Building ventilation requirements and inspection in Belgium

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ABSTRACT

In Belgium, the requirements for ventilation in buildings can be found in national ventilation standards, national health regulation and in regional environmental regulations and EPB regulations (Energy Performance and Indoor Climate). In 2006 the latter regulations were introduced for the first time including mandatory requirements for ventilation. From then on it was mandatory for all new and renovated, both residential and non-residential buildings for which a building permit is necessary to install a natural or mechanical ventilation system for acceptable indoor air quality. This paper further discusses the present ventilation requirements in buildings (both residential and non-residential), current trends in the Belgian building ventilation market, energy requirements, requirements for inspection of the systems, innovations in the market and the impact of Covid-19.
Although standards and guidelines are generally published at a national level in Belgium, building energy performance regulation is a regional matter, including ventilation requirements. This means that each of the three regions – Flemish, Brussels Capital and Walloon Region – can have a different approach. Although most regulations are similar, some parts of the regulation, for instance in relation to inspection, don't apply in all regions. The paper mentions the differences between the regions when this is the case.

1 NATIONAL TRENDS IN IAQ REQUIREMENTS AND MARKET

1.1 Requirements for the ventilation of dwellings

The Regional decrees on Energy Performance of Buildings in Flanders, Wallonia, and Brussels Capital Region (Energiebesluit 2010, Guide PEB 2015, Environnement Brussels 2024) refer to Annexes which specify the residential ventilation requirements. In general, these Annexes stipulate that ventilation in residential buildings must follow the Belgian standard NBN D50-001 (1991), and list the exceptions and additions to that standard. The standard contains guidelines for ventilation that were made mandatory through the decrees on Energy Performance of Buildings in 2006 in Flanders, and 2008 in Wallonia and Brussels Capital Region. Even though the standard was already 15 years old before it was integrated in the Regional Energy Performance Regulations, it didn't have a large impact in practice at the time. This changed in 2006, mainly as a result of the strictly enforced compliance framework of the Energy Performance Regulations, with declaration of performances after completion of construction works, and a fully operational fine system. As a consequence, the compliance rate of energy performance requirements and ventilation requirements is high.
The standard defines a general minimum rule of 3.6 $m^3/h/m^2$ supply air for habitable spaces (also named dry rooms), which are the rooms where people typically spend most of their time, like living rooms, offices, or bedrooms. For extract spaces (also named wet rooms) such as kitchens, bathrooms, laundry rooms and toilets, the same general rule applies for the extract air. Additionally, minimum and permissible maximum flow rates are set for the various room types, as listed in Table 1. The total supply or exhaust flow rate of the system is equal to the sum of the minimum required flow rates per room. Application examples are given in Annex A.

Table 1: Minimum required flowrates in dwellings according to EPB based on NBN D50-001

General rule (supply, extract, transfer)	3.6 m³/h/m²
Living room (supply)	min: 75 m³/h, max: 150 m³/h
Bedroom, office, games room, etc. (supply)	min: 25 m³/h, max: 72 m³/h
Closed kitchen, bathroom, laundry rooms (extract)	min: 50 m³/h, max: 75 m³/h
Open kitchen (extract)	min: 75 m³/h
Toilet (extract)	25 m³/h

The standard also specifies that the habitable and the extract spaces should be connected through grilles or slots that can transfer an airflow of 25 m³/h (50 m³/h for kitchens) when a pressure difference of 2 Pa is applied to both sides of the connecting elements. In practice, the connections between zones are represented as openings of 70 cm² between zones (140 cm² for kitchens), which normally correspond to the typical gap of 1-2 cm that can be found between the interior doors and the floor in a dwelling.
The possible ventilation systems in the standard are systems with natural supply and natural exhaust (defined as system 'A' in the standard), systems with mechanical supply and natural exhaust (B), systems with natural supply and mechanical exhaust (C) and systems with mechanical supply and mechanical exhaust (D). If a ventilation system includes components for natural ventilation such as trickle ventilators or passive stacks, they are sized to achieve the nominal flow at 2 Pa. The EPB ventilation annexes also allow sizing these components at 10 Pa, if the room is served by a mechanical component, for instance if there is mechanical extraction in a room with supply through trickle ventilators.
The user is not obliged to achieve the required flow rates in each room at all times. It is allowed to reduce the flow rates according to the demands at a given moment. Control can be manually via a simple control mechanism (switch or button) or via an automatic control system in response to measurements of humidity, CO_2,… Mechanical systems should however still maintain a permanent, although reduced, flow rate at all times.

1.2 Ventilation systems in residential building stock and market

In Belgium, the energy performance of new and renovated buildings is assessed at the moment of completion of the works by an EPB-assessor, who collects the as-built information, creates the necessary input in the EPB-software, and evaluates whether the building meets the requirements. The EPB-declarations with the results are uploaded to a database, managed by the regional authorities. The analysis of part of this data is publicly available, for instance for Flanders: https://apps.energiesparen.be/energiekaart/vlaanderen.
This database also contains extensive information about residential ventilation systems installed in the market, which allows to follow market evolutions. Most data relate to new residential buildings for which data are available since 2006. Although the ventilation requirements were also mandatory for renovation projects with building permit, they were only partially mandatory, depending on the extent of renovation works. As a consequence this data has not been systematically documented in the database. Since 2015 a ventilation system is also mandatory in residential buildings undergoing a deep energy renovation, for which financial benefits apply in Flanders. These data are also public.
Figure 1 shows the evolution of the distribution of residential ventilation systems since 2006 in Flanders. The mechanical extract (System C) and balanced mechanical systems (System D) dominate the market. Of all systems installed in the over 400.000 new dwellings constructed in between 2006 and 2021, 4% are natural ventilation systems (A), 55% are mechanical extract systems (C) and 41% are balanced mechanical systems (D). Since 2014 the share of balanced mechanical systems has gradually been increasing from 50% up to 66% in 2021. This is the result of an associated tightening of energy performance requirements during these years, which were easier to meet when balanced mechanical ventilation with heat recovery was installed.

This type of system is even slightly more prevailing in single family dwellings (67% in 2021), compared to multifamily dwellings (appartments, 60% in 2021). Also in deep energy renovation projects, the systems C and D dominate, with a share of respectively 56% and 42% of the projects constructed in between 2015 and 2021. The mechanical extract systems include systems with demand control, which can be taken into account in the energy performance calculation. However the share of these systems is not specifically documented in the regional analysis reports.

The figures shown in Figure 1 relate to newly constructed dwellings. The implementation of ventilation systems in the existing dwelling stock is much smaller. Analysis of the database of Energy Performance Certificates for dwellings that were for sale or for rent in between 2015 and 2018 showed that only 4% of existing dwellings were equipped with a mechanical ventilation system (B, C or D) (Van Hove et al. 2021).

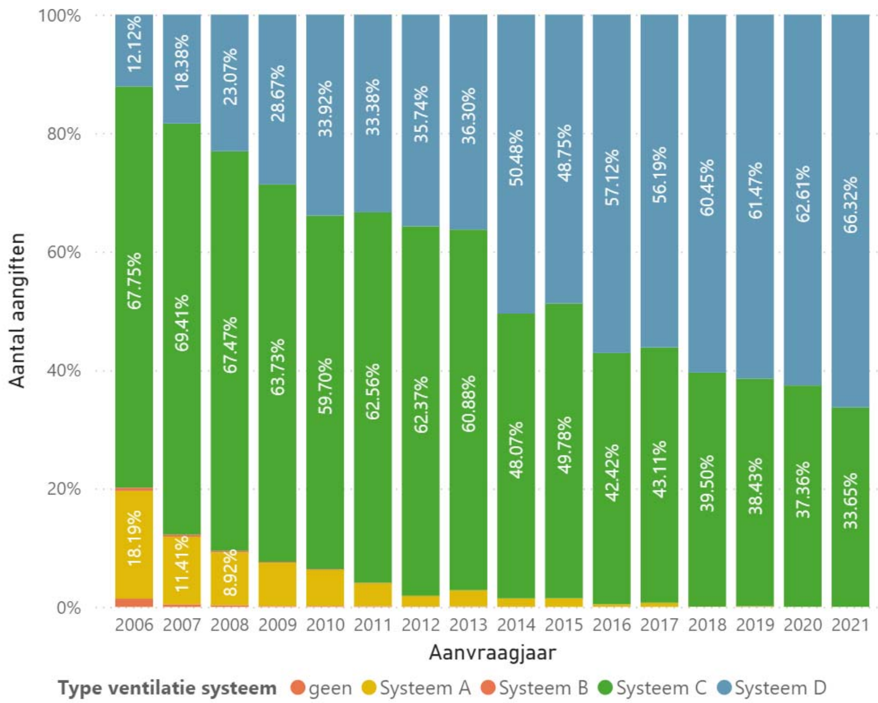

Figure 1: Evolution of the distribution of the type of ventilation systems in new dwellings in Flanders, Belgium between 2006 and 2021 (year of building permit), all dwellings combined

1.3 Requirements for the ventilation of non-residential buildings

Similar as for residential buildings, ventilation requirements for non-residential buildings are specified in separate Annexes to the Regional decrees on Energy Performance of Buildings in Flanders, Wallonia, and Brussels Capital Region. They also became mandatory for all types of new and renovated non-residential buildings with building permit, when the Energy Performance Regulations were introduced in 2006 in Flanders, and 2008 in Wallonia and Brussels Capital Region.
The Annexes refer to concepts and classes as defined in the standard NBN EN 13779 to express minimum requirements for the design and operation of ventilation systems. When sizing ventilation systems, the minimum flow rates corresponding to indoor air class IDA3 must be met. When specifying flow rates a difference is made between rooms serving for typical human

occupancy (offices, class rooms,…), and rooms not intended for long term human occupancy (corridors, toilets, storage rooms,…):

- In rooms for human occupancy a minimum flow rate of outdoor air need to be supplied depending on a flow rate per person (min. 22 m³/h per person), and the design occupation of the room. The design occupation follows from the design brief of the construction project, but should at least be equal to minimum design occupancies listed in the regulation, for a range of functions including restaurants, hotels, offices, theatres, shops, sport clubs, schools, prisons and hospitals.
- The required flow rates in rooms not for human occupancy depend on a minimum flow rate per unit of floor area (1.3 m³/h/m²), and the total floor area of the room. In case of sanitary facilities 25 m³/h per toilet needs to be provided. These flow rates may be met by transferring air from adjacent rooms and not necessarily by supplying outdoor air.

Application examples are given in Annex A.

Apart from specifying minimum flow rates, the regulation also imposes that a control system must be in place at least meeting class IDA-C3 (time control). This means that systems without control or with only a manually controlled switch are not allowed. Furthermore, supply and exhaust design flow rates don't need to be balanced, as long as an imbalance doesn't cause an underpressure larger than 5 Pa, or an overpressure larger than 10 Pa at building level. Finally, the regulation Annexes impose a maximum specific fan power that cannot be larger than class SFP-3 (< 0.4 W/(m³/h)). This requirement was abandoned in Flanders after 2014, since auxiliary energy use was already covered in the overall energy performance requirements (E-level, see §3).

In addition to the regional legislation on energy performance, there is a federal law "Codex on Well-Being at Work" (2017) which also imposes ventilation requirements, specifically for spaces where workers are employed. The requirements for ventilation came into force in 2020 for new buildings, and imposed the development of action plans for existing buildings to meet the requirements when planning renovations. As a result the Codex has had a stronger impact on the design of ventilation systems for non-residential buildings, than ventilation guidelines in older legislation for employment protection. In many non-residential buildings, the Codex leads to larger flow rates compared to the requirements for IDA3 in the energy performance regulations, thus in that case the Codex is decisive for the required design flow rates.
The Codex requires the employer to take the necessary measures to ensure that the CO_2-level in the workspace remains below 900 ppm or to ensure a ventilation flow rate of 40 m³/h per person present in the workspace. The CO_2-concentration requirement should be met during 95% of the occupation time, and assuming an outside concentration of 400 ppm. If the outdoor concentration is higher, the difference between 400 ppm and the actual outdoor concentration can be taken into account.
As an alternative, if the employer can demonstrate that pollution sources affecting indoor air quality have been eliminated or significantly reduced, e.g. by applying low-emission materials, the CO_2 requirement may be relaxed to 1200 ppm, or the minimum flow rate to be ensured amounts to 25m³/h per person present. The employer needs to seek advice from the relevant prevention adviser and committee in this case. The pollution sources mentioned in the Codex include building materials, flooring, finishing, furniture, equipment and cleaning of the workspace, among others. However, in practice, based on the methods and product information currently available in Belgium, it is sufficient that only floor coverings meet legal requirements for VOC-emissions, including formaldehyde (FOD WASO 2019, Belgian Government 2014).

2 NATIONAL TRENDS IN ENERGY REQUIREMENTS AND MARKET

2.1 Energy requirements

The energy requirements concern both energy efficiency of the building and indoor climate (summer comfort and ventilation), and are specified in a number of sub-requirements to which all new and renovated buildings have to comply:

- thermal insulation: maximum U-value of building envelope components and maximum overall heat loss coefficient
- maximum E-level (measure for total primary energy use of the project)
- minimum ventilation requirements
- maximum value of overheating indicator (summer comfort), only for residential buildings

The influence of ventilation is taken into account in the calculation of the heat loss coefficient of the building, and has an influence on the calculated E-level and overheating indicator. As a consequence energy performance requirements have an impact on ventilation system selection and design. There are two calculation procedures: one for residential buildings, and one for non-residential buildings. The following parameters, related to ventilation, can be taken into account (* = residential only, ** = non-residential only):

- Design flow rate** (for dwellings the flow rate is a function of the building volume only, regardless of design flow rates or system types)
- Building function**: defines function specific operation time of ventilation, e.g. 100% for patient rooms in health care, 30% for offices or schools.
- Heat recovery: temperature efficiency, automatic flow control to balance air flow rates, summer by-pass
- Demand control (see §4)
- Fan energy use
- Ventilative cooling (opening of windows, increased mechanical ventilation rates**, night ventilation**, earth-to-air heat exchanger, evaporative cooling)
- Pressure controlled trickle ventilators*
- Correctly commissioned flow rates*
- Ductwork airtightness*

As can be observed, these parameters not only involve system or product selection, made in the design stage, but also parameters that are a result of high quality installation and commissioning work. In between 2010 and 2021 the energy performance requirements saw a tightening to move towards nearly zero energy buildings, with the E-level to be achieved in new dwellings shifting from E100 to E30. As a consequence, energy efficient ventilation techniques received more and more attention.

2.2 Other drivers in energy performance

The recognition of EPB product data is a service that the Regions offer to all stakeholders with the aim of providing user-friendly product data that provides legal certainty for calculations in the context of the EPB regulations (Caillou 2017). The recognition of EPB product data is based on a voluntary scheme with procedures that ensure that the product data will be accepted without reservation by the administrations. This data is collected in a EPBD product database www.epbd.be and will never be questioned by the three Belgian regions when checking EPB declarations. It includes performance data of over 1000 ventilation components and systems:

- Trickle ventilators
- Air handling units and fans
- Demand controlled residential ventilation systems (DCV)

As an example Figure 2 shows the performance data of air handling units for balanced mechanical ventilation with heat recovery available in the database. There are data of units with a flow rate of up to 8000 m³/h, but since the majority of systems in the database are for residential applications the figure is restricted to units below 1500 m³/h. The comparison between systems with recognised data until 2023 and after 2024, don't show a systematic better performance for newer systems. The specific fan power was calculated as the ratio of maximum fan power (2 fans) and maximum ventilation flow rate documented in the database. The data show a large variation in SFP with only a small share meeting the SFP-3 class (< 0.4 W/(m³/h)).

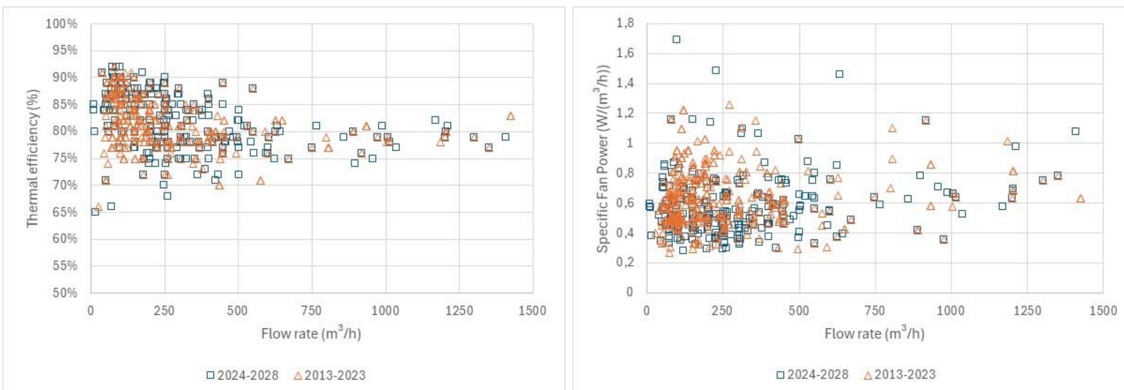

Figure 2: Performance data of air handling units for balanced mechanical ventilation with heat recovery: thermal efficiency of heat recovery system (left), and specific fan power (right) as a function of ventilation flow rate.

The performance of DCV is taken into account by means of a control factor which expresses the ratio between the ventilation heat loss in the DCV system and the ventilation heat loss in a reference system with constant air flow (CAV). In the energy performance calculation method for dwellings 60 different classes of DCV are described each with a predefined control factor varying in between 0.35 for systems with local CO_2-control of supply flow rates and local control of extraction rates in all spaces, and 0.95 for systems without specific control of supply flow rates and with central control of extraction rates (Caillou et al. 2014, Flemish Government 2018). For non-residential buildings DCV control factors are related to the control classes defined in NBN EN 13779 with values ranging from 0.70 (IDA-C6, direct control e.g. CO_2) to 1.00 (IDA-C3, time control).

3 NATIONAL TRENDS IN THE INSPECTION OF VENTILATION SYSTEMS

3.1 Requirements on the inspection of ventilation systems

Since 2016, the Flemish government has been focusing on improving the quality of ventilation systems in residential buildings. As a result, two documents have been required [28] as of January 1st 2016: (1) a ventilation preliminary design (VPD) before the start of the construction works and (2) a ventilation performance report (VPR) after the construction works have been completed. Both are mandatory in Flanders for all new residential buildings and all residential buildings undergoing a deep energy renovation.
The preliminary design of the ventilation system comprises a floor plan with indication of all ventilation components, including the position of the ventilation unit, the position and the

indicative diameter of the ductwork. Details can be found in a separate document (STS Werkgroep 2017a).
The ventilation performance report is so far the only mandatory document that relates to the ventilation system after it has been installed and thus it is the only document requiring an inspection. The result is an objective overview of the as-built energy related performances of the installation which must be used as a reference in the energy performance reporting of the dwelling (STS Werkgroep 2017b).
There are no obligations about inspection of ventilation systems for non-residential buildings. Although in the Brussels Capital region and Walloon region a reporting of the ventilation performance is necessary as part of the energy performance reporting of the building, no formal inspection framework is implemented there.

The key document is the "unified technical specifications for ventilation in residential buildings" (STS-P 73-1 2015). In these STS-P, the criteria for ventilation systems that could be prescribed and could be reported are listed. STS-documents are edited by the Belgian Federal Public Service for Economy and can thus be applied in the three regions in Belgium. In complement to the STS-P, technical guidance for installers was developed (Caillou & Van den Bossche 2016).
The STS-P does not prescribe requirements for the ventilation system, but lists possible evaluation criteria for ventilation systems and how to prescribe and determine the performance of the ventilation system for each of the criteria. For example, the STS-P does not impose or advice a certain specific fan power of the system (SFPsystem), but it defines the formula for calculating the SFPsystem, the classes, and the method for measuring the power consumption of the ventilation unit. It is then up to the builder to define which class of SFPsystem should be reached and to the ventilation inspector to determine the actual class of SFPsystem.
Different levels of requirements may apply to a ventilation system, e.g. the energy performance regulation sets only minimal ventilation flows, but a builder could require better IAQ, so higher ventilation flows. Therefore the output of the ventilation inspection is not a declaration of conformity to a requirement, but a report (the VPR) with objective data and figures about the performance of the ventilation system such as (neither exhaustive, nor applicable to all):

- per room the measured air flow or the nominal air flow of air inlets,
- the efficiency of the heat recovery unit,
- the power consumption of the fan at nominal air flow,
- the description of the demand controlled ventilation system,

The main concern within the inspection framework is the correct reporting of the performances of the ventilation systems. There is a system of auditing the ventilation reporters, described more in detail by De Strycker et al. (2019) to guarantee that the content of the VPR is representing the actual situation of the ventilation system at the moment of inspection.

3.2 Inspection protocols

The ventilation performance report must be compiled by one or more qualified ventilation reporters and delivered by a company, recognised by one of the organisers of a quality framework, which are recognised by the authorities.
The qualification procedure for the reporters includes:

- Optional theoretical training
- Theoretical exam for each component of the ventilation system
- For reporters qualified for measuring mechanical air flows a practical exam

Apart from passing the required exams and being recognised by an organiser of a quality framework there are no restrictions on who can compile the VPR. Mostly installers, energy performance reporters and airtightness measurers are acting as ventilation reporters.
In December 2017 and October 2020, the Flemish government has tightened the requirements for organisers of the quality framework for the inspection of residential ventilation systems. The organiser of a quality framework must have a qualification procedure for ventilation inspectors, which includes at least an optional training, and a mandatory theoretical and practical exam. The organiser must guarantee the reliability of the ventilation reporting by running desktop and on-site audits combined with effective enforcement. Minimal random annual desk and on-site audits is 10% each. Random checks are supplemented by targeted checks so that 90% of the active inspectors are checked at least once a year. He has to develop a database gathering all measurement data that can be consulted by the authorities. He should not have any members or directors who also carry out ventilation reporting in the context of the regulation.
Two types of measurement devices are necessary for the inspection: flow measurement devices and a power meter for the power consumption of the fan(s). The air flow measuring method used, must have a measurement deviation that does not exceed 15% of the measured flow value. The device must be calibrated every two years (BCCA 2024). The requirements for the power meter are defined by ministerial decree (Flemish Government 2018). It is not mandatory to measure and report the power of the fans, but it is strongly recommended and is done in the majority of cases. When the performance of the ventilation system is not conform the energy performance regulations, a penalty defined by the Flemish authorities is defined. Ventilation systems not conforming the requirements set by the builder are handled by contractual law.

4 IMPACT OF THE COVID-19 PANDEMIC

Belgium has passed a law in 2022 aiming to enhance the indoor air quality in publicly accessible spaces in the aftermath of the COVID-19 pandemic (FOD Health, 2022). Part of this legislation focusses on raising awareness about indoor air quality in the general population as they are often not aware of the risks linked to high pollutant concentrations indoors. This law, among other things, requires publicly accessible spaces to apply a CO_2 meter, defines two reference levels for IAQ based on the requirements of the Codex, and will provide an official label and underlying certification procedure that allows publicly accessible spaces to quantifiably showcase the efforts done to maintain good Indoor Air Quality (IAQ).
Since then, the Belgian Federal Public Health Service has been developing the more detailed, practical implementation of this new law, in consultation with stakeholders and research institutes. Originally it was the intention to have all necessary royal decrees ready to be able to bring into force all elements of the law by 2025. However a change in law has postponed the mandatory entry into force until 2038. Meanwhile, operators of publicly accessible spaces may implement elements of the law on a voluntary basis. To this end, Royal Decrees establishing requirements for CO_2-meters and air cleaners have been published in 2024.

5 ANNEX A: EXAMPLES OF MANDATORY FLOWRATES

5.1 Dwellings

House of 90 m² (2.5m height), 1 main room (32 m²), 3 bedrooms (1 master (2 adults, 12 m²), 2 kids (10 m² each)), 1 kitchen (12 m²), 1 bathroom (4 m²) and 1 toilet (2 m²)

- Total minimum supply flow rate: 230 m³/h
  - Main room: 115 m³/h
  - Master bed room: 43 m³/h

    - Children rooms: 36 m³/h each
- Total minimum extract flow rate: 125 m³/h
    - Kitchen: 50 m³/h
    - Bathroom: 50 m³/h
    - Toilet: 25 m³/h

Apartment of 50 m², 1 main room (24 m²), 1 bedroom (12 m²), 1 kitchen open to the main room (8 m²), 1 bathroom with toilet (4 m²)

- Total minimum supply flow rate: 130 m³/h
    - Main room: 87 m³/h
    - Bedroom: 43 m³/h
- Total minimum extract flow rate: 125 m³/h
    - Open kitchen: 75 m³/h
    - Bathroom with tolet: 50 m³/h

5.2 Non-residential

A classroom of 50 m² with 25 students, 1 teacher:

- Based on ventilation requirements EPB: minimum ventilation rate = 572 m³/h (26 occupants with 22 m³/h/person; design occupation is larger than nominal occupation of 13 persons (50 m² with max. 4 m² per person), so the design occupation is decisive)
- Based on ventilation requirements Codex:
    - If low-emission class room: minimum ventilation rate = 650 m³/h (26 occupants with 25 m³/h/person)
    - Otherwise: minimum ventilation rate = 1040 m³/h (26 occupants with 40 m³/h/person)
        - Another flow rate can be estimated based on the requirement of maximum CO_2-concentration of 900 ppm and an estimate of CO_2-emission rate for the expected metabolism and age of occupants.

An office of 12 m² with 1 occupant:

- Based on ventilation requirements EPB: minimum ventilation rate = 22 m³/h (design occupation is equal to nominal occupation (12 m² with max. 15 m² per person))
    - If the office would be larger than 15m², then the nominal occupation would become 2 persons and be decisive, even if the design occupation is 1. In this case the minimum flow rate would become 44 m³/h, and the EPB requirement would be larger than the Codex requirements.
- Based on ventilation requirements Codex:
    - If low-emission office: minimum ventilation rate = 25 m³/h
    - Otherwise: minimum ventilation rate = 40 m³/h
        - Another flow rate can be estimated based on the requirement of maximum CO_2-concentration of 900 ppm and an estimate of CO_2-emission rate for the expected metabolism and age of occupant.

6 REFERENCES

BCCA. (2024). Praktische uitdagingen bij het opmeten van ventilatiedebieten, versie 2.5. https://www.ikventileerverstandig.be/wp-content/uploads/2024/02/PraktischeUitdagingen_V025.pdf

Belgian Government (2014), *Royal Decree establishing the threshold levels for emissions to the indoor environment from construction products for certain intended uses*, C-2014/24239.

Belgian Government (2017), Codex over het welzijn op het werk (Codex on well-being at work) https://www.ejustice.just.fgov.be/eli/wet/2017/04/28/2017A10461/justel

Belgian Government (2022). Wet betreffende de verbetering van de binnenluchtkwaliteit in gesloten plaatsen die publiek toegankelijk zijn, C-2022/34199. https://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=nl&la=N&cn=2022110604&table_name=wet

Caillou, S., Heijmans, N., Laverge, J., & Janssens, A. (2014). Development of an evaluation methodology to quantify the energy potential of demand controlled ventilation strategies. *35th AIVC Conference Proceedings*, 587–596. Poznan. AIVC.

Caillou, S., Van den Bossche, P. (2016). TV 258 - Praktische gids voor de basisventilatie systemen voor woongebouwen. WTCB

Caillou S. (2017), Voluntary scheme and database for compliant and easily accessible EPC product input data in Belgium, *Towards compliant building airtightness and ventilation systems*, AIVC Contributed Report 16.

De Strycker, M., Van Gelder, L., Andrzejewicz, M., Leprince, V. (2019). Quality framework for residential ventilation systems in Flemish Region in Belgium – feedback after three years' experience. *40th AIVC Conference Proceedings,* 832-842. Ghent. AIVC.

Energiebesluit (2010) (Flemish Region), https://www.vlaanderen.be/epb-pedia/epb-regelgeving/energiebesluit-en-bijlagen

Environnement Brussels (2024) (Brussels Capital Region), https://environnement.brussels/pro/reglementation/textes-de-loi/legislation-coordonnee-de-la-reglementation-travaux-peb

Flemish Government. (2018). Bijlagen bij het MB van 28 december 2018. https://www.vlaanderen.be/epb-pedia/epb-regelgeving/ministeriele-besluiten-energieprestatieregelgeving/bijlagen-van-het-mb-van-28-december-2018

FOD WASO (2019), *Prakrijkrichtlijn 'binnenluchtkwaliteit in werklokalen'* (Practical guideline 'indoor air quality in workrooms', Federal Public Service Employment, Labor and Social Dialogue, in Dutch) https://werk.belgie.be/nl/themas/welzijn-op-het-werk/arbeidsplaatsen/basiseisen#toc_heading_3

Guide PEB (2015) (Walloon Region), https://energie.wallonie.be/fr/guide-peb-2015.html?IDC=9491

Institut Belge de Normalisation (1991), *NBN D50-001 – Ventilation systems for housings*.

Institut Belge de Normalisation (2004), *NBN EN 13779 - Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems.*

STS P 73-1 (2015). Systemen voor basisventilatie in residentiële toepassingen. https://assets.vlaanderen.be/image/upload/v1664213769/STS-P-73-1-Systemen-basisventilatie-residentiele-toepassingen_sjmqxc.pdf

STS Werkgroep (2017a). Werkgroepdocument A, Ventilatievoorontwerp (VVO), Aanvulling op STS-P 73-1: Systemen voor basisventilatie in residentiële toepassingen. https://assets.vlaanderen.be/image/upload/v1664214013/STS-P_73-1Ventilatie-WerkgroepdocumentA-ventilatievoorontwerp9februari2017_aaz0yi.pdf

STS Werkgroep (2017b. Werkgroepdocument B, Ventilatieprestatieverslag (VPV), Aanvulling op STS-P 73-1: Systemen voor basisventilatie in residentiële toepassingen. https://assets.vlaanderen.be/image/upload/v1664214128/STS-P_73-1Ventilatie-WerkgroepdocumentB-ventilatieprestatieverslag_ch3xwh.pdf

Van Hove M., Delghust M. & Janssens A. (2021). *Analysis of the feasibility of statistical models that can predict energy use in homes based on building parameters. Study ordered by Flemish Energy Agency* (in Dutch). https://assets.vlaanderen.be/image/upload/v1665674115/Analyse_haalbaarheid_statistische_modellen_die_energiegebruik_woningen_voorspellen_obv_gebouwparameters_quxvuv.pdf