ENTERPRISE IRELAND

Transforming Irish Industry

Sustainable Practices in Irish **Beef Processing**

Foreword

In recent years, environmental issues relating to food production have become some of the most significant currently facing the global community and weigh heavily on the public conscience. Climate change, over-reliance on fossil fuels, the destruction of water sources and declining natural resources all affect the capacity of the world to feed its growing population.

Agri-food remains one of Ireland's most important sectors in terms of wealth generation, exports and employment. In recent years, there has been a significant shift towards sustainable food production in the developed world and, as Europe's largest net exporters of beef, Irish beef processors are at the forefront of this initiative. This is especially evident in the high levels of waste reduction/recycling and in the marked reductions in high-strength effluent discharges that have been achieved by Irish beef processors during the course of this study.

Generally speaking, all of the process waste from the beef sector is converted into valuable by-products such as edible & inedible fats, food additives, biofuels, pet foods and soil improvers. Wastewater from the beef sector is now treated to such a high degree, i.e. Best Available Technique (BAT) standards, that effluent discharges can now be recycled for use in water-intensive applications such as lairage - and truck-washing. These improvements have the effect of almost completely mitigating the impact of individual beef processors on their surrounding environments.

Although significant reductions in CO_2 emissions have been achieved, the next big challenge facing the sector is to reduce energy consumption while maintaining the strictest hygiene standards and the exemplary levels of waste reduction. To this end, a wide range of energy efficiency and alternative energy solutions are being developed and these are expected to result in significantly higher levels of energy sustainability in the coming years.

This independent study sets a useful benchmark for future performance by the sector. Furthermore, it clearly demonstrates the on-going commitment of these companies to invest time and money in achieving best environmental practices and gives confidence to consumers of Irish beef that the industry operates in harmony with the environment.

I would like to express my thanks to all who have contributed to the project including An Bord Bia, the Irish Environmental Protection Agency and Sustainable Energy Ireland.

Mike Feeney,
Executive Director, Internationally Traded Business Sectors

1.0 Executive Summary

Ireland is synonymous the world over with quality beef products and Ireland's beef processing sector remains one of its most important in terms of wealth generation, exports and employment. The production of top-quality beef stock and significant investment in Ireland's state-of-the-art beef processing sector has helped transform the Irish beef industry over the past decade from bulk-commodity producers to leading suppliers to some of the world's top retail and fast-food chains. As with all food processing sectors, the beef industry must constantly seek to maintain price competitiveness while building on its reputation as a reliable and sustainable supplier of quality products to the export markets. It must also consolidate its position by facing the challenges of world trade liberalisation, retailer consolidation and currency fluctuations by reducing production costs and improving efficiency, environmental and quality standards.

This report provides an overview of the environmental performance of Ireland's beef processing sector between 2003 and 2008. During this period, Irish beef processors have consistently operated in compliance with their IPPC licences in relation to emissions to water by constantly seeking to lower emissions of key contaminants especially nitrogen and BOD, which were reduced by 57% and 41% respectively during the period of the study. This is partly due to continuous monitoring and upgrading of systems but also demonstrates the extent to which blood, fats, manure and other high BOD wastes are prevented from entering the wastewater stream. Furthermore, with only one exception, all of the plants included in this study treat their wastewater to Best Available Technique (BAT) standards and all continue to invest in ever more sophisticated systems to further reduce emissions.

Between 2003 and 2008 the Irish sector reduced emissions of CO_2 by 8.6%. This was mostly due to the introduction of renewable tallow as a substitute boiler fuel and to the increased use of less carbon-intensive boiler fuels such as liquid petroleum gas (LPG) and natural gas. Fugitive emissions of CFC were also significantly reduced as the Irish sector switched refrigerants from CFCs to ammonia. Another contributing factor was a 10% reduction in the carbon intensity of electricity from the Irish power generation sector due to the increased percentage use of natural gas in the fuel mix.

In an effort to achieve maximum efficiency, the quantity of recorded/collected processor waste increased by 8% to 415,100 tonnes in 2008 despite a 10% reduction in cattle throughput. When calculated on a per head basis, the quantity of recycled waste increased by 17% between 2003 and 2008. The majority of this material

(75.4%) was rendered to produce tallow and meat & bone meal which are employed as zero-carbon fossil-fuel substitutes. The remainder was either applied to land as a soil improver (21.9%) or land-filled (<1%).

Total water consumption by the sector decreased by 12.8% between 2003 and 2008 to 3.46 million cubic metres (m^3). During this period there was a 10% reduction in the number of cattle processed, however, there was a corresponding increase in the level and intensity of secondary meat and by-product processing. The overall effect was a 2.7% reduction in water use, which currently is 2.19 m^3/head, and a significant improvement in water efficiency relative to the quantity and value of end-products.

Total energy consumption during this period increased by <1% to 1.42 million gigajoules (GJ), i.e. 395 million kiloWatt hours (kWh). There was a 4.5% increase in electrical energy coupled with a 4.4% decrease in thermal energy consumption reflecting an increase in the level of secondary processing coupled with a decrease in the number of animals processed. In 2008, the average consumption of energy per head of cattle processes was 889 megajoules (MJ)/head.

Tallow consumption by the sector increased from zero in 2003 to 13% of total energy in 2005. Thereafter, because of the lower cost of oil, tallow use has decreased but it was still responsible for 5.8% of the total energy consumed by the sector in 2008. Tallow is a renewable, zero-carbon fuel and has the potential to replace much of the oil consumed by the sector should oil prices increase in the coming years.

Taken as a whole, the Irish beef sector has made impressive strides towards sustainability in the past 6 years. The sector's impact on the environment in terms of emissions to air and water has been consistently reduced and the sector has sought to reduce waste by deriving the maximum benefit from every part of every animal processed. In order to realise these changes there has been an increase in energy consumption per head, however, the sector is currently poised to take full advantage of the wide range of emerging opportunities in renewable energy including wind and biomass energy, improved energy efficiency using a combination of energy control systems and CHP and in the recovery of waste heat. The challenge will be to maintain Ireland's worldwide reputation for quality and safety while reducing energy and water consumption and the sector's dependence on fossil fuels and electricity from Ireland's power generation sector. At current levels of consumption, a 5% reduction in energy consumption across the Irish beef sector would have the effect of reducing energy costs by as much as €15 million.

1.1 Introduction

This is a study to investigate the environmental performance of Ireland's beef processing sector since 2003 in the light of enhanced regulation concerning air and water emissions, recycling/minimisation of waste and customer expectation of the sustainable use of resources such as energy & water. The aims of the review are outlined below :-

- To establish key environmental performance indicators (KPIs) for Ireland's beef processing sector and to identify reliable source of KPI data;
- To measure environmental performance by the Irish beef processing sector between 2003 and 2008 so as to have a baseline with which to compare future performance of the sector;
- To determine if the Irish sector has implemented practices which ensure that they comply with the Best Available Techniques (BAT) requirements of their IPPC licences;
- Benchmarking environmental performance and providing best practice guidelines for the medium-to-large, fully-integrated, export-oriented, customer-focussed beef processing/packing plants that make up Ireland's beef processing sector;
- To identify opportunities where productivity improvements and export gains can be made through improved environmental performance; and
- To assist Ireland's Clean Technology sector in determining where performance may be enhanced and in designing innovative goods and services targeted specifically at Ireland's beef sector.

1.1.1 The Irish Beef Sector

Despite the unprecedented growth of the Irish economy since the early 1990s, the agri-food (i.e. Food & Drinks) sector remains one of Ireland's largest industries as measured by wealth generation, exports and employment. Accounting for over 8% of Gross Domestic Product and 10% of total merchandising exports in 2008 (i.e. €8.6 billion), the sector directly employs 46,000 with a further 60,000 employed in ancillary services. Each year, it purchases €5 billion worth of agricultural products from Ireland's 120,000 farmers and a further €8 billion worth of goods and services. It supplies the majority of the €7 billion worth of food & drink products that Ireland consumes annually and exports almost €8.1 billion of food and drink products to 120 countries [11].

In common with all manufacturing sectors, the major issues facing the agri-food sector are maintaining price competitiveness, increasing innovation and meeting emerging consumer demands. Ireland's continued international success rests on its reputation as a reliable and safe source of quality products. This is especially true in the case of Ireland's beef industry which exports more than 85% of its total annual production and which commands high prices in the prosperous European market which it targets. Ireland is Europe's largest net exporter of beef and has a reputation for producing the world's highest quality beef. Over 100,000 Irish farmers, rear cattle and, of these, 69,000 are classified as specialist beef producers. The production of top-quality beef stock and significant investment in Ireland's state-of-the-art beef processing sector has helped transform the Irish beef industry over the past decade from bulk-commodity producers to leading suppliers to some of the world's top retail and fast-food chains. The most popular breeds represented in Ireland include the large, fast-growing continental breeds Friesian, Charolais, Limousin, Belgian Blue, Simmental and Blonde d'Aquitaine and some of the smaller UK breeds such as Aberdeen Angus and Herefords. Ireland's beef output in 2007 was valued by the Irish Central Statistics Office at €1.5 billion (producer prices) with exports of €1.57 billion (manufacturer's prices) and Irish retail sales of €463 million. The beef processing sector directly employs 7,000 with a further 7,000 employed in ancillary services [1].

After the BSE crisis in 1996 the National Beef Assurance Scheme was enacted to ensure the safety of consumers and to guarantee high standards in Irish beef processing. The scheme introduced systems for registration, inspection and for animal identification & tracking which require all cattle to be tagged at birth and all movements to be recorded in order to validate the origin of cattle before they enter the food chain.

Irish cattle are mainly grass-fed on pasture land and have a lower overall environmental footprint than grain-fed cattle, which constitute most of the world's supply of beef. Another advantage of this type of production is that grass-fed cattle, unlike grain-fed cattle, are not fattened in giant feedlots which consume agricultural produce such as corn (15kg/kg beef produced) that could reasonably be used to feed the human population.

Early in 2009, the Taoiseach, Brain Cowen, announced details of a programme of capital investment called the Beef and Sheep-Meat Fund which will invest €69 million in 15 processing plants as part of an overall investment programme by the sector of €170 million. This is aimed at increasing Ireland's processing capacity, boosting exports by €400 million and increasing employment by 800 between now and 2012. Ireland must consolidate its position in EU markets by facing the challenges of world trade liberalisation, retailer consolidation and currency fluctuations by reducing production costs and improving efficiency, environmental and quality standards [22].

1.1.2 Ireland's Beef Processors

Beef plants may be categorised on the basis of the final products which range from chilled sides of beef to vacuum-packed retail cuts. Traditionally, the slaughterhouse would kill, dress and chill the carcass, however, the majority of Irish beef processors engage to varying degrees in a wide range of meat and by-product processing. These activities include cutting & boning to produce retail cuts, grinding, mixing with additives, curing, cooking, canning, processing of by-products (e.g. casing & edible offal processing, fat processing, etc.), packing, freezing and cold-storage. The Irish beef sector is predominately export-focussed and research would suggest that export markets demand higher standards of hygiene and greater flexibility in production from the plants [18]. Since the early 1990s, the Irish beef sector has undergone significant consolidation and rationalisation with many of the older, less efficient plants closing and production shifting to state-of-the-art beef processing plants that are far more than just slaughterhouses.

1.1.3 Environmental Impact

Today nearly every Irish beef plant is unique in the way that it manages its energy, water consumption, emissions to water & air, by-products and wastes. As is the case with many food processing industry sectors, the main environmental issues associated with meat processing are:-

- high-strength wastewater discharges; and
- emissions to air associated with energy consumption;
- odour and solid wastes; and
- moderately high consumption of energy and water.

Central to the success of this exercise is the establishment of key performance indicators (KPIs) that can be used to determine the relative performance of each plant in the Irish sector and to demonstrate the adoption of sustainable practices in line with EU legislation and changing consumer and industry expectations.

1.2 Project Description

1.2.1 Key Performance Indicators

Benchmarking studies in meat processing typically explore 4 main areas of environmental performance as follows:-

1. Emissions to water;
2. Emissions to air;
3. Recycling and waste minimisation; and
4. Resource consumption

For the purposes of this study, as all of the 16 selected plants operate under Integrated Pollution Prevention Control (IPPC) licences and therefore submit AERs to the EPA, data was easily accessible and, therefore, KPI benchmarks were calculated independently of each plant.

1.2.2 Integrated Pollution Prevention Control (IPPC) Licensing

The IPPC licensing system is the principal mechanism under which the environmental impacts of industrial activities across Europe are managed. Ireland was one of the first EU member states to fully implement the IPPC Directive which was incorporated into Irish law by the Protection of the Environment Act 2003.

The objective of the Directive as it relates to the meat processing sector is to minimise the sector's environmental impacts by a process of licensing, monitoring and promoting best environmental practices based on Best Available Techniques (BATs). Article 2 of the Directive defines BAT as the *"most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practical, generally to reduce emission and the impact on the environment as a whole"*.

According to Article 9 of the Directive, emission limit values, equivalent parameters and technical measures must, without prejudice to compliance with environmental standards, be based on BAT, without prescribing the use to any technique or specific technology, but taking into account the technical characteristics of the facility, its geographical location and the local environmental conditions. Under Irish law, BATs are defined in Section 5 of the 2003 Protection of the Environment Act and Section 5(2) of the 2005 Waste Management Act as *techniques which either prevent or reduce emissions and the impact on the environmental as a whole*.

Techniques include both the technology employed and the way in which the plant is designed, built, maintained and operated. BAT-associated emission level values (ELVs) indicate levels achievable through the use of a combination of the process techniques and abatement technologies. The licensee must demonstrate to the satisfaction of the EPA, during the licensing process, that the plant will be operated in such a way that all the appropriate preventative measures are taken against pollution through the application of BATs with emphasis being placed on pollution prevention techniques rather than end-of-pipe treatment.

An IPPC licence in the context of a beef processing plant is a single, integrated document which defines the activity of the plant setting standards for the management of waste and emissions limits to air and water. It encourages plant operators to adopt an environmental management system thus promoting continuous improvement within the licensed plant. An IPPC licence requires each licensee to engage in continuous monitoring, to keep accurate records and to submit an annual environmental report (AER) which facilitates ease of monitoring both by the competent authority and members of the public. Furthermore, IPPC licences encourage the more efficient use of energy and other resources such as water, minimise waste, and prevent or reduce emissions to air, land and water.

1.2.3 Data Analysis

The study was conducted on the basis of AER data submitted to the EPA by Irish beef processors relating their activities between 2003–2008. During this period, the Irish beef sector comprised 33 plants of which 24 were engaged solely in processing beef. 19 beef-only plants were licensed by the EPA to process 50 or more tonnes of beef per day or 1500 or more units where 1 sheep = 1 unit; 1 pig = 2 units; and 1 head of cattle = 5 units. AERs from 16 of these plants were selected and these plants accounted for 68% of all beef processed in Ireland between 2003 and 2008.

AER data quality and consistency varied between plants, however, overall there was a high level of compliance with IPPC guidelines on monitoring and reporting. All of the plants have Environmental Management Programmes (EMPs) which implement environmental targets and objectives and co-ordinate efforts to improve awareness, review standard operating procedures and monitor performance. Furthermore, many plants also engage in sophisticated internal audits of energy and water consumption to assist them in calculating the costs of certain processes and to identify potential cost savings.

Cattle of varying breeds, sexes and ages are processed by the Irish beef sector. Therefore, while all environmental factors are presented on a "per head of cattle slaughtered" basis, where possible, they are also presented on a "per kilogram of carcass" basis. The average live weight of cattle slaughtered in Ireland has been determined roughly to be ~550 kg. The average carcass weight of the 1,684,900 slaughtered in 2005 was determined to be 324 kg/head [17]. In a separated study, the mean Irish cold carcass weight was found to be 321 $\pm$ 3.8 kg [14].

1.2.4 Benchmarks & international comparisons

An environmental benchmark is a guide to the level of best practice achievable in a specific area of activity and a useful means of assessing relative performance. Certain industries use environmental benchmarks extensively to gauge performance and competitiveness, however, the meat processing sector is not one of these. The paucity of environmental benchmarking in this sector results primarily from the considerable variation in the production processes and the scale of operation but is further complicated by the absence of a widely recognised standard unit of production.

There have been a number of benchmarking studies on beef slaughtering in both European and non-European countries. Despite differences in the cattle breeds and sizes and in the levels of product, by-product and waste processing, attempts have been made to compare the results of these studies with the results of the KPI analysis of Irish processors.

2.0 Emissions to Water

Unlike many European beef processing facilities which discharge partially treated wastewater to sewer, Irish plants discharge fully treated wastewater to rivers, streams and estuaries. Each plant employs sophisticated primary, secondary and tertiary treatment systems in order to achieve high levels of removal of phosphorus, nitrogen, BOD, suspended solids and FOG (fats, oils & greases) prior to discharge in compliance with their discharge licences. Furthermore, in compliance with their Environment Management Plans, each plant continuously seeks to lower levels of emissions despite operating well within their discharge emission limits. This chapter will describe the high levels of wastewater management achieved by the beef sector since 2003 and will explore some of the ways in which plants might continue to reduce emissions in the coming years.

2.1 Wastewater Discharge Volumes

The volume of wastewater discharges by meat processors are directly proportional to the volumes of water consumed. On average, 80-95% of water consumed is discharged as treated wastewater [13]. The remainder is either tied up in wastes or by-products or lost through evaporation and steam loss. Most plants in this study comply with this norm with a few notable exceptions (see Figure 2.1).

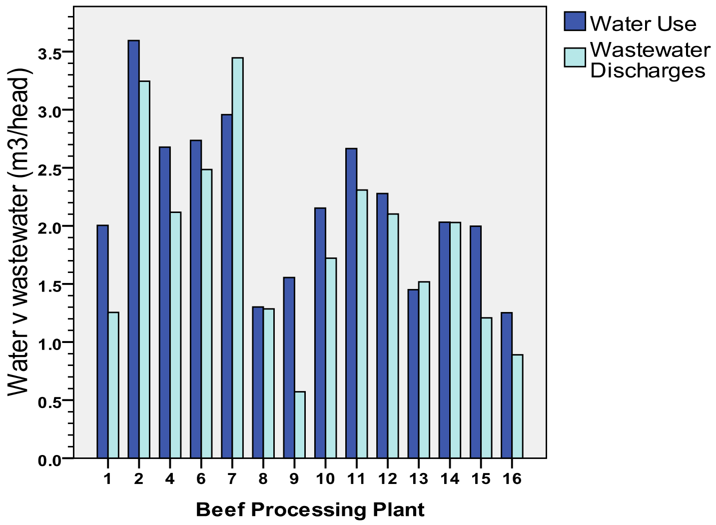

Figure 2.1 Mean water consumption between 2003 and 2008 compared with treated wastewater discharges

The mean treated wastewater discharge volume for each plant between 2003 and 2008 ranged from 0.57 to 3.45 m^3/head. Mean sectoral discharge volumes decreased by 18% from 2.23 m^3/head in 2004 to 1.83 m^3/head in 2008. When calculated as a percentage of their maximum allowable discharge volumes (i.e.

emission limit values) wastewater discharges ranged from 16.6 % to 86.9% ELV with a mean value of 40.5% ELV (+ 19.9%).

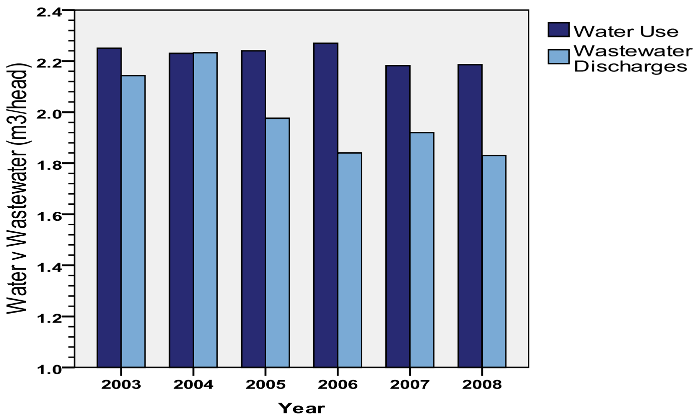

Figure 2.2 Mean water consumption compared with treated wastewater discharges between 2003 and 2008

2.2 Emission Levels for Discharges to Water

Regulatory requirements result in varying levels of enforced compliance resulting in wastewater discharges of varying concentrations. Plants that are located in environmentally sensitive areas have lower Emission Limit Values (ELVs) than plants in less environmentally sensitive locations such as estuaries. In order to facilitate easy comparisons emission levels for discharges to water of phosphorus, nitrogen, ammonia, BOD and suspended solids are presented in :-

- grams/head of cattle slaughtered (g/head),
- % of emission limit value (%ELV), and
- milligrams/litre of treated wastewater discharge (mg/litre).

2.2.1 Phosphorus

Phosphorus in wastewater originates from manure, undigested stomach contents, blood and rendering. Mean concentrations of phosphorus in wastewater discharges from Irish processors between 2003 and 2008 range from 0.15 – 36.1 g/head with mean for the sector of 4.9 g/head (+ 8.9) (see Figure 2.3). While average phosphorus discharges by the Irish sector have remained pretty constant at ~4.8 g/head between 2003 and 2008, mean sectoral phosphorus discharges, when measured as % ELV, fell from 40% to 12% of the allowable level (see Figure 2.4). When measured in mg/litre of wastewater discharge, phosphorus levels ranged from 0.17 to 10.5 mg/litre with a mean value of 2.1 mg/litre (+ 2.8) (see Figure 2.5). This value is well inside the BAT guideline range of 2 – 5 mg/litre in discharges to water [2]. Only one plant – plant 7 - exceeded the BAT guideline for phosphorus (see Figure 2.5a).

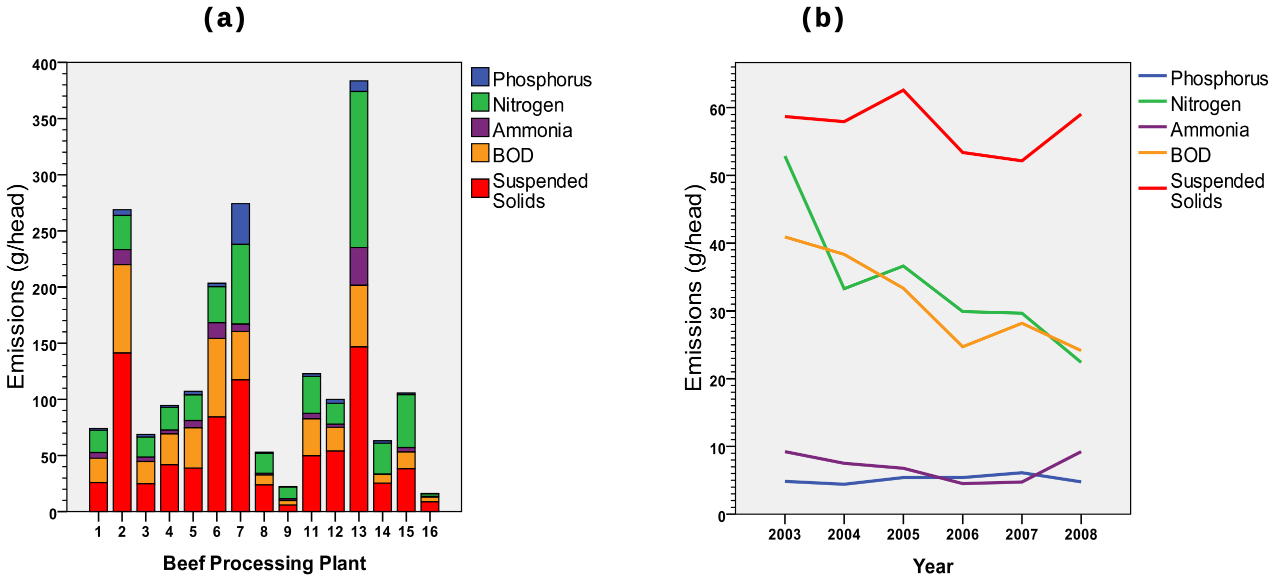

Figure 2.3 Mean emissions to water in grams/head (a) for each plant averaged over 6 years and (b) for each year by the Irish beef sector from 2003 to 2008.

2.2.2 Nitrogen & Ammonia

Nitrogen in meat processor wastewater occurs in the form of ammonia and nitrates and result mainly from the breakdown of proteins and amino acids. Blood is a significant source of nitrogen in meat processor wastewater.

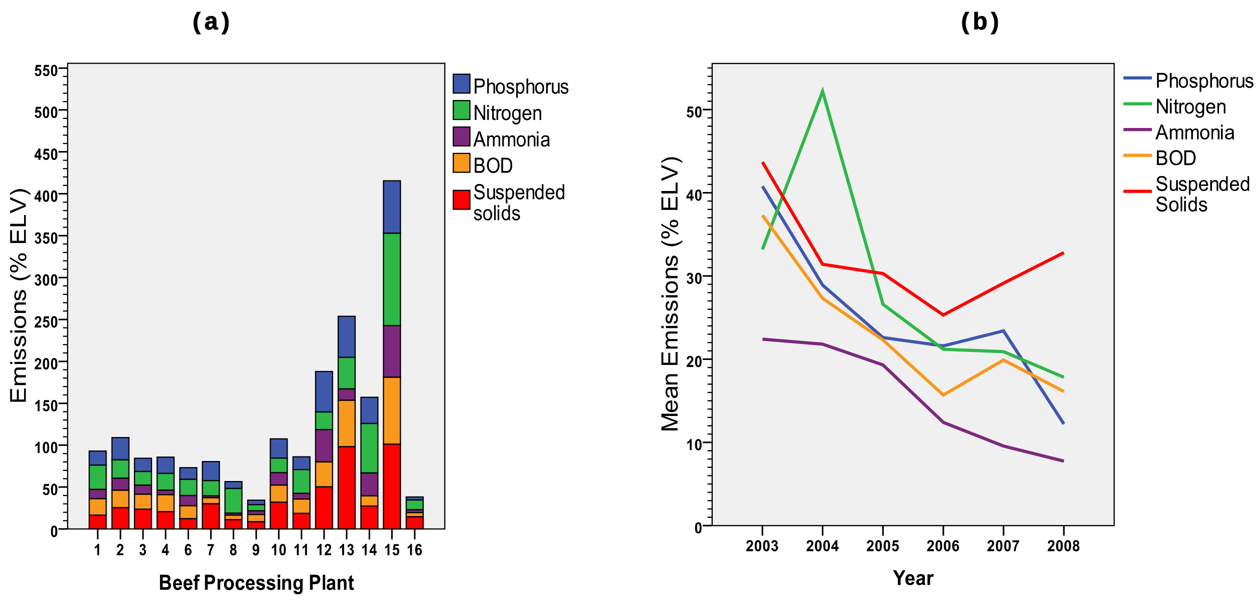

Figure 2.4 Emission Levels for Discharges to Water measured as the %ELV

The mean wastewater discharge levels of nitrogen for each Irish plant from 2003 to 2008 ranged from 2.3g to 139 g/head with a mean of 34 g/head (± 33) (see Figure 2.3). The average nitrogen emissions for the sector were reduced by 57% form 52.9 g/head in 2003 to 22.4 g/head in 2008. During the period of the study, the Irish sector operated well within its discharge limit values consistently reducing emission levels from 33.2% ELV in 2003 to 17.8% ELV in 2008 (see Figure 2.4). When measured in mg/litre of treated wastewater, nitrogen levels were reduced by 59% from 28.9 mg/litre in 2003 to 11.8 mg/litre in 2008 (see Figure 2.5). This value is

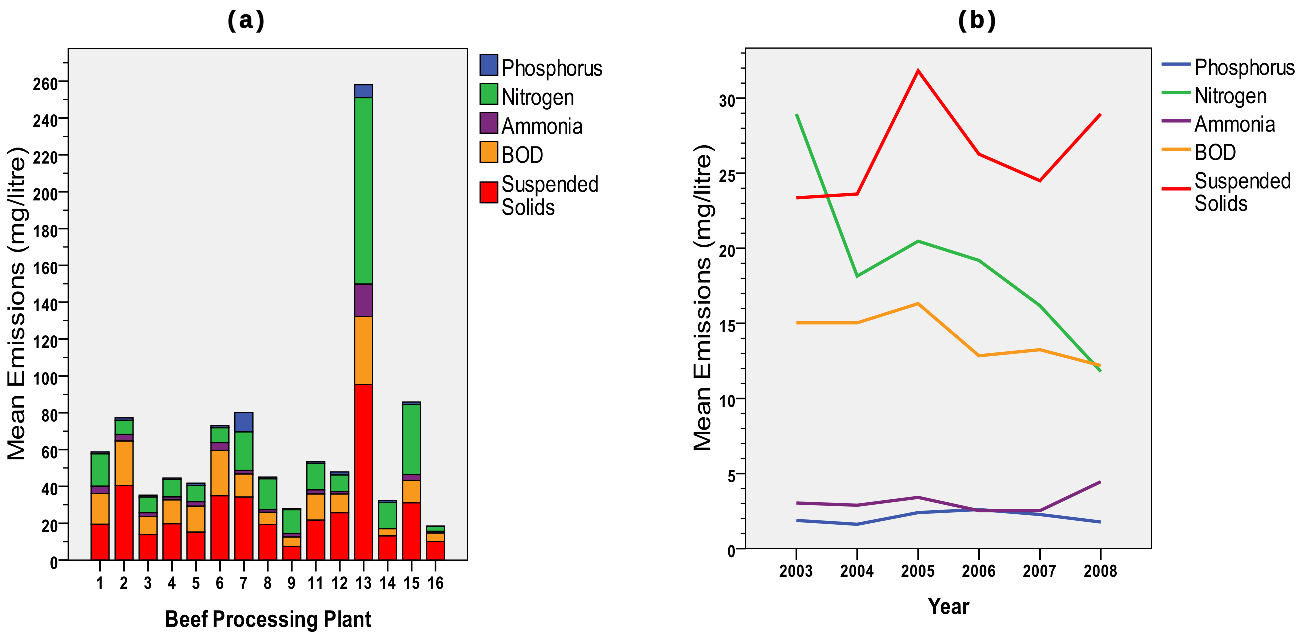

Figure 2.5 Emission Levels for Discharges to Water as measured in mg/litre of effluent outflow.

well inside the BAT guideline of 15 - 40 mg/litre in discharges to water [2]. Only one plant – plant 13 - exceeded the BAT guideline for nitrogen (see Figure 2.5a).

The average plant emission levels for ammonia for the period 2003 – 2008, ranged from 0.4 to 33.6 g/head with a sectoral mean of 6.8 g/head (± 8.4). Average ammonia emissions are largely unchanged between 2003 (9.2 g/head) and 2008 (9.2 g/head) (see Figure 2.3). During the period of the study, the Irish sector operated well within its discharge limit values consistently reducing ammonia levels from 20.4% ELV in 2003 to 7.7% ELV in 2008 (see Figure 2.4). When measured in mg/litre of treated wastewater, ammonia levels ranged from 0.22 to 17.6 mg/litre with a mean value of 3.2 mg/litre (± 4.1) (see Figure 2.5). This value is well inside the BAT guideline of 10 mg/litre in discharges to water [2]. Only one plant – plant 13 - exceeded the BAT guideline for ammonia (see Figure 2.5a).

2.2.3 Biological/Biochemical Oxygen Demand (BOD)

Organic matter, expressed as 5-day BOD is a key indicator of treated wastewater quality. The mean sectoral BOD emissions for each plant from 2003 – 2008 ranged from 3.9 g – 78.5 g/head with a 6 year mean of 29.7 g/head (± 23.3). Between 2003 and 2008 the mean sectoral BOD emission was reduced by 41% from 40.9 g/head (2003) to 24.1 g/head (2008) (see Figure 2.3). When measured as % ELV,

	Phosphorus	**Nitrogen**	**Ammonia**	**BOD**	**Suspended Solids**
Mean Sectoral Discharges (g/head)	5	34	6.8	29.7	55.1
Level Achieved (% of limit)	24.1%	28.7%	14.8%	21.8%	31.8%

Table 2.1 Mean treated wastewater discharge levels measured in grams/head and in % ELV.

mean sectoral BOD emissions fell from 37.3% ELV in 2003 to 16.1% ELV in 2008. Mean BOD emissions from 2003 to 2008 for each plant ranged from 4.6% – 79.8% ELV (see Figure 2.4). When measured in mg/litre of wastewater discharge from each plant, BOD levels were reduced by 8% from 15 mg/litre to 12.2 mg/litre between 2003 - 2008 (see Figure 2.5). These values are well within BAT guidelines of 20 - 40 mg/litre in discharges to water [2]. Mean BOD values for all of the plants included in this study were within BAT guidelines.

2.2.4 Suspended Solids and Fats, Oils & Greases

Discharges of suspended solids and fats, oils & greases originate from fat processing and from trimmings that fall to the meat processing floor and are washed into the treatment plant. Fats comprise a mixture of long-chain fatty acids and glycerol and are referred to as fats, oils & greases (FOG). FOGs from the beef sector exhibit very high BOD levels, often 2 grams of BOD for every gram of lipid. Average FOG levels for Irish beef processing from 2003 – 2008 range from 1.5 – 66.9 g/head with a sectoral mean of 19.4 g/head. Average FOG emissions for the Irish sector fell by 78% from 48.6 g/head in 2004 to 10.8 g/head in 2008.

The mean sectoral emission of suspended solids remained largely unchanged between 2003 (58.7 g/head) and 2008 (59 g/head) (see Figure 2.3). When measured as % ELV, suspended solids emission were reduced by 25% between 2003

(43.7%) and 2008 (32.8%) (see Figure 2.4). When measured in mg/litre in treated wastewater discharge, levels of suspended solids ranged from 7.5 – 95.4 mg/litre with a mean value of 26.8 mg/litre (± 21.3) (see Figure 2.5). This mean value is well within the BAT guideline of 60 mg/litre in discharges to water [2]. One plant exceeded the BAT guideline – plant 13 (see Figure 2.5a).

	Phosphorus (mg/litre)	**Nitrogen (mg/litre)**	**Ammonia (mg/litre)**	**BOD (mg/litre)**	**Suspended Solids (mg/litre)**
Mean Irish Sectoral Discharges	2.1	19.3	3.2	13.9	26.8
BAT levels	2 – 5	15 - 40	10	20 - 40	60

Table 2.2 Mean treated wastewater discharges measured in mg/litre. Also included are the BAT guideline levels in mg/litre.

In compliance with their IPPC licences, every plant has sought under their Environment Management Plans to continuously reduce emissions and to minimise their impacts on the surrounding environments despite operating well within their licence limits. Significant investments both in terms of capital and running costs have been made in primary treatment systems to ensure that the activated sludge units operate to the highest standard. These systems allow Irish processors to achieve significant emission reductions while engaging in secondary processing activities such as casing and offal washing which generate high BOD emissions. Such pre-treatment systems include dissolved air flotation (DAF) systems and aerated balance tanks which remove significant amounts of BOD, FOG and solids and also serve to manage volumetric flows ensuring a continuous flow of nutrients to the microbes in the activated sludge unit.

Irish processors are currently exploring ways to upgrade their secondary (activated sludge) systems by installing diffusers which are proven to be more efficient than surface aerators. Furthermore, diffusers offer a greater degree of control because they can reduce suspended solids, BOD and, in conjunction with the use of ferric salts, phosphorus.

Most plants that use ground water employ in-house water treatment systems to remove chlorides and sulphates. Rejected water is channelled directly to the wastewater treatment plant with consequent increases in volumetric loadings. Irish plants are exploring ways to use this water in applications such as lairage and truck washing, backwashing of tertiary sand filtration units, etc.

A wide range of factors influence the performance of wastewater treatment systems. Future studies will explore the energy inputs required to achieve such significant levels of removal, especially BOD, in order to determine the cost of operating in such a way as to minimise the impact on the surrounding environment. This will ensure that such inputs, especially in terms of energy, are included in any international benchmark.

3.0 Emissions to Air

Air emissions from Irish beef processing plants are mostly attributed to the consumption of energy and to odour discharges from rendering and wastewater treatment plants. Air emissions from the consumption of fuels and electricity comprise oxides of carbon, nitrogen and sulphur (CO, CO_2, NO_X, SO_X) as well as particulate matter and volatile organic compounds (VOCs). The principal greenhouse gas is carbon dioxide. Other greenhouse gas pollutants include fugitive losses of CFCs from refrigeration systems, however, ammonia is a far more commonly used refrigerant by Irish beef processors. For the purposes of this study only emissions directly associated with energy consumption have been considered.

3.1 Carbon dioxide (CO_2) emission

All of the plants included in this study operate steam boilers to generate hot water at various temperatures. Between 2003 and 2008, light fuel oil (diesel) was the most commonly used thermal fuel source followed by heavy fuel oil, tallow, LPG and a small quantity of natural gas. Boilers with a heat production capacity of 5 MW or more require an environmental permit and must have their air emissions monitored. This data is presented in the annual AER as emission levels (mg/m^3) and mass thresholds (g/hr). For the purposes of this study CO_2 emissions were calculated purely on the basis of boiler emissions from fuel consumed each year, as recorded in the AERs, and then divided by the annual cattle kill to give figures for CO_2/head.

Total CO_2 emissions by the Irish beef processing sector decreased by 8.6% from 162,400 tonnes (2003) to 148,400 tonnes (2008). This reduction is partly due to the reduction in the overall number of cattle processed but is also due to the introduction of renewable tallow as a substitute boiler fuel and to the increased use of less carbon-intensive boiler fuels such as liquid petroleum gas (LPG) and natural gas (see Chapter 5). An important factor here is also the reduction in the carbon intensity of electricity generation in Ireland which fell by 10% between 2006 and 2007. For the purposes of our calculations emission factors for 2006 and 2007 from SEI's Energy In Ireland 2007 and 2008 Reports were employed. The 2006 factor (i.e. 601 kgCO_2/kWh) was used for figures from 2003 - 2006 and the 2007 factor was used for 2007 & 2008 (i.e. 543 kgCO_2/kWh).

The mean CO_2 emission across the Irish beef processing sector in 2008 was 93.9 kgCO_2/head ($\pm$ 29.9) with mean CO_2 emissions for each plant from 2003 to 2008 ranging from 56 $kgCO_2$/head to 166 $kgCO_2$/head. Figure 3.1 provides a breakdown of the mean CO_2 emissions from both thermal and electrical energy consumption by each plant between 2003 and 2008.

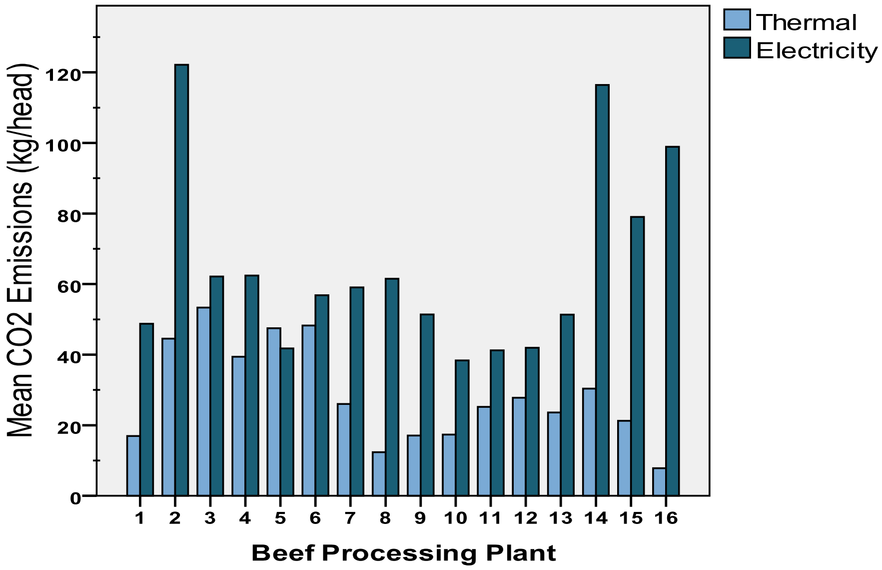

Figure 3.1 Mean CO_2 emissions from thermal and electrical energy use between 2003 and 2008.

While electrical energy on average accounts for 42% of overall energy consumption by each plant, it is clear from Figure 3.1 that electricity consumption contributes considerably more than thermal energy consumption to the overall CO_2 emission for each plant. In fact, electricity consumption is responsible on average for generating 68% of the total CO_2 emissions by the Irish beef sector. The mean 2008 CO_2 emissions for thermal and electrical energy consumption were 30.2 $kgCO_2$/head and 63.6 $kgCO_2$/head respectively. Figure 3.2 shows the trend in CO_2 emissions from the different source of energy employed by the sector. Mean CO_2 emission from fuel consumption has fallen by 4.7% since 2003. Mean CO_2 emission from electricity consumption peaked in 2005 but has since fallen by 11.7% (see Figure 3.2).

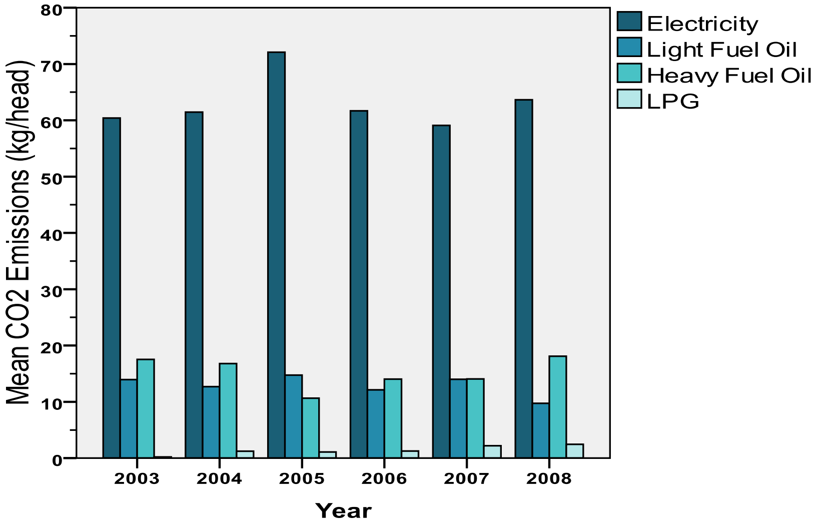

Figure 3.2 Mean CO_2 emissions from Irish beef processing

3.2 Odour

Odours can represent serious problems for meat processors depending on the location of a plant, storage of by-products, on-site rendering and biological treatment systems. Odour is the most common cause of complaints by members of the public against Irish meat processing plants. Odour emissions are not monitored and it is therefore not possible to make quantitative comparisons of odour occurrences between Irish plants or with the international sector on the basis of AER data.

4.0 Waste Management

The disposal of waste is controlled by legislation covering animal by-products and the waste management act.

4.1 Animal By-Products and Processing of Waste

Legislation on the disposal or recycling of animal carcasses, by-products and waste is carried out in accordance with EU regulations. On 3rd October 2002 the EU adopted *Regulation EC 1774/2002* governing animal by-products. The regulation laid down strict rules for the collection, transport, storage, handling, processing and use or disposal of all animal by-products. The regulations were transposed into Irish Law by the *Animal By-Products Regulations 2003 (S.I. No. 248 of 2003)* and by the *Animal By-Products (Amendment) Regulations 2005 (S.I. 707 of 2005)*. This legislation has since been replaced by *SI 252 of 2008 European Communities (Transmissible Spongiform Encephalopathies and Animal By-Products) Regulations 2008* and *SI 253 Diseases of Animals Act 1966 (Transmissible Spongiform Encephalopathies) (Fertilizer and Soil Improvers) order 2008*. The Animal By-Products Regulations are a separate legislative entity to the Waste Management Act.

Article 2 of the regulation defines an animal by-product as any part of an animal carcass or any material of animal origin not intended for human consumption. They include animals which die on farm, surplus or waste materials from slaughterhouses and a range of surplus or rejected materials that contain products of animal origin whether cooked or uncooked. The regulations divide animal by-products into 3 categories based on their potential risk to animals, the public or to the environment, and sets out how each category must or may be disposed. The regulation restricts the type of by-products that may be used for feeding animals, so that only material fit for human consumption may be used for livestock and pet feed. The regulation also prohibits intra species recycling and the feeding of catering waste to livestock.

In the context of beef processing,

- Category 1 waste includes:- Very high risk material including the carcasses of animals suspected or confirmed of being infected with BSE; parts of animals that have been administered certain prohibited substances; and floor waste where specified risk material (SRM) is generated.

- Category 2 waste includes:- Animals that die on-farm; manure and the digestive tract content; and by-products from animals that exceed permitted residue levels of certain substances (e.g. therapeutic drugs).

- Category 3 waste includes:- Material which has previously been fit for human consumption, including catering waste, raw meat and fish, hides and skins; parts of slaughtered animals which are fit for human consumption but which are not intended for human consumption for commercial reasons, or due to problems of manufacturing or packaging defects; animal by-products derived from the processing of products intended for human consumption (e.g. degreased bones and greaves); and blood from non-diseased ruminants.

4.1.1 Disposal of waste

There are a number of permissible disposal routes for each category as follows:-

- Category 1 - Incineration; rendering followed by incineration or landfilling;

- Category 2 - Incineration; rendering*; use as a fertiliser; treatment of manure and/or digestive tract contents in a biogas or composting plant; use in an oleochemical plant to produce tallow for technical use.

  NB. There are no category 2 rendering plants in Ireland. Category 2 material is rendered with category 1 material to produce category 1 tallow.

- Category 3 - Incineration; rendering followed by incineration or landfilling; rendering followed by use in feedstuffs or fertiliser; use in pet food; transformation in a technical plant; treatment in a biogas or composting plant; for feeding fish; use in an oleochemical plant to produce tallow derivatives.

4.1.2 Products and By-products

Products and By-products from the beef processing sector include:-

- Boned meat (40%)
- Edible offal (5%, tongue, liver, heart, kidneys for human consumption);
- Edible fats (shortening, margarine, sweets, chewing gum);
- Bones (soups for humans; buttons, bone meal);
- Blood (3%, human & animal consumption, pharmaceutical & food additives such as emulsifiers, stabilisers, clarifiers, nutritional additives);
- Glycerin (chemical additive, solvent, food preservatives, plasticisers);
- Intestines (sausage casings, surgical ligatures);
- Gelatin (confectionary additive);
- Rennin (cheese making additive);
- Numerous pharmaceutical products;
- Livestock feed;
- Pet food and fish food;
- Hides (7%); Hair; Glue;
- Inedible fats for industrial use in tyres, lubricants, insecticides, germicides.

4.2 Waste Management

4.2.1 Waste generation

Inedible material for rendering including condemned offal, bones, head, etc. can constitute as much as 39% of the live carcass weight [21]. The types of waste that are typically recorded in AER waste registers include :-

- material for rendering (i.e. bones, inedible offal, blood, SRM, scrapings, etc.);
- material for landspreading (i.e. sludges, lairage & truck washings, gut contents, etc.);
- material for recycling (i.e. waste oil, WEEE, paper, packaging, fluorescent tubes, COD vials, etc.); and
- material for disposal (i.e. black bin waste, office soiled packaging, etc.).

The overall level of waste material collected and recorded by Irish beef processors increased by 8% from 384,400 tonnes in 2004 to 415,000 tonnes in 2008 despite a 10% reduction in the number of animals processed. When calculated on a per head of cattle processed, the quantity of waste material as recorded on the individual AERs increased by 17% from 224 kg/head in 2004 to 263 kg/head in 2008. The average quantity of waste generated from plant to plant between 2004 and 2008 ranged between 171 – 326 kg/head with a mean figure for the sector of 238 $\pm$ 41 kg/head. Hides and other by-products such as pet food, tallow and meat/bone meal are only occasionally recorded in the AERs.

Figure 4.1 demonstrates the consistently high level of waste recycling achieved by the processing sector. The majority of waste arising is either rendered (i.e. blood, offal, bone, SRM – 75.4%) or land-spread (manure, sludge, paunch grass – 21.9%).

4.2.2 Rendering

By far the most significant waste stream from Irish beef processors is organic material for rendering. This is made up mainly of bone and inedible offal (42%; 75.5$\pm$34.4 kg/head), blood (11.5%; 21$\pm$5.4 kg/head) and specialised risk material or SRM (49%; 87$\pm$43 kg/head) (see Figure 4.1). In a conventional rendering process, material is dried in a cooker and then emptied into a percolator where some of the fat drains off while the remainder is screw-pressed out. The remaining material or meal is then milled while the fat or tallow is purified. Rendering in an energy-intensive and water-intensive process. It consumes both electrical (270 megajoules (MJ)/tonne) thermal (2790 MJ/tonne) energy with a further 72 MJ/tonne for odour abatement and wastewater treatment. Rendering consumes water at a rate of 0.5 – 1 m^3/tonne (i.e.

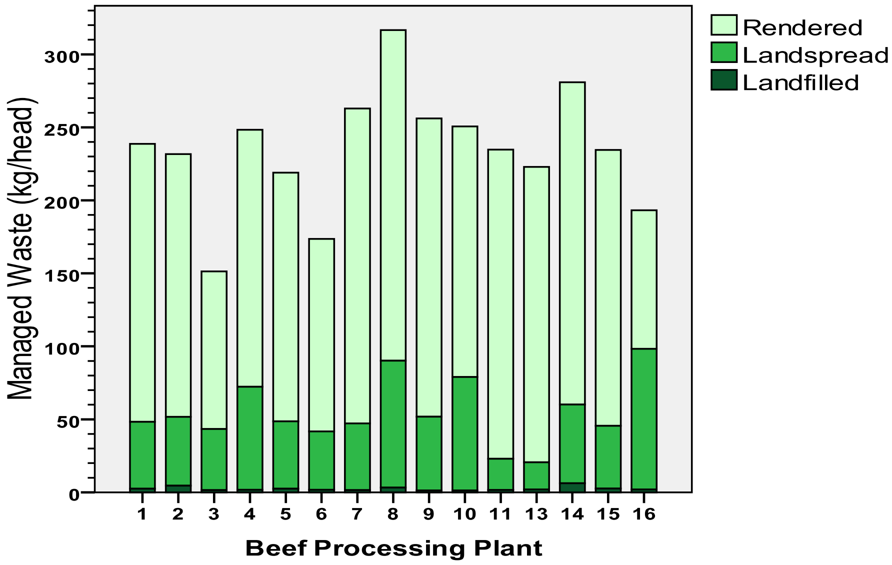

Figure 4.1 Mean levels of waste in kg/head for each plant between 2004 and 2008 that is either rendered, land-applied and land-filled.

0.2 – 0.5 for condensers; 0.15 – 0.2 for boilers; 0.2 – 0.3 for cleaning) and generates waste water (1.0 – 1.5 m^3/tonne) containing 0.6 kg nitrogen and 5 kg of COD, mainly contained in the condensate (~0.6 m^3). Rendering also generates 10^8 to 10^{10} airborne odour molecules (ammonia, amines, sulphur compounds, fatty acids) per tonne.

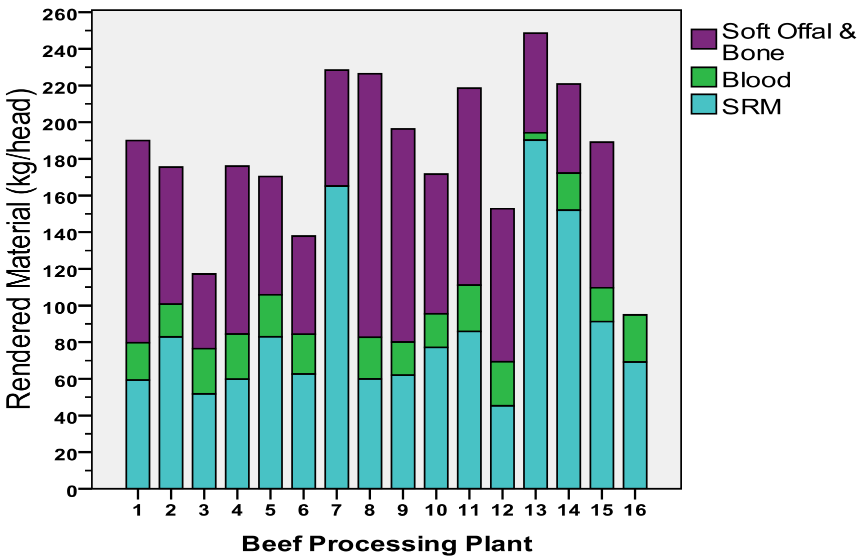

Figure 4.2 Breakdown of rendered waste material from individual processors

4.2.3 Land-spread/Land-Applied Waste

Land-spreading or land-application, which involves spreading waste on agricultural land, is commonly used to treat materials such as manure and paunch grass as well as sludges and other wastes from the wastewater treatment processes. An alternative to land-spreading is composting which is an aerobic process to decompose organic material carried out in windrows or reactors although this alternative is not usually employed by Irish beef processors. NB. Regulations prevent the composting and/or anaerobic digestion of animal by-products such as offal, bones, blood and SRM.

Land-spread material is the second largest waste stream from Irish beef processors and is made up of a mixture of dewatered paunch grass (40%; 20$\pm$8 kg/head) and sludge (60%; 30.4$\pm$15 kg/head) from the wastewater treatment process (i.e. the activated sludge unit and the dissolved air flotation (DAF) plant). Between 2004 and 2008 the average quantity of paunch grass that was recovered for use as a fertilizer increased by 16% from 20 kg/head to 23 kg/head and the quantity of sludge that was recovered, dewatered and land-applied also increased by 38% from 24 to 33 kg/head (see Figure 4.3).

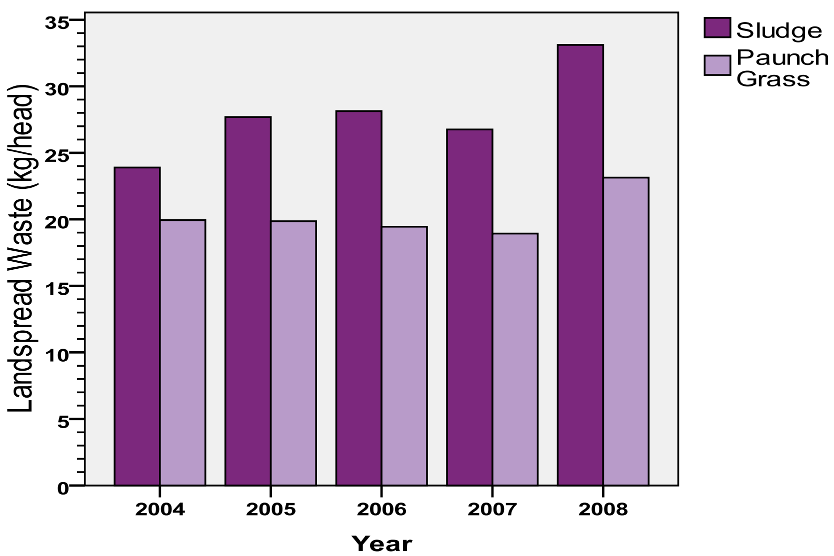

Figure 4.3 Trend in the collection and application of paunch grass and sludge to land as a fertilizer.

4.2.4 Landfilled Waste

Land-filled waste (2.3$\pm$1.3 kg/head) comprises mainly of office black-bin waste, soiled packaging material and other non-recyclable materials and makes up 1% of total waste.

4.2.4 Recycled Waste

The recycled waste and hazardous waste fractions make up the smallest waste streams from beef processing and usually comprise waste oil, metals (e.g. blades), glass (e.g. COD vials), WEEE, fluorescent tubes, packaging waste, etc. This fraction makes up <0.1% of total waste and all materials are recycled by specialist recyclers.

5.0 Resource Consumption

5.1 Water

In beef processing, water is used for numerous purposes including:-

- Livestock watering & washing;
- Truck washing;
- Washing of casings, offal and carcasses;
- Cleaning & sterilization of knives & equipment;
- Cleaning floors, work-surfaces, equipment, etc.;
- Make-up water for boilers; and
- Cooling of machinery.

Irish plants rely on water from a range of sources including treated water from local authorities and water abstracted from underground and surface (i.e. rivers & lakes) sources. Water consumption by the sector decreased by 12.8% from 3,968,400 m^3 in 2003 to 3,461,400 m^3 in 2008 (see Figure 5.1). During this period there was a 10% reduction in the number of cattle processed, however, there was an increase in the level of water-intensive secondary meat and by-product processing, as evidenced by 10% increase in energy consumption (see Section 5.2), so any reduction in water use must have resulted from the introduction of water efficiency systems. Most of the

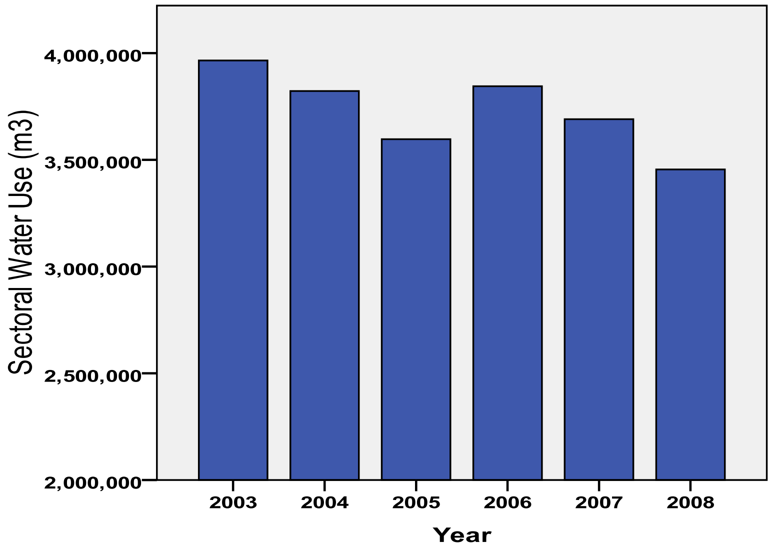

Figure 5.1 Water Consumption by the Irish Beef Processing Sector between 2003 and 2008

plants refer to water conservation systems in their Environmental Management Plans and the most significant improvement in water use/head was a 4% reduction between 2006 and 2008 (see Figure 2.2). When calculated per head of cattle processed, there was a 2.7% reduction in water consumption from 2.25 m^3/head in 2003 to 2.19 m^3/head in 2008.

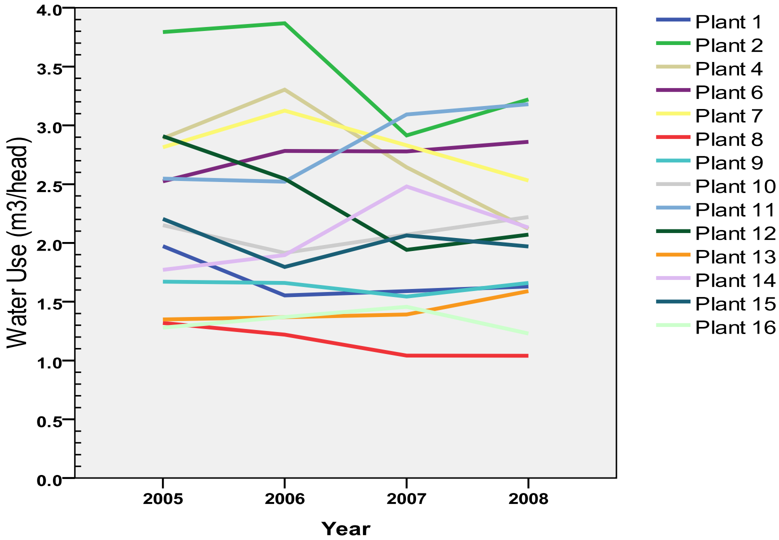

Figure 5.2 Water consumption trends for each beef processing plant between 2005 and 2008

Figure 5.2 provides water consumption profiles for each of the processing plants and demonstrates that while some plants reduced their water consumption during this period, others increased their consumption. The overall effect has been a small (1.8%) but gradual increase in water consumption between 2004 and 2006 followed by a 4% reduction from 2006 to 2008.

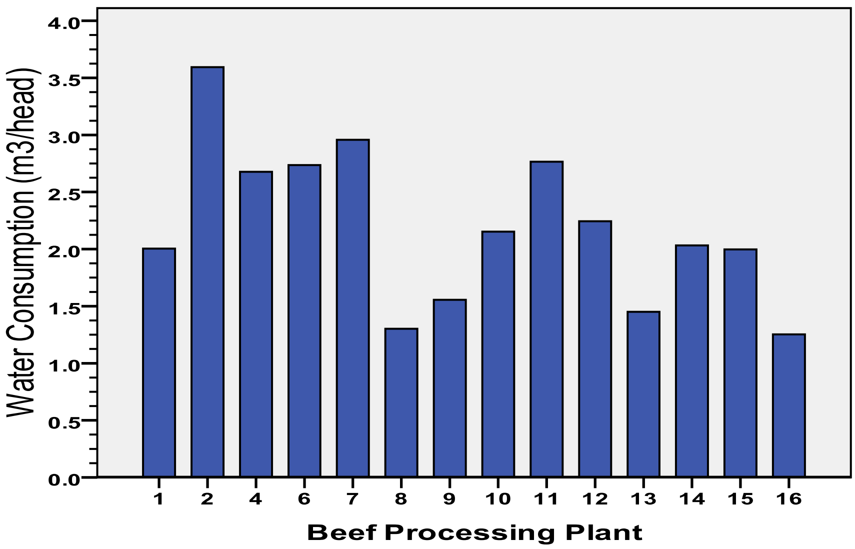

Figure 5.3 Mean water consumption by Irish beef processors, numbered 1 – 16, between 2003 and 2008.

Figure 5.3 shows the mean water consumption by each beef processing plant over the period of the study. Plants are numbered from 1 to 16 and mean consumption for each plant ranged from 1.25 m^3/head to 3.59 m^3/head.

NB Water consumption data was not available in the AERs of plants 3 and 5.

Table 5.1 shows the mean water consumption per head (± standard deviation) between 2003 and 2008 for each plant.

Mean Water Use (m^3/head)	Standard Deviation	Plant
1.252	0.171	16
1.302	0.194	8
1.450	0.122	13
1.55	0.153	9
1.997	0.135	15
2.005	0.424	1
2.031	0.325	14
2.153	0.173	10
2.244	0.419	12
2.678	0.439	4
2.736	0.146	6
2.766	0.294	11
2.958	0.368	7
3.595	0.515	2

Table 5.1 Mean water use per head for each plant from 2003 – 2008

5.2 Energy

In beef processing, moderate levels of both electrical and thermal (boiler fuel) energy are consumed in wide range of processes and applications. Electrical energy is used in ventilation, lighting, the use of equipment such as saws, hoists, conveyors and packing machines, refrigeration, rendering and wastewater treatment. Of these refrigeration, which includes chilled stores, air-conditioned areas, freezers and cold-stores, is consistently the most energy-intensive application in any beef processing plant using on average 42% of electrical energy consumption. By comparison, thermal energy is primarily used to produce steam which, in turn, is used to heat water for a wide array of cleaning & disinfection applications, meat and by-product processing and rendering.

	Electrical Energy	%	Thermal Energy	%
Cattle Slaughtering	Slaughter	26	Hot water for cleaning & disinfection	80-90
	Evisceration	3	Space heating	10-20
	Cooling	45-70		
	Compressed air, lighting & machines	30		
Meat Processing	Cutting, boning & mixing	40	Hot water for cleaning & disinfection	25+
	Cooling	40	Space heating	15+
	Packing	10		
	Lighting	10		
Rendering	Compressed air, lighting & machines	12	Vacuum evaporation	2
	Grinding & pressing	17	Drying, Grinding & Pressing	61
	Drying	23	Space heating	17
	Vacuum evaporation	6	Fat treatment	1
	Milling plant	8	Meal sterilization	3
	Meal sterilization	2	Miscellaneous	8
	Miscellaneous	34		

Table 5.2 A breakdown of energy consumption in beef processing [18]

Table 5.2 provides a breakdowns of electrical and thermal energy consumption associated with the most energy-intensive activities in beef processing and is based on a study of the beef industries in France, Germany, Holland and the UK.

Two additional energy-intensive activities that are not mentioned on this table, but which are associated with high energy users in Ireland's beef processing sector, are cold-storage and wastewater treatment. Wastewater treatment is especially energy-intensive where extensive secondary meat and by-product processing takes place and where emission limits are very strict.

All Irish beef processors use electrical energy from the Irish national grid and thermal energy from the combustion of fossil fuels such as diesel, heavy fuel oil, liquid petroleum gas (LPG), natural gas and from renewable tallow obtained from rendering animal waste. Figure 5.4 provides a breakdown in mean energy consumption by each processing plant between 2003 and 2008.

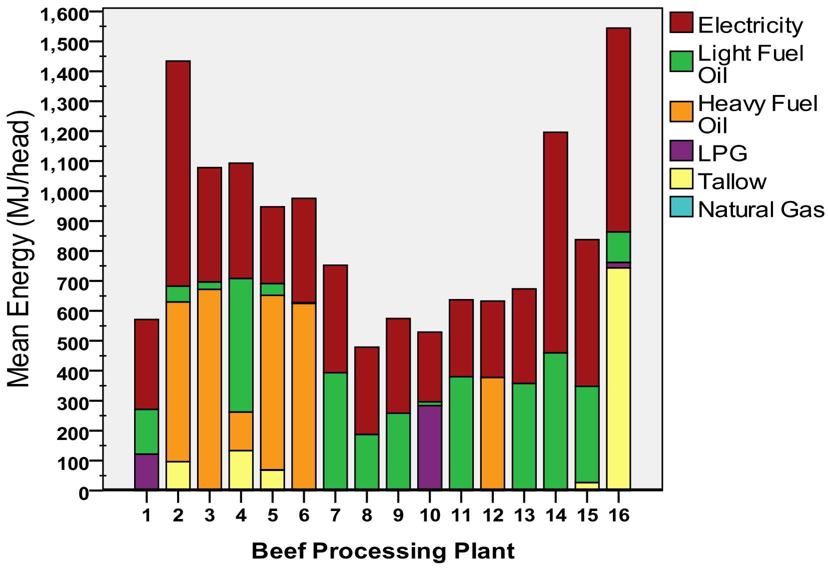

Figure 5.4 Mean energy consumption by Irish beef processors between 2003 and 2008

Total energy consumption by the Irish beef processing sector increased by less than 1% (0.66%) between 2003 and 2008 from 1,413,813.3 GJ (2003) to 1,423,172.3 GJ (2008). When calculated on a "per head of cattle slaughtered" basis, energy consumption when averaged out over the Irish beef processing sector has oscillated between 800 MJ/head and 935 MJ/head since 2003. Mean consumption over the past 6 years peaked in 2005 at 935 MJ/head and dropped by 14% the following year to 800 MJ/head. Since then, consumption has increased to 895 MJ/head in 2008 (see Figure 5.5). This trend is similar to that for water consumption except in reverse, i.e. as energy use increases between 2003 and 2005 and again from 2006 to 2008, there are corresponding reductions in water consumption.

When calculated on the basis of average consumption by each beef processor over the period of the study (2003 – 2008), there is a much greater range of values with the lowest energy user consuming an average of 520 MJ/head compared with 1490 MJ/head for the highest energy user. Larger energy users tend to engage to a

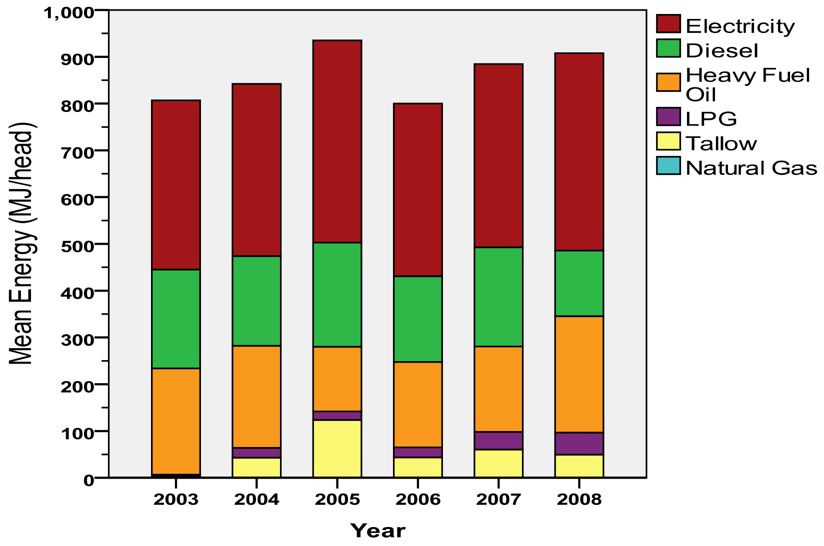

Figure 5.5 Average energy consumption by Irish beef processors between 2003 and 2008.

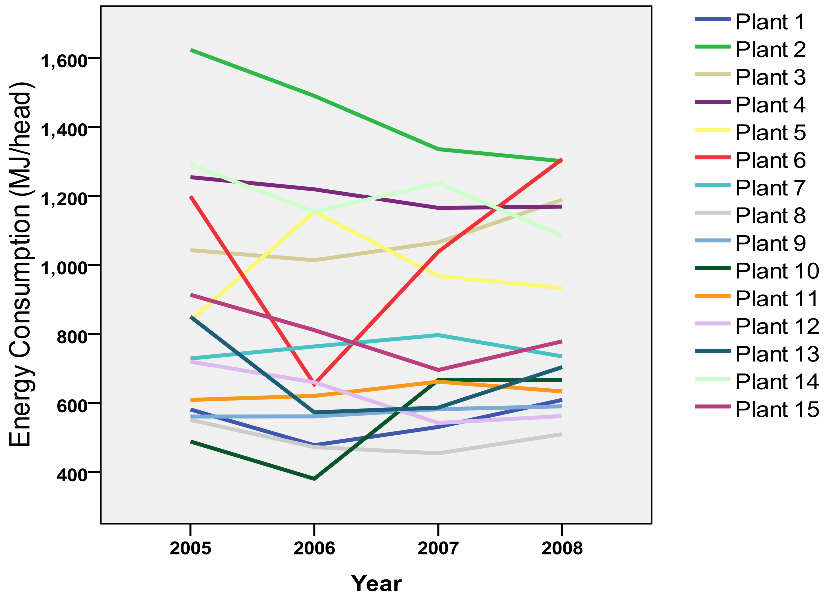

Figure 5.6 Energy Consumption profiles for each beef processing plant between 2005 and 2008

greater degree in secondary meat and by-product processing. There is also significant variation in energy consumption for individual plants from year to year with some plants (2, 4, 5, 12, 14 & 15) reducing energy consumption, while others increased energy use (3, 6, 10 & 13). Energy use at plants 1, 7, 8, 9 & 11 remain largely unchanged (see Figure 5.6).

Overall the Irish beef sector experienced a 4.5% increase in electrical energy consumption and a 4.4% decrease in thermal energy consumption between 2003 and

2008 (see Figure 5.7). When calculated on a per head basis , electricity consumption oscillated between 370 – 400 MJ/head while thermal energy oscillated between 330 – 370 MJ/head. In 2008 the ratio of mean electrical to thermal energy consumption was 43:57 (i.e. 422 and 475 MJ/head respectively).

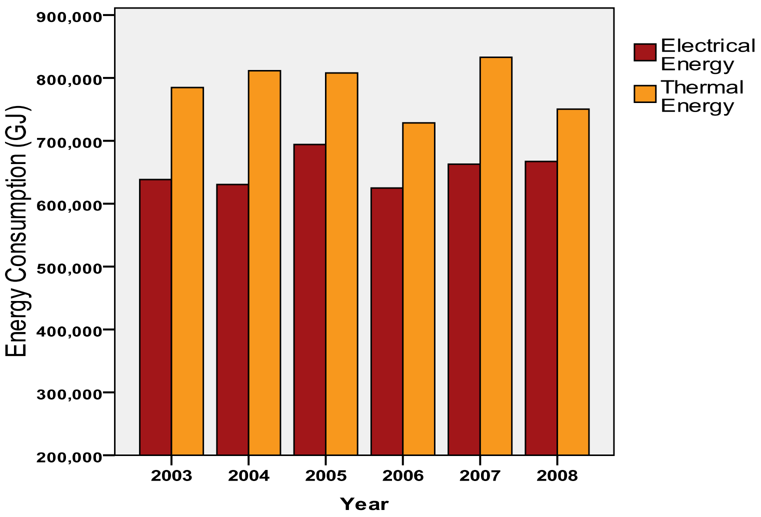

Figure 5.7 Trend in energy consumption by Irish beef processors (mean of 16 companies)

When the average consumption of electrical and thermal energy from 2003 to 2008 is calculated for each plant, mean electricity consumption ranges from a low of 260 MJ/head to a high of 750 MJ/head with an even greater range recorded for mean thermal consumption, i.e. from a low of 190 MJ/head to a high of 710 MJ/head (see Figure 5.8). This broad range of energy consumption figures, especially for thermal energy, would indicate that Irish processors are engaging to varying degrees in energy-intensive secondary processing. However, without a process by process breakdown of energy-consumption, it is almost impossible to draw any direct comparisons between one plant and another.

Between 2004 and 2008 there was a shift towards the use of cleaner LPG which, in 2008, accounted for 5.4% of total energy. Diesel consumption remained pretty constant between 2003 and 2007 and then dropped by almost 34% between 2007 and 2008. Heavy fuel oil usage dipped by 40% between 2003 and 2005, with corresponding increases in tallow consumption, but has since returned to a level 9%

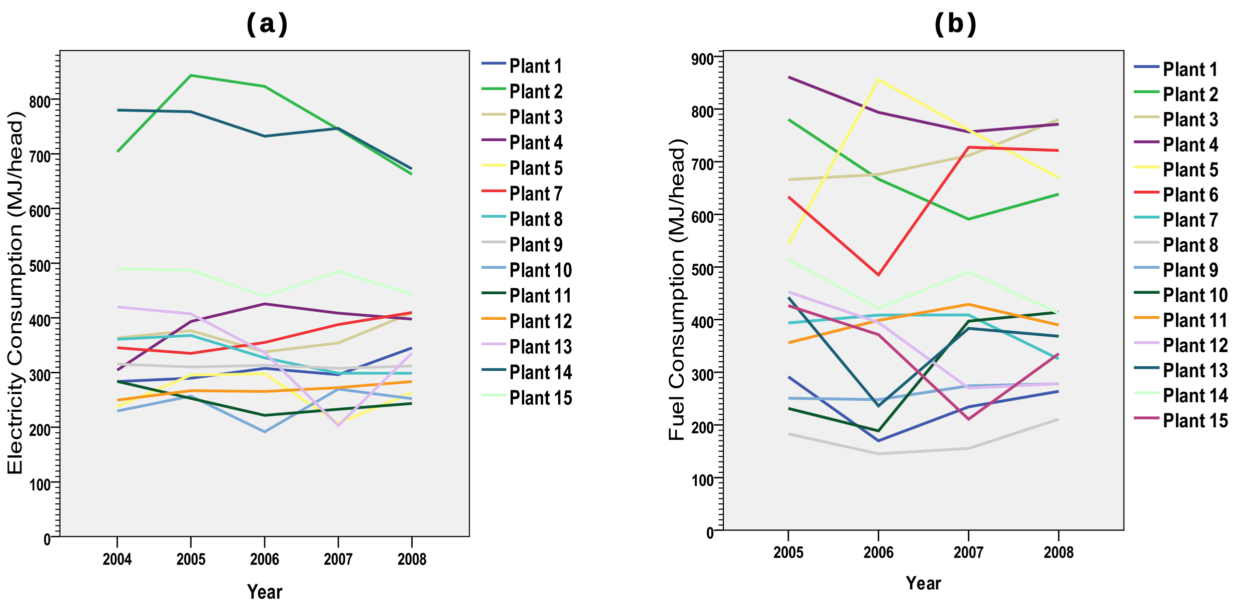

Figure 5.8 Electrical (a) and thermal (b) consumption profiles for each beef processing plant between 2005 and 2008

higher than 2003. An interesting development was the rapid introduction of renewable tallow, a by-product produced by rendering of processing waste, as a substitute boiler fuel. Despite a 10% increase in energy consumption between 2003 and 2008, there was only a 2% increase in CO_2 emissions and this was due to the sector offsetting fossil fuel use with tallow. The use of tallow oil increased from zero in 2003 to 13% of total energy by 2005. Although only employed by 5 of the 16 companies included in this study, it provided 24% of thermal energy consumed by the sector in 2005. As the value of tallow increased relative to fuel oil, there was a reduction in the use of tallow and a return to using cheaper fuel oil, however, in 2008, tallow oil was still responsible for 5.8% of the total energy consumed by the sector. In today's markets high grade tallow is more valuable than fuel oil and is used in a wide range of applications in the food and cosmetics industries. However, it is anticipated that as we come out of global recession that the price of oil will increase and that this, coupled with the proposed carbon levy on fossil fuels, may well result in a sectoral shift back to the use of tallow.

Based on AER data, Irish plants which listed tallow as a by-product produced between 14 – 51 kg tallow/head (80 to 280 grams tallow/kg of rendered material). This finding is backed up by a US study which found that the average 578 kg animal produced 63 kg of edible and inedible tallow [15]. The rendering of meat processing waste to produce tallow consumes 2.9 – 3.2 MJ/kg material mostly in the form of heat for drying and sterilisation [7]. Tallow has an energy content of 35 MJ/kg so for an average input of 558 MJ/head, the output in tallow would be in the range of 490-1785 MJ/head.

Table 5.3 shows the mean energy consumption per head (± standard deviation) between 2003 and 2008 for each plant.

Mean Energy Use (MJ/head)	Standard Deviation	Plant
536	126	10
570	132	8
573	58	1
576	14	9
621	70	12
636	27	11
678	129	13
760	25	7
836	169	15
949	110	5
982	246	6
1081	62	3
1095	187	4
1191	91	14
1437	115	2
1487	330	16

Table 5.3 Mean energy use for each plant from 2003 – 2008

6.0 Discussion

6.1 Emissions to Water

Irish beef plants are subject to tight emission controls as dictated by the properties (e.g. flow rates and assimilative capacities) of the receiving waters. The location of a plant can greatly influence its allowable emissions so this study has evaluated the performance of the sector not only in terms of overall emissions in grams/head but also in terms of % ELV and mean discharge concentration (i.e. mg/litre).

Meat processor wastewaters are characterised by high organic loads due to the presence of blood, fat, manure, meat scraps and undigested stomach contents. The degree of treatment required depends on number of animals processed and also the extent to which these materials are prevented from entering wastewater treatment plants. Wastewater is pre-treated using screens, grease traps and dissolved air flotation (DAF) to remove course particulates, BOD, suspended solids and FOGs which might overload the secondary activated sludge system. Aerated balance/equalisation tanks are also used to equalise wastewater flow and pollution load in order to supply a continuous feed of organic matter to the biological activated sludge system. Iron (III) salts and aluminium (III) salts are used for the removal of phosphorus.

Biological activated sludge is a dispersed/suspended growth system comprising a mass of micro-organisms which break organic matter down to CO_2 and water and partially convert ammonia by biological nitrification to nitrate. The process of breaking down organic matter in this manner is highly energy-intensive with every gram of BOD requiring four grams of oxygen which must be supplied by the aeration systems.

Overall, the Irish beef processing sector is highly effective at managing its emissions to water. Of the 16 companies evaluated in this study, all are in compliance with their IPPC licence emission limits and all but one operate to best available technique (BAT) standards. Notable emission reductions have been achieved between 2003 and 2008 for phosphorus, nitrogen (57%) and BOD (41%). The challenge faced by each beef processor is to continuously reduce emissions in the face of increasing secondary processing activities. Such activities include the processing of meat, by-product and waste aimed at deriving the maximum value from each carcass and at producing the highest value products all of which generate emissions. This necessitates significant on-going investment in new systems and the development of innovative in-house techniques to ensure, in each case, that systems operate to the highest standard. Such systems allow Irish processors the flexibility to engage in a wide range of secondary processing activities while maintaining low overall emissions.

Irish processors are currently exploring ways to upgrade their secondary (activated sludge) systems by installing diffusers which are proven to be more efficient than surface aerators. Furthermore, diffusers offer a greater degree of control because they can reduce suspended solids, BOD and, in conjunction with the use of ferric salts, phosphorus. Sophisticated tertiary treatment sand filtration systems are also being employed to achieve even higher levels of emission reductions.

Irish processors are also exploring ways to increase water efficiency and reduce discharge volumes by using treated wastewater and rejected treated ground water (ground water is often treated in-house to remove chlorides and sulphates) in cleaning applications such as truck/lairage washing and backwashing of tertiary sand filtration systems.

6.2 Emissions to Air

Air emissions from Irish beef processing plants are mostly attributed to the consumption of electrical energy and thermal energy. Also included in our calculations are transport fuels (forklift trucks, etc.) where such data were recorded. Total CO_2 emissions by the sector decreased by 8.6% from 162,400 tonnes in 2003 to 148,400 tonnes in 2008. This reduction is partly due to the reduction in the overall number of cattle processed but is also due to the introduction of renewable tallow as a substitute boiler fuel and to the increased use of less carbon-intensive boiler fuels such as liquid petroleum gas (LPG) and natural gas.

Although electricity consumption only contributed 45.8% of energy use between 2003 and 2008, it was directly responsible for generating 68% of the sector's CO_2 emission. By comparison, fossil fuel-based thermal energy accounted for 54.2% of energy use between 2003 and 2008 but only contributed 32%. Electrical energy is used in a wide variety of applications in beef processing and all of the electrical energy consumed during the period covered in the study was drawn directly from Irish power generation sources. Electricity in Ireland is carbon intensive because of the power generation sector's reliance on fossil fuels. However, with the introduction of renewable power sources, especially wind which now stands at 1055 MW of installed capacity (13.5% of Ireland's 7,800 MW of installed capacity) and the replacement of our carbon intensive peat- and coal-fired power stations with less polluting fuels such as natural gas, the carbon intensity of power generation in Ireland fell by 10% between 2006 and 2007 to 543 $kgCO_2$/kWh.

Many Irish beef plants are exploring opportunities in renewable energy e.g. wind turbines, biomass boilers, combined heat and power (CHP), etc. Other innovative GHG emission lowering solutions being explored by the Irish sector include improving electrical and thermal fuel efficiency in a range of applications including cooling/ refrigeration, space heating, cleaning, wastewater treatment and secondary meat, by-product and waste processing.

6.3 Waste Management

The overall level of waste collected and recorded by the beef sector increased by 8% from 384,415 tonnes in 2004 to 415,051 tonnes in 2008 despite a 10% reduction in the number of animals processed. When calculated on a "waste per head of cattle processed" basis, the proportion of waste being recovered and processed by the sector increased by 17% from 224.5 kg/head in 2004 to 263 kg/head in 2008. These figures do no include hides and other by-products such as high-grade tallow from in-house fat processing, casings, pet food, rendered tallow and meat/bone meal which are only occasionally recorded in the AERs.

The majority of waste recorded in the AERs is either material for rendering (i.e. blood, offal, bone, SRM) or material for land-spreading (manure, DAF and excess activated sludge, paunch grass). On average, 75.4% of total recorded waste is rendered. Material for rendering is comprised of bone and inedible offal (42%), blood (11.5%) and SRM (49%). On average 22% of total recorded waste is applied to land as a fertilizer. This is comprised mainly of de-watered sludge (from DAF units & activated sludge units), manure and paunch grass. Between 2004 and 2008 the average quantity of paunch grass that was recovered for use as a fertilizer increased by 16% and the quantity of sludge recovered, dewatered and land-applied also increased by 38%. An alternative to land-spreading is composting which is an aerobic process to decompose organic material and produce biogas and soil improvers. Carried out in windrows or reactors this alternative is currently not widely employed by Irish beef processors. A very small proportion (<1%) of processing waste is disposed of by land-filling. This is made up from office black bin waste, soiled packaging, and other non-recyclable materials.

Recommendations for improved waste management

- Collection and treatment of blood and solid materials separately from wastewater streams;
- Storage of wastes and organic by-products separately and in closed containers;
- Regular transportation of wastes from beef processors;
- Conversion of waste-to-energy, i.e. waste incineration and/or anaerobic digestion.

Rendering is energy- and water-intensive and can consume 3132 MJ/tonne and 1 m^3/tonne of water. Given that the average quantity of waste material for rendering is 183 kg/head, the energy required to render this material would be 907 MJ/head.

Anaerobic digestion is a process whereby an increasing diversity of organic material is degraded to methane under anaerobic conditions. Most of the nutrients remain in the treated material and can therefore be recovered for agriculture [19]. Anaerobic digestion, as mentioned earlier, is a sustainable alternative to composting or land-spreading.

6.4 Resource Consumption

Overall water consumption by the Irish beef sector decreased by 12.8% between 2003 and 2008, however, the mean water use per head only fell by 2.7%. Relative to the beef processing sectors in other European and non-European countries, the Irish sector consumes more water per head (see Table 6.1), however, the extent to which this relates to differences in the level of secondary processing and the product range, differences in the sizes of the cattle processed or differences in the efficiency with which water is used has yet to be elucidated.

Country	Water Use (m^3/head)	Average Carcass Weight (kg)	Water Use (litres/kg carcass)
Ireland	**2.19**	**324**	**6.79**
Denmark*[1]	0.625 (0.56 – 0.72)	250	2.5
Denmark**[2]	0.86 (0.52 – 1.66)	250	3.44
Sweden[1]	1.7 (1.35 - 2.03)	290	5.86
Norway[1]	1.12 (0.67 – 1.94)	263	4.26
Finland[3]	1.2 – 1.3	260	4.6 – 5.1
Nordics[3]			2.0 – 7.8
Australia[4]	1.48	240	6.17

Table 6.1 Comparison of levels of water consumption by beef processors in other countries

1 – Nordic Council of Ministers BAT Report, 2001 [20]
2 – Internal Energy Report, Danish Crown, 1999 [20]
3 – Finnish Environment Institute Report, 2002 [7]
4 – Meat & Livestock Australia Report, 2003 [5]

Table 6.1 compares water use relative to the number of cattle processed or to the weight of carcasses produced. It does not explore water consumption per unit end product or per unit process. There are 2 sets of data for Denmark. Denmark* relates to primary beef processing only (i.e. slaughtering, carcass-dressing and chilling) whereas Denmark** relates to primary processing and casing cleaning. Casing cleaning by Danish beef processors has the effect of increasing water consumption by 40% (i.e. 150 litres/head). By comparison, casing cleaning by Finnish and Swedish processors consumes 275 litres/head [7] and 800 litres/head [20] respectively.

Despite the overall reduction in water consumption, overall energy consumption by the sector remained relatively unchanged between 2003 and 2008. During this period, there was a 10% reduction in the number of cattle processed and a corresponding 10% increase in the mean energy consumed per head of cattle. This serves to demonstrate the shift in Irish beef processing towards minimising waste and maximising the value of every animal slaughtered and can be attributed to :-

- increased customer demand for high energy products such as chilled, vacuum-packed, fully trimmed, boneless cuts and pre-cooked, ready-to-eat products with consequent increases in the use of refrigeration, hot water, automated equipment and packaging; and
- increased use of energy-intensive processes especially in by-product processing (e.g. fat processing and rendering) and wastewater treatment.

Nevertheless, as is the case with water consumption, the Irish sector consumes more energy per head than beef processors in Scandinavia and Australia (see Table 6.2). The extent to which this relates to increases in high-energy products, energy-intensive secondary processes, export-driven hygiene standards or to inefficiencies in the way energy is used has yet to be elucidated.

High Energy Products

Studies have found that, depending on the degree of secondary processing, energy consumption can range from 356 MJ/head (i.e. slaughtering/ dressing/chilling) to 1465 MJ/head (primary processing with integrated secondary meat and by-product processing) [7]. Depending on the levels and types of secondary processing, electrical consumption can vary from 178 – 950 MJ/head while thermal energy use can range from 138 – 536 MJ/head. In a 2006 study on beef processing in the UK, Germany, France and Holland, the specific energy consumption for boned, cut-up, chilled beef was found to be 54% higher (2146 MJ/tonne carcass; 694.5 MJ/head) than the specific energy consumption for whole and chilled carcasses only (1390 MJ/tonne carcass; 449.8 MJ/head) [18].

High Energy Processes

By-product and waste processing (e.g. rendering, fat processing, casings and offal cleaning, wastewater treatment, etc.) can consume high levels of energy. Table 6.2 compares total energy consumption by the Irish sector with beef processors in Scandinavia and Australia. Two separate studies on energy consumption in the Danish beef sector provide two different sets of data, i.e. 242 MJ/head in Denmark* and 155 MJ/head in Denmark** [20]. Denmark* plants engaged in casing cleaning while the Danish** plants did not suggesting that casing cleaning in Denmark consumes 56% as much energy as slaughtering, carcass dressing and chilling alone. Furthermore, the Denmark* group used 40% more water and demonstrated a much broader min/max range in energy consumption (i.e. 111 – 371 MJ/head compared with 130 – 194 MJ/head). By comparison with their Danish counterparts, Swedish beef processors consume 4 times as much water and energy in casing cleaning. They also have a broader min/max energy consumption range (i.e. 238 – 1120 MJ/head) [20].

This serves to demonstrate the relatively high levels of energy and water that are consumed in secondary processing and also how KPI data from these processes can vary significantly from country to country.

Country	Energy Use (MJ/head)	Energy Use (MJ/kg carcass)
Ireland	**888.9**	**2.74**
Denmark* [1]	242 (112 – 371)	0.97
Denmark** [2]	155 (130 – 194)	0.62
Sweden[1]	540 (238 – 1120)	1.86
Norway[1]	530 (432 – 666)	2.01
Finland[3]	359 (318 – 400)	1.38
Australia[4]	463	1.93

Table 6.2 Energy consumption in beef processing in Ireland, Scandinavia and Australia

1 – Nordic Council of Ministers BAT Report, 2001 [20]
2 – Internal Energy Report, Danish Crown, 1999 [20]
3 – Finnish Environment Institute Report, 2002 [7]
4 – Meat & Livestock Australia Report, 2003 [5]

Another energy- and water- intensive secondary process in beef processing is rendering. Compliance with IPPC licensing requires that a relatively large proportion of each animal slaughtered (i.e. 30% of the live weight) is rendered. This consumes 3132 MJ/tonne of raw material or 528 – 594 MJ/head thermal energy and 119 – 220 MJ/head electrical energy [7]. Furthermore, the process consumes 0.5 – 1 m^3/tonne of water and generates 1.0 – 1.5 m^3/tonne of wastewater the treatment of which consumes further energy. One consequence of the implementation of the EU safety measures (i.e. Council Directives 90/667 and 96/449) which dictate that specified bovine material must be rendered in separate plants or dedicated lines (i.e. batches) was to increase energy use across the rendering sector. Originally rendering was a continuous process with lower (30-40%) thermal energy consumption [18].

Hygiene standards

Another significant contributor to energy consumption by Irish processors is hygiene. More stringent hygiene requirements mean that more hot water is used in sterilizing tools and cleaning carcasses and that more electricity is used in refrigeration to control microbial growth. Slaughterhouses that comply with EU temperature legislation use more electricity than those who do not [18]. Enhanced hygiene regulations have resulted in significant increases in energy use by beef processors in France, Germany, the United Kingdom and the Netherlands between 1986 and 2001 (see Table 6.3). In the UK alone, enhanced hygiene regulations were responsible for energy increases of 13 – 25% between 1990 and 2001 [18].

Country	Increases in fuel consumption (% p.a.)	Increases in electricity consumption (% p.a.)
France[1]	3.8	4.6
Germany[2]	3.4	6.3
Holland[1]	0.9	3.2
UK[3]	0.4	2.9

[1]1986 – 2001, [2]1993 – 2001, [3]1990 - 2001

Table 6.3 Annual increases in energy consumption by European meat processor from 1986 - 2001[18]

According to the Dutch Ministry for Economic Affairs "the introduction of the Hazard Analysis Critical Control Points method for food health, safety and quality led to an increase in energy consumption which eliminated the effect of conservation measures" [23, 24]. The extent to which improved hygiene standards during the period of this study have impacted on energy consumption by Irish beef processors remains unclear.

Recommendations for improved resource efficiency

While good hygiene is clearly a prerequisite and quality will never be sacrificed for the sake of improved efficiency, there is evidence to suggest that instruction and training can reduce resource consumption by as much as 30% [20]. Pressure hoses reduce water use while maintaining hygiene provided there is sufficient wash water to contain the material in suspension and transport it to the floor drains. The most efficient method employs foam-borne detergents rinsed with water at 50 – 60^{o}C at a pressure of 25 atmospheres. Any savings in water use will result in reductions in the volumes of wastewater for treatment which will, in turn, save energy.

Water consumption efficiencies may be achieved by:-

- minimisation of water use by instruction, training and monitoring;
- minimising contamination by collecting waste before it reaches the floor, avoiding spread of waste by installing floor troughs and raised edges and by not crossing areas with waste on the floor;

- continuous monitoring of consumption and setting monthly targets for reductions in consumption;
- regular documented inspection & maintenance of equipment;
- re-use of washing, chilling, and cooling water to vehicle, lairage and hide washing and in back-washing in tertiary (sand-filtration) wastewater treatment;
- use of rejected water and treated wastewater in vehicle, lairage and hide washing;
- optimisation of unit processes and operations;
- use of self-closing low to medium pressure hoses with efficient spray nozzles;
- recycling wastewater in non-food processing applications;
- fitting sensor and time controls at hand-wash stations;
- recycling refrigeration defrost water for non-food processing washdown application; and
- pre-cleaning with cold water and dry scraping of blood and solid materials before cleaning.

Energy consumption efficiencies may be achieved by:-

- Metering and conducting regular process by process audits of energy consumption;
- Inspecting & regularly maintaining refrigeration equipment; switching off of non-essential equipment; replacing condensers, etc.;
- Installing remote energy management systems;
- Recovering heat from slaughtered animals, from refrigeration, from cooling water, from air compressors, from rendering and using it to heat incoming process water;
- Using boiler blow-down heat to preheat boiler feed water;
- Installing motor optimisers;
- Installing insulated knife sterilisers;
- Installing renewable energy systems where technically/ economically feasible such as on-site wind turbines and biomass boilers; anaerobic digesters for sludge, manure & paunch grass; the use of renewable fuels such as low grade tallow oil, inedible meat & bone meal, sludge;

  NB Such options will become more relevant in the future for those companies involved in the Emissions Trading Scheme (ETS) as their carbon allowances are gradually reduced.
- Using ambient air in cooling. For 40% of the year the ambient air temperature is below 7^{o}C. This could be used to provide cooling for boning halls by use of heat pumps;
- Using process control and buildings energy control software solutions; and

- Using existing fossil fuel resources more efficiently in CHP or co-generation where fossil fuel efficiency is maximised by generating both electricity and heat.

6.5 Benchmarking

In some industries, environmental benchmarks are used extensively to gauge performance and competitiveness. Benchmarking in beef processing, however, especially for water and energy consumption, is not common and examples are hard to find mainly due to the considerable variation in production processes and in the scales of operation within the industry [4]. The issue is further complicated by the fact that there is no widely recognised standard unit of production.

There are some disparate benchmarks for water consumption by beef processors but the extent to which these benchmarks relate to secondary processing activities is not clear. UK/Danish benchmarks range from 1 – 5 m^3/head [4, 10] where 1 m^3/head is BAT and 5 m^3/head is the level associated with traditional techniques employed in developing countries. By comparison, the 2007 Environmental, Health and Safety (EHS) Guideline for Meat Processing provides an industry benchmark of 0.53 – 2.92 m^3/head [6].

Similarly there are some disparate benchmarks for energy consumption by beef processors but, again, the extent to which these benchmarks relate to the type and level of secondary processing activities that occur in a modern, fully-integrated beef processing plants remains unclear. UK/Danish energy benchmarks range from 252 – 1080 MJ/head [4, 10] where 252 MJ/head is BAT and 1080 MJ/head is the level normally associated with traditional techniques employed in developing countries. By comparison, the 2007 Environmental, Health and Safety (EHS) Guideline for Meat Processing provides an industry benchmark of 104 - 1274 MJ/head [6].

Fully-integrated beef processors engage to varying degrees in the manufacture of high- and low-energy products and in a wide range of energy- and water-intensive secondary processes. This can have the effect of increasing water and energy consumption to levels 2 or 3 times higher that primary processing alone. A reliable benchmark, or set of benchmarks, for energy and water consumption in beef processing should address these distinct processes. Having process by process guidelines to best practice would facilitate more meaningful comparisons and a more reliable calculation of the environmental performance of any given beef processing plant.

It remains unclear the extent to which the aforementioned water and energy benchmarks (or any of the consumption levels outlined in Table 6.2) relates to beef processing in Ireland as there is no way of determining if there are any similarities in the level of secondary meat, by-product and waste processing. The next step to generating a reliable benchmark for energy consumption by the Irish beef sector is to conduct a process by process analysis of energy consumption. This would allow us to better identify how Irish companies differ from their international counterparts on a process by process basis and to determine how and where savings might be made.

6.6 Conclusion

Ireland's beef processing sector has undergone significant sustainability improvements since 2003 especially in the way that it minimises emissions to water and waste. Ireland's beef processors now rank among the best in the world in terms of their impact on the environment. These improvements have come at the cost of increased resource consumption relative to other sectors of similar scale and the challenge now is to identify ways to reduce energy and water. To this end there is a wide range of potential options open to Irish processors ranging from relatively inexpensive, short-term solutions to longer-term, capital-intensive projects. Instructing, training and monitoring (turning off non-essential equipment), have been shown to be cost-effective and to have immediate effects, however, for these to work in the longer term, a culture of continuous efficiency improvements and conservation through behavioural change must be adopted throughout the workplace. Where such culture exists, energy management systems have been shown to be beneficial in framing the challenge, setting targets and maintaining continuous improvements.

In the medium-term, an energy strategy to recover heat (from slaughtered animals, refrigeration, cooling water, air compressors, fat processing, etc.) and to offset dependence on fossil fuels with renewable alternatives such as tallow and biomass can significantly reduce energy costs and greenhouse gas emissions. In the longer-term, investment in renewable wind or CHP/co-generation has the advantage of reducing carbon emissions, using existing fossil fuels more efficiently and offers the potential of selling excess power back onto the national grid. Waste-to-energy alternatives such as anaerobic digestion of sludge and paunch grass and the use of inedible meat and bone meal and dewatered sludge as boiler fuels also offer interesting alternatives to reducing the costs of both energy and waste management. A 5% reduction in energy consumption across the Irish beef sector would have the effect of reducing energy costs by as much as €15 million. .

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Abbreviations

AER	Annual Environment Report
BAT	Best Available Techniques
BOD	Biological/Biochemical Oxygen Demand
CFC	Chlorofluorocarbons
CHP	Combined Heat & Power
COD	Chemical Oxygen Demand
DAF	Dissolved Air Flotation
ELV	Emission Limit Value
EMP	Environmental Management Plan
EMS	Environmental Management System
FOG	Fats, Oils & Greases
GJ	GigaJoule (1000 MJ or 1 billion joules)
HFO	Heavy Fuel Oil
IPPC	Integrated Pollution Prevention Control
kWh	kiloWatt hours (3.6 kWh = 1 MJ / 1 kWh = 0.27778 MW)
KPI	Key Performance Indicator
LPG	Liquid Petroleum Gas
MJ	Megajoule (i.e. 1 million joules)
SRM	Specified Risk Material
WEEE	Waste Electronic and Electrical Equipment

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