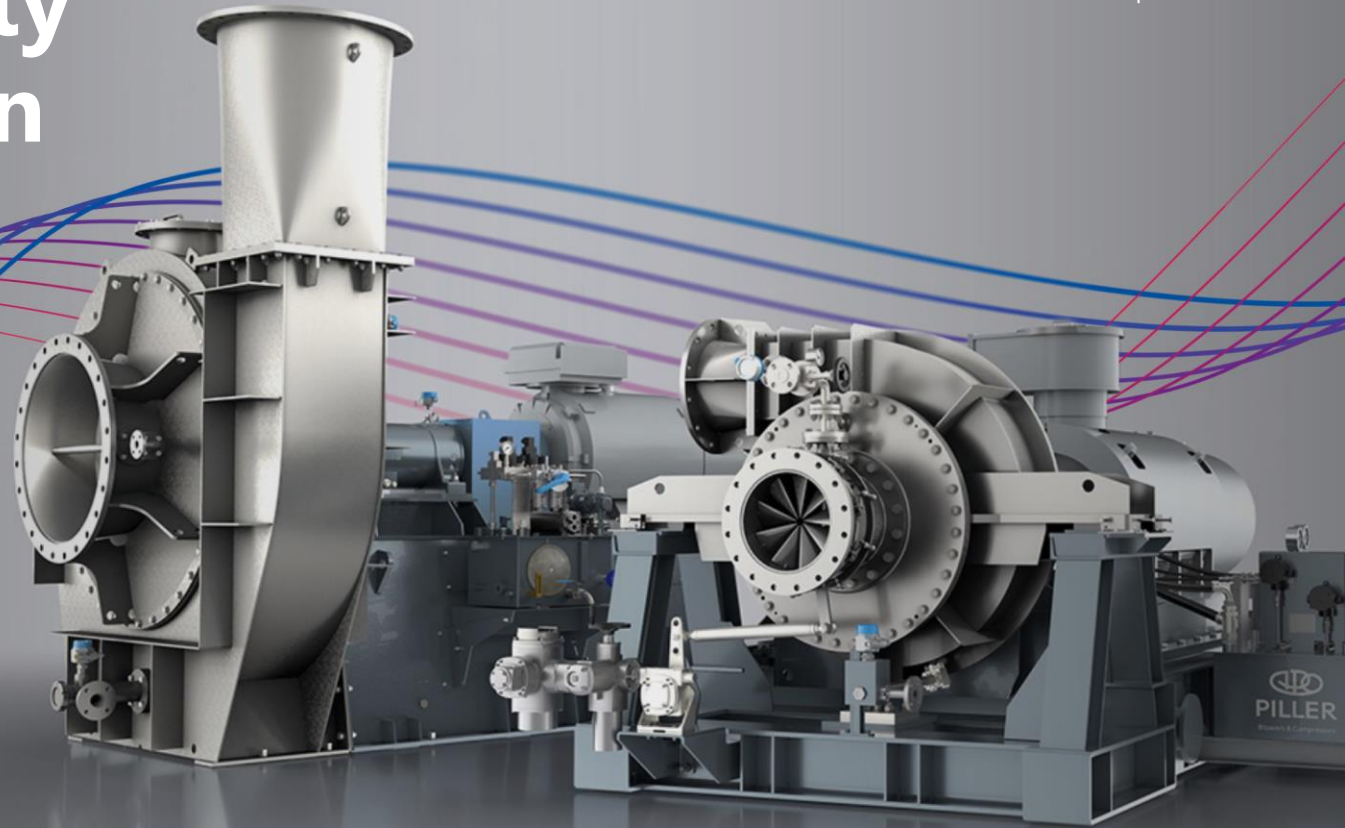


Waste Vapor/Steam Recovery to Reduce Utility Cost and Carbon Emission

Industrial Heat Pump Technology by
PILLER


PILLER
Blowers & Compressors




ALWAYS ADVANCING

Agenda

PILLER at a Glance



Jeff Choong

Head of Regional Sales (SEA)

Piller Blowers & Compressors

1. PILLER Introduction
2. Industries and Application
3. Why Waste Vapor is worth Recovering?
4. What is MVR?
5. References sharing

About PILLER



Founded
1909

Employees*
546

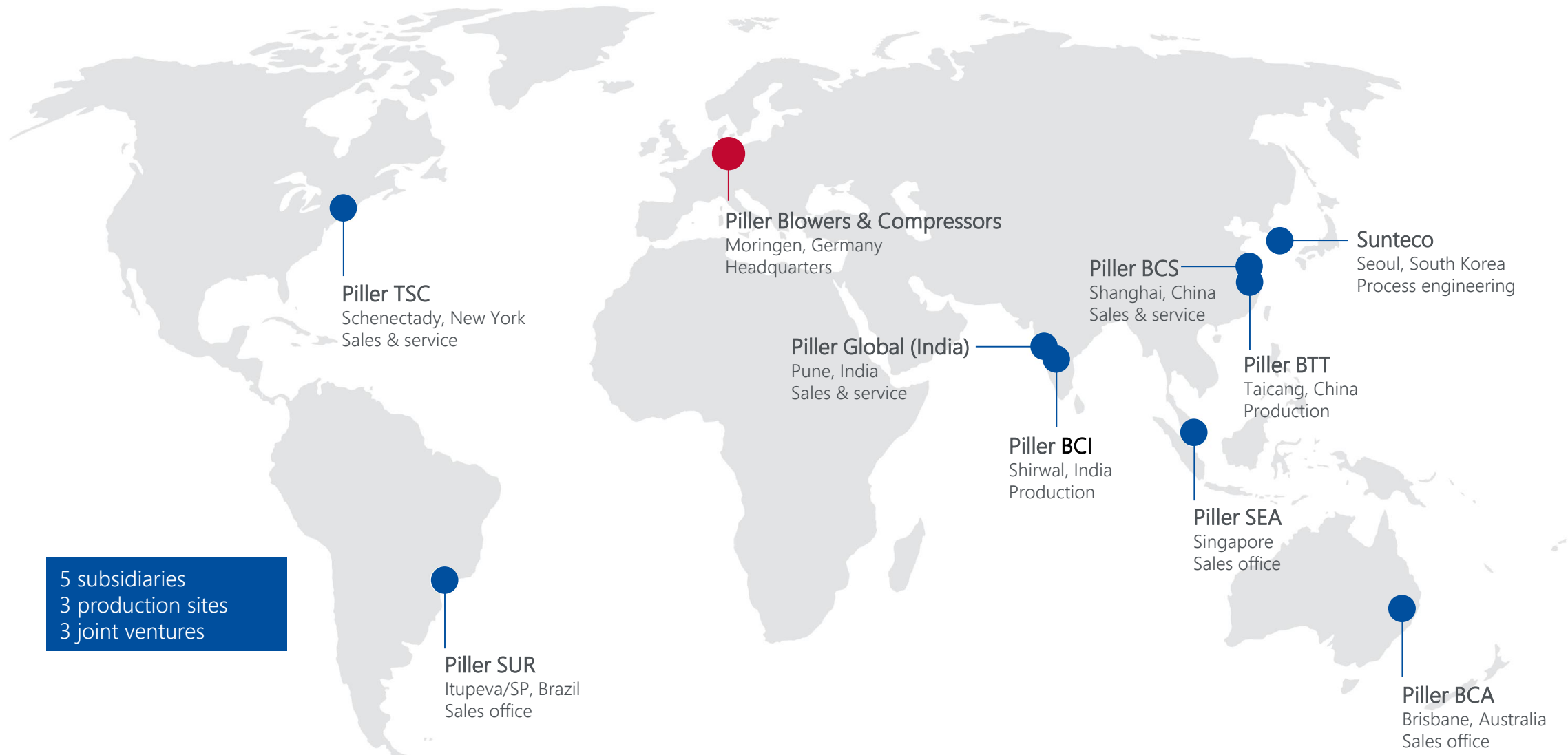
6,000+ MVR
Machines installed

100%
family-run

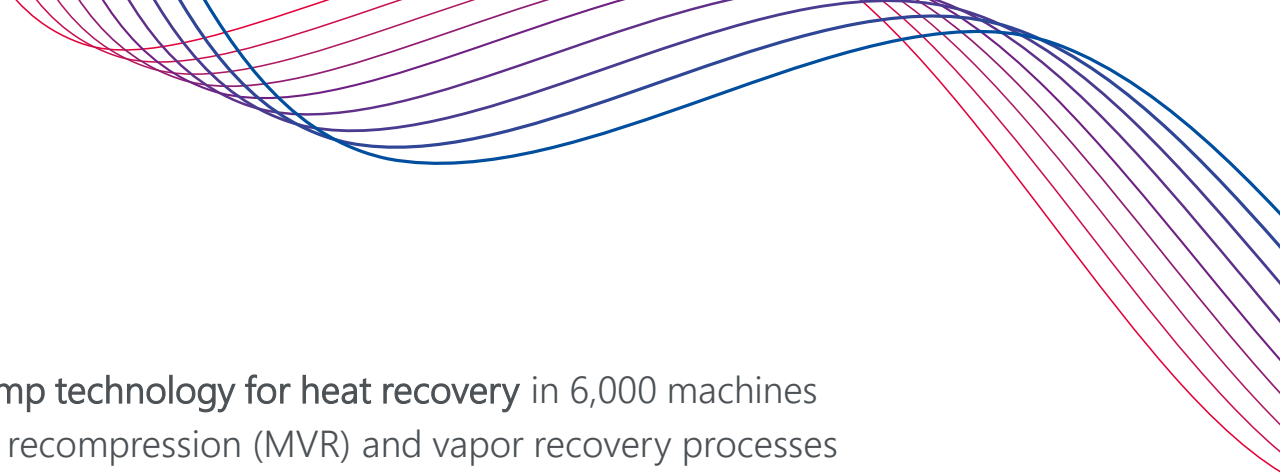


About PILLER

Worldwide, Sales, Service and Production



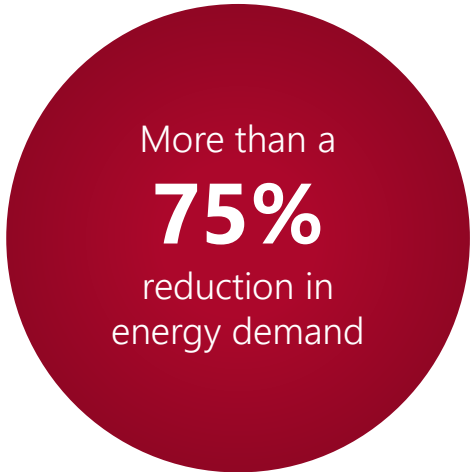
5 subsidiaries
3 production sites
3 joint ventures



Technological Focus

Strategic Focus

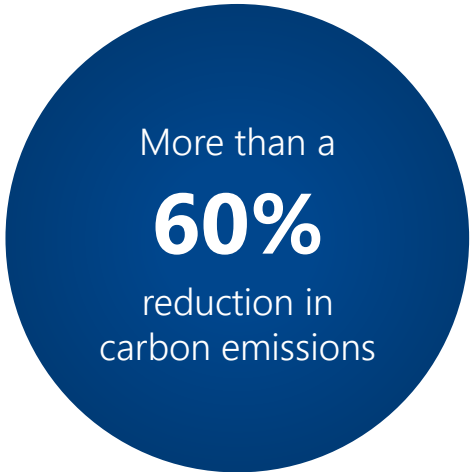
At present, PILLER supports customers with **innovative industrial heat pump technology for heat recovery** in 6,000 machines worldwide. Our powerful blowers and compressors for mechanical vapor recompression (MVR) and vapor recovery processes significantly increase energy efficiency, reduce primary energy costs and lead to carbon reduction in processes.



More than a
75%
reduction in
energy demand



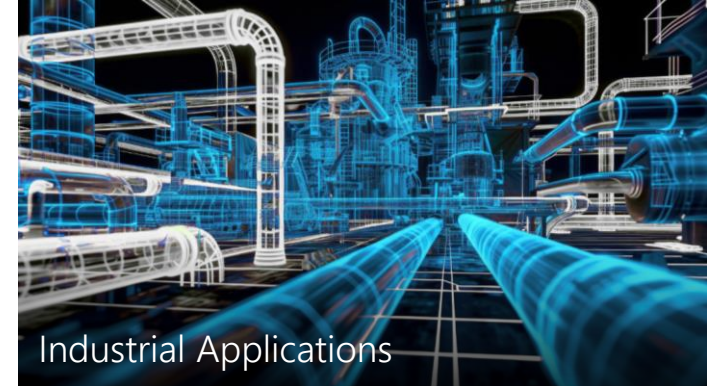
Up to a
90%
reduction in
energy costs



More than a
60%
reduction in
carbon emissions

About PILLER

Solutions for many Industries



Solutions for many Industries

Petrochemicals & Chemicals

- Platforming (CCR)
- Process blowers for Petrochemicals, Chemicals & Specialty Chemicals
- Carbon Capture and Storage (CCS)
 - Chemical Adsorption (Amine)
 - Membrane Absorption
 - Direct Air Capture
- Bioethanols
- Wastewater Treatment (ZLD)



Why is Waste Vapor Worth To Be Recovered?



1 ton of hot water from 99°C to 100°C

$$\begin{aligned} Q &= m \cdot c_p \cdot \Delta T \\ &= 1000 \text{ kg} \cdot 4.2 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} \cdot (100 - 99) \text{ K} \\ &= 4,190 \text{ kJ} \end{aligned}$$



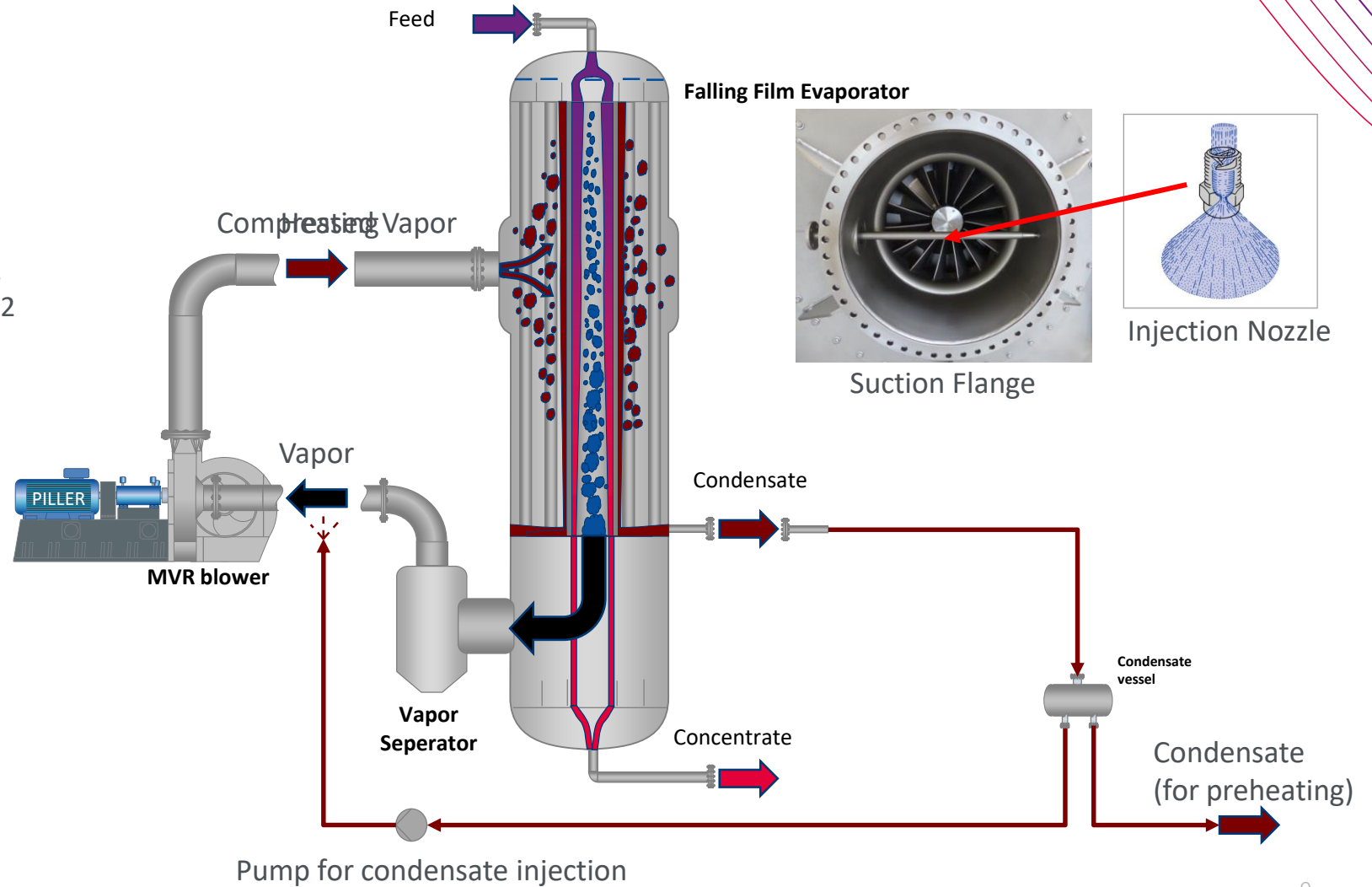
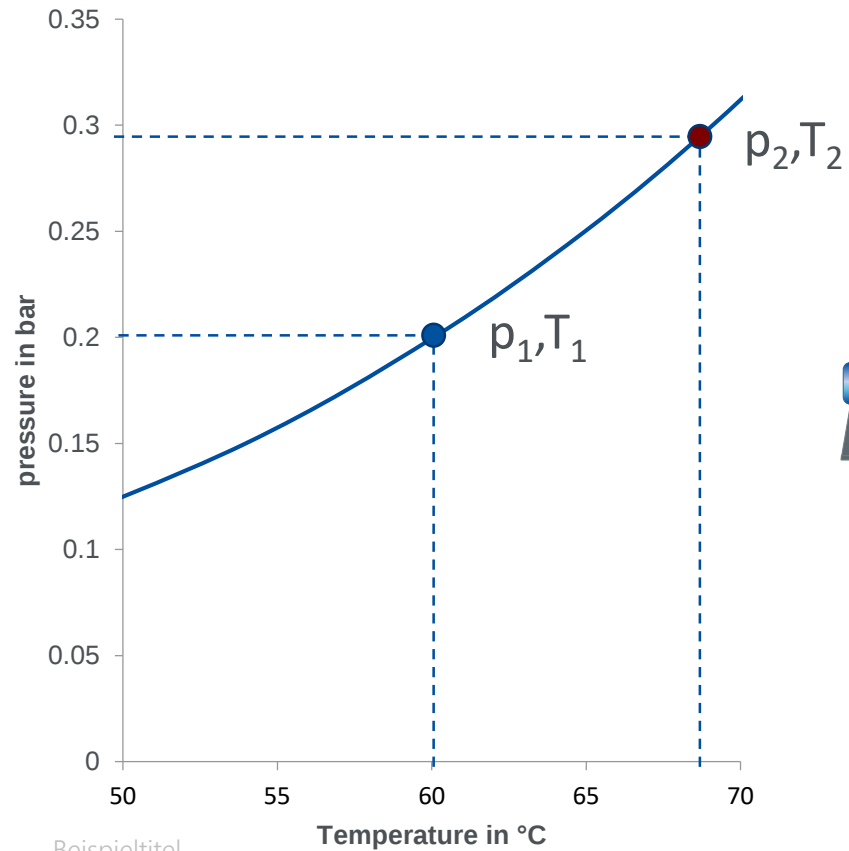
1 ton of 100°C water to 100°C Steam

$$\begin{aligned} Q &= m \cdot H_v \\ &= 1000 \text{ kg} \cdot 2256 \frac{\text{kJ}}{\text{kg}} \\ &= 2,256,470 \text{ kJ} \end{aligned}$$

538 times

HEAT PUMP PRINCIPLE

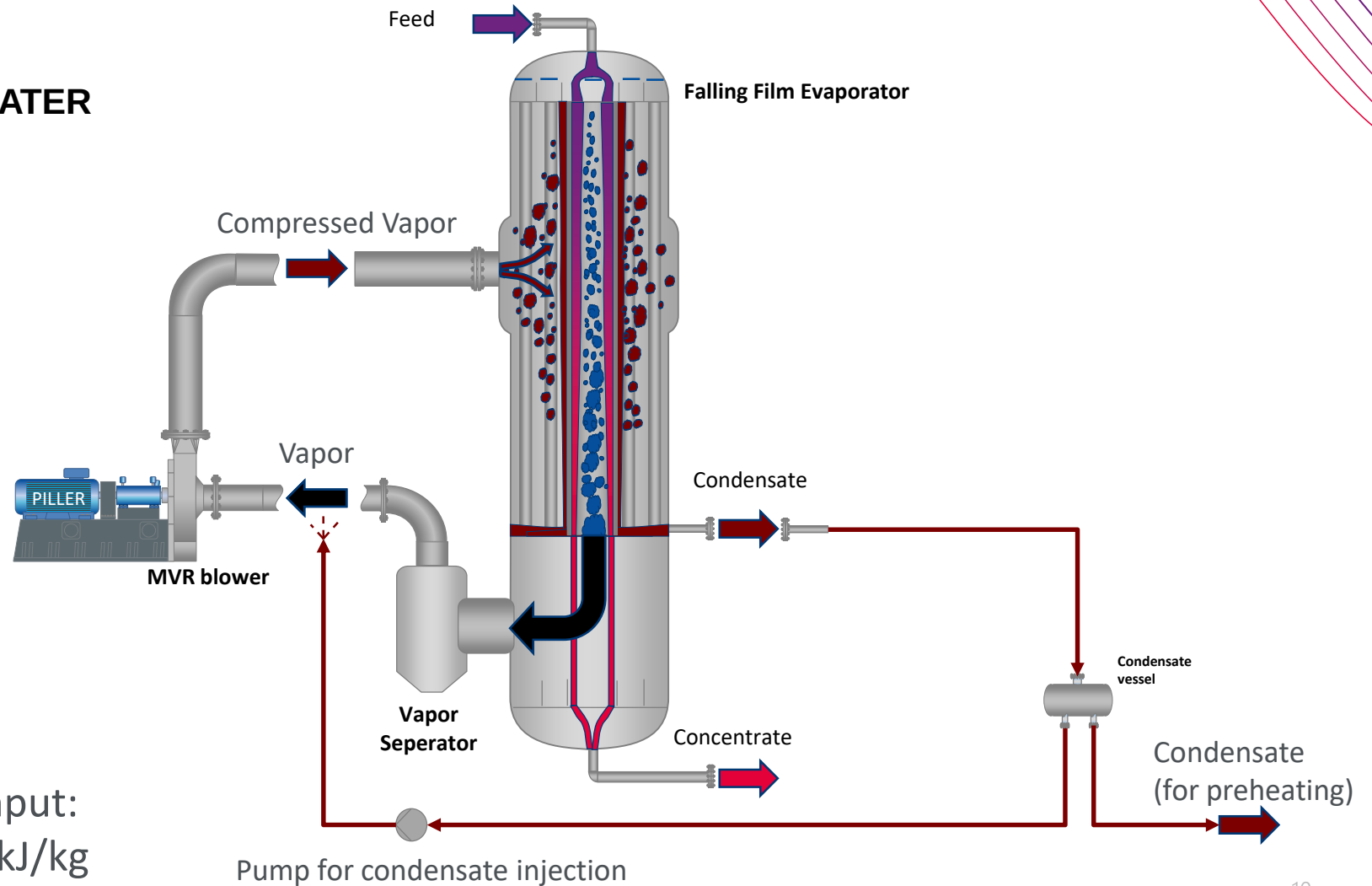
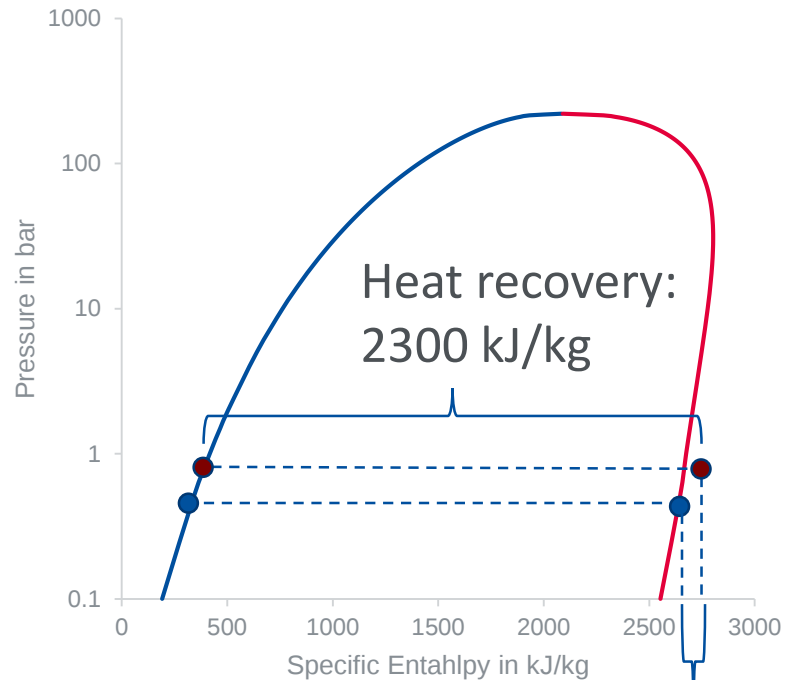
MECHANICAL VAPOR RECOMPRESSION (MVR)



HEAT PUMP PRINCIPLE

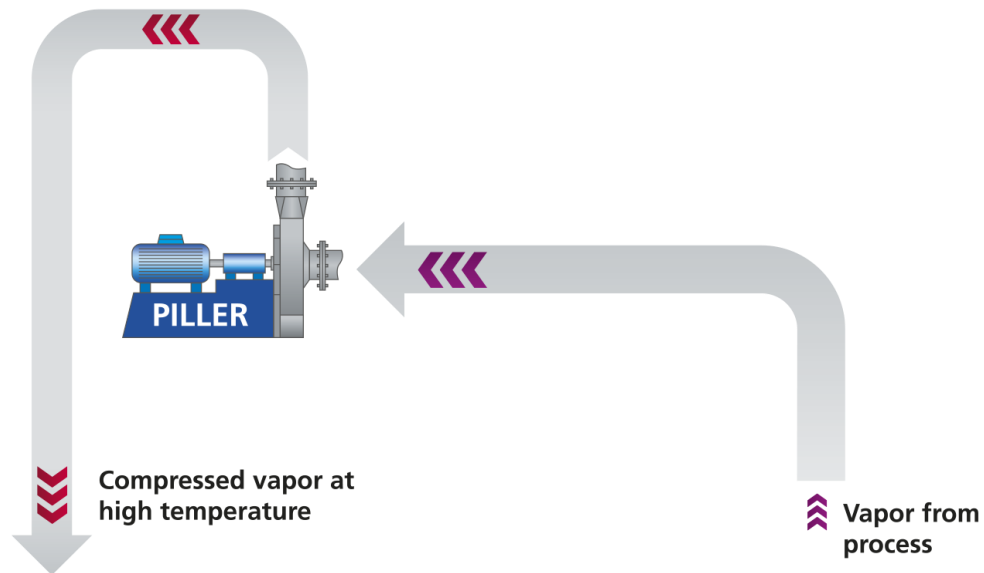
MECHANICAL VAPOR RECOMPRESSION (MVR)

LOG P – ENTHALPY DIAGRAM FOR WATER



Heat Pump Cycles with Piller Blowers & Compressors

MVR – OPEN LOOP HEAT PUMP



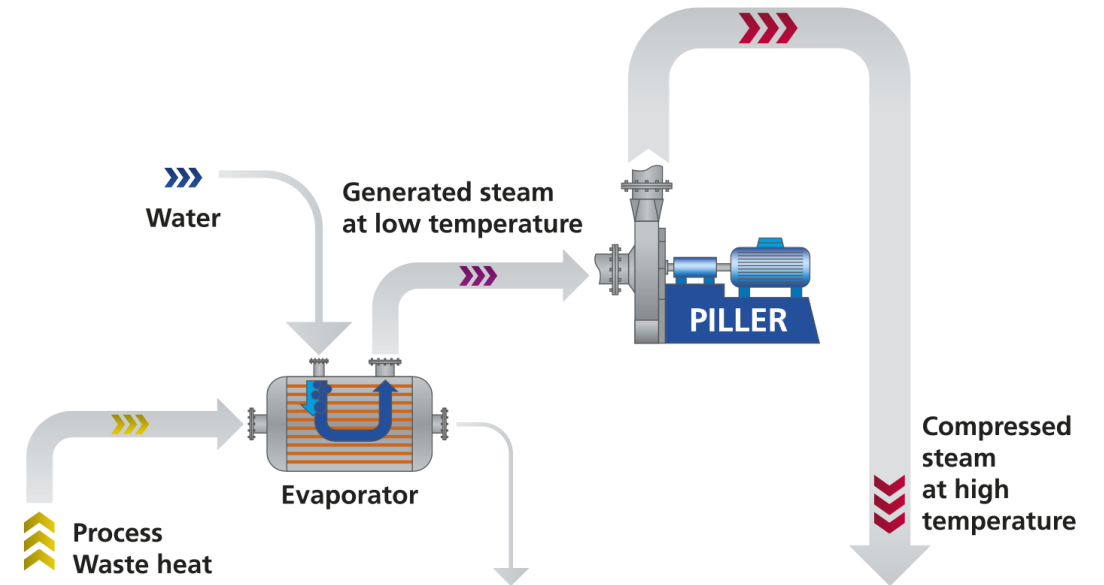
COMPRESSED VAPOR FOR

- Process Heating
- Steam generation

PROCESS VAPOR FROM

- Evaporation
- Crystallization
- Distillation
- Rectification
- Stripping
- Reactor
- Flash Vessel

COMPRESSION CYCLE WITH STEAM



WASTE HEAT FROM

- Contaminated process vapors
 - Evaporation
 - Crystallization
 - Rectification, Stripping
 - Reactor
- Waste streams (water, air, ...)

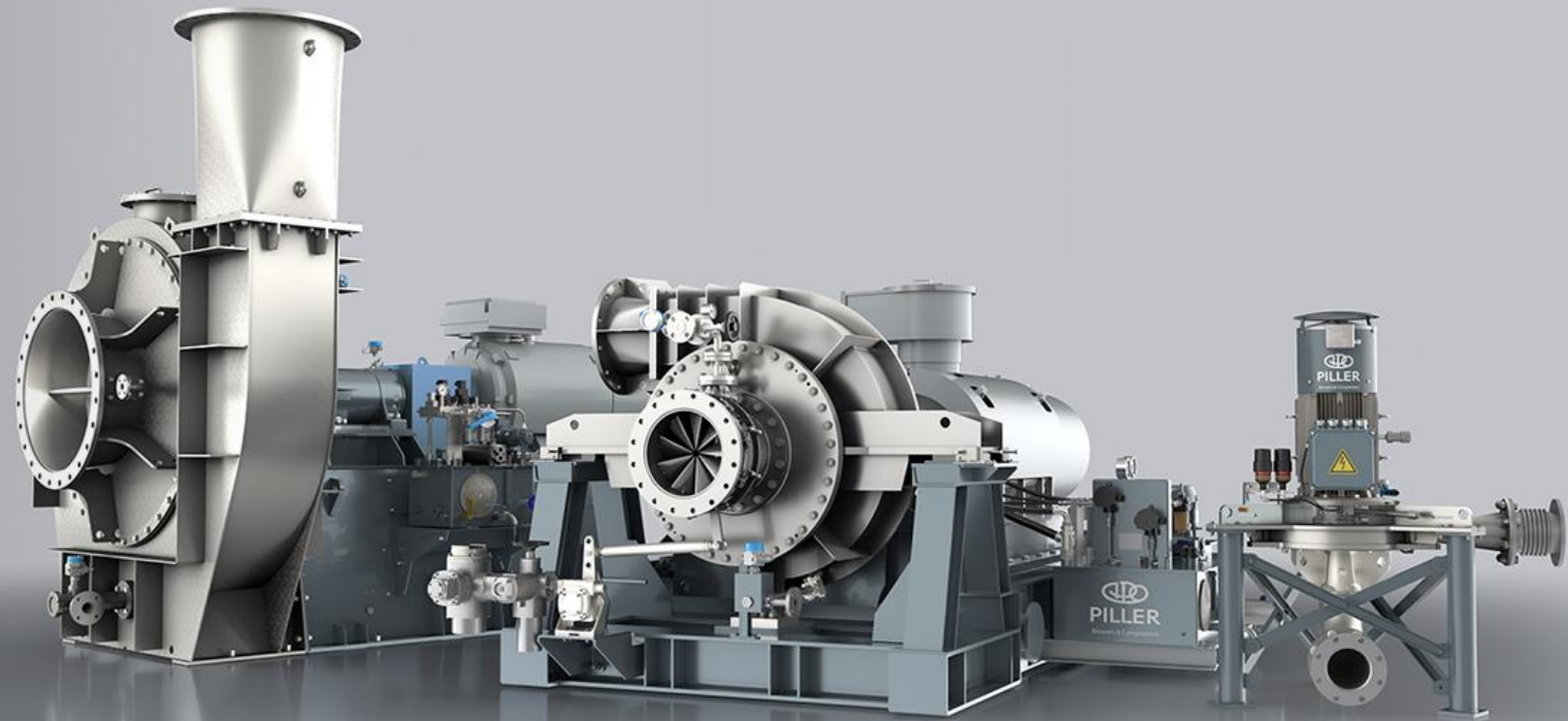
HIGH-TEMPERATURE STEAM FOR

- Process heating
- Feed in steam network

VapoLine®

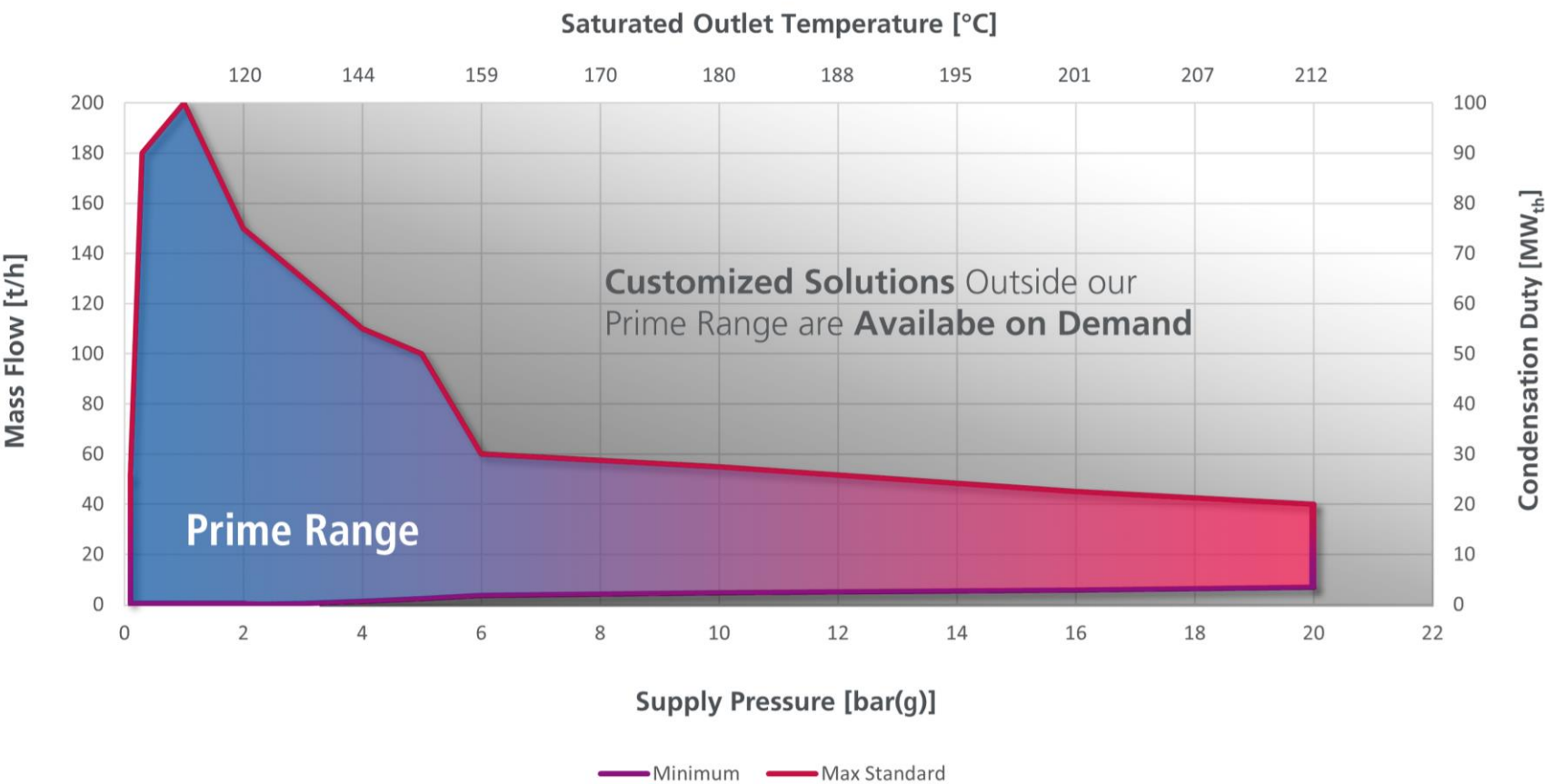
Expert For Mechanical Vapor Recompression (MVR)

- More than 40 years experiences with 6000+ installations



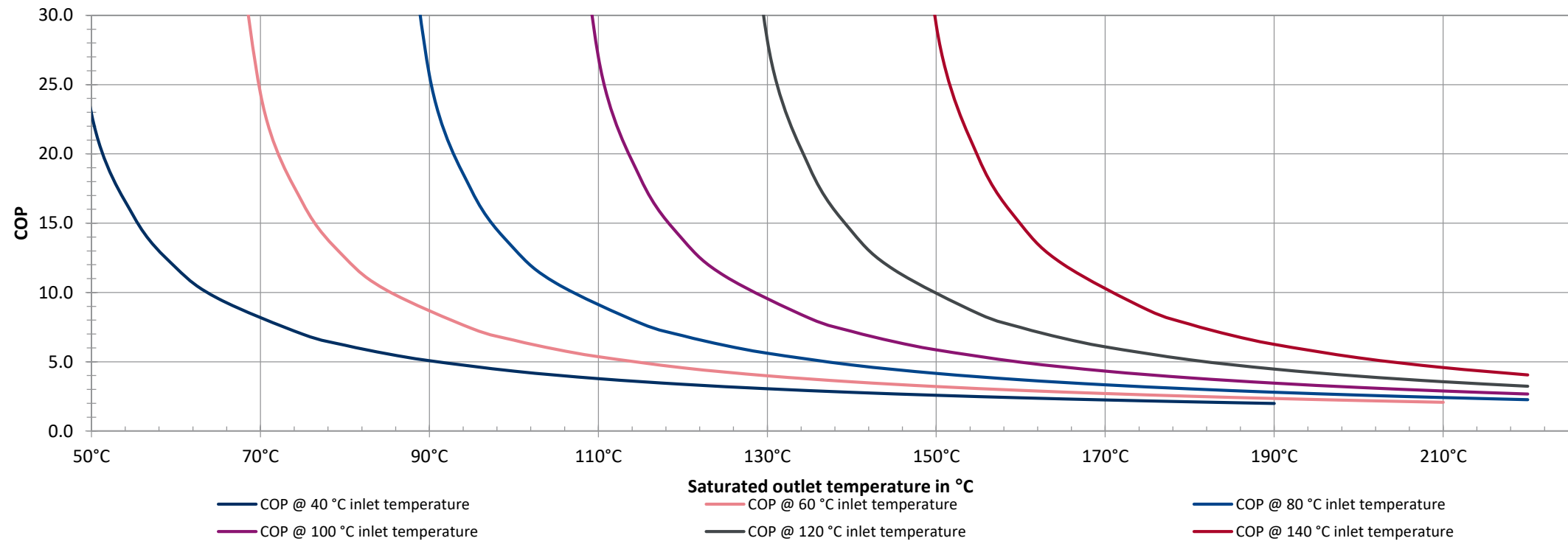
Performance Range

PILLER VapoLine® – Operation Range for Steam



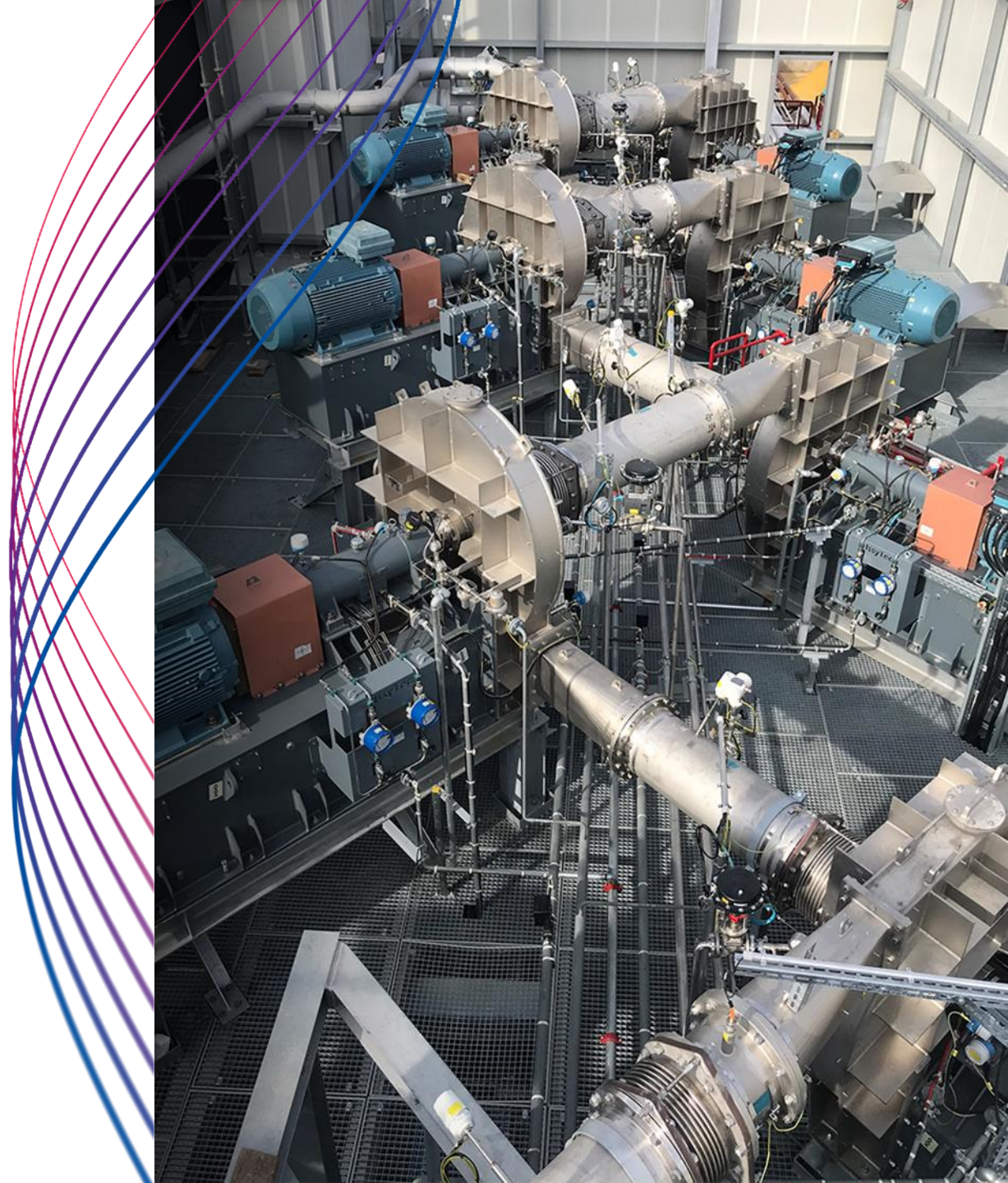
Performance Range

COP for different inlet temperatures - MVR steam heat pump



Bioethanol Compression

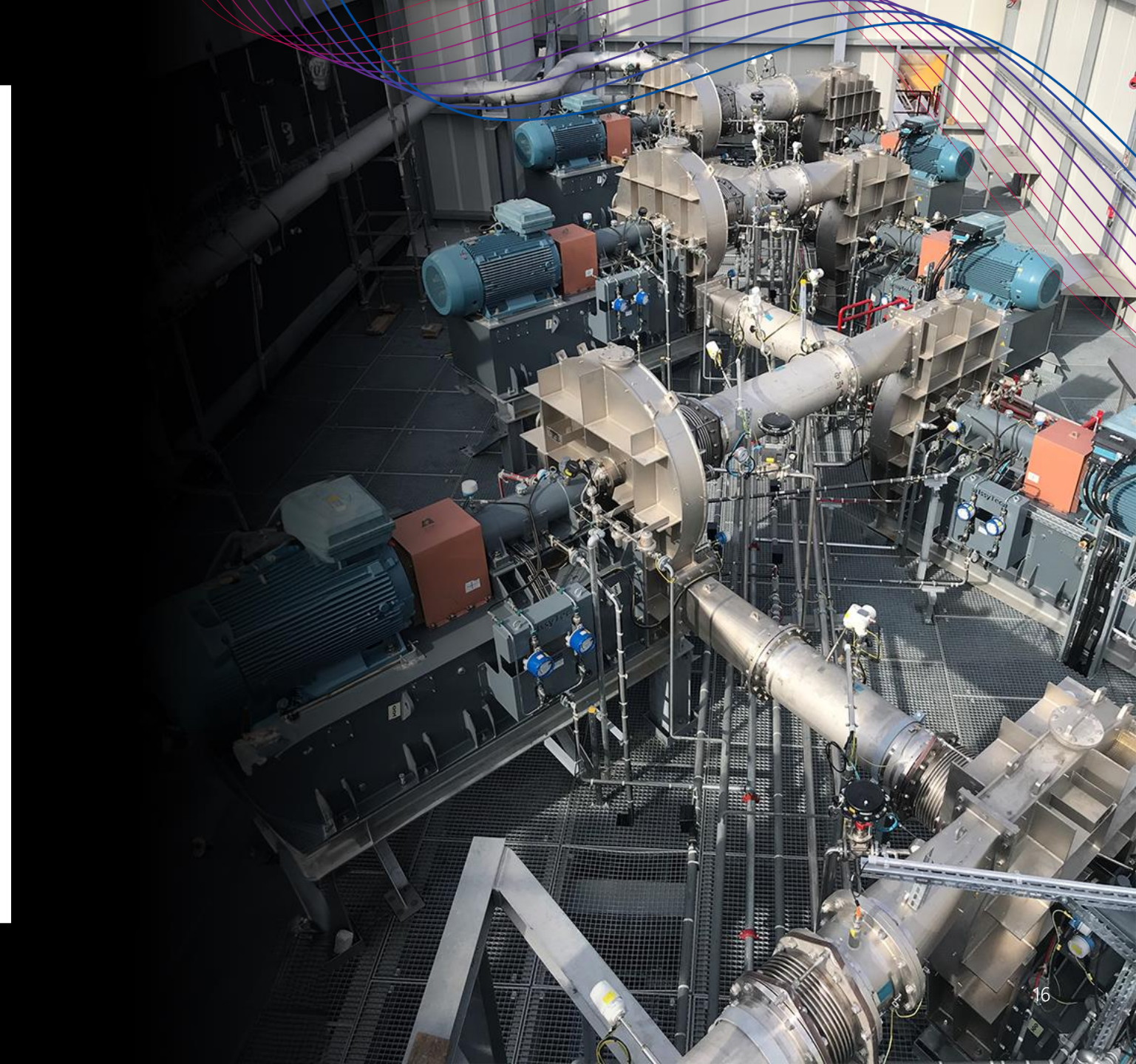
Success story: VapoFlex®



Pannonia Bio Case Study

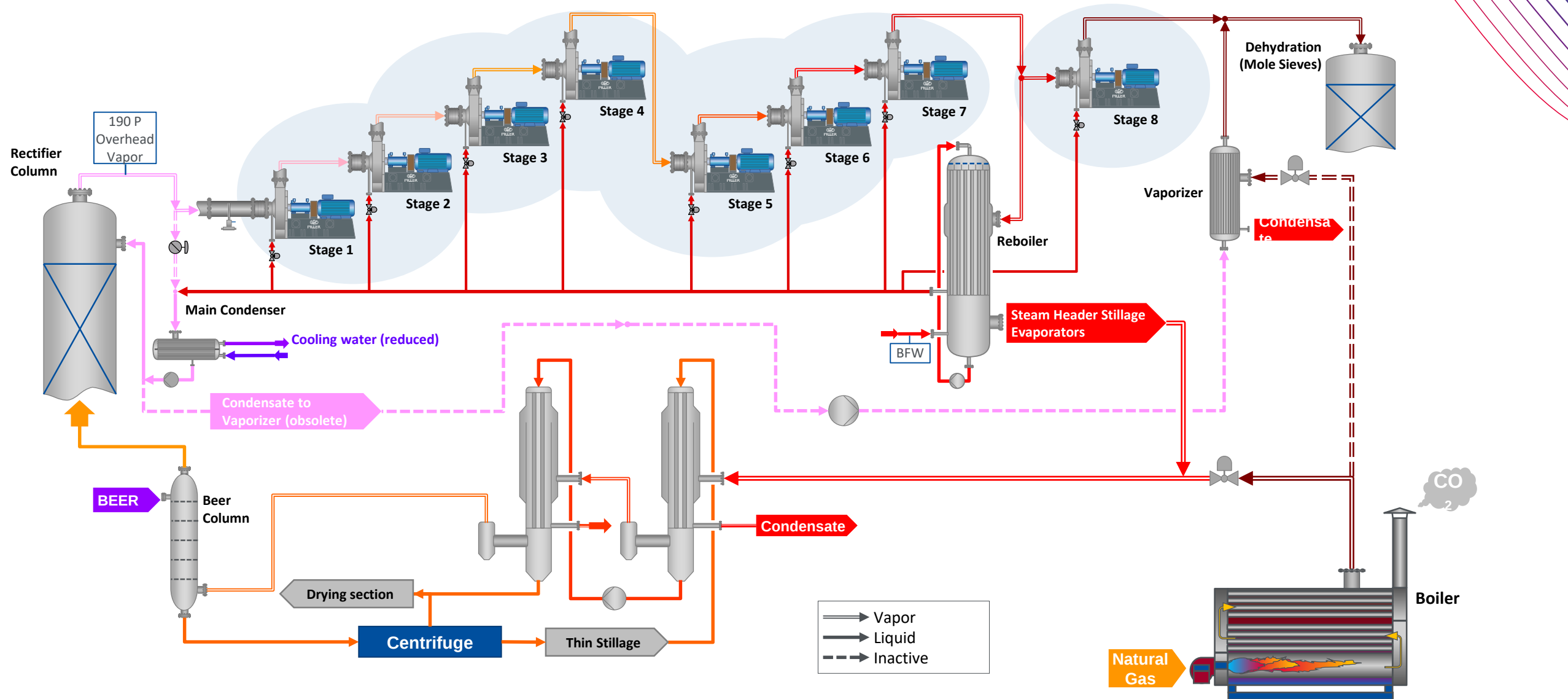
Bioethanol Production

- The largest bioethanol plant in Europe (Hungary) is now the most efficient plant in the world using state-of-the-art technology.
- Heat pump technology from PILLER based on the principle of mechanical vapor recompression (MVR) plays a major role in reducing carbon emissions and increasing energy efficiency.
- Both in the modernization of existing systems and plants and the building of new ones, Pannonia relies on the PILLER VapoFlex® with its impressive COP of 4.56 in the systems used.



Pannonia Bio Case Study

Bioethanol Compression



Pannonia Bio Case Study

Success Factors

- Scope of delivery: 7 + 1 VapoFlex®
- 50,000 Tonnes of CO2 saving per year
- 50% reduction in energy consumption
- COP 4.9
- Amortization period: 2 years*
- IChemE Global Awards 2021
 - Decarbonizing Biorefineries to Produce Greener Bioethanol

*Estimate based on a reference project. Value depends on the actual costs for gas and electricity.



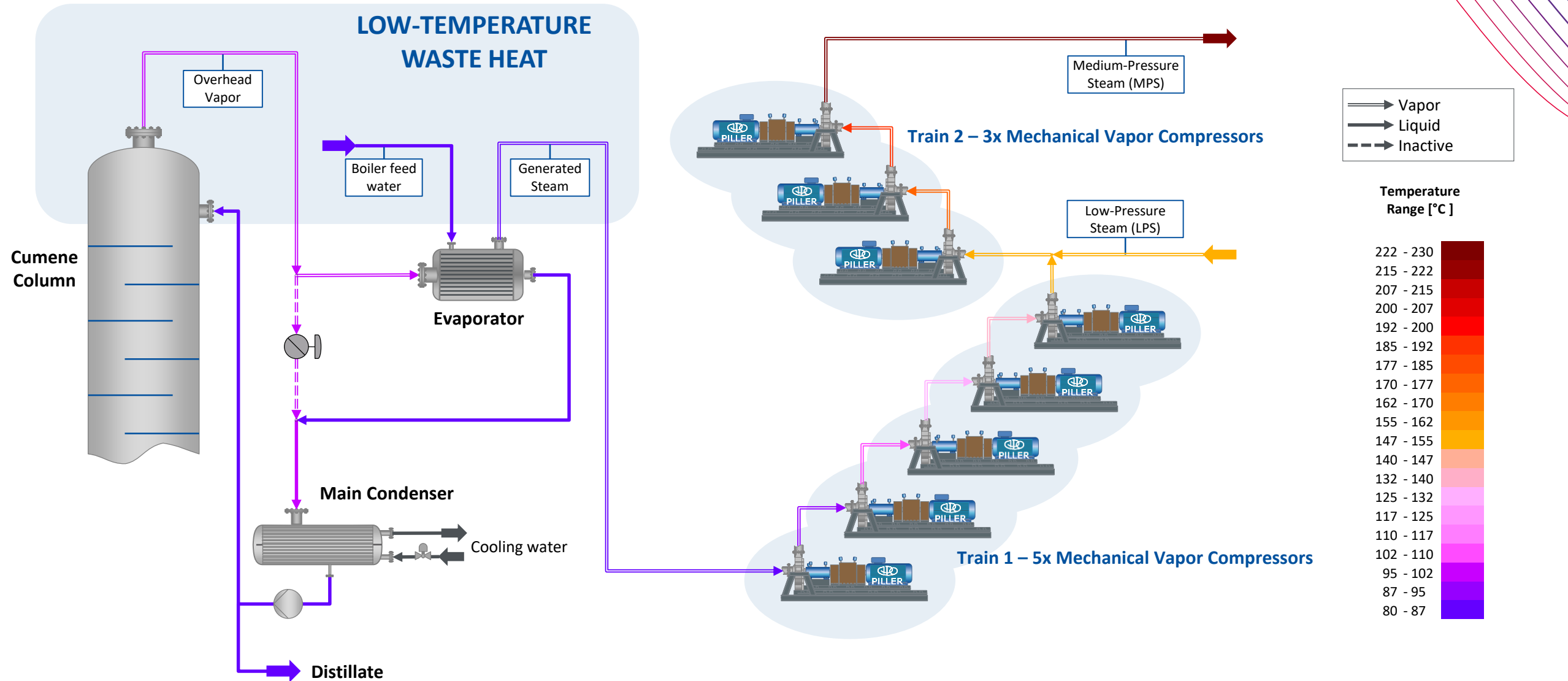
Industrial Heat Pump in Cumene Production

Success story: VapoMaxX[®]



Industrial Heat Pump in Cumene Production

Turning Overhead Vapor to into usable Steam



Cumene Case Study

Success Factors

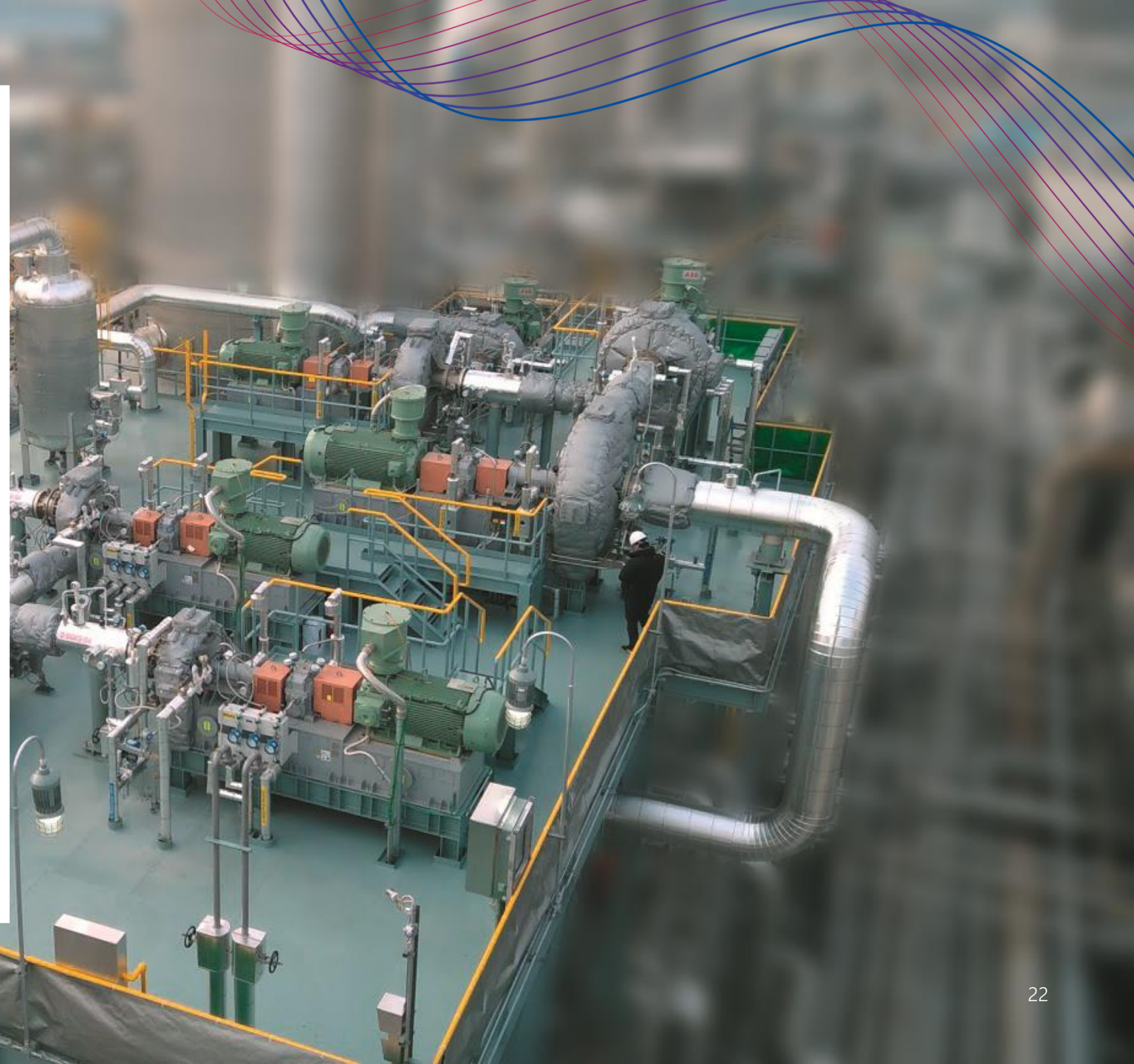
- 42 metric tons of steam per hour
- Energy cost savings: 8 million Euros annually
- Reduction in carbon emissions by 10,650 metric tons annually
- COP – First train: 3.81
- COP – Second train: 5.29



Cumene Case Study

Cumene Production

- In 2008 the first PILLER system for steam generation through the recovery of waste heat from a stripping process for solvents was implemented.
- Energy efficiency and climate protection are key company goals of our customers and are implemented consistently with the help of our waste heat recovery process.
- We have retrofitted nine other plants with our heat pump system.

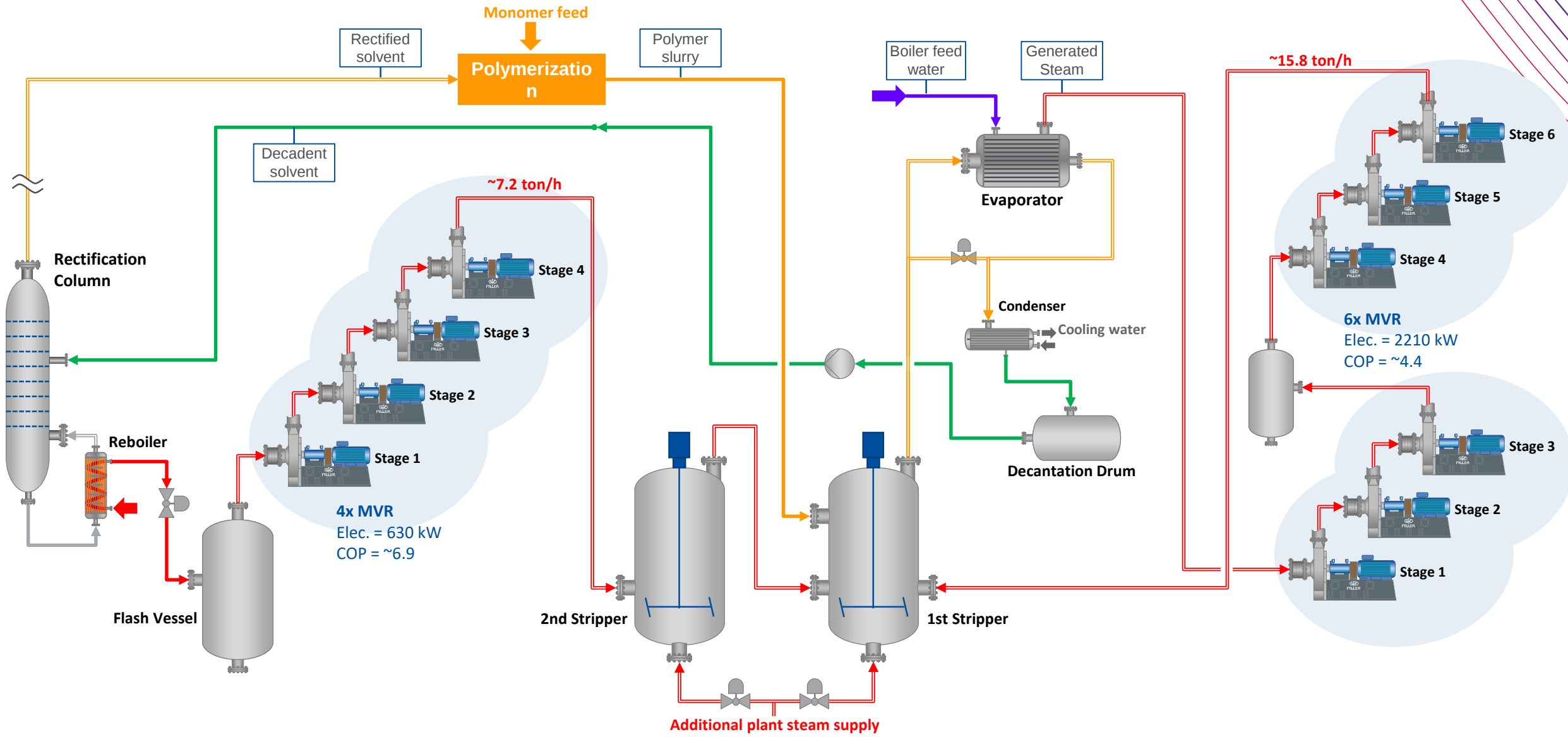


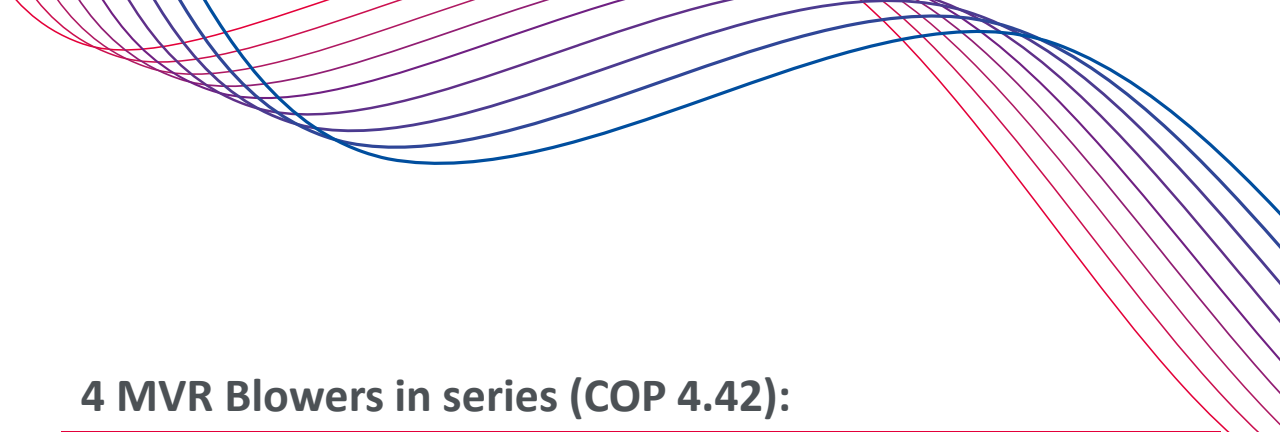
Industrial Heat Pump in EPDM Solvent Stripper

Success story



Industrial Heat Pump in EPDM Solvent Stripper





Industrial Heat Pump in EPDM Solvent Stripper

Facts & Figure

6 MVR Blowers in series (COP 6.9):

Inlet Conditions	Outlet Conditions	ΔT sat
68 °C	126.25 °C	58.25 °C
Inlet Mass flow	Outlet Mass flow	Electrical Power
14000 kg/h	15987 kg/h	2210 kW

4 MVR Blowers in series (COP 4.42):

Inlet Conditions	Outlet Conditions	ΔT sat
94.7 °C	130.6 °C	35.9 °C
Inlet Mass flow	Outlet Mass flow	Electrical Power
6527 kg/h	7167 kg/h	630 kW

- Breakeven within 1.5 years

Future applications

World's most powerful industrial heat pump system



Numbers and Facts

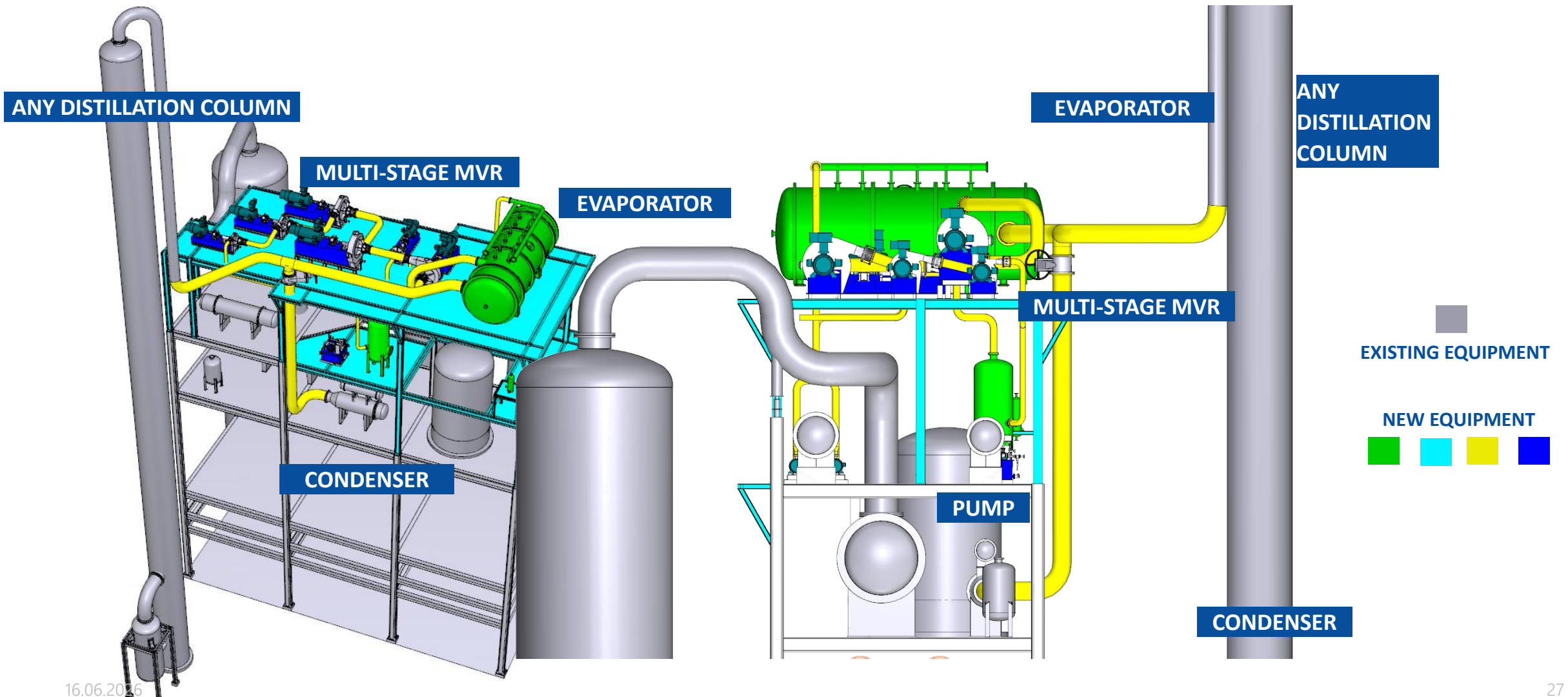
VapoFlex application (2027)

- Largest chemical producer in the world
- 2 trains totalizing 11 stages system (6+5)
- 55 tonnes /hour steam is recovered
- Reduce about 100 000 metric tons of CO₂ emissions annually

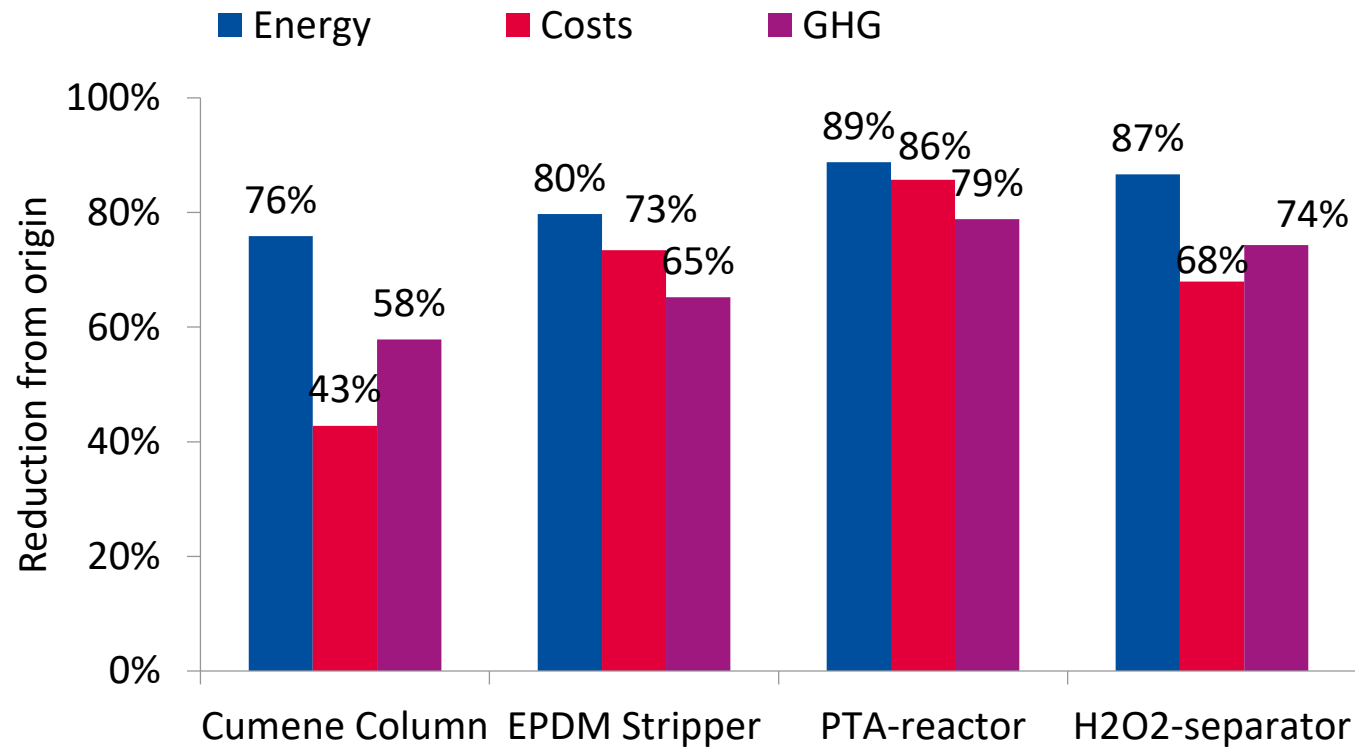
BASF reduces the greenhouse gases generated during the production of formic acids at its Ludwigshafen site by 98%.

Inlet Conditions	Outlet Conditions	ΔT sat
56.6 °C @ 170 mbar(a)	109.3 °C @ 1400 mbar(a)	52.7 °C
104°C @ 1180 mbar(a)	190°C @ 5800 mbar(a)	86 °C

Heat recovery from existing Distillation Column



The PILLER Industrial Heat Pump: Always a winner



- HOW YOU BENEFIT FROM THE PILLER INDUSTRIAL HEAT PUMP

- Significantly improved energy efficiency through heat recovery
- Extreme reductions in energy consumption and costs
- Amortization period of less than 3 years
- Improved climate protection and resource conservation thanks to reduced use of fossil fuels and lower CO₂ emissions
- Simple integration into existing systems: retrofitting without great effort and easy installation even in limited space conditions

GHG: Greenhouse gases (CO₂ equivalents)

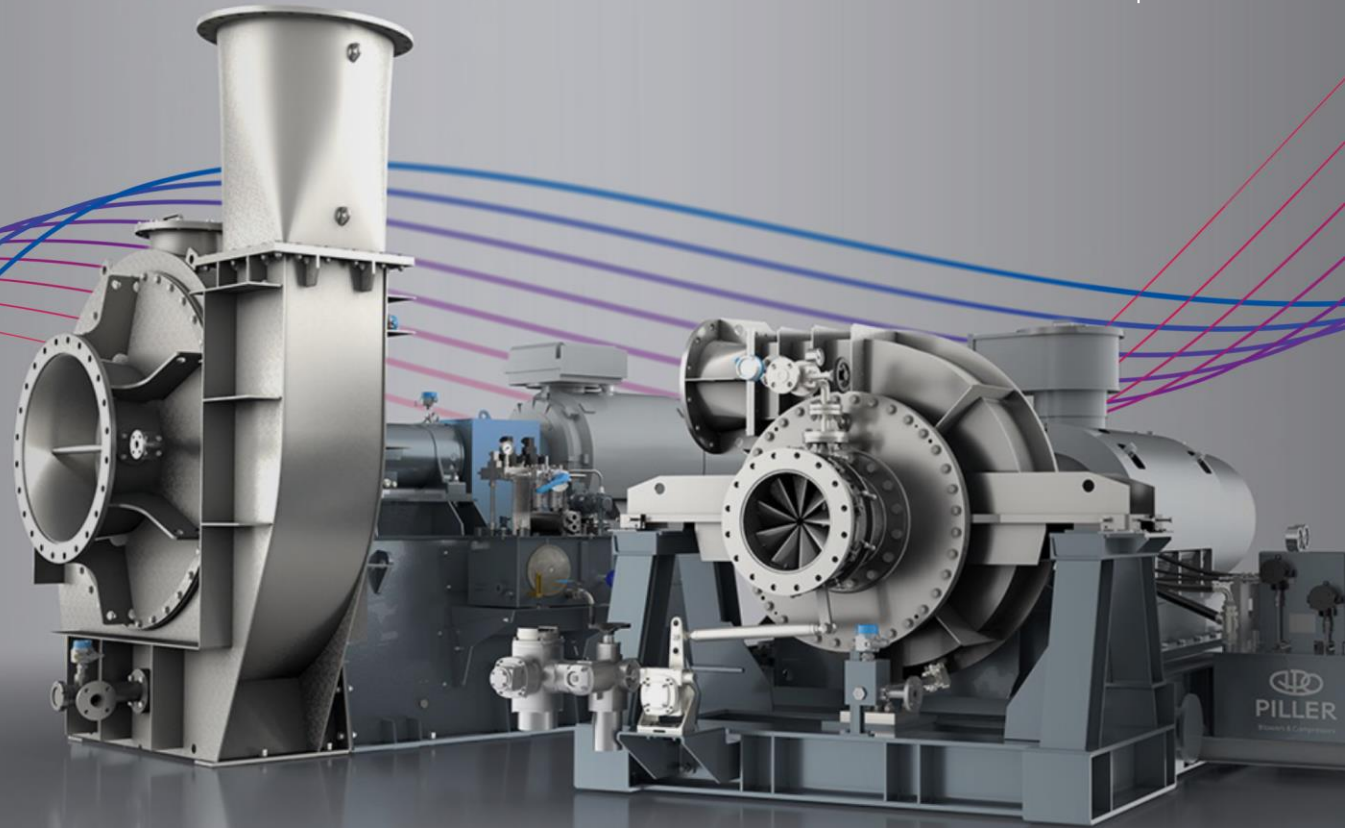
THANK YOU FOR YOUR ATTENTION

Piller Blowers & Compressors GmbH

Nienhagener Str. 6
37186 Moringen
Deutschland

Jeff Choong
Jeff.choong@piller.de
+6597869638


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