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Pametna rješenja za uštedu energije i energetska obnovu

Energy efficient heating and cooling: Evaluation, lessons learned

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Plus Energy Building Federal Environmental Agency (UBA) Dessau



Federal Institute for
Research on Building,
Urban Affairs and
Spatial Development

within the Federal Office for
Building and Regional Planning



Federal Ministry
for Economic Affairs
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energie
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Plus Energy Building

Federal Environmental Agency Dessau

Architects: **Anderhalten Architekten, Berlin**

Building services: **Winter Engineers, Berlin**

Construction costs: **ca. 14 Mio. Euro**

Effective area **2247 m²**, floor area **4780 m²**

PV roof **57,4 kWp**, PV facade **74,7 kWp**

Propan heat pump **53 kW**, geothermal **32 drills at 25 m depth**

Primary energy demand **32,8 kWh/ (m²a)**, **76 %** below EnEV

COP heating **4,6** (measured), COP cooling **58** (measured)

Monitoring/ Evaluation: BBSR



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Berlin (west): until 1989 several demonstration projects of sustainable construction (solar thermal, photovoltaic, cogeneration, graywater recycling, rainwater harvesting, green roof, façade and courtyard)



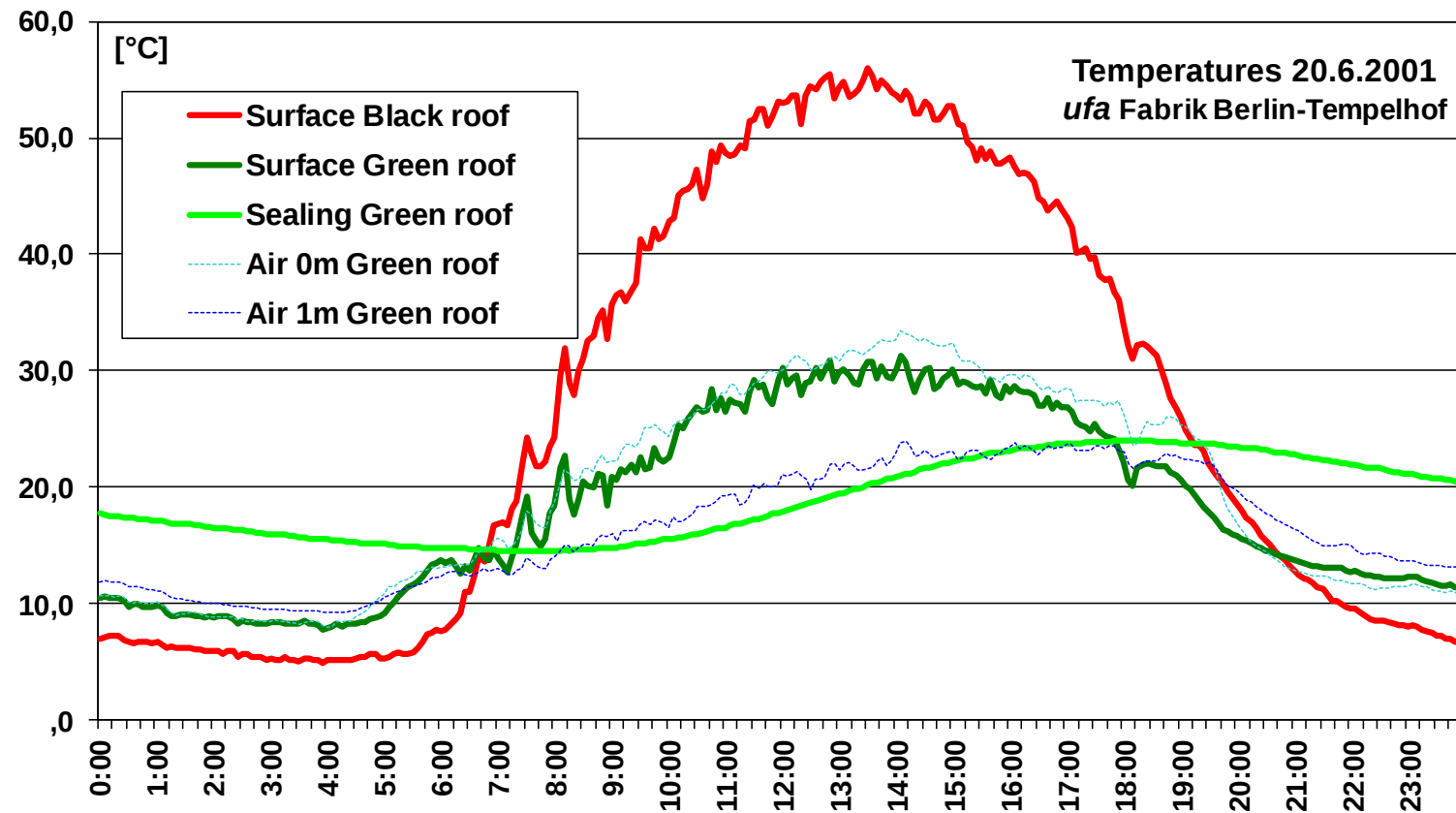
Bloque 108 Berlin- Kreuzberg 1983



Bloque 108 careful urban renewal 1987

Surface temperatures:

asphalt roof / green roof (infrared measurements)



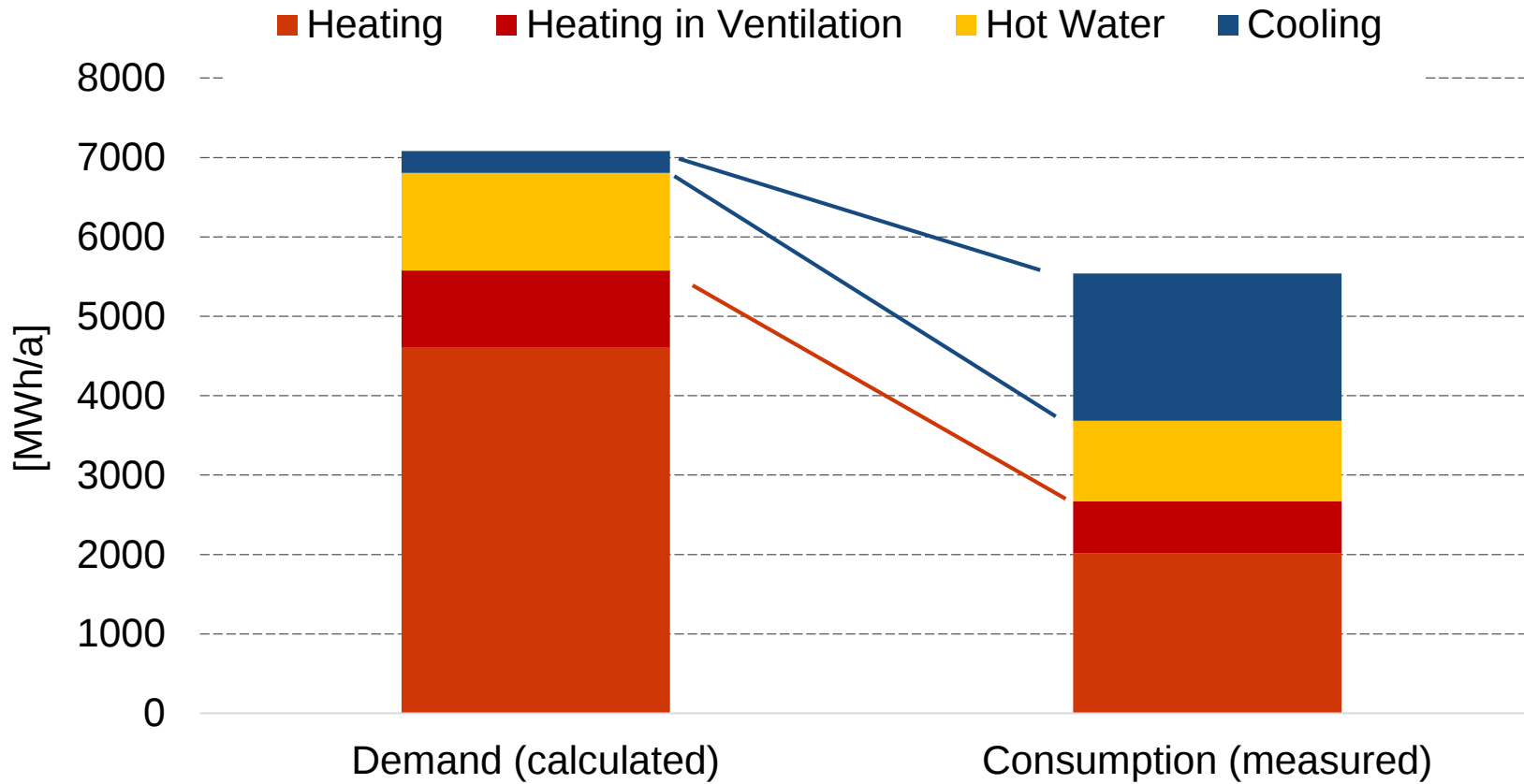


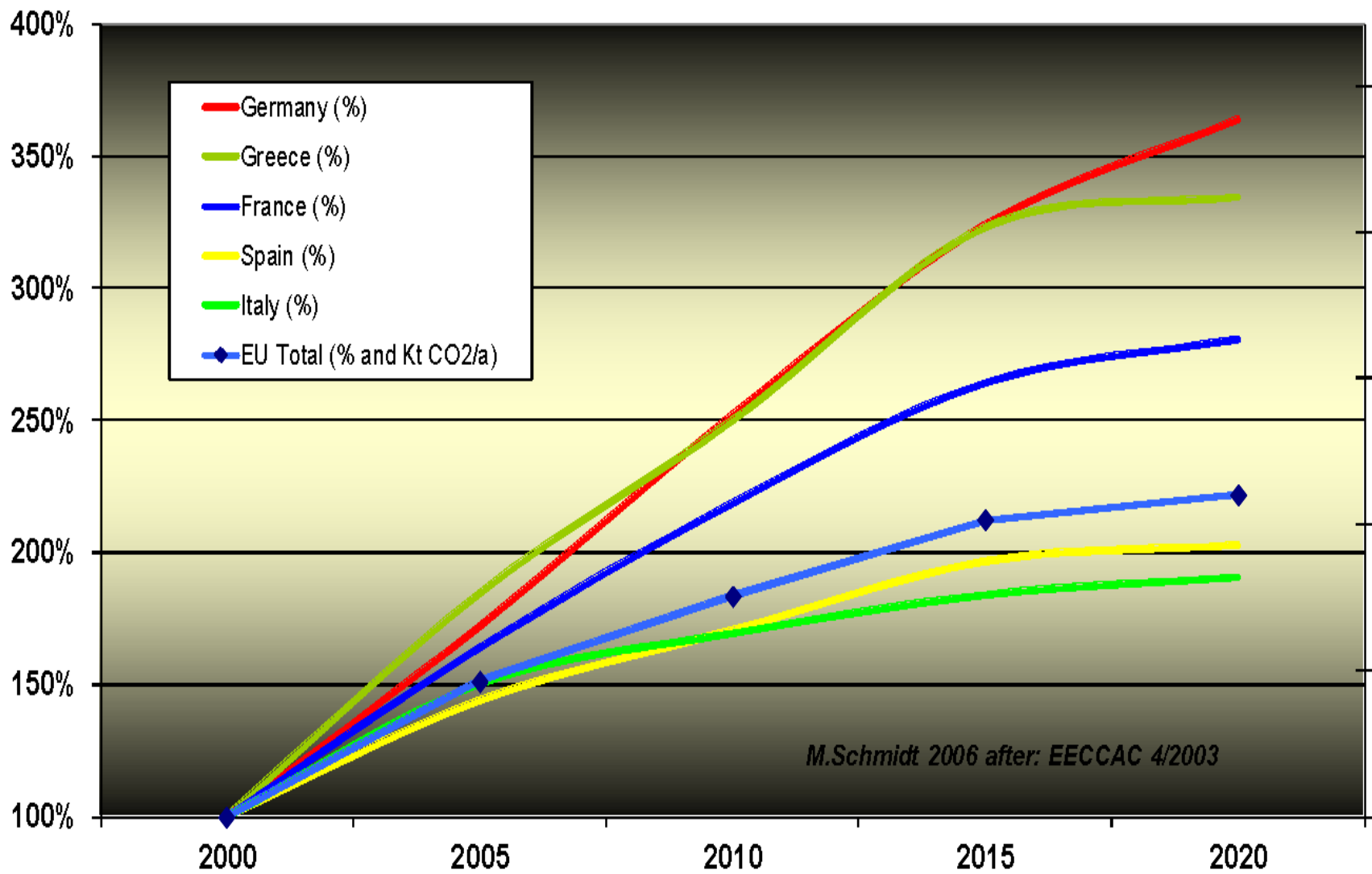
***Combination of
Photovoltaic
with Green Roofs***



Heat and Cold

Demand and Measured Consumption in MWh/a





Goal Germany:
 Decrease in energy
 consumption of buildings
 by 2020: **50%**

But forecast:
 Increase in energy
 consumption for cooling:
260%

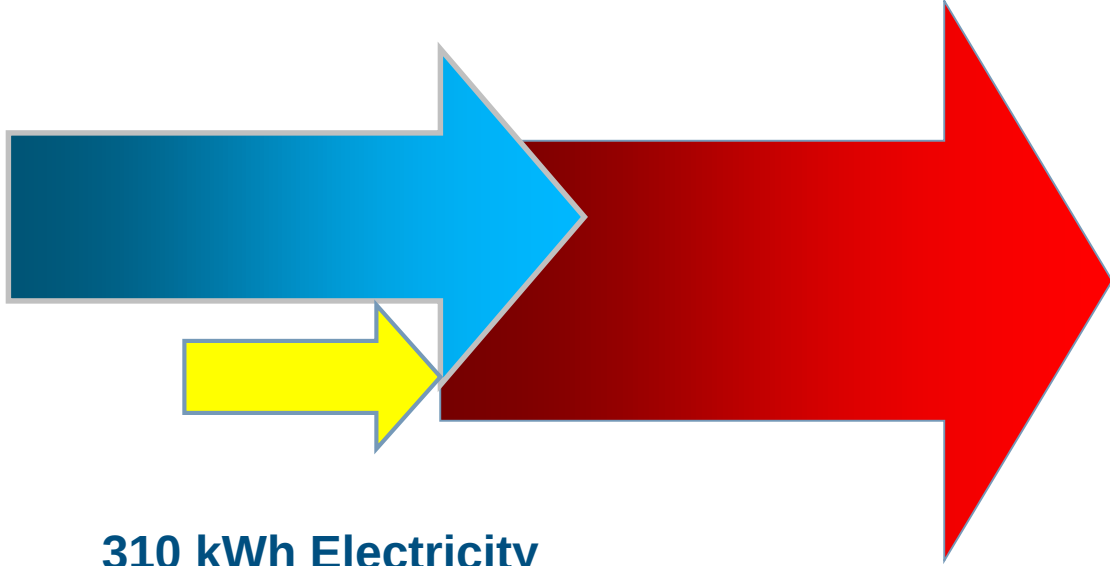
*Source: Energy Efficiency and Certification of Central Air Conditioners (EECCAC)
 Study for the D.G. Transportation-Energy (DGTREN) of the Commission of the E.U.*

Reasons for increase in cooling demand:

- 1: Increase in use of glass**
- 2: Decreasing heat capacity, use of lightweight materials**
- 3: Increasing electricity consumption**
- 4: Increasing Urban Heat Island Effect**
- 5: Global Warming**

Never use electricity to cool a building !

680 kWh Cold



310 kWh Electricity
(annual COP 2,2)



990 kWh
Sensible Heat
Release Outside



**Inefficient /
Unsustainable /
Dangerous**

+

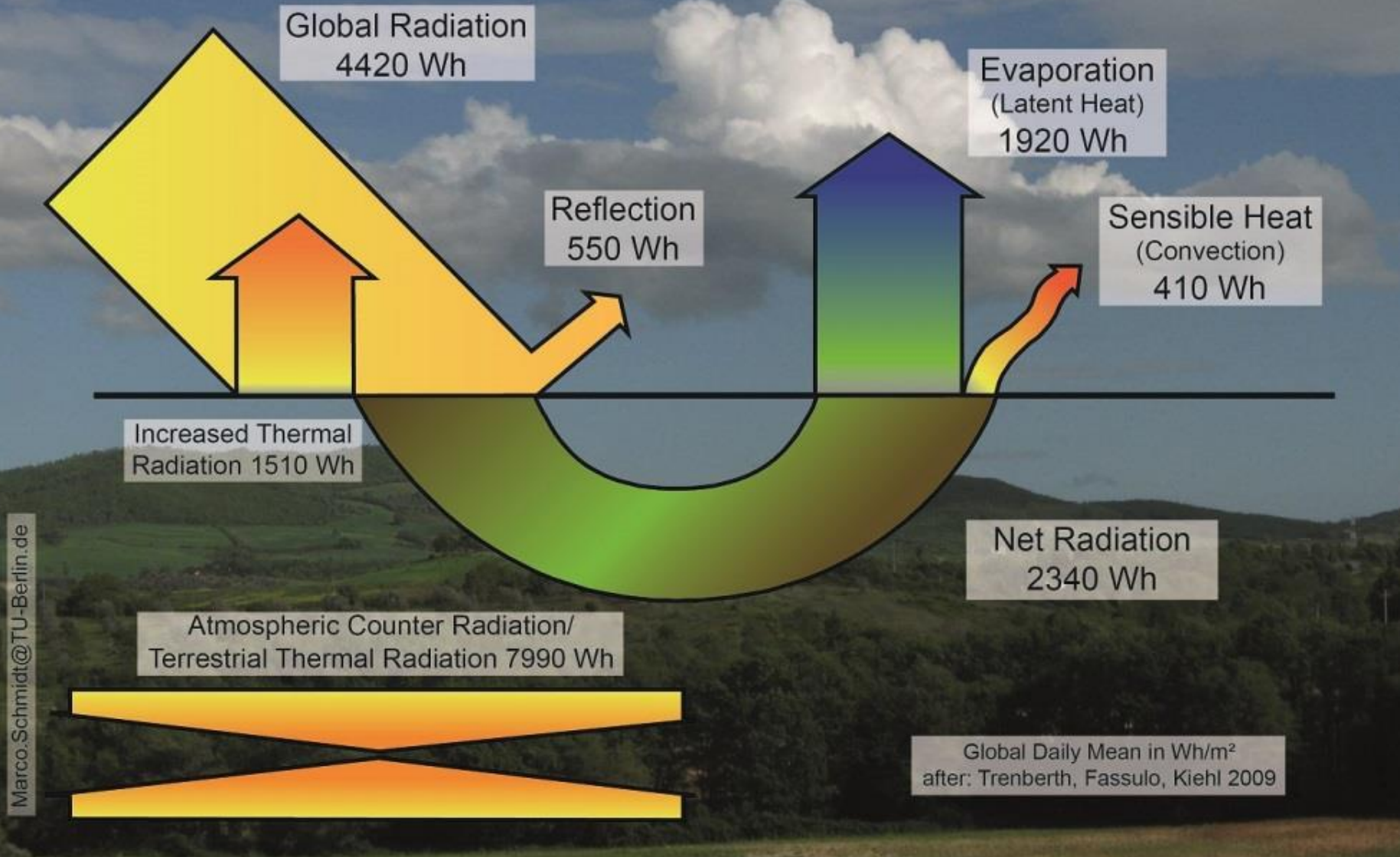
HFC Phase Down
Most of the common
refrigerants are not
available any more the
next years !

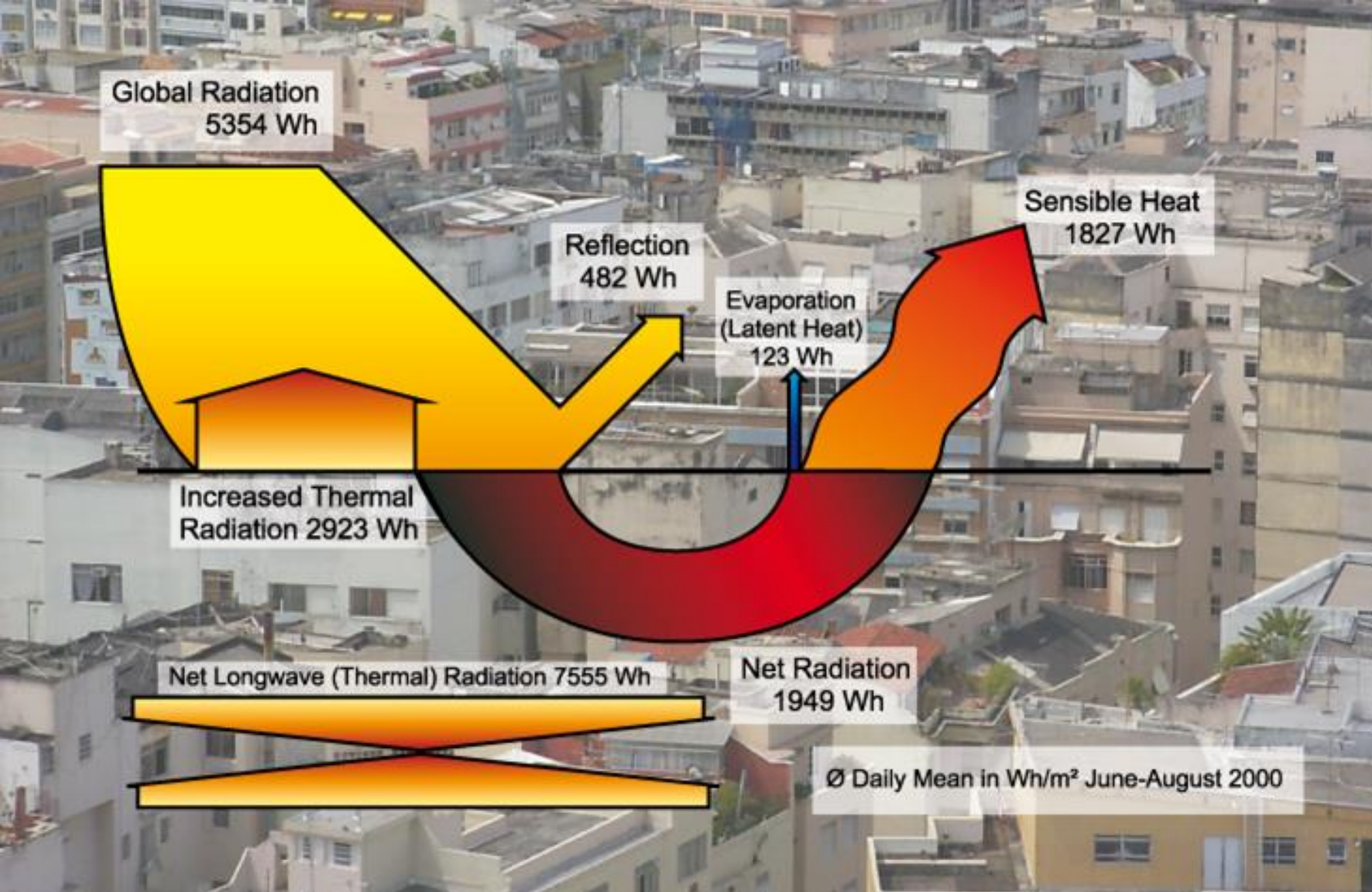
Global Radiation Budget

mean of one square meter worldwide

The entire global radiation at the surface of the earth is at 45% dominated by evaporation and condensation !

Date after
Trenberth, Fassulo, Kiehl 2009





Urban Radiation Budget

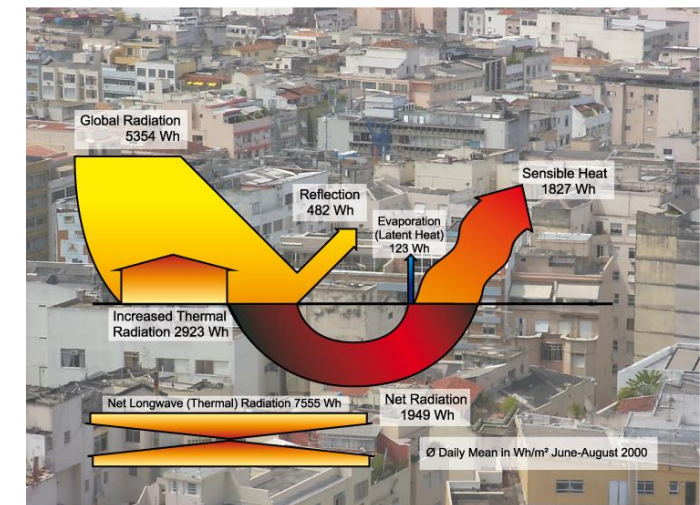
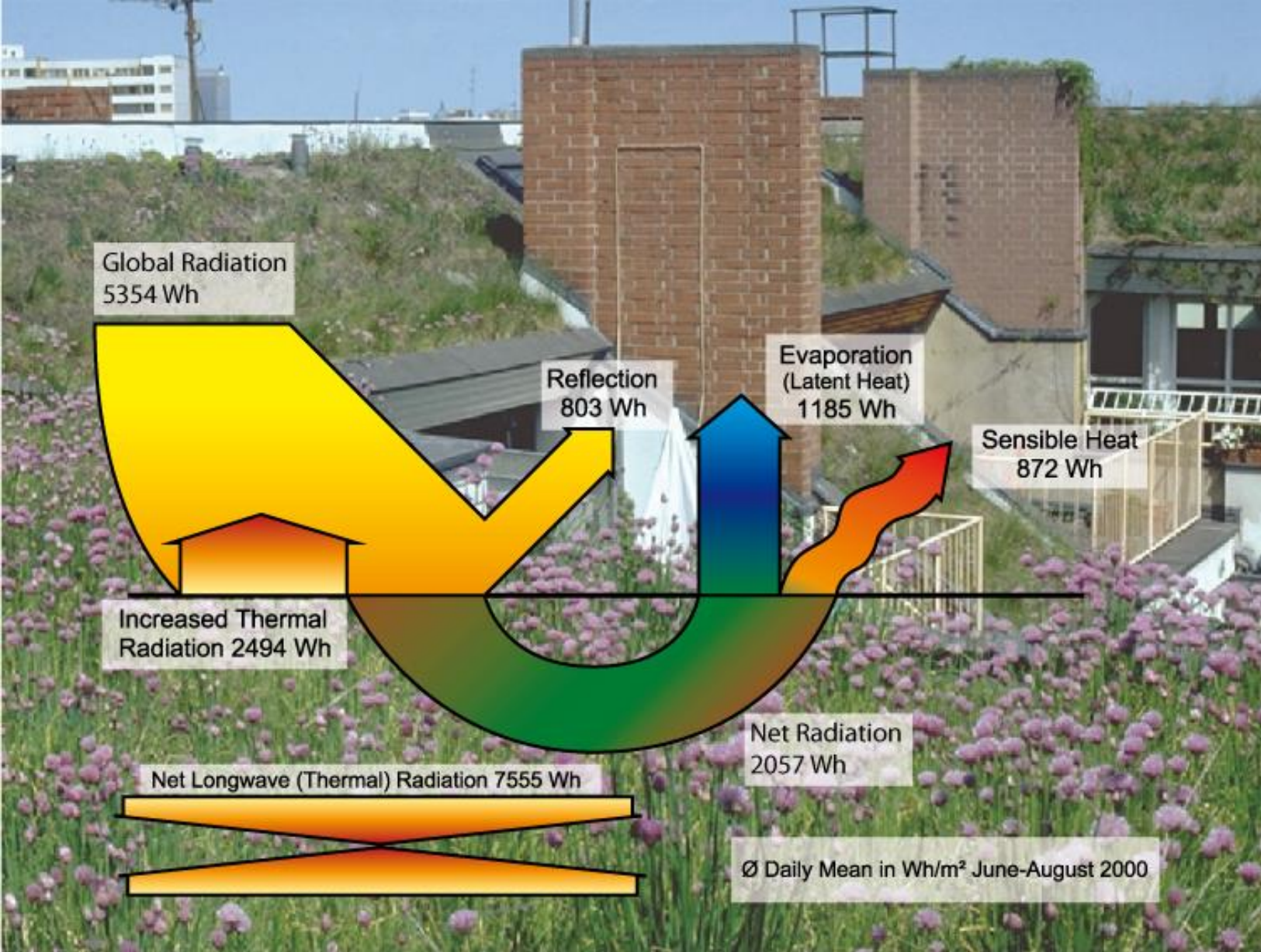
Example: Asphalt roof

Urban Heat Island Effect

Rainwater is funneled into sewer systems and has no chance to evaporate

Radiation Budget Green Roof

An extensive green roof converts
already 58% of the net radiation into
evaporation in the summer month





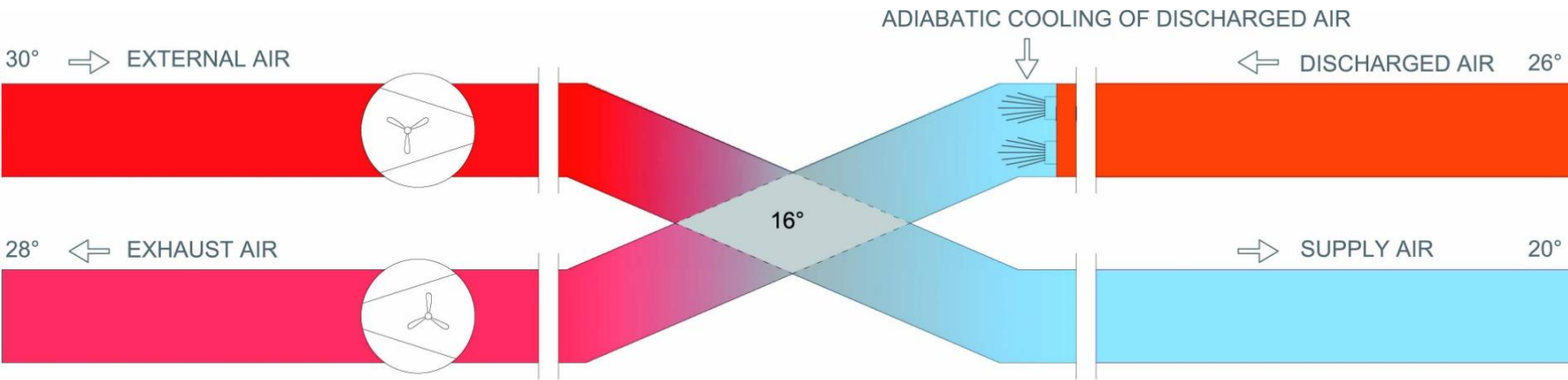
Evaporative cooling

**Air to Water
Heat Exchanger**
www.erichkeller.com



**Building of
Böll-Foundation, Berlin**
www.boell.de

TAZ Publisher, Berlin
www.taz.de



Evaporative Exhaust Air Cooling

Air to Air Heat Exchanger



Institute of Physics,
Humboldt-University Berlin
www.physik.hu-berlin.de

Costs for cooling (german prices)

Adiabatic cooling: 0,72 ct/kWh

Compression cold: 9,4 ct/kWh

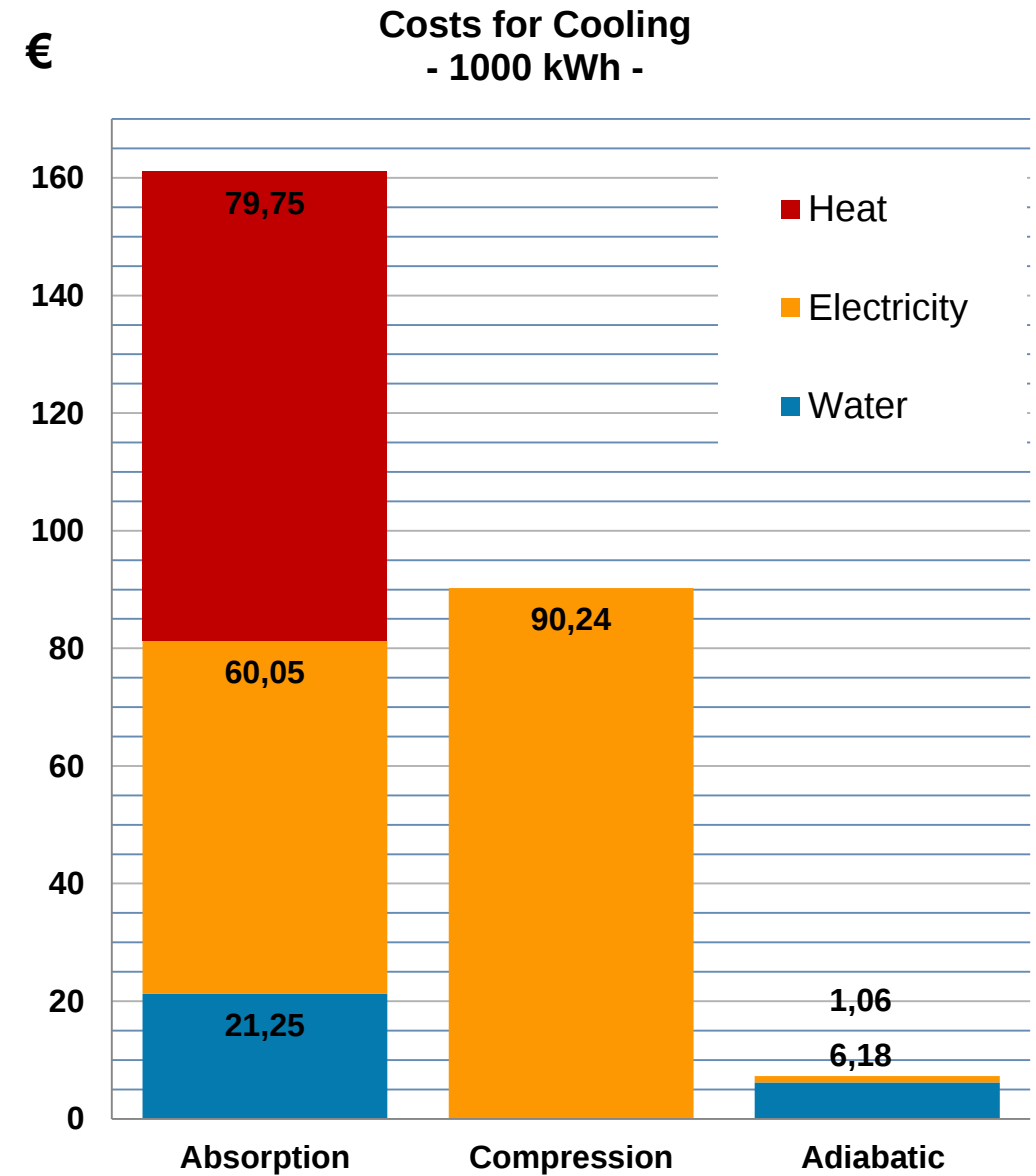
Absorption: 16,1 ct/kWh

Heat: 0,0376 €/kWh COP 0,47

Electricity: 0,185 €/kWh

Water: 2,22 €/m³

Wastewater: 2,57 €/m³



3win: Win + Win + Win

- Cheaper in investment
- Cheaper in operation
- Better for the environment

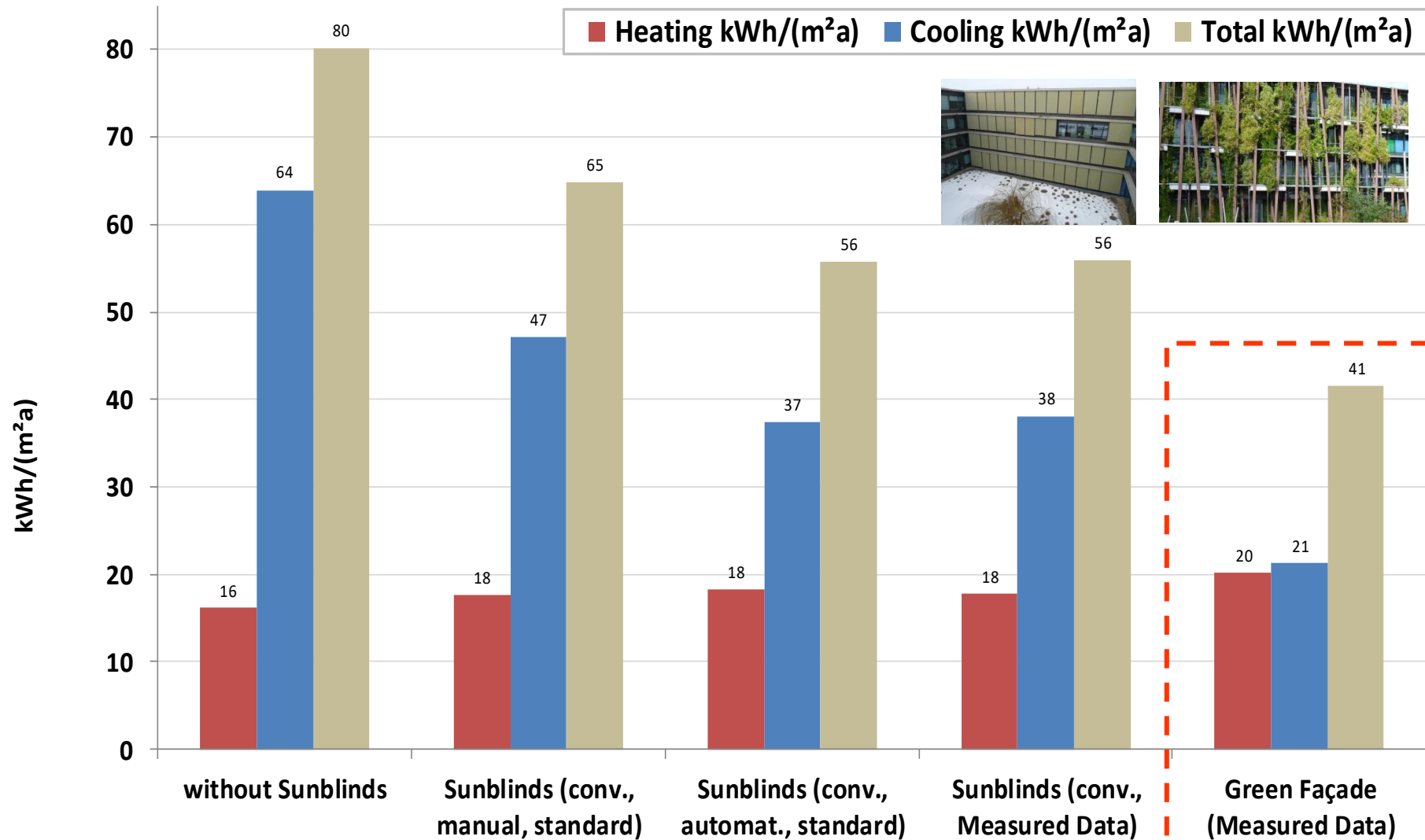
Operating Costs: 1.300 €/a

Operating Costs: 16.525 €/a

Comparison of Costs

**Conventional Blinds
with Green Facade**

**Institut of Physics
Humboldt-University
Berlin-Adlershof**



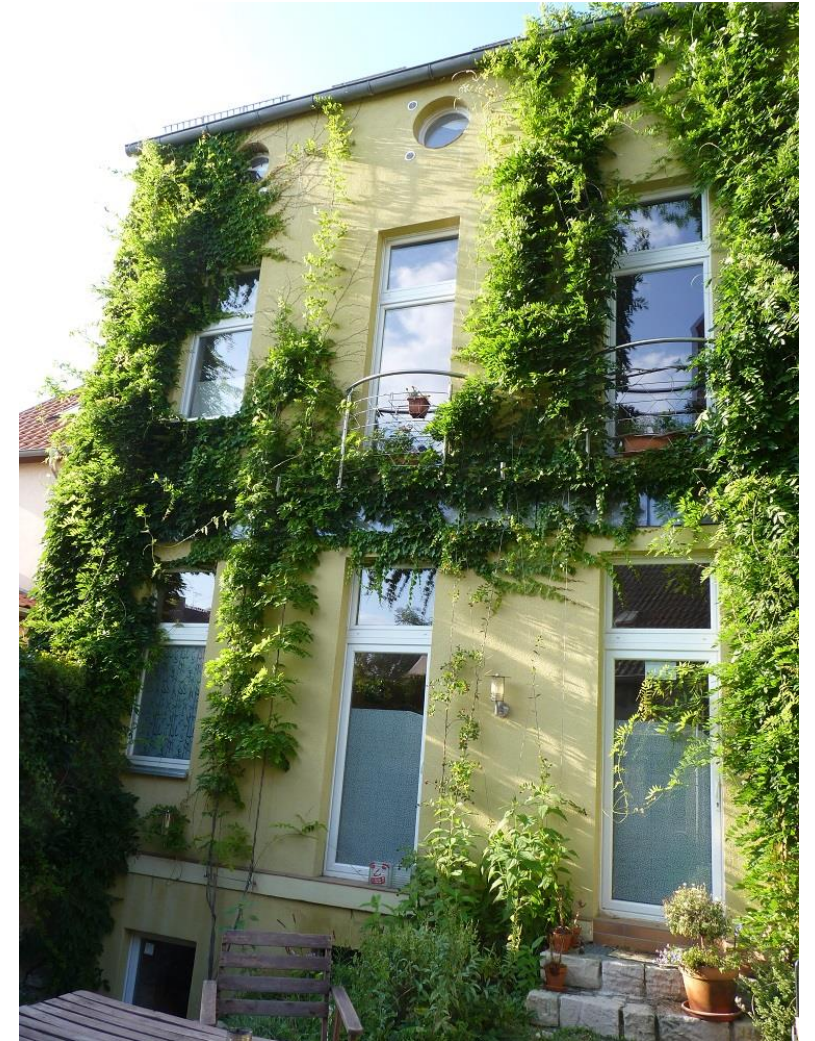
Primary Energy Demand for Heating and Cooling in Comparison of blinds with green Facade (after DIN V 18599)

Institut of Physics,
Humboldt-University
Berlin-Adlershof

4win: Win + Win + Win + Win

- Cheaper in investment
- Cheaper in operation
- Better performance for the building
- Better for the environment

Former empire postal office (1880), town hall (1930), office building (2018)



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Existence

- coal fired single stoves (1.+2. floor), gas heater (attic floor)
- single glazing (2. floor, north facade, staircase)
- coupled window (1. floor, 2. floor south facade, attic floor)
- Consumption demand: **320 kWh/m²a**



south facade and dormer north side before restruction



Restructuring measures:

- inside insulation
- insulation outside dormer
- outside insulation courtyard side
- translucent thermal insulation
- ventilation system with heat recovery
- solar thermal energy, photovoltaic
- grey water heat recovery
- rain water utilization
- building greenery

Refurbishment of wooden construction before inside insulation

Problem: dewpoint at beam head !



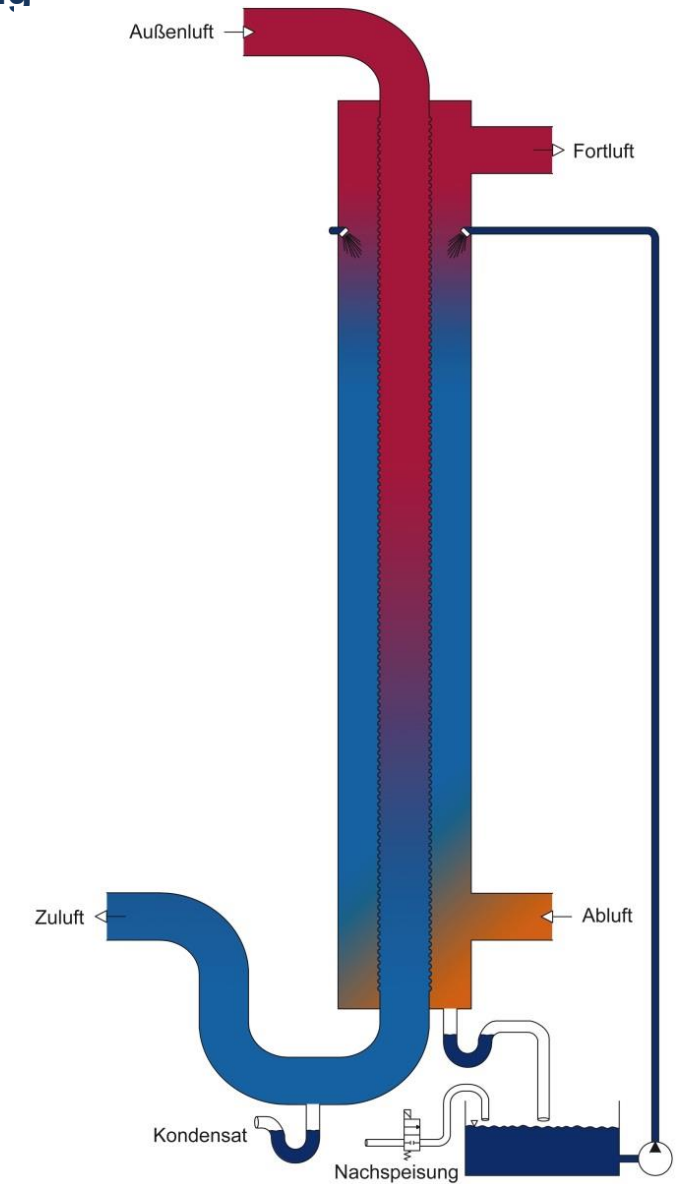
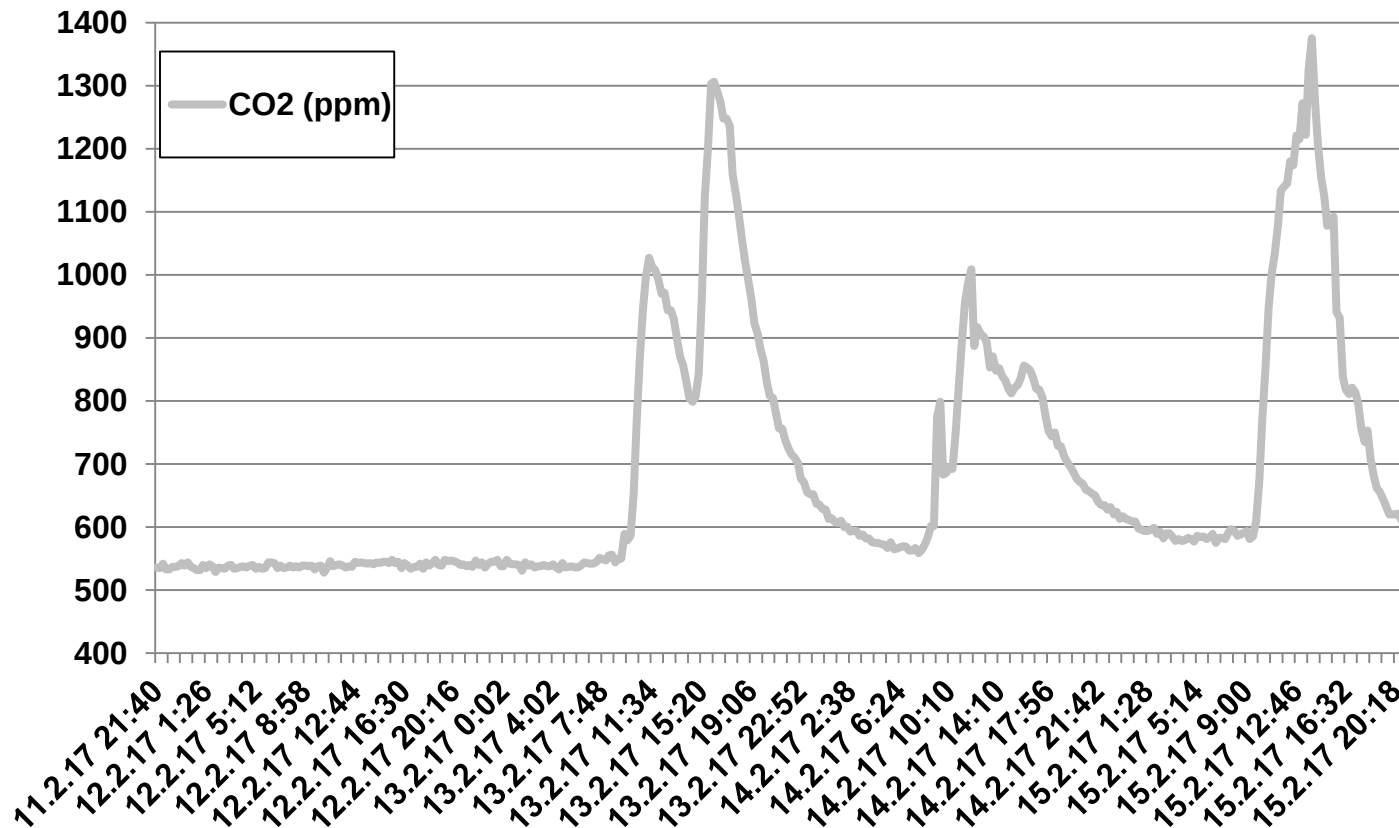
Emission of humidity in a single household:
about 10 liter per day

Heating period (180 days): 1,8 m³

Sensible heat consumption: 680 kWh/m³ = 1250 kWh



- Air exchange rate of **0,1 per hour** sufficient to fulfill 1500 ppm CO₂ and avoiding dewpoint on thermal bridges (=2,4/d)
- Integration of ventilation system (0,1/h) with 3 heat exchangers and adiabatic cooling of exhaust air (located in 2 former chimneys)



Integration of an translucent insulation (14 cm) into the south orientated facade; greened for shading in summer



Low-energy building

in existing context after restructuring (before: **320 kWh/m²a**)

- floor space: 639 m²
- heated volume: 1997 m³
- building shell: 0,49 W/m²K
- energy consumption: **54,8 kWh/m²a**
- consumption demand: 64,2 kWh/m²a
- thereof electricity: 2,6 kWh/m²a
- measured consumption: **46,0 kWh/m²a**
- solar thermal income: 5,57 kWh/m²a
- thereof measured solar heating support: 1,26 kWh/m²a





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Thank you very much for your attention !

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www.gebaeudekuehlung.de

www.rainforclimate.com

www.phasenwechsel.com



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