Decarbonizing Process Heat with Heat Pumps & Steam Compressors

March 14th, 2024

Atlas Copco Gas and Process

Introduction of Speaker

Rasmus Rubycz
Role: Market Segment Manager New Energy
Located: Atlas Copco Gas and Process, Cologne
Education: Process Engineer

Thank you for having me today in this Decarbonisation Technology Webinar.

The transition to sustainable fuels & energy

This is the Atlas Copco Group

- Customers in more than **180** countries
- **49 000** employees in **70** countries
- Established in **1873** Stockholm, Sweden
- Turnover of **141** BSEK/ **11** BEUR
- Operating margin of **21.4%**

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A decentralized Group

BOARD OF DIRECTORS

PRESIDENT AND CEO

GROUP MANAGEMENT

COMPRESSOR TECHNIQUE

- Compressor Technique Service
- Industrial Air
- Oil-free Air
- Professional Air
- Gas and Process
- Medical Gas Solutions
- Airtec

VACUUM TECHNIQUE

- Vacuum Technique Service
- Semiconductor Service
- Semiconductor
- Semiconductor Chamber Solutions
- Scientific Vacuum
- Industrial Vacuum

INDUSTRIAL TECHNIQUE

- Industrial Technique Service
- MVI Tools and Assembly Systems
- General Industry Tools and Assembly Systems
- Chicago Pneumatic Tools
- Industrial Assembly Solutions
- Machine Vision Solutions

POWER TECHNIQUE

- Power Technique Service
- Specialty Rental
- Portable Air
- Power and Flow

Atlas Copco Gas and Process
– An overview

Products manufactured

- Our equipment is “Engineered to Order” / API 617 and 672 engineered
- Custom-made integrally-geared centrifugal compressors in single and multi-stage (1 – 8 stages) configurations
- Integrally-geared and non-geared turboexpanders for process gas applications and energy recovery
- Non-geared turbocompressors for process gas
- Oil-free gas screw compressors
- API 610 centrifugal pumps
- Corresponding aftermarket products and services for our products

Worldwide support

Strategically located parts and service centers and more than 50 customer centers offer support worldwide

Global Structure
Gas and Process Division

Headquarters: **Cologne**

Sales, Application and Production Center USA
Atlas Copco Comptec LLC
Acquired in 1980

Sales, Application and Production Center USA
Atlas Copco Mafi-Trench LLC
Acquired in 2007

CPC Pumps International Inc.
Acquired in 2021

Sales, Application and Production Center Europe
Atlas Copco Energas GmbH
Acquired in 1984

Sales, Application and Production Center China
Atlas Copco (Shanghai) Process Equipment Co., Ltd.
Established in 2010

Sales, Application and Production Center Korea
Atlas Copco Korea Gas and Process
Established in 2021

Sales, Application and Production Center India
Atlas Copco (India) Ltd. Gas and Process Applications
Established in 1997

Markets Served by Gas and Process Division

Hydrocarbons

Air Separation

Power Generation

New Energy

Emerging Markets

Midstream

LNG

Olefins / Polyolefins

Chemicals / Petrochemicals

Refinery

Fuel Gas Boosting

Thermal Energy Storage

sCO_2 / Renewables

Industrial Heat Pumps

CCUS

Hydrogen

Decarbonizing Process Heat with Heat Pumps & Steam Compressors

- The vast energy-saving capabilities of **Industrial Heat Pumps** and **Steam Compressors**
- Case studies & ways in which **State-of-the-art Heating Technologies** have been proven
- Why energy efficiency and energy costs are a vital “**fitness factor**” in a global, low-carbon economy
- **Summary** and take aways

Technology to support **Sustainable Energy Use**

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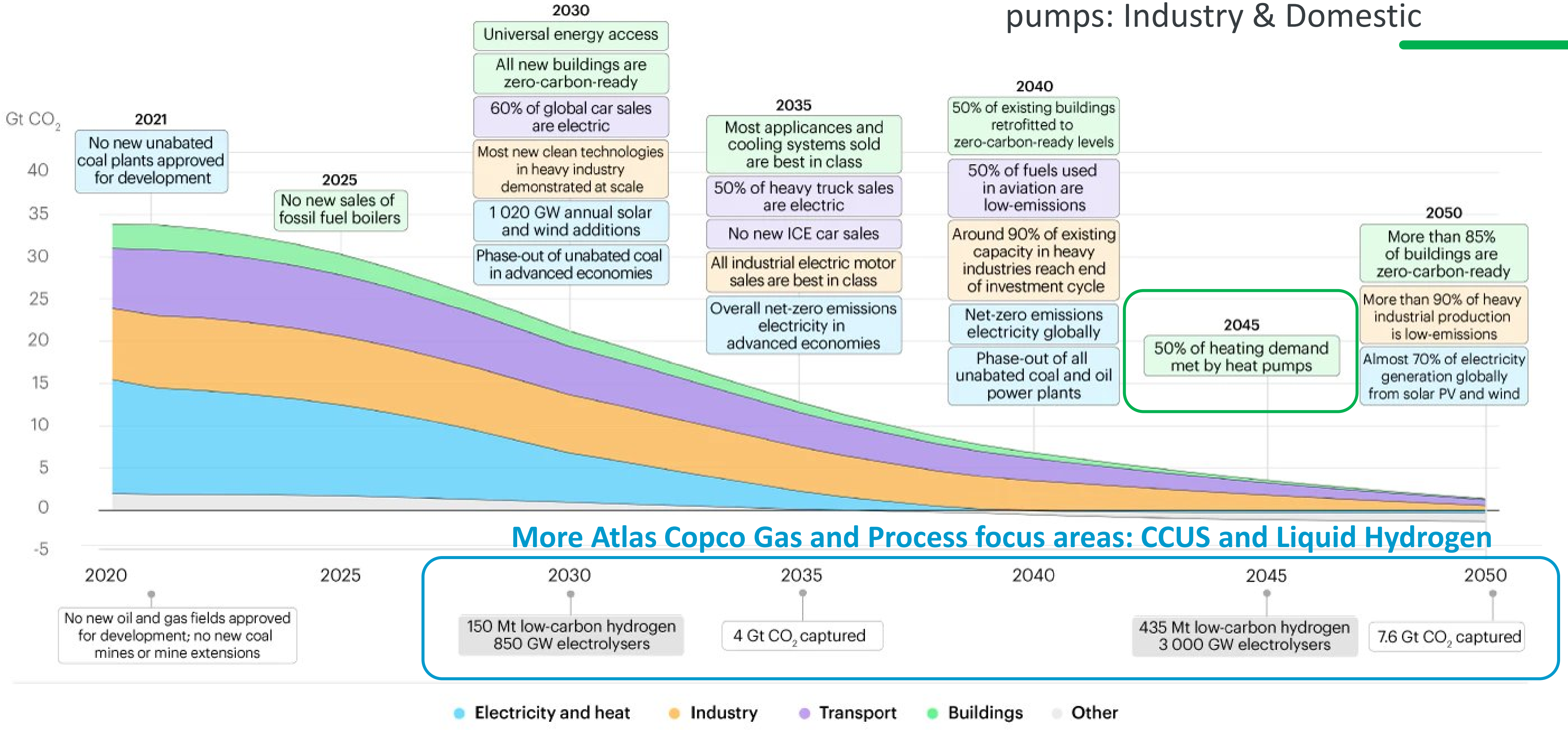
Vast Energy Saving Capabilities

Process Heat Electrification

IEA - Net Zero **2050** study

By 2045:
50% of complete heating demand met by heat pumps: Industry & Domestic

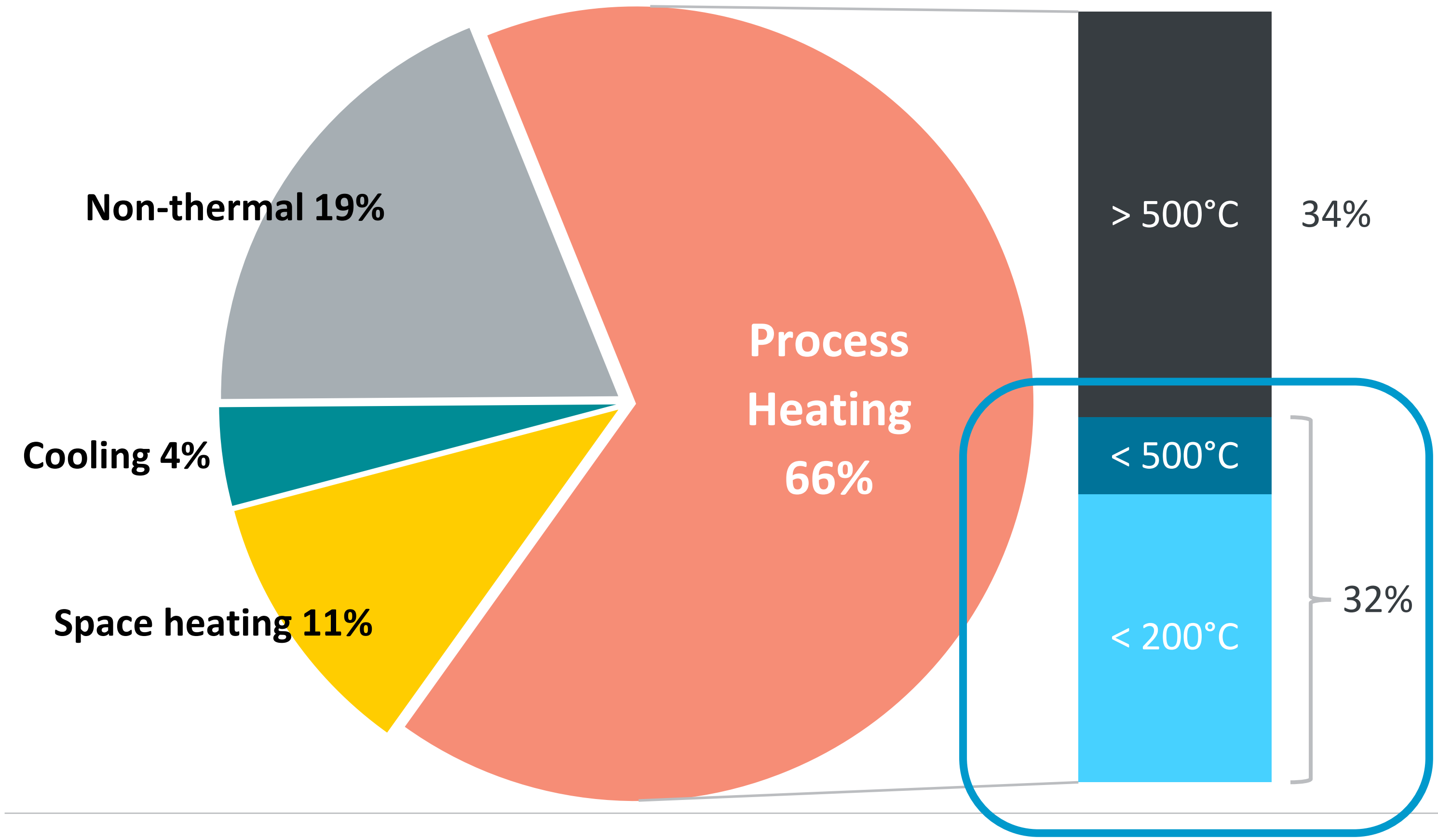


More Atlas Copco Gas and Process focus areas: CCUS and Liquid Hydrogen

Industrial Process Heat

Heat as biggest contribution to industrial carbon emissions

Total Energy Demand of Industry 2950 TWh/a



- Industrial process heat is major source of CO_2
- 90% of heat generation is still fossil based
- Heat pumps and MVR can cover approx. 1/3 of total industrial thermal energy demand

Source: „Strengthening Industrial Heat Pump Innovation", de Boer et al, 2022 – numbers represent European Industry

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Different Approaches for Industrial Heat Electrification

Example: Comparison of different heat generation systems

1 kWh

Heat Pump & MVR

Transition grid losses

0.95 kWh
Electricity

Driver Motor

„Coefficient of Performance“

2-8 kWh
Usable Heat

1 kWh

Hydrogen

Electrolyzer and Transport

0.6 kWh
H2

Combustion in Boiler

0.5 kWh

1 kWh

Electrical Heater

Transition grid losses

0.95 kWh
Electricity

Use in direct heater

0.95 kWh
Heat

Conversion Efficiency „Electricity to Heat“

Background – Industrial Heat Recycling Using Heat Pumps

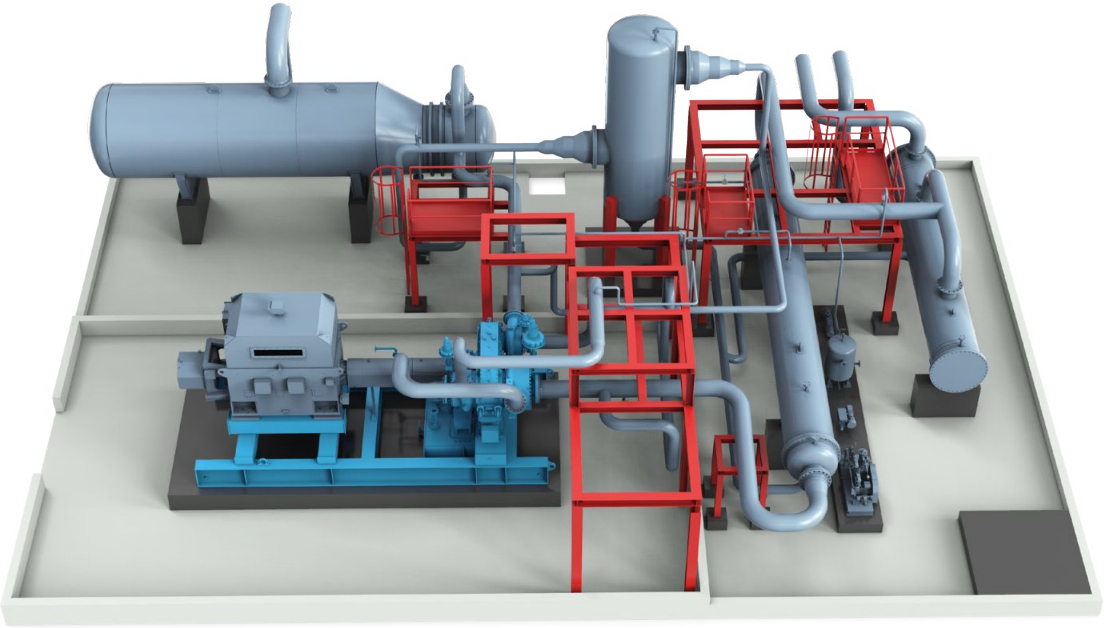
#1 heat source for new homes in the US, China and Europe, but not yet established in the industry

Picture: Daikin Europe

- For low power ratings <50kW established and well proven technology
- Domestic systems operate up to 80°C
- Heat source is ambient air, ground water or shallow geothermal heat

But what if you want to supply a whole factory with high temperature heat?

Introducing:
The superheroes of electrification



Industrial Heat Pump

Power: 10 - 65MW thermal

Temperature source: -20 to 80°C

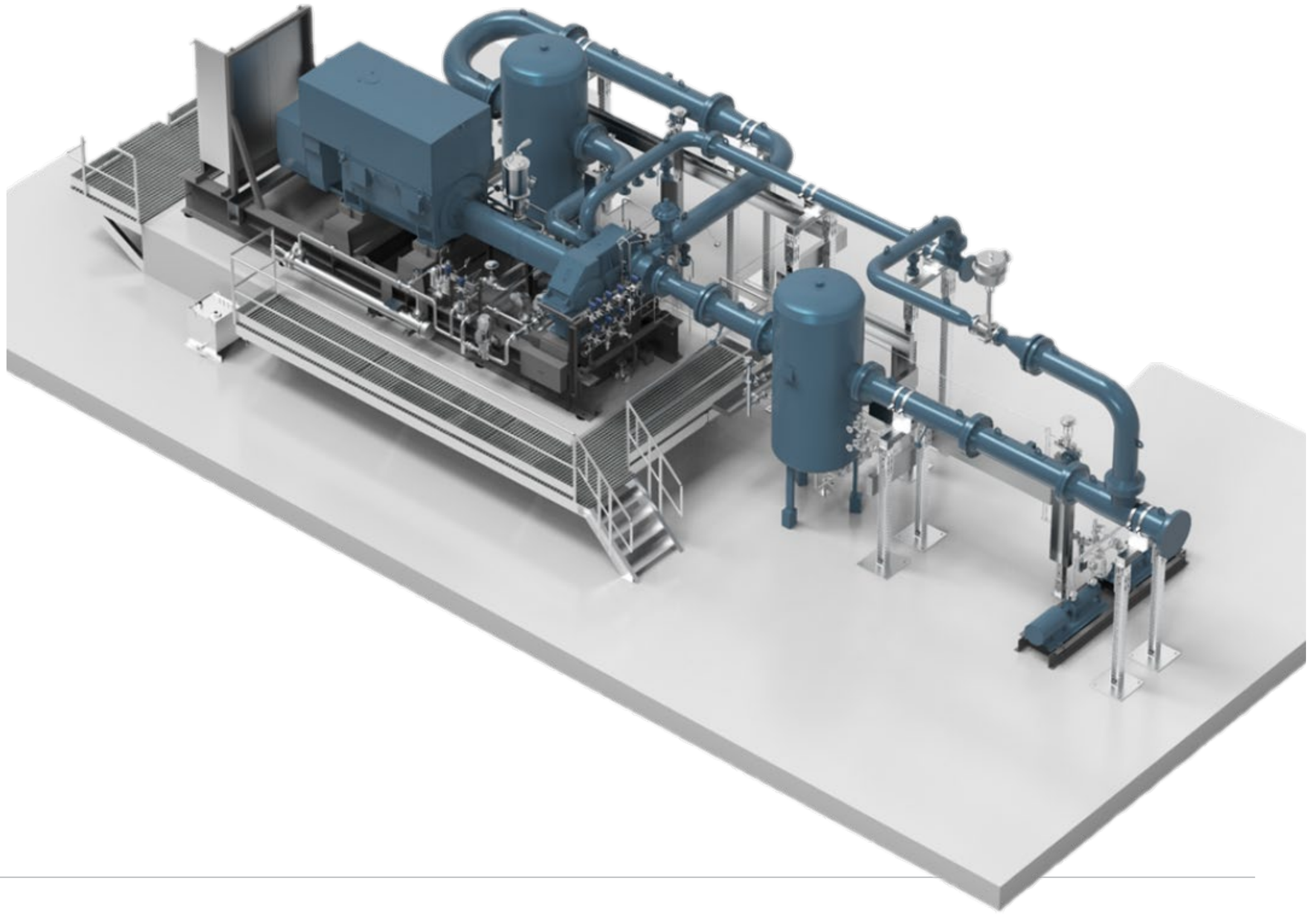
Temperature sink: 80 to 180°C

Steam / Mech Vapor Compressor (MVR)

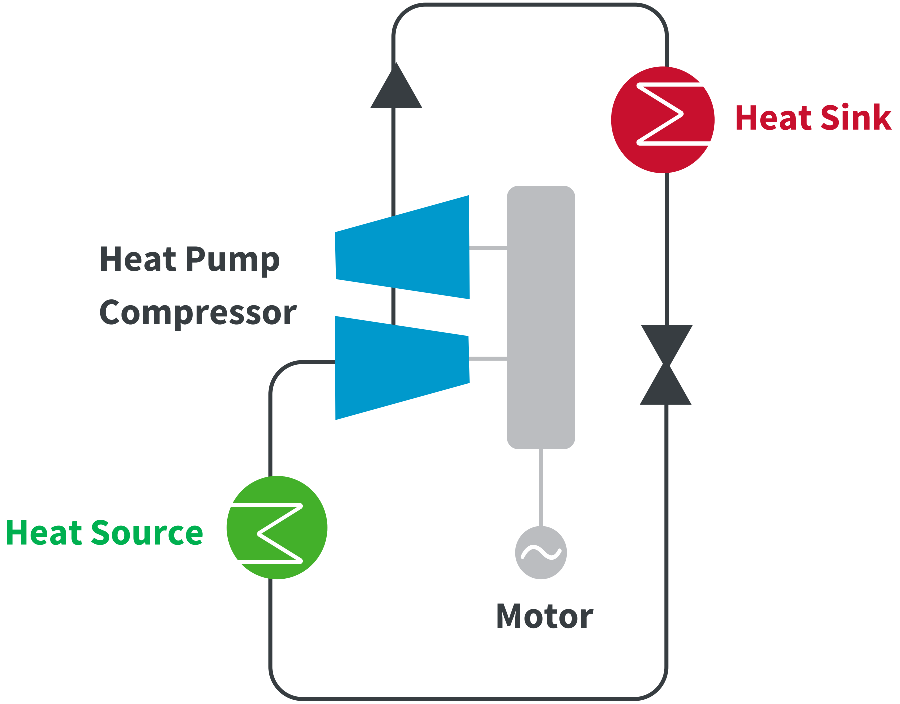
Power: 500kW - 65MW thermal

Temperature source: 50 to 200°C

Temperature sink: 80 to 250°C



Introducing:
The superheroes of electrification



Industrial Heat Pump

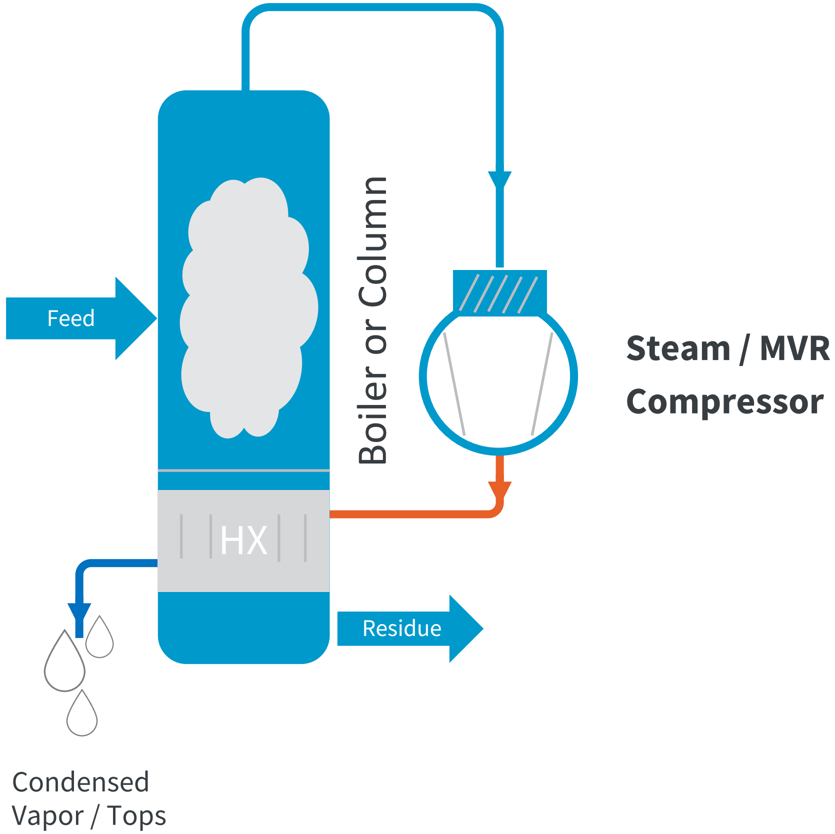
Defined by closed refrigerant loop

Fluid is typically different than process fluid

Steam / Mech Vapor Compressor (MVR)

Defined by open process

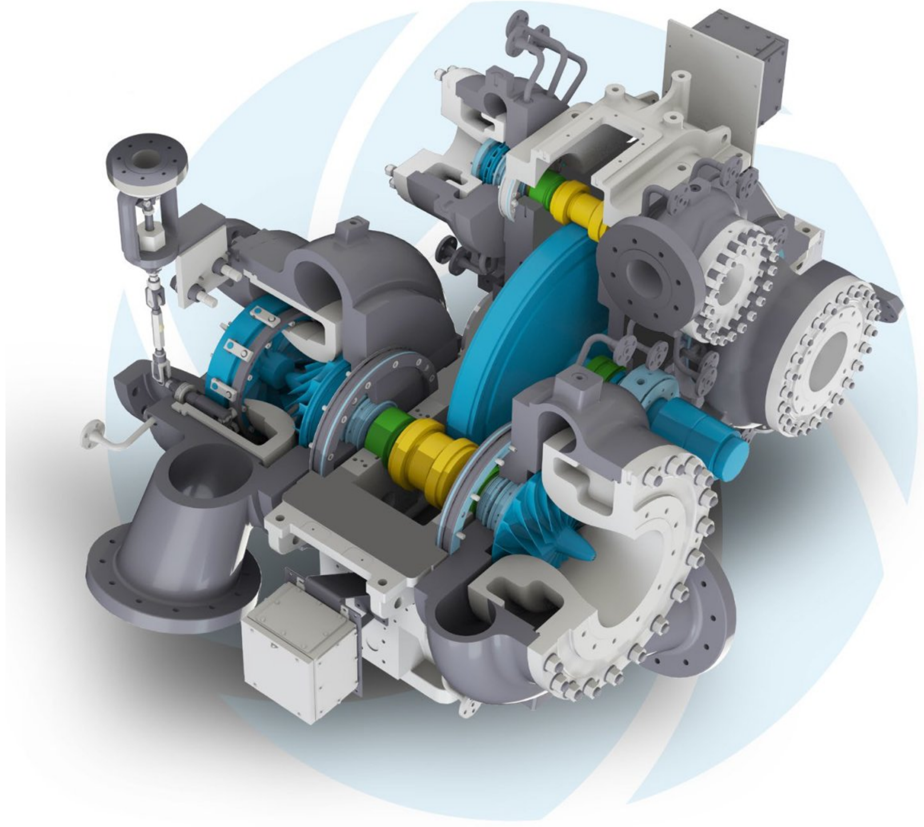
Fluid is typically the same like in the process



Wide performance range of Atlas Copco Gas and Process Compressors

Integrally Geared Machines for Heat Pumps and Steam / MVR Compression

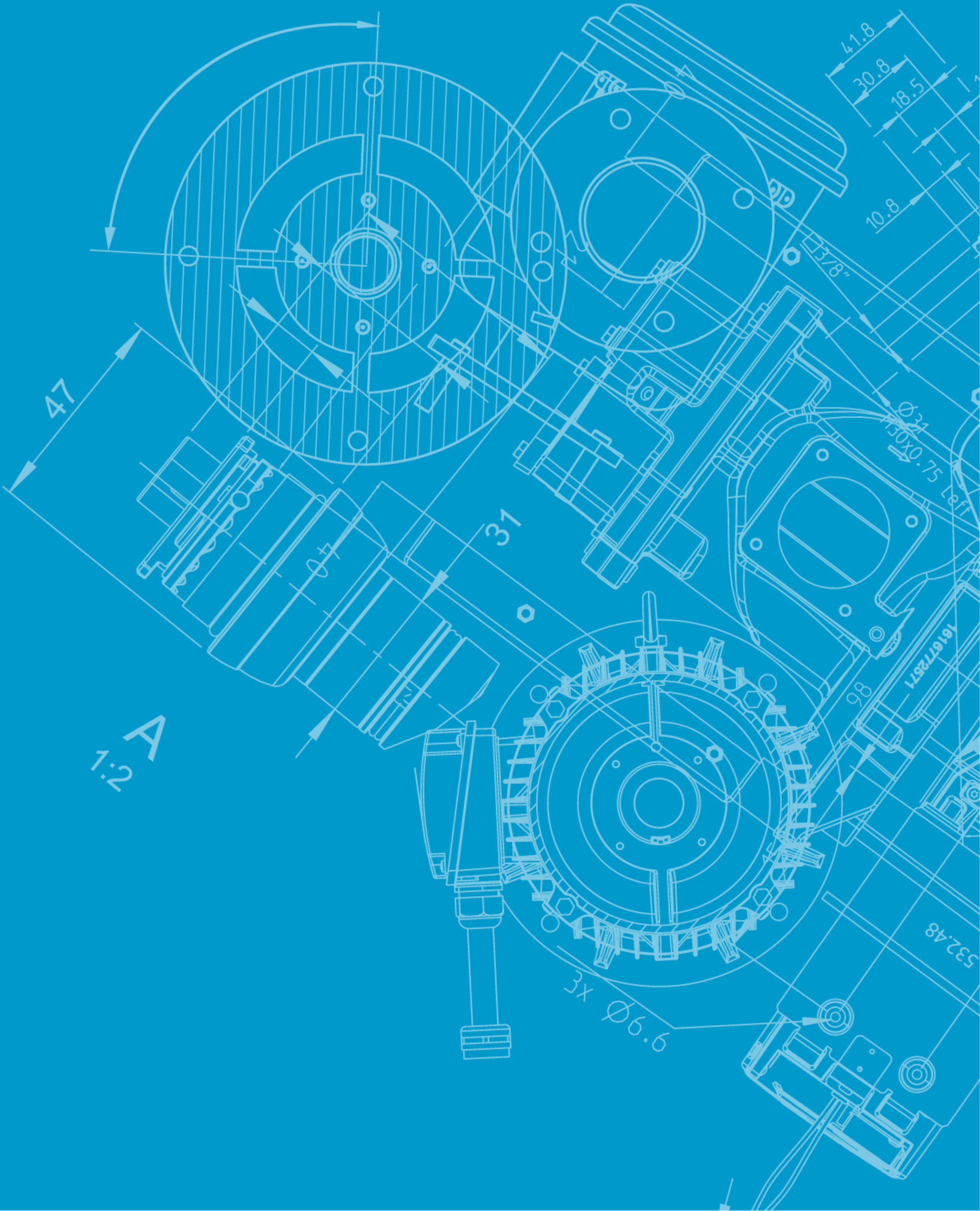
- More than **40 years experience**, with more than 150 running references for steam compressors and heat pumps
- Designed to specific process needs
- Highest efficiency, full-load or part-load due to **IGV** (inlet guide vanes)
- **Custom materials** - ability to manage corrosive vapors
- **Very high temperature lifts (> 100K) possible**
- **Multi-stage design** with interstage gas injection or water injection cooling (desuperheating)
- **Multi sectional machines** with different gases possible



6-stage GT-Series Compressor

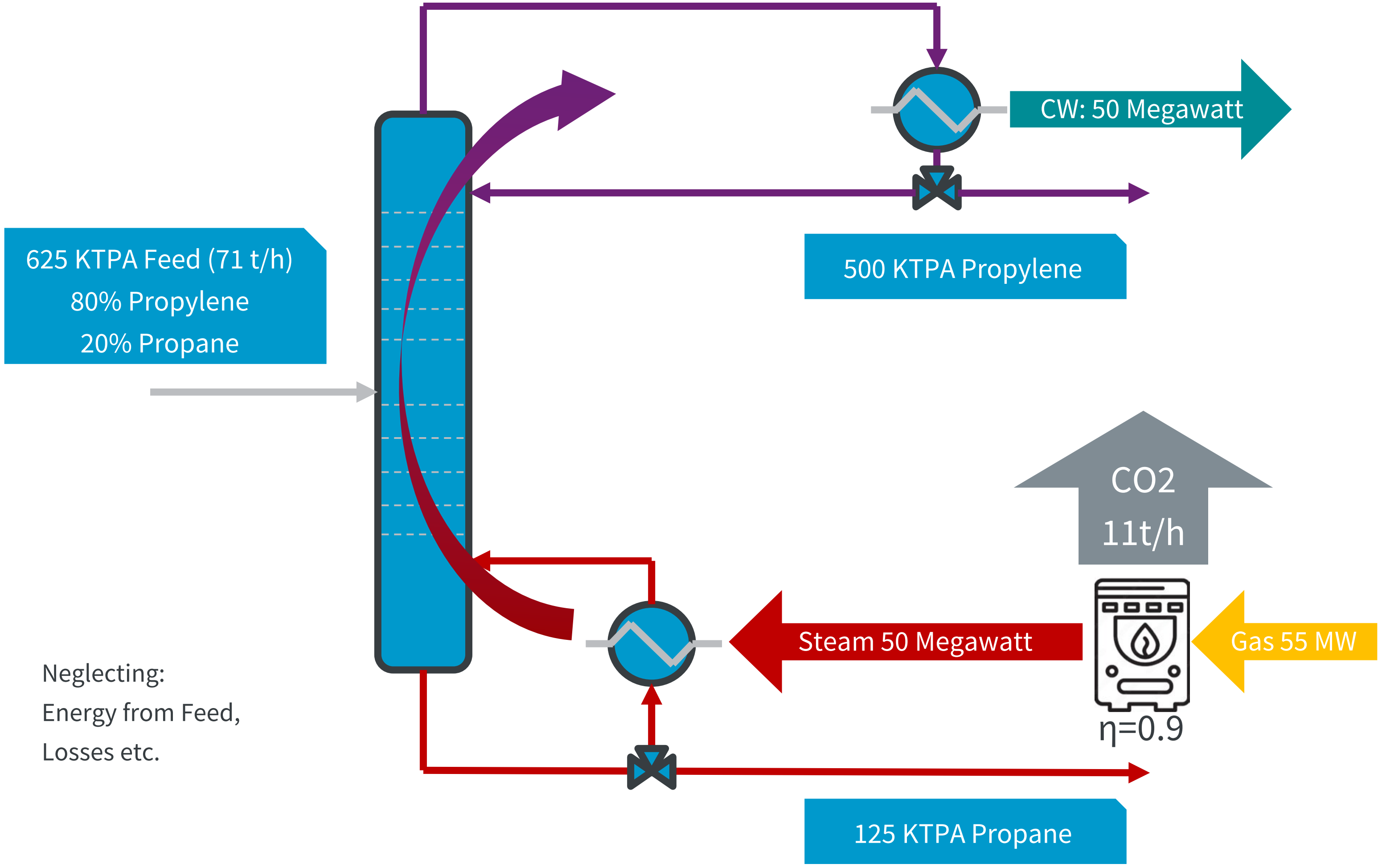
Proven, state-of-the-art Technology

References and case studies



Case Study – Electrification of C3-Distillation Tower with MVR

Typical 500 KTPA Propylene Splitter in PDH-Plant, SIMPLIFIED MODEL



Neglecting:
Energy from Feed,
Losses etc.

- **C3 separation** is energy intense task due to very similar properties of Propane and Propylene
- High top reflux ratio of 10:1 and higher is common
- Heating fluid is typically steam
- Heat of condensation is rejected to cooling water
- If Natural Gas is used for making steam, about **11 t/h of CO_2** is released
- Approx. **95KTPA CO_2** emissions

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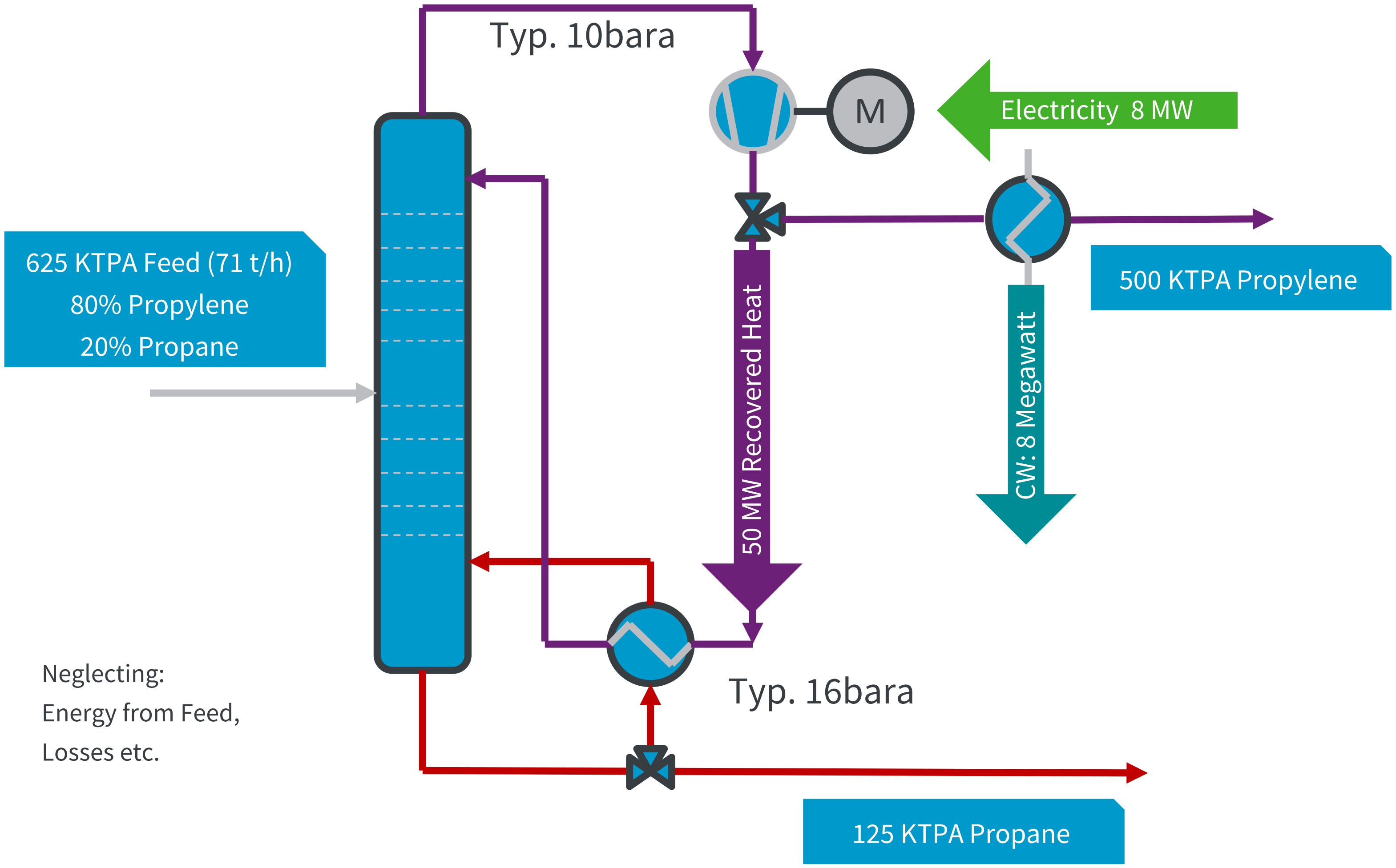


Neglecting:
Energy from Feed,
Losses etc.

- Steam Compressor is „**keeping the energy in the system“**
- Uses the condensation heat of top fraction for heating the bottom
- Only product stream is condensated against cooling water (trim cooler)
- For **moving 50 Megawatts** of heat, the compressor uses **only 8 Megawatts** electricity
- **COP** (Coefficient of Performance) of this system is 50/8 = **6.3!**
- If low-CO2 electricity is used, it is reducing the CO2 emissions to zero

2 Reference Case –LP Steam boosting with MVR

Customer Story

MVR Compressor as steam booster in DOW Polymer Plant (NL)

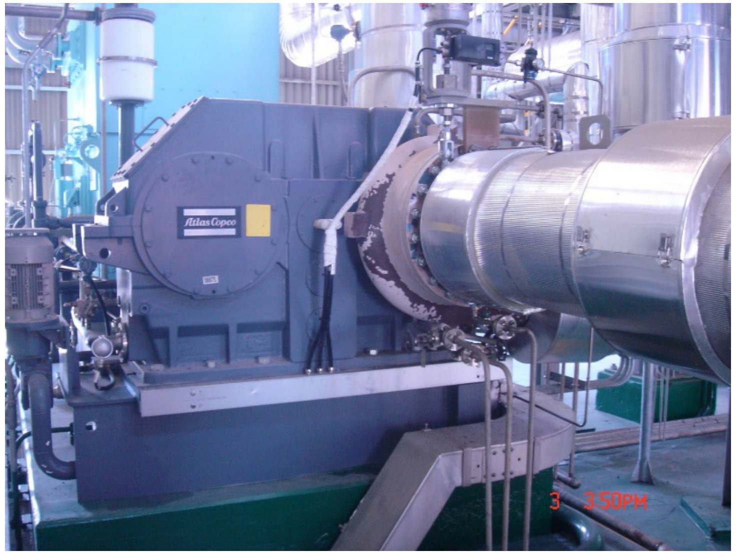
Code word	Name of buyer	Compressor type	Q'ty	Gas handled	Massflow kg/h	t1 °C	P1 bar(a)	P2 bar(a)	Driver Power kW
Terneuzen	DOW Chemical	GT026T2K1	1	H20	12 000	170	3.92	13.5	1 510

- Two-stage, compact radial steam compressor
- Upgrade of excess LP steam in Polymer production plant of Dow Chemical
- Output MP steam is injected into plant network and used in existing heat exchangers
- Annual CO_2 savings: Approx. 18 KTPA CO_2

Reference Case – LP Steam boosting with MVR

MVR Compressor as steam booster in Korean Chemical Plant

Code word	Name of buyer	Compressor type	Q'ty	Gas handled	Massflow kg/h	t1 °C	P1 bar(a)	P2 bar(a)	Driver Power kW
Korea	Conf.	GT032T2K1	1	H20	19 000	158	5.9	12.3	1 800



- Two-stage, compact radial steam compressor
- Upgrade of excess LP steam in Korean Chemical Plant
- Output MP steam is injected into plant network and used in existing heat exchangers
- Annual CO2 savings: Approx. 22 KTPA CO2

Heating solutions for plant upgrades & retrofits

- **Steam / MVR Compressors** need to be **installed locally** at the source of steam (e.g. distillation tower or reactor)
- Connecting low pressure vapor lines are oftentimes large in diameter
- In existing plants, there is **not always sufficient space** for installing a new compressor locally
- Instead, an **Industrial Heat Pump** may be installed at a central location
- It uses the **existing infrastructure**, heat sources and heat sinks:
  - Cooling water network
  - Steam network

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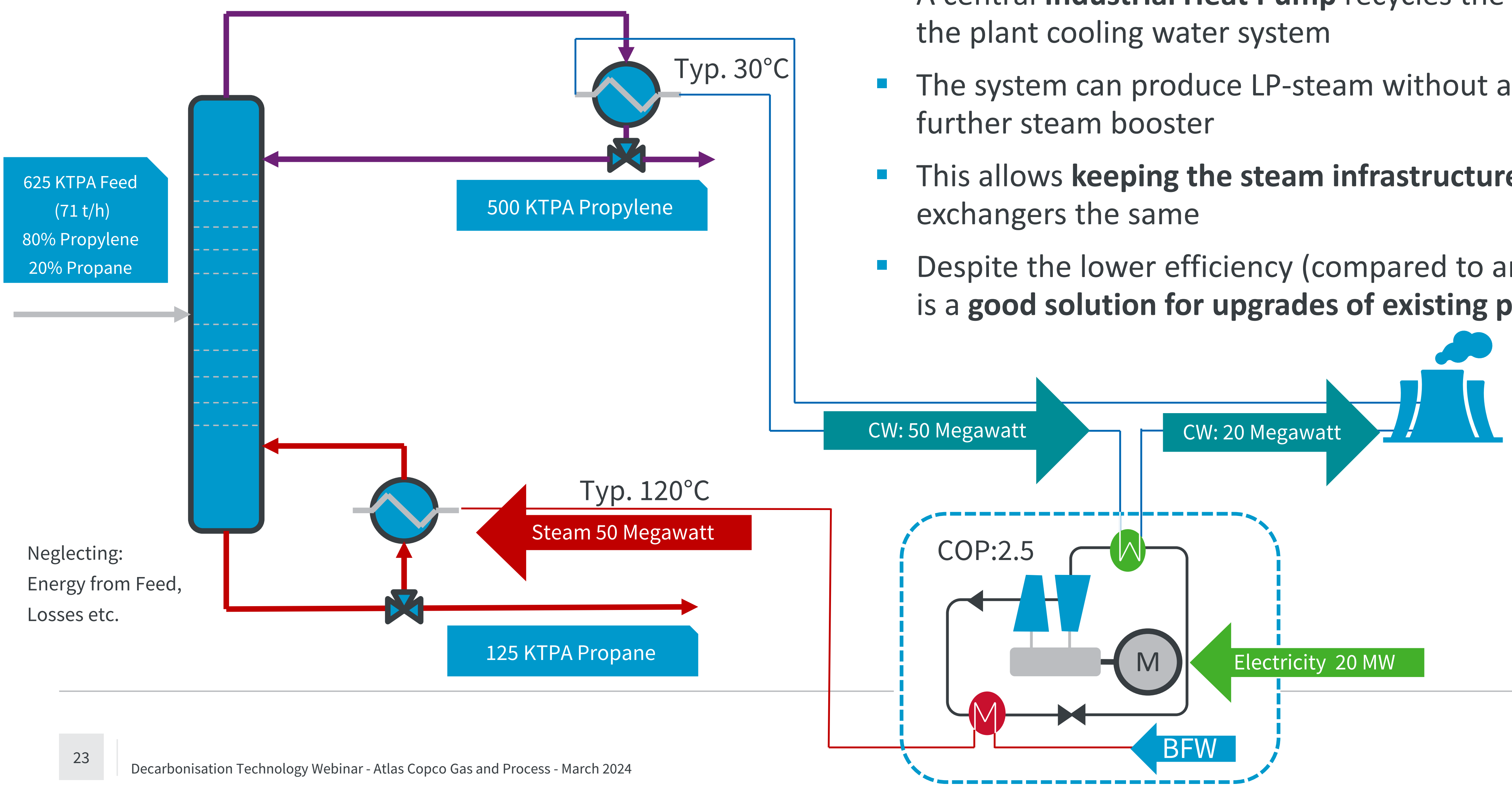
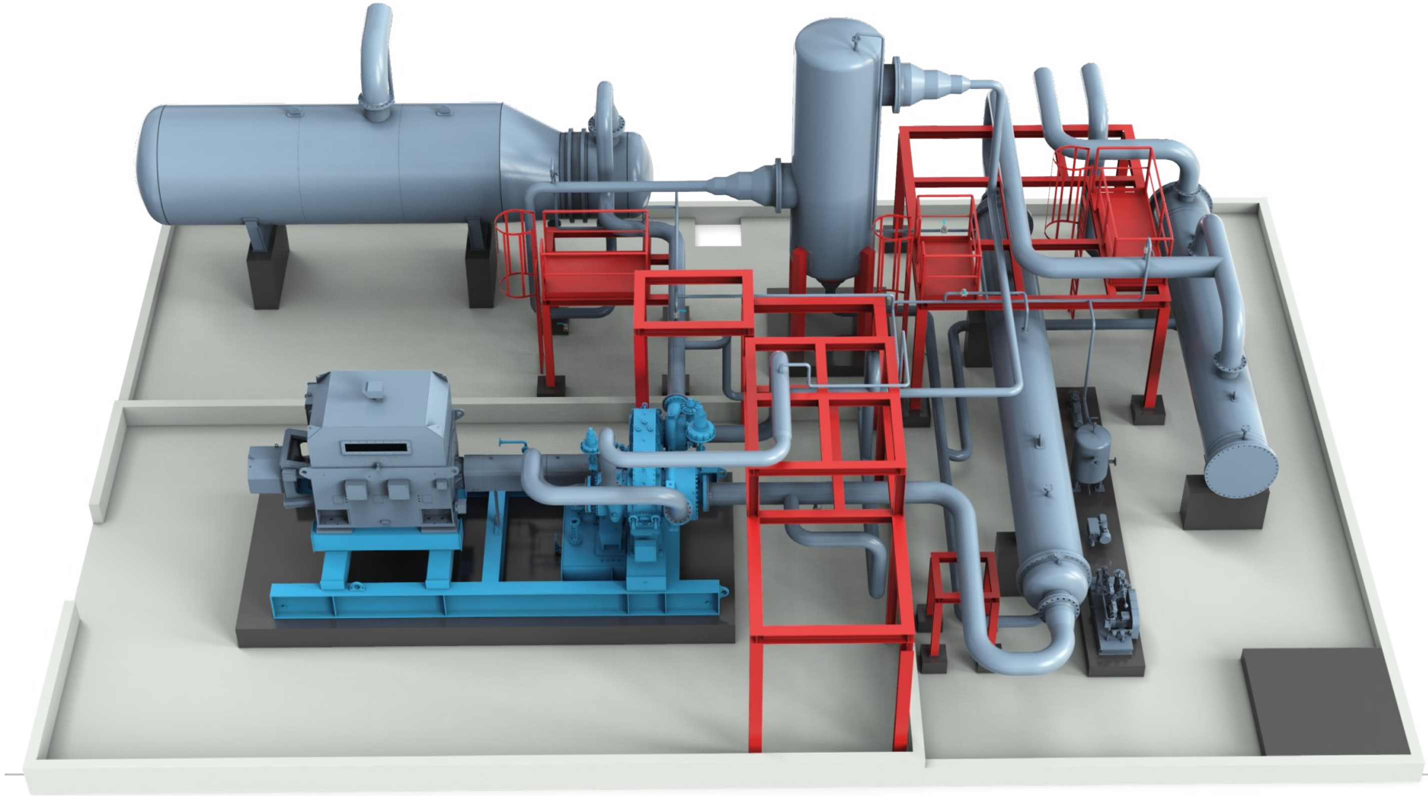
4 Case Study – Electrification of C3-Distillation with Heat Pump



- A central **Industrial Heat Pump** recycles the heat from the plant cooling water system
- The system can produce LP-steam without any further steam booster
- This allows **keeping the steam infrastructure** / heat exchangers the same
- Despite the lower efficiency (compared to an MVR), it is a **good solution for upgrades of existing plants.**

FEED Study – Heat pump for LP Steam production

- At a chemical park site in Germany, a butane heat pump shall generate process steam from waste heat (pre order phase).



Designation	Quantity	Unit
Steam massflow	17	t/h
Steam temperature	117	°C
Steam pressure	1.8	bara
Source parameter (in/out)	88/66	°C
Heat pump output	10.2	MW_{th}
COP (design case)	4.3	

Reference Cases – Industrial Heat Pumps

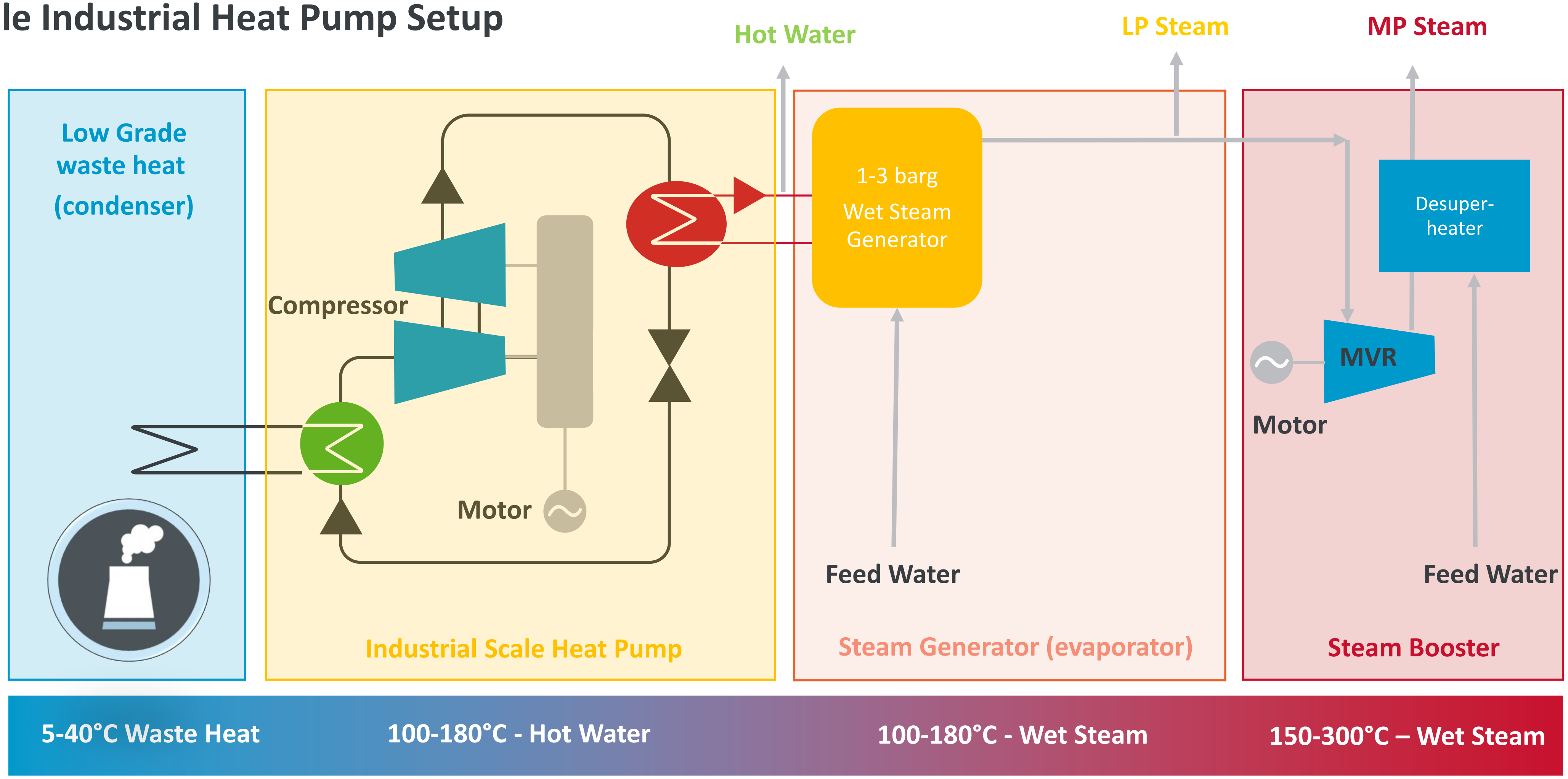
Customer Story

- Installations in heating systems
  - Göteborg
  - Hammarby
- District heat generation from Sewage Water
- RYA 3/4: **Worlds largest** and oldest industrial heat pumps
- In operation since 1984 / 1997
- Same technology applicable for process heat

Reference	Year	Quantity	Type	Thermal Power	Fluid
Hammarby	1997	2	GT078R3G1	40 Megawatt	R134a
RYA 3/4	1984	2	GT098R3G1	60 Megawatt	R12 (changed to R134a)

Steam Generation with booster compressor

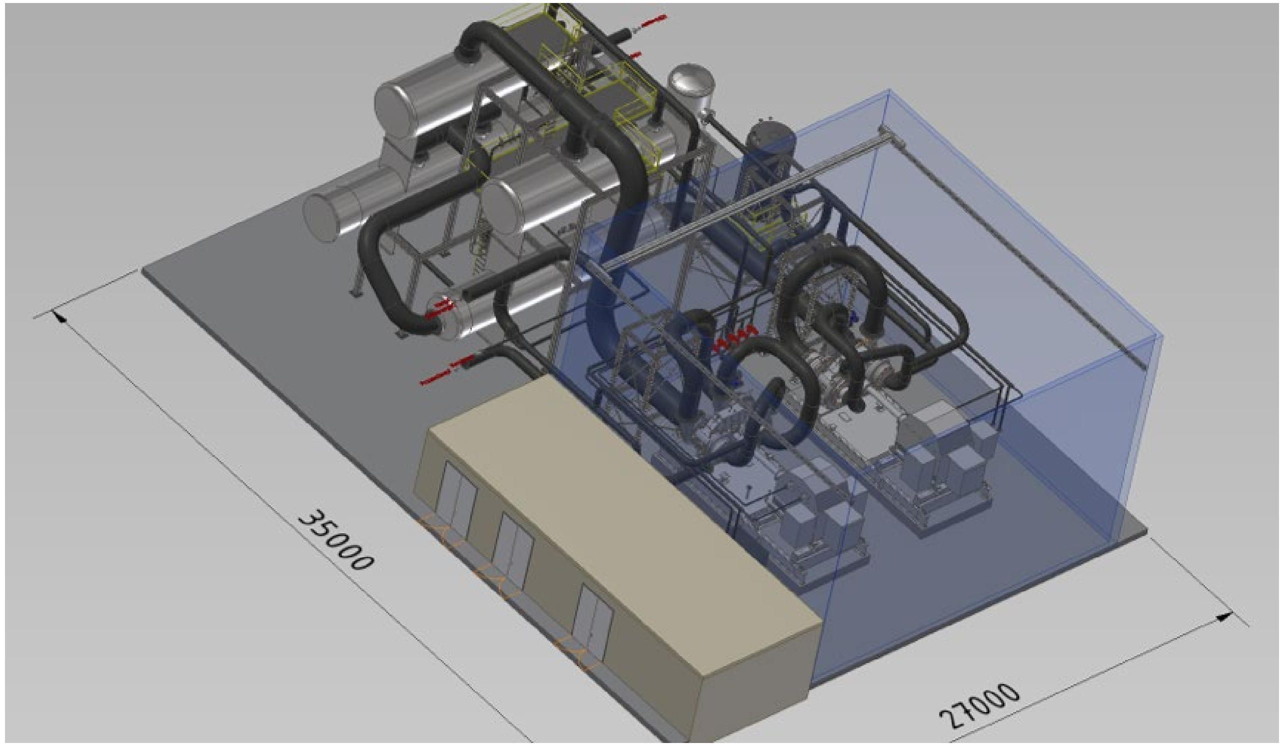
Possible Industrial Heat Pump Setup



7 FEED Study – Electrification of large scale steam supply system

Combination of heat pump and steam booster

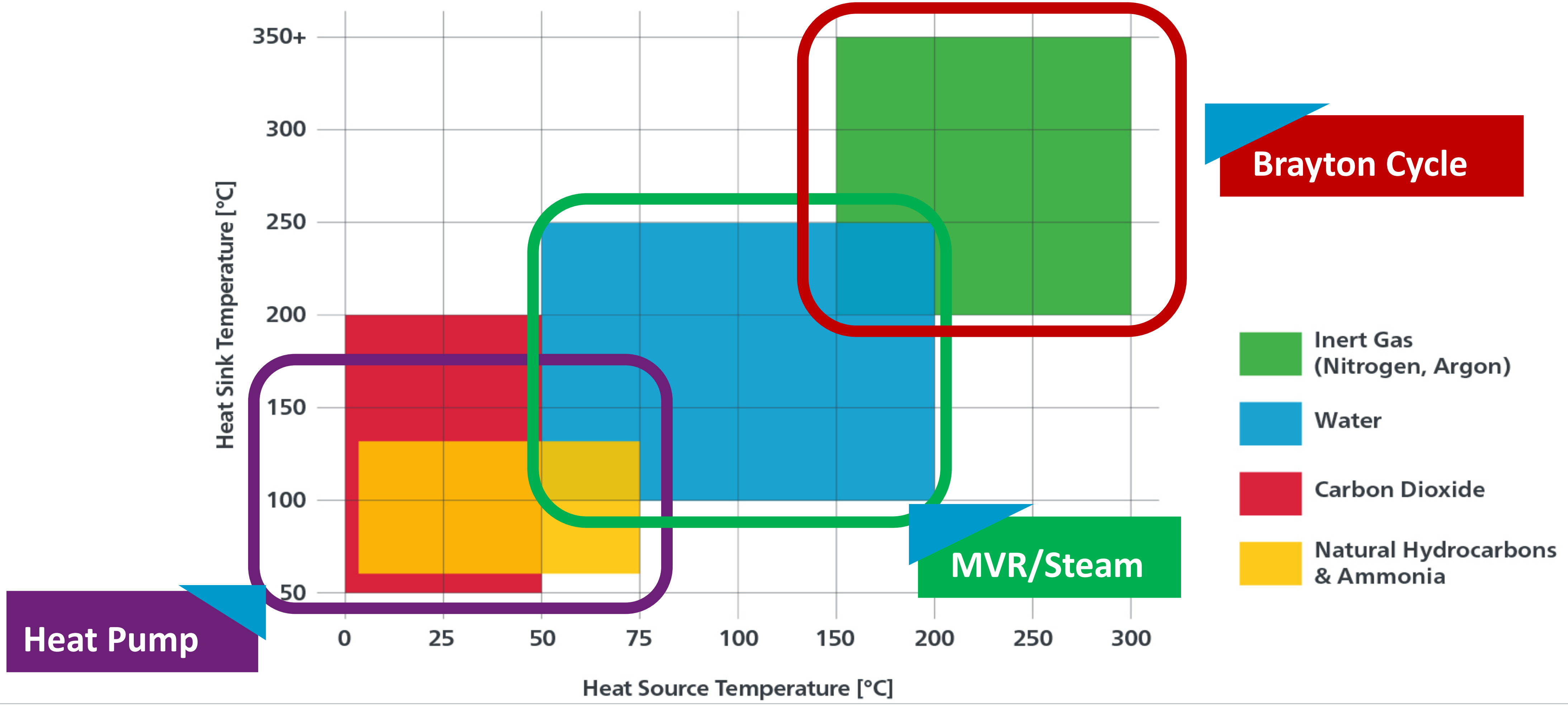
- For a planned paper factory, a butane heat pump with steam compressor shall produce 8bara steam from paper dryer waste heat at 45°C (pre-order phase)



Designation	Quantity	Unit
Steam massflow	65	t/h
Steam temperature	171	°C
Steam pressure	8.3	bara
Source temperature	48/35	°C
Heat pump output	44.5	MW_{th}
COP (design case)	2.0	

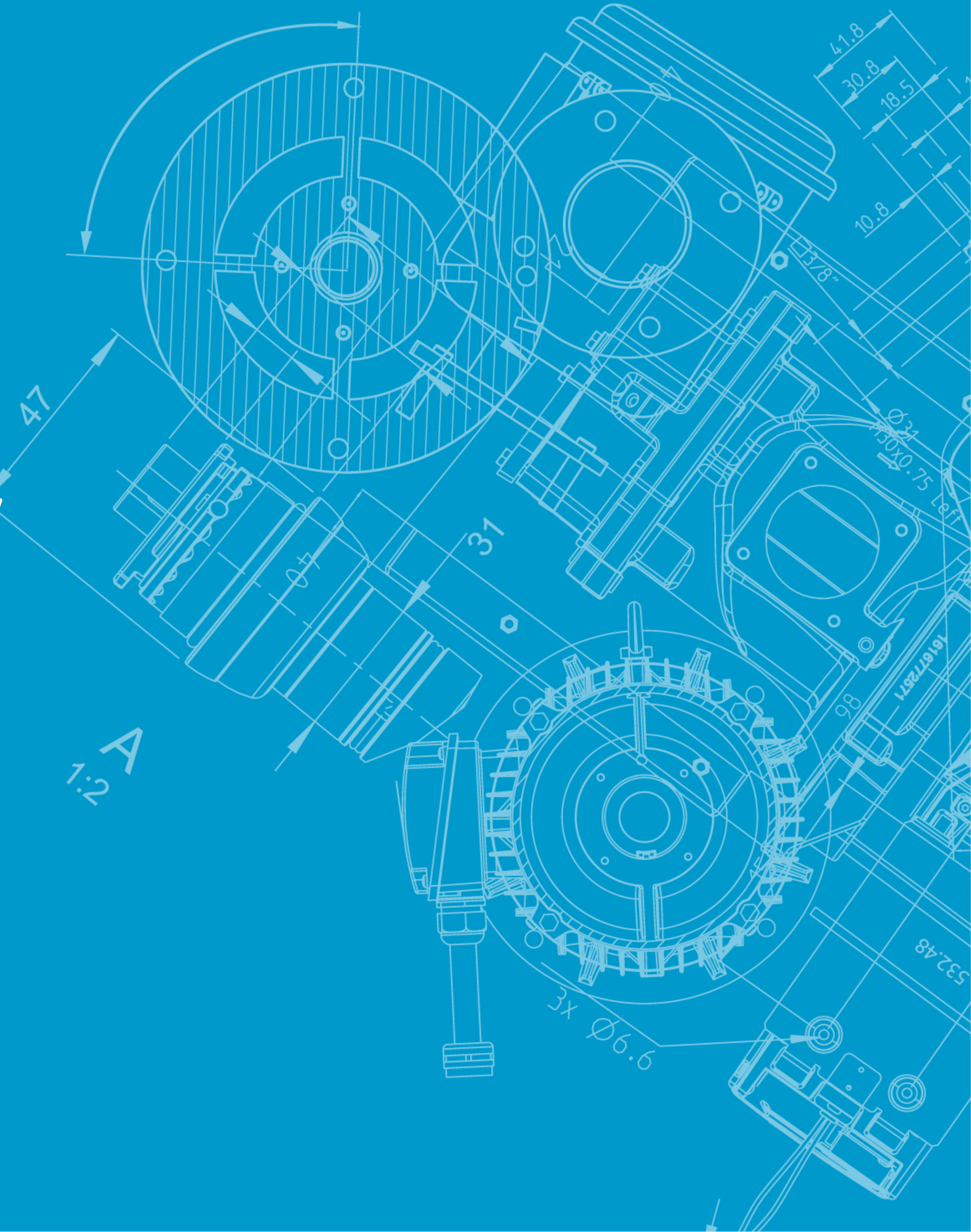
Industrial Process Heat

Atlas Copco Gas and Process turbomachinery can handle all common fluids and refrigerants

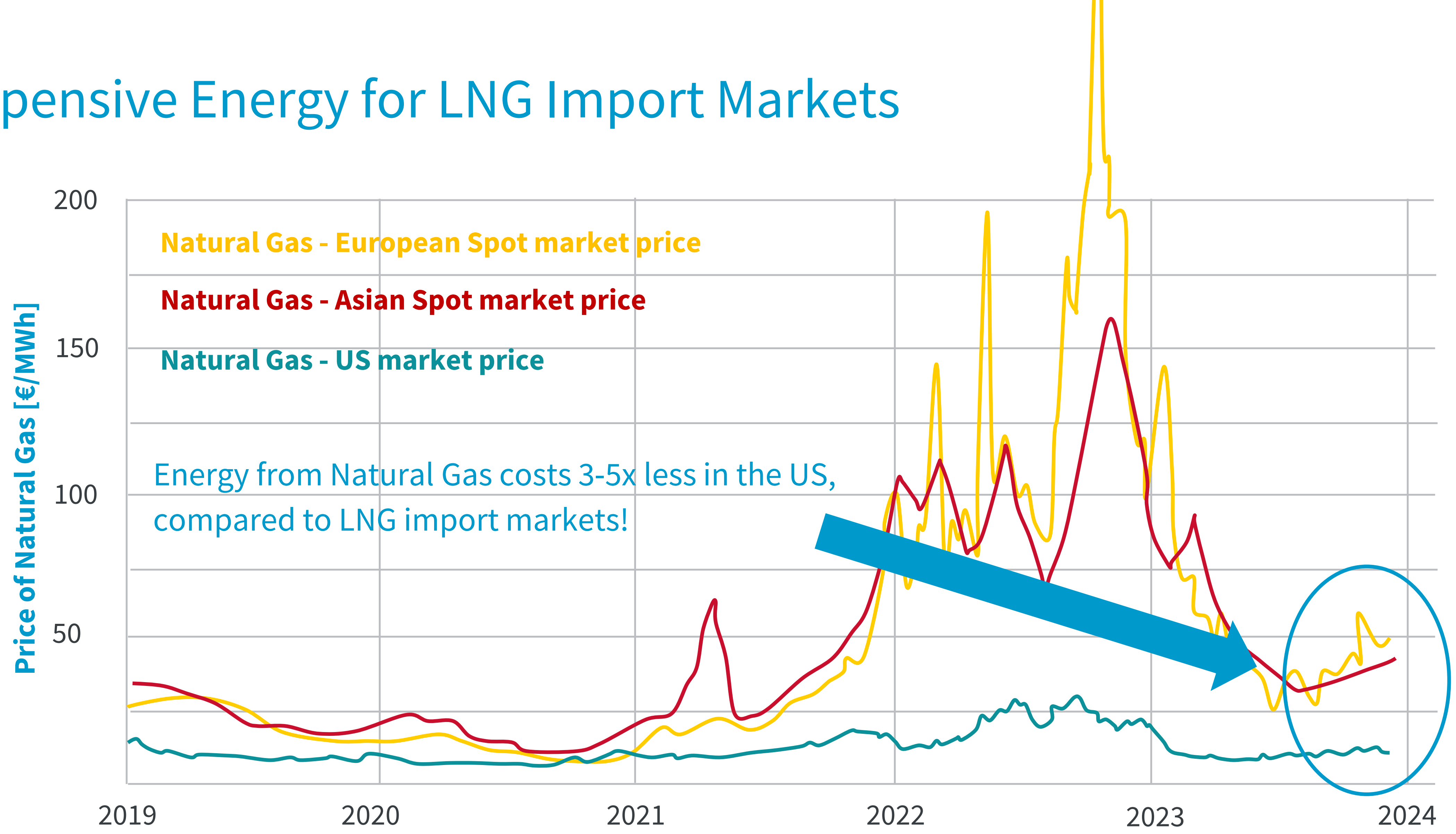


Economic aspects of energy efficiency

Fitness factors of a global economy

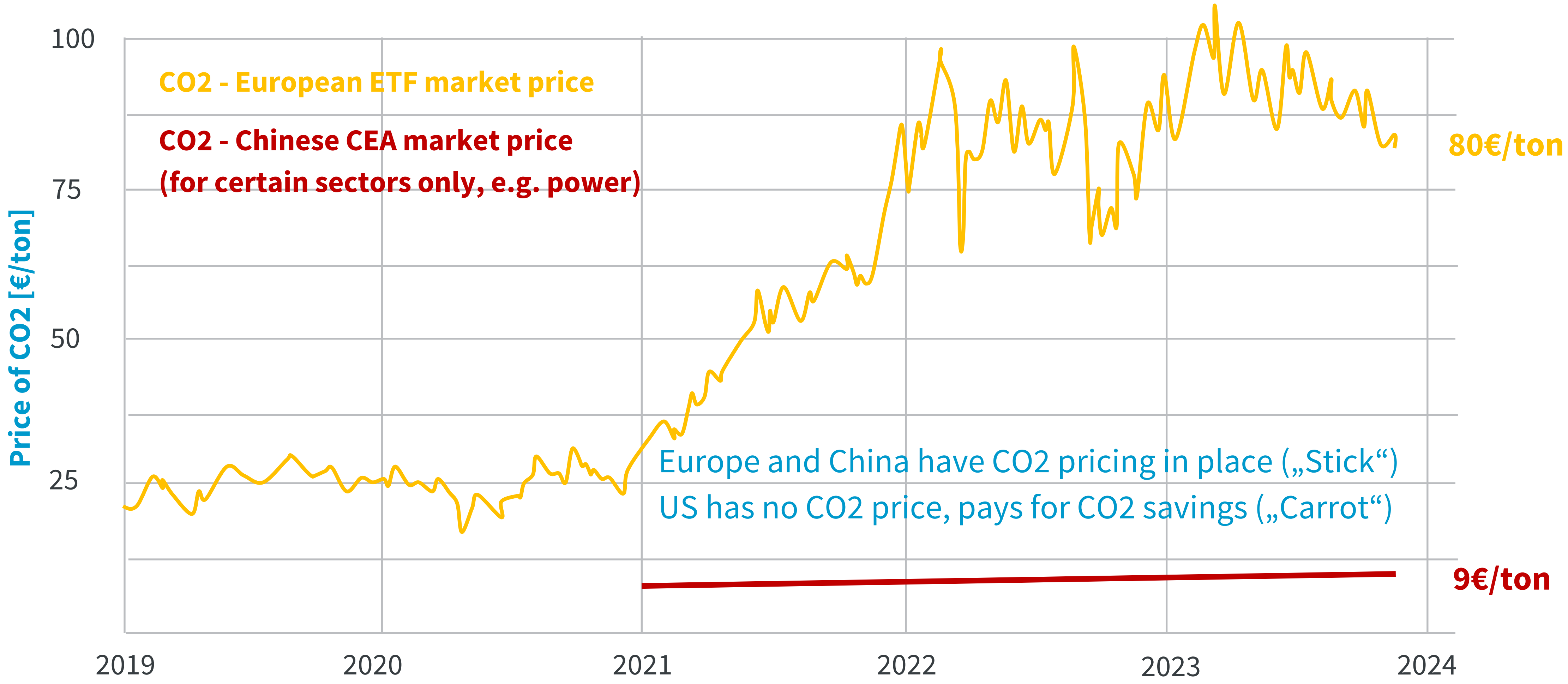


Expensive Energy for LNG Import Markets



Data from tradingeconomics.com and FRED Economic Data St. Louis

Carbon/CO_2 Tax catalyzes electrification



Data from S&P Global Commodity index

Soft factors driving decarbonsiation

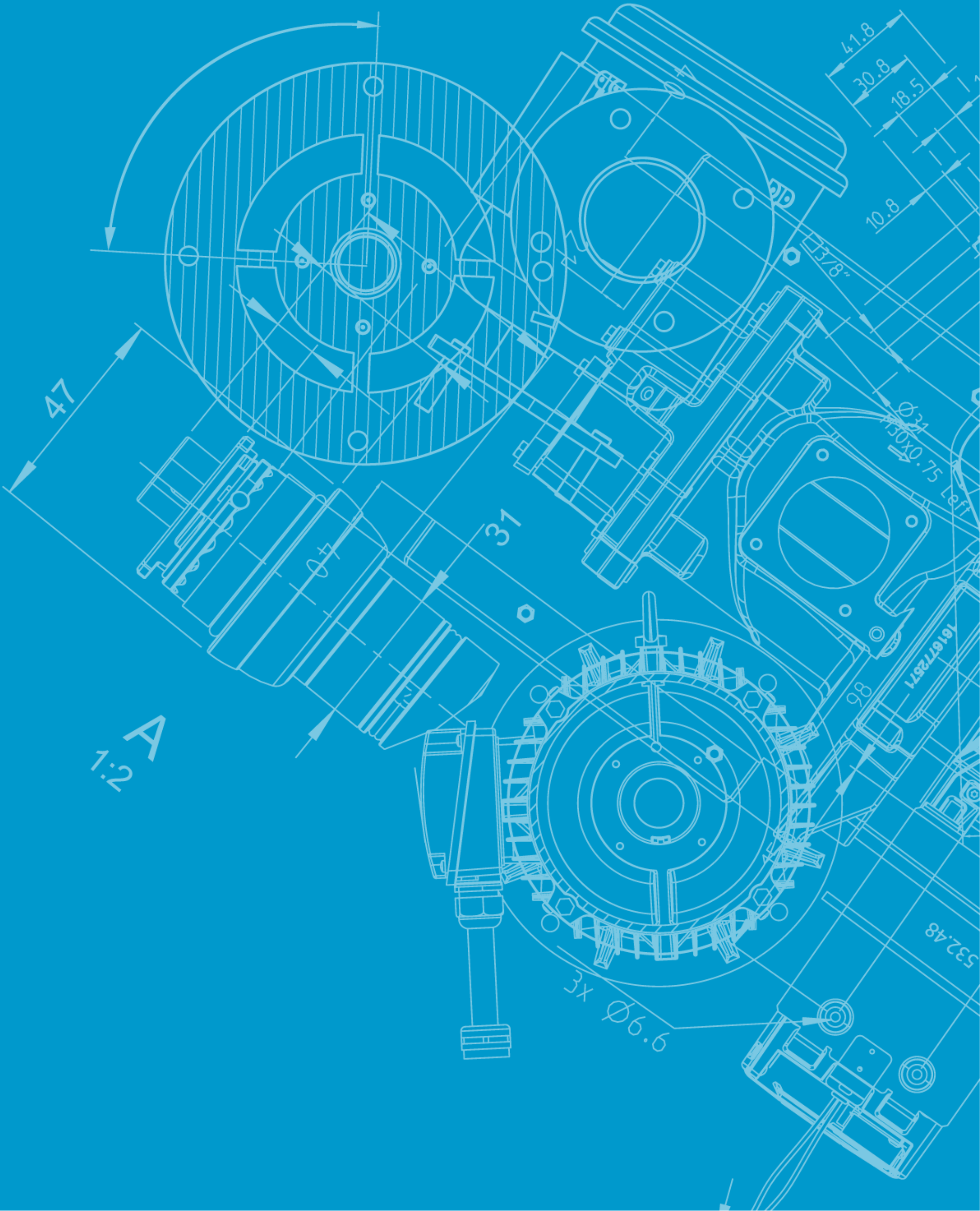
CO_2 footprint of products is moving into the focus of customer & investor awareness

- Examples of “carbon neutral” products and services
- No direct need for it (still good products and services!)
- However: image, investors, sustainability, and truly green thinking change our decision-making

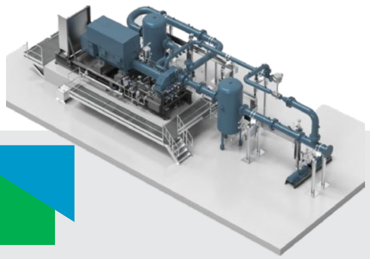
Climate neutral
Print product
ClimatePartner.com/53446-1901-1001

Summary and wrap up

What to keep in mind from this webinar

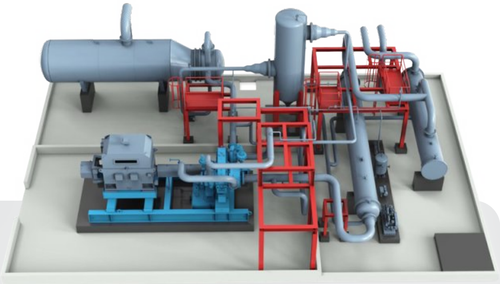


Comparison – MVR vs. Heat Pump



Steam Compressor (MVR)

- Use direct „high-value“ heat from vapor
- No temperature level losses in heat exchanger or in cooling water system
- Use either water or process fluid: no „content management“ required
- Much more compact than vapor blowers
- Large pipes, especially at low pressure
- Often hard to add in existing plants, as it has to be installed locally



Heat Pump

- Already low temperatures usable (<50°)
- Temperatures up to 150°C possible, 250°C with steam booster
- Can be combined with existing plant infrastructure (replacing cooling tower and boiler)
- Requires separate refrigerant / „content management“
- More complicated
- Less efficient in head-to-head comparison

Remember: The heat pump is the universal plan B, if direct steam compression by MVR is not possible!

Electrification of process heat is unavoidable

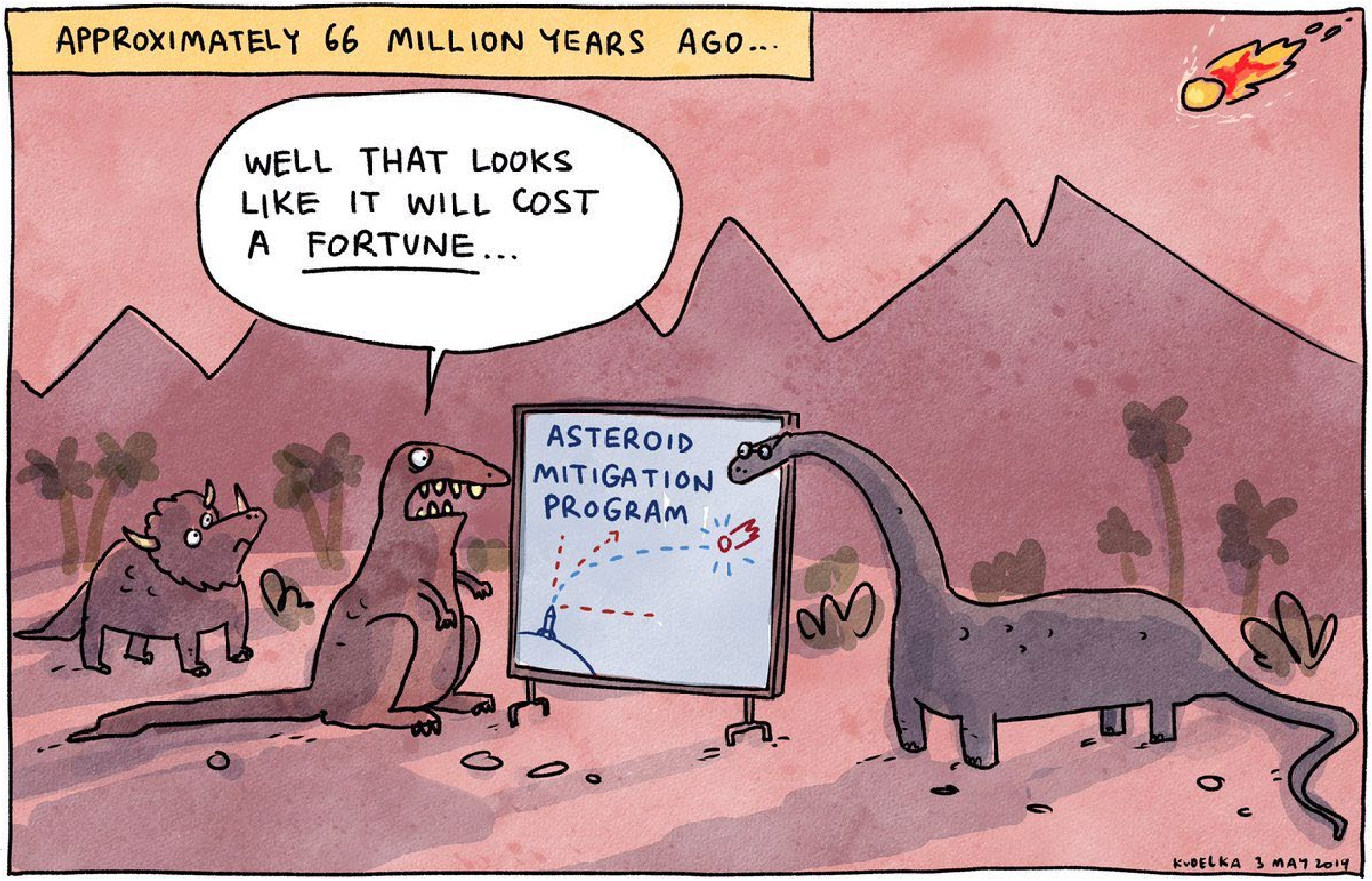
The next step in industrial evolution

Electrification is a trend that will go mainstage

- The availability of an energy source has always determined their use
- Wood, replaced by Coal, replaced by Natural Gas, now replaced by „abundant“ renewable/low CO_2 Electricity
- Heat Pumps and MVR are the tools for efficient electrification
- Not a „green thing“, just the next technology *
- Efficient and responsible use of energy a true **fitness factor** for industry

*= We believe that CCUS and Hydrogen will play important roles as well, but mainly for „hard to abate industries“ (steel, cement, transport etc.)

Speaking of Industrial **Fitness Factors**:



Thank you!

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