

DEFINING KPI FOR SMART VENTILATION IN THE NEW FRENCH REGULATION

Valérie Leprince

AIVC/Ashrae Workshop, Singapore, April, 2024

1

CONTEXTE: PRESCRIPTIVE REGULATION « ARRÊTÉ DE 1982 »

Art. 1: The air renewal in dwelling is general and permanent at least during the heating season.

Art2: 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

Art 3: The ventilation system shall be able to reach, simultaneously or not the following values:

Number of main rooms in the dwelling	Extract flowrate in m ³ /h				
	Kitchen	Bathroom	Other room with water source	Toilet	
				Only one	Multiple ones
1	75	15	15	15	15
2	90	15	15	15	15
3	105	30	15	15	15
4	120	30	15	30	15
5 or more	135	30	15	30	15

Additional requirements are set for fire safety and interaction with combustion appliance.

Art. 4: The total extract flowrate can be reduced as follow :

	Number of main rooms						
	1	2	3	4	5	6	7
Total minimal flowrate in m ³ /h	35	60	75	90	105	120	135
Minimal flowrate in the kitchen in m ³ /h	20	30	45	45	45	45	45

If the ventilation system **automatically control flowrate** to maintain an indoor air quality that is not dangerous for occupant and avoid condensation (except temporarily) the flowrate can be reduced. Provided that the **system has been validated by the ministry** in charge of construction and health. In any case the total extracted flowrate shall at least be:

	Number of main rooms						
	1	2	3	4	5	6	7
Total minimal flowrate in m ³ /h	10	10	15	20	25	30	35

Art.5: air inlet shall be designed to reach extracted flowrates defined at article 3.

2



NEW REGULATION

The new construction code states that :

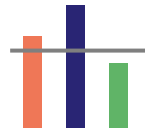
*“Air renewal, shall be such as, in normal condition of use, the **indoor air pollution does not endanger health and security of occupants** and that **condensation is avoided, except temporarily**”.*

This is respected if the system:

Respects

Arrete de 82 requirements
Art.1 _____
Art.2 _____
Art.3 _____
Art.4 _____
Art.5 _____

Or



Fulfills Key Performance Indicators levels*

*(named Résultats minimaux – Minimal results) as defined in a Regulatory text to be published by January 2025.



*Ambitious because **defining KPI for ventilation with minimum is still a matter of research**, this is worked on in IEA-EBC Annex 86*



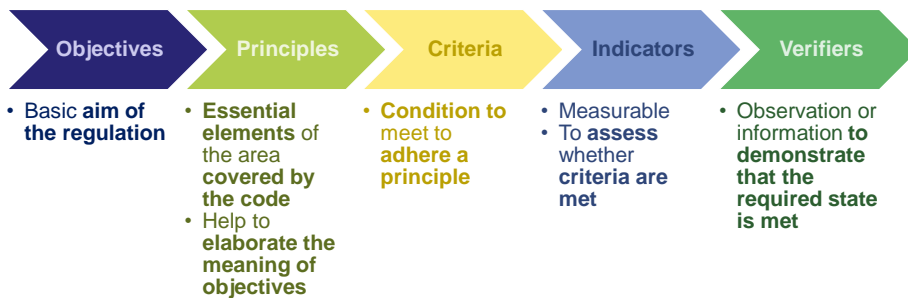
FRENCH PERFORMANCE BASED
REGULATION

3

3



GENERAL APPROACH TO ESTABLISH PERFORMANCE BASED REQUIREMENTS



FRENCH PERFORMANCE BASED
REGULATION

4

Objectives

WHAT CAN BE THE OBJECTIVES OF AN AIR RENEWAL SYSTEM?

The performance indicators should rate the impact of the **air renewal systems** on the Indoor Air Quality according to the following factors... within the context of EPBD.

- Health**
 - L.T. pollutant exposure
 - Acute effect
 - Disease transmission
- Comfort**
 - Perceived air quality
- Wellbeing**
 - Productivity
 - Quality of sleep
- Building durability**
 - Damaging condensation
 - Mould growth

REPUBLICQUE FRANÇAISE
 Cerema
 CLIMAT & TERRITOIRES DE DEMAIN

FRENCH PERFORMANCE BASED
REGULATION

5

5

Objectives

OBJECTIVES OF THE AIR RENEWAL SYSTEM IN THE FRENCH CONTEXT

The regulation deal with IAQ aspect that can be improved by an increase of air renewal flowrate

✓ Removal of pollutant produced indoor (inc. Humidity/CO₂, etc.)

✗ But **no requirement on air treatment**, ex: Increase of humidity level, temperature, Quality of supply air, etc.

- Health**
 - Exposure (long term and acute) to pollutants emitted by
 - buildings components
 - and by human activities
- Comfort**
 - The level of perceived air quality in the toilets
- Wellbeing**
 - The impact of systems on the sleep quality and the stuffiness in room.
- Building durability**
 - The risk of condensation that may lead to mould development

Not compromise those parameters with pollutants produced indoor

REPUBLICQUE FRANÇAISE
 Cerema
 CLIMAT & TERRITOIRES DE DEMAIN

FRENCH PERFORMANCE BASED
REGULATION

6

6



PRINCIPLES OF THE IAQ REGULATION

What should indicators be suitable for ?

- **On-site** assessment through **measurement**
- **Preliminary** assessment through **simulation**

When should indicators be verified?

- In **normal use**
 - In occupation
 - All the time
- In case of **disruptive event**

How threshold values are to be defined ?

- **Precautionary** principles
- As Low As **Reasonably Achievable**
- **Efficiency**
- **Durability**
- **Sustainability**
- In line with **other regulation** (ex. prescriptive)
- ...



7



PRINCIPLES OF THE FRENCH IAQ REGULATION

> The Performance indicator should be suitable for



validation through preliminary simulations



not through on-site measurements

Nevertheless, the ability of indicators to be compared to on-site measurement is a criterion to define them

> **Threshold values** for those indicators should be **consistent with** performance of systems that respect the prescriptive regulation of “**Arrêté de 82**”





> Some prescriptive requirements can be kept as safe-guards



8

Parameters						
Existing « single » pollutant						
CO ₂					X*	X
Humidity					X*	X
PM (1; 2.5, 10)					X*	X
Formaldehyde, Benzene, NO ₂ , Ozone, other...					X*	X
Group of pollutant						
“Smelly” pollutant						X
Health impacting					X*	X
Carcinogens					X*	X
Fictive pollutant/ Proxy-pollutant						
Emitted continuously					X	
Scenario of emission					X	
Air renewal rate						
Outdoor air					X	X
Clean Air Delivery rate (for a given pollutant)	Health	Comfort	Wellbeing	Building Durability	X	X

with emission scenarios
*






FRENCH PERFORMANCE BASED
REGULATION

9

Parameters						
Existing « single » pollutant						
CO ₂	Stufiness in room	Sleep quality			X*	X
Humidity	Damaging condensation/Mould growth				X*	X
PM (1; 2.5, 10)					X*	X
Formaldehyde, Benzene, NO ₂ , Ozone, other...					X*	X
Group of pollutant						
“Smelly” pollutant						X
Health impacting					X*	X
Carcinogens					X*	X
Fictive pollutant/ Proxy-pollutant						
Emitted continuously	Exposure (long term and acute) to pollutants emitted by				X	
Scenario of emission	<ul style="list-style-type: none"> • buildings components • and by human 				X	
Air renewal rate						
Outdoor air	The level of perceived air quality in the toilets				X	X
		Minimum air renewal				
Clean Air Delivery rate (for a given pollutant)	Health	Comfort	Wellbeing	Building Durability	X	X


with emission scenarios
*

FRENCH PERFORMANCE BASED
REGULATION

10


Criteria



SELECTED PARAMETERS FOR CRITERIA


CO2

- Known reference
- Adequacy between the ventilation system and the occupation
- Measurable
- Simulation possible




HR

- Relevant for the risk of condensation
- Measurable
- Simulation possible




Proxy P1

- Suitable for simulation
- Cover all pollutants emitted by material and passive equipments



Proxy P2

- Suitable for simulation
- Représentent episodic emissions linked with human activities






Why not include existing pollutant?

- Objective to cover all and not a specific one to avoid air cleaning that would remove only this one without taking care of others
- Simulation: need for relevant data of emission for each project prior to the project
 - Depend on occupant/construction behaviour
 - Depend on external conditions
 - Depend on complex physic phenomena
- Target values difficult to define
 - Health guidelines vs performance of existing systems

Air replacement

- Easy solution for the toilet
- Relevant to control safe-guard on minimum air renewal







FRENCH PERFORMANCE BASED
REGULATION

11

11

Indicators



WHAT IS A SMART INDICATORS?

Specific

- Targeting a particular area for improvement.
- One criteria

Quantifiable

- Quantifying (through measure or simulation)
- Possible to check

Achievable



- *Assignable*: Defining responsibility clearly.
- Sources to be taken into account

Relevant

- Directly connected to the IAQ objective.
- ≠ prescriptive flow rate


Time-bound

- Including a timeline for expected results (ex. peak vs average)



FRENCH PERFORMANCE BASED
REGULATION

12

Indicators 

POSSIBLE INDICATORS


Parameters	Possible indicators
Single pollutant (fictive/proxy or existing)	Mean exposure Maximum exposure over a period Cumulative exposure % of time below a given target Peak value
Group of pollutant	
Smelly	Maximum OLF (adapted/non-adapted)
Health impacting	DALY
Carcinogen	
Air renewal	Maximum reachable air flow rate Mean air flow rate Minimum air flow rate

FRENCH PERFORMANCE BASED
REGULATION

13

13

Indicators 

SELECTED INDICATORS

For CO₂

- For each room, the CO₂ 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 CO₂ concentration (in ppm) below which it remains 95% of the occupied time

For Humidity

- 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)

For pollutant P1 -> permanent emission

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

For pollutant P2 -> Emitted during cooking periods

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

Air renewal

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

Stuffiness in room

Sleep quality

Damaging condensation

Exposure to building component emissions



- Long term
- Acute

Exposure to human's emitted pollutants

- Acute
- Long term

Percieved air quality in the toilets


Safe-guard limit

FRENCH PERFORMANCE BASED
REGULATION

14


14

Verifiers 

THRESHOLD VALUES

Through simulations of each project with a software called “MATHIS” (⇔COMTAM) :


- **Fixed parameters:**
 - Occupation/emission scenarios
- **Project parameters**
 - Meteo (8 climatic zones, various wind exposure)
 - Ventilation system
 - Architecture (kind of dwelling, room volume, interconnexion, etc.)
 - Building exposure
 - Building airtightness
 - ...



To define threshold values

- More than **2000 simulations performed**
- **2 systems:** extract only with fixed air flow rate and extract-only with HR-based demand control system.
- **Statistically consistent** with the French housing stock


Objective: around 75% of simulations should comply with threshold values.








FRENCH PERFORMANCE BASED
REGULATION


15

15

Verifiers 

TARGET VALUES FOR INDICATORS

Param.	Indicator	Location	Suggested values
	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]
	Percentage of time over 75% of relative humidity during the heating period	Bathroom	~14% [12-16]
		Kitchen	~6% [5-8]
		Other rooms	~1% [1-3]
	The mean exposure	Most exposed person	~2300 P1/m ³ [2100-2500]
	Maximum exposure over one hour	Most exposed person	~7000 P1/m ³ [7000-9000]
	Maximum exposure over one hour	Kitchen	~1800 P2/m ³ [1700-2000]
	The concentration below which it remains 95% time	Maximum of main rooms	~100 P2/m ³ [50-200]
	Extracted Air Flow rate above which it is 95% of time E.A.F.R. above which it is 95% of occupied time Air replacement above which it is 95% of time	Toilets	~5m ³ /h
		Toilets	~15m ³ /h
		Full dwelling	0,38 m ³ /h/m ² [0,36-0,54]



FRENCH PERFORMANCE BASED
REGULATION

16

16

Verifiers

FORESEEN PROJECT VALIDATION PROTOCOL

For validation a system must include

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

Alternative 1

↓

Industrial system that is meant to be installed in multiple projects

↓

2 steps validation

Alternative 2

↓

Ventilation system fitted for one given project

↓

1 step validation

FRENCH PERFORMANCE BASED
REGULATION

17

17

Verifiers

FORESEEN PROJECT VALIDATION PROTOCOL

A commission validate:

- The modeling of the system in Mathis (and interface for end-user)
- Inc. input parameters
- The relevance of inspection and maintenance protocol

Done once for a given system
=> Validation of protocols, not a validation of systems themselves.

Qualified design office

- Design the ventilation system
- Check through simulations that KPI are met

Qualified ventilation inspector

- Apply the inspection protocol
- Conclude on the conformity (or not) of the system

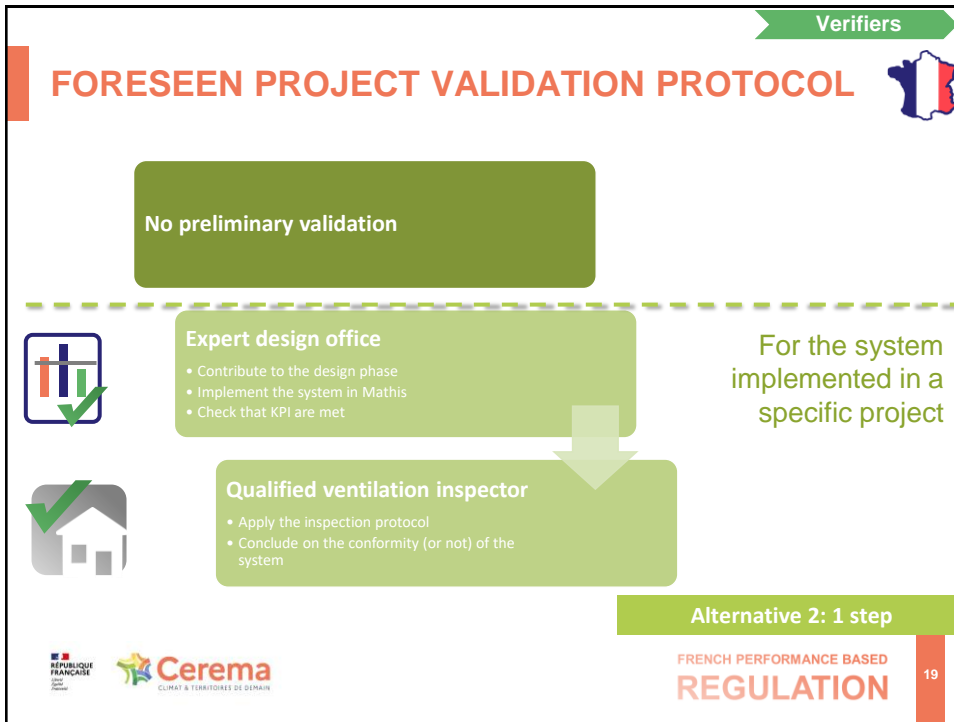
For each building project using this ventilation system

Alternative 1: 2 steps

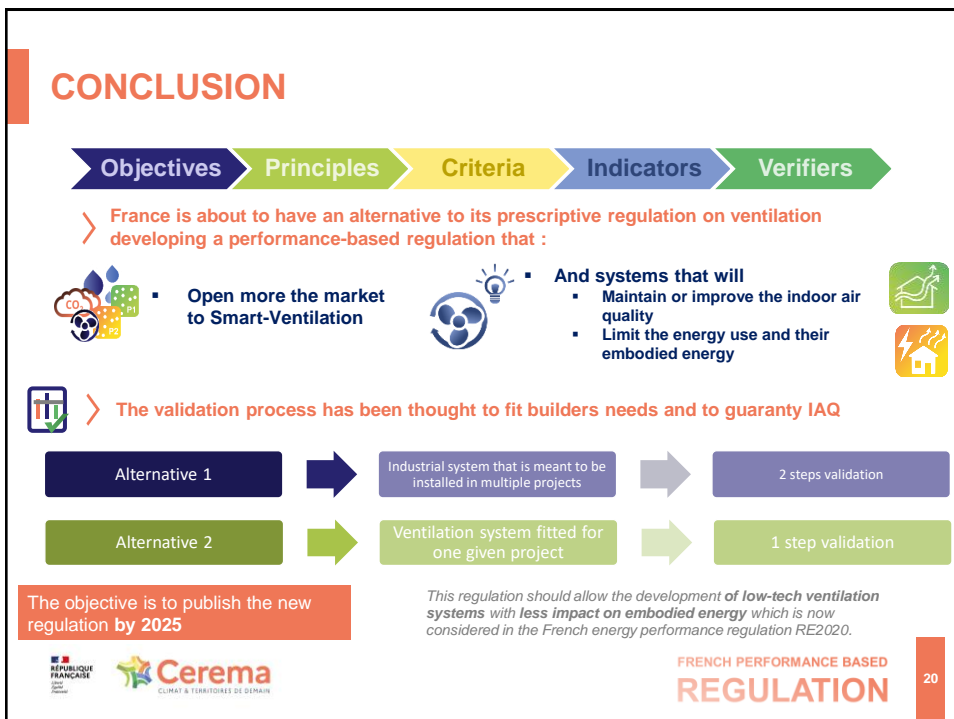
FRENCH PERFORMANCE BASED
REGULATION

18

18



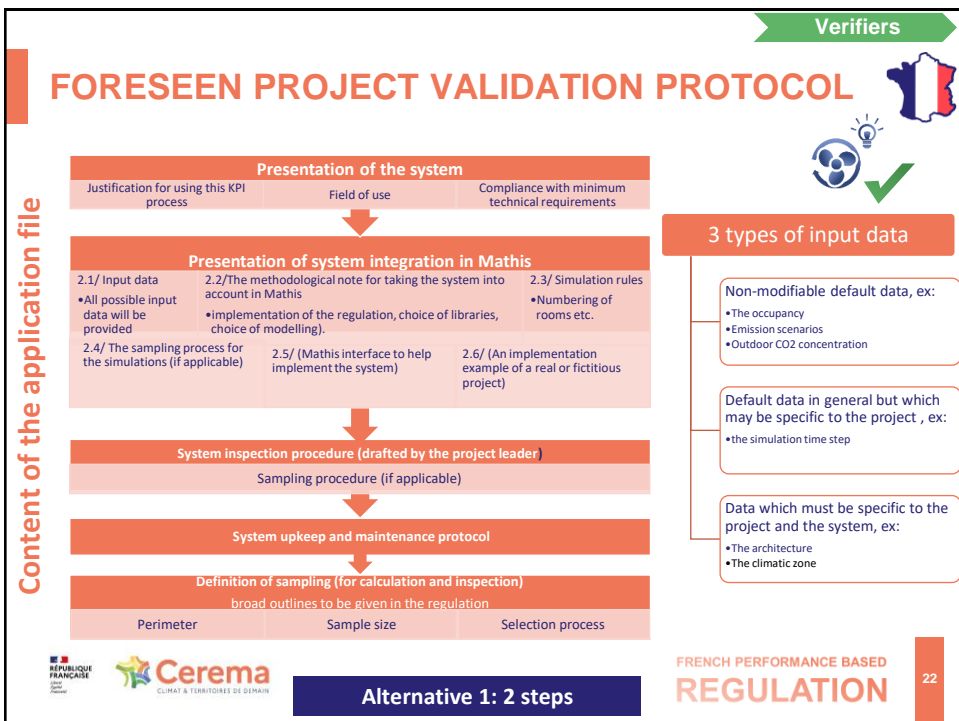
19



20



21



22