PROMEVENT: IMPROVEMENT OF PROTOCOLS MEASUREMENTS USED TO CHARACTERIZE VENTILATION SYSTEMS PERFORMANCE

Adeline Bailly*[1], Cedric Lentillon[1]

1 Cerema
Direction Territoriale Centre-Est
46 rue Saint-Théobald
38081 l'Isle d'Abeau, FRANCE
**Corresponding author: adeline.bailly@cerema.fr*

ABSTRACT

For the coming energy-efficient buildings, the guarantee of energy performance becomes a major challenge. It is therefore crucial to implement accurate and reliable measurements, in order to ensure this performance. The in-force French EP-regulation RT2012 already imposes compulsory justification of envelope airtightness. Moreover, the Effinergie+ label requires ventilation systems control and ductwork airleakage performance. These requirements, ventilation controls for IAQ concern and regulatory compulsory controls of buildings need reliable diagnostic protocols.
In 2014, several French partners, led by the Cerema[1], proposed a new project, PROMEVENT, which main objective is to improve ventilation systems measurements protocols. It aims to deal with different phases of a diagnostic:

1) Visual control
2) Airflow measurements and pressure differences measurements at air vents
3) Ventilation ductwork airleakage measurements.

Several points will be tested through repeatability and reproducibility assessments. Then measurements will be performed on laboratory benches, and on ventilation systems of single-family and multi-family dwellings. By the end of the PROMEVENT project, recommendations and a first version of a protocol for the measurement of residential buildings ventilation systems will be proposed. Moreover, one of the main objective is to produce a more reliable and optimised protocol which will be written as a proposed draft standard.
This paper presents the context in which the PROMEVENT project has been defined, and describes its different steps.

KEYWORDS

Ventilation – Measurements – Airtightness – Airflow - Improvement

[1] A new public scientific organism born from the merging of 11 scientific institutes (including the CETE de Lyon) of the French ministry for ecology, sustainable development and energy (MEDDE).

1 CONTEXT AND OBJECTIVES

The recent French energy performance regulations and labels have resulted in a new buildings generation. Since 2000, airtightness requirements have been gradually implemented in French regulations, leading to a reinforcement of air renewal systems and a need to ensure their reliability. First labels and mostly Effinergie-BBC label have imposed a requirement on building envelope airtightness for residential building. Since January, 2013, the in-force EP-regulation RT2012 imposes airtightness requirements for all new residential buildings.

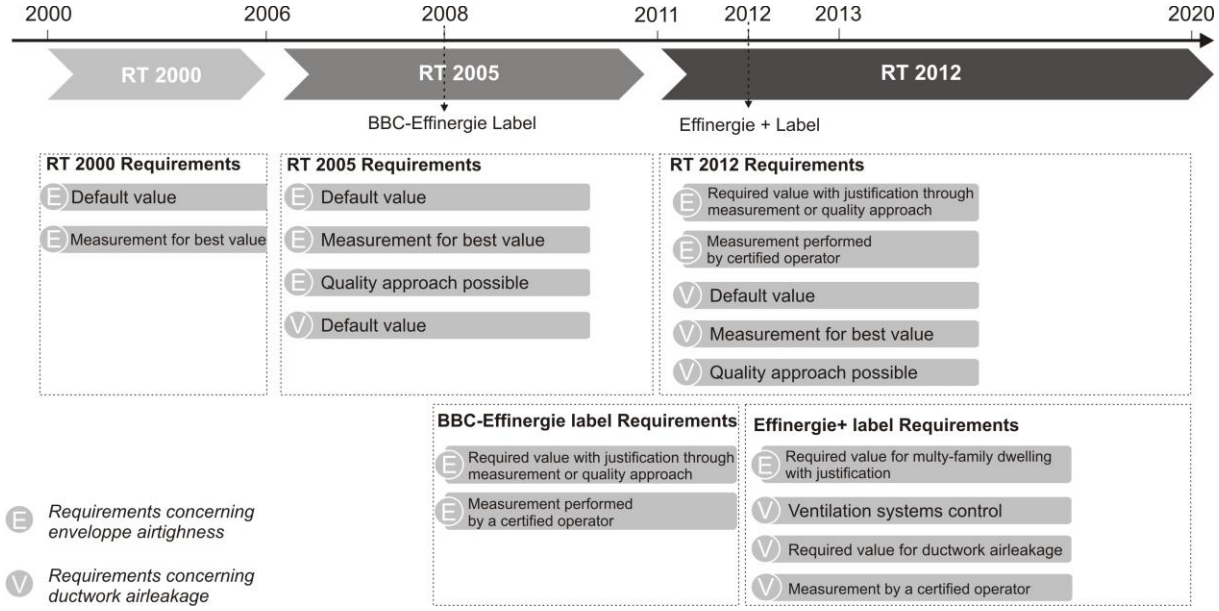

Figure 1: Evolution of French Thermal Regulations

These highly airtight buildings create an issue for both comfort and indoor air quality. Indeed, in these dwellings, air change rates are provided by ventilation system, which have to be efficient to ensure good indoor air quality, while limiting heat losses due to air change. Several recent studies illustrate this concern. The OQAI (French indoor air quality observatory) performed a national IAQ campaign from 2003 to 2005 (Kirchner, 2008). 567 dwellings (chosen in order to represent the national housing stock) have been investigated through ventilation systems diagnostics and indoor air quality measurements. This national study has concluded that the air change rate and the duration windows are opened are the most important factors of the indoor air quality. Moreover, calculations analysis which have been performed during the project QUAD-BBC have shown some typical evolution of pollutants in highly airtight low consumption buildings (Boulanger, 2012).

The French in-force regulation concerning ventilation requires a general and permanent ventilation for residential buildings. It also imposes minimal airflow of exhaust air. So as to meet those two seemingly divergent objectives, technically advanced mechanical ventilation systems have been developed. Nevertheless, high quality and technical skills are required during design phase, implementation and maintenance, which are often neglected. Ventilation systems have an influence on the sanitary aspects of the supplied and indoor air, through moisture development for example (Van Herreweghe, 2013). Moreover, inhabitants may have

not understood the functioning of new mechanical systems, especially for balanced ventilation, and might decide to take it down. The OQAI has recently carried out a field survey in seven new built energy-efficient houses in France (Derbez, 2014). All inhabitants have experienced some difficulties with their Mechanical Ventilation with Heat-Recovery systems, because they are difficult to use, the user's manual is complex, high noise levels can be produced or they cause a lack of comfort. But if MVHR systems are turned out or voluntary degraded (airvents closed for example), indoor air quality can become poor and present a risk to human health.

Therefore, in many countries, several studies have been launched to realize a state of the art of ventilation systems in dwellings. In France, a survey (Jobert, 2013) has been carried out through control reports performed between 2008 and 2011 concerning 1287 dwellings (88% are multi-family dwellings). Almost all buildings are equipped by simple exhaust ventilation systems.

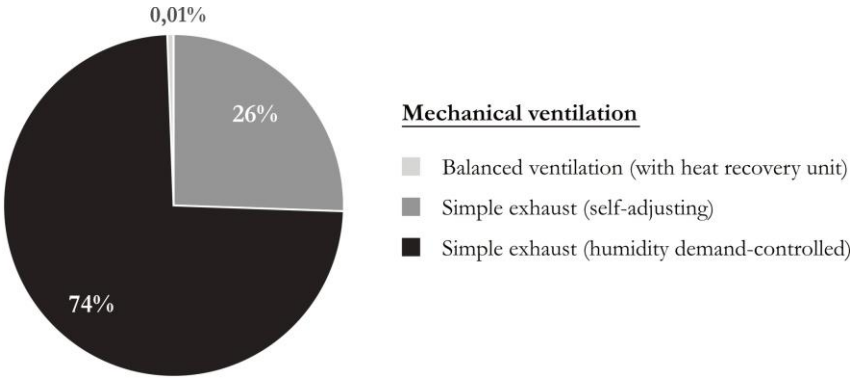

Figure 1: Ventilation system repartition in the analysed sample (Jobert, 2013)

47% of the sample do not comply with the airing regulation, which means that they present at least one non-compliance remark (68% for single-family dwellings, and 44% for multi-family dwellings). Those non-compliances are generally related to design errors, poor implementation and lack of maintenance. Same issues have been observed in many European and American countries (Van Den Bossche, 2013). Two practices could improve the quality of ventilation systems. On one hand, a quality approach could be set up. In France, such approaches have been successfully adopted for building envelope airtightness (Charrier, 2013). Moreover, the VIA-Qualité project is testing the feasibility of such approach for ventilation systems and IAQ (Jobert, 2013). In a second hand, as the French thermal regulation imposed the airtightness level justification, the ventilation system performance could also be controlled, what is already compulsory with a recent label, "Effinergie +". Those controls are in accordance with new approaches, which impose that standards and regulations compliance is ensured by on-site verifications. Those approaches might lead to financial or organizational consequences. Currently, ventilation systems controls are generally performed in France in three cases:

- For buildings applying for new Effinergie label (Effinergie +)
- During regulatory compulsory control (by the technical civil servants network of the Ministry in charge of the Construction's sector)
- When IAQ issues have been set out for a building.

Therefore, control protocols have to be unquestionable. In these cases, several diagnostic protocols are used: either labels reference documents or good practice guide, such as the Effinergie protocol, the DIAGVENT method and the European standard EN12599. The reliability of these protocols may be not sufficient. The PROMEVENT project proposes to

test repeatability, reproducibility and feasibility of these protocols in order to define a more reliable protocol for ventilation system controls.
This project may have to deal with such issues as: how can it be representative of all different situations? How can it characterize the equipment use impact? How will it overcome airflow measurement difficulties? The PROMEVENT established program is described in the second part of this paper.

2 PROMEVENT PROGRAM

PROMEVENT is an 8 organizations project whose main objective is to improve the quality of ventilation system controls. More precisely, it aims to ensure the reliability of ventilation measurement protocols concerning pressure and airflow differences at air vents, and ductwork airleakage. This program will focus on residential buildings. According to current practices in new constructions, two "dwelling/ventilation systems" associations will be studied:

- Single-family dwellings equipped with balanced ventilation
- Multi-family dwellings equipped with single humidity demand-controlled ventilation.

This project includes three workpackages. The first one consists in a characterization of existing protocols in order to evaluate their reliability, through experimental campaigns. The second one is the elaboration of a new protocol which must ensure controls reliability. The last one will lead to a verification of the new protocol feasibility, reliability and relevancy, through on-site tests.

The PROMEVENT project has been proposed to a call for proposals launched by ADEME within the subject "toward responsible buildings in 2020". The Consortium is constituted of 8 French partners, both private and public sectors: a public institution (Cerema[2] - ex CETE de Lyon), a laboratory (CETIAT), 5 consultancies (ALLIE'AIR, ICEE, PLEIAQ, CETii, PBC) and an association (Effinergie). They are quite complementary on scientific and operational dimensions. The Consortium, thus formed should be able to defend the importance of a unique and standardized protocol which will have to take into account uncertainty requirements and implementation concerns. It should also convey its discourse to all relevant professionals.

2.1 Existing protocols reliability

Several protocols are used in France and abroad to control ventilation systems performance, including visual diagnostic, proper functioning at air vents control and ductwork airtightness measurement. There are described in label reference documents, campaign protocols, standards or good practice guides. EN12599, DIAGVENT method, Effinergie protocol or OQAI protocol are some of them. In a first step, an inventory is being taken to compare the different protocols considering risks and sources of uncertainty, investigated components and technical feasibility. Moreover, different technologies and equipment used to perform measurements (concerning airflow, pressure difference and ductwork airtightness) are being listed and studied to describe their field of application and product liability according to their manufacturers. This review is also including a state of the art of international projects and studies dealings with this topic, in order to be able to integrate current evolutions.

This first step is preparing the second one: experimental campaigns. A methodology will be established to evaluate feasibility, relevancy and reliability of existing protocols. Two

[2] Centre for expertise and engineering on risks, environment, mobility, urban and country planning

campaigns will be performed in order to conduct repeatability and reproducibility evaluations from 2014 to 2015.
One campaign will be carried out in laboratory. It will study measurement equipment performance and calibration in different configurations: proper functioning without, then with components which might disrupt the flow. Thanks to a ventilation system assembled in laboratory, the impact of some specific configurations will be evaluated without risking a building deterioration.
A second campaign will be performed in situ on:

- 10 single-family dwellings equipped with balanced ventilation;
- 2 multi-family dwellings equipped with single humidity demand-controlled ventilation.

4 operating-teams will contribute to this campaign. Roles are defined in the following table.

Table 1: First in-situ campaign program

		Team 1	**Team 2**	**Team 3**	**Team 4**
2 multi-family dwellings	Building 1: *airflow, pressure difference at airvents and ductwork airtightness*	B1	B1		
	Building 2: *airflow and pressure difference at airvents*			B2	B2
10 single-family dwellings	House 1: *airflow, pressure difference at airvents, and ductwork airtightness*	H1	H1	H1	
	House 2: *airflow and pressure difference at airvents*			H2	H2
	House 3 to 10: *airflow and pressure difference at airvents*	H3 ; H4	H5 ; H6	H7 ; H8	H9 ; H10

This dwellings repartition has been defined to optimise repeatability and reproducibility evaluation regarding to geographical, financial and temporal limits. Several measurements (as much as possible) will be performed in each dwellings (for repeatability and equipment reproducibility evaluation). Ventilation systems of 4 buildings (B1, B2, H1 and H2) will be controlled by 2 or 3 different teams (reproducibility evaluation).

2.2 New protocol formulation

The results of the two campaigns and the review will be analysed to determine which points of currently used protocols are unreliable, to what extent and why.
The laboratory campaign analysis will help to determine measurement uncertainty of each equipment depending on the application, and the need of calibration. Impact of air vents type or non-alignment measurement will be assessed. It is also expected to detect the impact of some specific issues related to ventilation ductwork through tests performed on the ventilation system assembled in laboratory.
The in-situ campaign results will be analysed through several aspects:

- Repeatability of tested protocols
- Reproducibility concerning equipment impact
- Reproducibility concerning operator impact
- “Out of hand” in-situ conditions impact.

Main objectives are to evaluate uncertainty of the tested protocols and to specify uncertainties sources.

According to those results, the Consortium will formulate a new protocol. At this step, a group of relevant professionals will be consulted. It could be composed of ventilation experts and industrials, controllers, control equipment manufacturers, architects, certification organisms. Discussions on new protocols will focus on several points:

- Ensure sufficient reliability
- Ensure technical and financial feasibility
- Define self-checking equipment conditions
- Define needs and organisation of operators training, qualification and control.

2.3 New protocol validation

The last milestone of this project consists on the new protocol validation. It will be based on a second in-situ campaign results. According to geographical and financial limits and buildings availability, fewer buildings will be tested. Each team will perform several measurements (as many as possible), with different equipment. The following table presents the second in-situ campaign program.

Table 2: Second in-situ campaign program

		Team 5	**Team 6**	**Team 7**	**Team 8**
1 multi-family dwellings	Building 3: *airflow, pressure difference at airvents and ductwork airtightness*	B3	B3	B3	
4 single-family dwellings	House 11: *airflow, pressure difference at airvents and ductwork airtightness*			H11	H11
	House 12: *airflow, pressure difference at airvents and ductwork airtightness*	H12	H12		
	House 13 & 14: *airflow, pressure difference at airvents and ductwork airtightness*	H13 ; H14			

In order to evaluate the technical feasibility and the relevancy of the protocol, new teams will be composed with new operators: they will not have been part of the project before this step. Each team will be accompanied by an operator of team 1 to 4 (first campaign and all project) whose role will be to assist, to guide and to audit new operators. It will lead to evaluate of the understanding of the protocol. It will also ensure that diagnostics have been performed properly to evaluate repeatability and reproducibility of the new protocol.

Experimental results will be analysed to evaluate:

- New protocol relevancy: improvement of reliability
- Implantation ease, understanding and appropriation by new operator
- Financial feasibility: difference between costs of current used protocols and new protocol
- The self-checking relevancy.

Those evaluations will lead to a final protocol that will be drawn up as a proposed draft standard. It will also lead to a guide intended to ventilation operators. This guide will explain

and illustrate each step of this ventilation system diagnostic protocol. It will be available and free for download.

3 CONCLUSIONS

The PROMEVENT project objective is to define a new protocol for controls of ventilation systems performance. This protocol will be established based on many existing protocols currently used. Several laboratory and in-situ campaigns will be carried in order to test repeatability, reproducibility and feasibility of those protocols, including the equipment choice impact. It is expected that conclusions of this project will lead to a new standard which will be imposed in new buildings regulation, in order to impose compulsory check of ventilation systems performance. At the end of this project, training and recommendations will be provided to operators through a practical guide, which may be useful for measurements performed for label.

4 ACKNOWLEDGEMENTS

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The sole responsibility for the content of this publication lies with the authors.

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