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PROPOSED CHANGE IN SPANISH REGULATIONS RELATING TO INDOOR AIR QUALITY WITH THE AIM OF REDUCING ENERGY CONSUMPTION OF VENTILATION SYSTEMS

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ABSTRACT

The ventilation required in order to maintain acceptable indoor hygiene standards results in a significant consumption of energy. Currently the Spanish regulations on indoor air quality (IAQ) require minimum rates for delivery-to and extraction-from the habitable rooms of residential buildings. These rates are not adjustable, so ventilation systems based on variable ventilation rates, are not normally deemed acceptable unless a comprehensive statement of compliance is provided, justifying the proposed ventilation solution. However the use of variable ventilation systems is desirable, as it would almost certainly produce a reduction of the overall ventilation rate and, consequently, a reduction in the heating and cooling energy demand while maintaining a good level of air quality.

This paper presents part of the ongoing research towards the modification of the Spanish regulations in order to adapt required ventilation rates to real needs. This would mean allowing reduction in ventilation rates and energy demand but without any impact on indoor air quality.

The objective behind this research is to propose to the Spanish Government the substitution of the current required constant ventilation rates by maximum values of CO_2 concentration as an indicator of air quality. By establishing maximum values, the implementation of ventilation systems based on variable ventilation rates will be enabled because the justification will be more easily provided.

KEYWORDS

Ventilation, IAQ, regulations, energy efficiency

1 INTRODUCTION

The current Spanish Building Code was enforced in 2006 including IAQ provisions for dwellings which represented a big regulatory step. However the provisions are not as performance-oriented as was initially anticipated, requiring minimum rates for delivery-to and extraction-from the habitable rooms. These rates are not adjustable, so ventilation systems based on variable ventilation rates are not normally deemed acceptable, unless a

comprehensive statement of compliance is provided, justifying the proposed ventilation solution.
In 2010 with the adoption of the recast EPBD, EU Member States faced new challenges. The new goal is to increase the level of performance towards nearly-zero energy buildings by 2020. In order to achieve this goal in Spain, a deep review of the energy requirements has been made in 2013 increasing the energy efficiency of buildings. However, this is not enough, energy efficiency in buildings is affected as well by ventilation systems.
Therefore the use of variable ventilation systems is desirable, as it would almost certainly produce a reduction of the global ventilation rate and, consequently, a reduction of the heating and cooling energy demand, while maintaining a good air quality level.
As a consequence research is in progress to modify the Spanish regulations to allow the use of more efficient systems, adapting required ventilation rates to real needs. This would mean a reduction in ventilation rates and energy demand but without impact on indoor air quality.
The goal of this research is to update the regulations which should require an IAQ level that shall be provided. Equally, the goal is to provide a simplified verification method that facilitates the fulfilment of this IAQ level.

2 CURRENT IAQ REQUIREMENT

The current IAQ requirement establishes minimum ventilation rates (see Table 1) for delivery-to and extraction-from the habitable rooms. These rates have to be provided in a continuous way.

Table 1. Minimum ventilation rates

Rooms	Per person	Per usable floor area m^2	Per room
Bedrooms	5 l/s		
Living and dining rooms	3 l/s		
WC and bathrooms			15 l/s
Kitchens		2 l/s	

2 PROPOSED IAQ REQUIREMENT

IAQ level is usually characterized by a maximum level of pollutants that may affect people´s health and comfort and that could be achieved by different ventilation systems.
However, common pollutants are not easy to assess, so generally an indicator is used to model the state of the rest of the pollutants. Among the possible pollutants that are commonly produced indoors, CO_2 is the most commonplace and closest related to human activity. In spite not supposing a health risk in the usual concentrations that is found in dwellings, CO_2 is a very good indicator of the ventilation rate. This way is the most common indicator used in regulations and guides.
The required CO_2 concentration is limited in two ways:

- 900 ppm maximum yearly average;
- 500.000 ppm per hour maximum yearly accumulated above 1.600 ppm. This parameter shows the relationship between the CO_2 concentrations reached above a limit value and their duration over a year. It can be calculated as the sum of the areas (in ppm•h) within the representation of the CO_2 concentration as a time function and the limit value (See Fig. 1).

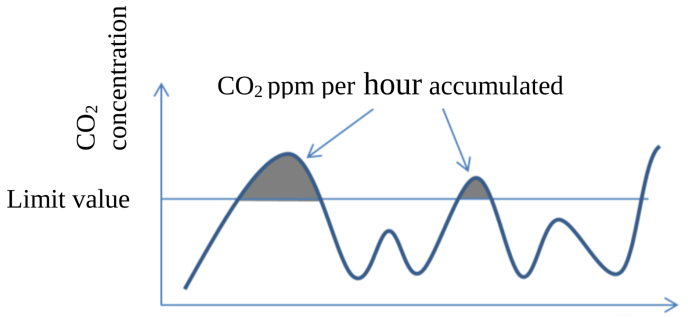

Fig. 1. CO_2 concentration over time

These required concentration levels shall be achieved under certain design conditions (such as occupancy scenarios, CO_2 production rate, yearly average outdoor CO_2 concentration, etc.) that should be set in the regulation. This means it is a design performance because it would only be measurable *in situ* under these conditions.
These values have been chosen based on the specified values in the RITE taking into account an outdoor CO_2 concentration of 400 ppm: the value corresponding to IAQ 2 for the maximum yearly average concentration and the IAQ 4 value for the base over which to calculate the maximum yearly accumulated. (See Table 2)

Table 2. IAQ classes according to RITE

IAQ Classification		**CO2 concentration (ppm)**
1	Best quality indoor air	750
2	Good quality indoor air	900
3	Medium quality indoor air	1.200
4	Low quality indoor air	1.600

4 PROPOSED VERIFICATION METHOD

The fulfilment of the requirement can be achieved by the use of expertise methods (like specialized software), but it is convenient as well that at least a simplified verification method is provided by the regulations for designers to use. This simplified method shall be easy to use by non-expert practitioners and will consist of different ventilation rates (continuous and variable) that will provide fulfilment of the requirement.
These ventilation rates are obtained from the results of an analysis of the IAQ of different dwelling types (case studies) assessed with pollutants distribution software CONTAM. The analysis consists of simulating these dwellings (with an occupancy scenario) with different ventilation rates in order to optimize them achieving the required IAQ.
By using CONTAM we have obtained for each dwelling CO_2 concentrations for certain ventilation flows in each room. (See Fig. 2).

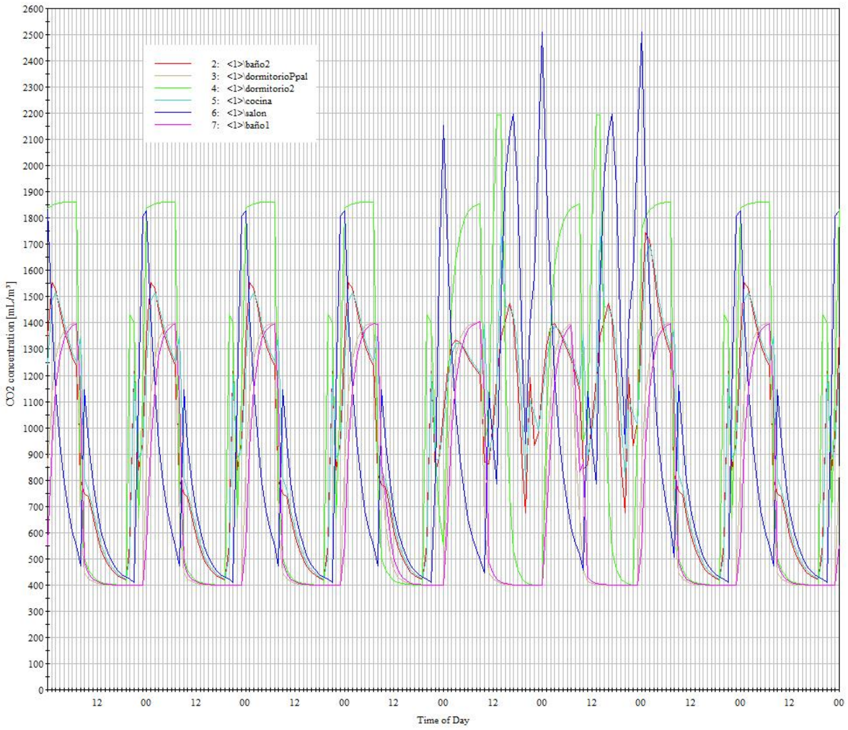

Fig. 2. Results for a week for dwelling 2 with variable ventilation flow:5-14 l/s. CONTAM.

From these data we can derive the yearly average and the yearly accumulated over 1.600 ppm, and compare them with the IAQ requirements. These ventilation flows are optimized, choosing the minimum ones that allow fulfilling the IAQ requirement.

Several dwelling types have been chosen for the analysis taking into account their bedroom and bathroom counts (See Table 3). They are real dwellings representative of the dwellings that have been built recently (the Spanish population and dwelling census has been used). The results for each of these dwellings can be extended to the rest of cases of the same type.

Table 3. Dwelling types

Kind and composition of dwelling	Type
Flat: Living/Kitchen+1 Bedroom+1 Bathroom	1
Flat: Living+Kitchen+2 Bedrooms+2 Bathrooms	2
Flat: Living+Kitchen+3 Bedrooms+2 Bathrooms	3
Flat: Living+Kitchen+4 Bedrooms+2 Bathrooms	4
Terrace house: Living+Kitchen+4 Bedrooms+2 Bathrooms	5

The occupancy scenario allows setting the CO_2 production for each room at any time. The number of occupants in each dwelling has been determined depending on the number of bedrooms. (See Table 4) based on the Spanish population and dwellings census.

Table 4. Dwellings occupancy

Bedroom number	Occupants
≤ 1	2
2	3
≥ 3	4

The scenario shall specify for each occupant: sleeping hours, number and duration of each stay in every room and times when the occupants are out from home. (See Table 5).

Table 5. Occupancy scenario for one person

Room	Monday to Friday	Room	Saturday and Sunday
Bedroom 1	0:00-8:00	Bedroom 1	0:00-8:00
Kitchen	8:00-8:30	Kitchen	8:00-8:30
Bathroom 1	8:30-9:00	Bathroom 1	8:30-9:00
	----------------	Living room	9:00-10:00
Living room	17:00-18:00		----------------
Bathroom 1	18:00-18:05	Living room	12:00-13:00
Living room	18:05-20:00	Kitchen	13:00-14:00
Kitchen	20:00-21:00	Living room	14:00-15:30
Bathroom 1	21:00-21:05	Bathroom 1	15:30-15:35
Living room	21:05-00:00	Living room	15:35-18:30

		Kitchen	20:30-21:30
		Bathroom 1	21:30-21:35
		Living room	21:35-00:00

5 RESULTS

Table 6 shows the continuous flow values for the different dwelling types.

Table 6. Results with continuous flow

Dwelling type	Continous flow (1) (l/s)	Total continous flow (l/s)	Yearly average CO_2 concentration (ppm)	Yearly accumulated over 1.600 ppm (ppm·h)
1	6	12	898	11.700
2	7	21	875	417.040
3	12	36	828	437.840
4	13	39	870	497.380
5	9	27	844	441.220

(1) In kitchen and each bathroom

Table 7 shows the possible variable flow values for the different dwelling types.

Table 7. Results with variable flow

Dwelling type	Variable flow (1)		Yearly average CO_2 concentration (ppm)	Yearly accumulated over 1.600 ppm (ppm·h)
	MAX (during occupation) (l/s)	MIN (during no occupation) (l/s)		
1	7	5	901	0
	10	4	883	0
2	11	6	862	261.560
	14	5	892	244.660
	21	4	898	106.340
3	14	11	844	421.720
	18	9	880	380.900
	33	6	897	185.640
4	22	12	874	264.420
	30	10	884	235.820
	47	8	897	127.920

5	14	7	864	398.840
	34	4	878	307.320

(1) In kitchen and each bathroom

5 CONCLUSIONS

Results show how it should be possible to achieve target IAQ requirements based on variable ventilation rates and lower continuous ventilation rates than the ones that are currently required, thus saving energy for heating and cooling without impacting air quality.
Ongoing research will quantify the saved energy in each case study.

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