Fachhochschule Nordwestschweiz
Hochschule für Architektur, Bau und Geomatik

Capacity controlled heat pump systems in combination with PV, batteries and heat demand

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Abstract

Capacity controlled heat pump systems in combination with PV, batteries and heat demand

The talk will be from two points of view:
Main part of the talk will be the view of a scientist working at a university of applied sciences and out of the research project LEWASEF that focused on the integration of an air-to-water-heat pump into a whole building energy control system for a single-family house.
The second part will set this system into a broader view on heat pump heating systems, quality assurance, the actual state of development and upcoming challenges.

A short general introduction will look onto heat pumps for the year 2030, what are currently new or developing boundaries, expected sales figures and challenges that arise thereof.
Then details from the research project LEWASEF will discuss heat pump control in a whole building energy control system for a single-family house using solar energy from photovoltaics in combination with a battery.
The summary will go back on a general level with a look on challenges of such systems in the market now.

Ralf Dott

Curriculum vitae excerpt:

05/2000	Diploma in Mechanical Engineering at RWTH Aachen
06/2000 – 07/2001	Project engineer at Engineering Consultants Heliograph GmbH
08/2001 – 07/2003	research associate at Solar-Institut Jülich - FH-Aachen
since 2003	research associate at Institut Energie am Bau - FHNW

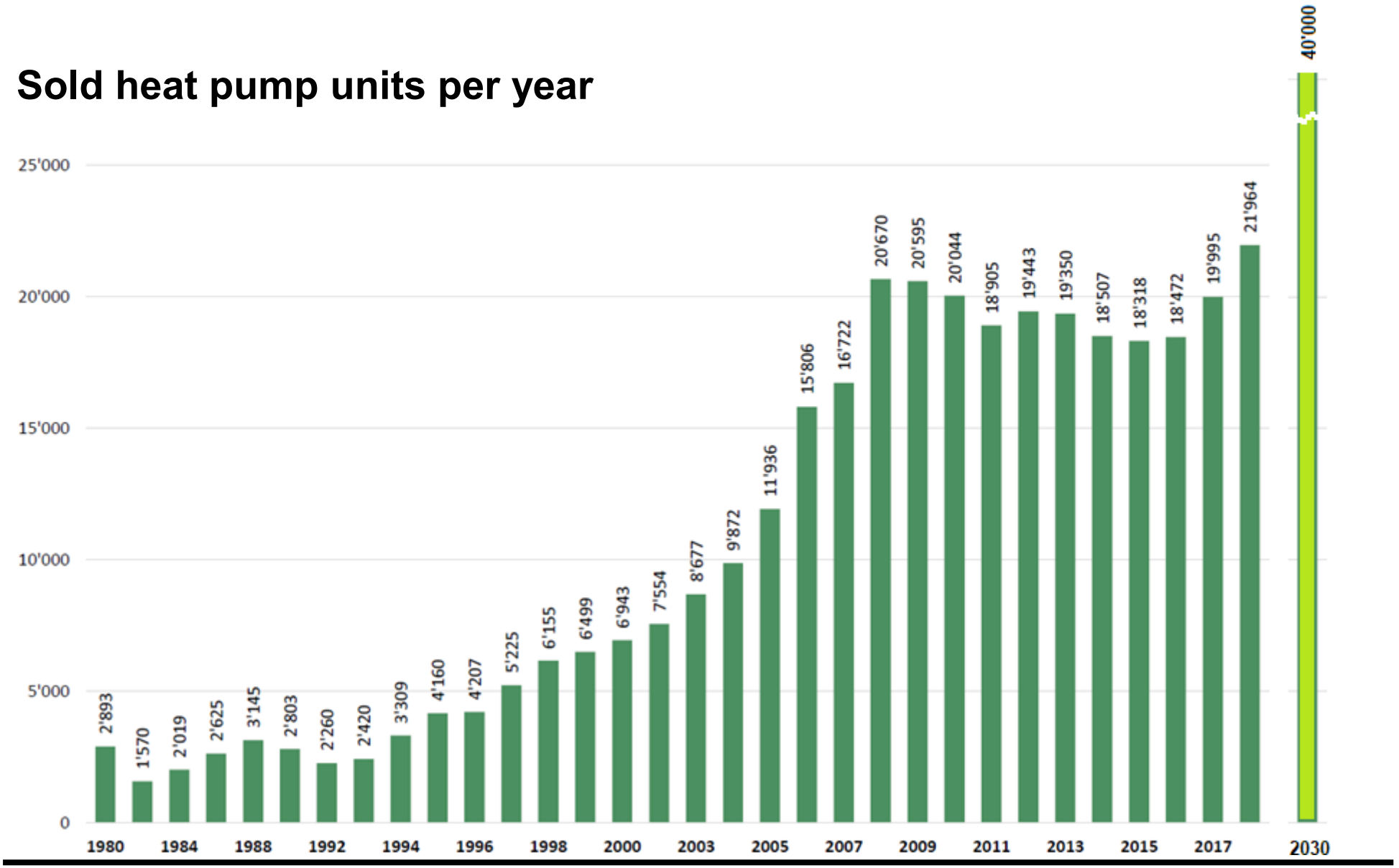
Current focus of activity:

- Chair of the Swiss Quality Label Committee FWS
  Vice-Chair of the European Quality Label Committee EHPA-QLC
  Chair of the certification group at pompe à chaleur system module PAC-SM
- Research projects on the system integration of heat pumps
  e.g. combination of heat pumps with solar technology; energy efficient cooling,
  City-compliable air-to-water heat pumps as main heat generator (City of Zürich)
- Industry projects in the fields of "heat pump with ice storage and/or Photovoltaics", "small combined heat and power systems with photovoltaics und battery storage", "Power2Gas in the building sector"
- Bachelor teaching course on heat pumps and refrigeration systems at FHNW in Windisch

FWS Fachvereinigung Wärmepumpen Schweiz

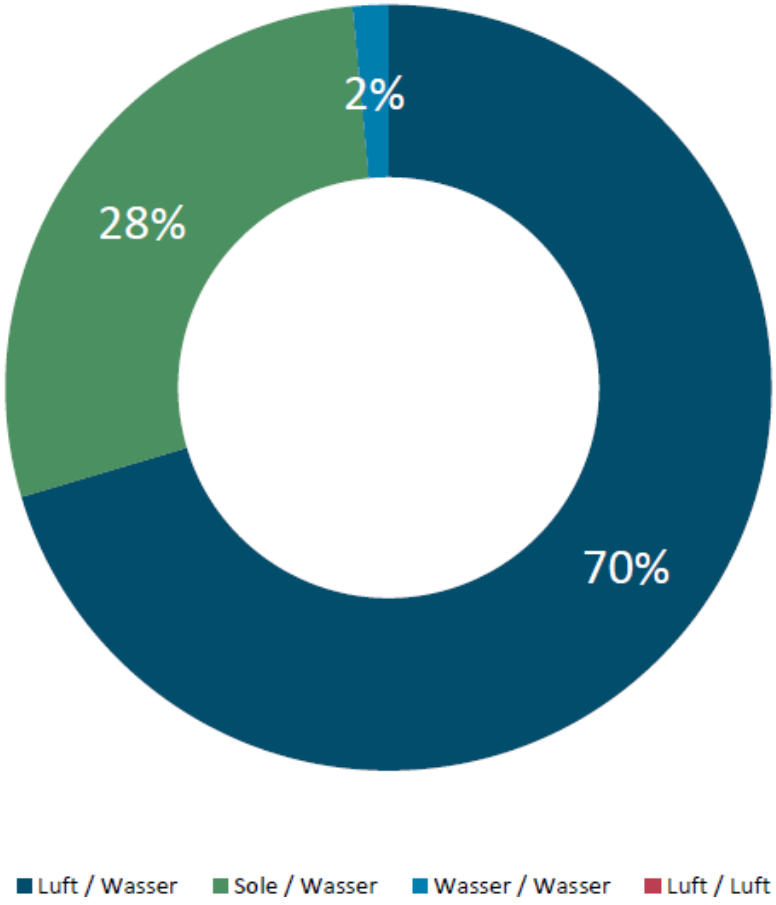
Introduction – statistics

Sold heat pump units per year



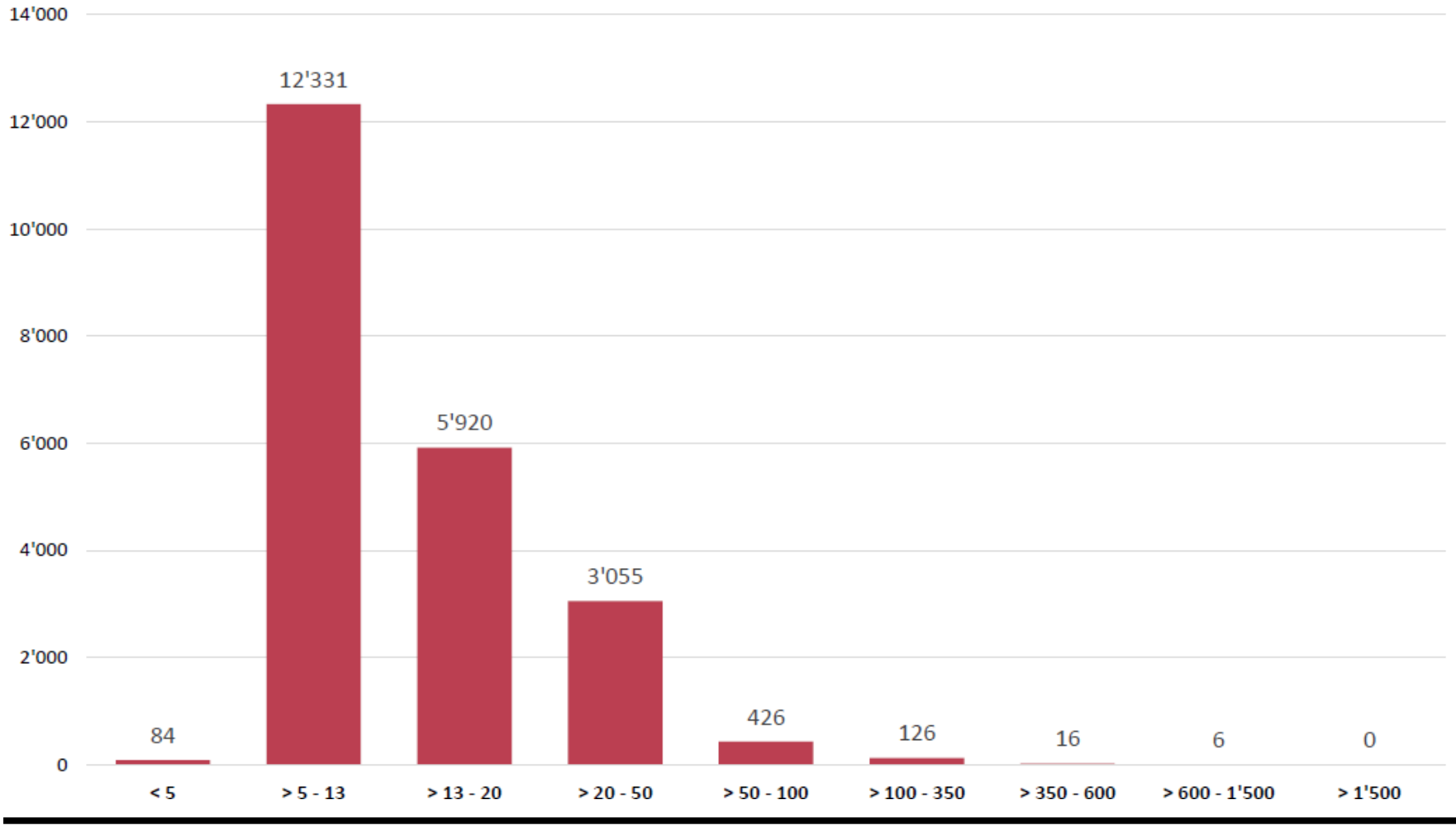
Introduction – statistics

Sold heat pump units per heat source

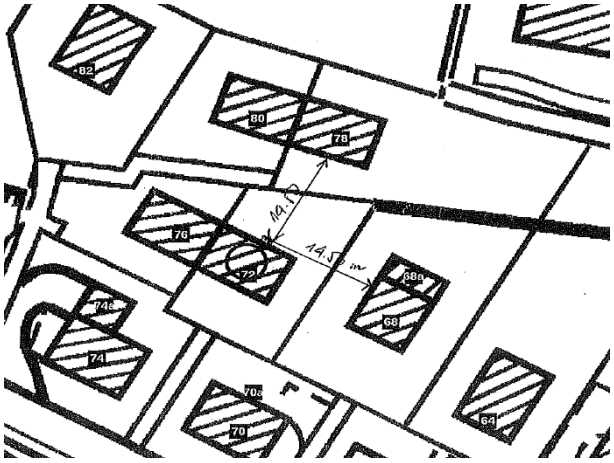


Introduction – statistics

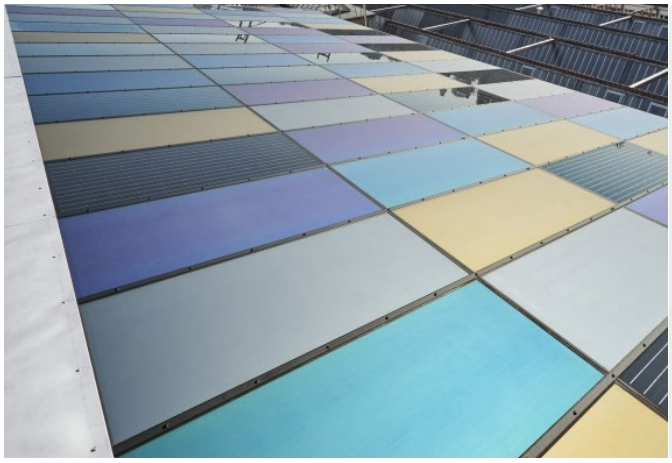
Sold heat pump units per capacity



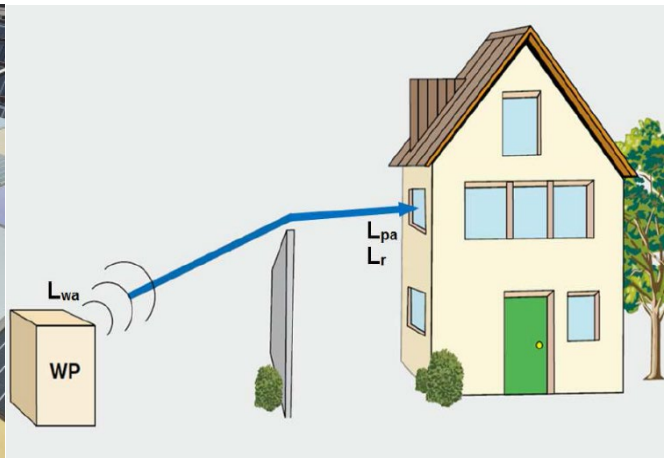
Introduction – future requirements & challenges



urban development
& energy strategy 2050



control integration



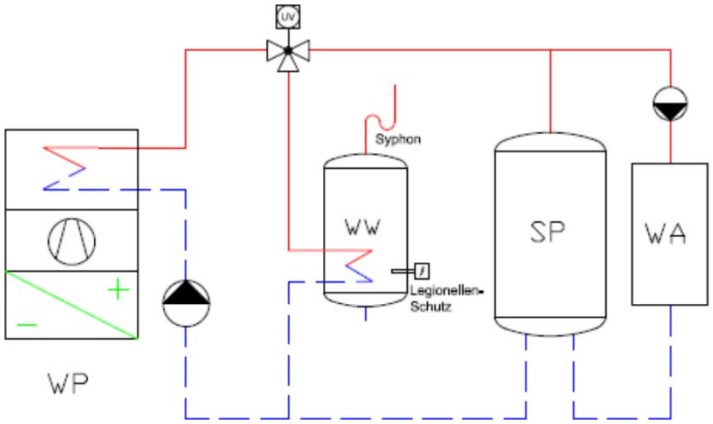
acoustic integration

replacing fossil fuels
from 20’000 hp per year
to 40’000 hp per year

improving unit and habits

complex multidimensional control demands
for capacity controlled heat pumps
energy efficiency, long-life product, self-consumption, grid-interactivity, peak capacity,
high temperatures, DHW-loading (HX-surface), heat source (BHX), sound level (night), …

Introduction – future requirements & challenges



hydraulic integration
& quality assurance

HFO

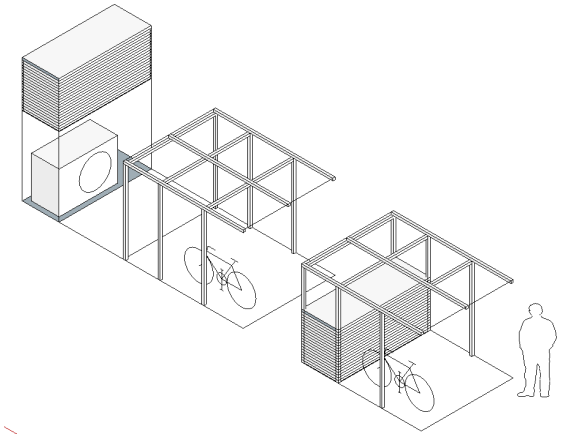
refrigerants / ChemRRV

design & positioning

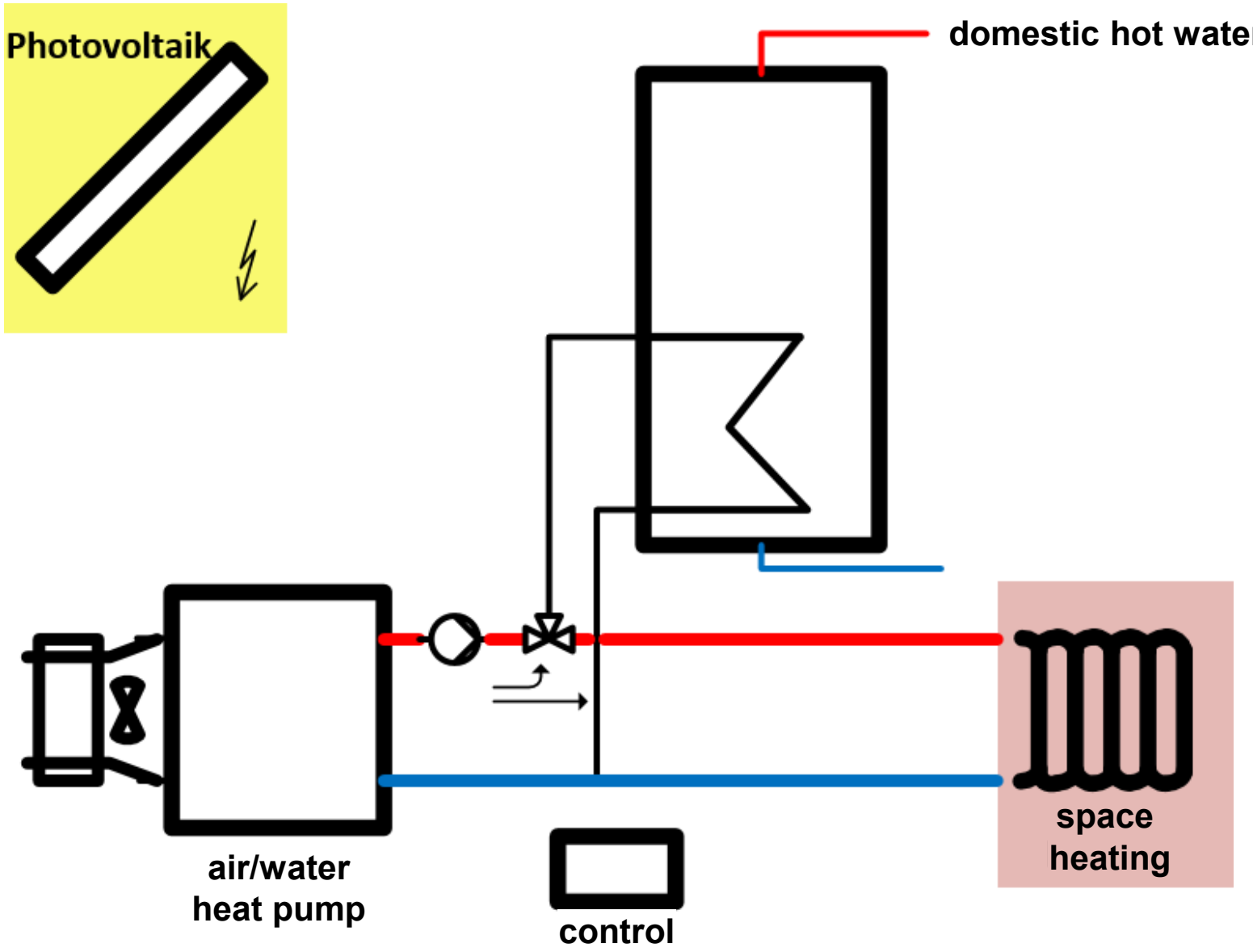
new / broader application

a/w-hp as universal heat supplier
more multi-family buildings
complex / bigger buildings
industrial applications

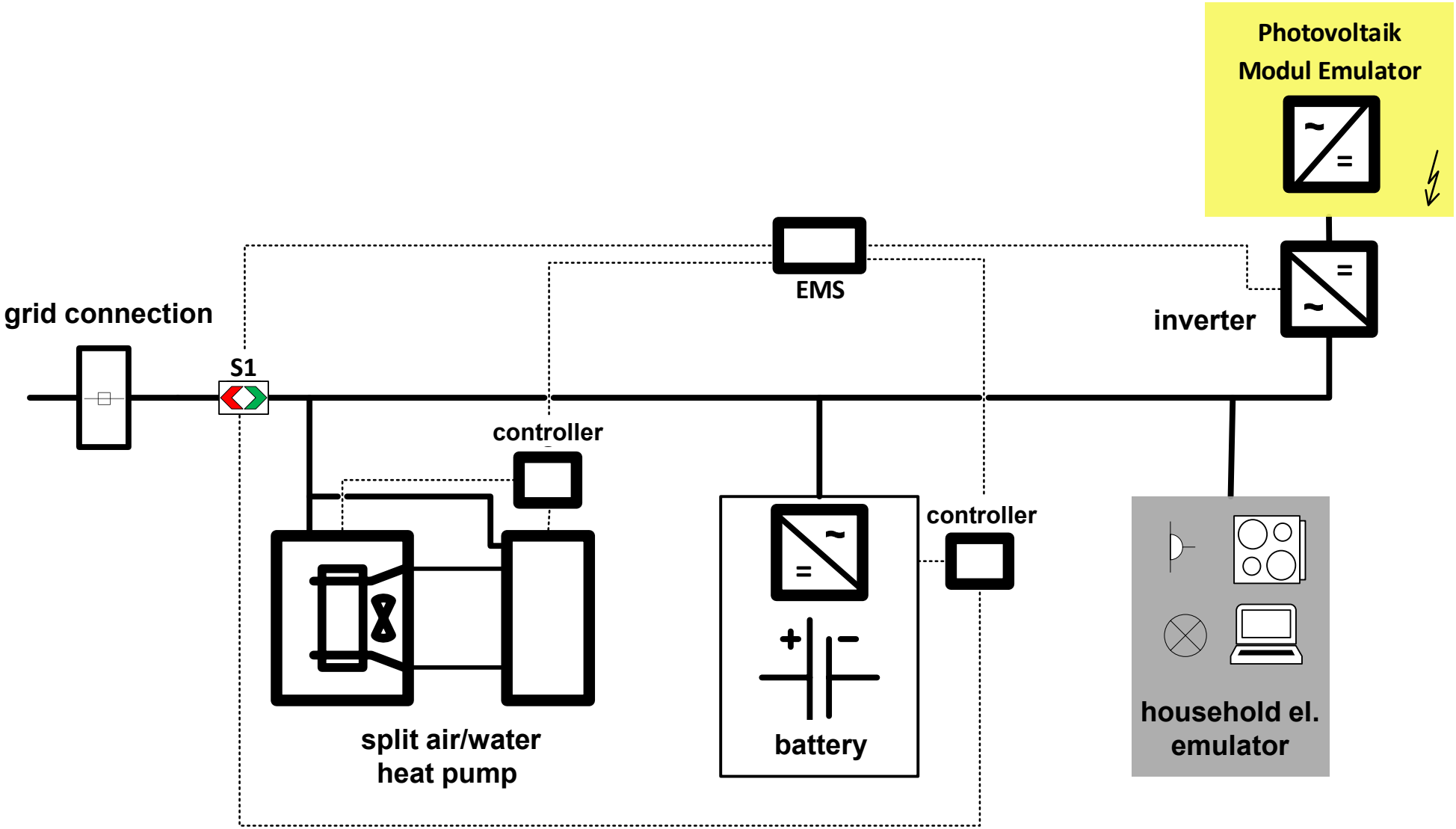
from 2020 GWP < 2100
long-term aim GWP ~<150



HP+PV – hydraulic system

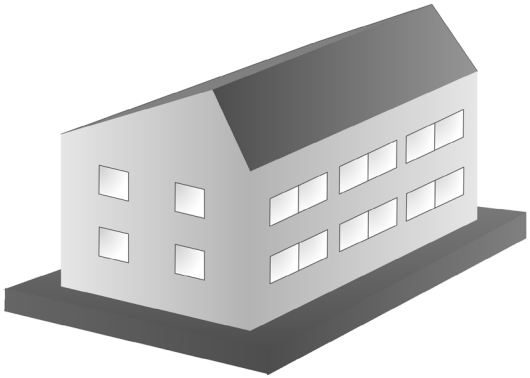


HP+PV – electric system

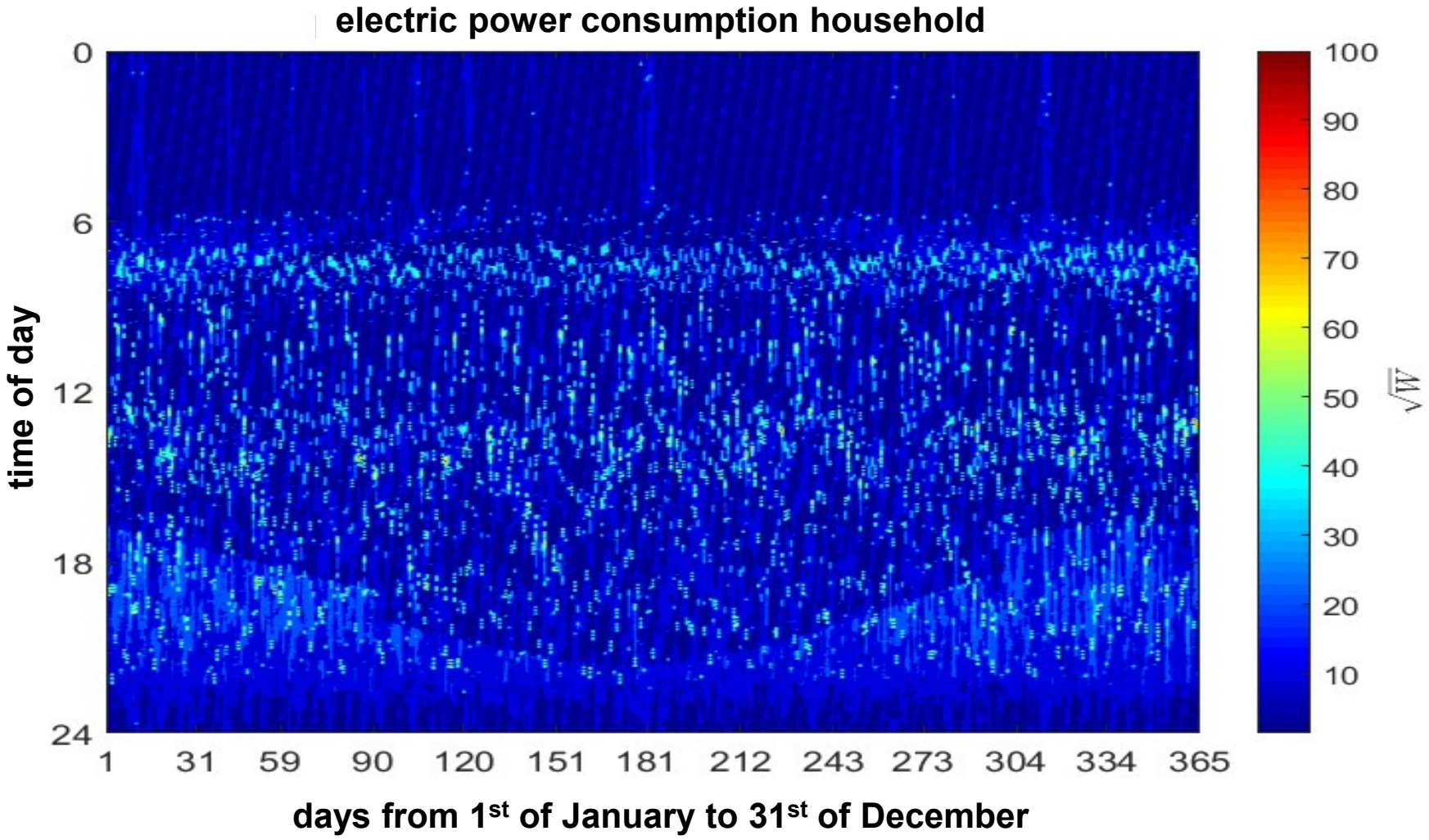


HP+PV – system boundaries

buildings	**SFH15, SFH45, SFH100 (IEA-SHC-Task44)**
heat pump	**split-a/w-hp 6 kW_{th}**
PV-system	**5 kW_{peak}**
DHW-storage	**390 litre, 4 m^2 HX**
climate	**Strasburg**
HH-electricity	**stochastic 2500 – 3385 kWh/a**
DHW-draw-offs	**4.2 – 11.6 kWh/d**

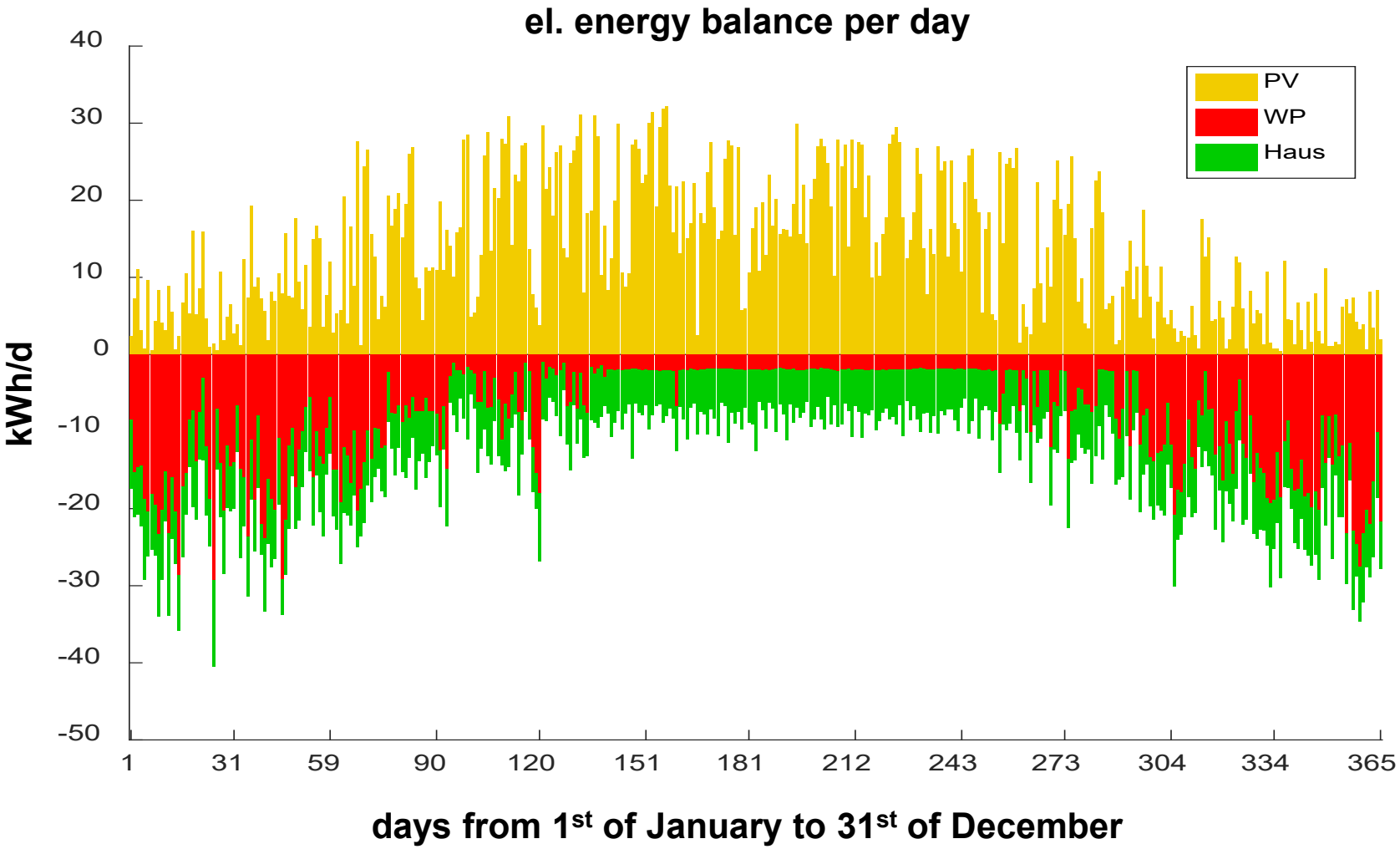


HP+PV – load analysis



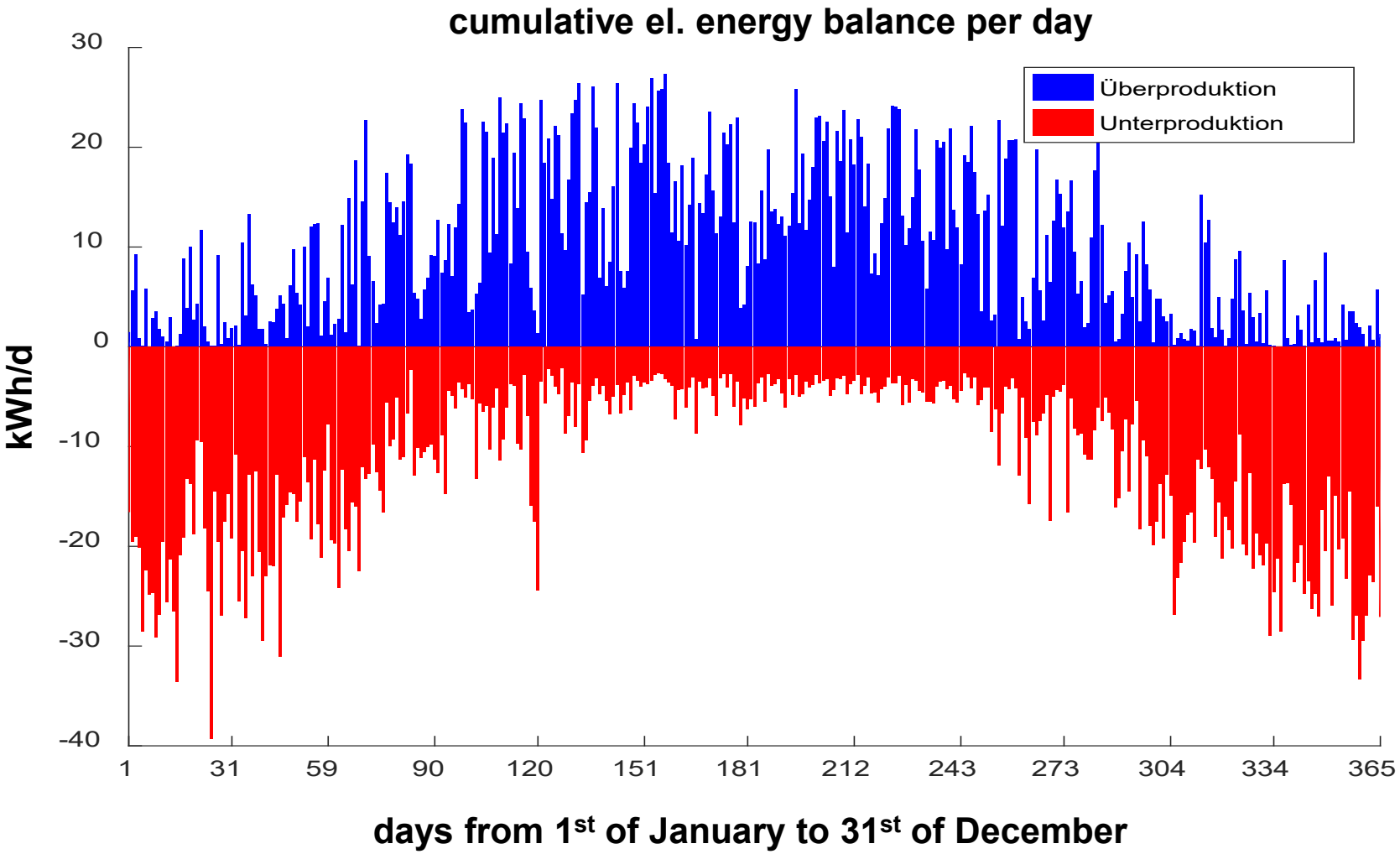
household-electricity: 2500 kWh/a, peak power 11.34 kW

HP+PV – load analysis



interim result for heat demand controlled heat pump operation

HP+PV – load analysis



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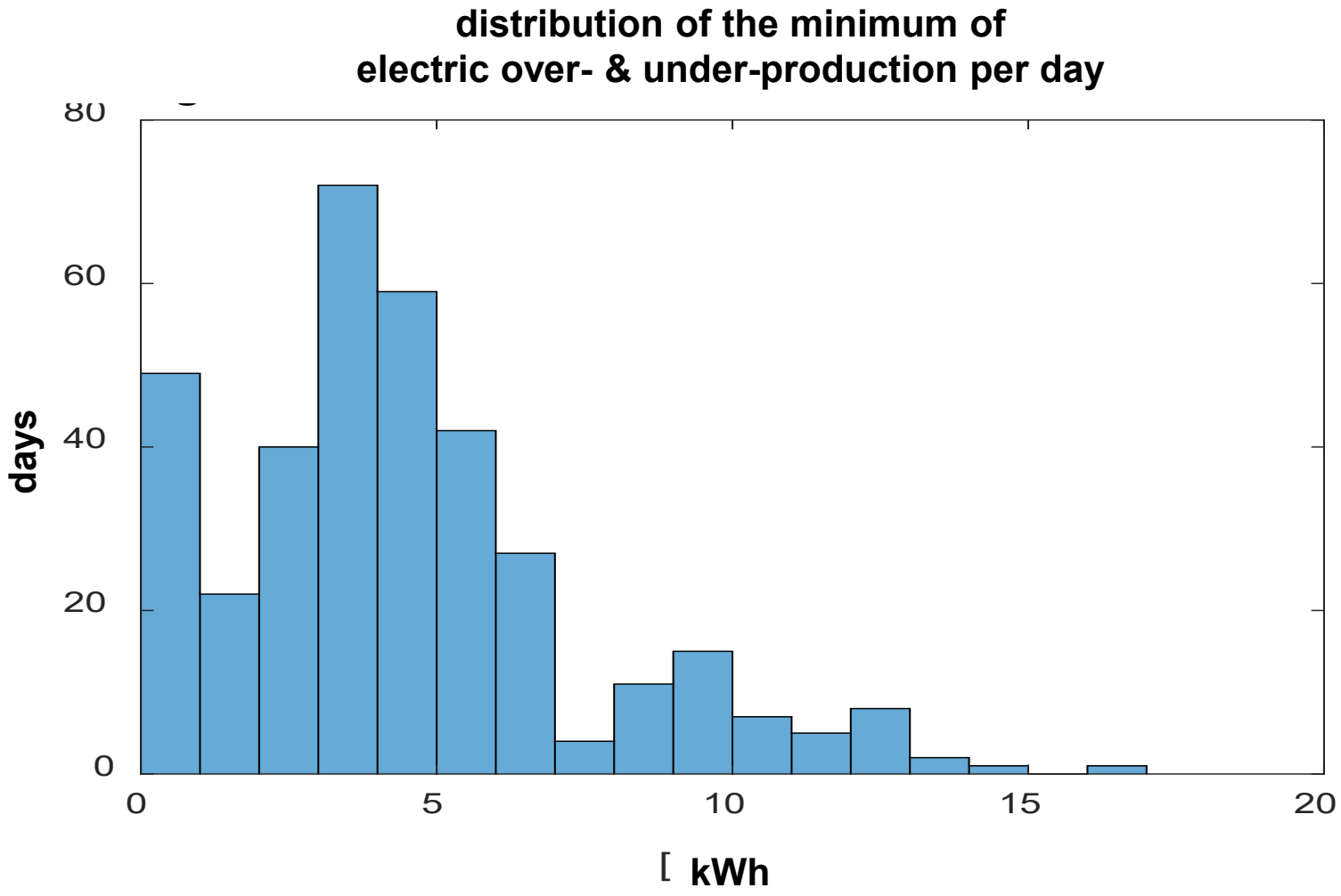

interim result for heat demand controlled heat pump operation

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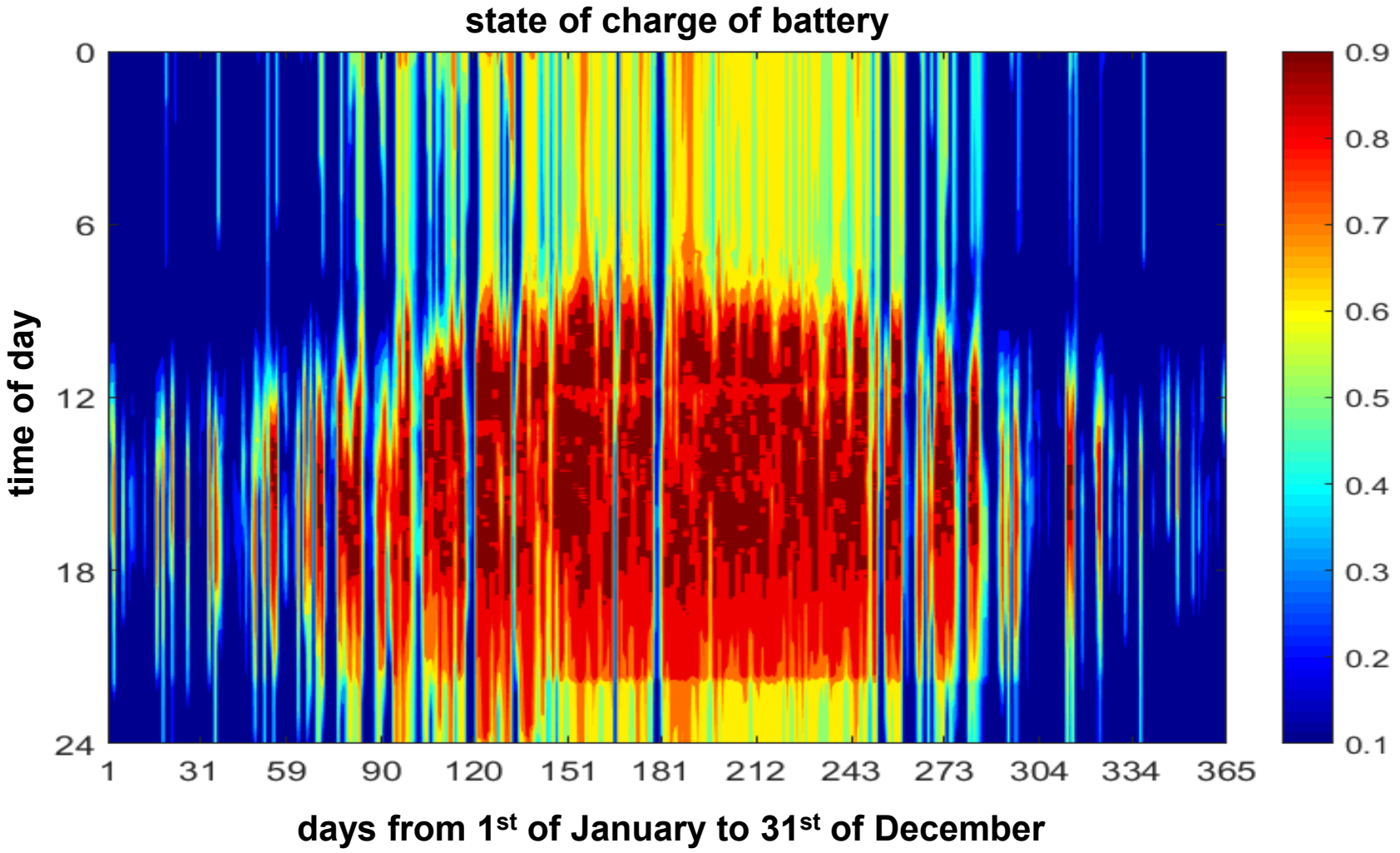
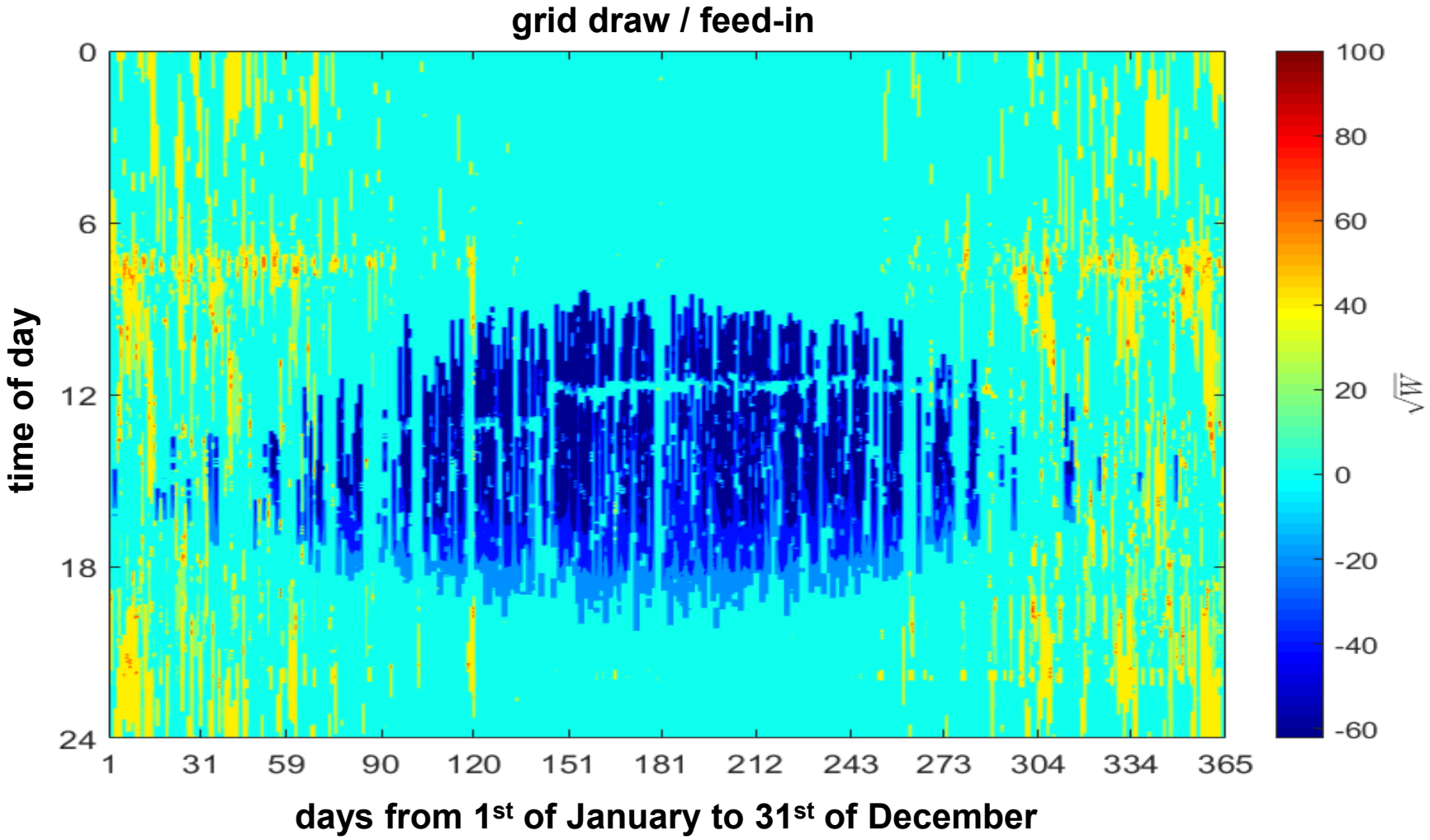


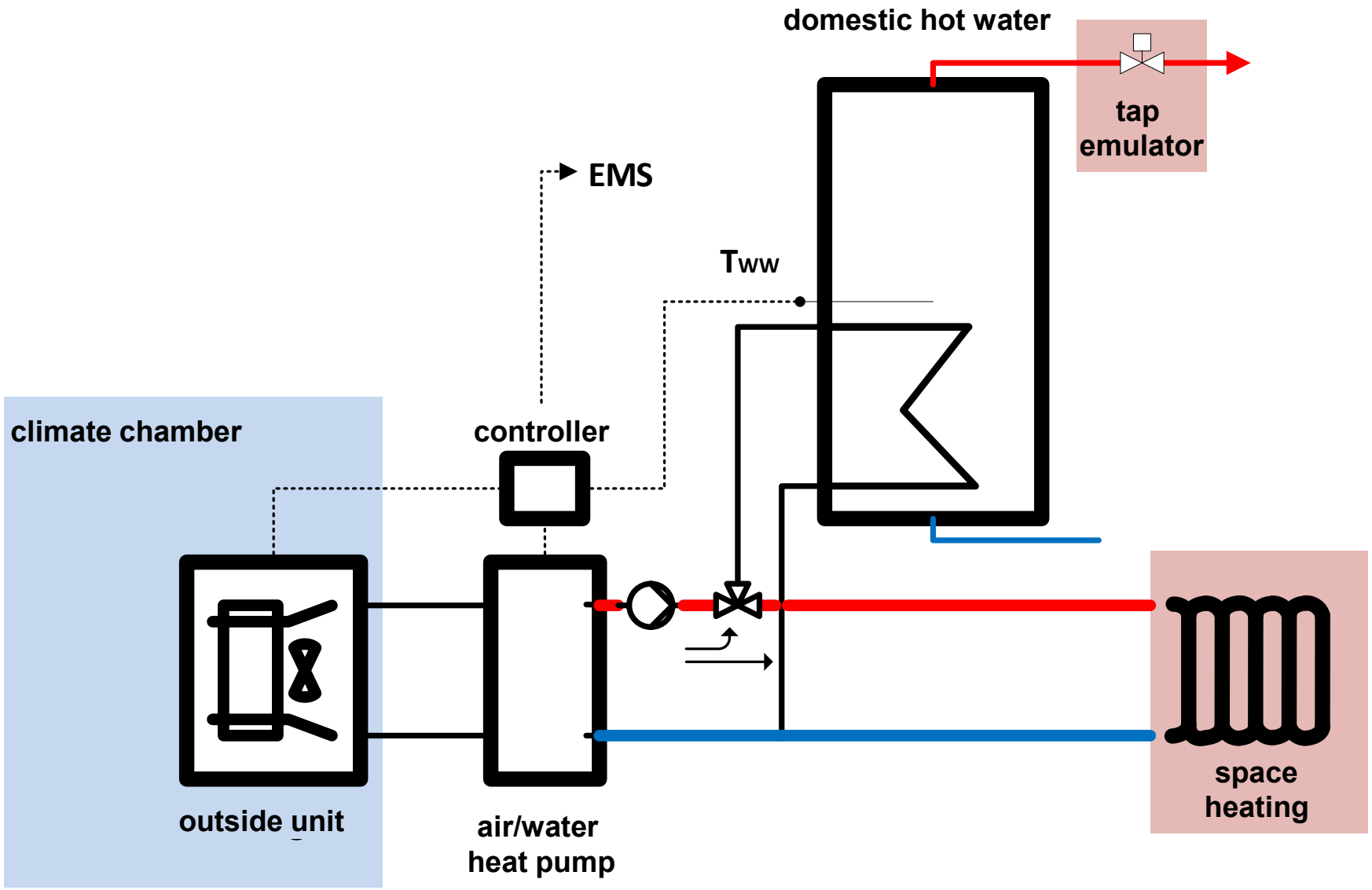
interim result for heat demand controlled heat pump operation

HP+PV – load analysis



interim result for heat demand controlled heat pump operation

HP+PV – laboratory measurements



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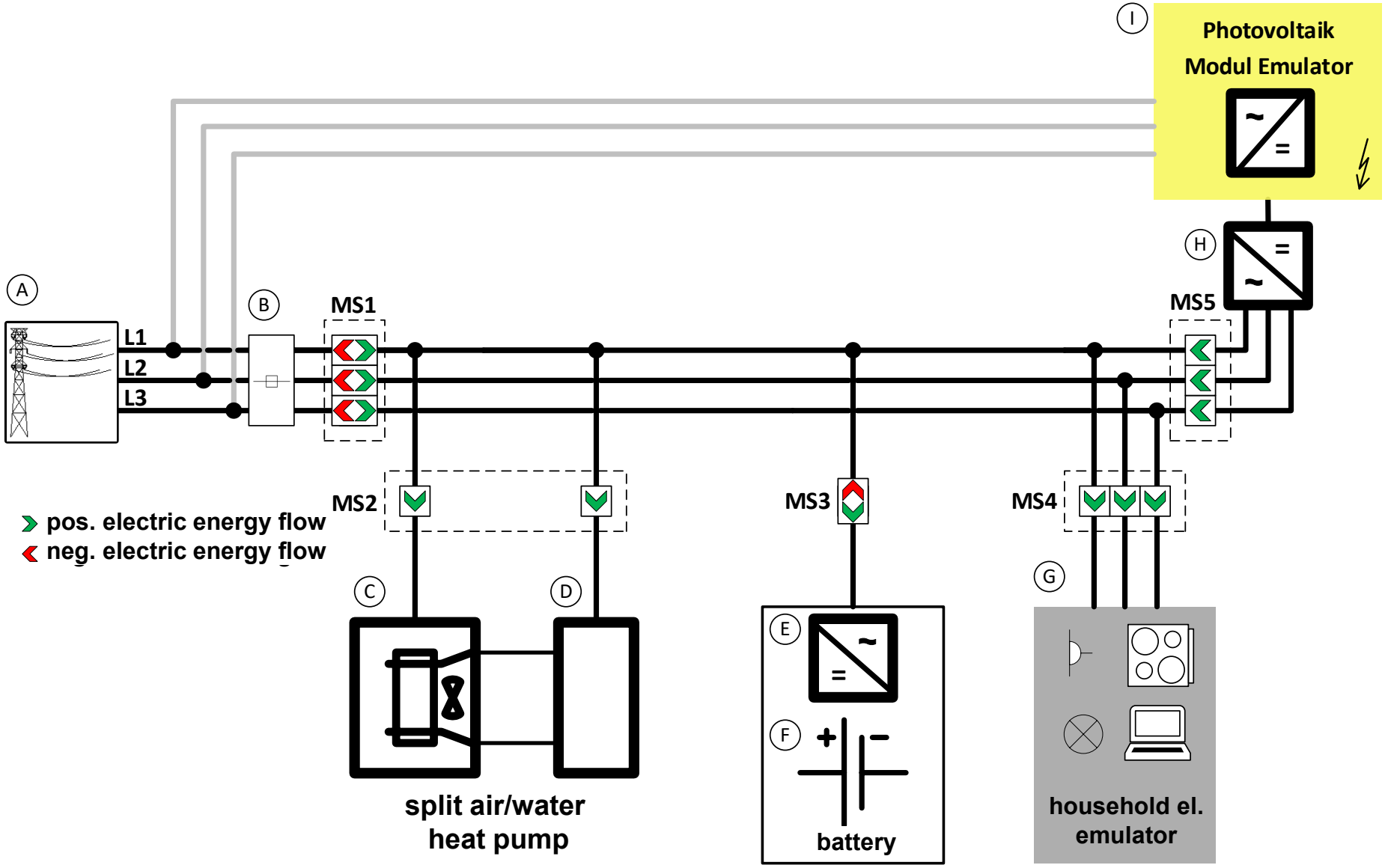
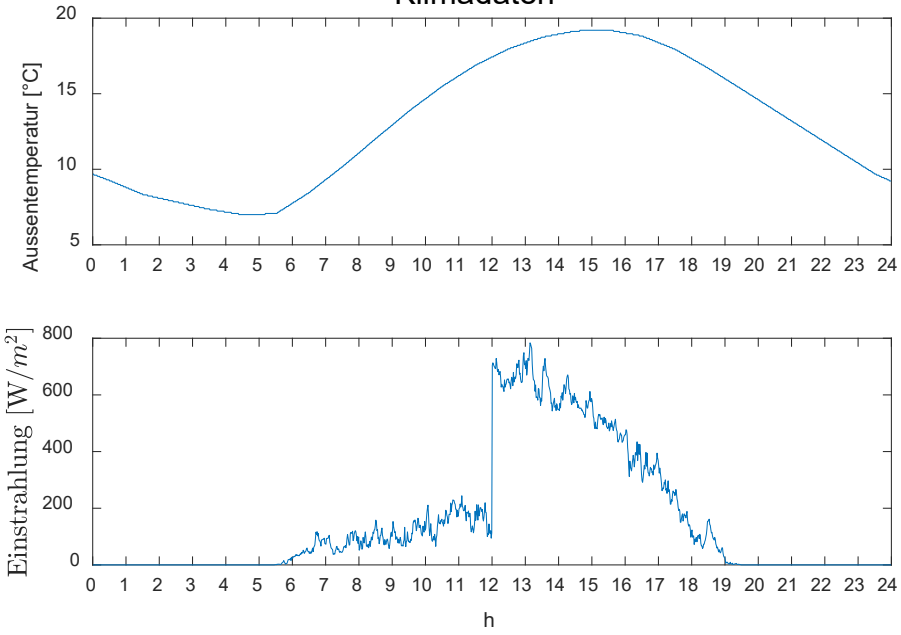


HP+PV – laboratory measurements boundaries - profiles

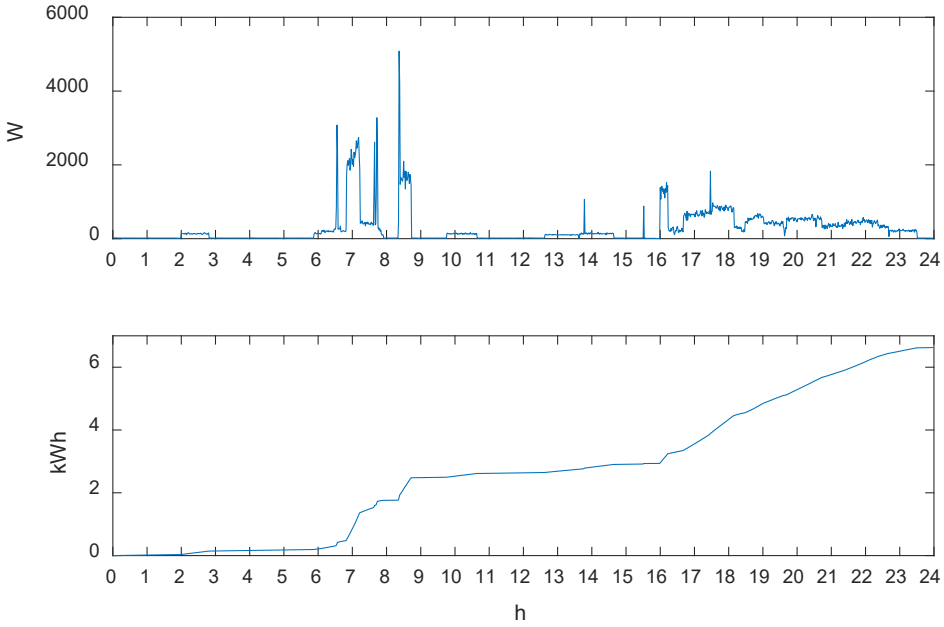
Fall		Randbedingungen			Einstellungen		
		Wetter	Wasser	Strom	Batterie	Regler	Testdauer
A	Ohne EMS	Ü-sN	WW-M	HH-M	5.9 kWh	Ohne EMS	4 d
B	Mit EMS	Ü-sN	WW-M	HH-M	5.9 kWh	Mit EMS	4 d

Wetter	PV-Produktion [kWh/Tag]	HH-Strom [kWh/Tag]	WP-Strom [kWh/Tag]	Bilanz [kWh/Tag]
Ü-sN	18	6.6	3.0	+8.4

Klimadaten

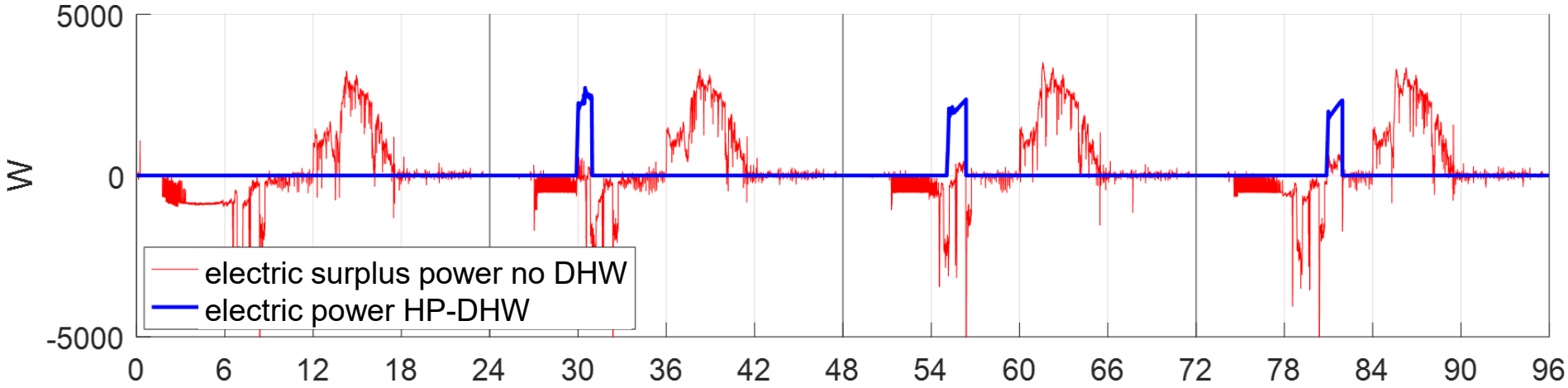


Haushaltsstrom-Profil

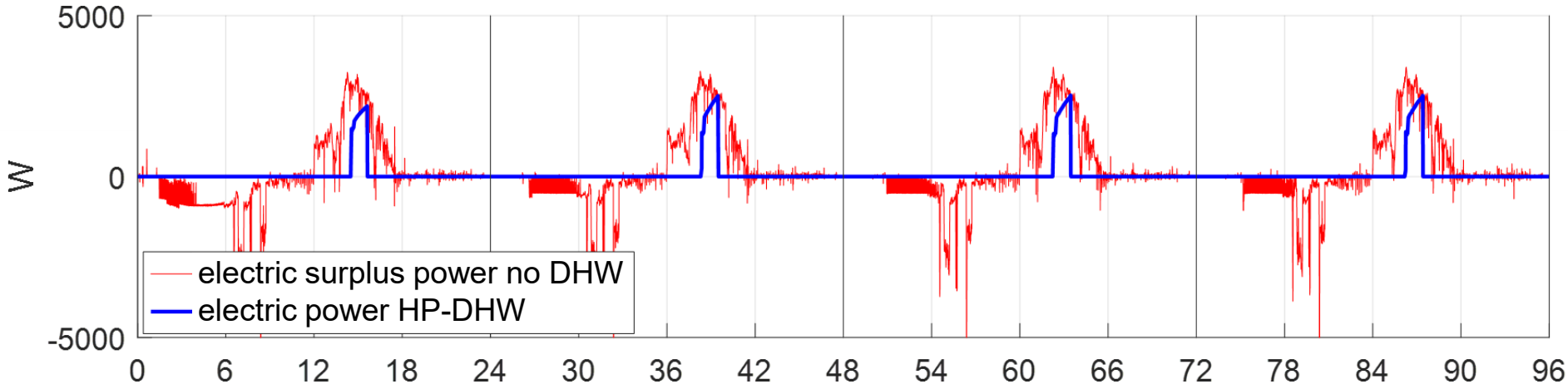


HP+PV – laboratory measurements

heat demand control

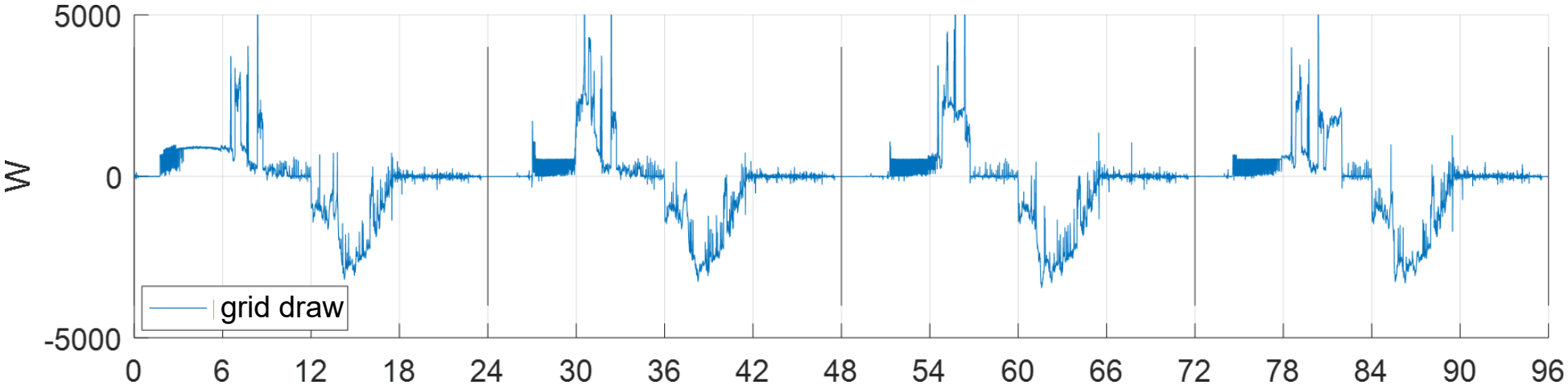


PV-oriented control

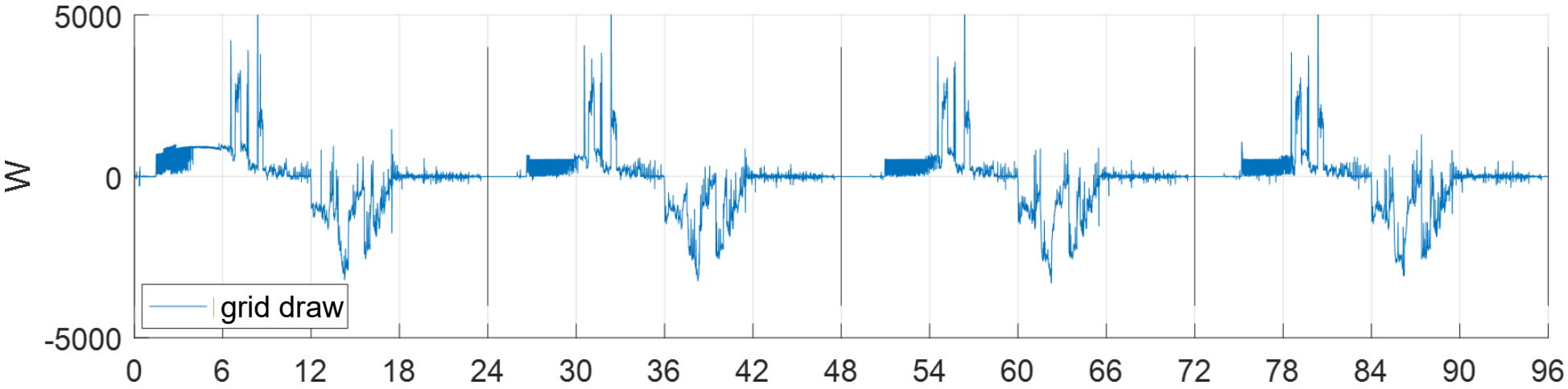


HP+PV – laboratory measurements

heat demand control



PV-oriented control



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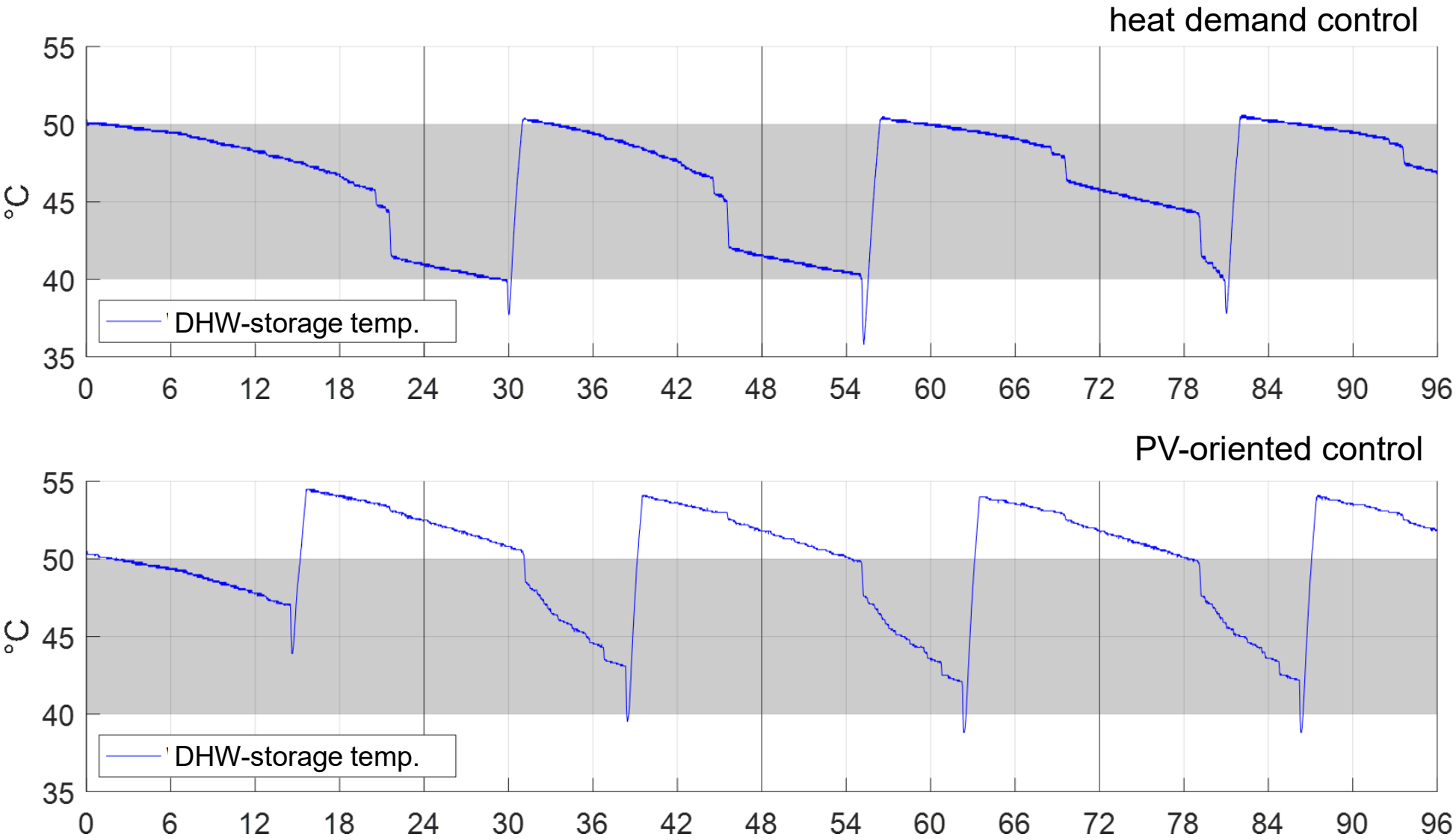

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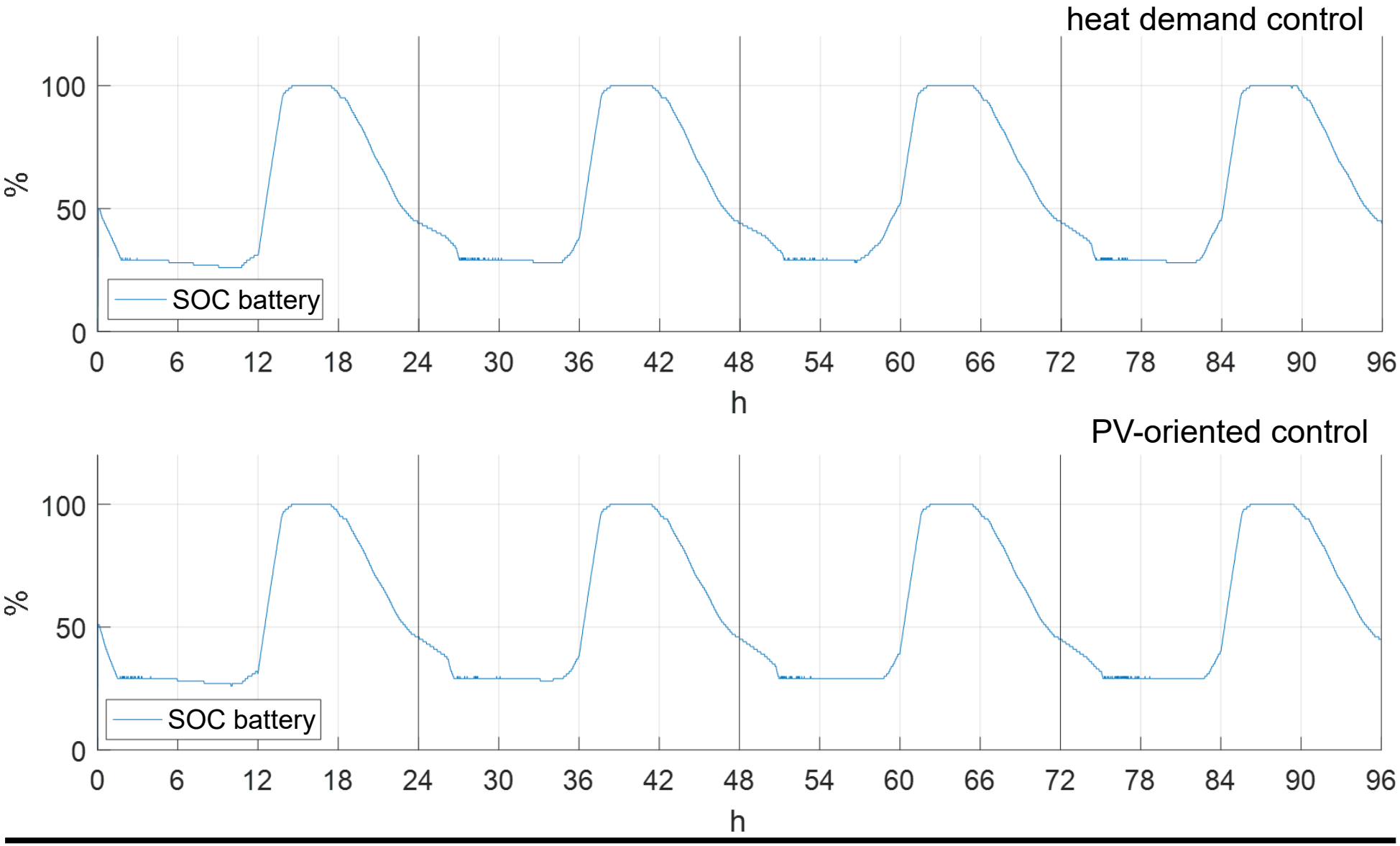
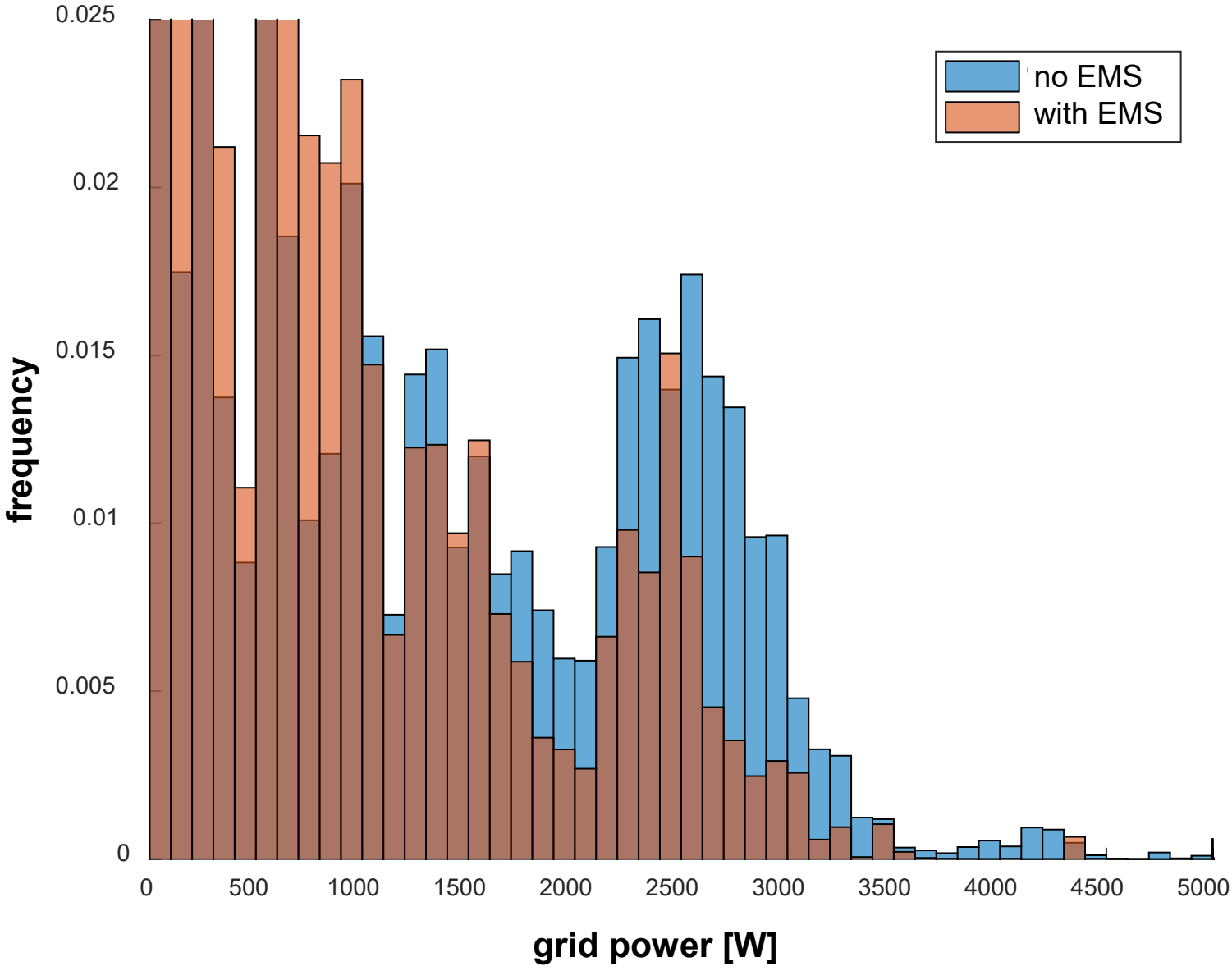
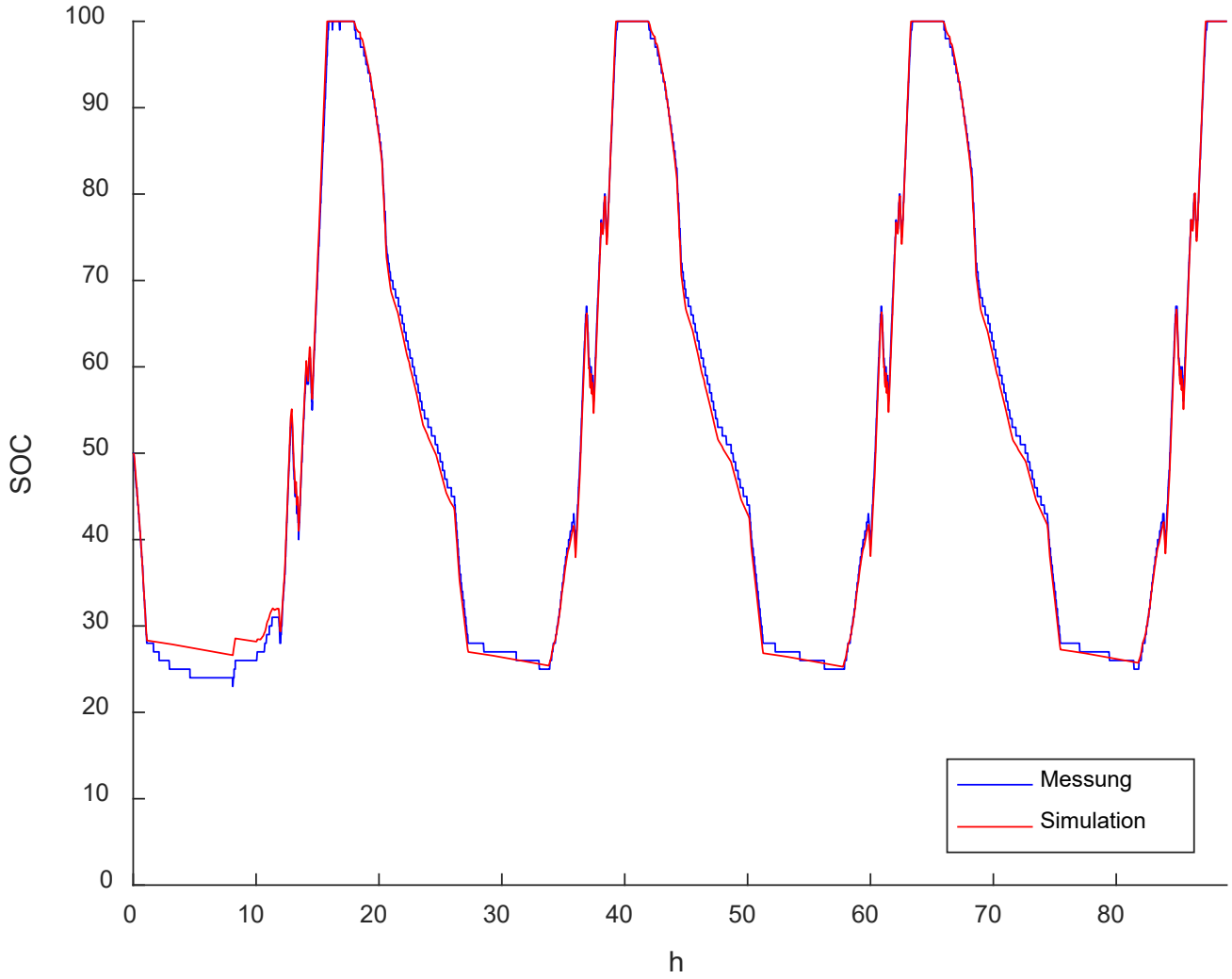


HP+PV – laboratory measurements



HP+PV – laboratory measurements
battery-efficiency



charge efficiency	96 %
discharge efficiency	88 %
stand-by power	15 W

HP+PV – laboratory measurements

Eigennutzung [%]

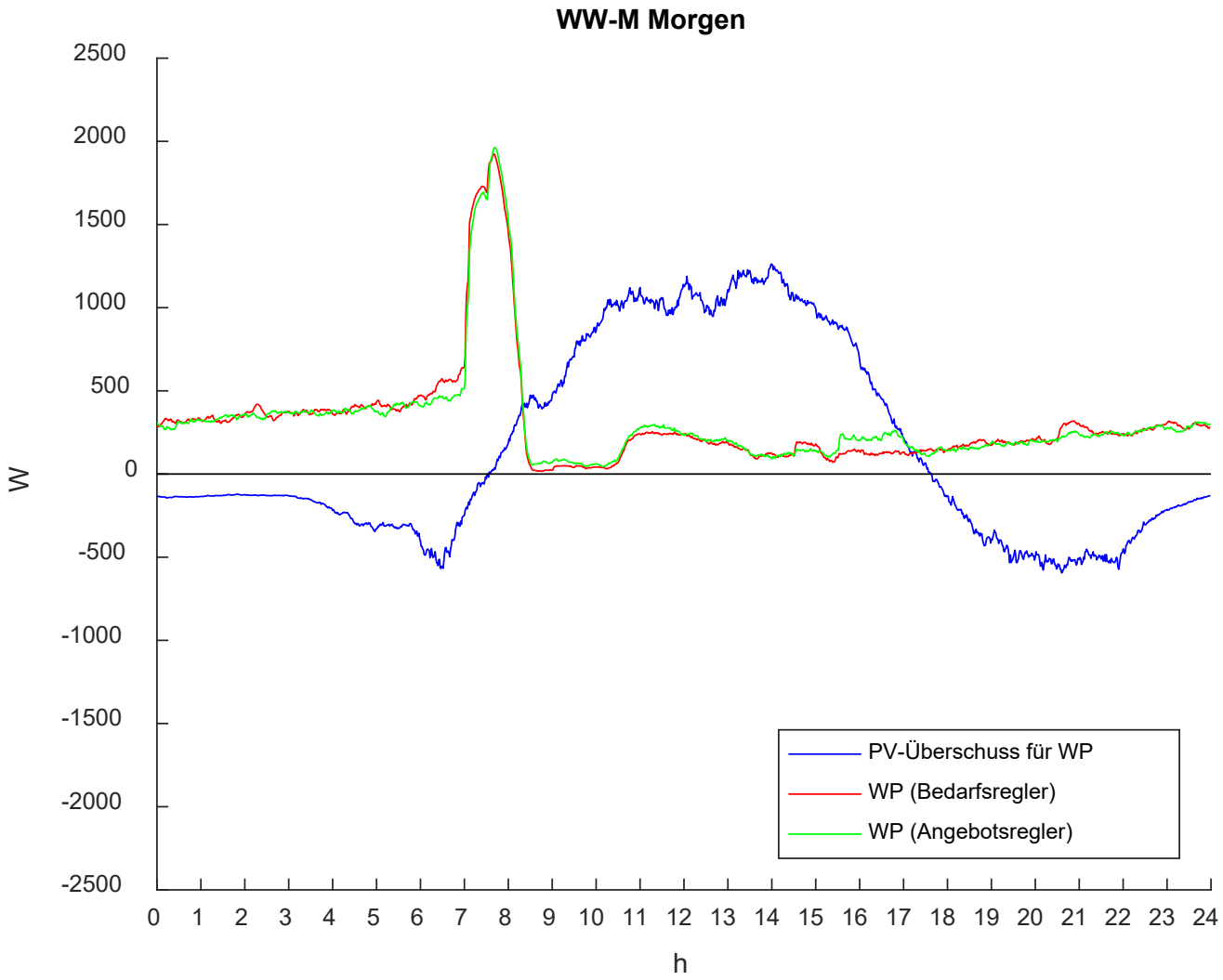
Fall	Tag 1	Tag 2	Tag 3	Tag 4
Messung A (ohne EMS)	52	49	45	47
Messung B (mit EMS)	62	61	61	61

Eigendeckung [%]

Fall	Tag 1	Tag 2	Tag 3	Tag 4
Messung A (ohne EMS)	53	53	52	52
Messung B (mit EMS)	57	66	67	67

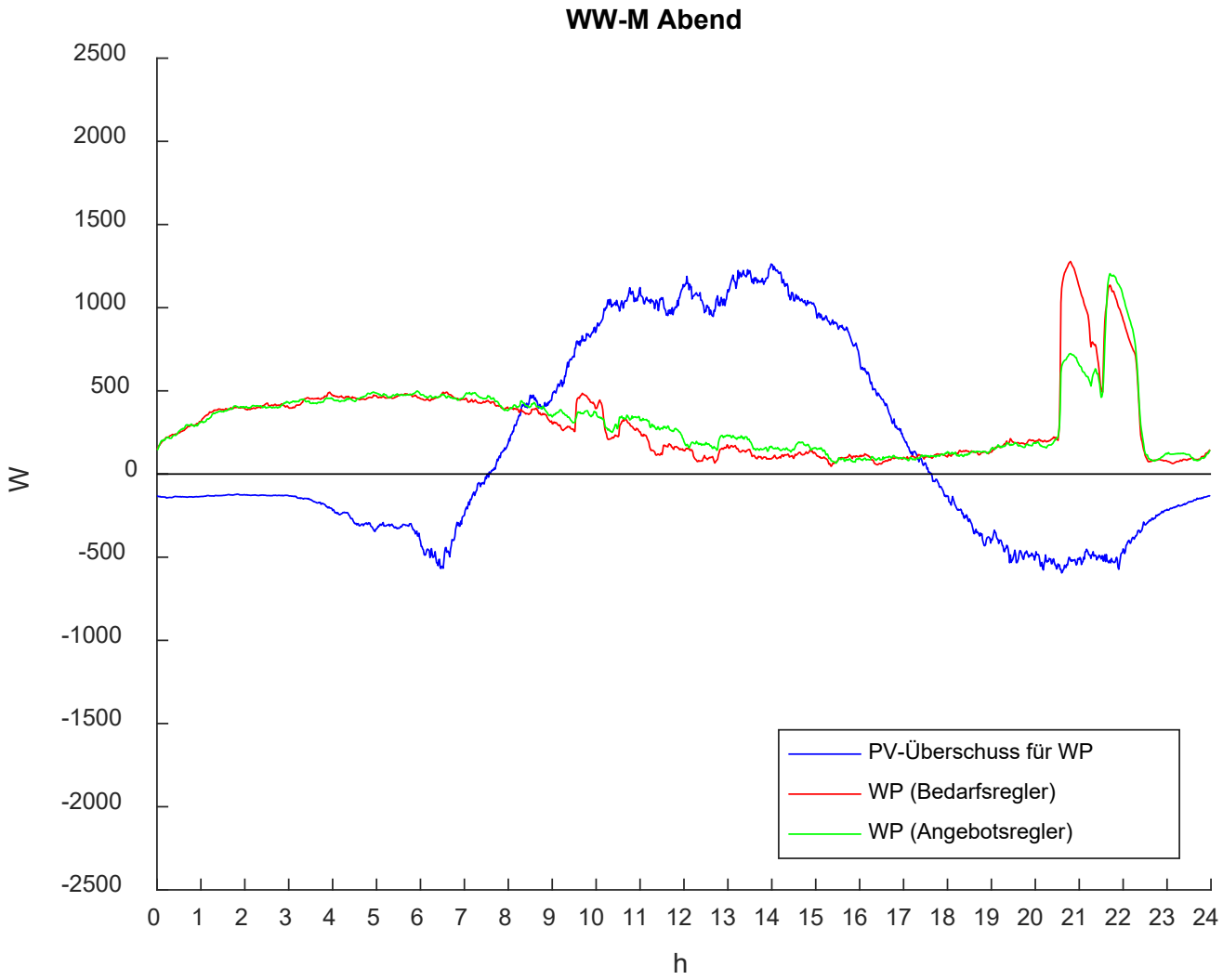
HP+PV – system simulations
control impact in dependence of DHW draw-offs

annually averaged daily profile of el. power



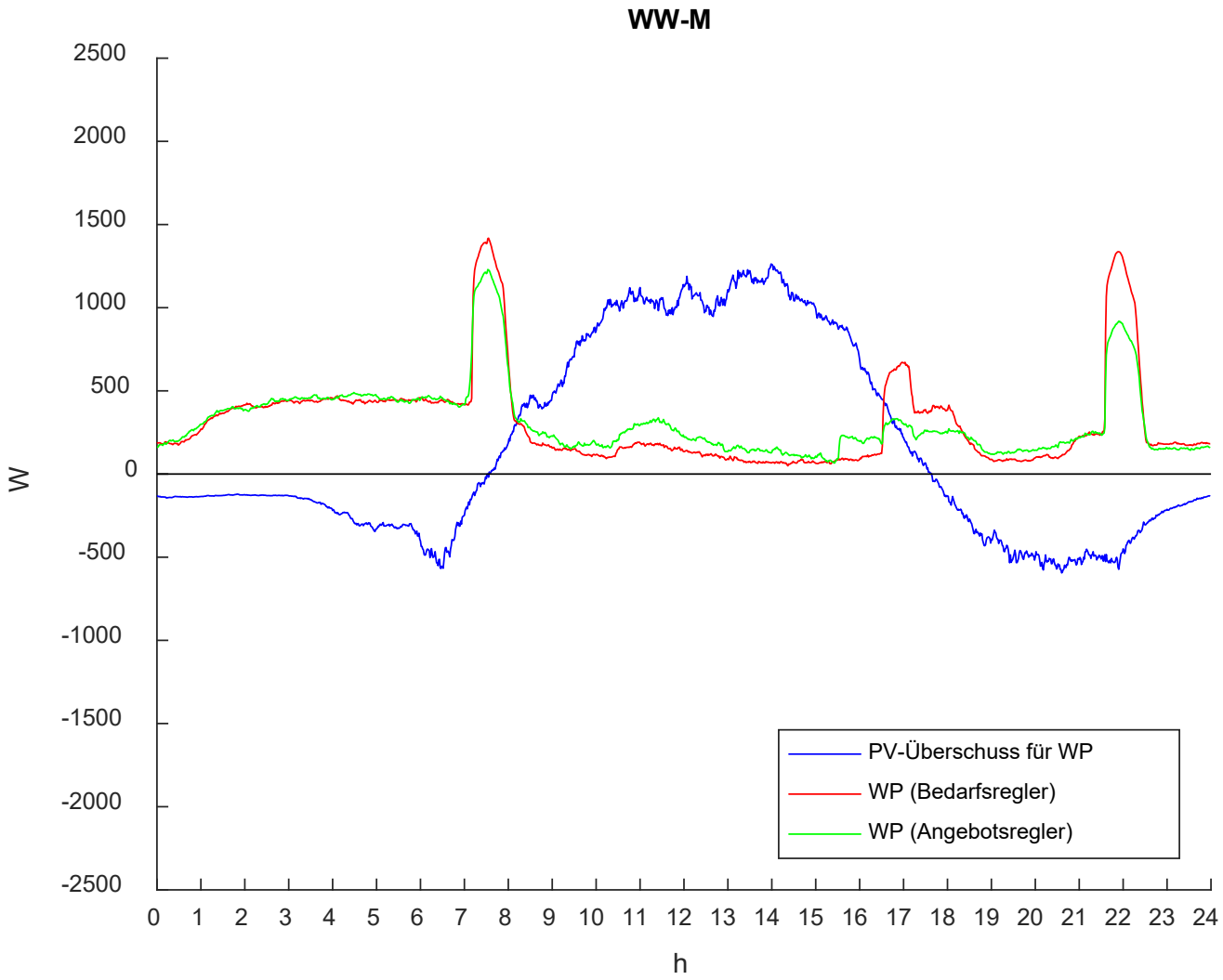
HP+PV – system simulations
control impact in dependence of DHW draw-offs

annually averaged daily profile of el. power



HP+PV – system simulations
control impact in dependence of DHW draw-offs

annually averaged daily profile of el. power



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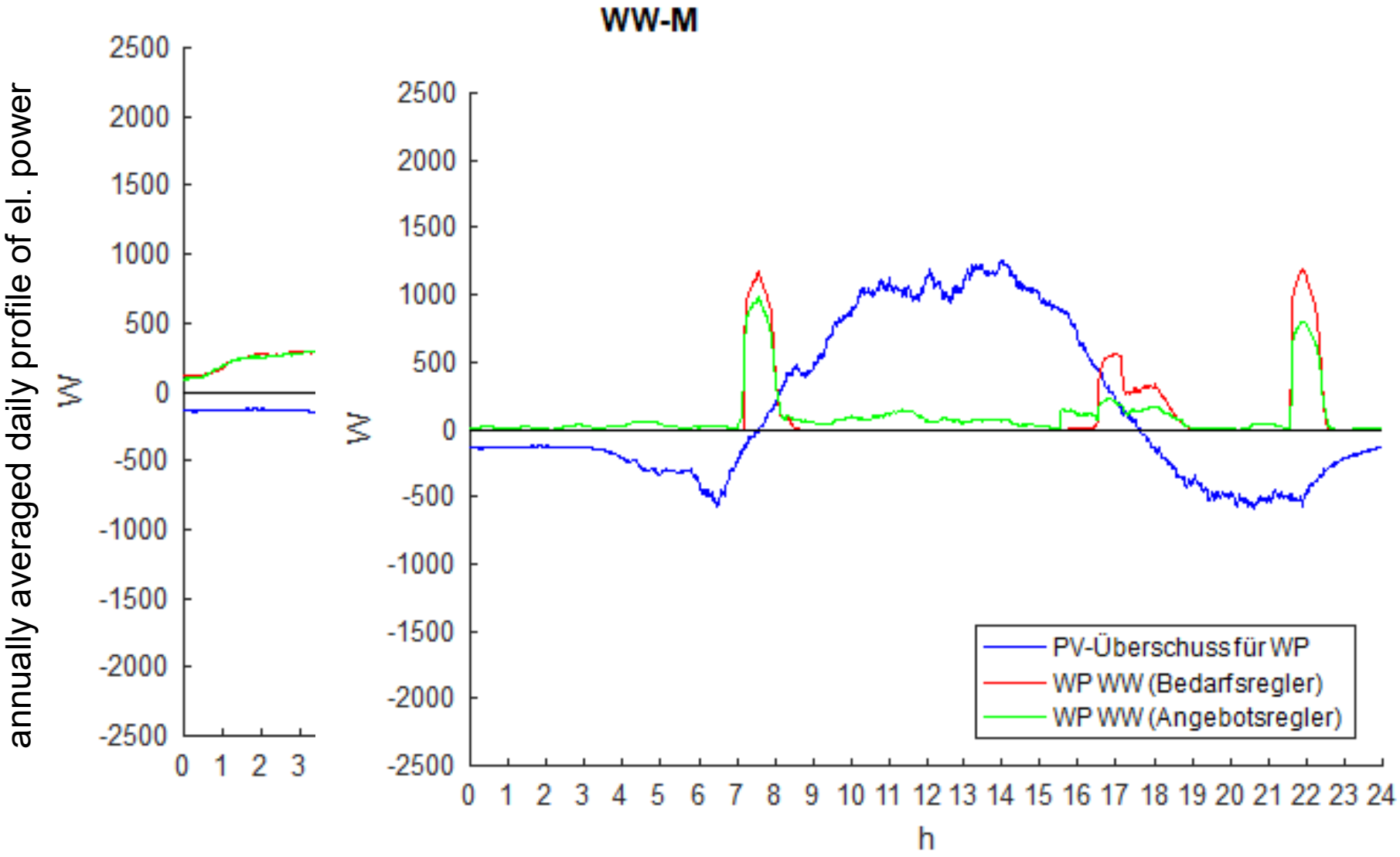
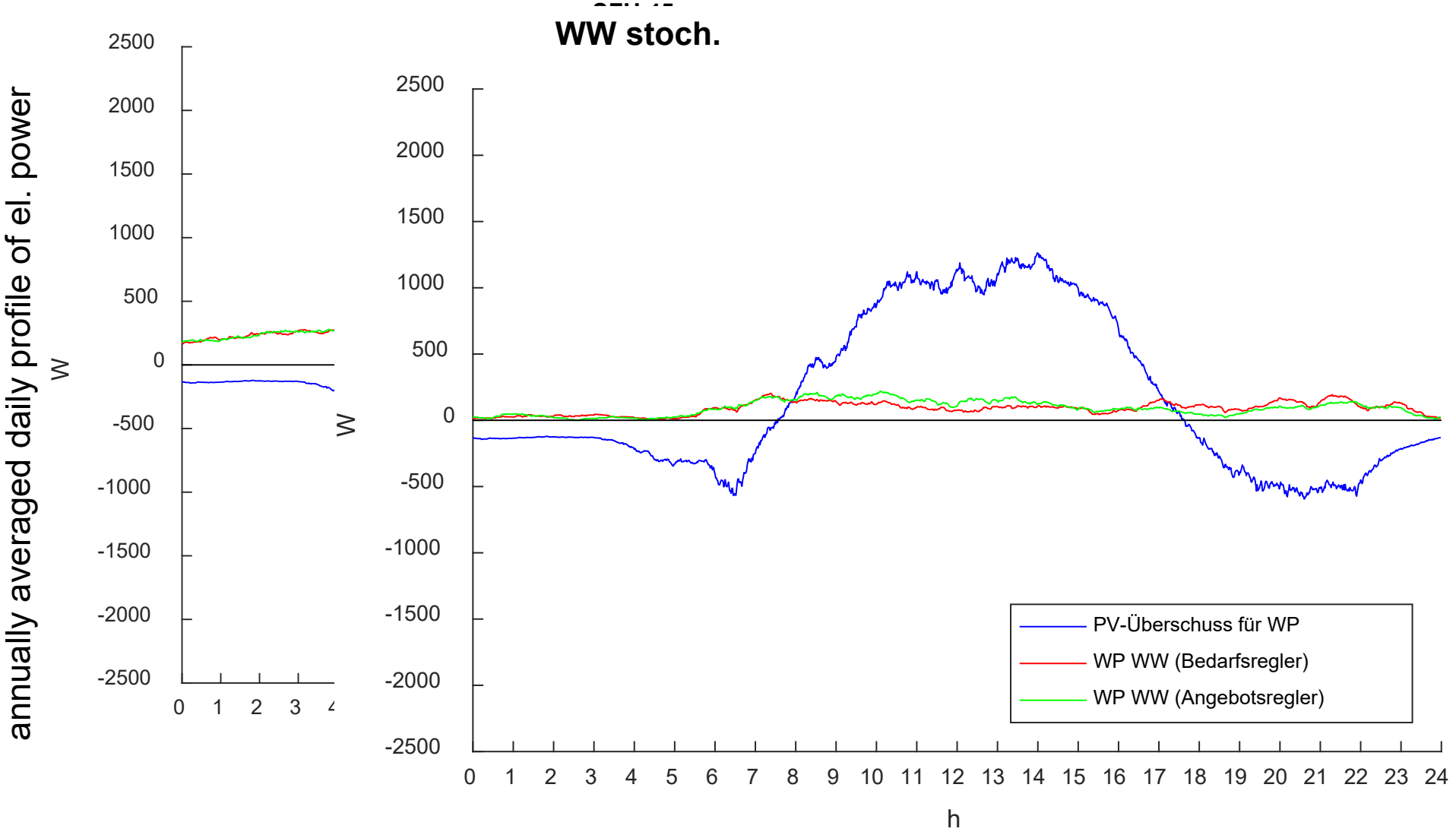
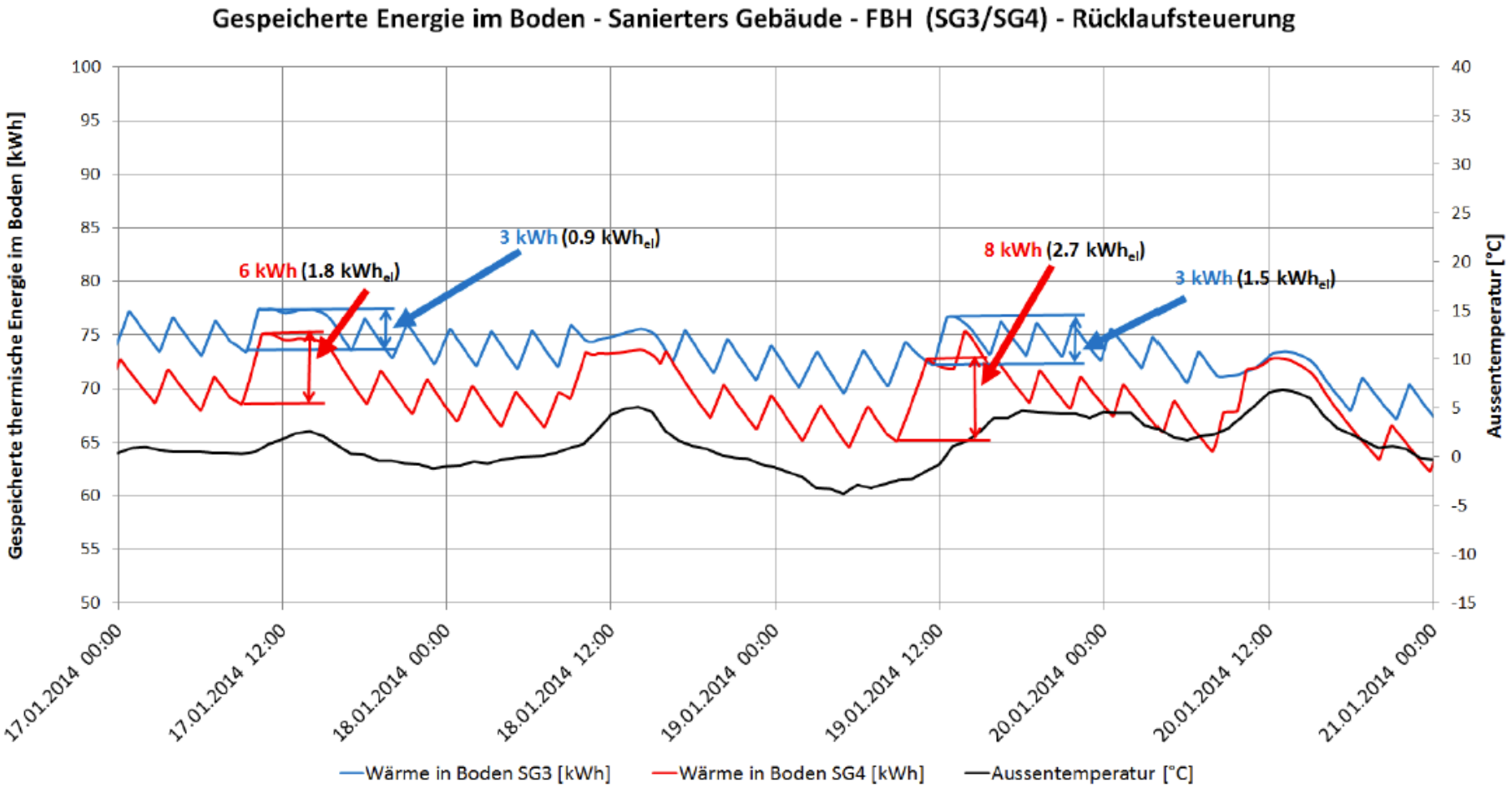


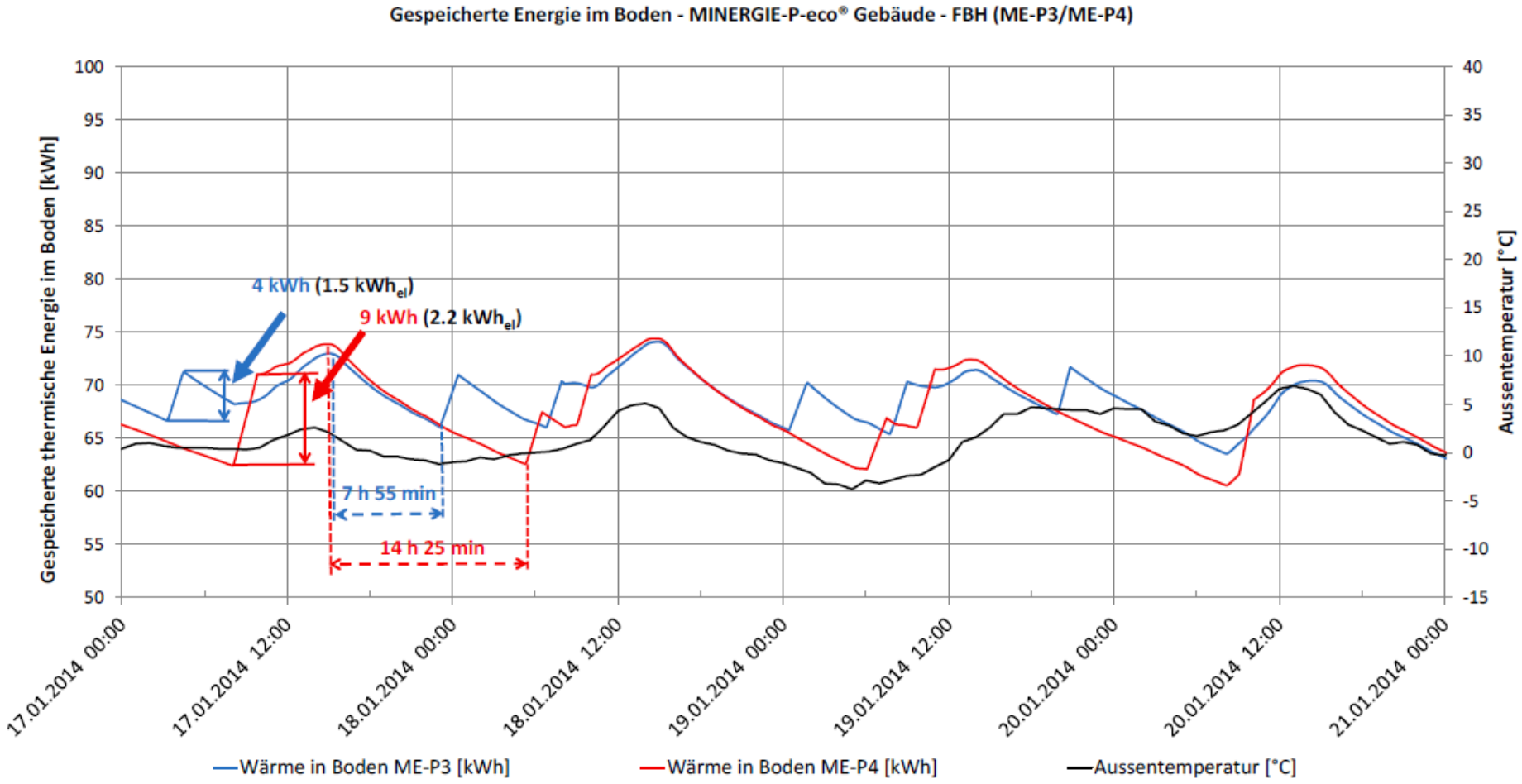
HP+PV – system simulations
control impact in dependence of DHW draw-offs



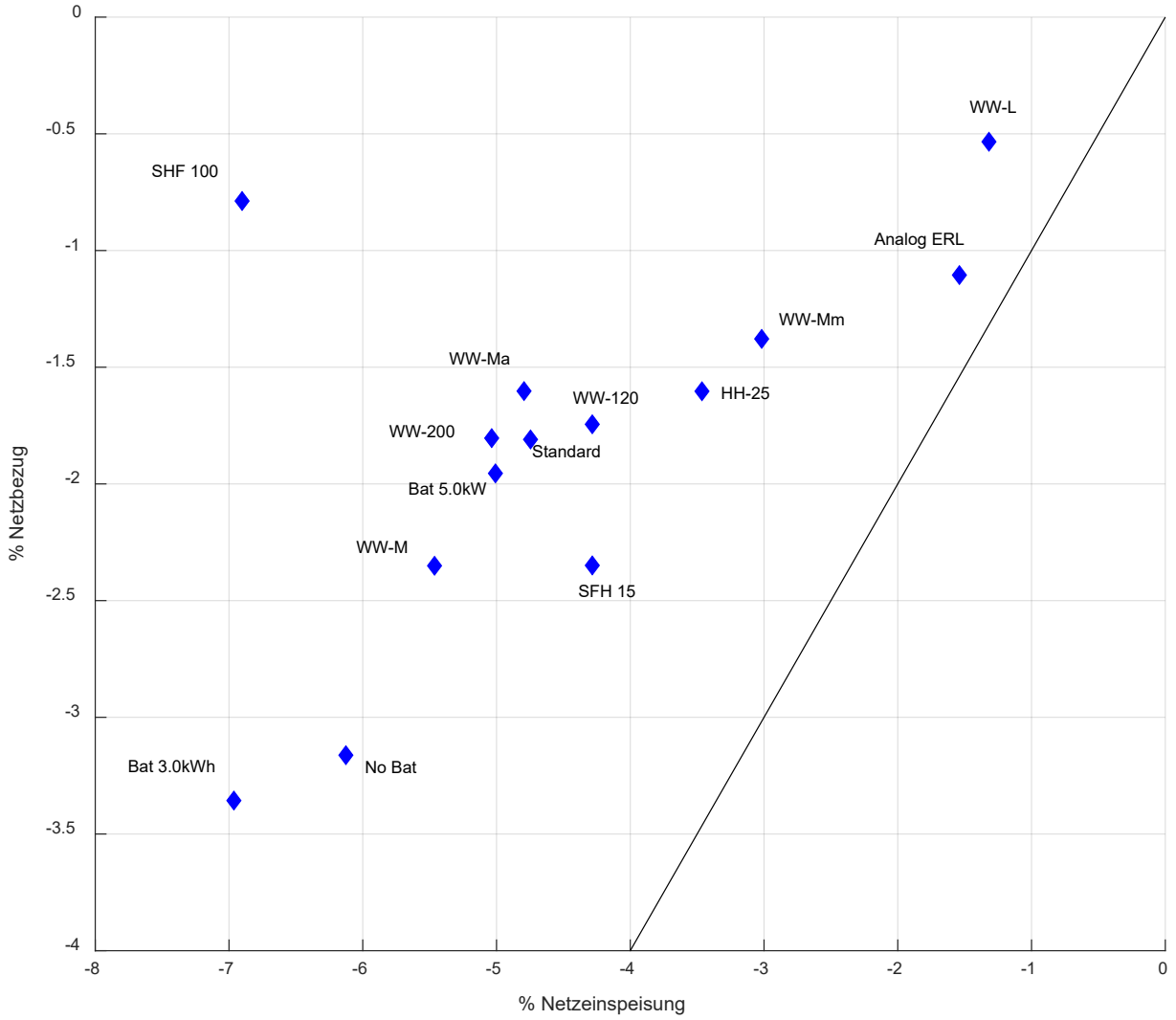
HP+PV – system simulations
effect of demand-response control on space heating



HP+PV – system simulations
effect of demand-response control on space heating



HP+PV – system simulations
effect of demand-response control on annual grid-electricity consumption & feed-in



Summary

Project results

load analysis shows	**dimensioning an storage capacity**
laboratory tests showed	**successful implementation of one control strategy** **challenges in setting up the systems communication**
simulations showed	**limited effect in yearly energy balance** **but positive impact on power consumption** **dependency of flexibility on sizing and user behaviour**

Summary

Todays challenges

heat pumps need to operate in reasonable application ranges.
(no shot time on/off-switching, reasonable temperature ranges)
→ information needed, extended safety functions of heat pumps

digital communication between HVACR components

finding qualified personnel
(thermal & electrical & control knowledge)

Summary

Future heat pump

**Todays and tomorrows heat pump are similar,
but a well established product needs to be further developed
to new application areas and requirement profiles.**

For that we need

**further developed, flexible, silent and energy efficient heat pumps
easy to handle units and workflows
appropriate system integration concepts for reliable and energy efficient operation
→ In the end, constantly satisfied users, neighbors, stakeholders, actors.**

Thank you
for the opportunity of exchange
and for your attention!