

# FINLA REPORT - Inorganic waste management at abattoirs

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## 1.0 Executive Summary

This report summarizes the investigation into how inorganic waste streams can be avoided, reduced, reused or recycled via projects that provide a Return on Investment (RoI). The industry has made significant efforts to improve the environmental sustainability of red meat processing, however further improvements can be made through better informed procurement; investment in innovative technologies, processes, and practices; training of staff; and ensuring sustainable use of resources in a responsible and efficient manner.

From a long list of potential areas for more detailed cost benefit analyses (CBAs), the specific option of interest was a review of options for waste polymer packaging materials. Generally, paper, cardboard and metals are recommended for segregation for recycling whilst contaminated plastics, paper and cardboard and wood tend to be landfilled.

The following table summarizes the key findings of this project:

Scenario	Findings
Current waste management	1031 tonnes per annum contaminated plastics, cardboard, paper and wood.
Waste co-firing in an existing solid fuel boiler	1 month to +1 year - depending upon material handling requirements and complexity for environmental approval
Packaged Plant Solid Fuel Boiler	3.4 years
Waste compaction	3 months
Small scale plastic pyrolysis	+10 years
Waste segregation for enhanced recycling	Immediate payback
Waste Recycling with local council	Immediate payback
Plastic procurement strategy	Immediate environmental improvement
Off-site waste to energy	Approximately break-even compared to landfilling assuming no capital / start-up costs. Further detailed analysis required.

## 2.0 Introduction

Meat processors are under pressure to reduce landfilling to reduce operating costs and are also experiencing a demand for increased environmental stewardship such as “zero waste to landfill”. The challenge is not to simply find new ways of disposing of the solid waste, but to find economically and environmentally acceptable means of recycling waste, thereby moving towards a circular economy.

Through ‘green supply chain management’ and environmentally sustainable practices, meat processors can minimize waste and achieve cost savings, leading to a stronger bottom line. Consumers are increasingly committed to “going green”, for example, eco-friendly businesses often benefit from favorable public opinion, greater customer loyalty and higher pricing strategies. McDonalds is an example of a company that has announced a push for sourcing increasing quantities of sustainable beef, and with enough scale to influence investment priorities within beef suppliers, with projects meeting environmental and sustainability program scorecards being an example [1].

Green supply chain management can be defined as integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product as well as end-of-life management of the product after its useful life (the emphasis of different aspects depending dependent upon the meat processors place in the supply chain).

Companies within the Fast Moving Consumer Goods (FMCG) sector have begun to generate money from the by-products they once threw out. They use sustainability as a tool to increase their competitive advantage [2]. The Green Supply Chain model can be utilized as a competitive advantage enabler for integrated processors. Woolworths (and their integrated supply chains), for instance, are offering environmentally friendly products, and are charging premium prices for them. They are also able to charge higher prices for organic food, including meat, since people are more than willing to pay for organically grown food [3]. Sustainability can offer a company a distinct competitive advantage. Through the creation of a sustainable supply chain, opportunities arise to save money that would have been spent on disposing waste materials and harmful by-products. Sustainable supply chains decreases the amount spent on waste by making money out of it, with no waste of precious material, financial and human resources.

Appendix 1 provides a summary of environment practices commonly employed by the meat industry and uses principles of the waste hierarchy, which favor redesign of system to prevent waste over reactive practices such as disposal of existing waste, and combines this with the importance of developing site level waste management plans to capture information on waste production and treatment and asses alternative options such as these presented in this report. Table 1. Give a brief summary of some frequently sited methods in waste management plans.

Table1. Summary of Meat industries environmental best practices. (Source: AMPC Impact Review 2003)

Environmental Best Practice Overview	
Develop a waste management plan that includes:	<ul style="list-style-type: none"> <li>- Waste types and quantities generated</li> <li>- waste management solutions</li> <li>- opportunities for minimising waste</li> <li>- staff training</li> </ul>
Reduce Waste	<ul style="list-style-type: none"> <li>- Consider Lifecycle issues when purchasing an item</li> <li>- Consider processing and packing procedures that minimise waste material</li> </ul>
Reuse/Recycle	<ul style="list-style-type: none"> <li>- Consider purchasing items made from recycled material</li> <li>- Separate recyclable material from general waste</li> <li>- Encourage/educate staff to separate recyclables</li> <li>- Convert organic wastes into usable products</li> </ul>
Minimise waste to landfill	<ul style="list-style-type: none"> <li>- Monitor and report amount of waste sent for landfill</li> <li>- Eliminate recyclables from landfill waste</li> </ul>
Processing wastes on site	<p>If processing organic wastes on site:</p> <ul style="list-style-type: none"> <li>- Consider the proximity of neighbours and the property boundary; and</li> <li>- Ensure processing does not contaminate the surrounding environment</li> </ul>
Compliance	<ul style="list-style-type: none"> <li>- Ensure activities comply with regulatory requirements</li> </ul>

These methods for waste reduction are merely elements in the toolbox of what is a broader and more comprehensive waste management strategy that should act to guide investment and the effective allocation of resources.



**2.1 Current Industry Performance**

**2.1.1 Overview of Key Performance Indicators (KPIs)**

To understand the use of waste management options, it is important to review current KPIs and industry performance. It is important to understand the tools that processors use to review performance and how far has the industry tracked since the implementation of these measures. What is missing that keeps companies from reaching their desired targets and holds the industry back from seeing optimal ROI from its funded sustainability programs and research? KPIs have been developed to measure and assess the progress and effectiveness of waste reduction and management programs and to improve environmental sustainability.

Traditionally, inorganic waste has been grouped under broad categories (solid waste and packaging) and measured in quantity per tonne Hot Standard Carcass Weight (HSCW). This broad industry measure can be applied independently of the animal species being processed. Table 2 summarizes the inorganic KPIs that were generally used in the meat processing industry.

Table 2: Solid Waste and the KPI Used to Measure waste management effectiveness (Source: AMPC Industry Environmental Sustainability Review 2010)

Solid Waste	
Small volumes of miscellaneous solid waste are sent to off-site landfill, which forms the primary KPI for solid waste	
Key Performance Indicators	
- Amount of solid waste to landfill	Industry average (20013/2014) • 5.6 kg/tonne HSCW
- Packaging waste	

This indicator tracks performance in reducing solid waste production and landfill burden. By reducing solid waste sent to landfill, red meat processors can limit demand for new materials and the various environmental impacts associated with solid waste disposal.

**2.1.2 Reported Waste Streams**

Organic waste in processing facilities is almost entirely processed into other beneficial products such as compost. The majority of solid waste from red meat processors is biologically derived: paunch solids, manure, yard wastes, sludges from wastewater treatment plants and dissolved air floatation plants, cardboard and paper. Scrap metals and waste oil are normally segregated and recycled. The remaining solid waste sent to landfill is generally “miscellaneous mixed waste” for which local recycling pathways are variable, not available or are cost prohibitive.

Solid waste reported as sent to landfill was 5.9 kg/t HSCW in the 2013-2014 period. Levels of waste to landfill have approximately halved since 2008/2009 when 11.3 kg/t HSCW was reported, with an overall 67% reduction in this KPI since 2003.

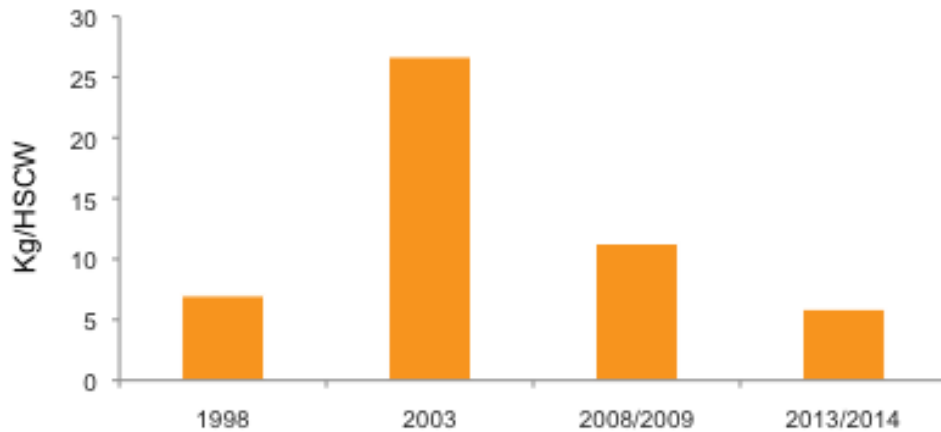


Figure 2: Historical measurements of kg/HSCW (Source: AMPC Environmental Performance Review 2013-2014).

Effective measurement and reduction targets appear to be strongly correlated to waste reduction sent to landfill. One third of facilities reported having a solid waste reduction target with these facilities producing approximately 20% less solid waste to landfill than facilities without such a target [7].

The 2003 environmental review report detailed the specific measurements of waste. Although measurement and recording has improved since 2003, data on recycling and waste disposal is suspected to be incomplete at least at some sites. It cited examples of unrecorded fullness of the bin at emptying and the estimated bulk density of the waste contributing to the inaccuracy of the estimation.

Sites currently do not provide an estimation of the quantity of different waste streams produced, recycled and disposed of to landfill. This proves difficult when identifying effective treatment/collection options for different waste streams beyond sourcing the most cost effective contractor. Both landfill waste and waste destined for various recycling streams, is contracted out to a third party providers with records of individual streams not kept by the plant.

The most notably recycled waste is cardboard and paper with a reported (2008/2009) 79% recycling rate. This material, with the exception of contaminated products, is considered easily recycled and collected in large enough quantities to justify collection. Data on the recycling of plastics within different plants is not readily available. Plastics are often associated with higher rates of contamination and lower quantities, which may explain this lack of data.

Estimated total usage of packaging materials and waste produced is summarized in Table 3 which is derived from a 1996 MLA report and is the most inclusive data within the existing literature.



Table 3: Packaging Waste Stream Estimates for the Meat Industry (Source: AMPC waste solids Environmental Best Practice Manual 2003)

Packaging	Domestic (tonnes)	Export (tonnes)	On-plant (tonnes)	waste	Total (tonnes)
Cardboard	14,191	28,568	985		43,745
Plastic	232	2,471	141		2,735
Vacuum bags	1,607	1,681	320		3,608
Strapping	375	781	23		1,179

Figure 3: Break down the waste streams into their constituent elements with associated percentages. It has taken the data from multiple reports of total waste produced by the meat industry and used data from the 1996 report to create a visual of approximate wastes generated by the industry.

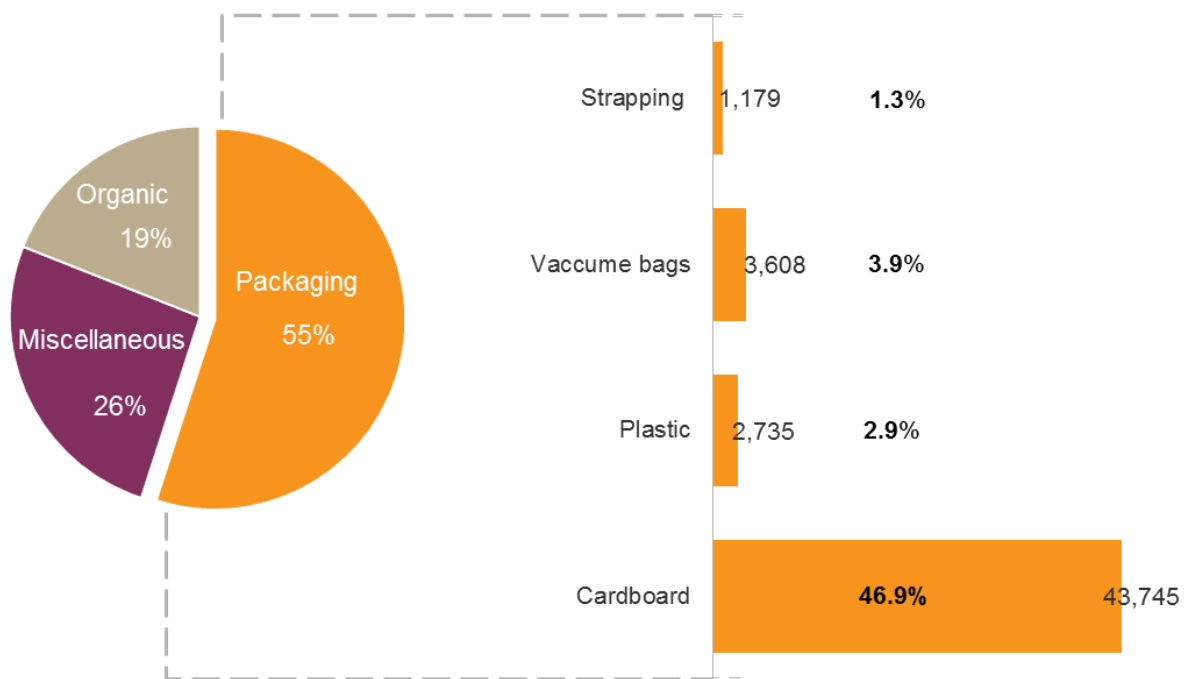


Figure 3: Estimate of overall wastes generated by the meat processing industry

Another category of waste reported widely by the FMCG industry, but generally not measured or reported by processes, are Class 3 greenhouse gas (GHG) emissions – being those emissions attributable to an organization’s activities and interactions with broader society (e.g. embodied energy in feed stocks, delivery trucks, airline flights). In one-way, the measurement of GHG emissions is indicative of how evolved an organization is to its sustainability agenda and the importance it places on assisting society at large. A lifecycle assessment of products, including meat trays and other organic wastes, would

inevitably include Scope 3 emissions and open up options to redesign entire systems to minimize environmental impact. This would have particular value for vertically integrated businesses to understand where their operations are “carbon heavy”.

### **2.1.3 Implications**

With the currently reported waste per hot standard carcass steadily improving, companies and individual processing facilities need to ask themselves how improvements can be executed to move to the next level and how to derive more value at a lower cost and to create more with less. Capturing data on individual waste streams, such as a waste audit, is a strong starting point for use within a broader waste management plan.

### 3.0 Project Objectives

This project included the following key works:

- Benchmarking of FMCG and Australian Meat Processing Practices
- Stakeholder input from AMPC and a facility for completion of a case studies based on appropriate tonnes per annum and composition of materials for an Australian facility.
- Review of previous works and existing practice.
- Review of additional drivers and constraints (i.e. budgetary and or space restrictions, lack of industry knowledge) for adoption.
- Preliminary Cost-Benefit and Return on Investment Analysis including Total Capital Investment (TCI) based on vendor submissions or cost of implementation analysis (in the case of a process); Operating and maintenance costs and revenue / cost savings; Economic analysis: Earnings Before Income Tax, Depreciation, Amortization (EBITDA in \$ pa), discounted pay back, simple payback, internal rate of return / return on investment and net present value.
- Presentation of findings and discussions with key stake holders.
- Sensitivity analysis to determine the variables and scenario assumptions that have the greatest impact on the overall economics.
- Refinement of findings, aggregation of feedback and integration into a final report and SnapShot.

## 4.0 Methodology

### 4.1 Facility Case Study

The abattoir chosen for the case study has a capacity to process 1500 head/day. The table below summarizes the current inorganic waste streams.

Stream	Vol. p.a. m <sup>3</sup> p.a.	Mass Tonnes p.a.	Volumetric cost \$/ m <sup>3</sup>	Mass based cost \$/ t	Assumed density kg/m <sup>3</sup>
Cryovac bag plastics	3036	598	22.82	115.83	197
Combined waste: plastics and cardboard	1395	432	23.32	75.22	310
Sub-totals contaminated	4431	1031			
Workshop waste: wood, metals, plastic	560	174	10.41	33.58	310
TOTALS	4991	1204			

The data was aggregated by Seonmi Lee from USQ and in conjunction with abattoir site staff under the supervision of A/Prof Bernadette McCabe.



Figure 4: Cryovac plastic bins



Figure 5: Boning room combined waste



Figure 6: Workshop waste

Cryovac solid materials can be PP and PS with films made from PVDC (polyvinylidene chloride), primary packaging of PVDC coated PA/PET films and PVC film with PE sealants; secondary packaging of corrugated board carton, rolls wrapped in PE film and tertiary packaging of timber pallets with corrugated board base and PE stretch film.

#### 4.2 Overview of Plastic In meat Processing

Waste streams generated from plastic represent a significant opportunity for waste management strategies. To analyse the opportunity the types, quantities and reasons for using packaging needs to be developed to facilitate the reduction of these waste streams.

##### *Packaging*

Packaging is one of the main factors that allow meat to have increasingly longer shelf lives, increased quality and appealing product, adding to the products value delivered to the customer. Packaging is used for storage, distribution and the reduction in microbiological and physiochemical alterations experienced over the life of the product. Material integrity must be maintained for vacuum packing and any cracks or punctures occurring in the handling and distribution. The plastic requires good mechanical, barrier and sealant properties. Years of research using certain plastics, not designed to be friendly for recycling, increase the difficulty for a recyclable packing replacement without similar research investment or sacrificing shelf life and robustness.

#### *Product and Regulatory Labeling*

Often the product labelling is a combination of a customer marketing perspective (labelling), as well as the regulatory requirements to display certain quality and product information to customer. Different mixes of plastics are employed and render potentially recyclable plastics redundant, as the difficulty in separation is too high and costly.

#### *Product differentiation*

Sales and marketing teams often are the main decision makers when it comes to the final product for consumers including the design and labelling. Often environmental issues are outweighed in favour of attractive labelling and the increasingly pre-packaged and ready microwavable meals etc. which are pushing to dominate in the quest for product differentiation. Collaboration with production and marketing teams could create benefit.

### 4.3 Supply Chain Contributors

Table 6: Overview of plastics used in the meat supply chain [20]

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) <sup>9</sup>	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
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) <sup>10</sup>	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 <sub>2</sub> + , water vapour –)	High recyclability
Recycled polyester (r-PET)				High recyclability
Crystalline polyester (C-PET)	Heat resistant	Trays for ready meals		High recyclability <sup>11</sup>
Polystyrene (PS)		Food trays, take-away trays, meat trays		Not common in UK
Polyamide (PA) or Nylon	Self-adhesive	Flexible film	(oxygen – , water vapour +)	
Polyvinylidenechloride (PVDC)		} used as barrier plastics		
Ethylenvinyl alcohol (EVOH)				

Depending on the location within the supply chain, generation of plastics can vary significantly. A broad overview of where plastic waste in the supply chain is presented.

#### Primal Packaging

Primals are whole muscles removed from the bones or skeleton and occurs in the section of the facility known as the boning hall. Dependant on the throughput, companies will vacuum pack for aging to occur. Once aging has finished, the primals are then transported for further processing or continued on site.

### *Retail packing*

Although some supply chains may be integrated processors, the second stage is retail packaging and involves removal of any primal packaging (dependant on what feeds into this section of a facility). These represent integrated processors, separate retail packaging facilities where packaging is removed and repackaged for specific customers after further processing has been carried out. Often the plastic from this stage, due to its contamination, is taken to landfill with other plastic.

Various synthetic packaging films are used for the packaging depending on the product and distribution requirements. These may include the presentation, shelf life, transportation needs and the corresponding properties: transparent, opaque, flexible, semi-rigid, gas-proof, permeable plastics.

A collection of plastics used in meatpacking is listed below. They are favoured for their versatile and robust properties and often in multilayer films.

- 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)

After the packing is completed the next step is the outer packaging, placement within a cardboard box packing or sturdy reusable plastic trays, which are placed on bulk wooden pallets and wrapped in shrink wrap (PE).

#### **4.4 Packaging Waste and where it is produced in the chain**

Carcases are distributed from abattoirs to the boning halls as naked carcasses. Some integrated supply chains may not vacuum pack primals but use large Dolavs with plastic liners to hold and transport meat. However vacuum packing does occur especially if it is being transported to offsite retail packaging companies, processors or wholesalers. Table 6 show examples of wasted generated at different points in the processing supply chain.



Table 6: Wastes Produced at different Stages and Facilities in the Meat Processing Supply Chain [20]

Waste in Processing Chain		
	Recyclable- Clean	Landfill- Contaminated
Abattoir	<ul style="list-style-type: none"> <li>- Office Waste</li> <li>- PPE packaging</li> <li>- Cardboard</li> <li>- Paper</li> <li>- Plastic</li> </ul>	<ul style="list-style-type: none"> <li>- Cardboard</li> <li>- Paper</li> <li>- Plastic</li> <li>- Canteen Waste</li> </ul>
Cutting Plant	<ul style="list-style-type: none"> <li>- Office Waste PPE &amp; PPE</li> <li>- Packaging</li> <li>- Off Cuts From Vac Pack</li> <li>- Cardboard (boxes and rolls)</li> <li>- Stringer Waste</li> <li>- Equipment Waste (plastic Trays, Dolavs, metal trays, rollers etc.</li> </ul>	<ul style="list-style-type: none"> <li>- Cardboard</li> <li>- Stringer Elastic</li> <li>- Plastic</li> <li>- Canteen Waste</li> <li>- VP Off Cuts</li> <li>- Primal Packaging</li> </ul>
Retail Packing Plant	<ul style="list-style-type: none"> <li>- Office Waste</li> <li>- PPE &amp; PPE Packaging</li> <li>- Skeleton waste</li> <li>- Empty Trays</li> <li>- Cardboard rolls</li> <li>- Clean Film</li> <li>- Separators</li> <li>- Labels/Paper</li> </ul>	<ul style="list-style-type: none"> <li>- Primal Packaging and Cardboard Plastic, Films</li> <li>- Dolavs</li> <li>- Separators</li> </ul>

*Clean Plastic*

Quantities of clear plastic are currently not reported and available data does not exist within Australia. In a ‘best-case’ scenario where uncontaminated plastic is available, a collector can be paid, if in large enough quantities, to collect material (dependent on the economies of post recycle plastic, the type of plastic and available recycling facilities often limited in Australia).

Either a large continuous throughput or appropriate storage facilities are required to collect and store waste until it is in economic quantities to ship off site. Abattoirs, cutting plants, retail packaging plants are often a source of this waste in the form of PPE and office wastes. The cutting process often produces waste as a result of oversized bags in trimming. Retail packaging plants have a similar problem of thermoformed plastics involved in the various machine startups, change over’s and associated waste etc. These wastes at least have the potential to be recycled.

Of course an economic advantage has to be clearly identifiable to justify investment in storage facilities for waste, sorting of waste and payment of recyclers as opposed to simply landfill.

Contaminated Plastic

Table 7: Contaminated Plastic Sources within the Meat Supply Chain

Contaminated Plastic Sources			
Description	Location	Contamination	Recyclability
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	Abattoirs that supply multiple retailers	- Blood - Faeces	- Non recyclable
The plants debone carcasses, pack, store and age the meat. When product is appropriately aged, plastic bags are commonly disposed of and rewrap the product in accordance with customers requirements	Cutting Plant	- Blood	- Non recyclable
The largest amount of waste plastic film is from the vacuum-pack bags used to store, age, protect and transport the primals <sup>15</sup> . This plastic is a multilayer film bonded together comprising three to five layers. Many tonnes of this plastic that currently go to landfill	Retail Packaging plants Retailers, meat processing and foodservice establishments (eg burger manufacturers, ready meal companies, sausage producers, canning factories etc.) also contribute.	- Blood	- Mixed, Non recyclable
All the above plastics currently get mixed with the canteen waste and floor contaminated plastics and end up in skips	Meat Factories	- Organics - Blood	- Mixed, Non recyclable
'common waste', the boxes and plastic bags in which the PPE is delivered, canteen and office waste.	- Abattoirs - Cutting plants - Wholesalers - Retail packing plants	- Mostly Clear - Mixture with blood	- Most is recyclable (clean Component)

Using as estimate of cuts and bag weights per carcase and the Australian slaughter figures from the ABS on monthly slaughter data for October 2015 and extrapolated over a 12-month period, an approximation of primal packaging quantities was generated. There is no data as to what types of facilities these carcasses are going to and what the integration of each supply chain is. The economies of scale with some retail processors have potential for economic recovery.

Table 8: An Estimate of the Wastes produced from Primal Packaging assuming all facilities package appropriate cuts [20]

	Cattle	Pork	Sheep
Home Slaughter Heads (000) (ABS 2015)	8534	4,904	8,807
bags Per Carcase	44	16	8
Weight of Bag (kg)	0.045	0.035	0.035
<b>Total Plastic Tonnes Per Annum (tpa)</b>	<b>16897.32</b>	<b>2746.24</b>	<b>2465.96</b>
Not All Primals Would Be Wrapped (Dryaged, no aging, etc.)	80%	50%	15%
Estimate 1 intermediate plastic used in AU	13517.856	1373.12	369.894

4.5 Traditional Strategies

Traditional control and waste management strategies have been implemented across the industry to reduce quantities generated. These include using less overall material in the manufacture and processing of products through correct sizing of plastic bags, to avoid off cuts and wastage. Another strategy has been attempting to use materials that can be recycled such as cornstarch meat trays for certain products and reducing amount of air in packages to reduce plastic size.

Reducing weight of plastic is another strategy and achieved through light weighting, tray design to reduce material not sacrificing to integrity.

The reuse of products such as dolavs, plastic crates for delivery and pallets etc. The larger the supplier the more likely to have these in place as contractors or individual suppliers can reuse and clean durable equipment containers.

*Plastic recycling*

Many types of plastic can be recycled however added complexity occurs with the mixing of plastic products and depends upon the available technical, economic and logistics factor within a facilities location. Due to the comingling, the relatively low quality of the collected plastics limits the environmental recycling benefits.

Table 9: Types of plastics and the current state of recycling technologies

Plastic Recycling		
Type	Location	Current State
Films and Trays	PET and HDPE are the most desirable material for recycling, with monolayer PP, PVC or PS less desirable	- Typical products being made from recycled films are refuse sacks, damp-proof membranes, fencing (garden furniture, etc.). Meat processors should move toward these materials
Plastic Film	The recyclability of pre-consumer film that is uncontaminated is largely confined to PE materials with the prices varying depending upon the coloring. 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 monolayer films ahead of multilayer films is not advisable, at present, if this results in a poorer performance and/or heavier gauge film.	- Currently, only carrier bags have a significant collection infrastructure
Heavy Plastic Containers	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.	- 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

**4.6 Plastic and Primal Packaging of Meat going to Landfill**

Australia does not have an extensive network of facilities for recycling plastics or recovering energy from waste especially considering the contamination of such plastic materials resulting in low recyclability. E.g. Using incinerators to generate electricity and heat, and the technologies used generally lag behind European waste recovery technologies with some of Australia’s waste exported to be used for energy recovery.

Organic waste has been shown a lot of attention in works commissioned through AMPC and MLA with little focus on the associated packaging and the flow of the meat and packing across the supply chain. Improvements in this space have been driven by supermarkets and other food retailers, with incentives to improve shelf life, reduce package weight, and the emergence of eco and organic labels. There has been little research and investigation into the reduction of primal packaging and other consumer disposed meat packaging within Australia.

**5.0 Project Outcomes**

**5.1 Technology Options**

**5.1.1 Solid waste co-firing in an existing boiler**

Where a facility currently owns a solid fuel boiler (e.g. coal; wood), there exists the opportunity for co-firing of solid wastes. The main requirement is to reduce the size of the fuel so that it does not block the fuel feeding mechanism. The fuel can either be added / mixed with existing fuel (low cost option) or be fed into the boiler using a designated hopper (high cost option).

Boiler monitoring and fine tuning for utilizing a new co-fuel is estimated at \$15,000. This study would include aspects of: ash handling, materials handling (e.g. impact of film on clogging of fuel feeding system), materials handling requirements, trials for EPA / council approvals.

Certain wastes that generate potentially hazardous emissions such as PVC or flammable materials would need to be segregated from the waste.

It is anticipated that council and state based approvals may be required for the co-firing of solid wastes. For example, the Queensland Government Dept Environment and Heritage Protection Environmentally relevant activities lists “2(a) Incinerating or thermally treating general waste: <5,000t/yr” with an aggregate environmental score (AES) of 18 and an annual fee of \$4,404.60. More than one ERA can be operated under the one environmental authority as part of a single integrated operation, with the annual fee being the highest annual fee for any ERA conducted under the environmental authority. A red meat processing (RMP) plant is likely to trigger:

- Meat processing (including rendering): >50,000t/yr, AES of 66, Annual fee of \$16,150.20.
- Fuel burning operation using equipment capable of burning at least 500kg/hr of fuel (AES of 35)
- Edible oil manufacturing or processing: 1,000t/yr or more (AES of 38).

Hence, as can be seen most RMPs will currently be undertaking several ERAs above that expected for thermally treating general waste, hence it is anticipated that there will be no major hindrance at the state level for co-firing of general waste. However, there may be restrictions on the emissions to air and the need for continuous emissions monitoring (CEM) which are estimated to be in the order of \$300,000 capital outlay and \$200,000 per annum ongoing maintenance and calibration.

At the council level, taking Brisbane City Council (BCC) as an example, classifies waste incineration and rendering as a “Special industry”<sup>1</sup> (e.g. potential for extreme impacts) as opposed to an abattoir without rendering (e.g. potential for significant impacts) which is a “High Impact Industry”. Hence, where rendering is already in place the level of industry is already in the highest bracket. The industry code calls upon items including air quality assessment, hazard and risk reporting, noise impact assessment, refuse and recycling, and storm water contamination. Council approval requirements vary throughout Australia.

The environmental permitting process is estimated at negligible if no additional modelling or material change of use submissions are required up to \$90,000 or more.

Boilers specify the maximum particle diameter. A typical boiler may require the fuel to be 25 mm. Hence, shredding and/or grinding of the waste may be required. The workshop waste has been excluded.

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<sup>1</sup> <http://eplan.brisbane.qld.gov.au/?doc=Definitions%23IndustryThresholds>



Figure 7: Example of a shredder for creating 20 mm particles from solid waste.

Cost Item	
Boiler monitoring and fine tuning	\$15,000
Environmental permitting	\$90,000 +
Shredder / Grinder	\$2000 to \$20,000 equipment only. Cost will depending upon materials to be processed; automation; materials handling requirements.
Screen	\$32,000 equipment only.
Sub-total costs	\$17,000 to \$157,000 +
Revenue / cost avoidance	
Avoided waste management costs	\$100,882 p.a.
Energy in waste off-setting coal energy at \$5 / GJ.	\$135,576 p.a.
Sub-total Revenue / cost avoidance	
Simple payback	1 month to +1 year (depending upon material handling requirements and complexity for environmental approval)

**5.1.2 Packaged Plant Solid Fuel Boiler**

Where a facility does not currently operate a solid fuel boiler, a small-scale packaged plant could be procured to generate steam and/or hot water to off-set existing site loads. The boiler presented in Figure 8 below was specifically designed for biomass pellets, hence would require revision in terms of the feeding auger mechanism, particle sizing requirements, combustion chamber residence time, fuel hopper, ash removal, boiler residence time and flue gas cyclone. The budget price fully installed is estimated at \$630,000. Such a plant is rated to combust approximately 1000 tonnes per annum of fuel, hence for the mixed waste feed would generate around 753 kWt if running at 80% efficiency. Assuming that the system costs \$1/GJ to run in terms of staff and maintenance, generates heat valued at \$5 / GJ, and has similar environmental permitting costs to 5.1.1 above, the simple payback period is estimated at 3.4 years.

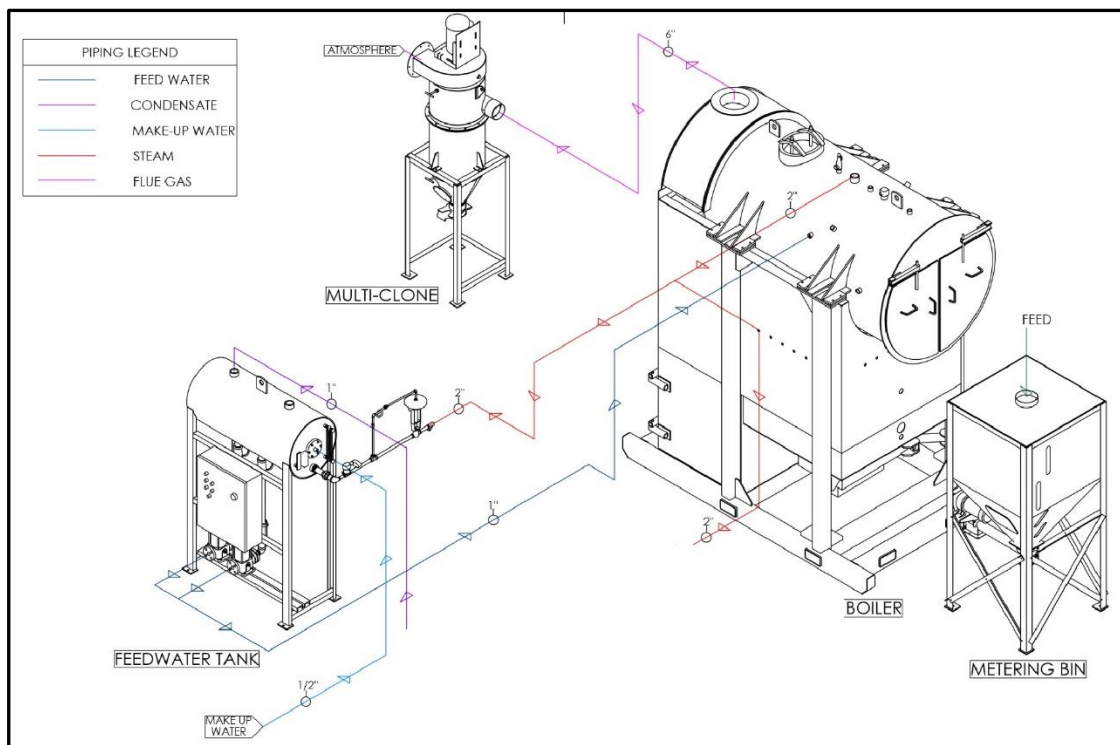


Figure 8: Small scale packaged plant solid fuel boiler.

**5.1.3 Waste Recycling**

Some councils (such as the Toowoomba regional council) commercial businesses are not charged a gate fee for dedicated loads of sorted recyclable materials<sup>2</sup>. Such facilities are strict in terms of materials receiving, for example require manual offload of the materials to 240L or 360L wheelie bins only and will not accept larger bins or skips. Hence, with annual waste handling costs of \$106,711, there exists the opportunity to segregate recyclables and recycle directly at a local council facility.

Depending upon materials handling requirements, it is estimated that such an activity would reduce waste management costs immediately.

<sup>2</sup> [www.tr.qld.gov.au/environment-water-waste/waste-recycling/waste-facilities-rubbish-tips/7390-waste-facilities-operating-hours-locations-fees-accepted-waste-materials](http://www.tr.qld.gov.au/environment-water-waste/waste-recycling/waste-facilities-rubbish-tips/7390-waste-facilities-operating-hours-locations-fees-accepted-waste-materials)

#### **5.1.4 Waste Compaction**

Waste management companies generate a great deal of revenue by collecting air or “void space”. Most RMPS are charged per bin movement, hence there exists an opportunity to reduce waste management costs via waste compaction. Waste compaction would increase the density of the waste to around 445 kg/m<sup>3</sup>, thereby reducing waste costs by approximately 40% to 67%, saving \$42,684. A suitably sized compactor is around \$8490 (WastePac 600 L) to \$25,000 (rotary compactor)<sup>4</sup>.

Simple payback is estimated at around 1.5 to 3 months (not including labour / operating costs).

#### **5.1.5 Off-site Waste to Energy**

Within Australia, cement kilns are one of the few avenues available for reuse / resource recovery of waste materials. Strict emissions to air laws means that few facilities have appropriate permits and continuous emissions monitoring in place for the combustion of wastes. In 2011/12, 127 kt of waste were converted into energy via cement kilns (7% of total energy), having risen to 10% by 2013/14. Sweden currently sends 49% of its waste for energy recovery.

Cement kilns are located at:

- Cement Australia’s Gladstone facility, Australia’s largest cement plant with a production capacity of over 1.7 million tonnes of cement per annum. The plant processes limestone, clay, silica sand and iron additives to produce cement and clinker (an intermediate product in cement manufacturing) for the Australian market. Lime is produced at the Fisherman’s Landing plant in a refurbished cement kiln, supplying up to 250,000 tonnes of lime per annum to Queensland’s sugar, mining and aluminium industries.
- Railton, Tasmania (Cement Australia)
- Berrima, NSW (Boral Cement)
- Angasta, SA (Adelaide Brighton)
- Birkenhead, SA (Adelaide Brighton)

For the specific project, discussions were held with regards to opportunities at the Gladstone facility. The main limitation for this opportunity is the cost of transportation, estimated at towards \$90 or more per tonne<sup>5</sup>. Additional costs are specialized compaction, loading, load out and materials handling (at the kiln end), which may require modification depending upon how the material is received. This opportunity requires a more detailed review and capital cost estimation to determine potential start-up costs.

#### **5.1.5 Small scale plastic pyrolysis for liquid fuel**

A packaged pyrolysis system is estimated to be in the order of \$2 million and capable of processing around 3500 tonnes per annum. Due to the low tonnages of available waste and the lack of a suitable combustion system for burning the liquid pyrolysis oil, the paybacks for this technology would be 10 years plus.

<sup>3</sup> [http://www.deq.state.ms.us/MDEQ.nsf/page/Recycling\\_MaterialDensityandVolumeConversion](http://www.deq.state.ms.us/MDEQ.nsf/page/Recycling_MaterialDensityandVolumeConversion)

<sup>4</sup> <http://www.wasteinitiatives.com.au>

<sup>5</sup> <http://www.freightmetrics.com.au/Calculators/TruckOperatingCostCalculator>

## 5.2 Procedural Options

### 5.2.1 Waste Management Plan

For a business to manage, there must first be measurement. The measure-manage-measure loop is required for facilities with the intent of moving towards the strategic vision of the plant. Without a waste management plan, facilities are less likely to reduce waste and highly unlikely achieve optimal waste reduction. By way of example, the increasingly emphasized waste measurement practices in the meat industry have resulted in a 67% reduction in waste intensity since 2003. Solidifying waste reporting into a site wide and consolidated waste management plan can only further strengthen the performance of such facilities.

Different streams of waste require different storage, processing (onsite / off site), waste contractors and disposal methods and all have some cost or risk tradeoff associated with them.

Each facility should have a waste management system in place. The environmental management system (EMS) should not only capture what waste streams are being produced but a range of other factors to understand the issues and cost-risk tradeoff for safe capture, processing and disposal. Steps and questions to be asked when developing a plan include [4]:

- What are the activities that generate waste?
- What type of waste is being produced and what quantities?
- How will this waste be stored, processed and disposed of?
- What tools do I have for identifying and implementing opportunities to minimize the amount of waste?
- What are my waste management risks?
- What are the procedures to deal with risks such as accidents, spills and other waste management issues?
- What key performance indicators will be used for waste management and will they differ for different wastes (Think kg/t HSCW)?
- How often the performance of the management practices will be assessed
- What incentives will staff have to encourage opportunities and progress towards waste management and reduction?
- What training will be needed to prepare and on board staff?
- Finally, what documentation needs to be developed to capture and record past measurement, current performance and future plans?

For processors to increase the value of waste management plans, a carefully selected and tailored portfolio of waste management investments need to be adopted by facilities that reduce waste and enable efficiency, ideally minimizing waste for combustion and landfill. Choosing and striving for the right practices can lead to reduction in disposal costs, conserve valuable materials and reduce GHG emissions, both on site and through the lifecycle of products. Figure 4 provides the different levels of waste management processors can aim for.



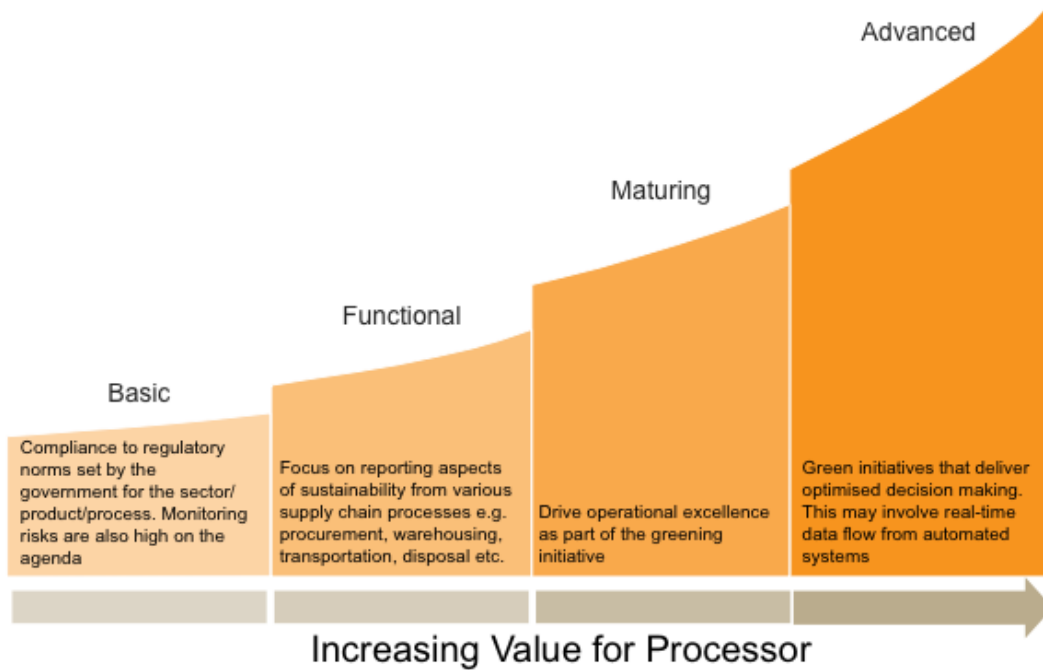


Figure 4: Levels of Waste Management and the increasing value for Processors [8], All Energy Pty Ltd.

Meat processing organizations use waste management plans as a tool to improve environmental performance. An emphasis on waste minimization and steps to deal with the multiple waste streams must be developed. The ISO 14000 series provides guidance for the implementation of environmental management systems with the ISO 14001, 'Environmental management systems—requirements with guidance for use', based on the Plan-Do-Check-Act (PDCA) methodology shown in figure 5.

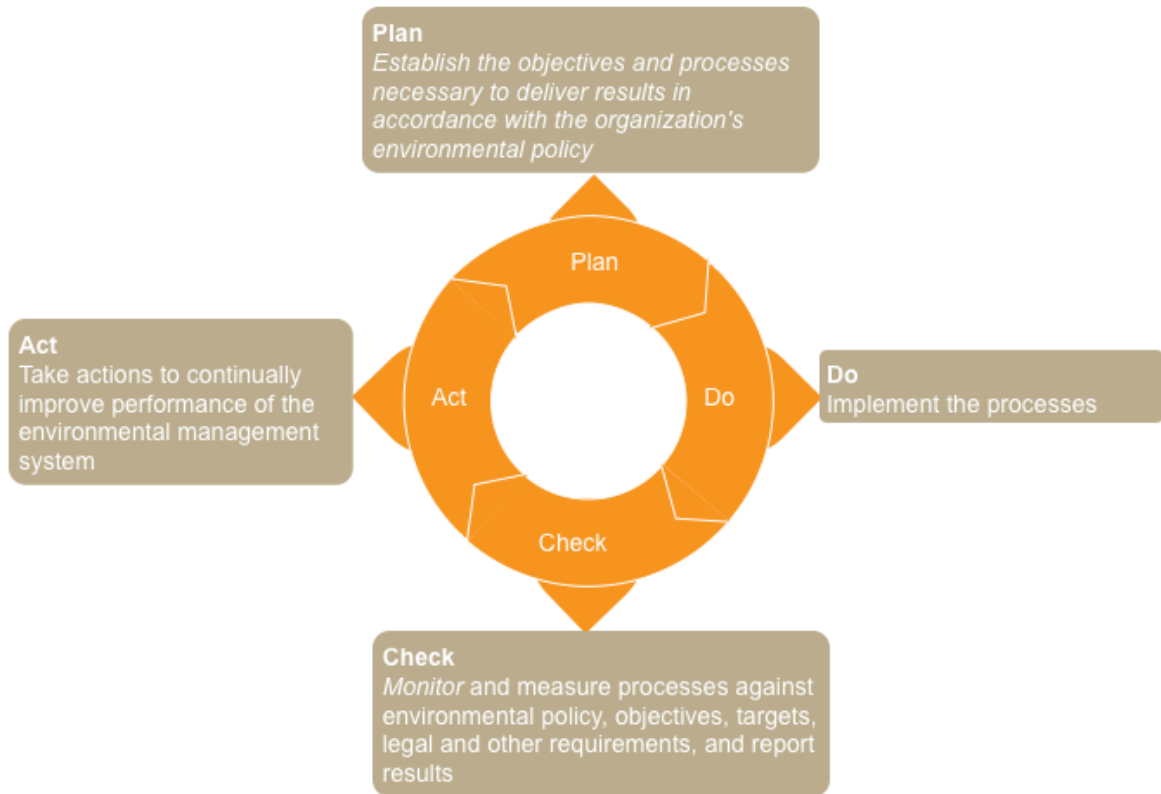


Figure 5: Plan-Do-Check-Act Methodology utilized in ISO 14001; 'Environmental management systems— requirements with guidance for use'

**5.2.2 Improving Success of Waste management Programs**

Waste management plans vary from processor to processor within the supply chain and their level of vertical integration as well as the size and environmental impact. A tailored bottom up design of strategies needs to be developed. Supply chains within the meat industry vary greatly, as does the breadth of products and value adding steps meat processors deliver. It usually starts with the birth of the animal, followed by maturing, slaughtering, butchering, processing, distributing, and POS. Producer facilities include (farms), abattoirs, rendering plants, dead stock collection points, border posts, quarantine stations, warehouses, distribution centers, cold storage facilities, retail grocery stores, and food service operator restaurants. Disposal of wastes across the value chain needs to be measured and sustainability initiatives developed to reduce waste quantity; to reduce waste, a lifecycle assessment of products can be carried out to identify where the ultimate benefit to their business and environment lies (i.e. Design packing to biodegrade).

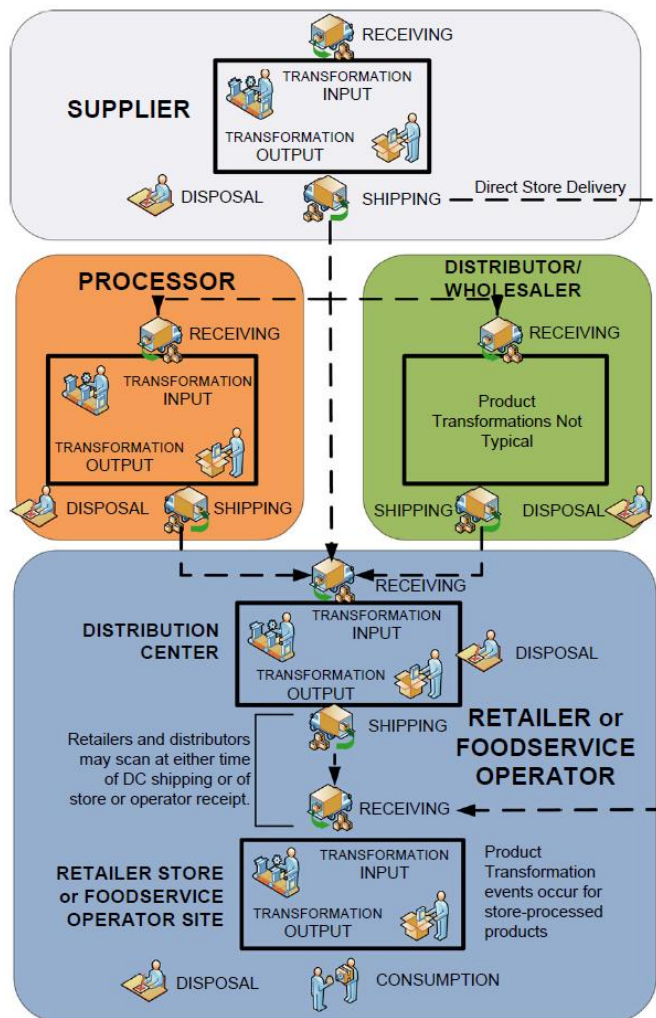


Figure 6: Broad view of meat supply chain [9]

Even when a waste management plan to improve sustainability has been developed the execution in various processor facilities can become a problem. Bringing discipline to sustainability initiatives requires a methodological approach: Select key focus areas, set measurable goals (KPI's), conduct cost-benefit analyses, and create incentives for employees and suppliers.

Sustainability



Returns on capital		
Sustainable operations	Sustainable value chains	Green Sales and Marketing
<ul style="list-style-type: none"> <li>Reduce Operating costs through improved internal resource management (eg, water, waste, energy, carbon, employee engagement)</li> </ul>	<ul style="list-style-type: none"> <li>Improve resource management and reduce environmental impact across value chain to reduce costs and improve products' value propositions</li> </ul>	<ul style="list-style-type: none"> <li>Improve revenue through increased share and/or price premiums by marketing sustainability attributes</li> </ul>

Figure 7: Different factors influencing the uptake of sustainability programs by organizations [10]

### **5.2.2.1 Focus**

A large number of focus areas in a waste management program is likely to dilute and overwhelm people in an effort to create buy-in and also the gathering of necessary resources to achieve goals. To maximize investment in programs it is best to select three to five strategic priorities [11].

Each processor needs to look at their entire value chain and find what matters most and what will have the most impact. This can be done through internal analysis, dialogue with various stakeholders including suppliers, customers, regulators and employees. The result should not be vague ideas but a concise waste and environmental management plan.

Australian Country Choice Pty Ltd (ACC) embarked on an ambitious corporate strategy to develop world best practice for environmental management in the Australian livestock production and meat processing industries [12]. A Cleaner Production Implementation Plan (CPI plan) was developed following a cleaner production assessment completed at the Cannon Hill central processing facility, which identified a number of eco-efficiency opportunities water, energy, wastewater and waste solids management. The plan involved various processing modifications to deliver potential economic and efficiency benefits over a ten-year term. As far back as August 2011 ACC achieved ISO 14001 certification for their central processing facility at Cannon Hill, Brisbane, Queensland. The commercial benefits have been showcased and demonstrate what is possible through meeting international standards for environmental management.

### **5.2.2.2 Set measurable goals**

Each focus area identified through analysis and stakeholder discussion needs to be accompanied by clear defined, quantifiable and measured goals for not just short term but a 3-5 year outlook and communicate these to internal and external operators and partners [11]. Think of the Hazelton Cargill meat facility that set the ambitious goal of zero waste to landfill and have become the first facility to do so in the world.

At a Cargill Meat facility, people and funds were allocated and partners found that could recycle plastic, bio-solids and other materials. Approximately 1,000 tons of unrecyclable plastic is used to produce energy. More than a ton of oil is repurposed for use as lubricants. By early 2015, the Hazleton facility had found non-landfill homes for all of its waste, making it the first Cargill facility in the world to achieve verified landfill-free status On March 29, 2015 [13].

### **5.2.2.3 Conduct cost-benefit analyses and communicate the results**

A McKinsey sustainability report it was shown that only around a 20% of survey respondents reported that the financial benefits are clearly understood across the organization [11]. Processors implementing sustainability programs have difficult times quantifying the financial impact.

As an example of clear financial benefit, the MLA/AMPC funded a study at Cargill Beef Australia at Tamworth NSW. Packaging made up 10% of the plants operational cost and by analyzing the dimensions of the standard 25 primal cuts, an opportunity to reduce material was found, four bags and four boxes were identified and produced an annual cost saving of \$50,000 [14].

The larger the scope of sustainability project the harder it is to gauge such as the savings or profits as they can be spread across the supply chain. Assigning a single manager to lead the initiative is often advisable so value can be tracked and captured rather than diluting responsibility across multiple managers increasing the difficulty of accountability. Sustainability initiatives should also try to capture value from enhanced corporate reputation and increased customer loyalty, which pay off over the longer term.

#### **5.2.2.4 Create incentives for employees and suppliers**

Failing to capture the expected benefits of investments in sustainability programs often comes down to linking progress with the proper incentives. Ultimately, each facility must define its own sustainability philosophy in the context of its specific processes. The examples described here illustrate what competitive advantages that sustainability initiatives can offer. Ensuring managers are tasked with sustainability efforts that are properly tied to compensation and rewarding employees for helping to identify these opportunities creates an employee driven sustainability program to be truly successful.

### 5.2.3 Management of Waste Streams

The Australian red meat processing industry has the potential to have a large and ongoing environmental impact on the environment. Recognizing the potential impact and the responsibility, significant investments have been made in technologies, processes, practices, and training of staff to ensure the sustainable use of resources in a responsible and efficient manner. A summary of past research and implementation of their recommendations, titled “Environment Best Practice”, includes a selection of technologies and practices to minimize environmental impact and maximize value from products [15], including

- Effective “end-of-pipe” waste treatment technologies,
- Eco-efficient operation, and
- Appropriate monitoring and reporting.

*“Environmental best practice in the red meat processing industry is processing meat to achieve company objectives while minimizing the ecological footprint of the operation. This is done by maximizing resource consumption efficiency, using best available knowledge, practices and technologies and minimizing emissions.”[16]*

The stringent regulations governing operation of meat processing facilities has helped shape these best practices often in meeting environmental regulations/ legislation. Some of the limitations and barriers are of food health and safety. Figure 8 shows the balance that must be met between pushing for ultimate sustainability and the often counterbalancing food safety requirements for the consumer with Table 4 showing the government bodies responsible for environmental legislation of the red meat industry.



Figure 8: The Balance between Environmental Sustainability and Customer Needs

Table 4: Governing Bodies Charged With Environmental Legislation (Source: AMPC Wastesolids Environmental Best Practice Manual 2003)

Current Legislation and Regulation	
Commonwealth ( <a href="http://scaleplus.law.gov.au/">http://scaleplus.law.gov.au/</a> )	- Environmental Protection and Biodiversity Conservation Act 1999 - National Environment Protection Council Act 1994
Queensland ( <a href="http://www.legislation.qld.gov.au/Legislation.htm">http://www.legislation.qld.gov.au/Legislation.htm</a> )	- Environmental Protection Act 1994 - Integrated Planning Act 1997 - Environmental Protection (Waste Management) Policy 2000
New South Wales <a href="http://www.legislation.nsw.gov.au/">http://www.legislation.nsw.gov.au/</a>	- Protection of the Environment Operations Act 1997 - Environmental Planning and Assessment Act 1979 - Local Government Act 1993 - Waste Avoidance and Resource Recovery Act 2001
ACT ( <a href="http://www.legislation.act.gov.au/">http://www.legislation.act.gov.au/</a> )	- Environment Protection Act 1997 - Land (Planning and Environment) Act 1991
Victoria ( <a href="http://www.dms.dpc.vic.gov.au/">http://www.dms.dpc.vic.gov.au/</a> )	- Environment Protection Act 1970 - Health Act 1958 - Catchment and Land Protection Act 1994 - Planning and Environment Act 1987
South Australia ( <a href="http://www.parliament.sa.gov.au/dbsearch/legsearch.htm">http://www.parliament.sa.gov.au/dbsearch/legsearch.htm</a> )	- Environment Protection Act 1993 - Development Act 1993 - Public and Environmental Health Act 1987
Western Australia ( <a href="http://www.slp.wa.gov.au/statutes/swans.nsf">http://www.slp.wa.gov.au/statutes/swans.nsf</a> )	- Environmental Protection Act 1986 - Soil and Land Conservation Act 1945
Northern Territory ( <a href="http://www.nt.gov.au/lant/hansard/hansard.shtml">http://www.nt.gov.au/lant/hansard/hansard.shtml</a> )	- Environmental Assessment Act 1982 - Environmental Assessment and Penalties Act 1996 - Waste Management and Pollution Control Act 1998
Tasmania ( <a href="http://www.thelaw.tas.gov.au/index.w3p">http://www.thelaw.tas.gov.au/index.w3p</a> )	- Environmental Management and Pollution Control Act 1994 - Land Use Planning and Approvals Act 1993

### 5.2.4 Resource Use

Resource inputs for meat processing include water, energy, packaging materials and chemicals. This results in the production of a range of solid wastes with the disposal often related with high costs, incentivizing processors to reduce their production.

Organic solid waste such as manure and paunch contents, are an unavoidable consequence of meat processing. High rates of recycling are accomplished with practically all organic material being beneficially used in value adding products of other composting processors [15]. The other category of waste includes non-organic solids. The main environmental concerns of the red meat processing industry pertaining to inorganic waste include: Waste solids generation and disposal. The existing Best Practice Guideline consists of several modules covering each element of waste within processing facilities including the waste solid management.

These wastes are often reduced through careful purchasing and recycling programs often an avoidance and minimization approach. Figure 9 shows the main inorganic waste streams at processing facilities, which are the target of recycling and waste management programs. Data on individual waste stream are unreported so it is difficult to estimate average plant quantities.



Environmental concerns arise from miscellaneous solids sent to landfill. Soil or water contamination, atmospheric pollution, greenhouse gas emissions as well as the high land filling cost associated with disposal, all provide an incentive to track and manage the use and disposal of these waste streams.

MLA and AMPC processing facilities have taken the following measures to reduce inorganic solid waste and its associated environmental impact: [17]

- Reduction in solid waste
  - Monitoring of waste produced
  - Improvement of processing and packaging procedures
  - Consideration of lifecycle of new purchase
  - Improvement of cleaning methods
  - Product recovery.
- Waste Energy Recovery
  - Co-combustion of waste products
  - Recycling of waste into a new product, for example compost.
- Value added products (Compost etc.)

The spectrum of wastes produced by meat processors can be considered raw material for a further process. Storage, processing and disposal of solid inorganic waste can lead to various forms of environmental degradation and need to be properly assessed and addressed.

Australian state governments have policies regarding wastes, which encourage waste minimization ahead of disposal. This follows the cleaner production, or waste hierarchy, shown in Figure 1. Priority should be given to avoiding the production of the waste ahead of reuse or recycling, with the least preferred being treatment and disposal as a last resort.

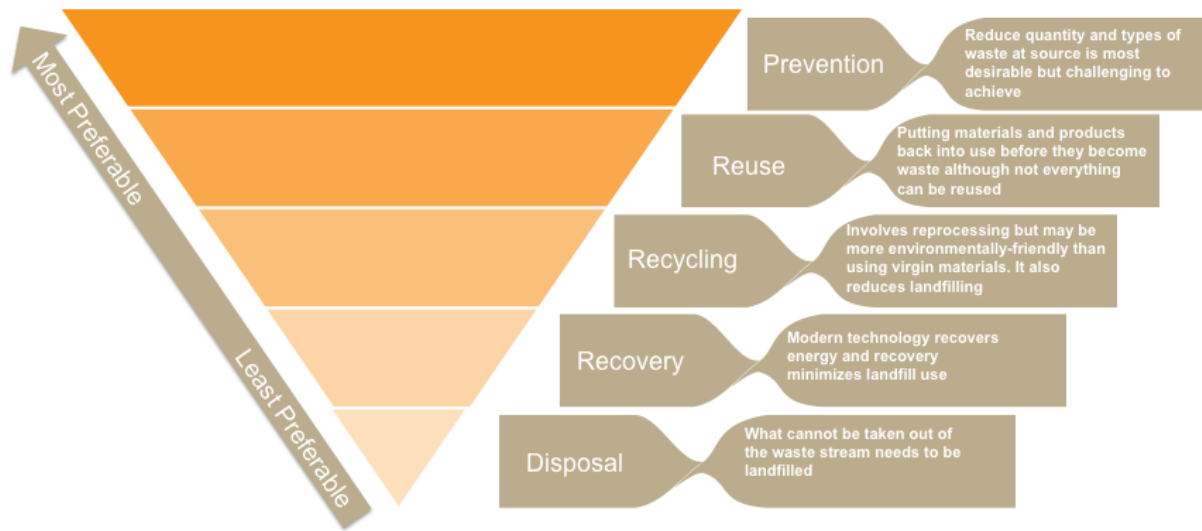


Figure 9: Waste hierarchy and its applicability to meat processors environmental programs

Waste management initiatives should be able to come from anywhere within the processing organization but commitment and support from top management is required to achieve effective long-term results. The environmental policy of many meat processors is showing a move towards waste minimization and a move towards not just management but redesign and re-engineering of processes creating waste, especially through automation of manual packaging processes. Rewards should follow the successful implementation of targets and the resulting achievement of those targets.

**5.2.5 Examples of Inorganic Waste Management**

Since the majority of inorganic waste on site is made up of packaging materials it is relatively effective to place them under two broad classifications; those that can be recycled such as cardboard and those that are either difficult or impossible to recycle by traditional methods or recycling facilities and include polyethylene, strapping, vacuum bags and other packaging material. Attempting to monitor and record these specific quantities will help to identify a measure of (kg/t HSCW).

Contaminated plastics and waste fall into another category as some non-recyclable channels such as incineration and land filling become required and are expensive. It is important to identify strategies to manage these wastes as well.

Relative to other industries, the meat industry is a heavy user of packaging materials. Recycling rates for many of the packaging components can be low. Best practice management of packaging wastes involves full use of cleaner production hierarchy principles to achieve the best environmental outcomes. Table 5 includes a summary of strategies for different waste streams with appendix one showing a more complete list.

Table 5: Summary of best practices for waste management of different streams (Source: AMPC Waste solids Environmental Best Practice Manual 2003)

Solid Waste Management Practice	Strategies		
	Avoid/Reduce	Reus/Recycle	Treat/Dispose
Cardboard	<ul style="list-style-type: none"> <li>Automated carton assembly to achieve up to 50% reduction in waste than manual assembly</li> </ul>	<ul style="list-style-type: none"> <li>Utilise reusable packaging systems, such as Pallecons, for transport of meat.</li> </ul>	<ul style="list-style-type: none"> <li>Avoid disposal in general Rubbish bins</li> </ul>
Plastic	<ul style="list-style-type: none"> <li>Reduce vacuum packaging through correct bag sizing and automation</li> </ul>	<ul style="list-style-type: none"> <li>Maximize the recycling of polyethylene and avoid contamination</li> </ul>	<ul style="list-style-type: none"> <li>Avoid mixture with other wastes and dispose of contaminated waste to landfill</li> </ul>
Drums	<ul style="list-style-type: none"> <li>Purchase largest containers to reduce waste after use</li> </ul>	<ul style="list-style-type: none"> <li>Look for drums with recyclable logos</li> </ul>	<ul style="list-style-type: none"> <li>Avoid plastic and metal container disposal</li> </ul>
Boiler	<ul style="list-style-type: none"> <li>Eliminate coal fired boilers in favor of gas fuels to prevent production of any ash</li> </ul>		
Redundant Plant and Equipment	<ul style="list-style-type: none"> <li>Sell scrap metal as soon as possible to avoid stockpiling and wasted area on site</li> </ul>		
Paper Towels/ Office Paper	<ul style="list-style-type: none"> <li>Provide Recycling bins to separate waste</li> <li>On site shredding and composting should be carried out in absence of recycling facilities</li> </ul>		
Canteen Waste	<ul style="list-style-type: none"> <li>Recycling of food scraps through compost</li> <li>Recycling and separation of aluminium cans and plastic bottles instead of general bins</li> </ul>		
Monitoring & Reporting	<ul style="list-style-type: none"> <li>Amount of solid waste to landfill and specifically packaging landfill should be measured and recorded in order to gauge environmental sustainability programs effectiveness</li> </ul>		

In the light of rising energy prices it is becoming increasingly feasible to use solid waste to produce bio energy. Energy can be produced from solid waste, for example through pyrolysis or by combustion in boilers. Most inorganic waste is combusted with European countries leading the way in wasted incineration. Figure 11 shows the process which waste material is commonly transformed into value added products such as oil of energy recovery.

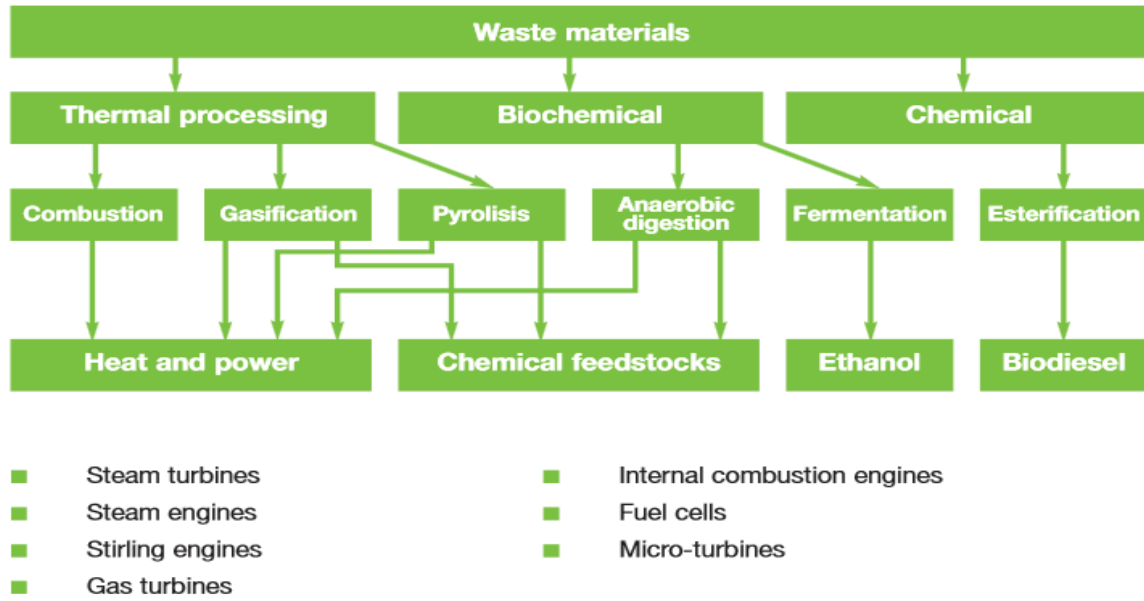


Figure 10: Different Options for Waste to Fuel. Technologies are dependent on the waste stream [18]

### 5.2.6 Waste avoidance

Due the reality of meat processing, it is impossible to eliminate waste entirely but it is possible to manage and minimize the amount being produced through avoidance strategies. Waste avoidance is the most cost effective out of all management strategies and focusing on eliminating the source of waste rather treatment or disposal [19]. This often manifests itself in sourcing and procurement policies designed to partner with sustainable sources.

#### Examples of avoidance [19]

- Lifecycle evaluation - purchase items that can be recycled/reused
- “Banning” certain materials such as PVC
- Supplier selection based on sustainability policies and/or packaging that can be recycled;

Also, some processes can be altered to avoid production of a waste material. Some examples of this are:

- Use of carton gluing—rather than strapping—which eliminates the waste strapping that can be difficult to recycle;
- Recyclable liner-less cartons for manufacturing meat eliminate polythene liners which are difficult to recycle after being in contact with meat;
- Use of tube stock (for vacuum bags) that is cut to size for each cut, eliminating the waste bag trim that can be up to 20% for pre-sized bags;
- Automated bagging of cuts, where bag selection is automated, can eliminate use of oversize vacuum bags, thus reducing waste;
- Freezing of naked blocks for pet food;
- Automated carton construction can generate up to 50% less packaging waste than manual construction, due to reduced rejects.

### 5.2.7 Waste reduction

Waste reduction strategies do not necessarily rely on high capital expenditure strategies. In fact close monitoring and control of purchasing, inventory, storage and maintenance can have impressive results in processing facilities.

#### Purchasing Strategies [19]

- Buy materials in containers of a size and type that minimizes material wastage, and in containers that can be readily handled and easily re-used or recycled. Consider buying in the largest packaged units practicable to reduce the number of empty containers to be handled.
- If using coal-fired boilers, buy a suitable coal with the lowest ash content to minimize ash disposal costs.
- Select vacuum bags of the minimum gauge necessary to ensure integrity in order to reduce the quantity of raw material used and waste generated.

#### Inventory control Strategies [19]

- Minimize inventory, especially of perishable supplies.
- Use a ‘first in—first out’ policy for raw materials.
- Have a computerized tracking system for stores.
- Maintain suitable temperature and humidity for supplies and raw materials.

#### Storage Strategies [19]

- Keep stores clean and well lit; aisles free of obstructions for easier access and less likelihood of product damage.
- Minimize damage to packaged product to reduce re-packaging and product wastage.
- Monitor and alarm storage temperatures to control product loss in case of breakdown.

### ***5.2.8 Re-use/recycle***

Regulation in the meat industry regarding food safety, place a limit on the options available for reuse and recycling. An emerging option is waste to energy through incineration at a reduced cost to cement kilns. Transportation of products via reusable containers is a commonly used method to reduce waste.

### ***5.2.9 Treatment/disposal***

Disposal is last in the waste management hierarchy and should be avoided and treated as a last resort. Removing recyclable products from contaminated waste streams such as plastics is important to recoup as much value from the waste stream as possible. Even materials uncontaminated, may not be able to be processed by nearby recycling facilities and will be sent to landfill or incinerated. This is where a waste reporting strategy should be implemented to measure and target a reduction in waste sent to landfill

### 5.3 Barriers to Recycling

The main barriers to recycling includes:

- Different polymers
- Different colours of raw materials
- Contamination of raw materials

#### *Mixed Polymers*

PET bottles have well developed infrastructure, whereas trays used in meat facilities have low levels. The separation of trays from other packing waste is difficult and would often rely on manual handling if at all. These are low value polymers making it non cost effective to recycle and unprofitable for recyclers.

#### *Multilayer plastics*

The packaging commonly used in consumer products contains different materials and colours and with labels glued or stuck on the outside. Although the benefit to meat products is high in terms of extending shelf life and product quality, it can reduce the grade of recycle and is therefore a main cause of not recycling.

#### *Contamination and barriers to its removal*

Meat dip contamination of packing wastes is another barrier for recycling. 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. Blood and animal by product is not favoured to go to landfill, but with such small quantities it can be, the contamination is too great for plastic recyclers however and the product cannot be stored in an open environment and without washing for more than a few days.

Contamination reduces the calorific value of the material. Although washing to allow for recycling has been trailed, the wastewater from this step produces biological oxygen demand and chemical oxygen demand has to be treated which reduces the economics through the energy use and eliminate any environmental benefits of recycling.

#### *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.

#### *Barriers to co-incineration*

Waste recycling companies and cement facilities have limitations to their feedstock. Handling of contaminated plastics besides dry plastic is unavailable. For a lot of facilities the plastic would need to be washed, dried, and possibly shredded prior to going for recycling or incineration at cement facilities. As can be predicted, economic benefit is reduced. However if facilities do have in place equipment to handle this feedstock the calorific value can be increased due the presence of the organic material.

**5.4 Procurement of plastics and supplier requirements**

A simple yet highly effective option is to be selective on the plastics that enter and are used in the facility. A number of different groups<sup>6,7</sup> have created “Plastic Hierarchies”, which recommend from most to least preferred the following plastics:

Best options: [1] Bio / biodegradable plastics e.g. poly lactic acid (PLA)  
 [2] High Density Polyethylene (HDPE)  
 [3] Low Density Polyethylene (LDPE)

Acceptable: [4] Polyethylene Terephthalate (PET)  
 [5] Ethylene Vinyl Acetate (EVA)  
 [6] Polypropylene (PP)

Least Preferred [7] Polyurethanes (PU)  
 [8] Polystyrene (PS)  
 [9] Acrylonitrile Butadiene Styrene (ABS)  
 [10] Polycarbonates (PC)  
 [11] Acrylic

Prohibited [12] Polyvinyl Chloride (PVC)

**5.4.1 Meat Industry Examples of Sustainable Procurement**

Table 11: Case Study on Compostable Meat Trays [21]

Case Study :Compostable Meat Trays, a competitive advantage
<p>Australian premium sausage and burger business Peppercorn Food Co. is changing to fully compostable and bio-degradable meat trays in response to mounting environmental consumer concern.</p> <p>The business underwent certification testing and packaging trials before making large investments in packaging materials. The new trays are biodegradable and also 100% compostable. The trays are made from cornstarch and fully comply with AS4736-2006, the Australian Standard for bio-degradable packaging material.</p> <p><i>‘I believe packaging contributes considerably to landfill when it doesn’t necessarily have to because of technologies such as these. It does impact upon my purchasing decisions and it is something I am willing to pay a little more for.’</i> Mitchell Leroy, Crows Nest NSW.</p>

Table 12: Case study on liner bags [22]

<sup>6</sup> The Green Guide Institute (TGGI), <http://www.thegreenguide.com/plastic-container-buying-guide>

<sup>7</sup> Aveda Corporation, as reported by <http://www.sustainablefoodservice.com/cat/disposables.htm>





**Case Study : CHEP Liner Bags**

CHEP Pallecon Solutions has a new range of liner bags designed to improve packaging efficiency and reduce waste in the bulk meat industry. CHEP's new liner range ensures food safety through the use of blue tint and a co-extruded film technology superior to commonly-used monolayer films in the Australian and New Zealand liner bag market.

Bulk meat producers in Australia and New Zealand typically double or triple bag their containers to prevent leaks, resulting in high packaging waste. These companies can avoid the practice of multi-bagging and also save on packaging cost by switching to the new CHEP Pallecon Solutions co-extruded liner bags.

CHEP's liner bags are produced with multiple, ultra-thin layers within a film that is capable of exceeding the performance characteristics of much thicker mono films in strength, puncture and flex crack resistance.

**Table 13: Case study on bulk bins [19]**

**Case Study :Use of bulk bins instead of cartons**

A processor manufacturing product for the domestic market moved from packaging beef in cartons to packaging in bulk bins. By packing 10 bins per day, it was estimated that over 400 fibreboard cartons were saved per day, along with the associated liners and strapping. This represented a saving in resources and waste disposal for the customer.

**Table 14: Case study on robotic bagging [19]**

**Case Study : Robotic bagging and semi-automatic bag makers**

An export boning room producing 1,000 cartons of vacuum packaged beef per day, converted from manual bagging of primal cuts to robotic bag selection and packaging.

For ease of getting the bag over the cut, manual operators will often select a bag size that is too large. Automatic bag selection based on the measured dimension of the primal cuts resulted in savings in the quantity of film used of 9,000 kg per annum with robotic selection and bagging.

## 6.0 Discussion

### 6.1 Looking to the future – Global review of Waste Management in the Fast Moving Consumer Goods Sector

Fast-moving consumer goods are broadly classified as products that typically have a lower unit costs and are purchased with higher frequency and a shorter service life than other manufactured goods. The quantity of materials used in FMCG products are higher than other products, and represent an estimated 35% of all inputs into the economy. Consequently consumer spending is heavily focused on these products and accounts for 75% of municipal waste with 90% of agricultural products being feedstocks for the FMCG category [23].

#### 6.1.2 The Current State of FMCG - Linear Economy

FMCG products typically follow a linear model, beginning with resource extraction which then leads into production and consumption, this does not take into account the design for reuse and recycling or waste disposal outside of what is legally binding in the geographical location. Active regeneration of systems is rarely accounted for in their initial design.

Only 14% of plastic packaging is collected for recycling, which is a terrible reuse rate compared to other materials: 58% of paper and up to 90% of iron and steel is recycled<sup>8</sup>. Almost a third of all plastic packaging escapes collection systems and ends up in nature or clogging up infrastructure (i.e. does not make it into recycling or landfills).

The process of creating products is both material and energy intensive. The cornerstone of the linear model is economies of scale in large globalized supply chains. These complex systems are designed around the consumer. For example the average citizen living within an OECD purchases 800kg of food and beverages, 120kg packaging and 20kg of new clothing and new shoes, with most of these not being returned into the production cycle returning no economic benefit. 80% of these will end up in incinerators, landfill or wastewater, think 'Take-make-dispose' [23].

#### 6.1.3 The Future of FMCG - Circular Economy

Moving forward, the key within the FMCG sector is challenging the current approach to design. Although the 'cradle to grave' model has been implemented and has achieved significant ground in terms of reducing harmful impacts, circular model aims to produce no waste by design. Materials that are generated as the result for a need of the product are regenerated in a closed loop. The incentive is clear for both business and environment perspective. Less material and energy input means less cost, less waste and more product. The business creates more value for the consumer, reduces the risk in material management, in an increasingly volatile market shielding from energy and commodity prices is often heavily sought after. This will create the challenge and opportunity to develop new supply chain designs.

In contrast to virgin materials, the linear economy extracts value from resources currently considered and treated as waste. If the circular model were developed it would achieve an inherently more productive system in the consumer goods sector by [24]:

- Reducing virgin materials use
- Development of market for secondary goods
- Waste stream will be recovered to the fullest extent possible

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<sup>8</sup> <http://money.cnn.com/2016/01/19/news/economy/davos-plastic-ocean-fish/index.html?source=linkedin>

- Leading economies will need to drive innovation and communicate the importance of conservation, recovery and efficiency

#### 6.1.4 Integrating Circular Economy Packaging Principles

FMCG companies are testing the waters by investing in sustainable packing within flagship products; this will hopefully morph into a sustainable culture, with other companies to follow. In order to move from a linear to circular model, new materials, new designs, modular packaging, designing for disassembly and reassembly, and elimination of mixed materials are necessary. To help, refilling strategies for certain products will be required and integrating and closing the loop by allowing recycled materials to create part of the solution. Younger consumers in particular are leading the drive for change and sustainable packaging.

Most companies are either not using recyclable packaging or do not actively recycle or re-circulate existing recyclable or reusable materials. When companies know the consumer will buy the product for its sustainability labels yet with the knowledge that it would not be recycled at end of life is known as green washing. Some sustainability plans are being conceived and implemented by retailers and manufactures however the road to sustainable packing is long and winding and will take just as much innovation as it took to get to our versatile and personalized packing we have today. There is potential revenue being lost without capturing the wasted resources of companies. Some strategies include:

- *Recovery for reuse* [24]: Selecting appropriate materials and implementing packaging designs that are more durable and link in with collection processes, material and energy costs will be reduced and saving captured. Needs to be coupled with high collection rates

- *Recovery for decomposition* is another option [24]. Some materials are non-recyclable and therefore the packing is more effectively designed with the intent to decompose in the most likely 'end of life' environment. End of life materials are designed to have specific energy and other material benefits which can be used in recycling, reuse or recovery processes

- *Recycling* [24] — Packaging for products that cannot be reused can be designed for recycling. Recycling companies can profitably collect and recycle materials to produce a secondary product that offsets virgin material input. In OECD countries the prices for raw material are often enough to incentivize the collection and transformation of these into other products. The goal should be to increase both range of products recycled and volume.

- *Biodegradable packaging* [24] — is an option for completely unrecoverable products. Returning nutrients back to the soil when no other end of life option is available. The definition of biodegradable varies with time to decompose and dependent on the environment. This option is more expensive than other materials, as the technology and techniques for manufacture are not designed around traditional materials. Premium 'sustainable' brands may be able to recover the price but for the majority this option is unavailable. With innovative solutions to reduce costs as well as the landfill levies, there may be a time when the use of this material is more common.

### 6.1.5 Driving Trends in FMCG

Meat processors are included within the food and beverages (F&B) category and are at the mercy of influential consumer needs and trends pushing for cost reductions. Below are summarized some key trends shaping F&B packaging and how the circular economy principles could apply in meeting consumer needs without blindly following sustainability for the sake of sustainability.



Figure 11: Trends driving packaging that could be utilized for a sustainability agenda [25]

**TREND 1: Busier lives driving growth in convenience packaging:** People increasingly eating alone due to the influence of busier lives and the rapid move towards urbanized environments. Companies are adapting to these needs in package design. The flexible packaging industry is expected to increase by 3.4% CAGR during 2015–2020 to ~\$248 billion. According to a 2014 study by market research firm Hartman Group, 47% of eating occasions in the US arise when people are alone. This increases the need for easy, on-the-go packaging.

**TREND 2: Increasing adoption of lightweight packaging by companies to reduce costs and wastage:** Reductions in production costs environmental impact are achieved. The drivers are of course reduced cost without sacrificing packaging designs used for product differentiation. The light weighting of packaging can be achieved through selection of lighter packaging material or cutting down on the amount of packaging material used, or both. Companies have already reached the limitations set by traditional materials such as PET. *“Flexible plastic will account for ~30% of all the packs added in the UK over the year (2015), helped by the fact that it is the most widely used packaging for FMCG products in the UK, covering the food, beverages, pet care, beauty, and home care sectors.”* – James Maddock, International Packaging Analyst, Euromonitor (January 2015).

**TREND 3: Personalization in packaging:** Influence through touch and look is an important marketing tool for companies in the race to differentiate their products. This enhances the buying experience of consumers.

**TREND 4: Growing use of sustainable materials in packaging:** Materials meeting current packing needs, technical specifications as well as marketing designs but reducing the environmental impact. This is not new, however the desired level envisioned by a circular economy has not been met. Packaging is frequently talked about in the continued quest for true sustainability. The most potential for this is a shift

on consumer awareness regarding environmental issues, one that places a potential premium on sustainable packaging and product practices. In a 2014 global online survey on corporate social responsibility by Nielsen (among 30,000 consumers), ~52% of respondents indicated checking product labeling before a purchase to ensure that the brand is committed to positive social and environmental impact. 51% of those who check product labeling and 51% of those willing to pay extra for products packaged in sustainable materials were millennial's (born between early 1980s and early 2000s). This trend will continue and companies need to watch for a tipping point in which sustainable supply chains rapidly begin to be economical and not just environmentally viable.

## 6.2 FMCG Best Practices and Direction for Inorganic waste reduction

In moving towards the circular economy, companies are focusing on reducing waste, reducing inventory, and eliminating process steps. Sustainability has focused attention on smarter and more efficient resource use across the value chain and plays well to cost reduction driven by the consumer and targeted by companies. Although the majority of waste is produced from consumer goods, due to cost reduction pressures, some of the best examples of sustainability are showcased.

Measuring and managing the waste and product streams is essential to driving change. Drivers for this activity are as follows [26]:

- Efficiency and cost containment
- Social and environmental factors –The brands social and environmental record become integral in purchasing decisions
- Retailers and supplier must comply to various scorecards (either placed on by governments or retailers themselves to increase customer appeal)
- Can't report so they develop the infrastructure and processes to report driven by the organizations objectives or business unit imperatives.
- Customers desire transparency and with companies trying to reduce opaqueness. Their supply chains are hard to align with their sustainability initiatives and therefore increase the need of reporting. Institutionalizing sustainability KPIs and reporting standards

### 6.2.1 Improving manufacturing efficiency

Manufacturing efficiency increases fuel and energy consumption and is the most immediate in recovery of costs. Water usage and waste reduction are also key drivers. Environmental, cost, and productivity improvements are gained from these initiatives. Energy saving modes, various equipment monitoring technologies the other spectrum is green facilities which utilize renewable energy, are completely designed as a system to use less energy and produce less waste.

### 6.2.2 Minimizing environmental impact

Producers have been influenced and encouraged to identify creative ways to reuse material that would otherwise be wasted. A waste to energy example from an Indian manufacturing company SC Johnson takes the palm shells from its palm oil operation and uses them as a source of fuel. Carbon emissions were reduced to previous fuel sources by 15% and achieved a diesel fuel reduction of 80% [26].

### 6.2.3 Investing in smarter packaging

Although key ways to reach consumers is by package design and ensuring durability and resilience in the delivery and transportation process, packing is being aimed to rescue the waste it produces. Packaging is a large global contributor to landfill waste and is expensive to produce. An average of 8% of product costs can be attributed to packaging within the broader FMCG sector. The redesign of packaging has naturally followed a minimalist and reductionist method to reduce cardboard, paper, plastic labels, and room. P&G

for example designed a different pump on its moisturizers, this is estimated to save 800,000 pounds of plastic for the company annually [26]. Reconfiguring design to fit more on pallets for transport fuel reduction is another common technique.

#### **6.2.4 Supply chain oversight**

Large companies including McDonalds are moving towards supplier certification of certain sustainability metrics. Kimberly-Clark requires wood suppliers to have independent certification. Suppliers gain increasing preference when company certifications and standards are met often allowing to capture a premium with some companies.

#### **6.2.5 Greenhouse gas (GHG) emissions reduction**

Reductions in emissions across the board are a strong focus by lowering energy consumption and costs across their operational footprint. Take Johnson & Johnson's corporate strategy for reducing GHG emissions: The five tiers of best practices: energy efficiency improvements in all operations; cogeneration – on-site generation of electricity and recovery of the waste heat for overall efficiencies of 80 percent or more; on-site renewable energy that produces no CO2 emissions; renewable electricity purchases; and carbon trading and sequestration [26]. These are strong guiding principles for individual facilities to take action; it is not just good for the environment but the bottom line for social economic and environmental purposes.

#### **6.2.6 Biomaterials**

Bio materials are being developed with increasing speed and increased application. This does not mean the complete decomposition of these products, but those which are derived from renewable biomass sources including vegetable fats, cornstarch, agricultural by products. A Belgium-based company that manufactures eco-friendly cleaning products, has developed Plant plastic packaging, which is made of plastic derived from sugarcane (75%) and recycled plastic (25%). Bio plastics have seen considerable development over the past 10 years and include plant based material PET.

#### **6.2.7 Reinventing Traditional Methods**

FMCG companies are creating new manufacturing techniques in package design, the incorporation of virgin materials in the process, a key component to valuing packing recovery from consumer sources. Packaging companies operating in the fast-moving consumer goods space are also using new manufacturing techniques to optimize packaging design and reduce their use of virgin materials. Lightweight packing techniques is a common example of this and reduces the raw material needed for the product and therefore cost. As long as this does not inhibit the functionality, since companies must ensure it is still number one priority.

#### **6.2.8 Extending the Product Lifecycle**

Sourcing, transporting, manufacturing and disposal are all required to be critically assessed and are recognized as contributors to ensuring the minimization of packaging. "Cradle to Cradle" approaches is a prerequisite of design thinking in ensuring that reuse or recycling is maximized to highest possible value multiple times after first use. This approach mimics the natural process of the environment helping to recover waste and energy value for both consumer and company

### 6.2.9 Packaging for a Purpose

What purpose is the packing being designed for? By asking this question before a product has been locked in, companies can develop environmentally responsible ways of disposal. Analyzing the target markets for products and its use is a critical step to ensuring return on investment in end of life design. Investments in materials that are more than just largest 'theoretical' reduction but a material that will actually actively be recycled in the most likely environment for the packaging. There is no environmental (Customer price advantage is applicable) for a manufacturer to make packaging from recyclable PET if there is package mixing or no recycling facilities available.

## 7.0 Conclusions/ Recommendations

### 7.1 General Recommendations and Opportunities

The following list are general opportunities that were uncovered as part of this work:

- Ensure each facility has an effective waste management plan in place. Crucial to measure not only aggregate waste to landfill (kg/t HSCW), but to expand and include separate measurement of plastic, cardboard and other wastes with recycling and recovery potential.
- Waste audit defines the current operation, opportunities and highlights low cost, easy wins especially around waste disposal contracts. For examples, if waste is paid per skip, then reducing volume may reduce landfilling costs. A waste audit forms the foundation of a waste management strategy.
- Further research should be conducted into the most sustainable use of plastics within the meat processing industry. This will need to consider cost, contamination, end user expectations and take a life cycle assessment approach to identify the environmental footprint and the best end of life treatment for both contaminated and uncontaminated material.
- AMPC's continued industry support and collaboration with retailers and retail packing companies to develop methods and product designs to reduce the amount of plastic both in use and the resulting waste both on and off processing facilities. This can be achieved via:
  - Increased knowledge transfer to processors and organisations in the meat supply chain by collaborating and detailing options, names and addresses of the companies to talk to about waste initiatives across the supply chain (recycling companies, packaging manufacturers, end users, cement facilities, etc.)
  - Information on specific waste streams is currently difficult to obtain. Although waste aggregates such as kg/t HSCW are collected, most companies collect little to no information on how much of each different material is going to landfill. Engage with groups such as the Australian Packaging Covenant, manufacturers/suppliers and environmental agencies to improve the quality and quantity of data collected.

- Identify Energy from waste (EfW) sites to inform the industry of possible contaminated waste options. In liaising with 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. Cement companies and the waste from fuel companies often have a preference for 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 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. Some 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 will be key to unlocking this end of life option.



## 7.2 Specific Findings

Summarized below are options for improved inorganic waste management for Australian red meat processing facilities.

Scenario	Findings
Current waste management	1031 tonnes per annum contaminated plastics, cardboard, paper and wood.
Waste co-firing in an existing solid fuel boiler	1 month to +1 year - depending upon material handling requirements and complexity for environmental approval
Packaged Plant Solid Fuel Boiler	3.4 years
Waste compaction	3 months
Small scale plastic pyrolysis	+10 years
Off-site waste to energy	TBC
Waste segregation for enhanced recycling	Immediate payback
Waste Recycling with local council	Immediate payback
Plastic procurement strategy	Immediate environmental improvement; use of the plastic hierarchy.
Off-site waste to energy	Approximately break-even compared to landfilling assuming no capital / start-up costs. Further detailed analysis required.