are only available for the period October 2009-February 2010. A small quantity of heat should probably have been used in September if it wasn't for this mistake. On the other hand, the winter 2009/2010 was extremely cold in Sweden so the figures on heat demand after renovation are higher than what the long term average will turn out to be.

Table 5 Energy use before and after renovation in the first 16 apartments being renovated in Brogården and the targets for the whole project. No correction for the extremely cold winter -09/-10 has been done.

	Before renovation [kWh/a/m²]	**After renovation (House D) [kWh/a/m²]**	**Brogården energy targets [kWh/a/m²]**
Space heating	115	***27***	27
Domestic hot water	42	18	25
Household electricity	39	28	27
Common electricity	20	21	13
Total energy use	216	***94***	92
Total excl. HH electricity	177	***66***	65

The figures according to Table 5 after renovation have not been standardized for an average year due to the fact that the existing standard for this procedure is not applicable to houses with extremely low heat demands. Instead, on the basis of calculations taking into account the fact that this winter in western Sweden was 3,5 degrees C colder than average, we have estimated that the heat demand in house D was approximately 40% higher than average. The resulting values are shown in Table 6.

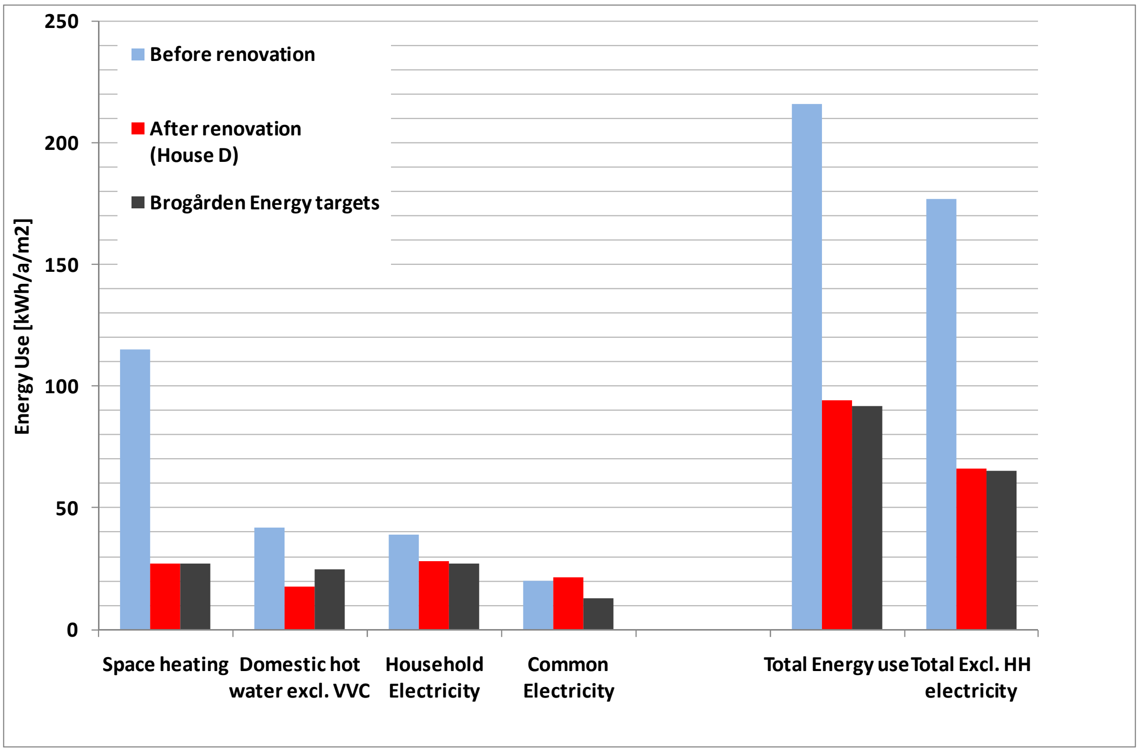

Figure 33 Energy use in house D before and after renovation without any corrections applied.

Table 6 Energy use before and after renovation in the first 16 apartments being renovated in Brogården and the targets for the whole project. A correction for the extremely cold winter -09/-10 has been applied to the space heating load which is estimated to be 30% lower than what was measured, in an average year.

	Before renovation [kWh/a/m²]	**After renovation (House D) [kWh/a/m²]**	**Brogården energy targets [kWh/a/m²]**
Space heating	115	**19**	27
Domestic hot water	42	18	25
Household electricity	39	28	27
Common electricity	20	21	13
Total energy use	216	***86***	92
Total excl. HH electricity	177	***58***	65

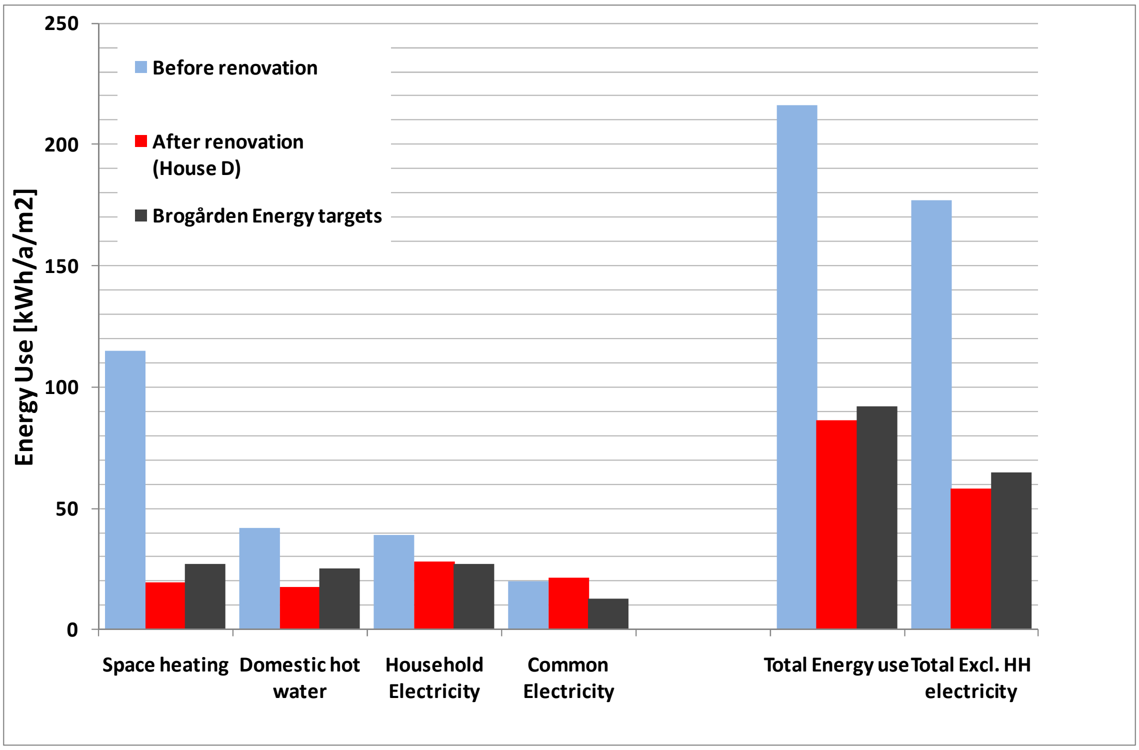

Figure 34 Energy use in house D before and after renovation with corrections applied to the heating demand figures after renovation.

The conclusion from these preliminary figures is that the renovation has been extremely successful.

- Heating demand reached the target value before taking into account the extremely cold winter
- After applying corrections according to Table 6 the energy use excluding electricity for domestic use is well below the target and almost reaches the Swedish requirements for passive house if we take into account that there is no solar heating in the building (58 kWh/m^{2}·a compared to the target 55 kWh/m^{2}·a)
- The specific value for heat to domestic hot water is far below the target value but still reasonable for a brand new installation with very efficient water taps i.e. the target value seems to have been set to high The value after renovation corresponds to a per capita use of 14,7 m^{3} hot water per year and it includes an estimated heat demand for hot water circulation losses of 2,7 kWh/m^{2}·a. Comparing values before and after renovation shows quite an amazing improvement!
- Household electricity use reaches the target more or less exactly on the kWh. The improvement is mainly due to new washing machines and dishwashers.

- Common electricity is the only subgroup that did not reach the target. On the contrary, it was quite far from reaching it according to the measurements and the reasons behind this is still being analyzed.

5 Lessons learned from the QA system implementation

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.

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´s not good enough that this knowledge is kept in the minds of one or two key persons in the organization.

5.1 Identified success factors in the implementation work

One success factor identified in the pilot project 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”.

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.

5.2 Identified barriers or difficulties in the implementation work

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´s 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 Alingsåshems’ 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 has 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.

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. Also see paragraph 3.1 regarding budgetary dispositions for handling “surprises” during demolition.

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, see chapter 6.

5.3 Dissemination potential

5.3.1 Within the organisation

SP is cooperating directly with the top level management of the organisation AB Alingsåshem. Thus, there are good opportunities for widespread dissemination within the organisation provided the SQUARE inputs are appreciated and seen as useful by the management.

5.3.2 External dissemination

A documentary film was made describing the renovation of Brogården. There are short cuts about the concept of renovating Brogården into low energy houses shared by the manager of the housing association. There are also short cuts describing the architects, tenants and carpenters views on design and construction phase. The film can be seen at www.lavenergiboliger.tv.

Further channels for external dissemination of findings from the Brogården renovation project were:

- Brogårdsbladet. A newsletter distributed to Alingsåshems' tenants in Brogården and to the local and central technical and administrative staff.
- Website for Brogården.
- Numerous seminars where Brogården and the renovation project was presented.
- Trainings arranged by BFAB
- Joint activities with Passivhuscentrum i Alingsås.
- Site visits and study tours: Until today, there have been approximately 300 sites visits at Brogården. The groups have been varying from the Swedish king and queen to groups of students.
- Dissemination of the Brogården experiences to other organization have been very thorough, with almost 300 visiting groups, lectures and many articles on the Brogården project. Focus has been as much on the technical solutions as on the partnering process.

6 Suggestions for improvements

Alingsåshems' target for their work on energy efficiency is to reduce the total energy use by 2 % per year, which will result in a reduction by 50% until 2050 which is also the national target. In this context electricity is weighted with a factor 2,2 and district heating with a factor 0,8. The average specific energy use of Alingsåshem today is 153,2 kWh/m^2

In order to ascertain continuity in the QA work and to have it properly anchored in all parts of the organization a change in directives, goals and policy has been suggested. Firstly these need to be broken down in a strategic document that clearly explains what the organization needs achieve in order to reach these goals. This strategy should then be used in development of the annual action plans that are used to further improve the status of their properties.

From the SQUARE project, the following proposal is therefore addressed to the Board of Alingsåshem:

Directive:

- That Alingsåshem shall surpass the Swedish national targets for energy efficiency improvements in dwellings.

Goal:

- That Alingsåshem by 2050 shall use 25% of today's energy use, per square meter residential floor area with the major share of the reduction taking place before 2030.
- That electricity as well as domestic hot water and heating shall be produced without any contribution from non renewable recourses by 2020.
- That these changes will benefit the tenants through improved indoor environment and good value for money from the rent paid.

Strategy:

- A survey is carried out in order to identify what is needed to achieve this, year by year. It should result in a time schedule for renovation needs, account for the energy use and intermediate goals building by building and also form the basis for the annual action plans.
- That lighting consultants are engaged to optimize outdoor lighting and that the most efficient energy solutions in the market are being used.
- That the options for efficient supply systems are always investigated when new building production or changes of whole areas are being planned.

As already explained the main building contractor Skanska has its own QA system but it was found that the majority of the sub contractors did not have a grip on this. Therefore, a template for a quality plan, in the best case somehow tailored for the main activities such as building, HVAC, electricity etc., could be a good help for the subcontractors in the development of their QA systems.

6.1 Training for passive house builders

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.

6.2 Introduction and training for tenants

In addition to the two hours' carpenter assistance provided to the tenants after moving in an additional users' instruction consultation should be very useful in order to get the tenants acquainted to the new technical systems in their apartments. From the interviews carried out with tenants in the newly refurbished apartments we could conclude that many of them were quite uncertain about how to handle heating and ventilation equipment etc.
Many of them also asked for a second visit from the building management some time after moving in, to make sure that everything was ok and to provide an opportunity for asking questions etc.

7 References

Supporting documents for the BETSI study. The National Board of Housing, Building and Planning – Boverket.

Andersson K, (1998) Questionnaire Reference: Andersson K. Epidemiological Approach to Indoor Air Problems. Indoor Air 1998; Suppl.4:32-39.

Technical description of pilot project

A.1 The building structure before renovation

A.1.1 Windows, wall and roof insulation

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

A.1.2 Heating and ventilation

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

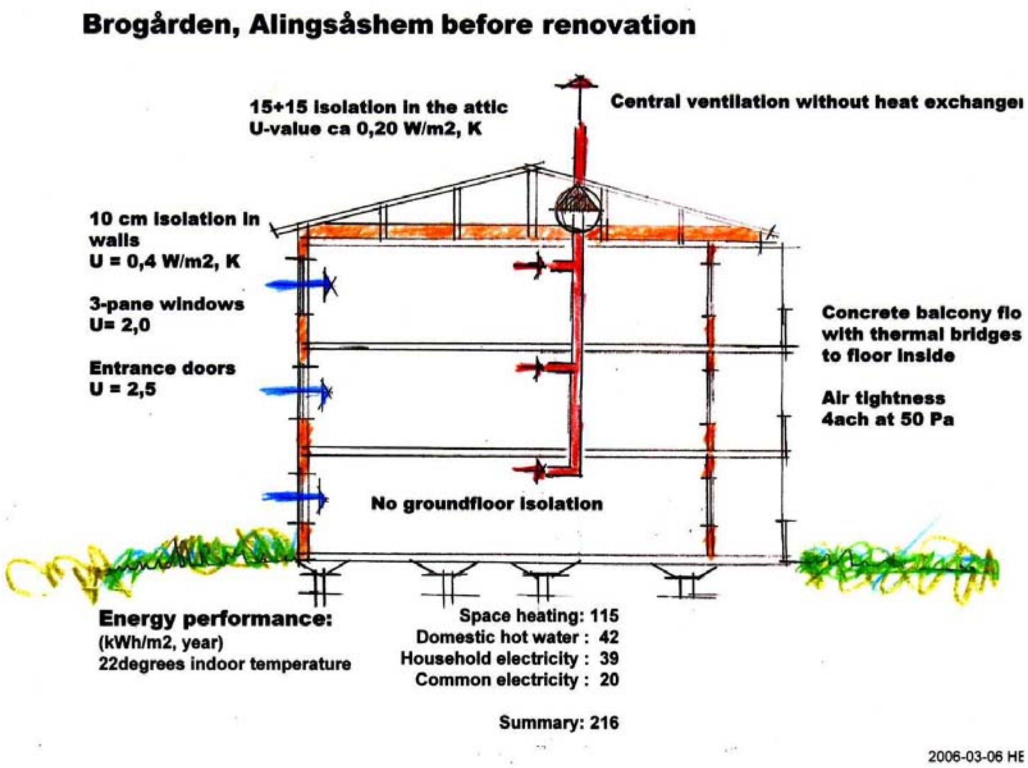

Figure 35 Building envelope and installations pre renovation. Illustration by Hans Eek.

A.2 The building structure after renovation

A.2.1 New construction materials

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

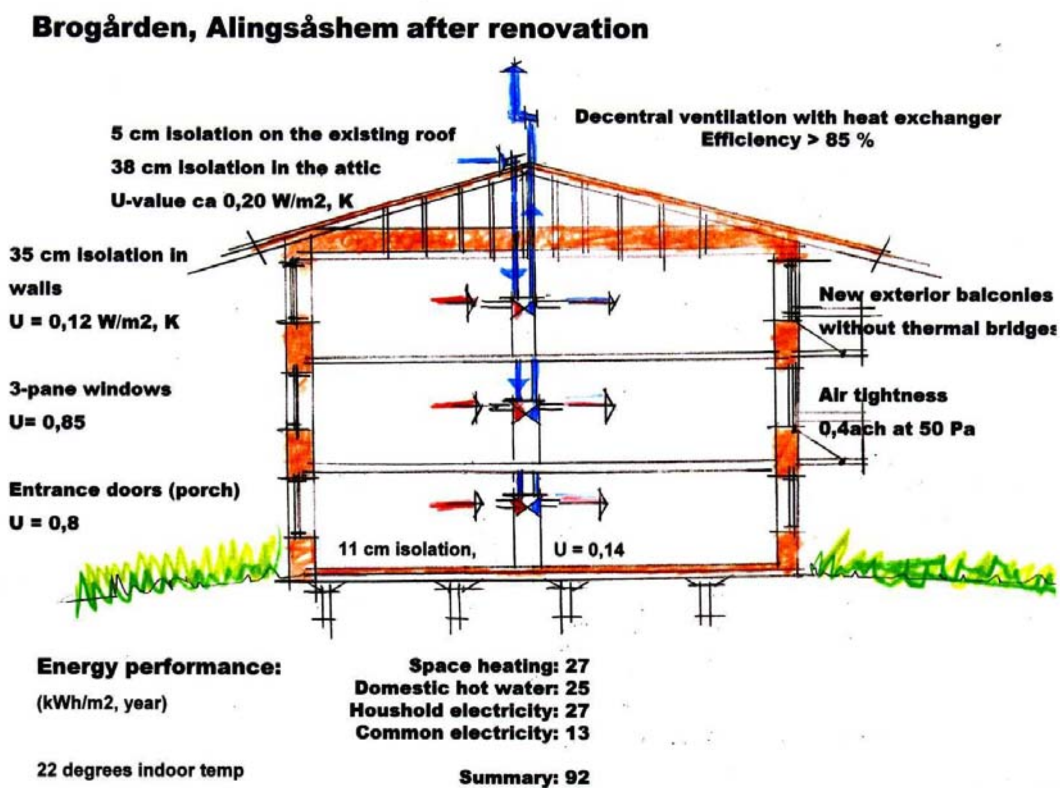

Figure 36 Building envelope and installations after renovation. Illustration by Hans Eek.

A.2.2 New heat, hot water and ventilation system

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

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

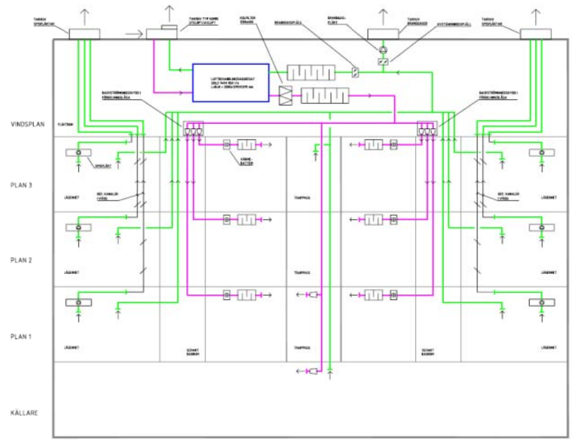

Figure 37 Designed ventilation system for the buildings with central ventilation, building E and F.

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

A.2.3 Electricity

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

A.2.4 Metering and monitoring equipments

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

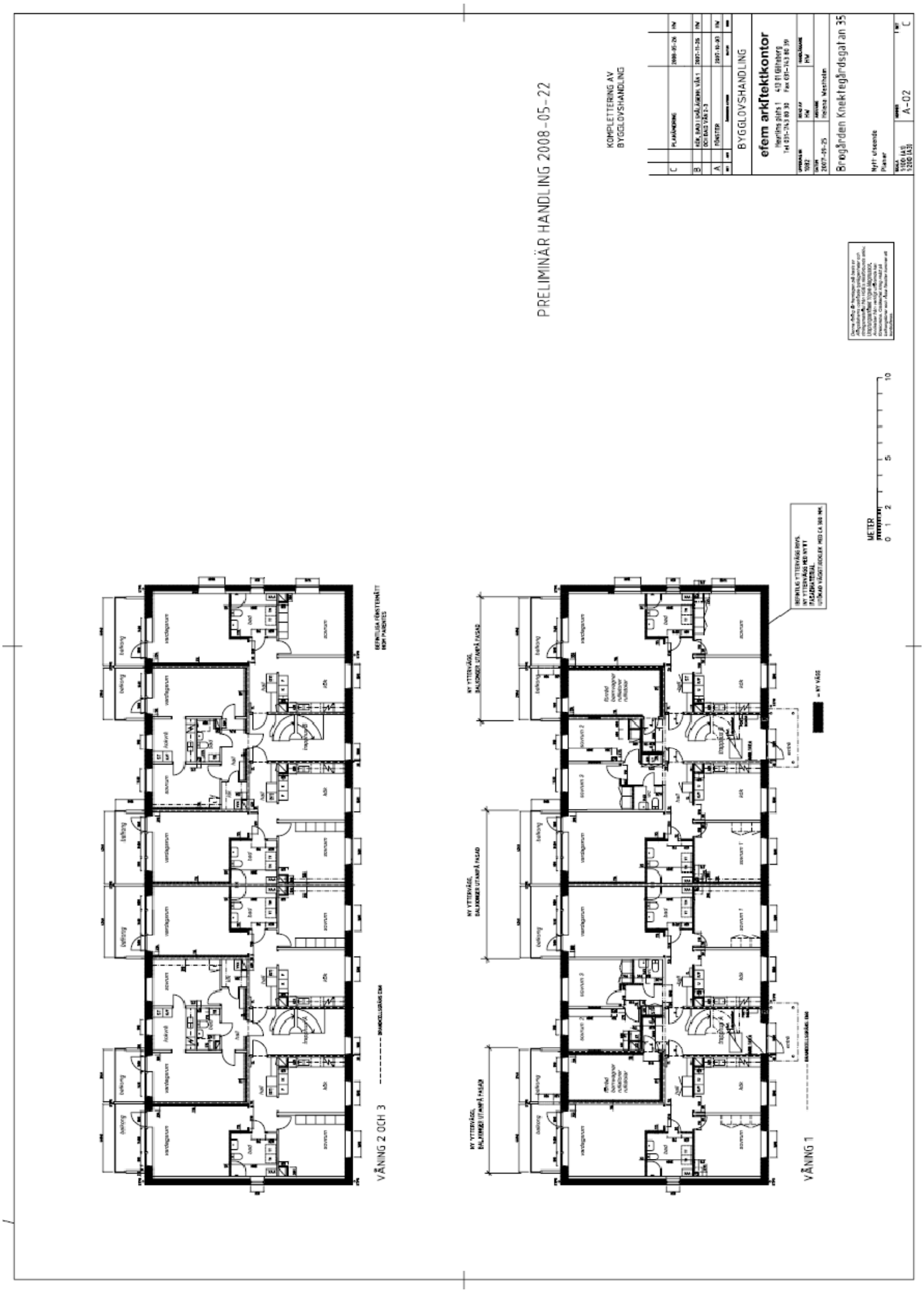

Figure 39 Plans of building D.

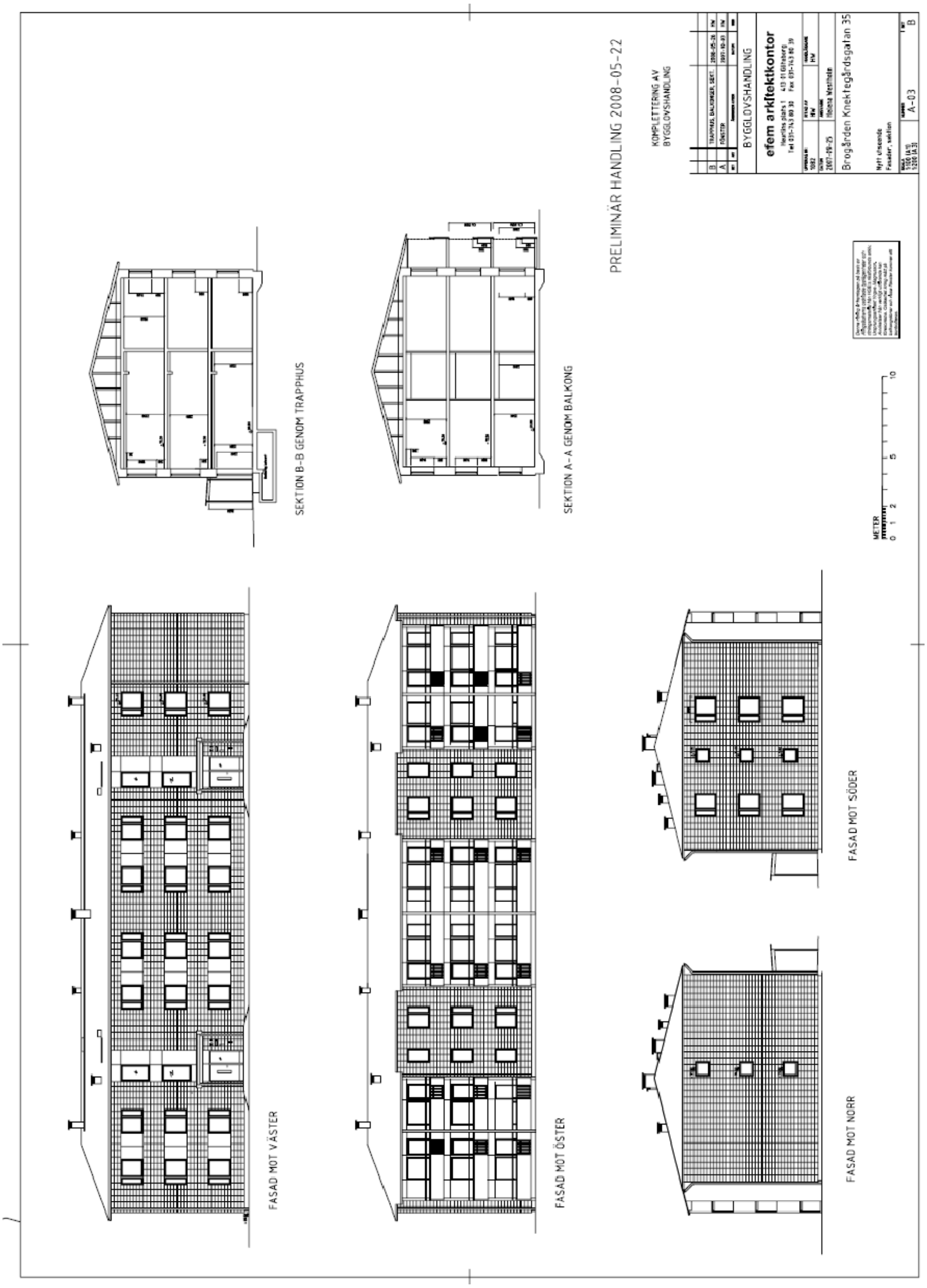

Figure 40 Facade sketches for building D.

Timetable for the pilot project

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

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

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