

Energy concepts for office buildings

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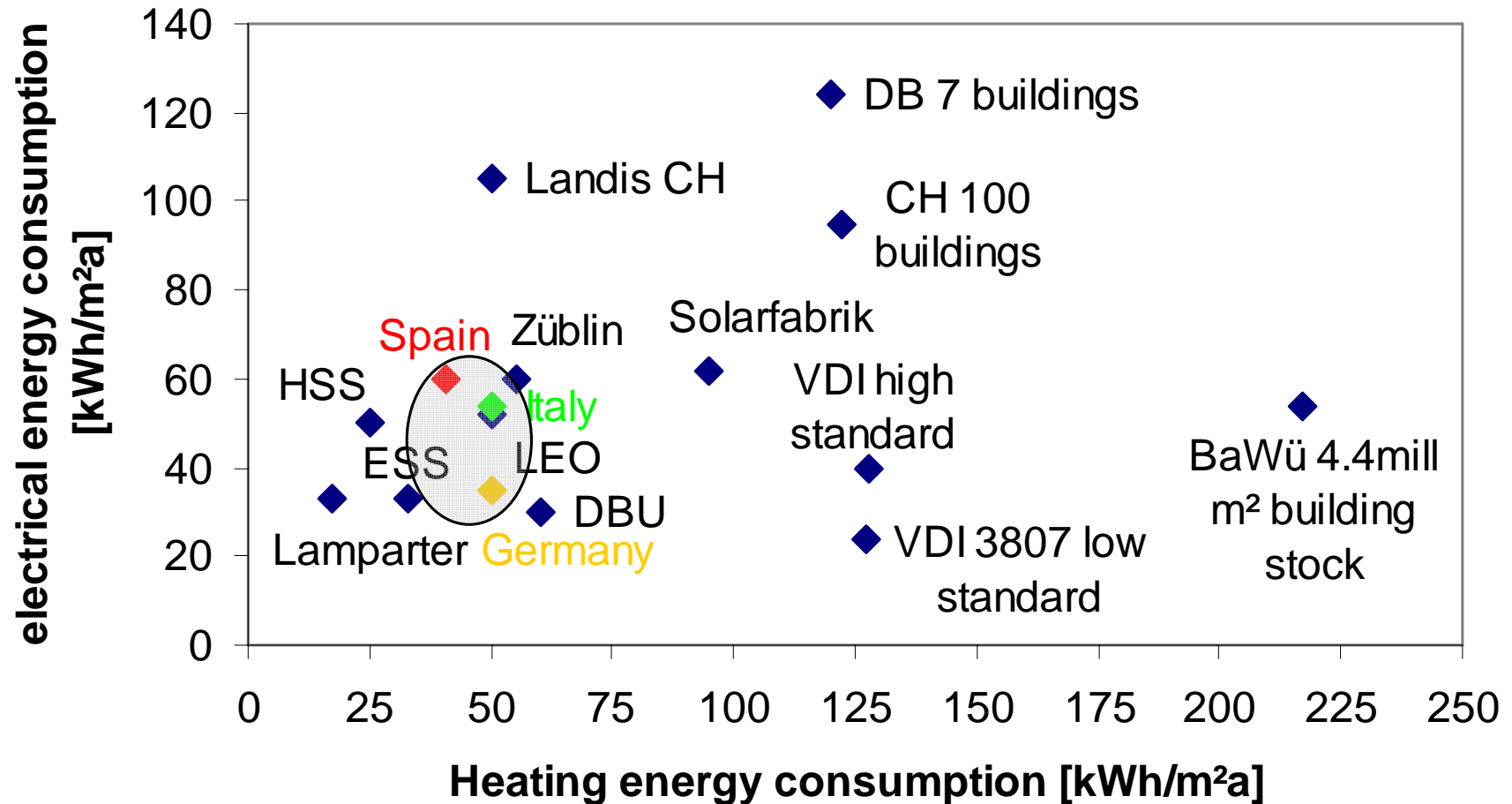
Zentrum für angewandte Forschung
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Issues in energy consumption

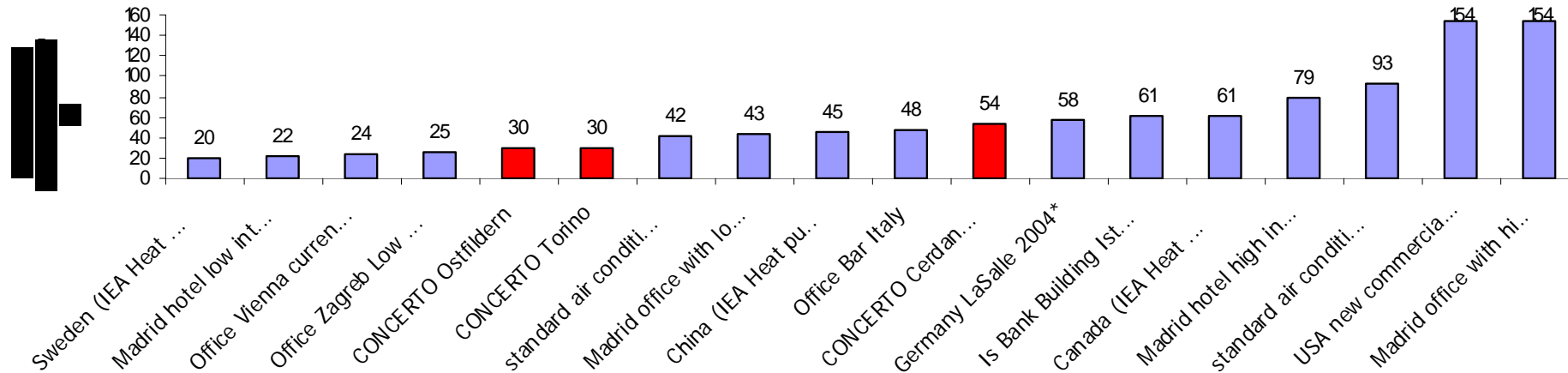
- Heating energy: Transmission losses, Ventilation losses
- Cooling energy: Passive or low energy cooling
- Electrical energy consumption: lighting and devices



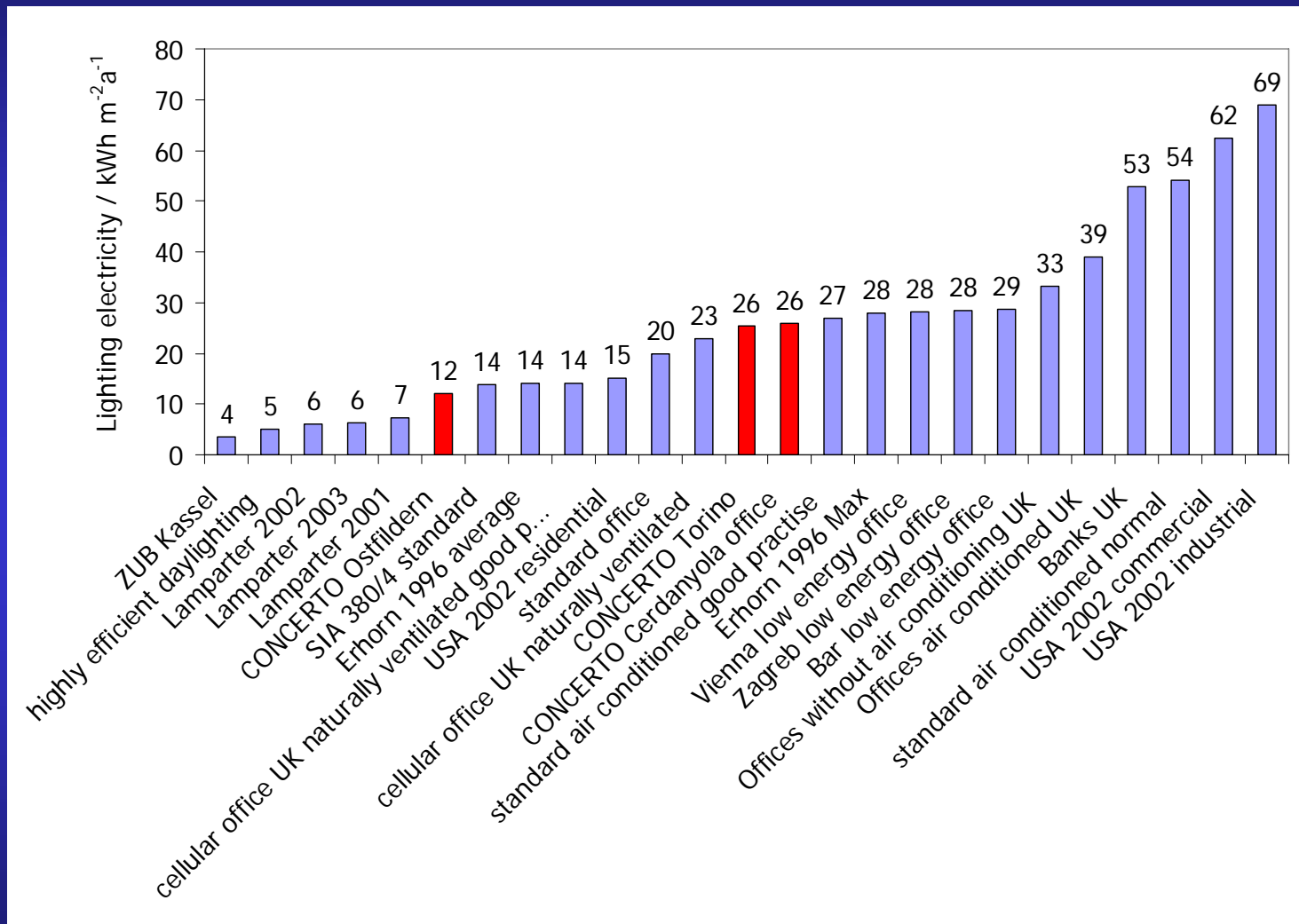
Measured energy consumption of office buildings



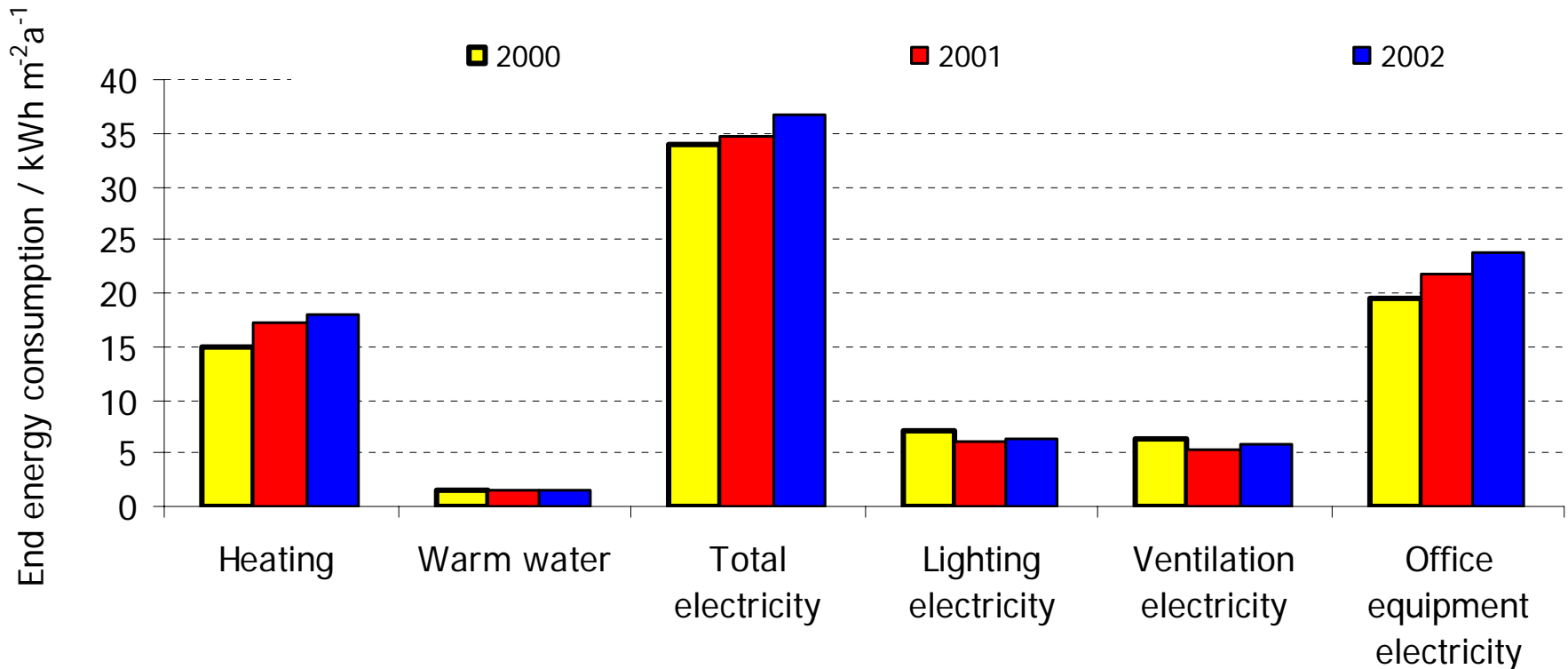
Cooling energy demand



Lighting energy demand



Best practise office building Lamparter in Germany





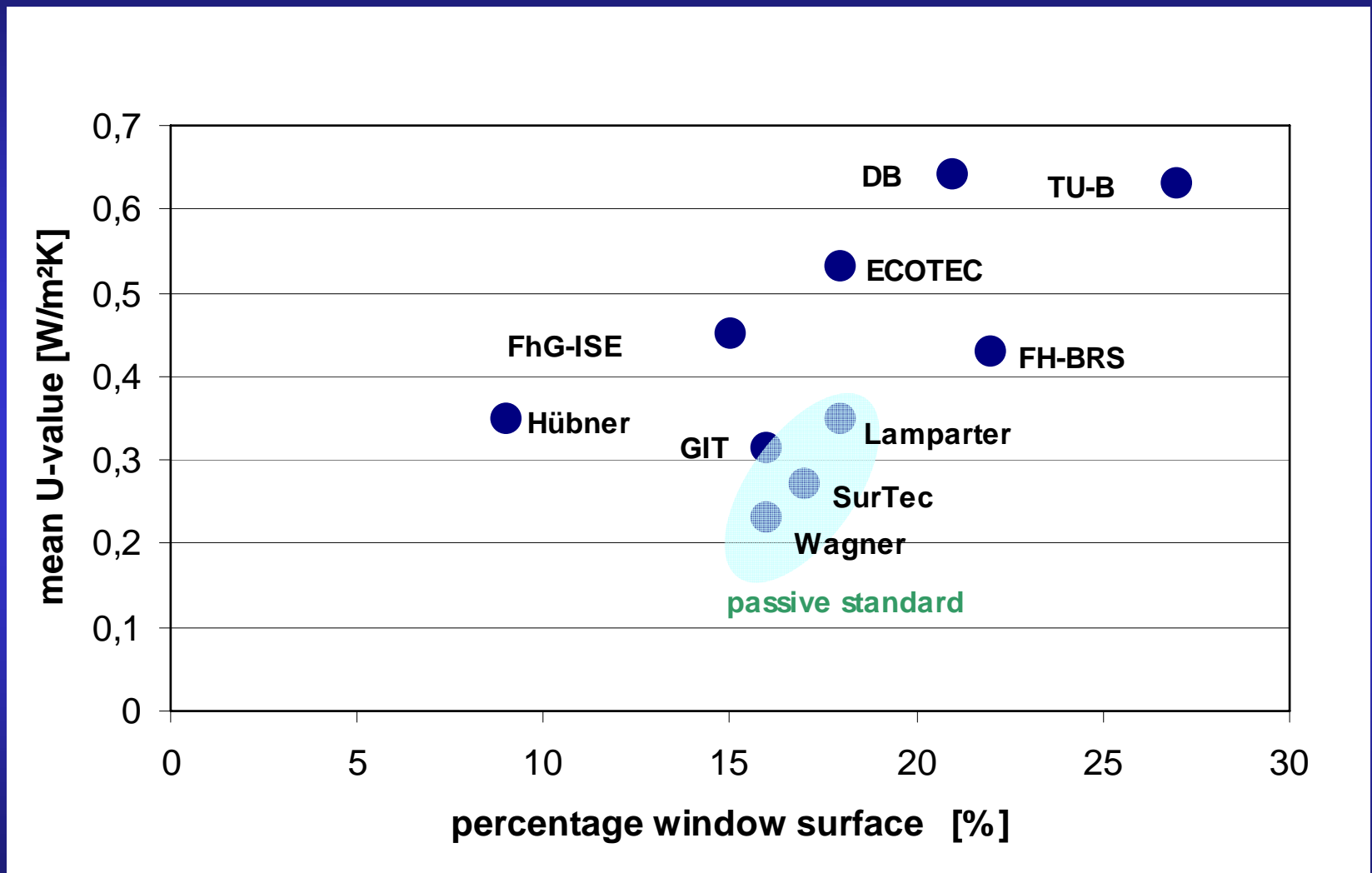
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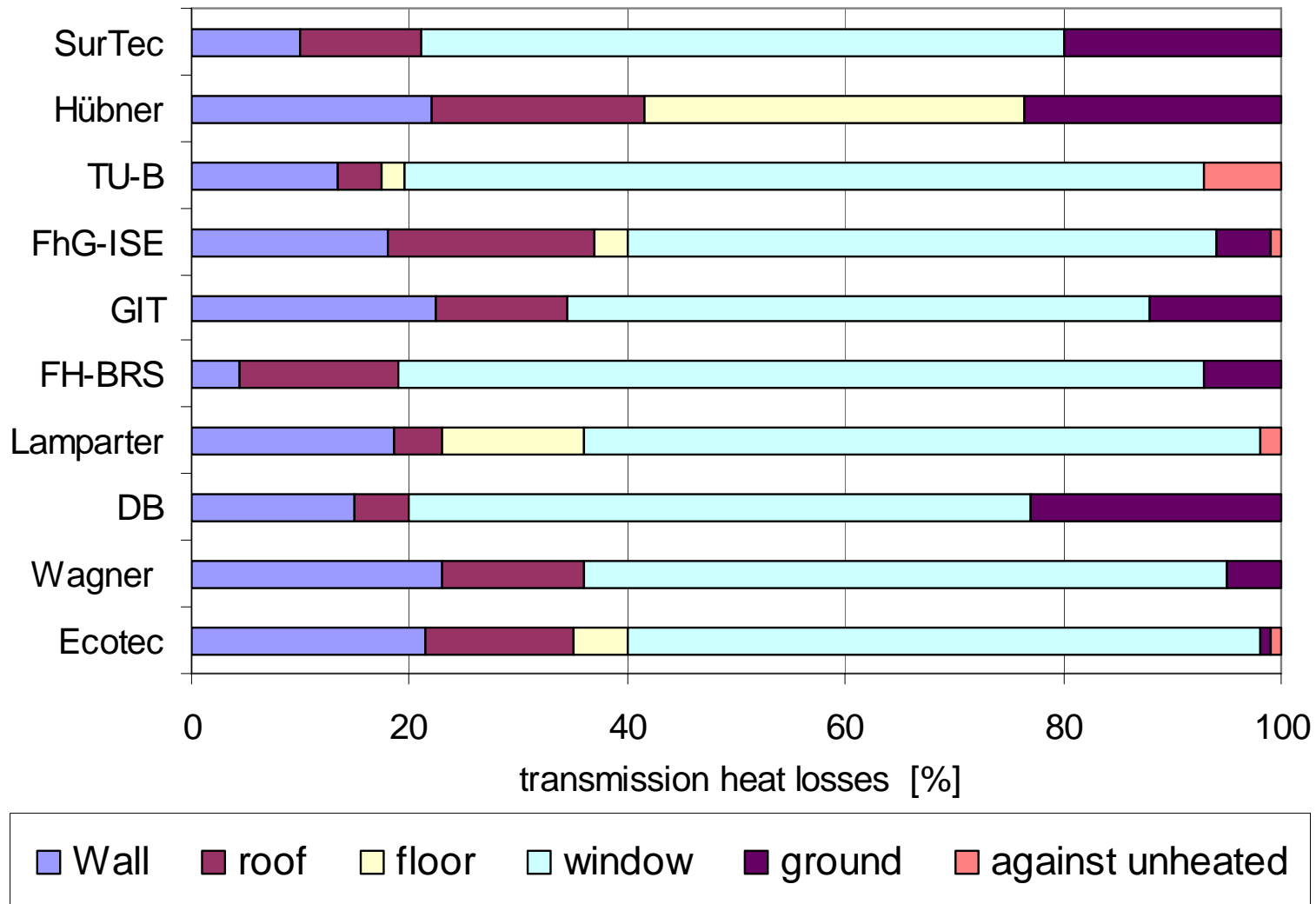
Basel 2-2006

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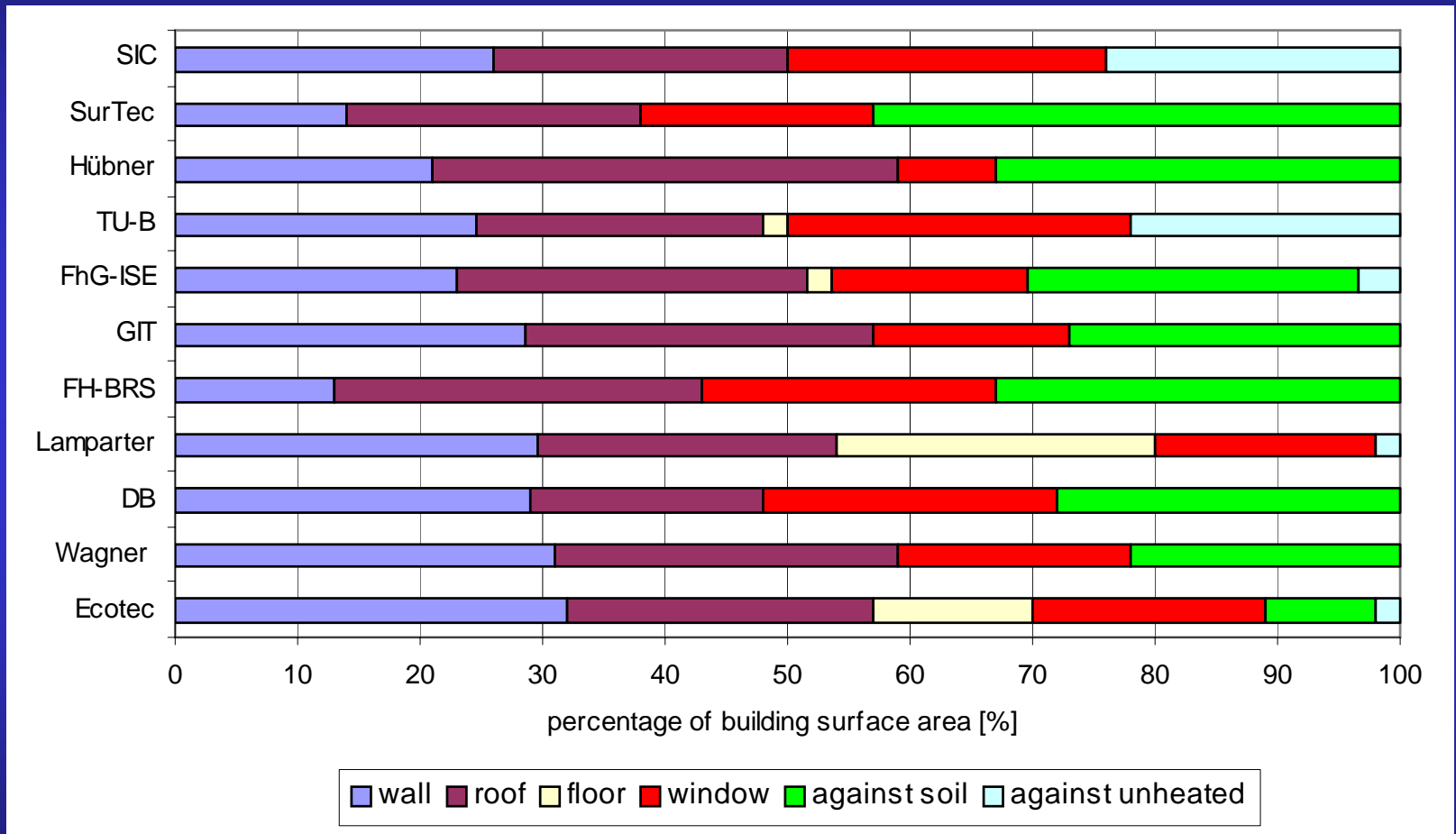
Heat loss building skin: mean U-values



Transmission heat losses in low energy office buildings



Heating energy: low energy buildings have moderate window surface areas



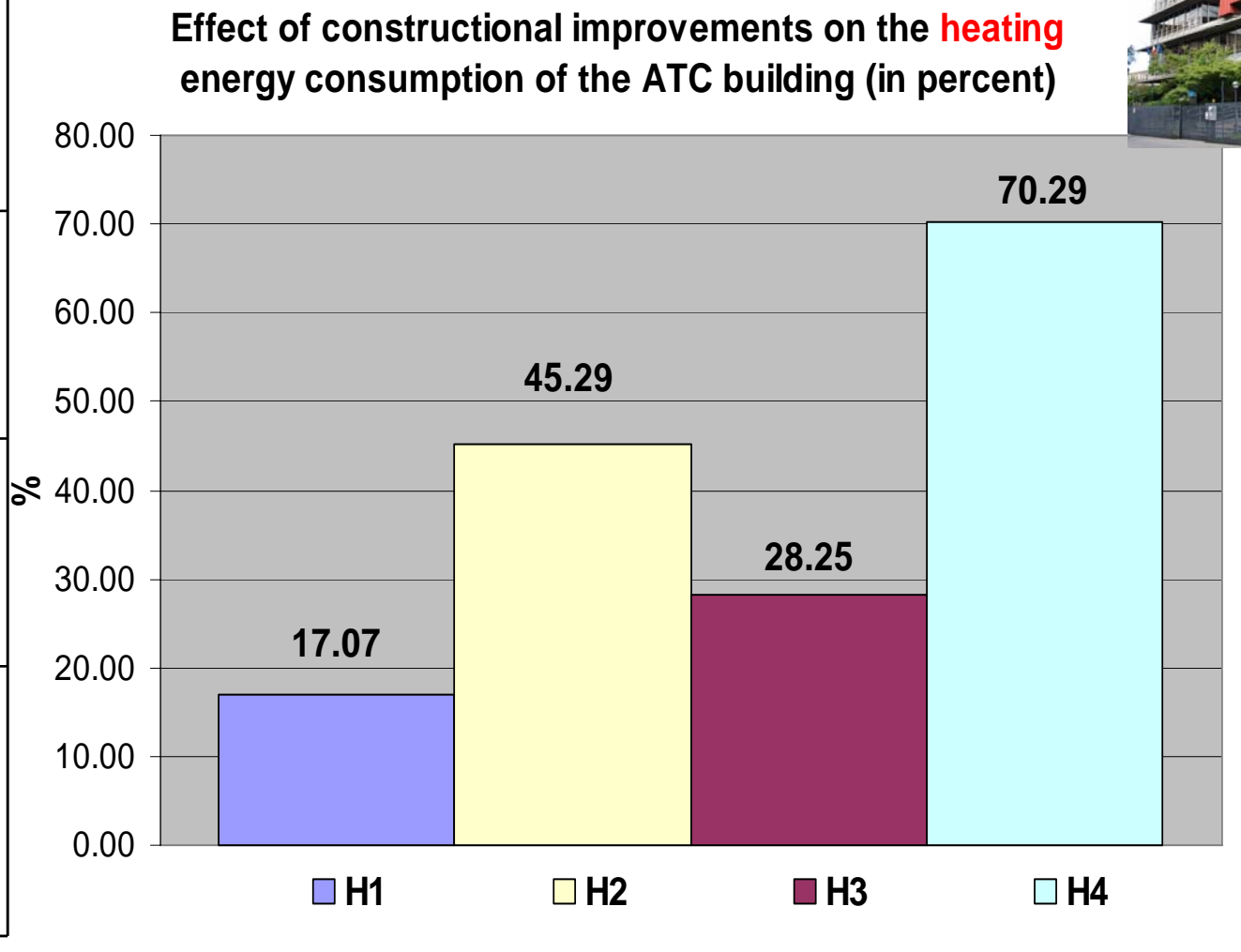
Transmission heat losses

- 50-70% of transmission losses via the glazings for window surface fractions of only 17-23%
- Triple glazing required for passive buildings without heating system (for comfort reasons), special frames not required (Passive building Lamparter has wooden frames with $U_{\text{window}} = 1.1 \text{ W/m}^2\text{K}$).

Transmission heat losses ATC building



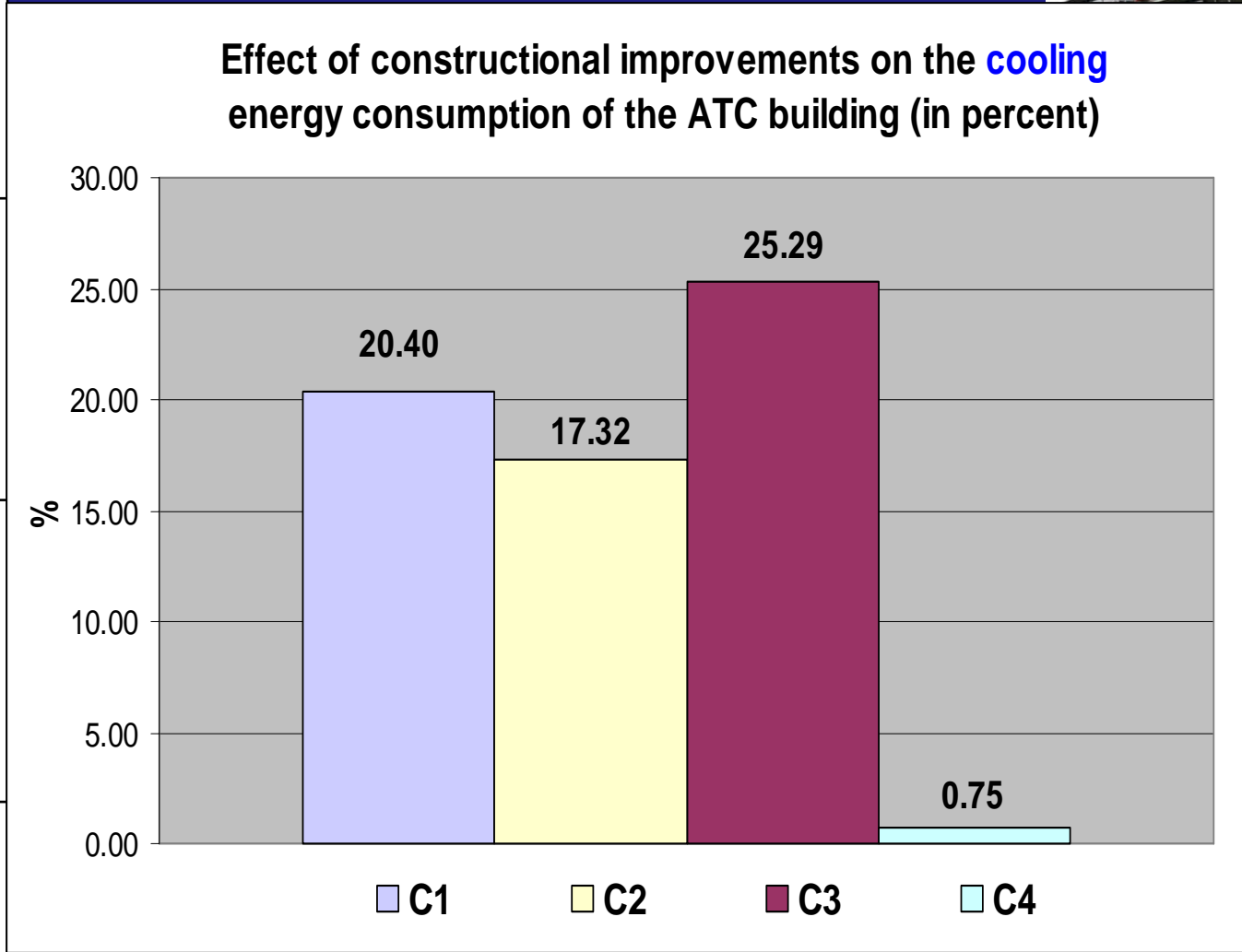
| | |
|----|--|
| H1 | Replacement of windows NE facade with windows $U=1.1 \text{ W/m}^2$ |
| H2 | Replacement of windows all facades with windows $U=1.1 \text{ W/m}^2$ |
| H3 | External insulation on walls and balconies (5-20cm) |
| H4 | Replacement of windows all façades / insulation on walls and balconies |



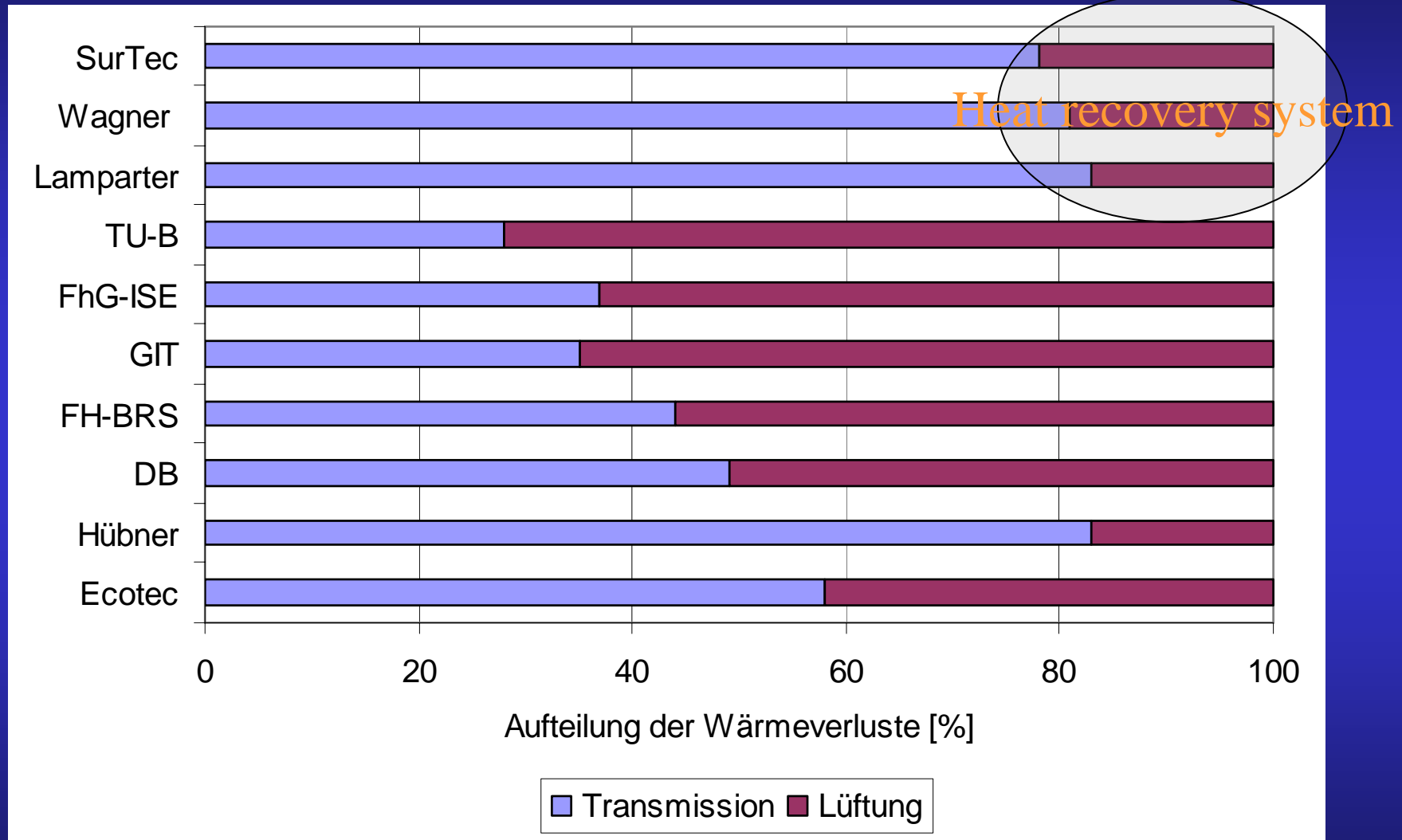
Cooling energy consumption ATC building



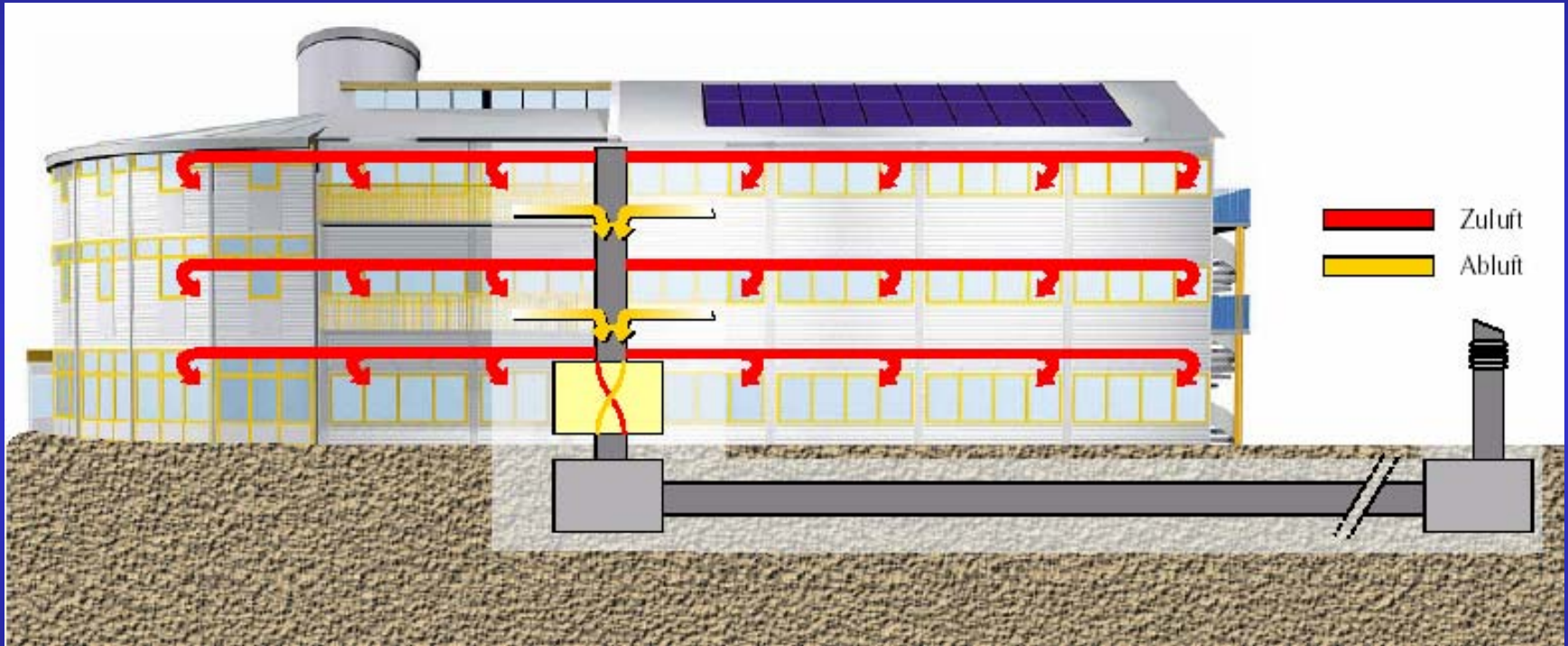
| | |
|----|---|
| C1 | Replacement of all windows, use of mechanical ventilation to cool the building at night |
| C2 | Automatic, adjustable shading elements on the NE and SW façades |
| C3 | Automatic, adjustable shading elements on the NE, SE and SW façades |
| C4 | Addition of PV modules to the SW facade |



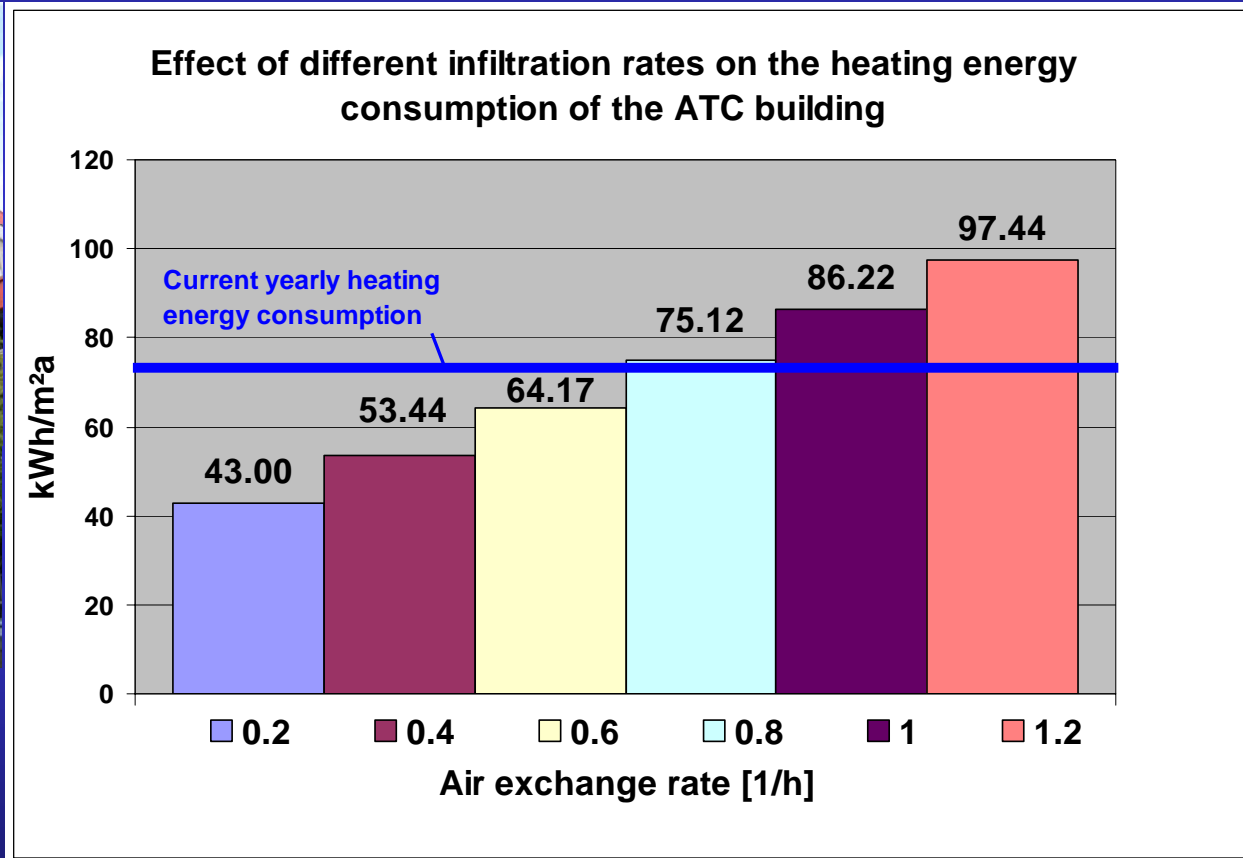
Transmission - Ventilation: distribution of losses



Heat recovery



Ventilation heat losses in ATC building



Development of the building Elektror GmbH mechanical ventilation

- ventilation system with heat recovery
- volume flow 8.500 m³/h (~1,0 1/h)
- fresh air supply via double floor with façade outlet
- exhaust air flow using openings to the floor area and central air exhaust at the top of the atrium



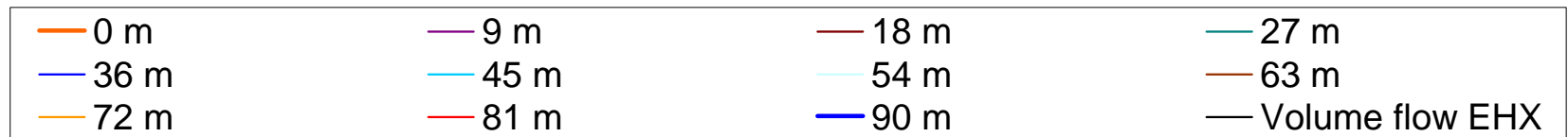
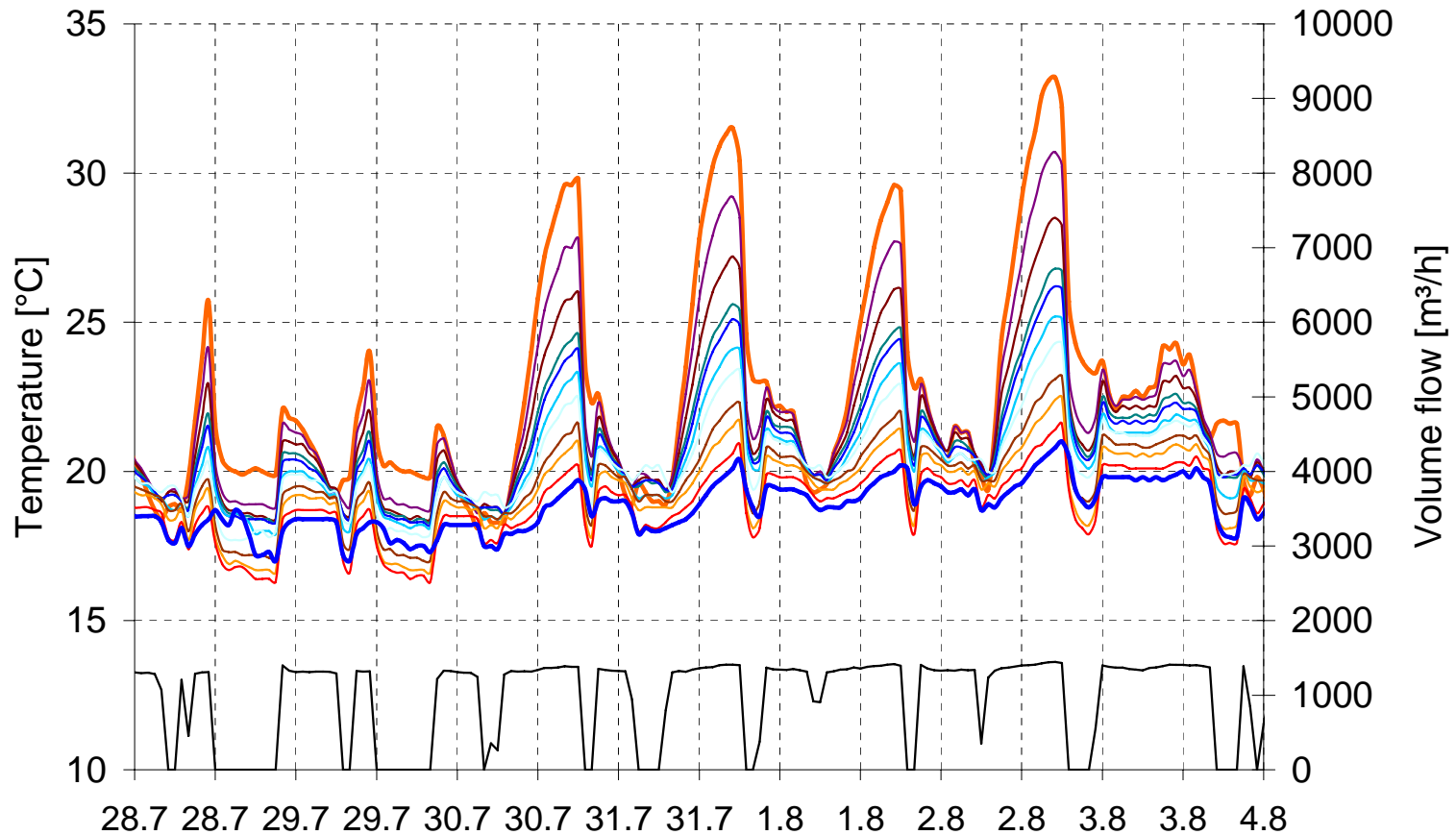
Earth heat exchanger for summer cooling and winter preheating



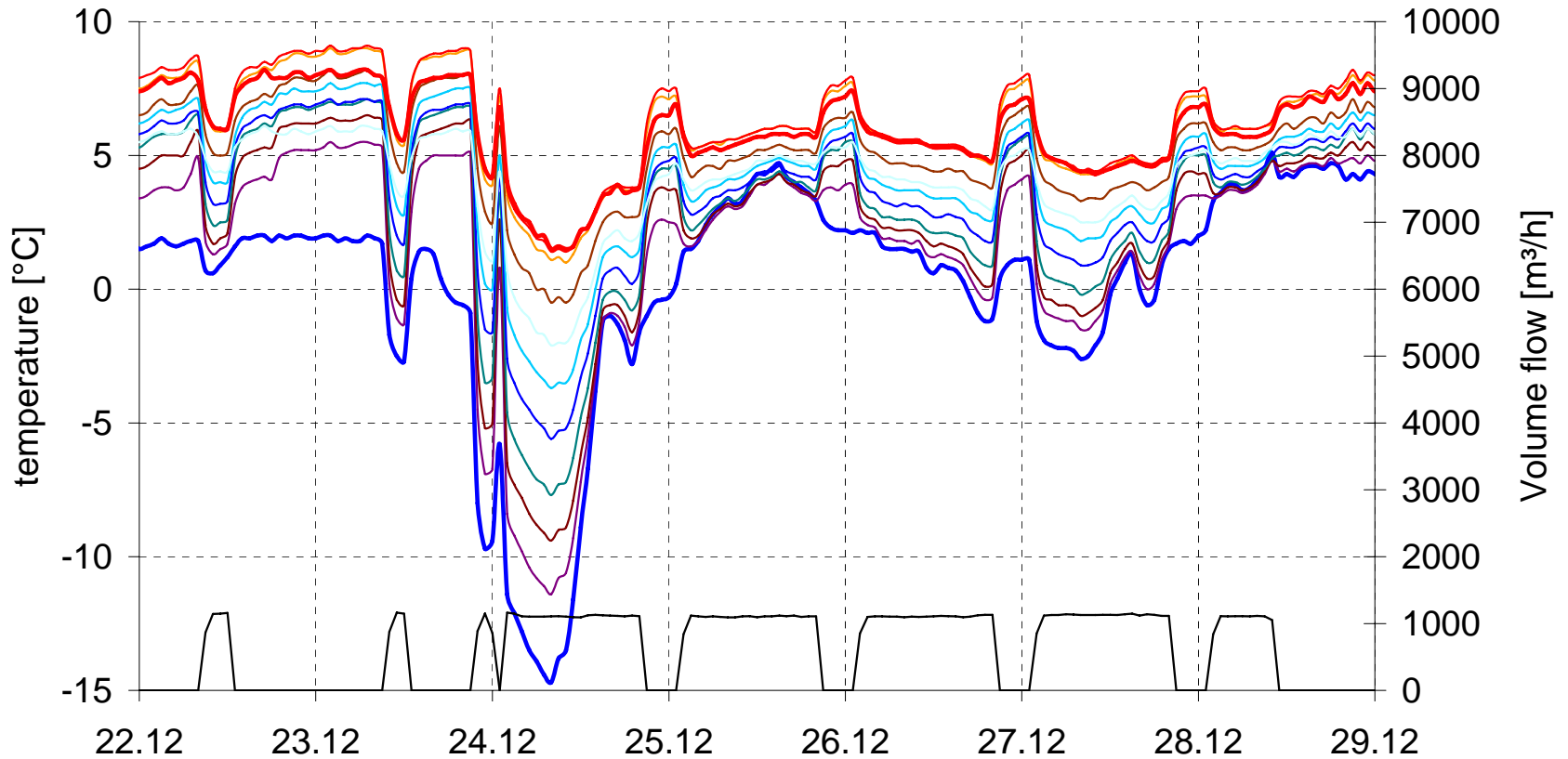
Earth heat exchanger 90 m length, 2 channels,
PE-tube, depth 2.8 m, diameter DN 350 mm,
volume flow 1.900 m³/h



Earth heat exchanger summer case

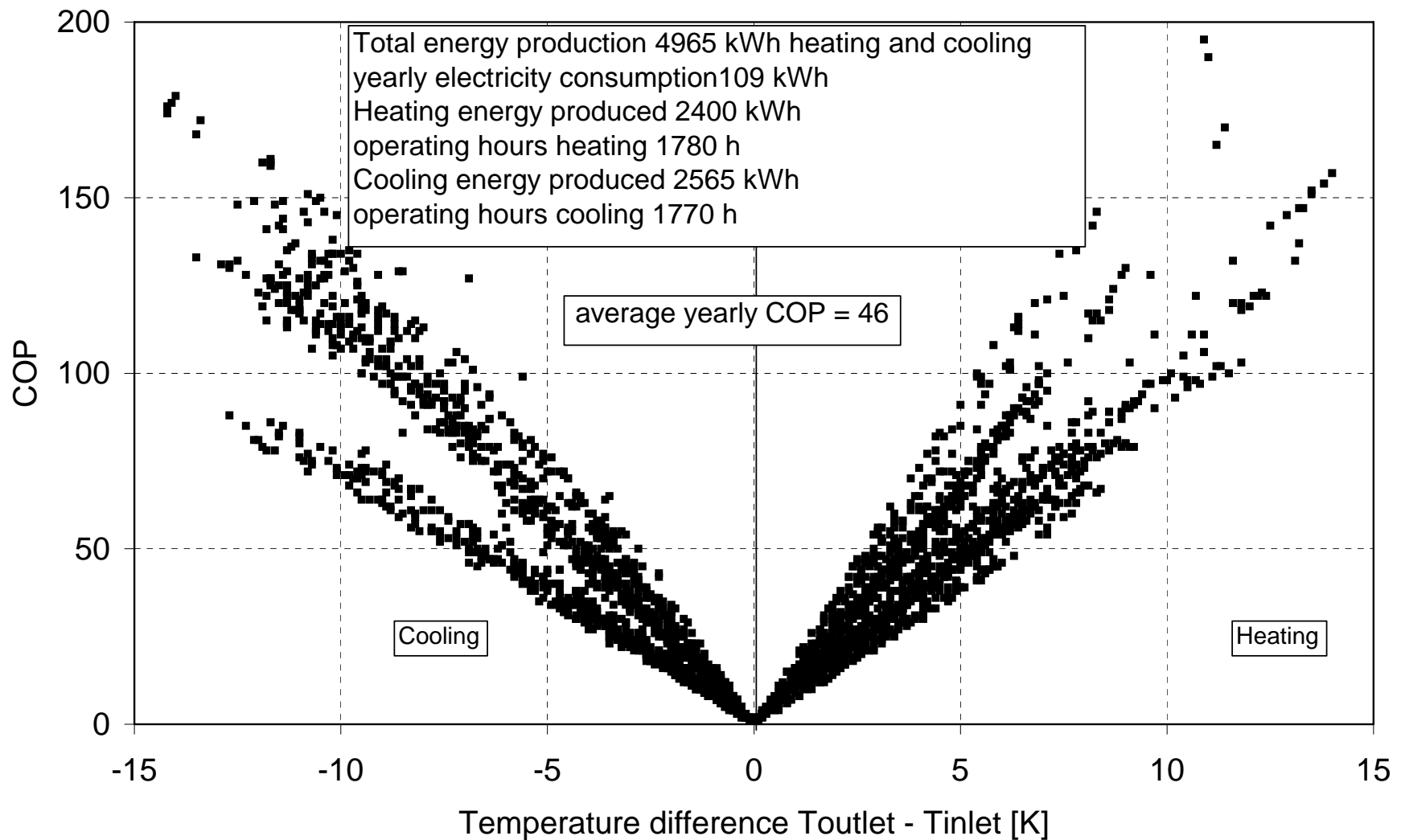


Earth heat exchanger winter case



- | | | | |
|------|------|------|-----------------|
| 0 m | 9 m | 18 m | 27 m |
| 36 m | 45 m | 54 m | 63 m |
| 72 m | 81 m | 90 m | Volume flow EHX |

Earth heat exchanger COP=46

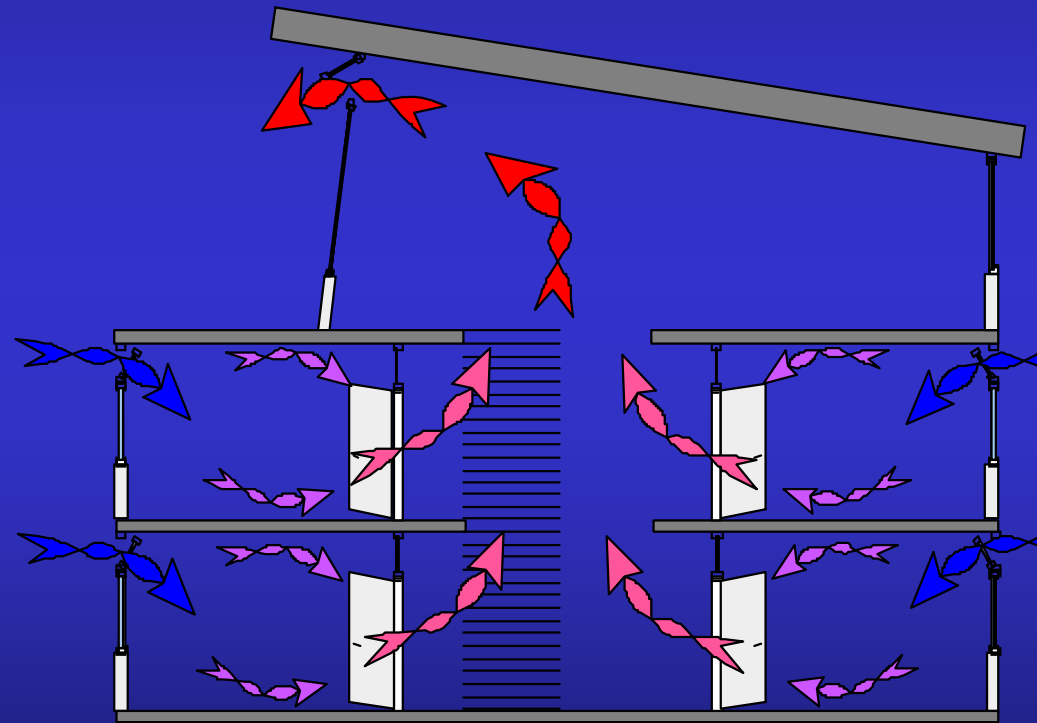


Development of the building Elektror GmbH geothermal water-air-heat-exchanger

- to precool or preheat the ambient air
- reduction of air temperatures by 5 K results in cooling power of 14,5 kW
- no hygiene problems using water based system
- small pressure drops through water-air heat exchanger



Passive cooling using night ventilation in summer



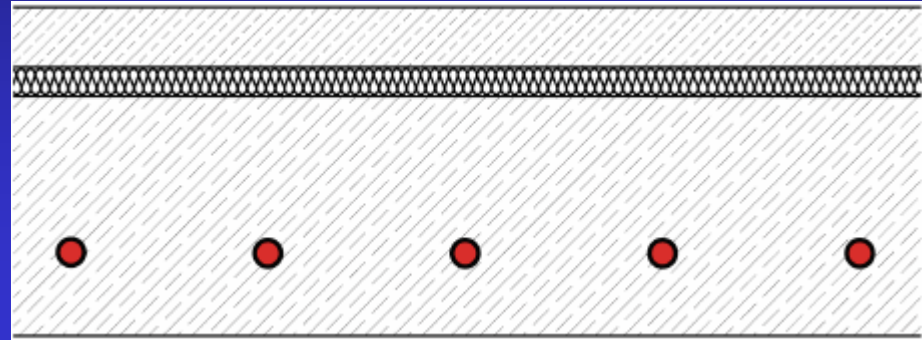
Low energy cooling: thermally activated concrete ceilings

- ENERGON building Ulm: 7000 m² surface area
- 40 ground heat exchangers with 100m depth to remove 120 kW cooling load



Development of the building Elektror GmbH

cold distribution



- thermally activated ceiling 35-90 W/m²
- cooling machine can be designed 30-40% smaller than conventional system due to storage capacity of the ceiling
- high thermal comfort

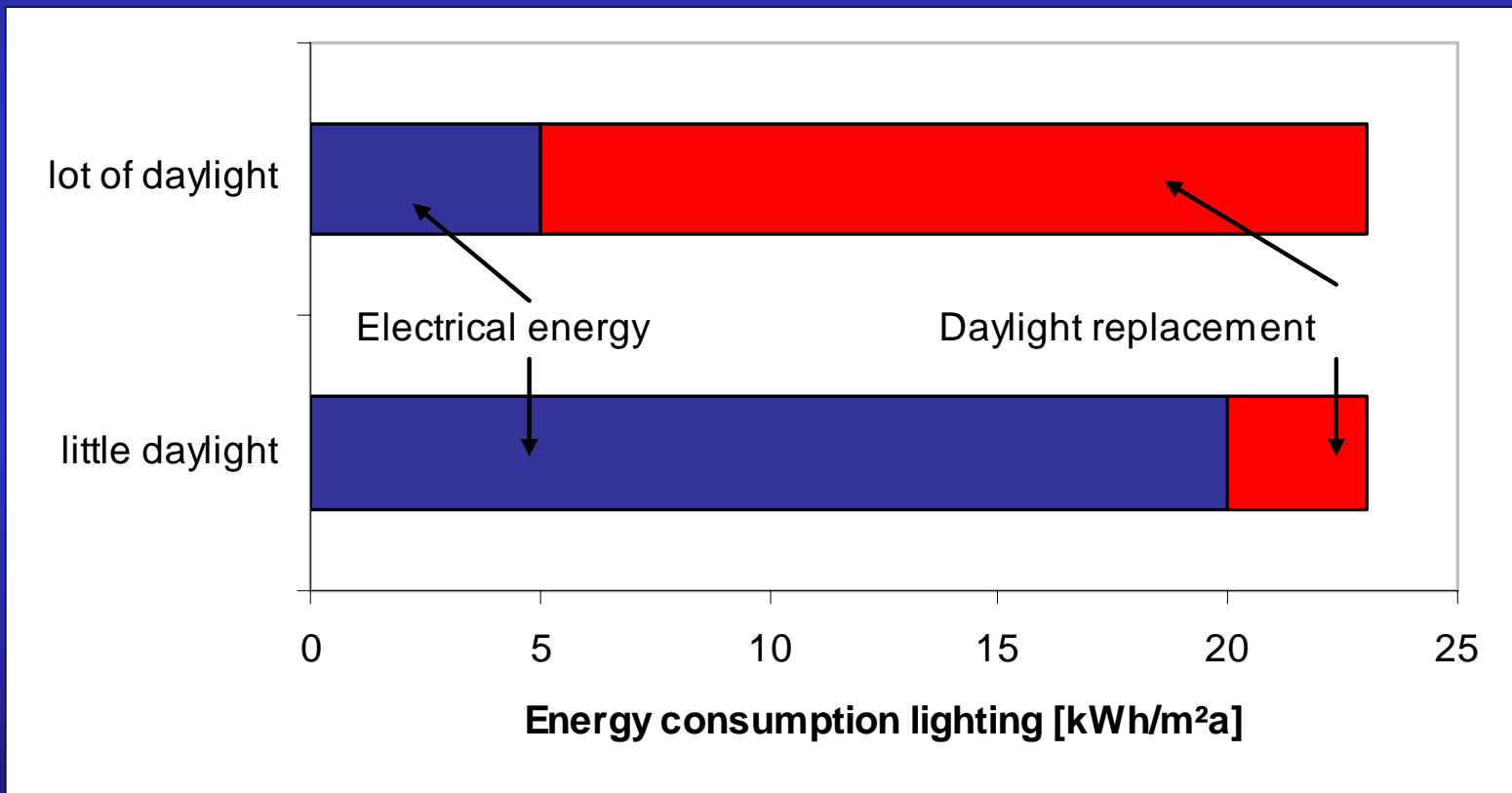
Energon Ulm:

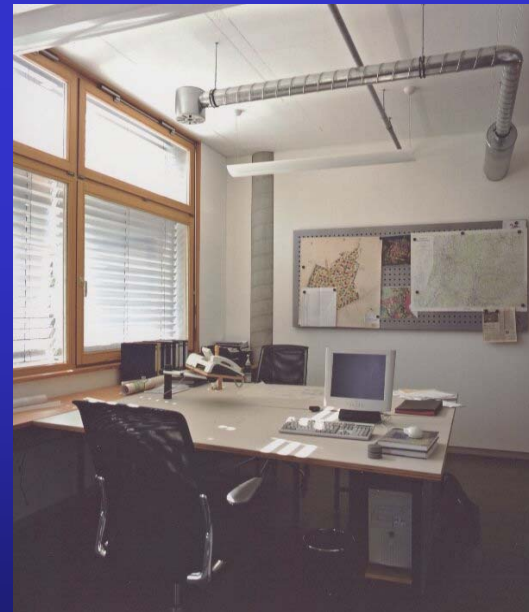
fresh air precooling using ground air heat exchangers (28m, 1.8m), additional cooling using water ground heat exchangers (28.000 m³/h)



Daylight use

Electricity consumption for lighting: 5-20 kWh/m²a





Summary and conclusion

- Good thermal properties of windows essential to limit heating energy consumption (U-value 1.1-1.3 W/m²K)
- Avoid thermal bridges (condensation + mould!)
- Ventilation losses important -> heat recovery (for airtight buildings)
- Earth heat exchangers very effective, but limited fraction of energy demand
- Electricity demand reduction through daylighting!
- Low electrical energy consuming devices