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The Circular Economy in the Refrigeration Sector

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Winner of the 2024 Beyond Refrigeration Environmental Award

Why you should attend:

- To understand the circular economy for the commercial refrigeration industry and its stakeholders.
- To hear a summary of the impact commercial refrigeration has on the environment.
- For an overview of the regulations and legislation surrounding hazardous waste.

This paper describes Sustain's recycling processes which won the IOR Beyond Refrigeration Environmental Award in 2024.

1. Introduction

In the UK retail sector, leading retailers change and update their commercial refrigeration systems and equipment on average, every 8 to 10 years. This creates a programme of development that drives the removal and installation of refrigerated equipment, including frozen and chilled cabinets. This cycle sees the removed "end-of-life" assets start their waste journey.

The refrigerant gases are reclaimed from the refrigeration systems and remote display cabinets, before these assets are removed from stores. The industry stakeholders lose control of the end-of-life assets as this is removed from their ownership. The hazardous elements of the assets have limited options available with the hazardous foam insulation heading into landfill and/or incineration with a lack of specialized recycling facilities for commercial refrigeration units. Improper disposal of commercial refrigeration units and their hazardous foam, significantly harms the environment through greenhouse gas emissions, toxic pollution, and resource wastage. Historically the refrigeration industry's waste options have been limited.

2. Market

Based on data from the Institute of Grocery Distribution (IGD) in 2023, the UK had approximately 87,000 grocery stores, including supermarkets, convenience stores, and specialised food retailers.

We have estimated the quantity of chilled and frozen cabinets, in use, across the UK in 2023 as follows:

- Larger supermarkets typically have between 50 to 100 refrigerated and frozen display cabinets.
- Smaller convenience stores may have between 5 to 15 units.
- Supermarkets constitute about 20% of the total grocery retail outlets.
- Convenience stores and smaller retailers make up the remaining 80% of the total grocery retail outlets.

2.1 Supermarkets:

With large supermarkets estimated at 20% of the (IGD) data of 87,000 = 17,400 Large supermarkets.

- Assuming an average of 75 units per store this totals an estimated 1,305,000 units.

2.2 Convenience Stores and Others:

With these stores estimated at 80% of the (IDG) data of 87,000 = 69,600 Small Convenience and other stores.

- Assuming an average of 10 units per store this totals an estimated 696,000 units.

2.3 Total Estimated Units:

1,305,000 (supermarkets) + 696,000 (convenience stores) = approximately 2 million refrigerated and frozen display cabinets in use across the UK.

- The number of retail outlets is based on data from the Institute of Grocery Distribution (IGD) 2023.
- The average number of units per store is derived from industry reports and case studies of typical store layouts.

- Please note that this is only an estimate, to illustrate the number of units in the UK, the likelihood being this number would be larger due to the base data being from 2023, and the cautious approach to the average number of cabinets per store.

By understanding the approximate quantity of units in use across the UK we can begin to estimate (based on an average 10-year cycle of replacement) the number of cabinets leaving stores and beginning their waste journey.

It is highly likely a small percentage of these cabinet assets will enter a refurbishment cycle prolonging the asset life on average by 5 to 7 years, before finally heading to its end-of-life waste journey. Cabinet refurbishment plays a vital step in maximising the core assets life expectancy. With limited information available regarding UK annual refurbishment figures, it is likely to be around 10% to 30% of the annual estimated figure.

Annual Market Estimations	Numbers
Cabinets in use across UK	2,000,000
10 year replacement cycle	200,000
Refurbishment Estimated 20%	40,000

This data allows us to understand the size of the market and illustrate the annual figure of end-of-life cabinets entering the UK waste industry. The above logic points to approximately 160,000 to 200,000 cabinet assets entering the UK waste stream per year. With the hazardous nature of this waste, and the current routes for the hazardous foam elements being limited, improving these routes and the opportunities available to reduce the CO_2 emissions the end-of-life waste journey is becoming even more important.

When equipment assets enter their waste journey, certain regulations apply. Below is a high-level overview of the key notable points relating to the Waste Regulations to be aware of.

3. Waste Regulations

Waste regulations apply to anyone who transfers or transports waste from one site to another.

The Waste (England and Wales) Regulations 2011 has several sections dedicated to transferring and transporting waste from or to a site.

- Section 12 - Anyone undertaking transport or transfer must apply the hierarchy of waste, this means waste should only be sent out as waste as a last resort. First you should try and prevent producing waste, if this can't be done then it should be re-used, if this is not possible the waste should be recycled or sent for recovery at another site and lastly if this is not possible then it should be disposed of.
- Section 25 – All dealers and brokers for waste must be registered with the Environment Agency (EA).
- Section 26 – Anyone transporting or moving waste must be registered with the Environment Agency. This is for anyone who doesn't process or hold any waste but will transport it from site to site, this is also a requirement of section 5 of the Control of Pollution Act 1989.
- Section 35 – All waste leaving site must have a Transfer Note or Hazardous Waste consignment note. [1].

4. Codes of Practice

The Duty of Care Code of Practice, is designed to be an essentially self-regulating system based on good practice. The Code of Practice is the practical guidance to comply with the Environmental Protection Act 1990 Section 34.

Section 3 of the Code of Practice states you must take all reasonable steps to:

1. Prevent unauthorised or harmful deposit, treatment or disposal of waste.
2. Prevent a breach (failure) by any other person to meet the requirement to have an environmental permit, or a breach of a permit condition.
3. Prevent the escape of waste from your control.
4. Ensure that any person you transfer the waste to has the correct authorisation. Provide an accurate description of the waste when it is transferred to another person.

It places a duty on anyone who in any way has a responsibility for waste to ensure that it is managed properly and recovered or disposed of safely.
The purpose of this code is to provide practical guidance for waste holders subject to the duty of care.

5. Waste Permitted Facilities

Given the hazardous nature of the waste, appropriate and permitted facilities must deal with the waste assets. Permits show that a site has demonstrated its compliance to the EA and its regulations. Permits prevent unauthorised or harmful deposit, treatment, or disposal of waste.

It is illegal to deposit hazardous waste except under and in accordance with an Environmental Permit or a registered Waste Exemption.

- It is also illegal to treat, keep or dispose of hazardous waste in a way that is likely to cause pollution of the environment or harm to human health.
- It is important to be aware of the level of permit your waste processor is operating under.
- A Standard Rules Permit sets out the operating conditions the site must conform to. This permit is an off the shelf permit that is the same across the UK.
- There are many different types broken down into 12 categories. [2]
- A Bespoke Permit is exactly that. It is unique to the individual site and defines the process exactly as it is and sets out all the requirements that are essential to maintain compliance.
- These permits do not fit the criteria or design parameters for Standard Rules Permits.
- Exemptions – Certain waste operations are exempt from needing a permit and can operate under a waste exemption.
- Exemptions are for when a limited quantity and type of waste it to be stored (S), used (U), disposed (D) of or treated (T). These are free to apply for and valid for 3 years. As of 2024 this will change to point more establishments towards a Standard Rules Permit.
- A Standard Rules Permit does not allow for any point source emission points though, if you need this then you will need a bespoke permit. For example, an emission point within a process such as a chimney.

6. Reducing the Environmental Impact

Sustain Recycling Ltd (previously known as Davis Commercial Services Ltd “DCS”) have been recycling commercial refrigeration equipment for 15 years.

Over this time a wealth of knowledge and experience has been obtained. Sustain have been able to identify the shortcomings of the waste processing industry when it comes to hazardous end-of-life commercial refrigeration equipment. They have developed a unique process for the commercial refrigeration industry. This process maximises the recyclability of all aspects of the refrigerated assets, reducing the environmental impact of the industry and its stakeholders. Sustain brings this together in one place further reducing the CO_2 impact of these services. By providing one destination for all environmental measures, industry stakeholders can control their assets waste journey and maximise its reuse potential ensuring the lowest possible impact to the environment.

With an option now available for stakeholders to be in control, and by actively reducing the movements of waste, this allows the whole process to become more reliably tracked. In addition, stakeholders can measure the benefits in the reduction of CO_2 emissions.

Reliable tracking is a key requirement especially in the pursuit of commitments and initiatives such as:

- Science-Based Targets Initiative (SBTi),
- Race to Zero Campaigns,
- UK Green Building Council (UKGBC) Net Zero Framework,
- PAS 2060: Carbon Neutrality,
- Better Buildings Partnership (BBP) Climate Commitments.

Maximising the reuse of all commercial equipment assets is the key to reducing the environmental impact of equipment including but not limited to: remote and integral chilled display cabinets, remote and integral frozen display cabinets, refrigeration packs / plant, gas coolers, condensers, deli serve over cabinets, cold and freezer rooms, bakery equipment, ovens, provers, etc.

Being able to unlock circular economy, each part, component, and raw material requires a specific approach in order to maximise its potential within a circular economy and reduced its environmental impact.

The following points and actions, some more common than others, can be taken to maximise the potential of waste assets from the industry.

6.1 Refrigerant Reclaim

Some integral refrigeration units travel to waste processing facilities with the gas refrigerant charge still contained within their system. Reclaiming this safely reduces leakages and the refrigerant entering the atmosphere. Reclaiming the refrigerant prior to waste processing prevents the refrigerant being mixed with other gases, such as foam gases or blowing agents. Taking this step allows the stakeholder to bank and save this refrigerant gas for reuse, preventing any secondary process being needed to separate the gases. This banked gas then can go on to be mixed with new gas or used to support other systems in service.

6.2 Cabinet and Equipment Dismantle

Dismantling refrigerated and frozen display cabinets is an intrinsic step for the quality and circular economy of component parts and the assets raw materials.

Alternative approaches would see the total refrigeration cabinet crushed/shredded. This approach is an efficient way of processing, with separation techniques employed to segregate the raw materials after shredding. With focus on metal segregation only, with foam, plastics and light fractions combined and sent for incineration.

Dismantling the equipment allows for better raw material segregation prior to waste processing reducing contamination and increasing the quality and desirability of raw materials. By dismantling the cabinet prior to waste processing also allows for component parts to be salvaged for reuse by reducing damage and maintaining their quality.

6.3 Part Salvage and Reuse

Part salvage and reuse is growing in popularity, with consumable parts being saved from end-of-life assets. Refrigeration maintenance engineers carry van stocks of commonly required parts, enabling them to achieve first time fix maintenance KPI's. With regards to refrigeration cabinet maintenance, some of the common parts would be fan motors, cabinet controllers, printed circuit boards, cabinet displays, for example.

With large operational budgets supporting the maintenance of retailer estates, the desire to reduce this expenditure and reduce the manufacture of new items is growing rapidly. Effective component part reuse is helping drive these savings.

By salvaging component parts, testing them in line with manufacturers guidelines, these commonly required parts can be reused substituting the need and demand for new components across the maintenance of equipment in service. Reductions in CO_2 emissions are available here too, when compared with the cost of manufacturing new parts and transporting into the UK maintenance market.

Salvaging commonly used parts improves component part availability, helping reduce trading assets downtime.

Positioning the reuse function along site waste processing also allows for additional benefits such as:

- Specific collection initiatives, e.g. shelving collections, cabinet performance modifications. This avoids the need to travel to stores prior to asset removal.
- Uncommon part salvage.
- Capture of parts no longer manufactured, reducing bespoke manufacture.
- Donor parts – supporting assets function, while permanent, long lead-time parts are sourced.

Combining these functions within one location allows for reduced transportation movements and greater control.

6.4 Raw Material Separation

Segregation and separation of the raw materials is a vital step in maximising material value and viability. Metal recycling routes require no more than 0.5% contamination. Dismantling the cabinet prior to processing helps maximise the quality routes of all the raw materials found within the equipment assets. For less desirable materials its quality being high and its contamination being low, is key to improving the routes available and unlocking circular economy.

6.5 Metal Recycling – Electric Arc Furnace

Routing recyclable ferrous metal into Electric Arc Furnaces (EAFs) is the most efficient way of creating new metal. In comparison to blast furnaces, EFAs are using 1.6 tonnes less CO_2 per tonne of steel when using renewable electricity.

Comparison: EAF vs. Blast Furnace

Aspect	Electric Arc Furnace (EAF)	Blast Furnace (BF)
CO_2 Emissions	0.2–0.6 t CO_2 /tonne steel	1.8–2.2 t CO_2 /tonne steel
Primary Feedstock	Scrap metal, DRI	Iron ore, coke
Energy Source	Electricity	Coal and coke combustion
Energy Efficiency	400–600 kWh/tonne	High energy demand, primarily coal
Recycling	Up to 100% recycled steel	Minimal scrap usage
Operational Flexibility	High	Limited
Pollutants (SO_x/NO_x)	Low	High

Substantiation of Data:

- World Steel Association reports EAFs require significantly less carbon-intensive processes compared to BFs.
- A study by McKinsey & Company highlights that EAFs emit up to 1.6 tonnes less CO_2 per tonne of steel when using renewable electricity.
- The International Energy Agency (IEA) supports the energy consumption figures, noting EAFs as a cornerstone of decarbonizing steel production.
- The IPCC (Intergovernmental Panel on Climate Change) corroborates the drastic difference in CO_2 emissions between EAFs and BFs.

Based on the findings of UK Steel, the United Kingdom generates approximately 10–11 million tonnes of scrap steel annually.

Destination	Tonnage (million tonnes)	Percentage
Exported	8–8.8	~80%
Domestic Use	2–2.2	~20%

With 80% of the UK scrap metal leaving the UK, this material is still creating a CO_2 emission footprint, through transportation, in its scrap form. At this stage of the process, it is hard to guarantee if this scrap metal ever reaches an EAF, and to even understand the true CO_2 cost of this becoming new metals. Taking steps to reduce the movements of the scrap metal journey will reduce the CO_2 emissions generated.

The refrigeration industry now has access to a direct route to a UK-based EAF, providing a streamlined solution for processing end-of-life refrigeration equipment. This route guarantees the final journey of the scrap metal for the industry and its stakeholders. This allows for the tracking and understanding of the true CO_2 cost involved in this scrap becoming new metals.

Ensuring it is processed in a UK EAF, removes all associated export CO_2 emissions, as well as saving 1.6 tonnes of CO_2 per tonne of metal recycled new metal.

6.6 Foam Processing and capture of hazardous waste

The Blowing agents used in the creation of the foam insulation have improved over the years. Historically, ozone-depleting & high GWP blowing agents such as:

- CFCs (Chlorofluorocarbons) - e.g., CFC-11 & CFC-12
  - Phased out due to ozone depletion (Montreal Protocol).
  - Still found in older refrigeration units.

- HCFCs (Hydrochlorofluorocarbons) - e.g., HCFC-141b & HCFC-22
  - Ozone-depleting and high global warming potential (GWP).
  - Banned in most countries for new production but present in older equipment.

Modern practices are now employing lower GWP Blowing Agents

- HFCs (Hydrofluorocarbons) - e.g., HFC-134a, HFC-245fa, HFC-365mfc
  - No ozone depletion but still high GWP.
  - Being phased down under the Kigali Amendment.
- Hydrocarbons (HC) - e.g., pentane (n-pentane, iso-pentane, cyclopentane)
  - Low GWP and no ozone depletion.
  - Increasingly used in new refrigeration systems.
- HFOs (Hydrofluoroolefins) - e.g., HFO-1234ze
  - Ultra-low GWP and non-ozone-depleting.

Many of the blowing agents and gases in refrigeration foam insulation are classified as Volatile Organic Compounds (VOCs), these require specific management during waste processing. Without proper management, refrigeration foam can release these environmentally damaging gases to the atmosphere.

The UK Environmental Agency classify PUR/PIR refrigeration foam as hazardous waste, in its Waste Management guidelines (WM3) and Hazardous Waste Regulations.

As explained in the introduction (1.0) appropriate processing and waste routes for foam are limited and foam generally ends up in Landfill and Incineration routes.

Aspect	Incineration	Landfilling
CO_2 Emissions	Immediate release, 1.5 – 3 tonnes of CO_2 -eq	Gradual release, 1 – 2 tonnes of CO_2 -eq over decades
Toxic Risks	High (HCN, isocyanates, dioxins)	Low to moderate (chemical leaching risk)
Energy Recovery	Possible (waste-to-energy plants)	None
Long-Term Impact	Short-term air pollution	Long-term persistence and contamination

Evidence and Supporting Data:

Incineration Studies:

- European Federation of Waste Management and Environmental Services (FEAD) reports that poor incineration of PUR/PIR foam can lead to the release of HCN and dioxins.
- IPCC (Intergovernmental Panel on Climate Change) confirms that improper handling of HFCs during incineration contributes significantly to global warming.

Landfilling Studies:

- United Nations Environment Programme (UNEP) highlights that foam containing HC's & HCFCs can release

up to 20% of its blowing agent content during landfill degradation.

- Journal of Hazardous Materials (2009) identified leachate risks from flame retardants and other additives in landfill environments.

Improving the management of this material and reducing its environmental impact would see the foam being processed into a non-hazardous material, with all harmful gases contained within the foam captured and prevented from reaching the atmosphere. This can be done through carbon filtration systems or at best through cryogenic recovery. Cryogenic units allow for the gases being released from the foam during processing to be captured and reused. This avoids the need for gas incineration and further reduces its impact on the environment.

6.7 Productisation of Refrigeration Foam

After metal, foam is the second largest waste substance from commercial refrigerated, frozen assets, cold-room panels, etc. Diverting this foam away from incineration and landfill brings huge environmental benefits as well as trackable CO_2 savings. Routing this waste into reusable products poses the greatest and most beneficial route for the future of our environment. Construction boards and cement products are notable routes for non-hazardous PUR/PIR foam. Removal of the hazardous gases and quality of the material are key to unlocking this circular route for refrigeration foam.

Use of these products in new industry and stakeholder related construction projects such as new or refitted retail stores, distribution centres, office spaces, etc brings this once hazardous foam waste back into service, unlocking further value across construction related initiatives such as BREEAM (Building Research Establishment Environmental Assessment Method).

7. Summary

There are many avenues to support CO_2 reduction throughout the waste journey. By employing all of the above steps and measures stakeholders are able to take better control of the full waste journey. This allows them to maximise the benefits to the environment and to business operations. Circular economy is achievable now due to the new processes created for the management of hazardous foam, changing this from a single use hazardous material set for incineration or landfill, into a reuseable material heading back into the construction of new spaces, greatly reducing its carbon impact, and extending its use. Shortening the metal waste chain adds greater value by improving the traceability through a less convoluted process. This guarantees one single movement of metal scrap to an electric arc furnace, and for data surrounding the CO_2 reduction thus supporting organisations and their environmental pledges.

Aspect	CO_2 Saving
Diverting Foam From Incineration	Average 2.2 tonnes of CO_2 -eq
Diverting Metal into Electric Arc Furnace	Average 1.6 tonnes of CO_2 -eq

Greater still is the consolidation of all measures in one place providing maximum value at a single point.

Sustain were awarded the 2024 “Beyond Refrigeration Environmental Award” for the development of a complete process with the best outcome for the Refrigeration Industry at its heart. Reducing the impact the industry’s waste has on the environment, and ensuring zero to landfill. This process allows the industry and its stakeholders to regain control and unlock reliable and trackable CO_2 emissions savings for all end-of-life equipment through their processes.

The recycling facility in Earls Barton, Northamptonshire is powered by 100% renewable electricity. The facility has been purposely upgraded to achieve optimum efficiencies for processes. All plant, machinery and specialist equipment is 100% electric, the onsite forklift fleet is also 100% electric. These actions are all playing their part in the reduction of carbon emissions for the refrigeration sector.

About the author

With over 20 years of experience across the Commercial Equipment & Refrigeration Industries, James Warburton has worked as Customer, Manufacturer and Contractor. James is now working with the Recycling side of the industry, bringing together knowledge and experience to provide greater solutions to end-of-life equipment. Helping the industry take control of their waste journey and reduce its environmental impact, while tracking the green benefits this brings.

References

1. https://www.gov.uk/dispose-hazardous-waste

2. https://www.gov.uk/guidance/waste-environmental-permits