final report

Project code: A.CIS.0027

Prepared by: Phil Green

Greenleaf Enterprises Pty Ltd

Date submitted: August 2011

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Value proposition for automated lamb evisceration

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Contents

Glossary

Term	Description
Brisket cut	Cut through the middle of the sternum bone: A long flat bone, articulating with the cartilages of the first seven ribs and with the clavicle, forming the middle part of the anterior wall of the thorax, and consisting of the corpus, manubrium, and xiphoid process. Also called *breastbone*.
Bung evacuation	Removal of dung pellets from bung – also referred to as "Milk and Tie"
Caudal	Caudally: toward the posterior end of the body
Cranial	Refers to the direction toward the head of carcass
Dorsal	Belonging to or on or near the back or upper surface of an animal
Enucleate	Process of removing kidney from outer membrane and fat deposit for inspection
HSCW	Hot Standard Carcase Weight
MAR	Machinery Automation Robotics – Australian robotics company that develops and sells automation equipment to the meat industry
MIA	The **Meat Industry Association of New Zealand** (MIA) is a voluntary trade association representing New Zealand meat processors, marketers and exporters. The MIA is an incorporated society which is owned by its members. The MIA represents companies' supplying the majority of New Zealand sheep meat exports and all beef exports.
NPV	Net Present Value
OAL	Ovine Automation Limited Nine New Zealand meat companies formed OAL, a $16.7 million partnership with a government research fund to further automate sheep processing. The Foundation for Research, Science and Technology is investing half the capital of $8.36 million, with the Meat Industry Research Institute of NZ contributing $1.3 million and the rest coming from the nine industry partners. The companies involved in the consortium are the Alliance Group, ANZCO, Auckland Meat Processors, Bernard Matthews, Blue Sky Meats, Crusader Meats, Progressive Meats, Silver Fern Farms and Taylor Preston. The research will be done by Industrial Research Ltd and Miller's Mechanical (NZ) Ltd, both of which have a record in automation of the meat industry.
OTH (Over-the-hooks)	Over-The-Hooks sales are when the transfer of ownership of an animal takes place as a carcase at the slaughter scale. Value is determined based on an agreed price per kilogram of carcase weight and may include bonuses or deductions for fat or quality parameters.
Pluck	An abattoir term for the thoracic viscera plus the liver, after separation from the oesophagus and the diaphragm. Includes the larynx, trachea, lungs, heart and liver, plus the spleen in sheep.
Skirt	Thin and thick skirts are two different groups of muscles in the abdominal cavity near the diaphragm.
Ventral	Pertaining to the front or anterior of any structure. The ventral surfaces of the carcass include the brisket /abdomen cavity
Viscera	The soft internal organs of the body, especially those contained within the abdominal and thoracic cavities.

1 Executive Summary

AMPC and MLA's abattoir automation program has not included automated evisceration solutions to date. This technology is of interest to the Australian sheep processing industry. A system developed by MIA in conjunction with Milmeq is now operating commercially in New Zealand. The evisceration processes, carcase specification and dressing standards are somewhat different between the two countries.

Onsite review of the existing manual evisceration operation, when compared with the automated evisceration process resulted in the development of the following frame work through which the value opportunity of the investment was considered (Table 1).

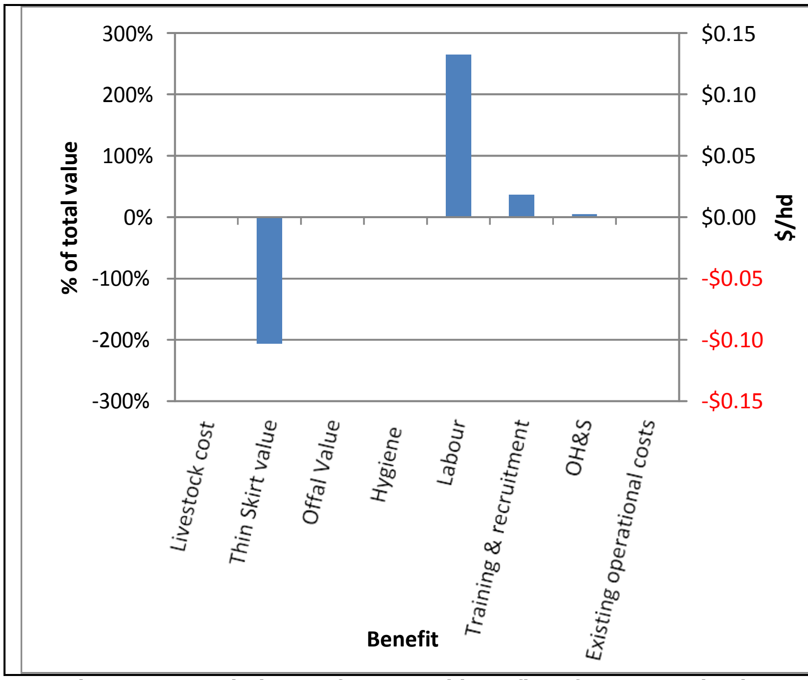
Table 1: Automation costs and benefits over manual operation

Item	Description
Total Benefits	
Product Benefits	Livestock cost Diaphragm value Offal Value Hygiene Other
Operational Benefits	Labour Training & recruitment OH&S Existing operational costs
Total Costs	
Capital Cost Service / maintenance Damaged Product	

The fundamental driver for automating evisceration in lambs is to reduce labour and eliminate OH&S risks associated with the current manual process. However, the automated NZ process removes the thin skirt on the slaughter floor (compared to leaving intact in Australia) impacting on carcase yield more than the OH&S benefits as depicted in Figure 1 (Assumes 30% carcase sales). Depending on each Australian plants livestock purchasing methods and boning and sales processes, this yield difference has significant positive or negative impact on commercial viability of this automation solution as depicted by return on investment ranging from negative to 0.5 years in Figure 2.

Only companies running two shifts with trays already under the chain, and boning more than 85% of carcases slaughtered should expected return on investment of less than 1.5 years.

One of AMPC and MLA's collaboration partners (MAR) has begun preliminary design of an automated solution for the Australian industry and wish to further develop the concept in conjunction with AMPC and MLA. This project identified that the NZ technology is directly transferrable to Australian processors in terms of technical capability. Chain modifications and manning changes to existing processing lines will not be significantly different to those required in NZ. However, there are a number of engineering considerations that if addressed differently could provide a more favourable return on investment for auto evisceration in Australia. These are summarised in Table 2. It is recommended that AMPC and MLA do not invest in any new or existing auto evisceration technology unless they address these engineering considerations.



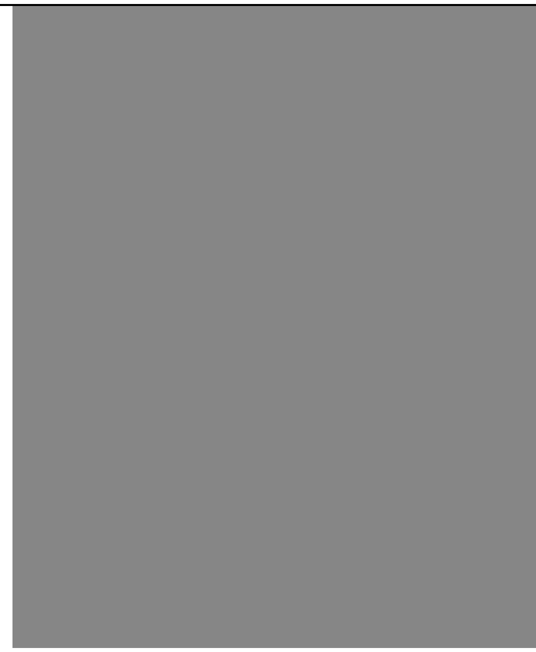


Figure 1: Break down of expected benefits of automated evisceration, and value opportunity type (value-add vs. cost saving)

Figure 2: Range in financial return depending on abattoir purchasing and sales processes

Table 2: Areas of existing design impacting some Australian processor ROI

Benefit area addressed	R&D Improvement Opportunities impacting ROI
Reduce Capital cost	Manage Offset viscera pans
Reduce yield loss for carcase sales	Thin Skirt remains intact
Reduce Capital cost	Carcase Stabilisation not gambrel specific (ROI saving - years)
Increase labour saving benefit	Save 1 extra labour unit - Gut removal
Increase labour saving benefit	Thin Skirt - no prep, save 1 FTE

2 Introduction

A New Zealand engineering company Milmeq Mechanical (owned by Realcold / Milmeq) in conjunction with the NZ MIA has developed an automated system for evisceration of lamb and sheep carcases. A commercial system is installed at an Alliance abattoir (Mataura) in the South Island.

AMPC and MLA's abattoir automation program has been developing independently to MIA with both Australian and New Zealand equipment manufacturers but has not included automated evisceration solutions to date. This technology is of interest to the Australian sheep processing industry. However, it was suspected the New Zealand technology would not be directly transferrable to Australian processors due to differences in carcase specification and dressing standards. Furthermore, the evisceration processes are somewhat different between the two countries.

One of AMPC and MLA's collaboration partners (MAR) has begun preliminary design of an automated solution for the Australian industry and wish to further develop the concept in conjunction with AMPC and MLA.

A range of additional information and research is required to facilitate AMPC and MLA deciding on the best development path. This document details the scope of works conducted and results of the CBA study for a range of Australian processing scenarios.

3 Project Objectives

The primary objectives of this project were to:

1) Benchmark the existing manual method used for processing the lamb carcasses in Australia and quantify the value opportunity that exists for automation (Considering benefits realised in NZ);
2) Quantify the differences between NZ and Australian lamb processing and carcase specifications and their impact on application of the NZ technology to Australia;
3) Review both MAR and MIA development paths providing a list of observations and considerations to assist AMPC and MLA in choosing their development path

4 Deliverable items

The key deliverables include:

1. A cost benefit analysis model
   1.1. The primary tool used to communicate the costs and saving opportunities (labour, OH&S, product value etc.)
2. This final report
   2.1. Summarises the findings of the analysis and explains the design and results of the cost benefit model.
3. Presentation File:
   3.1. Microsoft PowerPoint summary
   3.2. Video/photo's
   3.3. The objective of the presentation file is to provide slides that may be helpful to the client in communicating the value of the automation processes to potential customers or interested parties.

5 Data Collection & Calculations

Data collection for the Cost Benefit Analysis (CBA) occurred in three different plants:

- Alliance's Mataura plant in New Zealand South Island (Automated evisceration)
- Australian Plant 1 (Manual evisceration, single shift, carcase sales, chain over viscera pans)
- Australian Plant 2 (Manual evisceration, single shift export boneless sales, offset pans)

The two Australian plants were selected as they covered a wide range of the variables that will have an impact on the value of automated evisceration to the Australian industry. Six of these variables are critical financial drivers, summarised in Table 3 and detailed below.

Table 3: Plant specific drivers used in the to calculate value opportunities

6 Critical Drivers

Plant Specific Drivers		
Useful working life	15	
Discount rate (for NPV)	7%	
Viscera pans offset from chain	N	
Stabalisation Chain required (Y/N?)	N	
Standard Trim conversion (Y/N?)	Y	
% of lambs purchased HSCW* OTH**	70%	
Carcase sales as % of total	0%	
Is Thin skirt $ increase a benefit of system (Y/N?)		N
Hours/Shift & Shifts/day	7.5 Hrs	1
Chain speed (#/min) & #/day	8.5	3,825 Hd
Weeks of operation/year	48	

1. Viscera pans – need to be underneath the carcase during automated evisceration. Plants with pans offset from the chain will require the chain to be moved over the pans using the NZ system. This increases capital installation cost.
2. Carcase Stabilisation – This was a critical hurdle to overcome during the development of the NZ system and involves installation of a secondary chain to hold the gambrel and stabilise the carcase through the automated evisceration process.
3. Thin Skirt yield implications
   Counterfactual Assumptions - Automation impacts on thin skirt removal and increases value in some situations. However, thin skirt could be removed manually in these situations by adding an extra labour unit. For this reason, increased value of skirt meat has not been included as a benefit of the system and the model drivers 3.1 and 3.2 described here have been set to capture zero value in the model.

   3.1. Standard Trim Conversion - AUS-Meat standard trim includes thin skirt as part of the HSCW. NZ automation will remove the thin skirt on the slaughter floor. Conversion factor accounts for the difference in carcase dressing percentage (Thin Skirt removed) when calculating HSCW and carcase cost. If the supplier agrees to the new dressing standard without an adjustment in HSCW there is an advantage to the processor. See section 7.2 on page 18 for more detail.

3.2. Percentage of lambs purchased OTH – lambs purchased on per-head-basis provide a benefit to boned carcases as removal of thin skirt on the slaughter floor creates more value than in the boning room. Note these savings have not been included as per comments above. See section 7.2 on page 18 for more detail.

3.3. Carcase sales – Automated evisceration and removal of the thin skirt on the slaughter floor changes carcase value dependant on processor sales strategy. Thin skirt meat is worth less than selling as part of a full carcase price but more than leaving intact as part of the lamb flap primal. The percentage of carcases sold as full carcases impacts significantly on cost or benefit generated by auto evisceration. Using this auto evisceration system for carcase sales would significantly reduce sales value. See section 7.2 on page 18 and section 7.3 on page 20 for more detail.

6 De sign and Installation considerations

6.1 O ffset viscera pans

Most plants in Austr lia have the viscera pans running offset from the chain. This requires slaughtermen to lift and turn when placing offals in pans behind them. It also poses a problem for auto evisceration given the robot's primary job is to push offal down through the rib cavity directly below the carcase.

The New Zealand plant had previously had an offset chain. It was considered easier to move that section of the carcase chain sideways to align carcases directly over the existing viscera pans rather than design a system to work with the existing offset infrastructure.

Some plants in Australia already have viscera pans under the carcase as in the Plant 1 plant. Install costs will vary widely across plants depending on infrastructure constraints. This difference in installation cost has been captured in the model as a separate capital line item, adjustable on a plant by plant basis (Table 4).

Table 4: Capital cost assumptions

Capital Cost	1 Shift Basis		Life span	annual cost
Capital Cost of the equipment	$270,000	$270,000	15	$18,000
Gambrel Stabalisation Chain	$250,000	$250,000	20	$12,500
Moving Chain over Viscera Pans	$250,000	$250,000	20	$12,500
Total	**$770,000**	**$770,000**		**$43,000**

6.2 C arcase size

A range of carcase weights (~17-26kg in Figure 3) including lambs and sheep were processed while inspecting the evisceration system. The full range of a carcase weights (12-+30kg) was not able to be observed as the brisket cutter was not cutting through the sternum consistently in the later part of the day. Given the simple path of the robot the change in motion for different carcase weights is negligible. Brisket cutting occurred automatically prior to the evisceration system and inconsistent cuts had to be eviscerated manually as in Figure 4 below.

Figure 3: Auto Evisceration accommodates carcase weight ranges

Figure 4: Poor brisket cutting pre-evisceration prevented full testing of carcase weight range

6.3 Integration with brisket cutting

It is common practice in Australian plants to manually cut the brisket after evisceration. Manual evisceration allows the pluck to be lifted up out of the rib cavity. But during auto evisceration offals are pushed down through the chest cavity; the brisket bone has to be cut for this to occur. As the shovel pushes down the cut sternum allows the ribs to open, making room for the shovel to pass through. Subsequently, installing auto evisceration would require the brisket cutting job to occur before evisceration.

Ineffective brisket cutting was observed during inspection of the system in NZ. Where the sternum was not cut completely or was significantly off-centre excessive pressure was placed on the carcase/gambrel by the robot. The impact was minor in that the robot continued to operate and the carcase was not damaged. However, there was a greater chance of damaging product and increasing maintenance costs over time.

A range of automated brisket cutter solutions are available from various manufacturers. The auto-evisceration system will only work when the brisket and neck has been completely cut through.

6.4 Ceiling space

Ceiling space above the slaughter chain in some Australian plants is limited. The Milmeq system does not require space above the chain as the robotic arm starts below the chain as it enters the carcase cavity and moves downward.

For processing plants that require the chain to be moved over the top of the viscera table, ceiling height may become an issue where the chain has to be lifted to easily clear the top of the viscera trays. See section 9.4 on page 30 for a specific example.

6.5 Carcase stabilisation

During meetings in New Zealand, Milmeq highlighted the importance of carcase stabilisation for effective automation. Normal carcase swivelling on steel gambrels during the development process had to be prevented and resulted in development of a separate stabilisation chain and customised clamps that hold the carcase stable on its gambrel as in Figure 5. The stabilisation clamp supports under the stainless cross piece, lifts up and takes the weight of the carcase while preventing it from slipping off the hook. Note the larger clearance between the hook and the hocks in two Australian examples in Figure 6 as compared to minimal clearance in the New Zealand hook in Figure 5.

The carcase stabilisation chain is a large capital cost in addition to the robot and to moving the slaughter chain (where required). It is not part of the value adding process and should be redesigned or eliminated to reduce capital cost required to approach an acceptable return on investment.

Alternative carcase stabilisation designs should be considered for Australian hook formats that are significantly lower cost. Given the different format of the Australian hooks shown in Figure 6 this may not be an easy job.

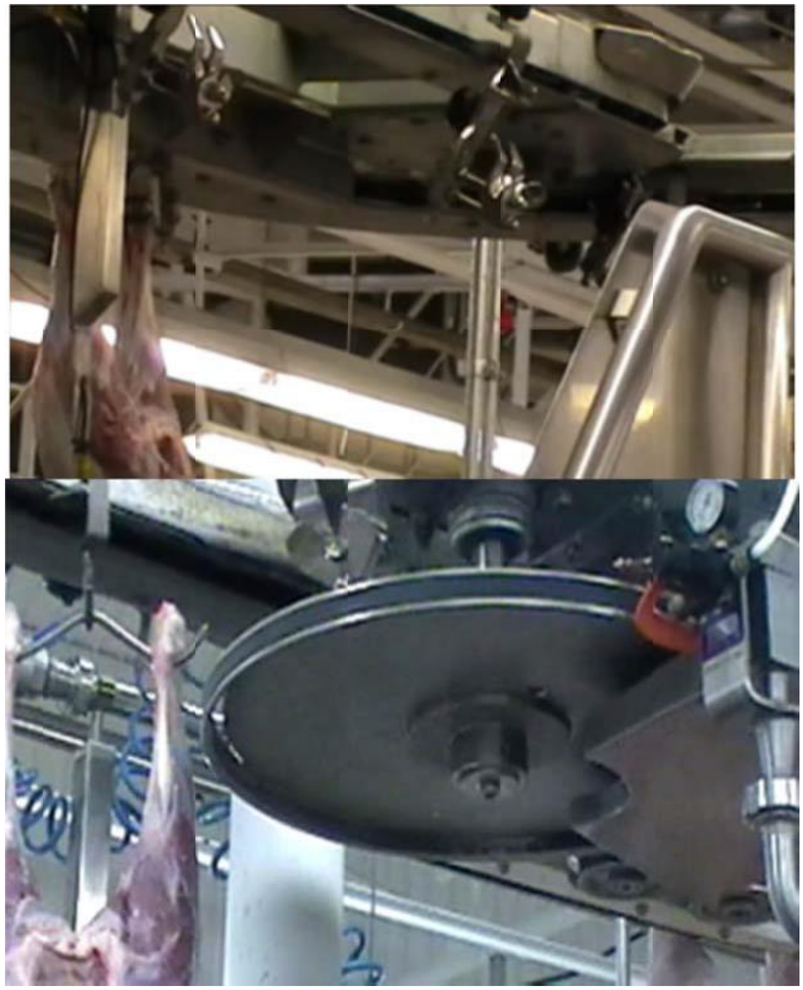


Figure 5: Separate carcase stabilisation chain integrates with slaughter chain to left and hold the carcase and gambrel prior to and through the evisceration process

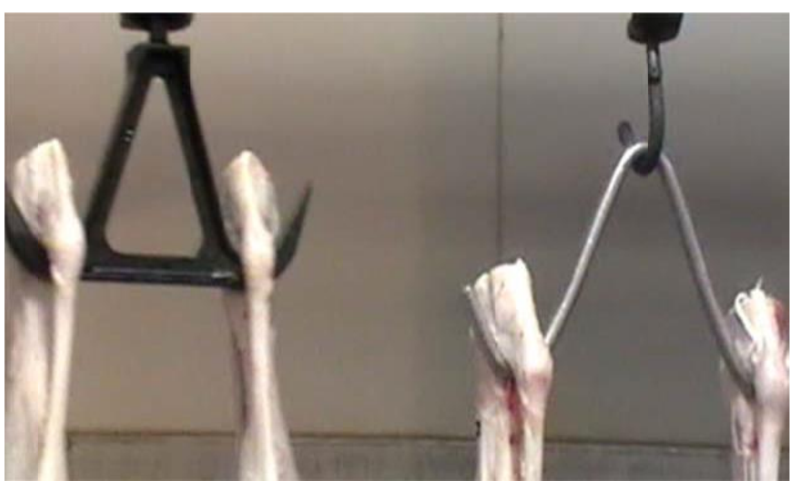


Figure 6: A range steel and plastic gambrels used in Australian abattoirs would require an alternative to, or an adjustable carcase stabilizer chain

6.6 T ool design

The design of the Milmeq shovel attachment as shown in Figure 8 did not require a significant development time to achieve an acceptable result. The angle of the prongs at the front of the shovel did require adjustment to avoid damaging to the tenderloin primals and the cavity wall but this was not significant. The design of the prototype shovel by MAR in Figure 7 was observed on video only. The shape of the shovel is slightly different to the Milmeq system but the range of motion is the same and delivered a similar result. There are no significant advantages or disadvantages to either system. The Milmeq system works as effectively on heavy carcases as it does on light carcases.

Figure 7: MAR prototype “shovel tool”

Figure 8: Milmeq “shovel tool” attached to robotic arm

6.7 No damage to offals

A concern prior to observing the system was the potential to burst the stomach and contaminate the work area resulting in downtime and product condemnation. However, the mechanism used to "scrap" the offals out of the body cavity is gentle enough that offals are not damaged. Three primary motions were observed in the removal of offals including:

- Placement of the "shovel tool" inside the carcase cavity on the posterior side of the diaphragm
- "Scraping" down of the shovel to separate the offals from the cavity and pushes them through the chest cavity, already opened by the brisket cutter.
- Guiding the offals downwards with gravity into the pan.

Video of scoping trials conducted in Australia by MAR showed more abrupt and less refined robotic movement on a number of carcases. No damage to offals occurred which further enforces that offal damage is unlikely to occur.

6.8 No damage to primals

As the "shovel" scraps down the inside of the carcase cavity it passes over the tenderloins. During initial development of the shovel there was potential to damage tenderloins. The shape and angle of "fingers" on the end of the shovel and the path of the robot in the commercial system does not risk primal damage.

6.9 R&D opportunities to enhance existing system

The existing NZ technology is directly transferrable to Australian processors in terms of technical capability. The core action of removing viscera does not require further refinement. But a number of design considerations could provide a more innovative approach to retain skirt meat and handle offset viscera pans. This would deliver a more favourable return on investment.

6.9.1 Installation costs

Chain modifications and manning changes to existing processing lines will not be significantly different to those required in NZ. However, the capital installation cost of moving the chain over the pans and installing a separate carcase stabilisation chain makes the ROI unacceptable (>2 years). In some Australian plant scenarios the cost is greater than the benefit and there is no return on investment.

6.9.2 Potential value created from enhancements

The specific areas impacting negatively on Australian ROI were mentioned earlier in Table 2 and listed in the bottom of Table 5. The purpose of this table is to quantify the likely improvement in ROI for each of the system enhancements.

Table 5: Estimated value of R&D improvements to existing system

Estimated Cost Benefit Analysis for automated lamb evisceration (1 Shift)								
Scenario #	1	2	3	4	5	6	7	8
Viscera pans offset from chain	Y	Y	Y	Y	N	N	N	N
Standard Trim conversion (Y/N?)	N	Y	N	Y	N	Y	N	Y
% of lambs purchased HSCW OTH	0%	0%	70%	70%	0%	0%	70%	70%
Carcase sales as % of total	0%	0%	70%	70%	0%	0%	70%	70%
Total Cap Ex (incl. Installation)	770,000				520,000			
Annual number of head	918,000							
R&D Improvement Opportunities impacting ROI								
Manage Offset viscera pans	⇨	⇨	⇨	⇨	✓	✓	✓	✓
Thin Skirt remains intact	✓	✓	⇦	⇦	✓	✓	⇦	⇦
Carcase Stabilisation not gambrel specific (ROI saving - years)	0.53	3.06	1.12	-1.51	-0.11	-0.57	-0.23	0.37
Save 1 extra labour unit - Gut removal ($0.06/hd)	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06
Thin Skirt - no prep, save 1 FTE ($0.06/hd)	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06
Existing Pay back years	2.00	11.49	4.21	-5.69	1.31	6.54	2.66	-4.23
Potential ROI with new R&D	**1.14**	**3.19**	**1.93**	**NO ROI**	**0.62**	**1.66**	**1.03**	**NO ROI**
New Stabilisation Chain Capex	$45,000	reduced from		$250,000				

The top yellow section of the **Error! Reference source not found.** summarises 8 different plant scenarios. The R&D improvements in the bottom section of the table indicate the change in value if that improvement was achieved. Sideways arrows (⇦ & ⇨) indicate the new scenario that would be achieved. For example:

- "Manage Offset Viscera pans" refers to reduction in installation capital of $250,000 from Table 4. This would apply to the first 4 scenarios from the left of Table 5. The arrows indicate the new ROI would be equivalent to that in the scenarios from column 5 through 8 on the right hand side of the table.
- "Thin skirt remains intact" refers to processors who sell carcases as in scenarios 3 and 4, as well as scenarios 7 and 8, that would benefit from skirt being left intact. If the system was improved to retain the thin skirt, ROI in these scenarios would be the same as scenarios 1 and 2, as well as 5 and 6. So scenario 8 with a negative payback would become a positive payback as in scenario 6 if modifications to the system enabled retention of thin skirt. Likewise scenario 3 would improve from 4.21 years ROI to 2.00 years as in scenario 1.
- The three rows of orange highlighted cells represent the three additional areas of R&D improvement that could be developed. The values (years or ROI and $/hd savings) are used to calculate the new potential ROI for each scenario at the bottom of the table if these improvements were achieved.
  - All scenarios are calculated on a single shift basis. Reducing the ROI by half is a quick way to calculate a two shift operation. Alternatively a detailed scenario can be run through the costing model.
  - Reduction in capital installation cost has been modelled in the bottom of the table resulting from redesigning the carcase stabilisation component.

7 C A Drivers B

7.1 H ygiene and Inspection

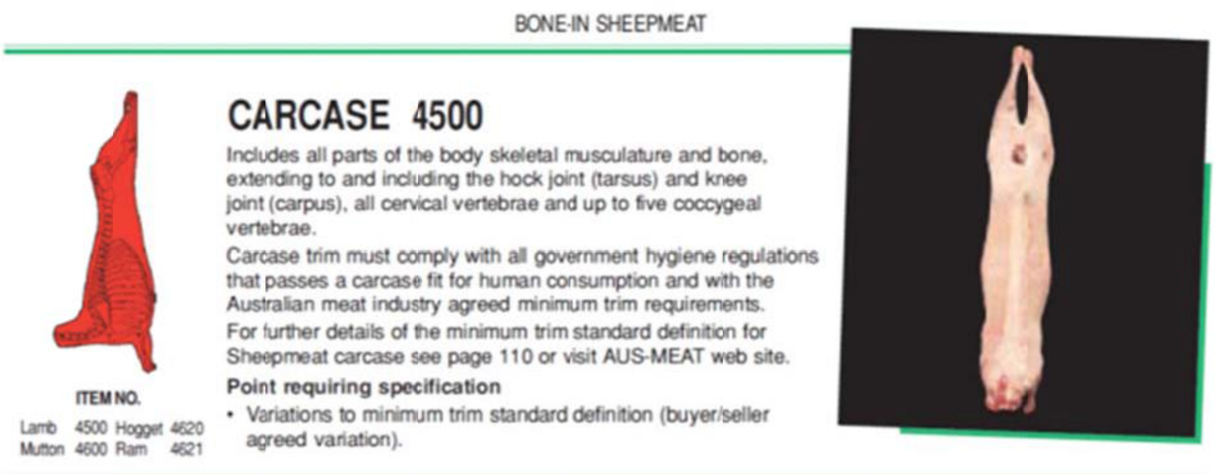
The process of sterilising the robot between each carcase is similar to other robotic installations. There was no perceived difference between the manual or automated processes.

Red and green offal is placed into separate pans by slaughterman for health inspection under manual processes. During automated removal all offals are removed into one pan. Additional labourers are required to separate the offals for presentation to inspectors. It has been confirmed through telephone discussion with AQIS inspectors that initial placement of red and green offals into one pan by the robot prior to separation by the labourers is an acceptable change to current processes.

7.2 Yield – Livestock Cost

The fundamental driver for automating evisceration in lambs is to reduce labour and eliminate OH&S risks associated with the current manual process. However, the automated NZ process removes the thin skirt on the slaughter floor (compared to leaving it in) impacting on carcase yield more than the OH&S bene its. Depending on each Australian plants livestock purchasing methods and boning and sales processes, this yield difference has significant positive or negative impact on the systems commercial viability.

Figure 9 and Figure 10 below describe the standard carcase trimming specification for lambs in Australia which include the thin kirt but exclude the thick skirt as shown in Figure 11 below.



BONE-IN SHEEPMEAT

CARCASE 4500

Includes all parts of the body skeletal musculature and bone, extending to and including the hock joint (tarsus) and knee joint (carpus), all cervical vertebrae and up to five coccygeal vertebrae.

Carcase trim must comply with all government hygiene regulations that passes a carcase fit for human consumption and with the Australian meat industry agreed minimum trim requirements.

For further details of the minimum trim standard definition for Sheepmeat carcase see page 110 or visit AUS-MEAT web site.

Point requiring specification

- Variations to minimum trim standard definition (buyer/seller agreed variation).

ITEM NO.

Lamb	4500	Hogget	4620
Mutton	4600	Ram	4621

Figure 9: AUS-Meat lamb carcase specification

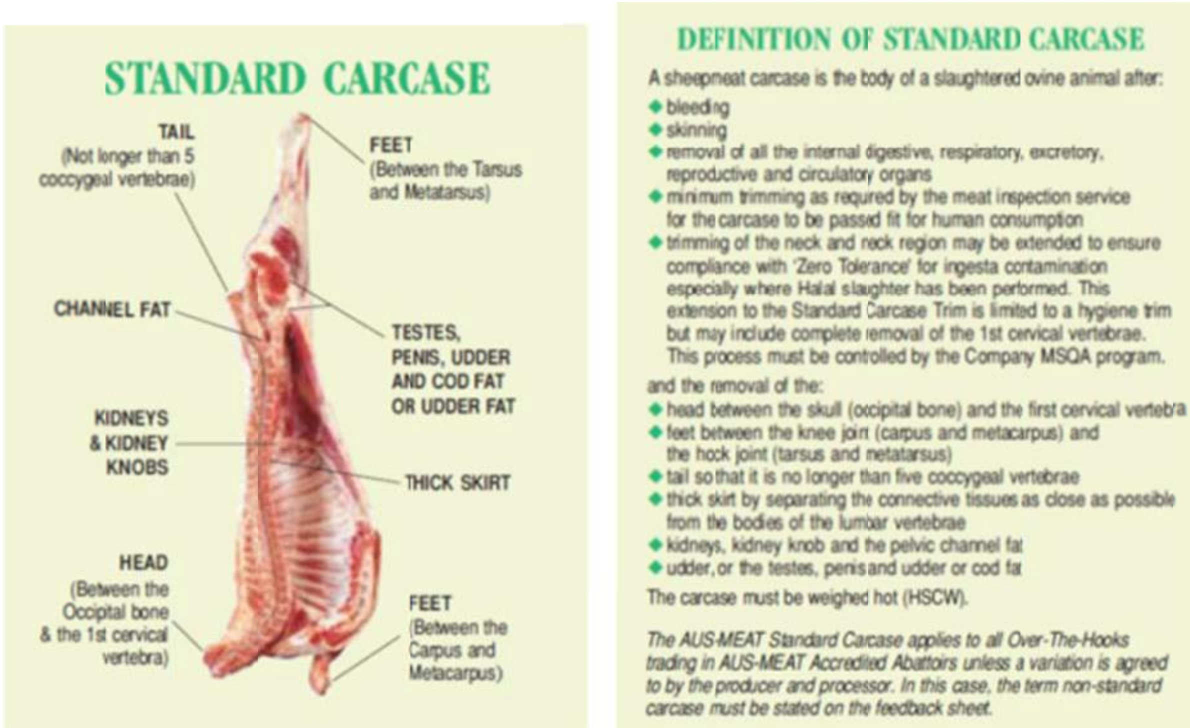


Figure 10: AUS-Meat Standard Carcase Trim Requirements (1)

The NZ automation system removes the thick skirt as well. Provision is made on Australian vendor declarations for suppliers to approve removal of thick skirt as a “Non-standard carcase trim”. Any change in the value of the carcase due to variation from standard trim is to be negotiated between the processor and supplier.

In the model a conversion factor is applied to ensure the carcase value does not change due to a change in dressing percentage. This can be adjusted in the summary page of the model under “Standard Trim conversion” as shown in Table 3 on page 9. If a standard trim conversion is not applied in the model the processor pays less for the carcase by the reduced weight of thin skirt removal. This saving is applied across the volume of carcases purchased OTH’s but not to lambs purchased on a per head basis.

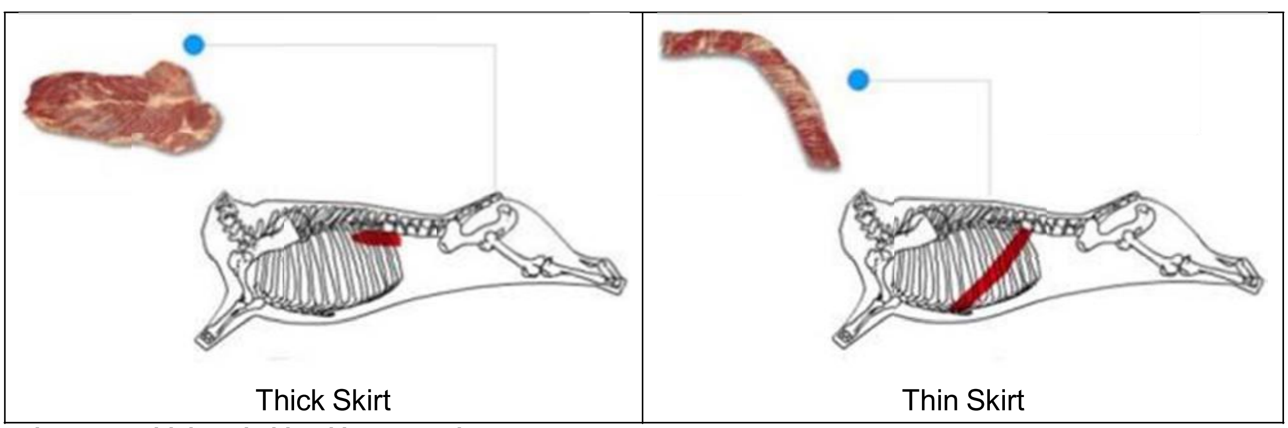


Figure 11: Thick and Thin Skirt removal

7.3 Yield - Product value

Because the Auto-Evisceration system removes thin skirt on the slaughter floor the value of that meat increases for boned product and decreases for carcase sales. Thin skirt can be sold as Breast and Flap in Figure 12 or Thin Skirt meat in Figure 13.

Figure 12: AUS-Meat HAM code/specification for breast and flap

Figure 13: Thin skirt meat removed hot as 85-90CL Thin Skirt Trim

Table 6 shows three indicative values used in the model for thin skirt, depending on how it is sold. Figure 14 below shows the significant difference in cost or benefit of the system depending on the market for the end product for Australian processors.

Table 6: Produc values used to calculate impact of alternative trim standards on carcase value

Item	HAM Code	$/kg	
Carcase Sale	4500	$6.00	
Breast and Flap	5010	$1.00	
Thin Skirt meat (85CL)		$2.50	
Heart			
Lungs			

7.3.1 Carcase Sales

Livestock destined for carcase sales stand to lose a significant amount ($1.75/head) which makes the system unviable for this type of business.

7.3.2 Product Sales

Some Australian companies have harvested thin skirt meat on the slaughter floor manually and sold as 85CL Thin skirt trim. The auto evisceration system can do this automatically but still requires at least half a labour unit to separate the thin skirt in the viscera trays or the offal room. For these reasons the increase in value achieved by selling thin skirt as trim instead of flap meat has not been counted as a benefit to the auto evisceration system although the increase in value (approximately $1.13/hd) has been reported in Figure 14 below.

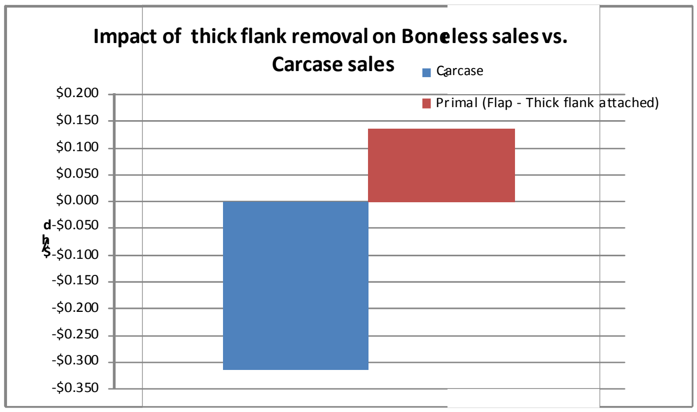


Figure 14: Removing thick flank on the slaughter floor impacts carcase and boned sales differently

7.4 P reparation technique

For the automated system to completely remove the diaphragm the slaughterman removing the kidneys and thick flank needs to place a knife cut about 5cm long through the diaphragm at the point where the diaphragm meets the backbone as in Figure 15. This allows the two prongs on the front of the robotic shovel to pass down through the diaphragm and tear the remainder of the diaphragm from the ribs cleanly.

Figure 15:Pre-evisceerastion preparation

Figure 16: Incomplete removal of viscera

If this job is not done correctly part of the diaphragm can remain in the carcase and will have an impact on dressing percentage and carcase value to the disadvantage of the processor. In a small percentage of cases (observed less than 2% of the time during site inspection) a large amount of viscera was left in the carcase as in Figure 16 and had to be removed manually by other staff. The costings in the model assume 100% of diaphragm is removed cleanly.

7.5 Staff savings

7.5.1 Reduced labour (observed during site visit)

Replacing the manual separation of the viscera from the carcase is the primary area where auto evisceration saves labour. Manual removal of viscera in parts to separate pans for red and green offal is replaced by one automated action removing the entire viscera as a group. The separation is still required prior to health inspection. The Mataura plant was able to save 4 slaughtermen but had to add an additional 3 people (1 to assist gut preparation, 1 to separate skirt, 1 to sort on the evisceration pans). It is easier to separate red and green offals with the help of gravity (hanging in the abdominal cavity) as compared to sliding around the viscera pan which posed a challenge in saving more labour.

The New Zealand learning's were a helpful guide to potential savings in Australia. However, not knowing the Mataura plants previous manning levels and efficiencies, the value of Australian labour savings has been assumed as the reduction on best practice manual manning levels in Australian plants. The left hand side Table 7 below represents the manning levels across two Australian plants operating at 8.5 – 9 carcases per minute. Three slaughtermen should be saved (right hand side of Table 7) but 2 knife hands would need to be added back. This represents a total saving of 1 person per shift plus a reduction in cost per person for the two knife hands in plants where slaughtering and knife hand pay rates differ (Table 8).

Note that one additional person has been added to the current manual scenario for the separation of thin skirt on the slaughter floor. This job was not happening in either PLANT 2 or Mataura prior to automation. However, given the increase in value of the thin skirt is not being counted towards the auto evisceration system (see section 7.3), the labour to do that job also needs to be counted prior to installing automation to compare manual and automated scenarios equally. In Section 10 of Plant 1 Considerations this labour unit is not included prior to automation as removal of thin skirt on the slaughter floor decreases product value.

Table 7: Manning levels before and after automation

Current Position	Description	FTE's (Slaughter man)	FTE's (Knife Hand)	Automation Changes	FTE's (Slaughter man)	FTE's (Knife Hand)
Tail removal		1		No Change	1	
Ringer		1		No Change	1	
Bung Evacuation	• Open stomach • Remove pellets, Tie off	2		No Change	2	
Gut removal	• Remove kidney and liver to pan • Gut hung on outside of carcase • Remove green offal's to pan • Separate heart	2		• Remove kidney and liver to pan • Gut hung on outside of carcase • Prep KPH and skirt	1	
Pluck removal	• Pluck and thick flank removed	2				0
Brisket Cutter	• After Evisceration	1		•Prior to Evisceration	1	0
Kidney	• Enucleate Kidneys		1	• Enucleate Kidneys		1
New Position				• Separate Pluck • Separate green offals		1
New Position*	• Separate skirt meat		1	• Separate skirt meat		1
Sub Total		**9**	**2**		**6**	**3**
Total		**11**			**9**	
* See section 7.3 "Yeild - Product Value" and 7.5.2 "Reduced Labour" in written report						
Labour FTE savings (per shift & per day)		**2**	**4**			

Labour saving for a plant running at 8.5 head per minute is approximately $0.12/carcase using the wage rates in Table 8.

7.5.2 Further labour reduction (post site visit)

In phone discussions with OAL since the site visit, the plant has saved 1 additional labour unit giving a total of 3 FTE's per shift. This additional saving has come from adjustment to work up practices prior to the brisket cutter and evisceration system. Automated brisket cutting is integrated as part of the NZ project and saves 4 FTE's across the two systems. It is not 100% clear what aspects of the work instructions have changed/reordered to allow the extra labour saving, and whether the 3 labour units could be saved on Evisceration without integrating with brisket cutter savings. We have not included the extra labour saving in this report. Direct discussion between OAL/Milmeq and Australian processors is needed to determine if applicable to each Australian plant.

7.5.3 Pellet removal – Bung evacuation

The removal of pellets in some parts of Australia is a more difficult job than in NZ due to being firmer and drier. Manning in Table 7 accounts for this but it is noted that only 1 FTE was required in the NZ plant and in Australian plants running at speeds less than 8 per minute.

Table 8: Slaughter floor labour savings

Labour		
Shift	Slaughtermen	Knife hand
FTE's saved/shift	3.0	-1.0
Hourly Rate	$30.00	$28.00
Hrs/ shift	7.5	7.5
Days worked	240	240
Hours worked	1800	1800
Saving/Wage Type	$162,000	-$50,400
Total/shift & /day	$111,600	$223,200
Saving per head		$0.12

7.5.4 Reduced Training and recruitment

The cost of training and recruitment will depend on the staff turnover that a plant experiences for this role, and the challenges associated with filling this role. For some Australian plants savings for this component may be limited, however for other plants facing the challenges of labour shortages or aging employees in these roles the benefits may be higher than the dollar values in Table 9 and Table 10. This recruitment saving does not account for the increasing challenge to find suitable operators who can be trained for this role.

Table 9: Recruiting cost per shift

Recruiting	
Turnover	100%
FTE recruited / yr	1
Cost of Recruitment	$5,000
Total Recruitment saving	$5,000
Recruitment saving /hd	$0.01

Table 10: Training cost per shift

Cost of Training	
No weeks training / recruit	2
Training rate	$ 33
Weekly cost	$1,320
Total cost / recruit	$2,640
Total annual cost	$2,640
Saving per head	$0.003
Total Training and recruiting	$0.01

7.5.5 Reduced OH&S costs

Manual evisceration is a physical job, particularly in plants where the viscera trays are offset from the chain. The lifting and twisting action of the worker 180 degrees with a full gut creates a high risk of injury. The risk of back injury over a 10 year period is quite high. In a lot of plants the benefit to team morale of creating a safe work environment and extending workers useful life in a job through reduced physical strain can be more valuable than the eliminated risk. It is difficult to quantify the cost of OH&S risk from this role. But for the purposes of this CBA a benefit has been estimated based on reducing by 80% the likelihood of a major back injury over a 10 year period.

Table 11: Potential OH&S savings over 10 years

OH&S		
Risk of back injury over 10 years		80.0%
Cost of claim in premium	$	50,000
Potential annual cost	$	4,000
Cost per head / annum	$	0.004

7.6 Equipment costs

Estimated equipment capital and operational costs have been provided Milmeq and are detailed in Table 12. Note the difference in installation cost varies significantly depending on whether the slaughter chain is already over the viscera pans or needs to be moved to align with the viscera pans. Given a 15 year life expectancy of the equipment, capital costs (excluding opportunity costs) range from $0.03 to $0.05/hd depending on slaughter chain adjustments. The operating costs of the automation equipment are estimated at a further $0.02/hd. This equates to a total operating cost of between $0.05 and $0.07/hd.

Table 12: Expected commercial capital and operational costs of automation

Capital Cost		Life span	annual cost	Cost /hd
Capital Cost of the equipment	$270,000	$15	$18,000	$0.02
Gambrel Stabalisation Chain	$250,000	$20	$12,500	$0.01
Moving Chain over Viscera Pans	$250,000	$20	$12,500	$0.01
Total	**$770,000**		**$43,000**	**$0.05**
Service maintenance	Total	Life span	annual cost	Cost /hd
Estimated - COSTS	6.90%			
Essential and insurance spares	$18,638	15	$1,243	$0.00
Cleaning materials	$3,345	1	$3,345	$0.00
Maintenance labour	$7,099	1	$7,099	$0.01
Maintenance materials	$900	1	$900	$0.00
Electricity	$5,280	1	$5,280	$0.01
Ongoing training	$1,000	1	$1,000	$0.00
Annual Sub Total (excluding major overhaul costs)			**$18,867**	**$0.02**
Major overhaul costs	$10,000	5	$2,000	$0.00
Sub Total: Operating Expense			$20,867	$0.02
Combined Total: (cap ex + operating)				**$0.07**

8 Value Benefit Results

This section provides the costs benefit analysis results arising from the data collection phase. This data is collected from several shifts, and processing plants and provides broad estimates only. The financial figures provided should be considered against the unique variables for each site specific installation for which the automation technology is being considered.

8.1 Plant Drivers

The drivers used in the cost benefit analysis were explained in section 5 on page 9 and summarised again in Table 13 below.

Table 13: Drivers used for estimating the value benefit

6 Critical Drivers

Plant Specific Drivers		
Useful working life	15	
Discount rate (for NPV)	7%	
Viscera pans offset from chain	N	
Stabalisation Chain required (Y/N?)	N	
Standard Trim conversion (Y/N?)	Y	
% of lambs purchased HSCW* OTH**	70%	
Carcase sales as % of total	0%	
Is Thin skirt $ increase a benefit of system (Y/N?)		N
Hours/Shift & Shifts/day	7.5 Hrs	1
Chain speed (#/min) & #/day	8.5	3,825 Hd
Weeks of operation/year	48	

Useful working life is used to calculate the cost of capital depreciation of the equipment, and also drives the number of years used for the net present value (NPV) of the investment. For the analysis provided a discount rate of 7% is in the NPV calculation. Number of head processed/ day and days of operation are used to calculate the total number of head processed per annum. All drivers are adjustable in the provided excel file.

8.2 CBA Drivers & Benefit Type

Various combinations of the parameters identified in Table 3 have been run through the model to indicate the wide range in value generated, dependant on a plants particular situation. These scenarios are summarised in Table 14 below. Given the wide range in variables and subsequent return on investment, the report does not refer to any one scenario but explains all the factors and impacts that should be considered across the range of Australian plant environments. Each specific situation should be run through the model to determine values for a specific plant.

Please make special note in scenario's 1, 3, 5 and 7 that not using a standard trim conversion contributes significantly to the net benefit of the relevant scenarios in terms of livestock cost, providing very attractive pay-backs. It is arguable though whether this benefit can only be realised with automation as one labour unit could remove the thin skirt with a knife and achieve similar returns by selling the diaphragm as 85CL trim. Implementing this meat recovery strategy may alter existing current arrangements between processor and producer, and it is up to each individual processor to establish the viability of this practice with its supplier. Refer to Section 7.3 for more details.

Table 14: Summary results of the cost benefit analysis for automated ovine evisceration on a single shift basis

Scenario #	1	2	3	4	5	6	7	8
Viscera pans offset from chain	Y	Y	Y	Y	N	N	N	N
Standard Trim conversion (Y/N?)	N	Y	N	Y	N	Y	N	Y
% of lambs purchased HSCW OTH	70%	70%	70%	70%	70%	70%	70%	70%
Carcase sales as % of total	0%	0%	70%	70%	0%	0%	70%	70%
Annual number of head	918,000							
Total Cap Ex (incl. Installation)	770,000				520,000			
Gross return Per head	0.49	0.14	0.27	-0.08	0.49	0.14	0.27	-0.08
Total costs Per head	$0.07	$0.07	$0.07	$0.07	$0.06	$0.06	$0.06	$0.06
Net Benefit Per head	0.42	0.07	0.20	-0.15	0.43	0.09	0.21	-0.13
Annual Net Benefit for the plant	$385,100	$67,013	$182,681	($135,406)	$397,600	$79,513	$195,181	($122,906)
Pay back years	2.00	11.49	4.21	-5.69	1.31	6.54	2.66	-4.23
Net Present Value (15 yrs)	$3,150,178	$253,069	$1,306,564	($1,590,545)	$3,383,823	$486,714	$1,540,208	($1,356,901)

All figures have been calculated on a per head basis, and then extrapolated by the number of head per year being processed on a single shift basis to calculate total expected benefit /year. Table 13 shows that the technology ranges from delivering a benefit of $0.43/ hd (no adjustment to livestock dressing percentage) to being a net cost depending on plant situation. This range in value limits the current system to the following type of plants:

- Double shift
- Slaughter chain over viscera trays
- Minimal carcase sales

8.3 CB A Financial analysis

Based on the 2 shift scenario outlined in Table 15 below, a net benefit of $0.11/hd and a total benefit to the plant of $206,400 per annum would be expected. This produces a payback period of 2.52 years, and a Net present value of the investment at $1.6 million over 15 years of operation.

Table 15: Financial analysis of cost benefit results

Estimated Cost Benefit Analysis for automated lamb evisceration	
Total Cap Ex (incl. Installation)	**$520,000**
Gross return Per head	**0.14**
Total costs Per head	**$0.03**
Net Benefit Per head	**0.11**
Annual Net Benefit for the plant	$206,393
Pay back years	**2.52**
Net Present Value (15 yrs)	$1,642,326

6 Critical Drivers

Plant Specific Drivers		
Useful working life	15	
Discount rate (for NPV)	7%	
Viscera pans offset from chain	N	
Stabalisation Chain required (Y/N?)	Y	
Standard Trim conversion (Y/N?)	Y	
% of lambs purchased HSCW* OTH**	70%	
Carcase sales as % of total	0%	
Is Thin skirt $ increase a benefit of system (Y/N?)		N
Hours/Shift & Shifts/day	7.5 Hrs	2
Chain speed (#/min) & #/day	8.5	7,650 Hd
Weeks of operation/year	48	
Annual number of head	1,836,000	

9 PLANT 2 Considerations

A site visit of PLANT 2 was conducted in July to understand the implications of auto evisceration to Australian processors.

9.1 Site visit objectives

- What processing requirements need to be considered for Auto-Evisceration in Australia?
- Is Milmeq existing Auto Evisceration system suitable for Australia
  - What modifications are required?
  - Is an alternative solution designed specific for Australia worthwhile?
- What specific challenges do PLANT 2 face in implementing Auto Evisceration
  - What barriers will limit the uptake of this technology?

9.2 Yield Implications

Because PLANT 2 sell most product as primals the removal of thin skirt on the slaughter floor does not disadvantage product value as it does with carcase sales. The potential benefit in increased value as described in section 7.3 has not been included as part of the automated benefit because the labour unit added to separate thin skirt in the viscera pan could manually remove the skirt without auto evisceration. The increase in value represents about $0.14/hd or $124,000 annually.

9.3 Location of brisket cutter

Automating the evisceration process would require brisket cutting to be moved towards the start of the chain as described in section 6.3 "Integration with brisket cutting" on page 13. If the Milmeq cleaver option were used the robot enters from the back while inverted and would have enough floor space on the main working side of the chain. If a manual brisket cutter or automated saw like the MAR solution were used the cut would be done on the side closet to the wall. Space is minimal as shown in Figure 18. However, the chain is currently offset from the viscera pans and would have to be moved away from the wall to align with the pans giving more space.

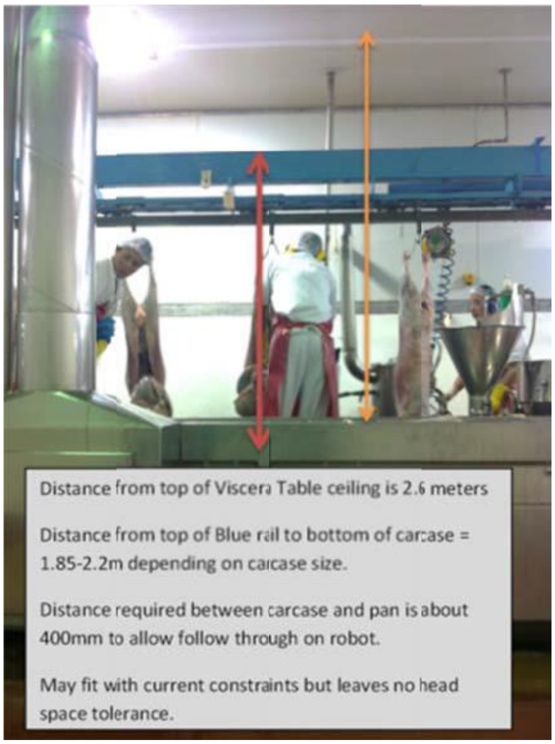
Figure 17: Allowance for Cleaver brisket cutter on open side of slaughter chain

Figure 18: Distance between wall and slaughter chain for manual or MAR brisket cutting may require recessing into wall

9.4 M oving the chain - ceiling height considerations

Ceiling height had already been flagged as a potential restriction for installation of an evisceration robot at Plant 2. Al hough the robot itself does not take up head space above the chain, moving a section of the chain over the viscera trays would only be possible by raising that section of the chain enough for the hanging carcase to clear the bottom the trays. During the site visit clearances were measured with the Plant Engineer.

Figure 19 indicates there is enough head space but does not leave any tolerance where a 400mm distance is left between the bottom of the carcase and the top of the viscera trays.



Replacing some sections of the slaughter chain may be required in the near future as part of general maintenance. If this is the case, shifting the chain may make auto-evisceration more feasible. Some example costings have been included in the next section.

Figure 19: Ceiling space considerations

9.5 Return on investment trade-off's

The likely return on investment for PLANT 2 assuming the chain needs to be moved but carcase stabilisation is not required is 6.5 years detailed in Table 16. Given PLANT 2 are considering refurbishment of the slaughter chain, removing the capital cost of moving the chain from the scenario gives a payback of 2.9 years.

For PLANT 2, as with many plants, other capital expenditure projects have paybacks of close to 12 months. This makes the current auto evisceration option unfavourable unless modifications discussed earlier in Table 2 are addressed.

Table 16: Cost benefit scenario assumptions for single shift boneless processing

Estimated Cost Benefit Analysis for automated lamb evisceration	
Total Cap Ex (incl. Installation)	$520,000
Gross return Per head	$0.14
Total costs Per head	$0.06
Net Benefit Per head	$0.09
Annual Net Benefit for the plant	$79,513
Pay back years	6.54
Net Present Value (15 yrs)	$486,714

6 Critical Drivers

Plant Specific Drivers		
Useful working life	15	
Discount rate (for NPV)	7%	
Viscera pans offset from chain	Y	
Stabalisation Chain required (Y/N?)	N	
Standard Trim conversion (Y/N?)	Y	
% of lambs purchased HSCW* OTH**	70%	
Carcase sales as % of total	0%	
Is Thin skirt $ increase a benefit of system (Y/N?)		N
Hours/Shift & Shifts/day	7.5 Hrs	1
Chain speed (#/min) & #/day	8.5	3,825 Hd
Weeks of operation/year	48	
Annual number of head	918,000	

**Hot Standard Carcase Weight **Over The Hooks (Carcase weight and grade)*

Drivers

Item	Description	$/hd	$/ annum
Product Benefits	Livestock cost	$0.00	$0
	Thin Skirt value	$0.00	$0
	Offal Value	$0.00	$0
	Hygiene	$0.00	$0
	Other	$0.00	$0
Operational Benefits	Labour	$0.12	$111,600
	Training & recruitment	$0.02	$15,280
	OH&S	$0.00	$4,000
	Existing operational costs	$0.00	$0
Total Benefits		**$0.14**	**$130,880**
Capital Cost		$0.03	$30,500
Service / maintenance		$0.02	$20,867
Damaged Product			$0
Total Costs		**$0.06**	**$51,367**
Net Benefit		**$0.09**	**$79,513**

10 Plant 1 Considerations

A site visit of Plant 1 was conducted in July to understand the implications of auto evisceration to Australian processors.

10.1 Site visit objectives

- What processing requirements need to be considered for Auto-Evisceration in Australia?
- Is Milmeq existing Auto Evisceration system suitable for Australia
  - What modifications are required?
  - Is an alternative solution designed specific for Australia worthwhile?
- What specific challenges do Plant 1 face in implementing Auto Evisceration
  - What barriers will limit the uptake of this technology?

10.2 Yield Implications

Because Plant 1 sell most of their product as whole carcases, removing the thin skirt devalues the carcase by almost $0.32/hd. The benefits of the system barely cover this cost.

Unless auto evisceration can be redesigned to retain the thin skirt it will not be a viable solution for this type of company.

10.3 Labour saving

The manning levels discussed earlier with saving of 1 labour unit apply to Plant 1. During discussions on the processing line, management felt it would be a challenge to save a full labour unit due to the extra work created in separating red and green offals and skirt in the trays. We believe with some focus the full labour saving could be achieved so have been assumed in the costing work below.

10.4 Return on investment trade-off's

The model assumes the lowest installation cost possible given viscera trays are already under the chain and a carcase stabilisation chain may not be required. However, it is not possible for Plant 1 to repay the current Auto Evisceration system as summarised in Table 17. The key driver is the majority of sales being domestic carcases. If an alternative evisceration system enabled removal of viscera while keeping thin skirt intact the pay back would go from negative to just under 8 years. A double shift operation and saving of more than one person would be required to achieve favourable return on investment.

Table 17: Cost Benefit Scenario and assumptions for single shift domestic carcase processor

Estimated Cost Benefit Analysis for automated lamb evisceration	
Total Cap Ex (incl. Installation)	$270,000
Gross return Per head	-$0.18
Total costs Per head	$0.05
Net Benefit Per head	-$0.23
Annual Net Benefit for the plant	($182,904)
Pay back years	-1.48
Net Present Value (15 yrs)	($1,783,566)

6 Critical Drivers

Plant Specific Drivers		
Useful working life	15	
Discount rate (for NPV)	7%	
Viscera pans offset from chain	N	
Stabalisation Chain required (Y/N?)	N	
Standard Trim conversion (Y/N?)	Y	
% of lambs purchased HSCW* OTH**	70%	
Carcase sales as % of total	85%	
Is Thin skirt $ increase a benefit of system (Y/N?)		N
Hours/Shift & Shifts/day	7.5 Hrs	1
Chain speed (#/min) & #/day	7.5	3,375 Hd
Weeks of operation/year	48	
Annual number of head	810,000	

**Hot Standard Carcase Weight **Over The Hooks (Carcase weight and grade)*

Drivers			
Item	**Description**	**$/hd**	**$/ annum**
Product Benefits	Livestock cost	$0.00	$0
	Thin Skirt value	-$0.27	-$216,878
	Offal Value	$0.00	$0
	Hygiene	$0.00	$0
	Other	$0.00	$0
Operational Benefits	Labour	$0.08	$61,200
	Training & recruitment	$0.01	$7,640
	OH&S	$0.00	$4,000
	Existing operational costs	$0.00	$0
Total Benefits		**-$0.18**	**-$144,038**
Capital Cost		$0.02	$18,000
Service / maintenance		$0.03	$20,867
Damaged Product			$0
Total Costs		**$0.05**	**$38,867**
Net Benefit		-$0.23	-$182,904

11 Summary

1) The core activity of removing viscera from the carcase works well in the New Zealand plant reviewed and is transferable to Australian plants. Further R&D around this activity alone is not required.
2) Some Australian plants will be disadvantaged due to yield/value loss issues involved with removal of thin skirt.
3) Capital installation costs are quite high due to adding and modifying slaughter chain infrastructure. This makes return on investment prohibitive except for the highest volume processors.
4) Labour savings are minimal relative to the capital cost.

12 Recommendations

1) Current installation costs are too high to deliver an acceptable return on investment for any Australian plant. Carcase stabilisation in particular should be redesigned for Australian plants with the potential to reduce capital cost by 30% ($210,000). This would make ROI worth considering for a 2 shift operation, particularly if the viscera pans are already under the carcase chain.
2) Further refinement to the core evisceration process will not contribute to improved return on investment except where skirt could be retained or where offset viscera pans did not require alignment under carcase chain.
3) More clarification is required around additional labour savings claimed by OAL since the visit and whether they translate to savings in Australian plants. These alone are not significant relative to 1) above.
4) Any processor considering this system needs to ensure the brisket cutting task cuts completely through the neck, creating a clear path for the evisceration robot.

13 Figures and Tables

14 References

Norton, K. and M. Rafferty (2010). Work, skills and training in the Australian red meat processing sector. Adelaide, Workplace Research Centre, University of Sydney: 45.