Ventilation in low energy housing retrofits

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SUMMARY

According to the definition, passive houses in Europe meet a target energy demand for heating of less than 15 kWh per square meter and per year. This low level for the heating demand is based on heating by a small post-heater in the hygienic ventilation system at 52 °C maximum, while the ventilation system can be dimensioned purely for ventilation purposes. In theory thus the installed heating power is less than approximately 10 Watts/m\textsuperscript{2}.

But what happens in practice in renovations? Example projects of low energy housing retrofits and their indoor climate systems in winter and in summer were examined. The study includes inspection of technical details and interviews with occupants of some renovation projects. It is shown that the practical realization of very low energy houses can be different from the original passive house definition, but also that the passive house standard is feasible in difficult conditions.

The results illustrate the concerns of occupants considering winter and summer comfort and health, and the difficulties of choosing adequate ventilation and backup heating when the passive house standard is not reached. Also, a good realization of (passive) cooling and solar shading is a very important issue.

The research further illustrates tendencies in innovation considering design of ventilation systems for renovation purposes, including possibilities of space reduction, prefabrication, decentral heat recovery and improved user friendliness of indoor climate systems for passive houses.

1. INTRODUCTION

Promoting energy efficiency is a consequence of the Kyoto Protocol. The European building sector is responsible for about 40% of the total primary energy consumption. To reduce this share, the European Commission (EC) has put forward a directive on Energy Performance of Buildings, the EPBD (2002/91/EC). A building energy label will be mandatory in Europe when selling or renting a house. In most European countries the energy label for buildings is introduced in 2007-2009.
Within the European Union the total building stock is responsible for about 40% of the total primary energy consumption. Housing accounts for the greatest part of the energy use in this sector. Space heating is responsible for 57% of the total energy use of households in the European Union, followed by sanitary hot water production (25%) and household equipment and lighting (11%). [1] In literature, a large number of research papers report on the success of implementing the passive house standard for new buildings [2-6]. One of the prescribed actions on buildings in the EU Action Plan on Energy Efficiency [COM(2006)545] is for the Commission to develop a strategy for very low-energy or passive houses (before 2009) towards a more widespread deployment of these building types by 2015 [7].

However, a decrease of greenhouse gas emissions will not occur if no energy is saved through retrofit of the present housing stock [8]. Several demonstration projects in Austria, Germany, Switzerland and Hungary have used the so called 'passive house technologies' to obtain substantial energy reduction [9-12]. In some cases even the passive house standard is reached after modernization [12, 13].

According to the popular definition [13], passive houses have to reach a target energy demand for heating less than 15 kWh/m²a. This definition is based on meeting the heating demand by heating the inlet fresh air to 52 °C, without recirculation or ventilation volumes that exceed hygienic ventilation requirements. In theory thus the installed heating power is less than approximately 10 W/m². But what happens in practice in Belgian demonstration projects?

Research methodology
Understanding example demonstration projects is a prerequisite for making right strategic decisions. Within the LEHR-project, two main levels of analysis are performed by means of interviews with the owner-clients of (Belgian) example projects:
- analyzing the general environment of example projects: the general environment (political, economical, social and technological factors) influences the market place and thereby influences indirectly each party involved.
- analyzing the competitive arena: suppliers, competitors, substitutes, customers, etc., have a strong and most direct impact on the development of a low energy housing retrofit project.

Findings from demonstration projects are presented, discussed, compared with other international projects and refined in the course of the international implementing agreement 'Solar Heating and Cooling' (SHC) of the International Energy Agency (IEA), specifically IEA SHC Task 37 ‘Advanced Housing Renovation with Solar and Conservation’.

2. PASSIVE HOUSE RETROFITS

What does Passive House retrofit usually mean?
In general, the passive house standard of 15 kWh/m²a, although easily implemented in new constructions, is often difficult to achieve in a cost-efficient way for retrofit. Especially protected facades, existing thermal bridges and highly valued ornaments are difficult to tackle. On the other hand, from the technological point of view, certain types of buildings can relatively easy be transformed into passive houses. The first exemplary renovation projects in Belgium demonstrate that renovation can achieve five-fold and more energy savings while improving living quality.
For low energy housing retrofit the passive house principles tend to take a more important lead than the strict passive house definition. These retrofit principles include [9]:

- Minimized transmission losses: The building envelope has a very high standard of insulation – typical thicknesses for wall and roof are around 20 to 40 cm. Typical windows will be triple-glazed or equivalent. Specific building details will reduce thermal bridges to practically zero.

- Minimized ventilation losses: Heat recovery in the ventilation system will reduce losses by about 80% while increasing both thermal comfort and air quality. A precondition for heat recovery is a high level of air tightness of the building envelope, minimizing losses from warm air leaking through cracks and crevices.

- Passive and active solar energy: Internal heat gains (from people, lights, electrical equipment etc.) and solar radiation are typically taken into account in to the heating demand. In addition to passive solar gains, active systems like thermal collectors or PV-systems can be used.

- Efficient energy supply: Low energy retrofits have a very low heating demand but still need a heating system for the coldest winter days and a system providing domestic hot water. This remaining energy demand is typically supplied by very efficient systems like special heat pumps, high efficiency gas boilers or wood pellet burners.

- Overheating control: As a very high thermal comfort is one of the main marketing arguments in the development of low energy housing retrofits, overheating control is an important issue. Mainly passive measures like overhangs, shading devices, (e.g. awnings) are used.

These principles can be translated into specific measures and performance criteria with typical cost, as illustrated by the Intelligent Energy Europe project ‘e-retrofit-kit’ [9].

Case studies
From literature one can notice that several demonstration projects already exist in Belgium: e.g. a renovation towards the passive house standard of a row house in the centre of Eupen [15], a renovation of a detached farm house towards a ‘K20’ insulation level in Herselt [16], a renovation of a semi-detached house towards the passive house standard in De Pinte [17]. Notice that the orientation of the common façade in this last project is to the south! Fulfilling the (motivated) owner’s needs was the main driver for renovation. These needs include the increase in comfort, health, living quality, area and personal experience. Most design decisions were based on providing an increase in comfort and energy performance.

In all cases, the overall condition of the house was poor with an outdated heating system and a need for space increase and a mixing of functions. Renovation was to be performed anyway since the houses needed a new roof and new windows. In all cases, the outdated windows and shutters were replaced. In the Eupen case, triple glazing was chosen for better thermal surface comfort, better acoustical performance and the ability to provide passive solar gains via the south façade. In the Herselt case, improved double glazing was chosen for better thermal surface comfort and extra passive solar gains were provided with a veranda. In the De Pinte case, also the placement, sizing and orientation of the improved glazing played an important role to be able to reach the passive house standard. In all cases, high levels of insulation were chosen for better thermal comfort, and thermal bridges were
eliminated. Heat recovery in the ventilation system was chosen for better thermal comfort of the incoming air.

We remark that in the Eupen case, specific health conditions of the child required a better solution than the existing dust provoking convectors. Thus, the owner decided to install a central mechanical ventilation system with appropriate filters.

In the Herselt case, a backup heating system was still needed due to extra losses through the (double) glazing. A floor heating system was integrated coupled to a solar collector. This initial design included a day-night switch to provide extra air in the sleeping rooms during the night. However, this option was deleted during the process.

Guaranteed airtightness of the building was a specific concern in Eupen and De Pinte, but not in Herselt.

3. DISCUSSION

The need for retrofit

Low energy housing retrofitting implies a thorough retrofitting of the building including eliminating or heavily reducing thermal bridges from outside into the building, e.g. by replacing existing windows and in most cases making outside insulation of the walls. Another element will be to make the building airtight and to integrate a central or decentral ventilation system with heat recovery.

To carry out such retrofitting measures can mean relatively big investments and the start of a time consuming process. Therefore it is important that there is a need for a thorough retrofitting not only based on energy savings. The need for this typically can be [9]:

- Physical degradation of main building components as roof, facade and windows.
- Bad in-door housing comfort, e.g. due to bad insulation, draft from windows or overheating problems in summertime.
- Health problems, e.g. due to problems with fungi (typically on thermal bridges and not insulated areas combined with bad ventilation) or allergic people who have problems with pollen or asthma.
- Social degradation of the building and the building area has a character of being in decline and less attractive.
- Wish for additional housing area, typically to include outside balconies, green area and/or extra space.

One of the needs or a combination of the needs mentioned above can as a result have the need for carrying out a thorough retrofitting of a building, typically comprising retrofitting of the roof, the facades, changing the windows and establishing a ventilation system. If this is the case, then there is a potential for carrying out a low energy housing or even passive house retrofit.

Lessons from the projects

Overheating in summer turns out to be an important characteristic also for renovations.

There is a real potential to renovate existing houses towards the passive house standard, also in Belgium. Passive house renovations are technically feasible, but require special competences. Controlled ventilation with heat recovery was noticed to be integrated in all example projects with substantial energy reduction.
The installation of ventilation systems causes a strong interference with the building and there were several discussions about the best solution for the ventilation system (central or decentral, cost, maintenance, disturbance, space requirements, risk of abuse, fire protection, comfort,...).

The design of the air duct system is crucial for reducing noise production and for energy efficient function of fans: the heat exchanger and fan unit require a central position in the dwelling, with air ducts designed for low pressure losses. Inlet openings should be far enough from outlet if one can not depend on induction or coanda effect of inlet dampers. Pollution from deposited dirt on ventilation tubes during construction, ands on filters and fan blades can become a health risk after some years. Care should be taken to avoid contamination.

The performance guarantees for climate installations in passive houses are not yet fully developed. Clients expressed concerns to have a guaranteed performance of ventilation systems.

Air volume control per room is sometimes wished for. Application of different zones supports different heating levels through ventilation air. The bathroom may require a heat source to provide instant higher temperatures: a radiator, a heated mirror or other (electrical resistance) heaters.

In low energy renovations the hot water demand dominates the heat request. Solar energy or biomass fired boilers can provide a heat storage that also feeds a simple post-heating system.

**Possibilities for innovation**

The Belgian market is still integrating products and systems for new constructions into renovation, instead of developing products and systems for the rapidly increasing low energy renovation market. E.g. in Austria, Germany and Norway there is development of small decentral ventilation systems with heat recovery for renovation. This development should be further explored, especially since the installation effort and the impact on the inhabitants is minimised. The user friendliness of such novel indoor climate systems can possibly still be improved by evaluation of practical experiences.

Also, prefabrication in renovation is a new trend shown in IEA ECBCS Annex 50: when a roof is to be exchanged anyway, prefabricated rooftop modules can integrate ventilation with heat recovery for underlying living units. Air supply for these living units can also be provided from the outside façade.

Providing performance guarantees of ventilation systems and EPB equivalency of novel systems might be a business opportunity for engineers.

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