

# How to collect reliable information regarding occupants' behavior during IAQ campaigns? Performance 2 project first feedbacks

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## ABSTRACT

The Performance 2 project (2020-2024) is a French national research project that aims to evaluate the robustness of Humidity-based DCV systems installed in two multi-family dwellings more than 10 years ago. This evaluation include analyses of results of measurements performed on the ventilation system and IAQ campaigns in 13 dwellings. As the emissions of indoor pollutants strongly depend on the occupant's behavior, information is required regarding the activities and habits of the occupants during the IAQ campaigns. The occupants often judge this information very intrusive and too big. Moreover, some bias may exist in the occupant's response who may give answers that they judged more socially desirable than the real answer. In Performance 2, an important preparation has been made with the participation of a researcher in social psychology, in order to define tools to obtain reliable information from occupants. As the information given to the occupants and the time when it is done may strongly influence the occupants' behavior during the measurement campaign, a reflection has also been conducted to limit the bias due to this behavior changing.

This paper presents the methodology tested in Performance 2 IAQ campaigns on 14 dwellings. It proposes in a second part an analysis of the results of the first IAQ campaign of Performance 2 (winter 2021-2022). This analysis regards the quantity of answers collected (including response rate to the weekly log and the duration of the interviews) and the quality of the answers (including variability of the answers and comparison between observations and answers). As the measurements are performed during a strong COVID wave, the IAQ perception of the occupants, and thus their behavior, may be influenced by the sanitary situation.

## KEYWORDS

IAQ campaign, occupants, interview, information reliability

## 1 INTRODUCTION

### 1.1 Performance 2 project presentation

Winner of the call for projects of ADEME "Towards responsible buildings – 2020 edition", Performance 2 project aims to qualify the durability of smart ventilation systems with humidity-based demand-controlled ventilation (Guyot et al. 2022), and especially their resiliency regarding long-term use by various tenants. This study relies on various on-site measurements (flow rates and pressure in air ducts, CO<sub>2</sub>, relative humidity, temperature, VOC, formaldehyde

and particles) in two multi-family buildings. These buildings, one in Paris and the other in Villeurbanne (near Lyon), were monitored since their construction during the 2007-2010 Performance project. The measurements are taken from in situ sensors in the air terminal devices (directly inside the ATD and with circuit board near the ATD), and additional air quality sensors arrays in the living areas of the housing units (living room and bedroom) and outside (on the roof of the buildings). This program includes 4 different technical tasks:

- On-site winter campaign: measurements in the dwellings of ventilation performance, the comfort parameters, and the indoor air quality, with interviews of the tenants;
- 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;
- Results 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;
- Development of technical recommendations, with a possible inclusion of such recommendations into IAQ regulations.

## **1.2 Campaign preparation work – the key role of the tenants**

When indoor pollutants measurements are performed, the analysis of the results requires information on the possible sources of these pollutants, including but not limited to: floorings, walls and ceilings, furniture, heating and air conditioning systems, and human activities such as cooking, cleaning, personal care, craft work, use of ambient scents... It is also important to gather information on the habits of the tenants regarding how often they open their windows. Feedback from previous such campaigns shows that it is often hard to get reliable and complete information, in part because the questions are seen as intrusive. To alleviate such psychological holdbacks, the teams in charge of the interviews worked with a social psychology researcher to develop three tools:

- A technical questionnaire on the dwelling itself, to be filled by the Cerema teams while in the dwellings, with a simple visual check,
- A weekly log to be filled by the tenants during the duration of the measurements, with easily readable tables and checkboxes to avoid having to write more than the bare essentials,
- An interview guide, with questions written in the most open way to avoid biasing the answers of the tenants.

Those documents have been used during the campaigns on the two buildings. In this paper, we first present the two documents we develop to obtain information regarding occupants' behavior during the IAQ campaign. We analyzed the answers we have obtained regarding the answers rate and the spread of the results for the 13 apartments of the Performance 2 project. Then, we present first results of the cross analysis of data from occupants answers and from IAQ measurements.

## **2 DEVELOPMENT OF TOOLS TO GATHER INFORMATION REGARDING OCCUPANTS' BEHAVIOR DURING IAQ CAMPAIGN**

### **2.1 The weekly log**

The on-site campaigns regarding IAQ in the Performance 2 project have been carried out for 2 weeks for each of the 13 apartments. On the first day for each apartment, when the project team installed the IAQ sensors, they briefly presented the aim of the campaign without detailed

explanation in order to limit their impact on the occupants' behavior. They also presented the weekly log that the occupants have been asked to fill during the 2 weeks of the campaign. The data collected through this log will be necessary to interpret the results of IAQ measurement. In particular, they are important to identify the pollutants sources and the occupants' impact on the ventilation system functioning. In various previous IAQ campaigns, weekly logs have been used but most of the time, very few data have been collected because 1- they included too many questions and too many tables to complete, and 2- because the occupants refused to give information they judged too intrusive. In the Performance 2 project, we collected some of these existing logs and we improve them with the participation of a social psychology researcher. Thus, the weekly log we propose for the first IAQ campaign of Performance 2 includes five parts dedicated to five types of action that may have a strong impact on the IAQ:









- **Cooking**

The objective of this part is to know when the occupants have cooked, and what type of pollutants they may have produced. Thus, in order to simplify the answers, we identify four types of cooking:

- Steam baking: for all types of cooking that will essentially produce water vapor and particles;
- Frying
- Oven and microwave
- Accidental burn

We propose a table with these 4 types of cooking, with 2 time slots per day (Table 1).

Table 1: Weekly log extract - Cooking section

Day of the week	Start time	Duration (in minutes)	Cooking mode				Start time	Duration (in minutes)	Cooking mode			
												
Monday												
Tuesday												

- **Housework**

As for the cooking part, the elements we need to collect here are when the occupants have done housework, and what type of pollutants they may have produced. As this information might vary a lot from one day to another, and strongly depends on the type of housework they did and the type of products they used, we decide to simplify this part asking only to put a cross in the corresponding room for each day they did housework. More information will be collected later during the interview.

- **Bathroom use**

This part is the most intrusive one: we need to know when they produce vapor and pollutants, that means when they take a shower or a bath, and when they use cosmetics. As another day-table to complete may demotivate the occupants, we propose to complete a table describing their weekly routine for each occupant (Table 2). Regarding the cosmetics, we ask only to indicate when they used a product in spray (with potentially a lot of aerosol pollutants) or a product like a cream (with less emission). The information may be less detailed, but it is better to obtain this information than an empty table and may be completed during the interview.

Table 2: Weekly log extract - Bathroom section

Bath	Shower	Sink	Day of the week	Start time	Duration (in minutes)

- Apartment airing

We propose here another day-table, in order to collect data regarding when the occupants aerate one room. We need to collect for each day, the times and the duration. To simplify, we ask to cross the column “less than 5 minutes” or “more than 5 minutes” (Table 3).

Table 3: Weekly log extract - Airing section

Day	Kitchen		Bathroom		Living room		Bedroom (with sensor)	
	- 5 min	+ 5 min	- 5 min	+ 5 min	- 5 min	+ 5 min	- 5 min	+ 5 min
Monday								
Tuesday								
Wednesday								
Thursday								
Friday								
Saturday								
Sunday								

- Activities of do-it-yourself and hobbies

In this part, we need to collect all others actions from the occupants that may significantly affect the IAQ. We ask the occupants to indicate if they did a DIY activity, painting, if they used perfumed candles or incense, if they did sporting activities in their apartment or other activities that they think may produce pollutants (leisure or manual activities).

When the log was presented to the occupants, different techniques has been used to motivate the occupants to complete the log:

- Ensure that the data will be analyzed using statistical tools, thus they are anonymous;
- Explain that we need to know what the occupants do to analyze the result, and that there is no good or bad answers, no judgment;
- Before leaving, the project team should have the engagement of the occupants to complete the log.

## **2.2 The interview**

After 2 weeks of IAQ campaign in each apartment, the project team did come back to remove the IAQ sensors. They spend time with the occupants to conduct an interview in order to collect more information. First, the project team explained in detail the objective of the project, which is to evaluate the performance on the ventilation system: the IAQ measurements are a tool to perform this evaluation, and thus the information we need will be only used to analyze the functioning of the ventilation system. The social psychology researcher has advised us to insist on the presentation of the campaign that aims to produce data regarding the comfort and the quality of the apartment. It is important to explain to the occupants that there is not good or wrong answers, and that the object of the study is the ventilation system, and not them.

Then, many questions have been prepared regarding:

- the occupants (including people, animals and plants), equipment (extra heating system, air cleaner) and renovation of the apartment;
- use of chemicals /cosmetics / cleaning products;
- furniture and soil/wall surfacing;
- cooking;
- laundry and shower/bath;
- airing and ventilation;
- general comfort.

To avoid influencing the answers, list of answers to cross are not used directly: we ask about the difficulty to maintain clean furniture to obtain clue regarding the frequency of the cleaning, or about the noise and the odors to obtain information regarding airing. Moreover, depending on the occupants' answer to one question, the project team is free to add new questions or to pass some others: the interview guide has to be adjusted to each situation.

## **3 ANALYSIS OF THE INFORMATION FROM OCCUPANTS' DECLARATIONS**

### **3.1 Presentation of the 13 apartments and their occupants**

The IAQ campaign of the Performance 2 project has been carried out in 13 apartments:

- 7 apartments are located in a social multi-family buildings in Paris, built in 2007.
- 6 apartments are located in a social multi-family building in Villeurbanne (near Lyon), built in 2007.

The construction of both buildings took place during the Performance 1 project, meaning that the occupants living in these buildings since their construction were aware of the quality management approaches regarding envelope airtightness and ventilation that have been tested on these buildings.

Then, they have been contacted at the beginning of Performance 2 to ask them to participate to this new project. Moreover, the team project came 2 times before the on-site IAQ campaign: first to remove the ventilation air terminal devices and then to put them back after a laboratory campaign. Thus, the occupants' behavior regarding the ventilation system might be impacted by their participation to Performance 1 and Performance 2 projects. Moreover, the on-site campaign happened during the pandemic, during the third Covid wave in France, when the

Medias have raised awareness of the importance of airing and ventilation in buildings. This situation may induce another bias in the occupants' behavior. Table 4 presents for each apartments the number of occupants and their age ranges.

Table 4: Information regarding occupants

Building	Apartment	Number of occupants	Age range
Villeurbanne	1	1	50 years
Villeurbanne	2	1	40 years
Villeurbanne	3	1	50 years
Villeurbanne	4	1	30 years
Villeurbanne	5	4	Adult – Adult – 9 – 5 years
Villeurbanne	6	7	50 – 50 – 18 – 17 – 15 – 6 – 3 years
Paris	7	4	50 – 50 – 20 – 18 years
Paris	8	4	50 – 50 – 20 – 19 years
Paris	9	4	50 – 45 – 20 – 15 years
Paris	10	6	55 – 55 - 30 – 20 – 15 – 10 years
Paris	11	2	65 – 30 years
Paris	12	4	65 – 60 – 21 -20 years
Paris	13	4	40 – 40 – 3 -1 years

We have collected 12 weekly logs for 13 apartments: one occupant has refused to fill in the document. Thus, in the next parts of this paper, 12 weekly logs and 13 interview answers have been analyzed.

### 3.2 Completeness of the documents

The weekly log has been fill in by the occupants during the 2 weeks of the IAQ campaign, without the presence of the project team. The filling of this document varies a lot from one apartment to another. It depends on the use of the apartment (if the occupants cook or not, if they eat at home or not, if they open often their windows, etc.) and on the rigor with which the occupants have completed the weekly log. Figure 1 represents for each apartment the average number of meals per day declared in the weekly log: it varies from 1.36 (in this case, we can consider than the great majority of the meal cook / eat in the apartment has been correctly declared in the log) to 0.0 (we can consider than the log has not been correctly completed).

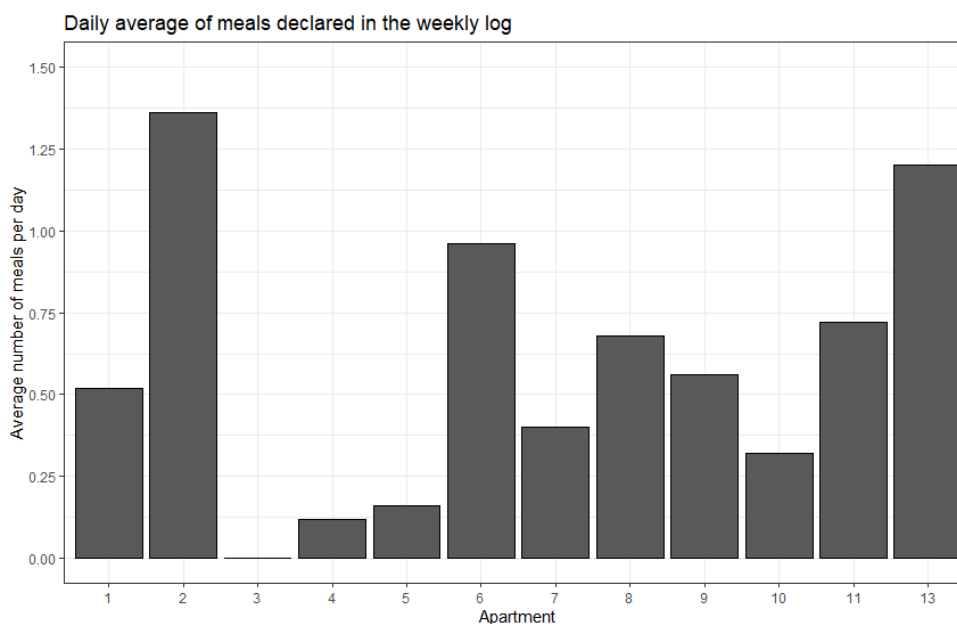


Figure 1: Daily average of meals declared in the weekly log

For the bathroom part, we asked occupants to describe their routine, thus we expected one routine per occupant. As we can see in Figure 2, for some apartments, we obtain routine for less occupants than the number declared during the interview. That means that there are missing data in the log (we observe one exception: for apartment 8, we have more “occupants” in the log than in the interview – it is because the occupants have declared the showers they gave to their dog in the log).

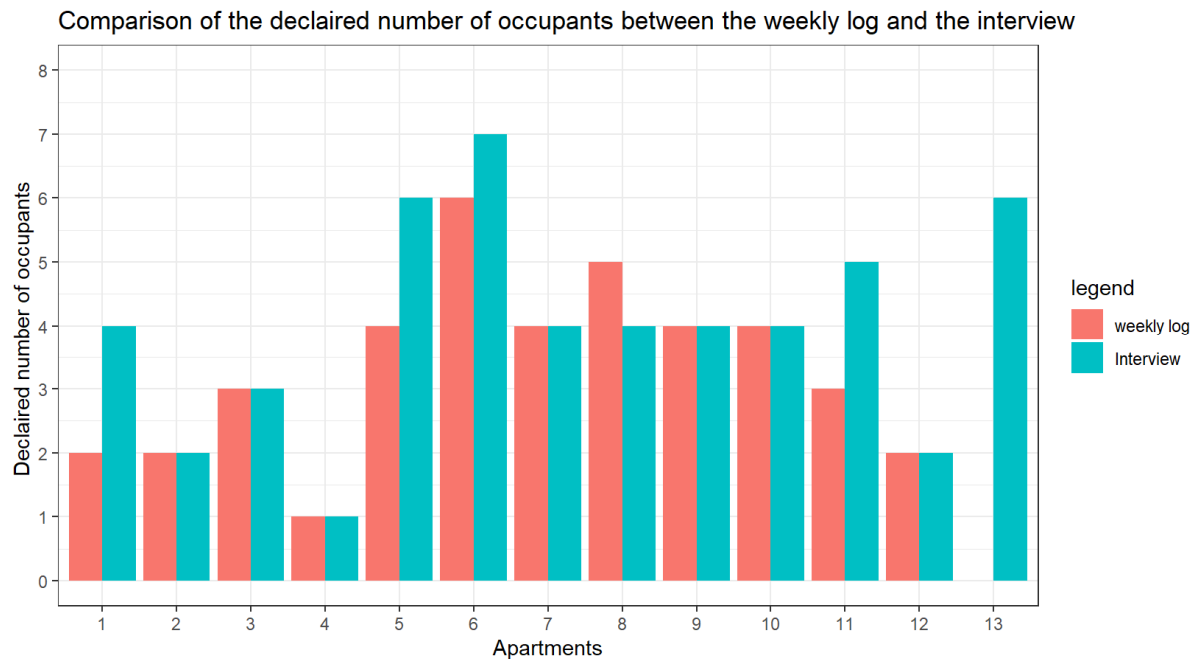


Figure 2: Comparison between occupancy declared in the weekly log and during the interview

### 3.3 Data consistency

- Airing during housework

The interviews have been conducted after the 2 weeks IAQ campaign for each apartment. As the questions have been directly asked by the project team, we obtained more answers and more details than from the weekly log. The interview includes questions regarding the weekly log topics. Thus, we have compared some answers from the two documents for some questions, in order to have some clues regarding the reliability of the answers.

During the interview, we ask the occupants about their habit regarding airing when they do housework. In the weekly log, we have information regarding when they opened a window in each room, and when they did housework. Thus, when occupants declared that they opened a window during housework, we verify the correspondence with their declaration regarding airing and housework in the weekly log. For the apartment 6, we see in Figure 3 that for day 10 and 11, they did housework but they did not open a window in the rooms that day. For the apartment 11, we observe the same situation on day 2. These three situations mean either that the occupants have forgotten to fill the weekly log regarding airing for these days, or they did not automatically open the window in the room when they did housework as they have declared in during the interview (as we do not have the time when they did the housework, we cannot know if the airing was done at the same time that the housework).



Figure 3: Occupants' weekly declaration regarding airing and housework for 2 apartments

- Number of showers/baths declared per occupant

For shower and bath declaration, we observe a large variability of the daily number of shower and bath declared by each occupant in all apartments (Figure 4).

One of the most intrusive questions according to the occupants' feedback is their routine in the bathroom. Even if it is not recommended for medical reason to take a shower every day, in order to provide judgement in a cleanliness matter, some people would rather declare a daily shower, even if this is not the true. Others might forget one or several showers or bath if they have filled in the log at the end of the week for example. Thus, we are not able to get the true information for each occupant.



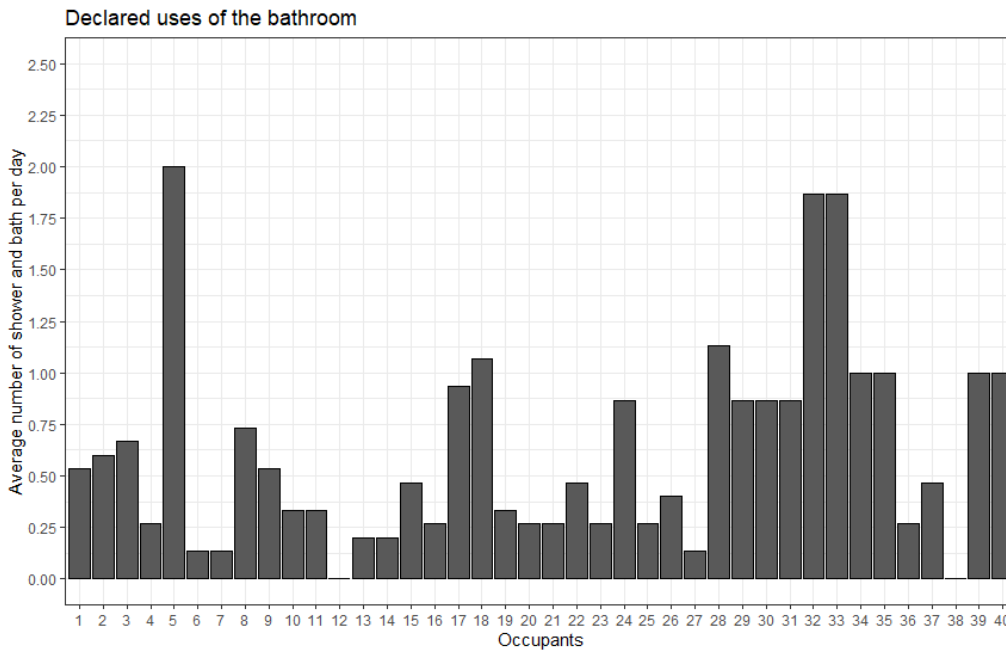


Figure 4: Daily use of the bathroom depending on the occupants

#### 4 COMPARAISON BETWEEN OCCUPANTS' DECLARATION AND MEASUREMENTS RESULTS

The objective of the collect of the occupants' data is to better analyze the measurements data, especially to understand VOC concentration. However, we can use the measurements data to get some clues regarding the reliability of the occupants' data. Indeed, the analysis of the CO<sub>2</sub> concentration and the relative humidity evolution may let us identify airing. Thus, in Figure 5, we draw CO<sub>2</sub> and RH during one day, and we indicate the declared airing. For this day and this apartment, we observe a perfect correlation between the declared data and the measurement data. As we have just collected the measurements data, the same analyses for all days and all apartments have not yet been performed: it will be done as a first verification.

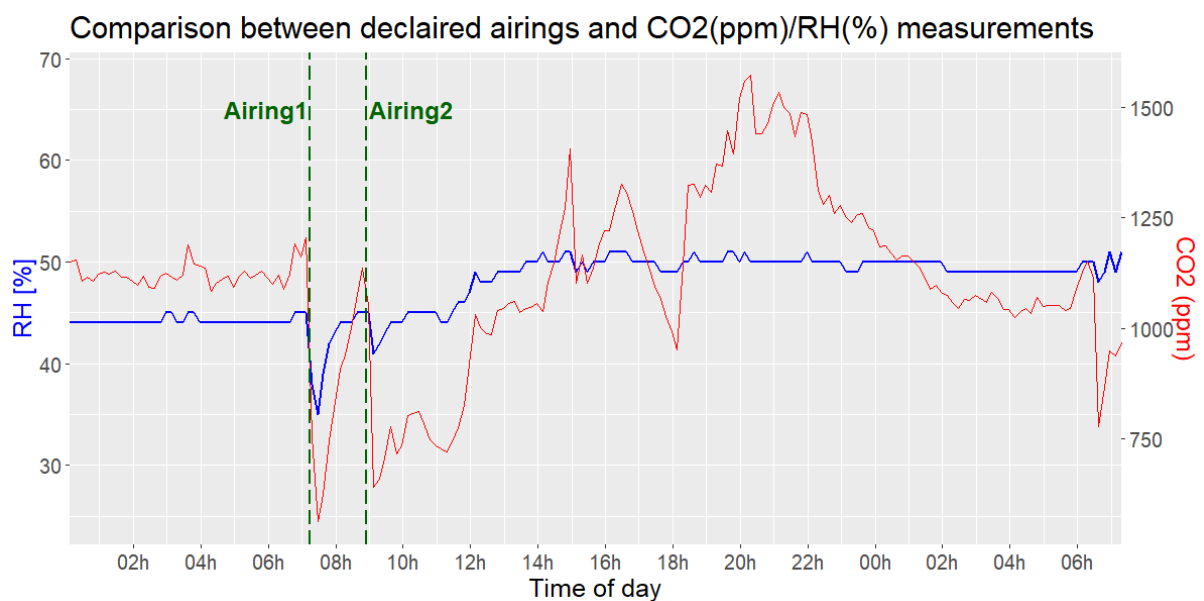


Figure 5: Correlation between declared airing, and CO<sub>2</sub> and RH in one apartment for one day

## 5 CONCLUSIONS

Two tools have been developed during the Performance 2 project in order to collect data regarding occupants' behavior during the first IAQ campaigns in 13 dwellings:

- A weekly log including cooking, housework, bathroom use, airing, and do-it-yourself sections;
- An interview guide with questions written in the most open way to avoid biasing the answers of the tenants.

The filling of the weekly log varies a lot from one apartment to another, depending on the use of the apartment and on the rigor with which the occupants have completed it. In particular, data regarding the bathroom use are intrusive and some occupants might be unwilling to fill in this section.

The cross analysis of some measurements data and occupants' declaration, as for example the CO<sub>2</sub> and RH levels and the declared airing may give some clues regarding the reliability of the data from the weekly log. It will be performed for all apartments of the Performance 2 projects. From occupants' feedback and first analysis of the weekly log and interviews answers, the documents and the methodology will be improved and then be tested during the second IAQ campaign of the Performance 2 project by the end of 2023.

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