Subtask 1: Defining the metrics

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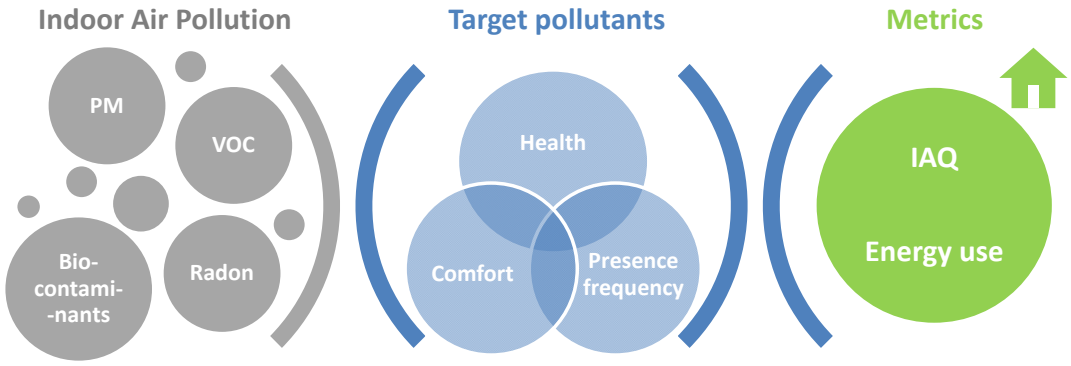


Contents

- Subtask 1: What is it?
- What's new from last meeting in Dresden?

Subtask1 – Defining the metrics

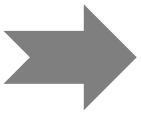
Previous attempts on the prioritization of Pollutants

Concentration Levels in Residences

Exposure Limit Values (ELV)

Non-low energy buildings

Low energy buildings

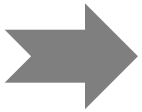


"SHORT" LIST OF POLLUTANTS for ANNEX68

IAQ indices from literature

Based on ELV

Based on DALY



METRICS for ANNEX68

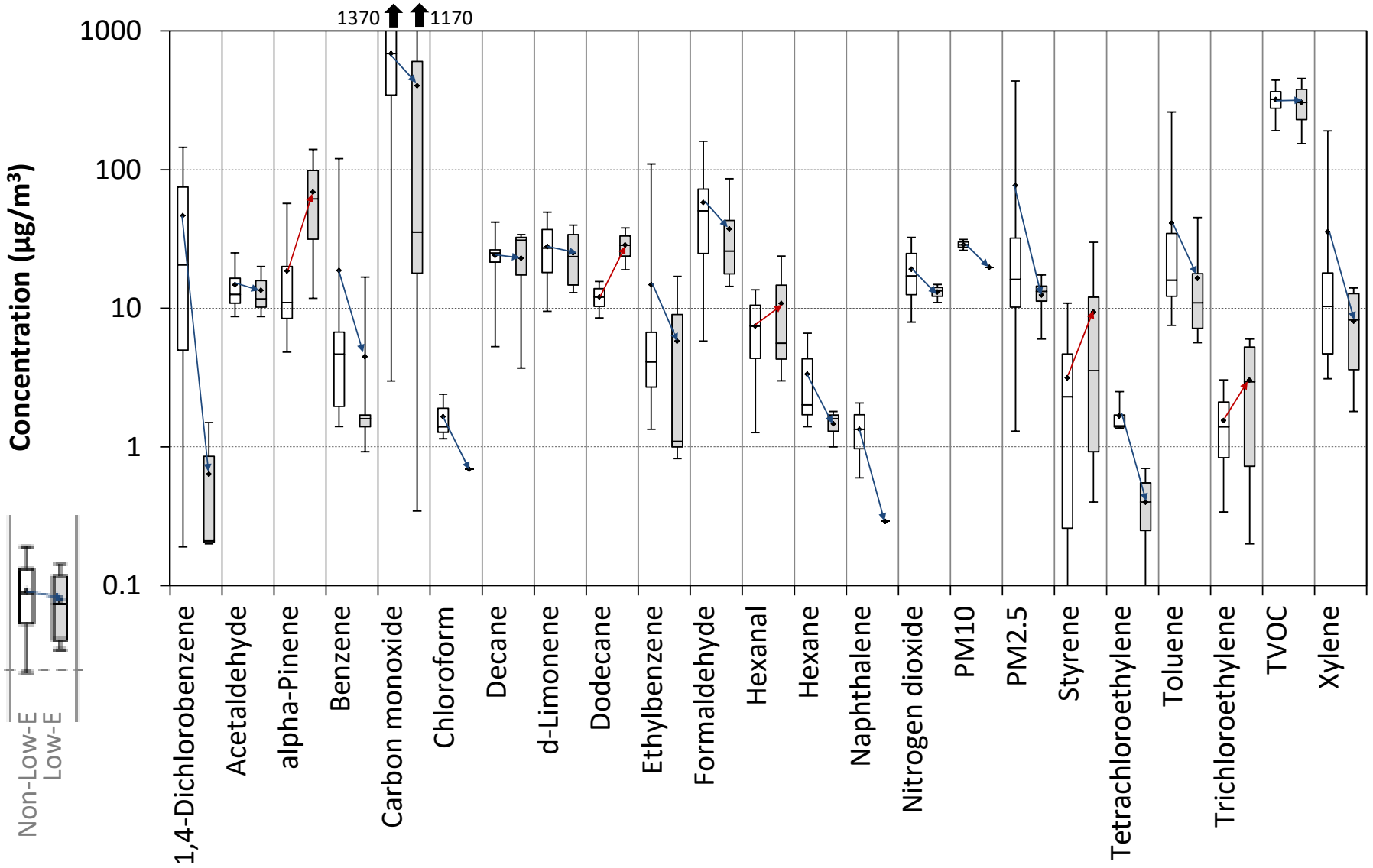
accounting for energy consumption

Pollution levels in residential buildings

- Non low-energy residential buildings:
  - Cheng et al. (2010) for **Australia**,
  - Stranger et al. (2012) for **Belgium**,
  - Zhang et al. (2013), Du et al. (2014) and Liang et al. (2014) for **China**,
  - Guo et al. (2009) for **China, Hong-Kong, Japan, Korea and Taiwan**,
  - Kirchner et al. (2006) for **France**,
  - Park and Ikeda (2006), Azuma et al. (2007) for **Japan**,
  - Langer and Beko (2013) for **Sweden**, and
  - Logue et al. (2011) for **USA** – about 50% of exposure levels come from US non-low-energy buildings and 9% from low-energy buildings; the other data come from other industrialized countries (Canada, Germany, France Spain, UK, Denmark, Finland, Japan, Hong-Kong, South Korea…).

- Low-energy residential buildings:
  - Cheng et al. (2010) for **Australia**,
  - Stranger et al. (2012) for **Belgium**,
  - Du et al. (2014) for **China**,
  - Derbez et al. (2015) for **France**,
  - Park and Ikeda (2006) for **Japan**, and
  - Logue et al. (2011) for **USA.**

Pollution levels in residential buildings



Exposure Limit Values

Countries and Organizations with Exposure Limit Values (ELVs)

Indoor Air Guideline Values (IAGVs)
(applicable for all indoor environments)

- World: GV – WHO
- EU: GV – INDEX
- France: VGAI (Valeurs Guide de l'Air Intérieur) – ANSES
- Germany: RW (Richtwerte) – UBA
- Netherlands: TCA (Tolerable Concentration in Air) – RIVM
- USA: NAAQS (National Ambient Air Quality Standards) – USEPA
- Canada: RIAQG (Residential IAQ Guideline) – Health Canada
- California (USA): REL (Reference Exposure Levels) – OEHHA
- …

Occupational Exposure Limits (OELs)
(applicable for working environments)

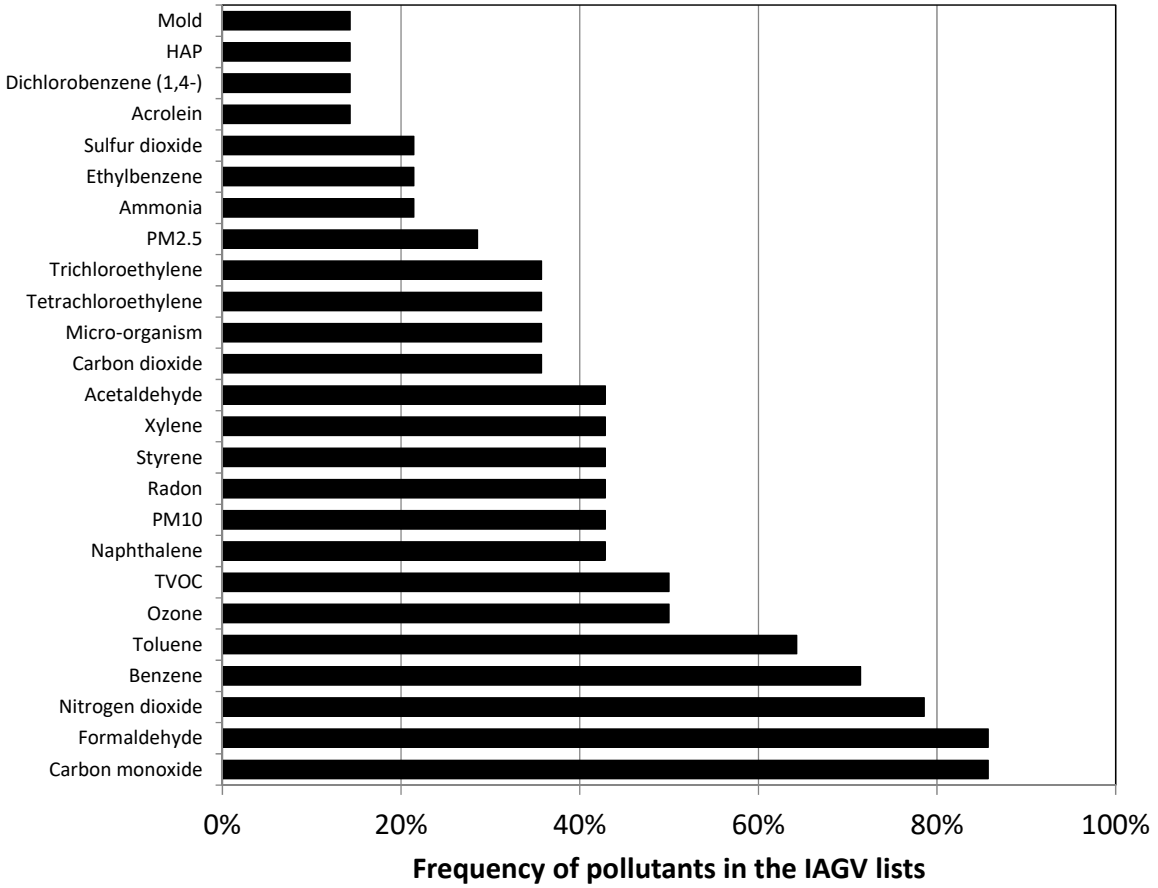
- World: TLV (Threshold Limit Values)
- EU: IOELV (Indicative Occupational Exposure Limit Values) and BOELV (Binding Occupational Exposure Limit Values)
- France, Belgium: VLEP (Valeurs Limites d'Exposition Professionnelle)
- Germany: AGW (Arbeitsplatzgrenzwert)
- Denmark: GV (Grænseværdier for luftforurening)
- Netherlands: OEL (Occupational Exposure Limits)
- Poland: MAC (Maximum Admissible Concentrations)
- Spain: VLA (Valores Límite Ambientales)
- UK: WEL (Workplace Exposure Limit)
- USA, Canada: TLV (Threshold Limit Values)
- California (USA): PEL (Permissible Exposure Limit)
- …

Lowest Concentration of Interest (LCI)
(applicable for characterization of emissions from building materials)

- World: none
- EU: EU-LCI – DG JRC
- France: CLI (Concentration Limite d'intérêt) – ANSES
- Germany: NIK (Niedrigste Interessierende Konzentration) – AgBB
- …

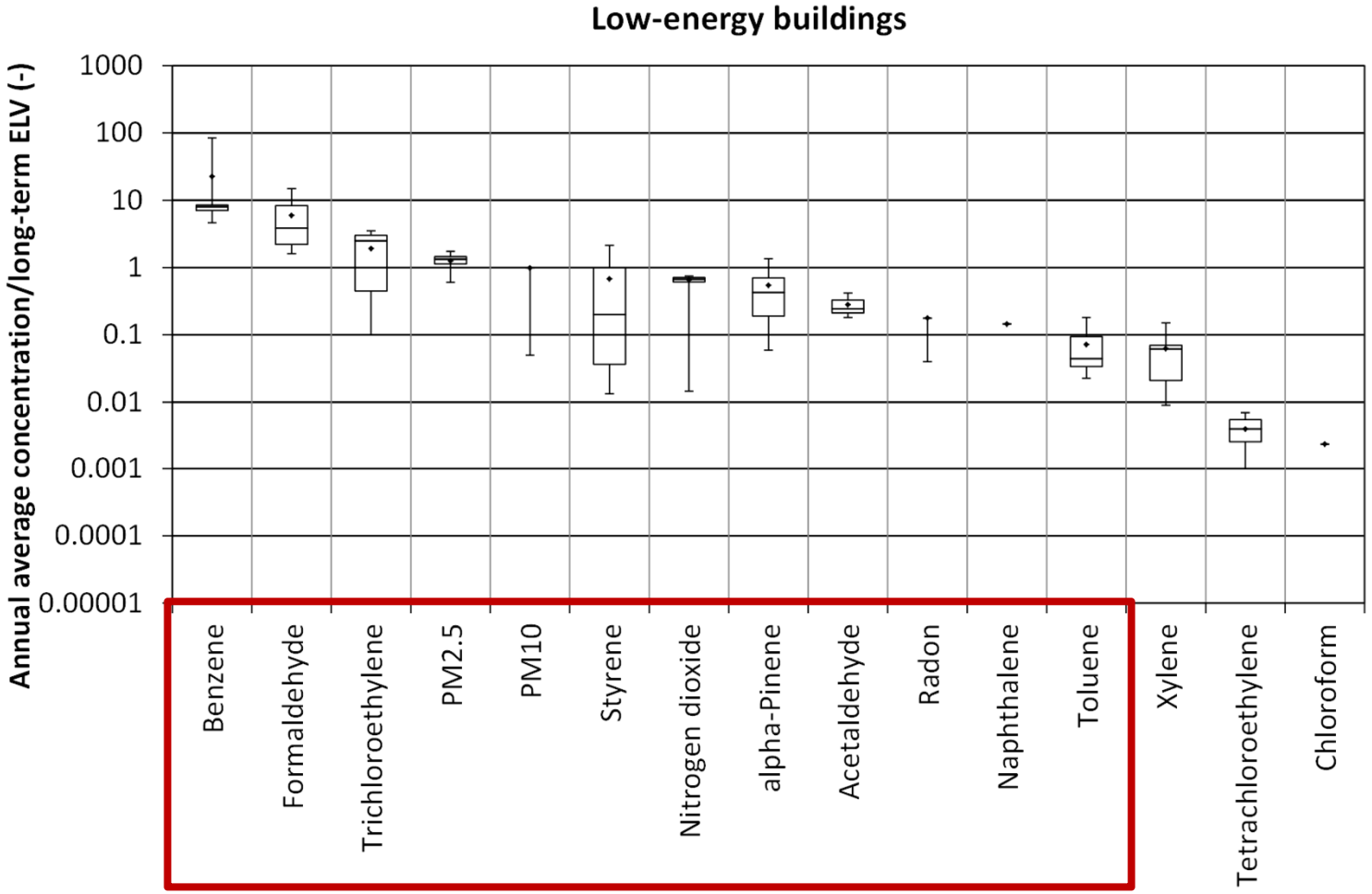
Exposure Limit Values

- ELV database:
  - World Health Organization, Europe, Austria, Belgium, USA – California, Canada, China, France, Germany, Hong-Kong, Japan, Korea, Portugal and United Kingdom (UK)



List of pollutants of concern for Annex68

- Illustration for long-term exposure

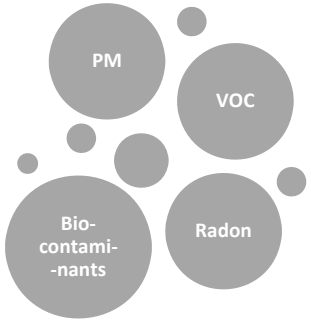


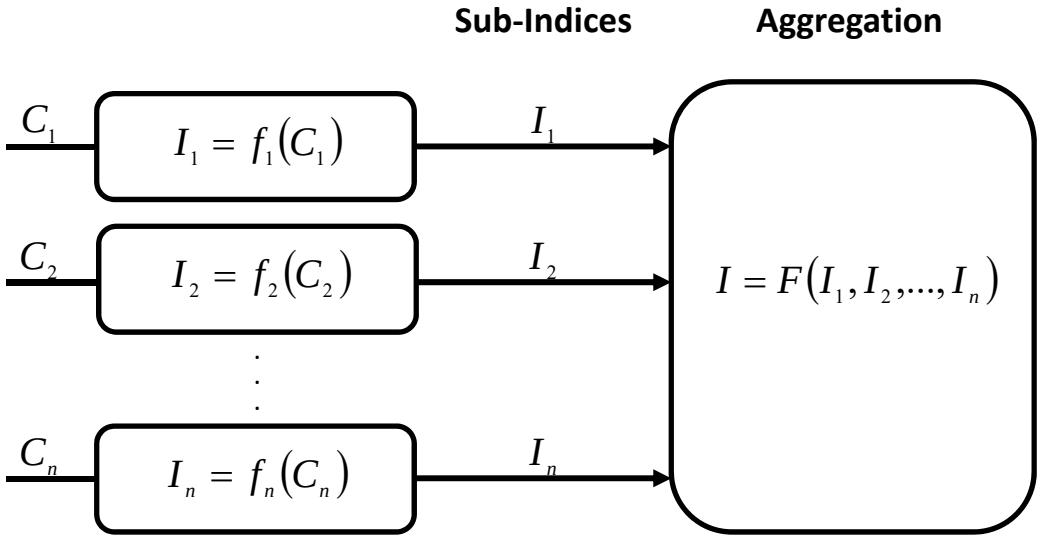
+ pollutants according to previous studies on pollutant prioritization (WHO, INDEX, ...)

List of pollutants of concern for Annex68

	Long-term Exposure			Short-term Exposure		
	ELV	Averaging period	Source	ELV	Averaging period	Source
Acetaldehyde	48	1 year	Japan	-	-	-
Acrolein	0.35	1 year	USA-California	6.9	1 h	France
α-pinene	200	1 year	Germany	-	-	-
Benzene	0.2	whole life (carcinogenic risk level: 10^{-6})	France	-	-	-
Carbon dioxide	-	-	-	1250	8 h	Portugal
Formaldehyde	9	1 year	USA-California	123	1 h	Canada
Naphthalene	2	1 year	Germany	-	-	-
Nitrogen dioxide	20	1 year	France, Canada	470	1 h	USA-California
PM10	20	1 year	WHO	50	24 h	WHO
PM2.5	10	1 year	WHO	25	24 h	WHO
Radon	200	1 year	Austria, Canada, Hong-Kong	400	8 h	Austria, China, Portugal
Styrene	30	1 year	Germany	-	-	-
Toluene	250	1 year	Portugal	-	-	-
Trichloroethylene	2	whole life (carcinogenic risk level: 10^{-6})	France	-	-	-
TVOC	-	-		600	8 h	China, Hong-Kong, Portugal
Mold	200	1 year	EU	-	-	-

IAQ indices: the problematic





adapted from IND-QAI (Sharma and Bhattacharya, 2012)

IAQ indices from literature

(based on Kirchner, Jédor and Mandin, 2006)

Max. operator

Cohas (1996)
any pollutant

$$I_{BILGA} = \begin{cases} \max\left(\dfrac{C_i^{obs} - ELVc_i}{ELVa_i - ELVc_i}\right) si\ C_i^{obs} > ELVc_i \\ \max\left(\dfrac{C_i^{obs} - ELVc_i}{ELVc_i}\right) si\ C_i^{obs} \le ELVc_i \end{cases}$$

Weighted Additive Form

Gadeau (1996)
CO, CO_2, NO_2, HCHO

$$I_{CLIM2000} = \frac{1}{4}\left(\frac{[CO]}{30} + \frac{[CO_2]}{4500} + \frac{[NO_2]}{0.4} + \frac{[HCHO]}{0.06}\right)$$

Castanet (1998)
CO, CO_2, Bacteria

$$I_{LHVP} = \frac{[CO]}{5} + \frac{[CO_2]}{1000} + \frac{[Bacteria]}{1000}$$

Chiang and Lai (2002)
CO, CO_2, HCHO, TVOC, PM_{10}

$$I_{IEI\_IAQ} = \frac{1}{p}\sum_{i=1}^{p} Grade_i$$

QUAD-BBC (2012)
CO_2, NO_2, SO_2, O_3, CO, HCHO, Acetaldehyde, Ethylbenzene, Styrene, Toluene, o-Xylene, Acetone, $PM_{2.5}$, PM_{10}

$$I_{QUAD-BBC} = \sum_{i=1}^{p} \frac{C_i^{obs}}{ELV_i}$$

Sofuoglu and Moschandreas (2003)
Formaldehyde, TVOC, CO, CO_2, $PM_{2.5}$, PM_{10}, Fungi, Bacteria

$$I_{IAPI} = \frac{1}{8}\sum_{i=1}^{8} 10 \times \left[1 - \frac{C_i^{max} - C_i^{obs}}{C_i^{max} - C_i^{min}}\left(\frac{ELVc_i - C_i^{obs}}{ELVc_i}\right)\right]$$

The DALY approach

(Logue et al., 2011)

Disability-Adjusted Life-Years (DALY):

WHO definition: *One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the* ***gap between current health status and an ideal health situation*** *where the entire population lives to an advanced age, free of disease and disability.*

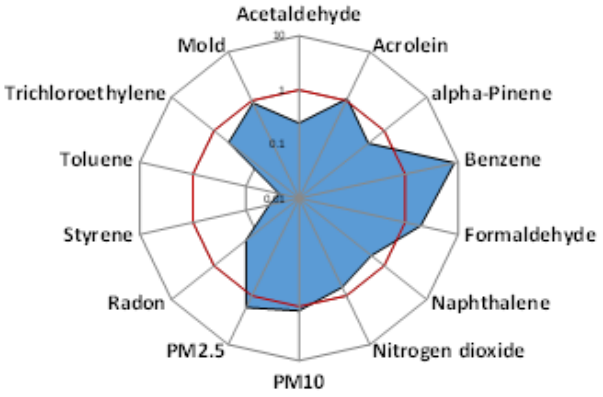
$$DALY_{disease} = YLL_{disease} + YLD_{disease}$$

$YLL_{disease}$: Years of Life Lost due to premature death from the disease,
$YLD_{disease}$: Years of Life Disability, weighted from 0 to 1 depending on disease severity.

$$\Rightarrow \quad DALY^{p} = \sum_{j=1}^{n_{disease}} DALY_j = \sum_{j=1}^{n_{disease}} f_j(C_i)$$

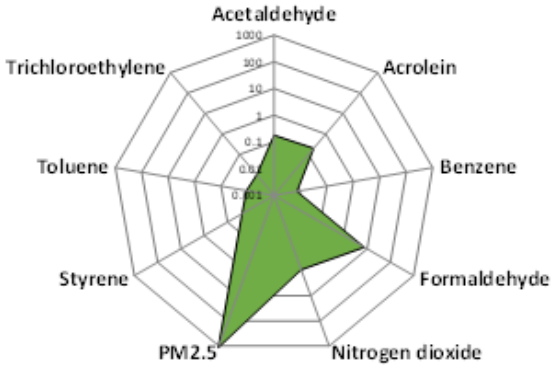
Metrics for Annex68 – Dashboard

IAQ – LTEL



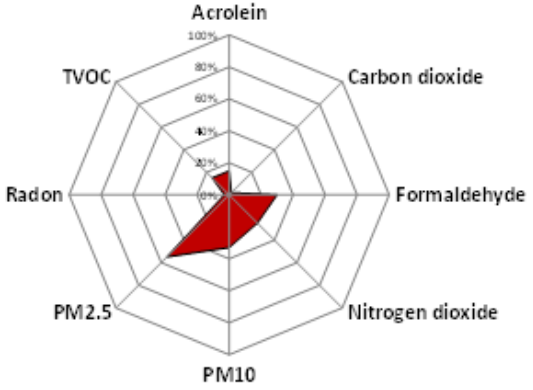
Maximal value: 8.5 (Benzene)

IAQ – DALY



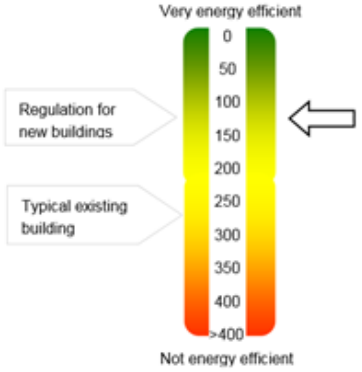
Total: 1166 DALYs lost/(year.100,000 persons)

IAQ – STEL



Maximal value: 55% (PM2.5)

Energy consumption



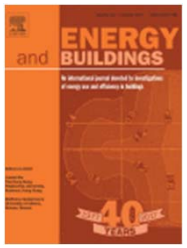
Energy consumption: 130 $kWh_{PE}/(m^2.year)$

Data represented here are just for display and do not represent actual situation

What's new from last meeting in Dresden?

- Writing of the report:
  - 1st draft ready in December 2016
  - Reviewed by William Bahnfleth
  - Reviewed by AIVC: Max Sherman and Willem de Gids
  - 2nd version resubmitted and accepted: April 2017
  - Reviewed by EXCO: Takao Sawachi and Xudong Yang
  - 3rd version resubmitted and accepted: May 2017
  - ***Report of Subtask 1 will be available soon (October) as an AIVC Contributed Report.***

- Energy and Buildings Special Issue for EBC Annexes:
  - Paper submitted: May 2017
  - 2 reviewers
  - Accepted for publication: July 2017
  - Published online: August 2017



L. Cony Renaud Salis, M. Abadie, P. Wargocki, C. Rode, Towards the definition of indicators for assessment of indoor air quality and energy performance in low-energy residential buildings, Energy and Buildings, 152, 2017, 492-502.


thank you
gracias
merci
danke
obrigado
謝謝
teşekkür ederim
ngiyabonga
go raibh maith agat
dziękuję
bedankt
sukriya
mochchakkeram
tapadh leat
спасибо
kop khun krap
terima kasih
감사합니다
arigatô
dakujem
grazie
takk
мерси
ευχαριστώ
ありがとう
dank je
mauruuru
hvala
sagolun
taiku
Баярлалаа
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faafetai lava
kiitos
dankie
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nandri
grácie
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