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WEBINAR ON HIGH TEMPERATURE HEAT PUMPS

7 NOVEMBER 2024

Case study Gustav Spiess: Integration concept and status

Cordin Arpagaus, OST

Spiess
Wurst für Feinschmecker.

Outline

- Introduction to the company
- Motivation for a HTHP
- Process, energy consumption, temperatures
- Status of the case study
- Challenges and next steps

Introduction & Motivation

- Family-owned company in Berneck, St. Gallen
- 160 employees
- Meat and meat products, such as sausages, ham, and bacon
- February 2023: Start production in new building

Introduction & Motivation

- New production building, including new energy supply
- Waste heat from NH_3 chillers and compressed air generation
- CO_2 reduction 2030/2050
    - Internal goals
    - SFOE agreement about CO_2 reduction
    - SBTi (Science-based Targets Initiative)
        - Reducing its Scope 1 (direct, electricity) and Scope 2 (indirect) greenhouse gas emissions by 50% by 2030 (2018 base)
        - Measuring and reducing its Scope 3 emissions

Introduction & Motivation

- Process, energy consumption, temperatures

2023

Natural gas
~ 1 GWh/y

2025
(estimate)

HTHP el.   COP ~ 2
~ 0.6 (0.3 el.) GWh/y

Natural gas
~ 0.4 GWh/y

Cooking meat products

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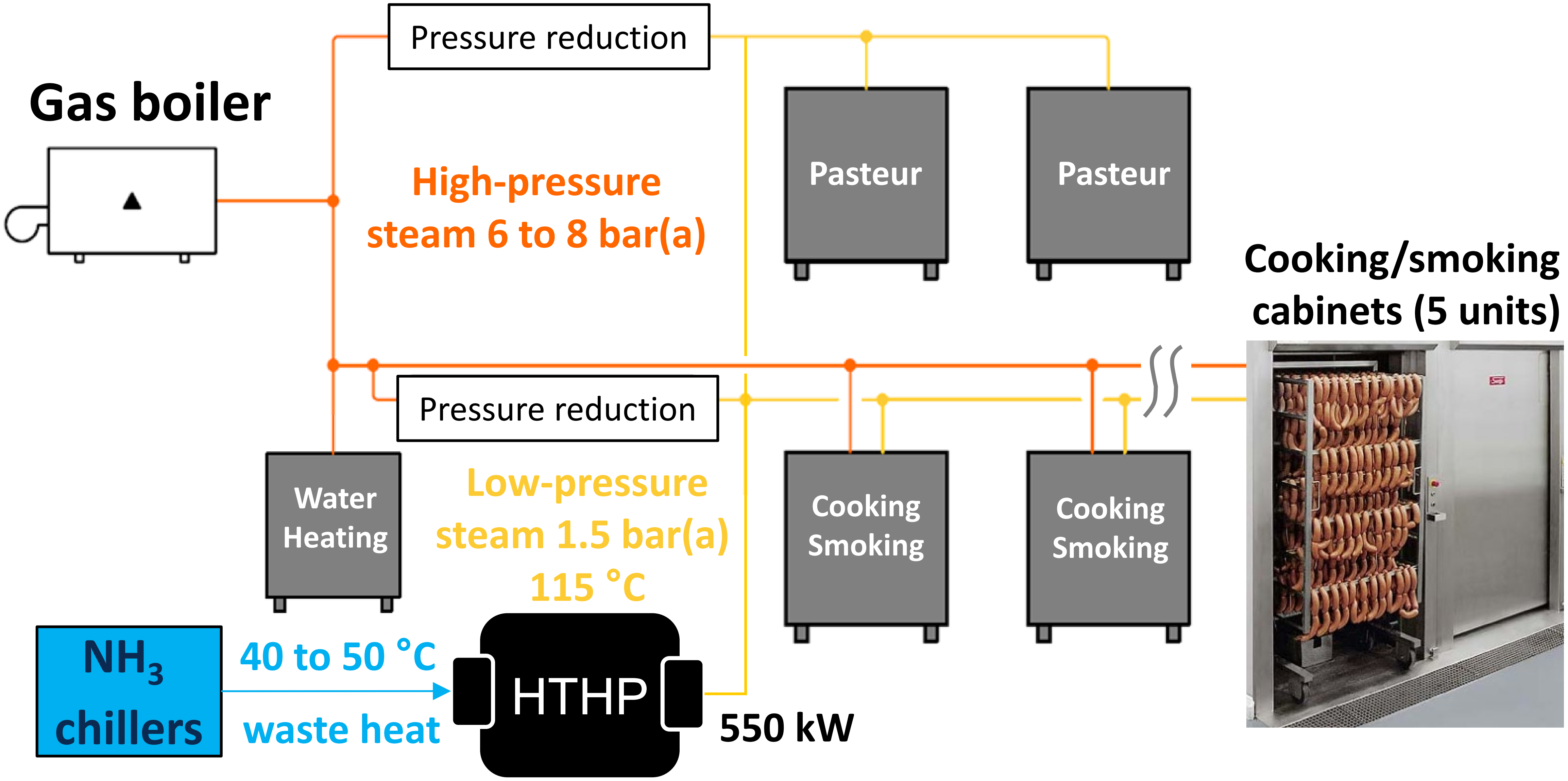
Cabinets
85 to 90 °C

Steam: 1.5 bar(a)
direct
wet heat

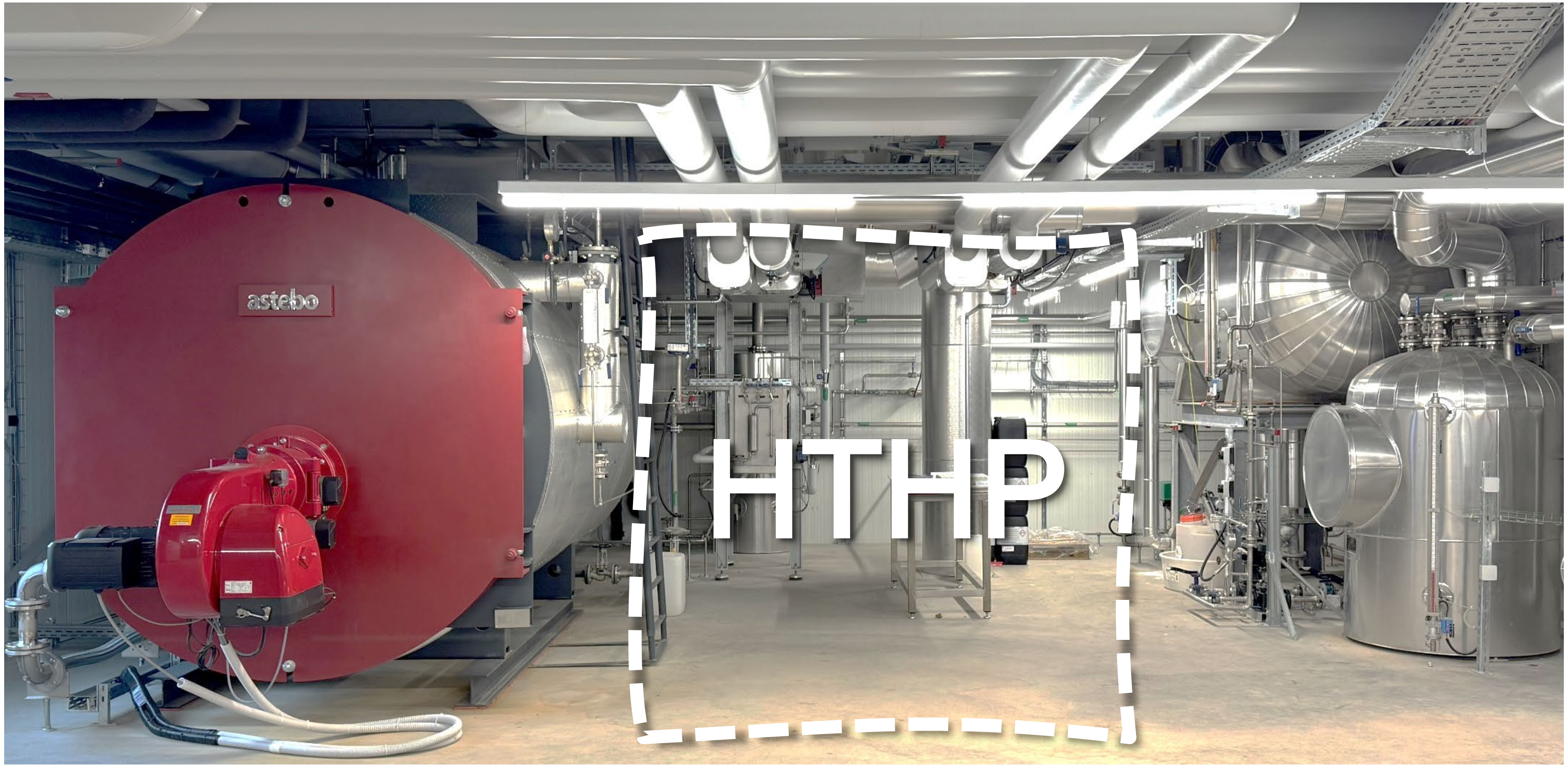
Steam: 8 bar(a)
heat exchanger
dry heat

HTHP Integration Concept



HTHP Integration Concept

Space for the HTHP beside the gas/oil boiler is restricted

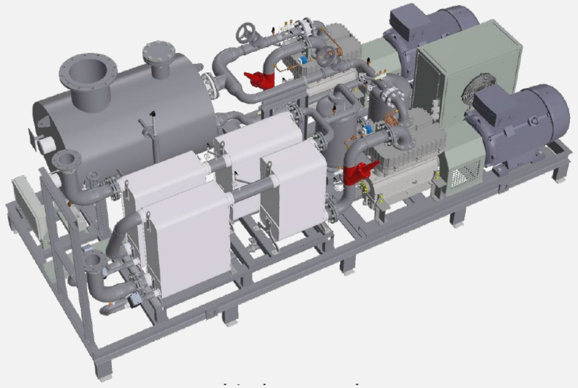


Flammable refrigerants would lead to additional costs for safety installations

Possible HTHP Technology

Heaten AS

HeatBooster HBL4-W/S
R1336mzz(Z)
R1233zd(E)
750 kW
670 kEUR
COP 2.8



SPH Sustainable Process Heat GmbH

ThermBooster LS2
R600 (n-butane)
634 kW
830 to 850 kEUR
COP 2.9

ThermBooster LS1-2
R515B/R1233zd(E)
652 kW
550 to 650 kEUR
COP 2.6

Ochsner Energietechnik GmbH

IWWDS ER4b
R1233zd(E)
550 kW
500 kEUR
COP 2.4

Combitherm GmbH

HWW 9583
R1233zd(E)
550 kW
540 kEUR
COP 2.4

Specific investment costs (excl. planning and integration):
840 to 1’000 EUR/kW (HFO refrigerants), 1’300 EUR/kW (n-butane)
COP between 2.4 to 2.9

Status: 01/2024

Energy costs & Economic calculation

Input parameters		
Heat sink inlet/outlet temperature	**°C**	**20/115 (1.5 bara steam)**
Heat source inlet/outlet temperature	**°C**	**50/45**
Temperature lift	**K**	**65**
Heating capacity	**kW**	**550**
Fuel (gas, oil) price	EUR/kWh	0.17
Electricity price	EUR/kWh	0.25
Electricity-to-fuel price ratio	-	1.47
CO_2 tax (or subsidies)	EUR/tCO_2	92.5
Electricity CO_2 emissions factor	kgCO_2/kWh	0.012
Fuel CO_2 emissions factor	kgCO_2/kWh	0.201
Annual operating time (12 h/d, 250 d/a)	h/a	3’000
Efficiency of fuel boiler	-	0.90
Maintenance factor (on capital costs)	-	0.04
Cost factor for planning & integration	-	2.0
COP ($COP = 52.94 \cdot \Delta T_{lift}^{-0.716}$)	**-**	**2.67**
Specific investment costs (HTHP)	**EUR/kW**	**840**

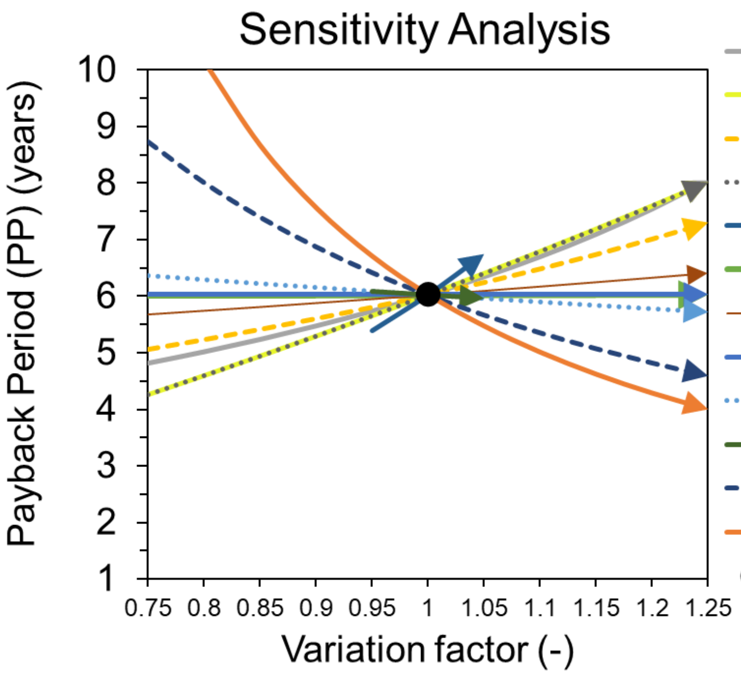
Status: 01/2024

Results at reference (Ref) conditions

Output parameters		
Total investment costs	**kEUR**	**924**
Annual CO_2 emissions reduction	tCO_2/a (%)	361 (98%)
Annual energy savings	MWh/a (%)	1’214 (66%)
Annual fuel cost savings	kEUR/a	312
Annual electricity costs	kEUR/a	155
Annual heat pump maintenance costs	kEUR/a	37
Annual CO_2 tax compensation	kEUR/a	33
Annual cost savings	**kEUR/a**	**153**
Discount rate	%	5
Payback period	**a**	**6.0**
Discounted payback period	**a**	**7.3**

Status: 01/2024

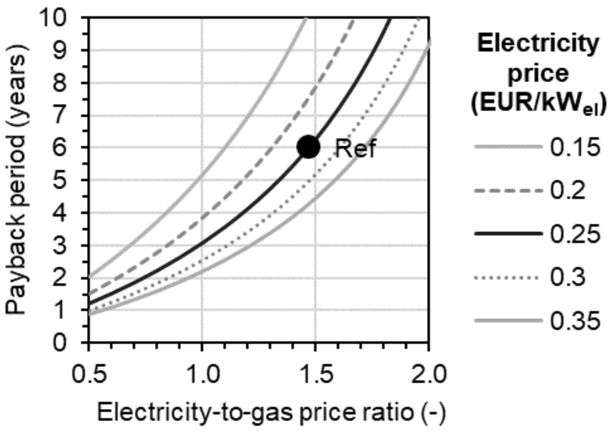
Payback & Sensitivity Analysis

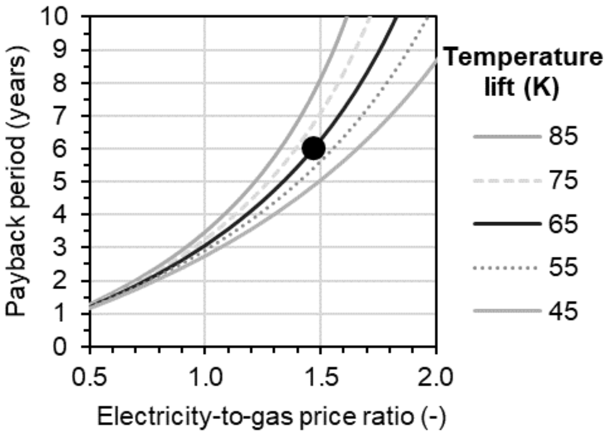


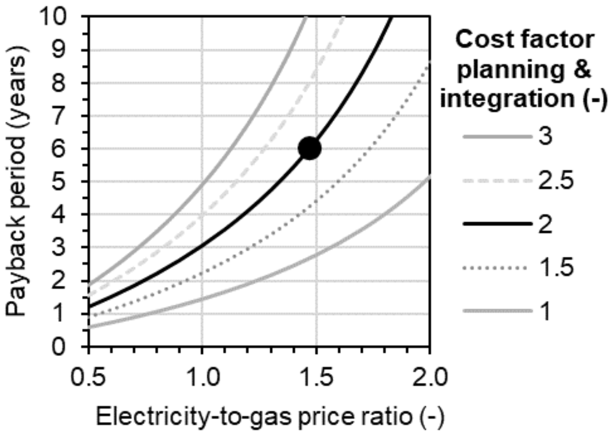
Parameter		-	Ref	+	Unit
Electricity price	PP ↑	0.19	0.25	0.31	EUR/kWh
Specific investment costs		630	840	1050	EUR/kWh
Temperature lift		49	65	81	K
Cost factor planning & integration		1.5	2.0	2.5	-
Efficiency of fuel boiler		0.86	0.90	0.95	-
CO_2 emissions factor of electricity		0.009	0.012	0.015	kgCO2/kWh
Maintenance factor		0.03	0.04	0.05	-
Heating capacity		413	550	688	kW
CO_2 tax		69	92.5	116	EUR/tCO2
CO_2 emissions factor of fuel		0.151	0.201	0.251	kgCO2/kWh
Annual operating time	PP ↓	2250	3000	3750	h/a
Fuel price (gas, oil)		0.13	0.17	0.21	EUR/kWh
Reference Case		-	Variation	+	

550 kW, 50 °C/115 °C (Heat source/sink), COP = 2.67

PP = 6.0 years, DPP = 7.3 years



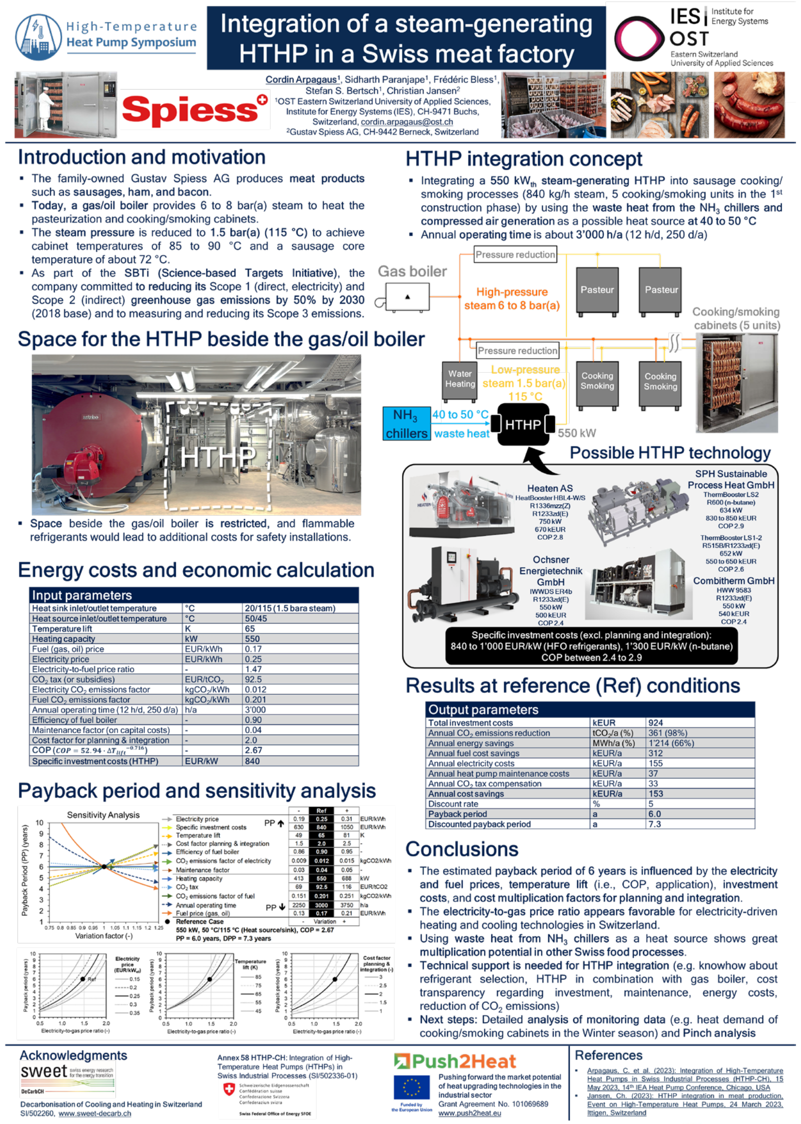




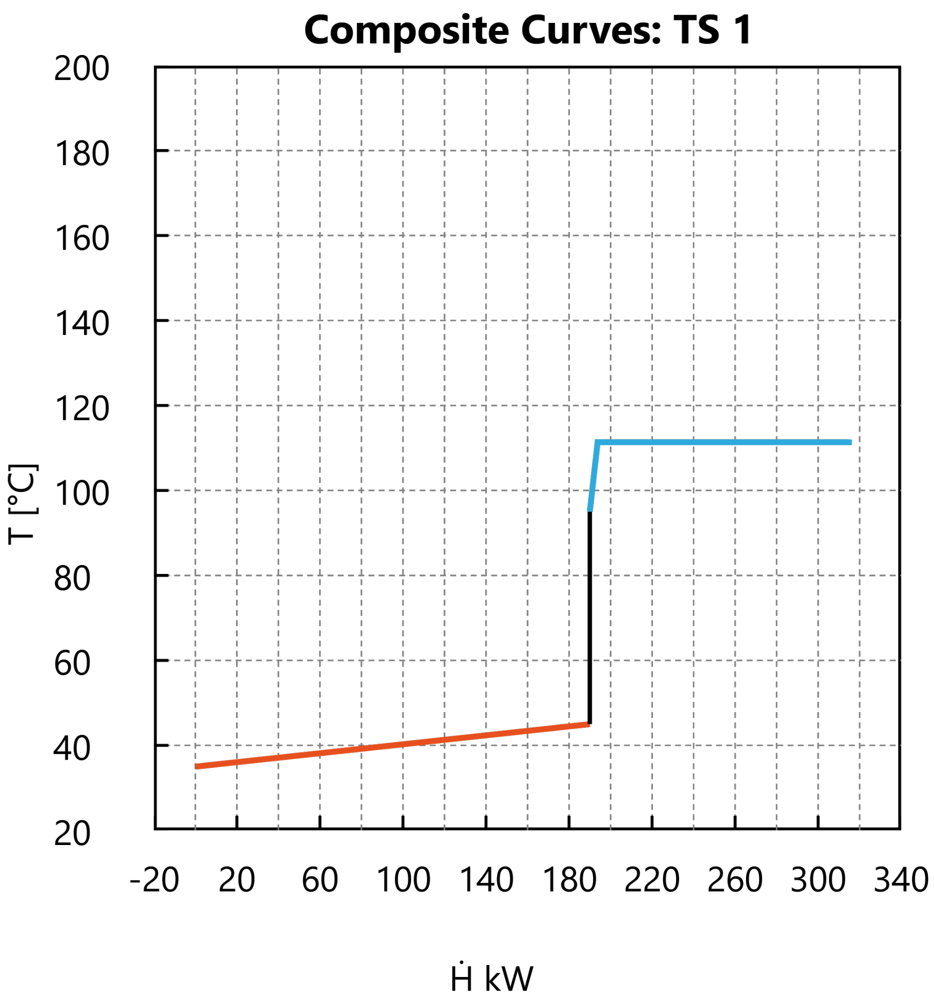
Status: 01/2024

Preliminary Conclusions

- **Payback period influenced by:**
  - electricity and fuel prices (electricity-to-gas price ratio),
  - temperature lift (i.e., COP, application),
  - investment costs,
  - operating hours, and
  - cost multiplication factors for planning and integration.
- **Waste heat from NH_3 chillers as heat source** shows **multiplication potential** in other Swiss food processes
- **Technical support is needed** for HTHP integration
- **Next steps: Detailed analysis of monitoring data** (e.g. heat demand of cooking/smoking cabinets in the Winter season) **and Pinch Analysis**



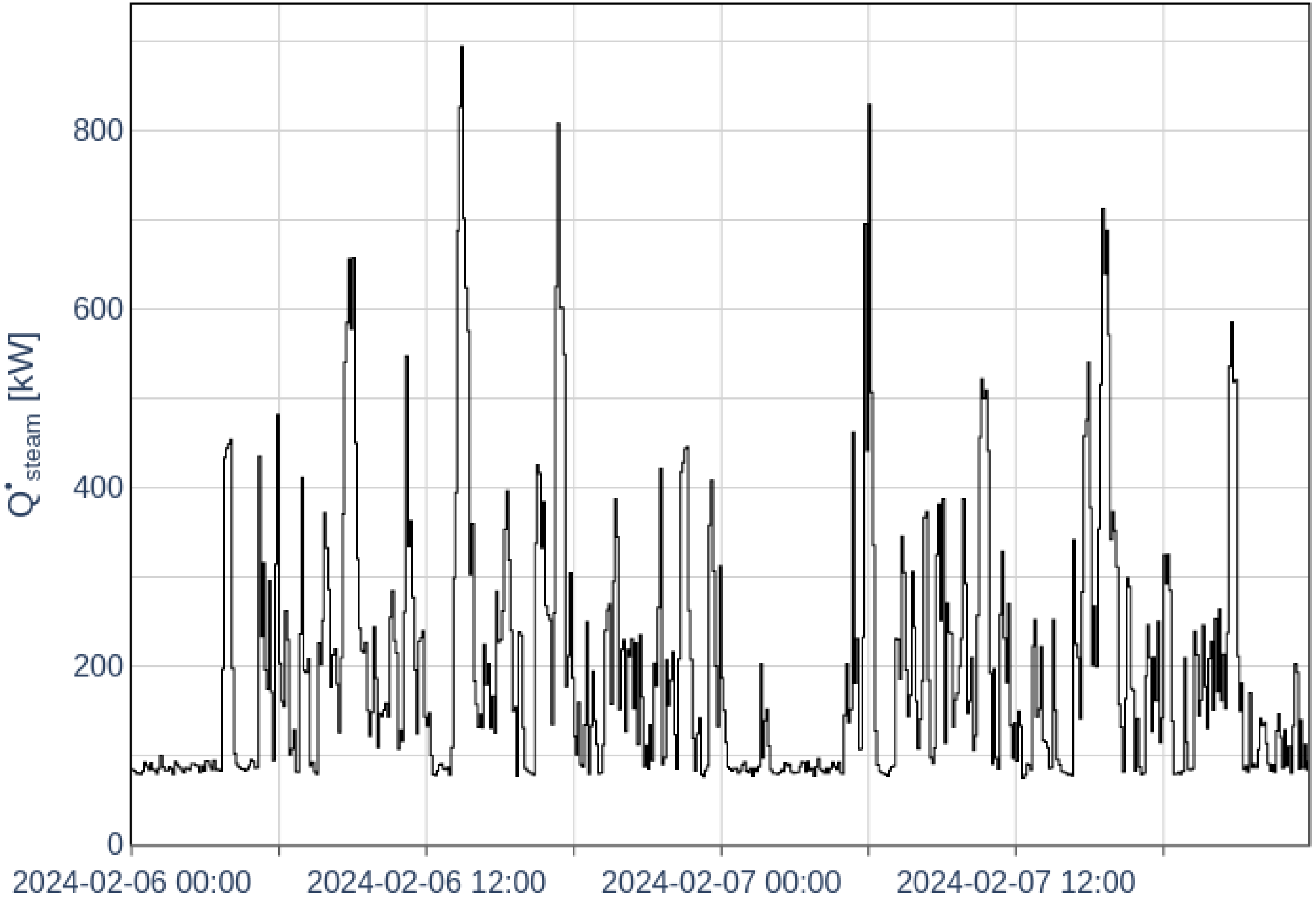
Pinch Analysis – Composite Curve



Source: Flimatec AG, Horw

- **Example Composite Curve over a 11 hours timeslice** with average steam consumption and waste heat from refrigeration (i.e. simplified with 2 streams)
- **Pinch temperature: 70 °C**
- **Steam demand: 125 kW**
- **Waste heat from refrigeration: 190 kW**
- (Gustav Spiess AG has an efficient heat recovery network in place in the new production building)

Measured Steam Profile



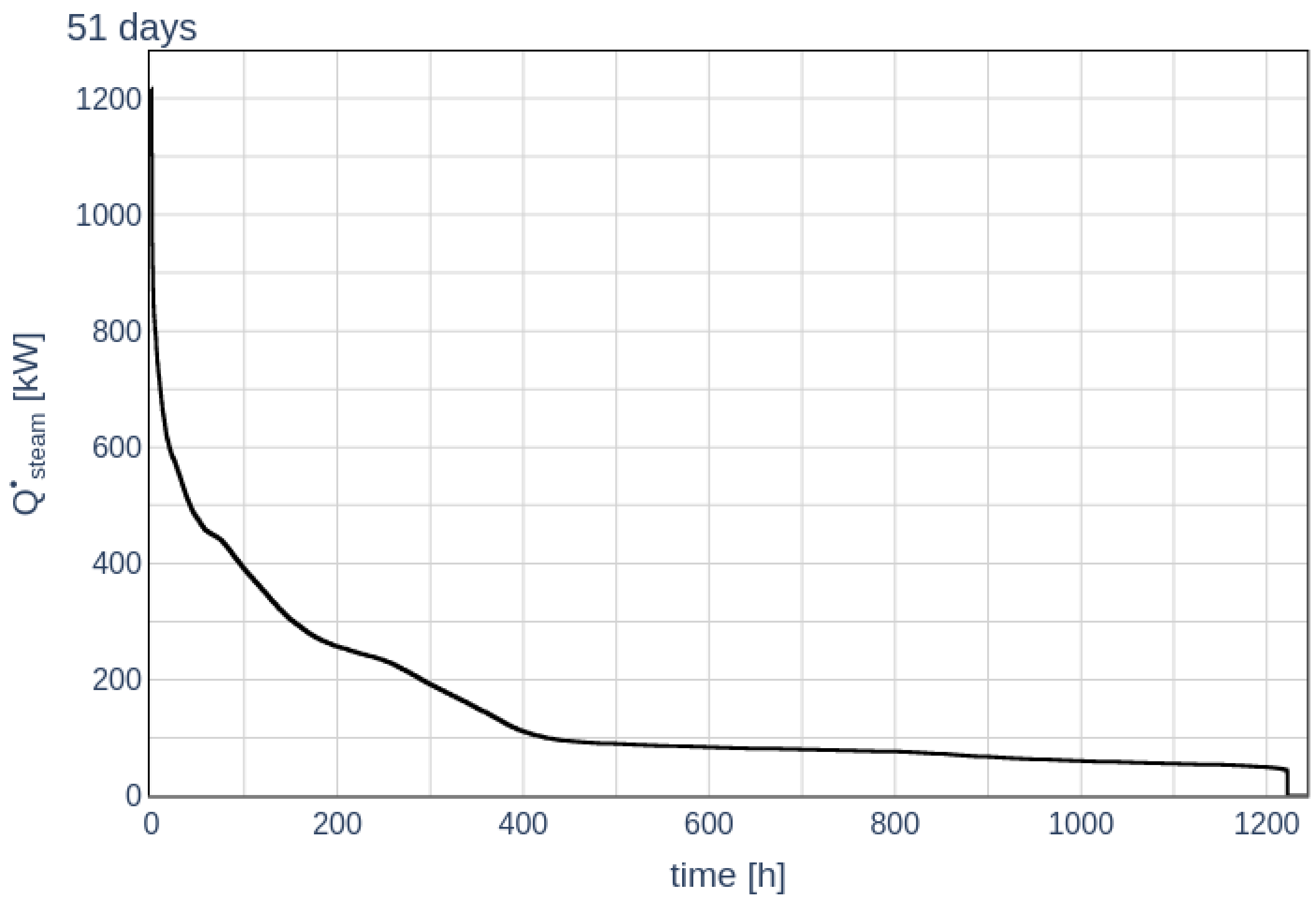
Challenge:
Fluctuating steam demand as an example for one production day

Source: Flimatec AG, Horw

FLIMATEC
Ihre persönlichen Energieberater.

Measured Steam Profile

Cumulative steam demand for 51 measurement days



Challenges:
smaller heating capacity, lower operating hours

Source: Flimatec AG, Horw

Conclusions

- **Steam-generating HTHP is technically feasible**
- **However, there are economic challenges**
  - High-temperature lift (i.e., low COP)
  - High investment costs
  - Low operating hours
  - High electricity prices and low gas prices
- **Steam profile and monitoring data** are essential for decision-making and HTHP sizing (fluctuations, peak demands)
- **Pinch Analysis supports decision-making** (defines integration point, temperatures, heating capacity)

Published Literature

- Arpagaus, C., Bless, F., Bertsch, S.S., Jansen, Ch: Integration einer dampferzeugenden Wärmepumpe in einer Schweizer Fleischfabrik, 30. Tagung des BFE-Forschungsprogramms «Wärmepumpen und Kältetechnik», 26. Juni 2024, Eventfabrik Bern, Link zum Tagungsband (Poster)
- Arpagaus, C., Paranjape, S., Bless, F., Bertsch, S.S., Jansen, Ch.: Integration of a steam-generating HTHP in a Swiss meat factory, HTHP Symposium 2024, 23-24 January 2024, Copenhagen, Denmark, Link to Book of Presentations
- Arpagaus, C., Bless, F., Bertsch, S., Krummenacher, P., Krummenacher, Flórez-Orrego, D.A., Pina, E.A., Maréchal, F., Calame Darbellay, N., Rognon, F., Vesin, S., Achermann, P., Jansen, Ch.: Integration of High-Temperature Heat Pumps in Swiss Industrial Processes (HTHP-CH), 15 May 2023, 14th IEA Heat Pump Conference, Chicago, USA
- Jansen, Ch. (2023): Case Study Gustav Spiess AG, HTHP integration in meat production, Event on High-Temperature Heat Pumps, 24 March 2023, Ittigen, Switzerland

Thank you for your attention!