# High-temperature heat pumps

## and the bio-/pharma industry

High-Temperature Heat Pump Symposium

**Project 68**
**Industrial High-Temperature Heat Pumps**

IEA HPT

BioPhorum

# IEA HPT Project 68
# Industrial High-Temperature Heat Pumps

Project 68 Industrial High-Temperature Heat Pumps

High-Temperature Heat Pump Symposium

14 countries confirmed, 1 strong interest

June 2025 to May 2028

**Task 1 – Technology developments (Lead: DTI)**

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

New update in October!

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

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

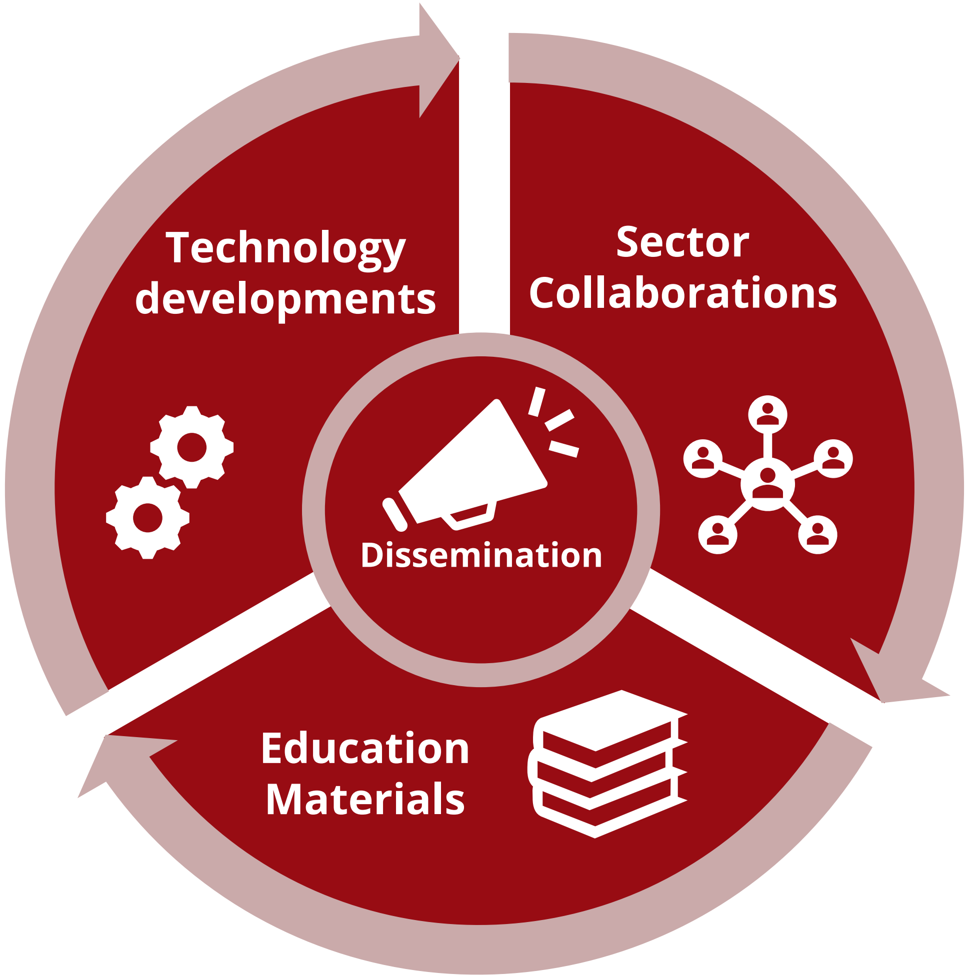
**Task 3 – Education materials (Lead: AIT)**

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

**Project Management:**


- Benjamin Zühlsdorf, bez@dti.dk &
- Martin Pihl Andersen, mapa@dti.dk

DANISH TECHNOLOGICAL INSTITUTE


https://heatpumpingtechnologies.org/project68/

High-Temperature
Heat Pump Symposium

# HTHP Symposium

- Meeting place for HTHP Community
- 02/2028 – Copenhagen
- +120 presentations
- +35 exhibition stands
- +550 participants

SINTEF DTU DANISH TECHNOLOGICAL INSTITUTE

http://hthp-symposium.org/

BioPhorum

# Sustainability Phorum Overview 2026

CONNECT
COLLABORATE
ACCELERATE™

# BioPhorum: a co-ordinated program of industry change

BioPhorum is at the heart of pharmaceutical manufacturing, addressing industry issues and shaping best practice

**Member-led**

**Safe and confidential**

**Cheaper, faster and better journeys**

**Consensus-driven**

This allows for cost reduction, lower waste, improved productivity, better environmental performance across the value chain, better investment decisions and the cost of poor decisions avoided.

There are currently 12 Phorums providing a wealth of opportunities for companies to align their interests with similarly committed organizations.


**300+**
memberships

**150+**
global programs for change

**5,000+**
leaders and subject matter experts

**170+**
published papers, presentations and resources in the last 12 months

# BioPhorum Sustainability

**Steering Group**

Drive industry-wide reductions in environmental impact (carbon, water, waste and nature) across supply chain, manufacturing and packaging.

Sustainable Supplies

Sustainable Manufacturing

Sustainable Packaging

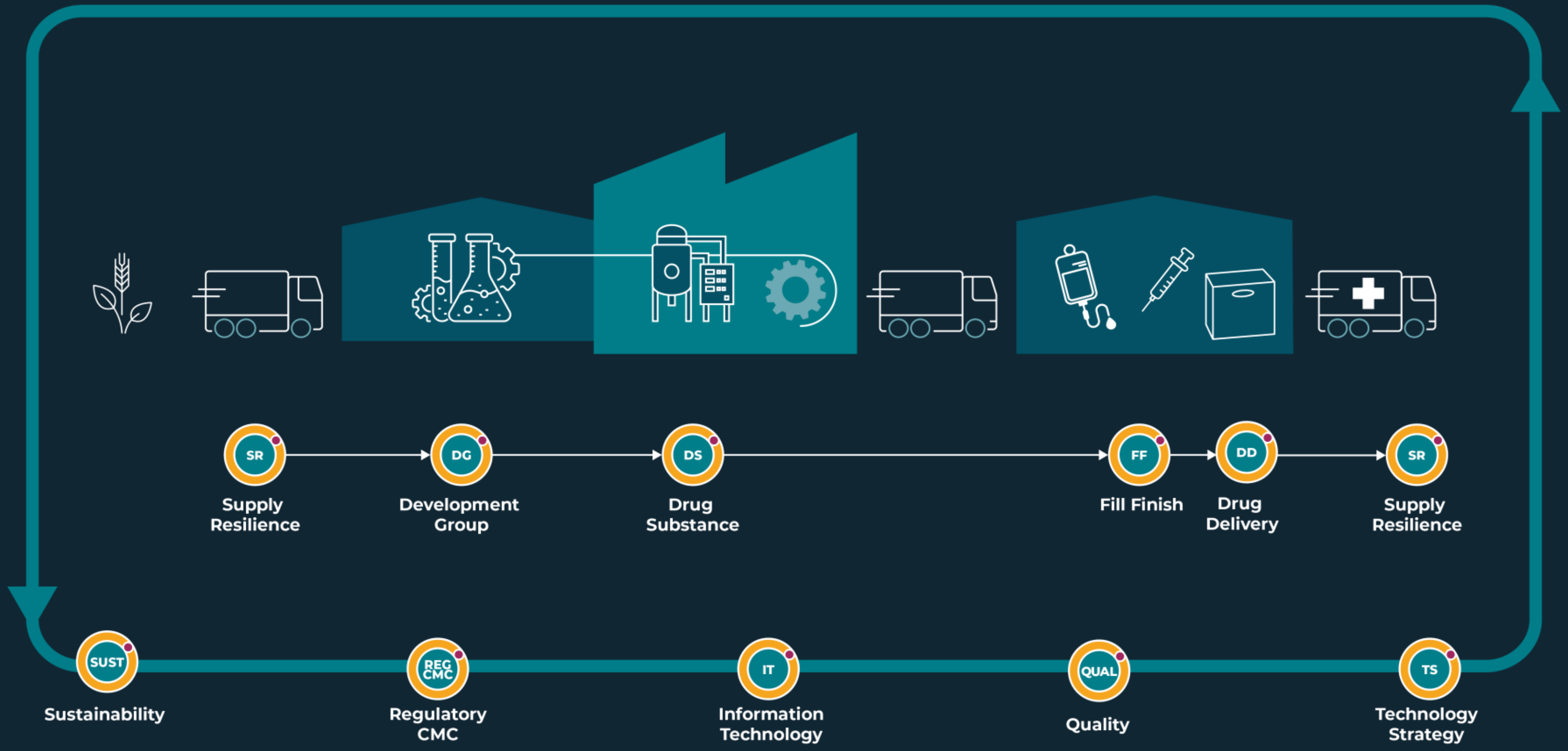
**Understand and Influence the operating environment** - hear the voice of the customer and the supplier through in-person and virtual safes, hear from curated content of expert speakers and system stakeholders, translate sustainability strategy for a biomanufacturing audience, learn from peer case studies, engage with system stakeholders.

**Build best practice** – compare and define sustainability best practice, augment operational best practice with sustainability requirements, incubate operational changes that are not yet "commercially ready" by building the business case for change and removing quality and regulatory friction to accelerate adoption.

**Assess** – use the **BioPhorum Environmental Excellence Maturity Model** to understand performance across sites, peers and value chain partners and create roadmaps for change. Use **AskBioPhorum** to crowd source solutions to immediate challenges. Use tools like the **HVAC Optimization Tool** to build the case for change.

# Embedding sustainability in operational excellence

BioPhorum acts as the translation layer – turning high-level sustainability strategies into practical, implementable programs for manufacturing, supply chain and product development teams. Through structured links between programs and Phorums – and active engagement with external bodies such as regulators, standards organizations, NGOs and industry initiatives – BioPhorum helps members connect sustainability initiatives that would otherwise remain isolated.



Energy

Water

Waste

# Interest and relevance in HTHP technology

- Reducing reliance on natural gas is a key driver to reducing scope 1 and 2 emissions in biopharma manufacturing facilities - HTHP technology is a key enabler for this
- Our members see clear applications in energy intensive critical utilities within the biopharmaceutical industry such as Water For Injection (WFI) generation systems
- Being able to share case studies and discussing the opportunities is an important initial step into making real improvements

# Webinar series continues

Including 40+ HTHP operating cases!

**Today:** 17th of September

HTHPs and the bio-/pharma industry

Co-host: BioPhorum

**Next webinar:** 2nd of December 2026

HTHPs for drying applications

**3-4 times a year**

Webinar homepage

Info on next webinars

# Today program



| | |
|---|---|
| 15:00 | Welcome |
| 20 minutes | Decarbonization concepts for pharmaceutical production sites |
| 20 minutes | AHEAD – Pioneering $CO_2$-Free Steam Without Gas |
| 20 minutes | Steam generation for pharma industry using Stirling heat pumps |
| 20 minutes | Decarbonization concepts for pharmaceutical production sites |
| End by 16:30 | Concluding remarks |

# Decarbonization concepts for pharmaceutical production sites

Anton Beck
Research engineer

AUSTRIAN INSTITUTE OF TECHNOLOGY

Project 68 Industrial High-Temperature Heat Pumps

High-Temperature Heat Pump Symposium

# DECARBONIZATION CONCEPTS FOR PHARMACEUTICAL PRODUCTION SITES

## Project 68 Webinar series, Thursday, 17 September 2026:

## HTHPs and the Bio-/Pharma Industry

Dipl.-Ing. Dr. Anton Beck

**AIT – Center for Energy**

# DEKARBPHARM CONSORTIUM

*Industry Association*

PHARMIG
Verband der pharmazeutischen Industrie Österreichs

*Research*

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

*Industry Partners*

Pfizer
NOVARTIS
Takeda
Boehringer Ingelheim
octapharma


*Funding*

FFG
Promoting Innovation.

Federal Ministry
Republic of Austria
Climate Action, Environment, Energy, Mobility, Innovation and Technology

# OVERVIEW

SCOPE OF THE PROJECT

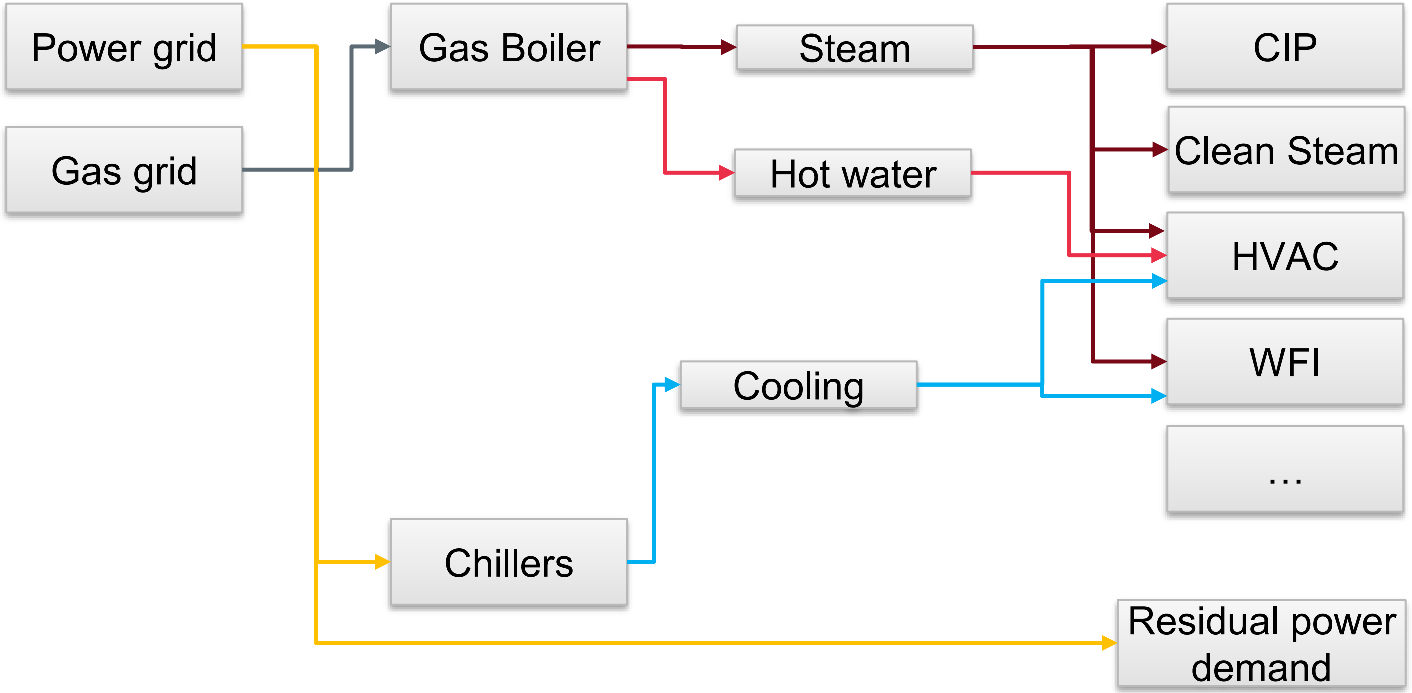
METHODOLOGY

ENERGY EFFICIENCY & HEAT PUMPS

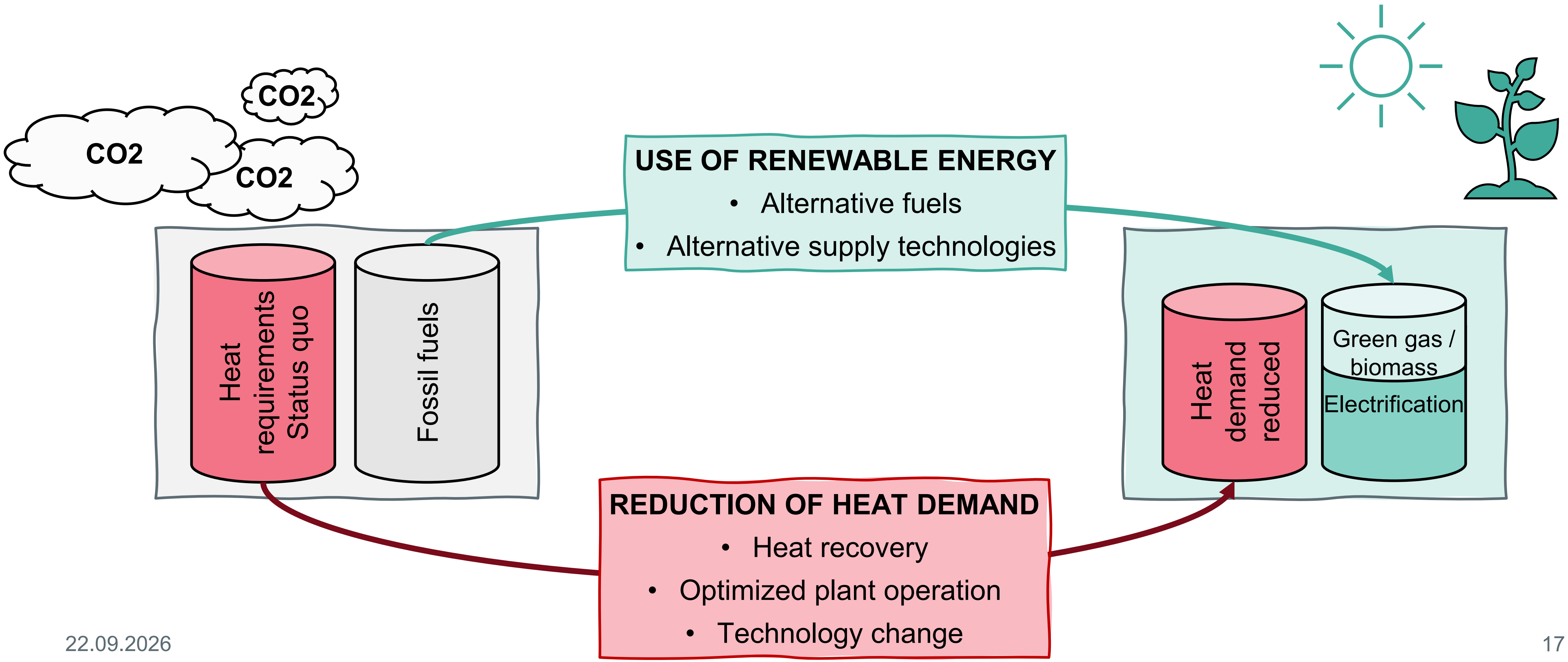
KEY FINDINGS

# TYPICAL ENERGY SYSTEM

- Natural gas is main source for onsite CO2 emissions
- Large cooling demand
  → excess heat potential
- Seasonal characteristics
  - Summer → cooling
  - Winter → heating



# TRANSITION TOWARDS A RENEWABLE ENERGY SYSTEM



# APPROACH

**Expert Interviews**
with six pharmaceutical production sites

**Data Analysis**
from six sites to determine decarbonization potentials.

**Decarbonization Measures**
Summary and evaluation

MILP

**Mathematical Modeling**

CO2

**Decarboni-zation Paths**

# IDENTIFIED MEASURES

**Tier 0: Status Quo**

**Tier 1: low impact**, mostly utility system

- CIP: heat recovery from caustic rinse, heat supply with hot water instead of steam
- HVAC: fresh air preconditioning, internal heat recovery
- Heat recovery for heat pumps: Chillers, Compressors, Waste Water

**Tier 2: moderate impact**, revalidation likely

- HVAC: extend ranges for set points, adapt control strategy, reduce supply temperature for heating
- Clean steam: possibility to switch to direct electric steam generation

**Tier 3: critical**

- HVAC: adiabatic air humidification
- Membrane based WFI generation (now considered Tier 2)

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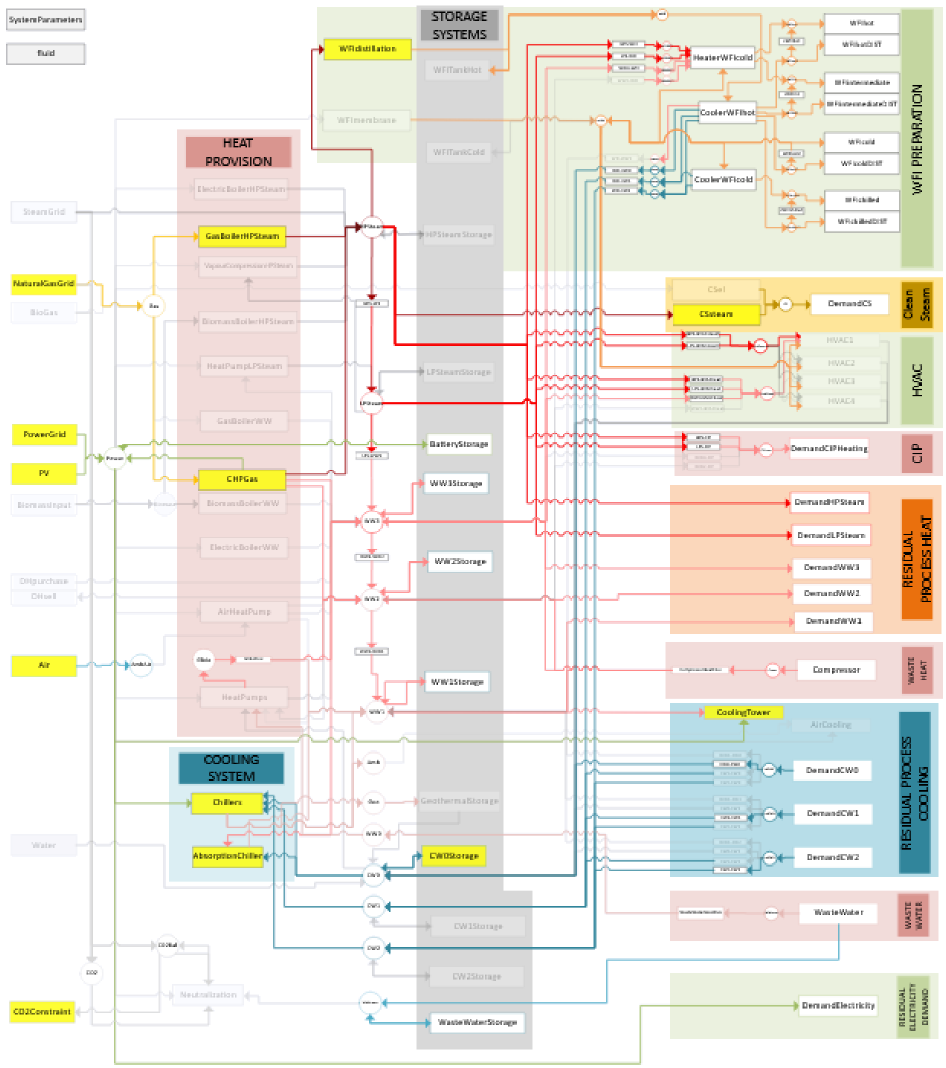
# SYSTEM MODEL

- Energy supply → energy conversion and storage → process demands (cooling, heating, clean media)
- Multiple **heat supply levels** (high pressure steam → sub ambient cooling)
- Important **process demands** explicitly modelled (HVAC, WFI-generation, CIP…)
- **Heat recovery** (off-steam, compressors, waste water)
- Investment decisions for **alternative systems** for heating, cooling and storage

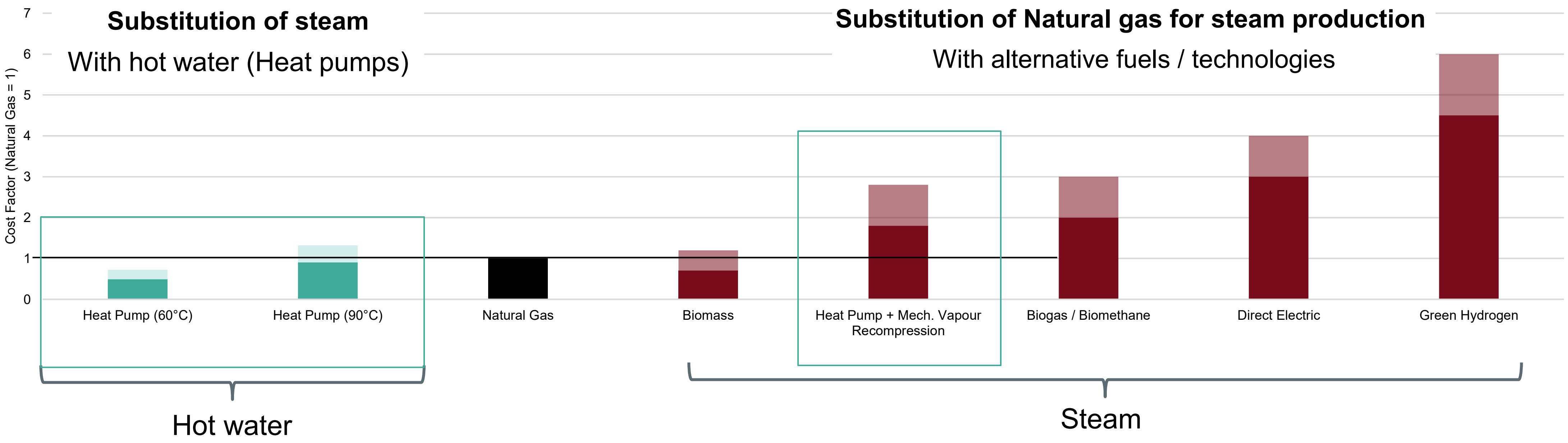


# LOW-TEMPERATURE HEAT CAN BE ELECTRIFIED COST-EFFECTIVELY

Assumptions:

- Power to natural gas price ratio: 3–4
- 2nd law efficiency (heat pumps): 50–55 %
- Biogas to natural gas price ratio: 2–3
- biomass to natural gas price ratio : 0.7–1.2

## Provision of process heat

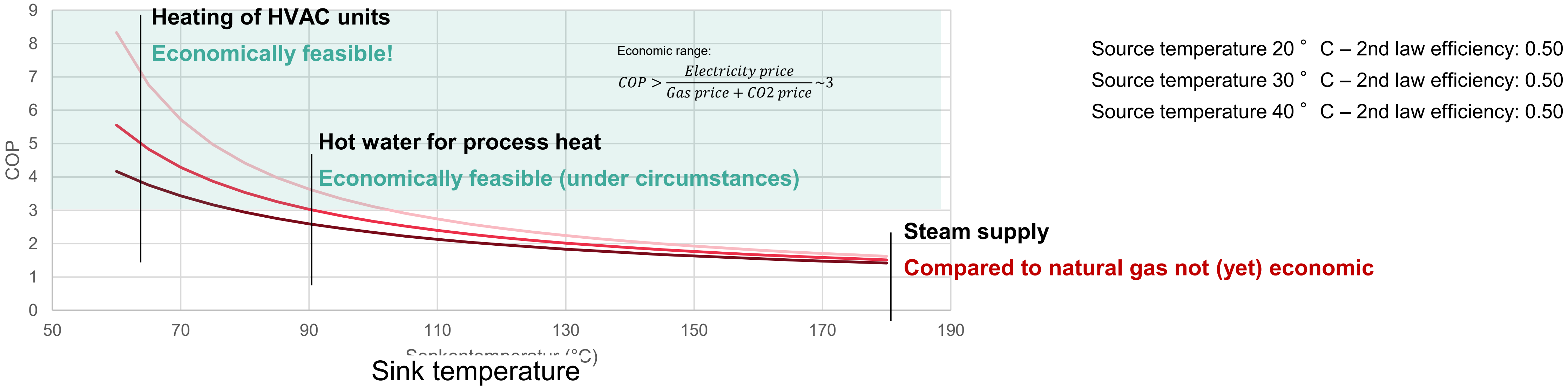



**Substitution of fossil-based steam with renewables is usually expensive!**

# HEAT-PUMP ECONOMICS DEPEND STRONGLY ON SINK TEMPERATURE

## Heat supply with heat pumps

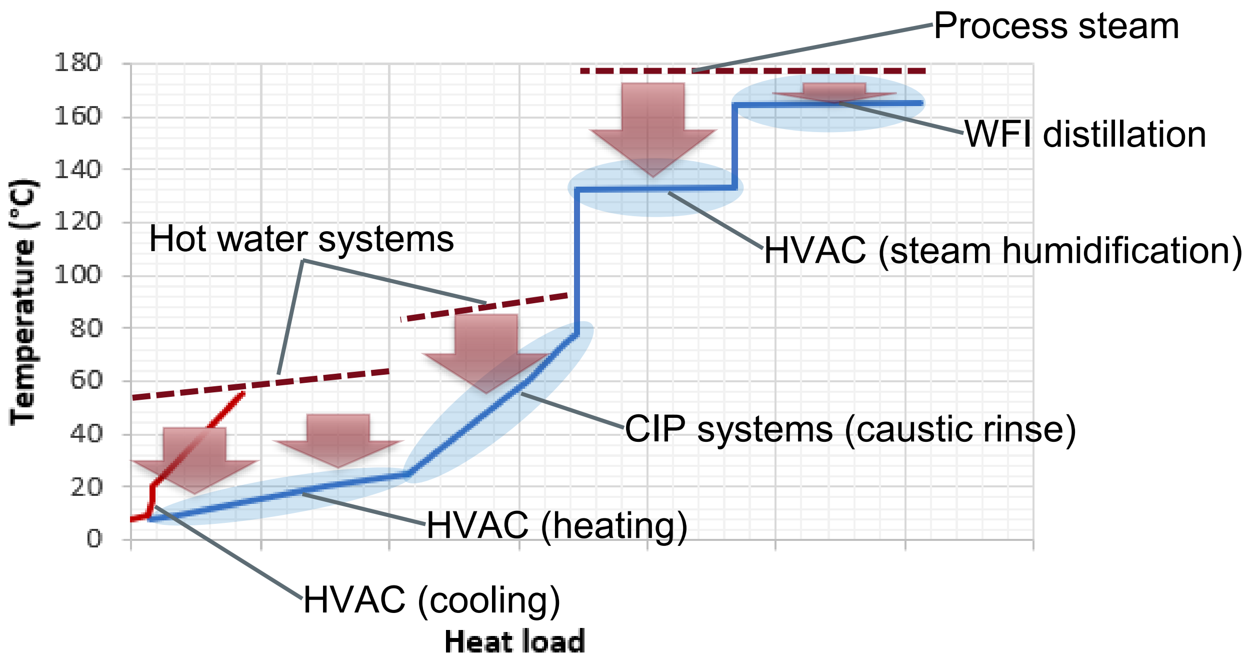
- **Demands:** Supply heat at temperatures as low as possible
- **Excess heat sources:** Temperatures as high as possible



# ENERGY EFFICIENCY
# ELECTRIFICATION – HEAT PUMPS

## Substitution with hot water supply

- CIP systems (80 ºC),
- HVAC (50-60 ºC),
- Preheating of drying processes
- WFI sanitization (with cold WFI production),
- Heating of WFI loops (80 ºC)
- Thawing processes,
- …

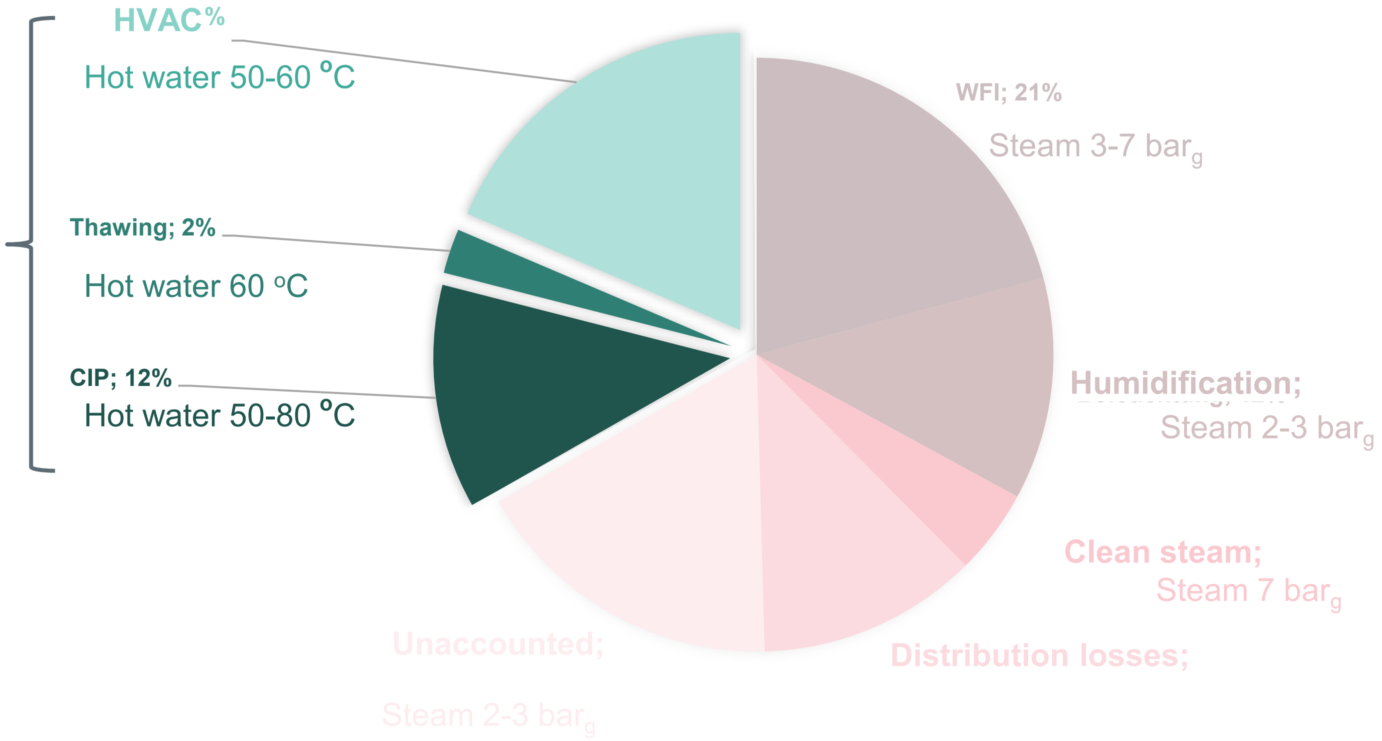


# ABOUT ONE-THIRD OF HEAT DEMAND CAN BE SUPPLIED BELOW 80°C

## Industry example – Potential for hot water

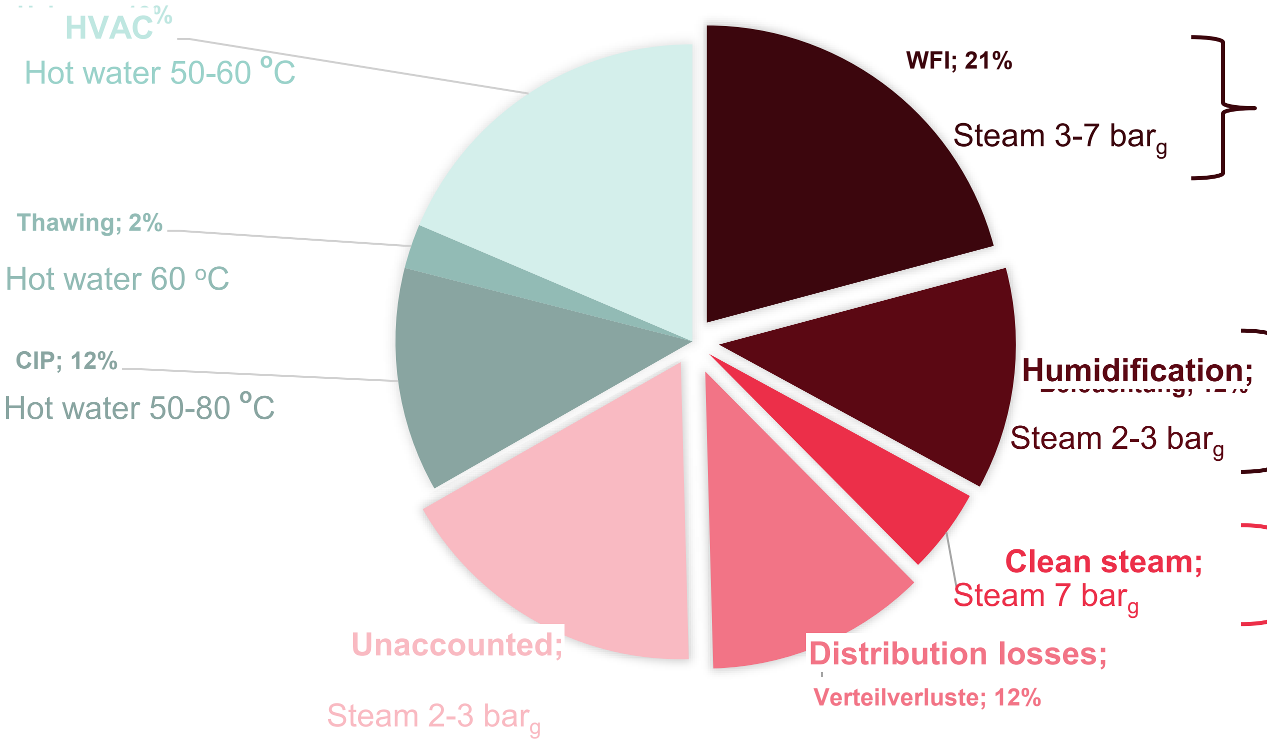
Potential savings through heat pump use!

About **33% of heat demand and of CO2 emissions**



# OVERVIEW OF HEAT DEMAND

## Industry example – Potential for technology change

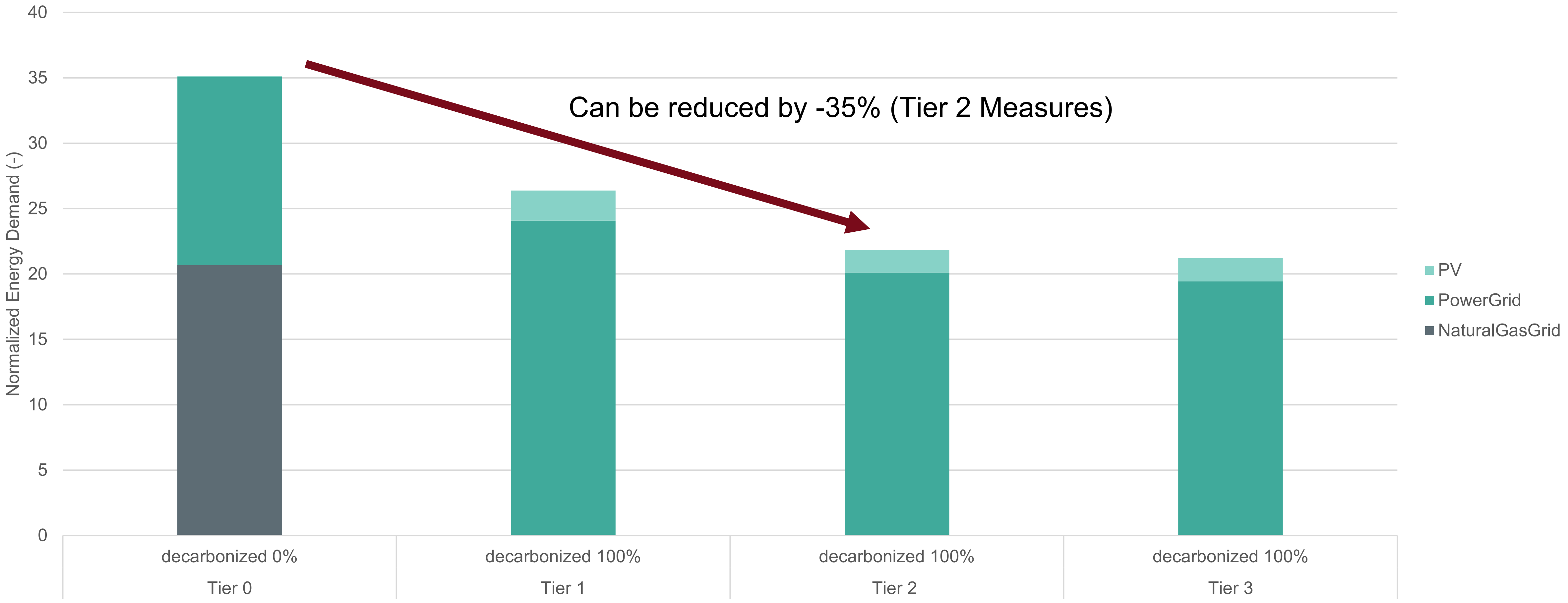



**WFI generation using**
**Membrane technology ("WFI cold")**
**➔ Steam requirement is eliminated**

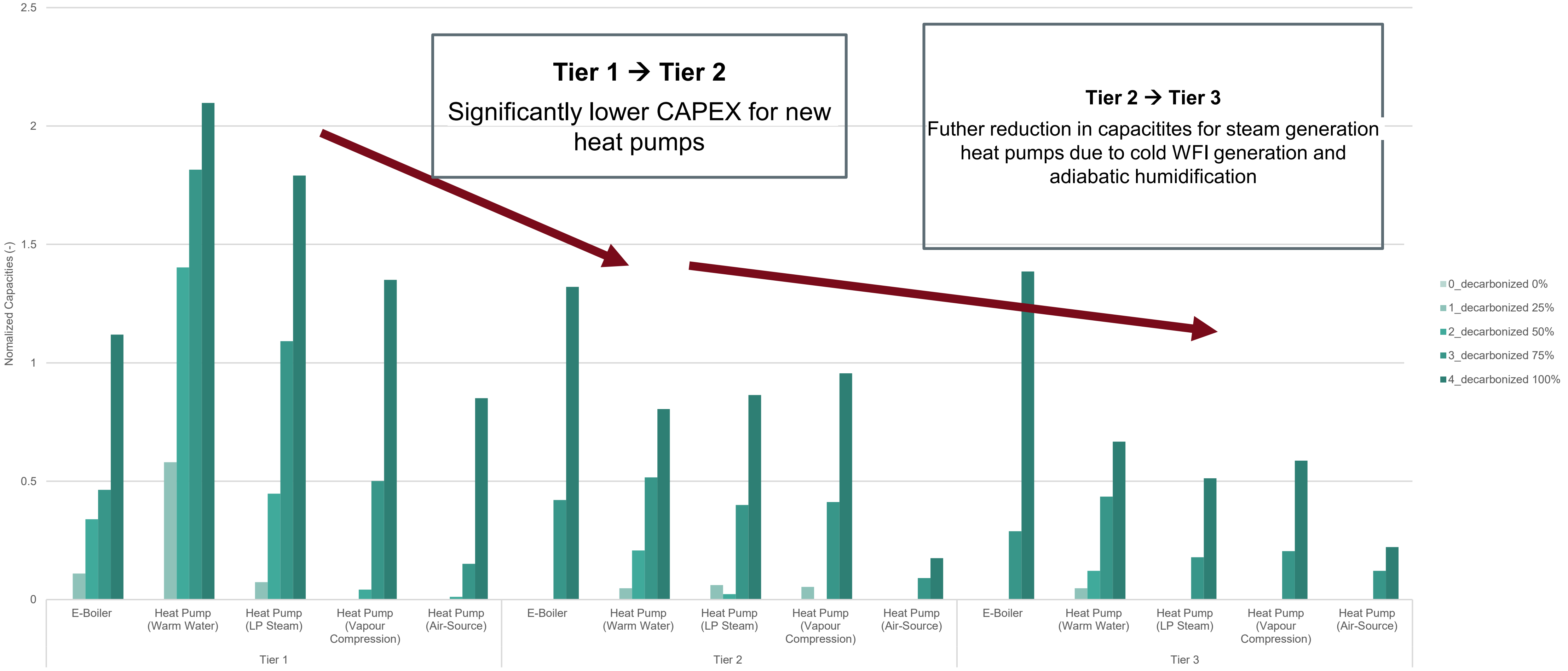
**Adiabatic humidification with cold-generated WFI**
**➔ Steam demand is replaced by hot water**

**Direct electrification or supply of renewable steam**

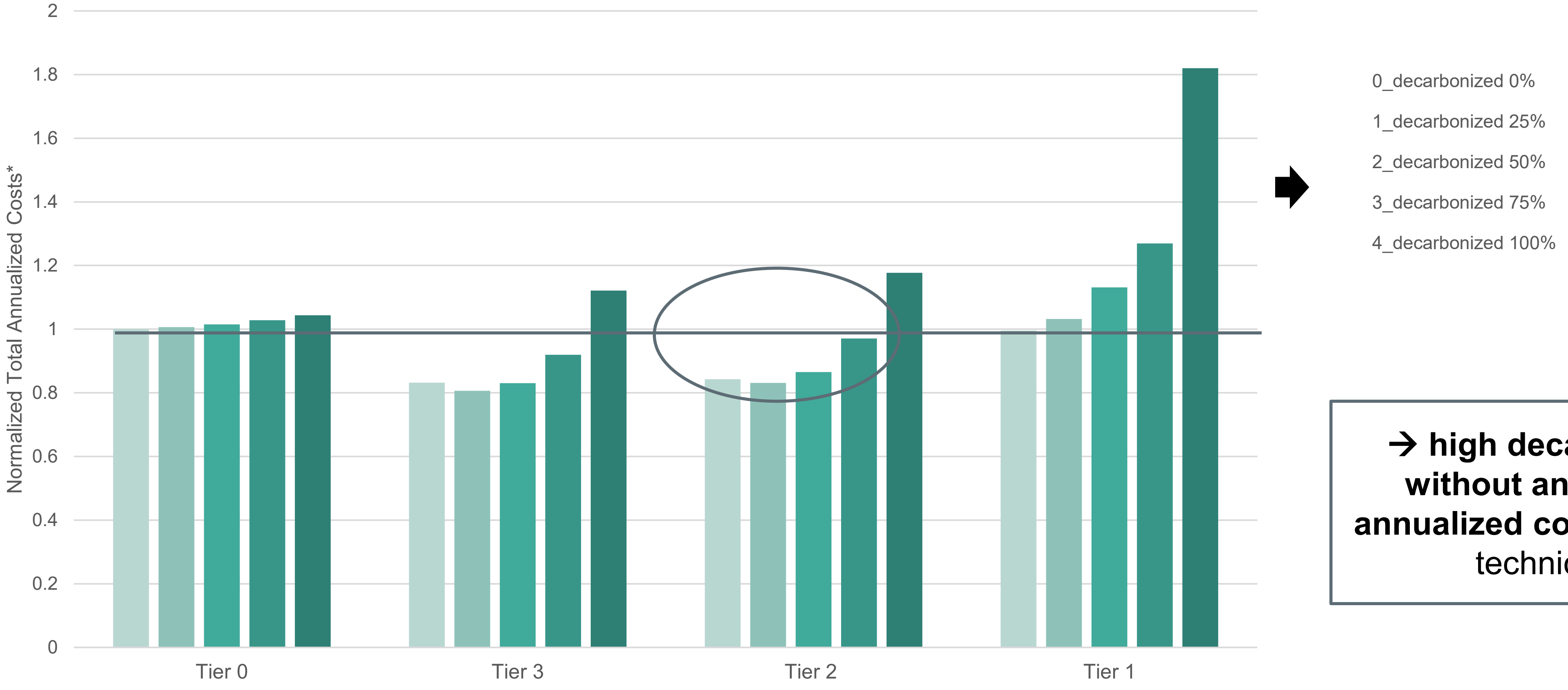
# EFFICIENCY MEASURES REDUCE FINAL ENERGY DEMAND BY 35%



# PROCESS CHANGES REDUCE REQUIRED HEAT-PUMP CAPACITIES



# EFFICIENCY ENABLES HIGH DECARBONIZATION WITHOUT HIGHER ANNUAL COSTS




*10-year depreciation period

→ **high decarbonization rates without an increase in total annualized costs** for energy supply technically possible

# CONCLUSION

A large share of pharmaceutical heat demand can be supplied efficiently by heat pumps

Energy efficiency and heat recovery reduce both electricity demand and required heat pump capacity

Technology changes such as membrane-based WFI generation unlock deeper decarbonization at competitive annual costs

# PHARMACEUTICAL SECTOR COLLABORATION

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

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- Part of the **IEA HPT Project 68** https://heatpumpingtechnologies.org/project68/
- Several workshops on the integration of HTHP in the sector with multiple stakeholders
  - Increase knowledge in the sector
  - More implementations in the sector
- **First Workshop (online):** October/November 2026
  - Opportunities and Barriers
  - Lectures and interactive group work

Coming soon!

**Would you like to join us?**

**Please contact:**

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Federal Ministry Innovation, Mobility and Infrastructure Republic of Austria

IEA Research Cooperation Part of open4innovation

FFG Promoting Innovation.

# THANK YOU VERY MUCH

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Sustainable Thermal Energy Systems

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Project 68
Industrial High-Temperature Heat Pumps

High-Temperature Heat Pump Symposium

# AHEAD – Pioneering $CO_2$-Free Steam Without Gas.

Refrigeration and Heat-Pump Engineer
Project manager

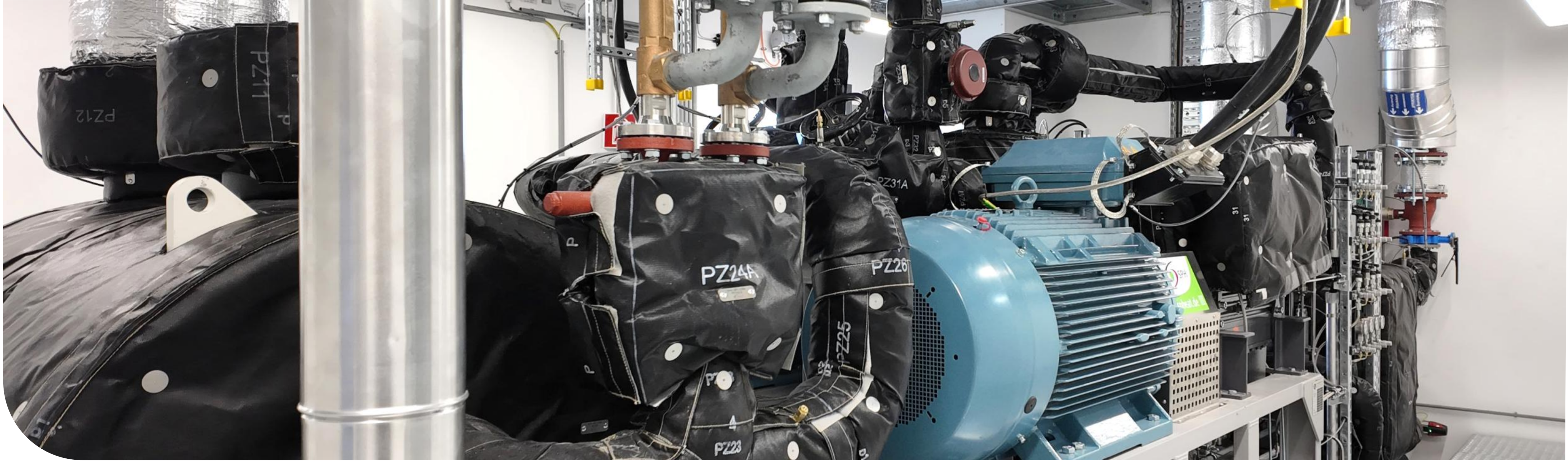
Takeda

Takeda

# AHEAD

## ADVANCED HEAT PUMP DEMONSTRATOR

Better Health, Brighter Future




# AHEAD - Pioneering $CO_2$-Free Steam without Gas

Challenges and Experiences in Producing Chilled Water (6°C), Heating Water (70°C), and Steam (184°C) with Natural Refrigerants

*Doris Hofbauer*
*Takeda Manufacturing Austria AG, Vienna, Austria*

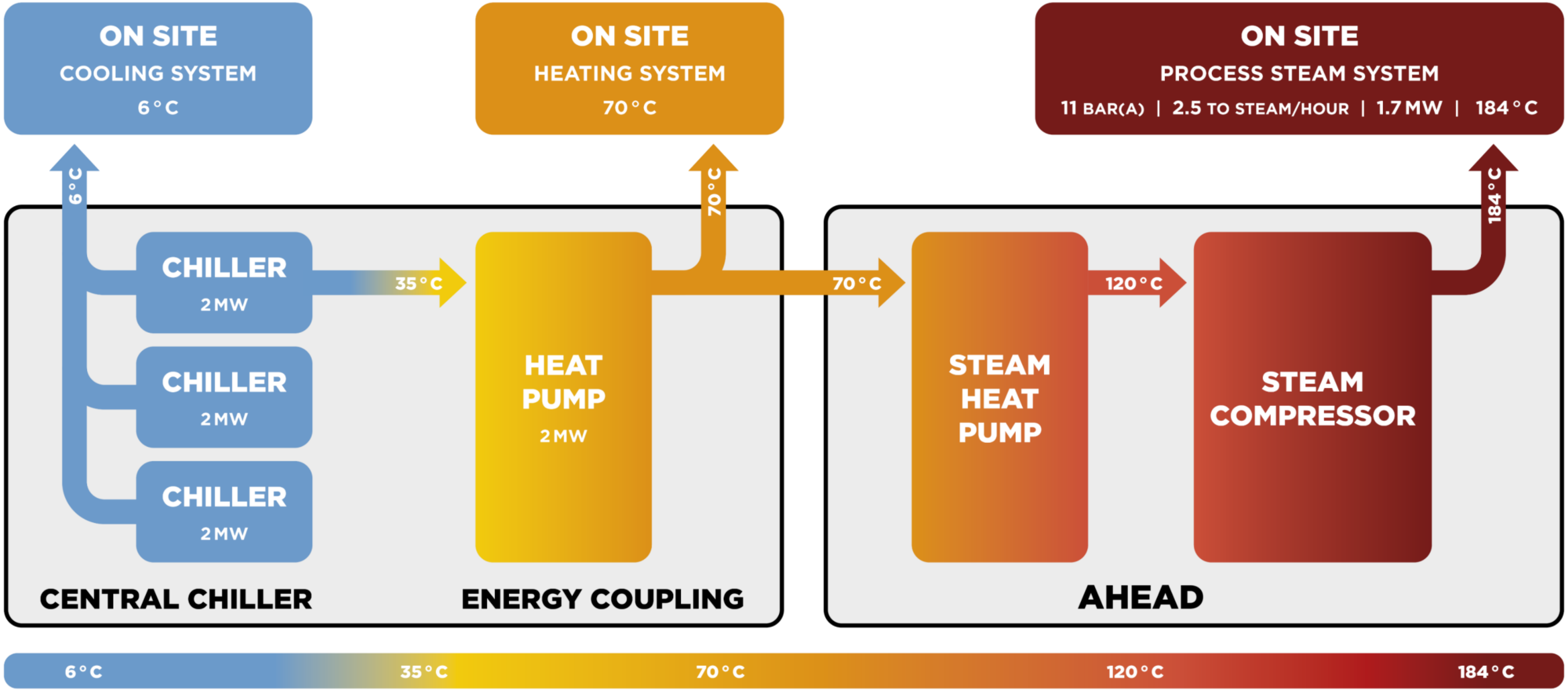
Better Health, Brighter Future

This project has the potential
to produce steam …

… with 184°C, 11 bar(a), 1,7 MW, 2,5 to/h
… with 100 % natural refrigerants
… with almost zero $CO_2$ emissions over 7 month a year on
… with up to minus 80 % greenhouse gas emissions
at Takeda's largest production site in Vienna

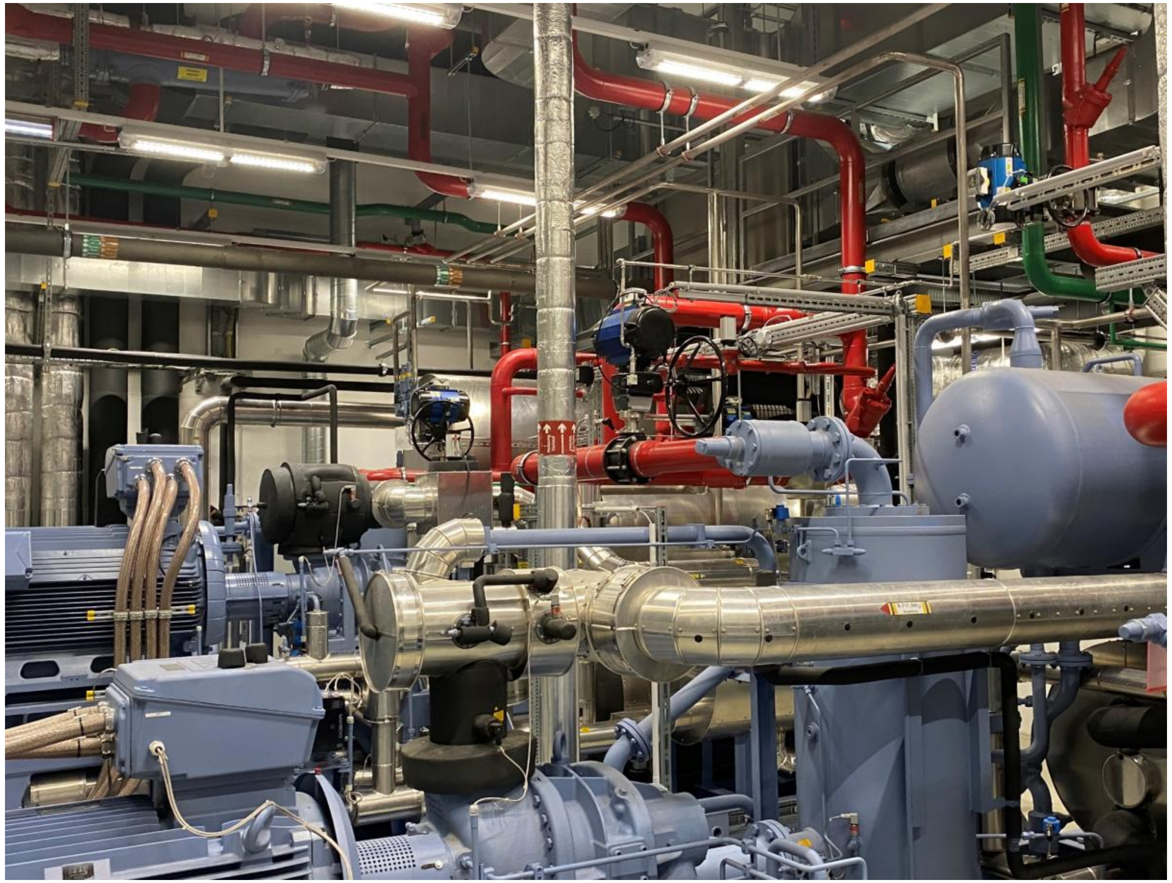
This project is essential for achieving site-specific and domestic Austrian goals, but it also makes a significant contribution to Takeda's net-zero GHG goal, as the project is scalable and can therefore be integrated into other locations worldwide!

# From Chilled Water (6°C) to Heating Water (70°C) and Steam (184°C)




The research project is funded by the Climate and Energy Fund and carried out as part of the FTI initiative "Vorzeigeregion Energie".

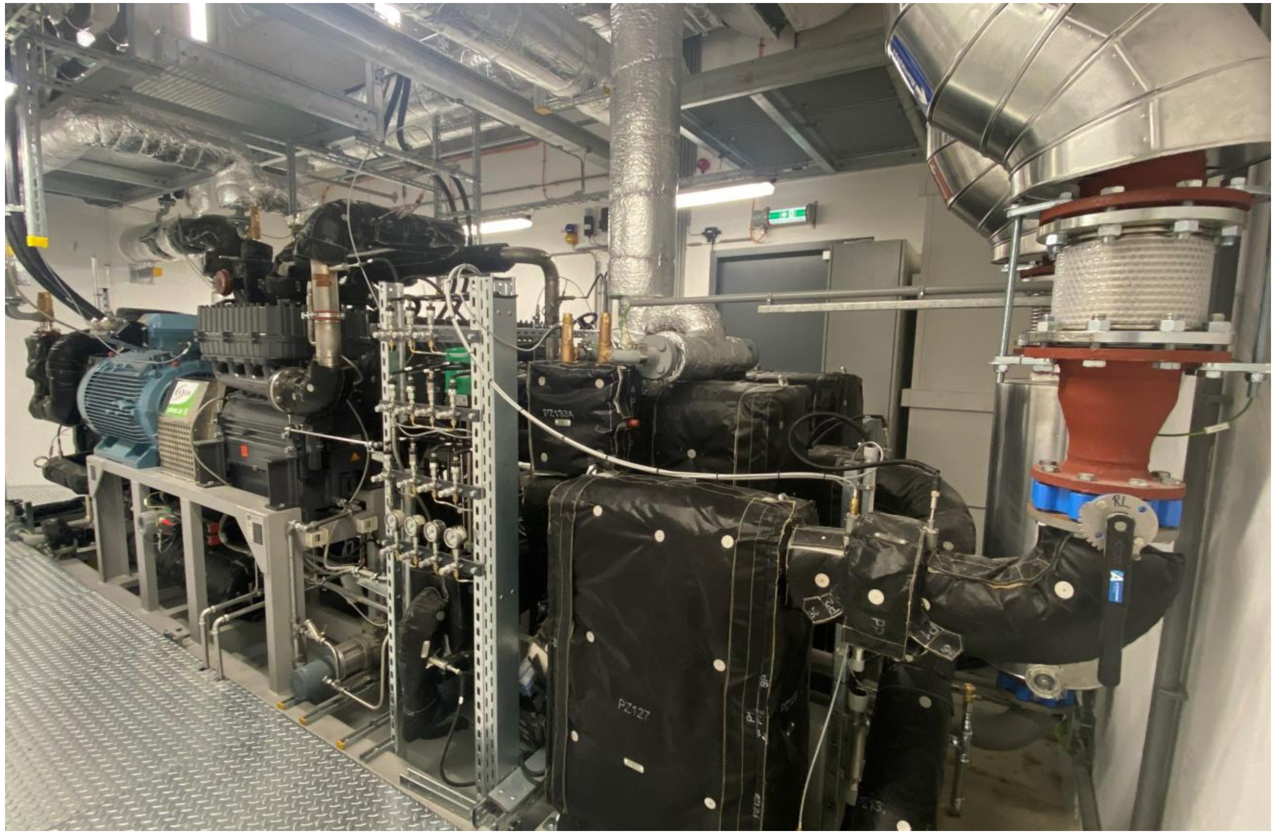
# Central Chiller (Chilled Water, 3x 2MW, 6°C, R-717) and Energy Coupling (Heating Water, 2MW, 70°C, R-717)



AIT AUSTRIAN INSTITUTE OF TECHNOLOGY · klima+ energie fonds · Takeda · SPH · NEFI NEW ENERGY FOR INDUSTRY

The research project is funded by the Climate and Energy Fund and carried out as part of the FTI initiative "Vorzeigeregion Energie".

# AHEAD: Heat Pump (Heating water 70°C ➔ 120°C steam, 1,7 MW, 180 kg R-600) and steam compressor (120°C ➔ 184°C, 2500 kg/h)



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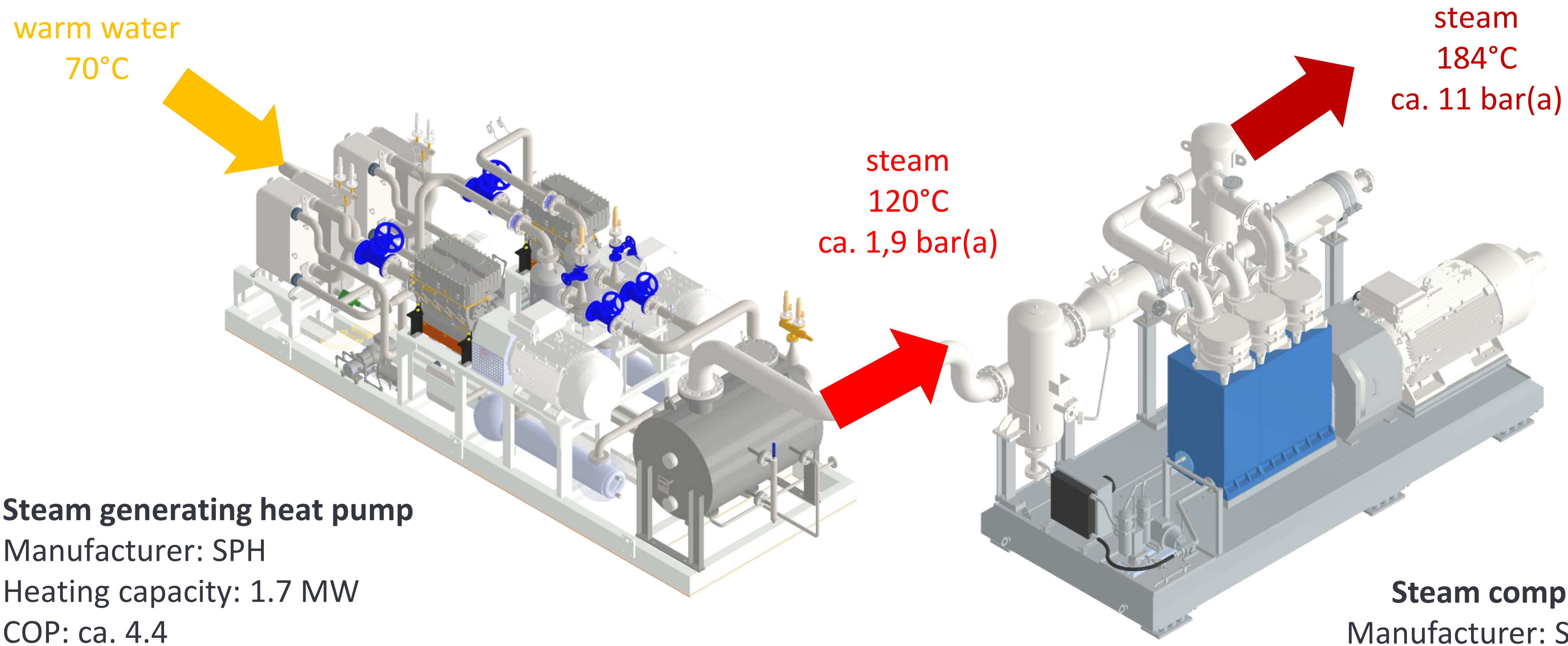
# AHEAD: ADVANCED HEAT PUMP DEMONSTRATOR




**Steam generating heat pump**
Manufacturer: SPH
Heating capacity: 1.7 MW
COP: ca. 4.4
Refrigerant: 180 kg R600 (n-butane)

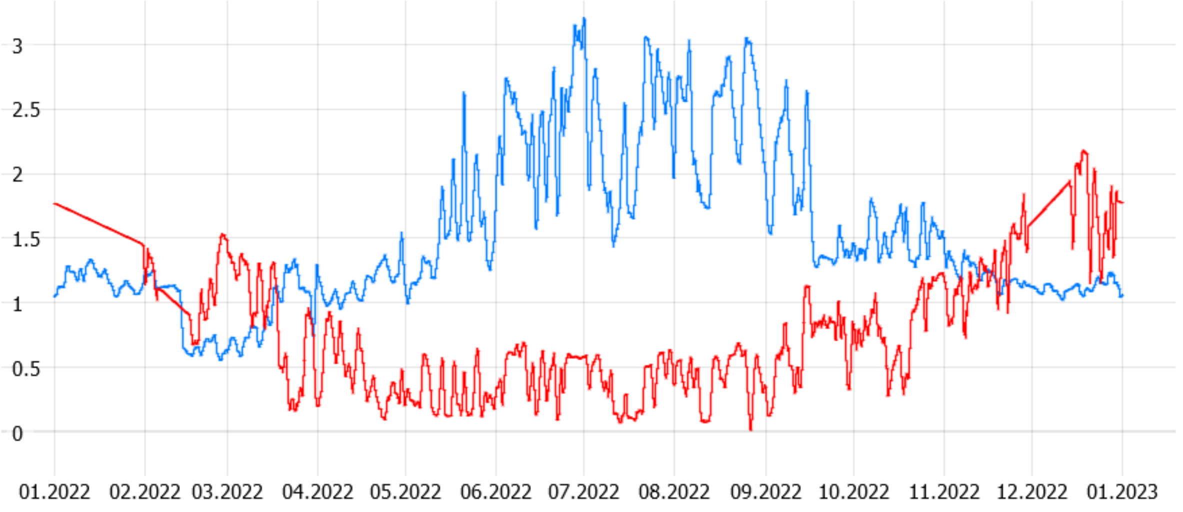
**Steam compressor**
Manufacturer: Spilling
Capacity: 2.5 t/h steam

The research project is funded by the Climate and Energy Fund and carried out as part of the FTI initiative “Vorzeigeregion Energie”.

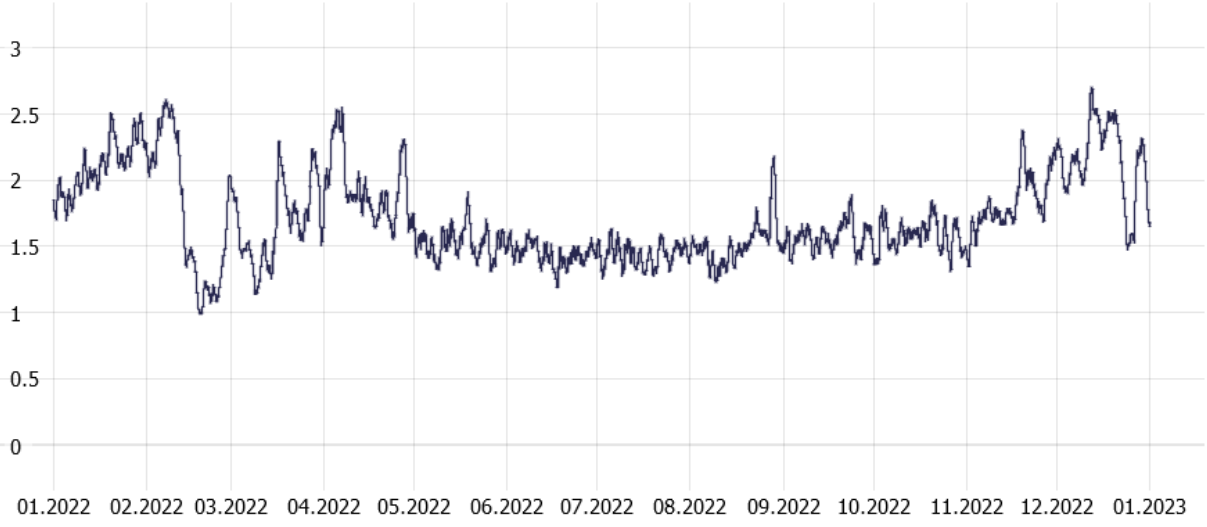
# Challenge: Proper operation through winter

Seasonal fluctuations of sources and sinks (heating, steam demand, available waste heat from the refrigeration machines)

Waste heat output of the refrigeration machines, MW
Heating demand of the heating system, MW




Steam demand, t/h

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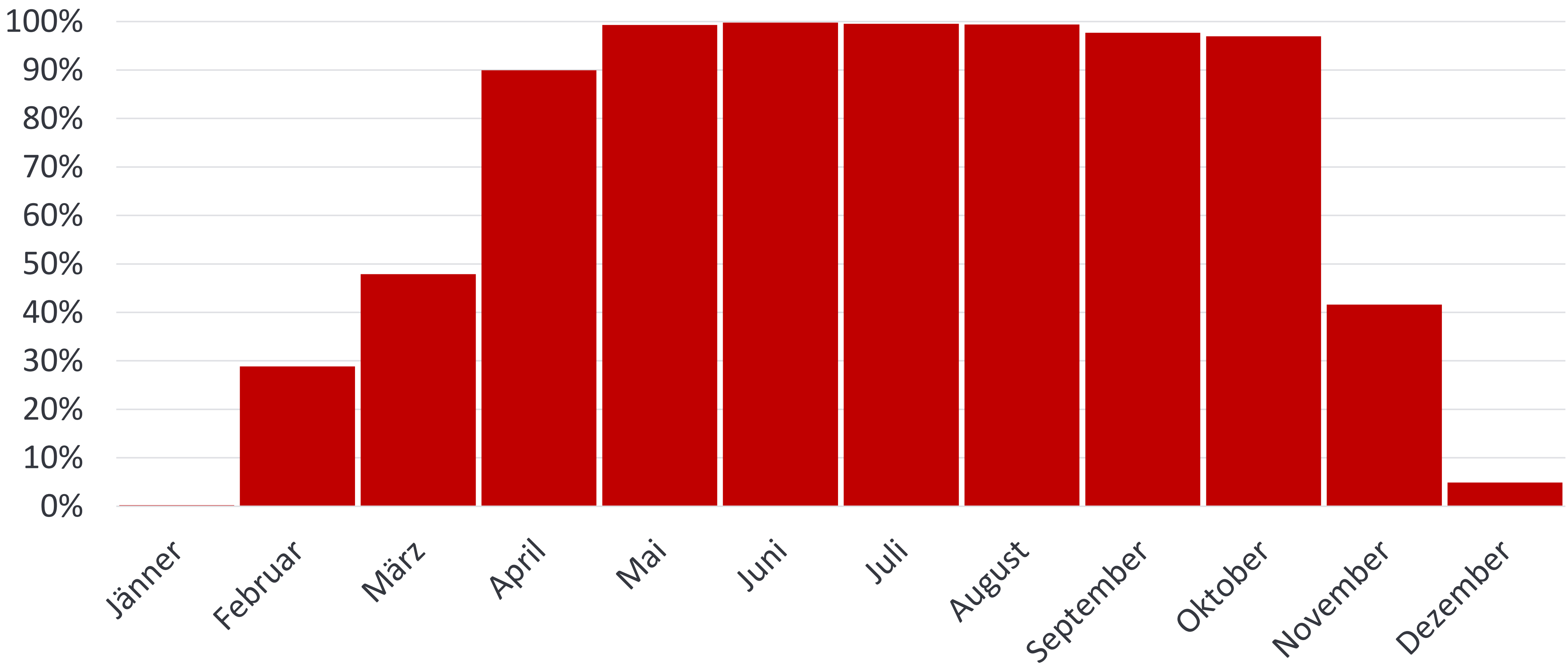
# STEAM Demand covered by AHEAD (Simulation)

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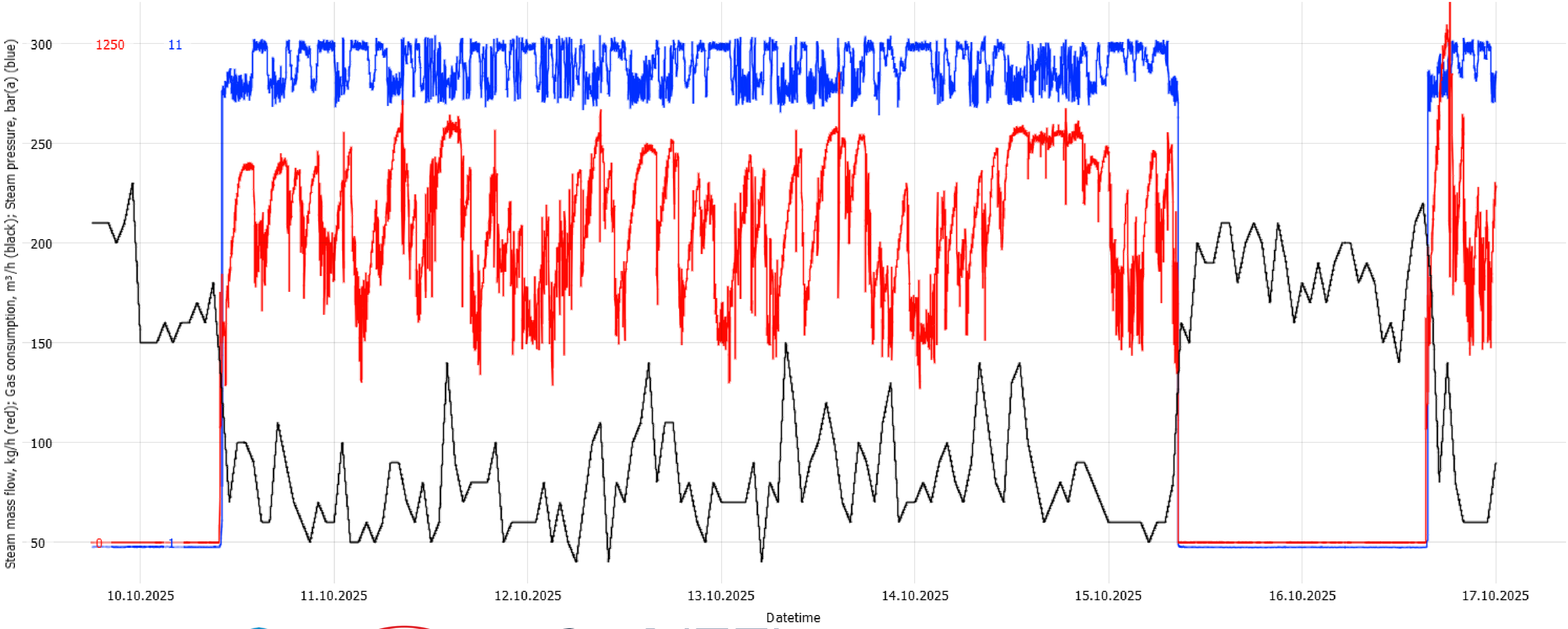
# One week of operation in mid-October

Gas consumption, m³/h (black); steam mass flow from the heat pump, kg/h (red); steam pressure from the AHEAD system, bar(a) (blue)

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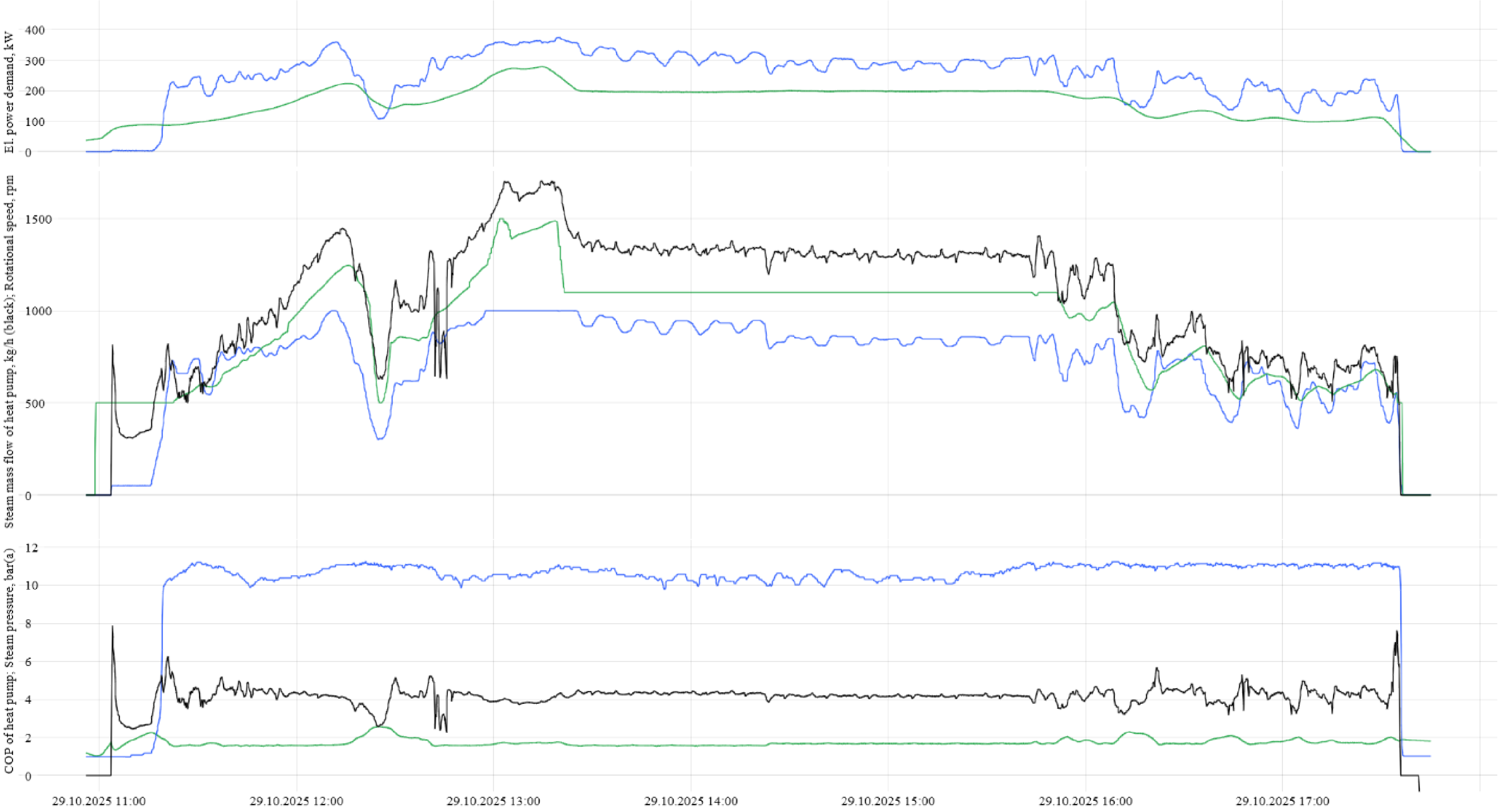
# One day of operation in October

- **Electrical power** demand in kW (<u>top</u>)
- **Steam mass flow** in kg/h (black) and **rotational speeds** for the heat pump and steam compressor in rpm (<u>middle</u>)
- **COP (black)** and **steam pressure** in bar(a) (<u>bottom</u>)

- Colors:
  SPH heat pump: green
  MVR: blue



# Milestones

Winter 2022: Launch of the research project

Spring 2024: Beginning of construction

Spring 2025: Initial test runs of the heat pumps on the test platform at SPH

Summer 2025: Start of the on-site trial phase

September 2025: Official launch

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The research project is funded by the Climate and Energy Fund and carried out as part of the FTI initiative “Vorzeigeregion Energie”.

# Challenges and Learning

- **limited long-term experience with large high-temperature heat pumps**
  oil, seals, component lifetime
  ➔ challenges with 2 MW R-717 heat pump
- **Complex start-up and operation of the full cascade**
  (refrigeration system / 70°C heat pump / steam heat pump / steam compressor)
  differences between summer and winter operation
  part load vs. full load
- **Once the system is running, it runs really well**
  COP even better than expected
- **Difficult to measure the real COP of the overall system**
  steam flow measurement issues in the slightly superheated range
- **It only works with a strong team**
  close cooperation between maintenance, engineering, suppliers and specialists

The research project is funded by the Climate and Energy Fund and carried out as part of the FTI initiative “Vorzeigeregion Energie”.

# Thanks to the whole team!

Kick-off Research Project, December 2022

Kick-off Implementation Project, May 2024


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# MMst. DI Harald Erös
# Ing. Doris Hofbauer, BSc

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Project 68
Industrial High-Temperature Heat Pumps

High-Temperature Heat Pump Symposium

# Steam generation for pharma industry using Stirling heat pumps

Torgrim Aase
Senior R&D Engineer

enerin
ENERGY ENGINEERING

# Industrial High Temperature Heat Pumps for pharmaceutical decarbonization

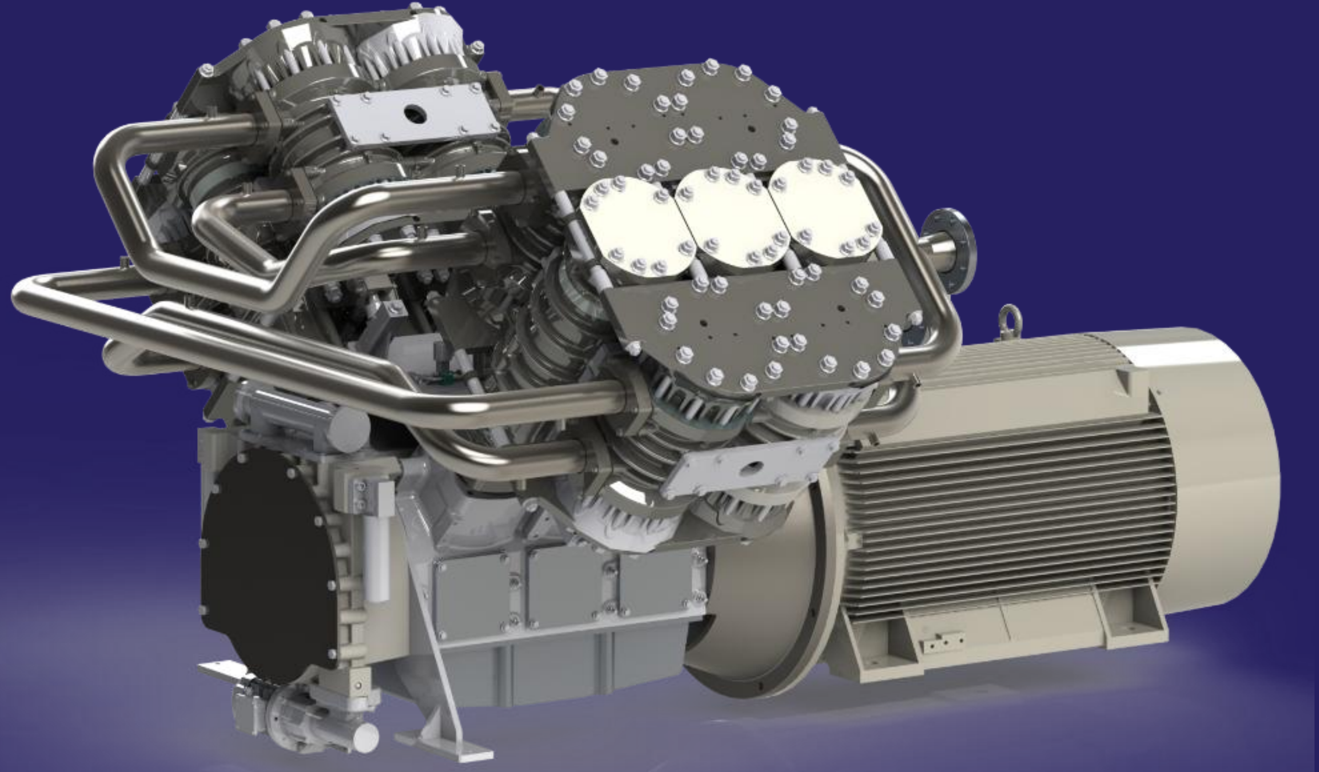
Torgrim Aase

Senior R&D Mechanical Engineer

17 September 2026

HoegTemp®
ENGINEERING BY ENERIN

**R-704 Helium:**
Inert, non-toxic, zero ODP, zero GWP



## 400 kW industrial heat pump

- Steam or hot water up to 200°C.
- Any heat source from -30°C:
  Waste heat, coolers, ambient.

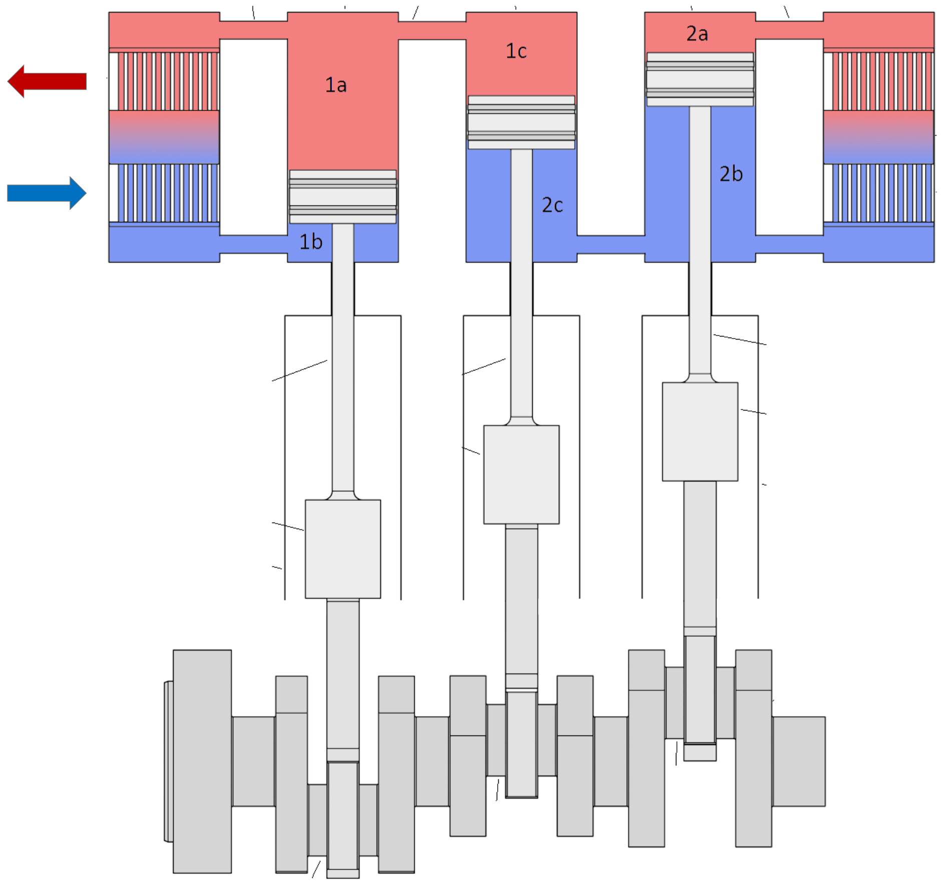
## Stirling cycle

- High COP at high temperature lifts.
- Robust to varying operating conditions.
- Heating capacity not affected by temperatures.

## Piston compressor with integrated heat exchangers

- Sink: Hot-water circuit to steam generator.
- Source: Cold-water circuit.
- Power: Induction motor/VFD.

# Stirling-cycle heat pump layout




## Power piston (mid-cylinder):

- Separates the circuits.
- Compression and expansion work.

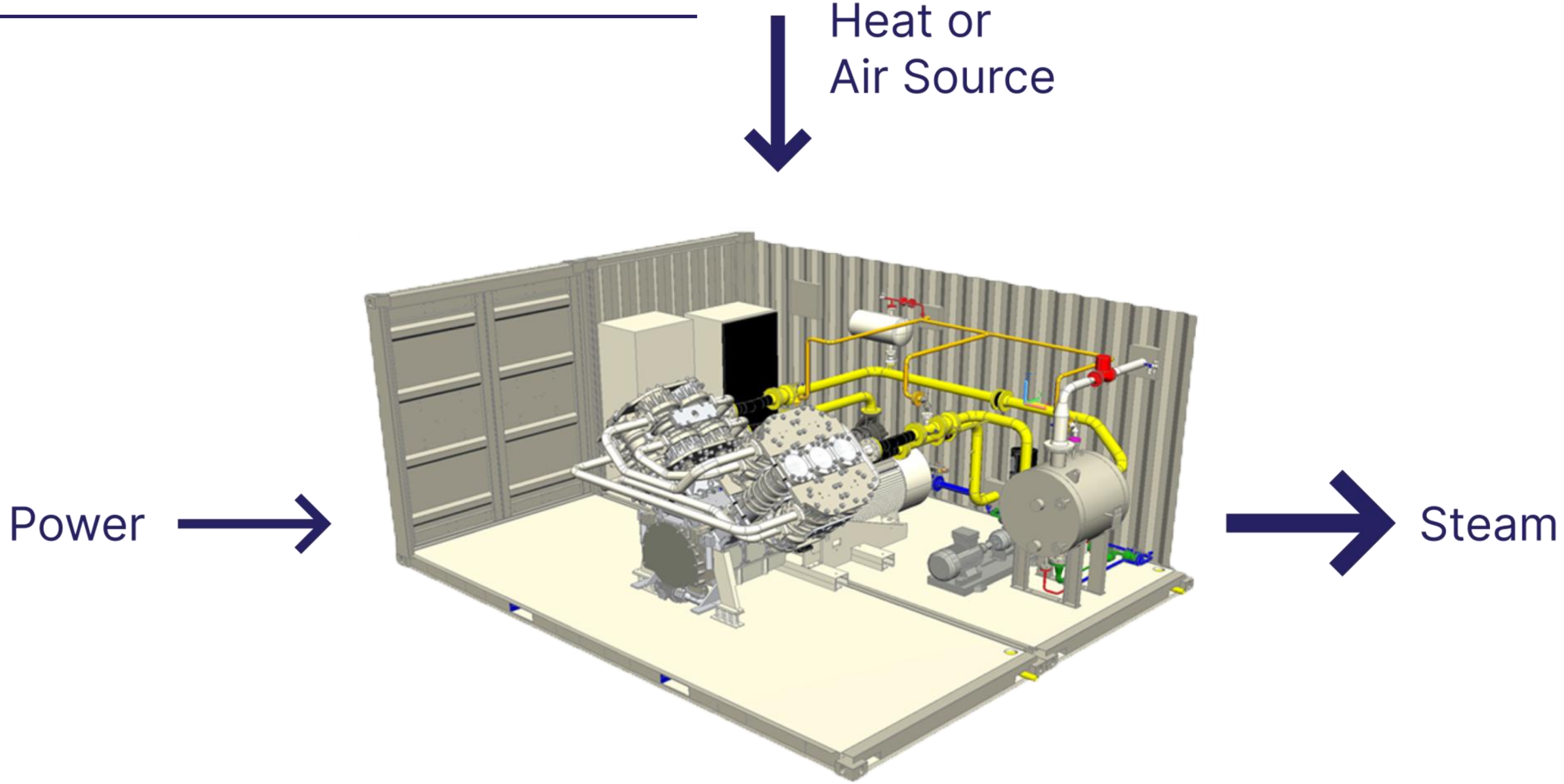
## Displacer pistons:

- Moves gas through the heat exchanger. through the regenerator between the hot and cold volumes.

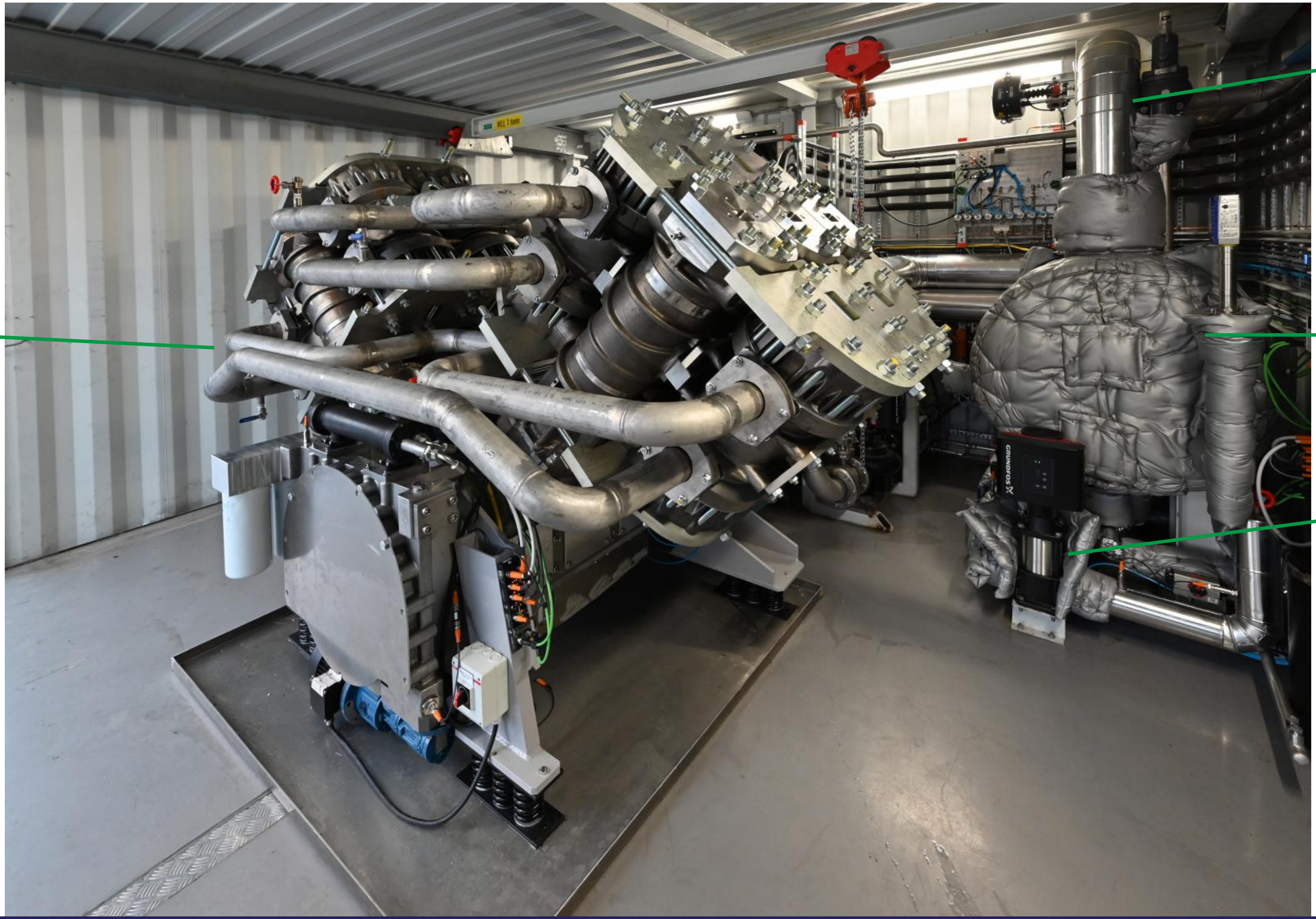
## Heat exchangers:

- Heat hot-water circuit (sink).
- Cool cold-water circuit (source).

# Simple integration — Future proof



# Heat pump and steam generator



Steam pipe to factory

Heat pump

Water-heated steam generator

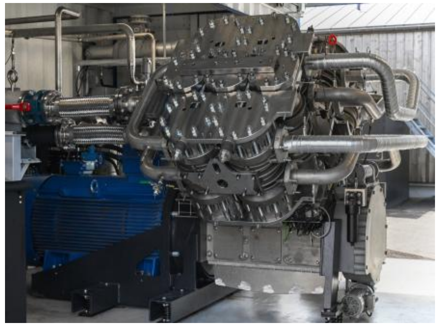
Feedwater pump

# Performance data from three industrial pilots

## Commercialization timeline

2017 — I·V·A·R — GE Healthcare — PELAGIA — Roche — 2026

**Enerin is founded on**
**~25 years of heat pump R&D**



- More than 18 000 hours of HoegTemp operation
- More than 50 000 hours of real-world experience

**Industrial demo pilot 2023**

400kW (1,365 MBH) Steam

2.5 bar steam

+20°C cooling

~12 000 hours

**Industrial pilot 2024**


400kW (1,365 MBH) Steam

1.8 to 2.5 bar steam

+25°C cooling

~5 000 hours

**Commercial pilot 2025**

400 kW (1,365 MBH)

5 bar steam

20°-90°C heat source

~1 000 hours

**V12 Commercial pilot**

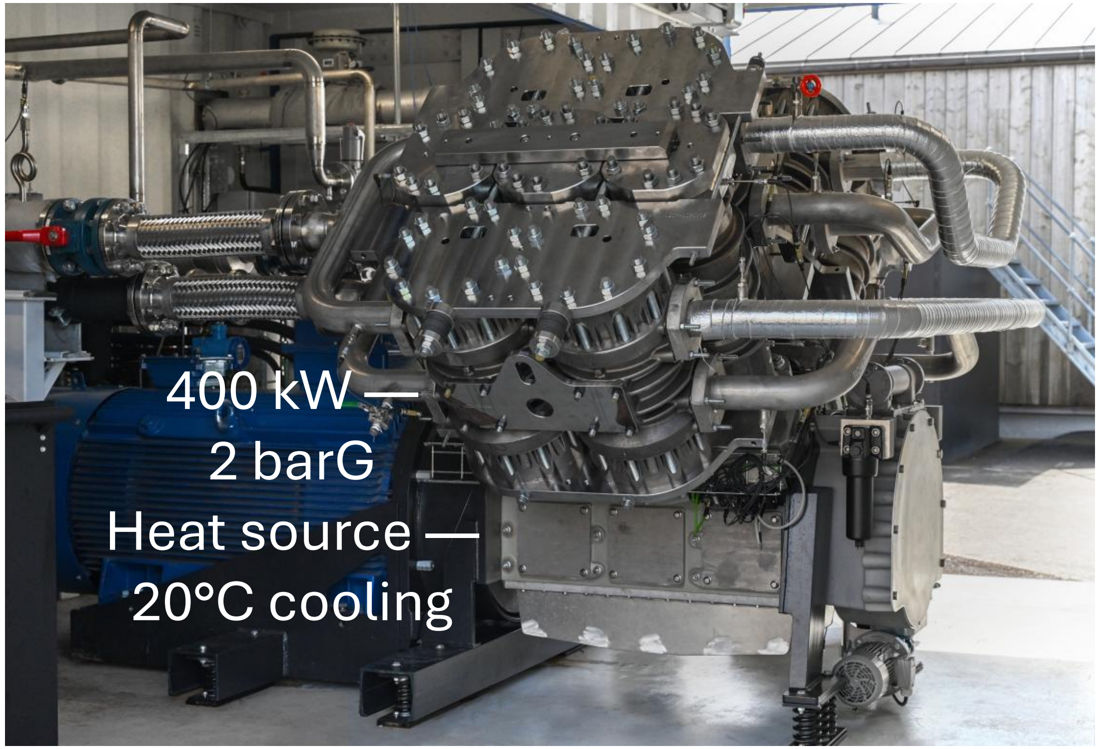
1.2 MW to be installed 2026

6 bar steam

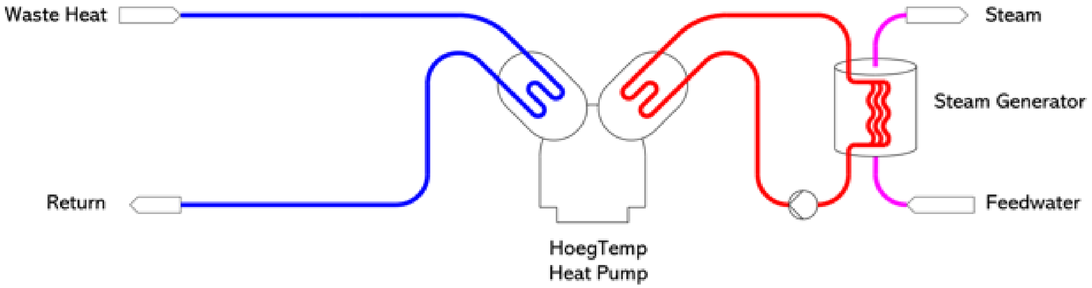
4°-40°C heat source

# IVAR IKS Bryne — Biogas 2023

Waste heat from the cooling water circuit (21–22°C) is collected in a closed-loop water circuit (heat sink).




The heat is transferred to a steam generator, producing steam at 140–200°C for reuse in the biogas $CO_2$ capture process.

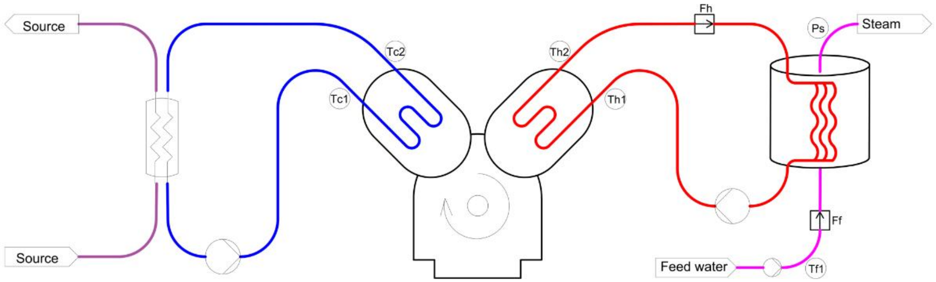


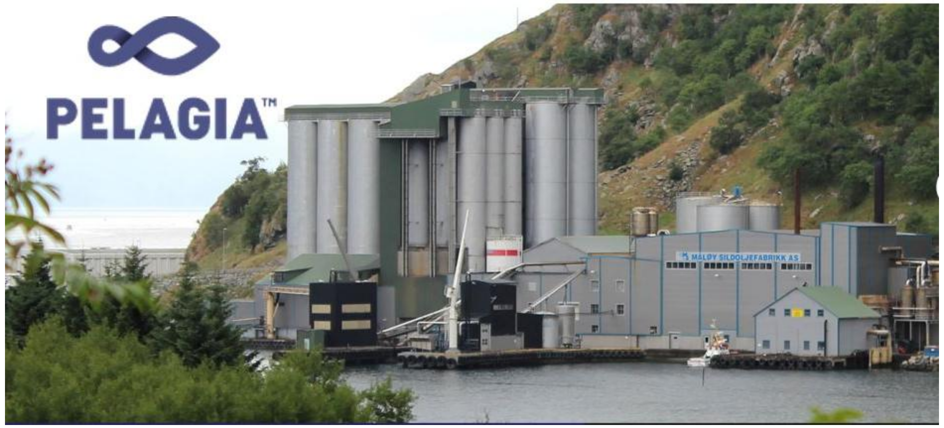

# Pelagia Måløy — Fish meal & fish oil 2025

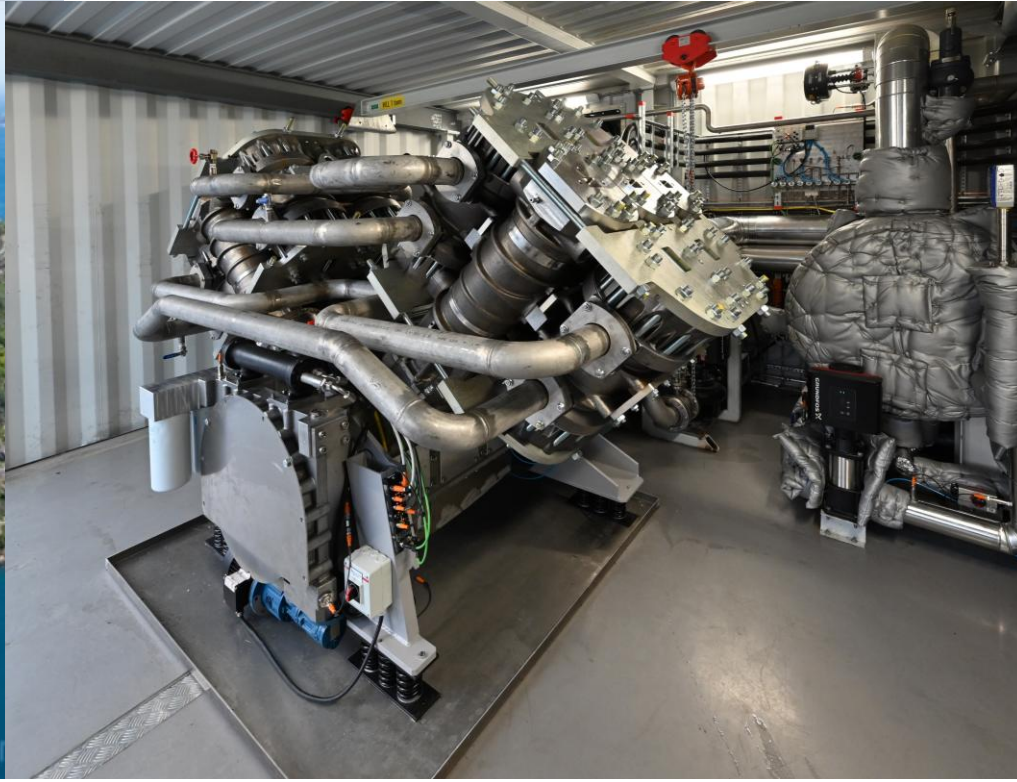
Steam used for drying fish meal in batch processing—catch dependent.
Heat source is end-of-pipe waste heat

High & varying temperatures / steam pressures with differing waste heat profiles.

- 400 kW steam at 5 barG, varying from 2 – 8 barG.
- Waste heat sourced from 15°C – 90 °C.
- Heat delivery at 130°C – 180°C.





# GE Healthcare Lindesnes

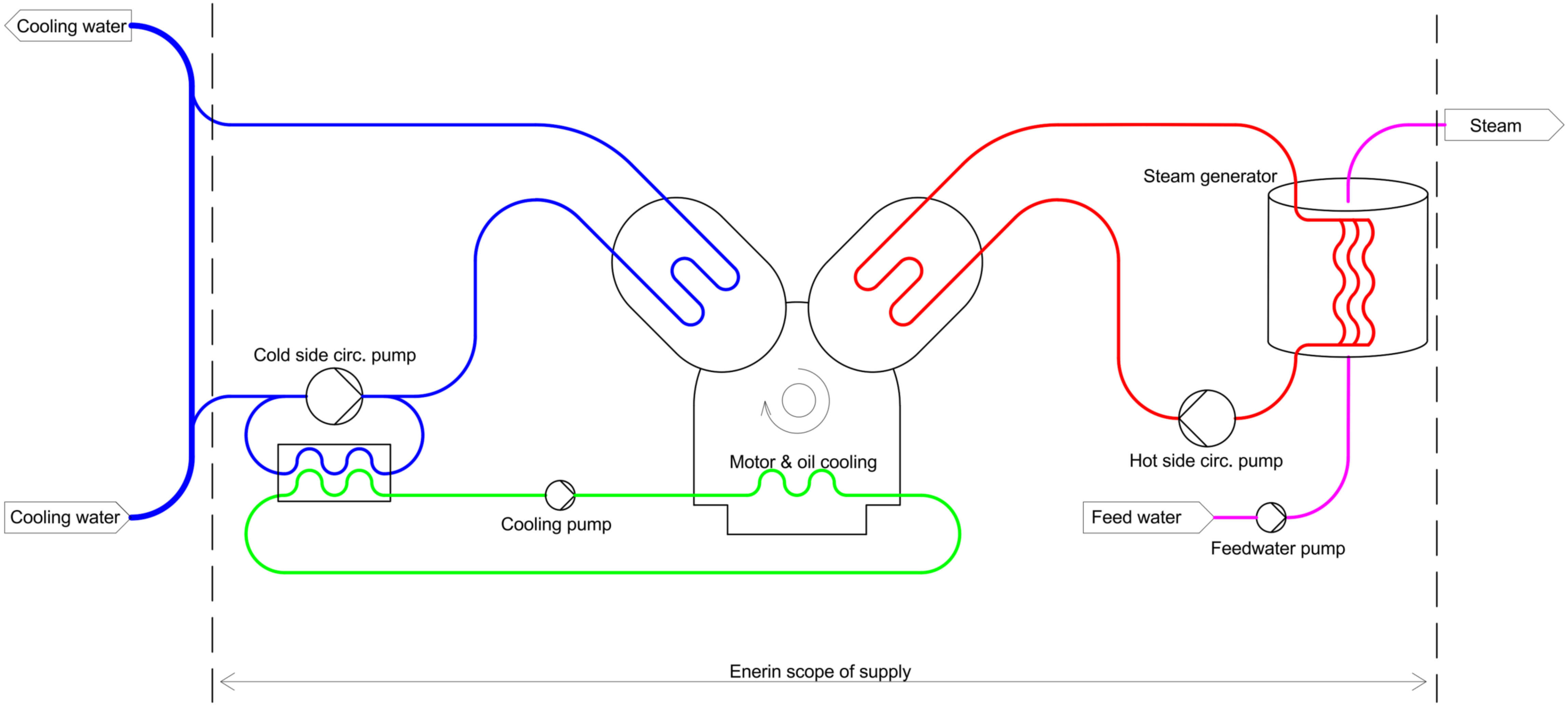
Pharmaceuticals 2024

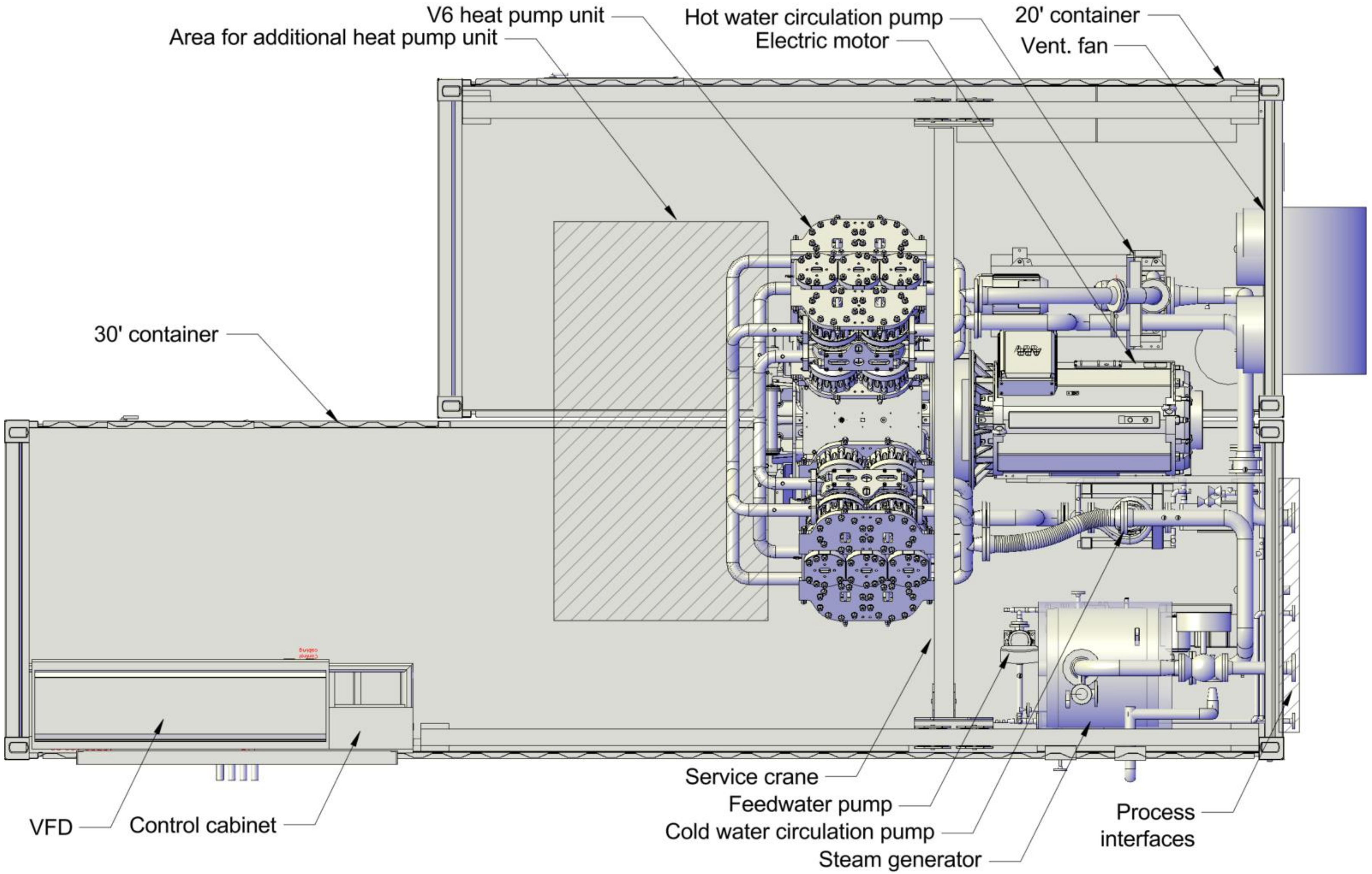
400 kW steam 2 $bar_G$

Heat source: 25°C cooling circuit

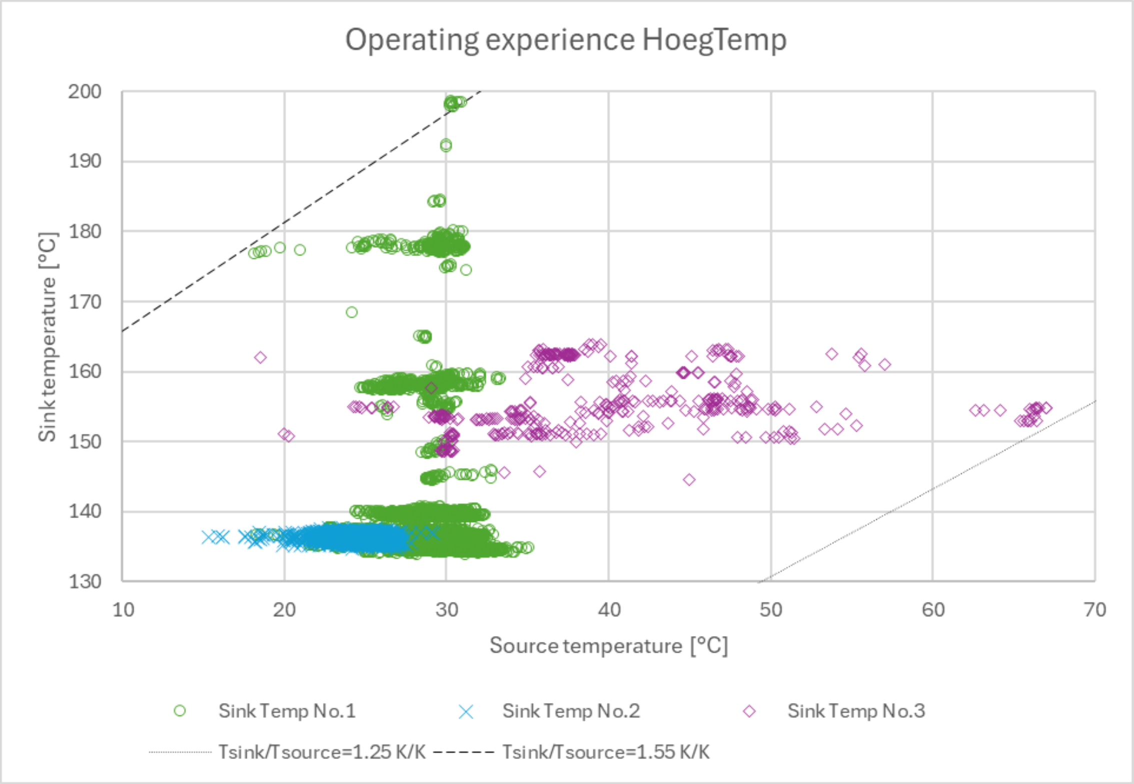
GE Healthcare

ENOVA


Cooling water
Cooling water
Cold side circ. pump
Cooling pump
Motor & oil cooling
Steam
Steam generator
Hot side circ. pump
Feed water
Feedwater pump
Enerin scope of supply


V6 heat pump unit
Area for additional heat pump unit
Hot water circulation pump
Electric motor
20' container
Vent. fan
30' container
Service crane
Feedwater pump
Cold water circulation pump
Steam generator
Process interfaces
VFD
Control cabinet

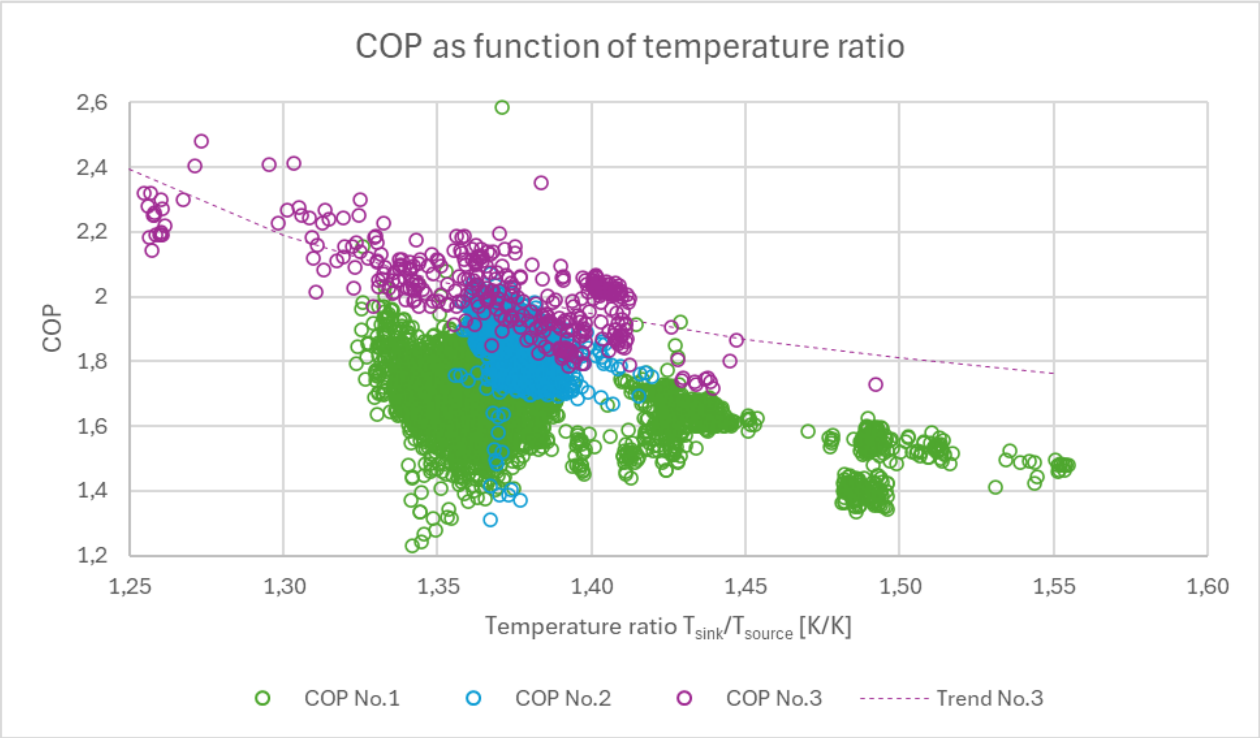
# Different temperatures – one design




- Data analysed from the 8,000 hours with the most stable operating conditions.
- 15,000 hours as of Nov, 2025.
- Three different scenarios: tested at high, fluctuating and stable temperatures.
- Source temperatures from 15°C to 68°C.
- Sink temperatures from 134°C to 199°C (200°C/198°C circuit).

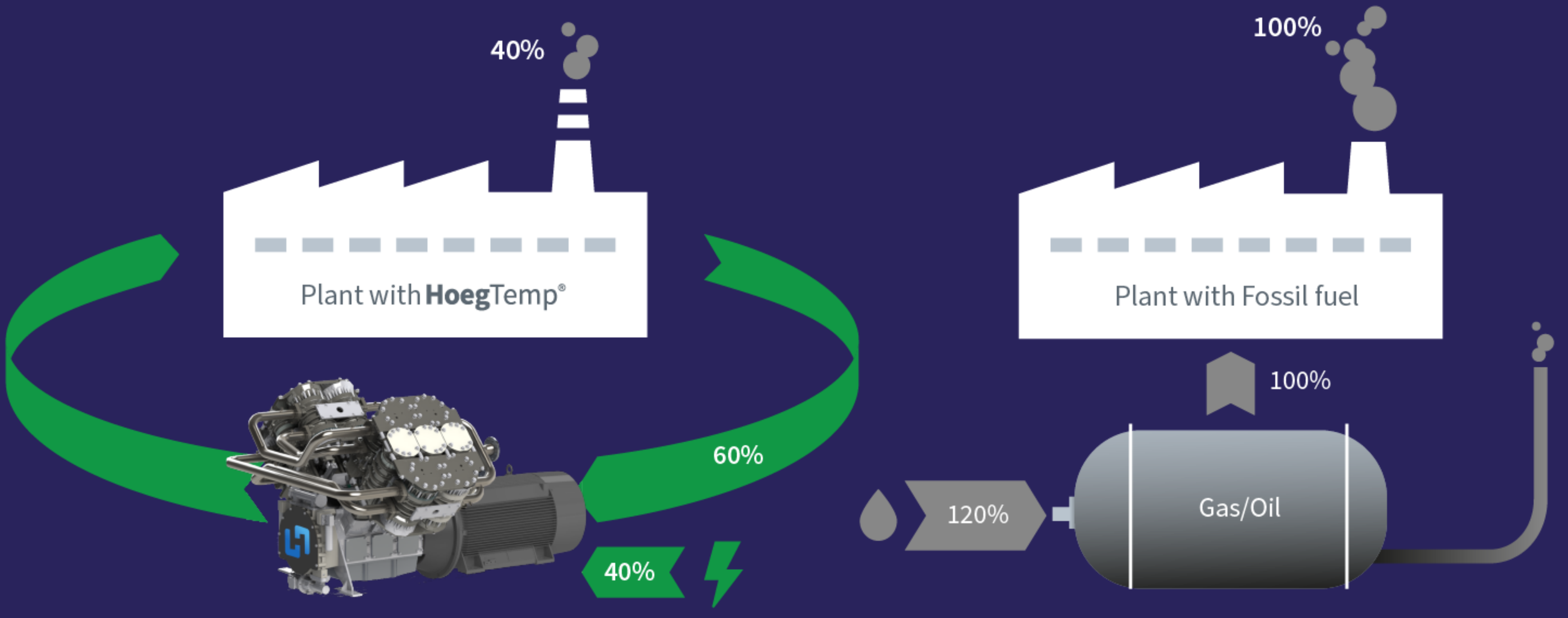
IVAR GE Healthcare Pelagia

# COP increased through minor updates




- COP a function of temperature ratio (K/K).
- GE Healthcare (blue): Modified pistons.
- Pelagia (purple): Modified heat exchangers.
- Different motor/VFD combinations — drive train efficiency excluded from charts comparing the three heat pumps.

# HoegTemp vs. Fossil boiler




- 50 –70% lower consumption
- Lower cost integration

- High cost price vulnerability
- Strain on cooling system
- Emissions

# Decarbonization concepts for pharmaceutical production sites

Kurt Engelbrecht
Senior Consultant
DANISH TECHNOLOGICAL INSTITUTE

# High temperature heat pumps in the pharma industry – learnings from CHASE

**IEA P68 Webinar**

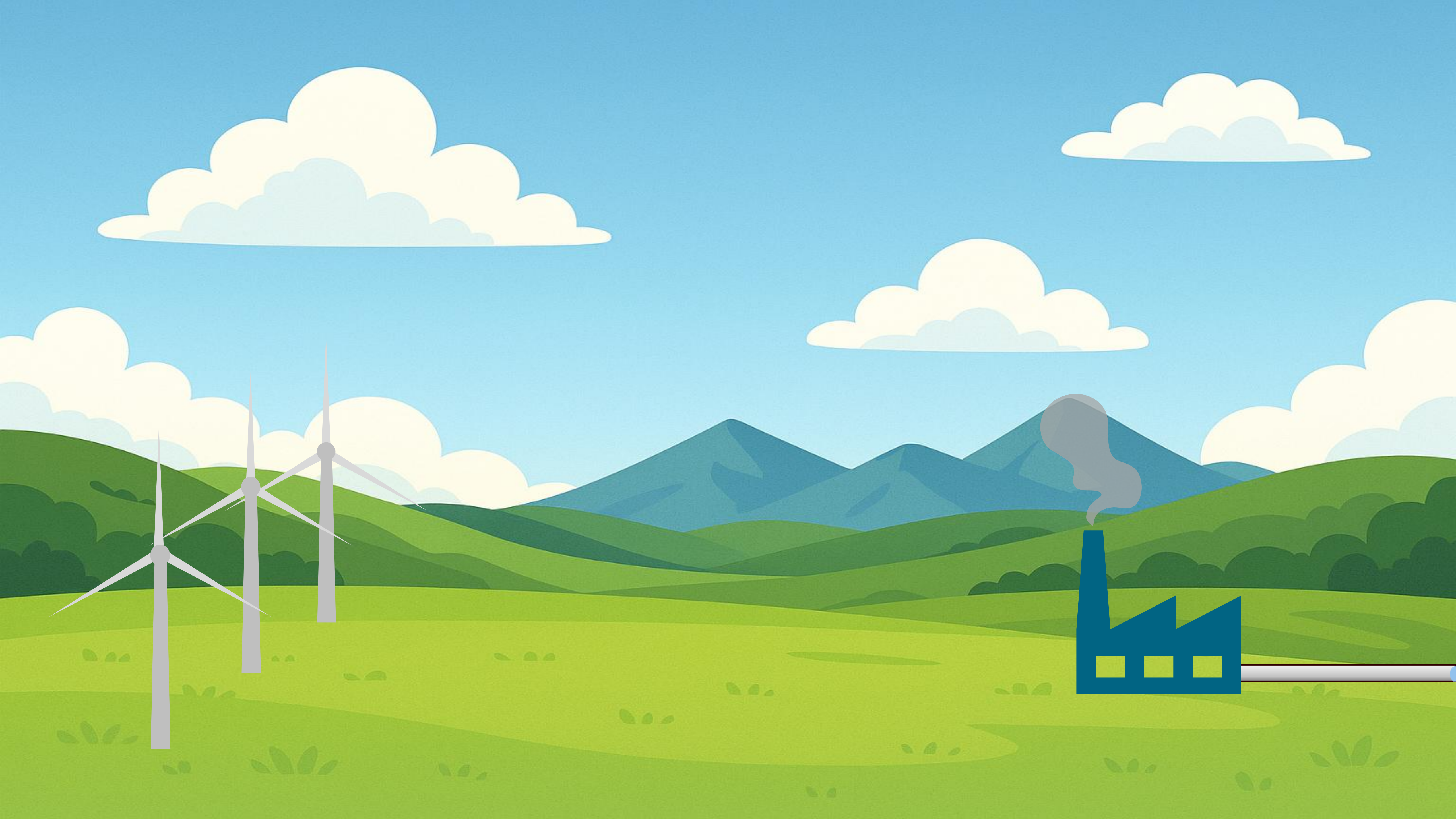
**17 September, 2026**

Kurt Engelbrecht

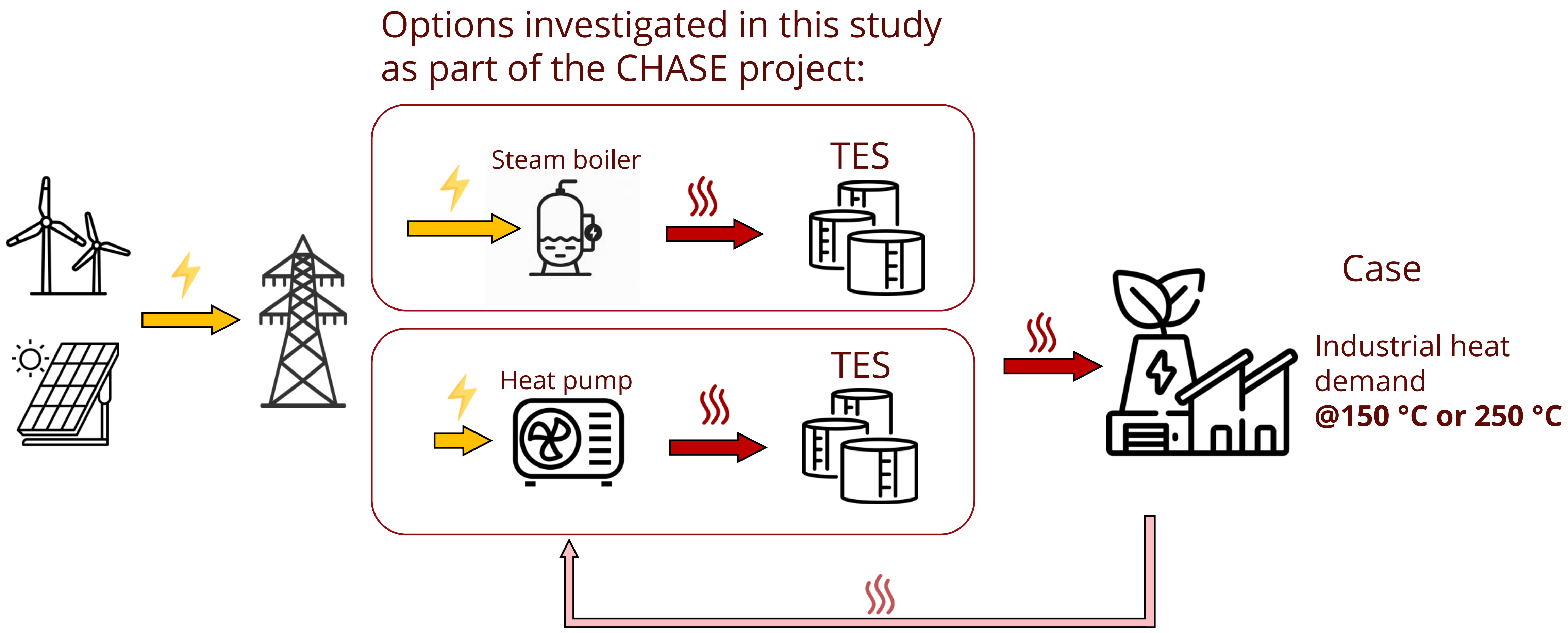
Francesco D’Ettorre

Wiebke Brix Markussn

Morten Herget Christensen



# CHASE project foundation



# CHASE partners

CHASE 4heat

TEKNOLOGISK INSTITUT

novo nordisk®

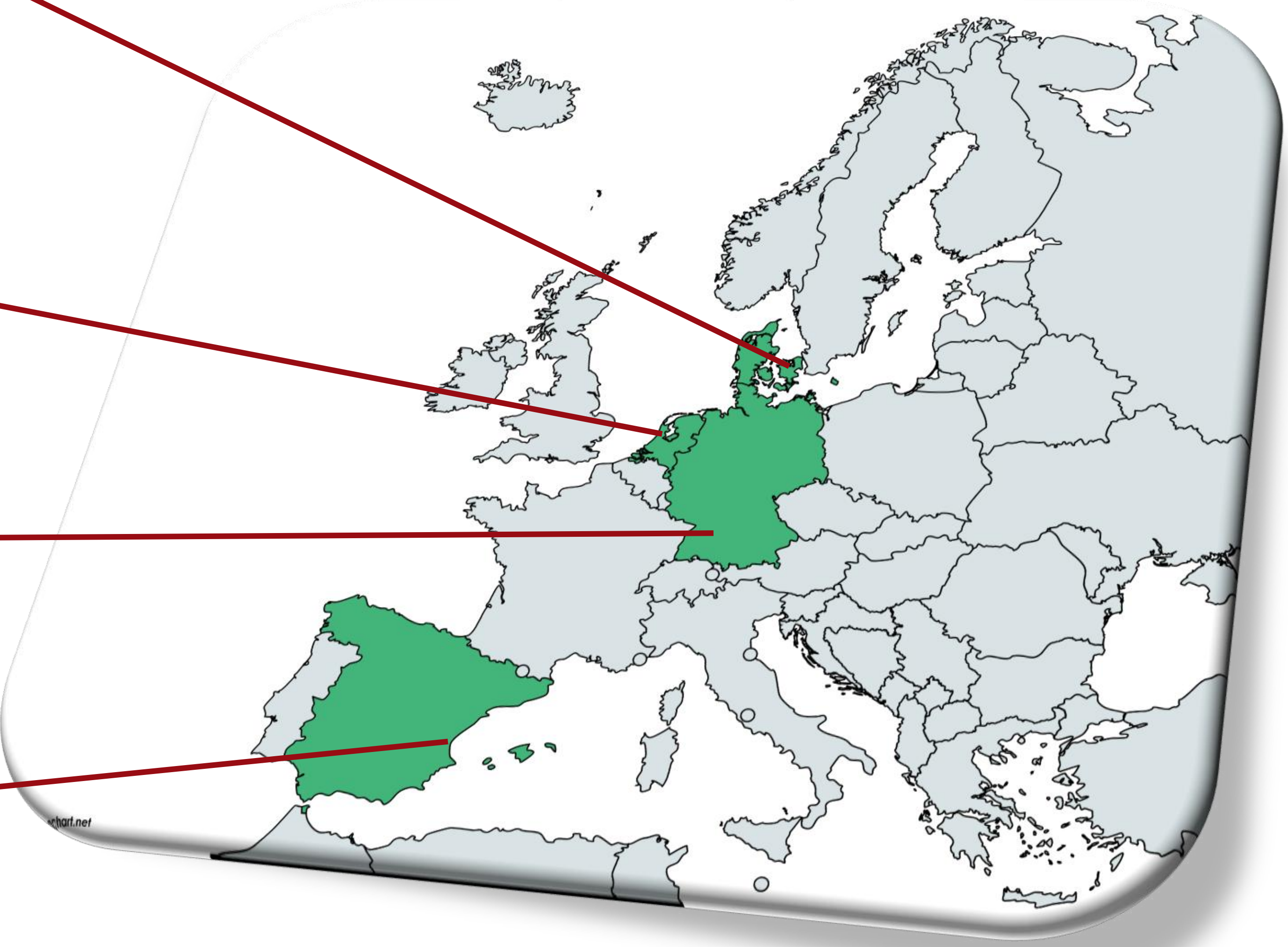
TNO

Standard Fasel

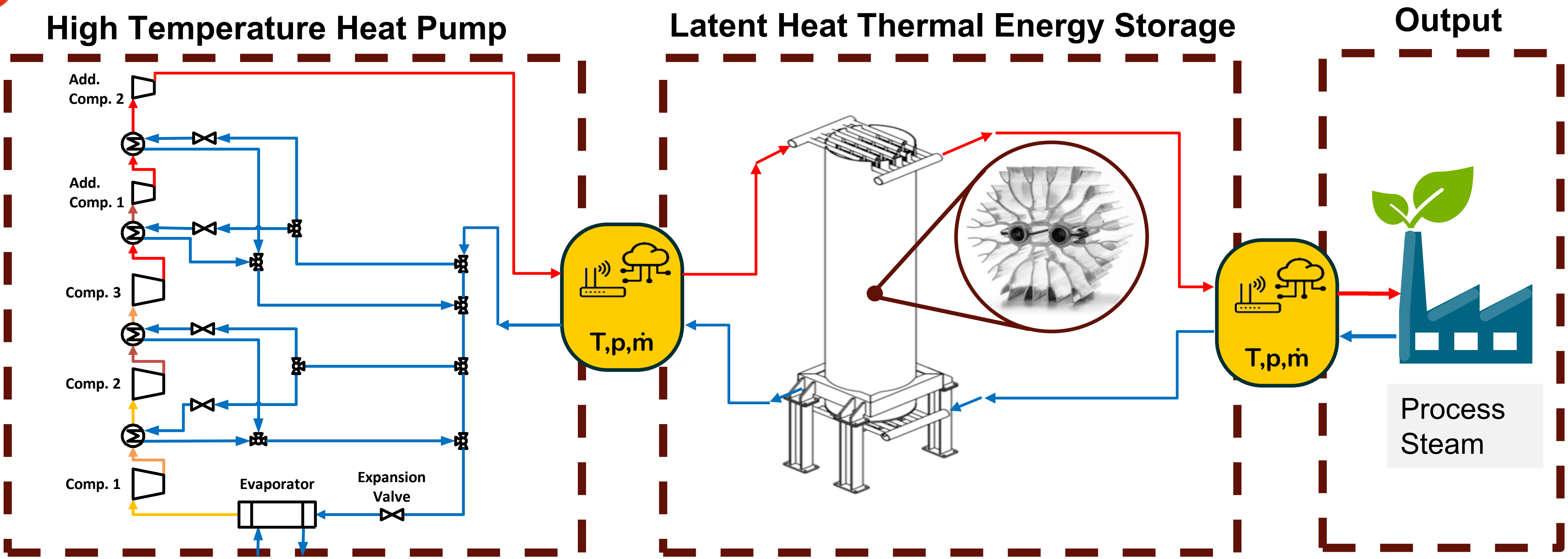
TRESPA®

DLR

UNIVERSITAT POLITÈCNICA DE VALÈNCIA



# (Digital) Coupling of HTHP2 and LHTES2 to CS2



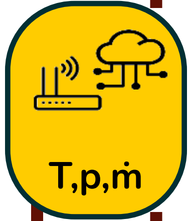
# (Digital) Coupling of HTHP2 and LHTES2 to CS2

## High Temperature Heat Pump

- Steam compression heat pump
- 5-stage turbo compression design
- Outlet of 5th stage: 250 °C/39.8 bar
- Direct driven geared at 120 k rpm

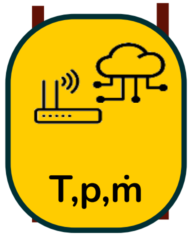
Project CHASE:

- Physical implementation of 4th stage, simulative implementation of 5th stage




## Latent Heat Thermal Energy Storage

- 1.6 tons of NaNO3/KNO3 (eu) as PCM, melting point: 222 °C
- Use of 19 dual-tube aluminum fins
- Charging and discharging with temperature difference <10 K
- Flexible steam up to 20 bar
- Heat storage capacity ≈ 60 kWh
- Experimental characterization of the storage within laboratory




## Output

- Provided by DTI
- Simulative coupling
- Tailored to industrial require-ments

# Pharma use case

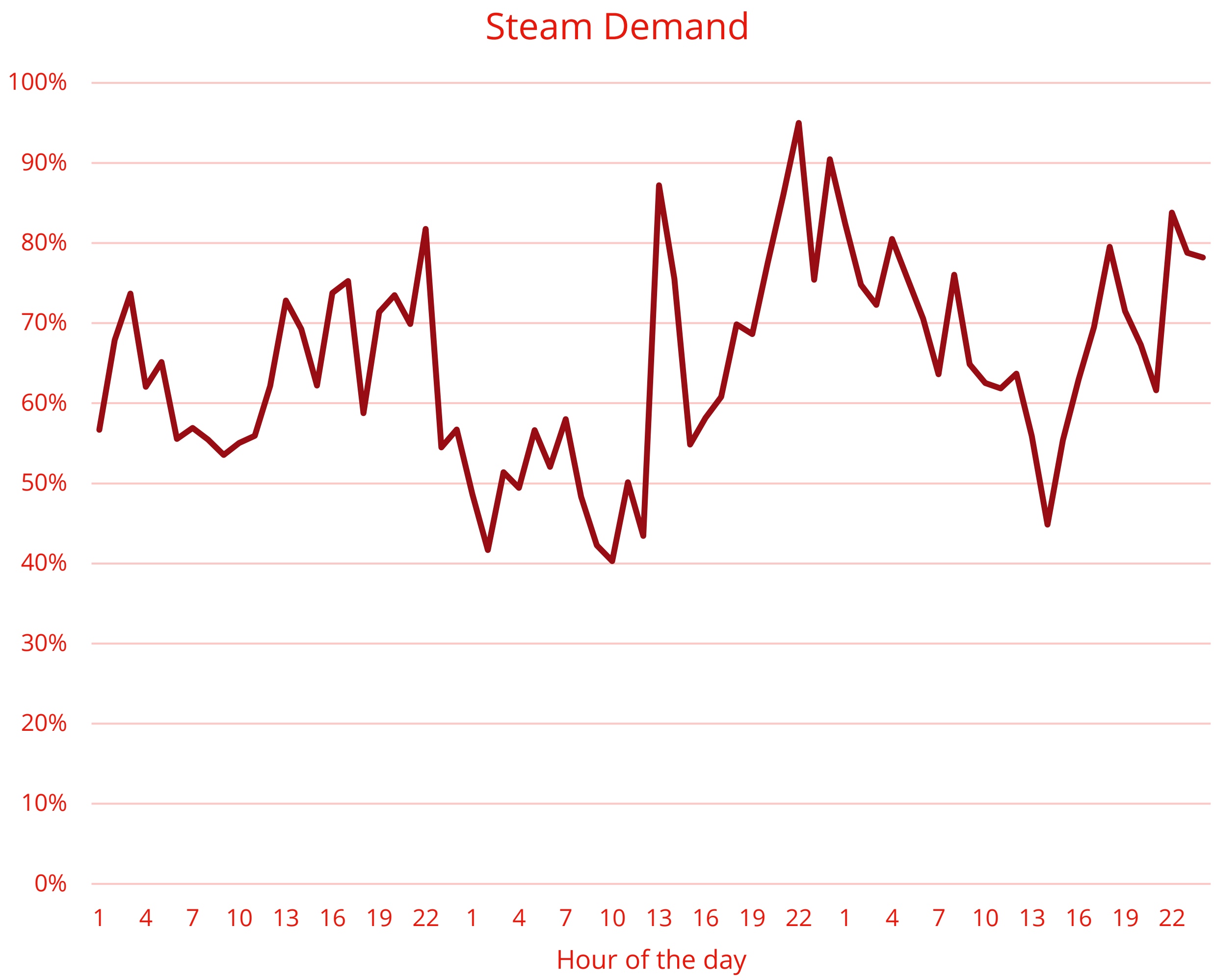
- Hourly steam consumption data from a relevant industrial steam user
- Production plant steam, or black steam, for general production
- Continuous steam demand over 8000 h/year
- Security of supply is extremely important
- Reducing cost of heat is an important objective
- Variation in load can be detrimental to some equipment in the steam production

# Optimization case

We have considered full year operation for a representative steam load. The data foundation is:

- 2024 electricity spot price, DSO and TSO tariffs in Denmark, the Netherlands and Spain
- Equipment CAPEX estimates

- Heat pump coupled to a thermal storage
  - Heat pump used to charge the thermal storage
- Optimization inputs
  - Heat pump COP = 1.9
  - Discount rate = 5%
  - Gas price, including tariffs and delivery = €95/MWh



# Optimization approach

**System configuration:**
HP and TES replacing existing steam generation.
Existing generation used for peak loads

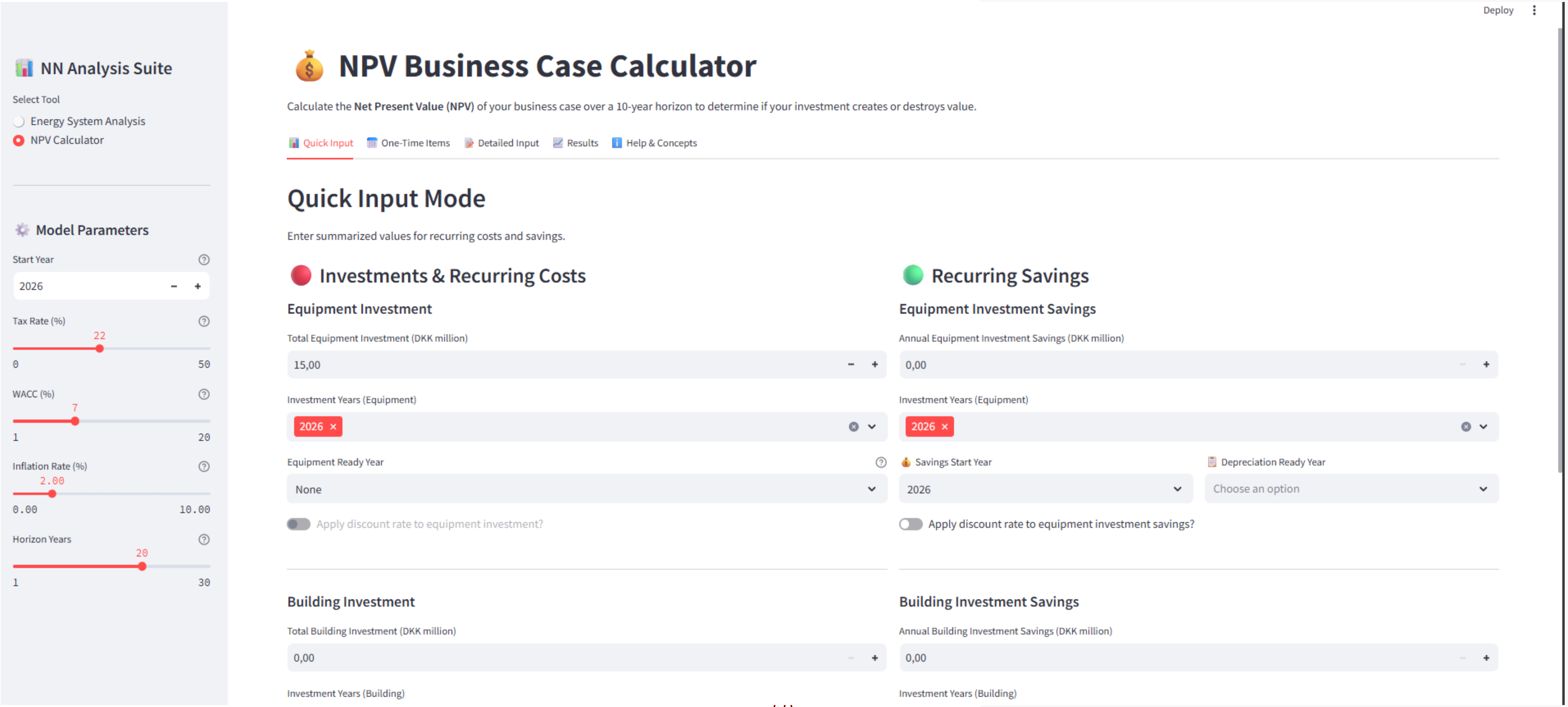
**Objective function:**

Minimize OPEX (Maximize net present value)

**Optimization approach**

Nested optimization
- Inner problem: operational optimization (MILP)
- Outer problem: exhaustive search over system sizes (HP, TES)

# Optimization study: Economic tool

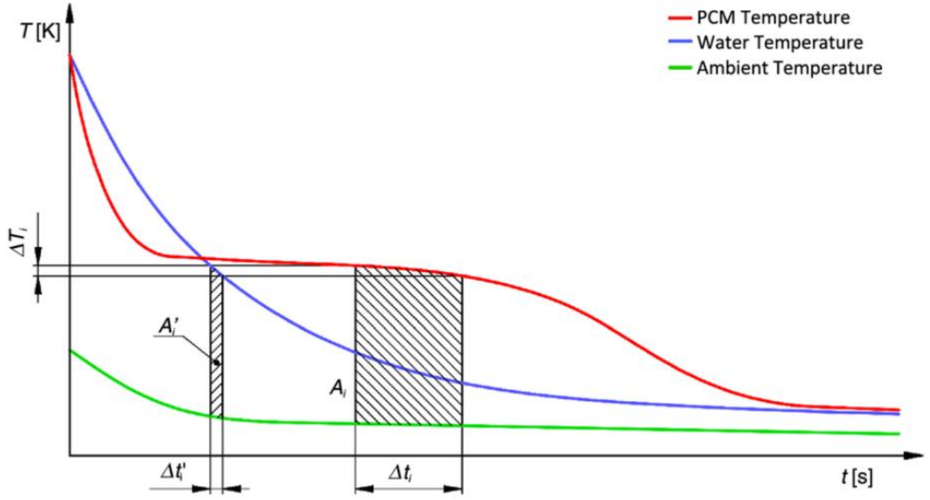


# Equipment characteristics

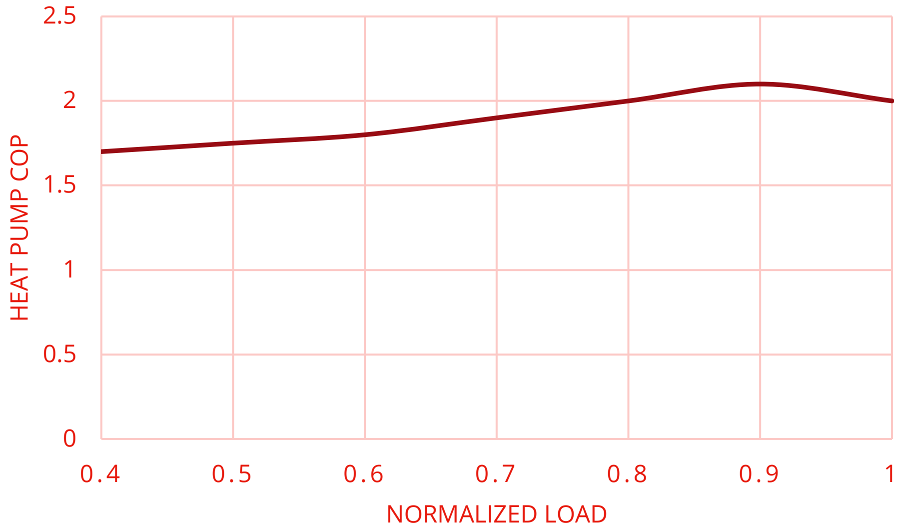
Device characteristics can be added to the MILP model

- Heat pump COP vs load
- Heat pump COP vs hot and cold temperatures
- LHTES charge/discharge curves
- LHTES efficiency as a function of SOC

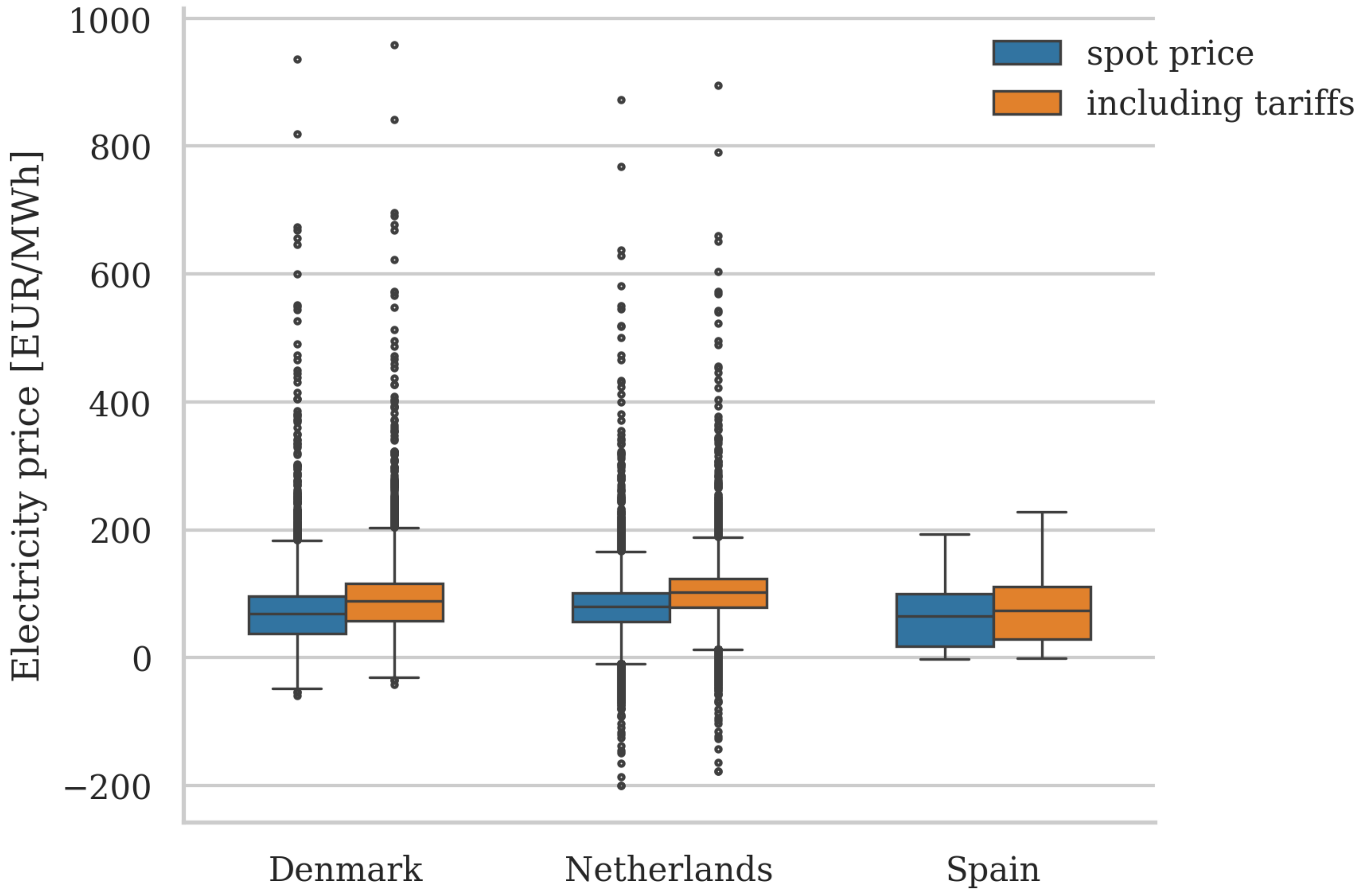
**These activities are an ongoing collaboration with the Technical University of Valencia (UPV)**



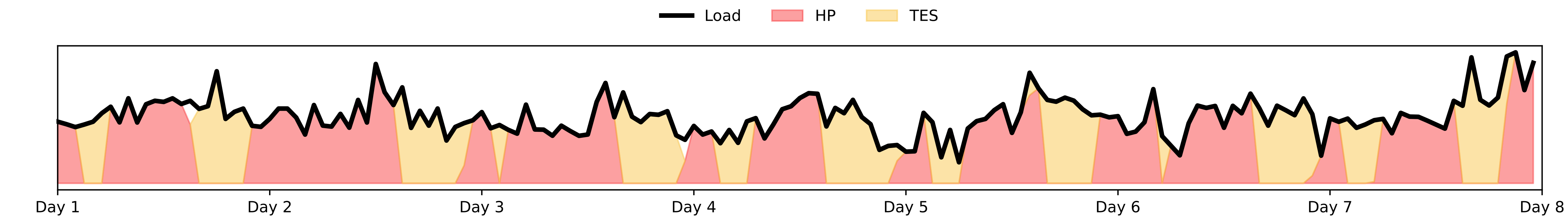

DOI:10.1038/s41598-021-02705-1

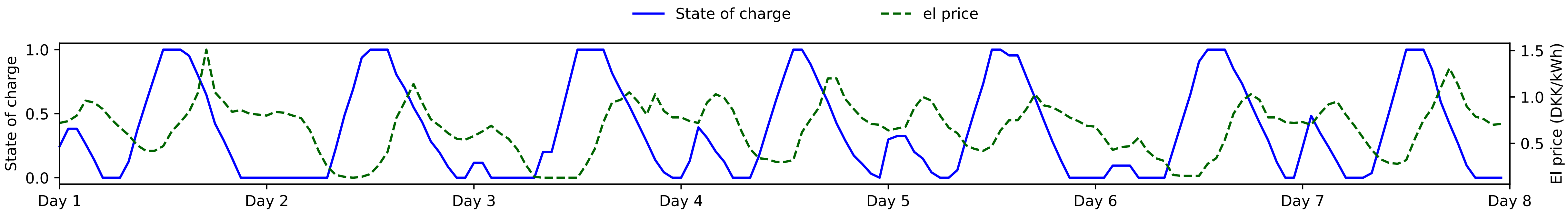


# Electricity markets



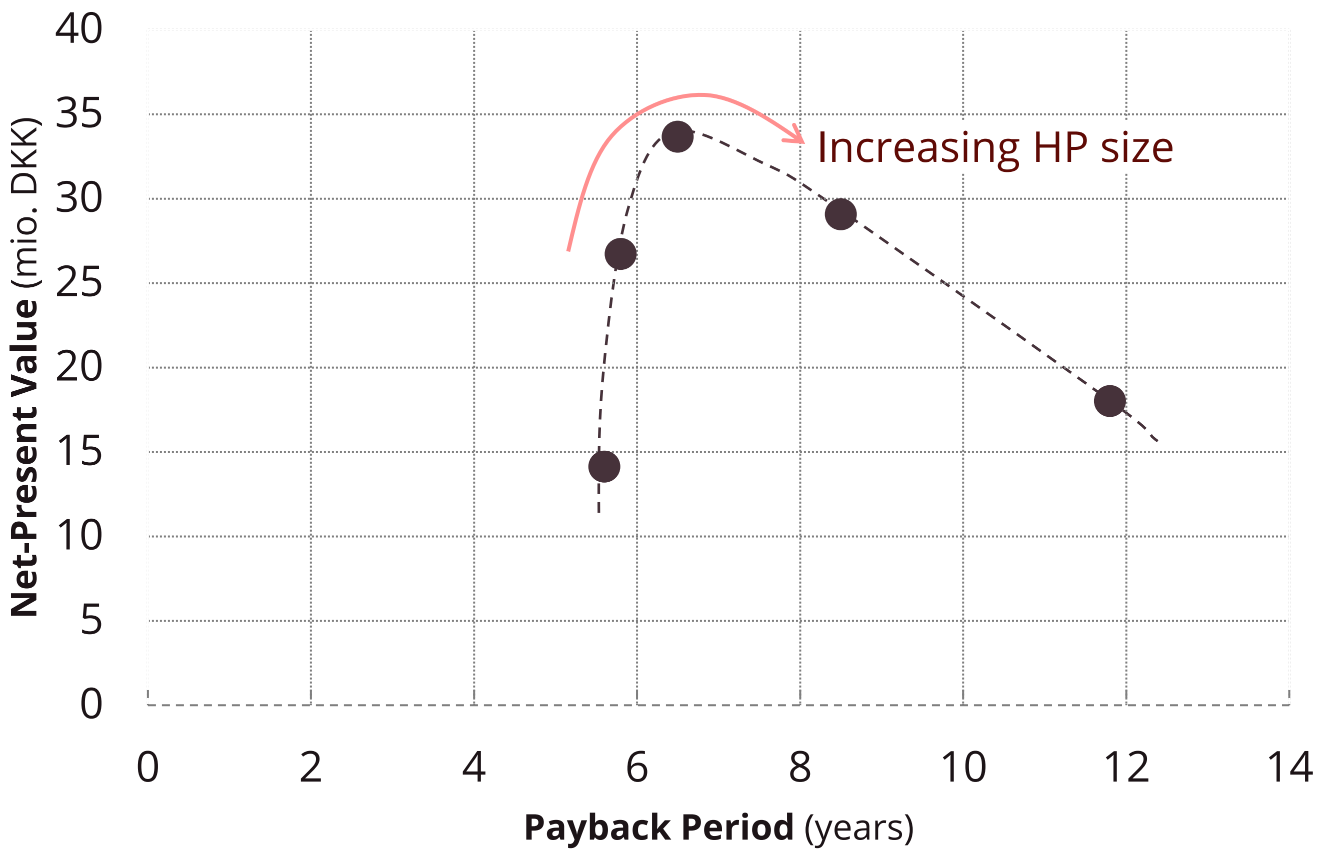
# OPEX minimization example




Teknologisk Institut

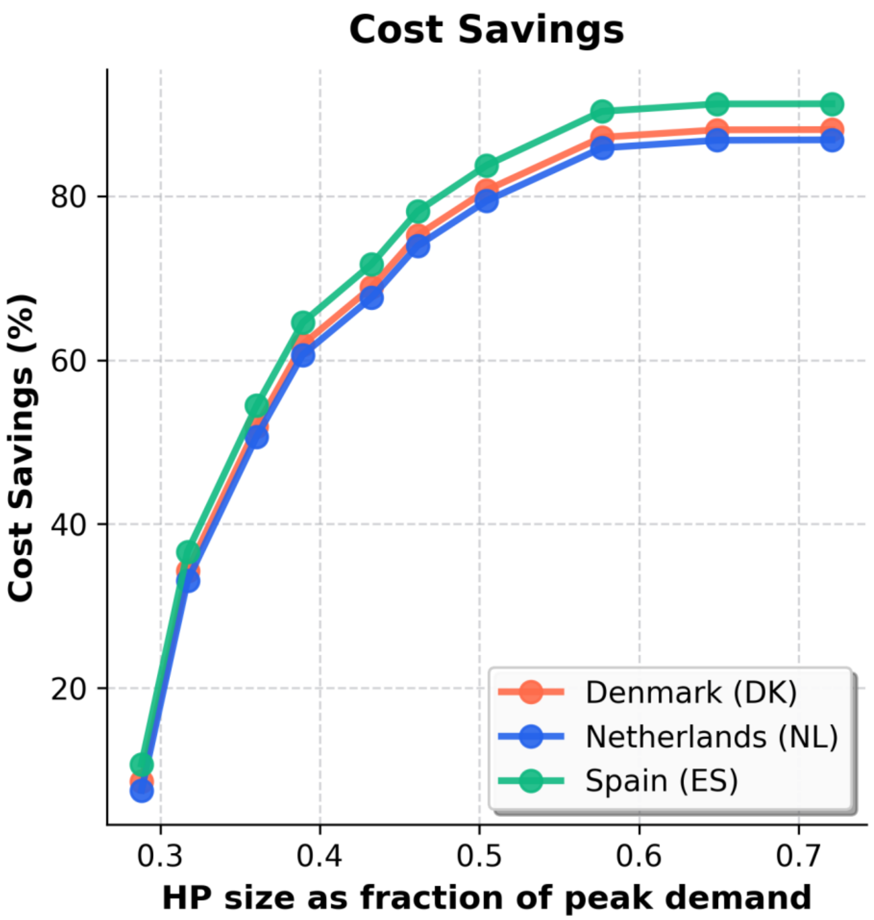
# Results – price-based control of HP

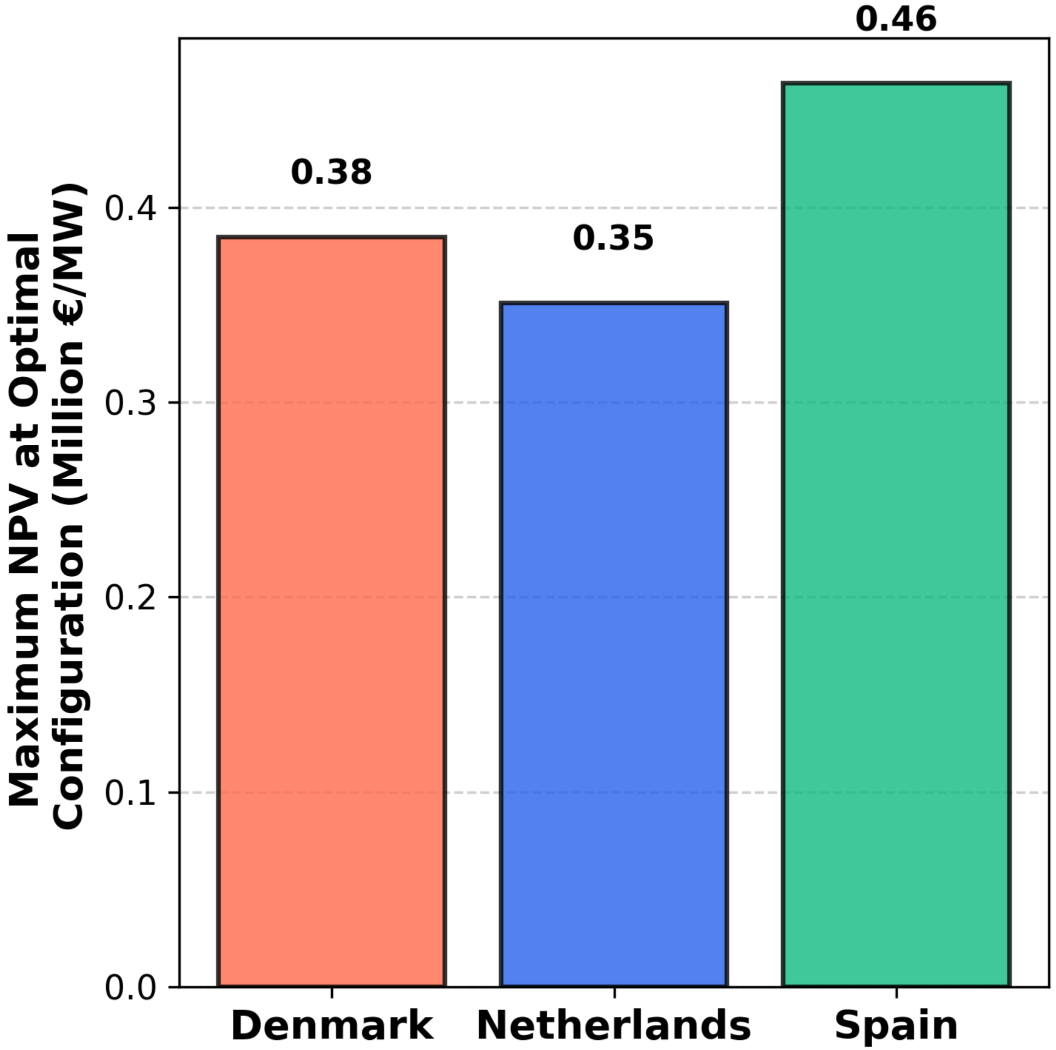



HP only – no TES considered

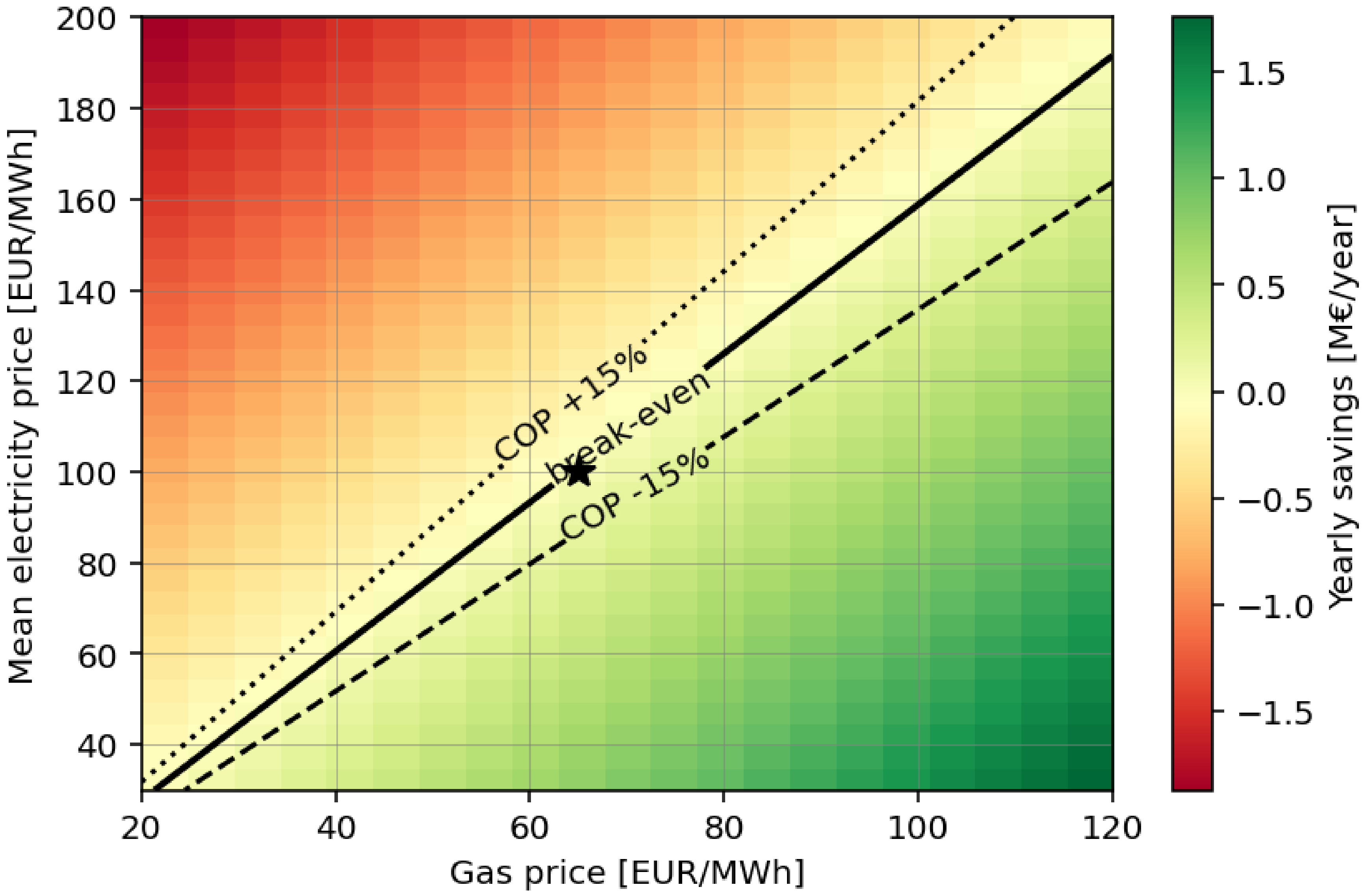
# Results of the economic optimization

- Heat pump sized to deliver ~55% of the peak load
- TES can store approximately 1 h of HP capacity



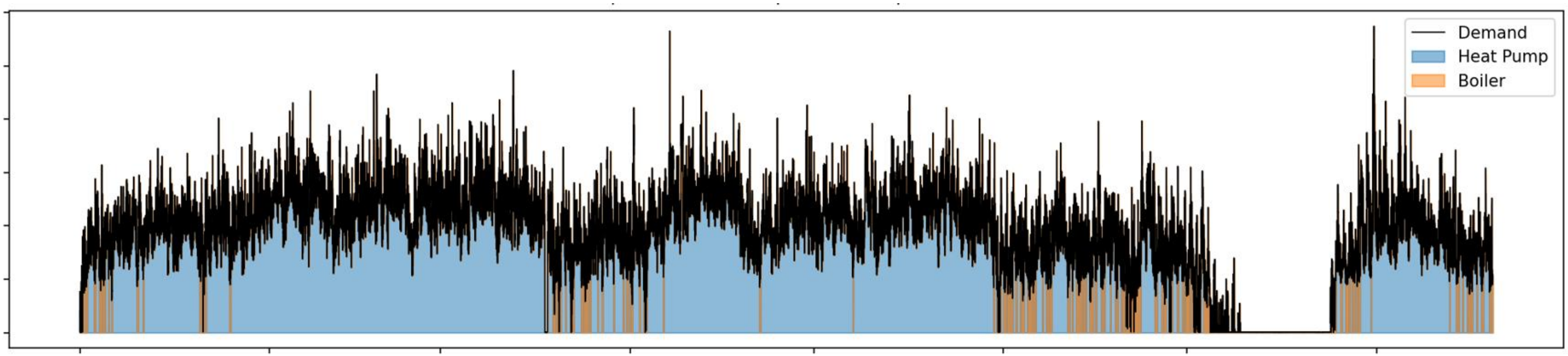
# Sensitivity to energy prices



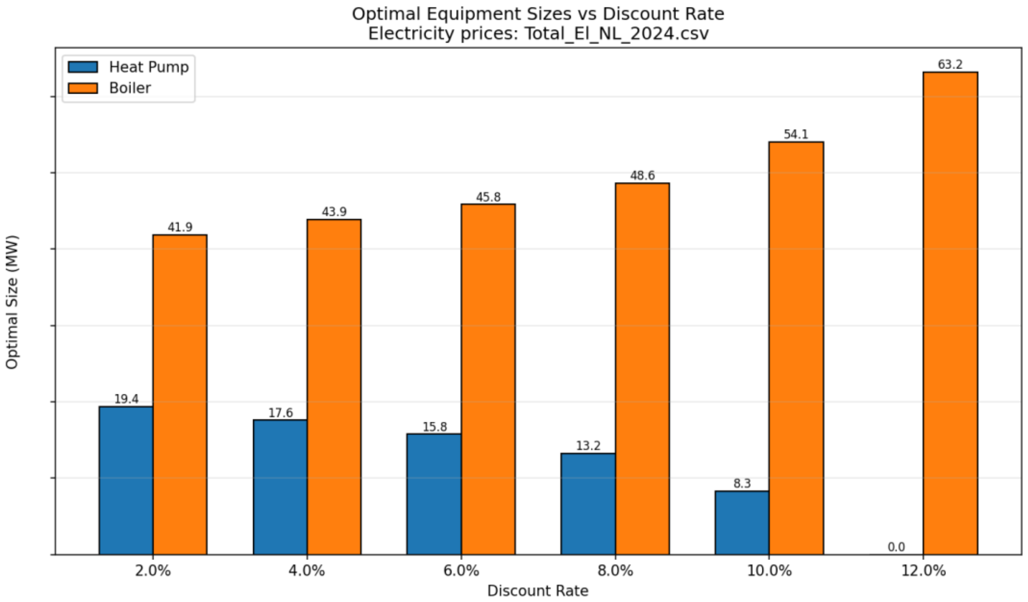
# Special case – full electrification with an electric boiler and heat pump

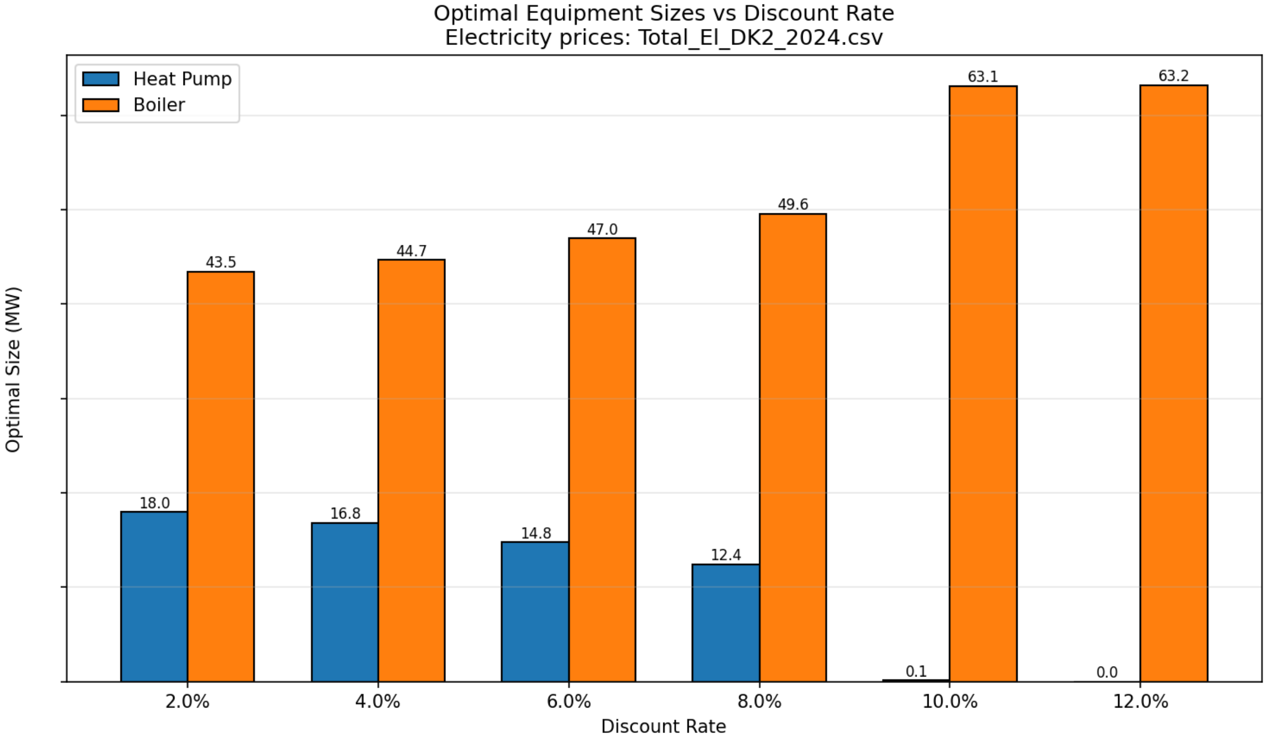
# Coupling heat pump and electric boiler

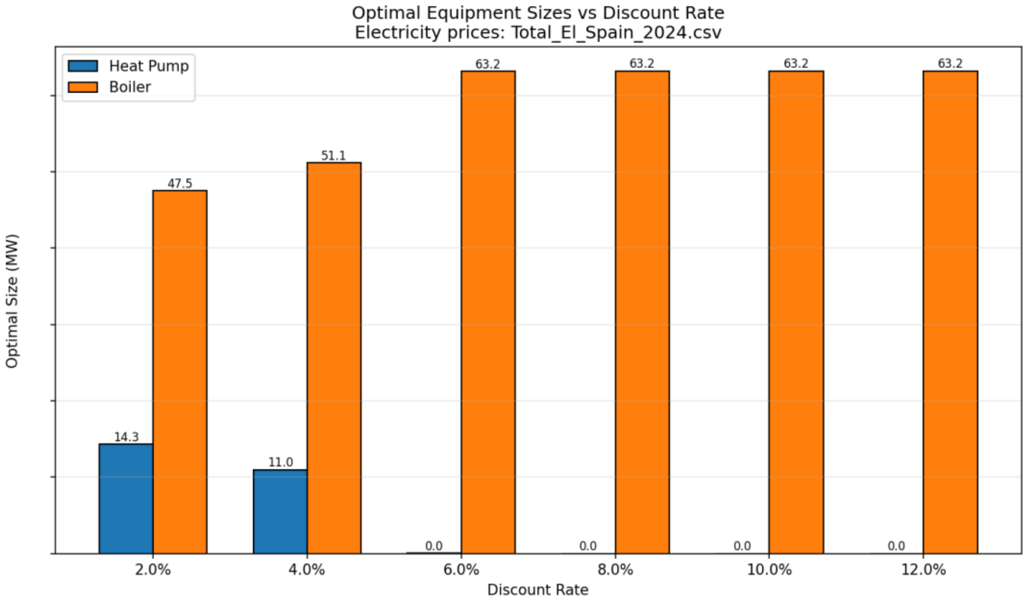
- Heat pump is always cheaper to operate when electricity price is positive so the heat pump operation becomes rules based
- Heat pump constraints
  - Min load is 40% of capacity
  - Min shutoff time is 60 min
  - Maximum ramp rate is 2%/min
- Electric boiler covers demand that heat pump cannot
- Size of boiler and heat pump can be optimized using the MILP model



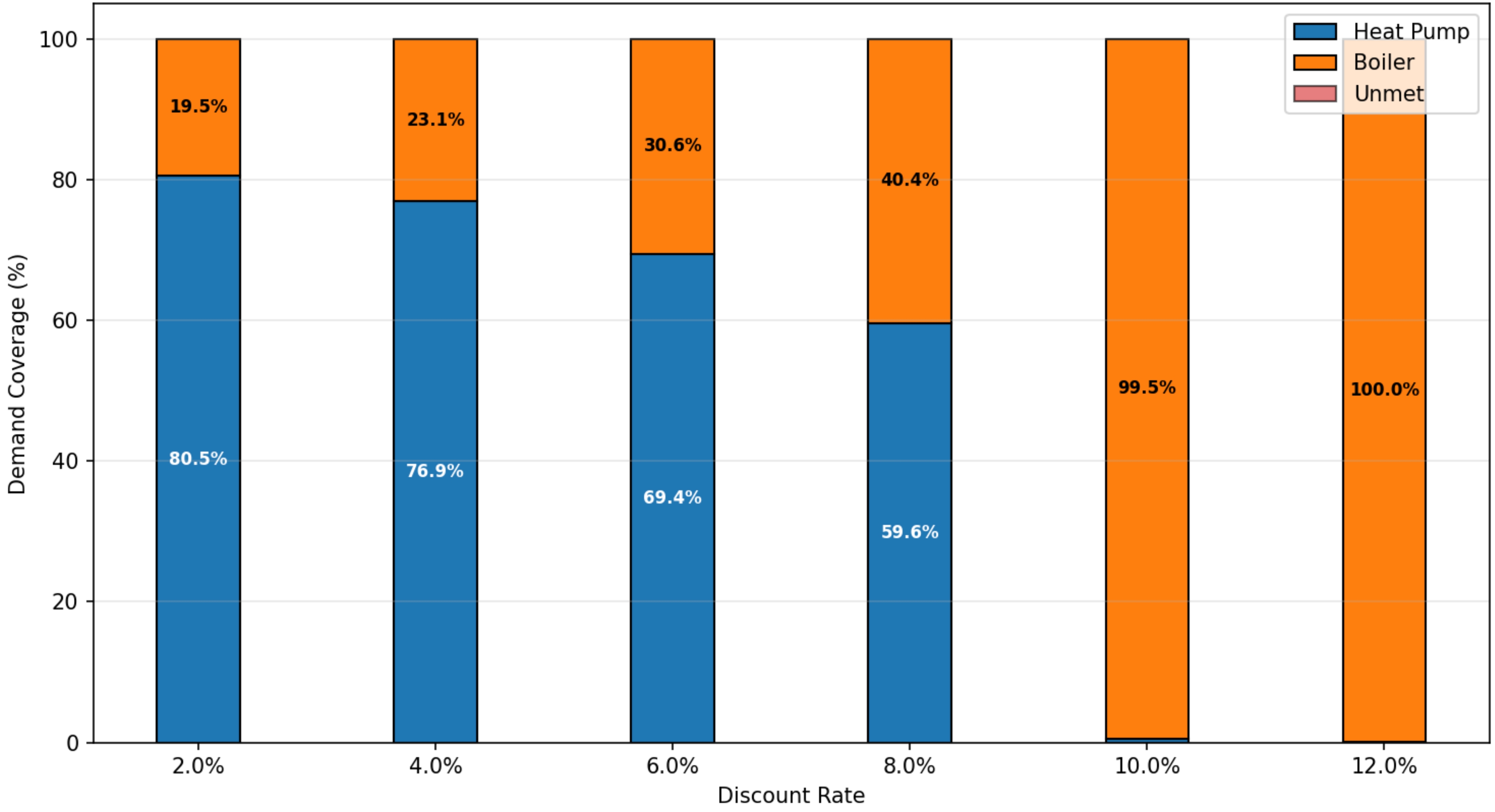
# NPV optimization for different electricity markets



# Load split for heat pump/electric boiler in Denmark



# Summary and conclusions

- The CHASE project aims to demonstrate heat pumps operating at 150 °C and 250 °C coupled to latent heat thermal energy storages
- DTI has developed a technoeconomic optimization tool that can be used to evaluate the business case of implementing heat pumps, thermal energy storage and electric boilers
- In this studied case, the storage is used to cover peak demands and reduce investment in the heat pump
  - Sizing of the TES and heat pump depend on electricity pricing and demand curve
- Electricity prices, including tariffs, in Spain are more attractive for TES applications than Denmark and the Netherlands

# Thermal Energy Storage for Industrial Systems - Symposium

- **Date**: 11-12 March 2027
- **Location**: Copenhagen, Denmark
- **Venue**: Langelinie Pavillonen, Langelinie 10, Copenhagen
- **Abstract Deadline**: 1 December 2026
- **Key themes**:
  - Case studies and techno-economic analyses of TES in industry.
  - Electrification of industrial heat via TES technologies.
  - System integration of TES to manage variable electricity prices and intermittent renewables.
  - High-temperature heat pumps and electric heaters in industrial applications.
  - Materials science and the development of novel materials for high-temperature TES.
  - Modelling, optimisation, and control of TES systems for industrial processes.
  - The translation of laboratory concepts to deployable, full-scale industrial solutions.

Symposium
Thermal Energy Storage
for Industrial Systems

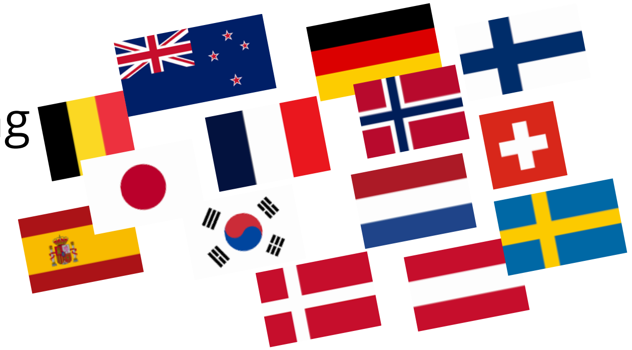
# Thank you for your attention.

keng@teknologisk.dk

This study was funded by the European Union under Clean Energy Transition Partnership (CETP) program and Innovation Fund Denmark under the project title “CHASE – Combined Heat Pump and Thermal Storage for Energy Efficient Industry

# Project 68: New results are in!

14 countries participating



June 2025 to May 2028

Task 1 – Technology developments (Lead: DTI)

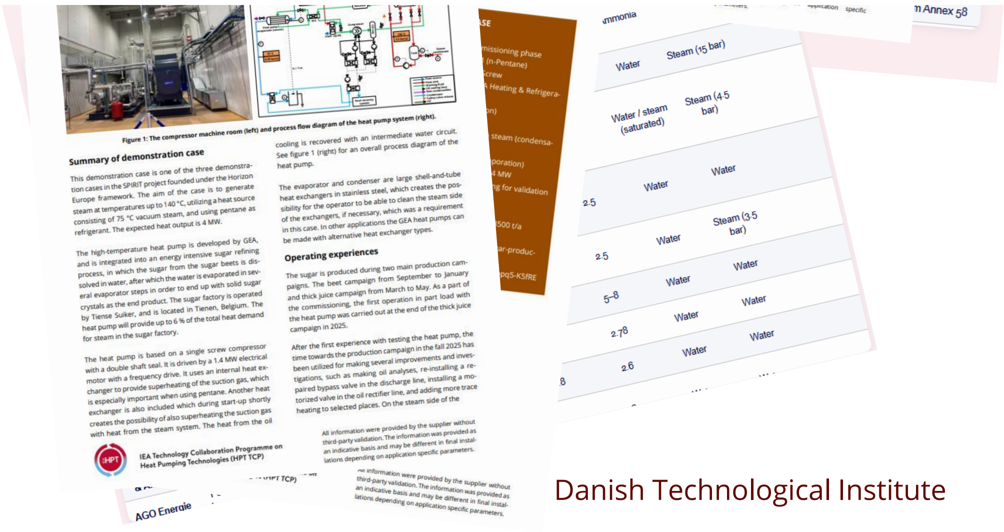
- Keep track of current and future technologies


https://heatpumpingtechnologies.org/project68/task1/

40+ Cases

55+ Technology suppliers

Newest trends



Danish Technological Institute

Project 68 Industrial High-Temperature Heat Pumps

High-Temperature Heat Pump Symposium

# Webinar series continues

**Today:** 17th of September

HTHPs and the bio-/pharma industry

Co-host: BioPhorum

**Next webinar:** 2nd of December 2026

HTHPs for drying applications

**3-4 times a year**

Including 40+ HTHP operating cases!

Webinar homepage

Info on next webinars