Final report

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Remote Optimisation systems for Ammonia Refrigeration Plant

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Executive Summary

Industrial refrigeration systems are significant energy consumers in meat processing facilities. These systems and subsequent energy consumption can represent significant operating costs to meat processing facilities.

This project explored the benefits of implementing new control algorithms (smart controls) by segregating from PLC code via a server based control system. The benefit of server based controls was to allow remote access to control systems for review by experts in the field.

The project found that the application of server based controls was not feasible in a commercial environment. The risks identified through the project outweighed the potential benefits.

However, the project did demonstrate that significant savings could be achieved through the implementation of smart controls integrated with existing PLC code.

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1 Background

Industrial refrigeration systems are significant energy consumers of meat processing facilities. These systems and subsequent energy consumption can represent significant operating costs to meat processing facilities.

The current operation of many of these systems is the result of repeated extension and addition of refrigeration equipment to cater for expansion of processing capabilities. These additions often result in the refrigeration plant being operated inefficiently, resulting in excessive energy consumption particularly at part load conditions.

The Teys Australia Wagga Wagga facility is an example where excess electricity was consumed as the result of limited control of specific plant items.

This project aimed to demonstrate the application of smart controls to an existing refrigeration system via the *Enerjust Remote Optimisation System ('Enerjust')*. The Enerjust system consists of a server based application, which can be imposed over existing PLC control equipment to implement modern smart controls to achieve improved energy efficiency of refrigeration equipment.

The Enerjust also records key operating parameters to allow review of performance and identify opportunities for improvement (e.g. current feedback, discharge pressures etc.). The Enerjust can also be accessed remotely by specialist consultants, removing the need for site based review of operating conditions and allowing remedial actions to be implemented without travel to the site.

2 Projective objectives

2.1 Overall objectives

The overall project objectives were to:

- Demonstrate the ability of a server based control optimisation system to improve plant operation and reduce power consumption under a range of ambient and operating conditions.
- Demonstrate the benefits of segregating "smart" control algorithms from implementation within PLC code. In particular, the ability to effect changes to the algorithm remotely without site attendance, and the ability to secure the algorithm from intentional or accidental de-activation.
- Demonstrate via recorded data that a saving in power consumption has been achieved over a set period pre and post implementation for each control module implemented.
- Demonstrate other benefits of a server-based system to the site management, including the ability of the site to access the server based system for observation and reporting of a range of plant attributes.
- Cost benefit analysis of adopting the Enerjust system at plant level.

2.1.1 Variable Head Pressure Control (VHPC)

VHPC utilises variable speed drives to control head pressure (discharge pressure) by altering the frequency of condenser fan motors in response to head pressure. The smart control also monitors ambient temperature and humidity conditions to calculate an optimal head pressure set point.

This part of the project was to demonstrate the application of this control to improve energy efficiency of the evaporative condensers.

2.1.2 Compressor Staging and Capacity Control (CSCC)

The site utilises screw type compressors with capacity controlled via slide valve operation, which are very efficient at full load conditions. However, energy consumption is not proportional to load, and efficiency is lost at part load conditions.

This part of the project saw VSDs installed on two compressors, and staging arranged to operate remaining compressors at full load and control capacity via the VSD.

2.1.3 Evaporator Fan Speed Control (EFSC)

Evaporator fans are also significant consumers of energy and are not properly controlled. This part of the project was to demonstrate the controlling of fan speed in response to chiller temperature to achieve energy savings.

3 Methodology

The Enerjust system was used prior to implementation of the smart controls to record operating conditions and calculate energy consumption for a two week period. This data was also used to model predicted savings following implementation of smart controls. The modeled savings were as follows in table 1:

Project	Annual Energy Savings	Annual Energy Cost Savings	Total Capital Cost	Annual GHG Savings	Simple Payback
	MWh	$	$	tCO2-e	years
VHPC + CSCC	1091	179503	454845	971	2.53

The same operating conditions were monitored following implementation of the new smart controls and energy consumption calculated and compared to the modeled savings. The actual savings were calculated using the same modeling techniques, but based on the observed data.

4 Results

4.1.1 Implementation of the Enerjust System

The Enerjust system was initially implemented as a recording system to monitor operating parameters. This proved successful, and data was readily accessible. However, due to size of data sets and internet speeds in the area, remote access of the data was unreliable and required download to portable media and posting to consultants.

The required hardware was installed to allow the implementation of smart controls (VSDs, PLC equipment). As preparations were made to implement the smart controls via the Enerjust system, it became apparent the Enerjust was not capable of handling emergency situations such as a machine failure or power outage. Due to uncertainty of these situations of the risk of equipment damage, the implementation of smart controls via the Enerjust did not occur.

4.1.2 Implementation of Smart Controls

With the required control equipment in place, it was possible to implement smart controls via the PLC program. This was completed for VHPC and CSCC. The EFSC was not implemented.

The energy savings achieved are shown in table 1 below:

Project	Annual Energy Savings	Annual Energy Cost Savings	Total Capital Cost	Annual GHG Savings	Simple Payback
	MWh	$	$	tCO2-e	years
VHPC + CSCC	437	80277	454845	389	5.67

5 Discussion

5.1 Heading

5.1.1 Enerjust System

The Enerjust system did not achieve the intended outcomes. A key selling point of the system was the remote access potential. As highlighted above, this could not be achieved due to slow internet speeds experienced in regional areas. It is acknowledged that roll out of the National Broadband Network may rectify this issue, however was not available for this project and considered not to be successful.

Some key concerns regarding emergency situations are as follows:

1. *Power Outage* – Following a power outage, the PLC would follow a standard start up sequence preventing overload of site transformers. The Enerjust system was not capable of recognising a power outage, and could potentially call for all compressors and condensers to start simultaneously, causing damage to site transformers due to high start-up currents of the equipment.

2. *Machine Failure* – In the event of a compressor shutting down due to a fault (e.g. high oil temp), the Enerjust did not account for these situations and would not start another compressor. This was of particular concern in plant downtime such as weekends, when typically only one compressor is required. If this machine was to fail, a backup machine would not start and render the plant without refrigeration.

These unknowns were considered to be too high a risk for plant operations, and the implementation of smart controls through the Enerjust was abandoned.

Based on this, the Enerjust System did not demonstrate the effectiveness of server based controls and benefits of segregating control algorithms from PLC code. The project also failed to demonstrate the benefits of remote access to the control system.

5.1.2 Smart Controls

The implementation of smart controls (VHPC + CSCC) proved successful in terms of achieving energy savings compared to the previous control method. However, it did not achieve the savings which were modelled. The reasons for this are not entirely understood, and the parameters of the model used are not known so comment cannot be made on this part of the project.

It is acknowledged that the smart controls currently in use are different to those used in the measurement period. The current control parameters used are the result of monitoring of operating conditions and energy performance, and making changes to certain parameters to achieve greater energy savings. Some changes to operating parameters include moving the VSD controlled compressors to position two of the staging to achieve greater savings on non production days.

It is therefore likely the actual energy savings have increased since the post project monitoring period. A review at the end of the 12 month period will demonstrate the full savings realised through the implementation of smart controls. Based on the initial review period, the project has demonstrated how smart controls can be used to achieve savings in energy consumption of industrial refrigeration plants.

6 Conclusions/recommendations

The Enerjust system did not achieve the projects intended outcomes, and requires further development before being distributed on a commercial scale. The implementation of the smart controls did demonstrate the energy savings which could be realised in existing refrigeration plants via current PLC control programs. Monitoring of system operating conditions did demonstrate smart controls were able to control parameters closer to set point (i.e. discharge pressure, suction pressure) and removed spikes in these parameters.

Further review will be completed following 12 months of continuous operation to evaluate the effectiveness of the smart controls under various climatic conditions. Further changes to operating conditions/set points will be made following this review as required to maximise savings.