Student Dorms as Passive Houses

Experience from Germany and Austria

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1 student living – basic data
2 the dorms
3 findings - technical analysis
4 findings - comfort and user influence
5 conclusions
student living data from Germany
### student living in Germany – numbers

#### housing type, data from 2009:

<table>
<thead>
<tr>
<th>Housing Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>parents</td>
<td>23%</td>
</tr>
<tr>
<td>student dorm</td>
<td>12%</td>
</tr>
<tr>
<td>sublet</td>
<td>2%</td>
</tr>
<tr>
<td>flat sharing</td>
<td>26%</td>
</tr>
<tr>
<td>single flat</td>
<td>17%</td>
</tr>
<tr>
<td>flat with partner</td>
<td>20%</td>
</tr>
</tbody>
</table>

enrolled in wintersemester 2007/08: 1,818,000 students
215,000 students live in dorms

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

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1) source: Bundesverband der Energie- und Wasserwirtschaft, 2002
2) source: U.S. Energy Information Administration, 2008
dorms – typical water consumption?

- average total water consumption in Germany: 45.6 m³/cap, yr
- US indoor use¹): 82 m³/cap, yr

¹) source: American Water Works Association
the dorms
„Neue Burse“, Wuppertal, Germany

- built in 1977
- two buildings, 600 occupants
- refurbishment 2001 / 2003
- LEH 303 occupants, 8,420 m² (90,632 ft²)
- PH 323 occupants, 8,597 m² (92,537 ft²)
„Neue Burse“, Wuppertal, Germany

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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
- $Q_{H, PHPP} = 26 \text{ kWh/m}^2\text{a} \ (8.3 \text{ kBtu/ft}^2)$
Molkereistraße, Vienna, Austria

- built as passive house in 2005
- 278 occupants, 8,842 m² (95,174 ft²)
- dorm for exchange students

images: Eduard Hueber
Molkereistraße, Vienna, Austria

- decentralized mechanical ventilation units
- air preheating using geothermal energy
- space heating by (mini) radiators near air-intake, thermostat in every room
- $Q_{\text{HP}}^{\text{PHPP}}$: 12 kWh/m²a (3.8 kBtu/ft²)
technical analysis
energy flow – from primary energy to the user

primary energy
- transformation loss power generation
- based on power
- transformation and distribution loss
- renewable / CHP credit

secondary energy
- measured data
- electric aux. energy
- household el.
- space heating
- storage and distribution loss
- internal gains: people and solar irradiation
- heat recovery

site energy
- mech. energy
- non-usable input from appliances
- usable heat from appliances
- usable heat loss
- hot potable water
- transmission and ventilation heat loss

long-term measurement
(incl. weather)

short-time / seasonal measurements
- Thermal energy consumption significantly lower than in other dorms.
- Electric power consumption equals average of others.
- Energy consumption for DHW gets dominating load.
energy flow – thermal energy consumption

Neue Burse, Wuppertal
- site energy: 79.8 kWh/m²a
- space heating: 36.3 kWh/m²a
- DHW: 43.5 kWh/m²a
- ww usage: 35.6 kWh/m²a
- storage loss: 5.5 kWh/m²a
- circulation loss: 3.4 kWh/m²a

Molkereistraße, Vienna
- site energy: 66.5 kWh/m²a
- space heating: 25.6 kWh/m²a
- DHW: 40.8 kWh/m²a
- ww usage: 40.3 kWh/m²a
- storage loss: 0.5 kWh/m²a

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

water consumption as indicator for occupancy
- weekend commuter
- semester break
heating loads
Neue Burse, LEH

analyzing heat loads – ambient temperature correlation

\[ \dot{q}_h = (H_T + H_V) \cdot \Delta T \]

\[ \dot{q}_h = (H_T + H_V) \cdot \Delta T - q_i \]

\[ n = 0.2 \left( \frac{1}{h} \right) \]
heating loads
Neue Burse, PH

analyzing heat loads – ambient temperature correlation

irradiation

- < 25 W/m²
- 25 to 90 W/m²
- > 90 W/m²

heating load [W/m²]

ambient temperature [°C]

heat loss during summer
comfort and user influence
comfort and user influence
window ventilation

Despite mechanical ventilation some users feel a need for window ventilation.
comfort and user influence
window ventilation

- Window ventilation depends on personal habits, but is also highly influenced by outdoor conditions.
- Low ambient temperatures significantly reduce window ventilation.
comfort and user influence
indoor temperatures

Newe 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
comfort and user influence
indoor temperatures

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
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.
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?”
comfort and user influence measurements

Measuring the CO\textsubscript{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).
comfort and user influence measurements

Due to mechanical ventilation, sufficient air exchange rates can be assured. Air exchange with dry outdoor air causes uncomfortable low humidity indoors.
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.
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.
thank you

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