Sector Focus

Dairy Processing

	Sector	GWh/y
1	Retail display	9,233
2	Catering – kitchen refrigeration	4,380
3	Transport	4,822
4	Frozen storage – generic	900
5	Blast chilling – (hot) ready meals, pies	425
6	Blast freezing – (hot) prepared products	316
7	Dairy processing – milk/cheese	250
8	Milk cooling – raw milk on farm	207
9	Potato storage – bulk raw potatoes	165
10	Primary chilling – meat carcasses	129

Mean estimated annual UK usage

Technology

Modern large-scale milk processing plants prevail in industrialized countries. The daily processing capacity per plant usually exceeds 100 tonne of milk intake but even smaller plants with a daily intake of about 30 tonne are generally equipped with modern machinery. Their specific energy requirements are similar to those of large-scale factories though usually slightly higher since they do not benefit from the effects of scale.

Energy used in sector

Refrigeration plays a very significant role in the overall energy requirements of a modern milk plant, often constituting above 40 percent of the total electric power consumption. In the specific energy consumption estimates, data concerning refrigeration are presented separately: (a) as total energy equivalent (heat removed from the product during processing and from the air in cold stores) and (b) electric power consumption by refrigeration machinery.

It has been estimated that cooling accounts for 19% of the energy used on milk and cheese processing in a dairy and as much as 66% of that used in butter production.

There is a wide range in use in different countries cooling/refrigeration of fluid-milk plants stated to use 0.2 MJ/kg in the Netherlands compared with 0.008 MJ/kg in Canada. This represents 19% and 2% respectively of the total energy consumed.

Cheese factory

Refrigerated systems in dairy processing establishments in the UK are estimated to use 250 GWh of energy per year.

Options for energy saving

- Keeping the condensing temperature as low as possible and the evaporation temperature as high as possible is one way to improve the efficiency of the compressor.

- To reduce the condensing temperature a) Ensure that the condenser is the correct size. A condenser that is too small for the refrigeration system may mean a small initial outlay, but running costs may be greatly increased by the need for a larger compressor. A condenser that is oversized, however, can sub-cool the refrigerant and affect the function of the expansion value. B) Allow the condensing temperature to float with low ambient temperatures in winter.
- To increase the evaporating temperature. A) Ensure that the evaporator is the correct size. B) Do not set thermostats in cold rooms and freezers lower than necessary. In some cases this may not be possible, due to production and humidity requirements; however, be sure not to overcool more than is required. C) Keep the evaporator clean and defrost when necessary, especially when cooling air to below 0°C, as ice can build up on the coil. D) Hot gas from the outlet of the compressor can be used to defrost freezers, but control must be accurate. The defrost water may then be used elsewhere in the plant.
- Match the compressor with the load. If a compressor is oversized it will operate at only partial load, and the energy efficiency may be reduced. A sequencing or capacity control system to match the compressor with the load could help to improve efficiency. The control system must be sophisticated enough to ensure that the load is properly shared. Some compressors are more efficient than others at part load, depending on the method of capacity control, and it is best to check with the manufacturer for a profile of efficiencies at varying loads.
- Leakages of refrigerant can reduce a system's efficiency by 40% and should be kept to less than 2% of the annual charge. You can calculate your approximate leakage rate from the amount of refrigerant you use to top up the system.
- A process study by a Nestlé ice-cream processing plant found that the compressors were operating when there was no load, there was a large number of start-ups, and the suction temperature of 12°C into the compressors was far above the design temperature of 3°C due to incorrect valve selection. The minimum condenser pressure was also being maintained at around 1000 kPa over the winter months. The plant improved the valve selection by upgrading the control system to correct the suction gas temperature, enabling the compressor to operate at a higher loading and minimize stopping. The condenser pressure was also modified to 750 kPa. Compressor start-ups were reduced by 92% and the run hours by 22%. There was a 20% overall reduction in maintenance costs for the refrigeration plant.
- Up to 10% of power consumption in refrigeration plants can be from heat ingress through doorways. It is important to encourage operators to observe good practice and keep doors closed. If this is not effective, consider automatic door closure (e.g. rapid roller doors or alarm systems). Plastic strip curtains or swinging doors are useful for frequently opened areas.
- High efficiency components such as compressors, heat exchangers, fans and lighting can reduce energy by up to 20%.
- Improving performance of the refrigeration system through liquid

pressure amplification, suction pressure optimisation, evaporative condensers and checking to ensure no leakage of refrigerant can produce energy savings of up to 30%.

- Consider reclaiming heat from refrigeration plant for heating water or space heating.
- Consider reclaiming heat from refrigeration plant for low temperature thawing, tempering, drying or smoking processes.
- Sensors and timers can be used to ensure lights are used only when necessary. Variable-speed drives, coupled with a programmable controller, can cycle fans off during low load times.

Energy saving potential of future technologies

A number of technologies are under development for use in the near future. Some of the most promising include:

- Absorption chillers allow cooling to be produced from heat sources such as fossil fuels, incinerated garbage, biofuels, low-grade steam, hot water, exhaust gas or even solar energy, generally using a lithium bromide and water refrigerant. While the COSP of absorption refrigeration is relatively low compared with compression refrigeration (1 kW of refrigeration for 1 kW of energy), absorption chillers can utilise a waste heat source, thus emitting less greenhouse gases than conventional vapour compression refrigeration systems.
- Greater use of renewable energy sources such as solar electricity (PV), solar thermal, wind energy, biomass, geothermal heating and cooling.
- Greater system integration by use of heat pumps, Combined Heat and Power (CHP) and Trigeneration.

The refrigeration energy requirement in a modern milk processing plant is dependent on the product being produced. It ranges from 40 KWh/t for UHT milk to 70 KWh/t for cheese.

Specific energy requirement in modern milk processing plants

Type of service	**Unit**	**Requirement-including CIP for one ton of milk processed into:**								
		Liquid products in bottles		**Liquid products in one-way containers**		**Skim milk powder and butter**	**Full cream milk powder**	**Ripened cheeses**		**Evaporated and condensed milk**
		pasteurized	**sterilized**	**pasteurized**	**UHT**			**Without whey processing**	**with whey processing**	
Net requirement										
Steam	kg/t	250	300	100	150	880	830	190	700	440
Refrigeration total energy equivalent	kWh/t	50	40	50	40	60	45	70	70	45
Refrigeration electric power requirement	kWh/t	20	16	20	16	24	18	28	28	18
Heating	kWh/t	165	200	70	100	585	530	125	460	295
Electric power (total requirement)	kWh/t	55	70	50	90	90	80	75	100	60
TOTAL NET REQUIREMENT	kWh/t	220	270	120	190	675	610	200	560	355
Gross energy										

requirement										
For heating (furnace fuel)	kWh/t	205	250	90	125	730	660	155	575	370
For electric power generator fuel)	kWh/t	195	250	180	315	315	280	265	350	210
TOTAL GROSS REQUIREMENT	kWh/t	400	500	270	440	1,045	940	420	925	580
% of energy in steam in total requirement	%	75	74	58	53	87	84	63	82	83
% of energy in furnace fuel in total gross requirement	%	51	50	33	28	70	70	37	62	64

Fostering the Development of Technologies and Practices to Reduce the Energy Inputs into the Refrigeration of Food

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For further information on saving energy see: www.grimsby.ac.uk/What-We-Offer/DEFRA-Energy