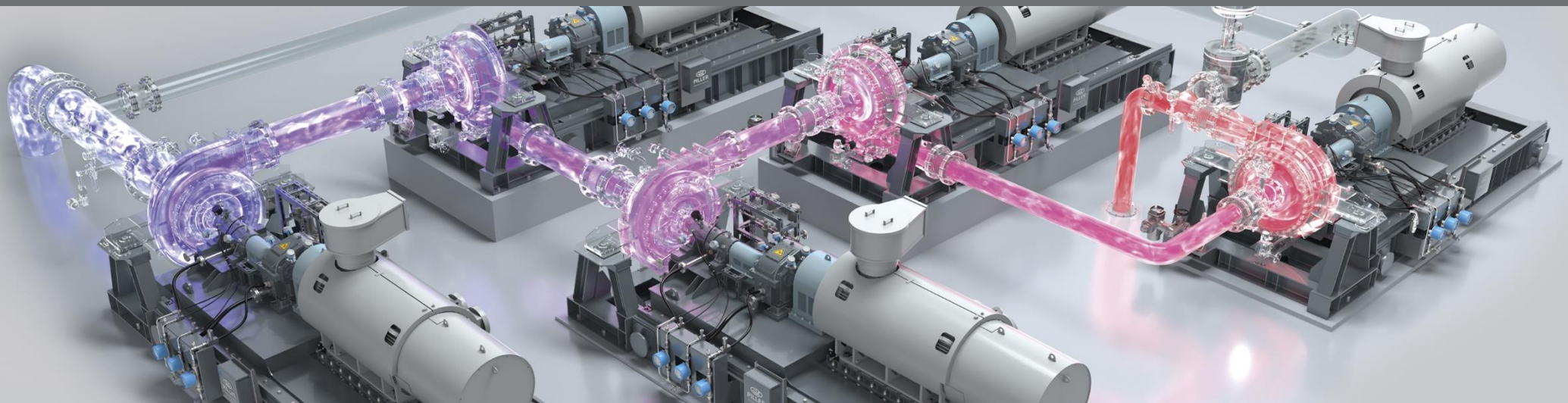


WASTE HEAT RECOVERY THROUGH STEAM/VAPOR RECOMPRESSION IN PETROCHEMICAL INDUSTRY

MVR Technology by PILLER



WASTE HEAT RECOVERY THROUGH STEAM/VAPOR RECOMPRESSION



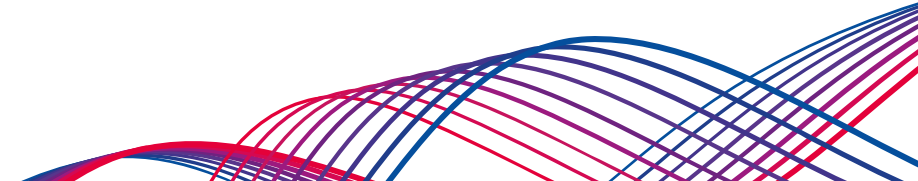
Jeff Choong

Head of Regional Sales & Spare Parts (SEA)

Piller Blowers & Compressors

OUTLINE

- PILLER – The Company
- Portfolio – MVR and Carbon Capture
- Applications in processes and applications
- Basic concept of Mechanical Vapor Recompression
- References in different industries
 - Heat pump cycle with evaporator: Retrofitting Cumene Column
 - Classic mechanical vapor compression: Compressing ethanol
 - EPDM solvent
 - Largest Industrial in the World: BASF
 - MVR for batch processes

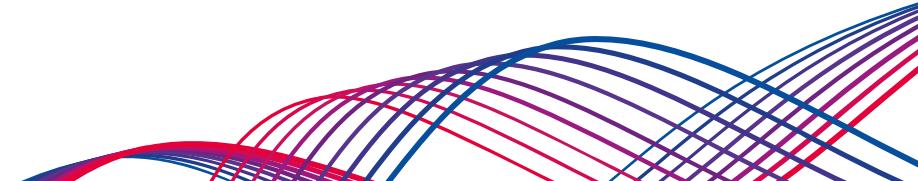


PILLER - THE COMPANY

- Founded in 1909
- Worldwide > 500 employees
- Sector Machine Building



PILLER HEADQUARTER IN MORINGEN, GERMANY



PILLER LOCATIONS WORLDWIDE



**9 LOCATIONS
WORLDWIDE**

**2 PRODUCTION
FACILITIES**

BLOWERS AND COMPRESSORS FOR A WIDE RANGE OF PROCESSES AND APPLICATIONS



CHEMICALS



FOOD & BEVERAGE



PETROCHEMICALS



METALLURGY



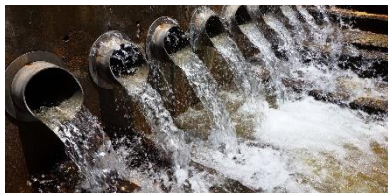
MINING



PULP & PAPER



SUGAR & ETHANOL



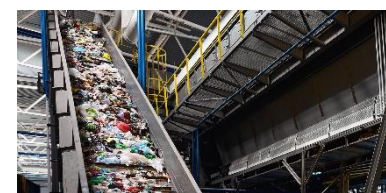
**INDUSTRIAL WASTE WATER
TREATMENT**



PHARMACEUTICALS



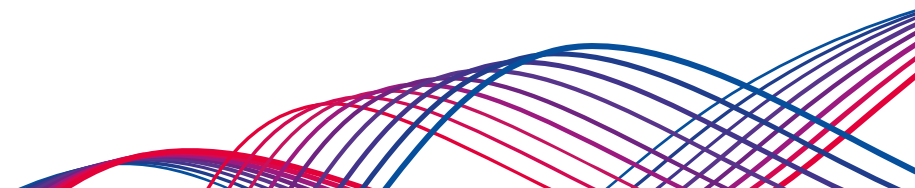
OIL & GAS



WASTE TREATMENT



HEAT TREATMENT



BLOWERS AND COMPRESSORS FOR VAPOR (RE-)COMPRESSION

THE PILLER VAPOLINE

PILLER - THE EXPERT FOR VAPOR (RE-)COMPRESSION

- Experience and continuous innovations since the 1980's
- PILLER is specialized in Vapor (RE-)compression (MVR/MVC) Technology with more than 5,000 installations worldwide
- Around 600 blowers for MVR are currently manufactured per year



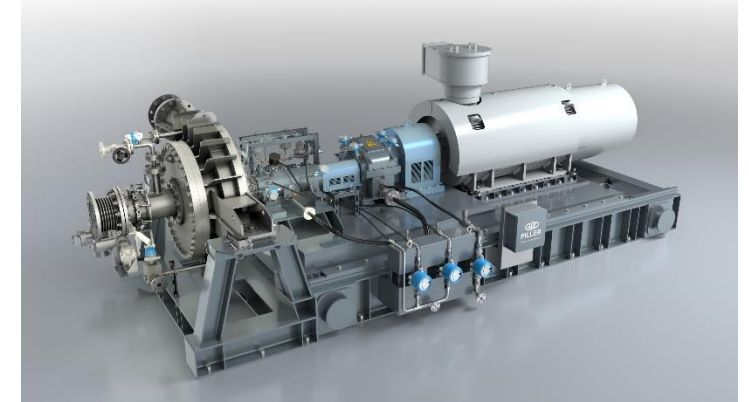
VapoFan

For low mass flows



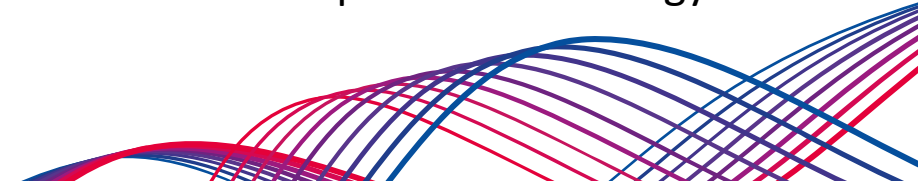
VapoFlex

Engineered-To-Order



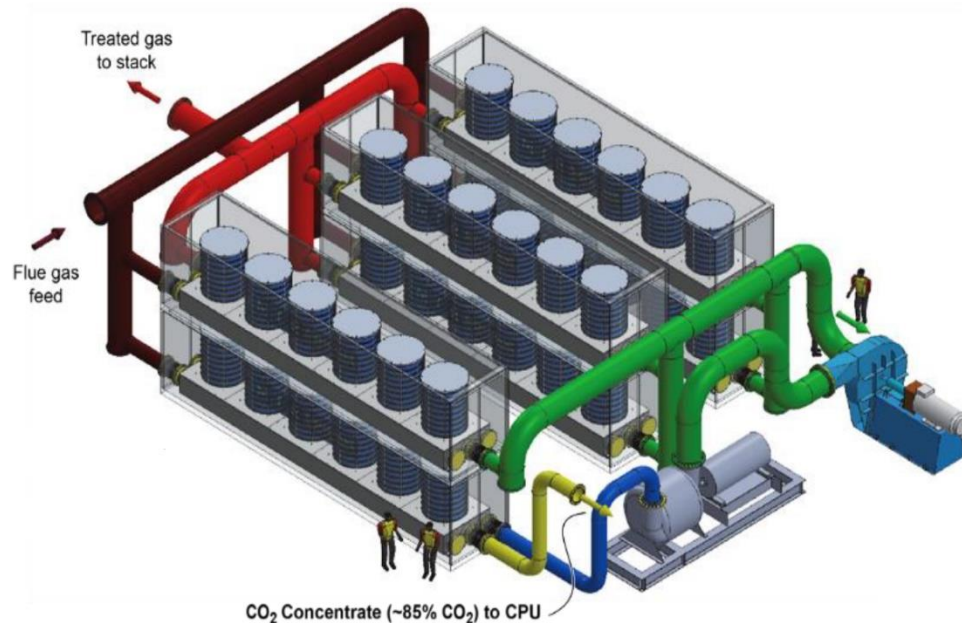
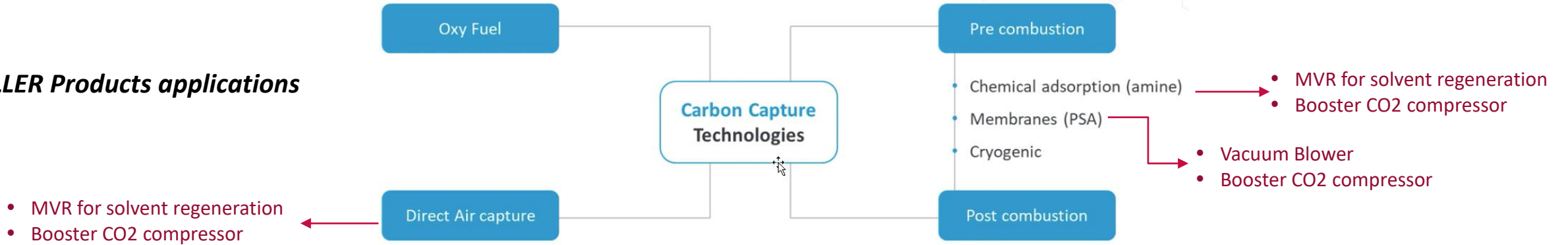
VapoMaxX

Smart compressor technology

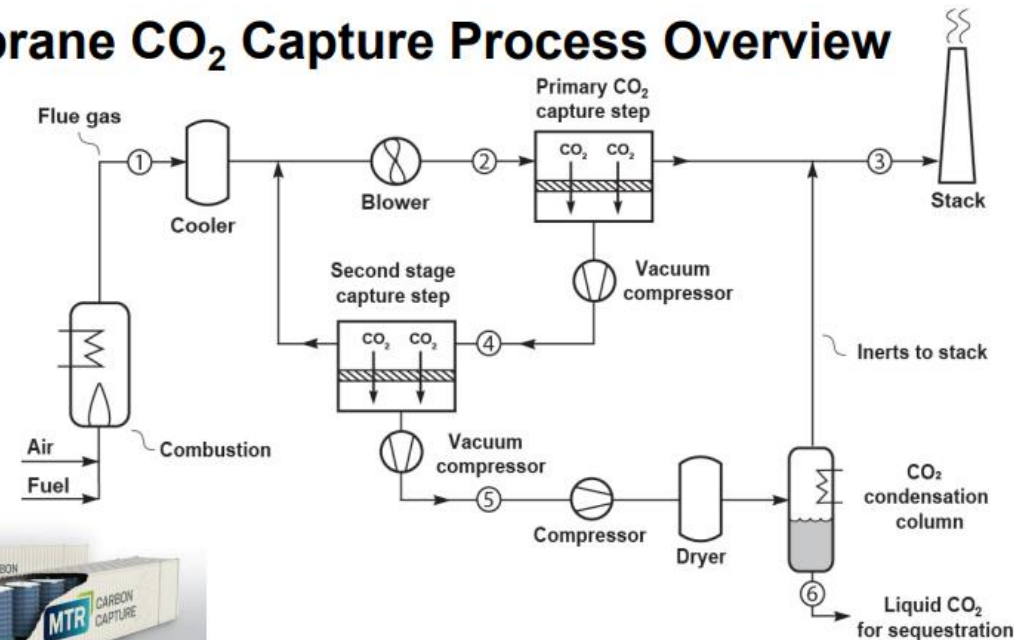


APPLICATION FOR CARBON CAPTURE

PILLER Products applications



MTR Membrane CO₂ Capture Process Overview



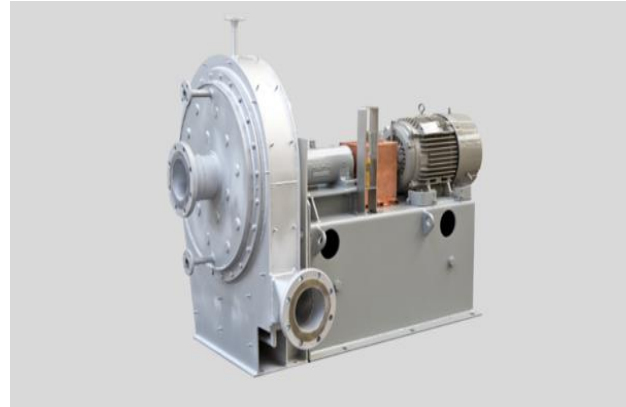
Source: Brice Freeman, MTR at 2023 FECM / NETL Carbon Management Research Project Review Meeting

BLOWERS AND COMPRESSORS

OUR PRODUCT RANGE



Air /Gas Handling Blower



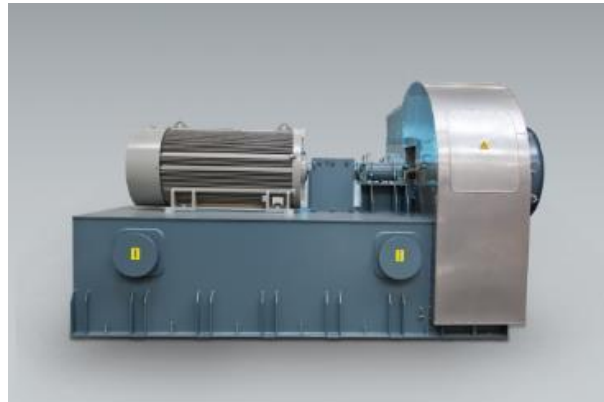
Blower with Steam Jacketed Construction



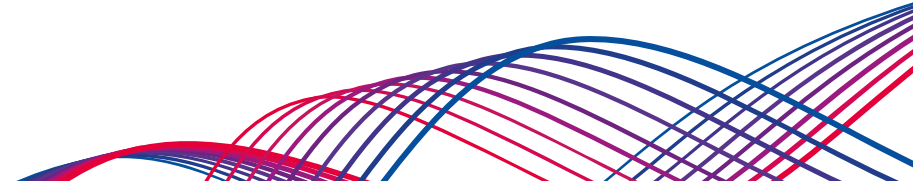
Fines Removal Blower



Regeneration Blower



Regeneration Cooler Blower



CARBON FOOTPRINT TAX ON GHG (UPDATED 2024)

Summary map of regional, national and subnational carbon pricing initiatives

IMPLEMENTED INSTRUMENTS

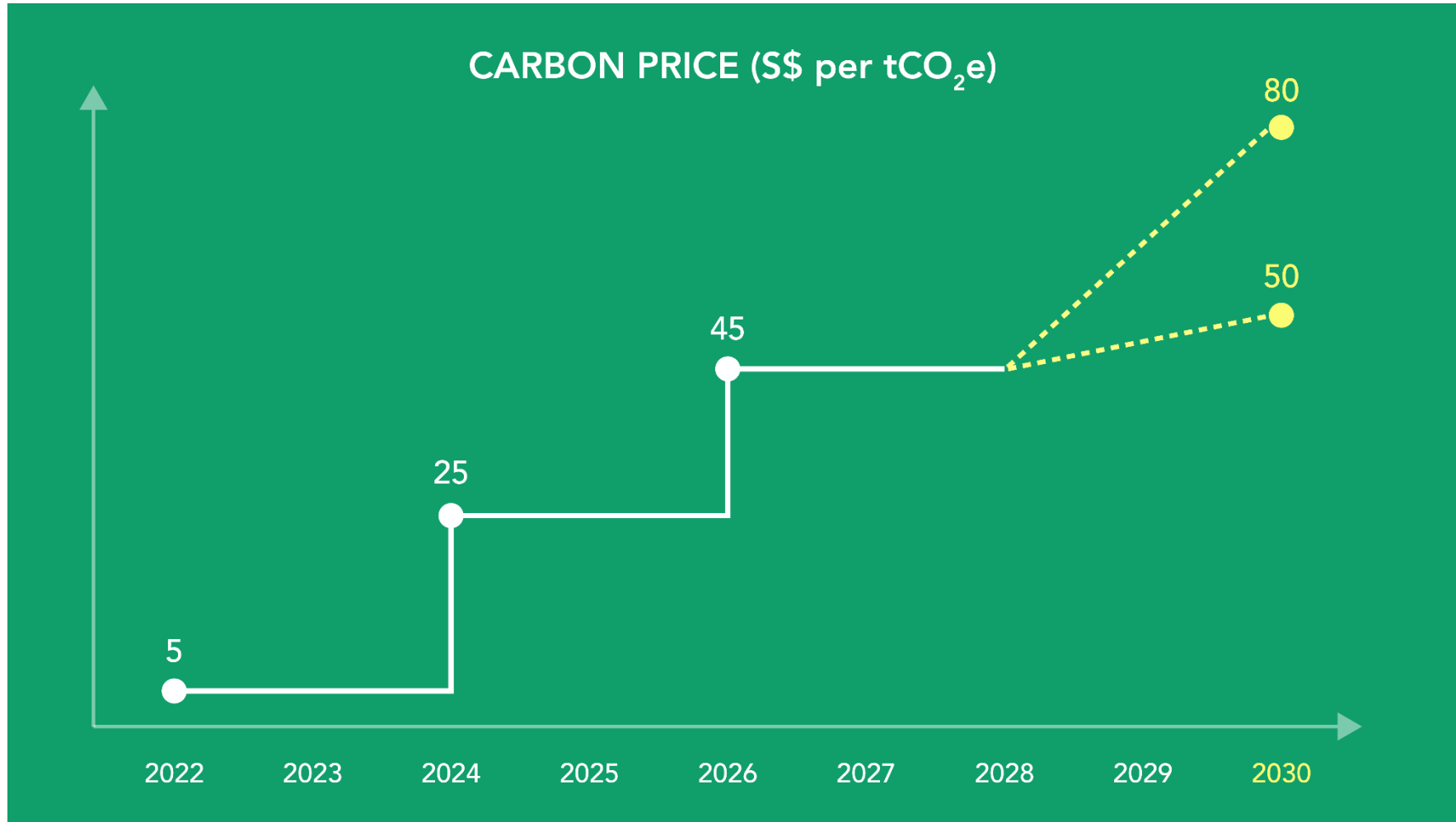
- Compliance
- Crediting
- Both



Country	Year	US\$ /tCO ₂ e	remark	
Japan ETS	2023	1.91		
Indonesia ETS	2023	0.61	Covered for coal powered plant	
Malaysia			Study started in 2023	
NZ ETS	2008	32		
Singapore CT	2022	18.5	45SGD by 26-27 50-80SGD by 2030	
Taiwan CF	2024	9.2	Estimated by Taiwan Gov	
Thailand	2025	5.8		
Vietnam			Pilot program starts in 2024	
S-Korea ETS	2015	6.4	Peaked in 2022 at 15.6 USD/tCO ₂ e	

Source:
World bank group, <https://carbonpricingdashboard.worldbank.org/>

CARBON FOOTPRINT TAX OF SINGAPORE



Source: <https://www.nccs.gov.sg/singapores-climate-action/mitigation-efforts/carbontax/>

MAXIMIZING ENERGY EFFICIENCY THROUGH WASTE HEAT RECOVERY

STRIVING FOR ENERGY EFFICIENCY AND CLIMATE PROTECTION

- **GOAL:** reducing CO₂ footprint through reduction of energy consumption
 - **SOLUTION:** re-using waste heat from industrial processes
 - **TECHNOLOGY:** compressing waste steam/vapor mechanically and converting it back into a useful energy source for the production process
-
- Why Recovering Waste heat?



WHY WASTE VAPOR IS WORTH TO BE RECOVERED



1 ton of hot water from 99°C to 100°C

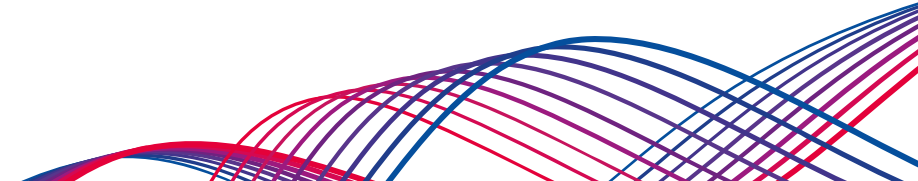
$$\begin{aligned} Q &= m \cdot cp \cdot \Delta T \\ &= 1000 \text{ kg} \cdot 4.2 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} \cdot (100 - 99) \text{ K} \\ &= 4,190 \text{ kJ} \end{aligned}$$



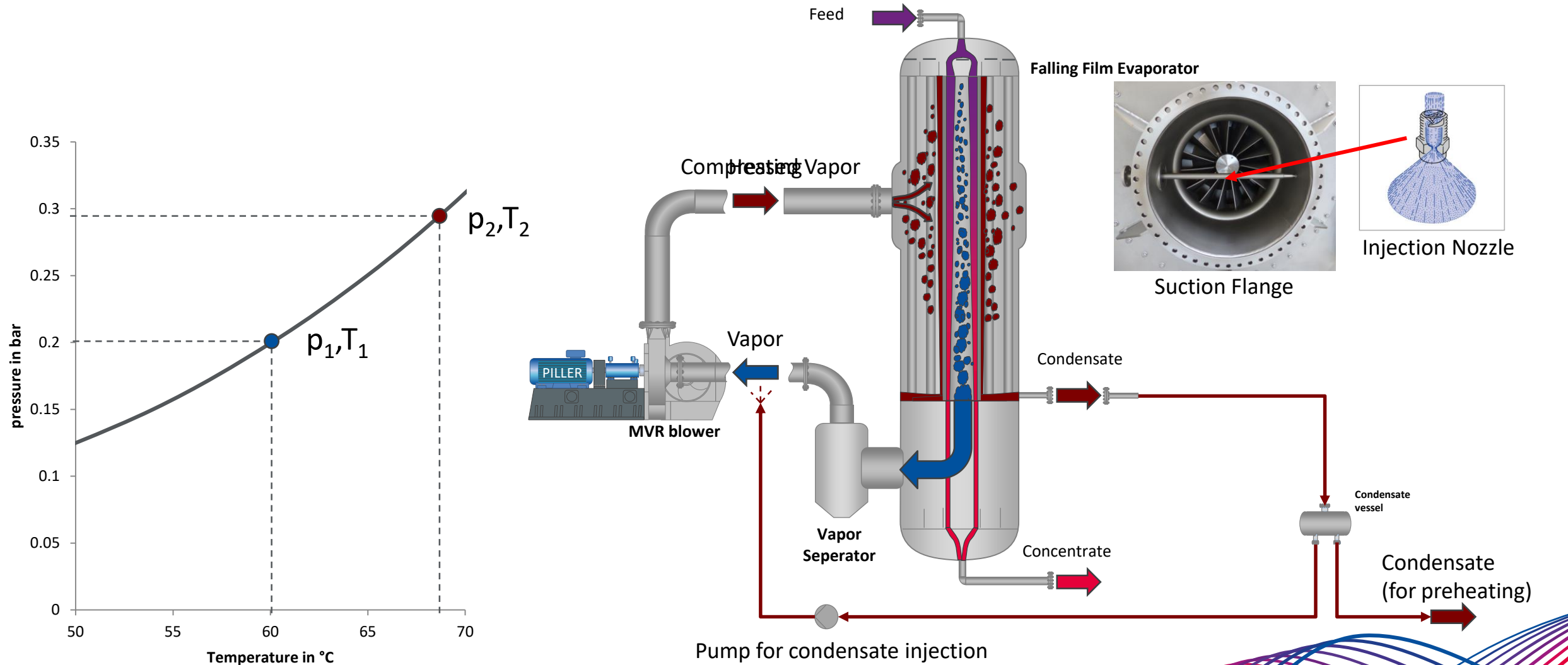
1 ton of 100°C water to 100°C Steam

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

538 times

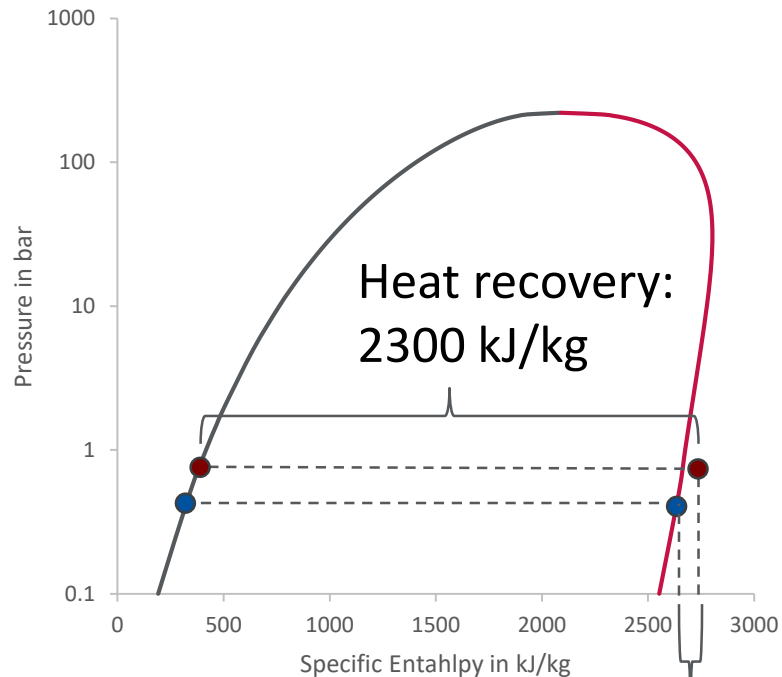


HEAT PUMP PRINCIPLE MECHANICAL VAPOR RECOMPRESSION (MVR)

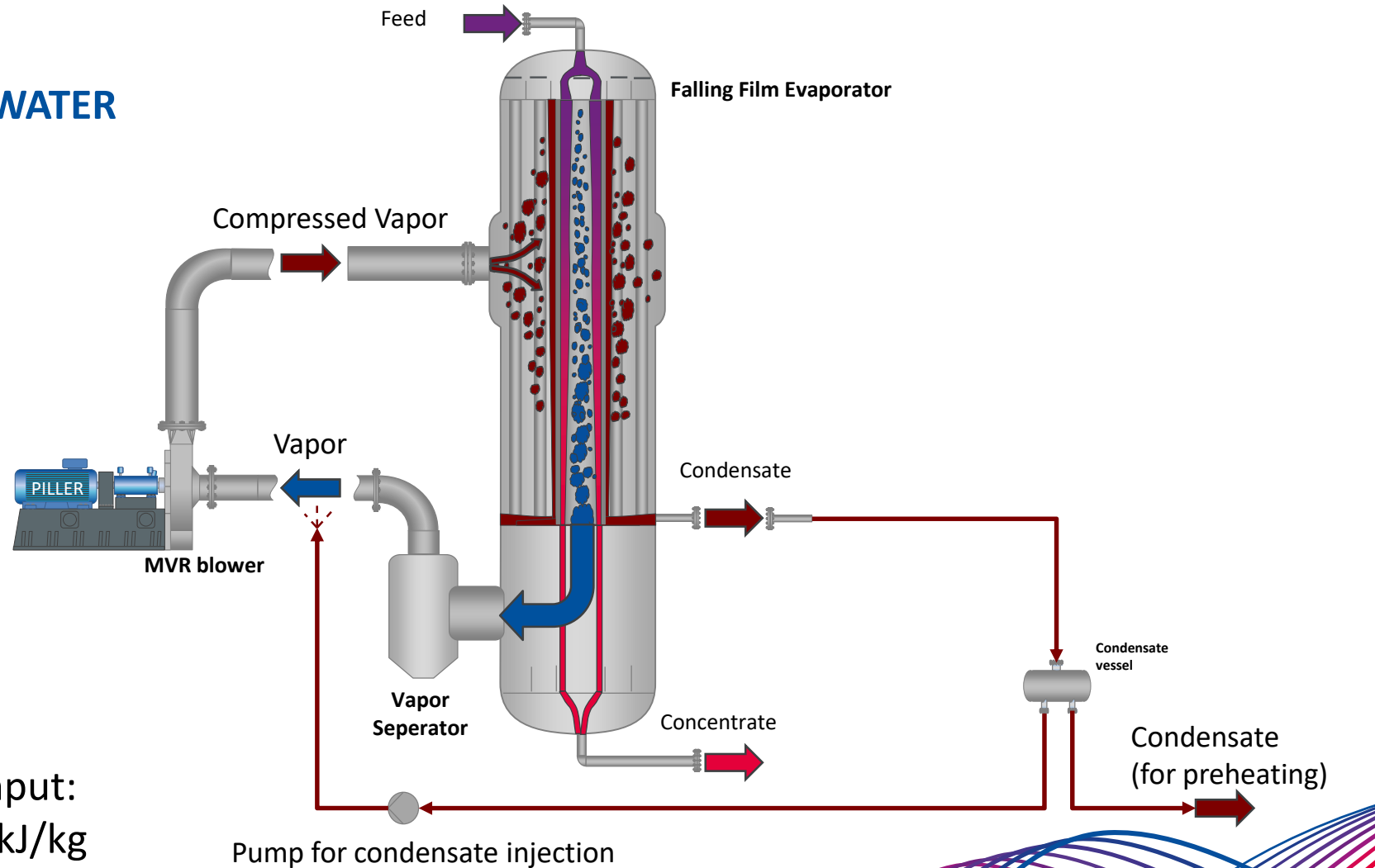


HEAT PUMP PRINCIPLE MECHANICAL VAPOR RECOMPRESSION (MVR)

LOG P – ENTHALPY DIAGRAM FOR WATER

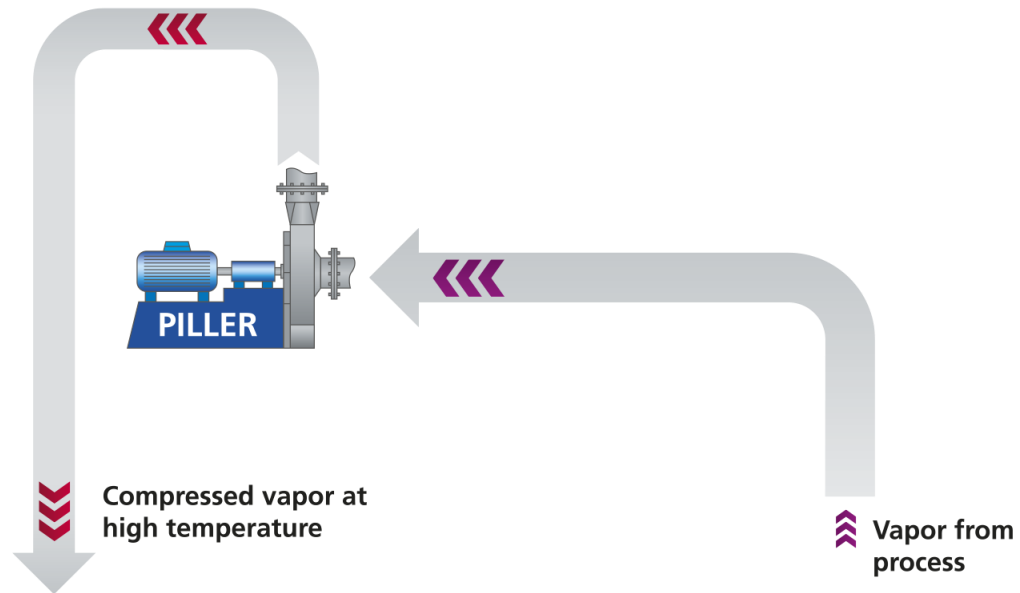


MVR Input:
50- 80 kJ/kg

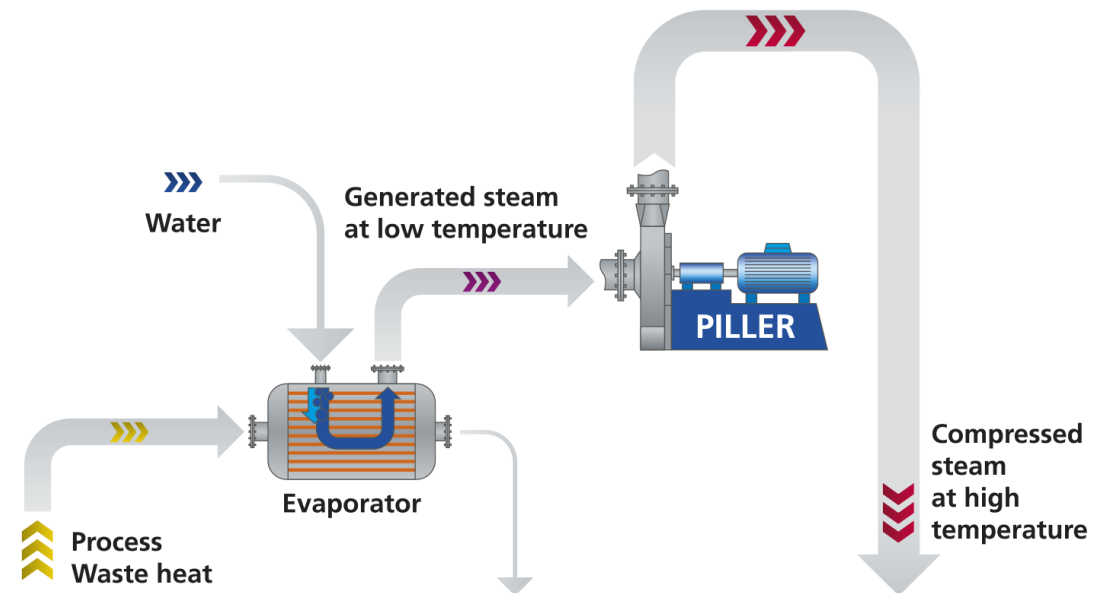


HEAT PUMP SOLUTION MADE BY PILLER

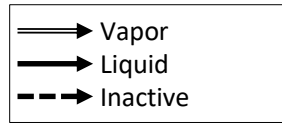
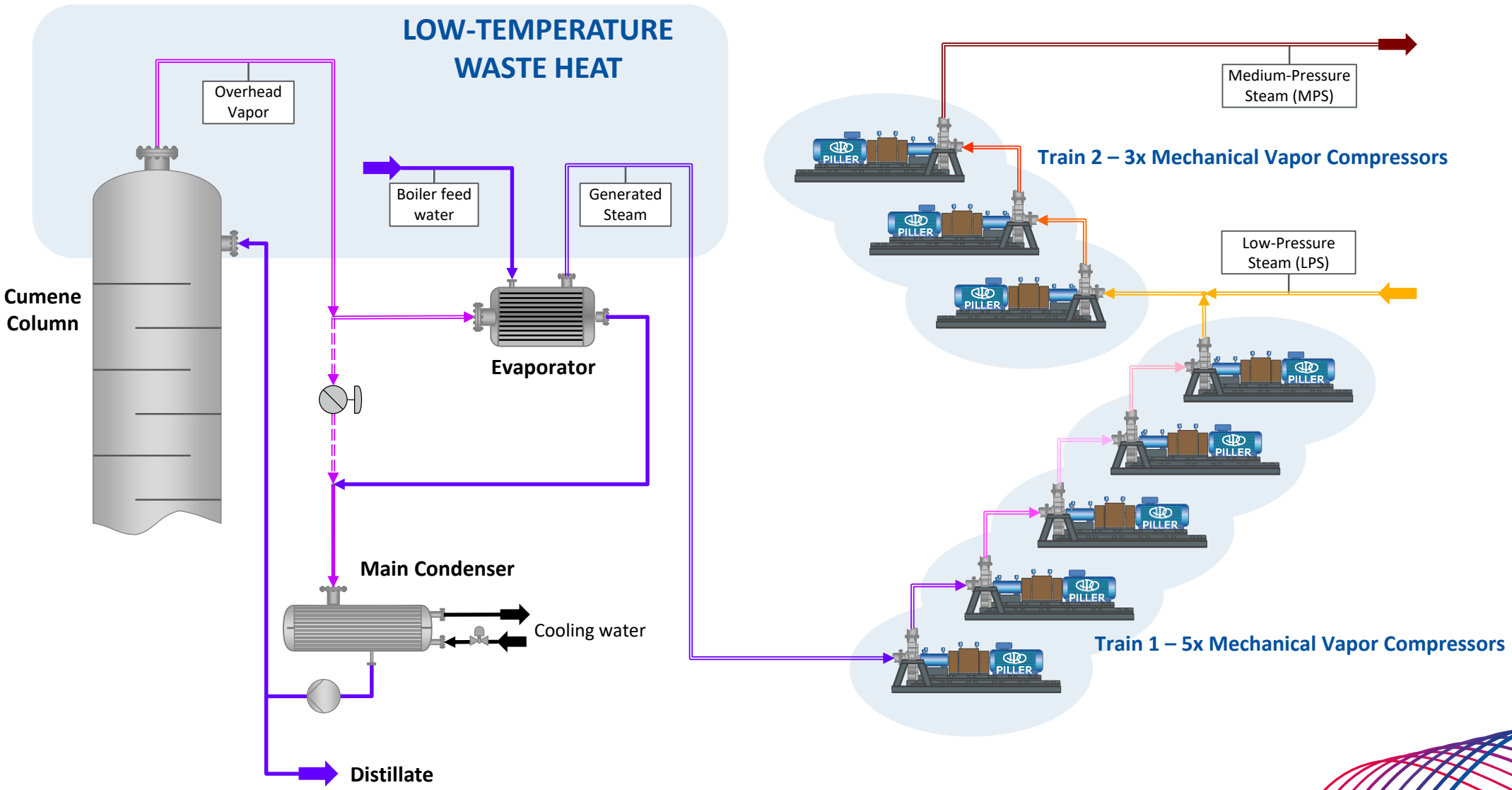
MECHANICAL VAPOR (RE-)COMPRESSION



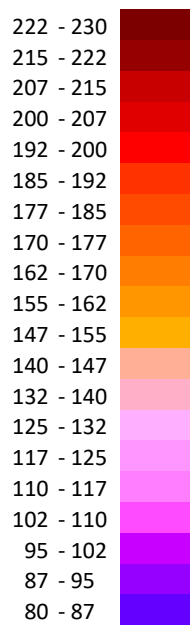
PILLER HEAT PUMP



IMPLEMENTING AN INDUSTRIAL HEAT PUMP TO A CUMENE COLUMN



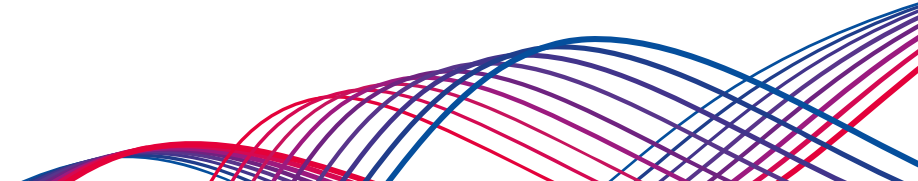
Temperature Range [°C]



CASE STUDY: OPTIMIZING ENERGY EFFICIENCY WITH VAPOR COMPRESSION TECHNOLOGY

IMPLEMENTING AN INDUSTRIAL HEAT PUMP TO A CUMENE COLUMN

- 42 tons of steam are supplied per hour
- Energy cost savings: 14.5 Million € per year
- Reduction of CO₂ emissions by 26,900 tons per year
- Resulting COPs
 - First train: 3.81
compression from 0.47 bara and 80 degC saturated steam to 5.2 bara and 160 degC low pressure steam (LPS)
 - Second train: 5.29
resulting in medium pressure steam (MPS) at 19.6 bara and slightly superheated to 230 degC
 - Combined: 2.24
compression from 80 degC to 211.5 degC saturated (train 2 weighted by inlet mass flow)



VAPOMAXX YEOSU CUMENE PLANT

Petrochemical Plant



42t/h @ 211°C, 19.7 bar(a)



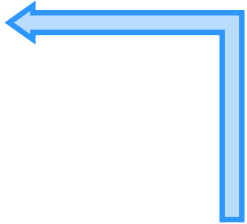
Cumene Column



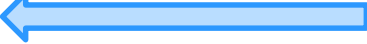
Piller Train 2 (3 stages)



32.4t/h @ 154°C
5.3 bar(a)



14.8t/h @ 154°C
5.3 bar(a)



17.6t/h @ 154°C, 5.3 bar(a)

Piller Train 1 (5 stages)



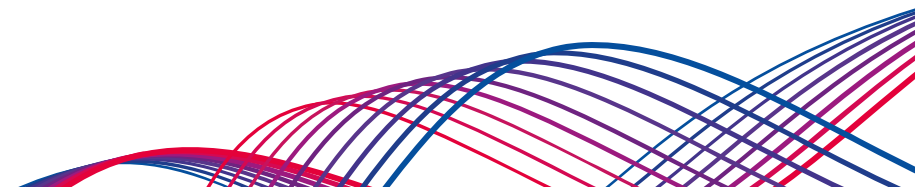
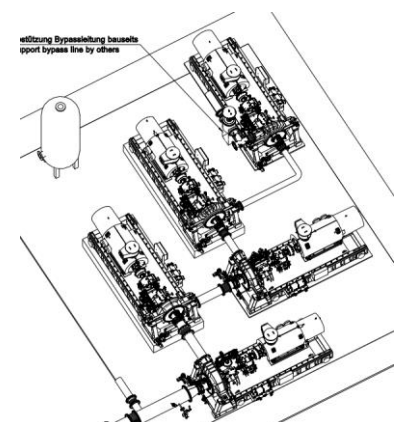
Heat Exchanger



14.1 t/h @ 80°C, 474mbar(a)



VAPOMAXX YEOSU CUMENE PLANT



REFERENCES IN DIFFERENT INDUSTRIES

INDUSTRIAL HEAT PUMP INSTALLATIONS DURING THE LAST DECADE

- EPDM
 - SSBR
 - Caprolactam
 - Sugar
 - Ethanol
- And many more....

DIRECT COMPRESSION FOR RECOVERY

- Methyl Acetate
 - Methanol
 - Bio-ethanol
- And many more....





EPDM solvent stripper (South Korea)

PILLER HEAT PUMP SYSTEM

6 Blower in series (2013/2015):

Inlet Temperature	Outlet Temperature	Delta T
68 °C	126.25 °C	58.25 °C

Inlet Massflow	Outlet Massflow	El. Power
14,000 kg/h	15,987.8 kg/h	2210 kW

4 Blower in series (2013/2015):

Inlet Temperature	Outlet Temperature	Delta T
94.7 °C	130.6 °C	35.9 °C

Inlet Massflow	Outlet Massflow	El. Power
6,527 kg/h	7,167 kg/h	630 kW



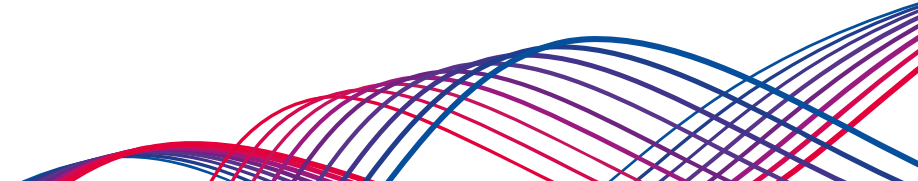
COMPRESSING ETHANOL VAPORS

- 7 + 1 Stage
- More than 60 t/h in one train
- Temperature Rise: 60 K
- Compression ratio: 12
- Cuts the plant's energy needs in half
- COP of 4.6
- 32 MW gas savings

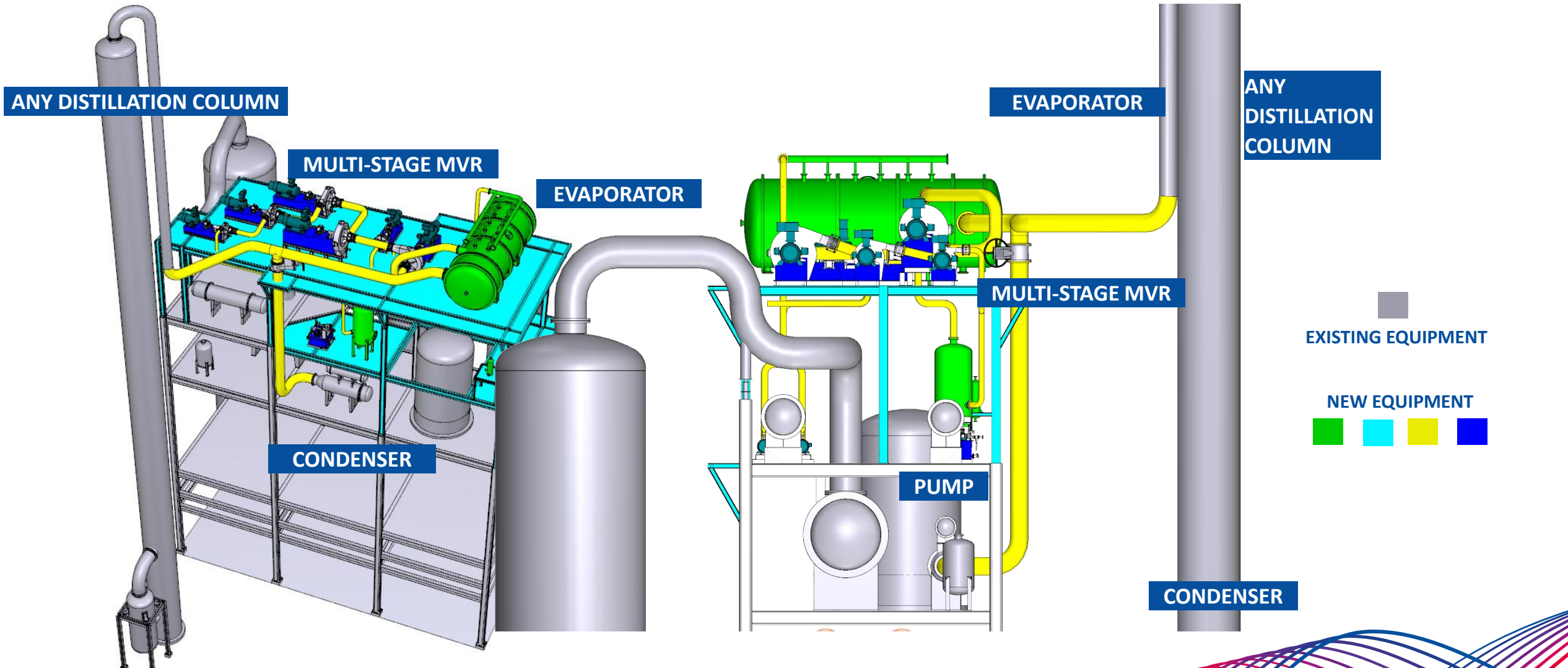
BIGGEST INDUSTRIAL HEAT PUMP PROJECT IN THE WORLD



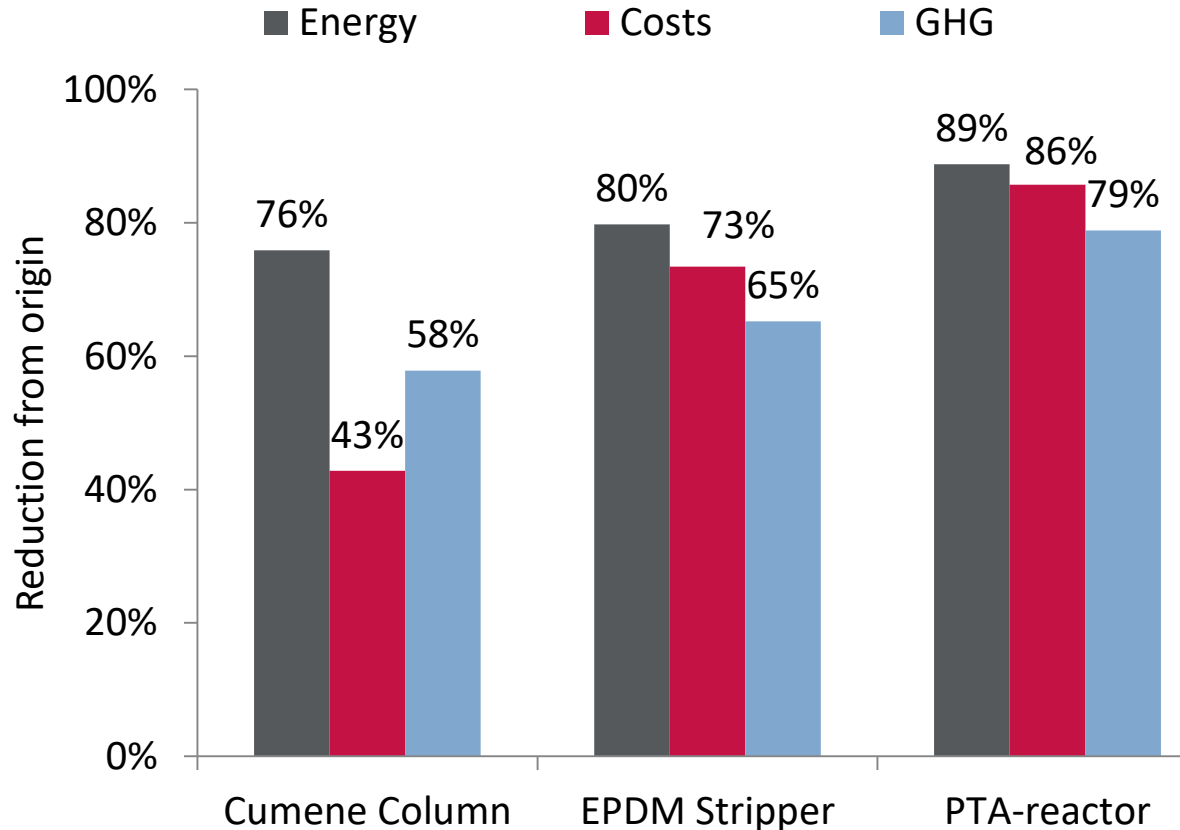
- Largest Industrial Heat Pump project in the world
- BASF's Ludwigshafen site
- Reduce GHG during production of formic acid by 98%
- Thermal output of 50MWth



HEAT RECOVERY FROM EXISTING DISTILLATION COLUMN



THE PILLER INDUSTRIAL HEAT PUMP: ALWAYS A WINNER



GHG: Greenhouse gases (CO₂ equivalents)

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

THANK YOU FOR YOUR ATTENTION

Piller Blowers & Compressors GmbH

