

Webinar 8. and 13. June 23

CO₂ heat-pump technology for best efficiency in DHN, high temperatures and more.

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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)

+14'000

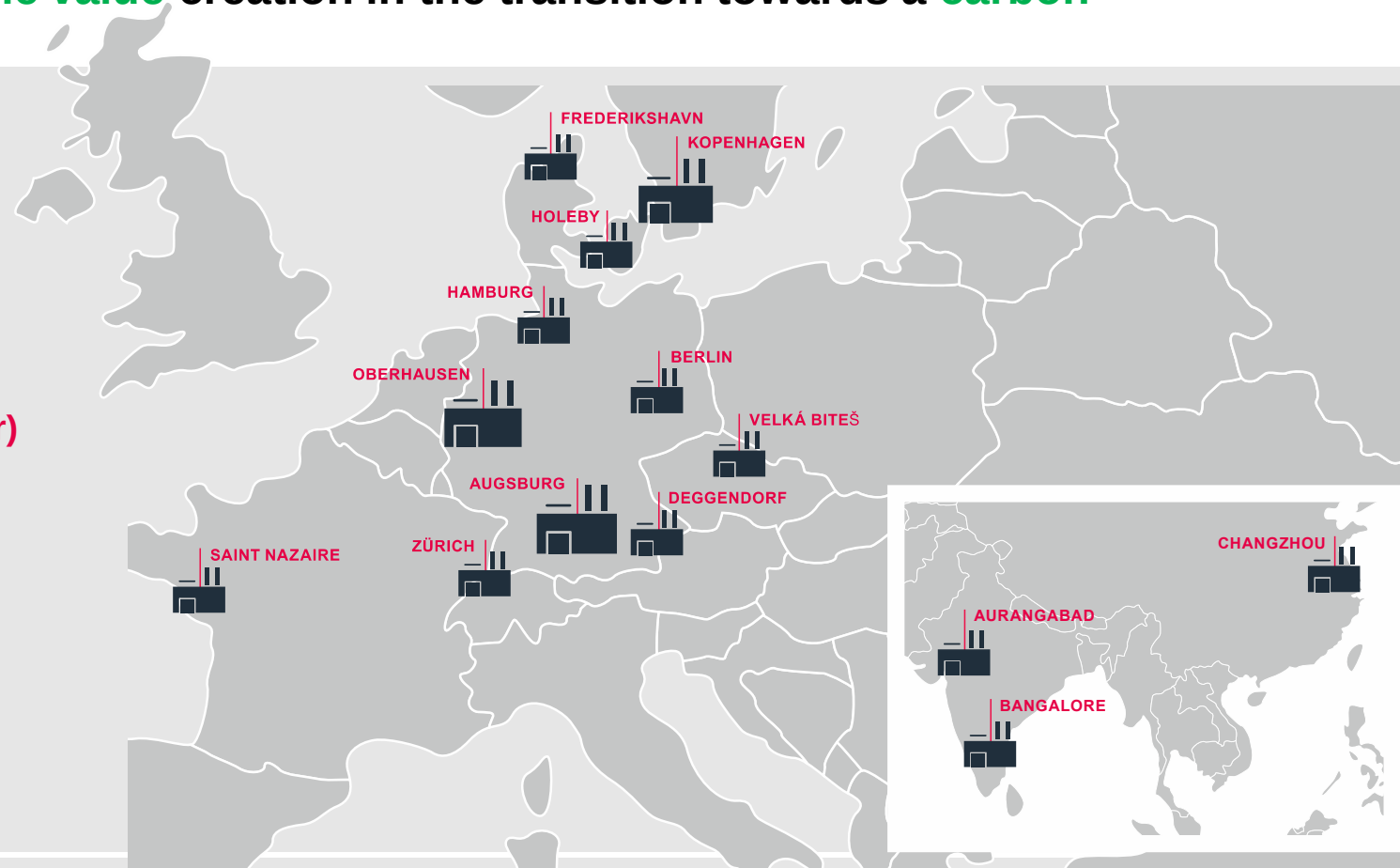
Employees worldwide

3.8bn €

Revenue 2022

HQ

Augsburg / Germany



MAN Energy Solutions strategy

Striving towards increased sustainability & CO₂ reduction

Marine



Energy & Storage



Industries



**Incumbent MAN-ES
business fields**

New forward strategy



Large HT Heat-Pumps



Carbon Capture (CCS)

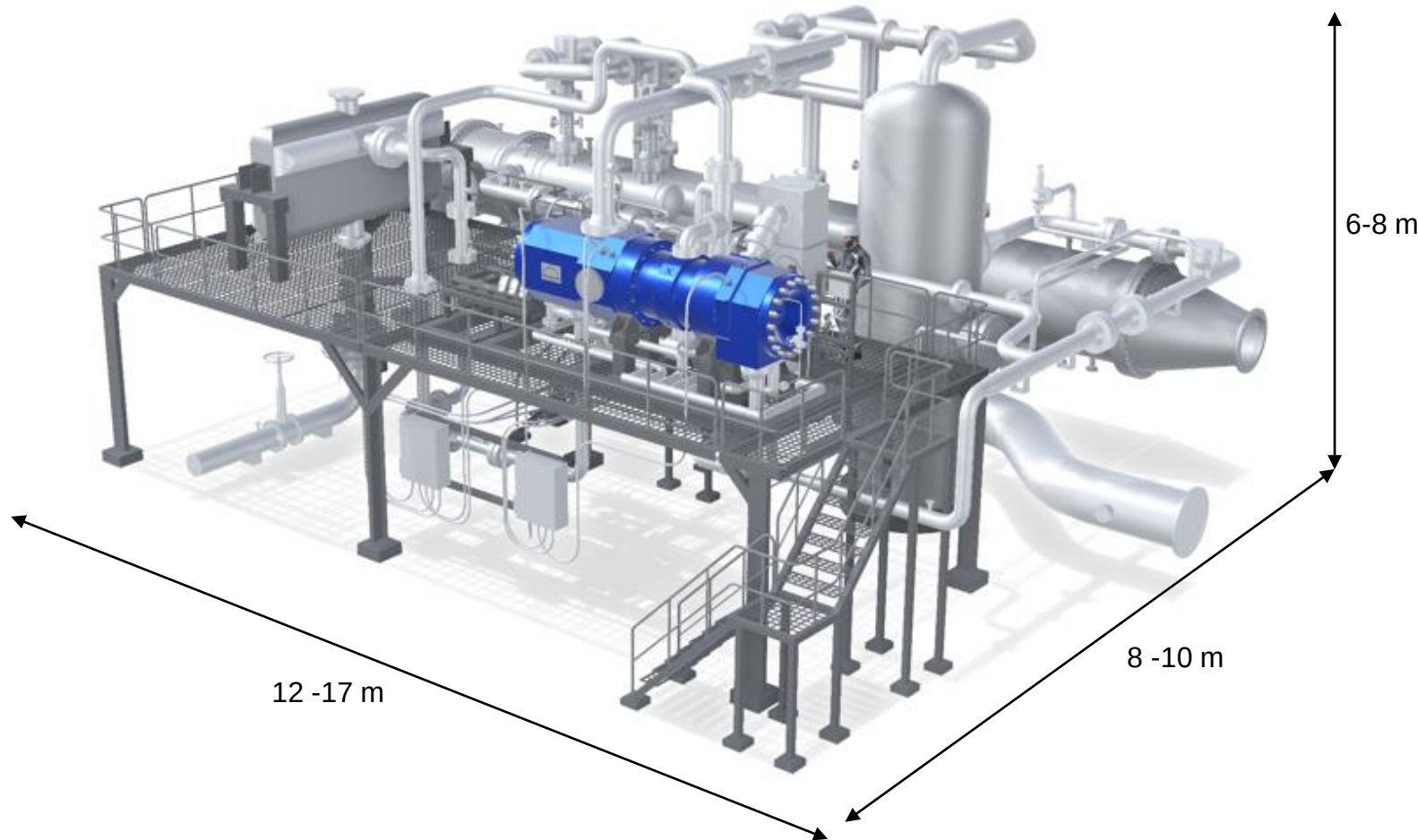


Hydrogen (H2)



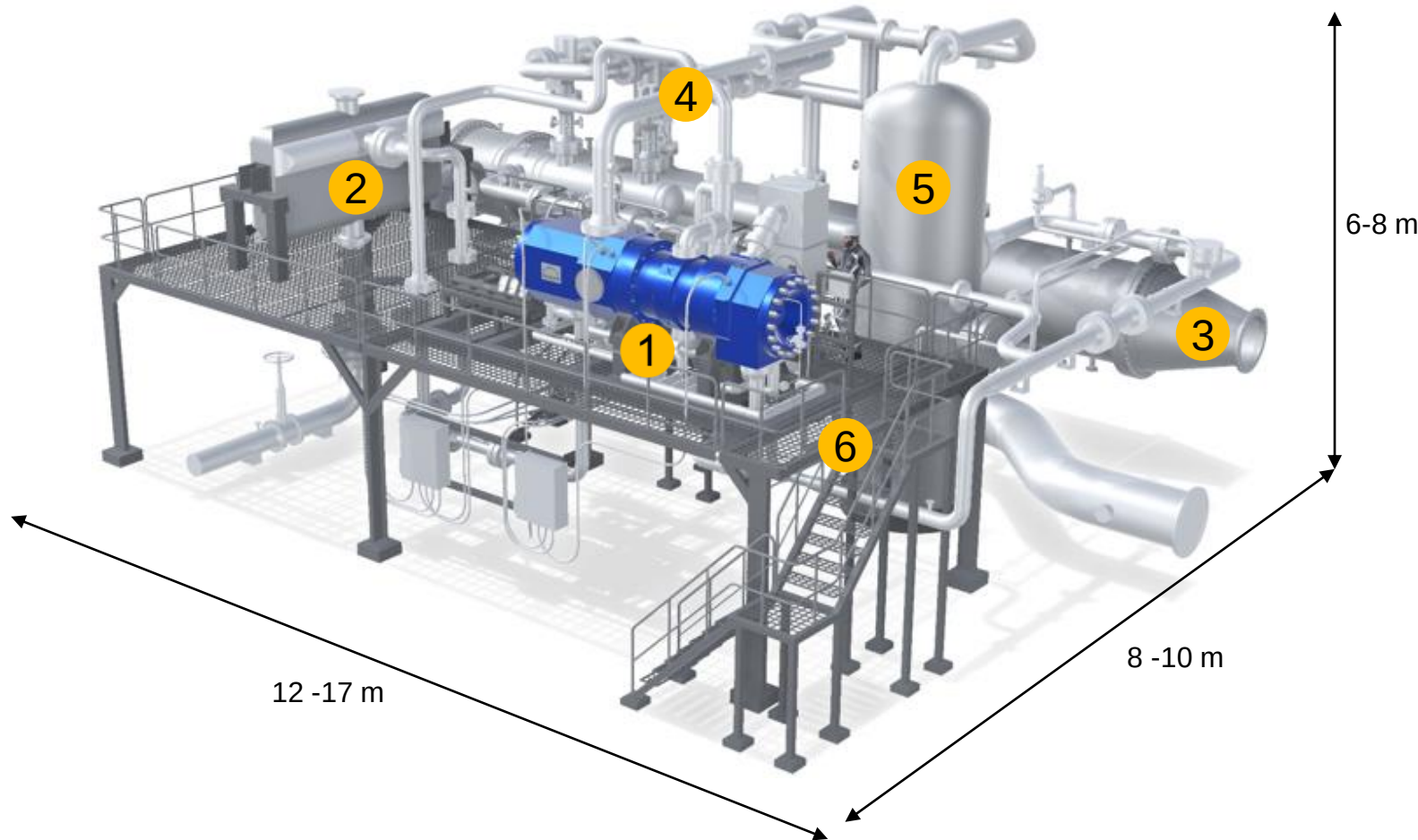
Global MAN Service Organisation PrimeServ

Possible heat-pump layout – Facts and figures



- **Compressor (HOFIM)**
 - Electricity input 5 / 9 /16 MWeI
 - Magnetic bearings (= no lube oil)
 - Hermetically sealed (= no leakage)
 - Integrated high-speed motor (10'000 – 18'000 rpm)
 - Reduced footprint (2/3)
 - Noise development ca. 90dB
 - Up to 220 bar
- **Thermal output: up to 50 MW_{th} heat + 30 MW_{th} cold** per heat-pump per day
- **CO₂ (R744)** as refrigerant
- **Temperature levels -20° - 150+ °C**
- **Lifetime: +35 years**

Possible heat-pump layout – MAN-ES delivery



MAN Energy Solutions delivery

1. Motor-Compressor HOFIM® with integrated expander
2. District Heating Heat Exchanger (Condenser)
3. Evaporator
4. Complete piping and valves
5. CO₂ (R744) separator tank
6. Steel structure

+

- Instrumentation, connecting cables
- DHN water pumps
- Complete electrical scope
- Complete control system
- FAT of main equipment
- Installation and commissioning
- On site testing

Heat & cold production capacities

E_{ch}

Electricity input

Compressors sizes

(2)-5 MWelectricity

(5)-9 MWelectricity

(9)-16 MWelectricity

Turndown operation:

From 50% to 100%

or

100% to 50% in <30 sec.

Heat production

Sensible storage
(30-150°C)



Thermal export

6-15 MWthermal

15-27 MWthermal

27-48 MWthermal

Q_{hot}

Q_{hot}^{bal}

Cold production

Latent storage (0°C)



Thermal export

4-10 MWthermal

10-18 MWthermal

18-32 MWthermal

Q_{cold}

Q_{cold}^{bal}

Assuming a hot COP of 3

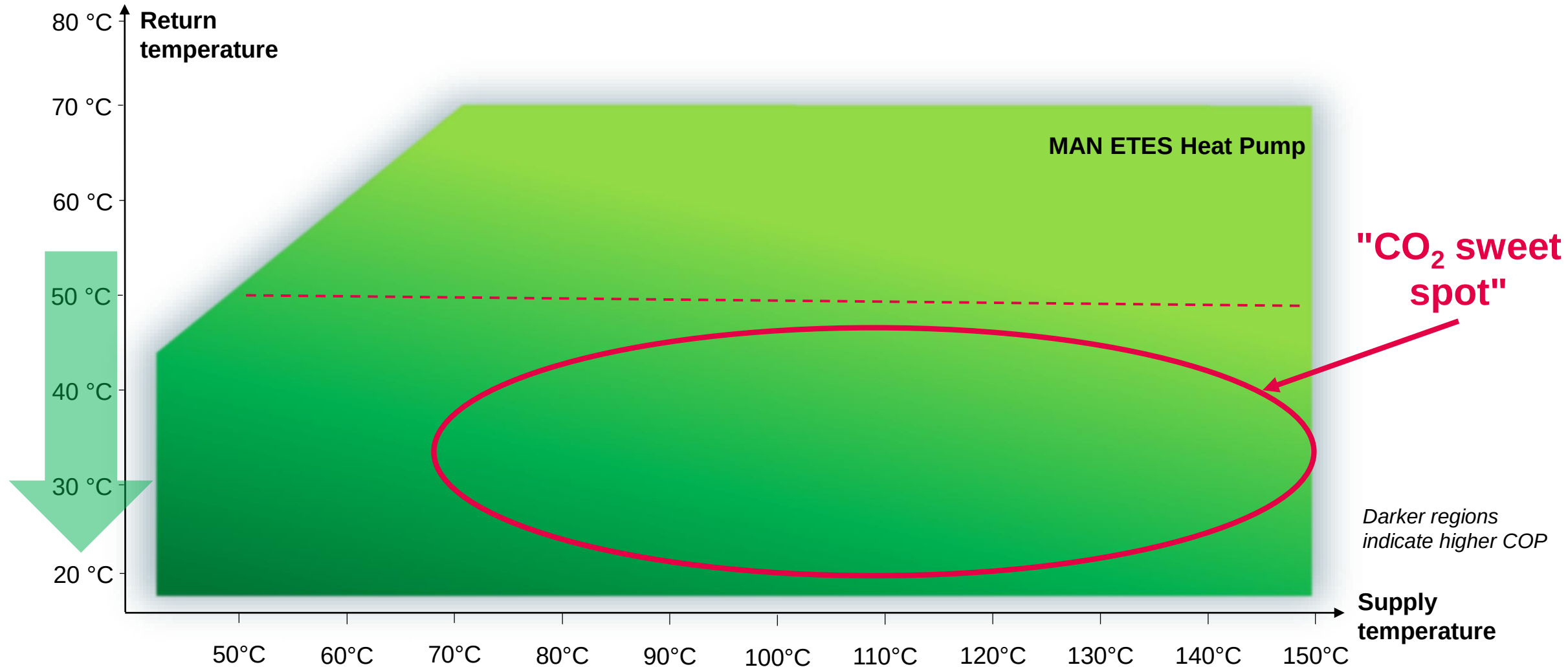
How much time does it take to bring the water of a Olympic sized swimming pool to the boiling point?



- Length: 50m
- Width: 25m
- Depth: 2m
- Water: 2.5 million litres
- 20°C

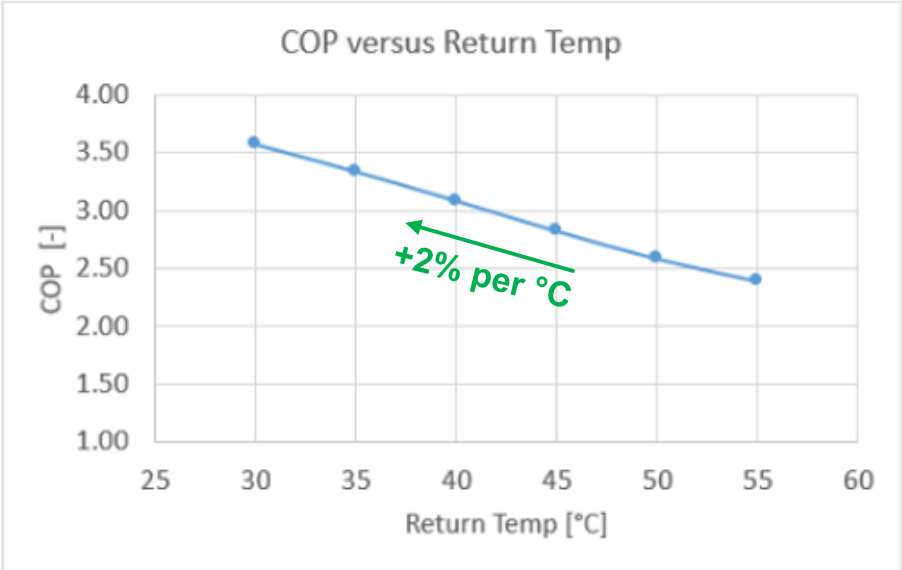
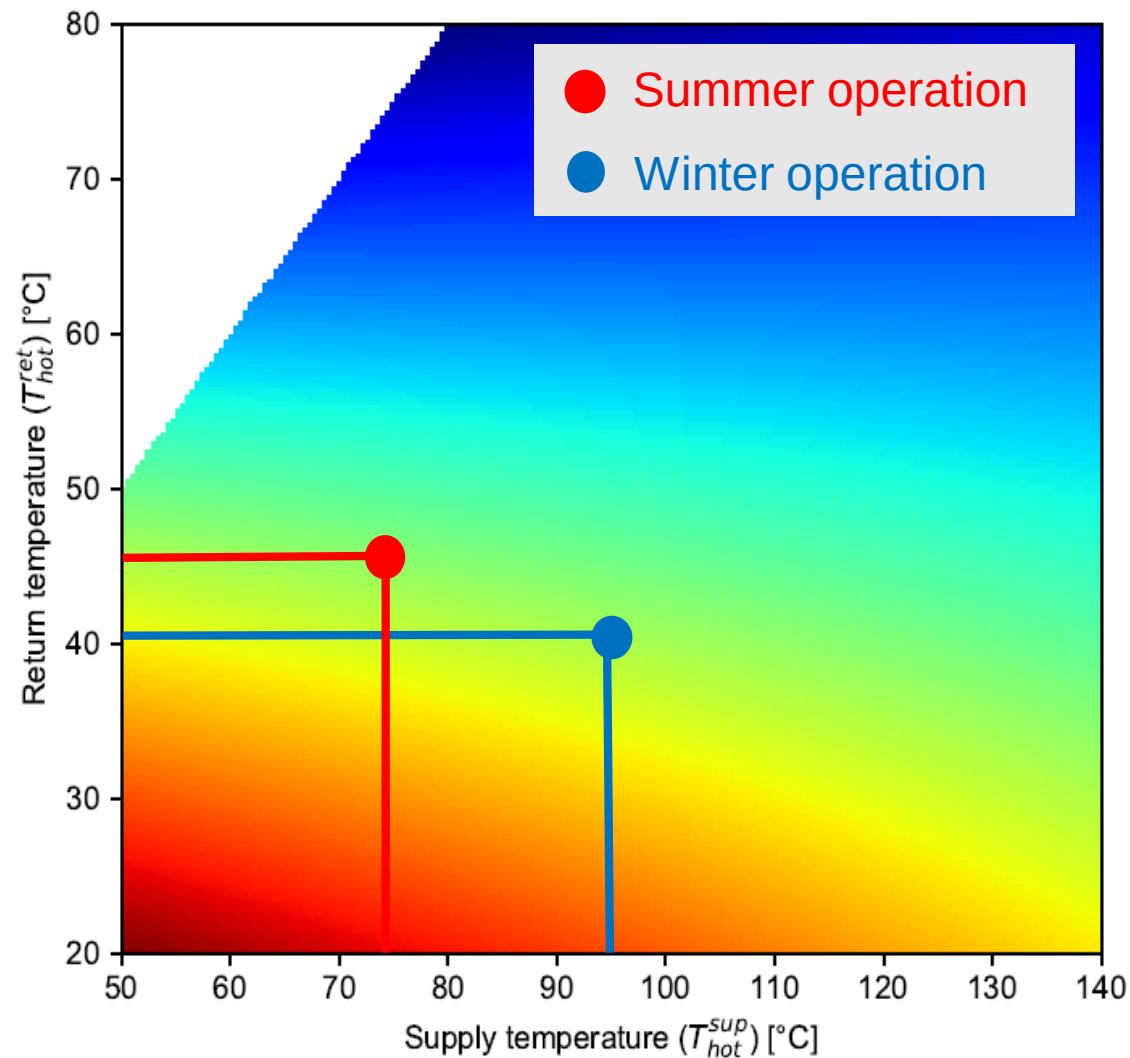
< 4 hours

CO₂ (R-744) Refrigerant – Best flexibility for District Heating



CO₂ (R-744) Refrigerant offers operation advantages

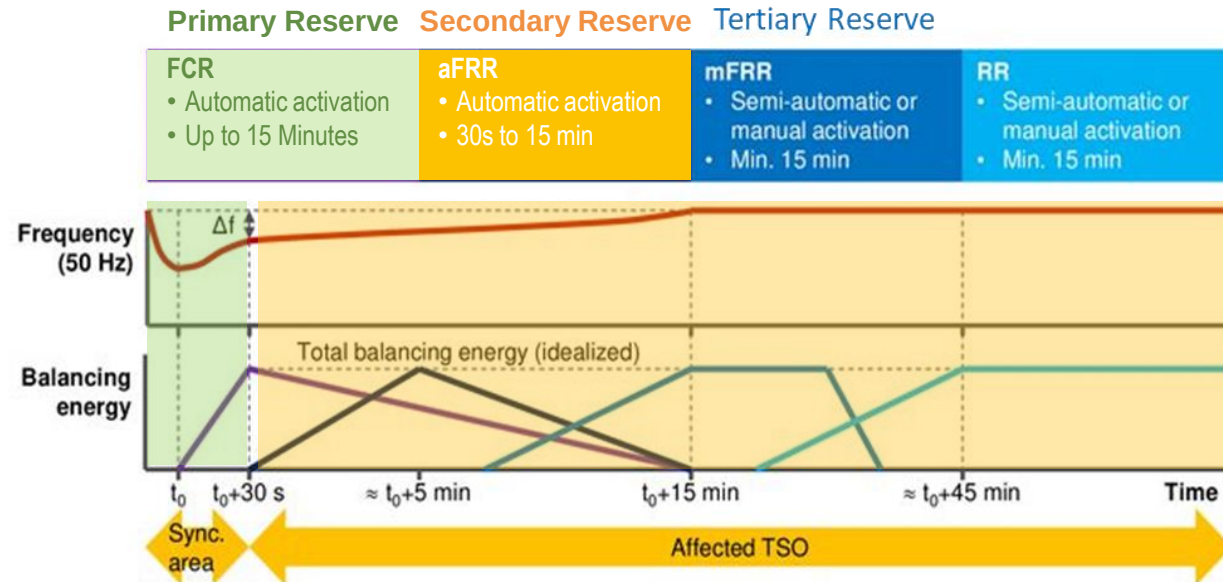
A good COP and high supply temperatures are not contradictory



*) 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
Costs saving per year [EUR] **	-	1'567'626	3'209'241	4'710'708	5'938'704	6'925'353

Heat-Pumps based on MAN HOFIM™ compressor technology enable fast grid balancing in <30 sec.

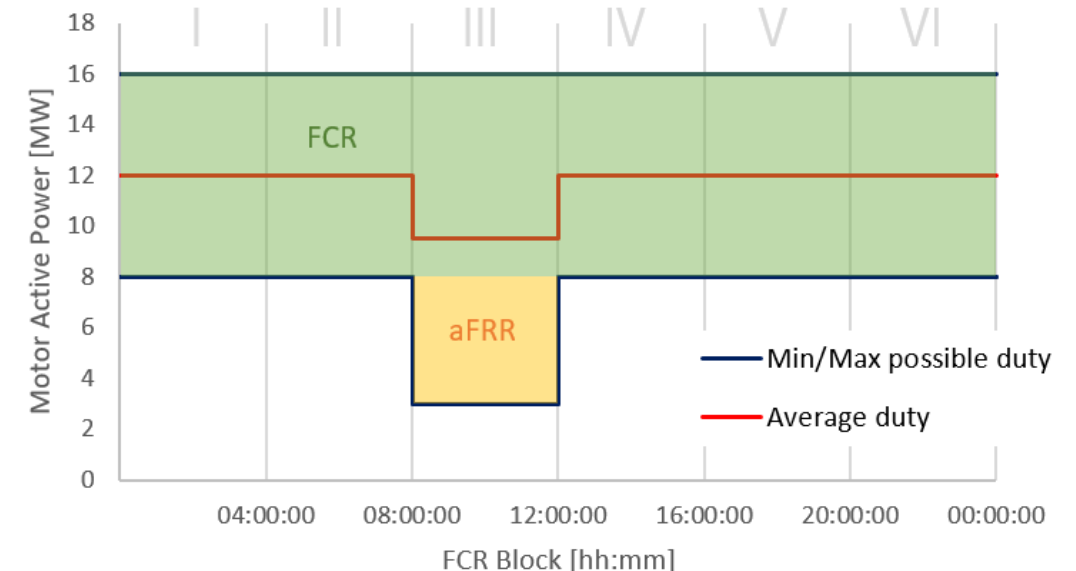


Additional revenue per year (200 days)

	FCR	aFRR cap	aFRR ava	aFRR act	Total
Belgium	€ 536'800	€ 17'600	€ 16'800	€ 84'000	€ 655'200
Austria	€ 421'600	€ 17'600	€ 16'800	€ 84'000	€ 540'000
Switzerland	€ 421'600	€ 17'600	€ 16'800	€ 84'000	€ 540'000
Germany	€ 421'600	€ 17'600	€ 16'800	€ 84'000	€ 540'000
Netherlands	€ 421'600	€ 17'600	€ 16'800	€ 84'000	€ 540'000
Slovenia	€ 421'600	€ 17'600	€ 16'800	€ 84'000	€ 540'000
Denmark	€ 421'600	€ 17'600	€ 16'800	€ 84'000	€ 540'000
Czech Republic	€ 421'600	€ 17'600	€ 16'800	€ 84'000	€ 540'000
France	€ 381'600	€ 17'600	€ 16'800	€ 84'000	€ 500'000

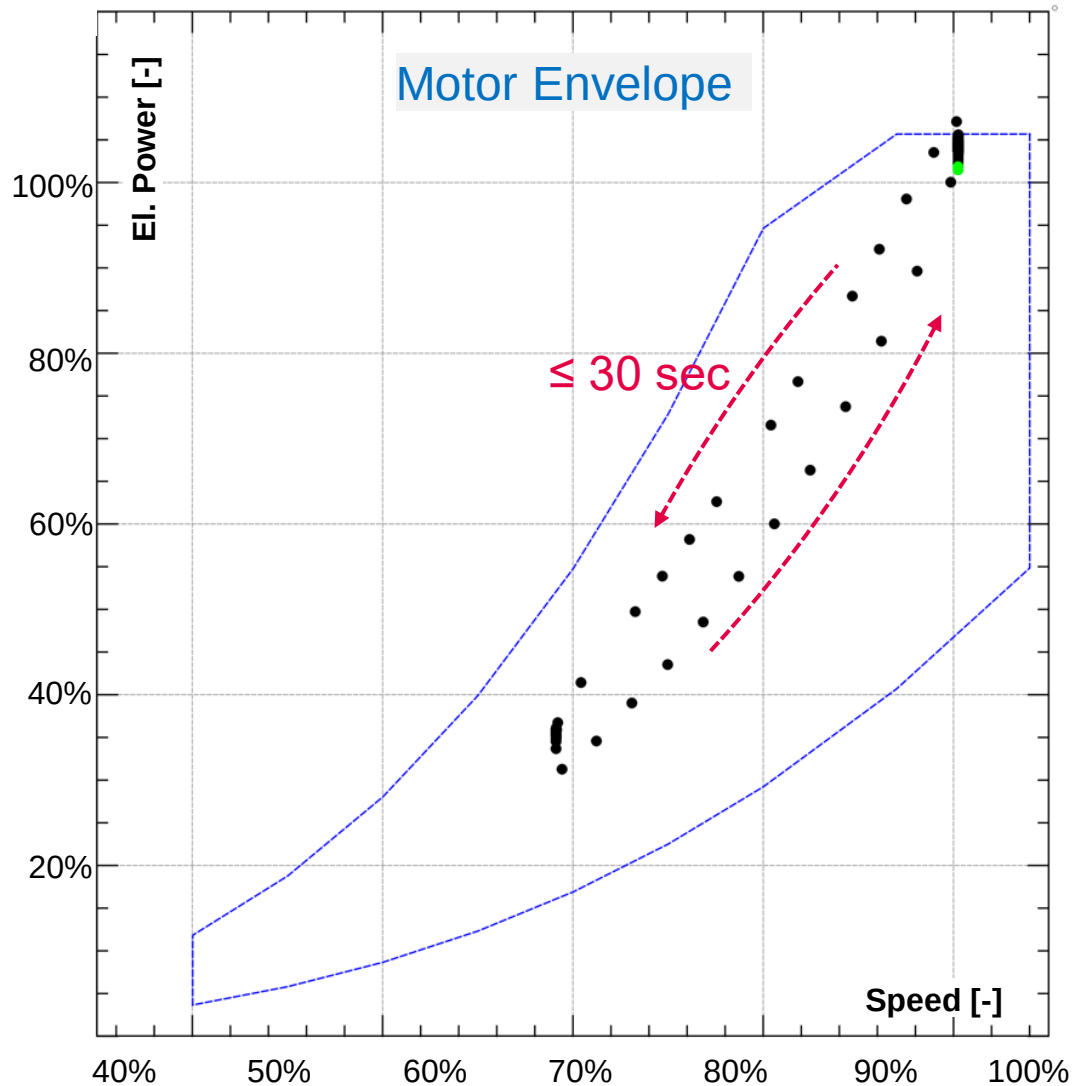
➤ Increase & decrease el. power consumption in < 30sec by +/- 30% during heat supply

➤ Run DH stable operation down to 20% of the nominal duty with thermal storage as buffer

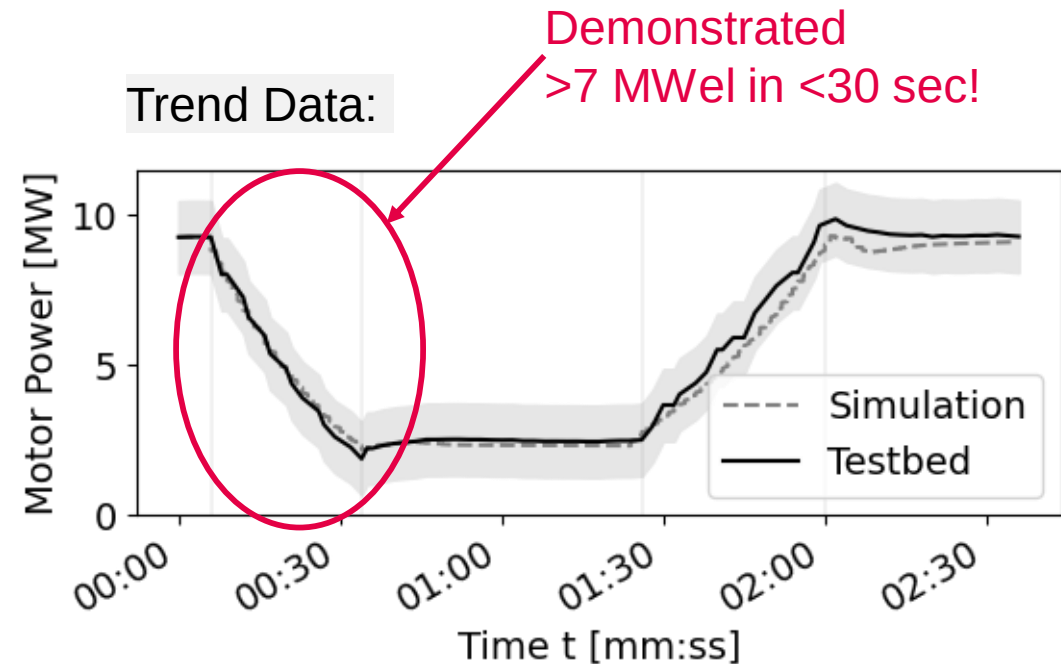


Fast electrical load change qualified by test bed measurements & simulation

Measurements:



Simulation:



- Dynamic reaction faster than expected
- Very good accordance between testing results and simulations

Esbjerg (DK) Project

Heat-Pump building

Q3 2023
Going operational

Project drivers:

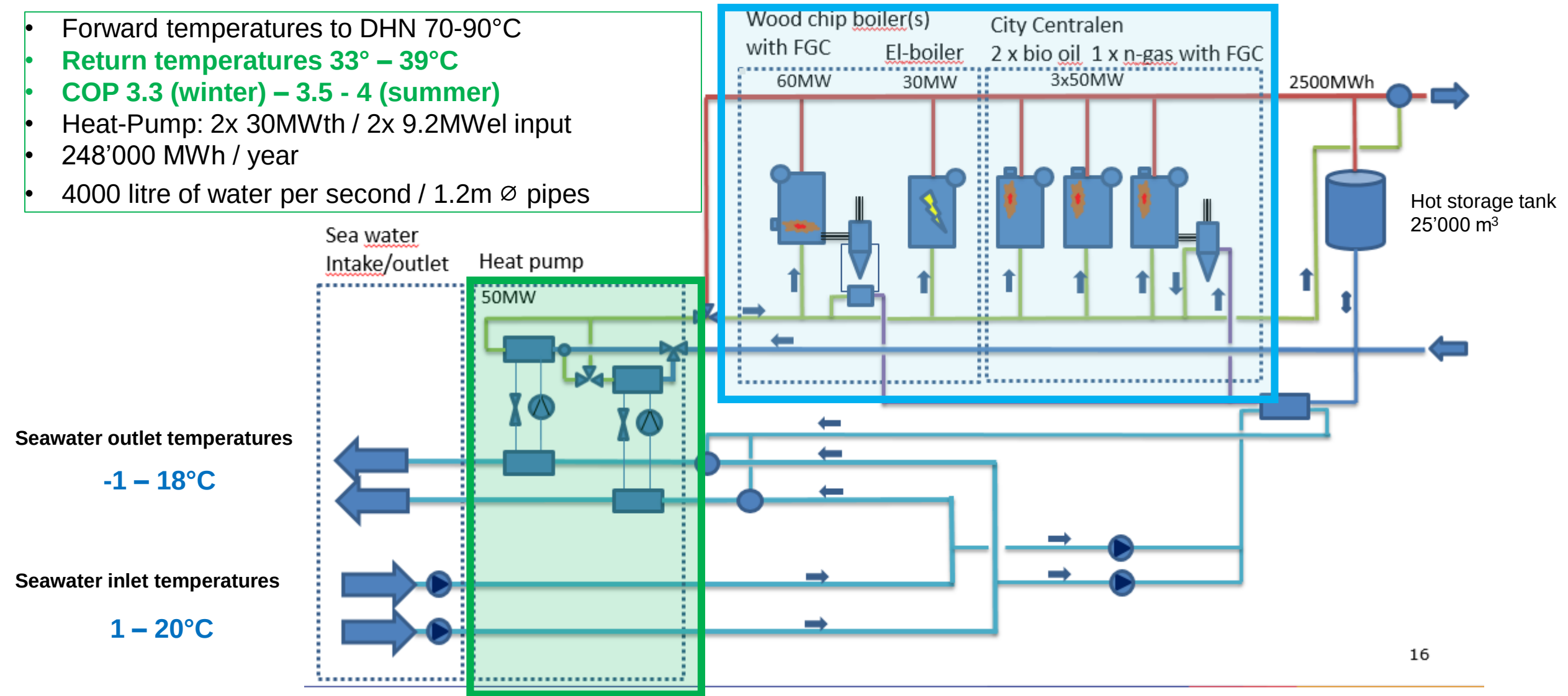
- Green energy transition: From coal to RES & HPs
- District heating for 25'000 households (100'000 citizens)
- CO₂ savings: 120'000 t / year = ~55'000 cars

MAN-ES USPs:

- CO₂ as refrigerant – natural gas / environmentally friendly
- High lift – from 1°C seawater to 90°C forward temp.
- 2 Heat-Pumps with 30 MWth each (2x 9.2MWel input)
- HOFIM Compressor – magnetic bearings / hermetically sealed

Esbjerg (DK) project

- Forward temperatures to DHN 70-90°C
- **Return temperatures 33° – 39°C**
- **COP 3.3 (winter) – 3.5 - 4 (summer)**
- Heat-Pump: 2x 30MWth / 2x 9.2MWeI input
- 248'000 MWh / year
- 4000 litre of water per second / 1.2m Ø pipes



16

Esbjerg (DK) project



Esbjerg (DK) project



MAN Compressor in factory



MAN Compressor @ site in Esbjerg



CO₂ storage tank



Esbjerg (DK) project



Esbjerg (DK) project



Thank you.

A wide-angle photograph of a city skyline at sunset. The sky is filled with soft, orange and yellow clouds, with the sun low on the horizon. Several tall, modern skyscrapers are visible, their silhouettes against the bright sky. A body of water is in the foreground, reflecting the light from the sky and the buildings. A bridge or elevated roadway runs through the middle of the frame, with some lights visible on it.

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