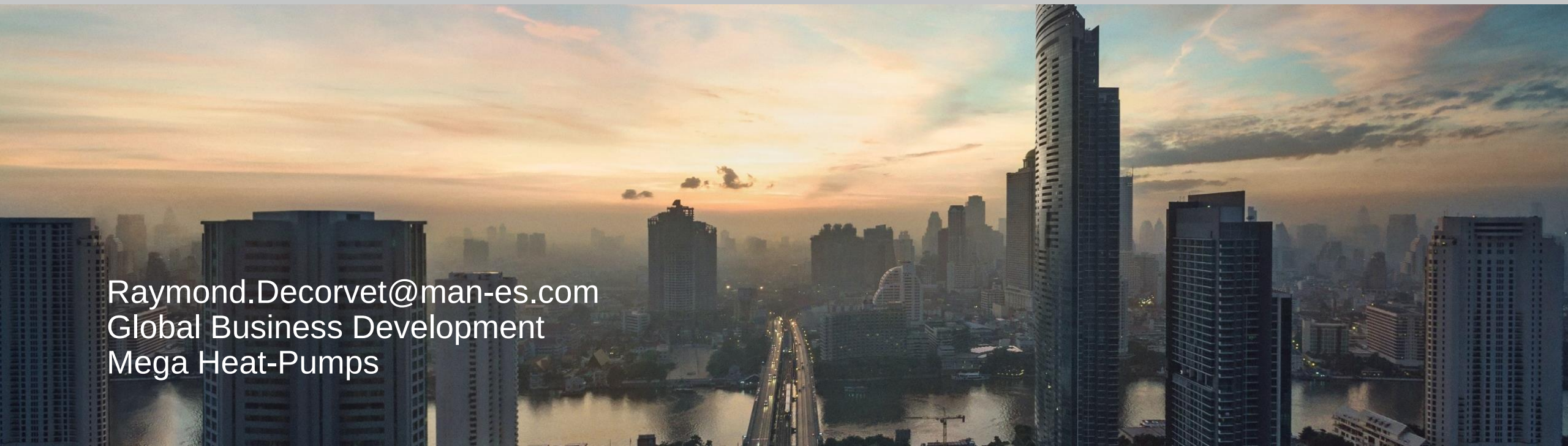
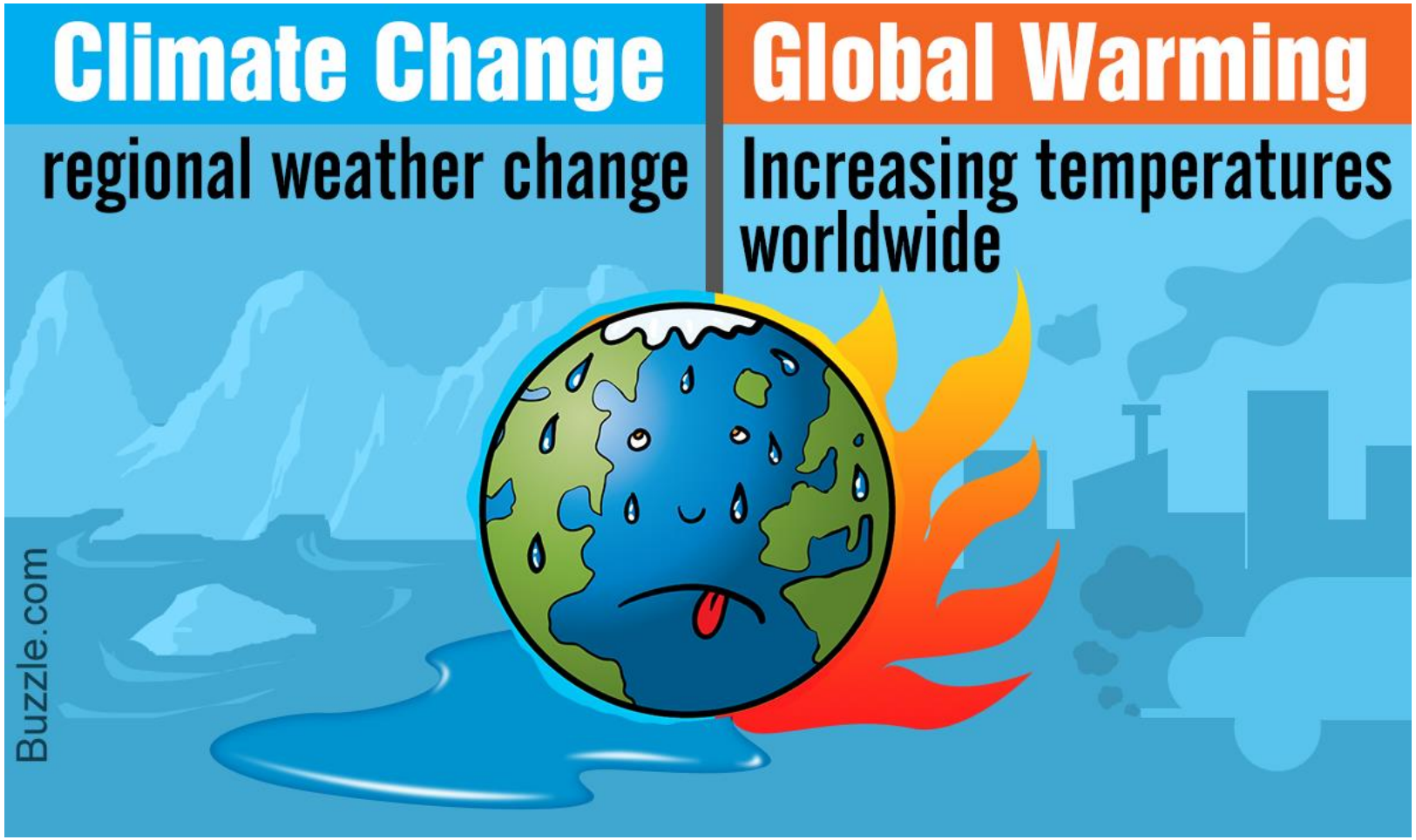
MAN Energy Solutions
Future in the making

Decarbonizing District Heating with Mega Heat-Pumps!



Raymond.Decorvet@man-es.com
Global Business Development
Mega Heat-Pumps

Decarbonization & CO2 reduction is the ONLY option !



MEGA Heat-Pumps & District Heating can make a big difference !

MAN-ES New forward strategies

Mega HT Heat-Pumps

Carbon Capture (CCS)

Hydrogen (H2) QUEST ONE

Global MAN Service Organisation PrimeServ

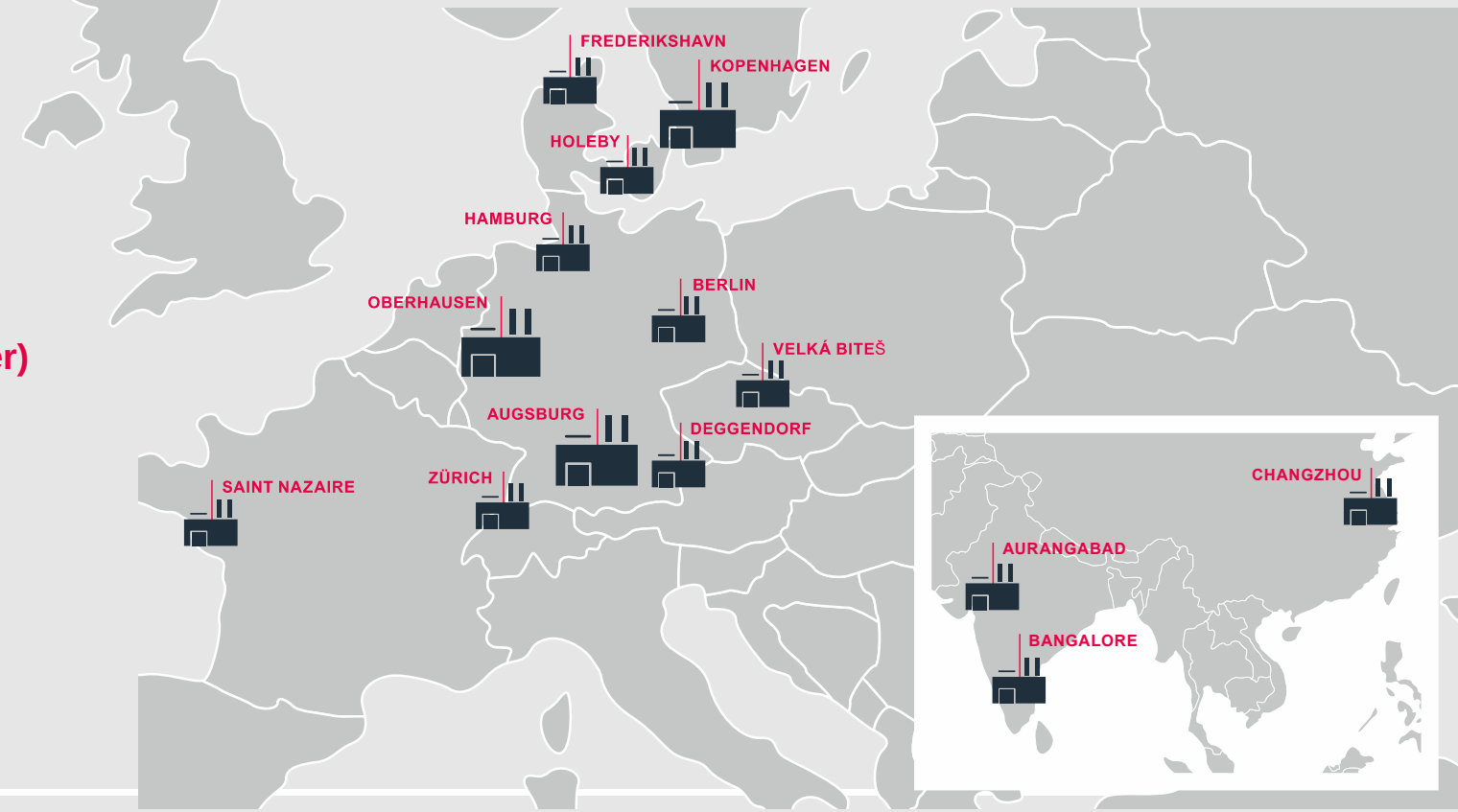
MAN Energy Solutions @ a Glance

Vision:

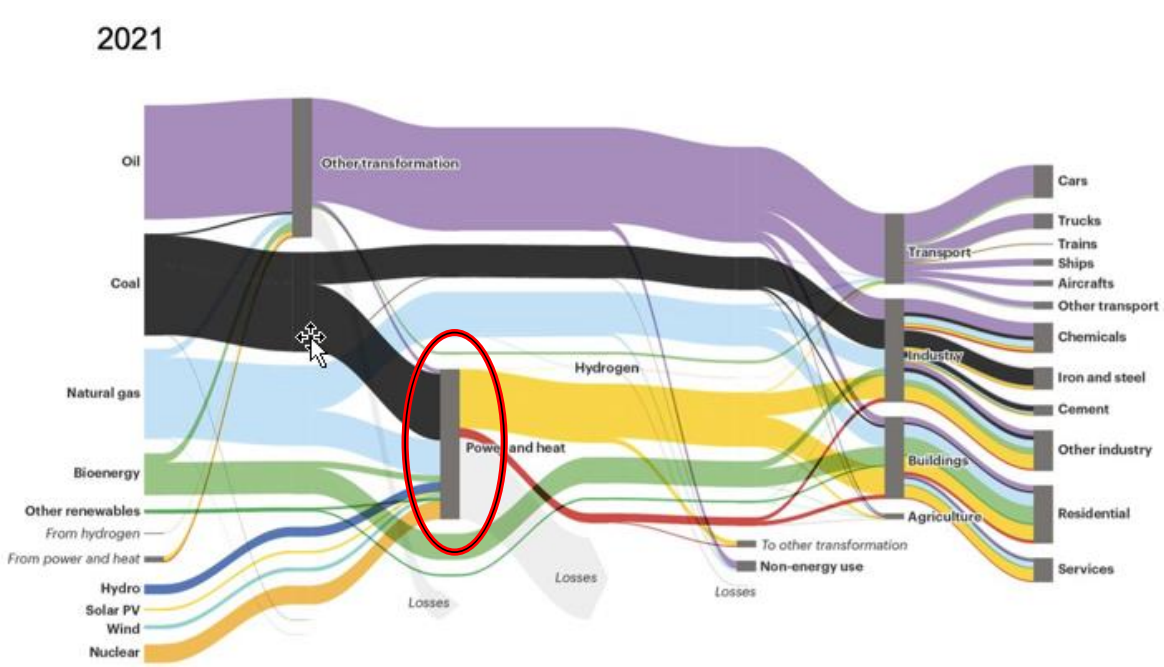
Building on our unique range of capabilities, we create pioneering solutions to master the business, technical, and operational challenges of decarbonization.

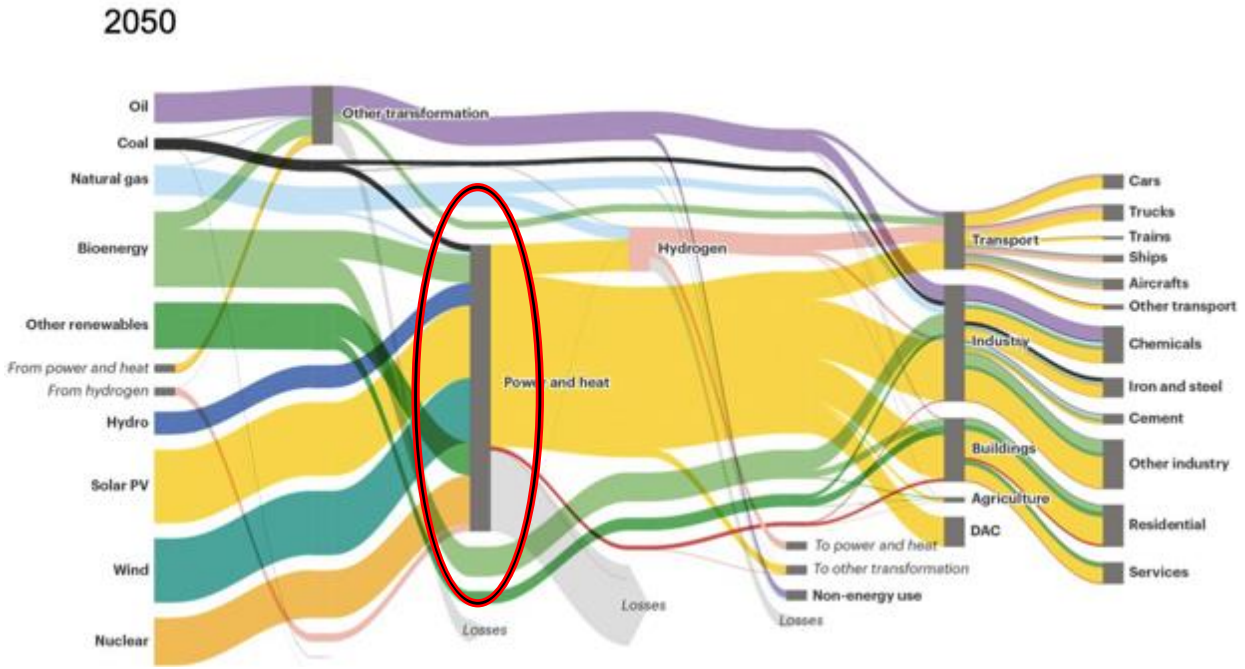
We enable customers to achieve sustainable value creation in the transition towards a carbon neutral future.

11	**Production sites in Europe**
3	**Production sites in Asia**
30	**Licensees in 7 countries (two- and 4-stroke, turbocharger)**
+15’000	**Employees worldwide**
5.3bn €	**Revenue 2024**
HQ	**Augsburg / Germany**



The future is electric: Energy- & Heat ‘n‘ cold transition !

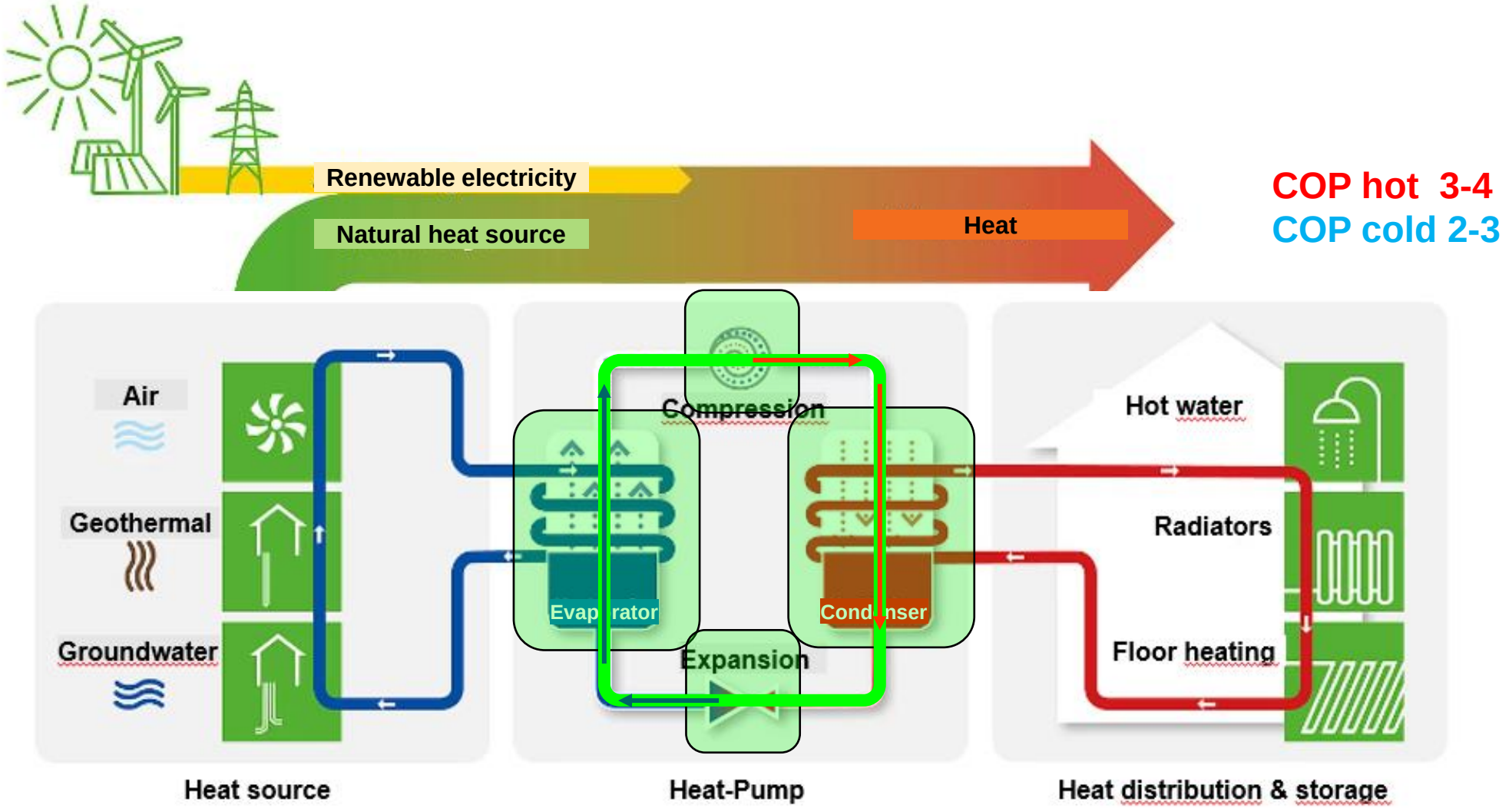




Source: IEA

MEGA Heat-Pumps & District Heating can make a big difference !

How does a heat-pump work?

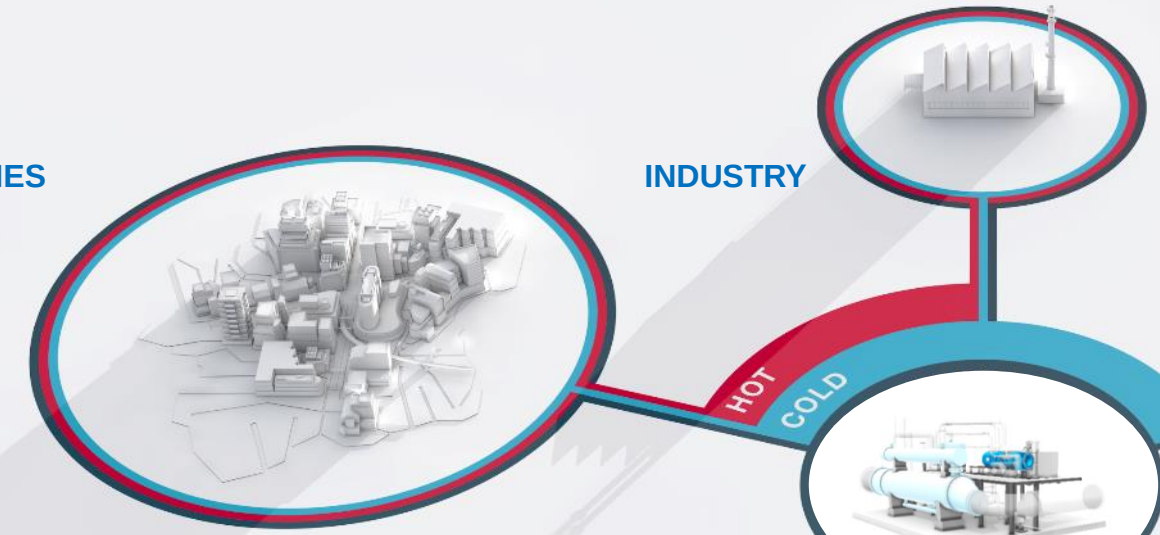


21st century – The age of the (mega) heat-pumps !

But what makes this technology so superior?

- **Proven and mature technology**
- **Supporting the energy- & heat-transition**
- **Sustainable and clean - NO compromises**
- **Decarbonizing heat AND cold production simultaniously. Steam generation.**
- **Highly efficient (COP 3+)**
- **Vast thermal capacities at high and low temperatures (-15 – 200+°C)**
- **Very robust, reliable and long lasting (>35 years lifetime) – No performance drop!**
- **Can handle various of heat sources (natural and heat recovery from industry)**

21st Century – The age of the mega heat-pumps !



CITIES / MUNICIPALITIES

INDUSTRY

SECTOR COUPLING

DATA CENTERS
CARBON CAPTURE
H2 PRODUCTION

THERMAL – STORAGE (LDES)

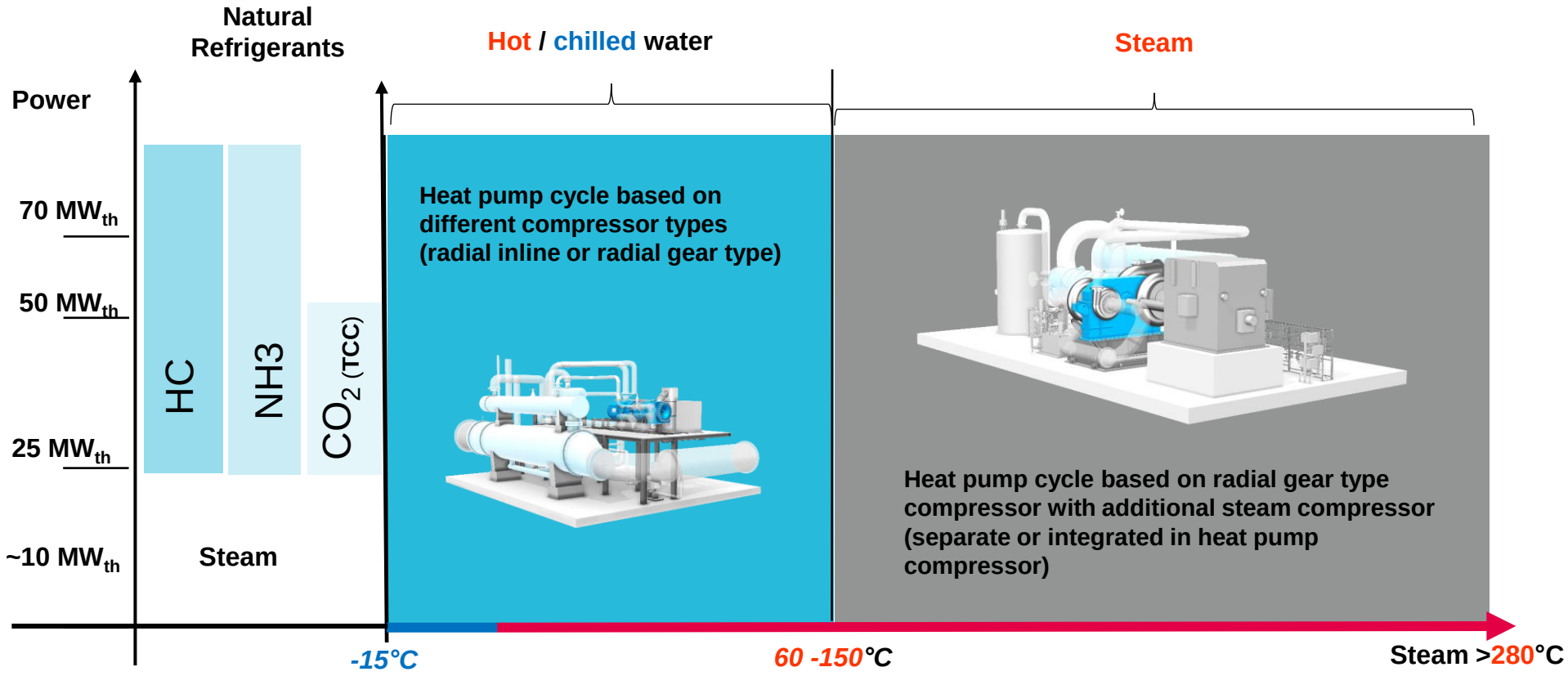
TSO / DSO

RENEWABLE INTEGRATION

GRID STABILIZATION
Primary- (FCR) & Secundary-Reserve (aFFR)

MAN (mega) heat-pump solutions

for wide power & temperature ranges



TCC: Transcritical compression cycle, VCC: Vapor compression cycle

Refrigerants: Environment over efficiency and cost !

Refrigerant	Synthetic or Natural?	Commonly Used	ODP	GWP	Flammability	Toxicity
CFC	Synthetic	Commonly recognized as Freon (R11, R12, R113, R114, R115, R502)	.05 to 1	10,000+	Low	Low
HCFC	Synthetic	R22, R123, R401a	.02 to .1	1,000 to 5,000	Low, but higher than CFCs	Low
HFC	Synthetic	R134a, R404a, R407C, R410a	0	<1 to 12,500	None	Low
HFO	Synthetic	R1234yf, R1234ze(E), R1234ze(Z)	0	<1	Low	Low
Ammonia (NH_3)	Natural	R717	0	0	Low	High
Carbon Dioxide (CO_2)	Natural	R744	0	1	None	Low
HC	Natural	R290, R600a, R170, R1150, R600, R601	0	<1	High	Low

Pushing the boundries

Olympic sized swimming pool

- Water: 2.5 million litres @ 20°C

MAN CO2 mega heat-pump

- 1 HOFIM compressor
- 16 MW electricity input

How much time does it take to bring this water to the boiling point?

< 4 hours

and to freeze

< 11 hours

Heat sources for MAN heat-pumps

Source: lghvacstory.com

(Waste-)Water / liquid

Source: Rogers & Sons

Geothermal

subsurface
@ 10 – 25°C

Ambient air

@ -20°C

Industry waste heat

Good industry heat sources

- Data Centers
- Carbon Capture
- H2 production sites
- Any decarbonised process

Thermal storage for operation flexibility & optimisation

Short term hot storage
1’000 – 80’000 m³

«Seasonal» hot storage

Ice storage

Groundbraking District heating projects

2021: Esbjerg (DK)

First seawater CO_2 Heat Pump for district heating 2x 35 MWthermal / in operation since Dezember 25

2023: Aalborg (DK)

World's largest seawater CO_2 Heat Pump for district heating 4x 44MWth

2024: Patola (FI)

World's largest Air-to-Water CO_2 Heat Pump for Helsinki's district heating 1x 22-33 MWth

2024: Vicinity (USA)

Largest steam Heat Pump for district heating 33 MWth

2024: RheinEnergie (GER)

Largest river water Heat Pump for Cologne's district heating 3x 50MWth

464 MW thermal

500,000t CO_2 savings

…. and more to come !

Esbjerg (DK) project

MAN Energy Solutions
Future in the making

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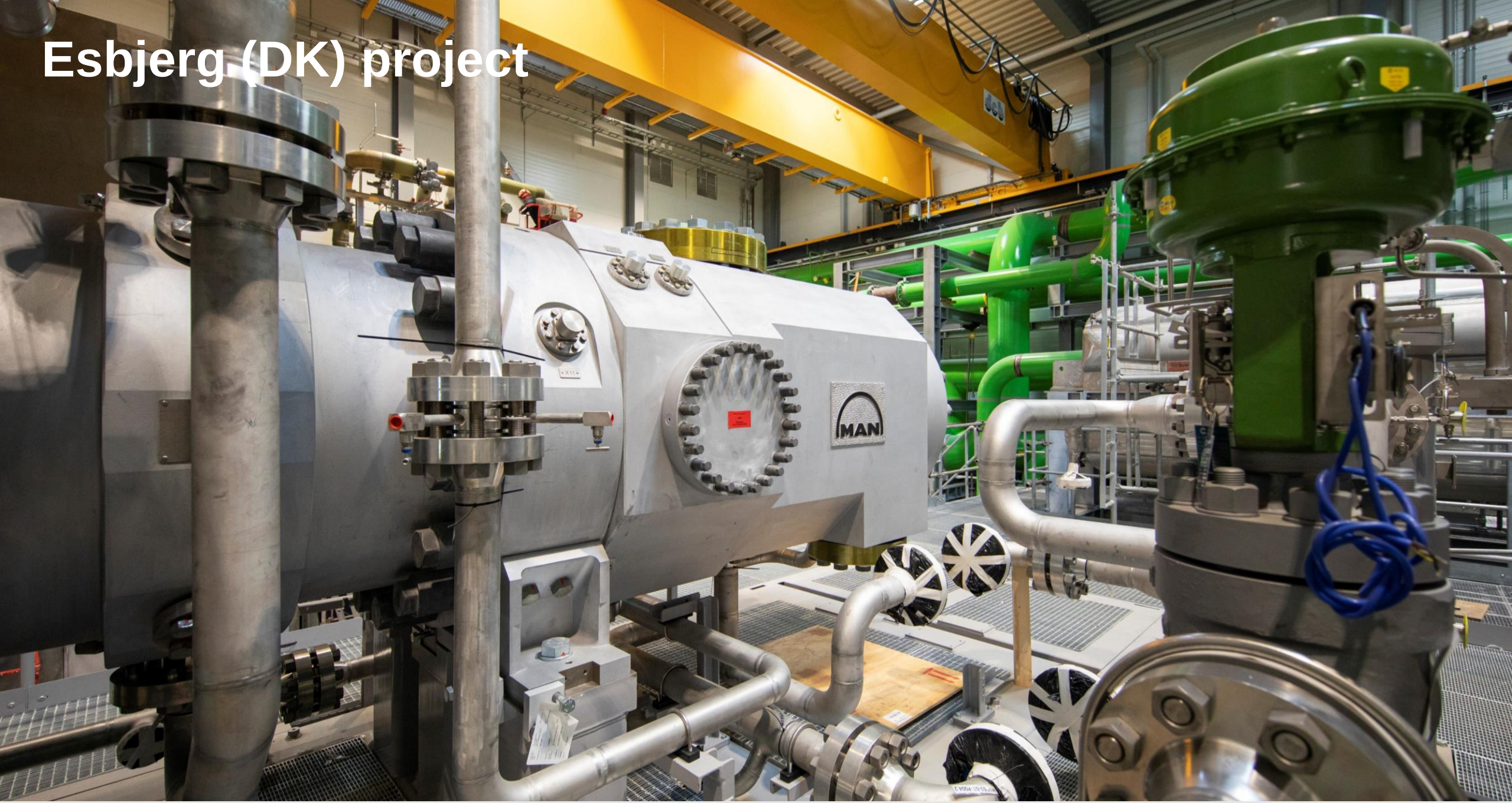
Future in the making

MAN Compressor in factory

MAN Compressor @ site in Esbjerg

CO_2 storage tank

Esbjerg (DK) project

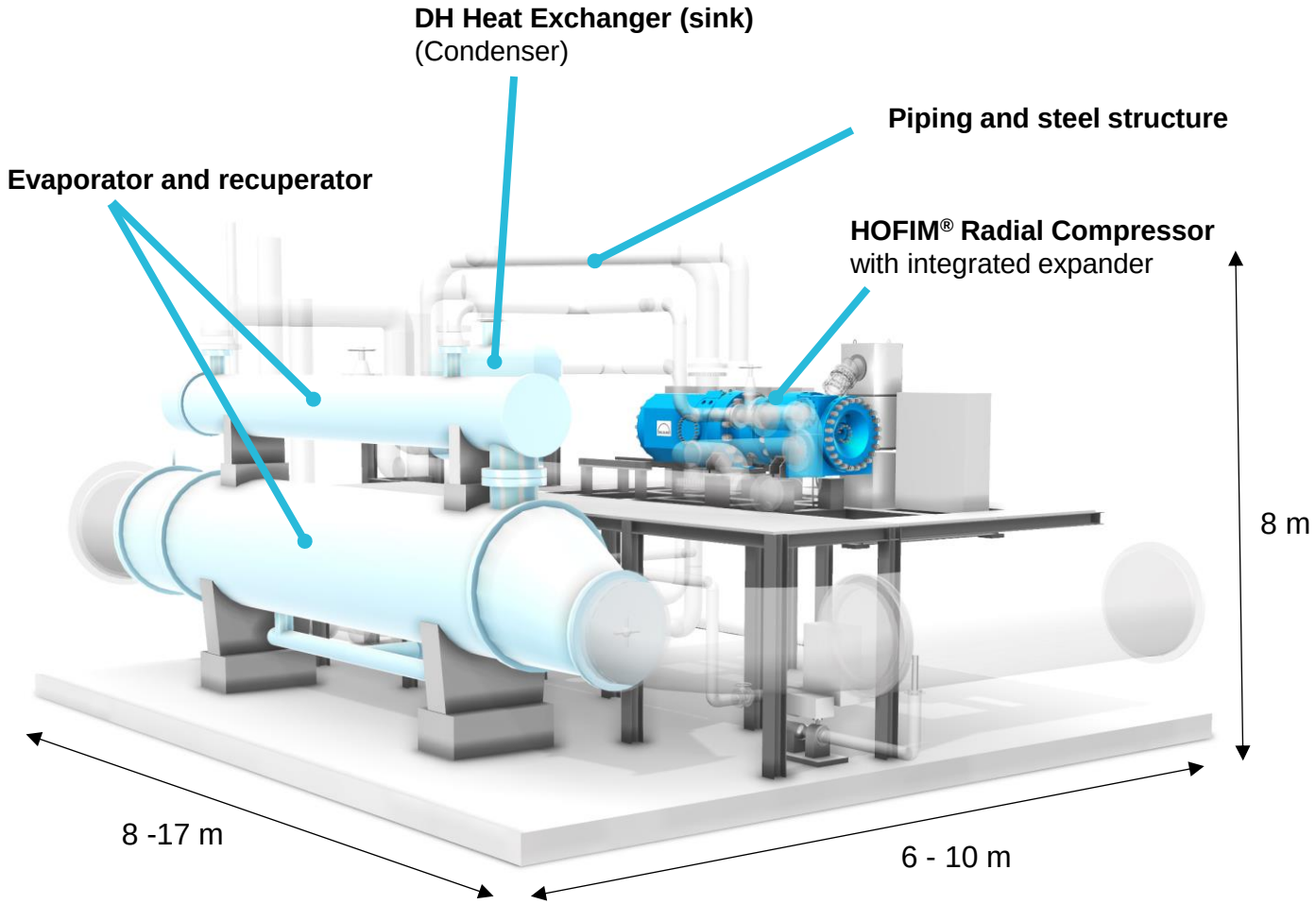


Esbjerg (DK) project

Esbjerg (DK) project

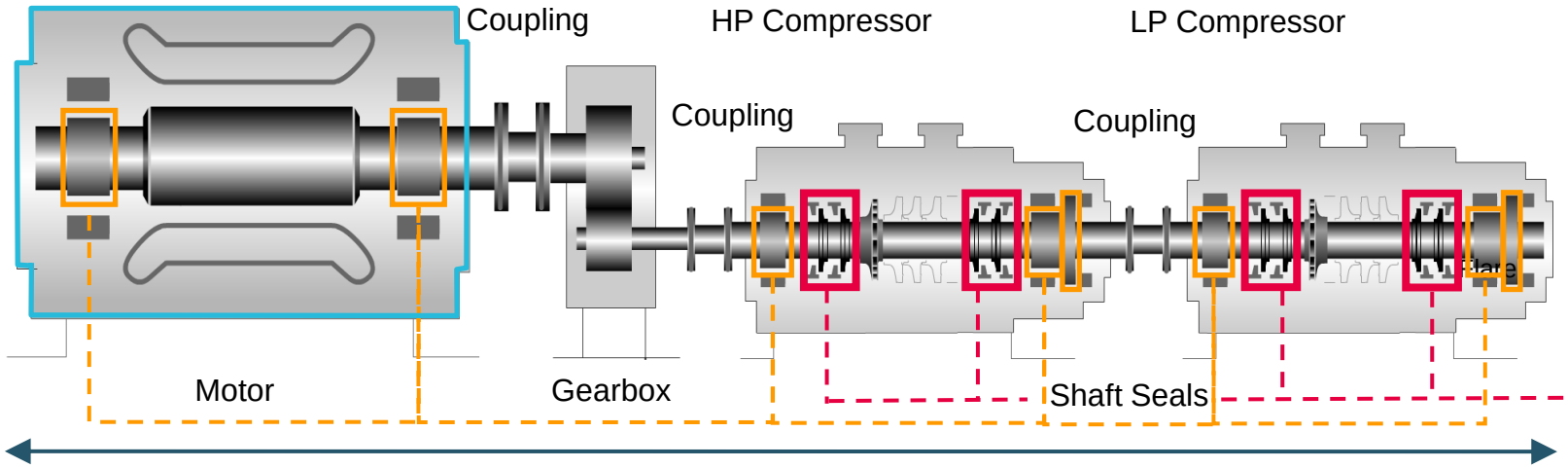
Transcritical CO_2 (TCC) heat-pump design

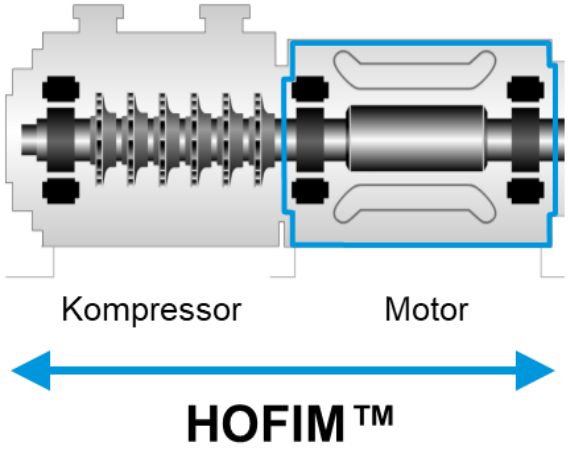
- **HOFIM Radial Compressor**
- **Thermal output per unit/day:**
  - **50 MW_{th} heat**
  - **30 MW_{th} cold**
- **CO_2 (R744)** as refrigerant
- **Temperature levels -15° - 150+ °C**
- **Lifetime:** +35 years



HOFIM Compressor for CO_2 (TCC) heat-pumps

High **S**peed **O**il **F**ree **I**ntegrated **M**otor compressor HOFIM™

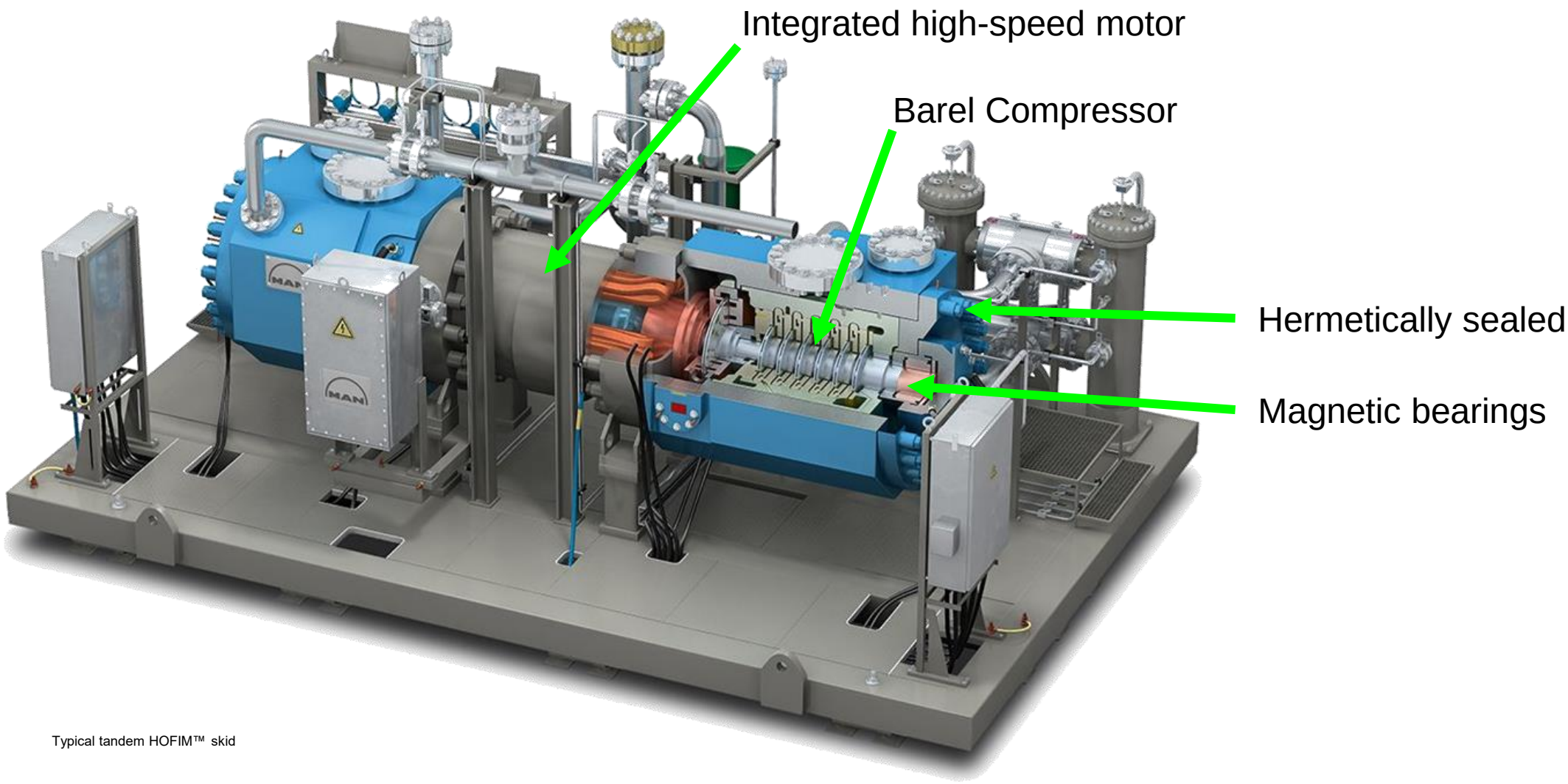




- **Reduced footprint (max. 4m x 8m)**
- **Integrated high-speed motor (10’000-18’000 rpm)**
- **No gearbox → noise reduction (ca. 90 dB)**
- **Magnetic bearings → no oil lubrication**
- **Hermetically sealed → No leakage / loss of refrigerant**

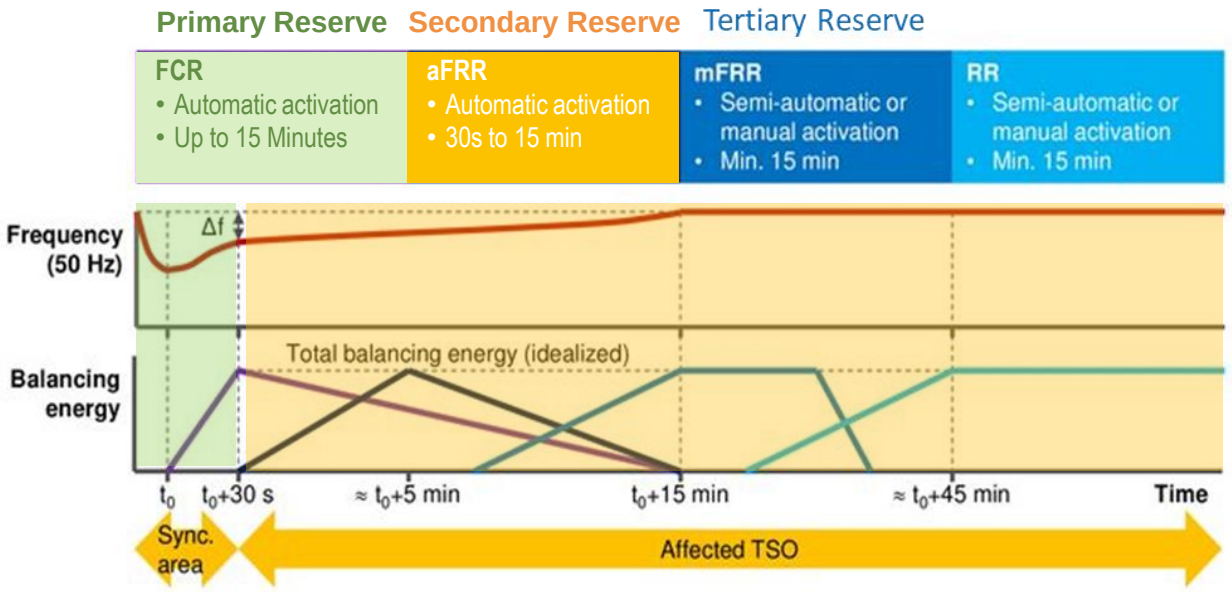
HOFIM™ Radial Compressor

High speed Oil Free Integrated Motor compressor

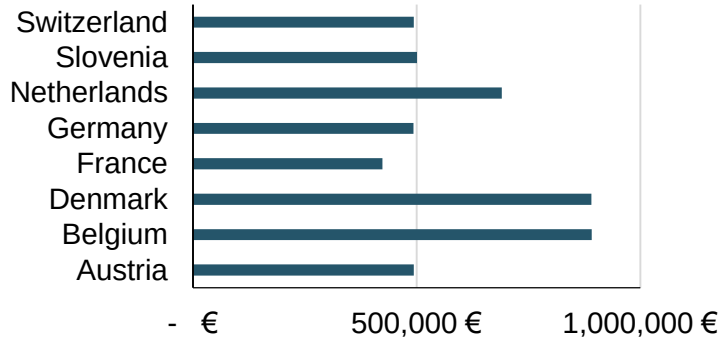


Typical tandem HOFIM™ skid

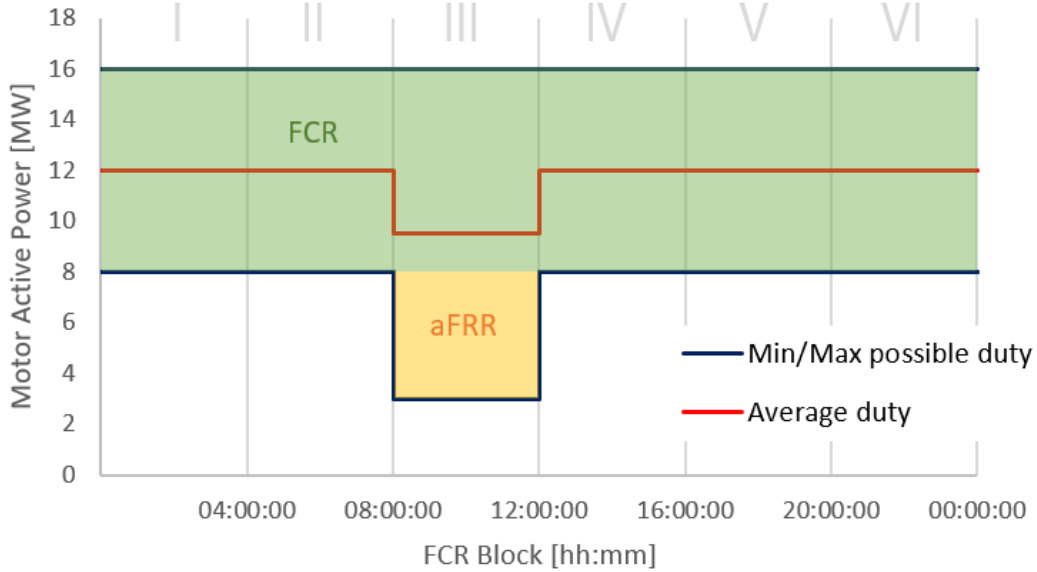
MAN HOFIM™ compressor technology for grid balancing



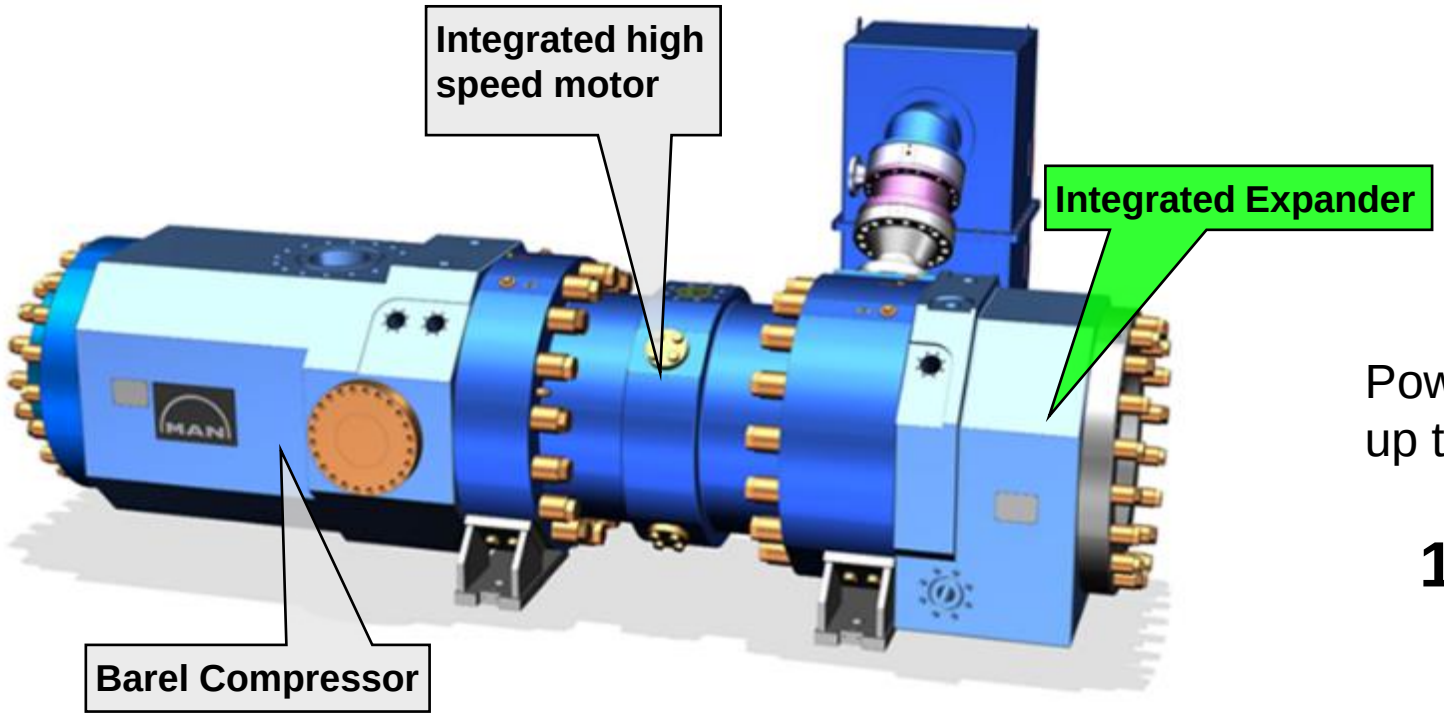
For all FCR cooperation countries on average between 2021 - 2023



- Increase & decrease el. power consumption up to 8 MWel in < 30sec
- Run DH stable operation down to 20% of the nominal duty with thermal storage as buffer



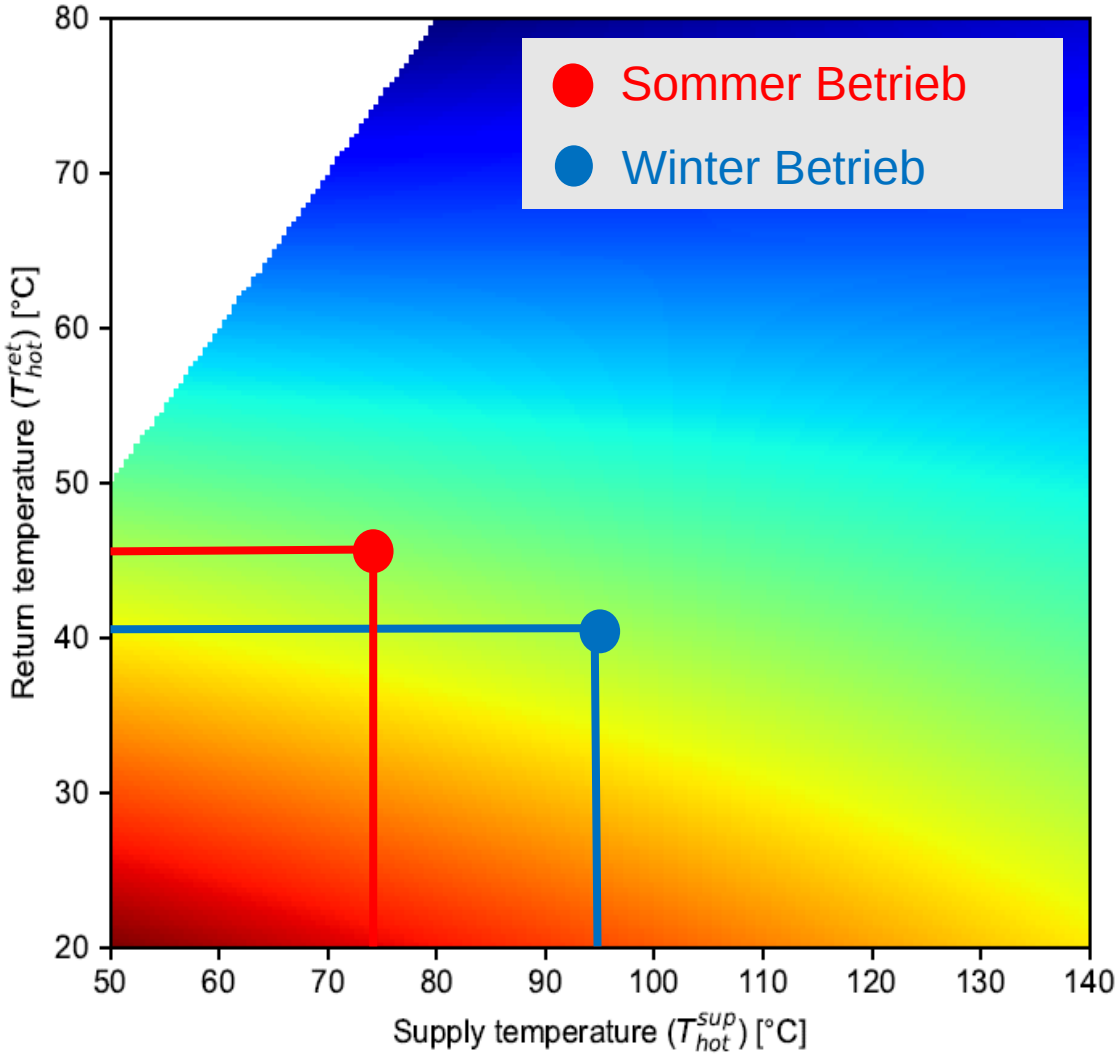
Compander: HOFIM® with integrated expander

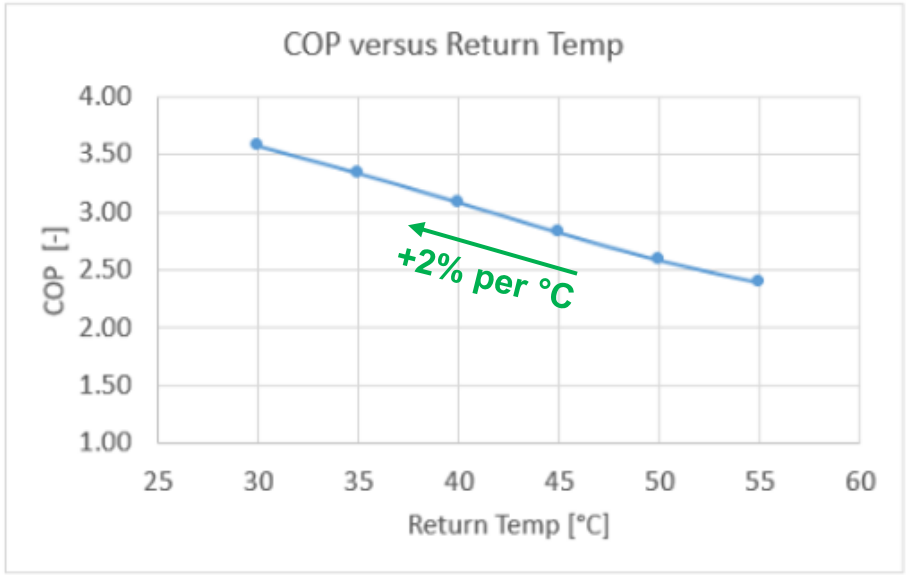


Power savings up to

10-15%

Efficiency DH: Return temperature down → COP up !





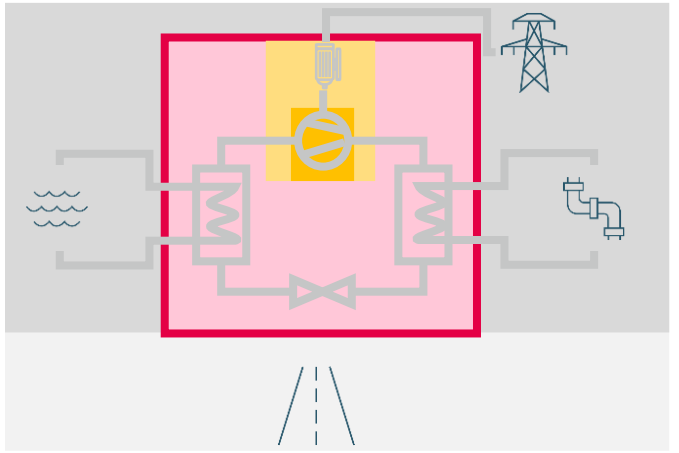
*) assuming 5000 h/year

**) assuming 0.2 EUR / kWh

= average price in EU in 2022 acc. to Eurostat

Heat duty [MW]	50	50	50	50	50	50
Supply Temp [°C]	90	90	90	90	90	90
Return Temp [°C]	**55**	**50**	**45**	**40**	**35**	**30**
COP [-]	**2.39**	**2.59**	**2.83**	**3.09**	**3.34**	**3.58**
COP Increase [%]	-	8.1%	18.1%	29.1%	39.7%	49.6%
El. Power [MWe]	20.9	19.3	17.7	16.2	15.0	14.0
El. Consumption saving per year [MWh] *	-	7'838	16'046	23'554	29'694	34'627

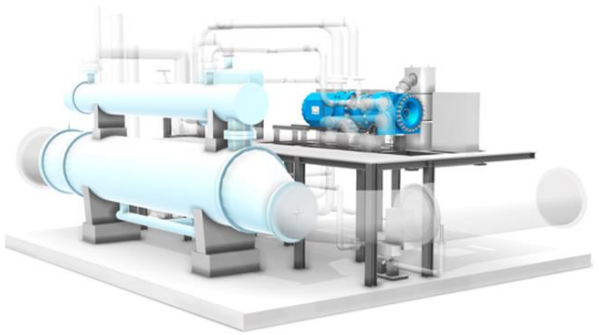
MAN turnkey solutions



MAN Energy Solutions delivery

- Compressor unit
- Heat Exchanger (Condenser) on hot side
- Evaporator on cold side
- Complete piping and steel structure
- Refrgerant tank
  - Valves, instrumentation, connecting cables, DHN water pumps, seawater pumps
  - Complete electrical scope
  - Complete control system
  - FAT of main equipment
  - Installation and commissioning
  - On site testing

Typical scope of delivery



Grid, heat-sink and heat-source connection

Civil work (e.g. roads, buildings)

«If you’re willing to change the world – let heat-pumps be your energy!»

mega