SECURING THE QUALITY OF VENTILATION SYSTEMS IN RESIDENTIAL BUILDINGS: EXISTING APPROACHES IN VARIOUS COUNTRIES

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ABSTRACT

In March 2013 an international workshop was organized in Brussels to discuss existing approaches to secure the quality of residential ventilation systems in various countries. In the past large-scale field studies have shown evidence that installation quality of residential ventilation systems is typically insufficient, so it is important to develop frameworks to improve the situation. In total 13 experts presented the status and perspectives in their country, with a major focus on the voluntary and regulatory schemes developed to secure the quality of ventilation systems in residential construction practice. These schemes intend to influence different steps in the process of the realisation and use of ventilation systems: training, products and systems development, design, installation en commissioning, use, maintenance and inspection.
This article gives a synthesis of the various applied quality approaches, together with practical experience in these countries. A critical review of the pros and cons of existing quality approaches presented at the Brussels workshop is given. Some examples of solutions to tackle the challenges in ventilation system quality will be discussed more in detail. Finally the applicability of the approaches in the Belgian context is discussed.

1 INTRODUCTION

Ventilation of dwellings plays an important role in the recast of European energy performance requirements towards “Nearly Zero Energy Buildings”, because of the need for providing a good air quality in highly insulated and airtight buildings in an energy efficient way. In the meanwhile shortcomings of ventilation systems in operation are frequently reported. Sometimes there is a big gap between the theoretical performance and the performance in actual operation. Typical problems are:

- Insufficient air flow rates
- Poor balancing of air flow rates
- Noise complaints
- Poor quality of supply air
- Inadequate operation by the occupants

Many of these problems are related to a poor design or installation, lack of maintenance, and to a lesser extent, poor product quality. The need for high quality remains an important issue, and could be defined as ‘to meet the end-user expectations’. The occupant requires a comfortable and healthy living area with regard to temperature, light, noise, safety,… and of course also with regard to the air quality. The ventilation system should be easy in daily use and have an acceptable cost. Considering costs, both investment costs and operation costs need an assessment. Operation cost is defined by maintenance costs and energy cost.

The authorities in the Flemish region (Belgium) initiated some studies (Caillou et al. 2011, 2012, 2013; Stranger et al. 2012) that confirmed the existence of aforementioned problems. The following recommendations were formulated (VEA 2013):

- Raise public awareness of the importance of ventilation system use and maintenance
- Increase attention to a correct dimensioning of the system
- Offer quality guarantee through performance testing
- Increase attention to noise problems

Partly based on these recommendations, the energy authorities in the Flemish Region (VEA - Vlaams Energieagentschap) initiated a project to evaluate the willingness to introduce a quality approach for ventilation systems. This project is commonly conducted by BBRI, Ghent University, Leuven University, INIVE and ICEE. As part of this project, an international workshop 'Securing the quality of ventilation systems in residential buildings: status and perspectives' has been organized on March 18-19 in 2013 (AIVC 2013). The results of the workshop will be made available in the form of edited proceedings, which contain an overview of the quality assurance approaches in each of the participating countries. This paper reports on the obtained results.

Apparently almost every aspect to realize high quality residential ventilation systems is available: ventilation standards, in most countries part of the building code or the EPBD regulation, performance requirements (air flow rates, energy consumption, comfort aspects such as noise levels), product and system standards (and product databases and labels), design and installation guidelines, testing and compliance standards and guidelines, educational and qualification programmes for installers,… However, there is increasing evidence (Caillou et al. 2012, Stranger et al. 2012, De Brauwere et al. 2010, AIVC 2013) that these instruments, although they are necessary preconditions, do not automatically lead to good quality installations. Reasons for this might be:

- Lack of collaboration and continuity at different stages of design and construction
- Lack of knowledge, awareness and care for quality at different stages
- Savings on investments: lack of willingness to pay for quality
- Lack of training of specific installers and commissioners, no training requirements
- Limited enforcement of legislation

Apart from the aforementioned instruments, there is a need for an integrated quality approach to ensure all available tools are used to end up in quality. These quality approaches can interact with one or more steps or parameters that interfere with the final ventilation system performance on site.

Below some important parameters which influence the final ventilation system performance are listed (see fig 1).

- The consecutive actions in the construction process, all of which affect the as-built situation of the ventilation system: design, selection of products and systems, the installation work and the commissioning.
- User behaviour: use of controllers; selection and use of polluting products like furniture, carpets, …; opening of windows,…
- Maintenance (after inspection if applicable)

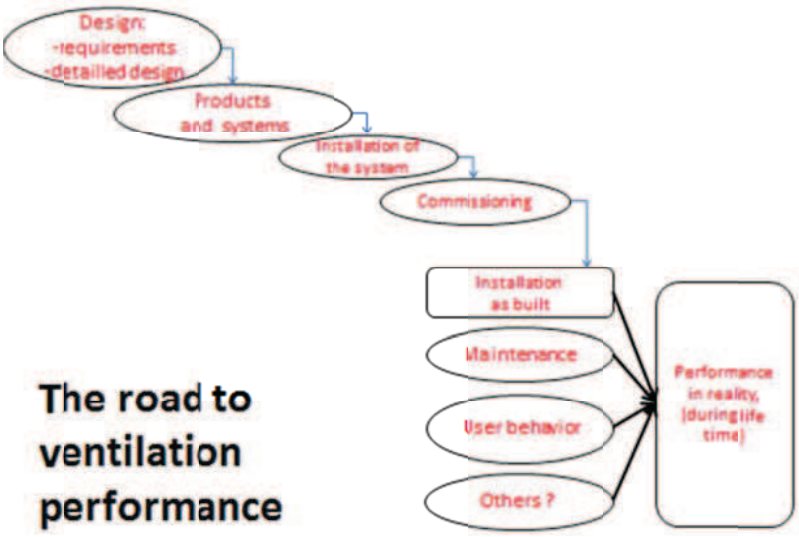

Figure 1: Parameters influencing the final ventilation system performance

2 INTERNATIONAL SITUATION

The intention of the aforementioned international workshop was to get an overview of the international situation regarding the following questions:

- What is the knowledge regarding the quality of ventilation systems in residential buildings in various countries?
- What is the status with existing approaches to improve the quality of these systems?
- What can we learn from targeted efforts to characterize or monitor real ventilation system performance?
- How can quality frameworks help to improve the situation and how can they converge with existing regulations or programmes?

Based on the answers, the pros and cons of existing approaches were discussed and ways to improve the situation with key experts from various countries were explored.
Following countries were represented at the workshop with a paper: Belgium, Canada, Germany, Estonia, Finland, France, the Netherlands, Norway, Poland, Romania, United Kingdom, United States, Sweden.
As an illustration, next paragraphs report some approaches used in 2 countries, selected at random.

2.1 Canada (Fig. 2)

In Canada, ventilation is a part of the obligatory building code. A voluntary 3 day contractor training exists that can lead to certification of ventilation installer. Local authorities are deemed to perform a compliance check with the building codes at key construction stages.
Products can get an HVI (Home Ventilating Institute) product certification on a voluntary basis in which rating of product performance in accordance with standards is required. No independent compliance check or permanent follow-up is provided.
On a voluntary basis, contractors can obtain a HRAI (Heating, Refrigeration and Air Conditioning Institute of Canada) contractor certification for 5 years. This requires passing an exam with at least 75 % and signing a certification agreement where the contractor commits to install in accordance with the aforementioned training. No third party compliance check of installations is provided. Withdrawal of the certification however, is possible after complaints. Inspection of installations in use are sometimes performed, in case of homes put for sale.

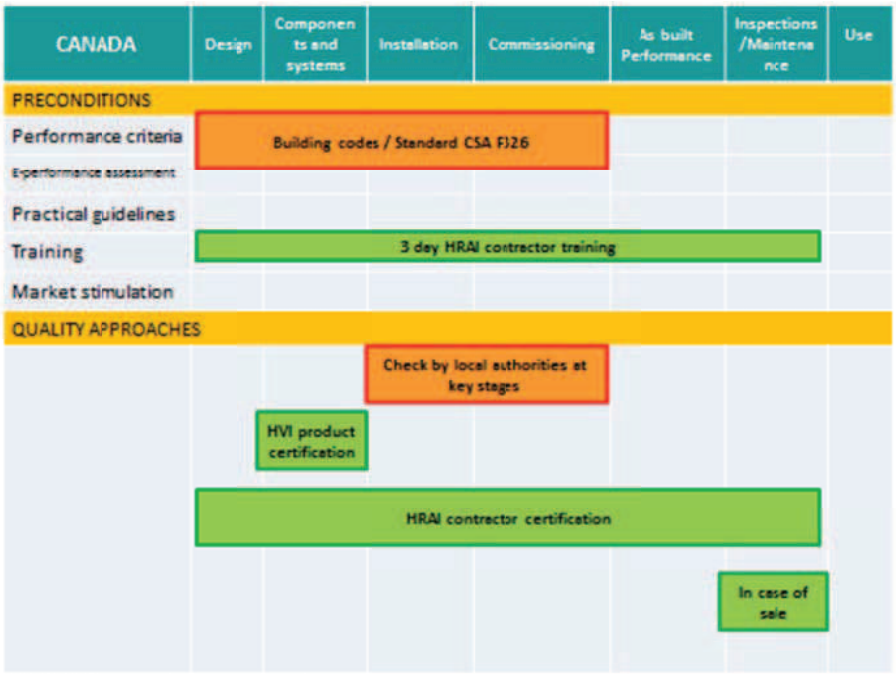

Figure 2: Preconditions and quality approaches in Canada

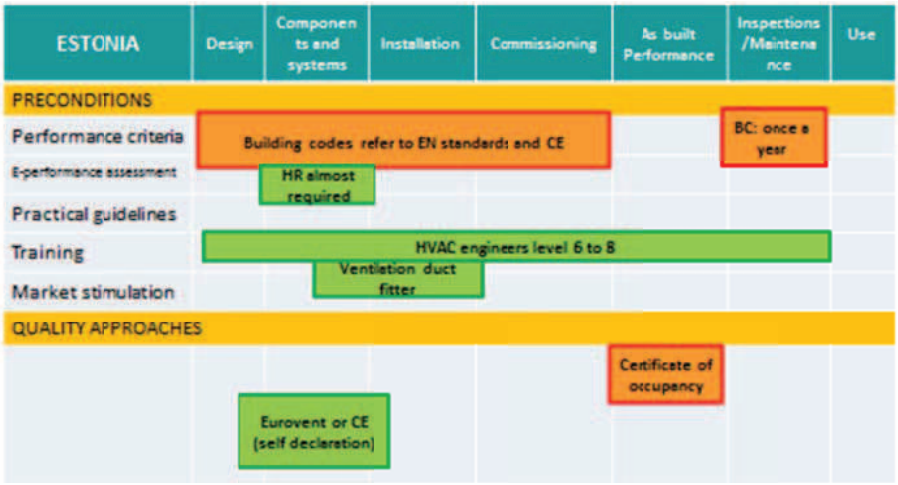

Figure 3: Preconditions and quality approaches in Estonia

2.2 Estonia (Fig. 3)

In Estonia, ventilation is a part of the obligatory building code, which refers to EN standards and to Finnish requirements. There is a requirement that installations are maintained once a year, but this is rarely done in practice. Ventilation characteristics are taken into account in the energy performance assessment, which makes the use of Heat Recovery ventilation (HR) almost obligatory in order to meet energy performance requirements. Engineers are educated, there is a ventilation duct fitter qualification, but 75 % of the installers do not apply for it.

A certificate of occupancy is needed before a newly built house is put into use. For detached houses, commissioning can be done by the house owner himself; the authorities lack competence to check for compliance. Product performances are mostly ‘self-declared’.

3 OVERVIEW QUALITY APPROACHES

Various quality approaches can be identified. They can be classified as necessary preconditions, as process improvements or as as-built evaluations. A number of interesting quality approaches were identified during the workshop, for each of them we mention some additional conditions to be fulfilled in order to make them work as intended.

3.1 Preconditions

A first precondition is the availability of clear quality criteria for which there is an agreement among the whole sector. As much as possible, these criteria are performance based on the condition they can be evaluated in practice. If these criteria are part of legislation, they should enable enforcement of this legislation. A link between ventilation aspects and the energy performance assessment can be a strong asset. In different countries the approach might differ a lot: from pure intentions and design conditions having effect on the energy performance to as-built approaches in which on-site measured performance (e.g. air flow rates, fan power) are a part of the calculation.
Example:

- Ventilation is part of the building codes to some extent in most countries.

In most countries a lot of guidelines on how to design, install, commission ventilation installations is available. An important issue however is whether this information is practical and directly applicable by the contractors.

The professional competences of various persons, active in the process chain, need to be increased. There might be a need for training of different profiles, such as: designers, installers, commissioners, inspectors, maintenance technicians,... The training shouldn't concentrate only on knowledge, but should be directed towards skills and attitudes.
The training approach can be limited to training on its own, or can require theoretical and practical exams and can end up in certification. Competence certification certifies that persons have obtained the required skills in the field of ventilation. The certification should also confirm or proof the ability of the person to conduct a certain function and should therefore be a continuous process. Training or competence certification schemes can be voluntary but also compulsory, e.g. when only certified persons are allowed to develop certain professional activities.
Examples:

- HRAI contractor certification ((Heating, Refrigeration and Air Conditioning Institute of Canada)
- OVK inspectors (Sweden, OVK = Compulsory Ventilation Inspection)
- License designers and supervisors (Poland)
- Competent person (UK)

3.2 Process improvements

Before attributing a building permit, the design could be checked, avoiding big mistakes from the start of the construction process. This approach requires that the ventilation system design is already done in a sufficient detailed way at the time of the building permit request, which is normally not the case. The method also requires that the authorities are competent in ventilation matter. Another drawback for this approach is that it gives little guarantee on the as-built result.

Examples:

- Check at building permit (Finland, the Netherlands)
- State Inspectorate (Romania)

With product and system characteristics declaration comparable data of various products are available for the designer. This should facilitate a proper selection, best suited to the application. In some cases this classification is limited to some reliable data on energy performance and flow characteristics – in that case the quality aspect is limited to 'quality of data'. Some approaches include additional quality aspects, such as cleanliness, hygiene, acoustical performance and can end up in labelling or certification in which minimum performance levels should be obtained.

With regard to the reliability of the declared performance data, different level approaches can be encountered. In a number of cases data are a result of an initial type testing (ITT), through self-declaration of the manufacturer or performed by a third party laboratory test, on one available sample or through a set of statistically selected samples. As a result, the reliability of the data might differ a lot. A real certification goes beyond an instant snapshot but evaluates the evolution in time through e.g. Factory Process Control (FPC). For some private labels neither the testing procedures, nor the certification process are publicly available, which makes an evaluation of the value of the label difficult. Because most manufacturers also act on an international level, the availability of uniform schemes across EU would be an important asset.
Examples:

- HVI (Home Ventilating Institute) certification (Canada and US)
- EPBD product database (Belgium)
- NF VMC, CSTBat (France)
- TUV-RLT (Germany)
- M1 cleanliness (Finland)
- Product characteristics SAP (Standard Assessment Procedure, UK)
- Eurovent-certification (Europe)

Innovation with regard to products or systems can play an important role in quality improvement. A product can be easy to install or maintain, systems can be self-calibrating, reducing the need of commissioning and the risk of mistakes.

With a follow-up in the installation phase, the authorities may check the compliance with the legal requirements or the building permit. It is crucial to conduct these visits at key stages in the building construction. The impact on the quality aspect is rather low: quality is more than 'legal compliance'. In general authorities lack the competence to go into detail, and often the visits are poorly sampled.
Examples:

- Compliance check at key stages (Canada)
- As a part of EPBD compliance (Belgium)

Whole company certification is an integrated approach in which the company is assisted to keep every step of the process under control. Elements are person competence assurance, organisation, management, document and complaint treatment. Such an ISO 9001-like approach seems to be limited to companies of a certain scale.
Examples:

- Qualibat, Qualifelec (France)

- Company registration (Norway)
- Specialist certification (Romania)
- Cleaning companies (Germany)

3.3 As-built evaluation

As-built performance evaluation looks at the final result, without bothering about the process needed to realize it. Evaluation can be limited to compliance with mandatory requirements or can be extended to additional quality issues. The evaluation may include visual, qualitative checks as well as measurements (air flow rates, electric power, acoustics, …). Document availability, e.g. user and maintenance manuals, can be added.
Various concepts may be used as different persons may perform the evaluation:

- Each installation is checked by a third party or by the authorities
- Sample checks are conducted at ventilations systems, installed by contractors. This can also be performed in a framework to label installers or for whole company certification.
- Declared by house-owner

Such an approach can be voluntary or mandatory. In some cases it will lead to a 'certificate of occupancy' in which the authorities allow to put the house into use. It requires a systematic and serious organisation with competent evaluators.
Examples

- Permit to use (Estonia)
- Acceptance before putting into use (Poland)
- VPK (voluntary Ventilation Performance Check, the Netherlands)
- OVK (mandatory Ventilation Inspection, Sweden)

This approach is a close to end user expectations approach, which gives, compared to process approaches, much more liberty when selecting solutions. It gives however direct feedback to the contractor, who might have to improve his process of realisation.

Even an excellent installation at the moment of commissioning, doesn't guarantee a good operation during the total service life. In some countries, regular maintenance is mandatory, but some lack a compliance framework. Inspections after a predetermined time can be helpful in order to define necessary repairs, replacements and maintenance. It could be part of an energy audit, required when putting the dwelling for sale or rent, but detailed ventilation performance isn't always included.
Examples

- OVK, but not for small dwellings (Sweden)
- Some housing companies (UK)
- At sale/rent (Belgium, Canada)
- As part of energy audit (Estonia)
- For passive stack by chimneys-sweeps (Poland)

3.4 Drivers for better quality

An important discussion point for the afore mentioned quality approaches is to make sure the approach enters into action, is correctly used and leads to actual quality improvement for the market as a whole (and isn't limited to a small niche market). Quality approaches may be imposed with fines in case of non-compliance or incentives can be created.

How far should legislation go to support quality? Legislation can be directed to requirements for design, products, commissioning, inspection or maintenance. Legislation can require minimum skills for ventilation contractors or specialists. Legislation can require an as-built performance evaluation or regular inspections and maintenance. The effect of pure mandatory requirements depends in practice on the country culture. In some countries the existence of a law suffices to have effect, in other countries systematic enforcement is needed. In some countries (e.g. The Netherlands) the authorities avoid enforcing requirements and leave the improvement of the quality of ventilation systems up to market commitments.
Generally speaking, financial incentives can generate an effect. Unfortunately, nowadays the authorities have to reduce this kind of spending.

Good quality ventilation systems can also be valorised in energy performance calculations. Various ventilation characteristics might improve the final performance. When not introduced, (more unfavourable) default values will be used to perform calculations. Examples are the flow capacity of natural ventilation openings, type and power of fans, temperature effectiveness of heat exchangers, a proven flow balance. Because of the need to further improve the energy performance of buildings in the next decade, favouring high quality ventilation systems in the EPBD calculation is an indirect way to enhance quality. It is important that this assessment refers as much as possible to the as-built situation, to avoid a merely 'paper quality'.
Example:

- As-built data as a base for E-level calculation (EPBD implementation in Belgium)

Finally, it is important to raise awareness by the users that good ventilation is important for everybody and to get support from the public for the various quality approaches. It is indeed the end-user who will have to pay additional costs!

4 APPROACHES FOR BELGIUM

Within the aforementioned VEA-project (search for quality approaches, supported by the whole ventilation sector), a number of quality approaches will be evaluated and discussed. Without looking too much ahead, following approaches might be withheld:

- Reinforce ventilation quality aspects into the EPB-legislation and the energy performance calculation. It doesn't seem to be realistic to increase the application control by the administration itself, but a link with the declaration of conformity might be made.
- Make training available for various professional levels: architects, installers, craftsmen and performance evaluators.
- Organize a system to deliver a declaration of conformity for each installation. This approach declares for each individual installation:
    - The conformity with the legal or additional performance requirements.
    - All relevant data enabling to calculate the ventilation aspects in the energy performance calculation: product performances such as flow rate capacities, auto-control capacities, fan power,… or system measurements such as measured flow rates.

5 CONCLUSIONS

Although market maturity might differ from country to country, various countries report the same kind of problems regarding residential ventilation systems. Almost every country in this review is looking for approaches to improve quality in the field. To solve the problem as a

whole, improvement can be expected from a well selected set of complementary quality approaches. Fully voluntary measures might not work too well, some kind of official enforcement will be required.

6 ACKNOWLEDGEMENTS

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