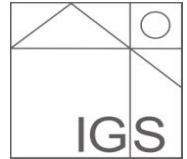




**Technische
Universität
Braunschweig**

Institut für Gebäude- und Solartechnik
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Case studies of indoor climate design in nonresidential buildings in Germany

Institute of Building Services and Energy Design

Department of Architecture

Univ. Prof. Dr.-Ing. M. Norbert Fisch

last update: 08.05.2014



Technology and Innovation Network MNF

UNIV.-PROF. DR.-ING. **M. NORBERT FISCH**

Stuttgart · Braunschweig · Aachen · Shanghai · Bangkok



Steinbeis-TZ
Stuttgart



EGS-plan
Stuttgart



Energydesign
Braunschweig



EGSplan Int.
Bangkok



Institut für Gebäude-
und Solartechnik IGS
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Synavision
RWTH Aachen
TU Braunschweig

Partner in
Research
+ Science

renewable
energy applications

integral
energy concepts

building
physics

building
services

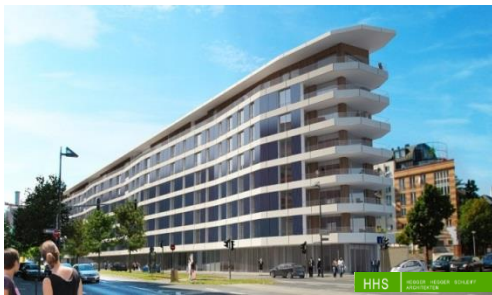




- holistic sustainable renovation of urban quarters



- energetic process optimization
 - buildings on the test bench



- net-plus energy buildings

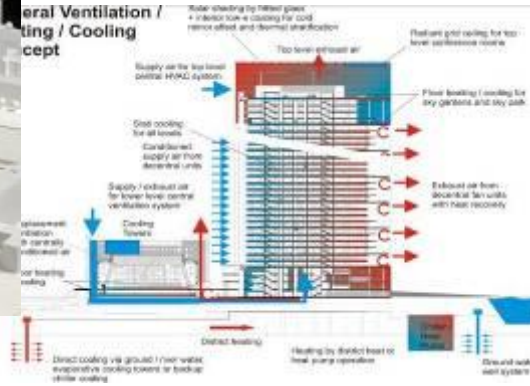


- export: energy efficiency and use of renewable energies
(→ German engineering)

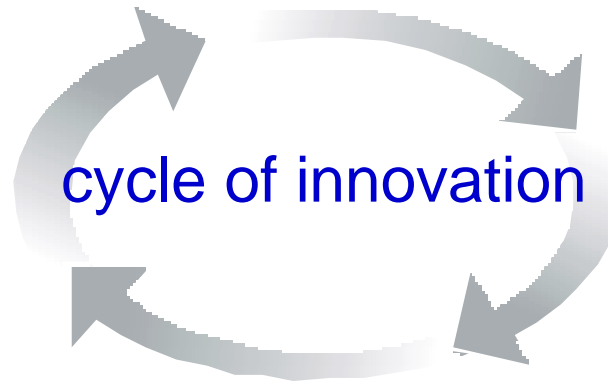
concept - design – construction - operation



concept
design process



construction
 realization
 quality control



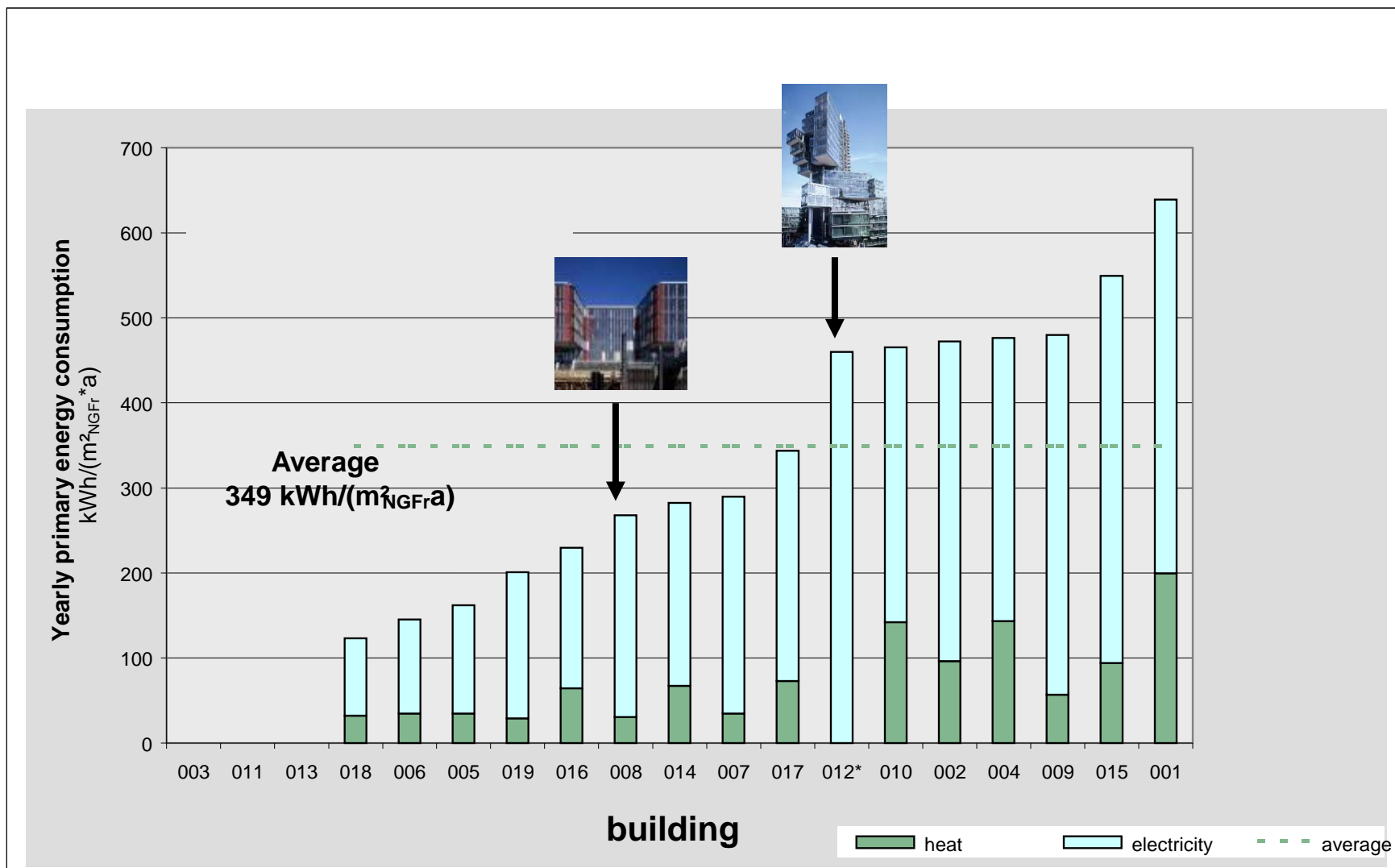
monitoring, evaluation optimizing
operation



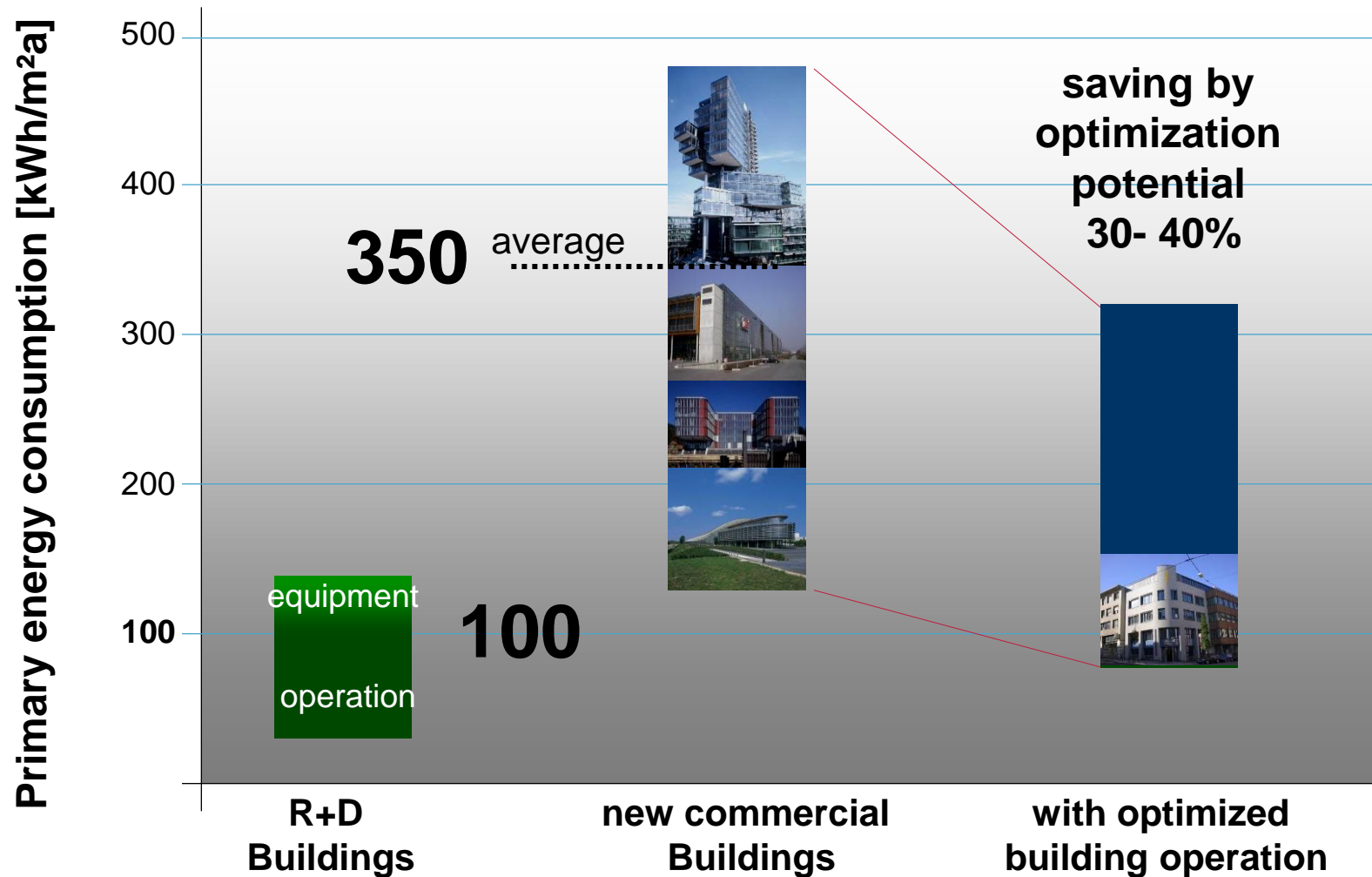
Case study of about 40 commercial buildings with **Primary Energy (PE) < 100 kWh/(m²a)**



Primary energy consumption – new office buildings

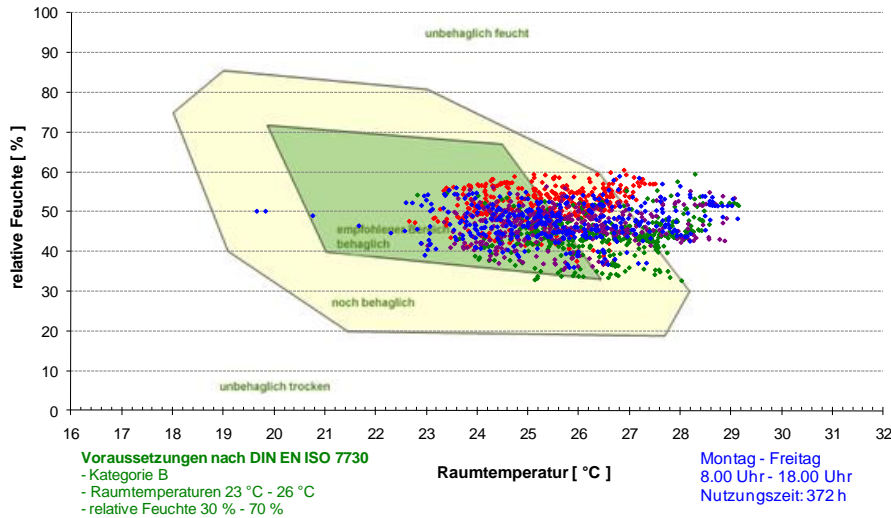


Energy- Optimized Building

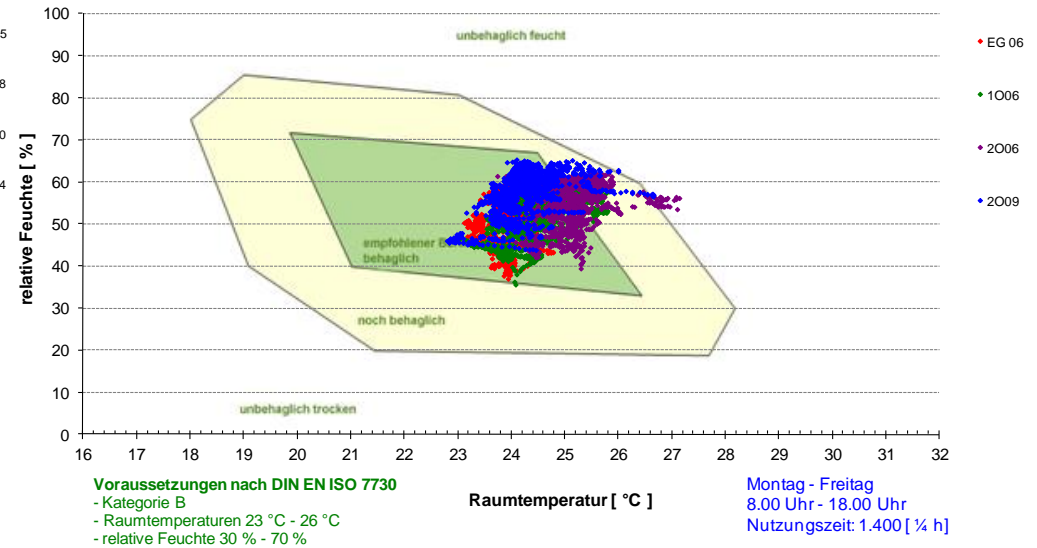


Room comfort long-term measurement Comparison Before - After

Thermische Behaglichkeit am Arbeitsplatz: REHAU Verkaufsbüro Wien
Abhängigkeit von Raumtemperatur und Relative Feuchte
Betrachtungszeitraum 23.06.2010 - 10.08.2010



Thermische Behaglichkeit am Arbeitsplatz: REHAU Verkaufsbüro Wien
Abhängigkeit von Raumtemperatur und Relative Feuchte
Betrachtungszeitraum 25.06.2012 - 10.08.2012



Before optimization:

Temperature-related discomfort (overheating in summer)

After optimization:

Significantly higher room comfort

Comprehensive concepts demanding
new requirements for
**Design, Construction,
Commissioning and Operation**

New Office Buildings



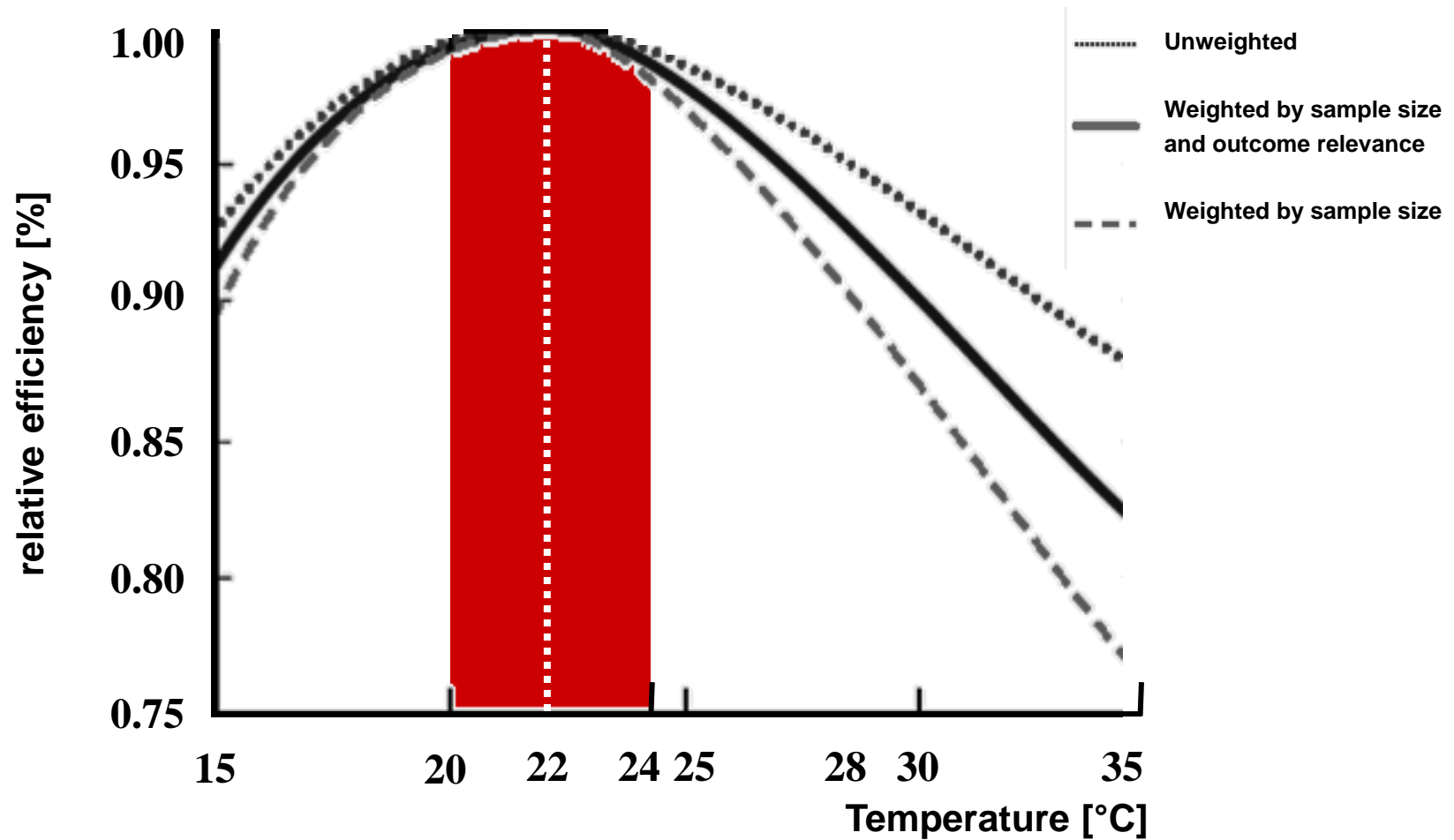
Indoor Environment Qualities make the difference:



Room Temperature
Ventilation
Daylight
Acoustics



Performance in relation to the indoor temperature



Spot monitoring for thermal comfort in office buildings



Field study

- 30 office buildings

Spot-Monitoring

- Indoor climate parameters
- User survey



Ernesto Kuchen: Spot-Monitoring zum thermischen Komfort in Bürogebäuden, Dissertation 2008

Concept of Spot Monitoring

1. Indoor climate parameters:

- Measurement per room
- Duration 5 minutes
- Winter, summer and transitional period
- Evaluation according to DIN EN ISO 7730

2. User survey:

- Specifying the parameter
- Evaluation of room conditions

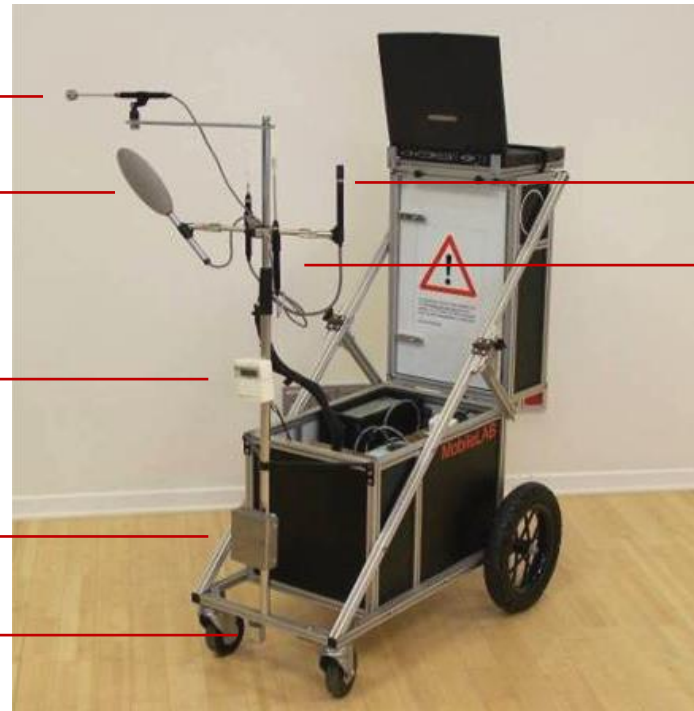
Radiation asymmetry

Data logger

CO₂ - Sensor

VOC

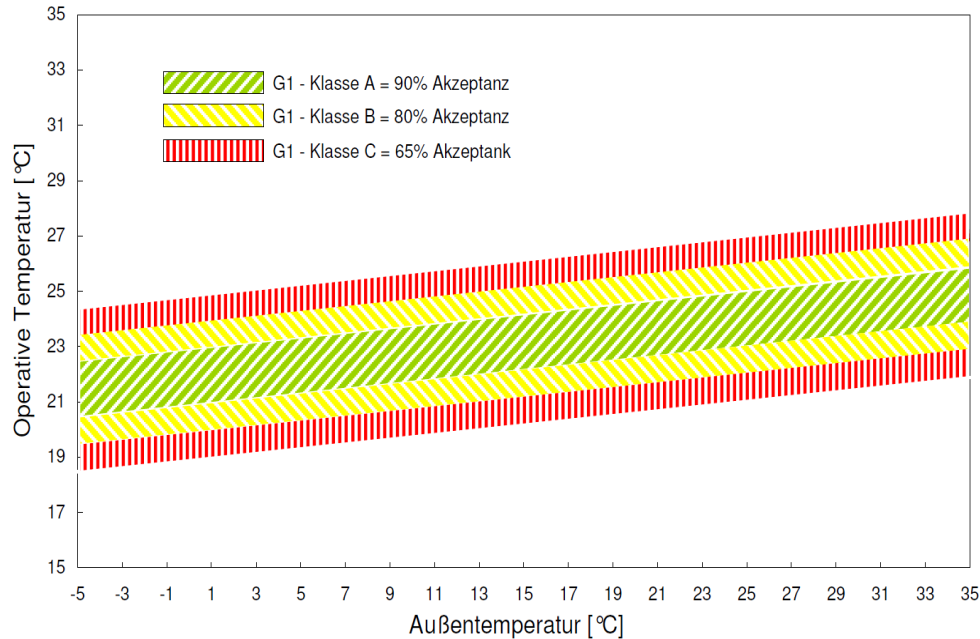
Temperature



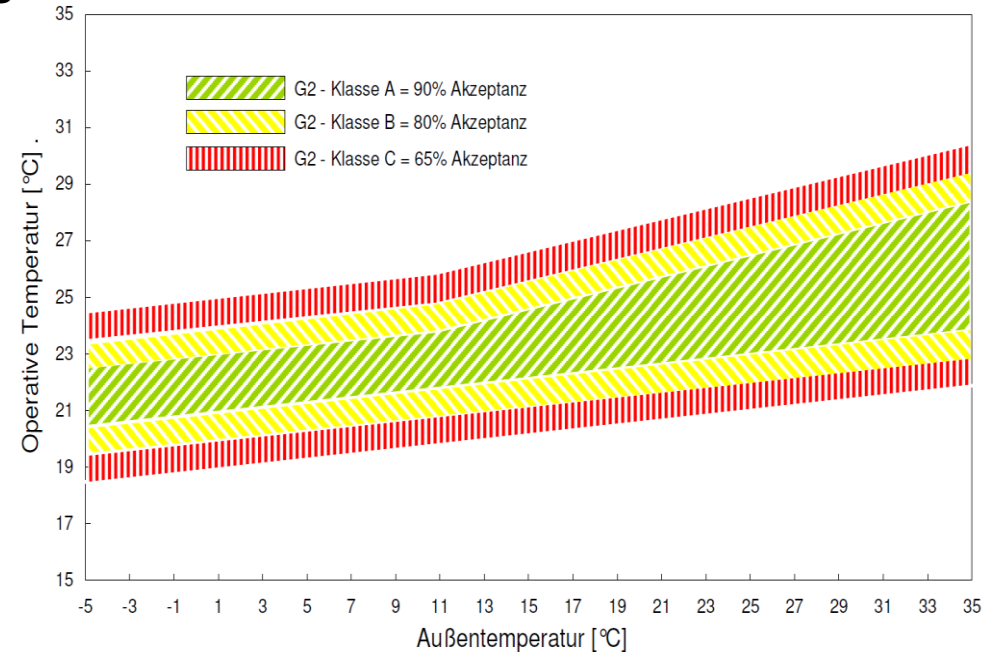
Humidity

Air velocity

Rooms with partial and full air-conditioning



Rooms with natural ventilation



Comfort zones of the operative room temperature depending on the outside air temperature

Adaptability of the user greater in naturally ventilated areas than in partially and fully air-conditioned rooms

Ways to avoid **overheating** in summer

in renunciation of active cooling

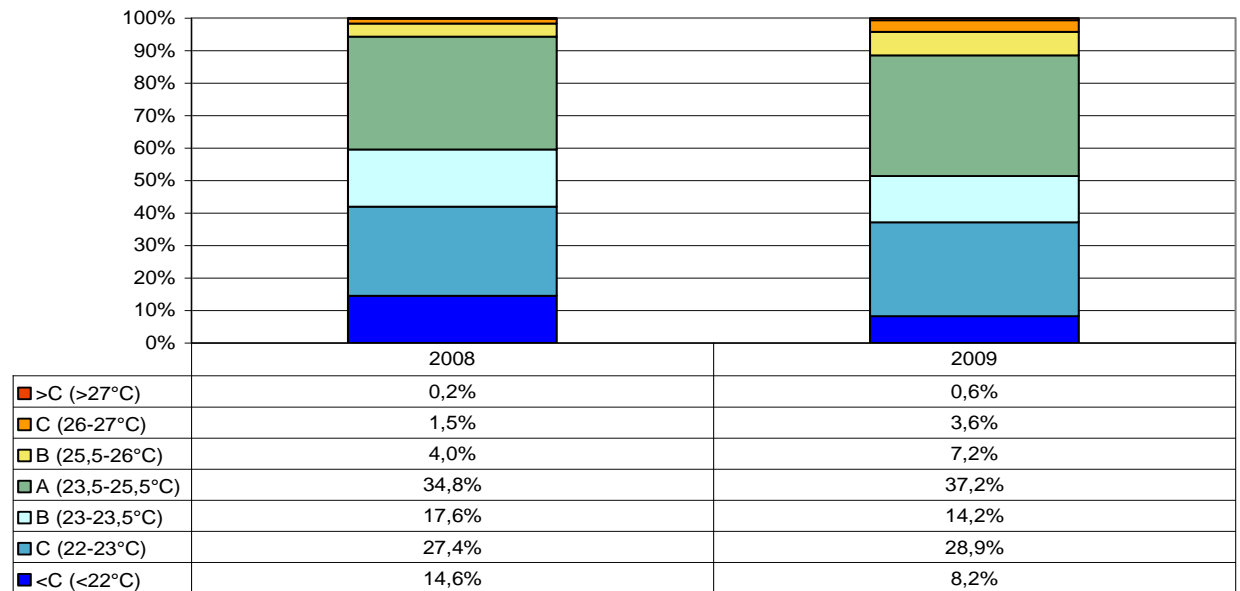
- Large storage mass
- Exterior sun protection
- Limited internal heat loads



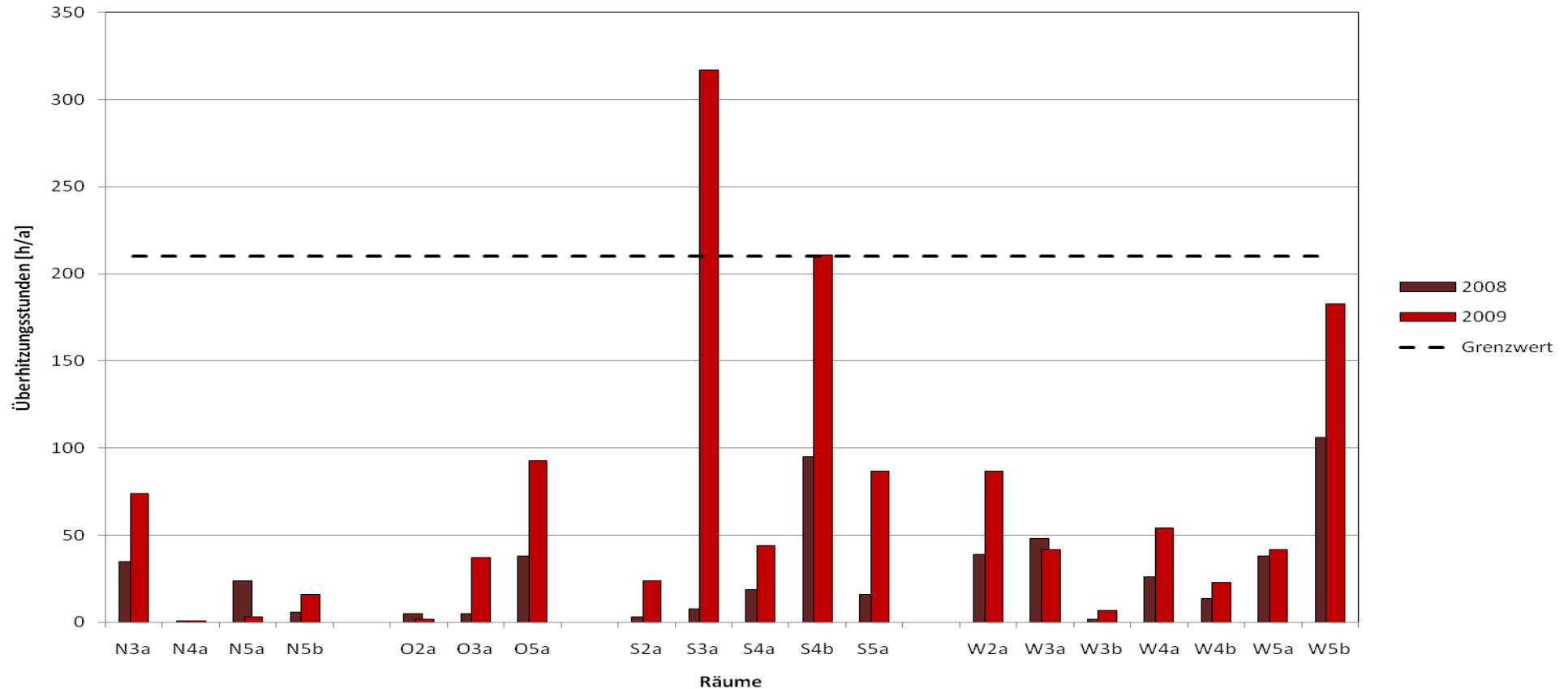
Measurement of the room temperature

Summer 2008 and 2009

Shares of its useful life (mean 24 rooms)



Overheating depends heavily on the individual user behavior!



Comparison of the year overheating hours > 26 ° C

use in time 2008 (4.392 h / a) and 2009 (4.380 h / a)

Limit according to functional Specifications (210 h / a)



Photo documentation

General conditions

- Outside temperature > 25°C
- Clear sky
- High radiation exposure

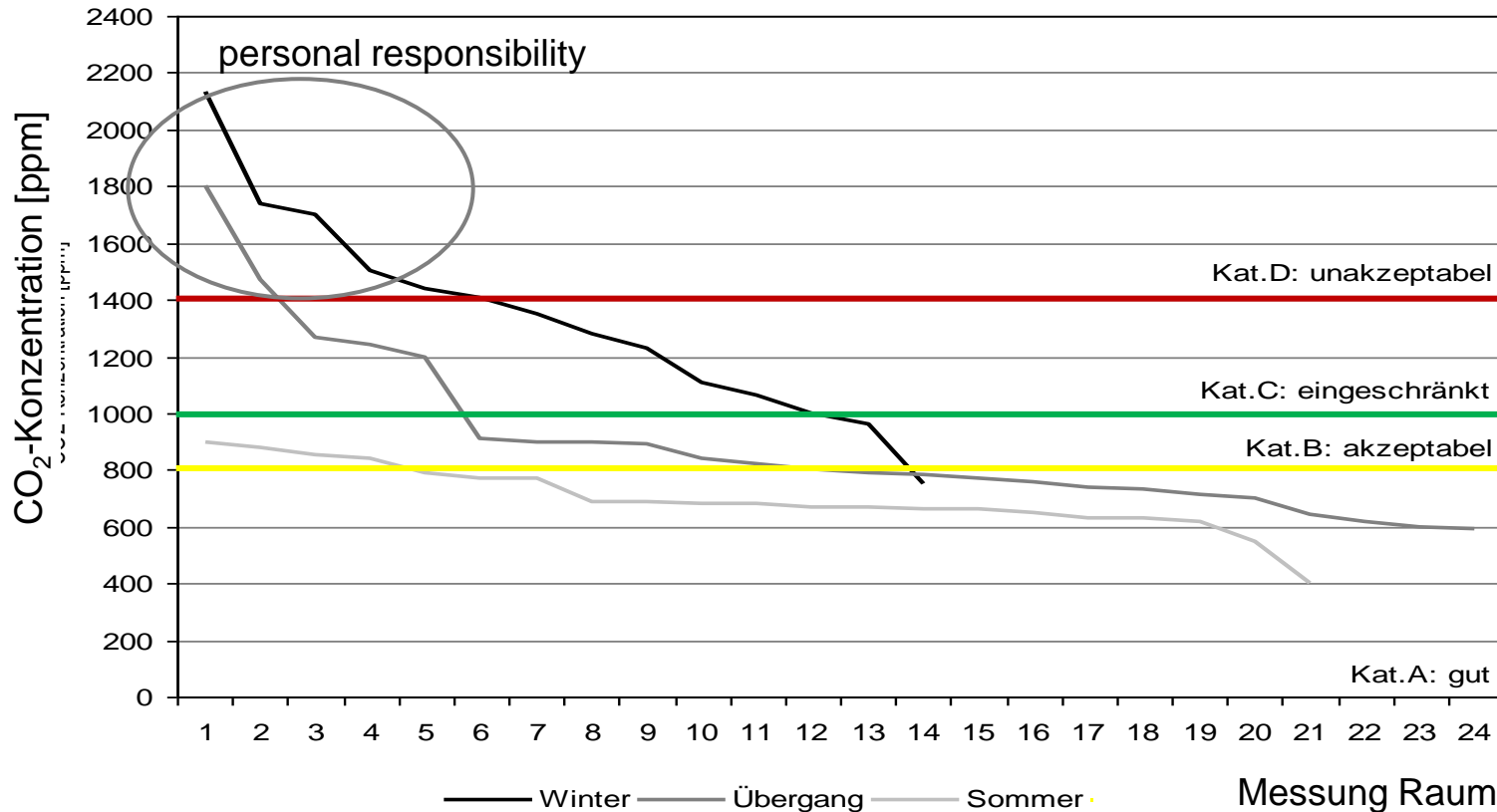
Window open

Sun protection (automatic!)
disabled by the user

Uncontrolled possible overheating despite passive cooling!

offices with personal responsibility manual window ventilation

human operator:
good indoor environment quality possible!



CO₂-concentration

Number of all room
 measurements in
 summer, winter and
 transition

20 m² Surface
 2 Pers.
 Windows „Tilt & Turn“

Indoor Environment Qualities make the difference:



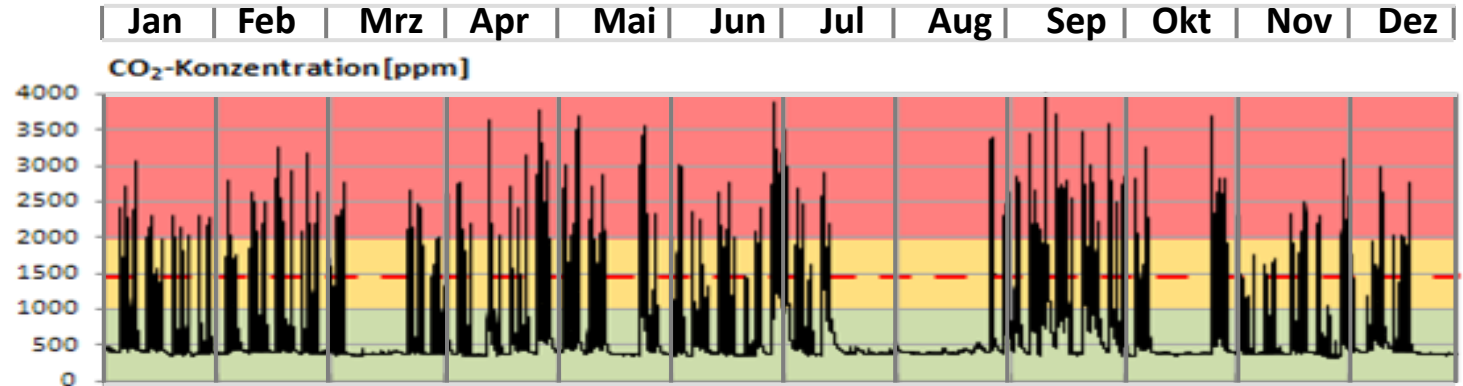
Room Temperature
Ventilation
Daylight
Acoustics





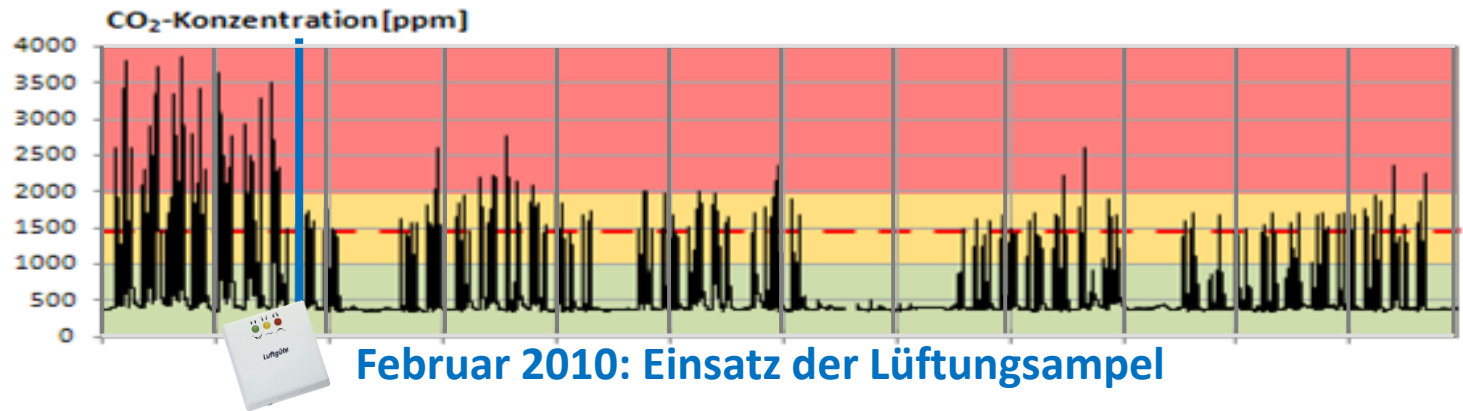
Room 16

- freely ventilated
- 2009
- guided



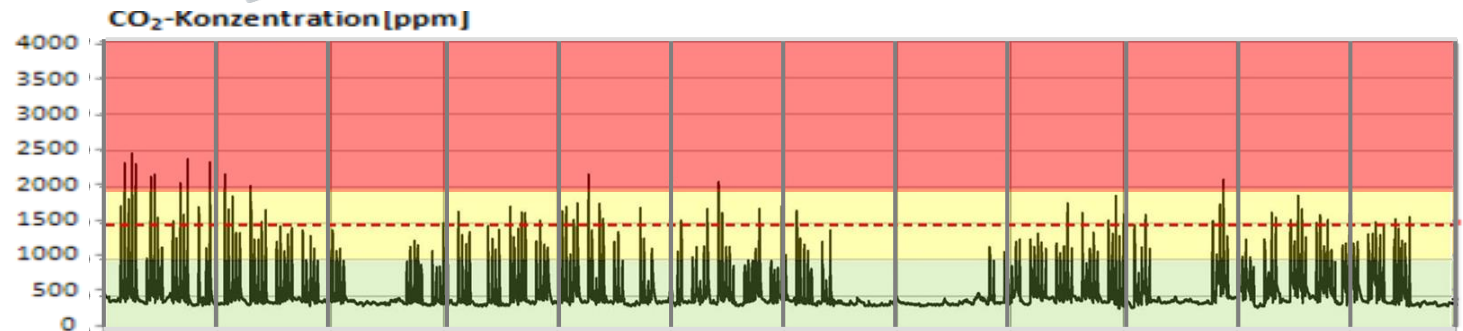
Room 16

- freely ventilated
- 2010
- guided

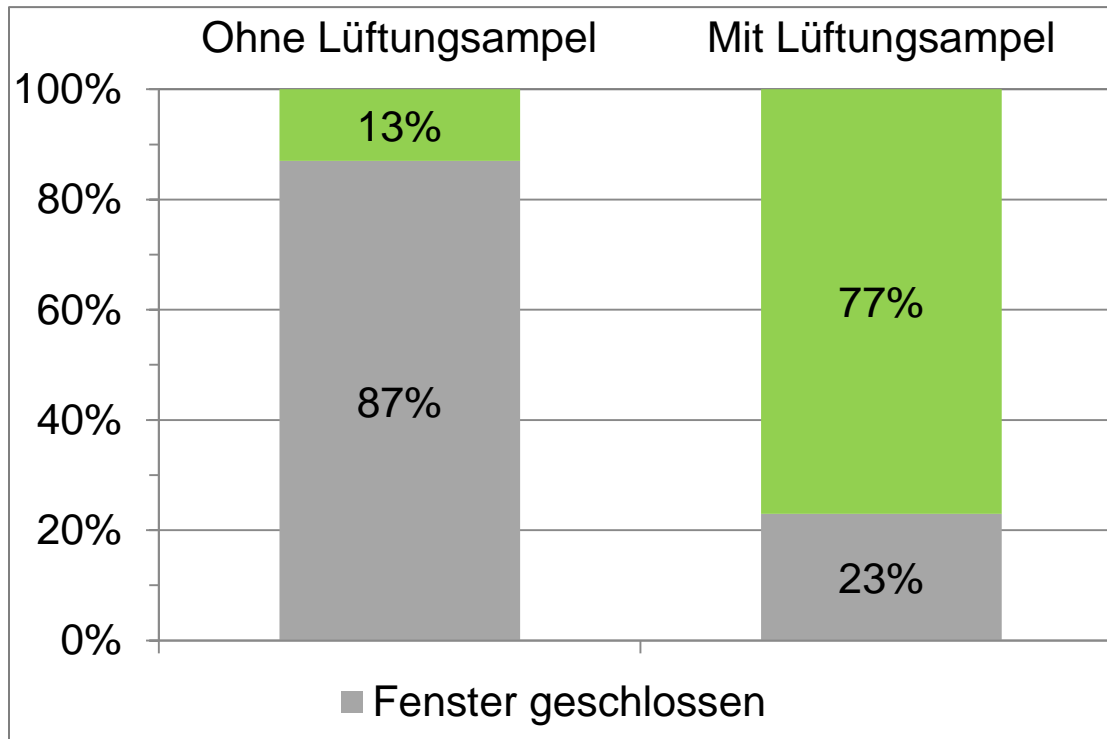


Room 13

- mech. ventilated
- 2009



**Motivated ventilation using ventilation traffic lights
 in young students (elementary schools) is possible.**



Quelle: Dissertation Jennifer König (IGS, TU Braunschweig)

- Field studies in a secondary school in Wolfsburg
- On two winter days
- Classroom with mechanical ventilation and with clear window
- 5 classes, 104 students
- **Performance tests in two ventilation scenarios**

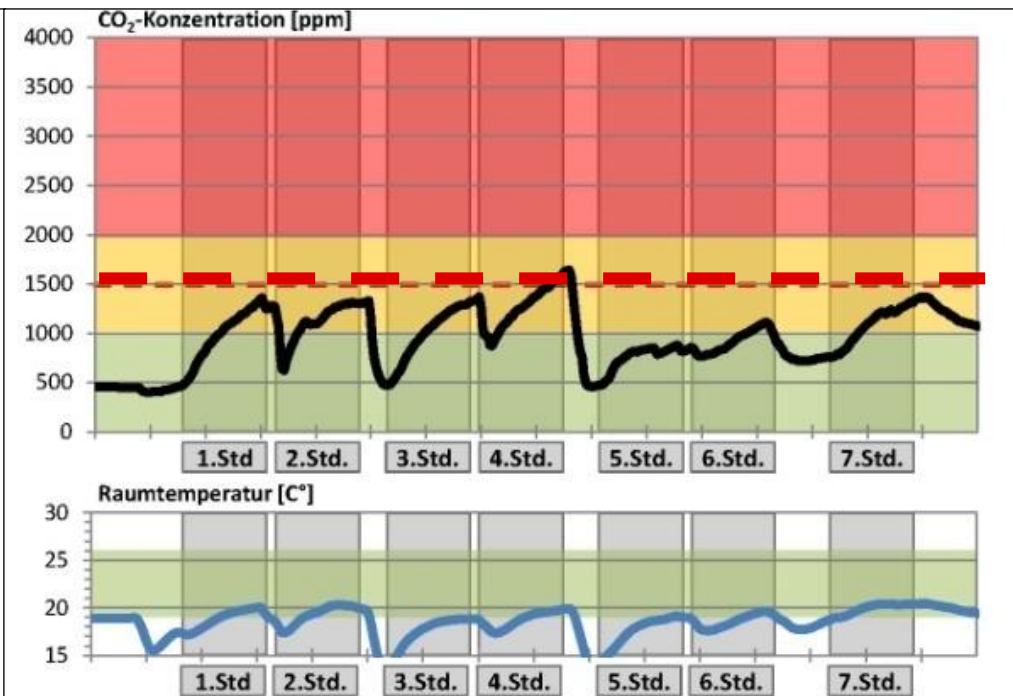
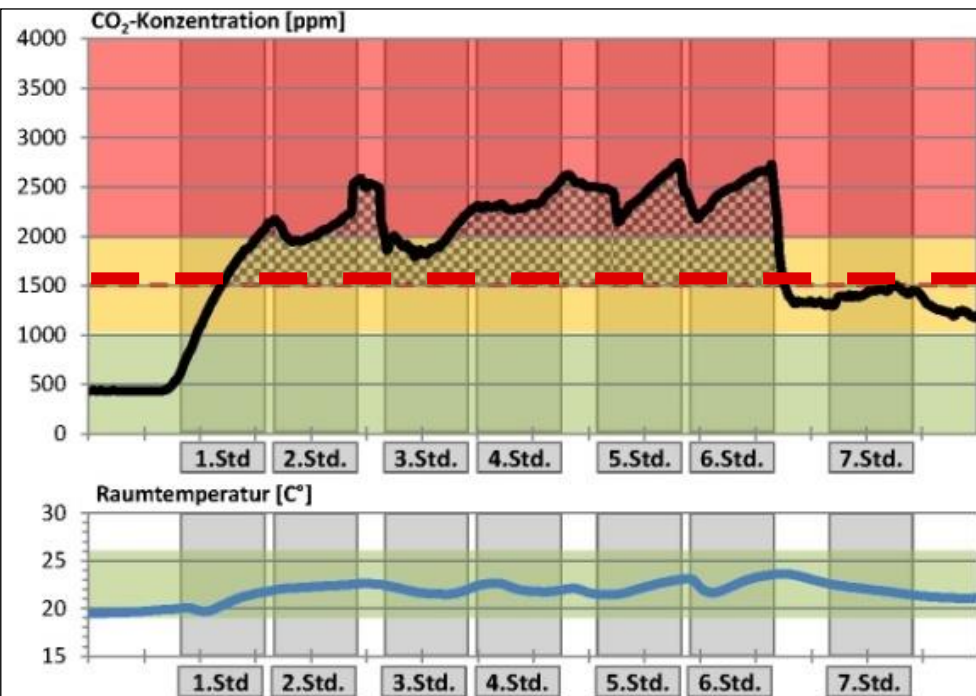
1	2	3	4	5	6	7	8	9																
÷)	+	┌	└	√	(÷	└																
2	1	4	6	3	5	2	1	3	4	2	1	3	1	2	3	1	4	2	6	3	1	2	5	1
3	1	5	4	2	7	4	6	9	2	5	8	4	7	6	1	8	7	5	4	8	6	9	4	3
1	8	2	9	7	6	2	5	4	7	3	6	8	5	9	4	1	6	8	9	3	7	5	1	4



Quelle: Dissertation Jennifer König (IGS, TU Braunschweig)

- **Test day 1:** 7°C outdoor temperature
- No operation of the ventilation equipment
- **No window ventilation**

- **Test day 2:** 0,5 °C outside temperature
- Operation of the ventilation equipment
- **Regular window ventilation**



Quelle: Dissertation Jennifer König (IGS, TU Braunschweig)

Throughs of tests respectively:

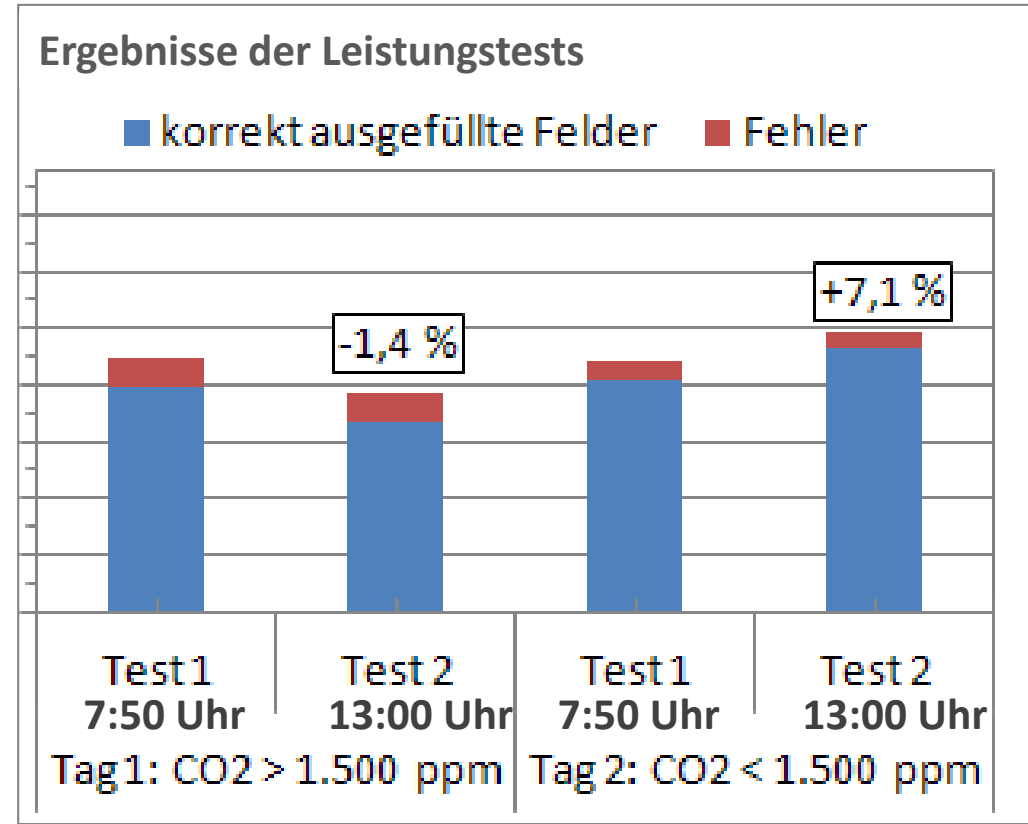
- Test 1: 7:50 Uhr (before class)
- Test 2: 13:00 Uhr (while teaching)

Test day 1:

- High CO₂-concentration
- > 1.500 ppm in 86 % of class time
- Power reduction of -1,4 %

Test day 2:

- Reduced CO₂ concentration
- < 1.500 ppm in 91 % of class time
- Power increase of 7,1 %



Quelle: Dissertation Jennifer König (IGS)

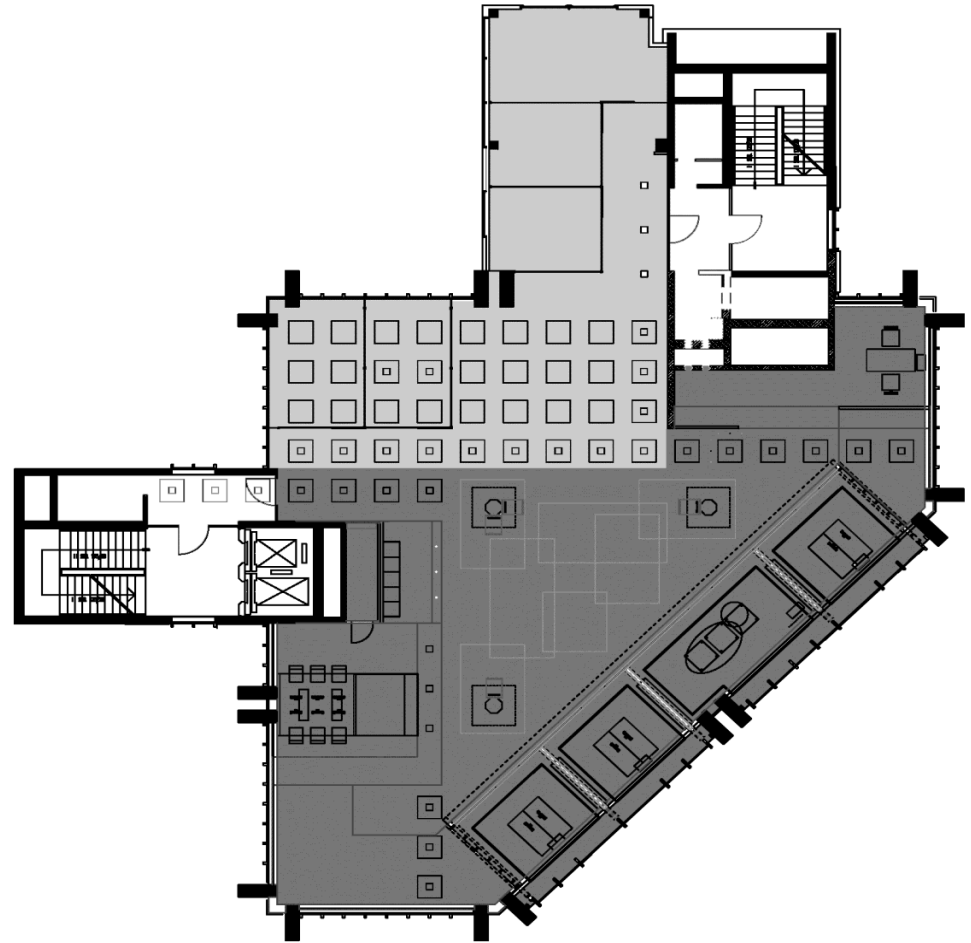
Indoor Environment Qualities make the difference:



Room Temperature
Ventilation
Daylight
Acoustics



Fotos: Hans Georg Esch fotografiert für Saint-Gobain Ecophon GmbH



Grundriss 9.OG

Initial situation

- Inefficient use of space
- Whistling
- Draughts
- Overheating in summer
- High energy consumption

Goals

- Indoor Environmental Quality
- Space efficiency – „using instead of owning“
- Functionality
- Energy performance



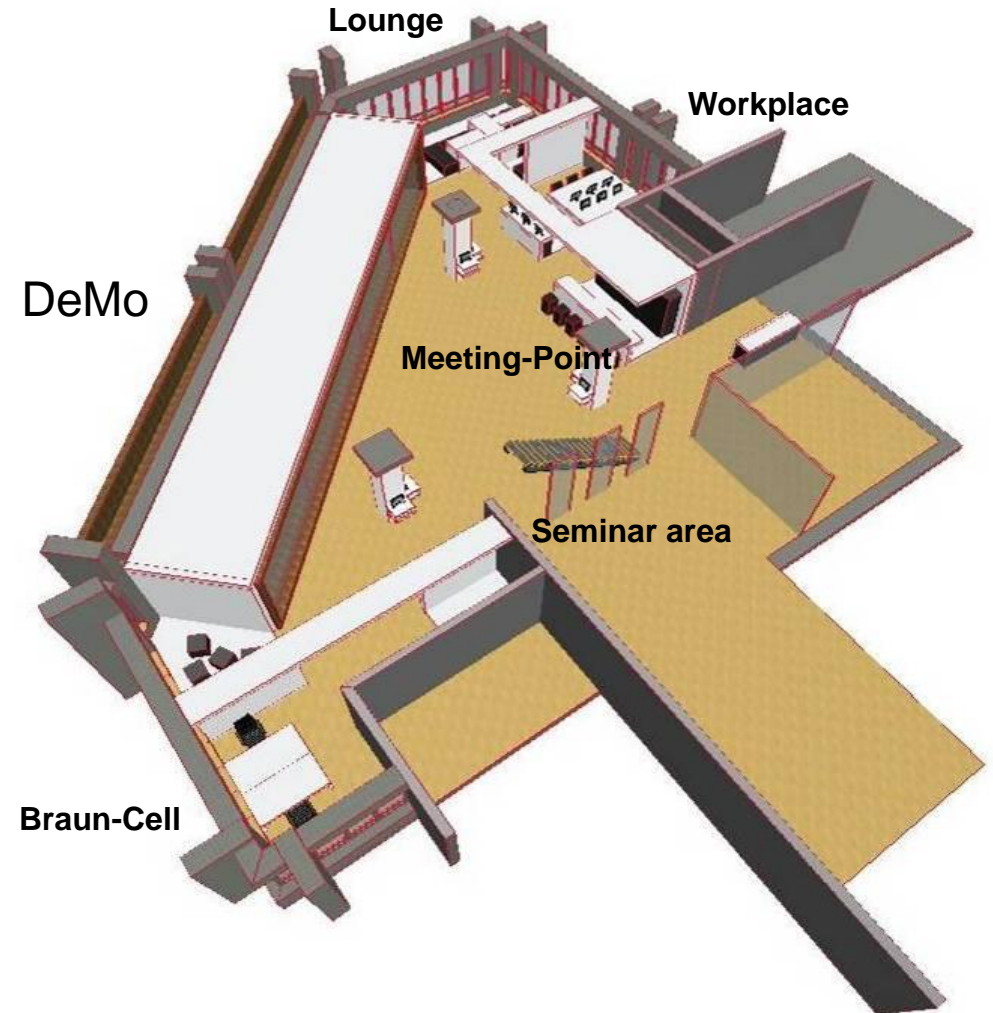
Entry



Seminar room



Fotos: Hans Georg Esch fotografiert für Saint-Gobain Ecophon GmbH





Fotos: Hans Georg Esch fotografiert für Saint-Gobain Ecophon GmbH

Relative performance

Good light!

Up to 4 %

Productivity increase!

(Source: P. Dehoff, Zumtobel AG, Dornbirn)

Lighting

Up to 2% of investment cost share

Lighting



Daylight

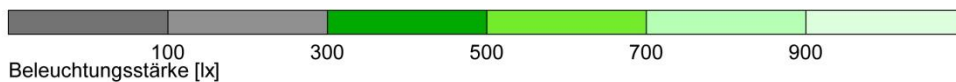
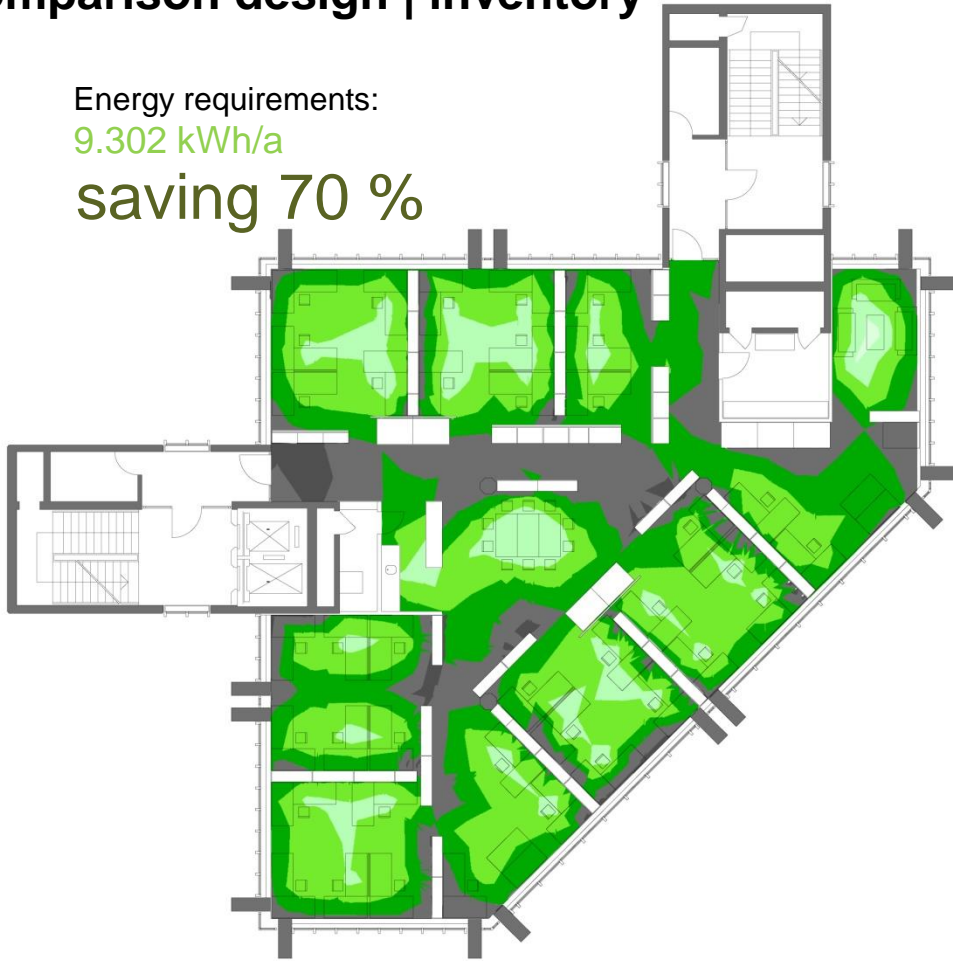


Dynamic Light

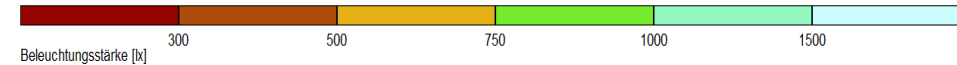
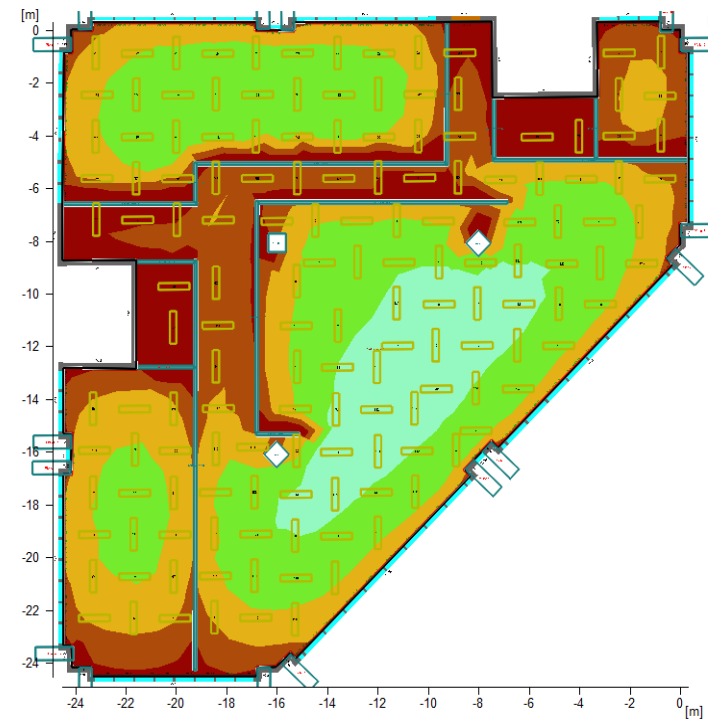


Comparison design | inventory

Energy requirements:
9.302 kWh/a
saving 70 %



Energy requirements:
31.147 kWh/a



Indoor Environment Qualities make the difference:

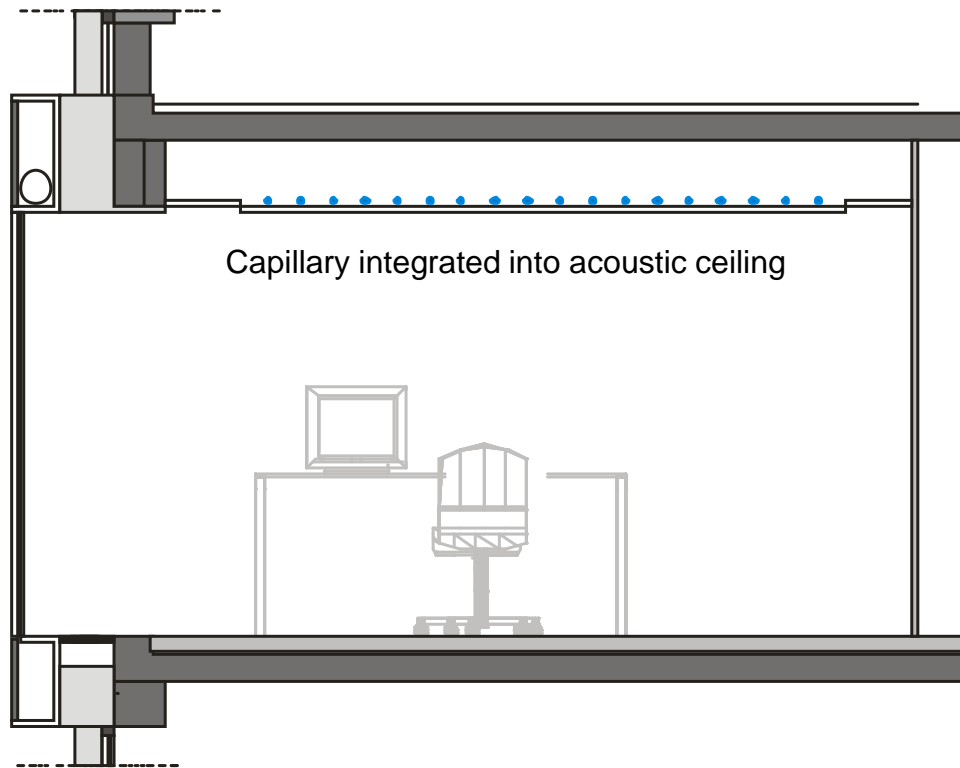


Room Temperature
Ventilation
Daylight
Acoustics



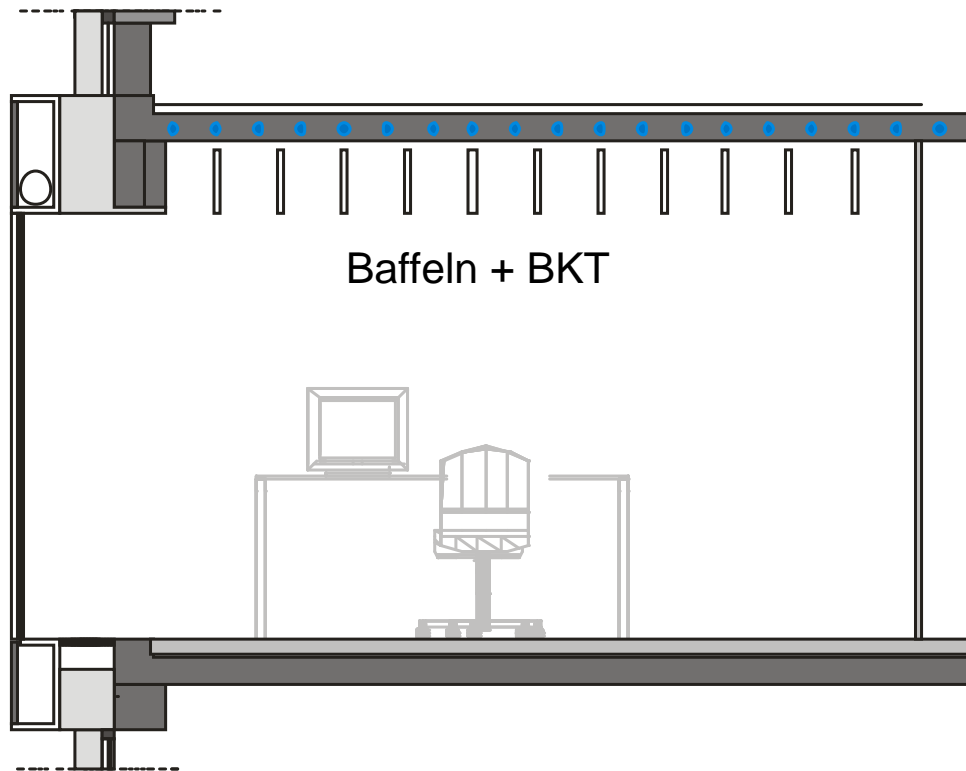
Office - DeMo

Average reverberation time T_m in seconds: 0,43 s

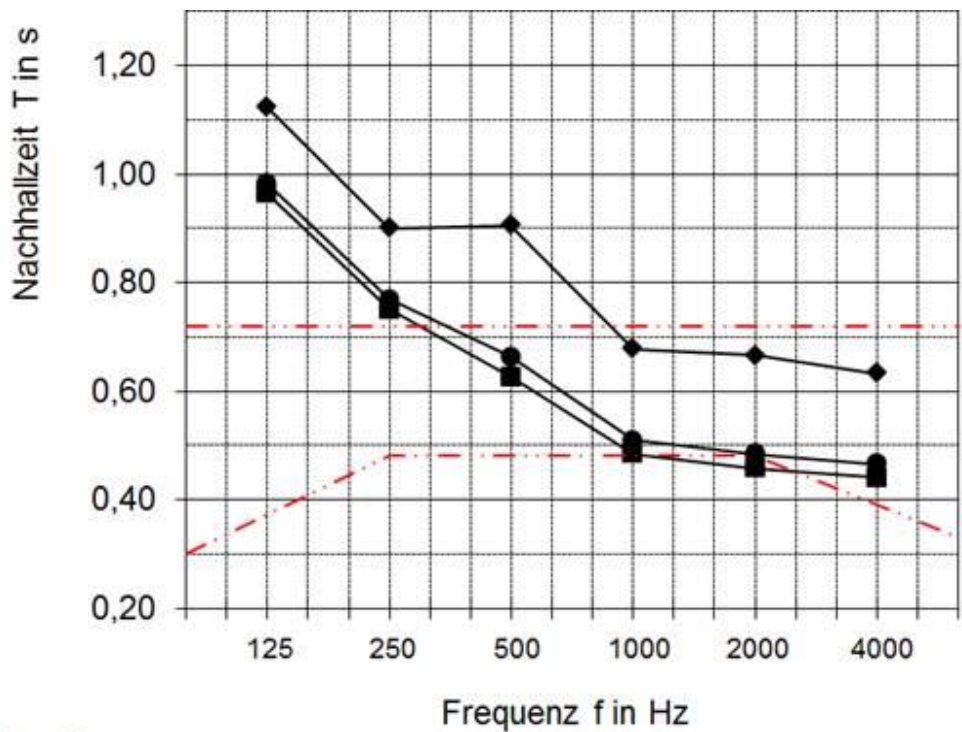



Lounge




Average reverberation time T_m in seconds: 0,60 s



Reduction of the cooling capacity < 16 %



 optimaler Bereich für Nutzung

Besetzung:
 leer
 23 Personen
 29 Personen

Nachhallzeit T in s in Abhängigkeit von der Frequenz

	125	250	500	1000	2000	4000	Hz
leer	1,12	0,90	0,91	0,68	0,67	0,63	
23 Personen	0,98	0,77	0,66	0,51	0,48	0,47	
29 Personen	0,96	0,75	0,63	0,48	0,46	0,44	

Reverberation time

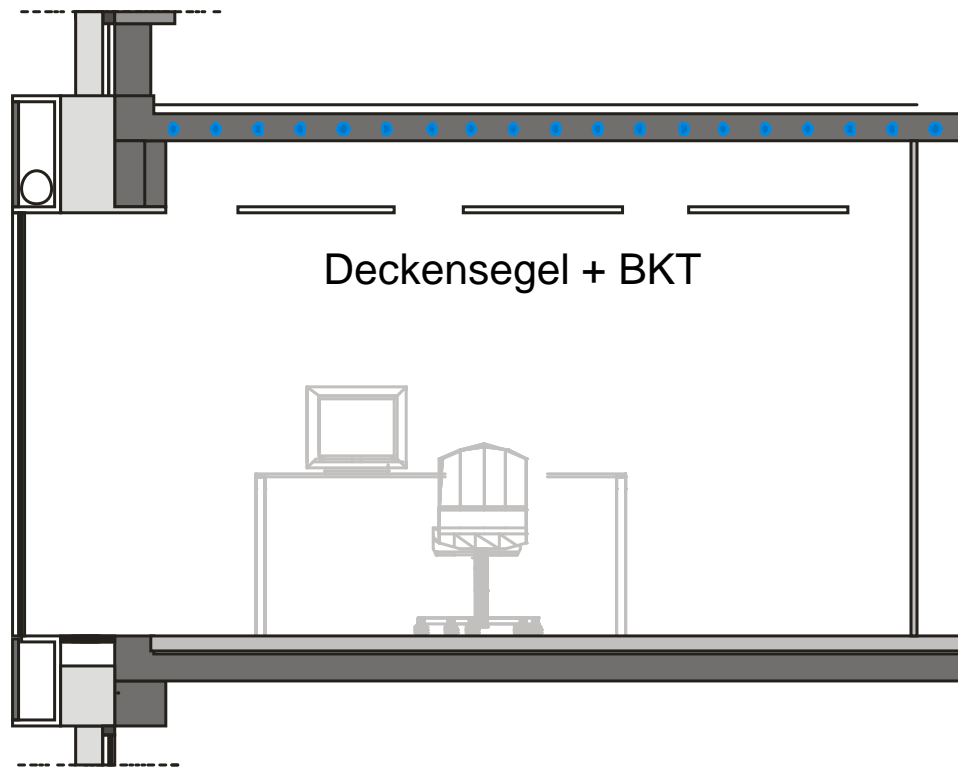
$$T = 0,16 V / A$$

V Volume

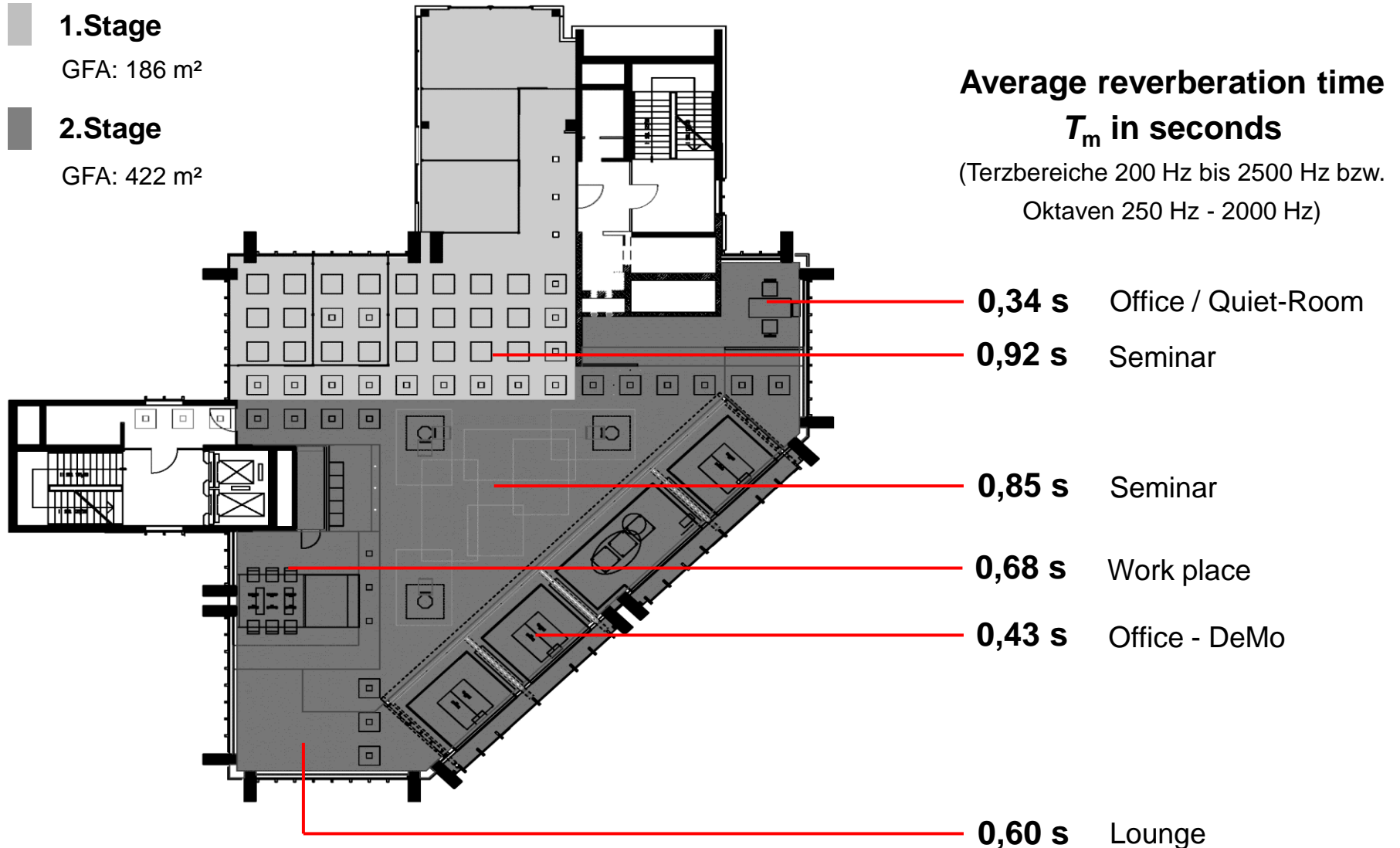
A equivalent to absorption area

Seminar

Average reverberation time T_m in seconds: 0,85 s



Reduction of the cooling capacity < 16 %



Indoor Environment Qualities make the difference:



Room Temperature
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In practice problems to achieve the goals
indoor comfort and **energy efficiency**

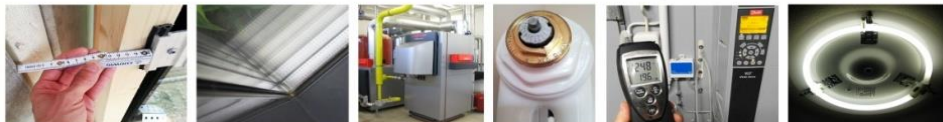
Quality differences between
planning and **operation!**

Integral quality management
 fastest and most economical way to improve efficiency

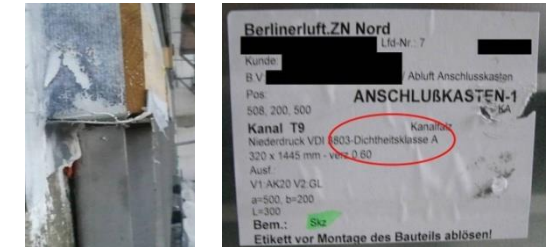


1. Internet-Plattform für
 Integrale Qualitätssicherung nach EnEV

IQS18599 ✓

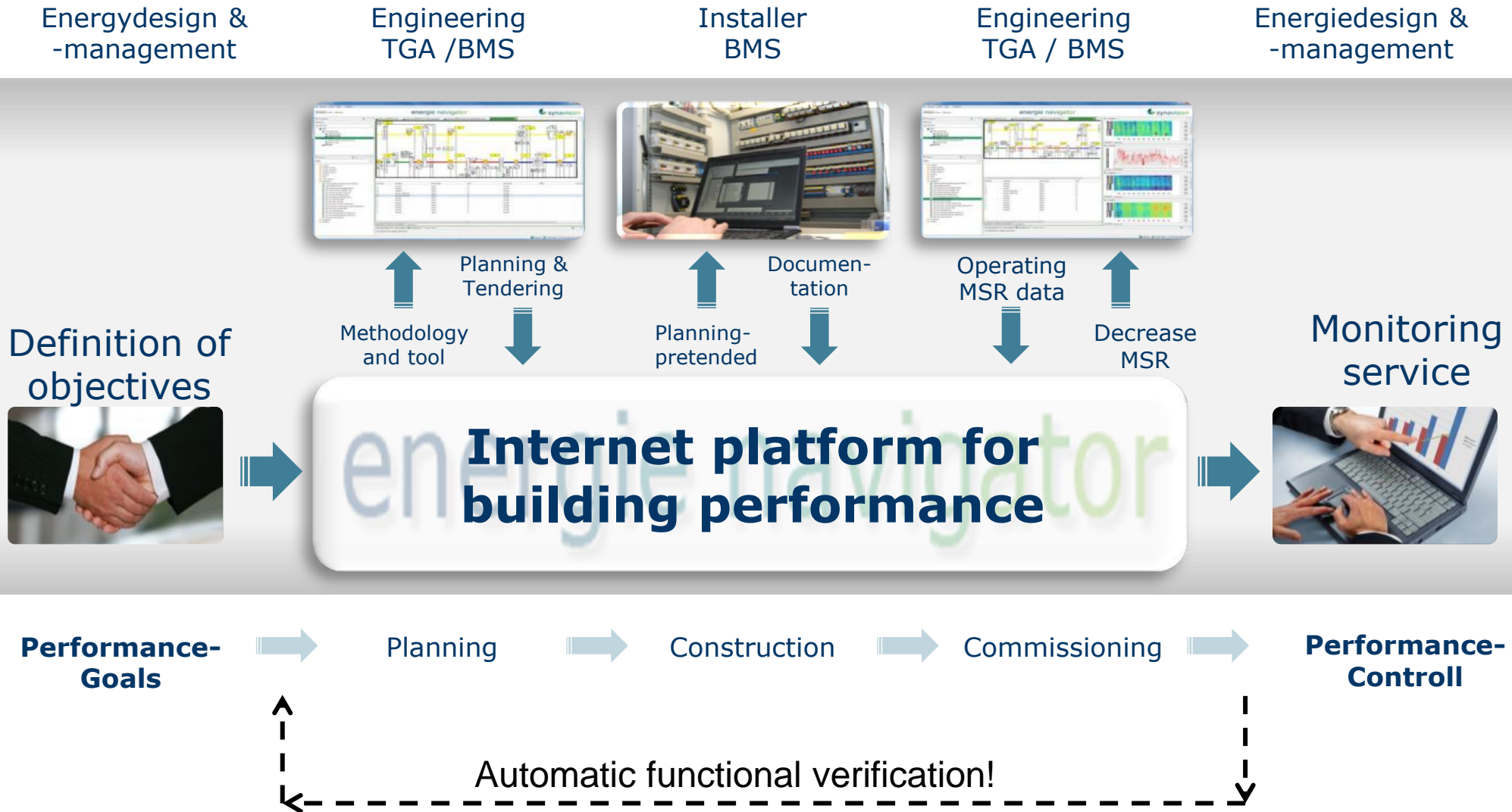


synavision
 energie navigator



Navigator

Quality assurance from design to operation



Thank You for your attention!

M. Norbert Fisch Thomas Wilken Christina Stähr

EnergiePLUS

Gebäude und Quartiere als erneuerbare Energiequellen



Eine gesicherte Energieversorgung, mit einem Deckungsanteil von 60 Prozent aus erneuerbaren Quellen bis Mitte des Jahrhunderts - das ist das ambitionierte Ziel der im Frühjahr 2011 von der Bundesregierung beschlossenen Energiewende.

Innovativ geplante Gebäude und Quartiere im EnergiePLUS-Standard können mit einem Energieüberschuss im Lebenszyklus für diese gemeinsam zu gestärktem Weg einen entscheidenden Beitrag leisten.

Zwei Aspekte werden dabei die zukünftigen Konzeptionen im Gebäudebereich nachhaltig verändern:

- Strom als Sekundärenergieträger gewinnt zunehmend an Bedeutung und lässt sich wirtschaftlich konkurrenzfähig zum Netzeinsatz durch gebäudeintegrierte Photovoltaik erzeugen.
- Zukünftige energetische Standards werden sich mehr denn je an ihrem gesamtwirtschaftlichen Optimum aus Bedarfdeckung und ökologischer Energieversorgung messen lassen müssen.

Das Buch setzt die relevanten Planungsaspekte der Architektur, Energie- und Gebäudetechnik für den EnergiePLUS-Standard in einen ganzheitlichen Bezug und zeigt realisierte Beispiele für Wohn- und Nicht-Wohngebäude, städtische Quartiere und die Potenziale für eine globale Anwendung.

EnergiePLUS-Gebäude haben ihre Praxistauglichkeit bewiesen. Das Gebäude als Kraftwerk und Energiespeicher ist ein Baustein der dezentralen Energieversorgung.



M. Norbert Fisch Thomas Wilken Christina Stähr

EnergiePLUS

M. Norbert Fisch Thomas Wilken Christina Stähr



EnergiePLUS

Gebäude und Quartiere als erneuerbare Energiequellen



aktivhaus