

VENTILATIVE COOLING CASE: TEST LECTURE ROOMS KU LEUVEN GHENT TECHNOLOGY CAMPUS

**Webinar: Hoe kunnen we aanvaardbare
comfortomstandigheden in tertiaire gebouwen
in België garanderen**

30/9/2021

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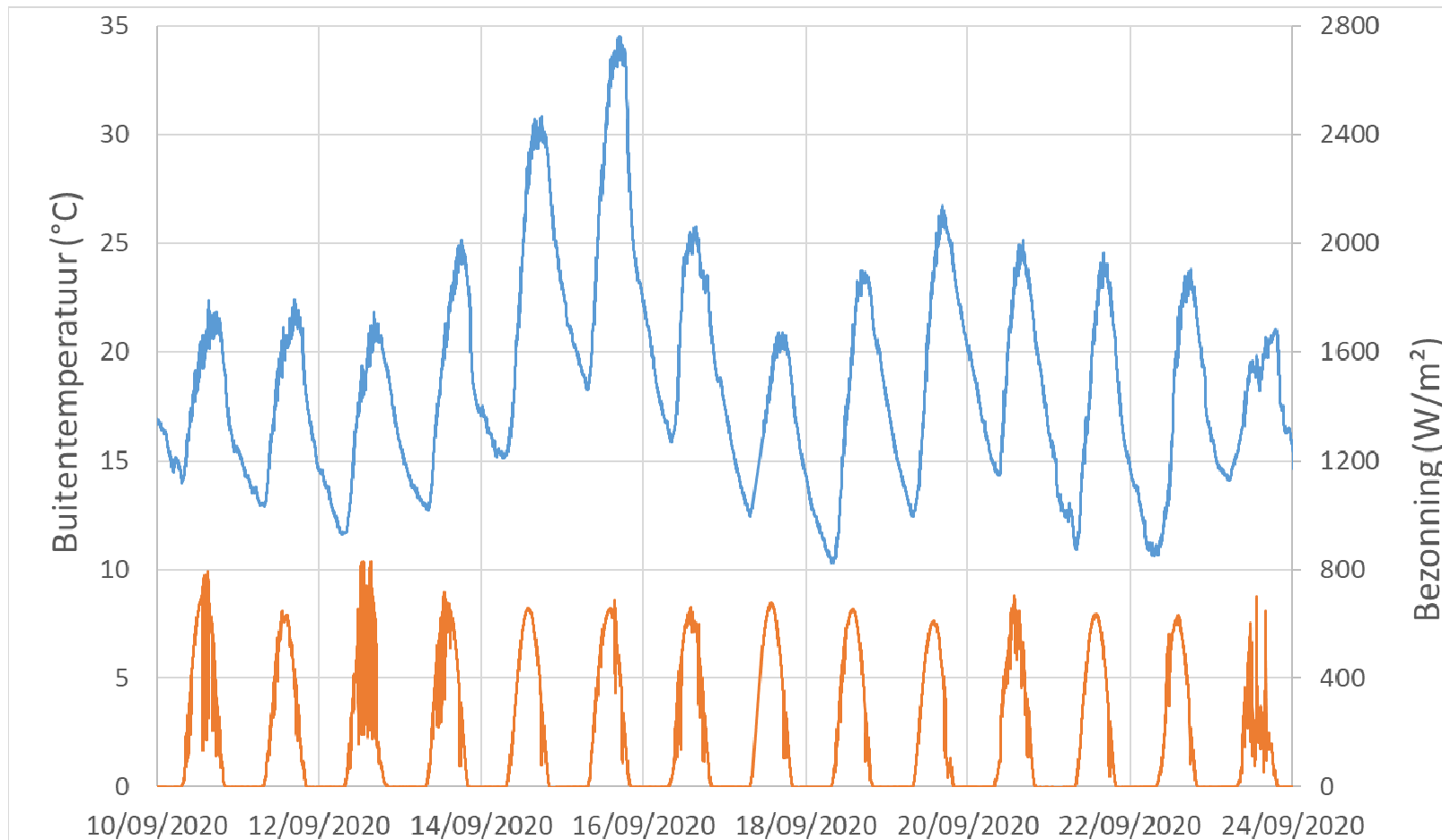
KU LEUVEN

Atic
for HVAC professionals

The logo graphic for Atic consists of several curved, overlapping lines in shades of blue and yellow, resembling a stylized flame or a fan.

Context

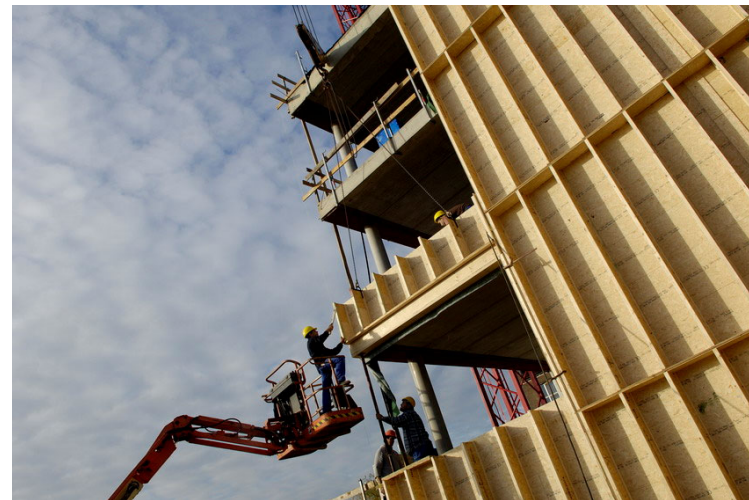
- High temperatures & solar radiation also in spring and autumn in moderate climates (Ghent, sept 2020)



Context

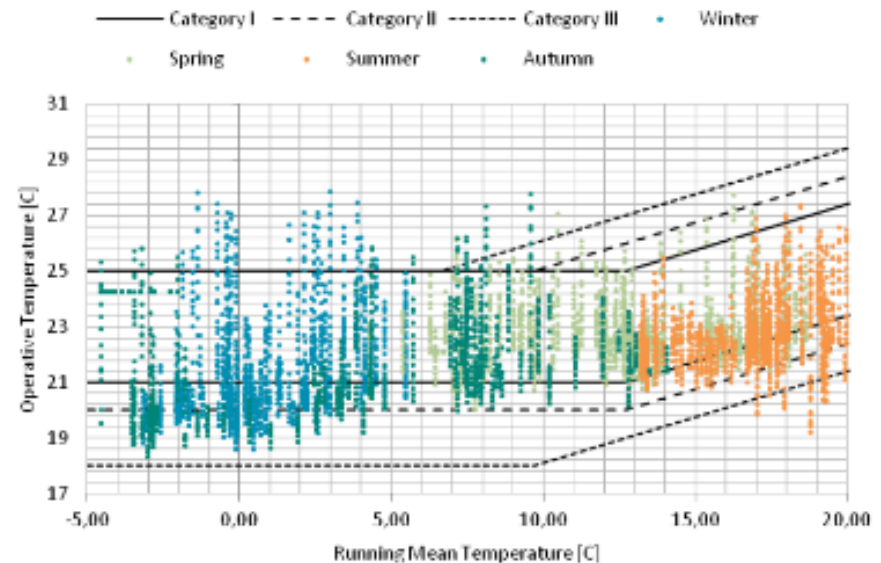


- Evolution to nZEB (nearly zero energy buildings)
 - Reduction of the heating demand
 - Airtight
 - Highly insulated



Context

- Challenges in nZEB buildings
 - Increase in cooling demand all year round
 - Cooling demand depends more on
 - Solar radiation
 - Internal heat gains
 - Overheating most reported problem
 - Need for
 - conceptual and building technical measures
 - energy efficient cooling systems



Context

- Resilient ventilative cooling

venticool
the platform for resilient ventilative cooling

WELCOME FAQs

IEA EBC
Annex 62
The IEA project
on ventilative cooling
EBC

IEA EBC
Annex 80
The IEA project
on resilient cooling
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Information on Venticool Information on Annex 62 Information on Annex 80

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Search Site

Dear visitor, Welcome to this combined website of the **venticool platform** and of **IEA EBC Annex 62 – Ventilative Cooling & IEA EBC Annex 80 – Resilient Cooling**

<https://venticool.eu>

Overview

- Context
- **Ventilative cooling**
- Test lecture rooms
- Future proof?
- Summary

Ventilative cooling: design guide

International Energy Agency

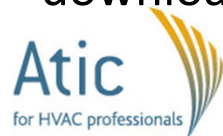
Ventilative Cooling Design Guide

Energy in Buildings and Communities Programme

March 2018



download via: <http://venticool.eu/annex-62-publications/deliverables/>



Ventilative cooling

- Attractive & energy efficient passive solution to cool buildings & avoid overheating
 - Ventilation already present in most buildings through mechanical and/or natural systems
 - Ventilative cooling: remove excess heat gains & increase air velocities -> widen thermal comfort range
 - cooling need not only in the summer period -> increased possibilities free cooling potential of low temperature outdoor air



iGent (Zwijnaarde)

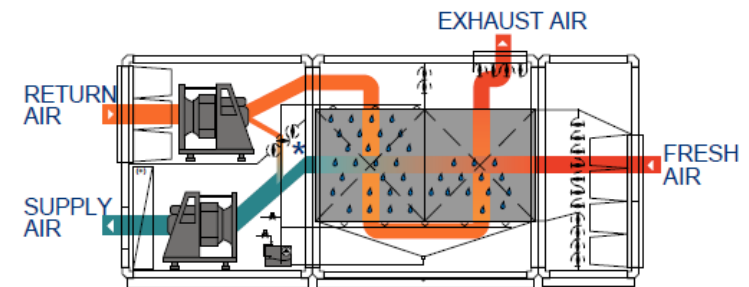
Ventilative cooling: strategies

Temperature Difference ¹	Ventilative Cooling	Supplementary cooling options
Cold (ΔT more than 10°C)	Minimize air flow rate - draught free air supply	-
Temperate (2-10°C lower than comfort zone)	Increasing air flow rate from minimum to maximum	Strategies for enhancement of natural driving forces to increase air flow rates Natural cooling strategies like evaporative cooling, earth to air heat exchange to reduce air intake temperature during daytime
Hot and dry (ΔT between -2°C and +2°C)	Minimum air flow rate during daytime Maximum air flow rate during night time	Natural cooling strategies like evaporative cooling, earth to air heat exchange, thermal mass and PCM storage to reduce air intake temperature during daytime. Mechanical cooling strategies like ground source heat pump, mechanical cooling
Hot and humid	Natural or mechanical ventilation should provide minimum outdoor air supply	Mechanical cooling/ dehumidification

¹ Temperature difference between indoor comfort temperature and mean outdoor air temperature.

Ventilative cooling: components

Functionality	Component
Air Flow Guiding	Windows, Rooflights, Doors, Dampers, Flaps, Louvres, Special Effect Vents
Air Flow Enhancing	Chimneys, Atria, Venturi Ventilators, Wind Towers, Wind Scoops
Passive and Natural Cooling	Convective Cooling, Evaporative Cooling, Phase Change Cooling
Control and Automation	Chain Actuators, Linear Actuators, Rotary Actuators, Sensors



Ventilative cooling: Case studies

International Energy Agency

Ventilative Cooling Case Studies



Energy in Buildings and Communities Programme
May 2018



download via: <http://venticool.eu/annex-62-publications/deliverables/>



Ventilative cooling: Case studies

- 11 non-residential & 4 residential buildings



Ventilative cooling: strategies

Ventilative cooling Concepts	Natural driven	Mech. Supply Driven	Mech. exhaust driven	Natural night ventilation	Mech. night ventilation	Air conditioning	Indirect Evap. Cooling	Earth to Air Heat Exch.	Phase Chang eMaterials
zero2020 (IE)	X			X					
Brunla Primary school (NO)	X			X					
Solstad barnehage (NO)	X		X	X	X				
UNI Innsbruck (AT)	X		X	X					
wk Simonsfeld (AT)	X		X						
Renson (BE)	X			X					
KU Leuven Ghent (BE)	X		X				X		
Nexus Hayama (JP)	X					X			
GFO Building (JP)	X	X	X			X			
CML Kindergarden (PT)	X			X					
Bristol University (UK)					X	X			X
Wanguo MOMA (CN)		X	X		X	X			
Maison Air et Lumiere (FR)	X								
Mascalucia ZEB (IT)	X			X				X	
Living Lab (NO)	X								

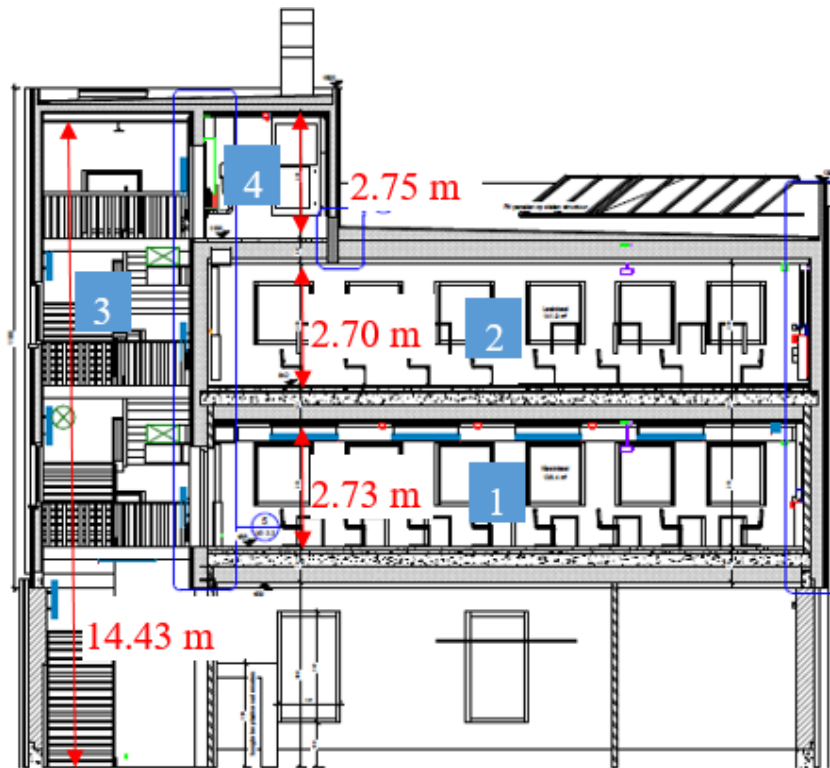
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Test lecture rooms

KU Leuven Ghent Technology Campus (BE)

- Zone 1 and 2: Floor area = 140 m²
- varying occupancy



Building envelope

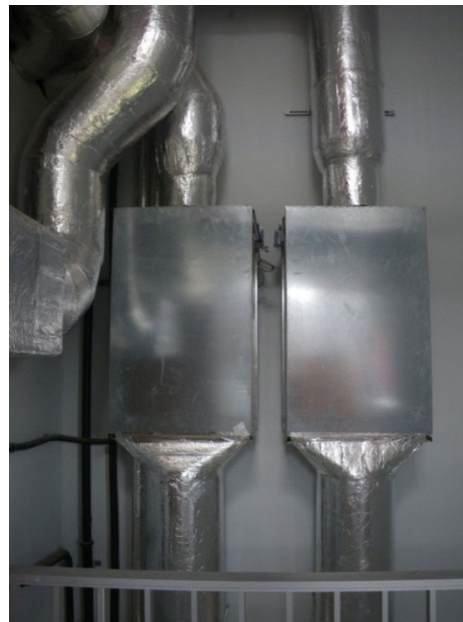
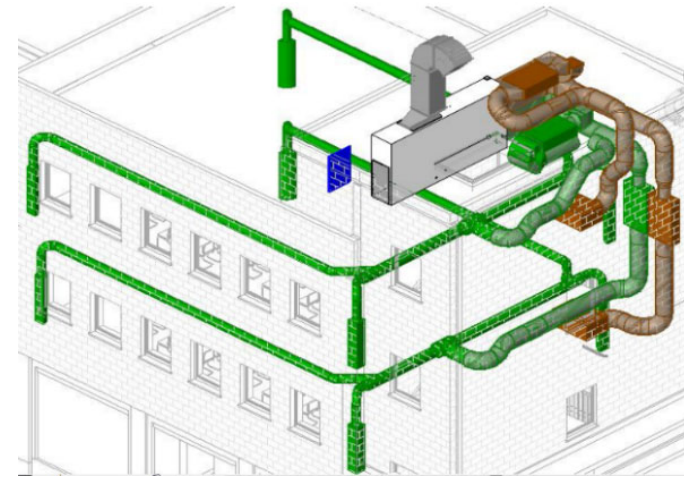
- PassiveHouse standard
 - U-values $< 0.15 \text{ W/m}^2\text{K}$
 - Air tightness $n_{50} < 0.6 \text{ h}^{-1}$
- Thermal mass: light/medium
- Solar shading
 - External: moveable screens (SW)
 - internal

	U (W/m ² K)
Ground floor	0.15
roof	0.14
façade	0.15
window (U_g/U_f)	0.6/0.75



All-air system

- Ventilation
 - Airflow = 4400 m³/h
 - Heat recovery: $\eta = 78\%$
 - CO₂-controlled
 - displacement ventilation



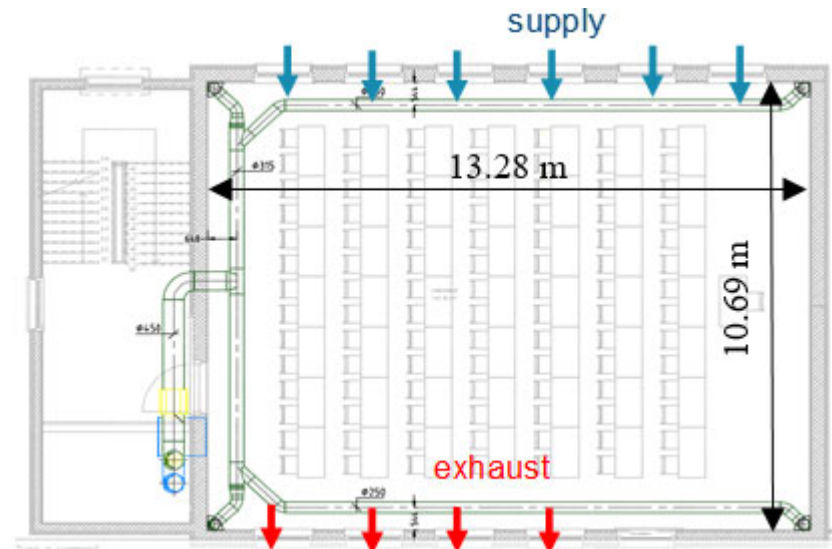
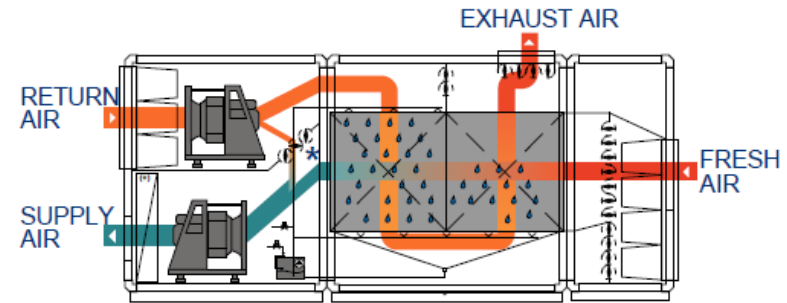
All-air system

- Heating
 - Production
 - Pellet boiler: $\eta = 1.06$, 8 kW, storage = 600l
 - Distribution and emission
 - Heating coils ventilation supply (2 x 7.9 kW)

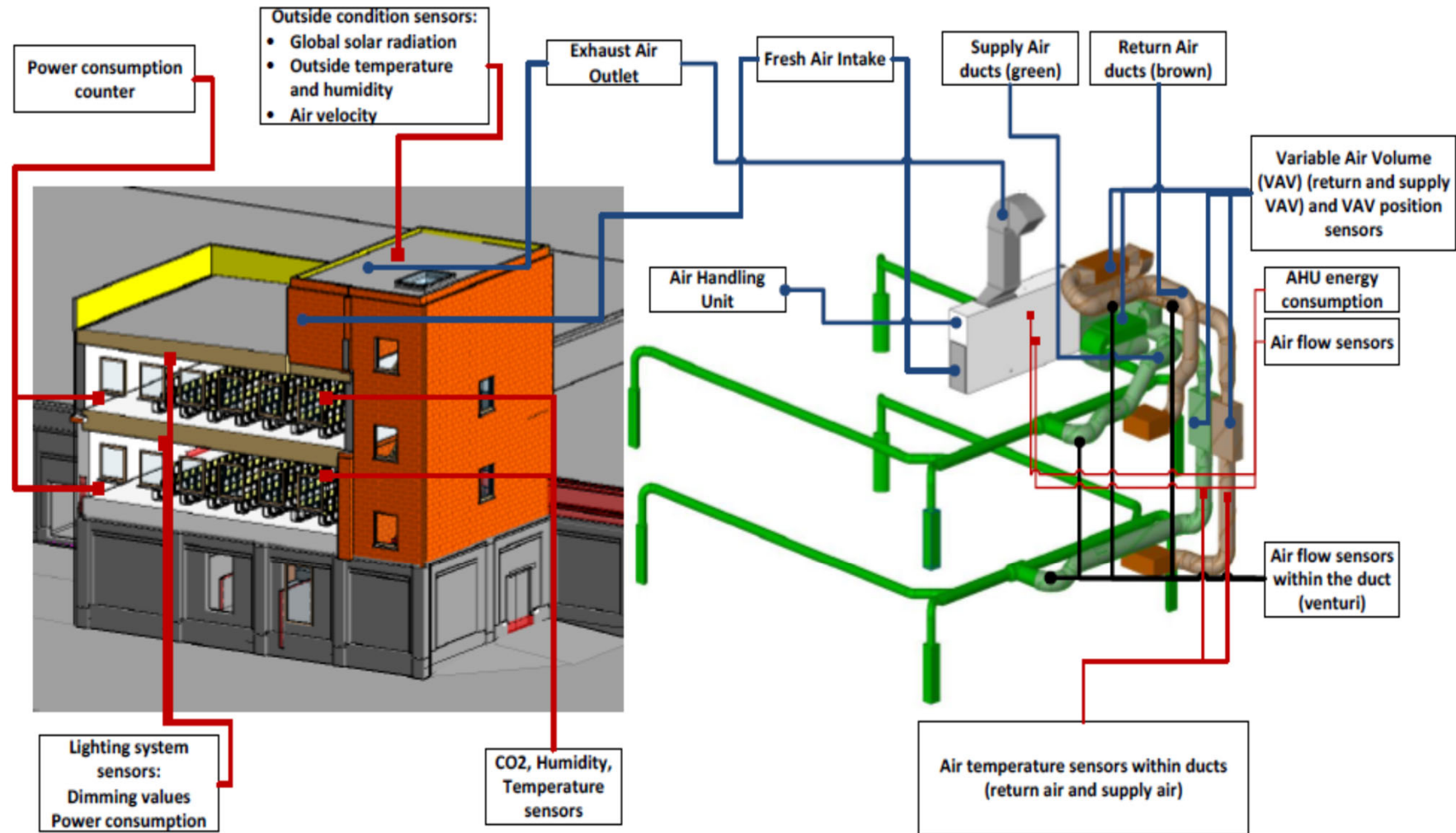


Ventilative cooling

- Indirect evaporative cooling in AHU
 - Max cooling capacity 13.1 kW
 - Activated: $T_i > 26^\circ\text{C}$ or $T_e > 22^\circ\text{C}$
- Natural night ventilation
 - Motorized bottom-hung windows
 - Effective opening area = 4% floor area
 - Cross ventilation

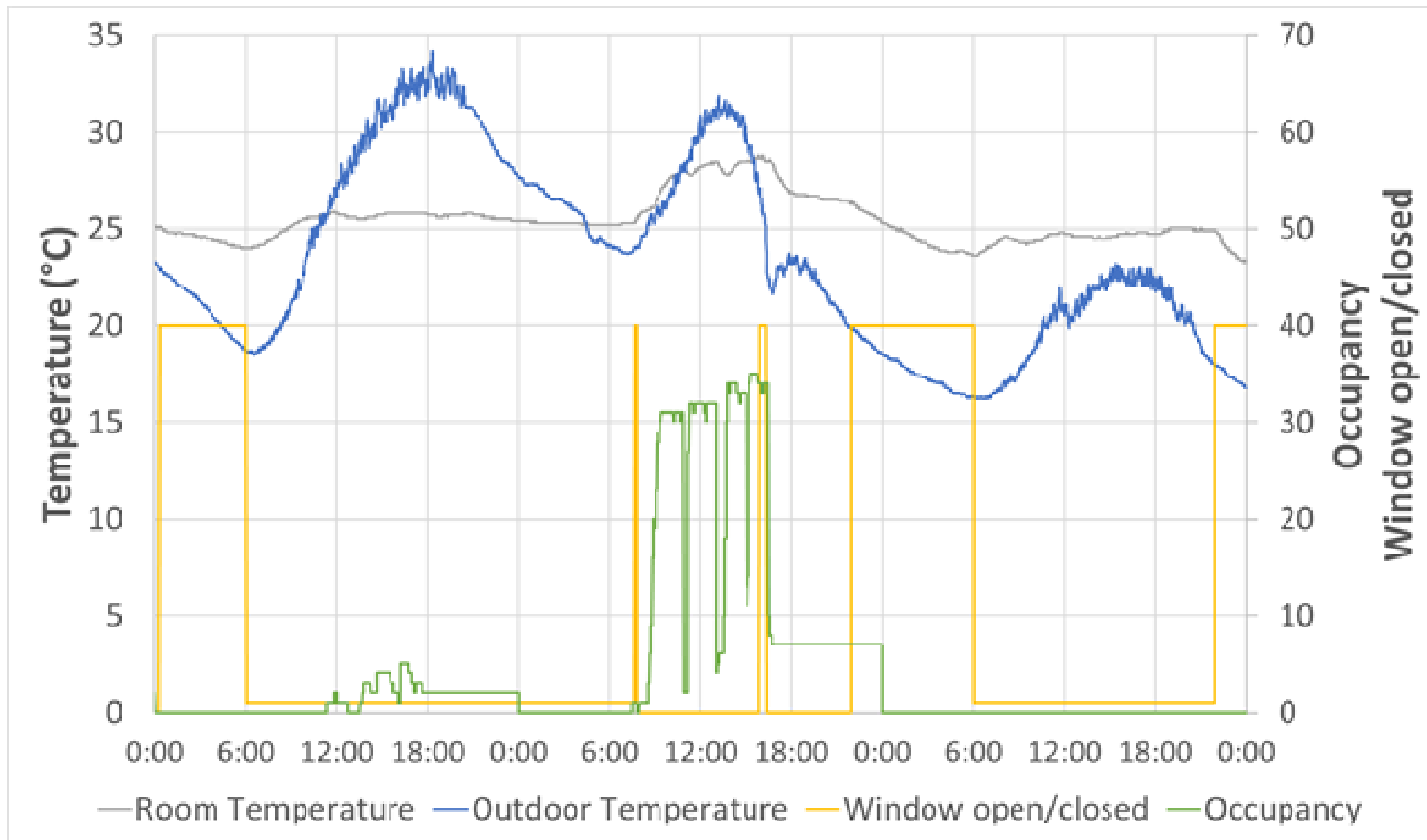


Monitoring



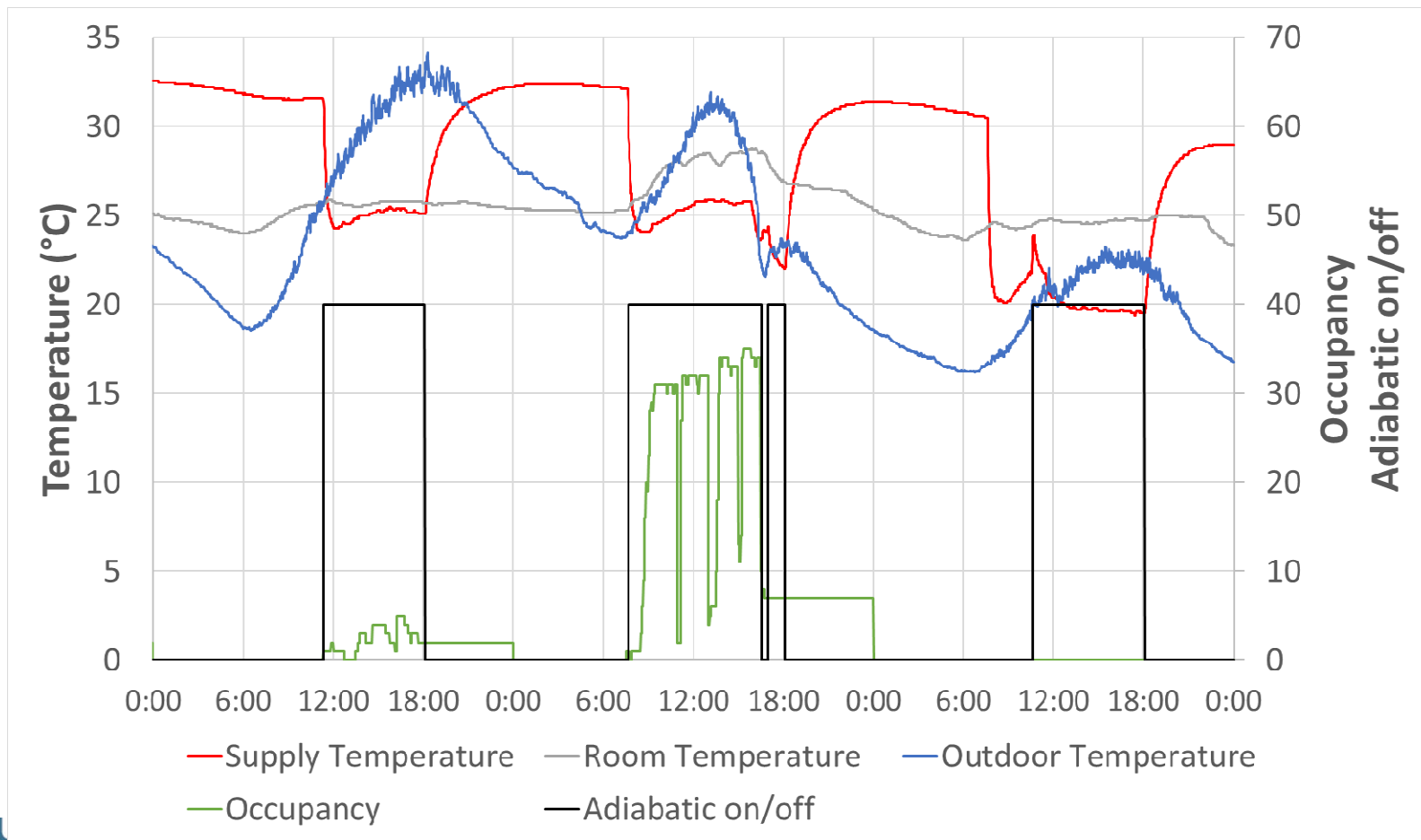
Operation Ventilative Cooling

- night ventilation during warm period



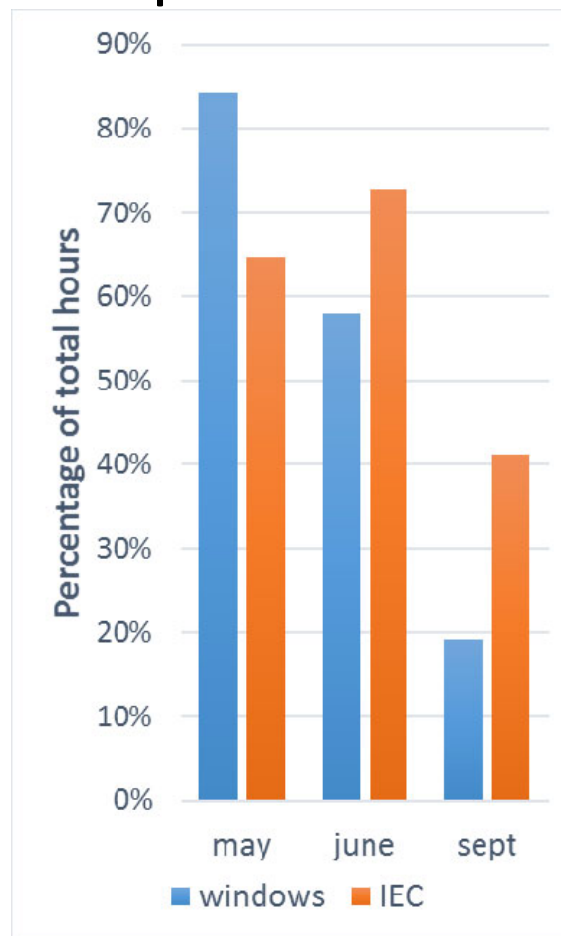
Operation Ventilative Cooling

- IEC during warm period



Operation & performance night ventilation

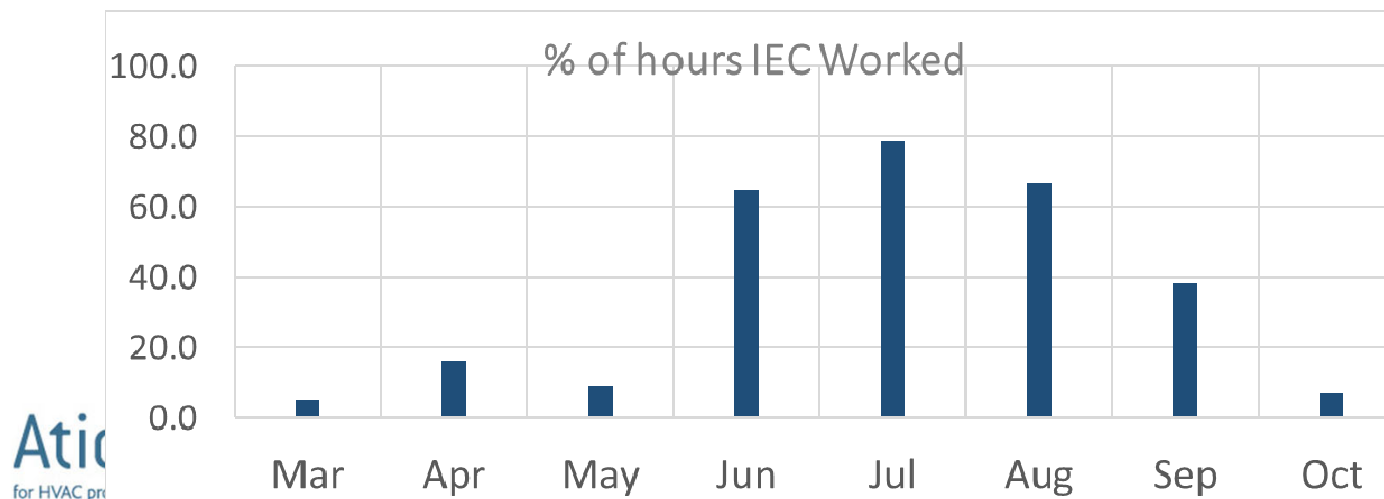
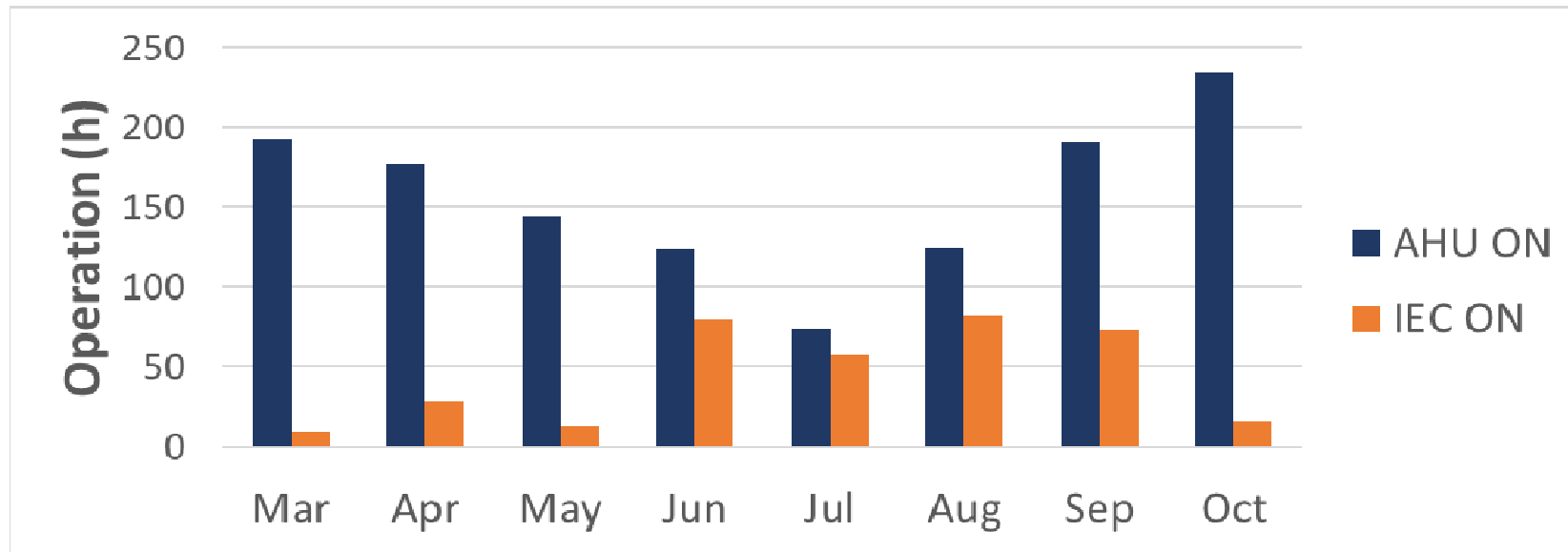
- Operation hours
- Airflow rate



Ventilation mode	ACR (h ⁻¹)	Wind speed (m/s)	Wind direction	ΔT (°C)
Cross ventilation	4,18 ± 0,42	1,9	WNW	4,3
Cross ventilation	3,76 ± 0,38	2,1	ESE	1,6
Cross ventilation	3,04 ± 0,30	2,2	ESE	2,4
Single sided	2,05 ± 0,21	2,3	SSW	-
Single sided	2,00 ± 0,20	2,68	S	-
Single sided	1,17 ± 0,12	1,45	SSW	5,1
Single sided	1,56 ± 0,16	1,78	S	8,6

Data from 2017

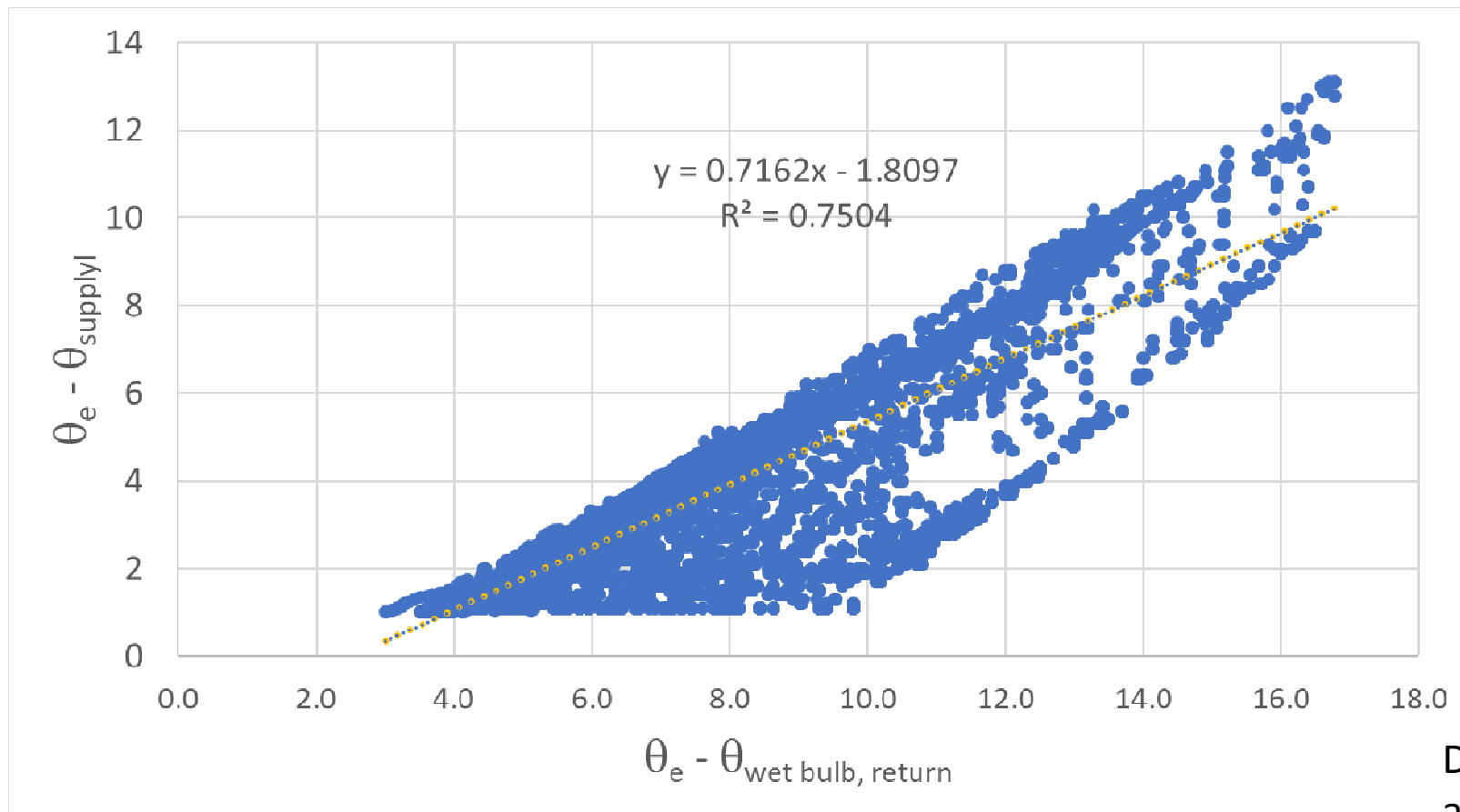
Operation IEC



Performance IEC

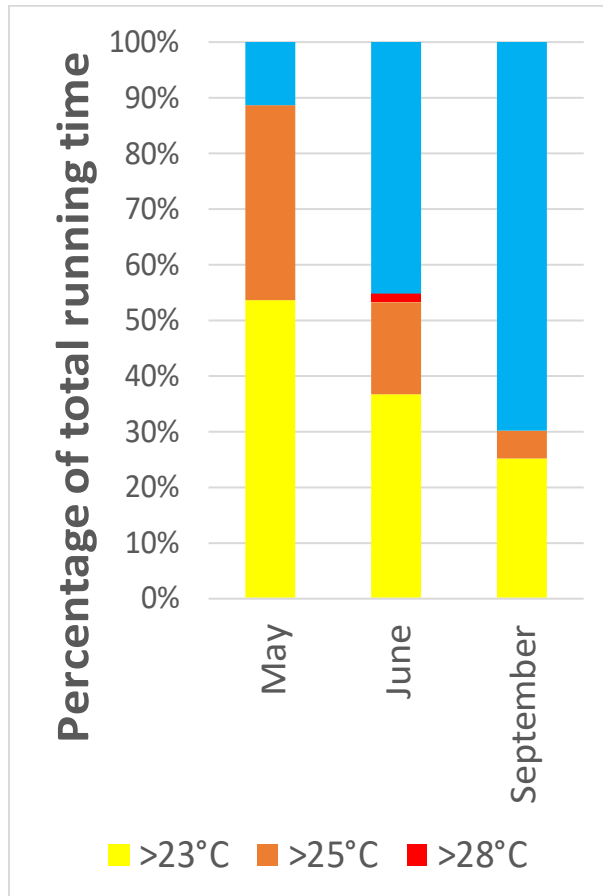
- Effectiveness

$$\varepsilon = \frac{\theta_e - \vartheta_{supply}}{\theta_e - \vartheta_{wet\ bulb, return}}$$

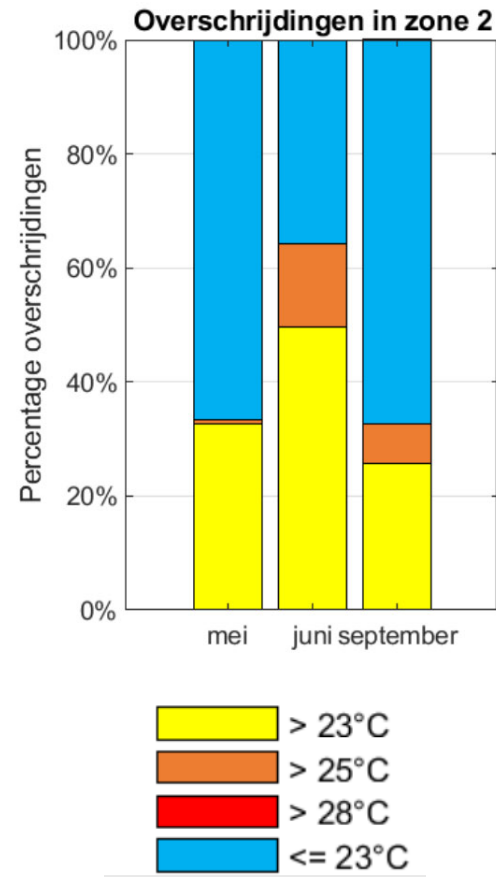


Data from
aug/sep 2021

Thermal summer comfort

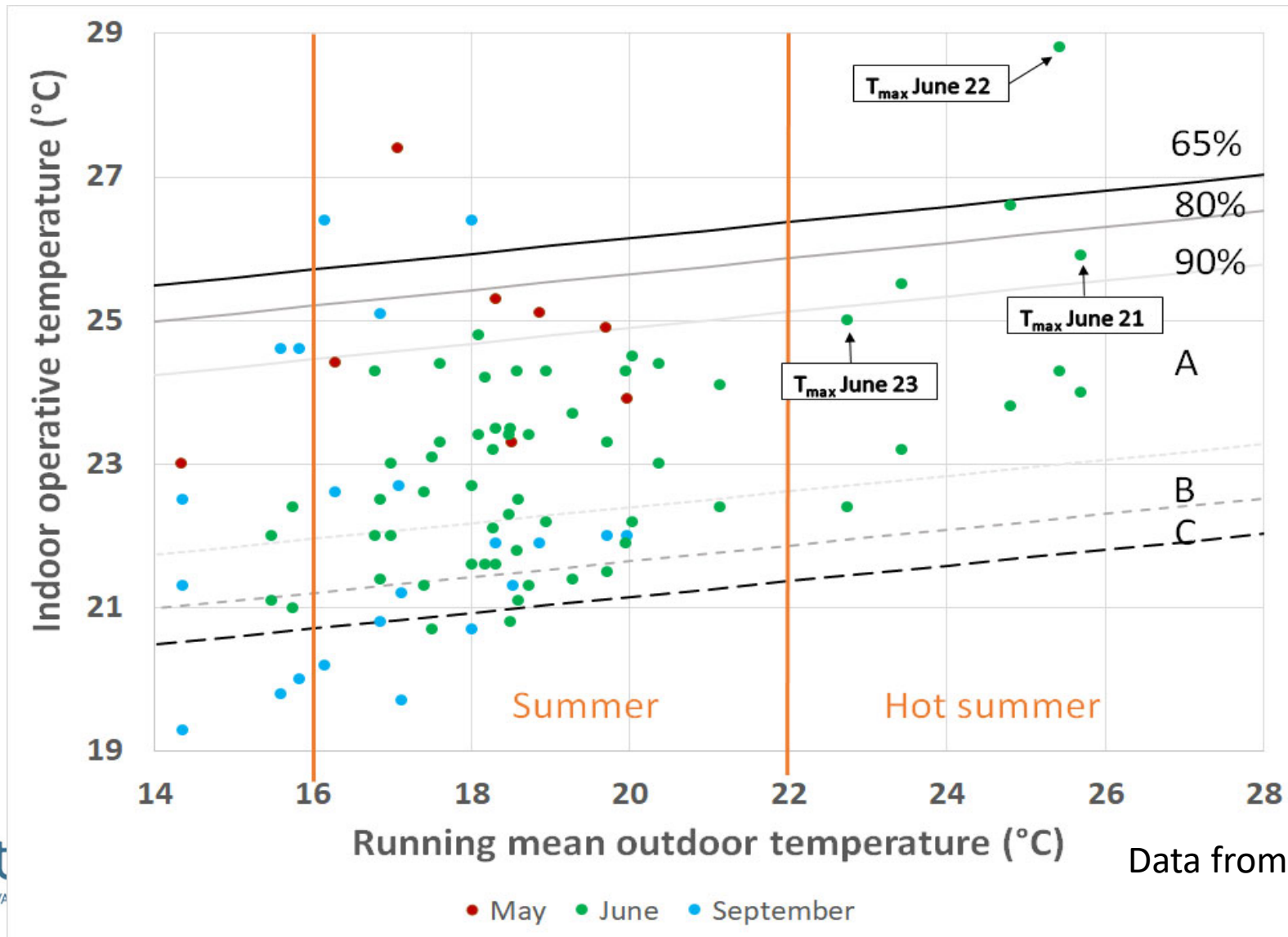


2017



2019

Thermal summer comfort

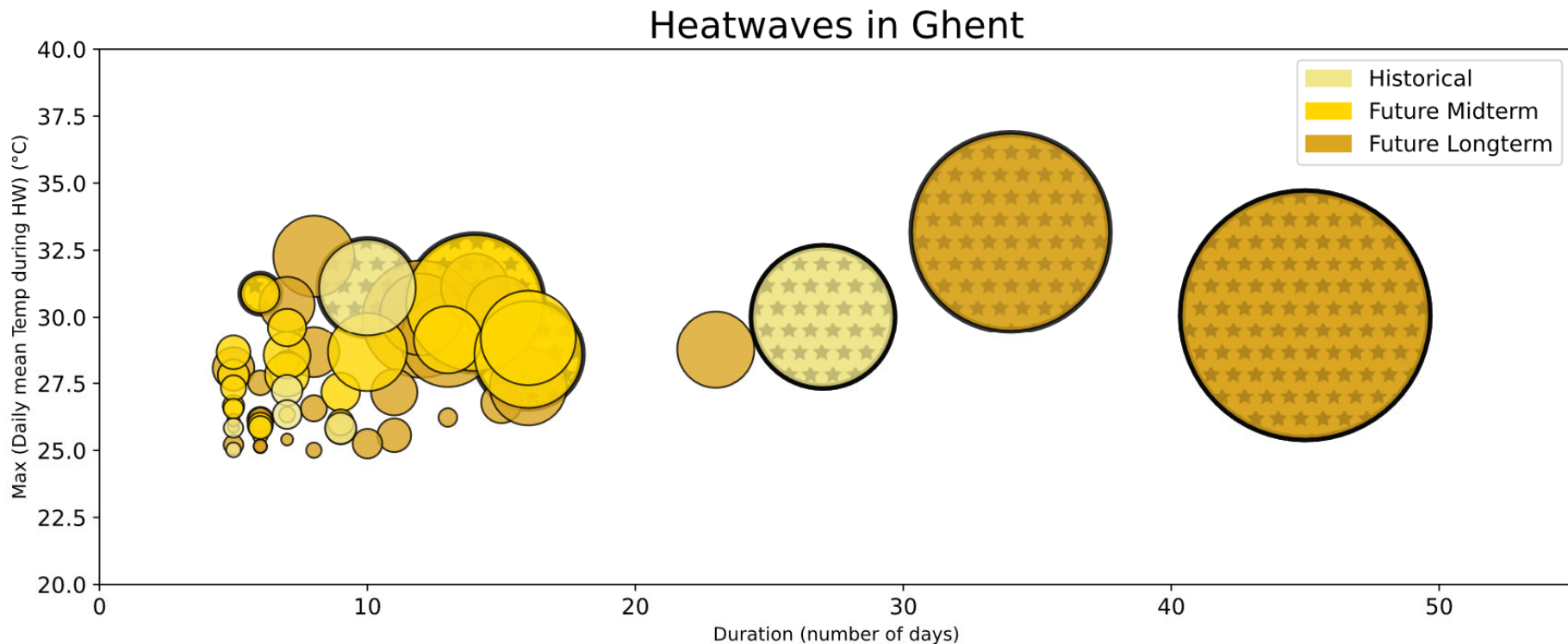


Overview

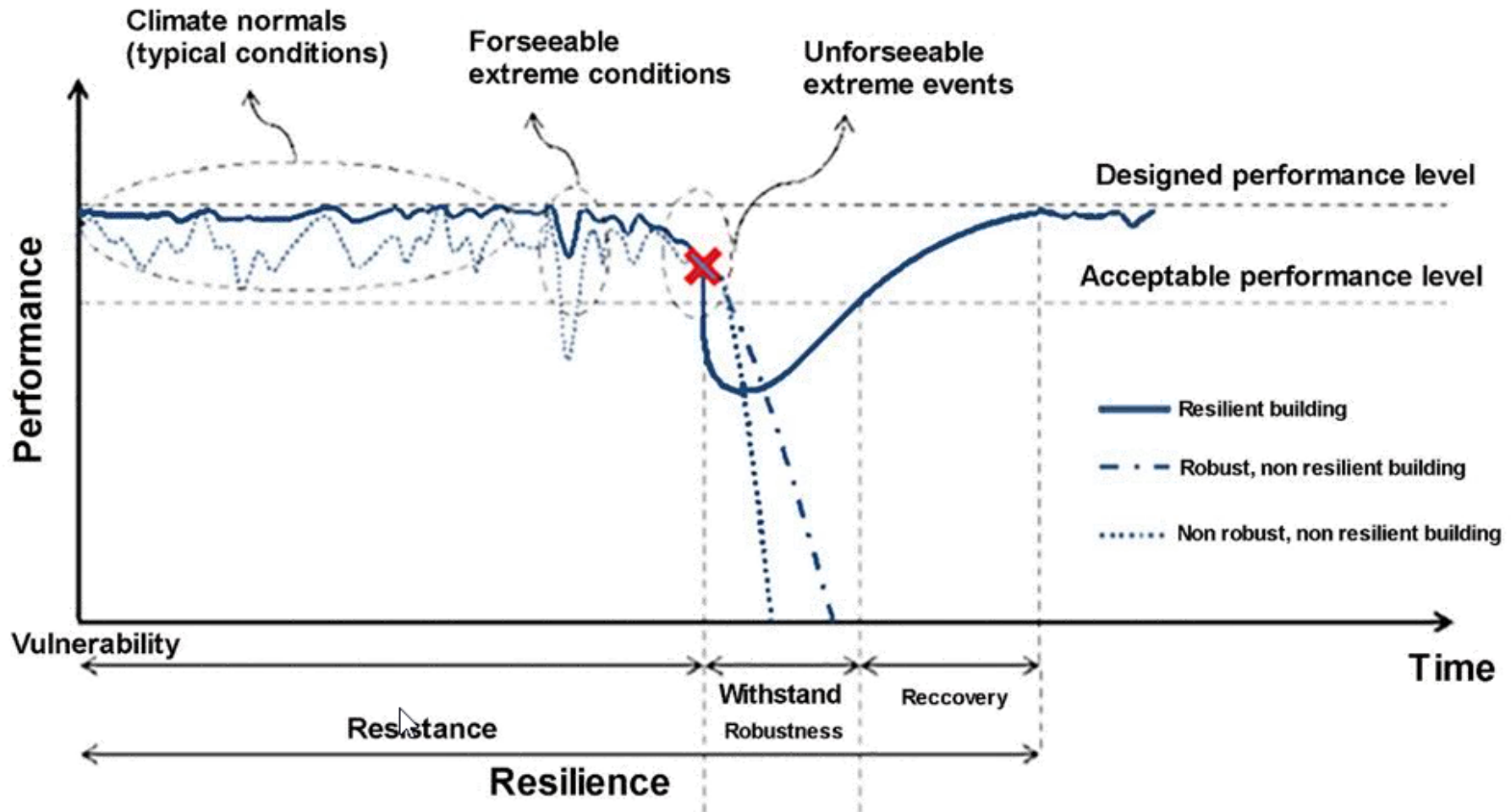
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Heat waves

- Increase in severity and duration



Resilience



Resilient cooling

- When capacity of cooling system allows
 - to withstand or recover from disturbances (heat waves + power outages)
 - To adopt strategies after failure to mitigate degradation of building performance (recover)



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<https://annex80.iea-ebc.org/>

IEA EBC Annex 80 - Resilient Cooling of Buildings

The world is facing a rapid increase of air conditioning of buildings. This is driven by multiple factors, such as urbanisation and densification, climate change and elevated comfort expectations together with economic growth in hot and densely populated climate regions of the world. The trend towards cooling seems inexorable therefore it is mandatory to guide this development towards sustainable solutions.

ANNEX INFO & CONTACT

Status: Ongoing (2018 - 2023)

OPERATING AGENT

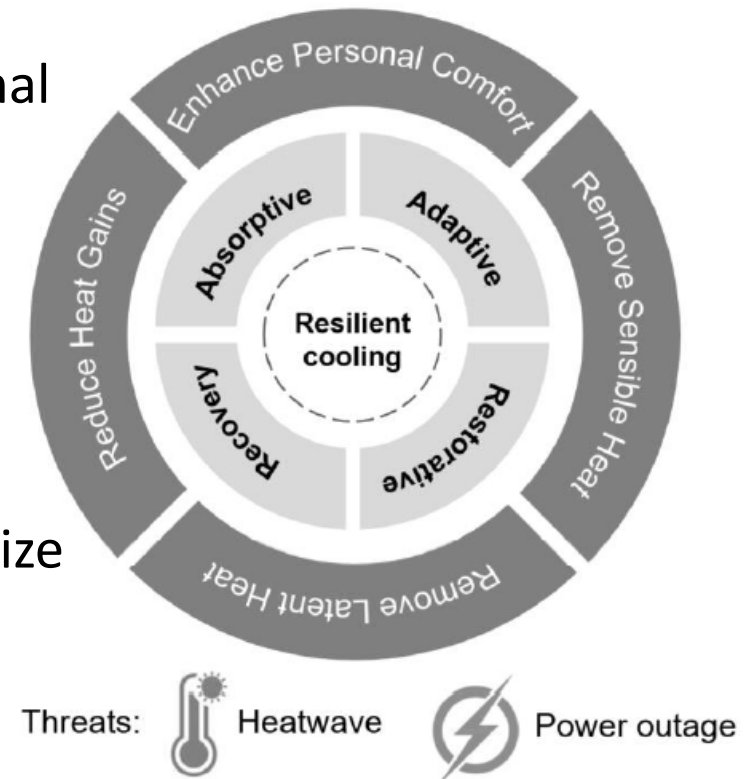
DI Dr Peter Holzer
Institute of Building Research &



Source: Shady et al. (2021), Resilient cooling of buildings to protect against heat waves and power outages: Key concepts and definition

Assess resilience of cooling

- Recovery speed
 - Time until reaching designed thermal conditions
 - natural VC: low - moderate
 - IEC: moderate - high
 - TABS: moderate - high
- Absorptive capacity
 - Ability to absorb impact and minimize consequence
 - natural VC: low
 - IEC: moderate
 - TABS: low - high



Overview

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Summary

- ventilative cooling
- Test lecture rooms
 - Good thermal summer comfort except during heat waves/high occupancy
 - Night ventilation
 - IEC
 - Significantly lowers supply temperature
 - Effectiveness of about 72%
- Future proof?
 - > resilience to overheating