IEA-EBC Annex 86

Energy Efficient IAQ Management in residential buildings

EBC Technical Day Copenhagen

Presented by:

Carsten Rode, Technical University of Denmark, DTU

IEA-EBC Annex 86

Energy Efficient IAQ Management in Residential Buildings

Operating Agent: Jelle Laverge, Gent University, Belgium

IAQ is an important constraint for energy efficiency optimisation in buildings

There is no consensus on a framework to rate IAQ as a basis for this optimisation

Scope and Goals

Provide a framework to improve energy efficiency of IAQ management for

Residential buildings

- both new construction and refurbishment

EBC
Energy in Buildings and Communities Programme

Scope and Goals

Provide a framework to improve energy efficiency of IAQ management for

Residential buildings

both new construction and refurbishment

- To select metrics to assess energy performance and indoor environmental quality of an IAQ management strategy and study their aggregation
- To improve the acceptability, control, installation quality and long-term reliability of IAQ management strategies by proposing specific metrics for these quality issues
- To set up a coherent rating method for IAQ management strategy that takes into account the selected metrics
- To identify or further develop the tools that will be needed to assist designers and managers of buildings in assessing the performance of an IAQ management strategy using the rating method
- To gather existing or provide new standardized input data for the rating method
- To study the potential use of smart materials as (an integral part of) an IAQ management strategy
- To develop specific IAQ management solutions for retrofitting existing buildings
- To benefit from recent advances in sensor technology and cloud-based data storage to systematically improve the quality of the implemented IAQ management strategies, ensure their operation and improve the quality of the rating method as well as the input data
- To improve the availability of these data sources by exploring use cases for their providers
- To disseminate about each of the above findings.

EBC
Energy in Buildings and Communities Programme

Workplan

6 Subtasks

ST 1 and 2: methodology

ST 3 and 4: application to technology

ST 5: new opportunities through IoT

ST 6: dissemination and management

Subtask 1 Metrics and development of an IAQ management strategy rating method
This subtask is devoted to the development of a general rating method for the benchmarking of the performance of IAQ management systems. In addition to relevant metrics, a set of appropriate tools, consistent modeling assumptions and monitoring protocols are also proposed.

Subtask 2 Source characterization and typical exposure in residential buildings
This ST creates consistent input values for the assessment method developed in ST 1 and control strategies in ST 4. It starts from information available in literature, adding new experimental results where needed and reviewing and developing models (empirical, semi-empirical or physical models) for characterizing relevant residential sources.

Subtask 3 Smart materials as an IAQ management strategy
This ST identifies opportunities to use the building structure and (bio-based) building materials (focussing on hemp concrete) and the novel functional materials inside it to actively/passively manage the IAQ, for example, through active paint, wallboards, textiles coated with advanced sorbents or hemp concrete, and quantifies their potential based on the assessment framework developed in ST 1.

Subtask 4 Ensuring performance of smart ventilation
This subtask focuses on practical conditions that assure reliable, cost effective and robust implementation of smart ventilation. This includes both installation and operation. A poor performance of smart ventilation systems can not only lead to waste of energy and aggravated IAQ. It can also create a bad reputation of smart ventilation among relevant stakeholders - designers, installers as well as occupants. This, in the end, can lead to adoption of more primitive, less efficient (in terms of energy use) and less effective (in terms of IAQ) forms of IAQ management. The subtask defines a smart ventilation according to the AIVC

Subtask 5 Energy savings and IAQ: improvements and validation through cloud data and IoT connected devices
This subtask is exploring the potential of the new generation of IoT connected devices (both standalone and embedded in eg. AHU's) for smart IAQ management. What can we learn from big data? Can we benchmark system energy and IAQ performance based on this data? How can we make sure that the data is available and can be accessed? Can we update what we think we know about what happens in dwellings based on what we see in big data rollouts? What are the best protocols and ontologies? How to create viable services out of the data/business plans? How can we integrate data with smart grids?

Subtask 6 Dissemination, management and interaction
The final subtask assures the close alignment of the activities within the annex and the interaction with the AIVC. This subtask includes the outreach of the annex, eg. by managing the dedicated section of the IEA EBC webpage. It uses the different platforms that the AIVC provides to interact with the broader target audience. This task will also ensure the continuation of the link with (the results from) other ongoing and ended annexes, especially annex 68.

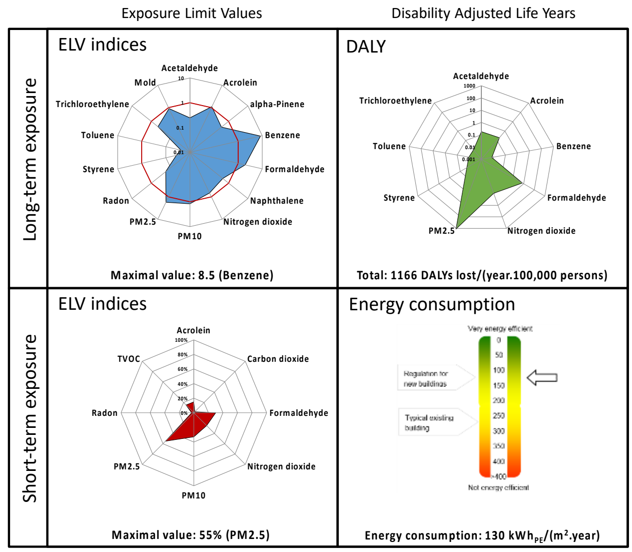
Rating?

3 cases

Comparing cases (**output Annex 68**)

Ranking options / engineering case

Across buildings / generic options



A RATING ECOLOGY

A framework that includes:

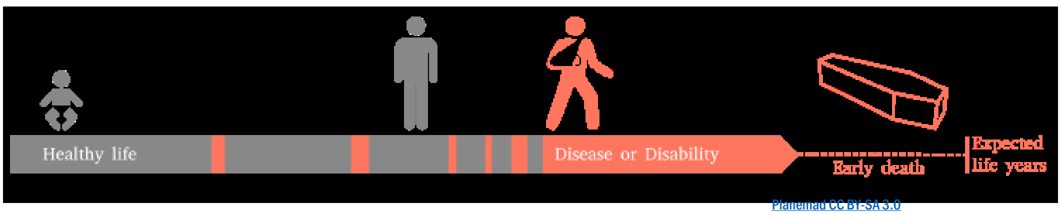
- Indicators
- Models
- Inputs

A RATING ECOLOGY

A framework that includes:

- **Indicators**
- Models
- Inputs

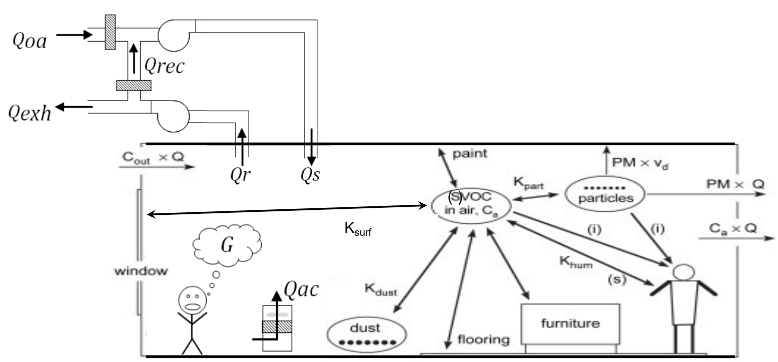
Primary goal of IAQ management = prevent harm
('healthy buildings', 'Well Building'…)
Metric of harm for WHO:
Disability Adjusted Life Year (**DALY**)



A RATING ECOLOGY

A framework that includes:

- Indicators
- **Models**
- Inputs



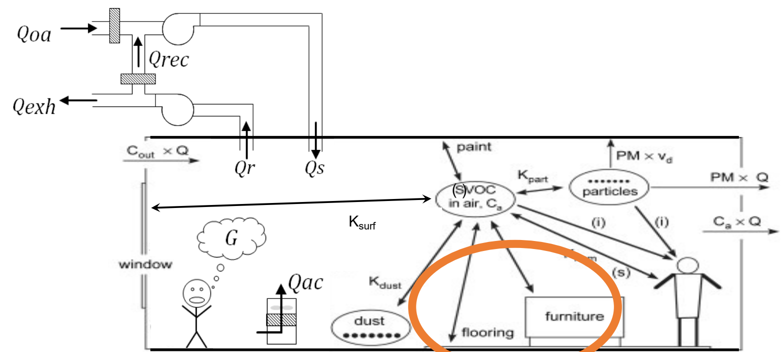
Mash-up of Weschler et al. & Dols, 2020, https://doi.org/10.6028/NIST.TN.2095 17

EBC
Energy in Buildings and Communities Programme

A RATING ECOLOGY

A framework that includes:

- Indicators
- **Models**
- Inputs



Mash-up of Weschler et al. & Dols, 2020, https://doi.org/10.6028/NIST.TN.2095 [17]

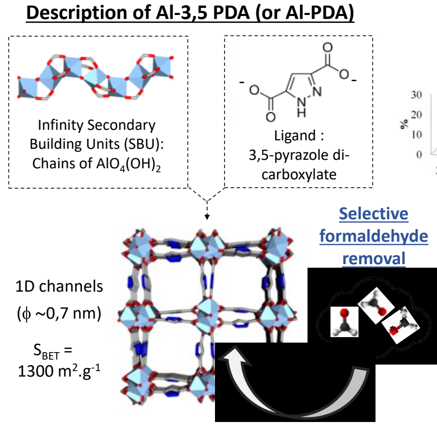
EBC
Energy in Buildings and Communities Programme

A RATING ECOLOGY

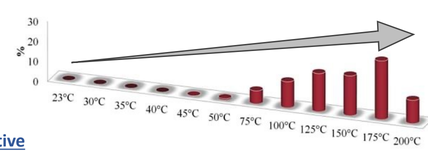
A framework that includes:

- Indicators
- **Models**
- Inputs

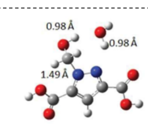
Description of Al-3,5 PDA (or Al-PDA)



Percentage of formaldehyde re-emitted from Al-PDA at different temperatures



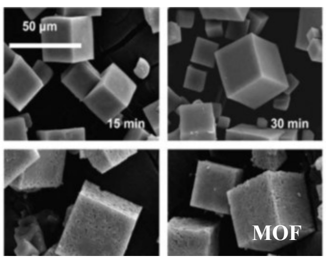
Formation of oxymethyl groups in the presence of H_2O (from DFT calculations, G. Maurin, Montpellier)

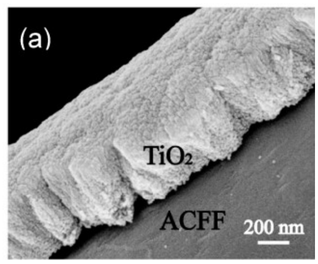


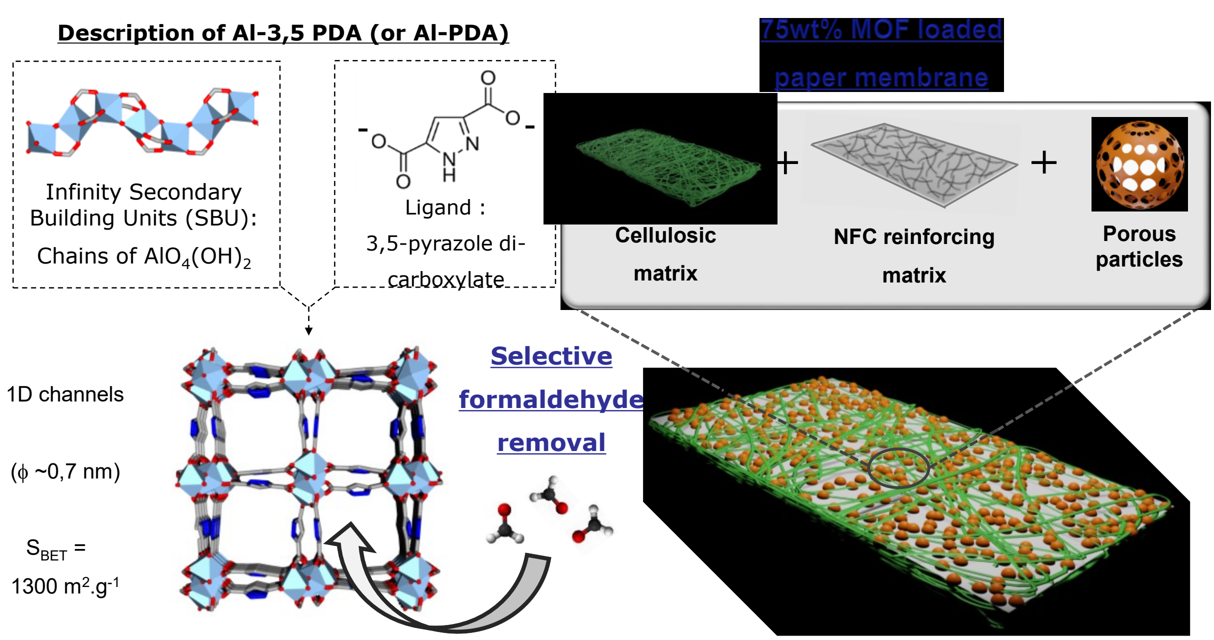
N. Sadovnik et al. Regenerable VOC filters with improved selectivity and efficacy. Patent WO2021089629A1

Subtask 3

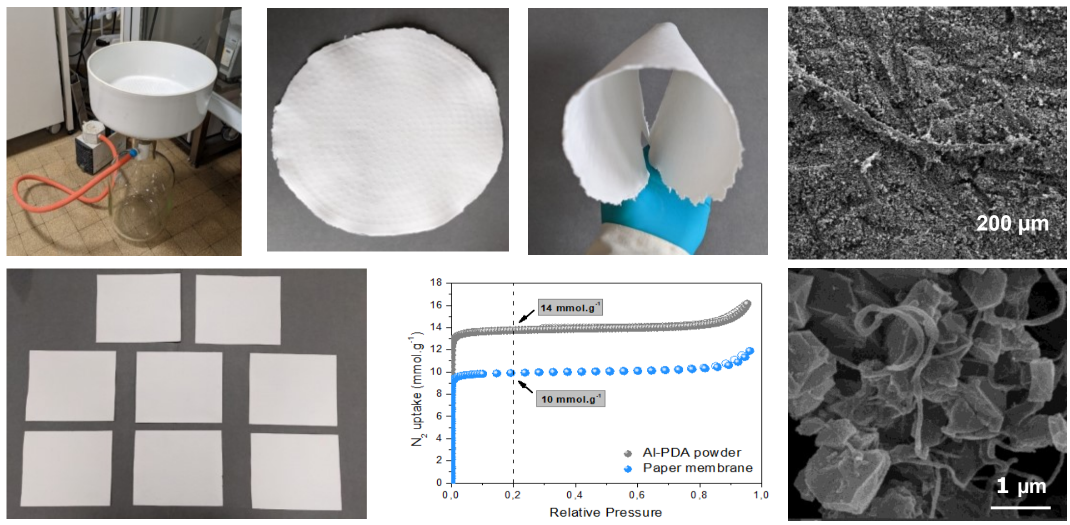
- ST 3 identifies opportunities to use novel materials (from advanced functional nano-materials to bio-based building materials) as building components to actively/passively manage the IAQ, for example, through active paint, wallboards and textiles coated with advanced sorbents or catalysts and quantify their potential based on the assessment framework developed in ST 1.



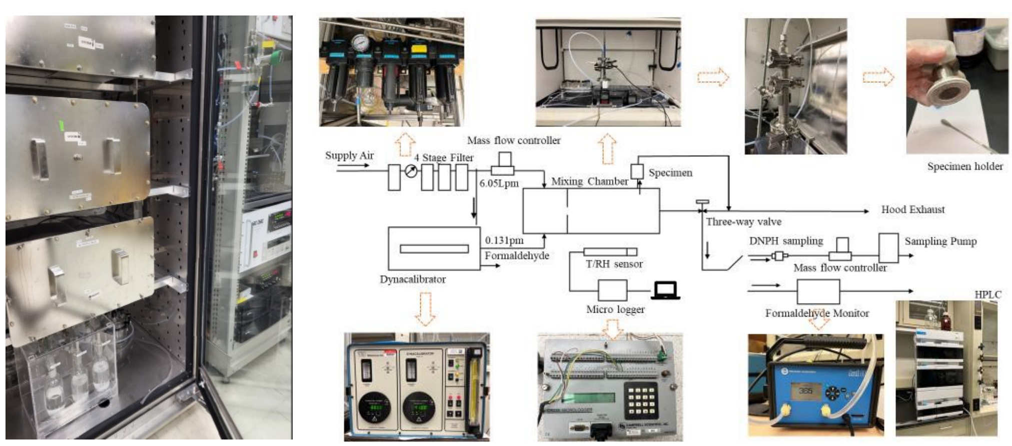




Al-PDA paper membrane



Experiments



Summary (regarding MOFs)

- MOF Al-PDA has a remarkably higher formaldehyde removal capacity than activated carbon in both low and high humidity conditions. The max. adsorption capacity of FA is **4,96 mmol/g.** (231 wt%, Syracuse U.)
- The change in relative humidity has little effect on the adsorption performance of MOF Al-PDA.
- The Al-PDA can be easily regenerated by water soaking for 1 hour or dynamic vacuum heating at 100 C for 16 hours.
- SIFT-MS tests confirm that no major byproducts.
- The tests have demonstrated the exceptional ability of this MOF to capture formaldehyde in indoor environments, even under high humidity conditions.

EBC

Energy in Buildings and Communities Programme

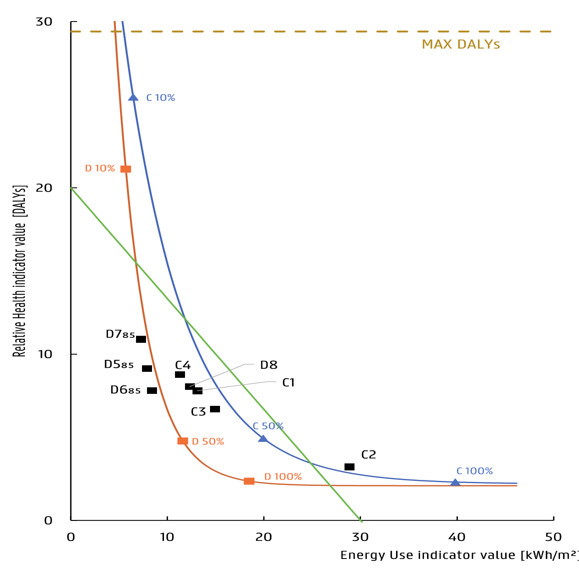
ST4: Ensuring performance of smart ventilation

- Methodological issues

Acceptability of IAQ?

DALY's

Conflicts of long-term vs. short-term effects

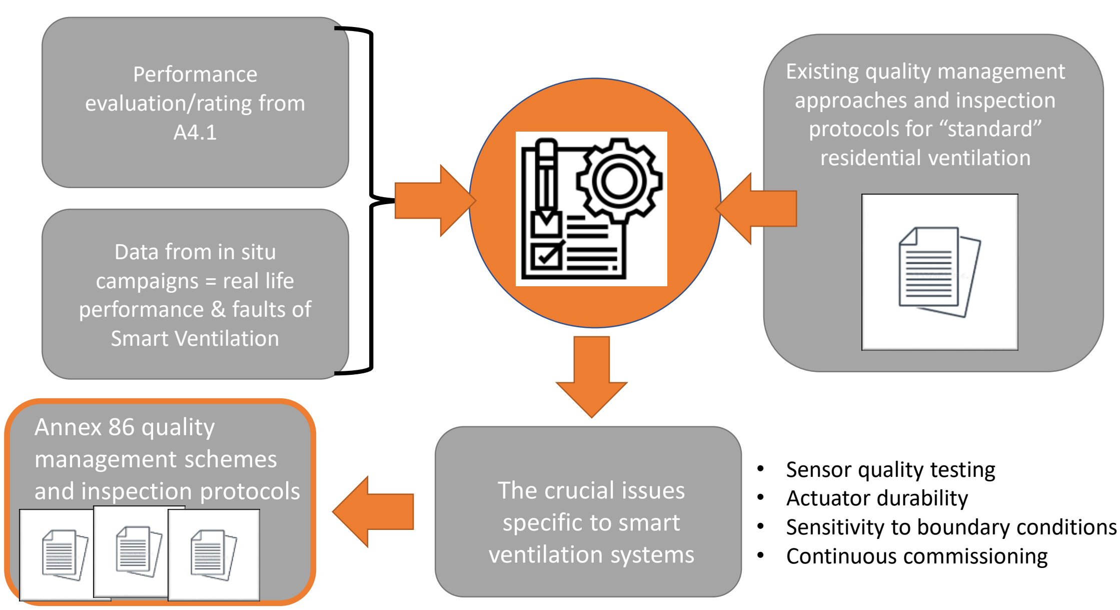


Source: Klaas De Jonge / Jelle Laverge, UGhent

A4.2: Quality control of implementation

- The quality of ventilation systems is an issue
- Ventilation is often badly designed, installed or used, achieving lower performances than expected
- We have references from 2012 – 2017 (see annex description) and miss more recent data
- We believe that there is no reason to assume that the situation has dramatically improved nowadays ☹

A4.2: Quality control of implementation



A RATING ECOLOGY

A framework that includes:

- Indicators
- Models
- **Inputs**

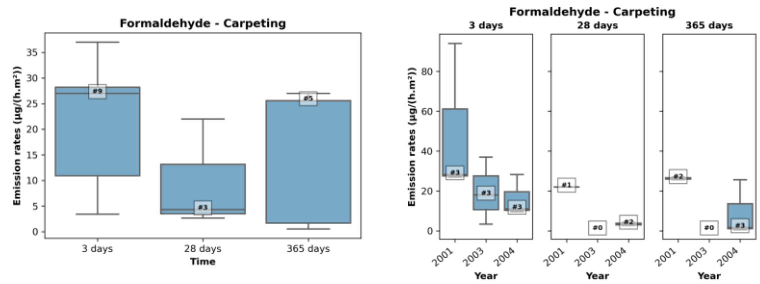
A RATING ECOLOGY

A framework that includes:

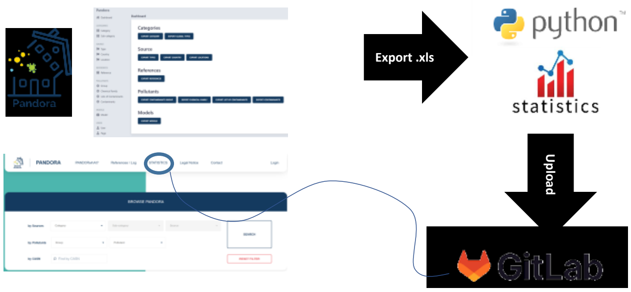
- Indicators
- Models
- **Inputs**

LEEFRUIMTE (zone 4)	m²	Formaldehyde (ug/h)	benzeen (ug/h)	naftaleen (ug/h)	tolueen (ug/h)
houten vloeren	42,50	421,18	0,00	0,00	0,00
houten meubels	10,03	30,70	14,04	56,98	0,00
houten deuren	4,20	18,90	0,00	0,00	0,00
synthetische meubels	12,60	37,80	25,20	0,00	138,59
tapijt	10,68	45,59	2,24	5,02	2,14
pleister (muren)	47,78	0,00	0,00	0,00	23,89
	TOTAAL	**554,2**	**41,5**	**62,0**	**164,6**

Example for formaldehyde

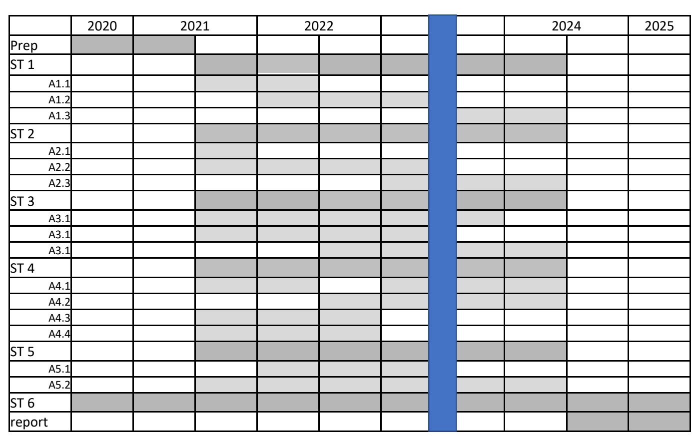


Calculating and sharing the statistical data



	Subtask leader	Co-lead
ST1 – Rating method	UK (UoN, Benjamin Jones)	Denmark (DTU, Pawel Wargocki)
ST2 – Input data	Austria (UIBK, Gabriel Rojas)	France (ULR, Marc Abadie)
ST3 – Smart materials	Denmark (DTU, Menghao Qin)	USA (SU, Jensen Zhang)
ST4 – Smart ventilation	France (Cerema, Gaëlle Guyot)	Denmark (DTU, Jakub Kolarik)
ST5 – Big data		France (ULille, Benjamin Hanoune)
ST6 – Dissemination	Denmark (DTU, Carsten Rode)	Belgium (UGent, Jelle Laverge)

Timing annex



EBC
Energy in Buildings and Communities Programme

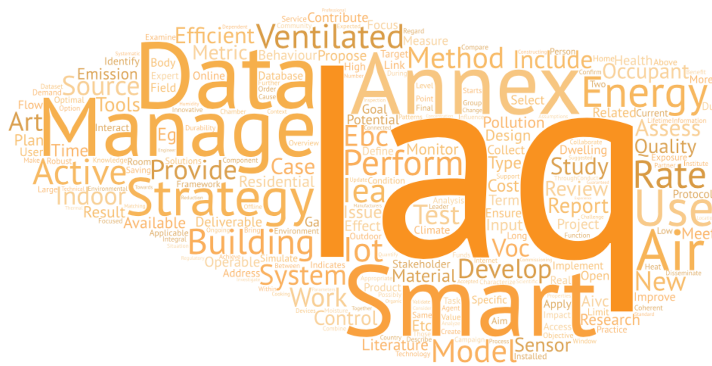
Conclusions

There is no consensus on a framework to rate IAQ as a basis for energy efficiency optimisation in residential buildings

To successfully get there, we need to

- Advance methodologically to define constraints and cost functions
- Provide a 'rating ecology'

Please help us provide these by contributing to the annex!

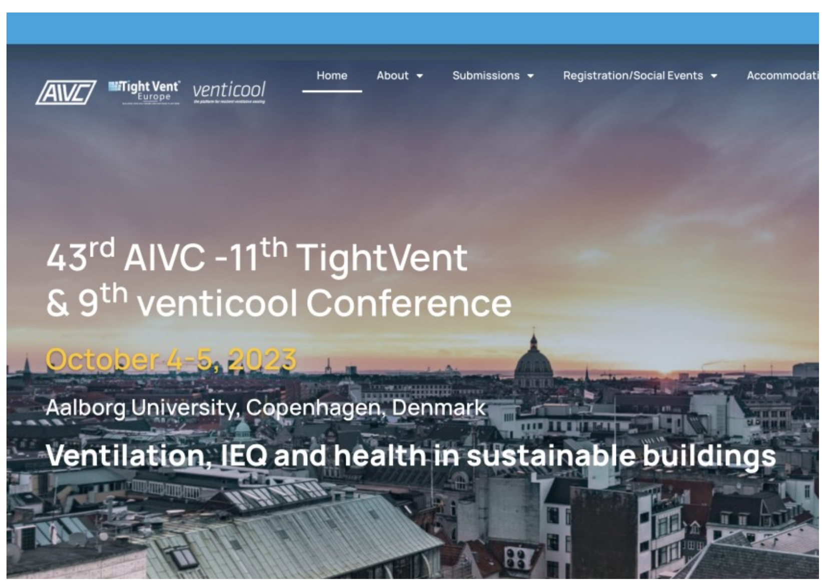


EBC
Energy in Buildings and Communities Programme

Next Meeting

Meeting in October @DTU
AIVC conference Copenhagen!

=> Onsite: 2-3 October 2023



CO_2 Declaration - my travel

TO, MAJ 18, 2023

KLM-ROYAL DUTCH AIRLINES KL 861 BEKRÆFTET

E-ticket: 0749244890082-83 | Bookingreference: TJUVV3

AFGANG

to, maj 18 | 17:30
Amsterdam Schiphol (AMS)

ANKOMST

fr, maj 19 | 16:15
Tokyo Narita (NRT)

Mellemlanding: Seoul Incheon, Korea Republic of ,
12:10 - 13:55 (1:45)
Sæde: ikke specificeret
Klasse: Economy (L)
Rejsetid: 15h 45m (1-stops)

Tilladt bagage til indtjekning: 1PC (Stk.)
Bonuskort: KL2011880322, AF2011880322
Fly: Boeing 787-9

Mulighed for forplejning: Måltid (Ikke Specificeret)
Beflyves af: KLM Royal Dutch Airlines

Noter:
VACCINATION TIL JAPAN KAN VAERE PAAKRAEVET
VACCINATION TO JAPAN MAY BE REQUIRED
CHECK WWW.VACCINATION.DK

Husk at afsætte tilstrækkelig med tid til check-in og sikkerhedsprocedurer

818.45 KG CO2 for dette fly

CPH-AMS	164 kg
AMS-NRT	818 kg
HND-CDG	1,270 kg
CDG-CPH	150 kg
Total	2,402 kg

EBC
Energy in Buildings and Communities Programme

IEA-EBC Annex 86

Energy Efficient IAQ Management in residential buildings

Jelle.Laverge@UGent.be