2 OVERVIEW OF MEAT PROCESSING

Meat and meat products are an important component of diet in many parts of the world, particularly in developed nations, where the consumption of animal protein per head of population is the highest. For developing nations, the production and consumption of meat is increasing as levels of affluence increase.

Table 2—1 provides an overview of world meat production, showing the contributions of different meat species to overall meat-production and the relative scales of production for the major meat producing countries. Of the red meats, pork and beef are produced in the greatest quantities. Poultry meat is also a major source of world meat production. China and the United States of America are the world's largest producers of beef and pork. Brazil, Mexico, the Russian Federation and a number of western European countries are also large producers.

The slaughter of livestock to produce meat and meat products is a widespread activity and can be an important industry in many countries.

Table 2—1 Overview of world meat production [1]

	Beef (includes veal)	Pork	Mutton, lamb and goat meat	Poultry
Total world production (1000 tonnes/yr)	45,293	69,696	6,435	53,282
Percentage of world production	26%	40%	4%	30%
Major producing countries (1000 tonnes/yr)				
Argentina	2,600	-	82	675
Australia	1,839	344	580	498
Brazil	4,475	1,300	-	3,491
China	3,300	32,048	1,609	7,550
Denmark	190	1,537	2	172
France	1,592	2,126	154	1,961
Germany	1,447	3,030	41	641
India	1,050	-	615	-
Italy	1,170	1,369	79	1,084
Japan	602	1,390	-	1,302
Mexico	1,810	900	140	1,240
Netherlands	603	1,673	18	594
New Zealand	572	45	513	-
Philippines	135	715	-	-
Russian Federation	3,100	2,260	310	1,170
Spain	478	2,107	240	880
Taiwan	5	1,204	-	604
United Kingdom	918	1,053	352	1,2789
United States of America	11,194	8,027	140	13,206

[1] Derived from data presented in Ockerman and Hansen, 2000

Terminology

Meat processing is the generic term used to describe the industry. However a number of terms are used to describe the facilities at which meat processing occurs, including abattoirs, slaughterhouses and meat packing plants.

The terms *abattoir* and *slaughterhouse* are synonymous and refer to plants which slaughter livestock and dress carcasses only, often with limited or no processing of by-products. The products from these plants are usually dressed carcasses, which are sold on a wholesale basis to butchers and other meat processing plants. However, it is common for abattoirs or slaughterhouses to also undertake the boning of carcasses to produce retail cuts.

Meat packing plants undertake slaughter and carcass dressing, but also undertake the further processing of meat products and by-products. A meat packing plant will often undertake the cooking, curing, smoking and pickling of meat and the manufacture of sausage.

Focus of this guide

Since livestock slaughter along with its associated activities contributes the most to pollution loads from the meat processing industry as a whole, this guide focuses on abattoir (or slaughterhouse) operations. There is no discussion on the further processing of meat. For simplicity the term *abattoir* will be used throughout this document.

Slaughtering can take place either on farms, at butchers' premises or at abattoirs. Consequently, the scale on which slaughtering takes place can vary enormously, from slaughtering only a few animals through to thousands each day. Methods and equipment for slaughtering may vary, but the basic principles are independent of plant capacity.

Large, highly automated abattoirs may specialise in the slaughter of one species of livestock. However it is also common for abattoirs to kill a number of species at a single premises. Species slaughtered include beef cattle, pigs, sheep, goats, horses and deer. This guide covers the slaughter of beef cattle and pigs only and does not discuss the other species specifically. However, many of the Cleaner Production principles will apply also to them.

For small-scale operations taking place on farms or at butchers' premises, mechanisation is limited and extensive use is made of all by-products, meaning that very little waste and pollution are created. This guide does not deal with such small-scale operations, since the Cleaner Production opportunities described in this guide are generally not applicable or viable in these situations. Instead, the guide describes the application of Cleaner Production to medium and large-scale abattoirs.

An increasing trend in many countries is for abattoirs to incorporate rendering facilities to process solid by-product materials into meat meal and tallow. For abattoirs without rendering facilities, by-products are sent to independent rendering plants. German abattoirs, for example, do not undertake rendering since by law it must be performed in a separate off-site facility.

Units of production

There are a number of units used to describe the scale of production in abattoirs. Commonly used units are per head of livestock slaughtered, tonne of live carcass weight (LCW), tonne of dressed weight (DW) or tonne of hot standard carcass weight (HSCW). Units based on carcass weight are often most useful because they allow for comparison between abattoirs slaughtering livestock with different unit weights. Data presented in this document are reported according to the units used in the original source, therefore the units may vary.

2.1 Process overview

The generic processes that take place at abattoirs are stunning and bleeding, hide removal or treatment, evisceration, carcass dressing and washing. Many abattoirs also have a boning process in which finished carcasses are cut into retail portions. Most abattoirs also have casings and offal processing departments, which produce value-added products from the casings (intestinal tract) and edible offal. The sections that follow provide a brief description of these processes.

2.1.1 Slaughtering and processing of pigs

The basic process for slaughtering and processing pigs is shown in Figure 2—1.

Pre-handling of pigs Pigs are delivered to the abattoir in trucks, and held for one to two days in holding yards. They are generally fasted for a day to reduce the amount of intestinal contents.

Stunning and bleeding Pigs are stunned using an electric shock or by anaesthetising in carbon dioxide, after which they are bled. Bleeding, also referred to as sticking, is carried out using a hollow knife, which directs the blood to a collection trough, from where it is pumped to an agitated tank for further processing.

Dehairing and finishing Before being processed further, hair is removed from the pig carcasses, by scalding in hot water followed by scraping. Carcasses are then singed to remove any remaining hair. This process leaves the hide almost white in colour, clean and smooth without any trace of hair.

Evisceration and splitting After dehairing and hide finishing, the carcasses pass to the evisceration area, where the stomachs are opened and the viscera removed. The breastbone is split and the plucks (heart, liver and lungs) are loosened and removed. The carcasses are then de-headed and split along the backbone. Finally, the carcasses are chilled rapidly overnight before the subsequent processes of cutting and boning can take place.

By-product processing Edible offal components and casings (intestinal tract) are separated from the viscera and sent on for cleaning and further processing, generally in other parts of the plant.

Rendering At various stages in the process, inedible by-products such as bone, fat, heads, hair and condemned offal are generated. These materials are sent to a rendering plant either on site or off site for rendering into feed materials and tallow.

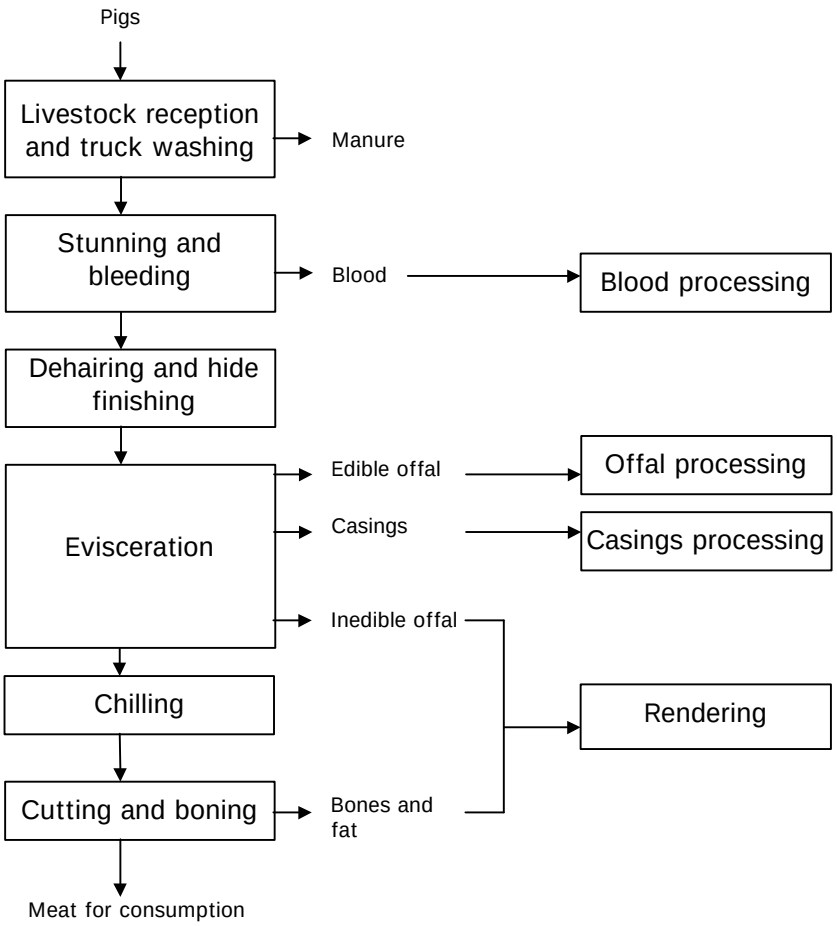

Figure 2—1 Flow diagram for slaughtering of pigs

Table 2—2 is a summary of the major products and by-products from the slaughter of a 90 kg pig, including an indication of the relative proportions.

Table 2—2 Products and by-products from the slaughter of a 90 kg pig

	Weight (kg)	Percentage of LCW
Live carcass weight (LCW)	**90.0**	**100%**
Boned meat	57.6	64%
Inedible material for rendering (bones, fat, head, hair, condemned offal etc.)	18.0	20%
Edible material (tongue, liver, heart, kidneys, trotters)	9.0	10%
Blood	2.7	3%
Miscellaneous (stomach contents, shrinkage, blood loss etc.)	2.7	3%

A pig carcass can be utilised to a much greater extent than any other farm animal species (up to 70% utilisation. This is because pigs have one stomach instead of four and are dressed with the feet and skin left on instead of removed. In addition, the proportion of edible components is higher than for cattle.

2.1.2 Slaughtering and processing of cattle

The live weight of cattle slaughtered for meat production can vary from 250 kg to 600 kg, depending on the age and breed of the animal. As a guide, heifers weigh 250–300 kg, cows 350–400 kg, and steers 400–600 kg.

The basic slaughtering procedure for beef cattle has become more automated and efficient over the past few decades. Most improvements have occurred in stunning, hide removal, evisceration and splitting techniques. As an example, processing rates in the United States now average around 350 head per hour (Savell and Smith, 1998).

The basic process for the slaughtering and processing of cattle is shown in Figure 2—2.

Pre-handling of cattle

Cattle are delivered to the abattoir in trucks and unloaded into holding pens, where they are rested for one or two days before slaughter. Any cattle classed as 'dirty' are washed.

Stunning and bleeding

The cattle are led to the slaughter area where they are stunned using a bolt pistol or electric shock. They are then shackled by a hind leg and hoisted onto an overhead rail or dressing trolley. Bleeding, or sticking, then takes place, with the blood collected in a trough for disposal or for further processing.

Dressing and hide removal

The bled carcasses are conveyed to the slaughter hall where dressing and evisceration take place. The first stage of this process, dressing, can be performed as the carcass hangs from the overhead rail, or the animal can be unshackled and laid in a cradle. The head and hoofs are removed, the head is cleaned with water, and the tongue and brain are recovered. Hides are then removed and conveyed to the hide processing area, where they are preserved by salting or chilled on ice.

Evisceration

The carcasses are then opened to remove the viscera. The stomach (paunch) and intestines are emptied of manure and cleaned in preparation for further processing. Edible offal (tongue, lungs, heart and liver) is separated, washed and chilled. The carcasses are then split, rinsed and then conveyed to a cold storage area for rapid chilling.

Cutting and boning

Carcass cutting and boning often take place after chilling, since a carcass is easier to handle and cut when it is chilled. Boning is the term used to describe the process of cutting meat away from the bone. Recent developments in processing technology have made it possible to undertake boning while the carcass is still warm, eliminating the need to chill the carcass at this stage in the process. This is referred to as 'hot boning'.

Inspection

Carcasses and viscera are inspected to determine if they are suitable for human consumption. Each carcass and its components are identified and kept together wherever possible until inspection is complete.

By-products

At various stages in the process, inedible by-products such as bone, fat, heads, hair and condemned offal are generated. These materials are sent to a rendering plant either on site or off site for rendering into feed materials.

Table 2—3 is a summary of the major products and by-products from the slaughter of a 400 kg animal, including an indication of the proportions of each.

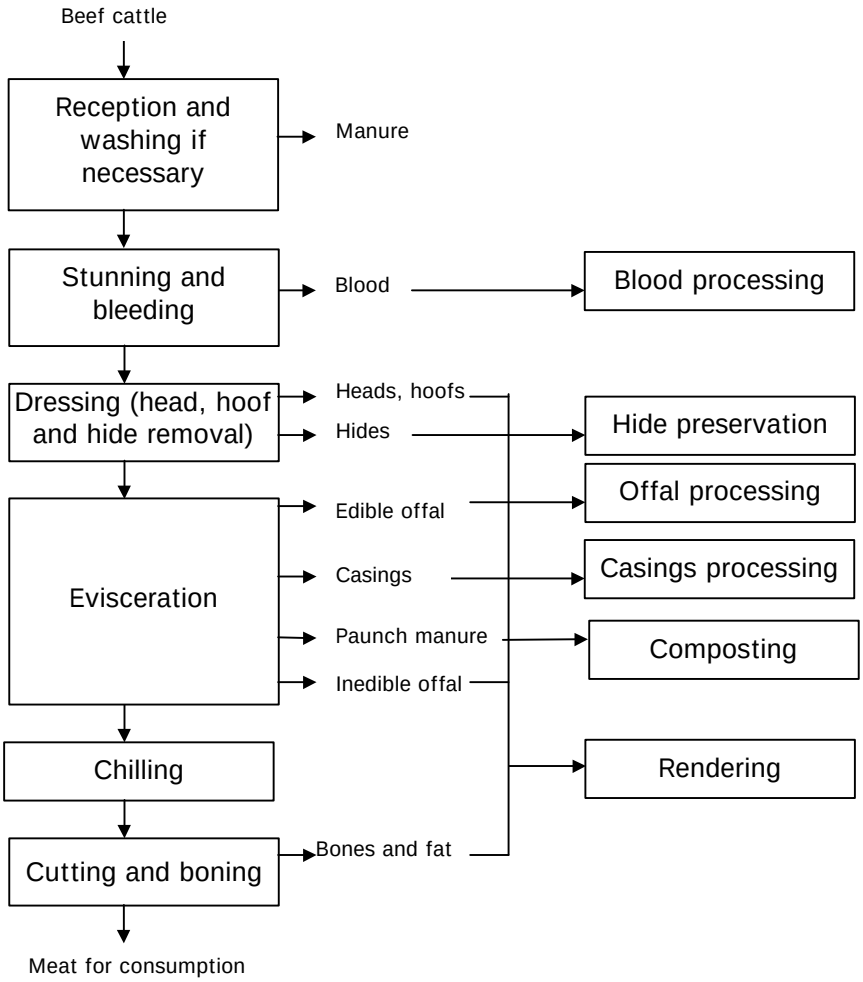

Figure 2—2 Flow diagram for slaughtering of cattle

Table 2—3 Products and by-products from the slaughter of 400 kg beef cattle

	Weight (kg)	Percentage of LCW
Live carcass weight (LCW)	**400**	**100%**
Boned meat	152	40%
Inedible material for rendering (bones, fat, head, condemned offal etc.)	155	39%
Hide	36	7%
Edible offal (tongue, liver, heart, kidneys, plucks etc.)	19	5%
Blood	12	3%
Miscellaneous (paunch manure, shrinkage, blood loss etc.)	26	6%

2.1.3 By-product processing

Meat is the most significant product from the abattoir, by weight and also in monetary terms. However, by-products can contribute significantly to the profitability of an abattoir operation since they generally have a commercial value.

If animal by-products are not used effectively a valuable source of revenue is lost, and the added and increasing cost of disposal of these products is incurred by the company. Also, from an environmental perspective, utilisation of by-products reduces the overall environmental load of the process.

The modern livestock industry is an effective user of by-products. However more than 2% of the carcass weight is often unaccounted for and is usually lost to effluent. Therefore, there is potentially more that can be done.

By-products from livestock slaughter include, but are not limited to (Ockerman and Hansen, 2000):

- edible offal for human consumption;
- edible fats for shortening, margarine, sweets and chewing gum;
- bone utilised in soup for human consumption, mixed with potter's clay, or the manufacture of buttons, knife handles and bone meal;
- blood for human consumption and for animal feed, pharmaceuticals and food additives;
- glycerin for numerous industrial uses, such as nitroglycerin, ointment bases, solvents, food preservatives and plasticisers;
- intestines for sausage casings, the strings of musical instruments and surgical ligatures;
- gelatin for confectionery items, ice cream and jellied food products;
- rennin for cheese making;
- numerous pharmaceutical products;
- livestock feed (usually high in protein, fat and minerals);
- pet food and feed for fish farming;
- hides and skins for use as fur, leather or leather goods;
- inedible fats for use in industrial products such as tyres, lubricants, insecticides and germicides;
- hair for brushes, felt, rugs, upholstery, plaster binding and insulation; and
- glue.

Edible offal for human consumption, such as liver, heart, kidney, tongue, sweetbread, brain and tripe is often processed at abattoirs. Processing of these materials is generally limited to trimming and rinsing. The preparation of animal intestines for use as sausage casings is a more involved process, requiring emptying, de-sliming and cleaning.

Other edible by-products include cheeks, head trimmings, lungs, spinal cord, breast fat and stomachs and cattle paunches. These are commonly sent to other facilities for the manufacture of animal feed, including pet

food. The processing of these materials at abattoirs is generally limited to cleaning in preparation for being sent off site.

Inedible by-products, such as fat, bones, hoofs, condemned offal and dead carcasses are rendered into tallow (derived from both cattle and sheep fat) or lard (derived from pig fat), and meat and bone meal. Tallow and lard have numerous applications and meat and bone meal are used predominantly as animal feed supplements. Rendering can take place either on site or at independent rendering plants.

In some regions, in particular the European Union, restrictions have been placed on the use of some animal by-products for human or animal consumption. This has been due to outbreaks of Bovine Spongiform Encephalopathy (BSE), which is a fatal neurological disorder of adult cattle. In those areas where BSE is a concern, the use of dead carcasses for the production of animal feed is prohibited, as is the use of the brain and spinal cord for human consumption.

Blood collected at abattoirs is a potentially valuable by-product. Blood is used in the formulation of food additives (emulsifiers, stabilisers, clarifiers, nutritional additives, egg albumin substitute), pharmaceuticals, fertilisers, animal feeds as well as in numerous industrial applications. At abattoirs, blood is usually collected and stored in tanks and then transported to specialised blood processing facilities.

Animal hide is one of the most valuable by-products from meat processing, since there are well–established markets for its use in most parts of the world. Hides are converted into a variety of consumer goods, in particular shoes, bags and clothing. However other parts of the original hide can be recovered for use in the manufacture of cosmetic ingredients and medical prosthetics. At abattoirs, hides may be chilled or salted and sent directly to the tannery. Alternatively, fleshing may take place at abattoirs to recover the meat trimmings and fat from the hides before they are sent to the tannery.

2.2 Environmental impacts

As for many other food processing operations, the main environmental issues associated with meat processing are the high consumption of water, the discharge of high-strength effluent and the consumption of energy. Noise, odour and solid wastes may also be issues for some plants. Common environmental issues are summarised in Table 2—4.

Water consumption

Hygiene standards necessitate the use of large quantities of fresh water. Water is used for watering and washing livestock, cleaning process equipment and work areas and washing carcasses. Cleaning, in particular, is a major area of water use.

Effluent discharge

One of the most obvious environmental issues common to all abattoirs is the discharge of large quantities of effluent. Abattoir effluent contains blood, fat, manure, undigested stomach contents and cleaning agents. It is typically characterised as having a high level of organic matter, fat, nitrogen, phosphorus and salt (sodium).

For plants located near urban areas, effluent may be discharged to municipal sewage treatment systems. This is the case in much of Europe. However, in rural areas effluent is often treated on site and irrigated to land.

If irrigation is not managed correctly, dissolved salts contained in the effluent can adversely affect soil structure and cause salinity problems. Nitrogen and phosphorus can also leach into underlying groundwater and affect its quality.

In some locations effluent may be discharged directly into water bodies. However this is generally discouraged as the high levels of organic matter can deplete oxygen levels and thus degrade water quality.

Table 2—4 Environmental issues at abattoirs

Process	Environmental issue
Reception of livestock Truck washing Cattle washing	Effluent containing manure wastes High water consumption Noise
Stunning and bleeding	Effluent with high organic load, especially if blood is discharged
Hide treatment (pigs)	Energy consumption for hot water used in scalding Generation of putrescible by-products Effluent with a high content of organic matter
Splitting and evisceration	Energy consumption for equipment sterilisation Generation of putrescible by-products Effluent with high organic load
Refrigeration	High energy consumption Fugitive losses of refrigerants, e.g. CFCs or ammonia
Cutting and boning	Electricity consumption Generation of putrescible by-products Energy consumption for equipment sterilisation
Casing and offal processing	Effluent with very high organic load Very high water consumption
Rendering	Effluent with very high organic load Potential for odour generation High energy consumption
Cleaning	High water consumption Consumption of chemicals Large volumes of effluent with high organic load

Energy consumption

Thermal energy, in the form of steam and hot water, is used for cleaning and sterilising and for rendering. Electricity is used for the operation of machinery and for refrigeration, ventilation, lighting and the production of compressed air.

Like water consumption, the use of energy for refrigeration and sterilisation is important for ensuring good keeping quality of meat products. Storage temperatures are often specified by regulation. As well as depleting fossil fuel resources, the consumption of energy causes air pollution and greenhouse gas emissions, which have been linked to global warming.

By-products

By-products from the slaughter of livestock can cause environmental problems if not managed correctly. They are highly putrescible and can cause odour if not heat treated in a rendering process or removed from site within a day of being generated.

Dead stock and condemned carcasses must be disposed of in a way that ensures the destruction of all pathogenic organisms. All materials that may contain condemned parts are considered high-risk materials, and have to enter an authorised rendering plant where proper sterilisation can take place.

For small plants, the handling of animal by-products can be an important waste management issue. Smaller plants are often too small to economically undertake on-site rendering and may have difficulty in securing access to rendering companies.

Air emissions

Air emissions from meat processing plants are mostly attributed to energy consumption. Steam, which is used for rendering and cleaning operations, is generally produced in on-site boilers. Air pollutants generated from combustion include oxides of nitrogen and sulphur and suspended particulate matter.

Odour

Odour can be a serious problem for meat processing plants if by-products and effluent streams are not managed correctly, or if rendering takes place on site. Biological treatment systems, commonly used to treat abattoir effluent, are another common source of odours. Insufficient capacity of treatment systems or shock-loadings to the system can upset the microbiological balance of the system, resulting in the release of hydrogen sulphide and other odorous compounds.

Refrigerants

For operations that use refrigeration systems based on chlorofluorocarbons (CFCs), the fugitive loss of CFCs to the atmosphere is an important environmental consideration, since these gases are recognised to be a cause of ozone depletion in the atmosphere. For such operations, the replacement of CFC-based systems with non- or reduced-CFC systems, such as ammonia, is important.

Noise

If an abattoir is located close to residential areas or other noise-sensitive receptors, the noise generated from various items of equipment and the manoeuvring of trucks delivering livestock and removing by-products, can cause a nuisance. These potential problems should be taken into consideration when determining plant location.

2.3 Environmental indicators

Environmental indicators are important for assessing Cleaner Production opportunities and for comparing the environmental performance of one meat processing operation against another. They provide an indication of resource consumption and waste generation per unit of production.

Environmental indicators for abattoir operations will vary according to the size of plant, degree of utilisation of by-products, implementation of Cleaner Production, climate and many other factors. Large variations are typical, particularly for water, effluent and energy figures.

2.3.1 Water consumption

In abattoirs, water is used for numerous purposes, including:

- livestock watering and washing;
- truck washing;
- scalding and hide finishing of pigs;
- washing of casings, offal and carcasses;
- transport of certain by-products and wastes;
- cleaning and sterilising of knives and equipment;
- cleaning floors, work surfaces, equipment etc.;
- make-up water for boilers;
- cooling of machinery (compressors, condensers etc.).

Surveys of water consumption per unit of production consistently show considerable variation within the industry. A factor that affects water consumption is cleaning practices. Plants which produce meat for export often have stricter hygiene requirements and therefore may consume more water for cleaning and sanitising.

Table 2—5 provides indicative figures for the breakdown of water consumption in abattoirs, based on Australian and Danish survey data. Slaughter, evisceration and casings and offal processing tend to account for a large proportion of total water use, where it is used principally for cleaning.

Table 2—6 provides a summary of data from industry surveys describing water consumption figures per unit of production. These figures are based on a variety of production units, depending on the source literature.

Table 2—5 Breakdown of water consumption

Australian survey data[1]		Danish survey data[2]		
Purpose	**General**	**Purpose**	**Pig**	**Cattle**
Stockyard washdowns and stock watering	7–22%	Livestock receipt and holding	8%	22%
Slaughter, evisceration and boning	44–60%	Slaughter	32%	28%
Casings processing	9–20%	Casings processing	24%	21%
Inedible and edible offal processing	7–38%	Scalding (pigs)	3%	NA
Rendering	2–8%	Hair removal (pigs)	8%	NA
Domestic-type uses	2–5%	Dressing (cattle)	NA	22%
Chillers	2%	Cleaning	25%	7%
Boiler losses	1–4%			

[1] MRC, 1995 (based on a survey of Australian abattoirs)

[2] Hansen and Mortesen, 1992 (based on a survey of Danish abattoirs)

Table 2—6 Water consumption per unit of production

Country	m^3/t LCW	m^3/t HSCW	m^3/t meat	L/head
US (1984) [1]	4.2–16.7			
UK (1990) [1]	5–15			
Europe (1979) [1]	5–10			
Hungary (1984) [1]	2–3.8			
Germany (1992) [1]	0.8–6.2			
Australia (1995) [2]		4–12		
Australia (1998) [3]		6–15		
Denmark (pigs)			5–20[4]	225[5]
Denmark (cattle)			4–17[4]	860[5]

[1] Johns, 1993 (based on a literature review 1979–1993)

[2] MRC, 1995

[3] MLA, 1998

[4] Hansen and Mortensen, 1992

[5] Hansen, 1997

2.3.2 Effluent discharge

The volume of effluent generated is a reflection of the volumes of water used, since 80–95% of water used in abattoirs is discharged as effluent (MRC, 1995). The remainder is held up with by-products and wastes or lost through evaporation.

Meat processing effluents generally exhibit the following properties:

- high organic loads due to the presence of blood, fat, manure and undigested stomach contents;
- high levels of fat;
- fluctuations in pH due to the presence of caustic and acidic cleaning agents;
- high levels of nitrogen, phosphorus and salt;
- high temperature.

The concentration of organic matter is a key indicator of effluent quality, and is commonly expressed as chemical oxygen demand (COD) or 5-day biochemical oxygen (BOD_5). Both of these indicators are widely used and this document uses both, depending on the literature source.

Animal fats contained in abattoir effluent are long-chain fatty acids and glycerol, collectively referred to as fats, oils and greases. For simplicity, this document will refer to them as fats. Fats from animal sources are generally biodegradable and exhibit extremely high specific BOD_5, more than 2 g BOD_5 per gram of lipid (Hrudey, 1984).

Nitrogen in abattoir effluent occurs mainly in the form of ammonia, due to the breakdown of proteinaceous materials into amino acids and then, ammonia. However the nature of the ammonia species present depends on the pH. Therefore, nitrogen levels in abattoir effluent are commonly expressed as total nitrogen.

Pollutant concentrations in abattoir effluent can vary significantly from one plant to the next, depending on the extent to which wastes are excluded from the effluent stream. Table 2—7 provides indicative figures for the concentration of pollutants in effluent from pig, cattle and mixed species abattoirs.

Table 2—7 Average concentrations of pollutants in abattoir effluent [1]

Parameter (unit)	Pig slaughtering [1]	Cattle slaughtering [1]	Mixed species abattoirs [2]
BOD_5 (mg/L)	1250	2000	-
COD (mg/L)	2500	4000	1000-3000
Suspended solids (mg/L)	700	1600	400–800
Total nitrogen (mg/L)	150	180	< 300
Total phosphorus (mg/L)	25	27	< 10
Oil and grease (fat) (mg/L)	150	270	< 350
pH	7.2	7.2	7–8.5

[1] Hansen and Mortensen, 1992

[2] MRC, 1995 (based on a survey of Australian abattoirs)

Organic matter contained in abattoir effluent originates from all areas of the plant where water comes into contact with carcasses, manure, offal and blood etc. Of all the components of the abattoir effluent stream, blood constitutes the highest pollution load, followed by fat.

Blood is also the single most significant source of nitrogen in abattoir effluent. Therefore slaughter and evisceration areas as well as rendering plants, where blood processing takes place, contribute the most to nitrogen levels.

Phosphorus originates from manure and undigested stomach contents. Blood processing within the rendering plant can also be a source of phosphorus, if this process is practiced.

Salt (sodium) originates from manure and undigested stomach contents, and also from rendering and pickling processes. In some areas, the raw water used in the plant can contribute towards high salt levels in the effluent.

Fat in the effluent stream originates from trimmings that are allowed to fall to the floor, some of which will inevitably find its way into the effluent stream. Fat can also originate from carcass washing.

It follows therefore that effluent quality depends on the extent to which blood, fat, manure and undigested stomach contents are excluded from the effluent stream. In the case of blood and fat, allowing these materials to enter the effluent stream increases the cost of effluent treatment and represents the loss of valuable products.

Another factor with an important bearing on effluent quality is whether rendering occurs as part of a plant's operations. At those plants where rendering occurs, the rendering plant is generally the largest single source of effluent contamination. Rendering typically contributes about 60% of a plant's total organic load but only 5–10% of the total volume (MRC, 1995).

Table 2—8 provides a typical breakdown of effluent loads generated from different processing areas within abattoir operations in terms of the key effluent contaminants.

Table 2—8 Breakdown of effluent loads for key contaminants in abattoir effluent [1]

	Organic load (COD)	Total nitrogen	Total phosphorus	Sodium
Fresh water	0%	1%	0%	10%
Recycled water	0%	5%	10%	7%
Stockyards	2%	6%	8%	6%
Slaughter and evisceration	7%	19%	4%	8%
Offal processing	7%	7%	7%	3%
Casings processing	1%	7%	6%	9%
Boning	1%	3%	0%	2%
Manure and paunch handling	13%	12%	37%	22%
Rendering	63%	33%	26%	15%
Pickling	5%	8%	2%	16%

[1] MRC, 1995 (based on a survey of Australian abattoirs)

In order to be a useful indicator of plant performance, effluent discharge is expressed as pollutant load per unit of production. Table 2—9 provides indicative figures for effluent pollutant loads generated per head of animal slaughtered (pig and cattle) and Table 2—10 provides figures based on tonne LCW and tonne HSCW.

Table 2—9 Pollution loads in abattoir effluent per head [1]

Parameter (unit)	Pig slaughtering (average 90 kg)	Cattle slaughtering (average 250 kg)
BOD_5 (kg/head)	0.5–2.0	1–5
Total nitrogen (kg/head)	0.075–0.25	0.25–1.0
Total phosphorus (kg/head)	0.015–0.03	0.030–0.1

[1] COWI, 1999

Table 2—10 Pollution load in abattoir effluent per unit of production

Parameter	Pollutant load (kg per tonne LCW)		Pollutant load (kg per tonne HSCW)	
	(1)	(2)	(3)	(4)
COD	-	-	12–66	-
BOD_5	12–15	6–16	-	8–66
Suspended solids	9–12	4–18	4–14	-
Total nitrogen	1–1.7	-	1–3	0.9–3.4
Ammonia nitrogen	-	0.08–0.25	-	-
Organic nitrogen	-	0.3–0.8	-	-
Total phosphorus	-	-	0.1–0.5	0.1–0.5
Soluble phosphorus	-	0.06–0.21		
Sodium	-	-	0.6–4.0	-
Oil and grease (fat)	1.5–8	1.5–23	2–12	-

[1] Ockerman and Hansen, 2000 (summary of survey data from US abattoirs)

[2] Hansen and Mortensen, 1992

[3] MRC, 1995 (survey of Australian abattoirs)

[4] MLA, 1998 (survey of Australian abattoirs)

2.3.3 Energy consumption

Overall energy consumption will depend on the types of activities occurring at an abattoir. For example rendering, if it occurs on site, will add substantially to overall energy consumption. Pig scalding is an energy-consuming process specific to pig abattoirs.

Approximately 80–85% of an abattoir's total energy need is for thermal energy, in the form of steam or hot water, produced from the combustion of fuels in on-site boilers.

Table 2—11 provides an indicative breakdown of thermal energy use in an abattoir. The figures assume that rendering and pig scalding take place as part of the operation.

Table 2—11 Breakdown of thermal energy consumption [1]

Purpose	Percentage of total
Rendering	42%
Boiler losses	25%
Hot water	14%
Pig scalding	3%
Blood coagulation	3%
Blood drying	3%
Others	10%

[1] Energy Authority of NSW, 1985

Fuel used for steam production in boilers is typically coal or fuel oil. However the use of natural gas and liquid petroleum gas is increasing due to environmental pressures to burn cleaner fuels. Fuel sources with a low sulphur content should be chosen in order to minimise sulphur dioxide emissions.

In some areas, abattoirs may be able to obtain heat energy from district heating or steam from outside sources. It is also possible to recover waste heat from high-temperature rendering processes to heat water.

The remaining 15–20% of an abattoir's energy consumption is provided by electricity. Table 2—12 provides an indicative breakdown of electricity use in an abattoir. As can be seen, refrigeration accounts for a significant proportion of electricity use.

Table 2—12 Breakdown of electricity consumption [1]

Purpose	Percentage of total
Refrigeration	59%
Boiler room	10%
By-products processing	9%
Slaughter area	6%
Compressed air	5%
Boning room	3%
Others	8%

[1] Energy Authority of NSW, 1985

To serve as a useful indicator of plant performance, energy use is expressed per unit of production. Table 2—13 provides a summary of data from literature describing typical energy consumption in those terms.

Table 2—13 Energy consumption per unit of production

	Electrical energy	Thermal energy	Total energy
Australia [1]			1200–4800 MJ/tonne HSCW
Denmark (pig) [2]			27 kW.h/head
Denmark (cattle) [2]			61 kW.h/head
Canada (pig) [3]	70–300 kW.h/tonne DW	500–900 MJ/tonne DW	
Canada (cattle) [3]	70–250 kW.h/tonne DW	200–500 MJ/tonne DW	

[1] Meat and Livestock Australia, 1998

[2] Hansen, 1997

[3] Ontario Ministry of the Environment, 1999

2.4 Benchmarks

A benchmark is a number that acts as a guide to the level of best practice that is achievable in a specific area, for example environmental performance. Often, suitable benchmarks are difficult to obtain and difficult to use. However, when they are available they can be useful in assessing the relative performance of a process or organisation.

Environmental indicators sometimes used by abattoirs to benchmark performance are water consumption, energy consumption and the organic load in effluent (COD or BOD_5), expressed as figures per unit of production. However, other indicators such as nitrogen and phosphorus loads in effluent have also been used.

In some industries, environmental benchmarks are used extensively to gauge the performance and competitiveness of a manufacturing process. For the meat processing industry however, benchmarking of environmental performance is not common and it is difficult to find examples. The lack of environmental benchmarking is thought to be due to the considerable variation in production processes and scales of operation within the industry. The issue is further complicated by the fact that there is no widely recognised standard unit of production. Units used to describe production at abattoirs vary from country to country and even within a country.

An additional problem is that existing benchmarks do not necessarily relate to specific types of processes. For example, in order to compare one process with another, or to compare a process with a specified benchmark, the scale, age, efficiency and type of process should be similar to enable sensible comparison.

It is recommended that companies should first establish environmental benchmarks internally. It may then be possible to compare performance with other similar organisations within the same state or country. From there, the next step may be to compare performance with industries in other countries as long as the factors contributing to those countries' level of performance are understood.

A selection of environmental benchmarks that have been established in a number of countries is provided in Table 2—14. These figures should be used as a rough guide only.

Table 2—14 Examples of environmental benchmarks for abattoirs

	Water consumption	Energy consumption	Organic load in effluent
Denmark[1]			
pigs	300 L/head	30 kW.h/head	0.5 kg BOD_5/head
cattle	1000 L/head	70 kW.h/head	1.2 kg BOD_5/head
Canada[2]			
pigs	180–230 L/head	500–900 MJ/ t DW	-
cattle	800–1700 L/head	200–500 MJ/t DW	-
Australia[3]			
mixed	12 kL/tHSCW	1700 MJ/tHSCW	15 kg BOD_5/tHSCW

[1] COWI, 1999 (based on best available technology)

[2] Ontario Ministry of the Environment, 1999

[3] Meat and Livestock Australia, 1998

Tables 2—15 and 2—16 provide examples of Denmark benchmarks that relate to the level of technology utilised. The levels of technology are described as follows:

- *Traditional technology:* medium to large abattoirs with low utilisation of installed capacity and no Cleaner Production (typically in developing countries and countries in transition);
- *Average technology:* large abattoirs using minimal Cleaner Production methods (many Western countries);
- *Best available technology:* industrial abattoirs with good utilisation of installed capacity, high throughput and good housekeeping.

Table 2—15 Benchmarks for pig abattoirs (90 kg pigs) [1]

	Unit	Traditional technology	Average technology	Best available technology
Water	L/animal	1400	700	300
Heat and electricity	kW.h/ animal	125	50	30
BOD_5	g/ animal	2500	1000	500

[1] COWI, 1999

Table 2—16 Benchmarks for cattle abattoirs (250 kg cattle) [1]

	Unit	Traditional technology	Average technology	Best available technology
Water	L/ animal	5000	2500	1000
Heat and electricity	kW.h/ animal	300	125	70
BOD_5	g/ animal	5500	2500	1200

[1] COWI, 1999