Case Studies

https://heatpumpingtechnologies.org/annex57/

ANNEX 57

Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks

Smart District Karlsruhe Durlach, Ersinger-Str. 2/4, Germany

"Implement and demonstrate smart operation control strategies for a photovoltaics (PV), heat humps (HP), cogeneration units (CHP) based heat supply system under reducing in a cost optimal way temperature levels"

KEY FACTS

RD&D Status:
demonstration

Type of heat pump:
Centralized HP with district heating-system

Building description:
Residential, refurbished

Energy distribution System:
District heating, Local 400 V electricity grid with own trafo station for HP/CHP, tenant electricity grid for PV, public electricity grid

Energy Storage:
Centralized battery, Centralized Thermal

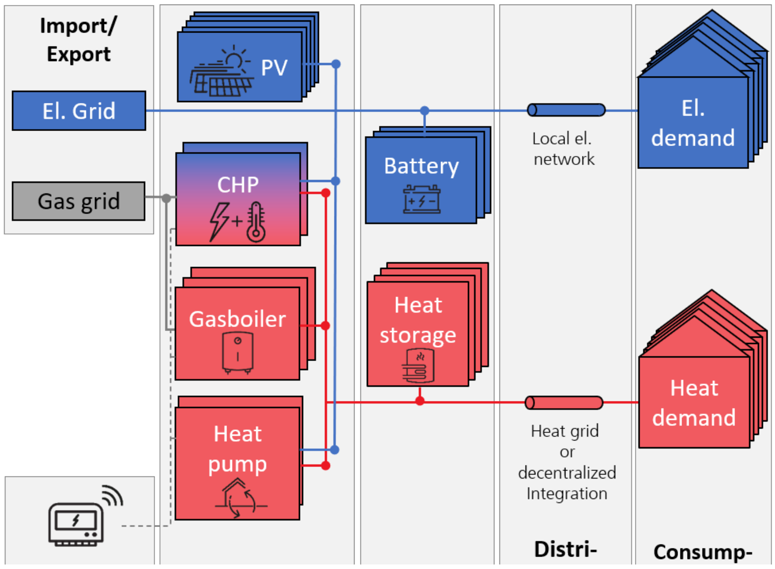
Control for the flexible heat pump operation:
Heuristic control: electricity self-consumption optimized, Reinforcement Learning Controller (simulation)

General description:
HP (ES2): bivalent (air/PVT): 55kW$_{th}$

HP (ES4): Cascade of two heat pumps (air/ground) with 27 kW$_{th}$ + 43 kW$_{th}$

PVT: 202 m² collector area

TES: DHW 2x 850 l, 1x 850 l



Summary of the project:

The building forms part of a cluster of five large renovated multi-family buildings from the 1960s within the Karlsruhe district Durlach, where an integrated energy system is demonstrated within the research project "Smart district Durlach". The demonstrated heat pump technology features finned PVT collectors as single source for the heat pump system. Ultrafiltration are units are integrated in the drinking water circuit to allow low temperatures and maintain the hygienic requirements. 13 out of 150 radiators were exchanged to allow a heating temperature reduction to 55/45 °C. The building was originally built in 1963 and renovated in 1995. The building features a heated floor area of 2112 m² on 5 floors with a total of 30 apartments. The building was renovated exchanging the windows with insulating glazing (Uwin = 1.7 W/m²K), and adding layers of thermal insulation (styrofoam, d = 60 mm, l = 0.035 W/mK) to the façade, cellar and to ceiling, thus reducing the overall U-value of the opaque envelope from Uenvelope = 1.71 W/m²K to 0.323 W/m²K.

Results:

- Reduction of CO_2-emission ~ 28 %

IEA Technology Collaboration Programme on

Heat Pumping Technologies (HPT TCP)

Delivered by:

Team Germany

Case Studies

https://heatpumpingtechnologies.org/annex57/

ANNEX 57 — Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks

Energy supply scheme:

PV modules are installed on all five buildings with a total power of 194 kWp. The optimization results indicate that large PV capacities are beneficial under both economic and energy efficiency considerations due to low levelized costs of electricity and low carbon intensity. However, owing to legislative regulations, the installed power is limited to 100 kWp per year. The PV arrays will therefore be installed in two stages. Two decentral heat pumps with a thermal power of 43 kW_{th} and 63 kW_{th} supply heat to two buildings. The heat pumps use innovative low temperature sources, which specifically address the challenge of limited availability of ambient heat sources in urban areas. The first heat pump system is coupled to hybrid photovoltaic/thermal PVT collectors with a total collector area of 202 m^2. Uncovered PVT collectors with enhanced heat transfer of ambient energy through a finned heat exchanger at the rear side are used as the sole source for the heat pump with a thermal power of 43 kW_{th}. The second heat pump system with a thermal power of 71 kW_{th} uses a dual heat source with intelligent control and hydraulics. Compared to a single-source heat pump, only 50% of the size of a conventional ground source heat exchanger is required. The remaining thermal power is supplied by an air-to-water heat exchanger.

Flexibility – scheme and control strategy of the system:

Different energy management strategies were compared in a simulation study: without energy management system, a simple heuristic, rule-based controller for the heat pumps, and a reinforcement learning controller. The objective of these smart controllers is the reduction of CO_2 emissions by increasing the self-consumption and by reducing gas import in peak load gas boilers and the CHP with optimized operation schedules. 13 % (Voigt, 2021). Despite the promising results of the RL controller, the heuristic controller will be rolled out in the summer period due to simpler implementation with expected better stability. In a second phase, the RL controller will be tested in the field.

Published articles:

Lämmle, M., Bongs, C., Wapler, J., Günther, D., Hess, S., Kropp, M. u. Herkel, S.: Performance of air and ground source heat pumps retrofitted to radiator heating systems and measures to reduce space heating temperatures in existing buildings. Energy 242 (2022),

FACTS ABOUT THE PROJECT

Place: Karlsruhe Durlach / Germany

Time Frame: 9/2018 - 11/2022

Project organisation:

Fraunhofer ISE

Owner/leader:
Volkswohnung Karlsruhe

Project partners:
KES Karlsruher Energieservice GmbH; Universität Freiburg, INATECH; Stadtwerke Karlsruhe; Volkswohnung Karlsruhe

Contact Information/Links

Axel Oliva, Fraunhofer ISE

https://www.ise.fraunhofer.de/en/research-projects/sq-durlach.html

https://www.ise.fraunhofer.de/en/research-projects/lowex-stock-analysis.html