Trends in building ventilation requirements and inspection in Spain

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ABSTRACT

In Spain, the construction sector has undergone significant changes over the last twenty years due to new ventilation standards driven by increased awareness of indoor air quality (IAQ) and energy efficiency, as well as environmental policies.

The *Código Técnico de la Edificación* (Building Code, CTE) (*Gobierno de España*, 2006) has been the main regulation governing the quality of buildings since 2006, addressing all related aspects, including energy efficiency and IAQ. The CTE includes provisions aimed at promoting adequate IAQ in residential buildings, while also limiting energy demand across all building types.

Furthermore, it is worth noting that since 1998, the *Reglamento de Instalaciones Térmicas de los Edificios* (Regulation on thermal systems in buildings, RITE) (*Gobierno de España*, 2021) has been setting the standards for IAQ in non-residential buildings.

It is important to acknowledge that both regulations are continuously evolving to keep up with advances in techniques and knowledge, as well as to ensure compliance with European Directives.

This paper is a summary of AIVCVIP 48.1 (Linares-Alemparte, P. et al, 2024) covering the following national trends:

- IAQ requirements and market,
- inspection of ventilation systems, and
- innovative systems and market.

1 NATIONAL TRENDS IN IAQ REQUIREMENTS AND MARKET

1.1 Requirements on ventilation of dwellings

As mentioned above, mandatory requirements on ventilation of dwellings are set in the CTE in Section HS 3 *Calidad del aire interior* (Indoor air quality). The current version dates from 2017.

Requirements for dwellings are established to be able to control pollutants generated by buildings' users, materials and furnishment. This way, indoor CO_2 concentration is set as the indicator of IAQ related to users' activities and, in addition to this, a minimum ventilation flow is required to extract pollutants derived from building materials, finishes and furnishment.

Therefore, taking CO_2 as an indicator, the following performance-based requirements must be fulfilled by means of simulation at design level (it is not required to demonstrate fulfilment via on site measurement) or by the use of minimum constant ventilation flows taken as accepted solutions:

- CO_2 average annual concentration in each room must not exceed 900 ppm,
- CO_2 annual accumulated over 1,600 ppm must not exceed 500,000 ppm·h, and
- minimum flow rate of 1.5 l/s per habitable room during periods of non-occupancy.

Simulation should be conducted under design conditions such as number of occupants, occupancy scenarios, weather conditions, CO_2 production rate, annual average outdoor CO_2 concentration, airtight envelope and doors in closed position. These design conditions are set out in Appendix C of Section HS 3.

For each room the minimum constant ventilation flowrates that perform as **accepted solutions** are displayed in Table 1, depending on the type of dwelling according to the number of bedrooms. These constant flowrates meet the performance-based requirements under the above design conditions.

Table 1. Minimum constant ventilation flowrates for dwellings (Table 2.1 of Section HS3, CTE)

Type of dwelling	Minimum constant ventilation flowrates (l/s)				
	Dry rooms			Wet rooms	
	Master bedroom	Bedrooms	Dining and living room	Global	Per room (kitchen and bathrooms)
0 or 1 bedrooms	8	-	6	12	6
2 bedrooms	8	4	8	24	7
≥ 3 bedrooms	8	4	10	33	8

Fresh air must be supplied to dry rooms and stale air must be extracted from wet rooms. Accordingly, two ventilation flows must be calculated using Table 1: total supply flow and total exhaust flow. Both flows must be balanced, so the biggest one is taken as the total ventilation flow for the design of the system.

1.2 Ventilation systems in residential buildings stock and market

According to population and housing census (INE, 2021) of the *Instituto Nacional de Estadística* (National Statistics Institute), in 2021 the total number of dwellings was 26,623,708, including 3,837,328 that were empty and 2,514,511 with sporadic use.

Regulations and standards in Spain have had a significant influence on the ventilation systems market, contributing to its sustained growth. In recent years, this market has experienced remarkable growth, driven mainly by increasing awareness of IAQ and regulatory updates.

Although there are not official statistics on the type of ventilation systems installed in dwellings, from 2006, when CTE was approved and came into force, all new dwellings must have a mechanical or hybrid ventilation system, with fully natural ventilation not allowed. In the DB HS3 hybrid ventilation is defined as a system designed to operate in accordance with the principles of natural ventilation when the atmospheric pressure and temperature conditions are favourable, and to function with a mechanical exhaust when they are unfavourable.

In general, the most widespread ventilation system in newly built dwellings in Spain consists of a hybrid centralised exhaust fan placed on the roof at the end of the vertical ventilation stack located in the wet rooms together with windows with micro-ventilation placed in the dry rooms to allow the inlet of fresh air. The micro-ventilation system is a device integrated into the window frame, usually tilt-and-turn, that is activated by the window handle leaving an opening of between 4 and 5 millimetres around the perimeter of the active window sash. It allows a small but permanent air flow.

Although air inlets such as trickle vents are also permitted in the CTE to supply fresh air, there is some rejection of their use because some of them do not have the means to be completely closed. In spite micro-ventilation not being the best way for delivering fresh air because it has to be operated manually and occupants are mostly unaware of its operation, developers and designers rather implement it because it does not arise as much rejection as air inlets.

The second most common ventilation system in newly built dwellings in Spain is the single-flow mechanical system. It usually consists of an exhaust fan which can be centralised, placed on the roof, or individual, placed in each dwelling in the suspended ceiling of one of the bathrooms. The fan is connected through ducts to all wet rooms. For the supply of fresh air, both micro-ventilation and air inlets can be used.

In more advanced cases, mechanical double-flow systems are used, where stale air is exhausted like in the previous system, but fresh air is taken from outside through a heat recovery unit and supplied to the dry rooms via a duct network. This latter system tends to be a smart and demand-controlled ventilation system (DCV). The deployment of DCV remains relatively uncommon, with the exception of humidity-controlled ventilation systems in dwellings.

In existing dwellings built before 2006, natural ventilation is the most widespread ventilation system. It is based on thermal buoyancy through a vertical ventilation stack in combination with airing, opening and closing windows, and infiltration through the building envelope, mainly joinery. The exploratory study carried out in recent years on the IAQ in traditionally ventilated dwellings based on natural ventilation (Garcia-Ortega, Sonia et al, 2023) has revealed that 50% of these existing dwellings would not satisfy the current IAQ parameters of the CTE.

For renovation, it is very common in Spain to install hybrid roof-mounted extractor fans at the top of vertical ventilation stacks.

The use of air filters and cleaners in dwellings is not generalized.

1.3 Requirements on ventilation of non-residential buildings

Mandatory requirements on ventilation of non-residential buildings are set in the RITE.

These buildings must have a ventilation system for providing enough outdoor air flowrate that avoids, in rooms with human activity, the accumulation of high concentration of pollutants according to Table 2, that establishes four IAQ categories (IDA) depending on the use of the building. Procedure from EN 13779 (CEN, 2008) can be used to fulfil this requirement.

Table 2. IAQ categories (RITE)

IAQ categories	Examples
IDA 1 (optimal)	Hospitals, kindergardens
IDA 2 (good)	Offices, museums, classrooms
IDA 3 (average)	Shops, cinemas, restaurants, gyms
IDA 4 (poor)	Laundry rooms

In order to fulfil such categories, RITE establishes 5 different methods for the calculation of the needed outdoor rate:

- airflow per occupant indirect method,
- airflow per net floor area indirect method,
- perceived air quality direct method,
- CO_2 concentration direct method, and
- dilution method.

According to the airflow per occupant indirect method, for habitable rooms, minimum ventilation flow rates are set out for each IDA (See Table 3).

Table 3. Minimum ventilation flowrates for each IDA (Table 1.4.2.1 of RITE)

IDA Categories	$dm^3/(s$ per person)
IDA 1	20
IDA 2	12,5
IDA 3	8
IDA 4	5

According to the net floor area indirect method, for non-habitable rooms, minimum ventilation flowrates are set out for each IDA (See Table 4).

Table 4. Minimum ventilation flowrates for each IDA (Table 1.4.2.4 of RITE)

IDA Categories	$dm^3/(s\ m^2)$
IDA 1	Non applicable
IDA 2	0,83
IDA 3	0,55
IDA 4	0,28

The perceived air quality direct method is based on CR 1752 (CEN, 2008). It is hardly used due to its complexity.

The CO_2 concentration direct method can be used for premises with a high metabolic activity such as party halls, sport and leisure centres, as CO_2 is a good indicator of human bioeffluent emissions (See table 5).

Table 5. Indoor-outdoor CO_2 concentration difference for each IDA (Table 1.4.2.3 of RITE)

IDA Categories	ppm (*)
IDA 1	350
IDA 2	500
IDA 3	800
IDA 4	1.200

* CO_2 concentration (in parts per million by volume) above CO_2 concentration in outside air

Dilution method follows the specifications established in EN 13779 (CEN, 2008). When there are known emissions of specific polluting materials, the dilution method shall be used.

In addition to this, RITE establishes filtration requirements based on outdoor (ODA) and indoor (IDA) air quality, requiring efficient filtration systems in areas with poor air quality (ODA3) or high indoor standards (IDA1/IDA2). Air filters and purifiers have become key to maintaining healthy spaces, reducing airborne contaminants.

1.4 Ventilation systems in non-residential buildings stock and market

According to the *Ministerio de Transportes, Movilidad y Agenda urbana* (Ministry of Transport, Mobility and Urban Agenda) the building stock in Spain for non-residential use is close to 2 million properties as stated by the statistics of the *Catastro* (Real Estate Cadastre).

Regulations and standards in Spain have had a considerable influence on the ventilation market, contributing to its sustained growth. During 2022, this market experienced a remarkable growth, mainly driven by the increasing awareness of indoor air quality and the regulatory updates in place.

There is no specific information on the number of buildings in Spain that are equipped with a ventilation system. However, there are several regulations and recommendations regarding ventilation systems, which suggests that there is a significant focus on ensuring adequate ventilation in buildings.

As per a market analysis carried out by AFEC (Air Conditioning Equipment Manufacturers Association) (AFEC, 2023):

- the market in air distribution and diffusion increased by 19.7% from 2021 to 2022,
- the Air Handling Units and Ventilation Units market also increased by approximately 10% from that same period,
- the residential ventilation market and the industrial/tertiary ventilation market increased 13.7% and 17.5% respectively. These categories represent 20.3% of the total revenue in 2022 from HVAC products.

Spain's market features mechanical filters such as HEPA, electronic filters (e.g., ionisers, precipitators), gas-phase filters (as activated carbon), and UVGI. The use of mechanical ventilation and autonomous equipment or filters in central air systems is encouraged in order to reduce the inhalation of aerosols in indoor spaces.

2 NATIONAL TRENDS IN THE INSPECTION OF VENTILATION SYSTEMS

2.1 Requirements on the inspection of ventilation systems

RITE regulates both initial and periodic assessments of ventilation systems. It is a mandatory regulation covering all buildings with thermal installations.

2.2 Inspection protocols

In Spain, inspections of thermal installations must be carried out by authorised companies or inspection entities. Inspection entities may inspect their own installations (first party), act on behalf of the buyer (second party) or represent a third party like an insurance company or the government. Accredited entities, complying with the EN ISO/IEC 17020 (CEN-ISO, 2012) provide maximum assurance of technical competence.

These inspections evaluate the system's integrity, cleanliness design adequacy, operational efficiency, and various parameters such as airflow, pressure, ductwork airtightness, power consumption, indoor air quality, noise levels, and thermal comfort parameters.

Heating, ventilation, and air conditioning systems should undergo inspections every four years, with a comprehensive check of the thermal installation every fifteen years. Maintenance must align with established schedules and equipment specifications. Part of the maintenance involves indoor air pollution measurements per UNE 171330 (UNE, 2014) and hygienic assessments of duct networks as per UNE 100012 (UNE, 2005).

These inspections rely on precise measuring devices capable of assessing air flow type and velocity, and air contamination levels. These devices must be user-friendly and accurate for optimal system tuning.

Detected non-conformities are classified by severity and managed through a methodology that includes detection, immediate repair, cause analysis, corrective and preventive actions, follow-up, and verification for effective resolution.

3 NATIONAL TRENDS IN INNOVATIVE SYSTEMS AND MARKET

In Spain, innovation in ventilation systems focuses on improving indoor air quality, energy efficiency, acoustics, thermal comfort, installation, maintenance, and cost reduction, with a special focus on smart ventilation. Trends indicate a strong focus on digitalisation and energy transition, as well as advanced metering and monitoring of systems. The adoption of smart ventilation systems helps buildings to become more sustainable and healthier, with optimised energy use and increased comfort for users.

Innovation in the ventilation sector faces regulatory barriers such as strict energy efficiency standards, complex and costly certification processes, regional differences in regulations and lack of standardisation. These challenges could limit flexibility in the adoption of new technologies and slow down the introduction of innovative products to the market.

The potential of these innovations lies in their ability to significantly transform both the energy performance of buildings and the well-being of their occupants (De Arriba Segurado, P., 2020)

3.1 Innovative systems and Building Code

The CTE contains the so-called *Documentos Básicos* (Basic Documents), which include deemed-to-satisfy solutions and performance-based requirements for compliance with the essential requirements established in CTE.

Innovative systems and solutions may deviate to a greater or lesser extent from the deemed-to-satisfy solutions of the DBs, but they must demonstrate compliance with the essential requirements. Compliance may be verified through a technical approval process.

In the case of innovative ventilation systems in dwellings, prior to the 2017 amendment to Section HS 3, compliance with the essential requirements could only be achieved by comparing its performance with the one provided by accepted solutions based on constant flow rates.

In 2017, the essential requirement was quantified as a function of CO_2 plus a minimum flow rate during non-occupancy. This made it easier for innovative systems to demonstrate compliance with CTE.

In the case of innovative ventilation systems in buildings other than dwellings, the RITE describes IAQ according to CO_2 concentration, so assessment can be conducted by comparing provided IAQ with it.

3.2 Procedure for the assessment of innovative systems: National Technical Approval

In Spain, there are three organisations authorised by the competent Public Administrations to provide technical approval assessments of the performance of innovative products or systems that facilitate the application of the CTE. These are the *Instituto de ciencias de la construcción Eduardo Torroja* (Eduardo Torrroja Construction Sciences Institute, IETcc), the *Institut de Tecnología de la Construcció de Catalunya* (Catalonia Institute of Construction Technology, ITeC) and the *Fundación Tecnalia Research & Innovation* (Tecnalia).

The *Documento de Idoneidad Técnica* (National Technical Approval, DIT) is a voluntary document which is issued by the IETcc that contains a favourable technical assessment of the fitness for use of non-traditional or innovative materials, products, systems or procedures in building and/or civil engineering.

In the field of ventilation systems, there are currently three valid DITs on humidity-controlled ventilation systems in dwellings. This system automatically regulates the amount of air intake and exhaust based on the relative humidity of the indoor air (strongly influenced by human presence and activity) and optionally by occupancy detection, always ensuring a minimum level of ventilation. Intake vents are located in dry rooms (living rooms, dining rooms, bedrooms) and exhaust vents in wet rooms (kitchens, bathrooms, toilets and laundry rooms).

The verification of compliance with CO_2 quantification and minimum flow rate of Section HS 3 is carried out through simulation under design conditions. Occupancy criteria are established based on the parameters outlined in Appendix C of Section HS 3, while also considering variations in outdoor temperature and humidity.

4 CONCLUSION

IAQ regulations in Spain are performance-based leading the most advanced regulations in the world. The IAQ requirement in dwellings is identified in terms of CO_2 concentration as an indicator. The main advantage of performance-based regulations is that they allow the use of innovative, energy efficient systems to fulfil the requirement. The requirements may be met through the utilisation of simulation or the implementation of minimum ventilation flow rates, which have been established as accepted solutions (see Table 1).

Ventilation market in Spain is a relatively recently arisen one but is strong and keeps increasing.

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