

# 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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Bundesministerium  
für Wirtschaft  
und Klimaschutz

aufgrund eines Beschlusses  
des Deutschen Bundestages

# Characteristics of the two houses

Parameter	Value
Usable space (EnEV)	853,5 m <sup>2</sup>
Area solar thermal (ST)	100 m <sup>2</sup>
Heat storage	24,6 m <sup>3</sup>
Additional heater (gas boiler)	48,2 kW
Photovoltaik power (PV)	29,6 kWp
Electrical storage (Li-Ion, netto)	46,8 kWh



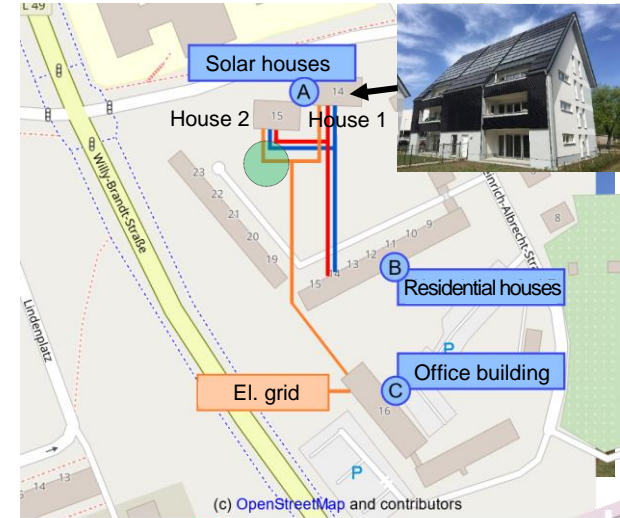
# Characteristics of the two houses

Parameter	House 1
Heating demand (kWh/m <sup>2</sup> /a) *	15,58
Primary energy dem. (kWh/m <sup>2</sup> /a) *	8,40
Solar fraction heat (%) **	65
Solar fraction electricity (%) **	77

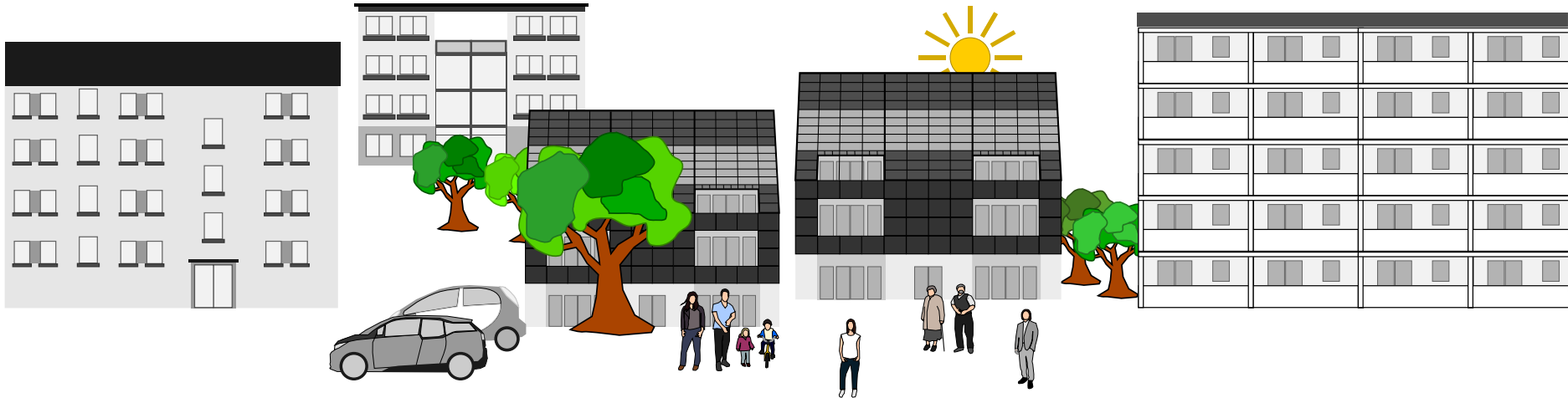
\* From EnEV energy certificate; \*\* Simulations for 6 flats variant → 7 realised

## 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



■ Local heating pipe (inlet and outlet)  
 ■ Neighbourhood power line (direct line)

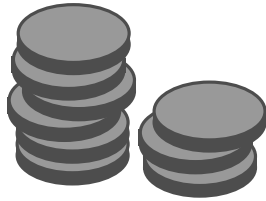


## Resident structure:

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

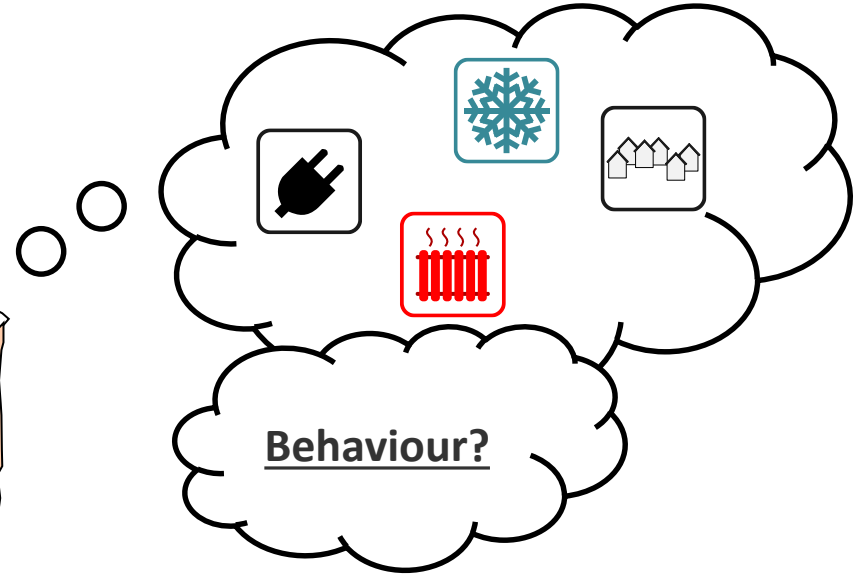
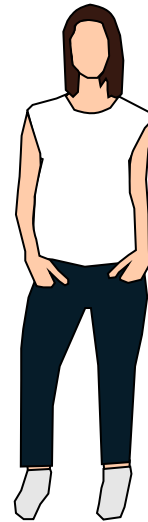
## Rental model (10.50 €/m<sup>2</sup> flat rate):

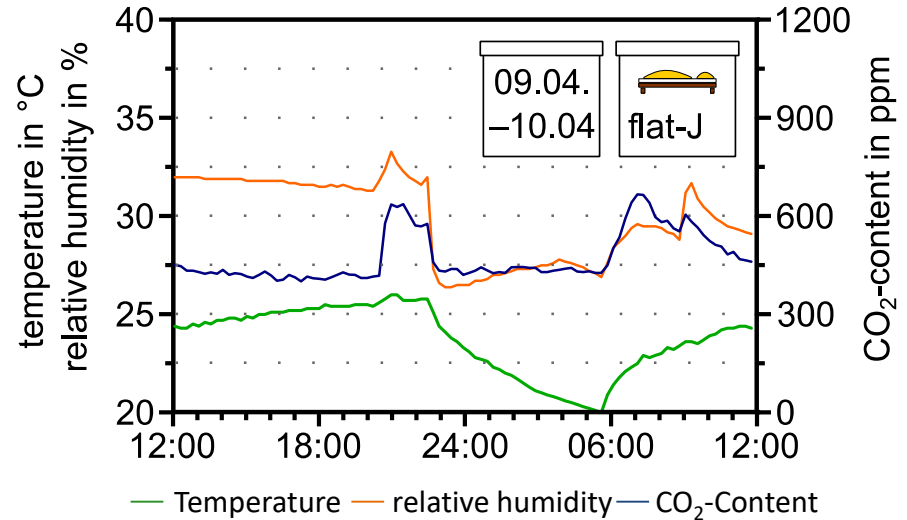
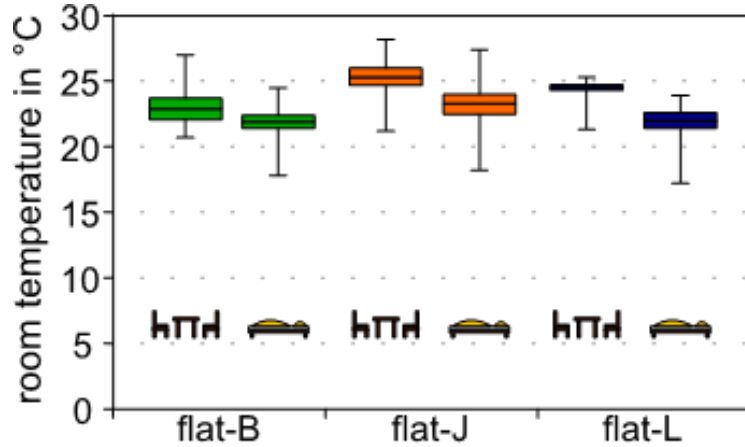
- Initially difficult to understand
- Disadvantageous in rental portals
- Current: residents mostly satisfied
- Main advantage: comfort



Rental model, 10.50 €/m<sup>2</sup>:

- Living
- Electricity
- Heating
- Cooling



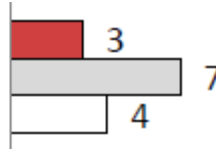


- High room temperatures compared to planning and energy certificate (assumption 19 °C)
- Problem with heating control + user behaviour (window tilted at night & floor heating on)

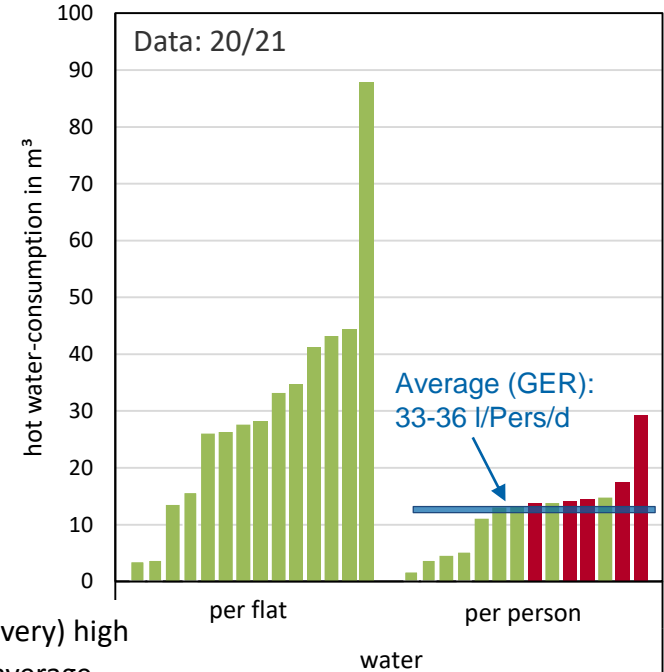
# Individual consumption: Hot water

- 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 :

How do you estimate your hot water consumption?



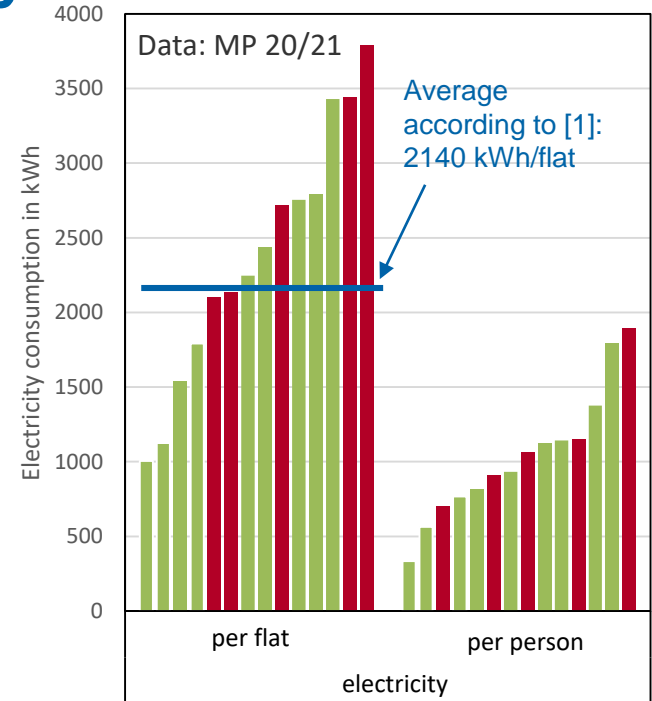
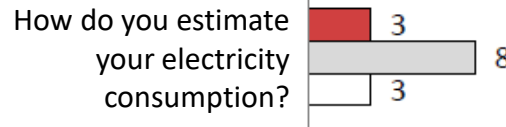
■ (very) high  
■ average  
■ (very) low



# Individual consumption: electricity

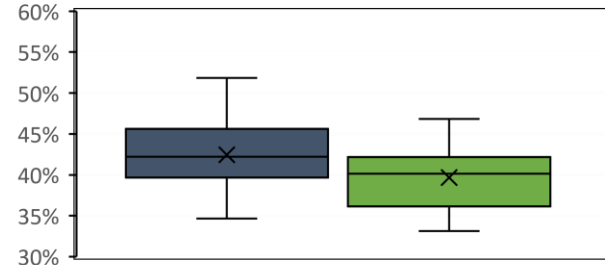
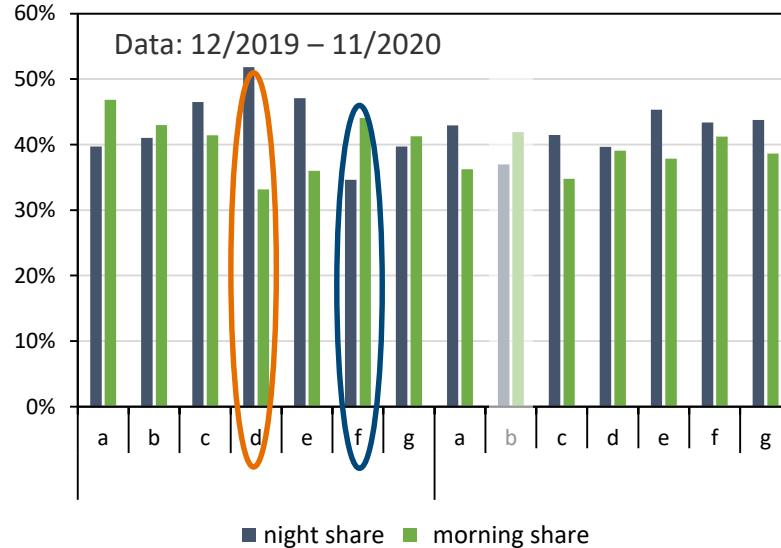
- Nearly normal distribution:  $\bar{x}$  2.378 kWh/a
- High and low consumption balance each other out
- No particular outlier  
→ no abusive behaviour
- **Washing machine / dishwasher with hot water-connection → no significant influence**
- Self-assessment (beginning of the lease) fits relatively well with measured values :

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





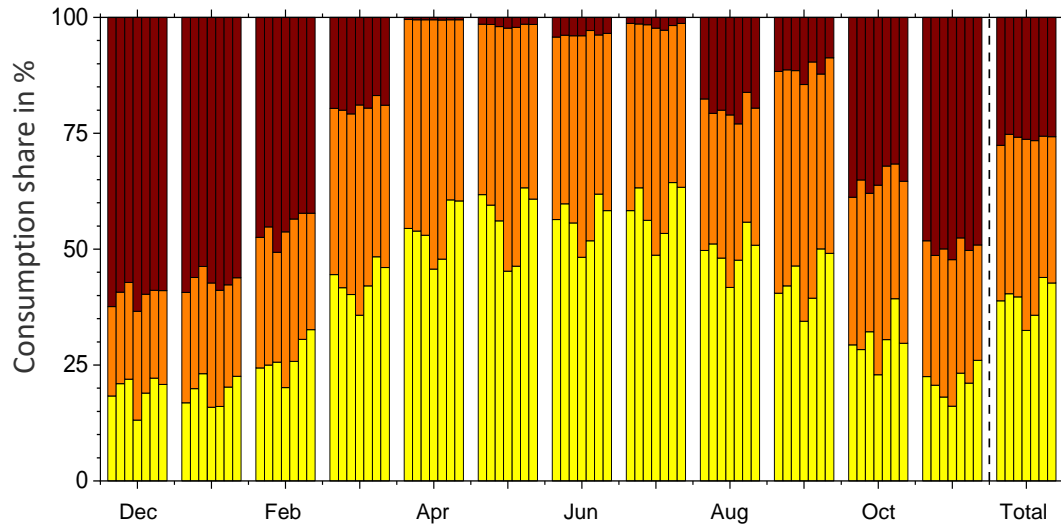
# Consumption according to time of day \*



- 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

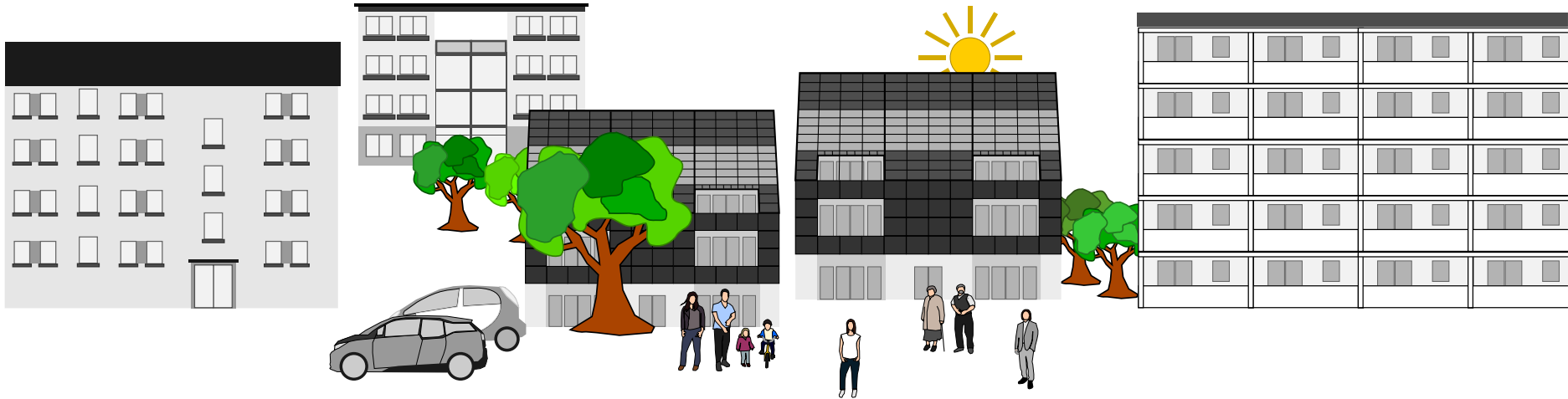
## User-specific mix



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

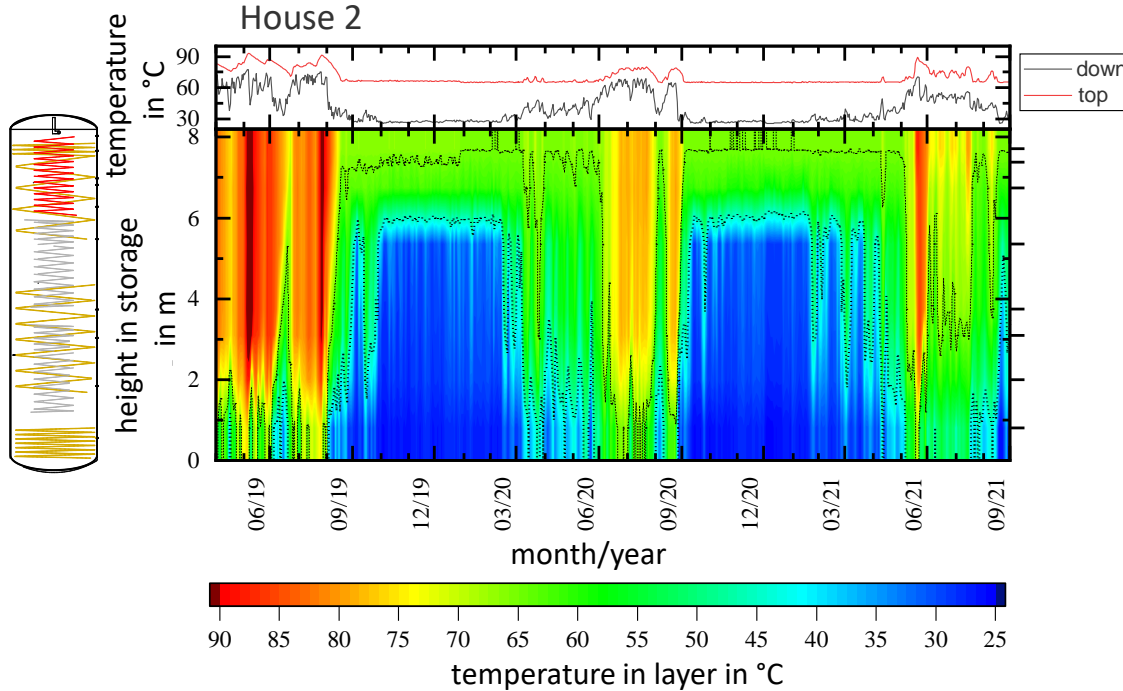


- Electricity mix individually from 15-minute balances
- Higher consumption: tends to be higher SF
- Direct consumption quite different
- Balancing in the house through battery use



And what lessons can be learned from the monitoring?

# Heat storage

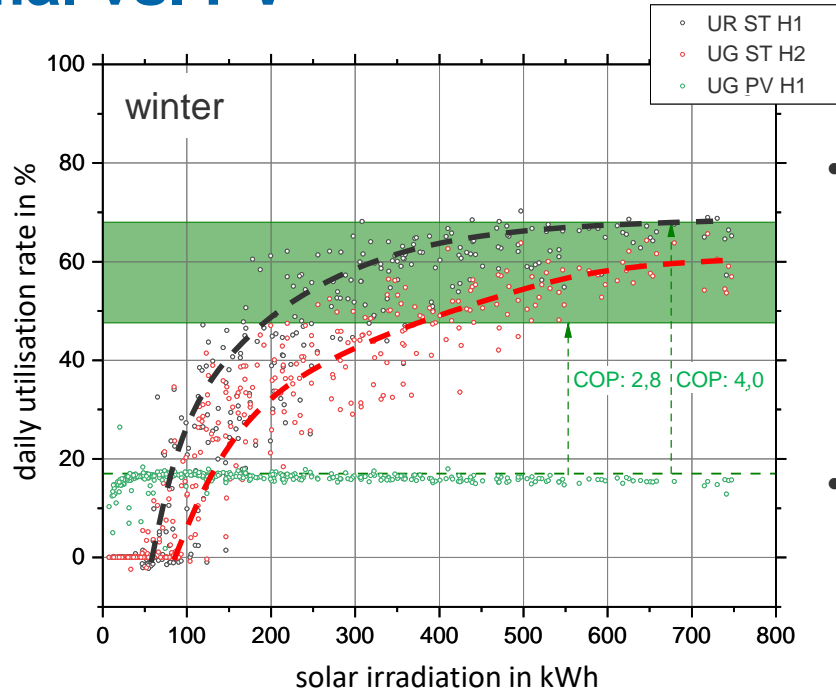
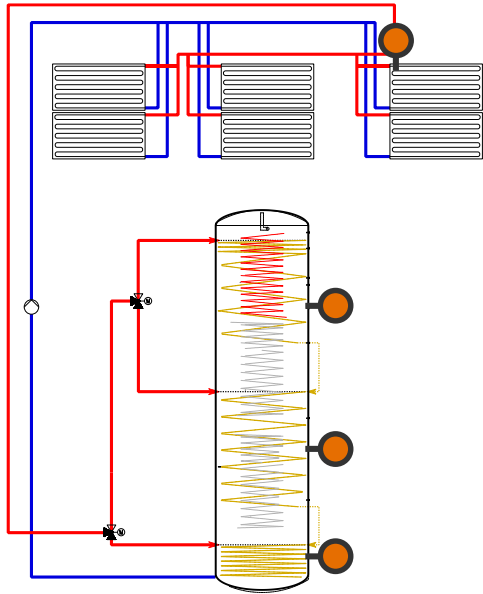


- Large  $\Delta T$  in storage  $\rightarrow$  good stratification
- $\frac{3}{4}$  of reservoir volume ST  $\rightarrow$  4 – 5 mon/year unused
- Retention time:  $\sim$  1 week

Recommendations:

- $\rightarrow$  Storage significantly smaller
- $\rightarrow$  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

## SOC battery

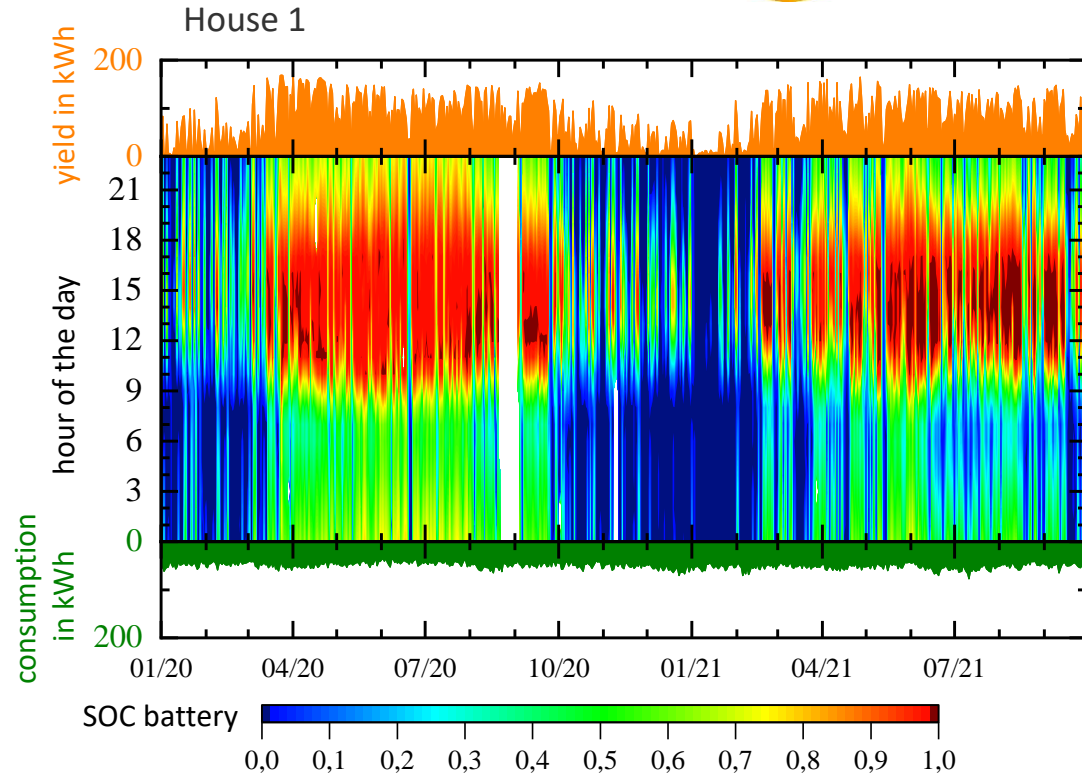
- No seasonal storage
- Utilisation of full capacity only in transitional periods

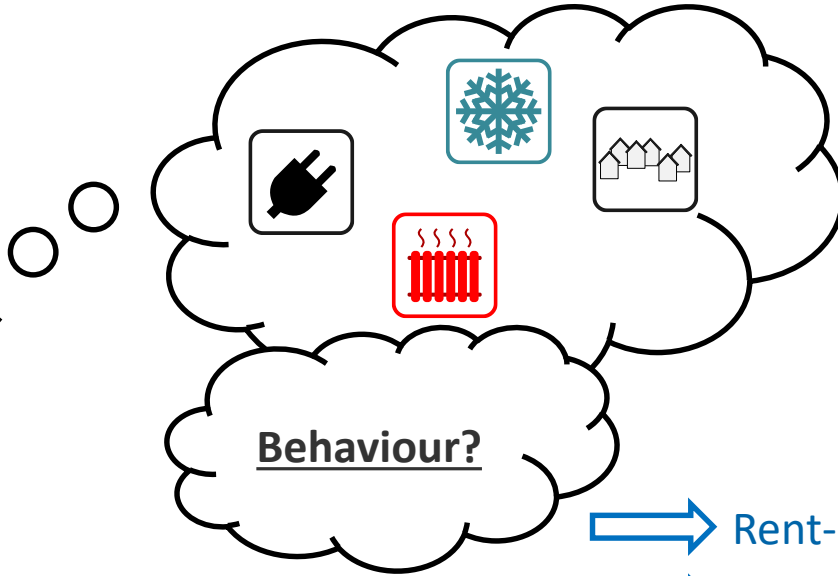
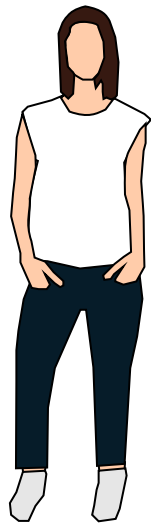
Measuring period 2 (2020/21):

- Storage losses: 2020 kWh
- Utilisation rate: ~ 75,4 %

Recommendations:

- Not fully utilised → smaller
- Integration in district grid





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

⇒ Rent-concept works

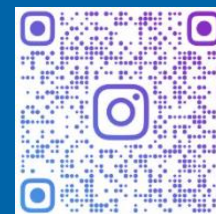
⇒ House concept can still be improved

- Smaller storages
- Smart communication heating system
- Expansion tank ↯ battery ↯ temperature



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More informations:  
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