Proposed modifications and guidelines for implementation of Article 11a ‘Indoor environmental quality’ in EPBD draft

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Common proposal by REHVA, Nordic Ventilation Group and EUROVENT

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New indoor environmental quality (IEQ) provisions added to Article 11 and 11a by the Commission's and Parliament's initiative, represent an important step forward to assure healthy and comfortable IEQ in buildings. This document suggests minor, but important changes in the text of Article 11a to make its implementation technically and economically feasible. The document also presents guidelines and examples how to implement the requirements of Article 11 and 11a on national level.

Guidelines are based on European framework for sustainable buildings LEVEL(s), focusing on implementation indoor air quality (IAQ) and thermal comfort requirements in national regulation, with specific instructions for continuous monitoring of the main parameters.

Summary of key guidelines for national IEQ regulatory requirements:

- Minimum requirements for indoor air quality, thermal comfort, lighting, and acoustic are to be set in the regulation for new buildings and major renovations;
- Indoor air quality, ventilation and thermal comfort requirements can be specified separately for residential and non-residential buildings;
- In non-residential occupied buildings, ventilation capacity must be 7 L/s per person plus 0.7 L/s per m^2 floor area, or alternatively CO_2 concentrations of 900-1200 ppm, depending on occupant density, must be fulfilled;
- In residential buildings an average ventilation capacity of a whole residence shall be 0.42 L/s per m^2 floor area and 7 L/s supply air per person which are recommended to be supported with room-based ventilation rate requirements;
- Room temperature ranges in residential and non-residential buildings must be specified for heating and cooling seasons;
- Establishing a requirement on the lower limit of relative humidity in cold climates and upper limit in southern humid climates can be considered;
- Requirements shall be specified so that it is possible to assess the compliance based on monitoring, measurements or simulations, therefore it is important to specify acceptable deviations;
- Application of measuring and control devices for the monitoring and regulation of indoor environmental quality shall be required at relevant unit level;
- Conducting continuous measurement of main indoor environmental quality indicators shall be required from continuously occupied spaces;
- It is good to support regulatory requirements with technical guidelines for the design and operation.

This version of the guidance document follows EPBD proposal March 14, 2023, and it will be updated when approved EPBD will be available.

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Articles 11 and 11a - Indoor environmental quality, EPBD draft 14.3.2023

Proposed minor changes that can be addressed in national implementation are marked in the original draft of articles 11 and 11a below. By our opinion the more clear distinction has to be made between continuously measured indicators, occasionally measured indicators and indicators measured only in inspections or commissioning.

Article 11

'3. Member States shall require the installation of measuring and control devices for the monitoring and regulation of ***indoor*** *environmental quality at relevant unit level and, where technically and economically feasible, in the following buildings:*

(a) zero emission buildings;

…'

Justification of proposed minor changes:

- It is proposed to add 'indoor' to clarify that environmental quality in the building is meant.

Article 11a - Indoor environmental quality

'1. Member States shall set requirements for the implementation of adequate indoor environmental quality standards in buildings in order to maintain a healthy indoor climate.

2. By ... [24 months after the date of entry into force of this Directive], Member States shall set requirements according to measurable indicators based on to those of the LEVELs framework.

Indoor environmental quality indicators shall be continuously measured inside the building and shall at least include:

(a) the level of carbon dioxide;

(b) the operative temperature ~~and thermal comfort~~;

(c) the relative humidity;

(d) the particulate matter;

The following indicators shall be measured and reported in the commissioning phase:

~~*(d) the level of daylight illumination or adequate daylight levels;*~~

(e) the ventilation rate in air changes per hour or supply and extract airflow rates at nominal fan speed;

(f) acoustic indoor comfort, such as the control of the reverberation time and background noise level and speech intelligibility.

The level of daylight illumination or adequate daylight levels and artificial lighting shall be verified and reported together with discomfort glare from both daylight and artificial lighting.

~~*Particulate matter of E*~~*emissions of indoor sources and target pollutant limits from indoor sources, on volatile organic compounds, classified as carcinogenic, mutagenic, or toxic for reproduction according to Regulation (EC) No 1272/20081, including formaldehyde, shall be reported on the basis of the available data at product level, or direct measurement where available.*~~*, of the relevant sources in relation to the indoor environment of the building.*~~

3. The Commission is empowered to adopt delegated acts in accordance with Article 29 to supplement this Directive by establishing a methodology framework for calculating the indoor environmental quality standards.

4. Member States shall ensure that new buildings and buildings undergoing major renovation comply with adequate indoor environmental quality standards.'

Justification of proposed minor changes:

- Regarding the indicators to be measured (from a to f), it is proposed to distinguish which indicators are to be continuously measured (a, b, c) and which ones once, in the commissioning phase, (d, e, f) and documented with a measurement protocol.
- '(b) the temperature and thermal comfort' indicates that thermal comfort should be monitored. Because standards use the operative temperature to assess general thermal comfort, the monitoring can be limited to operative temperature (see footnote 10 in par. 3.1).
- '(d) the level of daylight illumination or adequate daylight levels' does not include artificial lighting and glare which are important visual comfort parameters. Daylight provision is always simulated according to EN 17037 because it requires standard overcast sky conditions. Therefore, these parameters are proposed to be documented instead on measurement.
- The phrase 'Particulate matter of emissions of indoor sources' is not clear and should be rephrased, to enable to measure both exposures to particulate matter and to chemical compounds. For particulate matter, a continuous measurement is proposed in similar fashion with CO_2, temperature and RH, as low-cost sensors are well available.

Guidelines for implementing EPBD Indoor Environmental Quality requirements in national regulations

1 Introduction

EPBD draft[1] March 14, 2023 has established an ambitious target in Article 11a that *'Member States shall set requirements for the implementation of adequate indoor environmental quality standards in buildings in order to maintain a healthy indoor climate'*. These apply for new buildings and major renovations and include a list of measurable indicators. Additionally, Article 11 requires *'the installation of measuring and control devices for the monitoring and regulation of indoor environmental quality at relevant unit level'*.

EPBD Article 2 uses the following definitions for indoor environmental quality (IEQ):

57g. 'indoor environmental quality' means a set of parameters relating to a building, including indoor air quality, thermal comfort, lighting, and acoustic affecting the health and wellbeing of its occupants;

57h. 'healthy indoor climate' means the indoor environment of a building, which optimises the health, comfort and well-being of occupants in line with specific performance levels, including those related to daylight, indoor air quality and thermal comfort, such as mitigating overheating and enhancing acoustic quality.

Therefore, **minimum requirements in these four IEQ domains** (**indoor air quality, thermal comfort, lighting, and acoustic) are to be set in the regulation or building code for new buildings and major renovations**. EPBD article 11a states that requirements shall be set according to measurable indicators based on to those of the LEVEL(s) framework. Level(s) is European framework for sustainable buildings[2], providing IEQ indicators in User Manual 3, under Macro-Objective 4: Healthy and comfortable spaces, where indicators 4.1 to 4.4 can be found for IAQ, thermal comfort, lighting and acoustics. Regarding to numeric values, LEVEL(s) indicators 4.1[3] and 4.2[4] (IAQ and thermal comfort) refer to EN 16798-1:2019 standard which uses Categories I to IV to describe IEQ level. For daylight in buildings, LEVEL(s) 4.3 refers to EN 17037:2018 specifying parameters which are categorised as Minimum, Medium and High. As EPBD refers to 'healthy indoor climate' and 'optimising health', it is proposed to use the normal level of Category II specified in EN 16798-1:2019 which values will not only ensure avoiding adverse health effects but also improve comfort and well-being of occupants clearly above the minimum acceptable level.

Indoor air quality (IAQ) and thermal comfort depend on parameters which are continuously controlled with building technical HVAC systems, therefore acceptable ranges and deviations must be set in the requirements to enable verification as elaborated in separate sections below.

Acoustics' parameters may be verified by discontinuous measurements typically conducted in the commissioning phase. The same applies for artificial lighting, however, in the operation, energy efficient lighting is controlled based on daylight and occupancy. Daylight

[1] https://www.europarl.europa.eu/doceo/document/TA-9-2023-0068_EN.html

[2] https://environment.ec.europa.eu/topics/circular-economy/levels_en

[3] 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)

[4] Dodd N., Donatello S., & Cordella M., 2021. Level(s) indicator 4.2: Time outside of thermal comfort range user manual: introductory briefing, instructions and guidance (Publication version 1.1)

requirements are mostly verified during design phase by considering geometry, window types, orientation and shading. Some of the parameters are in practice difficult to measure as they require specific sky conditions and sun angles as well as receiver positions as for the daylight glare discomfort, verification which has to be assessed also for the artificial lighting glare according to EN 12464-1 specification and procedure. Some guidance on the formulation of minimum requirements for acoustics and lighting parameters are provided in EN 16798-1:2019 and EN 17037:2018.

In the following we focus on **specification of requirements for IAQ and thermal comfort**. The guideline is prepared to satisfy EPBD requirements so that only parameters which can be implemented in practice cost effectively are included. Monitoring is limited to those parameters which are useful and cost effective. As there are more cost-effective, indirect means than monitoring to control IAQ, such as filtration of ventilation air and reducing indoor pollutants by using low emission materials, requirements for air filtration and building materials are included to ensure achievement of IAQ target values and to avoid excessive air change rates which may otherwise be needed. Numeric values given in this guideline, following good indoor climate Category II, can be modified based on national conditions and culture.

2 Indoor air quality (IAQ)

Indoor air pollution originates from both indoor and outdoor sources, and from the interaction of pollutants and oxidants from both of these[5]. Indoor sources are building materials or cleaning products emitting volatile organic compounds[6], and respiratory effluents and body odours emitted by humans themselves, but also combustion, cooking, products with fragrances and resuspending floor dust[7]. Good IAQ requires controlling of indoor emission sources and concurrently reducing the entry of outdoor pollutants indoors which can be done by filtering of outdoor air pollutants and reducing infiltration. Multiple origin of indoor air pollutants makes IAQ monitoring complicated. Monitoring for all six pollutants included in WHO AQG[8] has shown to be infeasible because of the cost and complexity of compliance monitors to be deployed to all indoor spaces[9]. In addition to pollutants in WHO AQG many other harmful pollutants are common in the indoor air. Low-cost sensors for routine IAQ monitoring are available for particulate matter PM2.5 and CO that originates from combustion.

Thus, direct measurement of all indoor air pollutants is impossible in practice and generally requires sampling and subsequent chemical analysis. However, CO_2 concentration can be continuously monitored as a proxy for ventilation which is an important factor for good IAQ. PM2.5 monitoring will ensure that outdoor air for ventilation is clean or adequately filtered and there are no significant indoor sources of particulate matter. In the design of buildings, control of pollutant sources and ventilation requirements must be applied for good IAQ. To control particulate matter from outdoor sources, air filtration requirements are also

[5] Weschler, C. Chemistry in indoor environments: 20 years of research. Indoor Air 2011;21:205-218

[6] Harrison, P.; Crump, D.; Kephalopoulos, S.; Yu, C.; Däumling, C.; Rousselle, C. Harmonised regulation and labelling of product emissions-a new initiative by the european commission. Indoor and Built Environment 2011;20:581-583

[7] Qian, J.; Peccia, J.; Ferro, A.R. Walking-induced particle resuspension in indoor environments. Atmospheric Environment 2014;89:464-481

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

[9] Salthammer, T. TVOC-revisited. Environment International 2022:107440

needed. The following minimum requirements are to be established to control IAQ:

1. Source control must be applied for pollution sources from building materials and interior design through the use of low polluting building materials as defined in EN 16798-1:2019;
2. Ventilation rates to maintain an acceptable level of pollutants in the indoor environment are to specified according to EN 16798-1:2019 requirements;
3. To control particulate matter, ventilation with filters is one way of meeting the requirements in areas where the WHO limits for outdoor air are exceeded. For non-residential buildings filters are specified in EN 16798-3. If no ventilation with filters is used, other measures need to be considered. ;

As EPBD requires in Article 11 the installation of measuring and control devices for the monitoring and regulation of indoor environmental quality at relevant unit level and, where technically and economically feasible, this requirement shall be included to national regulation. By this requirement it is ensured that minimum requirements of ventilation rates, discussed in the following sections, can be treated as nominal (design) ventilation rates. During the operation, ventilation rates based on demand can be used according to CO_2, temperature and relative humidity control.

It is not specified in EPBD in how many spaces and which space categories these parameters must be monitored. However, the wording 'at relevant unit level' guides to monitor these parameters in all continuously occupied spaces, such as classrooms, offices, meeting rooms, restaurants, kitchens, shops, gyms, etc. The parameters to be monitored are CO_2, temperature, relative humidity and PM2.5. In residential buildings, it would be meaningful to monitor CO_2, temperature and PM2.5 in living rooms and bedrooms, and relative humidity in wet rooms such as toilets and bathrooms.

2.1 Indoor air quality and ventilation in non-residential buildings

To set ventilation airflow rate requirements as outdoor air flow rates, the first method (6.3.2.2 Method 1) in EN 16798-1:2019 based on perceived air quality can be used. This method is applicable in indoor spaces where the criteria for indoor environments are set by human occupancy and where the production or process does not have a significant impact on the indoor environment. In non-residential buildings, ventilation rates in occupied rooms are calculated based on perceived air quality by the visitors (unadapted persons) depending on the emissions from humans and building materials. The required outdoor air ventilation rate is:

$$q_{tot} = N q_p + A_R q_B \qquad (1)$$

where

q_{tot} total outdoor air ventilation rate for the breathing zone, L/s (1 L/s = 3.6 m^3/h)

N design value for the number of persons in the room,

q_p ventilation rate for occupancy per person, 7 L/(s person)

A_R room floor area, m^2

q_B ventilation rate for emissions from building, default value 0.7 L/(s m^2) assuming low polluting materials. When very low-polluting building materials (certified by national material emission control/labelling systems) are used, q_B = 0.35 L/(s m^2), and in the case of non-low-polluting certified building materials q_B = 1.4 L/(s m^2).

It should be noted that Equation 1 with provided L/s per person and L/s per floor area values can be set as ventilation requirement in the regulation, but the numeric values will depend on occupant density. Thus, it can be recommended to refer to standards or guidelines where default occupant density values can be found for straightforward and transparent application.

In the case of specific pollutants, the design ventilation rates shall be calculated based on a mass balance equation for the substance concentration in the space, taking into account the outdoor concentration (6.3.2.3 Method 2 using criteria for individual substances). This method is not discussed in this document because it is used only very rarely as the data on emission rate of pollutants is not available.

As an alternative to ventilation airflow rates, IAQ and ventilation requirements can be set with CO_2 values. Threshold CO_2 concentrations can be calculated with ventilation rates defined by Equation 1 and metabolic CO_2 generation (typically 20 L/(h person)) from CO_2 volume balance.

As these CO_2 concentration values depend considerably on the occupant density, it is an option to use in the regulation the following values where occupancy is fixed (absolute values, outdoor concentration 400 ppm):

- 900 ppm in rooms where floor area is >6 m^2 per person;
- 1000 ppm in classrooms;
- 1200 ppm in other rooms where floor area is <3 m^2 per person.

From these values, 900 ppm and occupant density >6 m^2 per person refers to typical offices. If occupant density is higher, i.e., <3 m^2 per person, that is the situation for instance in meeting rooms, auditoriums and restaurants, per floor area component in Equation 1 provides smaller addition to total airflow rate calculated per person, that increases CO_2 value. Classrooms belong to spaces with high occupant density (typically 2 m^2 per person), but the lower CO_2 generation rate of 18 L/(h person) reduces CO_2 value to 1000 ppm.

Regardless of the application and other factors, the objective should be not to exceed the CO_2 concentration threshold of 1200 ppm.

It should be noted that CO_2 values provided, represent steady state (long term occupancy) and in the ventilation control, lower values must be used as setpoints because it takes time while the concentration builds up. During occupied hours, minimum ventilation rate cannot be smaller than needed to remove emissions from building. These technical details should be provided either in regulatory or in technical guidance documents.

The above CO_2 values may be used also in the monitoring of IAQ by continuous measurement. In the assessment of compliance with IAQ requirements, acceptable deviation from these values shall be no more than 5% during occupancy hours.

2.2 Ventilation and IAQ in residential buildings

Ventilation requirements for residential buildings may be set by following B.3.2.2 in EN 16798-1:2019 which specifies 0.42 L/s m^2 (0.6 ach) total ventilation of a whole residence and 7 L/s per person supply air flow requirements. These general requirements are developed further in REHVA Guidebook GB 25, shown in Table 1. Typical number of occupants and are used, also distinction has been made between supply and extract air flow rates.

Table 1. Minimum airflow rates in residences.

	Supply airflow rate L/s	Extract airflow rate L/s
Living rooms[1] >15 m^2	8+0.27 L/(s·m^2)	
Master bedroom and bedrooms >15 m^2	14	
Living rooms and bedrooms 11-15 m^2	12	
Bedrooms <11 m^2, 3rd and successive bedrooms in large apartments	8	
WC		10
Bathroom		15
Bathroom in one room apartment		10
Utility room		8
Wardrobe and storage room		6
Kitchen[2]		8
Kitchen[2], one room apartment		6
Kitchen[3], cooker hood in operation		25
Average airflow rate of a whole residence L/(s m^2)	0.42	
Staircase of an apartment building, ACH	0.5	

[1] Transfer air from bedrooms can be used as a part of supply air but 12 L/s is minimum outdoor air rate

[2] Airflow rate in the kitchen when cooker hood is not in operation

[3] Requirements of national regulations including fire regulations are to be followed

The ventilation supply airflows to the bedrooms and living rooms are expressed as an outdoor airflow rates which shall be supplied primarily to living rooms and bedrooms. The ventilation air for the kitchen, bathroom and toilet has to be transfer air from the bedrooms and living rooms. Doors or specific openings must allow transfer air flows without significant pressure loss. From wet rooms extract airflows shall be used to remove pollutants and humidity.

In residential buildings, monitoring and regulation of all IAQ parameters is not economically feasible. The parameters that should be monitored and controlled are CO_2 in living rooms and bedrooms, and relative humidity in wet rooms. Demand controlled ventilation systems regulating the air flow to maintain acceptable CO_2 and humidity levels are recommended. It is possible to locate CO_2 and relative humidity sensors in the rooms or alternatively, inside the ventilation unit or extract ductwork. The latter option enables to detect occupancy and for instance to operate ventilation unit in 'at home'/'out of the home' mode.

3 Thermal comfort

3.1 Thermal comfort range

Indoor environmental parameters for thermal comfort are specified in EN 16798-1:2019 standard. These include parameters for general thermal comfort and local thermal discomfort (draught, radiant temperature asymmetry, floor temperatures, vertical air temperature differences). The minimum requirements in the regulation shall include at least room temperature[10] ranges for sedentary activities (1.2 met). Requirements may be split between non-residential and residential buildings where higher adaptation is possible (Category III temperature values in summer) in residences as shown in Table 2.

Table 2. Room temperature requirements, an example following Category II values (Category III values in summer in residential) and applicable for heating dominated climates

Building Category	Heating season, (1.0 clo) °C	Cooling season, (0.5 clo) °C
Non-residential buildings	20.0 - 24.0	23.0 - 26.0
Residential buildings	20.0 - 25.0	22.0 - 27.0

Values in Table 2 work for establishing design values for dimensioning of heating and cooling systems by using the lower value in heating season for the heating system and the upper value in cooling season for the cooling system. Heating season is defined when the outside running mean temperature is below 10 °C and cooling season when it is above 15 °C. Between 10 °C and 15 °C running mean temperature, room temperature may lie in between the heating and cooling season values.

Acceptable deviation from the specified range in Table 2 is maximum 5% of the occupancy time. In residential buildings, additionally 150 Kh (Kelvin hours) above 27 °C may be used as acceptable excess in heating dominated climates.

3.2 Relative humidity (RH)

For relative humidity in buildings with no other humidity requirements than human occupancy (e.g. offices, schools and residential buildings), EN 16798-1:2019 states that humidification or dehumidification of room air is usually not required. Example of recommended design criteria for the humidity in occupied spaces are given if the humidification and dehumidification systems are installed. This illustrates the complexity of regulating RH numeric values because the humidity criteria depend on many factors: health, thermal comfort, indoor air quality, condensation, mould growth etc. Poor ventilation and excess humidity can create ideal conditions for microbial growth especially in kitchen and bathrooms as well on surfaces cooled by thermal bridges. Microbial growth, in turn, can provoke respiratory or allergenic health issues, while very low RH (< 20%) can cause irritation of the eyes, nose and throat[11]. RH discussion in the context of Covid, lead also to the recommendation to avoid RH below 20% because respiratory track and mucous membranes are then more sensitive to infections[12].

Thus, there are two possible options to deal with RH requirements, either not to set at all or to set a lower limit following LEVEL(s) or EN 16798-1 values. Some Member States have

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[10] In EN 16798-1:2019 room temperature is specified as operative temperature that is calculated based on air temperature, mean radiant temperature and air velocity. In new and deeply renovated buildings, the operative temperature is almost equal to the air temperature.

[11] 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)

[12] Kurnitski J, Wargocki P, Aganovic A. Relative humidity effects on viruses and human responses. REHVA Journal, December 2021 https://www.rehva.eu/rehva-journal/chapter/relative-humidity-effects-on-viruses-and-human-responses

already specified national values in EN 16798-1 Annex A. The upper limit can be relevant in summer in southern humid climates where a requirement can be set following EN 16798-1 values. If requirements leading to humidification will be used it should be noted that the humidifier itself can be a source of pollution (microbial and chemical) if not properly maintained.

If the lower limit requirement of RH are set, they should be specified by the use of the building/building type.

Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA)

https://www.rehva.eu/

REHVA, founded in 1963, is a European professional federation that joins national associations of building services engineers. Today REHVA represents more than 120.000 HVAC designers, engineers, technicians, and experts from 26 European countries. REHVA is dedicated to the improvement of health, comfort, energy efficiency in all buildings and communities. REHVA provides its members with a platform for international networking and knowledge exchange, contributes to technical and professional development, follows EU policy developments, and represents the interests of its members in Europe and in the world. REHVA's mission is to promote energy efficient, safe and healthy technologies for mechanical services of buildings by disseminating knowledge among professionals and practitioners in Europe and beyond.

Nordic Ventilation Group (NVG)

http://www.scanvac.eu

Nordic Ventilation Group, founded in 1972, is a group of academics sharing the same interest and concerns regarding the indoor climate and ventilation. The objective of the Nordic Ventilation Group (NVG) is to develop Nordic ventilation technologies and services for good and healthy indoor environment with an energy efficient and environmentally friendly way. The work is 100% voluntary and free from commercial interest. Possible outcomes of the work can be published through various channels with the common agreement of the group.

EUROVENT

https://eurovent.eu/

Eurovent is Europe's Industry Association for Indoor Climate (HVAC), Process Cooling, and Food Cold Chain Technologies. Its members from throughout Europe represent more than 1.000 companies, the majority small and medium-sized manufacturers. Based on objective and verifiable data, these account for a combined annual turnover of more than 30bn EUR, employing around 150.000 people within the association's geographic area. This makes Eurovent one of the largest cross-regional industry committees of its kind. The organisation's activities are based on highly valued democratic decision-making principles, ensuring a level playing field for the entire industry independent from organisation sizes or membership fees.