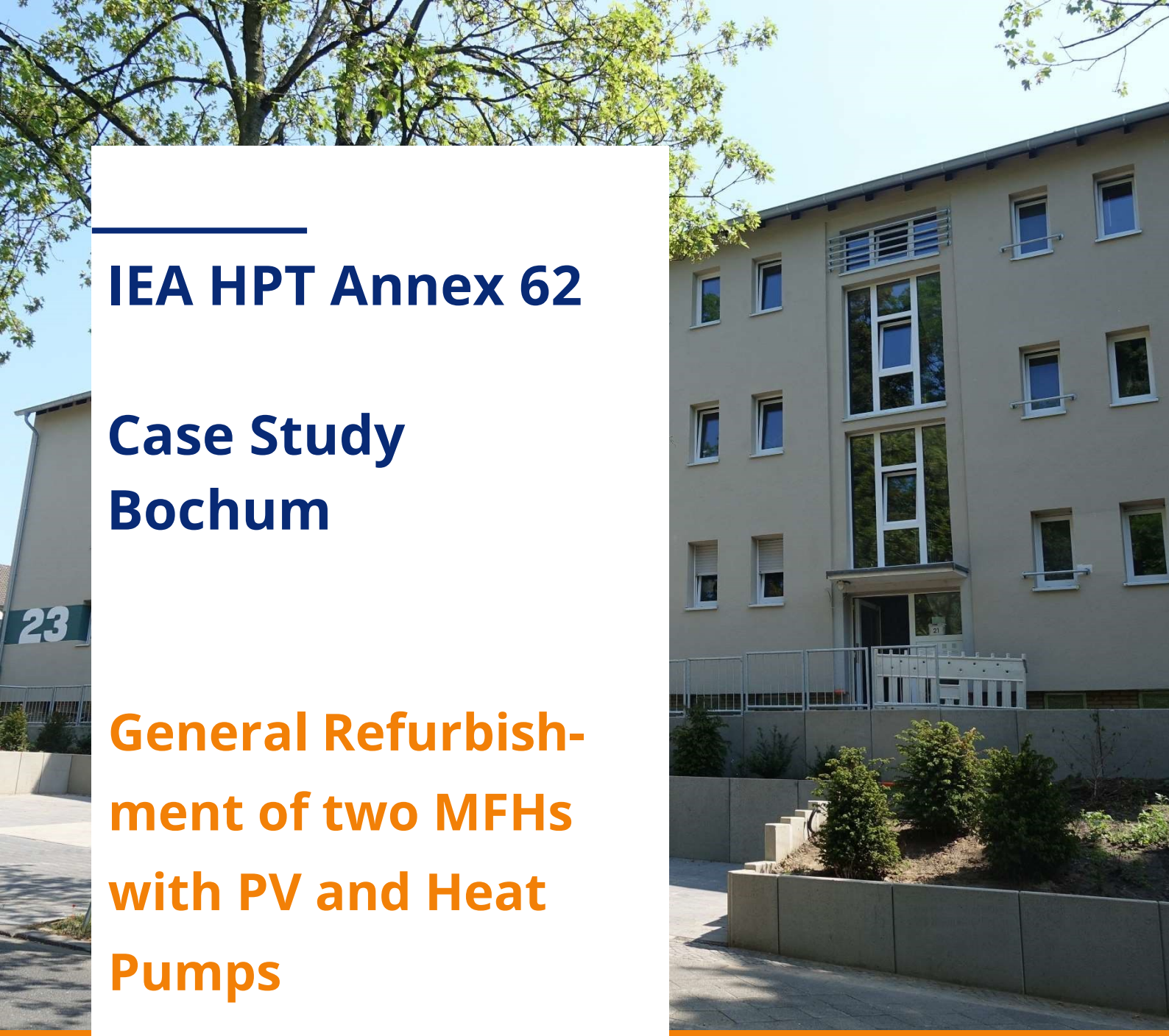

IEA HPT Annex 62

Case Study Bochum

General Refurbishment of two MFHs with PV and Heat Pumps

CASE STUDY 08/2024

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Data:
sustainable data platform - climate neutral buildings

Housing block 25,27 and 21,23, consisting of two supply units that are independent from each other

With great effort, a housing cooperative refurbished two multi-family houses (Heat Pumps, thermal insulation, photovoltaics). Nevertheless, the project failed to achieve the targeted reduction in heating costs and CO_2 emissions. Through monitoring on the *sustainable data platform c/o Stiftung Energieeffizienz*, the main problem was identified: the control of the heat pump and the affiliated electric (EL) heating rods. The according adjustments are currently being done to reach the targeted reductions after all. This case studies provides general "lessons learned" for the use and application of heat pumps.

Grave structural shortcomings on the roofs and windows were identified at these buildings from 1955. Thus, it was decided to give the buildings a complete make-over; a general refurbishment with thermal insulation, the installation of a PV-system and the switch from a gas heating to a central heat pump system.

The proclaimed goals were to keep future heating costs tolerable for the tenants and to comply with the climate protection target values.

The measures were executed in 2023. After an evaluation of the first heating period with problematic system coefficient of performance (COP) of 1.2 to 1.4, it was discovered that the EL heating rods were in use too frequently, thus lowering those values and allowing heat pump activation too rarely. By now, new external control was retrofitted to limit the use of the EL heating rods.

Adjustments and - if needed - further measures are being done during the second heating period to achieve intended use, avoid exceeding heating-related extra costs, and reduce overall heating costs for tenants in comparison to pre-refurbishment levels.

Key facts

Building	
Location	Bochum, GER
Construction	2023 (Retrofit)
Heat distribution	radiators
Heated area	820 m²
Level of insulation H'T	0,34 W/(m²K)
residential units	2 x 6

Heat pump and source	
Number of HP	2
Installed power HP	2 x 22,1 kW
Electrical heating elements	2 x 19,4 kW (2 x 3 elements)
Heat source	air
Operation mode	bivalent with electrical heating elements

Heating system	
Heating demand qH	39 kWh/m²a
Heating load	2 x 22,7 kW
Heating temperature	55°C
Heating buffer storage	2 x 2 x 500 L

Domestic hot water	
Type of system	fresh water stations
Max. temperature	55°C
Circulation system	fresh water system

Other information			
Efficiency heat pump (SPF)	1,2 / 1,4	Demand cover factor (self-consumption)	78 % / 36 %
Refrigerant	R 407 C	Supply cover factor (self-generation)	22% / 10%
PV peak power	2 x 30 kWp	PV battery capacity	2 x 24 kWh

Projekt-data for the two buildings

“Lessons learned”

The measured COP (therefore SPF) during the first heating period is 1.2 and 1.4 respectively, due to approximately 60% and 70% usage of the electric heating elements. The heat pumps are "cycling" on the heating elements.

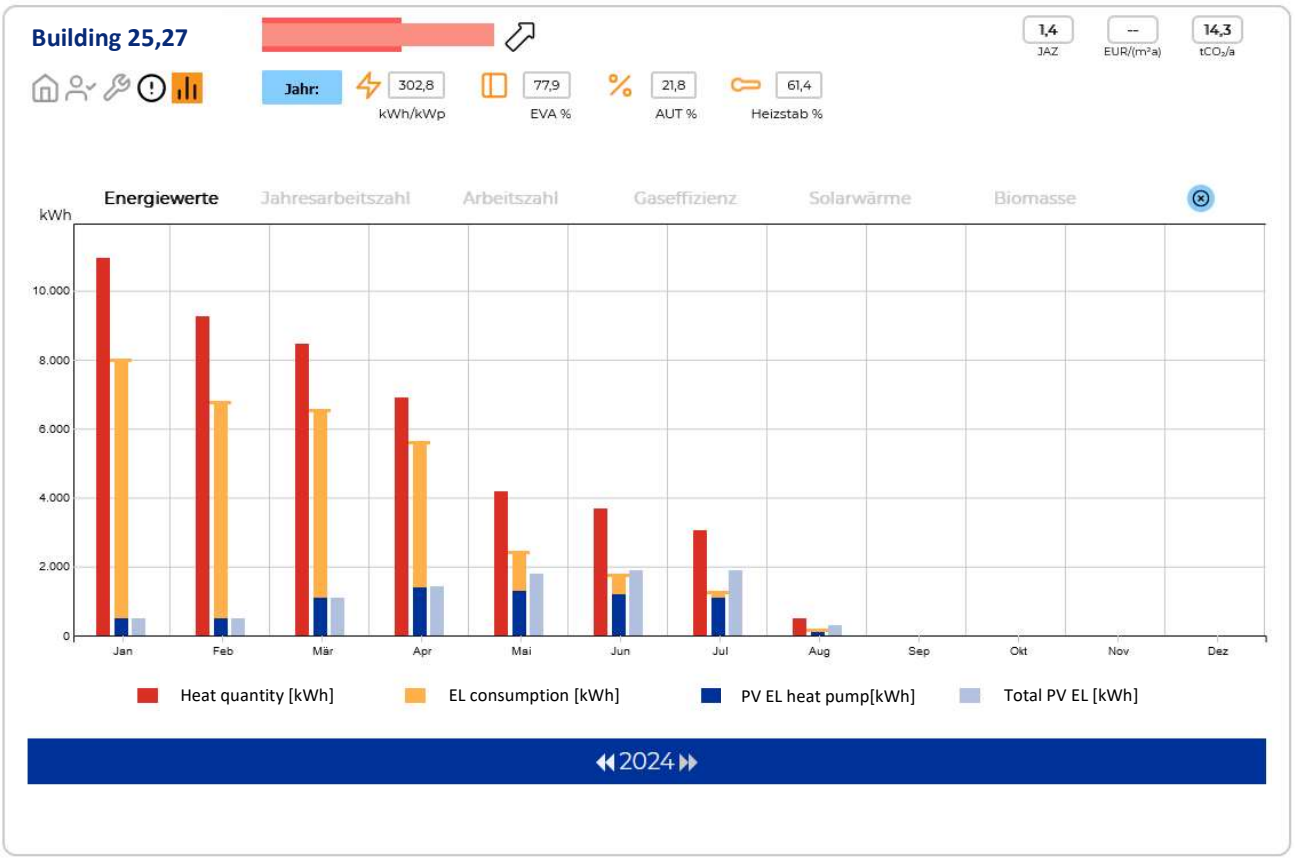
The causes are (a) high network flow rates with mixed storage tanks and (b) inadequate manufacturer control. The control system assumes a 24 kW electric boiler. However, such an electric boiler would lead to extremely high heating costs and, moreover, cannot be installed due to EnEV regulations, as electric heating elements are only allowed to provide a maximum of 5% of the total heat output in this project.

In the systems, a complex retrofit of an external control unit has now been carried out to regulate the use of the heating elements. This issue is also typical for other medium-temperature heat pumps when high shares of heating elements or "electric boilers" are required due to system constraints to reach the target temperature level. This has been taken into account for subsequent systems.

Experiences gained in the project were furthermore: i) the necessity of agreements concerning overall efficiency with planners and manufacturers and ii) and frequent monitoring, where measurements and commissioning should be planned seasonally to identify typical operating scenarios.

Results: Monitoring

Since fall of 2023, insights into the system operating were gathered in heating period one to optimize its running. Performance data regarding efficiency and CO_2 assessment is based on the data analysis from heating period one (up to July 2024) by the climate-neutral buildings portal (CNB-module sustainable data platform c/o Stiftung Energieeffizienz)



Energy data with information about COP and usage of PV-electricity for the heat pumps

IEA Annex 62 Heat pumps for multi-family residential buildings in cities

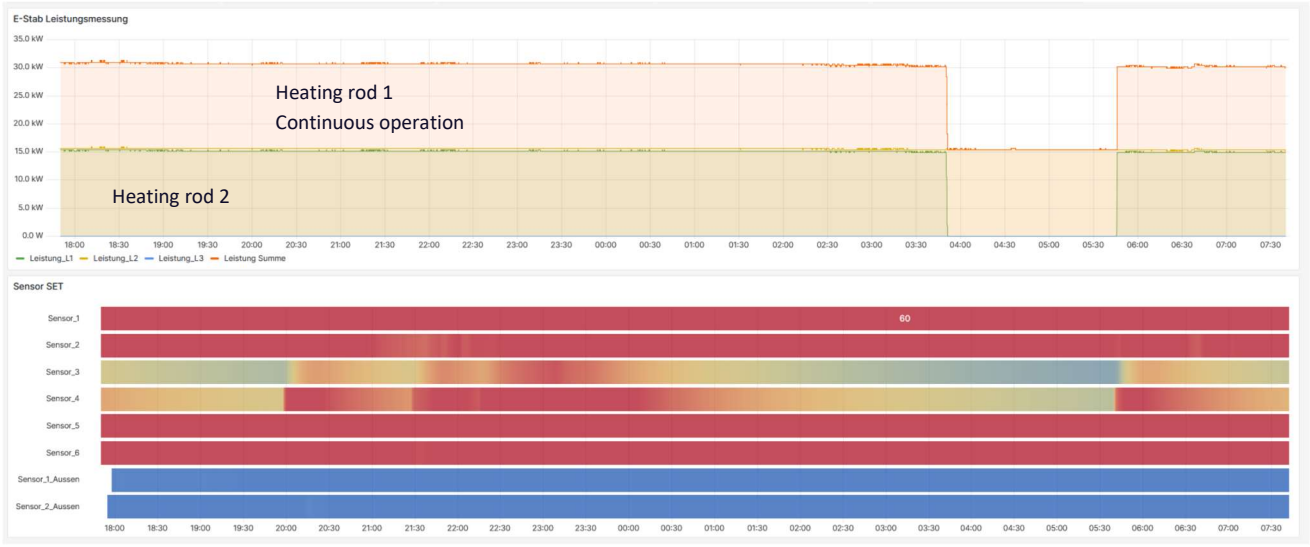
This Annex will focus on heat pump´s solutions for multi-family houses in high-density cities. In respect to the demand of the participating countries new buildings and retrofit will be considered, as well as buildings with higher specific heating demand.

https://heatpumpingtechnologies.org/annex62/

CNB-Monitoring of the heating shares of the HP and the heating rods

For error mitigation, additional analyses of system and of user behavior took place via non-invasive sensor systems (“Sensorkoffer“ by peer4).

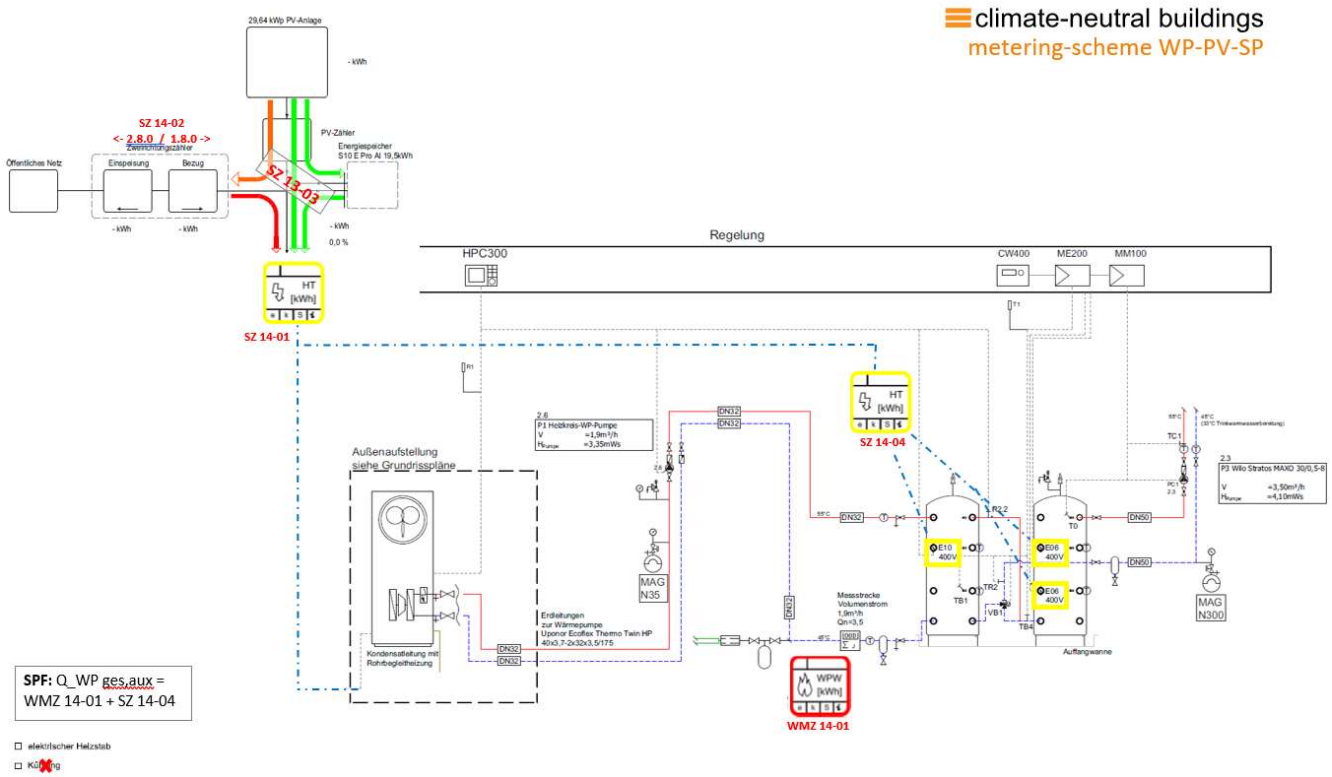
The graph below shows lacking temperature spread and the heating rods’ cyclic operations in late January.



Non-invasive analysis via peer4-tracking of temperatures (bottom) and heating rods (top)

A lack of net spreading, problems with the apartments (fresh water) transfer (overflow), uncontrolled usage of heating rods and wrong settings at the time of commissioning were identified as critical flaws. Evaluation of an internal HP-control-unit indicated a COP/SPF of 1.9 which worsened when including the electricity consumption of the heating rods.

hydraulic-flow-chart



CNB-measuring chart with information on the system (stand-by storage tank on the right) and metering

Noise protection
When installing air-sourced Heat Pumps, the requirements for an undistrupted air-flow while simultaneously complying with noise-regulations should be upheld. Constructional requirements are a matter of individual cases.

HP with noise protection in house 25,27

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Description of the technical system

The installation of the two 22kW air-sourced heat pumps was done on areas outside of the building, each in compliance with noise regulations.

In accordance with the manufacturer, the system's operation was agreed upon to run with 55°C storage temperature in each the buffer and the standby storage to avoid a permanent heating of the water in the buffer storage to only 45°C. Thus, usage of the heating rods was aimed to be reduced to a maximum of 3%.

Two 6 kW heating rods were installed in the standby storage tanks for heat dissipation below the bivalence point of approx. -2.5 °C. The 7.4 kW heating element in the buffer cylinder is used solely for defrosting.

The 2-pipe distribution circuit is to be operated all year with 55° C flow temperature and a maximum return temperature of 45°. The self-regulating stations are intended to limit the return temperature without thermostatic supply modules in the lowest station. The low overall temperature spread in the system causes increased demands on the control system.

Heat pump and PV-system House 21, 23