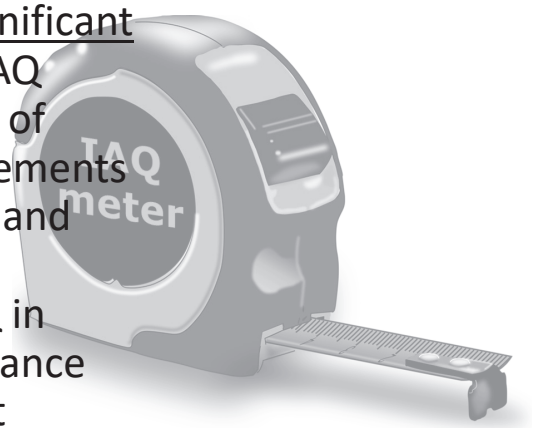
….is IAQ metric necessary?

- Lack of IAQ metric or disagreement what should constitute IAQ metric is a significant barrier holding back innovation of IAQ conducive technologies, emergence of undocumented methods of measurements of IAQ claiming their high efficiency and authenticity, this all resulting in undervaluing the importance of IAQ in different credit schemes and compliance metrics related to built environment



Source: Steinemann et al. (2016)

More and more pollutants present for which no toxicological data exist

"New chemicals and other contaminants appear in buildings almost daily. Many in the indoor air community fear that so me of these may be significant health hazards either singly or in combination. Undoubtedly some will.

But rather than speculate on that …(…) it makes more sense to work with the information we have on contaminants that have demonstrated harm to the population (…) .

Sherman (2013)

TAIL

A NEW RATING SCHEME FOR INDOOR ENVIRONMENTAL QUALITY (IEQ)

Pawel Wargocki
International Centre for Indoor Environment and Energy
DTU Civil Engingeering, Technical University of Denmark
paw@byg.dtu.dk

Background - ALDREN project

- Horizon 2020 Coordination and Support Action (CSA)
- Alliance for Deep RENovation in buildings (ALDREN). Implementing the European Common Voluntary Certification Scheme, as back-bone along the whole deep renovation process
- Main objective: To consolidate, promote and implement an extended harmonized procedure based on the European Voluntary Certification Scheme for non-residential buildings (EVCS) and a set of relevant instruments in order to support building deep energy renovation operations all along the process tackling its organizational, financial and technical components issues.
- Focus: offices and hotels undergoing deep energy renovation
- Duration: November 2017-September 2020
- Project number ALDREN 754159

ALDREN ALliance for Deep RENovation in buildings
www.aldren.eu

Specific goals of the ALDREN project (the packages)

- Development of a harmonized energy performance rating method based on the European Voluntary Certification Scheme (EVCS) mandated by the new Energy Performance of Buildings Directive (EPBD).
- Reduction of the gap between predicted (modeled) and actual energy performance of buildings to increase their reliability and compliance.
- **Inclusion of indoor environmental quality (IEQ) in the scope of deep energy renovation to promote solutions supporting comfort and health and to ensure that renovations will not be detrimental to indoor environmental conditions.**
- Linking the building rating in terms of energy, sustainability and IEQ with the private and national financing instruments to emphasize enhanced building value and thus create strong incentives for investment.
- Developing a building passport that integrates, illustrates and documents the different phases of a deep renovation process for proper documentation and dissemination and renovation roadmap (renomap).

A need for inclusion of IEQ in the scope of deep energy renovation

- To satisfy the mandate of the EU Energy Performance of Buildings Directive (EPBD)

- To guarantee that IEQ is not degraded during renovation
- To document any improvements in IEQ after renovation
- To estimate potential additional benefits from renovation including benefits for health and well-being, as well as the financial benefits from improved productivity and increased value of a building on a market

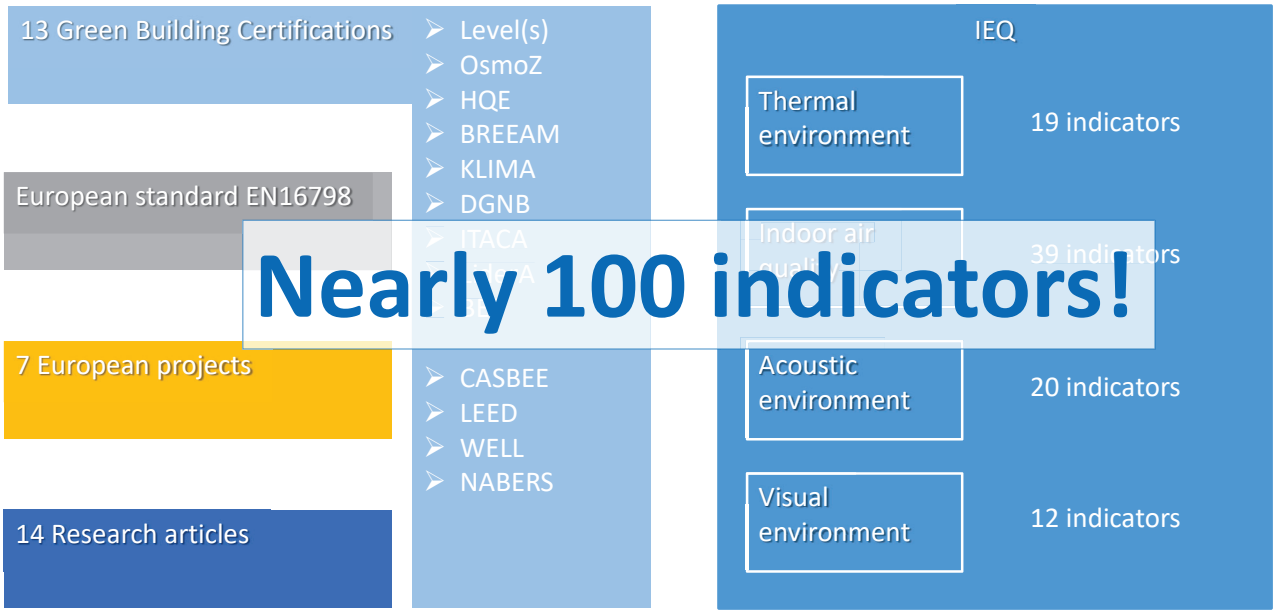
DIRECTIVE (EU) 2018/844 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency

Article 2a. Long-term renovation strategy

1. Each Member State shall establish a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, into a highly energy efficient and decarbonized building stock by 2050, facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings. Each long-term renovation strategy shall be submitted in accordance with the applicable planning and reporting obligations and shall encompass:
(…)

(g) **an evidence-based estimate of** expected energy savings and **wider benefits, such as those related to health, safety and air quality.**

Review of current certification schemes and standards



Wei et al. (2020) Energy and Buildings

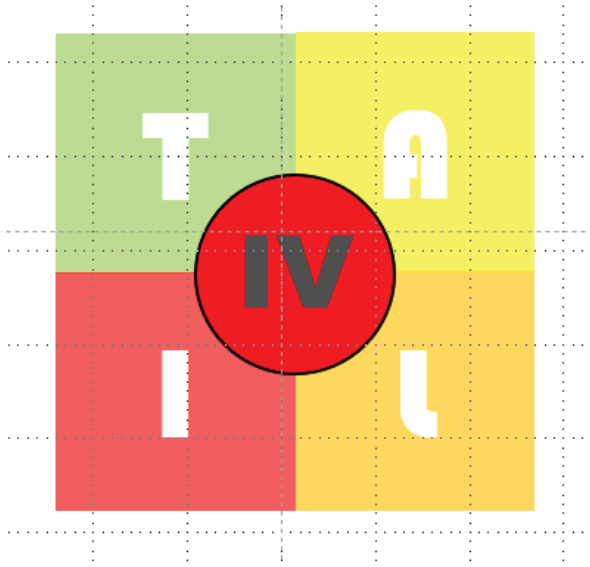
TAIL, a new proposed rating scheme for IEQ

Four components:

- **T**hermal environment
- **A**coustic environment
- **I**ndoor air quality
- **L**ight – Luminous (visual) environment

Overall IEQ:

- I II III IV

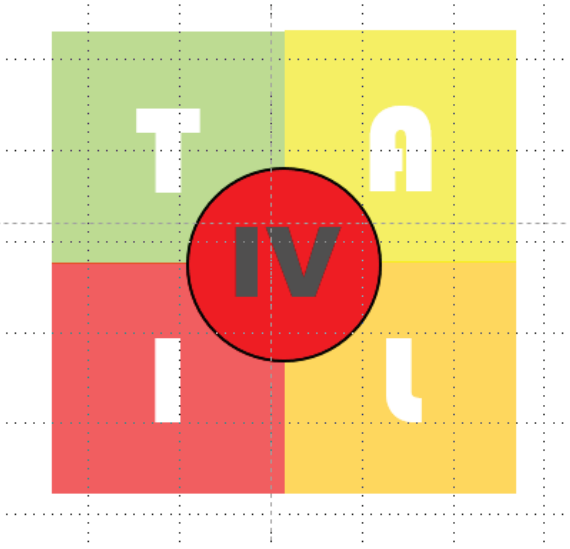


Wargocki et al. (2021) submitted to Energy and Buildings

TAIL, a new proposed rating scheme for IEQ

- Colors: green, yellow, orange, red
- Roman numbers: I, II, III, IV

- Compliant with the Standard EN16798-1(2019) supporting EPBD
- Category I: High level of expectation and recommended for spaces occupied by sensitive and fragile people with special requirements like some disabilities, sick, very young children and elderly persons, to increase accessibility
- Category II: Normal level of expectation
- Category III: Moderate level of expectation
- Category IV: Low level of expectation. Poor quality. Unacceptable regarding health



Criteria for selection of parameters defining TAIL components

- Parameters that may be changed due to the process of deep energy renovation (no deliberate action to change IEQ is proposed)
- Parameters that are included in existing building certification schemes and/or prescribed by the current standards (to allow quick adoption of procedures developed by ALDREN)
- Parameters that can be measured and/or modeled (to allow verification and rating of actual IEQ performance)
- Parameters that have been shown to affect productivity, as well as health, well-being and comfort of building occupants (to allow estimation of economic benefits of potential improvement of IEQ)
- No parameters that directly measure comfort, well-being, health or productivity

Parameters selected to define TAIL components

	IEQ parameter	**Measured**	Modelled	Visual inspection
T	Indoor temperature (°C)	×	(×)	
A	Noise level (dB(A))	×		
I	Carbon dioxide, CO_2 (ppm)	×	(×)	
	Ventilation rate (L/s)	×	(×)	
	Formaldehyde (µg/m^3)	×		
	Benzene (µg/m^3)	×		
	Particulate matter, $PM_{2.5}$ (µg/m^3)	×		
	Radon (Bq/m^3)	×		
	Indoor air relative humidity (%)	×	(×)	
	Visible mold (cm²)			×
L	Daylight factor (%)		×	
	Illuminance (lux)	×		

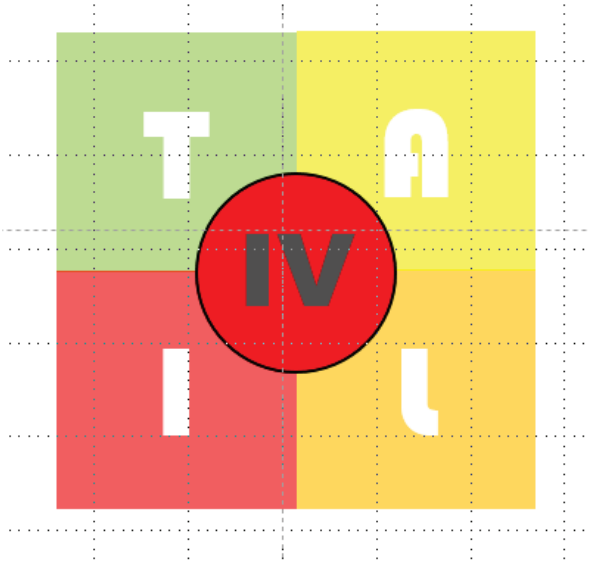
TAIL parameters in Standards, Environmental Assessments Frameworks and Green Building Certifications

	TAIL IEQ parameters	EN16798	Level(s)	WELL	HQE	OsmoZ	BES	LEED	BREEAM	KLIMA	CASBEE	NABERS	DGNB	LiderA	ITACA
T	Indoor temperature (°C)	x	x	x	x		x			x	x	x	x	x	
A	Noise level (dB(A))	x		x	x	x	x	x	x	x	x	x			
I	CO_2 (ppm)	x	x	x		x	x	x		x		x			
	Ventilation rate (L/s)	x	x	x	x	x	x	x	x		x	x	x		x
	Formaldehyde (µg/m^3)	x	x	x	x	x	x	x	x	x		x	x		
	Benzene (µg/m3)	x	x	x	x	x									
	$PM_{2.5}$ (µg/m3)	x	x	x	x	x		x							
	Radon (Bq/m3)	x	x	x	x		x								
	Indoor air relative humidity (%)	x	x	x						x					
	Visible mould (cm^2)		x	x											
L	Daylight factor (%)	x	x		x	x			x		x		x		x
	Illuminance (lux)	x	x	x			x	x	x		x			x	
	Number of parameters	*11*	*11*	*11*	*8*	*7*	*7*	*6*	*5*	*5*	*5*	*5*	*4*	*2*	*2*

Rating protocol, overall design (example for T)

Quality of the thermal environment (T)	Buildings with mechanical cooling		Buildings without mechanical cooling	
	Heating season	Non-heating (cooling) season	Heating season	Non-heating (cooling) season
Green	22±1 °C	24.5±1 °C	22±1 °C	upper limit $0.33\Theta_{rm}$+18.8+2 °C lower limit $0.33\Theta_{rm}$+18.8-3 °C
Yellow	22±2 °C	24.5±1.5 °C	22±2 °C	upper limit $0.33\Theta_{rm}$+18.8+3 °C lower limit $0.33\Theta_{rm}$+18.8-4 °C
Orange	22±3 °C	24.5±2.5 °C	22±3 °C	upper limit $0.33\Theta_{rm}$+18.8+4 °C lower limit $0.33\Theta_{rm}$+18.8-5 °C
Red	If other quality levels cannot be achieved		If other quality levels cannot be achieved	

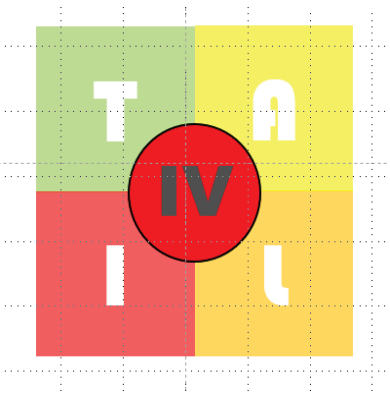
Rating protocol, determination of the overall level of IEQ



Measurements (the rating)

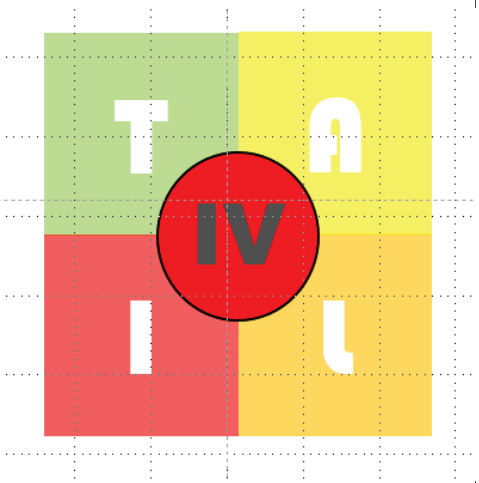
- Measurement to be performed before and after deep energy renovation (DER) at the **same season**, or ideally in summer + winter before and summer + winter after
- Measurements are performed 5 days (MO-FR) in offices and 7 days (MO-MO, or TU-TU, etc.) in hotels
- Measurements only offices/workplaces in office buildings and only in rooms in hotels
- Before renovation: results from previous surveys can be used provided that the same or similar methods were implemented

Summary



- The framework for rating of IEQ and its components is proposed.
- TAIL – a rating scheme describing IEQ level in offices & hotels that undergo deep energy renovation – allows rating of IEQ level before and after renovation.
- TAIL integrates all IEQ components. Based on actual measurements and measuring results. No arbitrary credits are given.
- TAIL treats all IEQ components equally. No weightings are used.
- TAIL complements the existing approaches for IEQ ratings and addresses EPBD mandate.
- TAIL is compliant with major certification schemes, EN16798-1 and the Level(s) which is EU's common assessment and reporting scheme on the sustainability of buildings.
- Even though TAIL may be perceived as fairly crude, it is expected to increase the interest of investors in IEQ.

TAIL perspectives



- Short-time frame: validation of the TAIL concept by measurements in buildings undergoing deep energy renovation, development of a prediction tool (predicTAIL).
- Medium-time frame: sensitivity analysis to distinguish differences in IEQ across buildings using TAIL, verification against modeling and occupant responses and against long-time measurements with more sophisticated instrumentation.
- Long-time frame: extension to new and existing and other public (schools) and residential buildings, increasing number of parameters underlying TAIL, inclusion of occupant ratings (occupanTAIL), extension to include occupant control and preferences, monetizing TAIL and developing instrument measuring TAIL as well as inclusion the aspects of building resilience (resilienTAIL)

Thank you

ALDREN ALliance for Deep RENovation in buildings

www.aldren.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 754159.

The information in this publication does not necessarily represent the view of the European Commission.