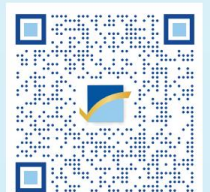




Case Study: Cranswick Country Foods





Cranswick Creates a Blueprint for Ammonia Refrigeration at Poultry Facility

The U.K. food processor works with SURE Solutions to develop an award-winning refrigeration system that also provides process cooling and AC and drives an integrated heat pump.

By Michael Garry

Nearly 40 years ago, a group of pig farmers in the Yorkshire area of Northern England decided to jointly mill their own feed. By the early 1980s, the business expanded to include food production, becoming one of the first U.K. companies to run a “farm-to-fork” organization. Today, Cranswick Country Foods, based in Hessle, U.K., operates more than 100 farms and 24 production facilities as one of the U.K.’s leading producers of high-end pork and poultry products.

Cranswick is also making a name for itself in the use of ammonia (R717) refrigeration and heat pump technology, teaming up with U.K. contractor SURE Solutions to build one of the most innovative and efficient food processing plants in the world at its “prepared poultry” facility in Hull, U.K. The factory, which includes a two-story production facility and a three-story service center, opened in February 2022 after overcoming the challenges and delays associated with the Covid pandemic in 2020 and 2021.

The creation of the Hull facility’s refrigeration and heating systems – dubbed “Project Aquarius” – reflects Cranswick’s passion for sustainable operations. (In astrology, Aquarius is ruled by Uranus, the planet that governs innovation, technology and surprising events.)

A central ammonia system, in concert with an integrated heat pump, serves all of the refrigeration, cooling and heating loads at a total capacity in excess of 3MW (853TR), covering varying system operational temperatures from -43°C (-45°F) up to 125°C (257°F). The operational temperatures and capacity of the plant can change at any time and need to adjust smoothly and efficiently. No f-gases are allowed.

Last October, Cranswick and SURE won the Environmental Collaboration of the Year award at the 2023 RAC Cooling Industry Awards in London, held by U.K.-based RAC Magazine. The award announcement cited the Hull prepared poultry plant, noting that it reduced its carbon footprint by 1,774kg of CO₂e per day, approximately 647 metric tons per year, by using a heat pump rather than natural gas.

In 2022, SURE received two awards for Project Aquarius: one from RAC Magazine (Building Energy Project of the Year) and one from the U.K.-based ACR Journal (Refrigeration Project/Innovation). That year Cranswick won the Sustainability Award given by U.K. trade journal Food Manufacture.

“Project Aquarius has been a national multi-award winning installation due to its size, efficiency, flexibility, heat recovery [and] heat pump and the fact that it’s a new factory and does not have any HFCs,” said Garry Shaw, SURE’s Managing Director. “We even installed a water cooling/heating system for the office AC which was fed from the ammonia plant and redesigned a GEA meat tumbler to remove the HFC system and run the heating and cooling from water/glycol.”

“Cranswick is a great company and client of ours to work with because it’s not a case of cheapest wins; they love to push the boundaries and develop and enhance previous projects successes,” said David Cooper, Design Director for SURE. He was the design lead for Project Aquarius, which he called “a dream project” – the type “you want to be involved with.”

Cranswick began working closely with SURE in 2017 as part of the food processor’s Second Nature sustainability strategy. Together, they have reduced Cranswick’s use of HFCs and boosted adoption of natural refrigerants ammonia and CO₂ (R744) refrigeration while reducing energy consumption in heating and cooling processes in several facilities.

Cranswick's Hull prepared poultry plant avoided approximately **647 metric tons CO₂e per year** by using a heat pump rather than natural gas.

 **647 tCO₂e**
(Per Year)
=



Considering the lifetime of a heat pump – **about 20 years** – how much emissions will **Cranswick's Hull prepared poultry plant** be able to avoid? Make your calculation! It will be **13,000 metric tons of CO₂e**.

 **13,000 tCO₂e**
(HP lifetime)
=





Engine room at Cranswick's prepared poultry facility in Hull, U.K., with four GEA screw compressors (right) and heat pump (left).

In 2021, Cranswick became the first U.K. agri-food business to join the Climate Pledge. The company also announced its adoption of science-based targets to reduce greenhouse gas emissions from its scope 1 (including refrigerants) and 2 (sourced energy) operations by 50% and cut GHG emissions from its scope 3 value chain by 50% per metric ton sold, all by 2030; the company aims to achieve net-zero emissions by 2040.

Meanwhile last December SURE became the first contractor to be recognized with the ATMO Approved label, a global gold standard highlighting best-in-class manufacturers and contractors of natural refrigerant systems and components. The label program is run by ATMOSphere, publisher of NaturalRefrigerants.com.



SURE Solutions is the first contractor to be recognized with the ATMO Approved label for excellence in applying natural refrigerants.

Filling gaps in the market

The prepared poultry facility, which is located near several other Cranswick sites in Hull, had to be built in a relatively small space (about 6,000m²/64,583ft²), replacing a parking garage. According to Graeme Watson, Cranswick's Group Engineering Director, who has worked for the company for over two decades, the prepared poultry plant is designed to further Cranswick's goal of becoming as big a producer of poultry as it is of pork.

The plant, which has 100 employees, produces 20 premium coated chicken products, including Kiev, goujons and steaks. The products are coated in a variety of crumbs and batters, such as southern fried, tempura and hot & spicy. The aim is to "hone in on gaps in the market to create new and original ideas based on key flavor trends," says Cranswick on its website. Its customers include supermarkets and food service businesses; with varying customers and their requirements, "we try and build in as much flexibility as possible," said Watson.

The timeline on development of the refrigeration and heat pump for the plant was "fast paced" – about nine months from the initial feasibility study, said Cooper. Covid added 10 weeks on delivery of most equipment. "The idea was to get to a design 'freeze' as quickly as possible. But there were so many questions still to be answered from the client. So you had to think a little bit ahead."

SURE built the system off site and installed it "like a jigsaw puzzle," said Cooper.

The prepared poultry plant, as a brand-new facility, offered Cranswick a unique learning opportunity, Watson explained. "Let's now understand, what do we need from energy? How much hot water do we need? How much cooling do we need? How much heat do we generate? How much heat can we reuse?"

Answering these questions created a "blueprint" for future installations, said Watson. But he sees the blueprint as "a living thing," noting, "it's not a piece of work that ends up in a file or a folder. It's something that's constantly challenged because obviously technology changes and process changes."

Ammonia was selected as the refrigerant, though CO₂ was considered. Ammonia and CO₂ are the only refrigerants Cranswick employs, except for acquired sites where f-gases are still used. "We are slowly working through those sites to upgrade to either CO₂ or ammonia," said Watson. About 90% of the refrigerant gas used by Cranswick facilities is ammonia, with CO₂ chosen when the refrigeration load is much lower, said Watson. He added that ammonia systems tend to last longer. "I've got an ammonia system that's 20 years old."

The Project Aquarius system has an ammonia charge of 4,000kg (8,818lbs). In the U.K., the safety requirements for an ammonia system become more stringent when the charge exceeds 3,000kg (6,614lbs), Cooper explained. For example, an ammonia detector is needed in any secondary loop, and automatic shutdown is required in the event of a leak underneath a surge drum.

"We've limited the ammonia where we could on this job," Cooper said. "But the load and the coil volumes in the spiral freezers and chillers are massive, and there is a lot of cooling that needs to be done in them."

At the Hull facility, the ammonia refrigeration system is the driver for spiral chilling and freezing and cold storage, with heat exchangers for secondary glycol cooling and heat recovery processes.

Secondary glycol cooling is used in a variety of ways, from product tumbling to cooling processing rooms, which run from 4°C to 10°C (39°F to 50°F), with an average of 8°C (46°F). For comfort cooling, the facility uses ambient air to the extent possible, supplemented by AC (20°C/68°F) supplied by chilled glycol.

The main refrigeration system is linked to a cascade heat pump, which provides the site with all hot water for sanitation. The heat pump maximizes heat recovery from the refrigeration system and creates a buffer tank of hot water. Heated glycol is used for space heating in the winter, preheating hot water and other purposes.



Evapco evaporative condensers on roof of Cranswick's prepared poultry facility, with ammonia receiver (light blue) and chemical-free water treatment system.

Production at the prepared poultry plant works as follows:

1. Raw poultry is held in an intake chiller. The poultry is brought into the process hall, where it's mixed and blended with marinades and the like (such as through a tumbler), and put on one of the four production lines.
2. The product goes through a forming machine that will create, for example, patties. Then it passes through batter, flour and crumbs and into an in-line fryer to flash-fry and seal the breadcrumbs.
3. The product moves into a dedicated -20°C (-4°F) spiral chiller (which could also operate as a $-43^{\circ}\text{C}/-45^{\circ}\text{F}$ spiral freezer).
4. The final product is put in trays or bags, boxed and placed in two storage rooms, which can be either chilled (at $1^{\circ}\text{C}/33.8^{\circ}\text{F}$) or frozen (at $-18^{\circ}\text{C}/-0.4^{\circ}\text{F}$).

“*SURE is constantly challenging what we do and the way we do it.*”

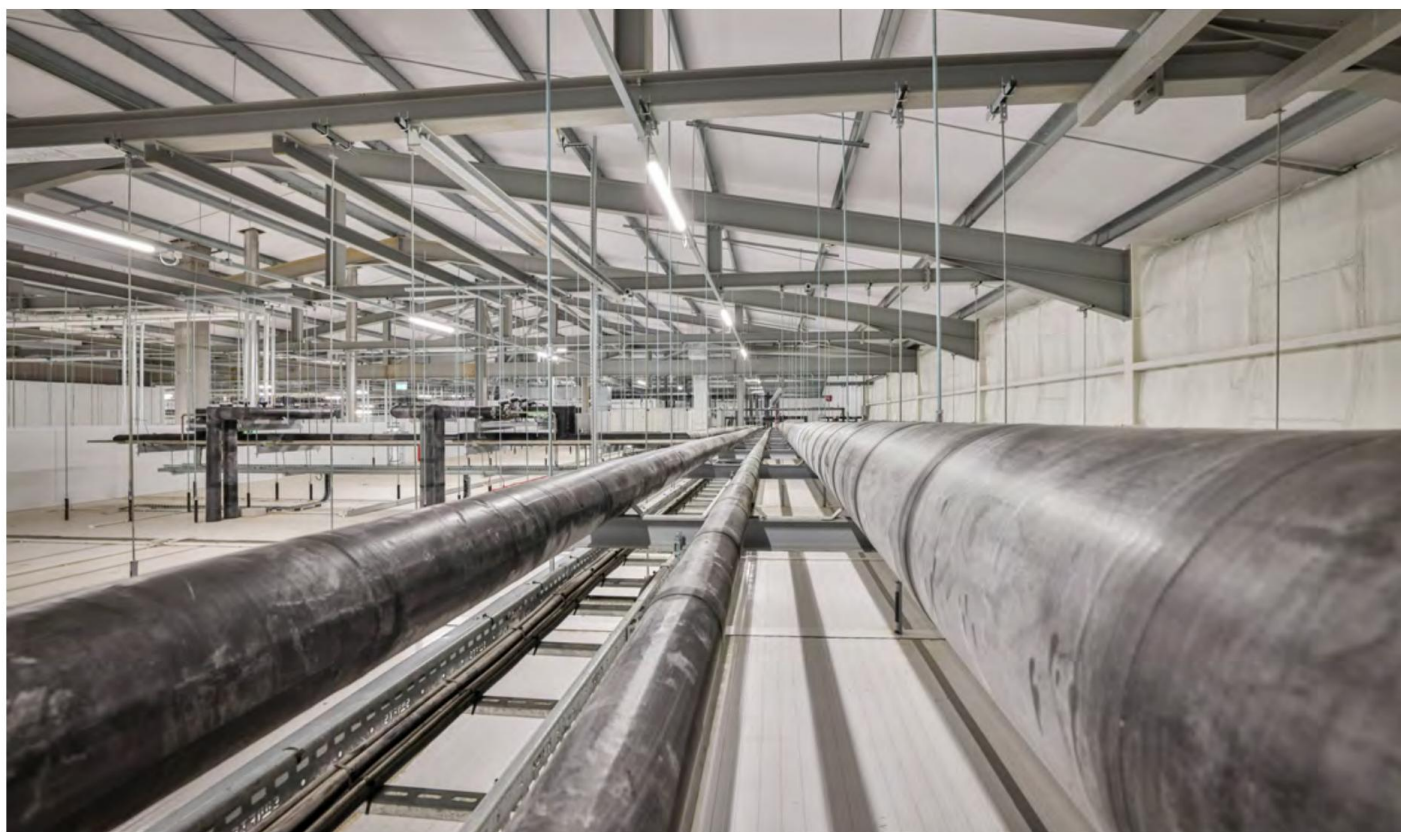
– Graeme Watson,
Group Engineering Director,
Cranswick Country Foods

RIGHT

In 2022, SURE Solutions received two awards for Project Aquarius: one from *RAC Magazine* (right) for Building Energy Project of the Year and one from *ACR Journal* for Refrigeration Project/Innovation.

BELOW

Ammonia piping at Cranswick's prepared poultry facility, including (from left): liquid, discharge gas and suction gas.





Computer (right) at Cranswick's prepared poultry facility that manages all switchgear, variable speed drives, leak detection panels, ventilation panels and other components, with ammonia leak-detection panel (middle) and ventilation panel (left).

One of the lines includes cooking so that the consumer only needs to reheat the finished product. This involves the same process, but after flash frying the product goes through a spiral cooker with deep-fat fryers (160°C to 170°C/320°F to 338°F) and then is pre-cooled by ambient air before going into a spiral freezer and finally to a frozen storage room.

A key requirement of Project Aquarius was to provide a dynamic, flexible operation, explained Cooper. "We needed to design a system to run it to different conditions. They want to either freeze or chill in the cold store and the spirals. It would be about how we could do that as efficiently as possible."

Efficiency tactics

Cranswick and SURE engineered a multi-faceted approach to improving efficiency at the Hull plant. One of the primary ways is leveraging floating compressor suction and discharge conditions.

The spiral freezers and chillers use compressor suction set points rather than evaporator pressure regulators. "A lot of people would have an evaporator pressure regulator on the suctions so you could still run the compressors at -40[°C] to achieve a chill condition," said Cooper. "The problem with that is that you expend a lot of energy running what I would call 'in anger.' So the plan was to run things as close to the optimal setpoint as we possibly could."

Cooper pointed out a rule of thumb about raising the compressor suction point (evaporating temperature): for every one degree Celsius you raise the evaporating temperature, you're saving approximately 3% in compressor energy.

Other efficiency measures:

- Compressors are sized for minimum pressure difference, with a high-suction and low-discharge design.
- Condensers are oversized to ensure no over-condensing during low load periods.
- Variable-speed drives (VSDs) and high-efficiency motors are used for all pumps, fans and compressors with drives greater than 2.2kW, including low harmonic drives for compressors.
- Air coolers with EC fans optimize air and temperature conditions.
- Mixing circuits are used to reduce the temperature difference between glycol and air, thus minimizing defrosting/downtime.
- Spiral freezers have closing hoods for sequential defrosting to remain fully in operation.
- For longer production runs, Cranswick is planning with SURE to install dehumidifiers within spiral freezers. "At the moment that's not a problem because they stop regularly, but when we want longer runs and more efficient runs, we will have dehumidifiers and will end up being able to run more efficiently and for longer," said Watson.

In addition, SURE employs a fully comprehensive SCADA (Supervisory Control and Data Acquisition) system to manage the plant for optimum efficiency. With the SCADA system, "you can quite quickly and easily respond to any sort of unforeseen issues or human error, such as someone's left the tap water on overnight by mistake," said Cooper. "Or it can identify a production line problem causing operations to stop."

SURE also monitors all energy usage, using recorded data to make controlled changes to improve system efficiency. "I can set the trends over three weeks, four weeks," Cooper said. "I'll quickly see across the graph if anything stands out."

"SURE is constantly challenging what we do and the way we do it," said Watson.

Cranswick has initially used natural gas for cooking, but the company aspires to switch to either a small electric boiler or hydrogen gas as a cooking fuel, said Watson. "We're actually looking to go over totally to hydrogen, and we've got an application in at the moment for funding. All the boilers that we're building and commissioning now have got to be hydrogen-ready."

If it receives funding by the end of this year, within the next two years "we'd love to convert the whole business over" to hydrogen, said Watson. Cranswick plans to invest in a local hydrogen production facility that would supply its factories with hydrogen. "As a nation, that is what we're looking to do, literally change over the gas networks to hydrogen networks." Already village trials are being planned, whereby a village or two will convert to hydrogen. But it may take until 2030 for the conversion to be widespread.

Multi-purpose heat pump

A cascade ammonia heat pump provides the site with all hot water for sanitation, with a boosted temperature design that recovers as much heat as possible from refrigeration. Heat recovery is also used for office heating, hot water preheating, under-floor heater mats in low-temperature areas, air-cooler defrosting and process-machinery defrosting. The heat pump was found to reduce the carbon footprint of the factory by 1,774kg of CO₂e/day compared to using natural gas.

About 50% of the discharge gas from the refrigeration system's ammonia screw compressors feed the heat pump system, which has reciprocating compressors, with the other half going to the refrigeration system's evaporative condensers, which are equipped with a chemical-free water treatment system. The ammonia from the heat pump circulates back to the refrigeration system, forming a closed loop.

The initial temperature of the ammonia going into the heat pump is about 30°C (86°F); the sanitation water is boosted to about 65°C (149°F) and "topped up" to 70°C–75°C (158°F–167°F) by a boiler to eliminate legionella bacteria.

SURE designed the refrigeration system to recover as much heat as possible for the heat pump. One way is to install oversized compressor oil coolers to raise the temperature of water from a water main from 10°C to 40°C (50°F to 104°F). Then a desuperheater is employed before the condensers to add another 5°C (9°F) to the water from partial condensation of the ammonia discharge gas, which also reduces the energy expended by the condenser fans. A chloride ion sensor is included to ensure the water main's chloride ions are within a certain parameter.

Because of the sanitation needs, SURE designed the system to satisfy the general daily use of hot water for 16 to 20 hours. This means generating enough water for a 60,000L (15,850gal) insulated buffer vessel tank that could be tapped when the refrigeration load is less, the refrigeration system isn't needed or there is a greater use of hot water.

SURE designed the Hull plant such that the refrigeration would do "the least work possible" while the cascade heat pump would do "the most work possible" to maximize the overall efficiency of the system, said Cooper.

For example, during the fall, lower ambient temperatures means that condensing might be handled at 20°C (68°F) rather than 32°C (90°F) during the summer, reducing the work done by the compressors. On the other hand, that means a higher temperature lift in the heat pump. "Someone might say, 'Why did you let the heat pump run more inefficiently compared to the refrigeration compressors?'" noted Cooper. The reason, he explained, is that the heat pump uses a 90–110kW drive motor, while the four refrigeration compressors each employ 350kW motors. "Once you start looking at 1,400kW absorbed power versus 110, you're going to have to make your refrigeration side more efficient."

Cranswick has installed heat pumps at other facilities but not in the integrated fashion used at the prepared poultry Hull facility, which provides "the best efficiency," said Watson. As a result, the company plans to install another six integrated heat pump across its

operations over the next eight months, following the "blueprint" at Hull. "This is what good looks like," he said. "Anybody that wants to make a change – well, we've done it. This is what you use. This is why you do it."

A new mentality

Though Cranswick has seen energy savings from aspects of its Hull operation – such as the 1,774kg of CO₂e/day reduction from using the heat pump rather than natural gas – it is difficult in a new facility with highly efficient systems to measure energy improvements since it is establishing a new baseline, noted Watson. "If there's an old factory, there's a cost saving [with a change,] and you'll pay it back within two years. If it's a new factory, you've got nothing to gauge against. But they're saving every day, every week."

During the past five years under Cranswick's Second Nature program, the company has been taking a more proactive approach to sustainability and energy reduction, in contrast to a solely "production mentality, getting product out the door," Watson observed. "Now the company is in a very different place, a new mentality has evolved. You've got energy managers, new positions within the business. As an engineer, you always knew the merits of metering and now people have turned onto it, which is good."

The prepared poultry plant in Hull is the culmination of this evolved philosophy, which allowed a larger, though "not massive" investment in technology, Watson said. This even extends to installations of wind turbines and solar panels. "Every conceivable opportunity, we're into that. If I was to do a new build, I would be questioned all the way through to make sure I haven't missed anything."

System Specs

Cranswick Refrigeration/Heat Pump, Prepared Poultry Plant, Hull, U.K.

Total capacity: 3MW (853TR)

Ammonia charge: 4,000kg (8,818lbs)

Spiral freezer: -43°C (-45°F)

Spiral chiller -20°C (-4°F)

Frozen storage: -18°C (-0.4°F)

Chilled storage: 1°C (33.8°F)

Glycol processing cooling: 4°C to 10°C (39°F to 50°F), with an average of 8°C (46°F).

Glycol AC: 20°C (68°F)

Spiral cooker: 160°C to 170°C/320°F to 338°F

Heat pump initial temperature: 30°C (86°F)

Sanitation hot water final temperature: 65°C (149°F)

Sanitation hot water topped-up temperature: 70°C–75°C (158°F–167°F)

Insulated hot water buffer vessel 60,000L (15,850gal)

GEA screw compressors (refrigeration)

GEA reciprocating compressors (heat pump)

Evapco evaporative condensers

Heinen spiral freezers/chillers

Coolers and Condensers Co. evaporators

Guntner, Vahterus and Thermowave heat exchangers

Danfoss valves, variable speed drives and low harmonic drives for compressors

Elecref SCADA controls



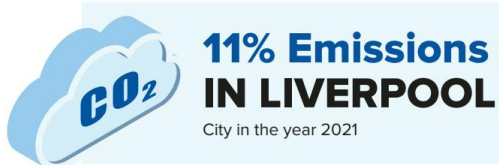
Ozone Friendly Climate Friendly PFAS free



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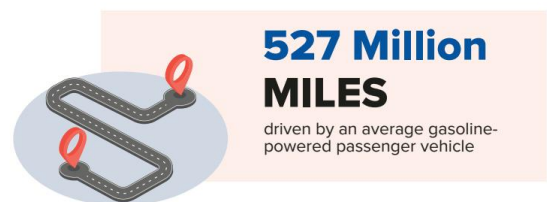
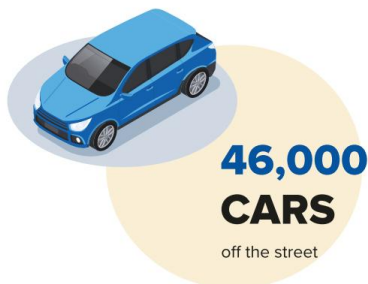


In 2023 SURE Solutions installed and serviced **Natural Refrigerant-based equipment** mitigating lifetime GHG emissions equal to



206,000 tCO₂e
(GWP₂₀ Years)

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This is what SURE Solutions customers say:

Service

Were you happy with the service you received?

Sure Solutions were very accommodating. They had travelled to Northern Ireland to complete works and were on site every day including weekends to deliver on time.

Scott Dalglish
Engineering Manager
Sofina Foods

Very satisfied, full project managed from design to delivery.

Gino Taj
Engineering Manager Projects
Muller UK & Ireland

Extremely happy. Cranswick Country Foods are committed to reducing our carbon footprint. Removing lots of hazardous F-gases from the site and reducing electricity usage by utilising the current system to cool the full site and the spiral, has helped us on our journey as well. Sure Solutions were and continue to be extremely easy to work, and the full team are very knowledgeable on the systems they install.

Alex Holden
Engineering Manager
Cranswick Country Foods PLC

ATMOsphere Natural Refrigerants Label

ATMOsphere launched a label to meet the growing market demand for a globally recognized quality label that qualifies and celebrates the best-in-class manufacturers and contractors in the natural refrigerants industry.

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