SQUARE –A Quality Assurance MANAGEMENT system FOR retrofitting with good indoor ENVIRONMENT and energy efficiency

M.Sc. Svein H. Ruud, Dr. Kristina Mjörnell and Dr. Åsa Wahlström
SP Technical Research Institute of Sweden
Box 857, SE-501 15 Borås, Sweden
Tel.: +46-105165514
E-Mail: svein.ruud@sp.se

Hans Eek, Passivhuscentrum, 441 81 Alingsås, Sweden

Abstract

A quality assurance (QA) system for good indoor environment and energy efficiency has been developed in Sweden. It has been used only for Swedish conditions. In order to obtain experience and to encourage retrofitting of buildings for good indoor environment and energy efficiency to become more mainstream in Europe, the SQUARE (a System for QUality Assurance when Retrofitting Existing buildings to energy-efficient buildings) project was initiated. Six European countries (Austria, Bulgaria, Finland, the Netherlands, Spain and Sweden) will participate in the project that is supported by the Intelligent Energy Europe programme and will run from November 2007 until April 2010. As a part of the SQUARE project the QA-system will be applied in retrofitting of a social housing in Sweden. It is Alingsåshem in Alingsås that are planning to retrofit 300 apartments. In the first round 18 apartments will be retrofitted with passive house principles. The energy use for heating, heating of tapwater and operation electricity are planned to be reduced from 177 to 65 kWh/m2. This paper will discuss the QA-system and how it will be used in the retrofitting down to passive house standard at Brogården in Alingsås.

1 Introduction

In the EU about 1-2 % of the building stock is renovated every year, which often gives cost-effective opportunities for major energy efficiency improvements. However, in order to achieve significant reductions of energy use in existing buildings, it is important to perform future large-scale retrofitting of buildings in a systematic and controlled manner. When retrofitting a building many aspects must be taken into account, such as local resources, costs, building traditions, legislation and financing. These aspects will have an impact on decision-making and on the outcome of the retrofit, which will differ from case to case, and so there are no universal solutions. However, to achieve the intended results of the retrofit requires knowledge, continuity and communication that can be assured by a dynamic and flexible quality assurance (QA) system that describes a systematic and controlled way of working.

1.1 Previous experiences with a QA system

One example of a quality assurance system is a Swedish QA system for indoor environment that was developed about ten years ago, and has since then been successfully applied to multifamily houses/social housing, schools, kindergartens and offices (Samuelson, 2000). The clients are very satisfied with the QA system of indoor environment which has been confirmed by two investigations with questionnaires and interviews of clients about experiences and satisfaction with the QA system (Emami and Forseaus, 2004; Cedås and Hilmarsson, 2006).

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. However, a reduction of energy use is appropriate only if it does not adversely affect the indoor environment. In order to avoid an

unbalanced concentration on either good indoor environment or energy efficiency that might result in mutually adverse effects, the building sector requested that the QA system should be extended to consider energy use as well. Consultants, specialist researchers, property-owners, builders and building managers have therefore jointly developed the QA system with the objective of including energy efficiency assurance (Wahlström and Ekstrand-Tobin, 2005). The system has been extended to a labelling system for the total building performance of both indoor environment and energy use and covers the planning, design, construction, commissioning and operation phases. It includes methods and routines to control the indoor environment and energy use by using occupant questionnaires, the building monitoring systems or other methods during operation. A third party certifies the energy and indoor environment and makes annual inspections.

The primary objective of the QA system is to work towards continuing improvements and encourage property managers, administrators and occupants to carry out improvements that otherwise would not have been considered. The QA system aims to be flexible so that it can be used for different building categories, different organisational structures and different parts of the building process. In order to obtain a first relatively quick evaluation of the extended system, it was applied to buildings which formed a special case in that their indoor environments had already been certified with the QA system. They therefore needed only the additional element of QA of their energy systems and consequently the evaluation considers only the operation phase. The pilot projects were therefore chosen to be a school building, an office and an area of multi-family houses.

The results show that the QA system is really flexible (Wahlström et al. 2006 and 2007). For each pilot project it was possible to introduce quantified and measurable goals, action plans for measures and management systems during operation with authorities, responsibilities and awareness for all actors within the process. All pilot projects have already shown, with their new targets and action plans for work, that they are moving towards improved energy performance. The projects have also led to a significant improvement in the systematic work related to the controlling energy use, while at the same time maintaining a good indoor environment.

1.2 Retrofitting of residential buildings

Good management of a building can typically reduce energy use by 5 - 25 % as, for example. shown in pilot projects for the QA-system. A retrofit of a building provides significant opportunities for introducing cost-effective measures for major reduction of operational energy, often between 30 -70 %. In order to achieve high targets of energy efficiency in buildings, it is not enough to introduce a QA-system first in the operational phase. It is important to refine and apply the QA-system during the complete retrofit of a building (the planning, design, construction and commissioning phase).

Since an important part of the energy efficiency improvement potential lies in residential building stock, the use of the QA system for retrofit improvements is justified as follows:

- there are several million residential buildings in the European Union
- many of these buildings were built before the oil crises of the 1970s, and therefore use unnecessarily high amounts of energy
- the need to make up for many years of neglected maintenance means that both the building envelope and building services need to be upgraded, which provides the owners with an opportunity for cost-effective energy measures
- since social housing stocks consist of many similar apartments, the measures can easily be replicated cost-effectively.

The QA system is flexible in terms of organisation, requirements and end energy-efficient solutions by concentrating more on a systematic way of working. Even though many aspects must be taken into account in different European countries, such as local resources, costs, building traditions, legislation and financing, it should be possible to develop a QA-system adopted to each country’s conditions. The QA-system is now ready to be applied in retrofitting of multi-family buildings in different European countries.

2 Description of the quality assurance system

The primary objective of the system is to work towards continuing improvements and to encourage clients, builders, architects, administrators and occupants to apply improvements that otherwise would not have been considered. This requires quantified and measurable goals, action plans for measures and management systems during operation.

Cooperation between all parties, from scientists and public authorities to designers, contractors, managers and users, is important for the end results. All need to listen to, and to learn from, each other. Good indoor environment and efficient use of energy can be achieved by creativity, planning and layout design, choice of materials, general designs and detailed and overall designs of systems for heating, ventilation, electricity and water supply. This QA scheme makes sure that the requirements set out in legislation, standards or common codes of practice are fulfilled as intended. An independent third party supervises, evaluates and checks that the requirements are fulfilled. Measurements show that the performance requirements have been met. Occupants' perceptions of the indoor environment are evaluated with the help of questionnaires, while energy use is evaluated with energy measurements or energy bills. The QA system includes new building and rebuilding work, as well as improvements of existing buildings, and covers the entire process, from planning and design, through the construction stage to final use and operation. Certification is based on ISO 9000 procedures and is described in (SPCR 114E, 2007). To ensure that the system's rules are accepted, and that they are needed by the building sector, the system has been approved by a committee consisting of representatives of private and municipality property owners.

2.1 The retrofitting phase

Certification work for existing buildings that are to be retrofitted begins with a TPI (Thorough Primary Inspection) of the indoor environment and a first energy analysis (FEA). The TPI and FEA consist of an survey of the property, with its actual status, aspects and performance of indoor environment and energy use (Wahlström, 2005). This can be done by examining construction drawings, operational follow-up programs, control systems or other documentation; visual inspections, interviews with staff and occupants, as well as additional measurements. The evaluation of the performance of indoor environment is primarily based on inquires to users while energy use is based on actual measurements. The procedures are illustrated in Figure 1.

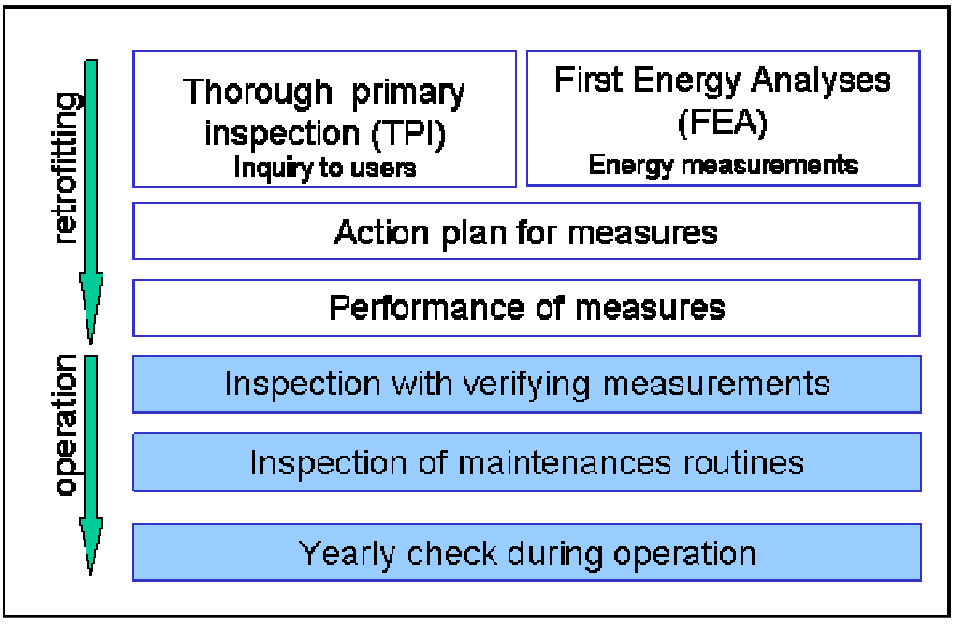


Fig. 1 - Illustration of procedures for quality assurance of indoor environment and energy use

The results of the TPI and FEA are then used to set objectives to be achieved, including a performance measurement specification of how the comprehensive targets should be measured and checked. The QA scheme considers the fact that each building project is unique, and therefore the annual energy use target will be set on the basis of the building's current condition and its associated limitations, rather than on the basis of a specific predefined figure. Limitations of energy use targets are related to building use, climate and existing design of the building. Targets for indoor environment are at least the same as set in legislation or authority recommendations, but may be stronger by request of the building client. Targets for indoor environment consider the parameters; thermal comfort, air quality, ventilation, moisture safety, acoustic conditions, airtightness, light and tap water quality.

The next step is to draw up an action plan for measures and carry them out in order to reach the set targets. Measures for reducing cold bridges and increasing airtightness are crucial for both indoor environment and energy use. It is also important to ensure that the building services work together with the building envelope in a complete energy system. The third party makes brief inspections, measurements and evaluations of the measures regularly during the complete retrofit, including advice and discussions. When the retrofit is complete, the building system is adjusted until the planned building performance is researched.

2.2 The operation phase

Experience shows that successful energy efficiency in a building will be maintained only if the building is efficiently managed, operated and maintained, with all parties steadily improving their performance and with the results regularly monitored. This means that the energy target must be regularly monitored and reviewed, and the QA system is therefore based on a management system modelled on a Swedish standard (SS 62 77 50, 2003). The standard includes comprehensive routines for energy management for any organisation, and has therefore been refined and customised to fit the building sector.

Clear and easily understood operating and care instructions for the premises are a prerequisite for continued good indoor environment and energy performance. The various documents need to be matched to the needs of the target personnel concerned: for example, to the building operator's staff, to cleaners and/or to occupants and users. There are instructions for cleaning, and instructions for the heating and ventilating systems which provide details of such aspects as the maximum number of persons with which the systems can deal and so on.

Routines for monthly and yearly monitoring and evaluation of energy performance with stated actions in response to deviations from the set targets will assure continued energy efficiency. Indoor environment parameters are measured at the end of the retrofitting process and are followed up by measurements in 20 % of the apartments every year, so that all the apartments have been monitored over a five-year period.

3 The SQUARE project

In Sweden, about a million apartments were built between 1964 and 1974 in order to tackle the country's housing shortage. Due to moderate rents, these apartments are mainly occupied by low-income families and may be considered social housing. These buildings are now due for renovation of the building envelope, as well as retrofitting of building services systems. As a result, an important part of the energy efficiency potential lies in the social housing stock.

The QA system of both indoor environment and energy use is now ready to be applied in retrofitting of social housing in Sweden. However, the QA system has been developed in Sweden and has been used only for Swedish conditions. In order to obtain experience and to encourage retrofitting of buildings for good indoor environment and energy efficiency to become more mainstream in Europe, the SQUARE project was initiated.

The SQUARE (a System for QUality Assurance when Retrofitting Existing buildings to energy-efficient buildings) project aims to assure energy-efficient retrofitting of social housing with good indoor environment in a systematic and controlled way. Six European countries (Austria, Bulgaria, Finland, the Netherlands, Spain and Sweden) will participate in the project. The project is supported by the Intelligent Energy Europe programme and is planned to start in November 2007 and will run for 30 months.

Each country has a unique stock of social housing with different needs of renovation The QA system, which is unique of its kind, could be adopted by other countries to suit their particular conditions since it is flexible in terms of organisation, requirements and end energy-efficient solutions by concentrating primarily on a systematic way of working. The Swedish QA system will be a very good base for other countries to start out from to develop their own versions adapted to their conditions, such as regulations, building traditions and climate. Within the project, the developed QA systems will be tested in pilot buildings, which is also intended to provide good examples for inspiring social housing owners to carry through energy-efficient retrofitting projects. An overview of the work packages in the project is given in Figure 2.

One example of the developments of the QA system is to introduce interviews with each actor before they are contracted in order to check their motivation for the projects goals and working procedures. This will be one further guarantee for a successful project and the core target.

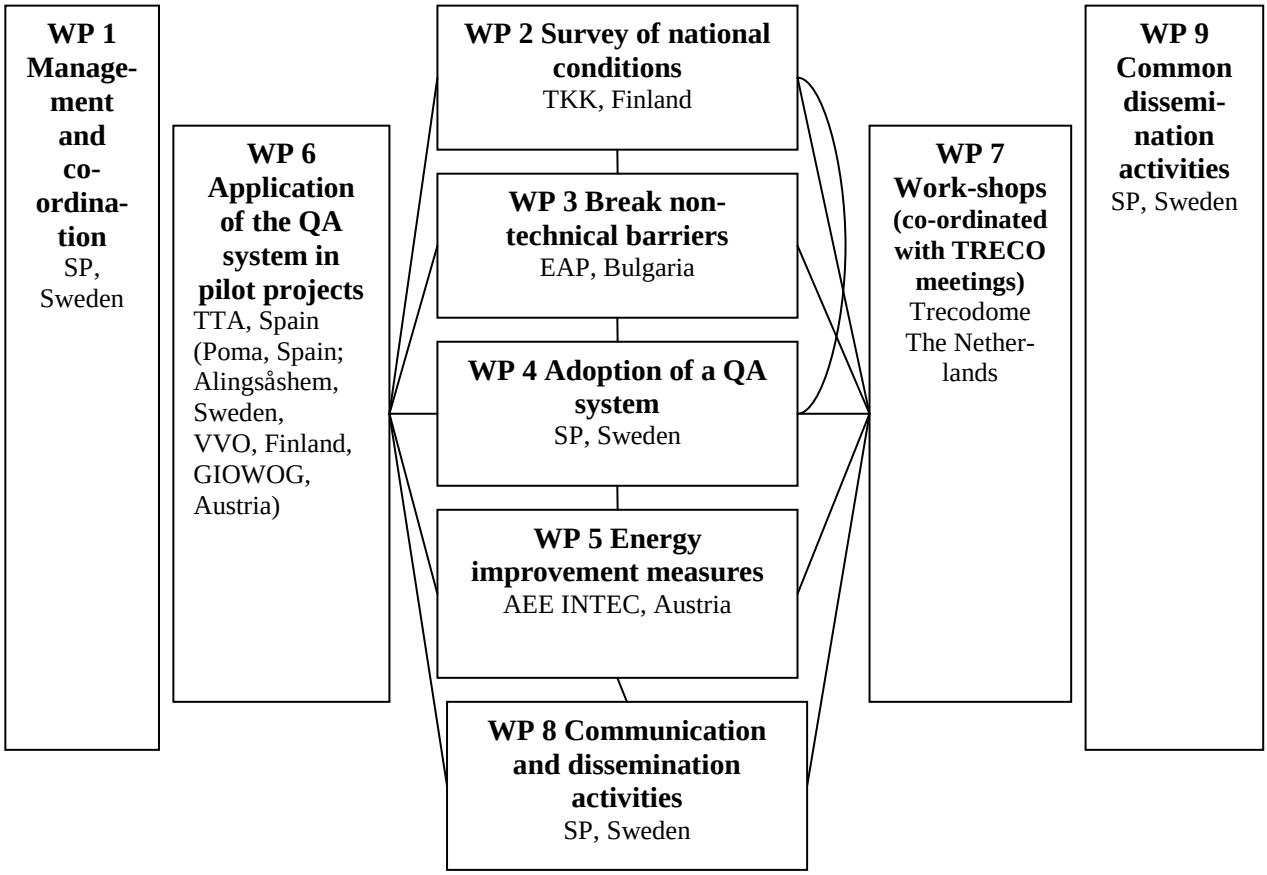


Fig. 2 – A flow chart with an overview of the work programme for the SQUARE project

3.1 Objectives of the SQUARE project

The SQUARE project aims to promote energy-efficient retrofitting with improved indoor environment in social housing by using the QA system adopted for each country with their quite different climatic and sociological conditions. An important task is to use the QA system in pilot projects in order to spread information and the methodology in European countries through practical experience and good examples.

In order to obtain a wider understanding and spread of knowledge of the system, it is important that the Swedish standard (SS 62 77 50, 2003) should be harmonised at a European level (i.e. become a CEN standard) as well as being developed, extended and aligned to the building sector. The project will therefore prepare rules for a future European energy management standard for the building sector that will be passed on to CEN.

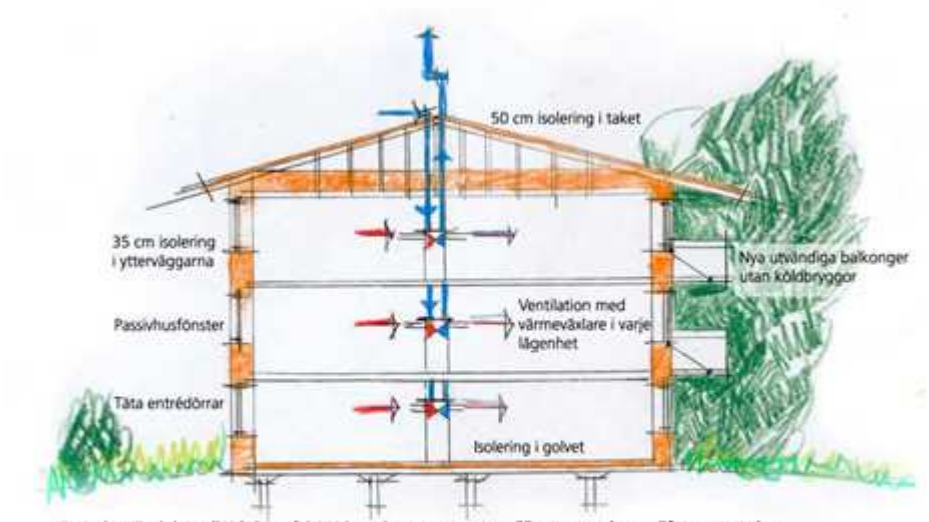
The QA system will also be a good example of how future labelling of buildings can be performed. The final results are important for those who buy or rent properties. It means a lot to know that the building to be occupied has been built or renovated and is operated to ensure a healthy indoor environment with minimum use of energy.

3.2 Description of the Swedish pilot project at Brogården in Alingsås

Brogården is a social housing area consisting of 300 appartments. It was built in 1970. There were about 1 million similar apartments built in Sweden during the period 1963 to 1973. Alingsåshem is here intending to retrofit the buildings to passive house standard. This will be achieved by:

- Thourough insulation of the building envelope
- Additional air-tightening the building envelope
- Changing to super-insulated windows
- Installing high efficient air-to-air heat recovery

The traditional heating system consisting of hydronic radiators will be substituded with small hydronic reheaters, one in each apartment. They will only be activated at very low outdoor temperatures.In the summertime tap water will be heated by solar panels. In the wintertime the tap water will be heated by district heating, as will the reheaters. The goal is the reduce the energy consumption from 216 kWh/m2 to 92 kWh/m2 (including household electricity). This means energy consumption well below the values set for new building in the Swedish building code.



Energianvändning: (kWh/kvm år) 22° inomhustemperatur	Före renovering	Efter renovering
Uppvärmning:	115	27
Varmvatten:	42	25
Hushållsel:	39	27
Fastighetsel (trappljus, tvättstuga etc):	20	13
Summa:	**216**	**92**

Fig. 3 – Sketch of the Brogården retrofit

4 References

Cedås D., Hilmarsson E., (2006), P-marking, Mapping the significance of P-marking in the building process. Examination work in Engineering in Building Technology, Högskolan i Borås, Ingenjörshögskolan, No. 9/2006. In Swedish.

Emami K., Forseaus A., (2004), Questionnaire in compulsory schools. Comparison of P-marked and non P-marked schools. Högskolan i Borås, Ingenjörshögskolan. In Swedish.

EPBD, (2002), Directive 2002/91/EC of the 16 December 2002, The European Community Official Journal, no. L 001, 04/01/2003 p. 0065-0071.

Samuelson I., (2000), Quality assurance of the indoor environment in schools, offices and dwellings through P-marking, Proceedings of Healthy Buildings 2000, Espoo, Finland, August 6-10.

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

SS 627750, (2003), Swedish Standard for Energy Management - Requirement Specification. SIS Swedish Standard Institute.

Wahlström Å., (2005), P-marked indoor environment and energy use -Handbook before certification of energy use, SP Rapport 2005: 41, ISBN 91-85303-73-9, Energiteknik, Borås, In Swedish.

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

Wahlström Å., Törnström T., Ruud S., (2006) A Quality Assurance System for Indoor Environment and Energy Use, Proceeding of EPIC 2006 AIVC, Lyon, France, 20-22 November.

Wahlström Å., Nielsen JR., Ruud S., Törnström T., (2007), A voluntary scheme for certification of indoor environment and energy use, Proceedings of CLIMA 2007, WellBeing Indoors, paper B01: 1235, Helsinki, Finland, 10-14 June.