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Overview of ventilation technologies supporting objectives of Directive 2024/1275 (EPBD) with respect to the provision and monitoring of IAQ.

Introduction

This document provides an overview of commonly available functions and capabilities of mechanical ventilation systems for non-residential and residential buildings that facilitate the implementation of Directive 2024/1275 (EPBD recast) requirements for the provision and monitoring of indoor air quality. Its objective is to indicate technically and economically feasible solutions for consideration in the guidance for the EPBD transposition by Member States.

Indoor Environmental Quality (IEQ) and Indoor Air Quality (IAQ)

Related to:	Article 2(66), Article 5(1) and Article 13(4)

As defined in the Directive, indoor environmental quality means the result of an assessment of the conditions inside a building that influence the health and wellbeing of its occupants, based upon parameters such as those relating to the temperature, humidity, ventilation rate and presence of contaminants. The presence of contaminants and relative humidity are generally considered to be determinants of indoor air quality (IAQ). Since ventilation systems discussed in this document play a key role in providing IAQ, the following sections focus primarily on IAQ and wellbeing aspects.

The subject literature lists almost 40 different air quality indicators, while in practice the relevant and comprehensive European standard[1] and common schemes[2] for assessing the environmental performance of buildings use only a few of them, which are most technically and economically feasible to be continuously monitored.

IAQ indicators technically and economically feasible for continuous monitoring

Ventilation rate

The correct ventilation rate, even though not directly perceived by occupants, is fundamental to maintaining IAQ parameters, i.e. relative humidity and presence of contaminants, at the desire level. It is essential that the actual ventilation rate is controlled and monitored against the design value or adjusted to the actual demand in DCV systems in order to optimise energy use. Ventilation rates to maintain an acceptable level of pollutants in the indoor environment are specified according to EN 16798-1:2019 requirements. Further comments on the specification of ventilation rates in relation to EN 16798-1:2019 are provided in the joint REHVA-EUROVENT-NVG guidance[3].

CO_2 level

CO_2 concentration is generally recognised as a proxy of ventilation effectiveness and is an important factor of good IAQ. The acceptable CO_2 levels indoors to be maintained and monitored are specified according to EN 16798-1.

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[1] EN 16798-1:2019 - Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.
[2] Such as Levels(s), WELL, OsmoZ, BES, LEED, BREEAM
[3] Proposed modifications and guidelines for implementation of Article 11a 'Indoor environmental quality' in EPBD draft. Common proposal by REHVA, Nordic Ventilation Group and EUROVENT, 2023

The CO_2 concentration should be controlled and monitored:

- For non-residential buildings: in all continuously occupied spaces, such as classrooms, offices, meeting rooms, restaurants, kitchens, shops, gyms, etc
- For residential buildings: in each habitable room, particularly living rooms and bedrooms.

Temperature

Indoor temperature is crucial for health and well-being and should be monitored in rooms for permanent occupation. The correct range of indoor temperature to be maintained and monitored is specified according to EN 16798-1. In winter, the correct indoor temperature in residential buildings, and typically in non-residential buildings is provided by a separate space heating system. Where applicable, in summer, the correct indoor temperature is provided by a separate space cooling system.

Relative humidity

The correct indoor relative humidity range, in addition to its significance for the human health and well-being, has a major impact on safety and counteracting the degradation of the building structure. Guidance on the correct range of indoor humidity to be maintained and, where appropriate, monitored is given in EN 16798-1.

Relative humidity should be controlled and monitored:

- For non-residential buildings: in all continuously occupied spaces and wet rooms.
- For residential buildings: necessarily in wet rooms such as kitchen, bathroom, laundry.

IAQ indicators of limited feasibility for continuous monitoring

In addition to the above listed parameters, there are other relevant indicators typically used in the IAQ assessment. However, with the currently available technology, their continuous monitoring is not economically feasible and justified. Their acceptable levels should be ensured by the correct design of ventilation system and validation measurements at the commissioning stage. These indicators include in particular:

PM2.5

The harmful effects of exposure to exceeded concentrations of particulate matter (PM) on human health have been proven by numerous studies, and an acceptable PM2.5 limit is recommended by the WHO[4]. PM2.5 pollutants can originate from indoor sources and/or outdoors. To eliminate PM2.5 pollution generated indoors (e.g. in the kitchen), the proper design measures must be applied (control of emission sources, appropriate ventilation rate etc.). To control the PM2.5 concentration originating from outdoors (ambient air), the mechanical ventilation system must be equipped with appropriate outdoor air filters that are properly maintained (timely replaced). Guidance on the proper selection of filters is provided in Eurovent 4/23[5].

Volatile organic compounds (VOCs)

The term VOC refers to a number of chemical compounds. One of the best know VOCs and at the same time easy to measure, is formaldehyde. In the assessment of IAQ, it is considered as an indicator of odours. The acceptable formaldehyde concentration may be ensured by an appropriate ventilation rate.

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[4] WHO Global Air Quality Guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization. Geneva, Europe; 2021

[5] Eurovent 4/23 - 2022 - Selection of EN ISO 16890 rated air filter classes. Brussels; 2023

Key performance indicators (KPI) for IEQ

For the time being, there is no single generally accepted and applied holistic method for assessing all IEQ parameters on a current and seasonal basis. The potential and worth mentioning methods are Levels(s)[6] and TAIL[7]. Furthermore, new whole year KPI's are to be included in the revised EN 16798-1-3, expected to be published in 2027.

Ventilation systems in non-residential buildings

Related to:	Articles 13(5), 13(9), 13(10)

The most typical ventilation system in non-residential buildings comprises a central ventilation unit (air handling unit) that serves a number of rooms or zones of similar requirements via ductwork for supply and extract air. For large buildings, this layout is replicated in individual parts or zones of the building, meaning that serval air handling units can be installed in a building.

Nowadays, most air handling units are equipped with an integrated control system, including controllers capable of advanced regulation and monitoring functions. According to Eurovent Market Intelligence[8], the rate of AHUs with integrated controls in the EU27 market in 2023 was 67, 3%.

System focused approach

Today's business model for HVAC suppliers, turns from a single product- focused approach to a system-focused approach. Most European HVAC manufacturers, in addition to air handling units with integrated controls, typically deliver all other system components necessary to ensure and monitor air quality, while optimising energy consumption to match actual demand. These elements include in particular, VAVs and room controllers with temperature, CO2 and relative humidity sensors, which makes HVAC manufacturers sort of a one-stop-shop for IAQ provision and monitoring.

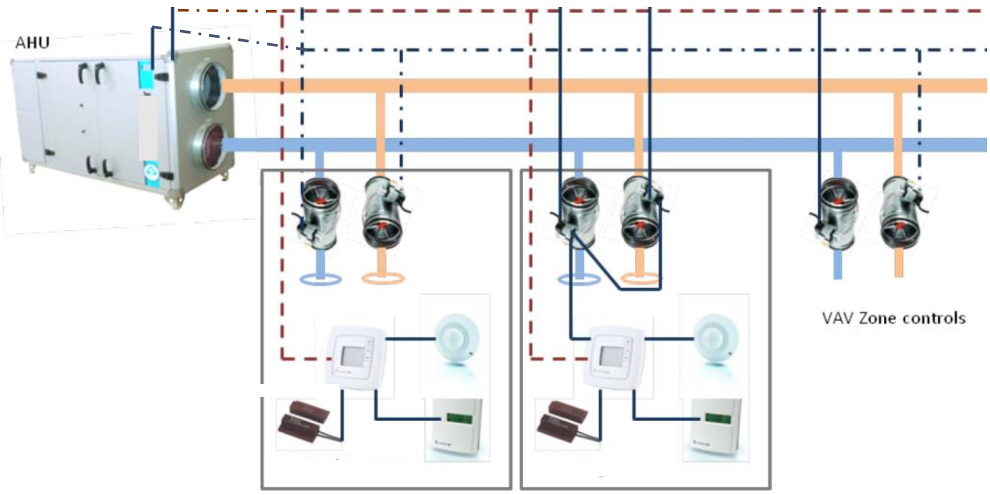

Figure 1. Example elements of a complete and optimised system for IAQ provision and monitoring.

[6] Dodd N., Donatello S. & Cordella.M., 2021. Level(s) indicator 4.1: Indoor air quality user manual: introductory briefing, instructions and guidance (Publication version 1.1)
[7] https://aldren.eu/aldren-tail/
[8] https://www.eurovent-marketintelligence.eu/

In practical terms this means, that IAQ can be effectively regulated and monitored by system optimised elements comprising a package delivered by one supplier as presented in Figure 2.

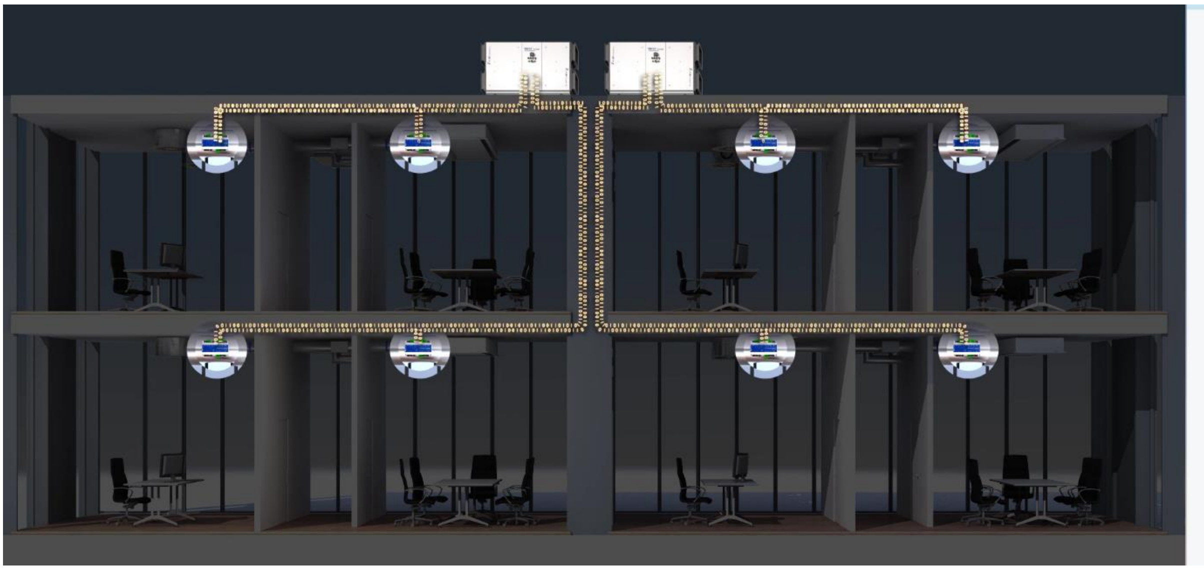

Figure 2. Package of optimised ventilation system components to control and monitor IAQ

Another key benefit of such an approach is that the integrated control system is designed to serve all components comprising the delivery package and is optimised in terms of effective and reliable operation, and easy and cost-effective installation.

Capability of ventilation systems for non-residential buildings to support the EPBD.

Elements of the ventilation system, usually offered as a package from a HVAC supplier, typically have the following features supporting the new EPBD provisions.

Air Handling Units

- Continuous measurement of ventilation air flow rate (supply and exhaust air).
- Continuous adjustment of ventilation air flow rate to the actual demand.
- Continuous measurement of ventilation air parameters (temperature, CO_2 level, relative humidity).

Variable Air Volume devices (VAV)

- Continuous adjustment and measurement of ventilation rate for individual rooms and/or zones.

Room controllers with integrated sensors or/and separate room sensors

- Continuous monitoring of room temperature, CO_2 and relative humidity

Integrated AHU control system

- Continuous monitoring and logging of ventilation rate, temperature, CO_2 and relative humidity at the AHU and room level.
- Adjusting system operation to the actual demand to regulate IAQ/IEQ and optimise energy consumption.

- Communication with other connected technical building systems, in particular heating and cooling generators, to adjust their capacity to the actual ventilation needs in order to optimise energy use.

User interface of AHU integrated control system

The integrated AHU controls, extended with additional system modules on site, if needed, are capable via user interface (e.g. online cloud applications) of:

- Analysing energy use for ventilation and allowing for its adjustment
- Detecting losses in efficiency of ventilation and air conditioning systems, and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement

Economical feasibility to comply with EPBD requirements for IAQ monitoring and BAC

The described functionalities of the ventilation system elements packages facilitate meeting the new EPBD provisions in an economically feasible way.

Given that in the majority of buildings, which are small and middle-sized, the ventilation systems in connection with heating and cooling systems, are the main technical building systems, and their integrated controls interoperative to adjust and optimise the energy use, they are able to meet the requirements of Articles 13(5), 13(9) and 13(10) without the need for installing a separate BAC system for integration. This considerably reduces the investment and operational cost rendering the compliance with new EPBD provision economically feasible, in particular due to:

- Integrated controls are delivered as a package from one supplier and contractor – no need for a separate BAC contractor.
- Integrated controls are an optimised system solution which does not require a separate project, which is the case for a separate BAC system.
- The integrated control system is optimised at the development stage and factory tested and configured, which – compared to separate and individual BAC systems - significantly facilitates and reduces cost and time of installation and commissioning

In the case of large and complex buildings (e.g. hospitals, big office buildings and hotels), which involve several technical building systems (lifts, solar shading system, advanced lighting control. etc), employing of a separate BAC system integrating other building technical system, will be necessary.

If a BAC system is required in light of the Article 13 and due to the complexity/size of a building, this requirement can be legally fulfilled by several BACS systems working together. This is important to avoid legislation or guidance promoting a single BAC system and delivering AHUs without their optimised integrated control systems.

Ventilation systems in residential buildings

Related to:	Articles 13(5), 13(11)

With regard to mechanical ventilation systems for residential buildings, two general types can be distinguished:

- Mechanical supply air and exhaust air system with heat recovery
- Mechanical exhaust air system with air inlets / infiltration

Both systems are applicable to single- and multi-family (multi-storey) residential buildings, while the first type is typical for cold climates and the second for moderate and warm climates. Examples of both systems in a single-family house are presented in Figure 3 and Figure 4.

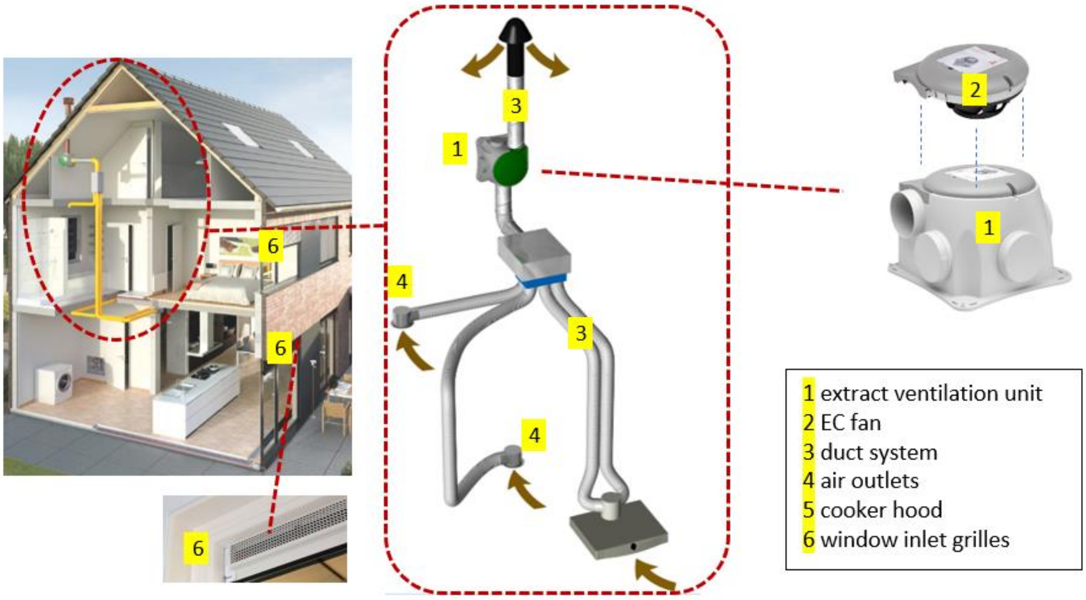

Figure 3. Example of a complete exhaust mechanical ventilation system in a single-family house.

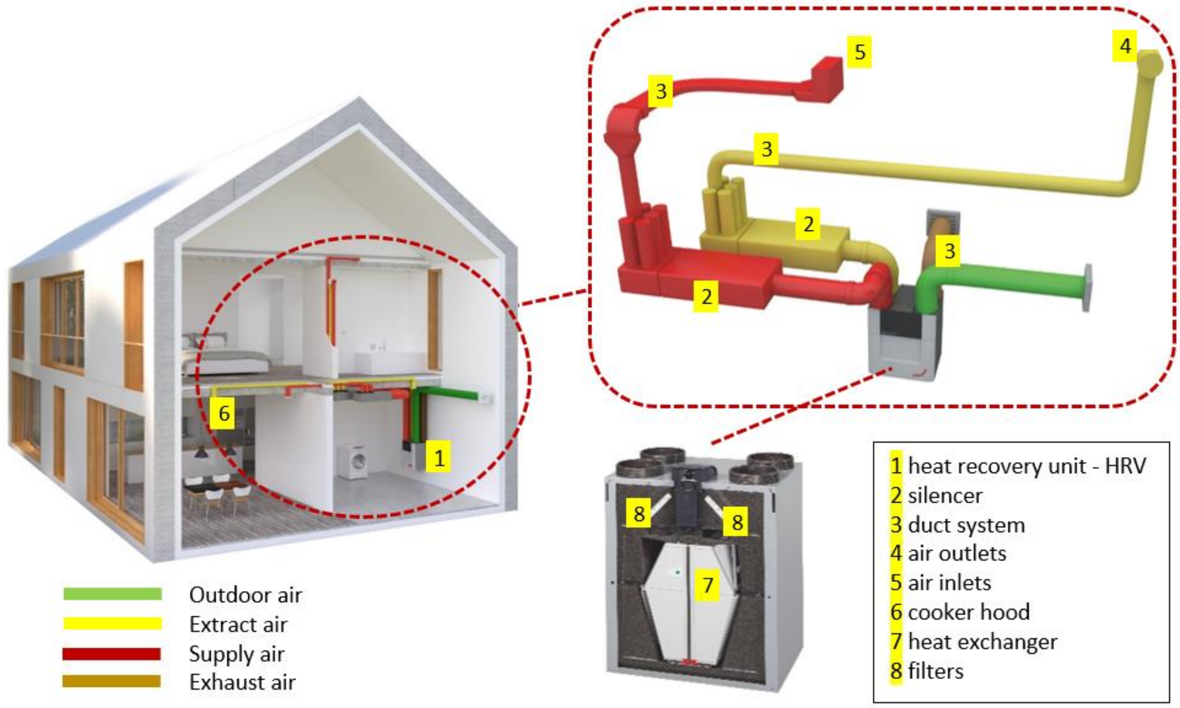

Figure 4. Example of a complete supply and exhaust mechanical ventilation system in a single-family house

A comprehensive overview of technologies with heat recovery is presented in the Eurovent guidebook[9] and a complete overview of all technologies that support the objectives of the EPBD 2024 recast will be outlined in a new recommendation (Eurovent 22/2), which is expected to be published by Q3 2024.

System focused approach

Similar to non-residential applications, today's business model for suppliers of residential ventilation equipment has shifted to a complete system approach. The manufactures typically offer all elements comprising the ventilation system, including ventilation units, ductwork with distribution boxes, air inlets and outlets and, of course, all components of the control system for the monitoring and regulation of indoor air quality.

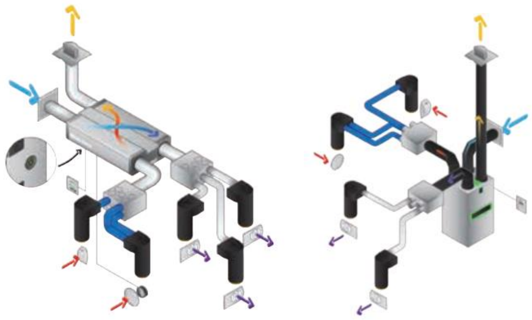

Figure 5. Examples of the delivery scope of components of a complete system

Capability of ventilation systems for residential buildings to support the EPBD.

According to Article 13(5), Member States may require installation of devices for the monitoring and regulation of indoor air quality in residential buildings. The following functionalities of the available technologies, notably due to their form of complete and optimised systems offered by one supplier, allow meeting this requirement without the need for any additional and separate BAC system.

Monitoring IAQ in individual rooms

Extract air devices (air outlets) can be equipped, depending on the room type, with different IAQ sensors (CO_2 and relative humidity) and thus monitor IAQ directly in the room they are installed in. Alternatively, IAQ may be monitored via sensors installed in the room controllers, or via separate sensors in the room, which can also be part of the complete system.

Adjustment of ventilation rate in individual rooms

Based on the measured actual IAQ values, the system adjusts a ventilation rate in individual rooms by means of either airflow control valves installed directly on a VU's duct connection that serves a particular room or control valves for individual rooms, installed in an air distribution box within the ductwork (see Figure 6). The total air flow rate of the VU fan is adjusted accordingly to optimise energy consumption.

[9] Eurovent Guidebook – Residential Heat Recovery Ventilation Units. Brussels: 2021.

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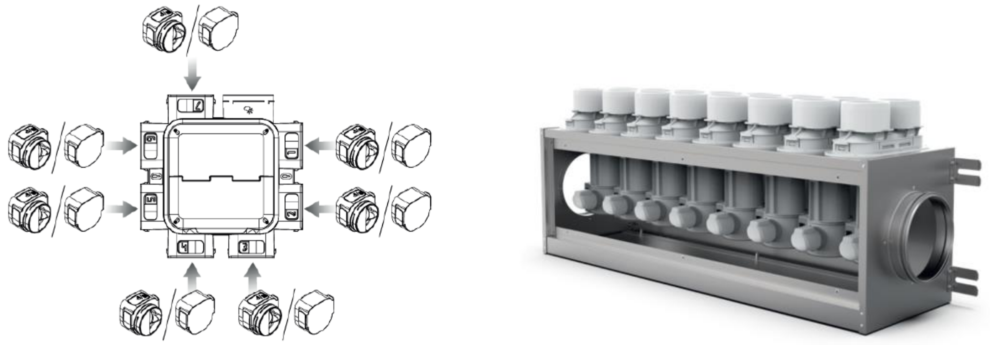

Figure 6. Extract fan with flow air controllers on duct connections (left). Distribution box with air flow controllers to individual rooms (right)

Further available functionalities of integrated controls systems

Integrated control systems of residential ventilation units may be independently capable of meeting the requirements of Article 13(11):

- The functionality of continuous electronic monitoring that measures ventilation systems' efficiency and informs building owners or managers in the case of a significant variation and when system servicing is necessary.
- The interoperability with other building technical systems, notably heating system, to ensure optimum generation and use of energy.
- a capacity to react to external signals and adjust the energy consumption.

However, their implementation may not be economically feasible in all residential buildings. Furthermore, in the opinion of Eurovent members, the capacity to react to external signal for electricity grid optimalisation, should not be applied to ventilation systems, in order not to interfere with the necessary continuous ventilation operation and to avoid risk of disrupting antifreeze protection systems.

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3. How European is the association? More than 90 per cent of manufacturers within Eurovent manufacture in and come from Europe. They employ around 150.000 people in Europe largely within the secondary sector. Our structure as an umbrella enables us to consolidate manufacturers' positions across the industry, ensuring a broad and credible representation.	**4. How representative is the organisation?** Eurovent represents more than 1.000 companies of all sizes spread widely across 20+ European countries, which are treated equally. As each country receives the same number of votes, there is no 'leading' country. Our national Member Associations ensure a wide-ranging national outreach also to remote locations.

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