Electric loads in solar energy buildings

Load management and grid relief

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Motivation

- Energy efficiency, electrification and volatile renewables are main drivers of decarbonization of the building sector → challenge for energy networks

- Development of solar energy supply concept with high solar fractions
  - 85% heating demand
  - 100% cooling demand
  - 60% electricity demand

How do solar supply systems and storage components affect electrical grid behavior?

Reference building

Simulation study

Building

Location

- Graz (Austria)

Demand

- High thermal standard
- U-Values 0.15 W/m²K

Dwelling

- 9 dwellings
- gross floor are 842 m²

User

Thermal comfort

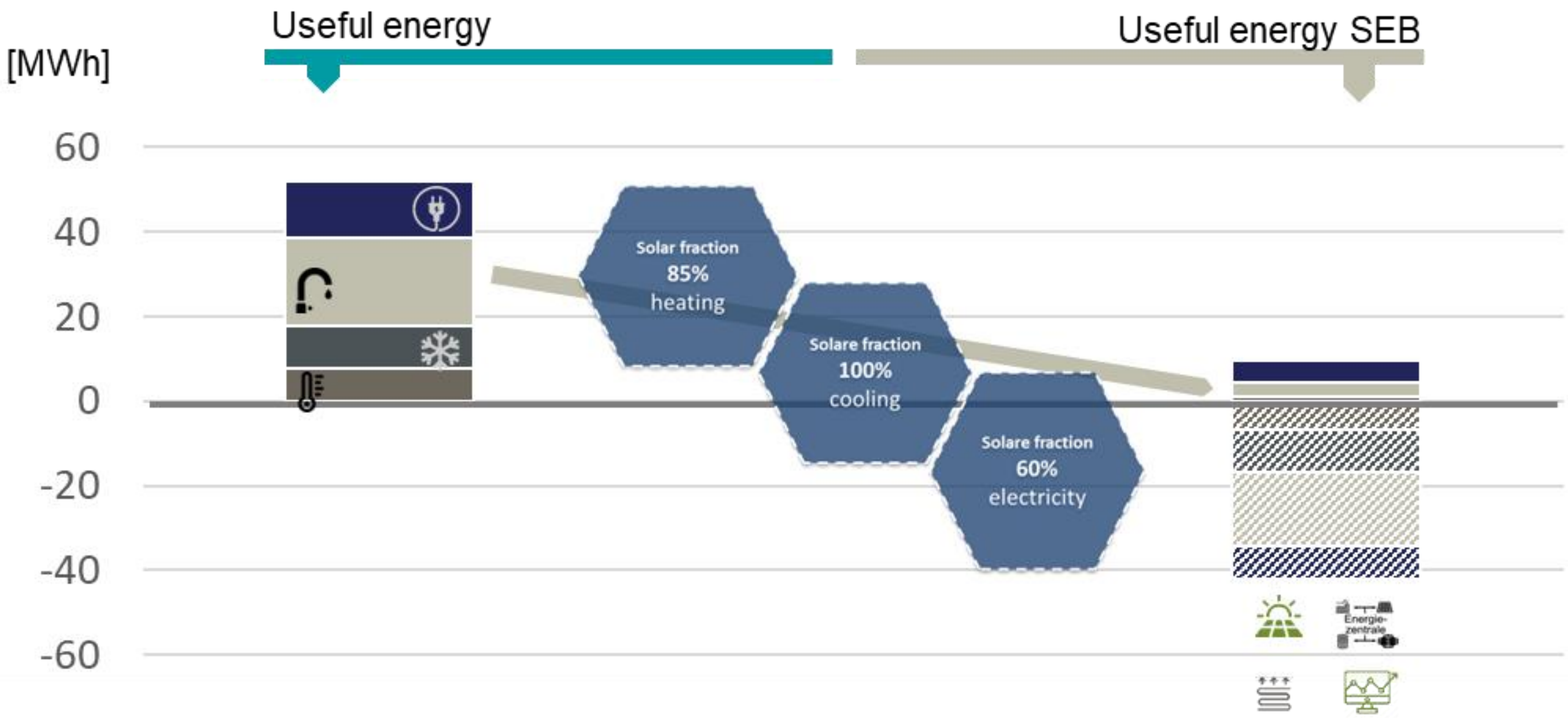
- 22°C (Heating)
- 25°C (Cooling)

Hot water demand

- 30 l/pers
- 2.5 pers/flow

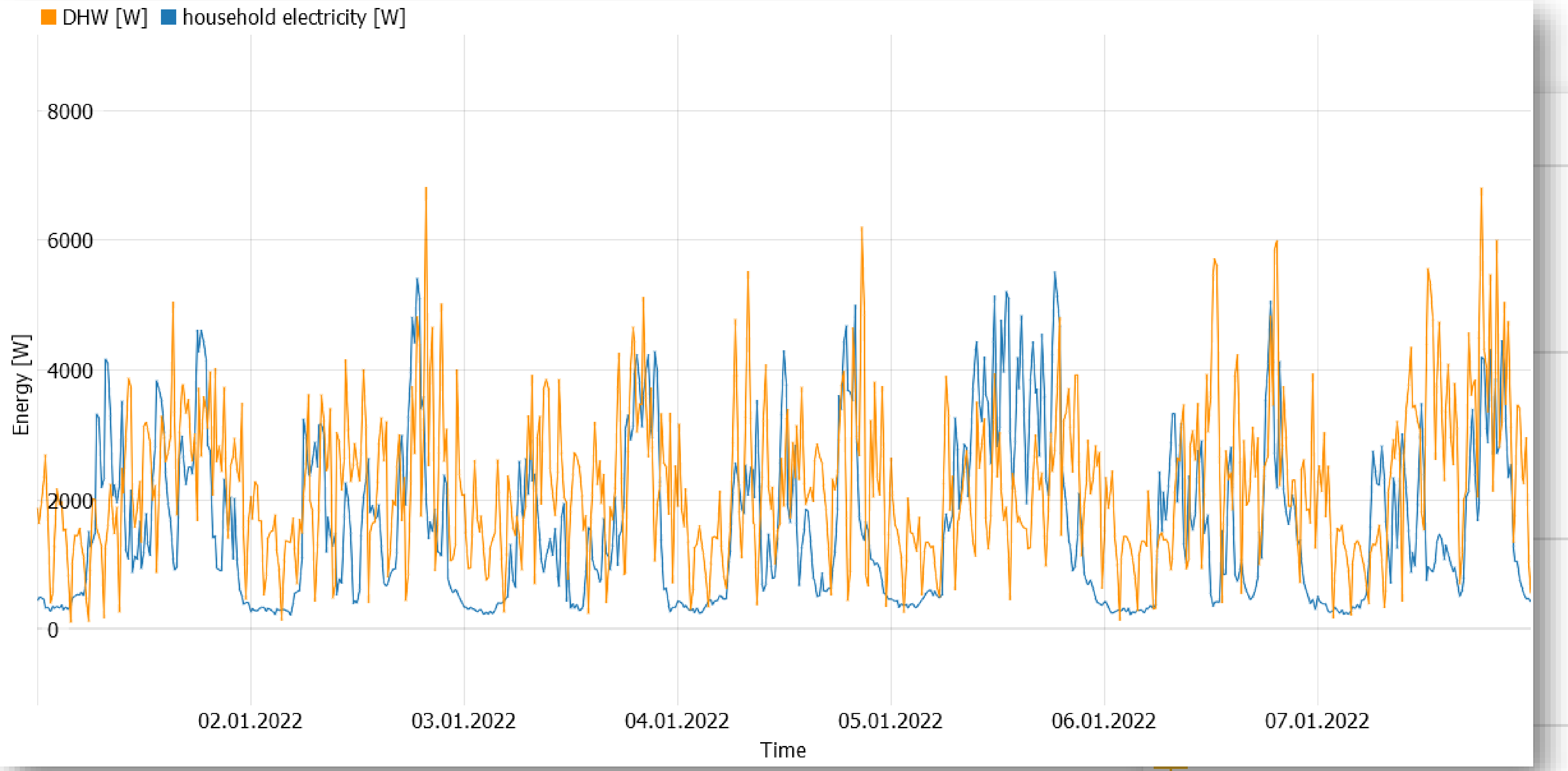
Household electricity

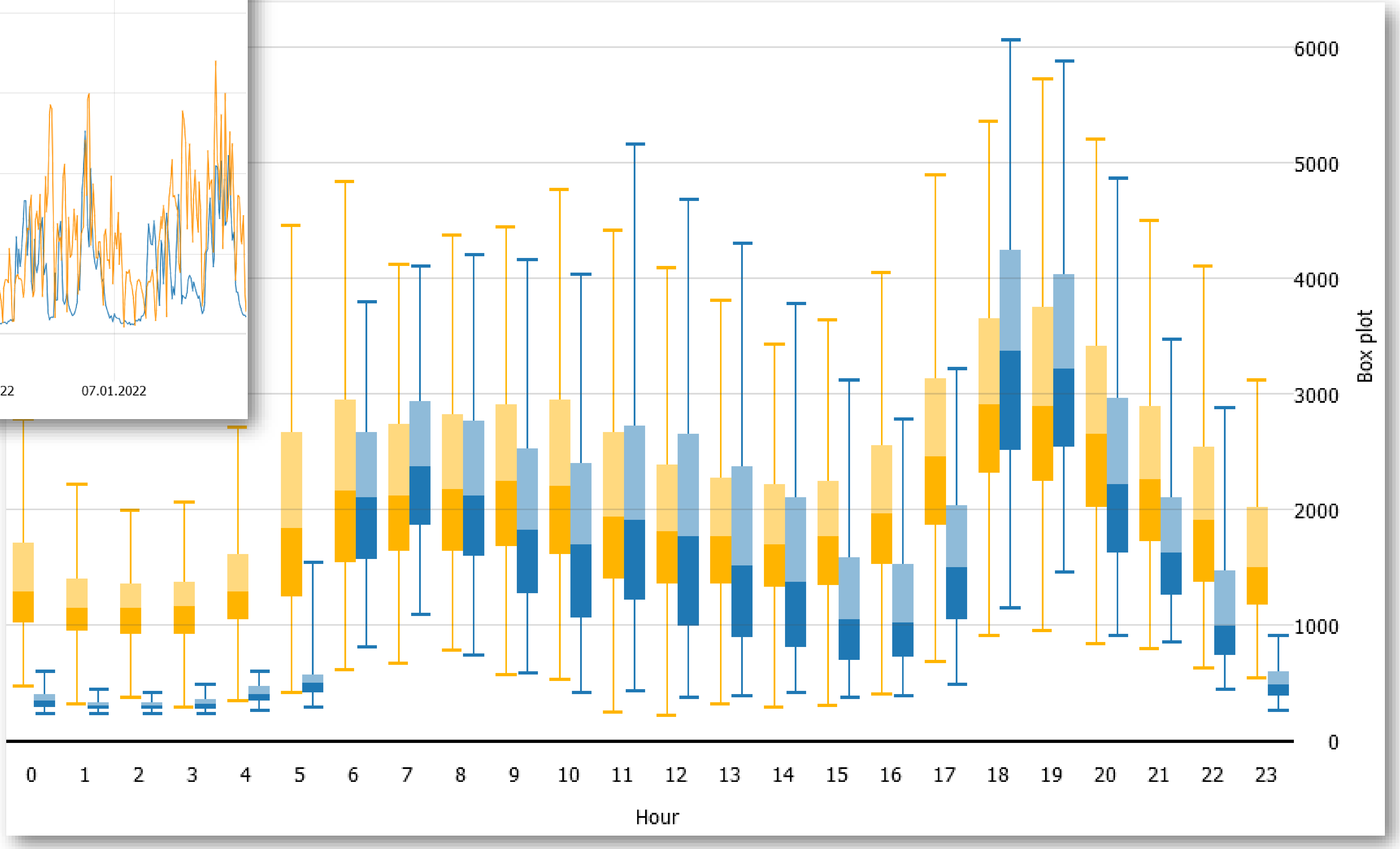
- 18.3 kWh/m²a



Electric Energy and Hot water

simulation study



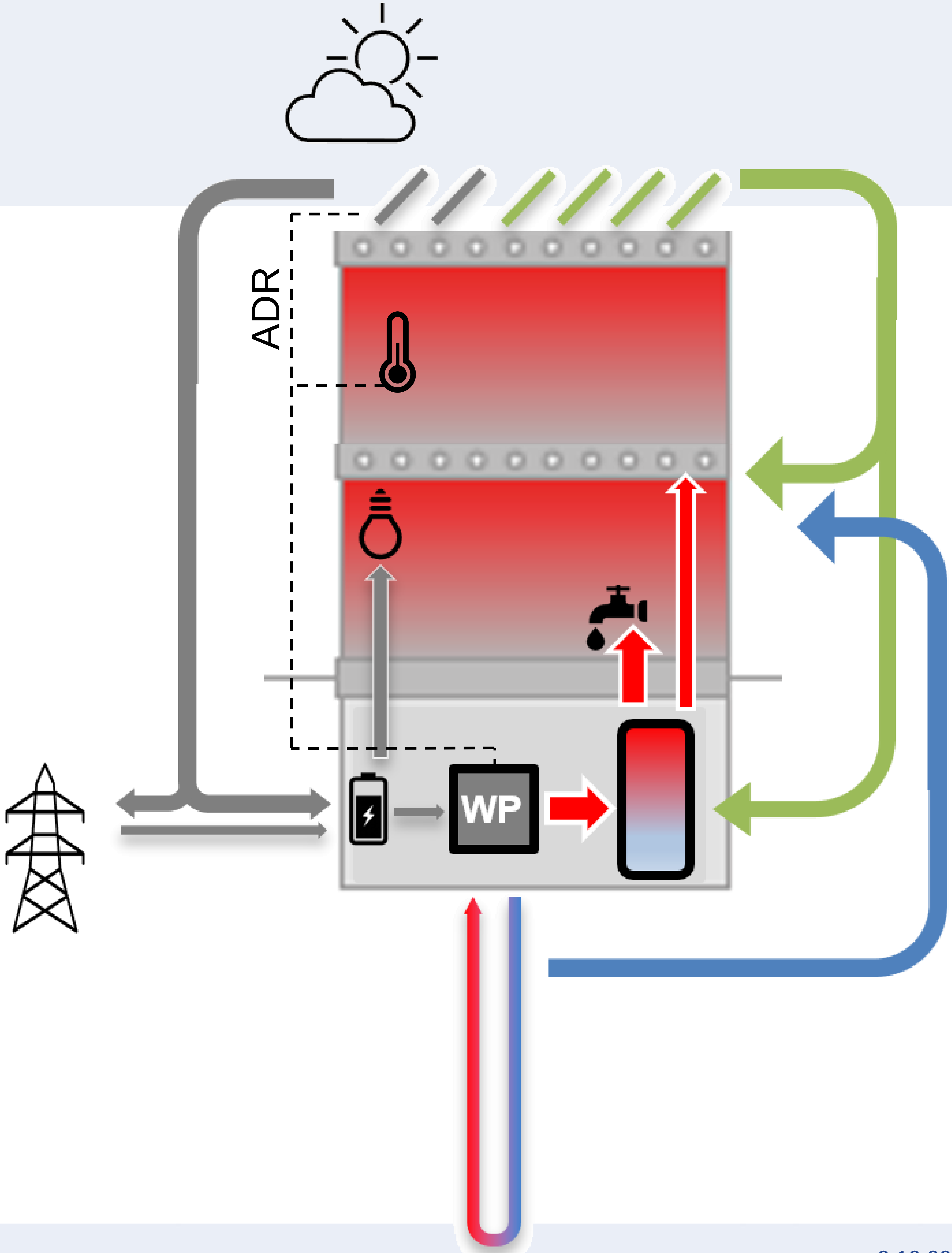


Individual load profiles per dwelling for DHW and household electricity

Energy supply concept

simulation study

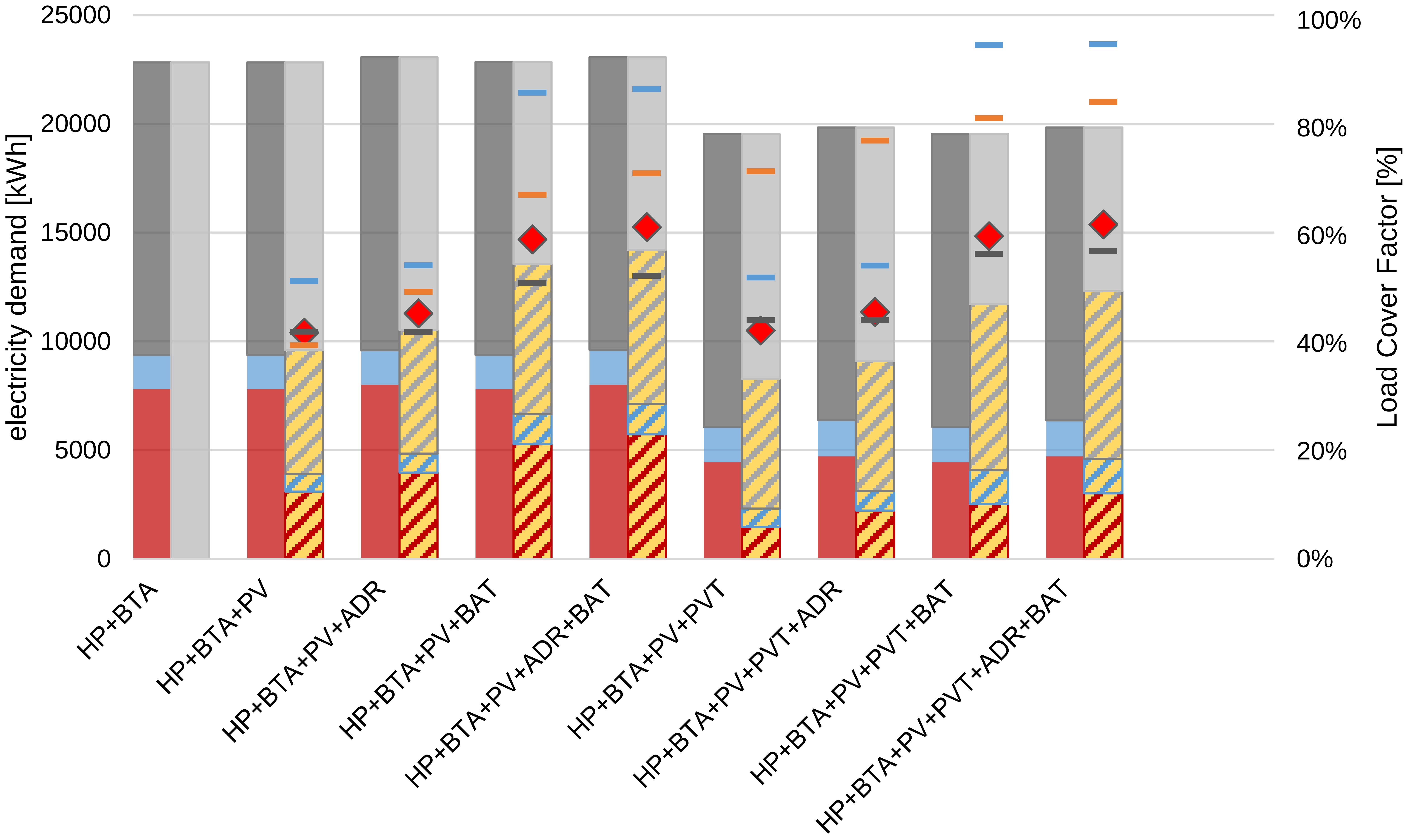
heat/cold generation	HP	Geothermal heat pump 10 kW_{th}
solar technologies	$PV_{100\%}$	Photovoltaic 148.8 m² (24.3 kW_p)
	$PV_{33\%}$ + $PVT_{66\%}$	Photovoltaic 49.6 m² (8.1 kW_p) + covered PVT 99.1 m² (16.2 kW_p)
load shifting mechanisms	ADR	Active Demand Response control overheating building mass
	BAT	Battery with 20 kWh



dynamic building and system simulation with IDA ICE

Results

Energy KPIs



$$LCF_{total} = \frac{\int_{t1}^{t2} min[g_{tot}(t), l_{tot}(t)]dt}{\int_{t1}^{t2} l_{tot}(t)dt}$$

$$LCF_{h} = \frac{\int_{t1}^{t2} min[g_{tot}(t), l_{H}(t)]dt}{\int_{t1}^{t2} l_{H}(t)dt}$$

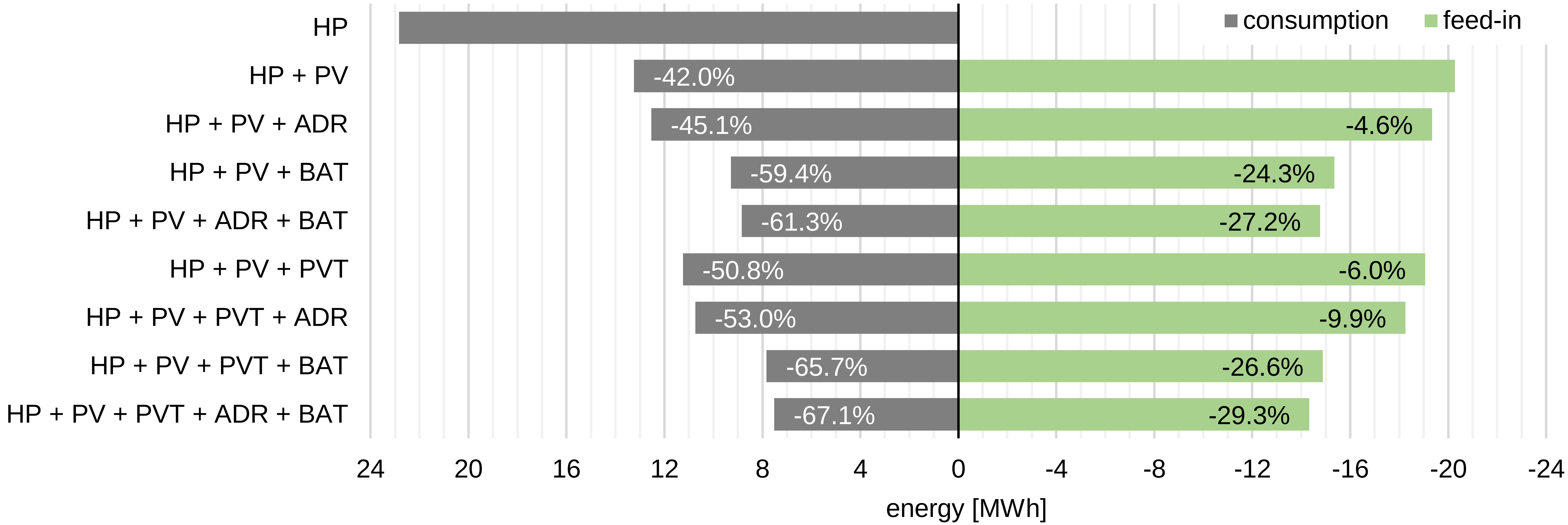
$$LCF_{c} = \frac{\int_{t1}^{t2} min[max[0, g_{tot}(t) - l_{H}(t)], l_{C}(t)]dt}{\int_{t1}^{t2} l_{C}(t)dt}$$

$$LCF_{hh} = \frac{\int_{t1}^{t2} min[max[0, g_{tot}(t) - l_{H}(t) - l_{C}(t)], l_{El}(t)]dt}{\int_{t1}^{t2} l_{El}(t)dt}$$

Results

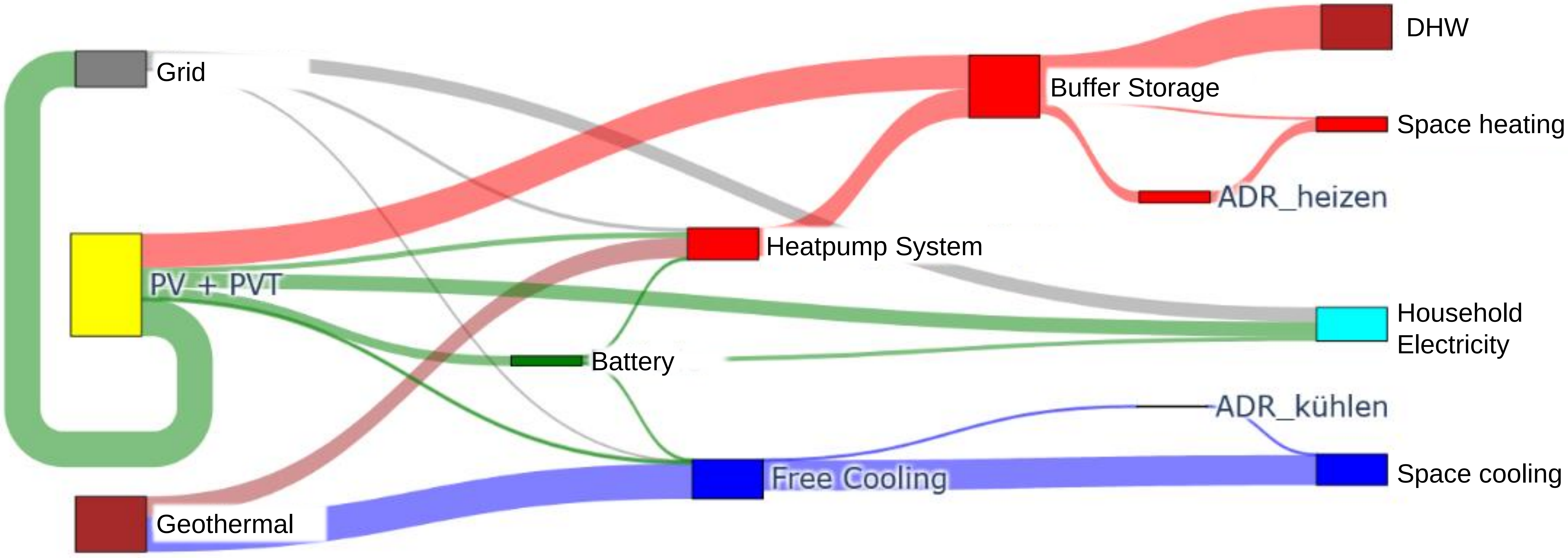
Energy demand

Annually exchanged energy with the grid for all system variants



Results

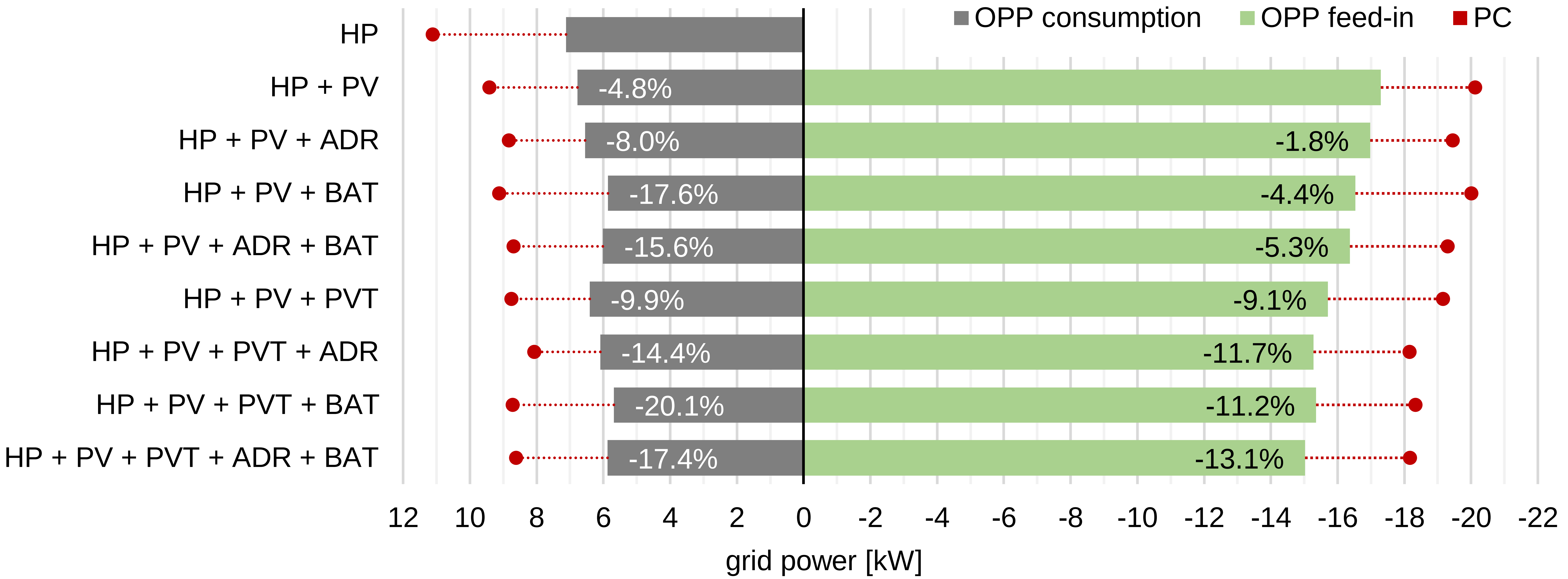
Energy flow



Scenario WP + PV + PVT + ADR + BAT

Results

Peak power



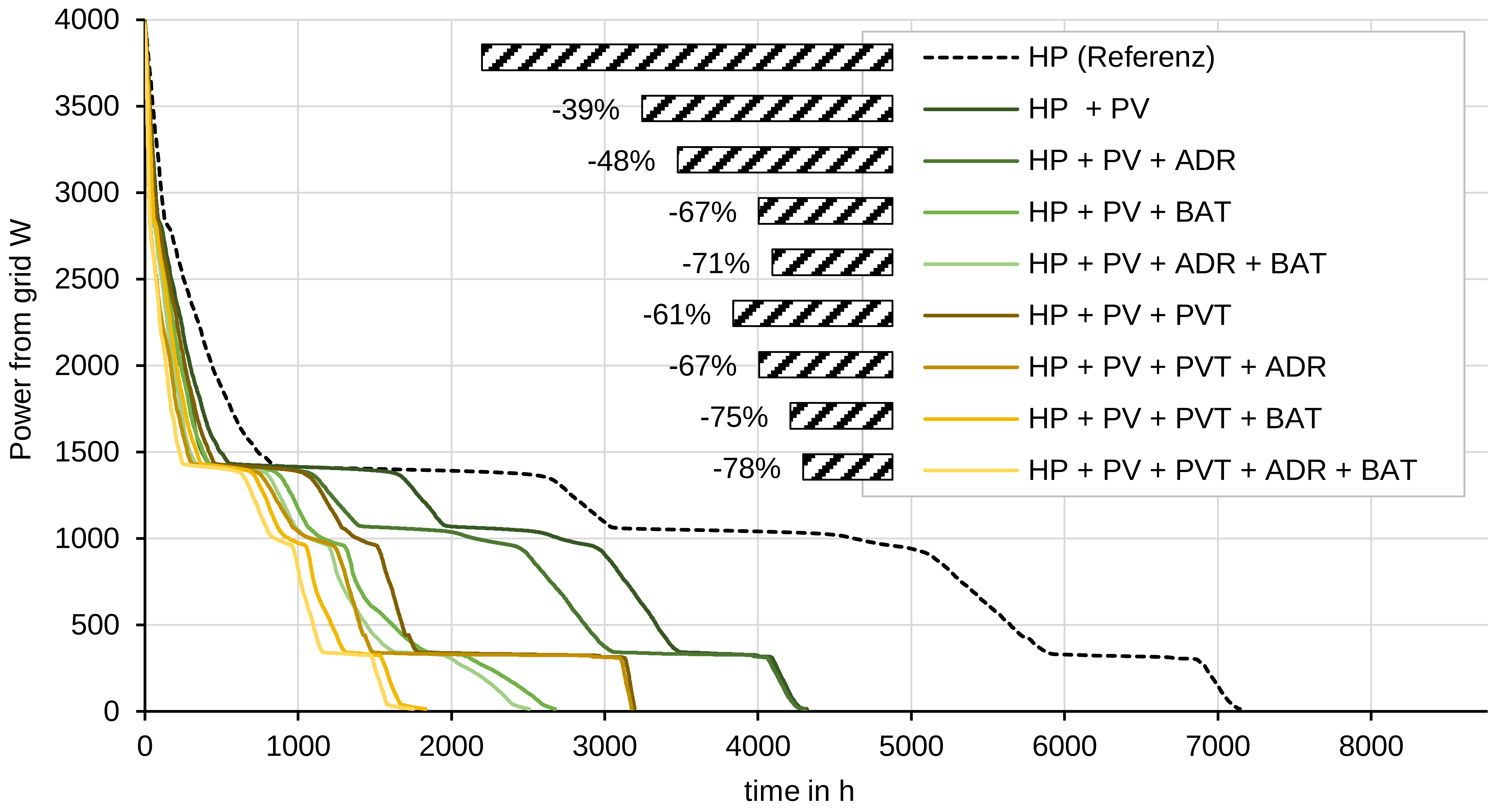
$$OPP = \frac{E_{1\%,peak}}{T}$$

$$PC_{consumption} = max \ \ |max[ne(t), 0]|$$

$$PC_{feed-in} = max \ \ |min[ne(t), 0]|$$

Results

Power from the grid (heating demand)



Conclusion

- PVT and both examined storage methods are necessary to achieve the required metrics
- Peak performances cannot be reduced using conventional methods
- Controllers should not only be optimized for energetic KPIs and must therefore include predictive methods
- The additional effort must be justifiable through regulatory measures or a market model (e.g. power-based tariffs)

Stadt der Zukunft
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