Technical procurement of heat recovery systems in existing apartment blocks in Sweden

Åsa Wahlström
CIT Energy Management
SE-412 88 Göteborg
Sweden
asa.wahlstrom@cit.chalmers.se

Tomas Berggren
Swedish Energy Agency
Box 310
SE-631 04 Eskilstuna
Sweden
tomas.berggren@energimyndigheten.se

Therese Rydstedt
SABO
Box 474
SE-101 29 Stockholm
Sweden
therese.rydstedt@sabo.se

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Abstract

The installation of heat recovery systems is one of the most important measures to save energy in existing apartment blocks and presents a technical potential of up to 5 TWh savings per year in Sweden. Today, most apartment blocks built before 1975 are ventilated by natural ventilation or mechanical exhaust ventilation, while heat recovery is seldom used. Components and systems exist, but require development and adaptation if they are to be suitable for widespread use in rebuilding projects. In addition, rational methods need to be developed to cover ordering, design, rebuilding and administration.

In order to help to start a market for heat recovery systems, five local housing companies in Sweden, in conjunction with SABO (Swedish Association of Public Housing Companies) and the Swedish Energy Agency, announced a technical procurement project for exhaust air heat recovery systems. The purpose of the project is to kick-start development and market availability of energy-efficient system solutions for such systems in the run-up to the coming extensive rebuilding of apartment blocks.

A technical specification has been produced with a call for tenders for installation of systems in seven demonstration blocks. Two nominated bids have been taken forward. An efficient air-to-air heat exchanger-based system with an visually acceptable duct system that is easy to install in the apartments. The other bid uses a heat pump to recover heat from the exhaust air, which efficiency is improved by a condenser.

Preliminary results show that it is possible to produce effective solutions for heat recovery from ventilation exhaust air in existing apartment buildings, and that it will be possible to reduce costs. Designs and methods have been developed that enable such systems to be installed in apartments with a minimum of disturbance for the tenant. The start of a market range of heat recovery systems in refurbishment seems to be established in near future.

Introduction

In the newly recast directive on the energy performance of buildings (Directive 2010/31/EU), there is a demand that "nearly zero-energy buildings" are to be a requirement for the construction of new public buildings from 1 January 2019 and for all new buildings from 1 January 2021. In addition, the member states are to undertake the measures needed to ensure that when buildings undergo a major renovation, the energy performance of the building, or the renovated part of the building, is improved so that it meets the minimum requirements regarding energy performance to the extent that this is technically, functionally and economically feasible. The requirement is to be applied to the renovated building, or the renovated unit, as a whole. The member states are to stimulate the transformation of buildings that are being renovated into nearly zero-energy buildings.

Pursuant to the Directive 2010/31/EU, the National Board of Housing, Building and Planning, has introduced new, stricter rules for making changes in buildings that applies from the 1st of January 2013 (BFS 2011:26). These rules state that the same quality requirements that apply to the construction of a new building will apply to mayor renovation of buildings. This means, in actuality, that energy consumption requirements for new buildings will also apply to extensive renovations of an existing building. In order to achieve such a change at major renovation, a number of cost effective measures are needed on the market.

THE NEW REQUIREMENTS AND PROPOSAL FOR COMING REQUIREMENTS

The Sweden's environmental objectives were recast in 2012. Energy use in the built environment should be seen as a part of Sweden's ambition to reach the goal of an energy efficiency for the built environment with 20 % to 2020 and with 50 % to 2050 (Ds 2012:23).

The new building code set by the National Board of Housing, Building and Planning has requirements for the building's energy performance. The requirements are described in terms of specific energy use (kWh/m² A_{temp}) and are shown in Table 1. A_{temp}, the heated area, is defined as the area on the inside of the building envelope, on all floors, that is supposed to be heated to more than 10 °C. The area of interior walls, openings for stairs, shafts, and similar are included. The area of the garage is not included.

The requirements specify not only maximum permitted energy use per square meter, but also the permitted installed electric power for heating, and a mean coefficient of thermal transmittance of the building envelope. In addition, the new building code specifies that energy performance must be verified by measurements within 24 months of completion of the building.

The building's energy use is defined as the energy that needs to be delivered to the building (often called "purchased energy" in Sweden and "site energy" in the U.S.), at normal use and during a normal year, for heating, comfort cooling, hot tap water, and electricity for the operation of the building. Electricity for domestic purposes is not included.

The requirements differ depending on: in which climate zone the building is placed (Sweden is divided into three climate zones, see Figure 1), if the building has an occupant activity of living (dwellings) or business activities (premises), and if the building is heated by electricity or in another way. The latter means that in most cases heat pumps need to be installed in order to meet the requirements for electrical heated buildings.

Electrically-heated buildings are buildings in which the installed electric power for heating is greater than 10 W/m². Installed power is the total electric power that can be received by the electrical heating appliances that are needed to maintain the intended indoor climate, domestic hot water production and ventilation when the maximum power needs of the building prevail, that is, during the design outdoor winter temperature.

APARTMENT BLOCKS IN SWEDEN

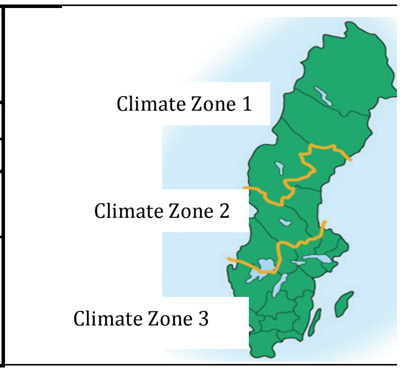
About half of the population of Sweden lives in apartment blocks. These contain approximately 2.4 million flats, with a total of about 180 million square metres. Energy used for the built environment in Sweden is about 160 TWh yearly and the apartment block sector stands for approximately 25 %. In 2011, the apartment block sector used about 24.3 TWh for heating and domestic hot water provision, see Figure 1. Heating was dominated by district heating. Of the total energy use for heating and domestic hot water provision, 92 % is from district heating, 5 % is from electricity, less than 1 % is from oil and the remainder is from natural gas and biofuels (ES 2012:05). Apartment blocks built before 1960 have primarily natural ventilation while the ones built after 1960 have primarily exhaust ventilation.

Just over half of the apartment blocks were built between 1950 and 1975. Apartment blocks can differ greatly regarding size, shape, materials, building technique, etc. Low-rise apartment buildings have been the dominant building type from the 1930s and onwards. They are often 3 to 4 stories high and are built as long, detached structures. Each story can be reached by several stairwells, often without an elevator. During the 1960s and 1970s, high-rise blocks of flats became very common as a part of the industrialized construction of the million homes programme. These high-rise blocks of flats are multi-story buildings, with an elongated form, usually 8–9 stories high, built on a rectangular ground plan and equipped with elevators. Tower blocks are free-standing buildings with a stairwell located in the core of the building. Tower blocks began to be used in the 1930s and were four to five stories high, but they became common first in the 1940s. Since the 1950s, the height of the buildings has increased, and often includes eight to ten stories (Björk et al., 2003).

A recent study shows that near 75 % of the existing flats needs renovation before 2050 and many of them in the near future. This leads to a renovation need of 50,000 flats yearly requiring totally investments of 2–5 billion Euros per year (IVA, 2012).

Table 1. Requirements for maximum specific energy use in the national building code for residential buildings (kWh/m² A_{temp}).

Residential buildings	Annual energy use for heating, comfort cooling, domestic hot water provision and other shared services in the building (kWh/m²)		
	Climate zone		
	1 (north Sweden)	**2** (middle Sweden)	**3** (south Sweden)
with heating systems other than electric heating	130	110	90
with electric heating	95	75	55



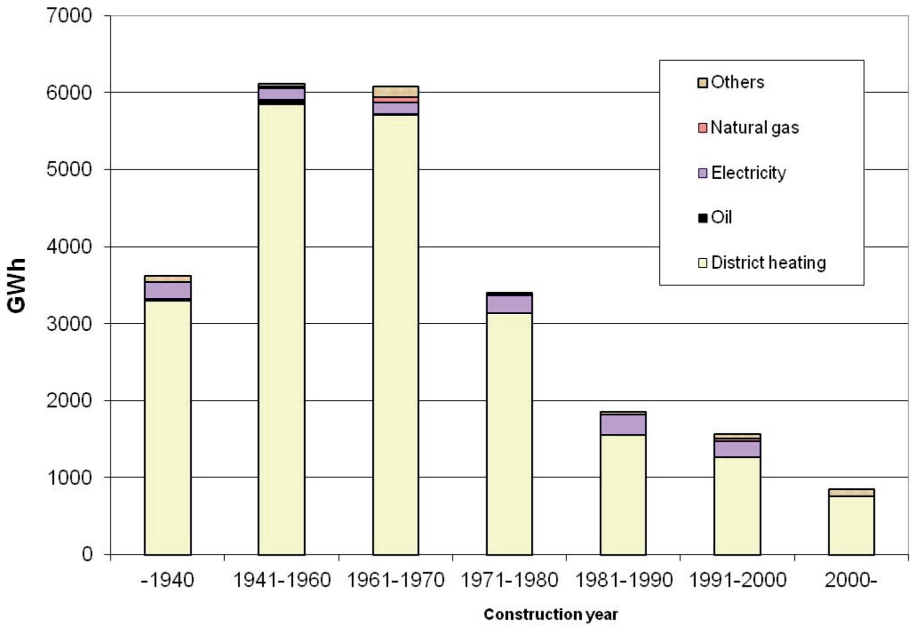


Figure 1. Energy use year 2009 for multifamily houses by year of construction and energy source.

HEAT RECOVERY AN IMPORTANT MEASURE

Many of the modernist apartment blocks built in the boom years between the end of the Second World War and the start of the oil crisis require and are awaiting substantial renovation work. The renovation need gives an opportunity to perform energy savings that do not need to fully cover the cost of the measure. The next opportunity after this profitable refurbishment may not be available for another 40 years.

Several studies shows that heat recovery systems, either with an air-to-air heat exchanger between the exhaust and the supply air or installation of an exhaust air heat pump, are among the most important measure for renovation of apartment blocks while considering decrease of life cycle costs (for example Filipsson et al., 2012). However, in order to reach a reasonable profitability, measures of installation of heat recovery systems needs further developments.

Preparatory study of potentials, opportunities and obstacles

In 2008 a preparatory study were made (Wahlström et. al., 2009). The objectives with the study was partly to collect existing knowledge and status of installation of heat recovery and energy-efficient ventilation systems in apartment buildings and partly to investigation of whether there was a need for further developments of heat recovery systems. This preparatory study was carried out through interviews with property-owners, property administrators, component manufacturers, suppliers, installers and ventilation contractors. Further input was provided by experience and data from renovation projects.

The interviews showed that very few heat recovery systems had actually been installed in existing apartment buildings. Little experience of installation and operation of heat recovery systems in existing apartment buildings was available.

One obstacle to installation of such systems, as seen by property-owners and building managers, was that it is difficult for heat recovery systems to be viable in relation to their investment cost, due to such factors as high cost of the systems and high service and maintenance costs. In addition, maintenance requires specially trained personnel. Those whom we interviewed also expressed doubts as to whether such systems are sufficiently robust and can continue to deliver their intended performance. However, manufacturers, installation contractors and other contractors claim that such performance metrics as heat recovery percentage do not change with time if the ventilation system is maintained as intended, with regular replacement of filters and cleaning of heat transfer surfaces and ducts. In addition, they claim that maintenance and service are not resource-demanding.

In addition to the economic obstacles, other arguments against heat recovery were that the necessary equipment is demanding of space, both for the running of ducts and the installation of equipment. A further argument, against systems using exhaust air heat pumps, was that even though the systems reduce the demand for energy use, it is of the cost of replacing part of the district heating savings with increase of electricity.

The biggest reason for failure to install heat recovery equipment, not even in connection with other renovation work, was that there is a lack of awareness and a lack of simple package systems with good overall performance. In 2008, for example, there were no package systems consisting of all-in-one heat recovery systems; instead, individual components had to be bought and put together to form systems by the designers or contractors in each project. In some cases, manufacturers worked closely with designers/installation contractors.

NOT JUST SYSTEMS – BUT DEMAND FOR THEM, TOO

Summarising, the preparatory study found that, in 2008, there was essentially no demand for installation of heat recovery systems from ventilation exhaust air, and equally that there was no market of parties offering equipment for, or installation of, heat recovery systems from ventilation exhaust air.

Components and systems admittedly existed, but required further development and modification to suit the refurbishment market. To make things simpler for purchasers, and to improve competition between different systems, there was a need for technical development, concentrating mainly on reduced costs rather than on improvement of the performance of components. There was a need for development of rational methods covering purchasing, design, conversion and building operational management. In addition, there was a need for good demonstration projects, with associated evaluation of results, in order to identify problem areas more clearly. By being able to demonstrate good examples, supported by experience from others, the risks perceived by property-owners could be reduced, thus allowing more projects to be run.

From the above, it could be seen that there was a need for a technology procurement project, with the aim of market introduction of competitive heat recovery systems, suitable for installation in most types of houses/buildings.

ENERGY SAVING POTENTIAL

In the preparatory study also the national potential for energy efficiency with installation of heat recovery were assessed. If heat recovery systems are installed during all refurbishment works involving apartment blocks until 2020, there is an energy-saving potential of about 1 TWh annually (Wahlström et. al., 2009). The estimation is based on that refurbishment will keep the same rate as it has done during the last years. The technical potential, that is, the potential with an increased pace of refurbishment, is considerably higher and may reach 5 TWh energy savings annually, if all Swedish apartment blocks will install heat recovery.

The technology procurement process

In order to assist the start of a market of heat recovery systems, five local housing companies in Sweden announced a technical procurement together with SABO (Swedish Association of Public Housing Companies) and the Swedish Energy Agency. Technical procurement is used as the method for development and introduction of new energy-efficient products and systems on the market.

The purpose of technical procurement of heat recovery systems in existing apartment blocks is to initiate the development of energy-efficient system solutions offered on the market in the run-up to the extensive refurbishment of apartment blocks which will come about over the next few years. The basis for the technical procurement is described below.

OBJECTIVES

The main purpose is to maximise the efficiency of the energy used in our existing apartment blocks by developing complete systems for heat recovery from ventilation air. Recovered heat can be used for heating rooms and/or for domestic hot water.

The systems should be designed so that requirements as to air quality and thermal comfort are fulfilled together with good energy performance. The installation of units and ducting should be possible with minimum disturbance to occupants. The siting and design of components should be aesthetically acceptable and should not restrict the use of various areas other than marginally.

This technology procurement project was aimed at parties who can offer a complete package, in the form of the necessary technology and hardware, a detailed description of the system, design, the necessary installation work and final operation. This can be produced and delivered within the tendering party's own organisation, e.g. a ventilation contractor, or in the form of a joint cooperative effort between contractors, manufacturers, consultants etc.

One objective of the work is also to acquire more detailed experience of operation and maintenance of heat recovery systems through monitoring of the systems in demonstration blocks.

CONDITIONS

The technical procurement covers the systems needed for heat recovery, including all components and measures, from ventilation air in an existing apartment block. This includes the modification of existing ventilation systems (natural, mechanical exhaust or balanced ventilation) for heat recovery. It includes a complete system for heat recovery, including installation and other measures necessary during the procedure (e.g. sealing of climate screens, construction of fan rooms, preliminary adjustment etc.).

In addition to the requirements for technical procurement, it is necessary that a complete bid should also include an otherwise complete and well-functioning heating and ventilation system which complies with legal requirements when modifying buildings, e.g. duty of care, accessibility, fire regulations, etc., i.e. all applicable rules and regulations shall apply.

One condition for a bid to be accepted is that the tenderer is qualified to fulfil all three stages of the technical procurement process. This means that, in addition to a written bid, he should also have the capacity to carry out installation of heat recovery systems in the demonstration blocks referred to in the tender and also be able to supply and install heat recovery systems on a large scale in buildings where similar conditions pertain.

CUSTOMER GROUP

The requirements in the specification have been drawn up by SABO and five property companies, who will each be installing the best bids in one of their blocks in order to demonstrate installation and gain operational experience. The customer group will, in addition to taking part in compiling the technical specifications, assessing the bids and demonstration in their apartment blocks, also act to bring about a public procurement through call-off order or local procurement with contracts in the run-up to continued refurbishment.

EXECUTION

The technical procurement consists of three stages.

1. In Stage 1, a technical specification has been written with an invitation to tender for seven demonstration buildings. Tenders have been evaluated by a panel, and two winning bids have been chosen for testing in the demonstration blocks. Procurement take place as a total controlled contract with functional responsibility.
2. In Stage 2, the winning proposals are tested and evaluated in the demonstration apartment blocks. A panel will choose one or more winning proposals, and the result will be pub-

lished for nation-wide dissemination. The technical specifications will be adjusted so as to form the basis for Stage 3.

3. In Stage 3, the customer group will describe what types of systems will be procured for other buildings in the customer's stock. This will be carried out by public procurement through either:
   a. A general agreement with call-off order managed by HBV (HBV is the central purchasing body that carries out procurement procedures for their members (owners), the municipal housing companies in Sweden.), *or*
   b. Local procurement with contractors by describing the system to be procured and chosen after installation on the best conditions.

TECHNICAL PROCUREMENT OF A COMPLETE SYSTEM

This is one of the first times that a technical procurement has been made on a complete system involving several actors, and not just on one component. It is a test of itself to see whether this kind of action is effective in starting the implementation process and involving local stakeholders. Execution is therefore somewhat different from that of traditional technical procurements that normally directly will guarantee a number of purchases for the winning party. Here the tendering parties have first and foremost been approved to install and demonstrate their concept of heat recovery from ventilation exhaust air in a number of existing apartment buildings, with the building owners meeting the full cost of the installation. The requirement specification will, thereafter, need to be modified after completion of the demonstration projects before the larger technology procurement project can be started.

Results stage 1

During the autumn of 2009, the purchaser group and experts working with the group prepared a performance specification for the invitation to tender. Two discussion meetings were held with the relevant sector organisations, Svensk Ventilation (trade association for ventilation organisations), SVEP (trade association for heat pump organisations) and the Swedish Construction Federation, during this stage.

REQUIREMENT SPECIFICATION

The heat recovery system must fulfil the following principal requirements:

- Technical solution: The technical solutions must be constructed such that heat from the ventilating air is recycled to the benefit of the building (for space heating and/or for domestic hot water). This requirement is meant to be technically neutral (i.e. to deliver the same evaluation regardless of technical solution).
- Energy efficiency: The heat recovery system must have good energy efficiency. This requirement means that the more electricity that the system uses, the more heat it must save.
- Costs: Limiting investment cost in relation to the reduction in energy use has been one of the important requirements. A viability and cost calculation has been produced, showing total costs over the operational life.
- Indoor climate: The ventilation plant must be designed so that requirements for the indoor environment are fulfilled. A number of indoor climate parameters are specified in terms of required performance.
- Design: Components that are visible in apartments or stairwells must be of a design acceptable to most residents.
- Functionality: The system solution must not have a negative effect on the building's function, e.g. with a significant encroachment on the area able to be let.
- Installation: Refurbishment must not cause significant disruption for the residents.
- Robustness: The system solution must be robust. Components which may need replacement during the plant's lifetime must be of standard sizes and be easy to replace.
- Operation and maintenance: Clear instructions must be included. The system must be designed so that it is easy to run and maintain by ordinary operating staff.
- Monitoring of temperature and energy use. It must be possible to continually measure the efficiency of the recovery system e.g. through integration with the block's existing control and monitoring system. This is important, not only in the demonstration blocks but also for future bulk procurements in order to ensure problem-free operation.
- System flexibility. An open-source, non-proprietary control and supervisory system that can be used with components of any make.

PERFORMANCE MEASUREMENT AND MONITORING PLAN FOR THE DEMONSTRATION BLOCKS

A performance measurement and monitoring plan for the demonstration blocks was drawn up in parallel with the performance specification.

Seven demonstration blocks were selected by the purchasers, representative of their properties. Preparatory measurements were made during the spring of 2010, in the form of measurement of air tightness, thermography and measurement of sound levels in all the blocks. Passive tracer gas measurements were made in the block having only natural draught ventilation.

CALL FOR TENDERS

The call for tenders was announced in the Official Journal, and the entire enquiry document was available in both Swedish and English. An information meeting was held with questions and answers being published in writing. No fees have been paid to bidders for participating in the technical invitation. Participation will however bring other advantages such as:

- Winning bids in Stage 1 will be allowed to install the heat recovery system in one or more demonstration blocks, with full cost recovery.
- Winning bids in Stage 2 will be able to sign a general agreement with call-off order or local contract agreements for ongoing procurement of systems.

- Around 70 % of all apartment property owners can be reached through the customer group. They will disseminate information within their organisations and make sure that solutions are utilised in practice.
- The market for energy efficiency measures in the apartment sector is expected to increase due to higher requirements in energy efficiency by authorities.

NOMINATED BIDS

Two tenders were accepted for installation (one with balanced mechanical ventilation plus heat exchange, and one with an exhaust air heat pump).

System solution with an exhaust air heat pump

This system consists of an air/water heat pump for recovery of heat from ventilation air. The system has a smaller heat pump, which supplies heat to the building's space heating system. The heat pump would be mounted in the roof space or on the roof, in some suitable position where it can be connected to the exhaust air discharge, and connected to the building's existing space heating system by insulated pipes. The heat pump is intended to cool the exhaust air flow down to -10 °C (possibly down to -20 °C), and can also utilise the latent heat of condensation of the moisture content of the exhaust air, thus giving good energy efficiency. This type of heat pump is referred to as a condensing exhaust air heat pump when installed in detached houses and, as far as the purchaser group is aware, has not previously been used in apartment buildings. The proposal uses the existing exhaust air ducts, and it was originally the intention not to do any work or install anything in the individual apartments, but to rely on the existing air terminal devices being sufficient to supply the apartments with supply air.

The jury concluded that the proposal would deliver a relatively good energy saving, but at the price of higher electricity use. There would be only little effect on the indoor climate of the proposed ventilation arrangement. However, this presents a slight risk of draughts if the air flows increase somewhat in those cases where the buildings before renovation had to low air flows in accordance with the ventilation rate regulations. This could be dealt with by fitting covers to the air inlets. The costs were assessed as reasonable, and are relatively low.

This system is installed in four demonstration buildings.

System solution with balanced mechanical ventilation with air-to-air heat exchanger

This proposal is a design that employs traditional heat recovery, with heat exchange between the exhaust air and the supply air. It uses the existing exhaust air ducts, but new supply air ducts would be installed in the stairwell. The heat exchanger would be of counter-flow type, with a temperature efficiency of 90 %. Newly developed square section ready-painted supply air ducts would be installed in each apartment, which would therefore involve a limited amount of work in the apartments. Apart from checking the air flows, no further post-installation work is regarded as necessary. Filters would have to be changed twice a year.

The jury regarded this proposal as innovative as far as running ducts was concerned. The bidder has invented a duct system that is easy to install in the apartment and aesthetically attractive. The energy performance would be good, and the design would deliver a useful saving in heat but with a slight increase in the use of electricity. Installation costs are regarded as reasonable, and relatively low. The indoor climate conditions should be better than before the system was installed, and there would probably be fewer draughts in the occupied zones than before. However, the installation of supply air ducts requires space to be available in stairwells, which means that the system would not be possible in all buildings without some modifications. This system is installed in three demonstration buildings.

PREDICTED PERFORMANCE OF THE BIDS

Energy savings for the system with exhaust air heat pump

For the four demonstration buildings the mean value of yearly saved district heating is predicted to be 168 kWh/m^2 and that will cause an increase in electricity consumption of 49 kWh/m^2. This means that the requirement of 30 kWh/m^2 energy saving will be fulfilled and also the requirement that the more electricity that the system uses, the more heat it must save. The season performance factor for the systems are predicted to 3.4.

Energy savings for the system with balanced mechanical ventilation with air-to-air heat exchanger

For the three demonstration buildings the mean value of yearly saved district heating is predicted to be 45 kWh/m^2 and that will cause an increase in electricity consumption of 6 kWh/m^2. This means that the requirement of 30 kWh/m^2 energy saving will be fulfilled.

Investment costs per apartment

The requirement specification used a model where the current value of savings and costs during a calculation period was recalculated to a new current value taking account of interest calculated and increased energy prices. The model was based on energy savings, increased energy costs, investment costs, maintenance costs and reinvestment. The requirement was to show that the investment has paid for itself during 12 years (i.e. the current value of savings must be greater than the current value of investment while interest rate was set to 4 %, energy price increase was set to 2 % for heat and 4 % for electricity, electricity price was set to 0.11 Euro/kWh and district heating to 0.07 Euro/kWh).

The mean value of investment costs is appr. 2,600 Euro per apartment for both the different winning bids.

Results stage 2

The winning proposals are tested and evaluated in the demonstration apartment blocks. The installations took much longer than scheduled. In most of the buildings it was not until January 2012 (six months after the planned installation date) that the installation work was completed. This was due to several reasons, affecting both the property-owners (including change of personnel) and the contractors.

MEASUREMENTS AND MONITORING

A performance measurement and monitoring plan for the demonstration blocks was drawn up in parallel with the performance specification. Measurements started in the spring of 2012.

However, the results are difficult to interpret due to adjustment troubles: partly to operational problems in the commissioning phase, and partly to problems found in connection with the measurements. Some of these problems were corrected as they arose, while others took a little longer to put right. The following problems are some of those that have been dealt with:

- The exhaust air quantity as given by measurement of the combined flow at one point exceeds the sum of the individual air flows as measured in each apartment/utility room/basement. This difference is less in one block, which has existing ducts in which leaks have been tightened with muffs. This may be due to leaky exhaust air ducts, but further investigations are needed.
- The detailing of the design and running of the ducts has been modified. In the first version, the back of the duct was placed against the wall a little below the ceiling, so that the front could be easily clipped into position. However, this formed a ledge on the top of the duct, on which dirt could collect and be difficult to get at when cleaning. In the modified design, the ducts are flush against the ceiling.
- The defrosting function has not worked satisfactorily for effective heat recovery. A new control system has been installed.
- Problems of odour carry-over occurred initially, as the exhaust air was being discharged to the atmosphere via a combination air terminal on the roof. Transfer from the one air stream to the other seems to be occurring through the drain holes in the air terminal, which are intended to drain rainwater or melted snow. The drain holes were moved after the problem was found.
- Control and operation of the heat pumps in conjunction with the blocks' district heating subscriber service units have been improved.

All this means that evaluation of the two nominated system proposals in the project has been extended by one year. The main reason for this is that it has taken longer to install and adjust the systems in the seven demonstration buildings than had initially been expected. During the first period none of the seven buildings have proved the predicted energy performance. Preliminary results for the system with exhaust air heat pump shows a season performance factor within the range from 2.6 to 3.1 and for the system with balanced mechanical ventilation with air-to-air heat exchanger the results shows a yearly saved district heating within the range of 25 to 35 kWh/m^2. Energy measurements and evaluation will therefore continue during the autumn 2012 and the spring 2013. After that, the technical specifications will be modified as necessary, and a public procurement through call-off order will be established. A final report from the project is expected to be published in the end of 2013.

Gained experiences

PROCUREMENT OF A COMPLETE SYSTEM

This technology procurement project for heat recovery from ventilation exhaust air is one of the first that has been run for a packaged system solution, rather than for an individual component. During the first period of testing in the demonstration buildings there were several drawbacks with installation and commissioning that needed to be rethought and modified as the work progressed (as mentioned above in *Results stage 2*). Therefore a cooperation between the customer group and the bidders were established there they together made some development of the system.

For technical procurement of a component this development during the demonstration in buildings may be avoided since the component in itself can be tested by the manufacturer in more detail in a laboratory before the demonstration and such a cooperation between the customer group and the bidders will not be needed. The planned execution for the procurement in three stages has proven to be useful.

TECHNICAL EXPERIENCE

This technology procurement project has shown that it is possible to find space for running air ducts. Such ducts must be visually acceptable not encroach on rentable floor areas, and be straightforward to run, particularly between floors. The project has shown how effective use can be made of stairwells and old refuse shafts for running ducts. Installing ducts in apartments is effective and does not cause significant disturbance to occupants. Heat recovery systems for ventilation exhaust air can be installed without problems without the occupants having to vacate the apartment.

OTHER EXPERIENCE

It can be noted that even though a package solution is agreed, the purchaser needs to be thoroughly familiar with the technology if, at this early stage of technical development, the system is to be installed correctly. This was found by the property companies, with some of them employing new personnel and setting up new posts. Another clear observation is the major importance of having good communication with the tenants if renovation and installation in existing apartment buildings is to work and if the new systems are also to work.

INVESTMENT COSTS

Above all, the work has shown that it is possible to reduce the investment costs that have previously been regarded as impossible to overcome. The bidders met the requirements in the specification but the problems during installation required a lot of work from the property companies' own personal which have led to additional costs. Furthermore correction of the different problems that aroused have also required extra costs. A preliminary estimation is that the final costs will be close to doubled from the costs given in the bids. This is still nearly half of the installation costs that have been paid for installation of heat recovery before the procurement. There is also a potential for further reduction in investment costs via a larger procurement quantity and with the incorporation of experience from the demonstration blocks.

ADVANTAGES AND DISADVANTAGES OF THE TWO TYPES OF SYSTEMS

The advantage of the balanced mechanical ventilation system, with air-to-air heat exchanger, is that it delivers a heat saving at the cost of only a marginal increase in the use of electricity, while the heat pump-based system requires considerably greater use of electricity for the same energy saving.

Exhaust air heat pumps have an advantage in investment terms, as there is no need for supply air ducts to be run. On the other hand, they have the disadvantage of not preheating the supply air, which can introduce a risk of poorer indoor climate in the form of draughts in the apartments.

Installing central the balanced mechanical ventilation system, with air-to-air heat exchanger, in each stairwell of existing multi-entrance low-rise apartment blocks has advantages over tower blocks or multi-entrance high-rise apartment blocks, in which stairwells often exceed six storeys. In multi-entrance low-rise apartment blocks, the sizes of the supply air ducts are such that they can be discreetly and appropriately run.

EARLY SPREAD

Although it has as yet come only half-way, awareness of and interest in this heat recovery from exhaust air technology procurement project has already spread in the building sector like rings on water. The seven apartment building blocks in the project have already received over a score of study visits from other apartment building owners. In particular, the work has attracted considerable attention to the subject, and provided the sector with an appreciation of the substantial market potential. Several new concepts and products are under development and some of them have already been launched. Furthermore, several property-owners who are not involved in the procurement project have started to investigate how they could install heat recovery from exhaust air, and some have already started work.

CONCLUSIONS

Summarising, it can be noted that technology procurement of an entire system, and not just of components, suffers from many problems and weaknesses that have to be dealt with as the work progresses. On the other hand, this has meant that the process has taught us much, and there are favourable prospects that the system solutions will be able to deliver good final results. In addition to performance results in terms of reduced energy use, the objectives of the work have been to encourage contractors etc. to develop and offer package system solutions, to reduce costs, and to develop designs and methods that enable such systems to be installed in apartments with a minimum of disturbance for the tenant. The project has shown that it is possible to produce effective solutions for heat recovery from ventilation exhaust air in existing apartment buildings, and that costs have been reduced. The start of a market range of heat recovery systems from ventilation exhaust air seems to be established in near future.

References

BFS 2011:26. The National Board of Housing, Building and Planning's Building Regulations, BBR 19, 2011.

Björk, C., Kallstenius, P., Reppen, L. The way buildings were built 1880–2000, fifth edition (in Swedish), 2003.

Directive 2010/31/EU of the European Parliament and of the Council, of 19 May 2010, on the energy performance of buildings (recast), 2010.

Ds 2012:23, "Svenska miljömål – preciseringar av miljökvalitetsmålen och en första uppsättning etappmål", Regeringskansliet, Miljödepartementet, ISBN 978-91-38-23762-5, ISSN 0284-6012, 2012.

ES 2012:05, "Energy statistics for multi-dwelling buildings in 2011", ISSN 1654-7543, 2012.

Filipsson, P., Heincke, C., Wahlström, Å., "Utredning av kostnadsoptimal energieffektivisering i befintliga flerbostadshus ", Effsysplus rapport, www.effsysplus.se, december, 2012.

IVA, "Energieffektivisering av Sveriges flerbostadshus, hinder och möjligheter att nå en halverad energianvändning till 2050", ISBN: 978-91-7082-845-4, www.iva.se, Kungliga Ingenjörsvetenskapsakademien (IVA), 2012.

Wahlström, Å., Blomsterberg, Å., Olsson, D., "Värmeåtervinningssystem för betinfliga flerbostadshus – förstudie inför teknikupphandling", Rapport utförd på uppdrag av Bebo och Sabo, www.bebostad.se, januari, 2009.

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