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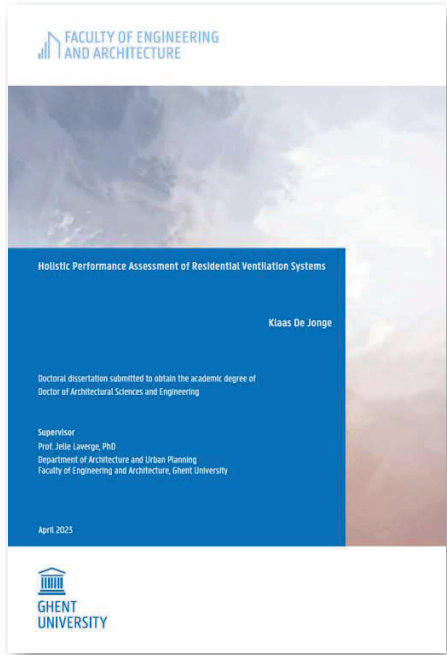
DEPARTMENT OF ARCHITECTURE AND URBAN PLANNING  
RESEARCH GROUP BUILDING PHYSICS

# A Set of Health, Comfort and Energy Performance Indicators for (Smart) Ventilation Systems

Webinar AIVC – 20 June 2024 – Dr. De Jonge Klaas

  
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# Holistic Performance Assessment of Residential Ventilation Systems

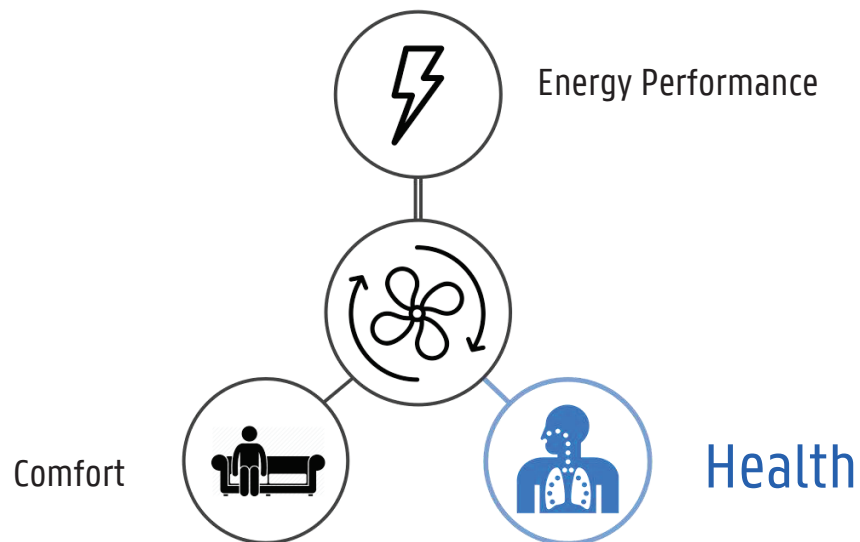
Klaas De Jonge - Promotor Prof. Jelle Laverge

## Chapter 6 - Assessment metrics

De Jonge, Klaas. 'Holistic Performance Assessment of Residential Ventilation Systems'. PhD dissertation, Ghent University, 2023.

<http://hdl.handle.net/1854/LU-01HOMTHJVNBH83NT709B3KGK37>.

How to assess the (health aspect of) indoor air quality?  
How to assess a smart ventilation system with regards to health?



## Desired Indoor Air Quality

“Desired Indoor Air Quality”

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“Desired Indoor Air Quality”

≠ “minimum” or “maximum” indoor air quality

# Desired Indoor Air Quality

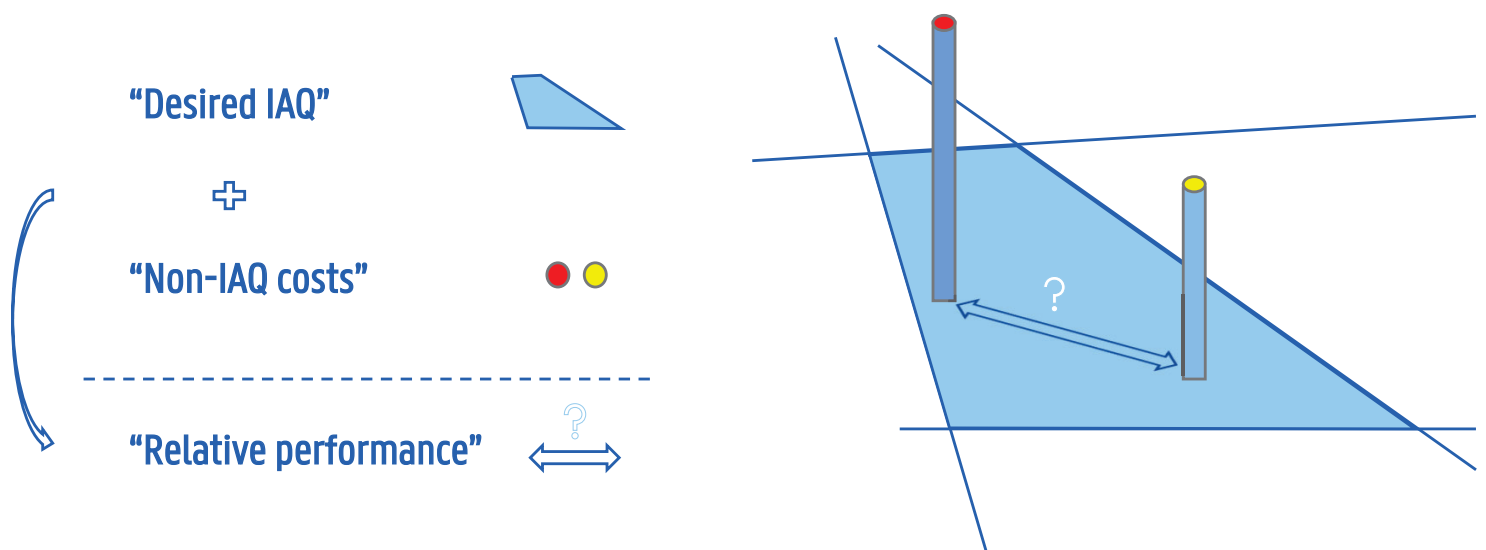
## “Desired Indoor Air Quality”



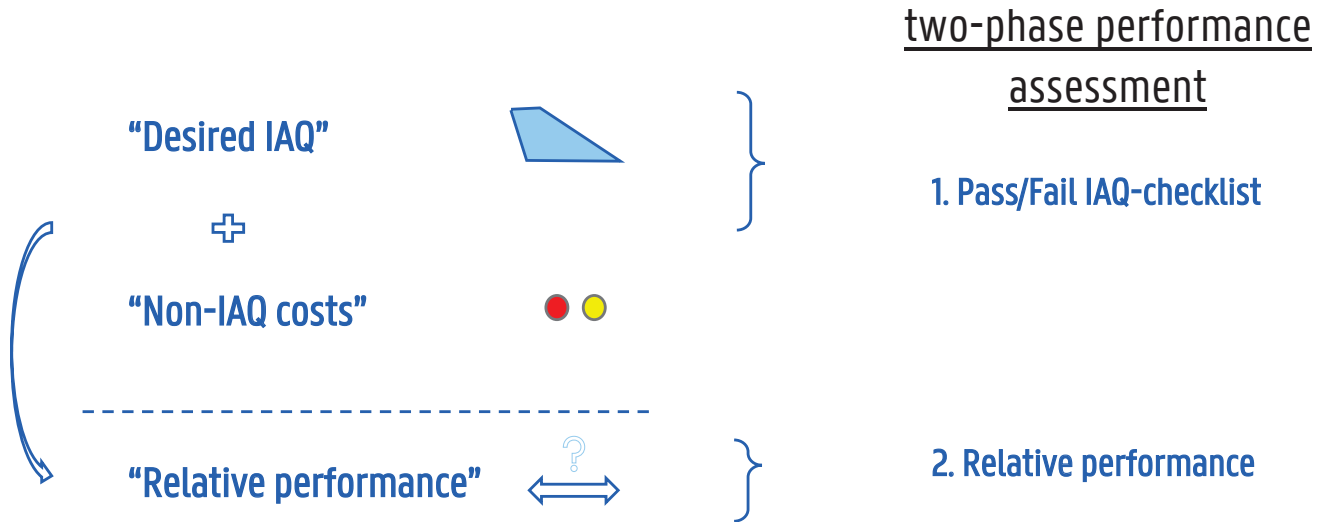
The goal of any ventilation system is:

- Provide and maintain the desired indoor air quality to the occupants.
- If a system succeeds in providing this level of performance (assuming correct boundary conditions), it is consequently a ‘good ventilation system’ with regards to IAQ.

# Base Principle



# Base Principle



# Set of indicators

## IAQ - Checklist

Health: Acute Limit Values  
Health: LCRI  
Health: Dynamic DALYs MAX  
Health: Mold growth indicator  
Comfort: RH  
Comfort: Perceived IAQ

## Relative performance

Health Indicator: Dynamic DALYs  
Energy use indicator  
Health-equivalent energy efficiency

## Set of indicators

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## Health

### Short-term health effects

- Fast negative physiological reaction due to exposure above a certain level
- **Limit values define desired air quality**
- e.g. AEGL-1, OEL



### Long-term health effects

- Health outcomes that occur because of prolonged exposure
- Rooted in epidemiological research and obtained through statistical correlations. Assumes that the dose of exposure is the key driver for the health outcome
- Existing Limit or guidelines values target limiting dose. They do **not** define desired air quality
- **Harm metric**



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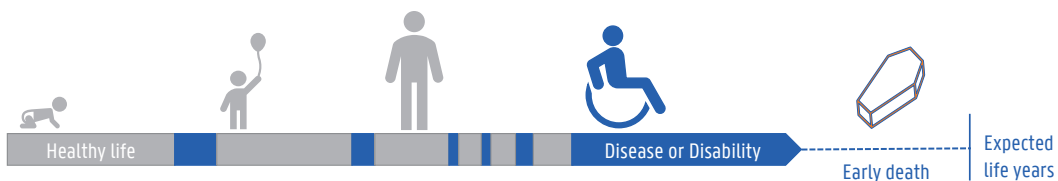
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# Health

## Long-term health effects

Disability-Adjusted Life Years (lost) = Metric of harm



Disability-Adjusted Life years (lost) = Metric of harm

Pollutant exposure  
concentration



EXAMPLE

PM2.5 exposure



Incidence of a  
health outcome



Chronic Bronchitis



DALY



Not able to do  
active sports  
&  
Early death

More on this:

**INDOOR AIR**  
International Journal of Indoor Environment and Health

ORIGINAL ARTICLE | [Full Access](#)

**Time-resolved dynamic disability adjusted life-years estimation**

Klaas De Jonge Jelle Laverge

First published: 18 November 2022 | <https://doi.org/10.1111/ina.13149>

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**Abstract**

The quantification of how healthy the indoor air is, is a complex issue comprising of a large number of contaminants of various sources. The health implication of exposure to each of the contaminant deemed of importance can be expressed using Disability Adjusted Life Years (DALYs). The sum of all DALYs indicates how harmful the indoor air

K. De Jonge and J. Laverge, "Time-resolved dynamic disability adjusted life-years estimation," *Indoor Air*, vol. 32, no. 11, p. e13149, 2022, doi: [10.1111/ina.13149](https://doi.org/10.1111/ina.13149).



# Set of indicators

## IAQ - Checklist

Health: Acute Limit Values

Health: LCRi

Health: Dynamic DALYs MAX

Health: Mold growth indicator

**Comfort: RH**

**Comfort: Perceived IAQ**

## Relative performance

Health Indicator: Dynamic DALYs

Energy use indicator

Health-equivalent energy efficiency



# Comfort

## RH

CR1752:1998: 'Normally few problems occur when the relative humidity is between 30 % and 70 %'

### Requirement

Exposure to indoor air with an RH which is too low or too high, can cause discomfort. A ventilation system should be able to keep this aspect in range most of the time.

### The desired RH comfort, for typical occupancy:

- "most of the time" is 90% of the exposure time at home.
- 5% can be below the range
- 5% can be above the range.

**OR**

The desired RH comfort indicators are:

- 95%-percentile RH exposure < 70% RH
- 5%-percentile RH exposure > 30% RH

## Bio-effluents

Bio-effluent emission of people can cause dissatisfaction with regards to perceived indoor air quality.

### Requirement

For the assessment of a residential ventilation system, providing an indoor air quality which is perceived as comfortable most of the time is a minimum requirement of the system.

### The desired perceived comfort, for typical occupancy:

- On average more than 80% of people should feel comfortable.
- Only 5% of the time, more than 50% of people may experience discomfort.

**OR**

The perceived comfort indicator is thus (PMV-PPD approach):

- 50 percentile of PD (Median) <20%
- 95 percentile of PD <50%

## Comfort

RH

Pass/Fail IAQ-checklist



Bio-effluents

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The perceived comfort indicator is thus (PMV-PPD approach):

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## Set of indicators

### IAQ - Checklist

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Comfort: RH

Comfort: Perceived IAQ

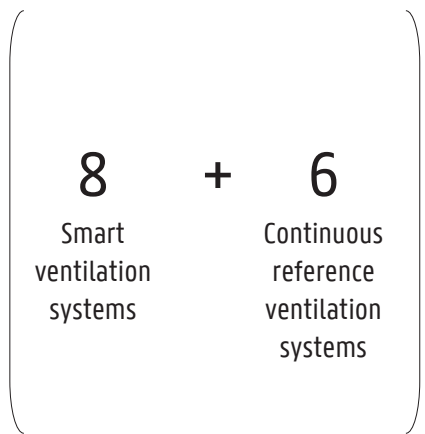
### Relative performance

Health Indicator: Dynamic DALYs

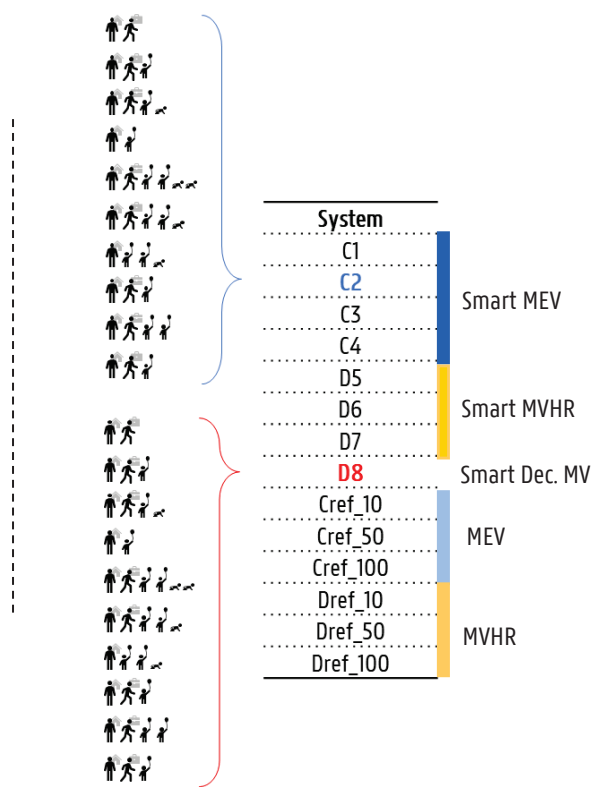
Energy use indicator

**Health-equivalent energy efficiency**

# Simulation results



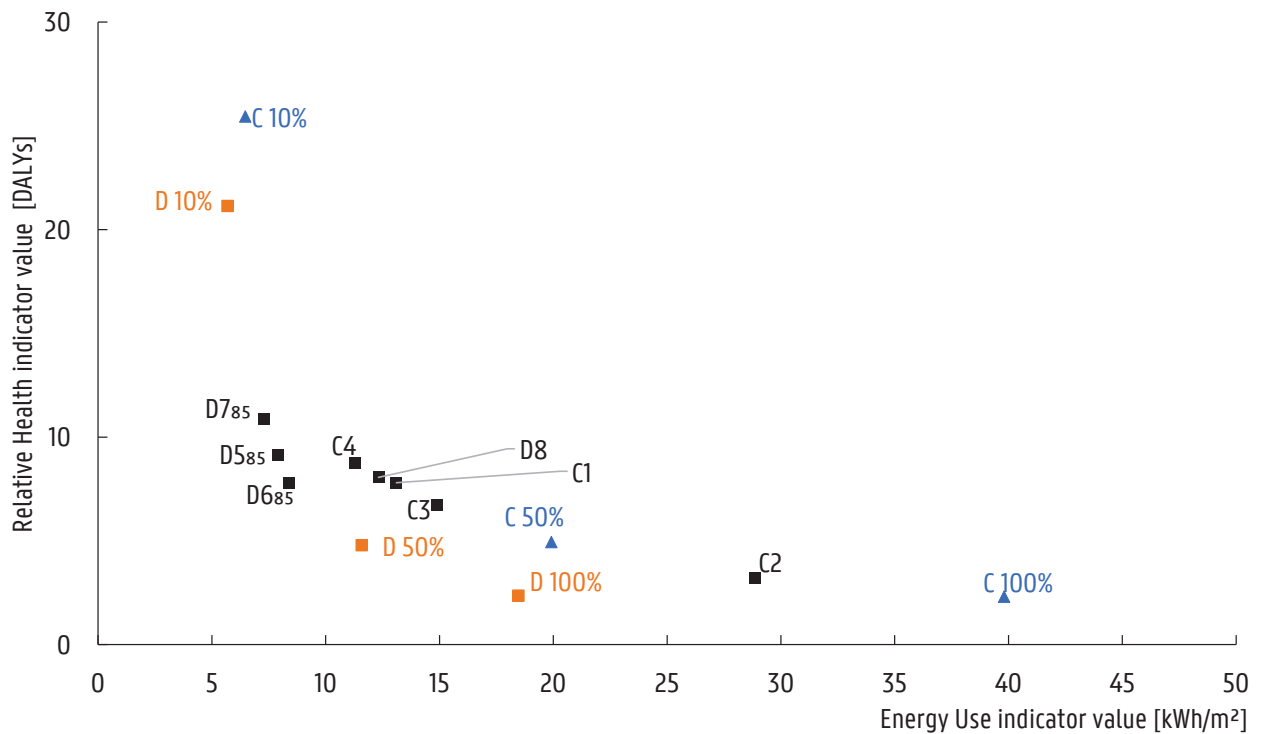
• 10 households

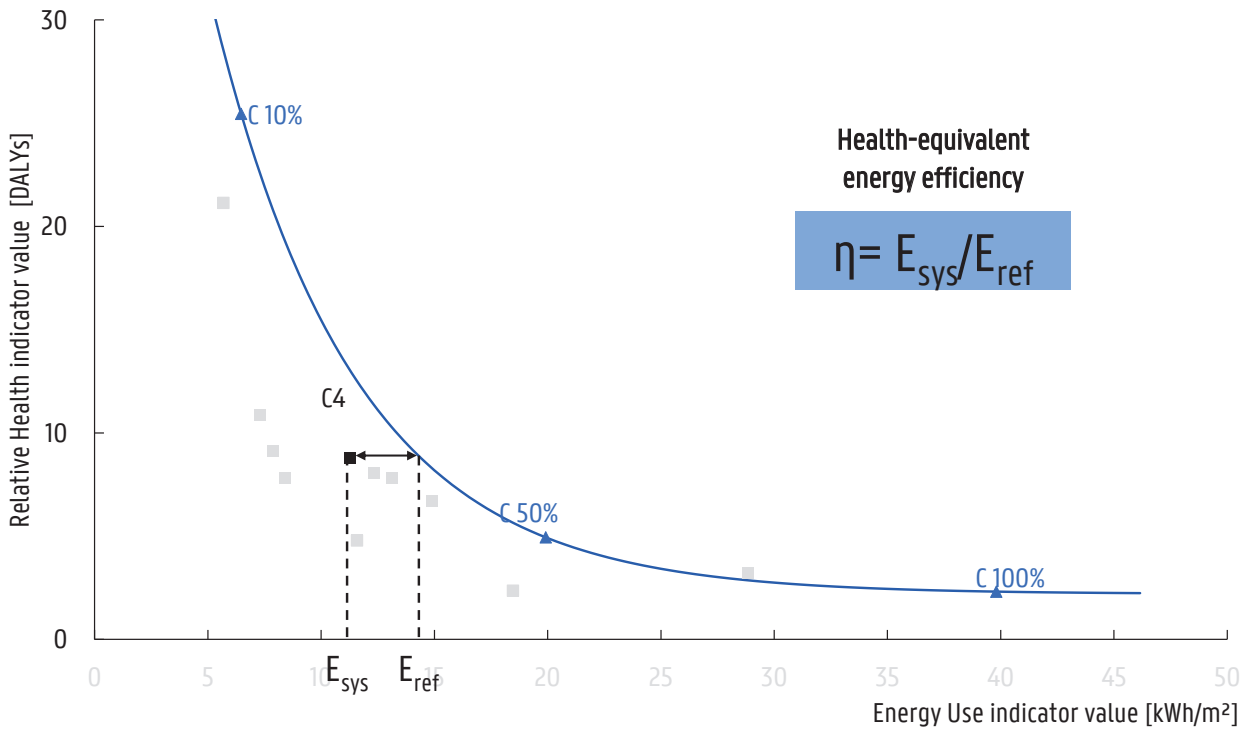
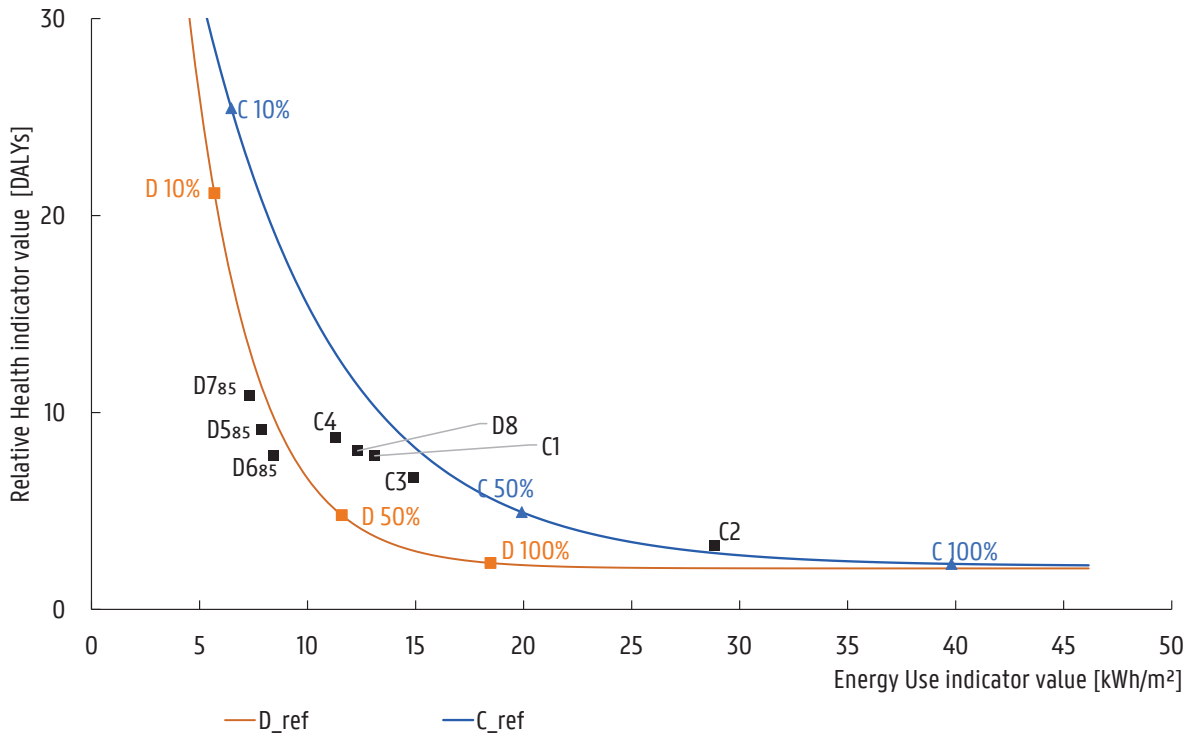


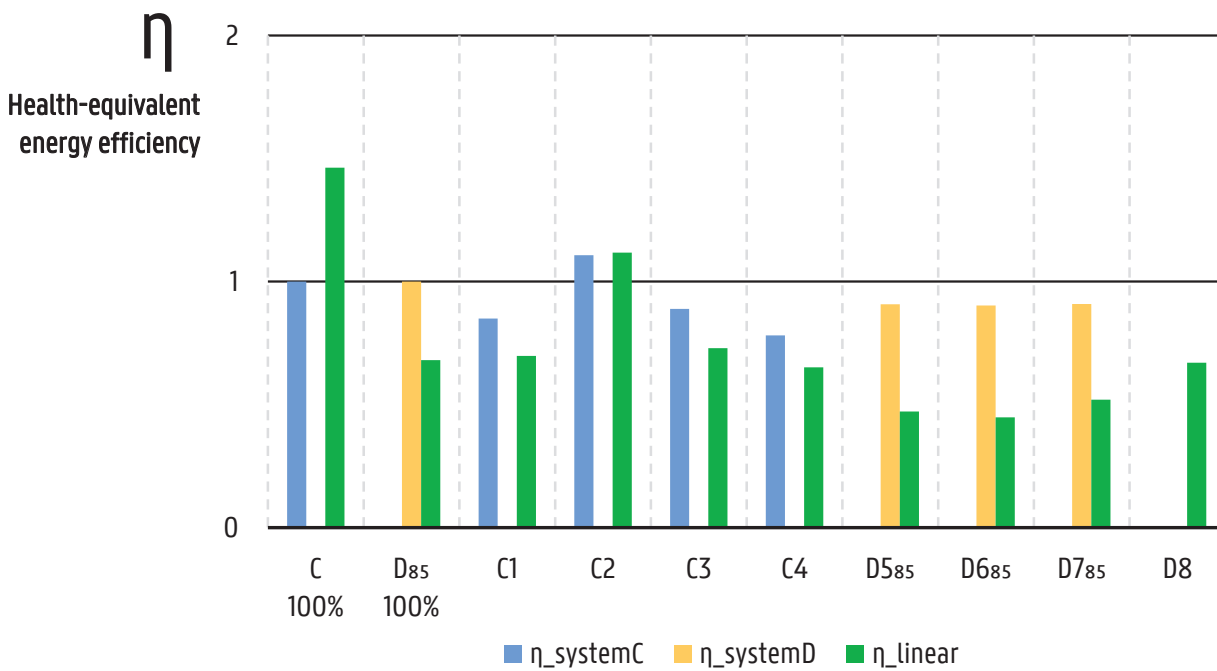
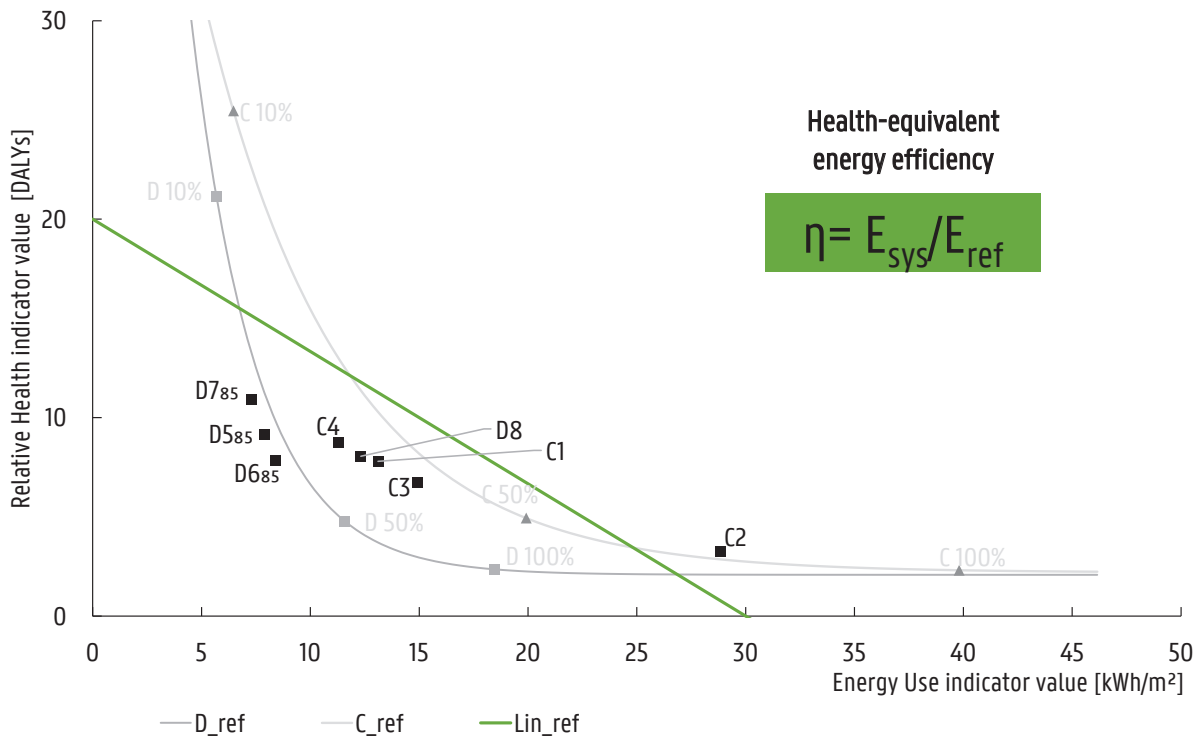
## 5 Volatile Organic Compounds

PRIORITY SUBSTANCES	WHO	CALE	IAQ Decree	IARC	EU-index	CONY	LOGUE
Acetaldehyde		X	X		X		X
Acrolein						X	X
<b>Benzene</b>	X	X	X	X	X	X	X
1,3 Butadiene							X
1,4 Dichlorobenzene							X
<b>Formaldehyde</b>	X	X	X	X	X	X	X
Carbon monoxide	X		X		X		
<b>Limonene</b>		X			X		
<b>Naphthalene</b>	X			X	X		X
Ozone			X				
PM2.5			X			X	X
Radon	X			X		X	
Molds						X	
<b>Nitrogen dioxide</b>	X		X		X	X	X
Styrene		X	X	X	X		
Tetrachloroethylene	X	X	X	X		X	
<b>Toluene</b>		X	X		X		
Trichloroethylene	X	X	X	X		X	
Xylene		X					

System		
C1		
C2		
C3	Short-term health effects	✓
C4		
D5		
D6		
D7		
D8	Perceived comfort	✓
Cref_10		
Cref_50	RH discomfort	✗
Cref_100		
Dref_10		
Dref_50		
Dref_100		







## Conclusions

- A curated and linked set of indicators in performance based assessment of IAQ management strategies
- Limitation of 1 metric can be overcome with another
- Harm-based health metric & Limit values
- Optimisation for Health and Energy within Comfort boundary

Room for improvement:

- Smells/odour from certain activities (e.g. unintended backflow of toilet air)
- Structural safety constraints for RH (wooden building)
- Acoustical constraints >> method now relies on best-practice installation
- Thermal comfort >> modelling approach keeps temperature within comfort for now



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