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FACULTY OF ENGINEERING
AND ARCHITECTURE

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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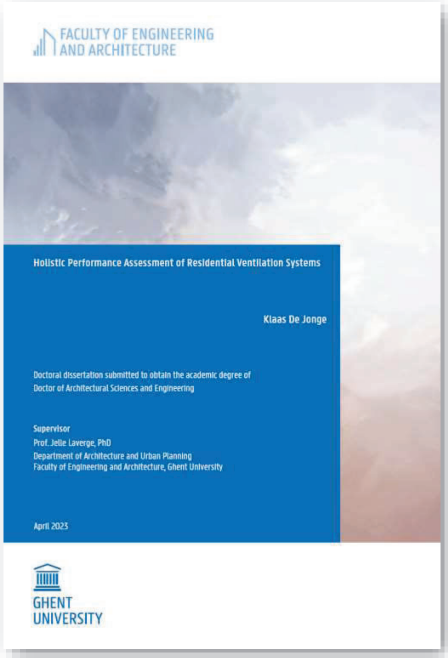


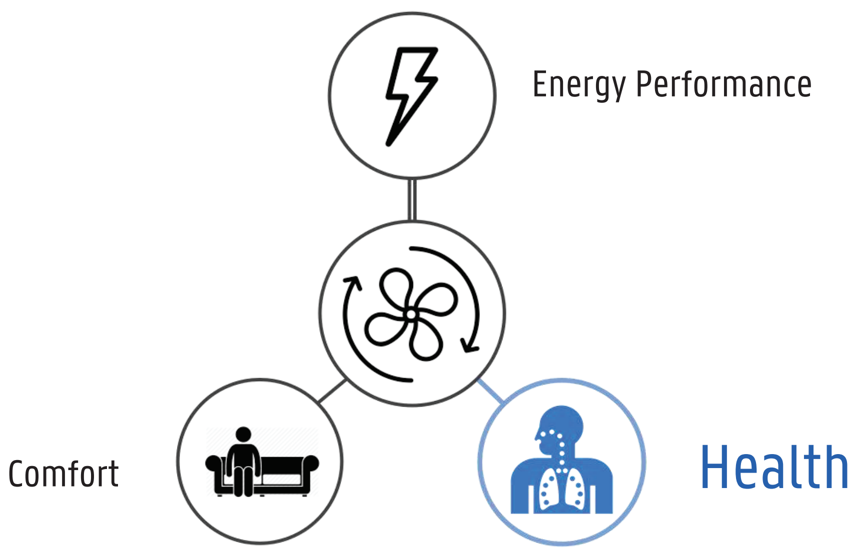
Holistic Performance Assessment of Residential Ventilation Systems

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-01H0MTHJVNBH83NT709B3KGK37.

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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*Durier, François, Rémi Carrié, and Max H. Sherman. 'What Is Smart Ventilation?' *Ventilation Information Paper*, no. 38 (March 2018). https://www.aivc.org/resource/vip-38-what-smart-ventilation.

Desired Indoor Air Quality

"Desired Indoor Air Quality"

≠ "minimum" or "maximum" indoor air quality

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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.

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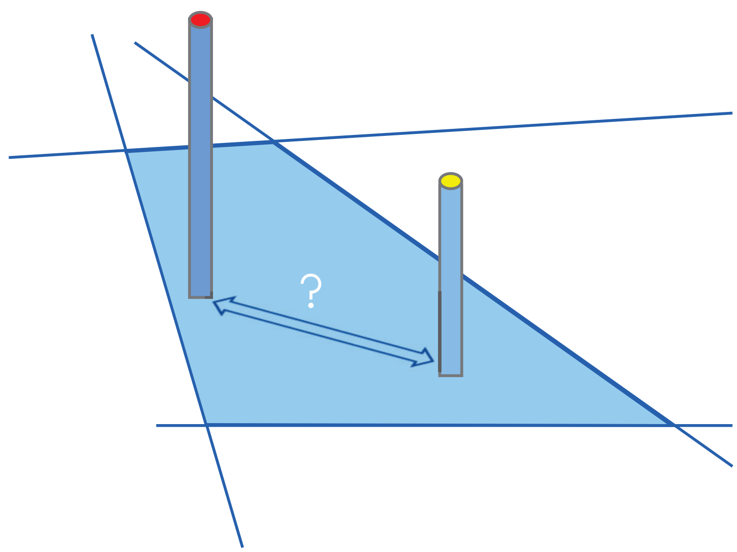
Base Principle

"Desired IAQ"

+

"Non-IAQ costs"

"Relative performance"



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Base Principle

“Desired IAQ”

+

“Non-IAQ costs”

“Relative performance”

two-phase performance assessment

1. Pass/Fail IAQ-checklist

2. Relative performance

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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

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Set of indicators

IAQ - Checklist

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Health-equivalent energy efficiency

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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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Health

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- Fast negative physiological reaction due to exposure above a certain level
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- **Harm metric**

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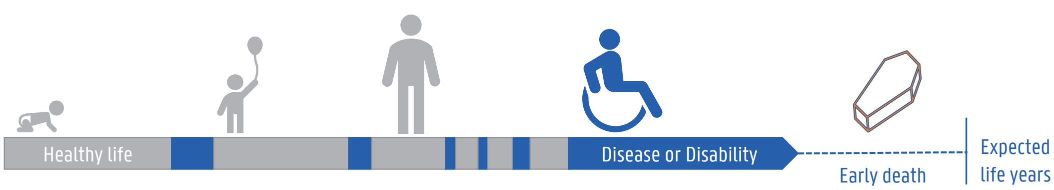
Health

Long-term health effects

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



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Health

Long-term health effects

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

	Pollutant exposure concentration		Incidence of a health outcome		DALY
EXAMPLE	PM2.5 exposure	》	Chronic Bronchitis	》	Not able to do active sports & Early death

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Health

Long-term health effects

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.

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Set of indicators

IAQ - Checklist

Health: Acute Limit Values

Health: LCRi

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Health: Mold growth indicator

Comfort: RH

Comfort: Perceived IAQ

Relative performance

Health Indicator: Dynamic DALYs

Energy use indicator

Health-equivalent energy efficiency

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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 then 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

Bio-effluents

Pass/Fail IAQ-checklist

The desired RH comfort indicators are:
- 95%-percentile RH exposure < 70% RH
- 5%-percentile RH exposure > 30% RH

The perceived comfort indicator is thus (PMV-PPD approach):
- 50 percentile of PD (Median) <20%
- 95 percentile of PD <50%

Set of indicators

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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

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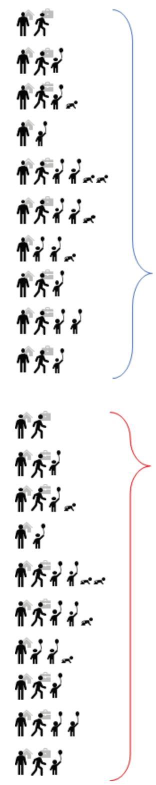
Simulation results

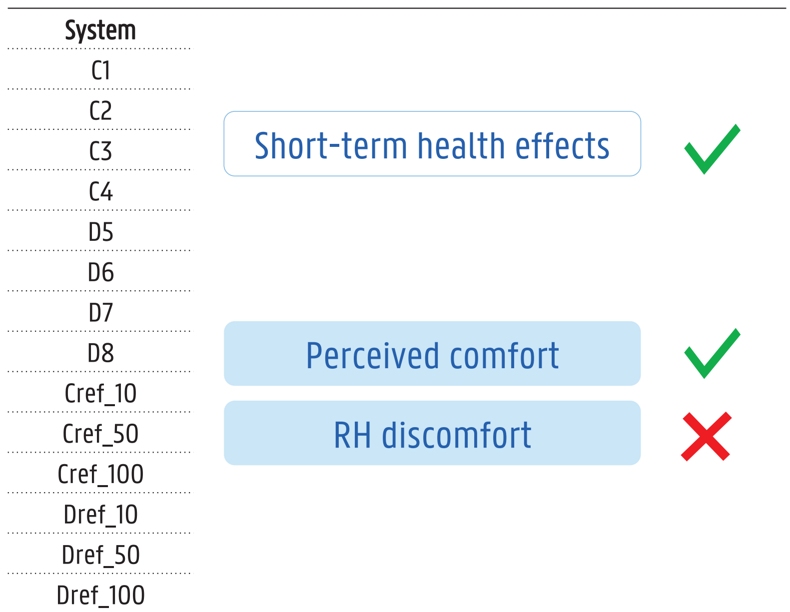
8 Smart ventilation systems + 6 Continuous reference ventilation systems · 10 households



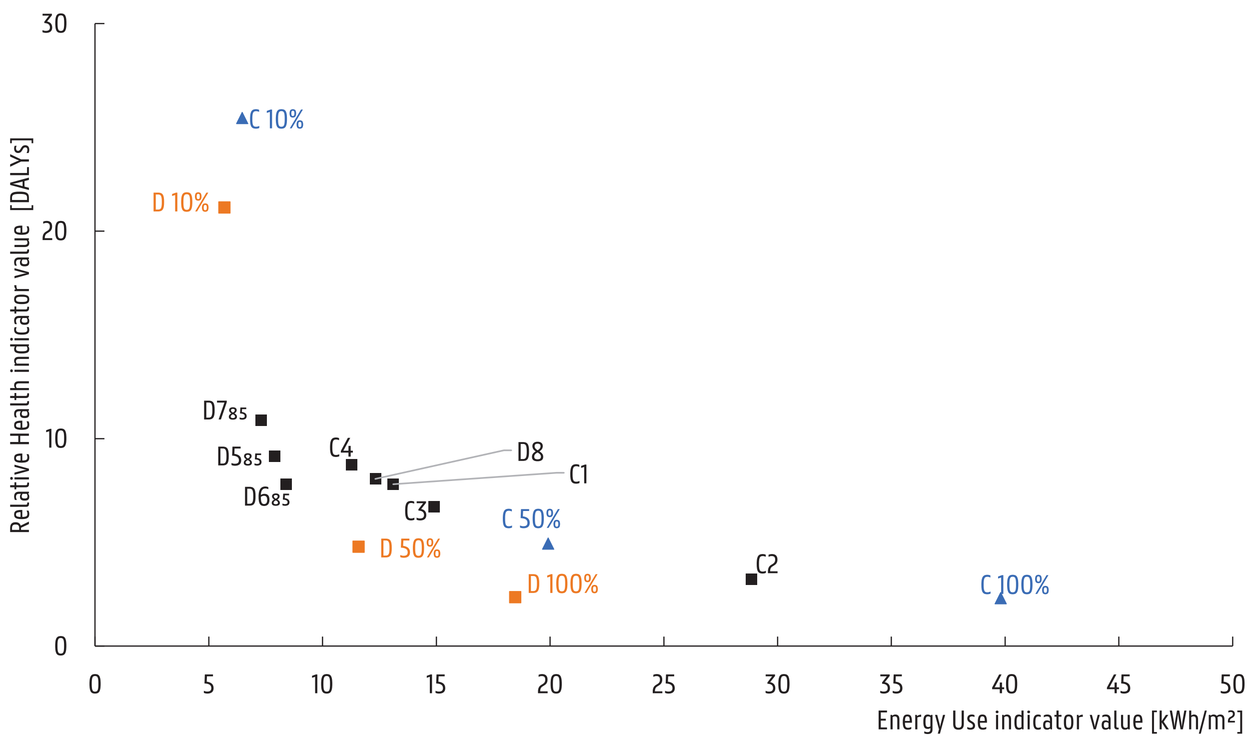
System	
C1	Smart MEV
C2	Smart MEV
C3	Smart MEV
C4	Smart MEV
D5	Smart MVHR
D6	Smart MVHR
D7	Smart MVHR
D8	Smart Dec. MV
Cref_10	MEV
Cref_50	MEV
Cref_100	MEV
Dref_10	MVHR
Dref_50	MVHR
Dref_100	MVHR

5 Volatile Organic Compounds

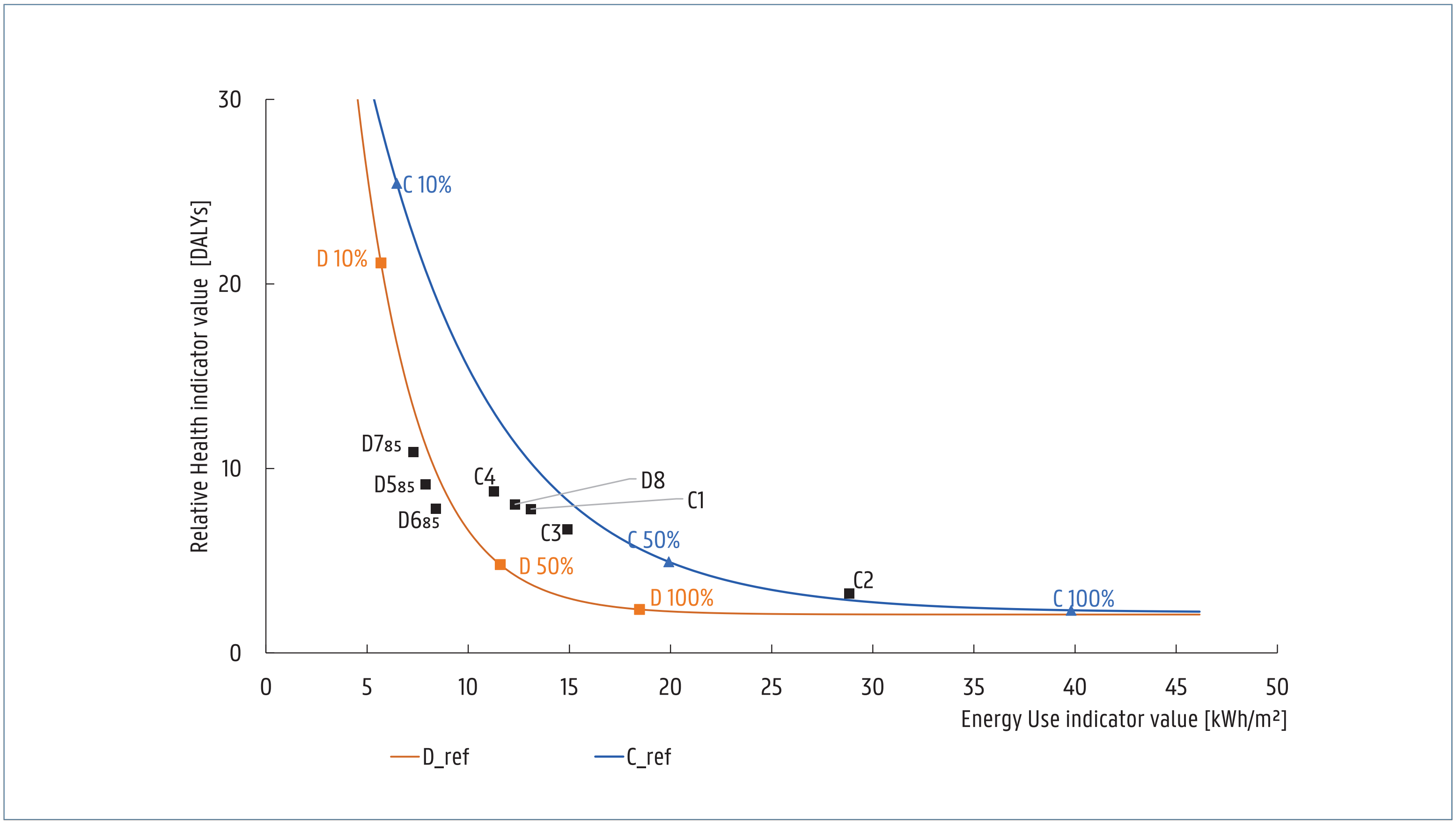
PRIORITY SUBSTANCES	WHO	CALE	IAQ Decree	IARC	EU-index	CONY	LOGUE
Acetaldehyde		x	x		x		x
Acrolein						x	x
Benzene	**x**	**x**	**x**	**x**	**x**	**x**	**x**
1,3 Butadiene							x
1,4 Dichlorobenzene							x
Formaldehyde	**x**	**x**	**x**	**x**	**x**	**x**	**x**
Carbon monoxide	x		x		x		
Limonene		**x**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



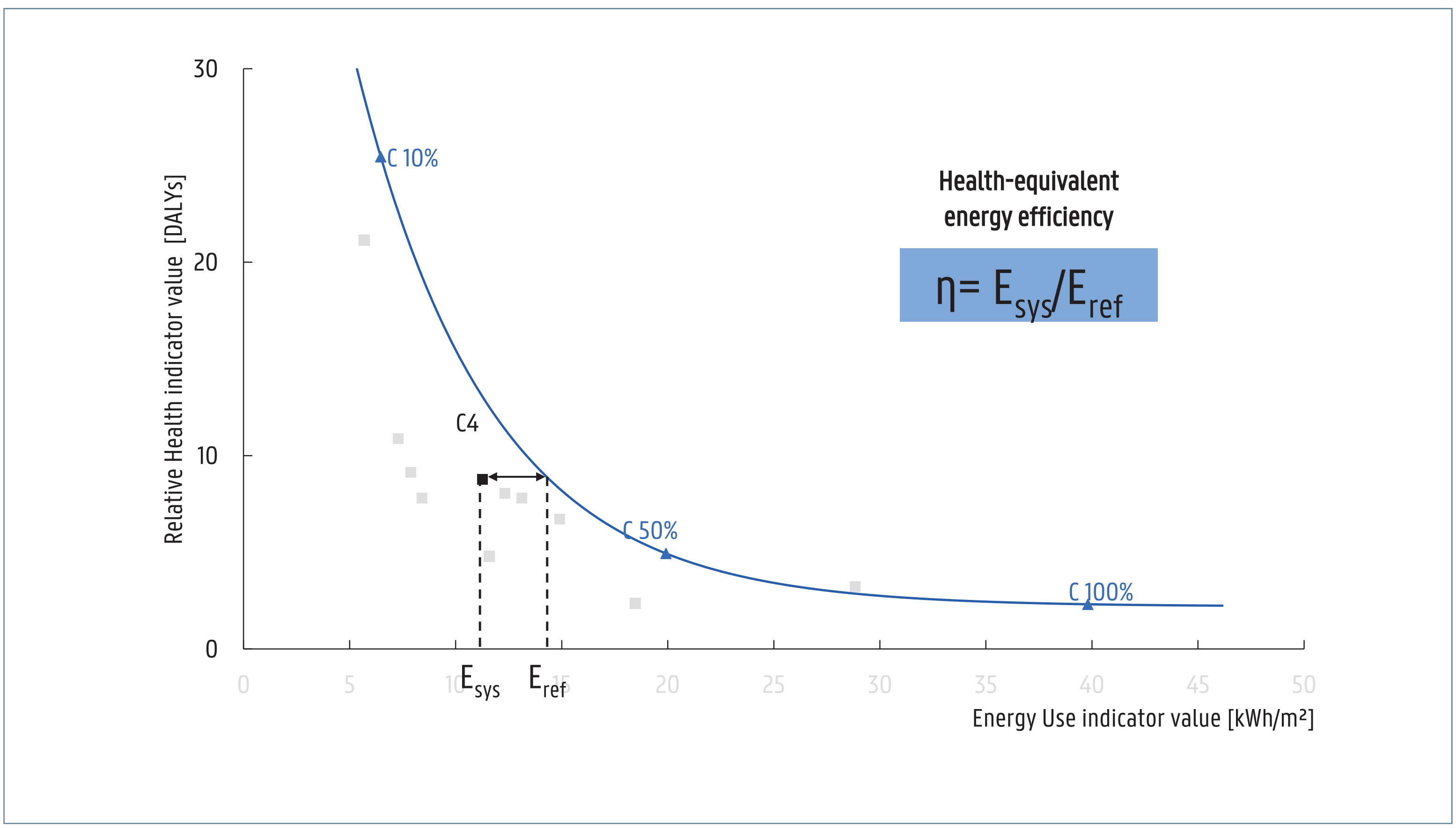
System
C1
C2
C3
C4
D5
D6
D7
D8
Cref_10
Cref_50
Cref_100
Dref_10
Dref_50
Dref_100
Short-term health effects
Perceived comfort
RH discomfort



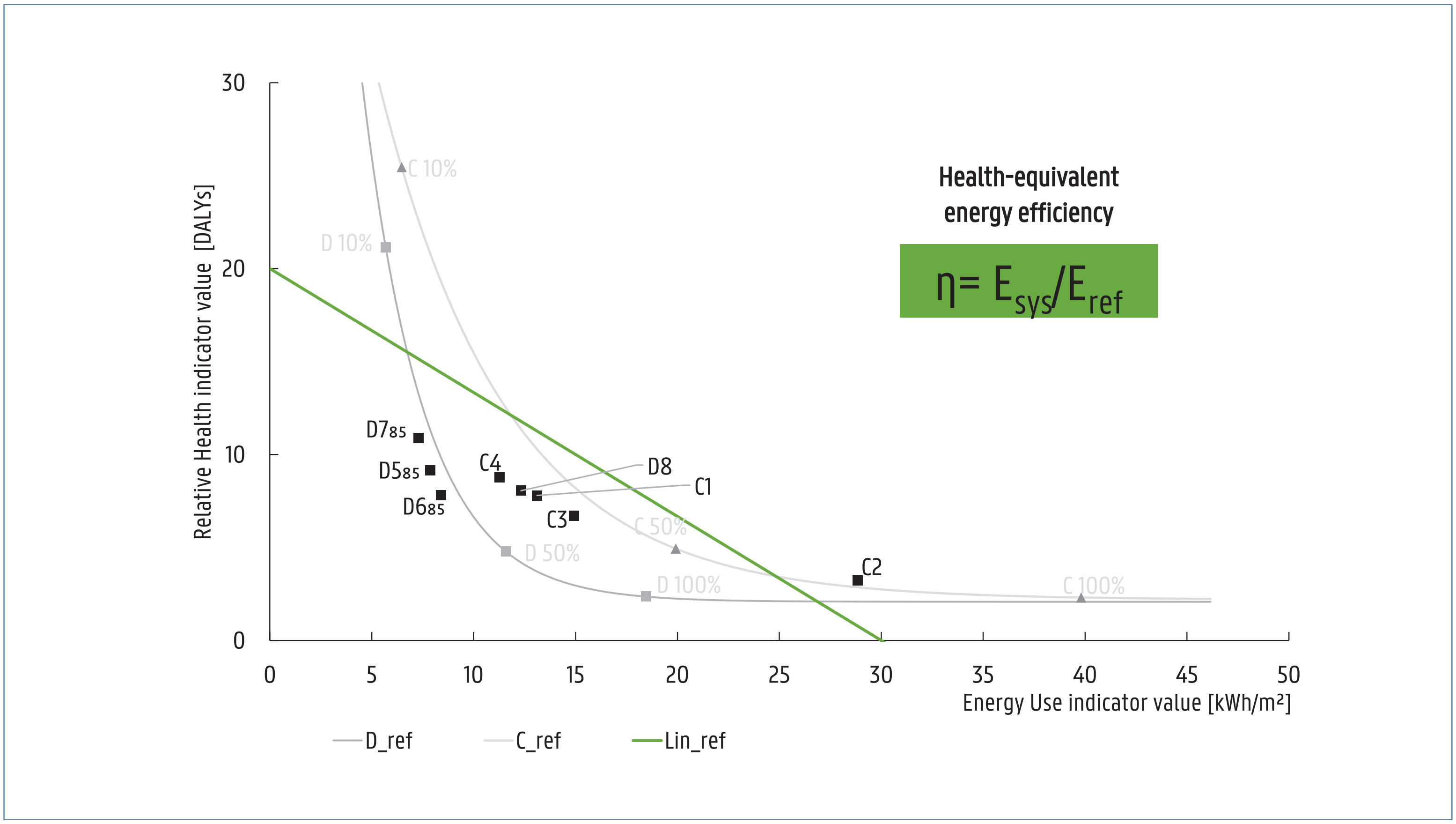
Relative Health indicator value [DALYs]
Energy Use indicator value [kWh/m²]
C 10%
D 10%
D7 85
D5 85
D6 85
C4
D8
C1
C3
C 50%
D 50%
D 100%
C2
C 100%
0
5
10
15
20
25
30
35
40
45
50

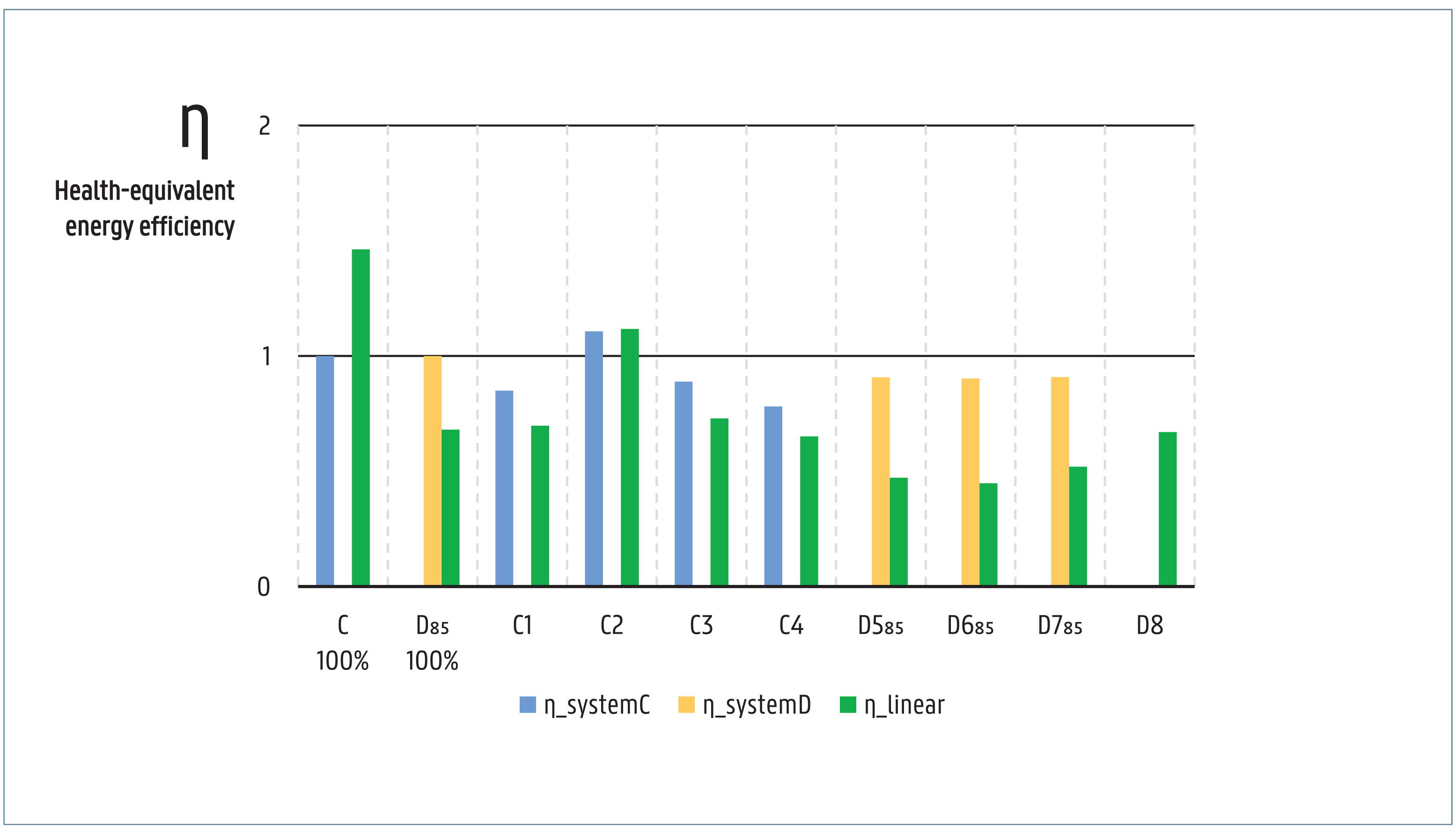


30
20
10
0
Relative Health indicator value [DALYs]
0
5
10
15
20
25
30
35
40
45
50
Energy Use indicator value [kWh/m²]
C 10%
D 10%
D785
D585
D685
C4
D8
C1
C3
C 50%
D 50%
D 100%
C2
C 100%
D_ref
C_ref



30
20
10
0
Relative Health indicator value [DALYs]
C 10%
C4
C 50%
C 100%
Health-equivalent
energy efficiency
η= Esys/Eref
Esys
Eref
Energy Use indicator value [kWh/m²]


Health-equivalent
energy efficiency
η= E_sys/E_ref
Relative Health indicator value [DALYs]
Energy Use indicator value [kWh/m²]
C 10%
D 10%
D7₈₅
D5₈₅
D6₈₅
C4
D8
C1
C3
C 50%
D 50%
D 100%
C2
C 100%
D_ref
C_ref
Lin_ref


η
Health-equivalent
energy efficiency
C 100%
D₈₅ 100%
C1
C2
C3
C4
D5₈₅
D6₈₅
D7₈₅
D8
η_systemC
η_systemD
η_linear

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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Klaas De Jonge
Postdoctoral researcher

RESEARCH GROUP BUILDING PHYSICS

E Klaas.DeJonge@ugent.be

www.ugent.be

Universiteit Gent
@ugent
@ugent
Ghent University

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TOWARDS PERFORMANCE-BASED APPROACHES FOR SMART RESIDENTIAL VENTILATION

A ROBUST METHODOLOGY FOR RANKING THE SYSTEMS AND DECISION-MAKING

Dr. Baptiste Poirier
baptiste.poirier@cerema.fr

Dr. Gaëlle Guyot
Pr. Monika Woloszyn

AIVC Webinar – New developments in design and characterisation of energy-efficient ventilation systems
20 June 2024

Presentation based on paper for :
33rd AIVC -11th TightVent & 9th venticool Conference
October 4-5, 2023
Aalborg University, Copenhagen, Denmark

1

INTRODUCTION

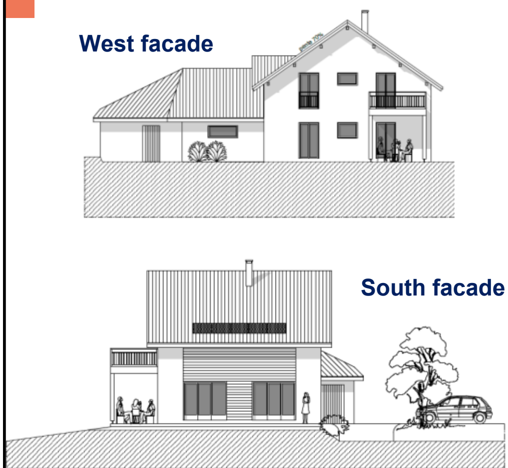
ENERGY, INDOOR AIR QUALITY AND VENTILATION

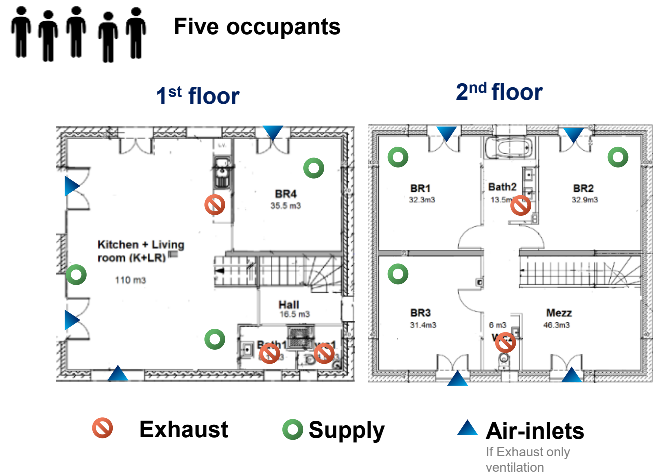
How to **aggregate performance** indicators **and balance IAQ and energy performance** assessment **to provide** a robust **ranking of the ventilation systems?**

2

INTRODUCTION

A FRENCH LOW ENERGY HOUSE CASE STUDY

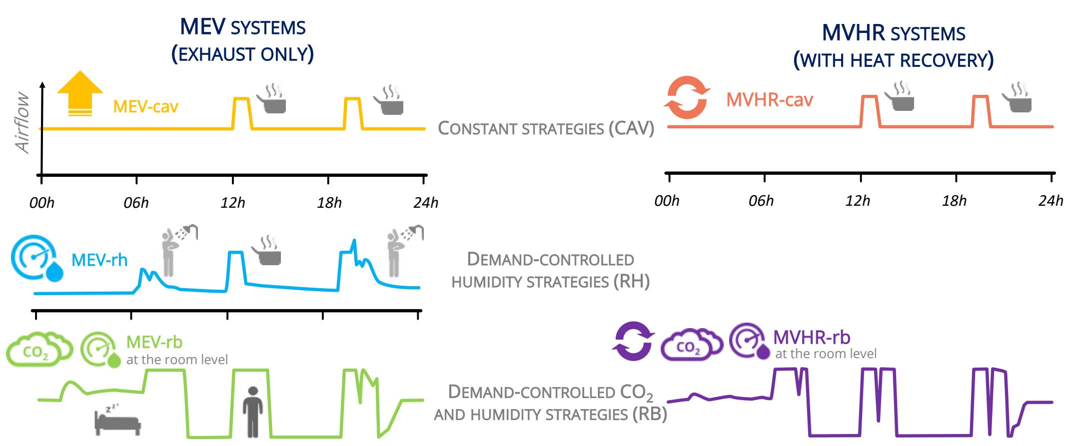




3

INTRODUCTION

FROM CONSTANT VENTILATION TO SMART VENTILATION



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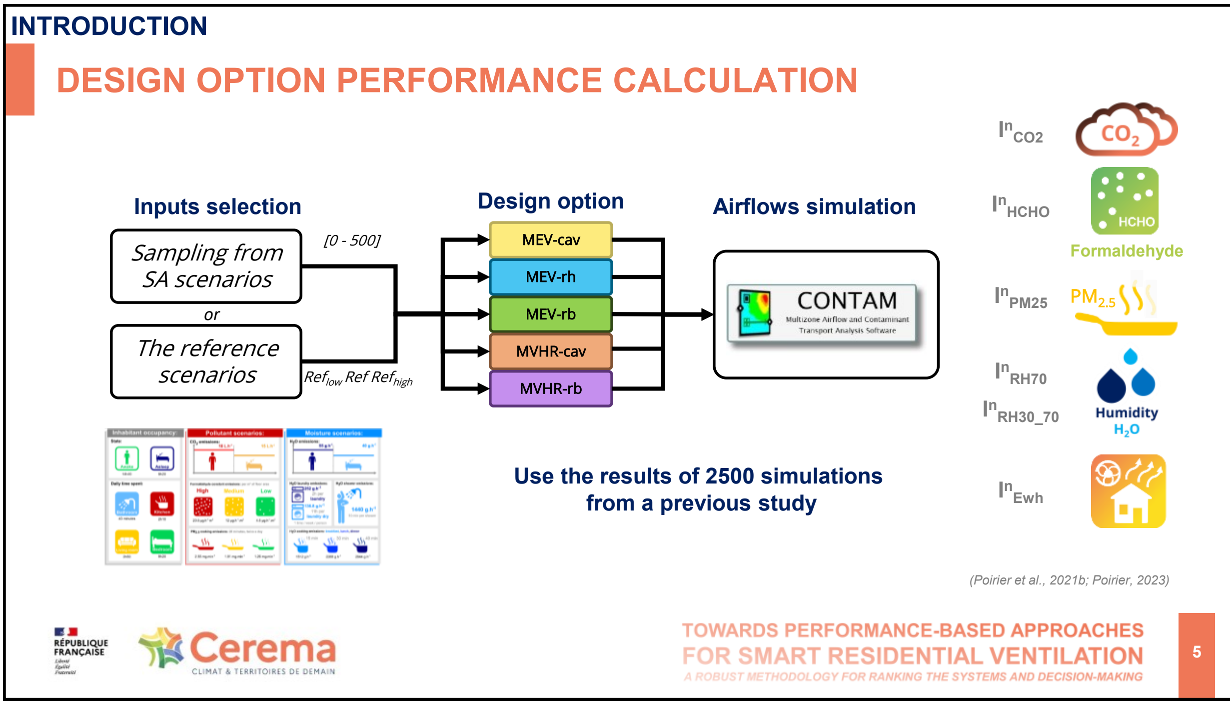
INTRODUCTION
DESIGN OPTION PERFORMANCE CALCULATION
Inputs selection
Sampling from SA scenarios
[0 - 500]
or
The reference scenarios
Ref_low Ref Ref_high
Design option
MEV-cav
MEV-rh
MEV-rb
MVHR-cav
MVHR-rb
Airflows simulation
CONTAM
Multizone Airflow and Contaminant Transport Analysis Software
Use the results of 2500 simulations from a previous study
I^n CO2
CO2
I^n HCHO
HCHO
Formaldehyde
I^n PM25
PM2.5
I^n RH70
I^n RH30_70
Humidity
H2O
I^n Ewh
(Poirier et al., 2021b; Poirier, 2023)
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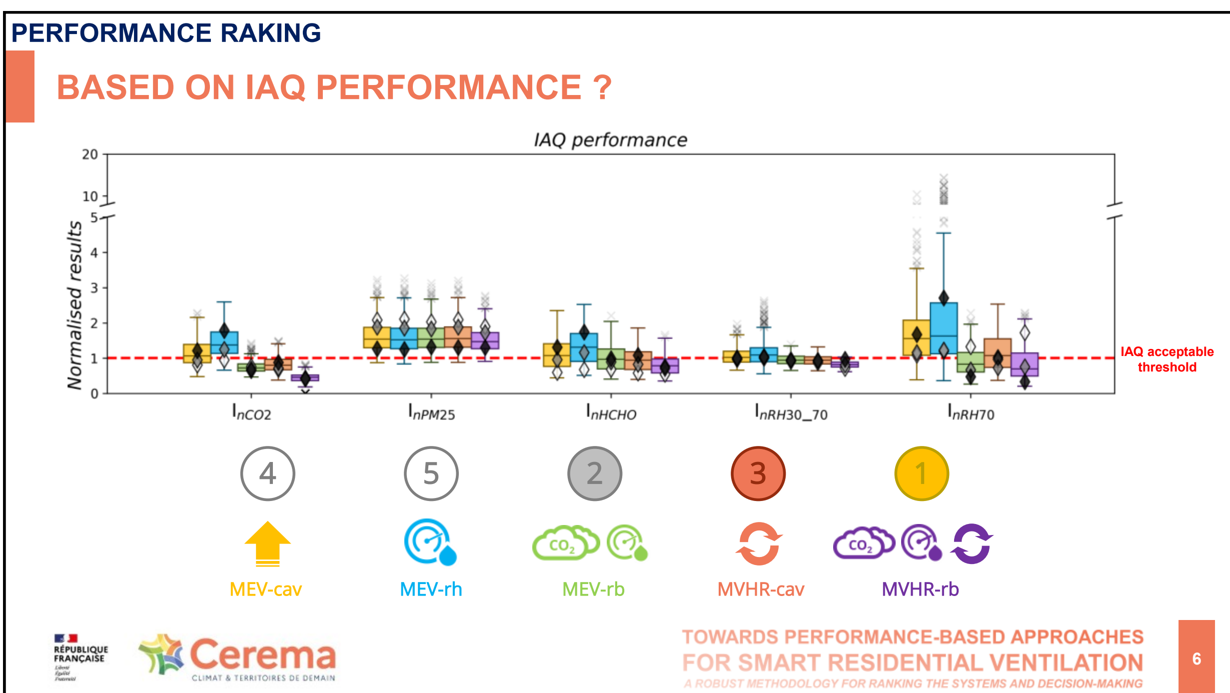
A ROBUST METHODOLOGY FOR RANKING THE SYSTEMS AND DECISION-MAKING
5

5


PERFORMANCE RAKING
BASED ON IAQ PERFORMANCE ?
IAQ performance
Normalised results
20
10
5
4
3
2
1
0
IAQ acceptable threshold
I_nCO2
I_nPM25
I_nHCHO
I_nRH30_70
I_nRH70
4
5
2
3
1
MEV-cav
MEV-rh
MEV-rb
MVHR-cav
MVHR-rb
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6

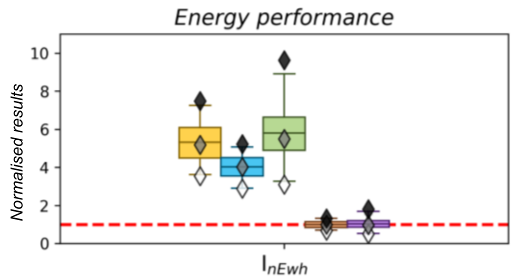
6

PERFORMANCE RAKING

BASED ON ENERGY PERFORMANCE ?

Heat losses from exhausted airflows

$$H_{th} = \frac{C_{p_m}}{3600}.(1-\varepsilon_{heat_{ex}})\int q_m(t).[T_{in}(t)-T_{ex}(t)].dt$$



5	3	4	1	2
MEV-cav	MEV-rh	MEV-rb	MVHR-cav	MVHR-rb

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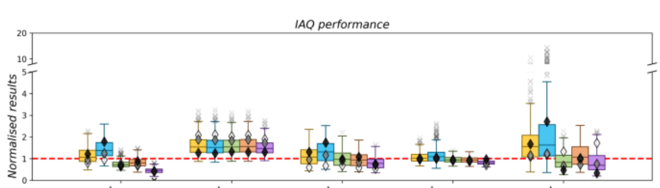
A ROBUST METHODOLOGY FOR RANKING THE SYSTEMS AND DECISION-MAKING

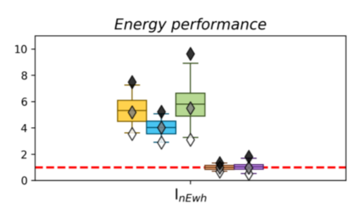
7

PERFORMANCE RAKING

BASED ON IAQ AND ENERGY PERFORMANCE ?

How to choose the most relevant one from global performance point-of-view ?





?	?	?	?	?
MEV-cav	MEV-rh	MEV-rb	MVHR-cav	MVHR-rb

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TOWARDS PERFORMANCE-BASED APPROACHES FOR SMART RESIDENTIAL VENTILATION

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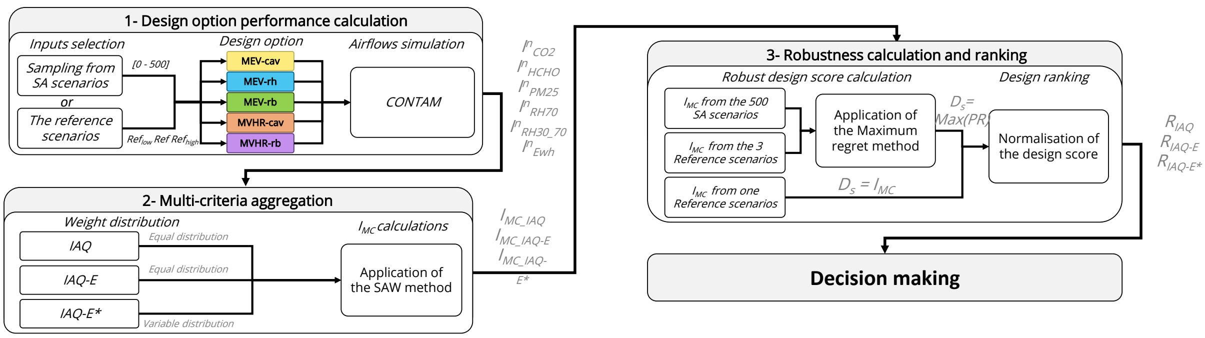
8

A ROBUST METHOD FOR PERFORMANCE RANKING

A SIMPLIFIED APPROACH IN 3 KEYS STEPS

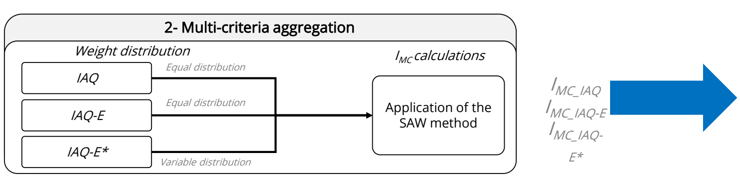


BASED ON EXISTING ROBUST ASSESSMENT METHODS ADAPTED TO BUILDING SECTOR

(Kotireddy et al., 2018; Velasquez and Hester, 2013; Hoes et al., 2009; Sharma and Bhattacharya, n.d.)

A ROBUST METHOD FOR PERFORMANCE RANKING

MULTI-CRITERIA AGGREGATION



From the six indicators to one aggregated value for each simulation

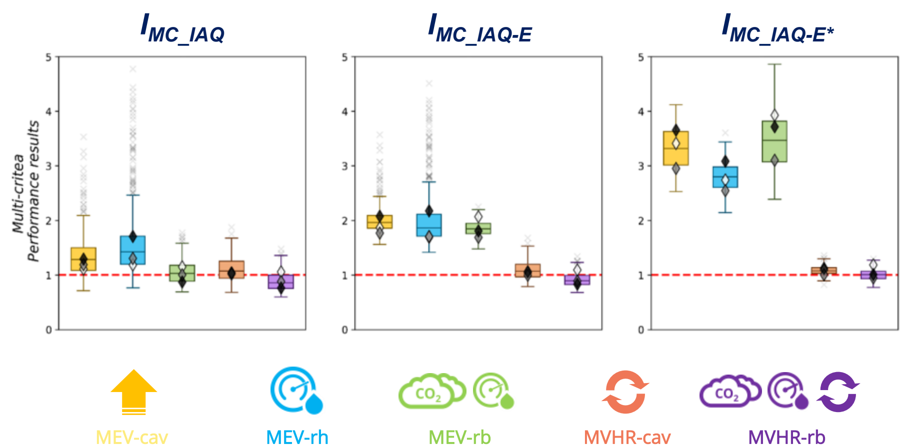
Simple Additive Weighting (SAW) method

$$I_{MC} = \sum_i \omega_i . I_i$$

(Podvezko, 2011)

Distribution	Weight ω_i						
	I^n_{CO2}	I^n_{RH70}	$I^n_{RH30\_70}$	I^n_{PM25}	I^n_{HCHO}	I^n_{Ewh}	
I_{MC_IAQ}	0.2	0.2	0.2	0.2	0.2	0	
I_{MC_IAQ-E}	0.16	0.16	0.16	0.16	0.16	0.16	**16% Energy / 84% IAQ**
I_{MC_IAQ-E*}	0.071	0.071	0.071	0.143	0.143	**0.5**	**50% Energy / 50% IAQ**

MULTI-CRITERIA AGGREGATION



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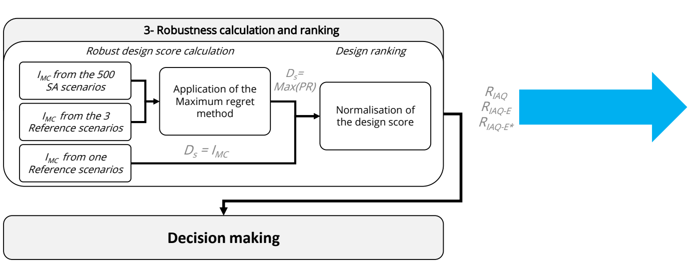
ROBUST DESIGN SCORE CALCULATION AND RANKING



Integrating into one design score (D_s) all the individual performance indicators **I_{MC}** across the tested scenarios**.**

The minimax regret method

(Kotireddy et al., 2019)

$$PR = I_{MC,Dopt,s} - C_s \,;with\; C_s = \underset{s}{\mathrm{Min}}(I_{MC(all\_Dopt),s})$$

$$MPR = \underset{D_{opt}}{\mathrm{Max}}(PR)$$

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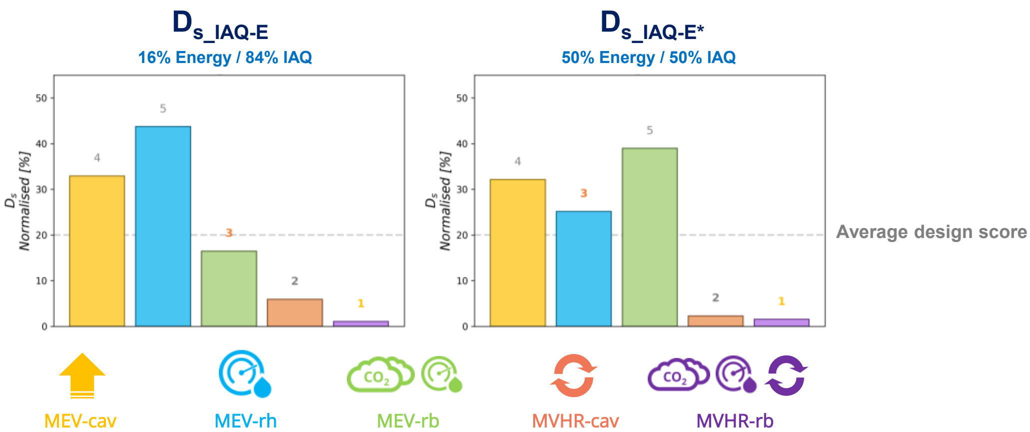
A ROBUST METHOD FOR PERFORMANCE RANKING

DESIGN SCORE RESULTS

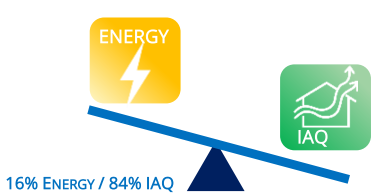


Design score calculation with the minmax regret method

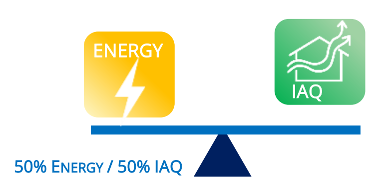
design scores were normalized In [%] by $\Sigma(D_s)_{Dopt}$ the sum of all the design scores

CONCLUSION

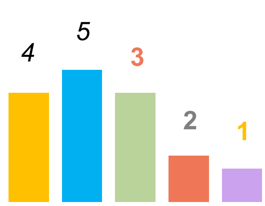
LEARNINGS REGARDING ROBUSTNESS



***IAQ-E distribution**: a conservative approach with **IAQ priority** for the decision maker*



***The IAQ-E* for** a decision maker with **equal proportion between IAQ and energy**.*



***The design score highlights the difference between the ventilation systems**, in order to rank them, including the uncertainty **from several simulations**.*

THANK YOU

FOR YOUR ATTENTION

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TOWARDS PERFORMANCE-BASED APPROACHES
FOR SMART RESIDENTIAL VENTILATION
A ROBUST METHODOLOGY FOR RANKING THE SYSTEMS AND DECISION-MAKING

15

Innovative ventilation systems easier to install for retrofitting dwellings

AIVC Webinar – 20/06/2024

Samuel Caillou
Buildwise - Belgium

Buildwise

1

The playground of the research: a social housing district in Brussels

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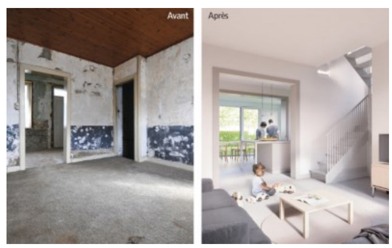
The houses have a long history and are being progressively renovated



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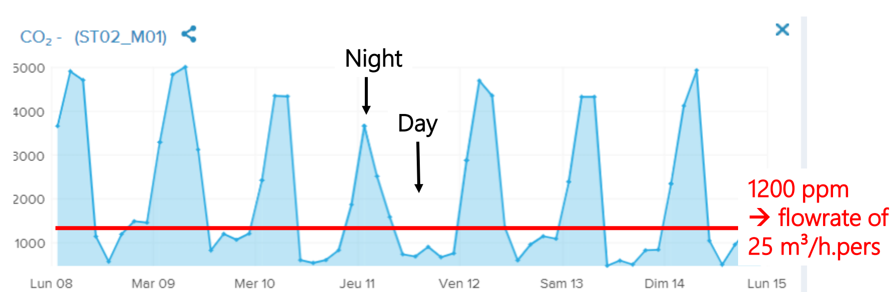
IAQ in existing houses is very poor

Example of CO_2 monitoring in a bedroom



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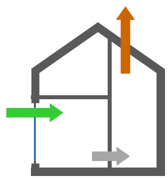
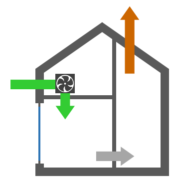
Classical ventilation systems are difficult to install in existing dwellings

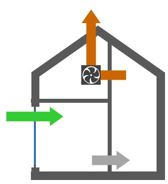
A: natural stack ventilation



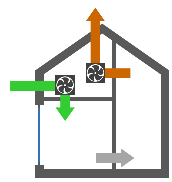
B: fan assisted supply ventilation



C: fan assisted exhaust ventilation



D: fan assisted balanced ventilation



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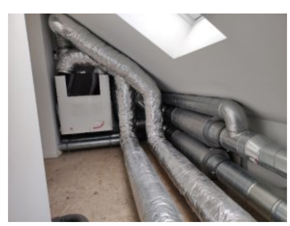
The main challenges of installing ventilation



Needed space for
- Ductwork
- Ventilation unit

Invasive works
- Natural supply requires windows modifications
- Extensive finishing works inside are necessary

Simplified or incomplete systems: are they efficient ?

Cost !

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Innovative ventilation systems easier to install

“D cascade”
→ D (balanced system) in (double) cascade mode

“C hallways”
→ C (exhaust system) with supply in hallways

D (balanced system) in (double) cascade mode

“D cascade”

"D cascade": how does it work?

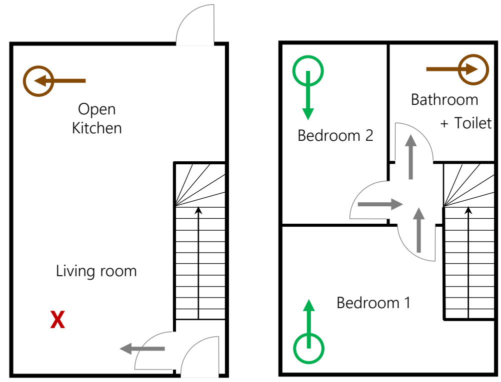
Mechanical supply
- In bedrooms

Air transfer
- To hallways
- To living room
- To service rooms

Mechanical extractions
- In service rooms

No direct supply in the living room!

(Reduced total flowrate)



2 story house

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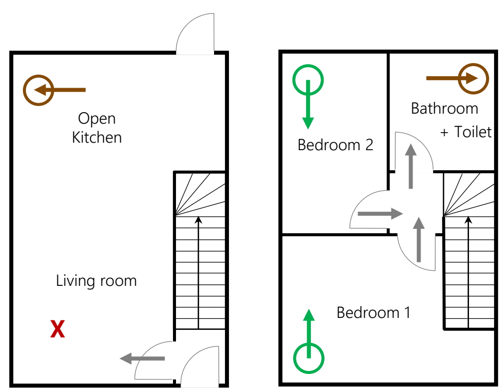
"D cascade": same components as classic D



2 story house

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Control options of the "D cascade"

The total flowrate is already reduced!

Option 1: central control – CO_2 living room

- *Minimum flowrate = total flowrate for bedrooms*
- *CO_2 living room → increases the total flowrate when needed*

Option 2: same as option 1 + time control for the bedrooms

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Main advantages of the "D cascade"

Easier to install

- No ductwork toward the living room

Reduced costs

- Smaller ventilation unit (reduced flowrate)
- Less ductwork

Efficient system

- IAQ as good as classic D system
- Heat recovery possible
- Reduced flowrate: demand control less necessary
- No influence of the airtightness of the building envelope

Applicable in many dwelling configurations

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C (exhaust system) with supply in hallways

"C hallways"

"C hallways": how does it work?

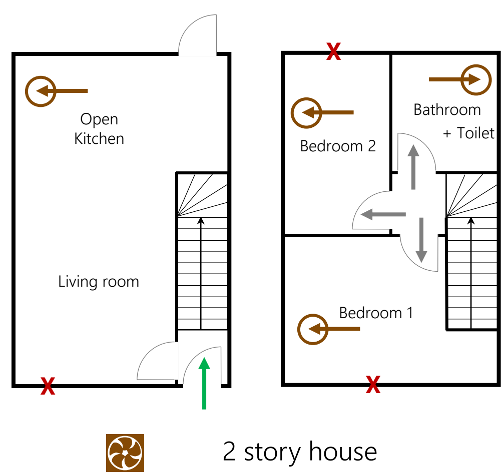
Natural supply
- In the hallways

Air transfer
- To bedrooms
- To living room
- To service rooms

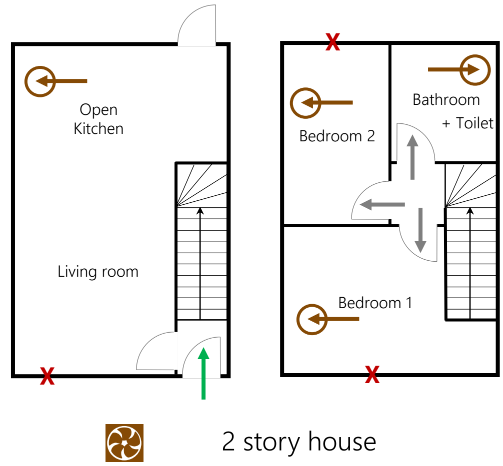
Mechanical extractions
- In service rooms
- **In bedrooms**

No direct supply in the bedrooms!

(Higher total design flowrate, but with DCV)



"C hallways": same components as classic C



Control options of the "C hallways"

Higher total design flowrate!

- Demand Control Ventilation (DCV) is necessary
- Higher impact and potential for control

Local Control

- Bedrooms CO_2
- Bathroom Relative humidity (RH)
- Toilets Presence detection or equivalent
- Kitchen CO_2 (+RH)

Main advantages of the “C hallways”

Easier to install

- No natural supply needed in bedrooms

Much more efficient system

- IAQ as good as classic D (balanced) system
- No influence of the airtightness of the building envelope
- Effective demand control ventilation
- Improved comfort: less draught and noise from outside

Applicable in many dwelling configurations

Additional innovative system for apartments

“C cascade”

→ C (exhaust system) in (double) cascade mode

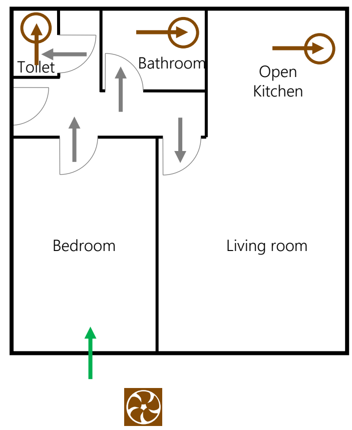
C (exhaust) in (double) cascade mode

Natural supply
- In bedrooms

Air transfer
- To hallways
- To living room
- To service rooms

Mechanical extractions
- In service rooms
- In living room (if open kitchen)

No direct supply in the living room!



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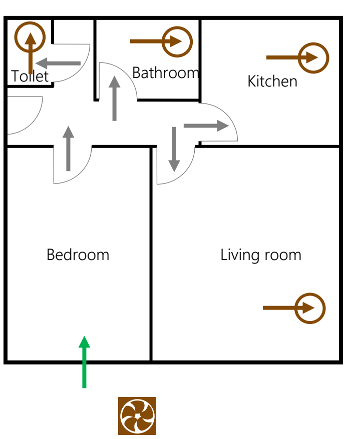
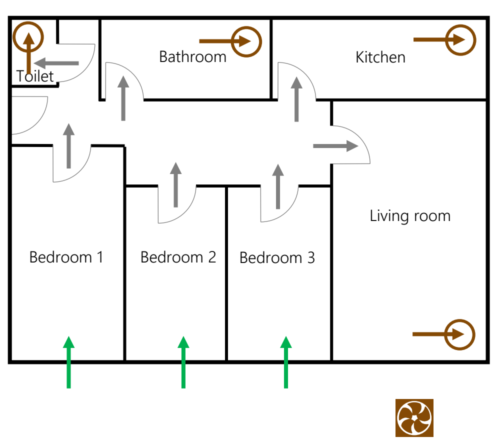
"C cascade": for open kitchen

1 bedroom apartment



3 bedrooms apartment



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Additional extraction in the living room: control on CO_2

Main advantages of the "C cascade"

Easier to install in apartments

- Or central exhaust system using existing duct
- Or smaller individual ventilation unit with C system

Efficient system

- Reduced flowrate
- Demand control is easy

But pay attention: very good airtightness of the building is required

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Thanks

You for your attention

The partners of Prio-Climat project

- Foyer Anderlechtois
- Free University of Brussels
- VELUX

VELUX

This research was carried out with the support of

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Ventilation Performance Assessment Tool

EVIA
European Ventilation Industry Association

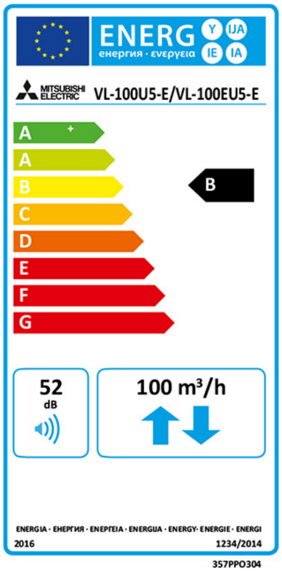
Van Holsteijn en Kemna B.V.

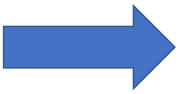
GHENT UNIVERSITY

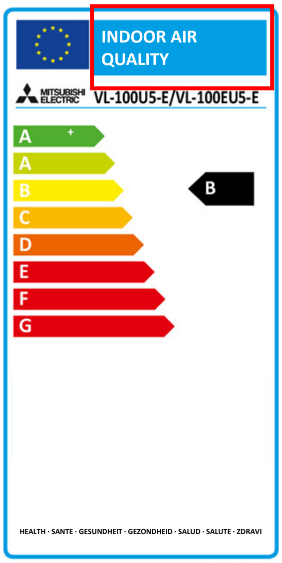
EVIA members

EVIA
European Ventilation Industry Association

1. Goal: promotion of high performance ventilation systems







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2. Methodology

The methodology assesses the actual occurring air exchange rates on room type level during presence and absence.

The Air Exchange Performance (AEP) determines to which extent the ventilation system is able to remove and/or dilute pollutant concentrations in the various rooms, especially during presence when exposure occurs.

Compared to current practice, where only the air exchange rate over the building is assessed, this represents a major step towards more relevant ventilation performance assessment. Current practice after all does not differentiate between the places in which the air exchanges occur nor between periods of presence or absence.

Van Holsteijn en Kemna B.V.

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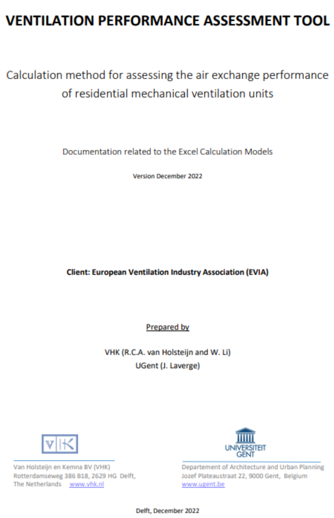
2. Methodology



VENTILATION PERFORMANCE ASSESSMENT TOOL

Calculation method for assessing the air exchange performance of residential mechanical ventilation units

Documentation related to the Excel Calculation Models

Version December 2022

Client: European Ventilation Industry Association (EVIA)

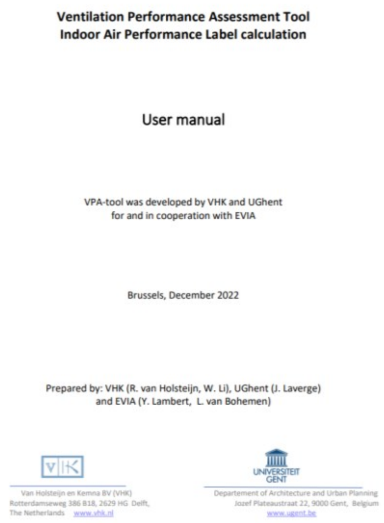
Prepared by

VHK (R.C.A. van Holsteijn and W. Li)
UGent (J. Laverge)

Van Holsteijn en Kemna BV (VHK)
Rotterdamseweg 386 B18, 2629 HG Delft,
The Netherlands www.vhk.nl

Departement of Architecture and Urban Planning
Jozef Plateaustraat 22, 9000 Gent, Belgium
www.ugent.be

Delft, December 2022



Ventilation Performance Assessment Tool
Indoor Air Performance Label calculation

User manual

VPA-tool was developed by VHK and UGhent
for and in cooperation with EVIA

Brussels, December 2022

Prepared by: VHK (R. van Holsteijn, W. Li), UGhent (J. Laverge)
and EVIA (Y. Lambert, L. van Bohemen)

Van Holsteijn en Kemna BV (VHK)
Rotterdamseweg 386 B18, 2629 HG Delft,
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2. Methodology

Assessment Method

Defining room types and ventilation strategy (1)

Habitable spaces: HS (living rooms, bedrooms, study, etc.)

Pollutants : Bio-effluents, building material emissions, emissions from interior products, pollutants from human activities
Exposure : Inhabitants during presence
Occupancy time: Long / very long

Reference ventilation strategy

Air-exchange : During presence, supply of sufficient fresh outdoor air is key
During absence, basic ventilation rates are required to prevent accumulation of building- and interior products emissions

2. Methodology

Assessment Method

Defining room types and ventilation strategy (2)

Wet or Extract spaces: ES (kitchen, bathroom, toilet, laundry room)

Pollutants : Moisture, odour, building material emissions, emissions from human activities
Exposure : Inhabitants during presence / building to high humidity levels
Occupancy time: Short

Reference ventilation strategy

Air-exchange : During presence, extraction of sufficient air (incl. moisture/odour) is key (supply is adjusted accordingly)
During absence, extraction of air until humidity levels are below threshold values; basic ventilation rates after that.

2. Methodology

Assessment Method

Defining technical system parameters

1. Ventilation System Type (VST) and associated air-exchange provisions in ES and HS
2. Type of MDE/MDS fan and type of NDS (natural direct supply)-grids used in the VST
3. Installed maximum and minimum airflow capacity (limiting factor for achievable air exchange rates)
4. Type of operation / controls (affects system's ability to achieve requested air-exchanges at the right time in the right place)
5. Type of dwelling: number and type of ES and HS, surface of HS, airtightness

2. Methodology

Ventilation System Type

UVU: VST 3–4; BVU: VST 5–7

VST	roomtype	air exchange provision		abbrev.
1	habitable spaces	supply	natural direct supply	NDS
		extract	natural indirect extract	NIE
	exhaust spaces	supply	natural indirect supply	NIS
		exhaust	natural direct exhaust	NDE
2	habitable spaces	supply	mechanical indirect supply	MIS
		exhaust	natural direct exhaust	NDE
	exhaust spaces	supply	mechanical indirect suply	MIS
		exhaust	natural direct exhaust	NDE
3	habitable spaces	supply	natural direct supply	NDS
		extract	mechanical indirect extract	MIE
	exhaust spaces	supply	mechanical indirect supply	MIS
		exhaust	mechanical direct exhaust	MDE
4	habitable spaces	supply	natural direct supply	NDS
		exhaust	mechanical direct exhaust	MDE
	exhaust spaces	supply	mechanical indirect supply	MIS
		exhaust	mechanical exhaust	MDE
5	habitable spaces	supply	mechanical direct supply	MDS
		extract	mechanical indirect extract	MIE
	exhaust spaces	supply	mechanical indirect supply	MIS
		exhaust	mechanical direct exhaust	MDE
6	habitable spaces	supply	mechanical indirect supply	MIS
		exhaust	mechanical direct exhaust	MDE
	exhaust spaces	supply	mechanical indirect supply	MIS
		exhaust	mechanical direct exhaust	MDE
7	habitable spaces	supply	mechanical direct supply	MDS
		exhaust	mechanical direct exhaust	MDE
	exhaust spaces	supply	mechanical indirect supply	MIS
		exhaust	mechanical direct exhaust	MDE

2. Methodology

Assessment Method

Principle for calculating occurring ***AER*** *:* $AER = q_{v;inst} * P_{qv;inst} * f_{ctrl}$ *(1)*

$q_{v;inst}$ = Installed min. and max. ventilation capacity in ES and HS

$P_{qv;inst}$ = The probability that installed ventilation capacity in ES &HS is actually achieved. This is calculated, taking into account the following parameters:

- Driving force (natural versus mechanical)
- Number and position of internal doors (i.e. open or closed, applicable to certain VSTs)
- Airtightness of the dwelling and location of leakages (applicable to certain VSTs)
- Duct leakages RVU (reducing intended mech. supply/exhaust airflows)
- Filter compensation BVU (reducing supply airflow due to clogging filters, acc EN13142)
- Internal leakage BVU (reducing share of air that is supplied or extracted, acc. EN13142)
- Airflow sensitivity 'v' (sensitivity RVU for pressure variations over façade, acc. EN13141-8)
- Indoor/outdoor airtightness 'q_{vio}' of (local) RVU (acc. EN13141-8)

2. Methodology

Assessment Method

Principle for calculating occurring ***AER*** *:* $AER = qv;inst * Pqv;inst * fctrl$ *(2)*

fctrl = The probability that the controls of the ventilation provisions are in the right position to achieve the required airflow rate.

*f*ctrl is calculated, taking into account the PCO-values of the related controls. For a list of *Ctrl*-types PCO values have been determined for ES and HS for both periods of presence and absence.

For **all ES** and combined **HS** the occurring **AER** is calculated for periods of presence and absence.

2. Methodology

Assessment Method

Principle for calculating Air Exchange Performance ***AEP*** *:* $AEP = AER / AER_{ref}$ *(1)*

AERref = The reference air exchange rate; a value is determined for ES and HS and for periods of presence and absence based on EN 16798-1, Annex B, Category II

AER*ref*	AER*ref* for HS	AER*ref* for ES		
		bathroom	kitchen	toilet
During presence	0,47 l/s/m^2	20 l/s	10 l/s	10 l/s
During absence	0,13 l/s/m^2	4 l/s	2 l/s	2 l/s

For **all ES** and combined **HS** the **AEP** is calculated for periods of presence and absence.

3. Input/output sheet

VST 5	EXHAUST SPACES (ES)	HABITABLE SPACES (HS)
SUPPLY PROVISIONS	MIS	MDS
EXHAUST PROVISIONS	MDE	MIE

> ALTER ONLY THE YELLOW CELLS! <

1. Dwelling airtightness

airtightness parameter	n50	value:	2,00	air changes per hour

2. Specify number of Exhaust (ES) and Habitable Spaces (HS)

	open_kitchen	bathroom	toilet	utility	other	total ES
	number	number	number	number	number	number
	1	1	1	0	0	3

habitable spaces	
number	total surface area in m²
3	66,00

3. Select BVU-type

BVU-type	1	CENTR.BIDIR.VENT.UNIT| VARIABLE FLOWRATE | FIXED FLOWRATE RATIO ES &HS
BVU *Ffc*	20%	Measured filter compensation factor according to Annex D EN 13142; if not known a default of 20% is used
BVU *Fil*	6%	Measured fraction of exhaust air recirculating in supply air, measured acc. to chamber tracer gas method EN13142; if not known a default of 6% is used

4. Specify maximum MDE (= MDS) capacity to be installed

MDE capacity per ES type

open_kitchen	bathroom	toilet	utility	other	total MDE
l/s	l/s	l/s	l/s	l/s	l/s
30,00	15,00	10,00			55,00

installed MDS capacity HS (with clean filter and not corrected for *Fil*)

habitable spaces	
l/s	l/s/m2
55,00	0,83

5. Specify minimum MDE (= MDS) capacity

open_kitchen	bathroom	toilet	utility	other	total MDE
6,00	3,00	2,00			11,00
20,0%	Ratio min/max capacity must be idential when MDE-type 1 is selected				

habitable spaces	
11,00	0,17

6. MIS- and MIE capacity as % of MDE and MDS acc. Good Practice

MIS capacity

open_kitchen	bathroom	toilet	utility	other	total
100%	100%	100%			100%

MIE capacity: 100%

7. Specify type of control from Exhaust and Habitable Spaces

Controls ES

MDE kitch.	MDE bathr.	MDE toilet	MDE utility	MDE-other
cntrl type	cntrl type	cntrl type	cntrl type	cntrl type
RH-local	RH-local	PIR		

Controls HS

MDS habitable spaces	
% of HS area	cntrl type
100%	no control

RESULTS

Probability that requested air exch. rate occurs in indiv. spaces

AEP ES

	open_kitchen	bathroom	toilet	utility	other	average ES
presence	95%	95%	95%			95%
absence	133%	133%	95%			130%
overall AEP	98%	98%	94%			98%

AEP HS

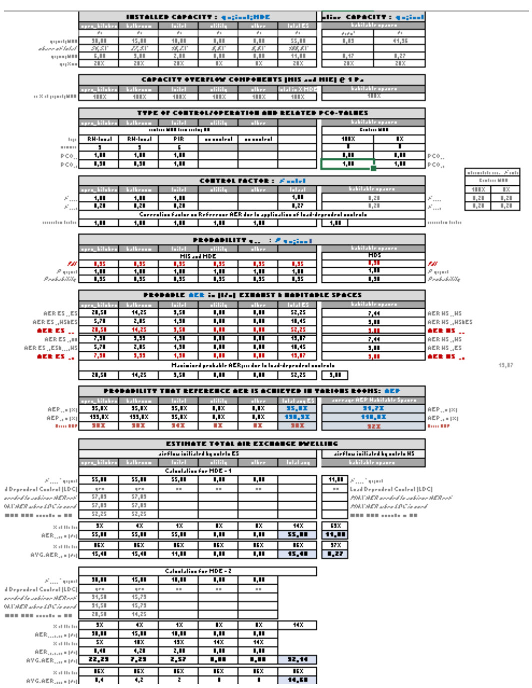
	average HS
presence	32%
absence	119%
overall AEP	32%

Average air exchange rate (AER) over total dwelling @ default occupation

average AER DWELLING

dm³/s	m³/h	ach	dm³/s/m² A_{fl}
21	75	0,31	0,23

4. Calculation sheet


INSTALLED CAPACITY
CAPACITY OVERFLOW COMPONENTS [MIS and MIE] @ 1 Pa
TYPE OF CONTROL/OPERATION AND RELATED PCO-VALUES
CONTROL FACTOR
PROBABILITY
PROBABLE AER in [l/s] EXHAUST & HABITABLE SPACES
PROBABILITY THAT REFERENCE AER IS ACHIEVED IN VARIOUS ROOMS: AEP
ESTIMATE TOTAL AIR EXCHANGE DWELLING

5. Lookup tables

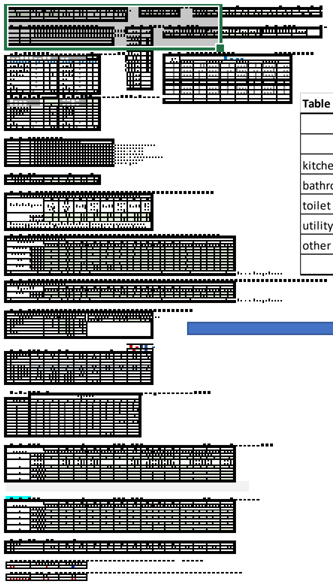
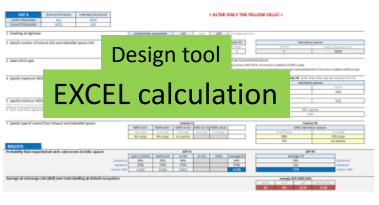
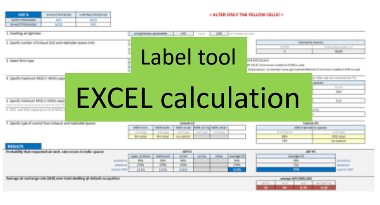


Table 13 : REFERENCE VALUES FOR OCCUPANCY IN ES AND HS									
Average occupation Exhaust Spaces					Average occupation Habitable Spaces				
Type ES		Number	% of the day		Type HS		%Occ;Inhab	% of the day	% Occ;Ahab
kitchen		1	9%	9%	all HS		60%	63%	50%
bathroom		1	4%	4%					
toilet		1	1%	1%					
utility		0	1%	0%					
other		0	1%	0%					
			Occupation ES	14%					





Ventilation Performance

Ventilation Performance Label

Any size of dwelling

Reference dwelling
(source : EU28 Buildings Database)

National Air Exchange Rates
(source: national ventilation standard)

EU Air Exchange Rates
(source: prEN 16798-1)

VU product data
(source: company)

VU product data
(source: company)

EVIA European Ventilation Industry Association

Table 8. Parameters of reference dwelling

Total dwellings surface (heated space)	92,40 m^2
Total internal volume	240 m^3
Total surface of habitable spaces	66 m^2
Number of Exhaust Spaces	3 : kitchen, bathroom toilet
Type of kitchen	Open kitchen (combined with dining room)
Number of habitable spaces	3
Airtightness dwelling	N50 = 2.00

17

VST 5	EXHAUST SPACES (ES)	HABITABLE SPACES (HS)
SUPPLY PROVISIONS	MIS	MDS
EXHAUST PROVISIONS	MDE	MIE

> ALTER ONLY THE YELLOW CELLS! <

EVIA European Ventilation Industry Association

1. Dwelling airtightness

airtightness parameter: n50 — value: 2,00 air changes per hour

2. Specify number of Exhaust (ES) and Habitable Spaces (HS)

	open_kitchen	bathroom	toilet	utility	other	total ES
	number	number	number	number	number	number
	1	1	1	0	0	3

habitable spaces	
number	total surface area in m^2
3	66,00

3. Select BVU-type

BVU-type	1	CENTR.BIDIR.VENT.UNIT| VARIABLE FLOWRATE | FIXED FLOWRATE RATIO ES &HS
BVU *Ffc*	5%	▾ asured filter compensation factor according to Annex D EN 13142; if not known a default value of 20% is used
BVU *Fil*	1%	Measured fraction of exhaust air recirculating in supply air, measured acc. to chamber tracer gas method EN13142; if not known a default of 6% is used

4. Specify maximum MDE (= MDS) capacity to be installed

5. Specify minimum MDE (= MDS) capacity

Ratio min/max capacity must be idential when MDE-type 1 is selected

6. MIS- and MIE capacity as % of MDE and MDS acc. Good Practice

MDE capacity per ES type

	open_kitchen	bathroom	toilet	utility	other	total MDE
	l/s	l/s	l/s	l/s	l/s	l/s
4. maximum	20,00	10,00	10,00			40,00
5. minimum	4,00	2,00	2,00			8,00
ratio	20,0%	20,0%	20,0%			
6. MIS capacity	100%	100%	100%			100%

installed MDS capacity HS (with clean filter and not corrected for *Fil*)

habitable spaces	
l/s	l/s/m2
40,00	0,61
8,00	0,12

MIE capacity: 100%

7. Specify type of control from Exhaust and Habitable Spaces

Controls ES

MDE kitch.	MDE bathr.	MDE toilet	MDE utility	MDE-other	
cntrl type	cntrl type	cntrl type	cntrl type	cntrl type	
RH-centr.	RH-centr.	RH-centr.			

Controls HS

MDS habitable spaces	
% of HS area	cntrl type
85%	CO2-local
15%	no control

RESULTS

Probability that requested air exch. rate occurs in indiv. spaces

AEP ES

	open_kitchen	bathroom	toilet	utility	other	average ES
presence	84%	84%	84%			84%
absence	279%	279%	279%			279%
overall AEP	102%	102%	102%			102%

AEP HS

average HS	
96%	presence
68%	absence
94%	overall AEP

Average air exchange performance (AEP) and air exchange rate (AER) over total dwelling @ default occupation

combined AEP DWELLING: 95%

average AER DWELLING

dm^3/s	m^3/h	ach	$dm^3/s/m^2$ A_{u}
25	90	0,38	0,27

18

When selecting the controls for HS, there is a possibility to choose the location and the type of sensor.

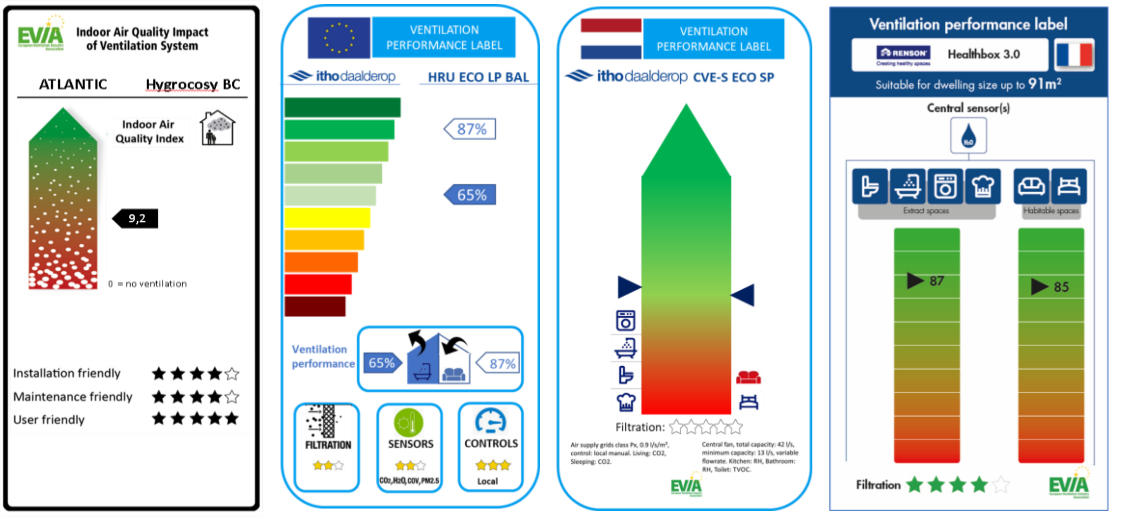
Controls HS

% of HS area	cntrl type	% of HS area	cntrl type	% MDE
100%	manual	60%	CO2-local	100%
		40%	no control	

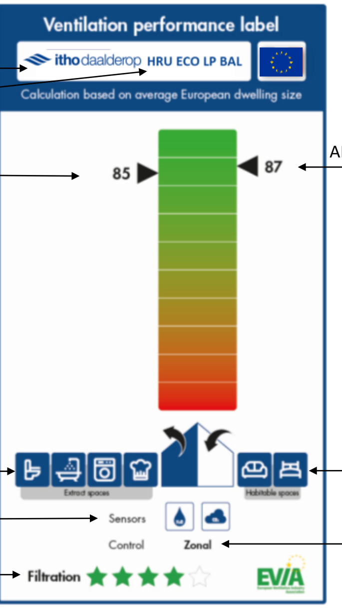
The % of HS area it affects is determined by this table :

Sensor in						
Living room	X	X	X			
Master Bedroom	X	X		X	X	
Children's bedroom	X			X		X
% of HS	**100%**	**85%**	**60%**	**40%**	**25%**	**15%**

6. Label design



6. Label design



7. Merged Air Exchange Performance

RESULTS

Probability that requested air exch. rate occurs in indiv. spaces

	AEP ES						AEP HS	
	open_kitchen	bathroom	toilet	utility	other	average ES	average HS	
presence	72%	31%	31%			57%	33%	presence
absence	171%	95%	95%			119%	89%	absence
overall AEP	79%	30%	30%			59%	32%	overall AEP

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Merged AEP %

Exposure occurs only during presence, so it is valid approach to use occupancy as the dominant weighting factor. According to the occupancy schedule, total occupancy in ES = 14% and in the HS = 63% of the day. This gives the following formula and subsequent classes:

AEPdwelling = ((AEP-ES)*14% + (AEP-HS)*63%) / 77%

55%	70%	C
70%	85%	B
85%	>100%	A

8. Indoor Air Performance label generator

Name or logo (upload)

Supplier's name or trade mark *

Supplier's name or trade mark

Supplier's model identifier *

Supplier's model identifier

VPAT score

A·

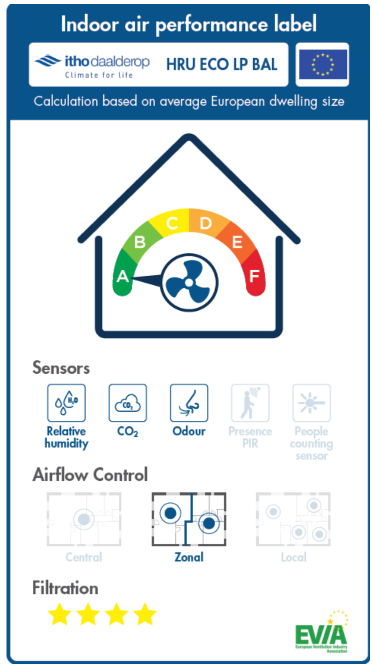
Sensor(s)	Yes	No
Relative Humidity	O	O
CO_2	O	O
Odour (TVOC)	O	O
Presence (PIR)	O	O
People counting sensor (Bidirectional laser)	O	O

Airflow Control

Central

Filtration

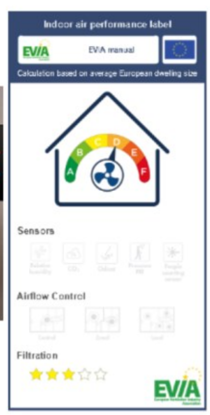
★★★★☆

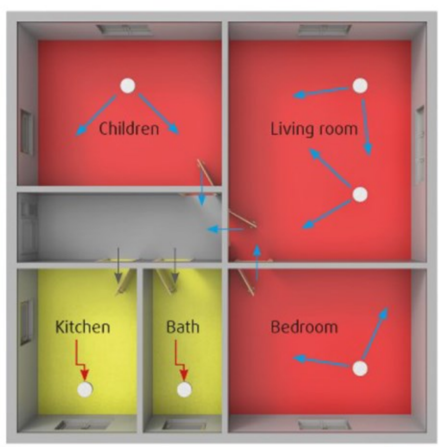


9a. Example: VST5 manual control

Manual control

Adaption of the Ventilation effect depends on actions of the user and the air volume change effects all rooms. In most cases, the result is an under or over ventilation which leads to a rather bad **air exchange perfomance class - D**

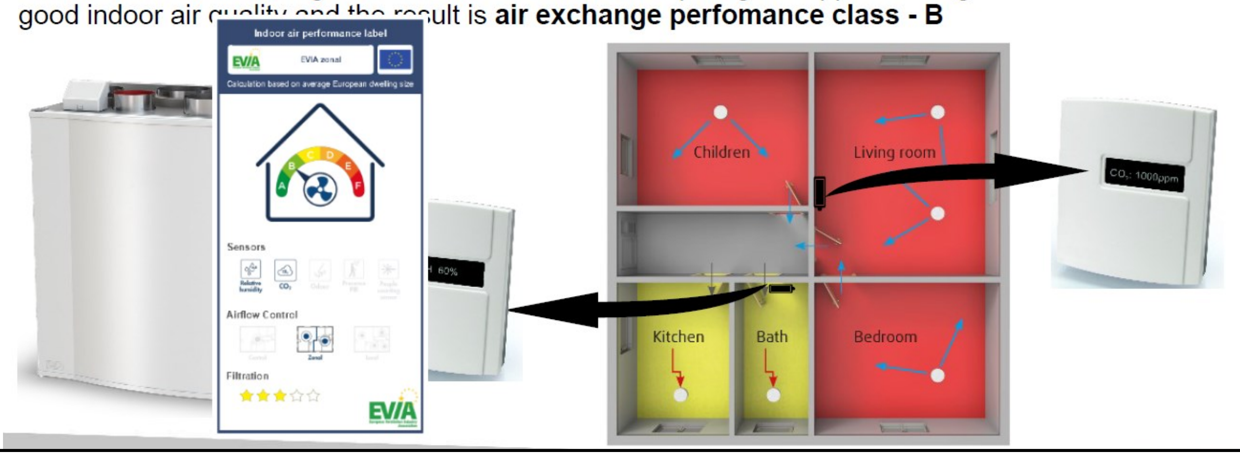




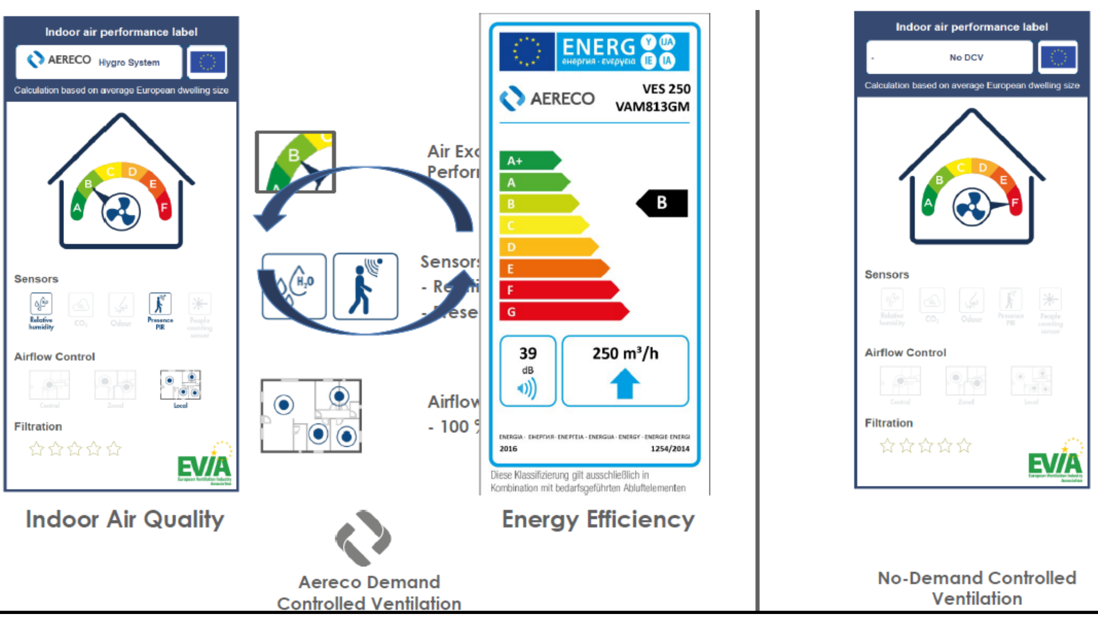
9b. Example VST5 zonal demand control

Zonal demand control with 2 sensors

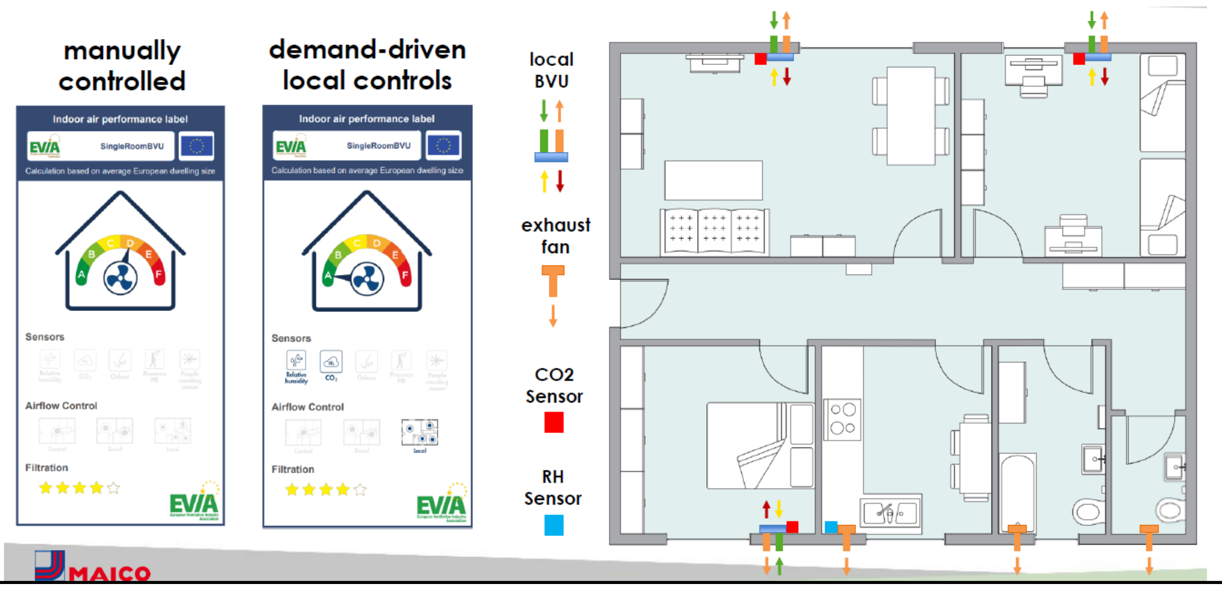
Adaption of the Ventilation effect depends on changes of the measured parameters and the air volume change effects all rooms. This is a quite good approach to get a good indoor air quality and the result is **air exchange perfomance class - B**



10. Example: VST3 without/with demand control



11. Example: VST7 Single room unit with heat recovery



Ventilation Performance Assessment Tool

Contact: secretariat@evia.eu