Student Dorms as Passive Houses

Experience from Germany and Austria

BUILD BOSTON 2010
NOVEMBER 17-19
SEAPORT WORLD TRADE CENTER

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Peter Engelmann

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1 student living – basic data

2 the dorms

3 findings - technical analysis

4 findings - comfort and user influence

5 conclusions

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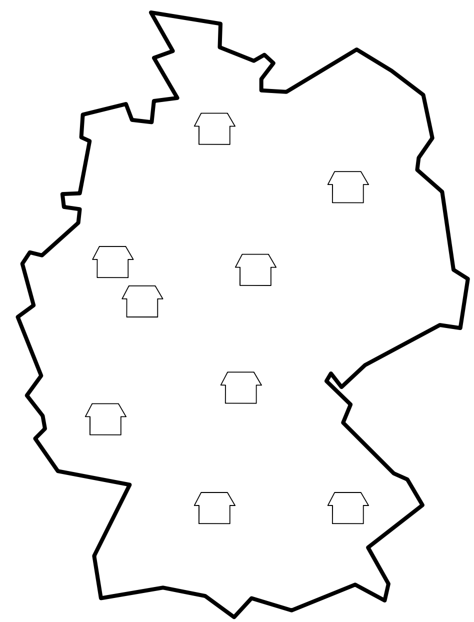
1 student living data from Germany



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student living in Germany – numbers

housing type, data from 2009:	
parents	23%
student dorm	12%
sublet	2%
flat sharing	26%
single flat	17%
flat with partner	20%

enrolled in wintersemester 2007/08: 1,818,000 students

215,000 students live in dorms

source: 19te Sozialerhebung des Deutschen Studentenwerks, Berlin, 2010

image: Tomas Riehle

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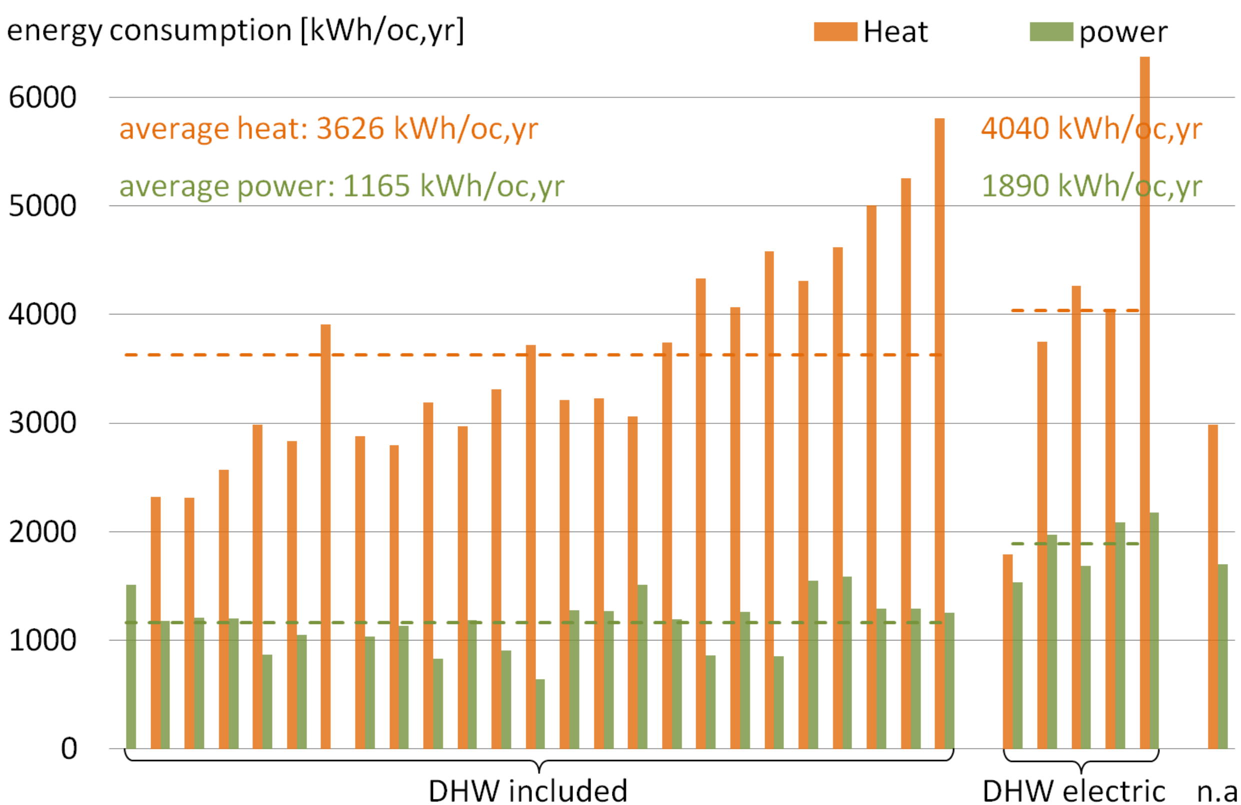
dorms – typical energy consumption?



Data from 28 dorms:

electric power consumption correlates with german average [1]:

- single household: 1,790 kWh/cap,yr
- 4- people household: 1,110 kWh/cap,yr (4,440 kWh/yr)
- average Massachusetts[2]: 7,416 kWh/yr
- average US[2]: 11,040 kWh/yr

1) source: Bundesverband der Energie- und Wasserwirtschaft, 2002

2) source: U.S. Energy Information Administration, 2008

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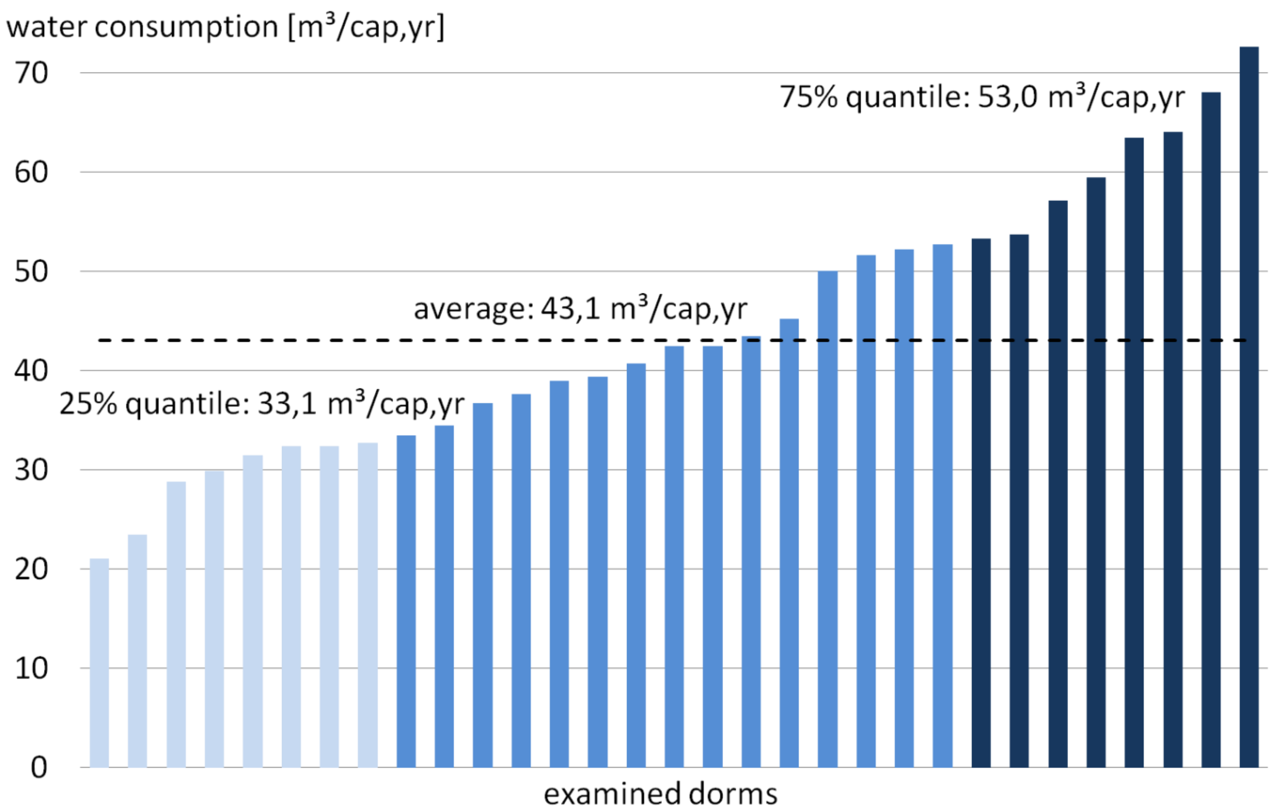
dorms – typical water consumption?



- average total water consumption in Germany: 45.6 m^3/cap,yr
- US indoor use[1)]: 82 m^3/cap,yr

1) source: American Water Works Association

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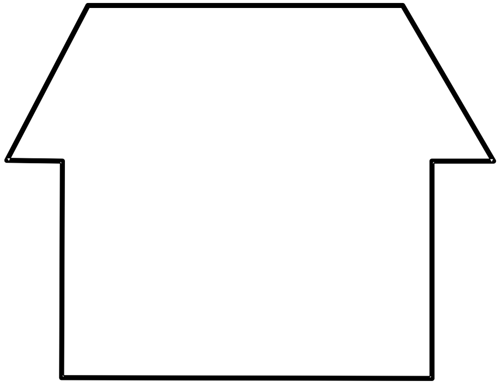
the dorms



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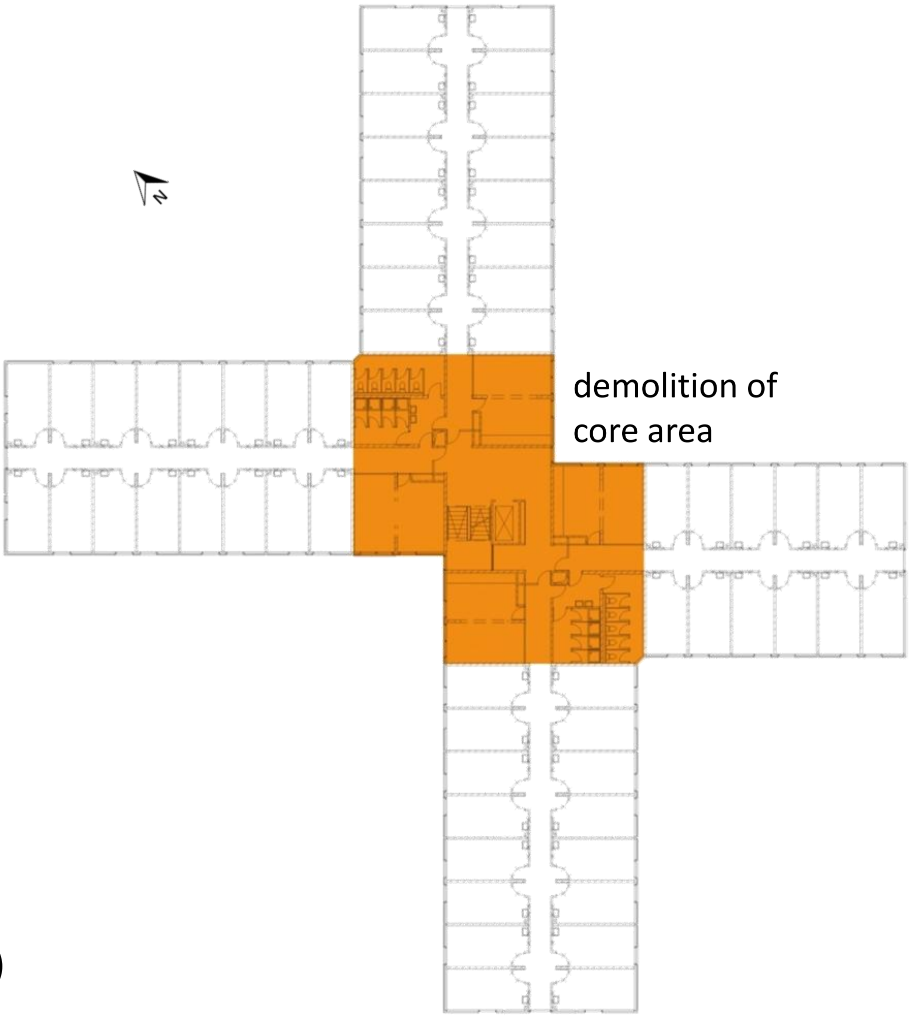
„Neue Burse“, Wuppertal, Germany

image: Thomas Rhiele



- built in 1977
- two buildings, 600 occupants
- refurbishment 2001 / 2003
- LEH 303 occupants, 8,420 m^2 (90,632 ft^2)
- PH 323 occupants, 8,597 m^2 (92,537 ft^2)

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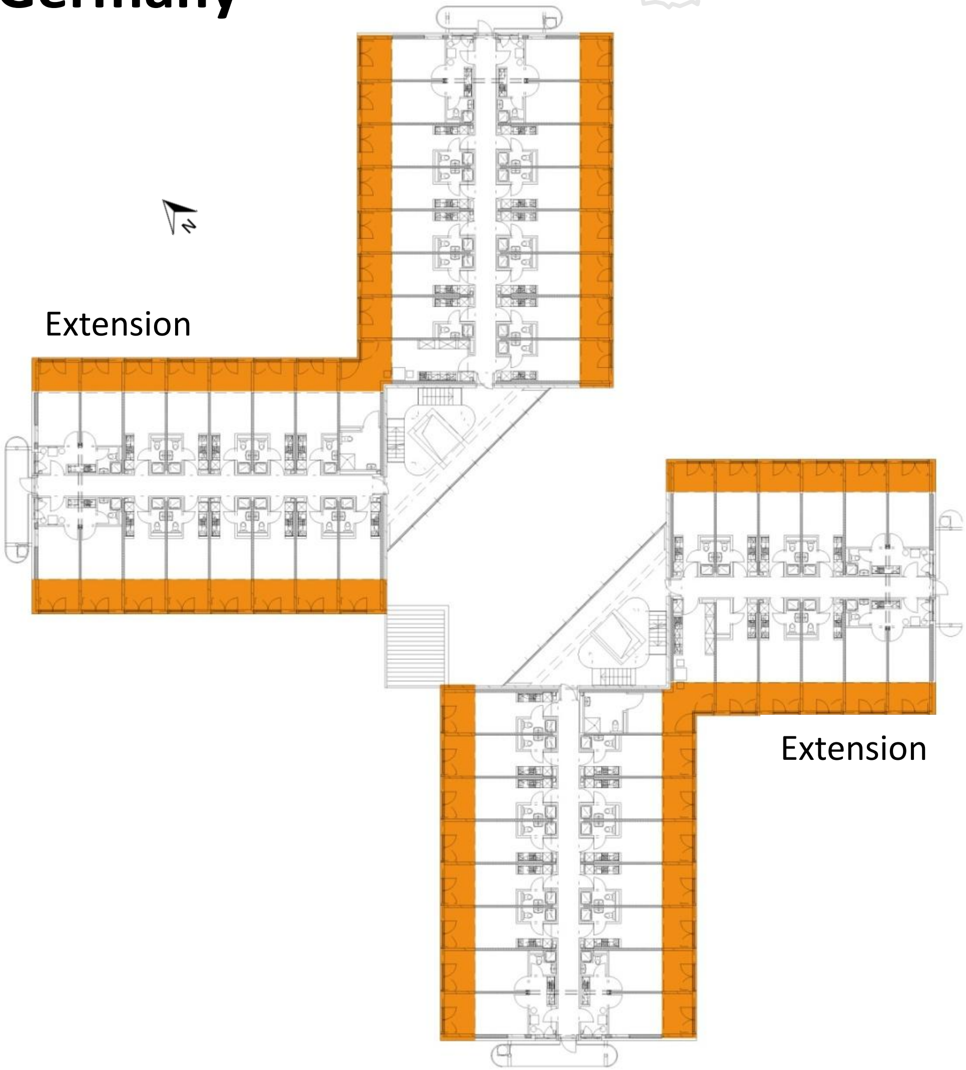
„Neue Burse“, Wuppertal, Germany

image: Thomas Rhiele



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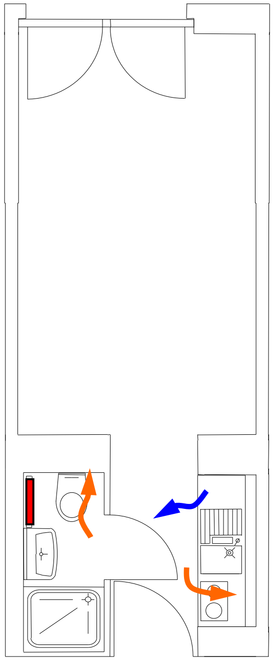
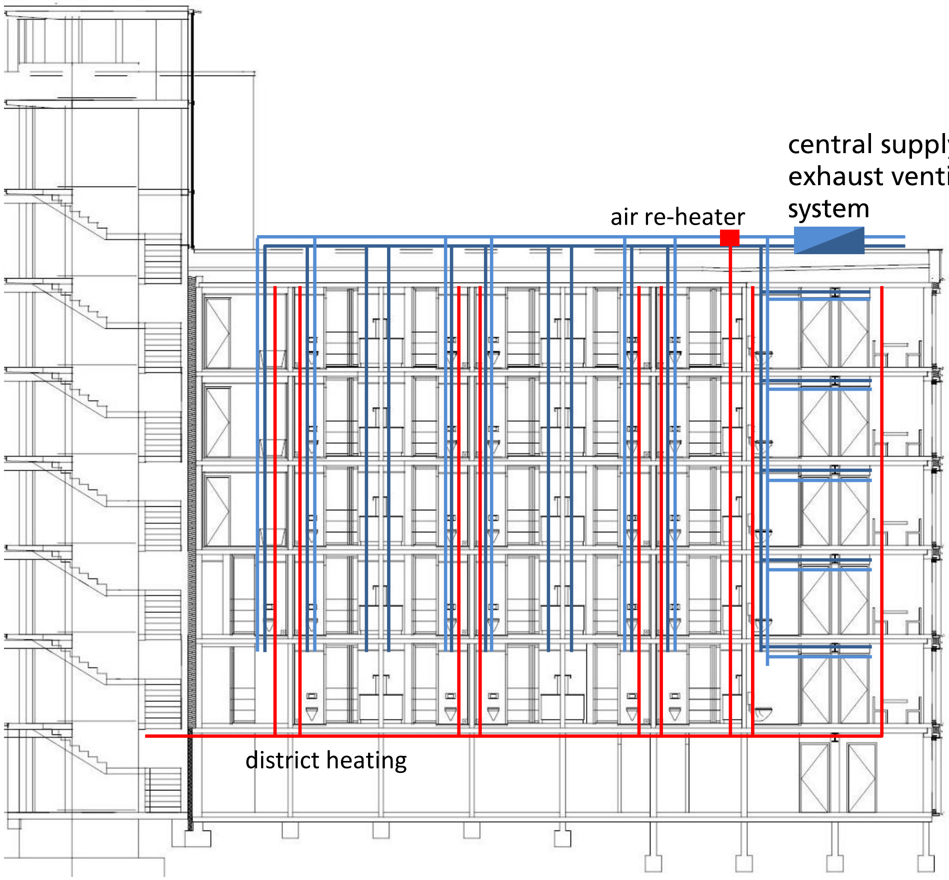
Neue Burse, Wuppertal, Germany





- central mechanical ventilation with heat recovery on every building wing
- space heating by reheating fresh air; radiators in the bathrooms
- Q_H,PHPP: 26 kWh/m^{2}a (8.3 kBtu/ft^2)

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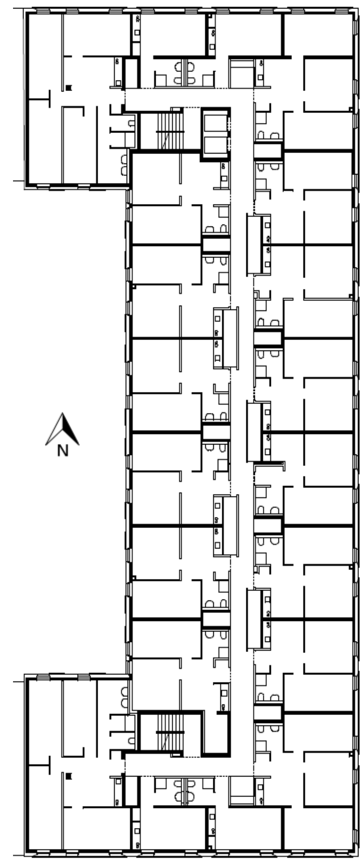
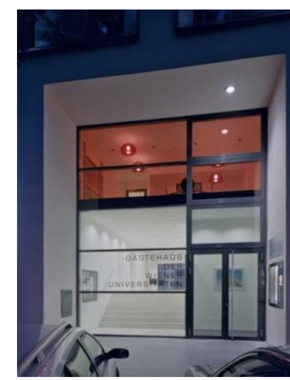
Molkereistraße, Vienna, Austria

- build as passive house in 2005
- 278 occupants, 8,842 m^2 (95,174 ft^2)
- dorm for exchange students





images: Eduard Hueber

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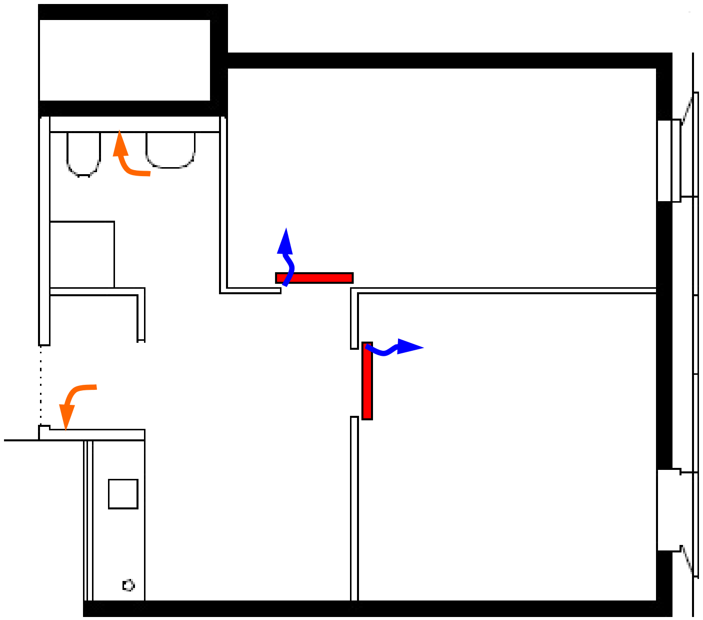
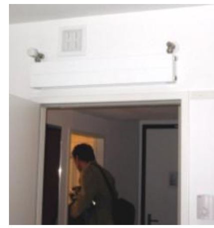
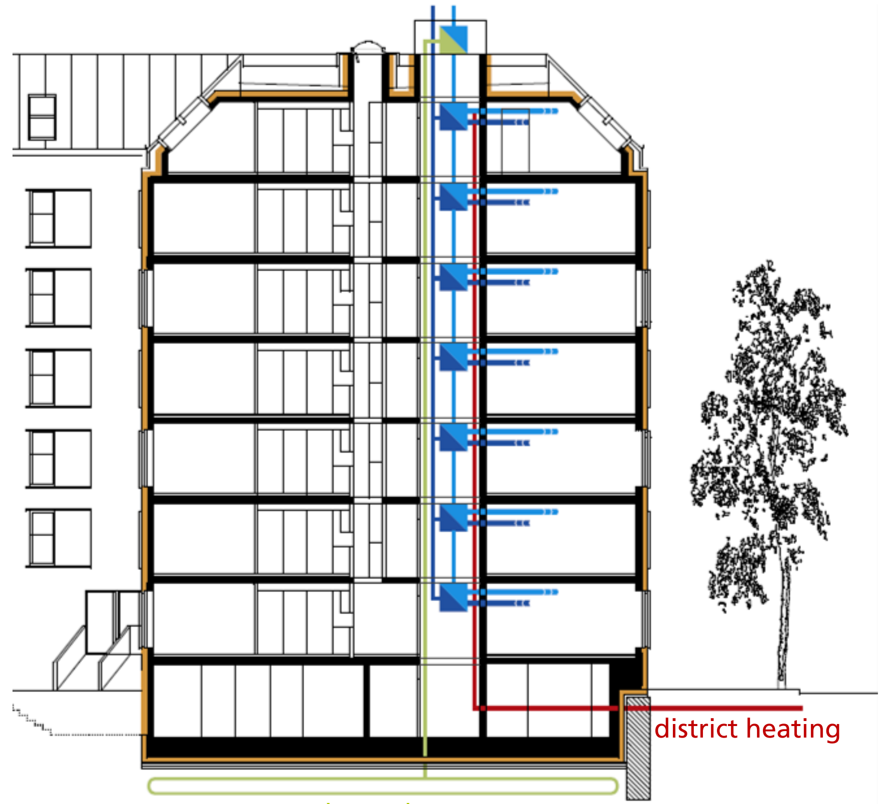
Molkereistraße, Vienna, Austria







graph: teamgmi

- decentralized mechanical ventilation units
- air preheating using geothermal energy
- space heating by (mini) radiators near air-intake, thermostat in every room
- Q_H,PHPP: 12 kWh/m^2a (3.8 kBtu/ft^2)

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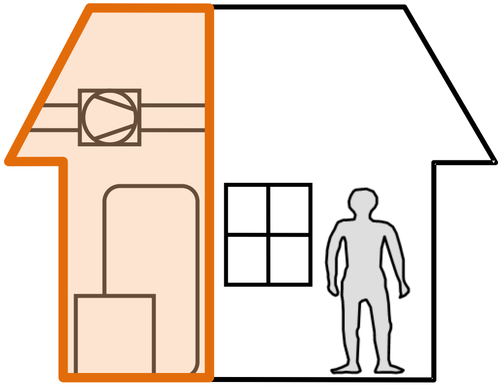
technical analysis



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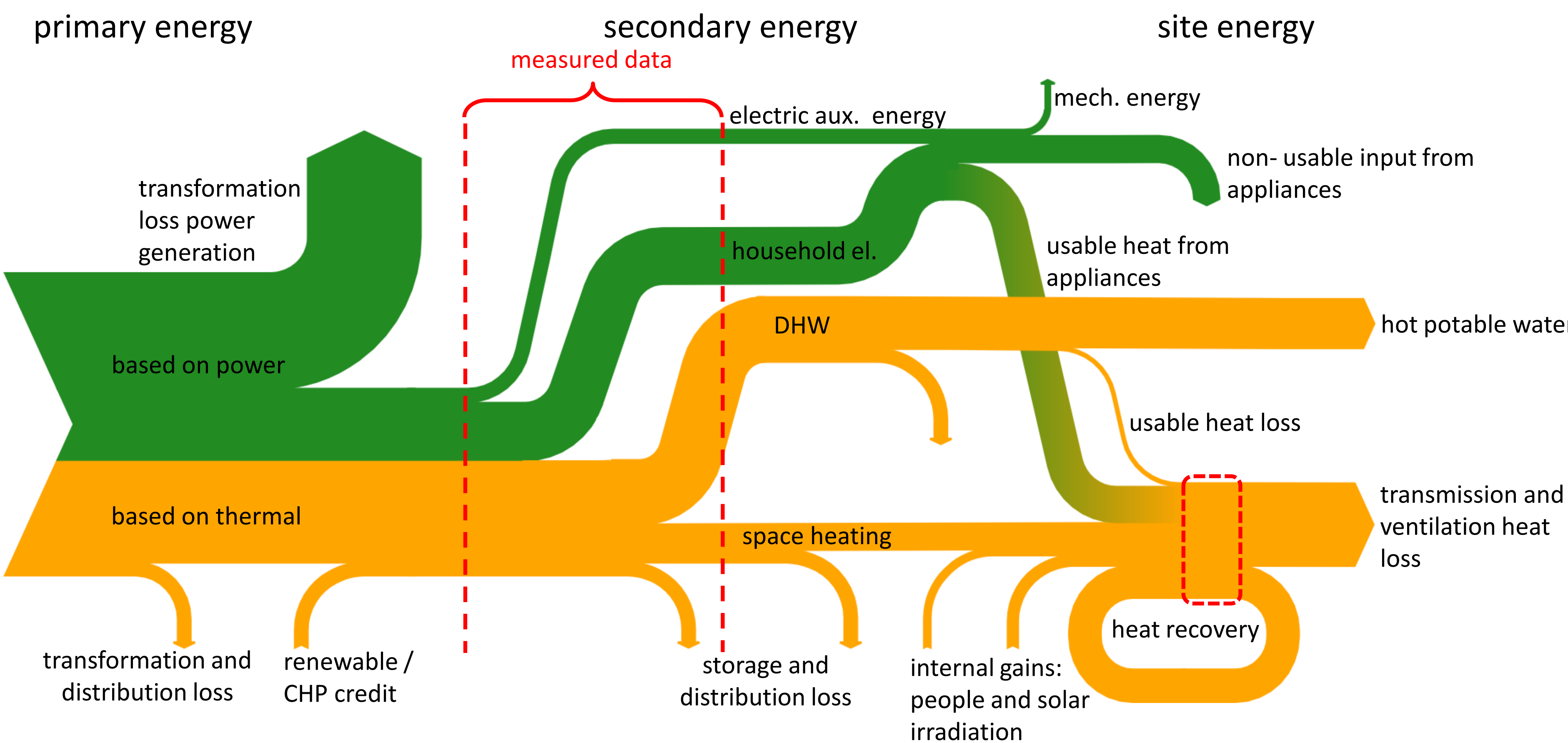
energy flow – from primary energy to the user



long-tearm measurement
(incl. weather)

short-time / seasonal measurements

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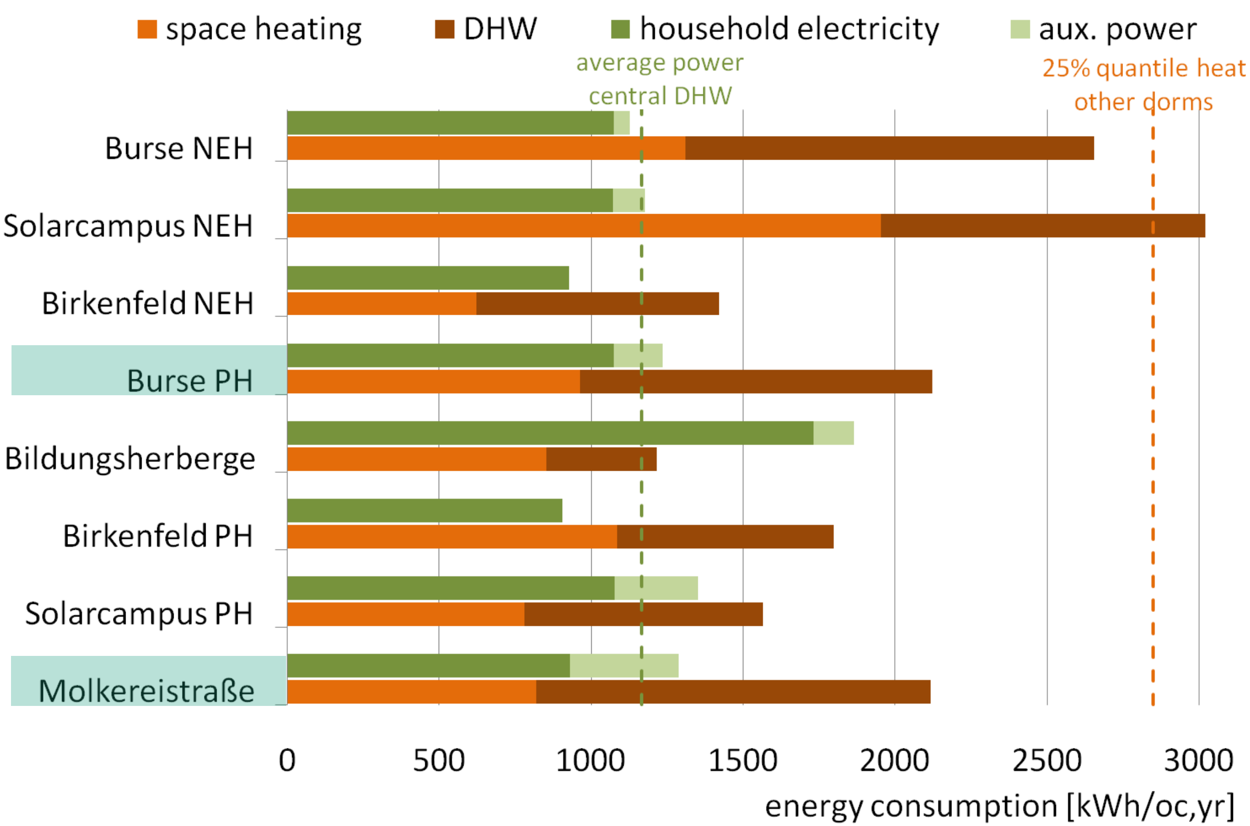
site energy consumption – dorm comparison



- Thermal energy consumption significantly lower than in other dorms.
- Electric power consumption equals average of others.
- Energy consumption for DHW gets dominating load.

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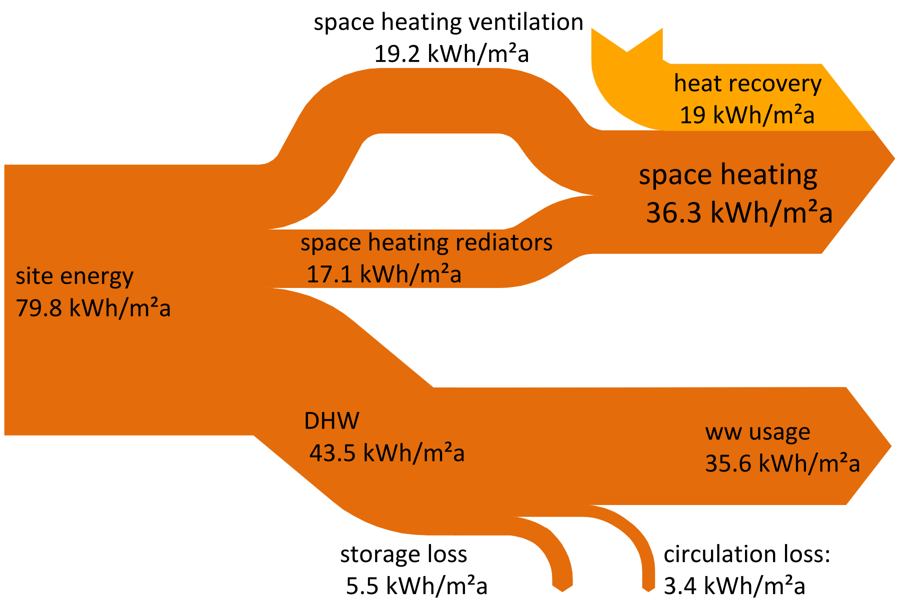
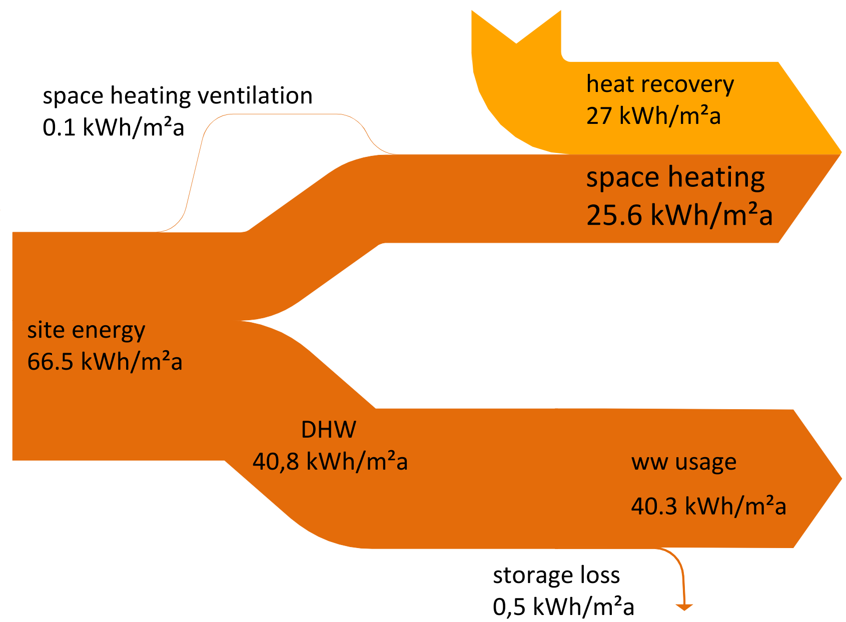
energy flow – thermal energy consumption

Neue Burse, Wuppertal



Molkereistraße, Vienna



- reference area: net floor area (NGF according DIN 277)
- data from 2007, not adjusted to climatic conditions

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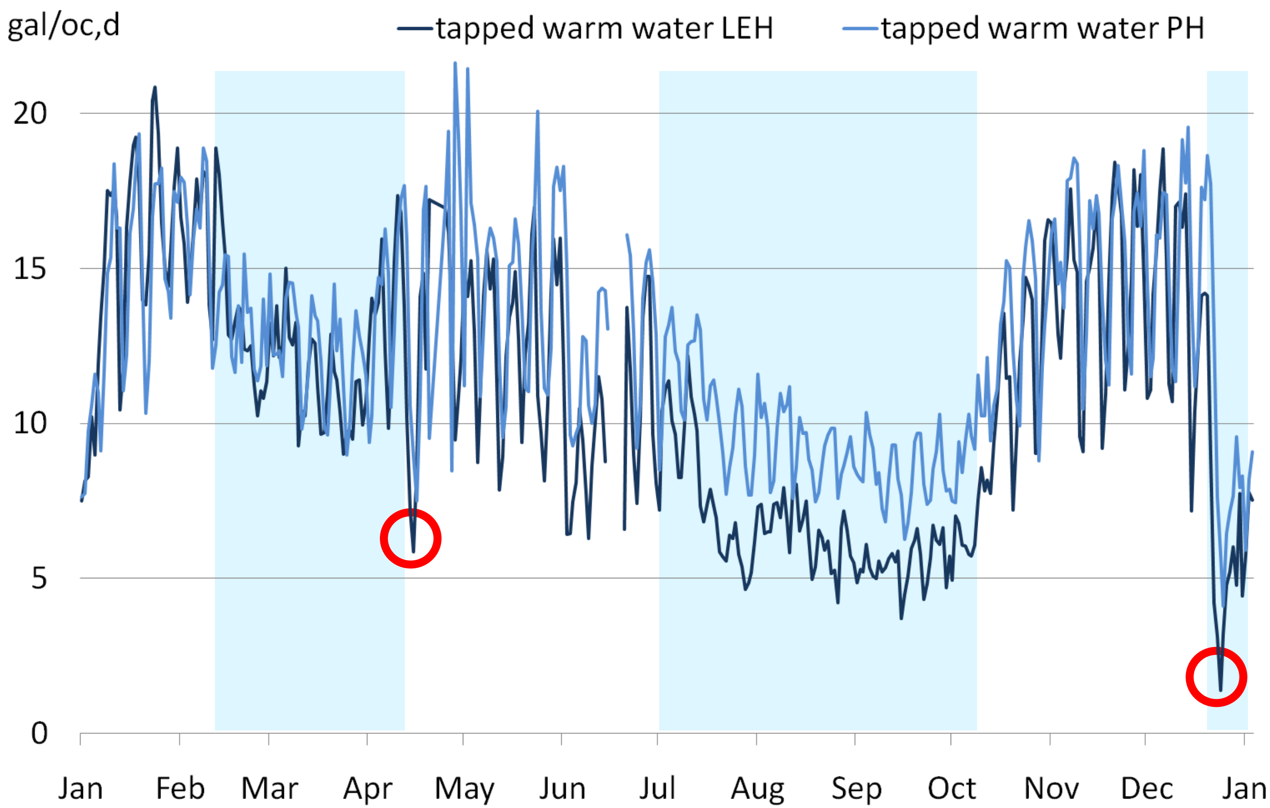
water consumption

water consumption as indicator for occupancy

- weekend commuter
- semester break



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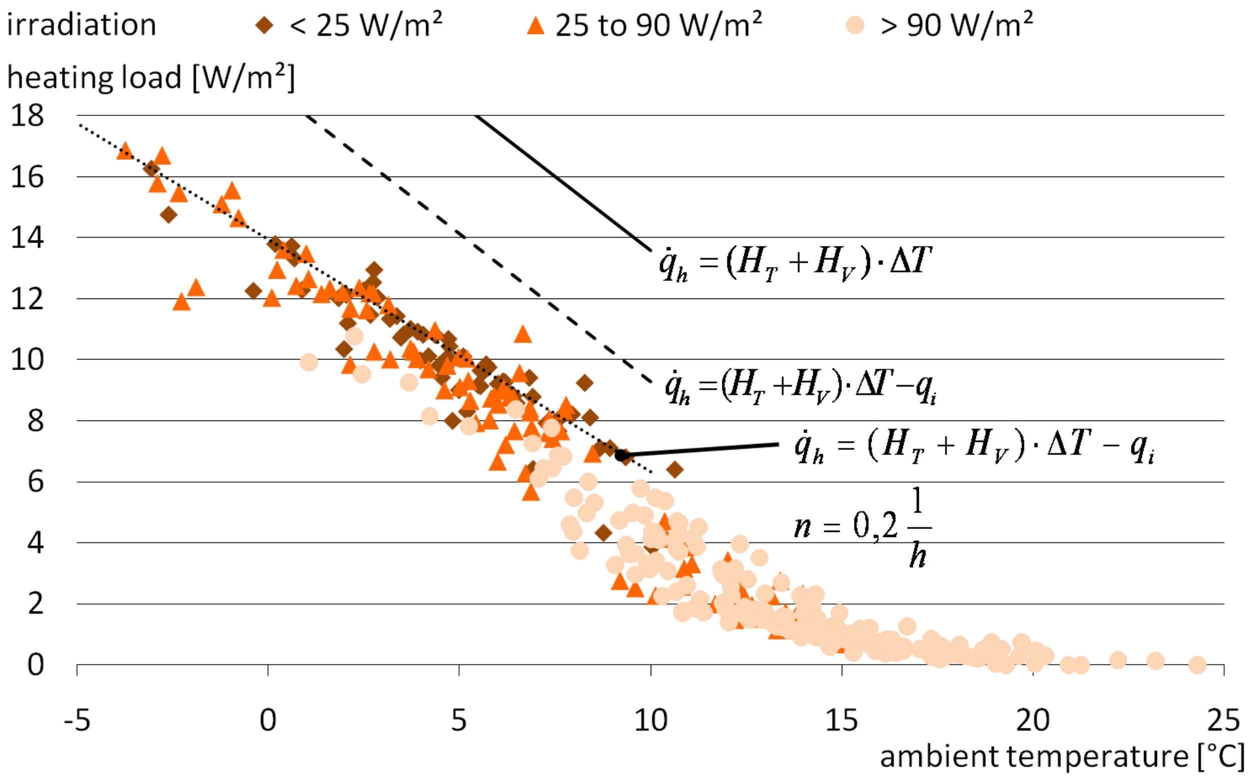
heating loads
Neue Burse, LEH

analyzing heat loads – ambient temperature correlation



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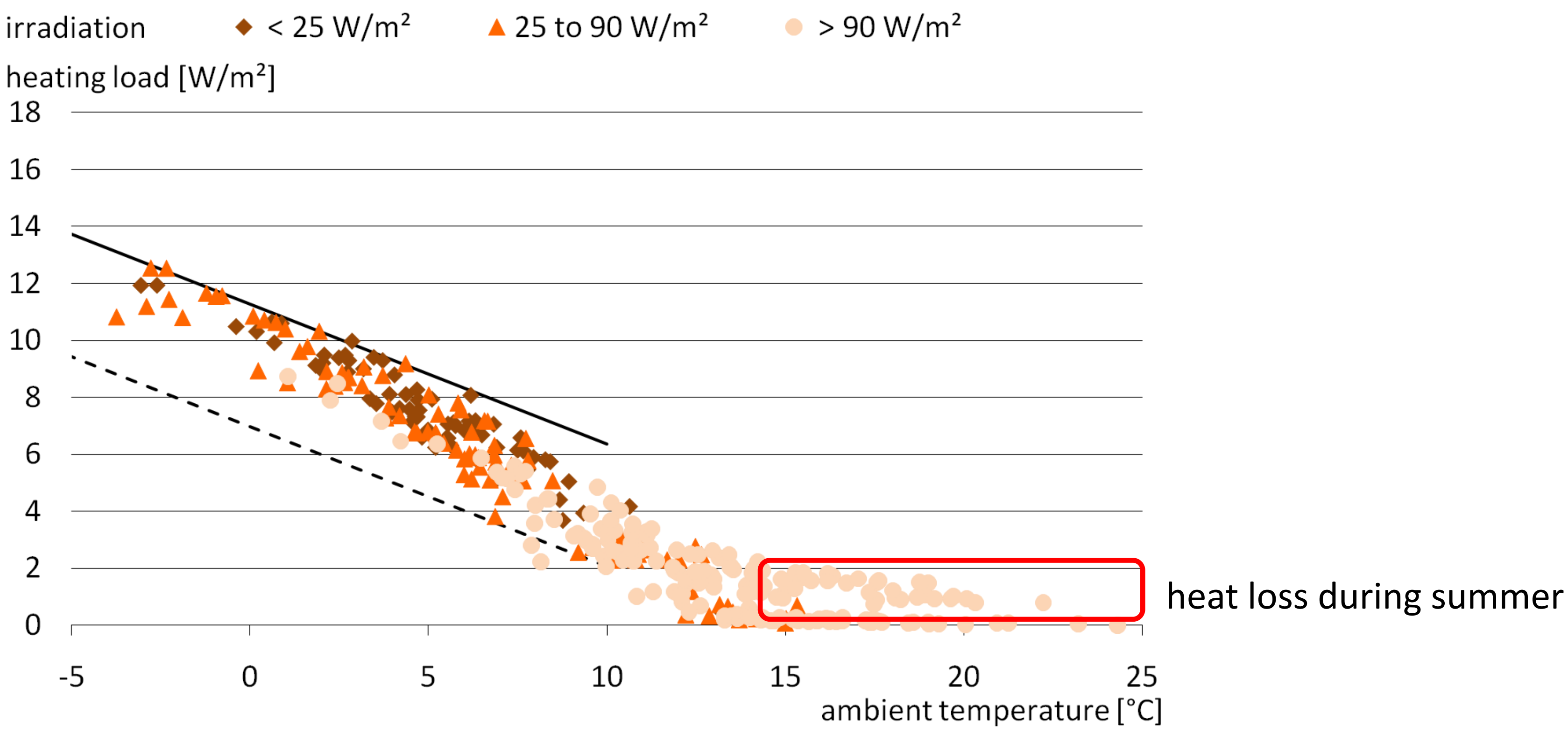
heating loads
Neue Burse, PH

analyzing heat loads – ambient temperature correlation



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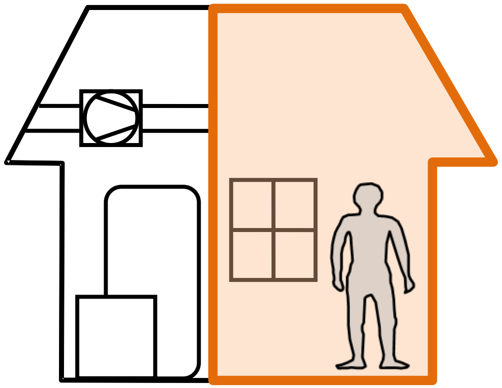
4 comfort and user influence



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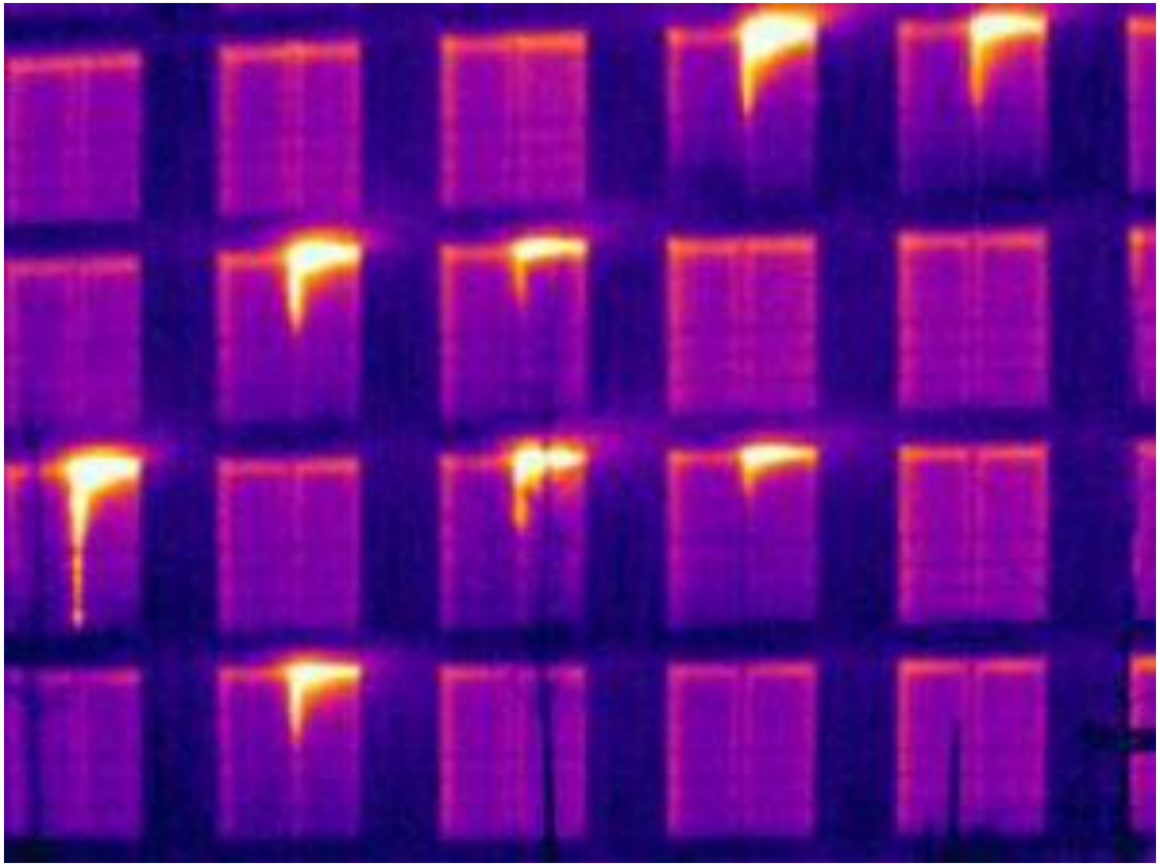
comfort and user influence window ventilation



Despite mechanical ventilation some users feel a need for window ventilation.

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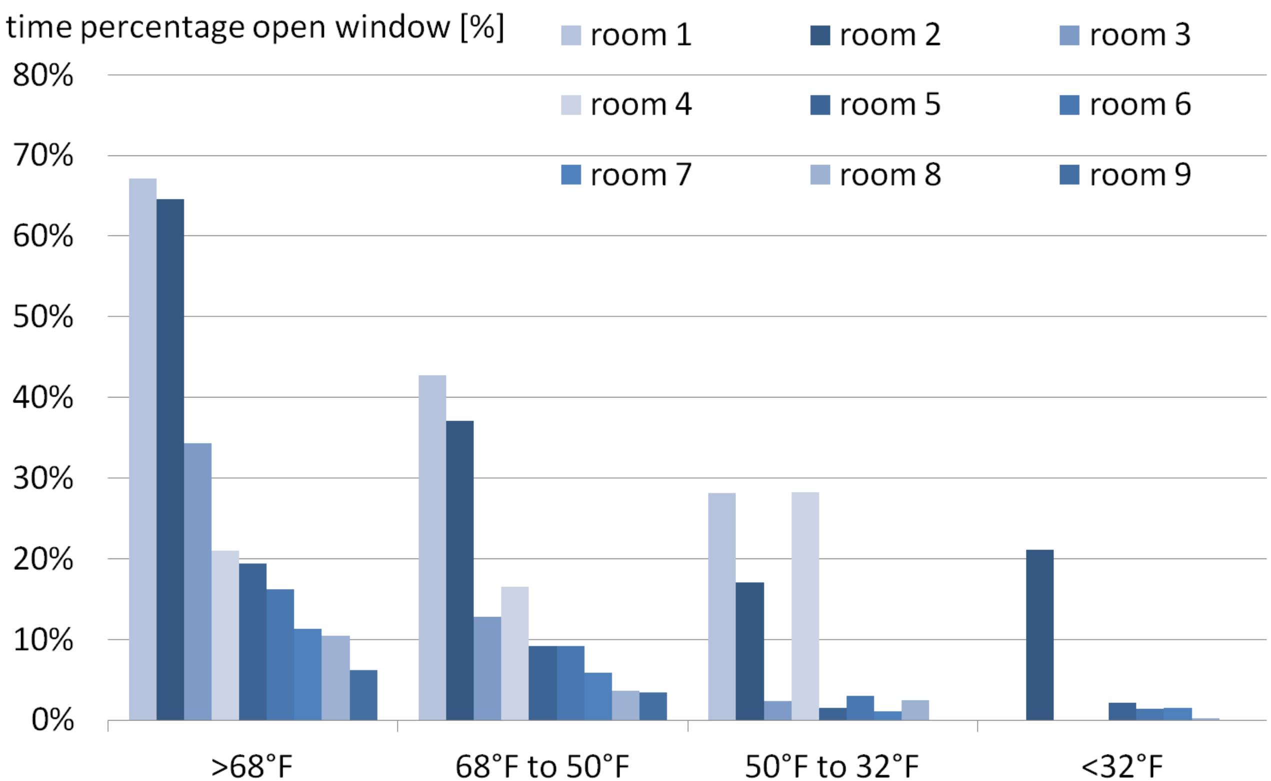
comfort and user influence window ventilation



- Window ventilation depends on personal habits, but is also highly influenced by outdoor conditions.
- Low ambient temperatures significatly reduce window ventilation.

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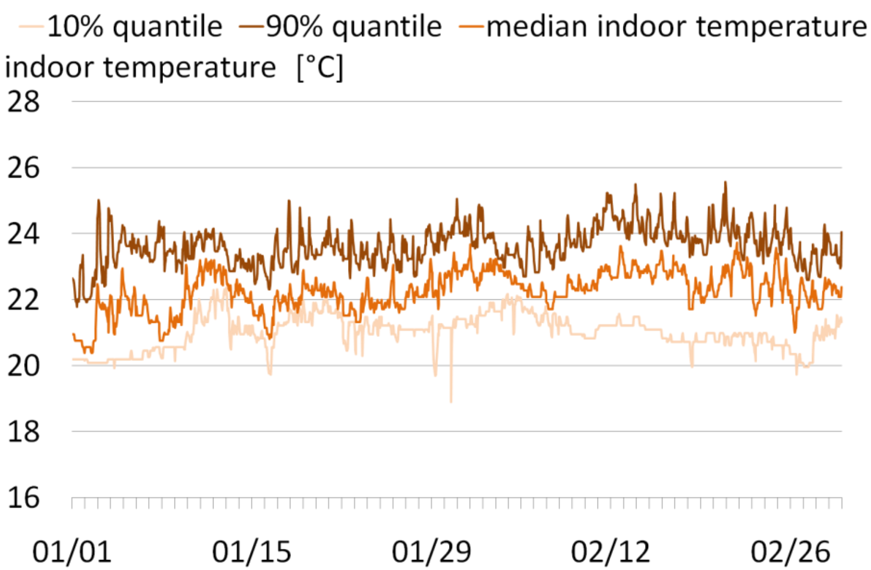
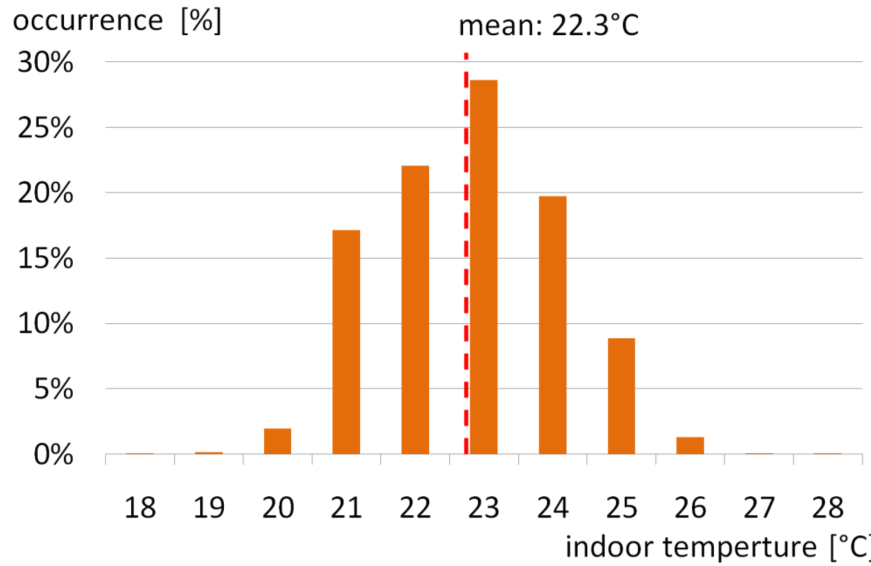
comfort and user influence
indoor temperatues

Neue Burse PH, January to March 2005





- mean value of indoor temperature: 22.3°C (72.1°F)
- median ambient temperature: 2.8°C (37°F)
- heating degree hours: 24.6 kKh

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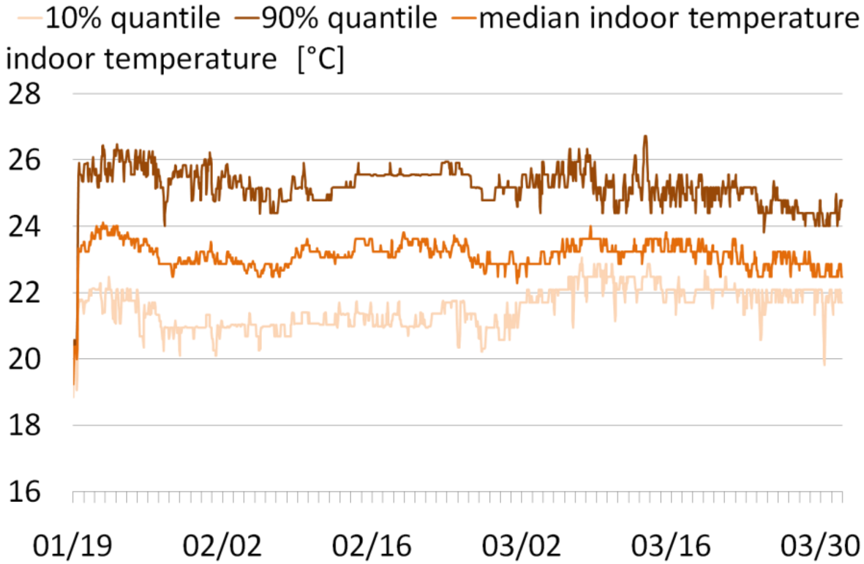
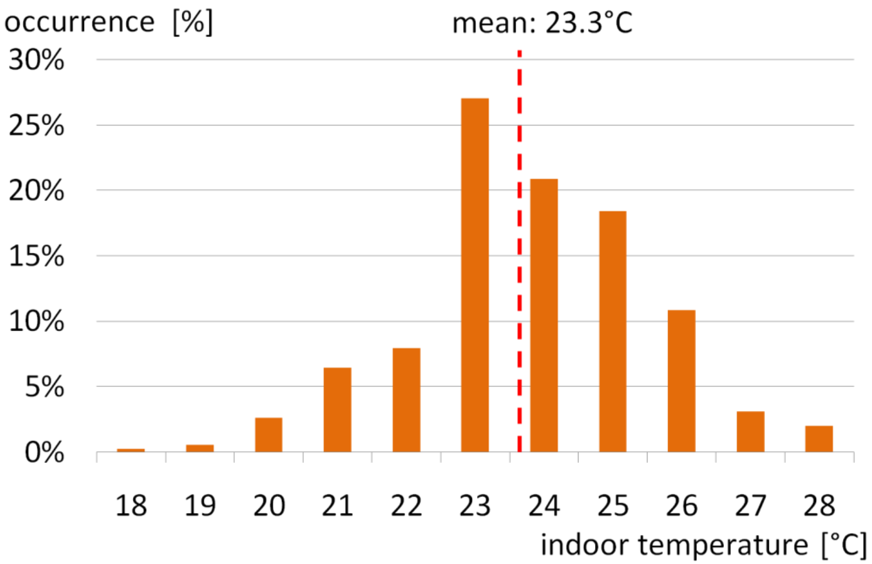
comfort and user influence
indoor temperatues

Molkereistraße, January to March 2007





- mean value of indoor temperatures 23.3°C (73.4°F)
- median ambient temperature: 6.0°C (42.8°F)
- heating degree hours: 22.8 kKh

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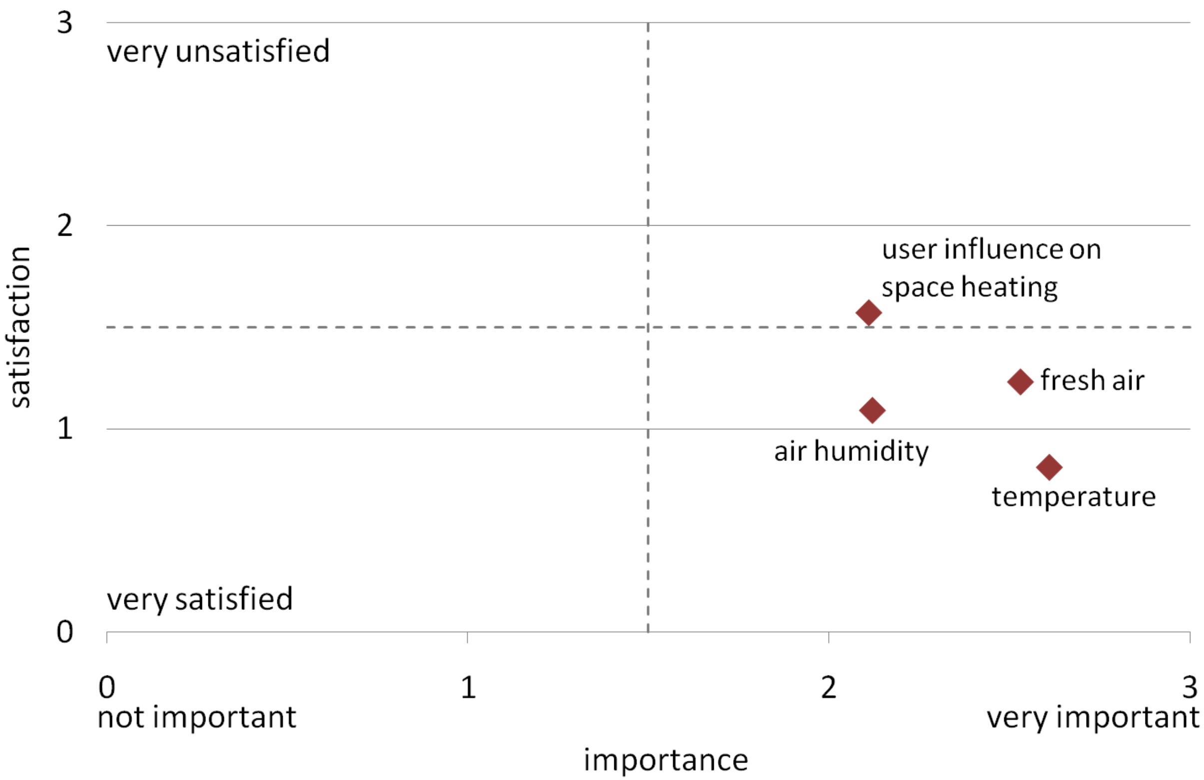
comfort and user influence
user surveys

plotting satisfaction and importance of different parameters shows potential need for action



- „temperature“ is most important.
- „user influence on space heating“ is critizised, despite individual thermostat in every room.
- Whereas measurements indicate problems with air humidity, users aren‘t aware of that.

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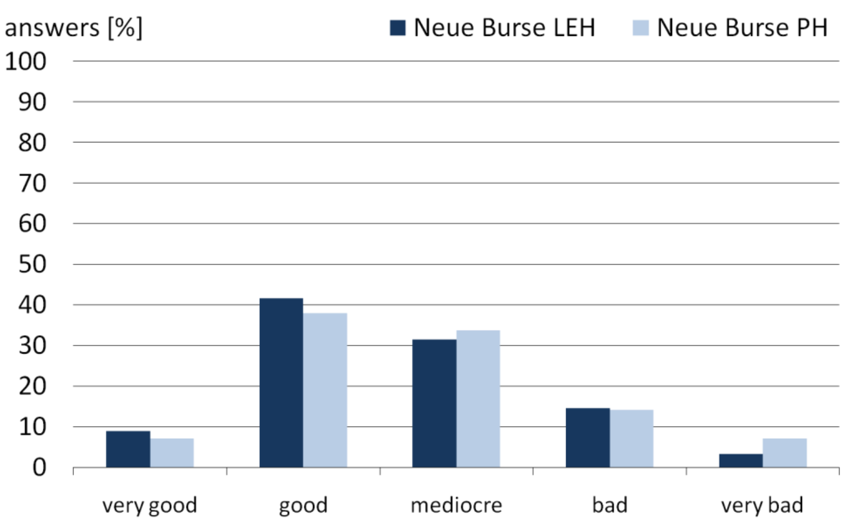
comfort and user influence
user surveys

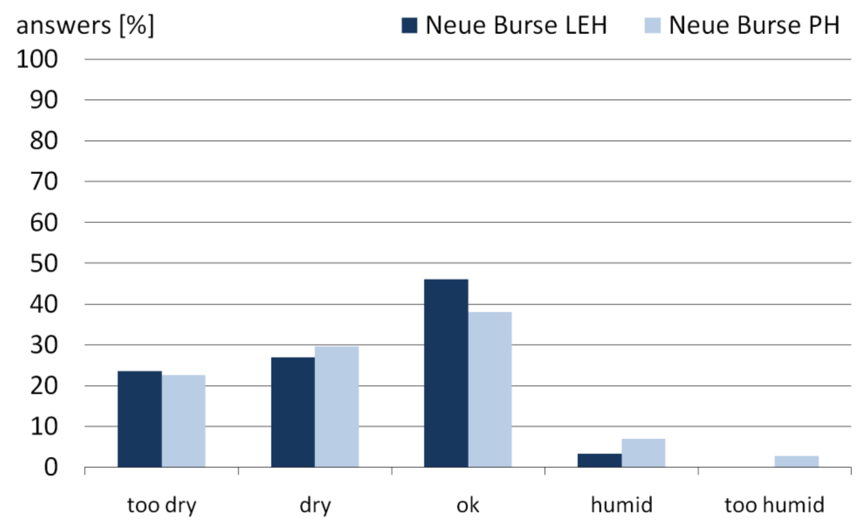
Question:

“What is your opinion on air quality during the last four weeks?”



Question:

“What do you think about air humidity during the last four weeks?”



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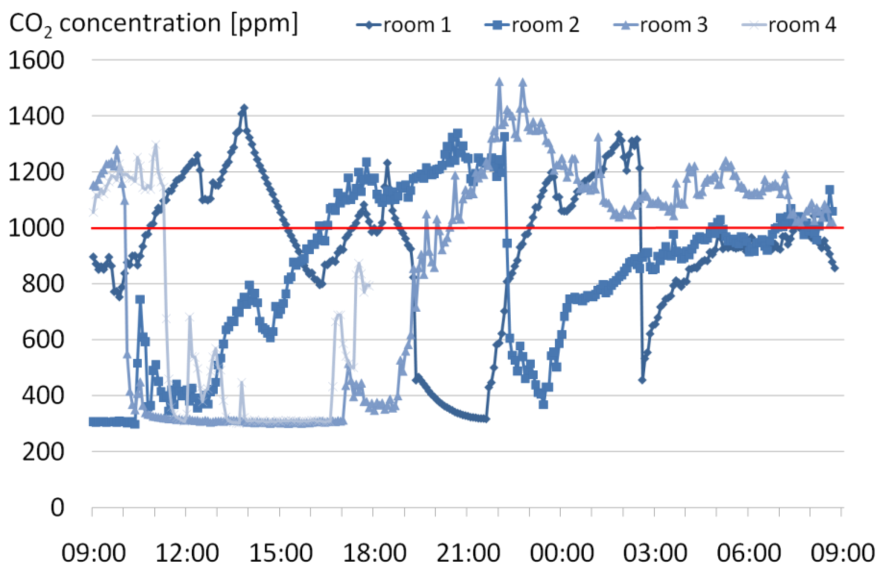
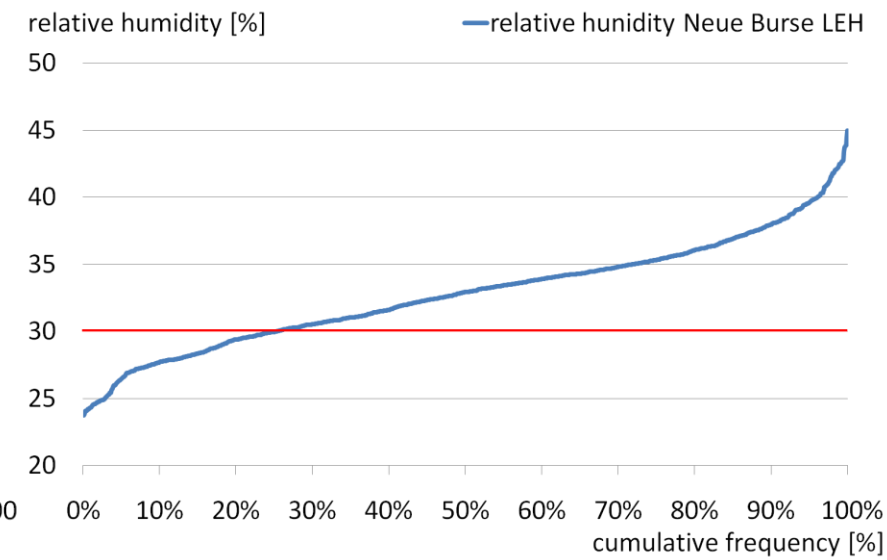
comfort and user influence measurements

Measuring the CO_2 concentration in different rooms over 24h: as soon as people are in, fast excess of 1000ppm.

Due to low air exchange rates, humidity is most of the time in comfortable range (during heating season).





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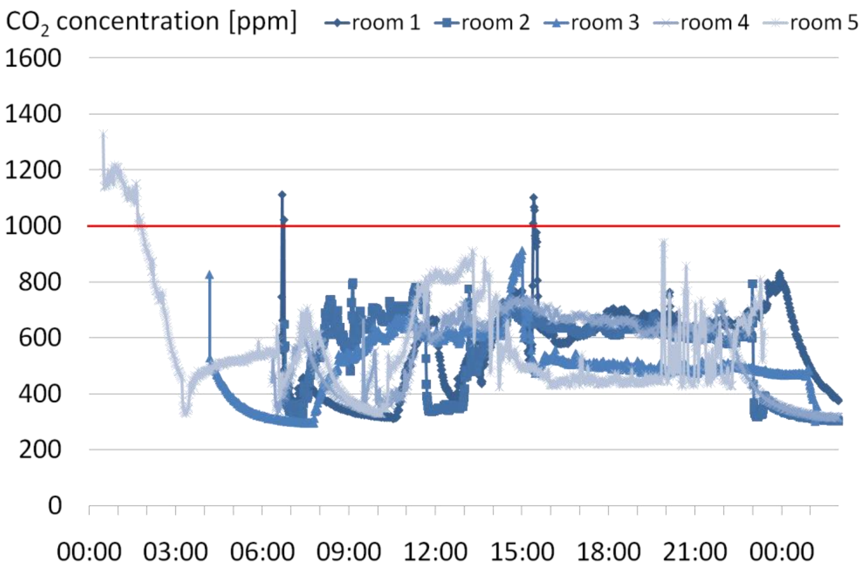
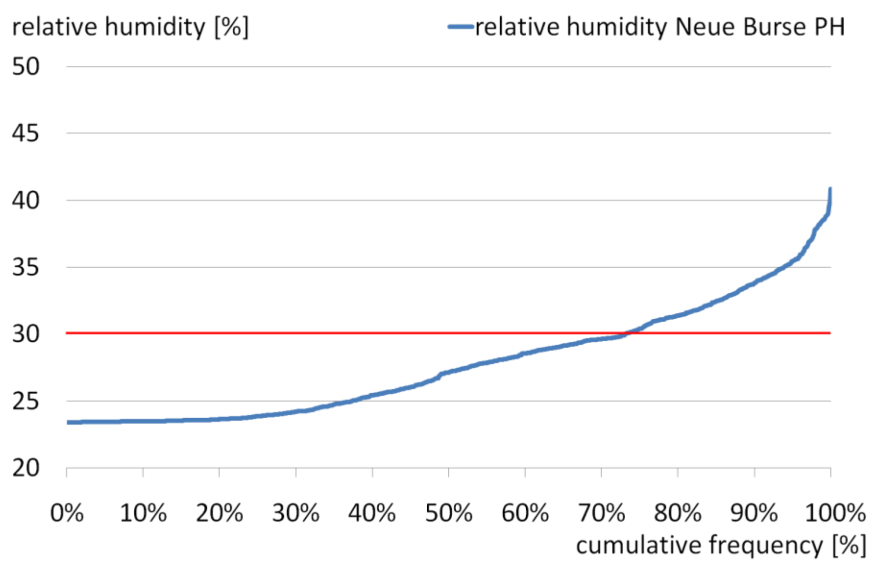
comfort and user influence measurements

Due to mechanical ventiation, sufficient air exchange rates can be assured.

Air exchange with dry outdoor air causes uncomfortable low humidity indoors.





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summary conclusions

Heat demand of DHW dominates the load for thermal energy.

High occupation density and fluctuating occupancy.

Exceeded expected energy consumption due to users‘ comfort decisions, inadequate user behavior and technical faults.

Errors in operating controls are often not detected

image: Thomas Rhiele

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summary
conclusions

Missing knowledge about technical features can cause misunderstandings.

High occupant turnover limits “learning effects”.

Potential benefit for passivhouse concept: necessity of mechanical ventilation, high internal gains.

Potential for improvement especially in fields of adapted ventilation concepts.

image: Thomas Rhiele

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thank you

additional information:
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www.bine.info/en (english)
www.btga.uni-wuppertal.de (german)