

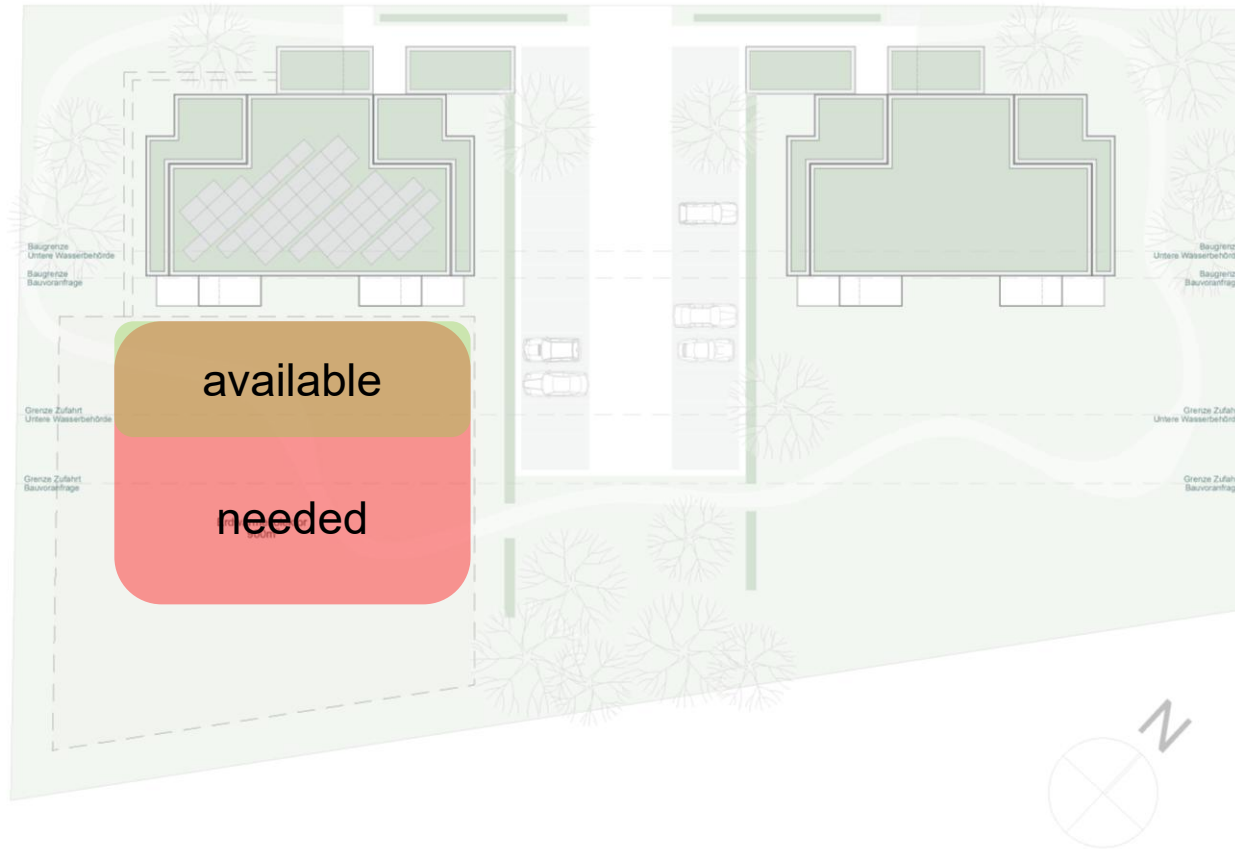


PVT - heat pump systems with ground heat exchangers in multi-family houses: Design, Implementation, and Monitoring

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Initiation of two multi-family houses



2 MFH buildings

à 9 flats, approx. 580 m², Efficiency Class 40

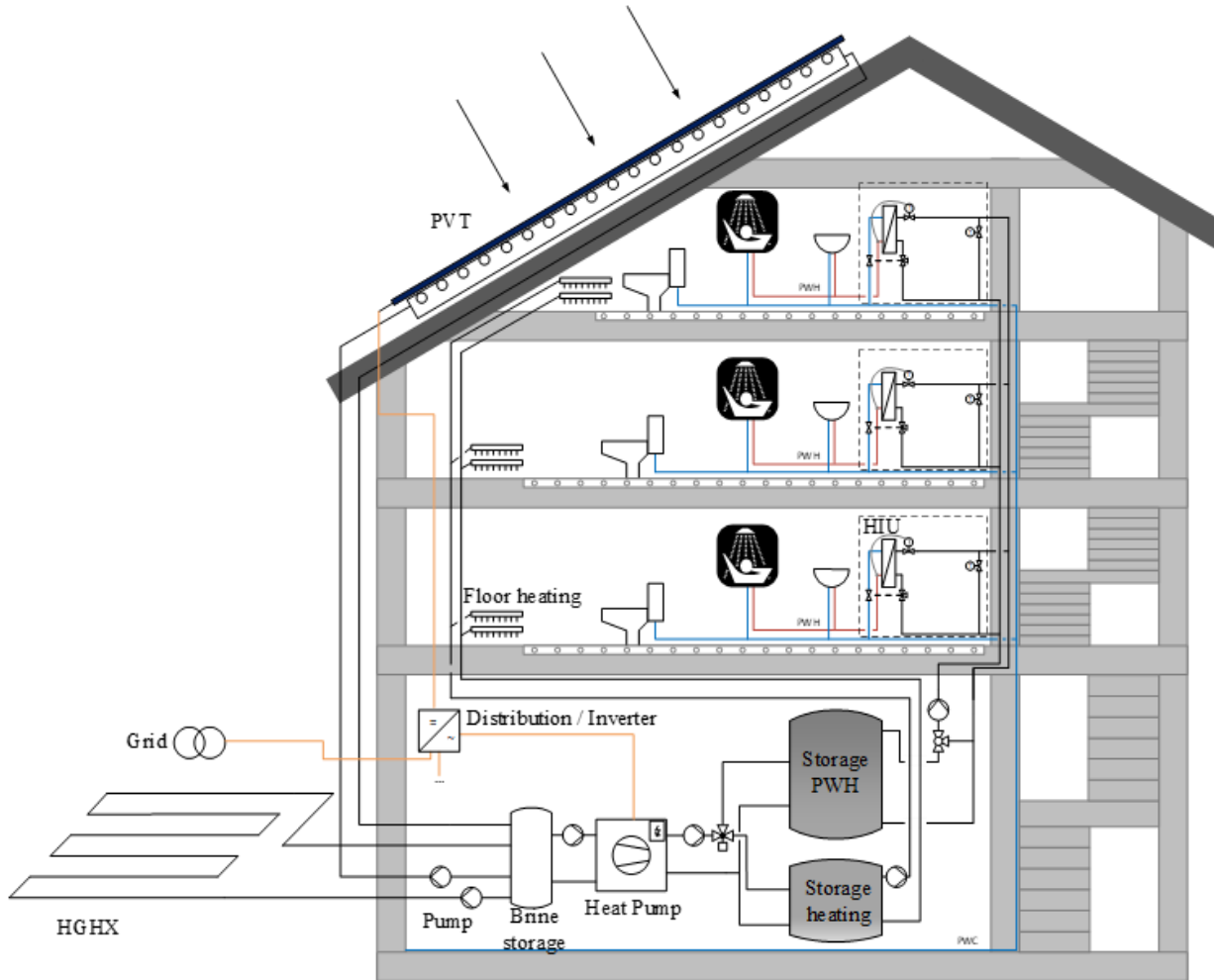
- Highly insulated building envelope
- Construction: prefabricated timber construction

Location: Hameln, Germany, near a small river and a forest

Available space:

- Roof: 150 m²
- Garden space: 550 m²

Restrictions: limited building land, protected mature trees, geological risks



Questions from the installers regarding the planning

- PVT vs HGHX area? What is the pipe spacing?
- Which PVT collector?
- ...

System-Simulationen

- SH: 8.8 MWh/a (ca. 15 kWh/m² a)
- DHW: 10 MWh/a
- HP: 16 kW_{th}

Objective: To reduce GHE and provide support through PVT

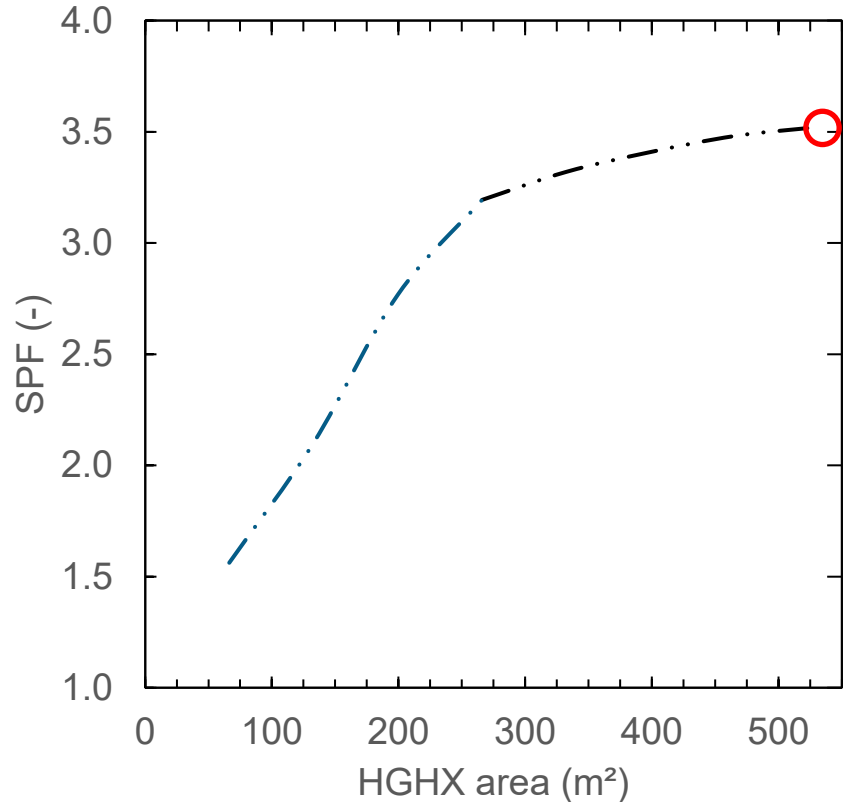
- HGHX Area, spacing
- PVT: Total area, design, regeneration

System Simulations

- HGHX area: 532 m², distance 0.7 m
- SPF 3.52

Small GHE sizes

- Critical frost
- Increased electricity consumption



System Simulations

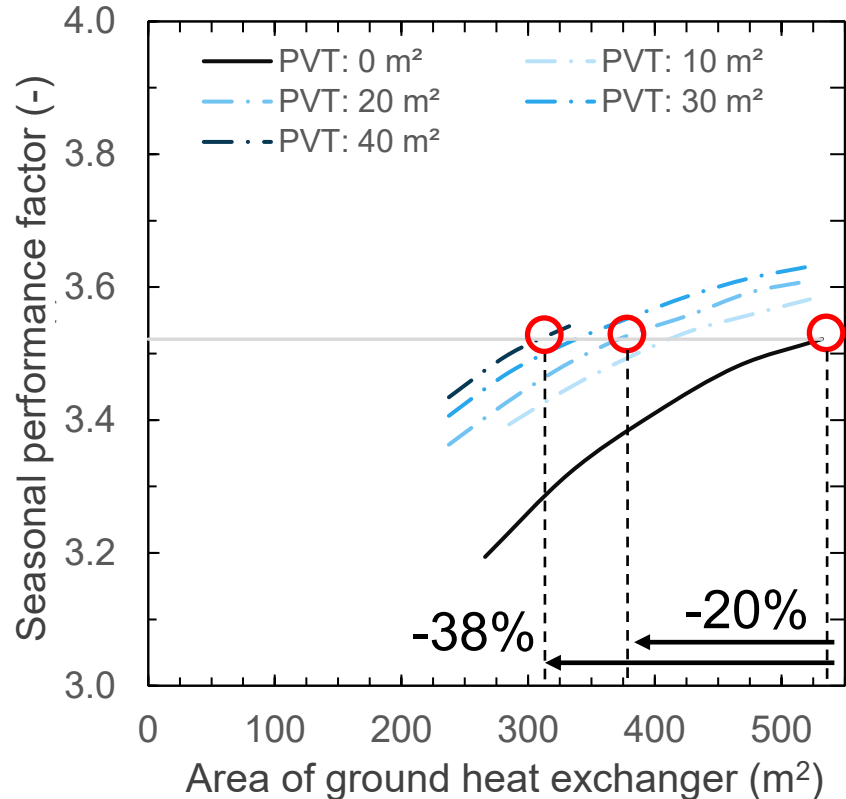
- HGHX area: 532 m², distance 0.7 m
- SPF 3.52

Small GHE sizes

- Critical frost
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Combination of PVT + HGHX

- PVT area increases SPF (particularly in the case of undersized HGHX systems)
- Higher SPF even with a reduced HGHX area



Implementation: Geothermal collectors



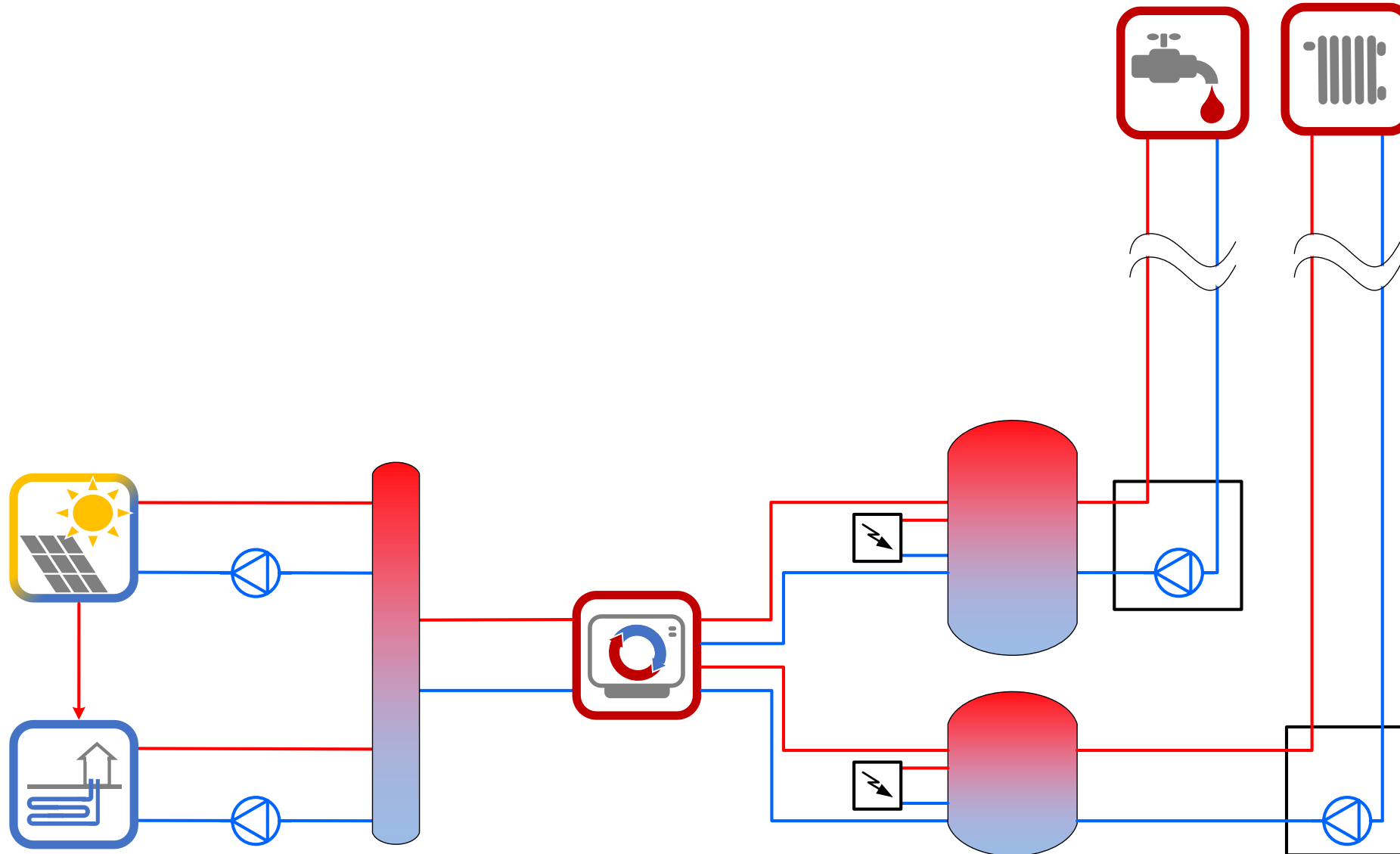
HGHX area: $532 \text{ m}^2 \rightarrow 385 \text{ m}^2$

Distance: $0.7 \text{ m} \rightarrow 0.5 \text{ m}$

Implementation: PVT collectors



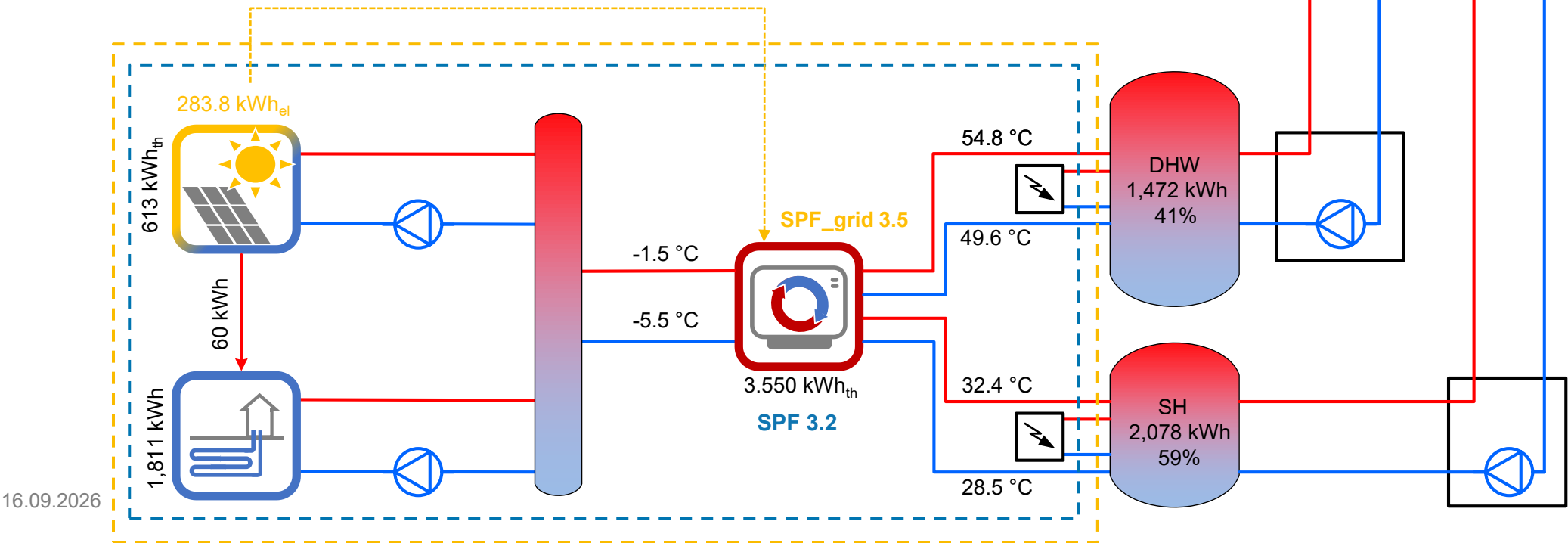
PVT area : ~ 48 m²



Measurement results: February 2026



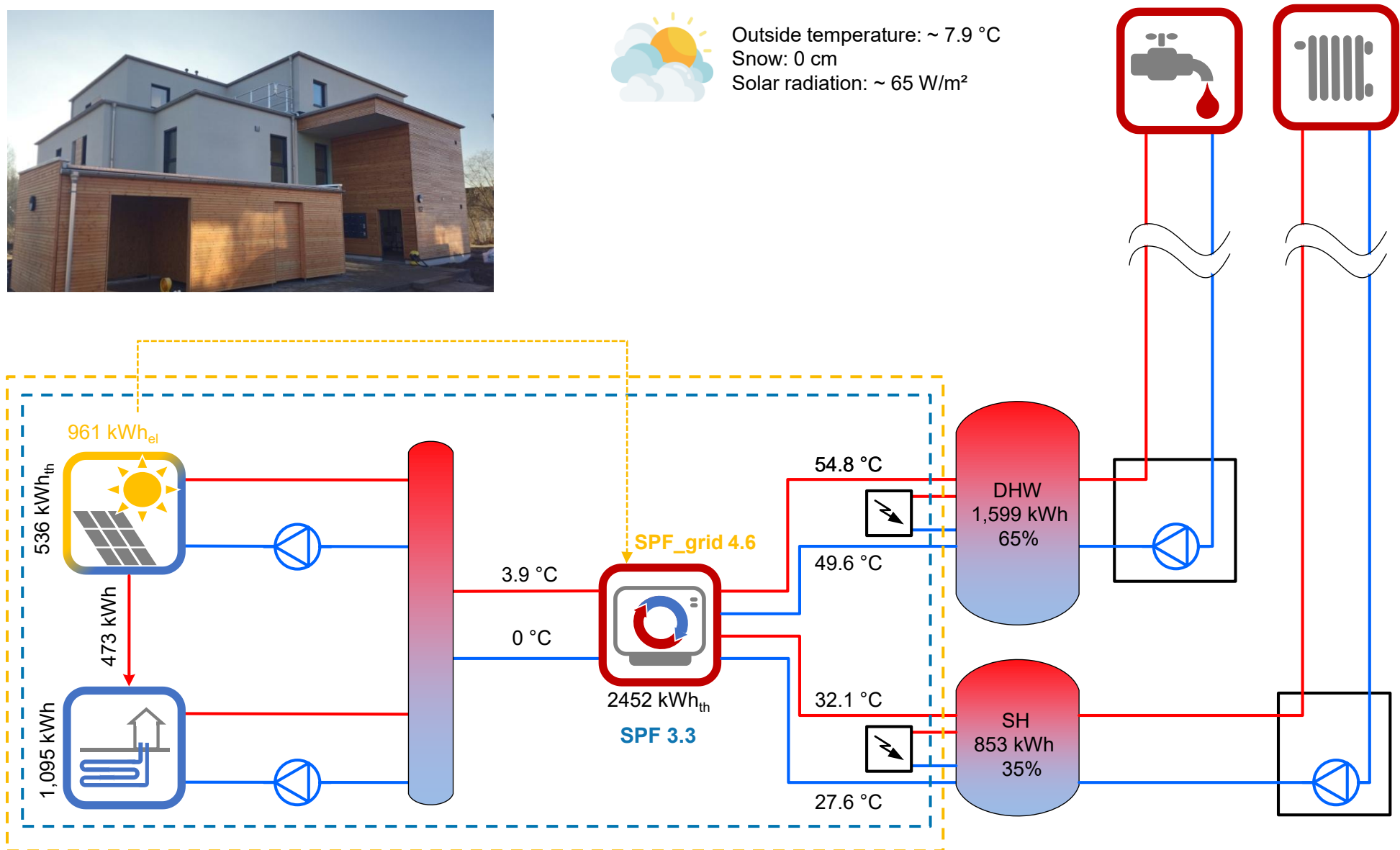
Outside temperature: ~ 3.4 °C
Snow: 5 to 8 cm (~ 9 days)
Solar radiation: ~ 52.41 W/m²



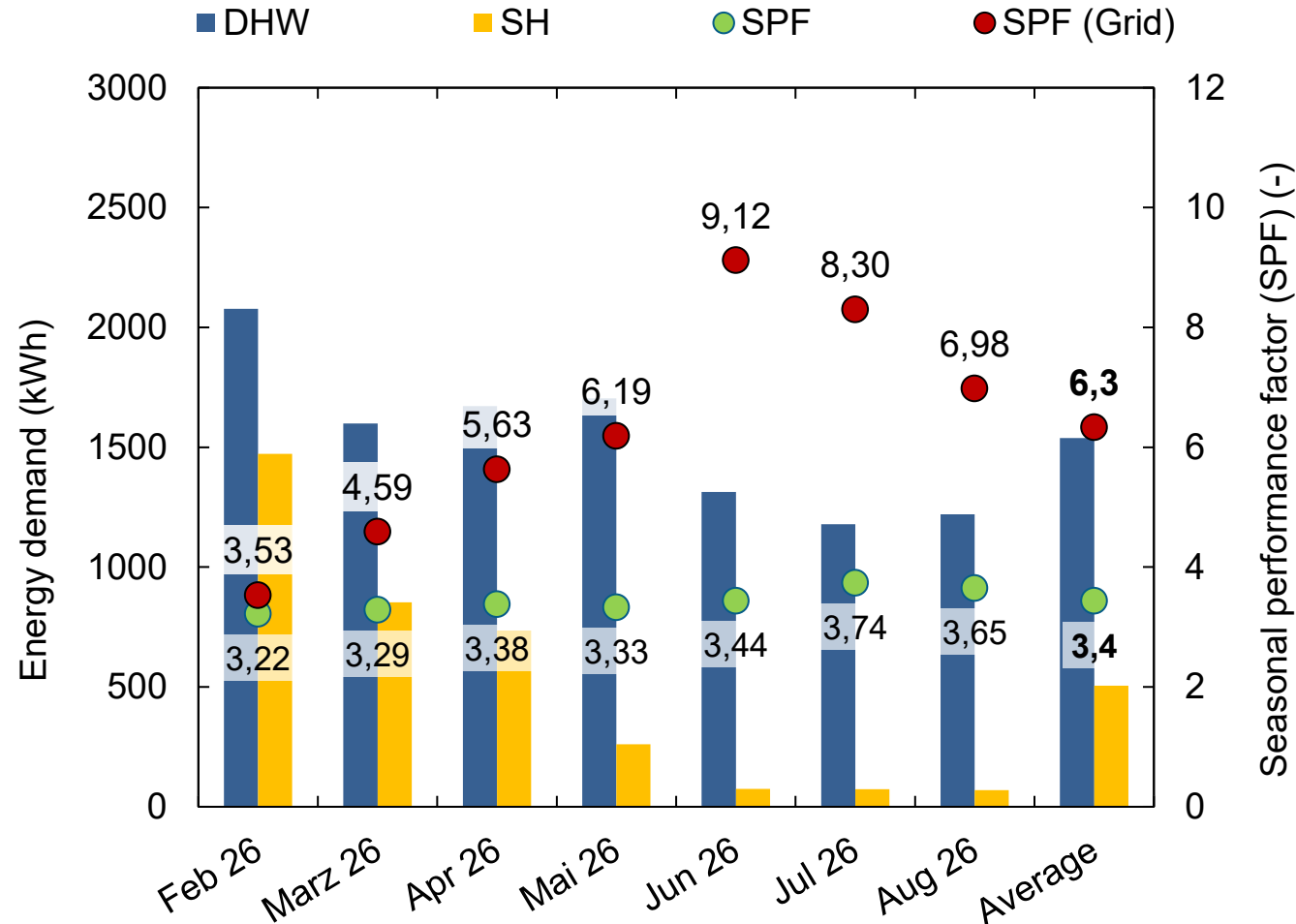
Measurement results: March 2026



Outside temperature: ~ 7.9 °C
Snow: 0 cm
Solar radiation: ~ 65 W/m²



Measurement results: Feb – August 2026



Seasonal Performance Factor

- SPF: between 3.22 and 3.74 (a

$$SPF = \frac{Q_{HP} + Q_{Aux}}{E_{el,HP} + E_{Aux} + E_{pumps}}$$

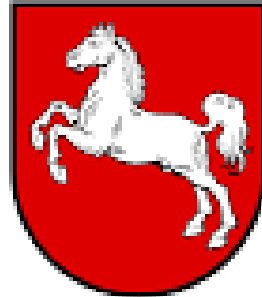
- SPF_Grid: average 6.3

$$SPF_{Grid} = \frac{Q_{HP} + Q_{Aux}}{E_{el,HP} + E_{Aux} + E_{pumps} - E_P}$$

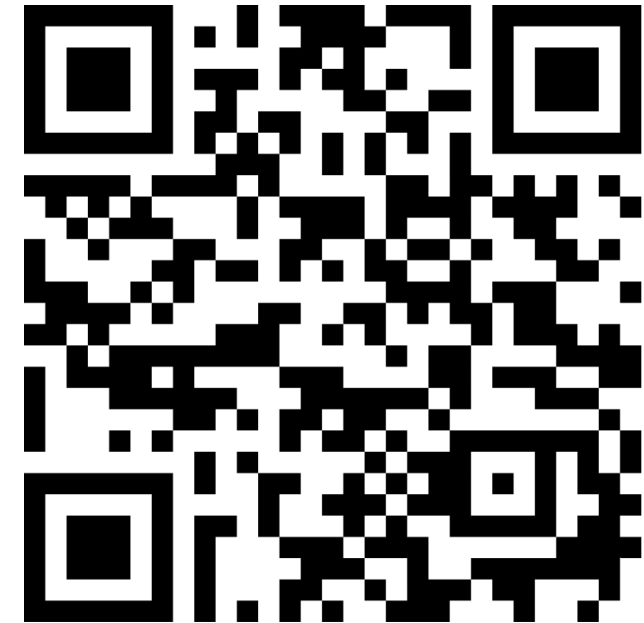
- PVT enables heat pumps to be installed where space is limited
- Reduced earthworks with the PVT ground-coupled heat pump system
- PVT is well suited both as a heat source and for regeneration
- SPF is reached up to 3.7, with an average of 3.4 from Feb to August 2026
- Achieved average SPF_grid of 6.4

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<https://heatpumpsystems.isfh.de>