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The Journey to Net Zero

Achieving Net Zero by 2050 – Commercial Refrigeration

Philipp Holzer MinstR

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Abstract

This paper discusses the current initiatives and the future challenges in achieving net zero in retail commercial refrigeration systems by 2050. It focuses on the decarbonisation of heating within stores, the switch to heat recovery and use of heat pumps. The paper outlines a number of the technologies actively being developed by retailers to reduce energy demand and concludes with an assessment on the likelihood of achieving the 2050 target.

Keyword: Commercial refrigeration, Net Zero, retail

Introduction

"The climate emergency is recognised as one of the greatest threats to our planet. The UK government is participating in global efforts to limit the global temperature rise to 1.5°C and has set legislative targets for the UK to reach net zero greenhouse gas emissions by 2050. UK retailers recognise and support the need for urgent action" [1]. As part of the decarbonisation of heating systems and the switch to electric heating, retailers are looking to recover waste heat and generate additional top-up from refrigeration systems utilising ultra-low GWP refrigerants. Systems must holistically consider the operation of both heating and refrigeration to ensure efficient operation and prolong the service life of equipment.

Background

Retailers are generally targeting net zero emissions in their own operation well in advance of the 2050 deadline [2]. The last decade has already seen a substantial reduction (circa 54%) in the carbon footprint of most retailers [Figure 1]. The largest part of the reduction is as a result of the switch to renewable energy and the replacement of HFC with CO_2 refrigeration systems.

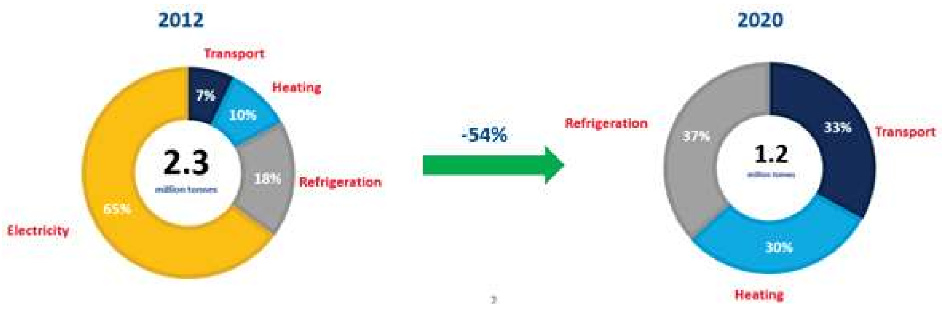

Figure 1: Reduction CO_2 emissions in the last decade

All retailers are committed to sourcing 100% of their electricity from renewable sources by at least 2035 [3]. Renewable energy is sourced in three ways. Either on-site, off-site generation or from certificate backed suppliers (REGO) [4]. Retailers are looking to increase both on and off-site generation [5] and reduce reliance on REGO backed sources. Therefore, the indirect emissions have largely been removed and the focus is now around the reduction of direct emissions. Refrigeration systems account for some 37% of this.

Switch to low GWP refrigerants

Replacement of HFC systems with transcritical CO_2 (GWP of just 1) is now commonplace and well established, having been undertaken for the last 5 years. The capital cost is more or less equivalent to HFC systems, due to their increased saturation in the market. Service engineers working in the retail sector have been upskilled and are now widely experienced in CO_2 systems.

Typically, a quarter of the retailer's estate have CO_2 refrigeration systems. There are significant challenges in the replacement of the remaining HFC systems ahead of 2035. Some of these include the availability of labour, material, and manufacturing resources and of course the capital budgets to deliver on the 2035 goal.

Decarbonisation

Retailers are also planning the decarbonisation of heating systems by 2035. Effectively requiring the replacement of all gas fired boilers and a switch to electric heating. This presents further challenges, most notably around the electrical supply infra-structure, as the demand for EV charging rises. To enable this expansion, it is critical that we consider the following:

- The capture of waste heat from refrigeration systems and its integration into the Heating and Ventilation plant. CO_2 systems provide a great opportunity to not only recover waste heat, but also to generate increased heat output during periods of high heating demand.
- The optimisation of all parts of the refrigeration and heating system to reduce energy consumption.

Heat recovery

Heat recovery from refrigeration systems is crucial, although its application should be carefully considered. Artificially loading refrigeration systems or the use of false load systems may not be the most efficient way of generating this heat in all conditions.

Refer to Appendix A. It provides an example of the heat recovery mode vs store heating demand and calculated cooling COP. Heating demand can be met by the refrigeration system giving up its free heat, running down to 17°C ambient. This maximises the system efficiency.

Table 1 indicates some of the considerations.

Table 1: Heat recovery modes of operation

Heat recovery mode of operation	Pros	Cons
Artificially operate the systems transcritically in low ambient temperatures, to generate increased heat output.	Reduces the amount of top-up heat required from other sources and reduced capital cost.	The COP will dramatically reduce. Typically consuming nearly three times as much energy, when operating sub-critically. Service life of the refrigeration system is likely to be reduced. Maintenance costs will be higher.
Extracting free heat from the refrigeration systems without elevating discharge pressures.	Higher system COP can be maintained. Increased service life Lower Opex cost	Limited heat output at very low ambient temperatures but enables higher COPs to be maintained. Increased capital spend as additional heat pump capacity required

Heat recovery plates need to be carefully selected to limit pressure drop near peak design conditions but selected at an optimal point to match the heating demand of the store. There is little point in providing a plate that can generate a heat output beyond the store's heat demand. The design of the heat recovery plate also needs to consider thermal stress, typically more than 60k between the gas inlet temperature and water outlet. This can readily be exceeded when running transcritically.

Heat recovery from refrigeration systems are unlikely to meet the store's heating demand on their own, therefore additional electric heating or heat pump systems will be required for top-up.

Although heat pumps may provide improved efficiency at certain conditions over a transcritical CO_2 system, the current technology has them operating on R32 with a GWP of 675 or HFO refrigerants with high embedded GWP. Even such relatively low GWPs are unlikely to help with the journey to NetZero and likely to be legislated against. CO_2 heat pumps are being developed by the major heat pump manufacturers. In the interim, an alternative source for CO_2 heat pumps may be the current refrigeration plant manufacturers, although they are unlikely to be able to compete with the high-volume heat pump manufacturers once they reach the market.

The integration of the Store's BMS controls with the refrigeration system can be difficult to facilitate efficient heat recovery. The BMS system normally signals the store's heating demand but does not really consider the most efficient way to operate the refrigeration system. Equally the "off-the-shelf" refrigeration controls can be very crude in their application of heat recovery, offering little flexibility to optimise the operation of the entire system. In addition, we must have control systems with open protocols to allow data to be drawn from multiple systems and allow inter-communication.

Future heating, ventilation and refrigeration systems will be integrated into packed units to provide a much more efficient heat and cooling system. Such systems are beginning to become available in the market. Such combined systems will require service technicians to be crossed trained in both the heating and refrigeration systems. SLAs and call-out responses will need to be aligned.

The switch from gas heating to heat recovery has some additional challenges around scheduling. HVAC and refrigeration plant replacement have rarely been aligned. Retailers are now fitting heat recovery to new refrigeration systems as standard, making stores effectively ready for a future gas boiler replacement and heat recovery utilisation.

Other areas for improved refrigeration efficiency

Most of the low hanging fruit around the use of EC fans, LED lighting and application of off-cycle defrost have already been taken. There are a number of other areas for improved energy efficiency. They are beyond the scope of this paper to detail, but worthy of further development and consideration.

- The use of doors on dairy and meat cabinets is widely used in small format stores, generally up to a maximum of 20,000 ft^2 of net sales area. The retailer's merchandising team normally object to their use in larger stores, citing the impact on the customer experience and sales. Refrigeration load is typically reduced by some 30-40%. Future limits in the electrical infrastructure may force doors to be more widely adopted. Their use would also negate the requirement for cold air retrieval (CAR) and heating offset in lower ambient temperatures. This can represent as much as 25-30% of the store's heating demand.
- The use of stepper EEVs over pulsing type can provide a more stable suction pressure and resultant energy benefit. This is well established on HFC systems, but not yet proven on CO_2.
- The use of cabinet "shelf edge technology" is now commonplace, providing reduced energy consumption of circa 5-7%. It also reduces air spillage and heating demand.
- A number of cabinet manufacturers are developing cabinets which will substantially reduce the connected load (up to 50%) with increased evaporating temperatures (up to 0°C).

These examples will of course reduce the potential heat output from the refrigeration systems, but their energy benefits can not be ignored, particularly when they also reduce the CAR heat demand.

Retailers should no longer be hung-up on a single controller manufacturer, but instead define the requirements and design the network infra structure to allow a simple switch to the latest most efficient technology.

Conclusion

The journey to NetZero is very much at the forefront of the retailer's core purpose. They are generally engaged with the latest technological advances and willing to assess and validate their performance in real world terms.

Budgets for the replacement of HFC systems were established a number of years ago and will enable their phase-out by 2035. Additional funding to support the decarbonisation of heating is also planned and fixed but closely wed with the installation of new CO_2 systems.

The traditional heat pump manufacturers must bring natural, sub-150 GWP refrigerants to the market within the next 2-3 years.

Controls manufacturers must provide open communications protocol devices that cross both heating and cooling markets to ensure heat is generated in the most energy efficient methods. Retailers have a responsibility to encourage, invest and challenge manufacturers. They should not accept standard offerings.

Retailers are generally in a good position to deliver Net Zero ahead of 2050.

[1] https://brc.org.uk/media/677373/climate-action-roadmap-executive-summary-apr21.pdf

[2] https://www.about.sainsburys.co.uk/news/latest-news/2020/28-01-20-net-zero

[3] Tesco is committed to sourcing 100% of its electricity from renewable sources by 2030 – to include over 50% from power purchase agreements and on-site generation. (https://www.there100.org/re100-members)

[4] https://www.ofgem.gov.uk/environmental-and-social-schemes/renewable-energy-guarantees-origin-rego

[5] https://www.edie.net/news/10/Tesco-to-support-creation-of-three-UK-solar-farms/

Appendix A: Example of heat recovery mode vs store heating demand vs system COP