

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

Quality Assurance System for Improvement of Indoor Environment and Energy Use when Retrofitting Social Housing

Supported by

Intelligent Energy  **Europe**



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

Quality Assurance System for Improvement of Indoor Environment and Energy Use when Retrofitting Social Housing

Work Package 4 Adoption of a Quality Assurances System

Deliverable 4.1 A report on a QA system for efficient energy use and improved indoor environment with adoption to specific conditions in different countries

SQUARE

Coordinated by

SP Technical Research Institute of Sweden

SE-Box 857, 501 15 BORÅS, Sweden

www.iee-square.eu

Preface

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

The partners of the SQUARE project are:

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

Authors: Peter Kovacs and Kristina Mjörnell, SP

The sole responsibility for the content of this report lies with the authors. It does not necessarily reflect the opinion of the European Communities. The European Commission is not responsible for any use that may be made of the information contained therein.

Summary

This report is part of the work in the SQUARE projects' work package 4, where a Quality Assurance (QA) system for ensuring energy efficient retrofitting of social housing with good indoor environment is being further developed and adopted to national conditions. The report describes a logical structure for and the essential parts of the QA system but is mainly restricted to the formal parts of the system. A guideline for the implementation of the system, including checklists, templates and links to useful additional resources is currently under development.

The main target groups for the report, and the QA system, are organizations, co-operatives and privates owning social housing and consultants, contractors and suppliers involved in retrofitting of social housing.

The work covered by this report started with describing the QA system so it could be understood by all partners, and then, to develop and adopt the system to the national conditions in each participating country. As a basis for achieving a common “European” QA system, as represented in this report, the survey of national conditions carried out in WP 2 and general inputs from project partners have been used. The next step in the process towards national versions of this report will be the partner’s respective application of the system in the pilot projects. Based on this, the partners will tailor the system according to specific national conditions. This will mainly affect the appendices with requirements on indoor environment and energy use.

Table of contents

1	INTRODUCTION	1
1.1	BACKGROUND	1
1.2	SCOPE	1
1.3	TERMS AND DEFINITIONS	2
1.4	A SUMMARY OF THE QA SYSTEM	3
2	QUALITY ASSURANCE SYSTEM REQUIREMENTS	5
2.1	ORGANIZATIONAL REQUIREMENTS	5
2.1.1	DEFINING A QUALITY POLICY	5
2.1.2	DEFINING RESPONSIBILITIES	6
2.2	PROCEDURE REQUIREMENTS	6
2.3	DOCUMENTATION REQUIREMENTS	6
3	FUNCTIONAL REQUIREMENTS AND TARGETS	7
3.1	EXTERNAL REQUIREMENTS ON INDOOR ENVIRONMENT	7
3.2	EXTERNAL REFERENCES OR REQUIREMENTS FOR ENERGY USE	7
3.3	DEFINING REQUIREMENTS FOR THE RETROFIT	8
3.4	DEFINING TARGETS AND REQUIREMENTS FOR INDOOR ENVIRONMENT AND ENERGY USE	8
4	QUALITY ASSURANCE PROCEDURES FOR THE RETROFIT	9
4.1	BASELINE INQUIRY AND ANALYSIS	9
4.1.1	THOROUGH PRIMARY INVESTIGATION - TPI	9
4.1.2	FIRST ENERGY ANALYSIS – FEA	10
4.2	RENOVATION CONCEPT DEVELOPMENT AND ANALYSIS	11
4.3	MEASUREMENTS AND CHECKS DURING CONSTRUCTION	12
5	QUALITY ASSURANCE PROCEDURES FOR THE PROPERTY MANAGEMENT	13
5.1	PLANNING OF OPERATION AND MAINTENANCE	13
5.2	OPERATION AND MAINTENANCE	13
5.3	MONITORING, METERING AND MEASUREMENTS	13
5.4	NON-COMPLIANCES, CORRECTIVE AND PREVENTIVE ACTIONS	14
5.4.1	NON-COMPLIANCES, CORRECTIVE AND PREVENTIVE ACTIONS FOR THE INDOOR ENVIRONMENT	14
5.4.2	NON-COMPLIANCES, CHANGES IN QUANTITIES, CORRECTIVE AND PREVENTIVE ACTIONS FOR ENERGY USE	15
5.5	COMMUNICATION AND INFORMATION FLOWS	15
5.6	EDUCATION AND TRAINING OF STAFF	16
5.7	INTERNAL AUDITS	16
5.7.1	INTERNAL AUDIT OF INDOOR ENVIRONMENT	16
5.7.2	INTERNAL AUDIT OF ENERGY USE	16
5.8	MANAGEMENT REVIEWS	17
6	DOCUMENTATION AND DOCUMENT CONTROL	18
6.1	DOCUMENT CONTROL	18

6.1.1	CONTROLLING/GOVERNING DOCUMENTS	18
6.2	BUILDINGS AND SUPPLY SYSTEMS' DOCUMENTATION	18
6.3	RECORDS	18
6.4	TEMPLATES	19
6.5	PROCEDURE DOCUMENTS	19
7	METHODS FOR MONITORING, METERING, MEASUREMENTS, AND TESTS	21
7.1	MEASUREMENTS OF INDOOR ENVIRONMENT PARAMETERS	21
7.2	HEAT, ELECTRICITY AND WATER METERING	21
7.3	MEASUREMENTS OF AIR TIGHTNESS AND AIR FLOWS	21
7.4	USER QUESTIONNAIRES	22
8	THIRD PARTY CERTIFICATION	23
9	REFERENCES (EXAMPLE)	24

Appendices

A	REQUIREMENTS ON THE INDOOR ENVIRONMENT (SWEDISH EXAMPLE)	25
A.1	THERMAL COMFORT	25
A.2	AIR QUALITY	26
A.3	MATERIALS	26
A.4	RADON	27
A.5	VENTILATION	27
A.6	MOISTURE SAFETY	28
A.7	AIR TIGHTNESS	29
A.8	ACOUSTIC CONDITIONS	29
A.9	LIGHT	30
A.10	TAP WATER	31
A.11	ADMINISTRATION	31
B	REQUIREMENTS ON THE ENERGY USE (SWEDISH EXAMPLE)	33
B.1	EMISSIONS OF GREENHOUSE GASES	33
B.2	ENERGY REQUIREMENTS FOR PARTICULAR COMPONENTS	34
B.3	THE PURCHASER'S OWN REQUIREMENTS	34

1 Introduction

This document describes the requirements and procedures for an organization's quality assurance system for the improvement of indoor environment and energy use of social housing through retrofit. The requirements are set for self-declaration of the quality assurance system. A guideline for the QA system, including more information on its practical application with checklists, templates etc is also being developed.

1.1 Background

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

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

1.2 Scope

The purpose of introducing a quality assurance system for indoor environment and energy use in the retrofitting process of social housing is to assure organization, routines, responsibility and resources to maintain the indoor environment and energy use performance according to pre defined requirements and targets. The purpose is also to

revise the targets with a certain periodicity and in case of changes in management or operation conditions.

The system is applicable to all types of social housing that is to be retrofitted and updated to present-day requirements concerning their indoor environment and energy use.

1.3 Terms and definitions

Audit – Systematic, independent and documented process for obtaining evidence and evaluating it objectively to determine the extent to which the energy and indoor environment system criteria set by the organization are fulfilled.

Declared values – Values of the indoor environment and energy use objectives that the organization has undertaken to achieve, both obligatory and voluntary.

Energy – Electricity, fuel, steam, heat, compressed air and other like media/energy carriers.

Energy use – In this *document/context*, the term '**energy use**' refers to the **energy supplied to a building** or building stock while in occupation in order to maintain the desired indoor environment conditions and other performance of the building. The energy use of the private household may sometimes include heating, hot water and/or electricity to fans and pumps. In those cases this part of the consumption must be included in the global energy use, i.e. it must be separated from the household electricity/energy. Preferably by separate meters, but sometimes estimated values must be used.

Energy aspect – Activities in the building or its environment or circumstances that affect its energy use.

Energy target – Energy targets are set, representing the amount of energy use that must not be exceeded when the building is in use. These targets shall be used by all those involved in the retrofit process (architects, planners, construction companies, building service companies) and in administration/operation (property management, occupants) of the building.

Energy efficiency – Ratio between an output of performance, service, goods or energy, and an input of energy.

Energy performance – Measurable results of the organization's energy management.

Energy diagnosis – Systematic process to provide a description of the organization's overall situation, quantifying possible energy savings and defining the actions necessary to achieve such savings.

Energy performance indicator – Ratio chosen by the organization to follow up energy performance

FEA – First Energy Analysis.

Functional requirements – Technical requirements defining e.g. maximum or minimum allowed values of different parameters related to the indoor environment and/or the energy use.

Indoor environment – As used in this document/context, the concept of 'indoor environment' refers not only to the indoor environment that an organization provides for the occupants (light, thermal comfort etc.), but also to the information or instructions for occupation and use of the building.

Occupant – Tenant and/or resident.

Organization – Company / property manager / owner / purchaser / developer.

Retrofit action – Construction work on social housing (building components and building services) in order to met the present-day requirements concerning indoor environment and energy use.

TPI – Thorough Primary Investigation.

1.4 A summary of the QA system

The overall objective of the quality assurance system is to ascertain that all predefined requirements on indoor environment and energy use performance are reached, i.e. that none of them is reached on too high expense of another. The essential elements of the process are illustrated in figure 1. It is based on a policy for retrofit actions, indoor environment and energy use defined by the organization. Two main parts can be distinguished in the process:

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

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

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

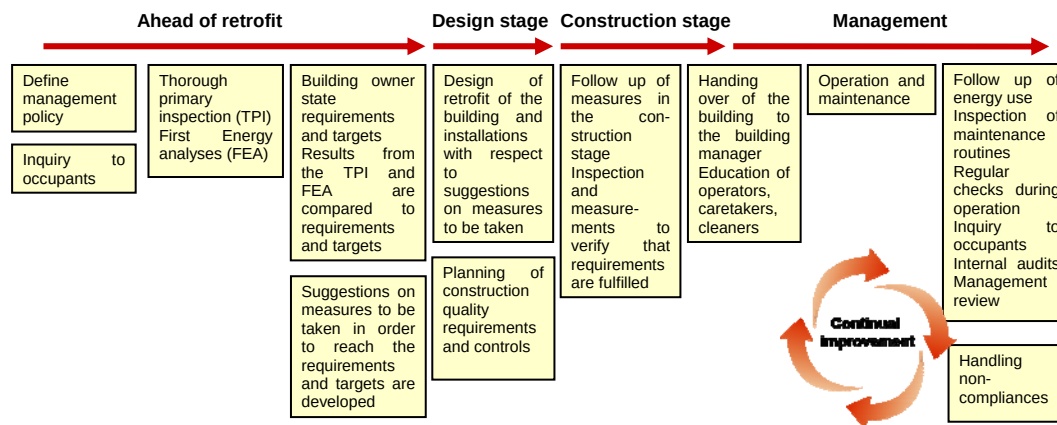


Figure 1. A quality assurance system for indoor environment and energy use adapted to the retrofitting process of social housing.

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

The procedures, document control, plans for improvements in energy efficiency and indoor environment and presentation of results as used in these rules follow the same logic structure as set out in SS 62 77 50 and in Draft prEN16001.

2 Quality assurance system requirements

2.1 Organizational requirements

The organization shall:

- define a policy for indoor environment and energy use
- start to establish, document, implement and maintain the QA system according to the following description
- define and document the scope and the boundaries of the QA system
- determine and document how the system will meet the requirements on the system itself and the technical requirements in order to achieve continual improvement on energy performance and maintain or improve the indoor environment conditions.

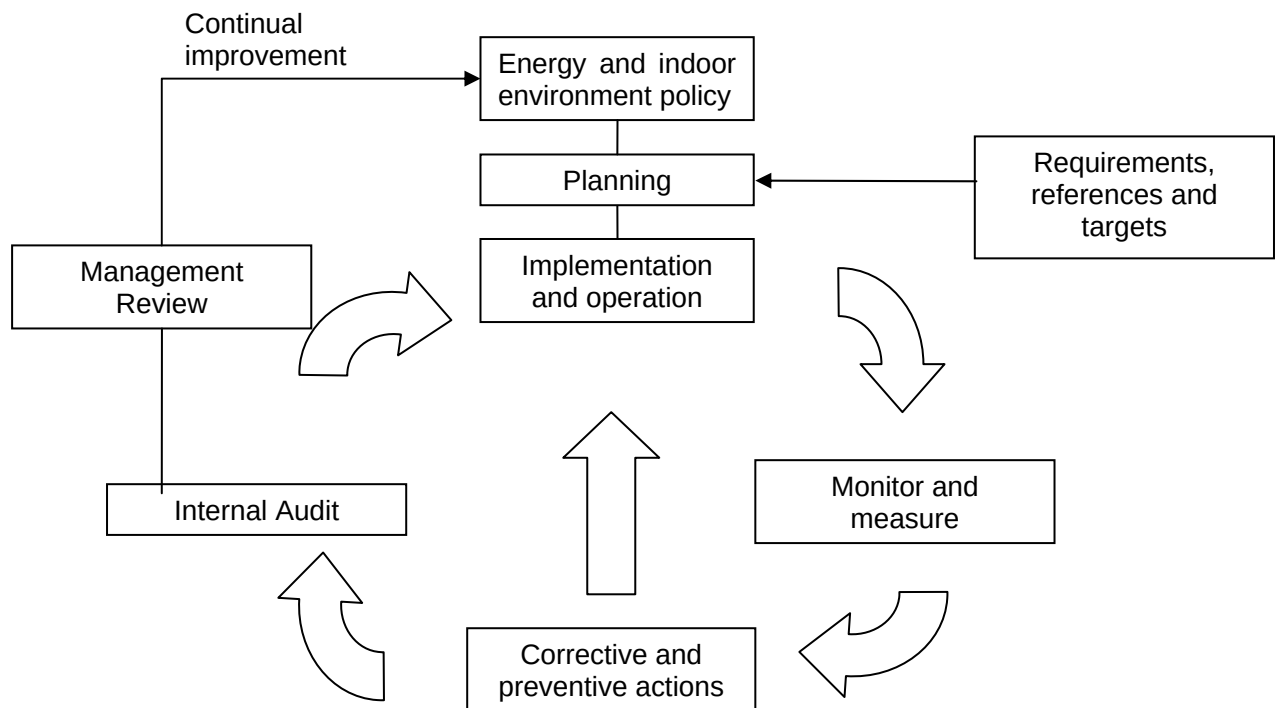


Figure 2. Energy and indoor environment QA system model.

2.1.1 Defining a quality policy

As already mentioned the quality assurance system shall build upon and reflect the organization's policy for indoor environment and energy use. To start with, the top management of the organization shall therefore establish, implement and maintain a policy for retrofit actions, indoor environment and energy use. This policy shall state the organization's commitment for achieving improved energy performance and maintained or

improved indoor environment through retrofit of social housing. The top management shall ensure that the policy:

- covers all energy and indoor environment aspects;
- is appropriate to the nature and scale of, and impact on, the organization's energy use;
- provides the framework for setting and reviewing energy and indoor environment targets
- includes a commitment to ensure the availability of information and of all necessary resources to achieve objectives and targets;
- includes a commitment to comply with all applicable requirements relating to its energy and indoor environment aspects; whether legally required or agreed on by the organization;
- is documented, implemented, maintained and communicated to all persons working for and on behalf of the organization;
- is regularly reviewed and updated;
- is available to the public.

2.1.2 Defining responsibilities

It is the organization's most senior management that is ultimately responsible for the retrofit actions, the indoor environment and energy use. It shall appoint a person having main responsibility (operative) for both the indoor environment and the energy use system within the organization.

The housing organization's organisational structure, with clear details of who is responsible, and who has authority, for each part of the organization, shall be defined, documented and communicated. Further, within each part of the organization, there shall be documentation defining who is responsible for the main part of the retrofit actions, for the indoor environment and for the energy use systems.

2.2 Procedure requirements

Procedures shall be prepared and kept up to date for guidance and control of activities, covering planning, operation and monitoring of the retrofit process and of the retrofitted buildings. In general a documented procedure should be prepared for each main type of action carried out, describing in some detail the contents of the action, what are the requirements of the QA system on the action, which records should be kept when performing the action etc. Requirements and recommendations for the specific procedures are described in section 4.

2.3 Documentation requirements

Documentation in the system covers the above mentioned procedures plus records (e.g. describing the results of adjustments, measurement readings etc.), templates (describing standardized formats for some of the records to be kept) and documentation describing the buildings and their supply systems. The specifics regarding documentation and document control are described in section 6.

3 Functional requirements and targets

The **functional requirements** should be acknowledged and applied by all those who work on and/or are **involved in the retrofit process** (architects, planners, construction companies, building service companies) and **subsequent administration/operation** (property management, occupants) of the building.

They help the organization to set targets for the building's indoor environment and energy use, in the case of retrofitting projects.

The targets shall be used by the **designer and architect** to ensure that the building achieves the intended quality. The **construction contractor shall ensure that the building fulfils the functional requirements** in order to ensure that the quality of construction is as intended, while the **property manager** as a representative of the organization shall ensure that the indoor environment remains at a high quality level in subsequent use.

3.1 External requirements on indoor environment

It shall be possible to verify all functional requirements by means of (preferably easily performed) measurements. The example requirements set out in Appendix 1 concerns thermal comfort, air quality, radon, ventilation, moisture resistance, air tightness, noise, light and domestic hot water. Organization- or building-specific requirements may be added to these. Further requirements that the organization could consider for any particular building could, for example, include anti-allergenic design/construction or materials recycling considerations.

Any voluntary requirements or undertakings that the organization has elected to apply shall be tested or measured using methods approved on by the organization. For requirements on the measurements, see 7.

3.2 External references or requirements for energy use

The energy targets to be defined cover all forms of energy supplied to the building or type of building as needed in order to maintain the required functions in terms of indoor climate, building services systems and activities in the building. They shall be built upon any applicable building codes as a minimum level. In addition to these the organization should examine financial implications of various further reaching requirements. It should aim at introducing additional, more strict requirements when such requirements are found technically feasible and economically or policy wise motivated. Energy input is described in terms of auxiliary electricity, heating and cooling, with heating and cooling further broken down into the different forms of energy. The requirements also extend to the associated greenhouse gas emissions (defined as CO₂ equivalents).

3.3 Defining requirements for the retrofit

For buildings to be retrofitted, requirements shall be set and documented for each specific building or groups of buildings. The energy requirements shall be observed by the designers, architects and contractors working on the retrofit of the buildings. Sometimes it is wise to set up targets that are tougher than legal or other requirements. Two values should then be defined, one that must be reached and another that is desired to reach. This approach is valid for the retrofit process as well as for the following use of the buildings.

Examples of such requirements or targets are:

- Energy requirements and targets for the buildings under consideration of the indoor environment
- Quality requirements and targets for the construction process
- Performance requirements on critical components

The representative of the organization carrying the main responsibility for the retrofit shall make sure that these targets and requirements are followed up through the design and construction process. This is done according to the procedures for renovation concept development (4.2) and for measurements and checks during construction (4.3).

3.4 Defining targets and requirements for indoor environment and energy use

The organization shall have a programme to establish objectives for the building management, shall define and document the targets and the requirements for energy use and indoor environment and shall set guide values for how to reach the targets. Programmes/procedures or plans shall be prepared for each building, type of building or part of the organisation.

It shall be the responsibility of the **property manager** as a representative of the organization to ensure that the targets are met during occupation/use, while also maintaining the building's functional requirements in terms of indoor environment *etc.*

Energy targets, representing the amount of energy use that must not be exceeded when the building is in use are defined in accordance with requirements as set out in Appendix 2. The organization may add special voluntary targets, tougher than the requirements, for particular components, for the whole or parts of the building to them.

The energy targets shall help the organization to ensure that energy use during occupation/use does not exceed the intended values.

4 Quality assurance procedures for the retrofit

The fulfilment of several of the energy and indoor environment requirements and targets in the operation phase will depend on a successful retrofit of the buildings. Specific procedures for the preparation, planning and supervision of the retrofit process will thereby help the organization to assure its quality.

4.1 Baseline inquiry and analysis

Technical investigations of the indoor environments and energy use are required as a basis for introduction of the QA system. The investigation includes the thorough primary investigation (TPI) and the first energy analysis (FEA).

The technical supporting documentation for the quality assurance system are:

- the results from these investigations together with the measurements and calculations made by the organization,
- target values and requirements for indoor environmental conditions and energy use

The results of the TPI and the FEA will be the basis for the retrofit planning process and operation of social housing.

4.1.1 Thorough primary investigation - TPI

The TPI consists of a survey and preparation of an inventory of the building, and of a questionnaire to the occupants.

The results from the TPI are the basis for preparation of the retrofit plan.

The indoor environmental status of the building is determined through *inspection and* measurement. This investigation may be carried out on one particular building, or on groups of buildings of the same technical design and with similar heating and ventilation systems. Measurements must be made to check if legal requirements are being fulfilled, and if subsequent requirements and regulations such as e.g. limitation of radon, PCB or formaldehyde concentrations, are also being fulfilled. Requirements on indoor environment, see Appendix 1. There must be a plan for the number or proportion of apartments or premises to be surveyed, covering not less than about 20 % of the total number of apartments etc. and comprising a representative cross-section of the apartments etc.

A questionnaire survey on indoor environment conditions before retrofit should be carried out among the occupants.

Shortcomings or faults identified through TPI must be dealt with. The presentation of results of the survey shall include the results of the inspection.

4.1.2 First energy analysis – FEA

FEA consists of a **presentation of an inventory/survey of the building** or building stock, with details of its **present energy status, energy aspects and energy performance**.

This inventory/survey can consist of material from

- drawings, (structure and U-values of building components, potential thermal bridges)
- operational monitoring programs,
- supervisory systems,
- other documentation,
- inspections,
- interviews with operating personnel and
- any complementary measurements.

The material must also include descriptions of shortcomings and faults that have been found in physical systems, information on earlier energy efficiency improvement work and details of the most recent adjustments etc. of heating, water, ventilation and other systems.

The results from the FEA shall provide a basis for deciding on energy requirements and targets and for a retrofit plan, together with reasons for the various choices.

The FEA also provides a basis for an energy declaration of the building(s). In Sweden, such energy declarations have been used as a tool in the implementation of the EPBD.

Clarification of the various parts of the FEA

The **description of the building** or types of buildings contains the name(s) of the building(s), its/their details on the property register, the building category, address, the name of the property-owner and building data (floor area, year of construction etc.).

Energy status is a description of the technical design and standard of the building envelope, climate screen and building services systems (U-values, structure of building components, heating, cooling, ventilation, water, lighting and control systems).

Energy aspects are presented in the form of a description of the local environment (microclimate), activities and conditions that can have a significant effect on energy use in the building.

Energy performance refers to energy input for heating and cooling, with auxiliary electricity separately accounted for, and with heating and cooling further broken down into figures for different forms of energy carriers or sources.

The material must include historical data for energy supplies, with energy use that varies as a result of varying ambient conditions having been corrected to corresponding values for a statistically average year.

4.2 Renovation concept development and analysis

In order to assure that all the shortcomings and faults identified in TPI and that the framework conditions assessed in FEA are carefully integrated in the retrofit planning, the organisation should develop a procedure describing how this shall be done.

The retrofit measures have to be determined in order to:

- improve indoor environment (increase of temperatures of inner surfaces, guarantee of adequate supply air volume,...)
- remove construction damages
- minimize thermal bridges (to avoid moisture damages and mould growth)
- minimize ventilation heat losses (close air leakages, efficient heat recovery)
- minimize transmission heat losses (insulation of exterior walls, high-performance windows, etc.)
- Increased share of renewable energy input
- enable continuous monitoring of energy performance parameters through proper instrumentation
- encourage “energy wise” behaviour of the occupants e.g. by means of separate temperature control and metering of hot water and electricity per apartment

Increasing the share of renewables should always be considered- but always as a complement, to be introduced once the energy efficiency has been thoroughly analysed and optimized.

Beside the construction supervisor, who is hired by the organization to supervise the construction works, the “*person having the main responsibility for retrofit actions, indoor environment and energy use*” should participate in each construction meeting during the retrofit process and communicate to the construction companies the influence of their work on indoor environment and energy use.

Targets and requirements for energy use and indoor environment defined for the retrofit should be highlighted at a start up meeting and monitored through the design and construction process. Specific requirements of the organization, requirements exceeding the current practice or legislation should be given particular attention during this cooperation.

Other means for improving the quality of design in the context of construction meetings are e.g.:

- Presentations and discussions on new energy efficient construction concepts and products
- Presentations on methods for measurements and checks during construction
- Consensus decisions on details in the design process

Additional effort should also be spent on the selection of a contractor for the retrofit project. The contractor should have a good understanding of the importance of high quality in the construction work in order to reach the specific targets and requirements for

energy use and indoor environment. Interviewing the bidders in the project could thereby bring forward useful information in addition to the standard selection procedures.

In order to facilitate the analysis of the renovation concept to the organisation, the contractor should be requested to account for how requirements on indoor environment and energy use shall be fulfilled. This can be done through calculations or simulations on representative parts of the building(s).

NOTE: If top of the line components are specified for critical parts of the retrofit, e.g. extremely well insulated windows, air diffusers with very low sound levels etc., additional third party quality or performance checks may be required.

NOTE: The better insulated the building becomes, the more critical are the requirements on indoor sound levels and increased attention must then be given to sound damping in between apartments, from ventilation systems etc.

4.3 Measurements and checks during construction

In order to keep additional costs down, if the renovation contractor has a mature QA system for control of the building process or is known to the organization, it may be trusted to carry out the main part of measurements and checks during the construction. The contents of these should be agreed upon during the design process and the outcome of all checks and measurements should be documented. A representative of an independent part can then perform sample tests on a limited number of apartments or parts of the buildings.

Examples of such measurements and checks are e.g.:

- measurement of air tightness in each apartment
- sample measurements of moisture content in various construction parts
- sample measurements on sound levels

5 Quality assurance procedures for the property management

5.1 Planning of operation and maintenance

Operational planning (for day-to-day normal operation) shall specify the activities that it covers, and who is responsible for them. If this involves the service of contractors, care must be taken to inform the contractor about the system in order to ensure that the system will be fulfilled.

Inspection and maintenance plans shall be documented, shall contain time plans and shall cover a period of at least five years.

5.2 Operation and maintenance

Procedures for maintaining the indoor environmental conditions and reaching the energy use targets shall be documented. Operation and maintenance instructions shall be prepared for the building or type of buildings and its/their technical systems. These instructions shall also include instructions for cleaning the premises, inspection (calibration) of meters and sensors, and regular inspection and adjustment of technical systems. The results shall be recorded. The instructions shall include clear and simple descriptions of functions and lists of system components (functions, position, instruction manual, setting values) and, when applicable, acceptance criteria. In addition, they shall include details of procedures for evaluation of energy use in connection with the purchase of system components and/or energy-demanding equipment or with renovation of the building. Checklists shall be designed in such a way as to assist follow-up and maintenance. The results of inspections, service visits and other work carried out shall be recorded and saved.

NOTE: If the organization decides to outsource part(s) of the operation and maintenance services the procedures and their requirements regarding records etc are still relevant. However in such cases the procedures must focus on more general requirements and should be coordinated with the internal procedures of the service provider.

5.3 Monitoring, metering and measurements

Text Residents or users shall be kept informed of how they can affect the indoor environment and energy use. There shall be procedures to ensure that relevant views from residents or users concerning the indoor environment or improvements in energy use are accepted, examined and documented, and that appropriate actions are taken to deal with departures from approved performance levels. Residents' views can be obtained via questionnaire surveys. Questionnaire surveys should be carried out at least every five years, although the organization may require them to be held more frequently. An example of such a case is if a building did not fulfil the technical requirements, but the surveys have shown that the proportion of complaints was nevertheless less than 20 %. The history of earlier complaints shall be considered when deciding on survey intervals.

By having short operation rounds carried out once a month in each building, the organization can be notified early on deviations from targets and general problems related to energy use and indoor environment. Points of attention for such rounds are e.g.:

- Indoor air temperature
- Moisture problems/ leakages
- Hot water temperature
- Cleaning
- Function of central heat and electricity meters

Energy targets shall be monitored monthly, by means of metering energy use for electricity, heating and cooling, with quantities for heating and cooling being broken down into those for the various types of energy used (space heating and tap water heating). The resulting associated greenhouse gas emissions shall be calculated and expressed as CO₂-equivalents. The monthly figures shall be collated into an annual report and be compared with the energy targets defined in accordance with the requirements as set out in Appendix 2.

Voluntary energy requirements shall be checked preferably when they are introduced into the energy management system and monitored on a regular basis.

Tests or measurements shall be performed using methods and equipment approved by the organization, preferably (and if possible) using the same instruments as used for billing of energy use. It shall be possible to verify all energy targets and voluntary energy requirements for individual parts of the building(s) by means of measurements and complementary calculations.

NOTE: If the organization itself does not hold the necessary competence for extensive measurements, data compilation and evaluation it may consider outsourcing this task to an external partner.

NOTE: Cases may occur in which the organization does not have access to the meter readings for electricity use by individual occupants, due to commercial or other confidentiality requirements. If, in such cases, the occupant shall be requested voluntarily to notify his energy use quantities, pointing out that it ought to be in the occupant's interests to learn whether his electricity use is unnecessarily high.

5.4 Non-compliances, corrective and preventive actions

5.4.1 Non-compliances, corrective and preventive actions for the indoor environment

There shall be procedures for dealing with faults, shortcomings and non-compliances revealed by measurements, questionnaire surveys or complaints. Resources shall be assigned and available for preventive actions and to deal with faults as quickly as possible.

All complaints shall be investigated, even if questionnaires show that more than 80 % of respondents are satisfied.

The reasons for complaints in questionnaire surveys shall always be investigated. Even if the proportion of complaints is less than the 20 % level that is regarded as acceptable, the

property manager must make sure that the complaints are not caused by damage to the building structure, poor ventilation etc. that must be corrected.

5.4.2 Non-compliances, changes in quantities, corrective and preventive actions for energy use

There shall be procedures for rectifying faults, shortcomings and non-compliances identified during operation, maintenance or in energy audits.

Resources shall be made available for dealing as quickly as possible with larger non-compliances and for applying preventive measures.

Changes in energy use revealed by monthly monitoring that exceed $\pm 10\%$ (compared to previous year starting with year 1 after renovation) shall be documented, with an initial analysis of the cause and details of any actions taken.

Changes in annual energy use that exceed $\pm 5\%$ (compared to previous year starting with year 1 after renovation) shall always be investigated. The property manager must determine whether the change has been caused by (for example) damage to the building structure, poor indoor environmental conditions (ventilation etc.) or damages to measurement equipment that needs to be dealt with. Details of the change, and of its investigation, shall be documented, together with details of plans for dealing with it (if so decided) and subsequent monitoring. If the change is of a less important character, or if there is some relevant temporary reason for it, the situation shall be looked at again to check that it has been put right within twelve months.

If no action should be taken, as a result (for example) of changes in the energy aspects such as in activities or businesses (other energy use being required for maintaining the indoor environmental conditions), the energy targets shall be reviewed. If the investigation shows that necessary actions cannot be taken within twelve months, a more long-term action and monitoring plan shall be prepared.

It is assumed that any regulatory requirements that applied at the time of construction of the building, together with any that may have been subsequently applied by the authorities are complied with. Any non-compliances shall be justified, and the occupant shall be informed of them.

5.5 Communication and information flows

The organization shall have procedures for ensuring that information on relevant legislation and other requirements is brought to the notice of personnel who need to know. In this respect, the legislation and other requirements that are particularly important are e.g. the National building codes, any environmental framework codes, Directive Concerning the Energy Performance of Buildings (EPBD, 2002/91/EC) and maintenance procedures connected to legal requirements for building services systems.

Procedures shall be prepared, and shall be kept up to date, for:

- a) internal communication between different levels and functions in the housing association/organization /owner 's own organisation, and

- b) the reception, documentation of and responding to relevant views from external parties, e.g. tenants and the mass media.

5.6 Education and training of staff

There shall be methods and requirements for qualification of personnel for various duties. Programmes shall be prepared for meeting the needs of training of personnel: not only general training, but also that as needed for those functions that require special competence. Examples of the latter include personnel for operation and maintenance if such personnel are part of the organization and the service is not externally procured. There shall be procedures for ensuring that all personnel are aware not only of the requirements imposed by the indoor environment and energy use system, but also of the opportunities, roles and responsibilities for achieving the requirements within the organisation and through individuals' own work.

5.7 Internal audits

Audits shall be carried out, in accordance with documented procedures and programmes, in order to monitor the efficiency of the indoor environment and energy use system. The procedures shall describe how check measurements and questionnaire surveys are applied according to an audit plan in order to provide feedback to the organization.

The persons performing the audits shall possess the necessary knowledge of the particular working area concerned and of the associated management system functions. Such audits shall be performed at least once a year within each part of the organisation, and the results shall be documented and archived.

5.7.1 Internal audit of indoor environment

Check measurements shall be made, in accordance with documented procedures, to monitor that indoor environmental conditions and functional requirements are being maintained.

Audit plans shall ensure that all apartments or premises are inspected during a certain period of time, e.g. a five year period. The results of measurements shall be recorded and kept.

Questionnaire surveys of the residents shall be carried out at certain time intervals as set out in the auditing plan for correction and comparison between measured and as-experienced conditions.

5.7.2 Internal audit of energy use

Checks to ensure that energy targets and voluntary energy requirements are being met shall be carried out in accordance with a documented audit procedure.

Audit plans shall require the technical systems in the building or the building stock of the same type to be inspected by means of a service inspection involving updating of the description of energy aspects, measurement, adjustments and maintenance. This should be carried out within a certain period of time, e.g. during a five year period. The results of measurements shall be recorded and kept.

5.8 Management reviews

Each year, the organization's senior management shall review the indoor environment and energy use systems in order to ensure their continued efficiency and suitability. In connection with these reviews, the management shall review and make any **necessary decisions** concerning the organization's energy use policy, indoor environment policy and targets and guide values, as well as review the necessary resources for introduction and operation of the systems. The results of these reviews shall be recorded.

The material examined for the management reviews includes records from internal audits, as well as complaints and the results of questionnaire surveys.

In addition, the potential for constant improvement is considered through the use of record material from system monitoring and analysis of energy targets containing updated reference values for similar buildings, energy aspects and other changed conditions for the energy use.

6 Documentation and document control

The organization shall prepare and maintain a general set of information as needed to:

- a) describe how several retrofit actions are intended to improve indoor environment or energy use
- b) describe the main parts, elements and features of the indoor environment and the energy use QA system, together with their associated procedures;
- c) provide necessary references to related documentation;
- d) identify and describe which buildings are covered by the system.

6.1 Document control

Procedures shall be prepared, and kept up to date, for identification and management of all instructional and descriptive documents that are needed in accordance with these rules. These documents shall be kept in such a manner that they can be easily found.

6.1.1 Controlling/governing documents

Examples of controlling documents include procedures, instructions and check-lists.

6.2 Buildings and supply systems' documentation

All physical properties, construction details and drawings of the buildings, a list of the buildings and all equipment used for the buildings' supply systems shall be documented and kept in the QA system. Information on technical systems should contain details of suppliers, functions, warranty periods and maintenance/service. Particular attention should thereby be given to maintenance requirements that should be integrated in the maintenance procedures.

6.3 Records

Records of all regular activities shall be produced and kept in the QA system. Records are used to verify that targets and requirements are met, to back trace adjustments, calibrations, services etc, to keep track of product and service warranties etc.

Examples of essential types of records to be kept are e.g.:

- records from adjustments of technical systems, ventilation inspections, indoor climate condition audits, calibrations
- records about retrofit measures
- supplier bills and warranty cards
- records from monthly metering/reading of energy use
- records from monthly monitoring of energy use, including reports of changes in energy use, with an initial analysis report and information on any actions taken

- an annual collation of monthly monitoring, with information on changes, analyses and planned and completed actions
- records from maintenance and service visits
- energy efficiency improvement measures that have been taken, with details of results
- list of staff competencies, training needs and training courses carried out
- records from internal audits
- records from management reviews
- discrepancy/fault reports

6.4 Templates

Model forms or templates (typical examples) for some of the records shall be prepared, showing how the documents are to be identified, used and archived. This is to assure that different data and information inputs are recorded in a systematic way.

Example templates are:

- template for indoor environment questionnaire
- template for records from adjustments, indoor climate condition audits, calibrations
- template for records about retrofit measures
- template for records from monthly metering/reading of energy use
- template for records from monthly monitoring of energy use, including reports of changes in energy use, with an initial analysis report and information on any actions taken
- template for an annual collation of monthly monitoring, with information on changes, analyses and planned and completed actions
- template for records from maintenance and service visits
- template for records from internal audits
- template for records from management reviews
- template for discrepancy/fault reports

6.5 Procedure documents

The procedures (plans, checklists etc.) governing the organizations' quality control of the retrofit process and the operation of the buildings shall be documented and stored in the system. Essential procedure documents are:

- procedures or check lists for the baseline inquiries-TPI and FEA
- procedure for the follow up on the design process
- procedure for measurements and checks during construction including check lists
- maintenance plan for technical systems in the building or type of building including check lists
- procedure for monitoring, metering and measurements
- property and building maintenance plans including check lists
- procedures for dealing with faults and complaints

- plan for information flows within the organization
- plans for internal audit and management review

7 Methods for monitoring, metering, measurements, and tests

Measurements and metering shall as far as possible be done according to approved, standardised methods using quality approved and calibrated instruments. International (ISO/ IEC etc.) standards should be used in the first place, European standards (CEN/ CENELEC) if international standards are not available and National standards if neither International or European standards are available. The same applies in general to the approval of instruments used.

More specific requirements and recommendations for selection of methods and equipment are given in the guidelines to this document.

7.1 Measurements of indoor environment parameters

Temperatures (air, temp. profile, floor temp, operative temp and domestic hot water temp.), humidity (relative), noise and air currents are examples of central parameters to be measured when monitoring the indoor environment. Additionally measurement of moisture ratio in structural parts can be used to assess the quality during construction.

Expert assistance may be required for some of these measurements.

7.2 Heat, electricity and water metering

Measurements shall be performed using methods and equipment approved by the housing organization according to the requirements stated above, preferably (and if possible) using the same instruments as used for billing of energy use. Where energy quantities used by individual users (apartments) are separately metered they should be summed to aggregated values for the whole building.

7.3 Measurements of air tightness and air flows

Extensive check measurements of air tightness and ventilation air flows are essential for assuring the quality of a building aiming for a high energy performance, a good indoor environment and a durable construction. They shall be performed using methods and equipment approved by the housing organization according to the requirements stated above.

As previously mentioned, a qualified construction company can be trusted with the majority of these measurements and the organization can have an independent part carrying out sample checks of these measurements.

The ventilation systems of a building must be designed so that check measurements of air flows, at least on the level of individual apartments, can easily be performed when the system is in operation.

7.4 User questionnaires

Questionnaire surveys are used to get feedback from the building users, mainly regarding their perception of the indoor environment. In order for the questionnaires to be an efficient tool in the QA process, they must be designed with great care and focus on essentials, in order to give unambiguous results that are easily compiled. The organisation may consider using a professional for the design of questionnaires.

8 Third party certification

As an option for moving the Quality assurance process one step further, third party certification can be considered. The organisation will then get a certificate showing it's commitment and ability to fulfil a specified set of requirements. This requires that there is an institution, preferably but not necessarily inside the country, that can perform the certification and that a set of certification requirements are at hand. The contents of the latter are to a large extent covered by the present document, but they would need to be complemented for example by rules governing:

- the certifiers' assessment of the results of TFI and FEA
- sample measurements made by the certifier, with the aim of verifying the measurements made for the TFI and FEA.
- assessment of the indoor environment and energy use system after an initial examination of documents
- a site audit
- interviews and checks of how procedures etc. operate
- external audits and reviews

Any voluntary requirements or undertakings that the company has elected to apply shall be tested or measured using methods approved by the certifier. The approval/acceptance criteria shall be as agreed by the company in conjunction with the certifier.

Once a year, the certifier will normally make sample-based technical measurements and audits of the management system.

The certifier may perform further inspections in order to decide whether important shortcomings have been put right.

9 References (examples)

BBR 12 Boverkets byggregler, BFS 2006:12. (Building regulations of the National Board of Housing, Building and Planning)

BVL, Law about technical quality requirements of buildings

Classification of indoor climate 2000. Target values, Design Guidance and Product Requirements. Finnish Society of indoor air quality and climate. Building information foundation RTS.

EN 12464-1 "Light and lighting - Lighting of work places – Part 1: Indoor work places"

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

ISO 9001:2000 Quality management systems-Requirements

ISO 14001:2004 Environmental management systems- Requirements with guidance for use

SFS 2006: 985, the law about energy declarations of buildings.

SS 62 77 50, Swedish Standard 62 77 50, Energy management system –specifikation, SIS Swedish Standards Institute, 2003.

The Obligatory Ventilation Inspection Ordinance (Lagen (1994:847) om tekniska egenskapskrav på byggnadsverk)

The Environmental Framework Code

The Work Environment Act

Wahlström, Å., Ekstrand-Tobin, A.: "Quality assurance of indoor environment and energy use", Proceedings of the *7th Symposium on Building Physics in the Nordic Countries*, pages 1041-1048, Reykjavik, June 13-15, 2005.

Wahlström, Å., 2003, Environmental assessment of energy systems for heating in dwellings, Proceeding of *ISES Solar World Congress 2003*, Paper no. O6 8, Gothenburg, Sweden, June 14-19.

A Requirements on the indoor environment (Swedish example)

The following requirements relate indoor environmental conditions in existing and new buildings. In addition to the function requirements, questionnaire surveys are used in order to obtain the views of users on the indoor environment. In existing buildings, in certain cases (which are indicated in each section) the requirements that applied when the building was constructed, can be accepted: however, this is conditional upon a sufficient proportion of users (> 80 %) being satisfied with the indoor environment in their overall assessment. Nevertheless, all complaints shall be followed up even if the proportion of complainants is less than 20 %. The replies to surveys are a useful aid to identifying faults when carrying out the Thorough Primary Inspection.

A.1 Thermal comfort

The values given in the following table relate to the building's occupancy zone which, in this context, is regarded as being an area bounded by a line 0.6 m from the outer wall and extending in height from floor level to 2.0 m above floor level. The requirements given in the table are largely in accordance with those given in the heating, water and sanitation technical association's rules 'R1 Classified indoor climate systems - Guidelines and specifications', of thermal quality class TQ2.

Factor	Requirements	References
Overall rating***	> 80 % satisfied	
Air temperature	20-24 °C */**	R1, TQ2
Temperature gradient	<3 K/m	R1, TQ2
Operative temperature, winter	20 - 24 °C */**	R1, TQ2
Operative temperature, summer	20 - 26 °C */**	Modified R1, TQ2
Floor temperature in the occupancy zone	19-26 °C > 16 °C	Retrofitted building, R1, TQ2 Existing building
Air velocity	<0,15 m/s (in winter at 20 °C) <0,25 m/s (in summer at 26 °C)	R1, TQ2 R1, TQ2
Radiation asymmetry	< 10 K (measured 0,6 m above floor level)****	R1, TQ2

* Most people regard thermal conditions within this temperature range as comfortable, but not everyone likes the same temperature. What can be comfortable for one person can be too hot or too cold for someone else. A good environment is therefore one that makes it possible for occupants to control their own indoor temperature.

** Other values can be temporarily accepted during periods of extreme outdoor conditions. During the summer, the indoor temperature may not be more than 3 °C higher than the outdoor air temperature.

*** To be valid, an overall rating based on the results of a questionnaire survey requires a sufficient number of respondents (normally at least 20) and a sufficiently high response rate (normally > 70 %). A suitable question in this context can be "What is your opinion of the thermal comfort in your apartment during the summer/winter on the whole?"

**** Corresponds to the requirement of <5 K operative temperature difference according to BBR.

A.2 Air quality

Factor	Requirement	References
Overall rating*	> 80 % satisfied	
Formaldehyde	< 50 µg/m³ under normal conditions	
Volatile organic compounds (VOC) and odour	There are no guidelines for individual VOCs. However, elevated concentrations can indicate (for example) moisture damage. Unpleasant smells or the smell of mildew from/in the building cannot be accepted.	SOS Notice no. 4/98
NO _x , mg/m ³	Values exceeding the limit values for outdoor air cannot be accepted. ** A special extraction shall be provided if the apartment etc. contains a gas cooker or other gas appliance.	R1/AQ2, AFS 2000:42, SOSFS 199:25 Skall de vara med?
Carbon dioxide, CO ₂	<1000 ppm. Under normal conditions.	
Carbon monoxide, CO, mg/m ³	Values exceeding the limit values for outdoor air cannot be accepted. **	
Particles, □ g/m ³	Values exceeding the limit values for outdoor air cannot be accepted. **	

* To be valid, an overall rating based on the results of a questionnaire survey requires a sufficient number of respondents (normally at least 20) and a sufficiently high response rate (normally > 70 %). A suitable question in this context can be "What is your opinion of the air quality in your sitting-room / bedroom / apartment on the whole?". Respondents can be assisted in qualifying their air quality by such questions as "Do you notice any of the following odours in your apartment: a sharp acid smell / mildew / stuffiness / stale air?".

** WHO publishes guidelines for maximum permissible values for outdoor air quality. Exceptions apply if the outdoor air, despite suitable positioning of air intakes, contains higher concentrations than the permitted values.

*** A new EU directive value for PM 10 applies from 2005-01-01. Om uteluften på grund av olämplig eller trots lämplig placering av luftintag kan förväntas överskrida dessa värden under längre perioder och upprepade gånger under ett normalt år så skall luften filtreras så att gränsvärden ej överskrids i tilluften.

A.3 Materials

This table provides advice on the choice of materials in respect of their potential emissions.

The inherent emissions and materials contents of surfacing materials, such as floor coverings, wallpapers, ceiling boards and paints, as well as formless materials such as adhesives, fillers and mastics, should be declared in accordance with the relevant industry sector standards or construction materials declaration regulations. Instructions for use, together with any restrictions or limitations, shall be stated, e.g. maximum moisture content, suitable pH values, maximum and minimum temperatures or limitations concerning combinations with other materials, together with advice on care and maintenance.

The following considerations should dictate the choice of materials:

- choose the material or product which, within its group, has the lowest emission level
- do not choose materials for which the declaration of contents states that they contain substances that are classified as allergens, or which in some other way can affect health or comfort
- choose materials that are suitable for the intended environment .

A.4 Radon

Factor	Requirement	References
Mean value of indoor radon concentration	< 200 Bq/m ³	Building Regs. (2002) 6:223 new building, SOSFS 2004:6

A.5 Ventilation

Property/ function	Requirements and recommendations	References
Outdoor air flow	Unless otherwise required as a result of activities or businesses in the building, residential apartments, offices, schools and child day-care centres shall be ventilated in relation to the number of occupants at a rate of at least 7 l/second per person and in relation to the building's emissions at a rate of at least 0,35 l/s per m ² *. It shall be possible to force the ventilation rate in kitchens and bathrooms. There shall at all times be a basic ventilation flow that ensures that air flows in the correct direction in the duct system, or a system or systems that prevents air flow in the wrong direction.	AFS 2000:42 §20 BBR 2006 avsnitt 6:25 SOSFS 1999:25
Efficiency of air exchange	Lokalt ventilationsindex >90% enligt NT VVS 114 or > 40 % efficiency of air exchange according to NT VVS 047	BBR 12 (BFS 2006:12)
Airtightness	Ventilation ducts shall be of airtightness Class C (or better)	VVS-AMA 98 table 57/1
Recirculation of extract air	Extract air systems in buildings shall be designed so that unpleasant smells or pollutants are not recirculated into the building's air intakes, openable windows or to nearby buildings.	AFS 2000:42 §20
Recirculated air	Recirculated air should not be used. However, within one and	AFS 2000:42 §20

Property/ function	Requirements and recommendations	References
	the same apartment, it can be permitted from a cleaner to a less clean area if it can be shown that this does not result in a deterioration of air quality.	BBR 2006, 6:25
Flexible ducts	It shall be possible to inspect ducts and to replace them if necessary.	
Filtering the supply air	It may be necessary to use Class F7 air filters and gas filters to remove particulates and gases from the supply air in balanced ventilation systems. If such filters are necessary, they shall be P-marked.	
Pressure difference	Unintentional air leaks may not introduce dirt into clean areas. The pressure conditions in the building shall be controlled such that undesirable effects caused by inward leakage of fouled air or outward leakage of moist air that could cause condensation do not arise.	
Condensation	Building services systems shall be so run or insulated that damage caused by condensation does not occur.	
Operating instructions for users	Instructions shall be provided, describing how the ventilation rate can be increased (forced), how the apartment or premises should be aired, and how the air terminal devices should be cleaned without altering their settings.	
Operation and maintenance, property caretakers	Written instructions shall available in the building, describing how the system shall be operated and maintained. Ventilation systems and components shall be accessible for cleaning, and it shall be possible to clean them without damaging them.	

* This means that homes, schools, child day-care centres and other premises may need demand-responsive ventilation, i.e. that the ventilation rate is higher when the premises are occupied than when they are empty.

A.6 Moisture safety

The current relevant requirements for new buildings, as set out in the Building Regulations, BBR 2006, Chapter 6, in HusAMA-98, Chapter HSD (moisture safety) and in BBR 2006, Chapter 9 (airtightness), applies for new buildings and major retrofitting projects. Moisture damage in buildings are a risk for human health, SOSFS 1999:21 (M).

Designs shall be suitable for withstanding the expected moisture loads, and the construction process shall ensure protection of materials and structures against damaging dirt and moisture.

For buildings to be retrofitted, structures shall be surveyed for risk areas (designs) and damage, using a checklist.

Part of the building	Requirement	Suggested method/tools
Roof, walls and foundations including connections and lead-throughs	Moisture safety design should be carried out and documented	ByggaF - A method for introducing moisture safety in the building process. Templates, checklists are available at www.fuktcentrum.se .
Wet areas	Protected against water damage in accordance with applicable industry sector rules	Solutions for water safe installations should be used. More information is available at www.sakervatten.se and Bygg vattenskadesäkert – Vaska visar vägen

A.7 Air tightness

The air tightness of the building is important to ensure good thermal comfort for example to avoid draught, good air quality, low energy use and to decrease the risk of moisture damages due to convection. Air tightness could also be required for separate rooms or apartments or fire cells to meet fire safety requirements.

Part of the building	Requirement	Suggested method/tools
Air tightness of the building envelope	Air leakage should be $< 0,8 \text{ l/s, m}^2$ at a pressure difference of $\pm 50 \text{ Pa}$ for buildings with exhaust air ventilation. $< 0.6 \text{ l/s, m}^2$ at a pressure difference of $\pm 50 \text{ Pa}$ for buildings with balanced ventilation.	Handbook for air tightness in buildings Lufttäthetens handbok, in Swedish

A.8 Acoustic conditions

The requirements are based on Swedish Standards SS 02 52 67, Edition 3, 2004-02-20 for residential buildings, and SS 02 52 68, Edition 1, 2001-06-21 for health-care premises, education premises, day-care centres and play centres, offices and hotels. The relevant regulations for new buildings are set out in Chapter 7:1 of the Building Regulations.

- For residential buildings, the requirement is Class B of SS 02 52 67 for new buildings and for conversions. **
- For health-care premises, education premises, day-care centres and play centres, offices and hotels, the requirement is Class B of SS 02 52 68 for new buildings and for conversions. **
- It is recommend that, for premises other than residential premises, noise from machines in the activity carried out in the premises, e.g. computers, refrigerators, dishwashers etc., should also be included.

Factor	Requirement
Overall rating	> 80 % satisfied

* To be valid, an overall rating based on the results of a questionnaire survey requires a sufficient number of respondents (normally at least 20) and a sufficiently high response rate (normally > 70 %). A suitable question in this context can be "Are you disturbed by noise from taps, water pipes, the ventilation system, other apartments, stairwells, lifts or outside, e.g. from traffic, industry or from children playing?".

** For existing buildings, the requirements that applied at the time of their construction must be fulfilled, provided also that the overall level of > 80 % of occupants are satisfied applies.

A.9 Light

The relevant regulations for new buildings are set out in Chapter 6.3 of the Building Regulations.

Residential buildings shall be provided with sufficient lighting points to enable good quality lighting to be provided.

In addition, the property manager should provide information on how good lighting conditions can be arranged. This applies to the choice of:

- **general lighting**
- **local lighting**
- **materials for surface coverings, in terms of their suitability in respect of contrast and dazzle**
- **colours of ceilings, walls and floors.**

For schools and child day-care centres, values as given in the National Board for Industrial and Technical Development's (NUTEK's) document 'Programme Requirements for Good and Energy-efficient Lighting in Schools and Child Day-care Centres', are recommended. Recommendations for workplaces are given in EN 12464-1 "Light and lighting – Lighting of workplaces – Part 1: Indoor workplaces".

Risk of dazzle shall be avoided by limiting the luminance of luminaires in the relevant sight lines to acceptable levels (less than 3500 cd/m²).

The energy efficiency of fixed lighting arrangements shall be optimised in terms of such considerations and parameters as the use of HF light sources, installed powers, lighting control and automatic extinguishing of lights (presence detectors) where appropriate.

The following values shall be provided in workplaces, in apartments, and in common areas:

Factor	Requirement
Overall rating*	> 80 % satisfied
Lighting	
- stairwells	100 lux
- entrances	200 lux
- general lighting	300 lux

Factor	Requirement
- local lighting	500 lux
- kitchens, cooking and dishwashing	500 lux
- bathrooms and toilets	500 lux
Daylight factor	>1%

* To be valid, an overall rating based on the results of a questionnaire survey requires a sufficient number of respondents (normally at least 20) and a sufficiently high response rate (normally > 70 %). Typical questions in this context can be "Do you think that your apartment is too bright or too dark?" or "Do you think that you get too little or too much direct sunlight into the apartment during the winter/summer?".

A.10 Tap water

Factor	Requirements	
Domestic hot water temperature	>50°C <60°C	To avoid risk of Legionnaires' Disease. To avoid risk of scalding.
Radon	<100 Bq/l	

A.11 Administration

Operation and maintenance instructions shall be prepared:

- for the administrator concerning ventilation, heating and maintenance of the building
- for the cleaners (where employed), e.g. for common areas
- for the users with information on suitable cleaning materials and methods of cleaning, as well as advice on care and maintenance, e.g. cleaning of ventilation air terminal devices, cooker canopy fans etc.

B Requirements on the energy use (Swedish example)

B.1 Emissions of greenhouse gases

Targets for energy use refer to all energy input to the building in the form of electricity, heating and/or cooling. They shall be determined by the organization, expressed as the target values for each form of energy carrier after correction to the expected value for a statistically average year. This means that the use of heating and cooling shall be specified for each form of energy carrier, after correction to express them as values for a statistically average climate year.

In addition to values for energy use, energy targets can also include reduced environmental impact through optimised use of different forms of energy carrier. Maximum values of total annual emissions of greenhouse gases, expressed as CO₂-equivalents, are therefore set for the entire building or group of buildings.

Emissions of greenhouse gases shall be expressed as the total Global Warming Potential (GWP), i.e. as grams of CO₂-equivalents in a 100-year perspective. GWP can be calculated from the following equation, using the characterisation factor of greenhouse effect for the respective substance:

$$\text{CO}_2 \cdot 1 + \text{N}_2\text{O} \cdot 310 + \text{CH}_4 \cdot 21 + \text{SF}_6 \cdot 23900 \text{ (g CO}_2\text{-equivalents)}$$

When calculating GWP, use reference values for emissions from each form of energy carrier. These can, for example, be calculated using the EFFem program, which is a free downloadable program from www.effektiv.org/miljobel. The calculation methodology used in the program is described by Wahlström (2003).

When determining the energy requirement /target, use input from:

- the FEA with information on energy status, energy aspects and energy performance.
- reference values for the building's energy use from existing statistics, bearing in mind the age of the building, its type, its location and its uses.
- availability of various forms of energy in the neighbourhood of the building
- energy use requirements in the Building Regulations, or other legal requirements.
- the management's energy use policy.

B.2 Energy requirements for particular components

The organization **shall additionally define energy requirements** for individual items or equipment in the building. These additional requirements have to be introduced in connection with retrofit of a building: Examples of such requirements are:

Building envelope:

- Thermal insulation / transmission losses
 - U-values for particular parts of the building ($\text{W}/\text{m}^2\text{K}$):
 - Exterior walls
 - Ceiling/roof space structures
 - Windows
 - Heat bridges
 - U-values for the entire building ($\text{W}/\text{m}^2\text{K}$):
 - This defines a specific heat loss if it is expressed together with ventilation losses.

Building services:

- Air handling and treatment installations
 - Temperature efficiency of heat exchangers (70 %)
 - SFP [kW/m^3] – for the entire air handling and treatment systems
 - Thermal power / design air flow rate (kW per m^3/s)
 - Electrical power / design cooling power (kW/kW)
 - Installed cooling power (W/m^2)
- Lighting and electric equipment
 - HF lighting
 - Maximum power ratings in corridors (W/m^2)
 - Maximum power ratings at work positions (W/m^2)
- Water use
 - Domestic hot water (l/year)
 - Cold water (l/year)
 - Low flow / low flush items/ware etc.

B.3 The Purchaser's own requirements

The Purchaser may have additional or special requirements relating to such aspects as energy conservation, environmental matters etc. These may be discussed from case to case, in order to decide how they shall be met without reducing the quality of the indoor environment.



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