Performance 2

Durability of ventilation performance

Durability and maintenance of smart ventilation components: analysis of the ventilation performance after 15 years of use of Humidity-based DCV systems

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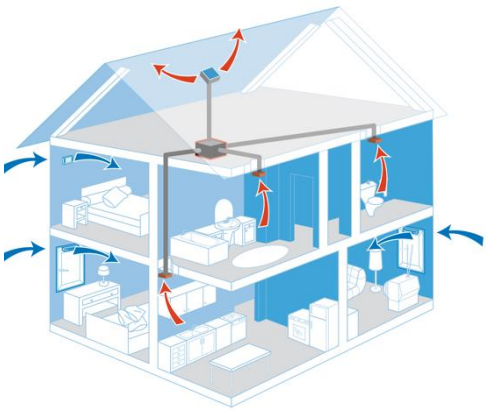
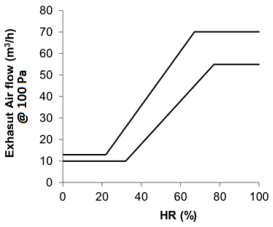
1

Principles of French HC-MEV System

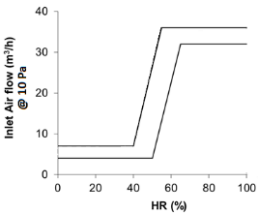
- Air circulation principle



Exhaust : air flow



Inlet : air distribution



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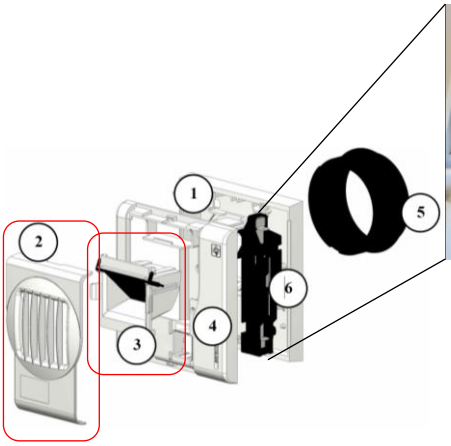
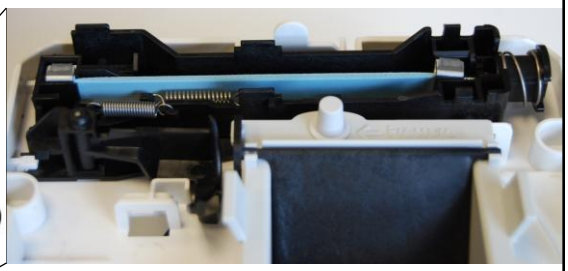
Principles of French HC-MEV System



Grid and Case are removable and washable



Hygroscopic mechanical sensor/actuator out of the flow

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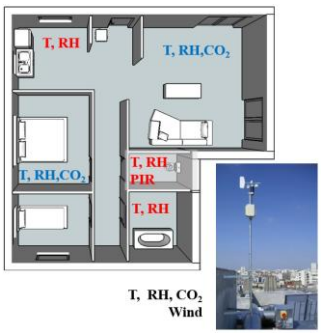
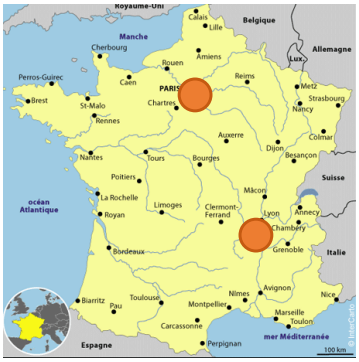
« Performance » Project – 2007-2009 monitoring

Site	Paris	Lyon
Type	1 to 4 bedrooms	1 to 4 bedrooms
Height	8 floors	6 floors
Monitored	13 dwellings	6 dwellings





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Performance 2 project (2020 – 2024)

Aim: qualify the durability of smart ventilation systems with humidity-based demand-controlled ventilation, and especially their resiliency regarding long-term use by various tenants

Paris Building
19 instrumented dwellings

Villeurbanne (Lyon) Building
12 instrumented dwellings

monitored since their construction during the 2007-2010 Performance project
→ in situ sensors in the air terminal devices (directly inside the ATD and with circuit board near the ATD)

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Performance 2 project (2020 – 2024)

- **Continuous monitoring + 2 winter campaigns on-site:**
  - Preliminary inspection of ventilation systems
  - Measurements in dwellings:
    - ventilation performance
    - comfort parameters (T°, RH)
    - indoor air quality (CO2, VOCs, Formaldehyde & PM)
  - Interviews of the tenants
  - Outdoor weather stations

- **Laboratory campaign:**
  - evaluation of the air terminal devices' performance before and after cleaning
  - calibration of the sensors and study of the reliability of the indoor air quality sensors

- **Analysis:**
  - assessment of the performance of the ventilation systems regarding indoor air quality, energy input, and their robustness compared to their use by the tenants

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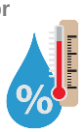
Analysis- Methodology

Performance regarding IAQ: new evaluations

Parameter	Sensors	Limits	Analyses
CO2	NEMOs Embeded sensor	Auto calibration	Descriptive statistics with precaution
Formaldehyde	NEMOs	Average values for 2h	Limited
Total VOC	Embeded sensor	Which VOCs? Unit? 24h Auto calibration	Only dynamic analyses
Light VOC	NEMOs	Which VOCs? Unit? High uncertainty	Only dynamic analyses
PM2.5	Embeded sensor	High uncertainty	Descriptive statistics with precaution
	NEMOs	High uncertainty	Descriptive statistics with precaution
PM1	NEMOs	High uncertainty	Descriptive statistics with precaution

Temperature and relative humidity sensor
Performance 1
Performance 2



CO2 sensor
Performance 1
Performance 2

Presence detection (WC)
Additional airflow
(Cuisine)
Performance 1
Performance 2

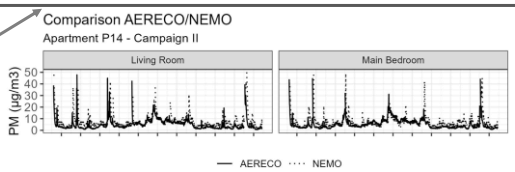
VOC sensor
Performance 2
(paint, cooking, fourniture, …)

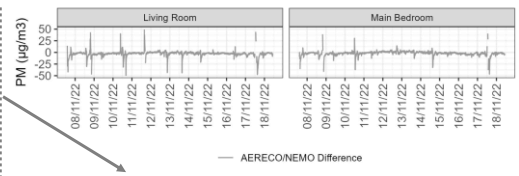
Paticle matter (PM) sensor
Performance 2
Mass concentration of PM2.5
(0.3 à 2.5 µg/m3)

Analysis- First results

- Comparison AERECO/NEMO sensors: Particle Matter (PM) 2.5

AERECO sensors → Installed in all the rooms - 1 record every minute for 2 years



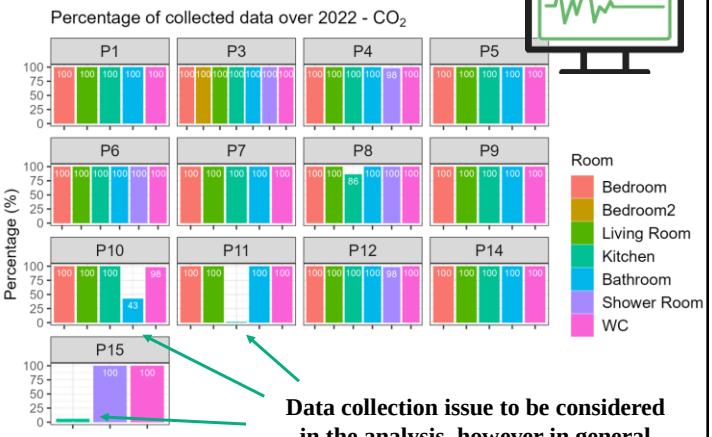


Very little difference between the 2

NEMO sensors → 2 IAQ campaings of 2 weeks each installed in the main chamber and living room - 1 record every 10 minutes

Analysis- First results

- Collected data over 2022:



Data collection issue to be considered in the analysis, however in general high data collection ratio

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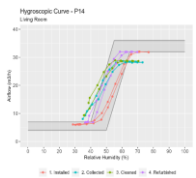
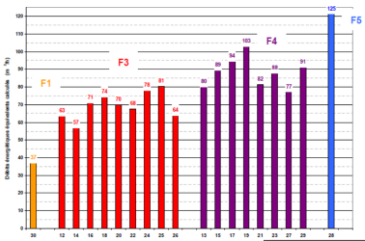
Analysis - Methodology

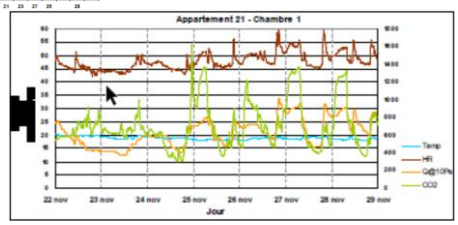
1) Durability evaluation (HR and CO2) : comparison Performance 1 / Performance 2

- In laboratory



- On-site





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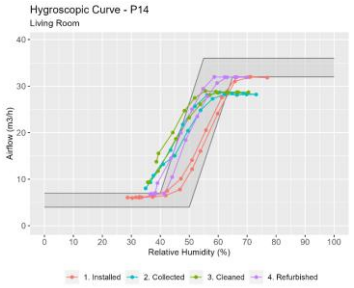
Analysis- First results

1. Robustness of the technology

- **Laboratory campaigns have shown issues relating to**
  - Cleanliness
  - Robustness of the technology
  - Resistance to occupant misuse
- **Nevertheless with proper maintenance (inc. cleaning)**
  - Without touching the hygroscopic fabric (sensing and actuator part)
  - ⇒ **100 % of the exhaust units and air inlets not purposely degraded by the occupant still reacted as expected to humidity to control ventilation**



Mélois et al. Durability of humidity-based ventilation components after 13 years of operation in French residential buildings – assessment of components performance in laboratory. Energy and Buildings, 2023.

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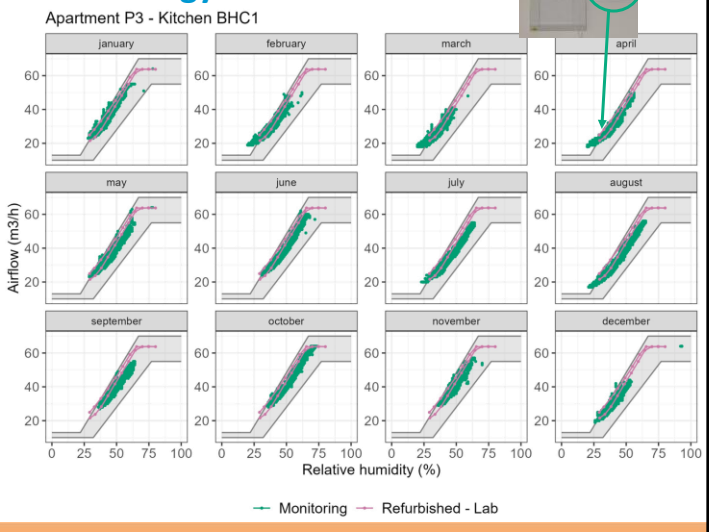
Analysis- First results

1. Robustness of the technology

- **Most of the performances remain within acceptable tolerance levels.**
  - Deviations from manufacturer tolerance limits occasionally occur due to real-world temperature variations, which impact humidity measurements.



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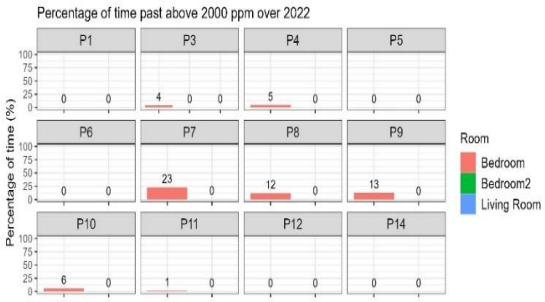
Analysis- First results

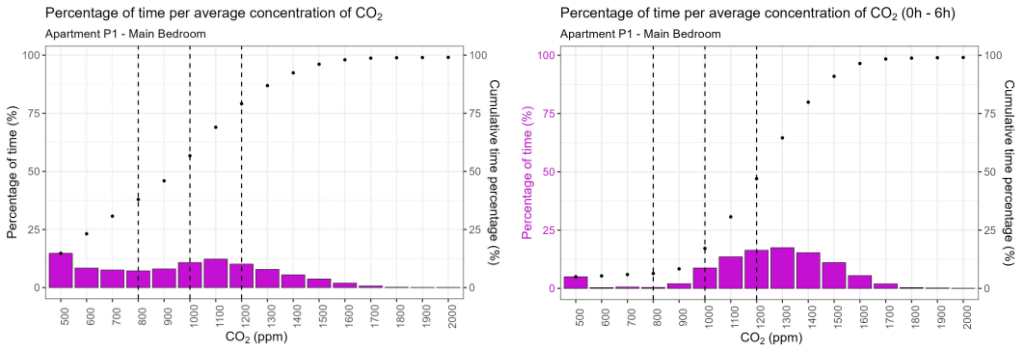
2. CO2 level in dwellings



- CO2 concentrations in most of the cases do not exceed 2000 ppm
  - Measurement have shown that despite high levels of occupation,
  ⇒ the ventilation system is effective
  ⇒ Only few cases show that ventilation sometimes is not enough to evacuate the CO2 in the bedrooms,
    ⇒ associated with situations of over-occupancy..

Analysis- First results

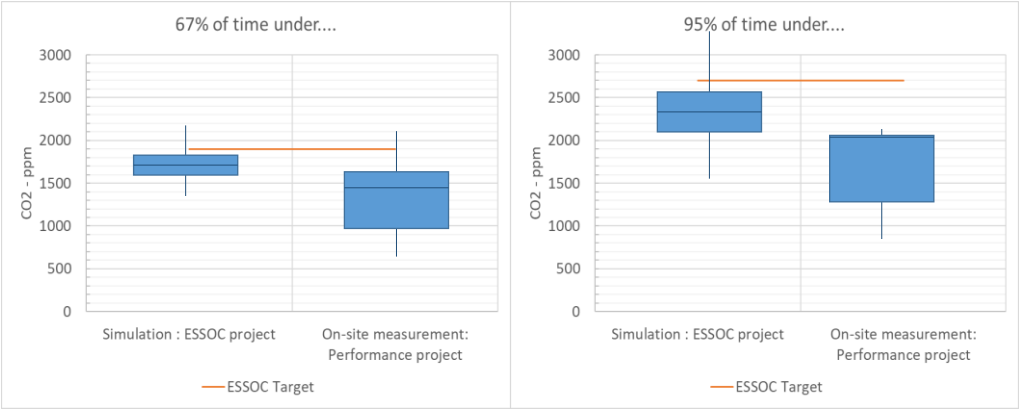
2. CO2 level in dwellings



More spent time at higher average CO2 concentration values when considering only 0h and 6h than for a 24h period

Analysis- First results

2. CO2 level in dwellings



Performance 2: Year 2022,During the heating season between 0 and 6AM (Main bedroom)

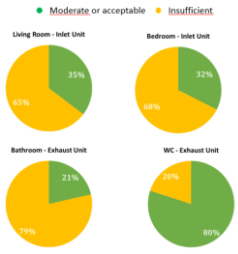
Analysis- Methodology

3) Durability: adequation between ventilation conditions & needs

- Diagnosis of the whole ventilation system

- Evaluation of the evolution of occupancy
- Number of occupants
- Age
- Home office

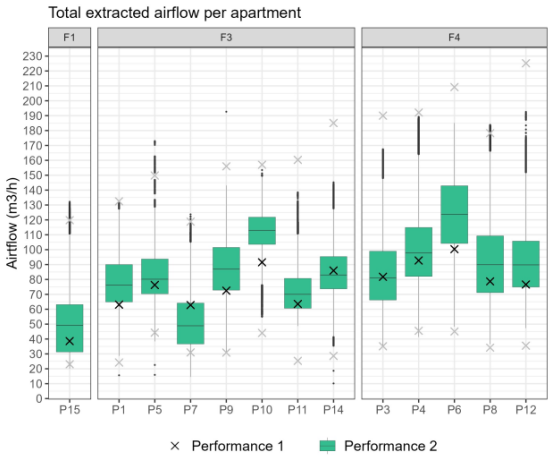
- Evaluation of the airing behaviour
- Evaluation of the internal sources of pollutants



Analysis- First results

3) Durability: adequation between ventilation conditions & needs

- **RH-MEV system in real conditions show**
  - consistent performance 15 years later compared to the commissioning state
  - performances according to the specifications of fabrication.
  - That the system effectively **guarantees IAQ** by regulating ventilation based on RH levels **under over-occupation scenarios**.



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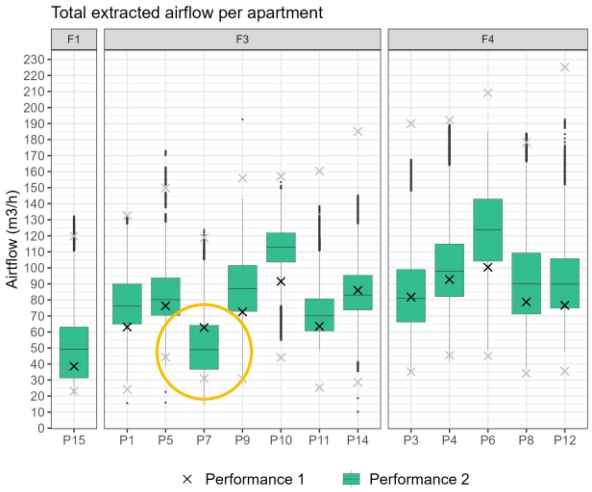
Analysis- First results

3) Durability: adequation between ventilation conditions & needs

Particular case with insufficient airflow → Apt P7



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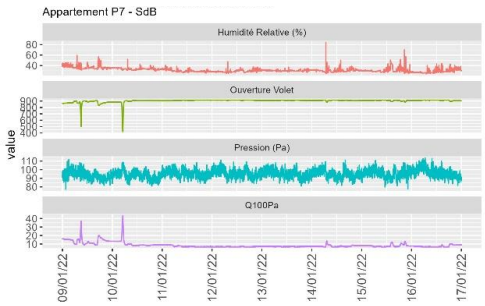
Analysis- First results

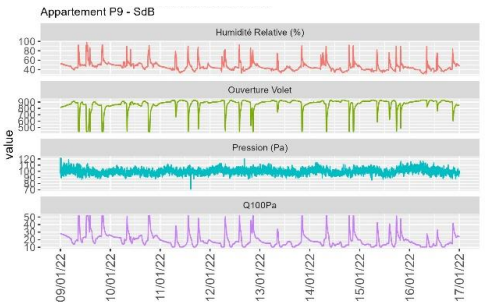
3) Durability: adequation between ventilation conditions & needs

Particular case with insufficient airflow → Apt P7:

Changes in relative humidity for 1 week between January 16 and 9 2022



Particular occupant behaviour



Normal occupant behaviour

Analysis- First results

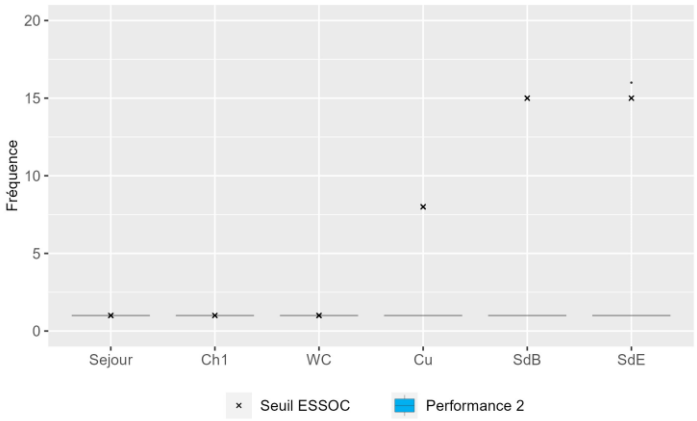
3) Durability: adequation between ventilation conditions & needs

- **Energy saving**
  - Performance 1 showed: average gain of 37.6% on heat loss rates, compared with the reference used in the calculations that correspond to constant ventilation rates.
  - Similar trends in total extracted airflow are found in Performance 2 and Performance 1 despite differences in occupancy levels or environmental conditions from 15 years ago

Analysis- First results

3) Durability: adequation between ventilation conditions & needs

Frequency of humidity above 75% over one hour (year 2022)



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Analysis- First results

- **Evaluation of the durability from on-site measurements**
  - Comparison with design documents
  - Comparison with Performance 1 project
- **Evaluation of actual performance of ventilation system regarding IAQ and Energy**
  - Indicators for IAQ performance
  - Evaluation of the humidity based system for others pollutants
- **Evaluation of the impact of the occupants**
  - Data collected with interviews
  - Data extrapolated from measurements
- **Many data: others studies may be performed after Performance 2 project**

Provided that the maintenance is done properly (annual cleaning, no obstruction) **the hygroscopic system is robust**

Performance 15 years later consistent with commissioning ones

- Relation between Humidity/flowrate remains within acceptable tolerance levels.
- CO_2 and other pollutants remain within acceptable limits

37% of energy saving compared with constant flowrate

End of the project: July 2024

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Performance 2

Durability of ventilation performance

Thank you for your attention

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