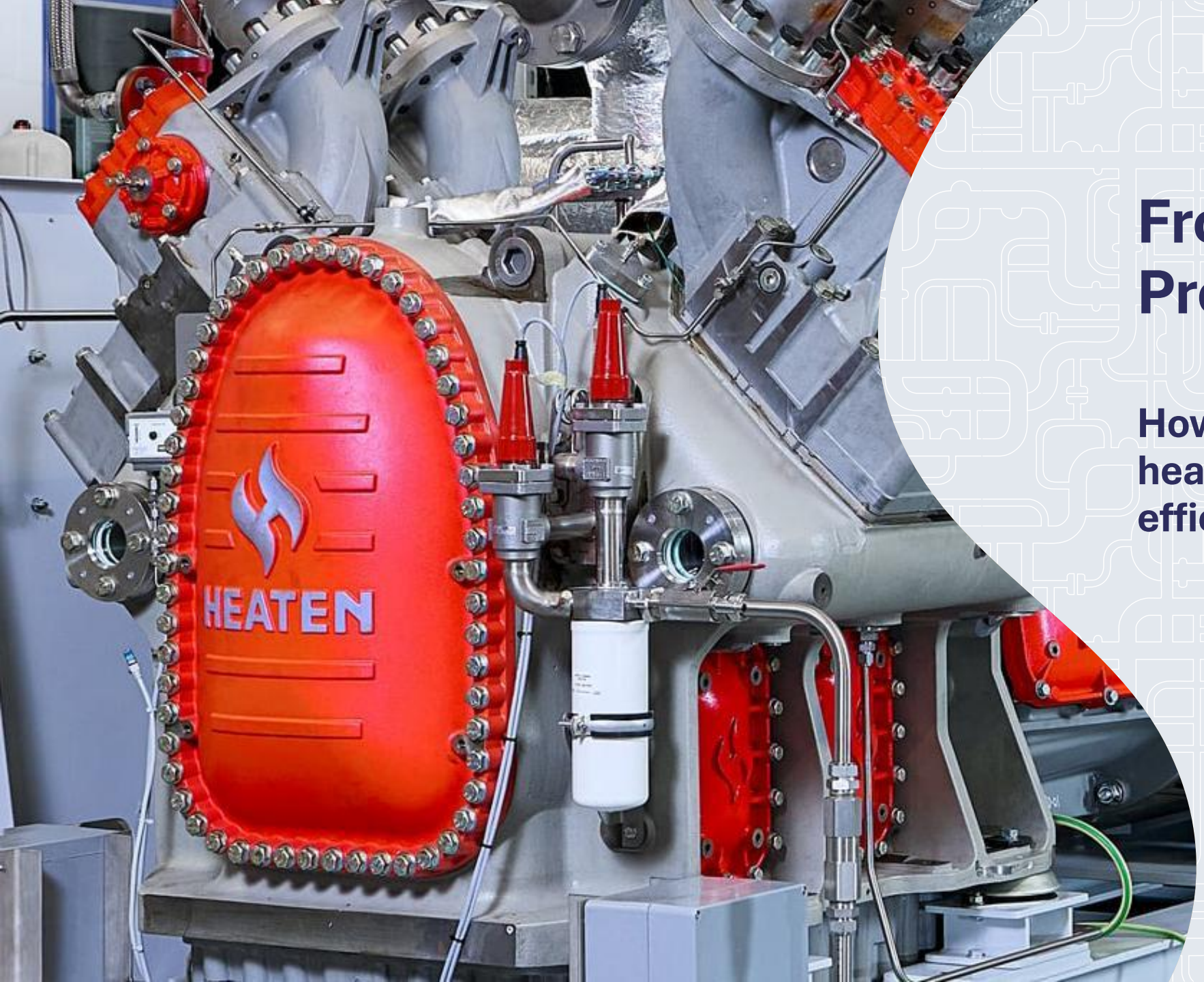


HEATEN

From Waste Heat to Process Heat

How HEATEN high-temperature heat pumps improve energy efficiency in paper mills

Power with Passion

Agenda

- **HEATEN**
- Challenges
- Solution HeatBooster
- Application

16 YEARS OF DEVELOPMENT

HEATEN

Concept Development

2011-2012
- **Development of Single Cylinder ORC Heat Engines for up to 215°C**

2013-2015
- Worldwide commercial deployment of demonstrators
- Gaining operational experience with refrigerants and lubrication

Technology Development

2016 – 2017
- Enhancement of technology

2018-2019
- **Commercial installation of Heat pumps one-cylinder (now running for more than 50,000h each)**

2020
- Acquisition of Viking IP, inventory and team by HEATEN

Product Development

2022-2023
- Product specification for HBL4 and HBL16
- Product development for HBL4

2024
- **Acquisition of HEATEN by Advent & Strategic Partnership INNIO**

2024-2025
- Testing on test bench and in field
- Stabilization of HBL4
- Concept study 2-stage conducted
- Serialization of HBL4 incl. variants

Portfolio Development

2025
- **Commercial role out**
- **Product development for HBL16**
- **Invest in test infrastructure Jenbach for HBL4 & HBL16**

2026-2027
- HBL16 testing on test bench and in field
- Launch of HBL4 2-stage
- Launch of HC's products

2028-2029
- Launch of HBL16 2-stage
- Standardization

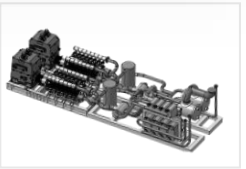












Source: HEATEN

STRATEGIC PARTNERSHIP

between INNIO and HEATEN

Advent
Financial Support

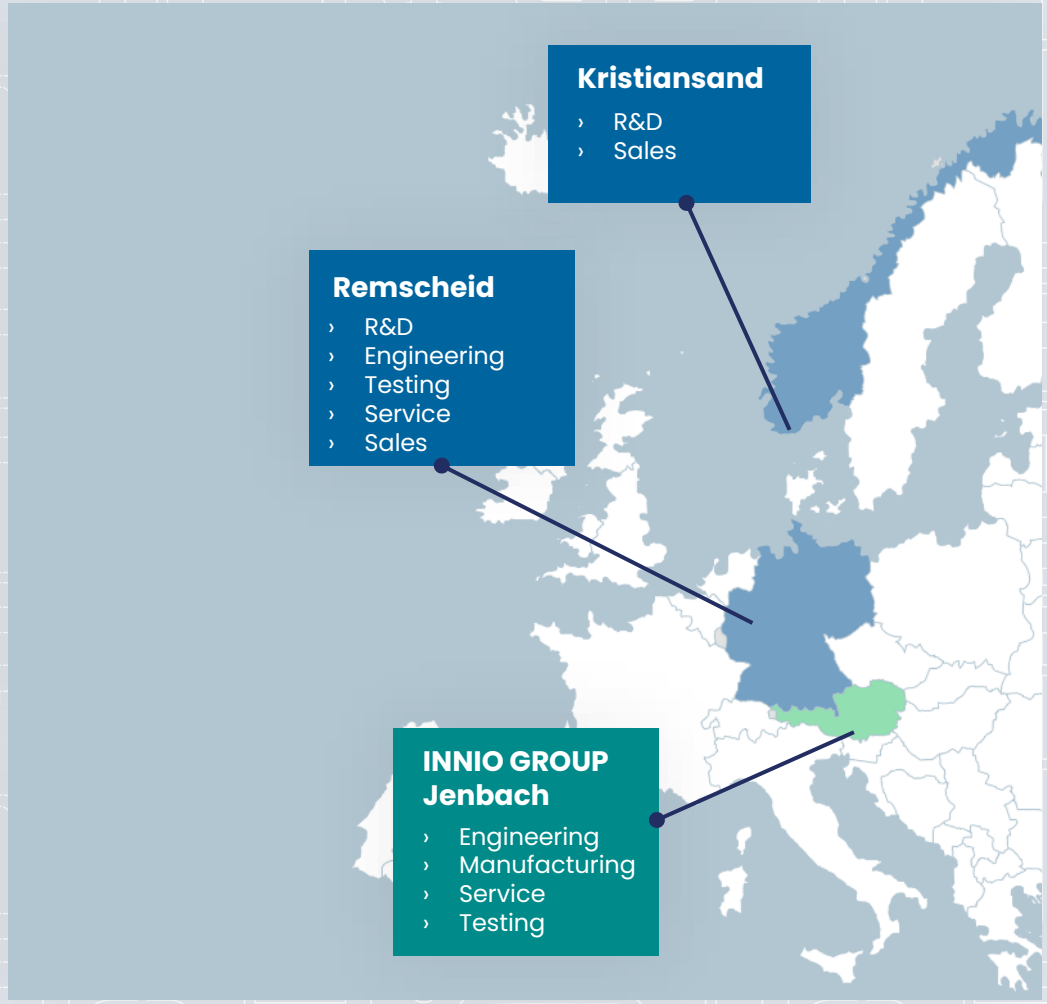
INNIO
Combustion Gas Engine
Gas-to-Power
JENBACHER Waukesha

Strategic Partnership

HEATEN
High Temperature Heat Pump
Power-to-Heat

INNIO has delivered more than 59,000 engines globally

- Through a team of more than 4,500 experts
- And a service network in more than 100 countries



Agenda

- HEATEN
- **Challenges**
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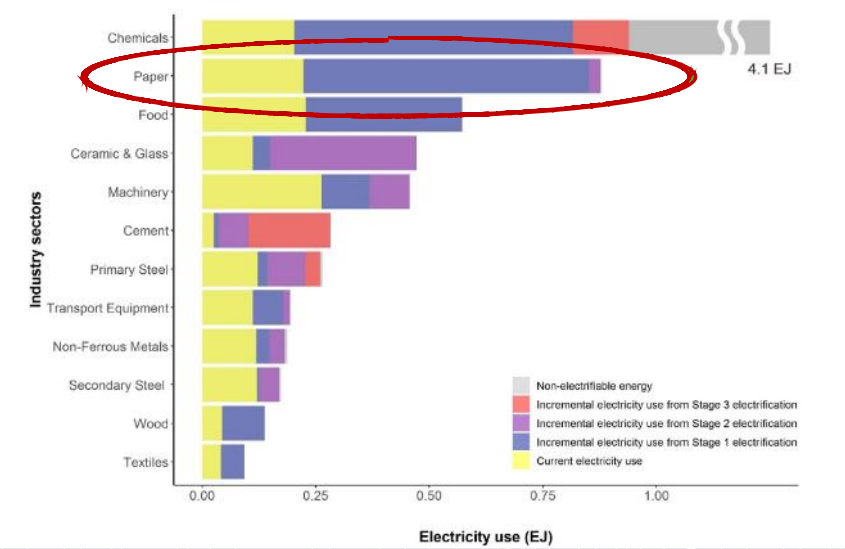
Energy Challenge in the Paper Industry

Paper production is one of the most heat-intensive industries



- Pulp & Paper Industry is **one of** the **most energy intensive sectors** with the **highest electrification potential**
- Thermal energy can represent up to **60 percent of total production costs** in paper
- **Energy security** concerns encourage industries to shift towards local and renewable energy sources
- Paper manufacturing **must improve its energy efficiency by more than 25 percent** this decade to stay on track with global climate targets (IEA)
- **Circular economy** trends push companies to **utilize waste heat**

Sources: Stage 1 - Entry points for industry electrification with mature technologies
Stage 2 - A more technologically advanced phase of industry electrification
Source: The CO2 reduction potential for the European industry via direct electrification of heat supply (2020); Strengthening Industrial Heat Pump Innovation Decarbonizing Industrial Heat (www.sintef.no/globalassets/sintef-energi/industrial-heat-pump-whitepaper/2020-07-10-whitepaper-ihp-a4.pdf)

Paper Mills already produce large amounts of Waste Heat

HEATEN

Temperature range 120 – 180°C / Steam

Pulping & Cooking

Washing & Bleaching

Drying & Coating

Paper machine section

…

Temperature range 10 – 80°C / Moistured air or water

Dryer hood exhaust air

Warm process water

Condensate streams

Cooling systems

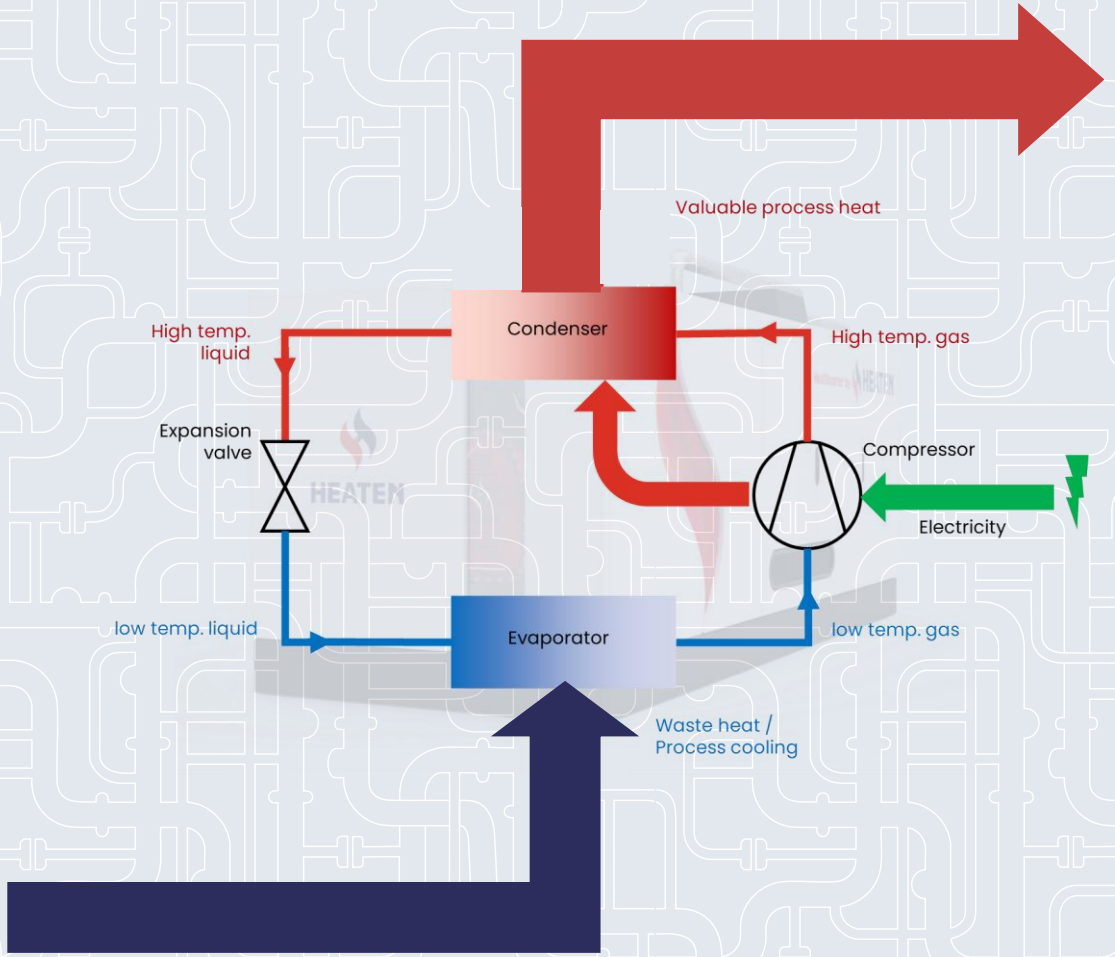
Waste Heat mostly released to the outside

Source: HEATEN

Upgrading Waste Heat with Heat Pumps

Heat pumps convert unused heat into valuable process energy

Waste Heat



Process Heat

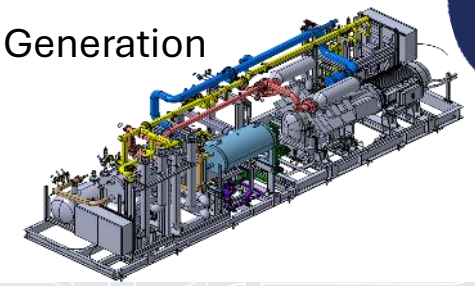
Agenda

- HEATEN
- Challenges
- **Solution HeatBooster**
- Application

High-Temperature Heat Pumps by HEATEN

HEATEN heat pumps are specifically designed to convert industrial waste heat into valuable process energy

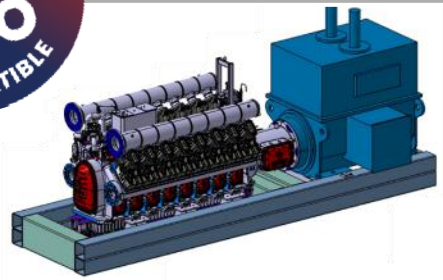
HBL4 (V4 → 1500 m^3/h) (4-cylinders)



2nd Generation

ONE HARDWARE HC & HFO COMPATIBLE

HBL16 (V16 → 6000 m^3/h) (16-cylinders)



Operating range

Temperature heat source	10–150°C
Temperature heat sink	90–200°C (HC), 90–165°C (HFO)
Thermal power range	0.8–2.5 MW_{th}

Dimensions

Length	mm	9,000
Width	mm	2,400
Hight	mm	2,500

Datasheets

Operating range

Temperature heat source	10–150 °C
Temperature heat sink	90–200 °C
Thermal power	3.2–10 MW_{th}

Dimensions

Length	mm	11,000 (2 skids)
Width	mm	2,400
Hight	mm	2,500

Source: HEATEN

HeatBooster TECHNOLOGY

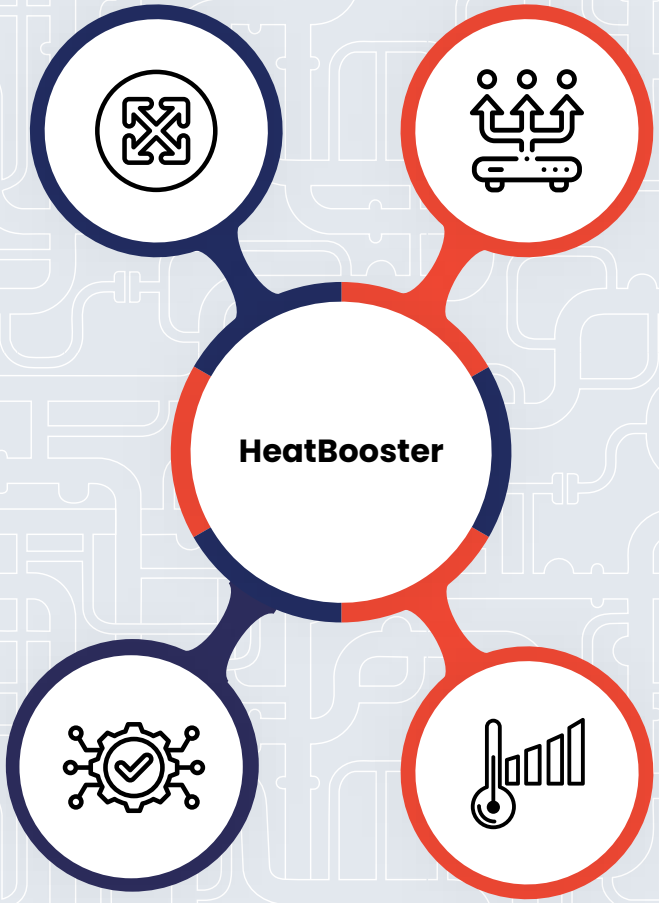
Unique Large Scale Piston Compressor – Bringing flexibility in the high MW_{th} range

Integration flexibility and modularization

- System scalability from **1 to 50 MW_{th} +** through parallel or cascaded installation
- Starting with a pilot and roll it out step by step
- HeatBooster systems can always adapt to customer needs, especially in brownfield applications

Scalability

- Standardization will be the key to reduce cost and speed-up the roll out
- Production scalability is proven by our partner INNIO
- We will leverage from service and maintenance network of INNIO



Operational flexibility (Load)

- Flexible load handling & high part-load efficiency, **even at 20% load**
- Super-fast load changes
- **Grid-balancing capability incl. in the intraday market**

Operational flexibility (Temp. range)

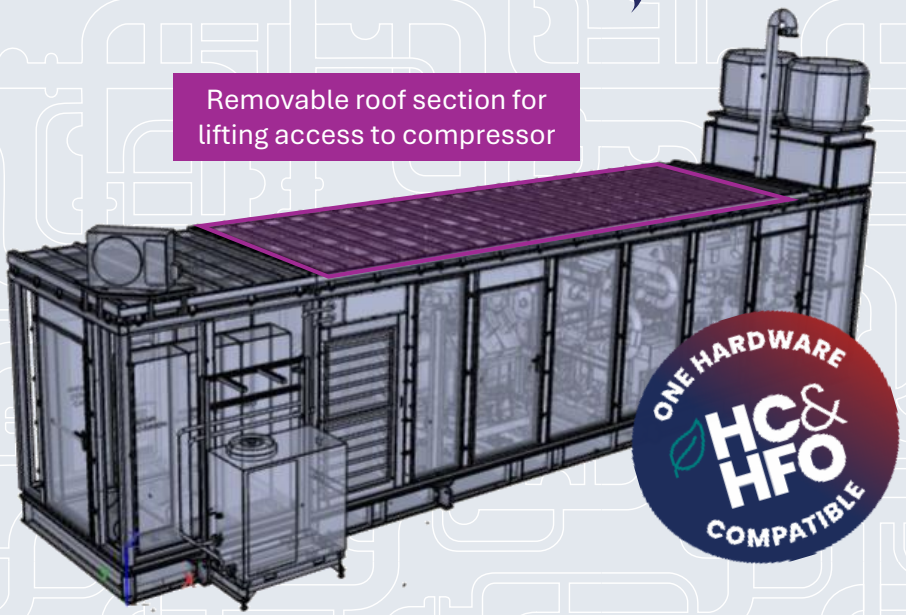
- The compressor is designed for 215°C
- Variable compression ratio allows
  - Different working fluids with the same Hardware
  - Operation across different temperature levels with same working fluid

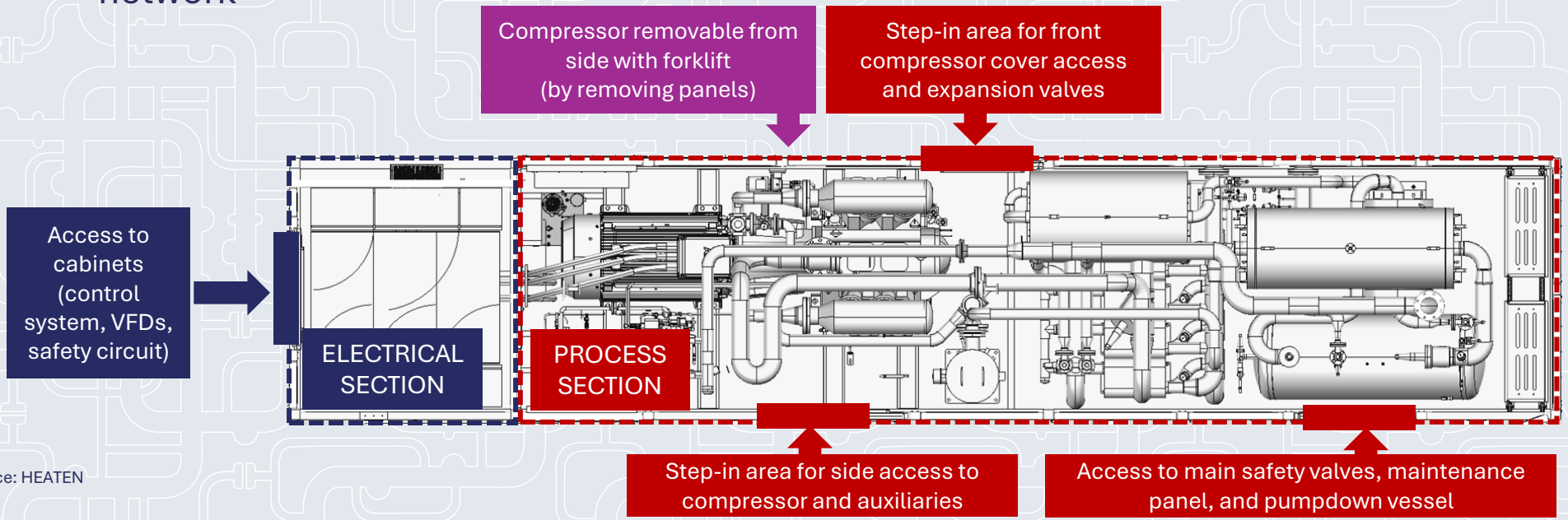
Source: HEATEN

HBL4 with Enclosure

Fully containerized and standardized solution

- Standardized solution incl. electrical section
- Weather protected design for ambient temperatures up to 45°C
- HC's ready solution
- Modular system for up to 150°C and 2.5 MW_{th}
- Deployment worldwide possible due to INNIO's service network





Source: HEATEN

Agenda

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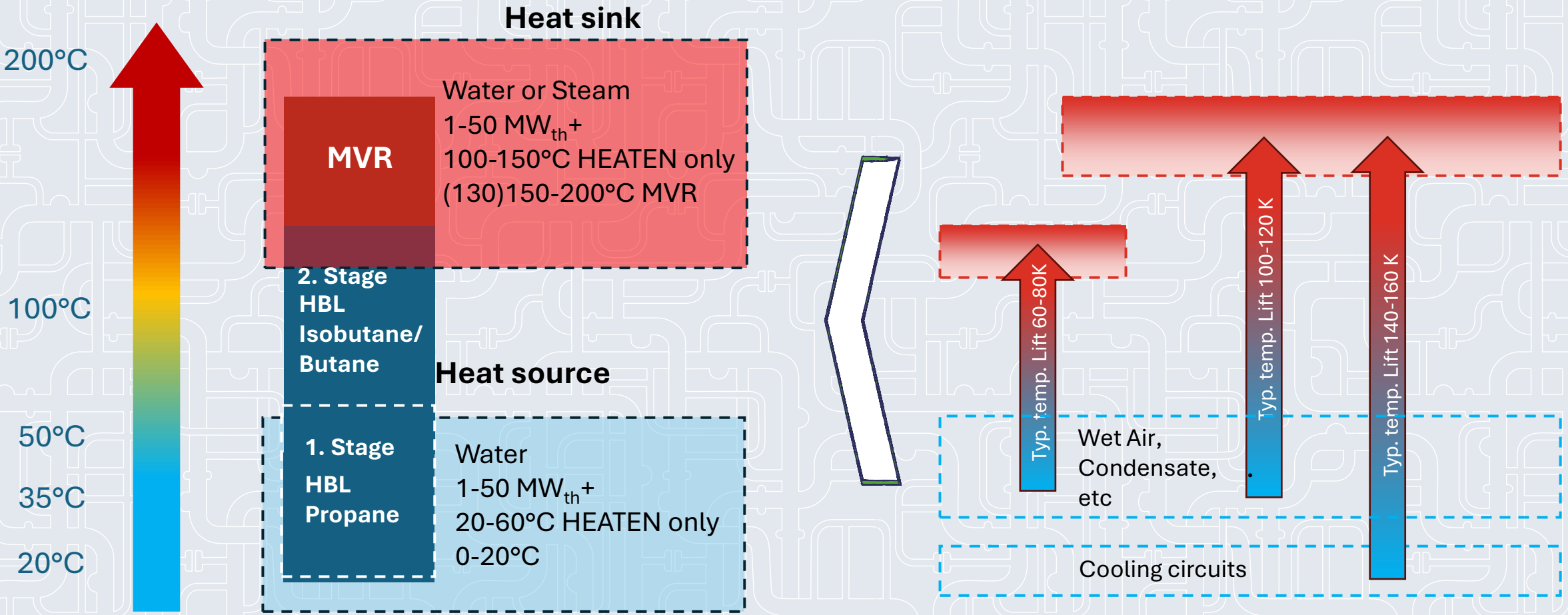
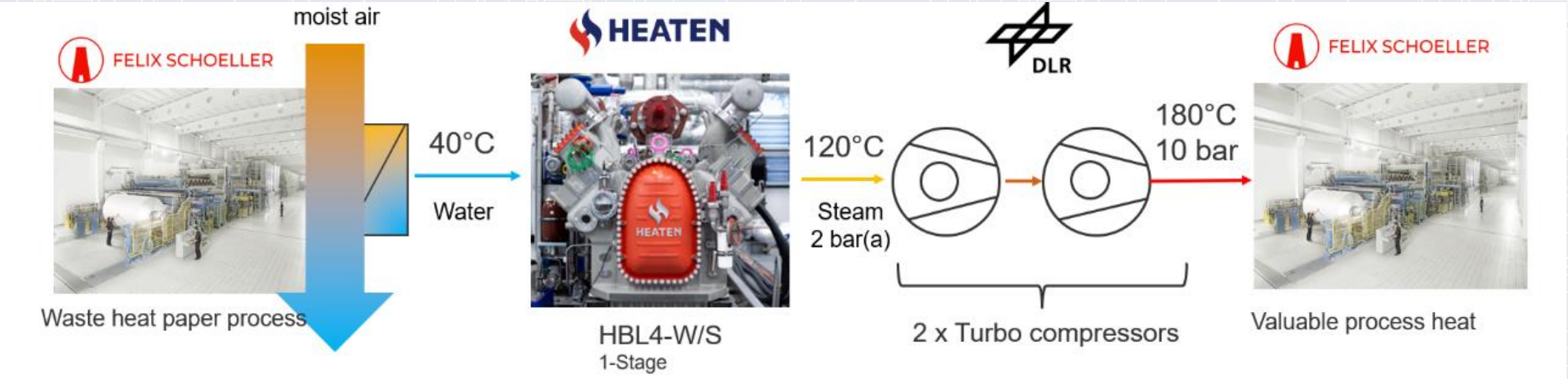
- **Application**

2-Stage HeatBooster to cover most processes which require temperature lifts beyond 80 K



EEETHOS – Demo III HTHP for Pulp & Paper

Heat supply for one individual process step



CASE HIGHLIGHTS	VALUES
Application	Pulp & Paper
Exp. Thermal power Output	> 1 MW_{th}
Working fluid	Isobutane
Exp. Steam supply	> 1.6 t/h
Steam temperature	180°C

Benefits:

- reduction in fossil fuel consumption
- lower energy costs
- improved energy efficiency
- reduced CO_2 emissions

Source: HEATEN

Decarbonisation of industrial processes step by step

- Standardization and modularization will be the key in the future
- Step by step decarbonization lowers the risk and integrates easier
- Several modules in the right sizing will enable redundancy and flexibility
- The overall efficiency will increase due to higher part load efficiency of the piston-based compressor technology
- At the same time we can balance the grid, almost as flexible as E-Boiler

Picture for illustrative purpose only

Source: HEATEN

Turning Waste Heat into Process Heat

1. Paper Mills already generate significant waste heat
2. High-temperature heat pumps make this heat useable
3. HEATEN technolgoy enables efficient industrial heat r

Source:

Thank you for your attention!

Feel free to reach out to us
ww.heaten.com

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VISIT OUR TEST BED
IN REMSCHEID, GERMANY
Limited seats, registration required
DEDICATED DAY
EVERY MONTH