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# Refrigeration

## Energy-Efficiency Opportunities

FOR THE AUSTRALIAN MEAT PRO-CESSING INDUSTRY

New Technology Handbook

# REFRIGERATION
## ENERGY-EFFICIENCY OPPORTUNITIES

FOR THE AUSTRALIAN MEAT PROCESSING INDUSTRY

NEW TECHNOLOGY HANDBOOK

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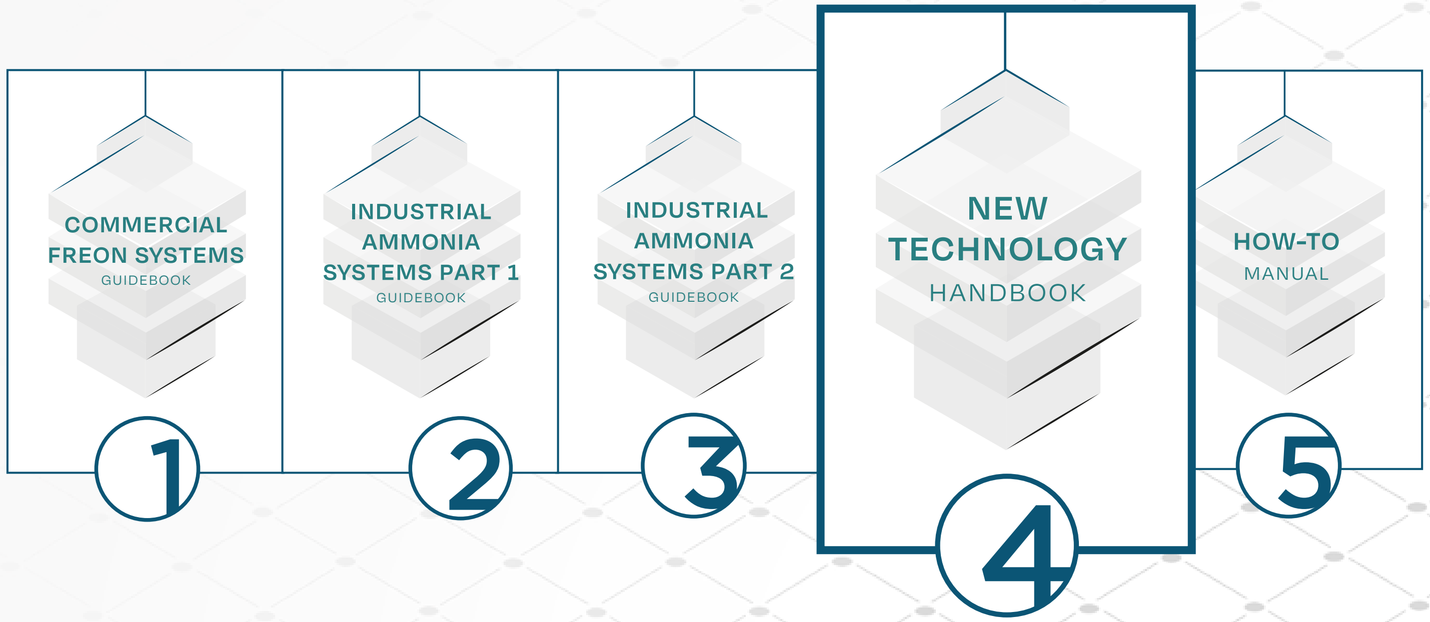
# INTRODUCTION

This Guidebook is one of 5 Guidebooks/Manuals which were developed during the **"Refrigeration Plant Energy Improvement"** research project.




Guidebook: Commercial Freon Systems covers **smaller abattoirs** which often use multiple small commercial refrigeration systems with freon refrigerants.

Guidebook: Industrial Ammonia Systems Part 1 & 2 cover **medium to large sized abattoirs** which use large, centralized ammonia systems for refrigeration. These systems are much more complex than small commercial systems and require a stepped, strategic approach to improve energy efficiency.

The New Technology Handbook covers the **most recent developments** in refrigeration as applicable to the red meat industry. Refrigeration is undergoing some decisive changes which will have major impacts on the operational costs of refrigeration systems. **Awareness of these developments** is crucial when it comes to decision-making on major plant upgrades/restorations as investments into outdated technologies could result in a competitive disadvantage.

To further **determine the viability** of opportunities discussed in the books mentioned above, the How-To Manual gives guidance on how to initially assess opportunities and use the Energy Efficiency Opportunity Calculation Tool where applicable.

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# NEW TECHNOLOGY HANDBOOK

Australian meat processors have a **high demand for refrigeration and heating**, and use a wide variety of technologies to provide these essential services to suit the scale and location of each facility. Traditionally, heating is provided by the burning of a variety of fuels (including recently the addition of biogas) to generate steam or hot water for rendering, sterilizing and wash-down, whilst refrigeration is provided by either centralized ammonia or decentralized synthetic refrigerant units to provide cooling for a range of processes such as freezing, carcass chilling, cold storage, process area conditioning, etc.

High fuel costs, decarbonisation, environmental pressures, refrigerant phase-out, availability of regenerative energy and high electricity costs are all factors in reconsidering whether the **current solutions can be improved upon or even entirely replaced.**

# WHY THIS HANDBOOK?

This New Technology Handbook has been prepared to provide succinct and relevant information on replacement options for such cooling and heating equipment, in a concise and consistent format, with links to additional reading and reference resources. The New Technology Handbook is intended to compliment the Guidebooks, Manual and Tool and provide the reader with the single-source summary of the technologies that are market-ready, commercially available, and likely to be financially viable under the right circumstances.

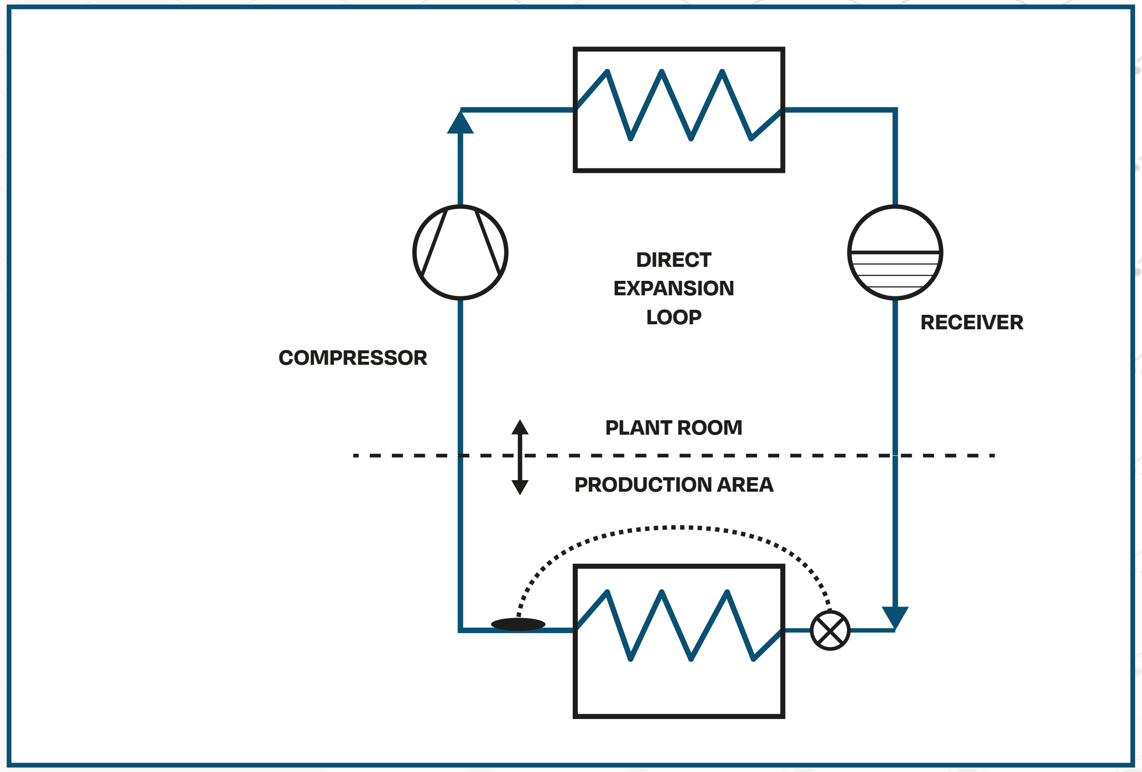
# DEFINITIONS & TERMINOLOGY

## TYPES OF REFRIGERATION SYS-TEMS

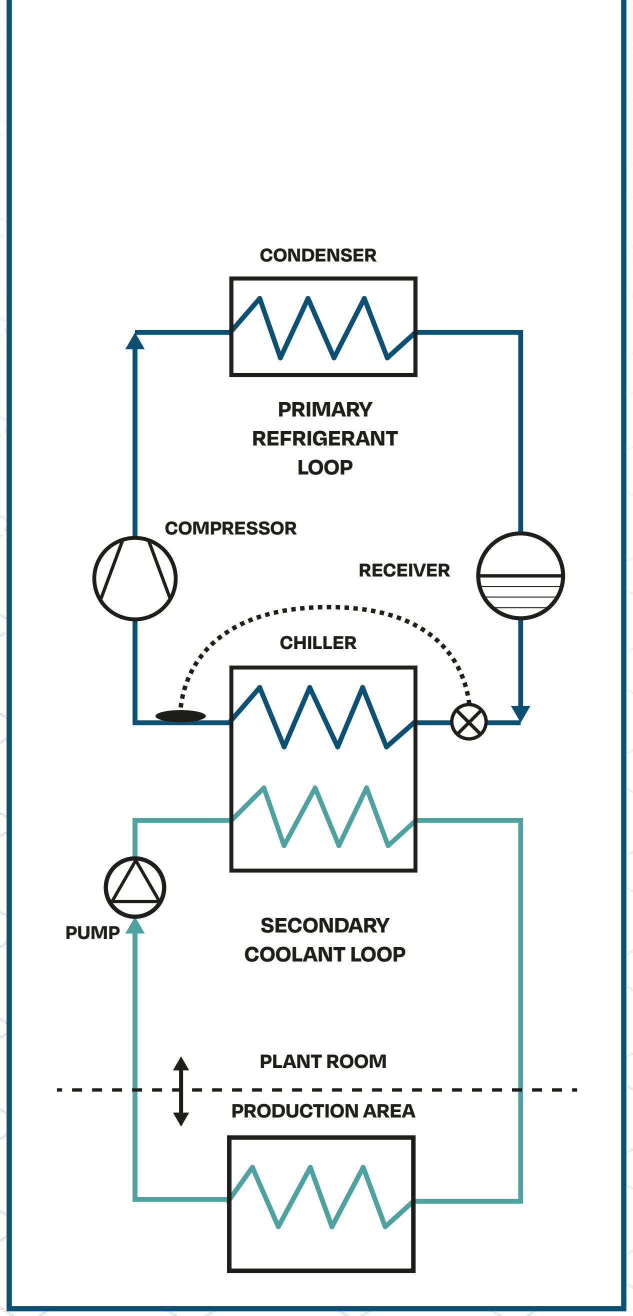
To assist the reader, some concepts common or relevant to many of the technologies covered in this handbook are explained in this section

### DIRECT EXPANSION REFRIGERATION SYSTEM

Direct Expansion (DX) refrigeration is the most basic refrigeration arrangement, with direct liquid feed to each evaporator via an automatic expansion valve that regulates the rate of liquid feed to each evaporator to match the need for evaporation, and a dry suction return line to the compressor. Most synthetic refrigerant systems are DX, but low charge ammonia systems have also adopted DX technology, albeit optimized for ammonia refrigerant. DX systems are generally compact with low refrigerant charge and less costly than other options.

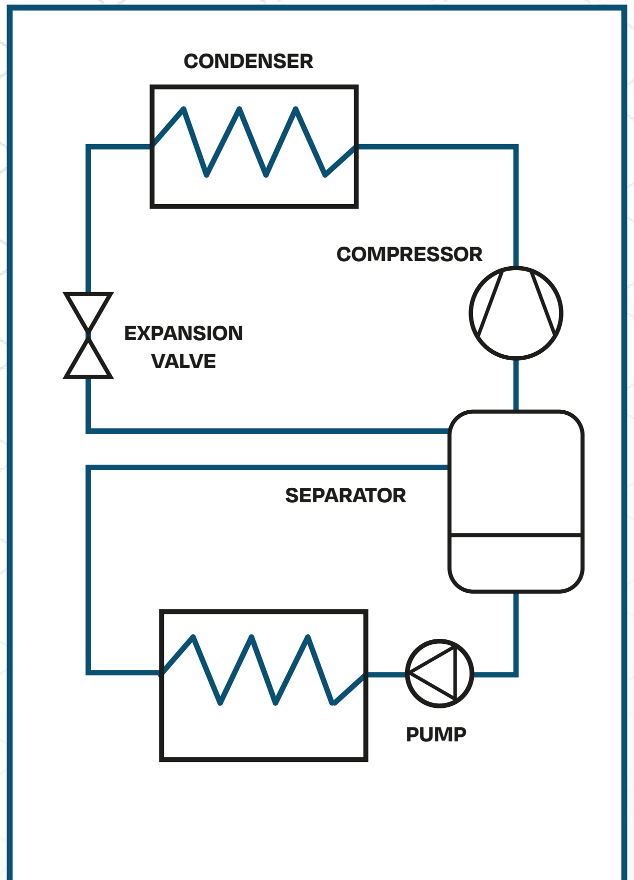





### SECONDARY REFRIGERATION SYSTEM

Secondary refrigeration systems, sometimes also referred to as brine or glycol systems, use a compact refrigeration unit typically in a plant room to chill a secondary fluid, which is then pumped through a pipe system to individual heat exchangers or fan coil units. Here the fluid warms up and is then returned to the plant room. Secondary systems avoid the need for primary refrigerant to circulate outside the plant room, reducing risk (ammonia) and costly leaks (synthetic refrigerants).




### LIQUID RECIRCULATION REFRIGERATION SYSTEM

Liquid recirculation (LR) refrigeration, also known as pump-flooded or liquid overfeed, involves refrigerant pumped through each evaporator at a higher rate than is needed for evaporation (hence overfeed), with the excess returning to a separator vessel where the suction gas is separated and drawn away by the compressor. Most conventional ammonia systems are LR, characterized by the presence of large vessels and high refrigerant inventory.

# REFRIGERANTS & PHASE-OUTS / PHASE-DOWNS?

### SYNTHETIC REFRIGERANTS (CFC, HCFC, HFC, HFO)

Synthetic refrigerants have been in wide use since the 1930's when they were developed as so-called "safety refrigerants", but are generally damaging to the environment due to their Ozone Depletion Potential (CFCs and HCFCs) and their Global Warming Potential (CFCs, HCFCs and HFCs), and most have either already been phased out (CFCs and HCFCs) or in the process of being phased down (HFCs). The only long-term synthetic refrigerant category that is neither damaging to the ozone layer not contributing to climate change are the HFOs, which are not yet in wide use, least of all in the meat processing industry, but are both flammable and toxic. Recent discovery of the harmful effects of fluorocarbon refrigerant degradation products are likely to further accelerate the phase-out of all synthetic refrigerants.

Synthetic refrigerants still in common use in the meat industry include R22 (an HCFC, hence already phased out and becoming expensive and hard to find), and R404A and R134A (both HFCs and being phased down). Hence ALL synthetic refrigerants used in the meat industry are problematic and will result in higher maintenance costs in the short/medium term.

### NATURAL REFRIGERANTS (AMMONIA, $CO_2$, HYDROCARBONS)

Natural refrigerant are substances found in nature and hence present no danger to the environment, and therefore have no risk of phase-out or other restriction on their wider use. Natural refrigerants are also generally inexpensive, and most are well suited to the design of energy efficient refrigeration systems.

The most widely used natural refrigerant in the meat industry is ammonia ($NH_3$, R717), which is mildly flammable and highly toxic, but low cost and lends itself to the design of highly energy efficient refrigeration systems. Compliance with safety requirements is a major challenge with ammonia systems.

Carbon Dioxide ($CO_2$, R744), which is mildly toxic but not flammable, is an old refrigerant that has experienced a resurgence in recent years with the phase-down pressures on synthetic refrigerants and has many advantages for the meat processing industry. Safety compliance is quite easy despite high system pressures.

$CO_2$ was one of the refrigerants used at the advent of mechanical refrigeration in the 1870's and was widely used until the 1950's and phased out in favour of the new CFC gases (R12, R502) in the 1930's.

The phase-down of synthetic refrigerants in Australia from 1998 (CFCs and HCFCs) and 2018 (HFCs) and increasing safety constraints on ammonia systems has seen $CO_2$ make a resurgence as refrigerant during the past 15 years, and it is now widely use in industrial and commercial refrigeration.

Hydrocarbons such as Propane (R290) and Isobutane (R600A) are increasingly being used for small systems (domestic refrigeration, split system air conditioners) but do not offer a realistic alternative for major refrigeration systems at meat processors.

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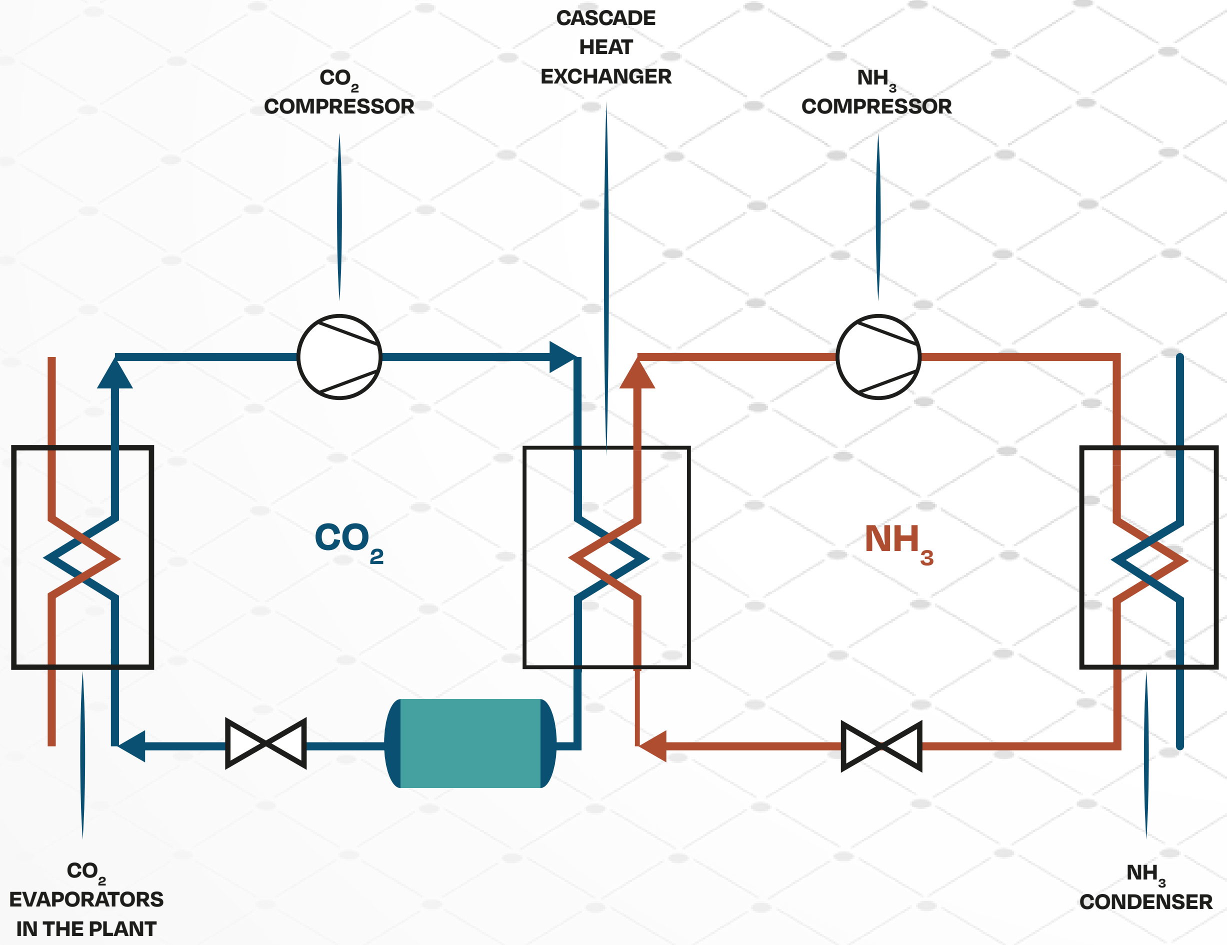
# $CO_2$ AS REFRIGERANT

## IN CASCADE/ SUB-CRITICAL SYSTEMS

## WHAT IS THIS TECHNOLOGY?

**$CO_2$ (R744) AS REFRIGERANT, AS LOW TEMPERATURE SYSTEM.**

$CO_2$ has a very low critical temperature of 31.1 C° (above which the gas cannot condense), unlike all other refrigerants, and therefore needs the assistance of a second refrigeration system to condense, especially in summer conditions. Such refrigeration systems, where $CO_2$ is used in conjunction with ammonia or a synthetic refrigerant to remain subcritical, are called cascade systems and because the system pressures remain below the critical pressure they are also known as sub-critical systems. The $CO_2$ system is referred to as the low-stage and the supporting system as the high stage.



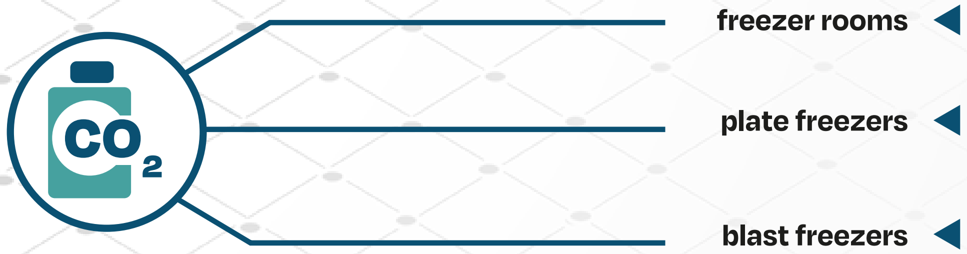

*Concept diagram for a $CO_2$ / $NH_3$ cascade refrigeration system for low temperature*

$CO_2$ Cascade systems provide low temperature cooling only (as opposed to full- $CO_2$ systems, see next Technology) and therefore best suited to freezing applications (below -20 C°, typically). Cascade/subcritical $CO_2$ systems are quite straightforward to design and are therefore already widely used in commercial and industrial refrigeration.

## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Most large processors in Australia use Ammonia (R717) as main refrigerant, and most small and many medium sized processors use various synthetic refrigerant (also known as Freon) systems, typically R22, R404A and R134A. $CO_2$ can replace all these refrigerants and offers several significant advantages over existing refrigerants.

Cascade or sub-critical $CO_2$ can replace all low temperature sections of the refrigeration system for all processors (small, medium and large).




## WHY IS IT NOVEL?

$CO_2$ was out of use as refrigerant for many decades. New engineering technology including better pipe materials, high pressure compressors, control valves designed for $CO_2$, and modern electronic controls has made the resurrection of this excellent technically and commercially refrigerant feasible.

$CO_2$ Cascade systems are already widely used but not yet mainstream in the meat industry.

## WHY IS IT BETTER?

$CO_2$ is a long-term refrigerant and natural substance (like ammonia) and is inexpensive and plentiful. $CO_2$ (like Ammonia) is part of the natural carbon cycle and very widely used for cold transport (dry ice) and for carbonated drinks and is an important industrial gas. Hence, we will never run out of $CO_2$, nor will its use as refrigerant ever be restricted for environmental reasons.

$CO_2$ is safer than ammonia (which is both flammable and toxic), as it is non-flammable and toxic only at high concentrations (unlike ammonia). Hence it can be safely used in occupied spaces (such as boning rooms).

$CO_2$ refrigeration systems using commercial compressors (Bitzer, Bock, Dorin, Copeland, etc) are generally lower in capital cost than ammonia systems and mostly also lower than Freon systems.

$CO_2$ refrigeration systems also use less space for compressors and pipework. Due to the high density of $CO_2$, pipework and compressor are typically 1/8th of the physical size of equivalent ammonia or freon units

$CO_2$ systems are easily installed by re-trained commercial refrigeration contractors (who currently do Freon systems) because they can be built with copper pipes (and not steel as needed for ammonia systems). Cascade systems operate at pressure levels similar to ammonia or Freon systems, and can therefore be built with similar pipe materials.

## WHAT ARE THE LIMITATIONS & CHALLENGES?

Cascade refrigeration systems require another refrigeration system for condenser cooling. Either through direct ammonia cooling or using chilled glycol. However, if that other system does medium temperature cooling anyway (e.g. carcass chilling), then Cascade $CO_2$ does make sense

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Because there are in effect two separate refrigeration systems (one $CO_2$, another ammonia/glycol), the total cooling system becomes more complex, with two refrigerants with different lubricants and pipe materials. However, glycol systems are already widely used by most medium/large processors and cascade $CO_2$ can be an easy add-on.

Many Australian refrigeration contractors have not yet been trained in the use of $CO_2$ systems but this is rapidly changing.

## WHERE CAN I GET THIS PRODUCT OR SERVICE?

Most reputable refrigeration contractors can offer to design and install $CO_2$ cascade systems

## SOME USEFUL LINKS & REFERENCE MATERIAL

https://www.linkedin.com/pulse/co2-natural-refrigerant-gaining-popularity-again-alec-johnson/

https://www.ampc.com.au/2018/02/An-Integrated-CO2-Production-and-CO2-NH3-Cascade-Refrigeration-System

https://www.hvacrschool.com/what-is-cascade-refrigeration/

https://www.refrigeratedfrozenfood.com/articles/92807-ammonia-vs-ammoniaco2-cascade-systems

**USEFUL MEAT INDUSTRY REFERENCE SITES**

1. AAA Co in NT (now decommissioned)
2. Australian Lamb, Colac

# $CO_2$ AS REFRIGERANT –

## FULL $CO_2$ SYSTEMS

### WHAT IS THIS TECHNOLOGY?

▶ **$CO_2$ (R744) AS REFRIGERANT, AS FULL $CO_2$ SYSTEMS.**

Full- $CO_2$ systems provide low, medium and high temperature cooling (as opposed to cascade- $CO_2$ systems that provide low-temperature cooling only, see previous Technology) and therefore under some operating conditions system pressures can rise well above the critical pressure. Full-$CO_2$ systems are therefore also known as trans-critical systems. Transcritical/ full- $CO_2$ systems are more complicated to design as they can operate in both sub- and trans-critical modes, and therefore they have only recently been more widely used in Australia.

Full- $CO_2$ systems have been the victim of a lot of "fake news" suggesting that these systems are only suitable for cold climates, but this has been proven to be untrue. Recently full $CO_2$ systems have even been successfully installed and commissioned in Dubai, fully disproving this fallacy.


*Full $CO_2$ system at NSW cold store, with transcritical (below) and low temperature compressors (above)*







### WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Can replace ALL refrigeration needs – freezing (low temperature), chilling (medium temperature) and air-conditioning (high temperature) – currently served either by ammonia ($NH_3$) or synthetic refrigerant systems (like R22, R134a, R404a). Even fully displaces some $CO_2$-cascade applications.

Mainly applicable to small/medium processors and not yet applicable to large processors, but technically plausible for large applications.

### WHY IS IT NOVEL?

$CO_2$ was out of use as refrigerant for many decades. New engineering technology including better pipe materials, high pressure compressors, control valves designed for $CO_2$, and modern electronic controls has made the resurrection feasible.

Full- $CO_2$ systems are increasingly being used in food retail and in food manufacturing applications, but not yet mainstream in the meat industry, although it offers some very distinct advantages that are particularly useful for the meat industry, like heat recovery.

### WHY IS IT BETTER?

$CO_2$ is a long-term refrigerant and natural substance (like ammonia), and is inexpensive and plentiful. $CO_2$ (like Ammonia) is part of the natural carbon cycle and very widely used for cold transport (dry ice) and for carbonated drinks, and is an important industrial gas.

$CO_2$ is safer than ammonia, which is both flammable and toxic, as it is non-flammable and toxic only at high concentrations (unlike ammonia). Hence it can be safely used in occupied spaces (such as boning rooms)

$CO_2$ refrigeration systems using commercial compressors (Bitzer, Bock, Dorin, Copeland, etc) are generally lower in capital cost than ammonia systems and mostly also lower than Freon systems.

$CO_2$ refrigeration systems also use less space for compressors and pipework. Due to the high density of CO2, pipework and compressor are typically 1/8th of the physical size of equivalent ammonia or freon units

$CO_2$ system are easily installed by trained commercial refrigeration contractors (who currently do Freon systems) because they can be built with copper pipes (and not steel as needed for ammonia systems). Full $CO_2$ systems operate at very high pressure levels (>100bar!), but the advent of cooper/steel alloy pies that can be installed by soldering like copper tubes (as opposed to TIG welding used on steel piping) has meant that current commercial refrigeration installers can easily adapt to installing full- $CO_2$ systems.

Full- $CO_2$ systems also produces vast amounts of hot (65 C°) and even very hot (90 C°) water as by-product, displacing conventional fuel-fired boilers. This feature alone often makes full $CO_2$ systems the least-cost replacement for existing refrigeration and hot water systems.

## WHAT ARE THE LIMITATIONS & CHALLENGES?

Many Australian refrigeration contractors have not yet been trained in the use of $CO_2$ systems and may therefore not be able to offer these systems, or advocate for conventional systems. However, this is changing.





## WHERE AND WHEN WOULD THIS WORK FOR ME?

New and upgraded small and medium processors, who would traditionally use commercial refrigeration and fuel-fired water/steam boilers

Adding more freezing systems far from the current plant room, which would be expensive with ammonia or synthetic refrigerants

## WHERE CAN I GET THIS PRODUCT OR SERVICE?

Many refrigeration contractors are undergoing training in $CO_2$ refrigeration, and there are several nationally operating $CO_2$ refrigeration installation suppliers who can provide on-site training for local service personnel not yet familiar with $CO_2$.

## SOME USEFUL LINKS & REFERENCE MATERIAL

https://www.hvacrschool.com/co2-booster-systems-codenamed-co2-interesting-weird/

https://issuu.com/shecco/docs/r744-guide-part1

https://www.r744.com/products/view/booster_transcritical_co2_refrigeration_system

# LOW CHARGE AMMONIA REFRIGERATION SYSTEMS

## WHAT IS THIS TECHNOLOGY?

As noted for earlier technologies, most large processors in Australia use Ammonia (R717) as main refrigerant, and most small and many medium sized processors use various synthetic refrigerant (also known as Freon) systems, typically R22, R404A and R134A. Low charge ammonia is a viable alternative to all of these and offers several significant advantages (and hence competes against full-$CO_2$ systems).


*Scantec low charge ammonia system*

The majority of the existing ammonia plants are conventional liquid recirculation plants (also known as liquid overfeed systems), which are characterized by very large ammonia charge levels (some Australian meat processors have ammonia charge levels on site in excess of 100,000 kgs!!) and high energy use. These conventional systems suffer from large energy losses in wet suction return lines and often wasteful blow-through defrost processes, which diminish the inherent benefits of ammonia as refrigerant.

Low charge ammonia systems use new evaporator technology to eliminate the need for liquid overfeed, thereby significantly simplifying the plant design, reducing ammonia charge and increasing energy efficiency. Compared to conventional air-cooled synthetic refrigerant systems, low-charge ammonia systems are vastly more energy efficient and offer far lower maintenance cost.

## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Low charge ammonia systems are viable alternatives to nearly all refrigeration needs currently served by ammonia or synthetic refrigerant-based systems, including

- Carcass chilling
- Freezer rooms and blast freezers
- Chiller storage rooms
- Glycol and water chilling (for boning/processing rooms and office air-conditioning)

Current large-scale plate freezer applications require exclusively ammonia liquid recirculation and cannot be served by low-charge ammonia plant. However, a hybrid or combined plant could be considered where such plate freezers are required.

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## WHY IS IT NOVEL?

Low charge ammonia relies on perfecting direct expansion (DX) evaporator technology (as opposed to liquid recirculation (LR) / liquid overfeed), which has been attempted in the past with mixed success. Getting DX ammonia systems to work reliably has historically been a challenge, with both superheat control and oil return the most common problems.

New technology, in particular the development of vapour fraction sensors to improve the superheat control on direct expansion evaporators using ammonia, and improvements in synthetic oils has enabled the wider adoption of DX ammonia, and consequently the design of entire ammonia systems with 1/3 to 1/5 of the ammonia charge of LR systems.

## WHY IS IT BETTER?

**LC ammonia has several distinct benefits:**

- Much lower ammonia charge and generally more cost effective than liquid reticulated ammonia systems
- Much lower energy use than most air-cooled HFC systems, and more efficient than conventional ammonia systems
- Lower energy use that full $CO_2$ systems in warm climates
- Generally industrial grade quality with usable life up to 25 years due to steel or stainless-steel construction and the use of industrial compressors.

## WHAT ARE THE LIMITATIONS & CHALLENGES?

**Low charge ammonia has some limitations:**

- It still uses ammonia, and hence must comply with ammonia plant safety design requirements. However, these are easier to comply with when the charge is lower.
- Compared to HFC or $CO_2$ systems, LC ammonia systems remain costly.

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## WHERE AND WHEN WOULD THIS WORK FOR ME?

- New and upgraded small and medium processors, who would traditionally use commercial refrigeration solutions
- When existing synthetic refrigeration systems approach end of life.

## WHERE CAN I GET THIS PRODUCT OR SERVICE?

- Most reputable industrial refrigeration contractors familiar with industrial ammonia plants can offer low charge systems. Seek references or engage a third-party consultant to ensure that you are offered a quality system as outcomes vary between contractors.
- Scantec Refrigeration, based in Brisbane, has been the leading proponent of LC ammonia systems in Australia for many years.

## USEFUL LINKS & REFERENCE MATERIAL

https://www.scantec.com.au/technologies/low-charge-ammonia

https://www.airah.org.au/Content_Files/EcoLibrium/2019/12-19-Eco-001.pdf

**Refer to**

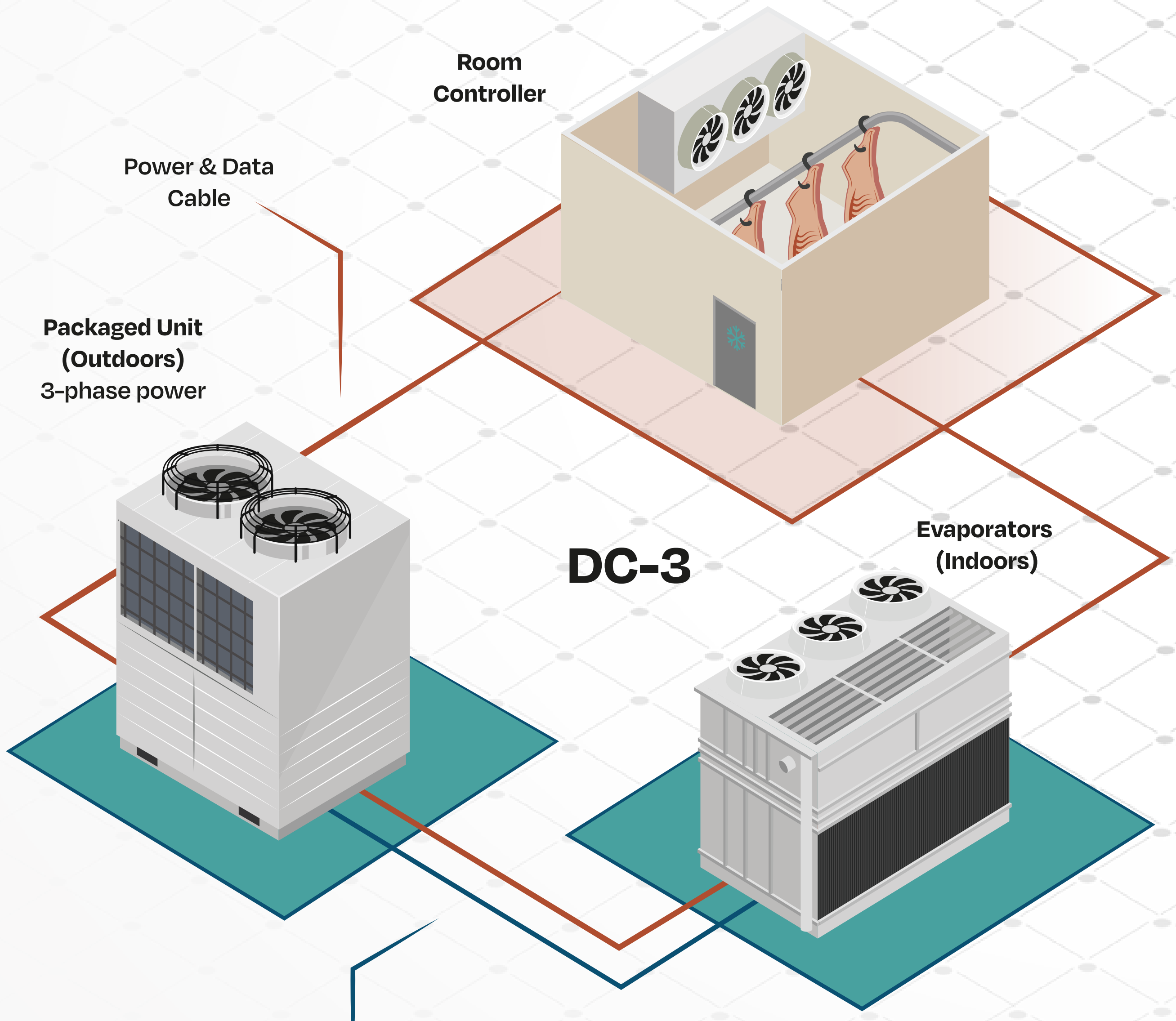
https://www.airah.org.au/Content_Files/EcoLibrium/2019/12-19-Eco-001.pdf

# SMART PACKAGED REFRIGERATION UNITS

FOR SMALL CAPACITIES

## WHAT IS THIS TECHNOLOGY?

Small capacity air-cooled plug&play refrigeration systems that incorporate key energy savings techniques into their in-built design and controls, including at least floating head pressure, compressor capacity control, demand defrost and adaptive suction pressure control. (Refer Guidebook Industrial Ammonia Systems Part 2 )




*Smart refrigeration system (Actrol DC-3)*

## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Conventional single-compressor air-cooled refrigeration condensing units are often supplied with undersized or marginally sized condensers, and with basic on/off controls for condenser fans and compressor and are generally installed in conjunction with thermostatic expansion valves on associated room evaporators. Evaporator and defrost controls are independent of the condensing unit controls. As a result, these systems have high energy use even during cool weather, and room and defrost controls are sometimes clumsy.

This technology replaces the conventional condensing unit/expansion valve/room evaporator/room controller with a pre-engineered hardware package with the smart features pre-configured and easily commissioned.

## WHY IS IT NOVEL?

Small air-conditioning units for domestic or commercial applications (think Daikin, Hitachi, Actron Air, etc) have long been available as plug-and-play indoor outdoor unit combinations, with multiple convenient and energy efficient features built-into the unit. Little effort other than competent installation is required by the installer to achieve a good and repeatable outcome.

This plug-and-play technology has not been available for the commercial refrigeration market, until recently, and represents an obvious and necessary development to meet modern energy efficiency needs with reducing industry skill levels.

## WHY IS IT BETTER?

Small commercial refrigeration systems are plagued by installation and design, installation and commissioning caused by mismatched equipment, poor installation practices and superficial commissioning. This is driven by the commercial imperative to reduce labour costs and aggravated by the absence of any incentive to achieve energy efficient operation. The final outcome is highly dependent on the skill and experience of the installer, and the attention to detail during installation and commissioning.

Smart refrigeration systems avoid these issues by making it easy for the contractor, to select, install and commission the complete system, with one-stop-shop purchasing. The smart energy-savings features are pre-programmed requiring no further optimisation, and the system comes with simple and clear instructions in relation to installation and commissioning.

## WHAT ARE THE LIMITATIONS & CHALLENGES?

The key challenge limiting uptake of this technology as alternative to conventional small refrigeration systems is capital cost, as the pre-engineered features and the use of inverter drives, and electronically commutated fan motors raises the cost above that of a basic conventional unit.

The smart units have a few other limitations that reduce their benefit when compared to alternative centralized systems ($CO_2$, ammonia, glycol), in particular:

- Heat recovery, for example to generate hot water for washdown, has not been catered for and is unlikely to be commercially feasible where multiple smart systems are installed. Where there is the opportunity to offset expensive fuel used for heating (e.g. LPG or diesel) or even natural gas, and especially if hot water generators or boilers are near end of life, a centralised refrigeration system with heat recovery may be a more economical solution than multiple smart systems
- At best, current smart systems have been released for operation with HFC/HFO blend refrigerants, but not yet with natural refrigerant (Hydrocarbon) or low GWP synthetic (HFO-only). It is hoped that in future smart refrigeration units will be released for these low-impact refrigerants to provide a long-term and future-proof solution.
- Single refrigeration units offer no redundancy, and loss of temperature control is likely with any component failure.
- A large number of smart units may be more expensive to maintain than a central plant, especially if the plant operates on $CO_2$ or Ammonia refrigerant.



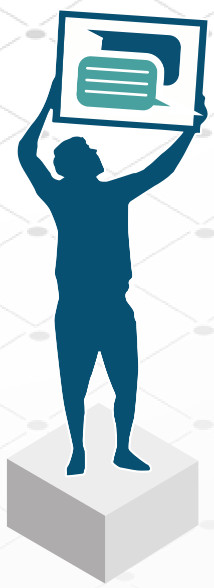
## WHERE AND WHEN WOULD THIS WORK FOR ME?

Smart refrigeration systems are useful for small processing sites, or for serving remote cooling requirements far from the central refrigeration plant. However, consider the following:

- If your site can benefit from heat recovery (by offsetting expensive fuel or replacing end-of-life boilers), a central plant ($CO_2$ or ammonia) may be more economical overall.
- Ensure that at minimum an HFO/HFC refrigerant is used (R448A) and not high GWP refrigerants such as R404A, which are likely to be impacted by current refrigerant phase-down.
- Consider if a central plant with in-built redundancy is feasible as alternative to many individual smart units.

## WHERE CAN I GET THIS PRODUCT OR SERVICE?

Currently Actrol is the only supplier of smart units on the Australian market.



## SOME USEFUL LINKS & REFERENCE MATERIAL

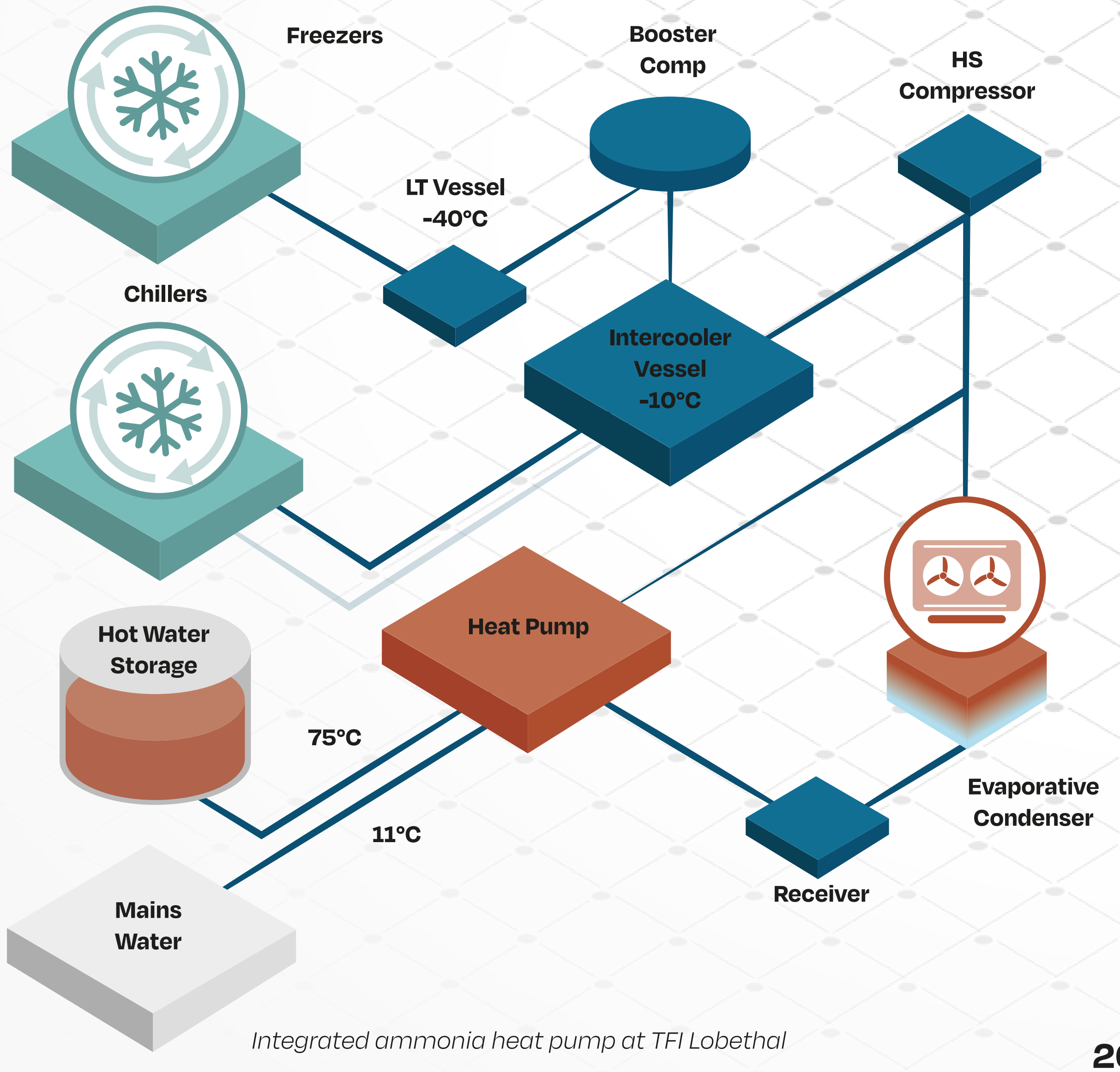
https://www.actrol.com.au/brands/dc3/

# AMMONIA HEAT PUMPS

## WHAT IS THIS TECHNOLOGY?

Ammonia heat pumps use waste heat (like the heat rejected by refrigeration condensers) to evaporate ammonia at high temperature, compress the ammonia and then generate hot water by condensing the ammonia at very high pressures. Water temperatures from 60 C° up to as high as 90 C° can be achieved in this way, using a waste heat source of 30 - 40 C° (typical cooling tower water).

Some heat pumps draw the waste heat from cooling water (water source), whilst others can draw the heat directly from the discharge gas from an existing ammonia refrigeration plant (refrigerant source).




*Integrated ammonia heat pump at TFI Lobethal*



## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Hot water generators or steam boilers using fuel such as coal, oil, diesel, LPG or natural gas to generate hot water directly, or steam that is then used to generate hot water via live steam injection or steam/water heat exchangers.

The ammonia heat pumps generate the hot water not by burning fuel, but by using electricity to drive the compressor. This is an essential step towards decarbonisation, as electricity can be produced renewably but most fuels cannot.

## WHY IS IT NOVEL?

Ammonia heat pumps have been around for a long time, but their use in Australia to generate hot water has only become feasible in recent years, with the cost of fuels increasing faster than the cost of electricity. So, the technology is not novel, but the application at meat processing sites is novel.

Recent technical advances have allowed heat pump suppliers to release new models of heat pump capable of generating 90 C° hot water reliably, thus addressing site sterilisation needs. This is very new and hence novel, enhancing the applicability to meat processors.

## WHY IS IT BETTER?

Ammonia heat pumps do not generate any direct emissions and produce even very high water temperatures with low energy input. If combined with clean and/or low-cost electricity, ammonia heat pumps can be the cheapest and cleanest way to generate hot water, with much lower maintenance costs.

Compared to $CO_2$ heat pumps, ammonia heat pumps:

- Are well suited to centralized hot water supply to the site (rather than using multiple units for distributed hot water generation),
- Are well suited and economical for large scale hot water generation,

## WHAT ARE THE LIMITATIONS & CHALLENGES?

Traditionally ammonia heat pumps could not generate water at temperatures greater than +75C, but recent advances has raised this to +90C for most suppliers. Hence traditional heat pumps were limited to providing washdown water only, but the modern models can also supplier water for steriliser duty.

## WHERE AND WHEN WOULD THIS WORK FOR ME?

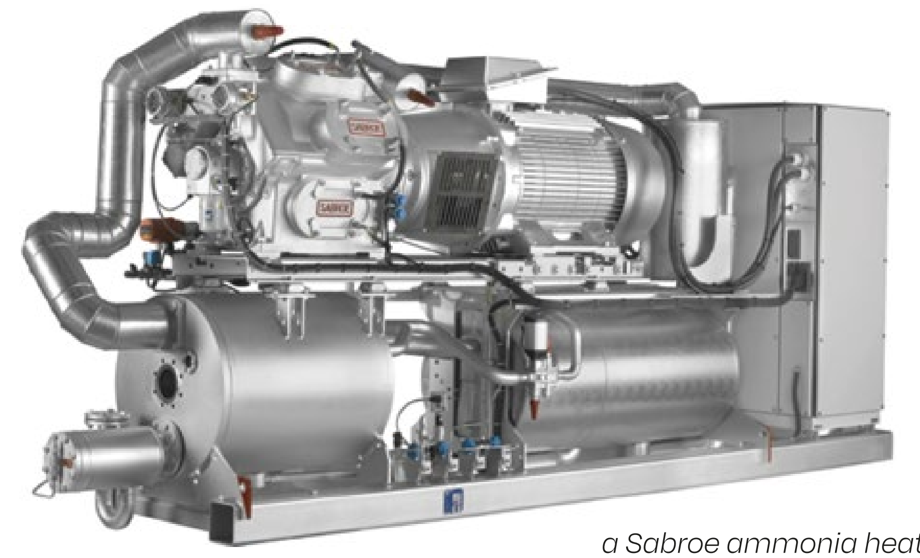
All meat processors require wash down water (60 - 65 C°) and most also use hot water (90 C°) for knife sterilising, and therefore have hot water generators or steam boilers to meet this demand. Ammonia heat pumps can be very useful if the site:

1. Already has an ammonia refrigeration plant that can be used as waste heat source (either water source or refrigerant source).
2. Uses expensive fuel for heating (e.g. LPG, oil, diesel or even natural gas)
3. Has access to low cost electricity, for example from on-site solar PV generation
4. Has hot water generators or steam boilers at end of life and requiring upgrade or replacement
5. Uses a ring-main for hot water supply, with return water reheat

## WHERE CAN I GET THIS PRODUCT OR SERVICE?

**The three major suppliers of ammonia heat pumps in Australia are:**

1. Mayekawa (Mycom)
2. GEA Grasso
3. Jonson Controls (Sabroe)



*a Sabroe ammonia heat pump*

Note that the ammonia heat pump must be carefully selected and integrated into the site refrigeration and hot water systems to operate effectively. Heat pump operation generally will **NOT** coincide with hot water consumption, so that insulated hot water storage tanks will be required, with associated pumps and controls.

## USEFUL LINKS & REFERENCE MATERIAL

https://www.ampc.com.au/2010/07/Heat-Recovery-From-Refrigeration-Plant

**Refer to:**

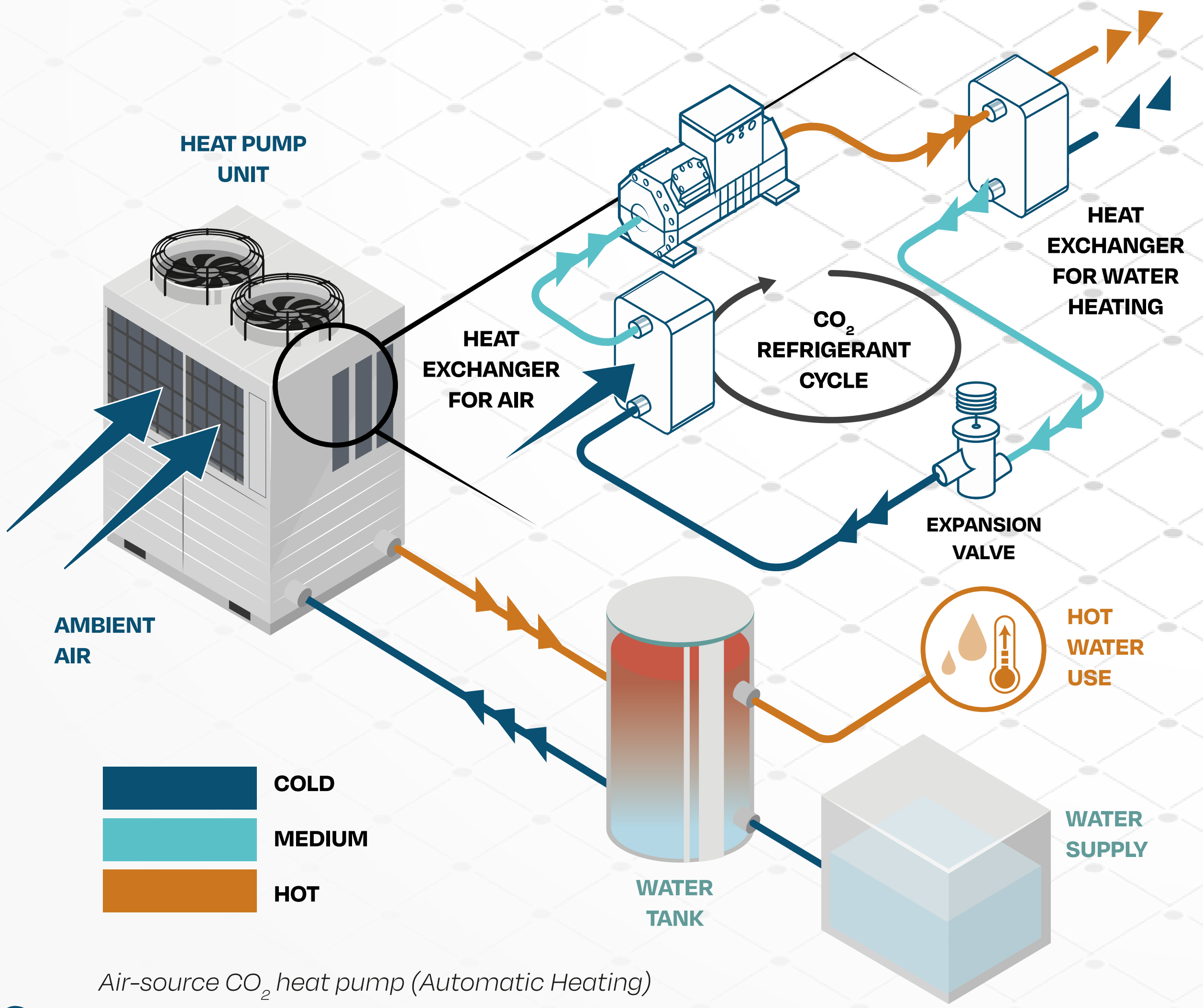
TFI Lobethal (see link above)

# $CO_2$ HEAT PUMPS

## WHAT IS THIS TECHNOLOGY?

$CO_2$ Heat pumps use either waste heat or ambient heat to evaporate $CO_2$ refrigerant, compress the $CO_2$ vapour and then generate hot water by cooling the $CO_2$ gas at very high pressures. Water temperatures from 50 C° up to as high as 95 C° can be achieved in this way even from cold ambient (winter) temperatures. Some $CO_2$ heat pumps draw the waste heat from cooling water (water source), whilst others can draw the heat directly from ambient air (air-source).

Hence $CO_2$ heat pumps are an alternative to Ammonia heat pumps but have different application. For example, ammonia heat pumps are good for providing small lift (reheating a ring main from 60degC back up to 70 C°) whereas $CO_2$ heat pumps prefer a high lift (heating cold water from 15 C° all the way up to 90 C° in one pass) and therefore could even be used in conjunction with one another.




*Air-source $CO_2$ heat pump (Automatic Heating)*





## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Hot water generators or steam boilers using fuel such as coal, oil, diesel, LPG or natural gas to generate hot water directly, or steam that is then used to generate hot water via live steam injection or steam/water heat exchangers.

The $CO_2$ heat pumps generate the hot water not by burning fuel, but by using electricity to drive the compressor, in the same way as ammonia heat pumps.

## WHY IS IT NOVEL?

$CO_2$ heat pumps are relatively new, with early models appearing on the market less than 10 years ago. The technology is now quite mature and there is a wide choice of manufacturers and capacities on the Australian market. However, their use within the meat industry is not yet widespread, although they offer significant advantages specifically to meat processors.

## WHY IS IT BETTER?

$CO_2$ heat pumps do not generate any direct emissions and produce even very high water temperatures with low energy input. If combined with clean and/or low-cost electricity, $CO_2$ heat pumps can be the cheapest and cleanest way to generate hot water, with much lower maintenance costs than fuelled heating systems.

**Compared to ammonia heat pumps, $CO_2$ heat pumps:**

- can more easily achieve high water temperatures irrespective of heat source,
- are available in smaller sizes, suitable for distributed arrangement (rather than centralized hot water generation), even for localized hot water generation for domestic hot water, and
- are very suitable for air-source operation even under cold winter conditions.

# WHAT ARE THE LIMITATIONS & CHALLENGES?

$CO_2$ heat pumps need to operate at high lift (i.e. with cold water inlet) to operate efficiently and therefore are not well suited for re-heat applications (e.g. hydronic heating, or ring-main operation).

# WHERE & WHEN WOULD THIS WORK FOR ME?

All meat processors require wash down water (60 - 65 C°) and most also use hot water (90 C°) for knife sterilising, and therefore have hot water generators or steam boilers to meet this demand. $CO_2$ heat pumps can be very useful if the site:

1. Uses expensive fuel for heating (e.g. LPG, oil, diesel or even natural gas)
2. Has access to low cost electricity, for example from on-site solar PV generation
3. Has hot water generators or steam boilers at end of life and requiring upgrade or replacement
4. Has steam generators used **ONLY** for sterilization



# WHERE CAN I GET THIS PRODUCT OR SERVICE?

- Mitsubishi (Q-ton, air source only)
- Automatic Heating (Revere, air-source only)
- Mycom (Unimo, air and water-source)
- Enex (Air-heat and GeoHeat, air and water source)

*80kW air-source $CO_2$ heat pump from Automatic Heating*

# SOME USEFUL LINKS & REFERENCE MATERIAL

https://www.automaticheating.com.au/product/revere-co2-air-to-water-heat-pump/#tab-2-1

https://mhiaa.com.au/q-ton-hot-water-solution/

https://www.mayekawa.com.au/products/heat-pumps/

https://www.automaticheating.com.au/complete-guide-to-heat-pumps/

https://www.airah.org.au/Content_Files/Industryresearch/19-09-17_A2EP_HT_Heat_pump_report.pdf

# CENTRAL GLYCOL SYSTEMS

## WHAT IS THIS TECHNOLOGY?

A glycol/water mixture is chilled by an ammonia refrigeration system and then pumped to the site to provide cooling to cool rooms and process heat exchangers


*Ammonia/glycol systems in plant room*

## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Existing direct refrigerant cooling systems, especially using multiple air-cooled Freon/HFC refrigeration units.

## WHY IS IT NOVEL?

Using a reticulated secondary refrigerant is common in many industries, and partly used on larger meat processor sites (mainly for boning room and process area condition), but modern ammonia chiller developments, new glycol blends, and efficient control of pump with variable speed drives has made a central ammonia system a attractive alternative to existing HFC package units.

In combination with glycol-cooled $CO_2$ cascade units, a central glycol system can meet all site cooling and freezing applications.

## WHY IS IT BETTER?

A centralized glycol system can be designed for inherent redundancy and in combination with a high efficiency glycol chiller, significant energy and maintenance costs can be achieved even for small meat processing sites.

Reticulated glycol systems require only plumbing skills to install and maintain, making such systems robust and very suitable for remote applications.

## WHAT ARE THE LIMITATIONS & CHALLENGES?

- Glycol systems need to be selected and engineered to suit the application, including chiller, cooling tower, pump and room cooler selection, requiring specific engineering skills and experience.
- Glycol systems are not suited to plate freezer applications, which require either direct ammonia or $CO_2$ refrigerant.
- Glycol systems have an energy penalty due to the additional heat exchanger and pumping power when compared to direct ammonia or $CO_2$ systems, but still have substantial energy benefit over small, air-cooled HFC packages.

## WHERE & WHEN WOULD THIS WORK FOR ME?

Meat processor sites can benefit from an upgrade to a central glycol system, with $CO_2$ freezing units and heat recovery options, if:

- The site is remote and local staff are not trained to install and maintain site-built Ammonia or $CO_2$ refrigeration systems,
- Site hot water needs are modest
- Existing Freon/HFC refrigeration systems are at end of life

## WHERE CAN I GET THIS PRODUCT OR SERVICE?

Most larger refrigeration contractors can install glycol systems.

## SOME USEFUL LINKS & REFERENCE MATERIAL

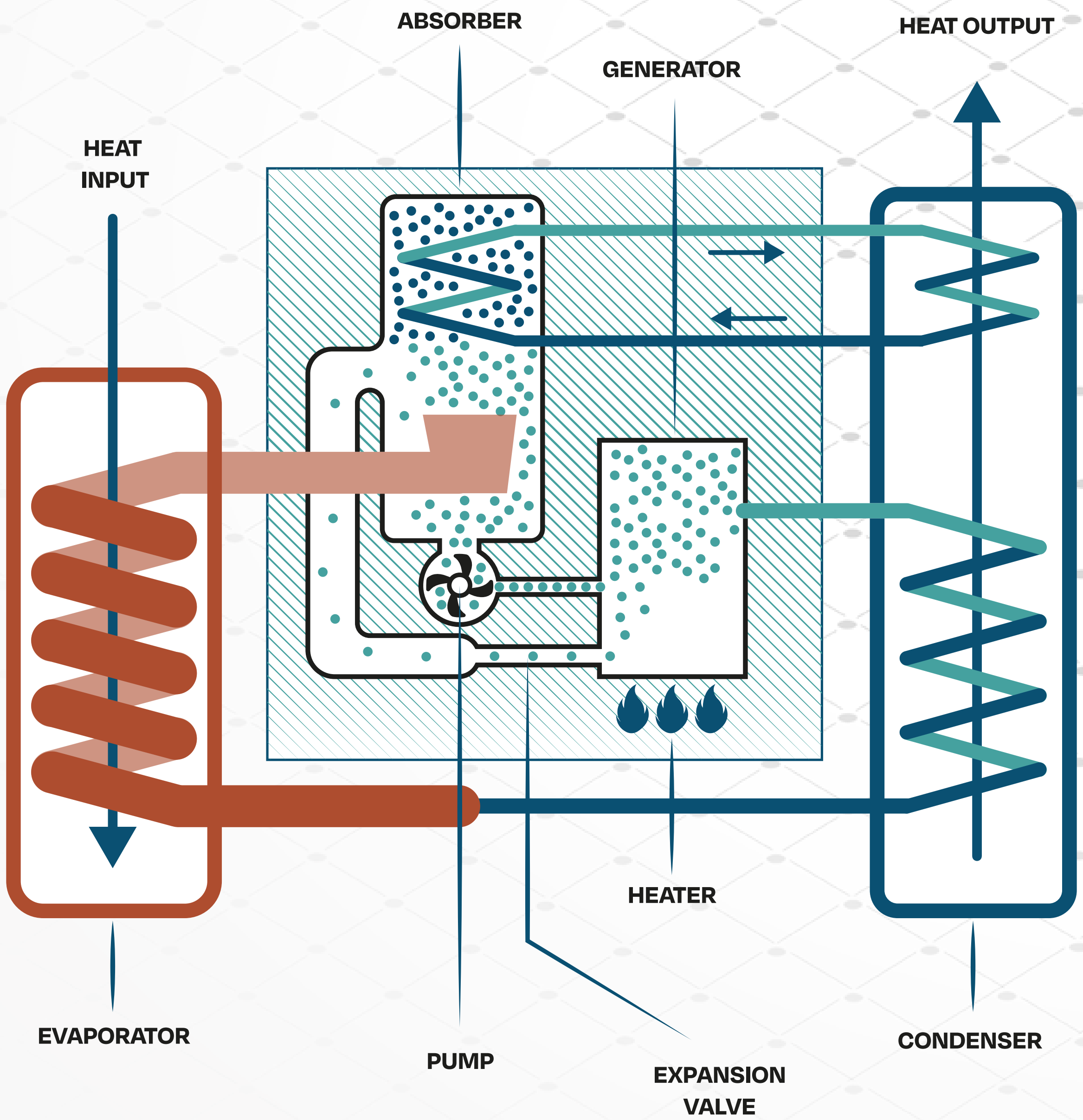
- Arnotts Biscuits, Virginia
- Radevski Cool Stores, Shepparton

# AMMONIA ABSORPTION REFRIGERATION

FOR SMALL CAPACITIES

## WHAT IS THIS TECHNOLOGY?

Absorption refrigeration is an alternative way to generate cooling by using high level heat (waste heat from an engine, steam or direct fuel burning) instead of electric power. Absorption refrigeration units use a water-mixture as working fluid in a complex process involving absorbers, generators, pumps and expansion devices that can be single, double or even triple effect. Lithium Bromide (LiBr) and Ammonia ($NH_3$) are most widely used working fluids, with LiBr limited to cooling at >0 C°, whereas $NH_3$ units can operate to very low temperature (even -40 C° is possible).






All absorption refrigeration units can operate as heat pumps also, generating usable hot water at 60 - 65 C° at the condenser outlet, in effect generating more heating than the energy input from the fuel alone (1kW of fuel could generate 1kW of cooling and then 2kW of hot water, for example)

## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Ammonia absorption refrigeration can replace, or at least augment, existing refrigeration and hot water generation plant, especially where a source of excess heat is available (excess unutilized steam, or waste heat from a gas engine, for example)

## WHY IS IT NOVEL?

Absorption refrigeration is an old technology and has been used for decades (just think of the old gas-fired camping fridges). Recent innovations have improved efficiency and versatility of the units, making them a viable option for meat processors.

## WHY IS IT BETTER?

Absorption refrigeration systems use high level waste heat (=low cost) to generate cooling that would otherwise have used electric power (=expensive) to generate.

## WHAT ARE THE LIMITATIONS & CHALLENGES?

Absorption refrigeration systems are bulky and generally costly, limiting their application to circumstances where their operation is possible at low cost (e.g. surplus high-level heat available on site).

These units also do not respond rapidly to load changes and operate efficiently at part load. Therefore, they are best used for steady loads, ideally loads that need to be met 24/7. This limits their wider uptake and usefulness.

## WHERE & WHEN WOULD THIS WORK FOR ME?

Ammonia absorption refrigeration systems are potentially very useful to meat processors if:

- There is waste heat available from gas engines using natural gas or biogas.
- Site steam boilers have surplus capacity AND fuel costs are low
- There is a steady demand for cooling that could be met with chilled glycol, for example boning room/processing area cooling or carcass spray chilling

## WHERE CAN I GET THIS PRODUCT OR SERVICE?

Most ammonia absorption systems are sourced from suppliers in Europe or the USA via local agents. See links for some supplier websites.

## SOME USEFUL LINKS & REFERENCE MATERIAL

https://www.ampc.com.au/2010/03/The-use-of-abattoir-waste-heat-for-absorption-refrigeration

https://www.vamtec.com/ammonia-absorption-chiller/

https://colibris.home.xs4all.nl/

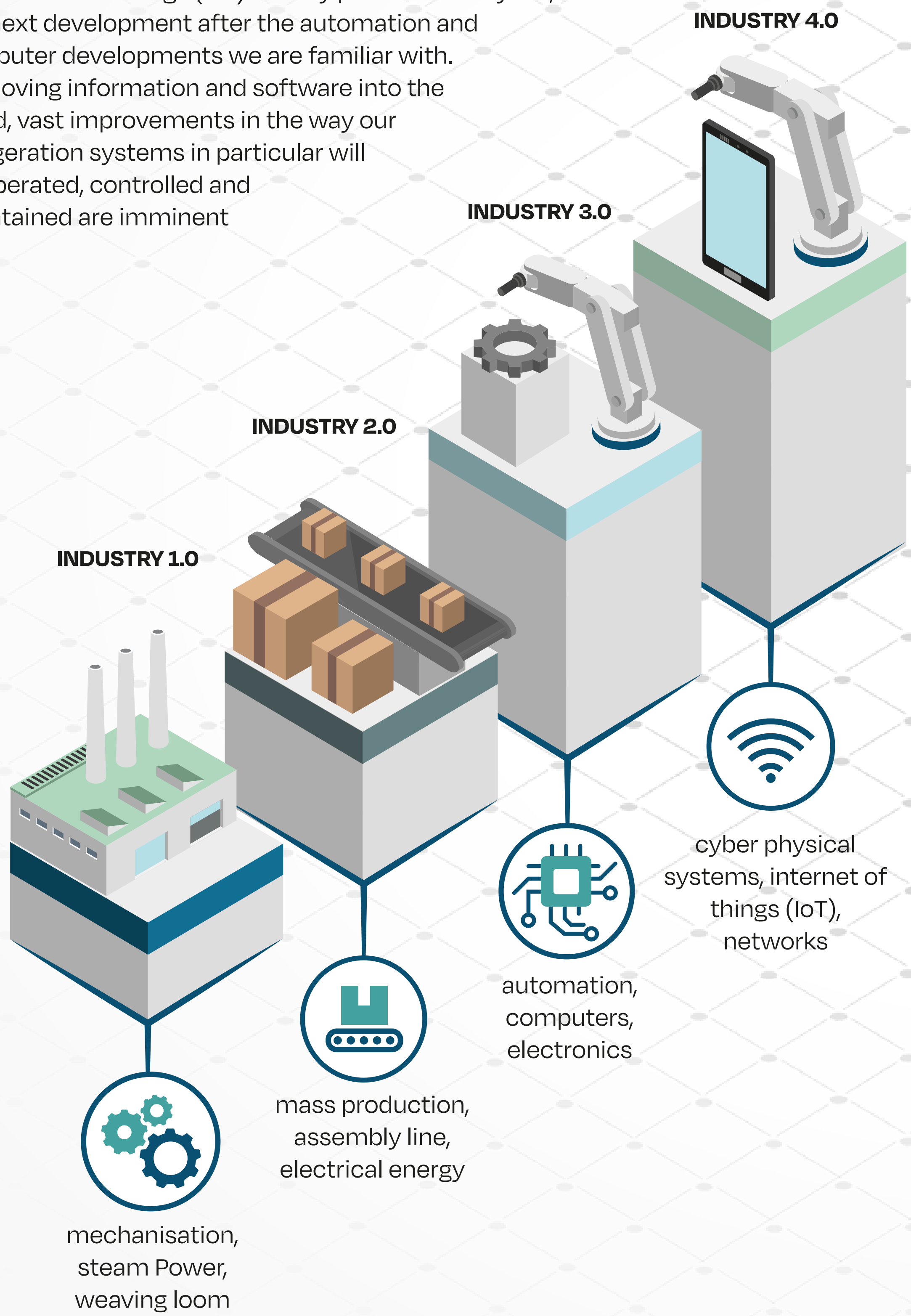
https://www.araner.com/solutions/absorption-chiller/

https://www.zudek.com/en/product/assorbitori-ad-acqua-ammoniaca/

# IoT Technology

## WHAT IS THIS TECHNOLOGY?

The Internet of Things (IoT) is a key part of Industry 4.0, the next development after the automation and computer developments we are familiar with. By moving information and software into the cloud, vast improvements in the way our refrigeration systems in particular will be operated, controlled and maintained are imminent




## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

Programmable logic controllers (PLCs) or similar local control hardware, with fixed operating software and local display, that are today used to control most industrial systems such as refrigeration systems.

## WHY IS IT NOVEL?

PLCs and the static software running on them are replaced by internet-connected devices (sensors, motors, actuators that are currently wired to the PLC) that push their data into the cloud or receive their instructions from the cloud. All control logic, data management and optimisation happens in the cloud where it can be constantly improved and updated.

## WHY IS IT BETTER?

PLCs and the software running on them are out of date quite soon after they are installed, never improve unless replaced of re-programmed, and only ever as good as the humans that installed and commissioned them on site.  And unless backed up manually, all data is easily lost.

**IoT solutions have several significant benefits:**

Being cloud-based, data is backed up and secure. 1

Software systems are automatically updated when newer versions are available. 2

Most importantly, improvements and optimisation can more easily be done remotely, a great benefit for a large country like Australia. 3

AMPC

# WHAT ARE THE LIMITATIONS & CHALLENGES

IoT needs a good internet connection, which can be a challenge in remote areas. New technology with back-up connectivity are rapidly developing to resolve these issues, and the NBN is set to improve.

Data and software in the cloud can theoretically be hacked but is probably safer there than on old servers on site. Most cloud providers, like Amazon, have massive cyber-security systems in place to keep data safe.

# WHERE AND WHEN WOULD THIS WORK FOR ME?

Most meat processor sites are remote from metro areas, and can certainly benefit from a stepwise introduction of IoT solutions, including first steps such as:

- Advanced monitoring with cloud data storage and web-based data visualisation – this helps remote support and plant optimisation
- Self-learning, fault detection and artificial intelligence based in the cloud - this improves automated fault detection and notification
- Remote and interactive communications, with augmented reality – this improves communication with remote experts to assist activities on site, such as commissioning, troubleshooting and maintenance.

**Future steps would include more advance technologies, such as**

- PLCs replace by cloud-based control software
- PC-based SCADA and HMI replaced by visualisation via the web, using the cloud data

# WHERE CAN I GET THIS PRODUCT OR SERVICE?

All major and minor players in the control and automation industries are actively transitioning to IoT and Industry 4.0, so the site's preferred provider is best consulted to advise on a phased transition to Industry 4.0

# SOME USEFUL LINKS & REFERENCE MATERIAL

https://www.energy.gov.au/business/equipment-and-technology-guides/industry-40

https://en.wikipedia.org/wiki/Fourth_Industrial_Revolution

https://www.austrade.gov.au/news/insights/industry-4-0-transforms-prospects-for-australian-manufacturing

# REFRIGERATION AS A SERVICE (RAAS)

## WHAT IS THIS TECHNOLOGY?

Refrigeration as a Service (RaaS) is not really a technology, but instead an alternative way to access refrigeration. In effect it is a form of outsourcing refrigeration, making the energy costs, maintenance costs, and reliability someone else's problem, and allowing the meat processor to focus on the core business and not running refrigeration plant.

**The basic tenets of RaaS are:**

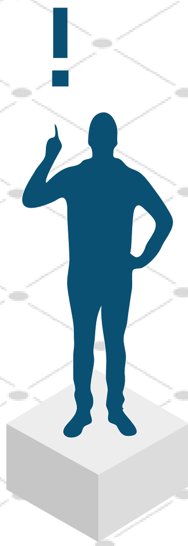
1. **The RaaS operator owns the refrigeration system.** The exact extent of ownership is specific to each contract, but ideally should include all the functional and energy consuming components of the system. The end-user can buy back the refrigeration system at any time at an agreed depreciated price and exit the contract.

2. **The RaaS operator pays for the power used by the refrigeration system.** In most cases, the power usage will be metered, and the costs refunded to the end-user who pays the total site energy bill. Hence, if the refrigeration system runs inefficiently, the RaaS operator loses money.

3. **The End-User pays the operator a fixed monthly fee to cover finance costs and maintenance.** If there is a major equipment failure, or significant maintenance work is required, the costs are borne by the RaaS operator. Hence the RaaS operator is incentivised to keep the plant running at lowest maintenance costs.

4. **The End-User pays the operator for actual metered refrigeration used, at a contractually agreed rate.** The rate is adjusted annually (up or down) in accordance with an agreed escalation rate (typically CPI) and to correct for changes in site operation or changes in power costs. Higher usage and lower energy costs will cause the rates to decrease, or vice-versa. Also, the end-user pays for wasteful use of refrigeration and is incentivised to use cooling sparingly.

5. **The RaaS operator guarantees the availability of the refrigeration unit.** If the refrigeration fails, the RaaS operator will become liable for penalty clauses and does not get to sell any refrigeration whilst the plant is down. Hence the RaaS operator is incentivised to install a plant with suitable redundancy and keep the plant in good running order.



In effect, a RaaS contract is quite like a Power Purchase Agreement for solar PV, where the service provider installs, owns and maintains the panels, and charges the site for energy consumed for a fixed contract period.

## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

RaaS replaces conventional ownership of refrigeration systems, irrespective of how these may have been funded (purchase, lease, rental) as it not only means that the meat processor no longer owns (and therefore no longer needs to finance) the refrigeration system, but unlike finance solutions, under RaaS the meat processors also is freed from the costs of maintenance, energy consumed, breakdowns and equipment insurance.

# WHY IS IT NOVEL?

Under RaaS the refrigeration equipment is installed, owned and maintained by a service provider who also pays for energy consumed, plant maintenance, breakdown and insurance, and the end-user pays for metered cooling output only.

This aligns incentives for the service provider to install efficient, reliable and low-maintenance equipment, and optimize energy use and maintenance, whilst the end-user is incentivised to use cooling sparingly. The nett effect is a wise use of resources that benefits both parties in the arrangement commercially and reduces energy use and other emissions.

# WHY IS IT BETTER?

Refrigeration as a Service (RaaS) puts the ownership of the refrigeration system into the hands of a refrigeration specialist, who is incentivised to keep the nett ownership costs low in his own commercial interest.

The RaaS operator makes a profit by investing into a good refrigeration system, keeping energy and maintenance costs down, whilst selling refrigeration to the end user at a lower rate than the end user would otherwise be paying if he owned the system (which may have been a low-capital cost, but high running cost alternative) himself. Both sides win as incentives are aligned, and both the RaaS provider and the processors can focus on what they are good at.

# WHAT ARE THE LIMITATIONS & CHALLENGES?

In principle, there are few potential issues with RaaS due to the alignment of incentives with both parties. RaaS contract forms are mature and balanced, especially those provided by the not-for-profit BASE organisation (see ref 1). But, as with many new ideas, moving to RaaS will impact on current processor staff and existing service providers, potentially causing discomfort and push-back.

Under current normal ownership arrangements, the refrigeration servicing organisation benefits from maintenance and breakdown service provided to the processor, whilst wearing no responsibility for energy costs, and little responsibility for plant reliability. RaaS arrangements can be at the expense of the incumbent service provider, who may either be replaced, or may provide reduced service levels for an optimized system.

Maintenance and plant operator staff may also be impacted as their roles could be diminished or even made redundant by RaaS. In some cases, some staff may be transitioned to employment by the RaaS provider or contracted out to the RaaS provider.

# WHERE & WHEN WOULD THIS WORK FOR ME?

RaaS can be applied to any processor site, as it does not necessarily require the installation of a new refrigeration system. There is also no size or scale limitation, so that even the largest refrigeration systems are potential candidates for RaaS.

Let's look at a few typical scenarios.

**Existing refrigeration systems are in good condition with plenty of useful life:**

Under these conditions the RaaS provider can purchase the existing refrigeration systems for an agreed price, further improve the systems to reduce energy and maintenance costs, and change the way the plant is operated and maintained.

**Existing refrigeration systems are in poor condition and at end of life:**

- Under these conditions the RaaS provider will design and install a replacement refrigeration system at his expense and decommission/remove the existing system or systems, with new plant operating and maintenance systems.

**A bit of both:**

- Some sites may have some new and some old refrigeration plant. The RaaS provider may choose to purchase the good bits and replace the rest.

**Any of the above combined with expensive heating or boilers at end of life:**

- Whether the RaaS provider installs new systems or purchases existing plant, he could also include heat recover to provide either wash water (65degC) or sterilizer water (90degC) to offset hot water generation on site.

**New or green fields processing site:**

- Additional benefit can be gained for both the RaaS provider and the processor by jointly developing a combined refrigeration/heating/power generation plant as single out-sourced energy services provision to the new site.

# WHERE CAN I GET THIS PRODUCT OR SERVICE?

Refrigeration as a Service is new to Australia and as yet the choice of providers is limited:

- Schneider Electric
- Metis Monitoring
- Energy Partners (South Africa)

# SOME USEFUL LINKS & REFERENCE MATERIAL


1. Basel Agency for Sustainable Energy (BASE). Frequently asked questions (FAQs) in relation to Cooling as a Service (CaaS), website: caas-initiative.org.

2. Koegelenberg, I.; "Outsourcing Model Offers Alternative to NatRefsw Capital Cost", Accelerate Magazine, October 2019

3. Basel Agency for Sustainable Energy (BASE). Cooling as Service Case Study: "South African Fruit Packing Company Upgrades Ammonia System"


**Lynca Meats – South African abattoir**

Lynca Meats comprises 28 temperature-regulated rooms to produce a host of processed pork products; an abattoir that markets carcasses, boxed meat and offal; and dedicated units that offer multi-principle cold storage warehousing and logistical solutions to clients.

Energy Partners Refrigeration upgraded the 20+ year old refrigeration system under a 10-year contract, at no capital cost to the client. In addition, Energy Partners Solar installed a 962 kW solar PV system and Energy Partner Steam a new 4ton/hour steam boiler, both on an outsourced basis, such that Lynca Meats now has all of items energy needs (power, cooling, heating) provided to it through an outsourced model, allowing the site to substantially reduce its personnel costs and focus on the production.

Refer: Macaskill, C. "Outsourcing builds a resilient Operation", Agribook blog, 17 January 2020, website: agribool.co.za

# ORGANIC RANKINE CYCLE SYSTEMS

## WHAT IS THIS TECHNOLOGY?

An Organic Rankine Cycle system (ORC) is in simple terms a refrigeration plant running backwards.

A refrigeration plant uses power to drive a compressor to create low temperature cooling and reject heat at high temperature. An ORC takes high temperature energy, drives an expander to generate power and rejects the heat at lower temperature.

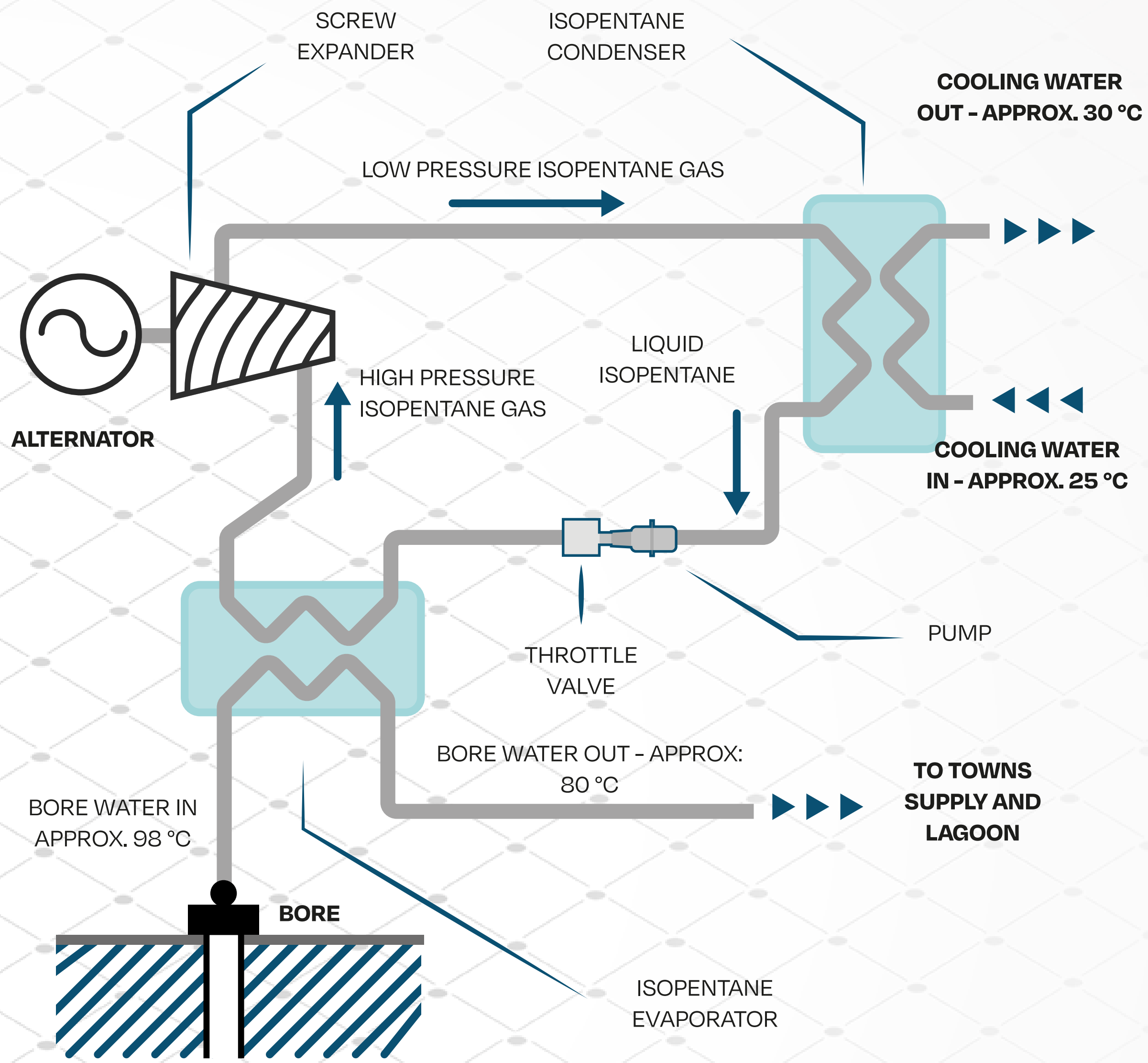
If a site has plenty of surplus heat at 100-150degC, an ORC could convert this heat to electric power and lower grade heat (such as 60-70degC water) which could still be used for wash down. In that respect an ORC is an alternative to an absorption refrigeration system, which would use the same surplus heat to generate useful cooling.

## WHAT CURRENT TECHNOLOGY DOES IT REPLACE?

An ORC (just like Absorption Refrigeration) is a better way to utilize medium temperature waste heat, which would otherwise have been either mixed down to lower temperature for washdown/sterilizer use or rejected via a cooling tower or air-cooled radiator.

## WHY IS IT NOVEL?

In principle, ORC technology is an old technology that has been used in some specialized applications such as geothermal power stations dating back to the early 1980's.




*The Geothermal power station at Birdsville using an ORC to generate power (source: Ergon Energy).*

Recent innovations have improved efficiency and versatility of the units, making them a viable option for meat processors where waste heat is available, for example from cooling water supplied by gas-fired engines drive by bio-gas or natural gas.

An ORC modelling study was conducted by AMPC in 2016 on the potential use of ORCs in combination with cogeneration plants run on bio-gas (refer project 2016.1002), which concluded that Cogeneration facilities operated on biogas and combined with an ORC would have an attractive payback. In view of the rapidly increasing cost of carbon abatement, the viability of such projects is likely to be better today than 5 years ago.

## WHY IS IT BETTER?

Organic Rankine Cycle systems use high level waste heat (=low cost) that would otherwise have been rejected to ambient or perhaps used for wash down, to generate electric power.

## WHAT ARE THE LIMITATIONS & CHALLENGES?

A limited range of ORCs are available as standard products at the moment, mostly generating several 100kW of power at most. All larger units would need to be custom engineered and would be more expensive.

## WHERE & WHEN WOULD THIS WORK FOR ME?

Organic Rankine Cycle systems are potentially very useful to meat processors if:

- There is waste heat available from gas engines using natural gas or biogas.
- Site steam boilers have surplus capacity AND fuel costs are low



## WHERE CAN I GET THIS PRODUCT OR SERVICE?

There are several Australian suppliers or importers of ORC systems, such as Turboden (Multistack) and Elektratherm (Bitzer)

## SOME USEFUL LINKS & REFERENCE MATERIAL

Investigation into cogeneration systems for abattoirs using micro-turbines, organic Rankine cycle units or reciprocating engines. Project 2016-1002.

Birdsville Organic Rankine Cycle geothermal power station. Ergon Energy

https://www.turboden.com/products/2463/orc-system

https://electratherm.com/

This Guidebook is one of five developed during the "Refrigeration Plant Energy Improvement" research project by the Australian Meat Processor Corporation (AMPC). The series aims to help plant personnel and stakeholders of meat processing facilities to identify energy efficiency opportunities within their refrigeration systems.

This "New Technology Handbook" is intended to compliment the Guidebooks and Manual and provide the reader with a single-source summary of the technologies that are market-ready, commercially available, and likely to be financially viable under the right circumstances.