Programm

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16. Symposium Energieinnovation

ENERGY FOR FUTURE - Wege zur Klimaneutralität

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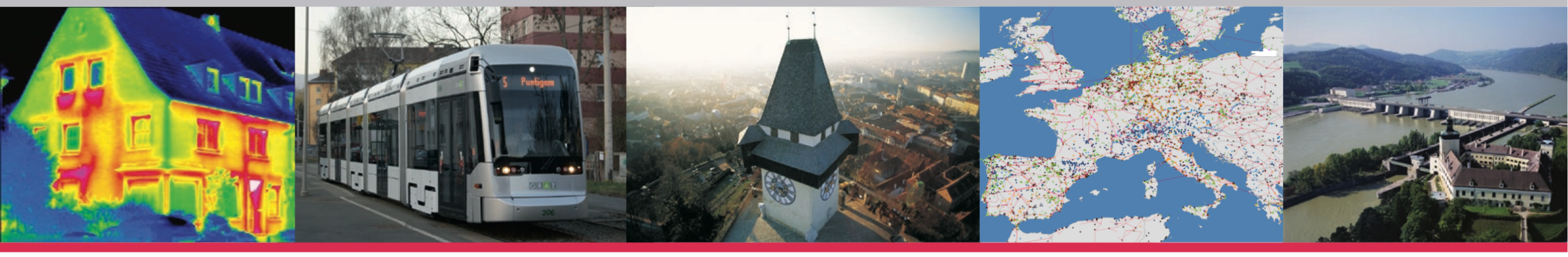

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TECHNO-ECONOMIC ANALYSIS OF USING SEWAGE WATER FOR DECENTRALIZED HEAT GENERATION IN LARGE DISTRICT HEATING NETWORKS

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16. Symposium Energieinnovation
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Graz

Overview

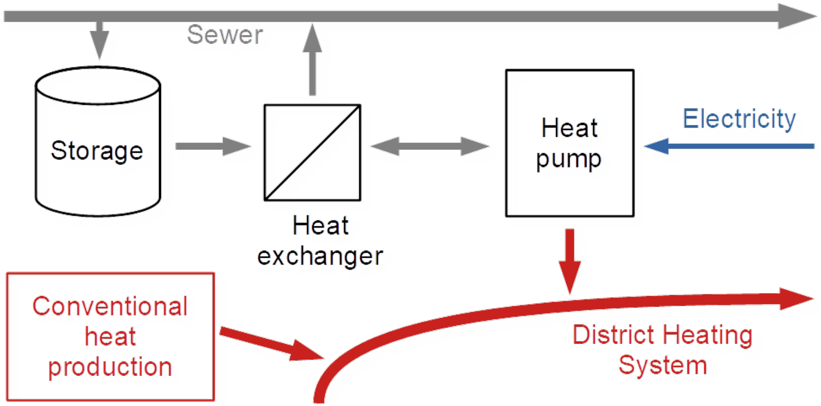
- Motivation
- Methods
- Input data and assumptions
- Results
- Conclusions

Motivation

The ThermaFLEX project investigates flexibility measures in the district heating sector.

In seven demonstration projects different ideas are examined, simulated and evaluated scientifically.

One demonstration project is heat recovery from waste water in Vienna-Liesing.



What is the optimal sizing of the storage and the heat pump?

Methods

(MILP) Optimization Problem

$$\min \alpha \cdot \left(ic^{HP} \cdot p^{th} + ic^{ST} \cdot v^{ST} + ic^{GC} \cdot p^{el}\right) + om^{HP} + om^{ST}$$
$$+ \Delta t \cdot \sum_{t \in T} \left((mp_t + gc) \cdot p_t^{el} + c_t^{other} \cdot p_t^{other}\right) + gc^{power} \cdot p^{el}$$

s.t.

$$st_t^{in} + spill_t = inflow_t$$
$$soc_t = soc_{t-1} + st_t^{in} - st_t^{out}$$
$$0 \leq soc_t \leq v^{ST}$$
$$0 \leq st_t^{in} \leq st_{max}^{in}$$
$$0 \leq st_t^{out} \leq st_{max}^{out}$$

$$\Delta t \cdot p_t^{th} = \Delta temp_t \cdot st_t^{out} \cdot \rho^W \cdot c_p^W$$
$$p_t^{th} = cop_t \cdot p_t^{el}$$
$$0 \leq p_t^{th} \leq p^{th}$$
$$0 \leq p_t^{el} \leq p^{el}$$

$$p_t^{th} + p_t^{other} = d_t$$

Variables

p^{th}, p^{el}	Installed thermal and electric power of heat pump
v^{ST}	Storage volume
p_t^{th}, p_t^{el}	Thermal and electric power of heat pump at time t
p_t^{other}	Heat production from alternative source at time t
st_t^{in}, st_t^{out}	Storage inflow and discharge at time t
$spill_t$	Unused sewage water at time t
soc_t	Storage state-of-charge at time t

Parameters

ic^{HP}, ic^{ST}	Investment cost of heat pump and storage
ic^{GC}	Grid connection cost
om^{HP}, om^{ST}	O&M cost of heat pump and storage
mp_t	Electricity day-ahead market price at time t
gc, gc^{power}	Grid charges (energy and power component)
c_t^{other}	Heat production cost alternative source at time t
$inflow_t$	Sewage water inflow at time t
$\Delta temp_t$	Sink-Source temperature difference at time t
ρ^W, c_p^W	Density and heat capacity of water
d_t	Heat demand at time t

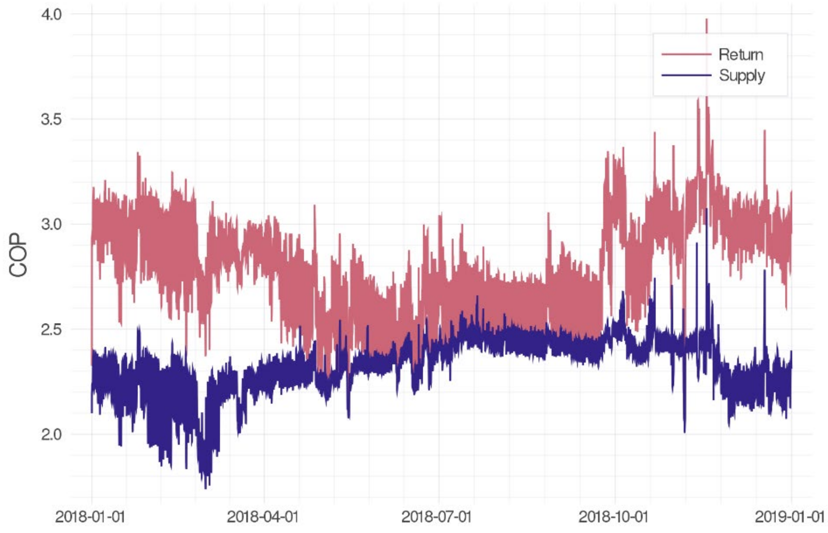
Input data and assumptions

Two technical scenarios:

- *Return*: Increase return temperature
- *Supply*: Increase supply temperature

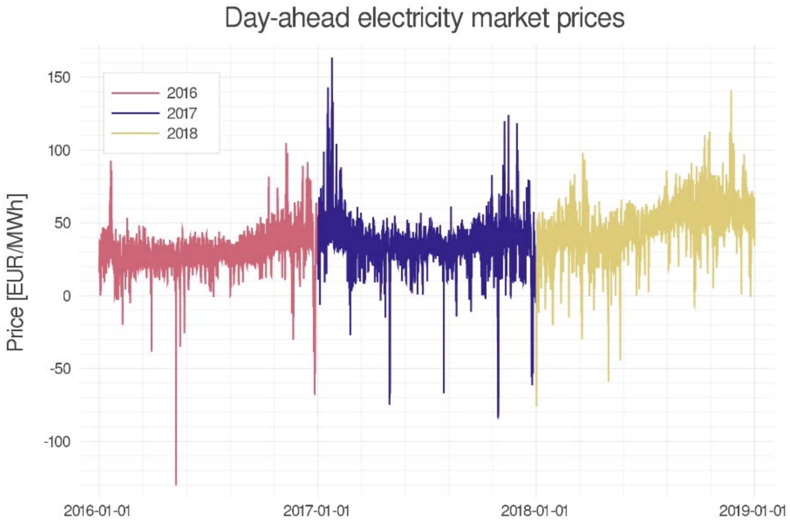
With data simulated by AIT:

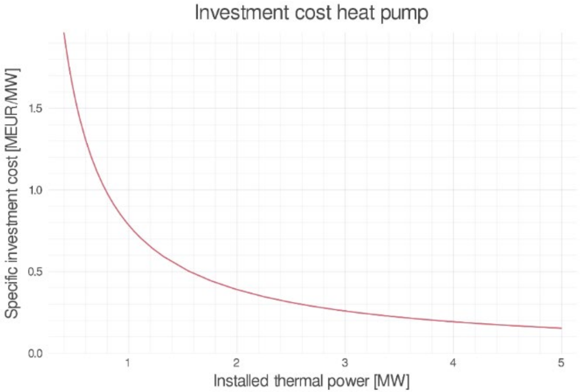
- Source temperature
- Sink temperature
- Inflow
- Heat demand
- COP

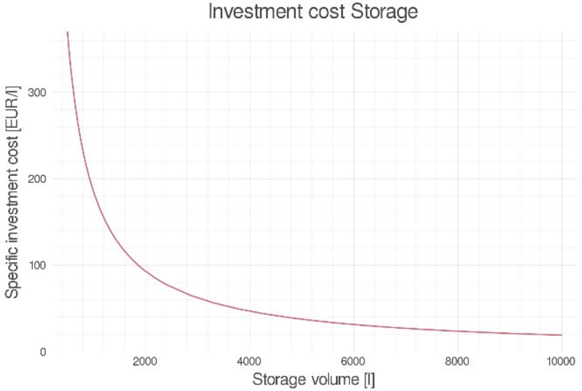


Input data and assumptions

- 5% interest rate
- 20 years economic lifetime
- 3 Electricity market price scenarios (2016-2018)
- Grid charges network level 5



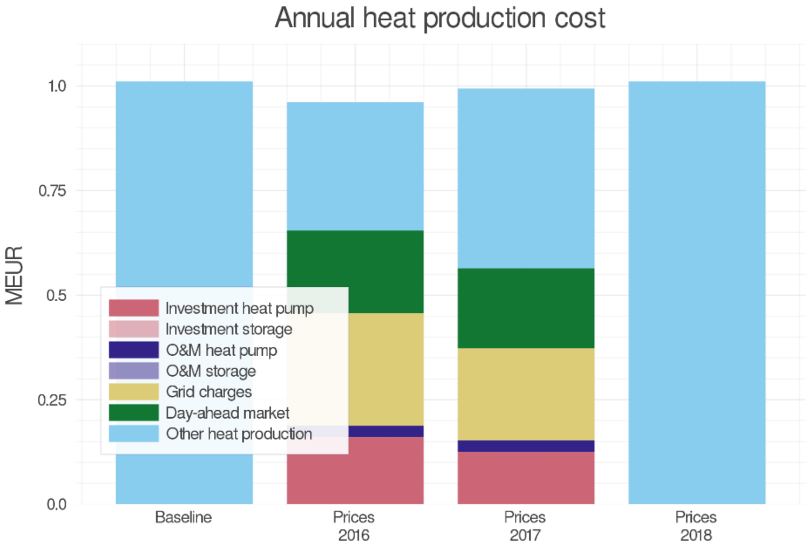




Unconstrained results

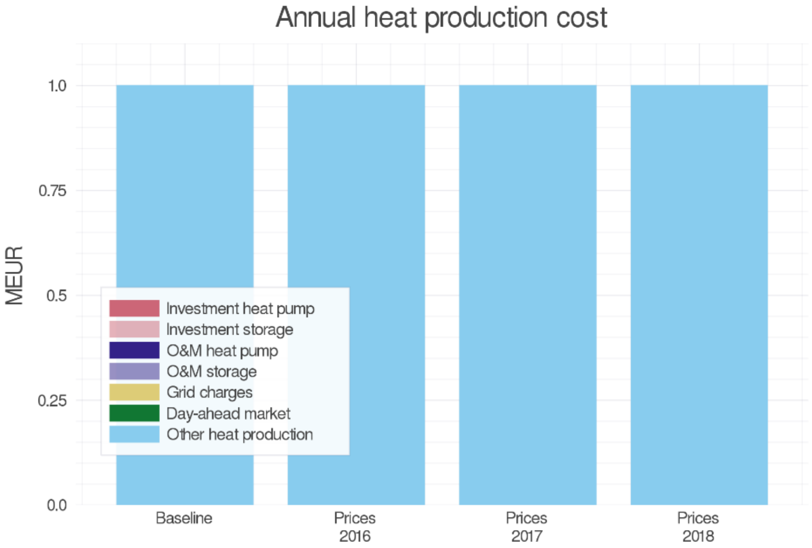
Return

Size	2016	2017	2018
Heat pump [MW_{th}]	3.16	2.42	0
Storage [l]	0	0	0



Supply

Size	2016	2017	2018
Heat pump [MW_{th}]	0	0	0
Storage [l]	0	0	0



Update assumptions

- The storage does not provide any economic benefit, but it is required from a technical perspective.

- Due to space constraints the power of the heat pump is limited.

- What is the optimal investment size in case the investment decision is already made?

Run the simulations with new input:

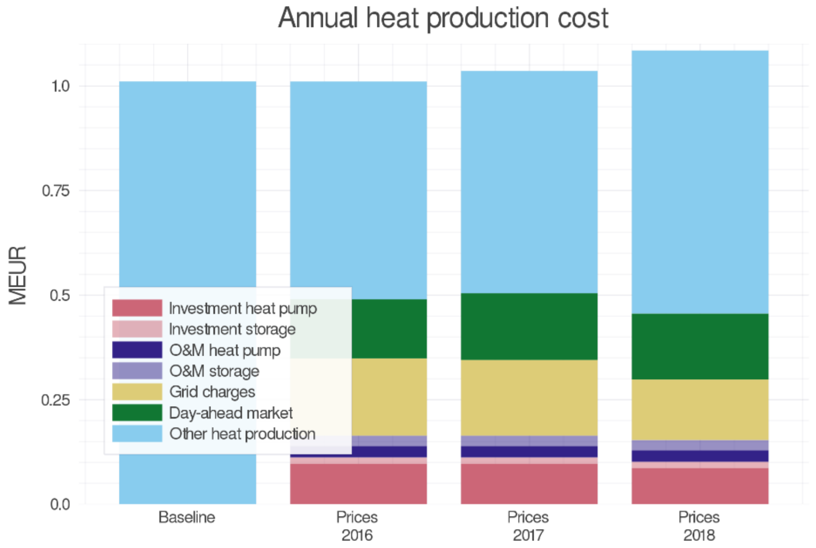
- The storage volume is fixed:
$$v^{ST} = 6000\ l$$

- The thermal power of the heat pump is constrained:
$$0.42\ \mathrm{MW} \leq p^{th} \leq 1.82\ \mathrm{MW}$$

Constrained results

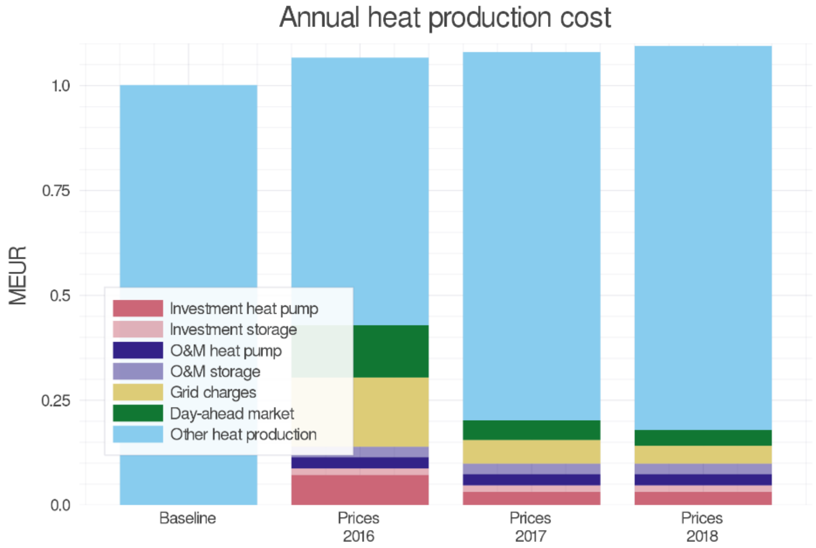
Return

Size	2016	2017	2018
Heat pump [MW_{th}]	1.82	1.82	1.6
Storage [l]	6000	6000	6000



Supply

Size	2016	2017	2018
Heat pump [MW_{th}]	1.3	0.46	0.46
Storage [l]	6000	6000	6000



Balancing market

- Can the benefit of the heat pump be increased by considering the secondary reserve market (aFRR)?
- Fixed heat pump thermal power
- Rolling daily optimization (Day-ahead and balancing market)
- Simulation of balancing market activations

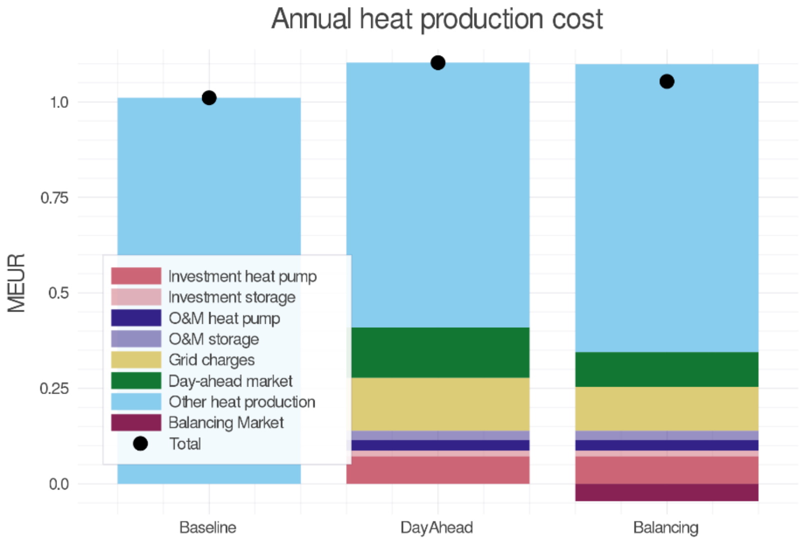
Implementation of the balancing market:

- 4h products
- Each product is described by two possible bids.
  - Low energy price – higher activation probability
  - High energy price – lower activation probability
- The heat pump is assumed to be part of a portfolio. Hence, minimal bid size is neglected.

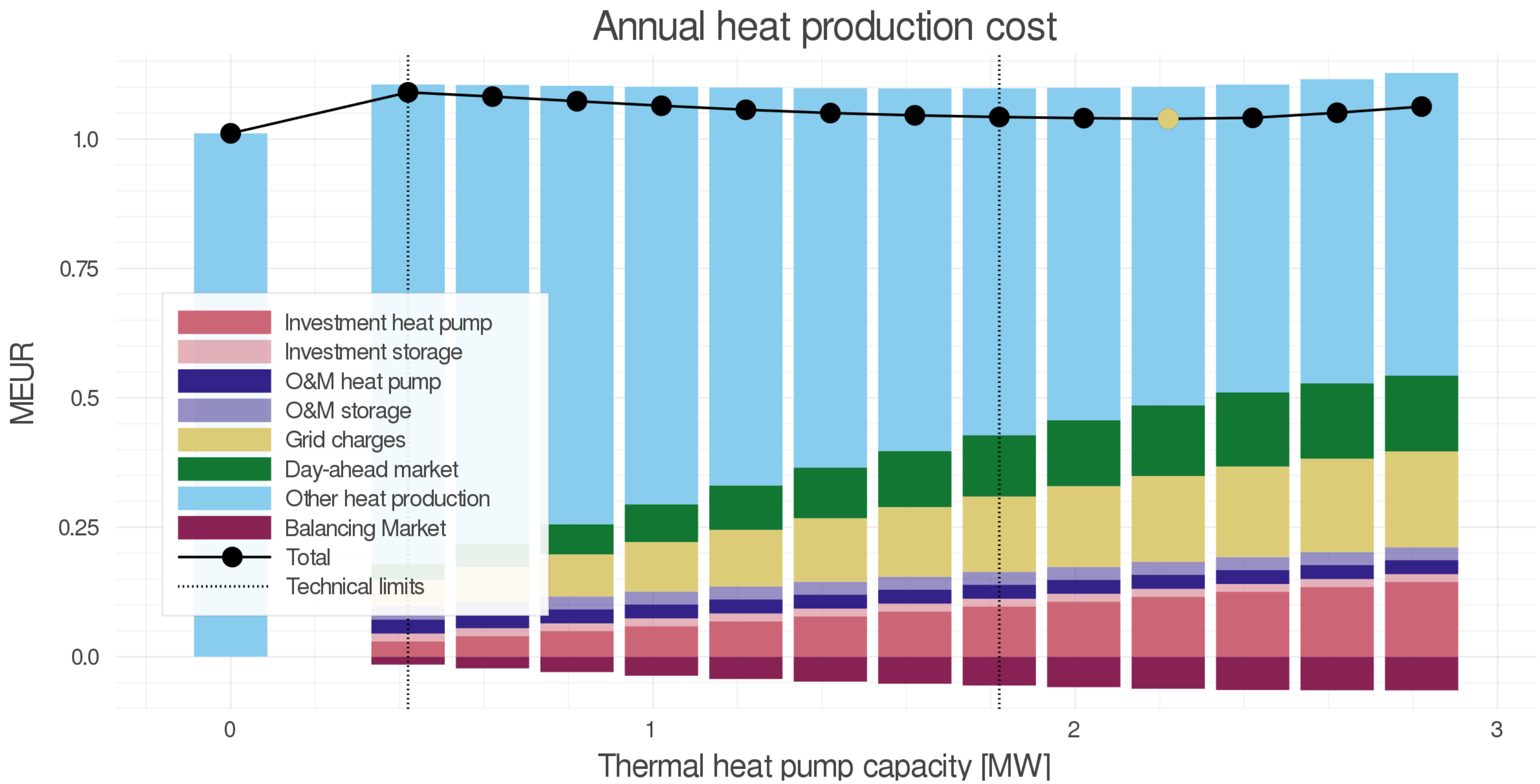
Balancing market

- Prices 2018
- Scenario *Return*
- 1.6 MW thermal power
- 6000l storage volume

Can different heat pump sizes provide better results with the balancing market?



Balancing market



Conclusions

- The results are very sensitive on input data (COP, electricity market prices)
- The storage investment is required for technical reasons. Economically, it does not provide benefits.
- The total investment is not quite feasible in the constrained scenarios.
- Considering the balancing market for heat pump operation provides additional benefits.

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