



Guidance for Owners and Operators of Refrigerated Cold Storage Facilities



Transport Industrial Commercial Refrigeration
moving businesses towards net zero

TICR - Transport, Industrial and Commercial Refrigeration

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This **Guidance for Owners and Operators** aims to provide sector specific advice on how to reduce emissions and support businesses in achieving net zero refrigeration.

The Transport Industrial Commercial Refrigeration Project (TICR) was launched in 2022 as part of the UK's national commitment to reach net zero emissions by 2050 and to gain a better understanding of all sources of emissions and tackle hard to abate areas. Refrigeration is increasingly being recognised as a significant, yet often overlooked, consumer of energy. The aim of this project, therefore, was to quantify the potential for emissions reductions and to answer some key questions:

- What are the current refrigeration energy demands and emissions across this sector?
- How is demand for cooling and subsequent emissions likely to increase?
- What are the market drivers and what environmental factors are having an impact?
- What are the most promising innovations to reduce energy use?
What is the abatement potential of different types of technologies?
- What measures would help end users and practitioners to deliver net zero?
- How could policy and innovation be part of the solution to decarbonising refrigeration?

The recommendations in this publication form are drawn from Roadmaps and Technical Appendices published by the Department for Energy and Net Zero. Read together, these documents, not only support the intelligent use of cooling equipment by owners seeking to improve the efficiency of equipment they operate, but also policy makers in working together towards net zero emissions.

Policy context

The following national and international policies are relevant to the need to work together to achieve net zero refrigeration.

- [Global Cooling Pledge](#)
- [UK National Cooling Outlook](#)
- [National Adaptation Programme and Climate Change Risk Assessment](#)
- [UNFCCC Global Cooling 5-year Stocktake as discussed at COP meetings](#)
- [BEIS Cooling in the UK 2021](#)
- [GB F-gas Regulations](#)

Authors and acknowledgements

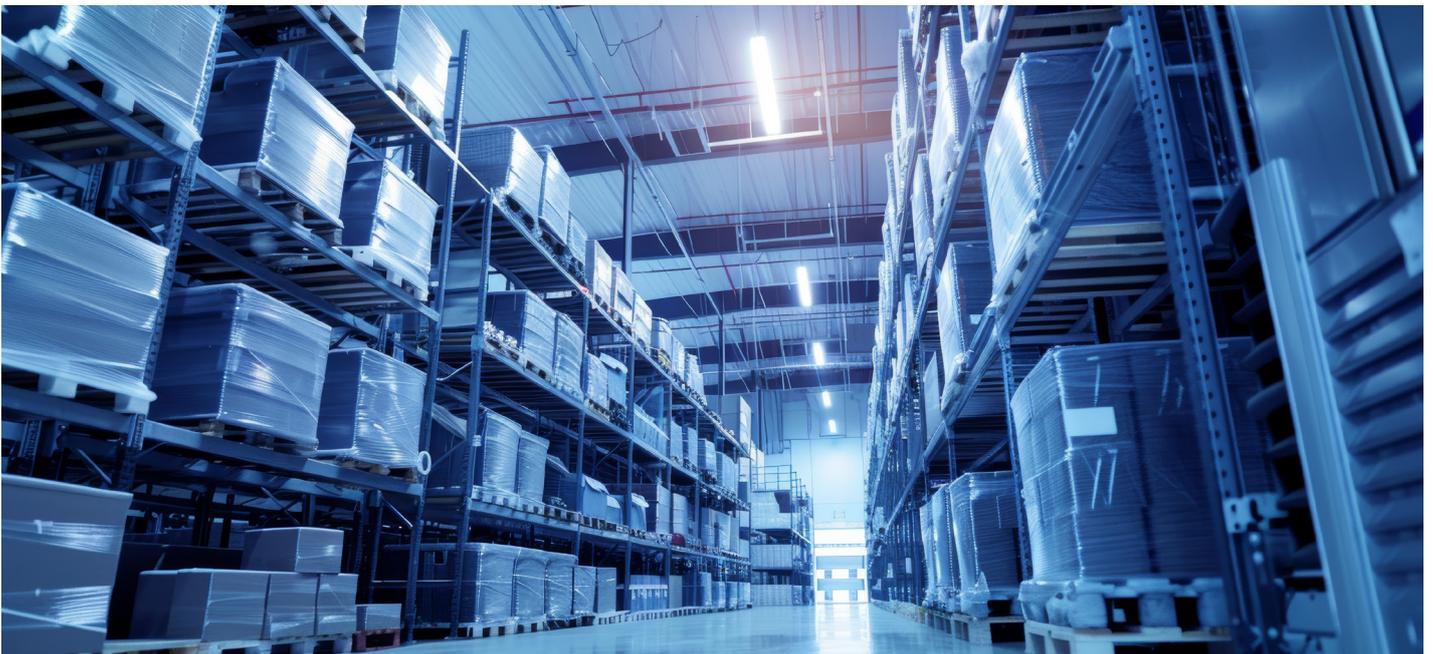
The TICR project was led by London South Bank University and includes the Institute of Refrigeration, Star Technical Solutions, Carbon Limiting Technologies, Carbon3IT and the University of Birmingham as partners in the consortium. The project acknowledges support from the UK Department for Energy Security and Net Zero, contract reference number FM21297.

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1. Summary

This guide has been developed based on the findings of site surveys carried out on a range of refrigeration equipment by experts during 2023/4. It also takes into account work undertaken by the project to evaluate the sector emissions, technology options and industry best practices. Further details are published in the [TICR Roadmap](#).

Emissions profile

Cold stores are mainly used for the food and drink industries, but are also used for other applications. The cold storage sector covered in this roadmap focus on large industrial cold storage facilities and large refrigerated distribution warehouses and a minimum floor area of 100 m² has been applied. However, the learnings from this research applies to all cold stores.

The sector was found to account for at least 0.73% of electricity consumption (DESNZ, 2024) and 0.2% of GHG emissions in the UK (DESNZ, 2025) in 2023. In a business as usual scenario, where grid carbon intensity remains the same and refrigeration energy use is affected by population growth and climate change, the energy consumption related to refrigeration use for cold storage refrigeration would grow 20% from 2.32 to 2.78 TWh from 2023 to 2050, with GHG emissions growing by 18% from 0.77 to 0.91 MtCO₂e in the same period. These figures do not include wider energy use or emissions. Please refer to the TICR Technical Annexes published by DESNZ for further details

The cold storage sector is likely to undergo significant changes in the future due to economic pressures and the effects of climate change. These challenges can potentially be mitigated by trends supporting decarbonisation, such as automation, increased use of renewable energy, demand-side response, and waste heat recovery.

Reduction opportunities

The TICR project found significant opportunities for reducing energy use and emissions from refrigeration in cold stores. The site surveys indicated that there are opportunities to improve refrigeration systems efficiency. If maintenance and operations are optimised, heat infiltration is reduced and the set point from frozen storage is raised by 3 K, energy consumption could be reduced by 48% when compared to a do-nothing, BAU scenario for 2050. This would result in a 72.5% reduction of Scope 2 emissions, which would also be tackled through the decarbonisation of the electricity grid. A wider uptake of PV and waste heat recovery by cold stores could also help to alleviate pressure on the grid. In terms of scope 1 emissions (refrigerant emissions), cold stores are already transitioning to ultra-low GWP alternatives, such as Ammonia. Compliance with EU F-Gas regulations would reduce Scope 1 emissions by more than 99% to 0.01 MtCO₂e in 2050 when compared to the do-nothing, BAU scenario, as indicated in the HFC Outlook model.

Recommendations

The following recommendations are detailed in this guide:

1. Prioritise Efficiency
2. Address the Information Gap
3. Get to Know your Assets
4. Take a Systems Approach
5. Start Thinking Long Term
6. Make Informed Investment Decisions
7. Work Together – People and Practices
8. Monitor Legislation, Regulation and Standards Frameworks

Further detailed guidance is provided on emissions trends, sector best practice, technology options, benchmarking tools and policy options and opportunities.

There is much that owners and operators can do to reduce current and future emissions. The steps recommended do not necessarily require significant financial investments or substantial legislative changes. The critical thread running through all the project findings is the importance of accessing and evaluating information that is often easily available about your refrigeration equipment. This is essential for owners and operators to understand how equipment is operating and measure its performance against how it should operate. If you do not have that knowledge, you need to work with a suitable expert to manage and plan accordingly.



2. Emissions and Sector Profile

Cold storage is a fundamental component of the cold chain, and the sector has been significantly impacted by rising energy prices since 2021. Conversely, recent years have seen increased adoption of renewable energy, with at least 25% of cold stores in the UK now equipped with local solar PV generation. Strategies such as demand-side response offer immediate payback, and digital twins can be employed to detect deviations in refrigeration system performance from optimal conditions. Raising the frozen food storage temperature to -15°C can reduce energy consumption and lower carbon emissions; however, further research is required to ensure food quality is not compromised.

Scope and sector size

The UK frozen food industry is estimated to be worth more than £8 billion and the chilled food industry more than £11 billion according to the Cold Chain Federation (CCF). In addition, the UK cold chain directly employs over 100,000 people, including warehouse operatives, drivers, systems analysts and engineers. The total number of cold stores in the Great Britain and Northern Ireland, has been estimated to be 440. These are members of the CCF, and account for a total volume for cold storage of 84,494 million m³, at an average size of 95,693 m³. In addition there are many more smaller cold stores.

The cold store industry faces challenges in recruiting, retaining, and upskilling staff, partly due to limited awareness of available roles. As automation and AI become more common, new skills are needed for technologies like robotic handling and smart inventory systems. Sustainability goals also demand enhanced skills, especially in energy management. To ensure energy-efficient systems, all stakeholders, from end users to designers and technicians, must be trained to design, operate, and maintain systems effectively, requiring significant investment in workforce development.

Trends

Climate Change

Cold stores as part of the cold chain may be more resilient to periods of extreme heat and thus provide a refuge for temperature sensitive products during periods of high temperatures. Nevertheless, future cold stores need to be designed to cope with higher ambient temperatures and there is a need to build resilience into existing cold stores by reducing condensing temperatures, infiltration and better controls.

Rising Costs

Rising electricity prices have made energy reduction increasingly important. Economic challenges, including inflation and high interest rates, have raised maintenance, equipment, and labour costs while limiting investment.

Renewable Energy

It is estimated by the Cold Store Federation that 25% of those participating in the Climate Change Agreement now using solar panels. Cold store roofs are well-suited for solar PV systems due to their size. These facilities have high energy consumption, particularly for refrigeration, making them prime candidates for offsetting electricity costs with solar power.

Grid Balancing

Cold stores can also help balance the electricity grid through demand side response, reducing power use during peak times by switching non-essential equipment off to cut carbon emissions.

Waste Heat Recovery

Recovering waste heat from refrigeration systems can improve energy efficiency and reduce costs, especially in new facilities. It is feasible to reclaim heat to produce hot water or to heat office areas associated with the cold store. Heat recovery can also be used for frost heave prevention.

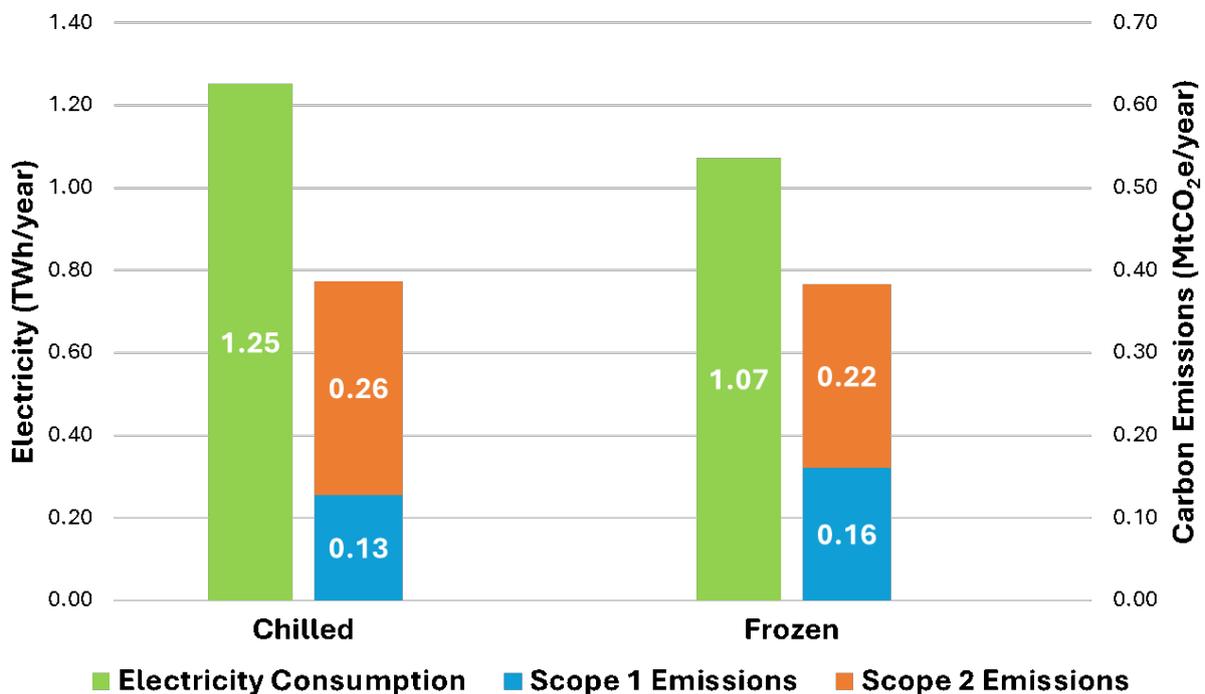
Emission Trends

Cold storage facilities emit greenhouse gases both directly, through leaks of high-GWP refrigerants, and indirectly, via electricity consumption. While larger facilities often use Ammonia, a zero-GWP refrigerant, many medium and smaller cold stores still rely on HFCs. As part of the TICR project, a baseline figure for emissions from the cold storage refrigeration sector has been calculated.

To estimate Scope 2 emissions from cold storage facilities, two primary data sources were utilized: the Valuation Office Agency (VOA) database and the EU-funded CryoHub project. Combined, the final dataset comprised 607 cold stores with a total estimated volume of 57.6 million m³. A review of existing literature confirmed a strong correlation between refrigerated volume and energy consumption in cold storage facilities.

Scope 1 emissions from cold stores have been estimated using the HFC model which uses average industry data on refrigeration systems and refrigerant types. The calculated annual energy consumption and GHG emissions for cold stores in 2023 is detailed below and it has been separated into frozen and chilled storage and Scope 1 and 2 values.

Figure 1: Annual energy consumption and GHG emissions (Scope 1 and 2) values for cold stores



Cold Store Refrigeration Equipment

Most cold store refrigeration systems use the vapour compression cycle, with a mix of refrigerants. According to the 2026 CCF report, 45% of large cold stores use ammonia refrigerant (R717), 9% use CO₂ (R744) and the remaining 42% still use HFC / HFO refrigerants .

Types of system generally include:

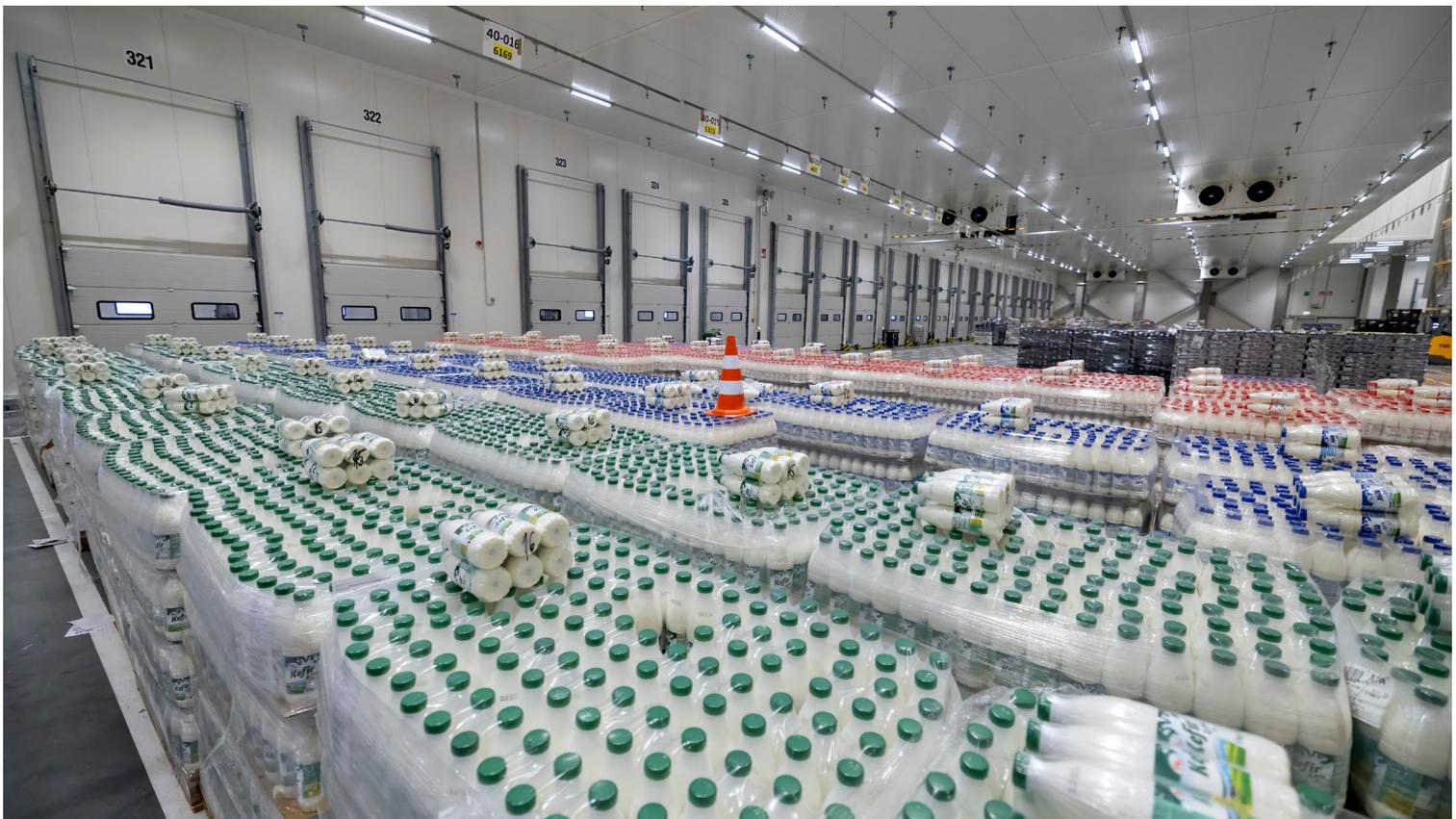
(a) Direct expansion (DX): The compressor sends hot refrigerant vapour to a condenser, where it is cooled into liquid and collected in a high-pressure receiver. This liquid flows to expansion valves at each evaporator, which regulate refrigerant entry. Vapour returns to the compressor, typically via a suction separator that removes liquid and oil.

(b) Pumped overfeed systems: The compressor draws vapour from a low-pressure surge vessel, compresses it, and sends it to the condenser. The condensed liquid goes through an expansion device back to the surge vessel, where the level is maintained by a float. Liquid is then pumped to one or more evaporators.

(c) Pumpless overfeed systems: The compressor pulls vapour from a low-pressure receiver (LPR), compresses it, and sends it to a condenser. The condensed liquid passes through a sub-cooler in the LPR and then through an expansion device to the evaporators—no liquid pumps are used.

(d) Gravity fed flooded systems: Compressed vapour goes to the condenser, then liquid refrigerant flows through an expansion device into a low-pressure receiver. From there, it moves by thermosiphon to the evaporators. Large pipes allow vapour to rise and return to the compressor.

(e) Cascade systems: Use two separate refrigerant loops - commonly low-temperature R744 for cold rooms and high-temperature R717 for heat rejection. R744 can serve chill store evaporators directly without a compressor or expansion valve.



3. Refrigeration Best Practice

This section describes the outcomes from 11 site surveys of cold stores that were carried out as part of the TICR project. The aim of these site surveys was to understand how cold storage refrigeration systems are currently being operated and identify actions that could be taken to achieve best practice. The 11 sites visited surveyed fall into three main cohorts: (a) frozen stores, including two high-rise (35 m) rack clad buildings with either internal or external insulated envelopes, (b) chilled stores and (c) multiple temperature facilities combining frozen and chilled areas.

Detailed results from the site surveys can be found in the TICR Technical Annex C and this section provides a summary of key findings.

Operations and maintenance

The key findings across the surveyed cold stores are summarised below:

- Insulated envelopes were generally in good condition, with fast-acting doors reducing air infiltration. However, some chill stores experienced significant air leakage at loading dock doors due to large gaps around trailers. Inflatable curtains could mitigate this issue.
- Several sites had newly installed refrigeration systems that were not optimally designed or operated, resulting in inefficiencies of 30–35%. This was linked to a lack of understanding of energy-efficient system design and a skills gap among designers and technicians.
- Only three sites had proactive refrigeration optimisation systems (e.g. digital twin comparison), operating efficiently. The remaining eight used around 20% more electricity than necessary.
- Sub-metering of refrigeration systems was limited, and where installed, was often underutilised due to insufficient data analysis capabilities.
- All sites had refrigeration monitoring and control systems, but these were not configured to optimise energy use, particularly in fan speed control and condensing temperature management.
- System inefficiencies were attributed to elevated condensing temperatures, suboptimal suction pressures, and unnecessary operation of air heat exchanger fans.
- Climate Change Agreement participation varied, with some sites failing to meet targets. Energy savings and Climate Change Levy (CCL) reductions were not consistently reinvested in efficiency improvements.
- Awareness and compliance with F-gas regulations among site owners was generally low.
- Onsite renewable energy use: four sites had solar panels installed, which supplied up to 30% of electricity demand.
- A lack of in-house refrigeration expertise was evident, with maintenance contractors prioritising system reliability over energy efficiency.

Overall, there are significant opportunities to reduce carbon emissions and energy consumption in cold storage refrigeration.

Opportunities

F-gas logs should be maintained and kept on site and used to identify opportunities to reduce leakage and improve system performance.

Refrigeration electricity use submetering and monitoring

Using evaporator fans and fan speed controls

Condenser head pressure control (including condenser fan speed control)

Optimisation of air-curtains

Use of inflatable flexible seals to bridge gap between transport vehicles and loading bay doors.

Training and Skills

The UK is experiencing skills shortages in all technical and engineering fields however training and qualifications are available through apprenticeships, T-Levels and industry or manufacturer's training. Training is particularly valuable for those with technician, design and specification drafting responsibilities, as well as for owners and operators responsible for managing or purchasing refrigeration systems and equipment.

The UK market is regulated by the existing F-gas regulation that requires certification of personnel in the handling of fluorinated gases via a short course. There is currently no mandatory training required for any of the low GWP alternative refrigerants such as ammonia or CO₂ which are currently widely used in manufacturing. There is no national database of trained persons, although there are databases of registered companies. Owners and operators must make sure that they use only registered certified companies and certified individuals to carry out work on their systems.

However the 2024 [EU F-Gas regulation](#) does include certification for low GWP alternatives and regular reassessment. This would be welcomed by the UK industry to drive up competency and ensure a sustainable transition to low GWP refrigerants.

Best Practice

1. **Reduce air infiltration** through doors
2. **Reduce refrigerant leakage** with regular leak testing
3. **Ensure F-Gas logs are maintained** and available on site
4. **Regularly clean condenser** to avoid fouling
5. **Reducing condensing temperature and adjusting suction pressure upwards** where feasible
6. **Review your cold store set points** to avoid over cooling
7. **Sub-meter energy use** of refrigeration system
8. **Pro-active refrigeration optimisation** by assessing performance against a digital twin
9. **Integration of renewable energy (PV on roofs and waste heat recovery).**

4. Evaluation Of Currently Available Technologies

The aim of the tables below is to compare different innovations and their potential benefits in terms of reducing the energy consumption for industrial manufacturing refrigeration systems, serving as an important tool for designers, specifiers and owners. More details of 17 different technologies evaluated is available in the TICR IndustrialTechnical appendix. Below only the top 10 technologies (in terms of emissions savings potential, payback period and applicability ie how widely it is use) are shown, including a Technology Readiness Level out of 10.

Technologies for energy and / or emissions saving potential

No.	Technology	Description	% System energy or Scope 2 CO2e savings	Payback (years)
1	Demand side response	Changing electricity use profiles: stopping evaporator fans or refrigeration system. Using renewable energy and reducing the cooling during peak hours.	12% (green grid only); 24% (when combined with onsite PV)	Immediate
2	Temperature set point	3K increase in freezer set point temperature from -18°C to -15°C.	10%	Immediate
3	Inflatable flexible seals	Inflatable seals allow more flexibility to cover varying gaps due to different vehicle sizes. Energy reduction from infiltration by up 50-70% (estimated in TICR surveys). Infiltration assumed to contribute 32% of total heat load.	Up to 28.2%	2.5
4	Condenser head pressure / fan speed control	For many air-cooled systems there is scope to reduce the condenser head pressure. Can also use VFDs on larger evaporative condenser fans and cooling towers in conjunction with floating head pressure control.	5-12% head pressure control; 3% fan speed control	<1
5	Evaporator fans and fan speed controls	Electronically commutated (EC) motor fans have high operating efficiencies and can modulate output speed from 10 to 100%, in accordance with load.	6.6% (or 8.5% if product chilling or freezing undertaken)	1.3
6	Renewable energy (solar PV)	The cold stores total roof area available for installation of solar panels was assumed to be 75%. PV panels can produce energy for the seasonal peak and energy required for the whole annum in the range between 40 and 60%. Can increase further with batteries. Can use both on-site and off-site solar PV.	Significantly lowers grid electricity but doesn't reduce overall system energy use	13.7 (without financial support)
7	Stacking patterns	Stacking patterns of vented boxes on a pallet determine the airflow rate through the pallet. This will determine the cooling rate and uniformity of cooling / storage. Consider the size, dimensions and alignment of vent holes in the stack, to create pathways for the airflow to remove the heat from the food.	High (if use blast freezer)	Unknown
8	Automation	Reduced personnel; faster loading/unloading and stacking of products; smaller access doors and faster opening/closing; reduced aisle space; greater stacking density; use of greater height; reduced lighting; reduced equipment heat loads.	High	3 - 5
9	Compressor controls	Includes variable speed drive (VSD), (variable frequency drive VFD), or variable capacity control (VCC). Compressors used are reciprocating, screw, scroll, rotating vane, centrifugal. For large scale cold stores, usually reciprocating or screw compressors.	5.9 - 15.8% reciprocating compressors; 9.9% for VSD/VCC; 2 - 5.9% by staging multi compressor systems	No information
10	Defrost on demand	Adjust defrost frequency to be less frequent during low demand periods. Or use frost sensors measuring frost build-up directly.	3%	<3

Most promising innovations

Overall, the greatest energy and emissions saving opportunities were not necessarily innovation based or requiring significant investment in new equipment.

The most promising innovations for reducing refrigeration energy use are increasing freezer set point temperature from -18 to -15°C, using inflatable flexible seals to bridge the gap between transport vehicles and loading bays and condenser head pressure and fan speed control. The impacts of these measures were quantified and included as a scenario in the decarbonisation pathways for cold stores.

Three degrees set point change

Freezing is essential for extending the shelf life of perishable foods while preserving quality and preventing waste. However, maintaining frozen conditions across the cold chain is energy intensive. Recent industry discussions, supported by the Three Degrees of Change report have explored the potential energy savings from raising the standard temperature set-point for frozen storage from -18 to -15°C. The report estimates that a 3 K increase could yield energy savings of approximately 10% for frozen storage operations. The TCR modelling considered that the potential reduction of 10% for frozen cold storage would be applicable to all frozen cold stores and the impact of the 3 K change on the annual energy consumption for refrigeration in the UK cold storage sector would be of 5%. While food safety would remain unaffected, potential impacts on food quality require further investigation. The proposed change could also contribute to broader reductions in energy use and emissions across the cold chain.



5. Recommendations for Owners and Operators

About these recommendations

What follows below is a list of evidence-based recommendations for strategies that will help owners and operators achieve net zero refrigeration and to improve the efficiency and reliability of their refrigeration operations. It includes check lists for action. Each check list is not designed to be exhaustive because we recognise that each site is different. However, it provides a suggested starting point for the minimum action needed to develop individual refrigerant management strategies. This is backed up with relevant examples drawn from the findings of surveys that underpin the recommendations to illustrate why the recommendation is important.

1. Prioritise efficiency

Assign responsibility for refrigeration efficiency, proactively improve performance by maintenance, monitoring existing performance, evaluating it and implementing energy reduction opportunities. It is not enough just to keep your cooling systems operating you need a programme of management and monitoring of energy use supported by planned preventative maintenance to maintain and improve performance.

Recommended actions:

- Review and revise current maintenance policies.
- Record, monitor and report information about performance and changes in performance.
- Appoint a refrigeration expert with a remit to identify energy saving opportunities.
- A refrigeration optimisation system based on digital twin should be installed to ensure continued operating efficiencies.

Example: Maintenance was not focused on energy efficiency. The operator was not even aware that their refrigeration systems were not optimised.

2. Address the information gap

Start measuring and monitor the energy use of your cooling systems.

For most operators there is a substantial information gap. Owners and operators are not well informed about the best way to operate the system, when or how it should be updated or adjusted as their needs change. Energy is not sub-metered so owners/operators do not know how much the systems cost to run and what are the impact of these changes. Records such as F-Gas must be made easily available as well as historical performance records to see the impact of changes over time and evaluate the operation and future life of systems.

Recommended actions:

- Install sub-metering and monitoring systems.
- Set data reporting and key performance indicators
- Ensure this activity is managed by a member of staff with both energy and refrigeration knowledge.

Example: Only a small number of the surveyed sites had functioning sub-metering. Even then, energy data on these sites were not accessible to refrigeration technician in a usable format.

3. Know your assets

Understand what refrigeration systems you have on sites, how they are designed to operate and what refrigerant they contain. Efficiency and reliability are interlinked, when you have access to good information you can make good business decisions to predict and prevent breakdown, identify which assets are coming to end of life, and plan effective refurbishment or replacement programme to fit with your business operations. Robust management and reporting systems are essential to this to review, reset and recommission.

Recommended actions

- Build and maintain an asset register.
- Collect system operating parameter data including energy and refrigerant leakage.
- Review and reevaluate current operation of systems against how they were planned/designed to ensure they are still fit for purpose.

Example: Setpoints on equipment were not set to the design documentation. Compressor settings were not adjusted correctly and so even greater efficiencies could have been achieved if settings were set correctly.

4. Take a systemic approach

Integrate your needs and the technologies available to minimise energy use. With an increasing range of different refrigerant and technology solutions available, owners and operators need to consider how these will impact whole system performance to achieve potential energy savings. The cooling needs of your business should not be considered in isolation. There are often opportunities to integrate heating and cooling in manufacturing processes, to reuse waste heat internally or with nearby businesses by connecting to heat networks, to use “free cooling” and reduced demand as well as employing alternative energy sources such as solar panels on factory roofs, etc.

This systems’ approach also relates to how expert teams operate within your organisations. There needs to be a closer working relationship between customer, specifier consultant, designer and those responsible for installing, commissioning, maintaining and servicing. So that those maintaining or servicing equipment understand how it was designed to operate and what can be done if your refrigeration needs or design conditions have changed. Refrigeration equipment should be seen as part of the building or process system, not a separate unit.



Recommended actions

- Establish multi professional project teams.
- Work closely with all those involved in your system design and operation.
- Evaluate potential savings to be gained from retrofit technologies.
- Evaluate potential savings to be gained from new technologies and whether they are suitable for the applications.
- Consult reliable sources of information on performance eg Enhanced Capital Allowances (ECA), Energy Technology List (ETL), TICR Roadmap and Guidance.

Example: Rejecting heat outside was the norm whilst at the same time other parts of the facility were being heated with gas and electricity. Sites were literally throwing useable waste heat away where heat recovery was viable.

5. Think long term

Make plans for end-of-life replacement of existing equipment. Businesses need to have plans in place for minor and major retrofits as well as end of life replacement or anticipated changes in your refrigeration needs in the future. A careful evaluation by experts is needed to ensure that when any change is undertaken there is also a review of opportunities to improve performance. In some cases making a change to an existing system may be the most environmentally friendly option, in others, for example if systems are using older type refrigerants, it may be necessary to completely replace with a new equipment. Replacing like for like is not usually an option – look for ways to optimise performance.

Recommended actions

- Consult the TICR Roadmaps for guidance on planning a long-term strategy for moving towards net zero refrigeration.
- Evaluate options using the TICR Roadmap to help evaluate potential savings from new technologies, suitability of their application (eg new systems or retrofit) by sector.
- Maintain an asset log with planned replacement or retrofit strategy.

Example: The latest high energy efficiency refrigeration systems were not general employed. These stores will have a legacy of many years of energy hungry refrigeration systems.

6. Make informed decisions

The cooling systems installed today are going to have to meet the demands for the next 20 years. Purchasing must be made on an informed basis to achieve long term reduction in energy use if businesses are going to move towards net zero. Purchasing, whether for a new system, replacement of existing equipment or maintenance contracts need to prioritise not just first cost and payback period but, additional factors such as efficiency of operation, flexibility of assets, repairability, reliability, energy reduction, sustainability, and circular economy.

Purchase of new equipment is an investment in the future of the business. It should be linked to overall net zero business plans by involving cooling expertise, that can identify refrigeration technology available to meet current and future needs, using resources such as the TICR Roadmap. The risk to businesses is sub optimally performing, costly and stranded assets that will not support business changing needs and growth – as well as compromising net zero objectives.

With an increasing range of different refrigerant solutions, new technology options need to be evaluated and effectively implemented or incentivised to achieve potential energy savings. This will necessitate a closer working relationship between customer, specifier consultant, designer and those responsible for installing, commissioning, maintaining and servicing.

Recommended actions:

- Include refrigeration experts in your purchasing team.
- Have purchasing policies that require best available practices and technologies such as using ETL listed products, highest EcoDesign category, ATP for refrigerated vehicles, proactive maintenance contract that report on energy use and identify energy saving opportunities.
- Consult the TICR Roadmaps for guidance on planning for NetZero.

Example: An expert in refrigeration energy efficiency should be involved in the purchasing decisions for new refrigeration equipment, and they should have access to information about equipment efficiency and performance.

7. Work together - people and processes

Collaborative practices between customer and everyone responsible for system design, installation, commissioning, maintenance and repair. People, consistency, responsibility, co-ordination with all parties involved whether external designer, commissioner, installer, service and planned preventative maintenance which are often different people. This also applies to non-technical roles and teams – those with responsibility for energy use, sustainability or financial policies need to have access to refrigeration expertise. Access free training or continued professional development activities for those responsible for managing refrigeration systems through trade associations, professional bodies and organisations supporting energy efficiency in the refrigeration industry.

Recommended actions;

- Specify that new refrigeration project teams must include refrigeration experts from the outset, including in developing specification for tender, monitoring installation and checking operation after commissioning.
- Even if you are using a different company to install or maintain, those responsible for the original specification should be included in reviewing operation data.
- Make use of TICR Training resources and webinars as well as its resources pages on the TICR website.

Example: Condenser and gas coolers were poorly located in several sites resulting in air recirculation. It was clear that the architects and the refrigeration design team have missed an opportunity to save energy by not working collaboratively.

8. Monitor legislation, regulation and standards frameworks

Ensuring compliance will help you to achieve efficiency.

There is an ever-growing range of obligations and requirements related to energy efficiency, environment and safety. These are often interlinked so ensuring that your business is complying with regulations and legislation is not only a legal requirement. It is good business practice to manage your refrigeration assets. Businesses can actively contribute to reviewing and improving legislation and standards through trade associations, professional bodies and other government forum. Trade magazines and online newsletters provide updates and summaries.

Recommended actions:

- ❑ Ensure you are a member of your relevant trade association to keep up to date with changes eg British Refrigeration Association, Cold Chain Federation, Chilled Food Association, British Frozen Food Federation, Food and Drink Federation, Datacentre Trade Association.
- ❑ Participate in external meetings to ensure you are up to date with latest legislative developments and standards.
- ❑ Employ individuals who are members of a relevant professional engineering bodies such as Institute of Refrigeration.
- ❑ These bodies can also make nominations to Standards Committees through the BSI so that you can contribute to future standards development.

Example: Maintenance contractors were working to the practices specified by the client and this resulted in different maintenance approaches and plant operating efficiencies across the estate. Consistency could have easily been achieved by consulting industry best practice recommendations.



6. Decarbonisation Pathways

The impact of potential future decarbonisation pathways for industrial refrigeration systems for the cold storage sector are explored below.

The trends considered in the modelling were:

1. Impact of market growth
2. Impact of climate change
3. Improved operation and maintenance
4. A 3 degrees C set point change for frozen cold stores
5. Reduced heat infiltration
5. Integration of renewables via solar energy and waste heat recovery
6. Impact of using low GWP refrigerants

As part of the TICR project, modelling has been carried out to assess how these trends may impact refrigeration in the sector in terms of its energy consumption and carbon emissions (scope 1 and 2). The Figures below show the refrigeration emissions and energy reduction potential by 2050. Using findings of the site surveys carried out, the energy saving technologies identified and the sector energy and emissions baseline described in the TICR roadmap, the potential cold store decarbonisation pathways have been estimated in the waterfall diagrams below. These have been developed by gathering and normalising energy use data from a variety of published sources, validated against data obtained from the site investigations carried out by the TICR project during 2023-2024. More details of the methods are provided in the Cold Store Technical Appendix C.

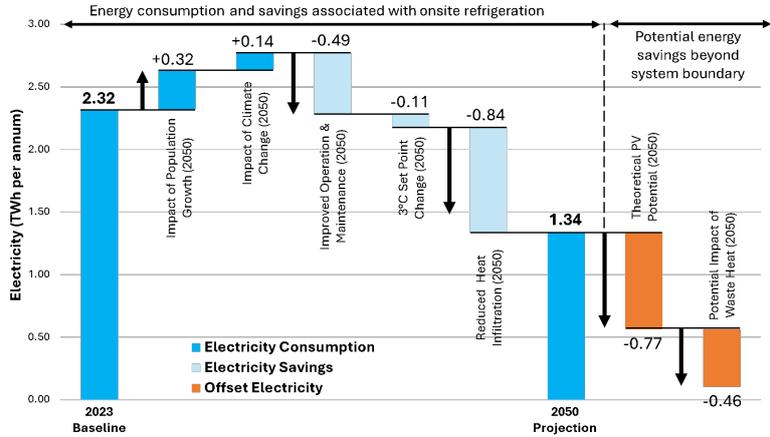


Figure 2: Projected refrigeration energy use in 2050 for cold storage refrigeration and estimated impact of different trends (source: TICR Roadmap)

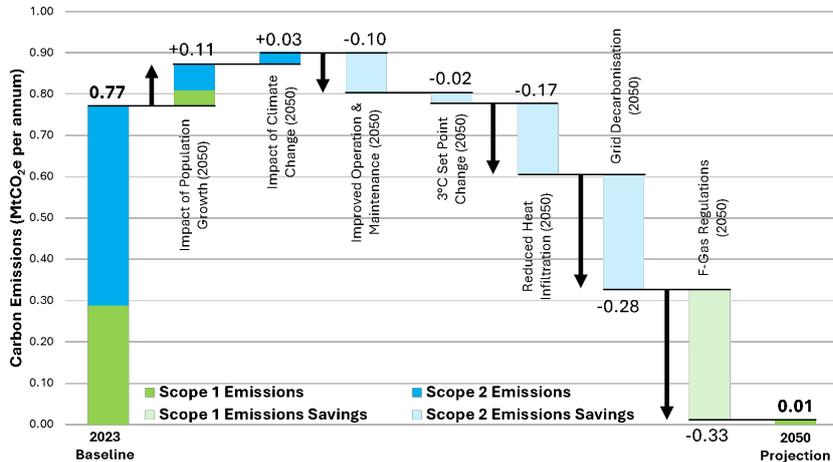


Figure 3: Projection of carbon emissions in 2050 for cold storage refrigeration, and estimated impacts of different trends (source: TICR Roadmap)

7. TICR Benchmarking Survey

The aim of benchmarking is to help identify poor, average, good, best and aspirational practice in the industrial refrigeration sector. TICR has developed a self-assessment approach to assist with this benchmarking.

Qualitative benchmarking

This approach allows you to benchmark your own practices and policies against sector specific recommendations detailed in this report. The questions cover best practice and opportunities for improving refrigeration system energy management, as identified through research and actual site surveys.

This provides a method for business owners, energy managers and in-house engineers to benchmark their business against the key recommendations of the project. You are encouraged to use the tool as many times as you need either for your complete estate or for individual systems to help you to improve your benchmark score.

As well as providing a final score based on your answers to the questions in the survey the tool will provide you with useful guidance and sources of further information that you can use to help reduce energy, reduce emissions and work towards your net zero refrigeration targets.

How to complete the survey

You will find a link on the www.netzerorefrigeration.uk website.

Before you start this survey, you should consult a copy of your most recent F-Gas logs, site or system energy use data, if available, and energy audit inspection reports. If you do not have access to this information, you can still complete the survey, but this will affect your results. You can complete this survey for a single site or for your overall estate - whichever data is more readily available to you.

Using the survey results

You will receive a score (Gold, Silver, Bronze or nil) at the end of the survey that you can use to benchmark the approach to refrigeration against best practices in the sector identified by the TICR project. This benchmark will also allow you to evaluate the impact of any changes in the future. Your results will include details of how you scored against each question which will help you identify areas for improvement and create an action plan.



8. Areas for Further Action

The TICR project has identified the following five key areas that support the decarbonisation of refrigeration systems. These areas that are outside of the direct control of the sector are interlinked and can accelerate industry transition to net zero emissions through the measures described below. For full details of these and supporting policy opportunities, see the [TICR Roadmaps](#).

1. Support for education and skills

Underpinning the decarbonisation of the sector is having the right people and skills to achieve the best cooling solution. This encompasses the shortage of people particularly in design roles, lack of availability of training and qualifications, and lack of awareness of operators. Intelligent users are needed to ensure that best available solutions are put in place. Improving the supply of qualified people requires national level support for training, minimum standards of competency to address shortage of provision and lack of qualifications.

2. Refrigerant policy

Legislation will affect the choice of refrigerant available in future and will have the greatest impact on which refrigerants are used on which equipment. Future legislation can be expected to further reduce direct emissions from leakage and restrict in which equipment higher GWP refrigerants can be used. There will be a cost and safety impact associated with moving to natural refrigerants due to the design/optimisation required as these refrigerants have higher flammability (hydrocarbons), higher pressure (CO₂) or toxicity (Ammonia). A shortage of skilled designers to ensure new refrigerants are used safely will be a barrier. Minimum standards for training and leak checking with mandatory registration are needed.

3. Data and benchmarking

Reliable data collection is a key missing factor in current legislation aimed at reducing GHG emissions, enhancing energy efficiency, and compliance with safety and environmental standards. Data plays a crucial role in enabling better decision-making, providing clarity on where focus and intervention are most needed and supporting the development of effective benchmarks. Without accurate data, owners, operators, and policymakers lack the ability to measure or monitor current emissions, estimate future trends or identify suitable benchmarks.

4. Technology incentives

Purchasers need to have reliable guidance to make intelligent investment decisions, and many sites extend or adapt existing equipment thus failing to capitalise on opportunities of new technologies. As UK ambient temperature change owners and operators need to be directed to technologies that will assist them in both adaptation and mitigation. This applies to schemes such as the Energy Technology List; Energy Savings Opportunity Scheme; Streamlined Energy and Carbon Reporting Scheme; NABERS UK actual in-use energy performance.

5. Sector specific innovation

Targeted capital investment support schemes to provide subsidies for investment in specific innovation. Business innovation funds to encourage start-up innovators of low carbon technologies identified by TICR Roadmaps. There are key research gaps in areas such as the impact of climate change and extreme heat on refrigeration systems failure; impact of raising frozen food set point by 3 K throughout the whole UK cold chain; quantifying energy, emissions and decarbonisation pathways for UK convenience stores; predict changing consumer preferences.

9. Relevant Policies and Incentives

National regulatory frameworks play the most significant role in shaping owners and operators' choices regarding equipment selection, while also determining the approach and direction of future transitions.

Refrigeration is important to the UK. It cuts across many Government departments and functions (DESNZ, DEFRA, DfT, DSIT, DfE, Institute for Apprenticeships and Technical Education, Local Government planning, Environment Agency and CCC) and collaborative, multi-level whole-of-government approach is essential to ensure the right scale of action across infrastructure sectors. The importance of refrigeration is not just in terms of its essential contribution to various business functions, but also to critical national priorities including energy use, net zero, and climate change adaptation and mitigation.

The most relevant national policy areas that were identified by the project that can be used to support decarbonisation are shown opposite. It is critical that owners and operators contribute to Government consultations and monitor changes to these policies to ensure that they continue to support future decarbonisation strategies and activity for the sector.

Climate Change Agreement a voluntary agreement between the UK government and energy-intensive industries that incentivises energy efficiency improvements and reduce carbon emissions by offering reduced rates on the Climate Change Levy (CCL).

Energy Savings Opportunities Scheme (ESOS) energy audits in buildings, processes and transport.

Fluorinated Greenhouse Gases Regulation regulates the use of certain refrigerants, including leak checking, recording and rectifying and training for refrigerant handling.

Enhanced Capital Allowance scheme provides first year tax allowances on investment in qualifying plant and machinery.

Energy Technology List assists businesses in making more energy efficient choices through testing against robust criteria with an updated list of products.

Innovate UK and EPSRC provide funding for research to support industry and academic partnerships



10. References

This guide was produced for the Transport Industrial and Commercial Refrigeration (net zero) project by the Institute of Refrigeration.

For additional documents, guides and technical materials see www.netzerorefrigeration.uk/resources

TICR Roadmap and Technical Appendices are referenced throughout. These are published by the Department for Business Energy and Net Zero and available from: www.gov.uk/desnz

Cold Chain Federation <https://www.coldchainfederation.org.uk/>
<https://www.coldchainfederation.org.uk/publications/>

Cold Chain Federation Energy Efficiency in a Cold Store: <https://www.coldchainfederation.org.uk/energy>

International Institute of Refrigeration “Three Degrees of Change. Frozen Food in a resilient and sustainable food system”
<https://iifiir.org/en/fridoc/three-degrees-of-change-frozen-food-in-a-resilient-and-sustainable-147847>



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