How to reduce your heat load (existing large systems)

Reducing the heat load on your existing large refrigeration systems can save energy and cut your running costs. It can also reduce the capital cost of a new plant and even eliminate the need to invest in a new plant altogether.

This guide is aimed at users of existing large refrigeration systems such as those in supermarkets, central air conditioning systems, large cold stores and large industrial processes. It will help you to minimise your cooling needs and to meet them as efficiently as possible using the most suitable refrigeration system. Both of these will result in energy savings.

Before you start any refrigeration energy efficiency initiative it is vital to review the heat loads on your cooling plant. If you understand the nature of your loads you can make sure they are met while at the same time minimising the energy cost of your refrigeration systems.

The business case

There are opportunities to reduce the heat load on refrigeration systems at almost all sites. Savings and costs will vary depending on the type of opportunity. Often payback periods are less than one year, and sometimes even no-cost heat load reductions are possible.

If you are planning to install a new plant, reducing its heat load could reduce the capital cost. If your existing refrigeration system currently struggles to supply enough cooling, reducing the heat load on your system could avoid the need for an expensive new plant altogether.

The technology

Heat loads can be split into process and non-process heat loads (the latter are often referred to as parasitic loads). *Figure 1* illustrates some common examples of each.

Figure 1 *Common heat loads*

Heat load type	Comments
Process loads	Examples include process water cooling, product/process cooling, blast chilling, blast freezing.
Non-process or parasitic loads	In cooled spaces such as chill or cold stores, the non-process heat loads are due to evaporator fans, lights, defrost, air infiltration through doors and gaps and heat transfer through insulation. In systems with a secondary refrigerant such as chilled water, glycol or brine, non-process heat loads include circulation pumps and distribution heat gains.

Opportunities to reduce the heat load on your refrigeration system typically fall into four general categories.

Category 1: Process free cooling. In some processes there is a simultaneous need to heat something up and cool something else down. A double saving is possible if you can use a heat exchanger to link two such streams and pass heat from the hot stream to the cold one. In this way you save both heating energy and cooling energy.

One example of process cooling is a regenerative pasteuriser. In the milk pasteuriser shown in *Figure 1*, hot milk at 72°C is fed through a plate heat exchanger in counter-flow to cold milk at 4°C. The incoming cold milk is heated to 58°C and the outgoing milk is cooled to 18°C. These temperatures depend on the number of plates in this regenerative section of the pasteuriser.

The dairy site in this example had several milk pasteurisers. By adding extra plates to the regenerative section of the equipment, the site's owners halved both the heating and cooling requirement. The energy cost savings gave a payback period of around one year. This had a significant extra benefit for the site, as it was short of capacity for a new pasteuriser and was considering a £300,000 investment in new refrigeration plant. By investing only £30,000 in modifications to existing pasteurisers they avoided the need for the expensive new plant.

Figure 2 *Process cooling using regenerative pasteuriser*

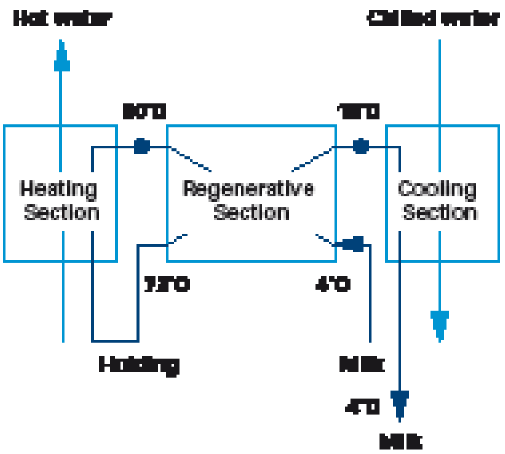


Diagram taken from *Guide 5, Energy Efficiency – Site Guidance* produced by the Food & Drink Industry Refrigeration Efficiency Initiative. Some modifications have been made.

Category 2: Ambient free cooling. Pre-cooling a product using 'free cooling' before using a refrigeration system is a common opportunity to reduce energy use. For example, a cooked product at 100°C should not go straight into a chiller or blast freezer. You should cool the product as much as possible using an 'ambient stream' first. This might be air ducted from outside the factory or water from a cooling tower, as shown in *Figure 2*.

Figure 3 *Example of ambient free cooling*

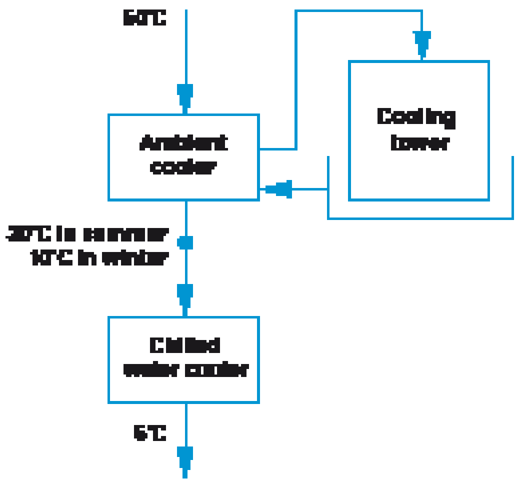
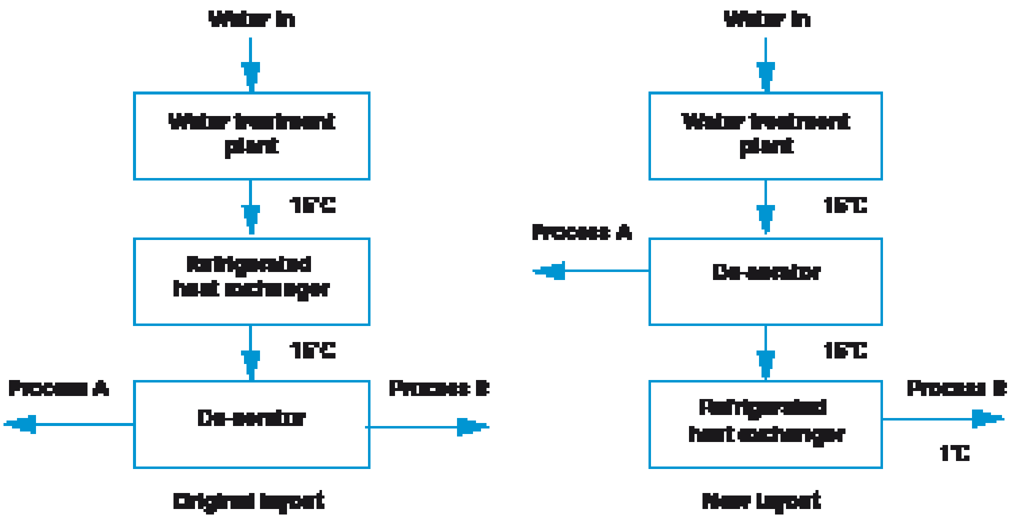


Diagram taken from Guide 5, Energy Efficiency - Site Guidance, produced by the Food & Drink Industry Refrigeration Efficiency Initiative.

Category 3: Reduction/removal of unnecessary process heat loads. Process streams are sometimes cooled unnecessarily, or a single cooling stream, such as chilled water, might be used for two different purposes, one of which requires a much lower temperature than the other.

In our example a site required de-aerated water for two processes. Mains water was treated, cooled to 1°C and then de-aerated before supplying the two processes as the original layout in *Figure 4* shows. About half the de-aerated water went to each process, but only process B needed it to be so cold – the other process worked adequately with water at 15°C. As shown in the new layout, by repositioning the de-aerator, it was possible to halve the heat load on the refrigeration system.

Figure 4 *Water treatment and cooling layouts*



Category 4: Reduction of non-process heat loads.
Heat loads which are not the result of a 'core process' are often referred to as parasitic loads. In cooled spaces, parasitic loads include the heat generated by pumps, fans and lights, as well as heat infiltration through insulation or open doors. In many cases you can take simple steps to reduce the impact. Examples include:

- switching off equipment in cooled spaces when not in use
- installing variable speed drives to improve pump and fan control
- improving lighting control using occupancy sensors
- improving door management
- fitting strip curtains or automatic doors to chill and cold stores.

For auxiliary equipment such as fans, pumps and lights, the actions will also result in direct energy savings.

As well as reducing the amount of cooling you undertake, you can also make significant energy savings by making sure that each load is cooled efficiently. Where a large central plant serves several cooling loads, it must operate at a temperature low enough to cool the coldest load. This 'lowest common denominator' load may well be much colder than some of the other loads on the system, meaning that the central plant is then inefficient at meeting the warmer loads. Ideally, they should be moved to another system operating at a higher temperature.

A common example involves the same refrigeration system being used for a very cold load, such as a cold store held at -25°C, and an adjacent warmer load, such as a chill room at +5°C. The energy used to cool the +5°C chill room could be halved if a dedicated refrigeration system operating at a higher temperature were used.

A less obvious problem is when a single load is cooled through a large temperature range. It may be more efficient to split the heat load, using two separate refrigeration systems for the top and bottom parts of the temperature range. If the heat load is small then the extra complexity is probably not justified, but if it is a large process load then such a change could deliver significant savings and be cost effective.

Looking for heat load opportunities

Figure 5 lists the heat loads in a fictitious frozen meals factory. For each example, the table shows the peak cooling duty, temperature range and load variations (daily and seasonal).

Figure 5 Example of heat loads at a frozen food factory

Load	Peak duty (kW)	Temperature range (°C)	Load variability	
			Seasonal	Daily
a) Process loads				
Process water	100	20 to 4	5 to 4 in winter	8 hours/day
Sauce cooling	200	70 to 5	None	12 hours/day
Blast freezer	500	50 to -20	None	20 hours/day
b) Finished product cold store loads (held at -20°C)				
Insulation	50	-20	Ambient related	24 hours/day
Evaporator fans	50	-20	None	24 hours/day
Lights	20	-20	None	24 hours/day
Defrost	25	-20	None	4 hours/day
Door air infiltration	50	-20	Ambient related	24 hours/day
c) Raw materials chill store loads (held at +4°C)				
Insulation	20	4	Ambient related	24 hours/day
Evaporator fans	15	4	None	24 hours/day
Lights	10	4	None	24 hours/day
Defrost	10	4	None	2 hours/day
Door air infiltration	15	4	Ambient related	24 hours/day

In this example, the following opportunities might exist:

- The sauce cooling load is a prime candidate for ambient free cooling.
- Half the process water is only needed at ambient temperature. It doesn't need to be cooled first.
- The blast freezer product load could be reduced in two steps by using ambient air free cooling followed by a blast chilling stage, before putting the product into the blast freezer.
- The evaporator fans in both the cold store and chill store run continuously. Using variable speed drives and/or an on-off control strategy could remove a significant parasitic heat load. Using high efficiency fan motors will save electricity directly and also indirectly as they produce less heat to be absorbed by the refrigeration system.
- The door infiltration loads could be reduced by better door management. This would also have a useful knock-on effect of reducing the need for defrost.
- The defrost loads could be reduced by using a 'defrost-on-demand' control system.

Opportunities checklist

Almost all sites will have opportunities to reduce the heat load on their refrigeration systems. So a good starting point is to list all your cooling requirements and then identify the key characteristics of these loads. To simplify things, split the list into process loads and other non-process loads. For each heat load you should collect data on the peak cooling duty, temperature range and load variations (daily and seasonal). You'll also need to know which refrigeration plant supplies the cooling for each load.

Once you've collated the information on the loads on your refrigeration systems, consider how you might be able to reduce each of them.

Figure 6 *Heat load opportunities checklist*

Considerations	Comments
Is there is a process stream that needs heating and could be used to cool another process stream?	The process stream which needs heating must be capable of providing enough cooling for the savings to be worthwhile. To take advantage of process free cooling, the heating and cooling requirements usually need to occur at the same time and be close enough to each other to be practical.
Could ambient air, borehole water, cooling tower water or even mains water be used to provide some or all of the cooling?	Ambient air can sometimes be used in the winter, backed up by a refrigeration system for use during warmer weather. Water from a cooling tower can be about 5°C in cold winter conditions and 25°C on a hot summer day. Borehole water is typically about 10°C. The resulting warm water could be used elsewhere to reduce heating costs.
Is the process temperature lower than necessary?	Many chill and cold stores are kept too cold. Turning the temperature setting up by just 1°C could reduce the heat load by up to six per cent. Sometimes you can increase a final process temperature without affecting the product.
Could you switch off the cooling to some users when not in use?	You might be able to switch off the cooling in a chill, cold store or production area when not in use. You could remove product from a blast chiller or freezer as soon as it is at the required temperature and switch off.
Could you reduce the running hours of any equipment in the cooled space?	Most equipment emits heat when on. You might be able to reduce running hours by improving control or simply manually switching off when not in use.
Could you reduce the running hours of any fans in the cooled space?	You might be able to introduce thermostatic control of evaporator fans or switch off air handling fans when the cooled area is not in use.
Do the evaporator fans need to run continuously?	You could replace the fan motors with more energy efficient ones. This will reduce the motor's energy consumption and the heat lost by it to the cooled space.
Could you install variable speed controls for the evaporator fans?	You may be able to reduce the evaporator fan speed when less cooling is required, e.g. at night or the weekend.

Could you install more efficient lighting in the cooled space?	By using high efficiency, low power lighting you can cut the electricity used by the lights as well as the heat load.
Could you improve the control of any lighting in the cooled space?	Make sure that lights are switched off when not required. You could control lights using a time-clock, a door switch or an occupancy sensor.
Could you reduce the running times of any secondary refrigerant pumps, or install variable speed controls?	You can cut any heat gain due to the pump by minimising its running hours and reducing its speed. This will also reduce the electricity used by the pump.
Could you improve the level of insulation of the distribution system?	When using a secondary refrigerant such as chilled water, you can reduce heat gain by improving the pipework insulation.
Is there evidence of ice build-up on the ceiling, walls or the floor of your cold store?	This suggests that a high level of air change is taking place and significant savings will result from reducing the warm air ingress through the door.
Could door management of your chill or cold store be improved?	Doors should be kept shut whenever possible. Improving door management will reduce the heat load at no cost.
Do you have a chill or cold store with a door that needs to be frequently open?	If so, then consider fitting a strip curtain to the doorway. An insulated strip curtain may be cost effective for a cold store. Consider whether automating the door would significantly reduce the time it is open.
Is a defrost-on-demand control system used?	If not, then installing one will make sure that the defrost system only operates for as long as it takes to control the build up of ice on evaporators.
Do any of the heat loads involve cooling over a large temperature range?	Splitting the heat load between two systems may be more energy efficient. You may be able to use free cooling for part of the load.
Is there significant variation in the temperature of the heat loads on the same refrigeration system?	You should consider splitting the heat loads between two or more refrigeration systems to match their temperature levels.
Do any of your refrigeration systems struggle at times of high production or warm weather?	You might be able to avoid the cost of a new plant or of increasing the cooling capacity of the existing plant by reducing your current heat loads.
Are you planning to install any new refrigeration systems to replace existing ones?	Cutting heat loads on existing systems could reduce the capital cost of new replacement plant.

Further information on reducing heat loads can be found in *Guide 5, Energy Efficiency – Site Guidance* produced by the Food & Drink Industry Refrigeration Efficiency Initiative which is available from www.ior.org.uk.

If you need help to identify the opportunities to reduce the heat load on your refrigeration system please call us on 0800 085 2005 for further advice. You can obtain a list of accredited consultants from the Energy Institute or the Institute of Refrigeration can supply a list of members who specialise in providing technical advice.

Finding a contractor

You may be able to reduce the heat load on your refrigeration systems by making changes in-house. Alternatively, you may need a refrigeration contractor to implement them for you.

Work on refrigeration systems should always be done by a reputable, suitably qualified refrigeration contractor. You may already know a suitable contractor. If not, you can contact a recognised trade association, such as the British Refrigeration Association or the Institute of Refrigeration, for advice.

Institute of Refrigeration

020 8647 7033
www.ior.org.uk

British Refrigeration Association (BRA)

0118 940 3416
www.feta.co.uk

Energy Institute

020 7467 7100
www.energyinst.org

Some refrigeration equipment comes under the Government's Enhanced Capital Allowances scheme. Guides on refrigeration equipment eligible for Enhanced Capital Allowances are available from the Carbon Trust website, www.carbontrust.co.uk. You can see a list of ECA approved suppliers at www.eca.gov.uk

See the Carbon Trust website at www.carbontrust.co.uk/refrigeration for further information to help you make your refrigeration more energy efficient.