Department of Energy

Energy efficiency guidance for the food & beverage sector

Introducing energy savings opportunities in refrigeration

UK Government

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Refrigeration

The F&B industry is one of the largest users of refrigeration. For many businesses within the sector the provision of chilling and freezing services will account for >50% of electricity consumption and costs.

Technology overview:

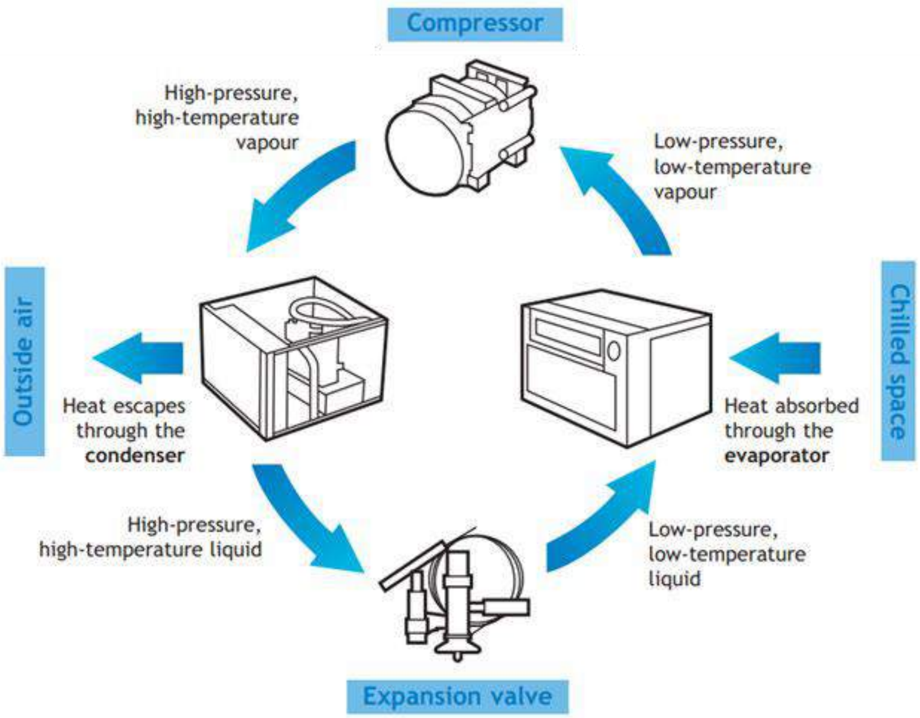
While applications and systems vary, the most common means of providing the refrigeration effect is the vapour- compression cycle.

The vapour-compression cycle is a closed-loop system wherein a refrigerant (or coolant) is used to extract heat from a product, thus cooling it. The extracted heat is then discharged to another area.

Heat is absorbed from the chilled space into a liquid (the refrigerant) by the evaporator. This heat turns the refrigerant into a low-pressure gas that flows away from the evaporator to the compressor where it is pressurised.

In the condenser, the gas gives up its stored heat (releasing it to the outside air) and condenses back to a liquid. It then flows through an expansion valve where pressure is released cooling the liquid and the sequence then begins all over again. The compressor also pumps liquid and gas around the system. Usually the condenser, expansion valve and compressor are outside the refrigerated space.

In small refrigeration applications such as stand-alone chilled display cabinets, fridges and freezers, all the components are commonly integrated into the housing of the unit. In larger systems, these components are often located in a central plant room or enclosure remote from the evaporator and cooled space.



Energy saving opportunities in refrigeration:

For organisations that operate cooled storerooms for bulk storage of frozen or chilled products, energy for refrigeration can represent a significant cost, often in excess of 50% of the total energy bill. Good housekeeping measures in cooled storerooms do not require special skills or training and can realise a substantial reduction in running costs.

Introduce a good maintenance programme

Refrigeration systems are at their most efficient when they are well maintained. Blocked, dirty and leaking components lead to increased energy demand, raising costs for the business.

- Establish a programme of regular checks to ensure that equipment is in good working order and that any problems are pointed out to the maintenance contractor.
- Identify scaling and ice-build up on evaporator fins.
- Check evaporators and condensers for damaged vent fins, which make it more difficult to transfer heat.
- Check that bleed/drip pipes are not iced up.

Check for leaks

Most large refrigeration systems have sight glasses where the refrigerant can be seen. If bubbles can be seen in the refrigerant when the system is in a stable operation, it usually indicates that there is a refrigerant leak in the system. As refrigerant levels drop, the system will operate less efficiently, reducing the cooling level.

The most common areas for leaks are joints, seals and other mechanical valves. However, the whole system, including the pipework, should regularly be inspected for leaks.

Many common refrigerants are powerful greenhouse gases. For instance, 1kg of the refrigerant R134a has a global warming potential 1,300 times greater than that of 1kg of CO2. So, one small failure in managing leakage could negate any environmental benefit of savings in CO2 through energy efficiency.

It is illegal to knowingly vent refrigerants. So, as soon as a leak becomes apparent, take action to find and repair it before recharging the system with refrigerant.

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Ensure correct temperatures are set

Food and beverage manufacturers often keep their cooled storerooms at lower temperatures than required due to worries about equipment failure.

Overcooling is expensive and does not improve the preservation of the product. In addition overcooling increases the probability of equipment failure by increasing the duty on the refrigeration plant.

Always ensure that the temperature setting satisfies the product storage requirements.

> *An increase in the frozen food store temperature from -25°C to -20°C saves 10 – 15% of the refrigeration energy.*

The following table provides indicative temperatures for storing various food products based on the temperature codes as defined in the European Union. Country-specific codes will have to be referred for each country.

Temperature code	Product temperature	Suitable for
L1	Below -15°C	Ice cream and frozen foods
L2	Below -12°C	Frozen foods
M0	Between -1° & 4°C	Poultry & meat
M1	Between -1° & 5°C	Meat & dairy products
M2	Between -1° & 7°C	Processed meat & dairy products
H1	Between -1° & 10°C	Produce & canned & bottled drinks
H2	Between -1° & 10°C	Canned & bottled drinks

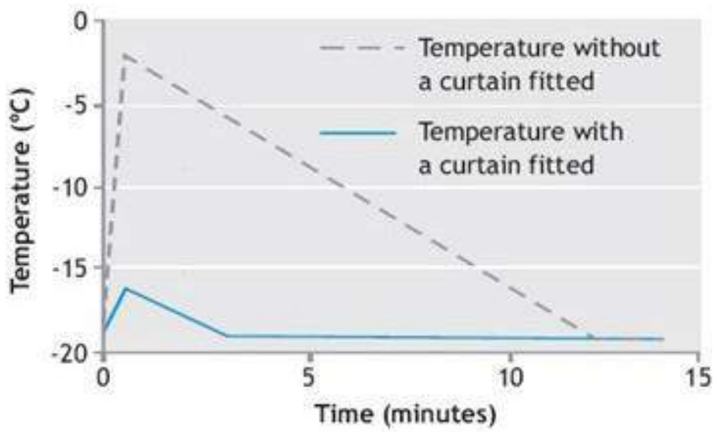
Minimise air changes

Air changes in cooled storerooms can account for up to 30% of the total heat load as cool air escapes and warm air enters. This can be minimised by ensuring that doors remain closed as much as possible. Consider fitting self-closing doors if possible.

Ice build-up on storeroom floors and walls is a good indication that a high level of air change is taking place. Where doors are used regularly, install a strip curtain to prevent cool air escaping from the storeroom. Ensure that the curtains are well fitted and in good condition. Replace damaged strips as required.

The graph below reflects the benefits of having curtainsfitted:

- Lower temperature change
- Quicker restoration of set cold storeroom temperature



Check that insulation is adequate

Ensure that pipe insulation is in a good condition. Condensation, frosting or ice on pipe insulation is a clear indication it has failed and needs replacing.

Plan loads

To ensure that refrigeration systems are used in the most efficient way, pre-plan production and storage needs. For example, if there are a number of cold storage areas, it is more efficient to have one of them on full-load, rather than two on part-load.

Equally, overstocking the cooled area will reduce the cold airflow around the products, reducing the performance and efficiency of the refrigeration system.

Minimise internal heat gain

Lighting and evaporator fans add heat to the cooled space making the refrigeration system work harder.

Ensure that internal lights in refrigerated spaces are LED and automated.

Change evaporator fan motors to electronic commutated (EC) low power fans.

Before introducing product to a chilled space allow it to cool to ambient temperature where possible.

> *Projects aimed at minimising internal heat gain in refrigerated spaces can payback in <3 years.*

Keep condensers clean and cool

Condensers are used to reject waste heat from the refrigerant. When these become blocked or fouled, the temperature increases. Ensure that there is ample flow of ambient over the heat exchange surfaces – remove any obstruction.

Grilles should be kept free of debris or dirt – clean regularly, also consider shading condensers from direct sunlight.

> *A 1^{0}C rise in condenser temperature increases running costs by 2-4%.*

Optimise evaporator performance

Ice will build up overtime over the evaporator causing the refrigeration system to work harder as it seeks to compensate for the drop in evaporator efficiency. Regular defrosting is essential to maintain optimised performance.

Most systems are fitted with automatic defrost so check that this is functioning as expected. If icing is a problem, consider defrost on- demand which initiates defrost when required rather than by timer function.

> *A 1^{0}C drop in evaporating temperature can increase running costs by 2-4 %.*

Checklist and tips for efficient operation of refrigeration systems

This checklist summarises the key criteria and characteristics of energy efficient refrigeration systems. If you are unable to indicate “YES” to all questions, it is likely that the efficiency of your system could be improved, saving you money and reducing your carbon emissions.

Checklist and tips

Ref	Best practice criteria	Response	Feedback
1	**Are the correct set point temperatures being used based on system duty/ requirements?**	[yes]/[no]	Refrigerated food must be stored at the correct temperature. Overcooling is expensive and does not improve the preservation of the product. Setting the refrigeration temperature 1°C higher than required will increase running costs by 2-4%. Payback is immediate
2	**Has every effort been made to minimise the ingress of warm air to the refrigerated spaces?**	[yes]/[no]	The ingress of warm air will significantly increase the demand made of the refrigeration system. Keep doors closed and seals in good condition. Utilise rapid closing curtain doors and strip curtains where appropriate. Regular maintenance to ensure the integrity of door seals, etc. could reduce the refrigeration load by as much 11%. Payback is immediate.
3	**Has the heat load within the refrigerated space been minimised?**	[yes]/[no]	The heat from evaporator fans and lighting can contribute 10-15% to the refrigeration load. Consider utilising electronically commutated low power fans alternatives on condensers and LED alternatives for chilled space lighting. Both projects will payback in under 3 years.
4	**Are the condensers kept as cool as possible and regularly cleaned?**	[yes]/[no]	Condensers should be kept clean and free of debris or dirt. Ensure an unrestricted flow of air over the surfaces and consider solar shading if required. A 1°C rise in condenser temperature will increase running costs by 2-4%. Payback is immediate.
5	**Are the evaporator surfaces free from ice?**	[yes]/[no]	Ice build-up on the evaporator surfaces will cause the refrigeration system to work harder as it compensates for the reduction in evaporator efficiency. If icing is a problem, consider defrost-on-demand which initiates defrost when required rather than by timer function. A 1°C drop in evaporator temperature will reduce running costs by 2-4%. Ensuring defrost is effective will have an immediate payback.
6	**Is the pipe insulation regularly checked for staining or ice?**	[yes]/[no]	Condensate or ice on pipe insulation indicates that the insulation has failed. Pipework should be checked for leaks/corrosion and that sufficient insulation is in place around pipes and the refrigerated space. A 1°C rise in refrigerant temperature to evaporator will increase running costs by 2-4%. Typically, insulation improvements will pay for itself in 3-5 years.
7	**Does the refrigeration system utilise Liquid Pressure Amplification (LPA)?**	[yes]/[no]	LPA involves fitting a pump to provide the pressure stability more efficiently than the compressor. Minimum compressor rating of 100kW. Up to 25% savings over compressor only system with payback < 1 year.

Checklist and tips

8	**Does the system utilise electronic expansion valves with feedback control?**	[yes]/[no]	Electronic Expansion Valves allow for a real time adjustment in refrigerant flow rate based on feed back control from the refrigerated space and can quickly respond to changes in demand. Typically payback of < 1.5 years.
9	**Does the system utilise heat recovery?**	[yes]/[no]	High grade heat comes from de-superheating the refrigerant before the condenser using a heat exchanger. Typically temperatures between 60 – 90°C are achieved. This heat is typically used to produce general use hot water and to meet CiP demand. Savings of up to 30% of the full cooling load can be recovered giving a project payback < 2.5 years.
10	**Do your current chillers use HFCs or HFOs as refrigerants?**	[yes]/[no]	With the level of uncertainty surrounding the long-term use and market availability of both HFCs and HFOs the use of the zero GWP refrigerant ammonia (R117) is a natural replacement choice. While ammonia chillers have high capital costs this additional expense over the purchase of high GWP alternatives wold be recouped in 3 years.
11	**Are you operating a 15+ year old chiller?**	[yes]/[no]	With the Coefficient of Performance (CoP) of chillers having increased dramatically over the past 20 years it has become very economical to upgrade chiller plant rather than replace completely. Replacing piston compressors with modern screw type will increase CoP by 30-40%, paying back in <2 years, efficiently and significantly extended the useful life of the plant.