



Decarbonizing industrial process heating with HTHPs

From market to application

IEA HPT TCP Project 68

Benjamin Zühlsdorf, PhD
Innovation Director

Martin Pihl Andersen
Consultant

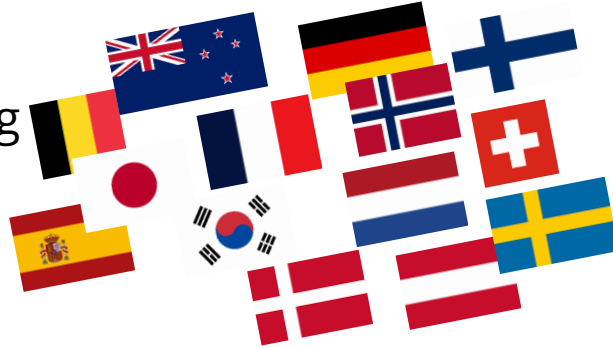
Danish Technological Institute

New
Project 68!

Industrial High-Temperature Heat Pumps



14 countries participating



June 2025 to May 2028



Task 1 – Technology developments (Lead: DTI)

- Keep track of current and future technologies
- Provide updated overview



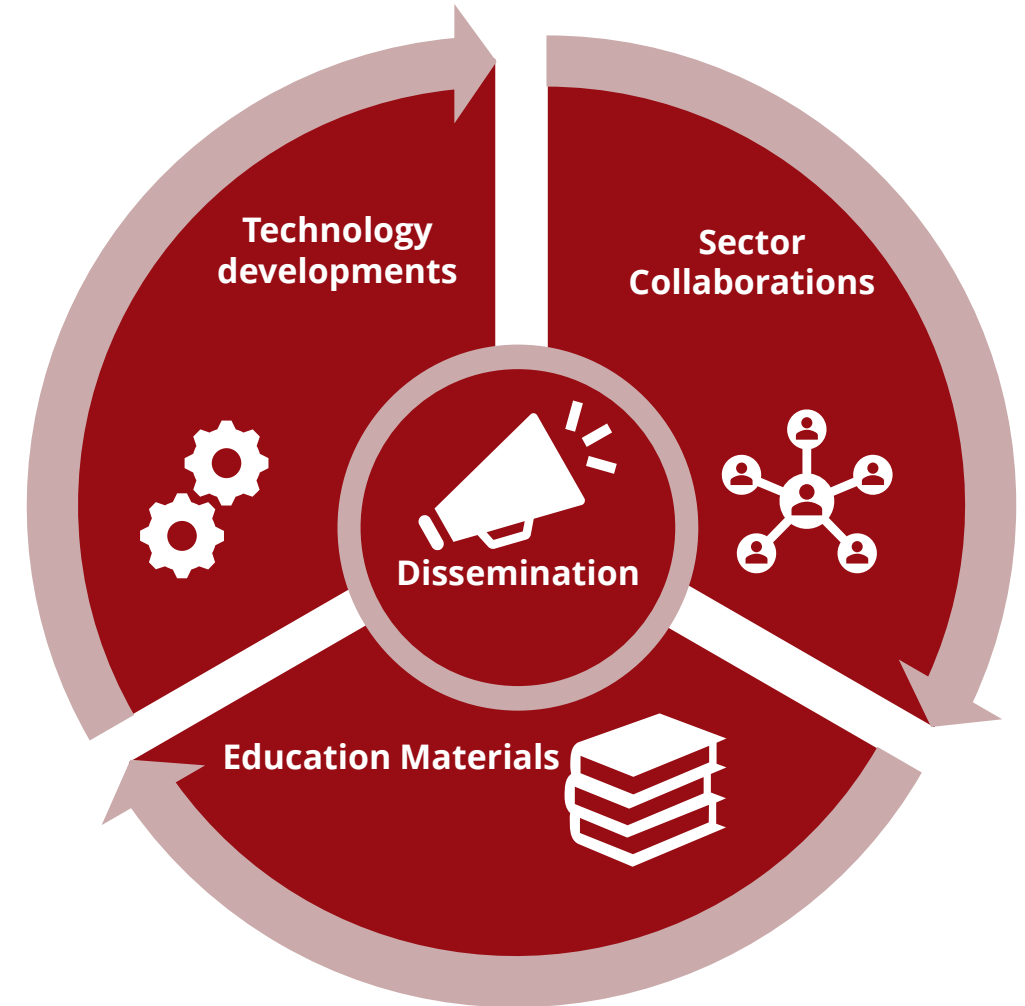
Task 2 – Sector collaborations (Lead: Uni-P)

- Highlight potential across sectors
- Identify common technology gaps
- Develop solutions to current barriers



Task 3 – Education materials (Lead: AIT)

- Industry (end-users, consultants, suppliers, management....), academia, governments



Workshop at IEA HP Conference in Vienna

- Workshop 1: Decarbonizing process heating with high-temperature heat pumps – from market to application

Background: High-temperature heat pumps have a considerable potential for decarbonizing industrial process heating by electrification and energy efficiency making them a key-technology in the sustainability strategy towards 2030 of various companies. While high-temperature heat pumps supplying above 100 °C are increasingly available, the number of demonstration cases remain limited. Nevertheless, the number of good examples continuously grow increasing awareness and know-how while yielding further competitive efficiencies and lower costs for future projects.

About the workshop, purpose and objective: To exploit the massive potential of high-temperature heat pumps for industrial applications, a variety of stakeholders must collaborate by:

- Develop and demonstrate a variety of high-temperature heat pump technologies
- Conceptualize and implement commercially viable integration projects
- Master the transition from fossil fuel-based heating systems towards heat pump-based heating systems

This workshop will bring together the key stakeholders from technology suppliers, end-users, policy makers and R&D organizations in order to create a common understanding of the technology's potential and the required actions to propel more successful projects into the industrial sector.

Organiser: Benjamin Zühlsdorf, Danish Technological Institute

- Interactive = Interactive!

Workshop at IEA HP Conference in Chicago



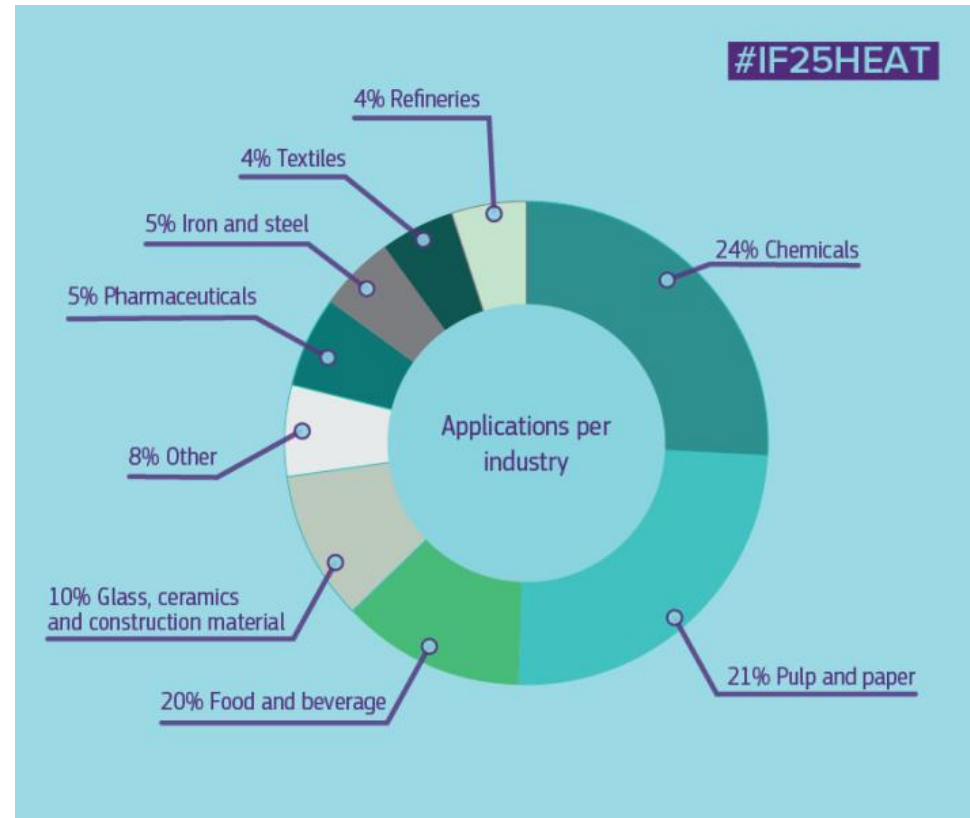
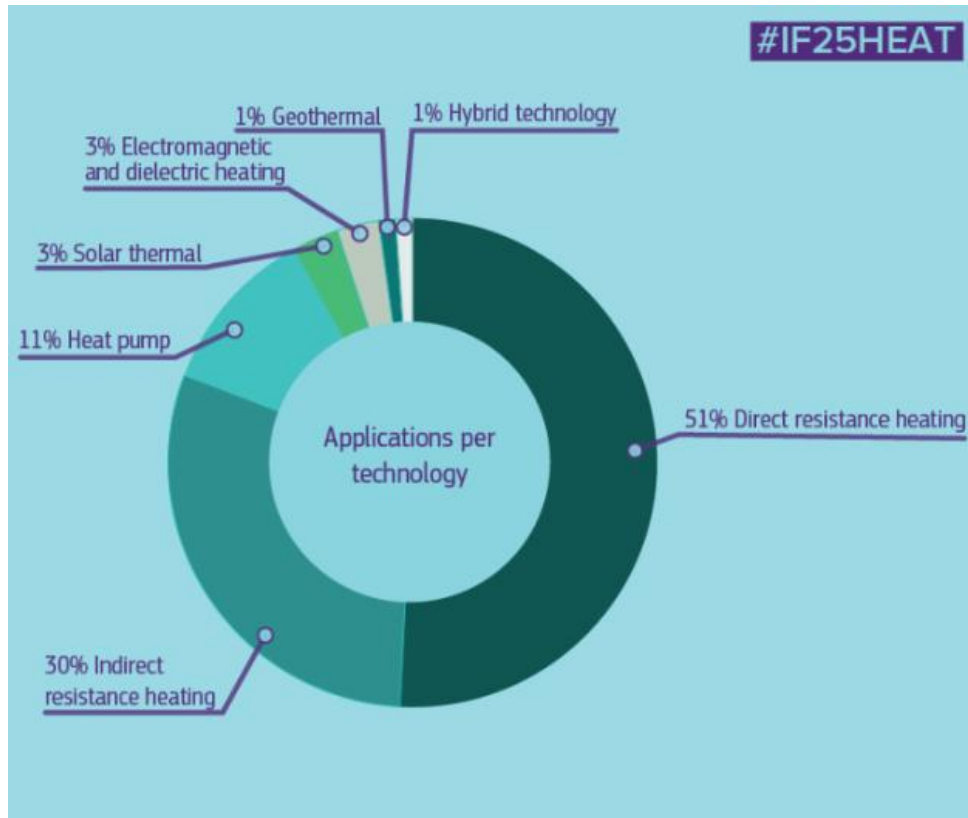
Workshop at IEA HP Conference in Chicago



Industrial heat auction 2025

Result from latest round

- 65 of 85 bids were granted
- 1.4 bn€ in total bids



Industrial heat auction 2026



EUROPEAN COMMISSION
DIRECTORATE-GENERAL
CLIMATE ACTION
Directorate C – Innovation for a Low Carbon, Resilient Economy
CLIMA.C.2 – Low Carbon Solutions (II): Research & Low Carbon Technology Deployment

Innovation Fund IF26 Heat Auction

Terms and Conditions



Highlights:

The 2026 auction is proposed to have a simplified design that

(2) incentivises solutions which reduce pressure on electricity grids (through lowering electricity demand during peak hours) **by providing a bid bonus** for projects that invest in energy storage, **deploy efficient heat pumps** or direct renewable heat or nuclear heat. In addition, solutions not meeting these requirements will have the number of operating hours that can receive the subsidy capped.

(4) lowers the minimum **eligible temperature to 80°C for large projects (>10MW)** implementing heat pumps with COP > 1.5, direct renewables or nuclear heat.

Public consultation

The IF26 Heat Auction was announced on 20 May during the [2026 Clean Tech Conference](#) , and the [draft Terms and Conditions \(T&Cs\)](#) , were published on 22 May for the consultation period of 6 weeks (ending on 2 July).

The publication of the draft T&Cs kicked off a 6-week written consultation period.

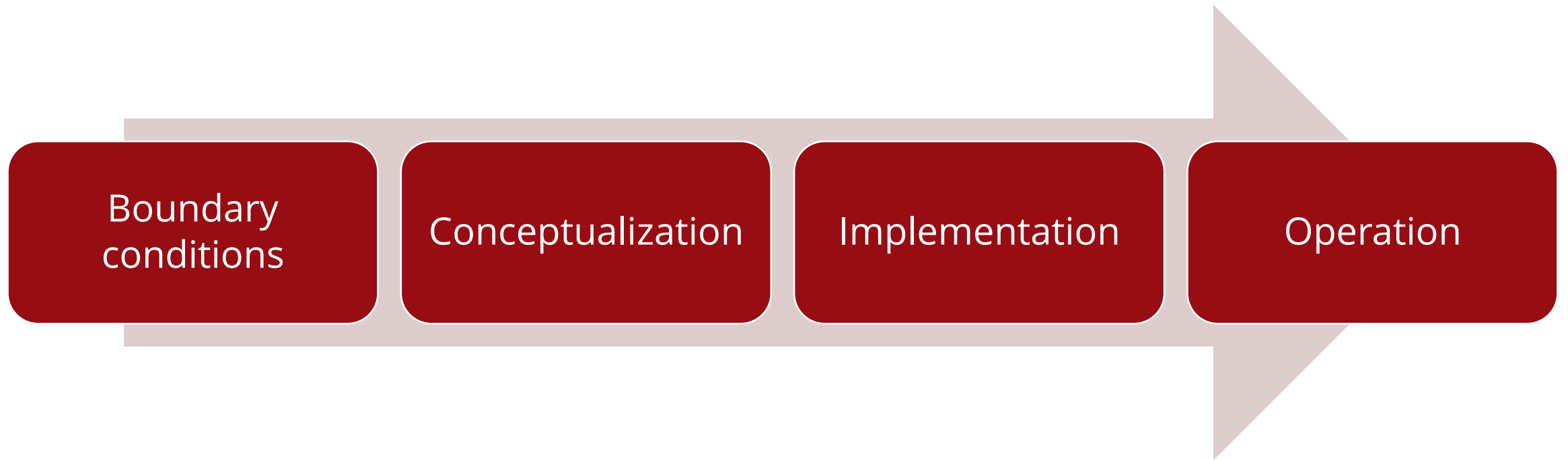
If you would like to express your opinion, **please use the below feedback template** and submit it to clima-auctions@ec.europa.eu **by 2 July 2026**.

- [Feedback template](#) 

→ **Stakeholder Workshop: 7th of July**

https://climate.ec.europa.eu/citizens-stakeholders/events/innovation-fund-webinar-public-consultation-and-stakeholder-workshop-upcoming-if26-heat-auction-2026-07-07_en

Project Phases



From market to application

General Introduction and Keynotes

10:00 – 10:10: General Introduction, Benjamin Zühlendorf, DTI

10:10 – 10:55:

- What is the developmental status of HTHPs, Martin Pihl Andersen, DTI
- Representative HTHP projects, Cordin Arpagaus, OST
- Experience in installing and operating HTHPs, Yannik Stark, GEA

Group sessions

	Boundary conditions	Conceptualization	Implementation	Operation
10:55 – 11:15		Session 1		
11:15 – 11:35		Session 2		
11:35 – 11:45		Break		
11:45 – 12:05		Session 3		
12:05 – 12:25		Session 4		

To discuss for each phase:

- Stakeholders and roles
- Helpful resources & tools
- Overall learnings
- HTHP focus

Summary & plenary discussion

12:25 – 12:45: Wrap-up of the group sessions & Plenary discussion

12:45 – 12:55: Sector collaboration and common solutions, Florian Schlosser, Paderborn University

12:55 – 13:00: Closing remarks



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TECHNOLOGICAL
INSTITUTE



HTHP Technologies

Status and Perspectives

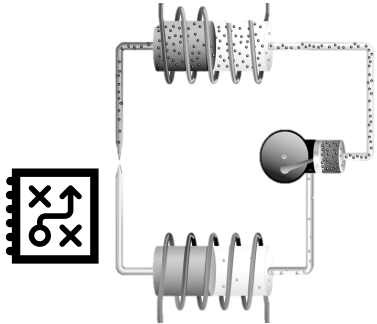
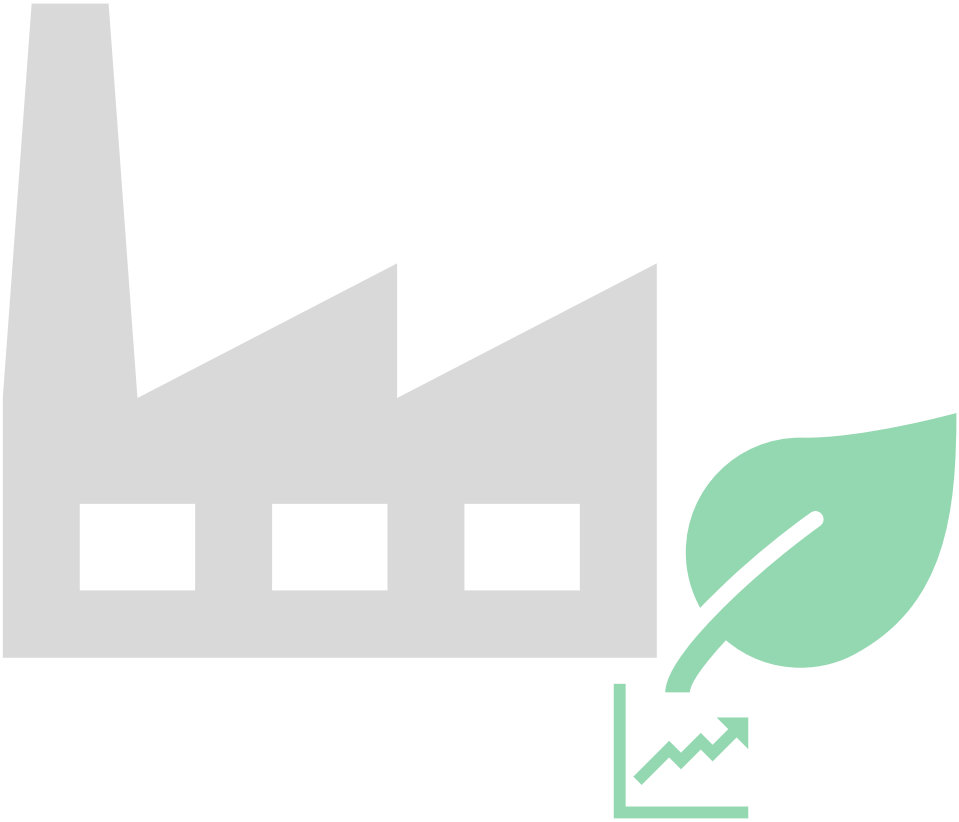
Martin Pihl Andersen

Consultant, PhD

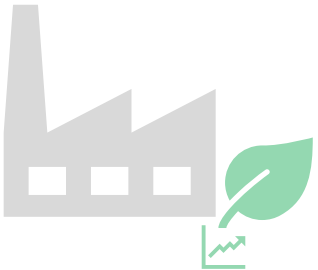
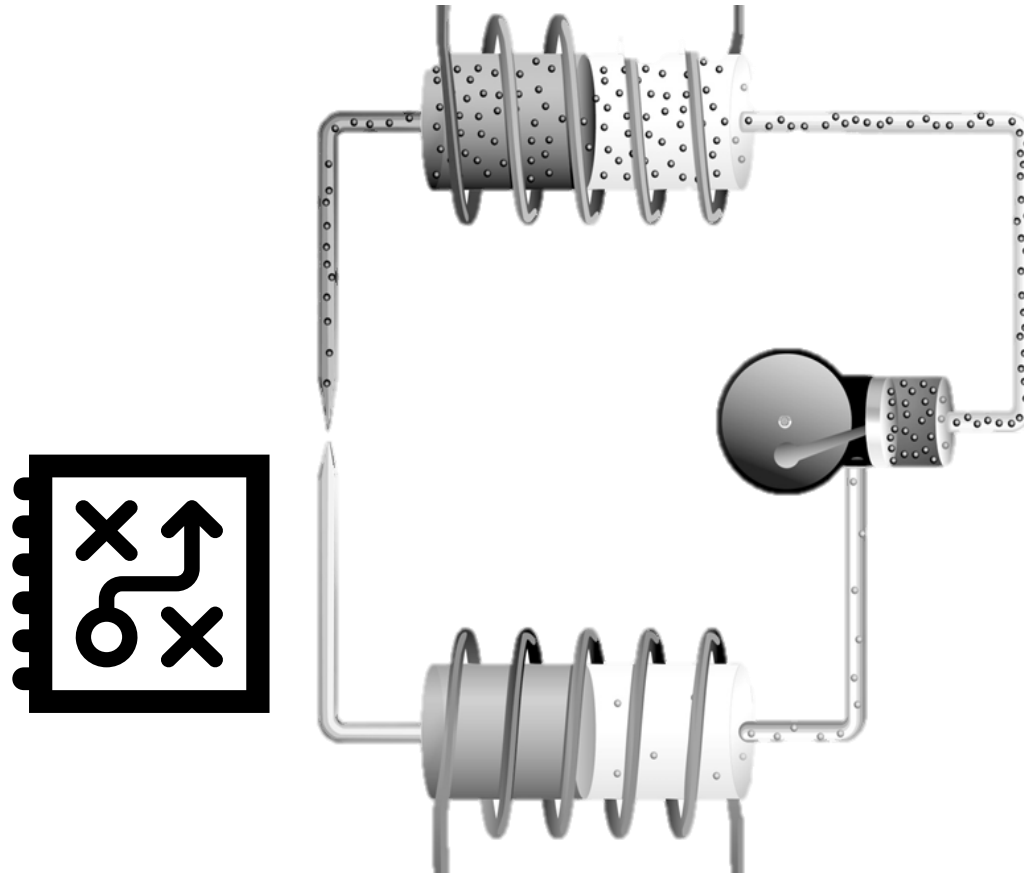
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From global targets to concrete units



From global targets to concrete units



Review of High-Temperature Heat Pump Technologies – IEA HPT Annex 58



Participating countries	DK, AT, BE, CA, CN, FI, FR, DE, JP, NL, NO, KR, CH, US
Project period	2021-2024
TRL level	4-9
Average specific cost	200 €/kW - 1500 €/kW
Capacity	0.02 MW - 100 MW
Max. supply temperature	100 °C - 280 °C
Availability	Geographical dependent, e.g. EU/JP
Number of technologies	37 technologies + 15 demo. cases





Project 68: New results are in!



14 countries participating



June 2025 to May 2028



Task 1 – Technology developments (Lead: DTI)

- Keep track of current and future technologies
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40+ Cases

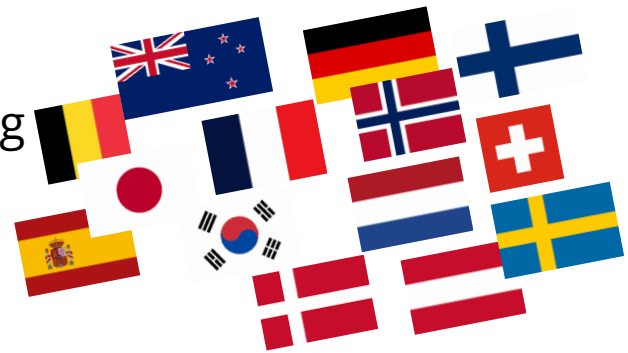


55+ Technology suppliers



Newest trends

<https://heatpumpingtechnologies.org/project68/>



Suppliers technology

Supplier
<120°C Dutek
Johnson Controls - Sabroe
Mayekawa
<140°C ITI

HitemHP - Hydrocarbon heat pump
Johnson Controls - Sabroe

Summary of technology
Sabroe's HitemHP is a high temperature industrial heat pump for heating applications up to 125°C. The heat pump is a commercially available product that is standardized to be configurable for each customer's specific application. This ensures the highest possible capacity with the lowest investment.

Demonstration cases

Heat Pump

Steam-producing pentane-based heat pump in megawatt scale

Summary of demonstration case
This demonstration case is one of the three demonstration cases in the DHT project founded under the Horizon Europe Framework. The aim of the case is to generate steam at temperatures up to 140°C, using a heat source consisting of 75 °C, wet-steam steam, and using pentane as refrigerant. The expected heat output is 4 MW.

Operating experiences
The sugar is produced during two main production campaigns: the beet campaign from September to January and the cane campaign from March to May. As a part of the commissioning, the first operation in part load with the heat pump was carried out at the end of the thick juice campaign in 2025.

Water/Steam Data Table:

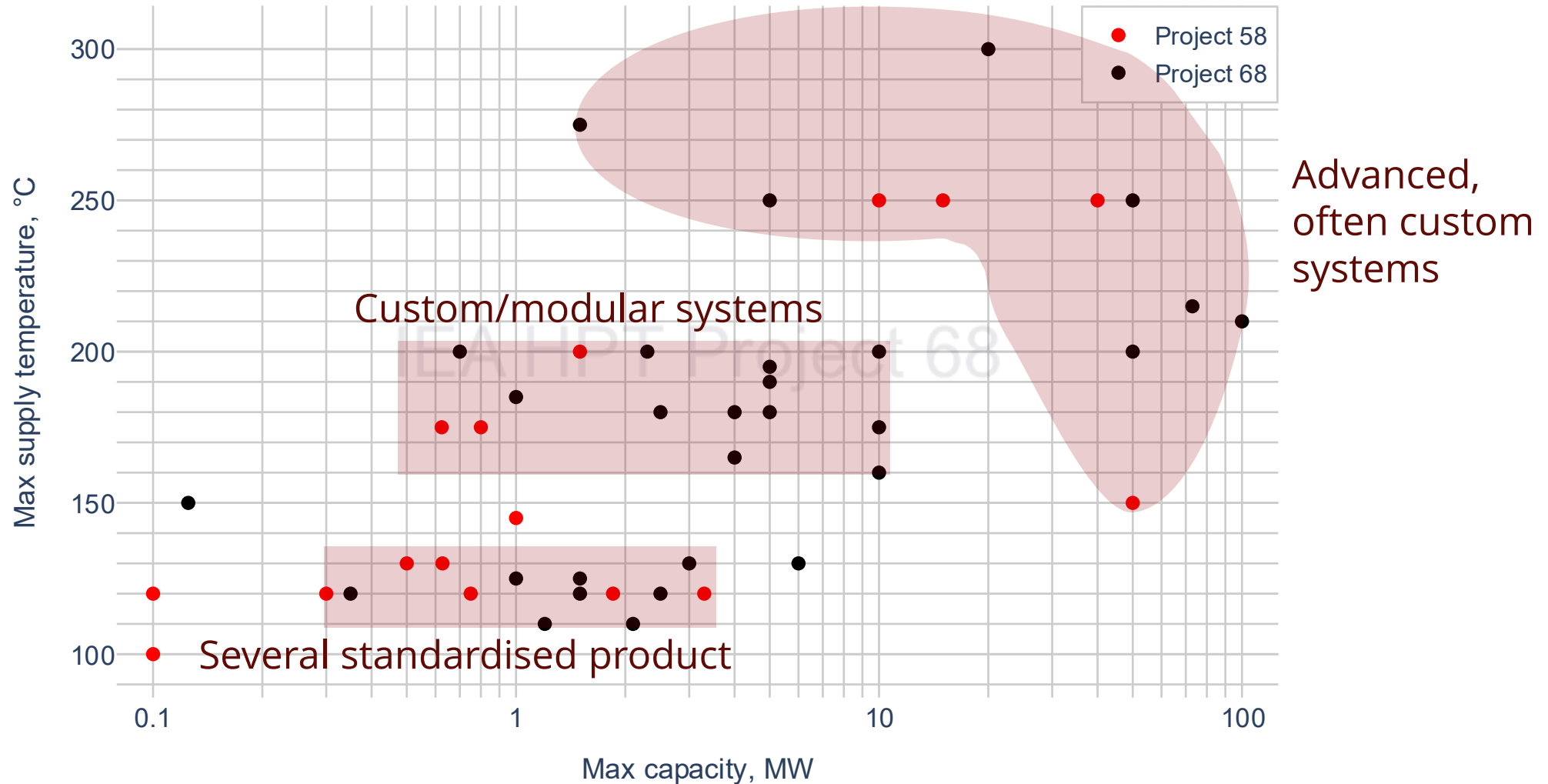
Water	Steam (1/2 bar)
Water / steam (saturated)	Steam (4.5 bar)
Water	Water
Water	Steam (3.5 bar)
Water	Water
Water	Water
Water	Water

IEA Technology Collaboration Programme on Heat Pumping Technologies (DHT TCP)

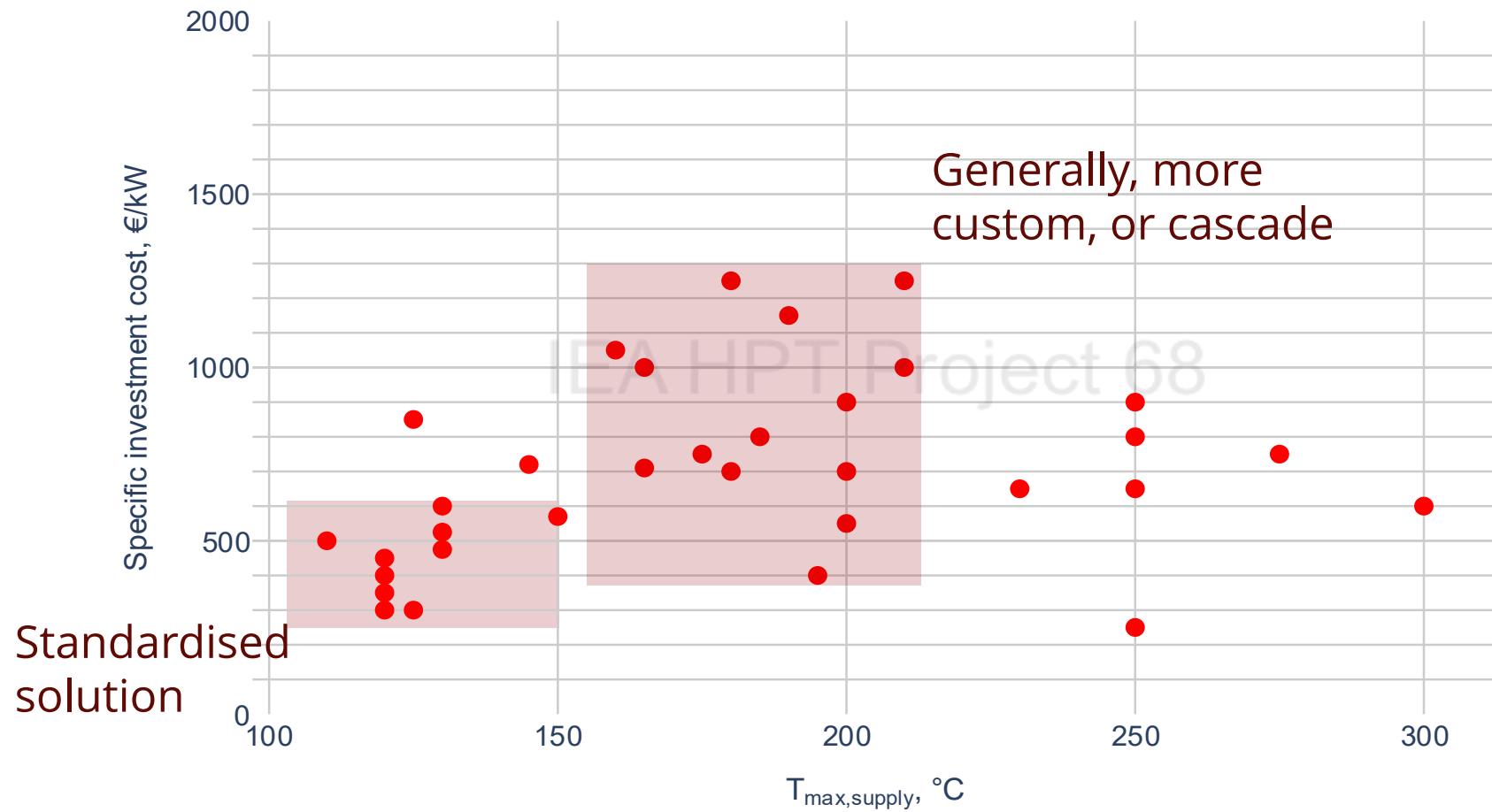
AGO Enerdale

Danish Technological Institute

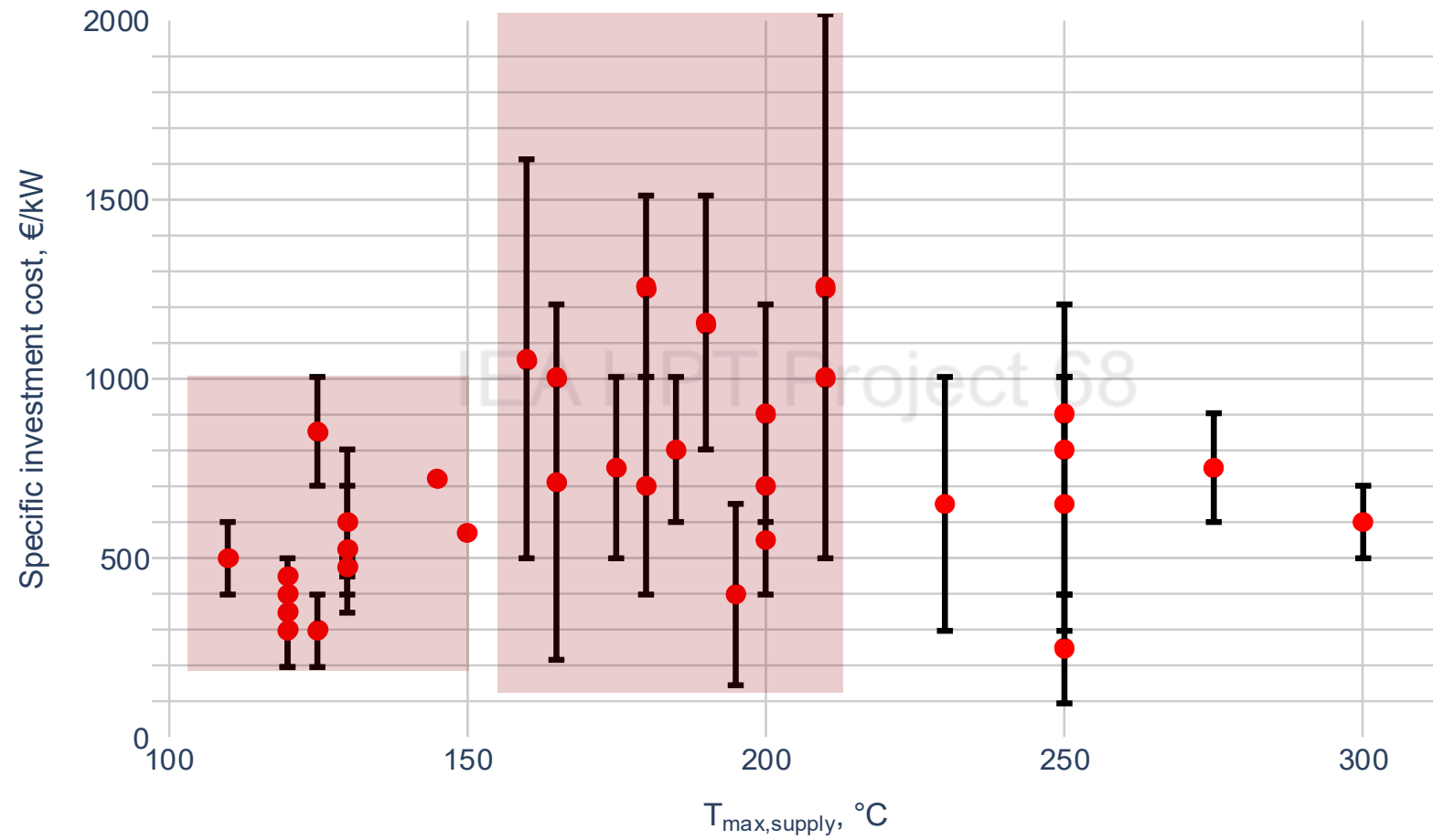
Where are the technologies today?



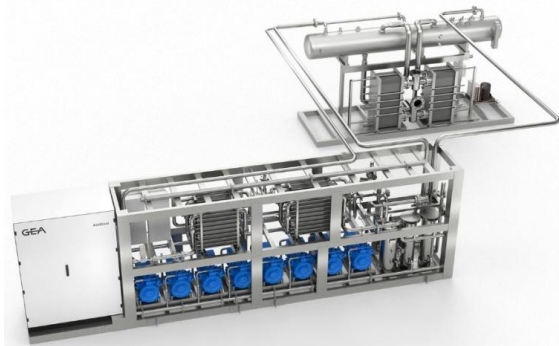
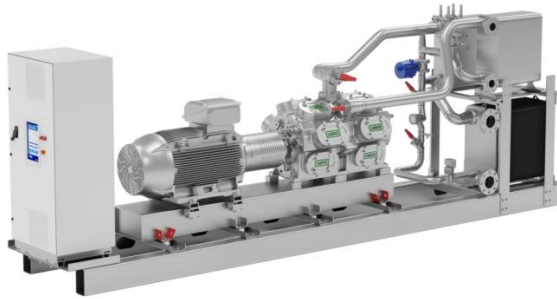
What do they cost?



What do they cost?



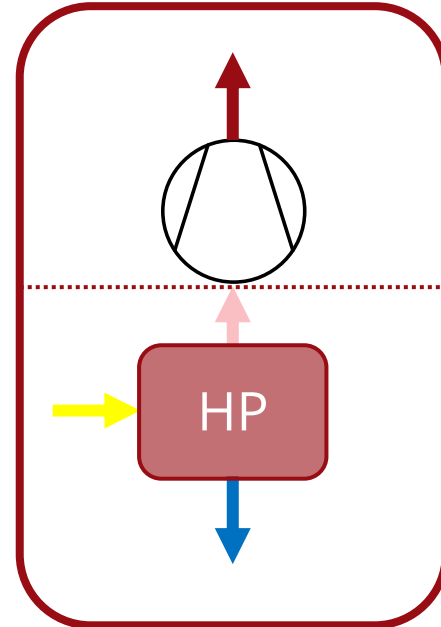
Standardised are coming



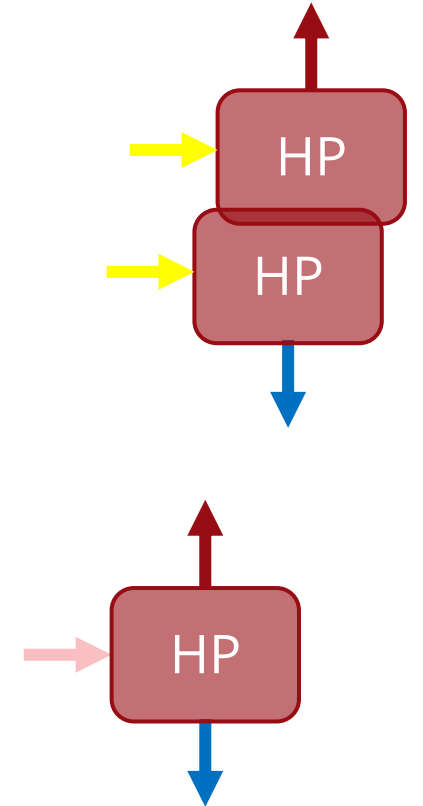
Standardised are coming



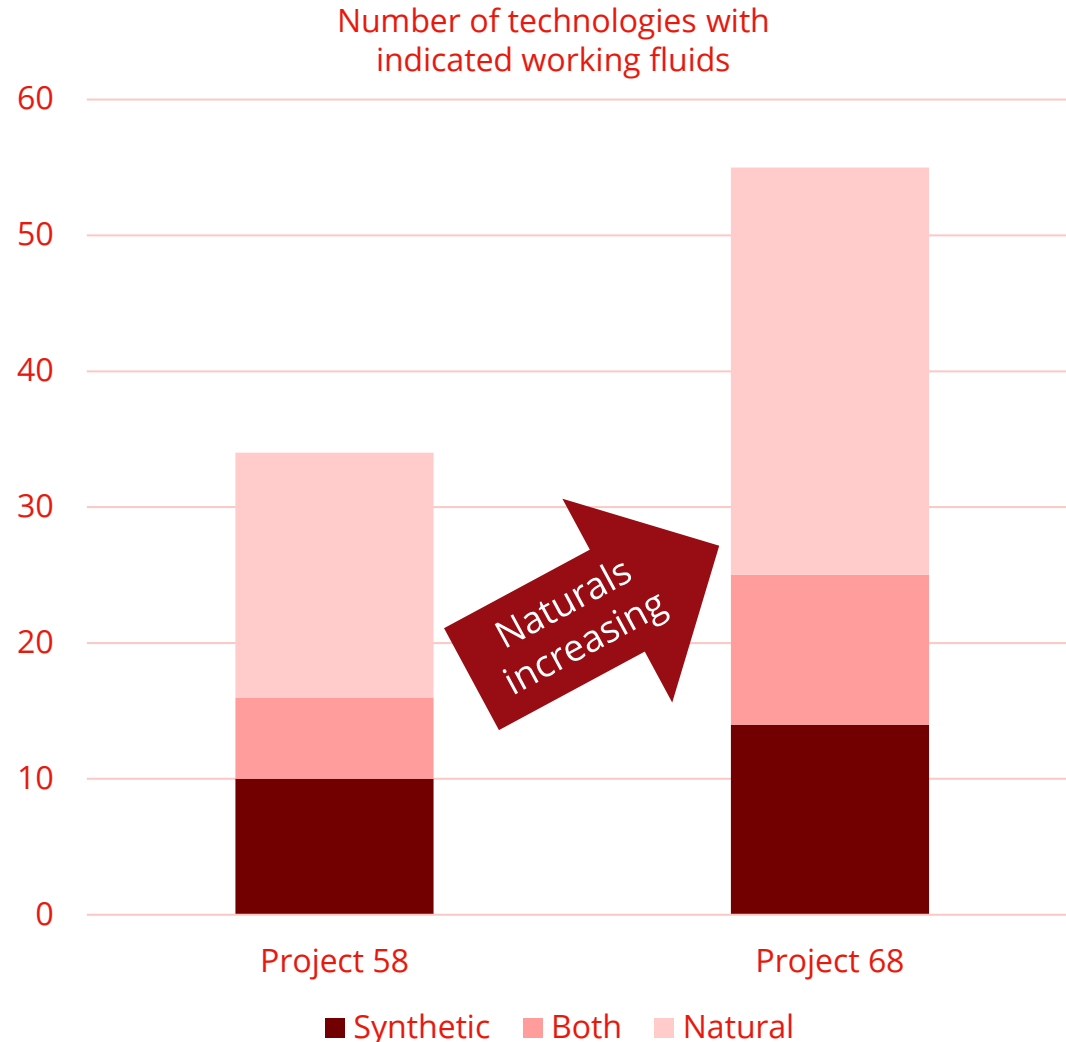
Majority



- Rankine/brayton cycles
- Stirling cycles
- Rotational
- Absorption



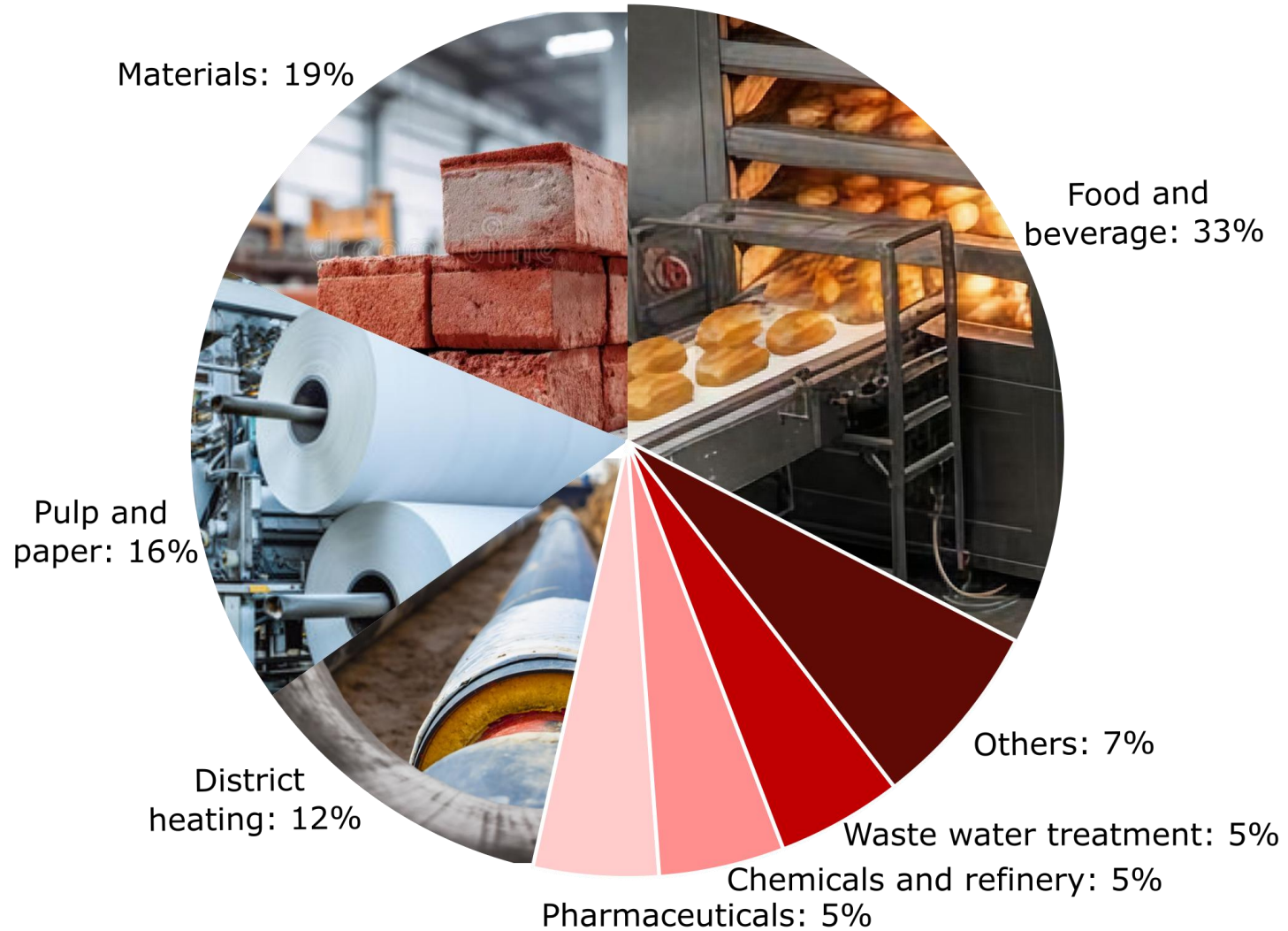
Refrigerants: the shift is happening



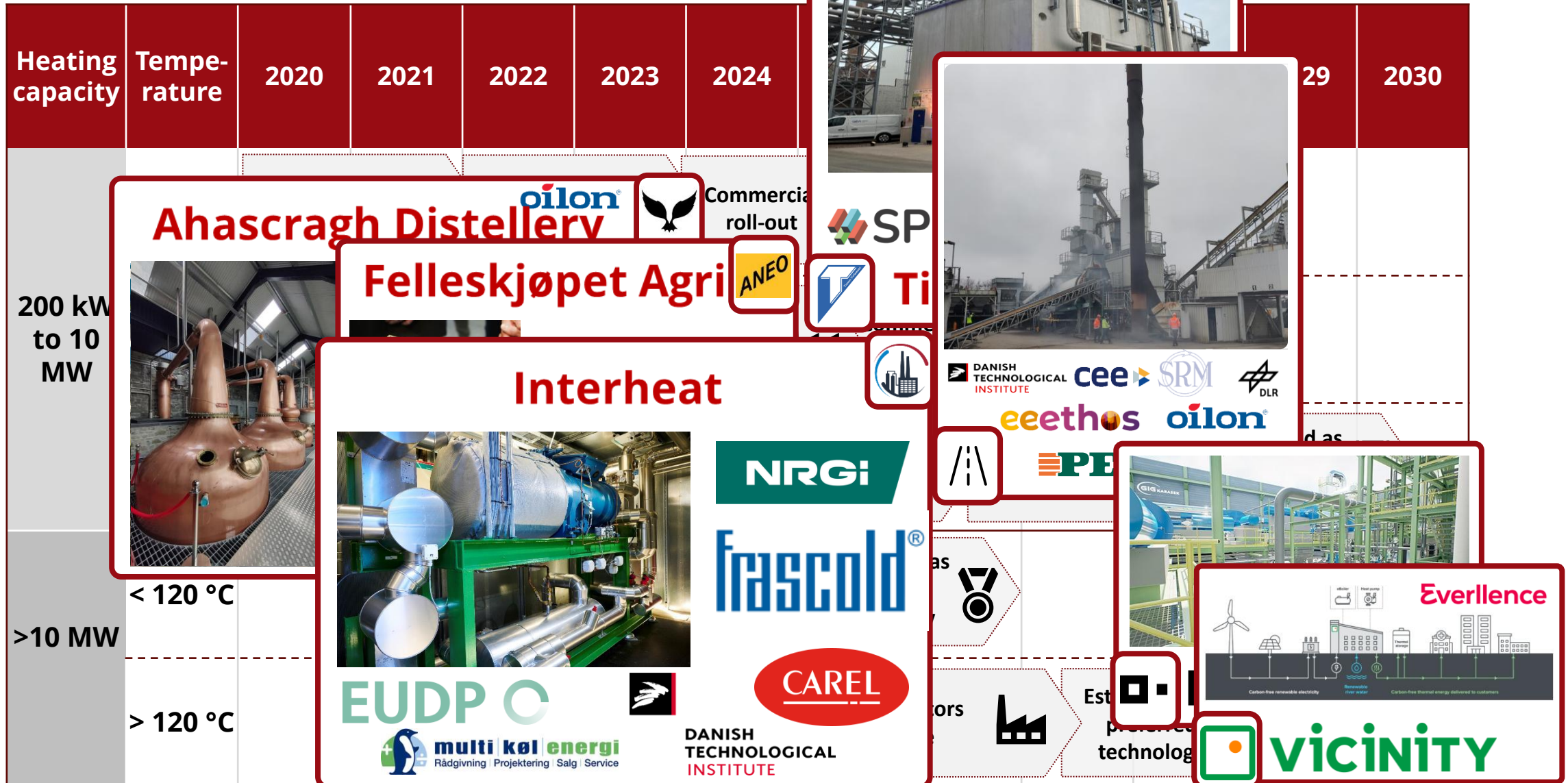
- Natural options now 75 % of reviewed portfolio; strongest growth in water/steam and hydrocarbons.
- Frequently used natural refrigerants: CO₂, Steam, Ammonia/Water, Hydrocarbons
- Frequently used HFOs: R-1233zd(E) R-1234ze(E) R1336mzz(Z)

→ For every HFO HTHP, there is a NatRef alternative

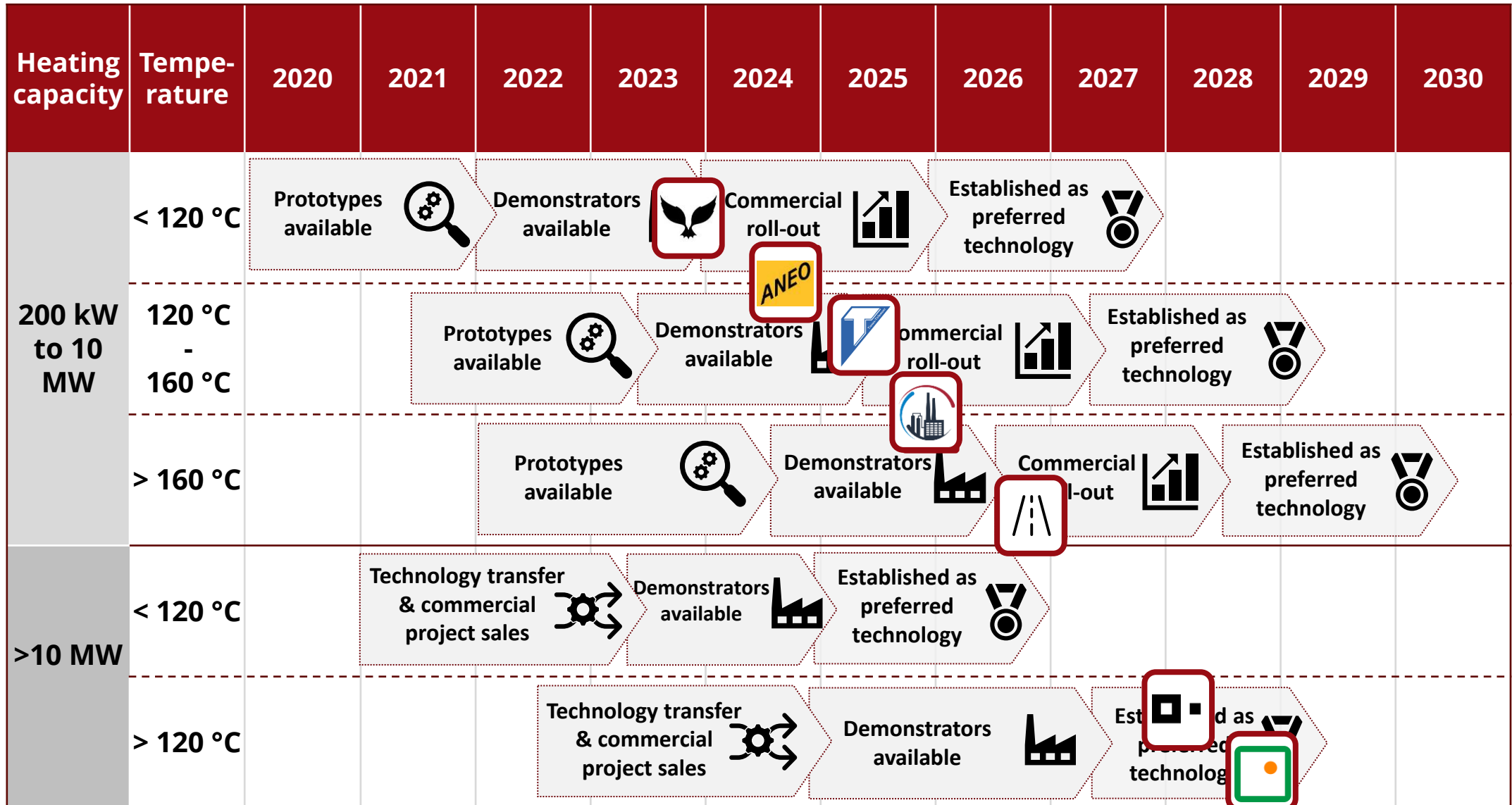
Where are they installed?



Development road



Development roadmap



Moving from potential to practice

High-temperature heat pumps are....



Standardized package <math><130\text{ }^\circ\text{C}</math>



Demonstrated in various sectors <math><160\text{ }^\circ\text{C}</math>



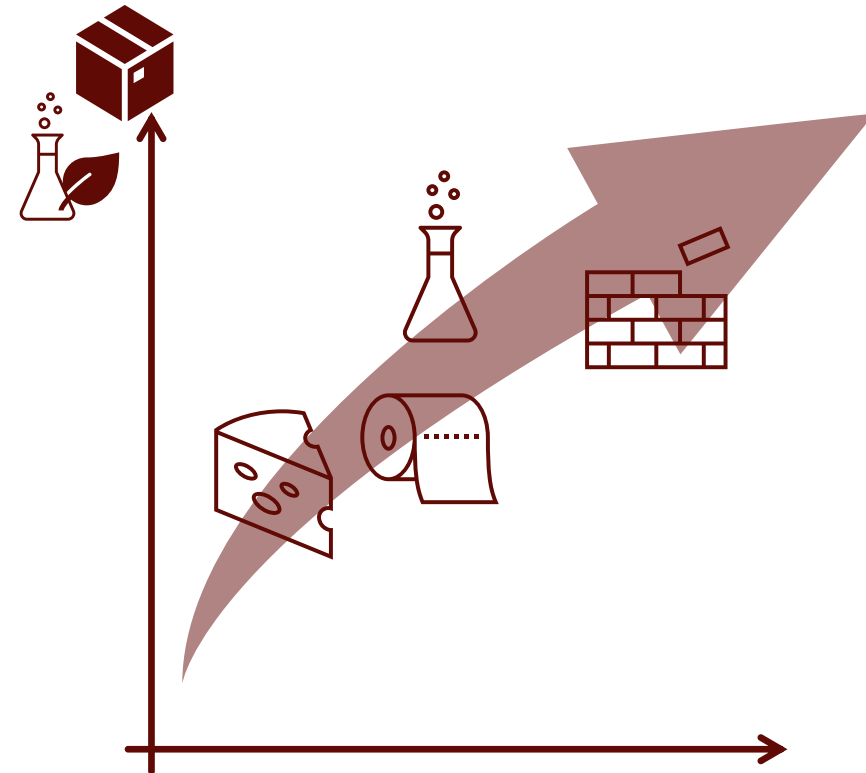
Demonstration ongoing to reach $200\text{ }^\circ\text{C}$



Predominantly using natural working fluids



Scaling to more sectors



15TH IEA HEAT PUMP CONFERENCE

MAY 26–29, 2026 | HOFBURG



OST

Eastern Switzerland
University of Applied Sciences

Realized projects and what is to come with focus on success factors

Workshop: Decarbonizing Process Heating with High-Temperature Heat Pumps – From Market to Application, 26 May 2026, Vienna

Dr. Cordin Arpagaus
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IES | Institute for
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www.ost.ch/ies

Realized projects and what is to come with focus on success factors

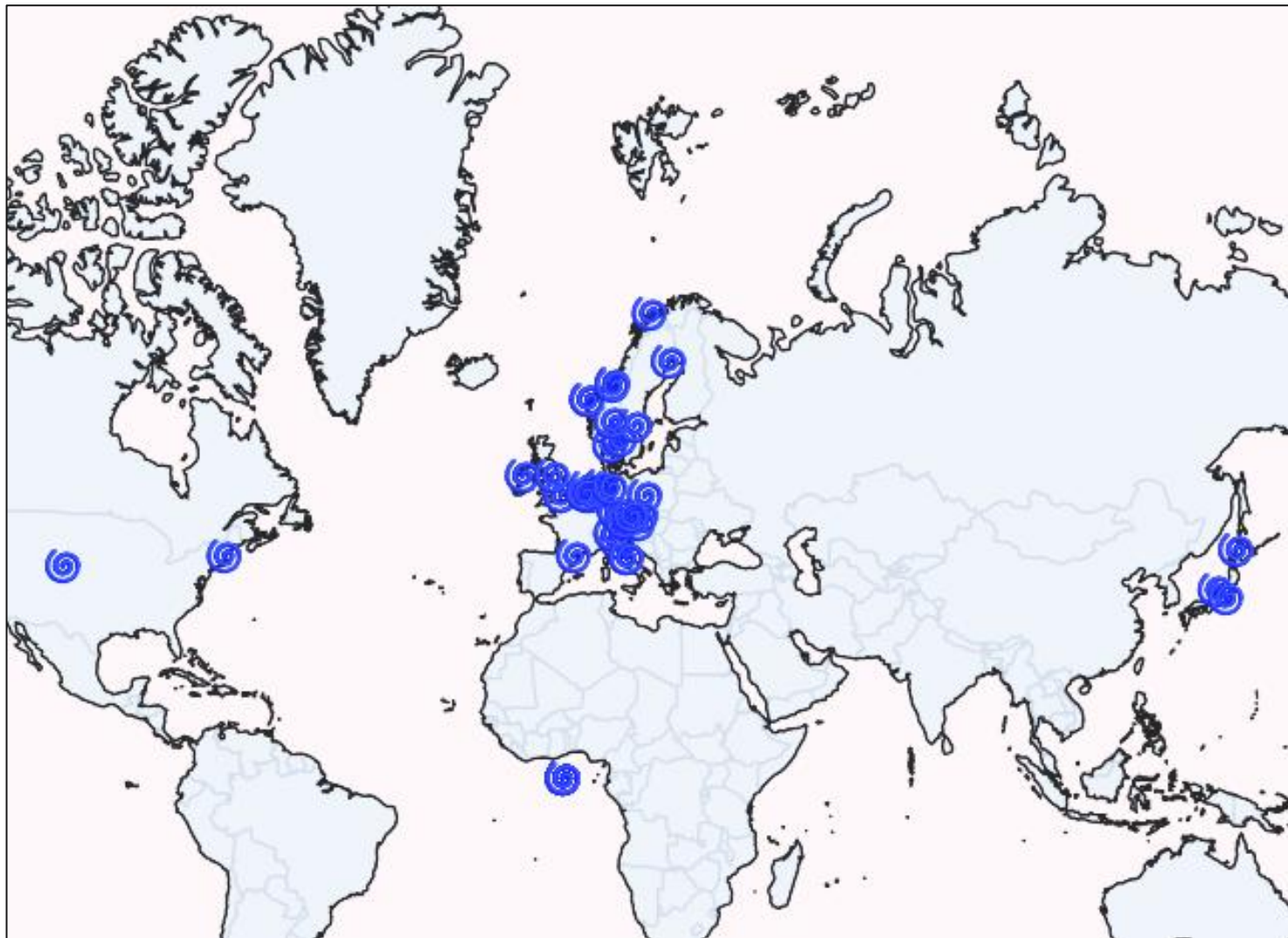
Content

- **Realized Demonstration Cases**
- **Representative Cases**
- **Success Factors**

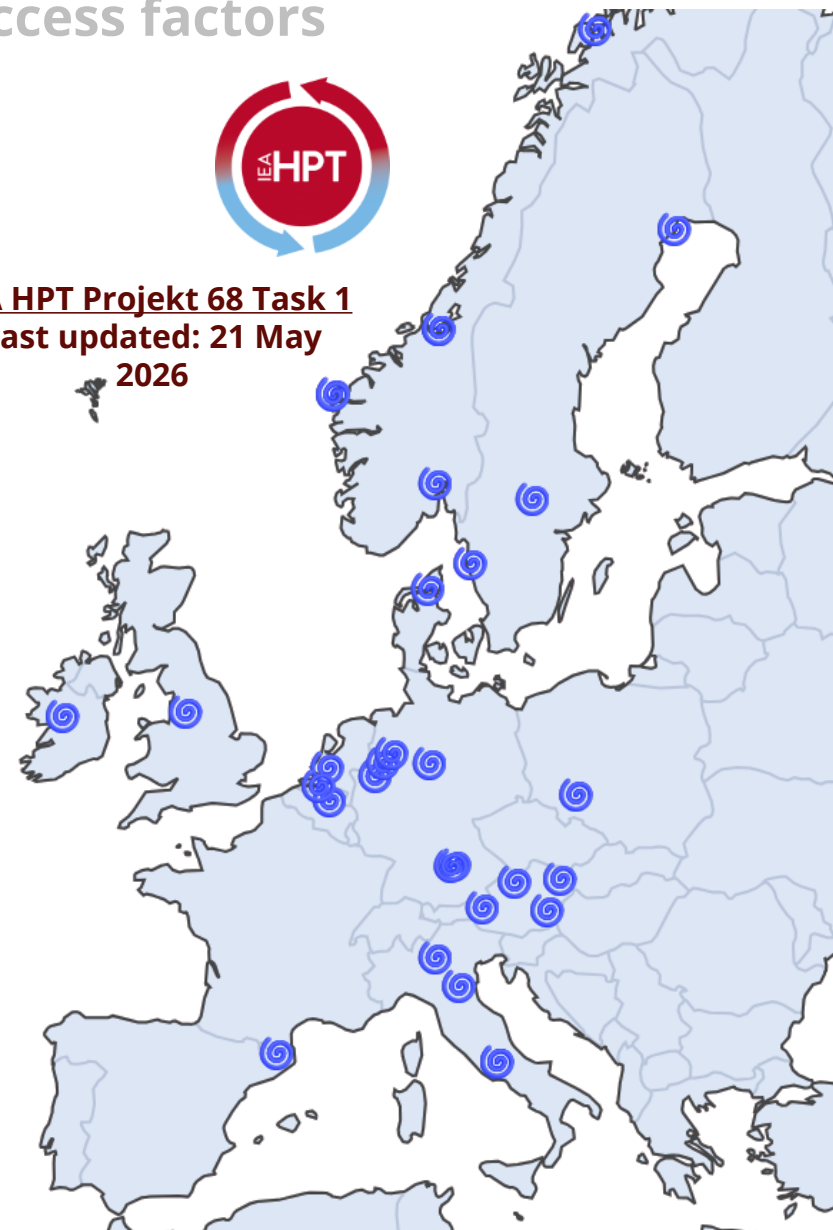


Realized projects and what is to come with focus on success factors

40+ Demonstration Cases




IEA HPT Projekt 68 Task 1
Last updated: 21 May
2026





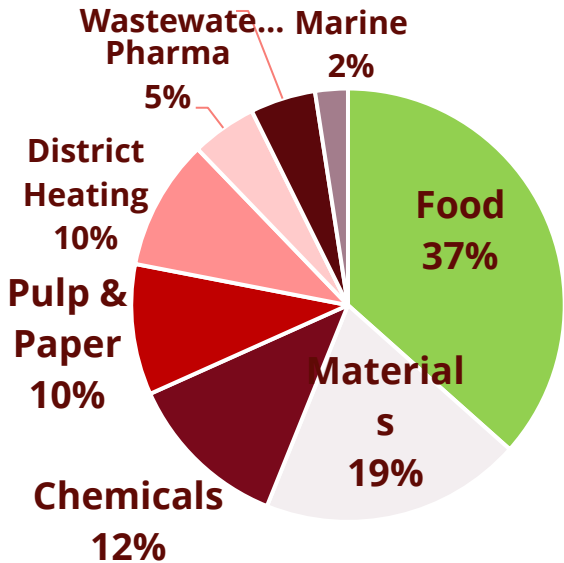
40+ Demonstration Cases from IEA Project 68

IEA HPT Project 68 Task 1
Last updated 21 May 2026

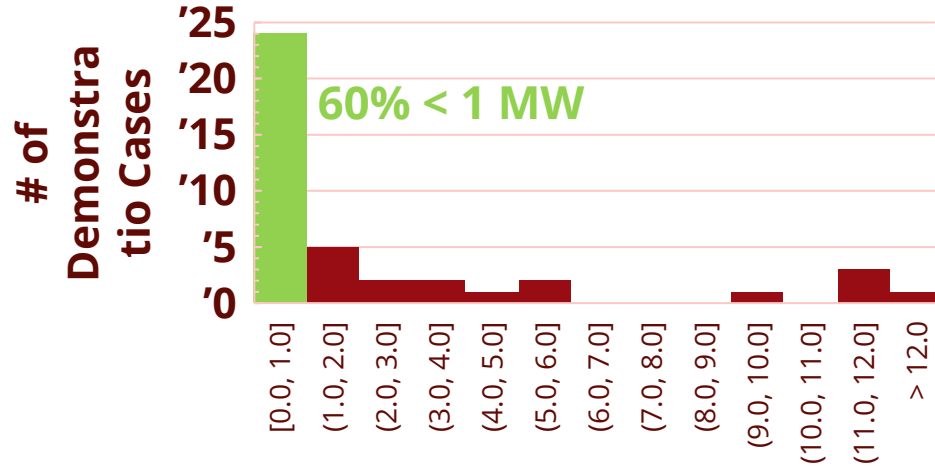
HTWP Supplier	Industry	Heat Source in → out (°C)	Heat Sink in → out (°C)	Refrigerant	Compressor Type	Heating Capacity (MW)	COP	Heat Source Media	Heat Sink Media
Kobelco	Wastewater (sewage sludge)	93 → n.a.	n.a. → 160	R718	Roots, Screw	0.7	2.9	Steam (saturated)	Steam (saturated)
Epcon/Rotrex	Wastewater (sludge)	100 → n.a.	n.a. → 125–146	R718	Turbo	0.5	4.5–8.7	Steam (saturated)	Steam (saturated)
Spilling	Chemicals	152 → n.a.	n.a. → 240	R718	Piston	12.0	5.3–5.8	Steam (5 bar)	Steam (19.5 bar)
Kobelco	Chemicals (Bioethanol)	65 → 60	20 → 110–120	R245fa	Screw	0.4	3.5	Water	Steam (saturated)
Qpinch	Chemicals (Ethylene Polymerization)	135 → 80	140 → 185	R718/H ₃ PO ₄	n.a.	2.9	0.45	Steam/Water	Steam (saturated)
Celeroton	Chemicals (Methanol Distillation)	75 → n.a.	n.a. → 157	Methanol/Water	Turbo	n.a.	n.a.	Methanol/Water	Methanol/Water
SPH Sustainable Process Heat	Steam generation	46 → 41	90 → 123	R515B, R1233zd	Screw, Piston	1.2	2.3	Water	Steam
Everllence	District heating	29 → 3	n.a. → 200	Natural	Centrifugal	40.0	>2	Water	Steam (15 bar)
Turboden	District heating	70 → 60	60 → 120	R1233zd(E)	Centrifugal	6.0	5–8	Water	Water
RANK	District heating	25 → 15	60 → 90/105/130	R1234ze(E), R1233zd(E)	Screw	1.0	2.78	Water	Water
AGO Energie & Anlagen	District heating	23 → n.a.	120 → n.a.	R717, R718	Piston	1.8	2.6	Water	Water
AtmosZero	Food	40 → 20	n.a. → 165	R513a/R1233zd(E)	Centrifugal	0.7	1.3–2.04	Air	Steam (7 bar)
AGO Energie & Anlagen	Food (Brewery)	90 → n.a.	120 → n.a.	R717, R718	Piston	1.2	6.1	Water	Water
TTI	Food (Deep-frying)	95 → n.a.	150 → 170	R718	Turbo	1.0	3	Process Gas	Oil
Olvondo	Food (Milk)	85/31 → 75/26	105 → 155	R704	Piston	5.4	2	Water/Water	Steam (5 bar)
Skala Fabrikk	Food (Milk)	5/20 → 0/12	95 → 115	R290, R600	Piston	0.3	2.5–3.4	Ice Water/Water+Glycole	Water
GEA	Food (Milk Spray Drying)	5 → 3	35 → 130	R744	Piston	0.9	2.5	Water	Water
Aneo Industry	Food (pelleting)	60 → 30	4 → 75/140	R717, R718	Screw, Piston, Centrifugal	1.7	3.1	Humid Air	Water/Steam (2 bar)
Aneo Industry	Food (Protein/fish oil)	80/98 → 35/98	n.a. → 148	R717, R718	Piston, Centrifugal	4.4	3.5–6.5	Water/Steam (saturated)	Steam (4.5 bar)
Mayekawa Europe	Food (Shrimp Processing)	12 → 7	140 → 145	R717, R601	Screw + Screw	0.8	1.8	Ammonia	Steam (4 bar)
AMT Kältetechnik	Food (Drying)	76 → 72	96 → 138	R1336mzz(Z)	Screw	0.4	3.2	Water	Water
Oilon/Astatine	Food (Whiskey)	60 → n.a.	n.a. → 115	Hightemp-Refrigerant	Piston	1.0	5	Water	Water
Heaten	Food (SugarPproduction)	102 → 100	128 → 130	R1233zd(E)	Piston	4.0	6	Steam (saturated)	Steam (saturated)
GEA	Food (Sugar Refining)	75 → 75	110 → 140	R601	Screw	4.0	3–5	Steam	Steam
Enerin	Food, animal feed (fish meal/oil)	16–72 → n.a.	n.a. → 163–167	R704	Piston	0.4	1.75–2.35	Water	Water
HTT	Food/Paper/Materials	90/150 → 70/130	n.a. → 265/200	Air	Turbo	0.6	1.5–1.8	Water	Oil/Water
ThermoDraft	Marine	75–85 → 65–75	90–100 → 110–120	R1233zd(E)	Screw	0.1	3.4–5.6	Water	Water
Psycotherm, Heaten	Materials (Roof Tiles)	85/60 → 70/50	230/125 → 300/225	Air, R600a, R718	Piston, Turbo	1.0	1.5/2.1	Air/Humid Air	Air/Steam (5 bar)
Piller Blowers & Compressors	Materials (EPDM)	92 → 60	n.a. → 126–131	R718	Turbo	10.0	4.4	n-Hexane/Water	Steam
Ochsner Energie Technik	Materials (Leather)	55 → 50	100 → 110	R1233zd	Screw	0.3	3.2	Water	Water
SPH Sustainable Process Heat	Materials (Metal Treatment)	92 → 84	90 → 159	R1336mzz(Z)	Piston	1.0	2.5	Water	Steam (6 bar)
SPH Sustainable Process Heat	Materials (Tobacco Drying)	50 → 36	90 → 139	R515B, R1233zd	Piston	0.7	2.5	Water	Steam (3.5 bar)
MHI Thermal Systems	Materials (Drying)	55 → 50	70 → 130	R134a	Centrifugal	0.6	3	Water	Water
AMT Kältetechnik	Materials (Bricks)	88 → 84	96 → 121	R1336mzz(Z)	Piston	0.3	5	Water	Water
Combitherm	Materials (Brick Drying)	102 → 74	110 → 120	R1233zd(E)	Screw	0.8	4.2	Water	Water
SPH / Spilling	Pharma	70 → n.a.	n.a. → 184	R600, R718	Piston	1.7	4.4	Water	Steam (11 bar)
Olvondo	Pharma	36 → 34	105 → 183	R704	Piston	2.3	1.7	Water	Steam (10 bar)
Turboden	Pulp & Paper	17 → 8	104 → 170	R600a	Centrifugal	12.0	2	Water	Steam (superheated)
Spilling	Pulp & Paper	133 → n.a.	n.a. → 240	R718	Piston	11.2	4.2–4.7	Steam (3.2 bar)	Steam (16 bar)
BS NOVA	Pulp & Paper (Steam)	90 → 80	n.a. → 162	LiBr-H ₂ O	Absorption	0.3	0.48	Water	Steam (6.5 bar)
Cannon Bono	Pulp & Paper (Steam)	90 → 80	105 → 162	R1233zd(E)	Screw	0.6	5.2	Water	Steam (6.5 bar)

Realized Demonstration Cases from IEA Project 68

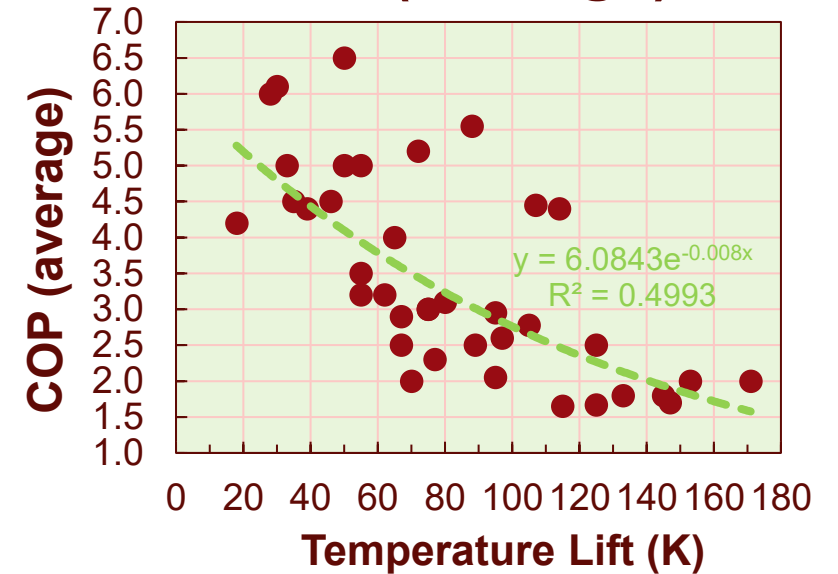
Industry



Heating Capacity

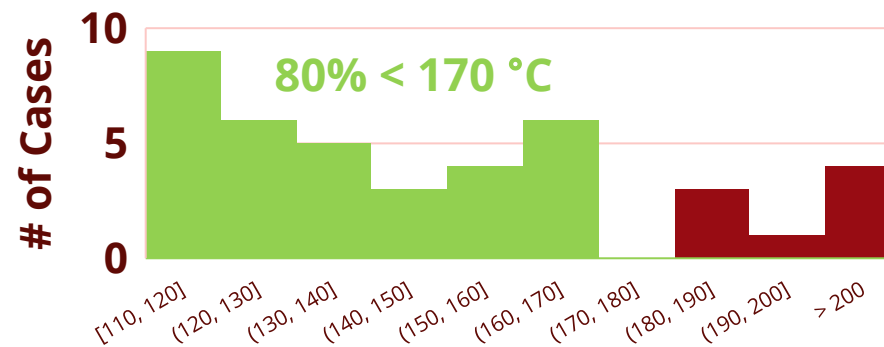


COP (average)



Heat Sink

Outlet Temperatures

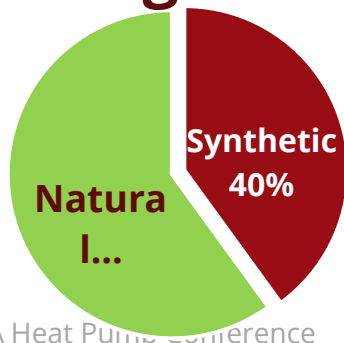


Heat Source and Sink

Media

	Heat Source	Heat Sink
Water	73%	41%
Steam	20%	59%
Air	7%	2%

Refrigerants

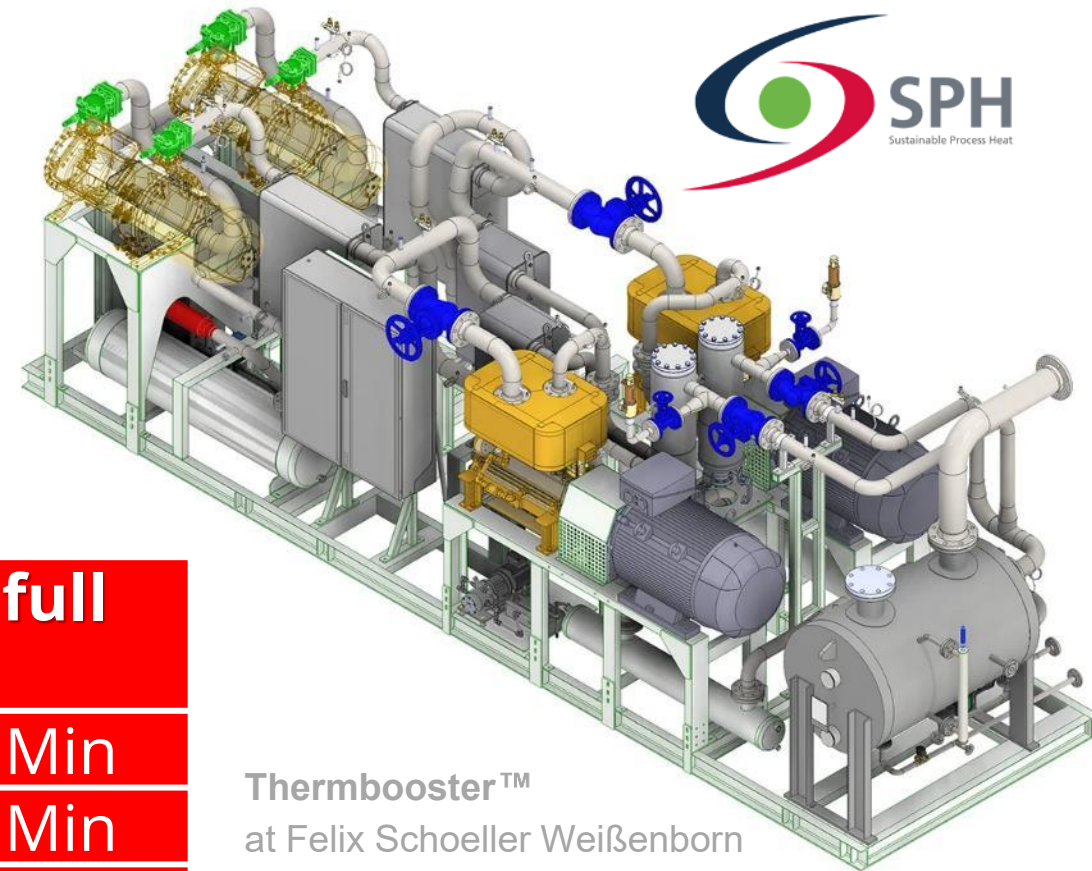


Piston compressor technology

Success factors = Flexibility

- Time to full load
- Shutdown: < 5 min incl. pumpdown
- Emergency stop: Few seconds
- Restart: within seconds after stop

Configuration	Time to start	Time to full load
Completely cold	Up to 30 Min	Up to 75 Min
Cold	< 5 Min	Up to 45 Min
Hot	< 5 Min	< 10 Min
Minimal capacity	0	< 3 Min



Thermbooster™

at Felix Schoeller Weißenborn

- Steam 2.2 bar(a) (123 °C)
- Waste heat 46 °C/41 °C (paper dryer)
- 1'180 kW, COP 2.3

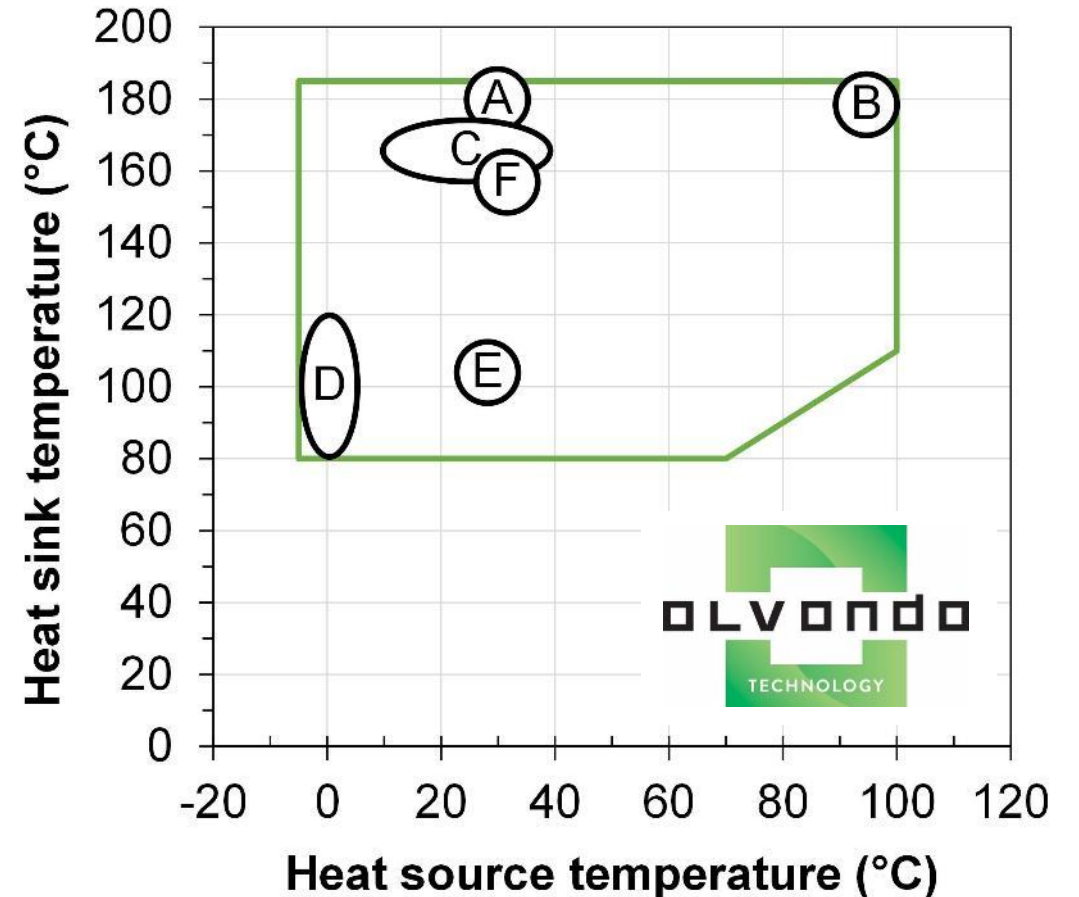
Realized projects and what is to come with focus on success factors

Reference projects from Olvondo HighLift



Success factors

- Flexible operating range & high lift



Images courtesy of Olvondo

15th IEA Heat Pump Conference

33 26 May 2026, Vienna

cordin.arpagaus@ost.ch

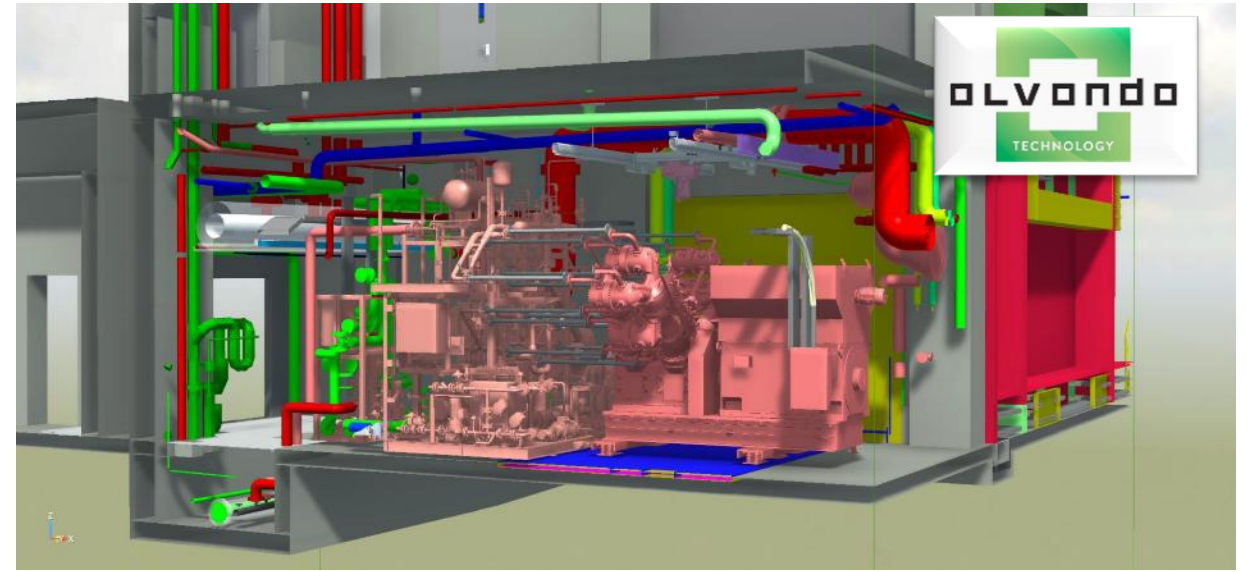
Danish Technological Institute

Realized projects and what is to come with focus on success factors

Pilot Plants at Pharma company F. Hoffmann-La Roche, Basel

Enerin: 1.8 t/h @ 7 bar(a)

Olvondo: 1.1 t/h @ 7 bar(a)



Images courtesy of Roche presented at IHW Forum at OST, 18/03/2026

Success factors:

- Steam generation: 7 bar(a), 165 °C
- Heat source: 6/12 °C low-temperature network
- Good controllability: 1:6 (target: 1:8) part-load
- Natural refrigerant / no HFOs

Realized projects and what is to come with focus on success factors

Steam-generating heat pump with ammonia + water

Success factors:

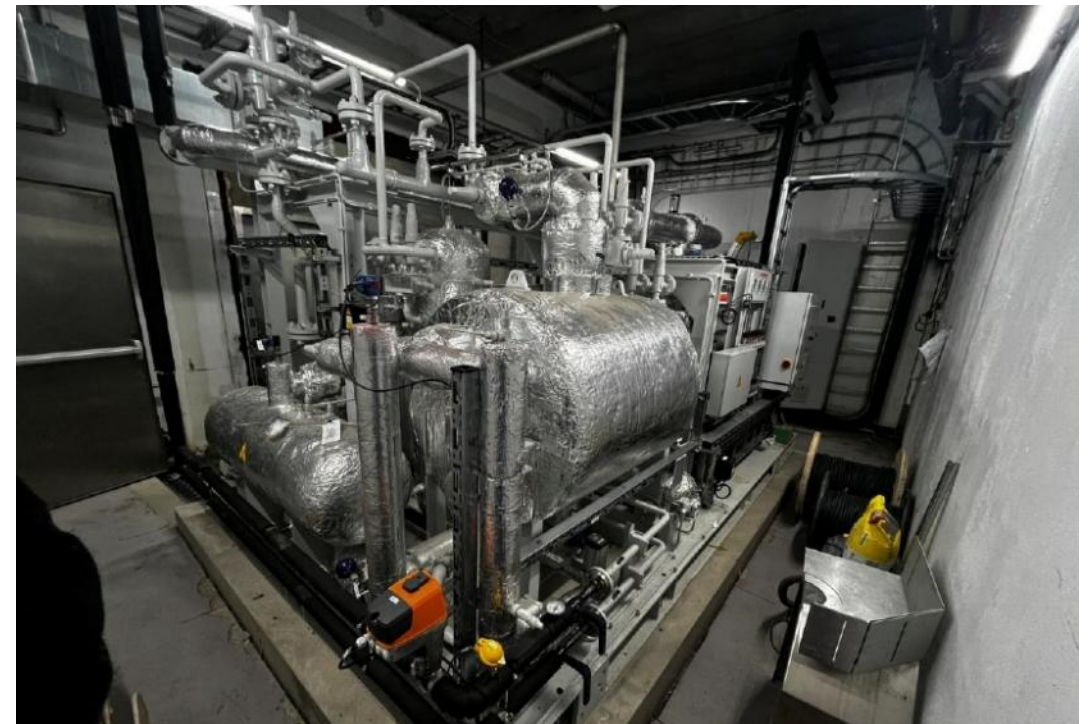
- Natural refrigerants, cascade of screw, piston, and 4 turbo compressors
- Waste heat recovery from moist air in pet food pellet production
- 1.6 MW, 2 t/h steam at 120 °C and 1.5 bar(a)



Realized projects and what is to come with focus on success factors
NH₃ heat pump for shrimp processing at Stella Polaris,

Norway
Success factors

- R-717/R-601
(ammonia/pentane)
- 12/7 °C → 140/145 °C (steam)
- COP: 1.8 (combined COP: 2.5)
- Heating capacity: 0.8 MW_{th}
- CO₂ savings: 621 t/CO₂/a
- Investment: 0.8 Mio. EUR
(excl. integration)



Realized projects and what is to come with focus on success factors

Electrified feed dryer



Success factors:

120 °C Hot Water

4 x HWW 2/9583I → **3.5 MW_{th}**

COP ~ 2.8

2/3 at COP 2.4 (40 °C → 120 °C)

1/3 at COP 4.0 (40 °C → 90 °C)

EWOS Cargill

Combigtherm
APPARATE- UND
ANLAGENBAU

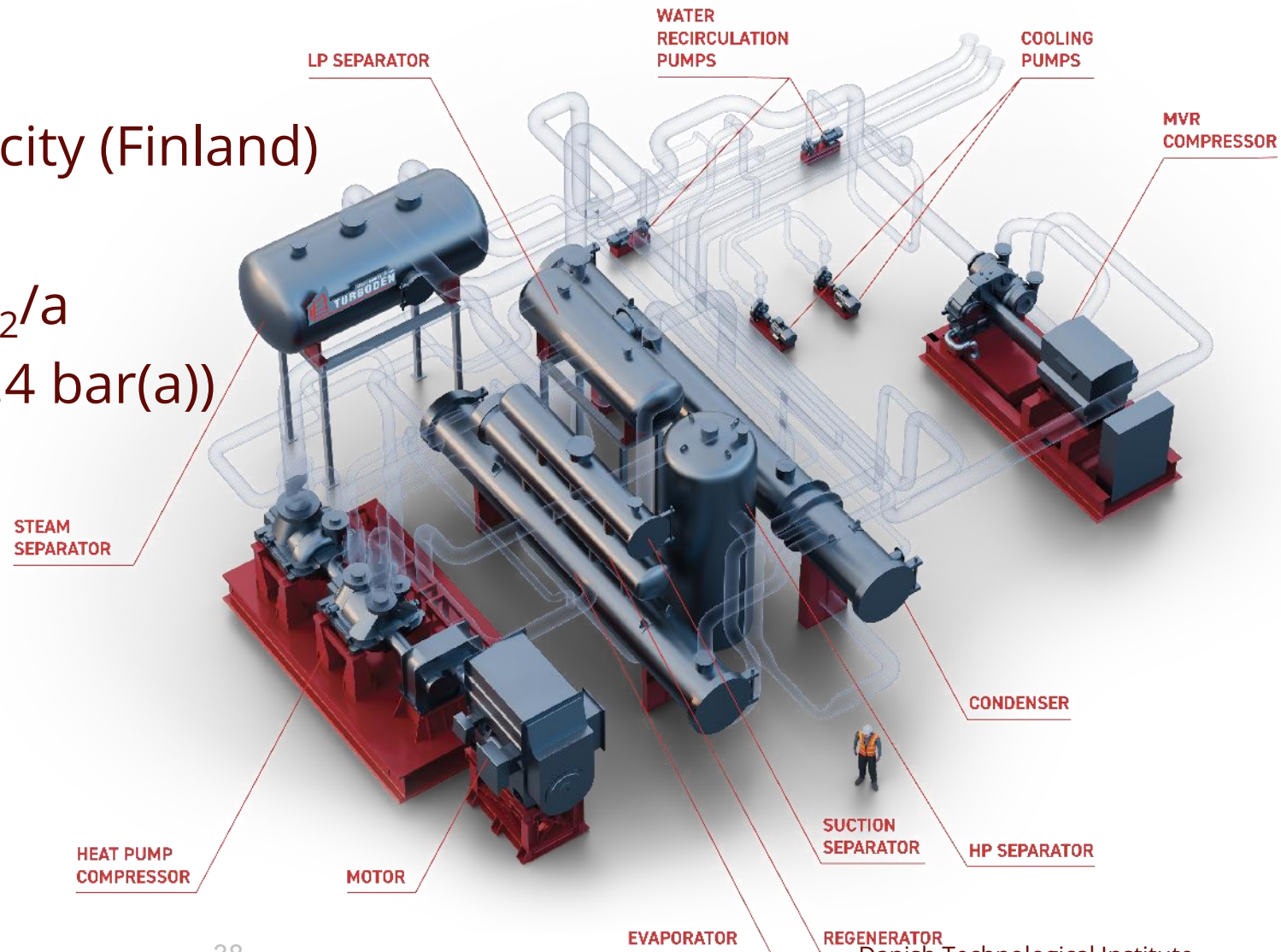
geelen counterflow
cool and dry

Realized projects and what is to come with focus on success factors

Largest Steam Heat Pump at Delfort Paper Mill

Success factors:

- Low-cost renewable electricity (Finland)
- Fully decarbonized steam
- CO₂ reduction >19'000 tCO₂/a
- 12.5 MW_{th}, 20 t/h steam (3.4 bar(a))
- 17/8 °C → 104/170 °C
- COP up to 2
- R600a (iso-butane)



delfort



clean energy ahead
TURBODEN



Key Takeaways



Success factors

- Proven references & operating experience
- High reliability (e.g., pharma applications)
- Scalability & part-load flexibility
- High temperature lifts
- Natural refrigerant solution
- Low-cost electricity (renewable)
- Fully decarbonized steam generation

Acknowledgements



DeCarbCH

DeCarbonisation of Cooling and Heating in Switzerland) ([SI/502260](https://doi.org/10.1016/j.scires.2021.1002260))
www.sweet-decarb.ch (2021-2028)

IEA HPT Project 68:
Industrial High-Temperature Heat Pumps
([SI/502999](https://doi.org/10.1016/j.scires.2021.1002999)) (2025-2029)

IEA HPT TCP Annex 59
Heat Pumps for Drying ([SI/502606](https://doi.org/10.1016/j.scires.2021.1002606))
(2023-2027)



Funded by the European Union

Grant Agreement No. 101069689
www.push2heat.eu



Zero-carbon Industrial heat production by ammonia water absorption heat transformer



Funded by the European Union

Grant Agreement No. 101146932
www.zimba-project.eu

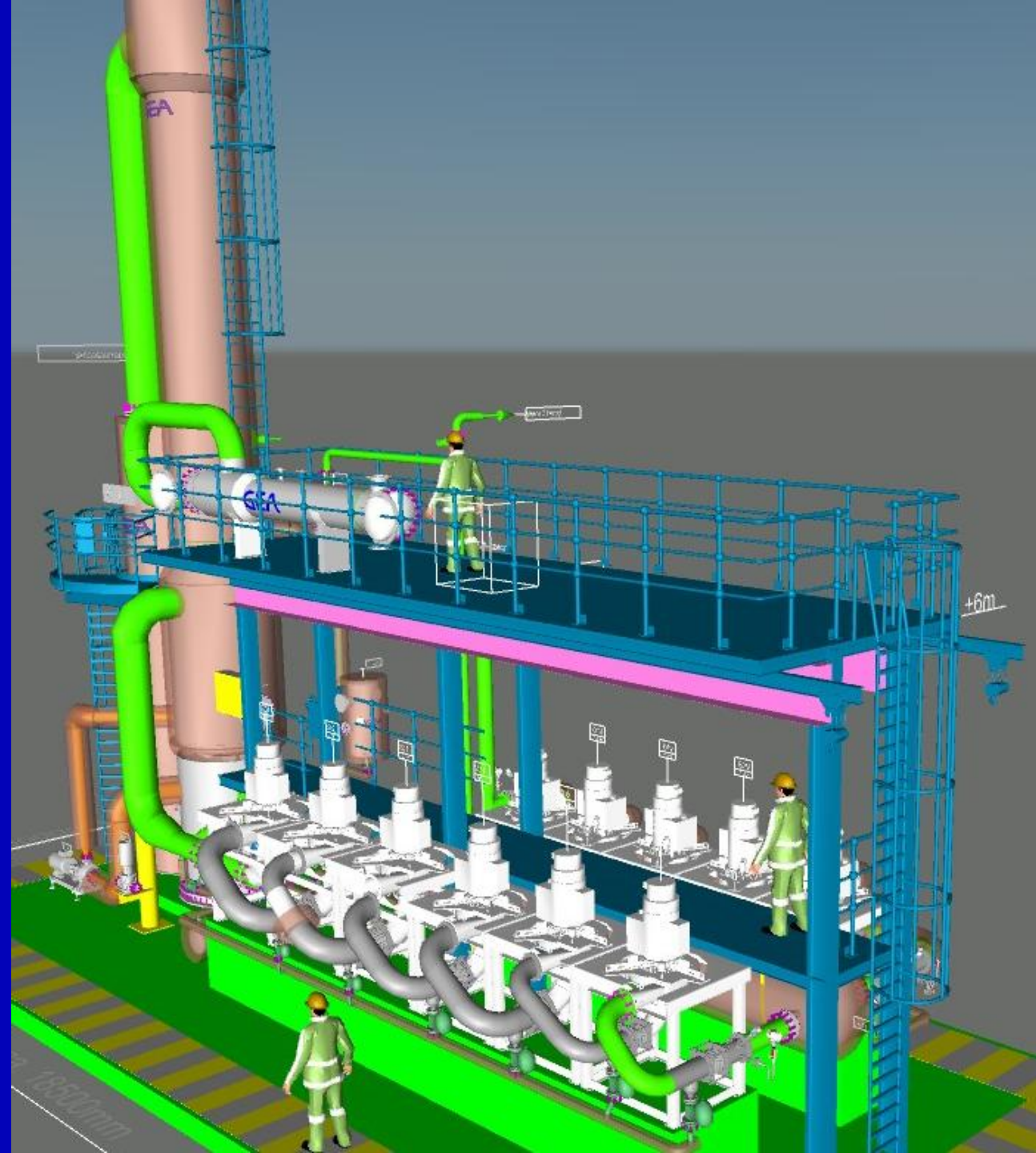
Mechanical Vapor Recompression Lessons Learned

Workshop 1

Decarbonizing process heating with high-temperature
heat pumps

IEA Heat Pump Conference Vienna 26-29th of May 2026

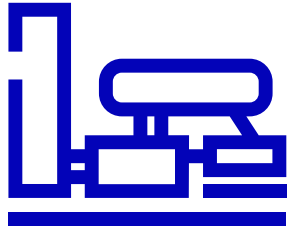
Dr.-Ing. Yannik Stark
GEA Group



GEA

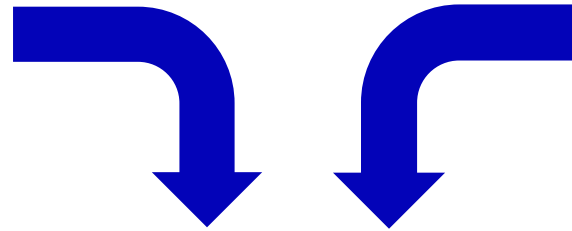
Engineering for a better world

Heating & Refrigeration



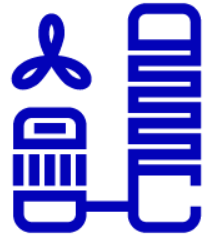
GEA RedGenium

GEA RedAstrum



meVap®
Compression

meVap®
Thermal separation



Evaporation

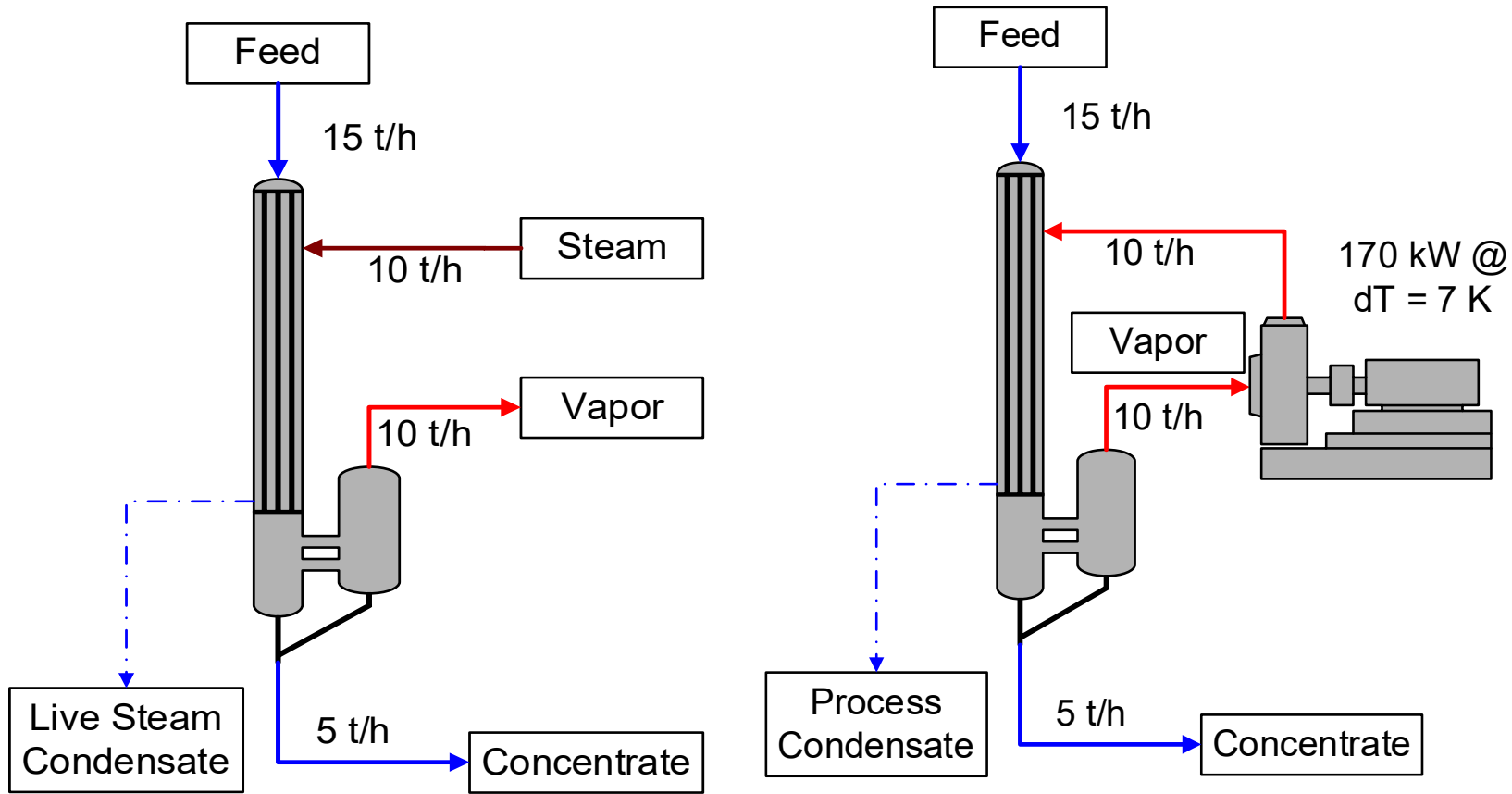
Crystallization

Distillation



Mechanical vapor recompression

Open cycle heat pumps



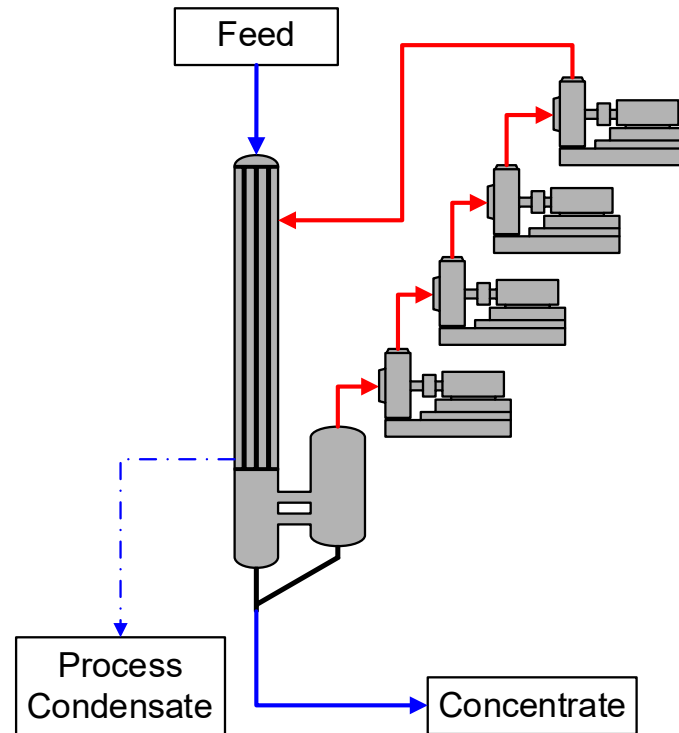
$$COP = \frac{\dot{Q}_{\text{thermal}}}{P_{\text{el}}} = \frac{6,1 \text{ MW}_{\text{th}}}{0,17 \text{ MW}_{\text{el}}} = 36 \quad \eta_{\text{Carnot}} = 70 \%$$



Mechanical vapor recompression

More complex evaporation plants for caprolactam

- $x_{\text{Caprolactam,inlet}} = 47 \text{ wt. \%}$
- $x_{\text{Caprolactam,outlet}} = 90 \text{ wt. \%}$
- $\dot{m}_{\text{Evap H}_2\text{O}} = 15.5 \text{ t/h}$
- $T_{\text{Evap}} = 81,5 \text{ }^\circ\text{C}$
- $T_{\text{Cond}} = 114 \text{ }^\circ\text{C}$
- $dT = 32,5 \text{ K}$



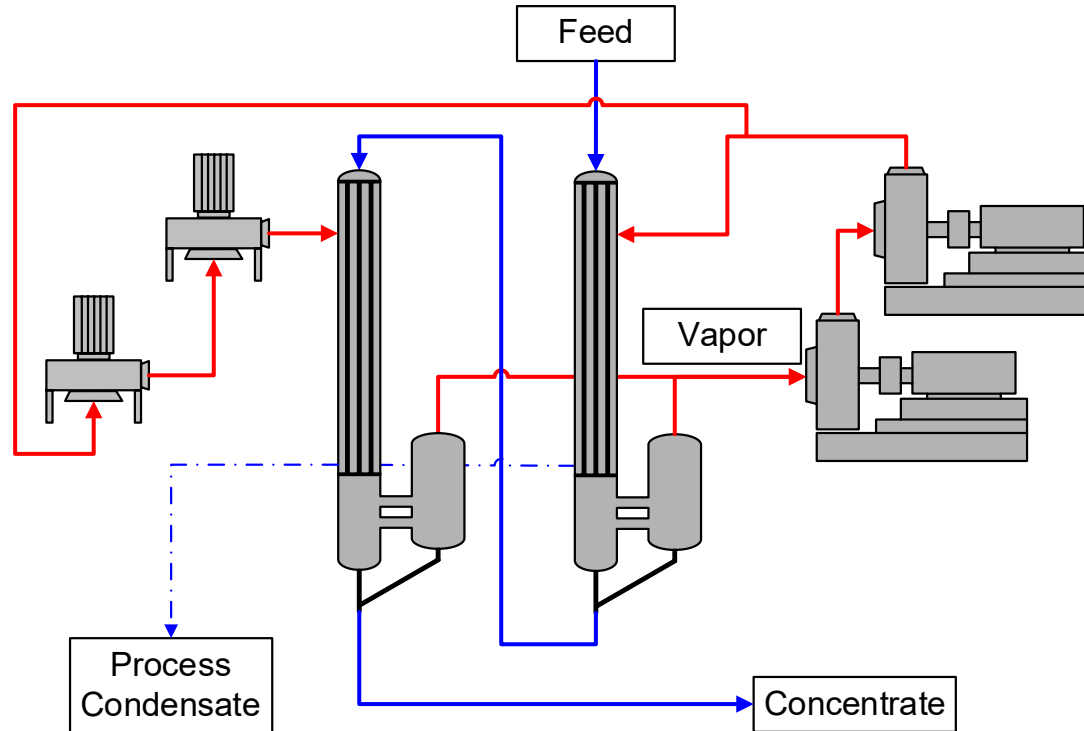
$$COP_{\text{standard}} = 8,3$$



Mechanical vapor recompression

More complex evaporation plants for caprolactam

- $x_{\text{Caprolactam,inlet}} = 47 \text{ wt. \%}$
- $x_{\text{Caprolactam,outlet}} = 90 \text{ wt. \%}$
- $\dot{m}_{\text{Evap H}_2\text{O}} = 15.5 \text{ t/h}$
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- $T_{\text{Cond}} = 114 \text{ }^\circ\text{C}$
- $dT = 32,5 \text{ K}$



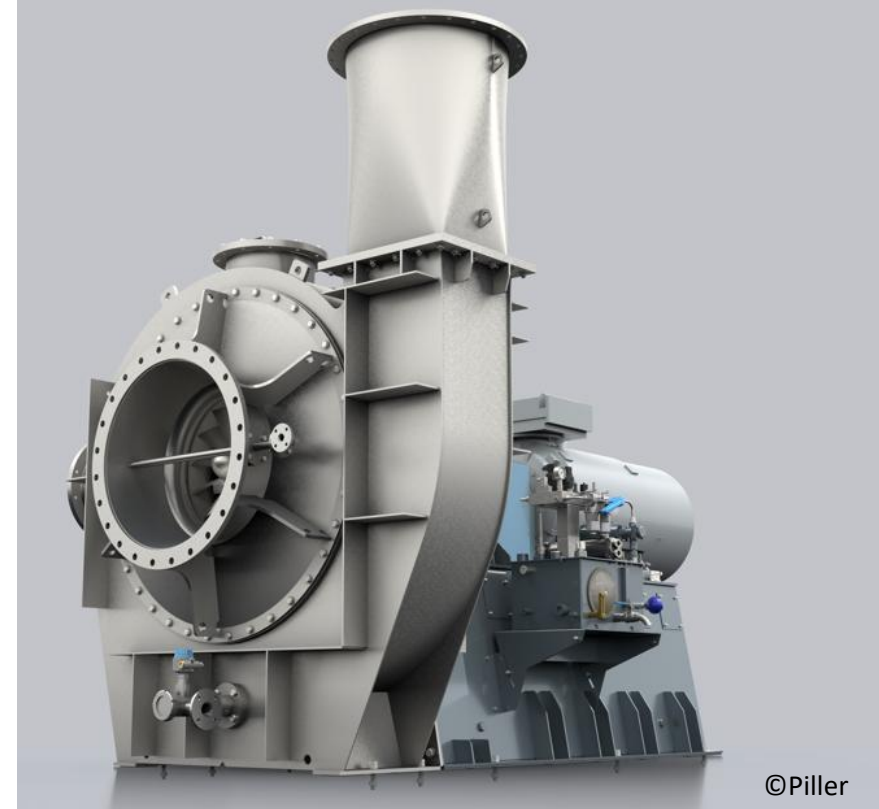
$$COP_{\text{optimized}} = \frac{9,9 \text{ MW}_{\text{th}}}{0,7 \text{ MW}_{\text{el}}} = 13,7$$



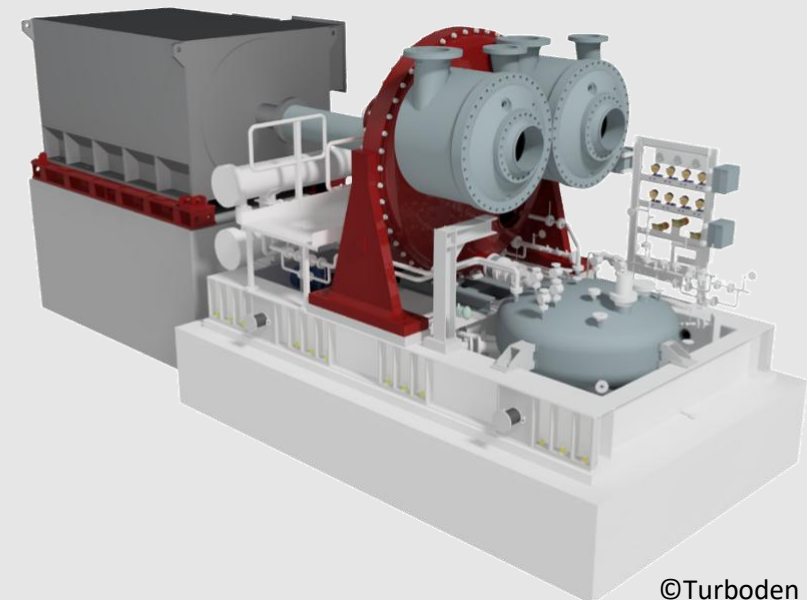
Definition of term “MVR”

Mechanical Vapor Recompression

- Contrast to TVR (Thermal Vapor Recompression)
 - Enabling electrification
 - Mostly Centrifugal Compressor
 - Mainly water
 - Hydrocarbons (butane, pentane)
 - Alcohols (methanol, ethanol, isopropanol)
 - Relevant for distillation
 - Use of already existing vapors
 - Relatively small temperature lifts
 - Reuse in the same process
- Well established technology since over 40 years (TRL9)
- Suitable for high-temperature applications and good scalability
- Not regarded as a heat pump in the past but the framing beneficial today
- **Due to the high number of installed units and long runtimes, the systems offer lessons learned and insight for other industrial heat pump applications**



©Piller

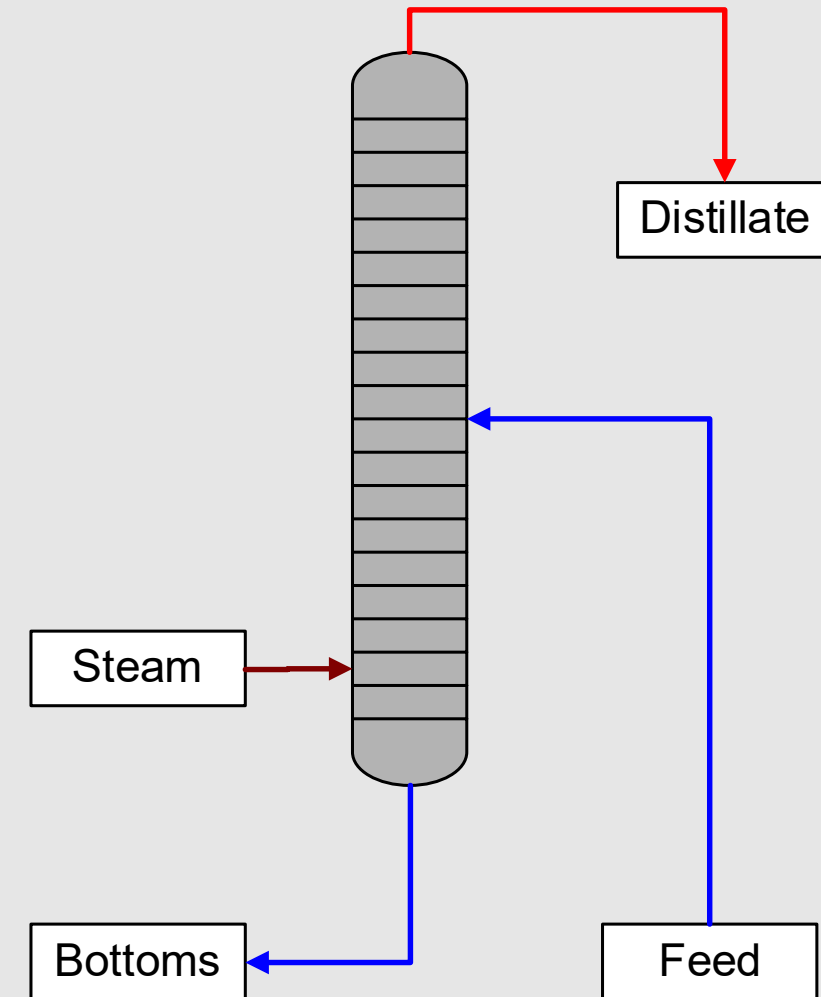


©Turboden

Utility vs process level integration

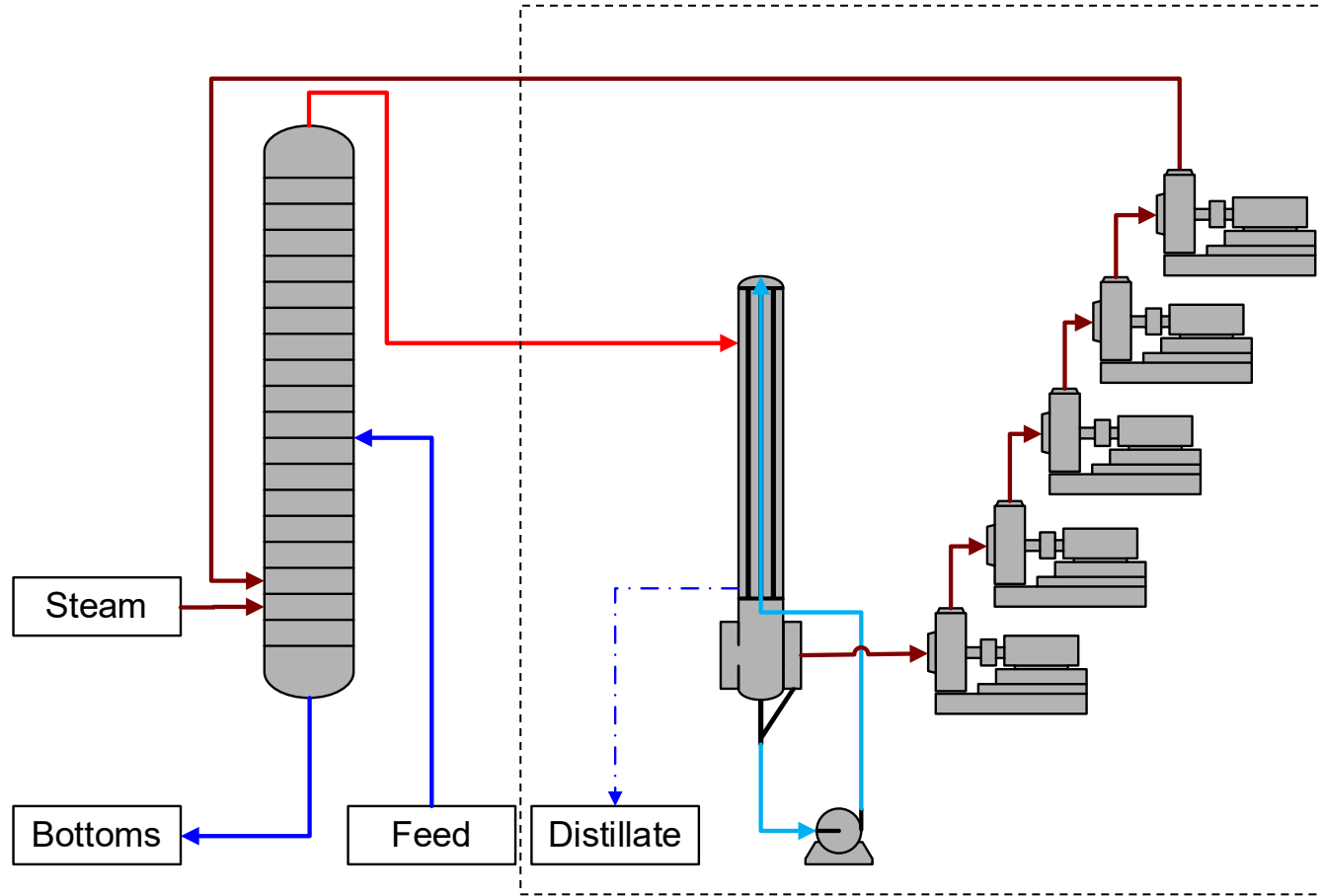
Case study Isopropanol (IPA) distillation

	Case 1	Case 2	Case 3
$x_{IPA,Feed}$	45 wt.%	40 wt.%	75 wt.%
$x_{BPA,distillate}$	80 wt.%	80 wt.%	85 wt.%
$x_{IPA,Bottoms}$	<0,1 wt.%	<0,1 wt.%	<0,1 wt.%
$\dot{m}_{Distillate}$	47.800 kg/h	35.500 kg/h	21.000 kg/h
$\dot{Q}_{Heating}$	12 MW	10 MW	6 MW
T_{Source}	80 °C	73,5 °C	72,4 °C
T_{Sink}	110 °C	103,8 °C	103,9 °C
dT	30 K	30,3 K	31,5 K
Project type	Brownfield	Greenfield	Greenfield



Isopropanol distillation

Case 1 - Low process integration



$$COP = \frac{12 \text{ MW}_{th}}{1,7 \text{ MW}_{el}} = 7,0$$

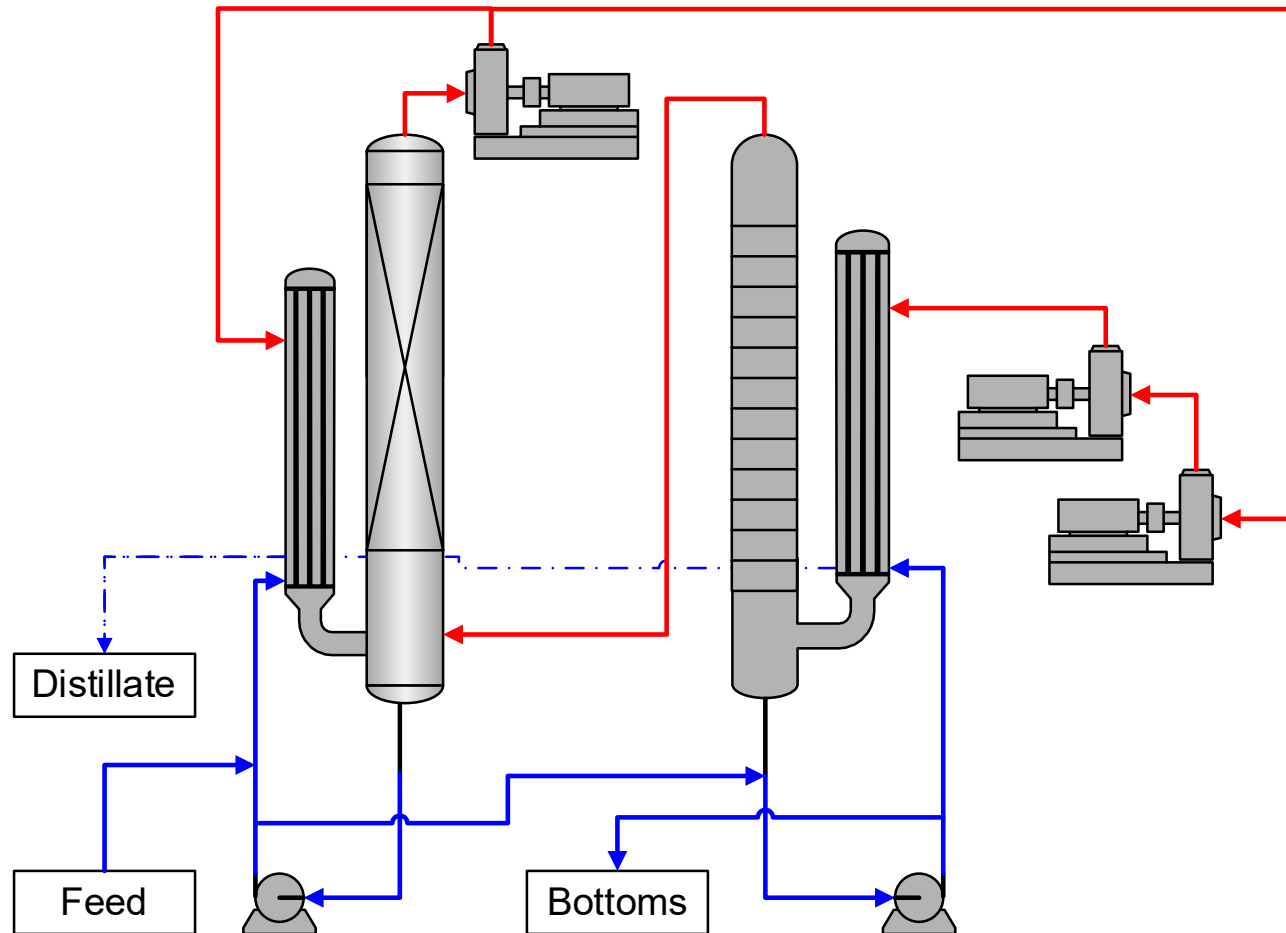
$$Cost_{Total} = 2100 \frac{\text{€}}{\text{kW}}$$

Cargill
Baupte, France



Isopropanol distillation

Case 2 - High process integration

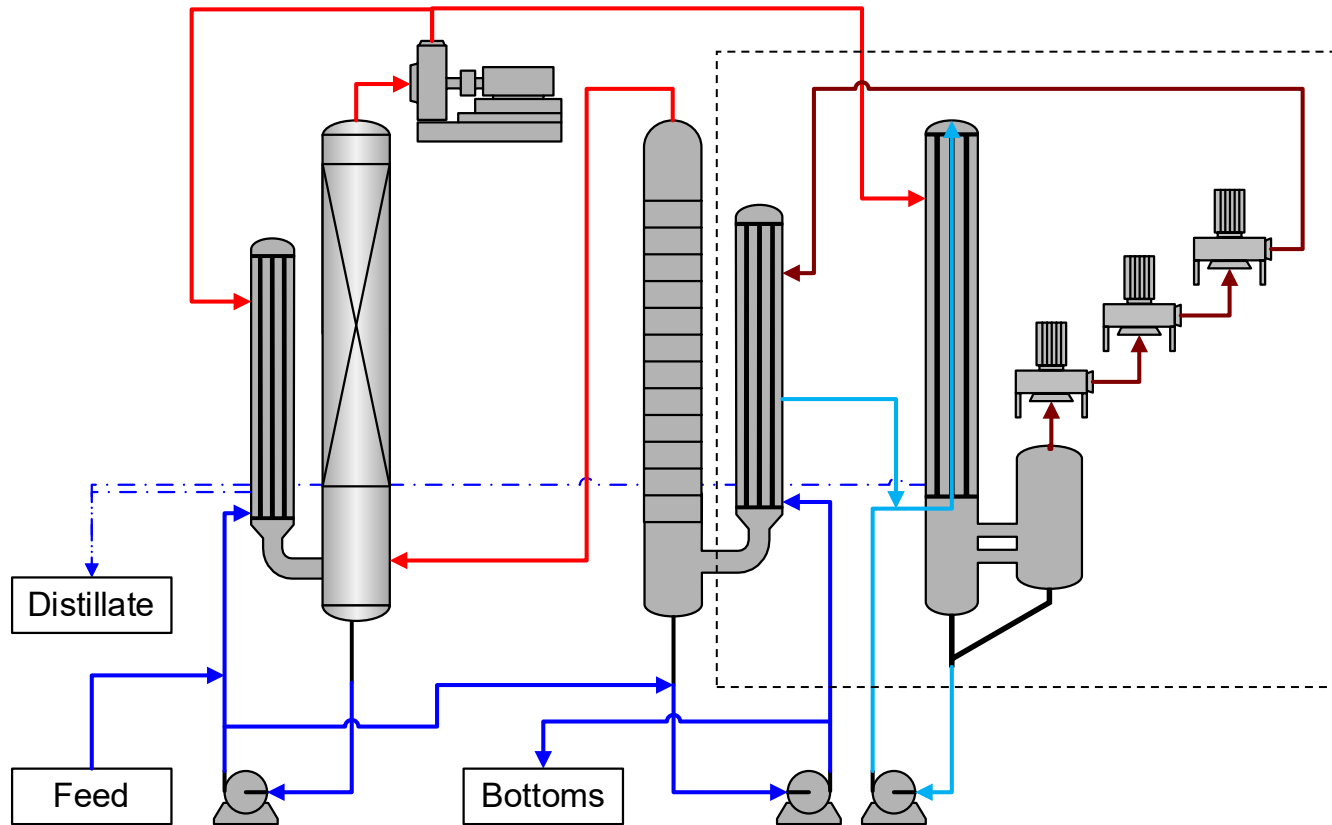


$$COP = \frac{11.140 \text{ kW}_{th}}{1060 \text{ kW}_{el}} = 10,5$$



Isopropanol distillation

Case 3 - Medium process integration



$$COP = \frac{6 \text{ MW}_{th}}{0,5 \text{ MW}_{el}} = 12,4$$



Utility vs process level integration

Conclusion

It depends...

Influence of level of integration

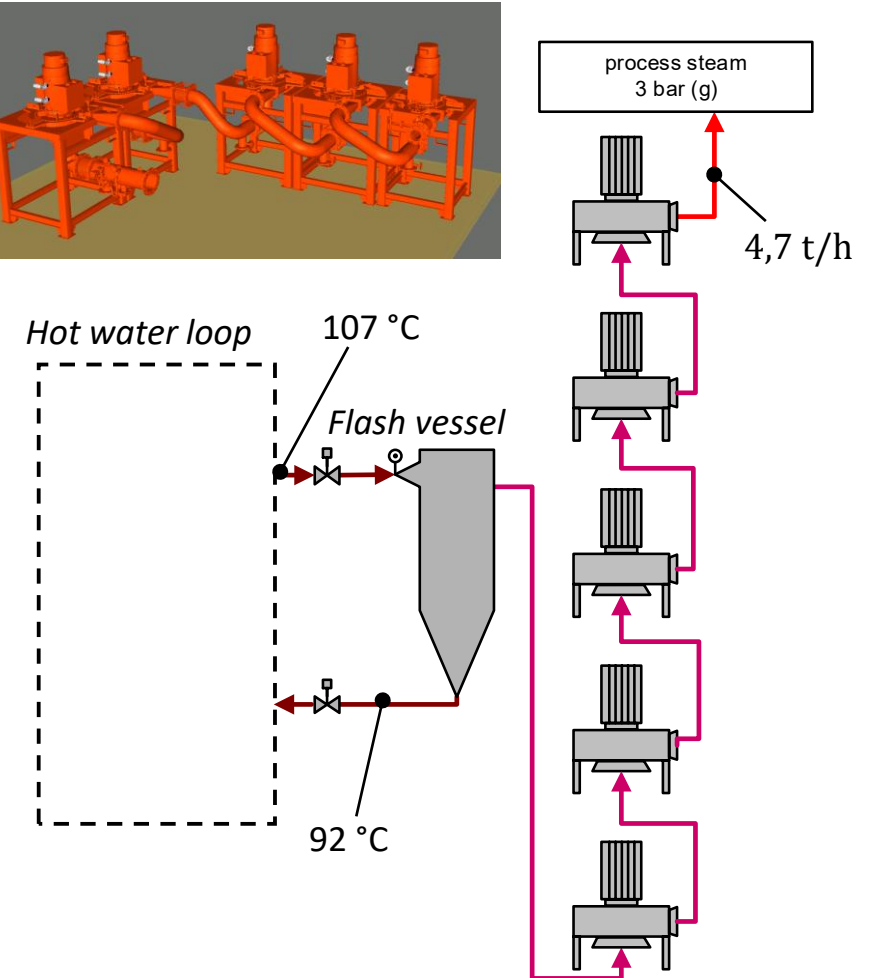
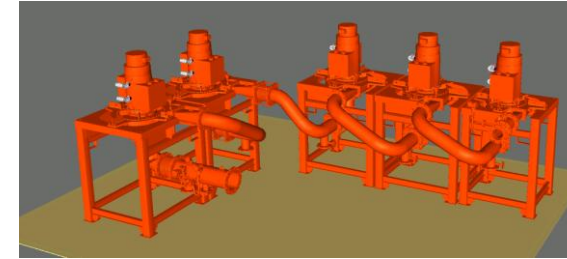
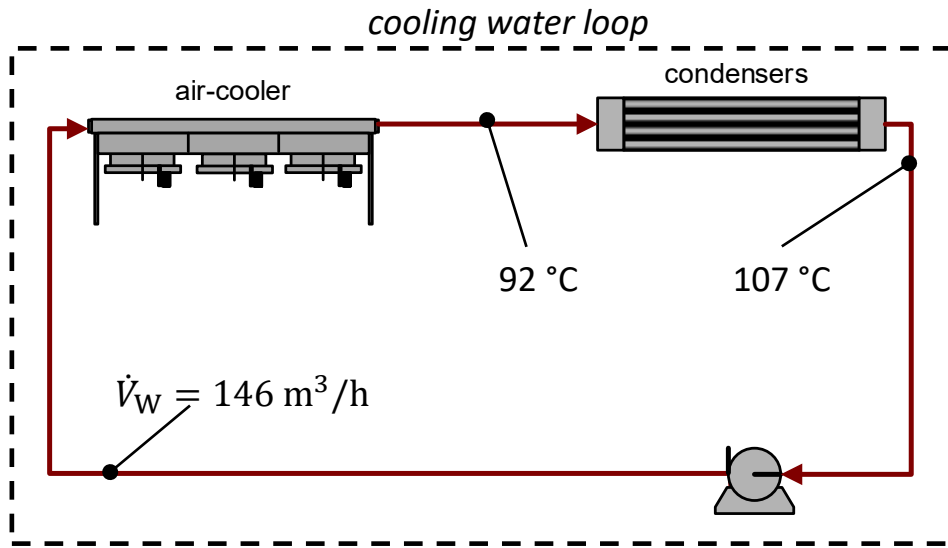
- Process integration improves efficiency
- Complexity increases but investment costs can stay similar
- Every tie-in point is a potential issue
- Plan and discuss commissioning early in the project
- Understand the customer's process

How to decide

- Green or brown field
- Age of the plant
- Space availability
- Equipment size
- Available compressors
- ATEX / pressure requirements
- Acceptable downtime
- Product properties

MVR based open cycle heat pumps

No process integration required



$$\text{COP} = \frac{2,8 \text{ MW}_{\text{th}}}{0,54 \text{ MW}_{\text{el}}} = 5,1$$

WANT TO LEARN MORE?

CONTACT ME



Dr.-Ing. Yannik Stark
Sales & Process Manager
yannik.stark@gea.com

GEA meVap® Compression



GEA meVap® Family



Industrial Heat Pumps for Process Heat

What is the status of technology deployment?

We are looking for a real-world feedback from all perspectives!

Share your opinion!
3 – 5 min



We are asking about:

- ? Key HTHP deployment status today
- ? Standardisation and guideline demands
- ? What would accelerate market uptake
- ? Current technology and market maturity
- ? Your open reflection in one sentence

Who should participate?

- ✓ Industrial operators
- ✓ Heat pump manufacturers
- ✓ EPC / engineering companies
- ✓ Consultants & investors
- ✓ Researchers & academics
- ✓ Utility providers

Link to questionnaire

- Fully anonymous
- Aggregated results only
- No project specific data to be desclaimed
- Academic research within project IndHP2Chem

From market to application

General Introduction and Keynotes

10:00 – 10:10: General Introduction, Benjamin Zühlendorf, DTI

10:10 – 10:55:

- What is the developmental status of HTHPs, Martin Pihl Andersen, DTI
- Representative HTHP projects, Cordin Arpagaus, OST
- Experience in installing and operating HTHPs, Yannik Stark, GEA

Group sessions

	Boundary conditions		Conceptualization		Implementation		Operation	
Coordinator	Alessia Arteconi	José Luis Ciganda	Steven Lecompte	Cordin Arpagaus	Ursula Wittstadt	Jonas L. Poulsen	Sabrina Dusek	Florian Schlosser
10:55 – 11:15	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
11:15 – 11:35	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 1	Group 2
11:35 – 11:45	Break							
11:45 – 12:05	Group 5	Group 6	Group 7	Group 8	Group 1	Group 2	Group 3	Group 4
12:05 – 12:25	Group 7	Group 8	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6

To discuss for each phase:

- Stakeholders and roles
- Helpful resources & tools
- Overall learnings
- HTHP focus

Summary & plenary discussion

12:25 – 12:45: Wrap-up of the group sessions & Plenary discussion

12:45 – 12:55: Sector collaboration and common solutions, Florian Schlosser, Paderborn University

12:55 – 13:00: Closing remarks

From market to application

General Introduction and Keynotes

10:00 – 10:10: General Introduction, Benjamin Zühlendorf, DTI

10:10 – 10:55:

- What is the developmental status of HTHPs, Martin Pihl Andersen, DTI
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Group sessions

	Boundary conditions		Conceptualization		Implementation		Operation	
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11:45 – 12:05	Group 5	Group 6	Group 7	Group 8	Group 1	Group 2	Group 3	Group 4
12:05 – 12:25	Group 7	Group 8	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6

To discuss for each phase:

- **Stakeholders and roles**
- **Helpful resources & tools**
- **Overall learnings**
- **HTHP focus**

- Who are the most important stakeholders for each phase and what are their roles?
- Are there helpful resources and tools?
- Which learnings did you make from realized projects?
- What is special for HTHPs compared to low-temperature industrial heat pumps and other energy efficiency and electrification projects?

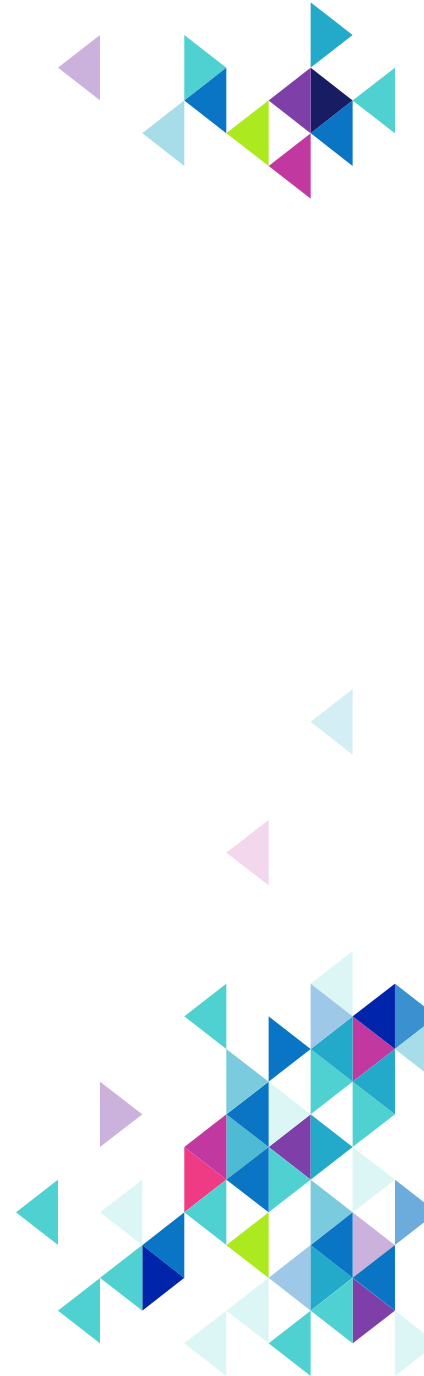
	Boundary Conditions	Conceptualization	Implementation	Operation
What are the most important stakeholders and what are their roles?	<ul style="list-style-type: none"> • Policy makers/regulators influence, electricity/gas prices, CO₂ incentives • Grid operators are important for electricity availability, tariffs and security of supply • End-users define targets and ROI expectations • Industrial associations and can support market knowledge and sector-specific requirements 	<ul style="list-style-type: none"> • Suppliers should be included to get reliable cost data. • Process owners, and process engineers are key for defining realistic heat demand profiles and integration options • Permit authorities may be relevant, especially for noise, refrigerants and safety aspects • Funding agencies and investors 	<ul style="list-style-type: none"> • Plant operators and integrators should really communicate • Management should know that the implementation is resource heavy • Subcontractors and safety experts are important for HAZOP, installation safety and start-up preparation 	<ul style="list-style-type: none"> • Suppliers/OEMs may be needed for maintenance, performance data and service support • External certifiers/third parties may be relevant for validation of KPIs, guarantees • Heavily relies on proper training of plant/process operators
Are there helpful resources and tools?	<ul style="list-style-type: none"> • Not a lot • Reference lists, site visits and demonstrator data help build confidence • Webinars • Maps for electricity grid connections 	<ul style="list-style-type: none"> • Technoeconomic tool is missing, taking into consideration pinch, proper integration, using guide lines • Testing facilities for compressors/components can support validation • HAZOP analysis early on • Clear Maintenance plan 	<ul style="list-style-type: none"> • Use the same documentation as any other complex process integration concepts • 3D scans and brownfield site assessments can reduce installation risks • Clear list of priorities/actions is useful before implementation 	<ul style="list-style-type: none"> • Data connections and dynamic controls systems are important • Digital Twin for predictive maintenance
Which learnings did you make from realised projects	<ul style="list-style-type: none"> • Life is much more complex than expected • Which funding schemes are available is important • Existing processes and heat distribution systems may not be ready for integration • Contractual liabilities should be considered early • Electricity should be available – also for start-up 	<ul style="list-style-type: none"> • Spend more time identifying boundary conditions. Need a lot of process data (temperature, pressures, contamination) • It is important to balance complexity of system • Communication on concept is key • Safety concepts are very important to discuss up front • End-user trust requires references, warranties, technology validation and transparent performance 	<ul style="list-style-type: none"> • Technology is new to many, so more time is needed to present the concept and how it works • Backup is essential • Fair conditions for all stakeholders, delays are rarely one stakeholder's fault • A need of flexible time plans are needed especially with narrow windows of integration • Integration can be 80 % of project costs 	<ul style="list-style-type: none"> • More standardised testing schemes Operation should be evaluated against KPIs, guarantees and contract conditions • More disciplined education is needed for operators, service staff and engineers
What is special for HTHPs compared to other energy efficiency/electrification projects?	<ul style="list-style-type: none"> • Boundary conditions like operation temperatures are even more important • Limited reference projects increase perceived risk • HTHP integration may require adaptation of the process or heat distribution system 	<ul style="list-style-type: none"> • Know-how of technology and trust in process data is needed • Maintenance and dynamics become essential • Detailed HTHP concepts are often more case-specific and need customised solutions 	<ul style="list-style-type: none"> • Extra safety concepts needed compared to other technologies • HTHP systems may have a larger footprint than alternative technologies • More detailed regulation, permitting and safety documentation may be required 	<ul style="list-style-type: none"> • Flexibility for variable production and electricity price variations can add value • Continuous monitoring, optimisation are important for reliable HTHP operation

Insights from IEA HPT Project 68 – Task 2

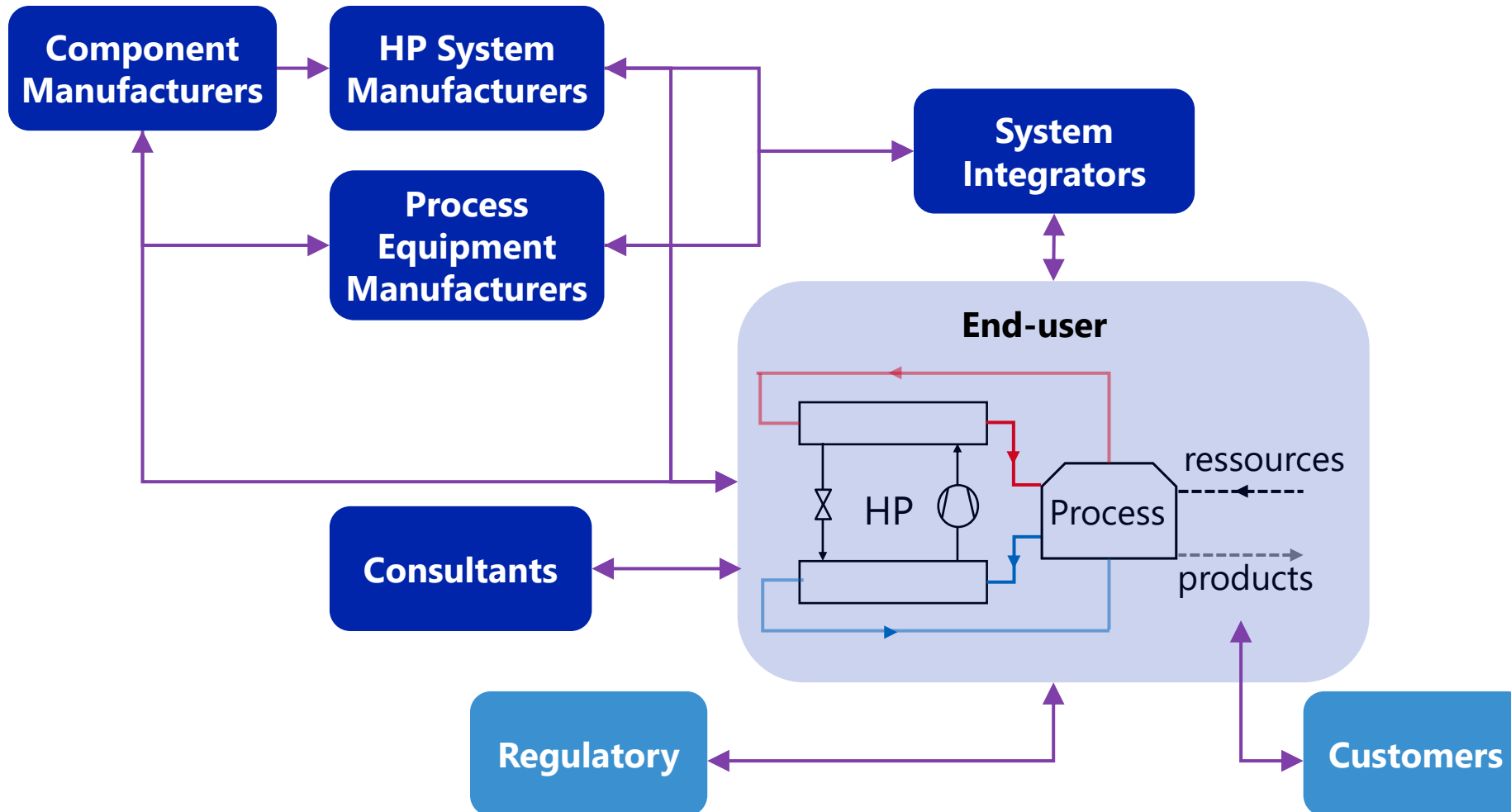
Sector collaboration and common solutions

Florian Schlosser

Decarbonizing process heating with high-temperature heat pumps – from market to application



Objective: Establish a network and commitment of stakeholders along the entire value chain for market-uptake of HTHPs



If you are interested in participating in one of the sector collaborations, please contact me!

Contact details:

Florian Schlosser

Team leader *Energy Transition in Industry*

Department of Energy System Technologies

+49 5251 60-4138

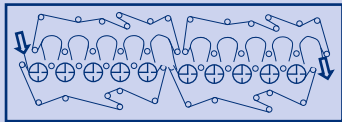
florian.schlosser@uni-paderborn.de

Further information on <https://heatpumpingtechnologies.org/project68/>.



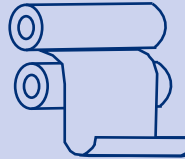
Sector collaboration leaders for the following sectors

Pulp & Paper



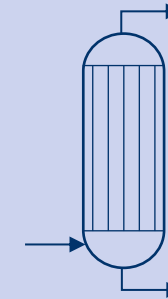
Seon Tae Kim, Panagiotis Stathopoulos
(DLR, GER)

Textiles



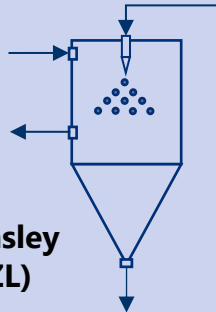
Sanduni Pathiraja, Martin Andersen
(DTI, DK)

Raw Chemicals



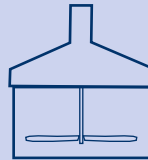
Fabian Ahrendts
(IEG, GER)

Dairy



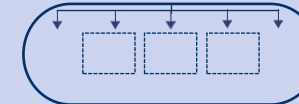
Tim Walmsley
(UWai, NZL)

Brewery



Milen Pérez Cammañ
(CARTIF, ESP)

Pharmaceuticals



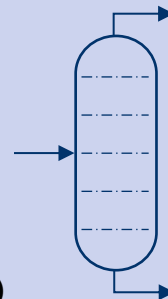
Sabrina Dusek
(AIT, AT)

Recyclates



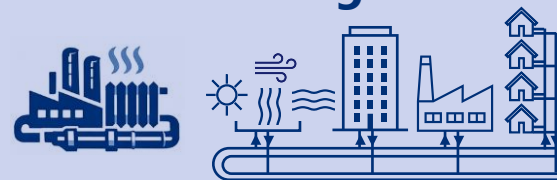
Kirsten Grübel
(RUB, GER)

Petroleum



Ole Moen
(SINTEF, NOR)

District Heating



Jaromir Jeßberger
(UBay, GER)





Workflow for sector collaboration

1st Workshop: Overcoming barriers for HTHPs



2nd Workshop: From opportunities to action



3rd Workshop: Communication

'What are the main barriers for market ramp-up? What chances are there?'

- Develop common understanding of the sector and the biggest market challenges
- Make stakeholders' perspectives and contributions transparent
- Develop concrete opportunities and solutions
- Define initial steps and responsibilities for collaboration

Outcomes:

- opportunity matrix
- prioritised top opportunities
- commitment statements from stakeholders

'What developments and concrete actions are needed?'

- Identify actions, involved stakeholder and needed resources
- Develop roadmap of actions
- Define responsibilities

Outcomes:

- concrete action plans for each field of action
- joint roadmap for market ramp-up (short, medium and long term)
- clear commitments and responsibilities

'How can stakeholders be reached?'

- Identify and prioritise relevant stakeholder groups
- Understand interests and potential resistance
- Develop core messages and communication channels
- Derive joint communication strategy

Outcomes:

- stakeholder mapping with priorities
- empathy maps (drivers & barriers per stakeholder group)
- communication messages & channels (message houses)
- joint communication strategy



Results



Project 68 Industrial High-Temperature Heat Pumps
<https://heatpumpingtechnologies.org/project68/>
 March 2026

Task 2 – Sector Collaboration: From Barriers to Opportunities: Sector-Specific Stakeholder Perspectives on Industrial Heat Pump Uptake



Sector Landscape

[Please characterize the **sector** and its value chain in these columns to describe regulatory, organizational and infrastructural factors that influence heat pump adoption.

- The summary may include information about:
- Sector organization:** Typical company sizes, vertical integration, degree of outsourcing, supply-chain dependencies
 - Energy prices and tariffs:** comparative cost of electricity vs. fossil fuels.
 - Policy and regulation:** CO₂ pricing, subsidy schemes, renewable energy incentives, industrial decarbonization programs.
 - Infrastructure:** Grid capacity, grid emission factor, availability of waste heat or renewable electricity.
 - Cultural and economic aspects:** Company risk perception, innovation culture, willingness to invest.

Project 68 Industrial High-Temperature Heat Pumps
<https://heatpumpingtechnologies.org/project68/>
 March 2026

Stakeholder Analysis: Barriers & Opportunities

[This template collects and analyzes the interests, challenges, and opportunities for stakeholders along the value chain in the context of industrial heat pump uptake. It identifies barriers, explores solution pathways, and highlights innovation and business model potentials. The matrix summarizes barriers and opportunities and maps them to stakeholders.]

Stakeholder-Specific Barriers and Opportunities [List observed barriers or challenges (technical, economic, regulatory, market-related, etc.) for each stakeholder group, outline potential opportunities, solutions, or enabling factors.]

Barrier	Opportunity	Stakeholder
Lack of full-scale demonstrators	Transfer of knowledge about European demonstrators	End-user, brands
Lack of sector-specific technical expertise in producing regions (e.g. far eastern countries)	Process integration studies Knowledge transfer regarding technology status and engineering/planning guidelines	Consultants, R&D
Carbon-intensive grids	On-site solar, or power purchase agreements on renewable electricity	End user, regulatory
Uncertainty in investment decisions due to grid reliability and capacity limits, peak demand charges and energy prices	Co-investment across the value chain shares risk and guarantees long-term commitments	Financing

Stakeholder Strategic Interests

[The following paragraph discusses each stakeholder's specific position and how barriers and opportunities affect their strategic interests and highlight synergies, potential conflicts, or collaboration needs. This section may answer the following questions from a stakeholder perspective:]

Shared Challenges: [Where do interests align for multi-stakeholder action?]

Collaboration Areas: [Where can cooperation most effectively foster innovation or reduce costs?]

Required Innovations: [What specific business model, policy, or technology innovations are needed?]

Project 68 Industrial High-Temperature Heat Pumps
<https://heatpumpingtechnologies.org/project68/>
 March 2026

Task 2 – Sector Collaboration: Integration possibilities of HTHPs [Pulp & Paper] – Felix Schoeller in Osnabrück, Germany

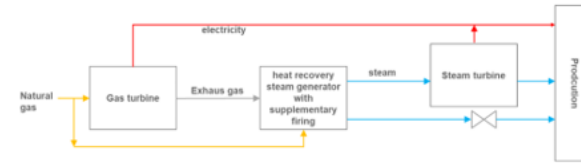


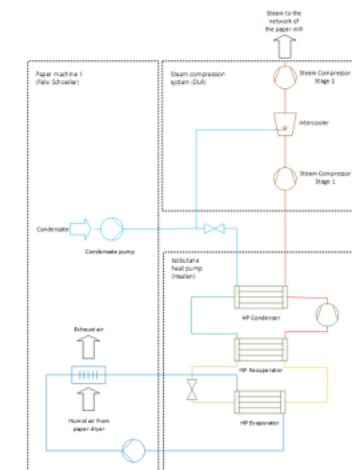
Figure 1: Typical production processes with combined heat and power supply on site

Overview of Key Production Processes

The specialty paper factory of Felix Schoeller GmbH & Co. KG in Osnabrück is located in the free state of Lower Saxony in Germany. 860 employees on that site are producing around 120.000 t of paper a year. Steam is currently produced by means of a central boiler that burns natural gas. With a consumption of nearly 120.000 MWh/a of steam the paper machine 1 (PM1) has the main energy demand in the mill. Most of that heat is used for the drying process. The paper factory has a yearly demand for natural gas of 280 GWh (0,0382 Gm3 NG). The yearly demand for electricity and process heat accounts for 84 GWh_{el} and 220 GWh_{th} (steam). The CO₂-emissions for providing these process energies are

Integration concept system/process

The HTHP system will be integrated to recover the waste heat from the moist air leaving a paper drying machine, and to provide steam to the main steam circuit supply, as a partial replacement of the fossil fuel (natural gas) used on-site. This will be led to less CO₂ emissions related to the thermal energy supplied by the new heat pump system.



supply conditions needed by the paper mill, thus achieve pressure ratio of 2-2.3 with a single stage centrifugal compressor, which is low compared to typical installed the pulp and paper industry. The second compressor will further raise the pressure to 11 bara (~271 °C), thus reaching a compression ratio of 5-6 with only two compression stages in series. The aim of the second stage to develop a replicable integrated system, specifically designed for the needs of the pulp and paper industry HEATEN can then potentially integrate to its own production portfolio. This builds on DLR's experience from design operation of two similar smaller compressor stages in pilot facility, which will be leveraged within EEETHOS to the technologies to a TRL of 7. DLR expects to reach a efficiency of around 75 % for the first stage and around for second stage, while the integrated (bottom HTHP + compressors) will have a COP of ~2.2 for the delivery of at 11 bara.

FACTS ABOUT THE CONCEPT

Heat Sink: 10 – 11 bar(a) at test rig; 1.1 MW_{th} at 5 – 6 bar (a) in the demo case

Heat Source: Humid air from paper dryer, Hot water cycle and Condensate for intercooler, 70 °C up to ~ 50 °C

Bottom heat pump by HEATEN: Isobutane heat pump with recuperation, Source: 55°C up to 50°C, Sink 95°C up to 125°C, up to 2.5 bar(a)

Compressor system by DLR: 2-stage steam compression with intercooler, Design and 200h operating hours for 11 bar(a), Process steam integration up to 6 bar(a) at demo case



Stakeholder Mapping: Results from Kick-off workshops

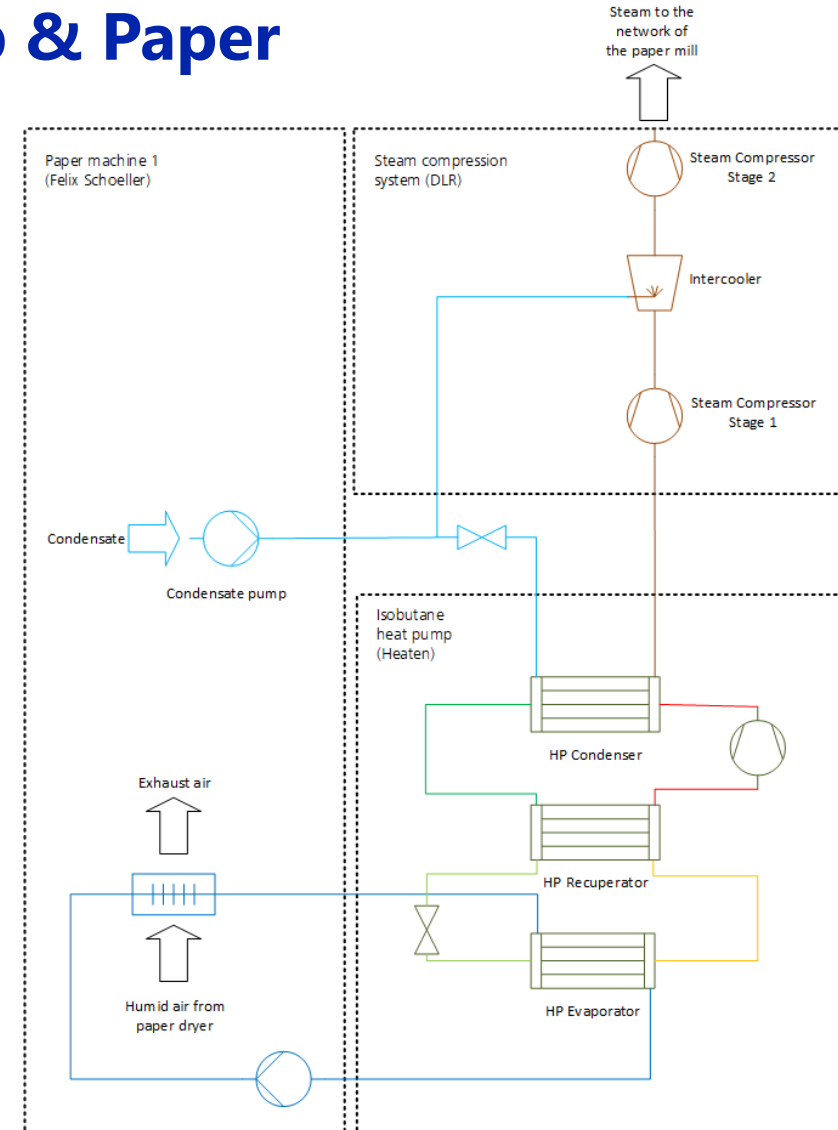
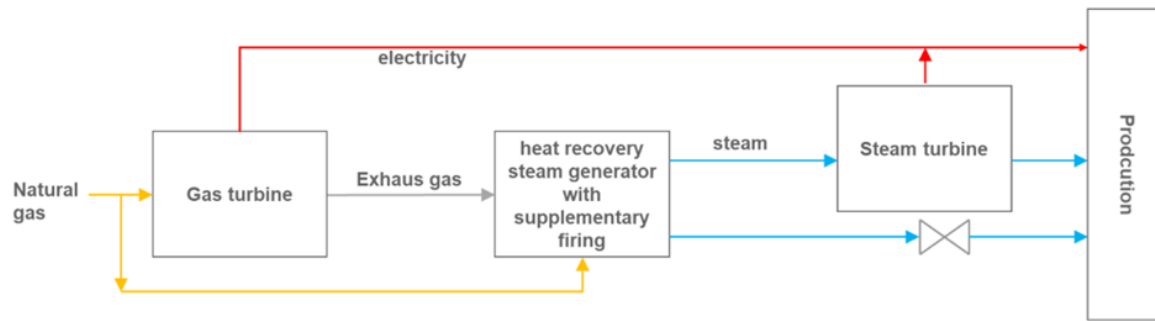
Textile sector

Barrier	Opportunity	Stakeholder
Lack of full-scale demonstrators	Transfer of knowledge about European demonstrators	End-user, brands
Lack of sector-specific technical expertise in producing regions (e.g. far eastern countries)	Process integration studies <hr/> Knowledge transfer regarding technology status and engineering/planning guidelines	Consultants, R&D
Carbon-intensive grids	On-site solar, or power purchase agreements on renewable electricity	End user, regulatory
Uncertainty in investment decisions due to grid reliability and capacity limits, peak demand charges and energy prices	Co-investment across the value chain shares risk and guarantees long-term commitments	Financing

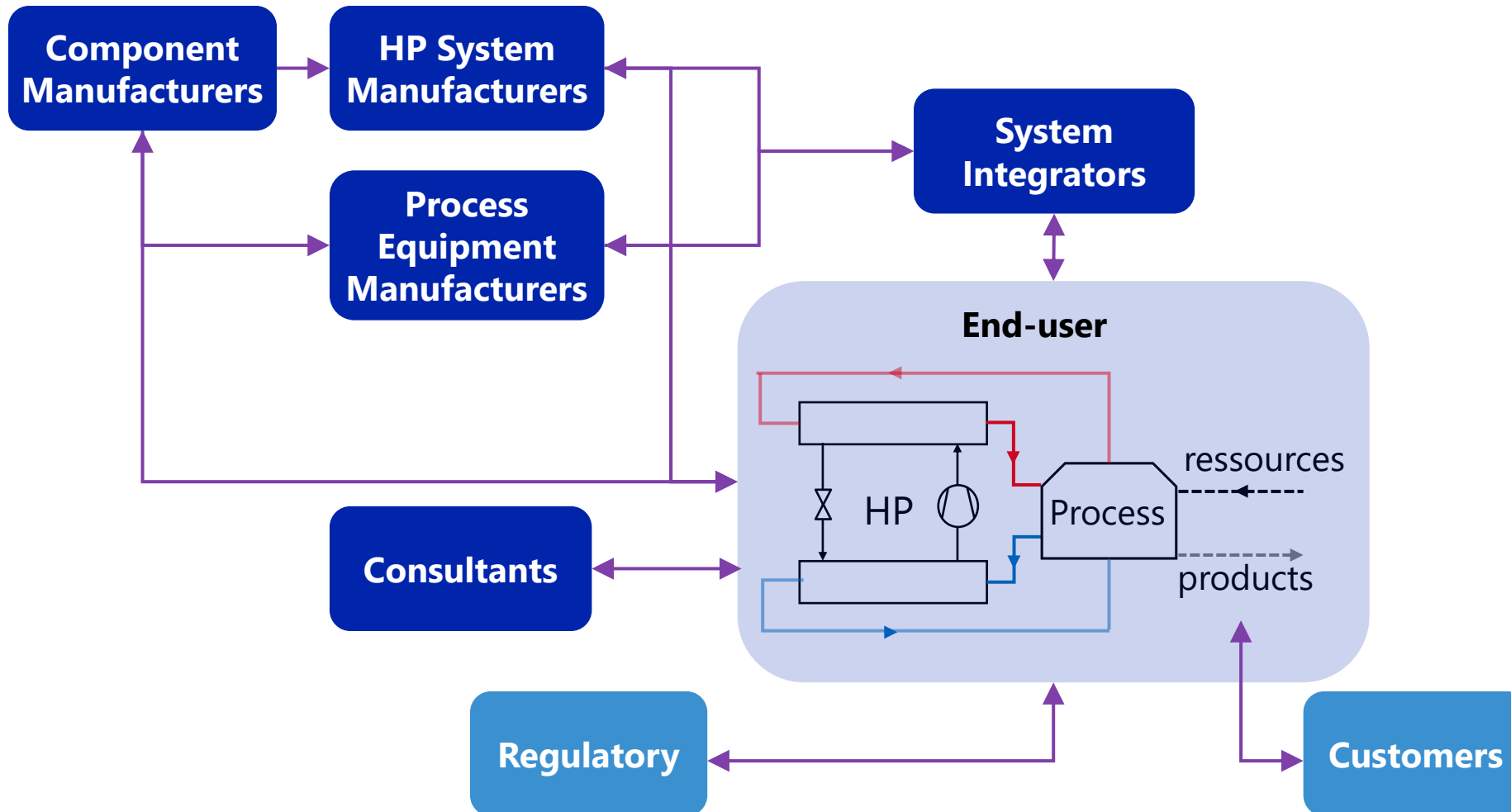


Integration Possibilities: Example from Pulp & Paper

Typical production processes with combined heat and power supply on side



Objective: Establish a network and commitment of stakeholders along the entire value chain for market-uptake of HTHPs



If you are interested in participating in one of the sector collaborations, please contact me!

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Further information on <https://heatpumpingtechnologies.org/project68/>.