Smart Thinking

Topic

An introduction to modern low carbon refrigeration systems for large distribution centres

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Considerations when purchasing modern low carbon refrigeration systems for large distribution centres

The cold chain is responsible for around 2.5% of global greenhouse gas output and finding more efficient and sustainable ways to deliver cooling in response to the UK's net-zero carbon target is a critical challenge.

Fortunately, the cold chain is well equipped and have a good track record of meeting and exceeding the energy efficiency standards set by the government's Climate Change Agreement. Despite population and economic growth, large distribution centres in the UK are handling more product than ever but using 17% less relative energy today than we were in 2008 and we expect to go further. However, there is still plenty of room for improvement as the Government report on cold chain performance against CCA targets showed that about 100 of the units surveyed in 2017/2018 did not achieve the energy goals.

The development and implementation of modern technologies play a big part in meeting the above targets. Alongside the 'internet of things (IoT) which allows for collection and analysis of refrigeration plant performance data to achieve business operational efficiency, the latest innovations in refrigeration technology such as condensers, compressors and controls are allowing large distribution centre operators to reduce operating costs. In turn, this significantly improves the company's carbon footprint, an element that is key to complying with industry standards and avoiding contravention of national and international legislation.

The transition to a modern low carbon refrigeration system should be a target for all large distribution centres in the UK.

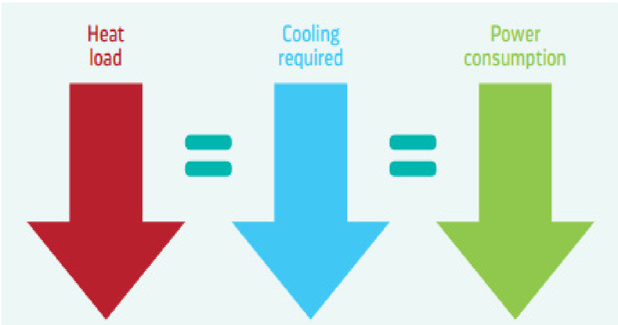
But what exactly does such a low carbon refrigeration system look like?

Well, in the simplest possible terms, a low carbon refrigeration system is one that uses the latest technology and implements best practices to consume as little electricity, water and gas as possible, while simultaneously using a refrigerant with the lowest global warming potential (GWP) that does not negatively impact efficiency.

Low carbon refrigeration system requirements

Reducing cooling requirements

First and foremost, the power consumed by a refrigeration system is directly related to the distribution centre's heat load which in turn has a direct impact on the amount of cooling required to efficiently run the system. By reducing the heat load, the cooling load will also be reduced and the refrigeration system will use less power to run which will decrease plant carbon emissions.



A typical distribution system has five main heat load sources:

- Fabric. It relates to the thickness of the sandwich panel and their material and condition. Increasing panel thickness help, but beware of diminishing returns.
- Equipment and people. Typically a lesser source of a TCS&D centre's heat load (4%).
- Product heat load. This is the largest source of heat load in a cold store. A cold product can arrive between 6 to 10K warmer than the storage temperature. For chill storage, the product throughput is often considerably higher with product arriving at temperatures ranging from 1 to 2K.
- LED lighting. Currently installed in most refrigerated chambers, led lighting has allowed for a reduction in heat load of around 3%. Dimming systems can reduce power consumption further.
- Air infiltration. This is one of the bigger factors affecting a cold store's heat load and almost a third and this can be reduced with changes in operator practices.

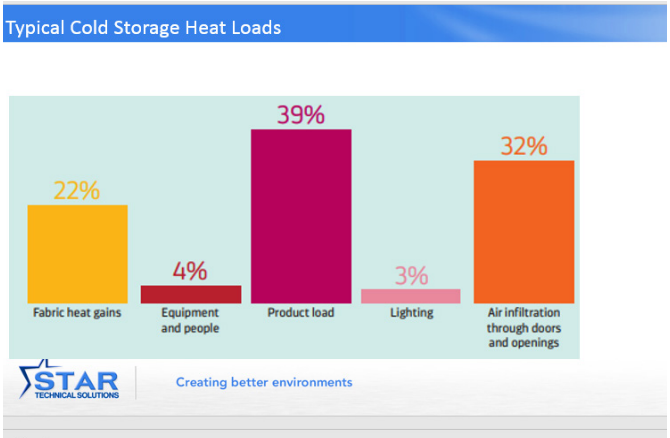


Figure 1. Typical sources of heat load in TCS&D facilities

While the biggest contributor to a typical cold storage heat load – the product load – cannot be altered without affecting business performance, it may come as a surprise that the second largest factor affecting heat load is air infiltration through open doors and openings. Responsible for a staggering 32% of a company's typical heat load, this could be easily addressed by improving the infrastructure and protocols surrounding connecting doors, including reducing door height, increasing transfer speed and introducing an air lock to achieve significant savings. Together, these steps will help to minimise ice and frost build-up and maintain a stable temperature in the chiller and freezer areas, therefore reducing the heat load and bringing down the cooling requirements at the same time.

Upgrading equipment

The second stage of modernising your plant's carbon profile is adopting the latest technology and using the most advanced equipment with regard to condensers, compressors, control systems and maintenance protocols to achieve improved efficiency, greater reliability and lower total cost of ownership. This also means installing a system that uses a low GWP refrigerant.

Advances in refrigeration technology have made possible the use of industrial pre-engineered packaged systems specifically designed to address concerns over large refrigerant charges and potential safety risks.
For instance, plug and play low-charge ammonia refrigeration systems have emerged as one of the key trends in the industrial refrigeration industry in the last few years, particularly within the temperature controlled storage industry. Modular low-charge ammonia refrigeration systems have the flexibility to be installed outdoors which negates the need for plant rooms requiring ATEX ventilation systems, ammonia detection, fire detection and emergency lighting systems.

Low charge ammonia refrigeration systems have the potential to not only replace traditional ammonia refrigeration plants requiring costly machinery rooms but also to reduce the ammonia charge by 96% -compared to traditional systems- without compromising the plant's efficiency. Check how Brakes reduced the ammonia charge of their plant in Stortford by 96% with the use of Star's Azanefreezer.

The interest in the use of CO_2 refrigeration solutions for smaller capacity applications (under 300kW) has also experienced significant growth in the last decade. Industrial build CO_2 refrigeration systems such as Star's CO_2 Envi range have been shown to provide high efficiency for temperatures ranging from 8°C to -40°C. CO_2 packaged refrigeration systems offer longevity along with high performance and a competitive price tag.

What are the questions a cold store operator should be asking when looking at purchasing new refrigeration systems?

- How expensive is it to build a machinery room vs the use of industrial pre-engineered packaged solutions?
- Do I need to install fire detection and ATEX equipment in the machinery room?
- How can I keep my refrigerant charge to a minimum? – The smaller the quantity the safer the system
- Do I need complex refrigerant safety systems in place including gas detection and ventilation systems
- Can I keep ammonia valves outside in order to reduce the risk of leaks inside the building.
- Should I choose a bespoke systems or a tested design?

- Will the control system manage individual components or the complete system?
- What will the maintenance costs be over the life time of the system?
- What are the utility costs? Ensure you ask for case studies showing real figures

Modern refrigeration technology

Here's a closer look at some of the pre-engineered low charge ammonia refrigeration systems that Star offers and which a modern facility should look to employ, in both a freezer and chiller capacity:

Modern refrigeration technology for a freezer

A modern refrigeration system for a freezer such as the Azanefreezer 2.0 consists of a self-contained unit complete with housing and a fully welded base frame that's conducive to rigid construction a long lifespan. Its exterior is constructed from removable panels that facilitate access during maintenance or emergencies. It has an integrated electrical panel with efficient controls that can be accessed remotely and condition based monitored via broadband, as well as an intuitive user interface with touchscreen controls.

As for the system's hardware, it is comprised of an air-cooled condenser with variable speed EC fans, complete with stainless steel tubing and coated fins for maximum durability. It has been proven that air cooled condenser operating cost are 15% lower than an evaporative condenser. The main reason is the costs associated with the use of water and water treatment. The research also found that air cooled condenser refrigeration systems only use 1 to 2% more electricity than evaporative condenser and therefore there is a strong justification for the use of air-cooled condenser technology.

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When compared with adiabatic condensers, air-cooled condensers were also shown to provide cold-store operators with an overall lower cost of ownership. In an adiabatic condenser, the water portion only switches on when the air temperature is >24°C. In the UK, this only occurs for about 190hrs per year. Therefore the water side in only used for <2.2% of the year, during which time, the system will save money. However, for the rest of the year (97.8%), the operating cost will be higher as there is less heat transfer surface and adiabatic pads increase fan power due to the additional pressure drop required.

The robust PIR insulation has aluminium-zinc cladding for optimum thermal retention, while the system's four-way valve delivers fast and efficient reverse-cycle defrost capabilities. Its low-pressure receiver offers overfeed operation without the need for pumps and Azanefreezer 2.0 is equipped with twin screw compressors with variable volume ratios. Screw compressor are excellent for freezer applications. For distribution centre these compressors run at full load or switch off, avoiding reduced efficiencies associate with part load operation.. For freezer applications, two-stage reciprocating compressor could be considered but their high maintenance costs will outweigh any electric saving when compared with using screw compressors.

In terms of performance, the AzaneFreezer 2.0 runs on just 12kWh/m3/year, which is considerably better than both the European average of 48kWh/m3/year and the UK 'Best Practice' of 32kWh/m3/year. As such, it's a highly efficient and advanced piece of machinery that is guaranteed to enhance a cold store's environmental credentials and financial margins in a single swoop, while simultaneously future-proofing it against any regulations which may be introduced in the coming years and decades.

Modern chiller technology

The AzaneChiller 2.0 is the epitome of a modern, modular refrigeration system. Its steel base frame provides the foundation for a robust construction, while the flatbed condenser has stainless steel tubing with AlMg fins for a longer life. The stainless-steel panel also contributes to increased durability in external environments, with the steel pipework fully welded for leak-tight operation and a longer lifespan. Its efficient control system offers touchscreen capabilities, remote access and monitoring.

In terms of its hardware, the Azanechiller 2.0 has one or two variable speed reciprocating compressors (depending on the needs of the plant in question). Reciprocating compressor are excellent for chill type applications where part load running is required. The reduced electrical cost outweighs the extra maintenance cost when single stage compressors are used. However when compressors are operated above 1500 rpm, the maintenance costs begin to outweigh the electricity costs. Reciprocating compressors should normally only operate at <1500 rpm.

Variable speed drive, IE3 compressor motors offers high efficiency and the variable speed EC condenser fans with AxiTop diffusers contribute to low power consumption and improved airflow. The heat exchanger has a fully welded plate and shell, meaning it comes with a low refrigerant charge and minimised risk of leakage.

Both the Azanefreezer 2.0 and the Azanechiller 2.0 employ ammonia as their refrigerant, with the former suitable in applications of between 150kW and 650kW and the latter appropriate for facilities with a capacity of between 140kW and 1,200kW.
For smaller capacities, a more economic carbon dioxide system can be used with similar efficiency, while subcritical CO2 is also appropriate in settings where heat can be rejected into glycol. However, it should be noted that occupancy and emergency ventilation and hoods over valve stations are required on larger internal systems where carbon dioxide is being used.

Planning for tomorrow

Given that the cold chain sector is responsible for 2.5% of all greenhouse gas emissions worldwide, it's understandable that the industry is being asked to do more to improve its carbon profile. That's especially true in light of the UK government's target of reaching a net-zero carbon target by 2050.

It makes sense to take action now to prepare your cold store facility for whatever may occur in the future. Simple precautions, such as minimising the ingress of ambient air into your plant through unsecured doors and other openings, is a key method of reducing the heat load of your operations and minimising cooling requirements as a result. Meanwhile, introducing the latest technology (in the shape of the Azanefreezer and the Azanechiller) is the best method of meeting those requirements in an economical and eco-friendly a manner.

For more information on any of the points discussed above or if you have any questions, please contact me directly at **dcotter@star-ref.co.uk**

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