TEST LECTURE ROOMS (KU LEUVEN GHENT TECHNOLOGY CAMPUS) EQUIPED WITH IEC

Webinar: IEC: an alternative to mechanical cooling in commercial buildings in Belgium?
29/4/2021

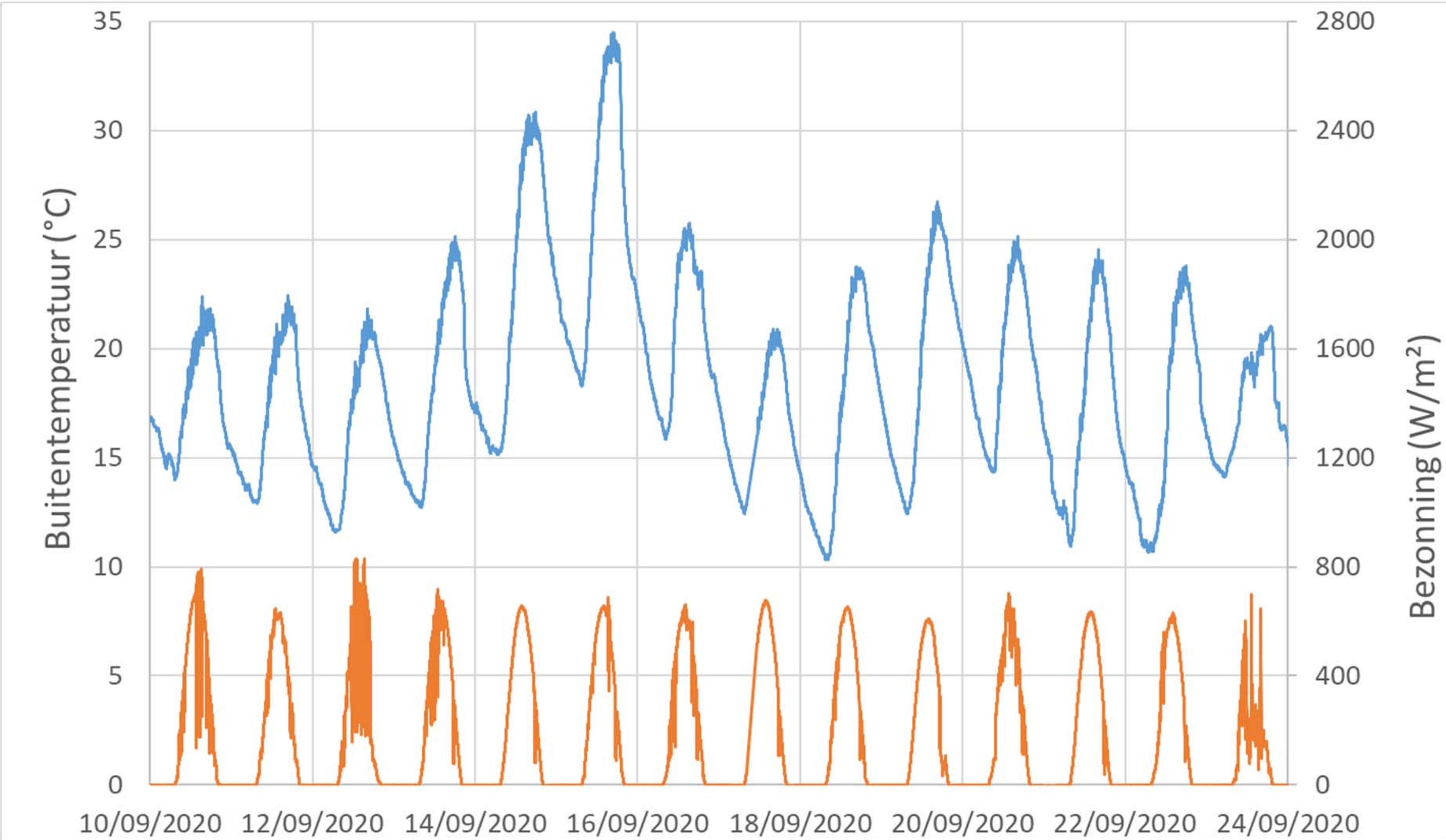
Hilde Breesch, Abantika Sengupta
Building Physics & Sustainable Design, KU Leuven

KU LEUVEN

Atic
for HVAC professionals

Context

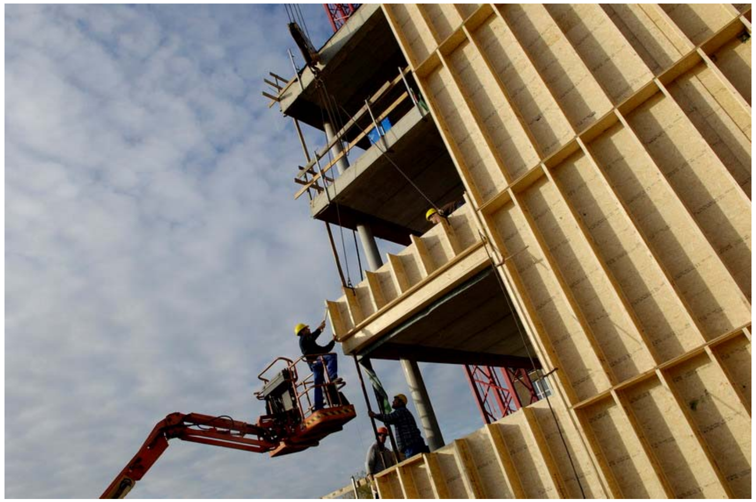
- High temperatures & solar radiation also in spring and autumn in moderate climates (Ghent, sept 2020)



Context

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

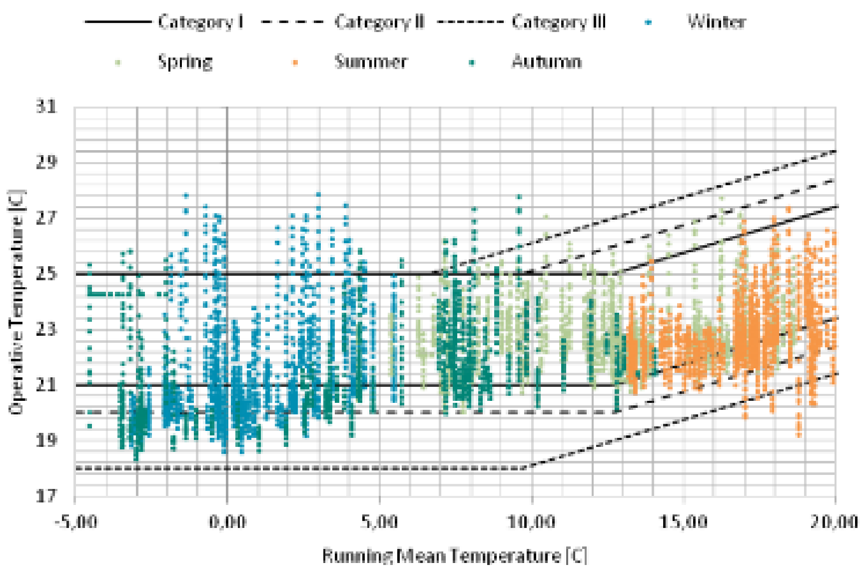
Passiefschool Ede (NL)
Source: BouwQuest



Passiefschool Nijvel
Source: A2M architects

Context

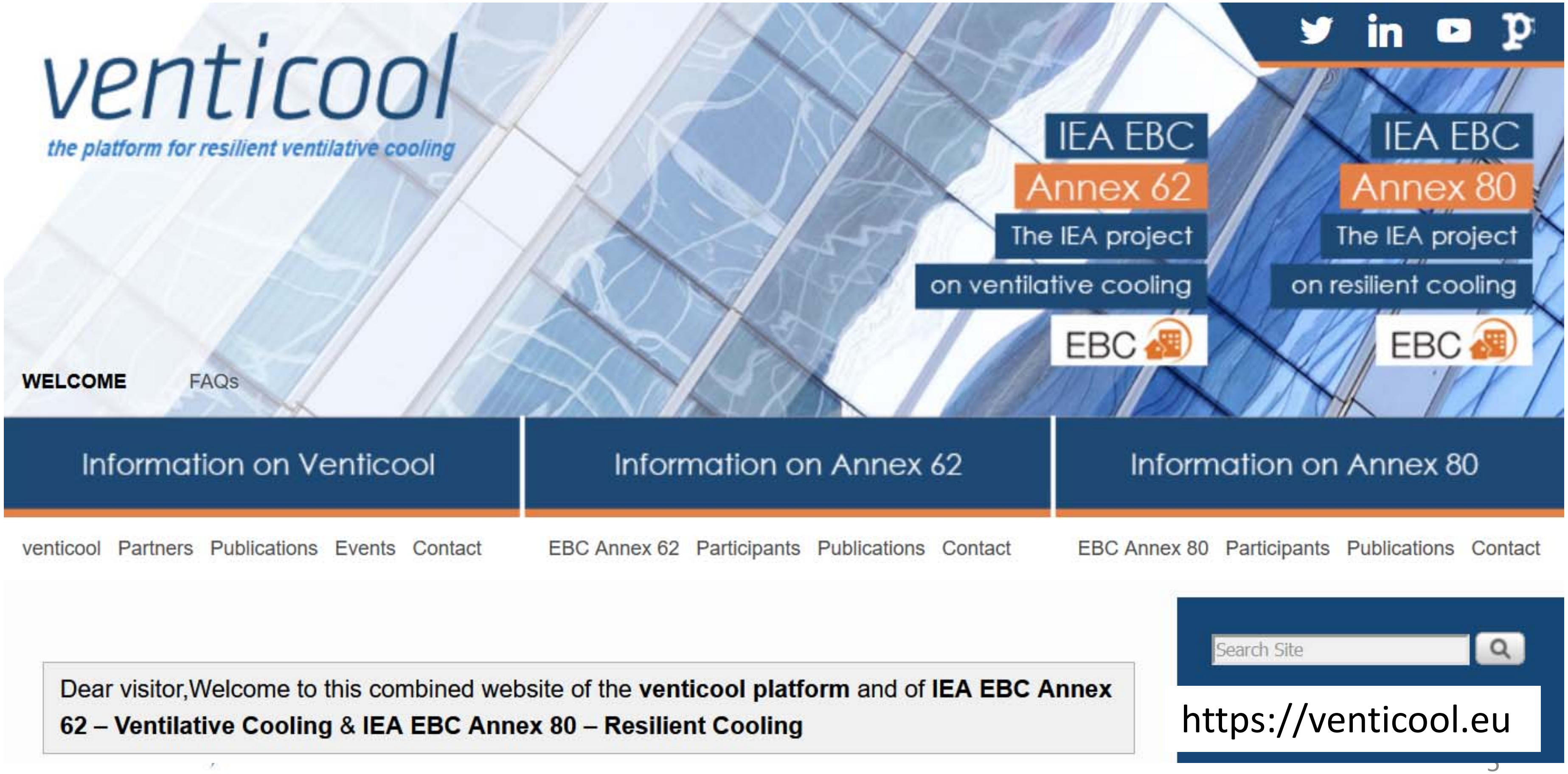
- Challenges in nZEB buildings
  - Increase in cooling demand all year round
  - Cooling demand depends more on
    - Solar radiation
    - Internal heat gains
  - Overheating most reported problem
  - Need for
    - conceptual and building technical measures
    - energy efficient cooling systems



Atic for HVAC professionals

Context

- Resilient ventilative cooling



Overview

- Context
- Ventilative cooling
- Test lecture rooms
- Future proof?
- Conclusions

Atic
for HVAC professionals

Ventilative cooling: design guide

International Energy Agency

Ventilative Cooling Design Guide

Energy in Buildings and Communities Programme

March 2018

EBC

Energy in Buildings and Communities Programme

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

Atic for HVAC professionals

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)

Atic
for HVAC professionals

Ventilative cooling: strategies

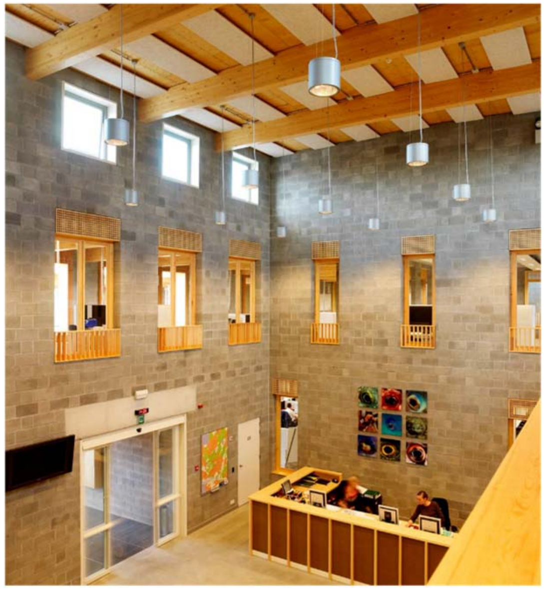
Temperature Difference[1]	Ventilative Cooling	Supplementary cooling options
Cold (ΔT more than 10°C)	Minimize air flow rate - draught free air supply	-
Temperate (2-10°C lower than comfort zone)	Increasing air flow rate from minimum to maximum	Strategies for enhancement of natural driving forces to increase 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

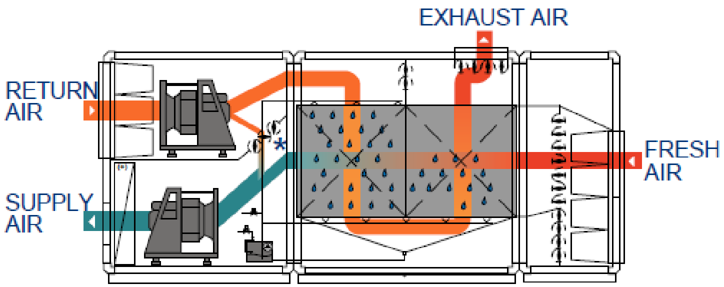
[1] Temperature difference between indoor comfort temperature and mean outdoor air temperature.

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

Atic
for HVAC professionals





Ventilative cooling: Case studies

International Energy Agency

Ventilative Cooling Case Studies

EBC

Energy in Buildings and Communities Programme

Energy in Buildings and Communities Programme

May 2018

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

Atic for HVAC professionals

Ventilative cooling: Case studies

- 11 non-residential & 4 residential buildings

Atic
for HVAC professionals

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								

ATIC for HVAC professionals

Overview

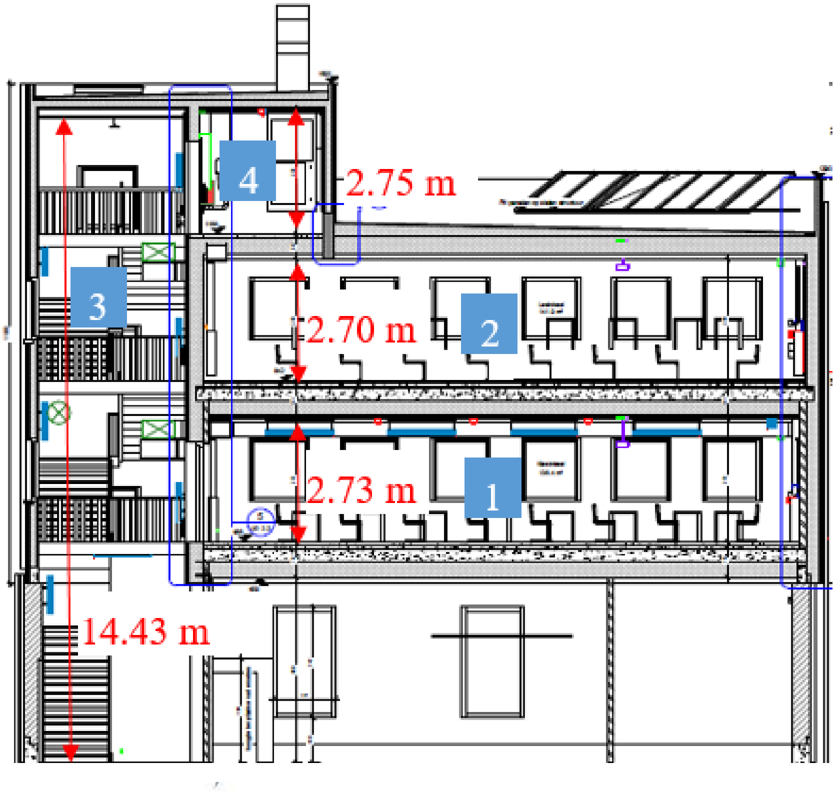
- Context
- Ventilative cooling
- Test lecture rooms
- Future proof?
- Conclusions

Test lecture rooms

KU Leuven Ghent Technology Campus (BE)

– Zone 1 and 2: Floor area = 140 m²

– varying occupancy



Building envelope

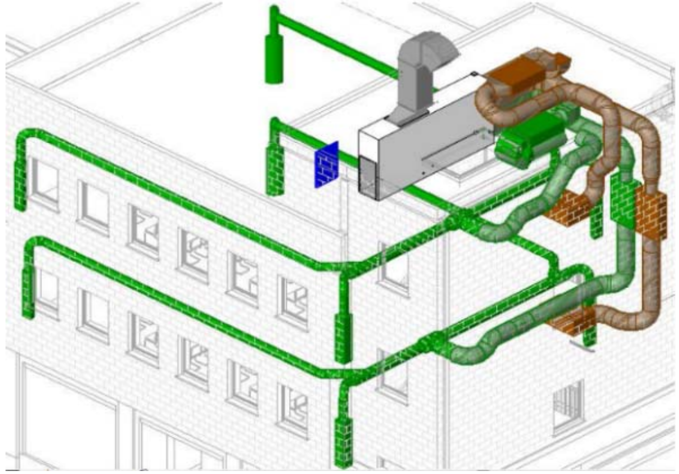
- PassiveHouse standard
  - U-values < 0.15 W/m²K
  - Air tightness $n_{50} < 0.6\ h^{-1}$
- Thermal mass: light/medium
- Solar shading
  - External: moveable screens (SW)
  - internal

	U (W/m²K)
Ground floor	0.15
roof	0.14
façade	0.15
window (U_g/U_f)	0.6/0.75

Atic
for HVAC professionals

All-air system

- Ventilation
  - Airflow = 4400 m³/h
  - Heat recovery: η = 78%
  - CO_2-controlled
  - displacement ventilation



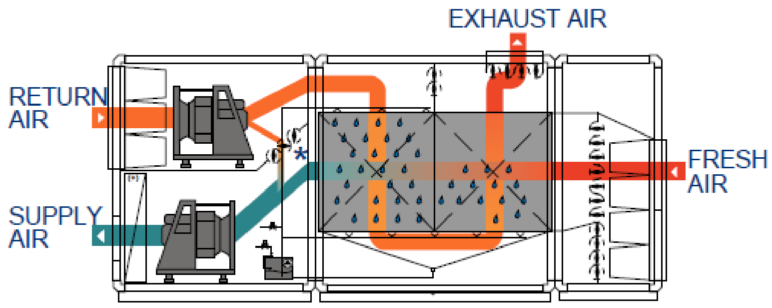
All-air system

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

Atic for HVAC professionals

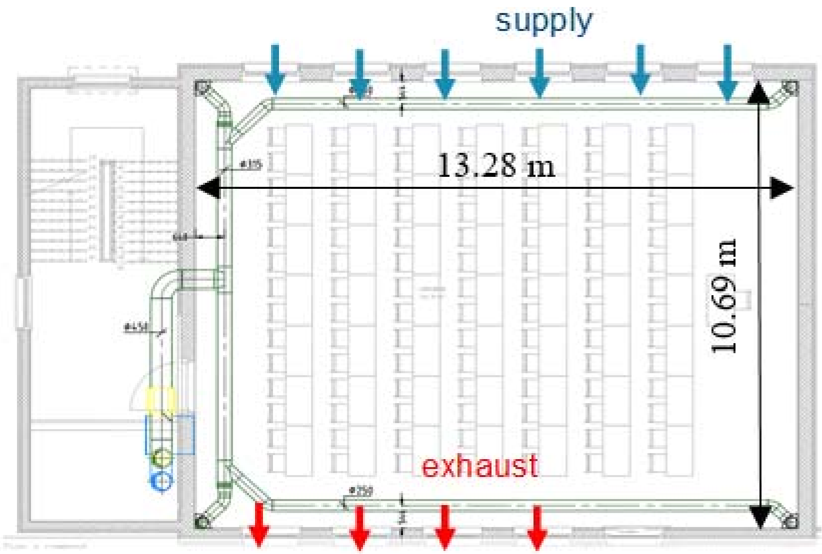
Ventilative cooling

- Indirect evaporative cooling in AHU
  - Max cooling capacity 13.1 kW
  - Activated: $T_i > 26°C$ or $T_e > 22°C$

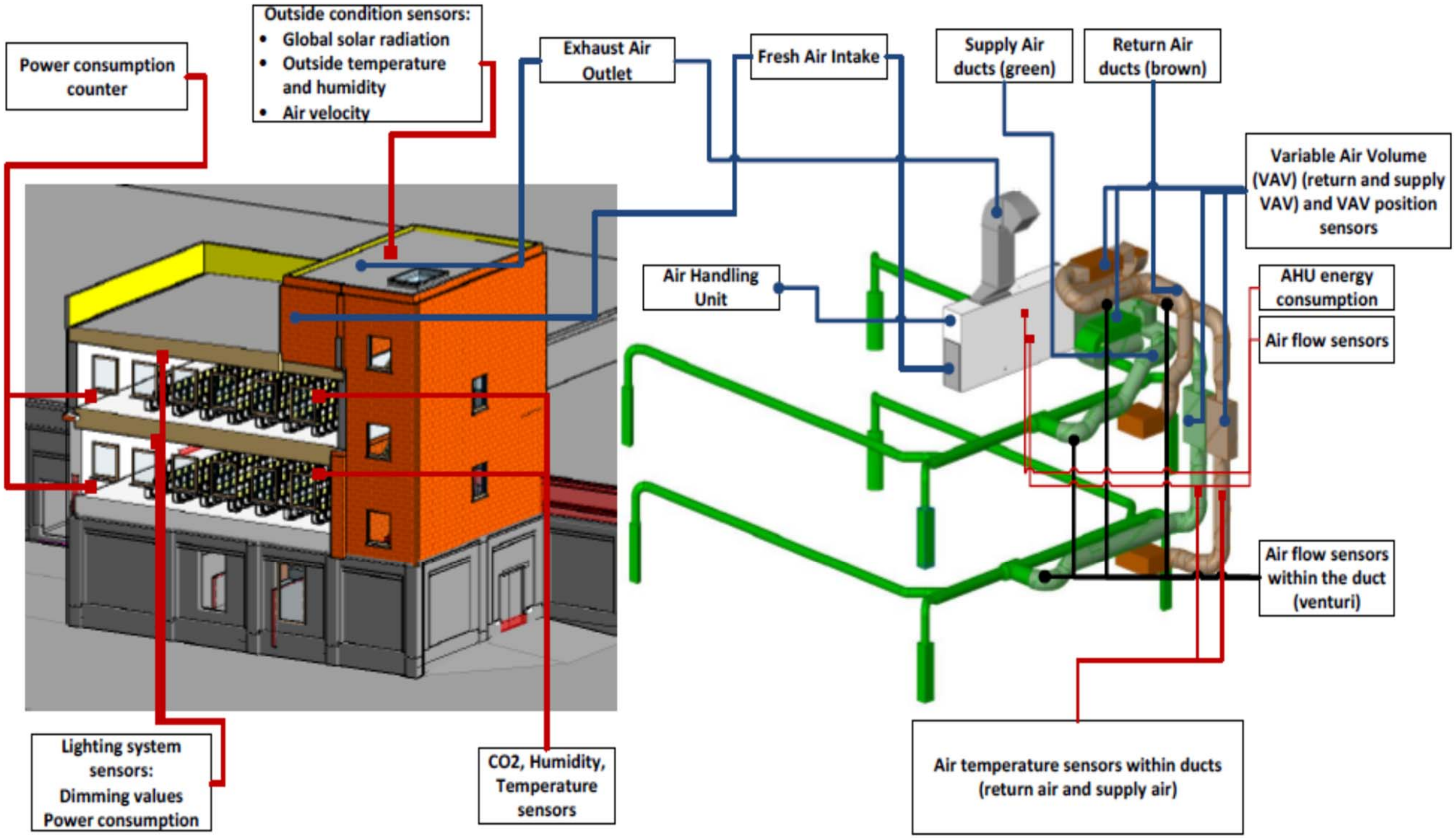


- Natural night ventilation
  - Motorized bottom-hung windows
  - Effective opening area = 4% floor area
  - Cross ventilation

Atic
for HVAC professionals



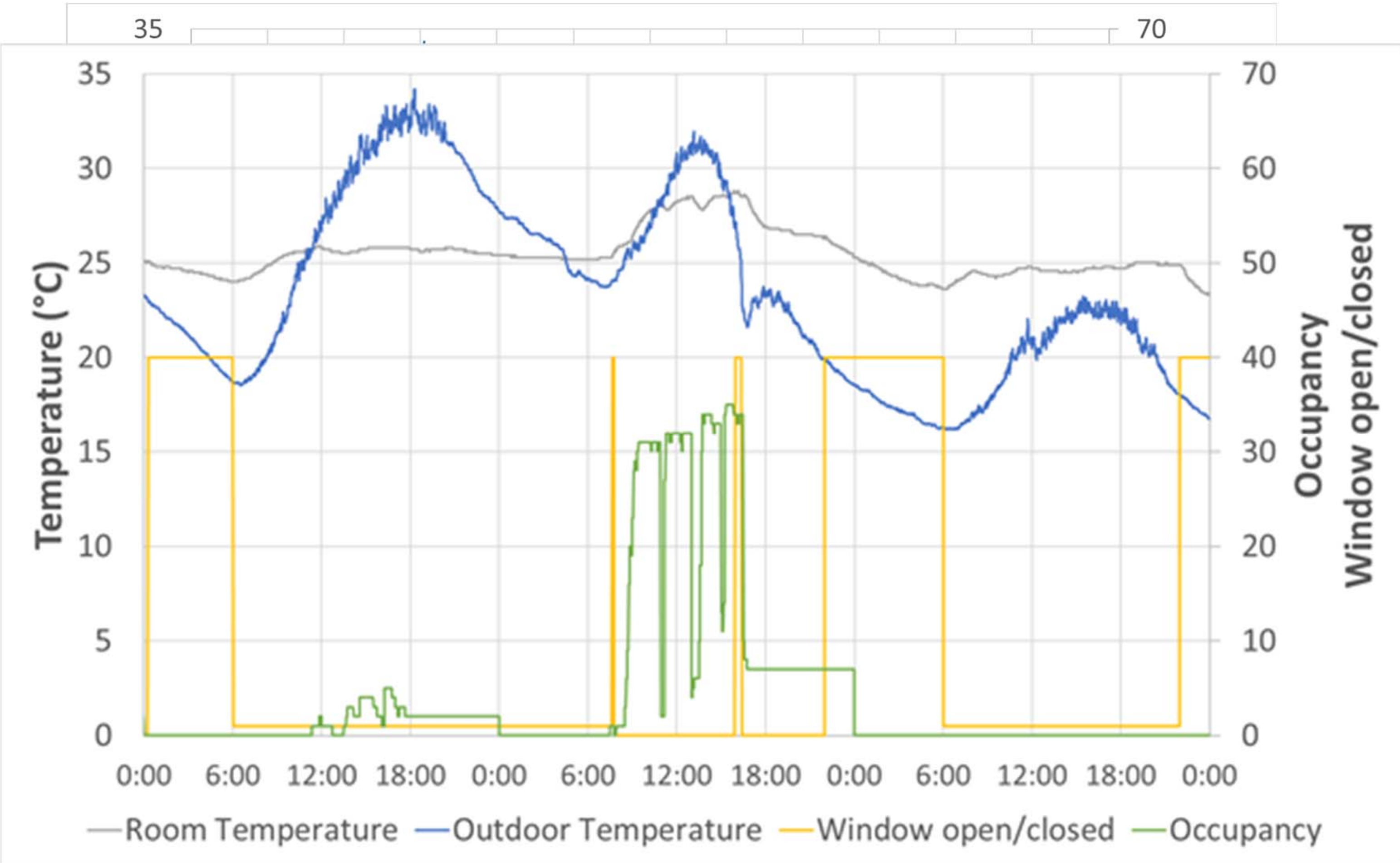
Monitoring



Power consumption counter
Outside condition sensors:
• Global solar radiation
• Outside temperature and humidity
• Air velocity
Exhaust Air Outlet
Fresh Air Intake
Supply Air ducts (green)
Return Air ducts (brown)
Variable Air Volume (VAV) (return and supply VAV) and VAV position sensors
Air Handling Unit
AHU energy consumption
Air flow sensors
Air flow sensors within the duct (venturi)
Lighting system sensors:
Dimming values
Power consumption
CO2, Humidity, Temperature sensors
Air temperature sensors within ducts (return air and supply air)

Operation Ventilative Cooling

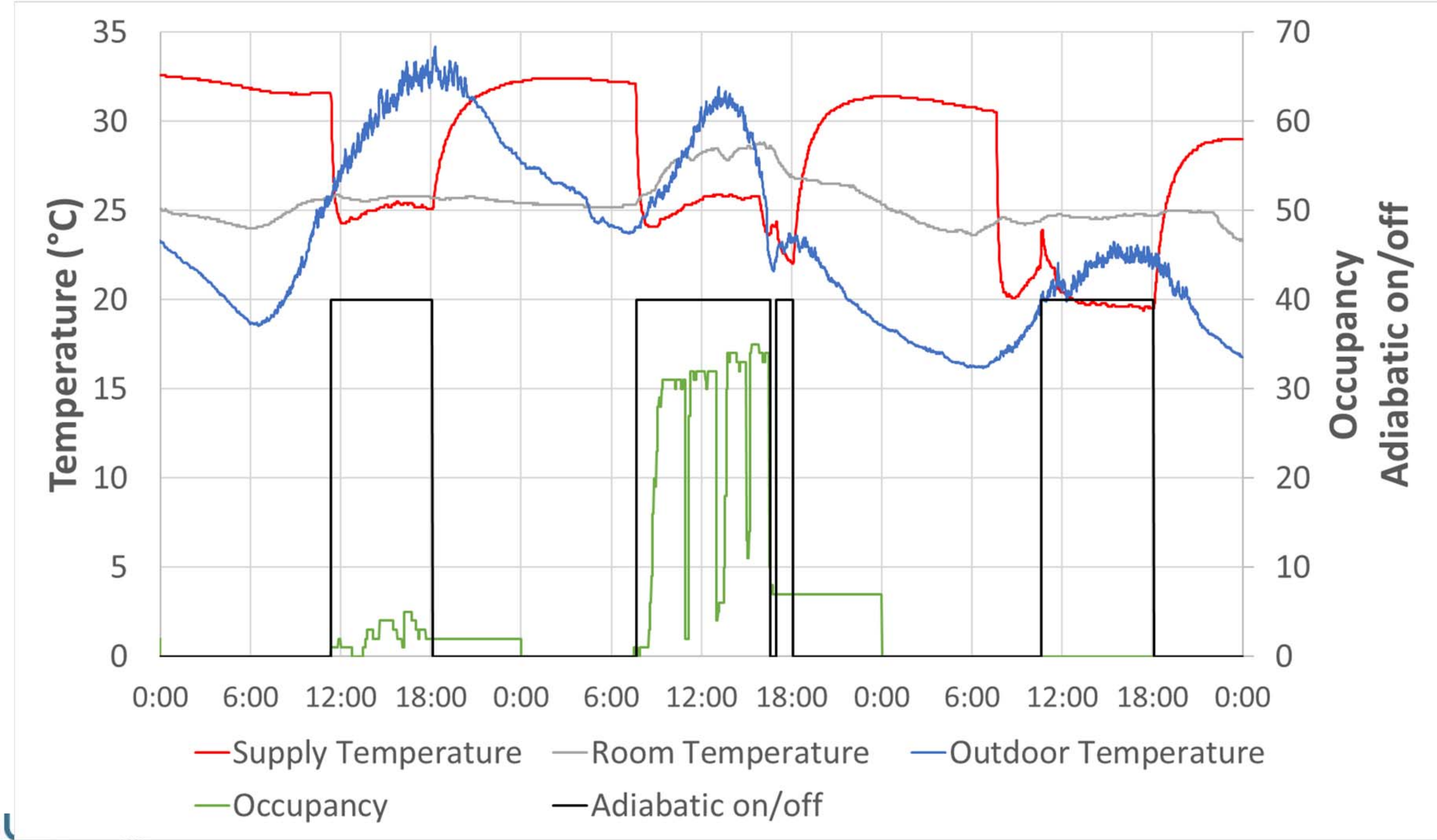
- night ventilation during warm period



for HVAC professionals

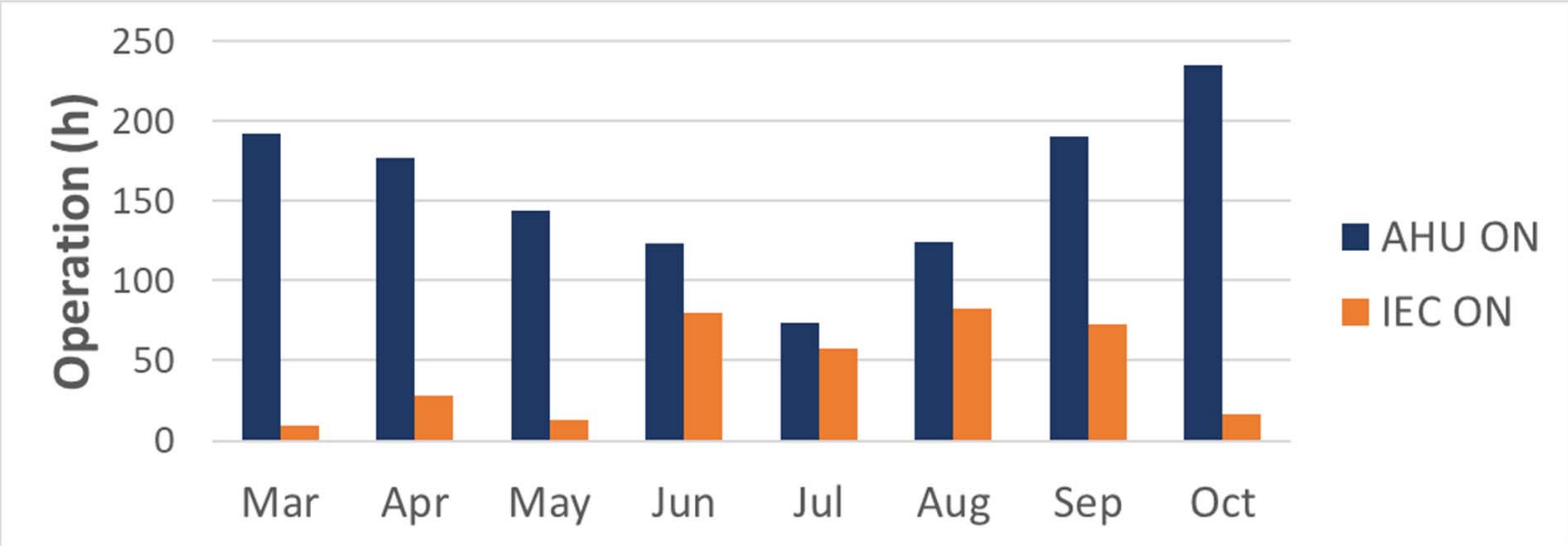
Operation Ventilative Cooling

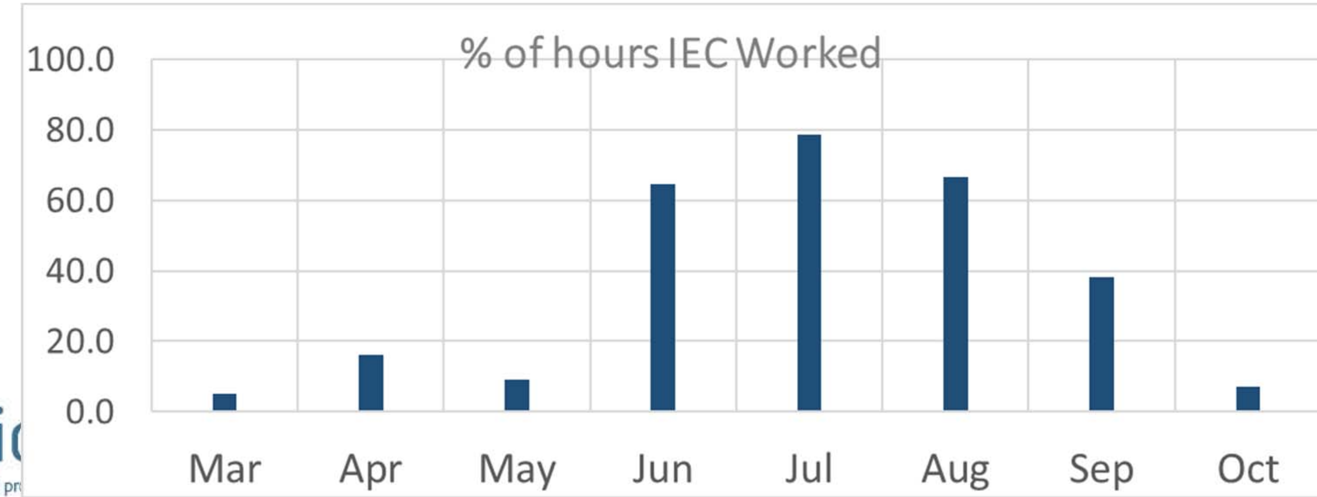
- IEC during warm period



for HVAC professionals

Operation IEC



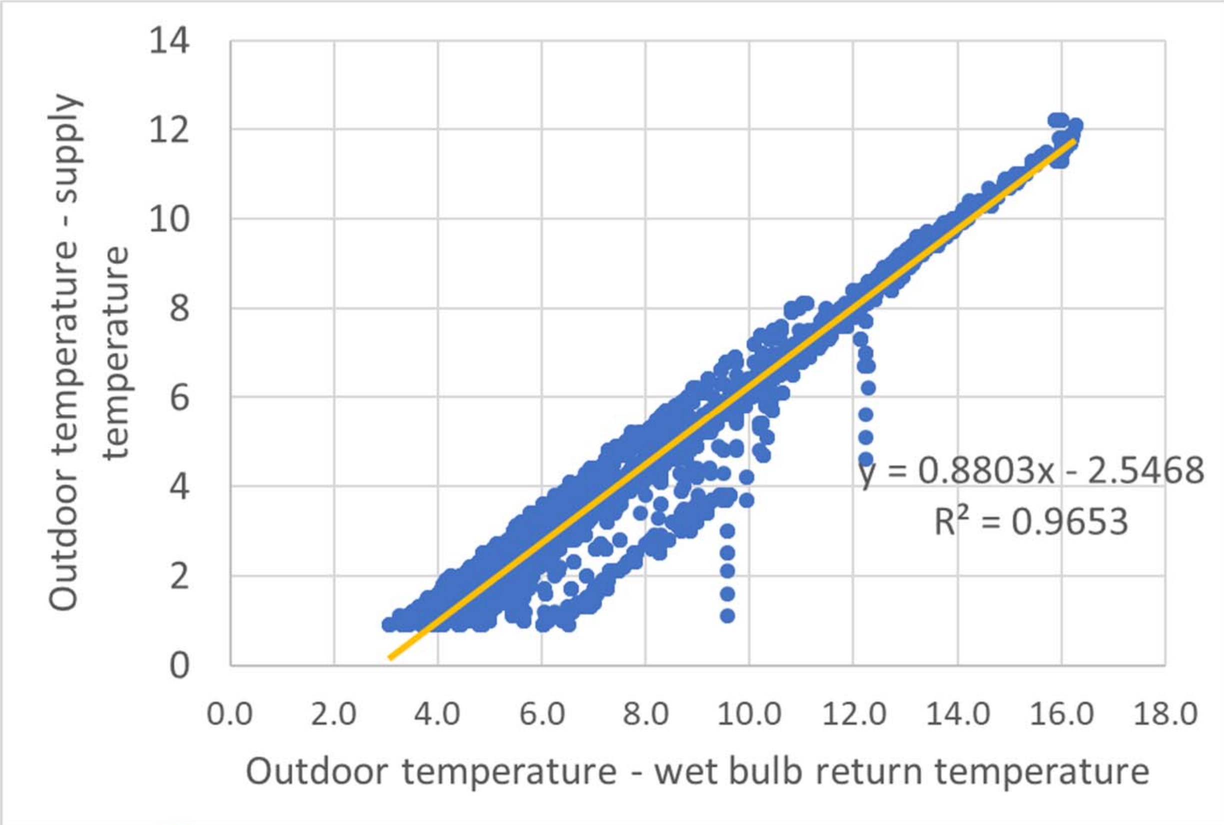


Ati
for HVAC pr

Performance IEC

- Effectiveness

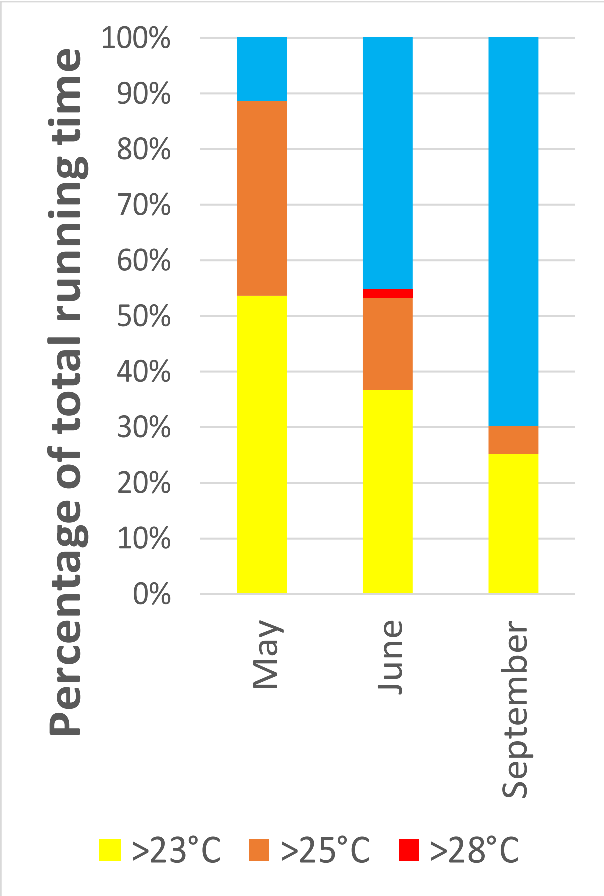
$$\varepsilon = \frac{\theta_e - \vartheta_{supply}}{\theta_e - \vartheta_{wet\ bulb,return}}$$



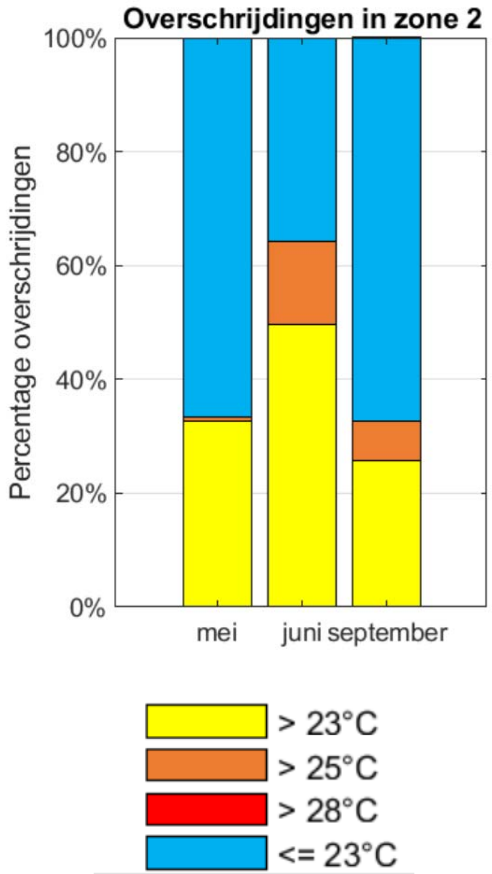
Atic for HVAC professionals

Source: Steeman et al. (2009), Performance evaluation of indirect evaporative cooling using whole-buildinghygrothermal simulations

Thermal summer comfort

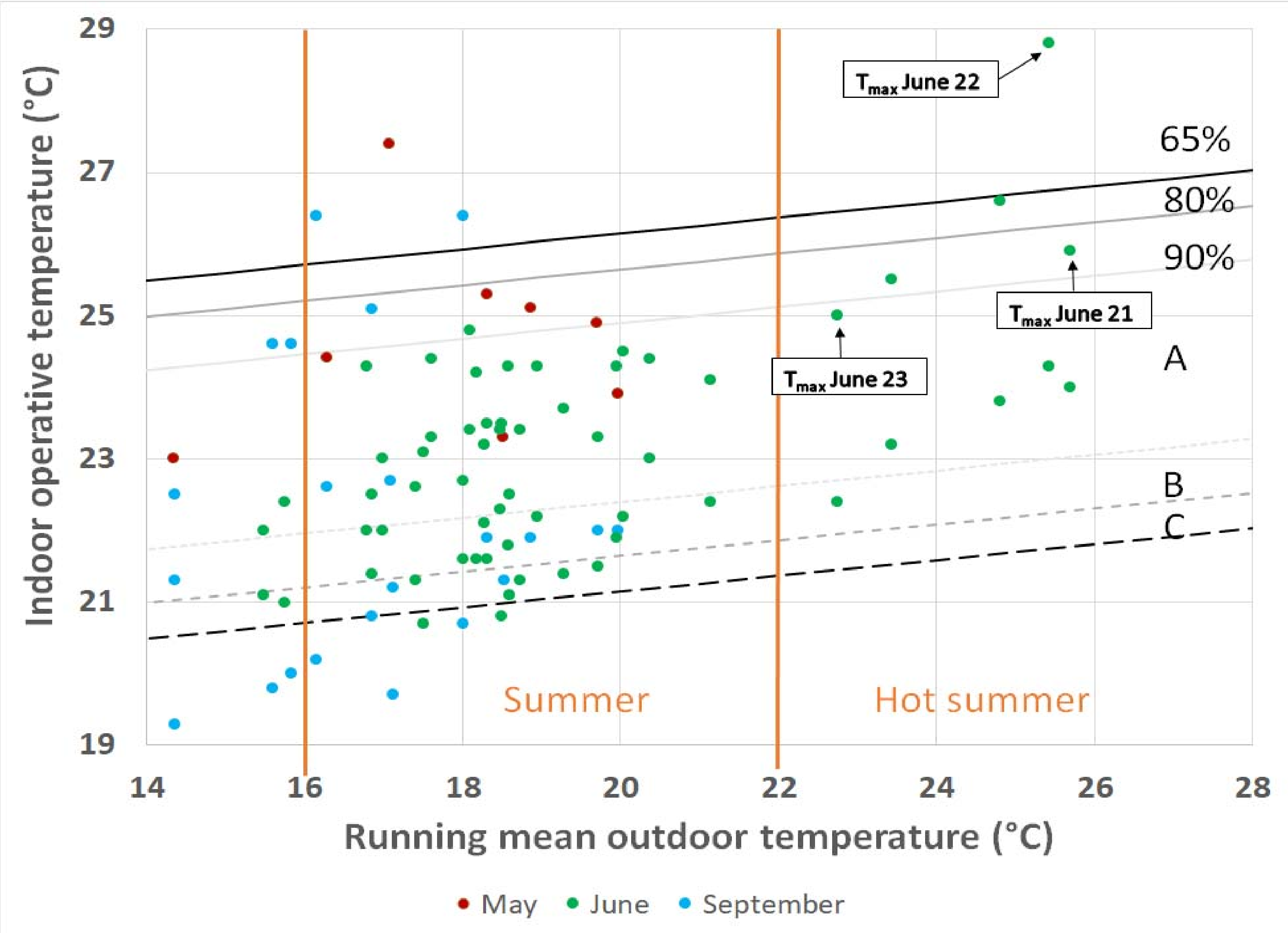


2017



2019

Thermal summer comfort



At
for HVA

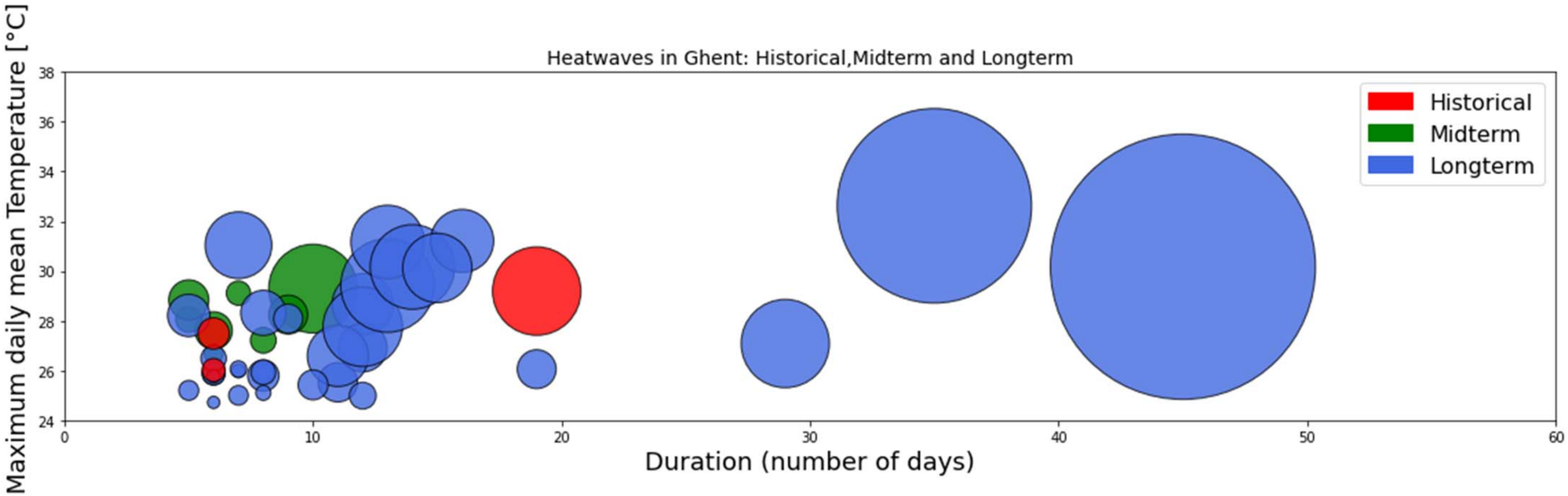
Overview

- Context
- Ventilative cooling
- Test lecture rooms
- Future proof?
- Conclusions

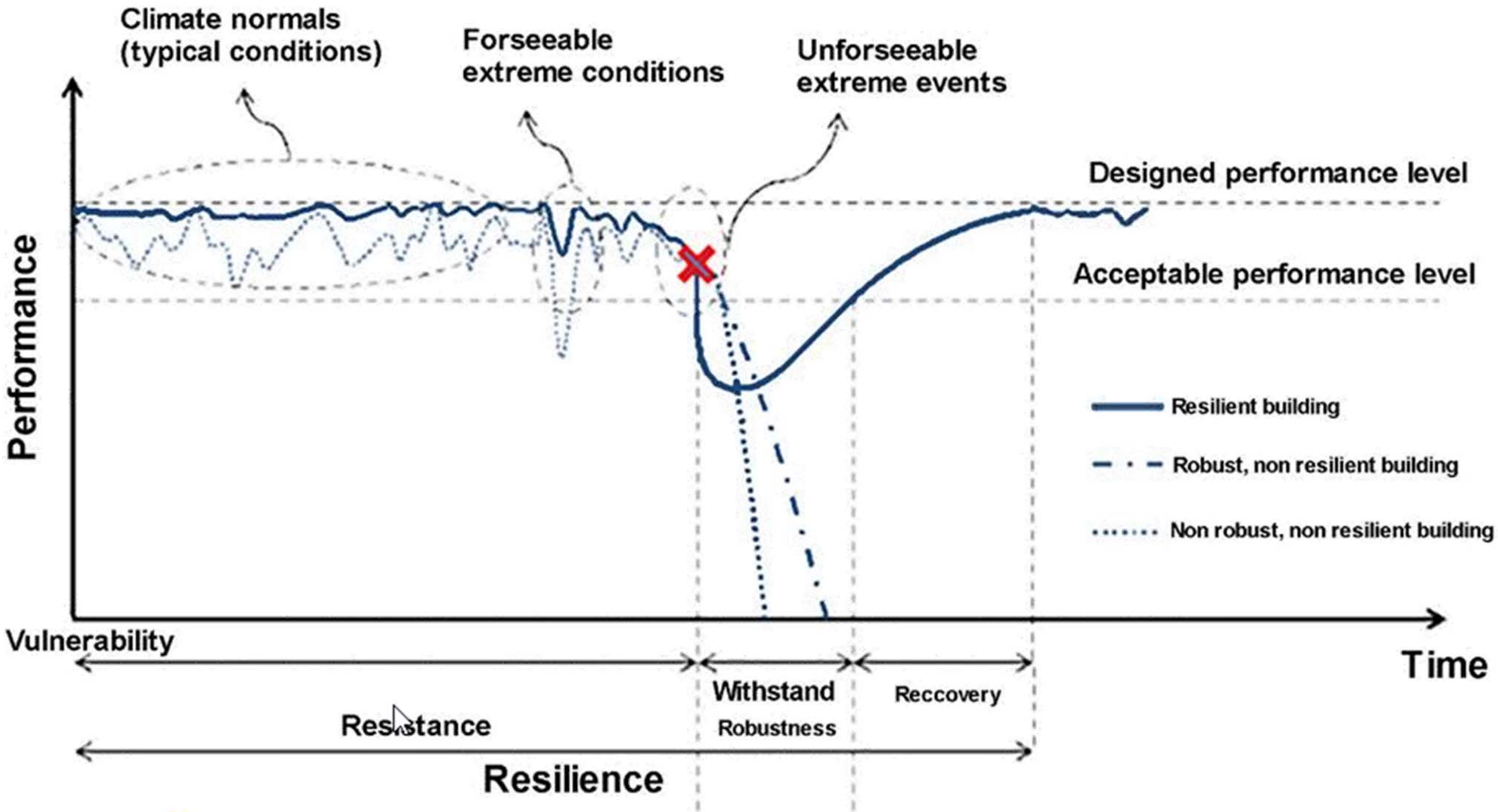
Atic
for HVAC professionals

Heat waves

- Increase in severity and duration



Resilience



Source: Moazami et al. (2019), Robust and resilient buildings: A framework for defining the protection against climate uncertainty

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)

HOME NEWS JOIN MEETINGS PROGRAMME PARTICIPANTS ABOUT

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

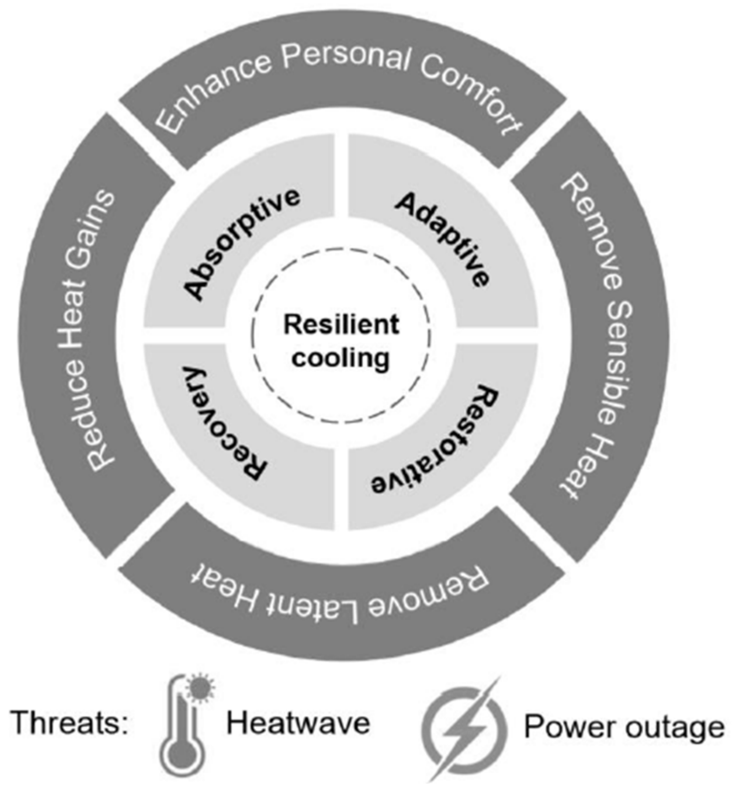
Institute of Building Research &

Atic for HVAC professionals

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 capacity
  - Time until reaching designed thermal conditions
  - Moderate/high for IEC
- Absorptive capacity
  - Ability to absorb impact and minimize consequence
  - Moderate for IEC



Source: Chen et al. (2021), Resilient cooling strategies- a critical review and qualitative assessment

Atic for HVAC professionals

Overview

- Context
- Ventilative cooling
- Test lecture rooms
- Future proof?
- Conclusions

Atic
for HVAC professionals

Conclusions

- IEC = natural cooling strategy supplementary to ventilative cooling
- Test lecture rooms
  - Good thermal summer comfort except during heat waves/high occupancy
  - IEC
    - Significantly lowers supply temperature
    - Effectiveness of 88%
- Future proof? IEC = moderate to high resilient to overheating

Atic
for HVAC professionals