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# Trends in building ventilation requirements and inspection in France

Valérie Leprince, Cerema
Laure Mouradian, CETIAT
Gaëlle Guyot, Cerema

## 1 General introduction

This paper presents evolutions of the French building ventilation regulations and market, it updates the VIP n°19 published in 2008.

France has 68 million inhabitants (2023)[1]. The building stock includes 37.2 million dwellings (2022)[2], 50% built before 1974. Main dwellings are houses (79%) with an average area of 100 m² and apartments (21%) with an average area of 64 m²[3]. 26% of buildings have an area of more than 100 m² and 26% of less than 60 m². In 2023, 16059 single houses, 205 multi-family buildings, 91 offices buildings and 12 educational buildings and have been finished[4].

The non-residential heated buildings' surface is 973 million m². New non-residential buildings are also almost all equipped with a mechanical ventilation system, (mainly balanced systems - 52%[4]).

French regulation regarding residential ventilation dates from 1982. Almost all new residential buildings constructed since then are equipped with a mechanical ventilation system. For non-residential buildings, the regulation dates from 1979 and does not impose the installation of a ventilation system as a prescriptive requirement. Nevertheless, if air renewal relies only on windows' opening, a significant windows area is necessary (according to the floor area) for the building to be considered compliant with the regulation.

Since 2019 the website www.batiment-ventilation.fr/ refers to all significant documents on ventilation, agenda and provides pre-defined questions and answers.

## 2 National trends in IAQ requirements and market

### 2.1 *Requirements on ventilation of dwellings*

The French Regulation for residential buildings ventilation mainly relies on the « *Arrêté du 24 mars 1982 relatif à l'aération des logements* » [1]. This text sets out the requirements on ventilation system in every new dwelling since 1982.

Its main requirements are:

- Overall and continuous air renewal,
- Air inlets (natural or mechanical) in main rooms, which can be adjustable or self-adjustable but cannot be closed.

[1] www.inse.fr
[2] www.ademe.fr
[3] https://www.statistiques.developpement-durable.gouv.fr
[4] https://re-batiment2020.cstb.fr/opee/

- Air exhausts in kitchen, bathroom(s), toilet and any utility room.
- Ventilation system must be able to reach air flow rates mentioned in *Table 1*
- Minimum flowrate must be maintained continuously, with values given in *Table 2* and depending on whether the system is demand-control (with a technical accreditation).

*Table 1: Requirements for achievable exhaust air flow rate*

| Number of main rooms | Achievable exhaust air flow rate ($m^3/h$) | | | | |
|---|---|---|---|---|---|
| | Kitchen | Bathroom with toilet | Other bathroom | Toilet | |
| | | | | First one | Others |
| 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 and more | 135 | 30 | 15 | 30 | 15 |

*Table 2: Requirements for minimum values of reduced air flow rate*

| Number of main rooms | Minimum values of reduced exhaust air flow rates ($m^3/h$) | | |
|---|---|---|---|
| | Without demand-controlled ventilation | | With demand-controlled ventilation |
| | Total Exhaust | Kitchen | Total exhaust |
| 1 | 35 | 20 | 10 |
| 2 | 60 | 30 | 10 |
| 3 | 75 | 45 | 15 |
| 4 | 90 | 45 | 20 |
| 5 | 105 | 45 | 25 |
| 6 | 120 | 45 | 30 |
| 7 | 135 | 45 | 35 |

Those flowrates have been defined with the primary goal to avoid condensation in buildings, due to human activities.

While the regulation covers flowrate to be reached in dwellings, the standard NF DTU 68.3 provides the design process to install a ventilation system that complies with the regulation. This document is considered as good practice.

As it is a standard, and not a regulation, applying the NF DTU 68.3 is not mandatory in general (only in the context of public contracting). However, if the installation doesn't comply with it, the insurance company may subsequently refuse to cover the damages.

The NF DTU 68.3 covers new ventilation installations and is divided into 6 parts:

– P1-1-1: General rules
– P1-1-2: Exhaust-only ventilation system-Design calculation and implementation
– P1-1-3: Exhaust-only ventilation system with gas extraction
– P1-1-4: Ventilation system with heat recovery – design calculation and implementation
– Part 1-2: General information on ventilation systems materials
– Part 2: Administrative clauses.

For hybrid ventilation (mostly used for refurbishment) this is covered by the "RAGE" guideline [2].

For extract ventilation with demand controlled ventilation (DCV) based on humidity, P1-1-2 apply and additional requirements are given in CPT 3827 [3] and CPT 3828 [4]. Additionally, to comply with the regulation and to be installed in new building those systems need to be certified through a specific protocol called "Avis Techniques" [5].

The construction code in France has been updated in 2021 [6] and now states that: *"Buildings shall be designed, built and maintained to preserve indoor air quality"*. To meet this expectation, there are 2 options:

- Either comply with the "Arrêté de 1982" (prescriptive method),
- or prove that the building complies with a minimum performance level.

The definition of these minimum performances and their implementation are currently discussed through a working group of the French ministry. The objective is clearly to propose a performance-based regulation to allow innovation as an alternative to the prescriptive regulation (see section 5 for more information).

### 2.2 *Ventilation systems in residential buildings stock and market*

In practice, requirements defined above have usually been achieved by using centralized-mechanical exhaust-only systems (*Table 3*).

Those systems have a two-stage exhaust rate in kitchens in order to extract pollutants during cooking activities (the user switch to maximum flowrate pushing a button or pulling a string). The contribution of cooker hood use on ventilation is not taken into account to fulfil regulation requirements. Moreover, due to the requirements on airtightness, cooker-hoods are mainly recirculation ones (no exhaust air)

Air inlets are self-adjusting natural trickle vents, usually located at the top or above windows of bedrooms and living room.

Almost all new residential buildings with exhaust-only ventilation are equipped with a humidity-based DCV system. The humidity control is, most of the time, not done through sensors but mechanically, thanks to a humidity-sensible tress inside exhaust devices and possibly inside inlets, which adjusts their opening size.

*Table 3 : Installed system in new dwellings in the last 10 years according to the French database of airtightness data in 2018 [7]*

| | Single houses | Multi-family dwellings |
|---|---|---|
| None | 0% | 0% |
| Other | 1% | 1% |
| Heat recovery | 3% | 1% |
| Extract only (constant flowrate) | 2% | 4% |
| Extract only, HR - demand control on extraction | 4% | 3% |
| Extract only, HR demand control on extraction and inlet | 89% | 91% |

In single-family dwellings the ductwork is usually built with plastic ductwork. Flexible ductwork is still very often used even if NF DTU 68.3 restricts it by limiting the length (from 1,5 to 3 m / ATD (Air transfer Device), depending on system type). As an alternative to flexible ductwork, semi-rigid ductwork is more and more used, even though cheaper plastic rigid ductwork is still preferred.

In multi-family buildings, for fire-safety reasons, the general ductwork is done with round metallic ductwork. For terminal ductwork (at the dwelling scale), flexible or plastic ductwork can be used.

The centralized fan is usually a constant pressure fan, which adjusts its speed to maintain a constant pressure whatever the size of the exhaust opening (varying with humidity and occupant behaviour in the kitchen).

Increasing-pressure fans (more pressure provided if more flowrate needed) are more commonly used. Constant speed fans are no longer installed in new buildings and are slowly replaced in the building stock.

Even if the proportion increases slowly, there are still few heat recovery systems in residential buildings. It is partially explainable by a limited reward in the energy performance calculation (see [8] Arrêté méthode RE 2020). As a result, in France supply air is usually not filtered.

Air cleaners have entered the market following the Covid Pandemic but reliable statistics on this topic are not available.

In refurbishment, for multi-family buildings already equipped with central natural ventilation by thermal draft (through passive cowl, which is very common in France) the objective is to guarantee a minimum continuous flowrate through hybrid and low-pressure systems. There are three different technologies on the market:

- Extraction with non-permanent mechanical assistance (switched on according to wind and temperature or when maximum flowrate is needed).
- Extraction with permanent mechanical assistance.
- Induction system (using venturi effect of an air jet injected in the duct).

Values on ventilation systems in existing buildings have been updated in 2017 and are presented in *Table 4*.

*Table 4: Ventilation systems in France Building Stocks ([9] INSEE 2017)*

| | Total number of dwellings (in million) | Ratio |
|---|---|---|
| No ventilation | 3560 | 10% |
| Room by room ventilation | 10760 | 31% |
| Overall natural ventilation | 6058 | 17% |
| Overall mechanical ventilation | 14437 | 42% |

## 2.3 Requirements on ventilation of non-residential buildings

The French regulation regarding non-residential buildings ventilation mainly relies on the "code du travail" (work code) for building occupied with workers (article R.4212-1 until R. 4222-21) and on the "Réglement sanitaire Départemental Type" (named RSDT) article 62 to 66 linked to the "Code de la santé publique" (Public Health Code), for any buildings (inc. receiving public).

The two regulations (RSDT and Work code) define air flow rates. Work code applies in new or existing buildings if workers are in it. RSDT applies to any new building built after 1979 (including those with workers).

These two codes distinguish between rooms without specific sources of pollution, such as classrooms, dormitories, offices, cinemas, restaurants, and sports buildings, where there is a requirement on the supply air flow rate, and rooms with specific pollution sources, such as bathrooms, showers, toilets, laundry facilities, and commercial kitchens, where there is a requirement on the extracted air flow rate.

Either a ventilation system is installed (mechanical or natural) or if the windows area in each room is sufficient it is considered that air replacement can be done through airing and the installation of a ventilation system is not required.

*Table 5* provides examples of requirements in RSDT. As this text has been developed in 1979, there is still the distinction between rooms with and without smoking allowance that is now outdated, because smoking is not permitted in non-residential buildings since 2008.

*Table 5: Air flow rates for non-residential buildings, required by health code*

| Kind of enclosure | $Q_{min}$ ($m^3/h$) per occupant | |
|---|---|---|
| | Smoking not allowed | Smoking allowed |
| School | 15 | - |
| High-school and university | 18 | 25 |
| Sleeping spaces (dormitory, etc.) | 18 | 25 |
| Office rooms | 18 | 25 |
| Meeting rooms | 18 | 30 |
| Shops | 22 | 30 |
| Bar and restaurant | 22 | 30 |
| Gymnasium (per athlete) | 25 | 30 |
| Swimming pool | 22 | 30 |
| Gymnasium (per onlooker) | 18 | 30 |

For the work code see Table 6.

*Table 6: Air flow rates for non-residential buildings required by the work code*

| Working place | $Q_{min}$ ($m^3/h$) per occupant |
|---|---|
| Offices (light work) | 25 |
| Meeting rooms, eating places | 30 |
| Workshop and light physical work areas | 45 |
| Other workshops | 60 |

Table 7, provides flowrates for rooms with specific air pollution sources, is similar in both codes.

*Table 7: Extract air flow rates for non-residential buildings, for rooms with specific pollution required by work and health code*

| Type of enclosure | $Q_{min}$ ($m^3/h$) |
|---|---|
| Individual use | |
| Bathroom (with or without toilet) | 15 per room |
| Toilet | 15 |
| Collective use | |
| Secluded toilet | 30 |
| Secluded bathroom | 45 |
| Bathroom with toilet | 60 |
| Grouped shower/bath/toilet | 30 + 15*Number |
| Washbasin | 10+15*Number |
| Washing/drying room | 5 per $m^2$ of floor area |

Ventilation can be stopped; the modulation of flowrate is allowed and recommended by the Energy Performance Regulation.

Contrary to the residential context there is not one national standard to describe the design and installation of non-residential ventilation systems. European standards apply but they are not mandatory.

Requirements on IAQ in buildings with sensitive populations or those exposed over long periods, such as day-care centres, schools, high schools, facilities for the disabled and juvenile detention centres have been introduced in 2010 and have been updated the 1st of January 2023. Airflow requirements are the same. But the law imposes the monitoring of IAQ at some specific point of the building life and a visual assessment of ventilation means (including windows airing). Pollutants measured are $CO_2$,

benzene and formaldehyde and in case of non-conformity an action plan shall be set.

The national ministry for health is now considering revising the ventilation part of the RSDT but the agenda for this revision is unknown.

### 2.4 *Ventilation systems in non-residential buildings stock and market*

The French association AIR.H estimated in a 2007 study for ADEME[5][9] that more than 57% of the square meter surface of the French stock of commercial buildings (Table 8) was equipped with an overall ventilation system or air handling unit.

About half of offices, shops and education buildings have as yet no ventilation system.

*Table 8: Ventilation systems in commercial buildings stock [9]*

| | Offices | Shops | Education Buildings | Health care buildings | Leisure buildings | hotels | Total |
|---|---|---|---|---|---|---|---|
| Stock ($10^3 m^2$) | 3026 | 3732 | 1747 | 1700 | 1666 | 821 | 12692 |
| /1/ | 50% | 40% | 60% | | 10% | 5% | 34% |
| /10/ | | | | | | 9% | 1% |
| /9/ | 10% | 10% | | 15% | 20% | | 10% |
| /6/ | 9% | | 20% | 25% | | 75% | 13% |
| /7 or 8/ | 1% | | | | | | 0,2% |
| /3/ | 10% | | 19% | 25% | | 10% | 9% |
| AHU | 20% | 50% | 1% | 35% | 70% | 1% | 34% |

*Table 9 : Installed system in new non-residential building in the last 10 years according to the French database of airtightness data (not all non-residential buildings are tested at commissioning [7]*

| | Other | Office building | Residence for student | Shops | Residence for elderly people | Education buildings | Childhood facilities | Health facilities | Young workers' hostel | Hotel | Industry or Caft | Restaurant | Sports hall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| /1/ | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 2% | 1% |
| /2/ | 31% | 3% | 0% | 1% | 0% | 4% | 3% | 3% | 1% | 1% | 2% | 2% | 3% |
| /3/ | 6% | 55% | 18% | 33% | 28% | 70% | 61% | 47% | 17% | 26% | 36% | 75% | 65% |
| /4/ | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| /5/ | 0% | 1% | 0% | 5% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 1% |
| /6/ | 0% | 20% | 4% | 20% | 0% | 14% | 13% | 20% | 21% | 12% | 41% | 8% | 21% |
| /7/ | 8% | 2% | 2% | 5% | 0% | 2% | 1% | 2% | 15% | 0% | 3% | 1% | 0% |
| /8/ | 54% | 18% | 76% | 35% | 72% | 10% | 22% | 28% | 45% | 60% | 15% | 12% | 9% |
| /9/ | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 1% | 1% | 1% | 1% | 0% |

/1/None

/2/ Other (could be multiple)

/3/ Balanced with heat recovery system

/4/ Supply only

/5/ Airing (windows opening)

/6/ Extract only (constant flowrate)

/7/ Extract only (HR demand control on extract terminal)

/8/ Extract only (HR-demand control on extract and supply inlet)

/9/ Local/room by room mechanical ventilation

/10/ Overall natural ventilation

# 3 National trends in energy requirements and market

## 3.1 *Energy requirements*

Energy requirements for ventilation are mainly covered by the building energy regulation RE2020[6] . It is an evolution of the previous regulation RT2012 which aimed at the generalization of low-energy buildings. It aims to limit not only the energy use of the building but also the embodied energy of building, and environmental impacts of construction materials and HVAC equipment.

The Energy performance (EP) calculation is performed with a calculation tool provided by the ministry. It's a dynamic calculation with an hourly timestep.

The estimation of air flow rates in the building is done through a pressure balance code. The ventilation system is implemented through flowrates at Air Terminal Devices (ATD), characteristics of air inlet, fan energy use and heat recovery characteristics if any.

Thermal losses through ductwork are considered (through leakages and conductivity), but the impact of leakages on fan energy use is not calculated through the tool.

[5] The French Agency for Ecological Transition

[6] https://www.ecologie.gouv.fr/politiques-publiques/reglementation-environnementale-re2020

Regarding DCV systems, for systems that have been validated through the "Avis technique", adjusted characteristics for average air flow rates and inlets are provided. In non-residential buildings, airflow rates for DCV systems could also be adjusted in the EP regulation, even if they don't have an "Avis Technique".

### 3.2 *Other drivers in energy performance*

In the refurbishment of residential buildings, the incentive scheme "MaPrimeRenov"[7] offers a subside for the installation of ventilation system (heat-recovery systems being more funded).

Building (new or existing) respecting the Effinergie label are very low energy buildings where efficient ventilation systems are promoted. Fulfilling this label usually allows to obtain a subside.

Information on the ventilation system installed is now included in the energy performance certificate that is required for selling or renting an existing dwelling.

### 3.3 *Changes over the last years & changes foreseen*

There is no change foreseen regarding the energy regulation on the way it considers ventilation and air renewal in its calculation, RE2020 is quite similar to RT2012.

## 4 National trends in the inspection of ventilation systems

### 4.1 *A high rate of ventilation non-compliance in residential buildings*

French authorities have the legal power to proceed to a regulatory compulsory check of any building. These data have highlighted for many years, that the ventilation did not comply with the regulations [10]: the ventilation installation in 50% of the controlled buildings does not meet the requirements, and therefore does not perform well; 43% of the controlled buildings do not meet mandatory air flow rates, exhaust airflows that are insufficient for 36% of the buildings and excessive in 7%. Those non-compliant rates could be even higher in single-family dwellings (68% reported in [11]).

### 4.2 *Requirements on the inspection of residential ventilation systems*

Given this high rate of non-compliance observed, the energy performance regulation RE2020 imposes since January 2023 a mandatory inspection of the ventilation systems for every new residential building.

This inspection shall be performed by a qualified tester (by qualification named "Qualibat 8741").

The inspection is mandatory only once at commissioning.

Every control performed shall be recorded by the tester on an online platform[8] that provides general statics on the performance of ventilation systems.

There is no mandatory inspection for non-residential buildings.

### 4.3 *Inspection protocols*

The inspection protocol for new residential buildings is available online on the ministry website[9]. Only people with a ministry agreement (delivered today only by Qualibat 8741) are allowed to perform the inspection in the context of the RE2020 (the list of operators is available on the ministry website). To be qualified, the inspector first has to complete and pass an approved training course (list also available on the ministry website), and then to send inspection's reports to the qualification body for approval.

Even though the regulation allows the inspector to:

- either be totally independent of the construction process
- or, in charge of the installation of the whole ventilation system.

In practice (in 2024), there is only one construction-company that has applied for this last qualification, which means that in most cases it is an independent inspector who

[7] https://www.maprimerenov.gouv.fr/
[8] https://www.observatoire-national-ventilation.developpement-durable.gouv.fr/
[9] https://rt-re-batiment.developpement-durable.gouv.fr/verification-des-systemes-de-ventilation-a561.html

performs the inspection (usually the same that performed the airtightness test[10]).

The inspection protocol is split in three parts:

- Pre-inspection
- Visual inspection
- Measurements

It focusses on checking the system's performance to ensure that the expected level of IAQ and energy use are met. An extensive visual inspection verifies compliance with best practices and confirms that the system is in working order. It covers:

- The completeness of the ventilation system (including alarms).
- The cleanliness and general state of the ventilation system.
- The accessibility of the system.
- The adequacy between regulation, design and installation.
- The good overall operation of the ventilation system.
- And measurements of flow rates or air pressures (for humidity-based demand control ventilation) at ATD.

There are requirements on the calibration of measuring devices that are also described in the protocol:

- For pressure measuring device Maximum Permissible Measurement Error (MPME) < max (3%, 0,5 Pa).
- For flowrate measurement device MPME < max (10%, 3.6 $m^3$/h).

Additional constraints are given on air flow rate measurement devices according to the technology and the ATD shape.

The ventilation system installed:

– Is deemed to comply with the RE2020 Ventilation Protocol if all the mandatory points.
– Complies with the RE2020 Ventilation Protocol.
– Is deemed not to comply with the RE2020 Ventilation Protocol if one or more mandatory point(s) is not compliant with the RE2020 Ventilation Protocol.

Therefore, all non-compliances must be corrected before the building can be declared complete.

Some optional points (good practices) in the protocol can be checked but do not impact the compliance with RE2020.

For non-residential building, there is no mandatory requirement, but an inspection protocol exists and is available on the Promevent website[11].

Building labels promote ventilation inspection in their program. As an example, the Effinergie Association has published guidelines for the inspection of low pressure and hybrid ventilation systems installed in refurbished multifamily buildings [12].

# 5 National trends in innovative systems and market

The prescriptive French ventilation regulation, and the way the regulatory EP calculation is performed, has led to exhaust only humidity-controlled demand control systems dominating the market. An alternative to this regulation is under development and shall be published by the beginning of 2025. This new alternative will be a performance-based regulation. The exact content of the regulation is not known yet, but preliminary decisions have already been taken (this new regulation only applies to dwellings):

- The validation of the compliance will be done project per project, through simulation prior to the building's construction.
- Some prescriptive requirements will be kept, such as the ventilation must be general and permanent (with a minimum air flow rate defined).
- Criteria will be checked for the compliance based on $CO_2$ level, humidity, a fictive/proxy pollutant P1 (emitted permanently), a fictive pollutant P2 (emitted during cooking events) and an air change rate.

Targets for criteria will be defined in line with the performance of systems complying with today's regulation. More information can be found in [13].

[10] Required for residential buildings by the RT2012 and RE2020 EP regulations

[11] http://www.promevent.fr/

This new regulation shall allow to:

- have on the market systems that do not comply with the actual ventilation regulation (such as supply-only ventilation),
- promote systems with higher performance than the one obtained with the current ventilation regulation.

# 6 Impact of the COVID-19 pandemic

On short terms, there has been no obvious impact of COVID-19 on the market of ventilation in France. The habits of airing classrooms and confined space have probably been kept.

The French Ministry in charge of education pushed for the installation of $CO_2$ monitors in classrooms. The local authorities (36 000 cities in France for primary schools alone) were then responsible for the cost, installation and support, as a result the real installation is disparate over the French schools. This may have had indirect influence on the ventilation market, but no data is available at this stage.

Nevertheless, following the COVID crisis, the French ministry for health is investigating on the relevance to review the non-residential regulation for ventilation.

# 7 Other points of attention or trends

Acoustic requirements impact the design of ventilation system, more specifically:

- The kind of air inlets depends on the outdoor acoustic constraints.
- Two different dwellings shall not be connected to a common duct at the same height.
- Constraints on the duct diameter are set to limit airspeed in ductworks.
- The fan must be suspended or placed on anti-vibration mounts.

The French "Association Francaise de la ventilation "[12] gathers all the stakeholders of the ventilation in France.

A national consultative body on ventilation issues has been created in 2016 called "Club Ventilation" with around 40 representative participants. The aim of this group was to identify the main pitfalls, to propose major projects and to prefigure future labels and regulations [14].

# 8 Conclusion

Since 1982, thanks to an ambitious regulation, almost every new residential building in France has a mechanical ventilation system. This is quite unique in the world. Nevertheless, checking the compliance to this regulation is only compulsory in new residential buildings since 2023. French statistics show a non-compliance rate of around 50% for residential buildings. Additionally, this very prescriptive regulation has prevented the development of innovative systems in France, except for the humidity-based ones. This shall improve with the new regulation coming in 2025.

On the topic of non-residential buildings, the "Réglement Sanitaire Départemental" from 1979 is outdated with required flowrates way below European standard recommendations and with the possibility to replace ventilation by airing. It is hoped that this regulation will be reviewed soon.

# 9 Example of mandatory flowrate for typical buildings

## 9.1 *Dwellings*

In a House of 90 m² (2.5 m height), 1 main room, 3 bedrooms (1 master (2 adults), 2 kids), 1 kitchen, 1 bathroom and 1 toilet. Flowrates to extract permanently are:

- 30 $m^3/h$ in the bathroom
- 30 $m^3/h$ in the toilet
- 45 $m^3/h$ in the kitchen and it must be possible to reach 120$m^3/h$ during cooking events (1 hour per day in average).

The system will extract permanently 105 $m^3/h$ with a peak at 180 $m^3/h$. An average of 108 $m^3/h$ can be considered.

In an apartment of 50 m², 1 main room, 1 bedroom, 1 kitchen open on the main room, 1 bathroom with toilets. Flowrates to extract permanently are the following:

- 30 $m^3/h$ in the bathroom/toilet

[12] https://www.afventilation.org/

- 30 $m^3$/h in the kitchen and it must be possible to reach 90$m^3$/h during cooking events (1 hour per day in average).

The system will extract permanently 60 $m^3$/h with a peak value at 90 $m^3$/h. An average of 61 $m^3$/h can be considered.

In both cases, if a demand control ventilation system is installed, the minimum flowrate can be reduced according to the values given in the "Avis techniques" agreements for each size of dwelling. This induces a reduction of 30 to 50% of the average flowrate with most of the systems.

There is no constraint on the supplied flowrate so it can be done through natural trickle vents or a mechanical supply to balance the extraction, but it needs to be done in every bedroom and main rooms.

### 9.2 *Non-residential*

In a classroom of 50 m² with 25 students and 1 teacher the flowrate to provide will depend on the age of the kids (from 15 $m^3$/h for the youngest to 18$m^3$/h in high schools and universities), as a worker the teacher shall have 25 $m^3$/h. So, the total for a class with young children is 15*25+25*1=400 $m^3$/h. The system can be switched off when the room is not occupied.

In an office of 12 m² with 1 occupant the flowrate to provide is 25 $m^3$/h.

The installation of a ventilation system is not mandatory if the volume of the room is higher than 6$m^3$ /person. and area of the windows in the room is sufficient (see Table 8).

*Table 8: Minimum window area regarding room surface*

| Room area ($m^2$) | Min Windows area ($m^2$) |
|---|---|
| 10 | 1.25 |
| 50 | 3.6 |
| 100 | 6.2 |
| 150 | 8.7 |
| 200 | 10 |
| 300 | 15 |
| 400 | 20 |
| 500 | 23 |
| 600 | 27 |
| 700 | 39 |
| 800 | 34 |
| 900 | 38 |
| 1000 | 42 |

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[3] Groupe Spécialisé n° 14.5 Equipements / Ventilation et systèmes par vecteur air, Cahier des Prescriptions Techniques 3827, Systèmes de ventilation mécanique contrôlée simple flux hygroréglable, (2023).

[4] Groupe Spécialisé n° 14.5 Equipements / Ventilation et systèmes par vecteur air, Cahier des Prescriptions Techniques 3828, Systèmes de ventilation mécanique contrôlée simple flux hygroréglable (habitat individuel), (2023).

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The Air Infiltration and Ventilation Centre provides technical support in air infiltration and ventilation research and application. The aim is to promote the understanding of the complex behaviour of the air flow in buildings and to advance the effective application of associated energy saving measures in the design of new buildings and the improvement of the existing building stock.