Lessons learned from a ten-year monitoring in residential buildings equipped with humidity based demand controlled ventilation in France

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SUMMARY

Humidity-based DCV systems have been widely used in France for 35 years and are considered as a reference system, including for low-energy residential buildings. Indeed, most of the new residential buildings, which must be low-energy buildings to comply with the RT 2012 energy performance regulation, are equipped with such systems. Feedbacks from two long-term studies show the durability of the humidity sensitive components and show the robustness of this system to bad maintenance or use by occupants. The on-going Performance 2 project delivers the first results of a ten-year monitoring in thirty social housing apartments. In the context of the increasing awareness about smart ventilation, from these feedbacks, it seems very important consider the durability of the systems and its components (including the sensors) and the robustness of the systems to a lack of maintenance by occupants.

KEYWORDS

Ventilation, performance, DCV, humidity, residential buildings

1 INTRODUCTION

1.1 Regulatory context

The French dwellings airing regulation (J.O. 1983) requires a general and continuous airing system, describes the compulsory general layouts of ventilation installation and requires exhaust airflows in each humid room, depending on the total number of rooms in the dwelling. This regulation has been modified in 1983 in order to reduce these airflows in case of demand-controlled ventilation system (DCV), for instance based on humidity. In this case, manufacturers must follow a compliance procedure to ensure adequate ventilation, with a performance-based approach. Indeed, the procedure (CCFAT 2015) describes the common scenario used to evaluate the DCV systems using the multizone software MATHIS (Demouge, Le Roux, and Faure 2011) and calculating two IAQ performance indicators: a condensation risk (number of hours with relative humidity higher than 75%) and a cumulative CO_2 exposure exceeding 2000 ppm, further described in (Guyot, Walker, and Sherman 2018). Each room of the dwelling is modelled as single zone, with a time-step of 15 min. Once a system receives certification of compliance via this procedure, called "Avis technique", it can be used in new dwellings according to its specifications. For each type and size of dwelling, the agreement gives the references of inlets and outlets and the input data for energy calculation.
As a result, humidity-based DCV systems have been widely used in France for 35 years. Most of the new residential buildings, which must be low-energy buildings to comply with the RT 2012 energy performance regulation, are equipped with such systems (Mélois et al. 2019). They are also considered today as a reference system.

1.2 Technological context: presentation of the reference humidity based DCV system

RH-MEV is a Demand Control Ventilation (DCV) system adjusting the airflows according to the estimated needs of the building and its occupants, with a direct relative humidity (RH) measurement in both the wet and dry rooms. The extensions and retractions of a hygroscopic

fabric modify the cross-section of inlets and outlets upon hygrometric changes in their environment without the need for motors or electronic sensors.
The reference system used in France includes as air terminal devices, humidity sensitive trickle ventilators in the dry rooms and humidity sensitive exhaust units in the wet rooms, except in the toilets which are equipped with an occupancy.
Energy savings have been estimated about 30% to 50 % of the heating energy compared to constant airflows exhaust-only ventilation (Savin and Bernard 2009).
They could be considered as a type of smart ventilation system, according to the definition given by (Durier, Carrié, and Sherman 2018).

2 FIRST FEEDBACKS ON ROBUSTNESS AND DURABILITY AFTER PROLONGED IN SITU OPERATION

In 2006, before generalizing the usage of humidity based ventilation in French residential buildings, the French Ministry for Housing ordered an evaluation of these systems after prolonged on-site operation. For this purpose, after 6 years of in-situ functioning, an independent laboratory collected 57 exhaust units in 21 social housings (Berthin and Parsy 2018). Despite an absence of sufficient maintenance observed for 75% of the units (dust), tests in laboratory conditions showed that 46 % of the kitchen units complied with factory specifications despite the absence of maintenance, 100 % of the bathroom exhaust units showed an airflow reduced by 5 m^3/h. 100 % of the non-damaged exhaust units exhibited a conform hygroscopic behavior or showed a slight shift of their characteristic when still soiled.

Once the devices have been cleaned and properly re-assembled, 75 % of the units complied with factory specifications. Among the other 25 %, the kitchen elements showed an increase of volume flow lower than 3 m^3/h, while bathroom units exhibited a decrease lower than 2 m^3/h. Results are further described in

These first results show the reliability of the components including humidity sensors and the robustness of their operation to a bad maintenance and use by occupants.

3 FIRST RESULTS FROM THE PERFORMANCE 1&2 PROJECTS

The Performance 2 project is based on a 10 years' follow-up study on a large-scale monitoring on thirty occupied social housing apartments in two residential buildings. The former Performance project was an on-field evaluation of the reference humidity-based components and systems from an energy performance and an indoor air quality point of view, over two heating seasons (2007-2009) (Bernard 2009). The ventilation terminals were instrumented, and the buildings were equipped with sensors during the construction phase, including temperature, humidity, and CO_2 in the different rooms of the dwellings, as well as pressure and volume flow sensors for monitoring the ventilation system. The Performance project showed the good IAQ in terms of CO_2 and humidity provided by the ventilation system, despite the over-occupation of some apartments.
Ten years later, in the framework of the Performance 2 project, the data acquisition system is turned back on with the intention to assess the ventilation system behaviour/performance after a prolonged in-situ functioning period (Jardinier et al. 2018). This preliminary study results shows:

- At start-up, more than 80 % of the metrology sensors is still in working conditions.
- Using this rough data, the average in-situ drift of the hygroscopic devices after 9 years of operation is estimated below ± 1.5 %RH and is lower than the announced accuracy of the electronical humidity sensors at installation (± 1.8 %RH).
- The observed drift of volume flows on some of the exhaust units is typical of an absence of maintenance.

- The battery of the presence-based toilet exhaust is often (90 %) discharged.

In July 2019, we organized a first meeting with the occupants, and got their first feedbacks. These first promising results on the durability and robustness of these systems need to be confirmed by the end of the Performance 2 project which shall include:

- The collection of the ventilation devices for a full quality control before and after the recommended cleaning.
- The collection of the metrology sensors for re-calibration and drift-correction on the measurements.
- A new set-up for each apartment including particle sensors to follow the latest interests of IAQ research.

4 PERSPECTIVES

In the context of the increasing awareness about smart ventilation, from these feedbacks, it seems very important to include in this definition the durability of the systems and its components (including the sensors) and the robustness of the systems to a lack of maintenance by occupants.

5 REFERENCES

Bernard, Anne-Marie. 2009. *Performance de La Ventilation et Du Bâti - Phase 3 - Performance Énergétique et QAI Des Systèmes Hygroréglables*. Projet PREBAT ADEME.

Berthin, S, and F Parsy. 2018. "Feedback on Installation, Maintenance, and Aging of Mechanical Humidity-Controlled Ventilation Exhaust Units." In *Smart Ventilation for Buildings*. Juan les Pins, France.

CCFAT. 2015. "VMC Simple Flux Hygroréglable - Règles de Calculs Pour l'instruction d'une Demande d'avis Techniques - GS14.5 - Equipements / Ventilation et Systèmes Par Vecteur Air." http://www.ccfat.fr/groupe-specialise/14-5/.

Demouge, François, Nicolas Le Roux, and Xavier Faure. 2011. "Numerical Validation Fo Natural Ventilation Design." In *32nd AIVC Conference " Towards Optimal Airtightness Performance."* Brussels, Belgium. https://www.researchgate.net/profile/Francois_Demouge/publication/232621659_Numerical_validation_for_natural_ventilation_design/links/542123d50cf241a65a1e606b.pdf.

Durier, François, F. Rémi Carrié, and Max Sherman. 2018. "VIP 38: What Is Smart Ventilation?" *AIVC*, March. http://aivc.org/sites/default/files/VIP38.pdf.

Guyot, Gaëlle, Iain S. Walker, and Max H. Sherman. 2018. "Performance Based Approaches in Standards and Regulations for Smart Ventilation in Residential Buildings: A Summary Review." *International Journal of Ventilation* 0 (0): 1–17. doi:10.1080/14733315.2018.1435025.

Jardinier, E, F Parsy, G Guyot, S Berthin, and S Berthin. 2018. "Durability of Humidity-Based Demand-Controlled Ventilation Performance: Results of a 10 Years Monitoring in Residential Buildings." In *Smart Ventilation for Buildings*. Juan les Pins, France.

J.O. 1983. *Arrêté Du 24 Mars 1982 Relatif à l'aération Des Logements*.

Mélois, Adeline Bailly, Bassam Moujalled, Gaëlle Guyot, and Valérie Leprince. 2019. "Improving Building Envelope Knowledge from Analysis of 219,000 Certified on-Site Air Leakage Measurements in France." *Building and Environment*, May. doi:10.1016/j.buildenv.2019.05.023.