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PRINCIPLES AND POTENTIALS OF VENTILATIVE COOLING

PER HEISELBERG
DEPARTMENT OF CIVIL ENGINEERING

OPERATING AGENT
IEA EBC ANNEX 62

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BACKGROUND

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THE CURRENT DEVELOPMENT TOWARDS NEARLY-ZERO ENERGY BUILDINGS HAVE LEAD TO AN INCREASED NEED FOR COOLING – NOT ONLY IN SUMMER BUT ALL YEAR.

ELEVATED TEMPERATURE LEVELS ARE ONE OF THE MOST REPORTED PROBLEM IN POST OCCUPANCY STUDIES, EVEN IN RESIDENCES IN THE “HEATING SEASON”

THERE HAS BEEN A LARGE FOCUS ON REDUCING THE HEATING NEED IN BUILDINGS. THERE IS ALSO A NEED TO ADDRESS THE COOLING NEED AND TO DEVELOP MORE ENERGY-EFFICIENT COOLING SOLUTIONS

WHY DO WE EXPERIENCE AN OVERHEATING PROBLEM?

OVERHEATING IS A ”NEW AND INCREASING PROBLEM” FOR LOW ENERGY BUILDINGS

- More focus on energy than indoor environment (less requirements for documentation)
- Is underestimated and is not given enough focus in the design process
- Old rules of thumb still used

TOO SIMPLIFIED DESIGN METHODS USED

- Averaging heat loads in time and space
- Uncertain correlation between cooling need and overheating risk

NO (VERY FEW) STANDARD TECHNICAL SOLUTIONS AVAILABLE, ESPECIALLY FOR DWELLINGS

NO (VERY LIMITED) USER EXPERIENCE ON HANDLING OF OVERHEATING PROBLEMS - “ONE-OF-A-KIND” SOLUTIONS ARE OFTEN NOT WELL-ADAPTED TO “PRACTICAL USE”

VENTILATIVE COOLING IS A SOLUTION

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VENTILATIVE COOLING IS AN ATTRACTIVE AND ENERGY EFFICIENT PASSIVE SOLUTION TO COOL BUILDINGS AND AVOID OVERHEATING.

- Ventilation is already present in most buildings through mechanical and/or natural systems
- Ventilative cooling can both remove excess heat gains as well as increase air velocities and thereby widen the thermal comfort range.
- The possibilities of utilizing the free cooling potential of low temperature outdoor air increases considerably as cooling becomes a need not only in the summer period.

Climate Potential & Limitations

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POTENTIAL AND LIMITATIONS

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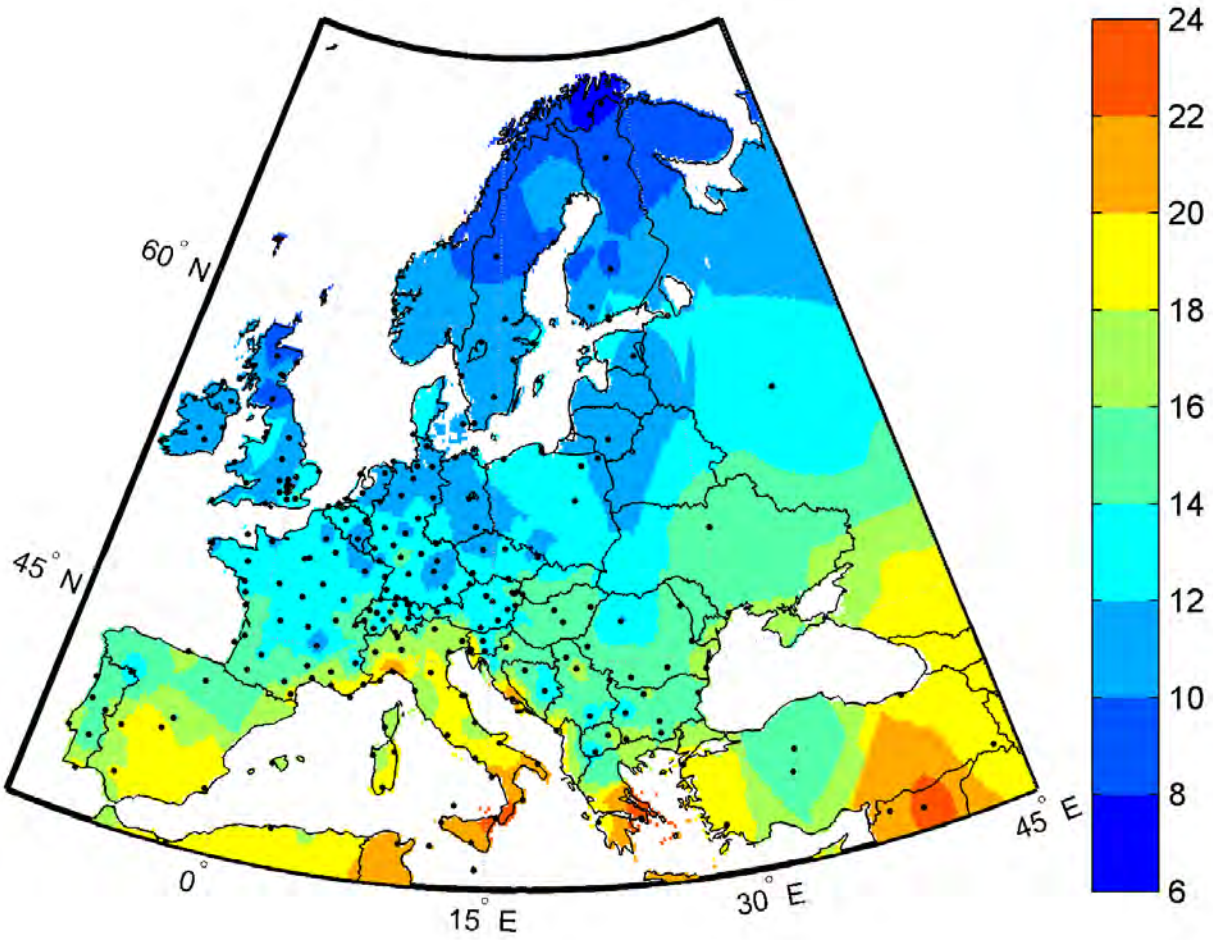
OUTDOOR CLIMATE POTENTIAL

- Outdoor temperature lower than the thermal comfort limit in most part of the year in many locations
- Especially night temperatures are below comfort limits
- Natural systems can provide “zero” energy cooling in many buildings

LIMITATIONS

- Temperature increase due to climate change might reduce potential
- Peak summer conditions and periods with high humidity reduce the applicability
- An urban location might reduce the cooling potential (heat island) as well as natural driving forces (higher temperature and lower wind speed). Elevated noise and pollutions levels are also present in urban environments
- High energy use for air transport limit the potential for use of mechanical systems
- Building design, fire regulations, security are issues that might decrease the potential use of natural systems

DAILY MINIMUM TEMPERATURE JULY



Meteonorm Data

CLIMATIC POTENTIAL FOR NIGHT-TIME COOLING

DEGREE HOURS METHOD TO QUANTIFY THE CLIMATIC COOLING POTENTIAL (CCP)
HARMONICALLY OSCILLATING BUILDING TEMPERATURE WITHIN A RANGE OF THERMAL COMFORT:

$$T_b = 24.5°C \pm 2.5°C$$

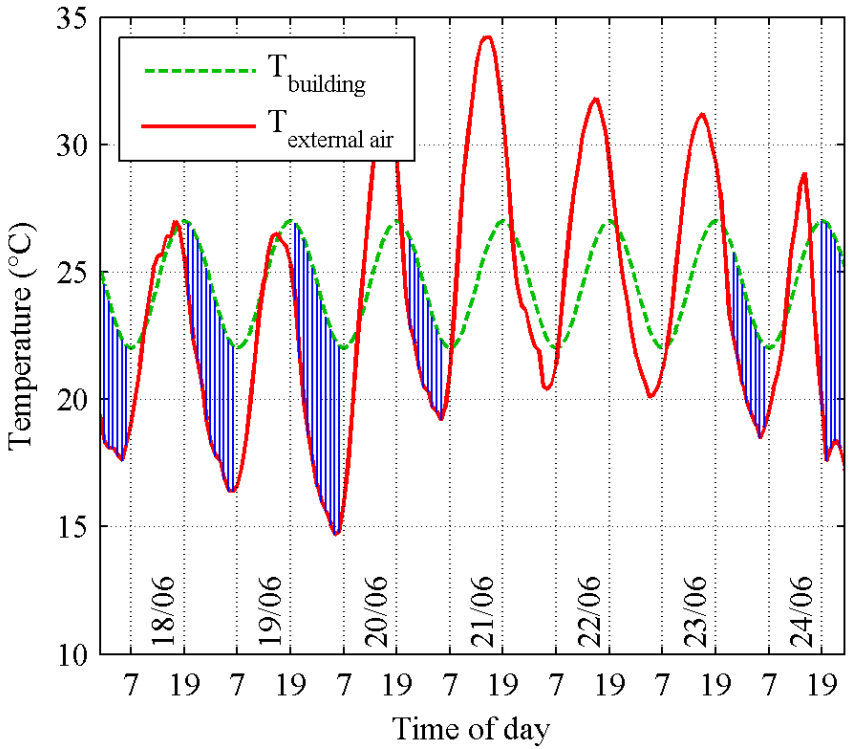
VENTILATION PERIOD: 7PM – 7 AM

MINIMUM TEMPERATURE DIFFERENCE: $\Delta T_{crit} = 3K$

CCP (KH)

$$CCP_d = \sum_{t=t_i}^{t_f} m_{d,t} \left(T_{b(d,t)} - T_{e(d,t)}\right)$$

$$\begin{cases} m = 1\,h & \text{if } T_b - T_e \geq \Delta T_{crit} \\ m = 0 & \text{if } T_b - T_e < \Delta T_{crit} \end{cases}$$



Shaded areas show the climatic cooling potential during one exceptionally hot week in summer 2003 for Zurich SMA (ANETZ data)

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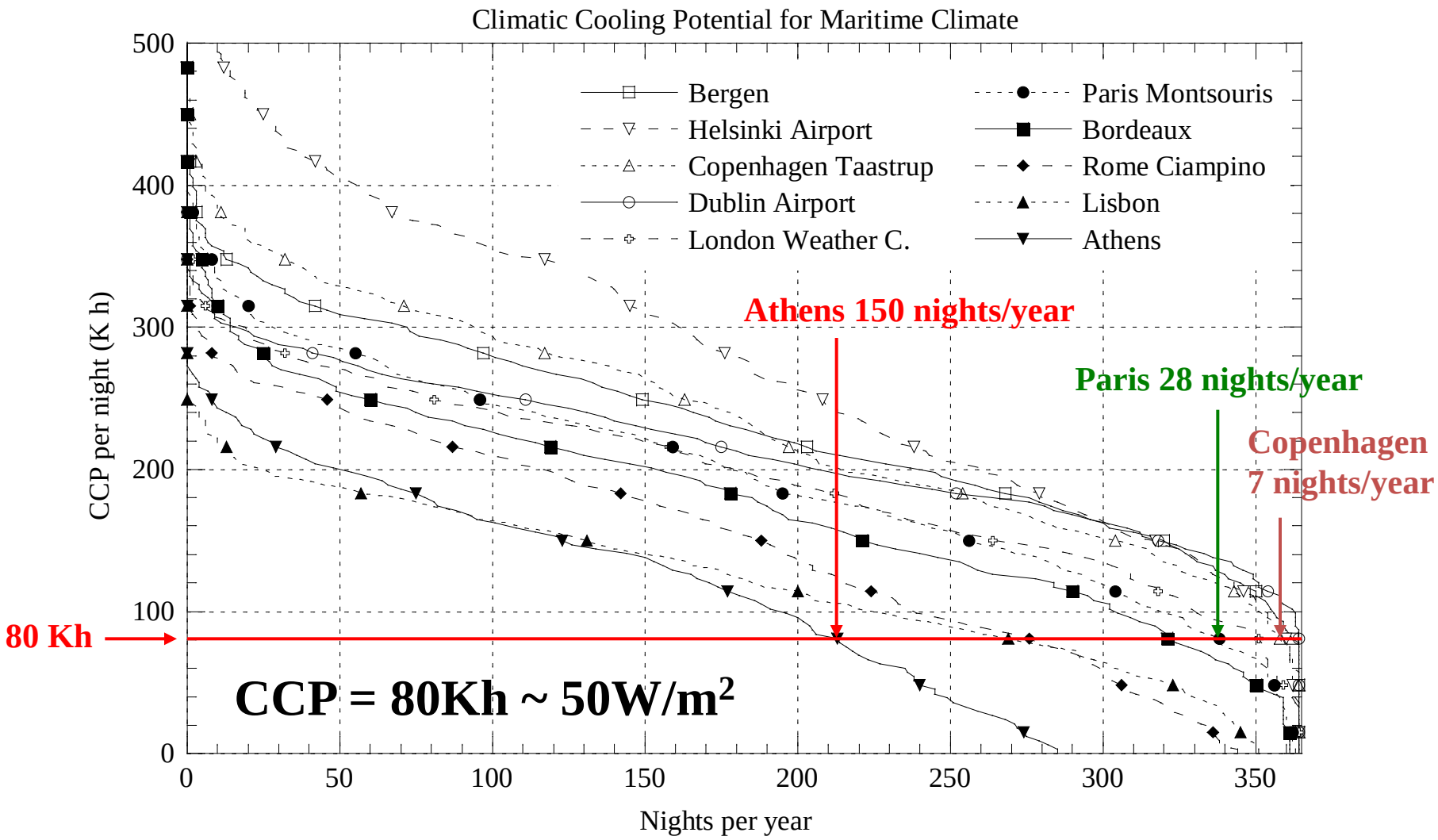
CUMULATIVE FREQUENCY DISTRIBUTION OF CCP



Solution Examples

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COOLING IN OFFICES AND EDUCATIONAL BUILDINGS IN COLD CLIMATE

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WITH HIGH INSULATION AND AIR TIGHTNESS LEVELS ALWAYS A COOLING NEED DURING OCCUPIED HOURS EVEN IN THE WINTER SEASON

COOLING IS NOT A NEW TECHNOLOGY, BUT THE NEED FOR COOLING IS INCREASING AND MORE EFFICIENT SYSTEMS HAVE TO BE DEVELOPED TO FULFILL FUTURE ENERGY REQUIREMENTS

APPLICATION OF THE FREE COOLING POTENTIAL OF OUTDOOR AIR IS WIDELY USED IN MECHANICAL VENTILATION SYSTEMS, BUT HIGH AIR FLOW RATES ARE NEEDED IN WINTER BECAUSE OF DRAUGHT RISK LEADING TO RELATIVELY HIGH ENERGY USE FOR AIR TRANSPORT

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VENTILATIVE COOLING IN COLD CLIMATE - DENMARK

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WHAT IS DIFFUSE CEILING VENTILATION

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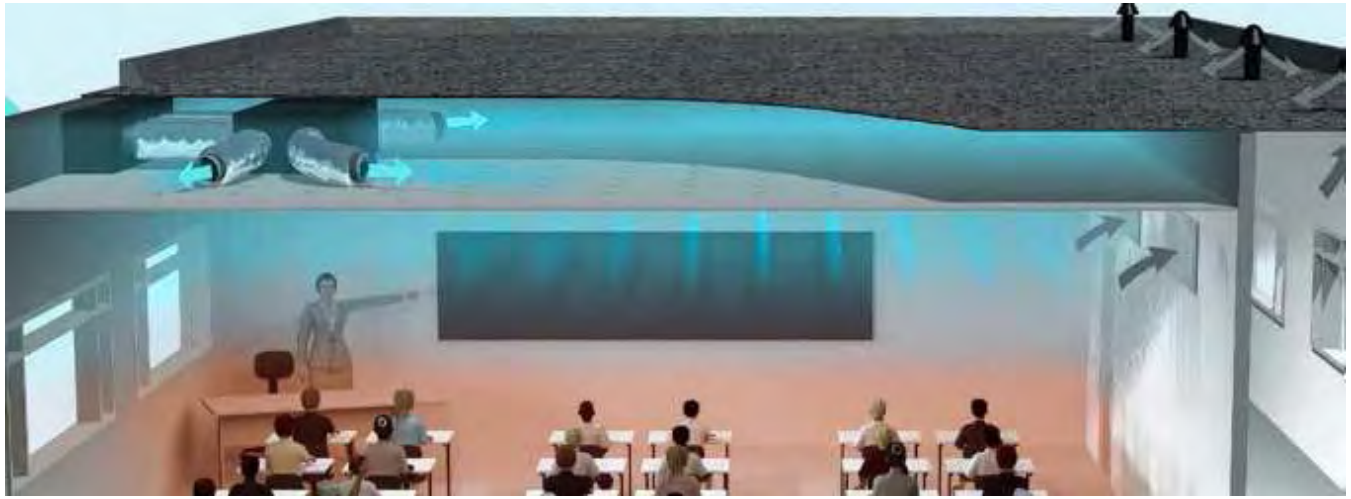
THE SPACE ABOVE A SUSPENDED CEILING IS USED AS A PLENUM AND FRESH AIR IS SUPPLIED TO THE OCCUPIED ZONE THROUGH PERFORATED SUSPENDED CEILING.



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THE PRINCIPLE

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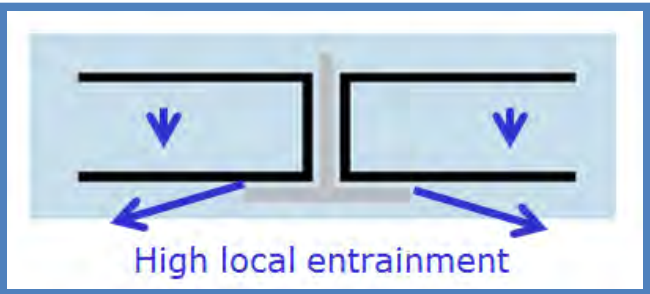
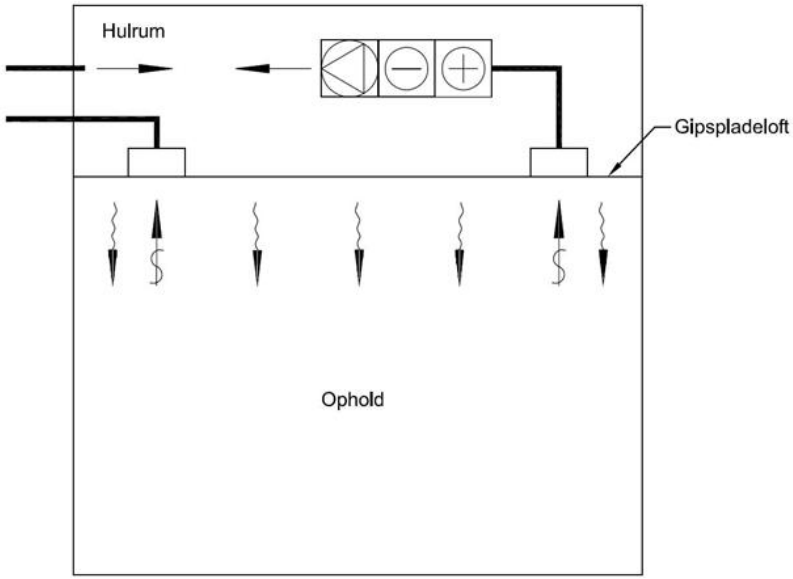
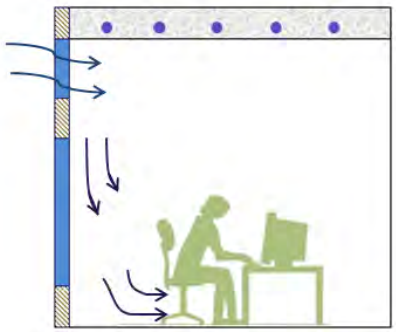
Rockfon / Troldtekt ceiling	
Ecophon ceiling	
Fully diffuse ceiling	

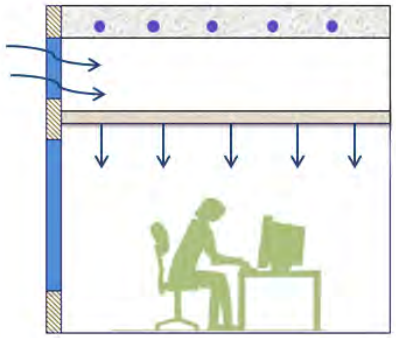
WIDEX / WESSBERG A/S

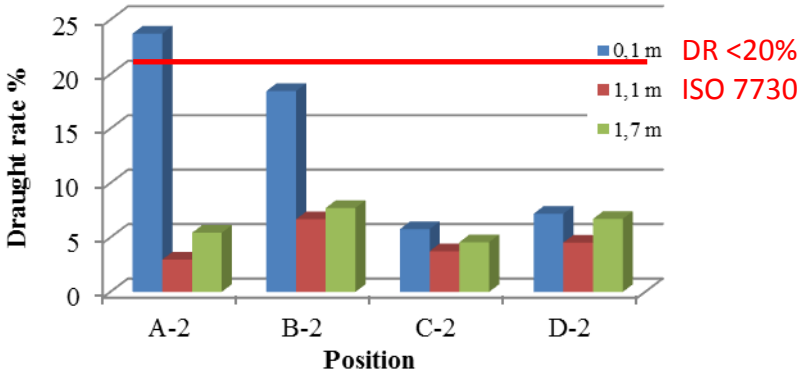


DRAUGHT RISK

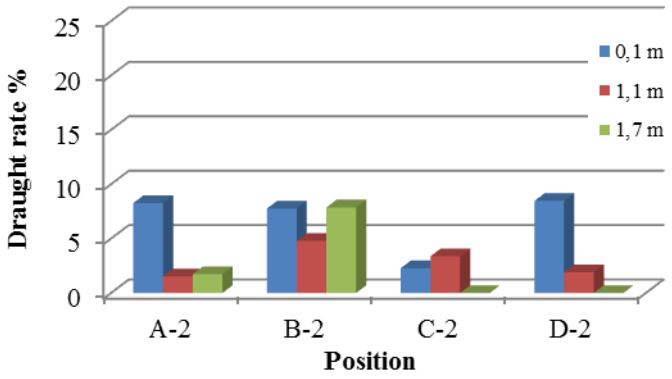
Extreme winter condition: supply air temperature -8 °C, ACH =4







DR <20%
ISO 7730



COOLING IN RESIDENTIAL BUILDINGS IN SUMMER

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WITH HIGH INSULATION AND AIR TIGHTNESS LEVELS AFTER RENOVATION OVERHEATING IS OFTEN THE RESULT IN THE SUMMER PERIOD AND AT HIGH SOLAR EXPOSURE IN OTHER PERIODS

TYPICALLY TO BE HANDLED BY MANUAL CONTROL OF SOLAR SHADING AND WINDOW OPENING, WHILE VENTILATION CAPACITY IS TOO LIMITED TO MAKE A DIFFERENCE

SUITABLE SOLUTIONS TO ASSIST USERS BY AUTOMATIC CONTROL VERY RARE

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TUEN, BIRKERØD, DENMARK
- TEST OF CONTROL AND USER INTERACTION

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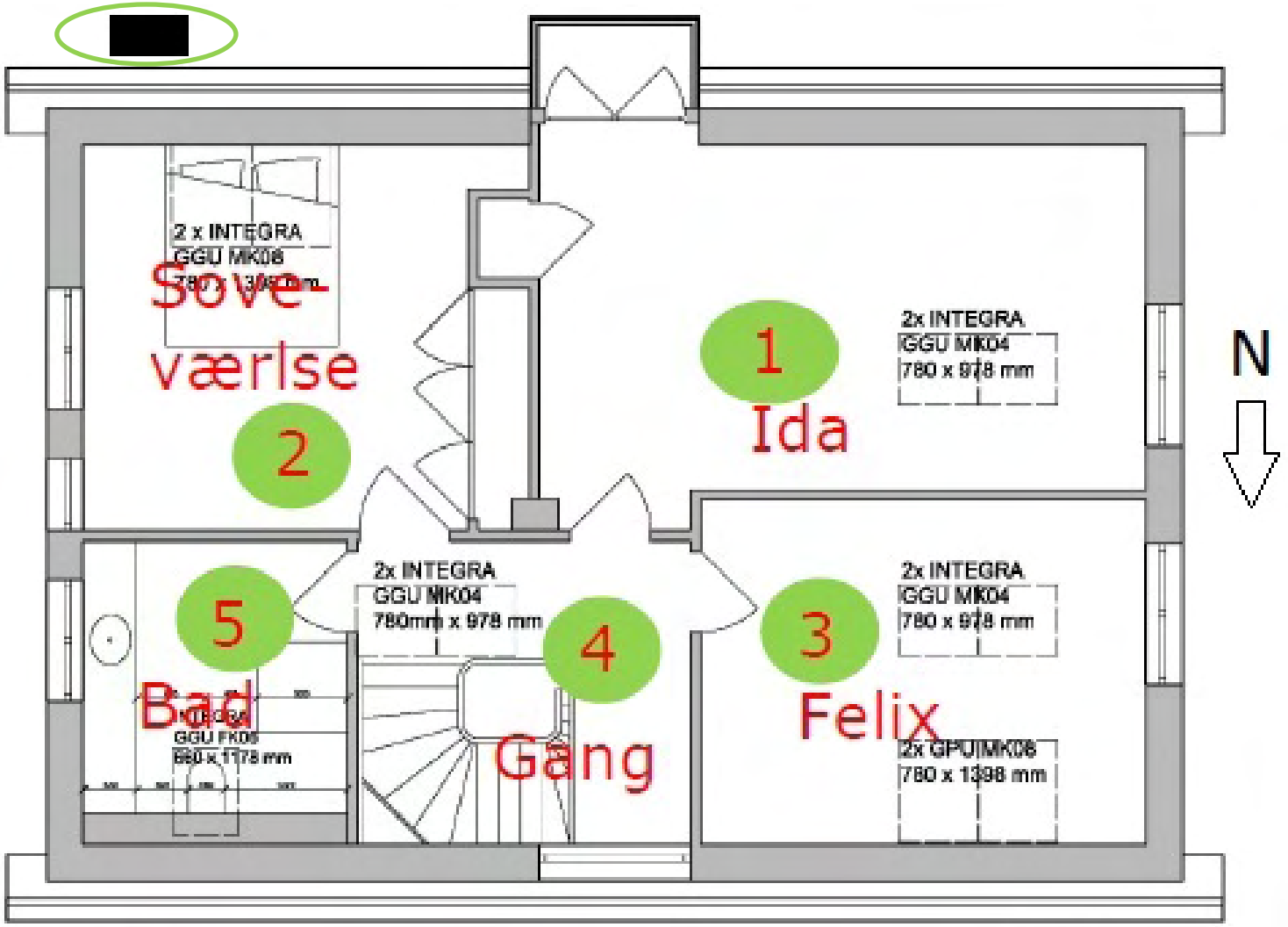
2 x INTEGRA
GGU MK08
Sove-
værelse
2
1
Ida
2x INTEGRA
GGU MK04
780 x 978 mm
N
2x INTEGRA
GGU MK04
780mm x 978 mm
5
Bad
4
Gang
3
Felix
2x INTEGRA
GGU MK04
780 x 978 mm
2x GPU/MK08
780 x 1398 mm

First floor

VENTILATION AND SHADING SYSTEMS COMPARISON

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2015 SUMMER

- ✓ MANUAL ROOF WINDOW OPENING AND SOLAR SHADING
- ✓ MANUAL USE OF FAÇADE-SHADING SYSTEMS
- ✓ CONSTANT MECHANICAL VENTILATION

2016 SUMMER

- ✓ AUTOMATIC OPENING OF ROOF WINDOWS
- ✓ AUTOMATIC SOLAR SHADING ON ROOF WINDOWS
- ✓ NO USE OF FAÇADE WINDOWS AND SHADING SYSTEMS
- ✓ NO MECHANICAL VENTILATION

MONITORED OVERHEATING

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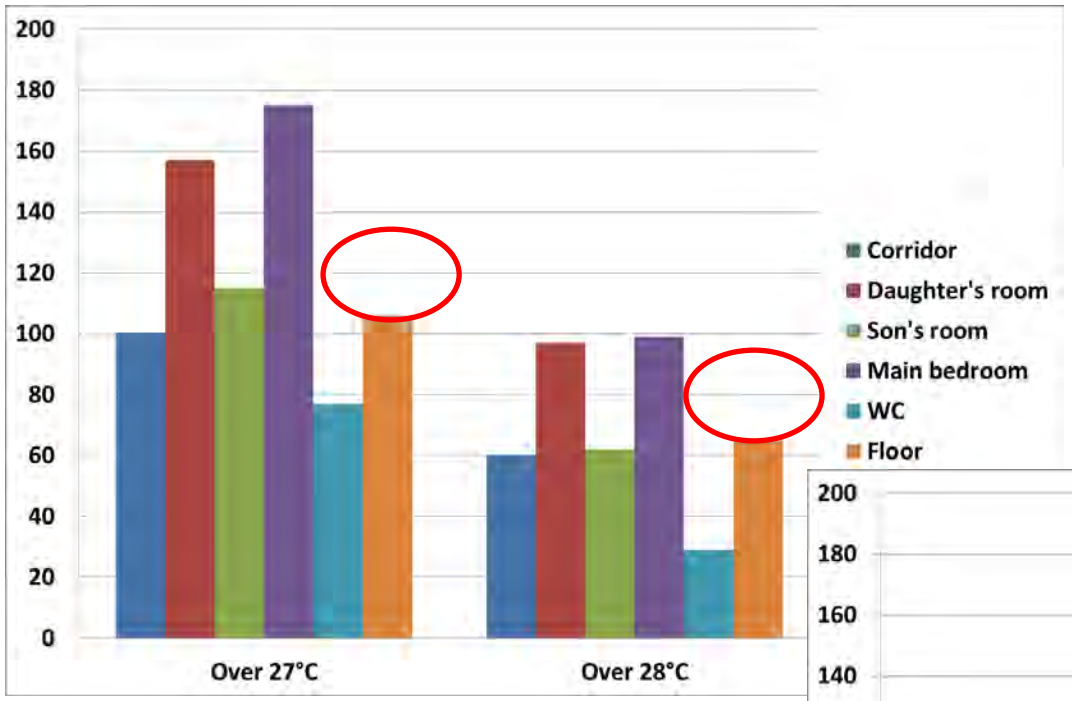
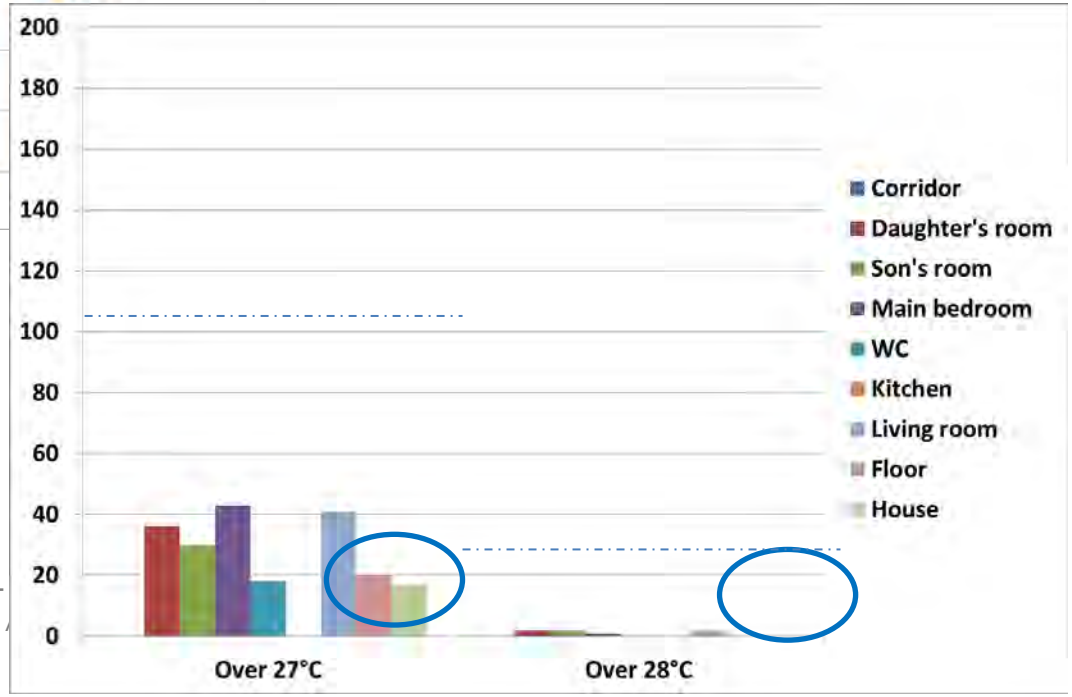


2015

2016



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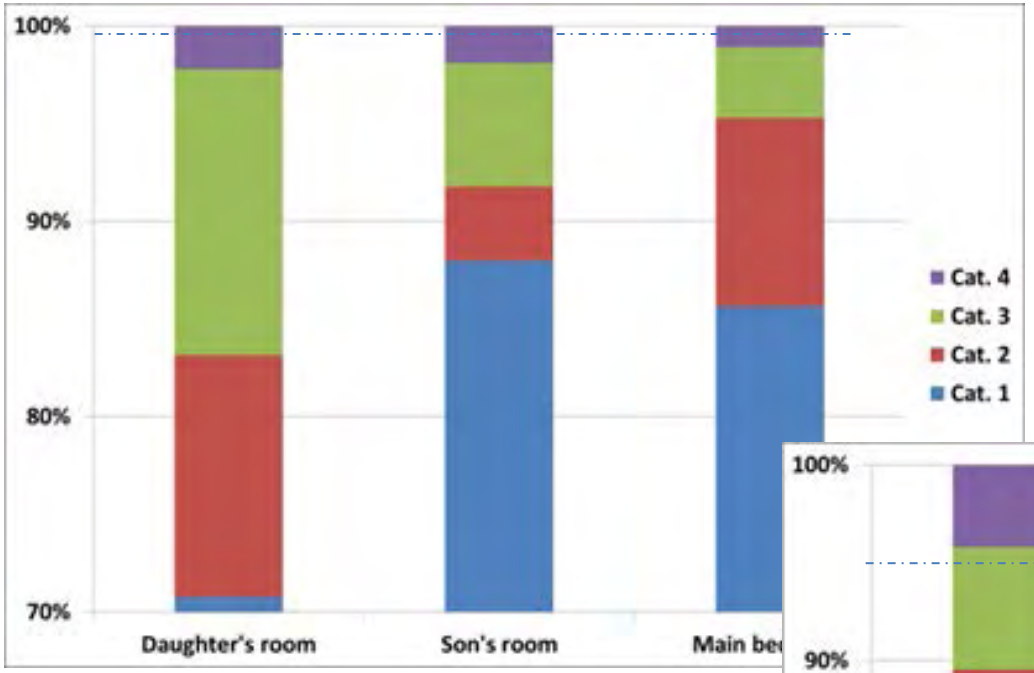
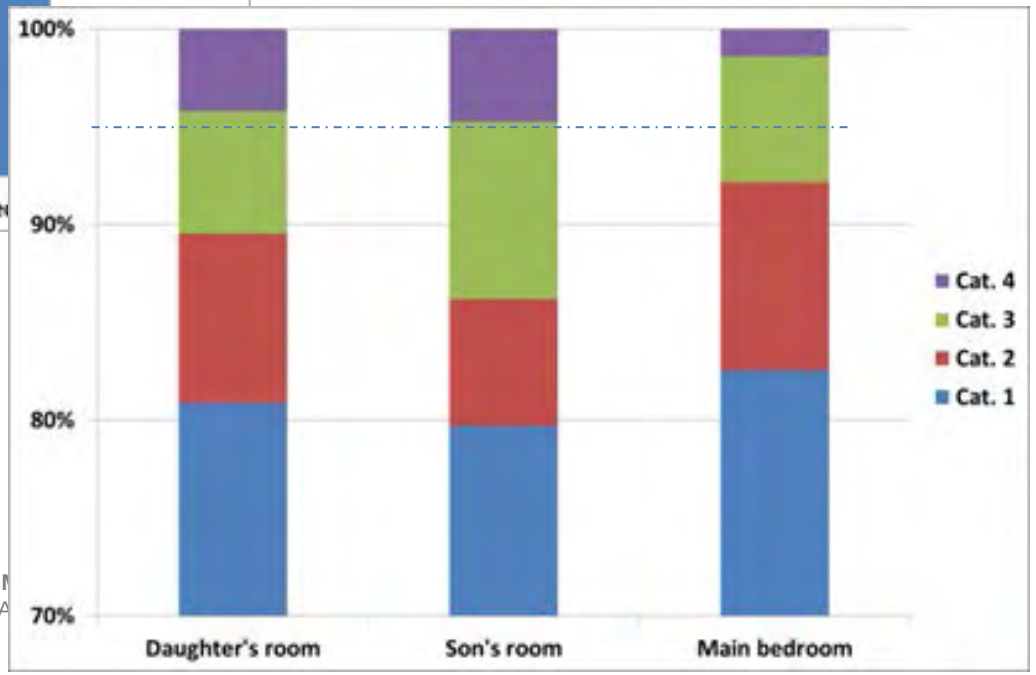


2015

2016



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Summary

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STATUS OF APPLICATION

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APPLICATION OF VENTILATIVE COOLING FOR RESIDENTIAL BUILDINGS IS AT A LOW LEVEL

- Few technical solutions available – mainly manual window opening only very few automated

VENTILATIVE COOLING IS A STANDARD SOLUTION IN OFFICES WITH MECHANICAL VENTILATION

- Designed for IAQ criteria
- Limited benefit due to fan energy use

VENTILATIVE COOLING BY NATURAL/HYBRID VENTILATION IS KNOWN

- But only used in a few cases in offices

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venticool

the international platform for ventilative cooling

IEA EBC
Annex 62
The IEA project
on ventilative cooling
EBC

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INFORMATION ON EBC ANNEX 62

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Search Site

Dear visitor,

Welcome to this new and combined website of the **venticool platform** and of **IEA EBC annex 62 'ventilative cooling'**:

The **venticool platform** was launched in October 2012 and aims to increase communication, networking and awareness raising about ventilative cooling to mobilize the untapped potential in terms of energy savings and improved comfort. Information can be found in the left part of the menu.

The **Annex 62 'ventilative cooling'** of the 'Energy in Buildings and Communities Programme (EBC)' of the International Energy Agency (IEA) was approved in November 2012 for a 1 year preparation phase. Information can be found in the right part of the menu.

As the venticool platform will act as a key partner for dissemination of annex 62 and in order to optimize the communication, it was decided to have one single website for a both actions.

Recent updates

- 35th AIVC – 4th TightVent – 2nd venticool Conference – Poznan, Poland – 24-25 September 2014!
- 34th AIVC– 1st venticool: 170 participants and more than 40 presentations on ventilative cooling!
- BUILD UP paper on ventilative cooling!
- 1st venticool conference: a total of more than 160 presentations!
- 2nd meeting of IEA EBC Annex 62 in Athens September 23-24, 2013
- Summary of International Workshop on Ventilative Cooling, Challenges and Solution Examples, Brussels


Thanks for your attention
More information on IEA EBC Annex 62 on www.venticool.eu