Final Report

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Review of current developments and future R & D opportunities for Lamb French Racking

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Executive Summary

Given the number of french racking R&D proposals and projects that have either been invested previously, or that are currently under consideration, it was evident that a review of 1) industry needs and specification, and 2) future R&D options, was required.

Collaboration with industry experts has identified frenching as the next big investment opportunity in terms of labour savings within the Australian Lamb Industry. In Australia, 29 million lamb racks are produced each year, 50% of these are frenched, requiring up to 10 operators at any given time. (McRae, et al, 2014 & DAFF, 2014). Compared to that of either automated or even semi-automated french racking solutions, the value and time spent manually frenching these racks is costing the Australian Lamb Industry $8.1m per year. This provides significant justification and opportunity for further investment into the development of an automated frenching system.

The development of a waterless semi-automated or automated frenching system that improves on the existing semi-automated systems will provide significant benefits to the lamb processing sector and facilitate wider adoption of automated frenching. The estimated economic opportunity per year for an automated system, prior to any additional costs is valued at $12.8 million per annum. The breakdown of these gross benefits is shown in Figure 1.

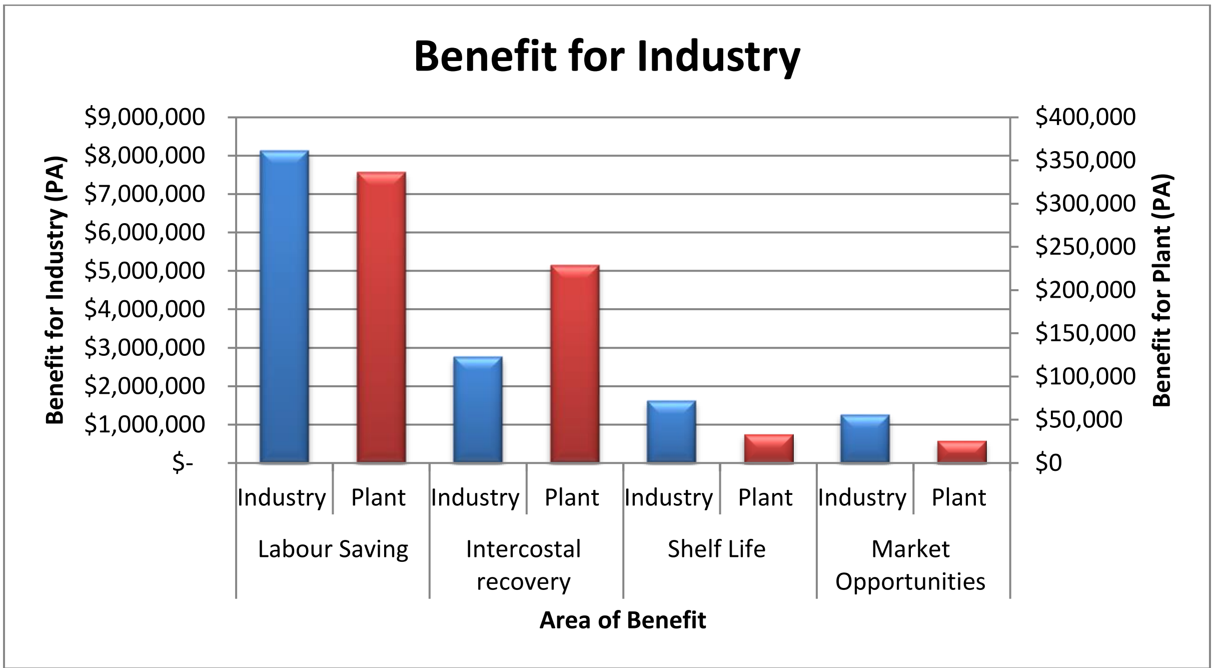

Figure 1: The Industry benefits for industry and plants processing 1.2m head a year achieved through developing a fully automated frenching system

Currently, there are two commercially available water frenching systems, McLaren iFrenching and WASSCO vertical frenching systems; however they have not been widely accepted by industry for the following reasons:

- Water frenching uses significant amounts of water which is difficult to recycle as it is heavily loaded with meat and fat
- The high operation costs of water frenching machinery

- The water affects the appearance of the meat and fat
- Water encourages cross contamination and bacterial growth and reduces shelf life
- The loading mechanism is not automated
- Minimal adjustment for frenching lengths and rack thickness limit adaptability
- Significant yield loss (intercostal)

The two commercially available systems being a semi-automated water frenching system (McLaren) and a manual assist water frenching system (WASSCO) both provide an acceptable return on investment. When compared to manual frenching, the expected payback period is between 1.75-2.17 years for the McLaren iFrenching system and between 1.33-1.67 years for the WASSCO vertical frenching system (refer to Table 1).

Table 1: Return in investment expected by the Water Frenching systems

SUMMARY PERFORMANCE MEASURES				
	McLaren		WASSCO	
Hd / annum	1,200,672		1,201,200	
Production increase with equipment	6.38%		6.43%	
	From	To	From	To
Capital cost (pmt option, upfront)	$250,000		$184,000	
Gross return Per head	$0.21	$0.19	$0.22	$0.19
Total costs Per head	$0.07		$0.07	
Net Benefit Per head	$0.14	$0.12	$0.15	$0.12
Annual Net Benefit for the plant	$172,814	$144,900	$176,730	$148,805
Annual Net Benefit for the ex cap	$139,625	$111,712	$138,136	$110,211
Pay back (years)	1.79	2.24	1.33	1.67
Net Present Value of investment	$1,139,360	$943,309	$1,195,083	$998,946

Given the cost of water, programs to reduce water usages and negative impact on shelf life, non-water frenching options are required in the longer term. But alternatives investigated to date have had significant commercialisation challenges. A two stage approach could focus on enhancements to existing systems in the short term while longer term development could address the hurdles to non-water alternatives.

To increase industry adoption, a number of incremental operational improvements could be made to existing water frenching systems. Importantly, these interim investments would further enhance the longer term development of an automated frenching solution that overcomes the issues of water frenching:

- Frenching specification adjustments – modifications to allow rapid adjustment of frenching lengths to meet customer requirements
- Capability to french all rack specifications produced in Australia including cap-on, cap-off and denuded
- Loading and unloading mechanisms – modifications to maximise processing rates

Given automated frenching is a large area of labour saving, market development and increased processing efficiency, it is recommended that future investments be directed towards the longer term development of mechanical, CO_2 or novel ideas for frenching that do not use water.

Water frenching systems are currently used commercially but with limited uptake on chilled product due to negative impact on shelf life, waste and noise. Comparatively, CO_2 pellets address all these issues but carry extremely high consumable costs. The cost variation between CO_2 and water is estimated at $405,000 per year per system. This cost difference and poor return on investment (ROI) would limit uptake of CO_2 frenching unless an innovative approach could overcome unit cost. However the viability and therefore uptake of CO_2 frenching could be increased if the following could be achieved:

- Development of additional applications for CO_2 pellets in different areas of the plant to offset costs of installing a CO_2 extrusion plant

To obtain a 2 year payback, Table 2 highlights the costs and benefits of frenching systems in small, medium and large lamb processing plants. Based on throughput, the savings highlighted in this table are the maximum benefit each plant size could experience including labour savings, intercostal recovery, shelf life and market opportunities. For example if a fully automated waterless system was developed the labour saving for a small plant would be $168,000, compared to $613,800 a large plant would experience.

Further, if a fully automated waterless frenching system was to be developed it would need to be priced under $510,000; otherwise uptake would be limited to medium and large plants

Table 2: Maximum cost associated with of frenching systems to obtain a 2 year payback for different sized plants

Maximum return			
	Small	Medium	Large
Head Processed (Yearly)	600,000	1,200,000	2,188,800
Labour Savings	$168,268	$ 336,537	$ 613,843
Intercostal recovery	$ 57,130	$ 114,261	$ 208,412
Shelf Life	$ 16,692	$ 33,383	$ 60,891
Market Opportunities	$ 13,025	$ 26,050	$ 47,515
Max Cost of System	$510,230	$ 1,020,461	$ 1,861,321

Finally, it needs to be considered that the following will directly impact on the value and uptake of an automated frenching system. To ensure success and achieve maximum benefit, these challenges would need to be overcome:

- It the system required a high level of consumables
- If the system cannot operate at speeds greater than 20 racks per minute
- If the system doesn't achieve the maximum benefit in all areas including shelf life, labour savings, intercostal recovery and market opportunities
- If the system requires the use of water
- If the system cannot rapidly change frenching specifications
- If the system cannot french all rack specifications including cap-on, cap-off and denuded racks
- If the system negatively impacted on the appearance of racks
- If the system has an excessive footprint
- If the system dramatically increases the amount of noise on the plant floor

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Glossary

Term	Description
AQIS	Australia Quarantine & Inspection Service
Automated	A waterless automated frenching system is a machine where no operators are required to place the rack into or out of the system to be frenched. At present this system does not exist. Longer term development of an automated frenching solution that overcomes the issues of water frenching is ideal, however may be limited by the cost of technology to grab and orientate racks.
CBA	Cost Benefit Analysis
Ex-ante	"*Before the event*". Ex-ante is used most commonly in the commercial world, where results of a particular action, or series of actions, are forecast in advance (or intended).
GMP	Good Manufacturing Practices
HSCW	Hot Standard Carcase Weight
Manual assist	A system which requires the operator to add and remove the primate
Mechanical frenching	The process of removing the intercostals from between the ribs by a machine-driven system.
MLA	Meat and Livestock Australia
OH & S	Occupational Health & Safety
ROI	Return on Investment
Semi-automated	A frenching machine where an operator is still required to place the racks into and out of the system to be frenched. Semi-automated machines exist in varying degrees including the two commercially available WASSCO and McLaren iFrenching water frenching systems. Future development will ideally lead to the design of a waterless semi-automated solution decreasing the number of operators required, followed by the invention of fully automated waterless solution ultimately require no operators.

1 Introduction

Frenching a rack of lamb is the removal of meat, fat and membranes (intercostal) that connect the individual rib bones. Currently Australian processors process around 50% of lamb product to a frenched rack.

A typical manual preparation involves using a knife to remove the intercostals to a straight line of the designed length of rib bone exposure. The manual task is very labour intensive with a typical throughput of 6,000 racks per shift requiring approximately 10 operators costing an estimated $0.28/hd (Green et al, 2014). Frenching racks manually using a bandsaw and knife poses significant issues around OH&S, quality and consistency of the product appearance.

There are several semi-automated frenching methods that have been investigated over the years by MLA and AMPC including water frenching, mechanical frenching and more recently frenching using CO_2 pellets. Currently, the water blast method is the only method used on commercially available systems. Commercial machines exist which remove the intercostal meat using high pressure water jets. The advantage of this method is that it can be used with minimal training and the end result in not dependant on the operator. Disadvantages of using high pressure water include:

- The loading mechanism is not automated
- Significant yield loss (intercostal) with minimal yield recovery attainable from waste water
- Water frenching uses significant amounts of water which is difficult to recycle as it is heavily loaded with meat and fat
- The high operation costs of water frenching machinery
- The water affects the appearance of the meat and fat
- Water encourages cross contamination and bacterial growth and reduces shelf life

Currently, there are two commercially available water frenching systems including:

- WASSCO Vertical French Racking Machine (WASSCO, 2014a WASSCO 2014b)
- McLaren iFrenching system (McLaren, 2014)

In addition to the above water frenching systems there have been other development attempts using CO_2 and mechanical frenching listed below but none of these have been commercialised:

- Ag Research and BLM Engineering have patented an anvil punching concept to mechanically french lamb racks
- McLaren Stainless CO_2 frenching systems

Given the number of R&D proposals and projects that have either been invested previously in, or that are currently under consideration, it was evident that a review of 1) industry needs and specification, and 2) future R&D options and strategies, was required.

As a result, this project will review previous french racking investments and current proposals, and will provide AMPC with a summary on the outcomes achieved to date and the future needs and investment opportunities in this area.

2 Objectives

The project reports on the previous investments, current gaps and future opportunities for R&D in relation to french racking. A recommendation towards building an R&D strategy which addresses the current challenges and identifies capabilities as well as a cost-effective and viable commercial solution has been detailed.

Specifically the report includes:

1. A detailed review of previous investment
2. Analysis of the previous investment outcomes
3. Advantages/disadvantages, success and/or failure, commercial outcomes, and cost/benefit for processing
4. Gaps in the previous investment outcomes
5. Industry needs - in relation to their products, the volume of product, the value proposition and customer specifications, and the likelihood of future uptake of a successful solution
6. Summary of industry views
7. Identification of new and emerging commercial considerations
8. Summary of recommendations towards building a future R&D strategy

3 Methodology

Processors and technology providers were engaged to identify the current french racking capability. Their collaboration was vital in describing existing gaps and the ongoing needs of the Australian Lamb Industry.

3.1 Desktop study

The desktop study was conducted to gain a detailed understanding of the current capabilities of commercially available systems and prototypes designed for frenching. Specifically:

1. Industry reports on each of the frenching systems was sourced
2. System capabilities were reviewed and gaps in the current information was identified;
3. System providers were then contacted to discuss actual system capabilities and specifications as well as customer feedback on what challenges currently exist

3.2 Industry review

To accurately identify current capabilities, challenges and future needs, discussions across four large domestic and export lamb processors were undertaken. Data captured included:

- Assessment of commercial gains
- Costs and benefits from frenching technologies
- The analysis of gaps in the available technology

- Processing requirements across different processing situations and the impact on required frenching capabilities

The process involved in the collection of this data was as follows:

1. Obtain the list of domestic/export lamb processors to be interviewed in collaboration with AMPC and MLA
2. Develop a semi-structured interview, enabling managers and staff of the processing companies to openly provide their ideas, concepts, concerns and challenges with regards to frenching systems
3. Contact processors to discuss their experiences, challenges/needs, concerns, concepts and ideas in relation to frenching systems
4. Compile a summary of industry requirements

To ensure the integrity and confidentiality of individual interviews the findings from each discussion have been documented anonymously

3.3 Modelling Assumption

There have been a number of high level calculations presented throughout this report to indicate the development opportunity of a frenching system. The costing's presented were modelled on a plant processing 5000 head per day as displayed in Table 3. Larger plants will benefit the most from the development of an automated frenching solution. However the investment costs will be the biggest limiting factor affecting the uptake for frenching systems in all plants.

Table 3: Assumptions used for the plant level cost and benefit calculations

Assumptions	Value
Number of head per day	5,000
Number of Shifts per day	1
Hours per shift	10.00
Days per year	240

4 Industry Overview

There is a range of rack specifications including cap-on, cap-off and denuded produced in Australia. These specifications vary as a result of the diverse markets that processing plants supply. The following section details the industry dynamics to identify the range of specifications a successful lamb frenching system would be required to perform.

4.1 Market Dynamics

The current industry environment, being that 50% of all racks produced in Australia are frenched costing industry conservatively $8.1m per year (DAFF, 2014), provides the perfect context and therefore considerable opportunity for future industry investment into lamb frenched racking. With reference to Table 4, the following section investigates current market dynamics including frenched and unfrenched, fresh and frozen and finally domestic and export. Further, the significance and impact each of these has on 1) the value to industry and 2) future investments into lamb frenching are explained.

Table 4: Percentage of frenched and unfrenched racks processed in Australia for domestic and export markets

		Product Type	
		Frenched	UnFrenched
Domestic*	Fresh	18%	26%
	Frozen	0%	0%
Export**	Fresh	23%	10%
	Frozen	11%	13%

*Green et al, 2014
** DAFF, 2014

4.2 Frenched & unfrenched considerations

Evident in Table 4, of the 29 million lamb racks produced in Australia, 50% are frenched (McRae, et al, 2014, DAFF, 2014). With a lack of viable semi-automated or automated frenching solutions, the majority of plants perform this process manually. Manual frenching requires a significant investment of labour. Therefore compared to that of either automated or even semi-automated french racking solutions, the value and time spent manually frenching these racks is costing the Australian Lamb Industry $8.1m per year. This provides significant opportunity and justification for investment into either enhanced development of a semi-automated and/or the future development of a fully automated frenching system to obtain the maximum benefit for industry. For costing's associated with labour savings refer to section 4.6.

Either the enhancements to existing semi-automated systems or the invention of an entirely automated frenching system will allow for an increased throughput of frenched racks. Increasing the sale of frenched racks from unfrenched racks by a further 20% is valued at an estimated $2.8m to industry (Green et al, 2014, DAFF, 2014). Reducing the number of slicers required to french through automating frenching can increase boning room capacity in some cases. Decreasing the labour requirements for frenching, which can be a bottle neck on the boning room floor, increases the volume of racks and other cuts that can be processed through labour reallocation. .

Finally, the improved development of a semi-automated or fully automated frenching system would decrease the costs associated with labour, shelf life and intercostal recovery. Consequently, frenched products could then also be sold through lower value market opportunities.

4.3 Fresh & frozen considerations

Depicted in Table 4, 76% of racks are sold fresh compared to 24% sold as frozen export. There is a $3.68/kg price differential between the fresh and frozen racks exported. Therefore by increasing the volume of fresh racks exported by as little as 4%, the value to industry can be increased by $1.8m per year. However, it is also important to consider that by increasing the amount of fresh racks sold, the value per kg could decrease in the case of oversupply.

As a result of reducing the cost of processing and increasing the shelf life, the development of an automated frenching system will further increase the quality of frenched racks being exported. Importantly, there will be a number of customers which will still require fresh racks due to the cold chain and shipping times.

There is no value to be added to domestic only abattoirs as currently there are no frozen racks sold domestically in Australia (refer to Table 4).

4.4 Domestic & export considerations

Currently, 56% of frenched racks are exported compared to 43% sold domestically (refer to Table 4). In this case, export abattoirs will benefit the most through the development of a viable automated frenching system as they will not only reap the labour saving benefits but also the benefits associated with increased frenched and increased fresh racks exported discussed above.

4.5 Industry summary

Improvements to existing semi-automated developments or the invention of an automated frenching system will provide significant benefits to the lamb processing sector. Discussions with industry experts have identified this area as the next big area of saving for processing plants. The estimated opportunity per year for the lamb industry is valued at $12.7 million pa (DAFF, 2014), if the frenching process could be fully automated (refer to Figure 1)

The further development of both semi-automated and automated lamb frenching systems would have significant benefit to the Australian Lamb Industry. The value and time spent manually frenching racks costs the Australian Lamb Industry between $6 and $8 million per year. The benefits outlined in this section are for a range of systems; however at present not one system offers the maximum benefit displayed. To increase the return on investment, future developments need to be selected on their ability to maximise the saving in all the following areas.

4.6 Labour savings

The two commercially available systems (McLaren iFrenching system & WASSCO Vertical frenching system) require operators to manually load racks. One to two labour units are required to operate the frenching systems but there is still a net saving in labour. As can be seen in Table 5, plants could save an additional $252,402 per year through the development of a semi-automated frenching system and $336,537 through the development of an automated frenching system. A total labour saving of up to $8.1 million per year for industry could therefore be expected.

Table 5: Labour savings for an automated or semi-automated french racking machine

Staff savings		
	Semi-automated	Automated
Number of staff saved	6	8
Hours per day	10	10
Number of days	240	240
Rate per hour	$ 35.41	$ 35.41
Percentage of racks frenched	49.5%	49.5%
Value per plant	$ 252,402	$ 336,537
Value per carcase	$ 0.21	$ 0.28
Number of racks	29,000,000	29,000,000
Value to industry	$ 6,099,727	$ 8,132,969

4.7 Intercostal recovery

The intercostals shown in Figure 2 are the result of manually frenching racks. The water frenching system destroys these intercostals costing industry $1.7m per year (See Table 6).

The variation seen in Table 6 between the manual and mechanical process is due to the slicers dropping an average of 60% of intercostals (JBS swift Australia, 2013, Thomas Foods International 2014).

Figure 2: Intercostals recovered during the manual frenching process

Table 6: The values of intercostal recovery for the industry for manual and automated frenching

Intercostal Recovery			
	Water	Manual	Mechanical
Average Intercostal length	45	45	45
Intercostal retention		60%	95%
Intercostal Weight	0.004	0.004	0.004
Value per intercostal	$ -	$ 0.008	$ 0.012
Value per carcase	$ -	$ 0.12	$ 0.19
Value per year	$ -	$ 144,329	$ 228,521
Percentage of rack Frenched	50%	50%	50%
Value to industry*	$ -	$1,743,979	$2,761,301
Price per kg of intercostal	$ 6.75	$ 6.75	$ 6.75
Number of Intercostals per rack	8	8	8

*DAFF, 2013

4.8 Increased throughput

The value achieved by increasing processing efficiencies will be site specific; however the introduction of automated systems in the past have shown to increase throughput by between 4% -18%. Due to the variation between plants, it is important to note that there has been no value benefit estimated for increased throughput in this report.

Additional benefits would also have a flow on effect in the following areas:

- Increased space on the boning room chain through a decreased labour requirement
- Decreased boning requirements per carcase

Bottle necks in the boning room may limit any increase in product flow however if additional infrastructure is installed plants will be able to increase their utilisation of the frenching system.

4.9 Consumables

Water frenching systems are currently used commercially but with limited uptake on chilled product due to negative impact on shelf life, waste and noise. Comparatively, the concept of CO_2 pellets is a new approach that could address all these issues but carries extremely high consumable costs. The cost variation between CO_2 and water is estimated at $405,000 per year per system (refer to Table 7). This cost difference and poor ROI would limit uptake of CO_2 frenching unless an innovative approach could overcome unit cost. However the viability and therefore uptake of CO_2 frenching could be increased if the following could be achieved:

- Development of additional applications for CO_2 pellets in different areas of the plant to offset costs of installing a CO2 extrusion plant
- Dramatically reduce the amount of CO_2 used through the frenching process

Table 7: Costs of water or CO_2 for frenching

	Water Frenching*	CO2 Frenching**
Number of head	5,000	5,000
Cost per rack ***	$ 0.0048	$ 0.17
Hours per day	10	10
Days per year	$ 240	$ 240
Total cost	$ 11,628	$ 416,752
Difference per year		$ 405,124
Cost to industry	$ 140,505	$ 5,035,753
Difference per year		$ 4,895,248

*McLaren, 2014, WASSCO, 2014a, WASSCO 2014b
**Hart, 2010
*** SA Water, 2014

4.10 Shelf life

Previous studies into the effects water has on the shelf life of frenched racks have indicated that the shelf life is affected 9 weeks post packaging. This therefore limits the saleability of racks 9 weeks after packaging. Any further equipment developments would need to maintain the shelf life at 13 weeks which is what is expected from manually frenched racks. Solutions like CO_2 could improve self-life.

4.11 Value to industry

It is clear from the evidence discussed above, that there are a number of considerable benefits the Australian Lamb Industry could experience through the investment and development of a waterless automated frenching system. The main consideration which should be incorporated into any future system developments should include the following capabilities:

- Ability to maintain shelf life when compared to manual frenching
- Removes all operators from frenching racks
- Allows all intercostal meat to be recovered for sale
- Increases OH & S on the boning room
- Allows boning room to increases their throughput

5 Previous Investment & Current Capability

There has been a significant amount of time and money invested in automating lamb frenching. Table 8 summarises the performance and current capabilities of 7 french racking systems:

- McLaren Water iFrenching
- WASSCO French Racking System (Water)
- McLaren CO2 French Racking System
- Mechanical Racking Macpro
- Waterless Frenching RTL (Mechanical)
- Dematec Boning Knife & Double Pin Robot (Mechanical)
- Dematec CO2

Initially 5 frenching systems were commercially available. However, discussions with manufactures revealed that two of these systems, the John Knight Pty Ltd and Interfoods French Racking systems, have been removed from the market for undisclosed reasons. The European supplier of the WASSCO system was identified as the fifth system. As these systems are identical it has been included as the WASSCO vertical french racking machine.

Table 8: Current capabilities for frenching as a result of previous investments from industry funds

Capability	Sub- Capabilities	Definition	McLaren water iFrenching (McLaren, 2014)	WASSCO French Rack Machine (WASSCO, 2014a & 2014b)	McLaren CO2 (McLaren, 2014)	Mechanical Racking Macpro (Macpro, 2014)	Waterless Frenching RTL (Robotic Technologies, 2010 & Scotts 2014)	Dematec Boning Knife & Double pin Robot (Hart, 2010)	Dematec CO2, (Hart, 2010)
Stage of development		What stage of development is the system currently?	Commercially tested	Commercially tested	Proof of Concept	Proof of Concept	Proof of Concept	Prototype developed	Proof of Concept
Process Flow	Equipment footprint (m2)	The system will be able to fit in most boning rooms as it is of a minimal size.	1.07	1.55	1.07	Unknown	Unknown	Unknown	Unknown
	Rack Frenching Speed (racks/min)	The number of racks which can be frenched per minute by one system	20	16	20	Unknown	20	5	5
	Increases noise on boning room floor	The system has a minimal affect on the noise in the room	Yes	Yes	Unknown	Unknown	Unknown	Unknown	Unknown
	Process flow maintained from manual	There have been no additional staff required or modifications made to the process flow of the room	No, Cap meat to be removed after frenching system	Yes	Unknown	Unknown	Unknown	Unknown	Unknown
Return on investment	Intercostal recovery	The estimated weight of salable intercostals per rack	0%	0%	0%	100%	100%	100%	0%
	Staff Savings		6	7	8	?	8	2	2
	Power consumption (KW)	What affect will the system have on energy status of the plant?	11	9	Unknown	Unknown	Unknown	Unknown	Unknown
	Water consumption (L/rack)	The additional water consumed per rack.	1.5	4.5	N/A	N/A	N/A	N/A	N/A
	CO2 consumption (kg/rack)	The estimated CO2 consumption required per rack.	N/A	N/A	Unknown	N/A	N/A	N/A	0.12
	High Maintenance costs	The system has a high number of moving parts which increases the costs of operation for the system	Moderate to low running costs	Moderate to low running costs	High running costs	Unknown	100mm	Unknown	Unknown
Product specifications	Acceptable for use of Fresh racks	System can be used on Fresh & Frozen racks	Yes	Yes	Yes	Yes	Yes	Unknown	Unknown
	Frenching length	Maxiumum frenching length	100mm	100mm	100mm	Unknown	100mm	Unknown	Unknown
	Adjustable frenching length	Is the frenching specifications changed manually of through an automated solultion	Manual	Manual	Manual	Unknown	Unknown	Unknown	Unknown
	Rack Width Adjustment	Can any thickness of racks be frenched?	Yes	Yes	Yes	Unknown	Yes	Unknown	Unknown
	Presentation of racks	Is the appearance of the racks imporved during the frenching process?	Improved	Improved	Unknown	Unknown	Unknown	Unknown	Unknown
	No affect on the ribs	Does is affect the ribs?	No	No	Unknown	Unknown	Unknown	Unknown	Unknown
Technical considerations	Affect on Shelf Life	Is shelf life affected?	None idenified	None ideified	Unknown	No	No	No	No
	Identification of Ribs	Does the system need to idenifiy the location of the ribs	N/A	N/A	N/A	Yes	Yes	Yes	N/A

The capability of frenching systems affects their utilisation. If further investments were to be made, a number of learnings need to be considered. The following section summarises the capabilities, challenges and considerations which resulted from the previous investment.

5.1 Loading Racks

There are two distinctly different mechanisms currently utilised for loading lamb racks for frenching. The mechanism used affects the size of product and labour units which can be saved. It is also important to note that the development of the loading mechanism for a frenching system will be affected by the plants specific requirements.

The loading system for the WASSCO frenching system involves placing the racks in a slot and shutting the lid, the lid then engages the frenching mechanism (seen on the right of Figure 3). This mechanism allows all different rack sizes to be frenched. However, with racks being required to be removed by hand, the frenching rate is highly dependent on the speed of the operator.

Figure 3: Rack loading mechanisms in the McLaren iFrenching system (left) and the WASSCO Frenching system (right)

Comparatively, the McLaren iFrenching system (left of Figure 3) allows the racks to be continuously fed into the system. This permits the operator to only concentrate on one movement reducing the handling of racks. However the design of the conveyor limits the size of the racks that can be processed. There were improvements adapted to this during a previous trial however the processor is still required to trim the rack on larger racks.

Overall both these designs provide benefit to the industry however their utilisation is affected by the variation in carcase sizes processed. The investment of additional funds should allow racks of all sizes to be fed through the frenching system.

5.2 Retention Mechanism

The retention of racks during the frenching process contributes towards both accuracy of the frenching line and the rate of frenching. The current frenching systems only utilise water however the retention of the rack in both these systems have been developed to minimise the amount of water contaminating rack.

Figure 4: Rack retention mechanisms in the McLaren iFrenching system (left, Source: Green et al., 2014) and the WASSCO frenching system (right, Sources WASSCO, 2014a)

The WASSCO system (right image in Figure 4) holds the rack at the edge of the cap with only the tail of the rack exposed to water. This minimises the contamination of the eye muscle however it increases both the work required by the operator and the use of water. This system allows processors to guarantee a 65 to 80 day (9 to 11 weeks) shelf life (WAMMCO, 2014).

The retention of racks by the McLaren iFrenching system (Left side of Figure 4) is between two conveyors using less water as only one jet is required. This process involves the rack being moved past the frenching jet. This retention mechanism therefore reduces the operator's workload as they are only required to place the racks into the frenching system. The frenched racks are then automatically returned back to the boning room belt.

5.3 Frenching Process

Currently there are only two water frenching systems commercially available, however previous investments has formed a depth of knowledge for future developments. The following section identifies previous learning characterised by the frenching process, including water, CO_2, mechanical and novel ideas.

Water Frenching

The frenching systems available all use high pressure water jets (see Figure 5) to remove the intercostal and cap from the racks. This process has the following associated risks:

1. Increased aerosols resulting in possible increases in bacterial counts
2. Decreased yield recovery from intercostal and cap meat destroyed during the frenching process
3. Increased water usage by the plant
4. Increased effluent treatment requirements by the plant
5. Increased noise level on the boning room floor

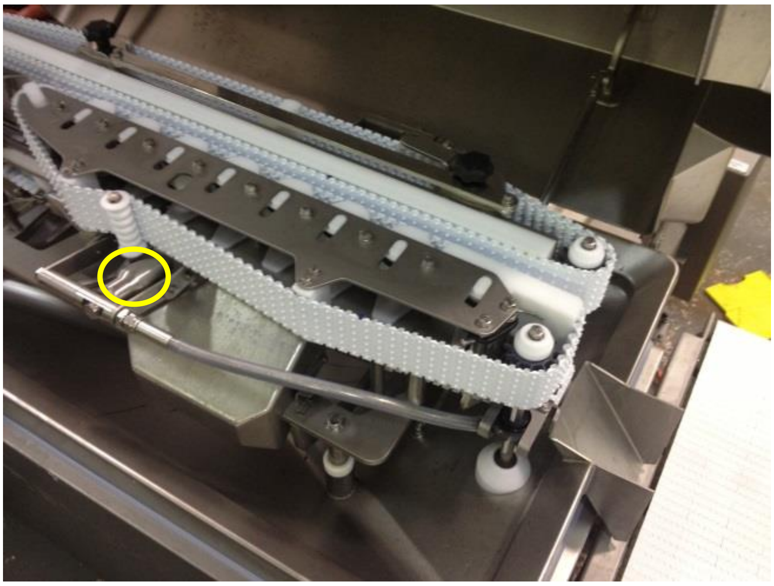


Figure 5: Water frenching jet of the McLaren iFrenching system (circled in yellow), (source: 2014)

The investment into water frenching by the Australia Lamb Industry has enabled the commercialisation of two quality water frenching systems. The following learnings and benefits are a direct result of these investments:

- Identification that a constant process flow and not a stagnant system is beneficial
- The frenching systems need to french a minimum of 20 racks per minute (Thomas Foods International, 2014)
- There is substantial value which could be added by the development of a mechanical frenching system with an automated rack adjustment mechanism

The two commercially available water frenching systems provide a relatively high level of value to the industry. When compared to manual frenching, the expected payback period is between 1.75-2.17 years for the McLaren iFrenching system and between 1.33-1.67 years for the WASSCO vertical frenching system (refer to Table 9)

Table 9: Return in investment expected by the Water Frenching systems

SUMMARY PERFORMANCE MEASURES				
	McLaren		WASSCO	
Hd / annum	1,200,672		1,201,200	
Production increase with equipment	6.38%		6.43%	
	From	To	From	To
Capital cost (pmt option, upfront)	$250,000		$184,000	
Gross return Per head	$0.21	$0.19	$0.22	$0.19
Total costs Per head	$0.07		$0.07	
Net Benefit Per head	$0.14	$0.12	$0.15	$0.12
Annual Net Benefit for the plant	$172,814	$144,900	$176,730	$148,805
Annual Net Benefit for the ex cap	$139,625	$111,712	$138,136	$110,211
Pay back (years)	1.79	2.24	1.33	1.67
Net Present Value of investment	$1,139,360	$943,309	$1,195,083	$998,946

Table 10 compares the benefits and costs associated with the installation of both the McLaren and WASSCO frenching systems, when compared to manual frenching. As can be seen, there are limited differences between the two systems, with the main benefit experienced being $0.19 cents per head labour savings.

Table 10: Breakdown of costs and benefits for the WASSCO and McLaren systems

COST DUE TO INACCURACIES AND MANUAL INTERVENTION		Manual	McLaren		WASSCO	
Cost of Frenching		$/hd From	$/hd From	$/hd To	$/hd From	$/hd To
1. Accuracy	Intercostals	$0.00	$0.06	$0.08	$0.06	$0.08
	Shelf life loss	$0.00	$0.00	$0.00	$0.00	$0.00
2. OH&S cost		$0.17	$0.09	$0.09	$0.09	$0.09
3. Labour cost		$0.19	$0.00	$0.00	$0.00	$0.00
4. Equipment costs	Maintenance	$0.00	$0.00	$0.00	$0.00	$0.00
	Operation	$0.00	$0.03	$0.03	$0.03	$0.03
	Risk of failure	$0.00	$0.02	$0.02	$0.02	$0.02
Total cost per head		**$0.36**	**$0.20**	**$0.22**	**$0.20**	**$0.23**
$ Annual Losses overall plant		**$436,128**	**$238,314**	**$266,227**	**$243,653**	**$271,566**

If water frenching was to have additional industry investment allocated, it needs to include the following:

- Maximisation of intercostal recovery
- Maintenance or increased shelf life when compared to manual frenching
- Minimisation or elimination of water contamination on the rack
- Minimisation of water usage

Collaboration with industry has identified that the use of water should be eliminated when considering future frenching developments.

CO_2 Frenching

There have been a number of plants trialling the use of CO_2 for frenching. Figure 6 shows a proof of concept being trialled (left) with the results shown in the right hand image; previous investments have not resulted in working prototypes.

Figure 6: CO2 Frenching trial being conducted (left) and the frenched rack as a result (right) (Source: Hart, 2010)

The benefits of frenching with CO_2 pellets are as follows:

- The use of CO_2 reduces the cross contamination of bacteria between racks
- Shelf life may be increased by decreasing the temperature of the rack

Previous results found the cost of frenching with CO_2 pellets will limit their commercial viability. However, if manufactures could utilise the following it may allow for a viable system to be developed:

- Minimise the use of CO_2 pellets
- Retain all intercostal and cap meat for sale
- Increase the sale of fresh racks internationally (value displayed in section 4)
- Minimise the number of operators
- French a minimum of 20 racks per minute
- Have a minimal footprint
- Must be able to french Cap-on, Cap-off and Denuded racks

The investment of industry funds into the development of a CO_2 frenching system would allow for the expansion of additional fresh export markets as long as the developers can maximise the benefits and minimise the costs.

Mechanical frenching

A number of trials have been conducted to test the viability of mechanically frenching racks. The capabilities of each of these prototypes or proof of concepts can be seen in Table 8. Additionally, there are detailed explanations of the trials completed in the final reports for the MLA project P.PSH.0518 (Robotic Technologies, 2010) and P.PSP.0304 (Hart, 2010).

The following are results by which mechanical frenching could increase yields of racks when compared to water, CO_2 and manual frenching systems.

- Increased weight sold as intercostal
- Increased weight of intercostal sold on the bones of the racks,
- Maximise the weight of cap meat
- The development of additional products as a result of a different frenching process

The following constraints need to be overcome during the development phase of a mechanical frenching system:

- Identify the location of the ribs without damaging the intercostal meat
- Leave only a minimal amount of intercostal on the ribs
- Operate at more than 20 racks per minute
- Have a minimal impact on the space available on the boning room floor
- Able to operate in a harsh environment

The development of a mechanical frenching system may be a feasible option if a developer can design a cost effective and accurate system.

Development of an Alternative Method

Collaboration highlighted that industry requires additional investments to develop an effective frenching system that would be widely accepted by industry. Investigations into alternative methods of frenching have revealed the following possibilities which have been trialled previously (refer to Table 11). Learnings from these trials need to be taken into consideration when considering future frenching developments and investments:

Table 11: Previous Innovative Investments & Findings

Investment	Considerations
Dematec boning knife and double pin systems (Hart, 2010)	The concept for the boning knife and pin system increased the value of intercostal recovered when compared to the water frenching systems. However during discussions regarding this option it was identified that the robot solution operated much slower than accepted by industry and as a result of the visioning technology it left holes in the intercostal.
Scraping bones with fine wire to remove the meat (Robotic Technologies, 2010)	The wire used only slid over the meat and didn't remove the meat from the bone. If this technology was to be re-tested it would need to be conducted using a piece of wire which would be course enough to cut the bone but without damaging the bone. For example, wire similar to piano wire would be too damaging to the bone to be affective.
Scraping using two blades oscillating to remove the intercostal meat (Robotic Technologies, 2010)	This technique rapidly removes meat from bone but destroys the intercostal meat and leaves very small fragments of meat on the bone
Membrane cutting force, cutting the intercostal with a fork (Robotic Technologies, 2010)	The main constraint with this concept that the fork shredded the intercostal meat in turn reducing the value of the product. This caused a reduction in the value of intercostal as it would only be able to be sold as trim.
Cutting the membrane and pushing the bone out, (Robotic Technologies, 2010)	This option has the potential to be utilised by industry to develop an automated solution. It was the only trial accepted by Robotic Technologies Limited as being a successful option for development. Robotic Technologies Limited currently has a patent on this technology. The only downside to this technology when compared to water frenching is that the presentation of the racks is slightly less appealing due to the glossing finish presented by the water frenching system.

6 Design Prerequisites

The design and capabilities will greatly affect the uptake of frenching systems by industry. The following section identifies the capabilities and specifications which future investments need to incorporate.

6.1 Product Specifications

There are over 40 different specifications of frenched racks produced in Australia. These specifications can be grouped into either cap-off, cap-on or denuded racks. Images of these racks can be seen in Figure 7. The frenching length of these products varies between 25mm and 75mm: demonstrated by the arrows in the last image of Figure 7.

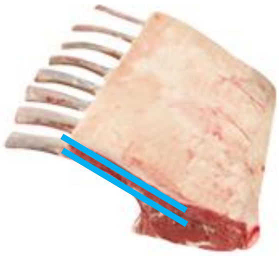
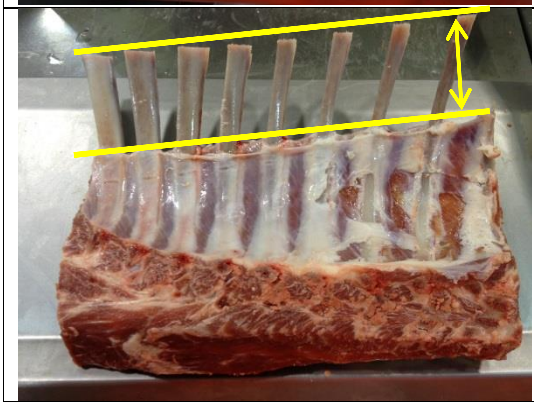
	Denuded frenched rack
	Cap-on 50mm frenched rack, the width of the area between the blue lines represents the thickness of the rack (Source: AusMeat 2005)
	50mm frenched cap-off rack
	Frenched rack with a 50mm frenching length.

Figure 7: Types of frenched products, denuded, frenched cap-on and frenched cap-off.

The capabilities of future developments would be required to french all rack specifications. This would maximise the utilisation of the frenching system irrespective of specific customer requirements. Future investments would need to be able to process the range of rack sizes shown in Table 12 without any modifications to the trimming method of the rack.

Table 12: Minimum and maximum sizes of racks processed in Australia

Requirement	Minimum	Maximum
Racks per min	20	
Frenching length (mm)	25	75
Weight per rack (kg)	0.44	2.00
Number of ribs	6	9
Rack length (mm)	145	190
Rack thickness (mm)	10	40

6.2 Product Presentation

The presentation of frenched racks can have a dramatic effect on the sale of the product to the final consumer. When compared to mechanically and manually frenched racks, the water frenching systems significantly improves the appearance of racks The three different frenching processes manual, water and mechanical, can be seen in Figure 8.

The development of future frenching systems needs to maintain or improve the appearance of racks. This provides processors with a competitive advantage over water and manually frenched racks.

Figure 8: The presentation of rack manually frenched (left) (Green et al, 2014), water frenched (centre) and mechanically frenched (right) (Robotic Technologies, 2010).

6.3 Shelf life

Studies have shown that water frenching can slightly reduce shelf life. Treffone, 2014 showed that water frenching caused an increase in bacterial counts and the presence of an unpleasant odour towards the end of the shelf life. Increased aerosols during the water frenching process decreased shelf life by 2 weeks.

The water and cold storage process can have a dramatic effect on the shelf life of products processed. The following recommendations were provided by Treffone, 2014 to maintain the shelf life of water frenched racks:

- Efficiently chill carcases to 5°C meat temperature before boning
- Chilled water to 5°C is used during the frenching process
- Chlorinate water at a minimum of 1.25ppm in the water used
- Rapidly chill vacuumed sealed racks to below -1°C
- Ship product between -1°C and -1.5°C

It would be a requirement of any future frenching system to ensure that they have no negative effect on the shelf life of products produced.

6.4 Frenching Rate

French racking processing rate and machine footprint are critical factors in determining the economic viability of alternative systems to manual french racking. The need for multiple machines to match current manual boning room output increases capital and infrastructure requirements and negatively impacts on ROI outcomes. As can be seen in Figure 9 there have been two frenching systems installed as a result of one system not being able to maintain the same speed as the boning room. Future investments would therefore require the frenching system to maintain a minimum frenching rate of at least 20 racks per minute to match current boning room floor throughput.

Figure 9: Effect of frenching rate on the number of systems required

6.5 Physical Footprint

The smaller the system the more processing plants will be able to install them. Both the current systems commercially available have a minimal footprint. However, the WASSCO system in Figure 10 has a slightly larger foot print but has a high operating speed. Therefore for Abattoirs requiring a higher operating speed, two iFrenching systems instead of one WASSCO system would need to be installed, dramatically increasing the space required to complete the same job (refer to Figure 9).

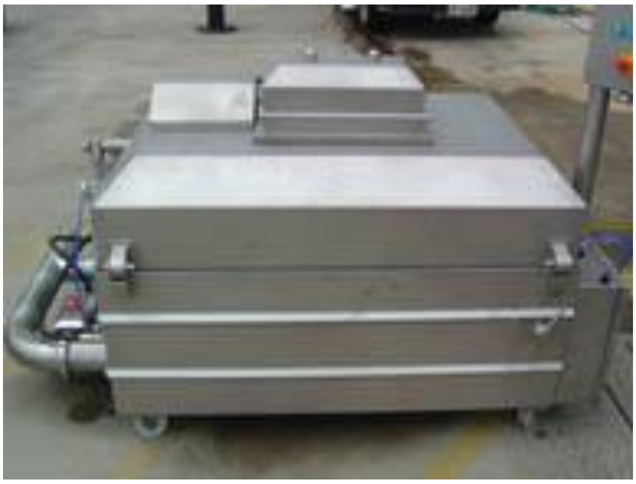


Figure 10: The WASSCO frenching system has a foot print of 1.5m^2 (Source: WASSCO, 2014b)

6.6 Operator Requirements

The current commercial frenching systems both require operators to feed unfrenched racks into the system. The following effects are the main limitations with the use of a semi-automated frenching system are:

- Increased space requirements to allow an operator to use the system
- The frenching rate is dependent on the operators ability to load the machine

6.7 Installation Requirements

There are installation requirements which affect the costs and acceptance of the system. Development of a self-contained unit limits the need for additional installations such as pumps however they have been shown to increase the noise in the boning room. Any future frenching system developments need to minimise any increases in noise and additional modifications required in the plant.

6.8 Barriers to Adoption

The main barriers to adoption relate to the environment in which individual plants operate. The uptake of a viable automated frenching system would be dependent on the following factors:

- Decrease OH & S incidents
- Easy to use and maintain by current plant employees
- The ability to rapidly change frenching specifications
- The system needs to have minimal footprint and no effect on the noise in the plant
- Be able to french cap-on, cap-off and denuded racks without compromising shelf life

6.9 R&D Risks

Development of a fully automated system in one step carries a high level of risk. To alleviate this level of risk, it is highly recommended that a phased development approach where components are developed over a two or three staged approach be considered. Figure 11 demonstrates the steps involved which will limit the risks associated with the development of a waterless semi-automated system or a fully automated frenching system.

The development of an automated frenching system needs to minimise any changes in product flow through the boning room. To maximise the uptake of a frenching system the following criteria needs to be met:

- The system can be maintained by current engineering staff
- The operators can rapidly change the frenching specification
- All specifications lamb racks can be frenched
- French 20 or more racks per minute
- Maintain the current product flow through the boning room

7 Summary – Key Findings/Recommendations

Discussions with industry experts have identified frenching as the next big investment opportunity within the Australian Lamb Industry. In Australia, 29 million lamb racks are produced each year, 50% of these are frenched requiring up to 15 operators at any given time (McRae, et al, 2014, DAFF, 2014). Compared to that of either fully automated or waterless semi-automated french racking solutions, the value and time spent manually frenching these racks is costing the Australian Lamb Industry conservatively $8.1m per year. This provides significant justification and opportunity for further investment into the development of an automated frenching system.

Given the cost of water, programs to reduce water usages and negative impact on shelf life, non-water frenching options are required in the longer term. But alternatives investigated to date have had significant commercialisation challenges. A two stage approach could focus on enhancements to existing systems in the short term while longer term development could address the hurdles to non-water alternatives.

7.1 Incremental Future Development - Existing Lamb Frenching Systems

Currently, there are two commercially available water frenching systems, the semi-automated McLaren iFrenching and manual assist WASSCO vertical frenching system; however they have not been widely accepted by industry for the following reasons:

- The loading mechanism is not automated
- Significant yield loss (intercostal)
- Water frenching uses significant amounts of water which is difficult to recycle as it is heavily loaded with meat and fat
- The high operation costs of water frenching machinery
- The water effects on the appearance of the meat and fat
- Water encourages cross contamination and bacterial growth and reduces shelf life

To increase their uptake across industry, there are a number of incremental operational improvements that could be made to existing water frenching systems. Importantly, these interim investments would contribute to the future development of a fully automated non-water based frenching solution.

These incremental improvements require progressive development of industry capability. There is a general strategic path that applies to all companies and requires capability development at a number of levels to support a faster rate of industry transformation. Figure 11 summarises this development path and breaks technology solutions broadly into either radical or incremental improvements. These general classifications are broken into three specific types of commercial solutions including:

- Small projects (Automated modifications for frenching specifications and increase capability to french all specifications produced in Australia)
    - Most likely to deliver short term incremental improvements
    - Can provide learning's to the plant and automation providers for development of future systems

- Integration technologies (Development of prototypes for different frenching process e.g. Water, CO_2 and Mechanical)
    - Larger scale solutions combining a number of different technologies or addressing a number of issues within a plant; AND
- Transformational projects (Development of a fully automated frenching system)
    - Most likely to support radical improvements
    - Usually limited by other smaller bottle necks that once addressed create a tipping point that justifies ROI

These commercial solutions are supported to varying degrees by enabling technologies that require integration with other capabilities to become a commercial solution. In this instance, enabling technologies refer to the incremental investments discussed previously in section 7.1. Development of these capabilities is often most neglected because new innovation is required beyond aggregation of existing technology and may not result in a commercial product in the first instance.

Understanding how new R&D investments fit in the capability evolution is helpful and should be mapped to some degree as solutions are developed.

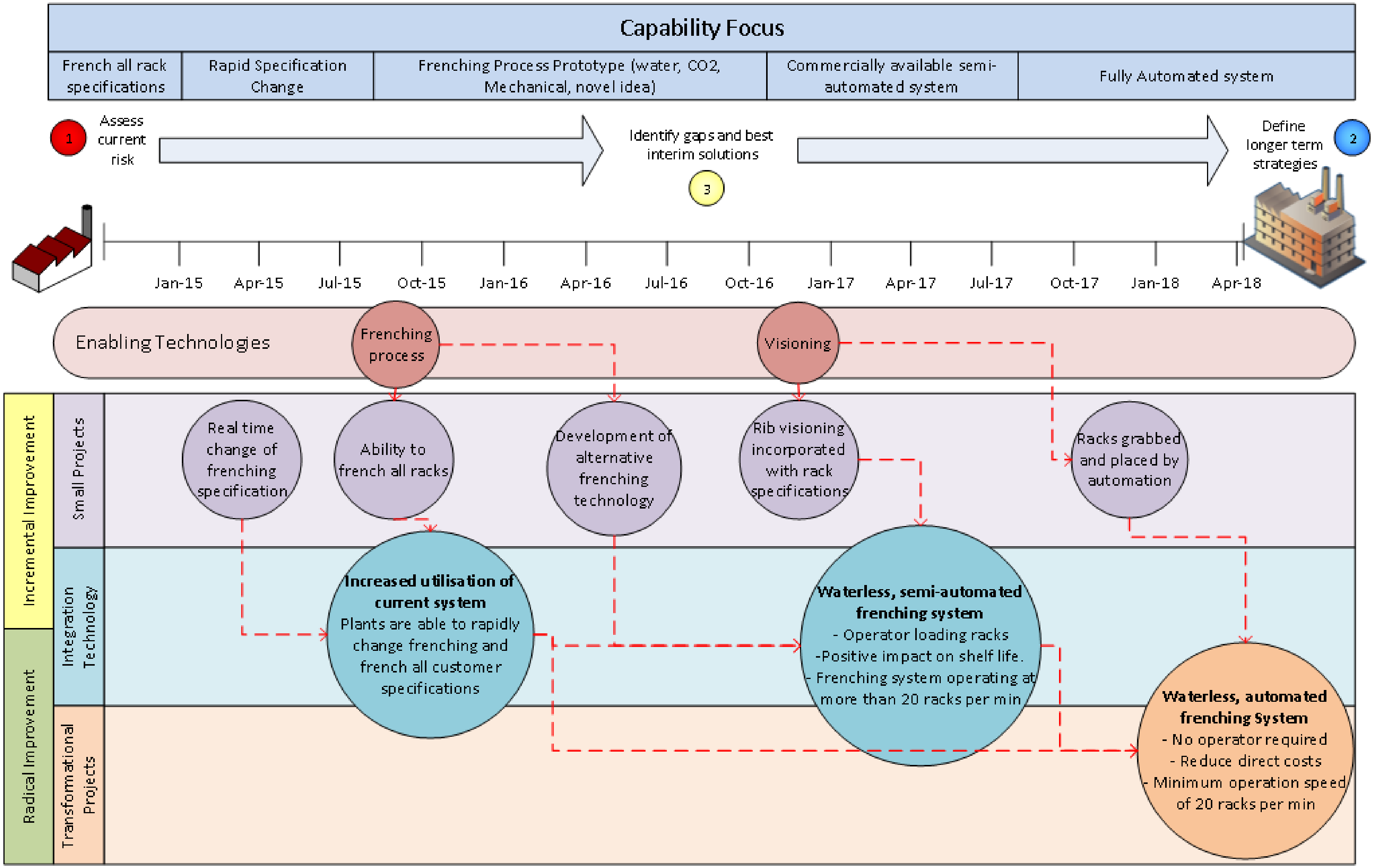


Figure 11: Strategic development scenario for lamb frenching systems

With this strategic development process in mind, the following section details the incremental improvements that could be made to existing commercial water frenching systems.

7.1.1 WASSCO Vertical Frenching System

Frenching Specifications

The frenching specifications can be modified on the WASSCO system by moving a handle up and down to modify the frenching length. This still requires the frenching length to be measured to ensure the correct distance is frenched.

This could be further developed to have a frenching specification gauge to indicate the frenching length or automate the process allowing for operators to enter the required frenching length. Either option would increase the rate at which the frenching length could be modified.

Loading & Unloading Mechanism

The loading and unloading mechanism in the WASSCO frenching system is manual requiring operators to add and remove the racks from the system. Only the rib portion of the rack is placed into a slot to hold it and minimise water contact. The main limitation of this design is the operators need to remove the racks from the system.

The way that loading and unloading mechanism has been designed limits its ability to be modified. It does however allow the operators to french any size rack as it is wide enough to allow any racks to be frenched through the system.

Frenching Rate

The frenching rate of the WASSCO system is directly related to the speed the operator can feed the racks into and out of the system. The manufacture recommends 16 racks per minute however 24 racks per minute have been achieved with experienced operators.

7.1.2 McLaren iFrenching System

Frenching Specifications

Currently the process of changing the frenching length requires engineers to adjust the height of the resting plate. This requires time so as a result the system tends to operate on one or two specifications while other frenching lengths are done manually.

Designing a real-time operator adjustment would allow the frenching length to be rapidly changed, increasing machine utilisation and eliminating manual frenching completely.

Loading Mechanism

The loading mechanism of the McLaren iFrenching system limits the use of the system on larger Australian lamb racks. This causes the users to manually french larger cap-on racks thus decreasing the utilisation of the system on the boning room floor.

This mechanism could be modified to allow for all specifications of racks to be processed in Australia without reductions in yield. This would require the conveyor configuration to meet changes to allow these racks to be processed. The actual method of changing this process would need to be completed in consultation with McLaren.

Unloading Mechanism

The unloading mechanism of this system is highly effective; automatically returning the rack to the boning chain. This reduces the labour required by the operator as once racks are loaded they don't need to re-handled.

Frenching Rate

The frenching rate of this system is directly impacted by the ability of racks to be manually loaded by the operator and the rate at which the conveyer is operating. There is therefore a very limited ability to increase the frenching rate of this system as it is directly correlates with the speed at which the operator can load racks, which varies between operators.

7.2 Future Development – Alternative Lamb Frenching Systems

The development of a semi-automated or automated frenching system that improves on the existing semi-automated systems will provide significant benefits to the lamb processing sector and facilitate wider adoption of automated frenching. The estimated economic opportunity per year prior to any additional costs is valued at $12.8 million per annum for a fully automated system. The development of a waterless semi-automated frenching system would reduce the labour saving component as operators would still be required. The breakdown of these gross benefits is shown in Figure 12.

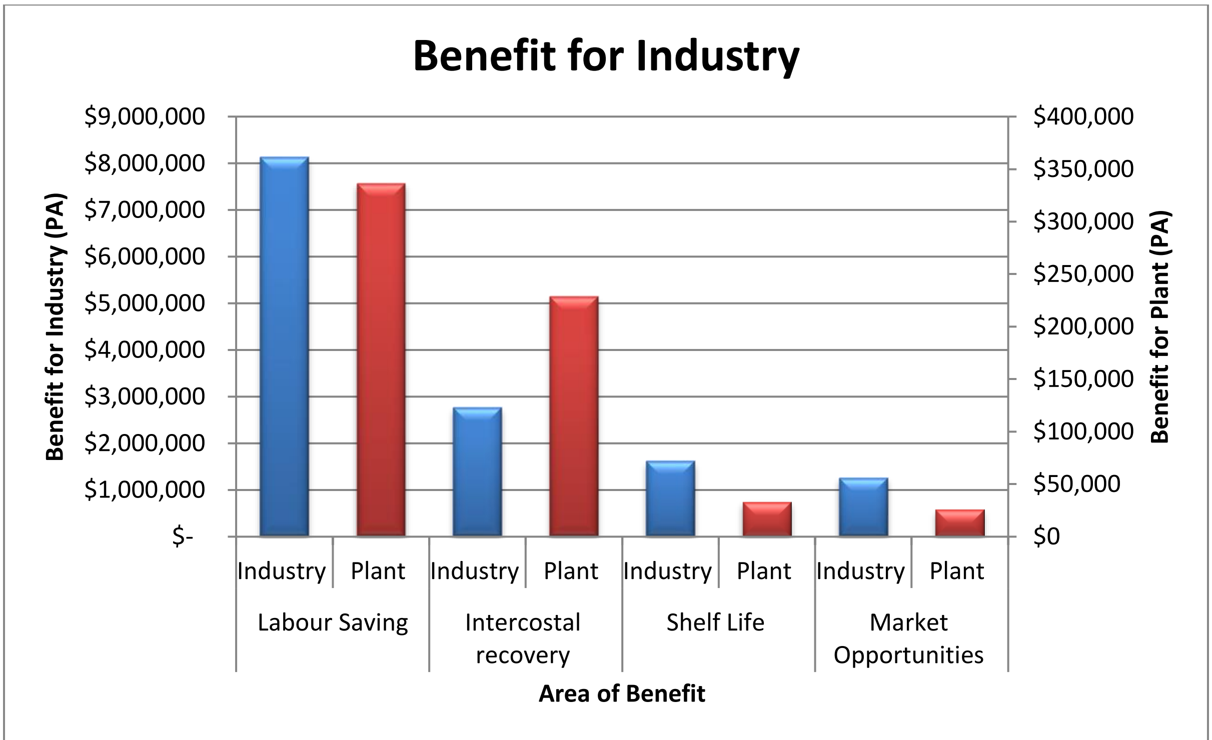


Figure 12: The Industry benefits achieved through developing a fully automated frenching system

Identified as the next big area of labour saving, market development and increased processing efficiency, it is recommended that future investments be directed towards the future development of mechanical, CO_2 or novel ideas for frenching. Water frenching systems impact negatively on shelf life, waste and noise, limiting the development of international fresh rack markets.

To obtain a 2 year payback, Table 13 highlights the cost and benefits of frenching systems in small, medium and large lamb processing plants. Based on throughput, the savings highlighted in this table are the maximum benefit each plant size could experience if the frenching system could be fully automated including labour savings, intercostal recovery, shelf life and market opportunities. For example if an fully automated system was developed the labour saving for a small plant would be $168,000, compared to the $613,800 a large plant would experience.

Further, if a waterless automated frenching system was to be developed it would need to be priced under $510,000; otherwise uptake would be limited to medium and large plants

Table 13: Maximum cost of frenching systems to obtain a 2 year payback

Maximum return			
	Small	Medium	Large
Head Processed (Yearly)	600,000	1,200,000	2,188,800
Labour Savings	$168,268	$ 336,537	$ 613,843
Intercostal recovery	$ 57,130	$ 114,261	$ 208,412
Shelf Life	$ 16,692	$ 33,383	$ 60,891
Market Opportunities	$ 13,025	$ 26,050	$ 47,515
Max Cost of System	$510,230	$ 1,020,461	$ 1,861,321

Finally, it needs to be considered that the following will directly impact on the value and uptake of an automated frenching system. To ensure success and achieve maximum benefit, these challenges would need to be overcome:

- If the system required a high level of consumables
- If the system cannot operate at speeds greater than 20 racks per minute
- If the system doesn't achieve the maximum benefit in all areas including shelf life, labour savings, intercostal recovery and market opportunities
- If the system requires the use of water
- If the system cannot rapidly change frenching specifications
- If the system cannot french all rack specifications including cap-on, cap-off and denuded racks
- If the system negatively impacted on the appearance of racks
- If the system has an excessive footprint
- If the system dramatically increases the amount of noise on the plant floor

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