final report

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Review of MQST Beef Electronics Generation 1

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Index

1. Executive Summary

Purpose of the program

The purpose of the Beef Electronics – Generation 1 Program was to develop and commercialiase electronic intervention tools to the beef processing industry. The developments were in response to a number of industry problems that were thought to be amenable to solutions via electronic stimulation. The program, in was and enabling program for the Meat Standards Australia (MSA)

Industry problems:

- Inconsistent eating quality due to reduced tenderness resulting from cold shortening,
- PSE type meat due to heat shortening resulting from poorly adjustable ES equipment used by the industry,
- Worker injuries due to insufficiently immobile carcases at the shackling workstation

The program was to:

- Provide beef processors with specific tools and processes that would allow them to provide consistently tender meat of high eating quality to the market, in line with MSA grading standards.
- Allow beef processors to adjust electrical stimulation to the specific needs of animal batches, taking into consideration their size, fat and glycogen reserves so over-stimulation could be avoided.
- Ensure that processors could realize as many additional benefits from the use of electronic tools as possible. It was necessary to increase meat quality without foregoing OH&S benefits (electro-immobilisers) or operating efficiency benefits. Although energy and water cost represent only a small proportion of the overall processing costs of beef processors (approximately 5%), electronic solutions were required to either increase plant efficiency or at least be cost neutral.
- Employ a systems approach to the development of the electronic tools.

Technical achievements:

Technical achievements were:

- A new controlled dose Low Voltage system (LVES) for installation in the bleed area to increase blood recovery and/or control meat tenderness,
- A new controlled dose Mid Voltage system (MVES) in the post-dressing area to control meat tenderness instead of the common dangerous High Voltage systems,
- A new controlled dose High Frequency Electroimmobiliser (HFEI) to ensure immobilisation of all animals at shackling without causing stimulation of the meat, especially in heavy and grain fed animals,

- The development of a Computer Process Management System concept (CPMS Concept) that in the future would ultimately allow the development, integration and central control of all electrical stimulation systems in a plant in response to data inputs related to animal and carcase parameters prior to and after ES.

Commercial Achievements

- MLA engaged Millers Mechanical (NZ) Ltd and their Australian sister company Millers Realcold Pty Ltd to commercialise the technology for the Australian market,
- A patent application has been filed for the CPMS business concept,
- Australian Country Choice (ACC) installs production prototype versions in two plants in conjunction with the Plant Initiated Projects Program.
- Installation of the Generation 1 Technology in the market has been according to schedule and on target with 16 LVES and 14 HFEI installed in processing plants,
- An adoption/innovation supply chain to processors from Millers,
- All IP relating to Generation 1 Beef Electronics is owned by MLA,
- Pre- and post-installation audits and interviews with processors give anecdotal evidence that the systems are performing as required and are delivering benefits to the processors.

Recommendations:

Benefits

Benefits to the industry from the MQST Generation 1 electronics have been calculated for the whole red meat industry including the sheep meat. The red meat processing industry NPV is $152m over 10 years at a discount rate of 7.5% or $95m at a discount rate of 16.5%, with approximately 75% flowing back to the beef industry. The beef industry related increase in meat tenderness are smaller than expected as the tenderness problem due to cold shortening affects mainly the prime cuts of domestic table meat. The direct revenue to the processor from an increase in tenderness is less than $5m per annum. Benefits from the use of electronic immobilisers is quite large due to the fact that reductions in WorkCover premiums would flow to the meat processing industry in general. Benefits from the increase in blood recovered or energy saved from less water used for cleaning are small. Similarly water savings are small.

Where to from here?

Industry feedback on the ES systems has been good; however, it is not possible to gain a good picture on the drivers for the installations. It appears, based on anecdotal evidence, that injury prevention and a lighter meat colour due to more effective blood recovery are major drivers for installing the technologies.

It is not clear that the industry sees the technologies as “system tools” to gain benefits across the whole system, the plant. This is not surprising as there are few benchmarks and baseline data available that would allow processors to assess the opportunities arising from the use of the technologies.

To facilitate faster adoption a number of initiatives could be embarked on by MLS and Millers that would allow processors also to see installations in the context of their whole system, not only to fix one or more distinct problems. It is doubtful that the installations would have been adopted at the current rate without the existence of the MSA specified pH and colour grade targets and information relating to the ideal pH/temperature decline relationships.

Recommendations

To facilitate the speed of adoption and use in the processing industry of ES technology benefits and operation of these technologies shown as based on a systems approach so that processors can ascertain costs and benefits to their total system (the plant).

- Develop pre- and post installation baseline data on meat tenderness. pH/temperature decline, PSE meat and other relevant criteria that can be used to demonstrate the benefits of the technologies.
- Develop pre-and post installation baseline data on injuries that can be prevented with the HFEI.
- Develop appropriate metrics on how, when and where in the processing line to measure so that common baseline data can be collected across all plants and give meaningful information for all processors.
- Substantiate that the effect of a lighter meat colour is due solely to the recovery on an extra liter of blood and not due to a faster decline in pH or over-stimulation, appropriate measurements need to be taken and used for information of the industry.
- Develop metrics that are relevant to enable an analysis of the installation and commercialization process and the use of the data for future improvement of the process. For example time to install, to train, to adjust, costs involved etc might be some of the metrics to be used.
- Analyse past installations and the installation and commercialization processes used.
- Improve Generation 1 electronics, processes and information material as required after the process analysis,
- Prior to all installations establish pre- installation benchmarks,
- Based on improvements on OH&S baseline data develop relevant information for processors to facilitate adoption of the HFEI.
- Fast track the marketing and installations of the HFEI into beef plants
- Monitor reductions in slaughter floor injuries.
- Obtain data on cost savings achieved due to shorter refrigeration times after the introduction of ES.
- Provide additional appropriate information material to the current marketing material that Generation 1 technology will not be made redundant by Generation 2 technology.
- Prior to the planning of any technology project or program define problem specific pre-program/project industry benchmarks,
- Together with all users and customers define all the information needs that Generation 2 technologies need to address, for example in terms of operation,

product flow, product type, measurement criteria etc.

- Prior to further development of Generation 1 and Generation 2 technologies, together with suppliers to the processing industry, processors, users of the electronics, customers of the meat, MSA and other relevant parties, conduct a Voice of the Customer (VOC) asignment (Burchill and Hepner Brodie 1997) to specifically define what aspects of the current (and future technologies) are currently not addressed in the development process. This information then can feed into the future development process.

2 The Meat Quality Science and Technology Program (Beef Electronics) – Generation 1

2.1 Context

Meat & Livestock Australia Limited (MLA) is a producer-owned company that provides services to the entire Australian red meat industry throughout the value chain.

MLA's core activities are geared to improve market access, build demand for Australian red meat, and to conduct research and development (R&D) to provide competitive advantages for all sectors of the industry.

R&D develops metrics on supply and risk for the red meat industry, develops innovative solutions to specific industry problems and commercialises these solutions for the supply chain.

Industry problem: Inconsistent beef eating quality.
Past estimates had established that approximately 10% of prime beef failed consumer expectation in eating quality.

To address this industry wide problem and to provide innovative solutions to it MLA has initiated a number of programs such as

- The Meat Standards Australia (MSA) Program, and
- The Meat Quality Science and Technology Program (MQST) – Generation 1, or Meat Electronics program

Although the MQST Program also has a sheep meat electronics component that supports the Sheep Meat Eating Quality Program (SMEQ), the sheep meat related aspects of the MQST Program will not be covered in this document.

When these MSA and the MQST programs were deployed a number of contributing factors to poor eating quality of beef had already been identified through past Australian and international research. For example it was known that:

- Poor eating quality was mainly due to lack of tenderness,
- Common causes of toughness were cold and heat shortening of muscle fibres, resulting in poor ageing of the meat (see Box 3). Variability in meat tenderness as perceived by the consumer is influenced to a larger extent by processing factors than by both animal and cooking factors (Figure 1),
- Cold and heat shortening could be prevented (Hwang et al, 2003, and Devine et al 2004) by specific processing procedures or by electrical stimulation (see Box 1, 2 and 3).

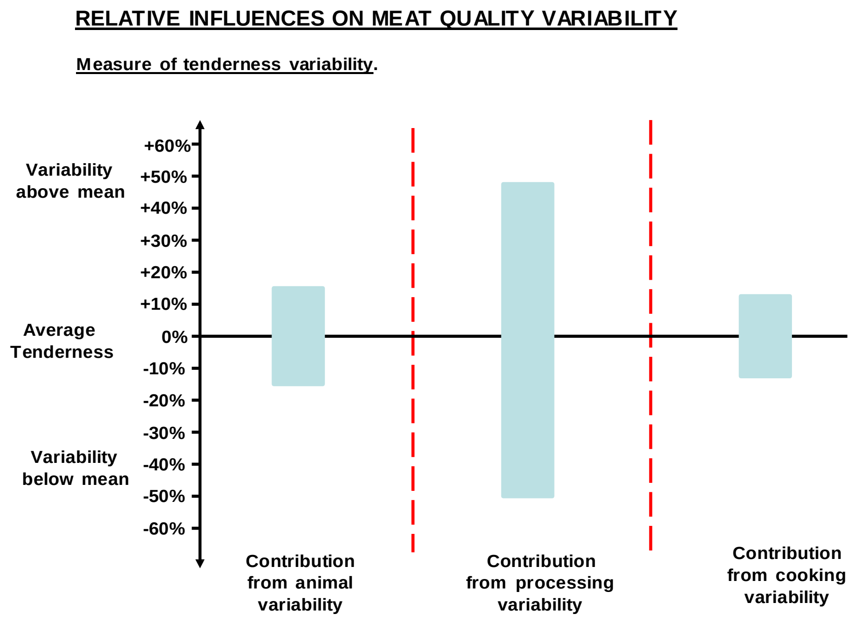

Figure 1: Relative influence of animal, processing and cooking factors on meat quality variability, measured as meat tenderness

> **Box 1 What is Electrical Stimulation (ES) of beef?**
>
> Electrical stimulation (ES) involves the passing of an electric current through an animal carcase after slaughter, to cause its muscles to contract. This phenomenon can be utilised to:
>
> - Immobilise the carcase after stunning to eliminate involuntary kicking movements and worker injuries (electro-immobilisers),
> - Stiffen the carcase at the hide pulling work station to avoid broken carcase backs (rigidity probes or back stiffeners),
> - Enhance meat quality and specifically tenderness (Electronic stimulators),
> - Improve blood recovery (Electronic bleeding stimulators).
>
> Electrical parameters such as peak voltage, total electrical energy, type, shape and frequency of pulses, but also time of stimulation after slaughter are important to generate the appropriate ES regime and desired effect.

The original purpose for developing ES equipment had been to save on refrigeration and storage costs by speed up meat ageing and management of meat quality in the environment of better freezing technology.

Research and empirical evidence since the 1970s had shown that:

- Electronic stimulation equipment for the purpose of increasing meat tenderness, if used appropriately, had been shown to improve tenderness in beef,
- Electronic stimulation equipment, if used incorrectly (over-stimulation), can have a negative effect on beef quality (heat shortening and increased toughness),
- Lighter and leaner carcases for domestic use in Australia are affected most by cold shortening and therefore benefit most from correct electrical stimulation
- Heavier and fatter carcass for export are cooling down too slowly and therefore require less or no electrical stimulation.
- Cattle with high glycogen reserves such as feedlot cattle require less or no electrical stimulation.
- The sequential use of immobiliser, back stiffener and stimulation equipment for increasing tenderness or increasing blood recovery could lead to over-stimulation of beef with negative effects on the visual appearance and eating quality of beef, especially in grain fed cattle.

Box 2 What are the effects of ES on the muscle and meat?

Muscle contraction requires energy and the muscle utilises glycogen in response to the repeated electrical stimuli. The increased rate of anaerobic glycolysis compared to non-stimulated muscle results in the build-up of lactic acid and an immediate fall in muscle pH after ES, followed by a change in the rate of the pH fall compared to non-stimulated muscle. This process hastens the process of rigor mortis, a required prerequisite for meat ageing enzymes to effectively tenderize meat.

Too much electrical energy input can increase glycolysis too much and muscles are damaged to such a degree that pale soft watery meat can results.

Prior to the deployment of the MSA and the MQST Programs it was also evident that:

- There was already ES equipment in use in a number of beef processing plants for a variety of purposes (ES for increasing meat tenderness, and the rate of blood recovery, back stiffeners, and immobilisers).
- Some of the ES equipment that was in commercial use was perceived to be associated with OH&S risks such as the danger of electrocution of operators. Installations therefore were expensive because of the need to shield operators from risks.
- The existing equipment did not cater for all modern processing requirements for all classes of animals, and in all plants.
- The technology on the markets did not allow sufficient adjustments to allow the targeted application of specific wave forms, pulse shapes and frequencies to provide appropriate stimulation to carcases with consistent results in terms of tenderness, meat appearance and eating quality .

Industry Problem: Over-stimulation of certain types of carcases

Equipment in use in the industry did not allow sufficient adjustment to prevent over-stimulation of certain types of carcases. The cumulative effects of immobiliser, back stiffener and stimulation equipment can result in the application of too much electrical energy in total, resulting in over-stimulation of carcases, especially in heavy grain fed cattle.

It was known that beef processors have a number of other concerns that they attempted to address through electronic interventions, such as OH&S related issues and plant efficiency problems.

For example, some plants attempted to address injuries on the slaughter floor (at shackling) by using electronic immobilsers. .Others installed electronic rigidity probes, called back stiffeners to prevent the separation of carcase vertebra at the hide pulling work station that resulted in expensive losses due to carcase damage, work flow interruption and worker injury risks.

OH&S problem – Shackling of cattle on the slaughter floor
Shackling of cattle after killing is a task with high risks of injury to slaughter floor staff

An industry's drive to increase efficiency and reduce costs of water and waste water treatment (MLA Industry environmental performance review 2005) in Australia and New Zealand led to the emerging use of electrical stimulation at the bleed rail to recover more blood per carcase.

2.2 The beef eating quality problem

Consumer issues with poor eating quality of beef are not new. There are a number of conditions that translate into poor eating quality of beef:

- Lack of tenderness
- Pale soft exudative (PSE) meat
- Dark cutting meat

A summary of how muscle turns into meat and how the process of tenderness, PSE and dark cutting meat result from is given in Box 3.

Management of cold shortening, dark cutting and PSE problems

Prevention of dark cutting meat is achieved by best practice pre-slaughter management of cattle relating. Recommendations on nutrition, transport and resting have been adopted by the beef value chain and are part of the MSA standards and the proportion of dark cutting meat has been much reduced.

Beef processors are generally aware of the optimum pH/temperature relationship, and measuring carcase pH and temperature has become part of the MSA licence requirements for grading abattoirs.

Observations that electrically stimulated meat was also lighter coloured led to the expectation of the beef processing industry that ES must lead to a brighter and better meat colour. However, more recent research has shown that this is not automatically the case. Researcher still debate whether a lighter meat colour is due to over-stimulation or a result of correct stimulation.

Since the introduction of ES equipment in the 1970s the proportion of smaller grass fed cattle that are likely to be affected by cold shortening is declining in Australia and the proportion of heavy grain fed cattle for the export market is increasing (see Appendix 1– Figure). Lack of tenderness is not a common phenomenon found in these animals although muscles close to the carcase surface still can be affected by cold shortening under certain chilling regimes.

As heavy fat cattle can have a very fast glycolysis rate an may experience a fast pH drop at high body temperatures even without ES, the use of electronic mid voltage mid frequency immobilisers and back stiffeners with these carcases has led to debates on how to use these technologies without causing an even faster pH decline and heat shortening.

Therefore the management of electronic stimulation equipment within the beef processing chain from stunning to freezing is not a simple and straight forward process that could guarantee that each carcase experiences a totally predictable pH/temperature decline, or that the variation temperature at pH6 within each batch of animals is within a small range.

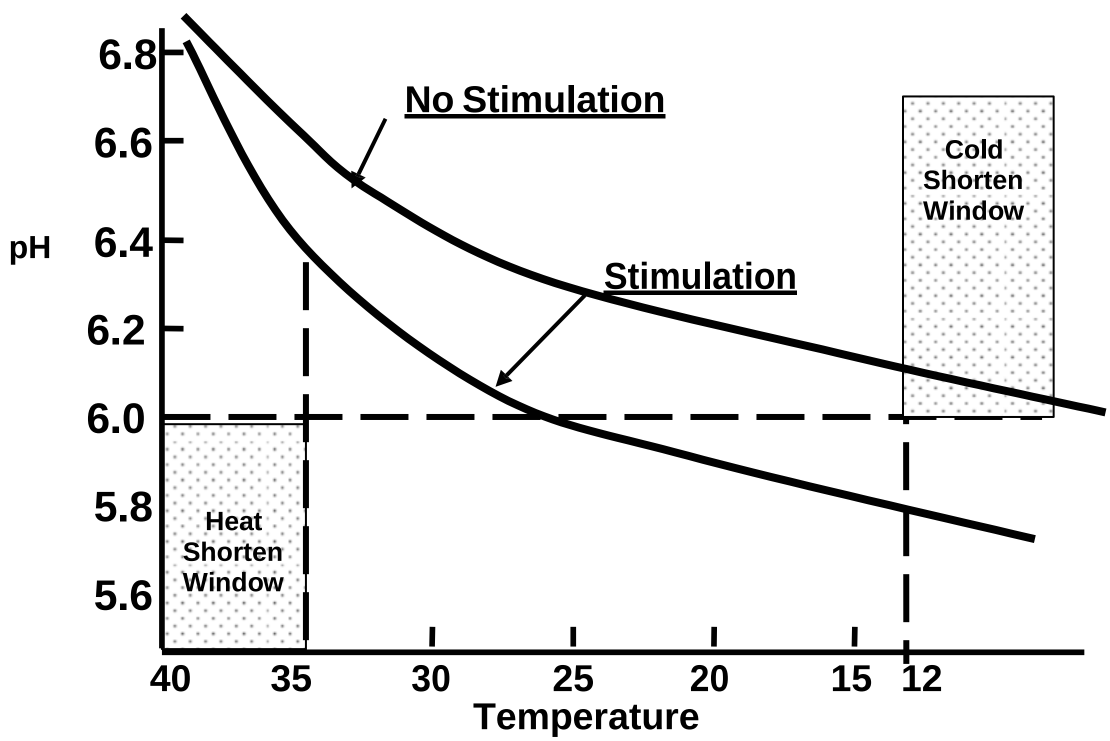

Figure 2: Required pH / Temperature “idealwindow” of 35^{0}C to 12^{0}C, with and without Electrical Stimulation for beef to avoid cold and heat shortening. Meat that exhibits pH/temperature combinations falling into the ideal window will not be tough or show PSE symptoms

Box 3 How does muscle turn into meat?

For meat to be of acceptable eating quality there has to be an **acceptable pH and temperature decline** during dressing from slaughter to chilling. Both pH and temperature have to decline at an optimal rate, i.e. they have to fall into an **ideal window (Figure 2**). Meat that has experienced an ideal pH and temperature decline will also **age** well as the meat tenderizing enzymes are less likely to become denatured. The cause of the pH decline is the process of anaerobic **glycolysis** of muscle **glycogen** which as an end product has lactic acid.

It has been established that beef carcases need to progress through rigor mortis prior to freezing and must not be cooled below 12^0C until they reach pH 6.0. If carcases are frozen at higher pH then **cold shortening** results. Rapid cooling can slow rigor mortis and the decline of muscle pH. The ageing enzymes that tenderize meat over time work more slowly and meat takes a long time to reach an acceptable eating quality. Upon thawing the meat usually is very tough.

The opposite effect, **heat shortening**, occurs if carcases reach a pH below 6.0 when still at temperatures above 35^0C. However, in contrast to cold shortening, the main effect is a shift to pale watery meat (**PSE-meat**) which will also be down graded. These types of carcases may never age as the ageing enzymes can be denatured.

Both phenomena lead to toughness and reduced eating quality. Reduced tenderness due to cold shortening can be created in smaller and leaner carcases. In heavy beef carcases, cooling is usually not rapid enough for the carcase temperature to fall below 12^0C before pH drops to 6.0 to result in cold shortening of all muscles. However, muscles close to the surface of the carcase or areas where the fat cover has been accidentally removed (during hide pulling for example) can be affected by cold shortening.

In heavy beef and especially in grain fed feedlot cattle, a steep pH decline coinciding with a very slow temperature decline prior to chilling can lead to heat shortening.

Dark cutting meat is the result of accumulated effects of poor nutrition and prolonged stress leading to exhaustion of the energy reserves prior to slaughter. As no glycogen is available for transformation to lactic acid the meat has a high pH and a dark colour. Dark cutting meat has low eating quality.

Economic pressures towards faster throughput in processing plants requires that the chilling process is managed so that carcases progress through rigor mortis and appropriate pH decline as rapidly as possible without jeopardising meat ageing and eating quality later on.

Electrical Stimulation (ES) of beef can hasten pH decline and rigor mortis by speeding up glycolysis. In small lean cattle this can prevent cold shortening. If in large heavy cattle the temperature after ES cannot drop below 35^0C by the time a pH of 6.0 is reached the meat will be tough due to heat shortening despite ES. Additionally it may look paler and more watery than unstimulated meat.

Research indicates that it is not possible to make already tender meat more tender by using ES.

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2.3 The OH&S Problem – Injuries on the slaughter floor

The meat processing industry has had one of the worst performances amongst any of the manufacturing industries in the area of Occupational Health & Safety.

In 1994/1995, a worker had a 1 in 5 chance per year to be injured or suffering an industry related disease. Nationally there were 5,153 cases with a total cost $76.4m, an average cost/injury of $14,826 and cost per employee of $1859.

According to National Occupational Health and Safety Commission (NOHSC), the average cost , of an injury from "hitting a moving object" was $1154,for the period of 1996-1999. Costs of being "hit by a moving object" were $907. The injury agency "carcass" averaged $2511 and "other animal part or product" $3,818.

Industry performance has slightly improved over time. For example, from 1997-98 the number of claims in the meat industry in Victoria decreased by 30% from 713 to 504 in 2001-02. However, the claims frequency and cost rates have stayed consistently above those of the general manufacturing industry of which meat processing is one component (Table 1).

Industry in Victoria	Claim frequency rate a	Claim cost rate b	Work Cover Premium
Meat Industry	3.03	$138,300	11.5 %
Manufacturing	0.81	$32,700	4.48%

Claim frequency a: number of claims per $1m remuneration
Claim cost b: fully developed cost per $1m remuneration
Source: www. Workcover.vic.gov.au/dir090/vwa/home.nsf/pages/manufacturing_new-meat_stats.
Claims data as at 31 August 2002 against remuneration data as at September 2002

Table 1 Claims rates and costs in Victoria 2002

Work cover rates vary from State to State (Table 2) but are highest in Victoria and NSW. There appears to be some cross subsidisation across industries within States which led NSW recently to introduce legislation that will abolish the 15% premium rate across all industries. The aim is to force poor performing industry sectors to take responsible action to reduce worker injuries.

NSW is the only State that splits premiums for the meat processing industry, all other States' figures are shown as totals.

State WorkCover premium %	NSW*	QLD	SA	TAS	VIC	WA
meat processing	8.53	6.592	7.5	8.86	11.79	9.14
Abattoirs	12.5					
Meat packing and freezing	11.99					

Source: State WorkCover Authorities websites
* NSW 2004/2005.

Table 2 WorkCover premium rates in 2005/2006

The abattoir sector in NSW has the highest premium of 12.5%, half a percentage point higher than the meat packaging and freezing sector. This may be due to specific injuries relating to animal related or slaughter floor specific tasks.

Specific problem – shackling of beef

One of the high risk tasks in beef plants is the shackling task on the slaughter floor. Following the animal being stunned and stuck it needs to be shackled. This involves placing a heavy shackling chain around the rear hock and then attaching the chain to a ram that is lifted onto the processing line. As animals after stunning and sticking can show various degrees of involuntary kicking movements of their legs, the task of shackling becomes a major injury risk. The handler is required to bend down close to the animal to attach the chain. Kicks to the head or body or the chain coming lose and catapulting through the room injuring other workers or damaging equipment can be expensive consequences.

Anecdotal evidence by MLA during an OH&S audit of a number of beef processing plants showed that in one plant in one year there were 11 incidents due to workers being directly kicked by a beast. This resulted in 73 lost days and a direct cost of $9000, not taking into consideration impact on WorkCover premiums, rehabilitation and workers compensation costs.

2.4 Meat processing industry efficiency problem

Production and operating costs vary from establishment to establishment. Total unit cost is lower for the larger establishments due to economies of scale.

Generally, the largest cost (77.5%) for processors are purchases of livestock at market price and consumables. Wages and salaries make up another 11.7% and profit of the industry runs at 7.3% before tax (Table 3). One of the contributing causes of high labour costs are workers compensation claims and high Work Cover rates.

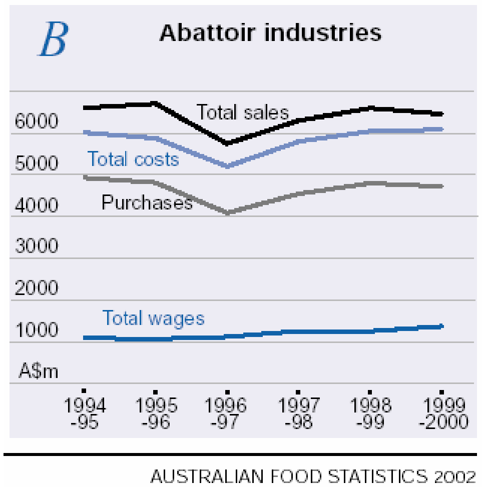
Item	**Cost**
Purchases, mainly livestock	77.5%
Wages	11.7%
Depreciation	3.5%
Profit	7.3%

Source: IBISWorld report C2111 Meat Processing in Australia (2005)

Table 3 Meat processing cost structure in the year 2004

Generally meat processing costs in Australia are high compared to compared to the USA. According to IBISWorld (2005) in 1998 average per head processing costs were $198 in Australia and $88 in the USA for beef plants.

Trends in the cost structure have not substantially changed over the last five years compared to the previous five years (Figure 3).



Source: Ibisworld report C2111 snapshot 2002

Figure 3 Trends in cost as a proportion of total sales over five year

Energy

Energy and water costs make up approximately 5% of the operating costs of meat processing plants. Meat processors have a high electricity demand for refrigeration, operation of equipment, hot water, light and ventilation (Table 4). There are increasing initiatives to reduce energy and water consumption and reduce waste flow and effluent.

The original benefits claimed by the developers of ES equipment was that refrigeration and storage costs could be decreased as chilling, boning and freezing of carcases and meat could be completed earlier.

Meat processing activity	Energy usage (%)
Refrigeration	59
Boiler room	10
Rendering	9
Slaughter	6
Compressed air	5
Boning room	3
Others	8

Source: Waste Reduction Resource Center(www.wrrc.p2pays.org publication 2005 (meat processing: environmental impacts

Table 4 **Meat (Beef and Pork) processing industry energy consumption**

Water and wastewater

Meat processing plants use high volumes of drinking water for washing livestock, carcases and equipment, and hot or warm water for cleaning slaughter and boning room floors. All of the water ends up as waste water which needs to be sufficiently treated in order to be safely discharged into waterways or communal treatment plants.

A project in New Zealand to minimise the amount of waste in beef and sheep meat processing (RDI Brief 80, October 2000) determined that per cattle beast 2-4 liters of blood are not recovered from the bleeding process, ending up in the waste water stream. It was calculated that by more efficient blood collection plants could reduce the amount of land needed to process effluent by 20%. By recovering 100 liters extra blood per day in plants discharging effluent to land the area required for effluent treatment could be reduced by three hectares. This additional blood would have netted these plants an additional NZ$4,500 per year (11.25 tons at a dried blood price of NZ$400/ton).

Anecdotal evidence has shown that by utilising electrical stimulation at the bleed rail an additional liter of blood can be recovered per cattle beast, thus making available 100 liters of extra blood for blood meal production per 100 head killed. Current prices for blood meal ex works in Australia are AUD 590/ton (MLA July 2005) and therefore net additional gain would be for Australian works AUD$6,640/year and 100 liters/100 cattle/day.

The benefit of reducing blood and debris from the slaughter floor has been confirmed by research in other countries, demonstrating that both overall water use and the BOD/COD* load of waste can be reduced by 7-10%[*]

According to MLA industry environmental performance reviews and economic data relating to processing plants from 1995, 1998 and 2003, the industry uses approximately 10 kL/tHSCW clean water and produces a similar amount of waste water.

The real costs of clean water including waste water treatment and disposal has been estimated at $1.95/kL if discharged into sewer, $1.55/kL if discharged into waterways, and $0.60/kL if discharged to land. Most of the Australian beef processing plants discharge to land.

Cost savings for an average plant from reducing water consumption by 1kL/HSCW at a cost of $0.60/kL (purchase, pumping, treatment and disposal of water to land) could be $22,500 per plant, $58,125 if discharged to water ways and $73,125 if discharged to sewer.

[*] BOD/COD = Biological Oxigen Demand/Chemical Oxygen Demand

2.5 Potential Solutions

Potential solutions to the stated problems were to either

- Promote processes alone that relied on achieving correct ph/temperature parameters prior to chilling – without the use of ES,
- Promote better processing practices and recommend installation of ES equipment that was available on the market at the time,
- Develop and commercialise better and safer ES equipment and facilitate market introduction, supported by promotion of better processing practice.

MLA decided that improvement of existing processing practices alone, without ES, was unlikely do be sufficient to achieve more consistency in beef eating quality. It was not likely that processors would stop using equipment that was already installed and that they had installed some years ago to increase tenderness or achieve a brighter meat colour.

A quick reduction in the variance of tenderness was needed and a more widespread use of ES equipment was believed to deliver faster results than relying on promotion of new concepts of adjusting chilling rate to pH decline alone.

To promote the use of existing ES technology and especially the more common high voltage stimulators would have required developing best practice processes with the manufacturers of these stimulators to ensure that correct pH and temperature could consistently be achieved in all carcases or at least in all batches. . Most of the ES systems in the industry were High Voltage stimulators that represented OH&S risks. To recommend adoption and routine use of such equipment throughout the industry was not seen as a viable option.

The third option was seen as the best option and the expected outputs from the MSA Program and research within the Beef CRC and other organizations were anticipated to underpin the commercialisation effort required to facilitate development and adoption of ES technology in the market.

2.6 Solutions

2.6.1 Beef Electronics Program – Generation 1 - and its strategy

The Purpose of the Beef Electronics Program

The purpose of the Beef Electronics Program – Generation 1 was to

- Provide beef processors with specific tools and processes that would allow them to provide consistently tender meat of high eating quality to the market, in line with MSA grading standards.
- Allow beef processors to adjust electrical stimulation to the specific needs of animal batches, taking into consideration their size, fat and glycogen reserves so over-stimulation could be avoided.

Ensure that processors could realize as many additional benefits from the use of electronic tools as possible. It was necessary to increase meat quality without foregoing OH&S benefits (electro-immobilisers) or operating efficiency benefits. Although energy and water cost represent only a small proportion of the overall processing costs of beef processors (approximately 5%), electronic solutions were required to either increase plant efficiency or at least be cost neutral.

- Employ a systems approach to the development of the electronic tools.

The beef electronics program was to draw on relevant information from the MSA Program on processing and consumer requirements and from other research on a the effects of ES and pH/chilling treatments on a variety of meat cuts. ..

Program strategy

The program strategy was to:

- Conduct R&D on stand-alone dose-controlled meat electronics technologies that interact with the carcase and can be used sequentially without detrimental effect on meat quality,
- Develop robust meat electronics technologies to the industrial prototype stage for beef,
- Protect appropriate Intellectual Property (IP),
- Test and trial the technologies in commercial processing plants through the Partners in Innovation Program (PIP),
- Promote benefits of the technologies to the appropriate market segments in conjunction with the SMEQ Program,
- Commercialise the technologies through a commercial company (commercialiser),
- Facilitate adoption by the processing industry.

2.6.2 Available knowledge about ES at the beginning of the Beef Electronics – Generation 1 Program

At the time of deployment of the Program there was substantial knowledge available about electrical stimulation (ES). The application of ES in the red meat processing industries was not new but developments had been quite erratic around the world. This revealed the existence of significant gaps in the body of knowledge on how to apply and optimise the ES technology.

Although ES for the purpose of hastening rigor mortis, ageing and saving on refrigeration cost had been originally developed in the 1940s with patents issued in 1951 (Table 1), commercial exploitation of this IP never happened. Only the pressing issue of cold shortening in lamb led to active pursuit of ES as a means to an end – tenderizing lamb and sheep meat, first in New Zealand and then in Australia.

Although most countries involved in good meat science had been working on electrical stimulation as a means of understanding meat physiology, New Zealand had been at the forefront, with Australia, USA and Great Britain not far behind.

A myriad of scientific articles had provided results of experiments using ES but as the use of ES was mainly for the purpose of establishing the mechanisms of rigor mortis or other muscle metabolic processes, there was no consistency in the experimental electrical parameters used, therefore leading to contradictory results and interpretations. Additionally researchers used a variety of muscles, breeds, species and experimental designs.

It is therefore not surprising that the knowledge of the mechanisms of action of ES (high, mid, and low voltage, pulse frequency and width, and other parameters) was still very sketchy, especially in the early days of ES. When the Beef Electronics Program began, the mechanisms of ES on the muscle were not clear.

There were contradicting reports on the effect of ES on the brightness and colour of meat and there also existed evidence that muscles could be damaged by for example applying too much current, for too long time, or at a too high pulse width. Muscles then appeared “cooked” or showed PSE signs.

In the more recent research focus has shifted more to the ultra structural protein and enzymatic systems of the muscle and there is still no complete understanding on how to completely control the glycolytic process in all individual animals with ES or to prevent adverse effects of the inappropriate application of ES. Current research is continuing to explore the biological basis of pH/chilling treatments on eating quality (Gaden 2005).

As it was initially thought that a functioning nervous system was needed to utilise low voltages to stimulate the meat. It was expected that lower voltages could be used at the beginning of dressing because less energy was needed to stimulate the nerves.

However, initially high voltage ES systems had been developed which stimulated the carcases at the end of dressing and before chilling. It was believed that the nervous system by then was no longer responsive to electrical inputs, and therefore high voltage (HV) systems were required.

A problem with these original HV stimulators was that they used a constant voltage to stimulate the carcase. A constant voltage produces a varying current through the carcase due to variations in contact resistance and different carcase resistance. This, in turn, led to animals of different types and sizes receiving either more or less stimulation with a varying tenderising effect. It was found that this type of stimulation led to unpredictable outcomes and sometimes to part of the carcase over-stimulated or under-stimulated.

First prototype versions of HV equipment appeared in the US and New Zealand, followed by Australia and other countries. Sam Kane Beef Processors in Texas claim to have been the first to install in 1978 a commercial high voltage stimulator in their beef production line and to have used it on all cattle going through the plant ever since. They trade marked their product as ELECTRO-TENDER-aged ™ beef. Much of the claims made on brightness of meat colour and effect of cold induced product faults in non-stimulated beef originate back to work that had been published utilising this equipment at the Texas A&M University.

Many plants in Australia chose not to use the HV equipment due to the potential danger of electrocution of operators and the expense of having to build a dedicated room or cabinet to make the process safe.

Since then, research and feedback from commercial operators has led to considerable fine-tuning of the more modern systems. The first improvements were Low Voltage (LV) stimulators for beef that were introduced into Australian beef plants as “Tenderpulse” stimulators and many plants still use them. It is not known how many of these machines are still in use and on how many carcases are stimulated with them.

From 1991 to 1994, Australia Meat Holdings (AMH) was the first beef processor to attempt the technical improvement of ES equipment in Australia on a commercial basis. This company, and others later, developed new dose-controlled low voltage stimulation systems (LVES) to overcome problems with using constant voltage.

LVES systems also were developed to increase efficiency of blood recovery in animals in which a thoracic stick (Blackmore and Newhook 1976) was applied. The application of LVES at the bleed rail allowed improved blood recovery but it also stimulated the meat. The Jarvis Product Corporation for example markets such a product.

Other equipment originally developed by AMH were a mid frequency electro immobiliser system (MFEI) for carcases to reduce post-stun kicking at shackling. The original low frequency NZ prototypes were providing too much stimulation and had led to meat damage in grain-fed stock. The result of the AMH work was an improved MFEI that had less muscle stimulation effect but allowed safer working on the slaughter floor.

A new medium frequency carcase muscle tensioning probe (or Electronic Back Stiffener, EBS) was also developed by AMH. The EBS stiffened the carcase's back and made the removal of the hide from the carcase safer whilst avoiding hide and meat damage from separating vertebrae in beef carcase backs ("broken backs"[*]).

All of these developments were implemented in AMH plants and are still in use. They could be used sequentially in a slaughter chain or individual components could be used as stand-alone units. However, there cumulative effects of electric stimulation were observed which could not be overcome at the time.

[*] No information on the cost of "broken backs" to the industry could be sourced during this project

Table 5 Key developments relevant to beef processing utilising ES

Year	Development	Reference
1749	Benjamin Franklin electrocuted turkeys, with the result that they were 'uncommonly tender'.	Devine et al 2004
1922	Observation that muscles contract on quick freezing but cause could not be explained.	Locker and Hagyard 1963
1940s	Work in the US by Harsham and Deatheridge (Kroger Corporation) with Rentschler (Westinghouse Electric Corporation) on tenderizing beef through ES. Initial provisional application for the process of tenderising meat filed in 1945. A number of voltages from 40 to 3000V were trialled and also different frequencies.	US Patent 2,544,681 US Patent 2,544,724
1951	In 1951 two US patents were filed on both the ES equipment (High voltage) and the process of tenderising meat. The intention was to hasten the ageing process and save on cost of refrigeration and storage equipment. The ES equipment patent is for a High voltage system. No commercial exploitation of the IP followed.	US Patent 2,544,681 US Patent 2,544,724
1960s	Complaints about lack of tenderness in lamb in NZ and Australia on the rise. Rapid freezing of slaughter warm carcases found to be the cause. This triggered research on muscle physiology and the search for practical solutions to the problem. Connection made between chilling, cold shortening and eating quality	Lawrie 1977 Locker and Hagyard 1963
1960	Research on the role of ATP in rigor mortis.	Bendall 1960
1970s	Established that glycolysis is faster at 37^0C than at ambient temperature Research in NZ, Australia, UK and the US focuses on the effect of ES on glycolysis, heat shortening, cold shortening and on the ultrastructure of muscle after ES. Established that cold shortening and heat shortening can be avoided if cooling takes into consideration pH and carcase temperature	Lawrie 1977
1970s	Research on the effect of a variety of electrical stimulation parameters and their combinations in relation to rigor mortis, muscle metabolism and physiology, and on tenderness results in the emergence of commercial ES equipment first in New Zealand, followed by Australia and the US (High Voltage equipment)	Variety of literature and internet sources
Late 1970s	New Zealand develops inverted dressing procedure for sheep which combined with thoracic stick provides benefits for ES being applied early in the dressing process	Inverted dressing Review 1997
1970s	Experiments with high voltage ES in NZ, Australia and New Zealand	Hwang et al 2003, Devine et al 2004
1978	LeFiell Company in the US develops a commercial high voltage stimulator LECTRO-TENDER™ Sam Kane beef processing plant offers the first trade marked beef ELECTRO-TENDER-aged™ in Texas.	LeFiell Website and Stiffler et al Texas Agricultural Estension Service Publication B-1375

1980s	Electro-immobilisation of live sheep for shearing and for de-antlering in deer had received a lot of exposure in the mid 1980s and early 1990s. The use of electro-immobilisation of conscious sheep was outlawed subsequently for animal welfare reasons but for unconscious animals post stunning, the method proved to be effective	Rushen and Congdon 1986
1980s	Debate whether a functional nervous system is needed for ES. Research at CSIRO shows that a functional nervous system is necessary for low voltage ES to be effective but not necessary for High Voltage ES. Later it was shown Mid Voltage stimulation is effective at the end of the dressing process	Morton et al 1982
1990s	Research focuses on meat ultra structure, muscle proteins and enzyme systems	Hwang et al 2003, Devine et al 2004
1991	From 1991 Australia Meat Holdings embarks on a Development program to improve on a variety of ES equipment for beef in their plants in conjunction with Applied Sorting Technologies in Victoria and Food Science Australia (CSIRO)	MLA
1993	AMH installs first improved low voltage stimulation system (LVES) in their plants	MLA
1994	AMH installs first improved mid frequency immobiliser production prototypes	MLA
1995	AMH installs first improved rigidity probe (Electronic Back Stiffener or EBS) production prototype	MLA

Table 5 Key developments relevant to beef processing utilising ES

2.7 Key Developments of the Sheep Electronics Program

2.7.1 Technical Developments

At the beginning of the program Ian Richard joined the MLA as Manager Technology Development and leader of the MQST program. He had a background in electrical engineering and had been the R&D Manager of Australia Meat Holdings, Australia's largest beef processor. From 1992-1995, in this role he had developed a new dose controlled low voltage stimulation system (LVES) for beef and a number of other electronic intervention technologies such as a mid frequency electronic immobiliser (MFEI) and an electronic back stiffener (EBS).

Applied Sorting Technologies, a Victorian company which developed X-ray equipment for the food industry to discover contaminants in packaged goods such as meat cartons. AST had been closely involved with the engineering of the AMH developments and they had built the commercial versions of the ES prototypes.

To develop better and safer equipment for beef carcase stimulation within the MLA Beef Electronics – Generation 1 Program, three avenues were pursued:

- A new controlled dose Low Voltage system (LVES) for installation in the bleed area to increase blood recovery and/or control meat tenderness,
- A new controlled dose Mid Voltage system (MVES) in the post-dressing area to control meat tenderness instead of the dangerous High Voltage systems,
- A new controlled dose High Frequency Electroimmobiliser (HFEI) to ensure immobilisation of all animals at shackling without causing stimulation of the meat, especially in heavy and grain fed animals,
- The development of a Computer Process Management System concept (CPMS Concept) that in the future would ultimately allow the development, integration and central control of all electrical stimulation systems in a plant in response to data inputs related to animal and carcase parameters prior to and after ES.

The design needed to ensure that each stimulation system could be used as a programmable stand alone unit, so that ES of batches of animals could be dose controlled. The design should also ensure that stimulation systems would not be made redundant by a future CPMS, i.e. compatibility with a future CPMS needed to be part of the design concept.

Alongside the design of the ES systems appropriate electrode systems needed to be developed also.

The Computer Process Management System (CPMS)

As most beef processors were expected to use more than one ES system, resulting in multiple electrical inputs along the processing chain, carcase over-stimulation was expected to be an issue potentially limiting adoption.

To design a central CPMS for beef processing plants was not possible with the information available at the time of the Beef Electronics Generation 1 Program.

Research results on animal characteristics influencing pH/chilling rate such as those used in Meat Standards Australia (MSA) grading needed to be tested in production lines first, so data processors could be calibrated appropriately in the future, and in return prescribe the right amount of electrical energy to be used on batched or even individual carcases. It was envisaged that this equipment would ultimately prevent potential over-stimulation of carcases.

In 2002 MLA took out a patent on the business method of using a Computer Process Management System Concept (CPMS Concept) that regulates the operation of the individual ES components via operator defined parameters and interaction with the individual component computers inside each of the electronic technologies.

The Mid Voltage System

The rationale behind developing a Mid Voltage system was that new research by MLA had revealed that pulses with 1/100th of the energy normally used with High Voltage stimulation post dressing had the same tenderizing effect as High Voltage stimulation. Therefore a mid-voltage stimulator (MVES) prototype which also proved to be safer, cheaper and much easier to install than the Low Voltage electro-stimulation (LVES) equipment on the market. It did not pose any electrocution risks to operators and did not require special cabinets to house the stimulation equipment.

The new Mid Voltage system could be deliver controlled doses of electrical energy and designed to be compatible with a future CPMS.

The Low Voltage System

Effective LVES systems for the bleed area needed to deliver controlled dose stimulation that resulted in increased blood recovery alone in animals that needed no stimulation to increase tenderness, while the LVES needed to be programmed differently to deliver low voltage stimulation for hastening pH reduction and increase tenderness. The design of these units needed to include the development of appropriate electrode systems.

As plant layout varied between processing plants it became obvious that individual plants might need specific electrode developments to achieve effectiveness of Low Voltage stimulation in all plants.

The Mid Voltage High Frequency Electro-Immobiliser

An effective dose controlled post-stun lector-immobilisation unit for cattle at shackling needed to disable the nervous system temporarily or permanently so that involuntary movements of the legs were not possible and handlers could fasten shackles without the risk of being kicked. However, electro-immobilisation was to take place without the effect of meat stimulation so that this equipment could be used even heavy fat cattle.

2.7.3 Technical achievements

The technical achievements of the Beef Electronics Program – Generation 1 are listed in Table 7 and in Figure 4). The program developed a set of four dose controlled technologies. As the optimum stimulation parameters for each carcase type become available after testing, they can be stored as one of six programs attached to each of the technologies micro-computer.

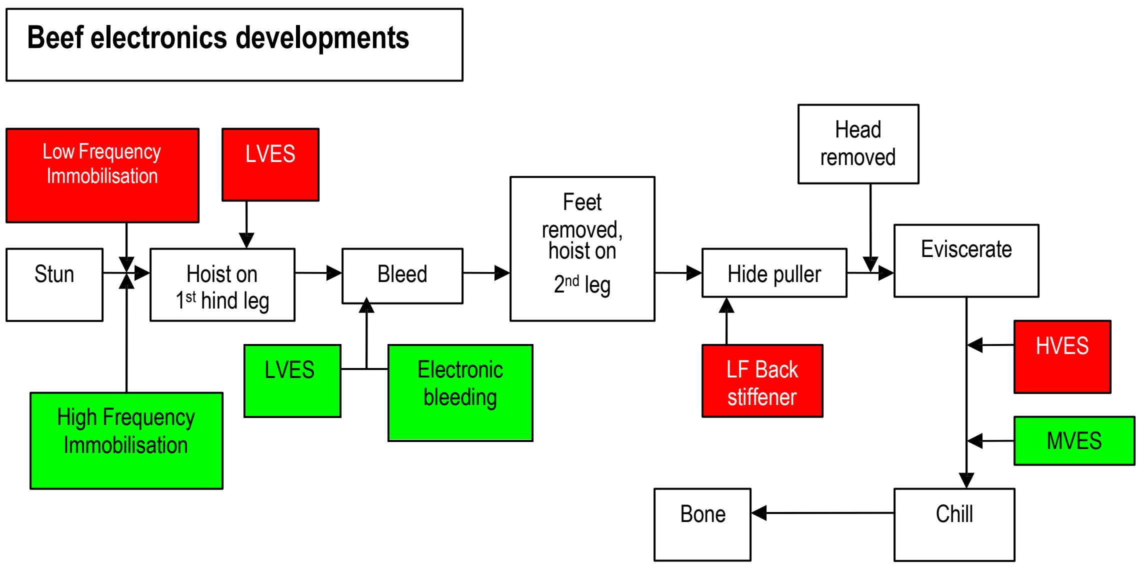


Figure 3: Technical Achievements of the Beef Electronics Program.
Red boxes: Systems in use in the industry prior to the Beef Electronics Generation 1 Program
Green Boxes: New developments of the Program

The first prototypes of dose controlled CPMS concept compatible versions of the LVES, MVES and High Frequency immobilization electronics were built in 2001, tested in 2001 and commercial prototypes were available by 2003. There were two types of LVES system developments for use in the bleed area, differing in their electrical input criteria, one to increase the recovery of blood without much stimulating effect on the meat, and one for increasing tenderness. The MVES for use in the post dressing area could be tuned so that optimum pH/temperature combinations in carcases could be achieved. .

An area of frustration was the lack of commercially available beef electrodes that could be used with carcases of all shapes and sizes. New electrodes had to be designed for cattle and trialled in beef plants. Challenges such as carcases becoming tangled in electrodes and electrical lines, needed to be overcome through better mechanical electrode design. Initially, commercial line speeds were not achievable. However, the final industry production LVES and MVES systems were installed together with automatically applied electrode systems

Additionally, effects on meat quality needed to be assessed by sampling of meat for temperature, pH trials and eating quality. Cooperation with CSIRO, UNE and the Beef CRC ensured that results could feed back quickly to the technical development team MLA.

Work on post stun electrical immobilisation initially resulted in a better dose controlled and CPMS concept compatible mid frequency electro-immobiliser (MFEI) with a mid voltage and mid range pulse rate that had a much reduced stimulation effect compared to other units on the market. Prototypes of this equipment was ready to be installed in 2001 but they still provided more stimulation than needed for heavy grain fed cattle.

Further development into a High frequequency Electro-immobiliser (HFEI) followed and by 2003, the production prototype of a mid voltage HFEI was available for installations in beef plants in the pre-dressing area to allow shackling without risk of injury.

2.7.4 Commercial Developments

In 2000 there was no easy way of deploying ES developments to most beef plants in Australia. MLA promoted the idea of developing dose controlled ES equipment to a number of beef plants. Within the Plant Initiated Projects Program (PIP) Australian Country Choice (ACC) installed the initial production prototypes as pilot installations.

In 2001, most of the electronics developments compatible with the CPMS concept were at a development stage that was convincing enough for MLA to make a decision of commercialising the technologies and encourage adoption by the meat processing industry.

In line with the program strategy and adoption plan, which had been updated in 2001, the decision was made to call for tenders from firms that had suitable experience in the industry and were capable of marketing and supporting commercial ES installations in Australia.

Australian Sorting Technologies (AST) had become a major partner in the development projects in 2000 and had entered into an agreement with MLA to provide and license their background IP to MLA for the purpose of the beef electronics project, resulting in an equal share of the resulting meat electronics IP. In 2005 MLA purchased the AST owned IP component and now fully owns all Generation 1 beef electronics IP.

The tender process eliminated a number of tenders and Millers Mechanical (NZ) Ltd was chosen and given an exclusive license to commercialise the Generation 1 Beef Electronics. The reason for choosing this firm was their extensive experience in the meat processing industry throughout the processing chain from slaughter to refrigeration.

Millers Mechanical is a part of the Realcold Group of Companies which also includes its Australian Division, Realcold Milmech Pty Ltd in Queensland. Millers Mechanical had extensive expertise in the design and manufacture of MILMECH abattoir systems, equipment, materials handling and refrigeration in the meat processing industries, and had also been involved in developing the inverted sheep dressing process and Shiny Robot Venture in NZ. Realcold Milmech's core business is the supply of meat processing systems, low temperature freezing systems and other meat processing equipment in Australia.

Since 2002, Realcold Milmech had been involved in the production prototype testing of the sheep electronics systems in commercial plants.

Millers Mechanical and MLA signed the licensing document that outlined the objectives of the commecialisation. Millers started marketing the new technologies immediately but installations were initially slow to follow.

The experimental prototypes had worked well in the pilot installations but each processing plant had a different set-up. Some could not fit the equipment in as there was no room or they needed to make structural and mechanical changes to incorporate it into their layout.

Management of the installation process proved to be a very time-consuming task. Realcold Milmech had been expected to do the installations mainly by themselves but it proved to be not cost-effective due to the time involved in site visits, engineering changes, and consequently Ian Richards needed to still spend a lot of time the technology at each site (Box 4).

Box 4 Processor technology adoption cycle

The following is a list of tasks that are typical of an installation:

- Promoting the technologies to processing plants.
- Designing variations to the electrode systems to match plant requirements
- Supervising construction and installation of equipment.
- Commissioning equipment.
- Performance testing.
- Reporting and interpreting performance data to plant personnel

Support of the ES technology in the market is time and resource consuming as the Generation 1 technologies cannot be just "bought out of the crate" and installed with local contractor knowledge alone.

In 2004, Miller's Paul Keane took on the project adding exceptional skills in engineering design, project management and getting the buy-in from processors. This has ensured that the project began moving along at faster speed.

The costs for beef installations can be substantial, depending on the plant layout. Typical approximate installation costs are:

- HFEI in the pre-dressing area for beef immobilisation: $10,000 - $20,000
- LVES for stimulation or bleeding at the bleed rail: $40,000 per unit. Additional costs may be incurred if substantial changes to the electrode system are required,
- MVES for stimulation in the post dressing area $50,000 -70,000,

Increasing the pace

The first commmercial installation of an dose controlled beef ES system was completed in November 2003.

In January 2005 the MLA innovation adoption plan for the MQST – Generation 1 Program was updated. Benefits from Generation 1 technologies (for both beef and sheep meat) were estimated to be $175 million over five years of which 68% of the benefit was estimated to flow back to the producers. By January the uptake of the technologies had not substantially progressed beyond the original pilot demonstration plants that had been part of the development.

In line with this plan a list of 60 beef and sheep processors were selected which represented approximately 80% of the national red meat production for both domestic and export use. This list was now targeted as a matter of priority to increase speed of adoption with a combined Millers and MLA effort.

The plan envisaged installations of 113 stimulation systems and 13 electro-immobilising units by the end of 2005, and a total of 34 stimulation systems and 25 immobilisation systems by the end of 2008. Although the beef MVES electronics had proven to be effective in production trials its benefits were thought to be greater if used in the context of a fully developed and functional Generation 2 CPMS system. Therefore the MVES system was not included in the roll-out plan for the Generation 1 technologies.

2.7.5 Commercial achievements

From January to June 2005 installations followed at a rapid rate and at the end of June the installations were on schedule and on target (Table 6)

	LVES	Immobilisation
2004	10	4
2005	3	9
2006	11	7
2007	6	2
2008	4	3
Total planned to 2008	**34**	**25**
Total planned by end 2005	**13**	**13**
Total achieved by end 2005	**16**	**14**

Table 6 Installations in beef plants – planned vs installed

Uptake of the new beef electronics by beef processors has been slower than the uptake of comparable electronics by sheep processors. In that industry the 2006 uptake targets have already been achieved by the end of 2005, one probable cause being market pull employed by supermarket chains for tender lamb.

The drivers for the uptake of beef electronics appear to be different. Pre and post installation interviews of beef processors by MLA in 2005 have shown that the two most important reasons to install the new technologies were:

- Better meat colour due to more efficient bleeding with the LVES
- Effective elimination of involuntary kicking at shackling with the HFEI.

Beef stimulation to increase tenderness did not appear to be a major driver for installing a LVES. This is possibly the result of poor understanding of the mechanisms and benefits of ES in many plants and especially those that are not MSA approved. The effect of the immobiliser is apparent instantly, a lighter colour of meat can be seen at carcase grading whilst benefits of increased tenderness cannot be "seen" at all in the processing plant. Processor interviews revealed a strong focus on immediately "visible" results obtainable with beef electronics.

The installations of the CPMS concept compatibe LVES equipment therefore appear to have been more difficult as far as tenderisation effects are concerned. Although 2005 installation targets have been met, they are likely to be due to the main drivers "better colour resulting from better blood recovery" and "lower injury risk due to immobilization at shackling".

The key developments and achievements of the program are listed in Table 6.

2.8 Collaborators

A big program such as this one needed a lot of collaboration and goodwill from other parties for the development, manufacture and testing of prototypes and especially commercial installation in processing plants.

AST was involved as a partner with the electronics development towards robust prototypes at the commercial prototype stage. Local contractors were used to effect the necessary mechanical changes in the plants to accommodate the electronics.

Australian Country Choice with their two plants, by utilising the Plant Initiated Project Program (PIP) were instrumental in pilot testing the production pilot systems under commercial conditions. These plants were subsequently making their systems available to the industry as demonstration plants,.

A number of research organisations and their staff were supplying the meat science knowledge as input into the design of systems, such as the Dept of Primary Industry in

NSW and Victoria, CSIRO, Murdoch University, the Beef and the Sheep CRC, and other organisations.

Close collaboration with AgResearch, MIRINZ and Meat and Wool New Zealand (MWNZ) was also sustained over the years.

The MSA Program provided the collaborative framework for the Generation 1 Beef Electronics technologies. The MLA Consumer Marketing team also supported the development of consumer demand and customer pull through for the technology through their key account managers for Woolworths and Coles.

Millers Mechanical Ltd and its Australian Division Realcold Milmech Pty Ltd have been responsible for most of the commercialisation effort and pre- and post-implementation plant support.

Year	**Developments**
1998	In 1998 MLA decision to deploy MQST Program and to develop safer, cost effective beef electronics technology for meat stimulation, effective bleeding and for carcase immobilisation
1999	Decision to develop individual ES units with their own individual programmable processors to control voltage, pulse type and frequency. It was envisioned that in the future these units could be coordinated from a central processing unit that controlled the whole plant
2000	R&D begins on both Low and Mid Voltage stimulation and immobilisation systems for beef
2001	MVES, LVES and Mid voltage HFEI prototypes installed and tested
2001	Program adoption strategy updated. Decision to engage a commerciliser for the technology.
2002	Patent application filed for CPMS business concept, titled “Electrical treatment of carcases”. IP jointly owned by Applied Sorting Technologies (AST) and MLA.
2002	Production prototypes installed and tested
2002	Millers Mechanical Limited engaged as the exclusive commercialiser of the Generation 1 Sheep Electronics technologies.
2002	Millers Mechanical licensed to commercialise the Generation 1 Beef Electronics with the agreement of the MLA Board and AST
2003	Both Low and Mid-voltage production versions installed and tested ACC agrees to install the technology in conjunction with the Plant Initiated Projects Program in two plants
2004	Adoption still slow. Support of pilot installations stepped up by Millers and MLA
2005	In January target set for implementation in processing plants for 13 Low Voltage systems and 13 high frequency electrical immobiliser. No targets were set for MVES systems
2005	Installation targets met
2005	MLA buy-out of all ATS owned IP. MLA now owns 100% of all generation 1 sheep electronics IP
2005	MLA conducts pre- and post-installation benchmarking in six plants and processor feedback 15 interviews

Table 7 Key Developments of the Beef Electronics Program

3 Benefits

MLA spent $1.7m on the developing the Generation 1 technologies with another $0.4m spent by industry partners. For calculating benefits to the industry, the financial model (Appendix 1) also includes the installation costs of the equipment and support costs by MLA.

The total NPV of the MQST program for beef and sheep meat is $152m over 10 years at a discount rate of 7.5% and of $95m at a 16.5% discount rate. Approximately 75% of the benefits will flow to the beef industry. The OH&S benefits of the immobiliser technology will be spread across both the sheep and the beef industry as WorkCover rates across states are applied across the meat processing industry in general.

In the absence of a number of baseline data, benchmarks and appropriate metrics to measure pre- and post installation improvements, benefits can only be estimated and are open to debate.

3.1 Baseline data

Benefits can only be claimed if improvements can and have been measured against baseline data sets. This requires that at the outset of the program appropriate metrics need to be in place to assess post-installation impact.

For reduced tenderness due to cold-shortening literature and industry quotes vary between 10% to 15% of beef and 20% variation within samples affected under current refrigeration regimes, without ES.

The incidence, severity and financial impact of PSE meat in heavy carcases with and without ES is mostly based on anecdotal evidence.

State WorkCover authorities do not report on specific injuries except on injury agents such as “being hit by a moving object” for example. It is uncommon that processing plants keep sufficiently detailed records on specific injuries related to workstations and therefore improvements can realistically only be measured after baseline data have been established.

Therefore, in the absence of many of these baseline data benefits can only be assessed using measures based on older literature, anecdotal evidence and figures “agreed on” industry wide such as 10% of beef is affected by cold shortening.

Although there are environmental performance data established in Australian meat processing plants, the plant audits have not been conducted to establish the benefits of one liter less blood/head discharged into the effluent stream of plants.

Baseline data required

- There are no recently established baseline data for the incidence of cold shortening or of heat shortening for specific types of cattle or types of muscles affected in the current commercial environment including variation within batches and carcases.
- There are no recently established baseline data for the incidence and value of brighter colour due to ES being applied either due to more efficient bleeding or lighter colour due to lower meat pH at an earlier point in time in relation to slaughter and grading.
- There are no recent baseline data on the incidence of PSE like meat in heavy carcases without ES having been applied.
- There are no baseline data available on the incidence and costs of injuries due to involuntary kicking at the shackling workstation.
- There are no recent baseline data on the savings in energy savings on refrigeration costs due to shortened ageing time in carcases after ES compared to non stimulated beef.

3.2 Demand Benefits

The main purpose of the Beef Electronics Generation 1 Program was to develop electronic tools that would enable processors to produce consistently tender meat of high eating quality from electrically stimulated beef carcases. The potential eating quality benefit expressed in increased total price gain or NPV should therefore reflect the intended purpose, i.e. most of the financial benefits should come from increased tenderness and more consistent meat quality.

As there are other initiatives in place to improve beef eating quality such as the the MSA Program, the genetic improvement of cattle, improvements in the specialist feedlot and finishing industry, any rise in domestic beef consumption or retail price cannot realistically be attributed to the Beef Electronics Program – Generation 1 program alone.

The program is to a large extent an enabling program for the MSA program and thus is contributing to improving beef eating quality. It would be more useful to summarise the eating quality benefits of the beef electronics program under the benefits of the MSA program with the beef electronics development costs being added in with the MSA program cost component. However, there were other technical improvements that result in OH&S benefits, increased revenue or decreased cost at the plant level so that the benefits of the program that are summarized in Appendix 1[*]. .

To quantify the proportional share of the eating quality benefits flowing back to the various segments of the beef industry value chain is very difficult (Figure 5 and Appendix 2).

The assumptions made in the financial model were that the tenderness issue mostly applies to the domestic market (800Kt/year) as beef exporters claim that beef will age

[*] The eating quality benefits of the total MQST program are also listed in Appendix 1

during transport and therefore does not require ES. Additionally markets for heavy feed lot beef cattle are also more likely to need less or no stimulation to enhance tenderness.

The benefits were calculated on the basis of 800Kt carcase weight at 65% usable meat rate, 16 % being prime cuts and 10% affected by cold shortening with the potential to cause adverse consumer reactions. It was assumed that this proportion of meat could be attracting $0.50 per kg at wholesale. The increased gross revenue to the processing industry from utilizing ES systems to improve consistency in tenderness would be under $5 million per year.

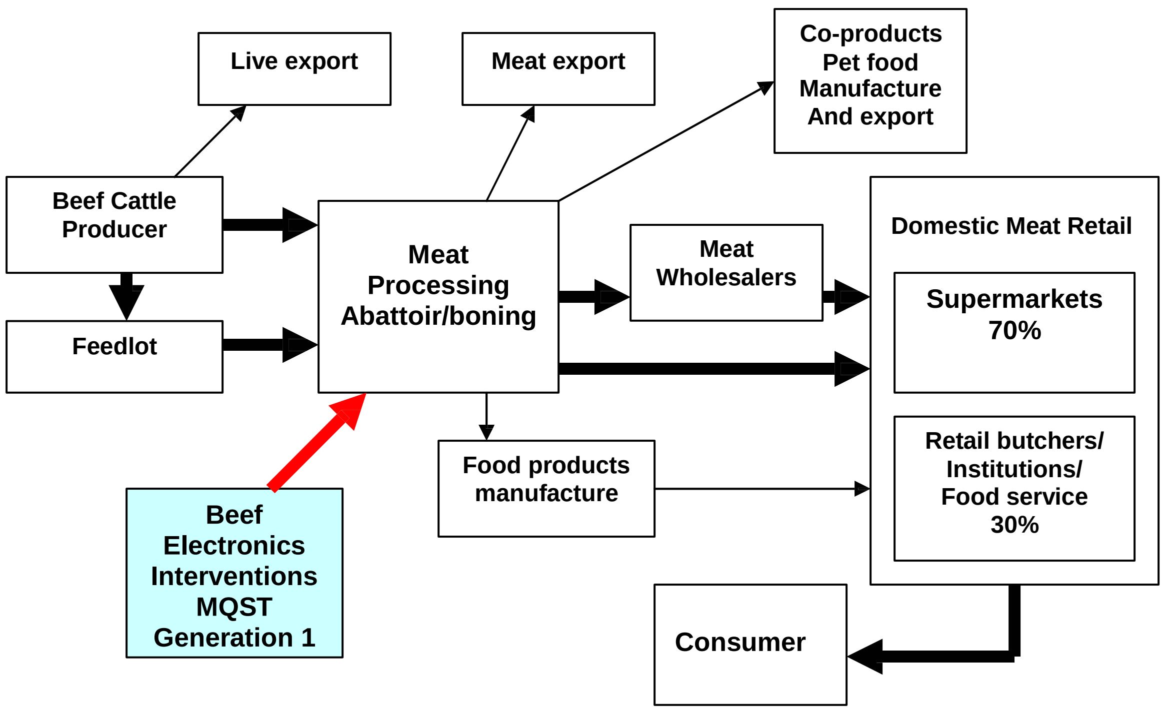


Figure 5 The beef industry chain.

However, this calculation does not include the benefit from increased security in demand and the benefit from improved supply chain relationships with the major supermarket chains. Any tough beef causing negative consumer reactions reflects on all beef and therefore the total benefit to the industry as a whole would be greater.

For example, based on the quoted percentage of 10% of beef being tough due to cold shortening one could assume that the other 90% would not benefit from stimulation and thus there would be no economic benefit. An investment in LVES equipment for only 10% of throughput would need to pay off with substantial price premiums unless further benefits are realised from the other 90% of beef.

According to Hassall and Associates (2004), the NPV of the MSA Program is $13.1m over 10 years. If the use of LVES equipment could enable more processors to meet

MSA standards and grades, the benefit of the MSA Program would be increased due to the Beef Electronics – Generation 1 program.

How an additional increase in tenderness would be rewarded at the point of the retail sale is not clear. In the financial assessment of the program the view was taken that the meat quality benefits in form of price premiums would be realised by the installer of the electronics, i.e. the processors only.

Due to the lack of baseline data (before the installation of ES equipment), effects of the new ES equipment on tenderness in specific classes of animals/carcases cannot be analysed or interpreted as more than anecdotal evidence of a positive effect.

Any positive benefit from increased tenderness could be made void by negative consequences from over-stimulation through too much or too severe electrical inputs. Realistically the economic impact of these events could be much higher than from cold shortening as the proportion of beef entering export is much higher than the domestic component of meat. PSE meat does not age well and an extended transport time cannot change that effect. Possibly the reluctance of beef processors to utilise ES technology other than for increased blood recovery and immobilisation is based on their attitude to risk.

3.3 Supply benefits

3.3.1 OH&S benefits.

Labour costs are the highest operating costs after livestock purchases. Assumptions on the beneficial effects of ES on the industry labour cost bill and WorkCcover rates could not be substantiated by current hard data yet.

Cost savings due to less injuries on the slaughter floor during shackling and bleeding would reduce labour costs in several ways.

Reduced workers compensation costs are expected to translate into a lower industry WorkCcover premiums. The model assumes that a reduction over five years from 1.2% to 0.95% of the wage bill (at a reduction of the WorkCover premium of 1%) could be achieved if immobilisers were to be used across the industry. This would translate into substantial industry savings.

Reduced labour costs due to lost time with replacement labour to be employed to fill the spot of the injured worker add an additional cost.

In the absence of industry wide exact statistics on injuries on the slaughter floor during shackling and bleeding a cost of $600/week lost was used in the model.

.If it is assumed that there are 140 beef chains and 49 sheep chains in Australia (Davenport 2004: The shiny robot venture case study) at two shifts each that would assume 5.5 days lost per shift/year. It is also assumed that more than one worker in each shift would be at risk from incidents at shackling and bleeding. The model assumes that this risk would be totally eliminated by using the immobiliser and no staff would need to be replaced. Hiring costs due to less staff turnover from fewer workers leaving the industry due to injuries or fear of injuries might also be a positive consequence of introducing immobilisers into all chains. The industry is notorious for high staff turnover on the slaughter floor and a safer environment might reduce it. Reduced efficiency in terms of slowed down production when an injury or incident occurs has not been included into the calculation.

According to the model the benefit from a reduction in OH&S claims is potentially greater than or at least as large as that from an increase in meat tenderness as a reduction in the WorkCover premium rate is applied to all workers across the meat processing industry.

3.3.2 Energy and water benefits

Benefits from reduced water usage or reduced BOD in waste water due to one liter extra blood recovered at the bleed rail are small (Appendix 1). However, these benefits may still make a difference for a plant and reduce pay-back time for the equipment.

As refrigeration consumes more than half the energy in a plant, benefits from shorter refrigeration time due to speedier ageing after ES could be significant on a per unit basis. However, as there are different refrigeration and freezing systems in use in the processing industry it is difficult without establishing baselines first to quantify the potential energy and also labour savings and consequent benefits of shorter ageing times.

4 Where to from here?

The Beef Electronics technology – Generation 1 – can be seen as a substantial success for MLA and the commercialiser in the ara of the HFEI and the LVES for blood recovery. Installations so far have achieved the set targets and are on schedule. Although reluctant at first, processors have "seen" the benefits of both technologies in their plants, such as workers on the slaughter floor refusing to work without the immobiliser, more blood recovered and more beef meeting MSA grade targets.

The program started on the assumption that consistently tender meat was a goal understood and also automatically pursued by the processors chosen . Sufficient scientific literature was available globally to know that ES could eliminate tough meat caused by poor pH-temperature decline relationships. AMH, the biggest beef processor, had invested time and money in the 1990s into the development of ES systems and that showed that the industry was interested in eliminating tough meat.

There seemed to have also been a an agreement amongst researchers that the industry needed and wanted the Generation 1 technologies. This is understandable as it seemed obvious that inconsistency in meat quality was one of the reasons turning consumers off red meat. The solution of using ES might have been obvious to the those involved with meat science and the technical developers of ES systems but industry needs more hard data taking the impact of a new technology on the whole system into consideration.

Key Problem

Anecdotal evidence based on the post installation interviews with processors shows that reported benefits are realised through achieving MSA grade after utilising the LVES. . However, finding the right balance between the amount of stimulation required to eliminate OH&S problems, increase blood recovery and achieve the correct pH window for MSA, especially in heavier cattle appeared to be difficult and required assistance from the commercialiser and MLA.

It appears that the time and effort required to install a system is very high and probably not cost effective for Millers Mechanical, mainly due to the individual plant layouts and support for “tuning” systems to the mix of cattle types slaughtered (grass fed lighter stock and grain fed heavy and fat animals). It cannot be assumed that the initial knowledge of the plant electronics operators is sufficient for a consistent correct programming of the electronics to realise all benefits from the equipment.

It is doubtful that installations and the commercialisation of the technologies would have progressed at the achieved rate without the combined effort of MSA, Millers and MLA.

The existence of a clear pH target and meat colour criteria for MSA grading and the beef specific ideal pH/temperature window made the introduction of the ES technology easier as processors are able to measure the result. The fact that better MSA grades have been achieved through meeting MSA pH and colour targets after installation of LVES systems should facilitate the uptake rate of these systems by MSA licensed plants in the future.

It can be argued that without these MSA targets installations might have been even more difficult leading to a potential commercial failure for Millers and MLA. In contrast to the lamb processing industry where the two major supermarket chains have adopted SMEQ guidelines and thus facilitated the uptake of ES by their suppliers, the demand pull for ES to achieve MSA grade is not as great.

One of the areas of concern is the potential over-stimulation of heavy fat carcases as this might potentially lead to substantial financial losses and loss of good will from buyers.

The prediction of pH/temperature decline relationships in all types and batches of cattles down to individual carcases appears to be difficult in practice, lessons learnt can be expensive. “Fool proof” user instructions for the LVES as a stand-alone epuipment or in sequential use with other meat electronics need to be established to facilitate “out of crate” installations.

It is doubtful whether installations of LVES systems will reach the adoption rate envisaged by MLA and Millers without other enabling support technology that allows the completely automatic dose control of ES equipment so that accidental over-stimulation of individual carcases can be avoided.

Processors have heard already about the development of a Generation 2 of meat electronics and potentially this is leading to processors waiting with installations until the Generation 2 equipment is on the market. To facilitate adoption of the current equipment it needs to be made clear to processors that the new developments will not make the current equipment redundant as it is already designed to be part of the new centrally controlled system of the Generation 2 electronics when it will become available.

Processors have been keen to adopt the HFEI system. Costs are relatively low and payback can be within a year depending on the number of injuries prevented. The success story of the HFEI for cattle could be exploited by Millers and MLA to

- further promote their use of the HFEI in a drive to reduce WorkCover premiums and improve OH&S, and
- As a vehicle of entry into non-MSA licensed and smaller beef processing plants to enable the introduction of other ES equipment for secondary installations.

5 Recommendations

To facilitate the uptake of ES equipment .

The 2005 installation targets have been achieved already. However, no "hard data" are yet available on their impact in terms of improvements over plant specific baselines.

Recommendations to develop baselines and benchmarks

- Develop pre- and post installation baseline data on meat tenderness. pH/temperature decline, PSE meat and other relevant criteria that can be used to demonstrate the benefits of the technologies.
- Develop pre-and post installation baseline data on injuries that can be prevented with the HFEI.
- Develop appropriate metrics on how, when and where in the processing line to measure so that common baseline data can be collected across all plants and give meaningful information for all processors.
- Substantiate that the effect of a lighter meat colour is due solely to the recovery on an extra liter of blood and not due to a faster decline in pH or over-stimulation, appropriate measurements need to be taken and used for information of the industry.

To make the beef electronics – Generation 1 installations a "fool proof" and "out of the crate" effort for plants that in future want to install the Generation 1 technologies, an analysis of past installations by MLA and Millers should be done. This could lead to identification of specific issues that often or always lead to an unexpected increase of time and resources invested.

An analysis might discover which issues are technology related, and which ones are operational problems or caused by knowledge gaps that could be addressed by better information flow. If there are specific technical issues that make installations or operation difficult and outcome unpredictable, they need to be addressed. Likewise, specific issues relating to the commercialization process could then be improved and benefits from a sharpened commercialization process will in future benefit other programs and projects

Recommendation to analyse the installation and commercialiation process

- Develop metrics that are relevant to enable an analysis of the installation and commercialization process and the use of the data for future improvement of the process.
- Analyse past installations and the installation and commercialization processes used.
- Improve Generation 1 electronics, processes and information material as required after the process analysis,

As the uptake of the HFEI by processors appeared to have been the most successful aspect of the commercialisation of the Generation 1 Beef Electronics, MLA and Millers could exploit the positive feedback from processors, substantiate benefits and fast track further introductions into as many beef plants as possible.

Recommendation to fast-track HFEI installations

- Based on improvements on OH&S baseline and impact data develop relevant information material for processors to facilitate adoption of the HFEI.
- Fast track the marketing and installations of the HFEI into beef plants
- Monitor reductions in slaughter floor injuries.

To substantiate the effect of ES on cost savings due to reduced refrigeration times relevant data need to be collected in plants with different refrigeration systems. Although cost savings due to water savings may be small benefits, if based on real data could help in the decision making process of processors to adopt an LVES system for improved bleeding/stimulation.

Recommendation to obtain baseline data on energy costs of refrigeration in processing plants

- Obtain data on cost savings achieved due to shorter refrigeration times after the introduction of ES.

To facilitate the adoption of Generation 1 Beef Electronics, MLA and Millers need to ensure that the industry accepts that the Generation 1 electronics will not be made redundant by the Generation 2 developments. Industry is widely aware of the Generation 2 program already and needs to be made aware that waiting for it may be not profitable in the meantime.

Recommendation to give industry confidence that Generation 1 technology will not be made redundant by Generation 2 technology

- To provide additional appropriate information material to the current marketing material that Generation 1 technology will not be made redundant by Generation 2 technology.

To avoid similar resource intensive installations of future Generation 1 and later Generation 2 electronics in the future, a thorough identification of the anticipated product, task, information and decision flows in beef processing plants needs to <u>precede</u> the design phase of the Generation 2 electronics technologies.

Recommendation to develop customer information, product and technology needs in context of total systems requirements prior to further developments

- Determine pre-program/project industry benchmarks.
- Together with all users and customers define all the information needs that Generation 2 technologies need to address, for example in terms of operation, product flow, product type, measurement criteria etc, using Decision Structure Matrix methodology.
- Prior to further development of Generation 1 and Generation 2 technologies, together with suppliers of cattle to the plants, users of the electronics and customers of the meat, MSA and other relevant parties, conduct a Voice of the Customer (VOC, Burchill and Hepner Brodie 1997) assignment to specifically define what aspects of the current and future technologies are currently not addressed in the development process. This information then can feed into the future development process.

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APPENDIX 1: MEAT PROCESSORS INCREMENTAL BENEFITS MODEL

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AUD000s	**Notes**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Revenue	1	8,400,000	8,610,000	8,825,250	9,045,881	9,272,028	9,503,828	9,741,424	9,984,960	10,234,584	10,490,449
less adjustments for:											
Cost of Goods sold	2	- 5,959,000									
Gross Profit	3	2,441,000									
less Operating Expenses	4	2,262,807									
EBT	5	178,193	182,648	187,214	191,894	196,692	201,609	206,649	211,815	217,111	222,539
Cost Savings:	6										
Water	7										
2,073,000 t x 1kl x 0.75c		1,555	1,594	1,634	1,675	1,716	1,759	1,803	1,848	1,895	1,942
Workers Compensation	8	-	4,305	8,825	13,569	18,544	19,006	19,480	19,970	20,470	20,980
Employee Injury Cost	9	94	96	99	101	104	106	109	112	115	117
Total Production Cost Savings		1,649	5,995	10,558	15,345	20,364	20,871	21,392	21,930	22,480	23,039
Revenue Gains:											
Additional Blood Sales	10										
AB 8,700,000 litres x 8c		696	713	731	750	768	787	807	827	848	869
Wholesale Price Gain	11	6,360	6,519	6,682	6,849	7,020	7,196	7,375	7,560	7,749	7,942
Total Revenue Gain		7,056	7,232	7,413	7,599	7,788	7,983	8,182	8,387	8,597	8,811
Revenue Gain + Cost Savings		8,705	13,227	17,971	22,944	28,152	28,854	29,574	30,317	31,077	31,850
Take-up Rate %	12	27.0	28.0	28.0	17.0						
Cumulative %		27.0	55.0	83.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Processor Benefit	13	2,350	7,275	14,916	22,944	28,152	28,854	29,574	30,317	31,077	31,850

NOTES

1 Industry revenue (gross value of slaughterings). Nominal values using 2.5% inflation rate (Partnerships Victoria 2003, Public Sector Comparator).

2 Cost of livestock purchased for slaughter

3 Revenue from meat sold less cost of stock purchased

4 Operating expenses (92.7% of revenue). Includes labour, services, energy,water, repairs, maintenance, interest, depreciation)

5 Earnings before tax

6 Benefits on the cost side of the production process from meat electronics generation 1.

7 Water savings 1kL/tHSCW at average price of $0.75/kL. Assumption that current use is 10kL/tHSCW at $0.75. Water price includes purchase of clean water, pumping, treatment and disposal. Water savings are from purchase of clean water, pumping, treatment and disposal. Savings are derived from less water used for cleaning slaughter floor, reduced treatment costs and reduction in blood effluent.

8 Standard projection is average annual wages bill of $982 million of which 1.2% is workers compensation premium. Reduction in workplace injury reduces premium from 1.2% revenue to 0.95% over 5 years.

	2,006	**2,007**	**2,008**	**2,009**	**2,010**	**2,011**	**2,012**	**2,013**	**2,014**	**2,015**
Revenue $ billion	8,400	8,610	8,825	9,046	9,272	9,503	9,741	9,985	10,235	10,490
Workers Comp. $ mill. (1.2%)	100,800	103,320	105,900	108,552	111,264	114,036	116,890	119,820	122,820	125,880
Workers Comp. (Rev. %)	1.20	1.15	1.10	1.05	1.00	1.00	1.00	1.00	1.00	1.00
Workers Comp. $ 000s	100,800	99,015	97,075	94,983	92,720	95,030	97,410	99,850	102,350	104,900
Saving	-	4,305	8,825	13,569	18,544	19,006	19,480	19,970	20,470	20,980

9 Reduction in lost time/replacement labour charges for employee injuries caused by kicking on slaughter floor. 140 beef processing lines x av. 5 days = 700 days @ $134.60 per day = $94,220 (2005). Escalation factor 2.5% pa.

10 An additional 1litre of blood recovered from each cattle at slaughter and sold for further use.

11 Calculated on the basis of 800 Kt beef x 65% x 16% premium cuts x 10% tough meat component (1.6%) x 50c kg; 220 Kt lamb x 50% x 20% (2%) x 50c kg. Escalation factor 2.5% pa.

	2,006	**2,007**	**2,008**	**2,009**	**2,010**	**2,011**	**2,012**	**2,013**	**2,014**	**2,015**
Beef Production (Kt)	800	800	800	800	800	800	800	800	800	800
Meat Component (Kt) (65%)	520	520	520	520	520	520	520	520	520	520
x 1.6%	21	21	21	21	21	21	21	21	21	21
x 50c Kg ($)	4,160	4,264	4,371	4,480	4,592	4,707	4,824	4,945	5,069	5,195
Lamb Component (Kt)	220	220	220	220	220	220	220	220	220	220
x 2%	7	7	7	7	7	7	7	7	7	7
x 50c Kg ($)	2,200	2,255	2,311	2,369	2,428	2,489	2,551	2,615	2,680	2,747
Total	6,360	6,519	6,682	6,849	7,020	7,196	7,375	7,560	7,749	7,942

12

13 The percentage of processors with the new technology calculated on a production tonnage basis 2004.

14 The net flow-on financial gain to those meat processors implementing the technology.

15 A risk weighted discount rate using industry beta and generic unsystematic (generic) risk data.

Hot boning option. See Table 1b.

FINANCIAL ANALYSIS

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Historical Investment	16	- 3,101									
Incremental Investment			- 2,713	- 4,000							
Processor Benefit		2,350	7,275	14,916	22,944	28,152	28,854	29,574	30,317	31,077	31,850
Net Cash Flow		2,711	11,790	22,096	22,944	28,152	28,854	29,574	30,317	31,077	31,850

		AUD000s
NPV	7.50%	152,485
	16.50%	95,970

16

Investment is recorded for the meat processor industry and Meat and Livestock Australia.

Appendix 2 The beef industry value chain

Table 8 shows that the Australian beef and veal industry provides 73% of meat processed by meat processors (beef and veal, sheep and lamb meat, and pork. Poultry is not included).

Product/Services	Share
Beef and veal	73%
Sheep meats	13%
Pork	14%

Table 8 Major meat market share segments (IBISWorld 2005)

Domestic meat consumption in Australia has been declining since the end of World War II. Over the last decade meat consumption has somewhat stabilized but consumers demand more variety in meat and are buying more poultry, pork and fish (Figure 6) at the expense especially of lamb and mutton.

However, according to MLA (2005) domestic consumption of beef has slowly increased over the last four years. Total expenditure on beef rose by 3% in 2004 with retail prices up by 2%. Beef retail prices have increased by around 42% since 1998 but consumers have been accepting these price rises.

Aggressive marketing of red meat and beef as a healthy meat appears to have halted the downwards trend. A general growth in consumer spending may also be responsible for sustained consumer demand for beef. However, better presentation of meat, cooking recommendations on meat packaging and higher awareness about nutritional facts by MLA and supermarket chains has led to a positive perception of beef in the market. The MSA program positively promotes grading of meet into different quality grades.

It is not clear whether and to what degree an increase in beef consumption might lead to a cannibalisation of the lamb market sector instead of taking market share from poultry and pork. Should that occur, the investment benefit of the MQST Program for MLA and its stakeholders would be reduced.

The outlook for the beef industry is favourable in the medium term (Table 9) as domestic consumption has stopped declining, exports are expected to rise. The consequences of BSE in Europe, North America and Japan can also be utilized in the short to medium term. However, uncertainty about the timing of the re-entry of US beef into the global market creates difficulties in predicting export demand in the future. Currently the major export markets for Australian beef are Japan, the USA, Korea, Canada and Taiwan. The demand for both grass and grain fed beef in Japan has sharply risen for the last three years.

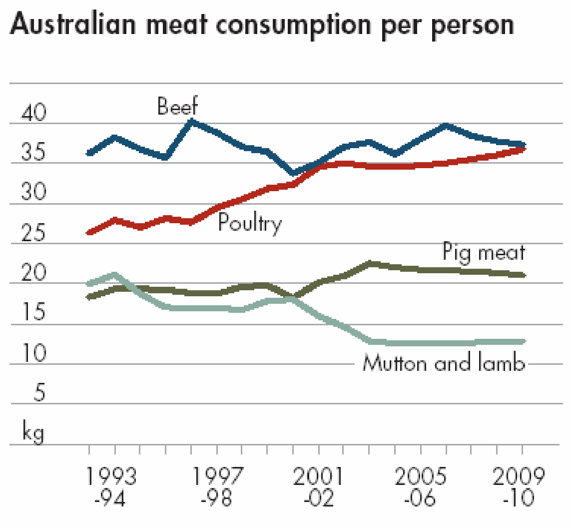


Figure 6 ABARE Commodities 2005 March

	Unit	2002 -03	2003 -4	2004 -05	2005 -06 z	2006 -07 z	2007 -08 z	2008 -09 z	2009 -10 z
Cattle numbers	'000	27,870	26,664	27,147	27,500	28,300	29,200	2,.900	30,400
Slaughterings - Cattle - calves	'000	7,972 1,081	7,806 1,100	7,930 930	8,300 985	8,200 1,030	8,400 1,100	8,700 1,170	9,000 1,200
Production c - beef - veal	'000 tons	2,055 35.0	1,959 38.2	2,095 31.8	2,220 33.9	2,200 35.5	2,250 38.0	2,350 40.0	2,420 41.5
Exports -total, carcase weight -total, shipped weight	'000 tons	1,362 920	1,246 841	1,357 914	1,470 995	1,440 975	1,465 990	1,515 1,025	1,575 1,065
Live cattle export	'000	972	774	635	580	600	650	700	750
Consumption per person	Kg	33.8	37.7	38.4	38.6	38.5	39.4	40.5	41.5
Domestic consumption - total, carcase weight	'000 tons	726	752	774	785	795	820	855	885

C Carcase weight, z forecast Source: MLA Australian cattle and sheep industry projections 2005)

Table 9: Situation and outlook for the Australian beef industry

Industry segments

All participants of the sheep meat value chain depend on the skill and integrity of their suppliers to provide a quality product. Value can be added along the supply chain up to the end customer, the consumer of the meat. However, value can also be lost along the way by inappropriate handling and processing at each stage. As each beef carcase provides up to 400 meals, any value lost at the animal and carcase stage will affect many consumers and their perceptions about meat quality.

Not much can be done beyond the processor's door to improve meat quality defects, regardless of their point of origin.

All segments of the value chain are increasingly putting their effort into prevention of problems and management of their supplier relationships with the aim of providing consistent and high quality products to their customers.

Primary production - beef cattle producers

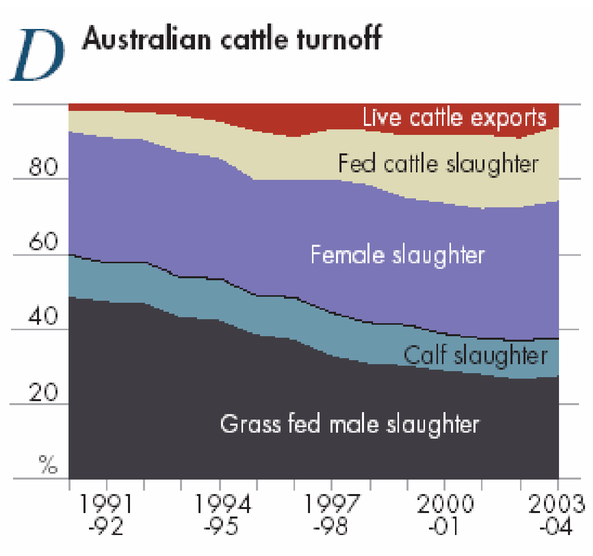
More and more beef cattle producers target their production to specific markets (domestic, export, feedlot etc). The most common selling method is still by auction (45%) but increasingly cattle are sold over the hook as this theoretically allows the producer to obtain feedback on the customer's satisfaction with the product, so that production systems can be adjusted. The amount of beef sold over the hook varies according to state from 11% (Victoria) to 61% (Tasmania) and is on average 40%. Over the past few years new beef brands started to emerge with forward integration from beef cattle producer to the retailer.

Feedlots

Today feedlots provide 27% of the total adult cattle slaughter, with the proportion of grain-fed beef having doubled over the last decade and now making up 30% of total beef production. This increase has been mainly at the cost of grass fed male cattle (Figure 2).

Live export

The live export of cattle has increased substantially over the last decade but has decreased during 2003-4 by 40% compared to the previous year.



Source: Australian beef industry 04.3, MLA report December 2004

Figure 7 Cattle turn-off

Meat processing

Meat processing occurs in all states but 75% of all establishments are concentrated in the three eastern states of Queensland, NSW and Victoria in 2000-01. The top 25 processing beef companies in Australia provide more than 80% of product output.

State	QLD	NSW	VIC	WA	SA	TAS	NT	ACT
% TO	45.5	24.2	14.8	7.4	5.5	2.6	0	0

Source: IBISWorld Report 2005: Meat Processing in Australia

Table 10 Proportion of industry turnover by state

Beef cattle are purchased, slaughtered and processed into fresh, chilled and frozen bone-in and boned out products, manufacturing meat and into co-products. Meat represents 89% of the value of production, co-products such as hides, offal and meat and bone meal represent 11% of the value of production. Meat processors sell their products both domestically and into export markets. Around 64% of beef production is exported. It is expected that the proportion of beef export will rise by 9% in 2005 (MLA 2005).

Due to forward vertical integration meat processors sell approximately 50% of their domestic output directly to supermarkets and 50% to meat wholesalers, i.e. they are themselves wholesaling.

Food products manufacturing

This segment utilizes manufacturing meat and other animal by-products for value added food products such as hamburgers, frozen dinners, sausages, pies and other smallgoods.

Wholesale

This segment mainly sells meat from processors to retail outlets and the food service outlets. Wholesalers are a declining force in the value chain as their buying power is steadily decreasing due to the increasing power of the supermarket chains and forward vertical integration of some of the largest meat processors.

Domestic retail

This segment includes supermarkets, retail butchers, the food service industry such as hotels, restaurants and organisational food service outlets (hospitals, military etc). Consolidation in the retail sector towards giant supermarket chains has led to a factual duopoly of the two major chains in Australia, Woolworth and Coles. Supermarket chains absorb approximately 70% of the meat for domestic consumption and therefore have enormous power over processors and their viability. Their buying power exerts considerable downward pressure on prices that processors pay to producers.

Retail butchers have declined in numbers over the last decade but this trend seems to have bottomed out, with specialist butchers servicing retail customers who prefer to purchase from butchers. A more varied offering of products, cuts, value added and cooking ready cuts has appeared over the last two years.

The food service industry such as fast food chains, hotel chains and restaurants, form a strong buying group of which the fast food chains and large hotel chains form the most powerful buying segment.

Institutions such as hospitals, nursing homes, educational facilities and the military are a cost conscious market and in the purchase of their meat and meat products choose suppliers mainly on price. Their suppliers are meat processors and wholesalers.

As the number of supermarket/wholesale meat buyers decreases, any factors that might negatively influence the consistency and eating quality of beef table cuts will be a powerful trigger to reduce prices. This applies also for the service industry with its large chains who will not accept that their customers will be affected by poor meat quality.

Consumers
Consumers increasingly opt for convenient meat cuts that can be purchased on the way home from work and then quickly grilled, fried or roasted with a predictable pleasurable eating experience. Usually both adult partners in a family work. They also appear to be more health conscious than a generation ago.

Fresh lamb has to compete with fresh beef, chicken and fish and also convenience foods such as frozen dinners.

Additionally, younger consumers have less experience than their parents in handling meat. They heavily rely on supermarkets and butchers for information on cooking instructions and storage time for specific cuts of meat. Switching costs to other meats are low and a bad eating experience can easily turn a consumer off a particular cut or a particular type of meat.

Predictability and convenience in all aspects of meat usage from the buying experience, preparation, cooking to the eating experience are strong factors for consumers to choose specific types and cuts of meat.

Pet food industry
The pet food industry purchases a quantity of manufacturing meat and also co-products such as meat meal, tallow and edible offal. The quality requirements of the pet food industry are substantial.

Co-products industry
Skins and offal and rendered products are purchased from meat processors and processed to various value added stages for export and domestic use.