Sweden gets the ammonia treatment

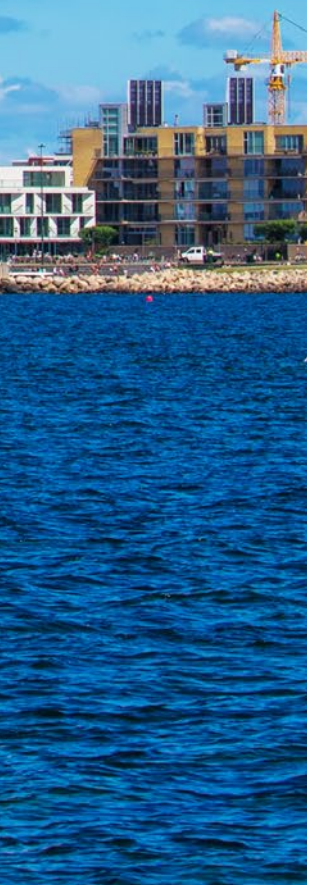
Using the heat from Malmö's sewage treatment and waste incineration plants, four ammonia heat pumps deliver heating to approximately 100,000 homes in the Swedish city.

— By Charlotte McLaughlin

Providing more climate-friendly space heating and cooling can help European countries to reach their climate targets under initiatives such as the Paris Agreement. Currently, heating and cooling buildings and industry accounts for half of the European Union's energy consumption, according to the European Commission (2016 figures). In EU countries, heating and hot water alone account for by far the biggest share of final energy use, with 79% taken up by residential areas.

Germany-headquartered E.ON – one of the world's largest investor-owned electric utility service providers – is looking at ways to reduce greenhouse gas emissions from the electricity and heating it supplies to European and global households and businesses.

Malmö's western harbour area.



A graphic representation of the GEA ammonia heat pump model installed in Malmö. *Credit: GEA*

"We will reduce our absolute carbon footprint by 30% [by] 2030 compared with 2016," says E.ON in its 2017 Sustainability Report.

With this in mind, the utility, "will reduce the CO_2 intensity of our customers – i.e. the CO_2 intensity of our power sales – by 50% until 2030 compared with 2016".

"One example is Sweden, where renewables already account for more than 50% of energy consumption," the report says. "In line with this, our local [Swedish] unit has developed ambitious climate protection targets. Under the banner of 'Clean 2025', it intends to [provide to its customers] 100% recycled or renewable energy by 2025 and has developed appropriate measures to achieve this goal".

In Sweden the company owns extensive electricity, district heating and gas networks. District heating networks centralise heating for entire residential and commercial areas, increasing the efficiency of heating compared to individual systems and thus saving costs. Mats Egard, E.ON Sweden's heating segment project manager, is confident the company will deliver on this goal. "We are going to supply district heating energy that is either recycled or renewable by year 2025," he explains.

"In 2014-2015, we made an internal investigation of different solutions for the district heating of the future," Egard says. The company chose heat pumps as one option, along with biomass and other renewable technologies, to mitigate greenhouse gas emissions from heating.

Installing the heat pump

E.ON first decided to use heat pumps for district heating in southern Sweden, where the company decided to install four GEA ammonia heat pumps each with a heating capacity of 10 MW (in total 40 MW), next to a sewage treatment plant and waste incinerator in the harbour area of the city of Malmö. "We started in 2015 and then we got our investment decision in May 2016. We signed the contract in July with *Francks Kylindustri* [a Swedish contractor specialised in cooling and heating with ammonia]," says E.ON Sweden's Egard.

The heat pumps take advantage of the waste heat from the sewage and waste plants, in the harbour area, to provide heating to approximately 100,000 homes in greater Malmö. Installing the four GEA heat pumps took approximately 14-15 months. Groundwork began in August-September 2016, "and we commissioned the last heat pump at the end of December 2017," says E.ON's Egard.

E.ON decided to use the sewage water to provide base heat for the heat pump due to the higher temperature emitted by the sewage plant (14°C) – making the water warmer than the sea near Malmö. "In January and February, sometimes the seawater even goes below zero, and then it's impossible to get any heat out of it. That's when the heat is at its most valuable – when it's colder outside," Egard says. "Basically the sea outside Malmö is too shallow. If you have deeper seas, you always have 4°C at the bottom of the sea, but you don't have that here."

RIGHT

GEA's ammonia heat pump system installed in Malmö. *Credit: GEA*

Kenneth Hoffmann is GEA's product manager for heat pumps. He was also involved in the Malmö project, and is keen to chime in. "They have [seawater heat pumps] a lot in Norway with the deep fjords, but then you can get down to the bottom of the sea, which is perhaps 20-30 metres deep – you have a constant temperature down there of 8°C," he says.

The four heat pumps withdraw 30 MW of heat from the sewage water. "On average the wastewater is chilled from 14°C to 8°C," writes Hoffmann in an Institute of Refrigeration (IOR) paper on '*Large scale heat pumps for high efficiency district heating projects*'. "The energy harvested is upgraded to useful heat for the district heating network through the heat pumps," he adds.

The heat pump has been integrated with the district heating network to work in conjunction with the nearby waste incinerator plant. "The water from the city returns to the waste incinerator plant at around 50°C, where in the flue gas economiser it is heated to around 55°C before going into the heat pump to 66°C," Hoffmann explains in the paper.

"The water then returns to the waste incinerator plant where it is […] heated to the requested temperature by the heating network, which can vary depending on the heating demand from 70°C to 90°C. The heat pump is designed for delivering heat up to 80°C, but will rarely deliver temperatures above 71°C," the paper says.

Ammonia: A long-term puzzle

This is not the first time heat pumps have been used in Sweden. "A lot of big heat pump plants were built in the 1980s, when electricity was cheap," notes E.ON's Egard. "So some of them are bigger than ours, but none of them use ammonia."

The four heat pumps work in parallel to deliver the promised temperatures. Each has a coefficient of performance (COP) above 3.50, "so for each 1 kWh of electricity used by the heat pump, 3.5 kWh of heat is produced for the city," says GEA's Hoffmann.

E.ON decided to opt for ammonia rather than chemical-based refrigerants due to the EU F-Gas Regulation, which aims to phase down HFCs by 79% by 2030, and the company's understanding of its environmentally conscious customers.

"It would have been cheaper to install [an] R134a [heat pump], I think by 30%, but we didn't believe in that refrigerant for the future, because we are going to become 100% [renewable]," says E.ON's Egard.

"We're going to supply district heating energy that is either recycled or renewable by 2025, and if we are then planning to use a heat pump with R134a, we fear that in future our customers might consider this refrigerant not to be totally green, since it has a global warming factor that is high [R134a's GWP = 1,430]," he explains. "So that's one reason we didn't want to choose that refrigerant," he adds.

The EU's F-Gas Regulation is widely expected to increase the price of HFCs substantially, as GEA's Hoffmann notes in the IOR paper. "Whereas older systems were running off f-gas refrigerants, the F-Gas Regulation has made these systems with large refrigerant charges unsustainable," he writes.

He does not see HFOs – the new generation of synthetic refrigerants – as sustainable alternatives either, pointing out that in future they might be phased down like HFCs. Moreover, the cost of these refrigerants is substantially higher than natural alternatives.

E.ON's Egard, meanwhile, told *Accelerate Europe* that the company is not currently working on more heat pump projects. But he did not rule out similar such projects in future. ■ CM