Feasibility Study to reduce the amount of Primal Packaging of Meat going to Landfill

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1 Executive Summary

The UK is responsible for producing nearly 290 million tonnes (mt) of waste per annum (Defra 2008). It is estimated that the food, drink and tobacco industry is responsible for producing 2.4% of this or 7 mt. The meat industry is responsible for a small portion of this waste, with an estimate of 30,000 tonnes per annum (tpa) produced by approximately 70% of the industry. This waste does not include what the end consumer throws away which is beyond the scope of this report, except when detailing the background to the industry. This 75% consists of the abattoirs, cutting plants and multiple supermarkets' retail packers. The other 25% of the industry is serviced by butchers, farm shops, wholesalers and foodservice.

Most of the plants sampled as representative of the large processors were actively engaged in trying to recycle their waste; however, many had not been able to find any outlets for contaminated waste. These companies produce approximately 11,000tpa of contaminated primal packaging and 3,000tpa of cardboard that is sent to landfill. A further 9,000tpa of cardboard is believed to be recycled.

The majority of the contaminated waste produced across the entire supply chain comes from 20 to 30 large plants. These plants can largely be grouped into a few main areas. This could make it feasible to deal with the wastes from these plants as a group rather than individually.

During the research it was not possible to establish the best use for this contaminated waste. The UK does not have an extensive network of facilities for recycling plastic or recovering energy from waste, eg using incinerators to generate electricity and heat, and the technologies used generally lag behind those being used on the continent. Consequently, the waste recovered from this sector is exported to be used for energy recovery.

2 Introduction

A number of studies have been done looking at waste in the red meat sector. Primarily, these have concentrated on meat and its by-products rather than the packaging associated with the flow of meat through the supply chain. However, in 2009, Waste and Resources Action Programme (WRAP) commissioned Meat and Livestock Commercial Services Limited (MLCSL) Consulting and Institute of Grocery Distribution (IGD) to produce a meat resource map to identify and quantify how each animal is utilised in order to generate data on product waste, packaging waste, water usage and greenhouse gas emissions. This study highlighted several issues, most of which are being targeted by the industry with support from EBLEX and BPEX. Packaging is an area where, in the supply chain, there is limited waste reduction activity. However, the supermarkets have been driving improvements through their supply chains, especially in the retail packs, mainly to improve shelf life, reduce weight of packaging and strengthen brand identity. The meat processing industry uses and throws away 110,000 tonnes of packaging for a variety of reasons including inter-country and inter-plant transfers and maturation.

The Environment Agency and WRAP have collected data on waste and worked to improve recycling opportunities, especially for uncontaminated cardboard; however, little to no work has been done in the UK on addressing the amount of primal [1] packaging being sent to landfill.

Meat is cut into primals and vacuum-packed to allow it to mature and/or transport to the retail packing plant or wholesaler or a final customer. This packaging is a multi-laminated complex material which tends to be an interim as the majority of meat will go to the retail packing plant where the primals are unpacked and sliced, diced or minced and repacked into retail trays. Currently, most of this primal packaging, when unpacked, is contaminated with liquid (blood) and fat from the meat. This contamination is thought not to be so bad as to stop it going to landfill. This is where the majority of meat packaging is disposed. Because of the contamination and the complexity of the product, it has always been thought to be uneconomical to recycle.

Around 110,000 tonnes of packaging is produced, of which 81,000 (73%) is landfilled. The majority of this material is cardboard and plastic that is mildly contaminated with liquid following contact with meat. Improving the disposal options of this material is a widely recognised issue. The material that is not sent to landfill is recycled and comprises wood, cardboard and plastic.

Recently, it appears that there may be a couple of acceptable alternatives to landfill.

The easiest would be to use the product in incinerators that provide heat and power, for example, the building industry has a requirement for raw material to burn to make cement.

[1] Primals: A carcase is deboned and split into primals. The term primal is the collective catchall covering all primary muscle groups, eg loin, fillet, rump, flank, chuck, fore rib, etc.

The press recently reported that a new type of process was going to be trialled by a waste company called CYNAR. This new process will transform plastic to diesel. This could potentially be a huge opportunity for our industry. It stated that this process is currently being successfully used in a couple of other EU countries. This report is the result of a study to establish if this would be a viable, cost-effective solution for the meat industry and its primal plastic packaging.

In order to better understand the waste streams from plastic packaging in the meat sector in particular, it is first useful to review exactly why it is being used, what is being used, where it is being used and the changes that could be made/are being made that will affect this use and the resulting waste streams.

All of the large retail packing plants, a few of the large abattoirs, cutting plants and wholesalers were surveyed as part of this project to understand to what extent the industry was embracing recycling. During the interviews, the following aspects were explored:

- The mechanisms already in place for recycling
- Where the material was going after it left the meat processing plants
- What materials were going to landfill
- Material quantities going to landfill
- The barriers for recycling the material or using it to create energy.

Parts of the recycling and plastic to diesel processing industry were interested in exploring the use of the blood contaminated plastic. To begin with, they wanted an overview of where in the country concentrations of the material would be available. It was believed that this information would be exceedingly useful for other waste processors who could perhaps use it for generating energy, ie energy from waste (EfW).

Quantifying the waste for this project was difficult. Although a lot of the large companies collect the information for their IPPC returns, most of the contaminated plastic is put in the general waste bin with canteen waste and paper towels, etc. The percentage of weights had to be estimated by viewing the waste bins.

3 Purpose of Packaging

The increase in the amount of food waste that households in the 'richer' countries generate has become a major environmental concern throughout Europe over the past decade[2]. WRAP estimate that one-third of all food in the UK ends up in the bin. Plastic and cardboard packaging produced by the meat industry, both clean and contaminated, was recognised as 'secondary' waste products in the report completed for Defra in 2008[3].

Packaging is seen to have a vital role to play in reducing waste and preventing losses by preserving and protecting the product, extending shelf life and ensuring that food can be distributed safely and securely.

3.1 Preserve and Protect

Packaging protects and preserves meat and meat products during processing, storage and distribution from undesirable impacts on quality including microbiological and physicochemical alterations, eg shrinkage caused by evaporation or surface drying resulting in discolouration. The further growth of microorganisms, which are already present in meat and meat products, cannot be interrupted through simple packaging. The design of packaging films has developed significantly over the last ten years, which in turn has increased the amount of time products can be stored either before or after retail packing. Different films are gas or moisture permeable and different gases can be added to the product to increase shelf life and processor flexibility.

Packaging alone does not account for extending the storage time. Combining the packaging of meat with other treatments will reduce or completely eliminate contaminating microorganisms.

- Refrigeration will slow down or stop microbial growth. Once the product is removed from the chiller microorganisms may start growing again
- Heating/sterilisation will significantly reduce or completely eliminate the contaminating microorganisms. Heat treatment or cooking for some meat products can be carried out in the package after vacuum-packing. Temperatures of 60-80°C or higher, up to sterilisation temperatures (above +100°C), can be employed for hams, sausages, etc. In these cases, a pasteurisation or sterilisation effect to the uncooked packaged products is achieved and recontamination avoided, as long as the package is not opened
- Gas flushing use is declining for primal packaging and being replaced with vacuum-packaging. However, it is still used for pork and lamb. (Several pork primals are placed into a large pouch and the gas mix is usually 100% carbon

[2] It is estimated that the per capita waste of food in the EU is 179kg per year and is forecast to increase 40% by 2020 if measures are not taken to reduce it (source EU 2012). Research carried out for Defra showed that in the average household 17% of the food purchased was subsequently disposed of as waste and 22% in single person households. Food and Agriculture Organisation FAO claims that the figures for so-called developed and industrial countries are even higher, with food waste at 300kg per capita per year.

[3] Material Flows in Livestock Product Utilisation. Defra Project FO 0203. AHDB Meat Services Consulting 2008.

dioxide.) Shelf life is typically 10 days, which is less than vacuum-packing. The CO_2 causes the meat to give off more drip and go grey which does recover on opening but not as well as if placed under vacuum. It tends to be used more widely for bone-in cuts but when the bag is opened all primals are exposed to air, so product has to be used as soon as possible. It can be used for gas flushing a dolav for trims, etc. as seen in photos

	System in photos is a nozzle system that is not efficient at removing all the air. Machine can be set to double or treble flush but this slows the process down

- Gas flushing was used on lamb for export from NZ into Europe. This is not used so much now, since primals are individually vacuum-packed. With lamb, all residual air needs to be removed otherwise product will quickly discolour. In NZ they did produce a 'chamber' gas flush system, rather than using nozzles but, again, this is not widely used now.

See appendix 8 for more on Gas Flushing

3.2 Fit for Purpose

Packaging needs to be able to withstand damage, eg cracks, punctures, etc during handling and distribution. It requires good mechanical, barrier and sealing properties, to ensure the integrity of the package. A lot of research goes into producing a specific type of tray or film for specific applications. Bone guards have been added and the gauge increased for some vacuum films, to improve the strength and integrity for long term storage of specific products.

3.3 Regulatory Labelling

Packaging also enables the product to carry the regulatory labelling and identification. All packaging needs to carry regulatory product information including ‘use by’ date. However, the beef labelling regulations, introduced after BSE, require information on where the animal was produced and slaughtered and where it was cut. It can carry other information, eg organic claims, etc. which also need independent verification.

3.4 Presentation

More design time is going into developing products with attractive presentation or identifying special features that consumers would like. This seems to be especially

prevalent in the added value and ready meals. Good examples are metal trays that can go from fridge to oven and plastic trays that can be used in ovens or microwaves.

Viewed in this way, the benefits of packaging cancel out (completely in the view of some), the negative environmental impact of packaging waste after use (particularly if it is able to be recycled). Therefore, packaging is a necessity in the meat industry because its advantages outweigh the disadvantages. It protects more than it consumes because food waste, especially meat waste, has a far bigger impact on the environment than food packaging.

4 The process and associated packaging

This section introduces in brief the meat supply chain, the associated packaging and a brief description of the different properties of the more commonly used plastics. The next section will deal with where the packaging is removed from the meat and where the waste packaging ends up and estimates of quantities. The food packaging industry has developed a range of different materials for the many different products, eg tin or aluminium cans, glass jars, film and trays made from plastic, Styrofoam or cardboard or combinations of some or all of these materials. Until recently, most retail trays also contained an absorption pad or peach pad to contain any liquid leaching from the meat.

4.1 Overview of the Process

The meat supply chain has several different stages, however, only a few actually account for the majority of the waste packaging. The next chapter will deal more with a breakdown of the process and the associated waste streams and estimated quantities. In this section, the different types of packaging are detailed and the associated qualities that render them recyclable. As detailed in the next chapter, there are normally two stages in the meat chill chain that involve different types of packing.

4.1.1 Stage One – Primal Packing

In the boning hall, whole muscles are removed from the bones or skeleton. These are known as primals. Most high throughput companies processing beef will tend to vacuum-pack (VP) the primals and allow aging to take place in the plastic. A few companies will not use VP, but dry-age higher value cuts normally on the bone especially the hind quarter (pistola or traditional cut). The primals are held for a set period and transported to the next stage.

4.1.2 Stage two – Retail Packing

The second stage is either the retail packing plant, foodservice sector, wholesale butcher or retail butcher. The second stage will tend to remove the packaging and repack the product in final consumer packaging. This waste packaging from the second stage normally ends up in landfill.

Over 80% of the meat consumed is bought through the supermarket either fresh, in a variety of retail packing or sold over the supermarket butcher's counter or frozen or purchased in a ready meal.

Stage two uses a primary packaging material which is in direct contact with the product. This primary packaging consists of one of the following:

- a thin plastic sheet to weigh the meat and place into
- a plastic bag (from the butcher's counter)
- a tray made from card, plastic, cellulose foam or metal and tightly wrapped or covered with either:
    - single-layer plastic film
    - a top film with multilayers

There are various synthetic packaging films available for the primary packaging, eg **transparent** or **opaque**, **flexible** or **semi-rigid**, **gas-proof** or **permeable** to certain gases. These materials are selected to serve specific purposes, such as protection from unwanted impacts or attractive presentation.

Most of these trays are packed in secondary cardboard outers (boxes) or sometimes in reusable sturdy plastic trays and delivered to the retailers on wooden pallets, often wound with a shrink-wrap film (PE) to prevent the stack of boxes or plastic trays falling and damaging the product.

4.2 Retail Packaging Trays and Films

A range of synthetic **'plastic'** materials suitable for meat packaging are available, which offer a range of benefits as a packaging material. This is because plastics are lightweight, resource efficient and offer excellent barrier properties. For the various purposes in the meat industry, packaging films can be divided into:

- Trays
- Single-layer films or
- Multilayer films

The plastics which can be used in meat packaging are:

- Polyethylene (PE)
- High density polyethylene (HDPE)
- Low density polyethylene (LDPE)
- Linear low density polyethylene (LDPE)
- Polypropylene (PP)
- Polyvinylchloride (PVC)
- Polyester, or polyethylene terephthalate (PET)
- Polyamide (PA)
- Polyvinylidene chloride (PVDC)

The properties of those used most commonly in meat packaging are described in section 4.4.

4.2.1 Trays

Trays can be made from single or multi-layer polymers depending on the required properties. Some retail packers purchase preformed multilayer trays, eg card, cellulose or metal (sometimes plastic-lined[4]). This project has not focused on improving recycling opportunities of this material because significant pressure is already coming from the retailers. Although trays can be difficult to recycle when they get to the consumers, manufacturers are paying more heed to recyclability and, certainly, if clean, the

[4] PVC or Polyvinyl Chloride was a basic material for lining trays or forming the top web. The principal advantages of PVC are the low cost and the ease of thermoforming. The main disadvantages are the poor barrier against moisture ingress and oxygen ingress. PVC has a negative environmental connotation due to its chlorine content.

opportunities are improving to recycle trays depending on the polymers used. The preference is for thin-gauge thermoforming to manufacture container trays on-site. Rolls of film, eg polypropylene PP are stamped into rigid trays during packing. The skeleton material, left on the rolls after stamping is being recycled by the retail packers, as are the trays that are not filled due to production problems. This has reduced the waste from retail packing companies significantly.

4.2.2 Single-layer Films

One use of single-layer films is the **overwrapping** of chilled meat pieces, processed meat products, bone-in or boneless meat cuts for self-service outlets (supermarkets, etc.) or even for entire carcases. These films are usually self-adhesive, eg cling film and commonly seen in butchers shops, where items are prepacked, and some supermarkets. These films tend to have low water vapour permeability to avoid the drying out of the meat during storage. They also provide good protection from external contamination but do not exclude oxygen, as they are permeable to oxygen, and are not hermetically closed or sealed packages. They allow oxygen to reach the meat, which produces the bright red surface pigment oxymyoglobin[5] that consumers generally associate with fresh meat. This packaging format is not as common as it used to be and is being replaced with other formats which extend shelf life.

4.3 Multilayer Films

Practically all the other films used for meat packaging are designed as strong **oxygen** and **water-vapour barriers**. In order to fully achieve these requirements, films with good barrier properties for oxygen and water vapour, respectively, are combined into two or more layer films, eg with the first outside layer being mechanically strong and/or providing a gas barrier to oxygen; the second, if used, providing a barrier to oxygen and the third inner (second) layer being a sealant (capable of being melted and welded to the sealant layer of the opposite sheet), also serving as a barrier to water. PE and PP materials provide a low barrier and, as such, are not acceptable for most foods. PVC, PET and PA provide a moderate barrier and are acceptable for some foods, while composites (multilayers) of these materials provide a high barrier and are acceptable for almost all foods.

One of the disadvantages of multilayer films is that two or more plastics are combined, therefore, when it comes to recycling it is impossible to separate the different layers into the constituent plastics. This limits the number of products into which they can be recycled.

4.3.1 Vacuum Bags

The film used for vacuum-packaging machines is composed of two or more sheets of multilayer films. By drawing the vacuum and sealing of such bags, the air is excluded from the package and the damaging effects of oxygen, such as rancidity or discolouration of the packed products, will be significantly slowed down or not develop at all. However, exposure to strong light may cause discolouration even under vacuum.

[5] Oxymyoglobin is not a chemical compound but a loose aggregation of oxygen to the red meat pigment myoglobin, which keeps meat bright red for a number of hours.

A very efficient combination is **PA/PE** where **PA** is used as the outside layer, for example, films for vacuum bags. PA is relatively oxygen-proof but permeable to some extent to water vapour. **PE** has the opposite properties, it is water-vapour proof but permeable to oxygen. The combination of both makes such a multilayer film impermeable to oxygen and water vapour evaporation. Moreover, the PE used as the inside layer has good thermoplastic properties and is well suited for heat sealing. The PA/PE combination is the simplest structure for a multilayer film. The packaging industry has refined the system by introducing additional layers which serve as strong oxygen barriers.

Sealant layers consist typically of Polyethylene (PE), while outside layers may be Polyamide (PA), Polyester (PET) or Polypropylene (PP). Barrier layers for oxygen are made of Polyvinylidenchloride (PVDC) or materials with similar properties.

For specific products, such as entire sausages, **semi-automatic vacuum-packaging** can be employed. A bottom film is moulded according to the shape of the sausages by using heat and force (compressed air or mechanical). These machines are called thermoformers. The sausages are loaded and a top film is sealed on after evacuating the moulded spaces. Individual product portions are cut apart along their sealing layers.

4.4 Shrinkable Films

Processed meat products in slices or as entire pieces are today increasingly being packed in small to medium-size vacuum bags. For larger-sized products, bags made of **shrinkable films** can be used where, after VP, the product in its package of synthetic film is sprayed with or dipped into hot water (80°C). The contact with the hot water causes the shrinkage of the thermoplastic film and results in tight impermeable wrapping of the goods. During storage, the pressure exerted on meat by tight-fitting films keeps the fluid within the meat, which limits microbial growth. However, the tightness of the film can increase drip loss once the product is unwrapped. Shrink films for vacuum skin packaging (VSP), may, for example, be composed as follows: PET/PA/EVOH/PO[6].

4.4.1 Skin Packaging

A packaging method commonly used in larger meat industries is **skin packaging**. Skin pack, or skin packaging, is a type of carded packaging where the product is placed on a piece of paperboard or rigid film, which serves as the bottom layer of the final package. Another and a thin sheet of transparent plastic is placed over the product and paperboard.

The plastic film (LDPE, PVC, ionomer, etc.) at the bottom and top are softened by heat and draped over the product on the card. Vacuum is sometimes used to assist a tight fit and purge wrinkles. The skin-like coverage of the product takes place in a sealing station in the packaging machine, where the top and bottom film are sealed around the edges. If the process is only using printed paperboard it will have a heat-seal coating

[6] EVOH – Ethylene Vinyl Alcohol film as a gas barrier layer.

and the top film bonds to the heat-seal coating on the paperboard. The skin-packed piece may then need to be cut into individual units. Individual packages are separated by cutting around the bottom seal perimeter, eg sliced bacon, fish and salami.

A derivative of this is "**form-shrink**" **packaging,** whereby products, eg meat cuts, chicken carcases, entire sausages or smaller portions of meat products are placed between two shrinkable films, which are moulded without wrinkles around the goods. Sealing seams can be kept extremely small (and is cost-effective in terms of usage of packaging films but requires expensive equipment).

4.4.2 Modified Atmosphere Packaging

Meat and meat products in a pack surrounded by air have a relatively low shelf life. Vacuum-packing meat produces a higher shelf life. Modified Atmosphere Packaging (MAP), although its use is declining in favour of VP, is still used to pack some non-beef primals in ordinary plastic bags/pouches. MAP packages are first subjected to a vacuum. Then a mixture of gases is introduced into the air-free space before sealing. The gas mixture usually contains nitrogen (N_2) and carbon dioxide (CO_2). N_2, which is also the major constituent of atmospheric air, is inert, ie it does not react with meat product components such as fat or myoglobin. Its function is to replace the atmospheric oxygen (O_2) and thus prevents O_2 induced negative impacts. The other component of the gas mix, CO_2, has a protective function, as it inhibits to some extent the growth of bacteria and moulds[7].

Such packaging uses very high barrier materials, which are gas-proof multilayer films, composed, for example of PE, PA and barrier layers making the packaging expensive. After closing, there is no exchange of gas atmosphere between the inside and outside of a pack.[8]

4.5 Suitability and Ease of Recycling Different Polymers

The most common synthetic polymer materials used for meat packaging and their suitability and ease of recycling are set out below:

Polymer	Properties	Used in	Permeability	Recyclability
Polyethylene (PE) (shrink-wrap)	Flexible, self-adhesive, low barrier	Flexible overwrap film	(oxygen + , water vapour –)	yes
High density polyethylene (HDPE)[9]	Low permeability to moisture,flexibility, good low temperature	-	(oxygen + , water vapour –)	HDPE bottles and trays Yes
Low density polyethylene (LDPE)	Durability	Bin liners, cling film, flexible containers	(oxygen + , water vapour –)	Increasing

[7] Under MAP, the shelf life of red meat portions can increase from 2 to 4 days to between 5 to 8 days, depending upon pack design and the chilled storage conditions.

[8] A similar nomenclature is Controlled Atmosphere Packaging (CAP), where, unlike MAP, the gas composition is maintained by some means. CAP is normally only cost-effective in cold storages or in a container but not in consumer packs.

[9] Foils made from the above synthetic materials are selected, based on their different properties related to oxygen and water vapour. Some come in various low and high density forms and are designated as such (iie Low Density polyethylene LDPE).

Linear low density polyethylene (LLDPE).		Not often used	(oxygen + , water vapour –)	
Polypropylene (PP) Other formats Polyphenylene oxide (PPO)	Moisture proof and high chemical fat resistant, self-adhesive, low barrier	Meat trays, thin flexible film eg pouches, flow wrap applications	(oxygen + , water vapour –)	Not common in UK
Polyvinylchloride (PVC) (soft)[10]	Self-adhesive and barrier properties, good heat-seal properties	Trays, pots, blisterpacks	(oxygen + , water vapour –)	Not common in UK
Polyester (PET) – polyethylene terephthalate	Good high-temperature properties, high strength, clarity	Boil-in-bag, meat trays, pouches of thin flexible film, flow wrap applications	(oxygen +CO_2 + , water vapour –)	High recyclability
Recycled polyester (r-PET)				High recyclability
Crystalline polyester (C-PET)	Heat resistant	Trays for ready meals		High recyclability[11]
Polystyrene (PS)		Food trays, take-away trays, meat trays		Not common in UK
Polyamide (PA) or Nylon	Self-adhesive	Flexible film	(oxygen – , water vapour +)	
Polyvinylidenchloride (PVDC)		} used as barrier plastics		
Ethylenvinyl alcohol (EVOH)				

TABLE 1 + = relatively permeable; – = relatively impermeable

Source: FAO Meat Processing Technology 2012, WRAP

PE is also the loose single layer film used to line tote bins and large trays. Sometimes, meat is stored and shipped in a chilled or frozen state in these liners. When these liners are clean, they should go into the recycling bins.

Another important utilisation for single-layer films is in freezer storage. For meat blocks, meat cuts or smaller portions or meat products, single-layer films are stretched tightly around the surface before freezing. The tight film prevents evaporation losses, which occur during freezer storage of unpacked products. The film is in tight contact with the product's surface in order to avoid evaporation, ice formation and freezer burn at non-contact spots. Suitable cold resistant films for freezer storage are PA or PE.

[10] PVC has received negative attention from environmentalists and very little growth is expected in the future according to the report written by Anyadike. However, the UK has generally been moving away from the use of PVC. Most of the incineration companies do not like to incinerate products with a chlorine content.

[11] All PET categories can become 'milky' if contaminated with other plastics, eg trays lined with PVC to allow for heat sealed PVC film lids. The resulting rPET is still usable but not for higher value applications. This means bottle to bottle recycling is preferred as it keeps a clear plastic. Contaminated PET tends to be 'downgraded' to coloured trays.

5 Packaging Waste and where it is produced in the Chain

Large quantities of beef, lamb and pork are still distributed in some parts of Europe unpackaged, usually in the form of hind and fore quarters. Certain consumers believe dry-aging delivers a premium product with improved tenderness and flavour. Although this does result in low packaging cost, it is at the expense of drip, hygiene, quality and shelf life. There are associated costs which are not wholly understood and retail/processor benefits not optimised.

In the UK most of our pork, beef and lamb is distributed from abattoirs to the boning halls as naked carcases. A lot of the meat (especially beef and lamb joints) are vacuum-packed after deboning for distribution, especially if it is going from the boning hall to the off-site retail packing companies, meat processors or wholesalers. Some of the more integrated supply chains may not vacuum-pack but use large dolavs with plastic liners to hold and transport meat, eg fore quarter meat for burger manufacture. Pork production tends to be carried out in more integrated supply chains but the distribution is wider, ie legs and other joints dry chilled and transported in dolavs or 'christmas trees' for curing or smoking to manufacture ham and bacon. Some of the lower value meats will go in large dolavs for sausage and processed ham manufacture. Therefore, only some pork primals are subjected to aging. Consequently, a lot of work has already been done to reduce the amount of plastic used in the pork supply chain. This means that probably less than 20% of all fresh pork is vacuum-packed. However, all primals still tend to be packed for distribution to non-local customers, ie from deboning halls to catering butchers, meat processors, retail packers and retail butchers and then in these companies potentially repacked in consumer ready packaging. There is also packaging used during the manufacture of the processed 'picnic'[12] hams, to maintain the shape. This tends to be a heavy breathable plastic that is discarded before retail packing.

TABLE 2
Waste produced during Red Meat Processing Chain

	Recyclable – CLEAN	**Landfill – CONTAMINATED**
Abattoir	Office waste **PPE**[13] packaging Cardboard Paper Plastic	Cardboard Paper Plastic Canteen waste
Cutting plant	Office waste PPE & PPE packaging Off cuts from vac pack Cardboard (boxes and rolls) Stringer waste[14] Equipment waste (plastic trays	Cardboard (boxes and rolls) Stringer elastic Plastic Canteen waste VP off cuts. Primal packaging

[12] Picnic hams are the square and round processed hams made by combining various muscles (normally shoulder and fore legs) with a ham slurry and using ovens or curing chambers.
[13] PPE **Personal Protective Equipment** includes rubber gloves, hair nets, wellington boots, ear defenders, etc.
[14] Stringer definition. The stringer machine will wrap the primal in an elastic string sock which is the placed in a VP.

	and dolavs, metal trays, rollers, etc.)	
Retail Packing plant	Office waste PPE & PPE packaging Skeleton waste Empty trays Cardboard rolls Clean film Separators Labels/paper	**Primal packaging and cardboard plastic, films** Dolavs Separators

Most of the abattoirs when questioned believed that their waste to landfill was negligible and could not or did not give us many responses. Those questioned closely estimated 5 to 15tpm, which, when multiplied up for a year, equates to 60 to 180tpa for the major abattoirs. This is substantiated by the IPPC returns that were available in 2008 which show a range from 50tpa to 300tpa. There are 257 abattoirs in the UK of these approximately 80 would be considered large, slaughtering over 600 GBU per week. Using the anecdotal information and taking the average figure of 120 tpa, these plants still account for 9,600tpa. This waste does not include that from the downstream operations nor is it known how much is plastic or cardboard. However, based on looking at the refuse bins, approximately 30 to 50% would be. More abattoirs are collecting the clean plastic and cardboard from PPE and office waste and recycling it.

5.1 Clean Plastic Packaging

There are no published figures available on the quantities involved. Some of this material, if it is uncontaminated, will today be paid for by collectors if it is available in sufficient quantity from any one company (market prices fluctuate depending on the economics of the recycled plastics market, particularly for food grade Post-Consumer Recyclate (PCR).

The amount of this product does depend on the size of the company and the throughput. It is produced mainly in abattoirs, cutting plants and retail packing plants coming from PPE packaging and office waste. In cutting plants, it is also caused by using

over-sized bags that get trimmed to size. However, in retail packing plants, substantial quantities of thermoformed plastic and film are generated and have to be dealt with from machine start-ups, change-overs, setting up reels and changing labels, breakdowns and shut-downs, as well as end of rolls including skeleton waste. All of this clean plastic could potentially be sorted and recycled.

The current cost for landfill is £75 per tonne. To enable recycling there must be an economic advantage, ie it must be less costly for it to be sorted, stored properly, protected from the elements (wind, rain, snow, rodents, etc.) and separately collected. Very few companies have the altruistic vision to embark on this behaviour if it costs more. Biffa and Cranswick have embarked on a partnership where Biffa have put specialists into the Cranswick production sites to identify where and how to collect plastic that could be recycled.

5.2 Contaminated plastic film

Plastic packaging waste has become a growing problem for various sections of the industry. For example, those buying packed meat for breaking down or processing (eg wholesalers, catering butchers, retail packers, processors), will have to dispose of volumes of some clean but much contaminated (with fat and drip) plastic packing (from vac-pack and over wrap).

- Waste plastic is generated in the abattoir especially if plastic is used to protect the cattle legs from contamination after the hooves and hide have been removed. This plastic is similar to the blue plastic used to line boxes. This plastic is contaminated with blood and faeces and is currently not recyclable. It tends to be used only by the abattoirs that supply the multiple retailers
- A larger amount tends to be generated in the cutting plant from burst vac packs or where some of them supply food service and butchers shops. These plants will debone carcases, pack, store and age the meat. When the product is aged and ready for sale the company tends to open and throw away the used bags and rewrap the product according to their customers' requirements
- The largest amount of waste plastic film is from the vacuum-pack bags used to store, age, protect and transport the primals[15]. The majority is discarded by the large retail packing plants supplying the multiples. There is also a fair amount thrown away from supermarkets with in-store butchers (eg Morrisons who normally have a large butcher counter and pack a lot of meat at back of supermarket), as well as meat processing and foodservice establishments, eg burger manufacturers, ready meal companies, sausage producers, canning factories etc. This plastic is a multilayer film bonded together comprising three to five layers. This is the main focus of this report, as there are many tonnes of this plastic that currently go to landfill
- In the meat factories, all the above plastics currently get mixed with the canteen waste and floor contaminated plastics and end up in the same skips
- The other packaging used by abattoirs as well as cutting plants, wholesalers and retail packing plants, tends to be 'common waste', the boxes and plastic bags in

which the PPE is delivered, canteen and office waste. Most of this waste (not kitchen waste) is recyclable, as it is clean and not contaminated with blood.

	
Mixed canteen waste	Mixed plastic and floor waste

5.3 Clean Cardboard Packaging

As stated before, cardboard is used throughout the industry. Most companies receive their personal and protective equipment (PPE[16]), office supplies, canteen supplies and even their raw materials in cardboard. Many companies ship both the primals, offals and retail pack product to their customers in cardboard boxes. Some cutting plants that supply butchers and foodservice sectors will debone the carcases and vac-pack the products. The vac-packed primals will be boxed (in cardboard boxes) and stored for maturation for a specific number of days or until they have customers for the meat. Consequently, downstream in the meat supply chain there is a lot of mostly clean cardboard. Most of this can be baled and recycled.

The market for recycling cardboard packaging has big fluctuations, depending on global economics. In 2008, meat companies interviewed as part of a Defra project maintained that, when the economics of the waste paper market moved against them in the early/mid 2000s, it cost them £35,000 a year to dispose of uncontaminated waste cardboard. However, during research for this report in 2012, an average of £70 per tonne was being paid for baled clean cardboard.

All of the plants interviewed during this study arranged for the collection of clean cardboard for recycling (eg by companies such as ***ACM, Shanks, Waste Management,***

[16] PPE are the consumables such as overalls, gloves, boots, hats, aprons, ear defenders, etc.

Cynar, Biffa[17]). At the time the report was completed, most companies were being paid for their clean cardboard by collectors, if available in sufficient volumes from individual companies[18].

For recycling purposes, while multi-material laminated boards or those coated on both sides with PE, PET or other plastics are not suitable for recycling, those coated on a single side are (as the recycling acts on the unlaminated side). Similarly, any labels should be printed on paper and not plastic.

The labeling systems generate a small amount of waste, especially when the retail customers order new product designs and stop or change promotions with little advance warning.

5.4 Contaminated Cardboard

Sometimes, during storage or shipping, the meat package, eg bag or tray, is damaged causing leaks and the blood will seep into the cardboard. Also, although cardboard should not be present in the same hall as the naked meat, this does happen and the cardboard becomes contaminated with fat or blood. Some cardboard is used with a simple liner and can become contaminated.

Cardboard that has been contaminated with blood drip, oil, fat or other substances cannot be recycled and has to be disposed of, usually using the LA dirty refuse service, or incinerated.

5.5 Method of Estimating the plastic used at each cutting plant.

The tables below name the main primals that most cutting plants will break a carcase into and pack. The primal is then unwrapped and the plastic will end up in landfill, either from the retail packing plant, cutting plant, wholesaler or food service.

[17] Biffa Polymers' rigid mixed plastics recycling facility at Redcar, Middlesborough, built with support from WRAP, on behalf of the Government, is the first integrated washing and sorting facility in the UK that is specifically designed to recycle rigid mixed plastics packaging.
The Redcar facility began processing in April 2011 and is expected to run at full capacity of 20,000 tonnes per year by 2013. It processes plastics from Biffa MRFs, as well as local authorities and commercial Biffa customers from England, Scotland, Wales and Ireland.
Once sorted and processed, the outputs, sorted by polymer type and colour are suitable for a wide range of end uses replacing the use of virgin plastic. Examples of new products include paint trays, plant pots, storage boxes, pallets, car parts and office furniture. In addition, some of the output will be processed through Biffa's food grade HDPE recycling facility at the same site and go back into the manufacture of new milk bottles.

[18] The cardboard recycling price fluctuates depending on the economics of the waste paper market. It was also established that most companies have to compact their cardboard before collection.

Cutting plants will tend to break a beef carcase into primals as listed in the table below.

Primal Types Cattle	Number of bags
Topside	**2-4**
Whole fillet	**2**
Silverside	**2**
Knuckle	**2**
Striploin	**2**
Rump heart	**1-2**
Brisket (ear on)	**2**
LMC (Bark Off. Muscles on)	**2**
Boneless rolled rib	**2**
70-75 VL	**4-6**
85VL Trim	**6-8**
95 -98 VL	**10-12**
	37-44

The beef packing plants are responsible for around 70% of the contaminated plastic that has to go to landfill. The main reasons are that:

- Normally, a beast is broken into between 37 to 44 different muscle types and separately bagged.
- Most beef primals and offcuts ready for mincing are vacuum-packed and this may be in 1 tonne dolavs or 25kg bags but the main format is 5 to 7kg bags.
- Most vac-packed primals are matured for a set period, eg rump steak, rib-eye steak, sirloin steak would be vacuum-sealed in separate plastic bags for maturation and storage.
- Most organisations try to minimise the number of bags they use but a lot will be dictated by their customer.

5.6 Lamb

Many abattoirs will ship the lamb in a carcase form to their cutting and wholesalers, however, product going to retailers can also be in vacuum-packed bags. This gives the retail packing operation flexibility to allow parts of the carcase to be stored if the sales of that joint are low. It also reduces drip loss and drying. Although lamb does not need to be matured for as long as beef, most retailers now specify 7 days for their lamb grilling and roasting joints. Mutton is recommended to be matured for 7 to 10 days.

Primal Types Sheep	Number of bags
Legs	**2**
Shoulder	**2**
Breast	**1**
Loins	**1-2**
Breast	**1**
Rump flank	**1-2**
	8-10

5.7 Pork

Pork loin should be matured for 7 to 10 days, however, the industry tends not to believe that other joints needs any maturation. Consequently, a lot of the larger companies are also moving away from storing and shipping product in vac-pack bags. Even the imported pork bellies/bacon are unwrapped. Most pork is chilled to nearly frozen and shipped in large one tonne plastic-lined cardboard or plastic reusable dolavs. Pork legs will be hung on trees and moved to the boning halls/cutting plants with little protection.

Although there has been a move away from the ubiquitous use of plastic within the pork supply chain, it is still extensively used in the further processing of product. Many companies still use plastic to cure and cook the ham especially 'picnic or sandwich' ham. Preformed and emulsified processed pork is steam cooked and/or smoked or tempered in heat resistance plastic socks in large ovens. Also, many of the small and medium-sized cutting plants will pack their primal to maintain flexibility or ship to their customer.

Primal Types Pork	**Number of bags**
Legs	**2 ***
Chump	**2**
Middle	**2**
Loin	**2**
Belly	**2**
Neck end	**2**
Shoulder incl. fore leg	**2**
Manufacturing	**1-2**
	15-16

5.8 Quantity of plastic used in the industry to pack primals for maturation

Estimate 1

Using the above information and the UK slaughter figures gives a rough approximation on how much plastic primal packaging is used. These figures do not include any imports or exports. At this stage, they also have no breakdown of what is going for foodservice or is retail packed for the multiples. Ultimately, it is what goes to be retail packed that will deliver economies of scale and enable improvement actions to be taken.

	Cattle	**Pork**	**Sheep**
Heads (000) (UK slaughterings M.I. AHDB)	2,761	9,813	14,485
Bags per carcase	44	16	8
Weight of bag (kg)	0.045	0.035	0.035
Total plastic tonnes per annum (tpa)	**5,467**	**5,495**	**4,056**
Not all primals would be wrapped (dry-aged, no aging, etc.)	80%	50%	15%
Estimate 1 intermediate plastic used in UK inc NI	**4,373**	**2,748**	**608**

5.9 Volumes of Plastic and Cardboard Disposed of by the Abattoir/Cutting Plant Sector

No actual data is collected on how much plastic is recycled or landfilled. In fact, although most companies had a measure of waste to landfill, this waste included canteen waste, discarded PPE (hairnets, gloves), extraneous packaging, contaminated intermediate cardboard and plastic. In this report, the amount of packaging has been estimated in three different ways and compared with historical data to ensure a decent approximation.

5.9.1 Abattoirs

Using the slaughter figures and sizes of abattoirs, it is estimated that 12,000 tonnes of landfill waste is generated in the UK from the slaughter houses in 2012. The majority of this will be canteen waste with a 4,000 to 6,000 tonne estimate of contaminated plastic and cardboard that would need to be disposed of in landfill.

5.9.2 Retail packing Plants

Retail packing plants tend to generate significant amounts of contaminated plastic. Table 3 has a **calculated figure** for the waste primal packaging only, ie cardboard and plastic that goes for landfill and recycling. The calculations and the assumptions are in Appendix 9. These calculations are based on the tonnages of meat going for retail; fresh, frozen or processed.

TABLE 3 Conservative estimates of how much primal plastic and cardboard is used in the red meat industry based on slaughtering and retail packing figures. 2012

Estimate 2	Cattle	Pork	Sheep	Total
Landfill PLASTIC (tonnes)	5,530	4,927	609	11,066
Landfill CARDBOARD (tonnes)	1,847	1,167	174	3,188
Landfill TOTAL	7,377	6,094	783	14,254
Cardboard for recycling (tonnes)	5,540	3,501	523	9,563

Below, in table 4, are the results from a sample of retail packing plants interviewed. It is worth remembering that the general waste is a mixture of production wastes, including contaminated cardboard and film as well as labels, old rolls (plastic and cardboard), ingredients, plastic containers, broken trays, PPE and canteen waste. Cardboard and plastic soaked in drip contamination could possibly double the plastic weights.

These figures have been estimated using the AHDB figures for amount of meat produced, minus exports and plus imports. The breakdown is in appendix 10.

Table 4 General waste from the retail packing plants based on survey results

Tonnes of packaging per annum tpa 2011/12				
Survey retail pack	**Beef**	**Pig**	**Lamb****	**Total**
General waste (landfill)	9,481	4,638	1235	15,353
Cardboard (recycled)	1,937	1,179	688	3,803
Plastic (recycled)	1,488	1,331	937	3,756

**A lot of the sheep that are retail packed tend to be done in the same plants as pork or beef, therefore it is difficult to split this out.

It is difficult to extrapolate these figures across the industry but using an educated estimate the volumes processed in the plants that sent returns could probably account for 50% of the total throughput for pork and beef and 40% for lamb processed for the retail sector.

Table 5 General waste and recycling extrapolated for the retail packing industry.

Survey results extrapolated for the industry

2011/12	Beef	Pig	Lamb	Total
General waste (landfill)	18,961	9,276	3,086	31,323
Cardboard (recycled)	3,873	2,358	1,719	7,950
Plastic (recycled)	2,976	2,662	2,343	7,981

Assumptions

Survey covered approximately 50% of the pork and beef retail packing sites

Beef and Pork: Double industry figure

Survey covered 40% of the lamb retail sites

Lamb: Multiplied the industry figures by 2.5

**A lot of the sheep that are retail packed tend to be done in the same plants as pork or beef, therefore it is difficult to split this out.

5.9.3 Review of the figures

Of the 5 million tonnes of plastics used per year in the UK, 2.4 million tonnes is packaging. According to WRAP, when disposed of, 1.7 million tonnes of this comes from households and the rest from commercial and industrial companies. Items such as plastic bottles, pots, tubs, trays, films and plastic bags are the most common types of household plastic waste. Of course, this is not all from the meat industry. We calculate that over 7,700 tonnes of plastic is used to wrap **some of the** 1.7 million tonnes[19] of meat produced in GB per annum. A balance of 950 tonnes (imports – exports) will be wrapped in 3,000 tonnes of plastic. At the consumer level, with the sale of over 76% of meat in supermarkets of which an estimated 70 to 80% of fresh meat is sold in prepacked format (and a similar proportion of processed meat), a large amount of

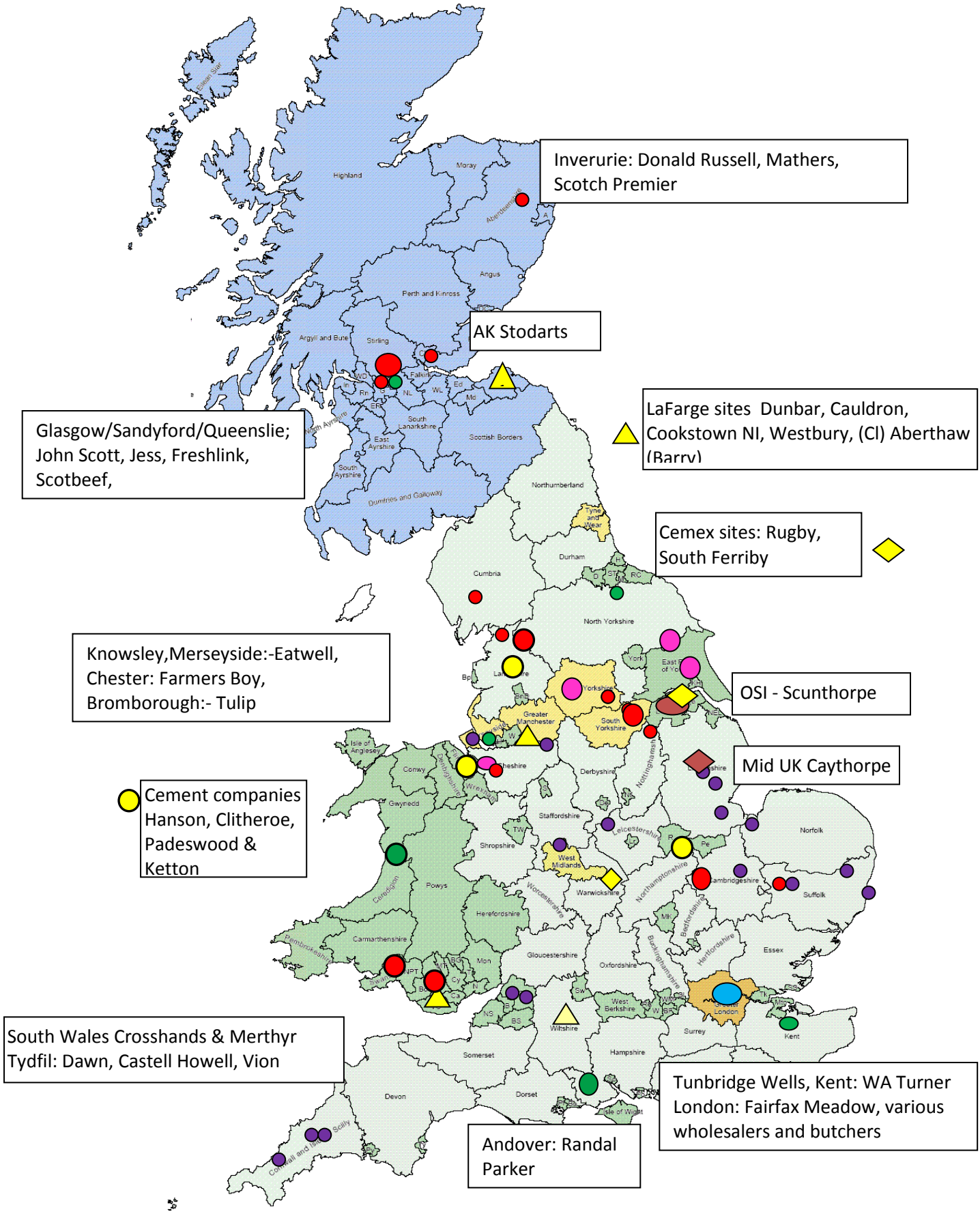
[19] Although GB produces 1.7 million tonnes, some of this will be exported as carcases or as primals and a small amount will go straight to retailers (butchers) in carcase form. A further 1.5 million tonnes of red meat is imported most likely in plastic packaging.

thermoformed plastic and card over wrap is left for consumers to dispose of. This plastic is not part of this study. Most of this is plastic that is landfilled due to contamination.

Of the estimated 30,000 tonnes of waste landfilled per annum, approximately 11,000 tonnes were primal plastic and 3,000 tonnes were cardboard, which could be relatively easily separated and sent to a recycling or EfW plant. The large recycling plants are, in the main, not too far from cement processing companies, EfW companies and incinerators generating energy. These types of plants represent big opportunities for the industry and trying to link them should be advantageous.

For example, the Retail Packers located close to the following companies that could take their waste

Wales		
Dawn -- Crosshands	Cement LaFarge	Abertawe
Vion -- Merthyr Tydfil	Waste for incineration or fuel	Sita/Cynar Bristol
Dunbia -- Llannybydder		
Castell Howell		
North East		
ABP -- Doncaster	Mid UK Caythorpe	
Dovecote -- Pontefract		
Cranswick-- Hull		
Farmers Boy -- Bradford		
Vion (Karro) -- Malton		
OSI -- Scunthorpe		
Dalepak -- N Yorkshire		
Northwest		
Farmers Boy -- Deeside	Hanson	Padeswood
Morrisons -- Winsford	”	“
Woodheads -- Colne		
Dunbia -- Preston/Sawley	Hanson	Clitheroe
Tulip -- Ashton		
East of England & Midlands		
Tulip -- Spalding	Hanson	Padeswood
Woodheads -- Spalding	Cemex	Rugby
Hilton -- Huntington		
Scotland Glasgow & Edinburgh		
Sandyford etc	Lafarge	Dunbar
Scotbeef		
AK Stoddart		


Inverurie: Donald Russell, Mathers, Scotch Premier
AK Stodarts
LaFarge sites Dunbar, Cauldron, Cookstown NI, Westbury, (Cl) Aberthaw (Barry)
Glasgow/Sandyford/Queenslie; John Scott, Jess, Freshlink, Scotbeef,
Cemex sites: Rugby, South Ferriby
Knowsley,Merseyside:-Eatwell, Chester: Farmers Boy, Bromborough:- Tulip
OSI - Scunthorpe
Mid UK Caythorpe
Cement companies Hanson, Clitheroe, Padeswood & Ketton
South Wales Crosshands & Merthyr Tydfil: Dawn, Castell Howell, Vion
Tunbridge Wells, Kent: WA Turner London: Fairfax Meadow, various wholesalers and butchers
Andover: Randal Parker

6 Options for Reducing Waste to Landfill

In order for a product or material to be truly described as sustainable it must be environmentally, economically and socially sustainable. These aspects have become known as the Three Pillars of Sustainability and, according to the British Plastics Federation (BPF), are met by plastics, to quote:

'P*lastics make an immense contribution to the environmental sustainability through their energy-saving potential, intrinsic recyclability and energy recovery options. Economically, plastics form an important part of the UK economy and are a major export product. Socially, the plastics industry is a major and inclusive employer with an attention to training and education'.*

However, according to a recent Price Waterhouse Cooper PWC report, the total UK packaging industry, leading retailers, manufacturers and consumer groups had unanimously agreed that the much used sustainable packaging term should be phased out and the focus should now be on ensuring packaging delivers maximum sustainability throughout the entire supply chain and is recoverable after use**. This has very much been the focus of this report for the meat industry, where currently, very little contaminated plastic is recovered and the majority is still going to landfill.**

The sustainability and the prevention of plastics going to landfill fits into the Waste Framework hierarchy of efficient and sustainable use of material resources. The hierarchy is now enshrined in law as a result of the recently revised Waste Framework Directive.

Waste Framework Hierarchy Diagram

This diagram shows that the options for reducing primal packaging going to landfill should be considered in the following order:

6.1 Prevention

One initiative is to reduce food waste and, thus, the total amount of packaging waste has seen the introduction of split packs that allow the contents to be divided into separate portion-sized compartments in MAP packs (eg the consumer can buy four portions of meat in one pack, use two and then put the remainder into a fridge or freezer in a sealed pack).

a) Use less material in design and manufacture
   - Within the meat industry this has been and continues to be implemented. The meat and packing companies are specifying the most appropriate sized packaging to reduce wasted plastic around the edges of bags and trays.
   - The heights have been decreased to reduce headspace and the transport of fresh air from retail packers to warehouses to supermarkets.
   - Use less hazardous material which can ultimately be recycled eg PVC

b) Reduce Weights
   - Light-weighting is not specifically part of this study but a brief mention will be made as it is the first consideration for many supply chains when tasked to reduce packaging waste. However in the meat industry it is more about 'life-cycle thinking'. This approach ensures that overall impacts are reduced while supply chain benefits are increased. For example, package designers will now take the product and its distribution environment into account to ensure that a total packaging solution is developed. A few red meat supply chains from producer to retailer have established that better packaging improves the environmental credentials of the products as less is wasted. This can result in the use of more or heavier packaging, eg bone guards or thicker gauge multilayered plastics are used that generate less food waste.
   - Careful tray design is used to reduce weight while retaining structural integrity.
   - The next step that these supply chains are starting to explore is the final destination of their waste. Many companies are working with waste management companies to identify and take action on their waste streams. Cranswick and Biffa have set up one such partnership. Biffa advises on all the materials that can be recycled. Biffa also provides consultancy to train Cranswick staff on how the materials should be separated at the end of the packing line. Other companies are also exploring similar partnerships.

6.2 Repair and Prepare for reuse

a) Keep products for longer and reuse.
   - This is achieved by the reusable dolavs, normally green plastic supermarket delivery trays and in-house brown and white trays. See Aubrey Allan case study on page 39 section 8.1. Many meat companies have integrated supply chains that allow recyclable packaging to be back-flushed (empty delivery lorries will return packing trays to production sites) with tray washes. On their return, the trays are checked, cleaned, repaired, or broken down to use as spare parts.

6.3 Recycling

Turn waste into a new substance or product. It can include composting if it meets quality protocols. The UK is slowly improving its plastic recycling credentials. In 2010, a WRAP report entitled "The Benefits of Recycling" detailed that the lack of domestic recycling facilities implied that the collected plastics need to be exported to be recycled and transportation is increasing the environmental impacts of the recycling process.

The other issue is that the majority tends to be co-mingled plastic that is collected, which results in a relatively low quality of the collected plastics and thus limits the environmental recycling benefits. If the UK were to move to separate plastic collections the benefits would be significantly higher.

Today, the British Plastics Federation lists 36 member[20] companies involved in collecting such plastic waste for recycling but, as is seen in Appendix 4, some types of polymer are more in demand than others.

6.3.1 Methods of Recycling Plastic

Nearly all types of plastics can be recycled, however, the extent to which they are recycled depends upon technical, economic and logistic factors. As a valuable and finite resource, the optimum recovery route for most plastic items at the 'end-of-life' is to be recycled, preferably back into a product that can then be recycled again and again and so on. It is estimated that of 5 million tonnes of plastics used each year in the UK about 24% is currently being recovered or recycled.

The commercial and industrial packaging recycling waste streams from red meat companies are largely made up of stretch-wrap films, which are often used to cover goods during shipping, and returnable transit packaging such as pallets, crates and drums. Retail packing plants produce a lot of clean skeleton waste (the remains of the plastic rolls when the trays and lids have been stamped out) and clean sealed empty trays from machine breakdowns, start-ups and changeovers.

There are two primary methods to recycle plastics, mechanical recycling and feedstock recycling:

Mechanical recycling is the simplest method. Mechanical recycling is where the plastics, which soften on heating, are reformed into moulding granules to make new products. The process involves collection, sorting, baling then size reduction into flake (film and sheet) or granules which may then need washing and drying. This is then re-compounded with additives and/or more virgin raw material, extruded and chopped into pellets ready for reuse as new raw materials.

Feedstock recycling involves breaking down polymers into their constituent parts through the use of heat or pressure. In turn, these parts or resulting chemicals can be used to make a range of products including new plastics and

[20] http://www.renewables-map.co.uk

chemicals. An example of feedstock recycling is the use of plastics waste as reducing agents in blast furnaces where it replaces coke, for instance. Feedstock recycling provides benefits when the materials that are being recycled are mixed or contaminated.

6.3.2 Films and Trays

It is estimated that over 1 million tonnes of plastic film from packaging arises in the UK waste stream with two-thirds from households and one-third from commerce, industry and agriculture[21]. Currently, PET and HDPE are the most desirable material for recycling, with monolayer PP, PVC or PS less desirable. The same logic applies to label and sleeve materials with paper needing to be used with water soluble glues.

WRAP is working in partnership with industry to develop a viable process to recycle post-consumer PP packaging waste into recycled PP (rPP) suitable for use in the manufacture of new food packaging, but currently there is an absence of food grade rPP.

With trays, retailers may move more to polymers such as PET – rPET where PCR content is available, rather than PS and PP solutions where it is less available. In the future, the declared recycled content can be a strong marketing message.

There is also around 30,000 tonnes of UK non-packaging flexible plastic waste film arising from agriculture under the heading of 'Non Packaging Agricultural Plastics' (NPAP). Only 20% of this non-packaging plastic film was estimated to be recycled in 2009.

Typical products being made from recycled films are refuse sacks, damp-proof membranes, fencing (garden furniture, etc.). While recycling of post-industrial, commercial, post logistics and agricultural films has been a success, the recycling of film from household waste still remains a challenge for the future.

6.3.3 Plastic Film

Relatively little post-consumer film is collected for recycling. Currently, only carrier bags have a significant collection infrastructure. Some retailers are encouraging other PE-based film packaging, eg cereal bags to be deposited in the carrier bag banks. The recyclability of pre-consumer film that is uncontaminated is largely confined to PE materials with the prices varying depending upon the colouring[22].

At the moment, with little recycling of any polymer film, the choice of what specific film to use will be dictated by technical performance, cost, etc. Similarly, specifying

[21] Source: BPF Recycling Group

[22] Averages 2011/12 – LDPE single colour natural - £200-250 per tonne, mixed colour £150–160, HDPE single natural £100-120, mixed colour £40–70 – WRAP market report 2012.

monolayer films ahead of multilayer films is not advisable, at present, if this results in a poorer performance and/or heavier gauge film.[23]

6.3.4 Heavy Plastic Containers

Most plastic dolavs and other semi-rigid plastics, such as meat trays or baskets which can be pre-made or thermoformed, are sent away to be shredded. They will be stored at central sites until there are economically viable quantities. However, companies still have to pay to get these taken away, PAAG recommends the use of PET, HDPE where possible or appropriate; or PP, with PS as less desirable and avoid PVC or PVC composites as most recycling companies do not want the chlorine contaminant. It is believed that after shredding, the products go to Holland for RDF[24] with little recycling occurring.

6.4 Methods of Recycling Cardboard

Paper, card and carton board packaging is inherently recyclable. Carton board and corrugated board generally contain a very high proportion of recycled material. Paper cannot be recycled indefinitely because the fibres get shorter and weaker each time they are recycled therefore some virgin fibre must be introduced into the process to maintain the strength and quality of the fibre.

While specifying the recycled content of card packaging helps reduce the environmental impact of a pack, a balance needs to be struck in some applications between the amount of shorter fibre recycled content and the performance requirements, eg strength of board, contact with food.

Cardboard and paper can also be composted or go for incineration for energy recovery. This product is considered to be almost as good as wood chip.

6.5 Other Recovery

This can include anaerobic digestion from biological waste, ensuring methane recovery, incineration with energy recovery, gasification and pyrolysis which produce energy (fuels, heat and power) and materials from waste.

- Turned into RDF and burnt to generate energy
- Co-incineration in cement kilns (see appendix 8)
- Convert plastic to diesel (Cynar) which is currently being trialled

[23] All of the companies supplying film (such as – ***Sealed Air Cryovac- Darfresh***, ***Reiser, Linpak, Krehalon, Sudpack, Wipak*** and ***Bernis)*** now have a duty to communicate to the customer the recyclability of the polymer films they supply as well as their technical properties.

[24] RDF –refuse derived fuel. (Refuse Derived Fuel (RDF) is a fuel produced by sorting (biological and mechanical separation), shredding and drying municipal solid waste (MSW).

6.6 Energy from Waste (EfW) [25]

The UK, since 2005, is a net importer of energy, leading to huge cost increases for households and businesses. The UK only recovers energy from 10% of the municipal waste incinerators. The European average is 30.4%. Switzerland has 78% EfW and Germany 72%. Until the mid 2000s, the UK's past legacy of cheap and abundant landfill and energy resulted in very little UK EfW capacity, but this is now changing[26]. EfA plant not only includes waste incinerators but also incinerating methane at landfill site, and anaerobic digesters. The regulations associated with waste collection, incineration, etc. are detailed in Appendices 6 and 7.

More than 100 million tonnes of municipal solid waste MSW made from household and commercial waste is produced in the United Kingdom every year. Most of this waste is destined for landfill but could also easily and economically be turned into RDF. This municipal waste, similar to the general waste, is also known as Specified Recovered Fuel or solid recovered fuel (SRF). By turning MSW into refuse derived fuel (RDF), not only is a valuable fuel produced but the need for landfill space is dramatically reduced.

The general industry view is that used plastics can be recycled up to six times but when it is no longer economic or environmental to recycle them, then they should have their energy recovered through Energy from Waste (EfW) incineration, which could provide much needed 'home-grown' power in the form of heat and steam to power electricity generators. Through controlled combustion of the plastic and recovering the energy in the form of heat, the packaging use of the plastic can be viewed as 'borrowing' the oil. The average value for polymers is 38 megajoules per kilogram (MJ/kg), which compares favourably to the equivalent value of 31 MJ/kg for coal. This represents valuable resources raising the overall calorific value of general waste which can then be recovered and reused.

Huge potential opportunities exist for meat companies in this area. Currently, none of the contaminated plastic is recycled but mostly goes to landfill. This is also true of the plastic from households. As stated before, a few companies are now looking to have this plastic collected and used to produce refuse derived fuel. Due to the shortage of EfW incinerators, all companies interviewed exported their RDF to the EU. In 2011, the UK sent over 272,000[27] tonnes of RDF abroad.

[25] https://www.gov.uk/generating-energy-from-waste-including-anaerobic-digestion

[26] ***Cynar*** is developing a pyrolysis unit that converts plastic into fuel. Pyrolysis is not a new process and plants have been operating in Europe for over 15 years. The process heats the waste in an oxygen-free chamber so that the waste does not 'burn' in the conventional incineration sense. Pyrolysis is often also referred to as 'gasification' but there is a subtle difference.
The process operates without the need for 'process air' and, therefore, does not require a chimney and does not produce any airborne pollution. It is hoped that the lack of a chimney will ease the problems of planning control and reassure the public that the process is environmentally friendly.

[27] Richard Benyon MP, Minister of State in the Department for Environment, Food and Rural Affairs

The only map that could be found of all the EfW stations is on 'The energy from Waste'[28] website which is pro-recycling and anti-waste incinerators. The move to divert municipal waste from landfill, lack of EfW incinerators and increases in landfill tax mean that it can now be more economic for companies to export this material than to send it to landfill.

6.7 Co-incineration in Cement Kilns

Some of the material could be used in the building industry in cement kilns to manufacture cement. However, this would tend to be done through the relationship of the waste collector and the cement company. Discussions with some parts of the cement industry indicate that this could be a practical use of this waste. Some cement companies wanted to carry out trials to identify the advantages and disadvantages of using this as a fuel source. Other cement companies are not keen on using this contaminated material due to environmental considerations (it smells too much) although they did say they already took Cat 1 meat and bone meal MBM.

6.8 Conversion into Diesel

An Irish plastic-to-diesel specialist company by the name of Cynar was established to focus on finding solutions to the end of life plastic (ELP). Internationally, there are several plants that will convert plastic to diesel using pyrolysis. This process is the thermal degradation of waste in the absence of air to produce char, pyrolysis oil and syngas, eg the conversion of wood to charcoal. Gasification is the breakdown of hydrocarbons into a syngas by carefully controlling the amount of oxygen present eg the conversion of coal into town gas. (Syngas is a generic term for a man-made mixture of gases that can be used as a fuel).

The intense heat breaks down the waste into base components – oil, ash and combustible gases. The syngases, oils and solid char from pyrolysis and gasification can be used as a fuel and can also be purified and used as a feedstock for petro-chemicals and other applications.

The first full scale 'End of Life Plastics to Diesel' facility (ELPD) plant has received all required permitting and licensing and is operating in Ireland. The second plant has successfully been awarded planning permission in the UK with SITA/Suez Environment and is proceeding to plan. Cynar has successfully agreed an exclusive contract with SITA/Suez for a total of 10 plants. This contract is valued at over £70m and is being followed by similar agreements with other reputable recyclers.

6.9 Disposal

Landfilling waste is not a sustainable solution. The London and Warwickshire sites are reported to be nearly full and there are only seven years landfill capacity left in England and Wales.

[28] http://www.letsrecycle.com/news/latest-news/waste-management/map-launched-of-all-planned-uk-incinerators

6.9.1 Biodegradeable Plastics

Research has been done on 'biodegradable' plastics that break down with exposure to sunlight. Starch is mixed with plastic allowing it to degrade more easily; however, the plastic is not completely broken down. Some researchers have genetically engineered bacteria that synthesise a completely biodegradable plastic, but this material is expensive at present and limited to some general uses. It is not considered suitable for meat packaging. Critics have pointed out that the only real problem they address is roadside litter, which is regarded as a secondary issue. When such plastic materials are dumped into landfills, they can become 'mummified' and persist for decades even if they are supposed to be biodegradable.

7 Barriers to Diverting plastic from Landfill

Most plastic, in its unadulterated form, can be recycled. Large containers are usually made from a single type and colour of plastic, making them relatively easy to sort out. However, the technology for recycling mixed or contaminated plastics is still being developed therefore co-mingled plastics usually have to be segregated by plastic type and cleaned. **Materials Recovery Facilities (MRFs**)[29] are important facilities in sorting, recovering and providing quality raw materials to the recycling industry. As demand for used plastic continues to grow on the world trading market, there are better economic incentives for UK recyclers to invest in new technology enabling the waste from household and commercial sources to be recovered and recycled. More recently, companies such as J&A Young of Leicester, Closed Loop Recycling London and ECO Plastics (formerly AWS Ecoplastics) in Newcastle have made substantial investment into developing domestic plastic recycling capacity. In particular, plants such as Closed Loop London have developed facilities to recycle plastic food packaging back into foodgrade material – which is attracting growing interest from the commercial sector.

The website 'letsrecycle' gives current and historic plastic prices

Plastic type	£/tonne
UK PE Printed	260-280
UK PP Printed	135-165
UK Clear - Natural	350-390
Export 80:20 [30]	35–55
Export 90:10	95–110
Export 95:5	165-180
Export 98:2	250-265

7.1 Barriers to Recycling

The biggest barrier to recycling is poor quality of raw materials:

- different polymers
- different colours of raw materials
- contamination of raw materials

This results in a poor quality of recyclate. If a large proportion of the input material cannot be recycled to sufficient purity to replace virgin plastic then the contribution to total global warming potential of the recycling process is likely to become greater than that of alternative reprocessing/disposal options.

Another barrier to recycling is waste to energy, ie there is sufficient value in waste for energy recovery to reduce the incentive to develop recycling supply chains.

[29] In most cases, MRFs are designed to separate co-mingled recyclables into their individual material streams and prepare them for sale in the commodity markets.

[30] Export 80:20 is a trade description of plastics that are exported. These are mixed plastics with 80% or the main plastic could be PE or PP and 20% of other plastics.

7.1.1 Different Polymers

The recycling technology for plastic trays is poor when compared with that for PET bottles. It is a challenge to identify different polymer trays from the packaging waste from retail packing plants. The sorting process to remove different types of plastic is difficult to automate making it labour-intensive. As the value of the material is low, recycling plastics is unprofitable.

7.1.2 Mixed and multilayer plastics

Consumer packaging may consist of many different types and colours, often with paper labels glued to the film or tray. Unfortunately for the meat sector, although barrier layers can provide significant benefits for performance and extending shelf life, some of the material used can have a high impact on recycling and could affect recyclate quality (eg PA materials). For this reason, the percentage of plastics recycled is very small.

7.1.3 Contamination and barriers to its removal

According to Loughborough University and British Plastics Federation (BPF), among others, once you have a uniform single material plastic, moisture contamination is the next largest barrier. Therefore, the problem with recycling plastic within the meat industry is the meat drip contamination and storage. Blood is an animal by-product and as such should not be allowed to go to landfill, however, as the amount of blood is considered to be only a small percentage of the weight, the packaging is allowed to be disposed in landfill. This percentage is considered to be too large for the plastic recyclers. There is also an unattractive smell given off by blood when left to decompose. This odour means that the product cannot be stored without washing for more than a couple of days.

Washing contaminated plastic primal packaging before recycling has been trialled but does not seem to have proved to be economically or environmentally viable. As the residues are mainly organic, the washing step can give rise to a significant COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand) load in wastewater. The energy requirements to treat the COD and BOD reduce the environmental benefits from recycling.

7.1.4 Colour

Clear PET and natural PE and PP are the most desirable for recycling, with pale tints of blue and green less desirable and black and other dark colours to be avoided. However, the use of black enables a high percentage inclusion of post-consumer recyclate (PCR) and so has clear benefits.

Black packs PET or CPET are less likely to be accurately identified and sorted by Near Infra-Red (NIR) auto sorting technology in a recycling plant due to the nature of the current detection technology. Therefore, black PET trays are likely to be sorted into ‘other’ low value polymers and not into the PET stream.

7.2 Barriers to co-incineration

At the moment, many waste recycling companies and cement companies are not prepared to handle anything but clean dry plastic. Therefore, the plastic would need to be washed, dried and shredded prior to being used in any of the above processes. This would add further cost to the product potentially making it less economically viable. Conversely, the organic content can be an advantage for incineration thanks to the heating value of the contaminants.

7.3 Energy from Waste

Probably the biggest barrier to recycling plastic is the high calorific value. There is considerable debate over whether or not the best route for some mixed plastics is incineration for energy recovery rather than recycling. Certainly, when considering all the requirements that need to be addressed as well as the shortage of fuel and the ease of incineration it seems to be far more practical to burn the product than sort, wash, dry and recycle.

Further investigation is required to understand the environmental and economic costs on use as a fuel alternative compared with recycling. Potentially, the industry could be paid for their plastic as it is a valuable alternate fuel with a high calorific value.

Several pressure groups, however, have been set up to pressure the government not to build EfW plants, citing the economic argument as well as highlighting that the emissions from these plants will affect local air quality.

There is a ground swell of protestors against EfW. Local populations see them as 'incinerators' and are not appeased by the 'green energy label'. Although there are many incineratorsthere is little understanding as to how efficient they are. Consequently, EfW companies are loathe to do anything that may bring about further complaints from the neighbours and do have issues with handling, contamination and odour. Currently, charges are below the £75 per tonne landfill charge, at £20-30 to cover the haulage costs. Most companies that would use this product tend not to be waste companies with their own logistics' fleets but require the product to be delivered ready to use.

7.4 What is the BEST option for primal packaging?

In 2010, WRAP produced a report 'Environmental benefits of recycling – 2010 update'. It included a literature review comparing end of life treatments for various plastics such as recycling, incineration with energy recovery, landfill and pyrolysis. The report concluded that recycling was the preferred end of life treatment when looking at climate change, depletion of natural resources and energy demand. However, the report was aware that insufficient research had been done into water demand especially when the plastic had organic contamination. Another burden on recycling performances is the low quality of the recovered plastic which is likely to result in a high loss rate during sorting. Compared to recovered plastics from other countries, UK

material is reported to be of lower quality (WRAP, 2007 (b)). This can be explained by the fact that most plastics are recovered from post-consumer as co-mingled waste.

Although the report stated that pyrolysis was not yet considered a mature technology and that relatively poor data was available on pyrolysis technologies, the belief was that it could generate some positive opportunities that could lead to benefits that were better than incineration. Two technologies assessed were feedstock recycling (leading to products substituting naphtha, paraffin and refinery gas) and conversion to diesel. Feedstock recycling and conversion to diesel is suitable for polyolefins (ie PE and PP) and polystyrene. PET and nylon have also been processed through feedstock recycling on a semi-commercial basis. Thus, the two pyrolysis scenarios assessed were not sufficient to draw general conclusions on the overall environmental performance of pyrolysis.

Further research is required to understand whether the same issues that beset recycling affect pyrolysis, acting as barriers for its adoption.

The report ranks incinerating plastic to recover energy below recycling and pyrolysis. The issues are with the emission and with the inefficiencies of energy from fuel plants. Efficiencies of electricity generation from waste alone was stated at 15-25% while electricity and heat was between 32-65% efficient and heat only was 90% efficient.

These points coupled with the fact, the UK tends not to have exploited municipal heating systems, could make incineration to recover energy a poor choice. On the continent, their use of combined heat and power units CHP that use RDF as the energy source are more efficient and, consequently, more sustainable.

It is not known what the result would be if contaminated primal packaging was the sole focus for the study. It is a mixed laminated plastic that is difficult to recycle. It is contaminated with organic waste therefore would need to be washed and dried to render it clean enough for recycling or pyrolysis. It has a high plastic content with no chlorine making it easy to burn and has a high calorific value.

Probably the ideal solution would be onsite or local incinerator which could be used to generate hot water and electricity for the plant or surrounding area.

8 What is happening currently in the UK?

The extent to which the recycling of plastic is undertaken and whether meat companies can take advantage of the potential opportunities still depends to an extent on geographical location. However, since the EU framework directive came into force, most municipal authorities have had to respond and this has been followed by the development of the private recycling companies (often providing an outsourced service to the municipal authorities, but also developing their own services collecting from the commercial sector). Although these companies are called recyclers, most are nothing more than collectors, sorters and traders. They take the waste, separate it into what can be recycled and sold (paper, cardboard, metals and some plastics), anaerobically

digested (food waste), composted (garden waste), converted to RDF or landfilled or incinerated and trade it with other companies.

The opportunities to recycle plastic have been discussed previously, however, this information should also be linked and taken into account by the meat companies when selecting which polymer materials should be used for the design and manufacture of the packaging.

The following are aggregated responses from the waste companies and some of the retail packing companies.

8.1 How companies are reducing their cardboard packaging waste

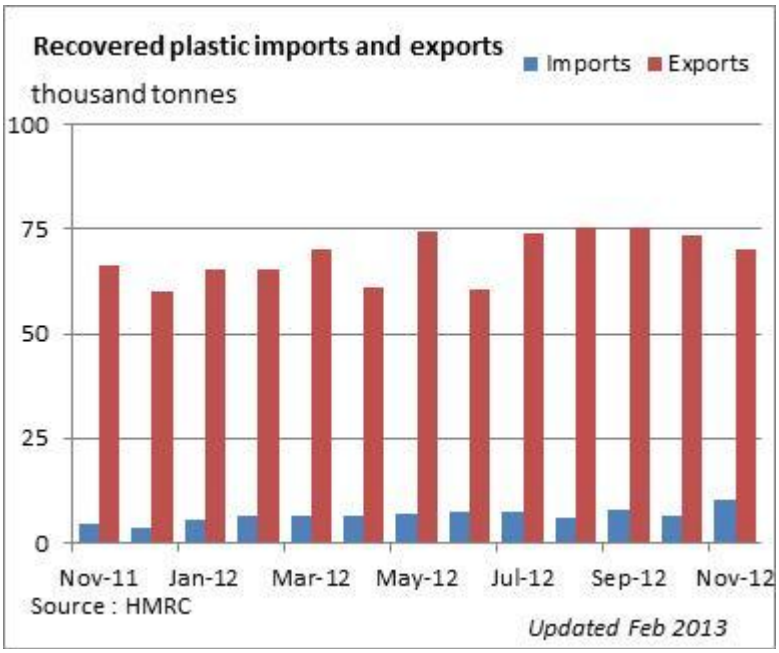
Many large abattoirs to supermarket supply chains are working hard to reduce cardboard waste by distributing product in plastic trays and plastic lined dolavs. All the retail packing plants state they have embarked on a waste reduction strategy to reduce the quantities going to landfill. Some of this work is being done by the companies themselves in the form of label and packaging redesign (light-weighting and head space reduction) as well as using returnable/washable plastic trays, large tote bins, and transporting pork legs on 'Christmas trees'. They have also worked with their waste collectors to improve the amount of material that can be recycled. Some of the more environmentally aware small and medium meat wholesalers and further processors also state they recycle their plastics and cardboard.

A lot of the clean cardboard, ie clean but damaged boxes and other cardboard, is baled by most of the large companies and sold for £70-£80 per tonne.

There are opportunities to encourage many smaller companies to adopt such practices, particularly with domestic product. An example of this is Aubrey Allen who embarked on reducing their cardboard waste a few years ago. Initially. they began using reusable trays for their primals similar to those used by the supermarkets. This was useful for their smaller cuts of meat. More recently, they have moved to trolleys with 10 trays so that large heavy cuts that are dry-aged in their chillers can be transferred easily. They will also transfer product to their customers in reusable trays. This has not only significantly reduced the amount of packaging they purchase but also reduced the amount of money they pay to the LA for refuse collection and they state that annual savings of £40Kp.a. are being made.

8.2 How companies are reducing their plastic packaging waste

Plastics recycling in the UK is strongly dependent on the export market, with a large amount of demand for material coming from the Far East. WRAP claims that dependence on the export market has grown ninefold in the past seven years, which leaves the domestic market susceptible to outsider influence and potential crashes like the one seen at the end of 2008.



In 2011/12, many of the large retail packing plants had set up a system to recover and recycle their clean or slightly contaminated plastic. There are markets for polythene and polypropylene. The clean plastics (eg laminated plastic films, pods, pods with film and labels) are collected by a variety of waste or recycling companies who pay the meat processors. No one would say how much but, overall, the consensus from the industry indicates a positive economic value. As well as the global market, the price is dependent on the type of material, the purity (no labels), available quantities, locations of plant, etc. This plastic is then normally marketed through traders. It goes to a shredding company where it is reduced to a 4mm particle size. In all cases, the interviewees stated that the product is exported to the EU for sorting and recycling or to EU EfW plants.

8.3 The Waste Bins

The current disposal of the dirty plastic and cardboard is normally mixed with the general waste including soiled clothing and PPE, canteen waste normally in black plastic bags, bits of rope, pallet bands (blue pallet straps), cardboard rolls, used blue gloves, hairnets, clear plastic, blue plastic, retail trays, blue hand towels, plastic forks and disposable plates.

8.4 Destination of the Contaminated Plastic and Cardboard

Currently, most of the contaminated packaging from the meat industry is going to landfill as general waste. The companies are paying £75 per tonne to have the product removed and many are not keen on investing any further money unless they see a return for their investment.

Some of the meat companies are tackling the contaminated plastic and cardboard issues with the help of their waste partner; for instance Cranswick is working closely with progressive Waste Management Companies (eg Biffa, Recyco) that are collecting

and recycling their broken trays, broken plastic pallets, wooden pallets and 25 litre plastic drums, clean plastic eg pallet wrap, offcuts from primal packaging, clean meat retail trays, tray end of rolls, kitchen packaging waste, clean blue octobin liners and tray liners.

This change in practice should continue to escalate over the next few years. There is more help for companies to recycle or avoid sending their waste to landfill.

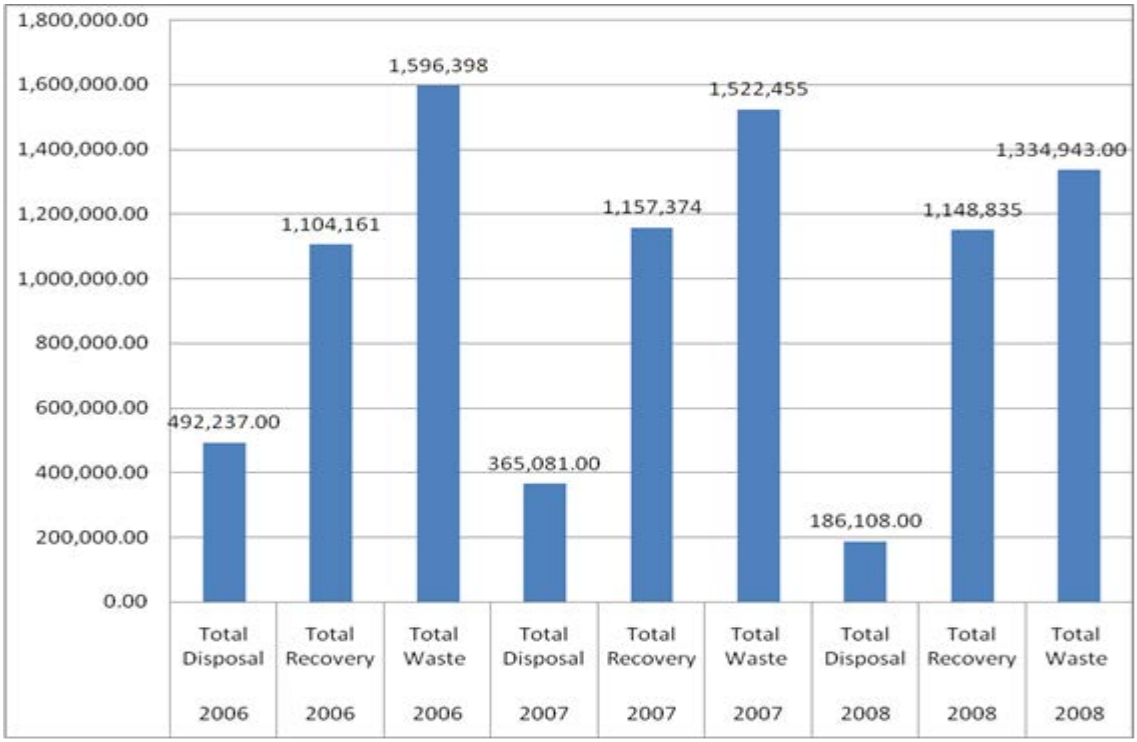
9 Conclusions

The meat industry has begun to address packaging waste issues. It has been reducing the weight of packaging it uses over the last 10 years by reducing the amount of cardboard in the supply chain and reducing plastic weights. The industry is now incorporating 'life cycle thinking' into the design process which should not only improve waste packaging but also reduce waste product.

Anecdotally, the industry has improved its recycling rates especially for clean cardboard and plastic. However, none of this information can be verified easily. Data was previously collected by the Environment Agency, however, they stopped collecting this information in 2008.

The EA pollution inventory data for the 74 largest meat production sites are shown in the chart below.

Figure 8: Pollution inventory (tonnes)



The data indicate

- In 2008, the majority of waste (some 86%) is recovered, compared with 14% which is disposed
- The total amount of waste (waste that has to be either disposed of or recovered) that has occurred over the three-year period has decreased by 16%
- The amount of waste that has been recovered during the three-year period has increased by 4% while the amount of waste disposed has reduced by 62%.

This information is extremely useful and, although the slaughter industry continues to submit it in their IPPC return, it is difficult to access the data. It proved extremely difficult to obtain reliable information from retail packing companies.

There is still a problem with the contaminated plastics with poor specific advice on what should be done with contaminated waste. The research and the condition of the contaminated plastic and cardboard seems to suggest that it would be very difficult and consequently expensive in time (sorting the different plastic), energy, water and effluent requirements to wash and dry the plastics to make plastic to diesel a viable alternative. Loughborough University and Cynar are working to identify the various process parameters to generate different diesel grades from pure material.

This appears to be a UK-wide problem as there seem to be few examples of best practice. The high cost of sorting and rewashing the plastic, coupled with the requirement for pure plastic material, make this material uneconomic to recycle.

The lack of EfW incinerators in the UK means that a good source of high calorie fuel is being wasted, or exported.

10 Recommendations

The aim of this report was to establish how much primal plastic packaging was available in the UK with a view to establishing the options for reducing the amount of primal packaging going to landfill. The recommendations are summed up below:

1. Carry out research into the most sustainable use for this product.

- Engage with WRAP to investigate if they would be interested in identifying the best end of life treatment for this material in the light of the global oil shortage and reducing landfill opportunities.

2. Continue to support the industry and the retail packing companies to develop methods to reduce the amount of plastic being used or waste being generated. This could be done in the following ways:

- Further work could be done to transfer knowledge to the meat supply chain as a result of this project, including detailing the options and the names and addresses of the companies

- Gathering information on this part of the sector is very difficult. Most companies collect little to no information on how much of this material is going to landfill. Engage with the BMPA and Environment Agency to improve data collection. This activity has started and the environment agency has become involved
- Continue EBLEX support for R&D activity.

3. Identify all the EfW sites and start to inform the industry. Liaise with the EfW and cement companies to increase their demand for this material, the following issues need to be considered in seeking opportunities to utilise this waste stream:

- Calorific value of the material. To this end, all material specifications are required. Getting this information from the original equipment manufacturers (OEMs) for all materials is difficult. To enable the material to be used as a fuel alternative it requires a value of greater than 17MJ/kg
- Moisture content. The cement companies and the waste from fuel companies want dry 'sterilised' plastic. The lack of moisture is important and has a direct impact on the odour and potential calorific value available. It will vary from site to site depending on storage and previous uses. Normal specifications require less than 15% moisture
- Contamination with any metal and dense plastic is unacceptable
- Chlorine (Cl) content. Most cement and RDF power companies treat chlorine as a contaminant. Burning PVC, etc. can result in Hydrochloric acid which is exceedingly corrosive. Must be less than 1% Cl
- Particle size. Most companies do not want large baled product in its ex-factory gate state. They require it to be washed and ground down into small particles. This enables it to be taken in with other raw materials
- Setting up geographical collaborative and cooperative meetings with the main players in the various regions and the associated waste and cement companies to identify what possibilities exist.

4. Investigate an alternative type of recycling plant which is an integrated facility using electrical and heat energy from low quality materials to run the recycling of the higher quality materials.

11 Appendices

11.1 Appendix 1 The Courtauld Commitment

Phase 1

1.2 million tonnes of food and packaging waste have been prevented over the last five years through the success of Phase 1. The results, announced in September 2010, show that 670,000 tonnes of food waste and 520,000 tonnes of packaging were avoided across the UK between 2005 and 2009.
This avoided waste is the equivalent to:

- 128,000 full standard refuse trucks, stretched bumper to bumper from Truro to Inverness.
- Approximately £1.8 billion of food and packaging waste was avoided.
- Around 3.3 million tonnes of CO_2 equivalent emissions, the same as 0.5 million around-the-world flights.

Achieving the targets:

Of the original targets set, two out three have been achieved:

- to design out packaging waste growth (zero growth achieved in 2008); and
- to reduce food waste by 155,000 tonnes (exceeded with 270,000 tonnes less food waste arising in 2009/10 than in 2007/08).

The target to reduce the amount of packaging waste over the same period has not been achieved. Total packaging has consistently remained at approximately 2.9 million tonnes between 2006 and 2009.

The main reason behind this is a 6.4% increase in grocery sales volumes since the agreement began in 2005 and participating retailers taking a greater proportion of the overall market for beer and wine. Bottles and cans for beer, wine and cider represent a third of all grocery packaging by weight.

However, on average, across the range of groceries we buy, packaging has reduced by around 4% for each product, whether that is through using more concentrated detergent, or lightweight cans, which is a significant achievement.

Phase 2

Phase 2 of the Courtauld's commitment was launched in 2010 and moved the focus away from weight based targets to the entire lifecycle of products from manufacture to consumption. The focus has increased from packaging and weight to the wider carbon impact .

WRAP is responsible for the delivery of the agreement and works in partnership with leading retailers, brand owners, manufacturers and suppliers who sign up and support the delivery of the targets - packaging, supply chain and household food waste. The targets were to reduce packaging weight and introduce packaging that could be recycled. To reduce packaging waste in the supply chain by 5% by end 2012

As part of this initiative 24 companies signed up for 40 case study projects to reduce supply chain packaging waste. Only one of these directly involved meat. The Moy Park initiative to replace trays in the sale of whole birds with hermetically sealed flow wrap that provides high barrier protection and MAP, has reduced packaging waste by 70% (i.e. the weight of the tray).

11.2 Appendix 2 EU Waste Framework Directive and National Legislation

EU Waste Framework Directive provides the overarching legislative framework for the collection, transport, recovery and disposal of waste and includes a common definition of waste. The directive requires all Member States to take the necessary measures to ensure waste is recovered or disposed of without endangering human health or causing harm to the environment and includes permitting, registration and inspection requirements.

The directive also requires Member States to take appropriate measures to encourage firstly, the prevention or reduction of waste production and its harmfulness and secondly the recovery of waste by means of recycling, re-use, reclamation or any other process with a view to extracting secondary raw materials or the use of waste as a source of energy. The directive's overarching requirements are supplemented by other directives for specific waste streams.

The Waste (England and Wales) (Amendment) Regulations 2012 were laid before Parliament and the Welsh Assembly on 19 July 2012 and came into force on 1 October 2012.The amended Regulations relate to the separate collection of waste.

They amend the Waste (England and Wales) Regulations 2011 by replacing regulation 13 so as to impose a duty on establishments and undertakings, from 1 January 2015, to separately collect waste paper, metal, plastic and glass. It also imposes a duty on waste collection authorities, from that date, when making arrangements for the collection of such waste, to ensure that those arrangements are by way of separate collection.

These duties apply where separate collection is "necessary" to ensure that waste undergoes recovery operations in accordance with the Directive and to facilitate or improve recovery; and where it is "technically, environmentally and economically practicable". The duties apply to waste classified as waste from **households** and waste that is classified as **commercial** or industrial. The amended Regulations also replaced regulation 14(2) to reflect the changes to regulation 13 to ensure a consistent approach. Consequential changes are also made to reflect changes in paragraph numbering in the new regulation 13.

11.3 Appendix 3 Legislation re Food Contact Materials and Recycled Materials

EC Framework Regulation EC 1935/2004 Food Contact Materials (FCM)

The Regulation - in force since 3 December 2004 - requires that food contact materials:

- Are safe;
- Must not transfer their components into food in quantities that could endanger human health, change food composition in an unacceptable way or deteriorate its taste and odour.
- Are manufactured according to good manufacturing practice (GMP)
- An article intended for food contact must be labelled or bear the glass-and-fork symbol. This labelling is not obligatory if food contact is obvious by the article's nature eg knife, fork, wine glass.
- Labelling, advertising and presentation of food contact materials must not mislead consumers.
- Information on the appropriate use of food contact materials or articles must be provided, if necessary
- Are traceable throughout the production chain.

Groups of materials and articles

The Regulation establishes 17 groups of materials and articles which may be covered by specific measures. The specific measures may cover also combinations of different materials or recycled materials:

- Active and intelligent materials and articles
- Adhesives
- Ceramics
- Cork
- Rubbers
- Glass
- Ion-exchange resins
- Metals and alloys
- Paper and board
- Plastics
- Printing inks
- Regenerated cellulose
- Silicones
- Textiles
- Varnishes and coatings
- Waxes
- Wood

There are specific measures for ceramics, regenerated cellulose, plastics, recycled plastics and active and intelligent materials and articles.

The Regulation includes definitions on active and intelligent packaging. If the materials release substances in the food that change the food composition or properties, then these substances must comply with food legislation, eg food additives.

This was the first step toward the harmonization of legislation about FCM and general good manufacturing practice, lacking in some countries of the European Community. The importance of the GMP was particularly evident after some cases of contamination of products due to inks present in packaging (i.e. Milk).

The specific measures referred to in Article 5 shall require that materials and articles covered by those measures be accompanied by a written declaration stating that they comply with the rules applicable to them.
The Regulation (EC) 1935/2004 introduced the following:

- Safety Standard for the Health of consumer eg sufficiently inert to ensure a high level of protection of human health
- Traceability
- Written declaration to report compliance of all FCM

EC Regulation No 282/2008 On recycled plastic materials intended to come into contact with food.

This regulation sets out the requirements for recycled plastics to be used in food contact materials and establishes an authorisation procedure of recycling processes used in the manufacture of recycled plastics for food contact use. It establishes requirements as regards the materials that can be recycled and the efficiency of recycling process to reduce contamination. The regulation aims to create a more efficient and practical system for regulating the use of recycled plastics in food packaging.
Any company wishing to use recycled plastics in food contact applications will need to gain approval from the European Food Safety Agency (EFSA), which will base its safety assessment on factors such as the quality of the recycled raw material, the efficiency of the decontamination process and the plastic's intended use. Once EFSA has evaluated a particular case, its verdict will be forwarded to the EC. If the EC authorises the case, it will then be added to the register of approved recycling processes.

11.4 Appendix 4 BPF Recyclers guide

Companies That **Buy** The Following Products:

	ABS	EPS	HDPE	HIPS	LDPE	LLDP	MDPE	Mixed	Nylon	PC	PET	PP	PS	PVC	Other	Compound/Pellet	Flake	Bottle Bales
2K Manufacturing (Ecosheet)	√	√	√	√	√		√	√				√	√		√	√	√	√
Axion Polymers				√				√				√	√		√		√	
Biffa Polymers			√	√	√	√	√	√		√		√	√			√	√	
Boomerang Plastics				√								√	√					
BPI Recycled Products			√		√	√	√									√	√	
Centriforce Products Ltd			√		√	√	√					√				√	√	
Chase Plastics			√		√	√	√					√				√	√	
C K Polymers	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Closed Loop Recycling Ltd			√					√			√							√
C L Rye Trading Ltd	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Cromwell Polythene Ltd	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√			√
Dennison UK Ltd	√		√	√	√		√		√	√		√	√				√	
Ecodek Vannplastics Ltd			√															
Eco Plastics Limited	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Environcom Ltd				√			√	√				√	√		√		√	
Iplas	√	√	√							√	√	√	√					
Jayplas	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
JFC Plastics Ltd			√		√	√	√	√				√				√	√	
Luxus Ltd	√		√	√	√		√	√	√	√	√	√	√		√	√		
Norpol Recycling Limited	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Oxford Plastic Systems Ltd		√		√	√	√								√		√		
PET Processors (UK) LLC											√					√	√	
Philip Tyler Polymers Ltd	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
PPR WIPAG Ltd	√		√	√	√		√	√	√	√		√	√		√	√	√	
REGAIN Polymers Ltd			√	√	√	√	√			√		√	√				√	
Repro Plastics Ltd	√		√	√	√				√	√		√	√	√	√			
R & P Recovery Ltd			√		√							√				√	√	
Sibani Eco Plastics Ltd	√			√					√	√	√		√					
Simba Plastics Ltd	√	□	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Sims Recycling Solutions	√		√	√	√		√	√		√	√	√	√		√	√		
T D G	√		√	√	√	√			√	√	√	√	√	√		√	√	
Veka Recycling Ltd														√				
Viridor Polymer Recycling Ltd			√								√					√	√	
Wellman Recycling											√					√		

11.5 Appendix 5 Regulations, Legislations and directives

From 1998, under the implementation of Directive 94/62 EC (2) by the Producers Responsibility Obligations (Packaging Waste) Regulations 1998, producers, manufacturers, wholesalers, packer/fillers, importers and sellers have a responsibility to recover and recycle packaging waste and to record the amount in tonnes of each type of material sent to a waste packaging processor eg for recycling, energy recovery or landfill. All companies with a turnover greater than £1million handling more than 50 tonnes of packaging material had to register with the EA or SEPA to do this.
Since the mid 2000's 'The Courtauld Commitment' has impacted upon this area. This is a responsibility deal aimed at improving resource efficiency and reducing the carbon and wider environmental impact of the grocery sector. Phase 1 took shape at a ministerial/industry summit in 2005. Phase 2 was announced in March 2010 and it runs until December 2012.

The Courtauld Commitment (see Appendix 1 for more detail) supports the UK governments' policy goal of a 'zero waste economy' and the objectives of the Climate Change Act to reduce greenhouse gas emissions by 34% by 2020 and 80% by 2050.
WRAP is responsible for the agreement and works in partnership with leading retailers, brand owners, manufacturers and suppliers who sign up and support the delivery of the targets.
The British Retail Consortium and the Food and Drink Federation are also aligned with its principles.

Today the EU Waste Framework Directive EC 98/2008 (see Appendix 2 for more detail), provides the overarching legislative framework for the collection, transport, recovery and disposal of waste, and includes a common definition of waste and recycling. Its implementation in the UK is through a number of regulations in England, Wales, Scotland and Northern Ireland. These regulations have recently been revised through The Waste (England and Wales) (Amendment) Regulations 2012. One amendment to the Waste (England and Wales) Regulations 2011 replaces regulation 13 so as to impose a duty on establishments and undertakings, from 1 January 2015, to separately collect waste paper, metal, plastic and glass.
The UK Budget 2012 confirmed higher packaging targets for 2013-2017. For plastic packaging recycling this involves a 5% point per year increase in each of the next five years, to 57% in 2017 for obligated plastic packaging. In the future issues such as energy usage in the packing process are likely to become more important as scrutiny of both cost and carbon footprint increases.

11.6 Appendix 6 Waste Regulations, directives and permits

There is an assortment of regulations, directives and permits that need to be followed to enable the legitimate use of conversion technologies e.g burning biomass for heat or power generation from waste plastic project are initiated. The details are found on the Defra website and only a brief summary is included below.

Environmental Permitting Programme (EPP)

Phase 1 of the Environmental Permitting Programme (2005-2008) created a single regulatory system to integrate Waste Management Licensing and Pollution Prevention and Control and create a simplified system. EPP 1 was introduced in 2007 as the Environmental Permitting (England and Wales) Regulations 2007, replacing individual 41 statutory instruments.

The specific provisions and thresholds for waste incineration and pollution prevention and control have not been significantly changed, simply consolidated into the single framework. There is information from Defra, the Environment Agency and NetRegs.

Waste Incineration Directive (WID)

The 'thermal treatment' which includes combustion, gasification and pyrolysis of solids or liquids that can be defined as waste ('which the holder discards or intends or is required to discard') is governed by the Waste Incineration Directive (WID). Guidance on the WID is available from Defra (Environmental Permitting Guidance The Directive on the Incineration of Waste). The guidance states that 'for the purposes of the WID 'waste' has the same meaning as in the EC Waste Framework Directive (WFD)', however there is no definitive list of what is and is not waste beyond the statement above, leaving courts to be the final arbiter. There are, however, a number of specific wastes excluded from the scope of WID:

- Vegetable waste from agriculture and forestry
- Vegetable waste from the food processing industry (providing the heat generated is recovered)
- Fibrous vegetable waste from pulp making (provided this happens on the site of waste generation and the heat generated is recovered)
- Wood waste (with the exception of wood waste which has been treated with wood preservatives or coatings containing halogenated organic compounds or heavy metals)
- Cork waste
- Radioactive waste
- Animal carcasses covered by the Animal By-Products Regulations

In addition, experimental plants that are used for research, demonstration and testing, and also treat less than 50 tonnes of waste per year, are also excluded from the WID. The WID imposes requirements on the types of waste permitted at a given plant, delivery and reception of the waste, the thermal conversion equipment used and the operating conditions required, abatement plant, emissions monitoring requirements

and emission limits values to air and water. Disposal of ash is not specifically covered by the WID, however other EU legislation is relevant, such as the Landfill Directive. Waste is defined as either non-hazardous under the WID (according to the European Waste Catalogue) or hazardous, and the technical requirements of the processing plant are different in each case.

Even plants that are excluded from the WID by virtue of the fact that they only treat excluded wastes may still require a Pollution Prevention and Control (PPC) Permit, a Waste Management Licence or an Exemption.

Under very limited circumstances waste derived fuel (WDF) may cease to be waste before it is used as fuel if it has been subject to some form of processing, however this is subject to ruling by courts and is not expected to apply in many cases.

Clean Air Act

The Clean Air Acts of 1956 and 1968 were a response to the smogs of the 1950s and 60s and allowed local authorities to define smoke control areas. They were consolidated into the Clean Air Act of 1993.

Within smoke control areas authorised fuels, which include gas, electricity anthracite and specified manufactured smokeless fuels, may be used. Any other fuels, including wood and pellets, may only be burned in an exempt appliance that has been specifically tested and approved under the Clean Air Act.

Pollution Prevention and Control Regulations (England and Wales)

The Pollution Prevention and Control Regulations in England and Wales are intended to regulate the emission of pollution into the air, water or land, or other forms of pollution including odour, heat, noise and vibrations and also cover the prevention of accidents. Installations are divided up into different classes of industrial processes or activities and three separate, but linked systems of pollution control cover the different classes:

Integrated Pollution Prevention and Control (IPPC) covers Part A(1) installations, regulated by the Environment Agency
Local authority Integrated Pollution Prevention and Control (LA-IPPC) covers Part A(2) installations, regulated by local authorities
Local authority Pollution Prevention and Control (LAPPC) covers Part B installations, also regulated by local authorities
Operation within these regulations is allowed by permits that set operating conditions, based on the use of 'Best Available Techniques' (BAT). Classification as Part A(1), A(2) or B depends on the activity undertaken and sometimes on production capacity.

Part A(1) activity includes burning any fuel in an appliance with a rated thermal input (or aggregated output from all appliances on a site) of 50 MW or more, and also the burning of waste oil, recovered oil or any fuel manufactured from, or comprising, any

other waste in an appliance with a rated thermal input of more than 3 MW. It also includes gasification and pyrolysis of carbonaceous material except wood that has not been chemically treated.

Part A(2) does not cover combustion, gasification or pyrolysis activities.

Part B activity includes burning any fuel in an (individual) appliance with a rated thermal input of 20 MW or more, but not covered by Part A(1), and also the combustion of waste oil, recovered oil or solid fuel recovered from waste by an activity involving the application of heat, in an appliance with a thermal input less than 3MW. It also covers the burning of other fuels manufactured from or including waste in an appliance with a rated thermal input of less than 3 MW, but at least 0.4 MW. Part B activity regulations only regulate emissions to air.

If a plant on a site was burning biomass purely to destroy it, it would be regarded as an incinerator, which, if of 50 kg/hr to 1 tonne/hr capacity, would also come under Part B.

If any of these activities are to be undertaken the appropriate permits must be obtained from the relevant regulating authority.

PPC regulations may be in addition to the requirements of the Waste Incineration Directive (WID).
There is also a Large Combustion Plant Directive which applies to combustion plants with a thermal output greater than 50 MW also available on the Defra website.

The Plastic Materials and Articles in Contact with Food (England) Regulations 2009 is the UK statutory instrument controlling the use and safety of plastics

11.7 Appendix 7 Cement Companies

Hansons
Currently burn tyre chips as well as secondary liquid fuels eg industrial solvents

North Wales Padeswood
Padeswood works in north Wales uses of alternative fuels. Alternative fuels used at Padeswood include Cemfuel, which is processed from the residue of recycled waste solvents; Profuel, which comprises paper and plastic wastes and also MBM which is processed meat and bone meal. Vehicle tyres can also be used as an alternative fuel.

Ribblesdale – Clitheroe; Lancashire
Set up in 1936 as a joint venture between Tunnel Cement and Ketton Portland Cement. The plant intends to increase the use of alternative fuels to replace the traditional coal used to provide energy for the kilns.

LaFarge Cement
LaFarge have 6 cement manufacturing sites in the UK
Cauldon Works Staffordshire Moorlandshas a permit to use chipped used tyres, Processed Sewage Pellets (PSP), Recovered Fuel Oil and has a permit to evaluate the use of Solid Recovered Waste (SRF) in addition to traditional fossil fuels. As well as replacing finite fossil fuels with fuels processed from waste materials, these fuels also have carbon neutral content, helping the company to meet its commitment to reduce its carbon footprint. The site also uses paper ash and ash as raw materials replacing, in part, naturally occurring minerals and helping to achieve the exact chemical composition required to make cement.

Cookstown Northern Ireland
The site has a permit to use of waste-derived materials derived from used tyres and recycled liquid fuels as fuels for its cement kiln. As well as replacing finite fossil fuels with fuels processed from waste materials, these fuels also have some carbon neutral content. However at present the plant is only using traditional fossil fuels to provide the energy for its kiln.

Aberthaw Works
Has a permit to use Meat and Bone Meal (MBM) as a fuel, in addition to traditional fossil fuels. The site also uses paper ash and slag (from the steel making industry) as raw materials replacing in part naturally occurring minerals and helping to achieve the exact chemical composition required to make cement.

South Ferriby
While traditional fossil fuels – coal and petcoke – still have a role to play, South Ferriby is increasingly using more sustainable and cost-effective alternative fuels. It has been successfully using Secondary Liquid Fuel (SLF) made from industrial liquid wastes that can't be recycled since 2002. More recently, it has added Climafuel, a fuel made from

household waste that is processed to a tight specification. It reduces landfill and saves fossil fuels for future generations.

Dunbar
The only cement works in Scotland has capacity to make over one million tonnes of cement a year.

Cemex - Rugby

11.8 Appendix 8 Gas Flushing

Gas Flushing is a technology that is gradually being replaced by vacuum-packing for primals. However it is useful when large quantities of meat are stored in dolavs etc.
Some of the issues with Gas Flushing

1. It is not suitable for beef muscles as they contain a higher content of the colour pigment myoglobin which, in the presence of oxygen, oxidizes to metmyoglobin, causing 'browning' of the meat. This can occur at oxygen levels as low as 0.3%. It is difficult under commercial conditions to create and maintain carbon dioxide atmospheres sufficiently low on oxygen to prevent this surface discolouration from occurring. Since beef cuts are generally boneless and of a shape that can be easily vacuum-packed, there is little advantage in MAP as an alternative for vacuum-packing single primals
2. Primals need to be removed and allowed to 'breath' before MAP retail packing. If removed from MAP, sliced and placed back into MAP retail, it has been seen for the retail packs to balloon, since the meat releases Co2 in the retail pack that cannot escape.
3. Another thing with gas flushing is that pouch needs to be of a very high barrier, which can make it expensive.

11.9 Appendix 10 Intermediate packaging

	Home Slaughter	Cattle	Pork	Sheep
	Heads (000) (UK slaughterings M.I. AHDB)	2,761	9,813	14,485
	Bags per carcase	44	16	8
	Weight of bag .see below	0.045	0.035	0.035
	Total plastic	**5,467**	**5,495**	**4,056**
	Not all primals would be wrapped (dry aged, no aging etc)	80%	50%	15%
	Estimate 1 intermediate plastic used in UK inc NI	**4,373**	**2,748**	**608**
1	Slaughtered production (000) tonnes UK	937	806	289
	Percentage of UK tonnage for intermediate packed	75%	50%	30%
	(000) Tonnes that gets packaged	703	403	87
ASS	Millions of bags 7 kg beef; 5kg pork & lamb per bag	100	81	17
ASS	Weight of bag for 7 or 5kg (kg)	***0.045***	***0.035***	***0.035***
	Weight cardboard 25kg boxes	0.4	0.4	0.4
	Weight of Plastic (tonnes)	4,518	2,821	607
A	**Tonnes of plastic**	**4,518**	**2,821**	**607**
ASS	Percentage in cardboard boxes	50%	50%	50%
	Tonnes of meat in boxes	351,375	201,500	43,350
	Number of boxes 25kg in a box	14,055,000	8,060,000	1,734,000
	Weight of cardboard box (kg)	0.4	0.4	0.4
C	**Total weight of cardboard**	**5,622**	**3,224**	**694**
Exported (000) tonnes				
	Carcases (000) tonnes	174	206	103
	Boneless cuts			
Imported	**(000) tonnes**	**384**	**958**	**104**
	Fresh/frozen	292	409	102
	Processed	92	221	2
	Bacon (pork only)		328	
Balance remaining in the country				
ASS	**Carcases + bone in cuts (000) tonnes**	**210**	**752**	**1**
ASS	% wrapped in plastic/or will be wrapped in plastic	75%	40%	30%
	Weight of meat wrapped in plastic (000) tonnes	157.5	301	0.3
	Millions of bags 7kg beef/ 5kg per bag	22.5	60	0.1
	Weight of Plastic (tonnes)	1,013	2106	2.1
B	**Tonnes of plastic**	**1012.5**	**2106**	**2.1**
A + B	**Total plastic (primal packaging)**	**5,530**	**4927**	**609.0**
	Percentage in cardboard boxes	70%	30%	80%
	Tonnes of meat in boxes	110250	90240	240
	Number of boxes	4410000	3609600	9600
D	**Weight of cardboard - Tonnes**	**1764**	**1444**	**4**
C + D	**Total weight of cardboard**	**7,386**	**4667.84**	**697.44**
A + B	**Landfill PLASTIC (tonnes)**	**5,530**	**4,927**	**609**
C + D	**Total weight of cardboard**	**7,386**	**4,668**	**697**
	Percentage to go as land fill	25%	25%	25%
	Weight for recycling	5,540	3,501	523
	Landfill CARDBOARD (tonnes)	**1,847**	**1,167**	**174**