Presentation of IEA EBC Annex 62 Ventilative cooling

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Background

Functions of building ventilation

- To provide fresh air for occupants – maintaining life
- To dilute and exhaust pollutants – maintaining indoor air quality for health
- To provide cooling – maintaining thermal comfort – ‘ventilative cooling’
- Also to protect the building against moisture – maintaining building structure

Each function requires different air flow rates, air flow distribution and control.

Why ventilative cooling?

Overheating in buildings is emerging as a challenge both at the design stage and during operation. This is due to a number of reasons:

- high performance standards to reduce heating demand by high insulation levels;
- restriction of infiltration in heating dominated climatic regions;
- the occurrence of higher external temperatures during the cooling season due to changing climate and urban climate not usually considered at design stage;
- changes in internal heat gains during operation not factored in the design.

Such factors have resulted in significant deviations in energy use during operation which is usually termed the energy ‘performance gap’. In most energy performance comparative studies, energy use is higher than predictions and post-occupancy studies frequently report overheating problems.

Ventilative cooling can be a solution.

IEA EBC research project Annex 62: Ventilative Cooling

- Duration 2012-2017
- OA: Per Heiselberg

http://venticool.eu/annex-62-home/

http://www.iea-ebc.org/projects/ongoing-projects/

Structure

- Subtask A: Methods and Tools
- Subtask B: Solutions
- Subtask C: Case Studies

Outcomes

- Guidelines for energy-efficient reduction of the risk of overheating by ventilative cooling
- Guidelines for ventilative cooling design and operation in buildings
- Recommendation for integration of ventilative cooling in legislation, standards, design briefs as well as on energy performance calculation and verification methods
- New ventilative cooling solutions including their control strategies as well as improvement of capacity of existing systems
- Documented performance of ventilative cooling systems in case studies

Annex Leadership

Participating countries: 15: Australia, Austria, Belgium, China, Denmark, Finland, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Switzerland, UK, USA

Operating Agent: Denmark, represented by Per Heiselberg, Aalborg University

Subtask A:

Leader: Switzerland, represented by Fourentzos Flourentzou, ESTIA

Co-leader: Italy, represented by Annamaria Belleri, EURAC

Subtask B:

Leader: Austria, represented by Peter Holzer, IBRI

Co-leader: Denmark, represented by Theofanis Psomas, AAU

Subtask C:

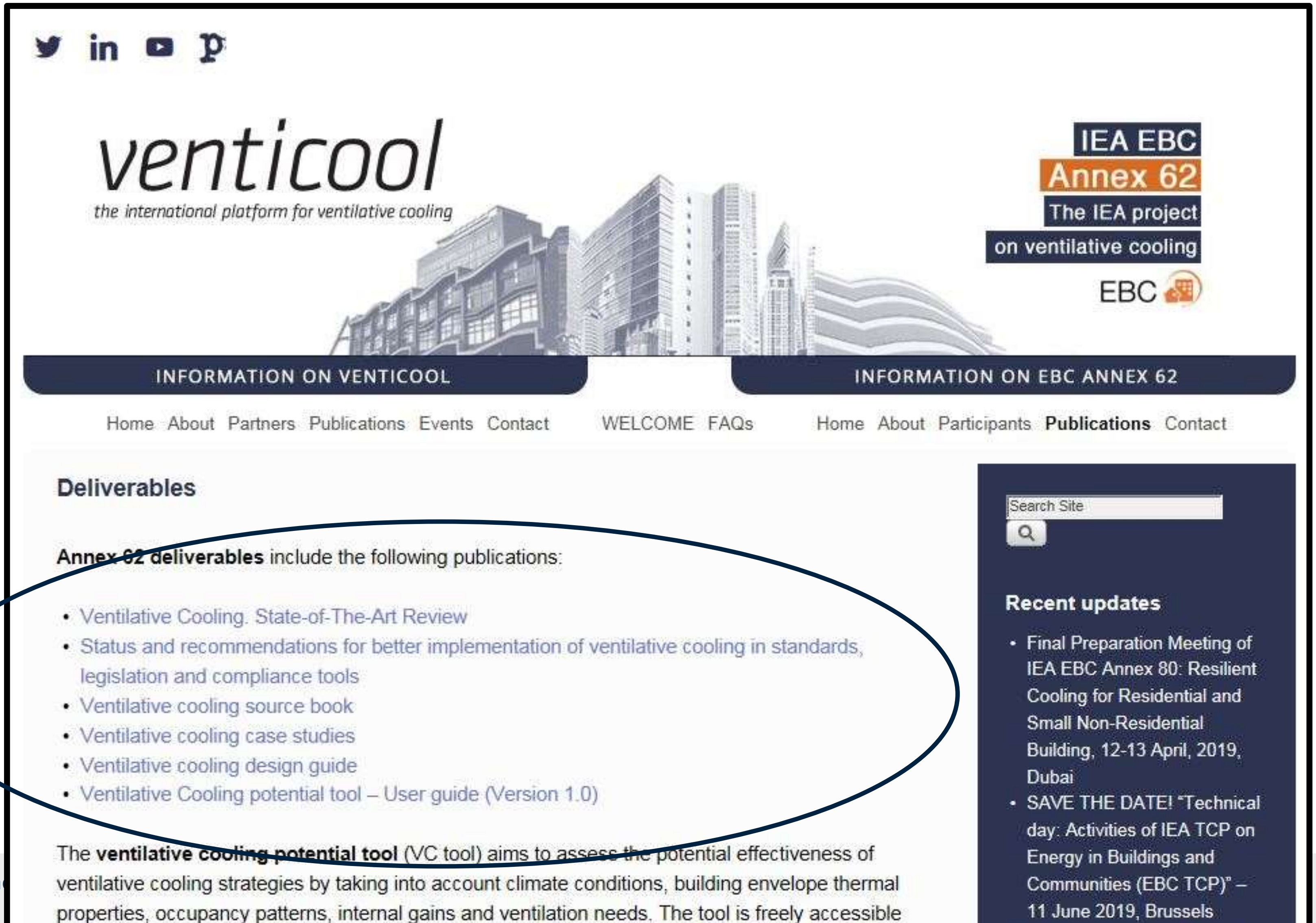
Leader: China, represented by Guoqiang Zhang, Hunan University

Co-leader: Ireland, represented by Paul O'Sullivan, CIT

Annex 62 Expert meeting – September 2014
In front of Brunel's statue at Brunel University

8th Annex 62 Expert meeting, Gent, Belgium, October 24-25, 2017

Annex Deliverables http://venticool.eu/annex-62-home/



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Deliverables

Annex 62 deliverables include the following publications:

- Ventilative Cooling. State-of-The-Art Review
- Status and recommendations for better implementation of ventilative cooling in standards, legislation and compliance tools
- Ventilative cooling source book
- Ventilative cooling case studies
- Ventilative cooling design guide
- Ventilative Cooling potential tool – User guide (Version 1.0)

The **ventilative cooling potential tool** (VC tool) aims to assess the potential effectiveness of ventilative cooling strategies by taking into account climate conditions, building envelope thermal properties, occupancy patterns, internal gains and ventilation needs. The tool is freely accessible here including the user guide and examples (Example 1 – Copenhagen, Example 2 – Madrid) to guide you through its use.

The research results are published in peer-reviewed journals and conference proceedings. Information on **published articles** is available here.

The **Ventilative Cooling Application Database** containing buildings which make use of ventilative cooling from several countries contributing to the Annex 62 can be found here.

The **venticool newsletter**, produced in collaboration with IEA EBC Annex 62 can be downloaded here.

Search Site

Recent updates

- Final Preparation Meeting of IEA EBC Annex 80: Resilient Cooling for Residential and Small Non-Residential Building, 12-13 April, 2019, Dubai
- SAVE THE DATE! "Technical day: Activities of IEA TCP on Energy in Buildings and Communities (EBC TCP)" – 11 June 2019, Brussels
- AIVC symposium "Quality ventilation is the key to achieving low energy healthy buildings" – 27 & 28 March 2019, Dublin
- Energy Efficiency and Indoor Climate in Buildings is out! Edition of January 2019
- AIVC 2019 Conference – Call for Abstracts
- venticool newsletter issue #13 – December 2018 now available
- Feedback from the AIVC

State-of-the-art Report: SOTAR 2015

Some Highlights

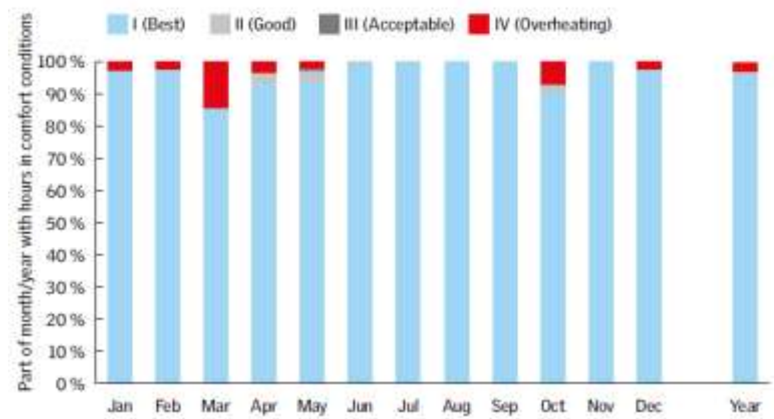
Potential: The ventilative cooling potential is favourable in most European countries, especially during night. The possible cooling energy savings is at a level of 30-50% in office buildings and lower in the residential sector.

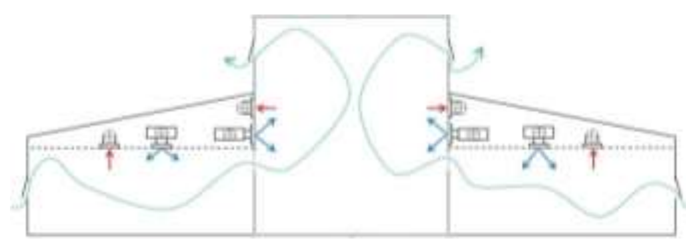
Available Tools: Design and analysis of ventilative cooling requires combined modelling of air flow and building thermal performance and at different level of detail in each design phase. Designers need clearer guidance regarding the uncertainty in ventilative cooling performance predictions and ways to improve the reliability and robustness

Regulations: It is complex to include ventilative cooling requirements in regulations as it includes aspects related both to ventilation, energy, building construction and comfort. Energy performance calculations in many countries do not explicitly consider ventilative cooling and most available tools used for energy performance calculations are not well suited to model the impact.

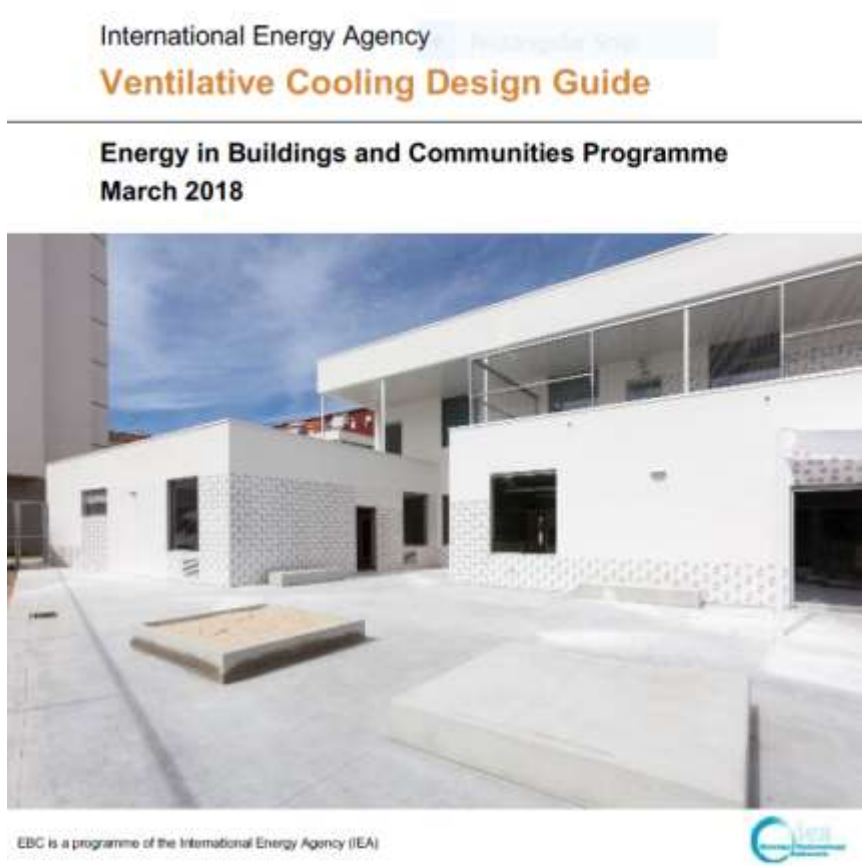
State-of-the-art Report: SOTAR 2015

Existing examples: A large number of building using ventilative cooling have already been built around the world. 26 existing buildings were studied and presented.





Design Guide


International Energy Agency

Ventilative Cooling Design Guide

Energy in Buildings and Communities Programme

March 2018

EBC is a programme of the International Energy Agency (IEA)

Design Guide

Principles (including type of components and system integration)

Key Performance Indicators (energy and thermal comfort)

Design Process

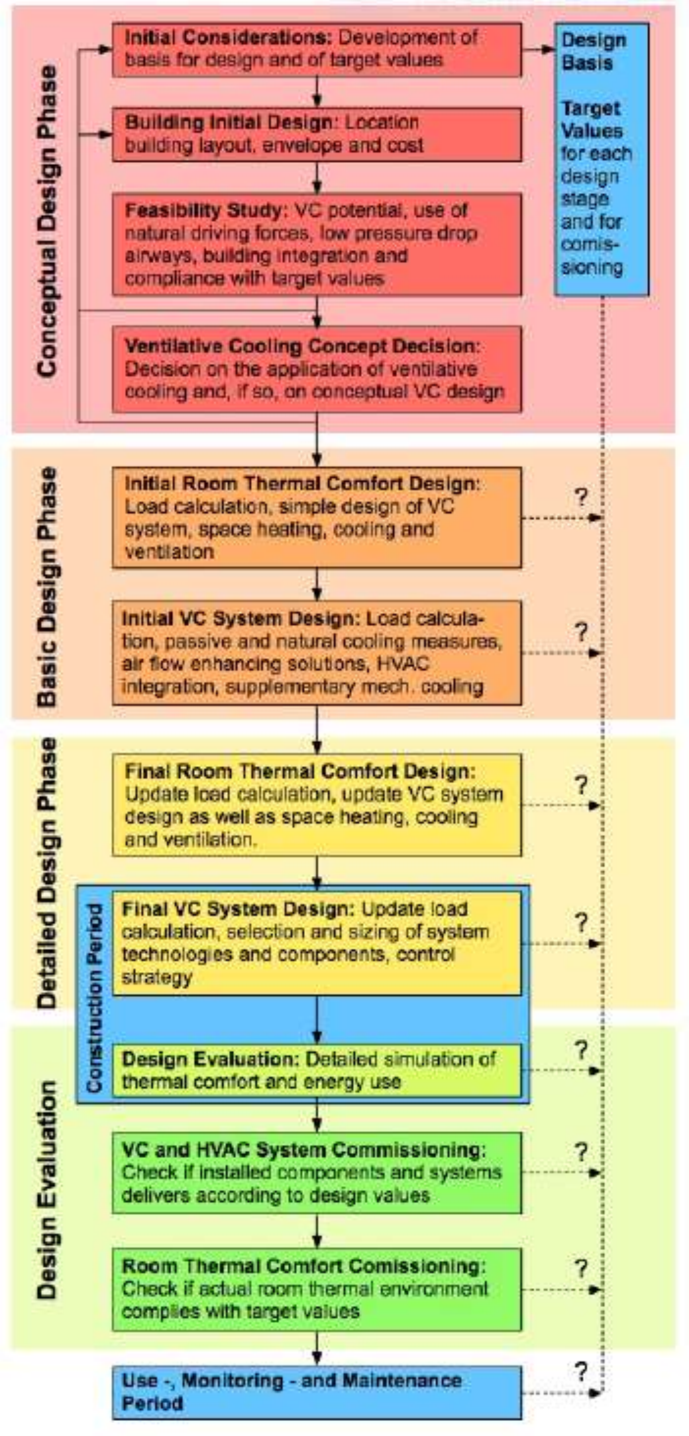
Ventilative Cooling Potential

Design Calculations

Performance evaluation

Control strategies

Case Studies



Ventilative Potential and KPIs

Key Performance Indicators for Ventilative Cooling were formulated for

1. Thermal comfort : The thermal comfort indicator is based on EN 15251:2007 for long-term evaluation of general thermal comfort conditions, where the combination of the "Percentage Outside the Range Index" (method A) and the "Degree-hours Criterion" (method B) enable the evaluation of both frequency and severity of overheating and overcooling occurrences. The reference comfort temperature can be derived from the Fanger model, the adaptive comfort model or briefed by the building owner/occupants.

2. For energy, two new indicators were developed;

   (a) the Specific Primary Energy Consumption of a ventilative cooling system, to express the primary energy consumed by the ventilative cooling system per heated floor area and

   (b) the Cooling Requirements Reduction (CRR), to express the percentage of reduction of the cooling demand of a scenario in respect to the cooling demand of the reference scenario.

3. For components efficiency two indicators were developed;

   a) Ventilative Cooling Seasonal Energy Efficiency Ratio (SEERvc) of the ventilative cooling system expresses the energy efficiency of the whole system. The SEER rating of a system is the reduction in cooling demand during a typical cooling season divided by the electrical consumption of the ventilative cooling system, in case ventilation rates are provided mechanically and

   b) the ventilative cooling advantage [-] (ADVVC) indicator defines the benefit of the ventilative cooling in case ventilation rates are provided mechanically, i.e. the difference cooling energy use divided by the energy use for ventilation.

IEA EBC Annex 62 – Ventilative cooling Design Guide http://www.iea-ebc.org/Data/publications/EBC_Annex_62_Design_Guide.pdf

Ventilative cooling potential tool
Example of an office in Dublin

10 April 2019

Ventilative cooling potential analysis

Developed within the IEA - EBC Annex 62 - "Ventilative cooling"

Created by: Eurac Research (co-funded by Stiftung Südtiroler Sparkasse), supported by Politecnico di Torino for evaporative cooling potential evaluation (co-founded by RTDgrant 59_ATEN_RSG16CHG)

V1.0

Location

City		Dublin	
Country		Ireland	
Latitude		53.35	°
Longitude		6.26	°
Time zone (respect GMT)		0	hr

Building data

Building type		Office building	
Ceiling to floor height	H	3.00	m
Envelope area	A	268	m²
Floor area	S	80	m²
Fenestration area	W	50	m²
Comfort requirement		category II	

Room volume V 240 m³

S Fenestration area orientation 90 ° Inclination

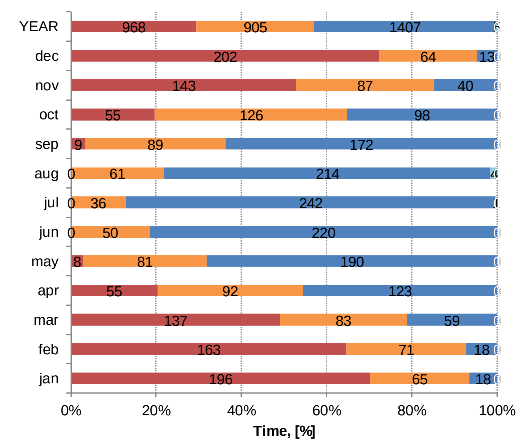
Technical specifications

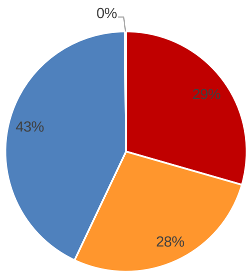
U-value of the opaque envelope	Uo	0.27	W/m²K
U-value of the fenestration	Uw	1.12	W/m²K
g value of the glazing system	g	0.3	-
Shading control setpoint	Shd	40	W/m²
Min. required ventilation rates	ṁmin	0.507	l/s-m²
Lighting power density	Qlight	10.00	W/m²
Electric equipment power density	Qel_equip	5.00	W/m²
Occupancy density	Qpeople	10	m²/pers

Avg. envelope U-value Uavg 0.43 W/m²K

ṁmin 0.6083 1/h

Avg. total internal gains Qint 16 W/m²





Required airflow rates in VC mode [2]

average 3.08 ± st. dev. 1.09 ach

- VC mode [0]: ventilative cooling not required
- VC mode [1]: potential comfort hrs by direct ventilative cooling with minimum airflow rates
- VC mode [2]: potential comfort hrs by direct ventilative cooling with increased airflow rates
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Comfort requirement		category II		i			

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Min. required ventilation rates	$\dot{m}_{min}$	0.507	l/s-m² i		$\dot{m}_{min}$	0.6083	1/h
Lighting power density	Q_{light}	10.00	W/m²				
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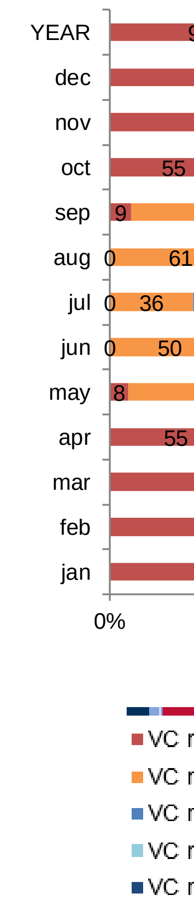
Occupancy density	Q_{people}	10	m²/pers	Avg. total internal gains	Qint	16	W/m²



Politecnico di Torino for evaporative cooling potential evaluation (co-founded by RTDgrant 59_ATEN_RSG16CHG)

eurac research

ume V **240** m³

90 ° Inclination

alue U_{avg} **0.43** W/m²K

$\dot{m}_{min}$ **0.6083** 1/h

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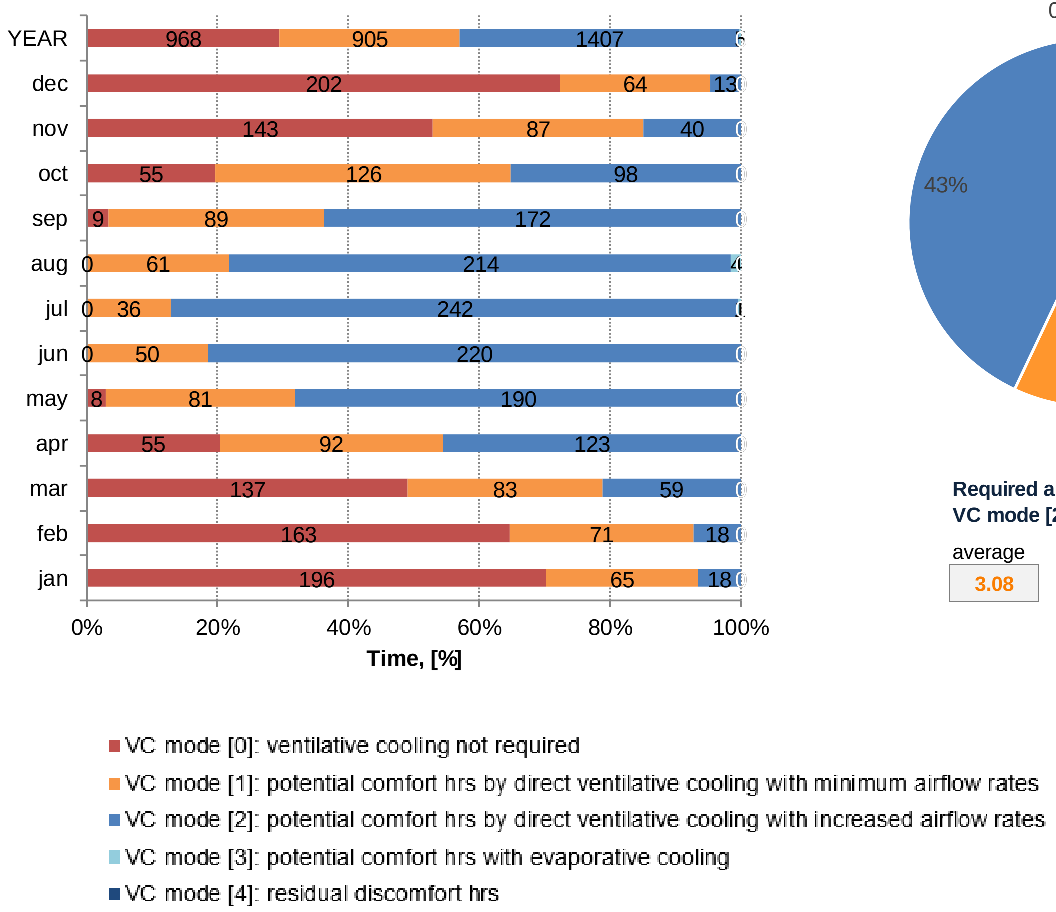

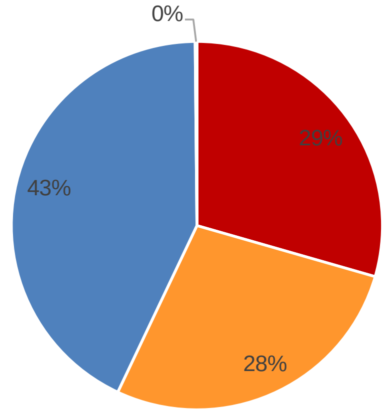

Required airflow rates in VC mode [2]

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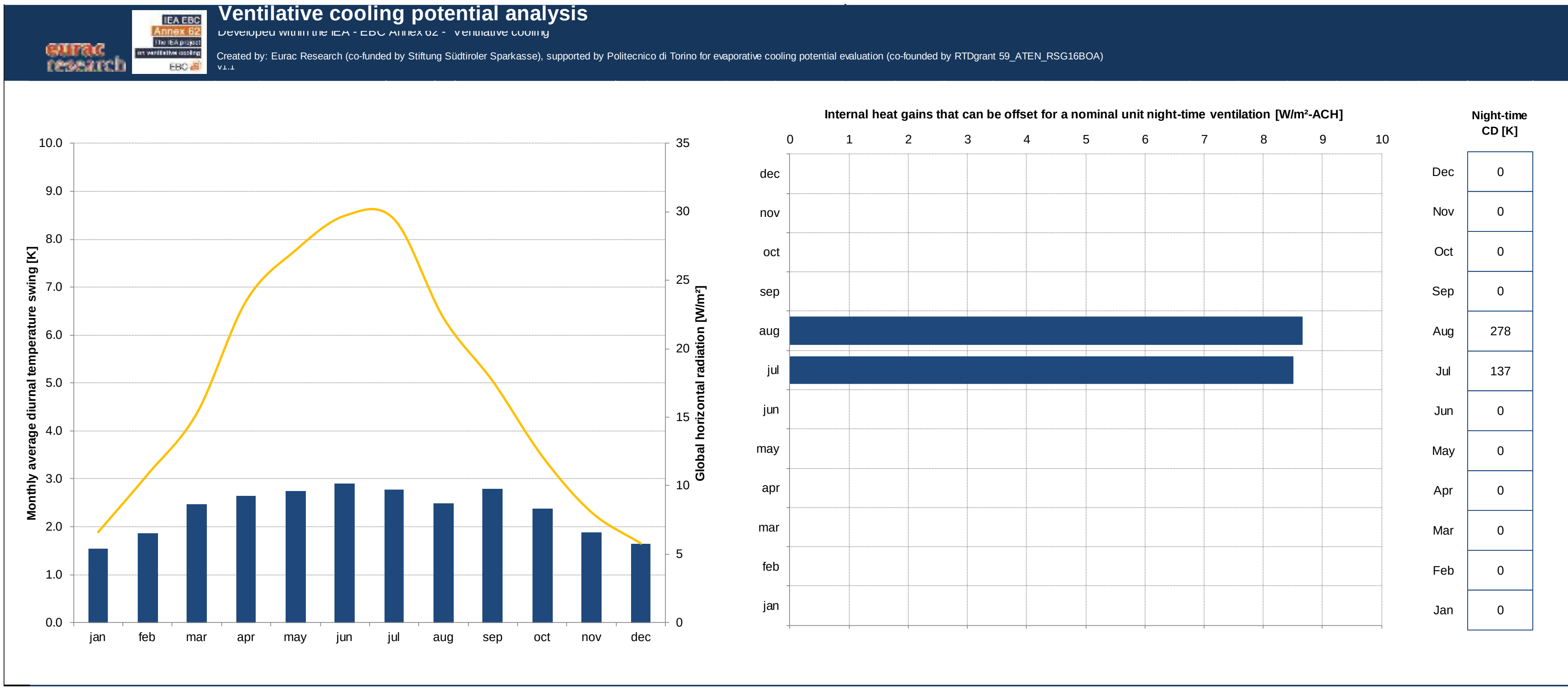
Ventilative cooling potential analysis
Created by: Eurac Research (co-funded by Stiftung Südtiroler Sparkasse), supported by Politecnico di Torino for evaporative cooling potential evaluation (co-founded by RTDgrant 59_ATEN_RSG16BOA)
IEA EBC
Annex 62
eurac research
Monthly average diurnal temperature swing [K]
Global horizontal radiation [W/m²]
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
Internal heat gains that can be offset for a nominal unit night-time ventilation [W/m²-ACH]
Night-time CD [K]
Dec 0
Nov 0
Oct 0
Sep 0
Aug 278
Jul 137
Jun 0
May 0
Apr 0
Mar 0
Feb 0
Jan 0

Ventilative cooling potential tool

10 April 2019

Extreme counter example: an office in Dubai

Ventilative cooling potential analysis

Developed within the IEA - EBC Annex 62 - "Ventilative cooling"

Created by: Eurac Research (co-funded by Stiftung Südtiroler Sparkasse), supported by Politecnico di Torino for evaporative cooling potential evaluation (co-founded by RTDgrant 59_ATEN_RSG16CHG)

V1.0

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City		Dubai	
Country		UAE	
Latitude		25.26	°
Longitude		55.30	°
Time zone (respect GMT)		4	hr

Building data

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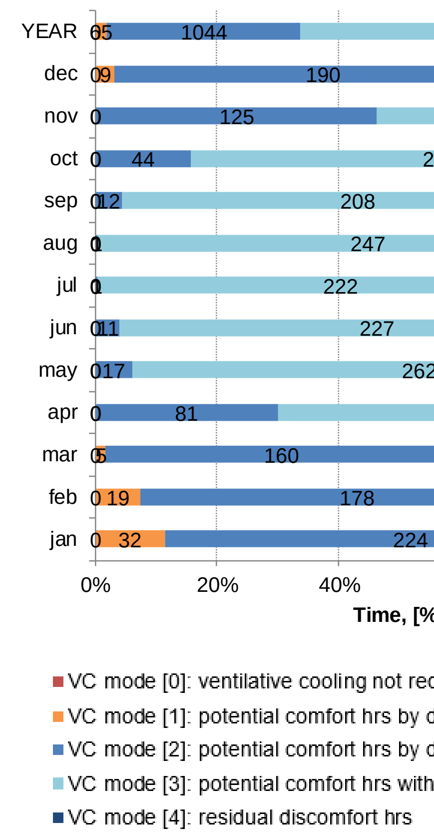
Avg. envelope U-value U_{avg} 0.43 W/m²K

$\dot{m}_{min}$ 0.6084 1/h

Avg. total internal gains Q_{int} 16 W/m²



Ventilative cooling potential tool

Extreme counter example: an office in Abu Dhabi

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oling"

se), supported by Politecnico di Torino for evaporative cooling potential evaluation (co-founded by RTDgrant 59_ATEN_RSG16CHG)

eurac research

Room volume V **240** m³

rea orientation **90** ° Inclination

envelope U-value U_{avg} **0.43** W/m²K

$\dot{m}_{min}$ **0.6084** 1/h

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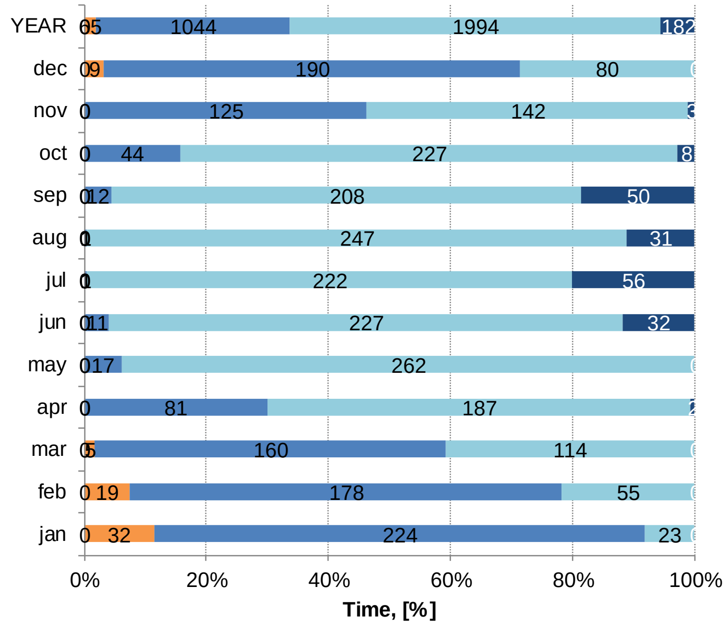

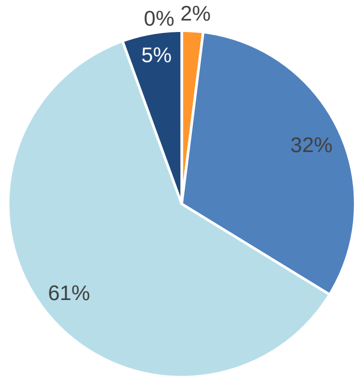

- VC mode [0]: ventilative cooling not required
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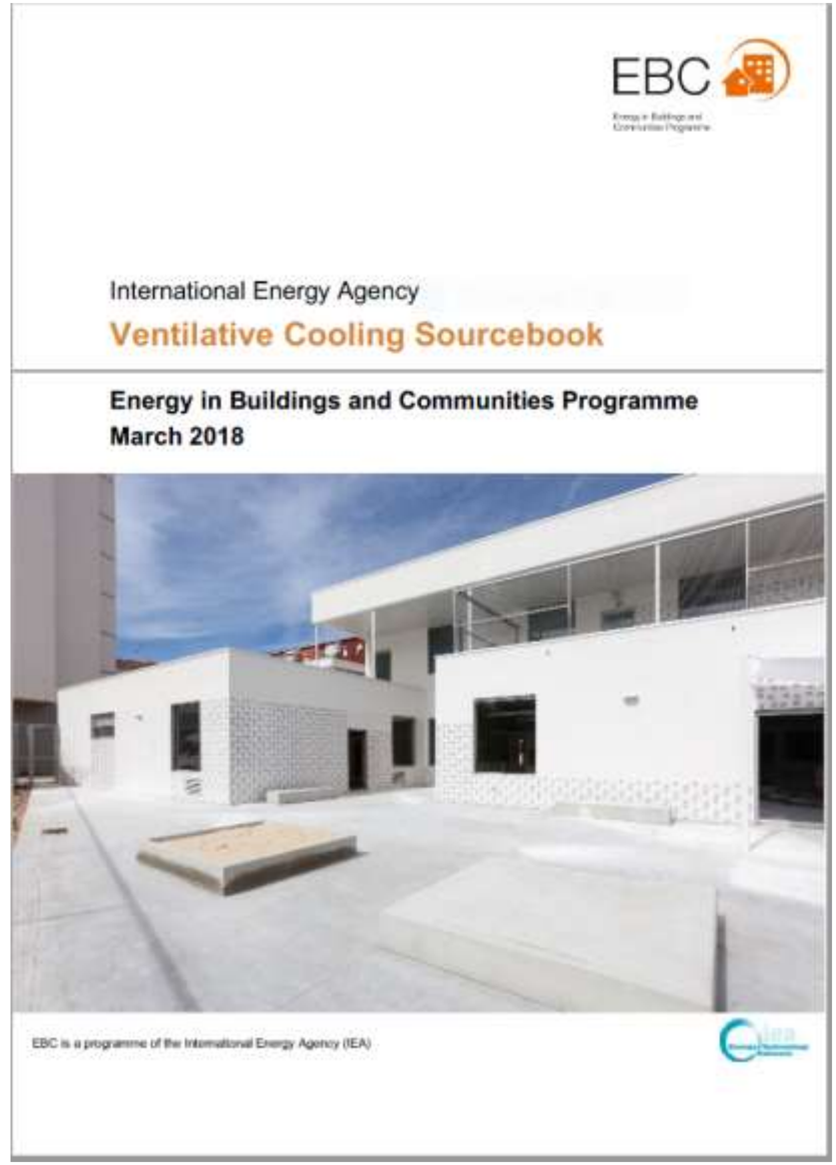
- VC mode [3]: potential comfort hrs with evaporative cooling
- VC mode [4]: residual discomfort hrs

Required airflow rates in VC mode [2]

average **5.46** ± st. dev. **2.51** ach

Source Book

- Airflow guiding ventilation
- Components
- Airflow enhancing ventilation
- Components
- Passive cooling ventilation
- Components
- Automation components
- Includes results of national research projects



Book of Case Studies

EBC

15 case-studies studied by annex participants as part of their contribution to the annex

International Energy Agency

Ventilative Cooling Case Studies

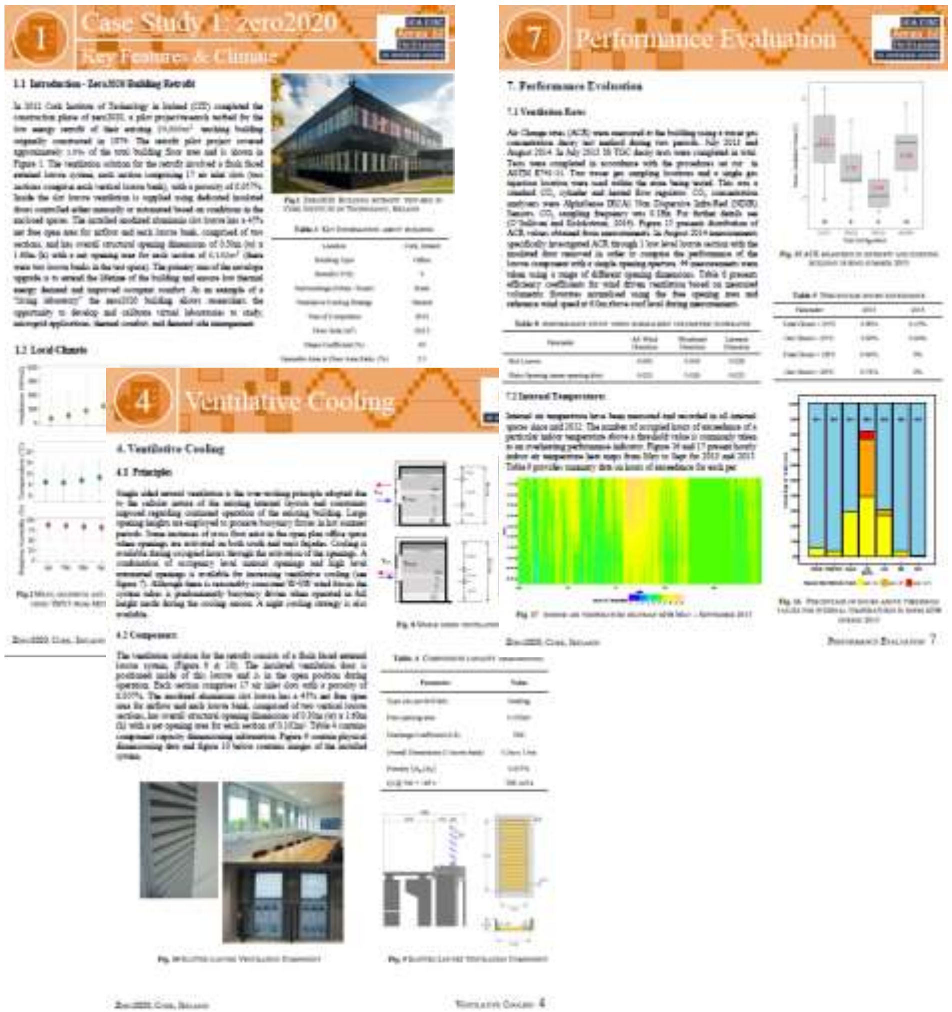
Energy in Buildings and Communities Programme

May 2018

EBC is a programme of the International Energy Agency (IEA)

Book of Case Studies

Pg	Information
1	Introduction, Local Climate & Key Information
2	Building Information & Design Influences
3	Energy Systems
4	Ventilative Cooling Principles and Components
5	Control Strategy overview and description
6	Design stage simulation, design criteria
7-9	Performance Evaluation
10	Lessons Learned
11	References & Project Contacts



Lessons learned from Case Studies

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				
Wanguo MOMA (CN)		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		
Maison Air et Lumiere (FR)	X								
Mascalucia ZEB (IT)	X			X				X	
Nexus Hayama (JP)	X					X			
CML Kindergarden (PT)	X			X					
Bristol University (UK)					X	X			X
Living Lab (NO)	X								

		Building	Initial costs	Maintenance Costs	Energy Costs	Solar Loads	Internal Loads	External Noise	Internal Noise	Air Pollution	Rain Ingress	Insect Prevention	Burglary Prevention	Privacy	Air Leakage
IE	R	zero2020	H	M	H	H	L	L	L	L	M	L	H	M	M
NO	R	Brunla Primary school	H	H	H	L	M	L	L	H	M	L	L	L	H
NO	R	Solstad barnehage	L	L	H	L	L	L	M	H	L	L	L	L	H
CN	U	Wanguo MOMA	H	M	H	H	L	L	L	L	M	L	M	L	H
AT	U	UNI Innsbruck	H	H	H	M	L	M	L	L	M	L	L	L	H
AT	R	wk Simonsfeld	H	H	H	M	L	L	L	L	L	L	L	L	M
BE	R	Renson	L	M	L	H	H	H	L	L	L	L	L	L	L
BE	U	KU Leuven Ghent	H	L	H	H	H	L	L	L	M	L	L	L	H
FR	U	Maison Air et Lumiere	M	M	L	H	M	L	L	H	L	L	M	L	M
IT	R	Mascalucia ZEB	H	M	H	H	L	L	L	L	L	L	M	L	M
JP	R	Nexus Hayama	M	M	H	H	L	L	L	L	M	H	H	M	M
PT	U	CML Kindergarden	H	L	L	M	M	L	L	L	M	M	M	M	L
UK	R	Bristol University	H	H	H	L	H	L	M	L	M	M	H	L	L
NO	U	Living Lab	L	L	H	H	M	L	M	L	H	L	L	L	H

Recommendations for legislation and standards

Annex 62 work revealed that ventilative cooling is in most cases not sufficiently integrated in standards, legislation and compliance tools.

However, it also revealed that there is a broad field of evaluation methods for ventilative cooling, ranging from very simple to detailed that can support a stronger integration of Ventilative cooling in the near future.

To allow for Ventilative cooling to be treated better, the following points are important:

- Standards: The support of calculation methods that fairly treat natural Ventilative cooling for the determination of air flow rates including e.g. the dynamics of varying ventilation and the effects of location, area and control of openings
- Legislation: Include assessment of overheating, e.g. (a) Requirements to thermal comfort, including adaptive temperature sensation and (b) Requirements to energy performance including cooling
- Compliance Tools: They should allow for assessment of increased air flows when efficient ventilative cooling systems are used; Differentiation should be made for:
  - cross- or stack ventilation vs. single-sided ventilation,
  - automated systems vs. manual control
  - large vs. small opening areas

Recommendations for legislation and standards

Work under CEN/TC 156 (Ventilation for buildings) and ISO/TC 205 (Building environment design); work focusses mainly on design aspects of natural and hybrid ventilation and ventilative cooling tackling both overheating and indoor air quality issues.

More specifically,

- Working Group 21 (CEN/TC 156) works towards a technical specification on “Ventilative cooling systems” focussing on overheating prevention.
- Working Group 20 works towards a technical specification on “Natural and hybrid ventilation systems in non-residential buildings” focussing on indoor air quality aspects.
- ISO standard on “Design process of natural ventilation for reducing cooling demand in energy-efficient non-residential buildings” is under development within working group 2 in ISO/TC 205.
- Work on new standard on natural ventilation has started in China.

Future Work on Resilient Cooling: Annex 80

Work on Ventilative Cooling to-date has not considered in detail issues of

- urbanisation and densification,
- climate change,
- extreme climates and
- elevated comfort expectations

There is international current work on these issues; for example a conference organized in Dubai in April 2019 includes Ventilative cooling discussions and how ventilation can be incorporated in the design and operation in climates where traditionally buildings are air-conditioned.

These open issues will be researched in the near future by the work of IEA EBC Annex 80 which started in June 2018 and will be completed in 2023. Comfort at the extremes international conference April 2019. https://comfortattheextremes.com/

http://annex80.iea-ebc.org/

Benefits of working in an IEA Annex

- Excellent forum for researchers
  - > Three Brunel PhD students directly contributed to the Annex; subtask B (Solutions) and C (Case-studies). All three have completed their PhDs.
  - > Ideas for future research including research proposals
- Exchange of research ideas with peers and industry from many countries
  - > Experts meetings every six months usually 2 days
  - > Nationals seminars organised alongside the expert meetings – opportunities to highlight on-going research of participants in the context of different countries
  - > Visit case-study buildings and facilities of participants. Interact with local students; summer school in Lisbon
- Work at an international context with specific deliverables; opportunities to learn different working cultures
- Participation to initiatives resulting from the work of the annex such as current contribution to ISO and CEN working groups.
- Opportunities to contribute to preparation of international projects such as the new annex 80 on ‘Resilient Cooling’.

Thank you!