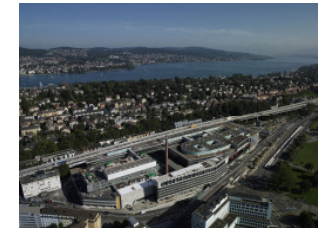


Hybrid Cooling Ceiling & Demand-oriented Ventilation: Ecologically and economically unbeatable!

Radiant Cooling Ceiling: The Advantages of the Hybrid Cooling Ceiling

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-

Radiant Cooling Ceiling: The Advantages of the Hybrid Cooling Ceiling



Hybrid Module
U44^{Hybrid}



Hybrid Cooling
Ceiling
A11^{Hybrid}

What does Hybrid mean?

The term **hybrid** is of Greek origin (*Hybrida*) and refers to something that is bundled, crossed or mixed.

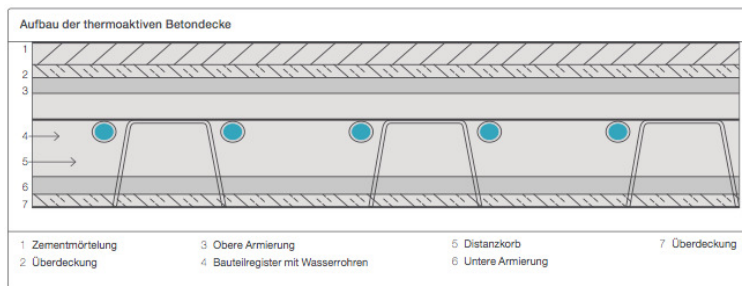
In technical terms, hybrid is a system which combines **two technologies** with each other.

Hybrid as a prefix emphasises an entity formed of different types or processes.

The special feature is that the combined elements as such themselves already represent solutions. The combination of them however, has the potential to generate new desired properties.

Hybrid Cooling Ceiling – The functional Principle

The **hybrid cooling ceiling** combines two systems:



Thermo-active Ceiling
+
Radiant Cooling Ceiling

Hybrid Cooling Ceiling – The Features

The **hybrid cooling ceiling** warrants for:

Thermal comfort in workspaces

- **Room Temperature**
 - Heating
 - Cooling
 - **Draught-free Atmosphere**
 - Low ambient air speeds
 - Low impulse air distribution
 - Cutback of temperature difference between supply air and compartment air
 - Prevention of a change of temperature at window surfaces in winter
-

Hybrid Cooling Ceiling – The Features

Acoustic Comfort

- Good sound absorption for ideal reverberation periods
- Prevention of telephony between the individual rooms

Hygienic Comfort

- Hygienically safe
 - Selection of materials
 - Constructions
 - Air supply with high ventilation efficiency
 - Reduction of the pollution and unpleasant odours due to ideal room temperatures
-

Hybrid Cooling Ceiling – The Features

The **hybrid cooling ceiling** is distinguished by:

Low Energy Consumption

- Cooling media water
 - Active utilisation of the structural mass
 - High cooling water temperatures
 - Demand-dependent control
 - Fast reaction capability to changing thermal loads
 - Heat exchange with a high ratio of radiation
-

Hybrid Cooling Ceiling – The Features

Reduction of the CO₂-Emission

- Utilisation of the free cooling potential
- Deployment of alternative cooling energy generators (ground water, sea water, free cooling, etc.)
- Low electrical energy consumption

Little Space Requirement

- Hybrid Module, Installation Height = 70 mm
 - Hybrid Cooling Ceiling, Minimum Suspension Height = 160 mm
 - Air Volume Flow reduced to the hygienic minimum
-

Hybrid Cooling Ceiling – The Features

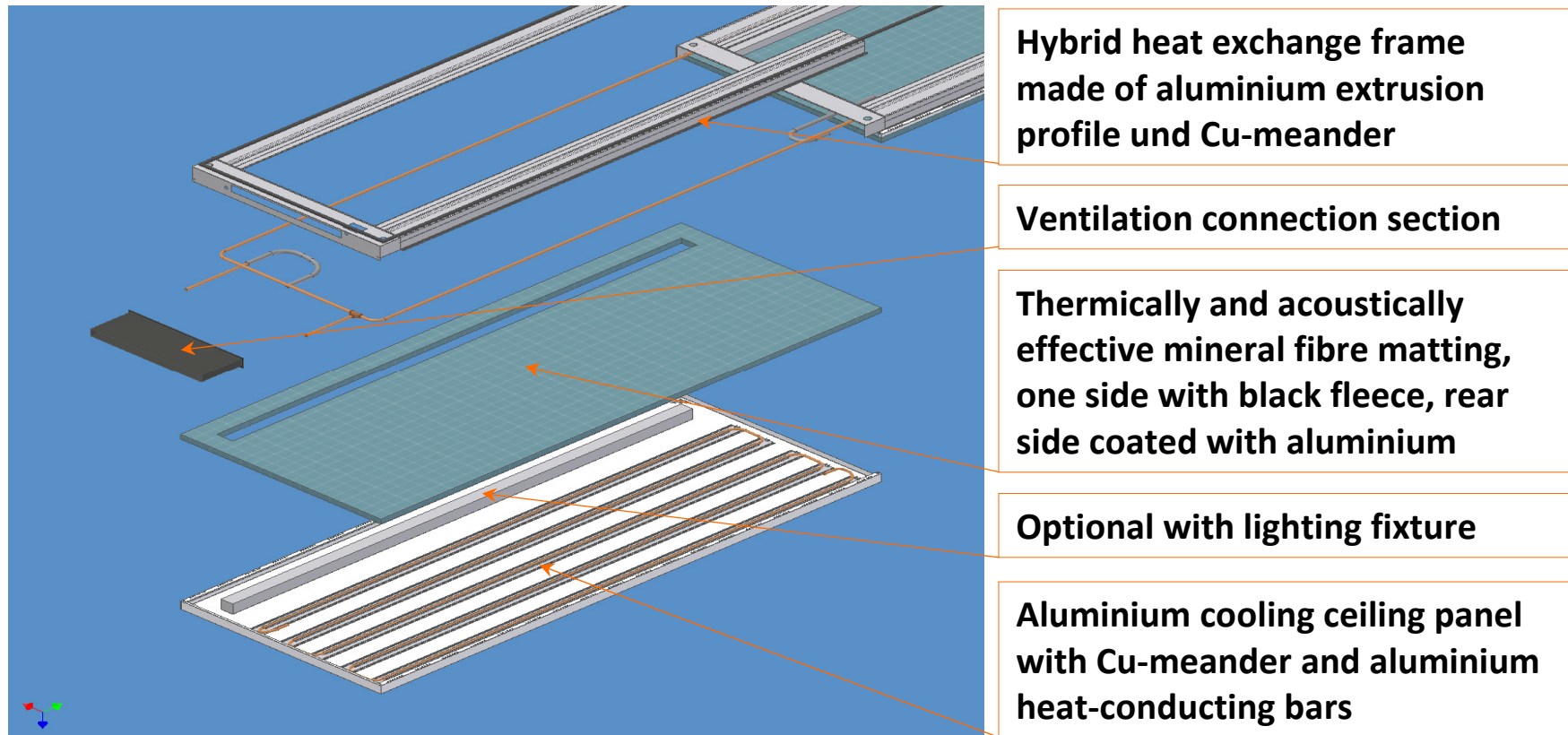
Saving Investment Costs

- Hybrid modules only require 30-50 % surface coverage
- Hybrid cooling ceilings dispose of a high specific cooling efficiency and therefore save up to 1/3 of the activation of the cooling ceiling
- Reduction of the installed refrigeration capacity (refrigerating machine) by 45%

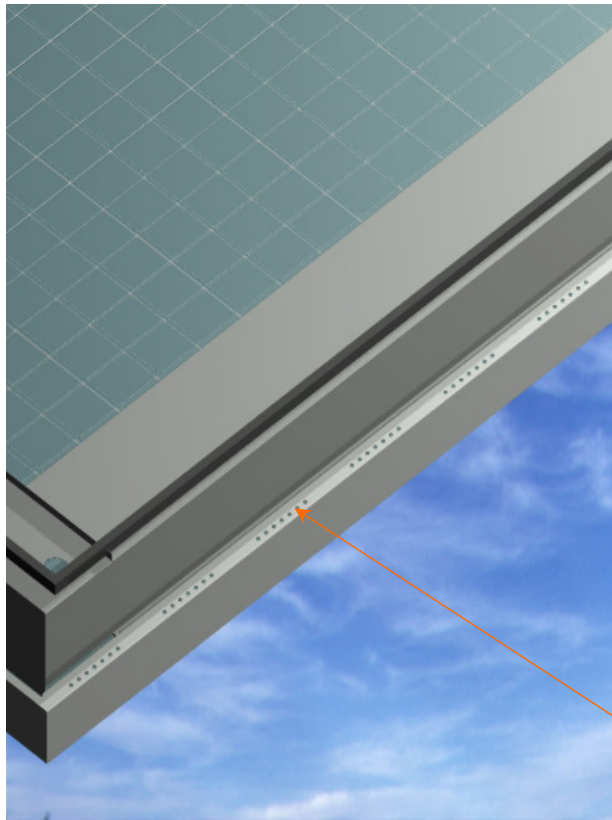
Saving Operating Costs

- Low Energy Consumption
 - Maintenance-free Systems
 - Low User expenditure due to low Reclamation Rate
-

Hybrid Module U44^{Hybrid} – The Construction



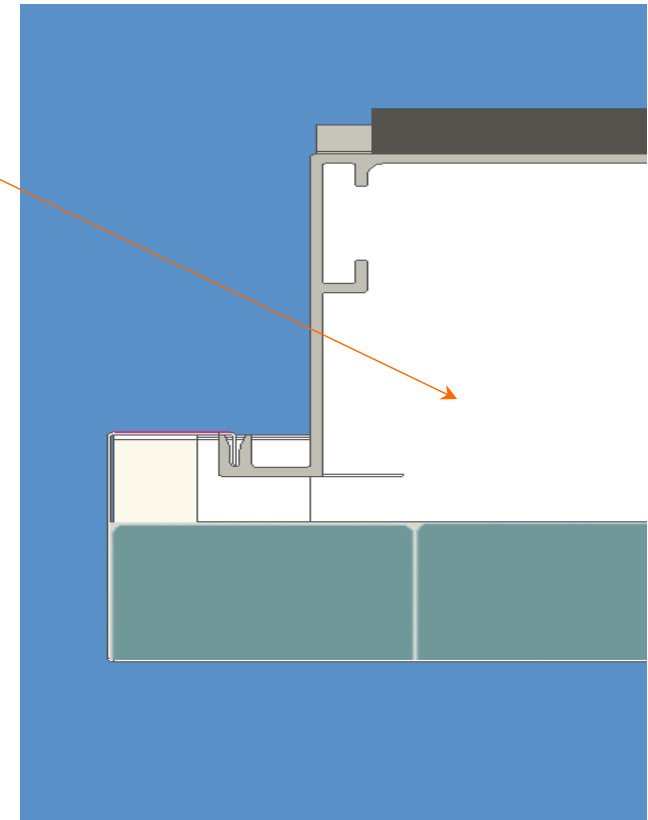
Hybrid Module U44^{Hybrid} – The Construction



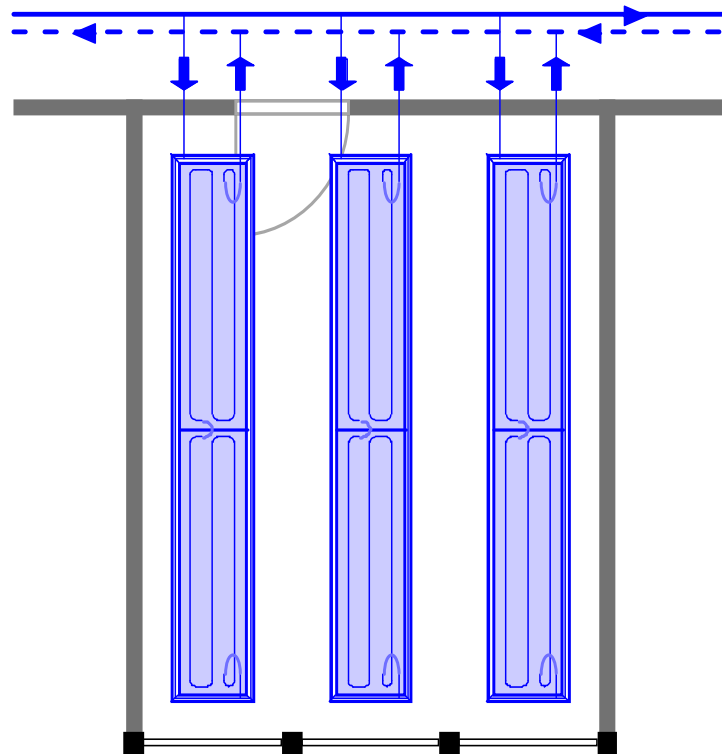
**Module Cavity
air-ducting**

Supply Air Ducts

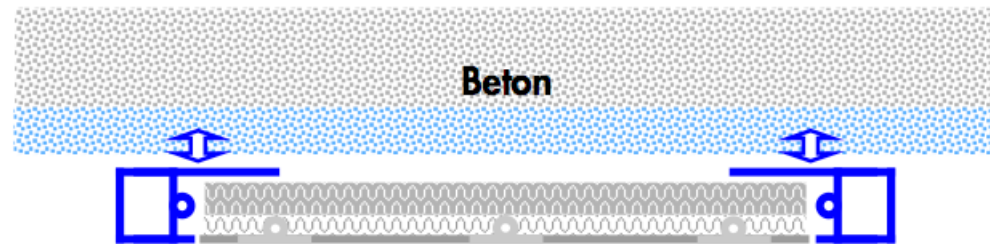
**The air jet is directed
at the concrete ceiling**



Hybrid Module U44^{Hybrid} – The Construction



Night Cooling Mode
Export of the heat quantity which was stored in the concrete the previous day

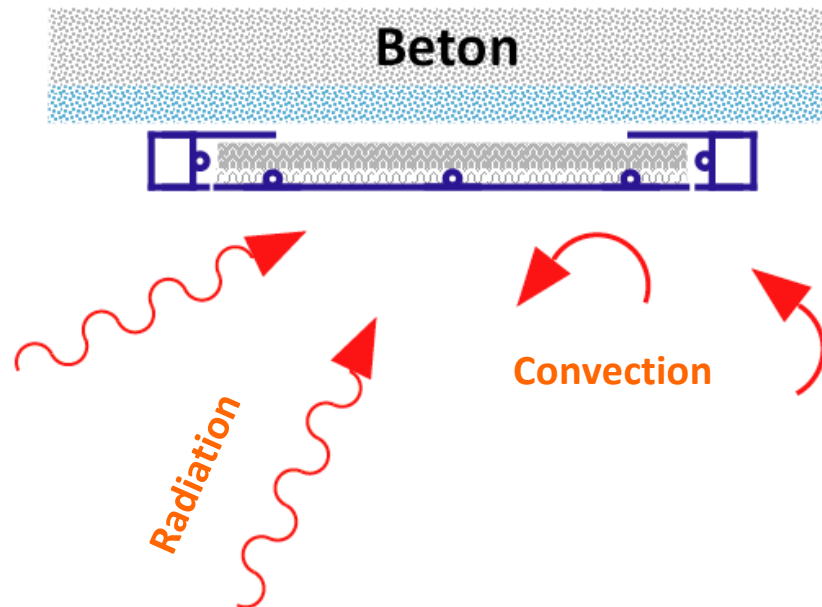


Heat transfer of the concrete ceiling in the lower area
(approx. 50 mm)
due to radiation

Hybrid Module U44^{Hybrid} – The Construction

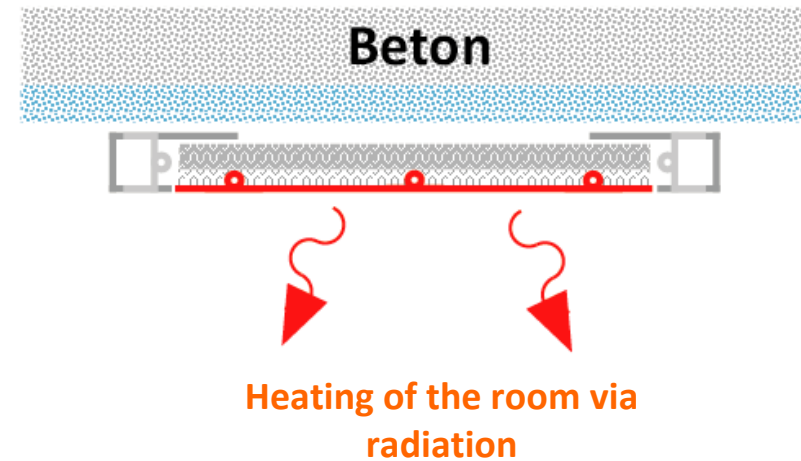
Day Cooling Mode

Export of the heat through the pre-cooled concrete ceiling and additionally through the fast reacting high-performance hybrid module



Heating Mode

The special construction of the hybrid module generates a radiation heating with the ceiling panels below. The concrete ceiling is not heated. This enables the fast and loss-free change-over to the cooling mode.



Hybrid Module U44^{Hybrid} – The Construction



Hybrid Module U46^{Hybrid}
Module per window axis



Hybrid Module U45^{Hybrid}
Cooling plates swung out



Ventilation connection section
in the ceiling cavity (floor)

Hybrid Module U44^{Hybrid} – The Construction



**Hybrid ducts in the ceiling cavity
aligned to the window axis**



**Hybrid ducts, view from above,
Activation – air pen stocks**

Hybrid Module U44^{Hybrid} – The Construction

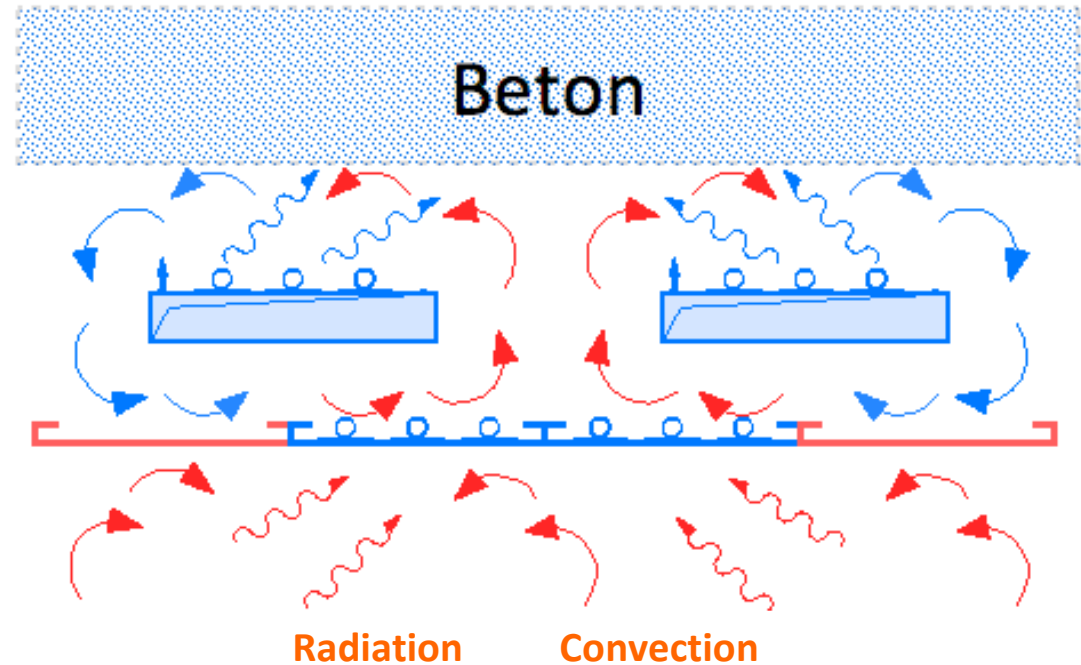


Hybrid Cooling Ceiling A11^{Hybrid} in Bandraster Design

Hybrid Module U44^{Hybrid} – The Construction



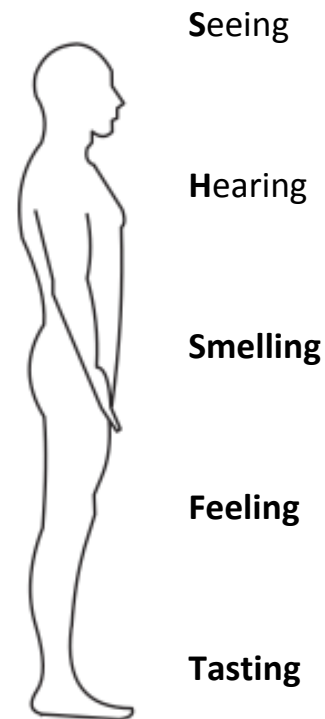
Hybrid ducts in the ceiling cavity,
cooling plates swung out



Cosiness and Comfort

Sensors and Senses of the Human Being

The human being perceives chemical and physical conditions of his environment with various sensors. The sensitivity range is relatively large.



Cosiness and Comfort

In order to control ambient conditions in regard to the **multi-dimensional comfort**, the same is subdivided into individual sections.

Thermically via the sense of warmth

Hygienically via the sense of smell

Hygric via the sense of warmth

Visually via the sense of sight

Acoustically via the sense of hearing

Electro-magnetically via the vital sense

Hybrid cooling ceiling has great influence

Hybrid cooling ceiling has medium influence

Hybrid cooling ceiling has little influence

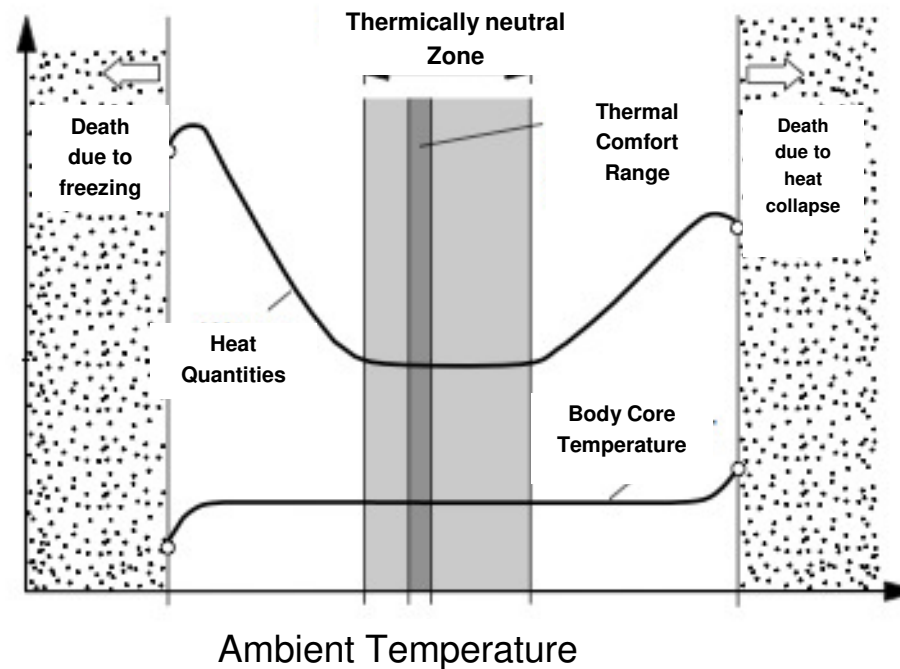
Hybrid cooling ceiling has medium influence

Hybrid cooling ceiling has medium influence

Hybrid cooling ceiling has no influence

Cosiness and Comfort

The **human being** belongs to the group of warm-blooded beings, the **body core temperature** of which is generally **consistent** and whose existence is dependent of a **permanent heat exchange**.



Source: W. Richter Manual of thermal comfort – summer cooling mode

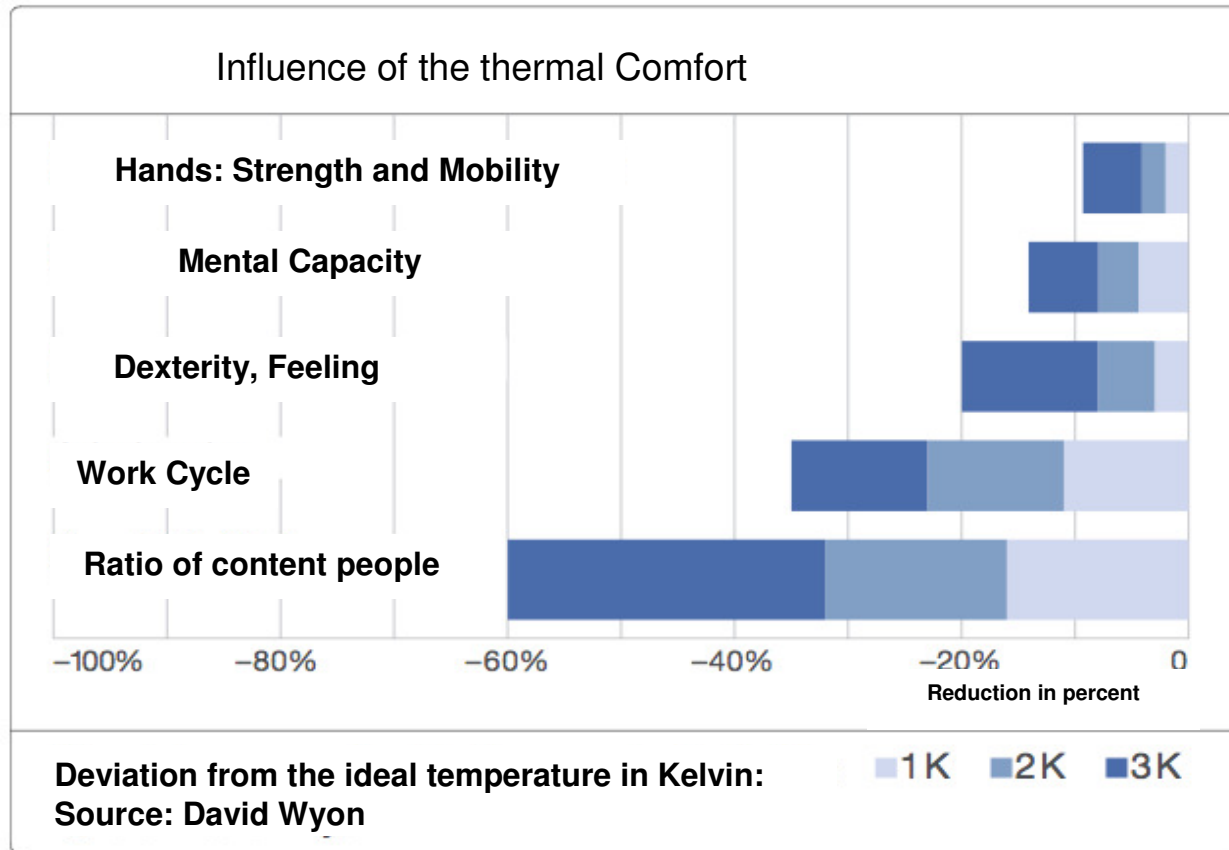
Cosiness and Comfort

The **human being**, depending on the occupation, feels comfortable in **different environments**.

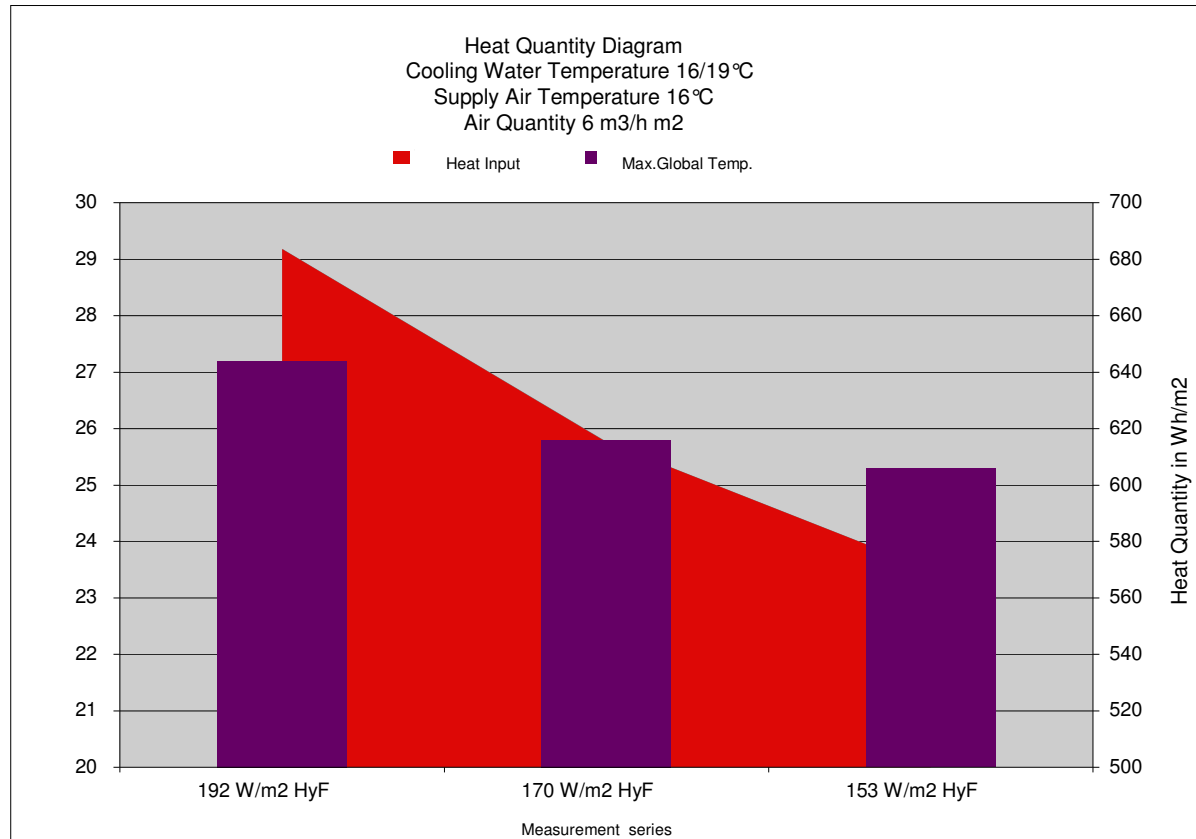
Comfort is given, if **none of the sense organs** is stimulated with such a **strong stimulus** that the body, as a whole, is induced to an **unwanted reaction**.

Comfort is therefore the **absence** of one or several **uncomfortable environmental conditions**.

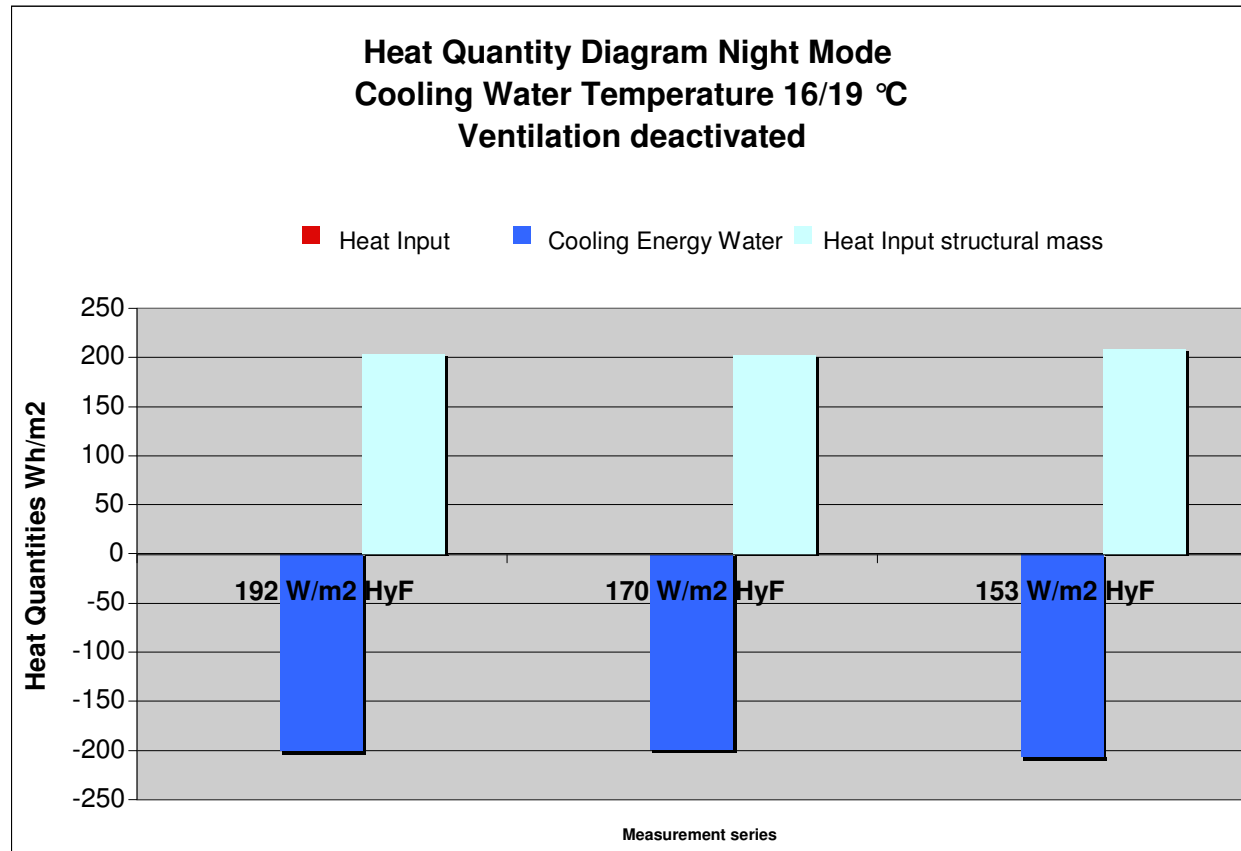
Comfort and Productivity



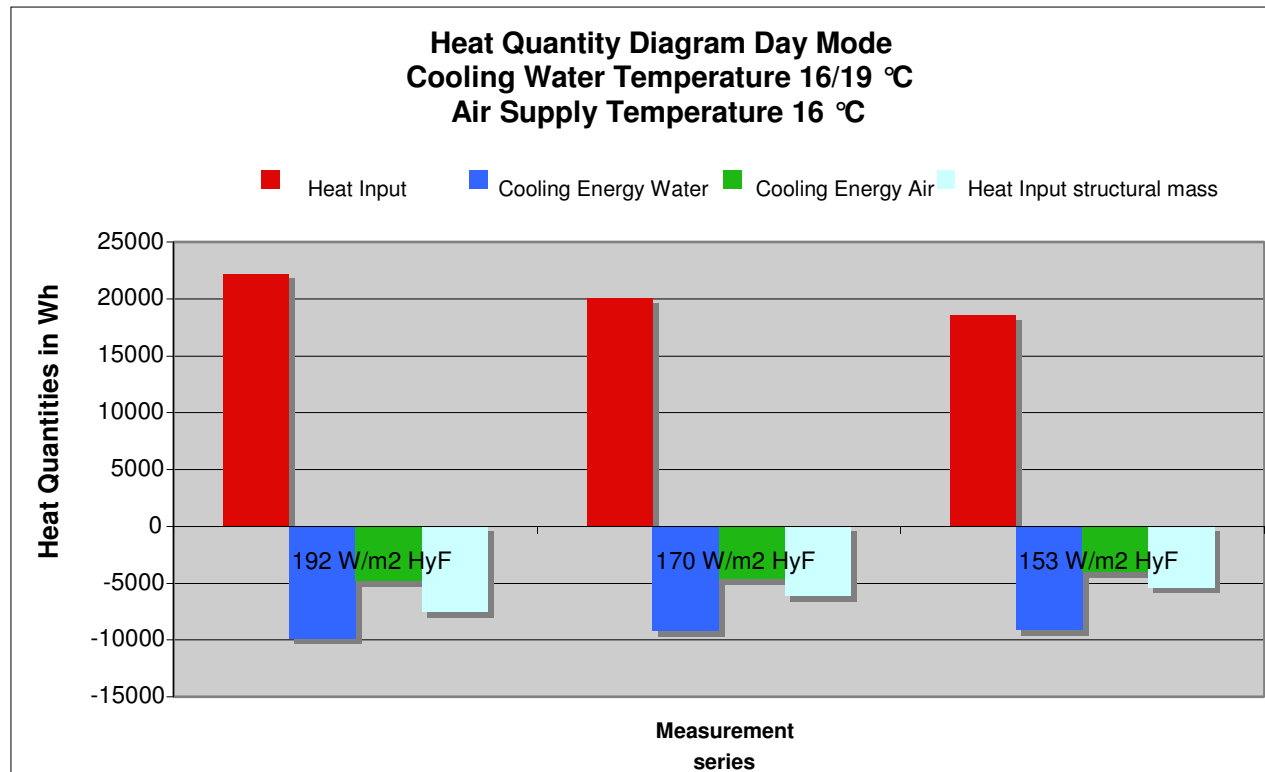
Hybrid Cooling Ceiling A11^{Hybrid} – Measurement Values



Hybrid Cooling Ceiling A11^{Hybrid} – Measurement Values



Hybrid Cooling Ceiling A11^{Hybrid} – Measurement Values



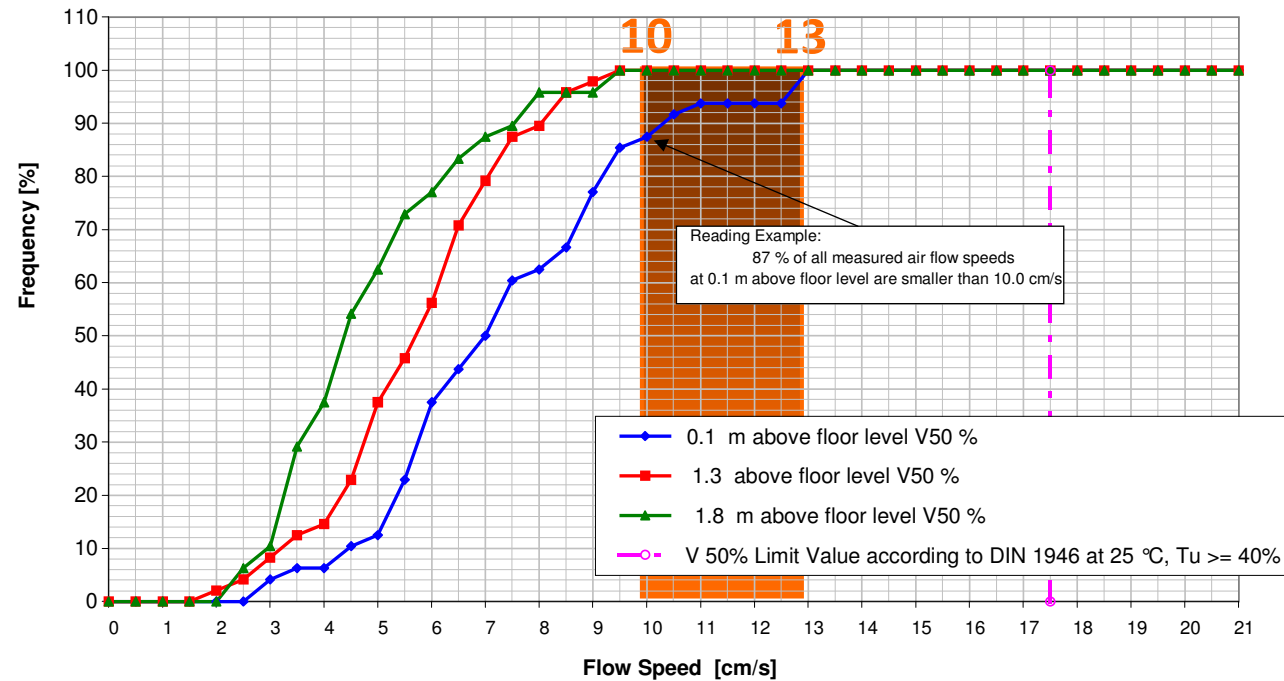
Hybrid-Module U45^{Hybrid} – Rooting of the Air Flow in the Room



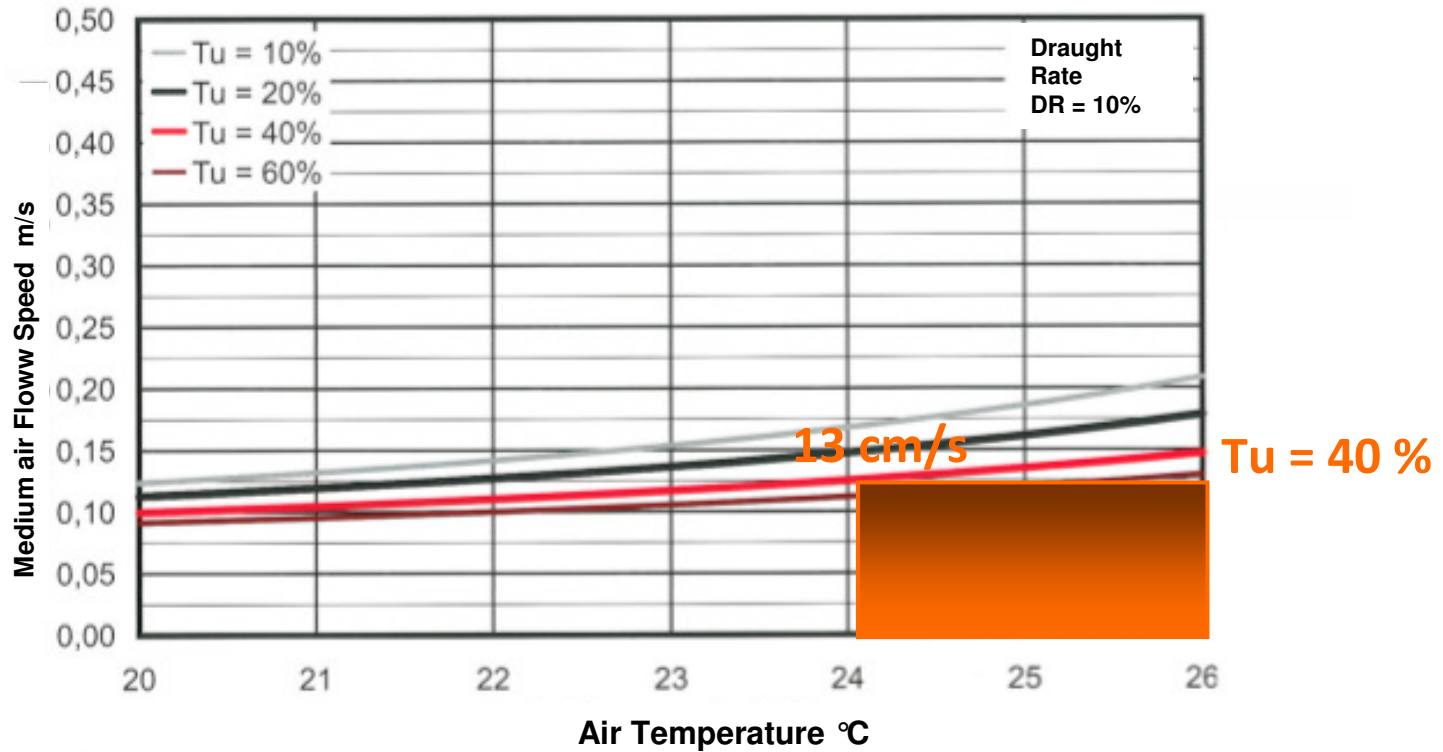
Hybrid Cooling Ceiling A11^{Hybrid}

Flow Speed of the Compartment Air Flow

Cumulative frequency of the Compartment Air Flow; 50% Time Value
 Air Volume Flow: 66 m³/h per axis



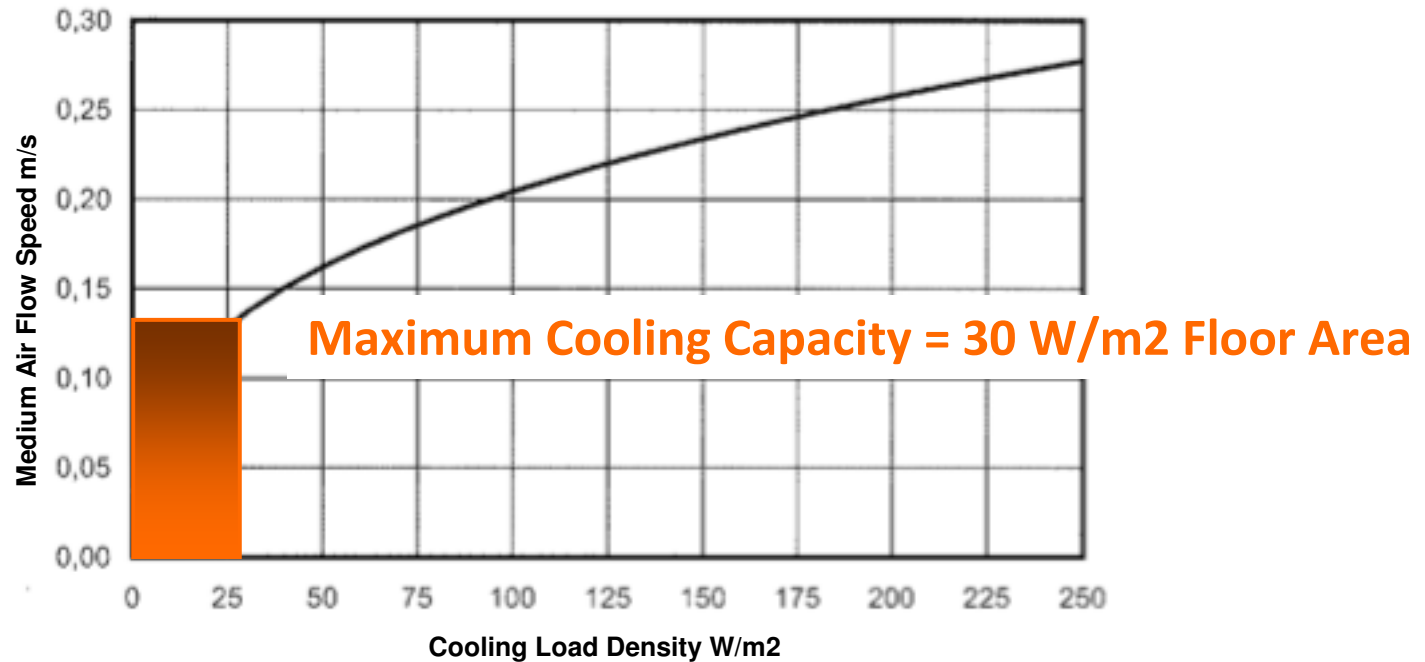
Hybrid Cooling Ceiling A11^{Hybrid} Flow Speed of the Compartment Air Flow



Maximum air flow speed in dependency of the local air temperature and of the intensity of turbulence according to DIN ISO 7730 – Category A accords to DR = 10%

Source: FGK Status-Report No. 17
Evaluation of the interior Climate

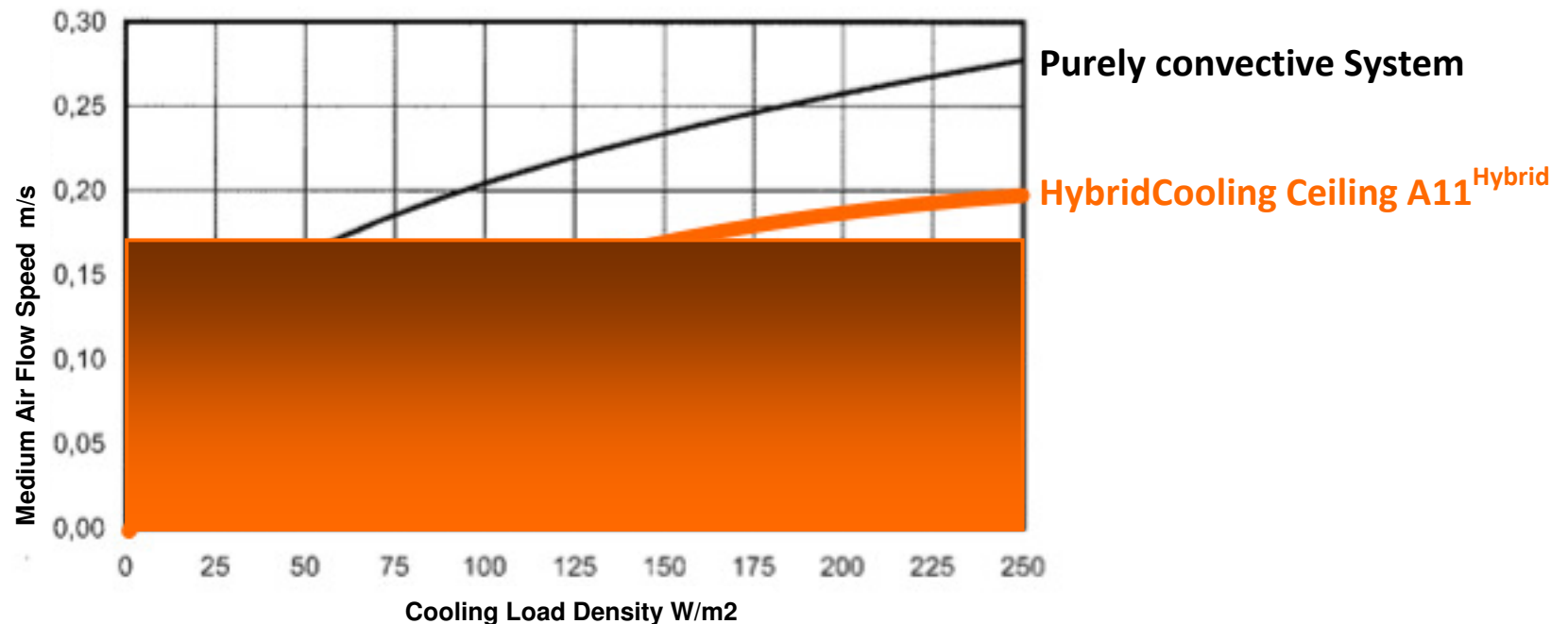
Comparison with a purely convectively operating System



Medium air flow speed in dependency of the cooling load density for turbulent mixed ventilation

Source: FGK Status-Report No. 17
Evaluation of the interior Climate

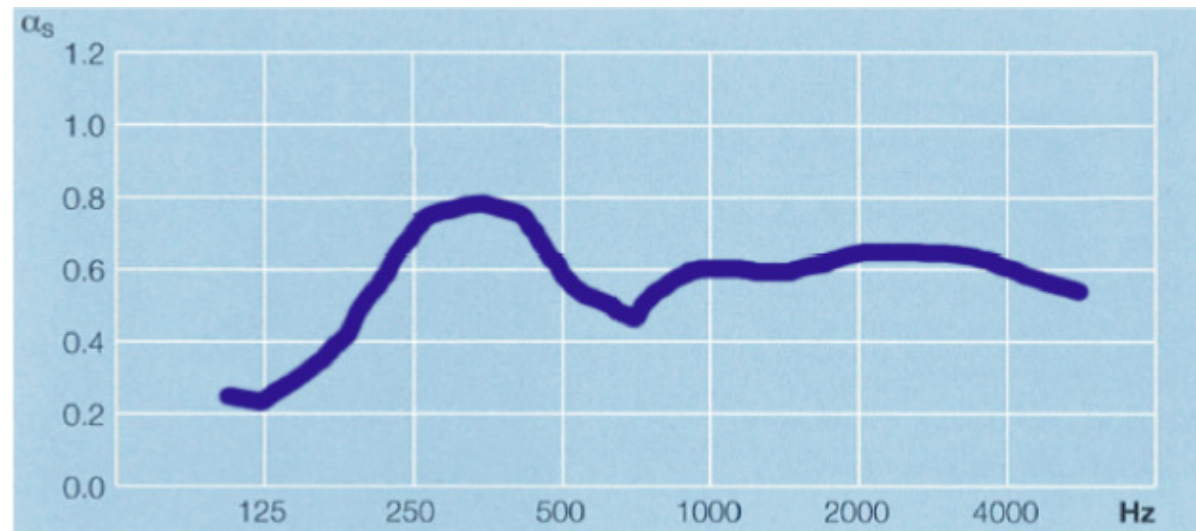
Comparison of the Hybrid Cooling Ceiling A11^{Hybrid} with a purely convectively operating System



At medium to high cooling loads, a comfortable cooling can not be achieved without radiation exchange

Hybrid Cooling Ceiling A11^{Hybrid} – Acoustic Absorption

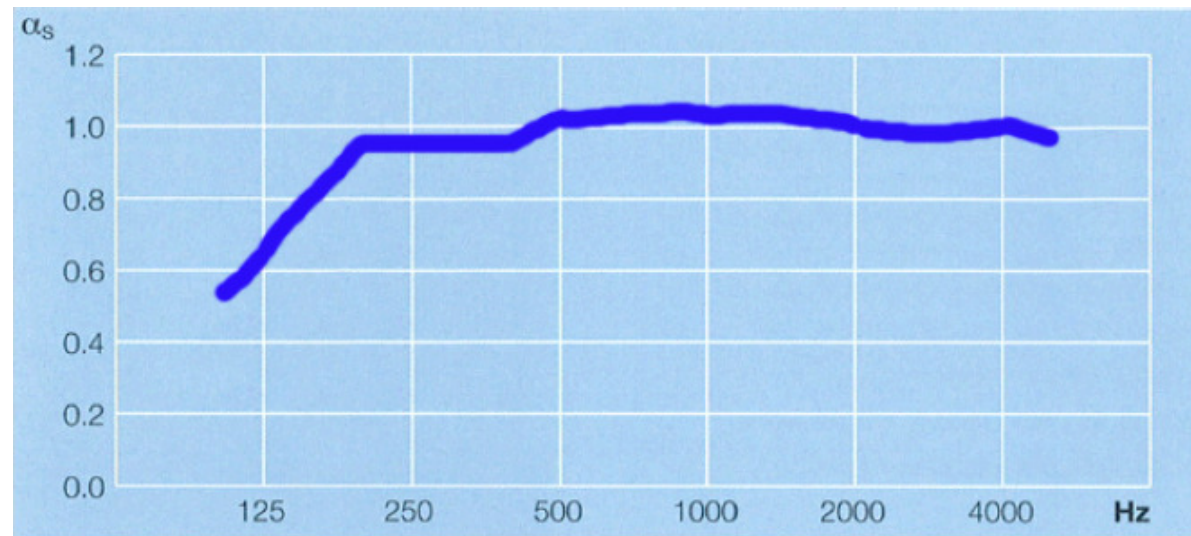
Static Acoustic Absorbance



Hybrid Cooling Ceiling Panels Perforation Rg1522 with Acoustic Fleece

Hybrid Module U45^{Hybrid} - Acoustic Absorption

Static Acoustic Absorbance



HybridModule Panels Perforation Rg1522 with acoustic mat 60 kg/m³, s=30 mm,
Visible surface coated with black glass-fibre fleece, rear side with aluminium foil

Acoustic Comfort – Guideline Values

Type of Room	Sound Level dB(A)	Reverberation Period s
Hospital Room Day/Night	30/25	1
Radio-/TV-Studio	15/25	1/1,5
Theater/Opera House	30/25	1/1,5
Concert Hall	25	2
Auditorium/Reading Room	30/28	1
Conference Room	30	1
Individual Office/Open-Plan office	30/35	0,5
Restaurant	35 ... 45	1

Air Quality – Air Pollutants

Limit Value

Exposure limit beneath which there is no risk, but above which undesired effects can possibly be expected.

Guideline Value

Concentration of a substance hazardous to health without legal force.

Precautionary Value

Medically relevant concentration, mostly smaller than the limit value.

Target Value

Reasonable basic load of a substance.

Air Quality – Air Pollutants

Pollutant		Concentration	Effects
		1 Vol-% = 10'000 ppm	
CO ₂	Breathable Air	4 ... 5 Vol%	impaired vision, dizziness, ...
	TLV Workplace	0,5 Vol%	
	Limit Value	0,15 Vol%	
	Target Value	0,1 Vol%	
CO	Limit Value	0,0005 Vol%	lack of oxygen in blood, blood becomes thicker, cohesive
Radon Guideline Value		400 Bq/m ³	lung cancer
TVOC	Target Value	0,3 mg/m ³	headache, impairment of nerve system ...
Sum of the volatile organic matters			

Source: Introductory
Lecture
Prof. Hansjürg Leibundgut,
ETH Zürich

Hybrid Cooling Ceiling A11^{Hybrid} – Ventilation Efficiency ϵ_V

The ventilation efficiency characterises how effectively pollutants which occur in a room are exported.

$$\epsilon_V = \frac{C_E - C_0}{C - C_0}$$

$$\epsilon_V = \frac{C_E}{C} \quad \text{bei } c_0 = 0$$

C_E = Pollutant concentration in the outlet air

C = Pollutant concentration at the measurement location

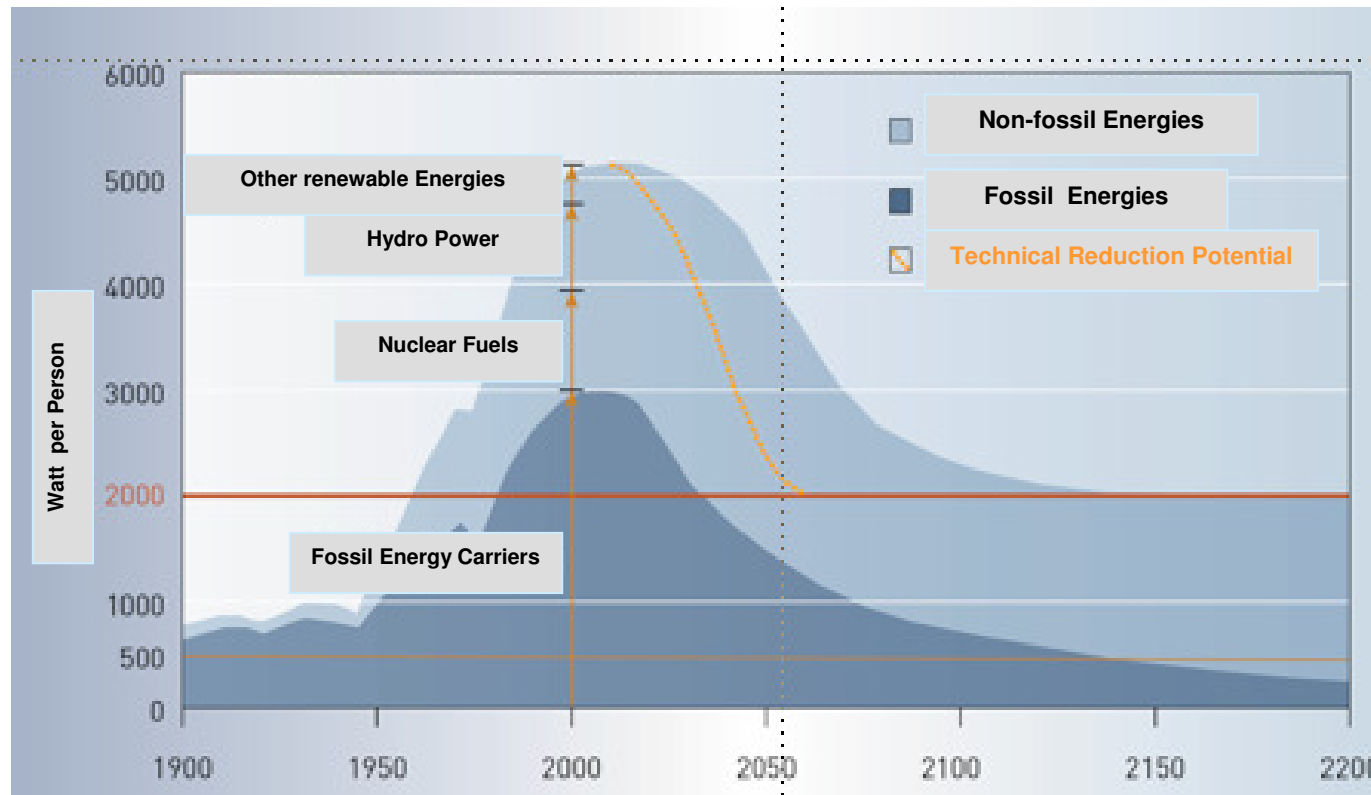
C_0 = Pollutant concentration in the supply air

The Ventilation Efficiency ϵ_V of the Hybrid Cooling Ceiling A11^{Hybrid}

At an air quantity of 6 m³/h m² $\epsilon_V = 1.5$

At an air quantity of 12 m³/h m² $\epsilon_V = 1.9$

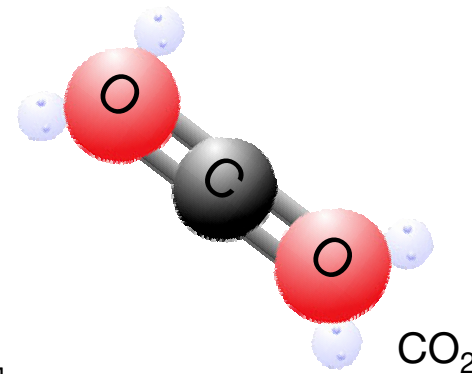
Energy Consumption and CO₂-Emission



Source: Lecture
Prof. Urs Rieder
Head of Department
Building Engineering
HTA Luzern

Energy Consumption and CO₂-Emission

„The scenario of the 2000-Watt society serves as a target for energy and climate policies. This, on the long term, would require a reduction of the greenhouse gases (primarily CO₂) to a sustainable value of 1 ton per head and the coverage of the energy demand at a ratio of 500 Watt/head from fossil and 1500 Watt/head from renewable energy carriers.“



„Strategy Sustainable Development 2002“ of the Swiss Federal Council, March 2002, Page. 24

Energy Consumption and CO₂-Emission

Energy Efficiency – Utilisation of the Potentials

Cooling Medium Water

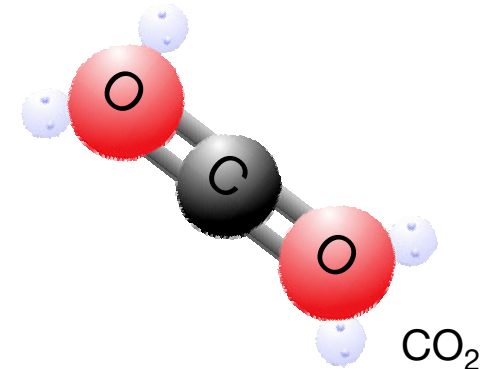
80 % of space cooling is conducted via cooling water

Active Utilisation of the structural Mass

1/3 of the energy is buffered and discharge in the nighttime

High Cooling Water Temperatures

16 .. 18 .. 20 °C



Energy Consumption and CO₂-Emission

Energy Efficiency – Utilisation of the Potentials

Demand-dependent Control

Quantity –variable and VV/S -capable without system restrictions

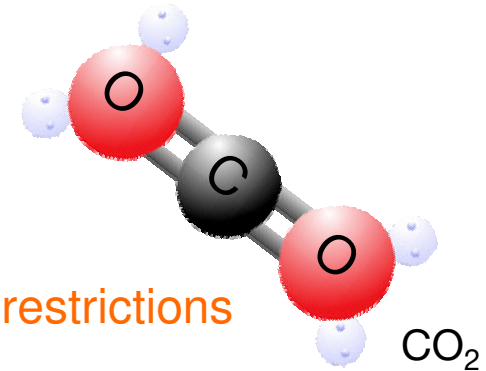
Loss-free change-over from heating to cooling

Fast reaction capability to changing thermal loads

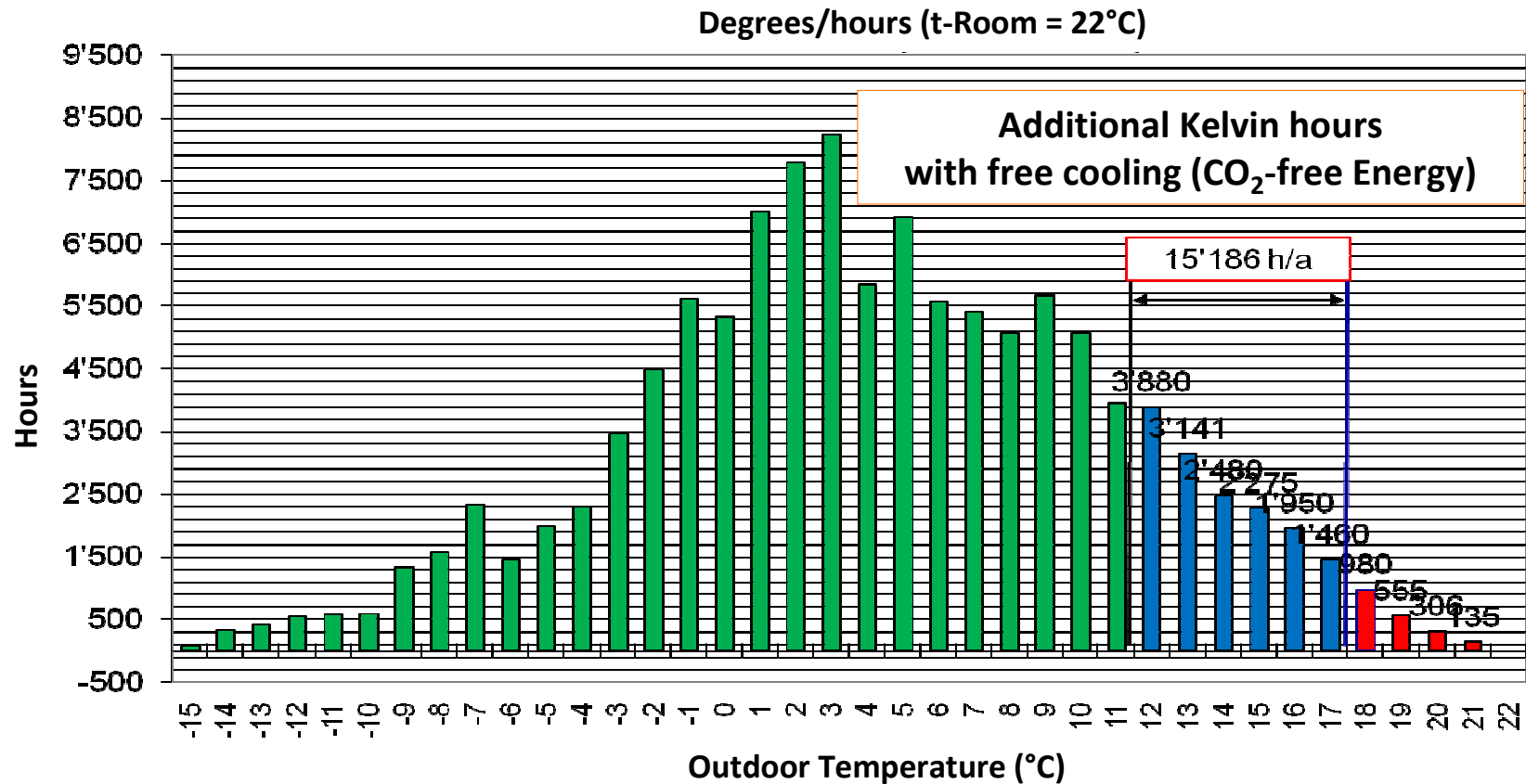
Response time (delay time) equal to cooling ceilings

Heat exchange with high radiation ratio

Compartment Air Temperature 1..2 K via (felt) Room Temperature



Energy Consumption and CO₂-Emission



Energy Consumption and CO₂-Emission

Comparison of the hybrid cooling ceiling to a conventional system (VVS-System)

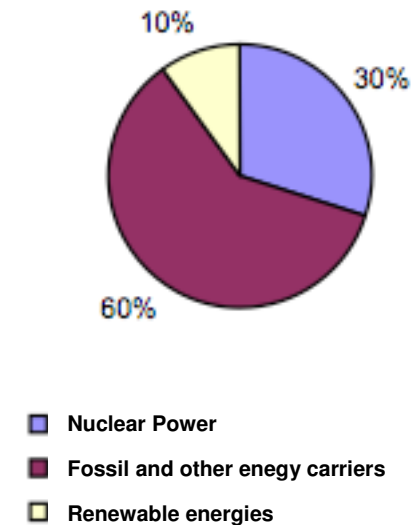
Saving of electrical Energy 20.1 kWh/m² a
11'055 g CO₂/m² a

Saving Thermal Energy 24.8 kWh/m² a
4'960 g CO₂/m² a

At 10 m² per person, the annual reduction of the CO₂-emission per person is

160.2 kg CO₂

Electricity Mix - Germany



CO₂ Emissions 550 g/kWh

Energy Consumption and CO₂-Emission

Comparison of a hybrid cooling ceiling to a conventional cooling ceiling

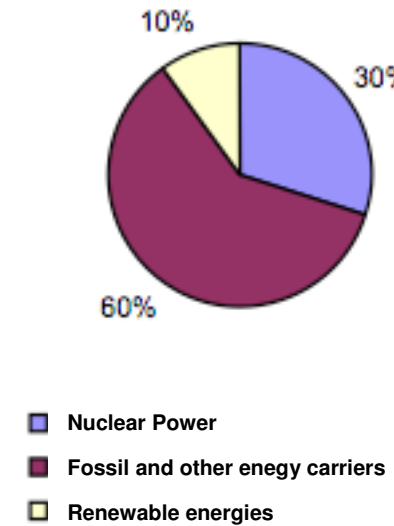
Saving electrical Energy 10.8 kWh/m² a
5840 g CO₂/m² a

Saving thermal Energy 3.6 kWh/m² a
720 g CO₂/m² a

At 10 m² person, the anual reduction of the Co₂-emission per person is

65.6 kg CO₂

Electricity Mix - Germany



CO₂ Emissions 550 g/kWh

Energy contra Comfort

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The conscious and sparing handling of energy is not necessarily connected with a loss of comfort.

In a comfortable state, the metabolism of the human being is only exposed to minimum amount of stress. This results in great power reserves and a low level of fatigue.

For this reason, comfort is neither a luxury nor excessive comfort but should be regarded as the decisive prerequisite for good health and a good work performance.

Thank you very much for your attention!
