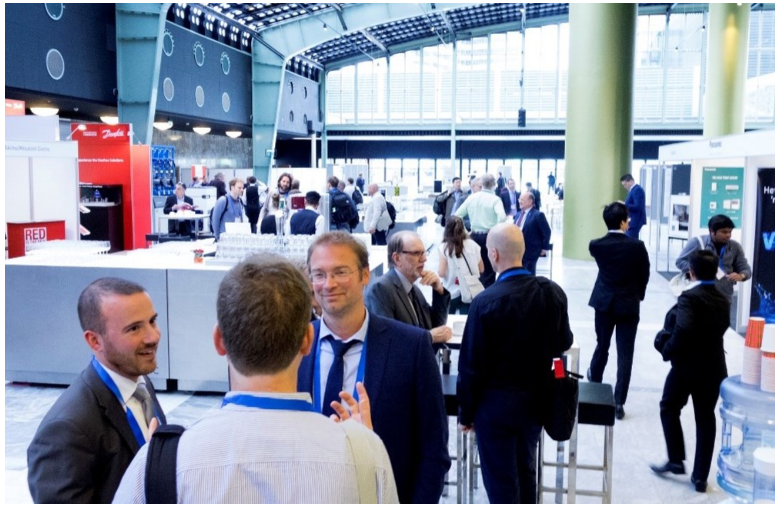
IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)



Research, Development, Demonstration, and Deployment of Heat Pumping Technologies

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Best practice examples of flexibility created with heat pumps

(Task 2),

Best practice examples of flexibility created with heat pumps

(Task 2),

by Dietrich Schmidt & Axel Oliva / Fraunhofer

Fraunhofer IEE

Fraunhofer ISE

Team Germany

Best practice examples

Best Practice Examples

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

Hallein, Austria

"Investigate and demonstrate the integration of an absorption heat in a biomass cogeneration plant for waste heat utilization"

KEY FACTS

RD&D Status:
Large-scale demonstration

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

Building description:
mixed of residential and non-residential.

Mix of new and existing buildings

Energy distribution System:
District heating

Energy Storage:
Centralized Thermal (in heat distribution network)

Control for the flexible heat pump operation:
Rule based control.

General description:
Number of heat pumps:

Absorption HP: 8 MW

Sink temperature: 90/63°C.

Heat Source:
Flue gas condensation
Source temperature: 60/30 °C

Summary of the project:

Salzburg AG operates district heating networks (DHNs) in Hallein and Salzburg. The city centres of Hallein and Salzurg are ≈20km away from each other. Since the capacity of the heat generation plats and the waste heat potential in Hallein is higher, than the demand, the two DHNs were connected in Elsbethen (between Hallein and Salzburg). Therefore, it is possible to transfer heat from Hallein to Salzburg to reduce the load on the plants supplying Salzburg and to increase the flexibility of the heat supply.

One of the flexibility measures in the district heating network in Hallein covers the implementation of an absorption heat pump (AHP) to increase the waste heat utilisation of unusable waste heat of a largescale waste heat source at the cellulose manufacturer AustroCel. As the low-temperature heat source for the AHP the flue gas of a biomass cogeneration plant is used.

Result of the project:

Reductions: For an annually delivered heat of ≈51.5 GWh (2021) to the heat distribution network the emission would have been ≈**10300 tCO2** due to a standard CO2-emission of the average Austria district heating networks. It's reduced to ≈**200 tCO2**,äq, by integrating the AHP.

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Best Practice Examples

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

Energy supply scheme:

The heat supply in the district heating network in Salzburg is supplied by 9 cogeneration plants which are powered by natural gas, oil and biomass. In the last years the amount of natural gas an oil was reduced and of biomass increased. Furthermore, waste heat potentials are located and if possible integrated into the district heating network. Therefore, the share of renewable sources should be significantly increased in the coming years.

Flexibility – scheme and control strategy of the system:

Various heat generation plants, which are partially cogeneration plants, supply the DHNs of Hallein and Salzburg. Biomass, waste heat, natural gas and fuel oil are used as energy sources. Due to optimisations in the last years, the use of fuel oil has been reduced to a minimum. The plants are selected for operation are chosen based on a superordinate operation strategy. This strategy includes, among others, the operating costs of the plant and the fuel, the current load and the expected load profile as well as the CO_2emissions related to the operation of the plant.

FACTS ABOUT THE PROJECT

Place: Austria / Hallein (Salzburg)

Time Frame: Start 2020

Project organisation:

Owner/leader:

Salzburg AG

Project partners:

Salzburg AG, Graz University of Technology.

Contact Information/Links

René Rieberer, Graz University of Technology – Institute of Thermal Engineering, +43 316 873 7303, rene.rieberer@tugraz.at

Published articles:

Absorptionswärmepumpe zur Abwärmenutzung - Modellierung einer Anlage zur Rauchgaskondensation in einem Biomasseheizkraftwerk / Philipp Wagner, Christoph Astl, René Rieberer / Deutsche Kälte- und Klimatagung 2022 / 2022 / Magdeburg / Deutsch / 14 Seiten

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Case study documentation with 2-pagers

Most also additionally with extended reports (19)

Best practice examples

- 28 cases are documented

from:

- 5 Austria
- 5 Denmark
- 7 Germany
- 5 The Netherlands
- 6 Sweden

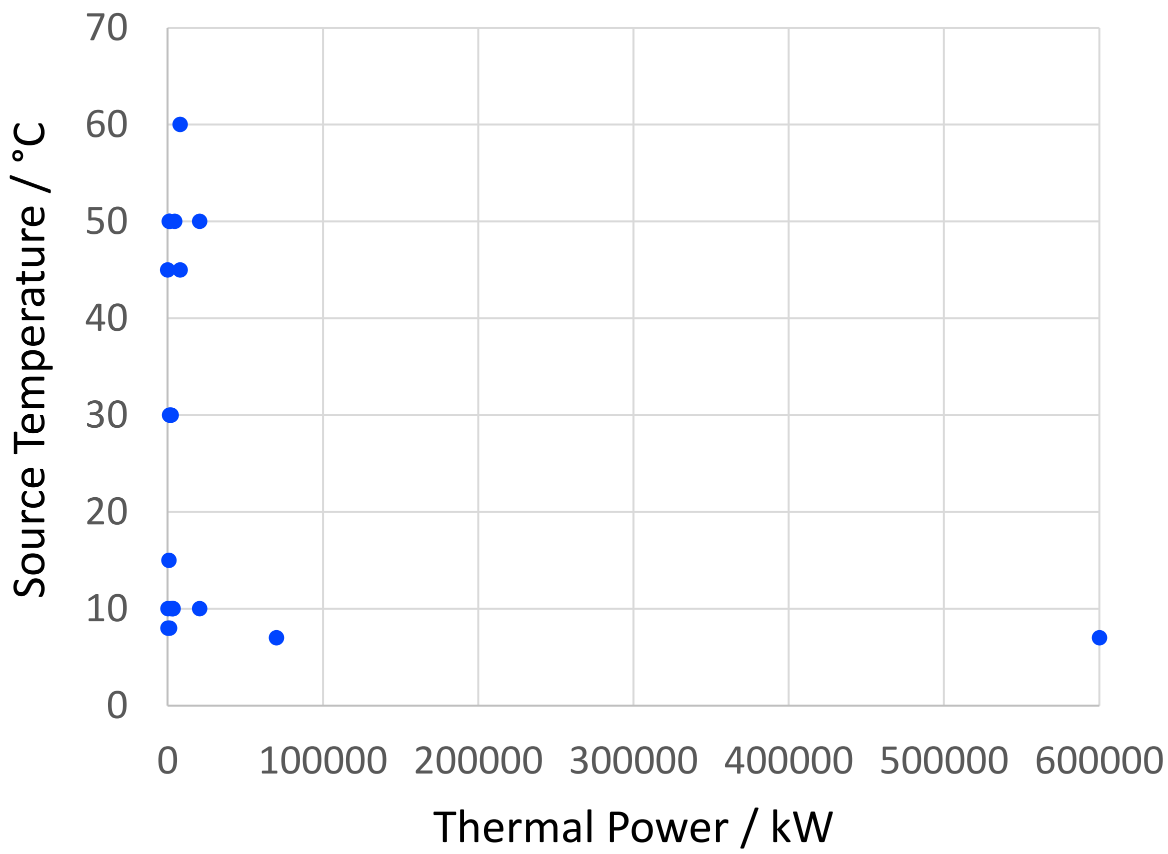
Size:

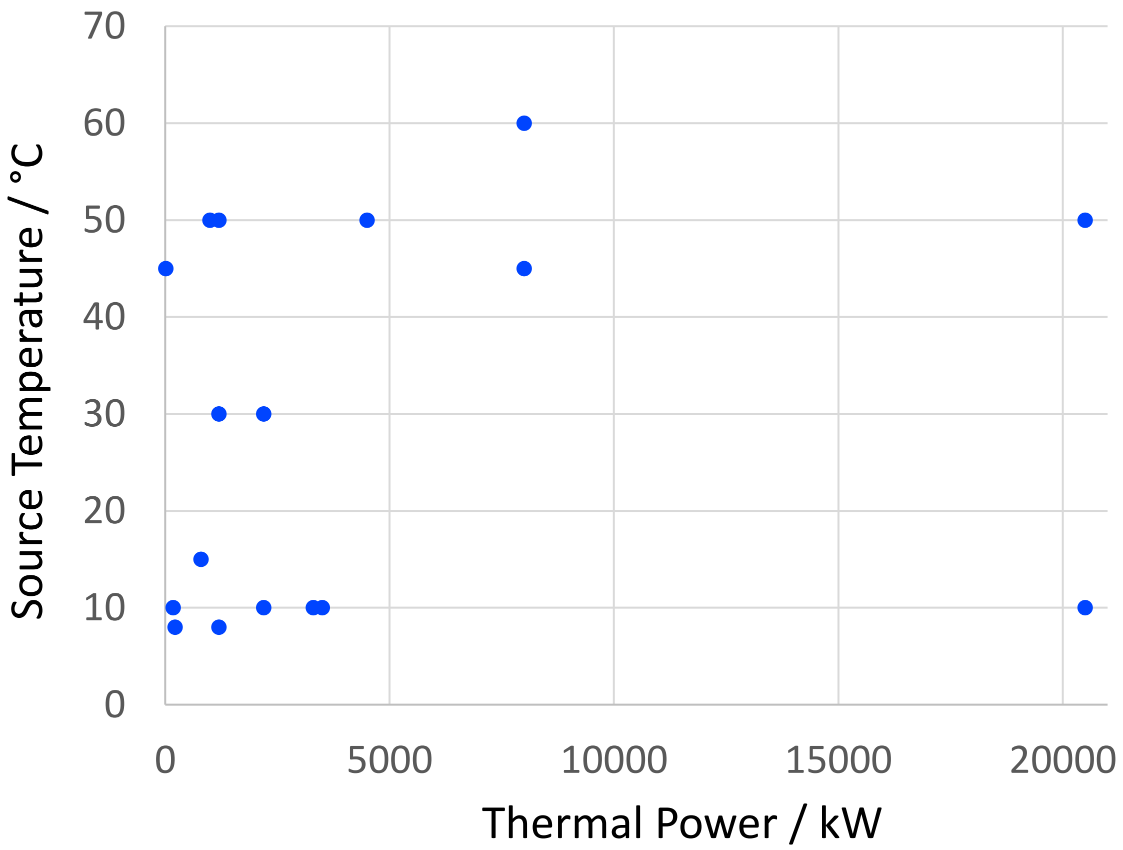
- 16 Large Scale Central Heat Pump Systems
- 12 Small Scale Decentral Heat Pumps

Kind of System:

- 5 Design Studies
- 1 Lab Scale System

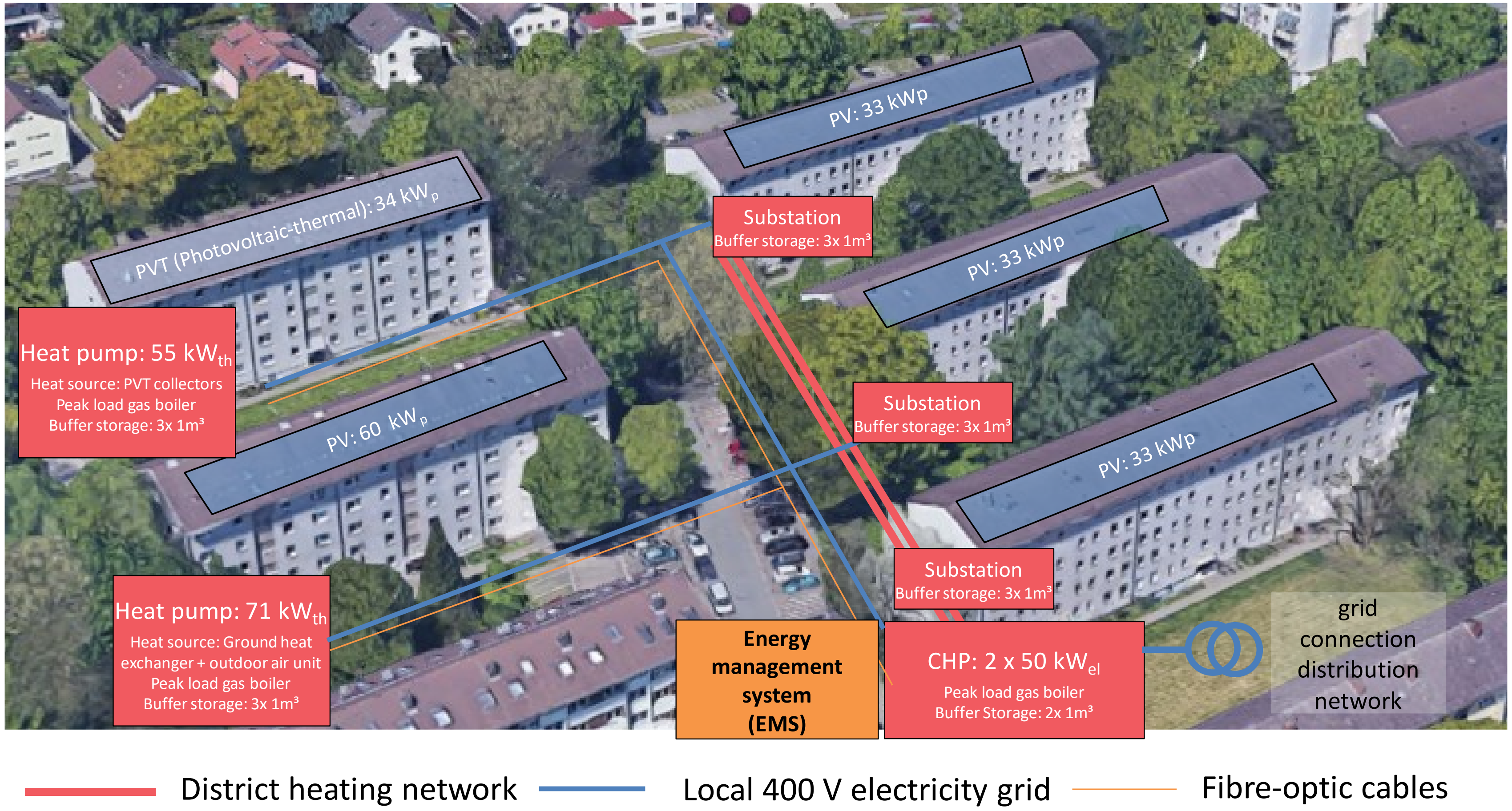
Best practice examples





Project overview „Smart District Karlsruhe-Durlach“

- Photovoltaics (PV)
- 2 decentralized heat pumps
- CHP with district heating for 3 buildings
- Local electricity grid with energy management system EMS



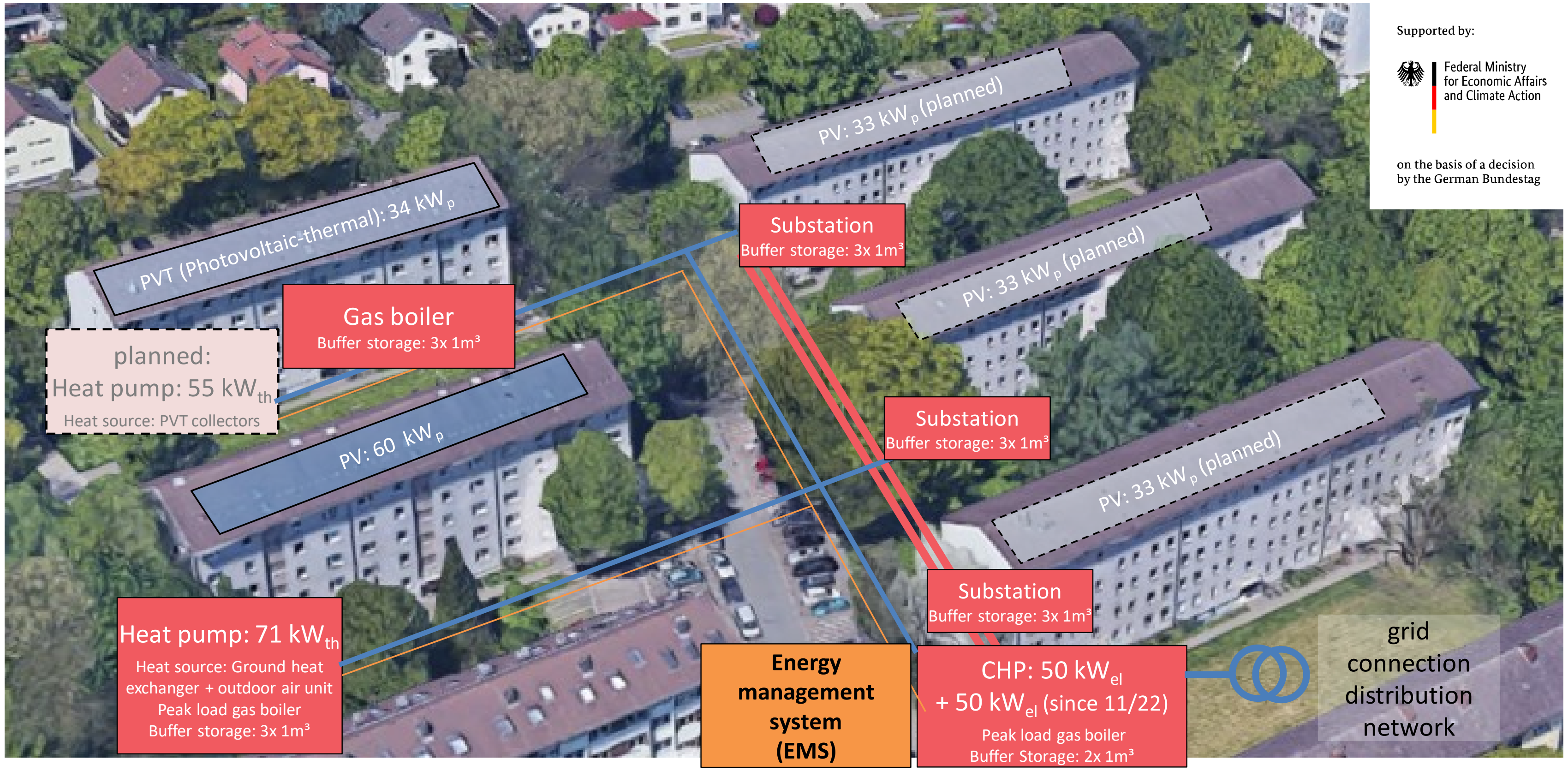
Project Network “LowEx-Bestand”: https://lowex-bestand.de/?lang=en

DOI: 10.1088/1742-6596/2600/3/032001

Gefördert durch: Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

Project overview „Smart District Karlsruhe-Durlach“

- Half of PV capacity installed
- 1 decentralized heat pump in operation
- Since 11/22 both CHP modules in operation
- Energy management system EMS not yet in operation



District heating network — Local 400 V electricity grid — Fibre-optic cables

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Implementation of energy concept

District Heating

CHP

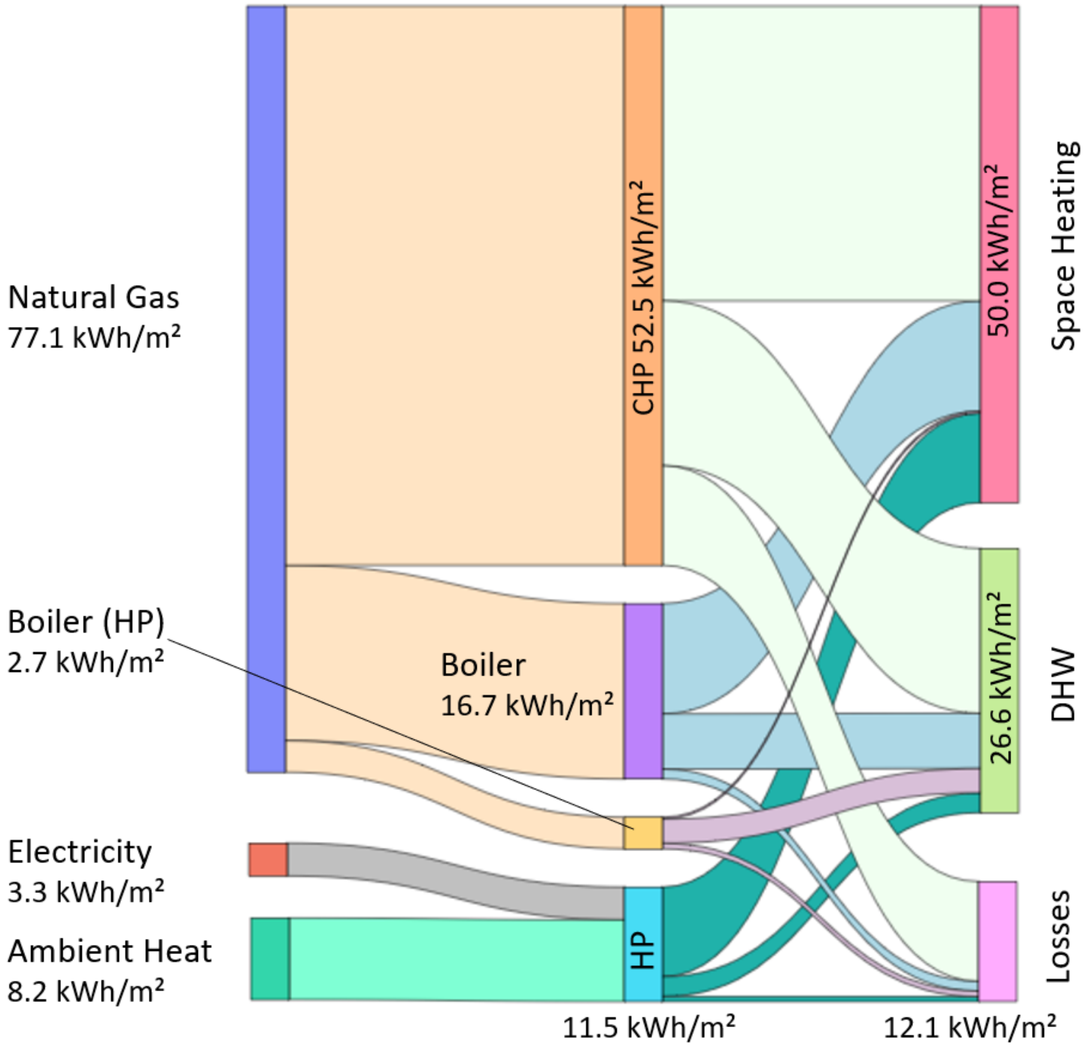
PV

Heat pumps

+ Monitoring concept with heat meters, electricity meters, gas meters and temperature sensors (> 700 datapoints)

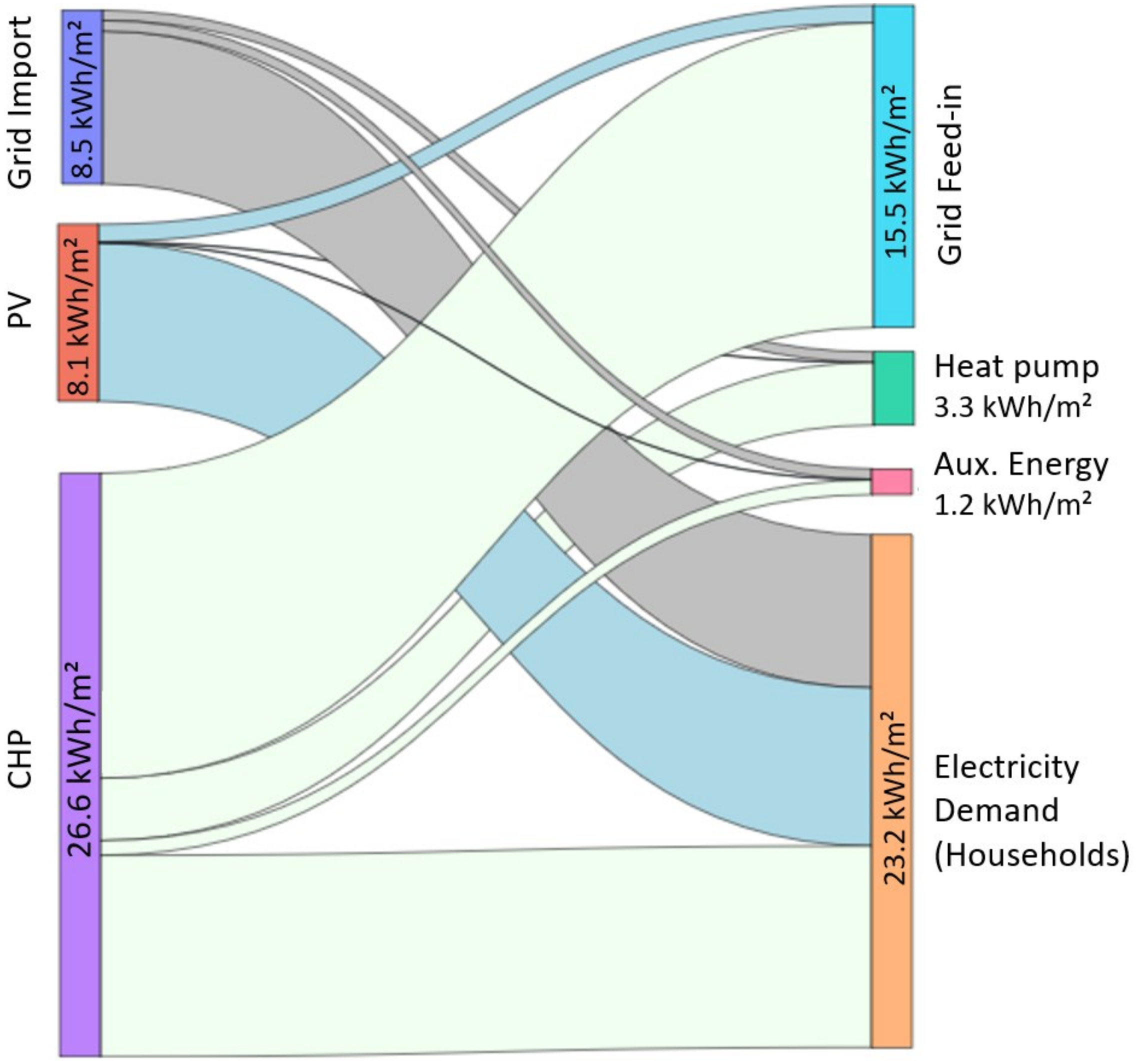
➔ Evaluation of first year of operation (05/2022 – 04/2023)

Energy flow of the neighborhood



- Consumption:
  2/3 Space Heating
  1/3 Domestic hot water preparation (DHW)
- High losses:
  - Efficiency of the heat generation
  - Thermal losses (Storage losses, losses in district heating network)
- High proportion of fossil fuels:
  - only one of two heat pump systems in operation
  - large share of gas boiler for DHW in heat pump system
- Adjustments of control and hydraulic systems are planned

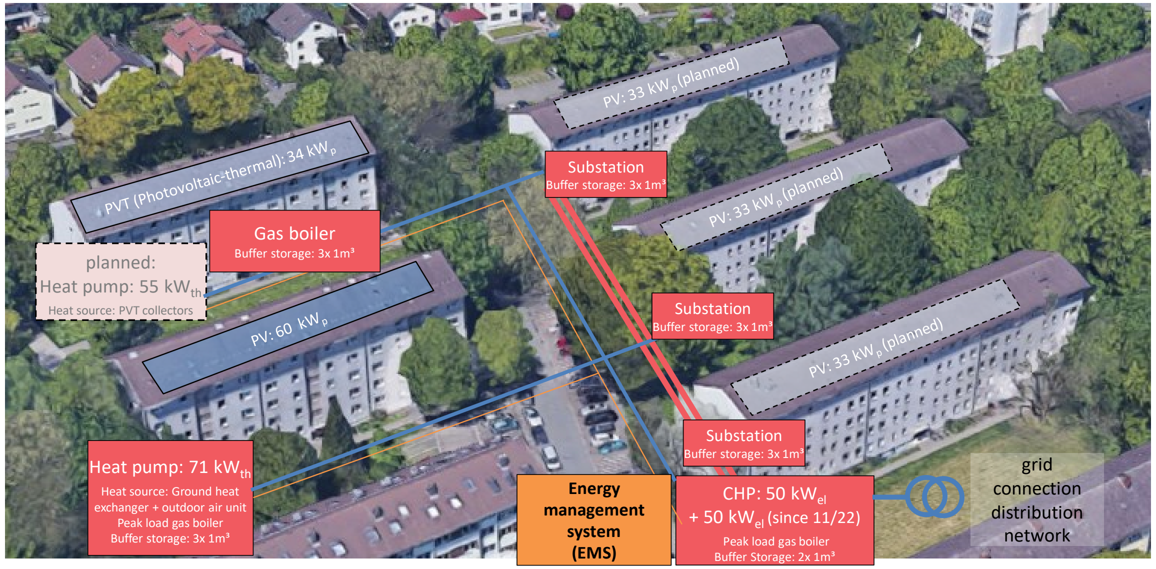
Energy flow of the neighborhood



- Electricity generation (34.7 kWh/m²a) exceeds consumption (27.7 kWh/m²a)
- Considering temporal aspects: self-sufficiency of 69 %
- 86 % of electricity consumption for heat generation was generated locally
- Seasonal differences:
  - high self-sufficiency of 91 % in winter
  - EMS is needed to increase self-consumption in summer
- Reduce dependency on grid
  - Reduction of electricity import
  - Reduction of maximum power from the grid by 5 %

Smart district energy concept

- Successful demonstration of the energy concept
  - Although only part of the system was in operation
  - 86 % of electricity consumption for heat generation was generated locally
  - Self-sufficiency of 69 %
  - Reduces dependency on grid
  - 37 % reduction of CO_2 emission
- Further improvements necessary to achieve CO2 goals of - 50 %
  - Increase the share of renewable energy sources
  - Synchronizing electricity demand and generation (EMS)
  - Optimizing thermal efficiency of heating systems
- Outlook
  - Commission of final energy concept planned for end of 2023
  - Rollout of advanced energy management strategies



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Fkz PtJ/BMWi: 03ET1590A-C

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universität freiburg INATECH

Reallaboratory „GWP“

- 2 x large-scale systems
  HFO: R1234ze(E)
- 3 x premounted hydraulic solutions
  Ammonia R-717

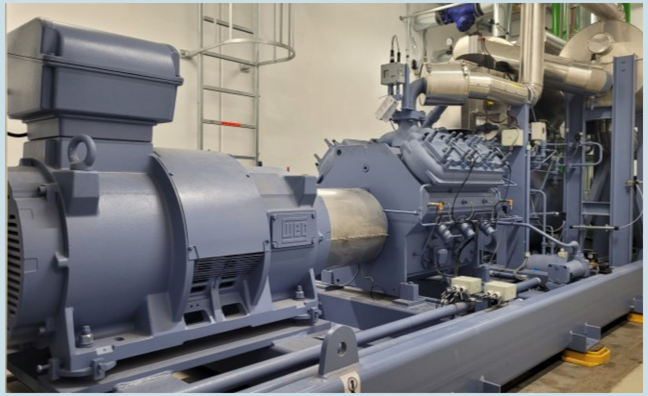
EnBW / Stuttgart

20 MW_{th} | 90 °C | Turbo

MVV / Mannheim

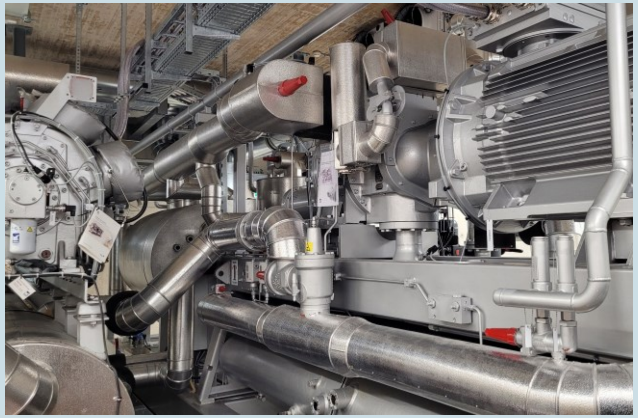
20 MW_{th} | 99 °C | Turbo

Fernheizwerk Neukölln / Berlin



1,3 MW_{th} | 80 °C | Kolben

Stadtwerke Rosenheim



1,5 MW_{th} | 88 °C | Schraube/Kolben

Vattenfall / Berlin

1,3 MW_{th} | 80 °C | Kolben

Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages
Funded by the European Union

source: EnBW, Vattenfall, Fraunhofer ISE

EnBW AG

- Currently: 3 waste-fired boilers, 3 coal-fired boilers
  - Pel = 184 MWel | Pth = 447 MWth
- Power of large-scale heat pump Pth = 22 MWth
  - GC: Mitsubishi / producer: Johnson Controls, Nantes (F), Turbo
  - Refrigerant: R-1234ze (20 t, incl. collection system)
  - Source: stilling basin, cooling water ducts (7,5 °C to 28 °C)
  - Sink: return flow of district heating (66 °C on average)
  - Supply flow HP: 90°C
- Location with very tight space conditions while maintaining the supply capacity

source: EnBW, Fraunhofer ISE

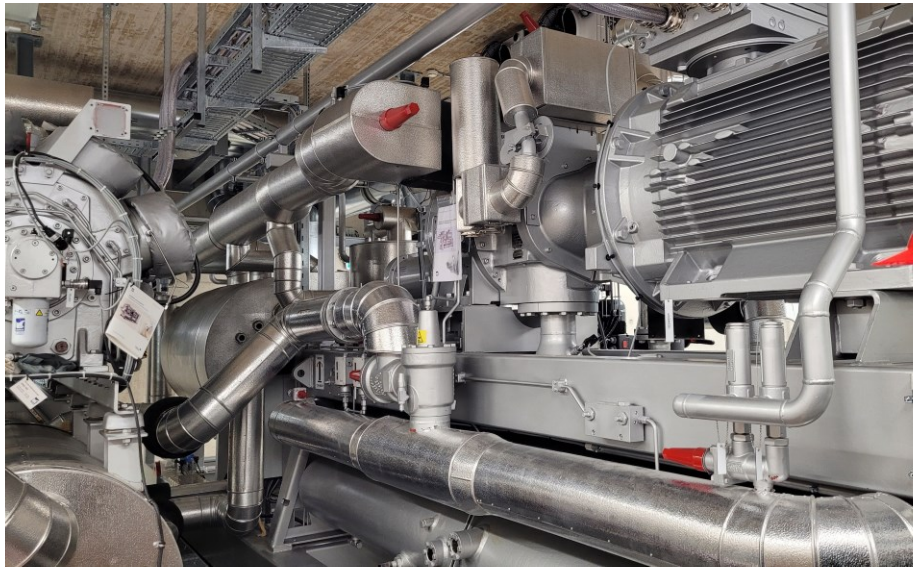
MVV RHE GmbH

- Currently: 4 heating power plant blocks with hard coal
  - Pel= 1.958 MWel | Pth= 1.500 MWth
- Power of large-scale heat pump Pth = 20 MWth
  - Producer: Siemens Energy, Turbo
  - Refrigerant: R-1234ze (12 t, incl. collection system)
  - Source: Rhein-water / cooling water (3 °C bis 25 °C)
  - Sink: Return flow of district heating (60 °C bis 65 °C)
  - Supply flow HP: 83 °C bis 99 °C
- Short pipe routes, very good infrastructure available on site, 43.000 m³ district heating storage

source: GKM, Fraunhofer ISE

Stadtwerke Rosenheim

- Currently: Waste-fired boiler, steam turbine, heating plants, CHP units
  - Pel = 33 MWel | Pth = 115 MWth
  - Waste, natural gas, biomethane, wood gas
- (3 x) Large-scale heat pump Pth = 1,5 MWth
  - Producer: Johnson Controls, double-screw + piston
  - Refrigerant: R-717 ammonia (260 kg)
  - Source: Creek water (3 °C to 21 °C),
Sink: Return flow of district heating (65 °C),
Supply flow HP: 88°C
- Innovative integration of river water with plate-HX



source: Stadtwerke Rosenheim, Fraunhofer ISE

resumé

Where is the potential of improvement?

- Approval procedures take a very long time, environmental impact and safety engineering of refrigerants (and operating materials) not known, no standard procedures
- Few standardized technical systems (e.g.: Rosenheim: 2-stage direct combination screw-piston)
- Lots of peripherals (source exploitation, high pipe radius due to small dT, electrical switch gear, safety engineering,...)

What´s next?

- Analyze measurement data
- Develop approaches for **optimizing dispatch strategies**, swift operation and performance

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Fkz PtJ/BMWi: 03EWR008A-L

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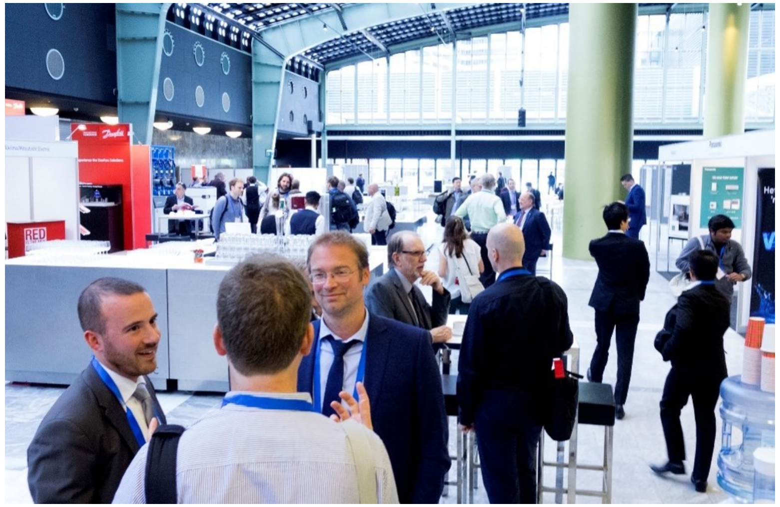

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