

DECARBONIZING INDUSTRIAL HEAT FOR A SUSTAINABLE FUTURE.

High-temperature Heat Pumps Overview and Applications up to 200°C

presented at:



HEATO Group presents
Webinar 2025

THE FUTURE OF HEAT SUPPLY

High temperature heat pumps & CHP technology for
industrial and municipal heat supply



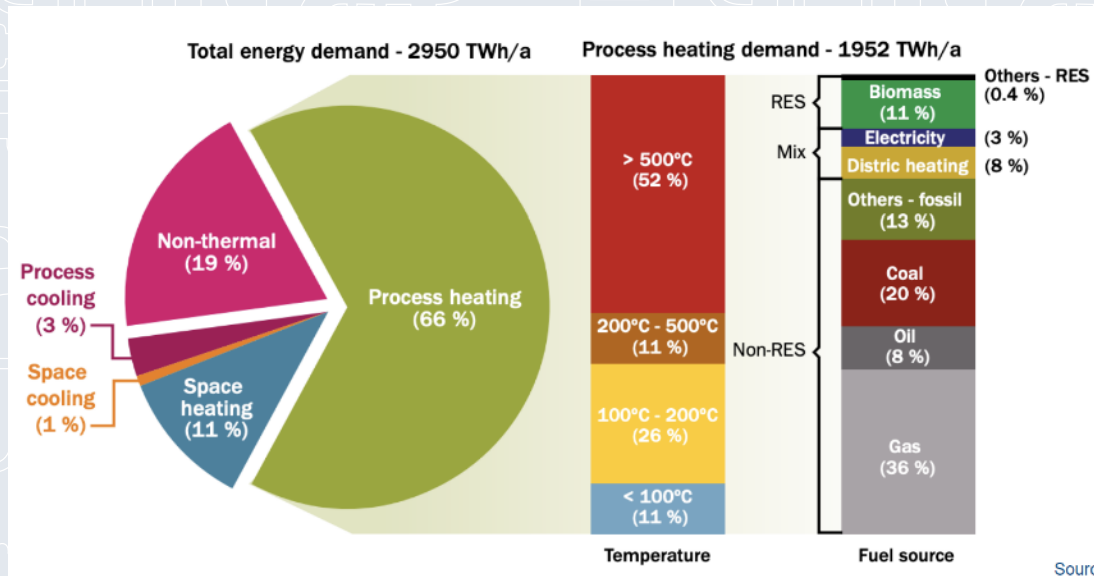
December 10,
2025



11:00 AM
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WHY HIGH TEMPERATURE HEAT PUMP?



Heat type	Capital expenditures, million €/MW	Operational expenditures, million €/MWh
Biomass	0.5	25–30
Solar thermal	~3.0–7.0	20–30
Hydrogen	0.15	80–200
Biogas	0.5	25–30
Electric	0.15	~50
Thermal storage	0.1–0.3	30–40
Heat pumps ¹	0.5 ²	~25 ²

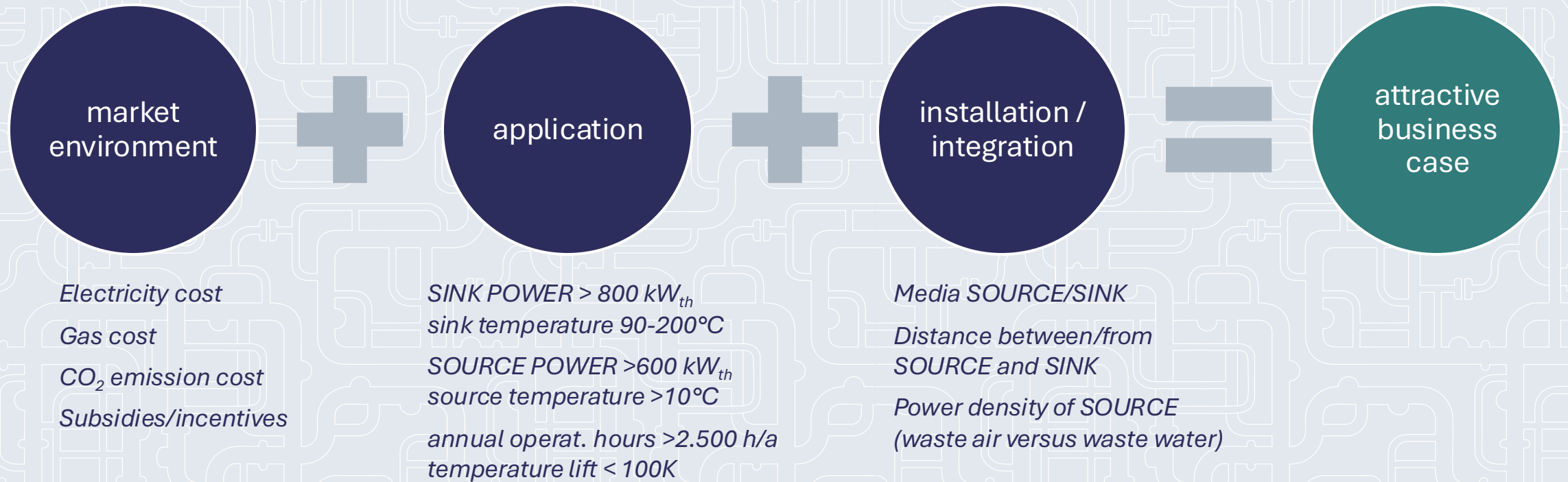
¹Mechanical vapor recompression recovering waste heat.
²Sensitive on waste heat, start temperature, and lift, based on a heat price of €50/MWh.

- ▶ **Huge decarbonization potential: only 3% of process heat in Europe currently electrified, 78% based on fossil fuels**
- ▶ **Process heat need in the range of 100-200°C in Europe of 488 TWh/y corresponds to 150 Mt CO₂/y.**

HTHP are the solution for decarbonization of process heat up to 200°C:

- ▶ **HTHP have lowest lifecycle cost (CAPEX-OPEX) compared to other decarbonization paths.**
- ▶ **HTHP do not face scalability issues such as biomass / biogas.**
- ▶ **Electric power cost in Europe is too high for E-boiler.**

BUSINESS CASE FOR HEATEN HEAT PUMPS



HeatBooster

Efficient. Flexible. Scalable. Powerful.

HBL4 (4-cylinder)

- Sink thermal power 0.8–2.5 MW_{th}
- industrial applications, medium medium power range

HBL16 (16-cylinder)

- Sink thermal power 3.2–10.0 MW_{th}
- High power range with excellent flexibility

TEMPERATURE RANGE

- **Heat sink:**
90-200°C
/ water or steam
- **Heat source:**
10-150°C
/ water or steam
- Temperature lift up to 80K per compressor stage

MODULAR & FLEXIBLE CAPACITY

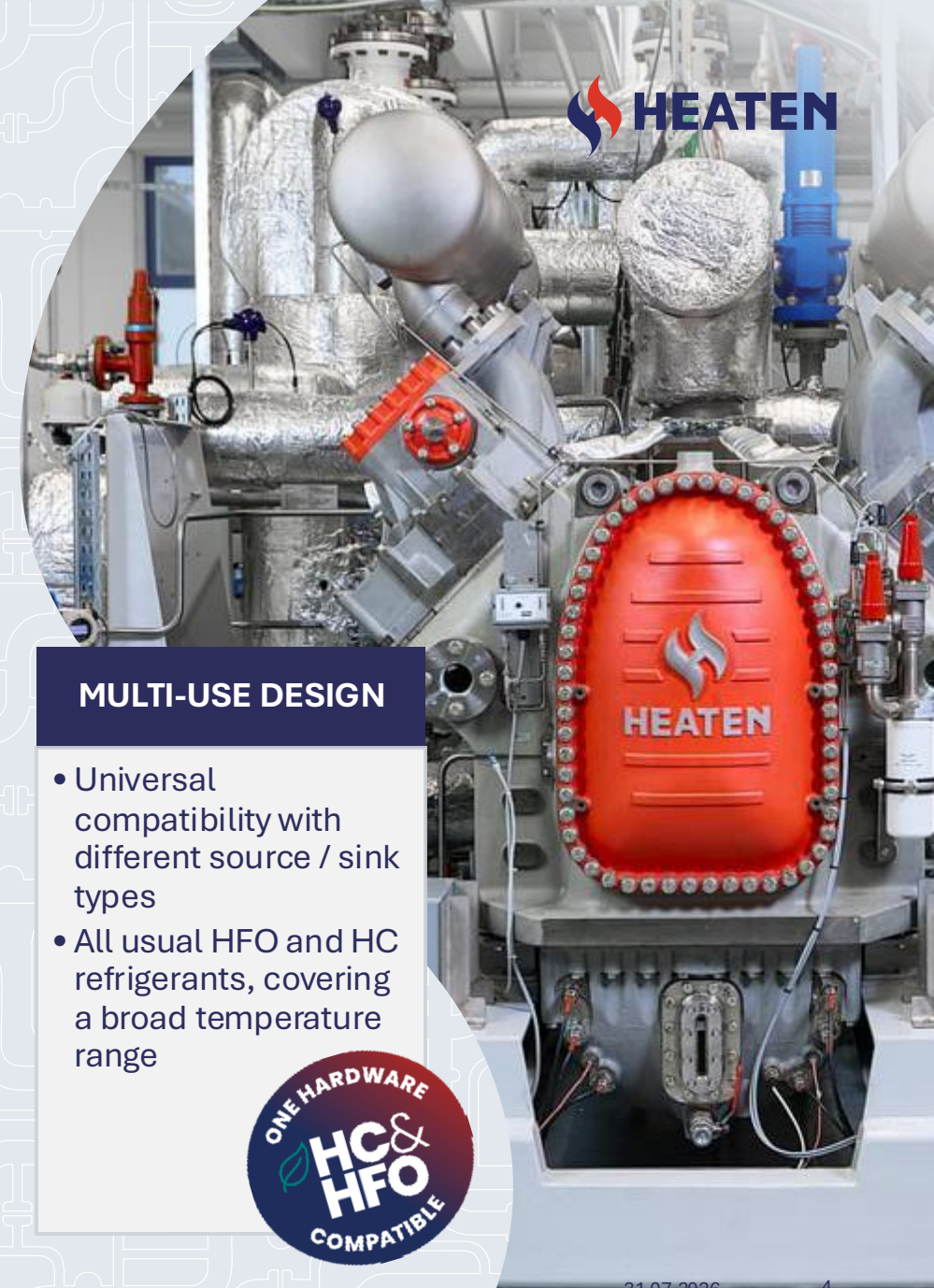
- Scalable, from **pilot** installation to full industrial power
- Modular setup by cascaded or parallel installation for **1 - 50 MW_{th}**

FLEXIBLE PART LOAD CAPABILITY

- High Carnot-quality down to 20% part load
- Variable, controllable temperature lift
- Excellent accommodation to thermal load
- possibility of grid balancing / energy arbitrage

MULTI-USE DESIGN

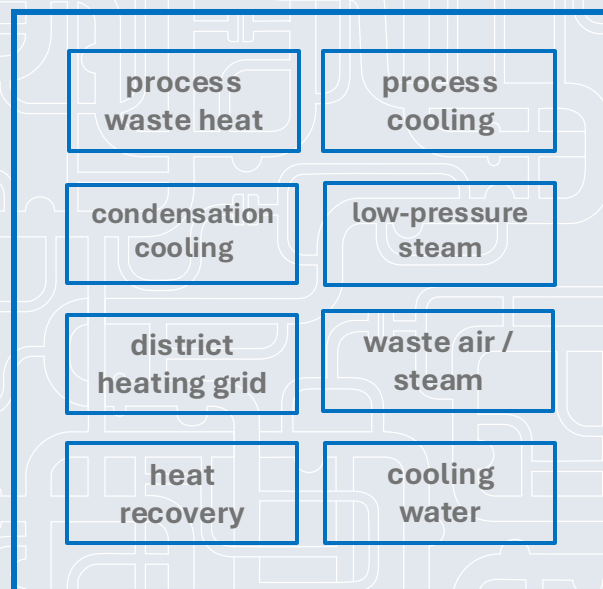
- Universal compatibility with different source / sink types
- All usual HFO and HC refrigerants, covering a broad temperature range



APPLICATION FIELDS

SOURCE (cooled by HP)

WASTE HEAT
water or steam



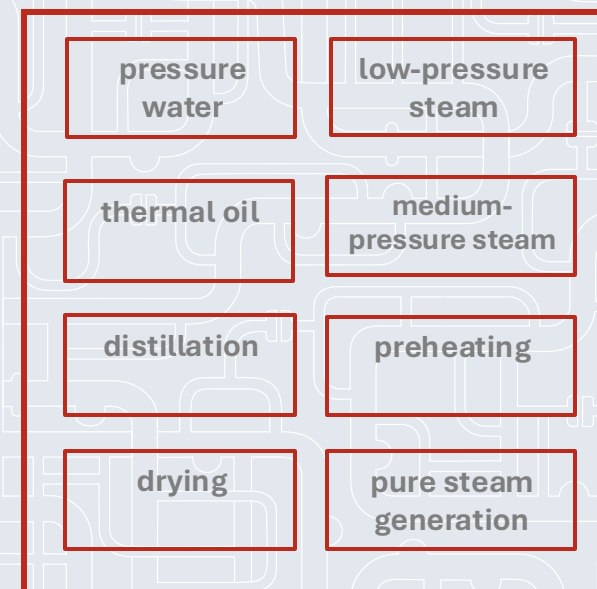
10-150°C



90-200°C

SINK (heated by HP)

PROCESS HEAT
water or steam



0,6 – 40 MW_{th}



Food, Beverages
& Ingredients



Chemical Industries
& Refineries



District Heating



Pulp & Paper

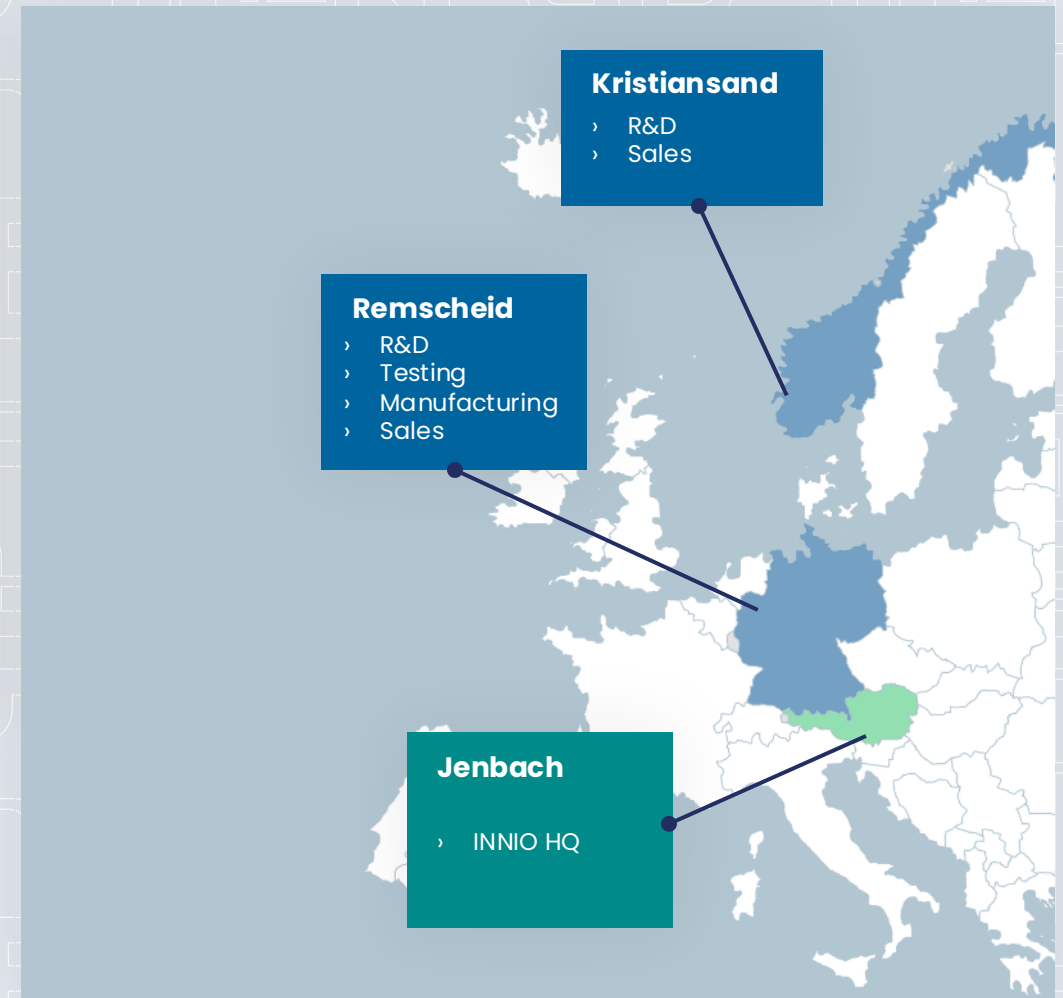
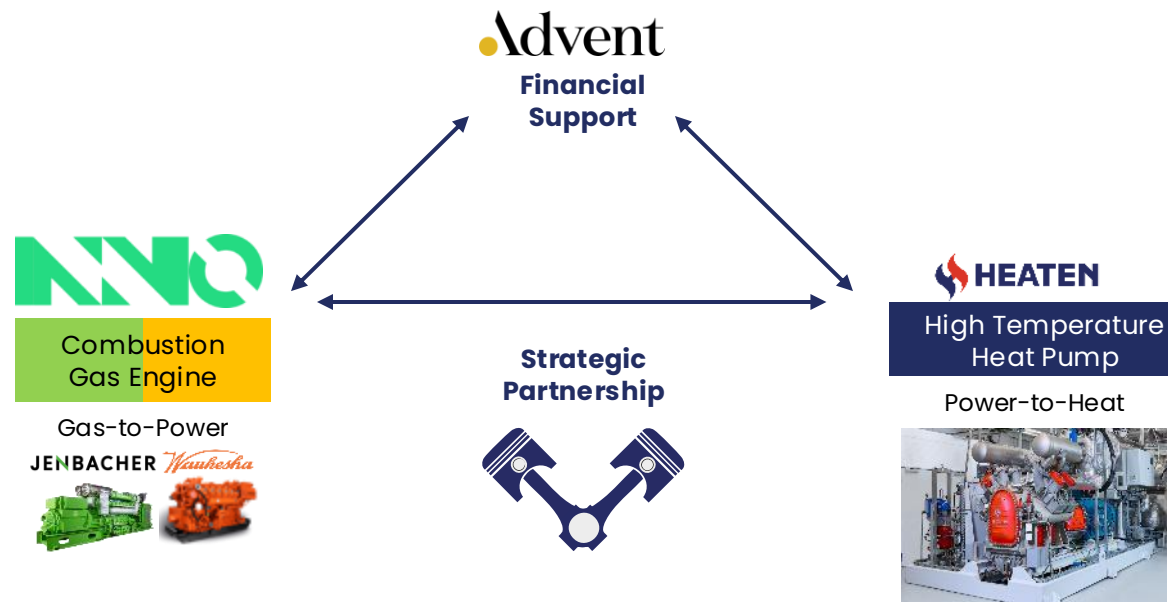


New Applications
(CCS, CCU, DAC)

1 – 50 MW_{th}

STRATEGIC PARTNERSHIP

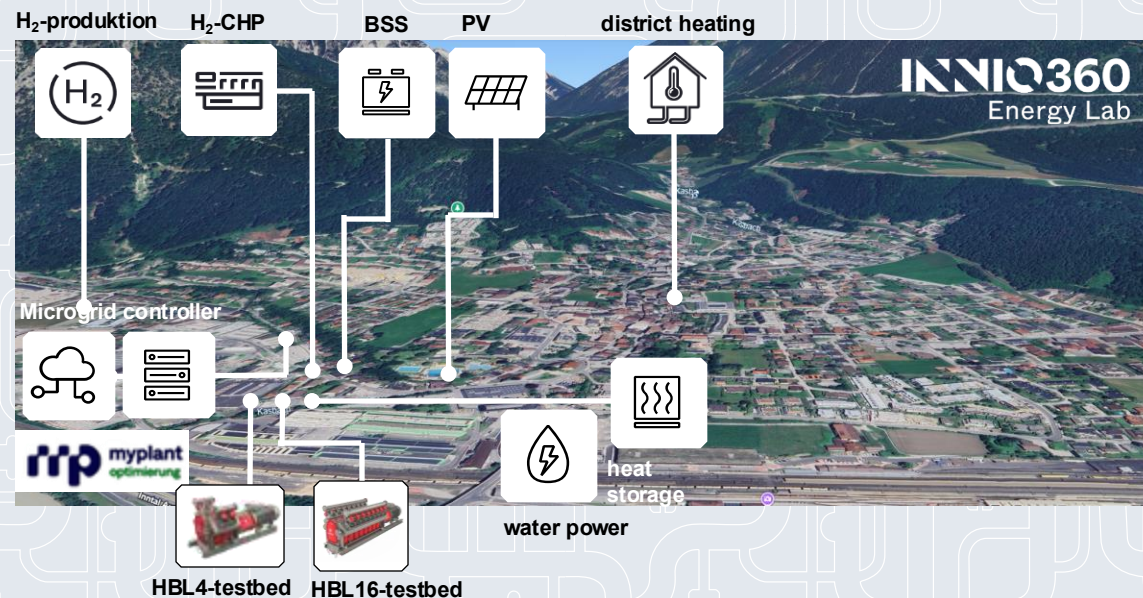
between INNIO and HEATEN



ROLLOUT HBL16 IN INNIO360 ENERGY LAB IN JENBACH

HBL4 and **HBL16** HTWP in INNIO360 Energy Lab in Jenbach (Ö), starting **2026**:

- ▶ 10MWth HTHP testbed
- ▶ HTHP as an element of microgrid / smart grid



1st customer delivery of **HBL16-W/W** in **2027** for HURRICANE District Heating Hub in Ghent (BE)

- ▶ water source **55°C**
- ▶ water sink **125°C**

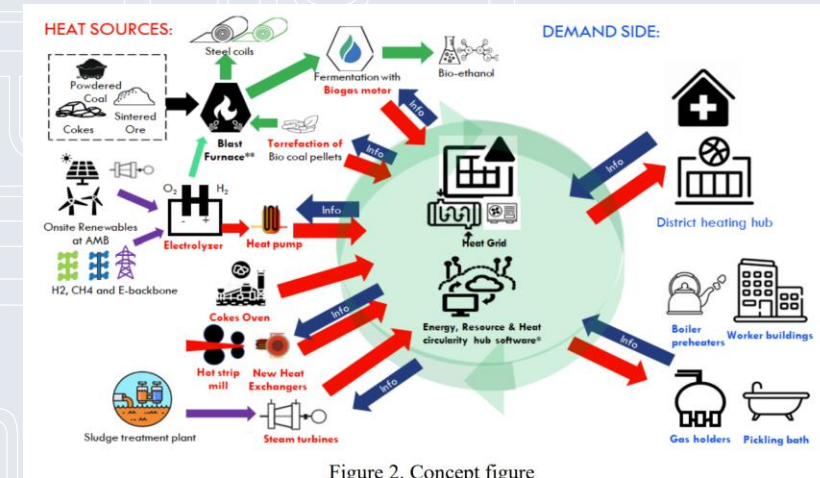


Figure 2. Concept figure



SELECTED REFERENCES



Food (typ. Drying)



Wijgmaal, BE

- › Drying application for rice ingredients
- › Water source temperature 20°C
- › Water output temperature 95°C



Food (Sugar)



Offenau, DE

- › Crystallization process
- › Steam source temperature 60°C
- › Steam output temperature 100°C



Food (Sugar)



Rain, DE

- › Evaporation process
- › Steam source temperature 100°C
- › Steam output temperature 130°C



Pulp & Paper



Osnabrück, DE

- › Drying process
- › Water source temperature 40°C
- › Steam output temperature 120°C



District heating



Gent, BE

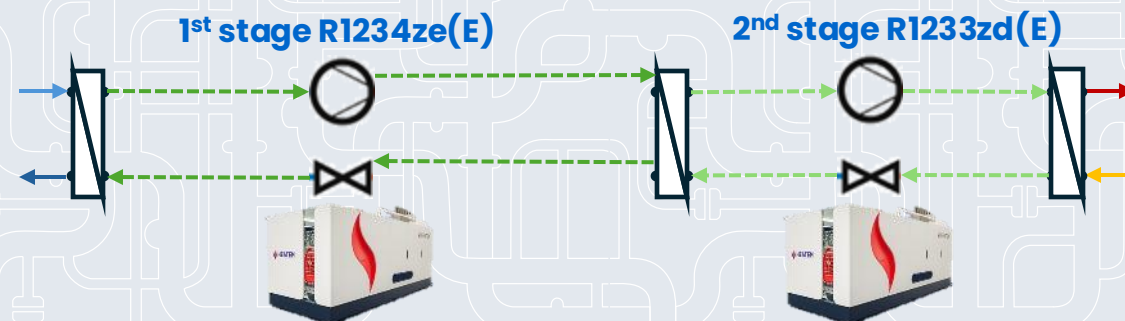
- › District heating
- › Water source temperature 55°C
- › Water output temperature 125°C

FLEXIBILITY WITH REFRIGERANTS AND 1- OR 2-STAGE COMPRESSION

Temperatur [°C]		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
HTWP Anwendungsfenster																						
Ammoniak	R717									82												
Propan	R290											97										
HFO	R1234ze(E)												109									
Isobutan	R600a														134							
Butan	R600																152					
HFO	R1233zd(E)																		166			
HFO	R1336mzz(Z)																		171			
Neopentan	R601b																	161				
Isopentan	R601a																				187	
(n)Pentan	R601																					197

Example:
(COP=2.3)

SOURCE supply:
cooling water 60°C
SOURCE return:
cooling water 35°C



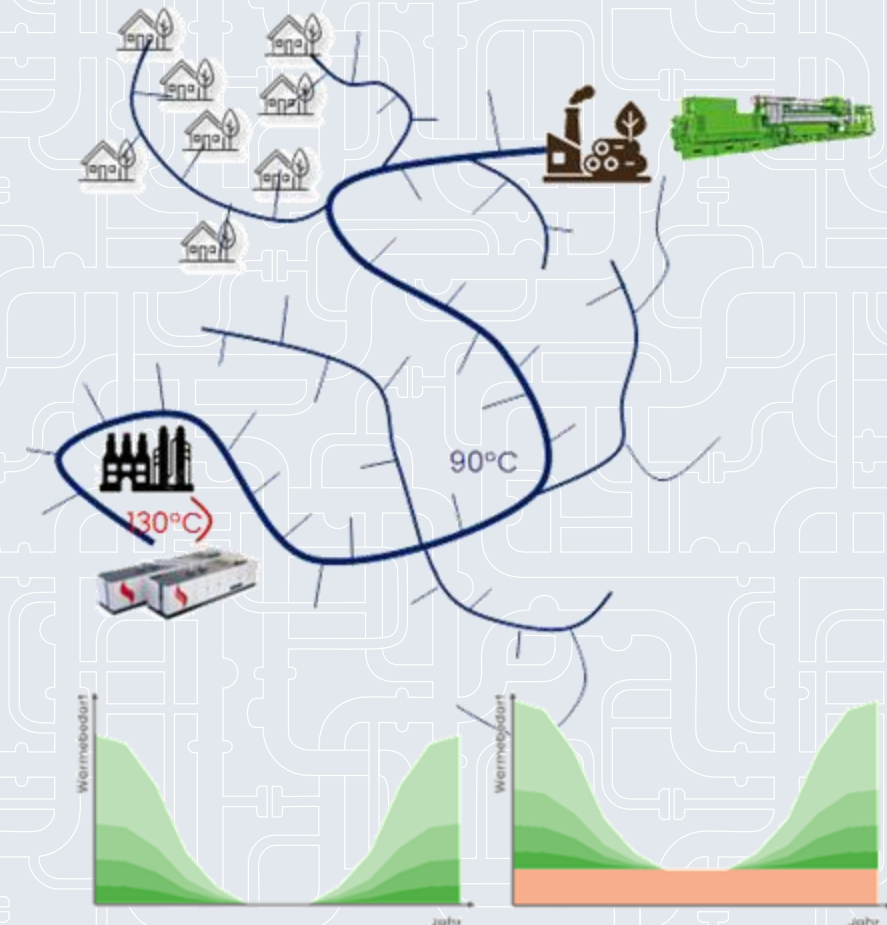
SINK supply:
saturated steam 138°C
SINK return:
condensate 99°C

HHP USING DISTRICT HEATING SOURCE

- ▶ Industry-/steam customer is anchor customer of district heating.
- ▶ Industry-/steam customer has got a steadier demand over the year.
- ▶ HHP enables lowering the supply temperature below $<100^{\circ}\text{C}$.
- ▶ Steam (or increased water temp. for more distant customers) is supplied by means of HHP as “peaker”.



COP	3.8
SINK thermal power	24.7 MW _{th}
SOURCE thermal power	18.8 MW _{th}
Refrigerant	R600 (butane)



HThP SERVING DISTRICT HEATING SINK

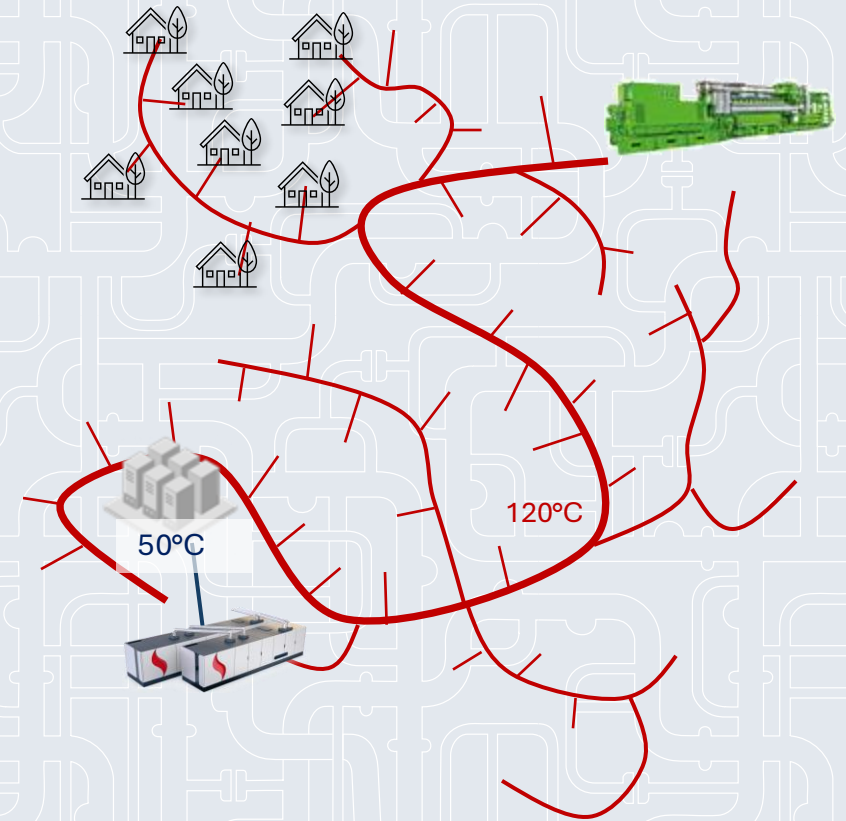


Waste heat recovery from industry and data centers

- ▶ EU-energy efficiency directive (EED, EU 2023/1791); Energieeffizienzgesetz (EnEffG); Data-Center waste heat must be made available for recovery.
- ▶ Kommunales Wärmeplanungsgesetz (WPG). Above an annual process heat need of >2.5 GWh unused waste heat sources must be published for municipal heat planning.



5x HBL16-W/W

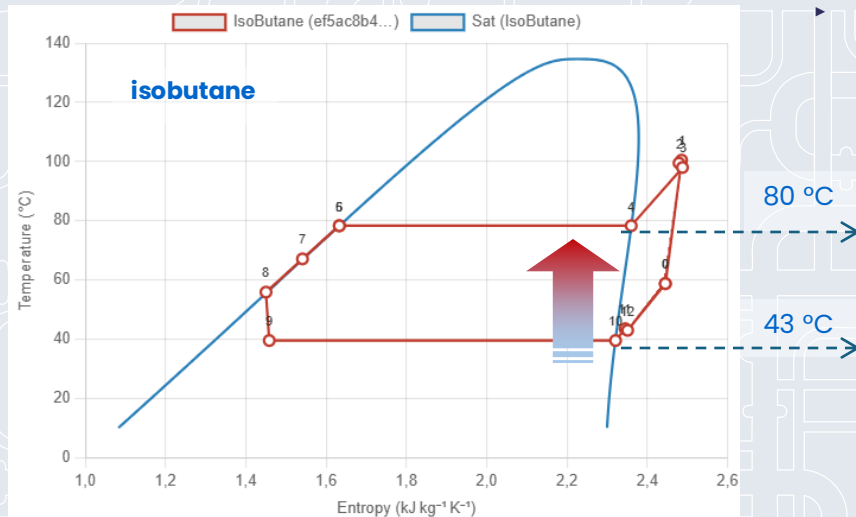


COP	4.1
SINK thermal power	31.3 MW _{th}
SOURCE thermal power	24.5 MW _{th}
Refrigerant	propane/isobutane

FLEXIBILITY WITH PISTON COMPRESSOR

summer load case:

- ▶ lower supply temperature
- ▶ lower temperature lift
- ▶ more source power from waste heat



Abwärme --> Wärmenetz Sommerfall						Quelle						Senke		
	Modell	COP	Elek. Verbrauch	Therm. Leistung	Vorlauf	Rücklauf	Massenfluß	Therm. Leistung	Vorlauf	Rücklauf	Massenfluß			
Units			[MW]	[MW]	[°C]	[°C]	[t/h]	[MW]	[°C]	[°C]	[t/h]			
1	HBL4-W/W	5,18	0,24	1,04	63,00	43,00	44,64	1,25	67,00	80,00	82,42			

HeatBooster features:

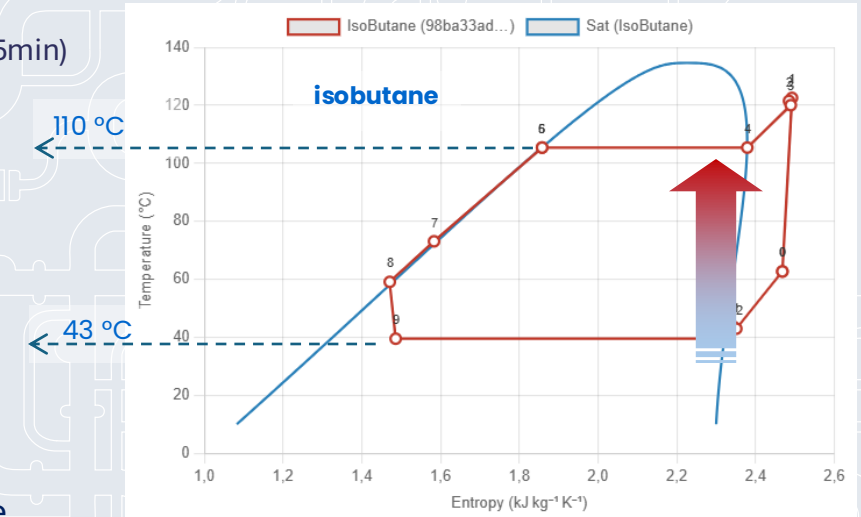
- ▶ variable motor speed (= sink power 30-100%)
- ▶ variable compression (= temperature lift)
- ▶ Extremely fast part load ($>1\text{MW}_{\text{th}}/\text{min}$ = energy arbitrage / ToU 15min)



...on the same machine / hardware

winter load case:

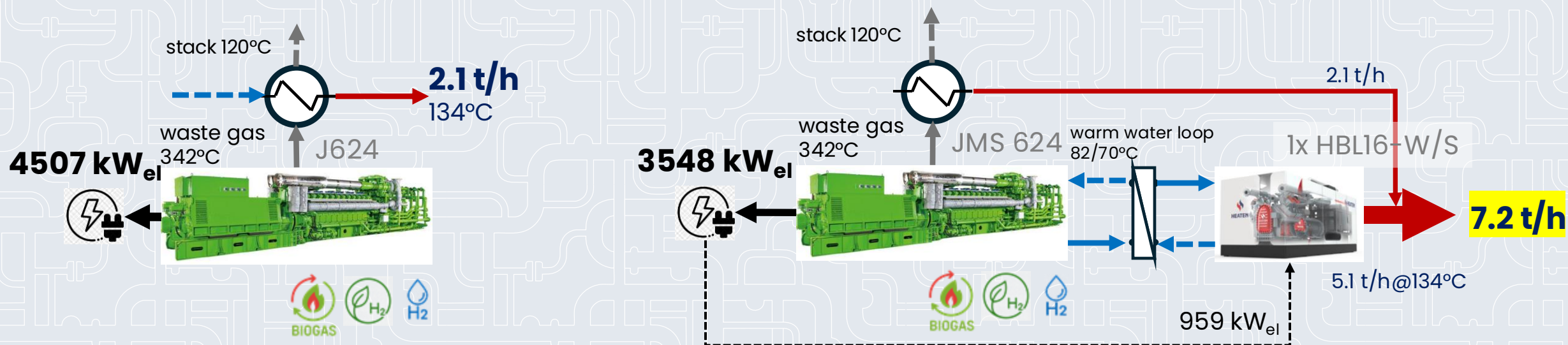
- ▶ higher supply temperature
- ▶ higher temperature lift
- ▶ less source power from waste heat



Abwärme --> Wärmenetz Winterfall						Quelle						Senke		
	Modell	COP	Elek. Verbrauch	Therm. Leistung	Vorlauf	Rücklauf	Massenfluß	Therm. Leistung	Vorlauf	Rücklauf	Massenfluß			
Units			[MW]	[MW]	[°C]	[°C]	[t/h]	[MW]	[°C]	[°C]	[t/h]			
1	HBL4-W/W	4,18	0,29	0,96	60,00	43,00	48,53	1,21	73,00	110,00	28,10			

MAXIMISING CHP-STEAM GENERATION WITH HTHP

- Example: saturated steam generation **134°C**

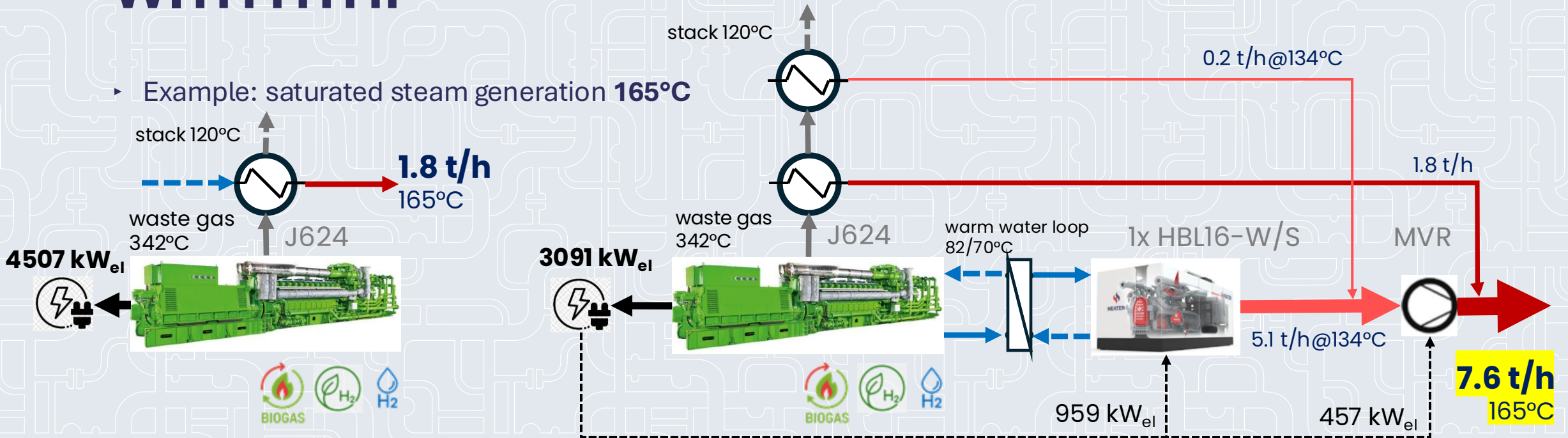


- HTHP enables tripling (3.4x) of CHP steam power, thereby consuming <25% of CHP-electric power.
- When using biogas or H₂, CHP+HTHP is a climate-neutral steam generation process.
- COP = 3.5

COP HTWP (70 → 134°C)	3.5
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MAXIMISING CHP-STEAM GENERATION WITH HTHP

- Example: saturated steam generation **165°C**



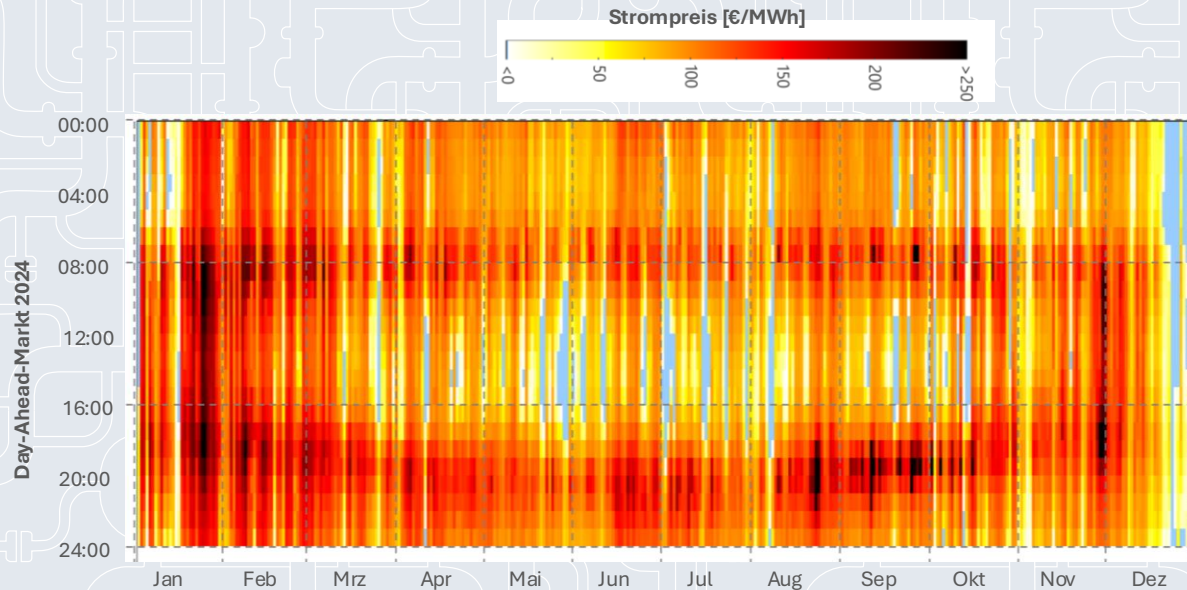
- HTHP+MVR enables quadrupling (4.2x) of CHP steam power, thereby consuming approx. 30% of CHP-electric power.
- High-pressure steam >180°C is possible, too with HTHP+MVR, e.g.: 2x **J920+HBL16**, steam generation up to 200°/15.6bar **30t/h**.

COP HTWP (70 → 134°C)	3.5
COP MVR (134 → 165°C)	8.8
Overall-COP HTWP + MVR (70 → 165°C)	2.5

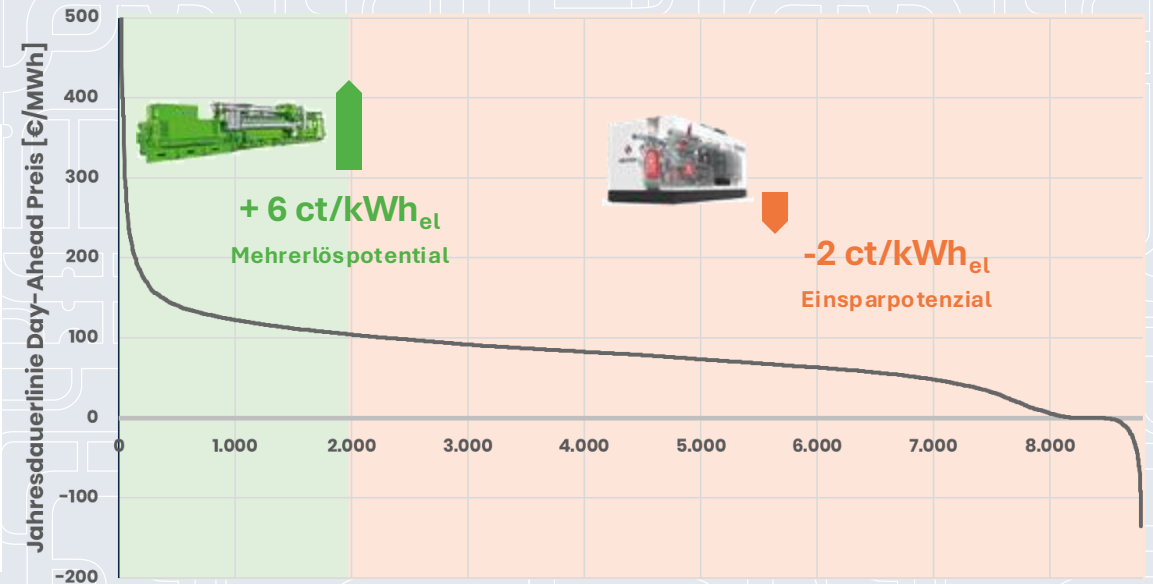
AUTOMATED CHP+HTHP ENERGY ARBITRAGE



(power-driven heat supply)



German power price exchange EPEX Spot 2024, Forschungsstelle für Energiewirtschaft (FfE) e. V., 09.01.2025

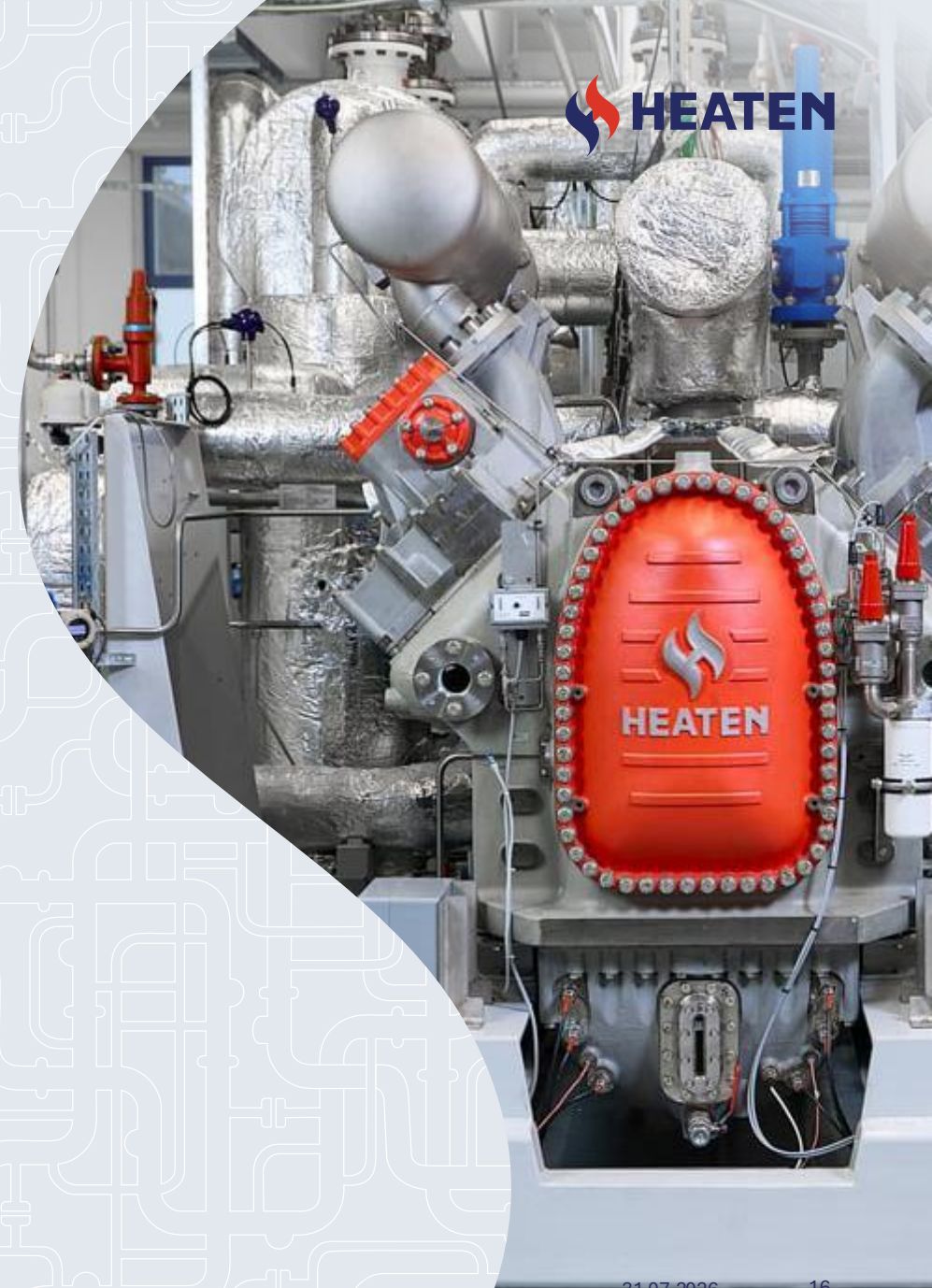


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- ▶ Seasonal and intra-day **price volatility in the electricity market** are further increasing with more power generation from renewables.
- ▶ Operating scheme of decentralized CHP-plants is seeing shift to power-driven operation with less operating hours.
- ▶ Combination of CHP and HTHP through **intelligent, automated optimization and marketing tools** enables significant additional revenues, or electricity cost reduction, respectively.
- ▶ The high **correlation of electricity price and its carbon footprint** leads to an additional decarbonization of heat supply during power-driven operation of CHP and HTHP.

Summary

- ▶ High-temperature Heat Pumps (HTHP) can supply up to 180°C (steam) and 200°C (pressure water).
- ▶ Heaten HeatBooster serve the power segment of up to 10MW_{th} per machine and up to 50MW_{th} per project with modular setup of several machines.
- ▶ HEATEN piston compressors feature excellent part load capability, enabling optimal combination with CHP-engines with attendant microgrid software for energy arbitrage.
- ▶ HTHP can both make waste heat available to district heating (=sink) and/or use district heating as a source for steam generation.
- ▶ HTHP can multiply the steam power of CHP-engines.
- ▶ Automated, AI-based, combined operation of CHP+HTHP enable additional reduction of power cost and carbon footprint of heat supply.



Thank you for your attention.

New White Paper on webinar topic:



Online version
available



Request a test bed visit:



- 29th January
- 25th February
- 24th March

Registration required,
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Laurenz Plöchl
Sr. Sales Manager
laurenz.plochl@heaten.com