Resource use in the British beef and lamb processing sector

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Executive Summary

Background

The British meat industry has contracted significantly since 1990, with many abattoirs, cutting plants and butcher shops closing. Although the British industry and especially the meat processing plants are not as large as their rivals elsewhere around the globe, the larger companies are expanding and consolidating and a relatively small number of the larger companies responsible for the majority of the kill and processing.

To capture the current position of energy and water usage in the industry this study was commissioned by English Beef and Lamb Executive (EBLEX), Hybu Cig Cymru-Meat Promotion Wales (HCC) and Quality Meat Scotland (QMS). These three organisations support the British meat industry and the production of high quality meat, from farm to fork through the development of a competitive and profitable supply chain. They are also committed to making the supply of meat more sustainable by assisting processors reduce their environmental impact.

Methodology

The collection of information proved to be exceedingly difficult for this study. The reasons were

- There was a reluctance by some companies to confide what was perceived to be sensitive information
- Many small companies do not have this information to hand. The only way they could obtain it was to better analyse their energy and water bills which many did not have the time or resource to do.
- Few companies had a breakdown to establish where the most energy or water was used throughout the plant because very few sub-metered at point of use. Even those that did sub-meter discovered they were missing significant percentages of energy and water.

The only way it was possible to establish the amount of energy and water used for cattle and sheep slaughter was to target single species abattoirs. Most of the information was collected through the good working relationships MLCSL have throughout the industry. As a trustworthy organisation based in many abattoirs it was possible to collect information that others had struggled to obtain.

Yields

It is well known that cattle carcases are getting heavier. This was apparent in the yield figures which ranged from 260 kg up to 430 kg (dressed carcase weight into the chiller) per beast. The average for Wales was approximately 320 kg, England 326 kg and Scotland 342 kg. This information is based on an average throughput tonnage from the abattoir and their kill figures.

Water

On average it took on average 465 litres to slaughter a beast; this equates to approximately 1.43m^3 per tonne. In total from abattoir to retail pack, to produce one tonne of beef would take on average 4.2 m^3 of water per tonne

On average it took 51 litres to slaughter a sheep. This varied as some plants do debone some of their carcases. To totally process a tonne of sheep meat from abattoir to retail pack took 4.19 m^3 per tonne.

Effluent
Establishing true KPIs for effluent was very difficult. A lot of plants do not sub-meter effluent therefore they rely on quarterly bills from their water company. These were on average similar to the ingoing water. Insufficient data was obtained to give a sensible average. The total average per tonne was 3.09 m^3 per tonne.

Energy
All the meat plants stated that their energy costs were the fourth highest cost after meat, people and packaging. However, energy is considered to be one of the key factors that determine competitive advantage between plants so it was difficult to get detailed information from many of the sites. It takes about 775 kWh to produce a tonne of beef. This is split approximately two thirds electricity and one third gas or oil. The energy per tonne varied considerably due to the type of processes within the plant..

The energy to process a tonne of sheep meat was on average 685 kWh. There was also a large variation between each of the plants with some of the very large Welsh plants having good controls and energy management systems. This is in contrast to a lot of the micro companies that were unable to give any information at all.

Environmental Management.
Managing water and energy is still in its infancy in most of the plants interviewed. If our industry were compared to the automotive industry there is still a considerable amount to be done.

Water is closely linked with energy consumption because potentially one third of the energy is used to heat the water.

Looking at this positively it is obvious that implementing an environmental management system will yield major cost reductions. There is a lot of opportunity to save money. This has been proved by the few companies who have embarked on this adventure. One company stated that by purely concentrating on their water use they are saving £20,000 per annum. Their energy costs are four times their water costs, therefore they could be looking at £80,000 by adopting similar policies.

Glossary of terms

ABP	Animal by-products are categorised according to the degree of risk they present
SRM	Specified Risk Material material referred to in Annex V to Regulation (EC) No 999/2001 of the European Parliament and of the Council of 22 May 2001
Cat 1	Category 1 material is the highest risk and includes SRM and generally goes for destruction. *Article 4 of Regulation (EC) 1774/2002)*. When a lower risk category of ABPs is mixed or cross-contaminated with a higher risk category the ABPs in question must be treated as the higher risk category.
Cat 2	Category Two Any material that does not fall into Category 1 or 3 must be treated as Category 2 material. Examples of Category 2 animal by-products are digestive tract contents and manure. These pose a risk to human or animal health. *(Article 5 of Regulation (EC) 1774/2002)*.
Cat 3	Category Three material is material which could be eaten by humans but the decision has been taken that it is not going for human consumption. It is low risk and goes for a wider variety of uses, including the manufacture of petfood, use as foodstuffs at hunt kennels, registered kennels or maggot farms.
BMPA	British Meat Processors Association
BAT	Best Available Techniques
CCL	Climate Change Levy
CRC	Carbon Reduction Commitment
EA	Environment Agency
GHG	Greenhouse gases
KPI	Key Performance Indicators
TSE	Transmissible Spongiform Encephalopathy
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
SS	Suspended Solids
FOG	Fats Oils and Greases
TDS	Total Dissolved Solids
CO_2e	Carbon Dioxide Equivalents
CIP	Clean in place
kWh	Kilo Watt hours
LCA	Life Cycle Analysis
EMS	Energy Management System
AHDB	Agricultural and Horticultural Development Board
WRAP	Waste Reduction Action Programme
HPLV	High Pressure low volume
IPPC	Integrated Pollution Prevention and Control
CHP	Combined Heat and Power
ECM	Energy Cost Management
TS	Total solids
ECA	Enhanced Capital allowance scheme provides businesses with enhanced tax relief for investments in equipment that meets published energy-saving criteria.

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PART ONE DATA COLLECTION

1.0 Background

Over the last 4 years the British meat industry has undergone significant changes. Every company in the red meat supply chain is under increasing cost pressure, and must constantly improve to maintain profitability. To remain a profitable company there is a need to have control of your business. When the export market opened in 2006 it gave the industry opportunities to reduce the amount of product sent as animal by-products for rendering and enabled a lot of that product to enter the human food chain. Some of these products require a lot more energy and water to process them.

Large cutting and retail packing plants have undergone many changes too. Most plants debone carcase and vacuum pack primals for maturing and send to a large remote retail packing plant. These packing plants are purpose built to supply one or two customers only. They have or are in the process of introducing a lot of automation. No longer do these large plants use cardboard boxes to transfer products but reusable tray that need to be washed when emptied.

This is a study to investigate the energy and water usage in the British beef and lamb processing sector. It was jointly funded by the English Beef and Lamb Executive (EBLEX), Hybu Cig Cymru-Meat Promotion Wales (HCC) and Quality Meat Scotland (QMS). The aims of the research were

- To establish separate key performance indicators KPIs for energy and water use in British beef and lamb processing from the abattoir to retail pack for the majority of the kill.
- Breakdown the energy and water usages throughout the chain in as many different processes as possible
- Benchmark the findings to investigate whether there are pronounced geographical differences in the energy and water figures between Scotland, England and Wales.
- Identify the prevalence of best available techniques BAT to comply with the plants IPPCs licences.
- To research and detail recommendation that could be used by all meat plants to improve their environmental performance

The first part of this report details the findings of the industry survey and benchmarks for water use and effluent management and energy use (electricity, gas, oil) for cattle and sheep slaughtering and processing from abattoir through to retail packing plant.. The BMPA and many processors from England, Scotland and Wales have contributed to the data.

The second part details procedures to manage, and reduce the amount of water and energy consumed. It also gives advice and many tips of opportunities in different areas of the plant to make savings.

Energy and water reduction are at the forefront of many company minds currently due to a number of government initiatives which are gathering pace and using both financial and regulatory powers to reduce consumption. Coupled with increasing costs for the purchase of these resources there will be increasing costs for their usage too. The carbon reduction commitment will mean that companies will pay for the amount of carbon they generate which should mean that they will start investigating greener energy. The Environment Agency (EA) is also increasing pressure to clean up effluent which will mean rising costs for dirty water leaving these companies.

1.1 Climate Change Measures

In April 2008 as part of the range of measures designed to help the UK meet its legally binding commitment to reduce greenhouse gas (GHG) emissions the government introduced a climate change levy. It is effectively a tax on energy, chargeable to industry on consumption of electricity, gas and fuel used for lighting, heating and power. Climate change agreements were available to all food and drink businesses and gave an 80% discount on the climate change levy as long as additional CO_2 reduction targets are met. Approximately 200 plants from Scotland, Wales and England signed up for the climate change levy using the British Meat Processors Association (BMPA) scheme. This comprised of the larger and medium sized abattoirs, cutting plants and retail packing plants. This scheme has now saved these member sites over £2 million of levy.

In 2008 the UK Climate Change Act introduced a legally binding target of an 80% cut in greenhouse gas emissions against 1990 levels by 2050. That target is for emissions from production across all sectors of the economy. The UK and other countries are aiming to reduce the GHG emissions associated with their consumption. This consumption approach excludes emissions associated with products that are produced in the UK for export but includes those associated with products and service produced in other countries and then imported. On a consumption basis research by the Food Climate Research Network puts food related emissions at 18% of the UK’s total footprint with livestock products accounting for 8% of the total or 43% of food related emissions.

The CCL scheme was closed in October 2009 however existing members are able to continue to claim discount until April 2013 when they will have to move to the new Carbon Reduction Commitment (CRC) scheme. A new initiative, the Carbon Reduction Commitment CRC energy efficiency scheme, started in April 2010, which enforces all businesses in the United Kingdom that use more 6000MWh of electricity to register with the EA. This is in preparation for a carbon emission pricing scheme aimed at capping total emissions and incentivising reduction. Only the larger meat companies and those with multiple sites are affected by the CRC. However if they are already signed up to the CCL it will only begin to affect them after April 2013. Up until then they will need to fill out the CRC documents and make their return to the EA.

Companies not covered by the CCLA and which qualify for the CRC scheme have already started to purchase allowances for each tonne of CO_2 emitted (1 tonne of CO_2 = 1 allowance).. During the 3 first years they will pay £12 for one allowance. After the 3 first years (2013), a cap will be introduced on the total number of allowances available. There will be an annual sale of allowances by auction, increasing the cost of carbon. This will put tremendous pressure on the industry as not only will they be paying for their energy (gas oil and electricity), they will have to bid in the open market for that carbon that energy generates which will significantly increase their costs.

1.2 Federation House Commitment

The Federation House Commitment (FHC) is a voluntary agreement under which signatories contribute to a food and drink industry target to reduce its water usage by 20% by 2020 against a 2007 baseline. WRAP are responsible for working with signatories to achieve the target and extend the coverage within the food and drink sector. While the FHC potentially covers the fresh meat sector only the Cranswick Food Group and the RWM Food Group are current signatories.

Even over the last 4 the British meat industry has undergone significant changes in the way many large abattoirs operate. When the export market opened in 2006 it gave the industry opportunities to reduce the amount of product sent as animal by-products for rendering and enabled a lot of that product to enter the human food chain. Some of these products were edible co-products which needed further processing before they were suitable for human consumption. This further processing required a lot of extra water and energy and put pressure on the effluent loads.

Large cutting and retail packing plants have undergone many changes too. Most plants debone carcase and vacuum pack primals for maturing and send to a large remote retail packing plant. These packing plants are purpose built to supply one or two customers only. They have or are in the process of introducing a lot of automation. No longer do these large plants use cardboard boxes to transfer products but reusable tray that need to be washed when emptied.

These changes mean that companies do not send for rendering or discard as much product or packaging, they do use significantly more water and energy. The other issue is whether they record all these extra sales.

As an example: Slaughter and dress a 600 kilo heifer the new weight would be about 318 kg. If the abattoir were to harvest the heart, skirt, liver, cheek meat, kidneys, stomachs, edible fats, hooves aorta, paddy wack, tongue, tail, lungs, oesophagus, trachea, and some soft bones they would gain another 40 kg that would go for human consumption How does an abattoir reconcile these weights? Using our example for water and energy
If an abattoir and cutting plant used 600 litres of water per head that could be 1.7 m^3 per tonne for an abattoir and cutting plant that harvested the above products or it could be 2.3 m^3 per tonne if they sent most of this product to the renderers.

2.0 Benchmarking the Industry

A mix of data is used from three different sources:

1. BMPA allowed us to see an anonymous list of energy usage and tonnage output from their members for cattle and sheep plants
2. Face to face interviews to see around the operations and investigate what was actually happening and capture good and bad practices. Telephone interviews were also used to understand which processes occurred at which establishments.
3. EA data was also used for England and Wales and the Scottish Environmental Protection Agency (SEPA).

Table 1 *Detailed information was collected from a mix of British meat plants performing different operation within the supply chain.*

	Abattoir	Abattoir and cutting plant	Abattoir, cutting plant and retail packing plant	Cutting plant	Retail Pack
CATTLE					
England	1	8	2		
Scotland	1	2		1	
Wales	No cattle only plant in Wales				
SHEEP					
England	1	2			
Scotland					
Wales			1		
MIXED					
England		2			2
Scotland	3	1	1	2	
Wales	1	1	2	2	1
TOTAL					
England	1	12	2		2
Scotland	1	2	1	3	
Wales	0	0	3	3	1

2.1 Methodology

Data was collected from 31 plants: abattoirs, cutting plants and retail packing plants from the large and medium sized beef and lamb slaughterers. Every effort was made to ensure that over 50% of the kill and pack of beef and lamb from each country was covered. In Wales it was not possible to collect data for any “cattle only” plants as none existed. Similarly in Scotland we were unable to get data from any “sheep only” company (they do exist however data capture was poor).

Enough plants have been sampled and sufficient detailed information has been obtained to enable the following cattle and sheep benchmarks to be established for Great Britain:

1. Carcase Yields broken down for England, Scotland and Wales
2. Total Water Consumption for the whole process from slaughter to retail pack broken down into cattle (England and Scotland) sheep (England and Wales) measured in m^3 per tonne.
3. British performance figures for cattle and sheep different processes throughout the supply chain The three main processes that produce approximately 80% of all meat are:
    a. The abattoir slaughters and chill carcases
    b. the boning hall debones carcases, cuts and vacuum packs primals and stores the primals for aging
    c. The retail packing hall processes the primals and rewraps in packs ready for supermarket shelves.

   It was not possible to obtain sufficient further breakdowns to enable us to make a statistical valid geographical breakdown for each process.
4. Total effluent
5. Energy Consumption
    a. Abattoir
    b. Boning Hall
    c. Retail Packing

2.2 Carcase Yields

This measure is what the abattoirs reported to be their output tonnage, the output tonnage can include the output of other edible products as well as the carcases so may include liver tripe cheek meat etc.. It is a simple calculation based on output tonnage divided by number of cattle or sheep. The carcase weights will be affected by the incoming weights as well as the breeds of animals.

Some of the reasons for variation would be due to:

1. Sex - steers, heifers, young bulls, bulls and dairy cows. Dairy cows are normally the lightest then heifers, (about 30kg less than) young bulls and steers and finally bulls.
2. How much of the 5th quarter the abattoir is harvesting, the more offal the higher the output tonnage.
3. Geographical variability – Scotland's cattle were heavier than those from England and Wales. There is little difference seen in sheep weights however when you talk to the abattoirs they explain there are a lot of cross border transfers.
4. Condemnations – when carcases have been condemned, it does not get included in the output tonnage figures.

These are potential reasons and no research was done to get the detail as this is considered by the abattoirs to be extremely confidential.

Table 2 *Carcase Yield across the Britain using data collected from this study*

	Average Abattoir Deadweight (kg)	**England (kg)**	**Scotland (kg)**	**Wales (kg)**	**Deboning (kg)**
Cattle	331	326	342	320	272
Sheep	18	19		18	No Info

2.3 Water Consumption

The food industry is a major water user. According to DEFRA (Food Industry Sustainability Strategy, 2007) the UK food and drink processing consumed 307 million m^3 of water, more than other sectors of the economy but less than half that used by agriculture. Meat processing is not a heavy user of water compared with dairies or the drinks industry; however according to the EA water consumption and effluent are the most significant environmental impacts of meat processing and thereby for resource management.

Water consumption in any meat factory is dependent upon the amount of floor area used, as well as the management practices.

***Table3** : Water usage by industry type*

Sector	**Water use millions m^3 (tonnes) per year**
Dairies	39.0
Breweries	35.2
Soft Drinks	27.5
Distilleries	25.9
Meat	7.2

Source: Defra 2007

The majority of the companies participating in this research obtain their water from the public supply. Only 2 companies made use of bore-holes as the main source though some companies relied on boreholes to top up the mains supply where licenses are granted. Bore-hole water may not be potable but instead usable for functions like yard or vehicle washing.

Factors which will increase water usage in the abattoir are certain value-adding activities such as processing cattle and sheep stomachs into tripes which requires a lot of hot water and processing sheep intestines into an intermediate sausage casing product called a runner which requires a lot of cold or hot water depending on much the intestine is processed.

All meat companies including abattoirs must comply with Meat Hygiene standards in accordance with legislation under 853/2004. These standards necessitate the use of large quantities of potable water, for almost all washing and rinsing operations. All process floor areas need to be washed clean at least once a day. Water is used for watering and washing livestock, rinsing the carcases, and cleaning the lairage, process equipment and work areas. Containment of infectious diseases is extremely important to the industry, and transport vehicles are washed upon site entry and exit.

These hygiene standards limit the extent to which water usage can be reduced; however improvements are possible as certain areas do not require potable water to be used.

This study estimates that the UK Beef and Lamb industry uses four million m^3 per year in the animal slaughtering, cutting process and retail packing process. This seems to be significantly higher than has been estimated by the WRAP project; however the data set for this study is twice as large. The issues with this estimate are the quantity of carcase lamb that is exported and how much imported lamb needs to be retailed packed. The table below shows water usage in the processing beef and lamb. The data are all derived from the research and adjusted onto a national basis.

Table 4 *Water usage for the beef process supply chain broken i*nto Scotland and England

Species	Water usage per head (litres)	Average Water usage (m^3/t)	Minimum Water usage (m^3/t)	Maximum Water usage (m^3/t)	Water and Effluent discharges (m^3/t)
Cattle Slaughter	464 **	1.43	0.93	1.98	1.28
Cattle Cutting plant		1.43	0.45	2.2	
(11) English Abattoir /cutting plant	966	2.81	1.75	3.96	
(3) Scottish Abattoir /cutting plant	917	2.69	1.75	3.11	
Retail Pack		1.34	0.56	3.85	
Cattle Total Usage		**4.2**	**1.75**	**7.9**	**3.09 – 3.94**

Table 5 *Water usage for sheep processing in England and Wales*

Species	Water usage (average litres per head?)	Average water usage (m^3/t)	Minimum water usage (m^3/t)	Maximum Water usage (m^3/t)	Water and Effluent discharges (m^3/t)
English Sheep Slaughter and cutting	56.	3.11	1.67	3.90	2.06
Welsh Sheep Slaughter and cutting	45	2.48**	1.54	3.41	2.06
Retail Packing Plant		1.34	0.56	3.85	
Sheep Total Usage		4.19	3.77	11.16	5.15

Notes: These figures represent some of the larger abattoirs actively working on water reduction

Table 6 Water usage for plants processing both cattle and sheep for the whole of Britain

Mixed species UK only recorded as m^3 per tonne					
		Average water usage (m^3/t)	**Minimum water usage (m^3/t)**	**Maximum Water usage (m^3/t)**	**Water and Effluent discharges (m^3/t)**
Cattle & Lamb		4.74	2.33	7.44	Insufficient data

Included in the mixed species plant data are some of the smaller plants only beginning to monitor water usage

Water consumption is highly dependent on:

- The layout and floor area of individual slaughterhouses, including lairages and yards
- Management practices including the rapid response to fixing leaks
- Gut room processing and management
    - Stomach emptying, washing and tripe polishing
    - Runner processing (runners are the intestines of sheep which when processed become sausage casings).
    - Hoof wash
- Dressing, carcase cooling and the degree of automation
- Lorry washing controls
- Water recycling
- Effluent management

A lot of participants monitored by total cost over a period (monthly, quarterly and annually), rather than m^3, and so are only aware of their consumption from utility bills.

Most large multi-site companies monitor water usage by plant only, i.e. they tend not to sub-meter the water or energy by area. The same is true for multi-species plants which meant that it is not possible to split water usage accurately by species. There are only a handful of plants that participated in the survey which practice any form of sub-metering within a plant – though a number said they aspire to do this. All of the companies that did manage their water consumption weekly by quantity were able to demonstrate considerable savings over the last few years. Those that monitored water usage and/or had sub-meters fitted by process area had made substantial cost savings through monitoring and targeting programmes. One company quoted savings greater than £10,000 per year.

The main cost in relation to water will be in the treatment of effluent before it leaves the plant, which could be up to double mains water supply charges.

2.4 Effluent

Abattoir effluent comprises of a mixture of water, blood, faeces, urine and wash water. In certain cases effluent can be discharged direct to sewer however most abattoirs are required or prefer to pre-treat the effluent as this will reduce their trade effluent costs and improve their environmental standing. The water companies use the Mogden formula to calculate the charges to industry for the conveyance and treatment of their effluents discharged to sewer. The effluent invoice details a number of coefficients relating to volume, Chemical Oxygen Demand (COD) and suspended solids (SS) discharged to sewer. By taking control of these factors and reducing them an abattoir can reduce what it pays in effluent charges.

According to the EA around half of the permitted installations have no on-site effluent treatment plant, and discharge effluent to foul sewer after basic screening only; a finding with which this survey broadly concurs. Other sites are unable to either treat or discharge and have to get their effluent collected in large tankers at considerable expense.

One of the surprising findings was that although a few abattoirs are actively managing the incoming water, very few seem to be reviewing their out-going water. This is apparent by the fact that few monitor the flow, were able to report on effluent figures and BOD, COD and SS. It may be the case that this information is highly confidential however anecdotal evidence would suggest that the information was only collected in the IPPC registered plants. Other abattoirs stated that their effluent was requested “dirty” as this helped the water authority balance the incoming effluent. Obtaining realistic figure for this study was difficult. It tended to be the larger more efficient plants who had information and this will show the effluent per tonne in a very favourable position.

- The plants that reported their effluent tended to be recyclying water.
- The plants tended to use and contol their water usage thereby decreasing their effluent.
- No plants were able to give COD, BOD or SS for the year.

A few plants did give effluent data which was actually more than their incoming water because they allowed rainwater escape into the effluent drains.

Total effluent discharged by abattoirs amounted to 5,807,283m^3 per year of which poultry accounts for 32%, cattle for 28%, pigs for 23% and lamb for 17%.

A big difference exists in water intake per animal between abattoirs. Some abattoirs have good primary and secondary effluent treatment methods, which enable them to reduce the amount of mains water they use as they are able to re-use their cleaned “effluent” for less sensitive areas such as lairage, lorry washes and yard cleaning. Other abattoirs have effluent that is 5-10% more than their usage which means they are allowing the rainwater go down the effluent drains thereby increasing their costs.

On-site effluent treatment offers opportunities to recycle treated water for some cleaning activities, which will reduce water consumption. The contamination of waste water can be minimised by collecting by-products and waste as close to the source as possible, and by preventing their contact with water. Minimising the water use in slaughter and carcase dressing can also reduce the actual contaminant load, by reducing the opportunities for the entrainment of organic matter such as fat or faeces. If by-products are entrained in water, the opportunities for their re-use are limited.

Some of the larger abattoirs have installed biological treatment plants that convert soluble and colloidal materials into bio-solids. These are usually activated sludge plants and can be high-rate or conventionally loaded plants preceded by sedimentation or dissolved air flotation (DAF), or extended aeration plants or oxidation ditches treating screened effluent. Bio-solids produced by the treatment plant may be dewatered prior to land spreading as soil conditioner or digested to yield biogas.

2.5 Energy consumption

2.5.1 Introduction

Approximately 20–50% of total energy consumed by abattoirs and cutting plants is provided by thermal energy from the combustion of fuels in on-site boilers. On average, it was about two thirds electricity and one third gas or oil. Thermal energy is used to heat water for cleaning, knife sterilisation, washing tripe, heating, blood drying and rendering. Rendering was only found at three sites. These sites rendered their fat and other category 3 product to produce either an edible oil or one suitable for biodiesel raw material. The remaining 50 - 80% of energy is provided by electricity, which is used for operating equipment in the slaughter and boning areas, for by-product processing, and for refrigeration and compressed air. Typical ranges for the energy consumption are 105-240 kW per tonne of hot standard carcass weight. This would normally include chilling the carcase and in plants where the energy consumption is higher it is assumed that further activities, such as electrical stimulation, rapid chill and processing edible co-products.

Energy is an area where substantial savings can be made almost immediately with no capital investment, through simple housekeeping efforts and good management. Additional savings can be made through the use of more energy efficient equipment and heat recovery systems.

Another point to note about energy is the amount of carbon produced per Kilowatt is dependent on the source of energy used. Energy produced using natural gas produces less carbon than oil which produces less than electricity.

Certain types of energy are carbon free. Renewable energy produces no carbon and if excess energy is generated, and could be sold to the national grid, carbon credits could be gained. None of the plants interviewed had any form of renewable energy. However they all had significant roof space which could be ideal for solar panelling. Some plants were also situated in exposed areas which may be ideal locations for installing a wind turbine. Investigating and developing opportunities to install renewable energy generators including anaerobic digestion are currently not on the radar of most plants. This is a growing area with the government giving incentives to establish new sources of energy. This is currently an opportunity that will be extremely important when the CRC scheme really takes off. It is the author’s opinion that opportunities exist should the meat industry start partnering up with some of their suppliers, customers and effluent companies and start processing their wastes.

2.5.2 Data Collection

The information collected for this benchmark is limited to electricity, gas or oil. Cattle and lamb abattoirs tend to need significantly less hot water than pork plants. A pork abattoir could have 80% of their energy in the form of thermal energy whereas cattle and lamb abattoirs tend to require about 30-50% thermal. This analysis was limited to producing an estimate of total KWH per tonne of meat produced associated with product so that upstream emissions of animal production and downstream emissions from households have not been included.

Table 7 *Energy consumed for cattle*

Cattle Only	Average electricity (kWh per head) [min – max]	Total energy (kWh per tonne) [min – max]
Abattoir	50 [16- 67]	96 [47-189]
English Abattoir and Cutting plant	85	373
Scottish Abattoir and Cutting plant	77	375
Retail Pack Per tonne		401 [203-733]]

Table 8 *Energy consumed for sheep*

Sheep Only	Average electricity (kWh per head) [min – max]	Total energy (kWh per tonne) [min – max]
English Abattoir and Cutting plant	3.23	271
Welsh Abattoir and Cutting plant	4.99	284
Retail Pack Per tonne		401 [203 – 733]

Table 9

Mixed Species Abattoir	Total energy (kWh per tonne) [min – max]
Sheep and Cattle Abattoir & cutting plant	505 [201 - 861]

The energy to process a tonne of sheep meat on average 685 kWh compared to 775 kWh for a tonne of beef . Sheep processing use less than cattle for a number of reasons.

- Less bulky animal therefore energy required for chilling
- Sheep meat is not normally aged for too long
- The stomachs are not normally processed so less hot water.

- Several sheep companies ship a lot of their product out as whole carcases rather than deboning and vacuum packing.

The data showed that the following:

i. There are 3 main forms of energy used in the processing sector - mains electricity, gas and oil. The gas and oil are primarily used to provide heat and hot water for the factories. Most plants run either a steam or hot water boiler depending on temperature requirements. - A small minority of plants had no access to mains gas and were solely reliant on electricity for all forms of energy; however a few did use oil without declaring exact volumes on the data sheet. Most plants tend to use gas, kerosene, or oil for space and water heating. No companies questioned used renewable energy such as solar or wind turbine, albeit some were currently investigating the economic viability of installing such systems.
ii. Only a few of the companies were recovering the heat from the refrigeration system to preheat the water going into the boiler. More plants would like to retrofit a system capable of doing this however the location of the refrigeration equipment was not adjacent to the boiler systems.
iii. A few did recycle the water from their boiler system.
iv. No company stated that they currently took filtered ambient air into the processing areas when the outside temperature was below 5^{o}C.
v. A lot of plants ran a steam plant which would provide water at over 100^{o}C. Some of these plants ran a tripe polisher at 95^{o}C and/or used the water for the knife sterilisers. The water is required to be 82^{o}C.

2.5.3 Electricity

Electricity is normally the least efficient energy source. Electricity tends to generate a higher tonnage of CO_2 than other fuels. This is due to the losses through inefficiencies at the generating companies that burn gas, coal or oil and the losses transferring the electricity to the meat plant. The chillers account for up to 70% of the electricity used by an abattoir. Concentrating on their refrigeration needs and addressing some fundamental issues will enable savings in energy.

The most common issues seen in the abattoirs around refrigeration were:

- Undersized chillers for throughput; carcases packed too closely. taking longer than expected to reach 7^{o}C
- Evaporators running poorly
- Iced up evaporators; reducing air velocities
- Doors were open for extended periods especially during loading
- Refrigeration equipment (condensers) located badly, full sunlight, hot attics etc. This takes more energy for them to reject the heat. Some were located so they ”sucked in the hot air rejected by its neighbour.
- Condenser coils caked with dirt.
- Lack of remote monitoring systems

2.5.4 Thermal Energy

The majority of plants used gas, liquid petroleum gas LPG or oil to generate the space heating and hot water throughout the plant. As far as carbon tonnage is concerned oil generates a higher carbon footprint than gas and both are more efficient at heating water than electricity. By fitting a combined heat and power CHP boiler is the most efficient method. A lot of plants had steam plants rather than boiler plants. Steam plants generate water temperatures in excess of 100^{o}C which then need to be cooled depending on the temperature required at the individual operations. They are normally the heaviest consumers of gas or oil.

2.5.5 Causes of Variation

There are a lot of reasons for variation which need to be considered when investigating energy usage.

These issues do need further investigation:

- Off site chilling
- Availability of mains gas; a lot of abattoirs are located in remote locations and have no mains connection
- While every effort has been made to use the same data collection periods this has not always been possible. The climate change levy CCL runs from 1 Oct to 30 Sept. This can mean that the electricity and gas are calculated over a different period to AHDB slaughter figures, which are collected from January to December, and the water figures when supplied quarterly by the water companies
- Abattoirs processing multiple species have greater water usage. Abattoirs with greater water usage require more energy to heat the water
- Some sites seem to have very high energy usage and the reasons are only suspected, for example:
    - Taking carcases for deboning from other plants
    - Process tripe and runners
    - Extended hanging and chilling for their customers
    - Aitch bone hanging
    - Poor refrigeration performance
    - Rendering fat in an on-site plant
    - Inefficient boilers and compressor plants
    - Unknown amount of retail pack on site

2.6 Costs

Anecdotal evidence has shown that abattoirs and cutting plants activities are aimed at reducing water consumption as it is easy to find and fix leaks, and turn off hoses. Wasted water is easy to see, however energy is a lot harder to review.

The study showed that most plants electricity and gas costs are four to eight times the cost of water, showing that there are potentially huge opportunities for energy savings.

PART TWO Improvement Initiatives

Part two of this report is taking the current situation and identifying activities which when introduced would reduce resources used by the companies. It is split into four different areas. The first is an introduction which gives an overview of the environmental management system. The second area looks after water, effluent, and finally energy in the form of electricity, oil or gas.

Transport fuel has not been included. Not many companies collected information of diesel required for their delivery lorries as many outsourced transport or company car mileage, however those that did could show year on year improvements.

3.0 Environmental Management

Environmental management system (EMS) such as ISO 14001 is a globally recognised system that enables a business to manage its environmental activities in a comprehensive, systematic, planned and documented manner in order to reduce its environmental impact.

3.1 Features of the EMS

The environmental plan focuses on energy (electricity, gas, oil diesel and petrol), water and effluent, and also airborne pollutants, including bad smells and noise.

- Serves as a tool to improve environmental performance
- Provides a framework to manage an organisation's environmental affairs
- Is the aspect of the organisation's overall management structure that addresses immediate and long-term impacts of its products, services and processes on the environment
- Gives order and control for organisations to address environmental concerns through the allocation of resources, assignment of responsibility and on-going evaluation of practices, procedures and processes
- Focuses on delivering continual improvement to environmental performance

3.2 Benefits

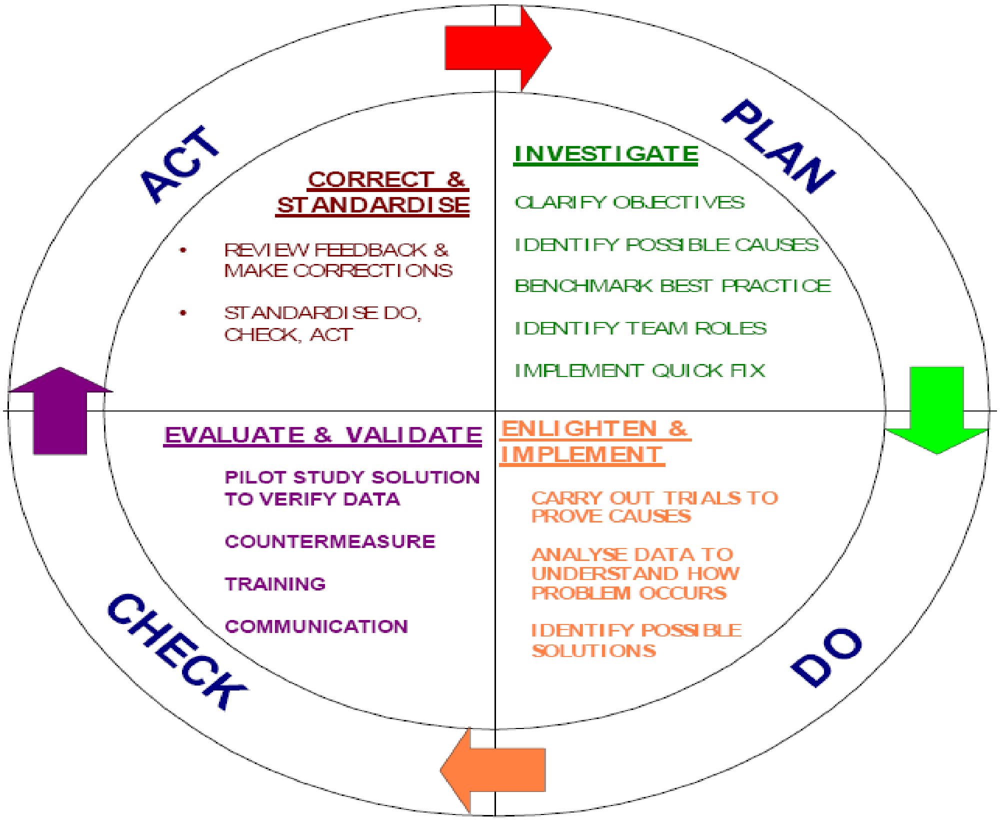
An effective EMS will:

- Define environmental responsibilities for all staff
- Identify opportunities to reduce waste, including raw materials, utility use and waste disposal costs
- Increase profits
- Reduce the risk of fines for non-compliance with environmental legislation
- Ensure all operations have procedures to minimise their environmental impacts
- Record environmental performance against set targets
- Provide a clear audit trail
- Attract shareholders and investors, for example DEFRA require an EMS if a plant wants to obtain TB contracts

3.3 Implement an Environmental Management System

An EMS follows a Plan-Do-Check-Act cycle, or PDCA. The diagram below shows the process of developing and implementing an environmental policy and management system. The process also includes checks to ensure the system is effective. This process is continuous and an organisation will need to revisit it regularly to ensure everything is up to date and relevant.

Figure 1 *Demming's wheel Plan - Do - Check - Act*



3.3.1 Example: EMS Steps for Water Usage

1. The first step is measuring water usage and discharge, accounting for 90% of the water will be sufficient to start with. Once you have these you can develop a *Water Balance* to know the business baseline. You measure the water being used at various points through the factory to understand where and how much is being used. Balance the discharges (effluent, rainwater, evaporation and product use) with the usages. If the discharges are higher than the intake this demands further research to identify causes.

   All levels of the organisation should be involved from the most senior managers to the line operators. The operators know where water is being wasted and the managers enable them to make improvements. The process needs to be owned by those involved.

2. Install localised sub-meters to record water use in different departments especially the high volume users, e.g. slaughter hall, lairage, gut room and main cleaning hoses. These meters can be connected remotely to data loggers and via the internet to a computer. This allows matching of production and cleaning shifts

to water use. Create a plan for measuring usage, identifying problem areas and implementing improvement activities.

3. Targets and objectives in the form of key performance indicators KPIs should be developed as part of EMS. These should be communicated throughout the factory as it is the whole workforce that needs to act to meet these objectives and targets.

Table 10 *Examples of key performance indicators KPIs used to manage water usage*

KPIs	Units	What is it?	What does it reflect
Total water consumption	Total m^3 consumed	Total water use on site (excluding cooling water)	Total volume of water consumed in any given time period
Process water	m^3 / tonne of product	Water used in processing operations e.g slaughterhall, cutting plant etc	Volume of water used in any given time period to produce a normalised unit of production. Few mixed abattoirs were able to split water consumption by species
Cleaning water	Total m^3 consumed	Water used for cleaning purposes	Volume of water used for cleaning (which could be broken down by different operations)
Cooling water	Total m^3 consumed	Water used as a coolant	May be difficult to determine
Water sub-metered	m3		Suggested areas could be lorry wash, tripery, gut room etc
Water reused/recycled	% by volume	Proportion of water re-cycled on site	Level of water reuse/recycling being achieved

4. Management review meetings should be held regularly because change will only be sustained if it is managed from the top. Training and communication are extremely important as part of the standardisation and continuous improvement process.

3.4 Water efficiency

There is considerable scope to improve water efficiency and reduce water consumption. One company has saved considerable amounts of water and money by introducing sub-metering and investigating anomalies weekly. Envirowise (now part of WRAP) has published a number of general and specific guides on minimising water use which provide the foundation for improvement. Details can be found in the back of this report.

3.4.1 General site maintenance

As part of the WRAP project a key finding was that sites generally did not have an accurate water distribution plan for their buildings although some steps were being made under the IPPC permits. The picture below shows neatly installed pipework but it is not easy to follow the flow of water (hot, cold or steam) without labelling.

Figure 2 *A free flowing barrel*

Figure 3 *Pipework with no labelling or arrows denotir direction of flow*

← Figure 4
Cooling Towers

- Optimise the blow down frequency
- Investigate chemical treatment options
- Dilute with collected rainwater
- Increase concentration cycles

- **Fix the drips and leaks**

A drip at home is noticed; in the abattoir or processing plant, a free running nozzle is often overlooked. Water intake and discharge from the plant should be checked weekly. Leaks must be fixed if a plant is to effectively manage and reduce its water intake. Leak reporting and repair should be a part of routine maintenance. This will not happen without a system for monitoring.

Leaks are easy to see when a plant is not in operation. Water use should drop at shift changes and during breaks.

Alternatively a waste water discharge meter will locate leaks and other sources of wasted water. It is common for one tonne of water per day or more to be discharged from plants that are not running because of taps not turned off properly, and from leaks, both visible and invisible (below ground). One medium sized abattoir that recorded daily water use was seen to be using $4m^3$ per day when the factory was shut; over a year this equated to over £4,000 down the drain.

***Table 11**: Water losses and costs of leaking taps, running hoses and toilets etc.* The costs are calculated on a cost of £1 per m^3 of fresh water into the business and £2 per m^3 for effluent. Total cost per m^3 would then equal £3 per m^3

Type and Condition	**Loss l/h**	**Loss m^3/yr**	**£ lost per annum if water cost £3/m^3**
Leaking Tap			
❖ 10 drops per minute	0.7	6.1	18.30
❖ 30 drops per minute	2.1	18.4	55.20
❖ 1mm run	9.0	79	237.00
❖ 1.5mm run	18.0	158	474.00
Water Hose Running fully open (250 days at 8 hours)			
❖ ½ inch (12.7mm)	3000	6000	£18,000
❖ ¾ inch (19mm)	5100	10000	£30,000
Toilet			
❖ Running so it can be seen with careful observation		99	£297
❖ Running and can be clearly seen		195	£585
❖ Unrest on surface		495	£1,485
❖ Pouring		3000	£9,000

Source: Envirowise

3.4.2 Water Pressure

Hot and cold water pressure should be checked regularly.

- Taps and Showers
  - Use low flow shower heads.
  - Install flow restrictors in non-process taps.
  - Restrict movement of knee taps
  - Lower water pressure to showers and washrooms.
- Toilets and Urinals
  - Ensure half flush pushes are fitted
  - Urinal restrictors / change auto frequency

3.4.3 Process Areas

- **Carcase Wash**

It is no longer acceptable or recommended to use a hose to remove visual contamination from the carcase. However some abattoirs also wash the carcase prior to the chillers. This practice is also not recommended. Abattoirs still wash carcases for 2 main reasons.

1. There is a belief that if you soak the carcase prior to the chiller the evaporation will come from the added water on the surface and not from the moisture within the carcase. This is supposed to reduce “drip loss”. The actual evidence shows that drip loss is more affected by the cooling curve and velocity of air in the chillers.
2. Removal of bone dust, contamination etc. Current thinking is that hosing actually increases carcase contamination. Any contamination on the carcase has to be removed with a knife so the amount of water used for washing should be minimal.

- **Hand and Apron Washes**

There is a requirement for hand, boot and apron washes, to be at a temperature of approximately 42°C. The amount of water used for hand and apron washing is controlled by the operator. However a number of issues were found that were outside their control.

- High pressure, so a lot of water was used when the tap was on.
- Not all taps switched off as soon as they should do. Some were still running 2-7 seconds later.

- **Equipment Sterilisers**

Equipment and knife sterilisers should be run at the correct temperature of 82°C. The amount of water used for knife and equipment sterilisers is influenced by its design. This can be done using an internal electric heating element or by having a constant top up of hot water or steam. The advantage of the constant top-up system is that it creates a constant overflow and keeps the water clean. However it can be adjusted so that more water than necessary overflows which wastes water and energy and makes more effluent. It also means that the steam plant needs to be run at approximately 90°C to maintain 82°C around the plant. Considerable savings can be made by switching to double skin insulated knife sterilisers with heating elements. The insulation helps to maintain temperature, by minimising heat loss, and therefore reduce the amount of water required to maintain temperatures in constant top up systems. For a 3 litre

Figure 5 *Wash basin and knife steriliser*	**Figure 6** *Knife steriliser, twin walled to improve insulation and fitted element to heat water and visual temperature gauge*
	

steriliser this can mean an overflow rate of 15 l/hr compared with 36 l/hr for conventional un-insulated sterilisers. The flow needs to be correctly set to give a balance between correct temperature control and uncontaminated water. As with all equipment used within process areas care must be taken to ensure the sterilisers dos not create a contamination risk and they must be impervious to high pressure wash down or all the potential benefits will be lost.

A further benefit could be the ability to reduce the temperature or eliminate entirely the steam plant and replace it with a boiler run at 60^{o}C.

- **Machine and Tray Washes**

1. Investigate opportunities for counter current rinses. In counter-current rinsing, the rinse water is circulated through a series of rinse tanks. Fresh water is fed into the rinse tank farthest from the process tank and overflows, in turn, to the rinse tank closest to the process tank. The products or containers that need cleaning are immersed in the least pure water first and the cleanest water last. It is useful for tray washes or tripe rinsing.
2. Tray washes should also have an automatic cut-off when no trays are in the wash.
3. Regularly you see a cleaner trying to access difficult areas by trying to target the hose at hard to reach areas rather than striping bits of kit down. Washing machinery and equipment in a retail packing plant may require detailed instructions to ensure it is done properly. These need to be clearly communicated including pictures to show the cleaners which panels should be removed to allow wiping first.
4. Cleaning in place (CIP) should be used whenever possible to eliminate operator input.

3.5 The Cleaning Regime

In any abattoir, the major factor affecting water consumption is the amount of floor area used. Hygiene regulations dictate that all process floor areas must be washed at least once a day. Water consumption is therefore highly dependant on the layout of individual abattoirs. Hygiene requirements also prohibit the use of high pressure low volume (HPLV) sprays in meat areas during processing operations as the atomised water can lead to airborne contamination, although they can be used for cleaning at the end of production.

3.5.1 Cleaning procedures

Introduce procedures and systems that increase cleaning efficiency. Map water use on site and reuse water for dirty rinses (e.g. first wash down water can be used to clean manure from floors). Reuse relatively clean wastewater (cooling systems, slaughter floor, carcass washing, etc) for non critical washing

3.5.2 Staff training and management

Factory washing processes (especially when contract cleaners are involved) need to be monitored and optimised to achieve cleanliness and hygiene. In the UK meat industry employees are becoming progressively more ethnically diverse and good practice on site can be jeopardised by language barriers. The constant problems with staff changes in the wash-down crew make this area one of the most difficult to control. The problem is that wash downs are usually performed on the late or night shift, when senior management isn't present. The cleaning gang can improve its water use in virtually every plant by setting limits and introducing incentives. **The night shift may be out of sight, but it should never be out of mind.**

- Meet the cleaning crew in person. Have senior managers come in early or stay late occasionally so that a personal relationship is formed and information exchanged. Too often, the cleaning crew is considered nothing more than an expensive requirement, resulting in high turnover. The result is continual retraining of new staff which management would do best to avoid.

- Explain the costs to employees so they understand the implications. Train them to brush waste away rather than washing, emptying drain traps before washing, and turning off hoses. Explain the wastefulness — and economic drawback — of wasting water and not washing meat waste and fat down the drains will reduce water use and effluent loading during the training.

Figure 7 *Brushes squeegees and access ladders neatly stored*	***Figure 8*** *Hose with quick release nozzle*
	

3.5.3 Scrape and brush before using the hose

One of the biggest offenses of excess water use during cleaning is using water as a brush substitute. A hose is regularly used to "wash" a piece of meat or paper across a small (and large) expanse of floor and into a drain. Educate employees to use dry cleaning techniques to pre-clean process areas. Ensure they have the proper dry cleaning equipment (squeegees, scrapers, brushes, wet/dry vacs) to collect floor droppings, including large pieces of meat.

- Establish area specific usage information
- Fit low volume high pressure nozzles on all hoses and restrict hose use. Ensure hoses are fitted with release grips and these are not tied down and select the smallest nozzle size without compromising function. These days some abattoirs are moving to foot switches to minimise RSI.
- A properly adjusted gooseneck should deliver about 3 litres of water per minute. However, it is common to see the nozzle removed from these hoses and the flow to be 10 litres per minute. Discourage the practice of removing or drilling hose nozzles to allow more water flow.
- Make sure that none of your hoses are left running clean water into the floor drain. This occurs when someone lays the hose down after use and forgets to turn it off.

The amount of water already in the drain makes it easy for the hose to be overlooked for long periods of time.

3.5.4 Lorry wash

To comply with the Regulations, animal delivery vehicles must be washed down after each delivery and most companies provide dedicated lorry wash facilities for this purpose. Most abattoirs do not charge for this water as they realise that the costs could be passed back to them in the form of increased delivery charges. Vehicle washing can use up to 5% of total water used at red meat abattoirs. Sites should ensure that washing processes are optimised and, where appropriate, wash water can be treated and recycled. Abattoirs should try and ensure that the lorries are dry cleaned before water is used.

Some abattoirs have installed a metered water dispenser and have successfully reduced the amount of water used in vehicle washing. Some companies use meters which take coins whereas other companies issue each
driver with a token on arrival. Although a driver would be able to request an additional token if he/she was unable to complete cleaning operations with the specified amount of water, the meter system has prompted drivers to reduce their water consumption. At the very least ensure the hoses have nozzles fitted, are all connected with no leaks.

3.6 Lairage and Gut room

Some gutrooms use more than 200 litres per minute. Regularly water was left on when no guts were being washed. In one gut room they used hot water which was running continuously to rough wash the stomach. This had no advantage and wasted water and energy. Another gut room was overmanned which meant that the operators has too much time on their hands. Between each stomach they would make an effort to clean the tables and floors.

- Eliminate offal and stomach contents transport systems that use water.
- Reduce the amount of water hoses running into a barrel for the rough wash of the stomach.
- State how often the operators should be cleaning their areas.
- Stop feeding animals 12 hours prior to slaughter. In Scotland there were significant differences between the amounts of contents in the stomachs of animals. This caused some abattoirs to be disadvantaged on four counts
    1. A dirtier lairage with more soiled bedding which would need more water for cleaning and producing more effluent
    2. In the gut-room it is difficult to manoeuvre well filled stomachs. Extra time went into orientating them to work on and trying to lift them to empty them.
    3. Extra contents meant that the stomach contents transfer system blocked up or needed extra water to flush through. When there was no automatic conveying away of the manure a man had to manually empty the dolavs more often.
    4. There was also more to be sent to the farmer or to be composted.

3.7 Tripery

Many larger abattoirs have introduced a tripe processing facility to clean and polish cattle and sheep stomachs for human consumption. The process uses two washes and these can use significant quantities of hot water. They can also add substantial loads onto the effluent plants. Flow control valves should be fitted onto the machines to ensure just the right amount of water is being used. Fit timers to limit wash time to exactly what is required. The heat from the out flowing water can be used to pre-heat incoming water. Water from the second machine can be used in the first wash.

Use mechanised grease traps for removing fat from the water. Fat, oil and grease (FOG) has a lower specific gravity than water and will float on the surface. A typically grease trap is a tank containing an integral baffle-wall. The wall runs from the top of the tank to just short of the base - effectively dividing the chamber into two compartments.

The grease trap system separates fat, oil and grease as follows
Effluent from the wash or polisher passes into the chamber which slows the flow and allows the fat content to separate from the water.

1. Once trapped/separated the fat content floats to the surface creating a layer.
2. 'Cleaned' water is allowed to pass under the baffle wall and onto the main drainage system. Alternately this water from the polisher can be passed back into the washer and reused for the first wash.

3.8 Rainwater harvesting

Significant water supply can be gathered from rainwater harvested from roofs on site. Underground or aboveground tanks can be used for storage. Rain water can be used to clean lorries, yards, lairage, flush loos etc. A standard charge is added to effluent bills for it to go down the drains. Therefore the minimum action should be to prevent it going down effluent drains

The regulations (852/2004 Annex II Water Supply: Chapter VII point 3) state:

> "Recycled water used in processing or as an ingredient is not to present a risk of contamination. It is to be of the same standard as potable water, unless the competent authority is satisfied that the quality of the water cannot affect the wholesomeness of the foodstuff in its finished form".

However when speaking to the processors not many were in favour of harvesting rainwater. Concerns were raised over the risks should an inexperienced operator connect to the grey water to wash a food area. This is considered to be a valid concern however numerous activities can be carried out to guard against this e.g. warning signs, location, and colour coded or different connector to prevent the wrong hoses being connected.

3.9 Recycling Water Options

Reuse relatively clean wastewater (cooling systems, slaughter floor, carcass washing, etc) for non critical washing

- Steriliser and hand-wash water collected and used in cattle yards
- Steriliser water collected from clean end of viscera table and used for initial table wash
- Carcase decontamination wash water collected, coarsely filtered, and reused immediately for same purpose whilst maintaining temp high enough for pathogen destruction

- Tertiary treated effluent water used as the initial wash

4.0 Effluent

Regulatory bodies including the EA define “trade effluent” as any liquid waste ‘produced in the course of any trade or industry’ which is discharged to the waste water system. It includes water used in production, washing or cooling facilities, and covers both large and small premises.
Any company with a significant trade effluent discharge must obtain a trade effluent consent, which is a legal document that sets limits on the volume and nature of the discharge.

4.1 Discharge Consent Forms

Most water companies carry out sampling of consented discharges to monitor whether the discharge complies with these limits, and follow an enforcement procedure in the event of serious breaches of the consent conditions.

Smaller discharges may be controlled by issuing a Letter of Authority.

To discharge treated effluent into a river, stream, estuary or the sea a discharge consent is required from the EA which is described in Schedule 10 of the Water Resources Act 1991: More abattoirs are being targeted and are being made to improve the “quality” of their effluent. These new controls can include both a volume and contaminant concentration problem. However savings can be generated if the wastewater is pre-treated.

1. Water volume: The simplest way to reduce the water bill is to use less water. Effluent volume is dependent on the volume of water in, minus the sanitary, cooking and usage allowances. Also included is an estimate for the rainwater that would be collected on roofs, if it becomes part of the effluent stream.
2. Reduce the COD: Blood has the highest COD (400,000 – 900,000 mg/l) of all effluents produced from abattoirs. Gut washing also produces effluent with high COD at about 80,000mg/l[1].
3. Reduce the biological oxygen demand (BOD) which is a measure of the quantity of dissolved oxygen consumed by microorganisms due to the breakdown of biodegradable contents in wastewater: Blood is also the highest contributor of about 100,000 – 200,000mg/l to BOD[2]. However under the current TSE regulations raw blood is no longer allowed to enter the public sewer system. It is still worth reducing the amount of drips that will enter the effluent system. As you can see the normal ratio of COD to BOD is about 1.9 for abattoirs
4. Reduce the amount of SS that go down the drain. All ruminant abattoirs are fitted with 4mm diameter traps to ensure solids do not enter the public sewer system and these must be emptied daily. (1774/2002 requires 6mm diameter but the EA requirement is 4mm)

4.1.1 Online analysers

Similar to metering, online analysers can provide site information. Analysers can be used to record effluent content (such as COD) leaving the site. This data may exist for

1 Guidance for the slaughtering of Animals (Cattle Pigs and Sheep) IPPC S6.12 Environment Agency
2 Normal waste water from a house has a BOD of about 300mg/l

IPPC registration purposes, but should be used by the site manager to monitor effluent loading against site production to optimise processes.

•Main contaminants of concern are:
Chemical Oxygen Demand (COD)
Biological oxygen demand (BOD)
Suspended solids
Total dissolved solids
Oil and grease
Phosphorus
Nitrogen

Cleaning and other hygiene-related activities require the greatest amount of water and contribute the highest contaminant loads into the effluent streams. As much as 80 percent to 95 percent of water used in slaughterhouses is discharged as effluent, much of it contaminated with blood, fat, manure, undigested stomach contents and cleaning agents. As such, the effluent typically is characterized by:

- high organic loads resulting from animal by-products and waste;
- long-chain fatty acids and glycerol, collectively known as fats, oils and greases (FOG)
- nitrogen from manure and blood
- phosphorous and salt are present in effluent as a result of manure, emptying stomach contents in gutroom and hide salting.

Nitrogen and BOD can be decreased by the reduction of total solids (TS) in the wash water; this will also reduce odours. It is important that the abattoirs separate as much total solids, blood, gut contents and manure from the wash water as possible. These solids contain meat scraps, intestinal contents, manure, hair and dirt, and they can be easy removed by using a mechanical separation device such as a drain cover, filter or screen with a fine mesh.

It can also be achieved by using best management practice where solids such as manure should be removed from the floor before water is used to wash the meat plant. The solid manure should go with the Category 2 waste for composting. The meat scraps can be added to the Category 1 skip for disposal by rendering. Many abattoirs are installing triperies which push up the effluent levels and increase the amount of FOG. If this goes down the drains it can block up the pipe work and unless removed regularly with an enzyme system (as used by McDonalds). Hot water is often used but because it cools rapidly it only moves the blockage further into the drainage system.

4.2 Effluent reduction

- Have ample bleed-time; trap and contain all blood with drip pans going-in and coming-out of the blood tunnel or room, even in the evisceration area. Ensure the edges are raised to avoid transfer of blood to the general effluent
- Dry clean the blood that spills on plant floor; use a shovel and squeegee to clean the whole area before cleaning with water.
- Discourage washing blood down the drains, especially off the drip pans. All drip trays should be fitted strategically for collection of blood drips along the slaughterline.

When a tray is full, the contents should be transferred to a container for Category 3 raw material for rendering.

- Fit collection trays to catch scraps falling from machinery.

Processors have two options for handling effluent: They can discharge it or re-use it. Due to its high strength and volume, however, the effluent typically requires pre-treatment, as most water authorities will not allow untreated waste and put punitive surcharges on the COD & BOD especially if they exceed specified levels.

Effluent from the lairage is high in nutrients and can be collected for agricultural use as a fertiliser, provided specific conditions explained in the MAFF Water Code (Ref. 11) are met. The preliminary step should involve dry collection of manure which should reduce the washing down water.

Effluent intended for reuse typically requires extensive treatment, but studies have shown that countercurrent flow of water may reduce waste discharge to one-third or less of previous volumes. Nonetheless, it's worth noting that wastewater reuse is heavily regulated in processes involving consumer products, and in the case of meat, must be limited to activities that don't expose the product itself to reused water. Accordingly, the treated water can be used to wash livestock lorries, and the lairage but not to steam-clean the slaughter hall.

Whether the effluent is re-used or discharged, the objective is to drive down the BOD to specified levels. In general, removal of FOG from the effluent is critical to achieving low BOD. Assuming the fat component is eliminated via strainers or 'fat traps,' as it can be handled as a solid waste for rendering.

Good blood collection systems where a hollow knife vacuum system is used to suck blood from the carcase and reduce further drips also significantly reduce wastewater BOD. The blood usually is collected, stored in tanks and transported to specialized processing facilities, which prepare it for use in emulsifiers, stabilizers, fertilizers and animal feeds, among other products.

While manure and stomach contents do not impact BOD levels as greatly as blood, they can significantly affect the waste water. They should be handled carefully and treated as a hazardous waste product. All efforts should be made to ensure that stomachs are emptied and all the contents collected in a container and not let go straight to drain. In the lairage manure should be collected and floors brushed before the hoses are used.

5.0 Improve energy use.

The rising concern over climate change, global warming and the recent sharp increases in energy costs has focused as well as government regulations such as CCL and CRC have meant that all of the large abattoirs work to reduce energy usage. It is difficult to see when looking at the figures as most abattoirs and cutting plants have been working to raise improve their throughput and increase added value.

The Carbon trust believes that most companies could cut up to 20% off the energy costs by employing some easy measures that may not cost anything. The EMS should form the basis of managing and reducing energy consumption. Energy should be mapped and split into all forms that are purchased by the site and a clear understanding of the equipment and requirement should be tabulated. During my visits it was apparent that the smaller plants in general seemed to be less efficient than some of the big sites. It was also apparent that all plants could cut their energy costs. Below are some pictures taken in a small plant which actively looking to save energy.

Figure 9 *Condenser on the verge of failing*

Figure 10 *A dirty Condenser with plastic bag blocking free flowing air*

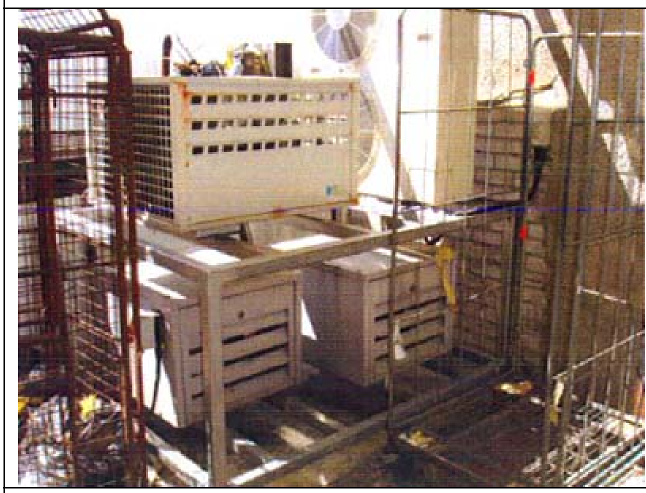


Figure 11 *Condensers in direct sunlight, drawing hot air in from its neighbour*

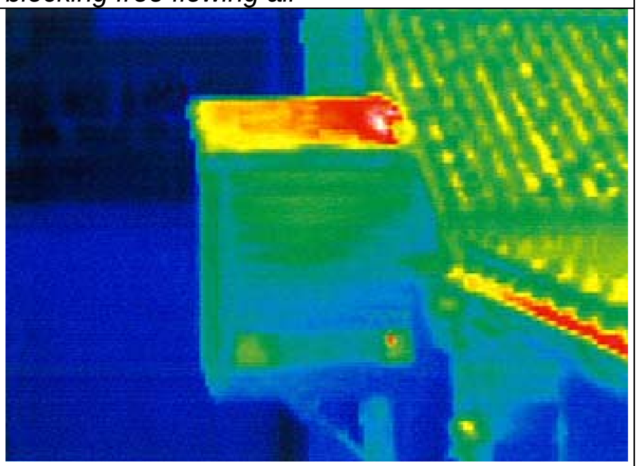


Figure 12 *Thermal image of condenser mounted in enclosure with black tar roof. The condenser should be in a shaded area or against a north facing wall of the plant; not in direct sunlight.*

The chillers account for up to 70% of the electricity used by an abattoir. Concentrating on their refrigeration needs and addressing some fundamental issues will enable savings in energy.

Figure 9 to 12 shows that a lot of savings can be made my good management during normal running, keeping the fins clean and free from debris; however a lot more could be made if the refrigeration boiler and compressor systems are designed and installed with the full life costs in mind. When designing a plant it is important to take into account heat generated by the equipment and opportunities to recycle both heat and water within the factory.

During this study most of the plants visited had grown organically over many years. In the past energy and water were never considered to be particularly important and no thoughts were give to resource conservation. Recently plant design and plant refurbishments have tried to used Best Available Techniques to conserve energy and water however sometimes it is not possible to retrofit good practice without huge financial investments.

5.1 Energy consumption

Approximately 20 - 60% of total energy consumed by cattle and lamb processing plants is provided by thermal energy from the combustion of fuels in on-site boilers. Thermal energy is used to heat water for cleaning, tripe washing and polishing, runner washing (not very often), rendering, blood coagulation and blood drying. The remaining 15–20% of energy is provided by electricity, which is used for operating equipment in the slaughter and boning areas, for by-product processing, and for refrigeration and compressed air. Typical ranges for the energy consumption are 400 (200 -800) kWh per tonne (range) of hot standard carcass weight.

Energy is an area where substantial savings can be made almost immediately with no capital investment, through ensuring the environmental management system as described in the water section covers all energy, gas and electricity.

Additional savings can be made through the use of more energy efficient equipment and heat recovery systems. Some key strategies are listed below:

- implementing switch-off programs and installing sensors to turn-off or power-down lights and equipment when not in use
- improving insulation on heating or cooling systems and pipework
- insulating and covering scald tanks to prevent heat loss
- recovering waste heat from effluent streams, vents, exhausts and compressors
- recovering evaporative energy in the rendering process using multi-effect evaporators
- maintaining a leak-free compressed air system
- favouring more efficient equipment
- improving maintenance to maximise energy efficiency of equipment
- maintaining optimal combustion efficiencies on boilers
- eliminating steam leaks
- Using external air when external temperatures are low enough

In addition to reducing a plant's demand for energy, there are opportunities for using more environmentally benign sources of energy. Opportunities include replacing fuel oil with cleaner fuels, such as natural gas, using CHP for heat and electricity .For some plants it may also be feasible to recover methane from the anaerobic digestion of high-strength effluent streams to supplement fuel supplies. Most plants have large roof spaces and remote locations which could be used for solar or wind power.

5.1.1 Refrigeration Management

As much as 70% of the electricity can be consumed by the chiller system it is worth concentrating on efficiently managing the cooling process.

1. EMS

As part of the Environmental management system set up an energy management programme for refrigeration. Details can be found at www.carbontrust.co.uk. Define the targets of the programme. It is essential that the programme has the full support of management and its aims are understood throughout the plant. Start by looking at refrigeration,. it often consumes the majority of electricity in abattoirs (typically up to 70%).

2. Assess all refrigeration systems

Familiarise yourself with the refrigeration equipment and the main components. Check the systems' components match the documentation. The more you understand the operation of the plant the easier it is to identify potential savings.

3. Meter energy consumption

Electricity bills provide a basic record of overall kWh consumption. Install sub-metering or use energy loggers to measure energy consumption of individual refrigeration systems. Ensure the associated equipment e.g. compressors, fans (evaporator and condenser), electric defrost heaters, lighting pumps, of each system are all measured.

- Relating energy consumption to throughput can highlight problem areas and also opportunities.
- Compressor drive motors tend to use the most energy, followed by fan motors.

4. Measure the current process performance

Before making any changes check the chilling performance of each refrigeration system against its specification. The primary carcass chillers tend to have the highest energy consumption so start here.

Measure and record:

- air temperature and relative humidity in the chiller
- surface and deep leg temperatures for a range of carcases throughout the day
- air speed at several points throughout the chiller
- ambient air temperature
- weight of carcases throughput

Recording data over a week gives more detail of how performance varies with production throughput and ambient temperature. By comparing current and previous performance measures, any adverse effects can be highlighted.

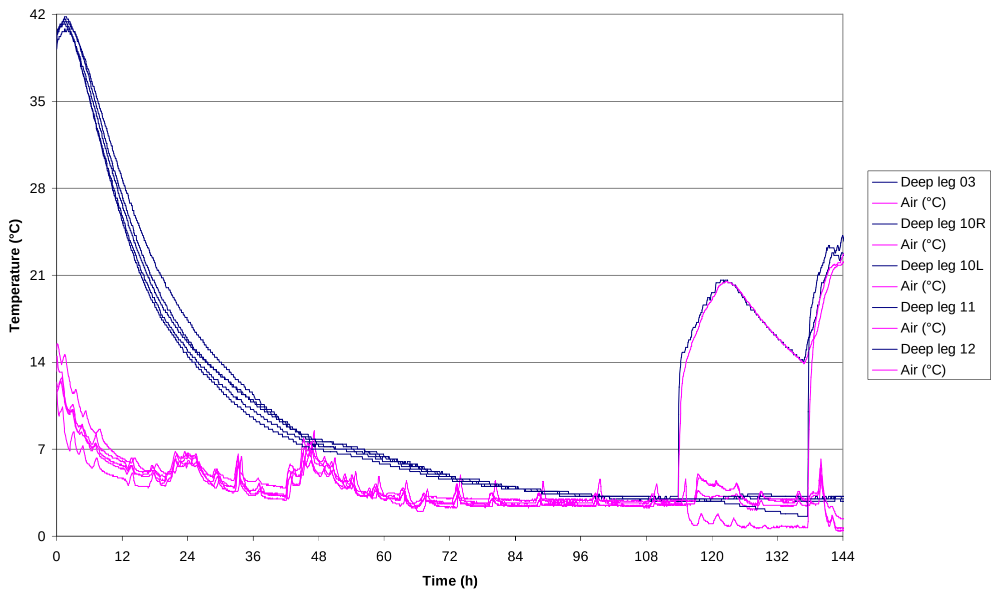


Figure 13 *A graph measuring deep leg temperature drop over a few days.*

The information was collected on a particularly warm day and showed that it actually took longer than 48 hours to get to 7^{o}C. It also showed the detrimental effect when the next days kill is loaded into the chiller. There was a rise in chiller temperature because the loading and unloading doors were opened which slowed the chilling down in the deep leg temperature.

Both theses issues are important as if they occur regularly other issues need to be considered. Drip Loss and bone taint are actually more important than reducing energy costs for an abattoir as more money could be lost through these factors than an abattoir could save by reducing their energy costs.

5. Analyse baseline data

Examine the chilling performance and energy baseline data to determine how each system uses energy throughout the production cycle. Identify the key features of the energy consumption profiles, especially periods of high and low energy consumption and determine reasons for them. Track trends against throughput and look for unusual events.

6. Increase the efficiency by improved compressor controls

The compressors consume the most energy in a refrigeration plant. To save energy here, the evaporating temperature should be as high as possible and the condensing temperature as low as possible while still maintaining the required control temperature. Remember that for every 1ºC less between evaporating and condensing temperature there is a saving of 2 to 4% in energy costs as the compressor has less work to do.

Seek advice from a good refrigeration contractor about reviewing and upgrading your system controls for more efficient operation including floating head pressure and electronic expansion valves.

7. Optimize condenser fan coil units

Keep condenser coils and fins clean and free of debris. Blocked condensers increase the condensing temperature – a 1ºC increase will increase energy costs by 2 to 4%.

Make sure that air entering the condenser units are as cold as possible (ideally shaded from direct sunlight on the north facing side of the building).

Upgrade to the most energy efficient fan motors and speed control systems.

When replacing condensers, consider installing units that are larger than standard issue. These may be more expensive to purchase but will improve refrigeration efficiency and save money in the long run..

8. Optimize evaporator fan coil units
Evaporator fan motors consume a significant quantity of energy, especially if they run continuously at full speed. Save up to 70% of fan energy by replacing inefficient fixed speed motors with more efficient variable speed drives.

Always make sure that the coils and fins are kept clean and not blocked to ensure efficient heat transfer.

Check that the frequency and duration of defrosts are only enough to keep ice build up from affecting evaporator efficiency otherwise they will waste energy, add to the heat load and disturb the room temperature control and air distribution.

9. Minimize door openings
Open or leaking doors waste energy. Ensure doors are easy to operate and educate staff to keep door openings to an absolute minimum.

Keep strip curtains in good condition and consider investing in air curtains, vestibules or automatic door closing devices especially when freezer temperatures are involved.

10. Check insulation
Over time insulation deteriorates or becomes damaged. Poor insulation increases energy consumption as external heat is gained through small gaps in the walls, ceiling, doors and floor. Thermal imaging cameras can quickly identify areas that need attention.

Check and replace any faulty insulation on cold refrigerant pipes between the evaporator and compressor (especially on larger suction line pipes).Also check that door seals etc. are not damaged allowing heat to leak in.

11. Fans
Using high efficiency electronically commutated motors (ECM) to replace evaporator fans, energy costs can be reduced by up to 50%.

An abattoir with 10 kW of installed fan power costing over £9000 per year to run reduced their fan speeds part way through chilling and changed to more efficient electric drives/fan units, made savings of over £2000 per year on electricity bills.

Similarly 50% energy savings (approximately £900 per year) were made by converting evaporator fan motors in their primary chiller to high efficiency motors. However, the payback period was over two years due to the cost of the fans. Replacing units with more efficient ones when they fail is the most sensible option.

5.1.2 Infiltration through doors

Doors especially those for the primary chillers are often left open especially when loading and unloading of the carcases. It is estimated that the electrical energy costs approximately £250 per year for every hour a chill room door is left open.

The additional heat load will increase with:

- the number of door openings, the length of time the door is open, the size of the opening and the greater the temperature difference between the air outside and inside the room
- Draughts, especially through-draughts due to more than one door open at the same time will add to the exchange of warm and cold air

By batching the carcases outside the chiller and loading a batch once per hour significant savings are made.

Install strip curtains. A well maintained strip curtain can be 80% to 90% effective, reducing this cost to £50/year for every hour each door is left open.

In a larger abattoir where several doors are left open for prolonged periods, savings of over £3000 per year have been reported by doing the following:

- Improve door closing discipline by installing door alarms
- Improve maintenance on door seals and protection

When freezer temperatures are involved it is worth costing out air curtains, vestibules and automatic door closing devices.

5.1.3 Gas and Oil

The Boilers

Boiler water is generally used for steam production, heating buildings and supplying hot water for wash downs. Excess water used by boilers will mean a waste of energy, as well as excess use of chemicals. Water used in boilers is often pre-treated -softened and/or had anti-scale chemicals added to it in ion exchange columns using hydrochloric acid/caustic soda for demineralisation or salt solution for softening plants (need re-ordering but not sure what it is meant to say). Every stage of treatment increases the value of the water and therefore the cost of its loss. Below are several ways to reduce water loss which will save energy, ion exchange costs and chemical additives as well as water:

- Maximise the amount of boiler condensate recovered from cooling of steam as it does not require pre-treatment and will retain much of its heat
- Use sub-metering on the hot well that tops up boiler water to monitor the volume of top-up water used, showing the influence that condensate recovery is having
- Only regenerate the ion exchange columns when it is required. Control systems are available to manage water consumption, based on conductivity monitoring. This reduces the amount of regeneration chemicals, energy and water that are wasted during the stabilisation period.

***Table 12** Comparable costs of different water types (2004/05 prices)**

Type	Typical cost
Potable mains water	£0.79 per m^3
Demineralised or softened water	£2 - £3 per m^3
Condensate	£3 - £4 per m^3
Steam	£10 - £12 per tonne
* Costs do not include disposal of waste water	

Source: Envirowise guide GG523 Water saving devices and practices – for industrial sites

Boiler blowdown is conducted to remove dissolved solids that build-up in the system. Blowdown is often conducted manually using timers; however this can be very wasteful. A conductivity meter can be used to ensure blowdown only occurs when necessary, as it will determine the concentration of TDS. Automatic blowdown control systems that use conductivity measurements are usually set to a conductivity equivalent of a TDS of 3000-3500 mg/litre. Typical treated water has a TDS concentration of 275 mg/litre:

6.0 APPENDICES

APPENDIX 1: This is some of the information collected for the WRAP report.
To date no formal LCAs have been completed for any animal species in the UK. The results have been split into meat processing including retailing and rendering. Technical details of the calculation are included in this Appendix.

The main source of emissions from meat processing is energy use followed by solid waste disposal while effluent treatment generates a GHG credit. A summary is shown in the table below.

Table 13: Summary of GHG emissions from both abattoirs and meat processing

Abattoirs	Beef	Pigs	Lamb	Poultry	All Species
Conversion of flows to CO_2e emissions	kt CO_2e / year	kt CO_2e / year	kt CO_2e / year	kt CO_2e / year	kt CO_2e / year
Electricity	61.1	22.6	13.9	244	342
Gas	5.00	0.84	2.02	42.3	50.1
Gasoil	0.12	4.04	0.23	0.00	4.40
Propane	0	1.90	0	0	1.90
Total energy	66.2	29.4	16.2	287	398
Water	0.90	0.44	0.42	2.14	3.90
Effluent	-0.34	-0.28	-0.21	-0.39	-1.21
Lairage	6.18	2.81	2.64	0.00	11.62
Packaging wastes					
General waste (landfill)	3.33	5.38	1.37	7.72	17.8
Cardboard (recycled)	12.6	10.0	0	0.099	22.7
Plastic (recycled)	0.22	0	0	0	0.222
Paper (recycled)	0.013	0	0	0	0.013
Wood (recycled)	0.00	0	0	0	0.001
Packaging wastes sub-total	16.13	15.41	1.37	7.82	40.72
Grand total	89.0	47.8	20.9	296	454
CoV	5.3%	6.7%	5.7%	6.4%	4.4%

Note:

a) Where data uncertainties arise estimates have been made using 'Monte-Carlo' simulations with the resultant uncertainty expressed as the coefficient of variation (CoV) – the standard deviation divided by the mean and expressed as a percentage.

GHG emissions associated with rendering are based on simplified data as the subject is being considered in detail at Harper Adams University College. The estimates produced below are thus intended to be only broadly indicative of the scale of the industry's activities. The industry is complex and very diverse at plant level thereby increasing the uncertainty over the data.

Table 14: Summary of estimates of emissions and emission credits from the rendering industry

Item	Emissions, kt CO_2e	CoV	Credit, kt CO_2e	CoV
Collection of materials	50	21%		
Energy and water use	1262	26%		
Plastic packaging disposal from retail	0.04	30%		
Rendered oils			284	25%
PAP - pet food			1584	25%
MBM and ash in cement			53	16%
MBM as fertiliser			39	31%
Total	1,312	25%	1,959	20%

The rendering industry creates larger emissions compared to slaughter and processing owing to the need for energy to maintain processes but it also creates large credits through the conversion of what are nominally wastes into useful products. Fats derived after rendering from animal by-products can be used to supply liquid and solid bio-fuels to industry which can replace fossil fuels such as oil and coal for steam and power generation and for use in biodiesel production. Proteins produced in the same way can be used to produce protein meal which can replace soya meal. While the credits from rendering appear to exceed the total emissions the results are not statistically significant. The results suggest that the value of useful outputs from rendering is broadly equal to the emissions incurred.

These data from our research are the first available and should be regarded as provisional until more detailed results are available from the research at Harper Adams.

Appendix 2

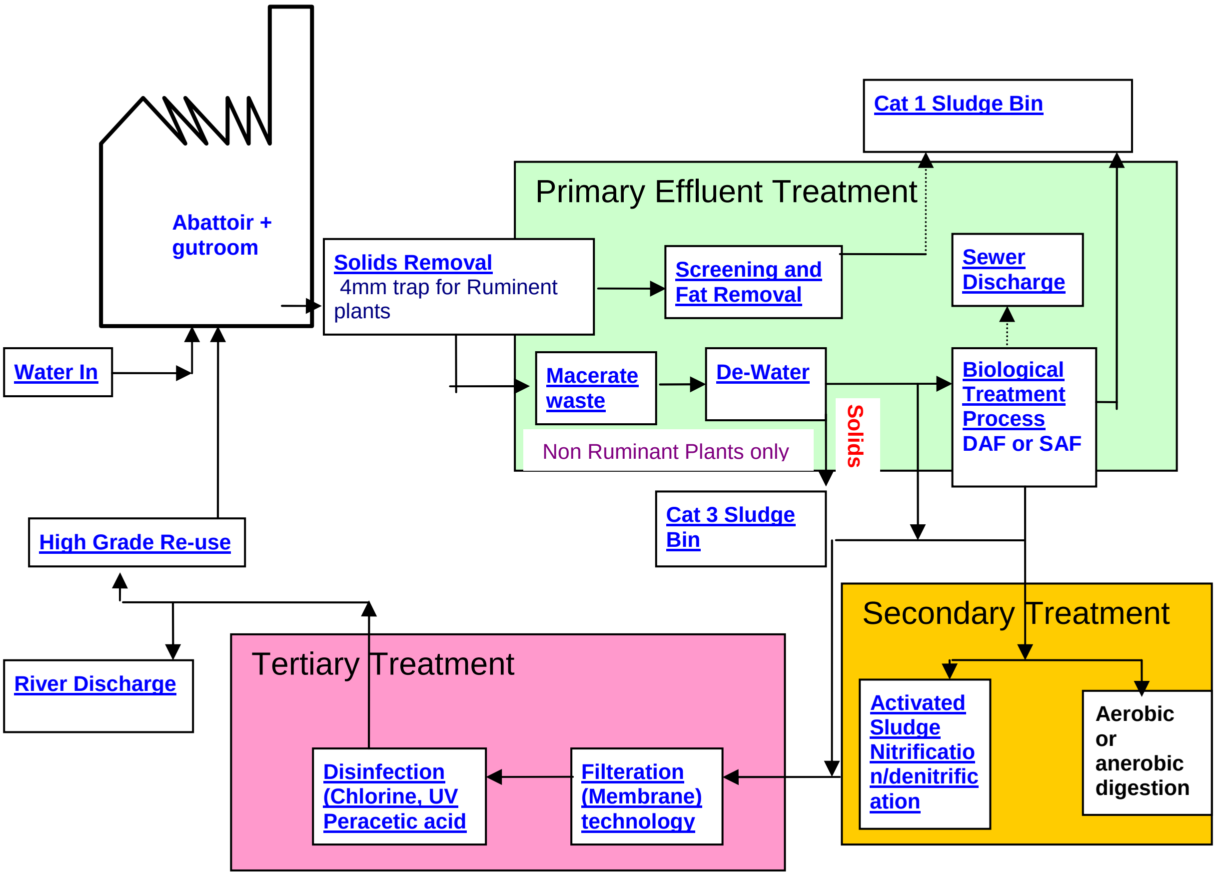
Effluent Treatment Options

Regulatory bodies including the Environment Agency define “trade effluent” as any liquid waste ‘produced in the course of any trade or industry’ which is discharged to the waste water system. It includes water used in production, washing or cooling facilities, and covers both large and small premises.

Treatment of this effluent fall into three exclusive categories which increase the degree of cleanliness

1. primary treatment--the removal of floating and settling solids, such as FOG
2. secondary treatment--the removal of most organic matter, usually in the form of soluble organic compounds
3. tertiary treatment--removal of nitrogen, phosphorus, suspended solids or some combination of the three

Figure 14:



Processing facilities that discharge directly into navigable waters (for which a National Pollutant Discharge Elimination System permit is required) must provide primary and secondary treatments and, in some cases, tertiary treatment as well. The type of treatment is determined by the final disposal option required. Usually no single process is adequate for internal reuse -more likely a treatment train utilising a number of processes, and different options can be used on different streams.

Primary Treatments
Primary treatments essentially accomplish two goals: the reduction of total suspended solids and BOD loads in subsequent treatment processes and the recovery of materials for further processing, including rendering. Specific methods typically incorporate:

- screens (or filters), which employ combinations of meshes and vacuum suction pumps to filter out effluent waters from influent, and pass solid particles into collection devices.
- Settling tanks or catch basins, which rely upon gravity separation, where wastes settle or float according to their relative densities to water. Settled solids are scraped and collected while the floating scum is skimmed off.
- dissolved air flotation DAF plants which introduces air-saturated influent into a flotation tank similar to the catch basin. The air is released from suspension at atmospheric pressure, generating a stream of particle-borne bubbles that rise to the surface, where the waste can be skimmed off. Larger particles settle at the bottom and are scraped and collected. Alternatives to DAF, including reverse osmosis, have their uses, but may not be as cost effective.

Secondary Treatments
Secondary treatments typically employ aerobic and anaerobic processes, which use microorganisms to reduce organic loads. This so-called biological approach generally is considered more cost-effective in treating high organic strength wastewater than physical and chemical treatment.

With the anaerobic method, various micro-organisms break down complex organic compounds into simpler compounds such as hydrogen, carbon dioxide, alcohol and short-chained volatile acids. The alcohol and acids are then further decomposed into 'biogas', which is methane produced by microorganisms known as methanogens.

High-rate anaerobic technologies include continuously stirred tank reactors, anaerobic contact reactors and anaerobic fluidized beds, while aerobic technologies variously incorporate activated sludge, oxidation ditches or sequencing batch reactors. In many cases, anaerobic and aerobic processes are combined into one treatment system, with anaerobic used to remove most organic matter from the waste water and aerobic to provide 'polish' by further removing nutrients and residual organic matter.

Anerobic digesters can require big settling tanks and take up significant amounts of space depending on the effluent quantity and quality. The process for abattoirs can take up to two weeks to biodegrade the organic matter. The process also requires a pasteurisation treatment prior to the digestion process for ruminant plants. This is process will vary depending on the particle size of material and is described in E.U regulations en_2002R1774. These regulations describe the different method which need tp be applied. The method should kill off any pathogens that are not destroyed by the digestion process. During the design phase the intention is always to harvest the methane and used it to power the pasteurisation process. In practice this rarely works as the process is slow and insufficient amounts of methane are generated for what is needed.

Aerobic digestion is perhaps more suitable for abattoir waste. One particular system takes abattoir waste, pumps it with air and heats the product up to over 70^{o}C which means faster aerobic digestion. It is able to cope with Category 2 and 3 wastes, but the temperatures are not high enough for Category 1 rendering to destroy the pathogens believed to be in Category 1 material. . The main products are high quality fertilisers with in-built pesticides which improve the carbon footprint of the user as these are not created from petrochemicals thereby less greenhouse gas.

The presence of nitrogen and phosphorous is becoming more of a problem with the EA looking at reducing the regulation levels. Traditional aerobic or anaerobic treatments do little to reduce these chemicals. Nitrification is also an important process when looking at abattoir effluent. The removal of nitrogen from effluent using activated sludge has been practised for many years. Briefly the process oxidises the ammonia to a nitrate using oxygen derived from the air, followed by reduction of the nitrate to nitrogen gas by bacteria using the BOD present in the incoming wastewater. The process is known as nitrification/denitrification.

Nitrogen is also removed by synthesis of bacterial biomass (activated sludge) during aerobic removal of BOD. However in the case of municipal sewage, nitrogen levels are high and only 20% to 30% of the nitrogen will be removed by this route.

Tertiary Treatments
The EA defines tertiary treatment as any method extending beyond secondary methods. In the case of meat, tertiary treatments typically target nitrogen, phosphorus, dissolved inorganic substances and total suspended solids (or those that have survived the primary and secondary stages.)

They do so in many ways. Passing the wastewater through a porous material reduces BOD and TSS by filtering out small particles and residual suspended materials. Introducing additional aerobic and anaerobic cycles to the waste water siphons off phosphorous, as does the introduction of metal salts or lime. Nitrogen removal requires nitrification and denitrification, in which microbes oxidize ammonia oxygen into nitrite, and nitrite into nitrate.

Membranes – Effluent streams can be treated through membrane systems by microfiltration, ultrafiltration, nanofiltration or reverse osmosis. Contaminants can be treated and removed to produce water of drinking water quality which is suitable for reuse on site. The enhanced capital allowance scheme supports membrane systems which treat water and reuse ≥40% on site.

Table 15 *Treatment Process Suitability for Specific Contaminants*

Treatment	Biological Oxygen Demand (BOD)	Suspended Solids (SS)	Total Disolved Solids (TDS)	Fats, oils and greases (FOG)	Phosphorus	Nitrogen
Primary Treatment Physical /Chemical Systems	Partial 40% to 80%	Good	Virtually nil removal	Good	Good with Chemical Precip.	Only what is in proteins
Secondary Treatment Biological Systems	Excellent	Generator of SS	Removal of organic only	Will process with time. Hinder bio process	Required for biomass	Can be designed to remove within limits
Tertiary Treatments Membrane Systems	Partial Cause problems	Excellent MicroFiltration	Excellent With RO	No - will cause problems	Good with Precip.	Excellent if oxidised

More information can be obtained from Envirowise/WRAP.

Other useful free publications and guides

Carbon Trust website:
GIL129 - Refrigeration Fact sheet
CTV002 - Refrigeration technology overview
GIL158 - How to get the best from your refrigeration system
GPG369 - Energy Efficient Operation of Boilers, produced by the Carbon Trust
GPCS443- Improved Condensate Recovery Reduces Boiler Operating Costs. Carbon Trust
ECG066 - Steam Generation Costs
GPG381 - Energy Efficient Boilers and Heat Distribution Systems

Institute of Refrigeration website:
Guidance for end users
Appointing and Managing Refrigeration Contractors

Purchase of Efficient Refrigeration Plant
Operational Efficiency Improvements for Refrigeration Systems

An Inventory of Methods and their effects on Diffuse Water Pollution, Greenhouse Gas Emissions and Ammonia Emissions from Agriculture
By Newell Price, J.P., Harris, D., Taylor, M., Williams, J.R., Anthony, S.G., Chambers, B.J., Duethmann, D., Gooday, R.D. and Lord, E.I. (ADAS) Chadwick, D.R. and Misselbrook, T.H. (NW Research)
Prepared as part of Defra Project WQ0106 *May 2009*

Appendix 3: The survey used in this study

EBLEX QMS HYBU CIG CYMRU MEAT PROMOTION WALES MLC CONSULTING

MLCSL Consulting,
Stoneleigh Park,
Kenilworth, Warwickshire
CV8 2TL
ph 024 76478629

Company			**Contact**		
Address			**Phone**		
			Email		
Would you be interested in further work to look at submetering electricity and water ?		**Number animals slaughtered**		**Amount/type of carcase meat processed; tonnes**	
Number of Employees		Cattle	Sheep	Cattle	Sheep
Year to which information refers detail year end date.	**2008**				
	2009				
Brief description of size of operation. What is killed/boned on which days?					
Additional information & significant changes from last year.					

UTILITIES SUPPLY AND COSTS	**Period**	**Cost (ex VAT)**	**Units purchased**	**Units**	**Supplier**
Electricity				KW Hrs	
Gas				KW Hrs	
Oil				000 Litres	
Water				Cubic Metres	
Hot Water				Cubic Metres	

WASTE AND ANIMAL BY-PRODUCTS	**Period**	**Cost (ex VAT)**	**Quantity**	**Units**	**Receiver**
Effluent				Cubic Metres	

What happens to your effluent?

Do you do anything to minimise its strength?

	Period	**Cost (ex VAT)**	**Quantity**	**Units**	**Receiver**
Cat 1				Tonnes	
Cat 2				Tonnes	
Cat 3				Tonnes	

Would you be interested in further help support and financial assistance with a view to improving to your company resource usages and sharing the information confidentially with EBLEX