# ADVANCED ENERGY STORAGE CONFERENCE 2024

## PART 2

TAASTRUP
NOVEMBER 28, 2024

DANISH TECHNOLOGICAL INSTITUTE

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# EXHIBITORS 2024

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# ADVANCED ENERGY STORAGE CONFERENCE 2024

## Use cases and benefits of high-temperature thermal energy storage

Martin Schichtel, KraftBlock

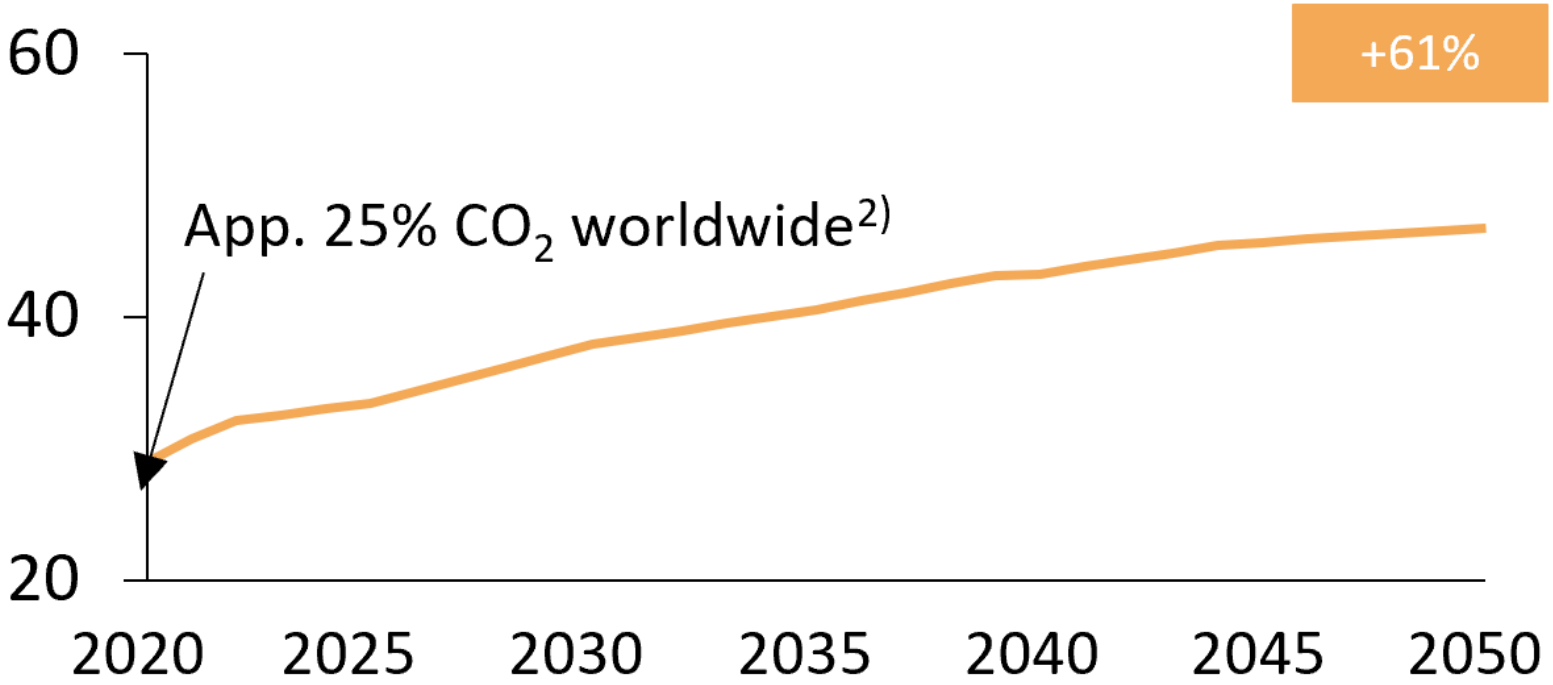

KRAFT
BLOCK

# Advanced Energy Storage 2024
# DTI, Copenhagen

Unveiling Kraftblock's groundbreaking high-temperature energy storage solutions, enabling a sustainable transition towards a decarbonized future.

# Heat in a global context

**Industry** Heat [PWh]




## Heat in perspective

- Over 50% of the globally consumed energy is heat
- In industries process heat makes up to three quarters of the energy demand
- The future holds growing heat demand in industries

1) Petawatt-hour (PWh) is equivalent to $10^9$ Megawatt-hours (MWh)

# Our support

2014

## Technology development

Developing a sustainable and high-efficient storage material for high-temperatures.

2019

## Full-scale pilot stationary

Installing the first proof of concept with 4.2 MWh capacity at a German ceramic manufacturer.

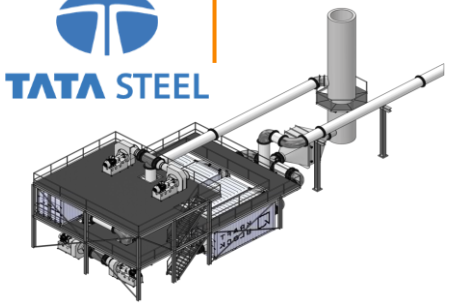
2020


## Full-scale prototype mobile

Proving the first mobile appliaction with a CHP operator in Germany to replace gas with waste heat.

2023

TATA STEEL



## 20 MWh under execution

Commercial project in Steel industry to improve efficiency in a sinter plant. Fast payback time.

Finished 2024

PEPSICO

Eneco

## 150 MWh under execution

Replacing natural gas completely at a PepsiCo food factory. Using renewable electricity as source.

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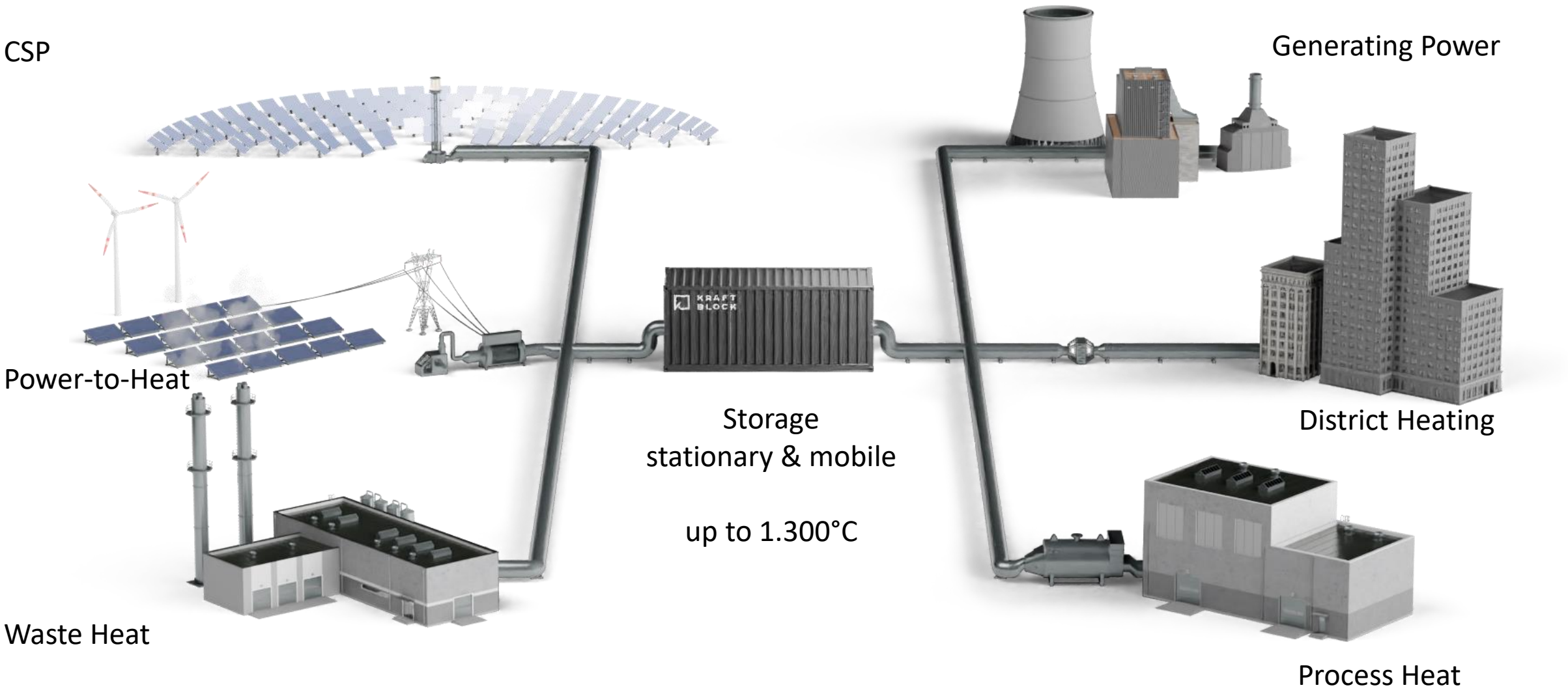
# TES desigened for Felxibility and Efficiency

# Our Platform-Approach



# The basis: our unique and sustainable storage material

**Upcycled** up to 85% (slags)

Tested for **15,000 cycles** and **1,500°C**

Low carbon footprint & circularity

Sustainable energy storage material without rare earths

Patented System

Different shapes, simple production
Many formulations possible

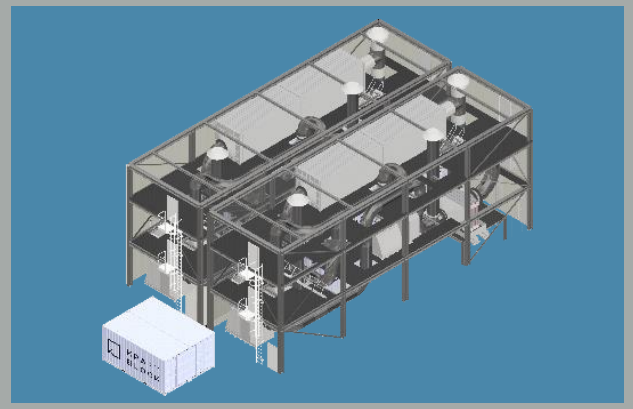
# Standard-Products based on the Analysis of 90 use cases

## Size S


Capacity: up to 12MWh
Charge: up to 10MW
Discharge: up to 5MW

Footprint: 20ft. containers

## Size M



Capacity: up to 150MWh
Charge: up to 50MW
Discharge: up to 25MW

Footprint: multiple 40ft.

## Size X


Capacity: up to 300MWh
Charge: up to 150MW
Discharge: up to 50MW

Footprint: individual

# We engineered flexibility in design and operations

| | Dimension \| Technology | Competition | Kraftblock |
|---|---|---|---|
| Design / Hardware | Max. Temperature | 1,500°C | 1,300°C (Standard) |
| | Integration of Components | Yes | No |
| | Flexibility (design) | No | Yes |
| | Flexibility (operations) | Limited | Yes |
| | Combination WHR + NZH | No | Yes |
| | “C-Ratio” | Defined | No, flexible |
| Operations | Adding Modules (storage and/or components) | Very Limited | Yes |
| | Maintenance Friendly | Limited | Yes |
| | Uptime + Availability | Limited | High |

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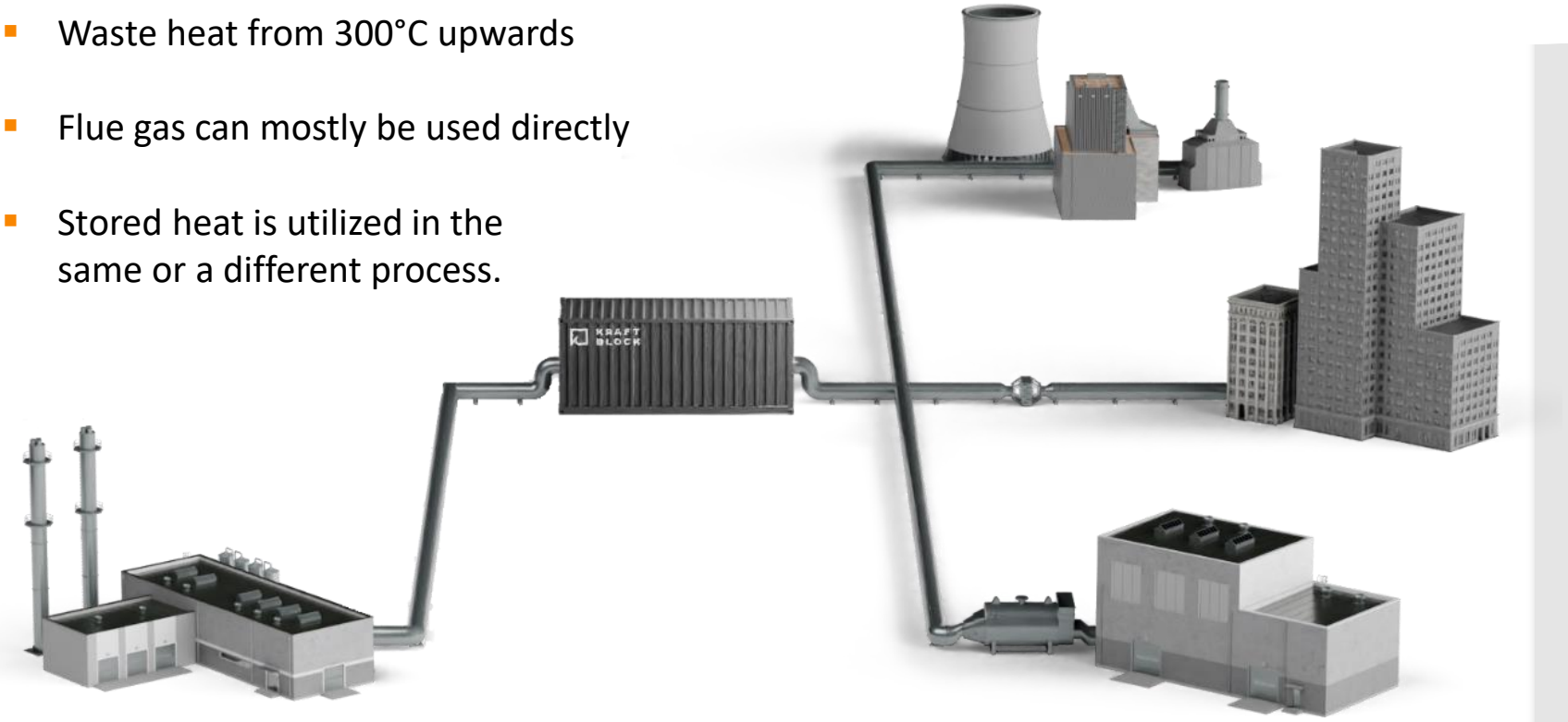
# Waste Heat Recycling System

# Waste Heat Recycling System

- Waste heat from 300°C upwards
- Flue gas can mostly be used directly
- Stored heat is utilized in the same or a different process.

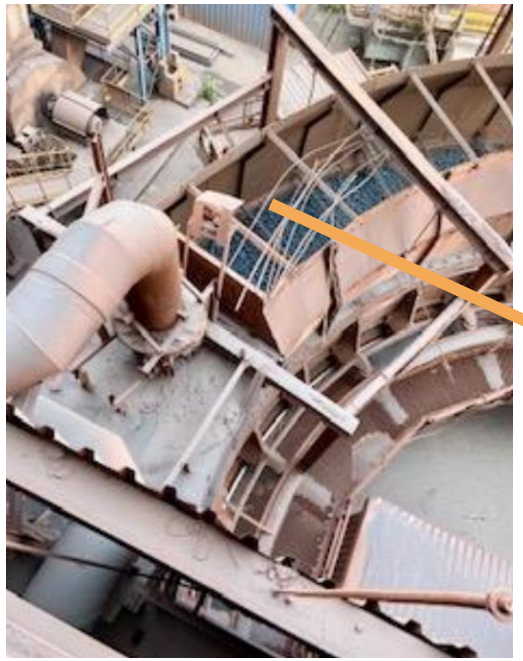



## Advantages

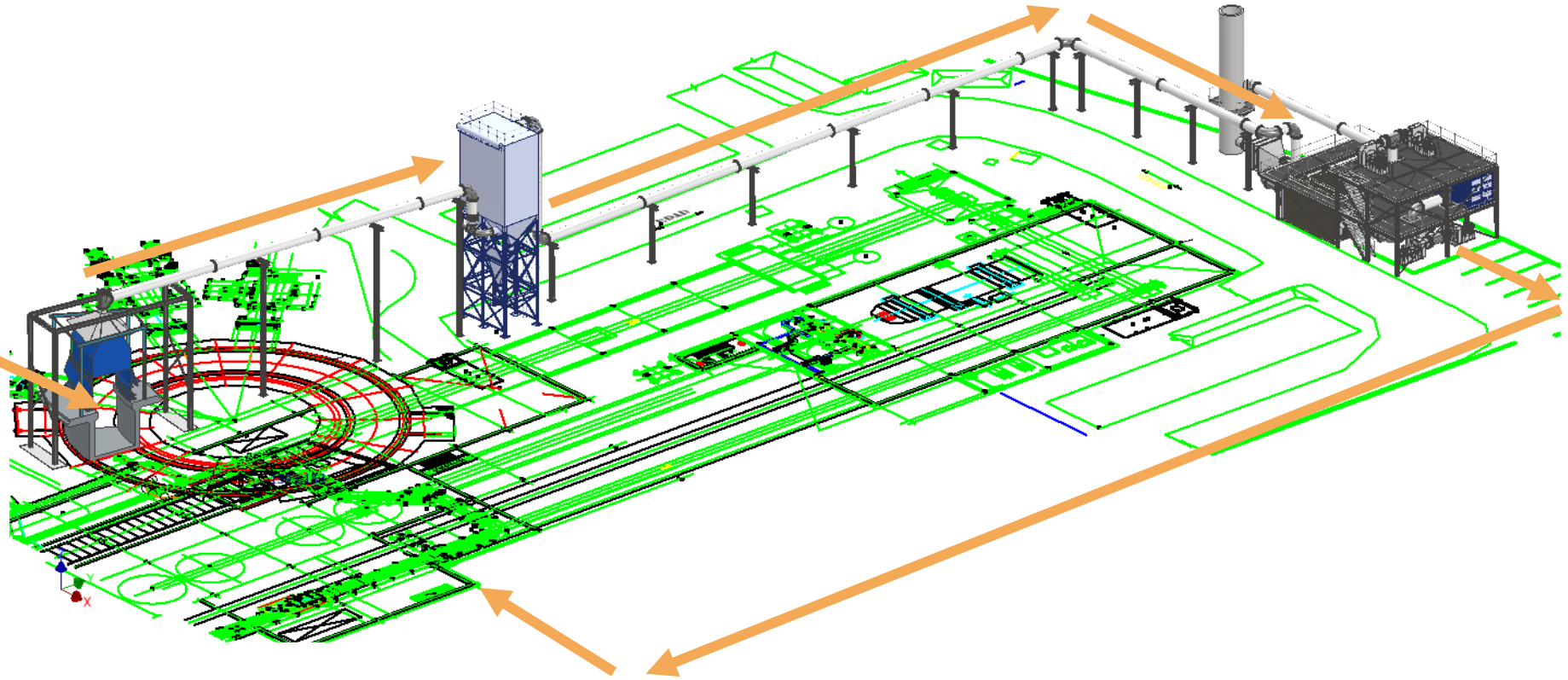
- Less primary energy needed
- Additional emissions avoided
- Cost savings
- No new energy source needed

# Steel-Industy

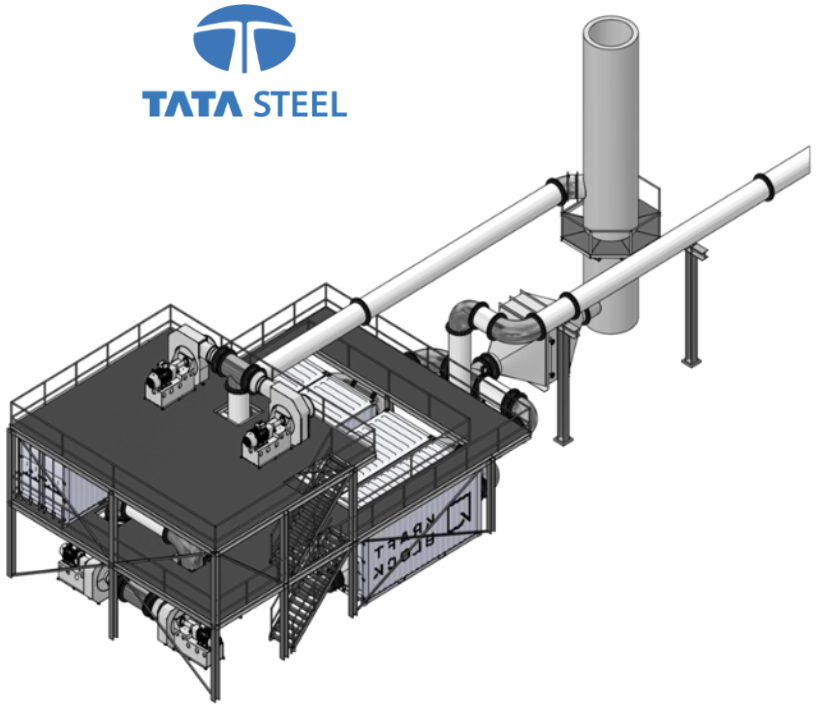
## Sinter cooler (waste heat source)



Storing waste heat



# Tata Steel



- commissioning: 2024 (Autumn)
- Capacity: 20 MWh
- Very fast payback
- 2% energy efficiency boost
- Location: Jamshedpur, India

## About the project

- Collecting waste heat from the sinter plant
- Operation: Sintering
- Application: NDA
- 20,000t of $CO_2$ per year reduced

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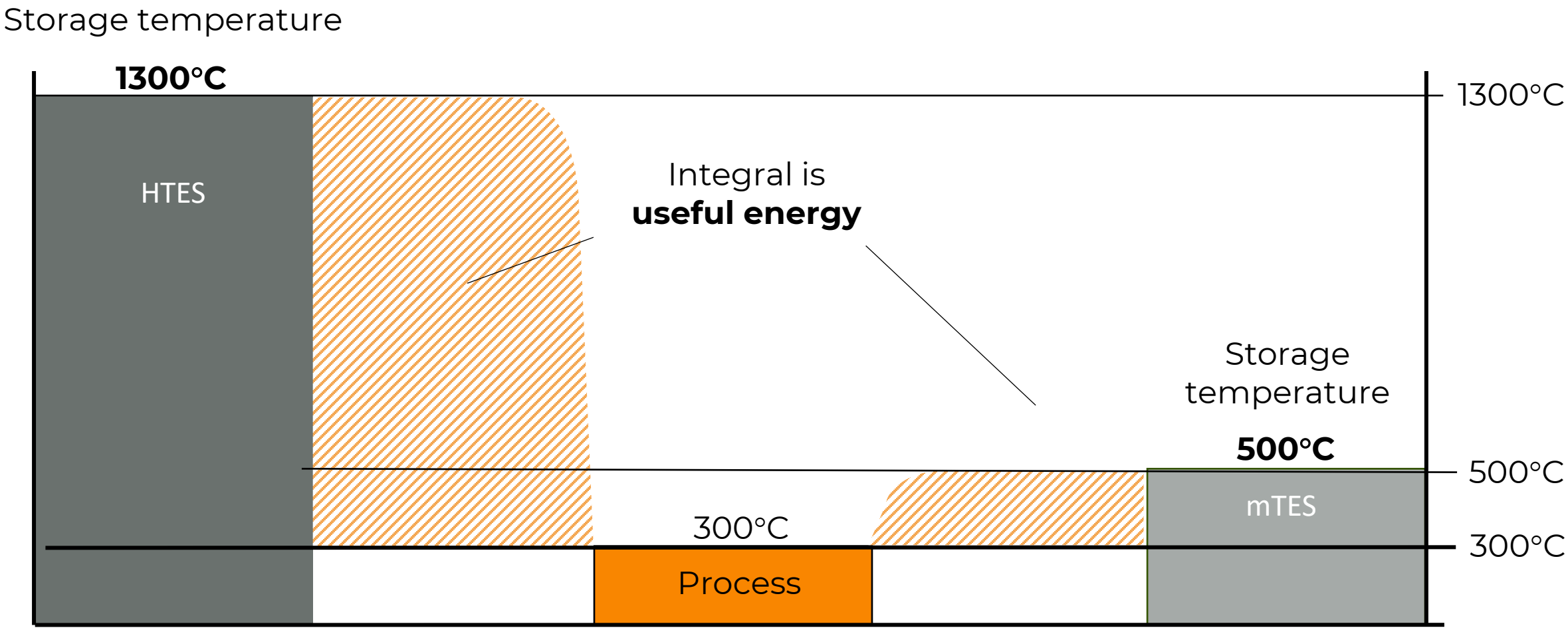
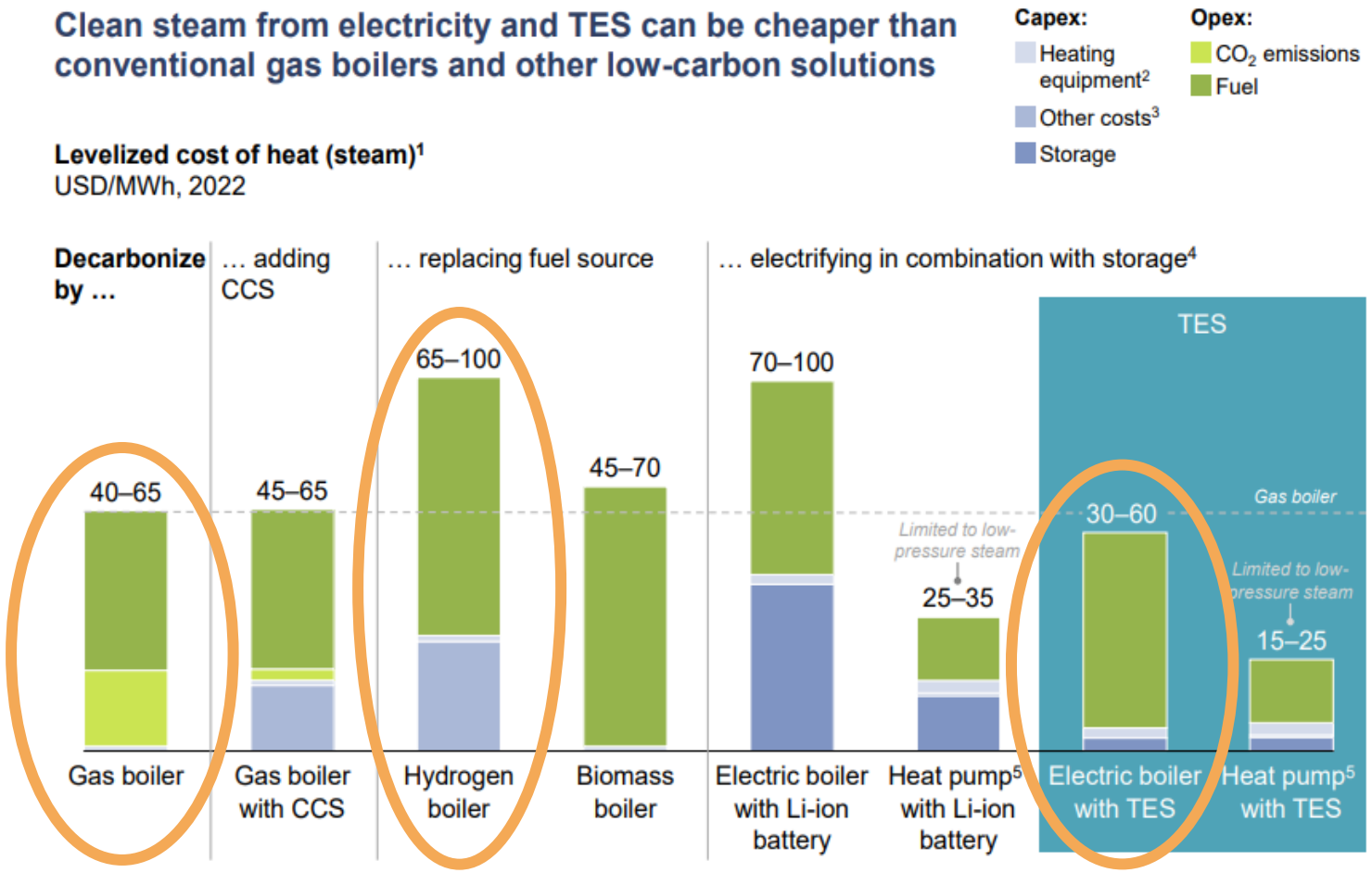
# Net-Zero-Heat System

# High-temperature storages for low-grade heat?




More useful energy, higher efficiency, better ROI

# TES and Electricity have lowest costs



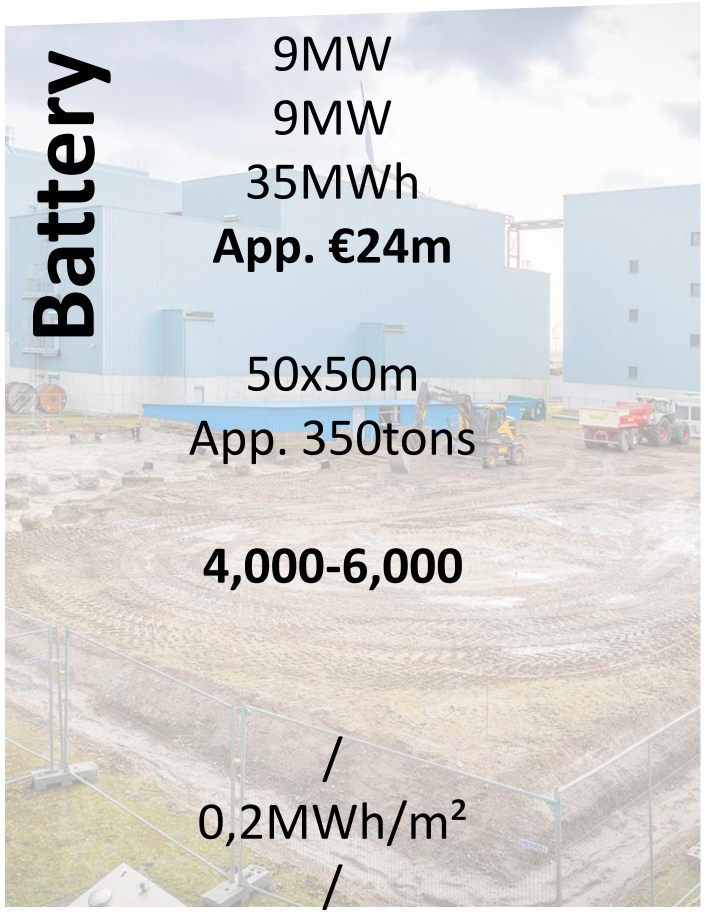

1. Ranges reflect representative fuel prices. Gas (USD 6–12/mmBTU), electricity (USD 25–50/MWh), biomass (USD 200–350/t). In the hydrogen boiler case, hydrogen production costs amount to USD 2.1–3.2/kg of hydrogen.
2. Boiler, heat pump, and charging equipment.
3. Electrolyzer, CCS.
4. Assumes on-site renewables.
5. High-temperature industrial heat pump. Maximum achievable steam temperature is ~160°C.

## Steam production

- Study with various technologies and providers
- Levelized cost of heat (steam)
- Electricity with TES best high-temperature solution
- Even better OPEX via privat wire

Source: LDES Council 2023. Systemiq 2024

# Battery Storage vs. TES

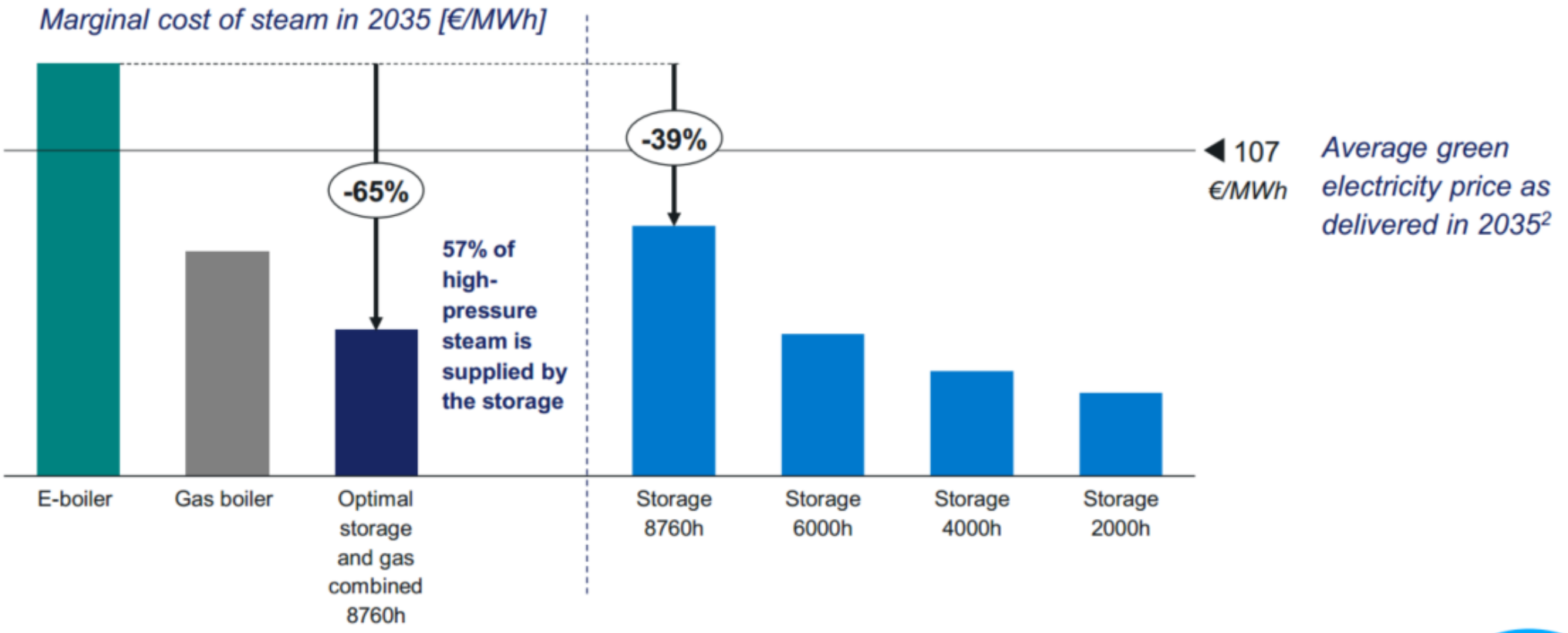



| Battery | | TES |
|---|---|---|
| 9MW | Charging capacity | 9MW |
| 9MW | Discharging capacity | 9MW |
| 35MWh | Usefull energy | 35MWh |
| **App. €24m** | **Costs** | **<€10m** |
| 50x50m | Footprint | 12x10m |
| App. 350tons | Weight | App. 750tons |
| **4,000-6,000** | Cycles | **>15,000** |
| / | <u>Energy-density</u> | 4,2MWh/m² |
| 0,2MWh/m² | Max. Temperature | 1,8MWh/m² |
| / | Av. Temperature | / |
| | Min. Temperature | |

Original Project: RWE Eernshaven, 35MW/41MWh
€24m

# Optimizing a TES reduces marginal steam costs

Simulating the potential set up in our optimization tool Prosumer proved that a storage is economically advantageous over a conventional e-boiler regarding the TCO[1] over 15 year (even without subsidies). **Considering additional revenues from the participation in flexibility markets could potentially further reduce marginal costs.**





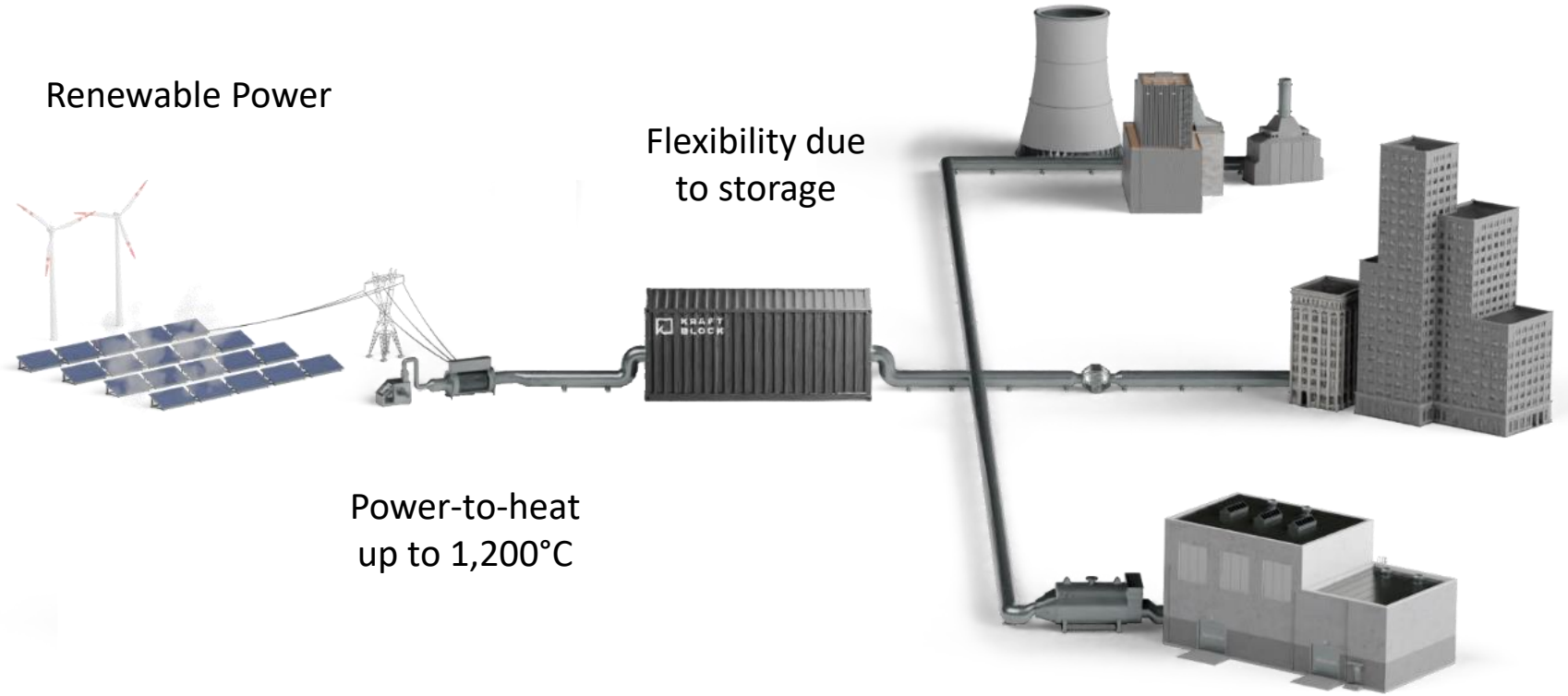

1) TCO: Total-Cost-of-Ownership / "Gesamtbetriebskosten" over 15 years. 2) Assumptions: 80% reduced grid fees due to atypical grid usage. GO price of 15€/MWh

# Net-Zero Heat System

Application in any form and temperature

Renewable Power

Flexibility due to storage



Power-to-heat up to 1,200°C

## Advantages

- Prevent curtailment
- Relieve grid
- Use low power prices
- Replace fossil fuels

# PepsiCo Project


PEPSICO

- Broek op Langedijk, NL
- 1 million bags of chips everyday
- For eight European countries
- Almost every emission in Scope 1 is burning gas for frying 24/7

# PepsiCo Project

- 25 MW boiler is replaced
- 9 million $m^3$ natural gas saved
- 16,000t of $CO_2$ avoided
- 98% of emissions are avoided when project is finished

# Net-Zero Heat System – Ready for TODAY

| | Food&Bev. | Pharma | Pulp&Paper | Chemical | Glass | Cement | Aluminium | Steel |
|---|---|---|---|---|---|---|---|---|
| Calcination | | | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Bonding | | | | ✓ | ✓ | | ✓ | ✓ |
| Drying | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Fluid Heating | ✓ | ✓ | ✓ | ✓ | | | | |
| Heat treating | | | | | ✓ | | ✓ | ✓ |
| Metal/glas melting | | | | | ✓ | | ✓ | ✓ |
| Steam generation | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ |

Heat-Transfer-Media: thermal oil, steam, hot air

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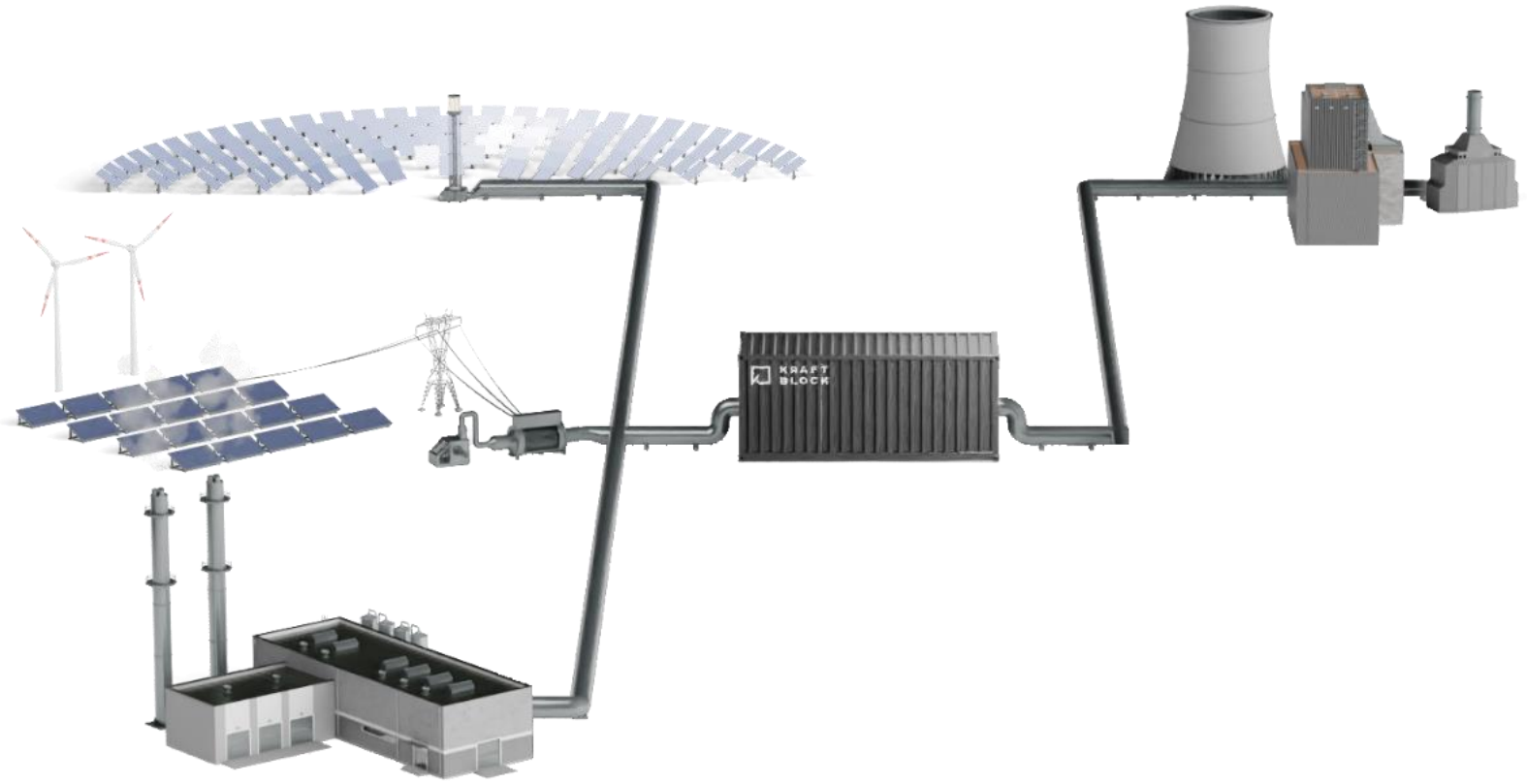
# Generating Power

# Repurposing fossil-fired power assets




## Advantages

- Using cheap surplus energy instead of curtailing it
- Stabilizing the grid
- Existing infrastructure can have a second life

## Industries

- Energy supplier
- Power plant operators
- Industries with a lot of intense waste heat

# Studies for power plants

## Feasibility Study for Torrens B

agl

Australian Government
Australian Renewable Energy Agency
ARENA

## About the project

- CCGT power plant
- Use of surplus PV from grid
- One 200MW block
- Operation for 8 hours
- New Steam generators
- → Technically feasible, investment decision pending

## Further Studies

- Verbund (Austria)
- Waste heat recovery and reuse in CCGT
- Iqony (Germany)
- Repurposing gas-fired or coal-fired boiler for power generation and district heating
- Storage heating plants for district heating

# Contact

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# ADVANCED ENERGY STORAGE CONFERENCE 2024

## Decarbonizing Industrial Processes through Electrification and High-Temperature Heat Pumps

José Joaquín Aguilera,
Danish Technological Institute

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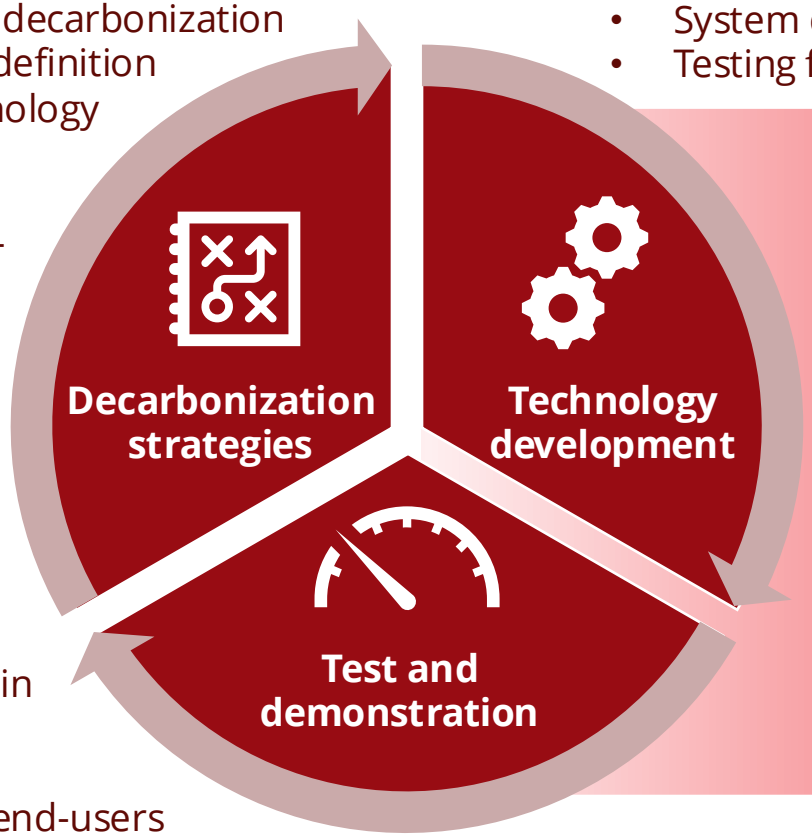
Advanced Energy Storage 2024

# Decarbonizing industrial processes through electrification and high-temperature heat pumps

José Joaquín Aguilera, Consultant
Frederik Dupond Holdt, Consultant
**Danish Technological Institute**

# Decarbonization of Industries

- Holistic consultancy approach supporting process industries in their decarbonization
- Process Analysis & Target definition
- Conceptualization & Technology Overview
- Roadmap development
- Support during implementation




- Component development
- System design and optimization
- Testing function and performance

**Technologies**
- Heat pumps
- Thermal storage
- Thermal networks
- Biogas & green fuels
- Unit operations
- Electric systems
- Water recovery

**Scope**
- Energy
- GHG emissions
- Water
- Economy

**Collaboration partners**
- Technology suppliers (system manufacturers, OEMs, …)
- Process equipment manufacturers
- End-users from various industries (Food & beverage, Pulp & paper, chemicals, minerals, utilities, industry symbioses, …)

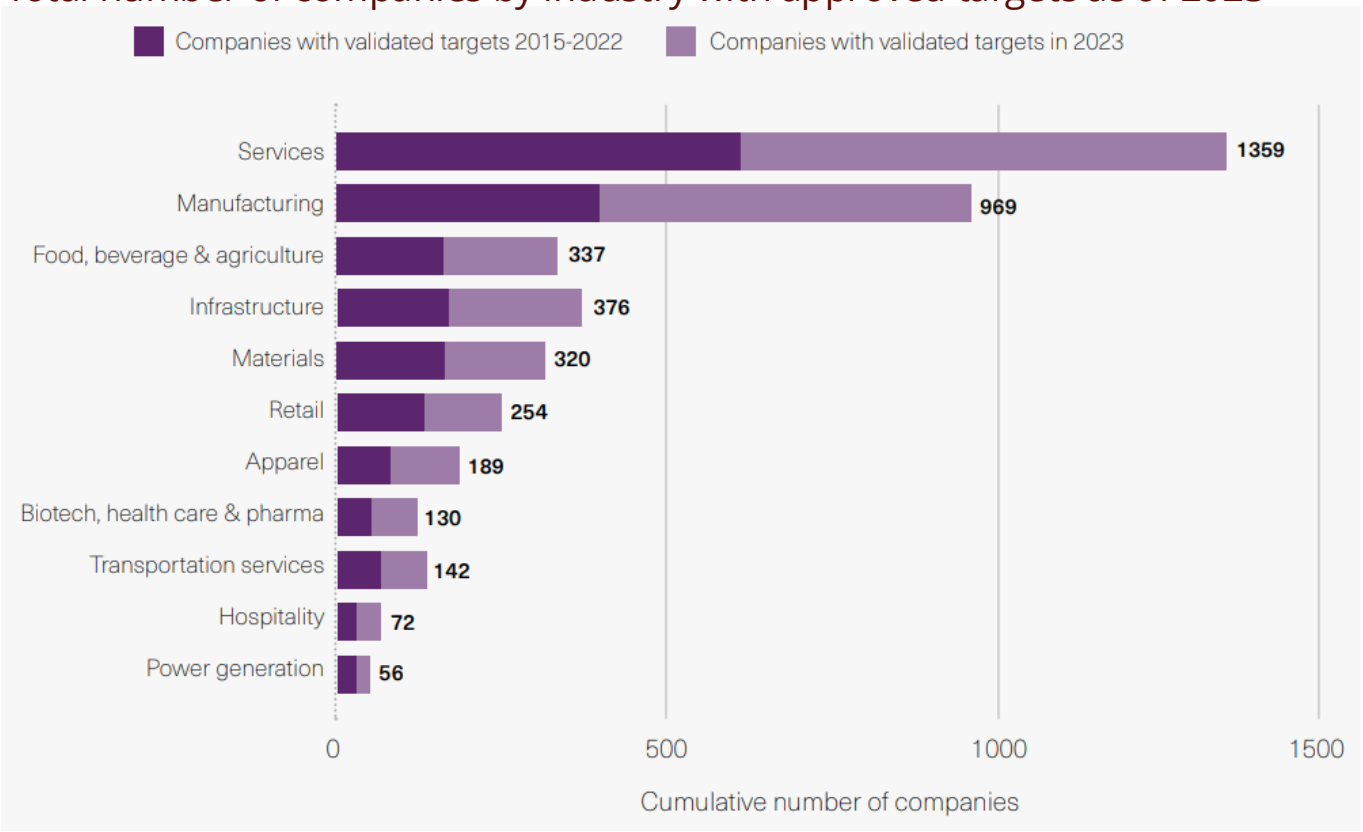
- Validation of technologies in full scale
- Industrial heat pump lab
- On-site demonstration at end-users

SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

# Decarbonization is gaining traction

Total number of companies by industry with approved targets as of 2023





https://sciencebasedtargets.org/ [accessed: 27.11.2024]

Source: https://sciencebasedtargets.org/resources/files/SBTiMonitoringReport2022.pdf

# INDUSTRIAL PROCESS HEAT DEMAND – EU28

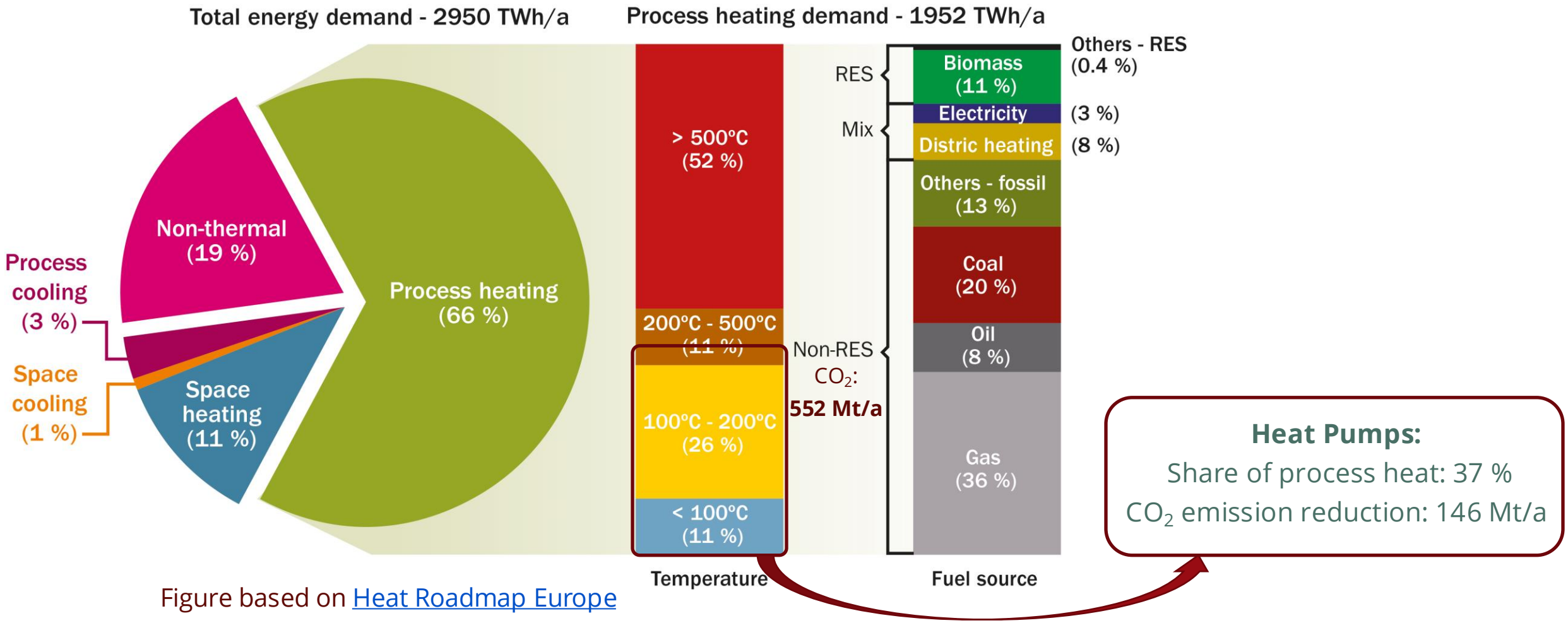
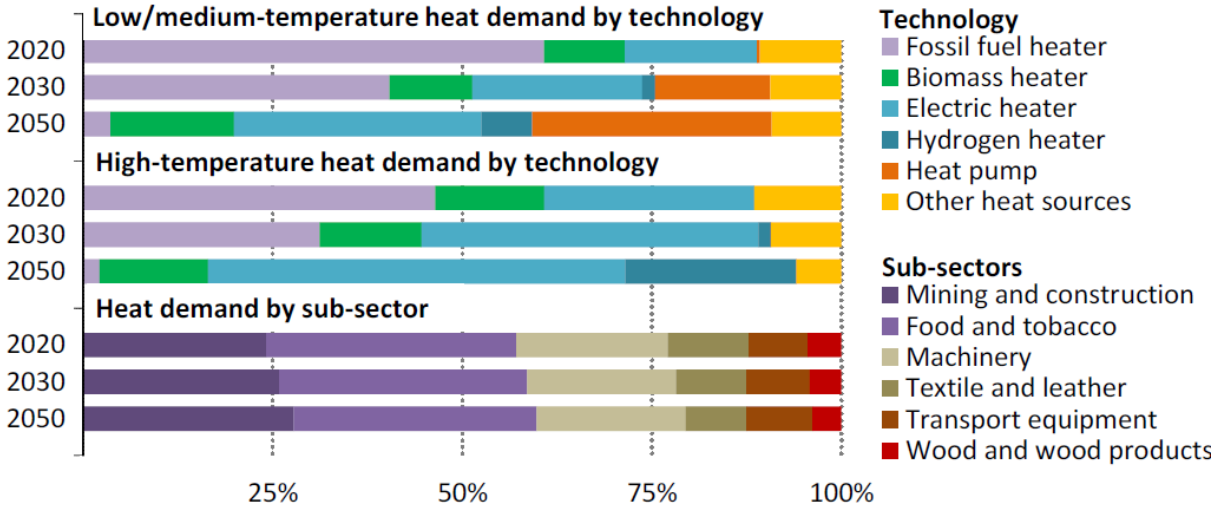
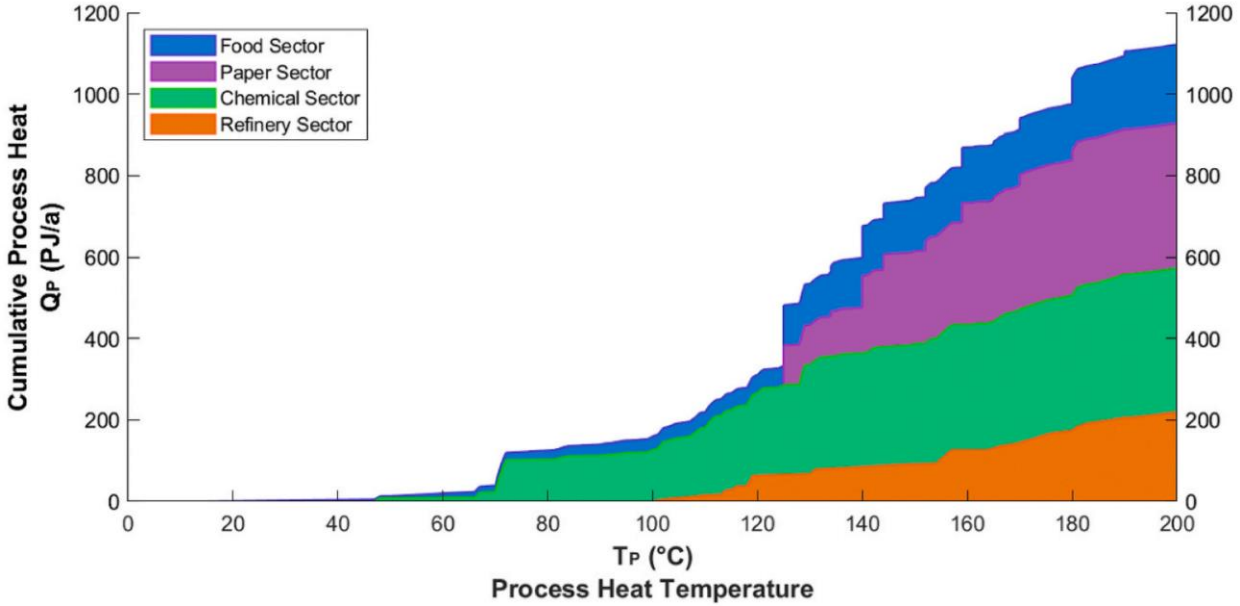



Figure based on [Heat Roadmap Europe]

# MARKET FOR HIGH-TEMPERATURE HEAT PUMPS IN THE INDUSTRY




Share of technologies for process heating accoring to temperature level ["*Net Zero by 2050 – A Roadmap for the Global Energy Sector*", International Energy Agency, 05/2021, https://www.iea.org/reports/net-zero-by-2050]




Process heating under 200 °C for selected processes in EU28 *[An estimation of the European industrial heat pump market potential*, Marina et. al (2021), https://publications.tno.nl/publication/34637767/MueE3v/marina-2021-estimation.pdf]

- IEA expects natural gas for process heating up to 250 °C will be phased out and be replaced by primarily heating pumps and electric boilers.
- Large potential for heat pumps, especially within the food, paper, chemical, and refinery sector.

# PROCESS HEATING WITH HEAT PUMPS

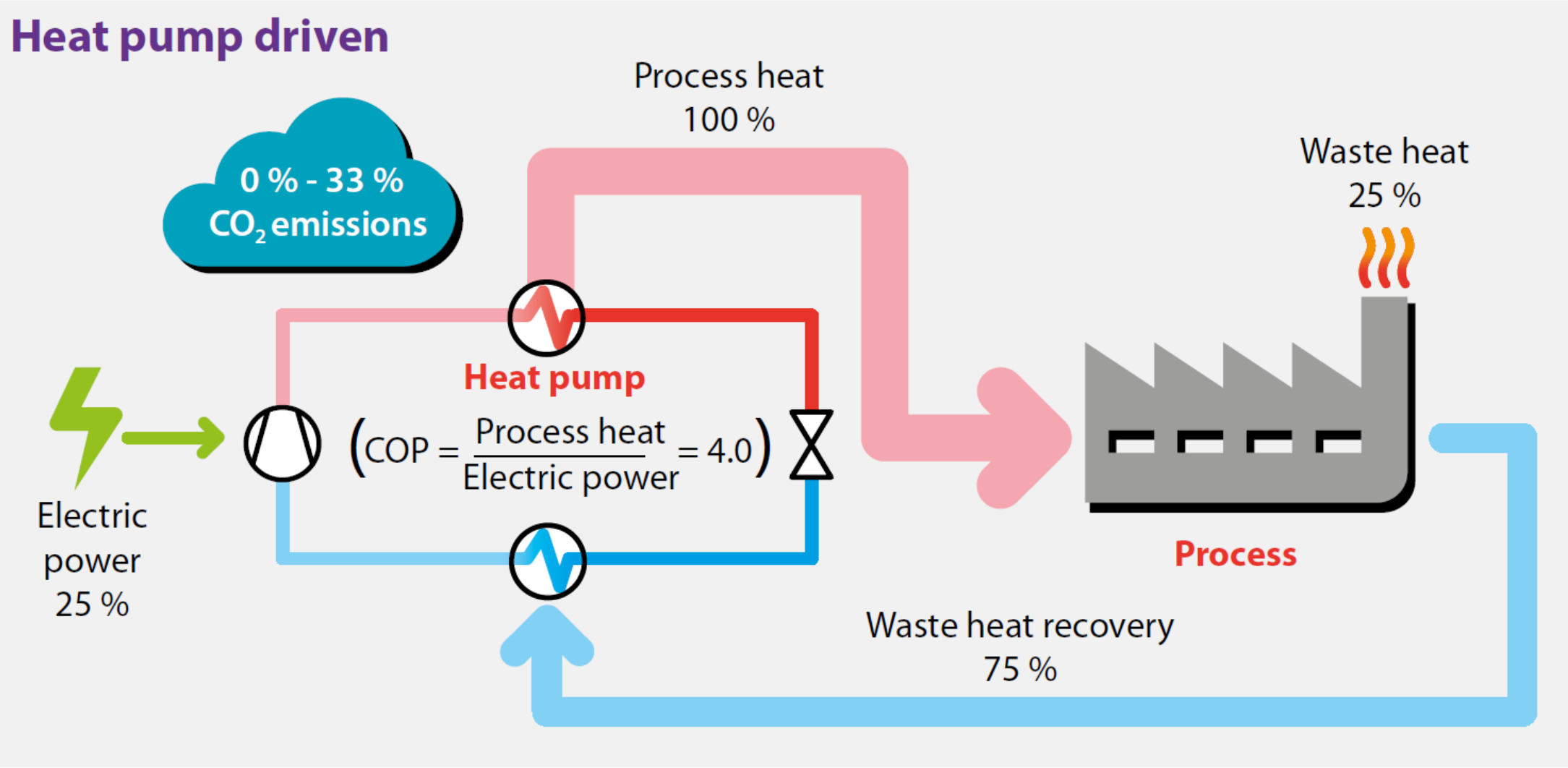
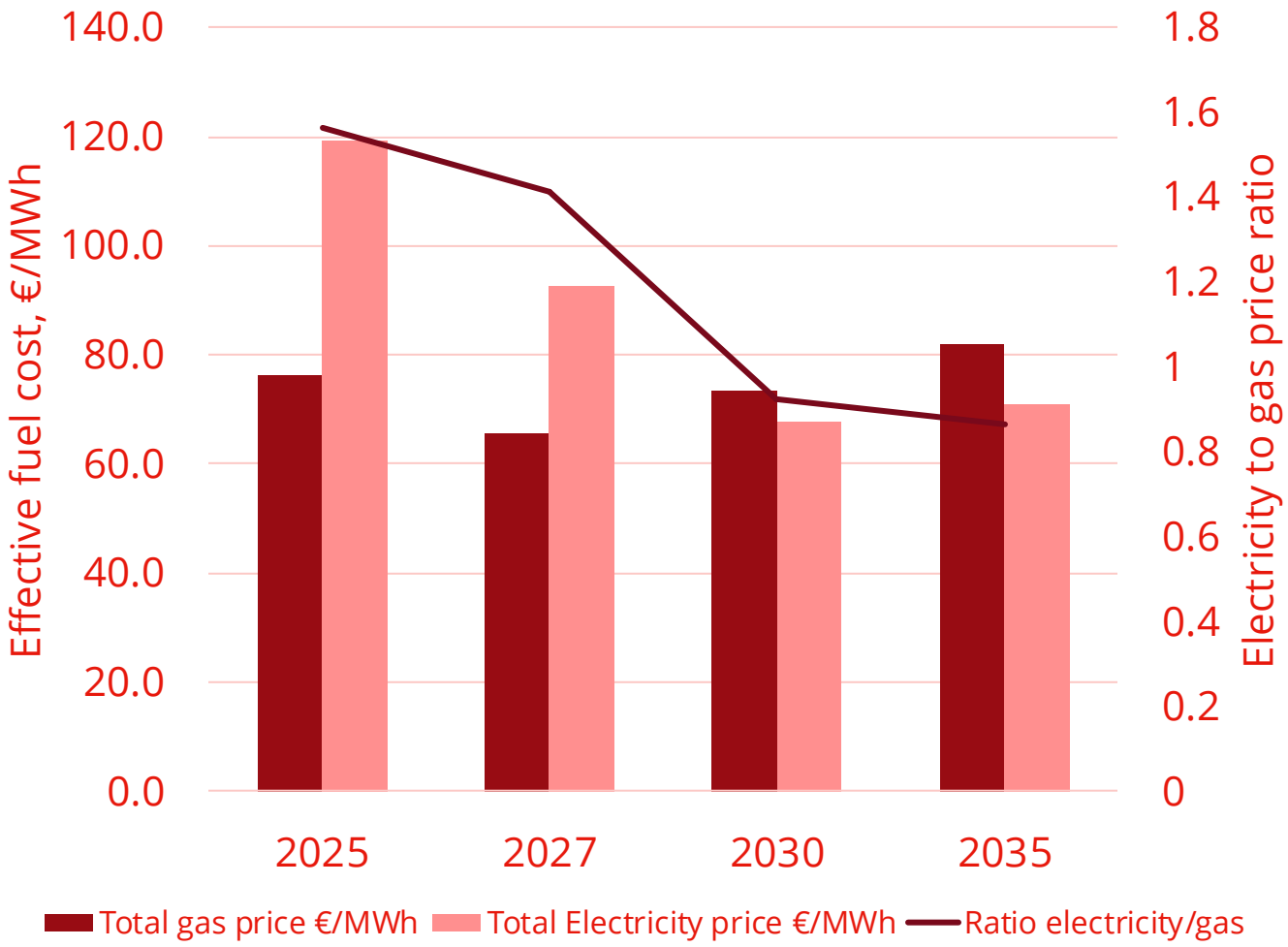



Figure from "White Paper - Strengthening Industrial Heat Pump Innovation - Decarbonizing Industrial Heat"
https://www.teknologisk.dk/white-paper-strengthening-industrial-heat-pump-innovation-decarbonizing-industrial-heat/43124

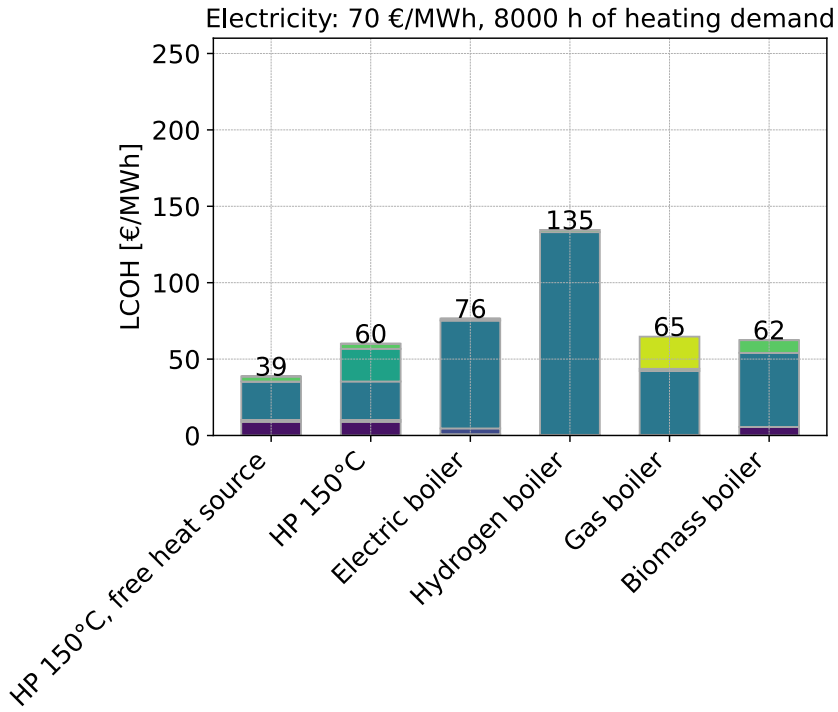
# Development of fuel prices

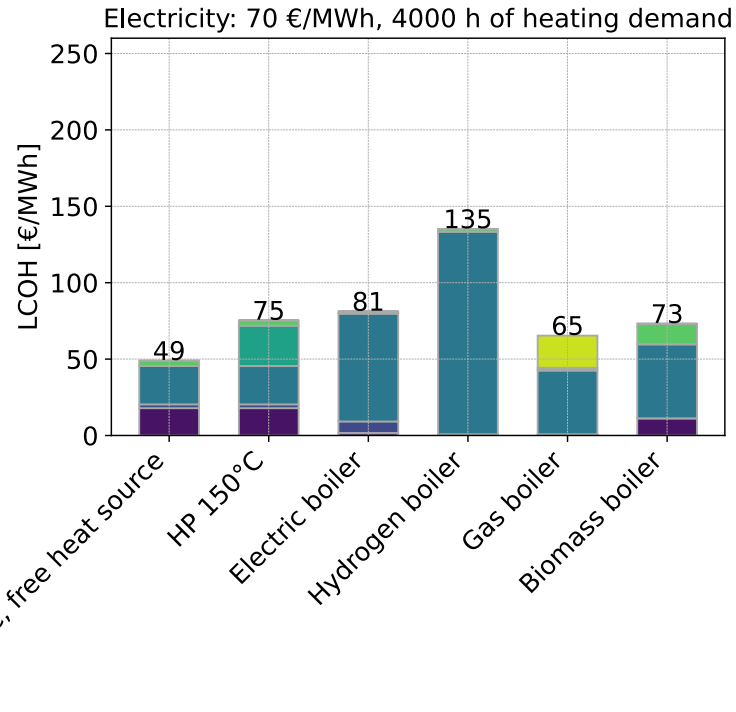



- Data from the Danish Energy Agency - climate status and outlook 2023
- Transportation cost for electricity varies depending on contracts and area's – average assumed
- Taxes for electricity are limited to EU-minimum

# Expected Levelized Cost of Heat in 2030 - Denmark

- Comparison of different technologies, 2030
- Investment prices based on the Danish Energy Agency's Technology Catalogs
- Fuel prices based on the Danish Energy Agency's Climate Projections
- Fixed Lorenz efficiency, $\eta_l = 0.5$ for all heat pumps

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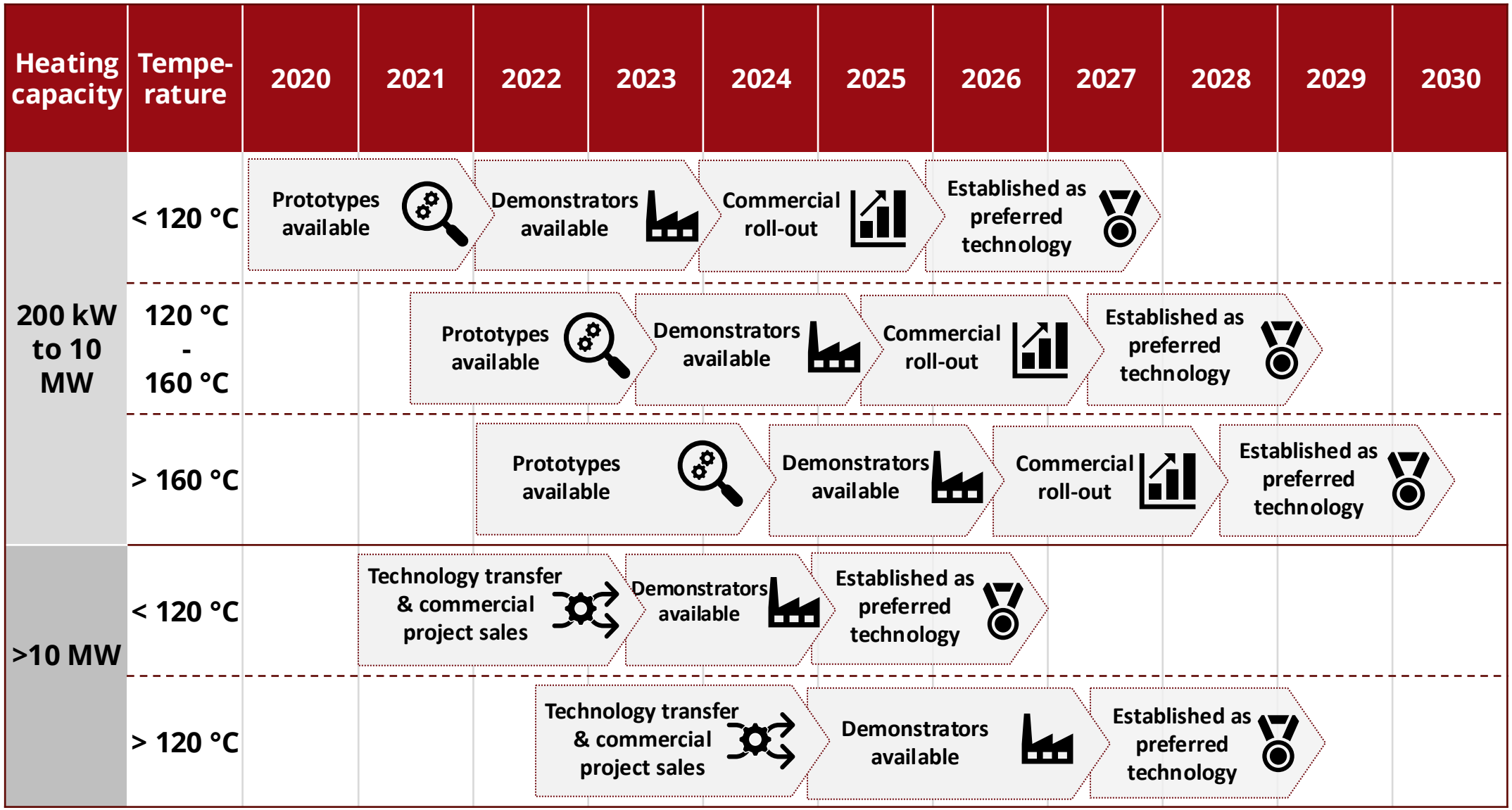
# Development Perspectives for HTHPs towards 2030

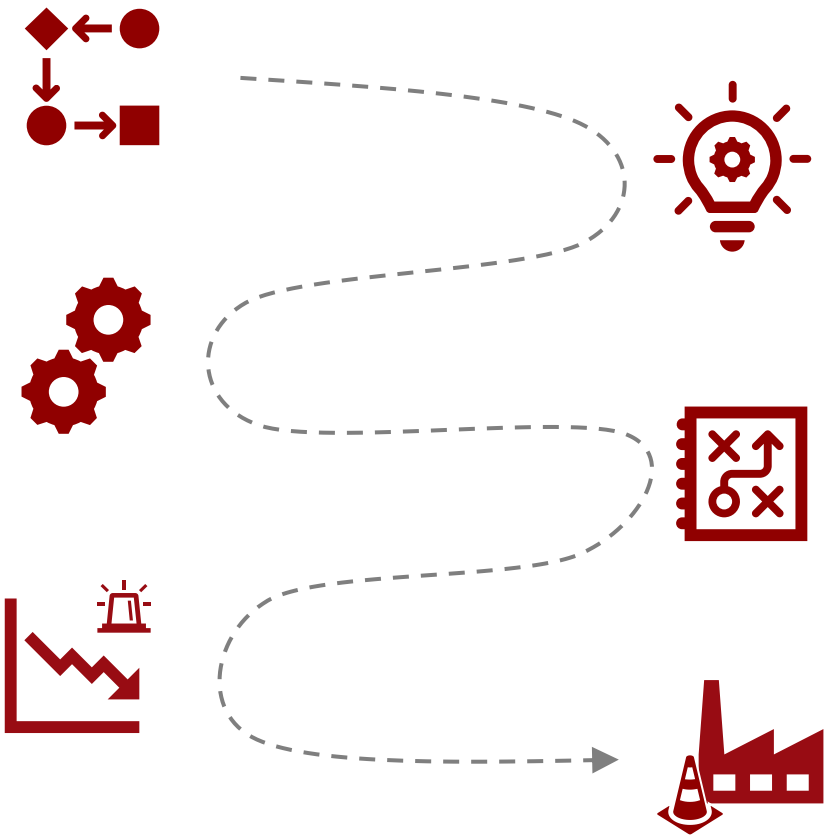


# Development of Decarbonization Strategies

**Mapping** of existing processes

Analysis of **technology availability and perspectives**

**De-risking** of decarbonization projects



Development of **concept solutions**

Development of **decarbonization roadmap**

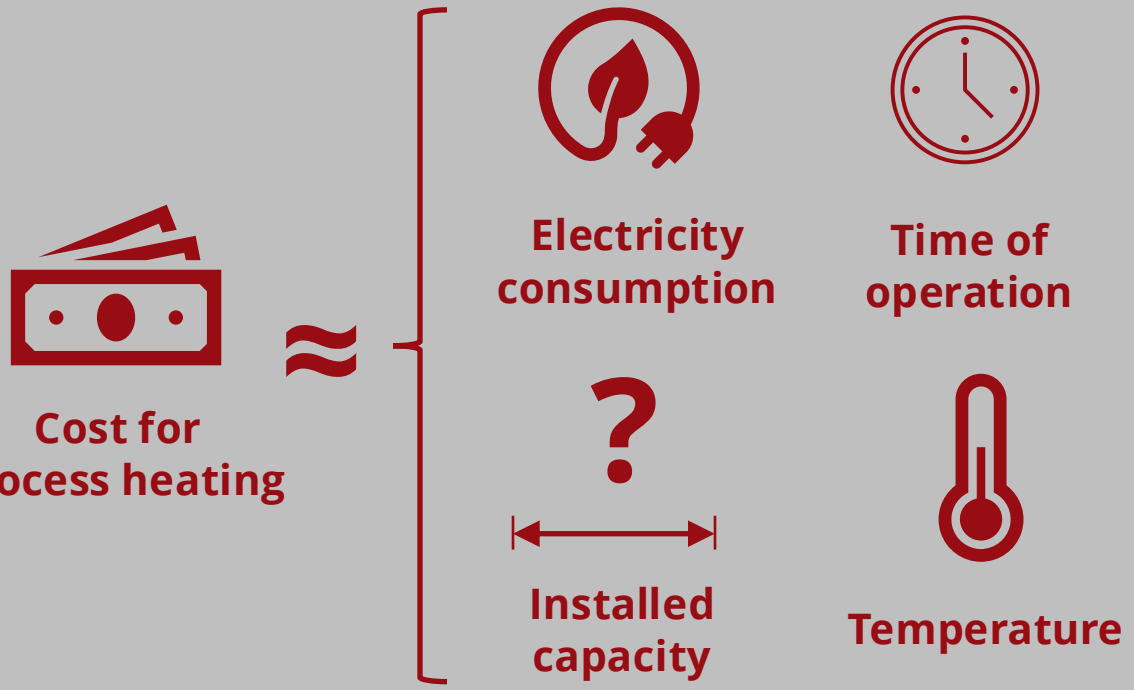
**Implementation** of decarbonization roadmap

# Complexity of HTHP costs

## Fossil fuel-based process heating


Cost for process heating ≈ Fuel consumption

## Heat pump-based process heating

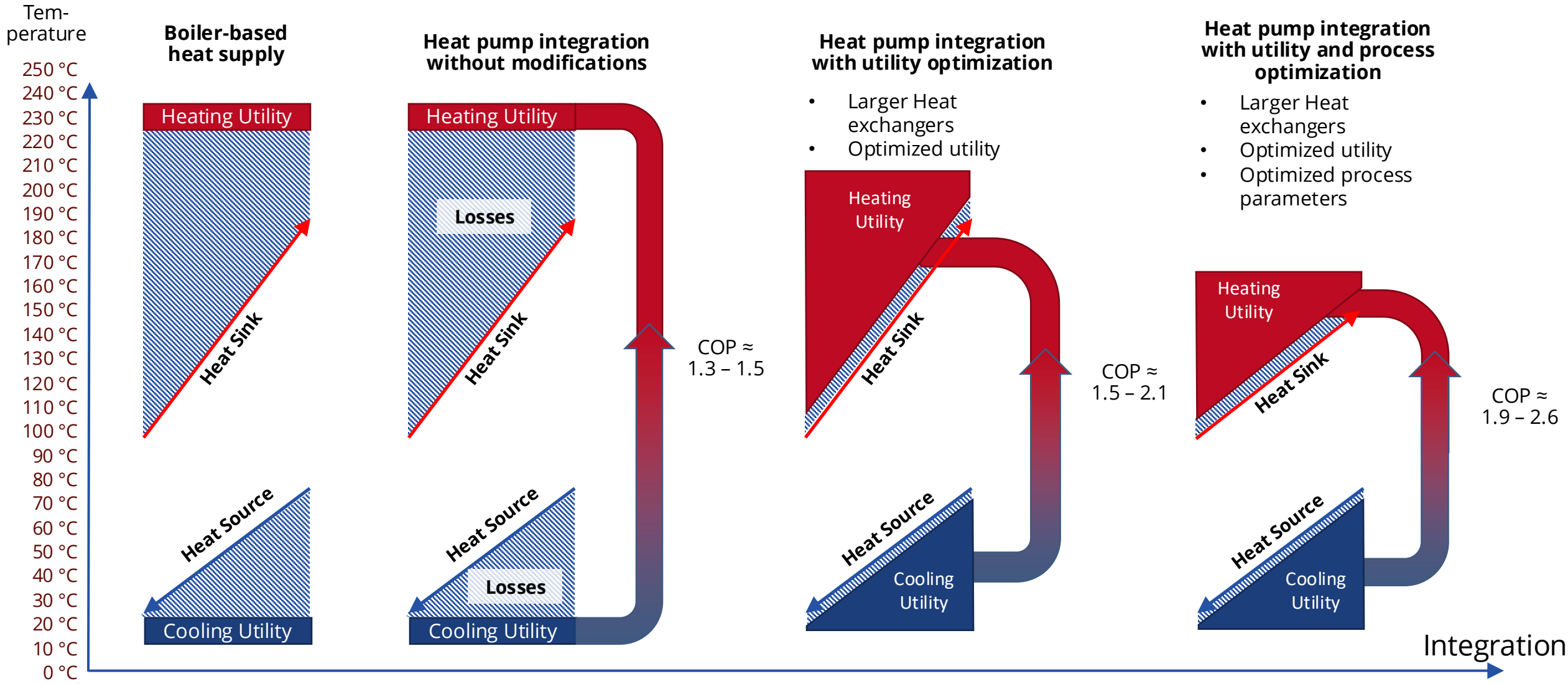



Cost for process heating ≈ Electricity consumption, Time of operation, Installed capacity, Temperature

**Low CAPEX risk**

**High CAPEX risk**

# Temperature demands & level of integration



# Things to consider – Can I get a heat pump?

- Avoid technology lock-ins
- Temperatures
- HTHP system layout
- Capacity (peak loads)
- Heat sources?

**Examples of technology lock-ins**

- Process equipment designed for high pressures
- Waste heat recovery from combustion processes
- Waste heat supply for external purpose

**Economy**

**Process reliability**

- Back-up boiler
- Electrification
- Sufficient temperatures
- Testing of HTHP
- Service intervals

**Integration**

- Reduce pipework
- Avoid complexity
- Support during installation
- Start-up testing at site
- (De)central installation?

# How to get a good business case?

## CAPEX


## Reducing CAPEX

**Engineering**

- Develop a long-term strategy.
- Avoid cutting costs on engineering.
- Conduct thorough analyses of production and potential HTHPs to find the best match.

**Integration**

- Consider positioning to avoid too much pipework.
- Can we avoid building a room for the system?
- Do we need to prepare the production infrastructure?

**System**

- Find the right system for the purpose.
- Avoid system complexity.
- Correct capacity and temperatures.

# How to get a good business case?

## OPEX


## Reducing OPEX

**Maintenance**

- Maintenance can be reduced by proper design and integration.
- Service and maintenance will always be necessary to increase process reliability.

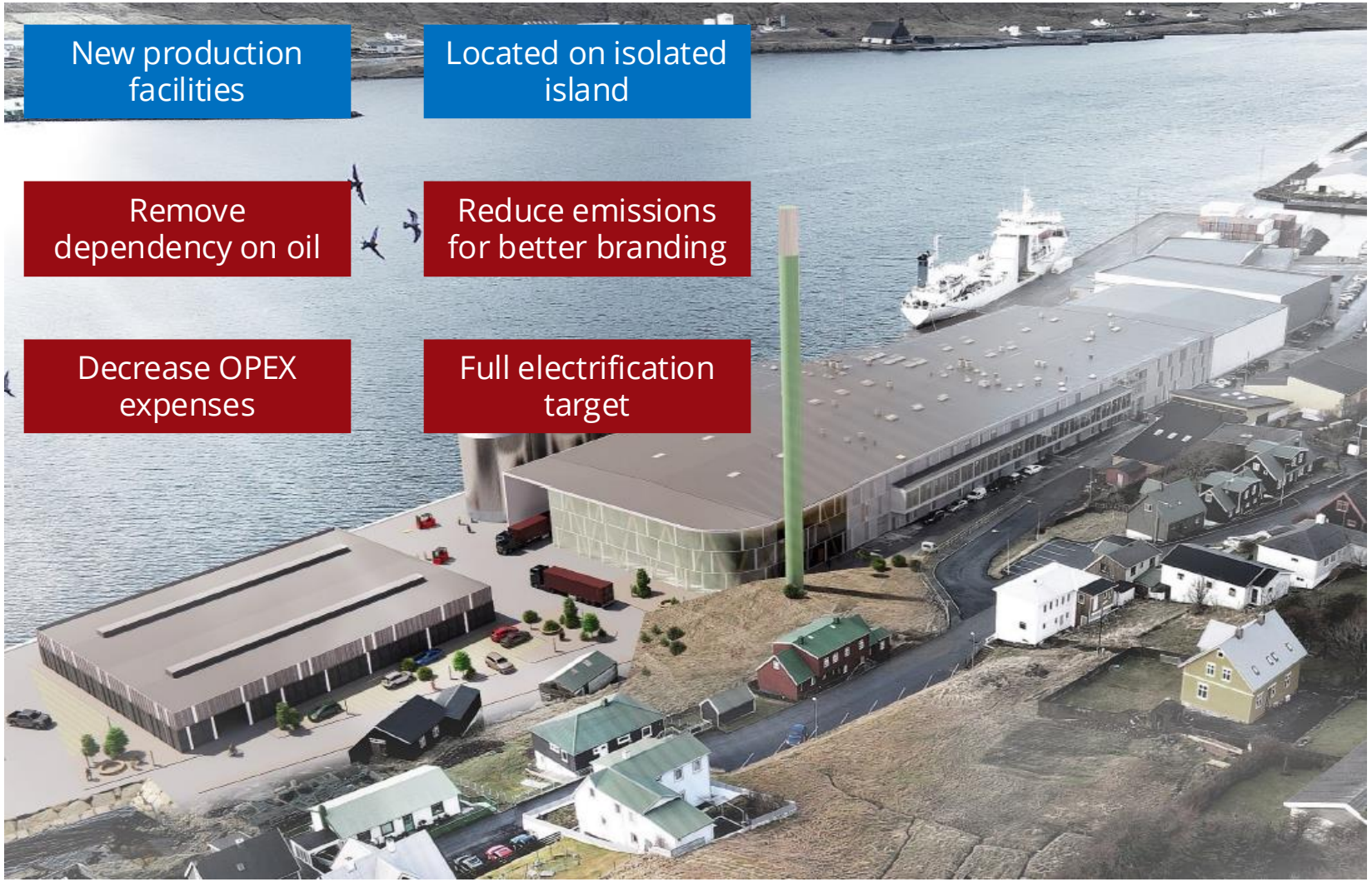
**Electricity**

- As high COP as possible to reduce electricity consumption.
- Consider using HTHP when electricity prices are low.
- Other ways to reduce costs?

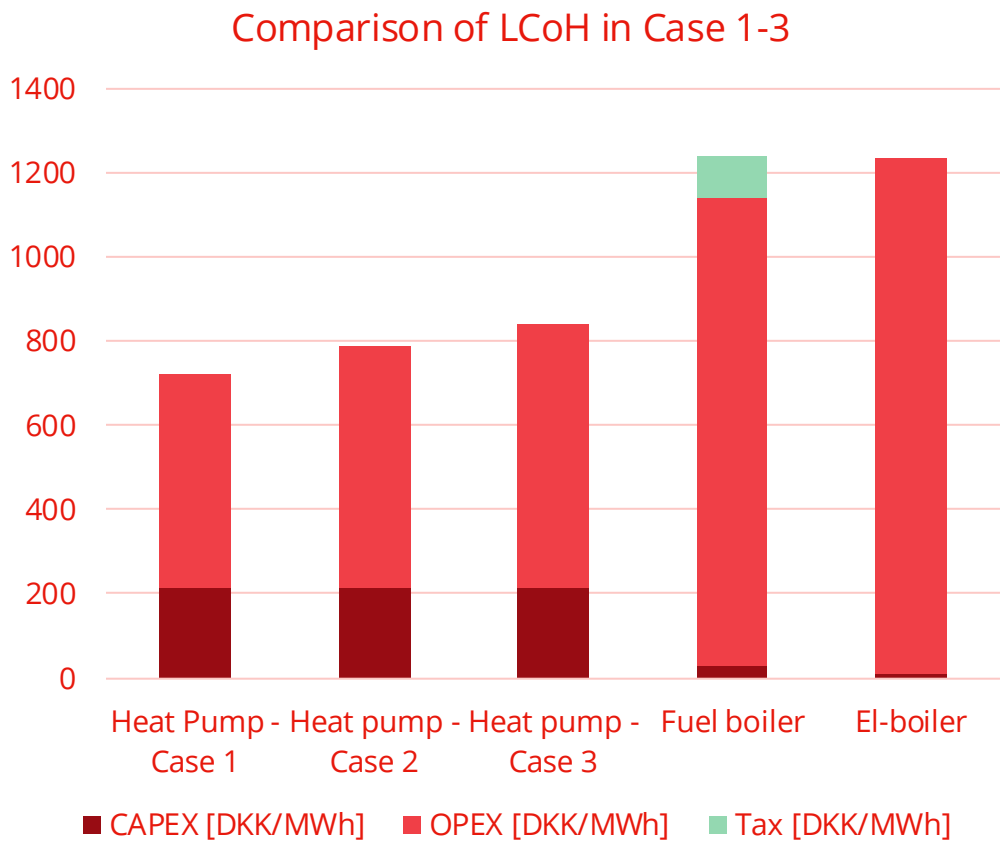
# Case – Vardin Pelagic

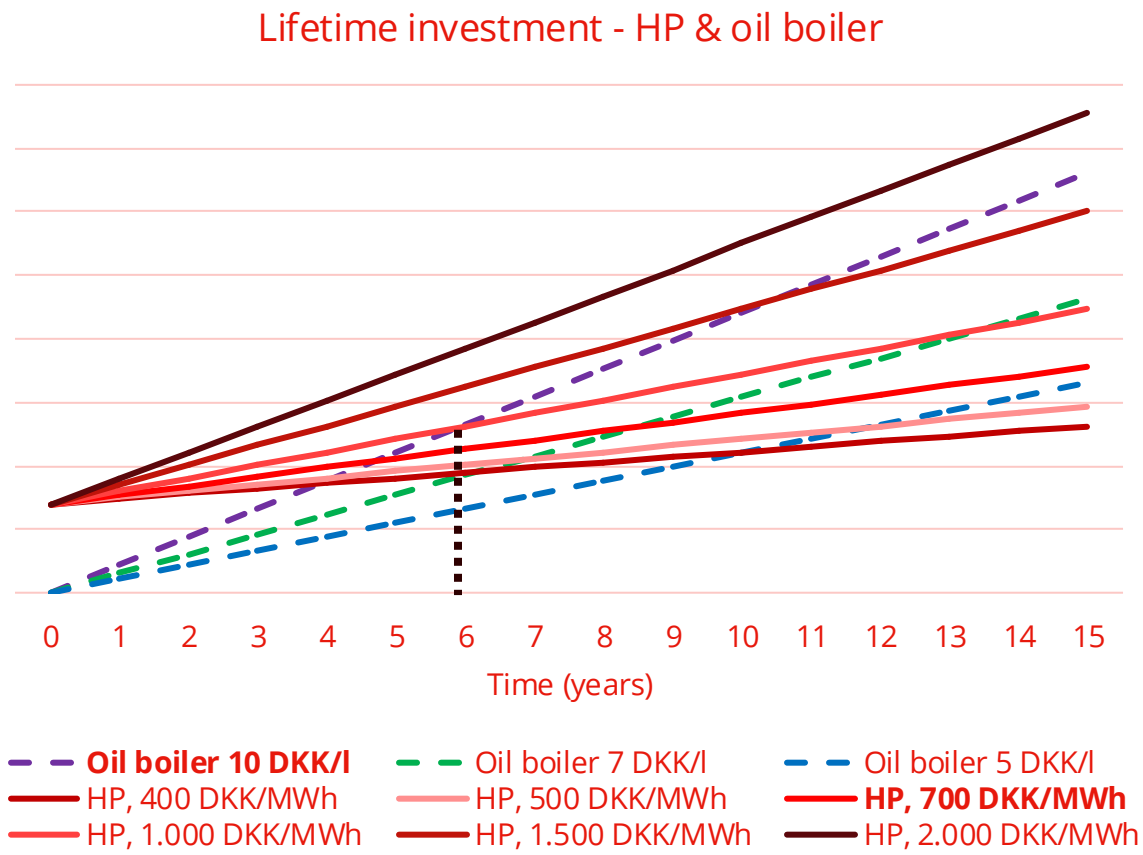
**Vardin Pelagic**

*Vardin Pelagic is a fish treatment plant located in the Faroe Islands, originally built in 2012. The factory burned down in 2017, following which a new factory was constructed in 2018. Now, a new area is added to the existing layout and high-temperature heat pumps are investigated as a part of this.*



# Case – Vardin Pelagic



# Thank you for your attention!

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# ADVANCED ENERGY STORAGE CONFERENCE 2025

Advanced Energy Storage Conference

**See you in 2025 for**
**Advanced Energy Storage 2025**
4 December 2025 - Aarhus, Denmark