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

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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?**

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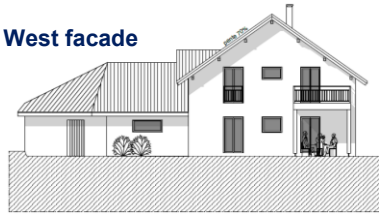
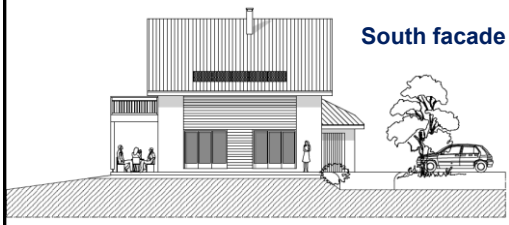
INTRODUCTION

A FRENCH LOW ENERGY HOUSE CASE STUDY

West facade



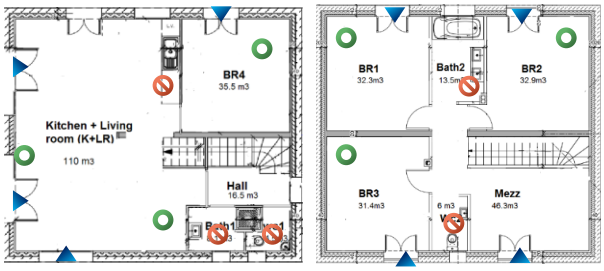
South facade



Five occupants

1st floor

2nd floor



Exhaust Supply Air-inlets

If Exhaust only ventilation

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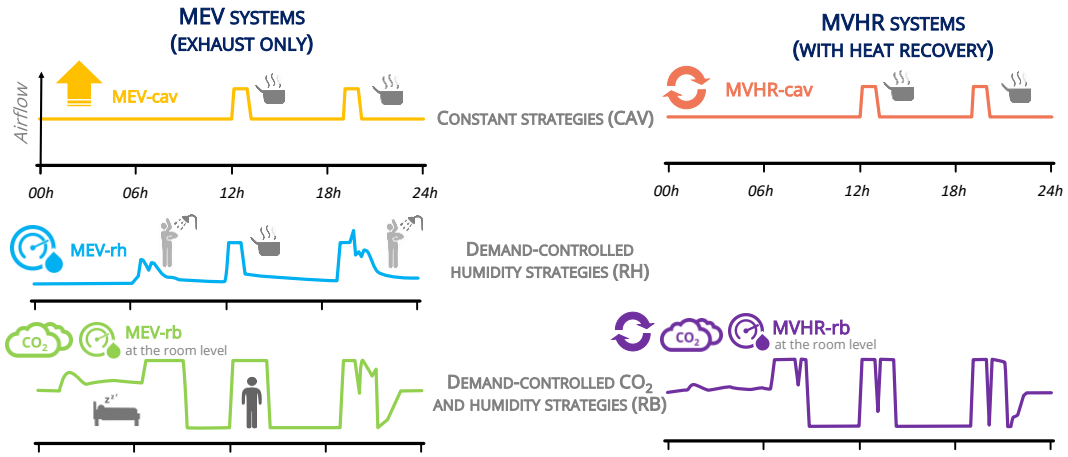
INTRODUCTION

FROM CONSTANT VENTILATION TO SMART VENTILATION



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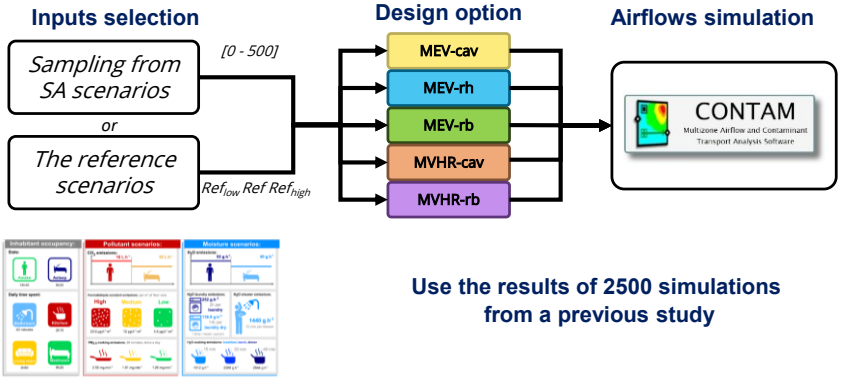
DESIGN OPTION PERFORMANCE CALCULATION



Use the results of 2500 simulations from a previous study

I^n_{CO2} I^n_{HCHO} Formaldehyde I^n_{PM25} I^n_{RH70} $I^n_{RH30\_70}$ Humidity H_2O I^n_{Ewh}

(Poirier et al., 2021b; Poirier, 2023)

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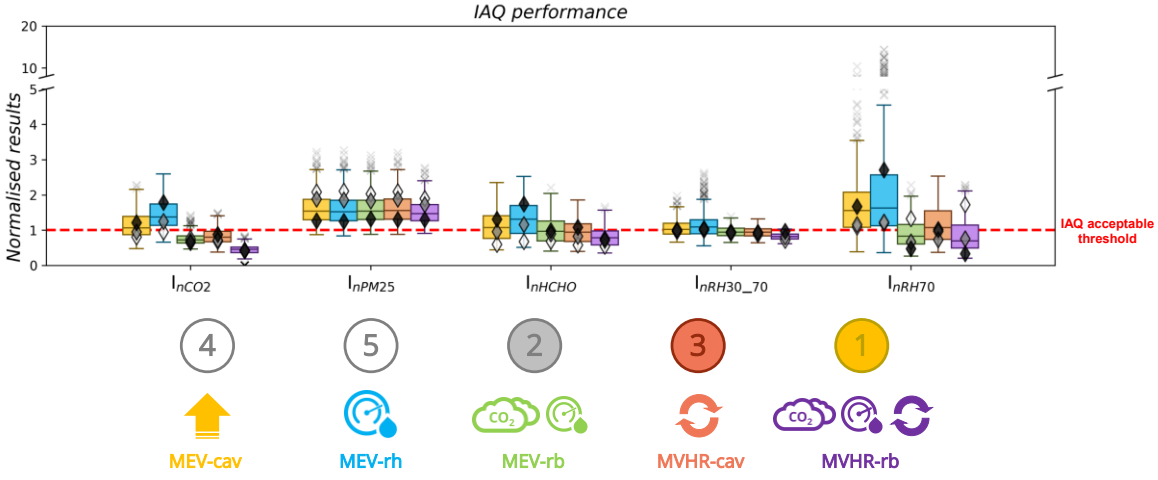
BASED ON IAQ PERFORMANCE ?



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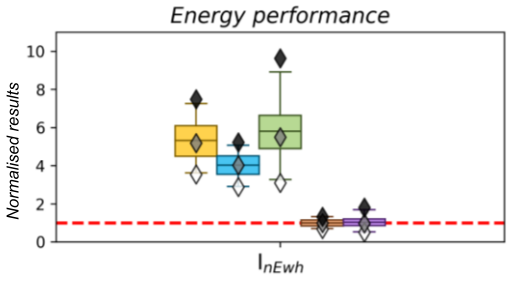
PERFORMANCE RAKING

BASED ON ENERGY PERFORMANCE ?

Heat losses from exhausted airflows

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



MVHR_cav median performance proposed as reference threshold

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

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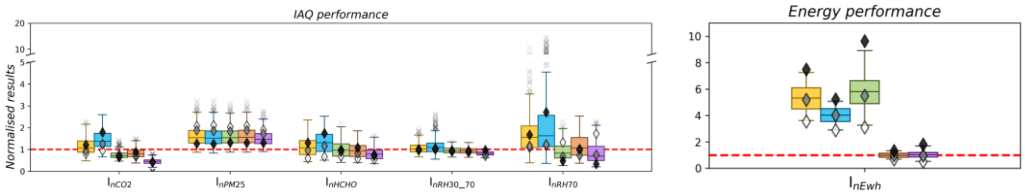
PERFORMANCE RAKING

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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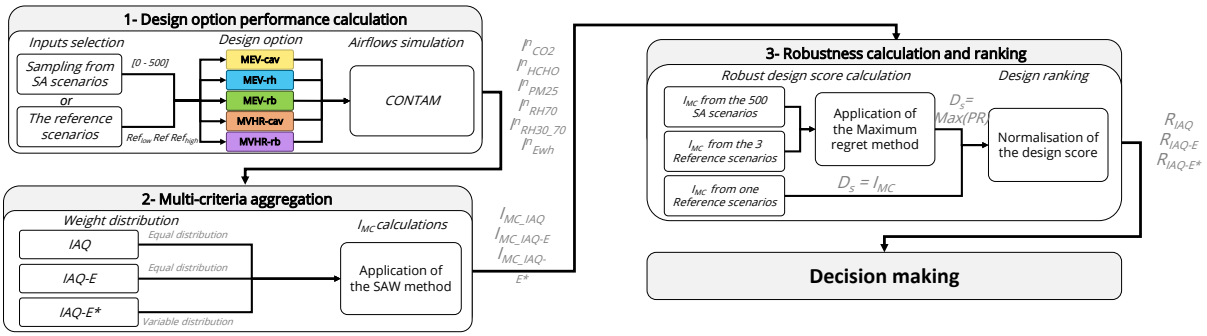
A ROBUST METHOD FOR PERFORMANCE RANKING

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.)

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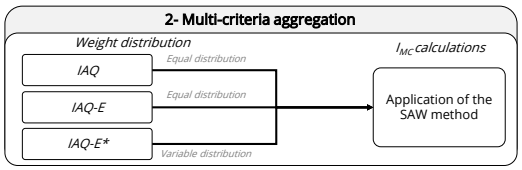
A ROBUST METHOD FOR PERFORMANCE RANKING

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**

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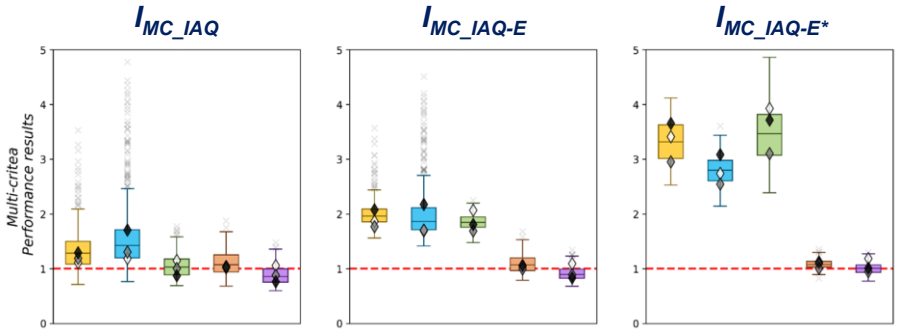
A ROBUST METHOD FOR PERFORMANCE RANKING

MULTI-CRITERIA AGGREGATION



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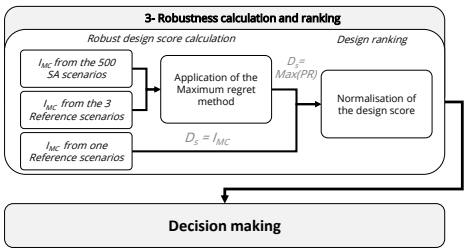
A ROBUST METHOD FOR PERFORMANCE RANKING

ROBUST DESIGN SCORE CALCULATION AND RANKING



R_{IAQ}
R_{IAQ-E}
R_{IAQ-E*}

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)

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

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

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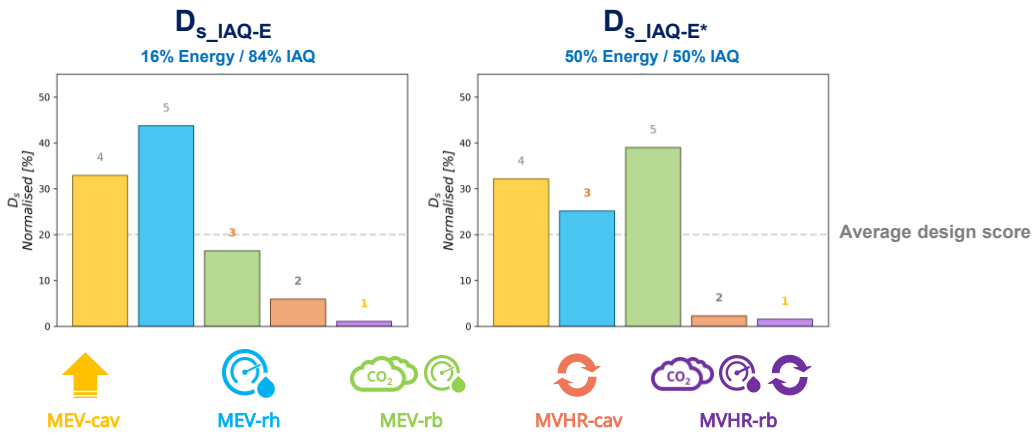
A ROBUST METHOD FOR PERFORMANCE RANKING

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

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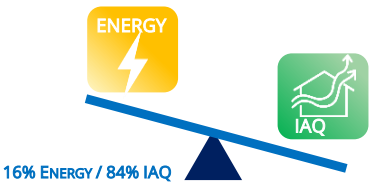
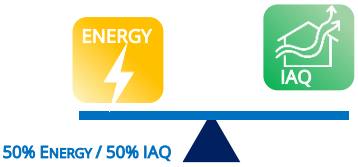
CONCLUSION

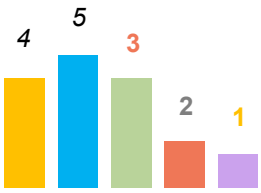
LEARNINGS REGARDING ROBUSTNESS



***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**.*

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THANK YOU

FOR YOUR ATTENTION