Methodology to define new performance indicator for ventilation regulation in France

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INTRODUCTION

In France, the regulation context for ventilation is based on the decree « Arreté de 1982 » which is a prescriptive regulation, requiring extracted flowrate in every utility room. These extracted airflow should respond to several principles:

1. The air renewal in dwelling is general and permanent at least during the heating season.
2. The air renewal system shall include natural or mechanical inlet in main rooms and outlet in utility rooms. The air shall circulate between main and utility rooms
3. The ventilation system shall be able to reach, simultaneously or not a set of prescribed flowrates by room with exhaust, function of the type of the room and the size of the dwelling
4. The total extract flowrate can be reduced with a minimal flowrate to be respected (function of the number of main rooms)
5. The air inlet shall be designed to reach the prescribed flowrates in utility rooms.

These principles were strong basis to generalise mechanical ventilations in residential building to avoid humidity issues and mould growth thanks to these minimal flowrates to be respected. However, it is quite restrictive for other ventilation systems with variable flowrate that could be temporarily lower. Moreover, this decree has no requirement on supply flowrate. As result, lots of existing systems are not compatible with the actual regulation such as supply only system, ventilation per room, system without higher flowrate in the kitchen, and generally more advanced control strategies.

The new building code « code de la construction » propose an alternative to the prescriptive approach, based on the following statement:

> *« Air renewal, shall be such as, in normal condition of use, the indoor air pollution does not endanger health and security of occupants and that condensation is avoided, except temporarily »*

These new principles in building code for air renewal open the possibility for a range of systems to be compatible with the regulation. But this switch from a prescriptive approach to

a performance-based approach need to be adapted in the regulation with a robust methodology to assess the effective performance of ventilation systems. In addition, the requirements for performance should be such as most of system that comply with 1982 requirements fulfil performance requirements.

The objectives of this work is to define a set of key performance indicator (KPI) for ventilation that are equivalent to the existing prescriptive regulation. Which is ambitious because defining KPI for ventilation is still a matter of research, this is worked on in IEA-EBC Annex 86.

1 APPROACH

To define performance-based requirement, the aim of the regulation needs to be clearly identified with its objectives. Including principles which describe the essential elements of the area covered by the code. To assess whether objectives are meet or not, measurable (or calculable) indicators should defined. Lastly verifiers demonstrate that the assessed performance met the required state based on observation and information.

1.1 Objectives and principles

In general, the performance indicators for IAQ measures should rate their impact on the Indoor Air Quality according to:

- **Health** aspect to prevent risk from long term exposure, acute effect and disease transmission.
- **Well-being** with the aim to improve quality of sleep, productivity and perceived air quality.
- **Building durability** to avoid mould growth and damage from condensation

In the French context, the regulation deals only with “ventilation” and no other IAQ measures (such as source reduction or air cleaning), so it will only evaluate performance that can be improved by an increase of the ventilation rate.
Objectives, and therefore requirements, are on the removal capacity of pollutant produced indoor (inc. humidity and CO_2) but they are no requirement on air treatment (increase humidity level, temperature, quality of supply air, etc.).
In IAQ regulation several principles have to be wisely choose to meet these objectives on health, well-being and building durability for ventilation performance assessment. These principles give orientations for the definition of the performance indicator and their ability to be relevant regarding the objectives.
The selected principles for the French IAQ are:

- Performance indicator should be suitable for validation through preliminary simulations not through on-site measurements.
    - Nevertheless, their ability to be compared to on-site measurement is a criterion to define them.
- The threshold values for those indicators should be consistent with performance of systems that respect the current prescriptive regulation « Arreté de 82 ».
    - In addition, some prescriptive requirement can be kept as safe-guards to guarantee a minimal air renewal and performance level.

1.2 Define performance Parameters & indicators

Regarding the objectives of the French IAQ regulation, five parameters are selected and declined across nine performance indicators:

CO_2, a well-known reference, to evaluate the adequacy between the ventilation air flow rate and the occupation, it is both measurable and suitable for simulation

- For each room, the CO_2 concentration (in ppm) below which it remains 67% of occupied time
    - An indicator in ppm is more easily readable than a cumulative exposure in ppm.h
- For each room, the CO_2 concentration (in ppm) below which it remains 95% of the occupied time

Humidity, relevant for the risk of condensation, measurable and suitable for simulation

- For every room, a maximum percentage of time over 75% of relative humidity during the heating period. The maximum value will depend on the type of room (as surface finishing standards depend on it)

Proxy pollutant P1, permanently emitted, cover all pollutants emitted by material and passive equipment, suitable only for simulation,

- The mean exposure (for the most exposed person)
- The maximum exposure over one hour (moving average, for the most exposed person).

Proxy pollutant P2, emitted during cooking periods, representative of episodic emissions linked with human activities, suitable only for simulation

- The maximum exposure over one hour (moving average, in the kitchen).
- The concentration below which it remains 95% time in bedroom

This selection of two proxy have the objective to cover all pollutants and not a specific one to avoid air cleaning systems that would remove only this one without taking care of others. Moreover, for performance assessment based on simulation there is a need for relevant data of emission for each project and that depends on occupant, construction behaviour, external condition and complex physic phenomena. This could be difficult to generalise with multitude pollutant declination. Lastly depending on the pollutant, the target values could be difficult to define with possible opposition between health guidelines and the assessed performance of existing systems

Air renewal, relevant to control sage-guard on minimum air renewal and easy solution for the toilet. It is suitable for simulation and measurable

- Minimum and reachable air renewal flow rate in the toilet
- Air renewal rate above which the dwelling is 95% of the time

1.3 Verification with simulated existing systems on reference cases

Associated with this performance indicators, acceptable thresholds are necessary to assess the performance of ventilation. However, performance validation through simulations could largely be influenced by input parameters such as the building configuration or weather. Sensitivity analysis experiment was made with the objectives to define the threshold values and to check the impact of the various input parameters.

Two typical French mechanical ventilations were simulated; an extract only mechanical ventilation with constant airflow and an extract only with relative humidity-based demand

control. The performance was assessed over 2000 simulations with variables parameters statistically consistent with the French housing stock (ventilation airflows, architecture, kind of dwelling, number of rooms, building airtightness). 8 climatic zones with various wind exposure were implemented. The only fixed parameters were the occupancy and the pollutant emissions scenario. The simulations were performed with a software called « MATHIS » which is a multi-zone airflow model equivalent to CONTAM.
Threshold values were suggested such as around 75% of simulations would comply with them.

1.4 Define Target values

Table 1: Target value for indicators

Parameter	Indicator	Location	Suggested values
CO_2	The CO_2 concentration (in ppm) below which it remains 67% of occupied time	Maximum of occupied rooms	~1900 ppm [1800-2000]
	The CO_2 concentration (in ppm) below which it remains 95% of occupied time	Maximum of occupied rooms	~2700 ppm [2500-2900]
Relative Humidity	Percentage of time over 75% of relative humidity during the heating period	Bathroom Kitchen Other rooms	~14% [12-16] ~6% [5-8] ~1% [1-3]
P1	The mean exposure	Most exposed person	~2300 P1/m3 [2100-2500]
	Maximum exposure over one hour	Most exposed person	~7000 P1/m3 [7000-9000]
P2	Maximum exposure over one hour	Kitchen	~1800 P2/m3 [1700-2000]
	The concentration below which it remains 95% time	Maximum of main rooms	~100 P2/m3 [50-200]
Air renewal	Extracted Air Flow rate above which it is 95% of time	Toilets	~5m3/h
	E.A.F.R. above which it is 95% of occupied time	Toilets	~15m3/h
	Air replacement above which it is 95% of time	Full dwelling	0,38 m3/h/m² [0,36-0,54]

1.5 Define Validation process

To be validated a project must:

- Include a system inspection and maintenance protocol
- Respect the minimum safeguards
- Prove through simulation (pre-project) that it meets the minimum IAQ criteria

Two alternatives are foreseen for the validation:

- Alternative 1 for industrial system that is meant to be installed in multiple projects
    - 2 steps validation
- Alternative 2 for ventilation system fitted for one given project
    - 1 step validation

For the first alternative

- First a commission will validate (once):
    - The modeling of the system in Mathis (and interface for end-user)
        - This will include input parameters
    - The relevance of inspection and maintenance protocol
- Then, for each project, a qualified design office will
    - Design the ventilation system
    - Check through simulations that KPI are met

- At commissioning of each project, a qualified ventilation inspector will
    - Apply the inspection protocol
    - Conclude on the conformity (or not) of the system.

For the second alternative, everything should be done for each project by a specifically qualified design office.

2 CONCLUSION

France will soon have a performance-based regulation for ventilation in dwellings has an alternative to the prescriptive one. Performance criteria defined are not ambitious but they are in line with actual systems performances.
Nevertheless, having establishing performance criteria is now a formidable opportunity for better performing systems to demonstrate so.
It also allows to developpe label of performance that go farther than the regulation.