Final Report

Brownfield Micro Bovine Boning Room Design (Stage 1)

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Contents

1.0 Executive Summary

Jimbour Beef and Bacon (JBB) operates a small abattoir processing Beef and Pork for the domestic butcher and food service markets in South East Queensland. JBB currently slaughter up to 60 beef per week and do not bone any product. Using typical Australian processing capacity segmentation data this places JBB in the micro category size. JBB is venturing into boning as a service offering and wanting to ascertain the best design options and equipment to either operate at their current throughput (as a micro facility) or to consider boning up to 250 head a week (or beyond) and move into a small category processing plant.

The industry, both private investment and RDC investment, has invested many years (and financially) in developing, evolving, and trialling advances in the innovations areas of (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment. Some of these innovations have been adopted, and some not. Few of these developments have been focused on micro or small throughput processing plants. This project allows a focus on plant of this size by firstly developing a suitable boning room concept design, and then assessing and reviewing the feasibility of incorporating some of these technologies into the concept.

With the support of AMPC, a concept design of the proposed facility was developed, and the feasibility of suitable technologies from the innovation areas was assessed. Technologies were identified as potentially feasible for incorporation into the design, specifically those utilising Internet of Things (IoT) innovations due to their relatively low capital cost and the low operating overhead of off-site monitoring and control facilitated by cloud-based platforms and software.

Two specific applications of IoT technologies have been assessed and it is recommended that both are further explored for suitability in a Micro or Small throughput Boning Room (MSBR) operating environment. The two applications, ***IoT Chiller Temperature Monitoring,*** and ***Iot Chiller Automation***, when reviewed against capital cost versus operating cost savings are expected to provide a return of less than 6 and 12 months, respectively. These two applications if successful will not only provide effective increases in efficiency and decreases in overall operating cost for JBB, they could be a simple and effective solution across a wide number of MSBR and abattoirs and boning rooms across the Australian meat industry.

2.0 Introduction

Jimbour Beef and Bacon (JBB) currently slaughter up to 60 beef per week and do not bone any product. Using typical Australian processing capacity segmentation data this places JBB in the micro category size. JBB is venturing into boning as a service offering and wanting to ascertain the best design options and equipment to either operate at their current throughput (as a micro facility) or to consider boning up to 250 head a week (or beyond) and move into a small category processing plant.

This project will enable JBB to engage external consultants and other industry experts (including AMPC and MLA) to ascertain the best boning room design for a micro plant using current best practice technology as well as undertake a what-if/bottleneck analysis of the maximum throughput achievable for the equipment designed, that will ultimately determine both the optimised boning room throughput and resulting design requirements.

JBB also process porcine and as such the conceptual boning room must be capable of processing both bovine and porcine at optimum business throughputs (albeit at different times of the day).

A stage two application may be submitted if any new technology or equipment design is identified during the stage one process.

3.0 Project Objectives

3.1 Project Description

To achieve JBB's vision, JBB are undergoing an entire company wide innovation program to de-bottleneck the process (from livestock receivals to cartons leaving the facility), reduce waste leaving the site (including being more resource/services efficient), and to change the nature of the work to both reduce the per head/hour labour requirement (as a KPI) and ensure that those resulting jobs are designed in a way to be open to both a wider physical stature workforce and hours of operations that suit varying employment demographics within the labour draw pool.

This project will enable JBB (and AMPC) to understand which innovations, and how to incorporate them in a de-risked method, into the pending brownfield design and build of the Jimbour boning room.

JBB will engage third parties as required (including AMPC and MLA) to ensure that all current innovation knowledge (and solution providers) are considered in the redesign possibilities as one of the few opportunities in Australia to commence the on-site proof of working and adoption process for these areas of industry innovation.

3.2 Project Background

JBB, are considering incorporating cold boning into their slaughter facility.

The industry, both private investment and RDC investment, has invested many years (and financially) in developing, evolving, and trialling advances in the innovations areas of (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment. Some of these innovations have been adopted, and some not. Few of these developments have been focused on micro or small throughput processing plants.

This project is a chance for JBB (and AMPC) to ascertain how any of the technologies developed for medium and larger plants may be incorporated (or the thinking of the concepts incorporated) into the design and de-risk the outcome for JBB.

3.3 Objectives

The objective is to:

Input objective: ascertain how a Micro (or small) throughput Brownfield boning room design can accommodate advances in the innovations areas of (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment.

Output objective: design of boning room(s) and identification of additional real estate required for incorporation and evaluation of either/or (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment. innovation leverage. The design must also incorporate processing of porcine through the same facility.

Stage two submission if applicable.

4.0 Methodology

Engage 3rd party consultants.

Develop ideal targeted state with respect to (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment.

Compile list of all possible approaches (supported by AMPC) and ascertain how they could be incorporated into the design.

Designs completed, including identification of any (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment, innovations incorporated into the designs.

Documentation of the risks of incorporating any (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment.

Innovations into the designs and the cost of the risk mitigation plan to ensure no product interruptions on recommencement of both facilities after the upgrades.

Stage two submission (if applicable) incorporating both innovation adoption costs and innovation adoption risk mitigation costs.

5.0 Project Outcomes

5.1 Boning Room Design

A boning room design was developed to adjoin the proposed new slaughter and chiller facility. Key outcomes required to be incorporated into the design are; to develop a process that utilised the same infrastructure and layout to process either beef or pork; develop a process that would result in a similar utilisation of labour and downstream resources for either species; identify a suitable method to manage the variation in beef carcass length and when changing over from beef processing to pork processing and; to explore new technologies that can be feasibly incorporated into a small scale boning operation.

A key metric that was required to be developed to enable a balanced production across either species was to ascertain a total “per day” mass balance or design throughput through the facility. Utilising known boning yields and carcass breakup plans that the current operation was producing, it was agreed that the design should be developed to process a total weekly output of 650 pig carcasses at an average weight of 80 kg, and 150 beef carcasses at an average of 320 kg. This weekly output could then be equated to approximately 130 pork or 30 beef per day producing a balanced daily output for each species respectively of approximately 400 cartons if carcasses were 100% deboned. The design can also provide further processing capacity with extended operating hours or double shifting during peak periods, and in the longer term by expanding the boning room building to provide another boning line, doubling the above throughputs.

5.1.1 Porcine boning process design requirement

The porcine boning process design has been developed utilising established industry boning principles and is arranged to process approximately 130 head per day (i.e. 17 hd / hr) at an average of 80 kg per body. The design will allow the full break-up of the pig carcass into primals (collar, shoulder picnic, tenderloin, loin, belly, and the full primal breakup of the 4 leg set muscles) as well as packing the full range of non-primal products (i.e. rind, jowl, trotter, trim, tail etc.). The process is also configured to produce other products and specifications as required including bone in and a 6-way bandsaw cut carcass break up which could be directly packed into boxes or FB4 crates.

The design is based around a traditional table boning system whereby product is processed at a table workstation located alongside a central conveyor. Once the product is processed the cut is returned to the central conveyor to allow subsequent Cryovac bagging, IW or bulk packing. Consideration of a rail boning style break up was undertaken however it was agreed the bandsaw type break up and flexibility to man the boning stations only as required to meet the boning specification was the preferred configuration.

5.1.2 Beef boning process design requirement

The beef boning process design has been developed utilising established industry boning principles and is arranged to process approximately 30 head per day (i.e. 4 hd / hr) at an average of 320 kg per body. The design has also considered the requirements of the operation when processing the expected range of beef categories (grain, grass, Ox, Cow) from up to a maximum of 400 kg bodies, down to a minimum of 250 kg bodies.

The design is based around a traditional table boning system whereby product is processed at a table workstation located alongside a central conveyor. Once the product is processed the cut is returned to the central conveyor to allow subsequent Cryovac bagging, IW or bulk packing. Consideration of a rail boning style break up was undertaken however the table boning will allow shared infrastructure between the species and will provide improved flexibility to man the boning stations only as required to meet the boning specifications.

5.1.3 Process design description

The boning room design has been arranged to integrate with the proposed slaughter floor and chiller facility into the boning room. The arrangement also considers the required flexibility of the overall facility to continue operations including the loadout of pork carcasses and beef quarters direct to truck for transport to local butchers and customer boning rooms as required.

The process adopted is consistent with current best practice and would be designed to meet Australian and export standards. A process layout was developed (*refer Appendix A, Concept Design Drawings*) with key components of the boning room facility and subsequent carton handling, chilling and freezing infrastructure as follows;

- Marshalling or holding chiller sized to hold a single day's production of pork or beef carcasses to be boned. This room is designed to hold the carcass at the required temperature and would typically be filled at the start of the day. This room could be utilised to provide additional chilling of carcasses if required by installing additional refrigeration capacity etc. the marshalling chiller has been designed to be fully sealed and lockable to provide the required security and flexibility in operation.
- Pre-trim and inspection station post the holding chiller to allow the required inspection and hygiene trimming of product prior to entering the boning room.
- Gravity carcass rail to transport carcass from the holding chiller to the boning process.
- Break down station utilising a hydraulic ram to raise and lower the carcass rail to allow for good ergonomics regardless of the size or species of carcass.

- Removable table/bandsaw to allow flexibility between species and break up requirements (i.e. between boneless and bone in production including a pork 6-way cut breakup).
- Table boning of beef or pork cuts.
- Simple end of line Lazy Suzan and Pack Off allowing for chilled cuts to be bagged and packed as well as IW, bulk and layer packing prior to carton weigh and label.
- Stillage and palletising make up and break down area to enable, stillages to be built prior to chilling or freezing in the blast cells and, stillages to be unpacked and pallets constructed to enable product to be shipped or stored in the onsite carton storage.
- Blast cell chiller to enable the 24-hour chilling of cartons in batch lots.
- Blast cell freezer to enable the 48-hour freezing of cartons in batch lots.
- Chilled and frozen carton storage to allow flexibility in timing of loadout and to accumulate product into pallet lots as per customer requirements.

5.2 Innovation in a Micro or Small Boning Room (MSBR)

This project is a chance for JBB (and AMPC) to ascertain how any of the technologies developed for medium and larger plants may be incorporated (or the thinking of the concepts incorporated) into the design and de-risk the outcome for a MSBR. When considering the adoption of technology for these smaller facilities, it is important to consider not only the benefit but also how the existing onsite resources and team will be able to maintain and operate the solution. The introduction of a new technology must not only provide real benefits but must not create an unsustainable level of complexity or additional operating (including labour) overhead.

When exploring potential technologies and assessing their feasibility in the MSBR environment, the possible benefits were considered against four key business efficiency drivers. These drivers have been selected to assist in the assessment of any technology and help the project team to focus on the needs of the business. These drivers are as follows:

- Improve food safety outcomes.
- Improve meat quality outcomes.
- Reduce operating costs.
- Reduce the cost of compliance to current statutory and licencing requirements.

On completion of the boning room concept design, the project team reviewed the agreed layout and process to consider what, if any of the current and emerging technologies in use or being considered by the larger operators in the industry could be applied. Innovations in the areas of (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment were explored with a number of ideas and possibilities identified for inclusion in a MSBR design.

5.2.1 Carcass chiller automation

Effective carcass chilling is one of the most significant value adding and quality enhancing processes in any abattoir. The meat industry has invested significant capital and resources in automating the chilling process as it not only underpins the quality and yield of the products processed but is a key driver to minimising the site's electrical energy consumed during operations.

Current large-scale operators deploy significant automation technologies via Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) devices and systems. These are expensive and utilise extensive hardwired sensors, variable speed drives, and sophisticated software to monitor and control the chilling cycle.

In a MSBR the carcass chiller is typically controlled manually with an operator setting the temperature of the chiller at the beginning of the cycle, which is then maintained for the duration of the chilling time without modulation or monitoring. If monitoring is required, the operator will manually configure a temperature data logger which is then inserted into a carcass to record the temperature profiles of the process.

The introduction of effective automation to a MSBR chiller would have significant effects on business. It would result in improved key business driver outcomes.

5.2.2 Primal traceability

Primal traceability has long been considered the holy grail of any abattoir, and in particular a boning room operation. The industry has explored and installed several technologies over the last 20 years with mixed success. There are commercially available turnkey systems that will provide traceability in the boning room, however due mainly to the capital required to modify existing boning rooms to install these systems, there has been only a few installed.

Traceability in a MSBR would be of assistance however is likely to be expensive. Additionally, due to the nature of the business, production is generally undertaken as a service to a range of clients including butchers, local producers etc, resulting in relatively small production runs. When the production run is small, traceability, and management of the products is less difficult.

5.2.3 Pick and pack automation

Requires automation and smart vision systems to identify product and move it to a predetermined position to enable placement into a bag or carton etc. These systems have not yet been widely adopted in large scale operations. A key driver of pick and place automation is to reduce the labour required i.e., automated materials handling and robots. The application of pick and pack automation can be capital intensive and feasibility in the MSBR is likely to be low due to the small number of personnel undertaking these tasks.

5.2.4 Industry 4.0

A new technology sector that is allowing the utilisation of smart devices (e.g. internet enabled sensors and remote monitoring devices) to collect data in the operating environment which is then transmitted via typically wireless internet or telco networks to remote (cloud based) computer systems that will then monitor, record and analyse the data. This technology area, often referred to as the Internet of Things (IoT) is rapidly growing, however widespread adoption in the large scale abattoir processing environment is relatively limited. One of the many advantages of these systems is the installation of devices without the added overhead of complex wiring, PLC and SCADA systems as noted in section 5.2.1 above. This technology area is likely to require a lower capital investment and the technical expertise to analyse the data is not required to be on site.

5.2.5 WHS innovations

Innovations in the WHS arena are constantly evolving. Recent advances in large scale processing include robotics and the development of mechanical aids to complete some of the routine manual and heavy lifting tasks such as carton packing and carcass boning. Examples can also include simple lifting and transfer mechanisms designed to eliminate or reduce the day-to-day manual tasks throughout the industry. The deployment of simple mechanisms and design features when developing a new process should be included in the overall design. If a solution or technique is identified as feasible, then the business should consider it for a high priority inclusion as the return on investment although often intangible is important to enable the attraction and retention of staff.

5.2.6 Material handling

Large scale operations deploy numerous strategies to transport and handle the quantum of materials required to support production through the plant. Technologies vary and can include, automated product conveyors, waste removal and extraction, automated sorting and storage systems, process utility and product liquid pumping and processing systems. In the MSBR application the total volume or weight to be transported through the plant is much less with materials handling systems being simple and manually operated including, gravity rails for carcass transport, gravity roller conveyors for carton transport, and forklifts or pallet jacks for movement of pallets and larger heavy items.

6.0 Discussion

When considering technology and advances in the innovations areas of (1) carcass chiller automation, (2) primal traceability, (3) pick and pack automation, (4) Industry 4.0, (5) WHS innovations, (6) material handling and (7) other new processing equipment, it became evident that when reviewing each of the innovation areas against the key business drivers referred in section 5.2 above, the low capital and overhead operating environment of a MSBR was not likely to be feasible if significant capital investment or additional overhead was required.

The JBB boning room has been designed in line with current industry best practice and materials handling. The process has been developed to allow an even and efficient flow of product whilst providing flexibility in staffing. Products and materials are handled, picked, and packed utilising gravity or manually operated conveying systems (carcass rails and carton roller conveyors) designed to also minimise WHS risk by arranging the process in line with good engineering design for ergonomics. No specific innovation is expected to be incorporated in these areas (items 3, 5, and 6 above), rather the process focuses on ensuring that best practice design and operating methods have been deployed in the design.

The design of the JBB boning room has been developed to process approximately up to 9T (HSCW) of raw material to produce approximately 400 cartons per day. Production will typically be arranged into several smaller lots and often will be undertaken as a service to various small butcher shops and local producers. The requirement to provide traceability is not expected to be required in the foreseeable future for individual cuts (i.e. primals). The process does provide traceability to production lots which maintains traceability to specific carcasses within a time window, which is standard practice. No new innovations in primal traceability (item 2 above) are expected to be incorporated into the design.

The innovation areas of chiller automation and Industry 4.0 (items 1 and 4 above) however did stand out as a likely area for technologies to be suitable for inclusion in the design. Any improvement in the logging and monitoring of temperatures during the chilling process will improve food safety outcomes. Additionally, the current practice of manually checking temperature throughout the operation and keeping temperature records for QA purposes is labour intensive.

Utilising industry contacts and networks the project team approached known industry specialists in the IoT area to explore how these types of technologies could be incorporated into the design. One company, Australian owned and ASX listed – Constellation Technologies (CT), provided a concept design and budget to incorporate a system into the JBB design to explore the feasibility of embedding this technology into the process (*Refer Appendix B IoT chiller monitoring proposal)*.

The project team hypothesised that by installing suitable temperature probes into specific refrigerated rooms, and product i.e. carcasses; real time data could be recorded, and logged via CT's central and cloud-based servers and then transmitted back to JBB and the management team as required to record, monitor, and act on temperature measurements and trends throughout the plant. The data would be transmitted directly from the plant to CT and return via the current Telstra network. It is expected that the labour savings generated if technically feasible would be approximately 2 hours/day for one staff member which equates to approximately $17,500 per year (250 days X 2 hrs @ $ 35.00 per hour (minimum wage plus 40% oncosts)).

Once the temperature-based data is captured and analysed the data would be made available on any internet connected computer or smart phone. This would allow additional functionality of trend analyses and more importantly, notification and alert of temperatures if outside any pre-set limits or operating ranges. This would provide additional direct but intangible savings of improved food safety through a more robust QA monitoring system and thus elimination of downgraded or lost product due to refrigeration systems malfunction or maloperation.

Further discussion and research into other functionality and/or features that could be incorporated once the data is collated and connectivity is established with the management team identified that it may be possible to also provide simple switching and control functionality to other equipment within the plant subject to the analysis of the temperature data collated. This additional IoT hardware could be used to change the operating condition, switching of plant or triggering alarms or indicators in response to the cloud-based analysis that has been undertaken on the temperature data captured previously.

In the MSBR the deployment of this type of system if technically feasibility would provide a low-cost solution to the automation of carcass chillers and provide start up and shut down functionality of other rooms etc as required, such as at the start and end of the day. The expected outcome would be initially to reduce energy consumption throughout the plant and more importantly allow for simple temperature set point switching of a compressor that is cooling a carcass chiller. The result would be the basic modification of the cooling cycle depending on the condition within the room without manual monitoring and switching. This would reduce overall energy consumption but would also reduce carcass shrinkage. If technically feasible this simple chiller control system would have a triple bottom line result of reduced operating (energy) costs, improved production yields and reduced worker injury, respectively. For the concept design and indicative budget to install a compressor control unit refer to *Appendix C – IoT chiller automation proposal*.

No other technology and advances in the innovation areas of other new processing equipment (item 7above) was identified or explored in the feasibility assessment or for inclusion into the JBB design.

The feasibility of the IoT chiller temperature monitoring technology installation for the boning room design can be summarised in the following table and shows a payback of less than 12 months.

Table 1 – Iot Chiller Temperature Monitoring Feasibility

IoT chiller monitoring Item	Functionality	Current cost $ p.a.	Expected cost of technology	Return on Investment (ROI)
Manual monitoring of temps throughout facility	1 person say 1.5 hrs / day @ $35/hr incl. on costs (20 min x 4 times / 24hr)	$10k-15k		
Capital cost to supply Equipment	Supply hardware and systems as per CT proposal		$ 5687.60	
Installation	Installation and fitting of equipment into facility (Local trades to install, supervised by CT)		$ 5000.00 (estimate)	
Service and subscription fees p.a.			$ 1920.00*	
TOTAL		**$10k – $15 k**	**$10,687.60**	**< 12 months**

* $p.a. for service & subcription fees

The quantification of the chiller automation technology feasibility is more difficult to ascertain and is contingent on the successful completion of the chiller monitoring installation as per above. However, the implementation of an IoT chiller automation technology would have cost savings including a reduction in energy consumption during the chilling cycle and increased production yield due to reduced moisture loss. As the existing operation does not include boning, it is difficult to quantify the potential savings and financial return on investment, however if a 0.3% saving could be achieved just for the boning room destined carcasses, this would equate to approx. 50 kg/day (10T HSCW). At a conservative $6.00/kg sold to the end user, this equates to approximately $300/day or 75,000 per year. These figures suggest a payback of less than 6 months - Refer Table 2 – IoT Chiller Automation Feasibility below.

Table 2 – IoT Chiller Automation Feasibility

IoT Chiller Automation Item	Current performance and possible efficiency gained	Cost to business of current practice $ p.a.	Expected cost of technology	Expected saving p.a.	Return on Investment (ROI)
Electricity	Electricity $ 3300 / month save assume 5% of existing across site	$32,000		@ 5% reduction **$1,600 p.a**	
Shrinkage	Current 2 - 2.5% assume 0.3% reduction in new boning room product (approx. 10t HSCW /day)	250 kg @ $6 / kg $1500 / day $375,000 p.a.		50kg @ $6/kg $ 300 /day **$75,000 p.a**.	
System development	One off development costs of Iot solution		$ 11,340		
Capital costs to supply equipment	10 off compressor / chiller control units @ $500/ unit		$ 5000		
Installation	Installation and fitting of equipment into facility (local trades to install, supervised by CT)		$ 10,000.00 (estimate)		
Service and subscription fees p.a.			$ 7200 *		
TOTAL		**$ 407,000**	**$33,540.**	**$ 70k -80 k**	**< 6 months**

*10 controllers x $60.00 per controller /month for service & subcription fees

7.0 Conclusions / Recommendations

JBB, when developing a design for a new Micro or Small boning Room (MSBR), have the opportunity to explore what technologies currently used in medium to large processing plants may be suitable for incorporation in a new greenfield design. With the support of AMPC, a concept design of the proposed facility was developed and the feasibility review of suitable technologies has been undertaken. In this review, technologies that were supported via the Internet of Things (IoT) platforms appeared to be feasible due to their relatively low capital cost and low operating overhead, with all functions being monitored and controlled by cloud-based platforms (i.e. not on site).

Two specific applications of Iot technologies have been assessed and it is recommended that both are further explored for suitability in a MSBR operating environment. The two applications, ***IoT Chiller Temperature Monitoring,*** and ***Iot Chiller Automation***, when reviewed against capital cost versus operating cost savings are expected to provide a return of less than 6 and 12 months, respectively. These two applications if successful will not only provide effective increases in efficiency and decreases in overall operating cost for JBB, they could be a simple and effective solution across a wide number of MSBR and abattoirs across the Australian meat industry.

8.0 Appendices

8.1 Appendix 1 – Boning room design drawings

8.2 Appendix 2 – IoT Chiller monitoring proposal

8.3 Appendix 3 – IoT Chiller automation proposal