



AIRAH

Walk-in cool room research project

Barriers to energy efficiency

DISCUSSION PAPER

AN INDUSTRY GOVERNMENT INITIATIVE

IN PARTNERSHIP WITH

**THE EXPERT GROUP AND THE DEPARTMENT OF ENVIRONMENT, WATER,
LAND AND PLANNING**

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About AIRAH

The Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) is an industry-led organisation that represents the entire heating, ventilation, air conditioning and refrigeration (HVAC&R) value chain, from the tradesperson on site through to university-educated engineers, researchers and business leaders. This overarching perspective – and reach to more than 25,000 industry participants – positions AIRAH well to develop and promote a safe, sustainable, healthy and comfortable built environment for Australia's future.

The 21st century imperatives of emissions reduction and energy productivity present our nation with significant change, challenges and opportunities. It is important that all stakeholders from the built environment and refrigeration sector come together to meet these challenges, because all of us have a part to play in achieving low emissions and in ensuring that technical challenges are met and risks are mitigated.

AIRAH is keen to work with all levels of government to improve the environmental performance and safety considerations of existing and new HVAC&R systems. We envisage a collaborative effort to get and keep positive action firmly on the agenda. AIRAH appreciates that it is important for all stakeholders to understand not only the vital role the HVAC&R industry has in the wider economy, but also the role the industry can play in helping Australia achieve its environmental aspirations, and international and national commitments.

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Barriers to energy efficiency

A discussion paper on the initial findings of industry consultation into barriers to energy efficiency in the Walk-in cool room sector in Victoria.

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1 Project Objective

The primary objective of this project is to provide visibility to AIRAH, DEWLP and the HVAC&R industry of the practices and system design, installation, operation and maintenance issues that lead to energy waste in the walk-in cool room sector.

The resulting report will identify the main barriers to energy efficiency and suggested solutions from a range of key stakeholders for improving energy efficiency. The report will identify priorities and suggested next steps for AIRAH and the industry to implement these solutions and provide information to help inform government policy development.

2 Discussion paper and workshop.

This discussion paper forms part of the process to engage with industry and key stakeholders to understand barriers to energy efficiency. The paper will support a face to face workshop. We have conducted research to identify current standards and guidelines for Walk-in cool rooms and freezers, conducted face to face interviews with industry experts, engaged on social media and conducted an industry survey. The main themes of the research to date are captured in this report for further discussion. Following the workshop we will prepare a final report with specific recommendations to address the barriers identified by industry.

2.1 Discussion questions

We have included several questions for your input to help us understand the market issues better.

The deadline for comments is **close of business August 31st 2018**

Please respond to the questions relevant to you into this Word document and email it to phil.wilkinson@airah.org.au

Example:

DISCUSSION QUESTION

Are you aware of any international or company in-house guidelines or standards for WICF?

3 Introduction

There are 260,000 walk-in cool rooms and freezers in Australia with approximately 26% in Victoria¹
Approximately 80% are cool rooms and 20% are freezers.

¹ Population pro-rata is sound proxy for refrigeration equipment as the main applications relate to consumption of foodstuffs and beverages by people.

Potential energy use in cool rooms and freezers in Australia is 4,800 GWh per annum with around 1,250 GWh consumed in Victoria. The average unit energy consumption is around 18,800 kWh per annum and the potential energy waste is conservatively more than 25%.

The national energy spend is \$775 million based on AEMO 2016 average commercial electricity price of 16c/kWh and is much higher in 2018 due to recent electric price increase.

Walk-in cool rooms and freezers are predominantly installed, owned and operated by small to medium enterprises (SMEs) across the refrigerated cold food chain from farm gate to supermarket (including all the independent supermarkets), and hospitality, convenience stores and restaurants. There has been significant growth in this sector over the last 7 years, with condensing unit and evaporator sales growing at more than 3.5% compound growth per annum.

There are essentially three main factors that affect indirect emissions from walk-in cool rooms and freezers:

System efficiency – influenced by design, installation, operation and maintenance.

System load and energy consumption – influenced by the cool room design (R-value of walls, floors and walls, and, solar gain), system design, efficiency characteristics of installed equipment and components, any local micro-climate effects (i.e. ambient temperature), air and moisture sealing, process efficiency, temperature settings, the modes and methods of operation and control, end user behaviour and maintenance.

Carbon intensity of energy source – influenced by fuel source for electricity generation (solar, coal, gas, etc) and by fuel type used on site (electricity, gas).

Direct emissions from cool rooms and freezers is also relevant as they typically have the highest leak rates (~15% per annum) in the economy and use high global warming potential (GWP) refrigerants (i.e. HFC-404A GWP of 3922, HFC-134a GWP of 1430 and HCFC-22 GWP of 1810).

This study primarily focuses on the first two items. Common industry practices, equipment types and operational issues have not changed much over the last decade or since the last formal review into this sector *In From the Cold* by Equipment Energy Efficiency (E3) program published in 2009². The main differences since the last review is there are more energy saving opportunities available due to advancements in technology, however they are often not taken up due to least cost.

² Refer Section 6: *Wall-in Coolrooms*, <http://energyrating.gov.au/document/report-cold-background-technical-report-volume-2>.

4 Definition of walk-in cooler and walk-in freezer

Walk-in cooler and walk-in freezer (WICFs) mean an enclosed storage space refrigerated to temperatures, respectively, above, and at, or below 0°C that can be walked into.

Includes those WICFs with display panels and doors and non-display panels and doors.

This includes WICs used for retail applications and liquor outlets where the consumer can reach into the WIC via a glass door (i.e. convenience stores) or walk into the WIC (i.e. liquor outlet) to select beverages and foodstuffs. These types of walk-in coolrooms (WICs) typically have transparent doors (i.e. glass) and windows.

Components that affects energy consumption include refrigeration equipment (condensing unit³ and evaporator, or packaged drop-in/slide-in), controls (integrated or separate), defrost method (electric, hot gas, or demand), doors, sealing, lights, windows, walls and floors.

Exclusions:

- Refrigeration display cases and merchandisers;
- Refrigerated Storage or service cabinets typically used in commercial kitchens;
- Cold storage facilities with a chilled storage area $\geq 280 \text{ m}^2$; and,
- Equipment and products exclusively for medical, scientific, or research purposes.
- Other applications that may or may not be included are:
- Food preparation rooms where the temperatures may be 5 to 7°C where they may have lower air flows to prevent draughts, require lower noise levels for operators and be humidity controlled.
- Process applications that include coolrooms with the introduction of other gases (e.g. ripening rooms with non-standard atmospheres).

Table 1: WICF nominal sizes.⁴

Description	Dimensions	Nominal capacity (kW _r at 5°C)
Mini	$< 9 \text{ m}^2 \times 3 \text{ m high}$	2,250
Small	$\geq 9 \text{ m}^2 \text{ and } < 24 \text{ m}^2 \times 3 \text{ m high}$	4,100
Medium	$\geq 24 \text{ m}^2 \text{ and } < 36 \text{ m}^2 \times 4 \text{ m high}$	9,000
Large	$\geq 36 \text{ m}^2 \text{ and } < 100 \text{ m}^2 \times 4 \text{ m high}$	20,400

³ Condensing unit means a product integrating at least one electrically driven compressor and one condenser, capable of cooling down and continuously maintaining low or medium temperature inside a refrigerated appliance or system, using a vapour compression cycle once connected to an evaporator and an expansion device.

⁴ Small warehouse is greater than 100 m² and up to 7m high.



Figure 1: New walk in coolroom with three evaporators.



Figure 2: Conventional condensing unit that is typically located outdoors to reject heat.

5 Approach

Industry research including:

- Review of existing international standards and guidelines;
- AIRAH online survey and social media forum discussions;
- Interviews of industry participants; and,
- AIRAH Workshop

The survey was conducted in April-May 2018, with an invitation for comments being distributed to all AIRAH members nationwide (3,000) and all social media contacts (over 15,000) Around 70 responses were received.

Members surveyed were representative of all States and Territories and from the following sectors of the industry:

- Equipment manufacturers and suppliers;
- Installation and maintenance contractors;
- Cleaning contractors;
- Designers, refrigeration engineers and environmental consultants;
- Training practitioners;
- End users (i.e. supermarkets);
- Energy retailers;
- Government employees responsible for energy efficiency; and,
- Controls companies.

6 International standards and guidelines

6.1 USA

The US Department of Energy (US DoE) introduced efficiency requirements and test methods for Walk-in Coolers and Freezers (WICFs) taking effect from 1 January 2009.

These set out the initial minimum design requirements for WICFs operating both above and below 0°C with chilled storage area of less than 278.71 m², covering construction materials and electrical energy using components. It includes those with display panels and doors and non-display panels and doors. Based on minimum insulation requirement (R-values) for insulated panels and doors and in addition design/construction requirements for components that has an effect on the heat load. Effective from June 2017 WICFs have minimum Annual Walk-in Energy Factor (AWEF) specified based on net capacity and labelling requirements.

6.2 Europe

EU Standards covering the performance of Walk-in Cold Rooms are currently being developed in Europe to meet the requirements of the ERP regulations including:

EN 16855-1:2017 Walk-in cold rooms – Definition, thermal insulation performance and test methods – Part 1: Prefabricated cold room kits.

Draft EN 16855.2:2017 Walk-in cold rooms – Definition, thermal insulation performance and test methods – Part 2: Customised cold room kits.

These standards reference ISO and EN standards relating to thermal performance of structures, windows, doors and shutters, as well as *EN 13771-2:2017 Compressors and condensing units for refrigeration. Performance testing and test methods.*

6.3 Australia and New Zealand

IPCA Code of Practice V4.2 published by Insulated Panel Council of Australia that covers structures built using Insulated Sandwich Panels (ISPs) and Expanded Polystyrene Fire Resistant (EPS-FR) insulated panels relating primarily to fire safety.

Safe operation of cold storage facilities published by WorkSafe Victoria, June 2008, that covers a number of operational aspect as well as some design aspects relating to safety.

Coldstore Engineering in New Zealand – IPENZ Practice Note 15, covers all aspects of coldstores, including insulation, refrigeration, electrical, structure, operations and maintenance.

DISCUSSION QUESTION #1

Are you aware of any international or company in-house guidelines or standards for WICF?

DISCUSSION QUESTION #2

What do you consider to be essential practice in the design, install and operation of WICF and what are the main barriers to this being met?

7 Technology development

A wide variety of energy saving opportunities exist with new and existing stock in the following key areas:

- New refrigeration technology, including DC technology (compressor, fans and controls), similar to air conditioning split systems, can save more than 25% and CO₂ refrigerant-only technology that can deliver similar savings in Victoria with a refrigerant with a GWP of 1;
- Controls including defrost controls;
- Increased insulation, proper sealing and improved construction of structure.
- Proper design, installation, commissioning and maintenance; and,
- Education, installation and operation instructions and documentation.

The most common themes and feedback are discussed under these key topics in this section, however some of these topics overlap (e.g. refrigeration technology and controls).

7.1 Refrigeration technology

Refrigeration technology used in this sector has remained relatively stagnant or conventional for much of the last twenty years, and new technology opportunities that can achieve savings of more than 25% have only recently emerged.

The existing stock of equipment comprises three configuration types:

- Drop-in/slide-in packaged sealed units for small WICFs typically up to 24 m² accounting for less than 5% of WICFs based on stock;
- Remote condensing unit located outside (or on top of the WICF) with one evaporator (one to one) or multiple evaporators on larger coolrooms; and,
- Small systems where there may be multiple refrigeration requirements for a coolroom, freezer and display cases for a retail outlet (i.e. convenience store).

A remote condenser and evaporator installed in a one on one arrangements account for the very large majority of applications. They typically use conventional hermetic reciprocating compressor technology, without electric commutated (EC) fans, basic controls and electric defrost on a timer. This sector is mostly served by basic refrigeration contractors working to the lowest denominator that does not consider electricity consumption to cater for the needs of SMEs with least cost behaviour and minimum maintenance. These contractors would typically have a certificate III in refrigeration and air conditioning and hold an Australian Refrigeration Council (ARC) refrigerant handling licence.

The new and emerging technology options include:

- DC technology (DC compressors, EC fans and electronic controls) that mimic air conditioning split systems technology to achieve flat line temperature control and can save more than 25%;
- Pulse modulation semi hermetic compressors with inverters, EC fans and room temperature probes to provide improved refrigerant and capacity control suited to larger one on one applications; and,
- Self-contained small capacity direct expansion (DX) CO₂ cascade low temperature system, designed to be close coupled to the evaporator and connected to a high side medium temperature ring main to satisfy multiple applications.
- The Internet of Things (IoT) is emerging in medium sized refrigeration technology to make products more intelligent and user friendly.
- Ammonia equipment is best suited to larger applications beyond the scope of this work and hydrocarbon is a potential candidate for small WICFs providing the requirements of *AS/NZS ISO 5149.1:2016 Refrigerating systems and heat pumps - Safety and environmental requirements* can be met.

DISCUSSION QUESTION #3

Are there any other new or emerging technologies that you are aware of?

7.2 Controls including defrost controls

WICF control types can vary from basic on-off control thermostats and an electric defrost timer to sophisticated electronic cold room controllers with smart or demand defrost.

Common practice is to use a basic electric defrost timer (i.e. switches on 4 to 6 times per day). Contractors use this because it's the easiest solution, but it is the most expensive to run. An alternative control approach is electric on demand via a controller based on temperature termination (i.e. switches off based on set point). Hot gas defrost is less common as it can be problematic and less common options include reticulating phase change materials.

Specialist cold room controllers that optimise the benefits of DC inverter technology have recently emerged to mimic the split system concept. These dedicated WICF controllers adopt an integrated approach that connects the controller, condensing unit, evaporator and electronic thermal expansion valve (TX) to achieve flat line temperature control (as close as practically possible). Other features include demand defrost and accessories to offer IoT features such as data logging and maintenance reminders and logs.

7.3 Cool room and freezer structure

The recommendations in *In From the Cold*⁵ almost a decade ago for minimum standards on all structural aspects that affect the thermal performance of the WICFs and major equipment is still considered a sound technical position. The recommendations relating to the structure were to harmonise with the regulations introduced by the US Department of Energy, 1 January 2009, as follows:

- Insulation panels for walls, ceilings and doors are to have an R-value of at least 4.5 m²K/W which equates to 100 mm polyisocyanurate (PIR) or 200 mm expanded polystyrene (EPS) on coolrooms and 6.0 m²K/W (thicker than 150 mm PIR) on freezers;
- Minimum thermal insulation ratings on floors of at least 4.9 m²K/W for all WICFs;
- Transparent windows and doors to have double glazed on coolrooms and triple glazed on freezers; all glass panes to have heat reflective treatment and gas fill;
- Proper sealing of room, which prescribes the joins of insulation panels, types of doors and door gaskets; and,
- Energy-efficient interior lighting to have an efficiency equal to or better than LED lights.
- Other considerations raised regarding the structure are:
 - The cladding type is important as it can range from aluminium (i.e. different gauges), plastic, stainless steel and checker plate up to a height to prevent damage (i.e. trolleys, fork trucks, etc.);
 - Bollards/rails to protect panel along accessible walls;
 - Damaged panels absorb moisture and are less thermally efficient;
 - Undertaking performance checks on medium and large WICFs every 5 years is good practice. For example, if the heat-loss was 100 W/m²/°C when installed and when retested it was twice that you know you have problems. This is particularly relevant with WICFs located outside (i.e. not in a conditioned space);
 - The thermal rating to suit local ambient conditions and room internal temperature and must be fire rated;
 - Essential that freezers have floor insulation and in many instances floor heating for frost heave protection;

⁵ Refer page 115, <http://energyrating.gov.au/document/report-cold-background-technical-report-volume-2>.

- A full vapor seal is important with all penetrations correctly sealed;
- Must have strip doors, spring hinged doors, or other method of minimizing infiltration when doors are open; and,
- Automatic door closers on doors for WICFs with fork truck access.

DISCUSSION QUESTION #4

What technical and non-technical barriers are there to uptake of these recommendations?

DISCUSSION QUESTION #5

Which sectors / clients follow good practice, design, install, commissioning, maintenance, behaviour?

DISCUSSION QUESTION #6

Do you know of any good practice case studies that have been published, or any sites that would make a good case study?

7.4 Good practice design, installation, commissioning and maintenance

Good design involves undertaking heatload calculations for the application and correctly matching equipment (i.e. condensing units and evaporators) to meet the design load.

There is no Australian industry design guide or standard, however all major suppliers of commercial refrigeration equipment (including Actrol, Airefig, Beijer, Bitzer and Heatcraft) have proprietary heatload calculators and product selectors to ensure the equipment is selected for the application.

A heatload calculation takes into account the product entering time and frequency; set point; condenser ambient conditions (38°C or 43°C); product characteristics such as specific heat; WICF dimensions and R-values for walls, floors and windows; door opening frequency; defrost type; and, typically a 10% safety factor to calculate the refrigeration load required based on a run time of 16 hours per day.

Practical installation considerations include evaporator and condensing unit positioning. For example, the evaporator should be located so cold air does not blow straight out the door. It is important to minimise air infiltration. This not only creates additional refrigeration load, it lets moisture into the WICF which ices up the evaporator (i.e. require more defrost) and can result in ice forming on the floor.

Common feedback from participants surveyed and interviewed was poor commissioning, particularly not setting up superheats correctly, which typically results in poor performance for the expected lifespan of the equipment.

Dirty coils, blocked drains, defrost not working and high refrigerant leak rates (~15% per annum) are other issues that are common place in this sector. Scheduled preventative maintenance should comprise

checking for refrigerant leaks, loose electrical connections, superheat, coils are clean (inside and out) and defrosts are adequate (not overheating the cold room).

In practice preventative maintenance is simply not recognised as a task that contributes to the bottom line. Rather breakdown repair, or “fail and fix” where end users simply wait for equipment to fail before fixing it is more common place. Poor hygiene (build-up of plastic bags, hair, lint, dirt and bugs on coils) and poor maintenance was a consistent theme throughout the survey feedback. Most participants suggested quarterly maintenance checks, and monthly with larger systems (i.e. refrigerant charge >20 kg and over 20 kW).

There is no statutory requirement to undertake a heatload calculation or maintain records so contractors undertaking maintenance understand the basis of the design or when it was last serviced.

DISCUSSION QUESTION #7

Are there any additional aspects of best practice you are aware of?

DISCUSSION QUESTION #8

Does best practice change from small to medium to large WICF?

DISCUSSION QUESTION #9

What level of skill is there in the refrigeration sector to undertake good practice design?

DISCUSSION QUESTION #10

What hygiene issues for the customers staff working around the WICF are you aware of as a result of poorly maintained equipment?

DISCUSSION QUESTION #11

What hygiene issues for product stored in WICF are you aware of as a result of poorly maintained equipment?

DISCUSSION QUESTION #12

It is recognised that safety issues often prevent ongoing maintenance. What safety issues are you aware of that might prevents good maintenance?

7.5 Education, installation and operation instructions and documentation

Unlike air conditioning, refrigeration equipment typically does not come with installation or operation guidelines. They are considered a custom design, and documentation is the responsibility of the installer. The extent of the documentation may typically include equipment data sheets and the controller operator manual.

There are no minimum performance requirements for WICFs or associated refrigeration equipment, and no requirement to fix a performance label. Whereas the large majority of air conditioning types must satisfy minimum performance requirements under the Greenhouse and Energy Minimum Standards (GEMS) Act.

There are many common sense operational factors that are commonly ignored that result in poor performance and increased energy consumption. Potential areas for improvement include:

- A loading and unloading policy: When product arrives, you need to ensure that it doesn't warm up any more than necessary, so load it as quickly as possible into your freezer.
- A lot of cool air is lost during opening and closing doors.
- Don't overload the WICF or stack produce in front of evaporator.
- Don't load equipment on top or in front of condensing units.
- Turn the lights off when not required.
- Door alarms are cheap but are no good if they are ignored or disabled.
- There is no specific training available for designing, installing or operating WICFs.
- Potential educational opportunities include:
- Guideline on the energy saving benefits of key energy saving initiatives: Top energy saving 10 initiatives.
- Simple on-line calculator to help end users understand pay back economics.
- Best in class equipment (30% saving) versus least cost.
- Higher thermal rating (range of opportunities and paybacks).
- Cost impact of poor operation (leaving doors open).
- Educate the trade on how to successfully install, commission and maintain equipment.
- Operational manual for contractors to give end users.

DISCUSSION QUESTION #13

What other behavioural factors of the end user, or operational factors waste energy in WICF?

DISCUSSION QUESTION #14

Are you aware of any factsheets, guides, awareness raising material from specific industry sectors that address energy efficiency in WICF? (eg Master Grocers Association have developed facts sheets for their members)

8 Industry feedback

Common themes from surveys and interviews regarding issues were as follows:

Behavioural	Equipment beyond life expectancy is not being replaced. Clients continually patching up with repairs, in some circumstances on equipment nearing 40 years old.
Behavioural	Leaving doors open to provide cooling in hot kitchens.
Design	Businesses often buy the minimum sized WICF to meet their requirements for cost reasons then tend to overload the room resulting in poor air flows (i.e. stacking produce in front of evaporator air flow).
Design	Smaller WICFs are more subject to design to the lowest dollar which leads to system inefficiencies.
Design	No floor insulation, then use of perimeter heating to avoid condensation.
Design	Not well thought out design in regard to evaporator selections and capacity.
Design	Strip curtains to all external doors, and fan cut-off switches.
Design	Avoid heat rejection into the kitchen.
Education	The majority of contractors working on this equipment are smaller businesses. These are the ones that need to be reached for education. This needs to be tackled at the end of the industry that deals with small business.
Education	End-user education regards the cost benefits of correctly selected equipment and the training for the staff using the WICFs is important as most waste is in the incorrect application, loading, leaving doors open, ignoring poor performance and lack of visibility of power consumption.
Equipment	When components are replaced sometimes they are replaced with the lowest cost fan rather than the same or right fan. Common to see different or incorrect fans on existing condensing units and evaporators.
Installation	Poor pipe insulation. The NCC specifies insulation requirements for pipe diameters >5/8" that says it should be 19 mm thick insulation – we sell a lot of 13 mm.
Installation	Pipework and electrical entry points not sealed.
Installation	Poor commissioning, particularly not setting up superheats correctly lead to poor performance, this seems to be an area of the trade that is being lost due to a lot of refrigeration mechanics doing an entire apprenticeship servicing air conditioning and installing split AC units.
Installation	Not sealing joins and repairing seals (Silicon and door seals are cheap).
Installation	Incorrectly matched and uncommissioned equipment are some of the key issues. For example, TX out of the box (i.e. superheat not set up) is very common place.

Operational	Often a disconnect between installation and service. Contractors that install the WICFs are not the same people that service.
Operational	Correct refrigerant charge and cleaning coils are the obvious maintenance items.
Structure	Poor design of door frames (i.e. aluminium) and heaters (i.e. w/m too high) resulting them being too hot.
Technology	HFC-404a (GWP of 3922) is still the most common refrigerant in commercial refrigeration although there are plenty of low GWP alternatives available including HFO blends HFC-448A (GWP of 1387 ^{AR4}) or HFC-449A (GWP of 1397 ^{AR4}).
Technology	Energy efficient solution for medium temperature applications can be achieved with HFC-134a (GWP of 1430). This also has the benefit of HFC-513A, also referred to as XP10, (GWP of 573) as being a retrofit at a future date.
Technology	Best practice: package trans critical CO ₂ equipment. Electronic expansion valves, variable speed compressor, EC fans with pressure control and leak detection installed inside condensing units over a certain size. Minimum standard for refrigerant GWP ≤ 1430.
Technology	There is a lack of cost competitive natural refrigerant options for WICFs.
Technology	Mechanical expansion valves are selected instead of electronic expansion valves.
Technology	Variable frequency drives are rarely installed.

End of Report



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