The influence of ventilation on CO_2 concentration, compared to the requirements of the I5/2022 regulation

Influența ventilației asupra concentrației de CO_2, raportat la cerințele normativului I5/2022

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Abstract: *The standard for the design, execution, and operation of ventilation and air conditioning installations, indicative of I5/2022, establishes four indoor air quality categories for the occupied area of civil premises. For residential civil buildings, the main source of pollution is bio-effluents emitted by humans. This article presents the result of measuring the CO_2 concentration values recorded in three buildings during the period when there were no users. The analysis of the recorded results does not show any causal links between the way ventilation is performed, through infiltration through leaks or mechanical ventilation with heat recovery, and the variation in indoor CO_2 values.*

Key words: ventilation, CO_2 concentration, indoor air quality

1. Introduction

A building is in use when the occupants carry out various residential or professional activities and it is necessary to ensure bioclimatic conditions, and it is in standby when there are no users in the building, but the bioclimatic conditions must be maintained at a higher level of energy efficiency.

Indoor air quality is the most important component in ensuring a healthy living environment; it is determined by a control based on real-time monitoring of the operation of heating, ventilation, and air conditioning systems.

To manage the quality of the living environment and evaluate the performance of technical systems, it is necessary to know the values of pollutants, including CO_2 concentration. [1].

Although in residential constructions the main CO_2 polluter is human presence, there are other potential sources that generate CO_2 emissions such as the construction

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materials from which the walls are made, the materials from which the furniture is made, the utility installations, the combustion of fuels for food preparation, etc. [2].

The literature focuses on monitoring and evaluating bio-effluent emissions generated by occupants/users [3], [4], [5], [6], [7], [8], [9], without identifying the value of CO_2 emissions generated by other potential sources [2].

This article analyzes the CO_2 emissions monitored in three buildings without users, buildings built in different periods, part of a condominium but also independent homes, made of established materials but also of earth and straw, with ventilation with recovery but also ventilation through infiltration through leaks.

2. Methods

The CO_2 concentration measurements were taken in actual living rooms and compared with the regulations mentioned earlier.

This indicates that when conclusions are drawn regarding the indoor climate, a satisfactory indoor climate is defined based on the presented regulations.

2.1 Description of the houses studied;

2.1.1. Passive apartment Bucharest.

The construction, completed in 1976 (see Figure 1), is part of a condominium consisting of 47 apartments. It is situated on the 10th floor of a 12-story building, at an elevation of 33 meters above ground level.

The condominium features a reinforced concrete frame structure with a BCA envelope.

In 2023, the building underwent thermal rehabilitation, which involved the application of a 10 cm thick layer of mineral wool with a thermal conductivity of λ = 0.036 W/(m·K).

Although the apartment originally had two bedrooms and a living room, it was reconfigured by transforming the kitchen into bedroom 3 and moving the cooking and food preparation activities to the balcony.

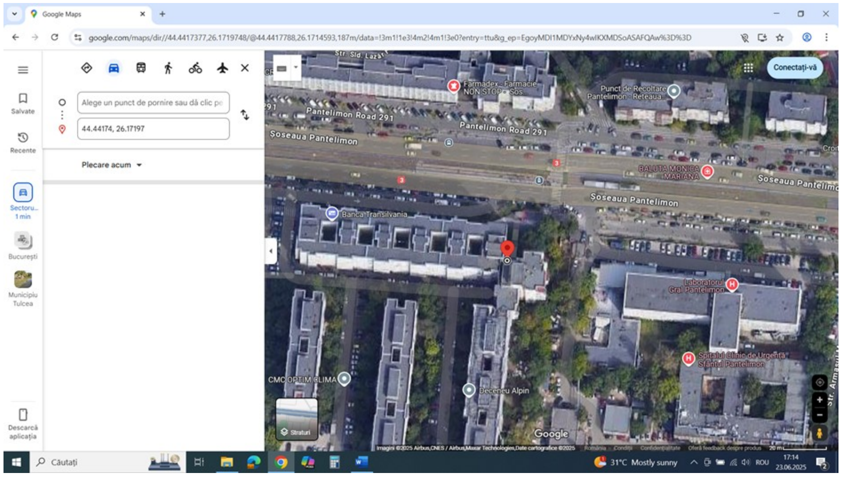


Fig. 1. "Passive" apartment location Bucharest

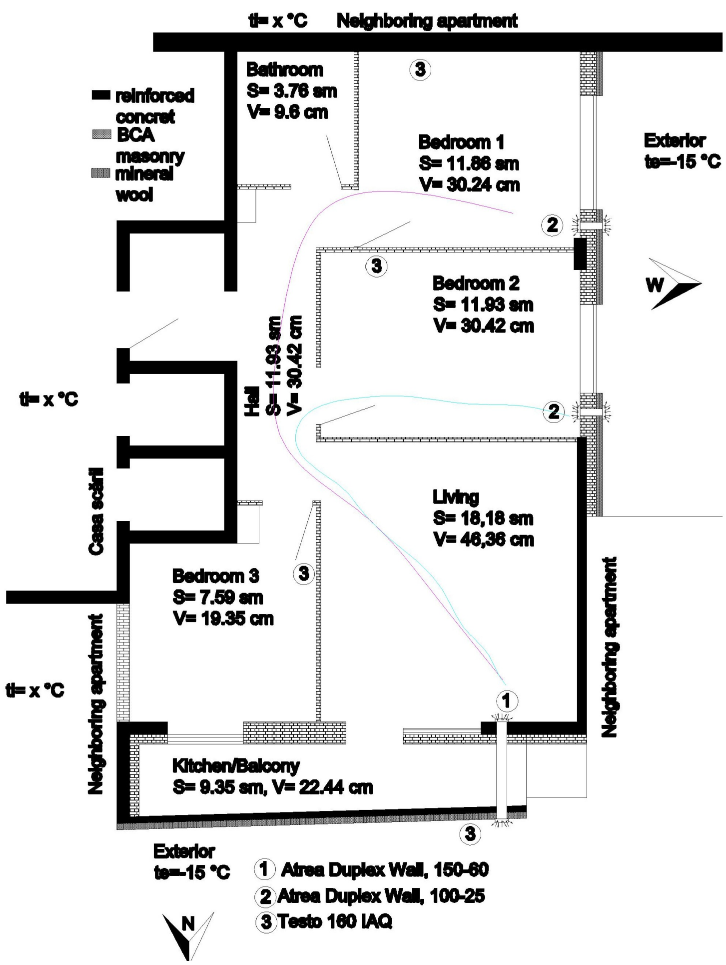


Fig. 2. Passive apartment Bucharest

Permanently inhabited by 4 people, of above average build, the apartment benefits from three ventilation units with alternating flow heat recovery with ceramic heat storage element positioned as follows:

- Atrea Duplex Wall 100-25, 2 units, each with a capacity of 25 m³/h, located in bedroom 1 and bedroom 2.
- Atrea duplex Wall 100-60, 1 unit with a capacity of 60 m³/, located in the living room.
- The internal volume of heated air is 189 m³.
- Total volume of ventilated air 110 m³/h.
- Nominal air flow rate per person 27.5 m³/h.
- Hourly number of ventilated air changes 0.582.

2.1.2. N-zeb House Varasti, Calaras County

The construction is carried out in the period 2020-2024, located in the town of Vărăști, Călăraș County, Figure 3. The resistance structure is made of reinforced concrete frames with porotherm brick masonry with a thickness of 38 cm and a mineral wool thermal system with a thickness of 10 cm and thermal conductivity λ = 0.036 W/(m·K). The construction complies with the minimum resistance requirement for N-zeb construction, according to the MC001/2022 normative.

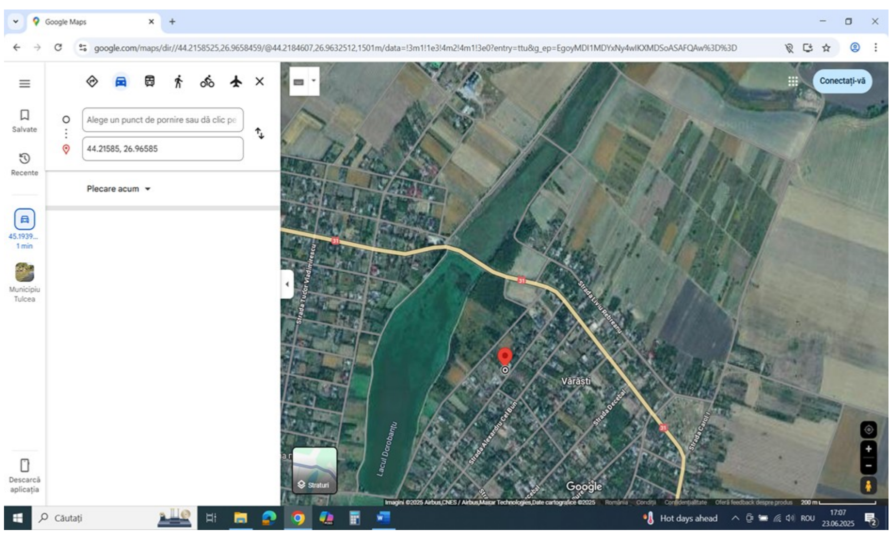
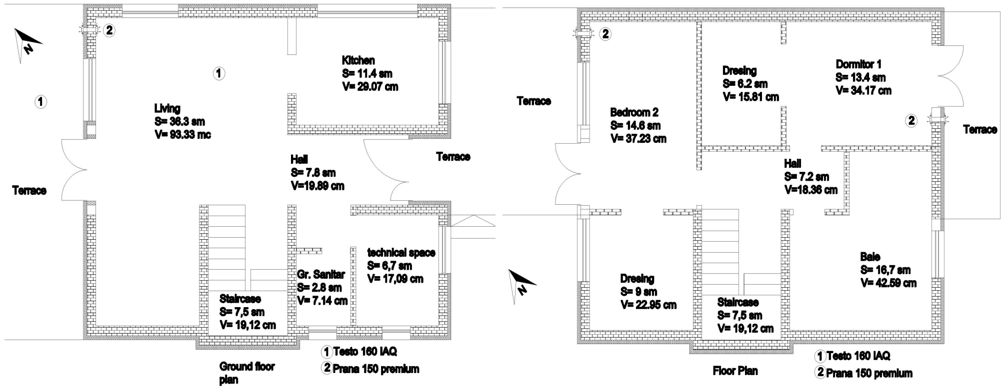


Figure 3. N-Zeb house location Varasti, Calarasi county

Home used during holidays and weekends; the maximum number of users is 3. It is equipped with 3 (three) Prana 150 premium-type countercurrent recovery ventilation units, the ventilation flow rate being 30 m³/h for each unit. These are located in the bedrooms upstairs and in the living room on the ground floor (Figure 4).



(a) (b)

Fig. 4. N-Zeb House Vărăști, Călăraș County
(a) ground floor plan, (b) first floor plan

- The internal volume of heated air is 356.51 m³.
- Total volume of ventilated air: 90 m³/h.
- Nominal air flow rate per person 30 m³/h.
- Number of hourly ventilated air changes 0.246.

2.1.3. Ecological house, Slava Rusă, Tulcea county.

Located in Slava Rusă, Tulcea County, Figure 5. the construction is made on a wooden structure with masonry made of unburnt bricks made of clay mixed with wheat straw (adobe). Figure 6. Collective memory identifies the year of construction as before 1900.

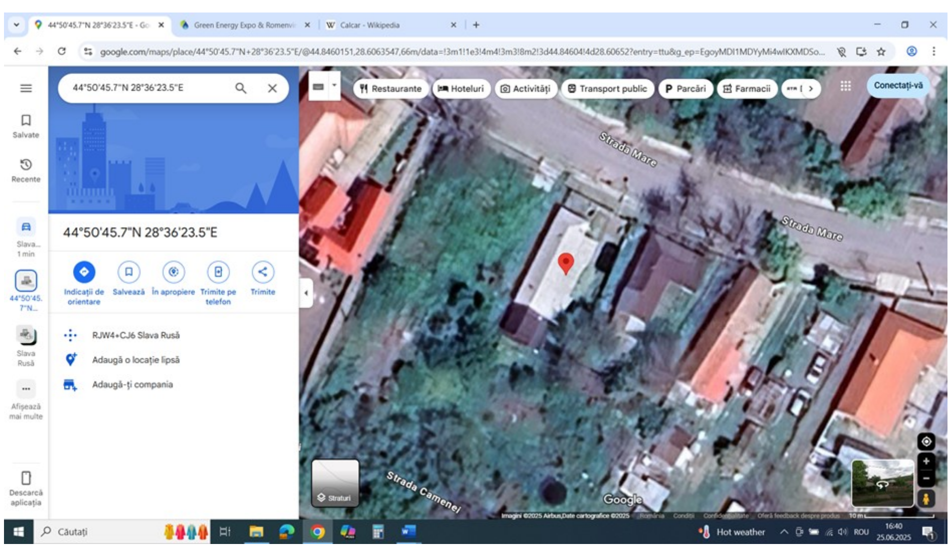


Fig. 5. Ecological house location, Slava Rusă, Tulcea county

The property is inhabited exclusively during the holiday period.

Fig. 6. Ecological house Slava Rusă, Tulcea county

2.2 Description of the Testo 160 IAQ measuring device

Table 1

Testo 160 IAQ measuring device

Temperature Measurement	
Measurement range	0 to +50 °C
Accuracy	± 0.5 °C
Resolution	0.1 °C
Humidity Measurement	
Measuring range	0 to 100 %RH
Accuracy	±2 %RH la +25 °C <80 %RH
	±3 %RH la +25 °C > 80 %RH
	±1 %RH hysteresis
	±1 %RH / year drift
Resolution	0.1% RH
CO_2 measurement	
Measuring range	0 to 5,000 ppm
Accuracy	±(50 ppm + 3 % of m.v.) at +25 °C Without external power supply:
	±(100 ppm + 3 % of m.v.) at+25 °C
Resolution	1 ppm
Pressure Measurement	
Measuring range	600 to 1100 mbar
Accuracy	±3 mbar at+22 °C
Resolution	1 mbar

The testo 160 IAQ is a WiFi data logger with display and integrated sensors for; temperature, humidity, and atmospheric pressure. [10]The equipment was purchased through a doctoral grant offered by the Doctoral School of the Technical University of Civil Engineering in 2022.

3. Measurement results

3.1. Passive apartment Bucharest

The apartment is permanently inhabited. For the measurements, the apartment was vacated for a short vacation..

The monitored period during which the users did not live in the building is between 31.12.2024 9:00 a.m. and 02.01.2025 4:00 p.m.

The period considered for the evaluation is between 01.01.2025 12:00 and 02.01.2025 12:00. Figure 7.

CO_2 concentrations were monitored in each bedroom. The recorders were placed in areas of the room where they were not directly exposed to the ventilated air stream.

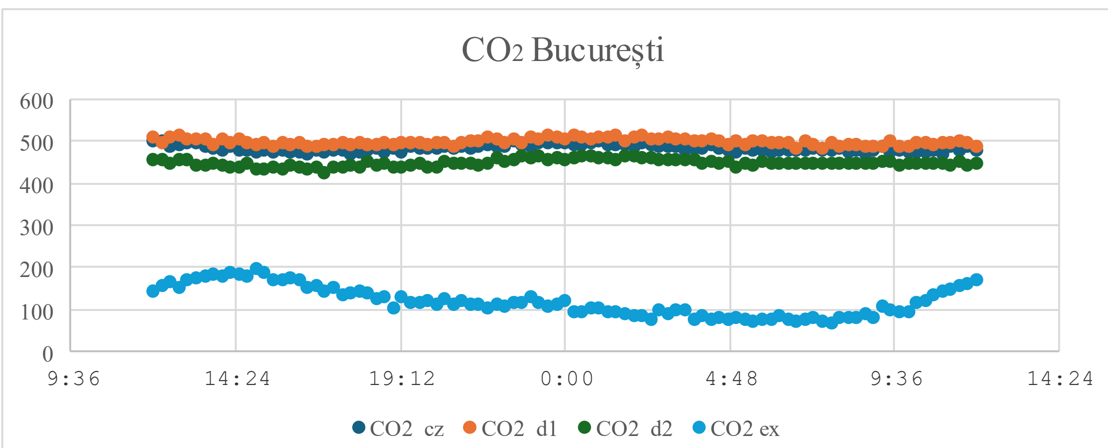


Fig. 7. CO2 values, passive apartment Bucharest

3.2. House N-zeb Varasti Calarasi County

The house is used during holidays and weekends from Friday 2:00 PM to Sunday 2:00 PM. The monitored period taken into account is 28.01.2025 12:00 PM and 29.01.2025 12:00 PM.

CO2 concentration values were monitored in the living room located on the ground floor of the building. Figure 8.

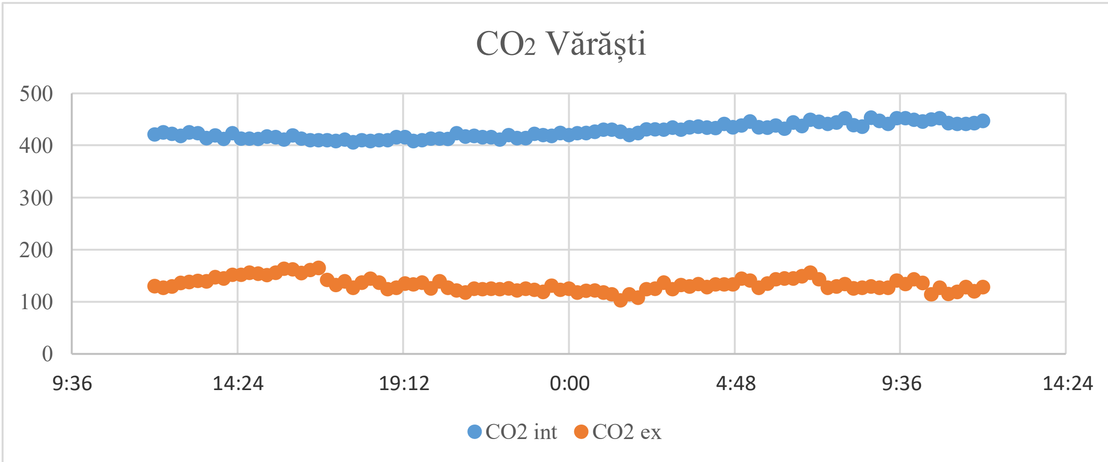


Fig. 8. CO2 values, N-Zeb house, Varasti

3.3. House N-zeb Varasti Calarasi County

The house is used mainly in the summer.
The recorded values are shown in Figure 9.

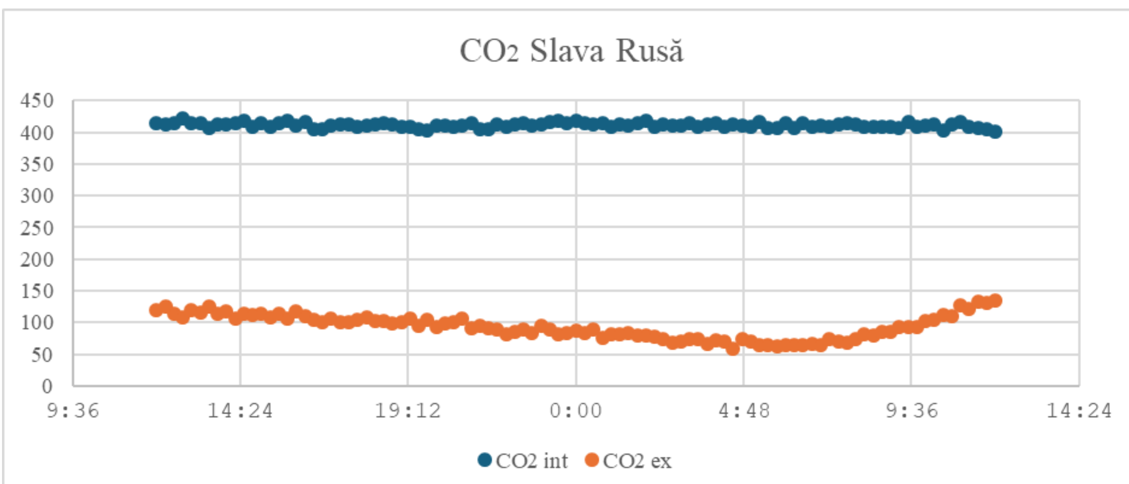


Fig. 9. CO2 values, ecological house Slava Rusă

4. Discussion

Chapter 2 of the Norm for the design, execution, and operation of ventilation and air conditioning installations, Indicative I 5 – 2022, establishes four indoor air quality categories (IDA1 – IDA4), mentioned in Table 2.

Thus, for civil buildings where the main source of pollution is bio-effluents emitted by humans, the classification into IDA categories is done depending on the purpose of the building, the activity in the rooms, the type of pollution sources, and the rooms where smoking is not allowed and is classified according to the CO_2 concentration accepted in the indoor air, above the outdoor concentration, Table 2.1.1.2, page 15 of I5/2022. [11], Table 2.

Table 2

Indoor air quality class	CO2 values above the outdoor air level, [ppm]	
	Supported domain	Default value
IDA 1 High indoor air quality	≤ 400	350
IDA 2 Average indoor air quality	400 – 600	500
IDA 3 Moderate indoor air quality	600 – 1000	800
IDA 4 Poor indoor air quality	≥ 1000	1200

By applying the default values presented in Table 2 to the average values recorded during the monitoring period, the reference values for establishing the air quality level are obtained. For IDA1, the values are presented in Table 3; for IDA2, the values are presented in Table 4; for IDA3, the values are presented in Table 5; and for IDA4, the values are presented in Table 6.

Table 3

		Average value measured [ppm]	Default value IDA 1 [ppm]	Reference value IDA 1 [ppm]
BUCHAREST MEASUREMENT	CO2 cz	483	350	833
	CO2 d1	498	350	848
	CO2 d2	448	350	798
	CO2 ex	120	350	470
SLAVA RUSĂ MEASUREMENT	CO2 int	411	350	761
	CO2 ex	93	350	443
VĂRĂȘTI MEASUREMENT	CO2 int	427	350	777
	CO2 ex	133	350	483

Table 4

		Average value measured [ppm]	Default value IDA 2 [ppm]	Reference value IDA 2 [ppm]
BUCHAREST MEASUREMENT	CO2 cz	483	500	983
	CO2 d1	498	500	998
	CO2 d2	448	500	948
	CO2 ex	120	500	620
SLAVA RUSĂ	CO2 int	411	500	911

		Average value measured [ppm]	Default value IDA 2 [ppm]	Reference value IDA 2 [ppm]
MEASUREMENT	CO2 ex	93	500	593
VĂRĂȘTI MEASUREMENT	CO2 int	427	500	927
	CO2 ex	133	500	633

Table 5

		Average value measured [ppm]	Default value IDA 3 [ppm]	Reference value IDA 3 [ppm]
BUCHAREST MEASUREMENT	CO2 cz	483	800	1283
	CO2 d1	498	800	1298
	CO2 d2	448	800	1248
	CO2 ex	120	800	920
SLAVA RUSĂ MEASUREMENT	CO2 int	411	800	1211
	CO2 ex	93	800	893
VĂRĂȘTI MEASUREMENT	CO2 int	427	800	1227
	CO2 ex	133	800	933

Table 6

		Average value measured [ppm]	Default value IDA 4 [ppm]	Reference value IDA 4 [ppm]
BUCHAREST MEASUREMENT	CO_2 cz	483	1200	1683
	CO_2 d1	498	1200	1698
	CO_2 d2	448	1200	1648
	CO_2 ex	120	1200	1320
SLAVA RUSĂ MEASUREMENT	CO_2 int	411	1200	1611
	CO_2 ex	93	1200	1293
VĂRĂȘTI MEASUREMENT	CO_2 int	427	1200	1627
	CO_2 ex	133	1200	1333

5. Conclusion

From the analysis of the graphs of the measured values, Figure 7 for CO_2 measurements in Bucharest, Figure 8 for CO_2 measurements in Vărăști, and Figure 9 for CO_2 measurements in Slava Rusă, the following conclusions are highlighted:

1. The variation in indoor CO_2 concentration values is not influenced by the variation in outdoor CO_2 concentration.

2. The variation in the values recorded at the passive apartment in Bucharest indicates the influence of the CO_2 concentration in neighboring apartments through migration through the building elements.

The reference values resulting from the summation of the default value according to the specifications of the I5/2022 normative for IDA1 of 350 ppm, with the outdoor CO_2 concentration values, Table 3, for the three locations, are similar to the CO_2 concentration values recorded indoors, both for mechanically ventilated buildings with recovery and for buildings ventilated by infiltration through leaks. It is necessary to establish thresholds independent of other indoor or outdoor CO_2 concentration values.

Applying the default value of 1200 ppm, corresponding to low indoor air quality for IDA4, leads to the maximum acceptable level for CO_2 concentration in civil buildings, according to the NP 008-97 standard, of 1600 ppm.

The CO_2 concentration in a building that is on hold and/or unused is not influenced by the existence of heat recovery ventilation.

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