Supplementing ventilation with gas phase air cleaning – Results of IEA Annex 78

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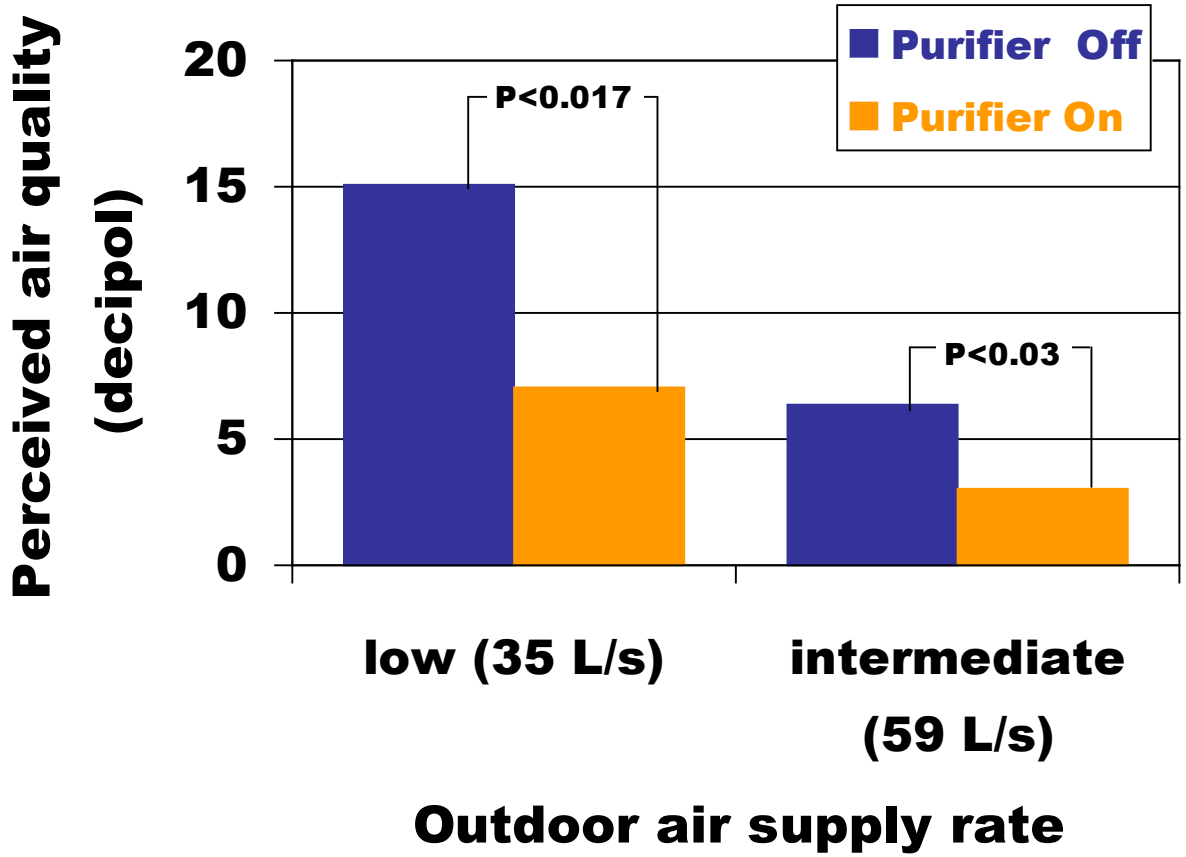
Annex 78 Project Period

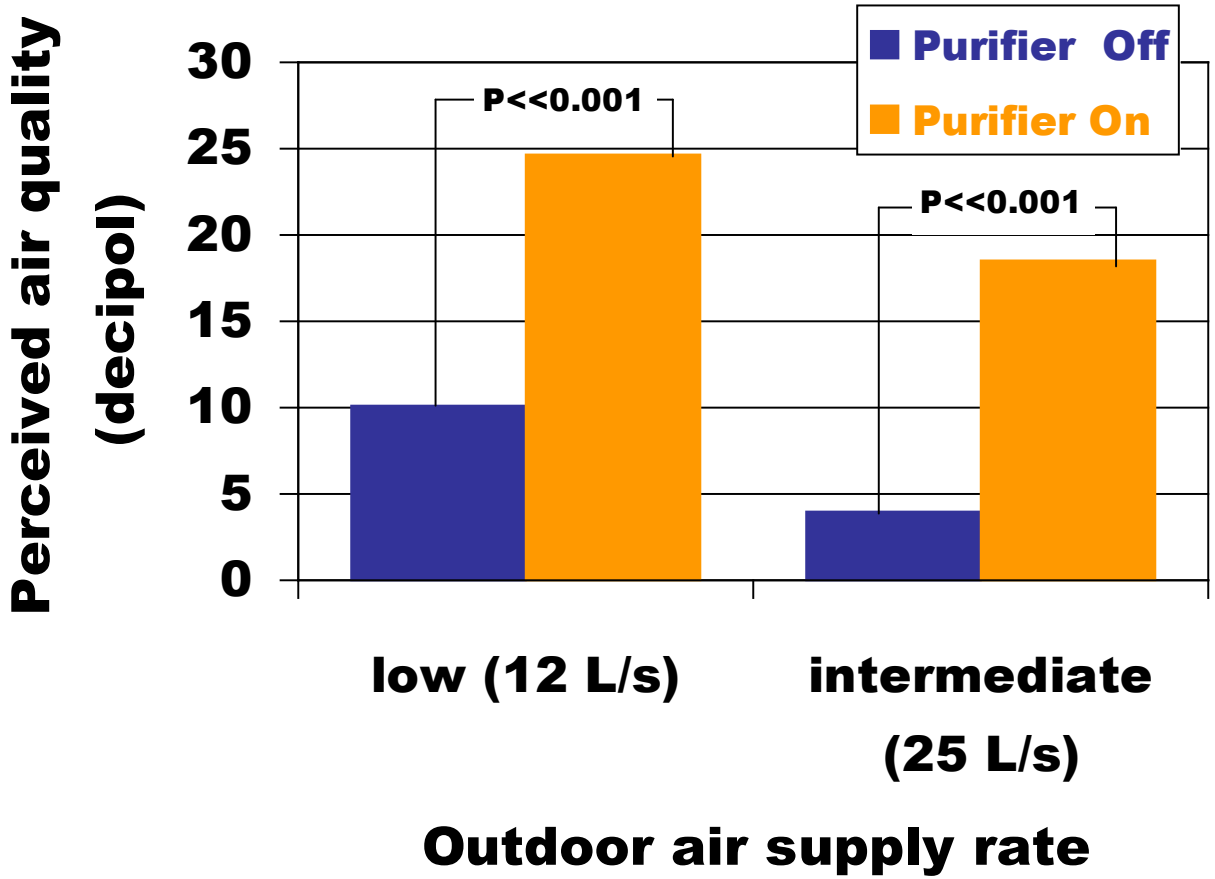
~~July 1, 2018 Preparation period~~
~~July 1, 2019 Activity~~ period
July 1, 2023 Reporting period
July 15, 2024 Finished

Danish participation supported by an EUDP project

Results: Bldg mat, PCs, filters



Results: Human bioeffluents



The concept for calculation of design ventilation rate

ISO 17772-1/2 EN 16798-1/2 ASHRAE 62.1

People Component

Building Component

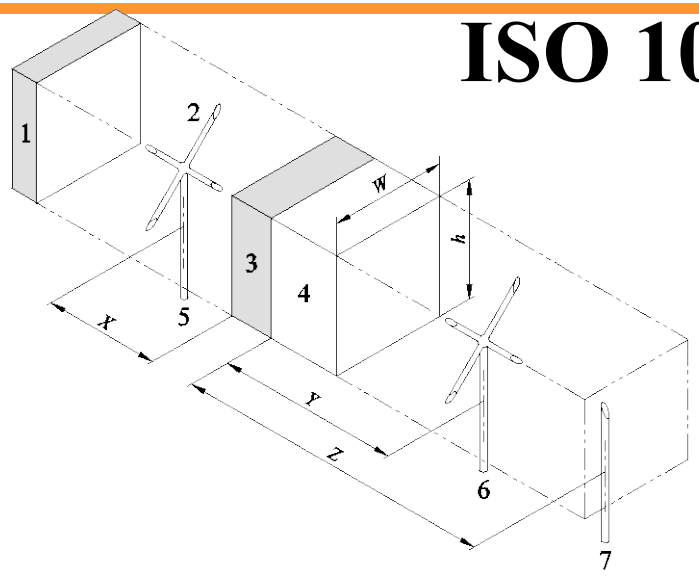
Breathing Zone Outdoor Airflow

$$V_{bz} = R_p P_z + R_a A_z$$

- R_p: Minimum l/s/Person
- P_z: Number of People
- R_a: Minimum l/s/m²
- A_z: Building Area

TESTING OF GAS PHASE AIR CLEANERS

ISO 10121-2:2014



Key

1 diffusor and Δ*p* device
2 sampling points – should be of "fork" type or similar with multiple inlet points to make a compounded sample over the whole cross section
3 GPACD under test
4 GPACD section of test duct
5 upstream sampling point for T_U, RH_U, p_U and C_U at *X* mm before the GPACD
6 Downstream sampling point for T_D, RH_D, p_D and C_D at *Y* mm after the GPACD
7 *Q*, air flow rate sampling point at *Z* mm after the GPACD
W internal width of the test duct along the GPACD section, 3+4
h internal height of the test duct along the GPACD section, 3+4

Figure 1 — Normative section of test stand showing ducting, measurement parameters and sampling points

Air Cleaning Efficiency

$$\varepsilon_{clean} = 100(C_U - C_D)/C_D$$

where:

E_{clean} is the air cleaning efficiency

C_U is the gas concentration before air cleaner

C_D is the gas concentration after air cleaner.

V entilation
I nformation
P aper
n° 42
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International Energy Agency's Energy in Buildings and Communities Programme

Air Infiltration and Ventilation Centre

The Concept for Substituting Ventilation by Gas Phase Air Cleaning

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PERCEIVED AIR QUALITY

INTERNATIONAL STANDARD **ISO 16000-28**

First edition
2012-03-15

Indoor air —

Part 28:
Determination of odour emissions from building products using test chambers

Air intérieur —

Partie 28: Détermination des émissions d'odeurs des produits de construction au moyen de chambres d'essai

Test Panel
- Trained
- Untrained

Odour
- Acceptance
- Intensity
- Hedonic tone

Examples of diffuser and mask used for odour evaluatio

Figure C.1 — Diffuser

ISO/TC 146/SC 6

Date: 2023-09

ISO/FDIS 16000-44:2023 (E)

ISO/TC 146/SC 6/WG 25

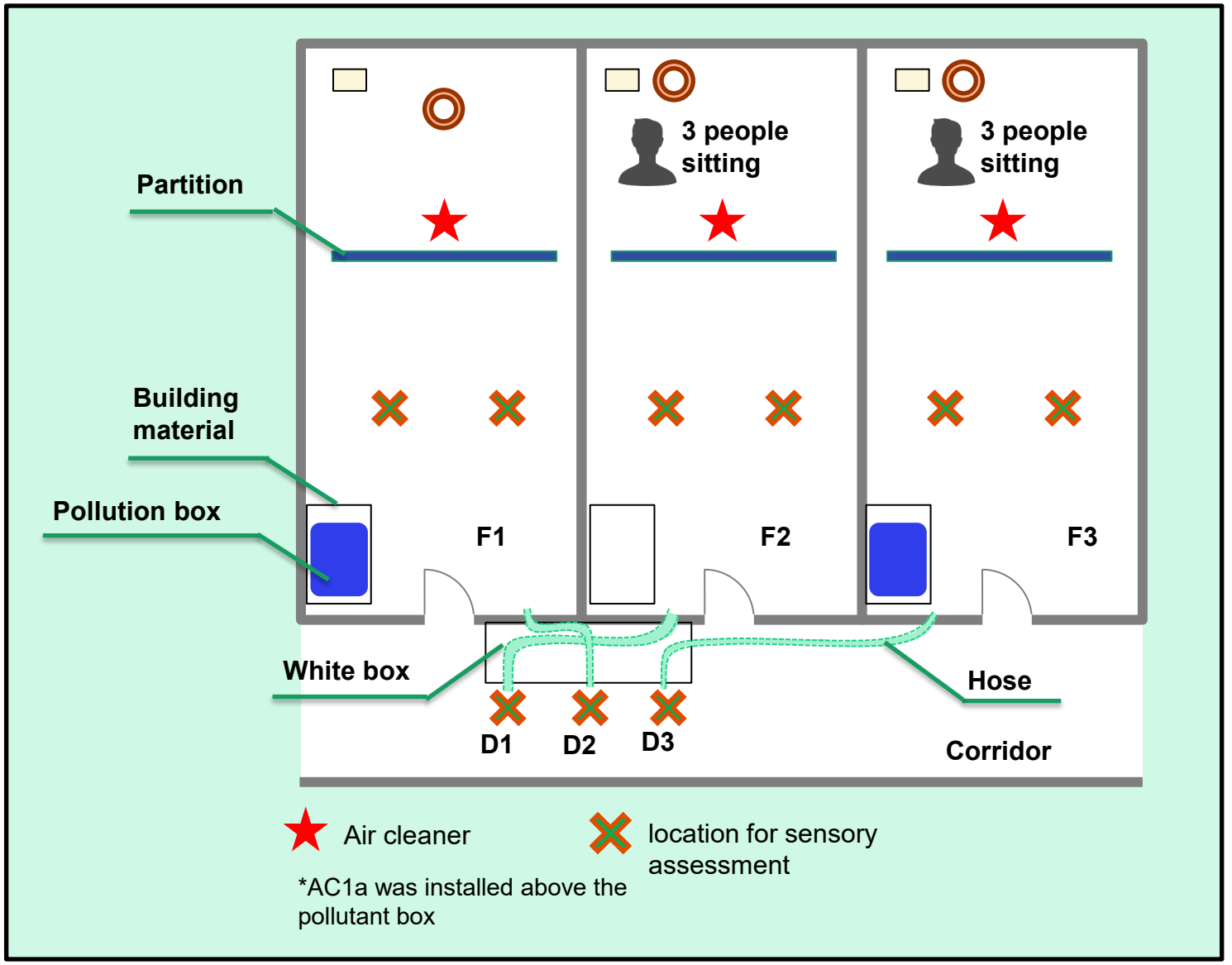
Secretariat: DIN

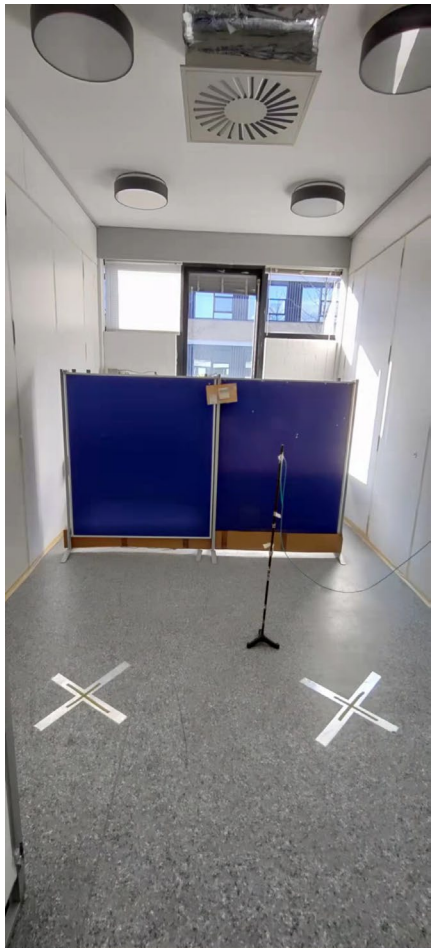
Indoor air — Part 44: Test method for measuring perceived indoor air quality for use in testing the performance of gas-phase air cleaners.

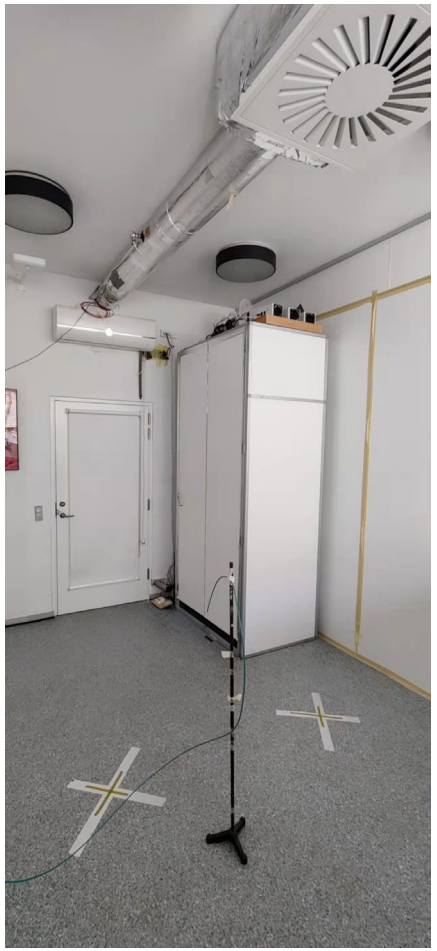
Air intérieur — Partie 44: Méthode d'essai pour mesurer la qualité perçue de l'airintérieur en vue de tester les performances des épurateurs d'air en phase gazeuse

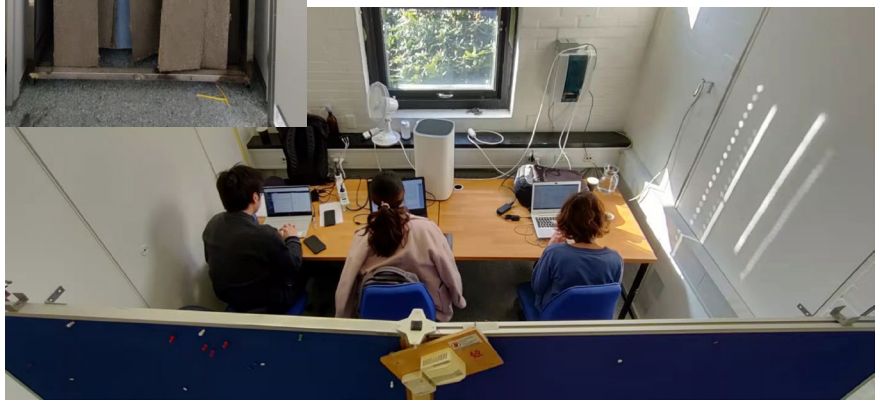
Testing of gas-phase air cleaners for improving perceived indoor air quality (PWI 23743) ISOTC142WG8

Setup


Partition
Building material
Pollution box
3 people sitting
3 people sitting
F1
F2
F3
White box
Hose
D1
D2
D3
Corridor
Air cleaner
location for sensory assessment
*AC1a was installed above the pollutant box







Sensory evaluations

Type of exposure

Whole-body exposure

Facial exposure

Scale

- Clearly acceptable
- Just acceptable
- Just unacceptable
- Clearly unacceptable

- No odour
- Slight odour
- Moderate odour
- Strong odour
- Very strong odour
- Overpowering odour

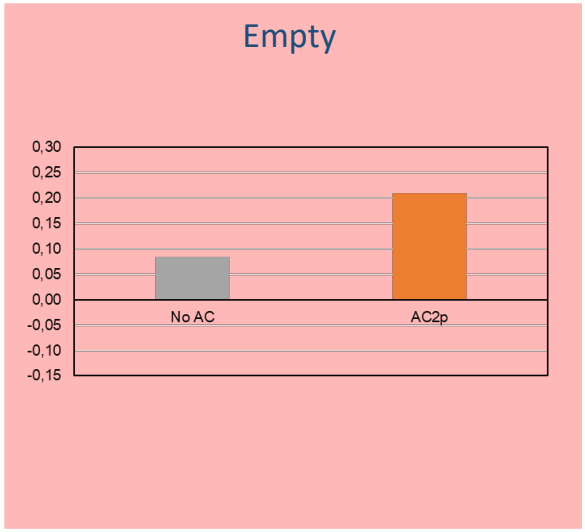
- Two-stage-testing
  - Stage 1: Pass/no pass with respect to the effect on indoor air quality
  - Stage 2: Determine clean air delivery rate (CADR) and compare with equivalent ventilation requirements

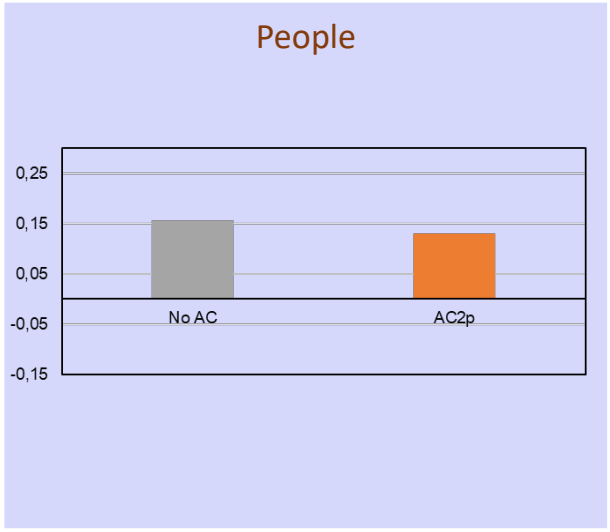
- Use sensory assessment of air quality by human panel

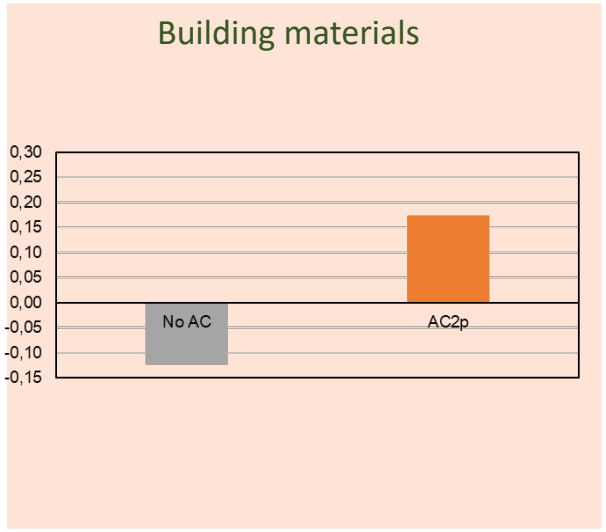
- No testing of long-term performance

Afshari et al. (2022)

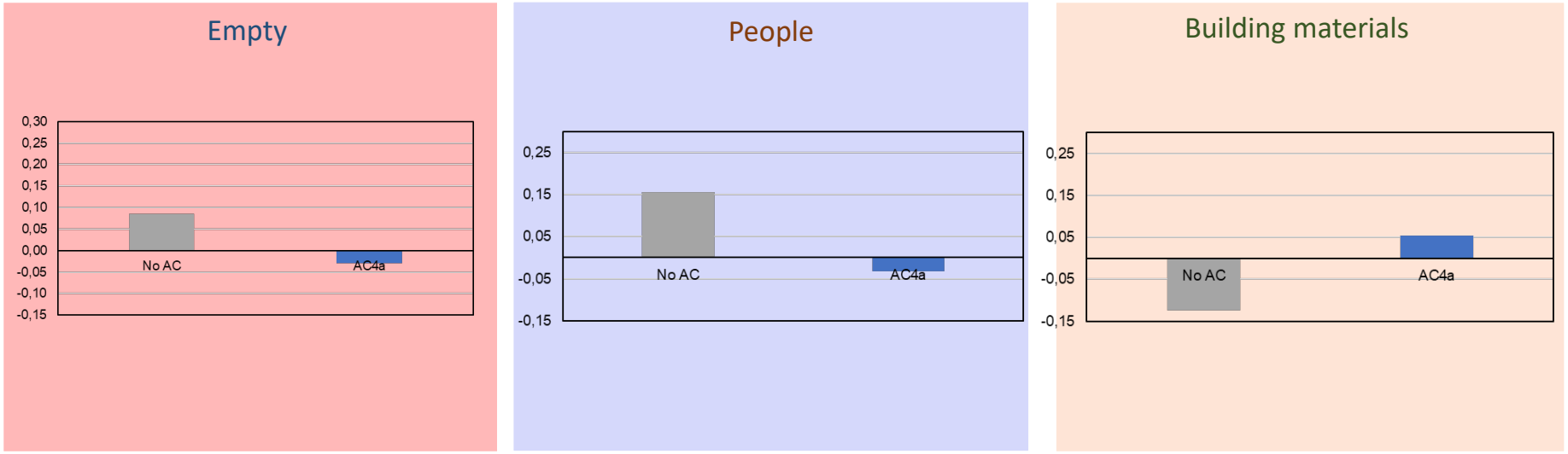
Air Cleaner 2-Acceptability







Air Cleaner 4-Acceptability



Stage 2

The purpose is to determine the Clean-Air-Delivery-Rate (CADR).

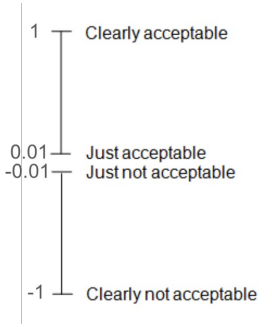
Conditions under test: ca. 22^{o}C and 30-40%RH

Four levels of ventilation with outdoor air were tested (three with air cleaner in operation): 7.5, 12, 21 and 30 L/s (0.5, 0.9, 1.5, 2.2 h^{-1})

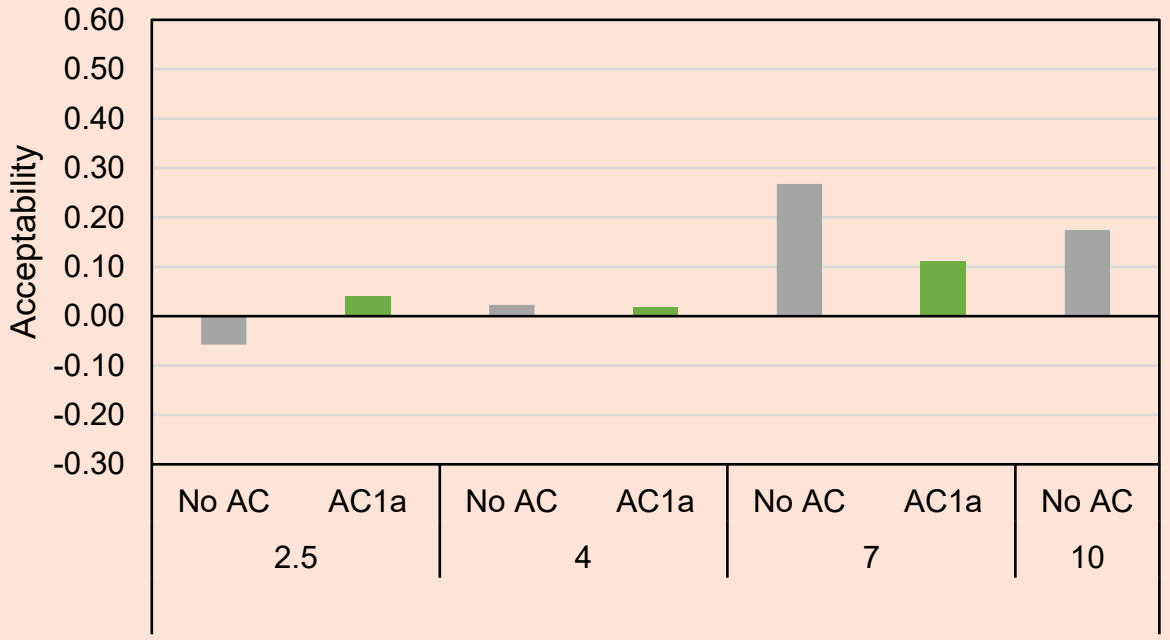
Sensory panel assessed the air quality with air cleaner idled and in operation

Chemical measurements were performed ay the lowest ventilation rate with air cleaners idled and in operation

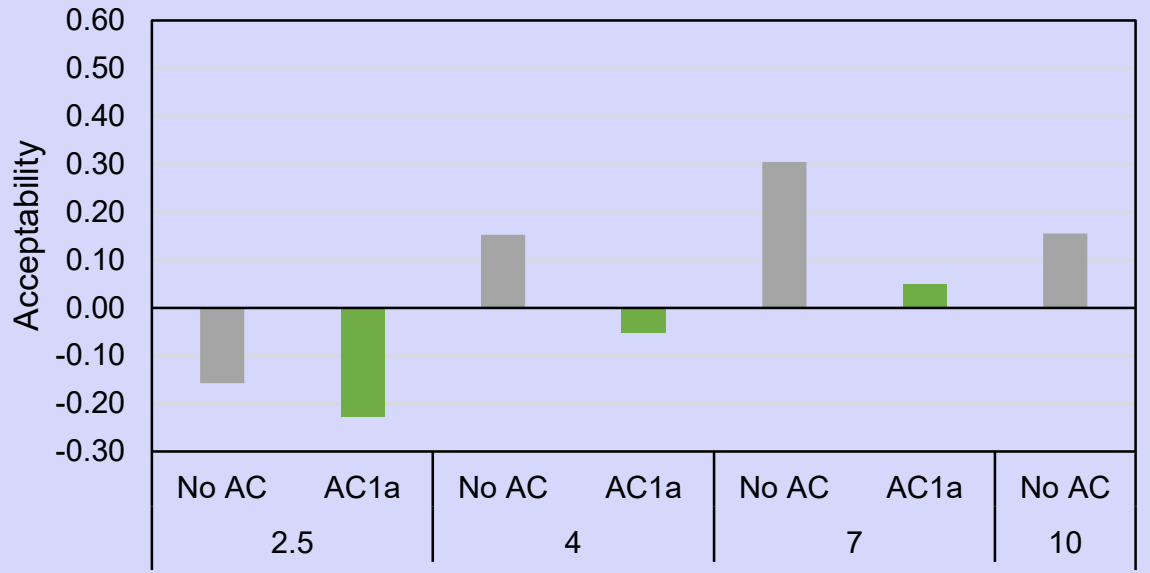
Active air cleaner (AC1a) acceptability



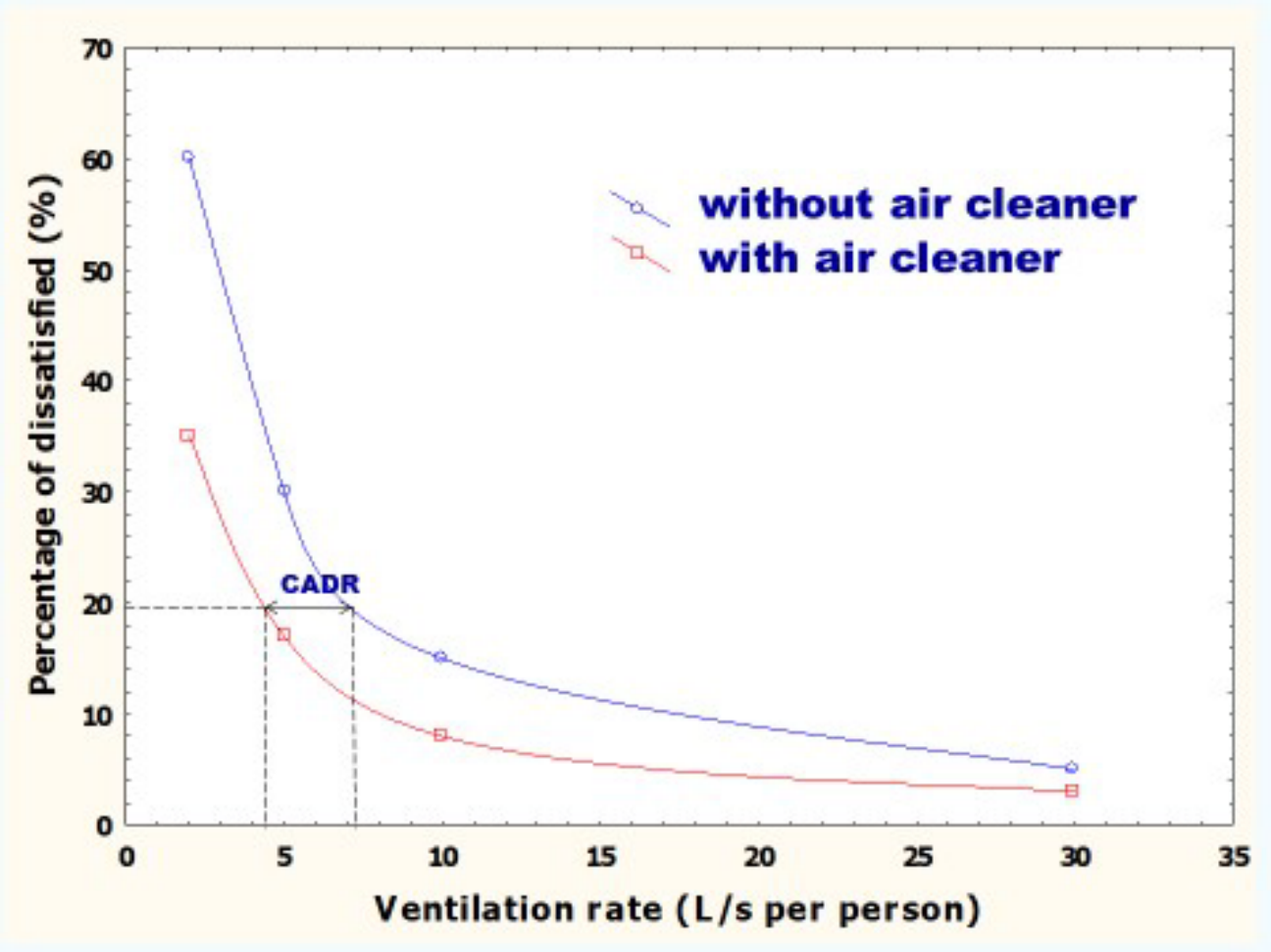
Building materials



People



More analyses – determination of CADR



Methods - CAE

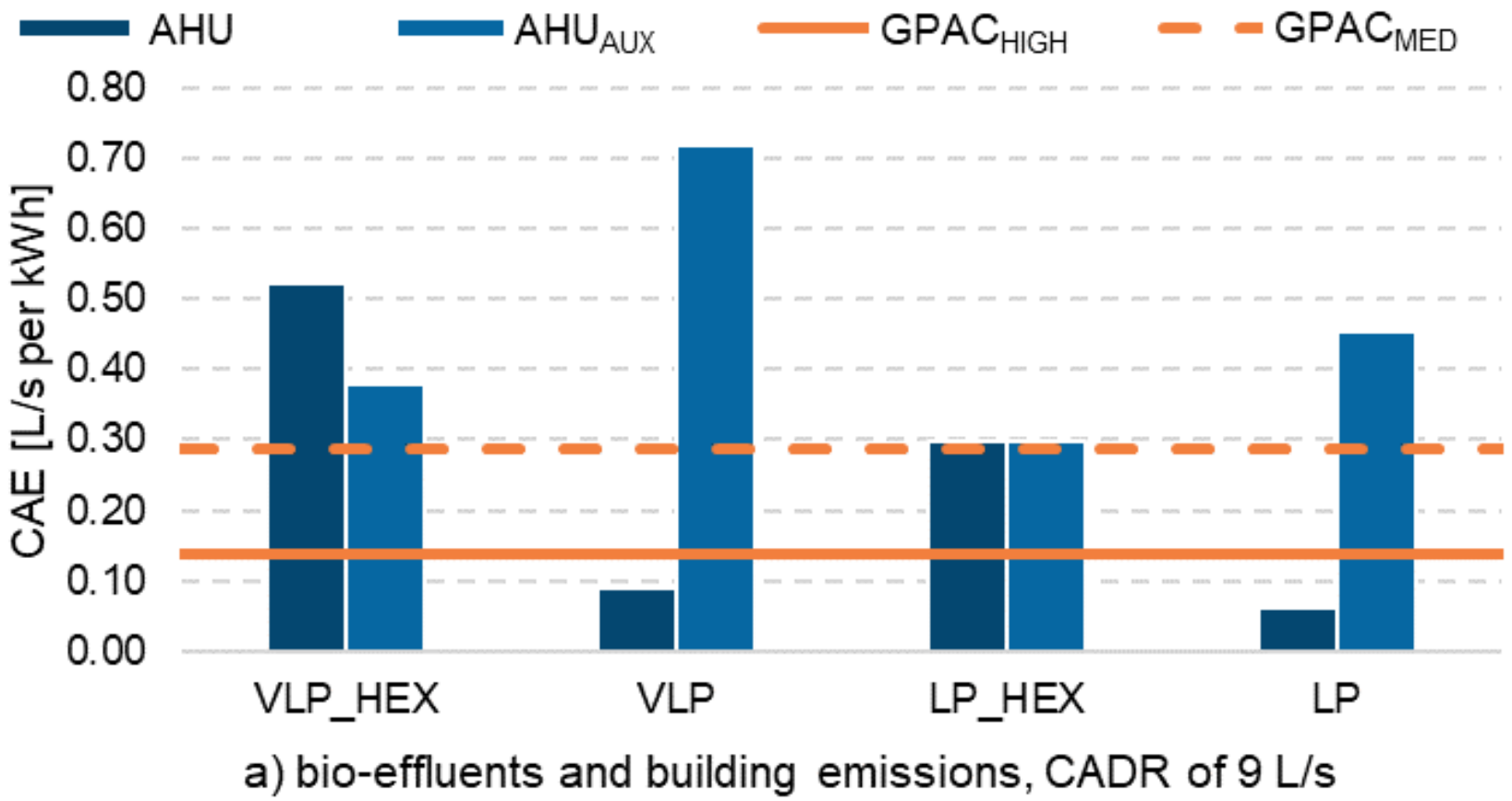
Indicator for comparing the efficiency of the AHU and stand-alone air cleaner

$$CAE = \frac{\text{CADR}}{Energy\ use} \qquad [\text{L/s per kWh}]$$

Amount of air, **CADR in L/s**, and energy use for **heating, cooling, and AUX** or **GPAC**

Results - CAE

- If the GPAC is compared only to AHU_{AUX}, the GPAC is never efficient
- If a HEX is included the GPAC is not efficient
- Higher savings can be achieved if GPAC can be operated at a setting lower than HIGH (22 W)



Bogatu et al. “Gas-Phase Air Cleaning Effects on Ventilation Energy Use and the Implications of CO2 Concentration as an IAQ Indicator for Ventilation Control.”, Proceedings of Building Simulation 2021, 2021.

Conclusion

- A concept for substituting part of the required ventilation with gas-phase air cleaning (GPAC) technology has been presented
- New testing standards need to consider perceived air quality and human emissions as a source.
- It must be verified that the reduced ventilation rate is still high enough to dilute individual contaminants.
- Adjusted CO_2 criteria must be used to express the indoor air quality and to use for demand-controlled ventilation.
- Clean-Air-Efficiency (CAE) can be used to compare different solutions for providing clean air the space.
- In Copenhagen, DK (high heating load), GPAC was competitive only if the AHU was not equipped with a HEX
- GPAC can be used to either improve IAQ or reduce air flow rate