



final report

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Data collection, base calculations, design and monitoring/SCADA implementation associated with hot water production and distribution upgrade

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Abstract

This report documents an energy and carbon reduction project achieved through the creation of a new modern hot water generation plant built and commissioned in 2013 at a Queensland abattoir. The project aims were to:

- Instigate a hot water upgrade.
- Illustrate that a plants' hot water system is an interconnected structure that impacts on all parts of a plants' operation and as such is affected by each of the plants' sub operations.
- Demonstrate the range of savings that can be achieved across a variety of areas rather than simply the traditional focus on the hot water heating load.
- Summarise the key considerations for any plant undertaking such a project.
- Provide insight into the kind of issues and potential pitfalls that can be present and provide practical advice on how to avoid or minimise these threats.

Executive Summary

The abattoir undertook a multi-faceted hot water upgrade project in October 2012 that was completed in the 3rd quarter of 2013. The project spanned a 12 month period with the first 6 months being dedicated to data collection and understanding how the current plant operated as little accurate data was available at the beginning of the project upon which a design could be based. The second phase of the project was to create the support infrastructure which included the replacement of plant steam mains, the building of pipe bridges and foundations, the construction of a suitable pad for the location of the tank farm and HW building.

The last 3 months of the project was dedicated to the construction of the hot water system itself, including the integration of the new hot water plant into the plants SCADA system and the automation of the plant. In addition to this numerous related projects were undertaken such as the installation of more efficient pipe and pumping systems, the installation of pipelines and the installation of additional flow and temperature monitoring.

With the new system in place the plant was able to reduce its coal usage and hence cost of hot water heating, although the amount has not been proven. Other savings such as pump energy and water minimisation were also achieved. In addition to this with the improved transparency of the plants' heat recovery systems and water usage a number of other existing problems were now clearly visible and could be addressed.

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1 INTRODUCTION

1.1 The Need for Hot Water

Thirty percent of the energy used in the red meat processing industry is dedicated to the production of hot water (HW). Abattoirs and meat processing companies cannot function without a readily available supply of HW at the correct temperatures, flow rates and available at the times and locations as required. A typical abattoir requires the following waters;

- Legislation requires sterilisation and specific process applications to have HW supplied at a minimum temperature of 82°C.
- There is a legal requirement to maintain hand wash water at 42°C.
- Best practice requires wash down water to be available at 65°C.
- Several other wash functions require 55°C.
- By-products processing requires HW at various temperatures, 60°C for pre-wash and 75 - 86°C for tripe and bible processing.
- Carcase wash / sterilisation requires 92°C.

HW is essential to plant function and operation. Without an adequate supply of HW no plant can operate. Often plants view utilities such as HW as a cost to production and as such allocate little time or investment to the maintenance of these services and their efficiency, until a serious failure highlights the issues and forces change on the plant.

1.2 The Abattoir

The hot water plant at the abattoir was the classic example of a plant that has grown past its original capability. The original HW plant was based upon a sparge steam injection system to produce 82°C water. Sparge systems inject steam directly into the water being heated and it is quite a violent process. Later, when 42°C water for hand wash became a requirement a 42°C sparge was added. As new plants and processes were added and HW demand increased, more steam sparges were added to the HW generation tanks. When these tanks failed, the “open” tanks were replaced with closed unpressurised tanks. As additional applications within the plant were added, sub systems were designed and implemented to meet the plant’s production needs. For example a steam valve was added to maintain temperature at 90°C for the carcase wash.

When wash down was reduced from 82°C to 65°C, thermostatic mixing valves were added. When water recovery from slaughter was introduced a steam valve was added to make it useful. Due to the state of the current pipe work the steriliser water production temperature was increased to 94°C. This higher temperature was required to overcome heat losses within the piping system and guarantee a minimum of 82°C water at the point of use. Larger pumps were introduced to push

more water through the existing piping system due to sizing constraints and the distribution being inefficiently laid out. With these issues in design and efficiency the system was in urgent need of replacement.

1.3 The Projects Motivation

The abattoir needed to improve the reliability and efficiency of the HW water system. With the current system being extended well past its use by date the abattoir had no choice but to invest in a new plant. By utilising modern technology with care integration into the plants existing infrastructure numerous benefits could be achieved.

Another factor for consideration was that the sparge system that is used is quite a violent operation and as such creates vibration that has a potential of causing tank failure especially with the steriliser tank. When this system is under full load, the side walls of this thin stainless steel tank shake and it is a concern that the tank may lose its integrity. If this occurred it would have serious consequences as 12,000 litres of 94°C water would spill out creating a serious steam cloud and water scalding risk to anyone near the tank. The following benefits could be obtained by replacing the HW system:

- Water and energy usage reductions
- Reduced coal consumption
- Mitigation of carbon liability
- Improved health and safety with the removal of the sparge tanks and better temperature control for 65°C and 45°C.
- Improved transparency of water and energy usage
- Strict critical control points maintained and logged
- Less maintenance and the opportunity to introduce a preventive maintained system
- Reduced operating cost for associated equipment such as pumps
- Security of supply
- capacity for growth and to take advantage of additional heat recovery

2 KEY ISSUES AND CONSIDERATIONS WITH THE EXISTING PLANT

2.1 Heat Recovery from Flow Gases

The current system collects waste heat from the flue gases exhausted from the rendering process via a condenser. The amount of hot water generated by this system is controlled via a flow control valve on the return line and it is a function of the temperature setting within the SCADA that controls the control valve set point (Picture 1 – red circle). During the day this set point is set at 53°C and at night it is increased to 65°C. This process is automated and the separate set point temperatures have been added within the last 12 months in an effort to improve heat recovery.

The reason for the two set points is that during the day the plant found that a lower set point improved the quality of the drying process during rendering and a higher set point left the rendering output too wet. At night the plant was generating excess hot water and this excess hot water was being vented via the fly ash cooling process. The plant found that by increasing the set point to 65°C, higher temperature, lower volume water was generated.

The benefit of this was that overall less water was generated and hence there was less potable water consumed. The water generated at night was of a higher temperature and therefore more suitable to the boiler feed water application, which was the sole use available for this water at night. Excess heat recovery water generated was directed to drain and this often exceed 100m³ per night.

During the day the heat recovered water is also used to top up the supply to the current 82°C and 42°C water production sparge tanks. Even though each tank has multiple cold water feed supply lines. The abattoir assumed this to be the primary supply of makeup water to both these sparge tanks. The heat recovered water feed is an extension of the potable cold water supply feed that runs to the boning room via the current hot water production area. Temperature readings on the lines indicated that the feed temperature was between 27-33°C and the return temperature during the day was 48-54°C. The key issues were;

- How can we improve the flue gas rendering recovery process so that during the day a higher grade heat can be recovered without leaving the rendering mixture overly wet?
- Is there any risk from increasing the temperature of the heat recovered water of under drying the rendering output?
- What is the potential volume available on a daily and hourly basis and at what temperatures?

- How does this match the abattoir's load profile?



Flue gas heat recovery on rendering

2.2 Boiler System Opportunities

The boiler feed system is comprised of four key components and has two separate feed systems attached to it. The original water feeds are from the original 3" copper water supply line that enters the system via the left side of the building near the boiler control room wall opposite the rendering plant facing the work shop and it discharges into the softening feed tank.

The primary boiler feed line is the heat recovered water line from the flue gases that junctions via a tee above the gantry at the in feed end of the rendering dryer. The main issue for the boiler water supply was the consistency and quality of makeup water. With the HW process being sparge based limited condensate was being returned to the boiler. No measurement of condensate returned was being collected nor was the mix of heat recovery water versus fresh water being recorded. Only the total amount of makeup water added to the boiler was being controlled with no

reference to its source. The loss of water from the system was not being recorded nor was the overflow of heat recovered water at night.



Boiler softener feed water tank with control valves indicated

2.3 Steam Distribution System

The boiler generates steam at 900-1,000 kpa and the volume of steam produced is measured by a steam flow meter that is connected to the SCADA. The steam on site is used in a variety of activities with the bulk of the steam used in the rendering process. The plant steam pressure is 600 – 650 kpa. The activities steam is used for are;

- Rendering
 - Dryers with condensate return.
 - Tallow tanks (no condensate recovery)
 - Soft offal direct sparge
 - Blood Cookers (poor condensate recovery if at all)

- Water production
 - 82°C sterilizer water (Sparge)
 - 45°C hand wash water (Sparge)
- Boning
 - Cryovac machines
- Slaughter floor
 - Recovered water sparge
 - Carcass wash (Steam injection)

2.4 Main Steam Distribution Considerations and Issues

- There are limited pressure gauges on the plant and those that are there are found in the rendering plant.
- Accuracy of gauges is difficult to determine and there is generally no isolation valves incorporated to allow for the quick change out of gauges.
- There is an extensive amount of pipe work that has been sized to undertake historical applications and the sizing of the pipes and control elements is unlikely to be appropriate for current applications.
- The current pipe work is all showing signs of significant wear and deterioration.
- The original pipe work for the rendering plant incorporates expansion and contraction sections. The additional pipe work added to supply plant applications has limited expansion joints with the exception of the 90° bend under the side of the boning room which discharges from a 30m plus run into the bend and then into a 1m flexible joint before connecting to an additional 25+m fixed pipe run.
- Steam leaks are evident and the external rust and condition of the pipes indicate that the steam lines themselves may be contaminating the steam supply.
- The steam pipes for the 45°C and 82°C water production sparges are uninsulated.
- There are a limited number of isolation valves and the system requires almost a complete shutdown of the system, post rendering plant, before it can be worked on.
- The existing main steam lines are insulated and the insulation (although aged) appears to be in reasonable condition. The only condensate return line extends from the rendering plant back to the boiler feed tank and this is because historically the steam applications in the slaughter and boning plants have been of a sparge style in nature.

- There is a cast iron pipe that is uninsulated and extends from the current water production area back into the rendering plant that has been verbally indicated as being a condensate return line for the boning room (Picture 5 - green circle).
- The steam line for the boning room extends from the 45°C water production steam sparge feed pipe and is only insulated in sections (Picture 5 - red circle).



Steam and condensate lines entering and leaving the boning room

2.5 45°C & 82°C Water Production

The 82°C tank was being heated to 97°C to supply the auto washer so as to ensure that this water is available at the 92°C temperature level at the auto washer. This means that 97°C water is supplied to both the 82°C ring mains for the boning room and the slaughter floor. There are a number of issues with this;

- The 97°C set point is extremely close to the boiling point of water so this means that this sparge process is an extremely violent process. The steam sparging flow control limitations mean that over shooting of the steam is impossible to prevent and as a result the water is flashing off. This means the existing tank is experiencing significant stress from the flashing off process. A considerable amount of the steam being added to the water is being lost

direct to the atmosphere. As much as 50% of the steam being consumed is being flashed to the atmosphere.

- At 97°C the thermal losses from the tank and the ring main are extremely large. The temperature of the return line from the slaughter floor was measured and found to be 74-77°C. This represents a Delta-T of 20-23°C and represents significant energy losses.
- The tank has been structurally compromised and is close to failure representing a health and safety concern as well as a business risk to the plant with the loss of the sanitizer water production. In such circumstances the plant would be unable to process stock.
- Basically none of the hot water pipe work is insulated and the energy losses are significant. In addition to this a number of the pipe runs and droppers are not in use and these dead legs act as large energy sinks.
- The boning room 82° return is not returning to tank and this means that the boning sterilisers are under temperature.
- There were no active 42°C return lines meaning the 42°C temperature was not consistent across plant.



82°C steam sparge system with original tanks

2.6 The Wash Down System

The wash down system was made up of two sub systems. One located in the plant hot water production shed that supplies the boning room and one located in the gut pit which supplies the slaughter floor. Both systems have had isolation valves fitted on the hot water input sides of the valves and both systems have had stub ring mains fitted in an attempt to supply nominal flow during low volume operation.

The boning room valve has the return line fitted to the hot water intake, which means that the valve does not register the return via the temperature sensing application. The correct methodology of how a stub ring main is supposed to work is that under a static condition the water flowing out of the valve is returned onto the cold input side of the valve and the valve sensors that the incoming temperature is the same as the required outgoing temperature and shuts the hot port.

Due to the issues with the lack of temperature control in low flow situations, several staff members have been burnt. In response to this situation the plant instigated an over temperature control system on each wash down valve. This consists of a PT 100 positioned post return junction on the output line connected to a butterfly valve with a pneumatic actuator. The PT 100 has been set at 70° and when the output temperature exceeds 70° then the butterfly valve shuts in order to prevent people from being burnt. Unfortunately the methodology behind this safety circuit is incorrect. The fail safe system regularly caused the temperature to over shoot the 70°C set.



65°C mixing station slaughter floor

2.7 Staff Amenities

The plant has a staff amenities block that is located to the side of the rendering plant and is going to be rebuilt at some point in the future. Currently the amenities (showers and toilets) are serviced by electric hot water heaters and the inclusion of this was judged beyond the scope of this project. At a later date it would be possible to supply hot water as an energy source to these areas from the plant utilities.

2.8 Water Monitoring

There are only 5 water meters on site that are connected to the SCADA, they are;

- Waste heat evaporator / flue gas condenser
- Sterilization water / 82°C
- Hand Wash water / 45°C
- Cold water / measured from the cold water pump located under the slaughter room floor
- Auto wash



Original SCADA screen display

The SCADA was failing to record flows through the waste heat evaporator, the sterilization water and the auto wash. Whether this was caused by the flow meters failing or a faulty connection to the SCADA is unknown. The cold water pump data appeared to be accurate but there was no historical data for flows available on the summary. The hand wash data collected was inaccurate and there was no trending available. The biggest issue was that the data was spread across a series of screens within the SCADA and the data was presented in a way that provide little meaning or interpretation for staff.

2.9 Insulation Considerations

None of the water lines are insulated, nor are the secondary condensate return lines. The main steam lines are insulated as is the main condensate return line. There is a large amount of pipe work and the number of dead and redundant legs means that the radiant heat losses are significant. The plant needs to address the following insulation issues to minimise heat losses.

- Insulate the main steam and water lines including the primary ring mains for the 82°C, 65°C and 45°C lines.
- Redundant pipe work should be removed or at least isolated.
- The 65°C ring mains should be isolated when not in use to minimize energy consumption.

2.10 The Abattoir's Load Profile

The accurate determination of what HW the plant uses and when is the key step in the successful design and implementation of any HW project. All too often this stage is overlooked and even when the plant feels that they have a good understanding of its requirements and how it works this seldom translates across into an accurate load profile.

Given the original design of the current system, the age of the technology employed and the dilapidated state of the current plant there is a significant opportunity to make savings.

3 THE OPPORTUNITIES

The opportunities for savings fell into three main categories: Savings from minimizing current energy losses, gains from more efficient hot water generation and more efficient control of the resource.

Underlying Key Perimeters

- The average cost of producing 1m³ (cubic metre = 1 kilolitre = 1000 litres) of 82°C water in Australia for a standard meat processing plant is \$5.20.
- An efficient modern day coal fired boiler can produce 8kg of steam from every kg of coal burned.
- 1kg of steam will produce approximately 7 kg of water at 90°C.

3.1 Key Energy Losses

Approximately 50% of the steam being consumed by the original hot water system is lost to atmosphere and not utilised for hot water production. The reasons for this are;

- 1 The sparge system has failed and as a result the steam bubbles are not collapsing (fill heat transfer) before they reach the water surface and hence the steam is released to atmosphere.
- 2 The bubble size is incorrectly calculated due to the sparge pipe sizing and layout.
- 3 The velocity and pressure of the steam being supplied is in excess of what is required.
- 4 The pressure reduction (PRV) for the sparge steam has failed and the steam is being supplied at a higher pressure than required.
- 5 The set point temperature was too high for the original control system to provide adequate turn down and as such the steam actuation “overshoots” consistently resulting in 20-40% more steam being injected into the water than is required.
- 6 No condensate was collected and returned from the PRV to the boiler feed tank. This is a key point as every litre of condensate not returned is extremely costly to replace.
- 7 No condensate was returned to the boiler feed tank because of the sparge process itself consuming any condensate. This means that boiler water has to be preheated first and hence additional energy is consumed for this

process. This is effectively equivalent to heating an additional 300m³ of water from 20°C to 99°C every day for no additional benefit.

- 8 The lack of condensate returned also affects the boilers performance by increasing the total dissolved solids (TDS) and therefore the amount of blow down, water softener, water conditioning, pre water treatment and wear and tear on boiler components.
- 9 The additives in the condensate also provide a food safety issue as they are dissolved in the water and shipped direct to plant along with the hot water.
- 10 None of the original steam sparge lines were insulated, which results in large amounts of radiant heat loss.
- 11 The current hot water tanks are uninsulated and located externally to the building. They are open to atmosphere and subject to the weather. The movement of air and the addition of rain creates large heat losses and when combined with a high set point for the steriliser and poor process controls this encourages cycling of the steam sparging resulting in additional losses.
- 12 The hot water pipe work is uninsulated as is the return pipe work.
- 13 1/3 of all steriliser water pumped to plant is returned back to the steriliser tank. The output temperature averages 94°C and the return temperature averages 76°C meaning that 20% of energy introduced into the system is lost from the plant pipe work while serving no useful purpose.
- 14 A typical ring main will return 3-5% total input water in order to maintain line temperature along the entire ring main. The typical return temperature of a well-insulated pipe system is 3-4°C less than the output temperature. The net effect of this poor ring main return is that the pumping system runs 26% more than required.
- 15 A ring main is required on the 82°C and 42°C system to maintain temperature for compliance. The original system failed to achieve this. The 82°C ring returns at to lower temperature so that any droppers on the return leg will be under temperature and the 42°C system has no return at all.
- 16 The 42°C system suffers from the same issues as the 82°C system with the exception of the flash steam issues created by the high set point of the 82°C system. The 42°C set point is so much lower that any over dosing of steam is unlikely to be creating lost energy as flash steam. The additional energy introduced is wasted because it overheats the water above the 42°C set point required, which creates a health and safety issue.

3.2 Energy Saving Opportunities Created by Building a New Plant

- 1 The proposed system will be significantly more efficient at heat transfer. A modern day heat exchanger process will be in the order of 84-88% efficient with no losses of heat through poor process control and all of the condensate will be returned to the boiler feed system, which in turn significantly improves the boiler efficiency.
- 2 The use of a Variable Speed Drive (VSD) pump skid as the primary pumping source utilising low energy motors and a well-designed control loop combined with correctly sized returns means that electricity pumping costs will be reduced by approximately 24%. (Final numbers are subject to current metering tests).
- 3 The addition of a HW water buffer tank will minimise cycling of the heat exchangers and pumps, which will lower operating costs and at the same time provide a buffer of HW to maintain plant operations in case the plant hot water systems needs to be taken off line for a short period of time.
- 4 Originally there are no storage facilities available for reheat water generated by the flue gas condenser in the rendering plant. Any water generated here is directed to the boiler feed tank or the 82°C hot water sparge tank. By adding adequate storage several advantages can be achieved. The rendering plants performance and the flue gas output can be improved by utilising the reheat water to draw heat from the flue gases at an optimised level rather than as flow is required.
- 5 Any additional water used currently is directed to drain as no storage is available. So for example at night after the plant wash down is completed there is a period of time when rendering continues and reheat water is generated. As there is no requirement for this water by plant the water is discharged to drain.
- 6 The negative effect of this is that the water intake allocation is used to feed a drain. The water is treated with chemicals, filtered and pumped to rendering when it is injected with energy from the gas cooling process and then disposed to drain where it becomes a burden on the wastewater system or alternatively is left to drain to ground. Currently this equals between 20 - 60m³ per night (\$104 - \$312). Per a night or \$36,400.00 - \$109,200.00 per a processing year (based upon 350 process days for rendering).
- 7 By adding storage for reheat water this also provides a buffer supply for the plant in case of interruption to the plants cold water supply.

- 8 In future the coldstore will come under increased load and as a result efficiencies in energy can be created utilising heat recovery from the refrigeration plant. The new design for the hot water system allows for this to happen providing that the water can be pumped from the IBEX site to the HW plant. This increase in available reheat water will reduce the consumption of cold make up water and coal required.
- 9 Currently a co-generation project is being considered that will deliver on average 15m³ of quality heat recovered water during each hour of operation. As with the coldstore generated heat recovery the savings in heat and water are directly related to the amount of reheat water utilised.
- 10 It is theoretically possible that with both heat recovery projects installed the plant would require no cold water make up water for hot water production in future.

3.3 Additional Financial Considerations

- 1 The original hot water system is effectively made up of two sub systems that are aged and fragile. Nether sub system has any form of redundancy and as a result if any element within the system fails the plant loses its hot water supply. This happens on a regular basis and on several occasions production has been forced to close-down for periods of time.
- 2 The original system required significant amounts of maintenance to keep running and aspects of the current system will be impossible to maintain shortly due to the age of the equipment meaning that spare parts are no longer available.
- 3 The lack of data collection makes the original system difficult to monitor and the control of production areas consumption of water is impossible to regulate. With the introduction of metering individual department's consumption can be monitored and improvement plans implemented.
- 4 The original pipe work system is reaching the stage of complete failure and the amount of rust and scaling produced is proving a food safety issue and is contributing to wear and tear on control and pumping elements.
- 5 There are extreme health and safety issues related to the sparging process and the current pipe work layout meaning that staff are exposed to burn and scald risks.
- 6 With the introduction of a carbon tax and the 25,000 tCO₂e threshold, any reduction in energy consumption provides a saving. If the plants' carbon output can be mitigated below 25,000 tons the savings are significant.

4 The PRE CONSTRUCTION PHASE

4.1 Instrumentation and Metering

Without accurate information on flows it is extremely difficult to analyse the plants' water usage and to design a new hot water production facility. As well as repairing the existing flow meters that are in place, the installation of meters in the following areas was required in order to build the abattoir's plant load profile.

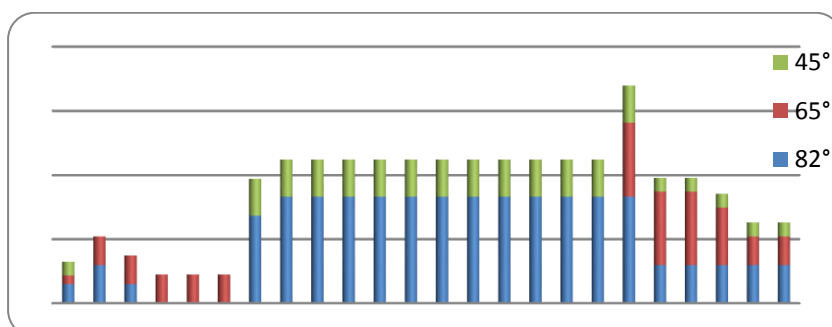
- 82°C Slaughter floor out take feed line so the split of 82°C water to both processing areas can be measured.
- 82°C Slaughter floor return line to measure the return from the slaughter floor. A temperature sensor at this point would also prove to be extremely valuable to working out the impact of the auto wash with respect to the effect on the return temperature.
- 82°C Boning room return line to measure the return from the boning room. A temperature sensor at this point would help determine the overall mix of 82°C return water.
- A meter on the auto wash return would enable calculations on the true cost of running the auto wash.
- A flow meter and a temperature sensor on the heat recovered feed to the boiler would provide significant information about the boiler feed costs and efficiencies.

A flow meter and a temperature sensor on the condensate return line would provide information useful for calculating the pay-back of condensate recovery projects and steam efficiency projects.

4.2 Load Profile Creation

Initially there was no load profile data available. The project to create the processing plants' load profile was partially funded by MLA and AMPC and was instigated in December 2012. The results obtained between January and April 2013 confirmed the initial estimations. The difficulty was that the integration into the SCADA only collected real time flow and cumulated litre data based on hourly intervals. It was possible to build up a daily profile, which was indicative of plants usage but trending for seasonal variance or long time frames was impractical.

The Abattoir's Load Profile



5 THE CONSTRUCTION PHASE

5.1 Initial Preparations

There were a number of separate projects that needed to be undertaken during the construction phase. The new HW plant was planned to be located next to the original HW location. The idea behind this was to reutilise existing pipe work and to minimise the amount of preparation and hence cost required. The abattoir decided to change the HW location in early 2013 to have it located opposite the rendering plant and in front of the engineering team's offices.

This resulted in delays and a number of additional projects needed to be undertaken before construction on the HW plant could begin.

- The site needed to be cleared
- A foundation created for the HW shed and tank farm
- Pipe bridges and supports needed to be constructed
- A new steam mains was installed to replace the aged existing system, accommodate the HW plants requirements and provide additional isolation and protection.

5.2 Tank Farm Construction

A tank farm consisting of two 60m³ tanks for primary storage and a 15m³ buffer tank was constructed and then erected on site. The tanks are fully insulated and sit on insulated plinths. They are connected to the HW shed by a common suction line to the primary pump skid. The HW plant is connected to the boiler via a stain main off take from the rendering department and returns condensate direct to the boiler feed water tank with a dedicated condensate return line.

5.3 HW Plant Construction

The HW plant is connected to the processing plant via an independent pipe bridge and supplies 82°C, 65°C and 45°C water systems. The HW consists of: a primary pump skid to charge the plate heat exchanger skids; a secondary pump skid to trim the output pressure; a cold water pump to supply the plate heat exchanger skid if the tanks are out of commission, the 65°C and 45°C mixer stations and the actual plant if required; a secondary cold water pump to supply rendering cold water for the heat recovery process; and mixer stations and associated equipment and instrumentation.

The plants' electrical distribution system is located to the side of the plant in an external enclosure. The HW plant has its own programme logic controller (PLC) and can operate stand alone or as via the SCADA system. The entire plate heat exchanger system, steam trains and condensate systems are located with the HW plant. The heat exchanger skid consists of two plate heat exchangers (PHX) that are

supplied from a common steam header and post separator station are completely independent allowing the plant to operate on one PHX system or the other under normal operating conditions or have both operating under cold start conditions.



Hot water tank farm and storage facility before construction



Tank farm and HW plant under construction

6 COMMISSIONING

6.1 Start Up

Upon completion of construction the plant was commissioned in late September 2013. The commission process took place over a two week period. The initial phase was bringing the plant online and ready for production. The heat recovery circuit was instigated first and the tank farm commissioned. What became clearly evident was that the amount of reheat capacity that was anticipated and the timing of this reheat, was significantly different than what was actually available. Cumulatively over a week or month the amount of heat recovery available was close to what was expected, but on a daily basis due to operational conditions and the differences between shifts and staff, the timing of events resulted in heat recovery being available at different times on different days and as such matching the heat recovery to the plants requirements was a challenge.

As with any commissioning process issues were experienced with the scaling of instrumentation and controls. These were quickly addressed and presented few challenges. The biggest challenge with the commissioning of the HW system was that water and practically HW was highlighted to the plant at large. The cautiousness shown by processing staff to any changes or perceived changes to HW production were quickly brought to the engineering teams attention; and as the plant was processing while the HW plant was being commissioned, the ability to trial the plant under live conditions was limited.

This then compounded the problem that the operational perimeters specified by the plant pre construction proved to be correct in the broadest sense, but at an operational level were incorrect. As a result some issues were experienced where the HW plant reacted to unexpected events and went into fail safe mode, which shut the plant down for short periods of time. The previous sparge system had the buffer effect of having water in storage within the sparge tank, which it could run onto plant where the new HW plant was a live feed system.

This meant that it produced water in accordance with the plants real time demand rather at a pre-set level. This is how the significant savings in energy consumption are generated. The result of these small interruptions in the first few months of commissioning, which typically lasted less than 4 minutes combined with a stringent processing regime and limited time available to commission under live loads meant that some frustration was caused at the plant level.

An example of this was the morning start-up. Under the old system the plant needed to be making HW at 4:30am to allow for production to begin at 6:00am. Based on this both heat exchangers were engaged at 5:00am. The actual water requirements of the plant were in reality insignificant until 6:30am when the carcass wash came on line and slaughter was in full production. As a result the heat exchangers went into

fail safe mode from going over temperature and needed re starting until the plant fully engaged in production. Once these kinds of problems were identified they could be quickly resolved.

The issue was not the technical problem per say, but the lack of information around the actual operating conditions combined with very short time frames in which to provide a solution and the pressure of production needing to be continued. The key to avoiding such issues in the future lays in gaining a better understanding of the actual operating perimeters. This includes the creation of buy-in from processing staff to what is required and needed during the commissioning phase and where possible conducting as much of the commissioning as possible outside of production hours. This may mean running parts of the plant under near full operating conditions at times that do not interrupt production. For this to happen the plant needs to contribute the human resources to make this a reality.

7 POST COMMISSIONING AND TUNING KEY LEARNING EXPERIENCES

7.1 The Differences

Post commissioning of the HW water plant a number of activities needed to be undertaken. The commissioning phase had highlighted differences in how the plant was thought to run pre implementation of the HW generation plant and what actually happened. There were a variety of reasons for this and basically it came down to embedded behaviours that differed from what the written or pre documented operations were supposed to be. The main areas where this was demonstrated was the rendering department, slaughter floor operation, auto wash, boning room and wash down water.

Fundamentally the key considerations that needed to be re-thought were when operations were supposed to happen rather than when they should happen relative to production; actual amounts of HW used, pressures and volumes; how staff arranged their water usage and how behaviour changed now that focus had been placed upon the plants water usage through the implementation of a new hot water system.

7.2 Rendering

As with so many plants rendering is the key source of heat recovery for the plant and generates a significant amount of hot water. Pre the HW project, rendering was run through the flow gas condenser and the temperature control was achieved by a semi-automated back pressure valve controlled by a set temperature that was set according to day and night pre-set perimeters. Staff had the ability to implement changes to both the set temperature and the day and night perimeters through the SCADA.

This system had been in place for many years and although the SCADA controls were available on the main screen for rendering, they were buried behind two operational screens and as is so often the case with such applications, were mainly forgotten until an issue was detected.

With the introduction of the HW plant two key findings were discovered. The first was the difference in how the rendering plant was thought to operate and what happened in practice. The key assumptions were that rendering was a fairly continuous process where after the initial collection of by-products from slaughter, rendering commenced operations some hours later and the cooking / rendering processes carried on well after slaughter stopped. On a typical day slaughter would commence at 6:00 and finish at between 18:00 and 18:30. Rendering operations were largely thought to run continuous but in practice rendering commenced cooking at 9:00 – 10:00 and proceeded to operate until 13:00 – 3:00. The assumption had always been that the rendering process was relatively consistent with respect to the dryer

activity and hence flue gas discharge and heat recovery. With the introduction of the heat recovery plant and the associated metering and data trending feedback of the rendering system, any operator with access to the HW page of the SCADA could easily detect when heat recovery was undertaken by the temperature return and the flow. Previously under the old system there were no accurate flow meters combined with temperature sensors to detect this information.

The second major difference was having all of the data available on one screen and having the combined story of this data easily available to the operator. The additional benefit of this was that any changes were instantaneously correlated back into detectable results, which allowed the operators feedback on what actually drives the plant and how.

Take away lessons:

- Make sure that the data that controls a process is all in one place.
- Ensure that the data is real time so that any actions implemented create feedback that the operators can understand and relate to.

What was discovered was that because rendering is a batch process the rendering operators collected product together into batches to maximise efficiencies. From their perspective this makes perfect sense. Furthermore they grouped the related tasks associated with rendering around the cooking / drying process so that they timed the drying processes to allow them to undertake other rendering activities including meal breaks and change of shift. The result was that rendering was not a consistent process and for a large part of the day heat recovery operations efficiencies were lost.

This occurred in two separate ways. Firstly, rendering was either not drying when expected and thus there was next to no heat recovery and the water coming back was at a lower grade temperature than desired. As such the storage tanks were being filled with low temperature water. This then caused two additional problems. The tanks were quickly filled to a higher capacity than required and therefore when rendering was resumed there was limited storage to collect the higher temperature water available. This problem was compounded further if the rendering tanks were filled with low heat grade water during the day or early evening and the rendering operations was delayed to later that evening than when the dryers were producing high grade heat recovered water there was limited storage and in turn water was lost.

A secondary and correlated problem with low grade temperature water was for the tanks that were already containing high grade reheat water the water was mixed down to a lower temperature often not much hotter than the ambient supply and

hence the plate heat exchangers had to work harder to overcome the larger Delta-T and thus coal consumption increased.

From a rendering perspective this grouping of rendering activities and the variation of when to cook and how much made sense. The rendering operators felt that they were being efficient and it was not till these matters were investigated further did a number of other interesting trends come to light. The rendering output differed between day and night shift and by who was on duty at the time. The amount of rendering done would change quite considerably between shift changes and the way and timing of when drying was conducted was also different between shifts.

The result of this was that the reheat water collected in effect became a useful way of charting the productivity of individual rendering shifts and the related output constraints of the plant. Operators of the HW plant struggled with this particular issue since there was a disconnect between the rendering department and the engineering department who operated the hot water system as to how and when the rendering was to take place for that shift and what was needed to be changed in the hot water system by manually over riding to match the process up with respect to timing.

Originally the heat recovery system was set up in a similar fashion as to what had been operating previously. Instead of a back pressure control valve being utilised, a speed control VSD on the pump was utilised to maintain control based on a set temperature. The set temperature and operating times as to when it changed temperature were the same as the original system.

What happened here was that the tanks were being over filled with low grade heat recovery water due to the discrepancy of the timing of the operations. The same problem existed under the old system but was masked by a number of factors.

- Being a direct injection system there was no recovery of condensate and under the new system there was.
- This led to less of the heat recovery water being consumed as boiler make up water. The boiler required less make up and therefore there was more heat recovery water available for storage.
- The difference was when the reheat water was consumed as boiler feed water there was no monitoring or controls in place to indicate the temperature of the water and the volume consumed in this process. The set point of the back flow valve was located in one place on the SCADA, the output of the flue gas condenser in terms of temperature of the heat recovery was located in another under the rendering plant operations. The boiler make up water did not have a flow meter on it, nor did the boiler have a temperature sensor on the input temperature of the heat recovered water directed to boiler feedwater. The flue gas condenser did supply this temperature but the disconnect existed because it was not readily evident to the boiler operators.
- The boiler took whatever water was available at whatever grade and heated it to the temperature required to create steam.

Prior to the HW water project being implemented the boiler used to overflow when too much heat recovery was available. In the past a secondary storage tank was created called the softener tank (which was different than the softener and water conditioner apparatus). This tank allowed for extra capacity for the reheat water from rendering to be stored. Any additional over flow was then directed down to drain behind the boiler sheds.

The loss of water was thought to happen only at night and to only happen when the boning and wash down processes had been concluded and rendering had carried on producing reheat water. The key issue here was that although water loss could be observed from the back of the rendering plant, in practice this was a difficult location from where to assess the water loss. At night after rendering the water loss was more evident because of the potential volumes discharged, but any loss during the day was difficult to detect as the operational requirements of the plant between make up water for the 45°C and 82°C tanks and the boiler feed water requirements combined with the sporadic nature of rendering meant that the water losses from over production of low grade heat recovered water were sporadic, in smaller volumes and discharged at varying times. It was only at night that the situation became more evident and furthermore there was a perception that it did not occur every night nor was it the same amount every night. While the excess production of heat recovered water did indeed change on a nightly basis this was a function of the different shift behaviours within the rendering department, the uncoordinated timing of the rendering drying, versus heat recovery requirements of the plant.

What the new hot water plant did was that it made this situation evident and explained how it came about. Suddenly staff had a real flow of data in the form of water at different temperatures and volumes. When the rendering plants' activities were not matched with production, the tanks quickly filled with low grade heat recovery and overflowed or they were starved of water and the tanks emptied, which meant the HW plant shut down until the tanks were replenished with cold water or the flow of water through the heat recovery system was increased.

Key takeaway:

- If you want to control a resource you need to make sure its production and consumption are observable to all.

In this case when the volume of water coming back from heat recovery was too high, the water spilled from the storage tanks onto the ground in front of the engineering administration office and then became an urgent issue especially since the water was spilling from the top of the tanks as the drain and overflow pipe work had yet to be installed. Even though the amount of water lost was very minor compared to the previous system, the visibility of the loss made it a prominent feature and point of concern. Previously the water loss was constant at low volumes during the day and

at night could eclipse 100m³ or more. But because it was effectively out of sight it was out of mind. A compounding factor of this was that any daytime spillage was in front a high traffic location and visible to management, where previously the only spillage or overflow noted only happened at night.

The solution to these issues was developed over four stages. As with the entire tuning process a log was maintained of events and these were investigated before changes were made.

The rendering problem required four fundamental issues to be dealt with:

- 1 Reduce the flow of heat recovery water when there was no cooking so as to not overflow the tanks with low grade water or to fill them and limit storage capacity for later when the opportunity for heat recovery existed.
- 2 Not starving the tanks of water regardless of rendering activities and to ensure the tanks had an adequate supply of water to guarantee production. Topping the tanks up with cold water reduced the available cold water for other plant activities and furthermore any heat recovery however limited ensured that less energy was required. The preference was to apply cold water through the flue gas condenser and scavenge any residual energy at all.
- 3 The rendering process producing the heat recovered water needed heat to be removed from the flue gas and under cooling or over cooling the flue gases affected rendering production and the quality of the product.
- 4 Rendering has time lags from when the dryers start to when they finish and the flue gas condenser takes time to heat up and maintain its temperature after the cooking process finishes.

Initially the first series of fixes focussed on controlling the flow of water through temperature. The new VSD pump CW2 (cold water no2 – plant) supplied to provide water to the rendering flue gas condenser had a minimum flow rate of 400lpm and when the opportunity for heat recovery from the flue gas heat was minimal and the tanks were moderately full, this minimum flow meant that the tanks progressively over filled with low grade heat. In order to automate we had the option of using tank levels, temperature and flow as the control variables. It was essential to maintain some flow through the condensers because of the difference between rendering stopping and starting. We needed to ensure that the flue gas condenser had an adequate supply of water to prevent damage from overheating. The key to avoid over filling the tanks was to reduce the flow further so as to avoid wastage. The issue with this was how to achieve a lower flow then the pumps minimum flow of 400lpm. The solution was to incorporate the back pressure control valve from the original

system. When this was combined with the new pump, flow could be effectively reduced to 90lpm and the temperature set point was used to control the low flow perimeter.

The temperature set point was set at 55°C during the day and 65°C at night as was the original set points with a 6:00-22:00 window governing daytime consumption. The issue with this was the non-uniform rendering loads and the fact that the operational requirements for water meant the plant would often be starved of water mid-afternoon and in the morning there was insufficient water in storage to meet the demands of slaughter after 10:00 when production had been ramped up for some hours. The operating patterns of the plant had not changed. Under the old system the thinking was that by increasing the set point temperature you would have reduced flow and thus less water produced at a higher temperature of 60°C meaning less water to store and the water stored was at a more usable temperature.

In reality, while there was some wisdom in this, the system had not actually worked as effectively as believed due to the masking effects of the sparge system absorbing any heat losses and the heat recovered water being diverted to the boiler feed water and the drain.

This situation was first attempted to be resolved by employing a number of manual adjustments to the start and finish times of the temperature set point operating ranges and to the set point temperatures. The issue was while a staff member was maintaining observation of the system they could adjust to suit, but at night between shifts or when staffs were involved in other duties, the system went astray. It had always been planned to fully automate the system and any manual adjustments were part of a settling / learning process in progress. What quickly became apparent was the manual adjustments were masking the operational issues and it was not until control was removed from the staff that the situation could be addressed.

The key to resolving the automation issues lay with data collection and understanding the reality of how the plant worked. The final solution rested in developing minimum levels for the tanks combined with temperature limits so that the plant maintained the tanks at pre specified limits subject to the temperature set points but when the volumes of storage rose above an operationally desired maximum, the set temperature was reduced to reduce flow and when the limits dropped below a pre specified set point then the tanks filled by allowing more flow at a lower temperature. It was the setting of the levels and the set temperatures that effectively resulted in the plant automation being achieved. The optimisation came about from giving these variable operational windows that allowed the PLC flexibility in how to respond.

Key takeaways:

- Allow time post commissioning to collect data on how the plant operates and feedback through errors before finalising the automation.

- Install the building blocks for automation but allow ranges of control to accommodate a wider spectrum of operational conditions than you initially expect.

7.3 Tank Storage

Under the original system the plant had no storage capacity for heat recovered water for HW generation. This caused a series of problems;

- 1 Excess heat recovery production was unavailable without having storage for water.
- 2 There was limited storage to generate water and form a buffer for peak demand periods.
- 3 The storage that was in place in the form of the sparge tanks was partially open to atmosphere and had next to no insulation.
- 4 What insulation was intact had deteriorated due to water damage and age.
- 5 The tanks were subject to heat losses from wind movements and atmospheric conditions.
- 6 There was no smarts around level control or feedback. Effectively the tanks remained full consistently and for portions of the day overflowed as valves and sensors were slow to react to the tanks overfilling.

Under the new system the tank storage was incorporated to alleviate the above problems. Effectively a tank farm was created comprising three tanks.

- Tank 1 - 60m³ (60,000 litres). Heat recovery tank.
- Tank 2 - 60m³ (60,000 litres). Heat recovery tank.
- Tank 3 - 15m³ (15,000 litres). Buffer tank.

Tanks 1 and 2 served as storage capacity to be filled with heat recovery water as it was produced and topped off with cold water if required to meet the plants demand for water. Tank 3 was designed as a buffer tank. A place for the nominal flow from the 45°C and 65°C mixing valves to be returned to so as to ensure a consistent nominal flow and hence stable water mixing performance. The 82°C return lines from slaughter and boning were returned to tank 3 as was the bypass line from the heat exchangers.

The concept behind this design was that tanks 1 and tank 2 could be segregated to capture water generated by different heat sources at different grades and then

utilised accordingly to optimise the plants operational efficiencies. Initially the only source of heat recovery is from the rendering flue gas condenser but eventually this is planned to be expanded to include refrigeration and a proposed biogas plant.

The tanks were fully insulated to a level of 98.2% efficiency and clad in a painted aluminium cladding to protect the insulation. The plinths the tanks were situated on were also insulated. Some thought was directed as to how the tank information would be displayed on SCADA and how best to manage the tanks. Originally the thought was to display the tank volumes in m^3 to give the operators an idea of the water capacity available for HW generation and the storage capacity available. After trialling this the plant quickly moved to a percentage basis as staff found this easier to understand and the data was more meaningful for them. They could interpret a percentage far more effectively than a volume. For example 50% meant a tank was half full and reciprocally half empty whereas 30m^3 had little meaning for most staff.

In general the tank management system worked very effectively with two exceptions. The issues with matching rendering heat recovery to consumption created an issue where tanks were either over filled with low heat grade water or alternatively were allowed to run down. The issue with having the tank displays as percentages is the rate of usage being a real time variable altered consideration. A measurement of a tank being 20% full at one time of day when consumption was relatively light and thus the balance in the tank would last some time was quite different to another time of day when consumption was high and the 20% level would run out quite quickly. A number of different solutions were trialled around automating the tanks' controls.

The original automation code supplied pre commissioning had been developed on the data obtained from the plants metering programme. This indicated that a base load of 15% in each tank would be sufficient to meet demand and intuitively this made sense as the original sparge tanks held approximately less than half that volume. The difference lay in how the sparge tanks operated in practice. The sparge tanks were filled by water from rendering but also had a 6" gravity main filling them as well with cold water. This was metered in m^3 per hour and the flow through this pipe was not trended. As a result no one was aware of how much water was actually introduced into the hot water system directly from the cold water main rather than from heat recovery. Furthermore the plants' assumption was that the bulk of the water came from heat recovery only. In addition to this the sparge system was unmetered and operated automatically with a set temperature of 94°C . It basically ran continually and excess energy was vented directly to atmosphere.

Between the radiant heat losses and the steam temperature control loop in place it is estimated that approximately 50% or more of the energy introduced into the system was lost direct to atmosphere. This however had the advantage of ensuring that for the bulk of the day ample hot water was available at an appropriate temperature to meet demand. When the original sparge system relied on the cold water supply only for makeup, then the steam system struggled to maintain the temperature and this is

when the auto wash started to underperform. This system was effectively working at full capacity most of the time with cold water contributing significantly to the feed water to maintain the volume required. This could be detected when one of the four sparges would fail and the systems' operating performance would be radically reduced.

The first part of the solution was to increase the minimum fill volume, which regulated when the system would call for cold water. The maximum fill height, which controlled the shutting off of supply to the tank was reduced and by changing the operating window perimeters that controlled items, such as how long it needed to stay below the minimum fill level before filling with cold water was commenced. The second part of the solution was to lock the operators out of the system so that they could not override the system. What was happening was that different operators' perceptions and interpretations of what the levels meant in relation to how much capacity was available varied considerably and as a result some situations were created by operators trying to proactively manage the system and causing additional issues.

Tank 3 was designed to work as a buffer tank and did so perfectly during the mornings but started to struggle in the afternoons. There were a variety of reasons for this. The return lines from slaughter were at a higher flow rate under the old system and they effectively provided the system a nominal flow thus creating a smoothing effect on the steam sparging. The radiant heat line losses from the uninsulated pipework were significant and the high return flow was required to meet the line losses and maintain the minimum temperature. In the new system the line losses were less due to the new HW plants location. The system was more efficient and many of the issues around water consumption at the plant level had been dealt with. By reducing the return flow and re piping it back into tank two this problem of overfilling tank 3 was reduced. This then means that tank 2 was charged to a higher temperature than tank 1 and some changes were made to the automation programme to make use of this fact from an energy optimisation efficiency stand point. This was able to be done quite simply because the initial design allowed for the management of different heat grades.

The nominal flows from the water mixers provided stability of flow for the heat exchangers during normal operations but under low flow conditions with the addition of the cold water for mixing down the temperature of the water they progressively filled tank 3. Reducing the flows or turning them off at night effectively solved this issue but as the last of the cleaners completed their shift with one or two hoses running in the early hours of the morning it was difficult to maintain temperature control. The solution to this issue was to allow the plant to run on tank 3 only under nominal flow conditions and when the tank level was reduced to a minimum point the tank was turned off and the plant run on either tank 2 or 3.

7.4 Slaughter Floor Operations

The slaughter floor has a culture within the business of being the driving force for the company. The processing of bodies at regular time intervals controls all other plant operations. Maintaining the slaughter rate is the key efficiency indicator measured by the plant and governs all further aspects of production. Any deviation causing a reduction in slaughtering is recorded and attributed to a root cause. In the case of water the key causes in the past had been;

- 1 The loss of temperature to the slaughter floor auto wash (carcase wash).
- 2 The loss of temperature to the sterilisers during operations.
- 3 The lack of temperature to the sterilisers during start up.

During the commissioning of the new HW plant, issues were experienced with these three problems. As a result, some of the underlying issues that was attributing to these problems were addressed.

The plant runs a carcase wash systems referred to as an auto wash. The set temperature for the system was set at a minimum of 92°C with a target temperature of 94°C and a warning engaged at 93°C. If the temperature fell below this temperature then the auto wash would time out until temperature was achieved and the slaughter floor was stopped.

Previous to the new HW plant being installed a number of issues had been experienced with this system over several years and this in turn had caused the slaughter floor much frustration. To cope with these issues the plant had introduced a new set point temperature of 94°C for the 82°C steriliser water to allow the carcase wash to achieve temperature.

Under the new system where plate heat exchangers were used rather than a sparge system, the opportunity to run a live load plant at 92°C was not available. This was because a 92°C set point was too close to maintain under the over-set point temperature of 95°C. As a result, the secondary heat exchanger came on and the over temperature system was activated. Although it would only last 2-3 minutes, being the time for the plant to go over temperature and then the system to automatically restart, this was enough for slugs of less than 80°C water to enter the system and although undetectable within the rest of the system the sterilisers would trip out because the secondary steam injection system either would not have the range in capacity to compensate for the floor or the piping layout to the auto wash meant that the water would pool as a slug of sub cooled water and the system would detect that as it cycled through its routine.

Issues pre installation of HW system:

- The key issue with the steriliser, was a high set point required by compliance as a part of a critical control point.
- The steriliser had intermittent flow and as a result with constant draw there was insufficient nominal flow for the steam mixing to maintain temperature.
- The pressure and flow to the steriliser was affected by other aspects of the slaughter floor water drawn and as a result this meant the input temperature and pressure drifted.
- The plants steam mixing was suffered originally by a series of light duty operation pressure regulators that failed. Ultimately these were replaced by a heavier duty pressure reducing valves, which although of high quality, were unfortunately incorrectly sized for the application and was effectively 15 times greater than what was required.
- The steam pressure varied depending on plant flow.
- The steam line to the slaughter floor was only partially insulated and the radiant heat loss resulted in condensate issues and steam not reaching the pressure reducing valve (PRV) at an adequate temperature, pressure and saturation point to be effective for the PRV or the direct mixer.
- The temperature point on the auto wash was located in what was effectively a dead pocket and stored the water where it was sitting prior to the routine injection.
- The temperature reading took place in the first second or two of auto wash operation capturing the temperature of effectively the cooler water.
- There was no bypass flow to the auto wash ensuring a constant temperature when water was called for.
- The water was drawn off by a solenoid opening, which created a back pressure issue when it closed.
- The bypass to the steriliser return line was originally incorrectly sized and eventually when re sized resulted in providing a path of least resistance to the auto wash so when water was called for it was not necessary present.
- The SCADA control for the auto wash had its programme set to provide a one second window to capture the operating temperature at the start of a cycle.

- The PT 100 (temperature probe) had an oversized stem and resulted in the auto wash having ambient air temperatures influencing the readings.
- The accuracy, responsiveness and replication of the PT100 was not adequate for the high duty application.
- The steam injections system introduced a scaling created by a variety of conditions that progressively reduced the steam port opening in the injection valve, affecting the way the valve controlled.
- The steam scaling also affected the PT 100 and resulted in a gradual deterioration in accuracy.
- The actuator controlling the steam injection valve was never adequately protected from wash down and eventually water would egress into the electronics and the unit would fail.

All these issues had been present pre hot water installation and because the new set point could not be set to 94°C, achieving an input temperature at the slaughter floor of between 88°C and 92°C, the auto wash system struggled to meet the new requirements without being retuned. The effect of the over temperature safety feature being triggered by other events then compounded this problem.

As with all things when you introduce a new function, process or piece of equipment it automatically becomes a point of focus. Old problems re surface and are perceived to be caused by the new system. Further, issues that were once masked by other processes or patches were revealed; and while they were always present, they suddenly escalate and need to be urgently addressed.

Initially the first stage of solving this problem was to try and reset the set point temperature higher at the HW shed. With all the hot water lines un-insulated and the radiant losses, this alteration had limited impact.

The over temperature set point of 95°C was designed to protect the system from flashing steam within the heat exchangers. This would cause damage from supplying water at too high a temperature to plant resulting in potential issues. These issues included staff accidents, damage to plant especially rubbers, seals and plastics and the effects of high temperature steriliser water causing a build-up of condensate within the processing facility. The condensate build up is of particular concern, where it may be atomised in areas such as sterilisers and other spray applications.

Under the old system when spargers were employed to heat the steriliser water, any over temperature issues were effectively dealt with by the spargers flashing the water off as steam and this disappeared to atmosphere as the sparge tanks were vented to atmosphere. The system itself was not a real time load and instead water was

maintained in the sparge tank at temperature and at level, which masked the draw effects and smoothed out the sparging to a constant over heating effect that was not easy to detect apart for the constant flume of steam from the sparge tank.

The second process undertaken was to tune the system by increasing the Delta-T that the steam injections system was set to maintain. While this proved successful the down fall of this approach was when one of the input perimeters changed significantly, then the system failed to maintain the set point temperature. As a result the system performed well most of the time except for intermittent errors that were blamed on the hot water system but had a variety of causes.

The only way the situation was successfully readdressed was for the underlying issues to be dealt with by relaying out the pipe work. Adding an automated isolation valve to stop the mixing valve bypass when the system called for water and changing the temperature probe location so it measured the real flow of water through the auto wash rather than a dead leg pocket that was flushed at the beginning of each cycle. Further efficiency in this area can be achieved and additional work is planned to capture these.

The loss of temperature to the sterilisers during operations was a two part problem which could be traced to different causes. The over temperature issue created by trying to maintain a higher set point to maintain the auto wash meant that when the system faulted out, the slugs of cold water would intermittently pass through the system and took time to flush through. Ultimately this issue was completely solved when the over temperature issues were solved by maintaining an operational set point. This was enhanced further with the introduction of storage pre carcase wash and a separate steam sparge to maintain the stored water at a far higher temperature than was required.

The second aspect of this that caused concern was that in the boning room some of the sterilisers failed to achieve temperature and as a result failed inspection. This was deemed to be a fault of the hot water system and upon investigation was being supplied to the boning room in excess of 90°C and being returned from the boning room at a temperature in excess of 84°C. Some of the sterilisers were measuring temperature of less than 78°C. The issue had to do with original layout of the sterilisers and that several of the droppers resulted in large dead legs that cooled. The boning room sterilisers were typically controlled by a sensor and as such ran intermittently. As a result it could take 10-20 sensor applications for the steriliser to clear the line with water and maintain temperature.

The question was really why this would only become apparent after up grading the hot water system. The answer lies in the fact that it was always there, but not noticed or not considered significant. The upgrade of the hot water system placed emphasis both on what water was being used and how it was being monitored. As a result routine activities, such as temperature testing, were more enthusiastically followed

and underlying issues gained prominence. The boning room solution is to re plumb the existing steriliser stations with ring mains and remove the dead legs that are creating the temperature losses.

7.5 Strict Controls

The enthusiasm for assessing the efficiency of the water generation upgrade reared itself in a number of different ways. The plant had always maintained strict adherence to water temperatures for steriliser and water quality. The extent of the testing programme for temperatures increased significantly as did the vigour to adhere to temperature testing guidelines. Effectively a new operational standard was thus set and achieved. This was illustrated by staff resetting the temperature test mark to include the error figure on the temperature testing equipment as an additional setting on top of the 82°C set point.

7.6 Lack of Temperature at Steriliser during Start Up

Under the previous system the hot water system took approximately one-two hours to achieve temperature from a cold start. As a result it was left running all night. Slaughter production begins at 6:00 and prior to this as part of the start-up procedure the steriliser temperatures are checked at approximately 5:45. From the time slaughter starts to the time the first carcass reaches the auto wash it is approximately 30 minutes and since the carcass wash uses half the steriliser water from the slaughter floor it is not till at least 6:30 that the steriliser demand for water from the slaughter floor reaches its full load.

When the new system was introduced in anticipation of start-up it was decided that the system should be brought on line at 4:30 to ensure that the water temperature and supply was adequate for slaughter to commence. The new system only requires a short window to engage, two-three minutes from a cold start to achieve temperature followed by the appropriate time to clear the ring mains of water that has been left sitting since last production. In an effort to save water and minimise energy consumption the 82°C steriliser supply line and return from the slaughter floor is turned off after slaughter each night.

As a result of this the plant had next to no demand so when the primary heat exchanger was engaged at 4:00 and then when the secondary heat exchanger was started at 4:30 the system went over temperature and shut down. When the auto start engaged the primary heat exchanger came on line and the system restarted. Due to the over temperature stop the second heat exchanger did not re-engage when peak demand was reached after 6:30 and until this was manually activated, the plant struggled for water. This problem was exasperated with the related rendering issue causing a lack of available reheat water for start-up.

The root cause of this problem was again a lack of understanding of the plants' needs and requirements. The original sparge system combined with the lack of

metering meant that over the years several assumptions had been created as to what the demand for water was and when it would occur.

The learning experiences here related to the following issues:

- 1 Start-up windows and time for the plant to begin were not as long as expected.
- 2 Flushing the ring mains and charging the pipe work with heat happened quicker than expected.
- 3 The slaughter floor's demand at start-up was far smaller than anticipated.
- 4 The amount of pre start cleaning varied and was dependent on several factors including the extent of the previous evening's cleaning, shift changes and who performed the final quality checks.
- 5 The auto wash was always expected to be a heavy user of steriliser water but no one anticipated over half the slaughter floors water consumption was dedicated to it.
- 6 Hand wash and amenities at start up were not a significant impact.
- 7 The time for the steriliser to be activated, meant that the second heat exchanger was not required until at least 6:30am.

A compounding problem created by having one primary heat exchanger running and then being forced to bring the second online under heavy demand was that an over temperature situation was created. As the heat exchanger coming on line ramped up to meet demand, it lowered the flow of cold water available to the primary heat exchanger and since it had been producing at 100% the sudden loss of flow meant the control valve was slow to react and with the high set point and the lack of reheat available an over temperature situation was created. The over temperature safety feature then shut down the primary heat exchanger causing the secondary heat exchanger to ramp as well and often over shoot and shut down.

The re start process happened within 90 seconds however the lag between the re start and the plant noticing a lack of temperature triggered by the auto wash meant that just as the plants water system came online the plant cut demand as the auto wash detected the loss of water and the plant stopped and demand ceased. Thus effectively shutting one heat exchanger off and depending on the timing of events, creating another over temperature situation.

Of course this all happened just as the slaughter floor was filling the chain and had reached full flight for the morning. This stop start activity at the beginning of shift then took prominence as the root cause of any further production delays for the day.

Several ideas were considered for addressing these events. The solution lay in understanding the plants' operation requirements and needs. The start-up process was controlled by times. By readjusting the times so that the secondary heat exchanger was not engaged until 7:30 this improved the situation immensely. In addition to this, creating a window for the second unit to start early if demand required it, based on the steam control valve opening position, meant that staffs were not required to undertake adjustments that often compounded the problem rather than solving it. When the secondary heat exchanger did engage, the temperature over shoot potential was reduced by adding a ramp down output function for the primary heat exchanger until the primary was increased. The bypass line to the ballast tank was utilised to ensure that sufficient flow was intact so that the secondary heat exchanger had demand.

Key Takeaway;

- Knowing how the plant runs and what its demands are, is the key to a successful project. The timing of operational events is often quite different than what is expected.

7.8 The Boning Operations

The boning room operations generally run from 5:00 till 0.00. The boning room's consumption of water during processing was significantly less than the slaughter floor. On a typical plant the boning room during operation would account for 15-20% of the plants sterilisers water consumption compared to 65-75% for slaughter.

At the abattoir the boning room uses approximately 10% of the water of slaughter and as such its usage has little effect on the HW water system. The extended operations of the boning room over slaughter, which ceases operations at 18:00 – 18:30 depending on the kill tally means that after 18:30 the HW plant only has to generate enough water to meet the needs of the wash down process for slaughter and the boning room's standard operational requirements.

Originally it was anticipated that a second heat exchanger would be required to operate till 0:00 to meet this demand. The reality was that the low flow situation created opportunities for the second heat exchanger to go on over temperature mode as the HW demand fluctuated in large swings due to the cleaning process which demanded water in differing amounts dependent on what cleaning processes were in operation at the time.

Most noticeable was when the cleaning staff took their breaks. They were accustomed to having their breaks together and this resulted in almost a zero

demand when they had a break with a significant increase in demand upon resumption of work.

The automation of the HW system allowed for the secondary heat exchanger to come on and off after certain low or high operating conditions were met. The situation at the abattoir was that these loads varied very quickly so that the timers for the load conditions to activate the heat exchangers to start or stop to meet demand meant that they failed to expire before conditions changed and they were reset. Some experimentation was done with shortening the timers but this only compounded the problem. The solution lay in increasing the nominal return flow from the slaughter floor and hence provide a stable flow for one heat exchanger to maintain.

7.9 Wash Down

The expectation was that wash down would be a relatively large consumer of water especially in the slaughter areas. The current wash down system for the slaughter area comprises a series of hoses and each hose displaces approximately 40 lpm (litres per minute). The boning room has installed a Foamico high pressure wash down system with each hose using less than 25lpm. In practice the slaughter floor wash down process consumed less than 50% of the water during normal slaughter floor operations. After the first 2-3 hours of wash down this consumption then dropped to half of that again as cleaning staff were deployed to other activities.

The plant traditionally ran three pressure settings during the process in an effort to limit water consumption and later during the day improve the wash down efficiencies. These pressure settings were 350 kPa during the day, 450 kPa after slaughter shut down and 500 kPa when cleaning was well under way. The impact of these pressure settings had little direct effect on the hot water plants generation ability but they did affect usage of water in two important ways. Higher pressures drove up demand and the higher pressures maintained a ramping effect on the water supply.

Under the old system the hot water system was supplied from a sparge tank with a nominal minimum volume into a pump. This static head combined with the pumps constant rate output to maintain pressure retaining the return lines back to the tank meant that the effects of the higher pressure on the ramping of sporadic demand combined with the lack of metering meant that this situation was not observed. Under the new system the plants demand is live on demand and when the plant calls for water at whatever pressure the system can meet this. The trend curves illustrate how after slaughter operations cease and the first of the main wash down process end, the demand radically changes and under the new system the amount of water and pressure and therefore heat and pump energy are delivered in line with demand meaning very little is wasted.

7.10 By Products Processing

With new visibility around water consumption on site, another opportunity for improvement came with the tripe refiner process. Tripe, like rendering runs past the slaughter production stage as the by-products only become available after slaughter. By ramping up the water pressure to assist the cleaners in the preliminary stages of wash down for slaughter the tripe room's pressures increase as well. The impact on the water consumption and demand was extreme because generally the tripe process uses water constantly and flushes to drain unlike a wash down process that uses water on a more systematic basis and has the back pressure of the spray hoses to work against and hence limit consumption.

By maintaining the water pressure to 500 kPa until the tripe room had finished processing water consumption could be radically reduced. So far the cleaning staff have not complained significantly over this point. It is envisaged at some point that a high pressure wash down system will be added to the slaughter floor, which will allow the wash down system to permanently be run at 350 kPa and hence this problem will be avoided.

7.11 Rendering Wash Down

The rendering plant utilises hoses during production for 'clean as you go' procedures. At the end of rendering operation the rendering plant performs its own wash down process. Rendering generally cease operations between 00:00 and 1:00 in the morning. Wash down generally cease operations around 2:00. Rendering operators complained that at wash down they had insufficient water to wash down and perform their cleaning tasks especially cleaning the fat off the grills. They advised that although the pressure of the hot water had not changed, according to their SCADA system there was insufficient pressure to achieve the desirable cleaning result.

The reasoning behind this was that under the old system the HW water plant was located close to rendering and rendering had a dedicated line for the wash down water taken right after the 65°C pump before other parts of plant were supplied. Under the new system the wash down water was sent to plant and rendering supply was now effectively the last point of connection after all the other users on site had first opportunity to draw. So this combined with line pressure losses meant that they had insufficient pressure to perform their duties. The red herring in this was that the SCADA page still indicated that they were achieving 500 kPa pressure during wash down because this was measuring at the pump point prior to the water entering the boning room and not where they draw the water off to the slaughter floor.

Key take away lessons:

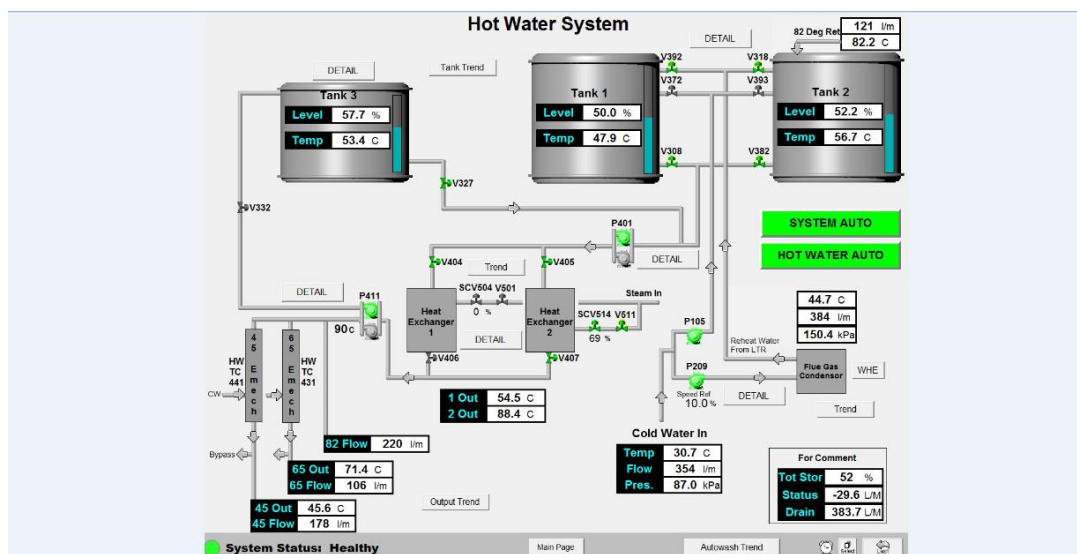
- Make sure that the meters in use are measuring what you think they are measuring.
- Make sure that when plumbing and pipe work layouts have changed that the meters left in place are still reading meaningful measurements.

7.12 SCADA Lesson's

The main lesson's identified above show how the bulk of the issues were contained around three themes.

- 1 Inadequate information on how the plant ran prior to the new hot water system being designed and installed. Through the metering programme data was gained about overall flows and then interpreted through the plants perspective of how it felt it operated or better yet how it felt it should operate. What quickly became apparent was that the actual driving forces behind the plants water consumption were not entirely understood and so once the new system was installed the operational issues that were experienced were compounded by attempts to use old ways of thinking to address these issues. Once proper investigation was completed and the root causes determined most of the operational issues had simple explanations that could easily be addressed.
- 2 In the old system the SCADA had limited water data and limited rendering available. What was there was effectively spread across the SCADA pages for rendering, the hot water system and the boiler operation. In the metering phase of the project this data stream was greatly increased by the addition of seven other meters and the repair of two. The additional data served to support the preliminary conclusions re potential savings. The new system brought all this data together under one master screen and served several useful purposes.
 - a. Firstly the effect of changing one part of the system or another was clearly obvious to operations.
 - b. The health and status of the system could be observed at a glance.
 - c. The inputs from rendering and the effects on the boiler were easily monitored.

- d. Trending and additional data were one click away from the main screen.
 - e. The screen layout grouped the data and measurement points in such a way that they represented the physical layout and location of the plant and this greatly assisted operators in their understanding and responsiveness.
- 3 The trend data allowed informed discussion to take place re events. By date stamping the trend, individual effects and feedback loops could be determined and monitored. The ease of trending allowed for clear decision making.



7.13 The Boiler System

Under the old sparge system no condensate recovery took place because the steam condensate was consumed in the hot water making process and left the sparge tanks as part of the hot water supply. Under the new system the condensate was recovered and returned to the boiler house from the plate heat exchangers through a condensate recovery system. This simple change in the process has a significant impact on the plant in a number of ways and is providing incredible savings both short and long term.

- 1 Through extrapolation it is calculated that between 35% and 40% of the plants entire steam production was used in generating hot water under the sparge system. With this amount of condensate now collected and returned to the boiler feed water tank the boilers' efficiencies are greatly increased.
- 2 The boiler does not need to generate as much steam to pre heat boiler feed water nor does it need to heat as much condensate as before. The

condensate return is of a high quality coming through newly installed steam and condensate lines.

- 3 The use of water softener, chemicals and other water treatment agents are greatly reduced.
- 4 The water treatment chemicals that were previously lost in the condensate leaving the HW plant in the hot water itself are no longer deposited around the plant on instrumentation, pipe work and other operating elements.
- 5 The amount of heat recovered water available for HW generation has been greatly increased as this was the primary source of makeup water for the boiler feed tank under the old system.
- 6 The load on the boiler is more even and it does not need to ramp as high or work as hard as before because it is not acting as the buffer for the energy requirements of the sparge system.
- 7 There is less energy consumed as the heat transfer efficiencies are significantly higher.
- 8 There is less energy lost through radiant heat losses through un-insulated pipe work and tanks etc.
- 9 The condensate recovered is aided by a dedicated condensate recovery line all the way back to the boiler feed water tank and the heat exchangers have pumping traps fitted that clear the heat exchangers even under the most severe stall conditions. Hence the efficiency of the system is greatly improved because condensate is being returned in volume at a high temperature and in good condition.
- 10 The addition of a separate water test point on the condensate return from the hot water plant serves to monitor this and provides evidence of these improvements.
- 11 The improved efficiencies allow the boiler to operate more efficiently and as such it has extra capacity to meet the plants peak load demands.
- 12 Recently the boiler had to have some remedial maintenance done and the addition of the HW plant and the condensate recovery meant that for the first time it was possible to operate the plant with a standby boiler. In addition to this as a statement of the efficiency to the system, the HW plant was still capable of meeting the plants HW demands even with the input steam pressure dropped from 10 bar to 2.5 bar as it was ramping down.

The combination of these efficiencies translate to savings in coal and depending on the situation with carbon taxes and carbon trading in Australia, with carbon tax itself. One of the main drivers of this project originally was to reduce coal consumption and the carbon liability and ensure that the plant did not produce carbon in excess of the 25,000 tons per a year threshold. Although data for this is still to be collected the initial findings indicate a strong reduction in coal usage and a significant improvement in boiler efficiency.

7.14 Reduced Maintenance

The original sparge system was a very violent process with maintenance being constantly required to fix the existing sparge tanks and lines. These tanks were constantly splitting and in need of repair due to the substantial thermal shocks incurred. Often this would happen at peak times during production and cause significant issues and production delays.

The use of a 45°C and an 82°C sparge tank meant a double up of equipment. More damage for issues and things to go wrong, a great area for heat loss to occur and a significant issue with complexity around multiple sparges and their maintenance.

Without the condensate being passed onto plant a number of potential issues are avoided. These include increased scaling on instrumentation, valves and seals, contamination of certain processes by steam scaling and reduced maintenance on equipment for scaling and the other effects of condensate.

The correct insulation of steam lines has resulted in significant reduced heat losses. In open areas the insulation has resulted in efficiency improvements of 99.2% and in closed areas where additional cladding has not been installed the line efficiency is 98.6%.

7.15 Health & Safety Advantages

The 45°C tank was only mixed to 48°C-50°C to maintain temperature for the hand wash application. There were two potential issues here. The first was that the lack of controls often resulted in the tank being over heated and hot water sent to plant. Slight over heating represented a waste of energy and significant over heading represents a serious health and safety issue and the potential to burn a staff member.

The second issue re the 45°C tank was that the cold water used to make up the supply of this tank when combined with steam to make the heat waste water was never actually heated to a pasteurisation temperature of 80°C minimum at any point. As a result, any chance for this water to be contaminated by pathogen egress through the open tank or through the water supply meant that this pathogen could effectively survive and multiply within the hand wash system and be delivered to the plant. The new system, removes both these risks from the plant.

The original HW plant steam sparge pipes were uninsulated and exposed to staff. By ensuring that all steam pipe work have been adequately insulated the risk to staff from steam burns has been radically reduced. The risk of steam and condensate pipe work break apart from water hammer has been radically reduced through the installation of new correctly sized pipe work with expansion joints included. The risk of tank failure from the old sparge tanks has been removed as the new HW plant is based on plate heat exchanger technology.

8 THE RESULTS

Post commissioning and once the SCADA implementation had been completed, the amount of data available about the heat recovery capabilities of the plant and where the water was being used and why, has allowed the plant to address a number of related matters, which have all generated significant savings. The increased vigilance from the operations staff around water issues resulted in the discovery that the boning rooms ring main provided inadequate circulation of water and as such even though the input temperature of the sterilisation water was in excess of 88°C and yet some sterilisers were recording temperatures in and around the 75°C range. Re piping of the boning room has removed this problem and improved the ring main return temperatures meaning less energy is being wasted.

The improvements in pipe work insulation, reduction in pipe runs and rerouting of pipe work has decreased the radiant losses. The highly efficient hydro pump sets mean that the pumps are running at their optimum energy consumption point saving electricity. The removal of the sparge tanks has meant that the plants' thermal losses have been slashed. The use of the heat exchangers means that all condensate is collected and returned to the boiler feed water tank. This means that in excess of 1/3 of the plants' boiler condensate was previously being lost through the sparge system and is now recovered. As a result, boiler chemicals, water treatment and water softener chemical consumption has been greatly reduced.

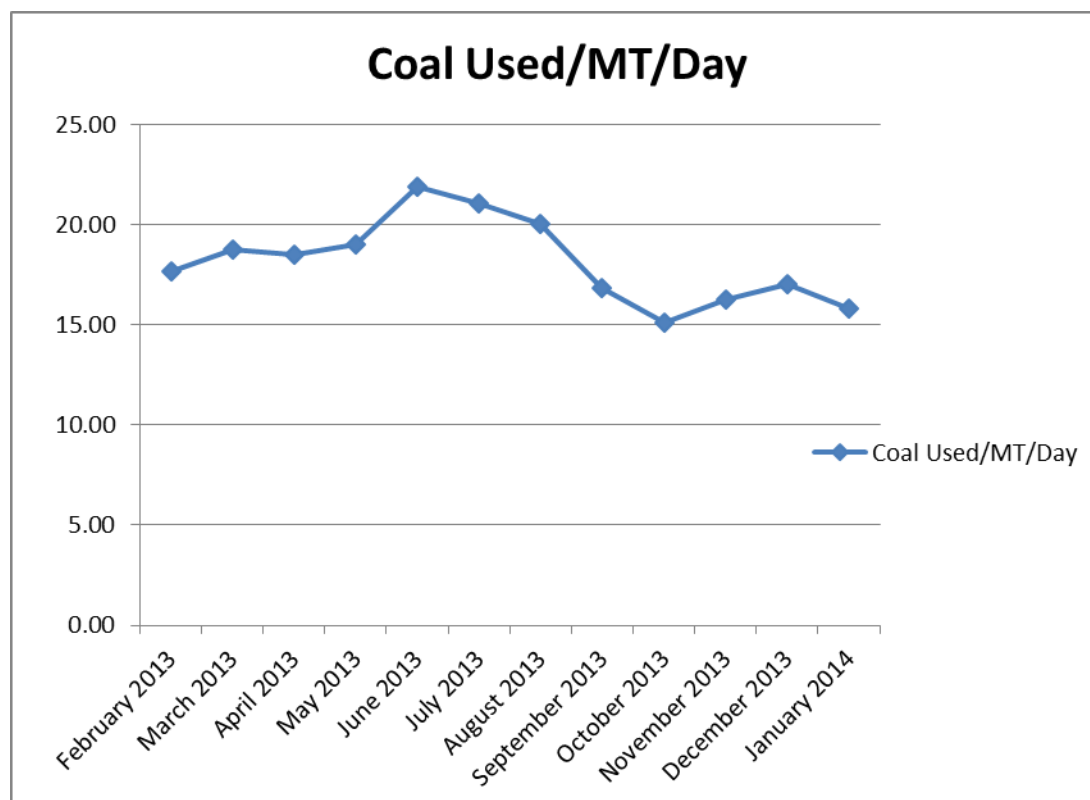
With the increased storage capacity for heat recovery and the data available to manage it, more free energy can be utilised from the heat recovery process and thus new energy from coal to heat steam to make HW is reduced. The extra knowledge gained from the plants' improved instrumentation and the handling of this information through the SCADA and the related trending processes means that many opportunities to minimise energy consumption on plant have become visible and been addressed. For example the sparge tanks no longer run 24 hours a day and water heating costs are greatly reduced after the slaughter operation has stopped. After the wash down has been completed between 2:00 and 3:00 (am) the hot water system effectively shuts down to just prior to start up. Over the course of the year these savings will have an even greater impact on coal consumption. As the plant learns to manage and optimise the system even more savings are possible and it is expected that coal consumption will trend down even further.

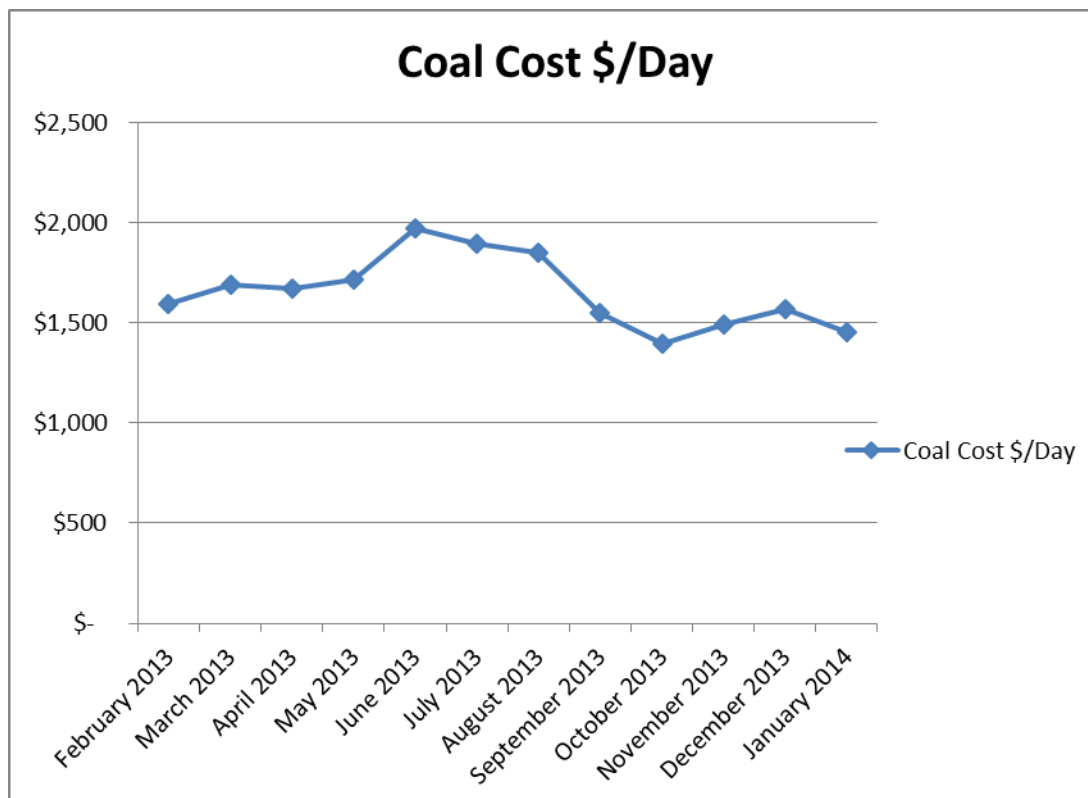
The collection of data is still ongoing at the current time. The boiler issues discussed above combined with the other plant issues previously discussed makes it difficult to make absolute statements. So far coal consumption has been reduced by 20%, which will easily result on an ongoing saving of over \$108K. It is expected that as the plant overcomes their boiler troubles and the blood cookers are repaired and allowed to return condensate back to the boiler feed tank, along with the other required repairs and modifications, coal consumption savings will pass 25% and will most

likely reach 30% with proper attention. The savings will then exceed \$150K per a year.

The cost of the project exceeded the initial budget expectations, but in the light of the project changes, the increased size of the plant, the change of location and the large amount of related improvements conducted to both the water and steam pipe work systems and the plants automation and SCADA systems; the project has been completed most cost effectively. One of the reasons for this is the plant contributed labour and resources during the construction and commissioning stages and this also had the benefit of the plant not only taking ownership of the new systems but contributed input of a high level of operational knowledge about the plant.

With the savings detailed above the payback period for the project is less than three years. Given that most utility based projects have a pay back of between 5 and 7 years, this is a satisfactory result. Excluded from these calculations is the savings in electricity and water from the better management of the pumping systems, the high efficiency motors and the improvements in water management created by the enhanced monitoring.





9 CONCLUSIONS

The old saying that you can only be certain of two things in life, death and taxes, I believe today needs to be changed to four things you can be certain of. That energy and water will only get dearer and that governments will want businesses to pay for more and more. This project is not only an energy reduction project it's an investment in the future.

Every dollar a business can save drops directly to the bottom line and the reduction in energy and carbon costs has a large impact on a plants' profitability. The reduction in maintenance costs, the flexibility to match HW production with consumption and the redundancy in capacity means that the plant has the capacity for growth without being constraint by lack of HW.

The security of supply of HW is perhaps the greatest reward from this project. On many occasions the old HW plant had broken down and stopped the plant from operating for significant periods of time. The new plant provides peace of mind for supply. As the processing plant undertakes additional energy projects in the future, such as heat recovery from refrigeration or co generation, they now have the ability to utilise these projects to their fullest extent. As the plant grows and builds a new slaughter floor or other facility they have the build-in capacity to supply HW and

match the plants enhanced requirements. The investment for the future has been made today and the benefits will flow on for many years.