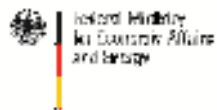




# Innovative Gebäudekühlung, Schlüssel für Energieeffizienz

**Marco Schmidt**  
**Technische Universität Berlin**  
**Institut für Architektur**  
**FG Gebäudetechnik und Entwerfen**

supported by:



as part of a research project  
by the German Bundestag



**Berlin Adlershof**



- [New Buildings](#)
- [Refurbishment](#)
- [New Technologies](#)
- [Commissioning](#)
- [Analysis](#)
- [Software and Tools](#)
- [Topic Search](#)
- [Research Areas](#)

## EnOB: Research for energy-optimised construction

"Buildings of the future" is the guiding concept behind EnOB – research for energy-optimised construction (the name EnOB is an abbreviation of the equivalent German term Energieoptimiertes Bauen). The research projects sponsored by the German Federal Ministry of Economics and Technology involve buildings that have minimal primary energy requirements and high occupant comfort, with moderate investment costs and significantly reduced operating costs. This requires sophisticated building concepts and innovative technologies. For this reason, EnOB places an emphasis on research and development in construction engineering and technical building equipment, such as low-exergy systems, building elements with vacuum insulation, or innovative glazing and facade systems. A second focus is on scientifically evaluating energy-optimised buildings. Therefore factors determining success and performance-related criteria are identified for designers, manufacturers and operators of buildings. Learn more about the various areas on which EnOB research is focussing, and about the testing of new concepts, technologies and materials in model projects.

[read more](#)



### [Net zero-energy buildings & co](#)

Net zero-energy buildings and energy-plus buildings demonstrate just what is possible. With these buildings, a neutral annual energy balance can be achieved by integrating architecture, energy efficiency and renewable energy sources in a systematic manner. Projects, concepts, methods and an international survey are shown here ...

[in detail](#)



### [Energy plus child day care centre](#)

The "Noah's Ark" is a child day care centre and energy-plus building, designed to generate more energy than its users will consume. The building concept includes not only a large photovoltaic system for generating energy but also several innovative systems and components for handling heat and electricity in an energy-efficient manner.

[in detail](#)



## News

13. Nov 2013 - [German Federal Ministry of Economics and Technology launches "School 2030" ideas competition](#)

14. Oct 2013 - [European energy-plus building prototypes challenge US competition](#)

26. Sep 2013 - [How do you get potted soil onto the roof?](#)

[all news](#)

## Events

20-21 March 2014 | Essen, Zeche Zollverein

[EnOB Symposium 2014 "Innovations in the new-build and refurbishment sectors"](#)

27-28 November 2013 | Würzburg  
[Workshop on high performance thermal insulation 2013](#)

12-13 November 2013 | Stuttgart  
[3rd "Zukunftsraum Schule" Congress](#)

[all events](#)



Supported by

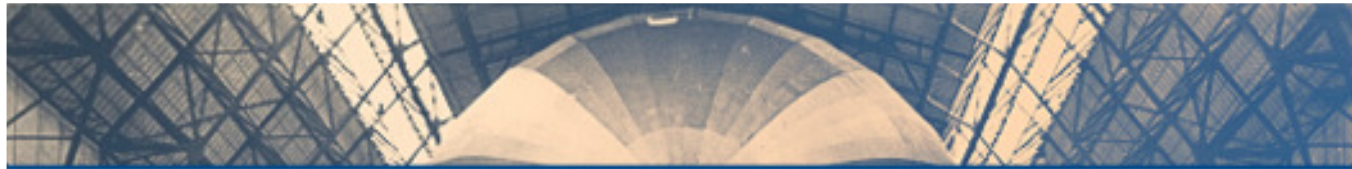


Federal Ministry  
for Economic Affairs  
and Energy

on the basis of a decision  
by the German Bundestag







# watergy

Water

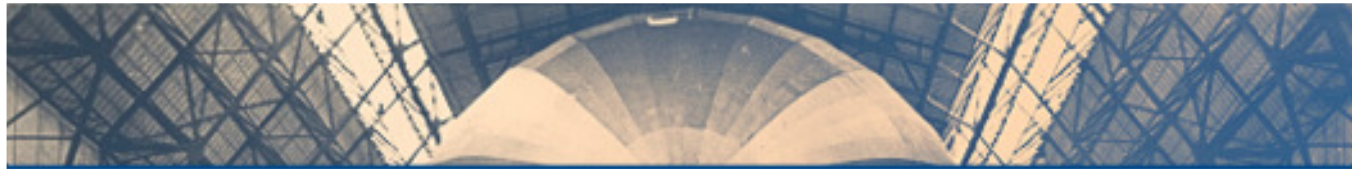


Energy

[www.watergy.de](http://www.watergy.de)

[www.phasenwechsel.com](http://www.phasenwechsel.com)





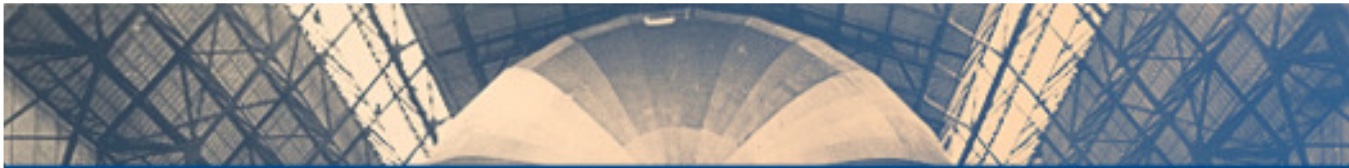
# 700 kWh/ m<sup>3</sup> at 45 °C

Water heated from 30 to 90°C = 70 kWh/m<sup>3</sup>

**Water** ↔ **Energy**

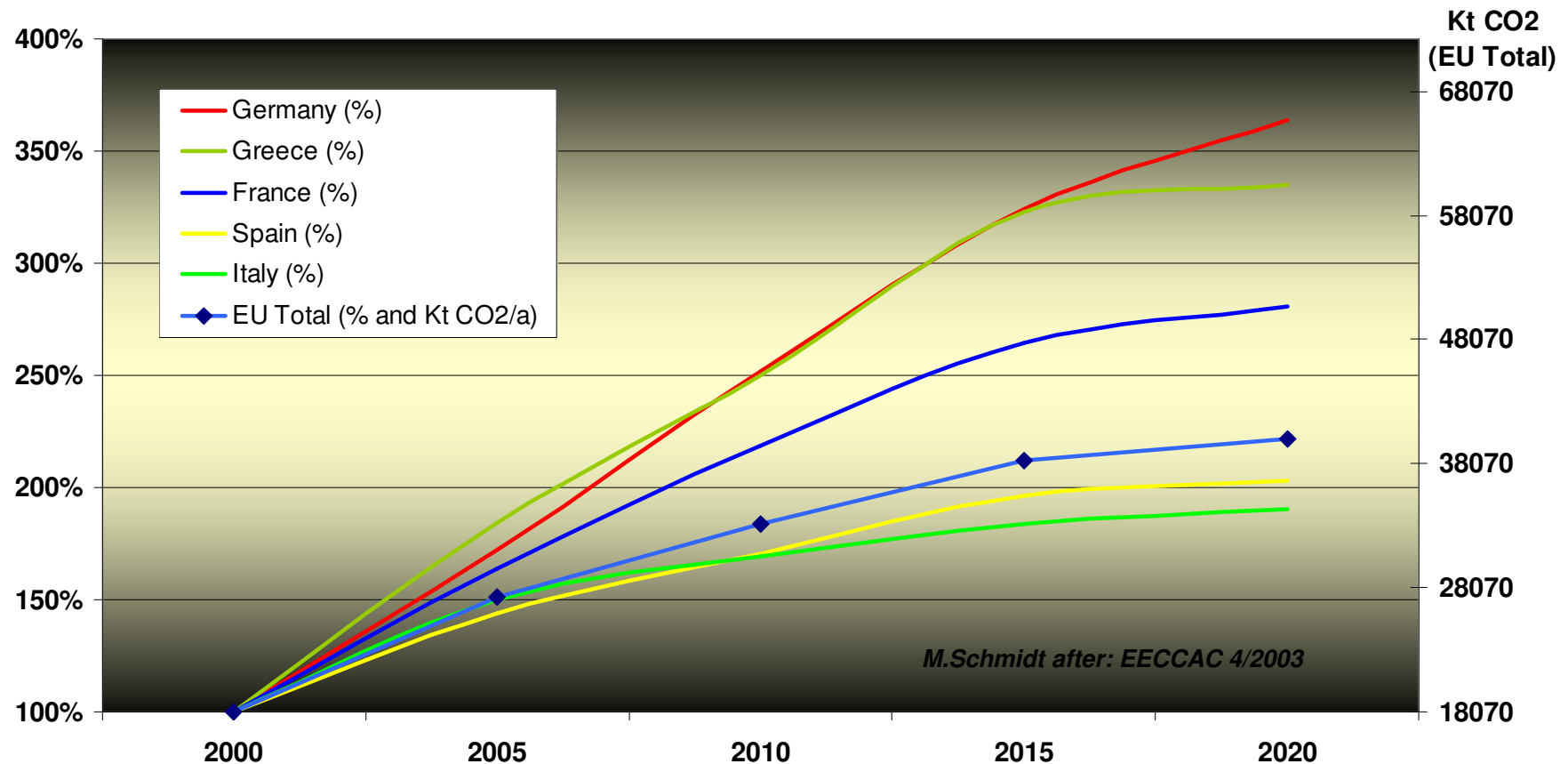
Phase Change Material (PCM) = 61 kWh/m<sup>3</sup>





## Ziel: Reduzierung des Primärenergieverbrauchs im Gebäudesektor um 50% bis 2020

### Prognostizierte Erhöhung des Energieverbrauchs im Bereich Gebäudekühlung



Quelle: Energy Efficiency and Certification of Central Air Conditioners (EECCAC)



**Bestand Physik (2001): 2x 330 kW Absorptionskälte  
Nachrüstung (2011): 240 kW Kompressor**







**Kleinkälte für Serverräume (2011)**



**Bestand IKA (2001): 550 kW Absorptionskälte  
Nachrüstung (2012): 200 kW Kompressor**

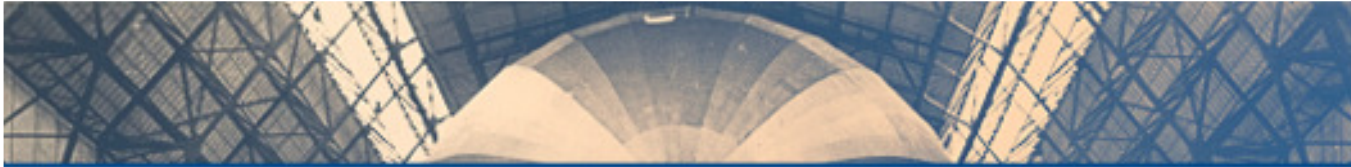




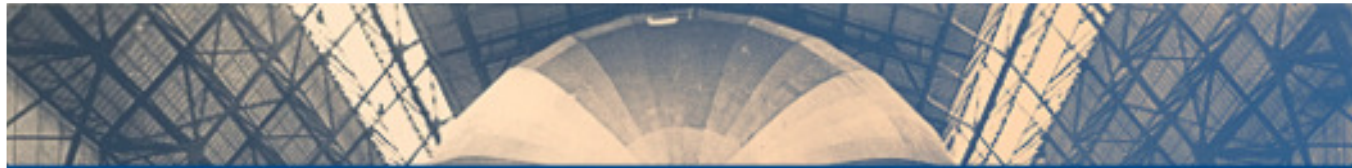


**Nachrüstung ZPO (2011 - 2013):**  
**400 kW Kompressor (19.51, 19.58)**  
**1040 kW Schraubenverdichter (19.5 und 19.53)**  
**1040 kW Schraubenverdichter (19.1, 19.2, 19,52)**

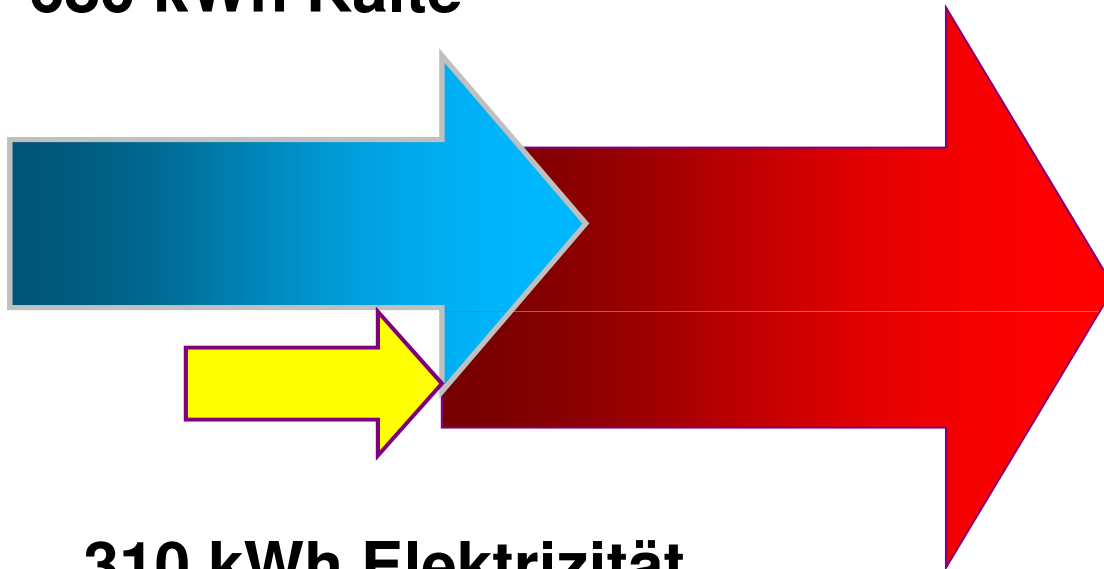




- 1: Increase in use of glass**
- 2: Decrease in Heat Capacity, use of light materials**
- 3: Increase in electricity consumption**
- 4: Increase in Urban Heat Island Effect**
- 5: Global Warming**



**680 kWh Kälte**



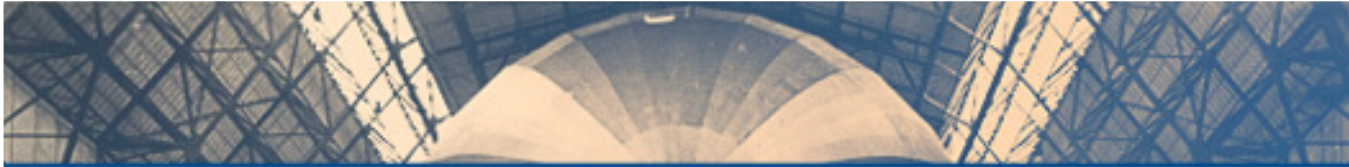
**310 kWh Elektrizität  
(COP 2,2)**

**990 kWh  
Sensible Wärme**



**Klimatisierung über Strom**

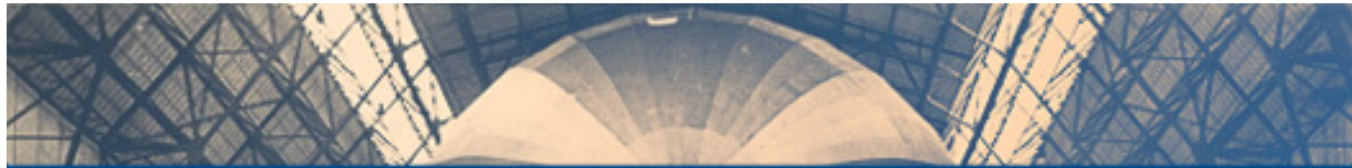




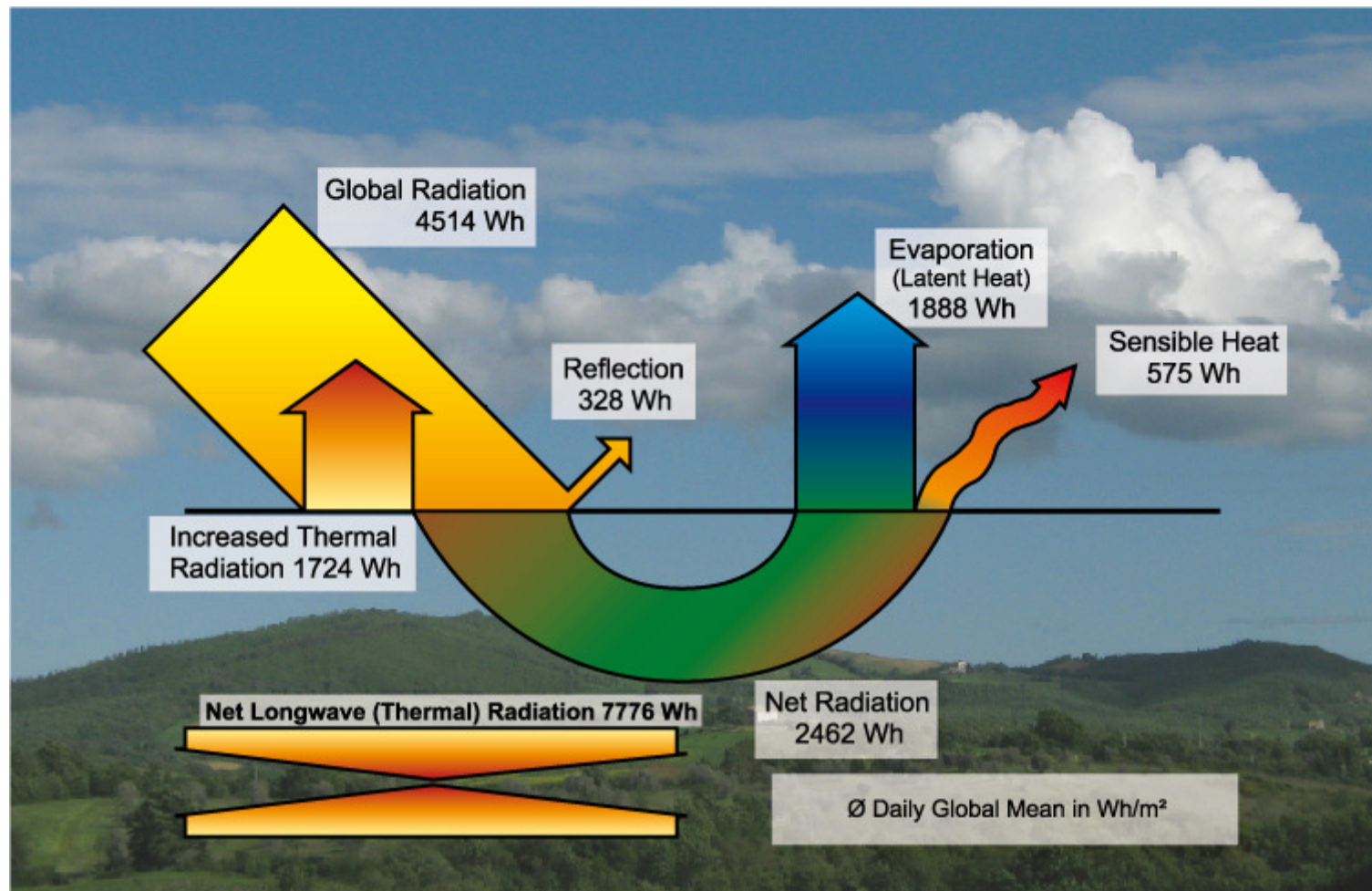
Berlin Adlershof



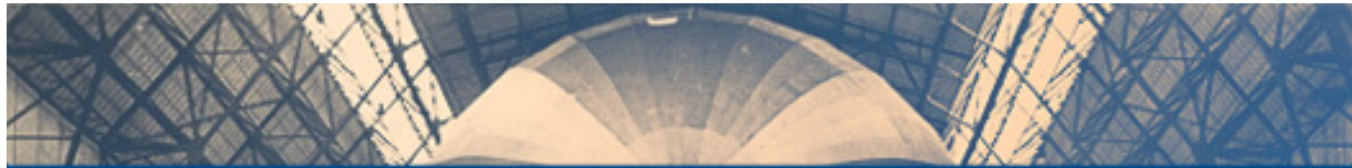




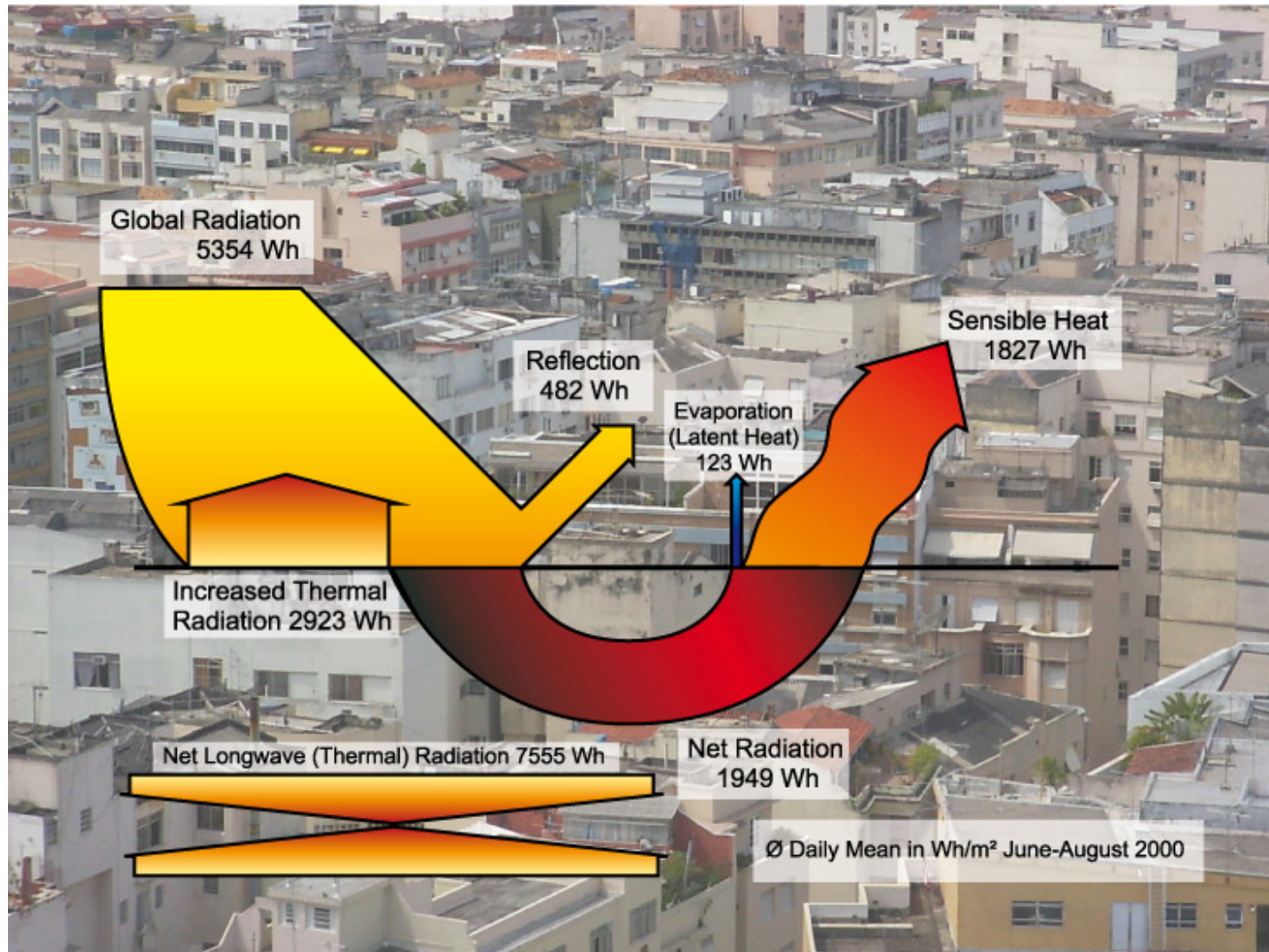
# Globale Strahlungsbilanz







# Urban Heat Island Effekt Beispiel: Asphalt Dach











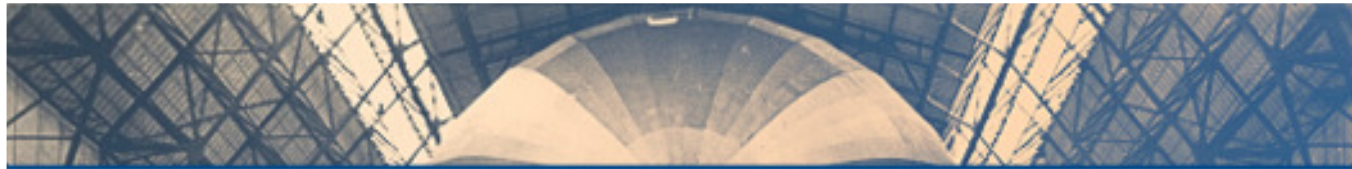




**Wissenschaftliche Begleitung/ Monitoring:**  
**2002-2010 Senatsverwaltung für Stadtentwicklung**  
**2011-2013: EnEff Stadt, BMWi über PTJ**  
**2014-2016: INIS, BMBF über PTJ**

**Institut für Physik,**  
**Humboldt-Universität Berlin-Adlershof**

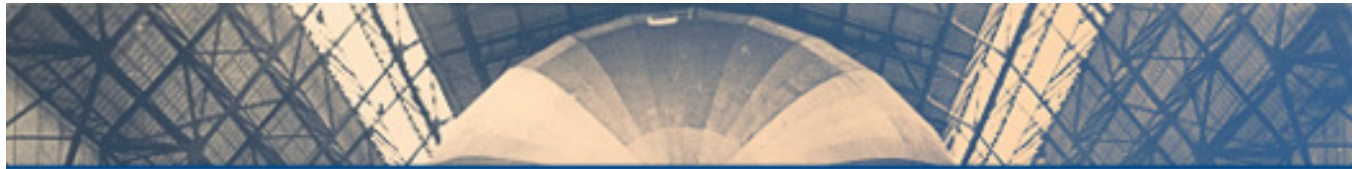




## Institut für Physik der Humboldt- Universität zu Berlin







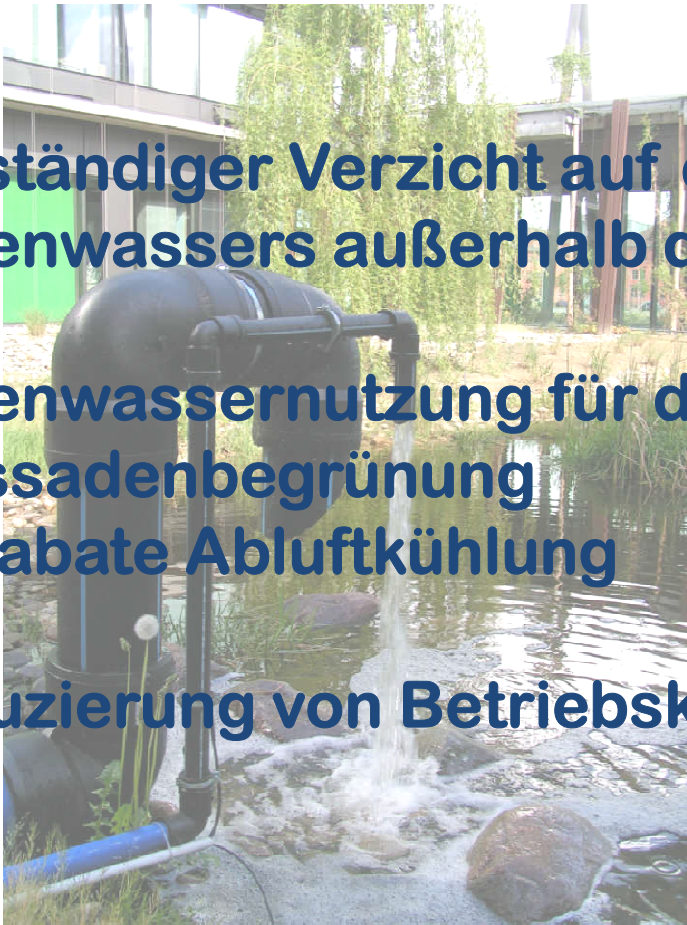
## Institut für Physik der Humboldt- Universität zu Berlin

**Vollständiger Verzicht auf eine Ableitung des Regenwassers außerhalb der Gebäudegrenzen**

**Regenwassernutzung für die Gebäudeklimatisierung:**

- Fassadenbegrünung
- adiabate Abluftkühlung

**Reduzierung von Betriebskosten**







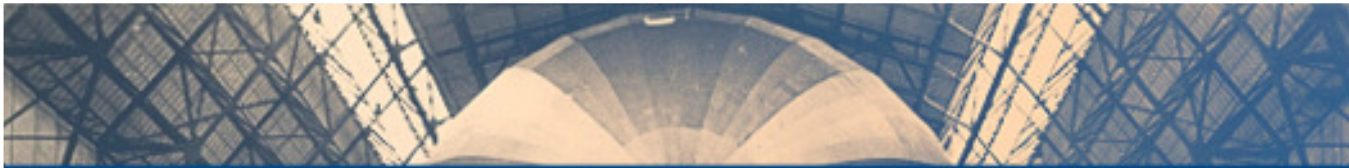
|                      |                            |
|----------------------|----------------------------|
| Heizwärmeverbrauch:  | 265 kWh/ m <sup>2</sup> a  |
| Fernwärme für Kälte: | 148 kWh/ m <sup>2</sup> a  |
| Kompressionskälte:   | 16,6 kWh/ m <sup>2</sup> a |
| Strom Kälte:         | 21,7 kWh/ m <sup>2</sup> a |

|                                |             |
|--------------------------------|-------------|
| Primärenergiefaktor Fernwärme: | 0.16        |
| Primärenergiefaktor Strom:     | 2.30 (2.60) |

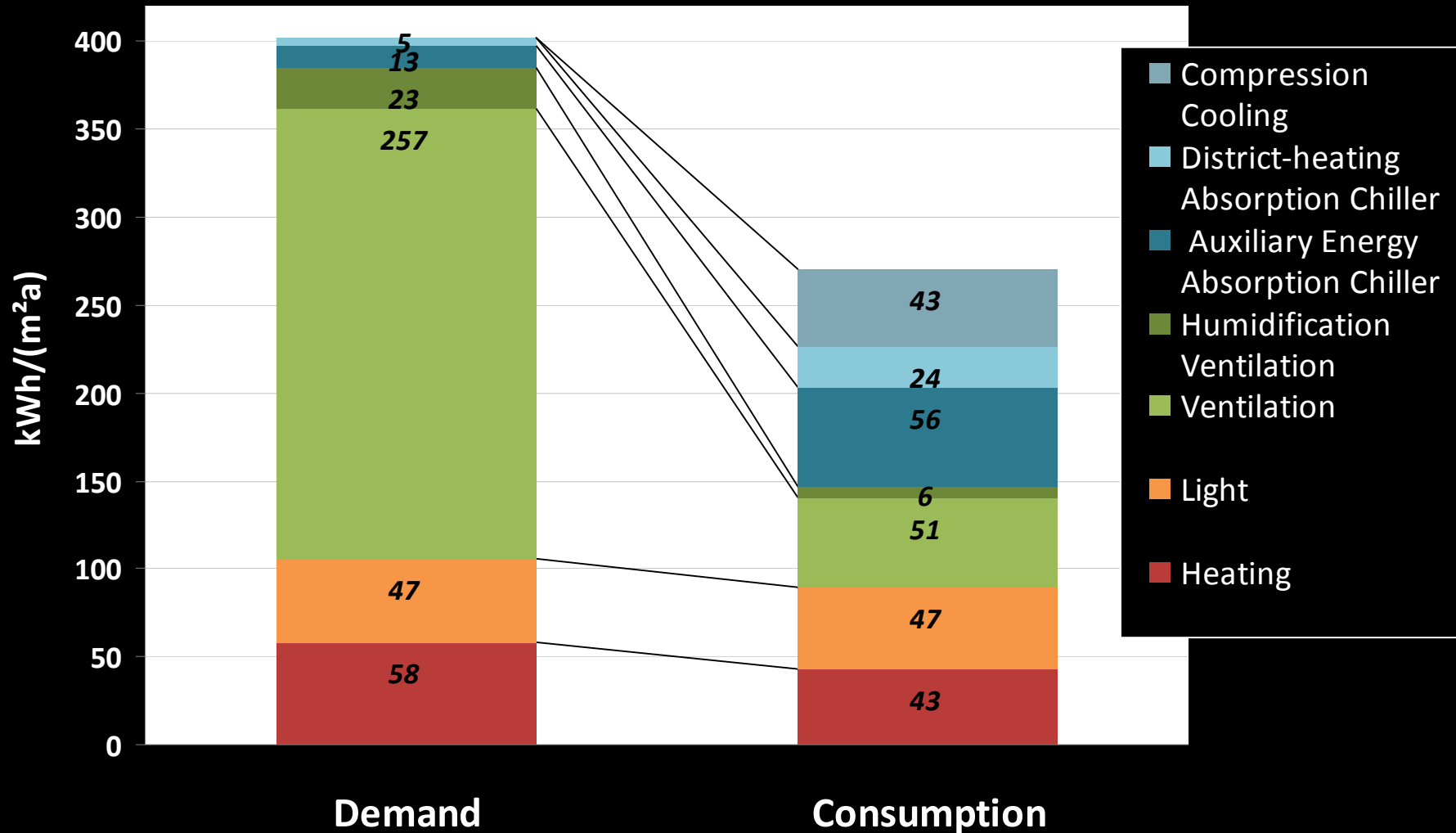


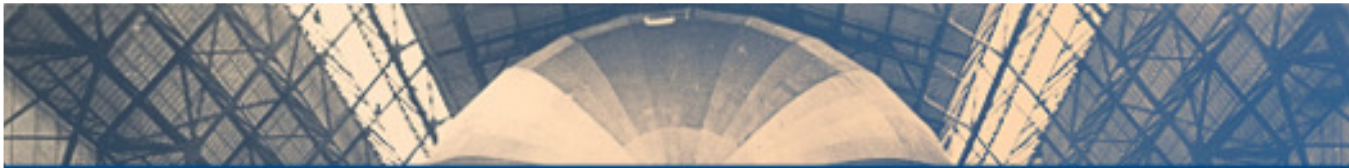
|                                  |                                 |
|----------------------------------|---------------------------------|
| <b>Heizwärmeverbrauch (PE):</b>  | <b>42,8 kWh/ m<sup>2</sup>a</b> |
| <b>Fernwärme für Kälte (PE):</b> | <b>23,9 kWh/ m<sup>2</sup>a</b> |
| <b>Strom Kälte (PE):</b>         | <b>49,9 kWh/ m<sup>2</sup>a</b> |
| <b>Kompressionskälte (PE):</b>   | <b>38,2 kWh/ m<sup>2</sup>a</b> |
| <b>Summe Kälte (PE):</b>         | <b>112 kWh/ m<sup>2</sup>a</b>  |



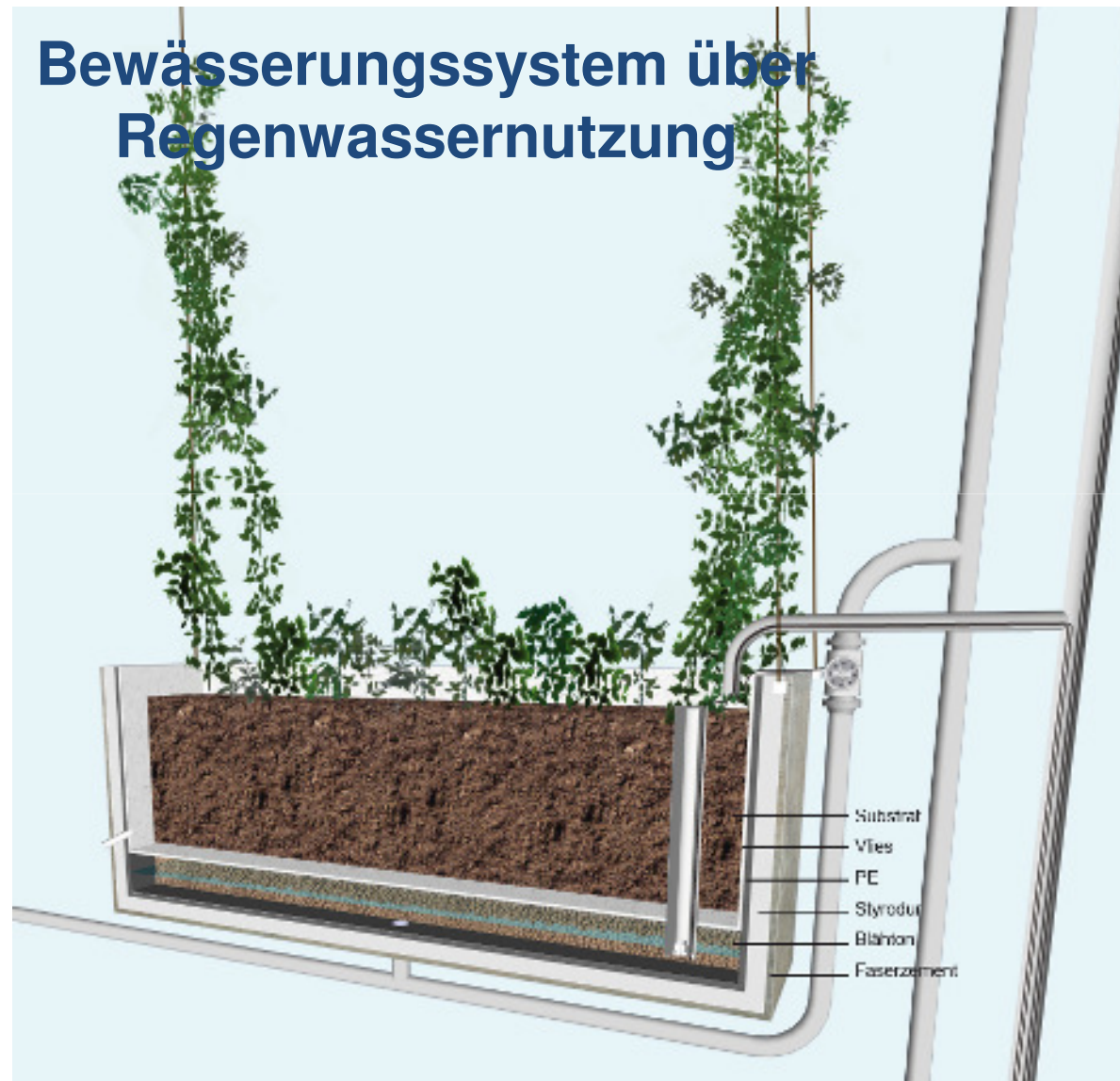


### Primary Energy Demand according DIN V 18599 (calculated) compared to consumption (measured)

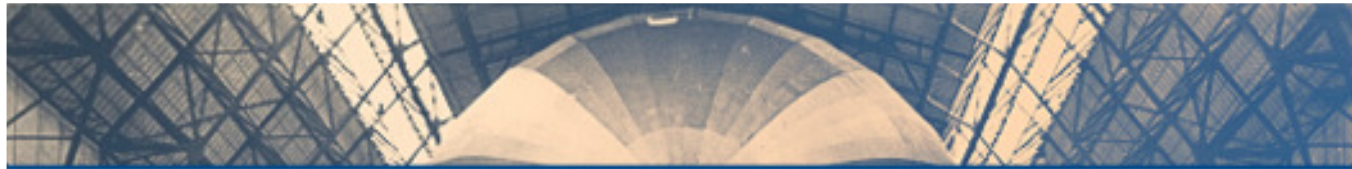




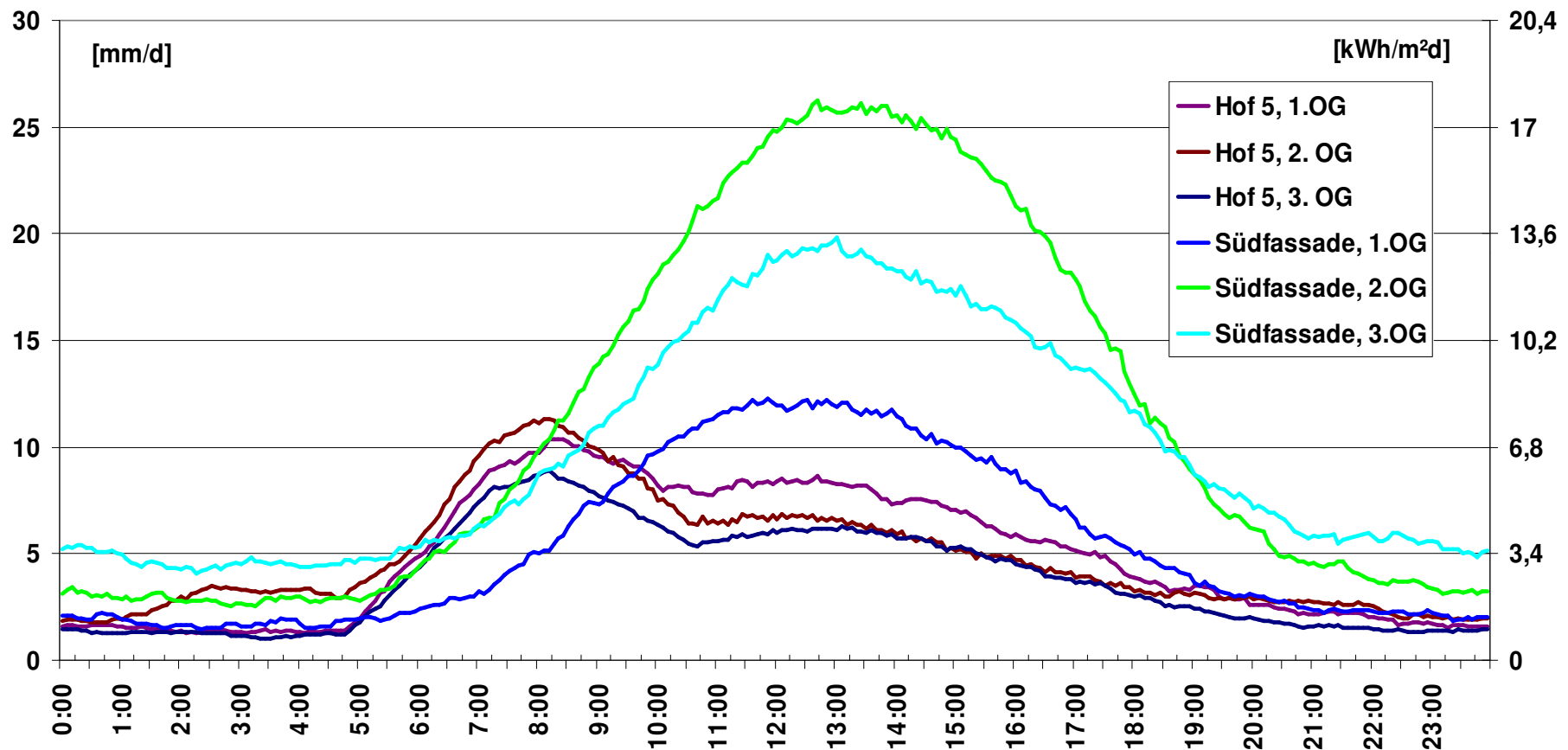
## Bewässerungssystem über Regenwassernutzung

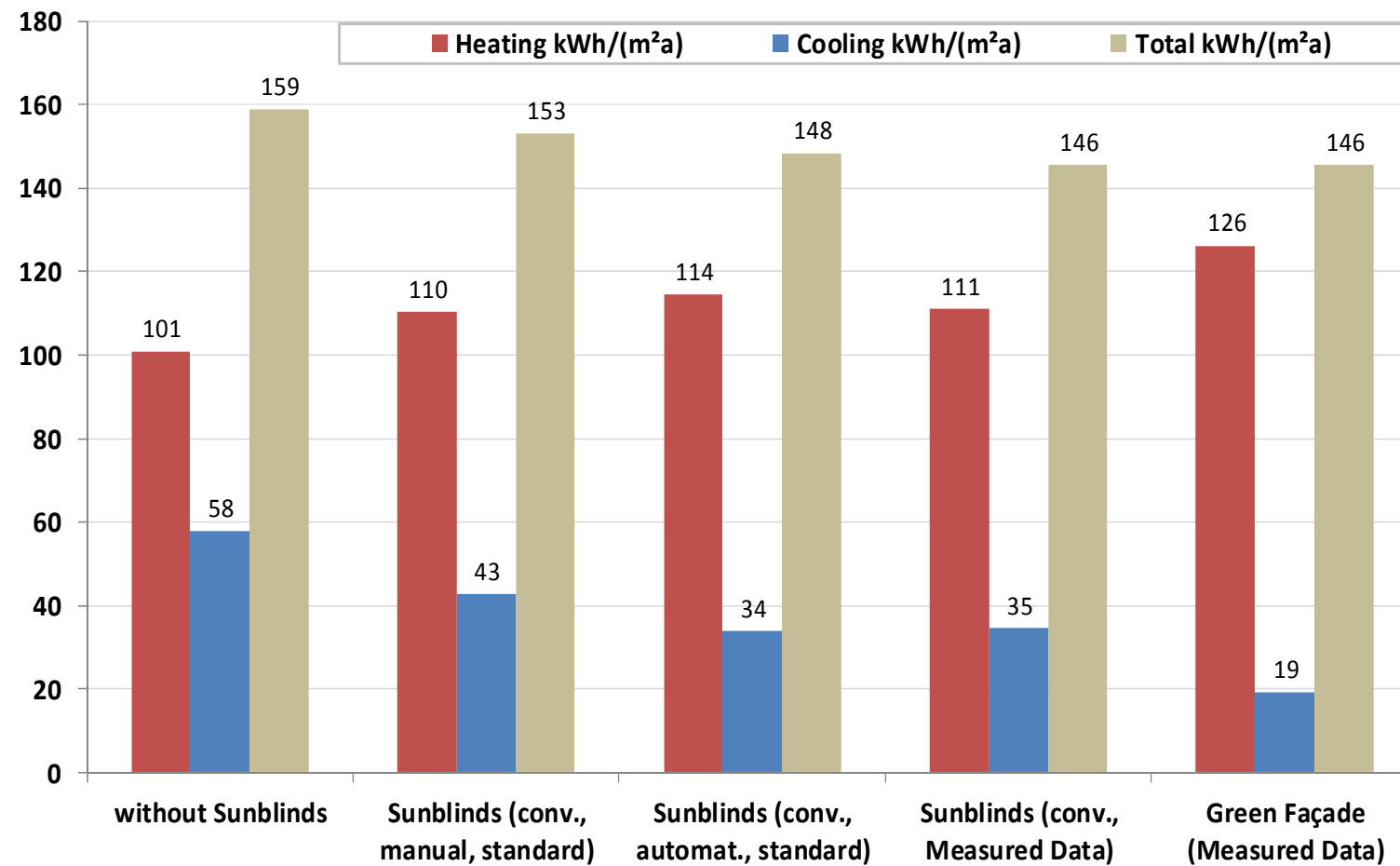
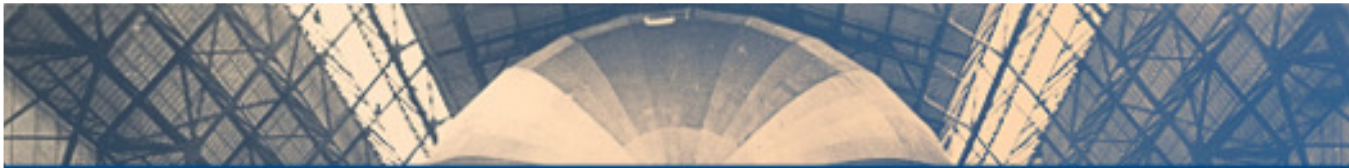




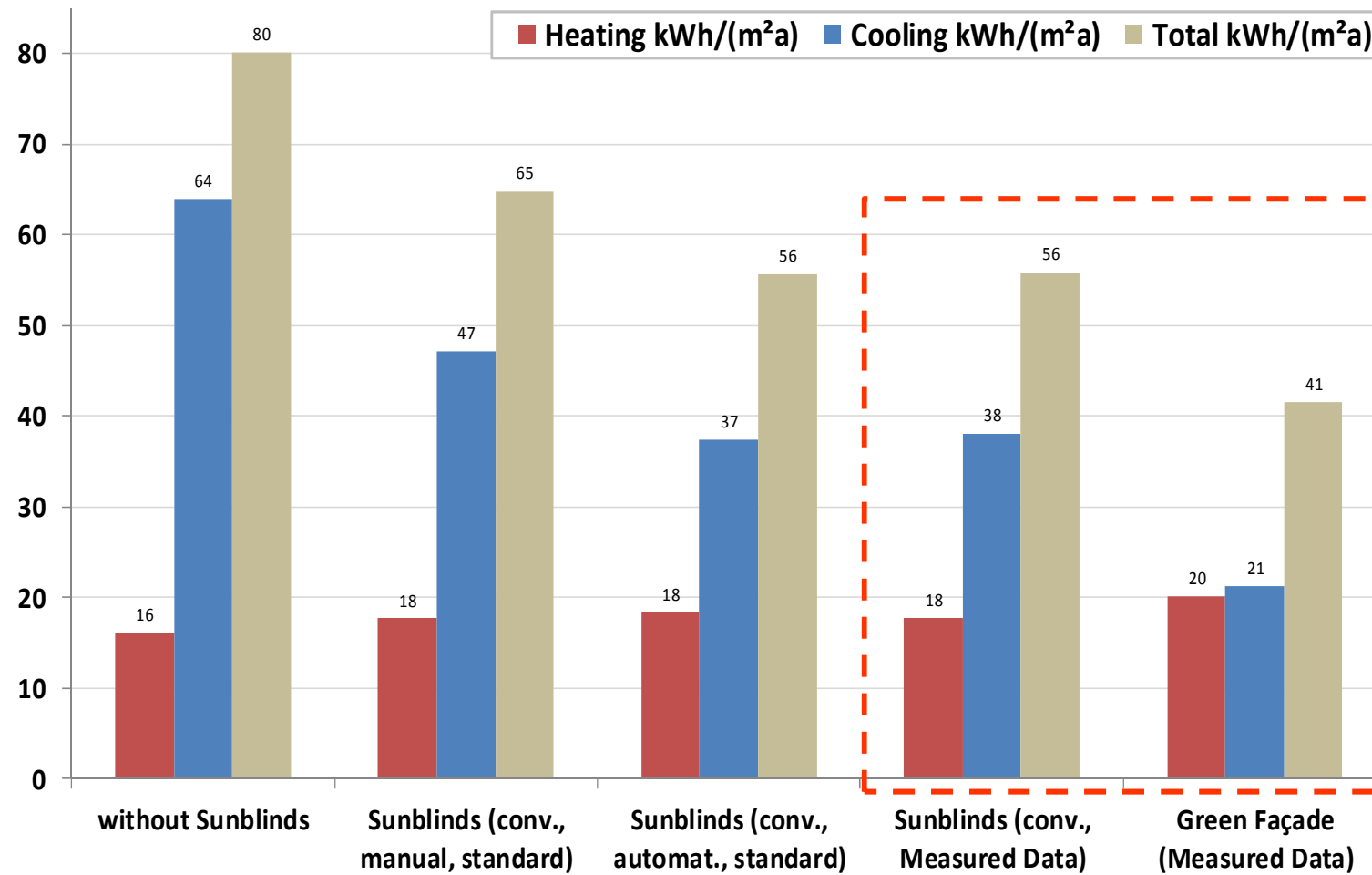
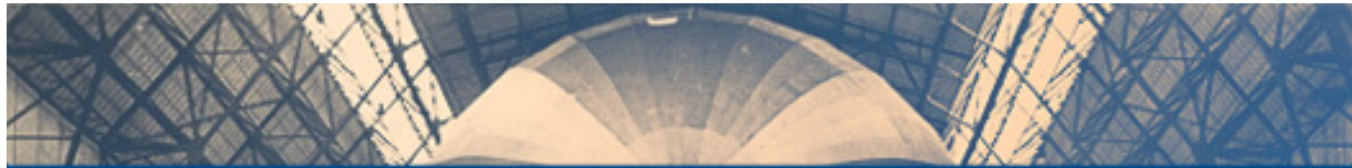


# Durchschnittliche Verdunstung der Fassadenbegrünung Adlershof Physik 15.7.05-14.9.05 erzeugte Verdunstungskälte: 280 kWh pro Tag



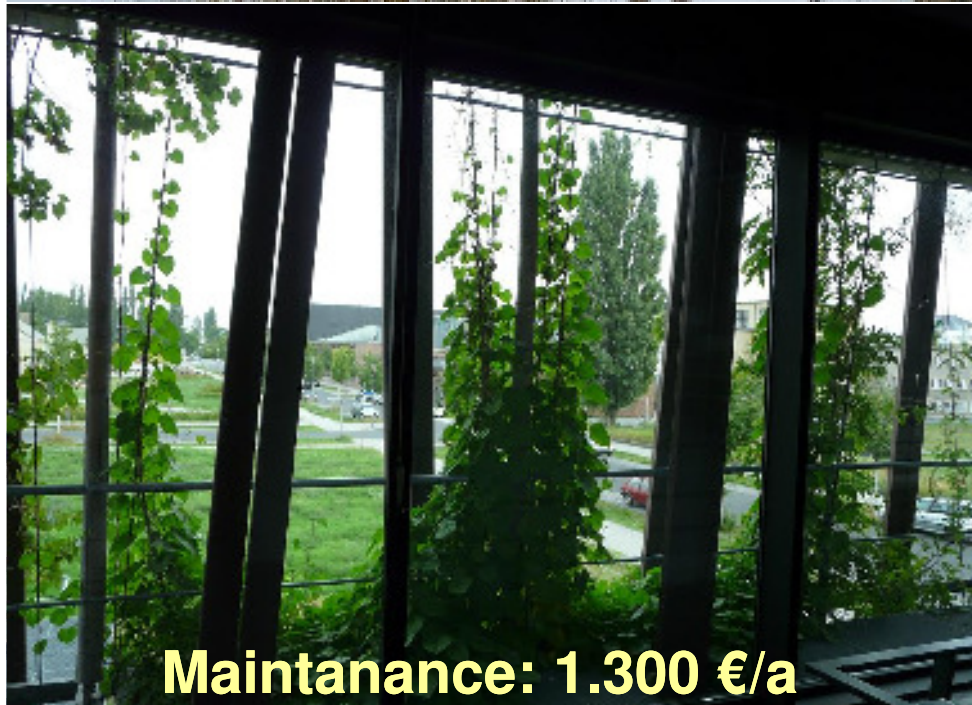








**Maintenance: 16.525 €/a**

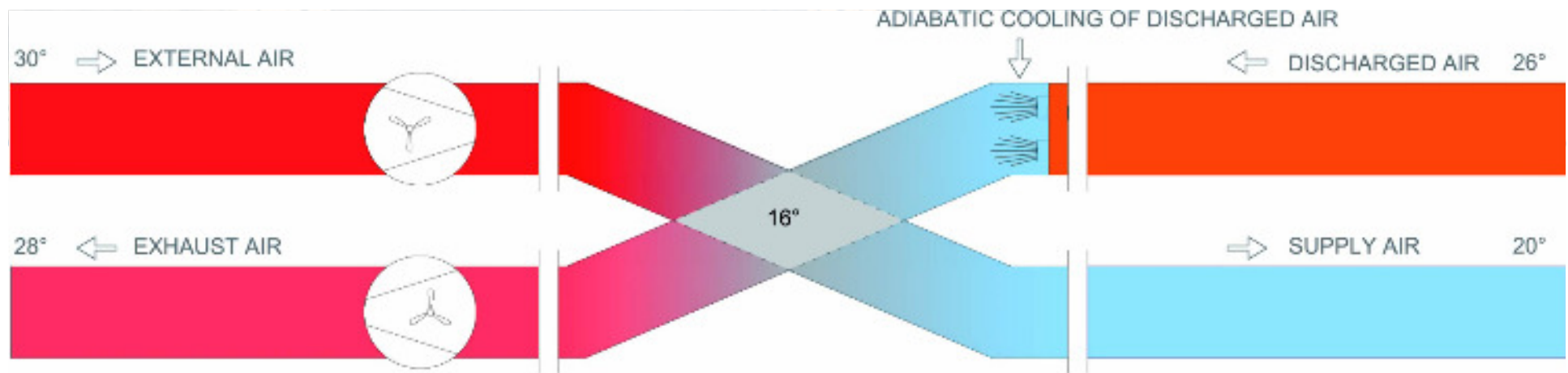


**Maintenance: 1.300 €/a**



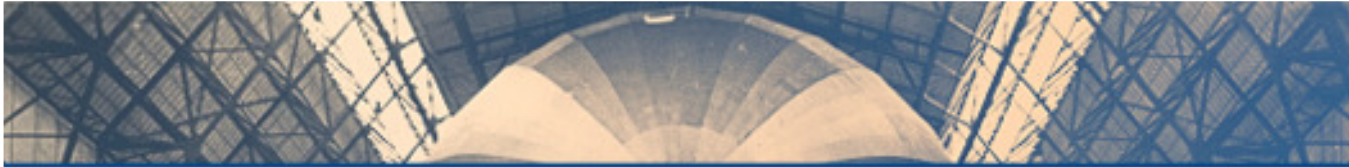
**Investment 3M membrane: 38.000 €**



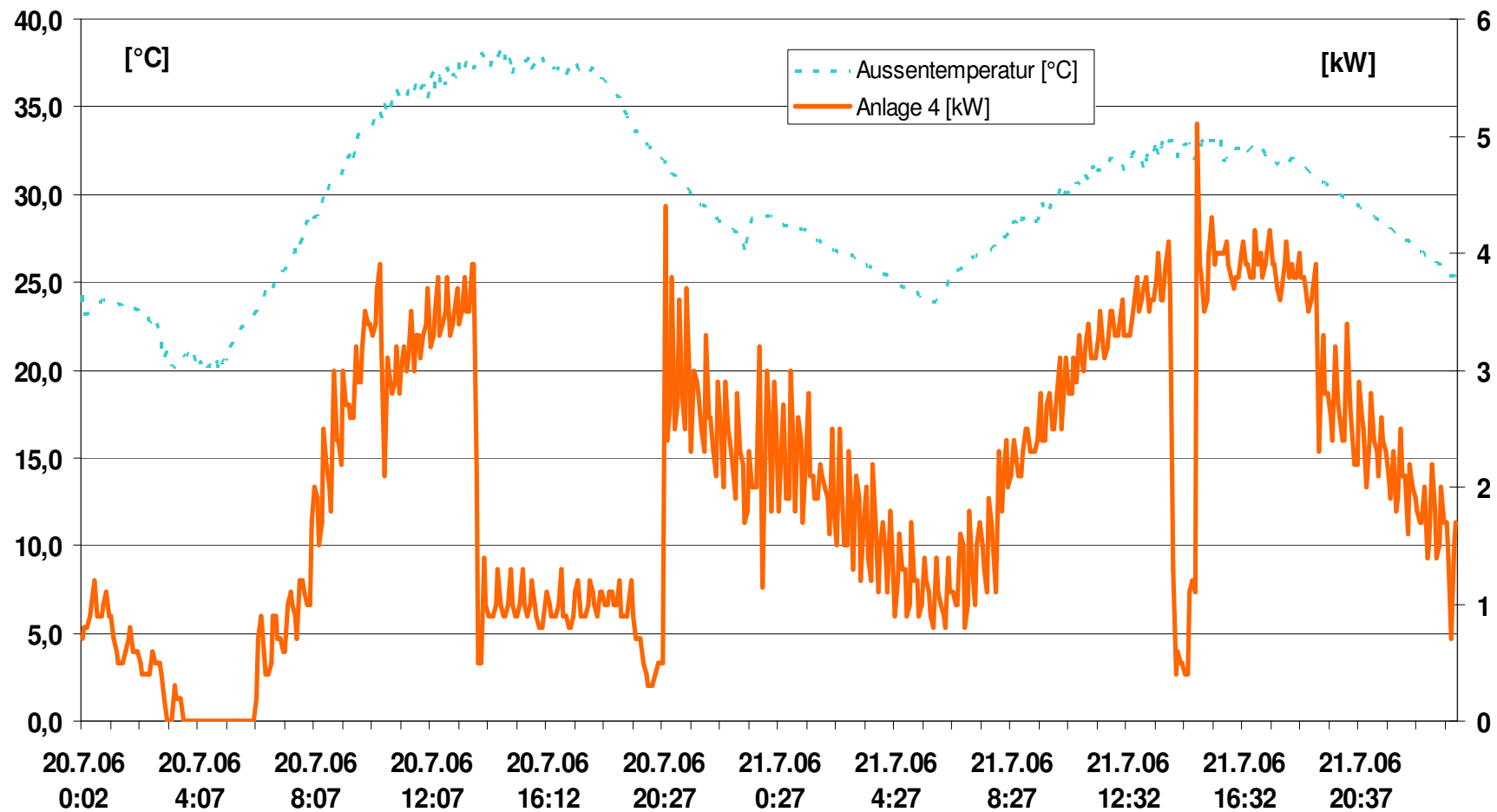


## Regenwassernutzung bei der adiabaten Abluftkühlung in Klimaanlagen

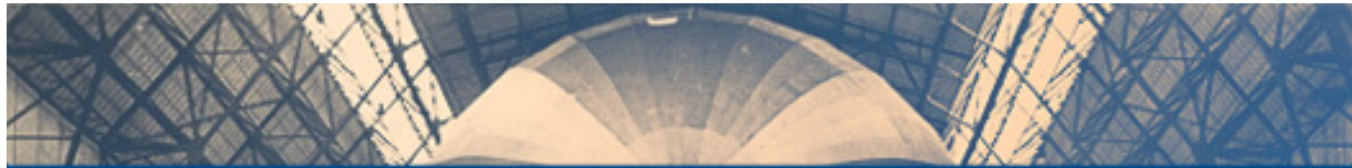




## Unterschied im Energieverbrauch mit und ohne adiabate Abluftkühlung – heißester Tag bis 38 °C







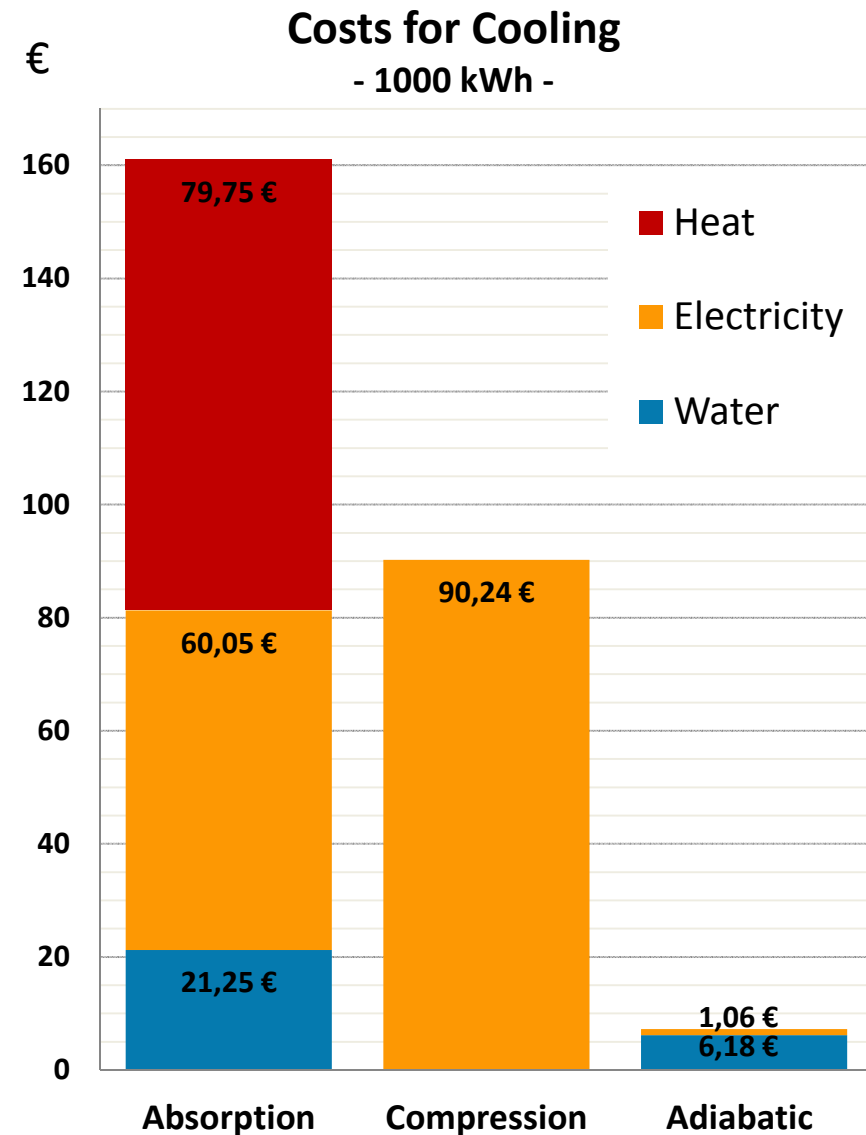
## Kostenvergleich Kälteerzeugung - für je 1000 kWh, Institut für Physik -

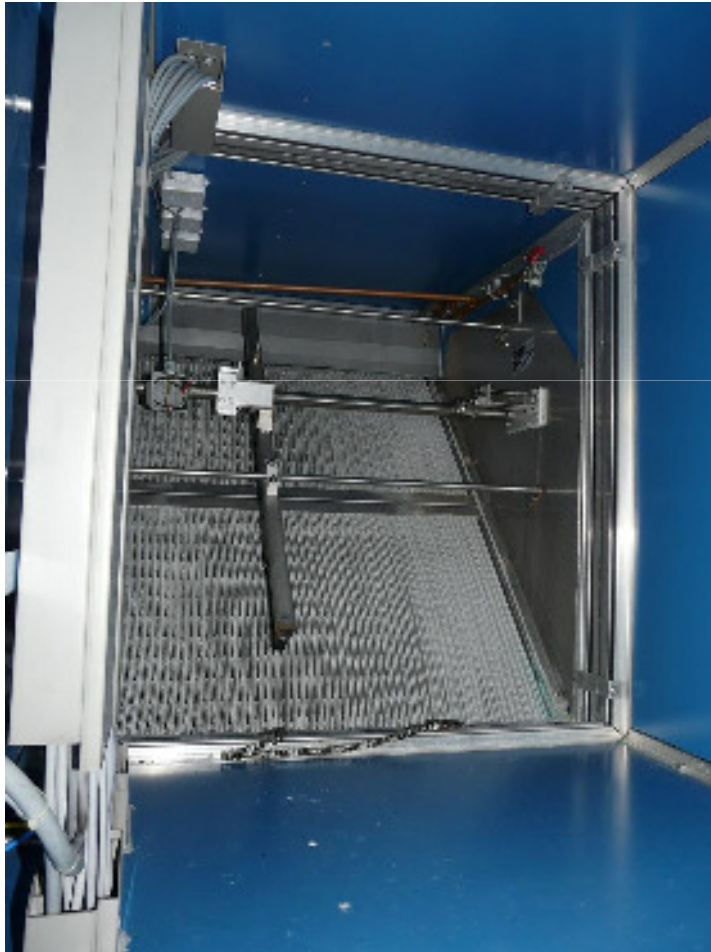
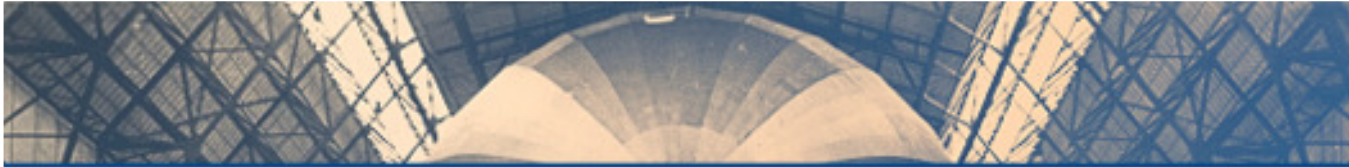
Adiabate Kühlung: **1,06 €** (0,185 €/kWh)

Kompressor: **90,24 €**  
(0,185 €/kWh COP 2,05)

Absorber: **161,04 €**  
(0,0376 €/kWh WZ 0,47)

Bei Regenwassernutzung:  
keine Aufbereitung und kein  
Abwasseranfall !





## **Projektziel:**

**Messung der Performance am Standort vorhandener Systeme (Solon, ZMM, UTZ, HUB Physik)**

**Vergleich mit konventioneller Kälteerzeugung**

**Entwicklung von Planungstools (u.a. zur Regenwassernutzung)**

**Übertragbarkeit**

**Akzeptanzforschung**





GHP GREEN HOSPITAL STUDY

## STAGE 1 - DETERMINATION OF BASICS

STUDY OF CRITERIA - EVALUATION MATRIX



## Rainwater Management Concepts

Greening buildings, cooling buildings

Planning, Construction, Operation and Maintenance Guidelines



**Vielen Dank für die Aufmerksamkeit !**

<http://www.gebaeudekuehlung.de>

<http://www.watergy.de>

<http://www.waterparadigm.org>

<http://www.phasenwechsel.com>

<http://www.enob.info>

<http://www.eneff-stadt.info>

<http://www.kuras-projekt.de>

