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A System for Quality Assurance of the Indoor Environment and Efficient Energy Use when Renovating Apartment Buildings

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ABSTRACT:
There is a great need of renovation of many apartment buildings in Sweden build during the period 1963 to 1973. In these buildings, it is not only important to assure an energy efficient renovation but also to guarantee a good indoor environment. To achieve this, a quality assurance (QA) system for renovation and maintenance has been adopted to the renovation process to ensure that the most efficient measures are chosen and that a high level of integrated energy and indoor environmental performance is maintained throughout operation of the buildings. The QA system has been introduced in the renovation of an apartment building in Brogården in Sweden that will be renovated to a higher standard of energy and indoor environmental performance. Experience from using the QA system has been collected. The QA system provides visible and marketable data on savings and indoor air quality performance of the renovated pilot project. This supports decision-making and ensures that suitable energy efficient renovation measures are chosen for each case. The QA system is spread in several European countries by the use in a number of other pilot projects in Europe and the experience will be used to improve the QA system and to suggest a future European energy management standard adapted to the building sector. The pilot projects also act as good examples to inspire apartment building owners and housing associations to carry through energy efficient renovation projects.

1 Introduction

Energy use in and by a building has the most important environmental impact during the building's lifetime, and is therefore the most important to reduce. New emphasis on energy conservation (such as in the European Energy Performance in Buildings Directive [EPBD, 2002/91/EC]), 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.

An important part of the energy efficiency improvement potential lies in the existing building stock, especially in the large areas of multifamily housing built between the oil crises in the 1970-ties. If we are to achieve significant reductions of energy use in existing buildings, it is important to perform future large-scale renovation of these buildings in a systematic and controlled manner. When renovating 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 renovation, which will differ from case to case, and so there are no universal solutions. However, to achieve the intended results of the renovation requires knowledge, continuity and

communication. This can be assured by a quality assurance (QA) system that describes a systematic and controlled way of working. The QA system should cover both renovation, maintenance, and administration since experience shows that a successful energy improvement renovation will be permanent only if use of the building is guided by effective routines and continuous capacity building of all parties.

2 Quality assurance system

2.1 Background

One example of such a quality assurance system is a system for indoor environment quality assurance (P-marked indoor environment) that has been developed in Sweden and has since then been successfully applied to multifamily houses, schools, kindergartens and offices [Samuelson 2000]. This QA system has recently been extended to include energy use SPCR 114E, [Wahlström 2008], [Wahlström, Ekstrand-Tobin 2005]. It is based on Swedish Standard SS 62 77 50, for energy management systems for organisations, and works in a similar way to ISO 14 001 (Environmental management) and Draft prEN 16001 (Energy management).

Another example of a QA system for indoor environment and energy use in Europe is the Austrian EQ^s, (Energy Quality trough Retrofit). The aim of the EQ^s is to achieve energy savings, comfort and to avoid structural damage by assuring energetic as well as structural quality during the retrofit process. The EQ^s retrofit procedure involves; structural survey and retrofit concept, planning and tendering, implementation and award in form of an energy certificate. Yet another example is the Total Quality Assessment tool (Total Quality Assessment, www.argeTQ.at) which support real estate developers, housing companies, planners, tenants and owners to create a sustainable building by defining special planning targets at the beginning of the planning phase (of both new and retrofitted buildings) and to perform a compliance check afterwards.

With in the European project SQUARE, a QA system, very much based on the Swedish QA system [SPCR144E], has been developed for the renovation process. [Kovacs, Mjörnell 2008a, 2008b]. The system is applicable to all apartment buildings that have to be renovated and updated to the requirements of today concerning their indoor environment and energy use. Since each country has a unique stock of social housing with different needs of renovation. The QA system, which is unique of its kind, has been adopted by other countries to suit their particular conditions, such as climate, building tradition and building regulations. This is possible since it is flexible in terms of organization, requirements and end energy-efficient solutions by concentrating primarily on a systematic way of working. Within the SQUARE project, the QA systems is tested in pilot buildings which are also intended to provide good examples for inspiring apartment building owners and housing associations to carry out energy-efficient renovation projects.

2.2 The advantages of using a QA system

The purpose of introducing a quality assurance system for indoor environment and energy use in the retrofit 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 and operation. In order to meet the more challenging requirements in respect of improving the efficiency of energy use and improving indoor environment conditions which result from the effects of climate change, depletion of resources, social changes, growing incidence of building-related ill-health and longer times indoors, modern renovation projects must meet new standards and requirements in respect of their methods of working and cooperating with other parties. The quality of workmanship and of components and systems is increasingly important in determining whether acceptable end results are achieved.

The main purpose is to ensure that optimum results are achieved in terms of improved indoor environment conditions and efficiency of energy use in renovation projects. Considering both these aspects in parallel avoids the risk of improving one at the expense of the other. In principle, the system covers the entire process, from the original idea to administration and operation of the building in use, with the same structure as that of traditional quality assurance systems. It should therefore be very suitable for integration with companies' existing quality assurance systems such as ISO 9001. In Sweden there is also a possibility for third-party certification by using SPs P-marking system.

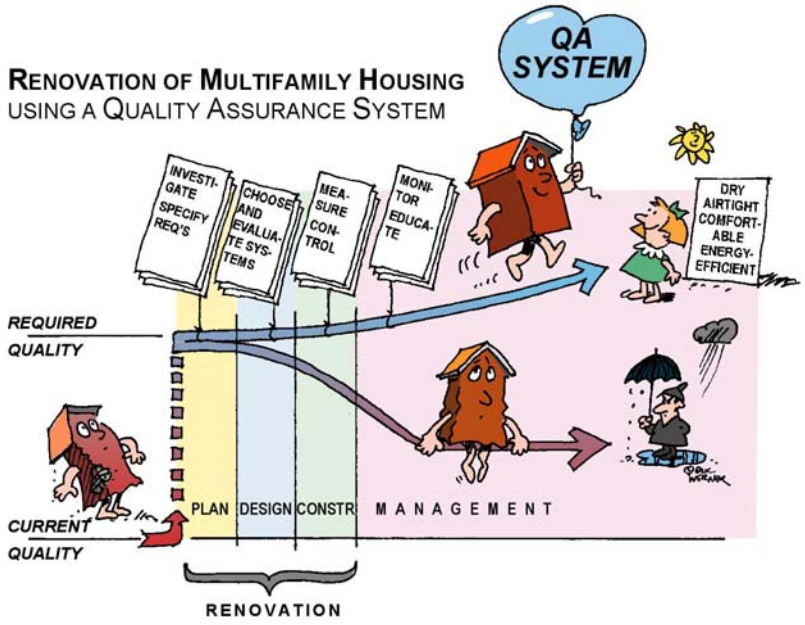

Figure 1. Principles of quality assurance in the renovation process. Picture by Eric Werner Tecknaren AB.

Although it takes time and money to establish a quality assurance system, this is a worthwhile investment for organisations taking the long-term view and expecting to carry out addition renovation projects in the future. It does, of course, require finding the right balance between administrative requirements, practical benefits and general acceptance within the organisation. If this balance is found, then the rewards will be received in the form of:

- Cost and environmental savings which, in the longer term, can be considerable.
- Fewer sub-optimisations and adverse effects of short-sighted concentration on either the indoor environment or improvements in the efficiency of energy use.
- Improved feedback and acquisition of experience within the organisation as a result of systematic, planned and carefully documented work. This provides a means of detecting shortcomings in time, before they result in more expensive mistakes, thus reducing the need for fire-fighting measures.
- Improved communications between owners, operators, occupants, maintenance personnel etc. through the establishment of clear targets and quantifiable results.
- More satisfied customers and fewer complaints through active participation by the occupants and through a systematic approach to dealing with non-compliances and complaints.

2.3 Preparing the quality assurance system

2.3.1 General

The quality assurance system itself is described in the report "Quality assurance system for improvement of Indoor Environment and Energy Use when Retrofitting Social Housing", [Kovacs, Mjörnell 2008a]. However, this describes the system in principle: 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, and anchor the system in the organisation.

2.3.2 Integrating the quality assurance system in an existing system

If the organisation has an existing quality management system, it should start by deciding how the requirements of the indoor environment and energy use quality assurance system can be integrated in the existing system. This should be followed by the drawing up of a plan to investigate how any necessary additional procedures best can be integrated into the existing system.

2.4 Applying the quality system to the renovation process

2.4.1 General

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

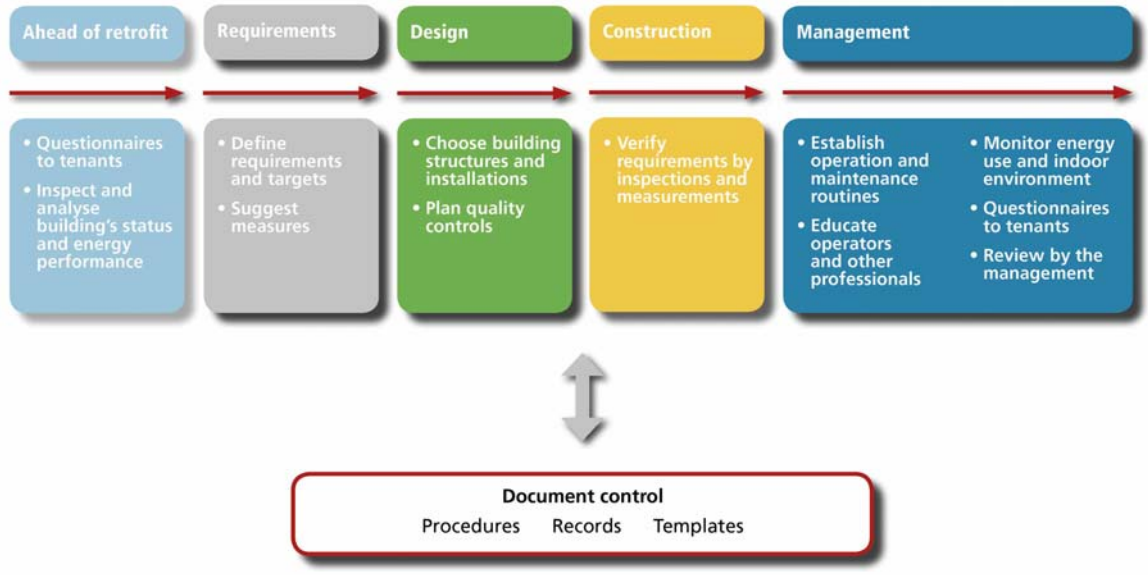

Figure 2. Application of the quality assurance system in the renovation process.

2.4.2 Establishing pre-renovation conditions

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.

A thorough primary inspection, TPI should be carried out 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/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, see examples in Appendix A. [Kovacs Mjörnell 2008a]. 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. Checklists etc for carrying out TPI are presented in [Kovacs Mjörnell 2008b].

Also, a first energy analysis (FEA) should be carried out before planning the renovation of apartment buildings in which energy use 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, the first energy analysis should be carried out at the same time as the thorough primary inspection, when aspects such as visual inspection and interviews with personnel are being carried out. Checklists etc for carrying out FEA are presented in [Kovacs Mjörnell 2008b].

In order to ensure that all the defects and faults identified in the TPI 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 foundations, 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).
- 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 meters in each apartment.

2.4.4 Follow-up during the planning stage

Planning of the renovation work must 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 renovation 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.

2.4.5 Follow-up during 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.

2.4.6 Follow-up during the work stage

At the start of the physical 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. 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. In the end of 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. When the work is completed, make confirmatory measurements in order to ensure that the specified requirements have been fulfilled.

2.4.7 Follow-up during the administration stage

It is appropriate, when handing over the building, 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 with 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.

Meetings of operational staff should be arranged 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. It is also important to arrange meetings 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. An occupants' representative should also be involved in the regular operational meetings and inspection rounds. Additionally, there must also be a procedure for dealing with complaints concerning the indoor environment.

3 Experiences from a pilot project

The QA system is tested in Brogården which is the Swedish pilot project for SQUARE. The Alingsås local authority housing association, Alingsåshem, has undertaken to carry out a very extensive renovation of a number of apartment buildings constructed over the period 1971-73. The target requirements for energy use after renovation are very demanding, of a level with a voluntary standard for passive houses recently developed in Sweden [Swedish Passive house criteria]. The indoor environment requirements are equally demanding, in accordance with the example in Appendix a of SQUARE's quality assurance system [Kovacs, Mjörnell 2008a]. 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 renovation work.

Alingsåshem has selected the partnering procurement and cooperation procedure for the project, entering into a several-year cooperation agreement with a number of contractors, subcontractors and building services systems companies. A fundamental thought behind this is that those responsible for the project want to have a greater element of dialogue concerning requirements and targets, with greater insight into all parties' cost calculations and planning of work than in a traditional construction project. It is expected that this will result in higher quality at a lower cost (in the slightly longer term) while making valuable contributions to knowledge and experience of new technologies and new methods for both the organisation and its partners.

Some important components of the joint work of the renovation include:

- The developer (Alingsåshem) arranged information meetings with all project participants at an early stage in order to arrive at a common evaluation and awareness basis.
- The building contractor continually supplies information to employees on quality targets, responsibilities, the work environment and the external environment by such means as information in the lunch room and at site, Friday meetings on different themes etc.
- The developer keeps residents informed of opportunities for participating in the process, of renovation targets and of the progress of the project. This is done by means of information meetings, a newsletter and television broadcasts over the local network.
- A display apartment has been completed, providing other occupants with the opportunity to examine the technical systems and practical arrangements planned for the renovation project as a whole. These can be aspects such as the running of ventilation ducts, window reveals, the placing of heat recovery units or replacement of air filters.

Brogården consists of a total of 300 apartments, of which 18 are included in a first stage of the work, with a planned occupation date of February 2009. Further information on the progress of Brogården, newsletters etc. (in Swedish) can be found at www.alingsashem.se/

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