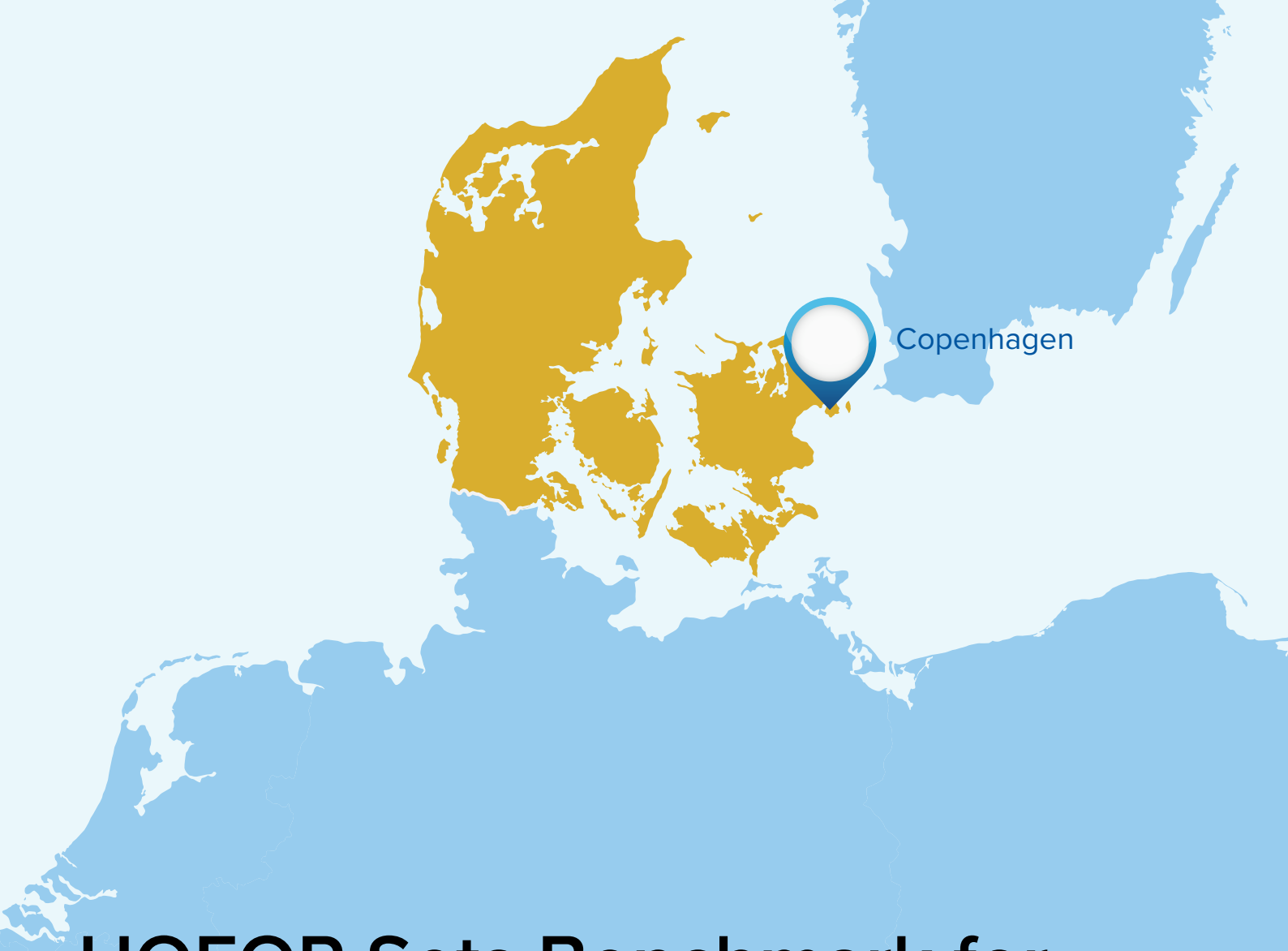
2024 Natural Refrigerants ATMO Approved

Ozone Friendly · Climate Friendly · PFAS free

FENAGY FUTURE ENERGY SOLUTIONS

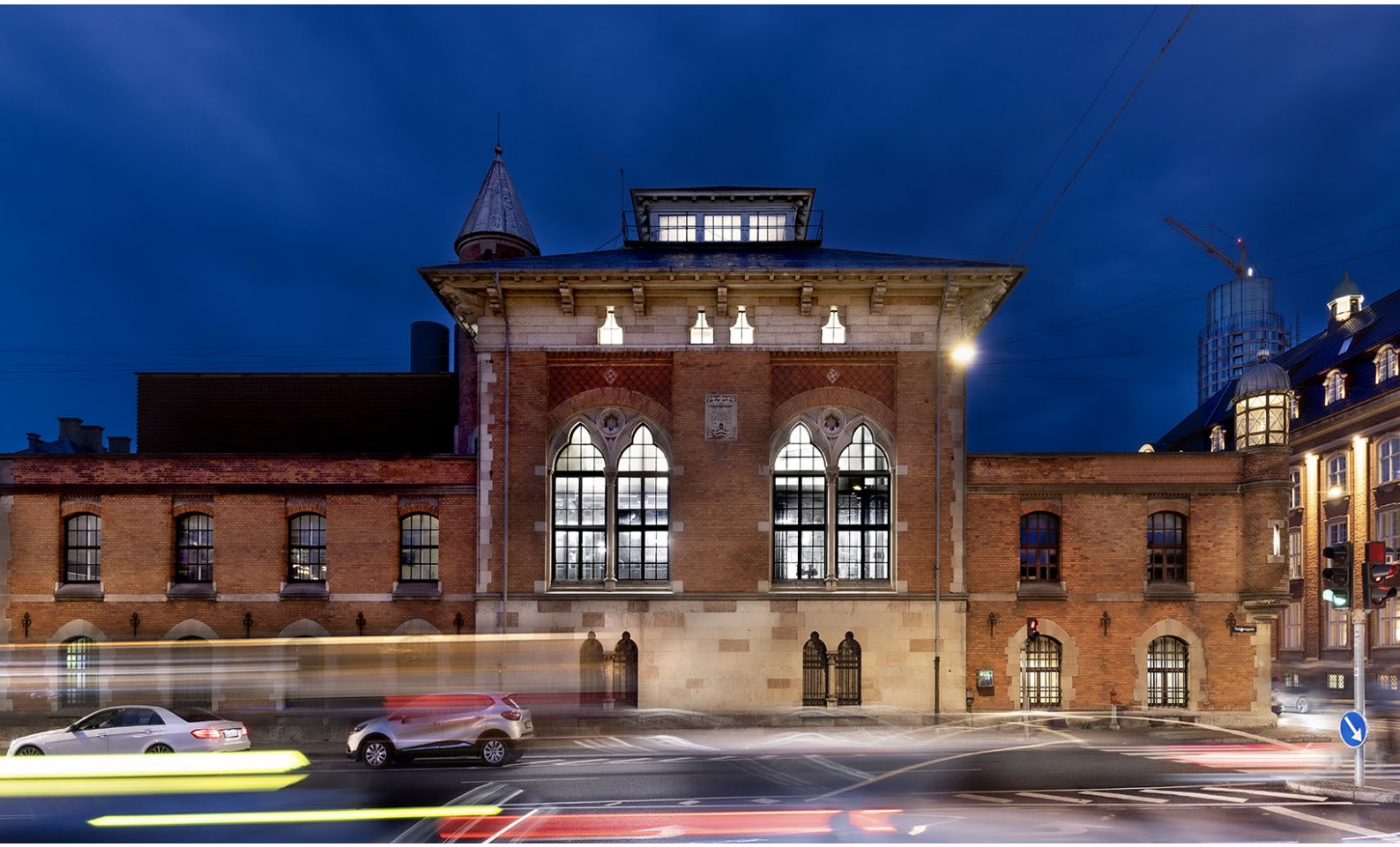
Case Study: HOFOR



HOFOR Sets Benchmark for Decarbonized District Heating and Cooling with Integrated CO_2 Heat Pump Project

Three Fenagy heat pumps connect to Copenhagen's district heating and cooling networks, capturing surplus energy from one system to use in the other.

By Christina Hayes



The three Fenagy CO_2 heat pumps are housed in a 126-year-old former power station in downtown Copenhagen. Photo credit: HOFOR and Fenagy

The Greater Copenhagen Utility (HOFOR) has set a new standard for sustainable urban infrastructure by electrifying its district heating network, which relies heavily on the burning of biomass and waste to supply heat to approximately 98% of Copenhagen's residents. Central to its mission is the installation of several innovative heat pump projects, including one that connects to the city's district heating and district cooling networks, capturing surplus energy from one system to use in the other.

The project, which is housed in a 126-year-old building on Tietgensgade street in central Copenhagen, consists of three CO_2 (R744) heat pumps from Danish manufacturer Fenagy. Working within the constraints of the historic site, Fenagy, HOFOR and other project partners overcame numerous spatial and technical challenges, customizing each component of the installation to maximize efficiency without compromising the building's structure.

The project reflects the commitments of Copenhagen and HOFOR to sustainability and serves as an example for other cities and utilities striving to reduce carbon emissions and enhance energy resilience within the constraints of urban environments. As cities face growing populations, rising energy demands, aging infrastructure and an urgent need for resource efficiency, projects like this showcase how advanced technologies can balance modernization with sustainability.

Waste not, want not

Built in 1898 as a power station to serve Copenhagen's former tram network, the facility on Tietgensgade was converted by HOFOR in 2014 to house an 18MW (5,118TR) ammonia (R717)-based district cooling plant. The system, which is cooled by seawater, serves the Copenhagen City Hall, the Danish National Archives and a number of large hotels and office buildings.

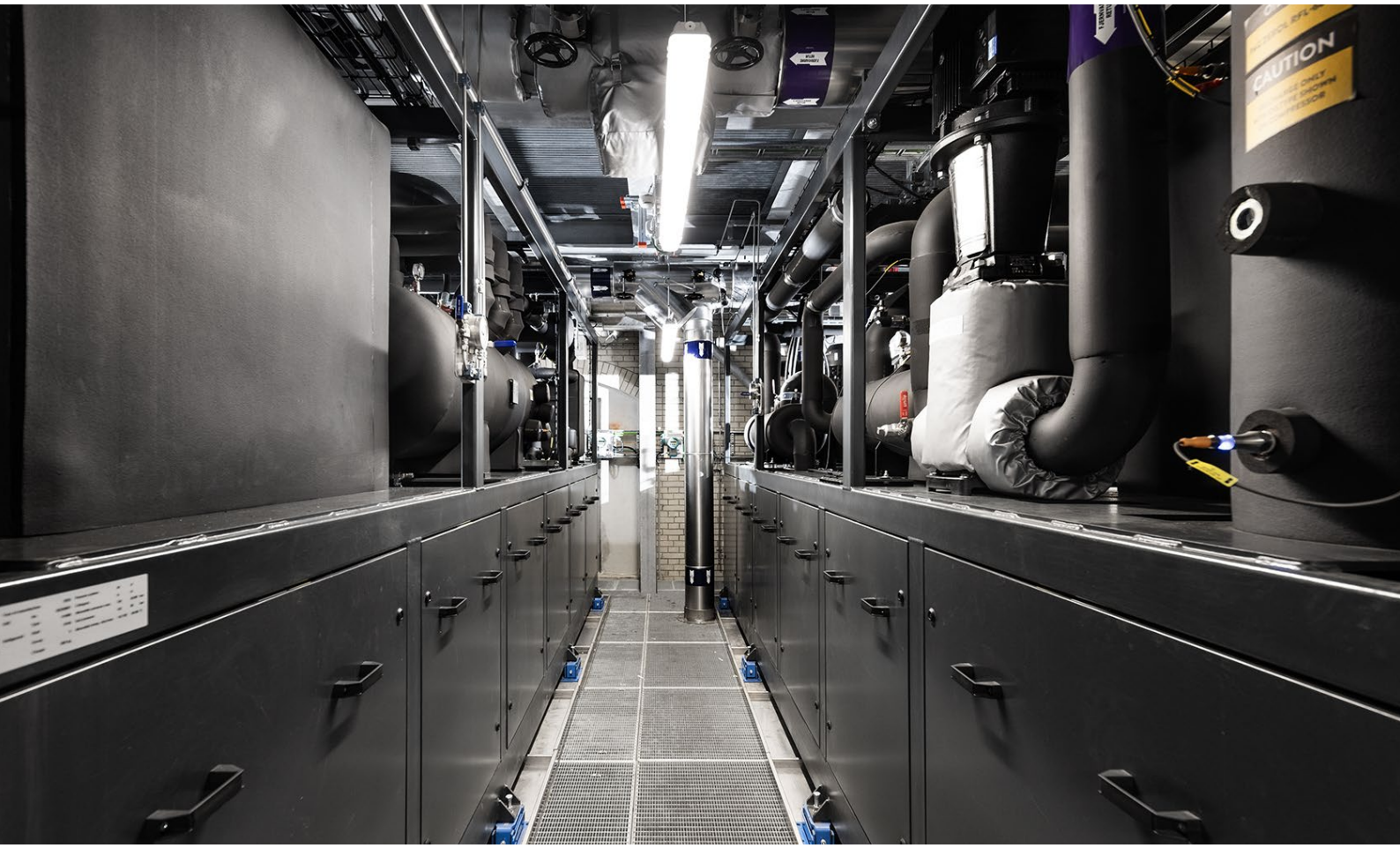
Ten years later, HOFOR has taken integrated heating and cooling to another level with the addition of three CO_2-based water-to-water heat pumps installed alongside the facility's existing district cooling plant. Originally planned to expand Copenhagen's district cooling network, which was established by HOFOR in 2009, the project evolved to feature a fully integrated system.

"The system serves both the city's district heating and district cooling networks," explained Kasper Hovmand Malskær, Project Manager at HOFOR. "It takes advantage of surplus heat from the cooling network to provide heating and vice versa."

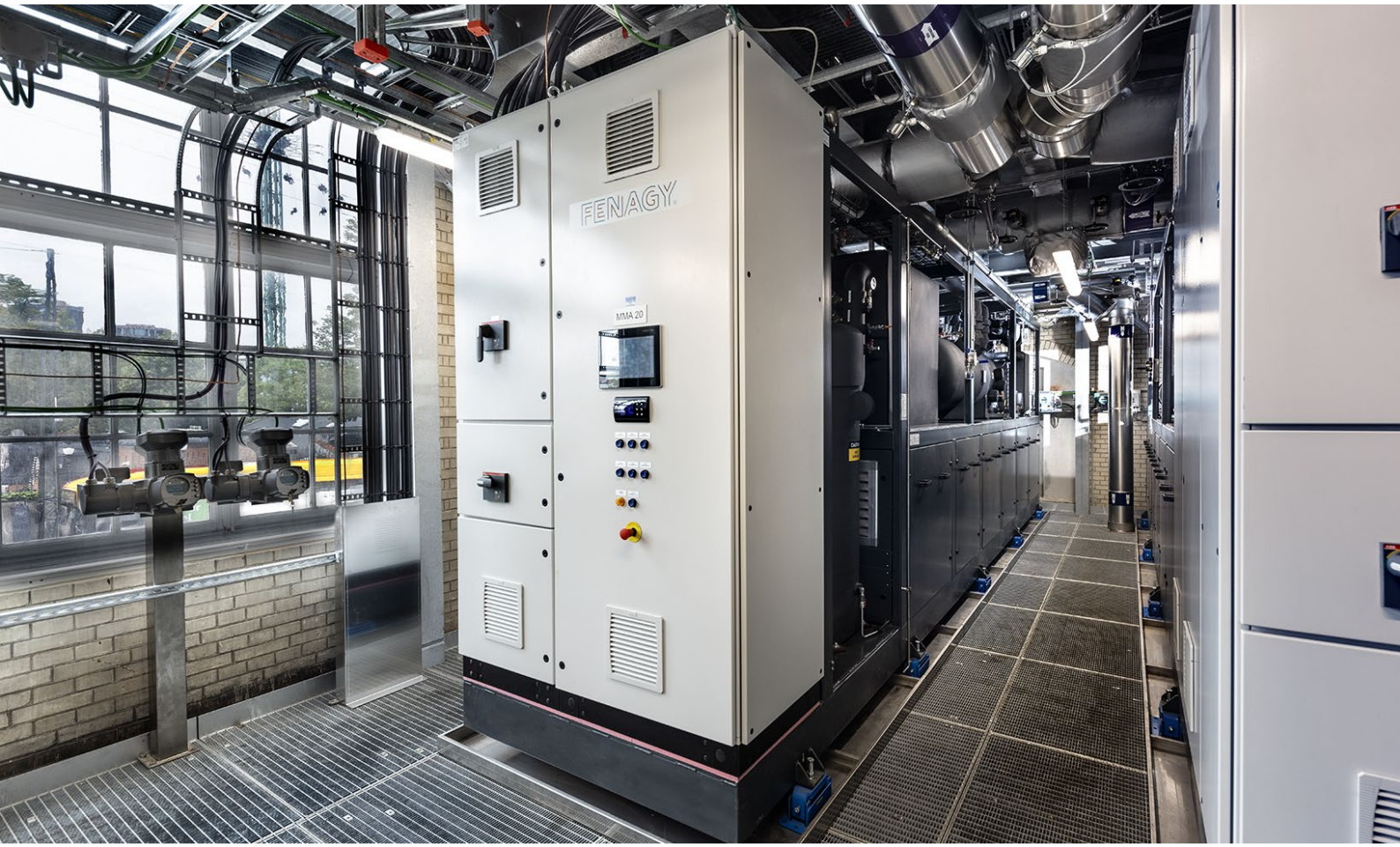
Collectively, the heat pumps provide up to 5.2MW (1,478TR) in heating capacity and up to 3.6MW (1,023TR) in cooling capacity, meeting the heating needs of around 3,000 apartments and delivering cooling to local hospitals, hotels, offices and data centers, he noted.

The heat pumps run at full capacity in the summer when cooling demand peaks, and the waste heat is funneled into the district heating network with the excess released into the Øresund Sea if heating demand is low, according to Kim Christensen, Managing Director of Fenagy.

During winter, heat production relies on demand from the district cooling system, with excess heat from the cooling process redirected into the district heating network, explained Hovmand Malskær. The heat pump will not run without waste heat from the district cooling system to utilize, but he noted that with a base cooling load of 3MW (853TR), there is "consistent demand" for cooling, even in the winter.



The three CO_2 heat pumps from Fenagy provide 5.2MW of heating capacity and 3.6MW of cooling capacity.
Photo credit: Fenagy



Two of the three Fenagy CO_2 heat pumps installed at the Tietgensgade facility with compressor panels and vibration feet. Photo credit: Fenagy

High supply and return temperatures

The system, which was designed and installed by Danish contractor EuRefa in the summer of 2024, consists of three heat pumps from Fenagy's H-range – two H-1800 models and one H-1200.

"The three heat pumps are fully optimized, using high-lift ejectors, parallel compression, special liquid injection control and optimized gas coolers," said Christensen. "These features are standard on Fenagy heat pumps today."

The design of the system requires the heat pumps to operate at very high supply and return temperatures, he explained, noting that this has been achieved thanks to optimized controls and fast off-loading of the ejectors.

"The typical condition for the heat pumps is 45/70°C [113/158°F] on the district heating side, but the heat pumps should be able to deliver 85°C [185°F] water even with return temperatures up to 55°C [131°F]," he said. "Temperatures on the district cooling side are always 12.5/5.5°C [54.5/41.9°F]."

> *"The three heat pumps are fully optimized, using high-lift ejectors, parallel compression, special liquid injection control and optimized gas coolers."*
>
> – Kim Christensen,
> Managing Director of Fenagy

Why CO_2?

HOFOR specified the use of natural refrigerants from the start, Christensen explained.

“Synthetics were out from the beginning, and, due to its central location, there was also some reluctance to flammable refrigerants like propane [R290],” he noted. “At the end of the day, it could only really be ammonia or CO_2.”

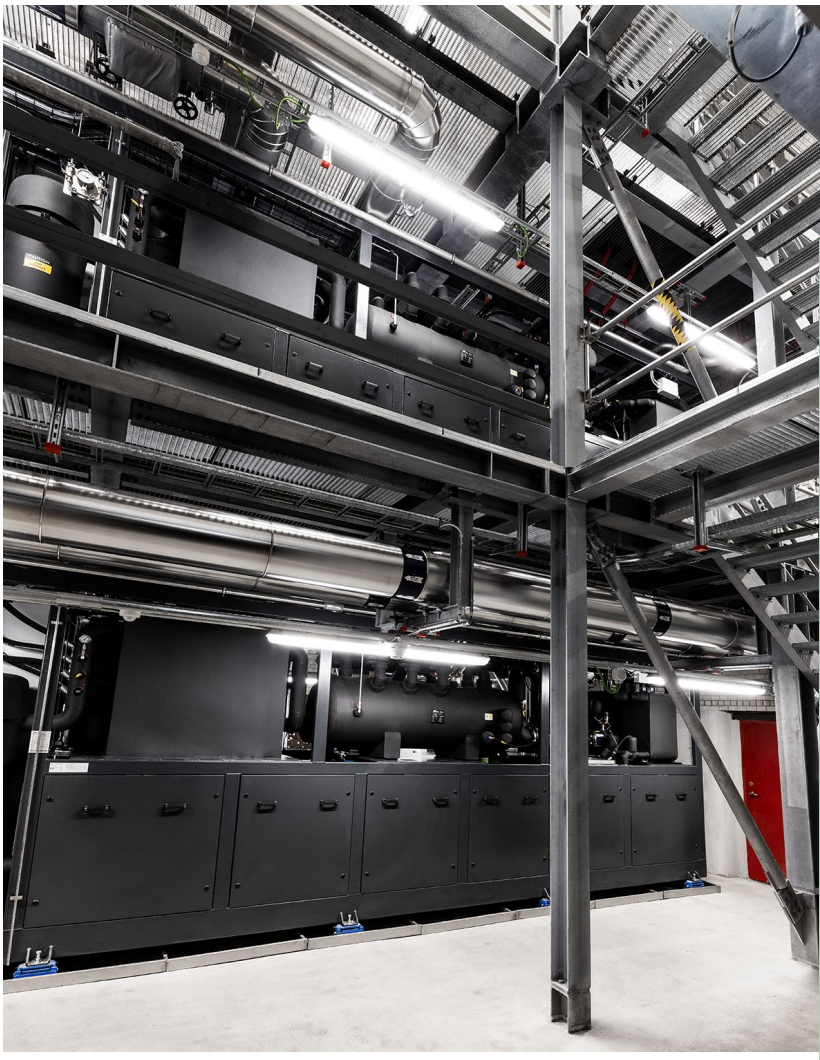
As the equipment was to be housed in a 126-year-old building, there were also limitations surrounding noise and vibration levels, as well as space. CO_2 outperformed ammonia in all criteria.

“CO_2 was able to deliver 3.5MW [995TR] of cooling with the same footprint as a 3MW-capacity ammonia unit,” said Hovmand Malskær. “The extra cooling capacity was then built into the business case.”

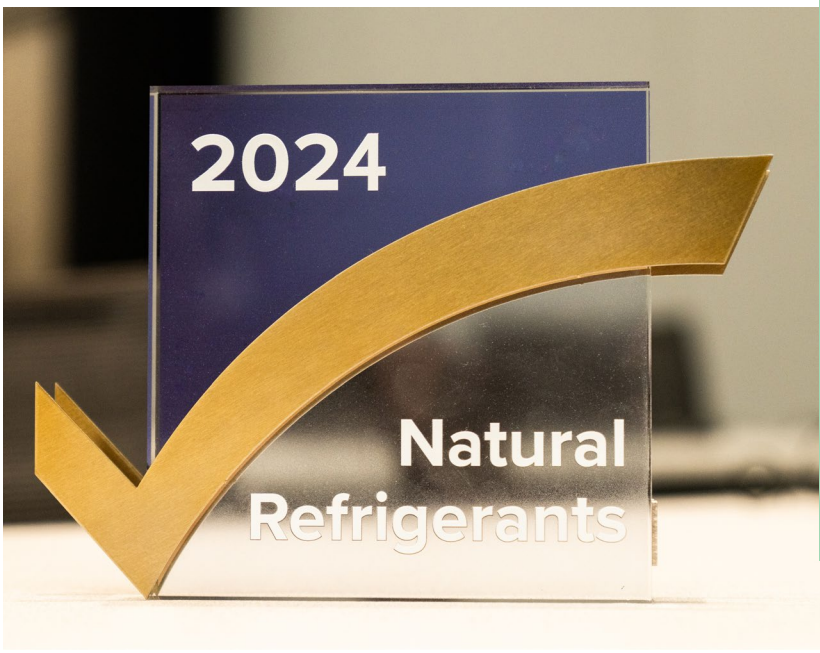
“It was natural that it should be CO_2,” added Christensen.

To optimize the heat pumps for the facility, Fenagy covered the compressors with panels to minimize noise and installed the rack on vibration feet. Thanks to the heat pumps’ light weight, it was possible to stack the heat pump units to fit them in the close quarters.

Fenagy earned reapproval for the ATMO Approved Label in 2024, reaffirming its dedication to advancing and advocating for natural refrigerants. The certification recognizes top-tier manufacturers and contractors who excel in delivering natural refrigerant systems and components. The label program is managed by ATMOsphere.



To get around space constraints, a mezzanine level was installed so the heat pumps could be stacked on top of each other. Photo credit: Fenagy



Fenagy earned reapproval for the ATMO Approved Label in 2024.

ATMO Approved

FENAGY
FUTURE ENERGY SOLUTIONS

In 2022 & 2023 Fenagy placed in the market
Natural Refrigerant-based equipment mitigating lifetime GHG emissions of

2022 2023

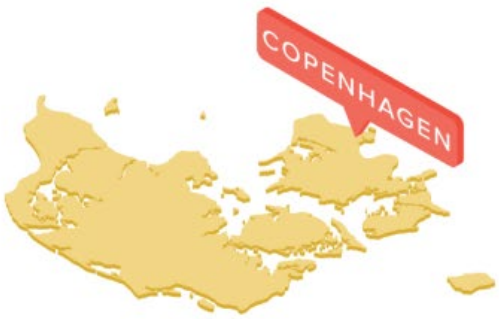
1,781,000
metric tons of CO_2e
(GWP_20 Years)

2022 2023

1,674,000
metric tons of CO_2e
(GWP_100 Years)

24 %
(GWP_20 Years)

22 %
(GWP_100 Years)



of the entire CO_2 emissions of
Copenhagen Metropolitan Region
in 2020

Monitoring performance

Following the system's commissioning by Fenagy, a rigorous 720-hour testing phase was implemented to ensure optimal functionality.

"The heat pumps have performed very well in terms of reliability and stable set points," Hovmand Malskær reported. "Efficiency-wise, the system is actually exceeding the terms of its warranty."

Christensen noted that the heat pumps are operating at 3–4% above expected efficiency, reinforcing the success of the system's design and installation.

"There are penalties for not meeting performance standards," he said. "If the system underperformed, Fenagy would be responsible for the costs of additional electricity or any shortfall in heat production, so we make sure the system delivers as promised."

To maintain these high standards, Fenagy offers continuous data monitoring to track performance metrics, with real-time comparison against a digital twin.

> *"The heat pumps have performed very well in terms of reliability and stable set points. Efficiency-wise, the system is actually exceeding the terms of its warranty."*
>
> – Kasper Hovmand Malskær,
> Project Manager at HOFOR

A new national legacy

Denmark has a long history of district heating, having established its first facility in 1903 to capture and use excess heat from a waste incinerator. The energy crises of the 1970s sparked a rapid expansion of the country's district heating network, and the 1979 Heat Supply Act provided a foundation for Denmark's transition to district heating.

Today the network supplies heat to around 66% of Danish households, placing the country at the forefront of district heating adoption worldwide, second only to Iceland. As Denmark aims for net-zero emissions by 2050, the Danish District Heating Association highlights that district heating will play a vital role in this goal by transitioning to low-carbon, renewable energy sources.

This transition, however, will also require district heating networks to be fed by more sustainable heat sources, such as heat pumps and recovered heat from industrial processes.

"As a utility company we have a responsibility to contribute to the green transition," said Søren Birch, Chief Operations Officer of Building and Construction at HOFOR. "We are therefore trying to investigate and implement new technologies to support this, such as using natural refrigerant in heat pumps. The Tietgensgade heat pump and cooling system is a great example of these efforts."

In Copenhagen, there are plans to invest 3 billion Danish krone (€402 million/$418 million) across 10 heat pump projects by 2033. Collectively, these projects will provide 300MW (85,303TR) of heating capacity, reducing Copenhagen's reliance on biomass in district heating by approximately one-third. Once operational, the newly installed heat pumps will provide sustainable heating to around 130,000 households.

Following a series of smaller heat pump projects, including Tietgensgade, HOFOR is now turning its attention to larger installations, including a seawater heat pump in the city's coastal Nordhavn district and a wastewater heat pump at the city's Renseanlæg Lynetten treatment plant. Together these systems will deliver 170–200MW (48,338–56,869TR) of heating capacity — meeting around 18% of Copenhagen's district heating needs.

Three medium-sized heat pump installations will also be built in Copenhagen's Kløvermarken, Kranparken and Bådehavnsgade neighborhoods, adding a further 70MW (19,904TR) of capacity to the network.

Although the specific technologies for each project will be chosen based on individual requirements, all systems will use natural refrigerants.

System Specs

HOFOR integrated CO_2 heat pump system, district heating and cooling, Copenhagen, Denmark

Manufacturer: Fenagy

Model: 2 × H1800-WW and 1 × H1200-WW

Heat source: District cooling network

Total heating capacity: 5.2MW (1,478TR)

Total cooling capacity: 3.6MW (1,023TR)

CO_2 charge: 800kg

District heating supply temperature: 70°C (158°F)

District heating return temperature: 45°C (113°F)

District cooling supply temperature: 5.5°C (41.9°F)

District cooling return temperature: 12.5°C (54.5°F)

Sound-dampening compressor panels

Vibration feet with spring off-load

Bitzer 8-cylinder high pressure compressors

Kelvion PHX heat exchangers

Siemens PLC controller with Fenagy-developed algorithms

2024 Natural Refrigerants ATMO Approved

Ozone Friendly Climate Friendly PFAS free

FENAGY® FUTURE ENERGY SOLUTIONS

2024 Natural Refrigerants

ATMO Approved

Ozone Friendly · Climate Friendly · PFAS free

×

FENAGY®

FUTURE ENERGY SOLUTIONS