Case Studies

https://heatpumpingtechnologies.org/annex57/

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

Demo No.:	**Location/City:**	**Country:**
D-002	Wien/Oberlaa	Austria

Project name:
Waste heat utilisation spa Vienna

Quotation: "Use energy from the thermal waste water of "spa Vienna

Schedule of the demo project (research study):	**Year of realisation:**
	2022

Leader organisation (owner, constructor, solution developer, research inst., etc.):
Wien Energie

Participating organisations – demonstration project part (involved other organisations):
Green Energy Lab, AIT, AEE, TU Wien Energy Economics Group

Budget of the demo (invest/monitoring etc.):
€3m

Summary of the project:
The overall system was developed to utilise the waste heat of the thermal (waste)water of "Spa Vienna" located in district "Oberlaa". The system based on heat pumps with a supply of about 2,2 MW to the DH network of the City, depending on the temperature and the mass flow of the source. The heat pumps are designed to get a maximum output temperature of 84 °C. An additional electrical boiler of 375 kW thermal energy increases the temperature up to 90 °C if the outdoor temperature is below -5 °C. Yearly produced heat amounts to around 11 GWh.

Expected results
- Produced heat of 11 GWh/a, supply for around 1,900 households
- Reduction of carbon emissions of around 2,600 t/a
- Reduction of biomass consumption of around 1,200 t/a

Published articles (paper, article etc.)
- Project was part of the thermaflex project (https://thermaflex.greenenergylab.at/)

Contact information

Country:	**Participating Organisation:**	**Contact/name:**
Austria	Wien Energie	Anna Gantner

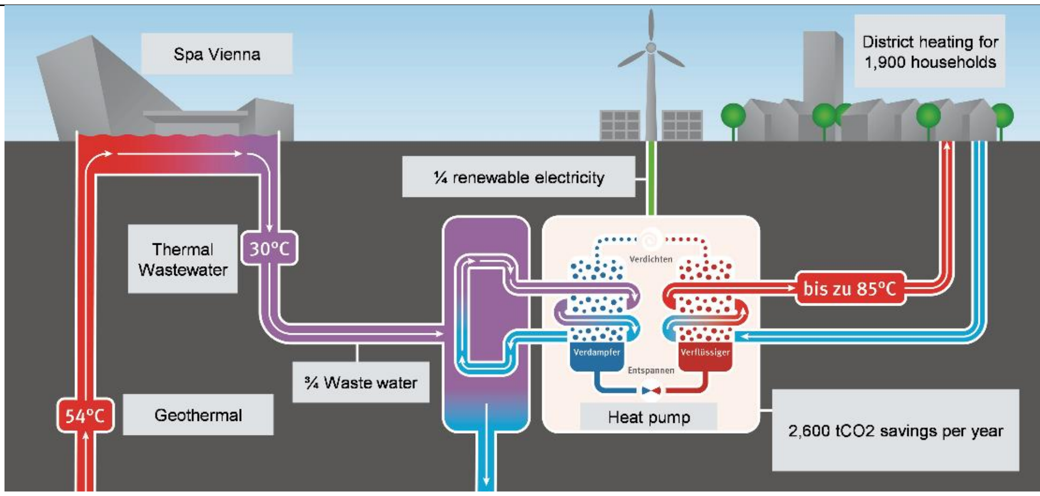

Figure 1 General layout

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Project classes:

RD&D status

Large-scale demonstration	Small-scale demonstration	Lab scale (results based on measurements)	Design study (results based on simulation)
☒	☐	☐	☐

Type of heat pump

Decentralized HP (cold district heating)	Centralized HP with a district heating system
☐	☒
Heating	Cooling
☒	☐

Heat source of HP: Thermal water

Power supply for HP (electricity grid, PV, wind turbine etc.): grid

Buildings

New buildings	Existing buildings	Mix of new and existing buildings
☐	☐	☒
Residential	Non-residential	Mixed use
☒	☐	☐

Energy storage

Battery storage		Thermal energy storage	
Centralized	Decentralized	Centralized	Decentralized
☐	☐	☒	☐

Control for the flexible heat pump operation

Heat driven control[1]	Predictive control[2]	Rule based control[3]
☒	☐	☐

[1] Operation of heat pumps to the cover heat demand depending on ambient temperatures
[2] Operation of heat pump using a model based heat demand prediction
[3] Heat pumps are controlled by a set of predefined rules (e.g. heat pump operation with blocking time)

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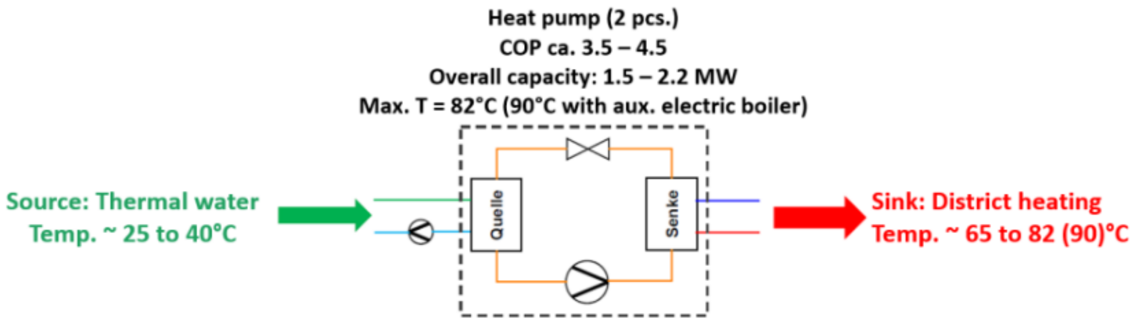
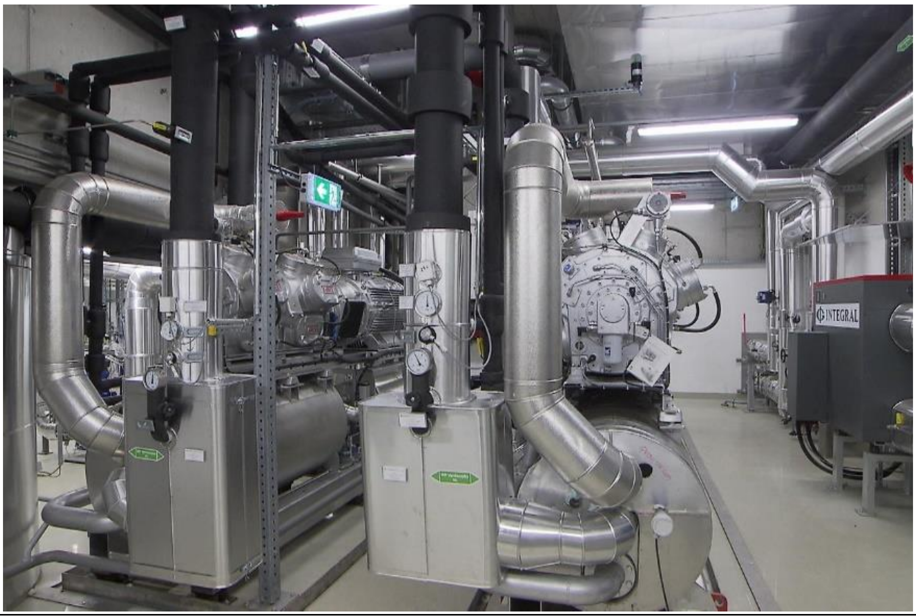
1. General description of the project

The project is located in Oberlaa, a district of Vienna and the location of the largest Spa. Wien Energie, as the local operator of the district heating network. In order to be able to increase the temperature level of the waste heat recovery system to a maximum level of 90 °C (output), an electric boiler is integrated in the inlet-line of the district heating network.



2. Building and system description of the project

The innovation of this concept lies in the intelligent use of waste water of the spa, which was unused before. The project is part of a larger strategy to use new/renewable sources of heat for the district heating system. By 2040, Wien Energie aims to connect 56% of the Vienna households to the district heating system.
The existing medium voltage system of spa Vienna had to be increased for the heat pump system. The assembly operations took place for a very short period of time during one night. The electrical supply for the heat pumps is provided by the public electricity grid of the City with 20 kV. For this purpose, a so-called “Three-winding transformer” (approx. 1,315 kVA) with 2 secondary voltage levels (690 V and 400 V) was integrated in a not equipped transformer box.



3. Energy supply – scheme of the heat supply system:

The heat pumps for the use of waste heat are operated on the source side by the thermal water pipe, which flows into the main sewage treatment plant in Vienna. The heat pump system consists of 2 identical heat pumps. The heat pumps are designed as water-cooled compact heat pumps with the refrigerant ammonia (NH_3, R717). The refrigerant ammonia was chosen for the heat pumps due to the low GWP and ODP value. The leakage of ammonia can be deadly for humans, therefore special safety precautions have to be carried out: gas sensors, a special ventilation system and a scrubber. The implementation of the scrubber was an additional demand of the local authorities. The heat is generated by 2 single-stage high-pressure ammonia heat pumps based on piston. compressors. These heat pumps are compact units that are characterized by a single-stage compression process.

4. Flexibility – scheme and control strategy of the system:

The challenge in this project consists in the fact that both, the source and the sink are varying with respect to volume and temperature. This is especially true for the source (waste water from the spa), less so for the sink which varies with respect to temperature on an hourly basis, the volume is more or less constant. This is in contrast to a typical DH grid, which has mainly seasonal fluctuations, less so on an hourly basis.

Due to these challenges, the HP is working in parallel to the heat exchangers of the DH system, as the peaks cannot be covered by the HP. In addition, the lowest operational point is 300kW for the HP. Therefore, the HP is designed to cover the 'medium' load of the system. It is neither able to cover the points of low heat demand (it would need to be switched off then), nor the peaks (capacity is not enough to cover ~4MW). The target of the design was to maximise the full load hours. In addition, the size of the heat pump was also determined by the available space.

5. Description of the business model with a flexible HP-operation

The plant is dispatched in a flexible way to make economic sense, depending on the constellation of gas and electricity prices. Depending on their relation, it can make economic sense to cover large parts of the heat load by the CHPs.

Participation on the balancing market was considered, but decided against in the end. To prequalify for the balancing market would have triggered additional investments and technical upgrades that where not justified by the economics. In addition, there are practical problems with regards to the fact that in particular heat supply and the availability of waste water is not predictable and compatible with the lead times required by the balancing market.

6. Results of the project

The plant has not completed a full year of operation yet and is still in trial operation. It is expected to be fully operational in course of 2023

7. Challenges / socio economical barriers and opportunities

A key lesson learned is that integration in the existing facilities of the spa has lead to some challenges and consisted some constraints with regard to the planning, in particular with regards to the space requirement. Since the heat pump is working underground, a positive aspect is that noise does not consist a problem for any other stakeholders.

In terms of security consideration, handling of the refrigerant (ammonia) is crucial.

8. Additional information: Flexibility options

Contents: district heat pump

Share of heat sources (in %)	Heat source: Waster water	100 %
Share of power supply (power grid, PV-units at site, wind turbine at site etc.)	Power supply: Grid	100 %
System boundary by calculation of the SPF		
Seasonal performance factor in design and measured (SPF)		
COP of HeatPump at the design condition (point in °C or traverse as function in °C), independent of site boundaries		
COP incl. all peripheral devices at source and sink side		
Location of heat pump (e.g. heating centre (centralized heating installation), using existing infrastructure etc.)		

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Contents: district heating network

Land area for buildings served by heat distribution network		
Total heated floor area in buildings connected	190,000	m²
Trench length for heat distribution network		
Heating capacity	2.2 + 0.375	MWth
Heat annually supplied into the heat distribution network	11	GWh
Heat annually delivered from the heat distribution network		
Annual average supply temperature in the heat distribution network	85	°C
Annual average return temperature in the heat distribution network		
Heat generation based on renewable sources		
Share of renewable sources		

Contents: description of energy storage system

Energy storage type:	
Storage size (capacity):	
Term of flexibility:	
Storage temperature (thermal energy storage)	

Contents: indicators for flexible heat pump operations

Cost (potential cost saving)		
Thermal level (losses of thermal comfort)		
Load matching factors (load supply & load cover factors)		

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

Delivered by:

Team Austria