Ventilation
Information
Paper
n° 48.4
May 2025

**Operating Agent
and Management
Sint-Pietersnieuwstraat 41,
B-9000 Ghent – Belgium
www.inive.org**

**International Energy Agency's Energy
in Buildings and Communities
Programme**

Air Infiltration and Ventilation Centre

Trends in building ventilation requirements and inspection in Italy

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1 General introduction

This information paper aims, for the first time, to provide information on ventilation trends in Italy. The main topics analysed are the regulatory framework and the market evolution.

Italy extends for more than 300M km^2 and has about 59M inhabitants. In the country there are more than 13,5M buildings, among which more than 90% are for residential use. As of early 2023, 70% of this building stock was built before 1980, and 50% before 1970 [1]. Given that the building energy renovation rate remains low and the annual rate of new construction is about 1%, the above figures effectively illustrate the sector's status in terms of energy performance.

The country has 20 Regions and 2 autonomous Provinces; this information is relevant as the energy issues are regulated at local level, which implies the existence of one set of national laws and a large number of regional laws. Luckily, most regions implemented locally the national regulation for both building energy requirements and the related technical regulations for assessment. As a result, this paper refers to the general framework; specific contexts, such as the exemplary case of the Province of Bolzano, are not covered in this paper, given the specificity of the regulation and the very small population affected by it.

Historically, mechanical ventilation has not been a major concern in the country, as in other Mediterranean regions, since airing was typically achieved through natural ventilation by manually operated windows. This applied not only to dwellings but also to several non-residential building typologies, such as schools (mainly public), office buildings and sport facilities. It should also be noted that the installation of mechanical ventilation systems is required by national laws [2-4] only for *blind* toilets (without external apertures), or as a supplement in case of rooms with a ratio of openable window to plan surface area lower than 1/8.

In the last decades, the trend has been changing rapidly, due to several factors: stricter energy requirements for new buildings, a rise in deep building renovation driven by favourable financial incentives, as well as both global and local overheating that significantly increased the installation rate of mechanical air conditioning systems, mainly for active cooling purposes.

What happens to mechanical ventilation requirements and the market in the coming years will be strictly connected with the contents and measures of the national implementation regulation of the latest version of the Energy Performance of Buildings Directive 2024/1275.

2 National trends in IAQ requirements and market

2.1 *Requirements on ventilation of dwellings*

Over the past decades, the Indoor Air Quality (IAQ) requirements to be ensured in Italian dwellings were defined by the technical standard UNI 10339:1995 [11] – *Impianti aeraulici ai fini del benessere. Generalità, classificazione e requisiti. Regole per la richiesta d'offerta, l'offerta, l'ordine e la fornitura* – which was withdrawn without replacement in July 2024. This standard was based on prescribed minimum outdoor airflow rates to be maintained in buildings, along with procedures for offers and supplies to be used in tenders.

The standard set the requirement for the external fresh air flow at $11x10^{-3}m^3/s$ per person (about $40m^3/h$ per person) for dwellings and bedrooms of buildings with similar use (i.e. barracks, monasteries, prisons, hotel rooms). The value was to be applied to all rooms within the dwelling, while air extraction was required in kitchens and toilets.

The standard also defined original filter efficiency classes and requirements for mechanical ventilation systems.

It should be noted that this was a design technical standard, providing specifications to ensure adequate IAQ in buildings and it was not a mandatory legislative regulation, yet some municipal building regulations referred to it. The only mandatory rule, already mentioned in the introduction, is the installation of mechanical air extraction systems in toilets and bathrooms without external apertures, as indicated in the Health Ministry Decree 05/07/1975.

The UNI 10339:1995 standard has been the reference technical document for almost 30 years; it was finally withdrawn on the 4th of July 2024. Although professionals and industry practitioners still use the withdrawn standard in practice, the alternative reference standard for IAQ in buildings is the well-known EN16798-1:2019 - *Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*. This standard, with its contents and requirements, was transposed by the Italian body for standardisation, UNI, in 2019. UNI EN 16798-1 has so far been formally adopted only for public buildings through the Decree of 23 June 2022 [4] for public residential buildings.

In the near future, this standard and its updates are expected to become the reference documents for IAQ in Italian dwellings.

2.2 *Ventilation systems in residential buildings stock and market*

No official data are available on the installation of mechanical ventilation systems in Italian residential buildings, also because the technology was rarely used in dwellings until just a few years ago.

Yearly data can be collected from different sources. Interconnection Consulting is an Austrian market research institute which, among others, publishes an annual report on the residential ventilation market in most of European countries. According to the document "*IC Market-tracking Residential Ventilation in Italy 2024*", the mechanical ventilation units sold in Italy in 2023 were 297.000, broken down as follows: 76% of the units are simple extractor fans (+1.4% vs. 2022), 17% are decentralised heat recovery (HR) systems (-3,4% vs. 2022), and 6% are centralised HR systems (-19.9% vs. 2022).

EUROVENT is the European Industry Association for Indoor Climate, Process Cooling and Food Cold Chain Technologies. According to the inner survey resulting from data collected among 37 participant members, residential centralized heat recovery units sold in Italy in 2023 were about 14.300 units, -5% compared with 2022.

ASSOCLIMA is the Italian association of air conditioning system industries. Since 2019, it carries out on an annual basis, a survey on the Italian market (www.anima.it/associazioni/elenco/assoclima/attivita/pubblicazioni/studi-di-mercato.kl) focusing on residential mechanical ventilation systems with heat recovery. The survey, based on data provided by the associates, is particularly relevant as it reflects changes in the building policy and construction market. To be noted that these figures may differ from those provided by IC because of the different sampled industries. To consider the variations in the participant list year by year, as inferred from the second row of Table 1, the published results refer to a constant panel. They refer to the national production sold in the country (not exported), as well as the units imported by local branches of foreign manufacturers. As a result of this data collection principle, the absolute values resulting from the survey appear underestimated compared to the market reality, while their trend over time suggests a clear growing interest of the industry in technology, as inferred from Figure 1 and Table 1.

According to the latest ASSOCLIMA survey, national production and imports of centralized systems up to $250m^3/h$ are balanced. In contrast, larger units (up to the common upper limit of $1000\ m^3/h$, as defined in all the aforementioned surveys) are primarily imported. Finally, the market for push-pull systems is dominated by the national industry, whereas decentralised units are largely imported.

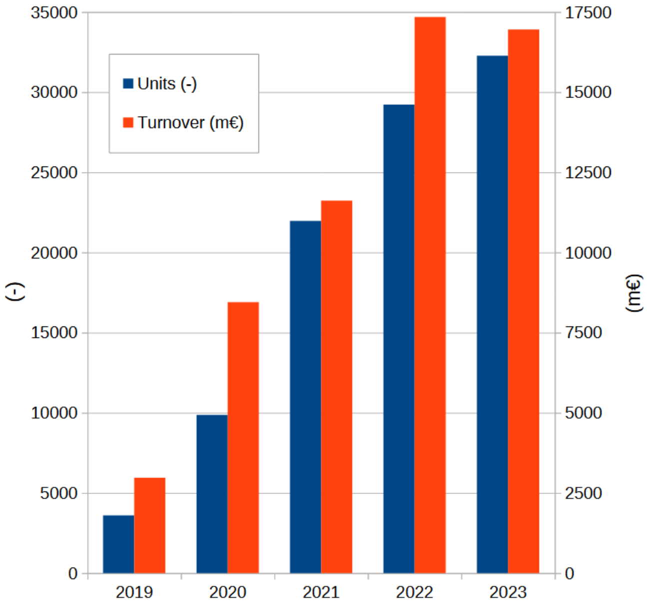

Figure 1: Annual installation of new units and turnover for mechanical ventilation in Italian dwellings

Table 1 : Breakdown of annual installations of new units for mechanical ventilation (MV) systems with heat recovery by technological solution (Central ⇔ 1 system serving the whole premise, Decentral ⇔ 1 system serving 1 or 2 rooms, Push-pull ⇔ system equipped with a regenerative heat exchanger, consisting of a ceramic heat accumulator, serving 1 room only), in Italian dwellings (Assoclima)

Year	2019	2020	2021	2022	2023
Participating companies	7	10	16	15	16
Central MVs up to 250 m^3/h	2455	5657	8026	9486	9815
Central MVs 251-500 m^3/h	1147	2071	2757	3741	3994
Central MVs 501-1000 m^3/h	0	2145	377	895	352
Push/pull units	-	-	10803	15108	15344
Decentral units	-	-	-	-	2765
Total	3602	9873	21963	29230	32270

Changes in the market will depend on the updated requirements for energy performance of buildings and on the availability of financial incentives for the energy retrofit of existing buildings (see the next sections). In parallel, the market will also benefit from new construction as most of new dwellings are nowadays equipped with MVs; however, after years of positive trends, it is expected that a contraction of new constructions may happen in the coming years (e.g. -7.4% expected in 2024).

2.3 Requirements for the ventilation of non-residential buildings

As with dwellings discussed in section 2.1, ventilation requirements for Italian non-residential buildings were defined by the technical standard UNI 10339:1995 – *Impianti aeraulici ai fini del benessere. Generalità, classificazione e requisiti. Regole per la richiesta d'offerta, l'offerta, l'ordine e la fornitura.*

Lower values were set for common areas in buildings compared to dwellings; examples include:

- 5.5x10^{-3}m^3/s per person in hotel conference rooms;
- 10x10^{-3}m^3/s per person in hotel dining rooms;
- 9x10^{-3}m^3/s per person in meeting rooms.

Adjustment factors for the building's altitude and the room's geometrical ratio were also considered.

The standard has been withdrawn and there is no current official replacement, covering the full scope of the UNI10339. Thus, the reference standard for IAQ in buildings became the well-known EN16798-1:2019 - *Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.* Specific categories of buildings are covered by laws or decrees, as in the cases of schools as well as educational [2] and health facilities [3]. Additionally, regional accreditation requirements might apply.

Table 2: Example of prescribed fresh air flow rate per person, for different building categories and types

Building category/type	Q (10^{-3}m^3/s)
Office rooms or open spaces	11
Office meeting rooms	10
Hospital (or similar) rooms	11
Cinemas	5.5
Museums rooms and halls	6
Library meeting rooms	5.5
Sport halls	6.5
Gyms – playing field / spectators	16.5 / 6.5
School classroom – kindergarten	4
School classroom – primary	5
School classroom – secondary	6
School classroom – high school	7
School classroom – university	7

As explained in section 2.2, UNI 10339:1995 remains widely used by professionals, designers and industry representatives, having been in force for nearly three decades. It is therefore relevant to recall some of the key requirements set in the document, particularly those in Table 2.

2.4 Ventilation systems in non-residential buildings stock and market

As in the residential sector, no official data are available on buildings equipped with mechanical ventilation systems.

According to the 2024 market analysis carried out by EUROVENT, about 13000 air handling units (AHUs) were sold in 2023; about 70% are equipped with plate heat exchangers and about 80% feature hydronic batteries.

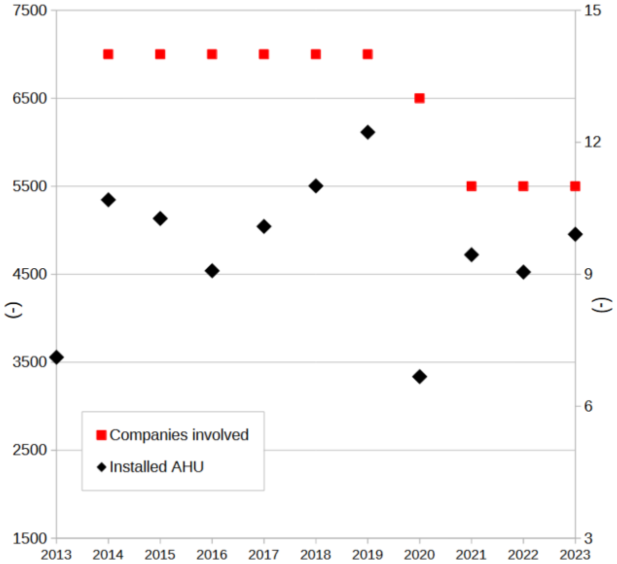

Figure 2: Annual installation of new air handling units in non-residential buildings and number of companies participating in the national survey (source Assoclima)

To better understand the evolution of the market sector, Figure 2 presents the annual sales of air handling units from 2013 until 2023, as collected by ASSOCLIMA. It should be highlighted that the figures are based on data from a limited number of industries participating in the survey (see red bullets in the figure). Therefore, while useful for identifying trends, they may not accurately reflect the absolute number of installed units.

The figure shows a steady market increase during the 2016-2019 period, driven also by the financial incentives. The market collapsed in 2020 due to the Covid-19 pandemic, then increased again in the following years, though it has not returned to pre-pandemic levels. It must also be noted that, during the same period, the number of industries involved in the survey decreased from 14 to 11; this aspect may affect the identification of the market trend. Most installations are of small to medium size, with 85% of the units treating air flows of up to 15000 m^3/h. Air handling units treating more than 50000 m^3/h accounted for only 2% of the market. The new regulatory framework will boost the sector's market in the coming years. The national decree 2022/183 sets out the minimum environmental criteria to be adopted in the design and construction of buildings. Several of these criteria are mandatory, including one related to aeration, ventilation and air quality. Two main cases are identified:

New buildings and first level building renovations (involving at least 50% of the building volume): It is mandatory to ensure the air flow rates specified by the national standard UNI 10339:1995 (see above). Alternatively, compliance can be achieved by meeting the requirements for *very low polluting building* class and *low polluting building* as defined in the UNI EN 16798-1 standard for the two above sub-cases, respectively.

Second level building renovations (involving at least 25% of the building volume) and building energy retrofits: Class II of the UNI EN 16798-1 standard is accepted, if the level of the previous case cannot be met. In such a case, the designer has to declare the adopted technical solution in a formal technical report.

For all new construction, demolition and reconstruction, extension and above-elevation of buildings and first level major renovations, the external air flow rates, as previously indicated by UNI 10339 or at least Class II of UNI EN 16798-1, *very low polluting building*, must be guaranteed. In both cases the requirements for thermal comfort and for limiting the thermal energy requirements for ventilation must be respected.

For major renovations of second level and energy retrofit, in the case of technical impossibility of achieving the flow rates foreseen by UNI 10339 or Class II of UNI EN 16798-1, the achievement of Class III is granted, in addition to compliance with the requirements of thermal comfort and containment of the thermal energy requirements for ventilation.

Because of the Covid-19 pandemic, a general awareness related to the air quality in schools led to the publication of the DPCM 26th July 2022 Decree containing the guidelines for the air purification devices, mechanical ventilation systems and minimum requirements for IAQ in school buildings. Concerning the latter, the requirements refer to existing standard, however a crucial point is the need to monitor several parameters (e.g. CO_2, formaldehyde, benzene, PM_{10}, $PM_{2.5}$, temperature, relative humidity-UR%.) and to implement technical measures to ensure acceptable IAQ levels, through adequate ventilation technologies and strategies.

In addition to the new regulations mentioned above, the MV market is also expected to benefit from investments in new constructions in the public sector supported by the PNRR (*Piano Nazionale di Ripresa e Resilienza - National Recovery and Resilience Plan*), the post-pandemic national plan based on the Next Generation EU programme. After several years of positive growth, a double-digit increase in investments in new non-residential buildings is expected. It will compensate, at least partly, for the substantial decline in new constructions, as well as in renovations, in the residential sector, primarily due to the substantial reduction in the generous tax incentives they have enjoyed in past years.

3 National trends in energy requirements and market

3.1 *Energy requirements*

The energy performance of buildings is determined through calculations based on the guidelines provided in the national decree, issued in 2015 by the Ministry of the Economic Development (now Ministry of the Enterprise) [1]. The energy requirements are set in a separate decree issued by the same Ministry [5].

The technical standards including the calculation procedures for determining the energy performance of buildings are the UNI-TS series [3, 4, 5], with UNI being the national body for standardisation. These standards refer to existing national and EU technical regulations, and provide simplified options for the standardised calculation, according to the national building energy certification scheme. For the energy performance assessment calculation in compliance with the energy certification scheme, a semi-steady monthly calculation method is applied.

As already mentioned, the installation of mechanical ventilation systems is not mandatory in most buildings, but minimum fresh air exchanges are prescribed, depending on the building use. The procedures to calculate the energy needs due to the ventilation and infiltration air flows are defined in [3] for buildings with or without mechanical ventilation systems, considering standardised reference or effective conditions. The latter are typical of the design approaches, the former are those (more simplified) used for the building energy certification. A typical example is the $0.5h^{-1}$ ACH (Air Exchange per Hour) rate, applied to dwellings in standard condition and without mechanical ventilation, reduced to $0.3h^{-1}$ once the occupancy factor is introduced.

If a MV system is installed in the building a set of equations is implemented, which determine the average air flow as a function of the:

- Volume of the zone
- Air exchange between indoor and outdoor with 50Pa pressure difference
- Wind exposure coefficient
- Period of utilisation of the MV systems
- Efficiency of the control of the system. As an example, Table 4 reports the efficiency factor for the case of a variable speed fan in different building types and for different controls. To be noted that the efficiency factor is set at 0.60 for the residential system based on relative humidity control.

The set of equations is adjusted to cover the following cases:

- Natural ventilation
- Mechanical ventilation
- Hybrid ventilation
- Ventilation provided by the air conditioning system

Also, a calculation module for night ventilative cooling is implemented.

Table 3: Efficiency factor for the mechanical ventilation control for the variable speed fan system and for different control modes

Building use	Presence	Movement	CO_2
Dwelling	0.80	0.70	0.70
Office rooms	0.64	0.57	0.61
Office open spaces	0.80	0.45	0.50
Meeting rooms	0.60	0.29	0.37
School primary classroom	0.68	0.57	0.61
School secondary classroom	0.80	0.41	0.47

The procedures to calculate the final and primary electrical energy use for the MV systems are defined in [7]; they are based on the following parameters:

- The electric power of the fans in each thermal zone
- The number of hours the MV system is working.
- The load factor, which depends on the efficiency of the control of the system and the fraction of usage of the MV.

To align with the national energy efficiency policies and objectives, minimum requirements for ventilation systems (in terms of used electricity per cubic meter of air moved) are set in [5] for different technological solutions. These values range from 0.25 to 0.5 Wh/m^3, from simple flow extraction to double flow with heat recovery. Minimum requirements for air handling units are those established by the 2009/125/CE and 2010/30/UE Directives. The standard [6] introduces also the efficiency factor when regulation devices are installed in MV systems.

It must be noted that the energy performance of a given building, and the resulting energy class, is determined through a comparison with a notional (reference) building according to the regulatory scheme. Thus, no absolute requirements are set for the building's overall energy performance, nor for specific energy services – including ventilation.

Considering the assessment method described above and the fact that most buildings in the country are ventilated simply by opening windows (which provides no information about the actual flow of fresh air), it is almost impossible to provide reliable data on the energy use of the mechanical ventilation, both in absolute terms and in relation to the overall energy performance of buildings.

3.2 Other drivers in energy performance

There is no clear evidence that the introduction of the Energy Performance Certificate (EPC), mandatory since 2009 for real estate sales and since 2010 for rental contracts, has been a driver for improved energy performance of buildings, particularly dwellings, nor has it served as an incentive for owners to improve the energy efficiency of their properties. Instead, two main drivers have been identified: i) stricter requirements for new buildings, ii) the implementation of a financial support scheme to foster building renovation, with a focus on energy related issues.

The landscape began to change about 15 years ago when a financial support scheme was introduced, initially to renovate specific elements of the building (roof insulation, windows, heat generators, room air conditioning units, etc.) and later to (deeply) renovate the whole structure.

As of 2025, the deduction for the installation of Controlled Mechanical Ventilation (CMV) systems is set to 50% for interventions on main dwellings, while for secondary or non-residential properties the rate was reduced to 36%. These benefits are granted only if the intervention ensures an actual improvement in energy efficiency that is certified by a qualified technician.

SIAPE (https://siape.enea.it) is the informative system for energy certification in Italy that started collecting data from 2015 [9].

Figure 3 shows the evolution of energy certification for buildings/dwellings (in residential buildings the energy certification is done at single dwelling level) grouped in three categories: A. certificates issued for sale or rent, typically for old buildings with very low energy performance (a G class self-declaration is often used to avoid the cost for the energy performance assessment); B. new buildings and building energy renovations; this category is relevant for assessing the use of mechanical ventilation; C. Certificates with no specified reason for issuance. The annual increase in energy certificates is a function of several factors: the first is when the Regions (responsible for EPC implementation), started populating the platform with their data; the second is the implementation of the 110% de-taxation scheme which strongly boosted the energy renovation market.

Figure 4 shows the number of units (buildings or dwellings depending on residential or non-residential use). Since 2019, the number of units with MVs installed according to energy certificates has been in the 7,000-8,000 range. The share relative to the total was in the 10-12% range until 2020, then steeply decreased because of the high number of renovated dwellings in which a MV was not installed for economic reasons.

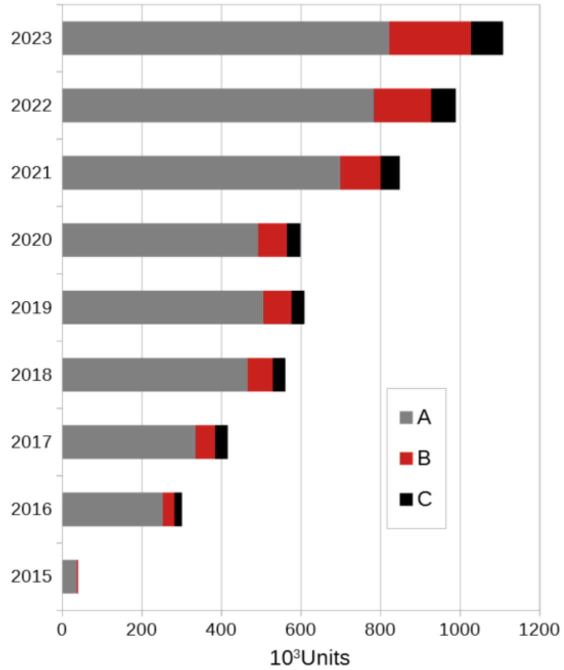

Figure 3: Thousands of building/dwelling energy certificates. A. certificate for sales/rents, B. certificates for new and renovated buildings/dwellings; C. certificates without specific indications.

3.3 Changes over the last years & changes foreseen

The favourable conditions, set by the aforementioned financial incentives, led to the deep renovation of more than 400,000 residential buildings (ranging from single family house to large condominiums). Those advantages affected MVs equipped with heat exchangers allowing an effective reduction in energy consumption attributable to winter heating and summer cooling.

Due to the extremely high public costs, a substantial review of such fiscal stimuli was carried out during 2023 and 2024. A tax-deduction of 50-65% is available for the installation of mechanical ventilation systems until 31st December 2024. In 2025, the permitted tax deduction will be 50% for primary residences and will drop to 36% for second homes, usually intended for holidays. Then, starting from 1st January 2026, tax deductions will be reduced to 36% and 30% respectively. As a consequence, the sales of centralized MVs dropped starting in 2023.

It is conceivable that this trend will continue at least for the next two years, given the current negative economic situation, which pushes owners to prioritize renovation expenses on interventions (such as creation of a thermal insulating coat, installation of windows capable of guaranteeing a better thermal insulation, replacement of traditional boilers with heat pumps), which lead to a direct improvement in the efficiency class of the building.

Relevant in this context is the persistent low public awareness of the importance of proper ventilation in enclosed spaces - both for the health and well-being of the occupants, and for the protection of the buildings themselves. Phenomena such as mould formation on walls, which often appears a few months after the completion of the insulation improvement of the building, are among the main factors driving the growth of the push-pull unit market, favoured for their ease of installation and low costs.

Another driver for the ventilation market should be the new Ecodesign Regulation of MVs, expected to be published by the end of 2026 and to become mandatory from January 2029, which should promote a more efficient operation (demand-controlled ventilation).

With the increase in renovated buildings, also in central zones of cities where the building stock is often obsolete in terms of energy quality, it is possible to develop the first analyses of the impact of energy performance on the economic values of buildings, getting rid of the extreme social, economic, and climatic heterogeneity of the country. A recent study by the Banca d'Italia, in fact, demonstrated that *"The price of the most energy-efficient homes is ceteris paribus 25% higher than the worst energy-performing houses"* [10].

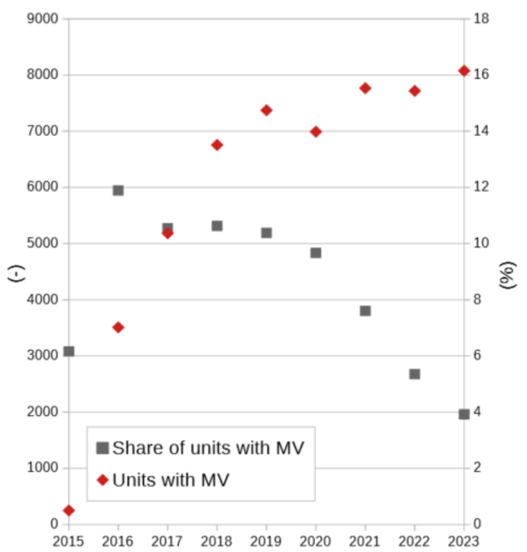

Figure 4: Number of units (building or dwellings) with mechanical ventilation indicated in the energy certificates and share with respect of total certificates.

It is now too early to predict the impact of the aforementioned financial support on the energy performance of buildings. In this perspective, it will be crucial to understand how the new EPBD Directive (2024/1275), with its innovative concepts not limited to the energy issues but including comfort, health and wellbeing, will be implemented at national level. It is foreseeable that only an incentive plan addressed to the economically weakest segments of the Italian population, who in most cases live in low energy class buildings and who remained largely excluded from the tax advantages guaranteed by the 110% Superbonus, will allow the achievement of the efficiency improvement of the Italian building stock set by the Directive.

4 National trends in the inspection of ventilation systems

4.1 Requirements of the inspection of ventilation systems

The current Italian legislation on health and safety in the workplaces, Legislative Decree N° 81/2008 [8] art. 64, requires employers to ensure that workplaces, systems and devices are regularly cleaned, in order to ensure adequate hygienic conditions. This obligation also concerns Air Conditioning and Ventilation systems, as well as their components.

Annex IV – *Workplace requirements* – point 1.9 *Microclimate sub-point* 1.9.1 "*Workplace ventilation*" states the following regarding ventilation and air conditioning systems:

- 1.9.1.4 *The air conditioning systems themselves must be periodically subjected to checks, maintenance, cleaning and sanitization to protect the health of workers*.
- 1.9.1.5 *Any sediment or dirt that could pose an immediate danger to the health of workers, due to pollution of the air breathed, must be eliminated quickly*.

The Agreement of the Permanent Conference for Relations between the State and the Regions of 5th October 2006, which adopted the "*Draft guidelines for the definition of technical protocols for predictive maintenance on air conditioning systems*" [12], had already underlined the obligations of employers regarding the regular cleaning and technical maintenance of the systems.

This Agreement, still in force, introduced new concepts regarding *Maintenance Planning* (Art. 1), *Hygienic requirements for maintenance operations on air conditioning systems* (Art. 2) *Qualification and Training of personnel* (Art. 3) who must be trained for this purpose and *Operation of ventilation and air conditioning systems* (Art. 4).

In November 2011, thanks to the implementation by UNI (the Italian Standardization Body) of the European standard EN 15780 "*Ventilation of buildings – Ducts – Cleaning of ventilation systems*" [16], the criteria for assessing the cleanliness conditions of air distribution ducts and the procedures to be adopted were introduced.

More recently, in February 2013, the Agreement established between the Permanent Conference for Relations between the State and the Regions "*Operating procedure for the assessment and management of risks related to the hygiene of air treatment systems*" [10] was published.

4.2 *Inspection protocols*

It is an obligation for the Employer, the owner of the systems and the responsible maintenance engineer to carry out the health and hygiene control activities provided for by [13] and [12] and compliant with the provisions of [11].

Right now there are no obligations to verify the energy performance, IAQ, acoustic and thermal comfort related to the MV system.

Periodic cleaning and maintenance operations must include a visual and, if necessary, a technical inspection.

The visual inspection allows to assess the state of the various components of the system in the context of scheduled maintenance interventions. This examination consists of evaluating the hygienic state of some critical points of the system and their functionality.

The technical inspection usually involves sampling and/or technical checks on the system components in order to evaluate their efficiency, state of conservation and hygienic conditions. It allows to diagnose the critical issues manifested by the system, the measures to be taken and the timeliness with which to intervene.

The measures to be implemented during inspections are listed in [13]. In detail, the first check must take place when starting the MV system, in order to ensure that it has been installed clean and, if needed, sanitized (absence of debris and construction dust, etc.)

The permissible limit for PM deposited in air ducts considered clean, without internal coating, is 0.075 g/m^2 (according to the NADCA vacuum test).

The MV systems must be checked regularly and must be cleaned, if necessary, by qualified personnel; a MV system is considered to be kept clean only when all its surfaces (in particular the air ducts) do not show accumulations of particulate matter exceeding 1 g/m^2.

Hygiene inspections of air conditioning systems must be carried out by competent technical personnel. In particular, [14] modifies the guidelines in [13] with regard to:

- The possibility of assessing the maintenance and hygiene status of the system through visual inspection, which can be carried out independently of the technical inspection.
- The possibility to program the frequency of execution of the two types of inspections (visual and technical) based on the results of the previous ones.
- In case of no specific issues or risks the maximum acceptable accumulation of particulate matter is 3g/m^2, also after [15].

The standard [15] establishes three classes of a mechanical ventilation system cleaning quality:

- Low: intermittently occupied premises, like archives, technical rooms, etc.
- Medium: offices, hotels, restaurants, schools, theatres, homes, commercial areas, exhibition buildings, sports buildings, common areas in hospitals, common areas in industries.
- High: laboratories, treatment areas in hospitals, high quality offices.

Based on previous visual and technical inspections, Table 4 presents the scheduled monthly frequency of technical inspections, as indicated in [15].

Table 4 : Frequency of inspection for different MV systems' element.

Cleaning quality	AHUs	Filters	Humidifiers	Ducts	Terminals
Low	24	12	12	48	48
Medium	12	12	6	24	24
High	12	6	6	12	12

Furthermore, [14] reiterates the need, already identified in [13], to establish a register of ordinary and extraordinary maintenance interventions carried out on the system, also providing a Check List of the checks subject to visual inspection which, together with a model report of the results of the technical inspection, must be attached to the aforementioned register.

5 Conclusion

The technical and regulatory framework in Italy is undergoing relevant changes due to several factors: the implementation of the new EPBD Directive, the change of relevant standards for the IAQ in buildings, a new approach to the energy retrofit of buildings with high standards for both, energy performance and environmental quality.

This framework is going to deeply affect the way mechanical ventilation systems will be used in the coming years. The current market is very small in the residential sector, as well as in a relevant portion of the non-residential stock. However, for an effective and positive change in the large-scale application of the technology, it is important that the coming building energy code is clearer than it is now about its relevance in new and renovated buildings, indicating solutions, requirements and post-evaluation controls. In addition, it is very important to maintain and support financial incentives for citizens to boost the energy renovation of buildings with high energy and environmental targets and standards, as the associated costs cannot be afforded by a large portion of the Italian population.

Another relevant issue, for a relatively *young* market, will be training and the information for the stakeholders, designers, dealers and installers.

6 Example of mandatory flowrate for typical buildings

The UNI EN 16798-1:2019 standard sets 4 categories of IAQ, referable to the percentage of dissatisfaction with the IAQ in relation to the fresh air flow rate [(m^3/h)/person] and presented in Table 5:

- Category I: corresponds to a high expectation; it is recommended in environments occupied by very sensitive or vulnerable people, disabled, sick or still young or elderly.
- Category II: corresponds to the average expectation; it is suggested for new or renovated buildings.
- Category III: corresponds to a moderate level of expectation; it can be used as a reference in existing buildings.
- Category IV: the perception is of poor quality; it should be considered only for buildings inhabited only in some periods of the year.

Table 5: IAQ categories and reference values according to the different methods defined in UNI EN 16798-1:2019

IAQ Category	1st method	2nd method	3rd method	
	Air flow/m²	Air flow/beds	Air flow/beds	Air flow/m² living space
I	0,49 l/s	10 l/s	3,5 l/s	0,25 l/s
II	0,42 l/s	7 l/s	2,5 l/s	0,15 l/s
III	0,35 l/s	4 l/s	1,5 l/s	0,10 l/s
IV	0,23 l/s	-	-	-

The EN 16798-1:2019 standard offers three alternative methods for calculating the flow rate of fresh air in a dwelling:

- the 1st is based solely on the surface area of the dwelling,
- the 2nd only considers the number of beds in the dwelling,
- the 3rd refers to the number of beds and the total surface area of the living spaces.

For non-residential buildings, the calculation of the fresh air flow rate according to the UNI EN 16798:2019 standard is based on two factors:

- the airflow required to remove / dilute bio-pollutants linked to the presence of occupants (Q_p),
- the airflow needed to remove / dilute pollutants emitted by the building and the systems present in it (Q_b).

Therefore, applying the EN 16798:2019 standard, we'll have:

$Q = Q_p \times N + Q_b \times A$, where:

- Q_p = fresh air flow rate per occupant
- N = number of occupants
- Q_b = fresh air flow rate per unit of surface area
- A = surface area of the room

Table 6: IAQ categories and reference values for non-residential buildings according to the different methods defined in UNI EN 16798-1:2019

IAQ Category	**Air flow / occupant**		**IAQ Category**	**Air flow / m²**
I	10 l/s	+	I	1 l/s
II	7 l/s		II	0,7 l/s
III	4 l/s		III	0,4 l/s
IV	2,5 l/s		IV	0,3 l/s

6.1 *Dwellings*

Two exemplary cases are presented here: 50 and 90 m^2 dwellings:

- 50 m^2 apartment (2,5 m high) occupied by 2 people and consisting of 1 main room, 1 bedroom (for a total of 40 m^2), 1 kitchen open on the main room and 1 bathroom with toilet.

Aiming to meet **Class II** requirements (**new or renovated buildings**), we'll have:

- 1st method: 50 x 0,42 = 21 l/s ⇔ 75,6 m^3/h
- 2nd method: 2 x 7 = 14 l/s ⇔ 50,4 m^3/h
- 3rd method: 2 x 2,5 + 40 x 0,15 = 5 + 6 = 11 l/s ⇔ 39,6 m^3/h

Overall, a flow rate between 50 m^3/h and 60 m^3/h, ⇔ between 0,4 to 0,5 air changes/h, represents a recommendable value.

Aiming instead to meet **Class III** requirements (**existing buildings**), we'll have:

- 1st method: 50 x 0,35 = 17,5 l/s ⇔ 63,0 m^3/h
- 2nd method: 2 x 4 = 8 l/s ⇔ 28,8 m^3/h
- 3rd method: 2 x 1,5 + 40 x 0,10 = 3 + 4 = 7 l/s ⇔ 25,2 m^3/h

Overall, a flow rate between 32 m^3/h and 40 m^3/h, ⇔ between 0,25 to 0,35 air changes/h, represents a recommendable value.

- 90 m^2 house (2,5 m high) occupied by 4 people and consisting of 1 main room, 3 bedrooms (1 master for 2 adults, 2 kids), for a total of 70 m^2, 1 kitchen open on the main room, 1 bathroom with toilette.

Aiming to meet **Class II** requirements (**new or renovated buildings**), we'll have:

- 1st method: 90 x 0,42 = 37,8 l/s ⇔ 136,1 m^3/h
- 2nd method: 4 x 7 = 28 l/s ⇔ 100,8 m^3/h
- 3rd method: 4 x 2,5 + 70 x 0,15 = 10,50 + 10,5 = 20,5 l/s ⇔ 73,8 m^3/h

Overall, a flow rate between 90 m^3/h and 110 m^3/h, ⇔ between 0,4 to 0,5 air changes/h, represents a recommendable value.

Aiming to meet **Class III** requirements (**existing buildings**), we'll have:

- 1st method: 90 x 0,35 = 31,5 l/s ⇔ 113,4 m^3/h
- 2nd method: 4 x 4 = 16 l/s ⇔ 57,6 m^3/h
- 3rd method: 4 x 1,5 + 70 x 0,15 = 6,0 + 10,5 = 16,5 l/s ⇔ 59,4 m^3/h

Overall, a flow rate between 60 m^3/h and 80 m^3/h, ⇔ between 0,25 to 0,35 air changes/h, represents a recommendable value.

In order to preserve adequate IAQ levels in both applications, ventilation should be kept running at night, possibly slightly reducing the airflow in relation to the lower production of endogenous pollutants and to limit noise emissions.

6.2 *Non-residential*

Two exemplary cases are presented here: 50 m^2 classroom and 12 m^2 office room:

- Classroom of 50 m² with 25 students, and 1 teacher

Aiming to meet **Class II** requirements (**new or renovated buildings**), we'll have:

7 x 26 + 0,7 x 50 = (182 + 35) l/s ⇔ 217 l/s ⇔ 781,2 m^3/h

Aiming to meet **Class III** requirements (**existing buildings**), we'll have:

4 x 26 + 0,4 x 50 = (104 + 20) l/s ⇔ 124 l/s ⇔ 446,4 m^3/h

- Office of 12 m² with single occupancy:

Aiming to meet **Class II** requirements (**new or renovated buildings**), we'll have:

7 x 1 + 0,7 x 12 = (7 + 8,4) l/s ⇔ 15,4 l/s ⇔ 55,5 m^3/h

Aiming to meet **Class III** requirements (**existing buildings**), we'll have:

4 x 1 + 0,4 x 12 = (4 + 4,8) l/s ⇔ 8,8 l/s ⇔ 31,7 m^3/h

In both cases, due to the specific applications, the ventilation system can be switched off at night to save energy.

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The **Air Infiltration and Ventilation Centre** was inaugurated through the International Energy Agency and is funded by the following countries: Australia, Belgium, Canada, Denmark, France, Italy, Japan, Netherlands, New Zealand, Norway, Republic of Korea, Spain, Sweden, United Kingdom and United States of America.

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