Esbjerg heat pump reference case

MAN Energy Solutions
Future in the making

The Danish utility DIN Forsyning commissioned MAN Energy Solutions to supply a turnkey technology solution for district heat generation, featuring two heat pump systems.

With a nominal heating capacity of 60 MW, the plant will supply around 100,000 local inhabitants with approx. 280,000 MWh of heat annually. The location enables the use of renewable power from nearby wind farms and seawater as a heat source. The heat pumps replace a coal-fired plant, which is scheduled for closure.

Key facts

- End customer: DIN Forsyning in Esbjerg (Denmark)
- Scope of delivery: Two heat pump units including HOFIM® compressors with integrated turbine
- Task: 24/7 heat production for district heating
- Function: transfer energy from the seawater to the district heating water using renewable energy from the grid

For more information about MAN heat pump technology, and to download our white paper, visit:
www.man-es.com/industrial-heat-pumps-and-ems

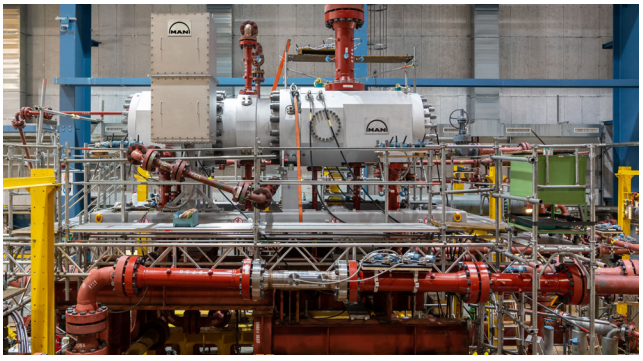
MAN heat pump put into practice

Esbjerg's road to climate-neutral district heating

The Danish parliament has set the goal of phasing out combined heat and power (CHP) plants by 2030. As a result, Ørsted has decided to shut down its coal-fired power plant in the port city of Esbjerg, which currently provides about half of the district heating in Esbjerg and the two neighboring towns of Varde and Nordby. DIN Forsyning, a water utility company, has decided to connect several solutions, which will together provide the city with the required heat supply.

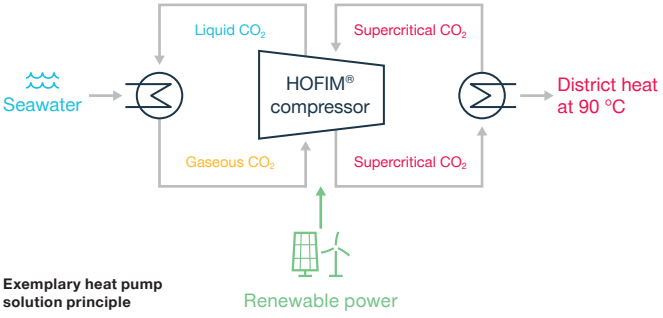
Scheduled to start operation in 2023, the heat pump in Esbjerg will help to ensure an efficient and environmentally friendly heat supply for about 25,000 households – saving 120,000 tonnes of CO_2 per year, the equivalent of the annual emissions of 50,000– 55,000 cars. The CO_2-based heat pump plant in Esbjerg will be the largest of its kind ever brought into operation in the world.

The 60 MW seawater heat pump system will run together with a new 60 MW wood chip boiler based on 100 % sustainable wood chips and a 40 MW electric boiler plant (for peak and back up load).



Heat pump unit on the test bed

Supercritical CO_2 heat pump



Exemplary heat pump solution principle

Performance data

- Refrigerant: CO_2 (R744)
- Source (seawater) temperatures: from 1 to 4 °C in winter and from 14 to 20 °C in summer
- Thermal heat capacity: up to max. 65 MW for two units
- Sink temperature: 60 – 90 °C
- Seawater intake: 4000 l/s
- Seawater pipe diameter: 1.2 m

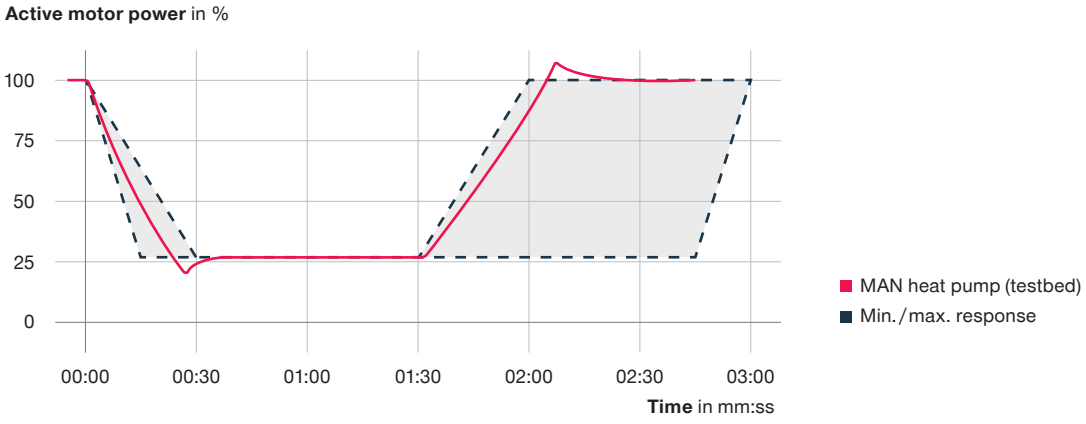
Performance table for two heat pump units	Winter	Summer
Heat sink		
Duty (MW_{th})	61	65
Supply temperature (°C)	70	70
Return temperature (°C)	33	37
Flow (kg/s)	400	516
Heat source		
Inlet temperature (°C)	4	14
Flow (kg/s)	4,000	4,000
Electrical input		
MW_{el}	18.4	17.4
COP	3.3	3.7
Power balancing capacity		
MW_e/30 sec	12.1	12.1

MAN heat pump unit solution

The MAN heat pump technology enables the use of renewable energy sources, which further reduces the need for fossil fuel power plants. The location at the port allows the use of renewable power from nearby wind farms and seawater as a heat source. Additionally, it is possible to generate electrical balancing power for short time variations and therefore to maintain balance on the grid. The system can be switched on and off many times a day with fast reaction capability.

The emission-free and oil-free MAN heat pump unit solution makes efficient use of the special properties that CO_2 has to offer as a working fluid. Operating with an optimized transcritical heat pump cycle provides DIN Forsyning the freedom to optimize the heat production according to their need. The heat pump can be used to supply preheated water for the wood chip boiler at 70 °C but also to supply directly into the district heating network at 90 °C independent of the seawater temperature.

With growing shares of wind-based and solar-based power generation, there is an increase in fluctuations on the electricity grid. The highly dynamic turbomachinery at the core of the heat pump allows for power regulation within a few seconds and qualifies the system to serve as a primary frequency reserve. In Esbjerg, the heat pump units can regulate up to 12 MW within 30 seconds and not only decarbonize but also stabilize the energy network of Denmark.



Power balancing

The eco-friendly refrigerant CO_2

MAN heat pump system is innovative in using CO_2 as a refrigerant. Thanks to its high density and heat capacity, CO_2 enables a small spatial footprint, maximum energy efficiency and low capital expenditure. Furthermore, its thermodynamic properties make it suitable for heat transfer under high pressures above 150 bar in the process loop of compression and expansion. CO_2 is also non-toxic, non-flammable, and safe to handle. This was of particular interest to DIN Forsyning given the sensitive ecosystem where it will be commissioned: Esbjerg is on the shore of the Wadden Sea, a UNESCO World Heritage Site.

Main benefits of CO_2

- Naturally occurring
- Available in large quantities
- Inexpensive compared to synthetic refrigerants
- Environmentally friendly
- Low global warming potential (GWP)
- Non-toxic, non-explosive
- High density
- High volumetric heating capacity
- Low thermodynamic critical point

Main technology features

The process loop consists of MAN's oil-free hermetically sealed HOFIM® compressor with integrated turbine, heat exchanger on the heat sink side and evaporator on the heat source side, and the necessary circuit piping. The largest heat pump unit can produce up to 80 MW of thermal power, with approx. 50 MW dedicated to the heating side (also called "sink") and 30 MW to cooling (also called "source"). Smaller units for heating requirements starting from approx. 15 MW can also be fitted with smaller compressors and process equipment in a modular fashion. Each system is tailored to and optimized for the customer's specific requirements (mainly power, temperature, and space requirements).

MAN Energy Solutions
Switzerland Ltd.
8005 Zurich, Switzerland
P +41 44 278-2211
F +41 44 278-2261
info-zur@man-es.com
www.man-es.com

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