IMPEL PROJECT: “*ENERGY EFFICIENCY IN PERMITTING AND INSPECTION*”, EXCHANGE OF EXPERIENCES ON HOW THE ISSUES OF ENERGY EFFICIENCY AND REDUCTION OF GREENHOUSE GASES ARE DEALT WITH IN PERMIT PROCEDURES AND INSPECTIONS IN THE MEMBER STATES – DEVELOPMENT OF A TEMPLATE FOR DOCUMENTS AND DATA REQUIRED REGARDING ENERGY EFFICIENCY IN THE PERMIT APPLICATION (2011/2012)

FOOD, DRINK AND MILK INDUSTRIES

SUMMARY OF ENERGY-RELATED INFORMATION FOR THE FOOD, DRINK AND MILK INDUSTRIES AND PROPOSAL FOR THE SECTOR SPECIFIC ANNEX TO THE DRAFT APPLICATION FORM FOR ENERGY EFFICIENCY

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1 Summary of Energy-related Information – Food, Drink and Milk

In the following, energy (efficiency)-related information has been extracted from the **Reference Document on Best Available Techniques in the Food, Drink and Milk Industries (FDM BREF; August 2006)** as well as from an **expert presentation (energy-related information for the dairy sector)**. The collected information serves as a basis for the development of a proposal for the sector specific supplements to the Draft Application form for Energy Efficiency in Chapter 2.

1.1 Food, Drink and Milk Industry

The most significant environmental issues associated with FDM installations are water consumption and contamination, energy consumption and waste minimisation. The FDM sector is dependent on energy for processing as well as for maintaining freshness and ensuring food safety.

The driving forces which result in improved environmental performance are changing. For example, traditionally maximising the utilisation of materials has had the consequence of reducing waste. An approach more directly associated with protection of the environment is now emerging, although this challenges the sector, e.g. with respect to reducing water and energy consumption and the use of packaging, while maintaining hygiene standards.

In general the food safety may have an influence on environmental considerations. For instance, food safety and hygiene requirements may affect the requirements for water use to clean the equipment and the installation, making it necessary to use hot water, so there are also energy considerations. Likewise, waste water is contaminated by substances used for hygiene purposes, for cleaning and sterilisation, e.g. during the production and packaging of long-life FDM products. These issues have to be considered to ensure that hygiene standards are maintained, but taking into account the control of water, energy, and detergent and sterilant use.

Mechanical processing, e.g. raw material preparation and sizing, thermal processing, e.g. dehydration, are the most common used techniques for food preservation and processing. Both require significant amount of energy. Process heating uses approximately 29 % of the total energy used in the FDM sector. Process cooling and refrigeration accounts for about 16 % of the total energy consumption.

Energy use is one of the key environmental issues for FDM sectors (e.g. meat and poultry, fish and shellfish, fruit and vegetables, vegetable oils and fats, dairy products, breweries, etc.). For further information see Table 1.6 within the FDM BREF document.

1.1.1 Energy generation

FDM manufacturing requires electrical and thermal energy for virtually every step of the process. Electricity is needed for lighting, for process control of the installation, for heating, for refrigeration and as the driving power for machinery. It is usually generated and supplied by utility companies. When steam and electricity are generated on site, the efficiency factor can be considerably higher.

Thermal energy is needed for heating processing lines and buildings. The heat generated by combustion of fossil fuels is transferred to the consumer by means of heat transfer media, which, depending on the requirements is steam, hot water, air or thermal oil.

The basic boiler/generator design generally consists of a combustion chamber, where fuel combustion takes place. The heat is initially transferred by radiation, followed by a tubular heat-exchanger for heat transfer by convection. The hot flue-gas and heat transfer media are separated from each other by a specifically designed heat-exchange system. Thermal efficiencies of heat generators very much depend on the application and fuel type. Efficiencies, calculated on the basis of lowest calorific value, range from 75 – 90 %. Some products are heated up by means of direct radiation with open flames or convection with directly heated process air. In this particular case, natural gas or extra light fuel oil is burned.

In-house combined generation of heat and power (CHP) is a valuable alternative for FDM manufacturing processes for which heat and power loads are balanced. The following cogeneration concepts are used in the FDM sector; high pressure steam boilers/steam turbine, gas turbines or gas engines or diesel generators with waste heat recovery for steam or hot water generation. The overall fuel utilisation factor of CHP systems exceeds 70 % and is typically about 85 %. Energy efficiency can be up to 90 or 95 % when the exhaust gases from a waste heat recovery system, such as a steam boiler, are used for other drying purposes. The fuel conversion efficiency greatly exceeds that of any design of a commercial power station, even the latest generation of combined cycle gas turbines, which can achieve a conversion efficiency of 55 %. Sometimes surplus electricity can be sold to other users.

Natural gas and fuel oil are the most convenient fuels. However, a few installations still burn solid fuels such as coal or process wastes. The utilisation of process wastes can be a convenient and competitive source of energy, and additionally helps to reduce the cost of off-site waste disposal.

1.1.2 General energy consumption information

In the FDM sector, energy, water and chemicals are consumed and gaseous, solid and liquid outputs are generated. These may have a negative impact on the environment and may be due to the inefficient use of materials or processes. Data on water and energy consumption vary, not only with the type of process and how it is operated, but also with the size of operation.

As mentioned previously, process heating uses approximately 29 % of the total energy used in the FDM sector. Process cooling and refrigeration accounts for about 16 % of the total energy consumption. In Germany, the FDM sector consumed about 54500 MWh/yr in 1998, representing 6.7 % of the total German energy consumption, making it the fifth largest energy consumer among all industrial sectors. The energy was produced using 49 % gas, 21 % oil and 7 % coal. The energy consumption doubled in 30 years from 1950 to 1980. There was a slight decrease in the 80s and 90s.

In the following, energy-related information for relevant unit operations will be summarised.

1.1.3 Energy consumption in unit operations

- **Material handling and storage**

Material handling is almost exclusively electrically driven. No significant heat is involved. The environmental issues are minor and relate to electricity consumption.

- **Sorting/screening, grading, dehulling, destemming/destalking and trimming**

Although sorting generally needs little energy, there are large variations in electrical energy consumption. For example, in vegetable processing, the sorting operation has an electrical energy consumption of 0 – 20 kWh_e/t frozen vegetable.

- **Peeling**

Flash steam peeling, caustic peeling and flame peeling require heat; the other peeling operations use electrical energy.

- **Washing and thawing**

The electricity consumption for washing operations heavily depends on the vegetable concerned. Washing spinach, for instance, is energy intensive.

During washing operations hot water can be used to increase the speed and efficiency of the washing. Most companies do not heat water. Sometimes hot residual water from the blanching system is used for washing.

Thawing using hot air consumes energy.

- **Cutting, slicing, chopping, mincing, pulping and pressing**

Electrical energy is used for various equipment.

- **Mixing/blending, homogenisation and conching**

These unit operations require mainly electrical energy input.

- **Grinding/milling and crushing**

Grinding requires a significant energy input.

- **Forming/moulding and extruding**

Typically, extruders are major users of electrical energy.

- **Extraction**

Electrical energy and steam is required; the levels depend on the type of application. For example, energy consumption is of 170 – 390 kWh steam (600 – 1400 MJ) and 30 – 60 kWh_e/t oilseed (100 to 200 MJ). The energy consumption depends mainly on the kind of oilseed and of the type of cooling water circuit.

- **Centrifugation and sedimentation**

Centrifugation uses significant amounts of energy. When sedimentation is used, electrical energy is required for pumping operations.

- **Filtration**

Pumping requires electrical energy.

- **Membrane separation**

Membrane separation is a pressure driven process, so electrical energy is required. In electrodialysis, electrical energy is required for the transport of ions.

- **Crystallisation**

Electricity is needed to power the pumps and drives. Energy is needed for the cooling system.

- **Removal of free fatty acids by neutralisation**

The steam generation required as the main source of energy for neutralisation and soap-stock splitting consumes significant amounts of energy.

- **Bleaching**

Steam is needed for oil recovery from the spent bleaching earth. The oil and spent bleaching earth are heated by steam during the bleaching process.

- **Deodorisation by steam stripping**

For this processing technique, energy is needed in the form of steam and electricity. The electrical energy consumption ranges from 17 – 42 kWh/t product (60 – 150 MJ/t), and steam consumption from 115 – 310 kWh/t product (420 –1120 MJ/t).

- **Decolourisation**

Any heating of the product used to meet the optimum conditions for the operation can usually be recovered by normal heat recovery systems. The regeneration of activated carbon involves kilning at elevated temperatures in the absence of oxygen. This is mainly done off site by specialised companies.

- **Distillation**

The distillation tower is heated by steam. For pot stills, 12 to 13 kWh per litre of pure alcohol is required.

- **Dissolving**

During the dissolving process, steam and electricity are used.

- **Solubilisation/alkalising**

An example of the typical energy requirements per tonne of cocoa is shown below (Table 3.8 of the BREF FDM document).

	Electrical power (kJ/kg)	Electrical power (kWh/kg)	Steam (kg/t)	Steam (kWh/t)
Liquid process	35 – 70	0.010 – 0.019	300 – 500	233 – 389
Nips alkalising	35 – 550	0.010 – 0.153	700 – 1000	548 – 778

Table 1-1: Typical energy requirements per tonne of cocoa

- **Fermentation**

Electrical energy is needed to circulate the cooling water.

- **Coagulation**

Steam energy is needed for heat treatment and electricity is needed for cooling.

- **Germination**

Energy is needed for conditioning and circulating the air.

- **Smoking**

Energy is needed for smoke generation and for heating and drying.

- **Hardening**

Energy is supplied as steam and electricity. Total energy consumption is between 110 to 280 kWh/t product (400 and 1000 MJ/t).

- **Carbonation**

Energy is required to operate heat-exchangers and coolers.

- **Melting**

In the melting process, the use of steam is the main energy component.

- **Blanching**

Energy is used for heating the blanching water.

- **Cooking and boiling**

Cooking and boiling uses energy to provide heat, e.g. for steam production.

- **Baking**

Ovens are heated using either electrical energy or fuel in the form of natural gas or oil. For infrared ovens, special types of burners are applied. The energy usage for baking normally ranges from 0.125 – 0.167 kWh/kg of product (450 – 600 kJ/kg).

- **Roasting**

The actual energy consumption depends on the type of roaster being used and also on the layout of the flue-gas system.

- **Frying**

The frying oven is usually oil-fired or steam heated.

- **Tempering**

Electricity is needed for the pumps and drives and for the cooling system.

- **Pasteurisation, sterilisation and UHT**

Energy, usually in the form of steam or hot water, is required for heat treatment. After heat treatment, energy can be recovered by heat-exchange in a recovery section. For the final cooling, a cooling medium is needed. Cooling can be accomplished by once-through cooling whereby the cooling water is cooled down in a cooling tower or with a recirculating chilled water system. The latter uses a mechanical refrigeration system, so energy is consumed.

- **Evaporation (liquid to liquid)**

Steam requirements for single-stage evaporators range from 1.1 to 1.2 tonnes of steam per tonne of evaporated water. Energy requirements may be reduced when using multi-effect evaporators. In the case of double or third effect, the steam requirement lowers respectively to 0.6 - 0.7 and 0.4 tonnes of steam per tonne of evaporated water. The steam consumption can also be reduced by applying mechanical or thermal vapour recompression. Sometimes exhaust gases can be used to recover energy from other processes such as drying.

- **Drying (liquid to solid)**

For the evaporation of water, theoretically 0.611 kWh/kg (2.2 MJ/kg) energy is required. In practice, due to energy losses in the process, the energy consumption for water evaporation ranges from 0.694 – 0.972 kWh/kg (2.5 to 3.5 MJ/kg).

- **Dehydration**

For the evaporation of water, theoretically 0.611 kWh/kg (2.2 MJ/kg) energy is required. However, in practice, this very much depends on the type of drier used and can range from 0.556 – 1.08 kWh/kg (2.0 – 3.9 MJ/kg). Steam driers can have a considerably lower energy consumption if they consist of more effects (multiple effect evaporation). Sometimes exhaust gases from a combustion (CHP) plant are used to dry products, thereby reducing the direct energy consumption. The energy consumption for dehydration can be further reduced by increasing the dry substance content of the wet product. This can be achieved by pre-evaporation or by using special dewatering equipment.

- **Cooling, chilling and cold stabilisation**

Electrical energy is needed to drive the pumps circulating the cooling water or the fans in air cooling. Mechanical refrigeration systems generally require 0.3 – 1.0 kWh power per cooling effect. However, overall, their energy consumption is significantly less than the total energy required for the manufacture and use of liquid N_2 or CO_2.

- **Freezing**

Energy consumption is the major environmental issue. Electrical energy is needed for the fans for air circulation and the freezing system. For example, deep freezing is the most energy consuming step in the manufacture of deep frozen vegetables consuming 80 – 280 kWh_e/t of frozen vegetable. Energy amounting to about 0.003 kWh/m^2 (0.01 MJ/m^2) floor surface of tunnel/hour of operation is also consumed in the form of hot water. The energy consumption of a freezing tunnel depends on various factors and the following list uses the deep freezing of fruit and vegetables to illustrate these. Energy consumption depends on, e.g:

- the type of food to be frozen, e.g. voluminous vegetables, such as cauliflower florets are more difficult to freeze than small vegetables such as peas or diced carrots
- the temperature of the food at the entrance to the freezing tunnel. The higher this temperature is, the more heat has to be removed from the food before it is frozen
- the mass flow rate of the food. The higher the flow rate, the higher the quantity of energy that needs to be removed, and the greater the demand for cold air in the tunnel
- the residence time, which also determines the demand for cold air in the freezing tunnel. The longer the residence time, the more chance the food has to freeze. The thickness of the layer of food is directly proportional to the required residence time

- the energy consumption which is determined by the airflow rates in the freezing tunnel. The higher the airflow rates, the better the heat-exchange between the evaporators and the air on one hand, and the air and the food on the other hand. Higher airflow rates lead to higher energy consumption by the fans and higher cooling loads for the freezing tunnel; the full output of the motors needs to be cooled
- the efficiency or the COP, which plays a role in the energy consumption of freezing tunnels. As explained earlier, the efficiency is mainly determined by the condensation and evaporator temperature. The energy consumption per unit of weight of frozen product depends very much on the parameters set for the evaporator temperature, fan rating and product flow rate, and the condensation pressures and type of product being processed. Since many factors affect the specific energy consumption, it is, therefore, only possible to give broad ranges for consumption

    - **Freeze-drying/lyophilisation**

For freeze-drying, mainly electrical energy is used.

    - **Packing and filling**

Energy is consumed by filling/capping/packing equipment and other associated activities.

    - **Cleaning and disinfection**

Cleaning is commonly carried out at elevated temperatures, which, therefore, requires the use of energy to heat water and produce steam.

    - **Vacuum generation**

The energy usage will depend on the type of compressor used, the absolute pressure to be achieved and the size of the system. For large operations, the consumption can be reasonably high.

    - **Refrigeration**

Refrigeration equipment needs a high electricity input.

    - **Compressed air generation**

Energy is consumed in the compressor.

1.1.4 Energy consumption levels in some individual FDM sectors

Meat and poultry

A considerable amount of thermal energy is used in processes involving heat treatments such as boiling, cooking, pasteurising, sterilising, drying and smoking. Other large energy consuming operations are chilling, freezing, thawing and cleaning and disinfection.

Table 3.11 of the BREF FDM summarises reported consumption levels expressed per tonne of finished product in the Italian meat industry for cooked ham manufacturing. With regard to electrical and thermal energy consumption during the manufacturing of cooked ham the BREF FDM indicates whether the energy consumption in different unit operations is low, medium or high, without providing any quantification.

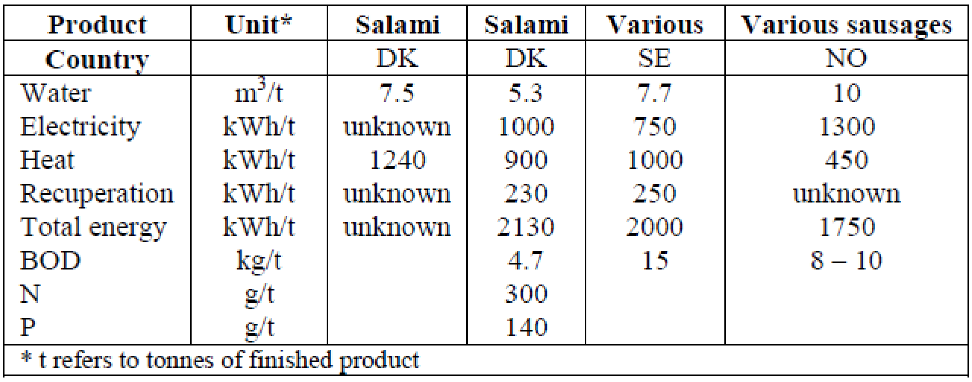
Cooke ham		
Unit operation	Electrical energy	Thermal energy
Materials handling and storage	*	
Sorting/screening, grading, dehulling, destemming/destalking and trimming	*	
Washing and thawing	*	**
Cutting, slicing, chopping, mincing, pulping and pressing	**	
Mixing/blending, homogenisation and conching	*	
Forming/moulding and extruding	*	
Brining/curing and pickling	*	
Smoking		**
Coating/spraying/enrobing/agglomeration/encapsulation		
Cooking and boiling	*	**
Roasting		**
Frying		**
Tempering		
Pasteurisation, sterilisation and UHT	*	**
Dehydration (solid to solid)	*	***
Packing and filling	**	
Cleaning and disinfection	*	*
Energy generation and consumption	**	
Water use	*	
Vacuum generation	*	
Refrigeration	**	
* low consumption ** medium consumption *** high consumption		

Table 1-2: Energy consumption for cooked ham manufacturing in Italy

Salami and sausage production

The main environmental factors relating to sausage manufacture concern the smoking and cooling processes. Effective ventilation and exhaust is necessary for kilns and rooms.

Only very limited information is available about the use of resources and pollution from the manufacturing of salami and Vienna sausage. One reason is that a meat processing installation or a slaughterhouse may have many other activities than those mentioned here and that the companies do not have sufficient separation of the figures for consumption or emission levels for each product line. The following table shows specific consumption of water and energy, and emissions of waste water in salami and sausage production.



Product	Unit*	Salami	Salami	Various	Various sausages
Country		DK	DK	SE	NO
Water	m^3/t	7.5	5.3	7.7	10
Electricity	kWh/t	unknown	1000	750	1300
Heat	kWh/t	1240	900	1000	450
Recuperation	kWh/t	unknown	230	250	unknown
Total energy	kWh/t	unknown	2130	2000	1750
BOD	kg/t		4.7	15	8 – 10
N	g/t		300		
P	g/t		140		
* t refers to tonnes of finished product					

Table 1-3: Specific consumption of water and energy and emissions of waste water in salami and sausage production

The following table summarizes energy consumption levels of finished products reported for the Italian meat industry for preserved meat products manufacturing. Again, the BREF FDM indicates whether the energy consumption in different unit operations is low, medium or high, without providing any quantification. However, quantitative data is available for the overall totals of typical installations.

Preserved products, e.g. sausages, dressed pork, ham, bacon, etc.		
Unit operation	Electrical Energy [kWh/t]	Thermal Energy [kg steam/t]
Materials handling and storage	*	
Sorting/screening, grading, dehulling, destemming/destalking and trimming	*	
Washing and thawing	*	**
Cutting, slicing, chopping, mincing, pulping and pressing	**	
Mixing/blending, homogenisation and conching	*	
Forming/moulding and extruding	*	
Brining/curing and pickling	*	
Smoking		**
Dehydration (solid to solid)	***	***
Packing and filling	**	
Cleaning and disinfection	*	*
Energy generation and consumption	**	
Water use	*	
Vacuum generation	*	
Refrigeration	**	
Overall totals of typical installations (all unit operations are not undertaken at each installation, so the totals are not the sum of the levels for each unit operation)	**2500 – 4000[1]**	
[1] Thermic + electric (1300 – 1400 kWh/t + 150 – 180 m^3 methane/t) * low consumption ** medium consumption *** high consumption		

Table 1-4: Energy consumption for preserved meat products manufacturing in Italy

Similar energy consumption levels also apply for cured ham (see BREF FDM, Table 3.14).

Canning

The use of hot water or direct steam heating for cooking, prior to canning produces waste water contaminated with fat, protein and fragments of meat. After canning, the meat must be heat-processed to achieve pasteurisation and shelf stability.

The following table summarises energy consumption levels reported for the Italian meat industry for canned meat manufacturing.

Canned meat manufacturing		
Unit operation	Electrical Energy [kWh/t]	Thermal Energy [kg steam/t]
Materials handling and storage	1 – 2	
Washing and thawing	0.5 – 1.5	
Cutting, slicing, chopping, mincing, pulping and pressing		
Pasteurisation, sterilisation and UHT	2 – 4	800 – 900
Cooling, chilling and cold stabilisation		
Packing and filling	100 – 120	
Cleaning and disinfection	5 – 10	
Energy generation and consumption		
Water use		
Vacuum generation		
Refrigeration		
Overall totals of typical installations (all unit operations are not undertaken at each installation, so the totals are not the sum of the levels for each unit operation)	**150 – 400**	**800 – 900**

Table 1-5: Energy consumption for canned meat in Italy

Fish and shellfish

Major environmental impacts associated with fish processing operations are the high consumption of water, consumption of energy and the discharge of waste water with a high organic concentration.

The consumption of energy depends on the installation, the equipment and the fish manufacturing processes that take place. Processes, e.g. canning, that involve heating, cooling, production of ice, drying, evaporation and oil production consume more energy than those that do not, e.g. filleting, where energy consumption is low. On average filleting consumes 65 – 87 kWh/t of fish and canning consumes 150 – 190 kWh/t of fish.

Fruits and vegetables

Processes involving heating, cooling, drying, evaporation, sterilisation, pasteurisation and blanching consume significant energy.

Almost every process step requires electricity. For steam production, natural gas boilers can be used. The frozen vegetable sector is a large consumer of electricity and natural gas. Deep freezing is the process which uses the most electricity.

During deep freezing, cooling to a very low temperature level, i.e. -30 to -40 ºC, is necessary. During this process, energy is consumed at a rate of 80 – 280 kWh$_e$/t of frozen vegetables. Other processes, e.g. washing, require less electrical energy, a maximum of 28 kWh$_e$/t of frozen product.

Deep freezing carrots consumes ±8 kWh$_e$/t and freezing salsifies consumes ± 20 kWh$_e$/t and these require a lot of electrical energy for sorting. Washing spinach for deep freezing consumes ± 4 kWh$_e$/t and is electricity intensive. The mechanical processing of frozen beans and salsifies consumes ± 6 kWh$_e$/t and ± 9 kWh/t respectively, i.e. much more electricity compared with other vegetables.

The electricity consumption of the belt blancher with air cooling, which produces 7 to 30 kWh$_e$/t of frozen product, is significantly higher than that of the belt blancher with water cooling, which produces 2 to 9 kWh$_e$/t of frozen product, or the drum blancher with countercurrent water cooling, which produces 1 to 2.6 kWh$_e$/t of frozen product. Spinach requires most electricity for intermediate processes such as packing or making of portions.

Steam is used for peeling and blanching. Steam peeling uses approximately five times more steam than caustic peeling. Belt blanching with water cooling consumes approximately half the energy of belt blanching with air cooling or drum blanching with countercurrent water cooling. For storage, electricity consumption is between 20 and 65 kWh$_e$/m^3 of storage space/year.

Tomatoes are one of the most processed raw materials. Italy is the second largest producer in the world after the US, and the largest exporter of tomato products. Reported figures for energy consumption in the different processing steps for canned peeled tomatoes and tomato juice are summarized below.

Canned peeled tomatoes (whole and cut)		
Unit operation	Electrical Energy [kWh/t]	Thermal Energy [kg steam/t]
Materials handling and storage	1	
Sorting/screening, grading, dehulling, destemming/destalking and trimming	1.5	
Peeling (refining)	2.5	100
Washing	0.5	
Cutting, slicing, chopping, mincing, pulping and pressing		
Mixing/blending, homogenisation and conching		
Filtration		
Blanching	4 - 5	60
Pasteurisation, sterilisation and UHT	2	450 – 500
Cans and bottles		200 – 300
Evaporation (for juice)	7 – 8	150 – 200
Packing and filling	1.5	
Cleaning and disinfection		
Vacuum generation	1 - 2	
Overall totals of typical installations (all unit operations are not undertaken at each installation, so the totals are not the sum of the levels for each unit operation)	**19 – 24**	**750 – 850**

Table 1-6: Energy consumption for canning tomatoes

Tomato juice, puree and paste (28-30 Brix puree)		
Unit operation	Electrical Energy [kWh/t]	Thermal Energy [kg steam/t]
Materials handling and storage	0.4	
Sorting/screening, grading, dehulling, destemming/destalking and trimming	1.5	
Peeling (refining)	8 – 12	
Washing		
Cutting, slicing, chopping, mincing, pulping and pressing	2.5	
Mixing/blending, homogenisation and conching		
Blanching	15 – 25	700 – 900
Pasteurisation, sterilisation and UHT	0.5	60 - 80
Evaporation (liquid to liquid)	60 - 80	1500 - 1800
Drying (liquid to solid)		
Packing and filling	3.5	10
Cleaning and disinfection		
Vacuum generation	4 – 5	
Overall totals of typical installations (all unit operations are not undertaken at each installation, so the totals are not the sum of the levels for each unit operation)	**90 – 125**	**2300 – 2800**

Table 1-7: Energy consumption for tomato juice, puree and paste

Frozen vegetables

Material handling and storage

In manufacturing frozen vegetables, transportation and storage operations require energy as follows:

- the transportation of frozen vegetables requires 2 – 14 kWh_e/t frozen vegetables. For most production lines, the electrical rating of the belts is between 5 – 30 kW_e
- the storage of vegetables needs 20 – 65 kWh_e/m^3 storage/year electricity and about 26.389 kWh/m^2 (95 MJ/m^2) storage/year is needed in the form of hot water.

Data from the literature show that the average energy balance is made up as follows:

- 11 % for the evaporator fans
- 5 % for the condenser fans
- 7 % for peripheral equipment
- 77 % for compressors, of which 21 % is used for heat input via doors/hatches, 48 % used due to losses via the building shell, and 8 % through the product.

Sorting/screening, grading, dehulling, destemming/destalking and trimming

The sorting operation has an electrical energy consumption of 0 – 20 kWh_e/t frozen vegetables. The following table shows the electricity consumption during the sorting of vegetables.

Product	Electricity consumption (kWh_e/t frozen vegetables)
Spinach	0
Cauliflowers	1
Peas	4
Sprouts	4
Beans	5
Carrots	8

Table 1-8: Electricity consumption during the sorting or vegetables

Peeling

In frozen vegetable processing, salsifies and carrots are peeled before being mechanically processed. Caustic peeling and steam peeling are two methods used. Caustic peeling needs less energy, both in terms of electricity consumption and steam consumption, than steam peeling, but creates more load for the WWTP. In the following the energy carrier and consumption for the caustic peeling of vegetables and the energy carrier and consumption for the steam peeling of vegetables is shown.

Energy carrier	Approximate consumption
Hot water (kWh/t frozen vegetables)	0
Steam (t/t frozen vegetables)	0.16
Steam pressure (bar)	7
Electricity (kWh/t frozen vegetables)	2

Table 1-9: Energy carrier and consumption for the caustic peeling of vegetables

Energy carrier	Approximate consumption
Hot water (kWh/t frozen vegetables)	0
Steam (t/t frozen vegetables)	0.9
Steam pressure (bar)	4 – 15
Electricity (kWh/t frozen vegetables)	3.5

Table 1-10: Energy carrier and consumption for the steam peeling of vegetables

Washing

Washing, as used in the production of frozen vegetables, needs 0 – 5 kWh_e/t frozen vegetables. Certain vegetables, e.g. sprouts and cauliflowers, do not require any washing and thus do not consume energy. In the following the electricity consumption for the washing of vegetables is shown.

Product	Electricity consumption (kWh_e/t frozen vegetables)
Sprouts	0
Cauliflowers	0
Beans	0.5
Carrots	2.5
Salsifies	3
Peas	3
Spinach	5

Table 1-11: Electricity consumption for the washing of vegetables

Cutting, slicing, chopping, mincing, pulping and pressing

Some vegetables are cut before deep freezing. The electrical energy consumption is up to 9 kWh/t frozen vegetables. The following table shows the electricity consumption of mechanical processing of vegetables before freezing.

Product	Electricity consumption (kWh_e/t frozen vegetables)
Peas	0
Sprouts	0
Spinach	0
Carrots (sliced)	1
Carrots (diced)	2.5
Salsifies	6
Beans	9
Peas	0

Table 1-12: Electricity consumption of mechanical processing of vegetables before freezing

Carrots, salsifies and beans require a reasonable amount of electrical energy for mechanical processing. Other vegetables examined do not require any electricity at all.

Blanching

Drum and belt blanchers are used in manufacturing deep frozen vegetables. Energy consumption depends on, not only the type of blanching device, but also the type of subsequent cooling step. Typical energy consumption levels are shown below.

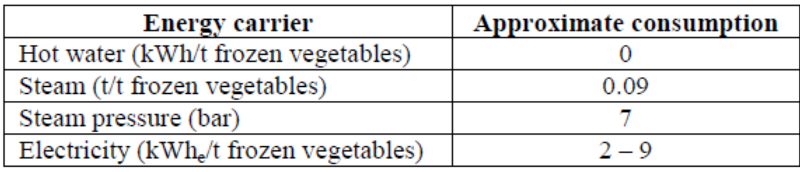
Energy carrier	Approximate consumption
Hot water (kWh/t frozen vegetables)	0
Steam (t/t frozen vegetables)	0.16
Steam pressure (bar)	7
Electricity (kWh_e/t frozen vegetables)	0.5 – 1.3

Table 1-13: Energy source and consumption for drum blanching in the deep freezing of vegetables

Energy carrier	Approximate consumption
Hot water (kWh/t frozen vegetables)	0
Steam (t/t frozen vegetables)	0
Steam pressure (bar)	0
Electricity (kWh_e/t frozen vegetables)	0.5 – 1.3

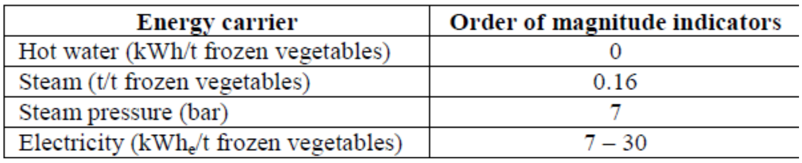
Table 1-14: Energy source and consumption for countercurrent water cooling of vegetables processing

Furthermore, the electricity consumption for the production of ice-water is included in the electricity consumption shown for deep freezing. For example, in terms of energy consumption, the belt blancher with water cooling has the lowest total consumption. The heat released by the cooling of the product in the cooling zone is used to preheat the vegetables. In this way, less steam is necessary for blanching. The following tables show the energy carrier and consumption for belt blancher with water cooling in vegetable processing and the energy carrier and order of magnitude indicators of the belt blancher with air cooling in vegetable processing.



Energy carrier	Approximate consumption
Hot water (kWh/t frozen vegetables)	0
Steam (t/t frozen vegetables)	0.09
Steam pressure (bar)	7
Electricity (kWh_e/t frozen vegetables)	2 – 9

Table 1-15: Energy carrier and consumption for a belt blancher with water cooling in vegetable processing



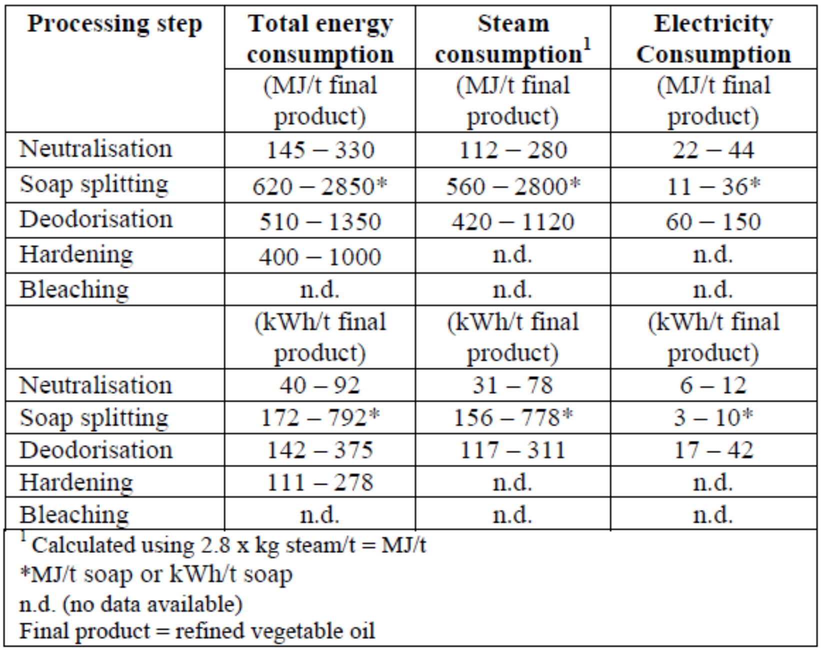
Energy carrier	Order of magnitude indicators
Hot water (kWh/t frozen vegetables)	0
Steam (t/t frozen vegetables)	0.16
Steam pressure (bar)	7
Electricity (kWh_e/t frozen vegetables)	7 – 30

Table 1-16: Energy carrier and order of magnitude indicators of a belt blancher with air cooling in vegetable processing

With regard to electricity consumption, the drum blancher for countercurrent water cooling has the lowest consumption. The water consumption for such an installation is rather high. The use of heavy duty fans (60 kW_e) in the belt blancher with air cooling, make the electricity consumption high for this type of operation.

Vegetable oils and fats

The energy consumption during the production of crude vegetable oil depends on the type of raw material, the equipment and the manufacturing processes. Heating, cooling, drying, milling, pressing, evaporation and distillation are the major energy consuming steps. Cold pressing, without heat conditioning of the raw material, which is especially used for olive oil production, needs twice as much energy as the pressing of heat conditioned oilseeds. Steam consumption is in the range 200 – 500 kg steam/t processed seed (155 – 390 kWh/t) and the electricity need is in the range 25 – 50 kWh/t processed seed (90 – 180 MJ/t). The following table shows energy and steam consumption for some processes in crude vegetable oil refining in German installations.



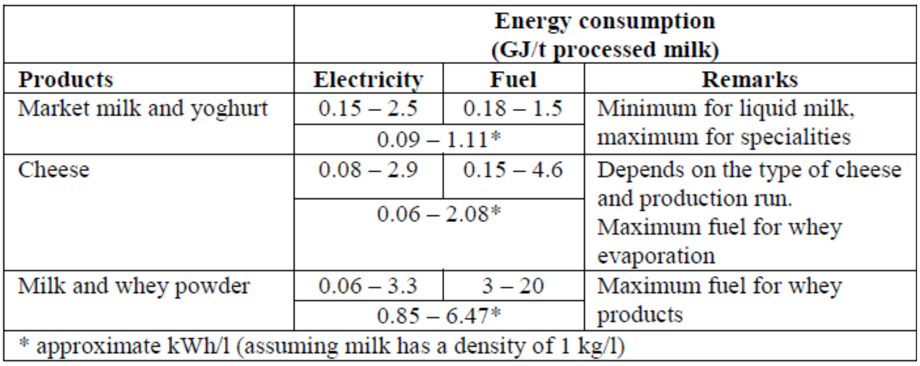
Processing step	Total energy consumption	Steam consumption[1]	Electricity Consumption
	(MJ/t final product)	(MJ/t final product)	(MJ/t final product)
Neutralisation	145 – 330	112 – 280	22 – 44
Soap splitting	620 – 2850*	560 – 2800*	11 – 36*
Deodorisation	510 – 1350	420 – 1120	60 – 150
Hardening	400 – 1000	n.d.	n.d.
Bleaching	n.d.	n.d.	n.d.
	(kWh/t final product)	(kWh/t final product)	(kWh/t final product)
Neutralisation	40 – 92	31 – 78	6 – 12
Soap splitting	172 – 792*	156 – 778*	3 – 10*
Deodorisation	142 – 375	117 – 311	17 – 42
Hardening	111 – 278	n.d.	n.d.
Bleaching	n.d.	n.d.	n.d.

[1] Calculated using 2.8 x kg steam/t = MJ/t
*MJ/t soap or kWh/t soap
n.d. (no data available)
Final product = refined vegetable oil

Table 1-17: Energy consumption in crude vegetable oil refining

Dairy products

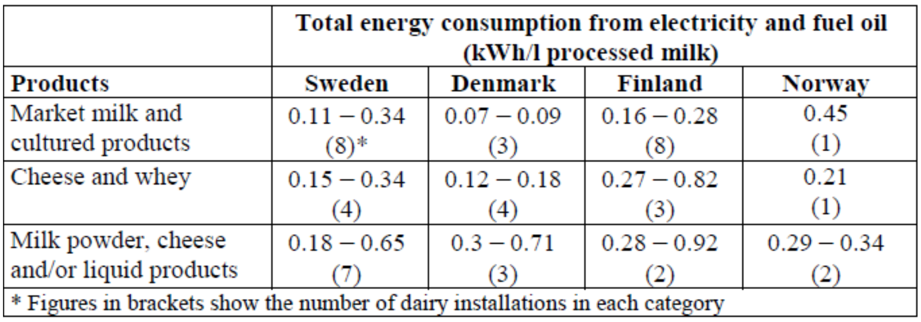
Dairies have significant energy consumption. Around 80 % of the energy is consumed as thermal energy from the combustion of fossil fuels to generate steam and hot water. It is used for heating operations and cleaning. The remaining 20 % is consumed as electricity to drive machinery, refrigeration, ventilation, and lighting. The most energy consuming operations are the evaporation and drying of milk. In pasteurisation, e.g. significant energy is also needed for the heating and cooling steps. Recovery of heat by heat-exchangers can be applied. Evaporation is normally combined with vapour recompression. A wide range of energy consumption data has been reported for the European dairy industry. Figures are summarised in the following.



	Energy consumption (GJ/t processed milk)		
Products	**Electricity**	**Fuel**	**Remarks**
Market milk and yoghurt	0.15 – 2.5	0.18 – 1.5	Minimum for liquid milk, maximum for specialities
	0.09 – 1.11*		
Cheese	0.08 – 2.9	0.15 – 4.6	Depends on the type of cheese and production run. Maximum fuel for whey evaporation
	0.06 – 2.08*		
Milk and whey powder	0.06 – 3.3	3 – 20	Maximum fuel for whey products
	0.85 – 6.47*		
* approximate kWh/l (assuming milk has a density of 1 kg/l)			

Table 1-18: Energy consumption in European dairies

Similar figures are reported for Nordic dairies.



	Total energy consumption from electricity and fuel oil (kWh/l processed milk)			
Products	**Sweden**	**Denmark**	**Finland**	**Norway**
Market milk and cultured products	0.11 – 0.34 (8)*	0.07 – 0.09 (3)	0.16 – 0.28 (8)	0.45 (1)
Cheese and whey	0.15 – 0.34 (4)	0.12 – 0.18 (4)	0.27 – 0.82 (3)	0.21 (1)
Milk powder, cheese and/or liquid products	0.18 – 0.65 (7)	0.3 – 0.71 (3)	0.28 – 0.92 (2)	0.29 – 0.34 (2)
* Figures in brackets show the number of dairy installations in each category				

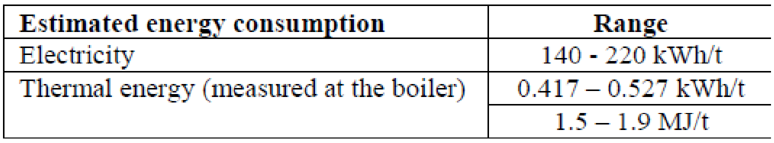
Table 1-19: Total energy consumption for some Nordic dairies

More energy is used in dairies where butter, as well as drinking milk, is produced and where the production of powdered milk is greater. Four installations of the ice-cream industry in Nordic countries have reported to have a total energy consumption in the range 0.75 – 1.6 kWh/kg of ice-cream produced. Other reports show an energy consumption of 2 – 10 GJ/t ice-cream produced.

Dry pasta

The drying step utilises about 85 – 90 % of the thermal energy and 50 – 60 % of the electricity consumption of the installation. These figures may even be higher for lines producing special products such as nests of lasagne. Air conditioning of the workspace needs 35 – 50 kWh/t energy.

In evaluating energy consumption in the sector, the results of a study on pasta factories with a production capacity over 75 t/d led to the estimated consumption of electricity, expressed in kWh/t of product, and of thermal energy, expressed in kWh/t and MJ/t.

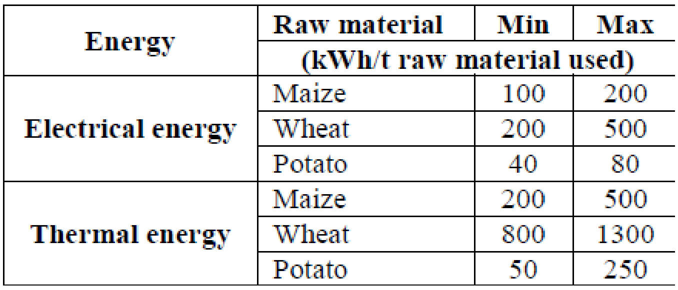


Estimated energy consumption	Range
Electricity	140 - 220 kWh/t
Thermal energy (measured at the boiler)	0.417 – 0.527 kWh/t
	1.5 – 1.9 MJ/t

Table 1-20: Energy consumption in the Italian pasta industry

Starch

The energy consumption depends on the starch and starch derived products produced on the site, i.e. on the techniques and processes involved in the starch production and co-products management. However, the main use of energy in starch production is thermal energy for the evaporation and drying processes. The energy used to produce starch slurry is low in comparison to the final production of dry products. More energy is consumed at sites where evaporation and/or drying processes are used for co-products such as fibre, solubles and proteins than at sites where solubles are landspread and fibre is sold as wet cattle feed. The general consumption of energy in the starch sector is shown in the following.

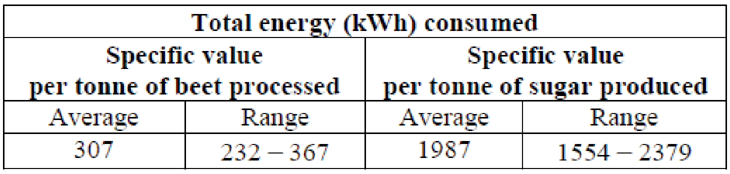


Energy	Raw material	Min	Max
	(kWh/t raw material used)		
Electrical energy	Maize	100	200
	Wheat	200	500
	Potato	40	80
Thermal energy	Maize	200	500
	Wheat	800	1300
	Potato	50	250

Table 1-21: Energy consumption in the starch industry

Sugar

Significant thermal energy is consumed for the evaporation and beet pulp drying. Electrical energy is needed for the pumps and for driving the centrifuges. According to CEFS, specific energy consumption was 31.49 kWh/100 kg beet in 1998. The following table shows the energy consumption in Danish sugar factories.



Total energy (kWh) consumed			
Specific value per tonne of beet processed		Specific value per tonne of sugar produced	
Average	Range	Average	Range
307	232 – 367	1987	1554 – 2379

Table 1-22: Energy consumption in Danish sugar factories

In a Greek study, a figure of 280 kWh/t is given for the electrical part of the energy consumption in sugar manufacturing.

Breweries

Breweries need both electrical and heat energy. Combined heat and power generation is in use in some facilities. Depending on availability, price and legal requirements, different fuels such as coal, oil or gas are used. The following table gives average energy consumption levels for German breweries with 20 or more employees.

Year	Heat				Electrical Power	Beer Output	Specific	
	Coal	Oil	Gas	Total			Heat	Power
	(x 10^6 kWh)				(x 10^6 kWh)	(x 10^6 hl)	(kWh/hl)	(kWh/hl)
1997	157	929	2992	4078	1199	114.8	35.5	10.4
1998	150	846	2943	3939	1187	111.7	35.3	10.6
1999	162	789	2956	3907	1175	112.8	34.6	10.4
2000	150	683	2809	3642	1163	110.4	33.0	10.5
	(x 10^6 MJ)				(MJ/hl)			
1997	565	3345	10771	14681			127.9	
1998	541	3046	10595	14182			127.0	
1999	583	2841	10642	14066			124.7	
2000	540	2458	10113	13111			118.7	

Table 1-23: Energy consumption of German breweries with more than 20 employees

A brewery without a sophisticated heat recovery system consumes about 27.78 – 55.55 kWh/hl beer (100 – 200 MJ/hl). The main heat consuming process steps are mashing, wort boiling, generation of hot liquor, CIP, sterilising, bottle/keg cleaning and pasteurising. Heat consumption for some departments is given in the following.

Department/ process	Minimum	Mean	Maximum	Literature[1]	Measured[2]
	figure			range	
	(MJ/hl beer)			(MJ/hl beer)	
Brewhouse	87	92	121	84 – 113	50 – 80
Bottling installation	58	86	94	25 – 46	38 – 58
Kegging installation	8	11	13	8 – 13	
Process water	3	4	8	4 – 8	
Service water				8 – 17	
Miscellaneous				33 – 46	95
Total	156	193	236	162 – 243	183 – 233
	(kWh/hl beer)			(kWh/hl beer)	
Brewhouse	24.17	25.56	33.61	23.33 – 31.39	13.89 – 22.22
Bottling installation	16.11	23.89	26.11	6.94 – 12.78	10.56 – 16.11
Kegging installation	2.22	3.06	3.61	2.22 – 3.61	
Process water	0.83	1.11	2.22	1.11 – 2.22	
Service water				2.22 – 4.72	
Miscellaneous				9.17 – 12.78	26.39
Total	43.33	53.62	65.55	44.99 – 67.50	24.44 – 64.72

1) 20000 to 500000 hl beer sold/yr
2) 300000 to 500000 hl beer sold/yr

Table 1-24: Heat consumption for different brewery processes

The major consumer of electrical energy are the packaging area, cooling plant, compressed air plant, if applied, the carbon dioxide recovery plant, WWTP and air conditioning. Pumps, ventilators, drives and electric lighting count for a large part of the electricity consumption, with about 8 – 12 kWh/hl in a brewery.

1.2 General techniques for the FDM sector (energy-related)

1.2.1 Optimise operation by providing training

Description

Giving staff at all levels, from management to shop floor, the necessary training and instruction in their duties can help to improve the control of processes and minimise consumption and emission levels and the risk of accidents. This may be undertaken with in-house or external environmental advisers, but they cannot be responsible for the ongoing environmental management of the process. Problems which can arise during routine operations, start-up, shutdown, cleaning, maintenance, abnormal conditions and non-routine work should all be covered.

Ongoing risk assessment of processes and work areas and the monitoring of compliance with identified standards and operating practices can then be undertaken by managers in partnership with shop floor employees.

Achieved environmental benefits

Reduced consumption and emission levels and reduced risks of accidents throughout the installation.

Applicability

Applicable to all FDM installations.

Driving force for implementation

Routinely, considering the environmental impacts can help to focus efforts for achieving lower consumption and emission levels, leading to cost savings and increasing the confidence of the regulatory authority.

For further details see Chapter 4.1.2 of the FDM BREF document.

1.2.2 Design equipment to minimise consumption and emission levels

Description

Careful design of pumping and conveying equipment can prevent solid, liquid and gas emissions. Energy consumption can be minimised by, e.g. energy-optimised planning, including re-use of heat and use of insulation.

Achieved environmental benefits

Reduced consumption of energy, water, substances and reduced emissions to air, water and land.

Operational data

Refrigeration plants and other equipment, e.g. boilers and cooling towers, can be adequately sized for the maximum expected demand and adequately controlled to always supply the required demand.

Applicability

Applicable to all FDM installations.

Driving force for implementation

Reduced consumption and emission levels and their associated costs.

For further details see Chapter 4.1.3.1 of the FDM BREF document.

1.2.3 Maintenance

Description

The effective planned preventive maintenance of vessels and equipment can minimise the frequency and size of solid, liquid and gas emissions, as well as water and energy consumption.

Achieved environmental benefits

Reduced consumption of energy, water, substances and reduced emissions to air, water and land.

Operational data

In general, the maintenance of utility systems receives much lower priority than maintenance that has a direct impact on production or safety. Examples of maintenance practices include:

Compressed air

- initiating an effective system for reporting leaks
- carrying out an "out of hours" survey, to listen for leaks, locate and tag them
- repairing leaks

Refrigerant

- checking the refrigerant for gas bubbles (bubbles in the sight glass usually mean a system is leaking)
- finding the leaks and repairing them before the system is recharged with refrigerant
- checking that the oil in the compressor sight glass(es) is at the right level (the compressor will be more likely to fail if the oil level is too low, or to high)

Applicability

Applicable to all FDM sectors.

Driving force for implementation

Smooth untroubled production which is not interrupted by breakdowns and accidents.

For further details see Chapter 4.1.5 of the FDM BREF document.

1.2.4 Methodology for preventing and minimising the consumption of water and energy and the production of waste

Prevention and minimisation requires the adoption of a systematic approach. A successful methodology usually consists of the steps described in the following sections.

These steps are described:

- Step 1: obtaining management commitment, organisation and planning
- Step 2: analysis of production processes
- Step 3: assessment of objectives
- Step 4: identifying prevention and minimisation options
- Step 5: carrying out an evaluation and feasibility study
- Step 6: implementing the prevention and minimisation programme
- Step 7: ongoing monitoring by measurement and visual inspection.

The importance of preventing and minimising the consumption of energy is described below.

In many of the FDM sectors, energy consumption is an important cost factor. Depending on the nature of the production activities, energy costs may vary from less than 1 % to more than 10 % of the production costs. Taking a systematic approach to reduce energy consumption is an important issue, both from the point of view of the environmental impact, e.g. greenhouse effect, and also due to cost savings.

The concept of energy efficiency is frequently used to measure the energy consumption in an industrial installation. Energy efficiency is often defined as the amount of energy consumed per unit of product. Improving energy efficiency, therefore, means reducing the amount of energy per unit of product. This will result in energy savings at an installation level if the product output remains at a constant level. In improving the energy efficiency, two aspects can be distinguished:

- a reduction of the energy consumption by efficient energy management
- a reduction of the energy consumption by process optimisation and innovation

Energy management is an approach to controlling and minimising energy consumption and energy costs. It depends, to a large extent, upon placing accountability for consumption on those individuals who are responsible for using it. An essential part of energy management is monitoring and targeting. In several case studies, energy savings of 5 – 15 % are reported (see Figure 1-1).

A further step in improving energy efficiency can be made by process optimisation and innovation. Sometimes this requires only minor investments. Nevertheless, for innovations that have an important impact both on the process and energy consumption, larger investments may be necessary. Investments in process optimisation and innovation without an efficient system of energy management cannot give a good insight into whether the expected energy savings are actually realised. Furthermore, it is possible that the effect of the energy savings gained by process adaptations can be offset if good housekeeping is not maintained.

An illustration of the relationship between the effects of efficient energy management and implementing energy saving measures, e.g. process optimisation and innovation, is given below.

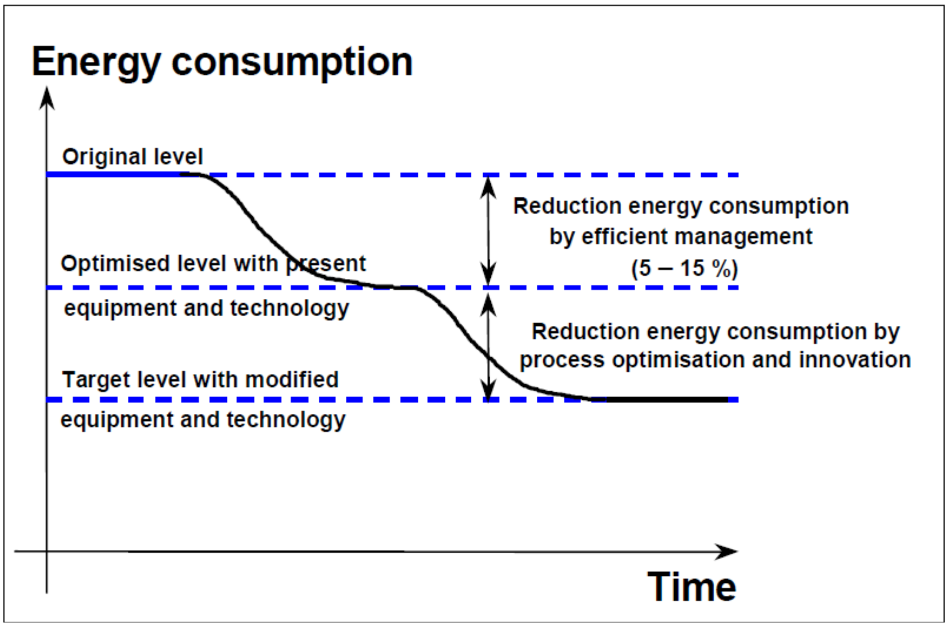


Figure 1-1: Reduction in energy consumption

Step 1: Obtaining management commitment, organisation and planning

To be successful, the programmes for preventing and minimising water and energy consumption, and waste production require commitment at senior management level. This can ensure that all individuals within the organisation work together in a positive manner to gain maximum benefit from the initiative. One of the best ways of gaining senior management commitment is to convince the managers of the financial benefits that can be achieved.

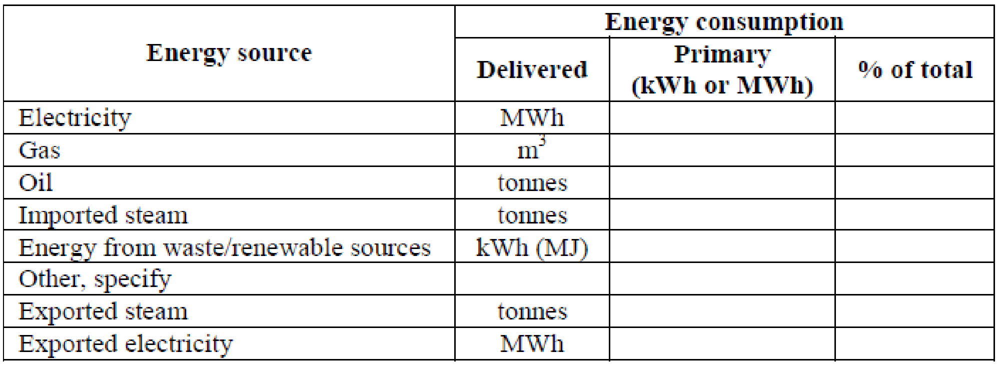
For more information see BREF FDM Chapter 4.1.6.1

Step 2: Analysis of production processes

An important condition for successful prevention and minimisation of energy and water consumption, and waste production is to have a good overview of the areas and process steps that are relevant to the loss of material, the generation of waste and the consumption levels. Such an overview makes it easier to identify measures. This requires a detailed inventory of all of the production processes. In developing this inventory, three levels of measurement can be applied i.e. collection of quantitative data at the site level, inventory for each process step and inventory of selected process parts.

Information about energy consumption is fundamental to identify where the most effective energy savings and cost effective improvements can be made. Furthermore, it is a basis for demonstrating that the installation is operated in an efficient manner and that energy saving measures are taken in the most appropriate areas.

First, the information needs to be broken down by energy source. As well as purchased electricity, this should also include fuels converted to energy at the site, heat imported directly from external sources and renewable energy sources. Recent values for delivered energy sources over a recent 12 month period may be used. Conversion to primary energy is advised. Where energy from a CHP installation is used, the calculated energy used is based on the energy input to the installation, not on the units of energy produced by the installation. An example worksheet for the breakdown of energy consumption can be as follows.



Energy source	Energy consumption		
	Delivered	Primary (kWh or MWh)	% of total
Electricity	MWh		
Gas	m^3		
Oil	tonnes		
Imported steam	tonnes		
Energy from waste/renewable sources	kWh (MJ)		
Other, specify			
Exported steam	tonnes		
Exported electricity	MWh		

Table 1-25: Example worksheet for the breakdown of the energy consumption

Next, an analysis of the energy consumption of the equipment, per department or production line, is made. It is advisable to supplement the energy consumption information with energy balances of flow diagrams to illustrate how energy is used throughout the process. A Sankey diagram can be used to present situations where energy conversion is highly integrated within the production activities.

Finally the specific energy consumption (SEC) is analysed. This means the amount of energy that is consumed per unit of raw material processed of product output.

For more information see BREF FDM Chapter 4.1.6.2 and in particular Chapter 4.1.6.2.2 FDM BREF.

Step 3: Assessment of objectives

Based on the analysis made in Step 2, the objectives of the prevention and minimisation programme are assessed. The objectives include targets, boundaries and time-scales. The objectives need to be measureable and scheduled into a programme plan so that they can be used to monitor if the programme is proceeding as planned. These objectives can be revised further in the process when implementing the actual prevention and minimisation programme (see Step 6).

Step 4: Identifying prevention and minimisation options

Various approaches can be applied to identify measures to prevent and minimise water and energy consumption, and waste production, e.g. brainstorming, internal investigation, external consultancy and pinch technology.

It is reported that, in the process of identifying energy efficiency measures, production processes, utilities and buildings need to be considered separately. There is a lot of information on energy efficiency techniques available from various public sources. However, the available techniques are strongly dependent on the particular site and the type of processes applied. Overall, total energy savings are usually the result of small savings in a number of areas. For example, reductions of up to 25 % are possible through improved housekeeping (see Section 4.1.7.11 of the BREF FDM) and fine-tuning processes. The use of more energy efficient equipment, heat recovery and applying combined heat and power (CHP) generation (see Section 4.2.13.1.1 of the BRF FDM) may also result in additional savings. An example pasta manufacturer indicated that an improvement in the energy efficiency of one of its boilers, from 85 to 90 %, could lead to a 5.56 % reduction in CO_2 emissions (considering a conversion factor of 84.6 kg CO_2/GJ).

Many measures applicable for reducing an environmental impact, e.g. reduction of energy consumption, have no effect on other polluting emissions associated with the installation. Such measures can be considered as “standalone” and are evaluated according to their individual economic and environmental benefits.

On the other hand, some measures can lead to positive or negative effects on other environmental issues, and in such cases, the wider environmental impacts need to be taken into account. In the case of trade-offs, e.g. between energy consumption and other environmental objectives, an assessment, taking into account the costs and environmental benefits, needs to be undertaken to justify the implementation of appropriate measures.

For more information see BREF FDM Chapter 4.1.6.4 and 4.1.6.4.1 (Pinch technology)

Step 5: Carrying out an evaluation and feasibility study

The objective of the evaluation and feasibility study phase is to evaluate the proposed options and to select those most suitable for implementation. The options are all evaluated according to their technical, economic and environmental merits. The depth of the study depends on the type of the option.

For further information see BREF FDM, Chapter 4.1.6.5.

Step 6: Implementing the prevention and minimisation programme

Use of an action plan can ensure that the selected options are implemented. The action plan can show the activities to be carried out, the resource requirements, the persons responsible for undertaking those activities and the deadlines for action. It is important to evaluate the effectiveness of the implemented measures and to monitor and review the effects periodically (see Step 7).

For more information see BREF FDM, Chapter 4.1.6.6.

Step 7: Ongoing monitoring by measurement and visual inspection

Description

It is important to evaluate the effectiveness of measures implemented to minimise consumption and emission levels and to monitor and review their effects periodically.

Achieved environmental benefits

By ongoing monitoring, the effectiveness of the chosen measure can be periodically checked to see whether it is meeting the set targets, e.g. consumption and emission performance levels.

Operational data

An example starch manufacturer processes maize into starch, starch derivatives, and glucose, both for food and non-food industries. By carrying out a systematic monitoring and analysis of this process, the company aims to reduce the energy consumption of the installation. The annual savings are equivalent to 3 million m^3 of natural gas (95 TJ), i.e. a reduction of approximately 10 %.

Previously, the energy consumption in the starch installation was determined from incidental measurements or from data provided by the energy supplier. The energy use of the separate production stages and their respective products was calculated from these data. This only gave an overview of the actual energy consumption and that was not enough to improve the energy efficiency of the installation. Therefore, a monitoring system that measures and registers the specific energy consumption of several process stages was installed at the site. The production process was divided into separate operational units. Each of the units comprises the manufacture of a particular product or group of products. The energy flows in each module are measured in real-time. The measurements allow the determination of both the energy flows at that time and the consumption over a prolonged period of time.

The new system has made it possible to compare the starch installation's actual and theoretical energy consumption, allowing optimisation of the process in cases of unfavourable differences. Moreover, the system compares the measured energy consumption with that of comparable process units at sister companies and is capable of changing process units according to the most favourable design.

The new monitoring system continuously measures the modules' water, steam, natural gas, and electricity flows. The collected data are transferred to a central processor and then converted into tables and graphs, which are distributed among the interested parties.

The system, in its present form, only registers and reports the actual energy consumption of the installation. Calculation of the specific energy consumption, related to the production of the installation, is still performed manually. The analysis of the data is based on comparisons with historic data of energy consumption under similar conditions.

An example UK dairy installed a computer-based monitoring and targeting system to help reduce costs and improve profitability. A number of meters were installed in the dairy to measure electricity, oil and water consumption. The meter readings were entered into the system, which presents data to enable the company to pinpoint areas of waste and to take corrective action. The principle of the system has been well proven in this case, with improvements in energy efficiency constantly being made. Substantial energy and utility savings were achieved. These savings, which were achieved with low capital costs, were partly due to the high motivation of staff at all levels.

Applicability

Widely applicable in the FDM sector.

Economics

The overall investment cost of the starch example installation amounted to EUR 700000. At a gas price of EUR 0.095/m^3, the annual savings are EUR 284000. This equates to a payback period of about 2.5 years.

Driving force for implementation

Reduced costs and improved profitability.

For further details see Chapter 4.1.6 of the FDM BREF document.

1.2.5 Apply production planning, to minimise associated waste production and cleaning frequencies

Description

Well planned production schedules which minimise the number of product change-overs and consequently the number “interval cleans”, can minimise waste generation, water consumption and waste water generation. If, instead of making the same product twice or more times it can be made in one batch, the number of changeovers can be minimised. The sequence of production may also influence the number of times cleaning is required and the extent.

Achieved environmental benefits

Reduced consumption of water, energy and chemicals and generation of waste water and waste.

Applicability

Applicable in FDM installations where the same equipment is used for more than one product and mixing between products has to be avoided for legal, food safety or quality reasons.

Driving force for implementation

Reduced consumption of water, energy and chemicals and generation of waste water and waste and the costs associated with these.

For further details see Chapter 4.1.7 of the FDM BREF document.

1.2.6 Minimise storage times for perishable materials

Description

Raw materials, intermediate ingredients, by-products, products and waste can all be stored for as short a time as possible. Considering their nature, shelf-life, inherent odour characteristics and how rapidly they biodegrade and create an odour nuisance, refrigeration may be used.

Processing products as quickly as possible and thereby minimising storage times can increase the quality and yield and, therefore, the profitability of the process. Rapid use of raw materials or partly processed materials or dispatch can reduce losses due to decomposition and the need for refrigeration.

Taking hygiene, food safety, shelf-life and product quality considerations into account, energy can be saved during treatments involving the addition of heat, by removing foods from refrigerated storage in advance of this treatment and allowing their temperature to rise. Likewise, if the temperature of foods destined for cold treatments is not allowed to rise first, energy can be saved during cooling.

Achieved environmental benefits

Reduced waste of raw materials, partly processed materials and finished products. Reduced odour emissions and reduced energy consumption for refrigeration.

Operational data

To optimise material losses and refrigeration requirements requires co-operation between the suppliers of raw materials and other ingredients, as well as auxiliary materials required for the process, such as packaging. There may be contractual arrangements affecting the price paid to suppliers, depending on the quality of, e.g. raw material provided.

Fish has a highly perishable nature compared to other food products and generally requires either refrigerated storage or storage in ice from the moment the fish are caught, to avoid decomposition and odour emission and to optimise product quality and yield. Product losses also contribute to the solid and liquid waste loads. Quick processing reduces waste, odour and energy consumption associated with refrigeration and ice production. It also allows fish to be used for products which can be sold for a higher price, e.g. for fresh, cured or smoked fillets.

Due to its high perishability, milk is kept in bulk milk coolers at the farm and quick heat treatment and further processing minimises losses.

If partially processed materials are dispatched as soon as possible from one FDM installation to another where they will be further processed, then refrigeration requirements may be minimised at the producer’s installation and waste may be minimised at the receiver’s installation, by maximising the yield from freshly made ingredients.

Applicability

Applicable to FDM installations handling, storing and processing perishable materials.

Economics

Usually a large proportion of the manufacturing costs within the FDM sector is related to the raw materials. The economic consequences of waste production are not just limited to the actual cost of waste disposal, but e.g. raw material losses, production losses and additional labour costs. Minimising refrigerated storage minimises the associated energy costs.

Driving force for implementation

Maximising quality and yield from raw materials, minimisation of waste disposal costs, reduced refrigeration requirements and prevention of odour problems.

For further details see Chapter 4.1.7.3 of the FDM BREF document.

1.2.7 Segregation of water streams to optimise re-use and treatment

Description

There are generally four types of water streams present in an FDM installation, i.e. water directly associated with use in the process, domestic/sanitary waste water, uncontaminated water and surface water. A water segregation system can be designed to collect these water streams and separate them according to their characteristics, e.g. their contaminant load.

When it is feasible to do so, and it will not affect food safety, the uncontaminated water streams can be re-used for specific process applications, e.g. washing, cleaning, make-up for utilities, for sequential re-use, and exceptionally, for the process itself. Uncontaminated water for which there is no re-use opportunity available can generally be discharged without treatment and doing so prevents an unnecessary burden being imposed on the WWTP.

Achieved environmental benefits

Reduced water contamination, by keeping clean water separate from dirty water and consequently also reduced energy consumption associated with the waste water treatment because not all of the waste water is subjected to every treatment.

Applicability

Some water re-use opportunities exist in existing FDM installations. Segregation of waste water is applicable in new and substantially altered existing FDM installations. For new installations, the waste water segregation system can be designed so that different types of waste water are separated. For existing installations, this may not be possible due to the costs involved and the physical or engineering constraints at specific sites.

Economics

For segregation of waste water there is a high capital cost, however, this may be offset by the reduced running costs due to the lower requirement for waste water treatment, whether on-site, at a MWWTP or a combination of both. It may not be economical to segregate small, isolated streams. Reduced costs associated with water consumption and in some cases with reduced energy consumption.

Driving force for implementation

Reduction of long-term expenses for treating waste water. Moreover, by segregating low strength streams, a treatment facility can be reduced in size. Reduced water and energy consumption.

For further details see Chapter 4.1.7.8 of the FDM BREF document.

1.2.8 Minimise heating and cooling times

Description

The times for heating and cooling processes can be optimised to minimise the energy consumed. This can be done in a variety of ways, e.g. by using a pre-treatment, by stopping the operation as soon as the required effect is required and by selecting equipment which can achieve the required effect with the minimum energy consumption.

Achieved environmental benefits

Reduced energy consumption.

Operational data

Examples of pre-treatments that minimise heating times are soaking vegetable seeds such as lentils and drying potatoes before frying, in the preparation of potato chips.

Stopping the operation when the required effect is achieved includes not cooking ingredients for longer than is needed, e.g. when baking bread or boiling wort in brewing or not cooling foods to colder temperatures than those needed either for processing or storage.

Examples of minimising heating times by equipment selection include direct heating during baking and using fluidised bed driers, e.g. for coffee roasting.

Applicability

Applicable where heating and cooling operations are carried out.

Driving force for implementation

Reduced energy consumption and associated costs.

For further details see Chapter 4.1.7.9 of the FDM BREF document.

1.2.9 Optimise start-up and shut-down procedures and other special operating situations

Description

Start-up and shut-down procedures and other special operating situations can be optimised. For example, by minimising the numbers of start-ups and shut-downs, waste gases from purge vents or preheating equipment, can be minimised. The emission peaks associated with start-up and shut-down can be avoided and consequently, the emissions per tonne of feedstock are lower. This also applies to the operation of abatement equipment.

Achieved environmental benefits

Depending on the application reductions in the consumption of energy; waste generation and emissions to air and water can be achieved.

Operational data

In air abatement, e.g. waste gas thermal oxidisers do not operate effectively until they reach the combustion temperatures of the pollutants they are used to destroy, so they need to be started up before they are actually required.

Driving force for implementation

Reduced consumption and emission levels.

For further details see Chapter 4.1.7.10 of the FDM BREF document.

1.2.10 Control temperature, by dedicated measurement and correction

Description

Raw material waste and waste generation can be reduced by controlling the temperature, e.g. storage vessels, processing vessels and transfer lines. Possible benefits from this include reduced deterioration of materials, reduced out-of-specification products and less biological contamination. The application of temperature sensors can sometimes be optimised by using them for dual purposes, e.g. for monitoring both product and cleaning temperatures.

Achieved environmental benefits

Reduced energy consumption and reduced waste generation. Potentially reduces water consumption, if water or steam is used for heating.

Operational data

It has been reported that in dairies, the temperature of the milk can be maintained during heat treatment by controlling the flow of steam or hot water. In confectionery manufacture, temperature sensors can be used to minimise the temperature drop during product transfer, thereby minimising product deterioration. In meat processing, the temperature of thawing baths for frozen meat can be maintained by controlling the water flow.

In an example meat processing company, installing thermocouples to provide temperature control allowed it to reduce its water supply costs by up to 10 %. Thermocouples on the water inlet and outlet to a chilling and washing system, feed into an automated control valve which optimises the flowrate. The control system has reduced water use, energy use and waste water generation significantly, while maintaining sufficient flowrate to meet the process’s hygiene requirements.

For further details see Chapter 4.1.8.1 of the FDM BREF document.

1.2.11 Use of control devices

Description

Valves are the most common control device and they are extensively used with both manual and automatic control systems. Valves are often used to modify a flowrate to control a different process parameter, e.g. the temperature of chocolate can be measured and, if necessary, adjusted by controlling the flowrates of heating and cooling water. Examples include flow regulators and solenoid valves; others are available.

Flow regulators are used to provide a constant flow at a predetermined rate. The flow through the regulator can be adjusted within a limited range, but these devices are designed with the intention that adjustments are infrequent. Solenoid valves are two position devices where a solenoid is used to open or close a valve on receipt of a control signal.

Achieved environmental benefits

Reduced water consumption and associated energy use.

Operational data

An example food manufacturing company identified that excessive water consumption by its vacuum pumps was due to a higher flow than necessary for the seal water. Although the maximum flow for the service liquid should have been 2.7 m^3/h, the actual flow was almost 11.5 m^3/h, i.e. over four times the design requirement. Installing constant flow valves to ensure the correct flowrate to each of the water ring vacuum pumps reduced water use by approximately 60000 m^3/year, corresponding to 7.5 % of the site’s mains water consumption. Water and waste water costs fell and there was reduced energy consumption and wear of the vacuum pumps.

Driving force for implementation

Reduced water consumption and associated costs.

For further details see Chapter 4.1.8.7 of the FDM BREF document.

1.3 Techniques applicable in a number of FDM sectors (energy-related)

1.3.1 Cooking

Shower oven

Description

Shower ovens allow a good uniformity of heating and use less water and energy than water bath ovens. They operate by the simultaneous heating action of water sent through the showers and from the saturated steam which rises from the heated collecting basin, at the bottom of the oven.

Achieved environmental benefits

Reduced water and energy consumption, compared to water bath ovens.

Cross-media effects

Energy consumption, e.g. for steam production.

Applicability

Widely applicable in the FDM sector, e.g. for meat, fish, shellfish and vegetables.

Hot air oven

Description

Hot air ovens include a recirculation system for hot air, which is obtained by passage through heat-exchangers, and a steam inlet to control food surface humidity. Hot air ovens distribute heat more evenly that other ovens, so cooking time and cooking temperatures can be reduced, thereby cutting energy consumption.

Achieved environmental benefits

Reduced water and energy consumption.

Applicability

Widely applicable in the FDM sector, e.g. for meat, fish and vegetables.

Microwave oven

Description

In a microwave oven, the food is heated by passing microwaves through it. The resulting generation of heat inside the food facilitates rapid cooking.

Achieved environmental benefits

Reduced water and energy consumption

Applicability

Widely applicable in the FDM sector, e.g. for meat, fish, shellfish and vegetables.

For further details see Chapter 4.2.6 of the FDM BREF document.

1.3.2 Frying

Recirculate and burn exhaust gases

Description

Air emissions are dependent on the operational temperature of frying, e.g. high temperature frying at 180 – 200 °C will result in more rapid production of oil breakdown products than frying at lower temperatures. The air above a fryer is extracted and vented. This exhaust air contains VOCs, and may lead to odour complaints. Oil and heat recovery and recirculation of exhaust gases to the burner minimises these emissions.

Achieved environmental benefits

Reduced air emissions, including odour. Recovery of oil. Recovery of energy. Recycling of exhaust gases.

Operational data

For example, when controlling a crisp frying process, ensuring that the frying process ends when the final moisture content is in the critical range of 1-2 % leads to minimisation of air emissions. Furthermore, to save energy, the heat-exchangers are mounted in the fryer exhaust hood.

Applicability

Applicable in the fish, meat and poultry and potato frying sectors.

For further details see Chapter 4.2.7 of the FDM BREF document.

1.3.3 Preservation in cans, bottles and jars

Avoiding cooking before preservation in cans, bottles and jars, if food can be cooked during sterilisation

Description

Before preservation in cans, bottles and jars, the food can be cooked before it is placed into the packaging container. Water bath, shower, steam, hot air and microwave ovens are used for such precooking. Precooking can be avoided if the food can be cooked subsequently, during sterilisation.

Achieved environmental benefits

Reduced water and energy consumption. Reduced waste water generation and pollution.

Operational data

In the fish sector, medium-sized and large fish are cooked, e.g. before canning, Small fish such as sardines are canned whole and are then cooked in the cans during sterilisation. The circumstances which enable precooking to be avoided and cooking to take place during the sterilisation step depend on factors such as the size of the food pieces; the size of the cans, bottles or jars; the recipe; ensuring the quality of the product and the length of the sterilisation time.

Applicability

Widely applicable in the FDM sector, for foods that are intended to be preserved cooked.

Automated filling incorporating recycling of spillages

Description

For foods that are preserved in liquids, automated filling systems for seasonings can be used incorporating closed-circuit recycling of spilled liquids, such as sauce, brine or oil.

Achieved environmental benefits

If hot water can be re-used, there is a reduced consumption of water and energy. Reduced waste water contamination.

Operational data

When canning fish, the cans are filled with brine, sauce or oil. Seasoning liquids can spill giving rise both to a pollution load in the waste water and resulting in an under-use of processing materials if they are not recovered. Contamination of water, e.g. in the steriliser, due to spilled material on the sides of cans reduces the possibilities to re-use that water.

Applicability

Widely applicable, e.g. in preservation of meat, fish, crustaceans, molluscs and vegetables in cans, bottles and jars.

Driving force for implementation

Reduced water consumption and savings in waste water treatment.

Continuous sterilisation after filling of cans, bottles and jars

Description

Continuous sterilisers enable close control over processing conditions and so produce more uniform products. They produce gradual changes in pressure inside the cans, bottles and jars and, therefore, less strain on the seams compared with batch equipment. Continuous sterilisers, e.g. cooker-coolers, can vary slightly in design and size and operate continuously. Some models can accommodate up to 25000 cans, bottles or jars. They carry them on a conveyor through three sections of a tunnel that are maintained at different pressures for preheating, sterilising and cooling. The food can be cooked during preheating and sterilising.

Achieved environmental benefits

Reduced water and energy consumption. Reduced waste water generation.

Cross-media effects

The waste water may contain some traces of oil, sauces and brines after sterilisation, if the cans, bottles or jars have not been cleaned properly first.

Operational data

When using a continuous steriliser, e.g. cooker-cooler, the water is re-used continuously and water is added, as required, to replace the minimal evaporation loss, thereby controlling the amount of water and energy consumed. The water is re-used for cleaning when it can no longer be used in sterilisation. The main disadvantages of continuous sterilisation include a high in-process stock which would be lost if a breakdown occurred, and in some, problems with metal corrosion and contamination by thermophilic bacteria may occur, if adequate preventive measures are not taken.

Applicability

Widely applicable in the FDM sector, e.g. in the preservation of meat, fish, crustaceans, molluscs, vegetables, milk, beer and oil.

For further details see Chapter 4.2.8 of the FDM BREF document.

1.3.4 Evaporation

Drying and evaporation are **often the main energy using processes within the FDM sector**. In some existing installations, complex combinations of different techniques are applied for various individual unit operations. Evaporation is widely applied to increase the solids content of liquids. Sometimes this is done as a preliminary step before drying, which can be done using a wide variety of techniques. Theoretically, for the evaporation of water 0.611 kWh/kg (2.2 MJ/kg) is required. In practice, this very much depends on the method of evaporation and the type of drier used and it can range from 0.556 – 0.972 kWh/kg (2.0 – 3.5 MJ/kg). The energy consumption for drying can be less if the dry substance content of the wet material is higher. This can be achieved by pre-evaporation or by using special dewatering equipment such as presses or centrifuges. Steam driers can have considerably lower energy consumption if they consist of more stages. Sometimes exhaust gases from combustion CHP equipment are used to dry the products, thereby reducing the energy requirement.

Multistage evaporation

Description

Evaporators may operate singly, or evaporation may take place in stages using several evaporators operating in series. Each evaporator is referred to as an effect. With multi-effect evaporator systems, the product output from one effect in the evaporator is the feed for the next effect, and the high temperature vapour that is removed from one effect of the evaporator is used to heat the lower temperature product in the next evaporator effect.

The surfaces within the evaporator are heated by steam, which is injected into the top of the evaporator space. This uses fresh steam or exhaust gases from other operations to boil off water vapour from the liquid in the first stage and is an example of energy recovery/re-use.

The evaporated water still has sufficient energy to be the heat source for the next stage, and so on. Vacuum is applied in a multi-effect chain to enable the water to boil off. The liquid being processed is passed through a series of evaporators so that it is subject to multiple stages of evaporation. In this way, one unit of steam injected in the first evaporator might remove three to six units of water from the liquid. The energy savings increase with the number of evaporation stages. Up to seven stages can be operated in series, but three to five is more common. In the final stage, cooling using cooling water may condense the vapour. Some of the vapours can be drawn off the evaporators to be used as heat sources for other process requirements.

In order to achieve further steam efficiency, the vapour leaving each evaporation stage can be compressed to increase its energy before it is used as the heating medium for the subsequent evaporator.

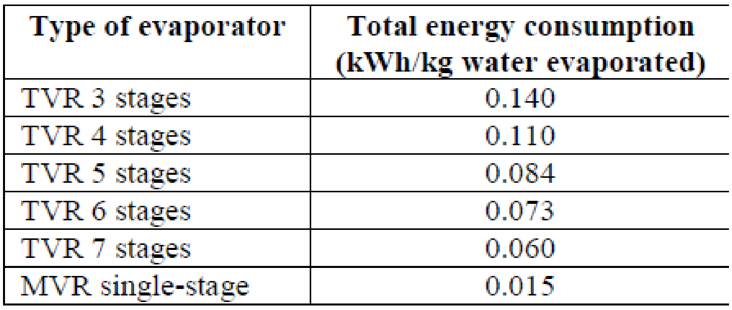
Achieved environmental benefits

Reduced energy consumption, e.g. by introducing evaporated vapours to the next stage of the evaporator in which the temperature is lower than the previous one.

Operational data

As the heat is used for the next evaporation stage, multistage evaporators save energy. In contrast, single-stage evaporation does not enable the heat to be recovered.

Steam requirements for single-stage evaporators are 1.2 to 1.4 t/t of evaporated water. The following table shows a comparison of energy consumption data for different numbers of evaporators using thermal vapour recompression (TVR). Further energy savings can be made using mechanical vapour recompression (MVR), as can also be seen in the table.



Type of evaporator	Total energy consumption (kWh/kg water evaporated)
TVR 3 stages	0.140
TVR 4 stages	0.110
TVR 5 stages	0.084
TVR 6 stages	0.073
TVR 7 stages	0.060
MVR single-stage	0.015

Table 1-26: Comparison of efficiencies of multi-effect evaporation in the dairy industry

Applicability

Applicable in the sugar industry; in starch processing; in tomato, apple and citrus juice concentration; and in the evaporation of milk and whey.

Vapour compression/recompression

By compressing exhaust vapours, it is possible to make major cuts in energy requirements for concentration processes in the FDM sector. For example, in wort boiling in breweries, the water vapour is given off when a solution is concentrated by condensation. The heat which is put in to evaporate the water and concentrate the solution, can be recovered by condensing the vapour that is driven off. Some common types of compressors used are rotary compressors, screw compressors, radial-flow turbo compressors and blowers.

To enable the heat of condensation stored in the vapour to be used to provide additional heat for the concentration process, condensation of the vapour must take place at a temperature higher than the boiling point. To raise the condensation temperature, the vapour is compressed by 0.1 - 0.5 bar (0.1

– 0.5 hPa). A heat-exchanger is then used to return the heat of condensation from the compressed vapour to the concentration unit.

Apart from the energy needed to drive the compressor, no further energy input is required. The ratio of recovered energy to energy input, i.e. the performance figure, may be as high as 40. In addition to saving energy and reducing energy costs, another important reason for condensing vapours is to reduce odour emissions.

The feasibility of installing vapour compressing techniques greatly depends on the investment costs and the payback due to lower operating costs. Different and changing energy costs in different countries may also influence the decision. In some sectors, operation is seasonal, e.g. 50 days for tomatoes and, therefore, the length of the campaign is also an important factor.

Mechanical vapour recompression (MVR)

Description

The evaporated vapour is compressed by a mechanical compressor and then re-used as a heat source. The latent heat is higher than the power input of the compressor and a large COP is available. With MVR, all the vapour is compressed, so a high degree of heat recovery is achieved. The system is driven by electricity, but needs a steam heated “finisher” to attain high temperatures. Two types of compressors are in operation, i.e. a fan and a high speed turbine. In practice, the fan is the most widely used compressor type as it has better energy efficiency.

Achieved environmental benefits

Reduced odour emissions. Reduced energy consumption compared to TVR (see Section 4.2.9.2.2). Reduced cleaning requirements due to less build-up of burned product.

Cross-media effects

Electricity is needed to power the vapour compressor. MVR generates noise, so sound insulation is required.

Operational data

It is reported that the energy consumption of an MVR evaporator is approximately 10 kWh/t of water evaporated, with negligible steam consumption. As all of the vapour is recompressed, rather than just a portion of it, as is the case with TVR evaporators, a higher degree of heat recovery is achieved. Also, a lower evaporation temperature is needed, which means less product burnout. Table 1-26 shows that higher energy savings can be undertaken using MVR compared to TVR.

An example Japanese dairy upgraded its milk powder process and installed a 4 stage MVR evaporator to replace its existing 4 stage TVR evaporator. When the MVR system was adopted, it was necessary to both maintain the designed evaporation capacity and to prevent milk being scorched and contaminating the surfaces of the heat transfer pipes in the evaporator. A falling film evaporator and an automated control system to control operating parameters, e.g. flowrate, temperature and pressure, were installed. The MVR has operated successfully with an overhaul every 2 years. Savings in the operating costs of up to 75 % were achieved, mainly as a result of the reduced steam consumption.

In an example Finnish dairy, an MVR system draws all the vapour out of the evaporator and compresses it using mechanical energy before returning it to the evaporator. No thermal energy is supplied, except for the steam required for the start-up. The only electricity required is for the operation of the evaporator. In this installation, the MVR can evaporate 100 – 125 kg of water using 1 kW of energy.

In an example brewery in Germany, the vapour condensation system draws off the boiling vapours produced by the wort boiling process from the whirlpool pan and compresses them with MVR. The compressed vapours are re-used as a heating medium for the boiling process. The advantages of condensing the vapours include reductions in the heat and water losses, improvements in the hot water balance of the operation and reduction in odour emissions. It is reported that approximately 1/3 of the electrical energy consumed by the brewhouse has to be used to drive the vapour compressor system.

Applicability

Applicable in sugar manufacturing; starch processing; tomato, apple and citrus juice concentration; brewing and in the evaporation of milk and whey. Most new evaporators are equipped with an MVR system.

Economics

As MVR systems are driven by electricity rather than steam, operating costs are considerably lower compared to TVR. For example, the operating costs of a 3 stage MVR evaporator are approximately half of those of a conventional 7 stage TVR evaporator. The difference in running costs for TVR and MVR increases with the capacity of the evaporator.

In the example Japanese dairy, the cost of the new MVR evaporator was EUR 1.5 million, compared with EUR 1.3 million for a new TVR evaporator. At an evaporation rate of 30 t/h, the annual operating costs of the MVR evaporator was EUR 175000, compared with previous annual operating costs of EUR 680000 for the TVR evaporator, i.e. savings of nearly 75 %.

Example plants

Dairies in Japan and Finland and a large brewery in Germany.

Thermal vapour recompression (TVR)

Description

TVR makes use of steam injection compressors to compress the vapour. Steam injection compressors may have fixed or variable injection nozzles. The thermal energy needed for compression is live steam from a boiler.

The live steam passes through the injection nozzle and is throttled to the pressure level of the receiving vapour. Vapour is entrained as a result of the difference in speed. Vapour and live steam are mixed in the mixing chamber. Changing the flow aperture in the diffuser determines the pressure at which the mixed steam leaves the steam injection compressor.

Achieved environmental benefits

Reduced odour emissions.

Cross-media effects

Higher energy consumption than MVR.

Operational data

By comparison with MVR, TVR offers advantages of having no moving parts and greater reliability in operation. It is reported that TVR allows for long production cycles and a reduction in cleaning frequency.

Applicability

Applicable in sugar manufacturing; starch processing; tomato, apple and citrus juice concentration; brewing and in the evaporation of milk and whey.

Economics

Lower purchase cost but higher operating costs than MVR.

For further details see Chapter 4.2.9 of the FDM BREF document.

1.3.5 Cooling

For further information see ‘Cooling BREF’.

Using a plate heat-exchanger for pre-cooling ice-water with ammonia

Description

Ice-water is used as a cooling medium, e.g. for cooling milk and vegetables. The amount of energy consumed for the production of ice-water can be reduced by installing a plate heat exchanger to pre-cool the returning ice-water with ammonia, prior to a final cooling in an accumulating ice-water tank with a coil evaporator. This is based on the fact that the evaporation temperature of ammonia is higher in a plate cooler than when evaporator coils are used, i.e. -1.5 ºC instead of -11.5 ºC.

Achieved environmental benefits

Reduced energy consumption.

Cross-media effects

Using ammonia involves safety risks. Leakages can be prevented by proper design, operation and maintenance.

Operational data

It is reported that the capacity of an existing ice-water system can be increased without the need to increase the compressor capacity by installing a plate cooler for pre-cooling the returning icewater. In an example dairy, this pre-cooling system saved almost 20 % of electricity when installed in an existing ice-water system.

Applicability

This cooling system is commonly applied in new installations, but it can also be applied in existing installations.

Economics

The price depends on the existing ice-water system and capacity. In an example dairy, the investment costs were estimated to be approximately EUR 50000, including a plate cooler, a pump, valves, regulators, pipework and installation.

Driving force for implementation

Reduced consumption of electrical energy and/or increased cooling capacity, without the need for an investment in a new ice-water tank.

Using cold water from a river or lake for pre-cooling ice-water

Description

Ice-water is used as a cooling medium, e.g. for cooling milk and vegetables. Cold water from a river or lake can be used for pre-cooling ice-water.

Achieved environmental benefits

The electrical energy consumption is reduced to some extent, depending on the temperature of the river-water.

Cross-media effects

Energy is needed for pumping the water to the cooling tower. The river-water returns unpolluted but with a slightly increased temperature.

Operational data

In an example dairy, cold river-water is pumped into a cooling tower, where the warm water of a closed ice-water system is pre-cooled prior to final cooling in a an ice-water tank. The river water is then led back into the river. The system saves cooling energy corresponding to a temperature decrease of 7 – 10 ºC.

Applicability

Applicable when the installation is located near a river with cold water.

Economics

The system requires pipelines from the river and back, as well as an efficient pumping system and a storage tank. An example dairy reports investment costs of approximately EUR 230000 and annual savings of approximately EUR 23000.

Driving force for implementation

Reduced energy costs.

For further details see Chapter 4.2.10 of the FDM BREF document.

1.3.6 Freezing

For related techniques under refrigeration, see Section 4.2.15 of the FDM BREF.

Energy efficiency in deep freezing

The **major energy savings can be achieved in cooling and freezing**. Savings are possible by correct adjustment of the working parameters, such as the evaporator temperature, conveyor belt speed and blower power in the freezing tunnel. These depend on the product being processed and the throughput. The consumption of energy in electrical systems in the freezing tunnel can be kept as low as possible by opting for frequency converters on the blowers, on the distributor conveyor and by installing high efficiency low energy lighting.

Lowering condensation pressure

Description

The efficiency or the COP of the freezer unit is mainly determined by the evaporator pressure and the condensation pressure. The reduction of condensation pressure raises the COP and lowers the electricity consumption. The condensation pressure is kept as low as possible by providing sufficient condenser units.

Achieved environmental benefits

Reduced energy consumption.

Applicability

Applied in the deep freezing and refrigeration of packaged and unpackaged food products.

Lowering condensation temperature

Description

The reduction of condensation temperature raises the COP and lowers the electricity consumption. This reduction can be achieved by fitting an adequate capacity of condenser batteries so that, even in summer, which is high season for the vegetable sector, sufficiently low condensation temperatures can be achieved.

Low temperatures can also be achieved by keeping the condensers clean and replacing badly corroded ones. Blocked condensers cause the condensing temperature to increase and the cooling capacity also drops, so the required temperature may not be achieved.

Ensuring that air entering the condensers is as cold as possible also contributes to lowering the condensation temperature. The warmer the air entering the condenser then the higher the condensing temperature is. This can be minimised by shading the condensers if necessary, ensuring that warm air is not recirculated, removing anything which obstructs the airflow and freezing at night.

Achieved environmental benefits

Reduced energy consumption.

Operational data

Lowering the condensation temperature by 1 ºC raises the COP by 2 %. Lowering the condensation temperature by 5 ºC causes the electricity consumption to fall by 10 %.

Applicability

Applied in the deep freezing and refrigeration of packaged and unpackaged food products.

Raising evaporation temperature

Description

Raising the evaporation temperature improves energy performance. To do this, a simultaneous optimisation of various freezing tunnels can be carried out. This optimisation needs to be undertaken again after a tunnel is shut down, a different product is processed and another flowrate is set.

Achieved environmental benefits

Reduced energy consumption.

Operational data

It is reported that if the evaporator temperature is raised by 1 ºC, the COP rises by 4 % and the refrigeration capacity rises by 6 %. A Flemish study on energy consumption during the freezing of vegetables in a freezing tunnel showed that the greatest savings can be achieved by adjusting the evaporator temperature, the residence time of the vegetables in the freezing tunnel, the air flowrates relative to the vegetable flowrate and the type of vegetables. This study shows that it is not always necessary to set the evaporator temperature at the lowest level, i.e. -40 ºC, for good freezing quality. Furthermore, it is very important to monitor the temperature of the product after it has gone through the freezing tunnel. Low temperatures, i.e. <-18 ºC, are not necessary as the vegetables will ultimately be stored in a confined space at -18 ºC. High temperatures, i.e. >-16 ºC, lead to lower freezing qualities. In a worst case scenario, the whole mass can freeze together during storage in crates.

For more information see Chapter 4.2.11.4 of the FDM BREF.

Applicability

Applicable to the deep freezing of packaged and unpackaged food products.

Using high efficiency motors and driving fans

Description

The motors for driving the fans are set up in the freezing tunnel. The electrical energy supplied to the motors must, therefore, be dissipated by the freezer unit. By opting for high efficiency motors for driving the fans, not only is there a direct saving in electricity, e.g. lower consumption by the fans, but also an indirect saving, e.g. through the lower cooling load on the refrigeration unit.

Achieved environmental benefits

Reduced energy consumption.

Applicability

Applied in the deep freezing of packaged and unpackaged food products.

Reducing the fan output during short production stops

Description

When freezing food, there are regularly problems with the supply to the freezer in a processing step or when switching from one product to another. During these periods, it is nevertheless important to keep the empty freezing tunnel at a sufficiently low internal temperature. For this to occur, the fans need to be kept running, but the air flowrates can be reduced. To do this, motors with regulated rotation speeds can be switched to the lowest possible frequency. In addition, a number of fans can be switched off. This reduces the energy consumption of the fans and of the refrigeration unit.

Achieved environmental benefits

Reduced energy consumption.

Operational data

Any reduction in the fan power by 1 kW_e results in a total saving of 1.4 – 1.6 kW_e.

Applicability

Applied in the deep freezing of packaged and unpackaged food products.

Operating without automatic defrosting during short production stops

Description

When freezing food, there are regularly problems with the supply to the freezer in a processing step or when switching from one product to another. During these periods, it is nevertheless important to keep the empty freezing tunnel at a sufficiently low internal temperature. To reduce energy consumption during these stops, the automatic defrosting of the evaporators can be switched off as, in an empty freezing tunnel, there is little or no transport of moisture or water, e.g. water is only transported with the food entrance and exit. This avoids re-cooling the evaporator after defrosting.

Achieved environmental benefits

Reduced energy consumption.

Operational data

An example evaporator weighs approximately 2 tonnes and is made of steel. To cool this mass again from 15 to - 35 ºC takes about 13.33 kWh (48 MJ) of refrigeration. Thus, switching off the automatic defrosting during short production stops yields a saving in the compressor consumption, i.e. savings of 5 to 9 kWhe can be made per evaporator that is not defrosted.

Applicability

Applied in the deep freezing of packaged and unpackaged food products.

For further details see Chapter 4.2.11 of the FDM BREF document.

1.3.7 Energy generation and consumption

Combined heat and power generation (CHP)

Description

Combined heat and power (CHP) generation, also known as co-generation, is a technique through which heat and electricity are produced in one single process. In-house combined generation of heat and power can be used in food manufacturing processes for which heat and power loads are balanced. For example, sugar manufacturing requires electrical and thermal energy in every step of the process. Electricity is needed for lighting, for plant process control, and as the driving power for machinery. Steam and hot water are needed for heating process vessels and buildings. As the size of dairies increases, the amounts of thermal and electrical energy needed for evaporation/drying steps is growing, making CHP a feasible alternative.

Achieved environmental benefits

Reduced energy consumption and air emissions, e.g. NO_x, CO_2 and SO_2.

Operational data

The energy efficiency of CHP can be as high as 90 %. This optimises the use of fossil fuels and reduces the production of CO_2. New CHP installations save at least 10 % of the fuel otherwise used in the separate production of heat and electricity. Furthermore, gas-fired CHP schemes can eliminate SO_2 emissions and NO_x can be controlled to meet environmental legislation. Modern CHP equipment is likely to require less effort to operate and maintain than many older boiler systems, as they are equipped with automatic control and monitoring systems.

It is reported that most of the energy required in sugar manufacturing is obtained by burning gas, heavy fuel oil or coal in a boiler house, which converts it, by means of CHP equipment, into steam and electricity. In this sector, the overall fuel utilisation factor of CHP exceeds 70 % and is typically above 80 %. This fuel conversion efficiency greatly exceeds that of any design of commercial power stations whose steam is not used further, including even the latest generation of combined cycle gas turbines, which are around 55 % efficient. Excess electricity produced may be sold to other users.

In the dairy sector, it is reported that CHP is a good option as evaporation/drying steps need both electricity and thermal heat in large amounts. For example, CHP is widely used during whey and milk drying, where high steam temperatures and pressures are needed, e.g. 220 - 240 ºC and 32 – 34 bar. Losses in the pipe system must also be taken into consideration, so that steam generation must occur at 40 bar minimum. CHP on the basis of a back pressure steam turbine is used. In this type of CHP equipment, the steam pressure difference in the back pressure steam turbine generates mechanical energy for the propulsion of an electric generator. Before whey and milk drying, lower steam temperatures and pressures are needed. This low pressure steam can be provided either by steam pressure reduction with throttle valves or by CHP on the basis of a back pressure steam turbine. The CHP option is more energy efficient as steam pressure reduction with throttle valves “destroys” energy.

If drying is not carried out in the dairy and the required steam temperatures and pressures are considerably lower, the back pressure steam turbine is not useful because the steam pressure head is too small which results in poor efficiency. In these cases, block-type thermal power stations with gas or diesel engines, or CHP equipment with gas turbines and downstream waste heat boilers, are reported to be more appropriate. Figure 4.18 of the FDM BREF shows Sankey diagrams comparing energy efficiencies in a conventionally operated gas turbine and generator and CHP equipment in a dairy.

In an example brewery, a CHP system generates electrical power using a 4000 kW_e gas turbine generator. High pressure steam at 1.5 MPa is produced from exhaust gas from the turbine using an 11 t/h exhaust gas boiler. This steam merges with high pressure steam from existing boilers, and runs a back pressure steam turbine-driven refrigerating machine with a 734 kW_{th} capacity. Exhaust steam from the back pressure turbine, with a pressure lowered to 0.6 MPa, is used as the heat source driving an ammonia absorption refrigerating machine with a 1.93 kW_{th} capacity, which supplies a secondary refrigerant, e.g. brine, used for cooling beer. The system thus makes cascading use of energy from steam and reduces the brewery’s electrical demand by 820 kW in total, 220 kW for the steam turbine-driven engine and 600 kW for the ammonia absorption refrigerator. If the process is run batch wise, the demand for steam is not constant. In this case, if a steam turbine-driven refrigerator alone was used to produce energy to chill, its availability would largely depend on this unstable demand for steam. This system can reportedly be used in ice-cream manufacturing installations, as they also consume large amounts of electricity and energy to chill.

The previously described CHP system reduced the energy consumption of the brewery, e.g. electricity and fuel by 14 % and the electrical demand by 40 %. The gas turbine had a rated output of 4200 kW at 0 ºC and burned low CO_2 emitting natural gas in a low NO_x premixed lean-burn combustion system. The premixed lean-burn combustion enhances turbine efficiency by 2 – 4 % and reduces NO_x emissions to less than 50 ppm, i.e. half that of conventional systems where water or steam injection is used for NO_x emissions reduction. The system reduced NO_x emissions from the brewery by 14.8 % in comparison with a conventional system, and CO_2 emissions by 7.9 %.

It is also reported that gas engines using clean fuel and with high thermal efficiencies are suitable for small scale CHP equipment, i.e. 1000 kW or below. An example brewery installed a 596 kW gas engine with a cooling system that uses boiling water for steam recovery. The CHP was mounted on a vibration proof foundation together with a generator of 560 kW in combination with a steam and water drum, which recovers 1 kg/cm^2 low pressure steam directly from the engine’s cooling water. The exhaust gas from the engine is used to generate 8 kg/cm^2 medium pressure steam by a waste heat boiler and to preheat feed-water to the boiler by an economiser. The CHP is equipped with a NO_x removal three-way catalytic converter, a silencer and other necessary control systems, and can be monitored from a central control room. The reported environmental benefits include a power generation of 541 kW, low NO_x emissions and low noise. The power generating efficiency, the heat recovery efficiency and the overall efficiency of the CHP during 18000 operating hours are 31.3, 45.6 and 76.9 %, respectively.

The electricity generated by the CHP supplemented 25 % of the purchased power from an electric utility supplier and the steam also satisfied 6 – 10 % of the operational requirements of the brewery. The payback period is within 4 years.

Applicability

Widely applicable. The applicability of CHP very much depends on several technical aspects. Although CHP is a well established and technically mature technique, it is vital that the right design decisions are made. The main factors to consider are the consumption pattern of electricity and heat in the installation and the ratio between electricity and heat consumption. Additional important factors are whether the installation is running continuously and whether large variations in processes occur. A simple rule of thumb is that the site needs to have a simultaneous demand for heat and electricity for at least 4000 hours a year.

Economics

A decision on whether to implement CHP based on investigation of the economic aspects will take account of the price of gas and electricity. A balance of relatively expensive gas or other fuels and cheap electricity mitigates against the selection of CHP. For example, if electricity prices fall or gas prices rise, the financial return from CHP will decrease. This is possible in a free energy market. One option, which is sometimes applied, is to design the CHP installation on the basis of heat consumption with excess electricity being sold to the public grid. Whether this is an attractive option very much depends on the price obtained for the excess electricity that is sold.

With regard to financing of the CHP installation, the tendency is for companies to not finance it themselves. Sometimes joint ventures with energy suppliers are formed and sometimes third parties completely finance the CHP installation. A contract for delivery of electricity and heat by the CHP installation normally runs for 10 to 15 years.

In the UK, it has been found that CHP can now reduce the total energy bills of an installation by 20 %. In the example brewery, the savings in energy costs were 16.2 %.

Example plants

Applied in sugar manufacturing installations, dairies, breweries and distilleries.

Efficiency of a heat generator

Efficiency is defined as the ratio of energy output to energy input of a process. The efficiency of a heat generator can be described as the ratio between the energy taken up by the fluid which carries the heat and the incoming energy of the fuel, estimated on the lower calorific power. The typical method for calculating the efficiency of the heat generator is the so-called “indirect method”. This method is based on the conventional evaluation of losses through perceivable heat in fumes, incomplete combustion and dispersions from the heat generator walls.

For the evaluation of losses to the chimney and of losses as a result of incomplete combustion, the recourse is generally to measure two of the following parameters, i.e. O_2, CO_2 and CO, and to use these to work out percentage losses by means of an Ostwald combustion diagram.

Losses due to dispersions through the heat generator walls are generally constant with the variation in load and may be evaluated by means of diagrams supplied by boiler manufacturers.

The controls to be carried out to monitor efficiency are the following:

- analyses of fumes and O_2
- use of the fuel and of the air combustion

- pressure, temperature and capacity of the heat carrying medium in the heater, e.g. diathermic oil, and the thermal carrier fluids to the users, e.g. steam or superheated water.

Improving the efficiency of a heat generator

Description

The efficiency of a heat generator may be improved by reducing losses or by increasing the efficiency of the transfer of heat by the heat carrying medium. To reduce losses in the fumes, the temperature of the fumes to the chimney can be lowered, so reducing losses in the form of perceivable heat. Also, the excess air can be regulated to match the needs based on the flow of incoming fuel, to reduce the losses as a result of incomplete combustion.

Achieved environmental benefits

Reduced energy consumption and air emissions.

Operational data

In an example pasta installation, to reduce heat losses through the chimney, i.e. which represented about 50 % of the total losses, the temperature of the fumes to the chimney was lowered. The excess air was regulated to prevent incomplete combustion. In existing installations, efficiencies could rise from 85 to 90 % with a reduction in CO_2 emission levels from 5.5 to 6.5 %. In new installations, the efficiencies could be higher than 91 % with a reduction in CO_2 emission levels greater than 7.6 %.

In addition, by preheating the combustion air by means of fume recovery, a 2 % increase in efficiency per every 50 ºC decrease in the temperature of the fumes was achieved. The temperature of preheated air generally varies between 170 and 200 ºC.

For existing heaters with correct combustion, efficiencies of 90 % can be achieved. For new heaters using diathermic oil with fume recovery that preheats the combustion air, efficiency values of 92 % under conditions of economic load and 91 % under conditions of maximum load, can be achieved.

Applicability

Applicable to both new and existing FDM installations.

Economics

The cost of implementation is low for existing installations, but high for new installations.

Insulation of pipes, vessels and equipment

Description

Insulation of pipes, vessels and equipment such as ovens and freezers can minimise energy consumption. Insulation can be optimised by selecting effective coating materials with low conductivity values and high thickness and by using pipes, vessels and equipment that are insulated prior to installation. Pre-insulation has the advantage that, e.g. the pipe supports are mounted outside of the insulation coating instead of being directly connected. This reduces the heat loss through the mounts.

Insufficient insulation of pipework can lead to excessive heating of the surrounding process areas as well as the risk of burn injuries.

Achieved environmental benefits

Reduced energy consumption and associated fuel consumption and air emissions.

Operational data

Insulation of pipes and tanks can reduce the heat/cold loss by 82 – 86 %. Additionally, 25 - 30 % heat can be saved by using pre-insulated pipes instead of traditionally insulated ones. Hot and cold products are stored and pumped in dairies. In an example new dairy in Denmark, all of the pipes with a temperature difference of at least 10 °C above ambient temperature were fitted with 30 mm insulation. Tanks were coated with 50 mm insulation. Pre-insulated pipes were used with a coating of mineral wool wrapped in a metal sheet. More than 9 km of pipework and 53 tanks were insulated. The calculated savings in energy were 6361 MWh/yr heating energy and 2397 MWh/yr cold energy, i.e. the equivalent of 479 MWh/yr electricity.

In an example Italian pasta installation, the energy dissipated all along pipework was investigated and the insulation was improved. In three cases, the thermal resistance was increased from 0.22 to 0.396, 0.574 and 0.753 m^2.ºC/W. This resulted in CO_2 emission reductions of 44.4, 61.6 and 70.7 %, respectively.

Applicability

Applicable to all FDM installations, whether new or existing. Pre-insulated pipes are applicable in new installations and where pipework, vessels and equipment are replaced.

Economics

In the example new Danish dairy, the investment cost was about EUR 1408000 with a payback period of 7.6 years.

Driving force for implementation

Reduction in energy costs.

Heat pumps for heat recovery

Description

The working principle of a heat pump is based on heat transfer from a lower temperature to a higher temperature by aid of electrical power. For example, the recovery of heat from warm cooling water. The cooling water is cooled and the heat can be used for heating hot water.

Achieved environmental benefits

Reduced energy consumption, e.g. heat recovery.

Cross-media effects

Heat pumps require electricity.

Operational data

It is reported that in 1997 there were more than 16 food companies in Australia using over 30 heat pump driers for LTD of food materials. The heat pump drier consists of a conventional drying chamber with an air circulation system and the usual components of an air conditioning refrigeration system. The drying air is dehumidified by an evaporator, which is the cooling section of the refrigeration cycle, and reheated by the condenser of the heat pump. The energy efficiency expressed by a specific moisture extraction rate, i.e. kg water removed/kWh energy used, is between 1 – 4, with an average of 2.5 kg/kWh. FBDs are not suitable for sticky materials or if the shape is irregular. The two driers can be used in series. Dehumidified air from the heat pump is directed first to the fluidised bed with the semi dried product. The airflow then passes through the cabinet drier. It is reported that using this combination, energy efficiency can be improved by up to 80 %.

Applicability

A good heat source is needed in combination with a simultaneous need for heat near the source.

Economics

The economic feasibility depends on the price of fuel in relation to that of electrical power.

Driving force for implementation

Reduced costs for energy and water.

Example plants

Several food companies in Australia.

Heat recovery from cooling systems

Description

Heat can be recovered from cooling equipment and compressors. This involves the use of heat exchangers and storage tanks for warm water. Depending on the cooling equipment, 50 – 60 ºC temperatures can be achieved.

Achieved environmental benefits

Reduced energy consumption, e.g. heat recovery.

Operational data

It is reported that recovered heat can be used for heating tap water or ventilation air, thawing deep frozen goods, or preheating the cleaning liquids or the product. The installation of a heat recovery system in the cooling unit of a Nordic dairy, which included both screw and piston compressors with a cooling capacity of 3200 kW, resulted in energy savings of about 1200000 kWh/yr.

Applicability

Widely applicable in new installations. The lack of space can be an obstacle for existing installations. The technique is economically feasible in installations with deep freeze storage, as normal cold storage does not produce sufficient quantities of heat during winter time.

Economics

Reduced energy costs. The investment cost in the Nordic dairy example above was about EUR 160000 with a payback period of 6.3 years.

Example plants

A dairy in a Nordic Country.

Switch off equipment when it is not needed

Description

Many simple, no cost and low cost energy saving measures are those that individual employees can take, for example switching off equipment, such as compressors and lighting. Pumps and fans that circulate cold air, chilled water, or an antifreeze solution generate heat, contributing most of the power they consume to the cooling load, so switching them off when not required saves energy. This is also true for lights in a coldstore or cooled room, as they contribute most of the power they consume to the cooling load.

The switching can be timed according to a fixed programme or schedule. Conditions can be monitored to detect, e.g. high or low temperatures, and switch off motors when they are not needed. The load of a motor can be sensed, so that the motor is switched off when idling.

Achieved environmental benefits

Reduced energy consumption.

Applicability

Widely applicable in the FDM sector.

Economics

Reduced energy costs.

Driving force for implementation

Reduced energy costs.

Reduce the loads on motors

Description

Motors and drives are used to operate many mechanical systems in industrial processes. The load on motors and drives can be reduced by ensuring that regular servicing and basic maintenance steps such as lubrication of machinery are undertaken.

If the following points are ticked, the loads on motors can be minimised:

- is the machine that the motor is driving efficient?
- is the system doing a useful and necessary job?
- is the transmission between motor and driven equipment efficient?
- are the maintenance programmes adequate?

- have losses due to, e.g. the pipework, ducting and insulation been minimised?
- is the control system effective?

Achieved environmental benefits

Reduced energy consumption.

Applicability

Applicable where motors are used.

Economics

Reduced energy costs.

Driving force for implementation

Reduced energy costs.

Minimise motor losses

Description

Motor losses can be minimised by:

- specifying higher efficiency motors where feasible
- when a motor fails, ensuring that proper care and attention is given in the repair process so as to minimise energy losses
- avoiding the use of greatly oversized motors
- considering permanent reconnection of the motor electrical supply in star-phase, as a no cost way of reducing losses from lightly loaded motors
- checking that voltage imbalance, low or high supply voltages, harmonic distortion or a poor power factor is not causing excessive losses.

Achieved environmental benefits

Reduced energy consumption.

Applicability

Applicable where motors are used.

Economics

Reduced energy costs.

Driving force for implementation

Reduced energy costs.

Frequency converters on motors

Description

Controlling the speed of the pump motor by frequency converters ensures that the speed of the impeller is exactly adapted to the required output of the pump, as are the power consumption and treatment of the liquid.

Achieved environmental benefits

Reduced energy consumption.

Operational data

The reduction of the power consumption depends on the capacity and number of pumps and motors. Generally, a 10 % reduction in the output of a pump corresponds to a 28 % reduction in the power consumption of the pump.

In an example German instant coffee manufacturer, the consistent implementation of frequency converters for all large electrical motors, allowed them to be adjusted in a way that suited the output and electricity peaks during start-up processes were avoided.

In a Danish dairy, 203 motors were equipped with frequency converters. The total power of the motors was 1216 kW. The estimated cost of the investment was EUR 311000. The estimated annual saving is EUR 90000 (1325000 kWh).

A whey products company processes whey into several raw materials for use in pharmaceuticals and foods. One of the products is lactose, the production of which involves a refining process, in which “wet” lactose (9 % pure) is dissolved in hot water in a circular process. Wet lactose is transported through a shaking tray to a mixing vessel, where it is mixed with hot water. The mixture is pumped into a buffer vessel, where it is stirred, and from which it is returned to the mixing vessel. Thus, the lactose content of the mixture gradually increases. After approximately 1 hour, the mixture is discharged from the mixing unit for further processing. The liquid level in the mixing vessel used to be controlled by regulating the water/lactose flow from the buffer tanks. This was achieved by a choke valve on the delivery side of the centrifugal pump used for the transport. This choke system had several disadvantages, e.g. it was inefficient causing unnecessary dissipation of electric energy and it caused unnecessary wear of the pump. The system was replaced with a speed control system on the motor driving the pump. This resulted in energy savings amounting to 12600 kWh/yr, with a value of NLG 1638 (1994), a reduction in maintenance costs of NLG 10257/yr (1994) and a payback period of 0.3 years.

In an example brewery, compressed air (6 bar) is produced by six screw-type and seven piston compressors. One screw type compressor is run as a frequency controlled machine and all compressors are centrally controlled. The advantage of this technology is that the pressure in the supply system does not fluctuate by more than +/- 0.05 bar. The system pressure can be reduced by 0.2 bar. It is reported that an electricity saving of approximately 20 % can be achieved by avoiding compressor idle time. Maintenance costs can be reduced by about 15 %. It is not possible to quantify the cost benefit resulting from the reduction in system pressure.

Applicability

Frequency converters can be used with standard three-phase motors. They are available for both manual and automatic speed controls. They can be applied in existing and new installations for pumps, ventilation equipment and conveying systems. It is reported that frequency converter driven motors should not exceed 60 % of the total energy use of the installation because they can have an adverse effect on the electricity supply and can lead to technical problems.

Economics

The price of a 5.5 kW frequency converter is about EUR 600.

Driving force for implementation

Reduced consumption of electrical power and a more gentle treatment of the product.

Use variable speed drives to reduce the load on fans and pumps

Description

Motive power in particular can make a significant contribution to energy consumption in industrial processes. The capital cost of a higher efficiency motor is no more than a standard quality motor but the efficiency gain of 2 – 3 % makes significant savings over the motor’s life.

In addition, the use of variable speed drives to reduce the load on fans and pumps is a much more energy efficient method of regulating flow than throttles, dampers or recirculation systems.

Achieved environmental benefits

Reduced energy consumption.

Applicability

Applicable to all FDM installations where fans and pumps are used.

Economics

Reduced energy costs.

Driving force for implementation

Reduced energy costs.

For further details see Chapter 4.2.13 of the FDM BREF document.

1.3.8 Water use

Only pump up water that is required

Description

By only pumping up the quantities of water that are actually required in the production process, the impact on groundwater levels is minimised and energy is saved. Water can be extracted on demand to avoid excessive storage and the risk of water being wasted, either through contamination or leakage.

Achieved environmental benefits

Reduced water and energy consumption.

Applicability

Applicable in areas where groundwater is extracted.

Driving force for implementation

Local shortages of groundwater.

For further details see Chapter 4.2.14 of the FDM BREF document.

1.3.9 Refrigeration and air conditioning

Optimising air conditioning and cold storage temperatures

Description

Not cooling air conditioned rooms and coldstores to a temperature below that necessary reduces energy consumption without compromising food quality. Coldstores are often held at lower temperatures than necessary because of worries about failure. Having a coldstore at a lower temperature than necessary makes it more likely that failure will occur.

It is reported that keeping controls simple and getting settings right can be a big step towards making a refrigeration plant operate as efficiently as possible by, e.g. setting the thermostat to achieve the best energy efficiency for the installation without compromising reliability. Marking the normal readings on gauges helps the early detection of equipment malfunction. Automatic controls can be used to switch off the refrigeration plant and/or lights when they are not required. Lights and motors in cooled spaces not only use electricity, but because they generate heat they contribute to the energy required to decrease the temperature to that required. If they can be removed where unnecessary and switched off when not required, energy can be saved.

Achieved environmental benefits

Reduced energy consumption.

Applicability

Applicable in all FDM installations which have air conditioned spaces and refrigeration

equipment.

Driving force for implementation

Reduced energy costs.

Minimising transmission and ventilation losses from cooled rooms, coldstores and freezing tunnels

Description

To reduce transmission and ventilation losses in the freezer unit, the following measures can be undertaken:

- keep doors and windows closed as much as possible
- fit fast-closing and effectively insulating doors between areas with different temperatures
- limit door size to the minimum necessary for safe access

- maintain good sealing around doorways. Build-up of ice around openings indicates poor sealing
- do not load materials in the doorway
- cool the area in front of the cooling room
- if a door has to be used regularly, fit a strip curtain
- restrict ventilation by fitting the passage between the loading/unloading space of the vehicle and the storage area with an effective seal
- limit air movements when doors and hatches are opened
- apply adequate thermal insulation and screening of freezing tunnels from their surroundings
- refrigerate at night, when the ambient temperature is lowest.

Achieved environmental benefits

Reduced energy consumption. In some cases, there may also be reduced odour and noise emissions.

Applicability

Applied in the deep freezing of packaged and unpackaged food products and air conditioned rooms.

Economics

In 2001, it was reported that an open door cost GBP 6/h for a freezer store and GBP 3/h for a chill store.

Regularly defrosting the entire system

Description

Evaporators that operate below 0 ºC should be completely defrosted before ice starts to cover the fins. This may be every few hours or every few days. When the evaporator is iced-up, the evaporating temperature drops, increasing energy consumption. The capacity also drops and the required temperature may not be reached. If the defrost elements are not working properly, then the frost build-up on the evaporator will worsen. For this reason, it is also important to check that the evaporators defrost properly.

Achieved environmental benefits

Reduced energy consumption.

Operational data

A 1 ºC drop in the evaporating temperature can increase the running costs by 2 – 4 %. A defrost-on-demand system, which initiates a defrost when needed rather than by a timer, has reportedly reduced power consumption by 30 % in some applications.

Applicability

Applied in the deep freezing and refrigeration of packaged and unpackaged food products.

Optimisation of the defrosting cycle

Description

To optimise the defrosting cycle of the evaporators, the time between defrosting cycles can be adjusted. If the time between two defrosting cycles is too long, then the efficiency of the evaporator falls and the pressure drops via the evaporator. If the time is too short, then considerable heat is generated unnecessarily in the storage area.

Achieved environmental benefits

Reduced energy consumption.

Applicability

Applied in the deep freezing of packaged and unpackaged food products.

Automatic defrosting of cooling evaporators in cold storage

Description

The layer of frost formed on the surface of evaporators reduces their heat-exchange efficiency. Warm gas from compressors can be used for defrosting and to remove this layer. Energy savings depend on the capacity/number of the evaporators and the operating time of the frosted evaporators.

Achieved environmental benefits

Reduced energy consumption.

Operational data

In an ice-cream installation, five evaporators running for 3000 hours per year with an ice layer of 0.87 mm were equipped with an automatic defrosting system. As a result, approximately 100000 kWh/yr energy could be saved. The estimated investment cost was EUR 15000, with a payback of 2.2 years.

Applicability

Widely used in new installations and can easily be applied to existing operations.

Economics

Reduced energy costs. Short payback periods.

Use of binary ice as cooling fluid (secondary refrigerant)

Description

Binary ice can be used as a refrigerant fluid. Binary ice may be described as “liquid ice”. It comprises ice crystals of 10 – 100 am, in suspension in water, containing antifreeze. The antifreeze is either ethanol-based containing an anti-corrosion substance, or if the binary ice is for the immersion of food, common salt (sodium chloride).

For more information see Chapter 4.2.15.6 of the FDM BREF.

Achieved environmental benefits

Under comparable conditions, the coefficient of performance for binary ice is normally better than for conventional chilling and freezing plants, i.e. less power is consumed. Smaller refrigeration units are required, so fewer materials are needed and reportedly, because they do not have to be so chemically resistant, they can be simpler and better suited for recycling. As the entire installation is not filled with potentially harmful refrigerants, the probability and severity of an accidental release is reduced. Unlike other refrigerants, binary ice made from water and alcohol can normally be released to the WWTP, with the permission of the regulator. The properties of an ice crystal’s rapid phase change reportedly ensure excellent heat transfer. The surface can, therefore, either be reduced or the binary ice can be “warmer”, which results in lower energy demand and less surface freezing. The product weight loss is consequently less and defrost may even be unnecessary for air chillers. Fluid coolers can reportedly also be 20 to 50 % smaller.

Applicability

Applicable to all FDM installations.

Economics

For the slaughterhouse and meat processing example referred to above, the service life was 15 years. With an interest rate of 7 % and a depreciation time of 10 years, the additional direct investment costs could reportedly be recovered in 2.2 years and the annual operating costs of the binary ice plant, including depreciation, immediately recoverable. It is estimated that the payback time would be 10 to 15 years for typical Danish slaughterhouses.

It is reported that binary ice plants normally run at off-peak tariff or during times when there is a low overall electrical loading.

Driving force for implementation

The phase-out of ozone depleting chlorofluorohydrocarbons under the “Montreal protocol” and the expected pressure to reduce the use of hydrochlorofluorohydrocarbons by the “Kyoto protocol”.

For further details see Chapter 4.2.15 of the FDM BREF document.

1.3.10 Compressed air generation and use

Optimise pressure settings

Description

The pressure at the compressor can be set at the maximum required and then regulated at each individual application to minimise the energy required to produce compressed air and reduce leakage. For applications which require higher pressures or have longer operating hours than the majority of the applications which use compressed air, it may be more energy and cost effective to install a dedicated compressor.

Achieved environmental benefits

Reduced energy consumption and reduced noise, if large compressors run for shorter periods.

Applicability

Applicable where there is more than one use for compressed air in an installation.

Driving force for implementation

Reduced energy consumption and associated costs.

Optimise the air inlet temperature

Description

Compressors operate more efficiently using cool air. This is generally achieved by ensuring the air is taken from outside the building. This can be checked by measuring the drier inlet temperature, which should not exceed 35 °C with the compressors on full load. The temperature of the drier room should be within 5 °C of the outside ambient temperature. If the room temperature is too high, this lowers the compressor’s performance.

Achieved environmental benefits

Reduced energy consumption.

Driving force for implementation

Reduced energy consumption and associated costs.

For further details see Chapter 4.2.16 of the FDM BREF document.

1.3.11 Steam system

Maximise condensate return

Description

If hot condensate is not returned to the boiler it has to be replaced by treated cold make-up water. The additional make-up water also adds to water treatment costs. Instead of routinely discharging condensate to the WWTP because of the risk of contamination, the condensate can be collected in an intermediate tank and analysed to detect the presence of any contaminant.

This also leads to savings in the use of chemicals for the treatment of boiler feed-water. Additionally or alternatively, if the condensate cannot be returned to the boiler due to contamination, heat can be recovered from the contaminated condensate before it is used for lower grade cleaning activities, e.g. yard cleaning.

The energy in any steam used for direct injection to the process may be considered to be fully utilised.

Achieved environmental benefits

Reduced energy and water consumption and reduced waste water generation. Reduced consumption of boiler feed-water treatment chemicals.

Operational data

If hot condensate is not returned to the boiler, it has to be replaced by treated cold make-up water and wastes some 20 % of the energy absorbed in the generation of the steam from which the condensate is derived. This may be the greatest single energy loss in steam use.

Applicability

Applicable where steam is produced in a boiler.

Driving force for implementation

Reduced energy consumption and associated costs.

Avoid losses of flash steam from condensate return

Description

When condensate is discharged from steam traps and flows along the return pipework, some flash steam is formed. Often flash steam is vented to the air and the energy it contains is lost. It may be possible to capture and use the flash steam, e.g. in the boiler.

Achieved environmental benefits

Reduced energy and water consumption.

Operational data

The flash steam typically contains about 40 % of the energy in the original pressurised condensate.

Applicability

Applicable where flash steam is produced and can be re-used.

Driving force for implementation

Reduced energy consumption and associated costs.

Isolate unused/infrequently used pipework

Description

There may be branches of the steam distribution system that are no longer used and can be removed from the system. Also, pipework that supplies steam to infrequently used equipment can be isolated using valves or slip-plates. Unused and infrequently used pipework causes energy to be consumed unnecessarily and is likely to receive less maintenance attention.

Removal of pipework may leave the remaining pipework inadequately supported, so additional support may be required.

Achieved environmental benefits

Reduced energy and water consumption.

Applicability

Fully applicable.

Driving force for implementation

Reduced energy consumption and associated costs.

Minimising the blowdown of a boiler

Description

The blowdown of a boiler is used to limit the accumulation of salts, e.g. chlorides; alkalis and silicic acid, and is, therefore, necessary to keep these parameters within prescribed limits. It is also used to remove the sludge deposits, e.g. calcium phosphates, and corrosion products, e.g. ferric oxides from the boiler and to keep the water clear and colourless. Waste water at high pressure and temperature is always discharged, either for a set time or continuously. It is, therefore, preferable to restrict the blowdown as far as possible.

The total dissolved solids content of the boiler water is best kept as close as possible to the maximum authorised value. This can be done via an automated system consisting of a conductance probe in the boiler water, a blowdown regulator or a blowdown regulating valve.

The conductance is continually measured. If the measured conductance exceeds the maximum value, then the regulating valve is opened more.

To reduce energy consumption, heat can be recovered from the blowdown of a boiler.

Achieved environmental benefits

Reduced energy consumption. Reduced waste water generation.

Operational data

At a steam pressure of 10 bar, a fuel saving of 2.1 % can be achieved if the blowdown volume is reduced by 10 %.

Applicability

Applicable where a boiler is used.

For further details see Chapter 4.2.17 of the FDM BREF document.

1.3.12 Cleaning

Dry cleaning of equipment and installations

Description

As much residual material as possible can be removed from vessels, equipment and installations, before they are wet cleaned. This can be applied both during and at the end of the working period. All spillages can be cleaned up, by, e.g. shovelling or vacuuming spilt material or by using a squeegee, prior to wet cleaning, rather than hosing them down the drain. This reduces the entrainment of material into water, which would consequently have to be treated in either an on-site or municipal WWTP. This is enhanced further by transporting materials such as ingredients, by-products and waste from processing as dry as possible.

Dry cleaning is facilitated by, e.g. providing and using catchpots with a mesh cover, making sure suitable, dry clean-up equipment is always readily available and providing convenient, secure receptacles for the collected waste. Catchpots may be locked in place to ensure that they are in place during cleaning.

As well as manual dry cleaning of equipment and installations, other measures can be used, such as letting materials drain naturally, by gravity, into suitably located receptacles and by using pigging (see Section 4.3.3 of the BREF FDM)

The cleaning procedure can be managed to ensure that wet cleaning is minimised and that the necessary hygiene standards are maintained. For example, the use of hoses can be prohibited until after dry clean-up.

Achieved environmental benefits

Reduced water consumption and volume of waste water. Reduced entrainment of materials in waste water and, therefore, reduced levels of, e.g. COD and BOD. Increased potential for the recovery and recycling of substances generated in the process. Reduced use of energy needed to heat water for cleaning. Reduced use of detergents.

Cross-media effects

Increased solid waste.

Applicability

Applicable to all FDM installations.

Driving force for implementation

Reduced energy and water use, reduced need for waste water treatment and lower detergent use and expenditure.

Pre-soak floors and open equipment to loosen dirt before cleaning

Description

Floors and open equipment can be pre-soaked before being wet cleaned. This can loosen the dirt and, therefore, make subsequent cleaning easier, e.g. less water, at high pressure and/or high temperature, may be required to dislodge hardened or burnt-on dirt and the use of chemical cleaning substances, such as caustic, may be minimised.

Achieved environmental benefits

Depending on the circumstances, the consumption of water and energy for heating water may be reduced. The consumption of chemicals may be reduced.

Applicability

Applicable where hardened or burnt-on dirt needs to be removed during cleaning.

Management of water, energy and detergents used

Description

If the consumption of water and detergents, and the cleanliness is recorded on a daily basis, it is possible to detect deviations from normal operation and then to monitor and plan ongoing efforts to reduce the future consumption of both water and detergents without jeopardising hygiene. This applies to all cleaning, whether it is manual, e.g. using pressure cleaning, or automated, e.g. using CIP.

Trials can also be undertaken, e.g. using less or no detergents; using water at different temperatures; using mechanical treatment, i.e. the use of “force” both in the water pressure, and from using tools such as scouring sponges and brushes.

Monitoring and controlling the cleaning temperatures can enable the required cleaning standard of equipment and installations to be achieved without the excessive use of cleaning agents. An important part of preventing the overuse of water and detergents on an ongoing basis is ensuring that staff are trained in the handling, and making up of solutions and their application.

For example, they should not make cleaning solution concentrations too high, either by pouring too much during manual dosing or by setting automatic dosing systems too high. This can happen easily, through lack of training and supervision, particularly during manual dosing.

Achieved environmental benefits

Potential reduced consumption of water and detergent and of the energy required to heat the water. The reduction potential depends on the cleaning requirements at each part of the installation or equipment to be cleaned.

Applicability

Applicable to all FDM installations.

Economics

The technique can result in reduced water, energy and detergent costs.

Driving force for implementation

Reduced water, energy and detergent costs.

Fit cleaning hoses with hand operated triggers

Description

Trigger control shut-offs can be fitted to cleaning hoses with no other modification, if a water heater is used to provide hot water. If a steam and water blending valve is used to provide hot water, it is necessary to install check valves to prevent steam or water from entering the wrong line. Automatic shut-off valves are often sold with nozzles attached. Nozzles increase the water impact and decrease the water flowrate.

Achieved environmental benefits

Reduced water and energy consumption.

Operational data

In an example installation, the energy saved was calculated for running a hose that had been fitted with an automatic shut-off valve and nozzle, using water at a temperature of 71 ºC. The flowrate before installation was 76 l/min and after installation was 57 l/min. The time the hose was running was 8 h/d before installation and 4 h/d afterwards. For a water cost of USD 21/m^3, an annual water cost saving of USD 4987 (costs in 2000) was calculated. An annual energy saving of 919 GJ has also been calculated.

Applicability

Applicable to all FDM installations.

Economics

If nozzles are installed without automatic shut-offs, the equipment costs are less than USD 10. An automatic trigger controlled shut-off with a nozzle costs approximately USD 90. (Costs in 2000). The payback is reported to be immediate.

Driving force for implementation

Reduced water and energy costs.

Supply of pressure-controlled water and via nozzles

Description

Where a supply of water is essential, it can be supplied through nozzles fitted to the equipment for processing or fitted to hoses used for cleaning equipment and/or installations. For cleaning operations, the water may be supplied to the hoses from a ring main.

Nozzles fitted to processing equipment are designed and positioned for each individual cleaning application.

Achieved environmental benefits

Reduced water consumption. Where heated water is used, the overall energy consumption can be reduced.

Operational data

The water flowrate at each nozzle can be set by the management, depending on the application. Also, the water pressure can be adjusted according to the cleaning operation requiring the highest pressure and a suitable pressure regulator can be installed at each of the other cleaning stations which require water. The water consumption can be optimised by monitoring and maintaining the water pressure and the condition of the water spray nozzles.

Applicability

Applicable in all FDM installations, according to in-line, general operational and cleaning needs.

Driving force for implementation

Reduced water consumption.

Low pressure foam cleaning

Description

Low pressure foam cleaning can be used instead of traditional manual cleaning with water hoses, brushes and manually dosed detergents. It can be used to clean walls, floors and equipment surfaces. A foam cleaner, such as an alkaline solution, is sprayed on the surface to be cleaned. The foam adheres to the surface. It is left for about 10 – 20 minutes and is then rinsed away with water.

Low pressure foam cleaning can either use a centralised ring main or decentralised individual units. Centralised systems supply pre-mixed cleaning solutions and pressurised water from a central unit and during cleaning they automatically change between foam spreading and rinsing. Mobile pressure cleaning machines require longer downtimes than those supplied from a ring main. Diesel operated pressure cleaners emit fumes, which make them unsuitable for use inside FDM installations. Electrically operated pressure cleaners require additional operator safety precautions, including residual current devices and high maintenance. Mobile machines reportedly also use more water.

Achieved environmental benefits

Reduced water, chemical and energy consumption compared to the use of traditional water hoses, brushes and manually dosed detergents.

Applicability

Applicable in new and existing installations, for cleaning floors, walls, vessels, containers, open equipment and conveyors.

Economics

The investment cost of the foam cleaning system in an example cheese installation in Denmark (reported in 2000) was about EUR 188000, with a payback time of 3.2 years.

Driving force for implementation

Better cleaning and the elimination of problems associated with high pressure cleaning, e.g. spreading of aerosols containing dirt particles and bacteria.

Cleaning with gels

Description

Gels are typically used for cleaning walls, ceilings, floors, equipment and containers. The chemical is sprayed onto the surface to be cleaned.

Achieved environmental benefits

Reduced water, chemical and energy consumption compared to the use of traditional water hoses, brushes and manually dosed detergents.

Operational data

Cleaning with gels provides a longer contact time than foams, between the soiling and active detergent, because of the tenacious nature of gels with surfaces and there is greater accessibility to crevices as access is not inhibited by air bubbles. However, gels are transparent and difficult to see and may be inconsistent at high temperatures.

Reported advantages of using gels include increased contact time with soiled surfaces, which allows improved cleaning results to be achieved, even though less aggressive chemicals are used. The chemical constituents soften soiling, resulting in improved rinsing efficiency and cleaning. As gels are very easy to rinse, less water is used. Labour costs are also reduced because, compared with traditional methods, cleaning takes less time. Due to less aggressive chemicals being used, there is reduced wear and tear on machinery and reduced risk to the operator.

Applicability

Applicable in new and existing installations, for cleaning floors, walls, vessels, containers, open equipment and conveyors.

Driving force for implementation

Elimination of problems associated with high pressure cleaning, e.g. spreading of aerosols containing dirt particles and bacteria.

CIP (cleaning-in-place) and its optimal use

Description

CIP systems are cleaning systems that are incorporated into equipment and can be calibrated and set to use only the required quantities of detergents and water at the correct temperature (and sometimes pressure) conditions. Incorporation of a CIP system can be considered at the equipment design stage and installed by the manufacturer. Retrofitting a CIP system may be possible, but is potentially more difficult and expensive. CIP systems can be optimised by incorporating the internal recycling of water and chemicals; carefully setting operating programmes, which coincide with the real cleaning requirements of the process; using water efficient spray devices and by removing product and gross soiling prior to cleaning. Equipment correctly designed for CIP cleaning should have spray balls located so that there are no “blind spots” in the cleaning process.

Secondary water from, e.g. RO and/or condensate may be suitable for direct use in pre-rinsing in CIP, or for other uses after treatment. Opportunities for re-using secondary water in CIP at dairies are shown in Table 4.107. The use of such water for pre-rinsing may depend on whether it is possible to recover materials for re-use in the process. If this is the case, then drinking water quality water is required.

Achieved environmental benefits

A reduction in the consumption of water, detergents and the energy needed to heat the water are achievable because it is possible to set the consumption levels, specifying the use of only that required for the surface area to be cleaned. It is possible to recover and re-use water and chemicals within the system. There is a subsequent reduction in the amount of waste water generated.

Cross-media effects

Possible energy use associated with pumping the water and detergent.

Applicability

Applicable to closed/sealed equipment through which liquids can be circulated, including, e.g. pipes and vessels.

Economics

The capital cost is high. Reduced costs of water, energy and chemicals.

Driving force for implementation

Automation and ease of operation. Reduced requirement to dismantle and reassemble equipment.

For further details see Chapter 4.3 of the FDM BREF document.

1.4 Techniques applicable in some individual sectors (energy-related)

1.4.1 Meat and poultry

Minimise the production and use of flake ice

Description

When processing ground meat, flake ice is often used to cool the meat mixture. By using a suitable mixture of chilled and frozen raw materials, it is possible to avoid the use, and therefore the production, of flake ice. Sometimes flake ice is added when processes such as chopping make the temperature of the meat rise, so causing a risk to the hygiene or the quality of the product or if only a small amount of water needs to be added to the product.

Achieved environmental benefits

Reduced water and energy consumption.

Applicability

Applicable in ground meat processing installations.

1.4.2 Fish and shellfish

Avoiding scaling if the fish is subsequently skinned

Description

Scaling equipment consists of a perforated rotating drum onto which water is applied to flush scales away. If the fish is subsequently skinned, scaling is not carried out.

Achieved environmental benefits

Reduced water consumption. Reduced energy consumption.

Operational data

Water savings of 10 – 15 m3/t are achieved.

Applicability

Applicable in the fish sector.

1.4.3 Fruit and vegetables

Abrasion peeling

Description

In abrasion peeling, the material to be peeled is fed onto carborundum rollers or fed into a rotating bowl, which is lined with carborundum. The abrasive carborundum surface removes the skin, which is then washed away with a copious supply of water. The process is normally carried out at ambient temperature.

Achieved environmental benefits

The peel can be recovered and used as animal feed. Reduced energy consumption.

Applicability

This technique is used for peeling onions, potatoes, carrots and beets, as the skin is easily removed and the quality of the product can be maintained. Sometimes abrasion peeling is used as a pre-peeling step before knife peeling.

Economics

The capital and energy costs are low. Steam peeling is reported to be more economical.

Knife peeling

Description

In knife peeling, the material to be peeled is pressed to against rotating blades, or is itself rotated against stationary blades. Although water is not used during the actual peeling operation, it is used for the continuous cleaning of rollers and blades, so contaminated waste water is produced.

Achieved environmental benefits

The peel can be recovered and used directly as animal feed or for recovery of its components. Less energy consumption than steam peeling.

Applicability

Knife peeling is particularly used for citrus fruits where the skin is easily removed and little damage is caused to the fruits and for small quantities of, e.g. potatoes, carrots, beets and apples, or when vegetables are used for catering or in institutional kitchens. Peaches and pears can be peeled using very small blades mounted on rollers.

Economics

Knife peeling is reportedly more expensive than steam peeling.

Wet caustic peeling

Description

The material to be peeled is either placed in or passed through a dilute solution, e.g. 1 to 2 %, but as high as 20 %, of caustic, heated to 80 – 120 ºC. This softens the skin which can then be sprayed off by high pressure water sprays. The caustic concentration and the temperature depend on the type of fruit or vegetable and the degree of peeling required. Although water is not used during the actual peeling operation, it is used for the continuous cleaning of rollers and blades, so contaminated waste water is produced.

Achieved environmental benefits

Reduced water and energy consumption compared to steam peeling.

Applicability

Applicable for all fruit and vegetables which are peeled. It can be used where the peel is relatively hard compared with the fruit flesh and where steam peeling cannot be applied.

Economics

Wet caustic peeling produces waste with a very high pH and organic loading, which then adds to the water treatment costs. Caustic peeling is reportedly more expensive than steam peeling.

Dry caustic peeling

Description

In dry caustic peeling, the material is dipped in a 10 % caustic solution heated to 80 – 120 ºC, to soften the skin, which is then removed by rubber discs or rollers. This reduces water consumption and produces a concentrated caustic paste for disposal. Peeling is followed by washing to remove the peel and any residual caustic.

In the case of peeling peaches and apricots, the skin is very fine and soft and not as easily distinguishable from the fruit flesh as that of e.g. tomatoes, peppers and potatoes, so it "clings" to the flesh. The skin clings to the flesh of less ripe fruit more strongly than it clings to ripe fruit. Peaches and apricots are immersed into the caustic solution and the skin is decomposed.

The residue is then removed by spraying the fruit with water. In practice, fruits of varying ripeness are peeled together and the process is prolonged to ensure that the least ripe fruit are peeled. In the case of e.g. peeling peaches and apricots for subsequent preservation either whole or in halves, the mechanical removal of the softened skin would cause unacceptable damage to the surface of the fruit.

Achieved environmental benefits

Reduced water consumption compared to steam peeling and wet caustic peeling. Reduced solid waste and waste water production compared to wet caustic peeling. Lower caustic consumption than wet caustic peeling. Reduced energy consumption compared to steam peeling.

Applicability

Applicable for all fruits and vegetables which are peeled. It can be used where the peel is relatively hard compared with the fruit flesh and steam peeling cannot be applied.

Economics

Dry caustic peeling produces waste with a very high pH, which adds to the water treatment costs. Dry caustic peeling is reportedly more expensive than steam peeling.

Flame peeling

Description

This technique was developed for onions. A flame peeler consists of a conveyer belt which transports and rotates the material through a furnace heated to temperatures above 1000 ºC. The skin or root hairs are burned off and then removed by high pressure water sprays.

Achieved environmental benefits

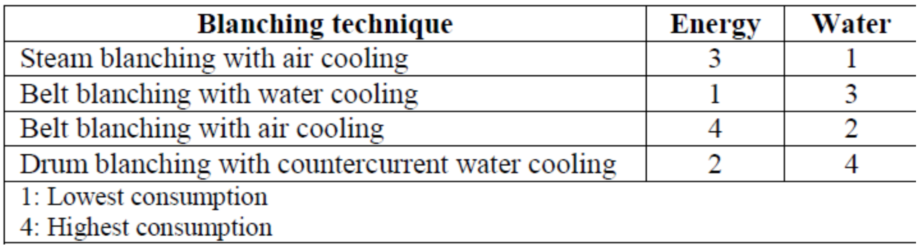
Flame peeling requires heat, in contrast to other peeling operations which require electrical energy.

Applicability

Flame peeling is used for peeling onions and peppers.

Blanching of fruit and vegetables

Blanching generally comprises three steps, i.e. preheating, blanching and cooling and is followed by further processing such as the manufacture of preserves or freezing. The following table shows a qualitative comparison of energy and water consumption levels within the different blanching techniques.



Blanching technique	Energy	Water
Steam blanching with air cooling	3	1
Belt blanching with water cooling	1	3
Belt blanching with air cooling	4	2
Drum blanching with countercurrent water cooling	2	4

1: Lowest consumption
4: Highest consumption

Table 1-27: Comparison of the energy and water consumption levels within different blanching techniques

For more information see Chapter 4.7.3.5 of the FDM BREF.

Cooling fruits and vegetables

Description

The temperature of fruit and vegetables as they enter the freezing tunnel is an important factor that also determines the energy consumption of the system. The lower the temperature, the lower the cooling load and the lower the energy consumption. The temperature of the fruit and vegetables can be lowered by bringing them into contact with sufficiently cold water for a sufficient time. This is generally the cooling step after blanching. If the ambient temperature of the water is above 4 ºC, an ice-water trough can be used to cool the fruit and/or vegetables to 4 ºC. Additionally, the circulating water in the ice-water trough can be continually cooled by fitting an additional water cooler in the ice-water trough or by placing an evaporator plate under the ice-water trough. This evaporator plate is connected into the freezer system in a similar way as the heat-exchanger for ice-water production. If the water is carried into the freezing tunnel it becomes frozen and adds an additional energy burden. This can be prevented by passing the food over a vibrating mesh or perforated belt which enables the water to be removed from the food and then collected for re-use in the cooling process.

Achieved environmental benefits

Reduced energy consumption in the freezing process.

Cross-media effects

Energy consumption in the cooling process before freezing.

Applicability

Applied in the deep freezing of fruit and vegetables.

Re-use of water in fruit and vegetable processing

Description

In new and existing installations opportunities may exist for the re-use of water, either directly in a unit operation or indirectly as a source, e.g. either heat or cold. In existing installations in particular, such opportunities vary depending, e.g. on the unit operations undertaken, the waste water treatment facilities available on the site and the hygiene requirements for the water used on the site. It may be possible to re-use water in the same unit operation either without any treatment, or after a simple filtration.

Achieved environmental benefits

Reduced water consumption and, where heated water is re-used, reduced energy consumption.

Cross-media effects

If treatment is required before re-use, energy is consumed and chemicals may also be consumed.

Applicability

Applicable in new and existing installations. Improving water re-use in existing installations, using equipment that will later be replaced with BAT, may be able to re-use water to minimise the environmental impact of the existing equipment.

Driving force for implementation

Reduced water consumption and, in some cases, reduced energy consumption.

1.4.4 Vegetable oils and fats

Countercurrent flow desolventiser-toaster (DT) in vegetable oil extraction

Description

After oil extraction, the meal contains 25 – 40 % solvent. The solvent is removed by evaporation in the desolventiser-toaster (DT) by means of direct and indirect steam. The DT vessel has several predesolventising and desolventising/stripping decks. The meal from the extractor enters the DT via the top and arrives at the first predesolventising deck. The predesolventising decks have only indirect steam heating to flash off the surface solvent. This configuration reduces the amount of water condensed on the meal at the stripping sections thereby reducing the energy input needed for the meal drying step following afterwards.

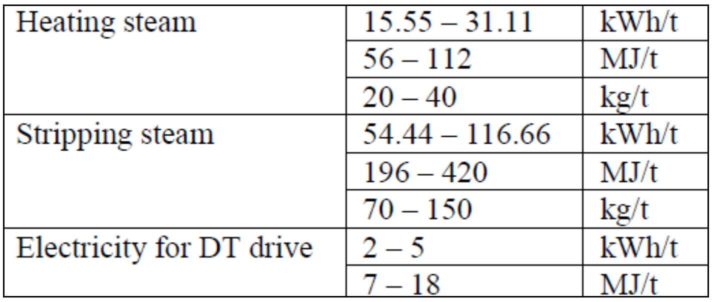
Direct steam is introduced in the system via a sparge steam deck at the bottom of the DT. The steam migrates through the layers of meal on each deck. Herewith a large proportion of the hexane is removed from the meal due to condensation of steam on the meal. The DT demonstrates a true countercurrent flow of live sparge steam and meal. The steam consumption is minimised by the countercurrent flow and the application of predesolventising decks. Vapours from the stripping decks and predesolventising decks are combined inside the boundaries of the DT vessel and re-used elsewhere in the extraction process as a heating medium in the miscella distillation after scrubbing (see Section 4.7.4.3). Due to the contact of steam with the meal, toasting takes place as well. The toasting process inactivates the enzymes, so ensuring optimum protein quality of the meal for use as animal feed and improving its digestibility.

Achieved environmental benefits

Reduction of solvent loss into the meal and the environment. Reduction in steam consumption for the desolventising and meal drying process. Reduced volumes of waste water. More balanced heat integration with miscella distillation system, so reducing the need for hot and cold utilities.

Operational data

Energy consumption is normally given for the DT and downstream drying operation as a whole. For example, by predesolventising via indirect steam in the top decks the amount of water condensed on the meal at the stripping sections is reduced in comparison with the case when direct steam is applied. Subsequently, the energy input needed for the meal drying step following afterwards is reduced. The following table shows energy consumption data for the DT and downstream drying operation in oilseed extraction.



Heating steam	15.55 – 31.11	kWh/t
	56 – 112	MJ/t
	20 – 40	kg/t
Stripping steam	54.44 – 116.66	kWh/t
	196 – 420	MJ/t
	70 – 150	kg/t
Electricity for DT drive	2 – 5	kWh/t
	7 – 18	MJ/t

Table 1-28: Energy consumption data for the DT and downstream drying operation in oilseed extraction

Applicability

Suitable for new and existing installations. The technique is easily available and has a good operating reliability.

Economics

High initial investment costs. Reduction in energy costs for the extraction installation.

Driving force for implementation

Potential lower residual solvent levels in the meal. Reduction of plant operational costs. Increased plant safety. Ensured operational safety of the downstream process. Compliance with legislation controlling VOCs.

Re-use of the vapours from the DT in the miscella distillation in vegetable oil extraction

Description

The DT removes the hexane from the meal (see Section 4.7.4.2). The vapours from the DT stage (steam/hexane mixture) are fed to the first stage of the miscella distillation pre-evaporator to provide a heating source, so recovering energy.

Achieved environmental benefits

Reduced energy and solvent consumption.

Operational data

The reported energy savings in the extraction process amount to approximately 37.5 kWh/t (135 MJ/t) (60 kg steam/t) seed. Energy is also saved by reducing the heat load to the cooling water system of the installation.

In the pre-evaporator, the miscella concentration (% oil in hexane/oil mixture) increases from approximately 20 – 30 % to 60 – 75 %. For example, when processing soya, the pre-evaporator arrangement results in an evaporation of about 0.4 tonnes of hexane per tonne of seed based on the DT vapour waste heat availability. This represents a significant amount of the fresh solvent input to the extraction. The re-use of the energy value reduces the heat load to the DT condenser. Also the steam demand for the downstream miscella distillation is minimised.

Applicability

Widely applicable in oilseed extraction. The technique is easily available and has a good operating reliability.

Economics

High initial investment. Reduction of plant operational costs due to energy recovery.

Re-use of heat in the hardening of vegetable oils

Description

The hydrogenation reaction that occurs during the hardening of oils to produce fats for cooking, eating and soap making, is an exothermic process. The reaction produces heat of 41.67 - 152.78 kWh/t (150 – 550 MJ/t) of feedstock. The heat generated depends on the feedstock and product specification and range, e.g. if fewer hydrogenated products are made, then less steam is generated. This heat is used to heat the product to the desired reaction temperature and to generate steam later in the reaction.

Achieved environmental benefits

Reduced energy consumption, e.g. improvement in the process efficiency through heat recovery. Reduction in emissions due to energy generation.

Operational data

In an example edible oil refinery, the steam generated is fed into the existing 350000 Pa (3.5 bar) steam main pipe of the installation, thereby reducing the primary steam consumption of the installation as a whole. The reported energy (steam) generation amounts to 25 – 125 kWh/t (90 – 450 MJ/t) (40 – 200 kg/t) unrefined oil. In addition, by using the exothermic energy from hydrogenation, a 5 to 10 % reduction in consumption of primary energy at the selected site is achievable.

Applicability

Widely applicable and good operating reliability. The following issues can restrict its applicability:

- proportion of the entire product specification and range which involves hydrogenation
- the existing energy supply strategy of the installation as a whole, e.g. external supply
- the existing energy mix of the installation as a whole, e.g. ratio of electricity to steam
- type of energy agreements with external suppliers/consumers.

Economics

Additional investment costs are needed. Lower operational costs due to the reduced input of steam generation.

Driving force for implementation

Precautionary energy management.

Water ring pumps for generating an auxiliary vacuum of 40 to 120 mbar

Description

Water ring pumps generate a low stable vacuum which can be used for degassing and drying of oils and fats of animal and vegetable origin. When degassing the oil, the vacuum is used during hydrogenation, where H_2 is used, and after interesterification, where water is used to inactivate the catalyst. When drying the oil, vacuum is used after degumming, after neutralisation, before and after interesterification and before hydrogenation. Vacuum is also used to ensure an oxygen free atmosphere in the reactor/evacuating reactor during hydrogenation and interesterification.

Achieved environmental benefits

Reduced energy requirements. Low pollution of the waste water. Reduced emissions from energy generation.

Cross-media effects

Generation of waste water.

Applicability

Applicable when a vacuum range of 40 to 120 mbar is required. It is readily available and its operating reliability is very good, allowing series production. The technique results in a low throughput.

Economics

Reduced costs due to appropriate vacuum conditions.

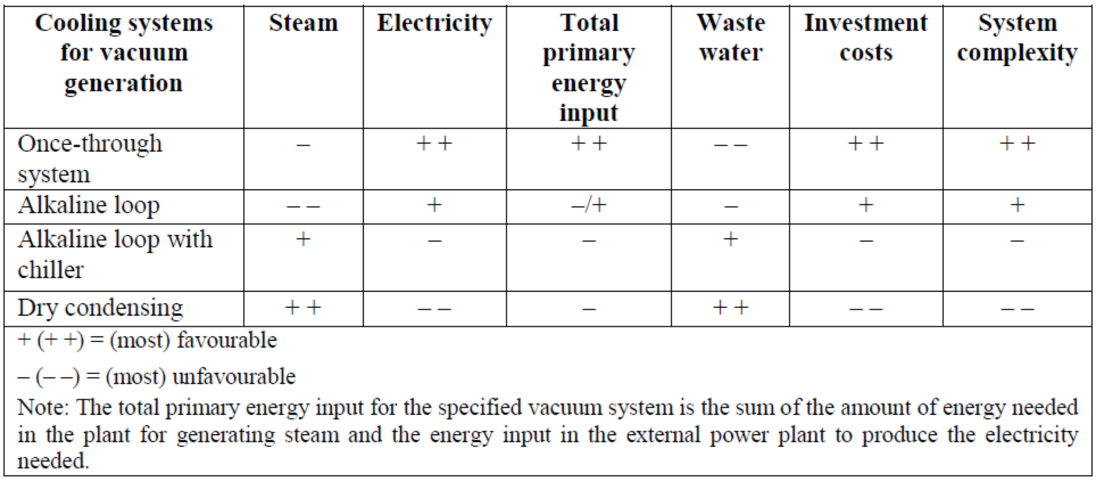
Driving force for implementation

Diversity of systems concerned. Completely different vacuum conditions than for distillative neutralisation/deodorisation.

Deodorisation

Deodorisation is the final treatment step in the refining process that converts crude oil to finished oil. The pre-treated oil is heated up to the deodorising temperature, i.e. 180 – 270 ºC, using a heat-exchanger and indirect steam. To prevent oxidation of the oil, the atmosphere in the deodorising equipment is at almost absolute vacuum, i.e. 0.5 – 8 mbar. At the given vacuum and temperature conditions, stripping steam provides the driving force and the carrier for removing volatile components from the feedstock.

Sections 4.7.4.12.1 – 4.7.4.12.3 of the FDM BREF describe some techniques used for deodorisation. The following table shows a comparison of the cooling systems used for vacuum generation in vegetable oil deodorisation based on generating a moderate vacuum of approximately 4 mbar.



Cooling systems for vacuum generation	Steam	Electricity	Total primary energy input	Waste water	Investment costs	System complexity
Once-through system	–	+ +	+ +	– –	+ +	+ +
Alkaline loop	– –	+	–/+	–	+	+
Alkaline loop with chiller	+	–	–	+	–	–
Dry condensing	+ +	– –	–	+ +	– –	– –

+ (+ +) = (most) favourable

– (– –) = (most) unfavourable

Note: The total primary energy input for the specified vacuum system is the sum of the amount of energy needed in the plant for generating steam and the energy input in the external power plant to produce the electricity needed.

Table 1-29: Comparison of cooling systems for vacuum generation in vegetable oil deodorisation

For more information see Sections 4.7.4.12.1 – 4.7.4.12.3 of the FDM BREF document.

1.4.5 Dairy products

Partial homogenisation of market milk

Description

The cream is homogenised together with a small proportion of skimmed milk. The optimum fat content of the mixture is 12 %. The rest of the skimmed milk flows directly from the centrifugal separator to the pasteurisation section of the pasteuriser. The homogenised cream is remixed into the skimmed milk stream before it enters the final heating section. Using this technique, the size of the homogeniser can be significantly reduced, leading to energy savings.

Achieved environmental benefits

Reduced energy consumption.

Operational data

In an example dairy, the introduction of partial homogenisation into a pasteurisation line with a nominal capacity of 25000 l/h led to a reduction in the homogenisation capacity to 8500 l/h. The total electrical power was reduced by about 65 % by installing a smaller homogeniser of 55 kW.

Applicability

Applicable in dairies.

Economics

Smaller homogenisers are cheaper in terms of investment costs and operational costs. The price of the smaller homogeniser is about 55 % of the price of a piece of equipment with the capacity to treat the nominal capacity of the line.

Driving force for implementation

Lower investment and energy costs.

Use of computer controlled milk transfer, pasteurisation, homogenisation and CIP equipment

Operational data

During pasteurisation, the greater surface area for heat-exchange and the recirculation of warm water reportedly results in about 25 % savings in energy consumption and about 50 % savings in water consumption, in comparison with the old pasteuriser previously used.

The computerised process control avoids or decreases milk losses in reception and during further processing. The automatic dosing reportedly results in about 15 % savings both in water and in the consumption of cleaning and disinfecting agents.

Applicability

Applicable in both new and existing installations.

Economics

Investment costs are high.

Driving force for implementation

Reduced costs for energy and water.

Use of continuous pasteurisers

Description

In continuous pasteurisation, flow-through heat-exchangers, e.g. tubular, plate and frame, are used. These have heating, holding and cooling sections. To reduce energy consumption and waste water generation, continuous pasteurisers are used instead of batch pasteurisers.

Achieved environmental benefits

Reduced energy consumption and waste water production, compared to batch pasteurisers.

Applicability

Applicable in dairies.

Economics

Reduced energy and waste water treatment costs.

Regenerative heat-exchange in a pasteurisation process

Description

Pasteurisers are normally equipped with some regenerative countercurrent flow heating sections. The incoming milk is preheated with the hot milk leaving the pasteurisation section.

Achieved environmental benefits

Reduced energy consumption.

Operational data

Typically energy savings over 90 % can be achieved.

Applicability

It is widely applied in dairies. In older dairies, heating and cooling energy can be further reduced by replacing the old plate exchangers by more effective ones.

Economics

Reduction in energy costs.

Driving force for implementation

Reduction in energy costs.

Two-stage drying in milk powder production

Description

After the milk has been thickened from 11 % to 50 – 60 % dry matter in an evaporator, the condensed milk may further be dried to 95 – 97 % dry matter content. Spray driers or roller driers are used in milk powder processing. Although roller driers may be found in the dairy sector and are sometimes useful for specialised products, spray driers with downstream or integrated FBDs have become more common. This is due to their lower energy usage, the primarily dust-free product, and due to their reduced thermal stress.

When using two-stage drying, lower residual product moisture with less harm to product quality as well as more efficient energy utilisation can be achieved. The solids leave the spray drier with 3 – 5 % residual moisture. The final drying step takes place under mild conditions with low energy usage.

Achieved environmental benefits

Reduced energy and water consumption. Reduced dust emissions.

Operational data

A large dairy in Germany produces skimmed milk and sweet whey powder. It processes 240000 t of raw milk and produces 19000 t milk and whey powder. The dairy uses a two-stage drying system with a capacity of 1 t/h. The waste gas volume is 45000 m^3/h. The drying process uses the largest share, i.e. 58 %, of the thermal energy consumption of the installation, i.e. 39 million kWh out of the total consumption of 67.5 million kWh, in 2000. About 30 % of the total power consumption, i.e. 18 million kWh, was reportedly attributed to the drying process.

In this example dairy, the reported specific electricity consumption was 315.8 kWh/t product or 25 kWh/t raw milk. The specific thermal energy consumption was 2052.6 kWh/t product or 162.5 kWh/t raw milk. Taking into account that about 600 kWh energy is required to evaporate 1 tonne of water, these figures are near to the theoretical energy need. The total water consumption of the drying step was also low, i.e. 9500 m^3 or 0.5 m^3/t product or 0.04 m^3/t raw milk.

It is reported that if an integrated FBD is used, the energy consumption for drying can be reduced by approximately 20 %. Investment involves additional capital and operational costs. Fire and explosion protection is required. An example of an early warning fire alarm is CO-detection.

Applicability

Applicable in the dairy sector.

Economics

High capital costs.

Driving force for implementation

Reduced energy and water costs.

Use of an aseptic packaging system not requiring an aseptic chamber

Description

An example dairy installation (also described in Section 4.7.5.4) receives 450000 litres of milk, at a quality complying with the Directive 92/46/EEC. The installation requires its suppliers to use mechanical milking, to have proper refrigeration capacity and to apply HACCP.

UHT milk processing is applied, followed by homogenisation and online aseptic packaging. High efficiency tubular type heat-exchangers are used in this process. The brick-shaped packages are made of paper-based laminated material, which includes several layers of plastic film and aluminum foil. The packages are formed from a continuous strip of the material, which enters the filling machinery through a hydrogen peroxide sterilising bath. Subsequently, the strip is formed into a tube around the sterilised product feed line, and appropriate longitudinal and cross seams are made by heat-sealing the plastic inner surfaces as the package is filled. This continuous aseptic packaging system does not require an aseptic chamber.

Achieved environmental benefits

Energy saving in heat treatment, lower packaging waste and lower milk losses.

Operational data

The spoilage, when this system is used, is reportedly below 0.5 %.

Applicability

Applicable in new and existing installations.

Economics

Investment costs are high.

Driving force for implementation

Reduced costs for energy and water.

Provision of in-line storage tanks to minimise product recirculation in pasteurisers

Description

A production line can be designed in such a way that the capacities of the individual components are optimised with respect to the others, in order to prevent product build-up or shortage in some parts of the line. Later changes in the production line or in the filling schedule might, however, disturb the balance causing interruptions in the continuous operation.

Achieved environmental benefits

Energy is saved mainly in the form of reduced cooling water consumption. The total consumption of electrical power required for the running of pumps, homogeniser and centrifugal separator also decreases, as the total processing time becomes shorter. Reductions in cleaning frequencies reduce the consumption of energy, water and chemicals. The negative effect of excess heat treatment on the quality of the product is also reduced.

Operational data

In an example dairy, supplying a pasteurisation line with in-line storage tanks before filling, together with automation of the product change-overs, resulted in a 30 % reduction of the processing time. The annual energy savings in this dairy amounted to 250 MWh in electrical energy and 230 MWh in thermal energy. The estimated payback period is 4.5 years.

Applicability

Applicable in dairies. Lack of space might be a constraint in existing installations.

Economics

Lower operational costs, e.g. reduced energy and water consumption.

Driving force for implementation

This solution offers improved flexibility, better quality and lower operational costs.

Using ultrafiltration (UF) for protein standardisation of cheese milk

Description

Ultrafiltration (UF) can be used for protein standardisation of cheese milk. The milk flows under pressure over a membrane that withholds the protein molecules, thus increasing the protein content of the retentate. The membrane pore size ranges from about 10 to 100 nm.

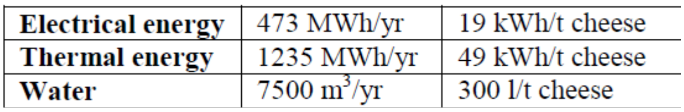
As using UF leads to an increase in the cheese yield per processed milk unit, the generated quantity of whey is smaller compared to traditional standardisation. Furthermore, even when UF requires additional electrical power, thermal energy and water compared to traditional standardisation, in large scale production, the increase in cheese yield compensates for the increased consumption of energy and water. The permeate from the UF unit is further treated by RO. The RO water, which is of drinking water quality, can be used for cleaning purposes.

Achieved environmental benefits

Reduced energy and water consumption, whey and waste water in comparison with traditional standardisation.

Operational data

The UF unit in a Danish dairy consists of 10 spiral wound modules equipped with polymer membranes, four pumps and the necessary flow transmitters and regulating valves. The filtration capacity is 65000 l/h. The protein content of the milk is standardised to 3.7 – 3.8 % by controlling the ratio between feed and permeate. Compared to the traditional standardisation method, the cheese yield is higher, i.e. about a 12 % reduction in milk volume was gained. A calculation made for a 25000 t/yr yellow cheese production, led to the estimated savings in water and energy shown in the following table.



Electrical energy	473 MWh/yr	19 kWh/t cheese
Thermal energy	1235 MWh/yr	49 kWh/t cheese
Water	7500 m^3/yr	300 l/t cheese

Table 1-30: Savings in water and energy consumption in a dairy using UF for protein standardisation

Applicability

UF can be applied to both skimmed milk and whey. UF units can be installed in new and existing installations because of their low space requirements.

Economics

The investment cost is high. Payback periods are acceptable only if the capacity is large enough. For example, the investment cost in the example Danish dairy is estimated to be EUR 430000 and the payback period 5.9 years.

Driving force for implementation

Cheese of homogenous quality can be produced using this technique. It also offers a larger flexibility for making different types of cheese.

Utilisation of heat from warm whey for preheating cheese milk

Description

The incoming milk is preheated with warm whey, which is simultaneously strained off from another vat. Heat-exchangers and tanks are needed for circulating the water. Savings in energy for heating the incoming milk and cooling energy for the processed whey are achieved.

Achieved environmental benefits

Reduced energy consumption.

Operational data

In a Danish example dairy, the cheese milk is heated from 12 to 32 ºC with heat from a closed system with circulating water at 34.5 ºC. The temperature of the water decreases to 13 ºC and it is subsequently reheated in the cooling section of the whey pasteuriser, where the whey is cooled from 36 to 14.5 ºC. In addition to the plate heat-exchangers, two buffer tanks of 150 m^3 were installed for the circulating water. Savings, assuming 250 million kg/yr whey, were estimated to be 1200 MWh/yr electrical energy, 6065 MWh/yr heat energy and 4200 m^3/yr water.

Applicability

Applicable in new and existing installations. In existing installations, the lack of sufficient space can be a constraint.

Economics

In the Danish example dairy, the cost estimation was made, but this was for the whole whey processing; including an RO unit as well as the heat treatment and heat recovery. The total costs amounted to about EUR 1.6 million with a payback of 3.8 years.

Driving force for implementation

Reduced energy costs.

High temperature cheese ripening with later humidification and ionisation of the ventilation air

Description

In cheese manufacturing, the temperature of the air is increased to shorten ripening times. This leads to a reduction in the demand for storage facilities, cooling power and ventilation energy. As a higher temperature increases the risk of dehydrating the cheese and of contamination by mould, the ventilation air is humidified and cleaned by a discharge tube which ionises the air which is passed through ventilation ducts. As ions in the ventilation air react with dust particles, micro-organisms and viruses, the air is effectively cleared of these sources of contamination.

Achieved environmental benefits

Reduced energy consumption.

Operational data

In an example cheese installation, a project was started in January 1994 to reduce energy consumption. Before the project, the manufacturer stored cheese at 12 ºC to allow ripening to take place. The temperature was increased to 15 ºC. The ventilation air was humidified and cleaned of dust and micro-organisms by ionisation prior to entering the warehouse. The new equipment allows the air temperature to rise to 16 ºC at 85 % relative humidity. Energy savings amounting to 272000 kWh/yr, or 85000 m^3/yr of natural gas, were reported. A shortening of the ripening time by 50 %, an improvement of the product quality and a reduction of the consumption of plastics and fungicidal agents were also reported.

Applicability

Applicable in cheese manufacturing installations. High temperature ripening is limited due to the desired taste, product quality and stability.

Economics

In the example installation, considerable savings were achieved in labour costs, maintenance and in the use of materials for cleaning the ventilation system. The payback period is around two years.

Driving force for implementation

Reduction in energy costs.

Heat recovery from pasteurisation in ice-cream production

Description

Heat and water can be recovered from the ice-cream pasteurisation process. The ice-cream mix enters the pasteuriser at a temperature of 60 ºC and is then heated to 85 ºC, followed by cooling to 4 ºC prior to ageing. The cooling phase consists of two steps. In the first step, the ice-cream is cooled to 70 ºC by regenerative heat-exchange and in the second step, cooling water is used for further cooling to approximately 20 ºC. The final temperature of 4 ºC is achieved by cooling with ice-water.

The heat released to the water, from the ice-cream mix in the second cooling step can preheat the water for various purposes, mainly for cleaning operations. This requires a number of storage tanks for the hot water.

Achieved environmental benefits

Reduced energy and water consumption.

Operational data

In an example ice-cream installation, the heat from the second cooling step is used for preheating approximately 25 % of the total amount of water used in the installation. The heat recovery yields hot water at approximately 70 ºC. The average inlet temperature of the cooling water is 10 ºC and the corresponding quantity of heat recovered is 7600 GJ/yr, which represents approximately 14 % of the energy consumption of the installation. The hot water is used for CIP and the quantity of water saved is approximately 1000 l/t of ice-cream mix produced.

Applicability

Applicable in new and existing installations. Space is needed for water storage tanks.

Economics

Reduced costs for energy and water.

Re-using warm cooling water for cleaning

Description

Cleaning is the most water consuming process in the dairy sector and large savings are possible in this area. Many dairy operations involve cooling with cold water in heat-exchangers, which results in warm cooling water. Usually the warm cooling water from the process is re-used for cleaning purposes, mainly for cleaning milk tankers. Warm cooling water can generally be used for the intra-plant cleaning, regardless of its temperature. In the dairy industry, water above 50 °C can be re-used for the cleaning of milk tankers or for the manual cleaning or CIP of equipment.

Achieved environmental benefits

The water and energy savings depend on the amount of re-usable warm cooling water used and its temperature.

Applicability

Re-using cooling water can be applied in new and existing installations. The space requirements for the warm water storage tanks may be a constraint in existing installations. Its use also depends upon what chemicals, if any, were previously used in the cleaning.

Economics

The costs are associated with the installation of the equipment required for re-using warm cooling water for cleaning, i.e. a storage tank and pipework for collection and distribution of the water.

Driving forces for implementation

Reduces costs for water and energy.

1.4.6 Sugar

Two-stage drying of sugar beet pulp

Description

For molasses-treated pulp drying, the first step is an LTD of the pulp using a belt drier. Molasses are mixed to the pulp, and then the whole mixture is dried with HTD in a rotary drum drier. LTD is used as a first step to make use of the lower energy heat from the HTD step and from the sugar production processes.

Achieved environmental benefits

Reduced energy consumption and air pollution compared to HTD. Drying the pulp produces animal feed that can be stored for a longer time than moist feed.

Cross-media effects

Dust and odour are emitted. NO_x, CO and organic compounds are emitted when flue-gas is used. Waste water is produced.

Operational data

If two-stage drying is applied, about 30 % energy can be saved by using the vapours of the HTD step for the first step, LTD. Most belt driers operate with hot air at approximately 60 ºC, which can be heated using the heat streams from the evaporation station and crystallisation unit of the sugar installation, which would otherwise be lost to the environment as waste heat.

This use of secondary energy from the sugar production process shows an advantage to beet pulp drying of carrying out sugar production and beet pulp drying at the same installation. This may be done if the heat is not re-used within the sugar production process.

Applicability

Applicable for drying molasses-treated pulp in the sugar sector.

Driving force for implementation

Drying the pulp produces animal feed that can be stored for a longer time than moist feed.

Steam drying of sugar beet pulp

Description

Drying is achieved by using superheated steam. If the steam is at 130 ºC, it expands and the temperature drops to 102 – 103 ºC at around 0.1 MPa by the uptake of water. If the steam is at 260 ºC at around 2.6 MPa, it expands and the temperature drops to 148 °C at around 0.37 MPa. FBDs can be used in steam drying.

Achieved environmental benefits

Reduced emissions of dust and odour, compared to HTD. As flue-gas is not used, NOx is not released. Another advantage is the lower overall energy consumption for drying compared to HTD and two-stage drying. The energy output, e.g. steam, can be re-used in the sugar extraction process. Drying the pulp produces animal feed that can be stored for a longer time than moist feed.

Applicability

Applicable for drying pulp in the sugar sector. Steam drying using FBDs with an integrated steam system can be used in new sugar installations. For existing installations it may require complete reconstruction of the energy generation and heat switching facilities. Retrofitting involves reconstructing the steam generation and electricity production sections including, e.g. revising the entire heat transfer arrangements within the installation.

Driving force for implementation

Savings in costs and energy. Drying the pulp produces animal feed that can be stored for a longer time than moist feed.

For further information (e.g. a comparison of steam, HTD and two-stage drying of beet pulp) see Chapter 4.7.7.1.5 of the FDM BREF document.

Reducing sugar beet soil tare

Description

Large quantities of soil, gravel and stones are transported to sugar factories as part of beet deliveries. Handling of this unwanted material consumes a lot of resources at the site, e.g. energy and water. A “clean beets” project, combining technical, economic and plant breeding measures, can reduce the amount of soil delivered to the installation.

Achieved environmental benefits

Reduced water and energy consumption.

Applicability

Applicable in sugar manufacturing.

Economics

Reduced energy and water costs.

Driving force for implementation

Reduced energy and water costs.

1.4.7 Coffee

Waste heat re-use in instant coffee manufacturing

Description

The instant coffee manufacturing process is highly energy intensive (for a description of instant coffee manufacturing see Section 2.2.13.2). Waste heat, e.g. from the extraction unit and air compressors, can be re-used during production, e.g. for extraction, and as a heating source, e.g. in offices and storage areas. A standard procedure for waste heat utilisation is also the recirculation of partial streams of exhaust air within the installation such as spray drying, e.g. using countercurrent heat-exchangers and within the roasting sector.

Achieved environmental benefits

Reduced energy consumption, e.g. heat is re-used.

Operational data

In an example installation in Germany, the hot liquid coffee extract produced during extraction is pumped over heat-exchangers that extract the heat from the coffee and, at the same time, heat the process water required for extraction. In addition, the heating of site offices and social rooms takes place using waste heat from the production. Also, the waste heat of the air compressors is used for heating the storage halls.

Applicability

Low grade heat is widely re-used in the FDM sector.

Economics

Reduced energy costs.

Recirculation of air during coffee roasting

Description

In terms of the feeding of roasting air, a distinction is drawn between non-recirculating and recirculating machines. Recirculating roasters consume less energy and produce a lower volume of waste gas for treatment.

Achieved environmental benefits

Recirculating roasters consume less energy and produce a lower volume of waste gas for treatment than non-recirculating roasters.

Applicability

Applicable in all coffee roasting installations.

Economics

Reduced energy and waste gas treatment costs.

Water mist cooling of roasted coffee

Description

Finely atomised water is fed into the chamber to cool the product. When the air-water aerosol comes into contact with hot roasted coffee, the water drops evaporate.

Achieved environmental benefits

Reduced air pollution and energy consumption compared to air cooling.

Applicability

The cooled coffee leaves the roaster at approximately 60 ºC and is not optimal for ground coffee. For some coffees, the 60 ºC final temperature can produce an acceptable taste, but for many other coffees it does not. More than 90 % of the roasted coffee market in Europe is ground coffee. This cooling system can, therefore, only be used under certain circumstances. The process is predominantly used in densely built-up residential areas.

Economics

Reduced costs with regard to energy and waste gas treatment compared to air cooling.

1.4.8 Drinks

Integrated bottling installation

Description

An example installation produces distilled wines, neutral alcohol, grain spirit, essences and distilled rum and whisky. The annual production volume is 70 million standard 0.7 litre bottles. A new bottling line was installed to reduce the energy consumption.

For further details (i.e. process description) see Chapter 4.7.9.5

Achieved environmental benefits

Significant reduction in energy consumption. Reduced noise pollution.

Applicability

Applicable in bottling installations.

Economics

The fully automated shuttle system saves the high running costs and operating resource requirements of the forklift truck technology. In addition to reducing resource consumption, the technological modernisation had a substantial economic effect as a result of the increased hourly output. This is one reason for the 10 % reduction in production costs per standard bottle and the 7.5 % increase in productivity, when comparing 1999 to 2001.

Multistage bottle cleaning system

Description

A reduction in water consumption can be achieved by a combination of different methods for the different zones of the cleaning machine.

For further details (i.e. process description) see Chapter 4.7.9.5.2

Achieved environmental benefits

Reduced water consumption and consequently waste water volumes. Reduction in waste water contamination loads, due to reduced chemical consumption. Reduced energy consumption. Reduction in transport, storage and handling of chemicals. The pH of the waste water is optimised.

Applicability

This system can replace bottle cleaning machines in existing bottling lines. For example, this process can be applied to all older bottle cleaning machines that have a water consumption of more than 400 ml per bottle cleaned, e.g. 80 % of the bottle cleaning machines in use in the German soft drinks sector are models of this kind.

It is reported that to ensure adequate cleaning quality, it is not realistic to work on the basis of a target water consumption of less than 200 ml per bottle cleaned. New models need only 150 ml of cleaning water per bottle cleaned. There is thus no potential saving for these machines.

Economics

To achieve an acceptable payback period, a water saving of at least 200 ml per bottle cleaned is needed.

Driving forces for implementation

Reduction in water, cleaning and disinfection agents consumption and costs.

Mash infusion process (Brewing)

Description

Shredded malt is fed, together with warm brewing water, into the mash vat. This so-called mash, is heated to a temperature of 78 ºC and is stirred constantly. The mash infusion process is all carried out in the mash vat.

Achieved environmental benefits

Reduced air pollution, e.g. odour, and energy consumption compared with the mash decoction process.

Applicability

Mash infusion is applicable in the processing of full malt beers. The mash infusion method traditionally requires high quality malt, though the malt grades available permit the use of a mash infusion process for many beer types.

Economics

No additional costs compared with the mash decoction process.

Driving force for implementation

The mash infusion process is primarily used because of its lower energy consumption, because it requires less equipment and because it is easier to automate, compared with the mash decoction process.

Re-use of hot water from wort cooling

Description

Hot water consumption is one of the key issues in regard to energy savings. Hot water is normally produced in a heat-exchanger when cooling down the wort from 100 ºC to the fermentation temperature, e.g. about 10 ºC. The hot water is stored in insulated water tanks and used for various processes, e.g. for use in production, cleaning operations, flushing brew kettles or for room heating.

Achieved environmental benefits

Reduced energy consumption. Reduced water consumption and improvements in the hot water balance of the operation. Reduced odour emissions.

Applicability

Applicable in all breweries.

Heat recovery from wort boiling

Description

Wort boiling is the largest single heat consuming process in a brewery. When the wort is boiled, 6 – 10 % normally evaporates. The vapour is usually emitted to the air, wasting energy and producing unpleasant odours. Recovering heat from wort kettles saves energy and avoids odour problems.

Achieved environmental benefits

Significantly reduced energy consumption. Reduced water consumption and improvements in the hot water balance of the operation. Reduced odour emissions.

Applicability

Applicable in new breweries and in existing breweries when the installation has a high and inefficient energy consumption. In these cases, heat recovery is only considered after other significant energy reductions have first been made, e.g. to a level of 41.66 – 55.55 kWh/hl (150 – 200 MJ/hl).

Economics

High capital costs.

Driving forces for implementation

Cost reductions, e.g. lower energy and water consumption costs.

1.5 General BAT for the whole FDM sector (energy-related)

A number of techniques have been determined as general BAT applicable to all, or the majority of, FDM industrial operations and these are described in this section. These are general techniques that are commonly used across the whole sector, regardless of the processes used or the products produced. **In the following the general energy-related BAT are summarised.**

- ensure, e.g. by training, that employees are aware of the environmental aspects of the company’s operations and their personal responsibilities (see Chapter 1.2.1)
- design/select equipment, which optimises consumption and emission levels and facilitates correct operation and maintenance (see Chapter 1.2.2)
- operate regular maintenance programmes (see Chapter 1.2.3)
- apply and maintain a methodology for preventing and minimising the consumption of water and energy and the production of waste incorporating (see Chapter 1.2.4):
  - ➢ obtaining management commitment, organisation and planning
  - ➢ analysis of production processes, including individual process steps to identify areas of high water and energy consumption and high waste emissions to identify opportunities to minimise these, taking into account the water quality requirements for each application, hygiene and food safety
  - ➢ assessment of objectives, targets and system borders
  - ➢ identification of options for minimising water and energy consumption, and waste production, using a systematic approach, such as pinch technology
  - ➢ carrying out an evaluation and doing a feasibility study
  - ➢ implementing a programme for minimising the consumption of water and energy and waste production and
  - ➢ ongoing monitoring of water and energy consumption; waste production levels and the effectiveness of control measures. This can involve both measurement and visual inspection
- implement a system for monitoring and reviewing consumption and emission levels for both individual production processes and at site level, to enable actual performance levels to be optimised. Examples of parameters to monitor include: energy consumption; water consumption; waste water volumes; emissions to air and water; solid waste generation; product and by-product yield; consumption of harmful substances and frequency and severity of unplanned releases and spillages. A good knowledge of the process inputs and outputs is required to identify priority areas and options for improving environmental performance. A good monitoring system will include records of operating conditions, sampling and analytical methods and will ensure that measuring equipment is calibrated. For further information see the “Reference Document on the General Principles of Monitoring”

- maintain an accurate inventory of inputs and outputs at all stages of the process from reception of raw materials to dispatch of products and end-of-pipe treatments (see Chapter 1.2.4; Step 2)
- apply production planning to minimise associated waste production and cleaning frequencies (see Chapter 1.2.5)
- minimise storage times for perishable materials (see Chapter 1.2.6)
- optimise the segregation of water streams, to optimise re-use and treatment (see Chapter 1.2.7)
- avoid using more energy than needed for heating and cooling processes, without harming the product (see Chapter 1.2.8)
- where heat processes are applied and/or materials are stored or transferred at critical temperatures, or within critical temperature ranges, to control the temperature by dedicated measurement and correction (see Chapter 1.2.10)
- where materials are pumped or flow, to control flow and/or level, by dedicated measurement of pressure and/or dedicated measurement of flow and/or dedicated measurement of level and using control devices, such as valves (see Chapter 1.2.11)

1.6 Additional BAT for some processes and unit operations applied in a number of FDM sectors (energy-related)

1.6.1 Frying

In all FDM installations carrying out frying, BAT is to do the following:

- recirculate and burn exhaust gases

See also Chapter 1.3.2

1.6.2 Evaporation

- use multi-effect evaporators optimising vapour recompression related to heat and power availability in the installation, to concentrate liquids

See also Chapter 1.3.4

1.6.3 Freezing and refrigeration

In all FDM installations carrying out freezing and refrigeration, BAT is to do the following:

- avoid keeping air conditioned and refrigerated areas colder than necessary
- optimise the condensation pressure
- regularly defrost the entire system
- keep the condensers clean
- make sure that the air entering the condensers is as cold as possible
- optimise the condensation temperature
- use automatic defrosting of cooling evaporators
- operate without automatic defrosting during short production stops
- minimise transmission and ventilation losses from cooled rooms and coldstores

See also Chapter 1.3.6

1.6.4 Cooling

In all FDM installations carrying out cooling, BAT is to do the following:

- optimise the operation of cooling water systems to avoid excessive blowdown of the cooling tower
- install a plate heat-exchanger for pre-cooling ice-water with ammonia, prior to final cooling in an accumulating ice-water tank with a coil evaporator
- recover heat from cooling equipment. Water temperatures of 50 – 60 °C can be achieved

See also Chapter 1.3.5

1.6.5 Energy generation and use

BAT is to do the following:

- for installations where there is a use for the heat and power produced, e.g. in sugar manufacturing, milk powder production, whey drying, instant coffee production, brewing and distilling, use combined heat and power generation in new or substantially altered installations or those renewing their energy systems
- use heat pumps for heat recovery from various sources
- switch equipment off when it is not needed
- minimise the loads on motors
- minimise motor losses
- use variable speed drives to reduce the load on fans and pumps
- apply thermal insulation, e.g. of pipes, vessels and equipment used to carry, store or treat substances above or below ambient temperature and to equipment used for processes involving heating and cooling
- apply frequency controllers on motors

See also Chapter 1.3.7

1.6.6 Water use

If groundwater is used, BAT is to do the following:

- only pump the quantities of water that are actually required

See also Chapter 1.3.8

1.6.7 Compressed air systems

For compressed air generation, BAT is to do the following:

- review the pressure level and reduce it if possible (see Section 4.2.16.1)
- optimise the air inlet temperature (see Section 4.2.16.2)

See also Chapter 1.3.10

1.6.8 Steam systems

For steam systems, BAT is to do the following:

- maximise condensate return
- avoid losses of flash steam from condensate return

- isolate unused pipework
- improve steam trapping
- repair steam leaks
- minimise boiler blowbown

See also Chapter 1.3.11

1.7 Additional BAT for some individual FDM sectors (energy-related)

1.7.1 Additional BAT for the meat and poultry sector

For meat and poultry processing installations, BAT is to do the following:

- avoid the use of flake ice by using a suitable mixture of chilled and frozen raw materials

See also Chapter 1.4.1

1.7.2 Additional BAT for the fish and shellfish sector

For fish and shellfish processing installations, BAT is to do the following:

- Avoiding scaling if the fish is subsequently skinned

See also Chapter 1.4.2

1.7.3 Additional BAT for the fruit and vegetables sector

For fruit and vegetable processing installations, BAT is to do the following:

- peel fruit and vegetables using a batch steam process or a continuous steam process not using cold water to condense the steam and, if for technological reasons steam peeling cannot be applied, use dry caustic peeling, unless the recipe requirements cannot be met if either of these techniques is used
- after blanching, cool fruit and vegetables before freezing them by passing them through cold water

See also Chapter 1.4.3

1.7.4 Additional BAT for the vegetable oils and fats sector

For vegetable oil processing installations, BAT is to do the following:

- use a countercurrent flow desolventiser-toaster in vegetable oil extraction
- in vegetable oil processing, use the vapour generated in the desolventiser-toaster in the first step of the miscella distillation pre-evaporator
- use the exothermic reaction heat from the hydrogenation of vegetable oil to heat the product to the desired reaction temperature and to generate steam later in the reaction. The achievable energy (steam) generation is 25 – 125 kWh/t (90 - 450 MJ/t) (40 – 200 kg/t) unrefined oil
- use water ring pumps to generate an auxiliary vacuum for oil drying, oil degassing or minimising oxidation of oil
- deodorise vegetable oils using a double scrubber in combination with a once-through cooling system

See also Chapter 1.4.4

1.7.5 Additional BAT for dairies

For dairies, BAT is to do the following:

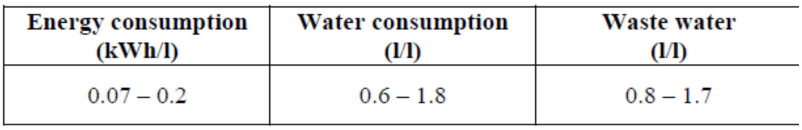
- partially homogenise milk
- replace batch pasteurisers with continuous ones
- use regenerative heat exchange in pasteurisation
- for large dairies with highly branched tubing, use several small CIP systems instead of a centralised CIP system
- re-use cooling water, used cleaning water, condensates from drying and evaporation, permeates generated in membrane separation processes and final rinse-water after the treatment, if any required, to ensure the level of hygiene necessary for the re-use application

See also Chapter 1.4.5

Additional BAT for the production of market milk

For the production of market milk, BAT is to do the following:

- achieve the energy consumption level of 0.07 – 0.2 kWh/l



Energy consumption (kWh/l)	Water consumption (l/l)	Waste water (l/l)
0.07 – 0.2	0.6 – 1.8	0.8 – 1.7

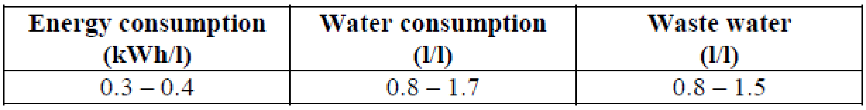
Table 1-31: Consumption and emission levels associated with the production of market milk from 1 litre of received milk

See also Chapter 1.4.5

Additional BAT for milk powder production

For milk powder production, BAT is to do the following:

- to produce powdered milk use multi-effect evaporators, optimising vapour recompression related to heat and power availability in the installation, to concentrate liquid milk before spray drying, followed by FBD, e.g. integrated FDB
- achieve an energy consumption level of 0.3 – 0.4 kWh/l



Energy consumption (kWh/l)	Water consumption (l/l)	Waste water (l/l)
0.3 – 0.4	0.8 – 1.7	0.8 – 1.5

Table 1-32: Consumption and emission levels associated with the production of milk powder from 1 litre of received milk

See also Chapter 1.4.5

Additional BAT for cheesemaking

For cheesemaking, BAT is to do the following:

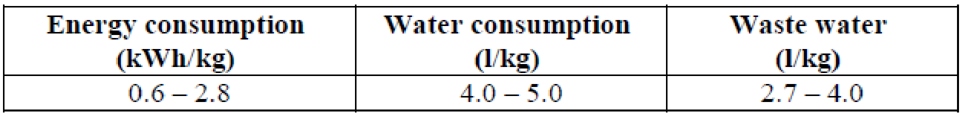
- use the heat from warm whey for preheating cheese milk
- to produce whey powder use multi-effect evaporators, optimising vapour recompression related to heat and power availability in the installation, to concentrate whey before spray drying, followed by FBD, e.g. integrated FDB

See also Chapter 1.4.5

Additional BAT for ice-cream manufacturing

For ice-cream manufacturing, BAT is to do the following:

- achieve an energy consumption level of 0.6 – 2.8 kWh/kg



Energy consumption (kWh/kg)	Water consumption (l/kg)	Waste water (l/kg)
0.6 – 2.8	4.0 – 5.0	2.7 – 4.0

Table 1-33: Consumption and emission levels associated with the production of 1 kg of ice cream

1.7.6 Additional BAT for the sugar sector

For the sugar beet sector, BAT is to do the following:

- avoid drying sugar beet pulp if an outlet is available for pressed sugar beet pulp, e.g. animal feed; otherwise dry sugar beet pulp using steam driers or using high temperature driers, combined with measures to reduce emissions to air

See also Chapter 1.4.6

1.7.7 Additional BAT for the coffee sector

For the coffee sector, BAT is to do the following:

- when roasting coffee, recirculate air from the roaster back into the roaster
- in instant coffee manufacturing, use the waste heat from the hot liquid coffee extract to heat the process water prior to extraction and use countercurrent heat-exchange to use the heat from spray drying within the roasting sector

See also Chapter 1.4.7

1.7.8 Additional BAT for drinks manufacturing

For drinks processing installations, BAT is to do the following:

- if CO_2 is used in the installation, use CO_2 which is either recovered from the fermentation process or as a by-product of another process, to avoid the production of CO_2 directly derived from fossil fuels especially for use in the installation
- use multistage bottle cleaning systems

See also Chapter 1.4.8

Additional BAT for brewing

For breweries, BAT is to do the following:

- optimise the re-use of hot water from wort cooling and recover heat from wort boiling

See also Chapter 1.4.8

1.8 Expert Contribution (energy-related information; dairy sector)

During the 2nd Expert Group Meeting in Copenhagen (31 August – 01 September) a presentation was held by Mr. Peter Maagøe Petersen (Viegand & Maagøe Aps). Mr. Petersen is working as a (energy) consultant for a number of dairies (e.g. Arla Foods in Denmark) and provided valuable energy-related information for the dairy sector which can be used for the purpose of this document.

In the following the main energy-related information from the presentation will be summarised and utilised in the subsequent chapter to draft the sector specific supplement (see Chapter 2). The following information can only be used for the dairy sector and not for other FDM sectors discussed in this document.

1.8.1 Dairy industry sub-sectors

The dairy industry sub-sectors are quite different when it comes to the use of technology and also regarding their energy intensity. As shown in the following table, the most important dairy industry sub-sector with regard to energy efficiency is the milk and whey powder sub-sector followed by the cheese manufacturing and market milk and yoghurt manufacturing sub-sector.

Other dairy subsectors are for instance the butter, ice-cream, special products, etc.

	Energy consumption (GJ/t processed milk)			**Importance of Energy Efficiency**
Products	**Electricity**	**Fuel**	**Remarks**	
Market milk and yoghurt	0.15 – 2.5	0.18 – 1.5	Minimum for liquid milk, maximum for specialities	*
	0.09 – 1.11 [1]			
Cheese	0.08 – 2.9	0.15 – 4.6	Depends on the type of cheese and production run Maximum fuel for whey evaporation	**
	0.06 – 2.08 [1]			
Milk and whey powder	0.06 – 3.3	3 – 20	Maximum fuel for whey products	***
	0.85 – 6.47 [1]			

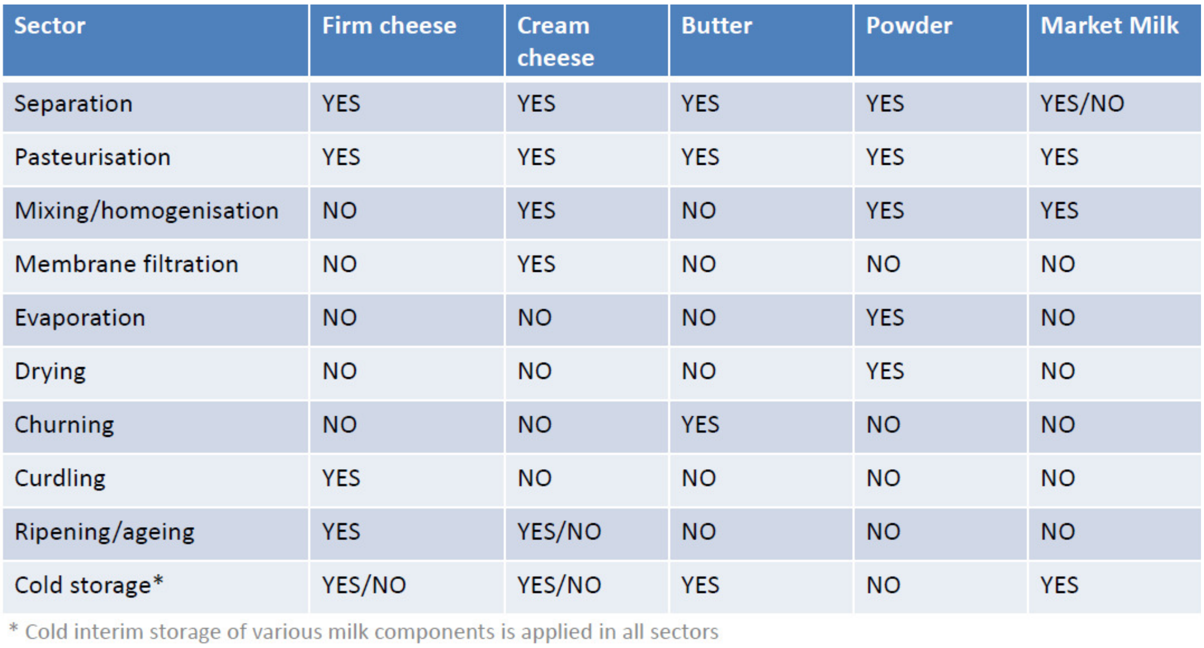
[1] approximate kWh/l (assuming milk has a density of 1 kg/l)

Table 1-34: Energy consumption and importance of energy efficiency in different diary industry sub-sectors

1.8.2 Main processes/technologies

Mr. Petersen introduced the main processes/technologies in relation to energy efficiency and highlighted that various energy relevant processes, from raw milk to finished products (e.g. centrifugation and separation, pasteurisation, mixing, filtration, evaporation) need to be taken into account.

The following table displays a sector technology overview of significant energy demanding processes.

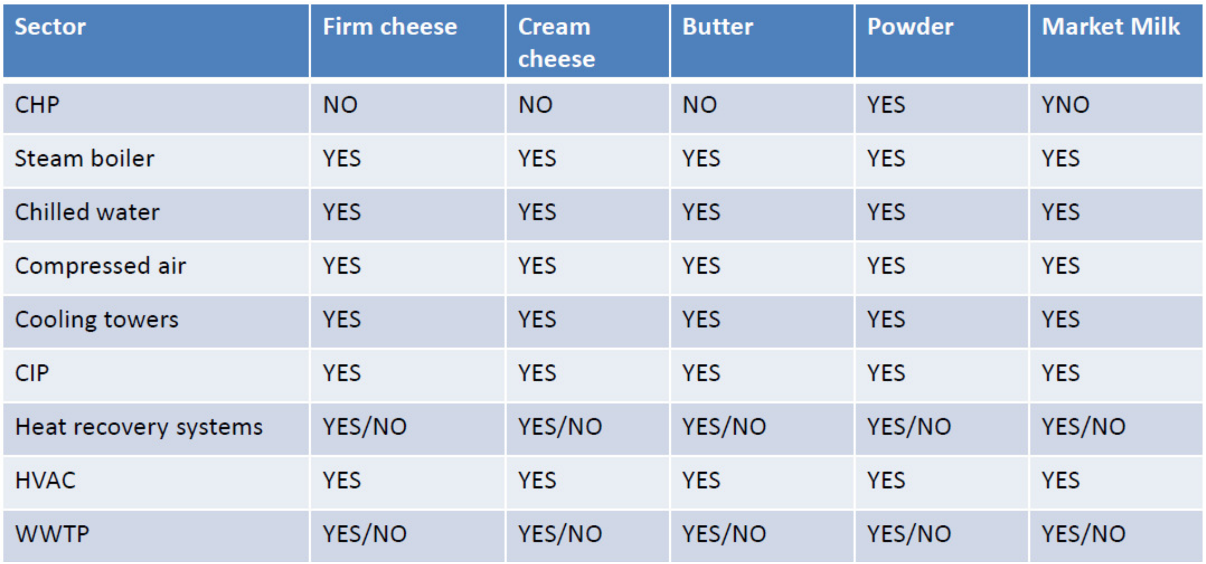


Sector	Firm cheese	Cream cheese	Butter	Powder	Market Milk
Separation	YES	YES	YES	YES	YES/NO
Pasteurisation	YES	YES	YES	YES	YES
Mixing/homogenisation	NO	YES	NO	YES	YES
Membrane filtration	NO	YES	NO	NO	NO
Evaporation	NO	NO	NO	YES	NO
Drying	NO	NO	NO	YES	NO
Churning	NO	NO	YES	NO	NO
Curdling	YES	NO	NO	NO	NO
Ripening/ageing	YES	YES/NO	NO	NO	NO
Cold storage*	YES/NO	YES/NO	YES	NO	YES

* Cold interim storage of various milk components is applied in all sectors

Table 1-35: Technology overview of significant energy demanding processes

The following table summarises the main utilities applied in different dairy sub-sectors.



Sector	Firm cheese	Cream cheese	Butter	Powder	Market Milk
CHP	NO	NO	NO	YES	YNO
Steam boiler	YES	YES	YES	YES	YES
Chilled water	YES	YES	YES	YES	YES
Compressed air	YES	YES	YES	YES	YES
Cooling towers	YES	YES	YES	YES	YES
CIP	YES	YES	YES	YES	YES
Heat recovery systems	YES/NO	YES/NO	YES/NO	YES/NO	YES/NO
HVAC	YES	YES	YES	YES	YES
WWTP	YES/NO	YES/NO	YES/NO	YES/NO	YES/NO

Table 1-36: Overview of major utilities applied in different dairy industry sub-sectors

It was concluded that the energy balances within the dairy sector are highly complex and that 'system integration' is of major importance for energy efficiency.

The presentation went further to introduce a number of energy recovery and/or energy-saving techniques for the main processes. The following common energy efficiency optimisation techniques/processes were summarised:

- apply and optimise regenerative heat exchange in pasteurisation units

- minimise cleaning procedures (CIP) and sterilisation in terms of frequency, time and hot water consumption
- scrutinise plant for waste heat recovery opportunities – system integration and "secondary" utilities are crucial
- raise cooling demand temperature wherever possible (e.g. intake temperature of raw milk, intermediate storage tank temperatures etc.)
- review chilled water system efficiency
- training of operators to avoid excess rework, CIP, product changeovers, etc.

Moreover, it was expressed that energy efficiency of dairies is to a certain degree determined by system solutions (which are complex to evaluate), SOPs and recipes, operator behaviour, products, etc. Besides, production facilities are quite different even in the case that same products are produced. Semi-finished products are also often traded between facilities, as for instance in the powder industry.

1.8.3 Milk powder/food ingredients

The following figure shows the typical heat and power distribution of the milk powder/food ingredients sub-sector.

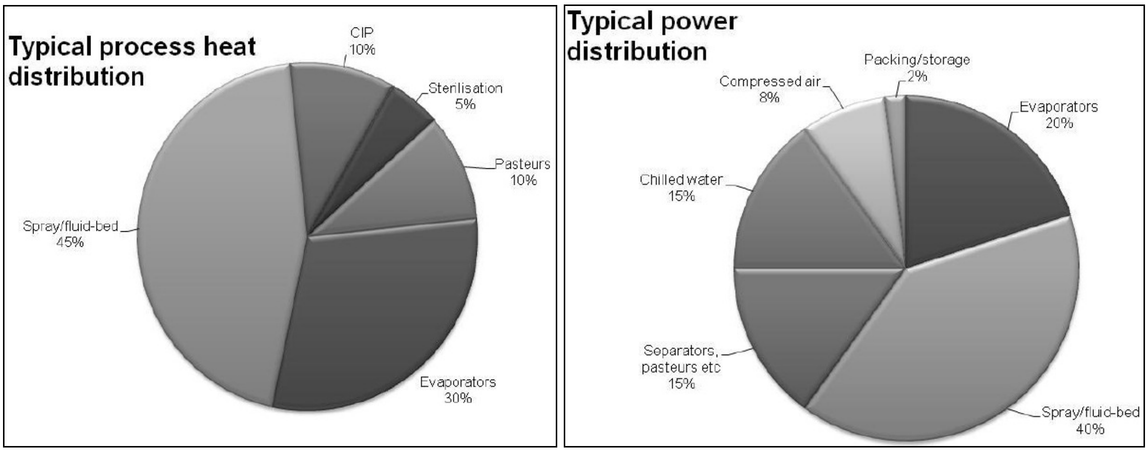


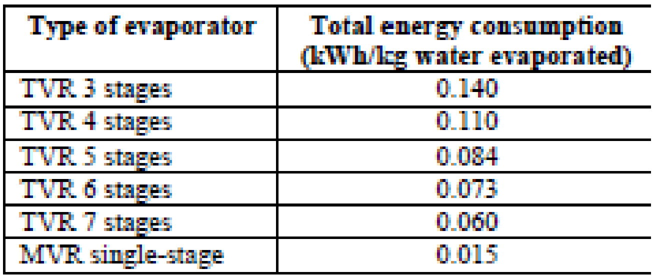
Figure 1-2: Typical process heat and power distribution (milk powder/food ingredients sub-sector)

As it can be seen, the spray/fluid-bed and evaporators are by far the largest heat and power consumer within the milk powder/food ingredients sub-sector.

The energy related BAT definitions in milk powder production are:

- Use multi-effect evaporators to concentrate milk before spray drying
- Use vapour recompression (MVR) to replace steam evaporators
- Use Fluid Bed Dryers after spray drying
- Energy consumption of 0,3-0,4 kWh/litre of processed milk

Typically 2-4 stage traditional steam heated evaporators can be replaced with MVR – compressors thus replacing steam consumption by < 5 % electricity consumption (see Table 1-37).



Type of evaporator	Total energy consumption (kWh/kg water evaporated)
TVR 3 stages	0.140
TVR 4 stages	0.110
TVR 5 stages	0.084
TVR 6 stages	0.073
TVR 7 stages	0.060
MVR single-stage	0.015

Table 1-37: Comparison of efficiencies of multi-effect evaporators in the dairy industry

In order to optimise energy efficiency the following was proposed:

- MVR evaporation is the most efficient
- Use bag filter technology on spray dryer to recover powder in exhaust air
- Optimised nozzle design in spray dryer
- High-efficient ventilator and VSD control for spray dryer and fluid bed air systems
- High efficient pump systems for supplying milk pressure to spray nozzles

In addition, the following energy recovery measures were proposed:

- Use of waste heat from spray dryer exhaust
- Use of waste heat from evaporator condensate
- Heat can be raised in temperature by heat pump technology
- Air preheat for spray drier / fluid bed
- Milk preheat for evaporator, spray dryer
- Milk preheat for pasteurisation

1.8.4 Cheese production

The following figure shows the typical heat and electricity balance for cream cheese production.

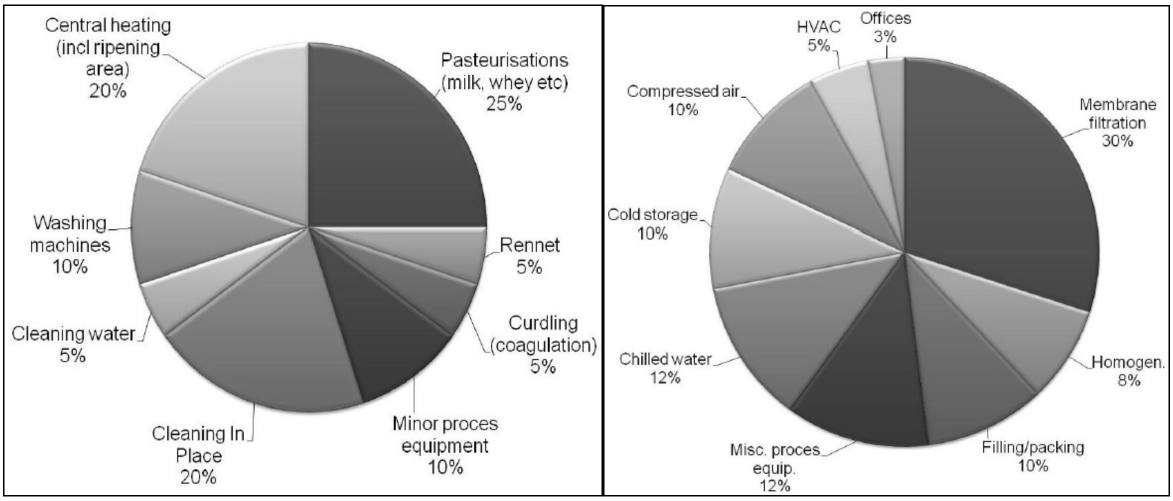


Figure 1-3: Typical heat and electricity balance for cheese production

In order to optimise energy efficiency the following was proposed:

- Avoid multiple pasteurisations of milk, e.g. as raw milk, skimmed milk, cream and standardised milk
- Optimise control and operation of equipment and processes for mixing, homogenisation and filtration
- Avoid recirculation of milk due to unmatched capacities of sub-processes
- Review and minimise hot water consumption for cleaning
- VSD control on large pumping systems, e.g. UF filtration

In addition, the following energy recovery measures were proposed:

- Use of waste heat from filtration unit cooling
- Use of waste heat from whey
- Heat can be raised in temperature by heat pump technology
- "Complex systems" can transfer large amounts of waste heat
- Milk preheat for pasteurisation
- Cleaning In Place (CIP) water and chemicals
- Room heat in ageing areas (typical 25-30 C required for yellow cheeses)

1.8.5 Butter production

The following figure shows the typical process heat and power balance for butter production.

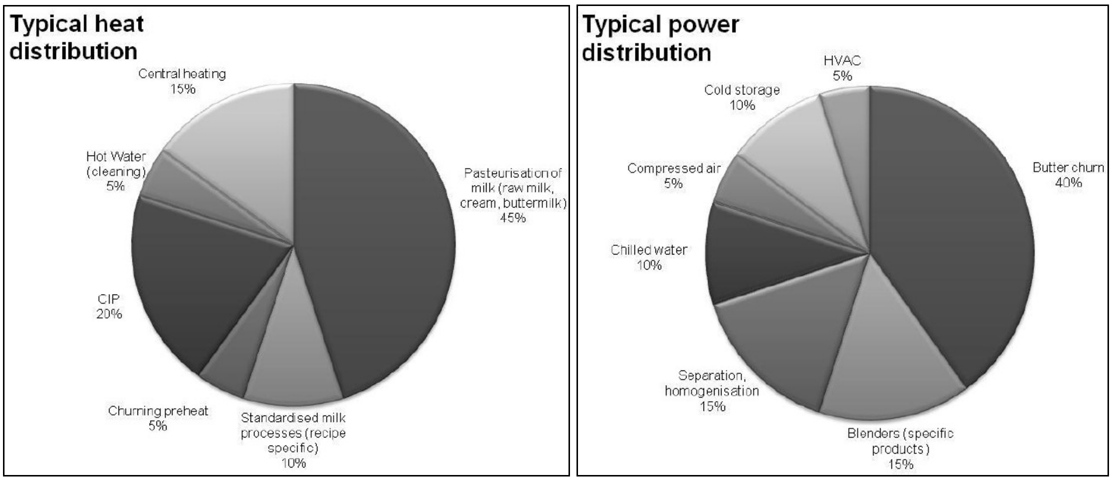


Figure 1-4: Typical heat and power distribution for butter production

In order to optimise energy efficiency the following was proposed:

- Avoid multiple pasteurisations of milk, e.g. as raw milk, skimmed milk, cream and standardised milk
- Optimise control and operation of butter churns and cooling of buttermilk
- Consider using buttermilk for cooling churn
- Review and minimise hot water consumption for cleaning
- VSD control on large motor systems, e.g. butter churn

At the end of the presentation it was highlighted that in general energy efficiency is to a certain degree determined by:

- Systems solutions (complex to evaluate)
- SOPs and recipes
- Operator behaviour (CIP, rework etc.)
- Products

At the same time, production logistics can vary significantly even for same facilities (e.g. in powder industry the powder is traded between facilities).

All these factors influence the key performance indicators and are difficult to ‘inspect’.

2 Proposal for the Sector Specific Supplement – FDM Industries

2.1 Techniques to reduce specific energy consumption (entire FDM sector)

Are the following techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
Ensure, e.g. by training, that **employees are aware of the environmental aspects** of the company's operations **and their personal responsibilities** (energy-related)		
Design/select equipment, which optimises consumption and emission levels and facilitates correct operation and maintenance		
Regular **maintenance programmes**		
Methodology for preventing and minimising the consumption of energy: ➢ obtaining management commitment, organisation and planning ➢ analysis of production processes, including individual process steps to identify areas of high energy consumption and to identify opportunities to minimise these ➢ assessment of objectives, targets and system boundaries ➢ identification of options for minimising energy consumption using a systematic approach, such as pinch technology ➢ carrying out an evaluation and doing a feasibility study ➢ implementing a programme for minimising the consumption of energy ➢ ongoing monitoring of energy consumption and the effectiveness of control measures (both measurement and visual inspection)		
Maintain an accurate **inventory of inputs and outputs at all stages of the process** from reception of raw materials to dispatch of products and end-of-pipe treatments		
Production planning to minimise associated waste production and cleaning frequencies		
Minimise storage times for perishable materials		
Optimise the segregation of water streams, to optimise re-use and treatment		
Avoid using more energy than needed for		

Are the following techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
heating and cooling processes, without harming the product		
Where heat processes are applied and/or materials are stored or transferred at critical temperatures, or within critical temperature ranges, to **control the temperature by dedicated measurement and correction**		
Where materials are pumped or flow, to **control flow and/or level**, by dedicated measurement of pressure and/or dedicated measurement of flow and/or dedicated measurement of level and **using control devices**, such as valves		

2.2 Additional techniques for some processes and unit operations (number of FDM sectors)

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
*For all FDM installations carrying out **frying***		
Recirculate and burn exhaust gases		
*For all FDM installations carrying out **evaporation***		
Use **multi-effect evaporators** optimising vapour recompression related to heat and power availability in the installation, to concentrate liquids		
*For all FDM installations carrying out **freezing and refrigeration***		
Avoid keeping air conditioned and refrigerated areas colder than necessary		
Optimise the **condensation pressure and temperature**		
Keep the condensers clean		
Regularly defrost the entire system		
Make sure that the **air entering the condensers is as cold as possible**		
Use **automatic defrosting** of cooling evaporators		
Operate **without automatic defrosting during short production stops**		
Minimise transmission and ventilation losses from cooled rooms and coldstores		
*For all FDM installations carrying out **cooling***		

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Optimise the operation of cooling water systems to avoid excessive blowdown of the cooling tower		
Install a plate heat-exchanger for pre-**Cooling ice-water with ammonia**, prior to final cooling in an accumulating ice-water tank with a coil evaporator		
Recover heat from cooling equipment		
Energy generation and use		
Use **combined heat and power generation** in new or substantially altered installations or those renewing their energy systems (installations where there is a use for the heat and power produced, e.g. in sugar manufacturing, milk powder production, whey drying, instant coffee production, brewing and distilling)		
Use **heat pumps for heat recovery** from various sources		
Switch equipment off when it is **not needed**		
Minimise the loads on motors		
Minimise motor losses		
Use **variable speed drives** to reduce the load on fans and pumps		
Apply **thermal insulation (**e.g. of pipes, vessels and equipment used to carry, store or treat substances above or below ambient temperature and to equipment used for processes involving heating and cooling)		
Apply **frequency controllers** on motors		
*For installations **using groundwater***		
Only **pump the quantities of water** that are **actually required**		
*For **compressed air generation***		
Review the pressure level and **reduce** it **if possible**		
Optimise the **air inlet temperature**		
*For **steam systems***		
Maximise condensate return		
Avoid losses of flash steam from condensate return		
Isolate unused pipework		
Improve steam trapping		
Repair steam leaks		
Minimise boiler blowbown		

2.3 Additional techniques for some individual FDM sectors

2.3.1 Meat and poultry

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Avoid the use of flake ice by using a suitable mixture of chilled and frozen raw materials		

2.3.2 Fish and shellfish

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Avoiding scaling if the fish is subsequently skinned		

2.3.3 Fruit and vegetables

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Peel fruit and vegetables using a batch steam process or **a continuous steam process** not using cold water to condense the steam and, if for technological reasons steam peeling cannot be applied, use dry caustic peeling, unless the recipe requirements cannot be met if either of these techniques is used		
After blanching, cool fruit and vegetables before freezing them by passing them through cold water		

2.3.4 Vegetable oils and fats

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Use a countercurrent flow desolventiser-toaster in vegetable oil extraction		
In vegetable oil processing, **use the vapour generated in the desolventiser-toaster in the first step of the miscella distillation pre-evaporator**		
Use the exothermic reaction heat from the hydrogenation of vegetable oil **to heat the product to the desired reaction**		

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
temperature and to generate steam later in the reaction		
Use **water ring pumps** to generate an auxiliary vacuum for oil drying, oil degassing or minimising oxidation of oil		
Deodorise vegetable oils using a double scrubber in **combination with a once-through cooling system**		

2.3.5 Dairies

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
For dairies		
Partially homogenise milk		
Replace batch pasteurisers with continuous ones		
Use **regenerative heat exchange** in pasteurisation		
For large dairies with highly branched tubing, use **several small CIP systems instead of a centralised CIP system**		
Re-use cooling water, used **cleaning water**, **condensates** from drying and evaporation, **permeates** generated in membrane separation processes and **final rinse-water after the treatment**		
For the production of ***market milk***		
Achieve the energy consumption level of 0.07 – 0.2 kWh/l		
For the production of ***milk powder***		
Produce powdered milk using **multi-effect evaporators**, optimising vapour recompression related to heat and power availability in the installation, to concentrate liquid milk before spray drying, followed by FBD, e.g. integrated FDB		
Achieve the energy consumption level of 0.3 – 0.4 kWh/l		
For the production of ***cheese***		
Use the heat from warm whey for preheating cheese milk		
Produce whey powder using **multi-effect evaporators**, optimising vapour recompression related to heat and power availability in the installation, to concentrate		

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
For dairies		
whey before spray drying, followed by FBD, e.g. integrated FDB		

2.3.6 Sugar

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
Avoid drying sugar beet pulp if an outlet is available for pressed sugar beet pulp, e.g. animal feed; otherwise dry sugar beet pulp using steam driers or using high temperature driers		

2.3.7 Coffee

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
When roasting coffee, **recirculate air from the roaster back into the roaster**		
In instant coffee manufacturing, **use the waste heat from the hot liquid coffee extract** to heat the process water prior to extraction and **use countercurrent heat-exchange to use the heat from spray drying within the roasting sector**		

2.3.8 Drinks

Are the following additional techniques applied in order to improve energy efficiency/reduce energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
For the processing of ***drinks***		
If CO_2 is used in the installation, **use CO_2 which is either recovered from the fermentation process or as a by-product of another process**, to avoid the production of CO_2 directly derived from fossil fuels especially for use in the installation		
Use **multistage bottle cleaning systems**		
For breweries		
Optimise the re-use of hot water from wort cooling and recover heat from wort boiling		

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