Monitoring results of two highly solar-powered apartment buildings in Germany – residential concept of the future?

IEA SHC Task 66, Industry Workshop No 3

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Supported by:
## Characteristics of the two houses

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usable space (EnEV)</td>
<td>853.5 m²</td>
</tr>
<tr>
<td>Area solar thermal (ST)</td>
<td>100 m²</td>
</tr>
<tr>
<td>Heat storage</td>
<td>24.6 m³</td>
</tr>
<tr>
<td>Additional heater (gas boiler)</td>
<td>48.2 kW</td>
</tr>
<tr>
<td>Photovoltaik power (PV)</td>
<td>29.6 kWp</td>
</tr>
<tr>
<td>Electrical storage (Li-Ion, netto)</td>
<td>46.8 kWh</td>
</tr>
</tbody>
</table>
### Characteristics of the two houses

<table>
<thead>
<tr>
<th>Parameter</th>
<th>House 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating demand (kWh/m²/a) *</td>
<td>15,58</td>
</tr>
<tr>
<td>Primary energy dem. (kWh/m²/a) *</td>
<td>8,40</td>
</tr>
<tr>
<td>Solar fraction heat (%) **</td>
<td>65</td>
</tr>
<tr>
<td>Solar fraction electricity (%) **</td>
<td>77</td>
</tr>
</tbody>
</table>

* From EnEV energy certificate; ** Simulations for 6 flats variant → 7 realised

Further highlights:
- Passive floor cooling through geothermal pipes (no heat pump)
- Surplus heat is transferred to neighboring buildings (hot water)
- No own electricity connection (sub-grid) → Surplus used by office building
Solar houses with flat-rate rent

Resident structure:
- 34 residents (incl. 7 children)
- Predominantly 30 - 49 year olds
- High level of education
- Income > 2,500 €

Rental model (10.50 €/m² flat rate):
- Initially difficult to understand
- Disadvantageous in rental portals
- Current: residents mostly satisfied
- Main advantage: comfort
Solar houses with flat-rate rent

Rental model, 10.50 €/m²:
- Living
- Electricity
- Heating
- Cooling

Behaviour?
• High room temperatures compared to planning and energy certificate (assumption 19 °C)
• Problem with heating control + user behaviour (window tilted at night & floor heating on)
Individual consumption: Hot water

- Approximately normal distribution
- High and low consumers are present, but balance each other out
- No particular outliers → no indicating of abusive behavior
- Washing machine / dishwasher with hot water-connection → higher HW-consumption
- Self-assessment (beginning of the lease) fits relatively well with measured values:

  ![Hot water consumption bar chart](chart.png)
  
  **Average (GER): 33-36 l/Pers/d**

<table>
<thead>
<tr>
<th>How do you estimate your hot water consumption?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(very) high</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>
Individual consumption: electricity

- Nearly normal distribution: $\bar{\Omega} 2.378 \text{ kWh/a}$
- High and low consumption balance each other out
- No particular outlier $\rightarrow$ no abusive behaviour
- Washing machine / dishwasher with hot water-connection $\rightarrow$ no significant influence

- Self-assessment (beginning of the lease) fits relatively well with measured values:

[1] with the same flat composition with average values according to: BDEW-Stromspiegel 2017

How do you estimate your electricity consumption?

- per flat
- per person

Data: MP 20/21

Average according to [1]: 2140 kWh/flat
Electricity consumption

Consumption according to time of day *

Data: 12/2019 – 11/2020

- Individually very different behaviour
- “Night owls" with low morning share → little PV use
- Ideal: high morning and low night share

*according to: J. Weniger et al: Dezentrale Solarstromspeicher für die Energiewende
Electricity consumption

**User-specific mix**

- Electricity mix individually from 15-minute balances
- Higher consumption: tends to be higher SF
- Direct consumption quite different
- Balancing in the house through battery use

Data: 12/2019 bis 11/2020; House 1

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And what lessons can be learned from the monitoring?
Heat storage

- Large ΔT in storage → good stratification
- ¾ of reservoir volume ST → 4 – 5 mon/year unused
- Retention time: ~ 1 week

Recommendations:
→ Storage significantly smaller
→ Caution: Stagnation ST
Solar thermal vs. PV

- **House 1 (unshaded):**
  Higher utilisation rates

- **PV:**
  Low radiation:
  Advantage
  Very stable values

- **Heat pump + PV:**
  Area efficiency
  Similar to solar thermal

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Electrical storage

**SOC battery**

- No seasonal storage
- Utilisation of full capacity only in transitional periods

Measuring period 2 (2020/21):
- Storage losses: 2020 kWh
- Utilisation rate: ~ 75.4 %

Recommendations:
→ Not fully utilised → smaller
→ Integration in district grid
Residential concept of the future?

- Electricity and hot water consumption → Average
- Heating consumption → Significantly above plan → Users not only reason

- Rent-concept works
- House concept can still be improved
  - Smaller storages
  - Smart communication heating system
  - Expansion tank ⇔ battery ⇔ temperature

Behaviour?
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Thanks for your interest.

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