Assessment of the economic viability of the integration of industrial waste heat into existing district heating grids

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Motivation

- Remarkable amount of industrial waste heat currently unused
- Low-temperature heat demand in district heating grids
- Increase efficiency of the overall energy system by using this excess heat in district heating grids

→ Need for an understanding of the economic performance of industrial waste-heat-to-grid systems

Research question

"What is the economic feasibility of the integration of industrial waste heat into existing district heating grids under different conditions?"

→ identify the parameters that have the highest influence on the economic efficiency of industrial waste-heat-to-grid systems

→ estimate expectable supply costs for industrial waste-heat-to-grid systems

METHODOLOGY

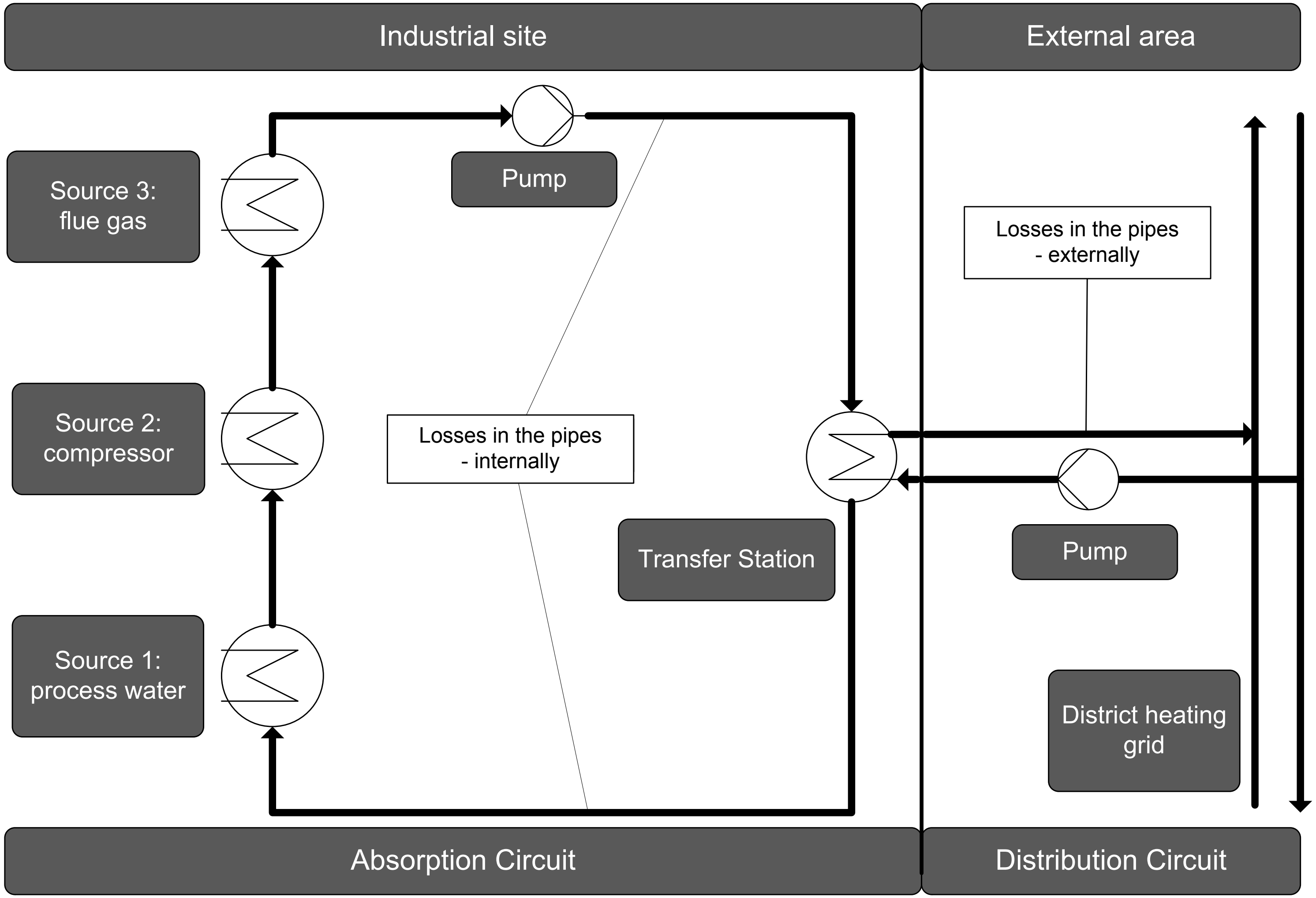
Methodology overview

(1) A **techno-economic modeling tool** is developed that simulates industrial waste-heat-to-grid systems on an hourly basis

(2) Data research is conducted on costs of industrial waste heat recovery and feed in district heating grid systems

(3) a **reference scenario** is defined and a **sensitivity analysis** is carried out in order to identify the parameters with the highest influence on the economic feasibility

System concept used for the analysis



Economic representation

- Calculated on the basis of one representative year
- Dynamic economic assessment: discounted cash flow calculation
- Chosen assessment value: Levelized Costs of Heat (LCOH)

$$LCOH = \frac{\sum_{t=0}^{\tau} C_t \left(1+r\right)^{-t}}{\sum_{t=0}^{\tau} E_t \left(1+r\right)^{-t}}$$

DATA & DEFINITION OF REFERENCE CASE

Costs for the waste-heat-to-grid system

➢ **Heat Exchangers, transfer station**: investment, O&M

$$c_{invest} = a\, Base^{b} + c$$

heat exchanger	base value in the cost curve	parameters of the cost curve				
		a	b	c		
plate heat exchanger	heat transfer surface [m²]	410	-0.30	200	300 - 400	€/m²
compressor heat exchanger	rated motor power [kW]	199	-0.32	21	50 - 80	€/kW
tube bundle heat exchanger	heat transfer surface [m²]	363	-0.10	265	500 - 550	€/m²
transfer station	transfer power [kW]	1,048	-0.63	3	10 - 15	€/kW

➢ **Pipes**: investment for pipes and insulation

- 27 – 213 €/m inside plant area (above ground, 25 – 150 mm)
- 300 – 500 €/m outside plant area (underground, 25 – 150 mm)

➢ **Pumps**: Investment, O&M, electricity

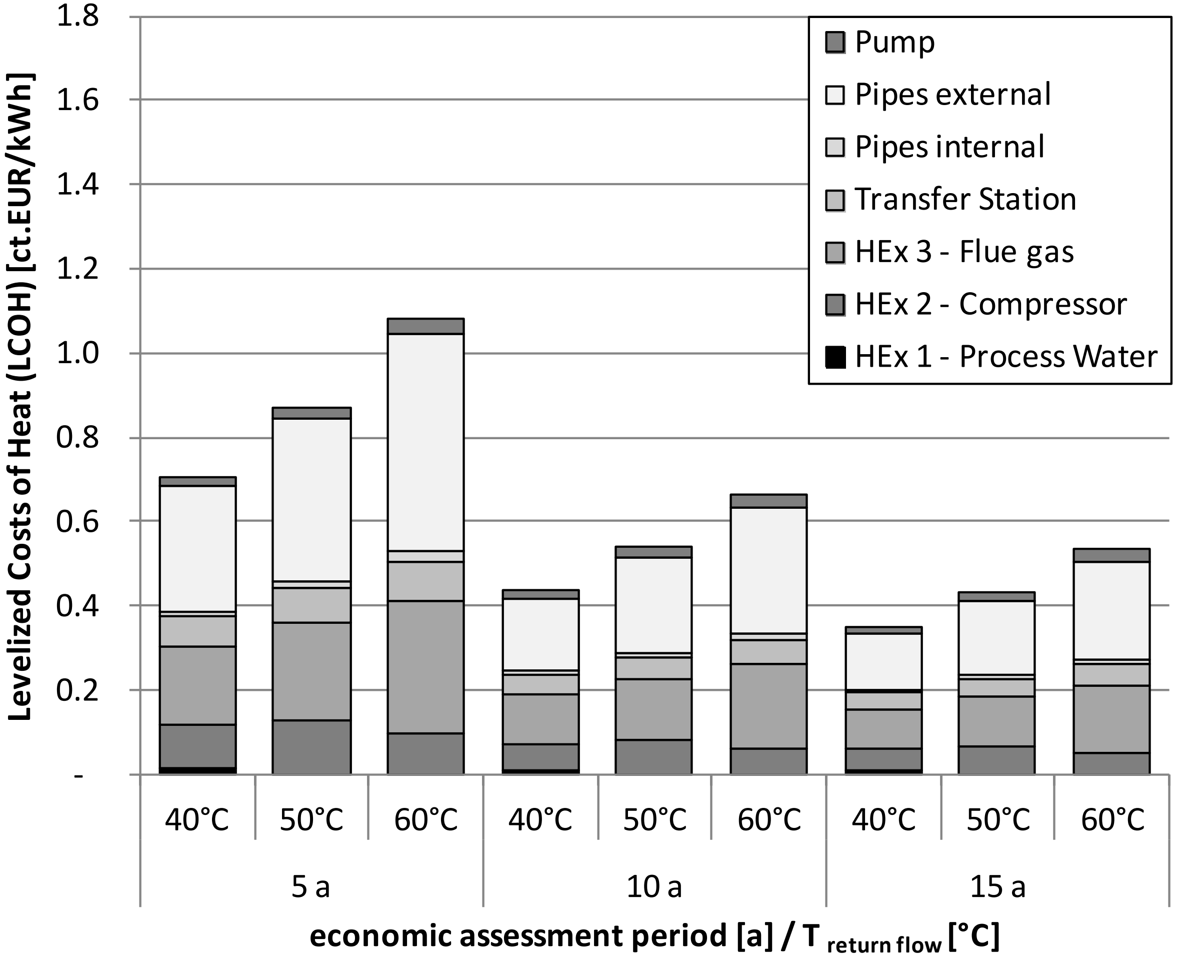
- 1500 – 6900 € (32 – 150 mm)
- 11 ct.EUR/kWh electricity

Definition of the reference case

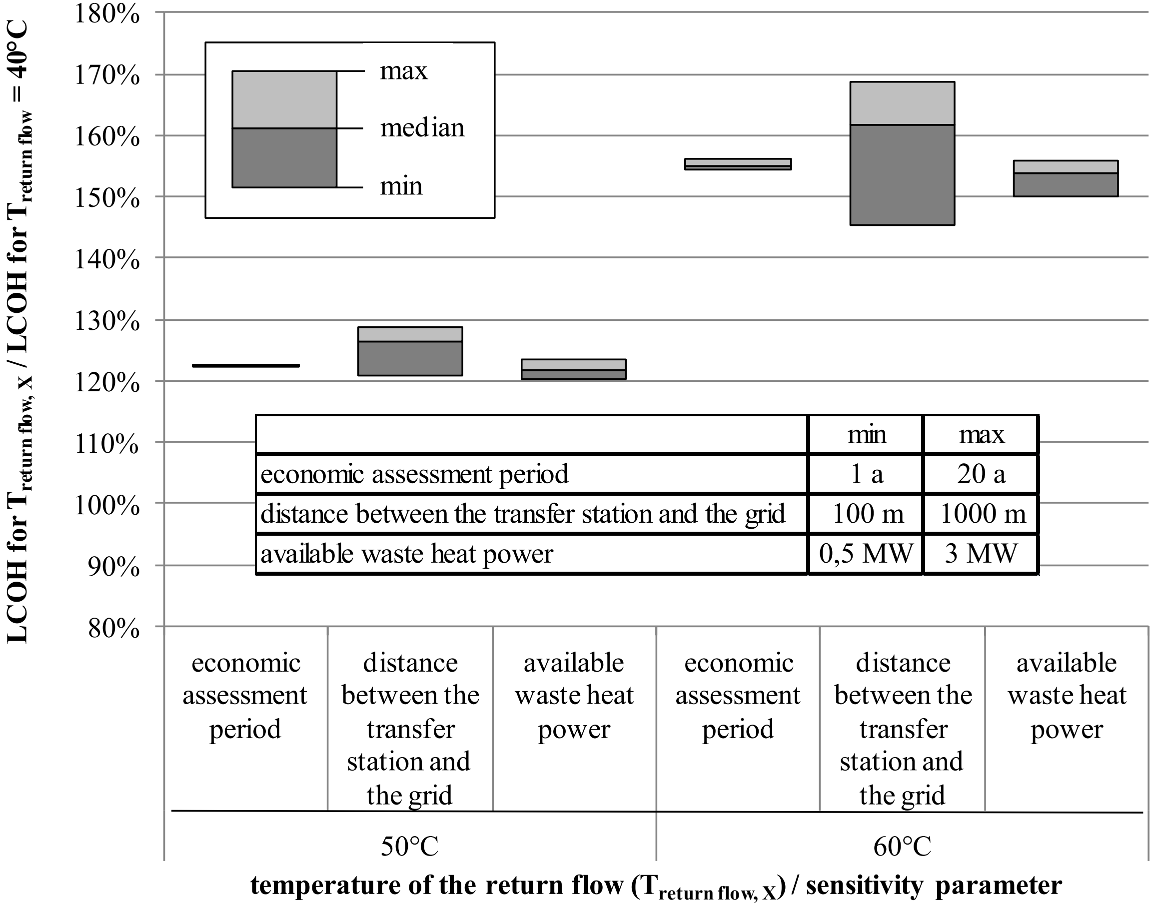
parameter	unit	reference case	range of sensitivity analysis
available waste heat power	MW	1	0,5 - 3
$T_{\text{return, district heating grid}}$	°C	50	40, 50, 60
$T_{\text{flow, district heating grid}}$	°C	70 - 90	no variation
economic assessment period	a	10	1 - 20
interest rate	%	7	no variation
distance between the transfer station and the grid	m	250	100 - 1000
load profile	-	2 shifts, no weekends, no holidays	2 / 3 shifts, weekends yes/no, holidays yes/no

RESULTS

return temperatures of the district heating grid, economic assessment periods, cost components

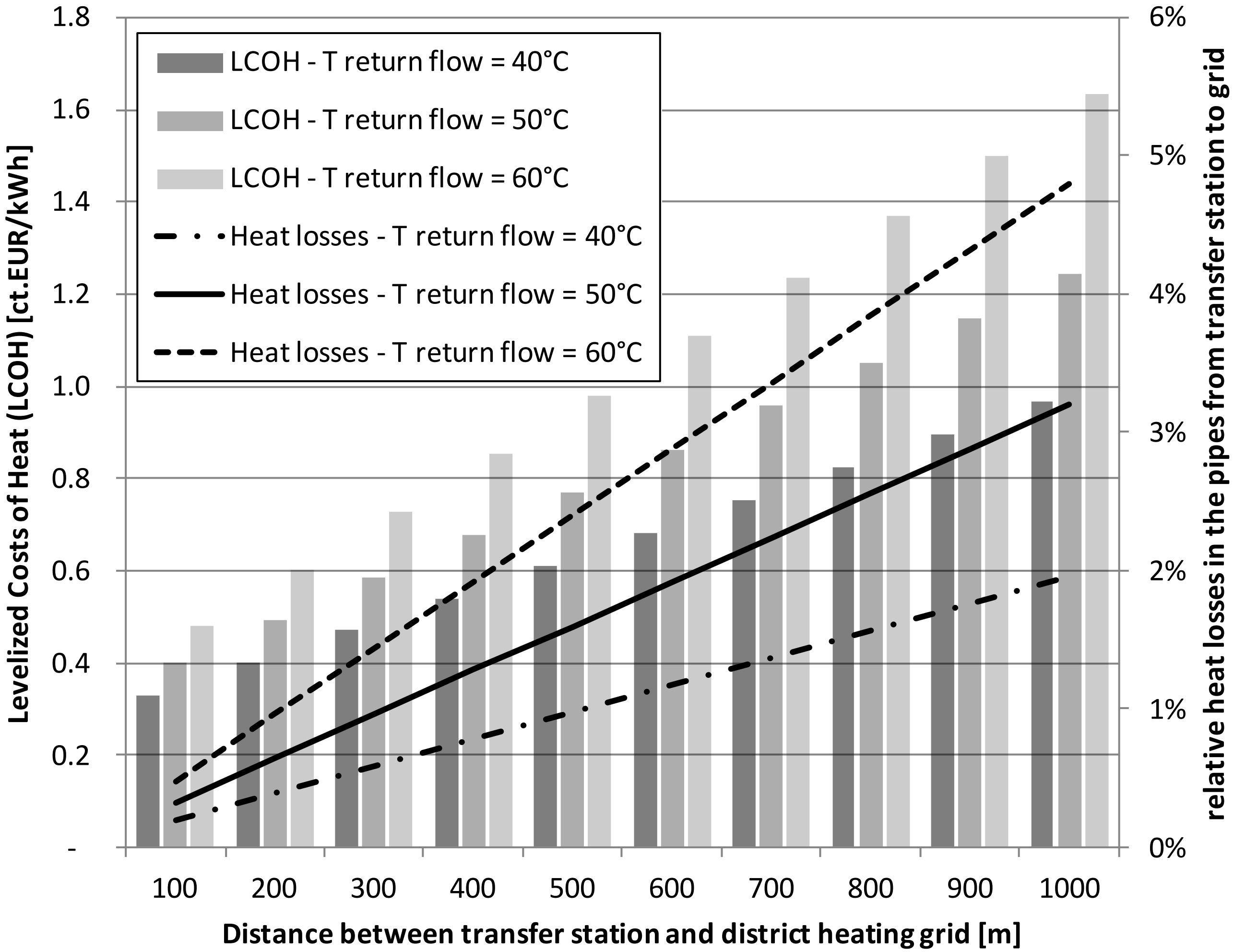


Sensitivity comparison

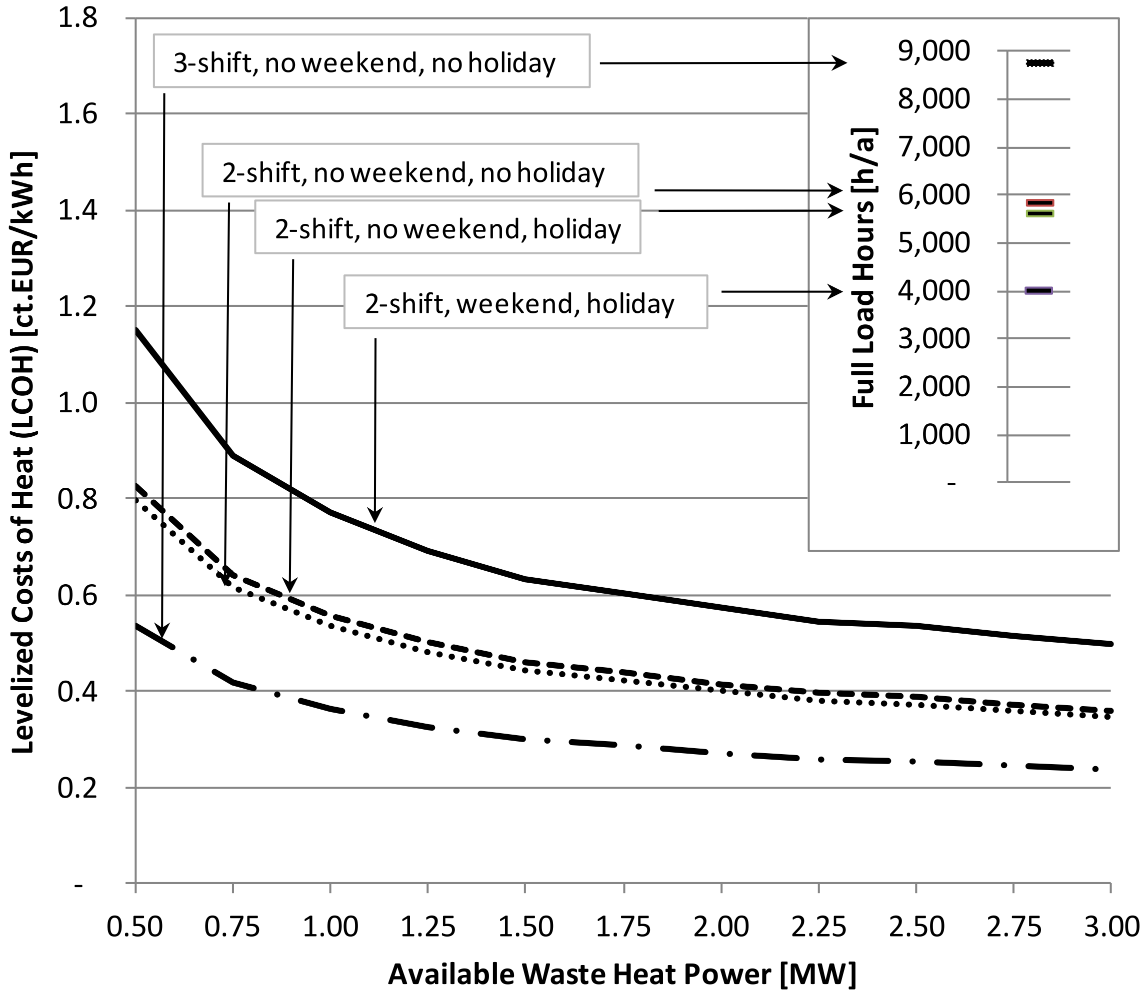


	min	max
economic assessment period	1 a	20 a
distance between the transfer station and the grid	100 m	1000 m
available waste heat power	0,5 MW	3 MW

return flow temperature, distance to grid



available waste heat power, full load hours



CONCLUSIONS & DISCUSSION

Conclusions & discussion

- Highly influencing factors on the economic efficiency of industrial waste-heat-to-grid systems:
  - return temperature of the district heating grid
  - distance between transfer station and the district heating grid
  - economic assessment period
  - available waste heat power
  - full load hours of the system

- For many combinations of these parameters → costs below 1 ct.EUR/kWh (purchase prices in Europe 4 – 5 ct.EUR/kWh)

- However, this is a first and theoretical estimation!

Further important aspects – at the plant side

- **Variation of load and temperature profiles for waste heat from various processes:** strong assumption that all processes have the same load profiles for this study

  → Storage tank needed, increase of costs especially for short economic assessment periods

- **Differences in materials treated within the processes:** sometimes need for special materials of the heat exchangers to avoid erosion

  → remarkable increase in the investment costs possible

Further important aspects – at the grid side

- **High flow temperatures in some existing district heating grids**: In primary parts of large district heating grids also temperatures up to 110°C and above occur (vs. 70 – 90 °C in this study)

  → reachable with waste heat or heat pump needed?

- **Limitations regarding the amount of waste heat to be integrated:** depends on the existing supply structure in the grid (base load in summer approx. 10% of peak load in winter)

  → could be a barrier for implementation if base load is filled with waste incineration (often occurring in large cities)

Questions for the discussion

- What is your experience regarding costs for HEx and piping?
- Do you know data sources for further research: costs for components / transaction / permission?
- Do you have (heard of / seen) calculations for industrial waste-heat-to-grid systems? What were the results there?

→ Thank you!