LARGE-SCALE MONITORING STUDY OF DEMAND CONTROLLED MEV IN OCCUPIED DWELLINGS

PERFORMANCE PROJECT

PERFORMANCE PROJECT:
A TWO-YEAR MONITORING STUDY OF DEMAND CONTROLLED MEV IN TWO BUILDINGS IN FRANCE

Paris building

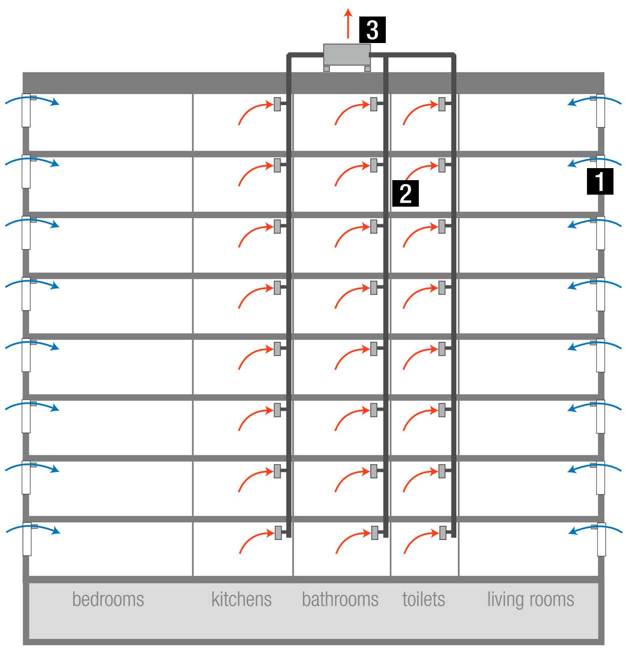
While requirements on ventilation systems have been improved with the implementation of the EPBD in the EU countries, one can wonder if the real performances of the installed systems are consistent with theoretical calculations. Quality of building construction (air tightness) and ductwork installation as well as hypothesis and models for simulation tools are parameters that could create a gap between the predictive and the reality if they are not well managed.

Applied to two new buildings erected in Paris and near Lyon in 2007, the Performance project created an opportunity to measure precisely the efficiency of humidity sensitive mechanical exhaust ventilation in general, and of the Aereco DCV system in particular, in a large set of dwellings. A total of 30 occupied dwellings were monitored for two years beginning in November 2007 to measure representative energy consumption and indoor air quality parameters. This monitoring led to a better understanding of the parameters that may influence ventilation performance.

The monitoring study has made it possible to better understand the parameters which can influence the ventilation performance. The results have demonstrated the efficiency of humidity controlled ventilation in managing the indoor air quality by measuring CO_2 and humidity concentrations. Energy savings on the equivalent airflow for energy have been evaluated at 30 % on the over-occupied monitored dwellings but the extrapolation to the average occupancy of the French building stock have shown to be around 55 % energy savings, which is consistent with the theoretical calculation of the CSTB technical approvals.

This project is the fruit of the cooperation of numerous partners such as builders, buildings owners, technical centres and manufacturers. It has improved the general knowledge on ventilation in order to prepare the route to future innovations.

Ventilation system and measurement tools



The systems installed in these dwellings is typical of standard ventilation systems in new buildings in France (more than 50 % of the new dwellings are equipped with such a system). Fresh air is admitted through humidity sensitive air inlets **1** located on rolling shutter casings or on top of windows in bedrooms and living rooms. The polluted air is exhausted in wet rooms (kitchen, toilets and bathrooms) through humidity sensitive and/or presence detection extract units **2**. A boost airflow is available in the kitchen for cooking times. All the extract units are connected to a centralised fan **3** located on the roof.

The two buildings have been equipped to measure the outdoor conditions (wind speed and direction, CO_2, temperature and humidity). In all the rooms of the monitored dwellings[1] the indoor climate parameters (CO_2, temperature and humidity) and the ventilation parameters (pressure, opening sections, airflows of air inlets and extract units) have been recorded every minute during two complete heating seasons (2007-2008 and 2008-2009). It is the first time that CO_2 is measured in occupied dwellings on such a large scale.

1. Located on the five top floors of the buildings

DEDICATED MEASUREMENT DEVICES FOR A LARGE, PRECISE AND RELIABLE MONITORING

Performance project has needed the development of specific devices to enable a very precise measurement of parameters such as pressure or air cross sections at the level of extract units and air inlets. Developed by Aereco, all the probes have been connected by wires to the central management system located in the building. This particularly critical phase has been carried out during the construction, in tight cooperation with the builders to ensure that the wires were located and connected properly. Except for the small IAQ sensors, all measurement systems were concealed from the occupants.

On the roof, centralised fan and weather station for wind and external conditions (temperature, humidity and CO_2).

Aereco humidity controlled extract unit with presence detection (for bathrooms with WC).

Aereco humidity controlled air inlet on a rolling shutter casing (a). Humidity, temperature and CO_2 sensor (b).

Central management system to record and store the collected data.
It was transferred by internet connection.

HOW TO MANAGE INDOOR AIR QUALITY BY THE MEANS OF A DC MEV[2]

CO_2 concentrations

The measurements of CO_2 concentrations plotted in the histogram of figure 1 show that indoor air quality is maintained in a low-occupancy bedroom (one adult – light blue) and in a high-occupancy one (four adults – dark blue). The peak CO_2 concentration was shifted from 700 pm in the low-occupancy bedroom to 950 ppm in the high-occupancy one, but even in the latter, **the 1 500 pm level was exceeded for only a very few hours in the heating season.**

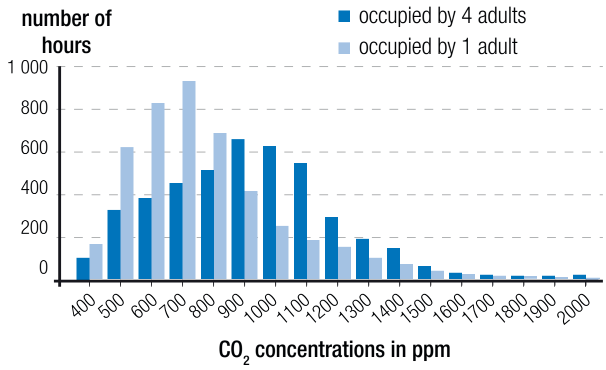


Figure 1: CO_2 concentrations in two bedrooms with different occupancy levels.

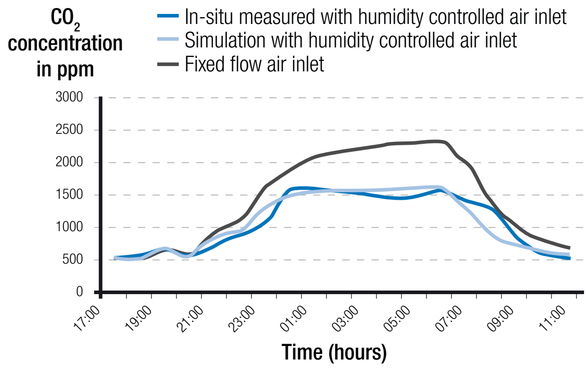


Figure 2: Overnight variation of CO_2 concentrations in a bedroom. Comparison of HC air inlet (measured and simulated) and fixed-flow air inlet (simulated).

The chart of figure 2 confirms the efficiency of the humidity sensitive air inlet on representative overnight variations compared with a simulated fixed ventilation system: **the humidity sensitive air inlet keeps the CO_2 level below 1 500 ppm, but an air inlet with a fixed airflow would have led to a CO_2 level of over 2 200 ppm.** The monitoring also created an opportunity to test the impact of the global system on indoor air quality: the fan was stopped for a short period (one month) and the CO_2 concentrations were compared with the other months (with ventilation) of the heating season. **The histogram of figure 3 clearly shows the value of the ventilation and its positive impact on IAQ.** When the fan was stopped, a strong rise in CO_2 concentrations (above 1 900 ppm most of the time) was observed. The occupants did not react to compensate for the lack of air renewal. **This confirms the impact of ventilation on IAQ and shows that occupants are unaware of poor ventilation and fail to compensate, for instance by opening windows.**

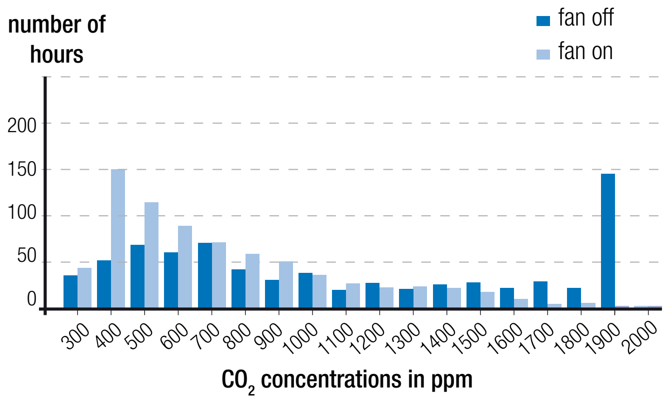


Figure 3: CO_2 concentrations with/without ventilation. Measurements for one month with fan off in a bedroom compared with fan-on for the rest of the heating season. 3 occupants in a bedroom.

Humidity and condensation risk

A calculation of the condensation risk on the double glaze window[4] showed that the humidity controlled ventilation system is particularly efficient on that side, as only a very few hours were presenting such conditions. The majority of dwellings presented a no risk; the maximum risk observed has been evaluated to 8 times per year (condensation during more than one hour on a window). The rare dwellings and periods with a condensation risk all have a particularly high occupancy level, and some of them have a dryer releasing its humidity in the room.

2. Demand Controlled Mechanical Exhaust Ventilation 3. Measurements in a 35 m[3] bedroom occupied by two persons (door closed). 4. The calculation was based on measured internal and external temperatures and humidity levels. Window Ug value = 3 W/m²K (low efficiency glaze).

REDUCE THE AVERAGE AIRFLOW TO IMPROVE THE ENERGY PERFORMANCE

The energy consumption of a ventilation system is the result of the thermal losses induced by the heat of the incoming air plus the fan consumption.

Thermal losses due to the air renewal

The chart of figure 4 presents the average equivalent-heat-loss airflow for every dwelling in the monitoring sample during a complete heating season. The dwellings are grouped by type (number of main rooms). The differences in measured airflows result from the adaptation of the ventilation systems to different occupancy levels, activities, occupant behaviours, and dwelling sizes. The comparison with the French regulatory reference (fixed airflow, black bars) shows the statistical airflow reduction – thus the energy savings – with the DCV system. The measured savings on the airflow in this project are evaluated at 30 %. But a survey showed that most of these dwellings are over-occupied, especially on the Paris site. When this result is extrapolated to the statistical average French occupancy for each type of dwelling, the result is about 55 % energy savings on ventilation heat losses. This statistical airflow reduction does not affect the IAQ; indeed, the IAQ, in terms of CO_2 and humidity, has been shown to be better, as stated earlier.

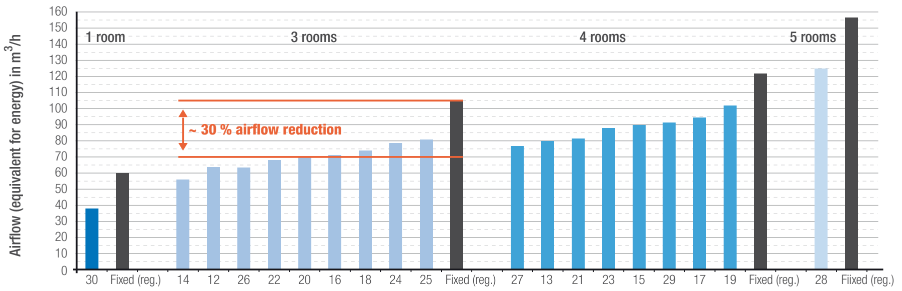


Figure 4: Statistical equivalent-heat-loss airflows per dwelling (numbers in abscissa) on Paris site. Rated by dwelling types by comparison with the constant airflow required by French regulations (black). 2007-2008 heating period.

Seasonal variations of average humidity controlled airflow

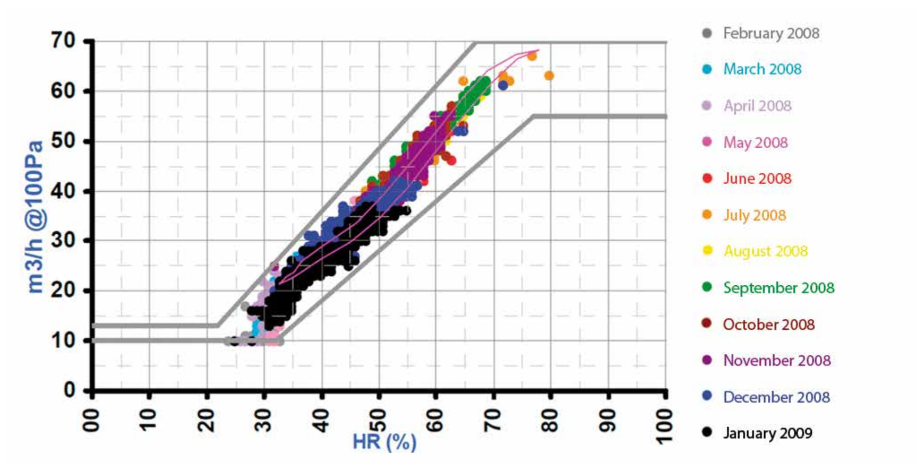


Figure 5: Airflow/RH behaviour of a humidity controlled extract unit in the kitchen. Pink curve = laboratory measurement. Grey lines = tolerance envelope. Dots points = measurements.

The [airflow Vs relative humidity] measurements have shown that all the humidity controlled terminals have been working in their tolerance envelope, following in-situ the laboratory nominal curve, as presented in Figure 5 for an extract unit in the kitchen. The statistical[6] [airflow / RH] couples presented in different colours for each month show the impact of the external absolute humidity rate: the dryer outdoor air induces a lower basic indoor relative humidity which gets the extract unit close to the minimum opening. This phenomenon, already observed on various monitoring such as "HR-VENT" (2004), **contributes largely to the ability of humidity controlled ventilation to save energy when the outdoor temperature is low.**

How DCV reduces fan consumption

An additional advantage of airflow modulation by DCV is to reduce the average global airflow exhausted by the collective fan, and therefore the power consumption too. Measurements have shown that the ventilation needs are time-dispatched so that the global airflow is at any time largely lower than the sum of the maximums. **The resulting energy saving[7] on the fan consumption has been measured between 35 % and 50 % on the two locations.**

5. The equivalent airflow for energy corresponds to the fix airflow equivalent in terms of heat losses through ventilation. It takes into account the [indoor-outdoor] temperature difference.
6. 80 % most frequent airflow / RH points have been represented to show the statistical behaviour.
7. In comparison with the French Thermal Regulation fan consumption data for a constant airflow system. The use of low consumption fans have improved their nominal performance.

PERFORMANCE PROJECT:
A NEW EVIDENCE OF THE HIGH PERFORMANCE OF THE DEMAND CONTROLLED VENTILATION

The large-scale in-situ monitoring study realised in Paris and Lyon on 30 dwellings has demonstrated the ability of the DCV systems tested to reach a high level of indoor air quality compared to a fixed flow system. The condensation risks are negligible; the monitored systems enabled 30 % energy savings in comparison to the regulatory fixed airflow on these over-occupied dwellings. An extrapolation to the French average statistical occupancy leads to 55 % energy savings on heat losses. Fans consumption has been decreased between 35 % and 50 % in the 2 locations. The monitored humidity controlled ventilation components have shown in-situ working characteristics in compliance with the laboratory tests, and a seasonal airflow vs RH behaviour favourable to energy savings. This project has also been the opportunity to validate the hourly evaluation tool (SIREN) used in France for Technical Agréments.

With this new complete in-situ monitoring study, humidity controlled ventilation and Aereco systems have shown once more a high performance in terms of indoor air quality as well as a huge potential to save energy on ventilation heat losses.

Validation of hourly thermal-aerodynamic software (« SIREN »)

An additional purpose of the project was the validation of the hourly simulation software “SIREN*” which is used for the assessment of the humidity controlled ventilation systems in the French Technical Agréments. The measured results (airflows, CO2 and humidity concentrations, risks of condensations, etc.) and their comparison with the simulation through SIREN have demonstrated a very good reliability of the dynamic tool for energy and aerodynamic simulations. This software is particularly relevant for the evaluation of humidity and demand controlled ventilation systems.

* SIREN has been developed and proposed by French CSTB (Centre Scientifique et Technique du Bâtiment).

Acknowledgments

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