A guide to quality assurance for improvement of indoor environment and energy performance when retrofitting multifamily houses

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SQUARE

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This document complements that entitled “Quality Assurance System for Improvement of Indoor Environment and Energy Performance when Retrofitting Multifamily houses”, Work package 4, Report no. 4.1.

Preface

This report is part of the work carried out in the SQUARE project (EIE/07/093/SI2.466701) - **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 Intelligent Energy Europe (IEE) programme. The SQUARE project aims to ensure energy-efficient retrofitting of social housing to produce a good indoor environment, in a systematic and controlled manner.

The partners of the SQUARE project are:

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

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Summary

This publication is a support document and practical guidance for the "Quality assurance system for improvement of Indoor Environment and Energy Performance when Retrofitting Multifamily Houses" report. Both these documents are the result of international cooperation in the SQUARE project. The report, which sets out formal requirements in respect of the quality assurance system, is complemented by these guidelines, which are intended to be helpful when introducing a quality assurance system.

The document starts with a brief introduction to the various target groups, and how they can use the system. The main part of the guidelines consists of brief reviews of the various parts of the quality assurance work: starting from establishment of the actual quality assurance system itself, and applying it in day-to-day work, including ideas, retrofitting and administration of the housing stock, attempting to express the formal requirements of the quality assurance system in more practical terms. These sections are complemented by a number of appendices, bringing together checklists, procedural descriptions and templates, together with guidance on appropriate methods of calculations, measurement and instrumentation.

We hope that these guidelines and their associated documents will assist the work of introducing quality assurance systems and the work carried out in connection with renovation and management operations.

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Appendices

1 An introduction to quality assurance of the indoor environment and energy performance in retrofitting projects

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

This publication is intended to serve as guidelines for the "Quality assurance system for improvement of Indoor Environment and Energy Performance when Retrofitting Multifamily Houses" report, the prime purpose of which is to ensure that optimum results are achieved in terms of improved indoor environment conditions and energy performance in retrofitting projects. Considering both these aspects in parallel avoids the risk of improving one at the expense of the other. In principle, the system covers the entire process, from the original idea to administration and operation of the building in use, with the same structure as that of traditional quality assurance systems. It should therefore be very suitable for integration with companies' existing quality assurance systems such as ISO 9001.

References and tools that are quoted in the text but are available only in national (Swedish) language have been written in blue colour in order to facilitate their identification. It is expected that these are replaced by similar tools in English or in other national languages in the countries where the system and the guide is being used.

As presented here, the main purpose of the system is to provide a means of checking by the building owner or building operator. The description of the quality assurance system in Chapter 8 briefly describes an alternative approach, of third-party certification.

1.1 Five good reasons for quality-assuring the indoor environment and energy performance

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

- Cost and environmental savings which, in the longer term, can be considerable.
- Fewer sub-optimisations and adverse effects of short-sighted concentration on either the indoor environment or improvements in the energy performance.

- Improved feedback and acquisition of experience within the organisation as a result of systematic, planned and carefully documented work. This provides a means of detecting shortcomings in time, before they result in more expensive mistakes, thus reducing the need for fire-fighting measures.
- Improved communications between owners, operators, occupants, maintenance personnel etc. through the establishment of clear targets and quantifiable results.
- More satisfied customers and fewer complaints through active participation by the occupants, and through a systematic approach to dealing with non-compliances and complaints.

1.2 Background

The main target of the SQUARE project is to develop a generally applicable quality assurance system for the indoor environment and energy performance, suitable for application to retrofitting of apartment buildings or social housing. The starting point for the system has mainly been the Swedish P-marking rules for the indoor environment and energy performance [1], together with other existing systems [2].

The proportion of apartment buildings in need of renovation varies widely from one EU country to another. Austria and Finland, for example, have already renovated 30-40 % of their apartment housing stock, while Sweden has renovated only about 15 %, and Bulgaria is essentially in need of renovating its entire stock. Estimated potentials of resulting energy savings also vary widely. 50-60 % reduction of the total energy demand is a common result, while setting sights higher, to passive house standards, can achieve considerably greater energy savings [3].

An example from the Swedish market shows that about half of the Swedish residential stock is in the form of apartment buildings. Total energy use, including domestic electricity, of buildings in the Million New Homes programme (built from 1961 to 1975) amounts to about 9.5 TWh/year. Specific energy use in these properties is about 210 kWh/(m^2, year) on average. Table 1 shows the total estimated energy use and potential savings of relevant sub-systems [3]. Savings of up to a half of energy use can be achieved.

Table 1. Energy use and savings potentials for the Swedish housing stock.

Energy use	Present energy use, (TWh)	Savings potential, (TWh)
Replacement or renovation of windows	1,5 – 2,0	0,5 – 1,0
Insulation of the building envelope	1,0 – 1,5	0,5 – 1,0
Airtightness improvements	0,5 – 1,0	0,5
Ventilation improvements	2,0 – 2,5	1,5 – 2,0
Domestic hot water	1,5 – 2,0	0,5 – 1,0
Heating system losses	0,5 – 1,0	0,5
Domestic electricity	1,0 – 1,5	0,0 – 0,5
Total	**8,5 – 10,5**	**4,0 – 5,5**

In parallel with the need to improve the efficiency of energy use and to shift energy supply towards sustainable sources, there is also a considerable need to improve indoor environment conditions in the European building stock. Today, more than 40 % of the European population suffers from poor indoor environment conditions. One of the targets of the EU in this respect is to improve indoor environment conditions and reduce the number of cases of sick building syndrome. In addition, the general conditions for housing to play its part in improving social conditions can be substantially improved if experience of modern research and successful renovation projects can be applied.

1.3 Target groups, and application of this guide

The purpose of this guide is primarily to provide the various target groups with practical support for establishing and applying a quality assurance system. It is very important that the various parties are involved in the process both before and during the renovation.

1.3.1 The developer (client/building owner)

It is the developer (client/building owner) who has overall responsibility for the work, and who should therefore also go through all parts of this guidance document in order to have a good overall picture. The main value of these guidelines is to provide the developer (client/building owner) with concrete tools for the introduction and application of the quality assurance system to the entire retrofitting process.

1.3.2 The building manager

In some organisations, the developer is also the building manager, which provides the best conditions for an overall approach. When some organisation other than the developer is to take over responsibility for operating the building when renovation work has been completed, there are good reasons for involving the building manager in the renovation process.

1.3.3 Operation and maintenance managers

Operation and maintenance managers constitute a key group for maintaining the performance of the improvements carried out during the renovation. It is they who will prepare and apply most of the procedures and checklists of the quality assurance system in their daily work. For them, the templates, descriptions of procedures and checklists in the appendices of this document can be an excellent starting point.

1.3.4 Contractors, architects and consultants

All those involved in the renovation process – architects, designers, consultants, installation contractors, suppliers and general contractors – must be properly informed of the developer's requirements and of the procedures involved in the quality assurance system. These aspects include procedures for checking, measurements and inspection during the design and construction stage, together with their resulting documentation.

1.3.5 Occupants / residents

The occupants should be told of how they can help to save energy, electricity and water, possibly supported by the incentive of potential rent reductions, and of how they can help to improve indoor environment conditions by replying to the satisfaction questionnaires and participating in consultations and meetings.Preparing the quality assurance system

2 Preparing the quality assurance system

2.1 General

The quality assurance system itself is described in the "Quality assurance system for improvement of Indoor Environment and Energy Performance when Retrofitting Multifamily Houses" report, [4]. However, this describes the system in principle: For the system to be applicable to, and effective for, a specific project, it needs to be customised to the particular procedures and activities of the organisation concerned. In concrete terms, this means that the organisation must, either by means of its own efforts or by bringing in an external consultant, construct the quality assurance system, draw up the necessary procedures and documents, and anchor the system in the organisation.

2.2 Integrating the quality assurance system in an existing system

If the organisation has an existing quality management system, it should start by deciding how the requirements of the indoor environment and energy performance quality assurance system can be integrated in the existing system. This should be followed by the drawing up of a plan to investigate how any necessary additional procedures best can be integrated into the existing system. If the organisation has ISO 9001:2000 certification, paragraphs 4.1 and 7.1 can provide assistance here.

2.3 Document control

The quality assurance system consists of a number of documents, which can be handled either in paper format or electronically, or in a combination of the two methods. Procedures are needed, describing how documents are to be identified and stored. Appendix A is a list of appropriate controlling documents, such as organisational descriptions, training requirements, document handling and various miscellaneous procedures. It also includes several examples of management and presentation documents as appendices to the guide.

2.4 Internal performance auditing

In those cases where the system is used for the organisation's own inspection and approval procedures, internal performance auditing can be regarded as a dress rehearsal for external auditing or prior to a management review. Internal auditing should be performed at the same intervals as external auditing, or prior to a management review, e.g. once a year. When the system is new, it can be worth while to carry out internal audits more frequently, e.g. twice a year, and then on selected parts of the system, so that all the main parts are audited at least once a year.

Audits must be performed by someone with the necessary knowledge of quality assurance, indoor environment conditions and energy use. He or she should preferably be a third party, i.e. not one of those involved with the organisation's quality assurance system on a day-to-day basis. This means that work will be checked by fresh eyes, progressively improving the prospects for improving the system.

Appendix E is a checklist for planning and carrying out internal performance audits.

2.5 Management reviews

The rules of the quality assurance system require the top management of the organisation to review the indoor environment and energy use quality assurance system at least once a year, in order to ensure that the system is suitable for purpose and is effective. In these reviews, the management must carry out an in-depth review of the organisation's energy efficiency policy, its indoor environment policy and its targets and guide values, as well as reviewing the resources required for application and operation of the system. The results of such management reviews must be documented.

Appendix F is a checklist for planning and carrying out management reviews.

2.6 Continuous improvement work

The organisation should constantly review and examine the results and suitability of the quality assurance system. The annual management reviews of the system provide the main opportunity for initiating changes and carrying out work intended to result in improvement of activities. Ultimately, the driving force for improvements lies in the requirements and targets for indoor environment and energy performance that have been set up by the organisation. An important part of the work of improvement is therefore that these requirements and objectives should be regularly reviewed and, if necessary, revised in the light of changing circumstances, technical developments, available resources etc. This may turn the spotlight on various parts of the work, depending on whether improvements are being considered in the renovation or in the in-use stage, and also on how successfully the organisation has previously managed to evolve the various parts.

The main potential for improvement may, for example, be found to lie in methods of working together, contract texts etc., and on how they can bring in quality aspects. Improvements in management activities can also be concerned with overall aspects such as the possibility of contracting out parts of the work, although it is more likely that such improvements will be concerned with aspects such as preventive maintenance and service, together with feedback from occupants in the form of replies to questionnaires, dealing with complaints and actual measurement of parameters such as energy use, indoor temperatures etc. in order to quantify how well the targets for indoor environment conditions and energy performance are being met.

ISO 9004:2000 describes general methods of improvement of activities.

2.7 Learning and training

Long-term work on improvement of skills and knowledge within the organisation is another important component of performance improvement. The feedback from measurements and performance follow-ups assured by the quality system also provides support for learning and the accumulation of experience. However, if the quality system is to operate as intended, the organisation must invest time in introducing its staff to the structure of the system, its purposes and its targets. Such an introduction must be a basic part of the organisation's procedures and its work on the quality system in order to create motivation and a feeling of participation.

It is very important to include operation and maintenance personnel and cleaning staff in training courses, and keep them up to date with latest developments in their respective working areas. Cleaning staff, for example, should receive specialised training in the handling of chemicals, appropriate treatments for various surfaces, methods of cleaning etc. They should also be told how to report irregularities such as leaks, damaged surfaces, smells etc.

An example of training material that can be used for staff development in organisations that own or operate residential buildings can be found in the 'Bygga Bo Dialogue' (In Swedish only!). This information material describes healthy, low-energy and resource-efficient construction, dealing with areas such as ventilation, lighting, moisture and high-performance windows. It is available for free downloading from www.byggabodialogen.se

An informative publication that can be used for ensuring protection against moisture damage during the construction process is 'ByggaF', which is also available for free downloading from www.fuktcentrum.se. (In Swedish only!).

The ROSH project (Retrofitting of Social Housing) is an international project concentrating on developing and marketing various integrated concepts for energy-efficient and sustainable renovation of apartment buildings. It has produced material for property-owners, property managers and tenants, as well as for designers, architects and contractors. It includes a presentation of commercial and freely available IT aids for moisture, energy and cost analyses in connection with retrofitting projects, good examples of financing methods and technical designs, as well as various training material. Further information can be downloaded cost-free from www.rosh-project.eu/.

2.8 General experience from application of the quality assurance system

Of necessity, a quality assurance system contains a certain element of document handling and administrative procedures. It is important to find the right ambition level when setting up the system so that those working with it realise that, in the little longer term, the benefits of the system outweigh the administrative work. However, it must be understood that there is an initial demand for investment of both time and money in order to get the system up and running.

However, when the system does not involve any third-party certification, as is the case in the basic version, it is up to the user to define the required ambition level for the system. The organisation should take this opportunity of finding a good level for its administrative procedures. If an external consultant is involved, it is important to discuss aspects such as these thoroughly before the work starts.

The following points can assist in establishing a suitable level for administration and operation of the system:

- As far as possible, coordinate the system for quality assurance of the indoor environment and energy use with any existing quality systems operated by the organisation, such as ISO 9001:2000 or procedures for managing aspects such as the environment or the work environment.
- Evaluate options for using Building Information Modelling (BIM) in order to further integrate the information management within the organisation
- Discuss what would be a suitable ambition level for your organisation before setting up the system.
- Possibly employ an external consultant to set up the system and start it up, but take steps to ensure that it remains the organisation's own product, e.g. by involving the company's own quality manager as much as possible.
- It is better to start at a lower level, and add new procedures as the system develops, rather than to try and include everything right from the start.
- As far as possible, use computerised aids for operational monitoring and documentation, as well as for administration of the system as such.
- Don't re-invent the wheel: use templates and existing procedures as far as possible, possibly with minor modifications.

An investigation which looked at how companies experienced the advantages and drawbacks of ISO 9000 certification (in this case, ISO 9000:1994) discovered the following:

The benefits that were noted were:

- Better control of activities (78 %)
- Increased awareness of problems in processes (77 %)
- A usable tool for marketing (73 %)
- Improved customer service (70 %)

The drawbacks that were noted were:

- Considerable volumes of paperwork (27 %)
- Time demand for writing manuals (31 %)
- Substantial costs for implementation (25 %)

Another conclusion was that the improvements in an organisation when it has been certified are due primarily to the internal work on the quality system and not to the certification as such. This supports the approach of the SQUARE quality assurance system, which does not as such involve any certification, but does operate as if the organisation must act 'as if' certification was the end target.

3 Applying the quality system to the retrofitting process

3.1 General

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

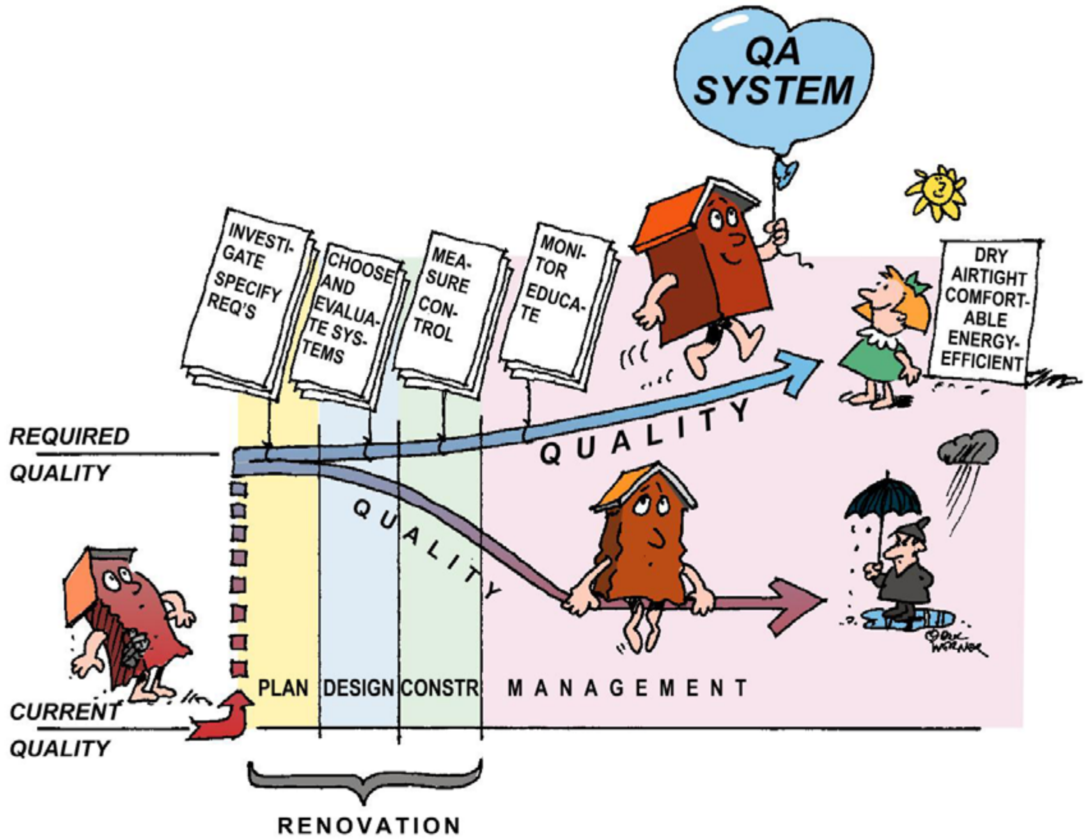


Figure 3.1 Achieving the required level of indoor environment and energy performance by applying a QA system from retrofit planning to facility management. Source: Eric Werner, Tecknaren AB

3.2 Establishing pre-retrofitting conditions

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

3.2.1 Residents' questionnaires

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

3.2.2 The thorough primary inspection

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

A range of measurements is required in order to check whether the indoor environment meets the conditions specified by public authorities or by the developer or administrator: see also Appendix A in the report [4]. This involves inspection of walls, floors and roofs, measuring moisture, odours, mildew, bacteria and radon. Ventilation systems must be checked to see whether they are providing adequate ventilation rates and not generating too high noise levels. In apartments, noise levels from sources such as traffic must also be checked. The inspection must be carried out in a sufficient number of apartments to ensure that the results are representative of the entire stock. Defects and poor performance found by the inspection form the basis of the renovation plan drawn up before starting the work.

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

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

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

Appendix K is a checklist for planning and performing thorough primary inspections.

Appendix L is an example of an inspection form for an individual apartment.


Figure 3.2 and 3.3 Building and installation inventory Source: Peter Friedl and AEE INTEC

3.2.3 First energy analysis

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

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

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

Appendix M is a checklist and templates, with examples, for the various parts of a first energy analysis.

3.3 Dialogue and cooperation

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

Figure 3.4 and 3.5 Information about plans and achievements through newsletters and stakeholder meetings for information sharing and decision making are two ways of encouraging tenants to take an active part in the process.
Source: AB Alingsåshem

Source: AB Alingsåshem

Figure 3.6 A well prepared startup meeting involving the housing organisation and all contractors is important for achieving a common view on the work ahead. Regular meetings for sharing experiences and discussing upcoming problems is also more essential in a major renovation project with tough requirements on indoor environment and energy performance than in a conventional construction project.

3.4 Formulation of requirements and targets prior to renovation

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

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

The developer decides on the performance requirements for the indoor environment and energy use. Proposals for suitable requirements are set out in Appendix 1 of the report of the quality assurance system [4]. Appendix N of these guidelines includes templates for energy performance and for determination of suitable energy targets. All requirements must be accompanied by suggestions for appropriate methods for determining their achievement, and of indication of who is responsible for ensuring that the requirement is fulfilled. In this respect it is also desirable to define requirements on measuring equipment that is to be included in e.g. HVAC units or heating systems in order to enable control and follow up of the energy performance.

www.energilotsen.nu [5] provides a cost-free web-based resource for developers, helping them to formulate their requirements in terms of energy use and indoor environment conditions. Although the toolbox that it uses has admittedly been developed for new construction work of residential buildings or commercial premises, many parts of it are also suitable for renovation projects. The report 'Function requirements for residential buildings to achieve low energy use' [6] can provide further assistance to the developer. See www.effektiv.org. A requirement specification for passive houses in Sweden [7] recently developed can also be useful in this context. ([5] to [7] available in Swedish only!).

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

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

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

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

For ventilation technologies and products the major organisation is Eurovent: www.eurovent-association.eu/web/eurovent/web/index.asp

For solar heating and cooling technologies and products the major organisation is the European Solar Thermal Industry Federation, ESTIF: www.estif.org

For Solar PV in Europe, it's the European Photovoltaic Industry Association, EPIA: www.epia.org

The major information resource in Europe on heat pump technologies is the IEA related Heat Pump Centre: www.heatpumpcentre.org

The European insulation manufacturers association, EURIMA: www.eurima.org

A (so far) Scandinavian initiative on Energy and Quality rated windows, the so called "EQ Window": www.energifonster.nu

3.4.1 The indoor environment

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

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

Source: SP

Figure 3.7 and 3.8 Protecting a building site and stored materials often pays back as improved work efficiency even though the main purpose is to avoid moist/damp construction parts and mould growth.

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

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

Source: SP

Figure 3.9 Measuring the operative temperature in an apartment in a passive house in Frillesås, Sweden.

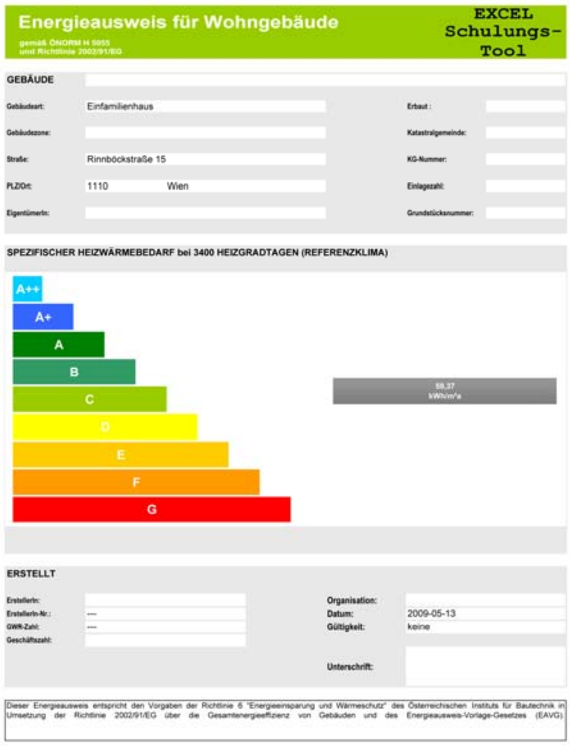
All formulated requirements must be possible to verify by means of measurements or in some other way.

3.4.2 Energy performance

Energy performance requirements can be expressed in the form of function requirements, such as 'Maximum power of 10 W/m² for heating' or energy requirements 'Maximum 45 kWh/m² for heating', complemented with the applicable boundary conditions. Function requirements are preferable, rather than more detailed requirements, as they permit greater freedom for the designer to choose appropriate system solutions. Requirements should include not only energy for heating purposes (including electricity for domestic purposes), but also energy for domestic hot water production.

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

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



Source: Energy performance certification is from the "Excel-Education - Tool" made by "Dr. Christian Pöhn, MA 39 VFA" July 2008 (http://www.oib.or.at/ 2009-05-13)

Figure 3.10 Example of a requirement and declaration of energy performance of a building.

3.5 Follow-up of targets and requirements

3.5.1 Follow-up during the planning stage

Planning of the renovation work should include the requirements in respect of energy use and indoor environment conditions, as well as the results from the thorough primary inspection and the first energy analysis.

It can be advisable to review the requirements when the retrofitting programme has been formulated, in order to decide whether they are practical in the light of the planned work.

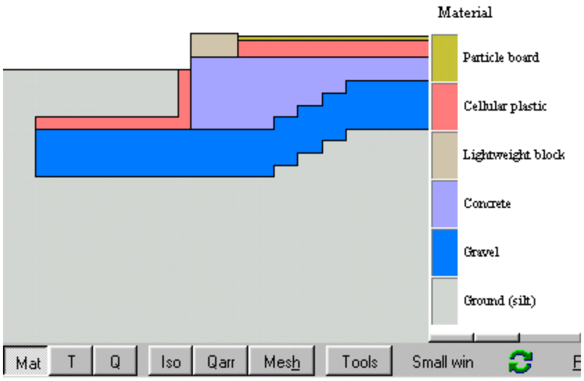
It is important that the specified requirements and the procedures for following up their achievement are clear when negotiating with architects, consultants, contractors, installation contractors and suppliers. Unclear requirements can result in misunderstandings and high costs at later stages.

3.5.2 Follow-up during the design stage

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

Managing and monitoring protection against damp can, for example, use the ByggaF method for moisture-protected construction processes. It includes checklists and procedures for appropriate design, and can be downloaded cost-free from www.fuktcentrum.se.[8] Similar assistance material is available for dealing with airtightness considerations [9]. Both these tools are in Swedish language only.

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



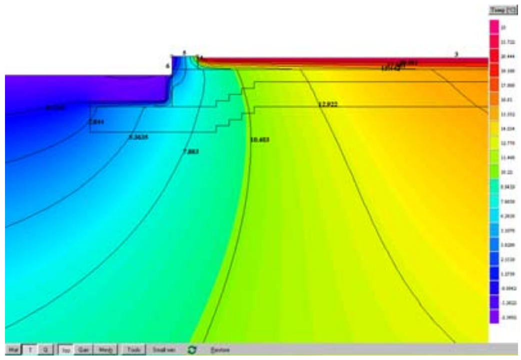
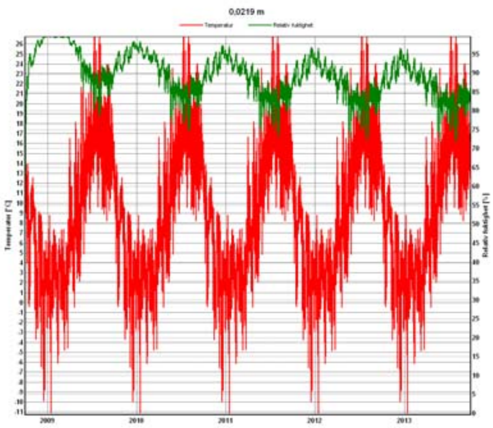


Figure 3.11 and 3.1 Screen shots from HEAT2 – Heat flow through floor construction (slab on ground)



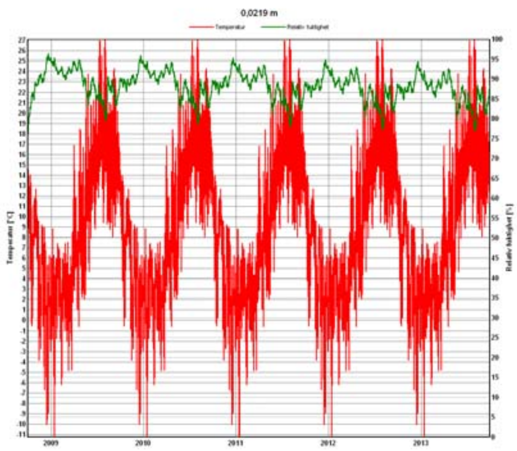


Figure 3.13 and 3.14 Screen shots from moisture and temperature calculations with the WUFI software. Wall construction with mineral wool insulation (left) and polystyrene insulation (right). Green line showing condensation problems (RH>100%) in the former

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

3.5.3 Follow-up during the work stage

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

Figure 3.15 and 3.16 Joint meetings with all contractors and well defined control programs during the design and construction processes are important means of improving the overall quality of the project.

Source: AB Alingsåshem and TTA Trama Tecno Ambiental S.L

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

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

See the ByggaF method for moisture-protected construction processes at www.fuktcentrum.se for information on moisture protection during the building process. See the "The airtightness handbook" [9] for information on achieving airtightness during the production stage. This latter document includes descriptions of methods for pressure-testing large buildings (in Swedish).

Source: AEE INTEC

Figure 3.17 and 3.18 Testing the airtightness of a wall during the construction stage (left) in order to verify airtightness. Air leaks are traced e.g. with smoke and anemometer measurements (right)

3.5.4 Commissioning and hand over

There is a growing concensus among building management professionals about the importance of the commissioning process as a powerful tool for ensuring the fulfilment of requirements on indoor environment and energy performance. There is no absolute

Source: SP

Figure 3.19 The commissioning process reaches from construction and into the management phase

definition of the word "commissioning" and the process is hardly separable from the construction and management stages. On the contrary, commissioning and handover is a process that should be a bridge between the two and therefore it should be in operation during both stages. It should NOT be limited to a short period of time in between the two stages as in the case of a traditional final inspection when handing over the building.

IEA ECBCS Annex 40 "Commissioning of Building HVAC Systems for Improving Energy Performance" [10], one of the major international projects in the field, defines commissioning as:

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

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

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

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

- The main objective of the commissioning is to verify that "what was ordered has been delivered" through optimum co-functioning of the building and it's technical systems'.
- A project's technical result should never be approved on the basis of a conventional final inspection only. On the contrary, the commissioning process should ideally

reach over at least a one year period in order to exhibit all types of operating conditions for the building and its systems and to allow for adjustments and repeated check ups.

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

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

3.5.5 Follow-up during the management stage

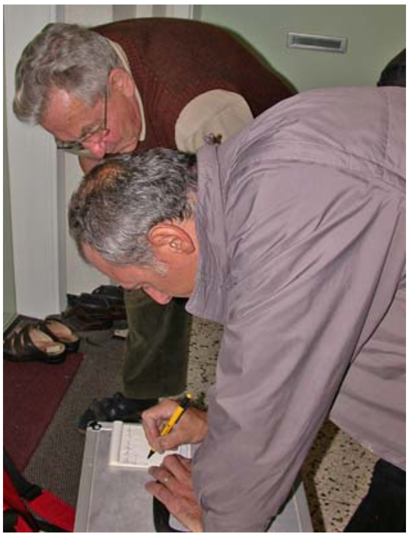
It is appropriate, when handing over the building, for the contractors to go through the building with the developer, pointing out critical designs, structures and details, demonstrating how systems work, how they need to be looked after, and how they are adjusted. It is also important that operating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

Some aspects can be checked and monitored in connection to inspection rounds: examples include inspection of particularly moisture-exposed parts, checking for odours, checking that water is not collecting on roofs or ground surfaces, checking that cleaning and lighting of public areas are satisfactory, and so on. See also Appendix R, Checklist for inspection round, Appendix F, Procedure for dealing with non-compliances, and Appendix G, Template for non-compliance reporting.

Temperatures, energy use, energy flows, electricity and domestic hot water can most suitably be monitored by computerised supervision of the entire building and/or of each individual apartment. Experience indicates that this makes it easier to save energy without sacrificing comfort, and also provides more rapid indication of operational problems, helping to repay the investment more quickly. In this context, look-ahead control can also be something to consider. Examples of companies selling equipment for building energy management systems include TAC, Honeywell INU Control, Siemens, Abelco, Exomatic and Bastec.

It is advisable to hold meetings with operational staff regularly in order to discuss and deal with any problems or suggestions for improvements that have been picked up by inspection rounds or operational supervision.

The building owner should also arrange meetings in order to hear residents' views on the indoor environment in their apartments and in public areas. Occupants' views can also be collected by the regular questionnaire surveys and from reporting of complaints. An occupants' representative should also be involved in the regular operational meetings and inspection rounds. See also Appendix Q, Agenda for operational meetings, and Appendix R, Checklist for inspection rounds.

Source: AEE INTEC

Figure 3.20 and 3.21 Installations checkup during inspection rounds and interaction with the users are not always seen as positive from the user, but involving them early in the renovation process also makes the follow up more likely to be effective.

There must be a procedure for dealing with complaints concerning the indoor environment. Appendix H, Procedures for Handling Indoor Environment Complaints, is an example.

Deal with departures from requirements, such as complaints or shortcomings and faults, at regular meetings with the developer's organisation during the management reviews, when decisions are made concerning action to be taken in order to fulfil the requirements. Appendices E and F show checklists for internal auditing and management reviews.

3.5.6 Measurements and measurement equipment

Reliable measurements of a range of parameters constitute an important part of the quality assurance of renovation projects and of subsequent building operation. This requires appropriate levels of competence on the part of those making the measurements, and on the quality and calibration of the equipment used. In addition, the choice of measurement methods and references for the measurements is often decisive for the end results. As far as possible, apply international, European or Swedish standards.

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

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

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

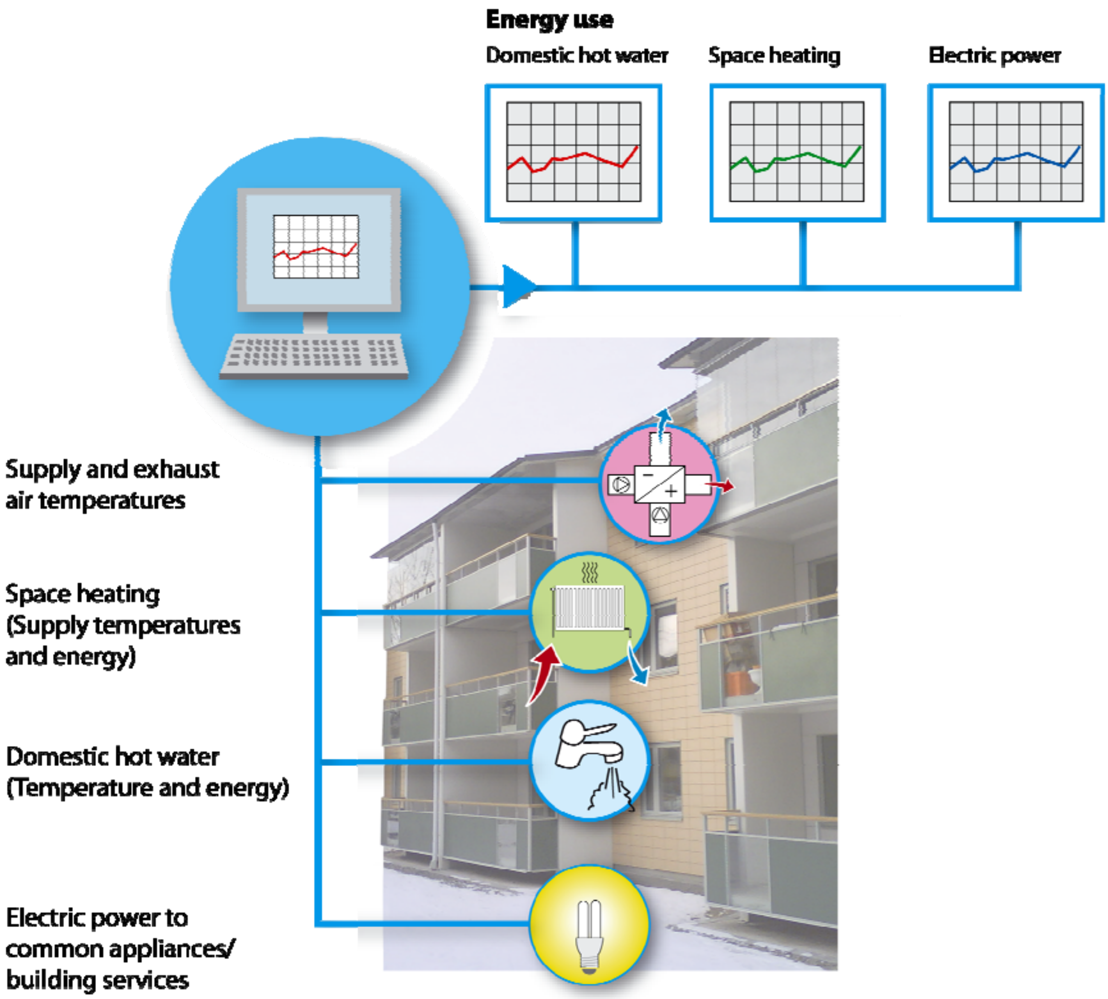


Figure 3.22 Illustration of computerised supervisory or building energy management systems (BEMS).

Source: SP

Appendix O: 'Template for selecting instrumentation for energy monitoring' can be used by the organisation to bring together important information on the meters used in the continuous energy monitoring system. Appendix P 'Methods of measurement, measuring instruments and calibration (guidelines)’, briefly describes methods and equipment for measuring temperature, moisture, airtightness etc.

4 Good examples from renovation of apartment buildings

4.1 Sweden – Alingsåshems Brogården

As part of the work of Sweden's Brogården pilot project for SQUARE, the Alingsås local authority housing association, Alingsåshem, has undertaken to carry out a very extensive renovation of a number of apartment buildings constructed over the period 1971-73. The target requirements for energy use after renovation are very demanding, of a level with a voluntary standard for passive houses recently developed in Sweden [7]. The indoor environment requirements are equally demanding, in accordance with the example in Appendix 1a of SQUARE's quality assurance system [4]. Considerations of accessibility – i.e. designing technical and physical installations with the needs of disabled residents and visitors in mind – have also received high priority in planning the retrofitting/renovation work.

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

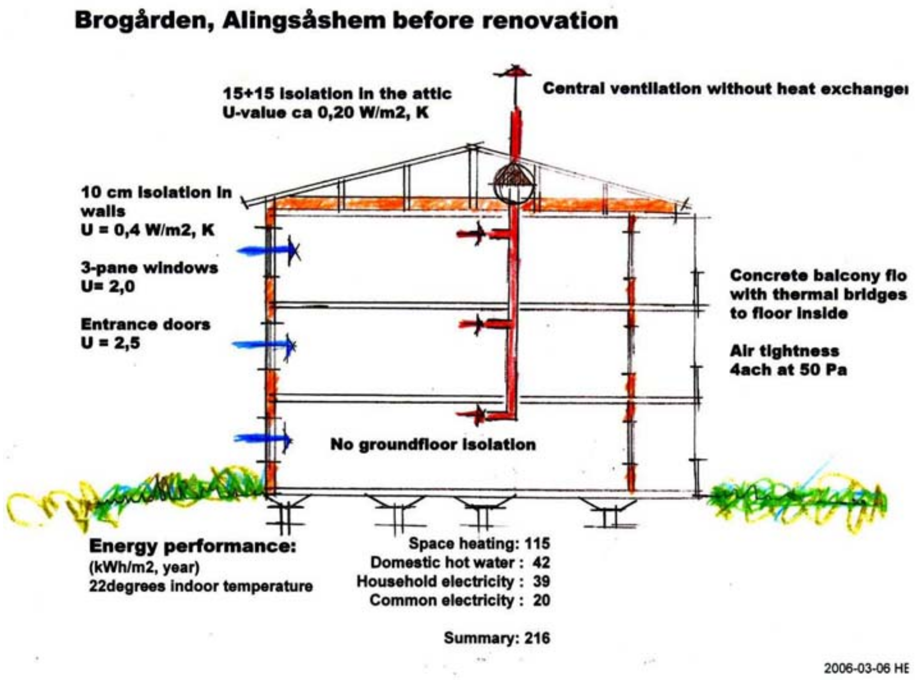
Some important components of the joint work of the renovation include:

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

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

Figure 4.1and 4.2 Exterior of Brogården, the Swedish SQUARE pilot project before and after renovation.

Source: SP



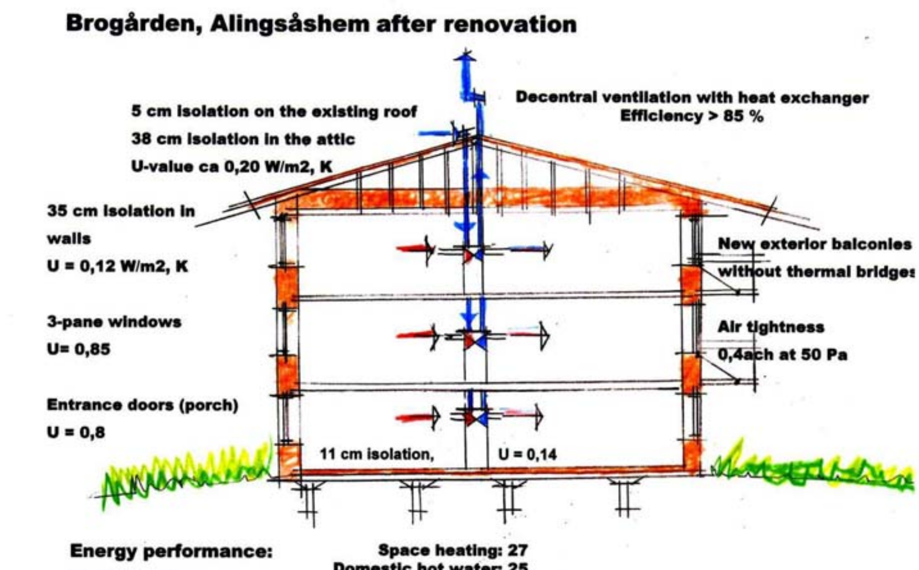


Figure 4.3 and 4.4 Building plan drawings and energy performance figures of Brogården, the Swedish SQUARE pilot project, before and after renovation

Source: Hans Eek

4.2 Finland – Tornipolku 6, Porvoo

Source: TKK Helsinki University of Technology

Figure 4.5 The Tornipolku project in Finland

Apartment building with 35 flats, built in 1972. District heating and water base central heating with radiators. Total renovation in 1996. Replacement of all building service systems and extra insulation. New ventilation system with small ventilation unit in each flat. Wall discharge of exhaust air. Heat recovery from exhaust air and supply air heating connected to district heating. Improved ventilation in bedrooms: 7-12 l/s per bedroom. New saunas in most flats and increased ventilation rates.

U-values before and after renovation

Structure	Before renovation W/m^2,K	After renovation W/m^2,K
Outdoor walls	0,4	0,28
Windows	2,5	1,12
Roof	0,3	0,19
Base floor	0,4	0,20

Use of energy before and after renovation.

Parameter	Before renovation	After renovation
Heat	50 kWh/m^3	38 kWh/m^3
Water	198 l/s,habitant,day	162 l/s,habitant,day
Electricity (facility use only)	3,5 kWh/m^3	3,0 kWh/m^3

4.3 Austria – "Dieselweg"

The residential area "Dieselweg" is located in the south of Graz. The existing situation of the building structures - erected in the 50s, 60s and 70s and the energy performance was really bad. Therefore the non-profit-making housing association wanted to carry out a renovation. But before doing this, an essential problem had to be solved: the 212 flats (rental units) were occupied and there was no feasible possibility to relocate the tenants during the construction works. Therefore it was first and most formative intention of the GIWOG to find a solutions-set, which could realize very ambitious objectives.

The general policy of the GIWOG is focused on a comprehensive and sustainable quality appreciation. The management strategy is very innovate-oriented and therefore they tried to arrange a pilot project right from the beginning. To create showcases means to be ahead in retrofitting.

The key objectives were defined clearly - they comprised gaining an energy-efficient building (targeting passive-house standard), improving the quality of indoor environment and supplying social aspects. [*see WP 6 – Report on National PilotProjects, 1.2*].

The implementation of the QA- System followed nearly all steps of the SQUARE – QA-system, some procedures are more strictly regulated in Austria. The builder – GIWOG- established in very early stage a team of project-partners with clearly defined responsibilities and project communication structures. The implementation of quality assurance could be arranged easily, because the organisation was originally set-up with an efficient system for quality management. The general strategy could be described in the following way:

Figure 4.6 Implementation of a national QA- system Source: AEE INTEC

One of the important solution-sets is the use of pre-fabricated modules for the building envelope and the installation of the new components for building services in the space between old and new façade. This innovative concept made it possible to let the occupants in their apartments during the construction works. Nobody had to move out.

The timetable separates the project – first – ahead of retrofit and during the planning a parallel development, but the construction works is separated into three phases according to the different building types and to coordinate the implementation in the most efficient way.


Figure 4.7 and 4.8 The building stock of the residential area "Dieselweg" before the renovation (April 2008)

Source: AEE INTEC

Figure 4.9 and 4.10 Pictures of the construction work (left side) – the pre-fabricated modules are brought by a truck and trailer on-site. Afterwards they are lifted by a truck-mounted crane to the buildings façade. The picture on the right side shows the new envelope – with the integrated balconies (to be used as additional living space)

Source: AEE INTEC

The implementation of this pilot project will push the standard of renovation to more ambitious targets and receive methodologically advanced systems for quality assurance in Austria. Experiences from design, construction and operation can be evaluated and disseminated.

The further development of the Austrian TQ – tool ("Total Quality") to the TQB ("Total Quality Building") gains by the results from the SQUARE project. [*see WP 6 – Report on National PilotProjects, 3.6*].

4.4 Spain – Espronceda neighborhood

Espronceda neighbourhood, in the town of Sabadell (around 20 km from Barcelona), began to be build from 1962 and it was accelerated as a result of a catastrophic floods occurred at the end of that year. It received many families affected by the floods. The development was done by the Ministry of the Dwelling, and the apartments were rented. 92 blocks with a total of 960 apartments were initially built. In 1976 the first retrofit works and improvements were done in the neighborhood, which was already enough deteriorated because the low quality of the construction. The urbanization of the neighbourhood was implemented in 1980.

Figure 4.11 and 4.12 The Espronceda neighbourhood Source: TTA Trama Tecno Ambiental S.L

In 1985, with the works finished, the Spanish Ministry of the Dwelling does the transfer of competence and ownership to the Catalan Autonomous Government. ADIGSA is the public company that manages the maintenance and the retrofitting of the public housing stock in Catalonia, and between 1992 and 1998, has carried out an integral retrofitting program that corrects the main defects of the bad initial construction: thermal isolation of façades by the outside, waterproofing roofs, indoor installations, windows, centralized ventilation, etc. Also three blocks affected by a concrete patology were demoslished.

The improvement of the buildings was innovative, 17 years before the actual energy efficiency in buildings rules:

- Thermal insulation of the outside of the building, elimination of thermal bridges (1990-1998)
- Façades retrofit
- Deck retrofit (1990 - 1997)

Also was established a new equipment of ventilation of the indoor air of the apartments in order to improve the indoor environment quality, prevention of humidity and smoke evacuation (1991- 1996):

- New ventilation ducts by façade
- Windows replacement , with vents integrated on carpentry
- Cut of the doors among indoor spaces for to favor the air flow
- Mechanical extractors in deck
- Electronic regulation system of the speed of the extractors and hourly programming

The total amount invested in these works by ADIGSA has been approximately 24 million euro, of which some 8 million euro would correspond to improvements of the internal systems and the ventilation equipment.

During 2007 ADIGSA contracted TTA to evaluate the actual situation of the apartments indoor environment, the state of the ventilation system and the analysis of the tenants complaints. Many apartments were visited and inspected, many tenants were interwied and a questionnariy was distributed between all the 1,284 apartments. 133 complete surveys answered by the tenants have been analyzed.

The result of this study has been a project of necessary improvements in order to reduce the energy consumption and increase the quality of the indoor air. The project budget was 404,000 €, and now a tender is in process.

5 References

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[2] An overview on existing QA systems for energy efficient renovation with improved environment. SQUARE WP2.1 summary report. August 2008.

[3] Overview of potentials and estimated costs for energy savings in retrofitting of social housing. Reports from Austria, Bulgaria, Finland, Spain and Sweden. SQUARE WP2.2 summary report. August 2008.

[4] Quality assurance system for improvement of indoor environment and energy performance when retrofitting multifamily houses. SQUARE WP4.1 report. October 2008.

[5] Energilotsen *[The Energy Pilot]*, www.energilotsen .se (In Swedish)

[6] Functional requirements for dwellings with respect to low energy use. Rapport EFFEKTIV 2003:06. www.effektiv.org (In Swedish)

[7] Requirement specification for passive houses in Sweden- Energy efficient dwellings. Version 2008:1. LTH rapport EBD-R—08/21 (In Swedish)

[8] The ByggaF Method for Dry Construction, www.fuktcentrum.se. (In Swedish)

[9] The Airtightness Handbook, R&D-väst report 2007, Swedish Association of Construction Industries, ISSN 1652-6384. (In Swedish)

[10] Commissioning tools for improved energy performance. Results of IEA ECBCS ANNEX 40. www.ecbcs.org/annexes/annex40.htm

A Checklist for controlling documents in the quality assurance system

The organisation must have a documented quality assurance system for the indoor environment and for energy performance, in accordance with the requirements of the report. The following table is a checklist of the obligatory controlling documents (or parts of documents) that must be included in the quality assurance system. (Note that what are shown as several parts in the table can often be coordinated into one document. It is not, in other words, a requirement that separate documents must be prepared for each operation.) Controlling documents are primarily simple descriptions of activities, routines and procedures controlling the overall work. These activities in turn result in descriptive documents (Appendix B) and presentational documents (Appendix C).

Content	**Description**	**Assessment**
Documentation of the quality assurance system	*E.g. Electronics manual.* *In a folder on the local network*	
Description of the organisational structure and responsibilities	*E.g. Described in the manual.*	*E.g. OK*
Training requirements and qualifications of personnel		
Procedures for comm-unication and information		
Document control procedures		
Procedures for basic investigations (TFI and FEA) prior to planning of the renovation (available as an appendix)		
Procedures for activities management (some examples available as appendices)	*E.g. planning and performance of operation and maintenance activities, including procedures for monitoring and metering. Procedures for follow-up of design and construction, including check lists.*	
Procedures for dealing with non-compliances, corrective and preventive actions (available as an appendix)		
Procedures for internal system audits (available as an appendix)		
Procedures for management review (available as an appendix)		

Italic text is an example of entries.

B Checklist for descriptive documents

It is by no means critical whether a document is defined as descriptive or as presentational: documents can also be treated in the quality assurance system as a joint type of document. Here, we have chosen to define descriptive documents as those that are the results of individual (not regularly recurring) work or operations intended to describe the conditions for retrofitting and for ongoing operation and maintenance.

Descriptive document	Status	Comments
Design and construction material: drawings, calculations etc.		
Results from indoor environment questionnaire survey (an example of a questionnaire is included as an appendix)		
Report from the thorough primary inspection (checklists for the inspection and a record form for apartment inspections are included as appendices)		
Report from the first energy analysis, including a property description, energy status, energy performance and descriptions of earlier energy efficiency improvement measures (an example of a check list is included as an appendix)		
Energy template (available as appendix)		
Maintenance and action plan		
Description of measurement methods and equipment (template and guidance available as appendix)		
Documentation of comprehensive measures to improve energy efficiency, with detailed results.		

C Checklist for presentational documents/ records

Documentation of all regularly recurring activities must be prepared and filed in accordance with the procedures of the quality assurance system for the indoor environment and energy performance. Standard forms are used in order to indicate that targets and requirements have been met, in order to trace the history of previous adjustments etc., or to trace products and warranty periods etc. The following table can be used as a checklist to confirm that important presentational documents or records are included in the quality assurance system.

Presentational document	Status	Comments
Documentation from adjustment of physical systems, ventilation system inspections, inspection of indoor environment conditions, calibrations		
Invoices and warranty documents		
Documentation from monthly measurements / meter readings and follow-ups of energy use		
An annual summary of monthly follow-ups, with information on changes, investigations and planned and completed actions		
Documentation from service and maintenance visits		
Documentation of personnel qualifications, training requirements and of completed courses		
Documentation from internal audits		
Documentation from management reviews		
Non-compliance or defect reports		

D Examples of templates

Functional templates are useful aids for the quality assurance work for several reasons:

- Saving work, as the format can be re-used for regularly recurring activities.
- Simplify interpretation of results, records etc., if the same results are always presented in the same way.
- Assist a structured method of working through the fact that the templates can and should contain information on how the document should be identified/named, and where it is to be archived.

It is difficult or impossible to create templates for some activities, and so such cases should be treated with common sense. Many templates are available on the internet, and can easily be customised to suit some particular activity, thus avoiding the necessity of preparing a form from the ground up. The following table gives examples of templates that can be usable.

Template	**Status**	**Comments**
Template for documentation of adjustments, audits, inspection rounds, calibrations (partly available as an appendix)		
Template for documentation of work carried out as part of the renovation		
Template for documentation of monthly measurements, meter readings and follow-ups of energy use		
Template for documentation of annual presentations of monthly follow-ups, with information on changes, investigations and planned and completed work		
Template for documentation of service and maintenance visits		
Template for documentation of internal audits		
Template for documentation of management review		
Template for documentation of non-compliances (available as appendix)		

E Checklist for internal audits

Carry out internal audits at least once a year. The following points can be used as a checklist for planning and performing audits.

- The organisation's quality manager has the main responsibility for planning internal audits and ensuring that they are carried out. He/she may also perform the audit, or can choose to delegate the work. Assessors and assessees should be notified of the audit and its planned extent at least two weeks in advance.
- Allow assessors at least one day to read up on the system concerned before performing the audit.
- The audit must review all main parts of the quality assurance system at least once a year:
  - Purely administrative elements, such as document control, non-compliance handling etc.
  - Indoor environment aspects, concentrating particularly on measurements and inspections carried out as part of (for example) a rolling five-year plan.
  - Energy performance, concentrating on continuous measurements and statistics, as well as on inspections carried out in accordance with (for example) a rolling five-year plan.
- The assessor must draw up a checklist based on activities and procedures to be inspected.
- The assessor must present the results of the audit in a report to the organisation's quality manager. Where defects or non-compliances have been observed, the report must suggest proposals for corrective and/or preventive actions, and the time requirements for them.
- The report must be taken up as an item in its own right on the agenda of the management review.
- The assessor, or the organisation's quality manager, must be responsible for monitoring the progress of corrective actions initiated by the audit.

F Checklist for management reviews

At least once a year, the organisation's senior management must review the indoor environment and energy performance quality assurance system in order to ensure its continuing suitability and effectiveness. Opportunities for constant improvement should also be considered at the review, resulting in an appropriate plan of action.

- The organisation must appoint a person to draw up the agenda (normally the quality manager), and another with responsibility for convening meetings (normally the managing director).
- Persons taking part in the review must include the organisation's technical and finance managers, the quality manager and persons having operative responsibility for renovation projects and operation and administration of properties.
- The following points should be included on the agenda:
  - Minutes of the previous meeting
  - An indoor environment and energy performance policy
  - Targets, guideline values and reference values, changed conditions
  - Available resources
  - Report from the internal audit (if carried out)
  - Reported non-compliances in the indoor environment conditions or energy performance
  - Status of corrective/preventive measures
  - Complaints and feedback from occupants
  - Information to occupants
  - Additional skills in the organisation
  - Plan of action
- The organisation's quality manager is responsible for writing the minutes of the management review and distributing them to persons concerned.

G Procedure for dealing with non-compliances

In order to prevent indoor environment problems arising it is important to deal with any non-compliances, and that this is done in the correct way. All noted faults or defects, departures from procedures or sources of irritation must be documented. Proposals for improvements must also be written down. Someone in the administration organisation must be appointed responsible for receiving complaints about non-compliances or suggestions for improvements, and for recording and safely storing them. It is important that everyone in the area is told of whom they should contact when they come across a problem or wish to put forward suggestions for improvements. The person responsible for noting such input should then regularly – suggested: once a month – go through them with the property manager.

Each non-compliance report must note details of the report and/or improvement suggestion. Reports must be submitted to the property manager and be logged. The non-compliance and/or improvement suggestion will be analysed by the property manager, who is responsible for ensuring that an action is carried out, and who then passes on the non-compliance report if necessary, e.g. to the construction manager if the work is still within its warranty period. Logged report records are reviewed each year as part of the management review. Minor faults can possibly be dealt with directly: instead of recording details of such faults, it can be sufficient to note them in the non-compliance list as documentation.

Non-compliance reports must also be discussed and reviewed during operation and maintenance rounds.

Property	Non-compliance / complaint	Dated	Person responsible	Status of action

The purpose of this procedure is to pick up any non-compliances, to analyse them and then propose improvements or preventive measures, as well as to ensure that the work of improvements is put up on a systematic basis.

Send a copy of the report to the person who initiated or reported the non-compliance report, for him/her to decide whether the work carried out or decided upon is sufficient or has been carried out. If not, a new non-compliance report must be issued.

H Non-compliance reports

Document non-compliances, when discovered, in a non-compliance report, and then submit it to the purchaser for information and possible decision on action.

To be filled in by the person who found the non-compliance.

Non-compliance reported by:	
Name:	Date:

Description of the non-compliance:			
Property	Building	Part of building / apartment	Equipment /Item
Analysis of the reason for the non-compliance:			
Suggestion for action:			

To be filled in by the person responsible for the action.

Decision: ☐ Work will be performed		☐ Work will not be performed
Decided by:	Confirmed, date:	Reason for not performing the work:
Responsible for the work:	Work to be completed by:	

To be filled in by the person reporting the non-compliance.

Follow-up: ☐ Work performed, successful	☐ Problem remains, see **Improvement no.:**
Initials of person monitoring the result:	Date:

I Procedure for dealing with complaints about indoor environment conditions (Swedish example)

Background

Many complains about indoor environment conditions grow from a limited problem into a larger problem, often based on mistrust due to too long interval until something is done. Complaints must be responded to quickly: always assume that they are justified.

Purpose

Problems with the indoor environment have a tendency to cause conflicts between tenants and property managers. It is therefore important to have a clear strategy for dealing with problems of the indoor environment.

Requirements and coverage

The Environmental Framework Law defines potential harm for human health as an *"effect that, from a medical or hygiene point of view, can adversely affect health, and which is not slight or wholly temporary"*. The National Board of Health and Welfare has issued general guidelines on indoor climate conditions, and on how *"potential harm for health"* is to be interpreted:

SOSFS 1999:45 (M) Moisture and microorganisms
SOSFS 1989:45 (M) Health risks from certain flooring materials
SOSFS 1999:25 (M) Ventilation
SOSFS 1996:7 (M) Indoor noise and high noise levels

The Environmental Framework Law – General compliance regulations

The National Board of Housing, Building and Planning's Building Regulations
The Act Concerning Obligatory Ventilation System Inspection

Responsibility

According to the Swedish building regulations it is the property owner who is responsible for ensuring that occupants do not suffer from the indoor environment.

Complaints handling procedure

1. Initial survey of the problem:
    a. Listen to the occupants' description of the problems.
    b. Visit the building and obtain an idea of the complaints and the environment.
    c. Talk to the caretaking staff to find out whether there have been operational problems, changes or renovations that can have affected the indoor environment.
2. Determining the extent of the problem:
    a. Issue a questionnaire to obtain a picture of the extent and character of the problem. See also Appendix J.
    b. Interpret the results of the questionnaire.
    c. Take direct action if the problem is minor.
3. Setting up a working party.
4. Physical measurements.

5. Presentation of the results of the investigation.
6. Follow-up and later monitoring.

Documentation and communication

All conversations, meetings and site visits must be documented. In most cases, investigation of indoor environment problems is carried out locally, in conjunction with those affected by the problems and in accordance with given recommendations. It is important to maintain open communications. Information on how the work is to be carried out, who will be involved, and when the results can be expected, must be given as early as possible.

References

Questionnaire for investigation of indoor climate conditions, My home environment, MM050A, Apartment buildings. This questionnaire can be ordered from the Work and Environmental Medicine Clinic, Örebro University Hospital, Örebro.

J Questionnaire – My home environment

Personal information

Name*: ___________________________________ *(*Voluntary information)*

Address:____________________________________ ____________________________

General information about the dwelling

Type of ownership: □ tenancy right □ co-operative flat □ other type ____________

Floor level: ______ (0=Ground floor, 1= first floor etc.)

Dwelling space: ______ rooms (excl. kitchen and bathrooms) ______ m^2 (approx.)

Year of moving in: __________

Number of inhabitants in the dwelling on a permanent basis (including yourself) ______ adults (over 18 years of age) ______ children

Environmental Factors

Have you been **bothered** during the **last 3 months** by any of the following factors in your **dwelling**?
(Please, answer every question even if you have not been bothered!)

	Yes, often (every week)	Yes, sometimes	No, Never
Draught	□	□	□
Room temperature too high	□	□	□
Varying room temperature	□	□	□
Room temperature too low	□	□	□
Stuffy “bad” air	□	□	□
Dry air	□	□	□
Unpleasant odour	□	□	□
Static electricity, often causing shocks	□	□	□
Passive smoking	□	□	□
Noise	□	□	□
Dust and dirt	□	□	□
Other………………	□	□	□

General Questions

What is your general opinion of the dwelling with respect to the following terms:

	Very good	Good	Acceptable	Poor	Very poor
- Size of the dwelling	□	□	□	□	□
- Planning, layout	□	□	□	□	□
- Day light	□	□	□	□	□
- Housing standard	□	□	□	□	□

Thermal Comfort

	Very good	Good	Acceptable	Poor	Very poor
What is your opinion of the **temperature** in the dwelling in general?	□	□	□	□	□

Please indicate any **problems** regarding the thermal comfort in the dwelling:

(more than one choice is possible)

□ Too cold during winter season

□ Too warm during summer season

□ Too warm all year around

□ Vary as outside temperature

□ Cold floor during winter season

□ Draught from windows

□ Draught from outer door

□ Not being able to influence the indoor temperature

Noise conditions

	Very good	Good	Acceptable	Poor	Very poor
What is, in general, your opinion regarding **noise** in the dwelling?	□	□	□	□	□

Please indicate any **problems** regarding the noise in the dwelling:

(more than one choice is possible)

□ Disturbing noise from pipes and conducts

□ Disturbing noise from the ventilation

□ Disturbing noise from neighbours, staircase, lifts

□ Disturbing noise from outdoors (traffic, industry, children playing old floor during winter season

□ other,

____

Indoor air quality

	Very good	Good	Acceptable	Poor	Very poor
What is your opinion of the **the indoor air quality** in the dwelling in general?	□	□	□	□	□

Please indicate any **problems** regarding the indoor air quality in the dwelling: (several choices are possible)

□ Feeling of stuffy air
□ Feeling of dusty air
□ Odours that are irritating

□ Smell of own cooking
□ Smell of cooking from neighbours
□ Tobacco smoke or other odours from neighbours
□ Odours from outside (traffic etc)
□ Remaining moist air in bathroom/shower room
□ Windows that are regularly covered in condensation during winter
□ Windows that are regularly covered in condensation when cooking
□ Limited possibilities of airing due to noise
□ Limited possibilities of influencing the ventilation

Other questions about the residential area

	Very good	Good	Acceptable	Poor	Very poor
What is your general opinion regarding the residential area?	□	□	□	□	□

What is your opinion regarding:	Very good	Good	Acceptable	Poor	Very poor
- Management and care of the area	□	□	□	□	□
- Lighting in the area	□	□	□	□	□
- Security in the area	□	□	□	□	□
- Service from the property manager/caretaker	□	□	□	□	□

Have there been any **water leakages** during the past 5 years? □ Yes □ No □ Don´t know

If yes, where? □ In shower room/bath room □ Another place

Have you regularly had any symptom that you associated with the indoor environment in your dwelling? □ Yes □ No □ Don´t know

Has any one of the children living in the dwelling had any symptoms associated with the indoor environment in the dwelling?	□ Yes	□ No	□ Don´t know	□ No children living at home

Current symptoms

During the **last 3 months**, have you had any of the following symptoms? Please answer the questions even if you have no such symptoms)

If yes: Do you believe that it is due to the indoor environment in your dwelling?

	Yes, often (every week)	Yes, sometimes	No, never	Yes	No	Don´t know
Fatigue	□	□	□	□	□	□
Feeling heavy-headed	□	□	□	□	□	□
Headache	□	□	□	□	□	□
Itching, burning or irritation of the eyes	□	□	□	□	□	□
Irritated, stuffy or runny nose	□	□	□	□	□	□
Hoarse, dry throat	□	□	□	□	□	□
Cough	□	□	□	□	□	□
Dry or flushed facial skin	□	□	□	□	□	□

Supplement questions

Sex: □ Male □ Female

Age: □ 18-64 years of age □ 65 years of age or over

Do you smoke? □ Yes □ No

	Yes	No	**If yes:** during last year? Yes	No
Have you ever had asthmatic problems?	□	□	□	□
Have you ever suffered from hay fever?	□	□	□	□
Have you ever suffered from eczema?	□	□	□	□

Other comments:

Thank You!

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

K A checklist for a thorough primary investigation

The purpose of the thorough primary investigation (TPI) is to find out whether the building/buildings meet indoor environment requirements in respect of the following aspects:

- thermal comfort
- air quality
- moisture
- noise
- light
- radon
- domestic hot water temperature

A TPI must be carried out by a person, or group of persons, with sufficient theoretical knowledge, experience of similar work and ability to make physical measurements. These abilities can be supported by reference to earlier work, training and/or experience, and must cover:

- building physics
- moisture
- thermal comfort
- acoustics
- ventilation (equivalent to that required for performing obligatory ventilation inspections)
- experience from similar investigations

Calibrated instruments must be used: Methods of measurement, instruments and calibration are described in Appendix P.

A TPI consists of the following elements:

- ☐ A review of drawings and technical descriptions of designs and systems.
- ☐ Carrying out the questionnaire to provide a basis for the inspection. The results of the questionnaire indicate problems in the building or apartments that must be investigated by the inspection.
- ☐ Review of any complaints from occupants.
- ☐ Review of earlier measurements/investigations carried out in the building.
- ☐ Interviews with operating personnel, caretakers etc.
- ☐ Planning of which apartments/premises should be investigated as part of the work of the inspection (partly depending on the results of points 1-5). Experience of previous similar investigations is important when deciding on the selection. In a group of similar buildings, the apartments selected for closer inspection must comprise at least 20 % of the total number of apartments, and be typical of a cross-section of the apartment stock. In those cases where restaurants, shops, child day-care centres, activity centres or shared premises are included in residential buildings, investigations must also be carried out in a representative selection of these premises. If the building is devoted to a single purpose (school, child day-care centre, offices etc.), the entire building must be inspected.
- ☐ A plan of how the work will be carried out must be prepared and submitted to the property-owner/manager before inspection and measurements are started. It should

include a summary of the results of the questionnaire, indication of planned measurements (extent and procedure), and a presentation of personal skills/qualifications and instruments.

- Information to the occupants of the apartments to be inspected must be sent out in good time before the inspection. It must describe the purpose of the inspection, state when it is to be carried out and by whom. It is important that those performing the inspections are given appropriate identity documents.
- Visit the selected apartments/premises and make measurements and observations to decide whether they meet the appropriate indoor environment requirements.
- Investigation of roof spaces, roofs, exterior walls, windows, foundations, ventilation equipment, heating system, stairwells, utility rooms etc. Make measurements and observations to determine whether indoor environment requirements are being fulfilled.
- Prepare a summary of the results, describing the results of the inspection and indicating whether the building/buildings meet the necessary indoor environment requirements, and/or what measures are necessary in order to meet the requirements.

L Inspection record form for apartments (example)

Area:______________________________ **Initials:**____________________________

Home address: ________________________ **Date, time:**_____________________________

Apartment number: _____________ Outdoor temperature:______ °C,

Outdoor RH:______%

Floor no.______ of ________

Weather: ☐ Sunny ☐ Cloudy ☐Rain/snow

Apartment area:________________m² Wind: ☐ Weak ☐ Moderate ☐ Strong

Thermal comfort	0,1 m above floor	1,1 m above floor	Comments, measurement site
Air temperature (°C)			
Air velocity(m/s)			
Operative temperature (°C)			
Radiant temperature asymmetry (°C)			

Floor temperature (°C) (0,6 m from outer wall)	Room: °C	Room: °C	Room: °C
Surface temperature elsewhere e.g. outer wall (°C)	°C	°C	°C
Relative humidity (%)	°C	°C	°C
Vapour concentration (g/m³)			

Domestic hot water	Kitchen: °C	Bathroom: °C	Comments

Ventilation	Kitchen (l/s)	Bathroom (l/s)	WC (l/s)	Walk-in wardrobe (l/s)	Other room (l/s)	*Total flow. (l/s)*	*Flow/m² (l/s)*
Exhaust air flow at air terminal							

Forced flow							

Air pressures	Pressure(Pa)	Pressure	
Apartment-stairwell		□ Neg. pressure indoors □ Pos. pressure indoors	Comments
Apartment-exterior		□ Neg. pressure indoors □ Pos. pressure indoors	Comments

Moisture indications	Bathroom	Other rooms:

Noise levels	Kitchen: dBA	Bedrooms: dBA	Comments

Light	Kitchen: lux	Bathroom: lux	Comments
	Stairwell: lux	Entrance: lux	Comments

Tenant's observations	**Other comments from caretaker or inspector** *Odour, reason for complaint, maintenance etc.*

M Checklist and templates for first energy analysis

A first energy analysis must be carried out as part of the preparations for renovation. The following table is a check list to ensure that all parts of the energy analysis are included.

Requirement	**Description**	**Assessment**
Property description	Administrative data	*E.g. OK*
Energy status	Climate screen	*E.g. OK*
	Heating systems	
	Cooling systems	
	Ventilation	*E.g. further information needed on ......*
	Lighting	
	Water	
	Control and supervisory system	
Energy performance	Domestic electricity	
	Electricity for building services	
	Heating	
	Cooling	
	Domestic hot water	
Earlier energy efficiency improvement measures	*E.g. Changed from oil to district heating, 2003.* *E.g. Possibility of adding solar heating investigated*	*Documentation OK* *Ongoing, 2008*

Italic text is an example of entries.

Template for property description for FEA (example)

Where?	Description
Name/number of building as given by owner	
Type code for property taxation classification	
Address	
Property ID on national land and property register	
Property classification on national land and property register	
Property owner	
Name	
Address	
Organisation number	
Contact person	
Building data	
Floor area[1]	
Year of construction	
Year of retrofitting/renovation	
Most recent change of ownership	

[1] Area may be expressed as gross floor area or usable floor area, but should be the same as that used for applicable reference values. It is the area inside the climate screen that must be used for calculating the building's energy performance.

Templates for FEA Energy status (example)

Climate screen

Climate screen	**Type**	**Proportion, %**	**Notes** (repairs, replacements, adjustments or other measures)
Type of construction	*E.g. raised foundation, slab on ground, basement*		
Type of structure	*Massive/light*		
Facade	*E.g. brick, stone, plaster*		
Roof	*E.g. slate, copper, tiles, roofing felt*		
Windows	*Proportion of façade area*	*E.g. 30 %*	*E.g. 80 % of window area faces south*
	Single pane		*E.g. should be replaced within one year*
	Double-glazed		*E.g. sealed glazing units*
	Triple-glazed	*E.g. 50*	*E.g. replaced 2004*
Insulation	**Type**	**Thickness**	**Description**
Floor			
Walls			
Roof			
Additional insulation			
Floor			
Walls			
Roof			

Italic text is an example of entries.

Additional information

Additional information that can be relevant to energy performance, e.g.:

- Calculated U-values
- Known thermal bridges
- Recurrent/known problems
- Earlier improvement measures (when and why)

Heating and cooling systems

Heating / cooling	**Type**	**Proportion (%)**	**Description**
Distribution system	*E.g. water radiators*	*50*	*From 1967*
	E.g. local (in-room) cooling units		
	E.g. waterborne floor heating	*50*	*Installed 2005*
Energy source	*E.g. district heating, oil boiler, pellets boiler*		

Heating / cooling control	**Type**	**Proportion (%)**
Sensors	*E.g. room temperature, outdoor temperature*	
Time	*Time switch*	

Operating times, heating/cooling	**Proportion (%)**	**Time**
24-hour		
E.g. night setback, morning boost		

Documentation, heating / cooling	**Available**	**Attached**
Drawings		
Flow diagrams		
Service record card		
Operation and maintenance instructions		
Adjustment records	E.g. *from 051010*	
Design documents		

Ventilation systems

Ventilation system	**Proportion (%)**	**Description**
Natural draught		
Mechanical exhaust	*100 %*	*Many complaints about the ventilation system*
Balanced mechanical		
Balanced mechanical with heat exchange		
Exhaust air heat pump		

Control, ventilation	**Type**	**Proportion (%)**
Sensors	*E.g. occupation, pressure or* CO_2	
Time	*E.g. time switch*	

Operating times, ventilation	**Proportion (%)**	**Time**
24-hour		
Whole year		
Night setback		
Temporary boost		

Documentation, ventilation	**Available**	**Attached**
Drawings		
Flow diagrams		
Service record card		
Operation and maintenance instructions		
Obligatory inspection records	*E.g. from 051010*	
Design documents		

Lighting

Lighting	**Type**	**Power (W/m^2)**	**Description**
Stairwell			*E.g. recently replaced by low-energy lamps*
Basement			
Outdoor			

Control, lighting	**Type**	**Proportion (%)**
Sensors	*Occupancy*	
Time	*Time switch*	

Water

Water	**Type**	**Proportion (%)**	**Description**
E.g. electricity heating, hot water storage tank			*Not replaced since the block was built.*
Distribution system	*Copper pipe*		*Not replaced since the block was built.*
Domestic hot water circulation	*E.g. time-controlled*		
Taps, valves and fittings	*Low-flow*	*50 % of apartments and 100 % in common areas*	*Replaced in 2004*

Documentation, water system	**Available**	**Attached**
Drawings		
Flow diagrams		
Operating and maintenance instructions		
Inspection records	*E.g. Yes, from 051010*	
Design documents		

Control and supervisory system

Control and supervisory system	**Type**	**Proportion of the building or group of buildings (%)**	**Description**
Ventilation system	*Central or decentralised supervision*		*Incompatible with modern systems*
	Includes maintenance routines		
	Includes alarms		
	Includes calibration routines		
Heating / cooling system	*Central or decentralised supervision*		*Uses xxx standard for communication with other systems*
	Includes maintenance routines		
	Includes alarms		
	Includes calibration routines		

Documentation, control and supervisory system	**Available**	**Attached**
Drawings / Descriptions		
Service record card		
Operation and maintenance routines		
Log book		

Energy monitoring system

Energy carrier	**Readings - manual / automatic**	**Intervals**		
		Monthly	**Quarterly**	**Annually**
Domestic electricity				
Building services				
Heating				
Cooling				
Cold water				
Domestic hot water				

Italic text is an example of entries.

Templates for FEA Energy performance (example)

Energy performance covers all supplied energy in the form of electricity, heating and cooling, with heating and/or cooling further broken down to indicate proportions between different energy carriers. The figures must include historical values (preferably three years) of energy supplies, with energy use that is dependent on outdoor climate conditions having been corrected for a statistically average year. (This means that, for example, thermal energy used for space heating requires correction, while that used for domestic hot water does not.) Values can be taken from stored statistics, or by going through old energy bills. The presentation can also include CO_2 equivalent emissions resulting from the use of energy.

Energy supplied for space heating / cooling, corrected for stat. average year	**Year 1 MWh**	**Year 2 MWh**	**Year 3 MWh**	**Mean MWh**	**CO_2 / kWh**	**CO_2 total**	**kWh/ m^2**
E.g. electricity, oil, district heating							
…..							
Total heating / cooling							
Total electricity							

Electrical energy supplied, in addition to heating / cooling	**Year 1 MWh**	**Year 2 MWh**	**Year 3 MWh**	**Mean MWh**	**CO_2 / kWh**	**CO_2 Total**	**kWh/ m^2**
Domestic electricity							
Building services							
Total electricity							

Use of heat	**Year 1**		**Year 2**		**Year 3**		**Mean**		**m^3/m^2**
	MWh	**m^3**	**MWh**	**m^3**	**MWh**	**m^3**	**MWh**	**m^3**	
Domestic hot water									
Total water use									

Allocate the total energy use over the entire area of the building: it is the gross area inside the climate screen that provides the basis for energy declarations. Gross floor area or usable floor area may be needed for reference values.

If possible, give the monthly readings from each meter, after correction for climate conditions (e.g. print-outs from statistics programs or monthly values in an Excel sheet). This makes it possible to set monthly energy targets.

In order to provide complete data for an energy declaration, performance must be listed per building. This means that it may be necessary to give details of energy readings from each meter, and to indicate to which buildings the energy is supplied, in order to apportion the energy correctly.

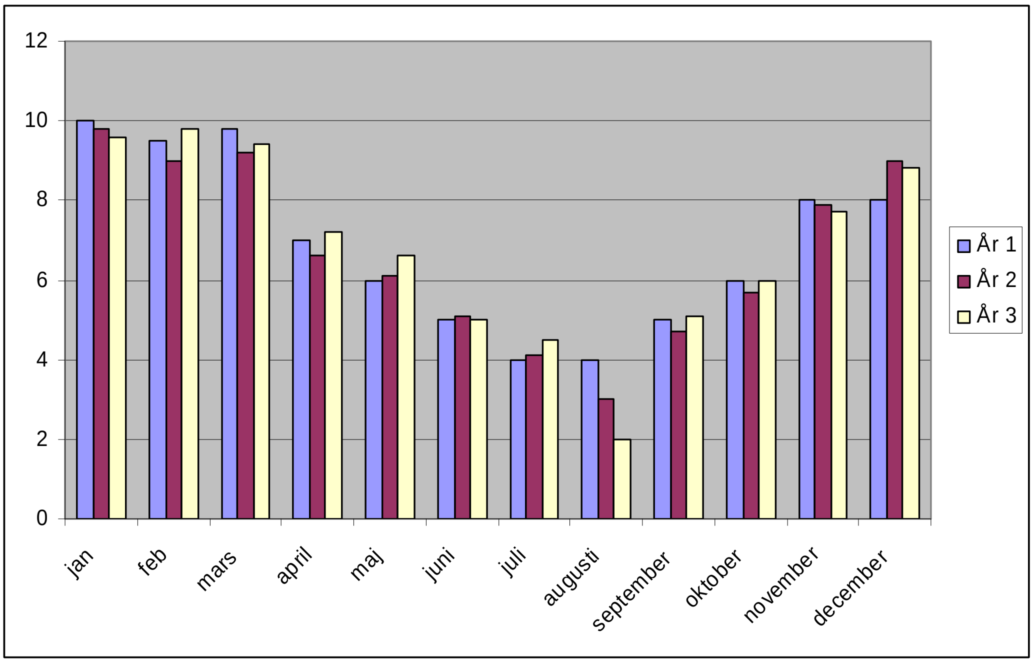

Figure L1. An example of a three-year log of energy use in diagrammatic form

Description of implemented energy efficiency improvement measures

Present the results of energy efficiency improvement measures in terms of costs or cost savings, energy savings or other terms. Other valuable information includes the results of experience of work with contractors, operation of new installations etc.

N Template for setting energy targets (example)

Energy targets (Values affected by outdoor climate must be corrected for stat. average conditions)	**Performance, mean**		**Reference value**	**Energy target**		**CO_2 - equivalents**	
	MWh	kWh/m²	kWh/m²	kWh/m²	MWh	Per kWh	total
E.g. electricity, oil, gas for heating or cooling							
Renewable alternatives, e.g. district heating, solar heating, for heating or cooling							
E.g. electricity, oil, gas for domestic hot water							
Renewable alternatives, e.g. district heating, solar heating, for domestic hot water							
Total heating / cooling							
Total domestic hot water							
Total electricity							
Total energy use							

CO_2 equivalents

In addition to reducing energy use, or improving its efficiency, energy targets can also include reduced environmental impact through optimised use of various energy carriers. The results of surveys can therefore include values of maximum annual emissions of greenhouse gases (expressed as CO_2 equivalents) for the entire building or for the building stock.

Express greenhouse gas emissions as total Global Warming Potential (GWP), i.e. as g CO_2 equivalents in a 100-year perspective. GWP can be calculated using the respective characterisation factors (in terms of CO_2 equivalents) for the gases concerned, as follows:

$CO_2 \times 1$ $N_2O \times 310$
$CH_4 \times 21$ $SF_6 \times 23\,900$

Use the above reference values for emissions from each form of energy carrier when calculating the GWP. They can be calculated with (for example) the EFFem program, which is available free on the internet from www.effektiv.org/miljobel (In Swedish only!). The calculation methodology used in the program is described by Wahlström (2003).

Voluntary/special energy requirements for individual components

In addition to the above energy targets, the purchaser can of course set more stringent voluntary targets for individual components in, or parts of, the building. Such requirements may be appropriate when replacing components, or in connection with more extensive renovation. One or more voluntary energy requirements can be applied, as decided on a case-to-case basis.

Examples of voluntary energy requirements include:

- Thermal insulation/transmission losses
    - U-value requirements for particular parts of the building (W/m²K):
        - Exterior walls
        - Roof structures
        - Windows
    - Total U-value requirements (W/m²K):
        - A mean value for the entire envelope area
- Air-handling systems:
    - Temperature efficiency of heat exchangers (70 %)
    - SFP [kW/m³] – for the entire air-handling system
    - Electrical power/design cooling power (kW/kW)
    - Installed cooling power (W/m²)
- Lighting and electrical equipment:
    - HF light sources
    - Energy-efficient pumps
    - Maximum power demand in common areas (W/m²)
    - Maximum power demand for outdoor lighting (W/m²)
- Use of water:
    - Domestic hot water (l/year)
    - Cold water (l/year)
    - Low-flow items

O Template for selecting instrumentation for energy monitoring

Energy supplied and meter ID	**Description**	**Calibration / inspection status**	**Location**	**Area, m²**
Building services, Meter no. 1	*Induction meter*	*Checked against Meter y, 06-05-01*	*Block no. 1*	542
Domestic electricity	*= Total electricity (meter y) - Building services (meter 1)*		*Block no. 1*	542
Oil, meter no. 1	*Own, volume flow*	*Calibrated 08-01-31*	*Block no. 3*	
District heating, meter no. 1 (space heating)				
District heating, meter no. 2 (domestic hot water)				
…..				
…..				
Total heat, meter no. x				
Total electricity, meter no. y				

P Methods of measurement, measuring instruments and calibration (guidelines)

Temperature

Measure thermal comfort in accordance with SS-EN ISO 7726:1998 and SS-EN ISO 7730:2006. Measure the temperatures of air and surfaces using instruments having an uncertainty of measurement of, or better than, ± 0.3 °C. Simpler measurements of air and surface temperatures are often perfectly adequate for identifying temperature-related comfort problems.

Pt100 sensors are usually more stable, and have a lower uncertainty of measurement, than thermo-element sensors. However, in most cases, despite poorer uncertainty of measurement, the readings from a calibrated thermo-element sensor will normally be sufficiently accurate.

Measure temperature gradients in the middle of a room and close to windows (= 0.6 m from a window). In both cases, measure the temperatures at heights of 1.1 m and 0.1 m above floor level.

Measure floor temperatures in the occupation zone, i.e. not closer than 0.6 m to outer walls. Measure the temperature either by means of a surface temperature sensor on the floor, spot measurements using an IR meter, or with the use of a thermography camera.

Measure operative temperatures in the centre of the room and close to windows (= 0.6 m from a window). In both cases, measure at a height of 1.1 m above the floor. In the normal case (low air velocities) the operative temperature is the mean value of the radiant temperature from surrounding surfaces and the air temperature.

Measure domestic hot water temperatures directly in the water after substantial run-off.

Moisture

Measure temperature and relative humidity indoors and outdoors. Use a Mollier diagram, or tables of saturated vapour pressure, to determine the moisture content of the air, in terms of vapour concentration, g/m^3. Compare indoor and outdoor values. Substantial differences (with an additional moisture content >3 g/m^3) indicate either poor ventilation or high internal moisture release, or possibly both.

Relative humidity is usually measured with a capacitive sensor: accuracy must be better than ± 5 %. Relative humidity can also be determined by simultaneous measurements of dewpoint temperature and air temperature, from which the relative humidity can be read from a Mollier diagram. This method gives a more accurate determination of the vapour concentration (g/m^3) of the air. Compare sensors with each other, or against a different type of RH or dewpoint sensor when making the measurements. In addition, calibrate instruments at least once a year. Simple user calibrations can be done using salt solutions to produce known values of relative humidity: traceable calibrations require the instruments to be calibrated by an accredited calibration centre.

If moisture damage to wood is suspected, measure the moisture ratio of the wood by an electrical method, with the electrical resistance of the wood providing a measure of the moisture ratio of the material. This method provides good accuracy in untreated wood, but a significant error (>5 percentage points) can arise if measurements are made in impregnated or dirty wood.

Measure or indicate moisture in structural parts (e.g. moisture in basement walls, concrete ground slabs or around floor drains) by means of electromagnetic indicator instruments. These instruments provide information on differences in density between different measurement points, with such density differences possibly being caused by moisture. A high measured value can – but not necessarily – indicate a high moisture content.

Acoustic measurements

Make acoustic measurements in accordance with the methods prescribed in SS 25267 and SS 25268.

Light measurements

Measure illuminance (lux) in stairwells at ground level, on landings, on stair rises and on any intermediate levels. Measure also lighting in general areas, such as utility rooms, storage basements etc. Make the measurements at a height of 0.85 m above floor level: in doorways, measure the value about 30-50 cm from the door. Make sure that the person making the measurements does not shadow the photocell of the meter.

The lighting experience is graded by the person making the measurements on a scale of 1-5, with 5 being the best. Note whether any lighting is dazzling.

Ventilation air flows

Measure ventilation air flows in ventilation systems, preferably in accordance with one of the methods stated in 'Methods for measuring air flows in ventilation systems', T9:2007/ T22:1998, Formas.

Measure air flows through exhaust air terminal devices using a suitable air velocity sensor and measurement duct. Place the duct over the terminal device and determine the air flow rate either by measuring the air velocity in the centre of the flow stream using an air velocity meter, or by the hot wire system, with wires in the measuring duct.

Measure airtightness using a calibrated VEAB tube, or similar, to determine the air flow.

Air velocity sensors and air mass meters should be calibrated annually by an accredited calibration laboratory.

Air currents

Measure air currents in the occupancy zone using a hot-wire anemometer of the low-velocity type. Hot-wire anemometers can also be used to measure the local air velocity around air leaks.

Smoke can also be used to estimate the severity of draughts due to air currents. Release a puff of smoke, and see how far it moves in a given time to provide a measure of air velocity and an indication of direction. However, it is important to be aware that the sensation of a draught may be caused by cold radiation from a surface that is colder than the room air, i.e. this can occur without any measurable air currents.

Pressure difference

Measure pressure difference generally with an electronic micro-pressure gauge. Measure the difference between the apartment and the stairwell, and also between the apartment and the outdoor air. Electric micro-pressure gauges should be calibrated at least once a year: it is recommended that a new pressure gauge should be calibrated every six months until a picture of its reliability is built up.

Airtightness

Measurement of the airtightness of a building envelope involves combination of the results of measurements of air flows and pressure differences, as described above. Measure the pressure difference between the apartment and the exterior: if this is done via the stairwell, there must be unrestricted connections between the stairwell and the exterior. Protect the pressure sensors against the effects of wind and insolation. Depending upon the equipment used, it may be necessary to apply temperature correction, i.e. measuring the air temperature as well.

Calibration (general)

Instruments should be traceably calibrated by an accredited calibration laboratory at least once a year. In the event of damage, or uncertainty as to correct function or stability of the instrument, instruments should be calibrated before use.

Q An agenda for progress meetings

Preparations

- A review of the agenda
- List of participants (building managers, operational managers, caretakers, cleaners, tenants' representative, apartment owner)

The quality system/administration system

- What types of non-compliances/complaints concerning the indoor environment have been received?
- Is non-compliance reporting operating as intended?
- Are correction measures and improvement suggestions being applied?
- Have there been any changes in procedures since the previous meeting?
- If so, have descriptions of routines/procedures been modified accordingly?
- Have there been any personnel training sessions since the last meeting?
- Is further training needed?
- Have any documents been updated since the last meeting?
- Have there been any changes in the responsibility structure?

Inspection round

- Have inspection rounds been carried out in accordance with a checklist (Appendix R)?
- Have the results of the inspection round been minuted? Deal with any non-compliances in accordance with established routines.
- Can the inspection rounds be improved?

Any other business

- Any other matters.

R Checklist for inspection rounds

Building, exterior
☐ Facades
☐ Windows
☐ Roof
☐ Water from roof
☐ Foundation
☐ Ground drainage
☐ Drainage
☐ Moisture damage
☐ Other damage

Common areas (entrance lobbies, stairwells, utility rooms etc.)
☐ Lighting
☐ Acoustic environment
☐ Odour
☐ Moisture damage
☐ Cleaning
☐ Accessibility
☐ Safety

Individual apartments
☐ Indoor temperature/floor temperature
☐ Draughts from windows, balcony doors or floors
☐ Ventilation (are terminal devices open, is there condensation on windows?)
☐ Kitchen fan performance (cooking smells)
☐ Can the apartment be aired?
☐ Carry-over of smells from other apartments or stairwell
☐ Noise from ventilation system or from outdoors
☐ Moisture damage
☐ Domestic hot water temperature

Building services systems
☐ Preventive maintenance in accordance with program/ Service record card
☐ Planned or current service
☐ Cleaning/replacement of air filters
☐ Checking of supply and return temperatures for heating and cooling systems
☐ Checking of domestic hot water temperatures
☐ Inspection/checking of fans, pumps, motor-operated valves, damper actuators, frost protection etc.
☐ Manual meter readings
☐ Checking of alarm functions and data storage

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