



# Esbjerg heat pump reference case

# Everllence heat pump put into practice

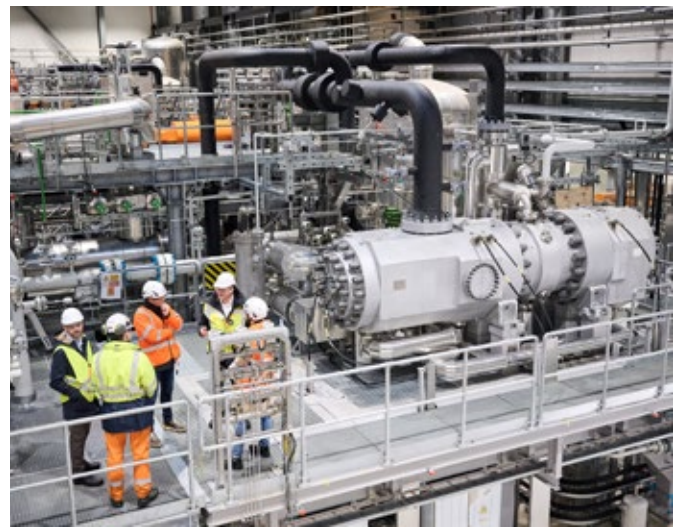
The Danish utility DIN Forsyning commissioned Everllence to supply a turnkey technology solution for district heat generation, featuring two heat pump systems.

## 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 seawater to the district heating water using renewable energy from the grid
- Heating capacity: 60 MW (nominal)
- Annual heat supply: Approx. 280,000 MWh
- People supplied: Around 100,000 local inhabitants
- Energy source: Renewable electricity from nearby wind farms and seawater
- Replaces: Existing coal-fired plant



Heat pump unit on the test bed



## Performance data

- Refrigerant: CO<sub>2</sub> (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
<b>Heat sink</b>		
Duty	61	65
Supply temperature (°C)	70	70
Return temperature (°C)	33	37
Flow (kg / s)	400	516
<b>Heat source</b>		
Inlet temperature (°C)	4	14
Flow (kg / s)	4,000	4,000
<b>Electrical input</b>		
MW <sub>el</sub>	18.4	17.4
COP	3.3	3.7
<b>Power balancing capacity</b>		
MW <sub>e</sub> / 30 sec	12.1	12.1

## 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<sub>2</sub> per year, the equivalent of the annual emissions of 50,000– 55,000 cars. The CO<sub>2</sub>-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).

## Everllence heat pump unit solution

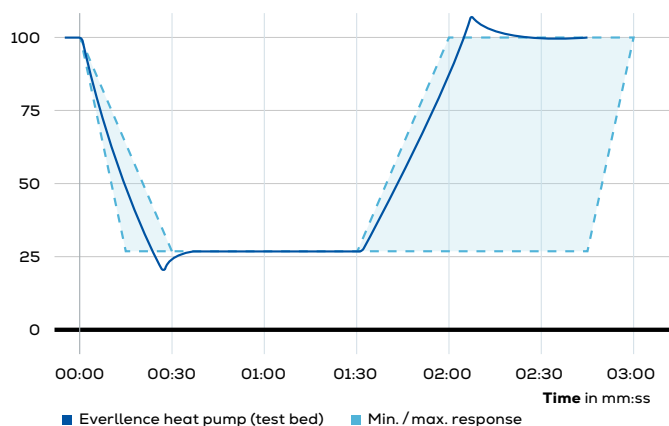
The Everllence heat pump technology enables the use of renewable energy sources, which further reduces the need for fossil fuel power plants. The location at the port allows the use of renewable power from nearby wind farms and seawater as a heat source. Additionally, it is possible to generate electrical 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 Everllence heat pump unit solution makes efficient use of the special properties that CO<sub>2</sub> 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 turbo-machinery 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.

Active motor power in %



Exemplary heat pump solution principle

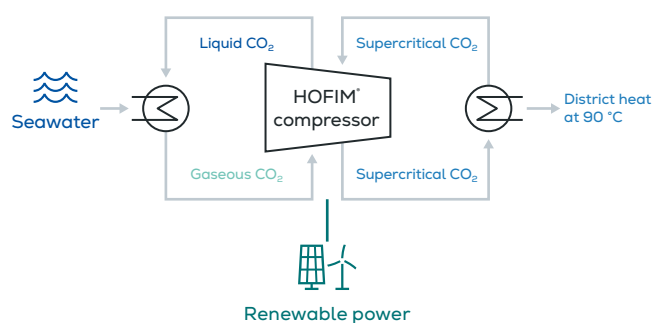
## The eco-friendly refrigerant CO<sub>2</sub>

Everllence heat pump system is innovative in using CO<sub>2</sub> as a refrigerant. Thanks to its high density and heat capacity, CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>

- 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

## Supercritical CO<sub>2</sub> heat pump



Power balancing

## Main technology features

The process loop consists of Everllence 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).

# Everllence

## Everllence

86224 Augsburg, Germany

P + 49 821 322-0

F + 49 821 322-3382

[info@everllence.com](mailto:info@everllence.com)

[www.everllence.com](http://www.everllence.com)

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