final report

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Innovation and energy management and reduction

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1 Background

Energy consumption in the form of hot water, electricity and gas is a major cost for meat processing plants and is a focus of greenhouse gas emission concerns in Australia. Midfield Meats has signed up with the Greenhouse Gas Challenge program but believes that modern process control technologies utilising electronic sensors and associated management systems offers the potential for gaining significant efficiencies in energy consumption in-plant. Initial discussions with utility suppliers identified opportunities for efficiencies and discussions with technology suppliers highlighted the potential of what state-of-the-art control technology can achieve. This project aimed at capturing benefits for Midfield Meats in the form of reduced energy consumption on-site that could also be extrapolated to other Australian processors. Those benefits were particularly relevant to abattoirs which associated rendering plants may be distant from the processing site and where hot water is not available from this source, although some of the recommendations may be applicable to other cases.

For Midfield the overall goal of the project was to maximise plant efficiency, reduce operating costs, reduce emissions and to free up capital for other improvement projects.

Objectives of the project

- Identify the appropriate technologies for monitoring and control of on-site water, electrical and gas consumption;
- Implement these technologies at Midfield's Warrnambool plant and identify energy consumption levels; and
- Improve the efficiency of on-site energy consumption and demonstrate these benefits against established benchmarks.

2 Energy program summary

Specific Refrigeration Services Pty Ltd was asked to review the current operation of the heating and cooling systems on site at Midfield Meats International Pty Ltd in Warrnambool. This process established that there was insufficient information and information gathering equipment to analyse the operation of the plant. Equipment was therefore selected to record, correlate and graph data so that it could be analysed.

This information clearly identified that both the heating and refrigeration systems were operating inefficiently. Effectively the refrigeration system was operating at around55% efficiency and the heating system was around 72% efficiency. No use was being made of waste heat from heat rejection from the compressors, water off the kill floor, and 42°C water was being generated from 86°C water.

Following this realisation of inefficiency, significant changes were made to the operation and set-up of the refrigeration system – and an increase of 50% in heat load led to slightly reduced total energy costs.

Older, less efficient boilers in the heating system were replaced with boilers operating at 85% efficiency.

In summary, the refrigeration plant was improved from a COP average of 1.0 to 4.4 and a heating system from 72% to 85% efficiency. Further gains were made following the installation of the final water circulation system.

2.1 Major energy consumption sources at the beginning of the research

Midfield Meats International Pty Ltd is a major meat producer in Warrnambool, Victoria and to operate the business they have a large demand for power to operate the refrigeration plant and natural gas to generate hot water for sterilisation and hand wash requirements.

Previous to this project, the existing system had been developed on the basis of demand rather than energy efficiency when the plant was built at the beginning of the 1990's. The refrigeration plant consisted of a system that serviced two temperatures. The first was a -14°C plant that operated chillers, load-out areas and a glycol system for the boning rooms. The second was a -42°C plant that operated the freezer store and plate freezer facility. This plant was upgraded with Mycom screw compressors operating at various conditions and varying COP's providing the desired output, but with insufficient information to accurately know what the input was relative to the output.

The system used evaporative cooling towers to control the oil temperature and evaporative condensers to control the condensing temperature. Liquid management had no real control and caused costly plant restarts that affected the maximum demand. There was little or no information on the pipe layout and system efficiency due to the lack of drawings and data collection sources.

The site hot water system was operated via three Raypak type hot water boilers that were over-fired and rejected heat loss through the stack. A fourth, Hunt, boiler was correctly set up to provide water at the desired 86°C.

Without any monitoring source, the efficiency of the system was difficult to analyse and lack of pipe layout drawings made it even more difficult.

Further, the main power supply was ineffectively balanced over the existing three transformers and again lack of data to assess their operating made adjustment difficult.

2.2 Design of logging system to evaluate operation

With a view to assess the situation with the various components of this plant, Specific Refrigeration Services Pty Ltd designed a Citect based system to provide the necessary information.

Each of the Mycom Compressors would provide:

- Suction Temperature and pressure
- Discharge temperature and pressure
- Oil temperature and pressure
- Oil filter differential pressure

With this information Specific Refrigeration Services Pty Ltd would be able to accurately calculate the performance of each piece of equipment and set them to operate at that duty.

The operation of all chillers, freezer, boning rooms and plate freezers would be monitored via Citect to establish what effective operating hours and temperatures were required.

A system of level probes was set up to monitor the location of refrigerant so that a minimum charge sufficient to operate the refrigeration plant was charged.

Each of the boilers was fitted with monitoring equipment to assess temperature flow and pressure. Each of the water supply sources either main or bore water will be fitted with monitoring equipment to assess temperature, flow and pressure.

This system would produce and display graphic trends, reports and alarms. Where necessary, the system would automatically total the information to provide daily or monthly figures.

2.3 Improving efficiency

End users should improve efficiency to reduce overall usage. Installing newer, more efficient equipment and controls can typically save between 20% and 40% of energy costs, depending on the age and efficiency of the facility and equipment. Although this initiative requires a capital investment, the energy efficiency incentive and rebate programs offered by many states would reduce the payback period on these projects to less than three years.

Food processors and cold storage end users have successfully implemented energy efficiency projects in the following areas:
- Condensers
- Condenser and suction piping
- Automatic purgers
- Controls (refrigeration and whole facility)
- Demand defrost
- Energy efficient doors/vestibules
- Variable frequency drives (VFD’s)

Detailed below are some specific recommendations in these areas.

Condensers
- Increasing condenser capacity can lower the condenser discharge pressure which will result in reduced compressor kW per ton
- Installing new condensers can reduce fan HP requirements by 50%, compared to older style centrifugal fans, for the equivalent heat transfer
- Installing new condensers that use more efficient, higher flow pumps that more effectively wet surfaces can achieve better heat transfer coefficients with no net increase in horsepower.

Condenser and suction piping
- Installing properly sized pipe and valves can reduce pressure drops in discharge piping
- Floating compressor head pressure to within 10° F of the wet bulb temperature can lead to big savings
- Floating suction pressure can improve efficiency if critical control temperatures are monitored

Automatic purgers
- Installing auto-purgers can ensure that air is continually removed from the ammonia piping system

Refrigeration controls
Refrigeration controls can improve operations and energy efficiency by:
- Sequencing compressors and condensers
- Floating suction and discharge pressures
- Controlling defrost cycles
- Ramping VFD’s

- Controlling flywheel operation

Demand defrost controls
- Replacing a time-clock-based system with a system using an infrared sensor that detects the presence of frost and initiates a defrost cycle, allows monitoring of temperatures to stop the defrost cycle so that it does not continue longer than necessary
- Reducing the minimum frequency and duration of defrost cycles can boost savings

Energy efficient doors
New doors can do a good job of minimizing infiltration heat gain, eliminating frost and snow in the freezers and reducing door maintenance. New doors can have many other benefits as well:
- Eliminating radiant or electric heaters used to keep old style doors from frosting
- Allowing hot gas to be used for curtain doors that have heated air curtains (instead of electric heat)
- Reducing door open time by installing electric eyes
- Reducing infiltration
- Eliminating frost in freezer
- Reducing door maintenance
- Reducing manpower injuries dur to frost and ice
- Reducing product damage from frost and ice

Variable speed drives
In general, variable speed drives should be added to condenser fans. With controls upgrades and adding wet bulb temperature control loops, the fans will be slowed during operations at cooler temperatures. Slowing fans to 80% of normal speed reduces the power required by 50% for significant energy savings, but be aware that these savings are partially offset by increased compressor energy use.

Actual projects for cold storage and food processors
Several projects have shown significant impacts in overall savings and tremendous benefits from the use of state incentives.

Implementation of these energy efficiency technologies were not part of this project and were purely given as recommendations to the plant.

2.4 The advantages of a ‘Citect’ Scada System

Installation of new measuring equipment and connection to the existing PLC and Scada (Supervisory and data acquisition system) will provide a method to monitor, record and trend information. Data provided by the Scada system will allow plant personnel to identify energy and water consumptions and effluent discharge at various points within the plant, allowing the implementation of energy reduction and effluent minimisation plans.

The Citect Scada system provides a number of benefits
- Provides historical and real-time trending, reports and data logging of plant flows, temperatures and pressures, allowing for a better understanding of the performance and efficiency of the plant.
- Protects valuable plant equipment and personnel. The Citect alarm facility constantly monitors plant data and alerts operators of abnormal conditions.
- Protects the environment. The Citect alarm facility constantly monitors effluent flow rates and temperature and alerts operations of abnormal conditions.

- Records and displays breakdown of energy consumption and water usage within various parts of the plant at any given time. Wastage and problem areas can be instantly pinpointed.
- Provides operators with effective plant monitoring using clear concise graphics pages (screens).

A Citect SCADA system was configured and implemented at the Midfield plant to allow operators and supervisors to monitor plant services and discharges. The application was operated through the keyboard and mouse located at the Citect server. Citect runs in the Windows environment. The plant is monitored by the Scada system on a single computer, through two PLC's.

The monitoring systems were originally financed by the project and bought back by the plant at depreciated value after the completion of the project.

2.5 Information gained from data logging system

The following information was collected after installation of the monitoring system:

- The existing ammonia refrigeration plant had compressors operating at very poor COP's.
- The existing average monthly power consumption was 1,032,000 kWh (over 4 months).
- Existing average maximum demand was 2180 kW (over 4 months)
- The discharge pressure was rising above a specific cost point, desired maximum operating pressure due to no condenser control and inadequate purging system.
- The rooms were operating at temperatures below the desired temperature due to lack of control.
- The high stage and low stage system were operating at lower operating pressure due to lack of adequate control.
- There was no liquid management system and as a result the plant high levels from time to time a system restart affected the maximum demand.
- The existing hot water system had hot water boilers that were operating very inefficiently at between 67% and 73% efficiency. The biggest boiler was the most efficient.

2.6 Upgrade of refrigeration system as a result of information gained

The refrigeration system was upgraded with improvements to operate COP's on all compressors.

The control system would now operate the compressors, condensers and liquid management system at the design and desired temperatures. The system was fitted with a fully automatic air purger, which helped maintain a low discharge pressure. The freezing capacity was increased by an additional 690 kwr at -40°C and freezer storage capacity by 95 kwr. In addition, the high stage load on the plant was increased by installing load areas and marshalling areas that total 203 kW at -14°C.

The average monthly power consumption fell to 940,750kWh (over 4 months).

Given that the freezing capacity increased from 855 kwr to 1545 kwr with virtually no change in power consumption and a reduction of the monthly kWh average by 10%. The maximum demand also dropped from 2180 kW to 1754 for the same 4 months.

In regards to the water heating system and as a result of the information collected from the data logging system, it was calculated that a gas saving of between 7% and 15% was achieved if the correct equipment was installed. In addition to this, the CO_2 emissions to the atmosphere were reduced and the heating system efficiency was increased.

Following this project the intention was to install two Cleaver Brooks Fire Tube Boilers with the appropriate capacity.

At the time of the project, the capacity of the installed boilers equalled 5055 kW. It was intended that the Hunt boiler with a capacity of 2325 would remain and a CB2500 (2500 kW0 and CB3000 (3000 kW) would be installed along with a revised heating system. It was estimated that only the CB3000 would operate for the majority of the time. The efficiency of the proposed boiler was 85%.

3 Summary of benefits to the industry

This project showed the importance of a data logging system to improve efficiency of energy and refrigeration plants at abattoirs.

The following benefits were confirmed:

- Identify current energy consumption levels and benchmark improvements in efficiency as they are gained;
- Identify individual costs in relation to productivity
- Identify times of inefficient use of energy
- Reduce greenhouse gas emissions
- Potential to reduce labour costs
- Allows monitoring staff to concentrate on improvements
- Optimisation of plant