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EBC
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AIVC
TightVent Europe
venticool
the platform for resilient ventilative cooling

The 44th AIVC conference
"Retrofitting the Building Stock: Challenges and Opportunities for IEQ"

IEA-EBC Annex 86
working meeting 7 - Symposium session

Impacts of Climate Change on IAQ

"Insights from the OCCuPANt project"

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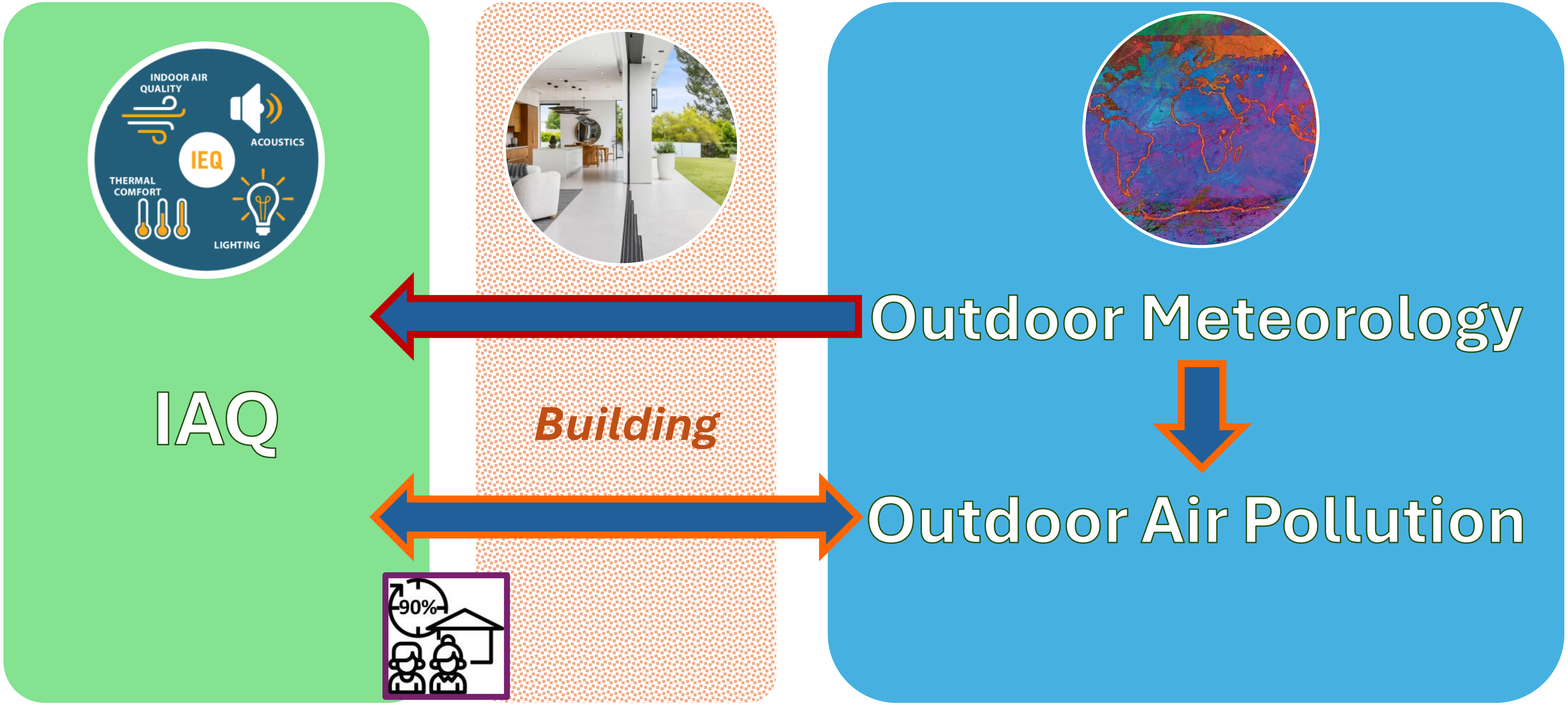
Outline

- Problem definition & scientific objectives
- Background & limitations of current approaches
- Methods (***OCCuPANt***)
- Results
- Summary and Conclusions

Problem definition & scientific objectives

- **IAQ**, a subset of IEQ
- Climate Change

*Temporal nature (**10-30 years**)*



Problem definition & scientific objectives

- Expected impacts

Qualitative

Climatological Effect		Indoor Environmental Effect
Outdoor temperature rise & Extreme heat waves	→	Indoor temperature rises, Increased use of air conditioning, Potential for increased off-gassing of VOCs, Inability of air conditioning to condition indoor air, Extreme heat stress.
Increased outdoor pollution	→	Increased PM & O_3 come indoors, etc. O_3 can induce byproducts (indoor chemistry).
Increased mean outdoor humidity & Extreme precipitation episodes	→	indoor RH, Indoor condensation, and mold growth, Damp conditions, building damage.
Pressure to reduce energy use to lower GHG (reduced air ventilation)	→	All existing indoor pollutants rise in inverse proportion to reduced ventilation.

Ref: IOM: Institute of Medicine. 2011. Climate Change, the Indoor Environment, and Health. https://doi.org/10.17226/13115.

1st comprehensive qualitative analysis:
by Prof. Nazzarof. 2013: Nazaroff, W. W. (2013). Exploring the consequences of climate change for indoor air quality, https://doi.org/10.1088/1748-9326/8/1/015022

Quantitative?

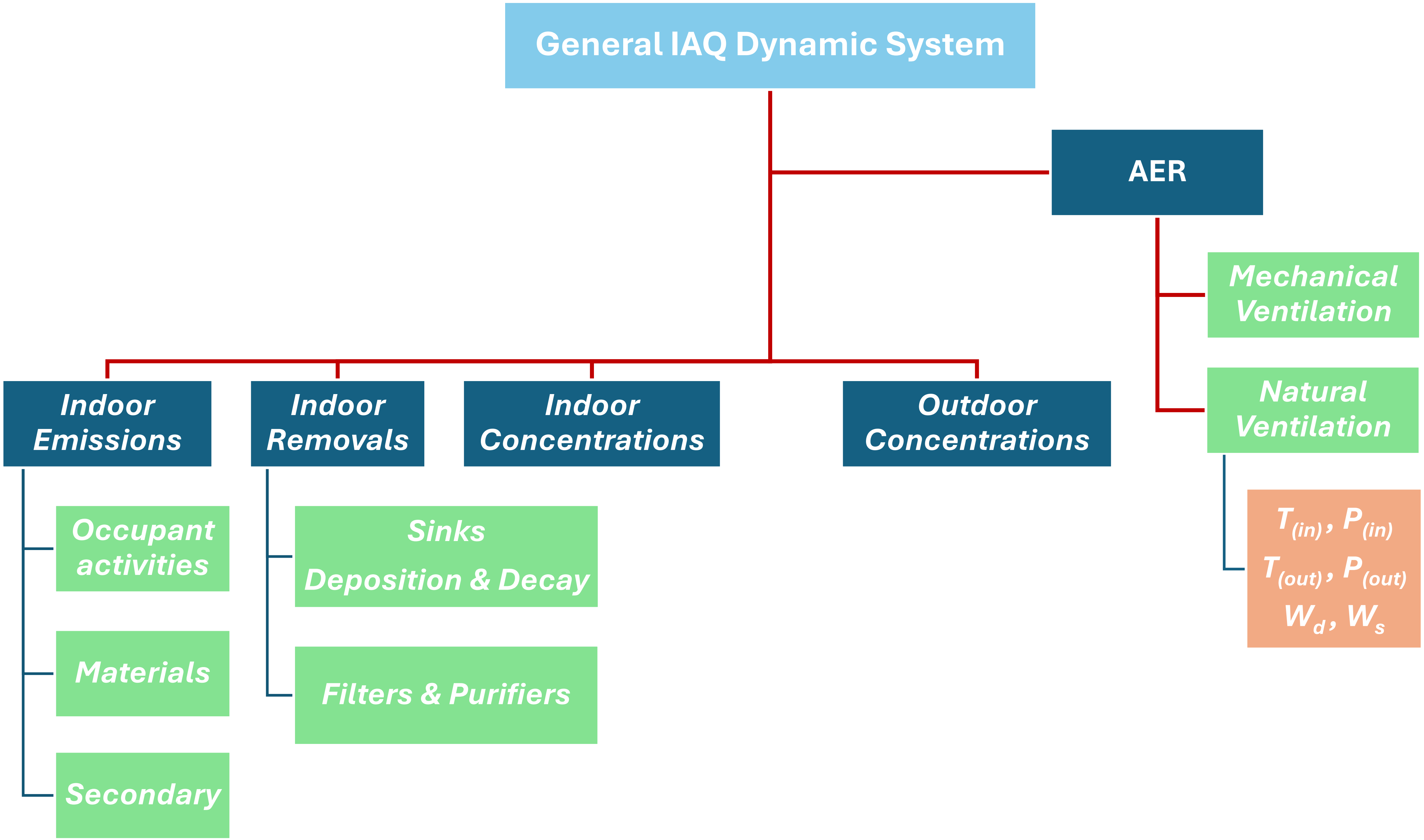
Background & limitations of current approaches

✘ ***Common methodological limitations can be summarized as :***

*In the context of **Climate Change**;*

Not considering IAQ as a ***“Dynamic System”*** interacting with the ***“Outdoor Environment”***

Background & limitations of current approaches



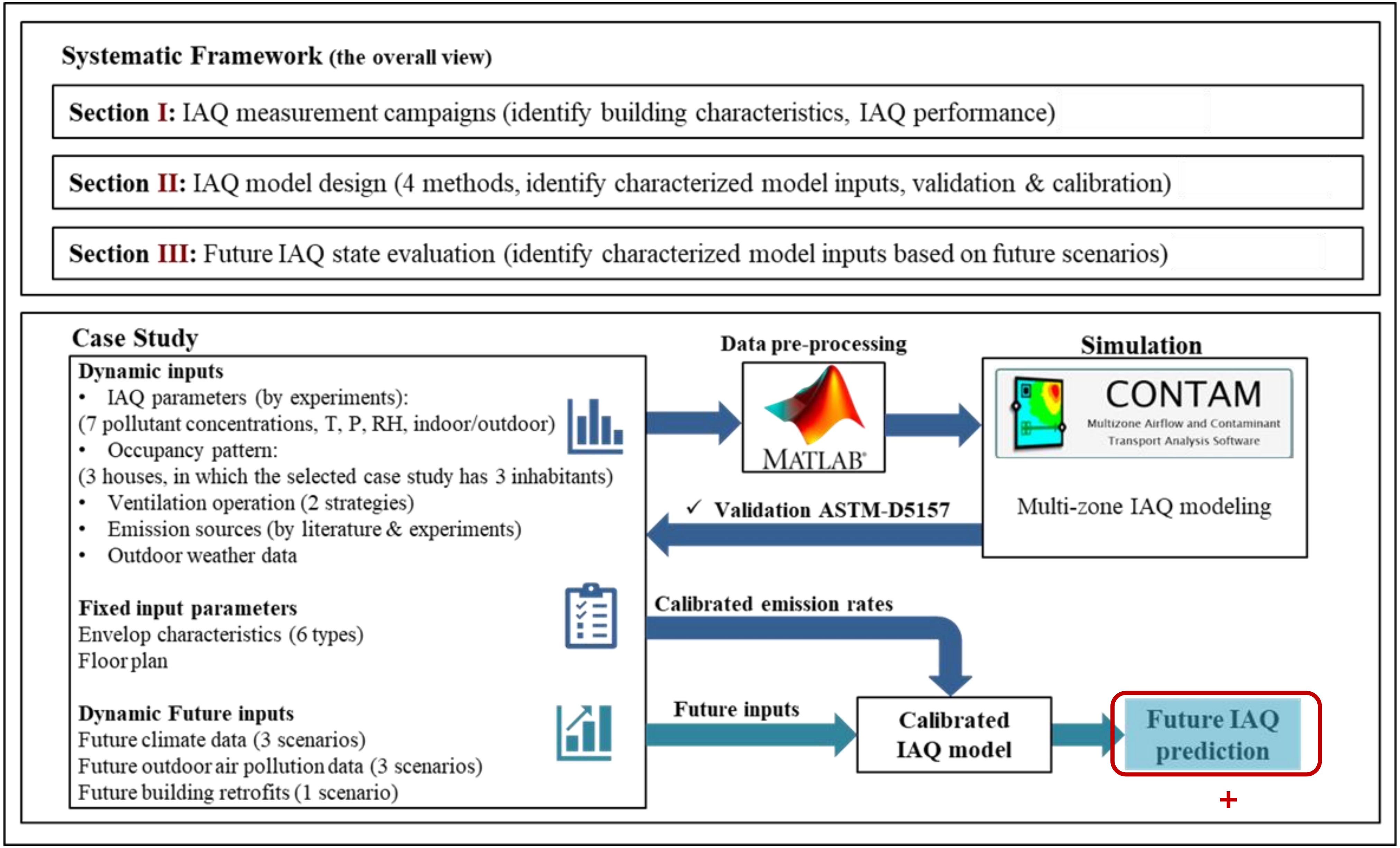
Background & limitations of current approaches

*Quantitative assessments of IAQ (**as a system**) under future climate scenarios:*

IAQ-CC Studies	IAQ Model	Ventilation	Climate Scenario	Air Pollution	Building	Occupant	Pollutants
Taylor et al. 2015	EnergyPlus	N	UKCP 09	-	✓	✓	$PM_{2.5}$ (↑)
Ilacqua et al. 2017	single-zone mass balance	-	IPCC* A 2	-	-	-	Rn, PM_1, $PM_{2.5}$, O_3, Carbonyl, NO_2, HNO_3 (↑↓)
Chang et al. 2018	mass balance	N+V	IPCC RCP 8	KPOP-CC	✓	✓	Formaldéhyde (↑↓)
Salthammer et al. 2018	single-zone mass balance	-	IPCC RCP 8	-	-	-	$PM_{2.5}$, PM_{10} (↓)
Fazli et al. 2021	single-zone mass balance	N+V	IPCC RCP 8	CMAQ	✓	-	PM_1(↓), $PM_{2,5}$(↓), NO_2(↓), O_3(↑), VOC(↑), Aldehyde(↑)
Pourkiaei et al. 2024	multizone mass balance **CONTAM**	N+V	IPCC **SSP 2,3,5**	**CNN-BiLSTM**	+	+	**CO(c), $PM_{2.5}$, PM_{10} (↓↑), NO_2(↑), NO(↓), O_3(↑), VOC(-)**
Zhao et al. 2024	single-zone mass balance	-	IPCC SSP 1,2,5	~	-	-	O_3, Limonene(↑↓) (24 hr)

"until Q2-2024"

Methods (*OCCuPANt*)

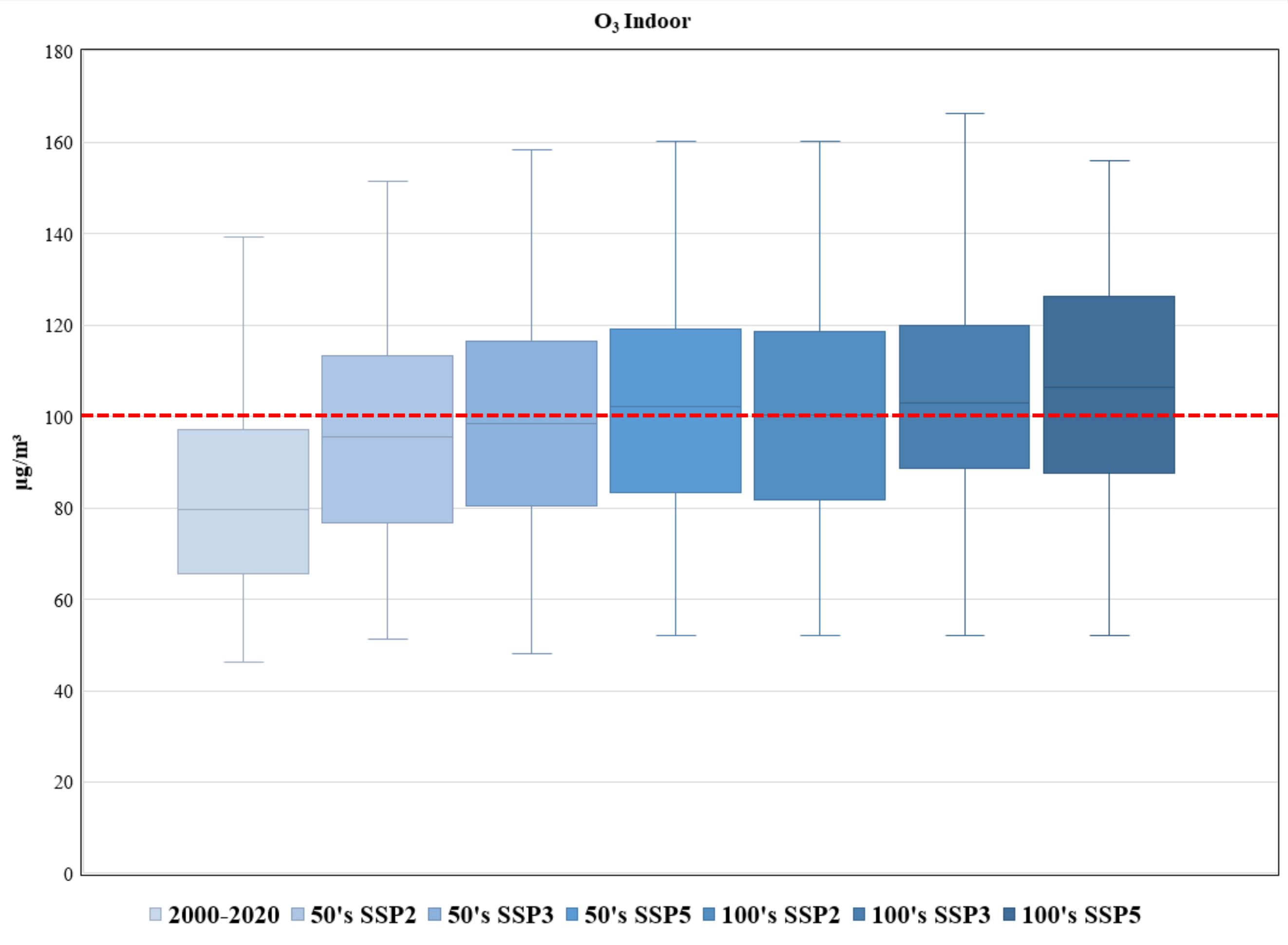


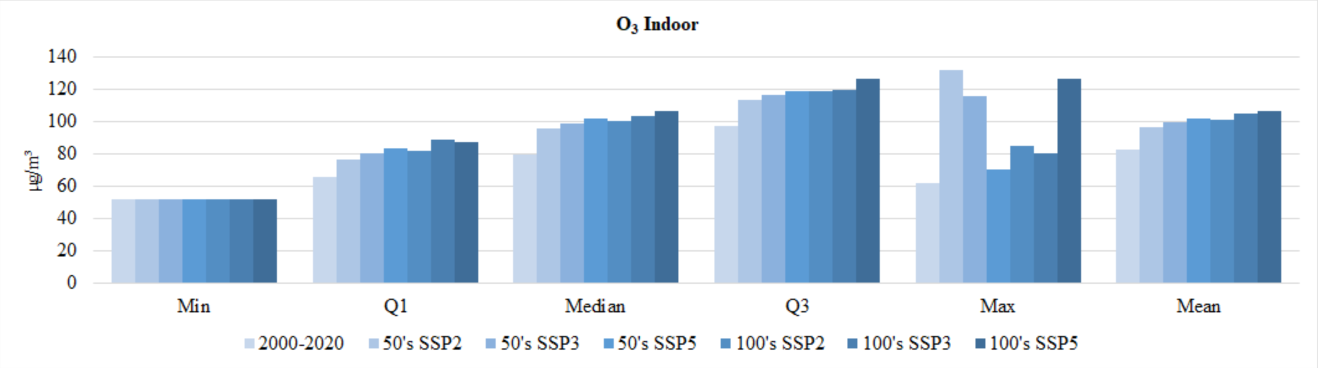
Decision Supporting Tool

Results

CONTAM (IAQ modeling) results with future inputs:

- ✓ IAQ Basis Model: 2021
- ✓ Ventilation: Naturally Ventilated Case Study + Exhaust Fans
- ✓ Future Climate: MAR Model (5km x 5km)
- ✓ Future Outdoor Air Pollution: 1D-CNN-BiLSTM RNN
- ✓ Future Indoor Climate: I/O
- ✓ Future Natural AER: CONTAM
- ✓ Future Building Characteristics: Kept Fixed
- ✓ Future Indoor Activities and Emission/Sinks: Kept Fixed

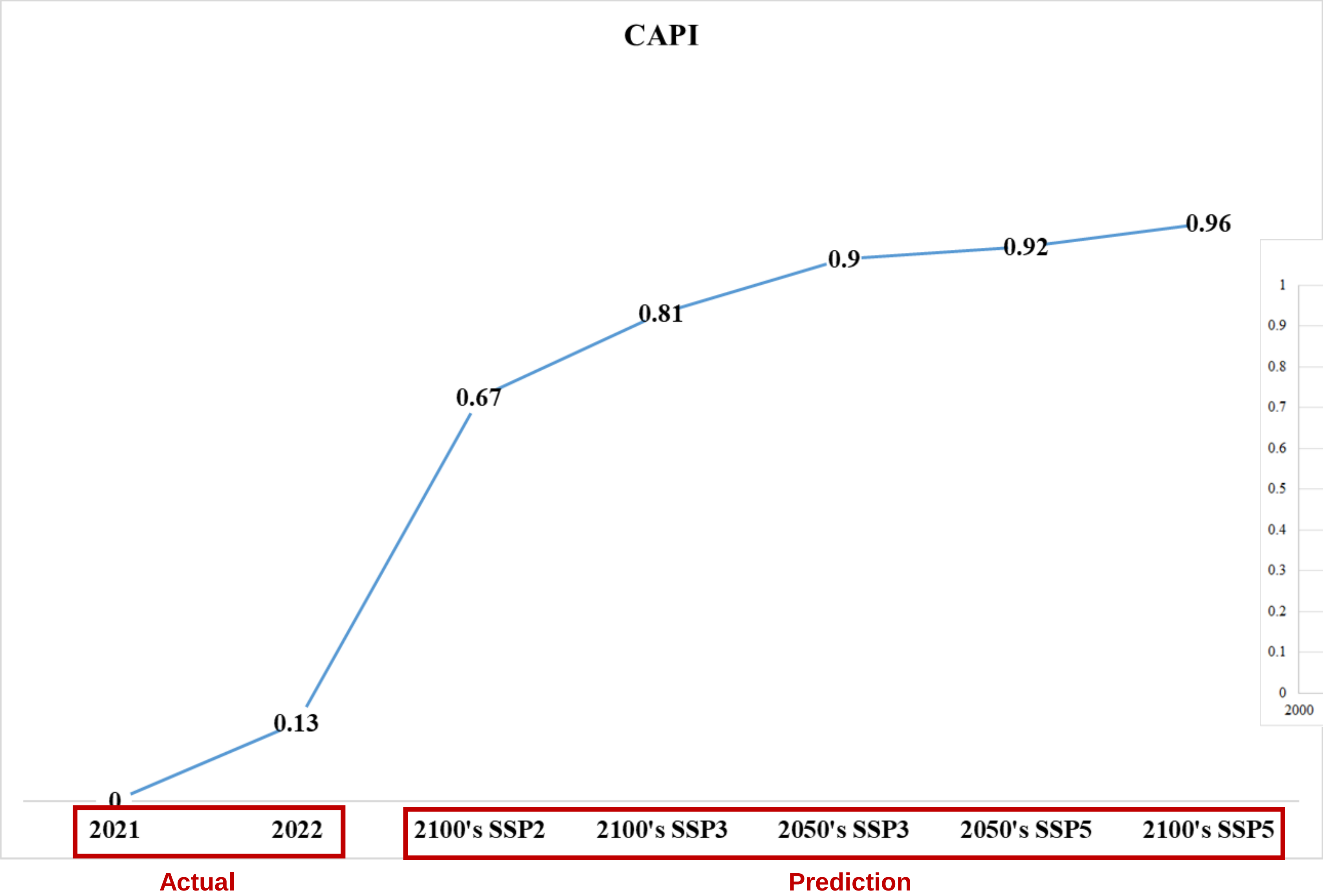




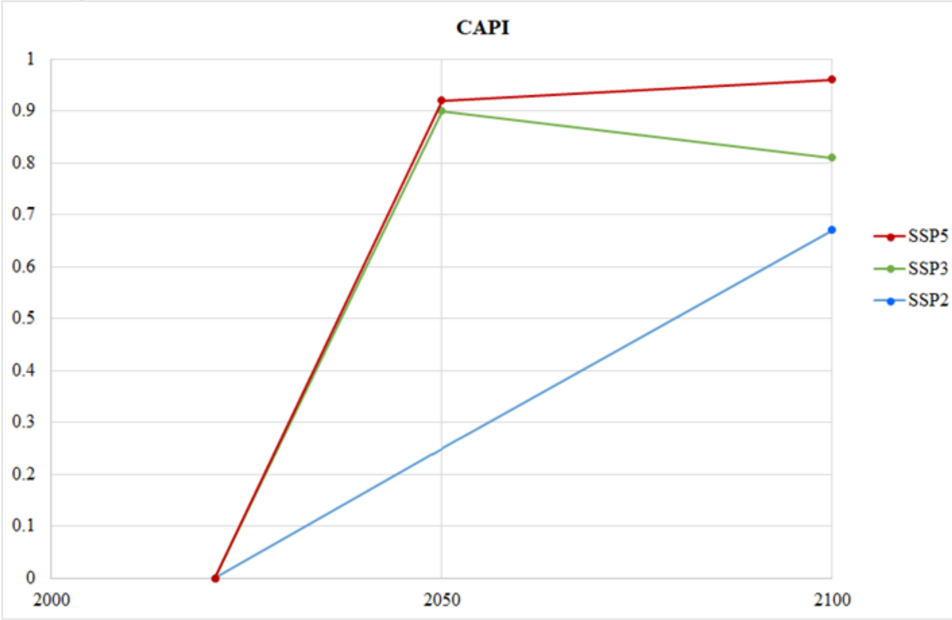
Results

Climate Change-IAQ Index (*CAPI*)

$$\text{“}\textit{CC-Affected Poor IAQ}\text{” Ratio} = \left(\frac{\text{Days with “}\textit{CC-Correlated}\text{” Poor IAQ}}{\text{Days with } \textit{CC} \text{ Events}}\right) \quad [0,1]$$



Future CAPI temporal projections via SSP 2, 3, 5



Summary and Conclusions

✓ Region Specific Problem

✓ Approach Optimality and Time Efficiency

- OCCuPANt Project
- **LCS** (Design & Develop by SAM Laboratory)
- **CONTAM** Application for IAQ Modeling
- **AI** Application for Future Outdoor Air Pollution Prediction

✓ Decision-making Support Tool (***CAPI***)

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UR Spheres, Department of Environmental Science and Management, Faculty of Sciences, University of Liège, Arlon, BE.

Low-Cost Air Quality Sensors For IAQ Experiments

SAM LAB-made OCTs:

Contaminant Sensor	Concentration Range	Commercial Sensors
CO	2-1000 ppm (±2)	Alphasense Electrochemical B4
NO	2-20 ppm (±2)	Alphasense Electrochemical B4
NO_2	2-20 ppm (±2)	Alphasense Electrochemical B43F
O_3	1-20 ppm (±2)	Alphasense Electrochemical OX-B431
$PM_{2.5}$	0-1000 µg/m³(±10)	Light scattering Sensirion SPS30
PM_{10}	0-1000 µg/m³(±25)	Light scattering Sensirion SPS30
VOC	0.5 ppb - 2 ppm	Photoionization detector AMETEK MOCON (Blue)
T	-40 to 85 °C	Bosch BME280
RH	0 - 100%	Bosch BME280
P	300 – 1100 hPa	Bosch BME280

PM & Gas sesnors:

400 mV to 3.37 V

1.7 V to 3.6 V

0.045-2.5 V
10.6 e.V

PM | CO-B4 | NO-B4 | NO2-B43F | OX-B431 | VOC

Open Access References:

Thesis: https://hdl.handle.net/2268/322013

Paper: https://hdl.handle.net/2268/318033

Thank You For Your Attention

Any Question and Suggestions?

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