Final Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Refrigeration Plant Energy Improvement

Capability building, grant application support and improved information dissemination

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1.0 Executive Summary

Refrigeration is a critical service to the red meat processing industry, consuming the bulk of electrical energy used on most processor sites. Due to the complex nature of refrigeration systems as used on meat processing plants, reliance on external resources for engineering support and maintenance is significant due to lack of on-site skills. The end result is suboptimal refrigeration systems with excessively high maintenance costs.

The project's primary objective was to enable site engineering and maintenance staff to identify and quantify energy savings and new technology opportunities for their refrigeration systems with no or minimal external assistance.

This would empower the site staff to commence direct discussions with suitable technology providers and reduce reliance on external advisers or consultants, thereby accelerating the uptake of these opportunities to the benefit of each site. This would be achieved by generating various easy-to-use documents and a software tool to enable site engineers to identify, quantify and assess the viability of energy savings opportunities relating to site refrigeration plant, and to conduct awareness and information dissemination by way of seminars on the topic.

To ensure that the outcomes of the project meet the specific needs of the red meat processing industry, a series of interactive workshops (10) across a range of processor sites were conducted to identify and assess EEOs and obtain feedback on documents and software tool in progress. The commencement of this project unfortunately coincided with the start of the COVID-19 pandemic, which necessitated significant changes to the workshop approach, and to proposed interim dissemination of results via seminars. The use of remote collaboration headsets and online webinars allowed these steps to continue in altered format, albeit with some compromises in terms of quality of site data and interaction with site staff.

The documents and the tool were developed and evolved with several changes of direction, style and content during the course of the project to adjust to site findings and feedback, with significant changes from original intent to the content and presentation of material in the Guidebooks, as well as substantial evolution of the software Tool. Reasons for these changes are presented in the report. The final products for both the documentation and the tool are user-friendly, approachable and practical, and are a novel solution that the authors expect will be widely used even outside the red meat industry. The final deliverables include:

1) Commercial refrigeration systems Guidebook
2) Industrial refrigeration systems Guidebook, parts 1 and 2
3) New Technology handbook
4) How-to Manual
5) Software tool
6) Documentation of software tool

Several key insights from the project were formative in defining the style and content, such as:

a) The sequence in which improvements are implemented was seen to be critical, leading to a classification of the industrial refrigeration Energy Efficiency Opportunities (EEOs) into four phases – Essentials, Hard Yards, Refinement and Integration. Several of the participant sites had implemented advanced EEOs, but these were dysfunctional because basic precursor projects had been omitted.
b) Synergies between EEOs, and the coining of the useful terminology of Enablers and Followers to assist with the optimum sequencing of EEO implementation was found to be helpful and assisted with the structuring of the Guidebooks.

c) To the surprise of the investigators, many of the refrigeration systems at participant sites showed quite rudimentary issues impeding energy efficiency, such as plant stability issues, insufficient control capability, or inaccurate sensors. This caused an expansion of the Essentials section to ensure these basics where clearly highlighted.
d) Also, to the surprise of the investigators, very few of the participant sites had adopted many or any of the classic energy efficiency opportunities. It had been hoped to develop a library of examples of EEO implementation to illustrate the documentation, but this was only possible in limited fashion.
e) Generally, the level of adoption of EEOs across all participating sites was very low. It became clear that the key driver was lack of awareness of what is available and possible, rather than cost of each EEO. The focus of the Guidebooks therefore shifted emphatically to awareness and understanding, at the expense of more detailed guidance on EEO costing and business case development.
f) The two most significant disruptors of energy efficiency on industrial refrigeration systems were found to be the use of hot gas for carcass reheat on sites processing high-fat cattle causing significant false load on the refrigeration plants, and fundamental plant stability issues that overwhelm most EEOs

Key conclusions from the study align with the insights

1) Low levels of adoption of energy efficiency techniques amongst participating sites, for various reasons.
2) The need for much deeper understanding on site level of basic plant efficiency fundamentals, such as the need for stable plant operation, accurate sensors and good-quality control and monitoring systems, ahead of more flashy (and costly) opportunities such as compressor speed control.
3) Integration of refrigeration systems into other services, such as the provision of hot water for washdown or sterilisation, was not observed on any of the participant sites. Significant advancement of integration on all sites will be required in the interests of industry decarbonisation.

The authors recommend that all sites adopt a coordinated and staged approach to the improvement of the energy efficiency of their refrigeration systems. The new Guidebooks should be of significant value in this regard, as these do set out a logical sequence of implementation.

Selective adoption of new technologies (refer to the New Technology handbook) should be considered, especially the use of information technology solutions such as IoT and Refrigeration as a Service, which enable the improvement of site systems with ongoing remote expertise. This is a vital step considering the physical remoteness of most meat processing sites, aggravated by the recent COVID 19 pandemic.

2.0 Introduction

Refrigeration is a vital service in the meat processing industry. Cooling of products and spaces is required at nearly all stages of animal processing, from the moment the hot carcass leaves the kill floor, to the point where frozen or chilled product is loaded into refrigerated transport at the other end of the facility. Hence it is ubiquitous in a meat processing facility. Refrigeration is needed during

1) Carcass chilling (direct and spray chilling)
2) Offal chilling and freezing
3) Cooling of the boning, processing and packaging areas
4) Re-chilling and freezing of packaged and/or cartoned product
5) Chilled and frozen storage of finished product before loading for dispatch

Refrigeration is a complex thermodynamic process that is also energy and maintenance intensive. Typically, around 60% and up to 80% of the site electrical energy is expended in the refrigeration plant room, and a significant portion of site maintenance costs also.

Because of the complexity of refrigeration systems, on site staff generally do not have the detailed engineering and service skills required to optimize and maintain the refrigeration systems at peak efficiency and reliability levels, let alone upgrade the systems when new and viable technology opportunities arise. This results in a disproportionate reliance on external expert resources (refrigeration contractors and consultants) to rectify this situation, whilst many other services such as hot water or steam generation, compressed air and general mechanical/electrical systems can quite easily be managed by site service staff.

A further consequence is the continued use of outdated refrigeration technology or worn equipment, causing higher-than-necessary refrigeration plant operating costs.

This project therefore originated from the desire to break this reliance on external experts and empower site staff to more easily understand and identify improvements and find viable upgrades to the site refrigeration systems. Currently available guidebooks on refrigeration energy efficiency are highly technical and wordy, do not provide much practical guidance and do not effectively serve to inform meat processor site staff on what works and what is applicable to their specific site.

3.0 Project Objectives (Documentation and Tool)

The project's primary objective was to enable site engineering and maintenance staff to identify and quantify energy savings and new technology opportunities for their refrigeration systems with no or minimal external assistance.

This would empower the site staff to commence direct discussions with suitable technology providers and reduce reliance on external advisers or consultants, thereby accelerating the uptake of these opportunities to the benefit of each site.

This would be achieved by generating various easy-to-use documents and a software tool to enable site engineers to identify, quantify and assess the viability of energy savings opportunities relating to site refrigeration plant.

To ensure that the outcomes of the project meet the specific needs of the red meat processing industry, a series of interactive workshops (10) across a range of processor sites were conducted both to

1) test the applicability and accuracy of the advice contained within the documentation against the opportunities observed on these sites, and to
2) obtain feedback and input from each site on the effectiveness of the WIP documentation and tools.

Interim project progress was shared with AMPC members by way of a series (3) of online webinars and seminars to provide an opportunity to disseminate results from the workshop activities to the members. The need to resort to online delivery was necessitated by COVID-19 restrictions.

Site observation and feedback from site personnel encouraged significant changes, developments and refinements to the content, style and approach found to be useful, effective and accurate for both the documentation and tool. The project authors are confident that the resulting deliverables meet the original objectives of informing and empowering site staff.

The authors made various adjustments to the project methodology and deliverables from the original proposed approach, and the changes and reasons for undertaking these are reported below.

3.1 Guidebooks

The Guidebooks are designed to help site staff to identify energy efficiency opportunities on their own refrigeration systems. Therefore, these books need to cover relevant topics and should be accessible, uncluttered and user-friendly even to non-engineering-trained personnel. Finding out what works and what does not was key to achieving a good outcome.

3.1.1 Guidebooks as proposed in the research proposal

The project proposed to achieve this by developing Energy Efficiency Opportunity (EEO) Guidebooks tailored to three specific types of sites:

1 – ammonia refrigeration with site rendering.

2 – ammonia refrigeration without site rendering; and

3 – non-ammonia refrigeration.

These site types have fundamentally different economic drivers and at the time of proposal submission, there was assumed to be little overlap between the commercially viable opportunities for the different site types. Separate guidebooks would therefore focus each site on those opportunities more likely to be relevant.

An early assumption informing this classification was that rendering would at all times provide all the site heating needs for both washdown and sterilisation, such that all integration related EEOs would be inapplicable to rendering sites.

3.1.2 Issues identified with the original Guidebook structure

Draft Guidebooks were prepared ahead of the first workshops, containing known EEOs assumed to be applicable to the three categories of site as defined in the research proposal. After conducting early workshops, it became evident that whether or not rendering is conducted on a given site is an imperfect identifier for suitable refrigeration EEOS:

1) Some small sites with non-ammonia refrigeration were found to be conducting rendering.
2) Due to the physical arrangement of refrigeration, steam boilers and rendering on each site, integration of the refrigeration systems were found to be potentially feasible on several sites, simply because the heat requirement would be closer to the refrigeration systems than the steam boilers/rendering.
3) On several sites with rendering, timing issues with steam plant operation meant that heat from the rendering was often not available at some times such as early mornings, and often steam boilers were started earlier than needed on these sites, only to provide wash-down water. Integration of the refrigeration systems would indeed make sense on these sites, in spite of the presence of rendering.
4) Other factors beyond the presence of rendering were found to have a more fundamental influence on the viability of refrigeration EEOs, such as the use of carcass reheat in carcass chillers and the widespread absence of basic/foundational conditions enabling most EEOs.

Consequently, the rendering vs non-rendering classification was found to be inappropriate and was ditched in favour of a revised structure.

Furthermore, significant developments with widespread media coverage affecting the medium- and long-term viability of synthetic refrigerants arose during project, including:

1) The environmentally damaging effects of some common HFO refrigerants proposed for long-term use became known. Specifically, it was found that R1234ze and R1234yf, both key components in commercial HFO blends proposed for the temperature ranges typically used in meat processing facilities, were shown to degrade to R23 once released to the atmosphere. R23 is a highly damaging substance with massive global warming potential. It is likely that these breakdown products will be considered in future restrictions on the application of HFO refrigerants, accelerating their phase-out in future.
2) The accumulation of long-term stable and unnatural breakdown products of all synthetic refrigerants (including the proposed long-term HFO refrigerants) in all fresh water bodies (and hence human drinking water) have been shown to be increasing rapidly. The effects on human health, whilst scientifically unclear and disputed, will accelerate the phase-out of this class of substances.
3) The direct global warming emissions resulting from refrigerant leakage will need to be offset in future, adding additional costs to every operation using synthetic refrigerants.

Consequently, upgrading existing HFC-based refrigeration systems, or replacing these with HFO-based systems is unlikely to be a wise, long-term decision for Australian meat processing sites. Suitable caveats have been added to the non-ammonia Guidebook to inform site staff.

3.1.2 Final developed Guidebook structure

The final Guidebook structure developed in response to the issues identified during the project still resulted in the development of three Guidebooks, but structured as follows:

1) Commercial Refrigeration Systems Guidebook, providing guidance on short/medium term improvement of existing synthetic refrigeration systems, and substantive guidance on non-synthetic replacement options. Typically, this Guidebook would inform many of the smaller non-ammonia sites.
2) Industrial Refrigeration Systems Guidebook, two parts.
    a. Part 1 covers Essentials (basic first steps required for all ammonia plants) and Hard Yards (major investments to be conducted early in the efficiency improvement process.
    b. Part 2 covers Refinements (EEOs that achieve significant savings, but that follow on from the Essential and Hard Yards and are ineffective if implemented too soon) and Integration (using waste heat from refrigeration systems to offset fuel consumed on site for heating purposes).

The classification of the EEOS into the four stages above (Essentials/Hard Yards/Refinement/Integration) were in response to the findings during workshops that:

- The refrigeration systems on several sites lacked basic requirements such as sufficient or accurate instrumentation and modern PLC controls, making it practically impossible to correctly implement many common EEOs.
- Several sites had implemented expensive EEOs, such as installing large VSDs on compressor drive motors, without the above basic requirements in place, and/or with other significant control issues such as plant stability not resolved prior. These sites therefore were experiencing little benefit from these investments.

To further assist with informing the correct staging of EEOs, the Guidebooks were expanded to cover Synergies between EEOs (for example – economisers must follow compressor speed control) and the terminology of Enablers (speed control in this example) and followers (economisers) was coined and applied through both Industrial Refrigeration System Guidebooks.

It should be noted that these synergies, and hence the need for staging of EEOs is not applicable to Commercial Refrigeration Systems.

3.2 New Technology handbook

One of the project objectives was the preparation of a New Technology Handbook (NTH) to highlight new and potentially disruptive technologies that could offer viable alternatives to current refrigeration systems even when these are improved by implementation of EEOs.

Some known technologies, such as heat pumps using ammonia and full CO_2 refrigeration systems, are continuously evolving as suppliers develop more capable equipment, and hence their current and near future capabilities uncover opportunities that earlier versions could not. These technologies are therefore included in the Guidebooks and the New Technology Handbook.

Some well-established older technologies, such as Absorption Refrigeration or Organic Rankine Cycle systems, are now facing renewed interest due to their applicability to effective use of biogas.

3.3 Software Tool

Another objective of the project was to develop a tool (software tool) to accompany the Guidebooks and Manuals, with the intention to trial the tool during the workshops to get feed for further development.

Due to the COVID pandemic, the intended face-to-face workshop format was abandoned and the original intent of working with site personnel to use the draft tool with site information gathered with the staff, had to be abandoned.

Instead, the approach was taken for the site to gather and provide more information for offline assessment by Minus40, and then to provide a demonstration of the results in a later online session of the workshop. Unfortunately, this approach gave site staff less direct exposure to the tool than originally intended. This should ideally be rectified by running several online workshops on the capabilities and use of the tool (See recommendations). It did provide Minus40 with the opportunity to do more off-line development of the tool using the collected site data.

Ultimately, the final tool is easy to use even for non-engineering staff, and provides common data entry for all EEOs, as well as an overview of refrigeration energy use site wide.

3.4 How-To Manual and reference manual

An energy efficiency opportunity implementation guidance (How-To) Manual was prepared to compliment the Guidebooks and the Tool. A style similar to the Guidebooks, in non-jargon, diagrammatic and pictorial format was chosen. The Manual covers all opportunities contained in the three EEO Guidebooks, but not those in the New Technology Guidebooks.

The emphasis of the How-To Manual was changed from how to quantify savings of EEOs to how to implement EEOs and apply the Tool for quantification of the EEOs. Already quantifiable EEOs were included in the Tool, avoiding the need for specific guidance on such calculations in the Manual.

3.3.1 Original How To Manual scope VS final result

As per the original research proposal the How to Manual was intended to cover all opportunities and include the following for each EEO:

Original research proposal	Tool	How To Manual	Comments
What information is required to assess each opportunity	Measured data entered into Tool	Information required detailed in Manual	
How to collect and assess/analyse it?		Collection of data described in Manual, including diagrams or photos to illustrate	
What additional metering or measurement in some		Described in Manual	

cases is needed, and suggestions of How to do this.			
It will also include guidance on How to interpret your power bill.	Data from power bill to be entered into Tool input sheet	Guidance on what information to extract from power bill included	The tool uses entered power bill data for energy calculations
What calculations need to be conducted using the gathered information to estimate annual savings in energy and cost?	All calculations are managed by the underlying sheets in the Tool	No formulae are used in the Manual. These are included in the Tool and detailed in the documentation of the Tool	The Manual and Tool in their final format do not require site staff to apply manual calculations using formulae.
Formulae will be provided, and where plausible a spreadsheet-based tool will be provided with the Manual to assist.	The Tool provides savings estimates for all calculable opportunities once data input sheets have been populated	The need for formulae to be applied by site staff has been avoided	
Guidance on hardware (mechanical and electrical) and software (PLC programming) requirements to implement each EEO. Where plausible, suitable suppliers and/or costing rules of thumb will be provided to develop budget project costing.	Not included	Guidance on hardware and control included in Manual.	Supplier recommendations are not included as this would cause the Manual to be out of date quickly. For the same reason, and to focus on implementation guidance, implementation costing has not been attempted in the Manual (or Tool)
Guidance on long-standing government energy efficiency support programs (NSW ESCs, Vic VEECs) and how to estimate project contributions. This will not include short- lived state or federal programs	Not included	Not included	An overview of available support measures was provided during the final Webinar and Seminar, to include federal ACCUs. Specific guidance on calculation of these contributions has not been included into the Tool or Manual due to the technical complexities associated with certificate creation.

Guidance on "How to prepare a Business Case" (drawing from OEH material) using the information generated above.,	Not included	Not included	The Manual was significantly expanded to include more details on implementation of EEOs and estimation of project costs and the subsequent business case preparation have been excluded to compensate.

3.3.2 Treatment of NTH in How To Manual

As per the original research proposal, the Manual was intended to cover the New Technologies also, but it was found that usable and basic guidance suitable for site staff could not realistically be developed for these novel technologies, and consultation with field experts is advised for all New Technologies.

3.3.2 Reference manual

Also, as per the original research proposal, the How-To Manual was to be accompanied by a separate reference manual to document the underlying assumptions and information sources used to develop the guidance in the Manual.

The final How To Manual does not contain guidance on the calculation/quantification of EEOs as all EEOs found to be readily calculable were included into the Tool. Therefore, the reference manual now documents the calculations and assumptions as applied within the Tool only.

This provides a basis for later updating of the Tool with changes of technology and market factors.

4.0 Project Approach and Methodology (Workshops and Seminars)

A fundamental premise of the project methodology was to conduct up to 10 workshops on a range of small and large participating processor sites to gather information with which to develop and fine-tune the documentation and the tool. In addition, three seminars would be held to provide feedback to participants on project progress and interim documentation.

This approach was successfully taken, but the COVID-19 pandemic necessitated several significant changes to the

4.1 Methodology as per research proposal

The original intended approach as per research proposal was that documents and tool will be trialled and improved during a series of on-site workshops, which would serve the additional purposes of gathering material to illustrate examples referenced in the guidebooks and manual and directly assisting participating sites by training the site staff and identifying energy opportunities at each site.

These workshops are primarily used to TEST the guidebooks and manuals but have the secondary benefits of providing direct guidance to each participating site, and training of the site staff.

The EEO and the New Technology Guidebooks will initially be developed in draft format with information deficits identified (e.g., where good or sufficiently documented examples are not available). Subsequent trials/workshops can be tailored to address these deficits.

The workshops would involve the following:

- Introductory presentation by Minus 40 on Energy Efficiency Opportunities from the applicable Guidebook and the New Technology Guidebook, but without addressing specific site observations.
- Working session where all participants individually note opportunities applicable to their site.
- Workshop session where all opportunities identified by each participant and Minus 40 are tabled, listed on whiteboard and discussed. Shortlist of around 5 opportunities is jointly developed.
- 2nd Working session where all participants individually use the How-To Manual and the software tool (as applicable) to attempt to quantify the savings for each opportunity.
- 2nd Workshop session where the quantification for each opportunity is worked through as a team exercise. This could also include discussion of possible practical hurdles to the uptake of each opportunity.
- 3rd Workshop session to obtain practical feedback on Guidebooks and Manual, to be specifically recorded as workshop outcome.

At the conclusion of each workshop a site audit and workshop report will be compiled to summarize the opportunities identified, expected savings and identified hurdles to implementation.

After completion of the 2nd, 6th and final workshops, a seminar would be held to present the results from the earlier workshops and provide an overview of the documentation and tool as developed at that time.

4.2 Methodology as adapted to suit site access restriction

The COVID-19 pandemic eliminated the possibility of site visits and face-to-face seminars.

Minus40 conducted an extensive investigation into technology options to conduct the site workshops remotely.

The investigations were focused on identifying the most suitable software (of at least 25 options on the market) to use in conjunction with the unique Realwear HMT-1 interactive headset.

The HMT-1 is a transformative technology that enables a wide range of remote collaboration use-cases ranging from inspections, guided installations, emergency support, troubleshooting, remote guidance, documentation control and many more. Consequently, a vast range of software platforms and applications have been developed, many very specific to one industry or use case only.

The objective of this investigation was to evaluate commercially available, ready-to-use software solutions that utilize the HMT-1 features of value to site inspections, and provide a high quality, effective and comfortable user experience for all parties involved with the inspection.

Whilst many software solutions were examined, and a quite large number offered a usable solution, the stand-out solution for reasons detailed in this report, and at the time of evaluation (April-May 2020), was the Ubimax xAssist solution.

Minus40 then acquired two Realware headsets and a 1-year Ubimax software licence and commenced to use the headset for workshop investigations. This was generally successful, but Wi-Fi and 3G connectivity on sites did end up limiting the usefulness of this technology. Minus40 worked with the site engineers to additionally provide sets of photographs of equipment needed for the off-line investigations.

The workshop structure was then adapted to suit the new realities, and were generally conducted as follows:

- An initial site familiarization session was conducted with one site support person wearing the headset. This was then generally followed up by a wish list of data and photos for the site to collect and send through, generally via Dropbox upload.

- Introductory presentation to the site team via Zoom by Minus 40 on Energy Efficiency Opportunities from the applicable Guidebook and the New Technology Guidebook. As this presentation followed site familiarisation, reference t observed opportunities was generally made during this presentation
- Subsequent to the presentation, site participants were requested to indicate which EEOs would be of interest to them. This was then discussed and an agreed list of target EEOs for investigation was compiled.
- A second and more detailed remote site investigation was subsequently conducted with the site support person. More information was then gathered on site and forwarded to Minus40
- Minsu40 then conducted modelling and calculations using the current tool version in preparation for the second workshop session.
- A second workshop session involving the same site team was scheduled, generally a few days after the first. During this session the results of Minus40 modelling was presented and discussed, and the tool demonstrated showing results achievable. The workshops outcomes were noted and included into the workshop report.

At the conclusion of each workshop a site audit and workshop report was compiled to summarize the opportunities identified, expected savings and identified hurdles to implementation. Due to the more extensive modelling conducted by Minus40 these reports were comprehensive and detailed and included a summary of main refrigeration equipment on site (compressors and condensers), relevant photographs and recommendations for site actions.

5.0 Project Outcomes (Deliverables)

The adjustments to the documents and tool during the project have been detailed in section 3.0 above. The final deliverable therefore include:

5.1 Commercial Refrigeration Systems Guidebook

This guidebook is largely aimed at smaller sites not currently using ammonia refrigeration. A total of 11 EEOs relevant to sites with Freon systems were detailed in the guidebook:

- Fan speed control
- Condenser fans upgrade
- Staging and variable speed compressor control
- Adiabatic cooling of condensers
- EXVs and floating head pressure control
- Defrost termination
- Solar PV and thermal storage
- Plant Upgrade
- Heat recovery
- CO2 air-source heat pumps

5.2 Industrial Ammonia Systems Guidebook, Part 1

This guidebook is aimed at all processors using centralized ammonia refrigeration systems, and makes extensive reference to the synergies between the EEOs (Enablers and Followers), as developed during the project

Part 1 covers the Essentials (7 EEOs) and Hard Yards (12 EEOs):

Essentials:

- Control &monitoring upgrade
- Plant stabilisation
- Vessel liquid level control
- Condenser fan speed control
- Compressor speed control and staging
- Air & water removal
- Oil injection optimisation

Hard Yards

- Suction flow meters
- Compressor block replacement
- Dedicate hot gas compressors

- Hot gas float valves
- Bottleneck removal
    - Undersized condensers
    - Undersized discharge line
    - Undersized suction line
    - Wet riser removal
    - Undersized evaporators
    - Undersized compressor motors
- Condenser upgrade

5.3 Industrial Ammonia Systems Guidebook, Part 2

Part 2 covers Refinement (7 EEOs) and Integration (3 EEOs).

Refinement

- Evaporator fan speed control
- Variable head pressure control
- Suction pressure optimisation
- Efficient compressor motors
- Defrost drain to his stage suction
- Defrost optimisation
- High stage economisers

Integration

- Heat recovery
- Integrated heat pumps
- Air-source heat pumps

5.4 New Technology Handbook

This handbook covers 11 new technologies applicable to all sites

- CO2 cascade system
- Full CO2 systems
- Low Charge ammonia systems
- Smart packaged refrigeration units
- Ammonia heat pumps
- CO2 heat pumps
- Central glycol systems
- Ammonia absorption systems
- IoT technology

- Refrigeration as a Service
- Organic Rankine Cycle systems

5.5 How To Manual

The manual is a practical guide to implementing the EEOs covered in the guidebooks and the tool

5.6 Software Tool

The tool provides initial estimates for the energy savings opportunities that can be calculated with at least some level of confidence (not all EEOs covered in the guidebooks lend themselves to quick or high level yet usable analysis) for all sites. Specifically, the tools provides estimates the benefits of:

- Compressor speed control and staging
- Compressor block replacement
- High efficiency motors
- Dedicated hot gas compressor
- Variable head pressure control
- Condenser fan speed control
- Evaporator fan speed control
- High stage economiser
- High stage suction pressure increase
- Low stage suction pressure increase
- Heat recovery
- Heat pumps

The tool yields a very usable site-wide dashboard for sites with a central refrigeration system

In addition, the project delivered 10 off site workshop and audit reports

6.0 Discussion (Insights)

The project delivered a number of usable insights and learnings that were largely informed by workshop results and interaction with site staff, but also as a result of internal development and brainstorming.

6.1 Sequential implementation of EEOs

The sequence in which improvements are implemented was seen to be critical, leading to a classification of the industrial refrigeration Energy Efficiency Opportunities (EEOs) into four phases – Essentials, Hard Yards, Refinement, and Integration. Several of the participant sites had implemented advanced EEOs, but these were dysfunctional because basic precursor projects had been omitted.

6.2 Synergies between EEOs

Synergies between EEOs, and the coining of the useful terminology of Enablers and Followers to assist with the optimum sequencing of EEO implementation was found to be helpful and assisted with the structuring of the Guidebooks.

6.3 Rudimentary issues hindering EEOs

To the surprise of the investigators, many of the refrigeration systems at participant sites showed quite rudimentary issues impeding energy efficiency, such as plant stability issues, insufficient control capability, or inaccurate sensors. This caused an expansion of the Essentials section to ensure these basics where clearly highlighted.

6.4 Low uptake of proven, classic EEOs

Also, to the surprise of the investigators, very few of the participant sites had adopted many or any of the classic energy efficiency opportunities. It had been hoped to develop a library of examples of EEO implementation to illustrate the documentation, but this was only possible in limited fashion.

6.5 Generally low uptake of EEOs

Generally, the level of adoption of EEOs across all participating sites was very low. It became clear that the key driver was lack of awareness of what is available and possible, rather than cost of each EEO. The focus of the Guidebooks therefore shifted emphatically to awareness and understanding, at the expense of more detailed guidance on EEO costing and business case development.

6.6 Methodology as per research proposal

The two most significant disruptors of energy efficiency on industrial refrigeration systems were found to be the use of hot gas for carcass reheat on sites processing high-fat cattle causing significant false load on the refrigeration plants, and fundamental plant stability issues that overwhelm most EEOs

7.0 Conclusions and Recommendations

7.1 Conclusions

7.1.1 Significant energy efficiency improvement potential available

A significantly positive conclusion from the workshops (refer to 10 workshop reports) are that all sites exhibited significant potential for energy efficiency improvement.

7.1.2 Low and generally unplanned uptake of EEOs

The significant energy efficiency improvement potential on the participant sites is a result of low levels of adoption of energy efficiency techniques amongst participating sites, for various reasons. Specifically, with reference to the four stages of improvement identified in this project (Essentials / Hard Yards / Refinements / Integration), the 10 participating sites:

- 6 have not progressed beyond the Essentials
- 3 have started implementing some of the Hard Yards
- 8 have implemented some of the Refinements, mostly only 1 EEO
- NIL have implemented any Integration

Furthermore, of the total number of EEOs identified in the study, the highest achieving site has implemented 36% of these EEOs, and on average only 17% of EEOs have been implemented per site.

In conclusion, assuming these 10 sites are indicative, Australian meat processors are still removed from optimum refrigeration plant design and operation to their international competitive disadvantage.

7.1.3 Need for better on-site understanding of refrigeration plane efficiency fundamentals

There is a significant need for much deeper understanding on site level of basic plant efficiency fundamentals, such as the need for stable plant operation, accurate sensors and good-quality control and monitoring systems, ahead of more flashy (and costly) opportunities such as compressor speed control.

The documentation generated by this project can serve as basis for informing site staff and management on the importance of controlling these fundamental.

7.1.4 Lack of integration of refrigeration with site heating systems

Integration of refrigeration systems into other services, such as the provision of hot water for washdown or sterilisation, was not observed on any of the participant sites. Significant advancement of integration on all sites will be required in the interests of industry decarbonisation.

7.2 Recommendations

7.2.1 Webinars on the Software Tool use

The Software Tool is a simple and useful tool to assist site managers to understand where potential savings on their refrigeration systems can be achieved.

To encourage uptake of the tool across the industry, it is proposed that a series of webinar or alternatively interactive workshops should be conducted for members, AND that the tool should be made easily accessible via the AMPC website.

It is also recommended that the tool is scheduled for an annual revision to ensure accuracy and relevance.

7.2.2 Webinar series on Guidebooks and How To Manual

The Guidebooks and the How-To Manual contain a wealth of practical and usable information. It is well suited to self-learning, but a structured series of webinars for members on the EEOs, their identification and their implementation is recommended.

7.2.3 Planned and stage approach to refrigeration energy efficiency improvement

The authors recommend that all sites adopt a coordinated and staged approach to the improvement of the energy efficiency of their refrigeration systems. The new Guidebooks should be of significant value in this regard, as these do set out a logical sequence of implementation.

7.2.4 Use of information technology to accelerate uptake of improvements

Selective adoption of new technologies (refer to the New Technology handbook) should be considered, especially the use of information technology solutions such as IoT and Refrigeration as a Service, which enable the improvement of site systems with ongoing remote expertise. This is a vital step considering the physical remoteness of most meat processing sites, aggravated by the recent COVID 19 pandemic.

8.0 Bibliography

The authors have relied on Minus40 internal records and the following external resources in preparing this research document

1) ***Ammonia Refrigeration Piping Handbook*** published by the International Institute of Ammonia Refrigeration (IIAR), 2000
2) ***I am your industrial refrigeration guide*** prepared by Minus40 Pty Ltd and published by the NSW Office of Environment and Heritage, 2017
3) ***Float Regulation Hot Gas Defrost***, published by TH-Witt GmbH, undated.
4) ***HT Series & HD101 refrigerant float drain regulators,*** Bulletin D409a published by Hansen Technologies Corporation, Jan 2004