

KPHI Decarbonisation Workstream 2 Final Report

Drop-in replacement refrigerants

Final Revision

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Executive Summary

Workstream 2 of the Kiwifruit Post-Harvest Industry (KPHI) Decarbonisation Programme focused on replacing high Global Warming Potential (GWP) refrigerants (e.g., R404A) with lower GWP alternatives (e.g., R449A) in existing coolstore systems across four pilot sites.

The aim of Workstream 2 was to assess real-world costs, performance impacts, and practical considerations of these “drop-in” refrigerant replacements.

This report summarises the findings of 28 pilot projects which collectively recovered 35% of the total known R404A refrigerant charge identified by the 2024 DETA Kiwifruit Post-Harvest Refrigeration Survey, which covered 97% of the industry.

Key findings include:

- **6,723 kg** of R404A refrigerant was recovered across 28 systems. Replacing it with R449A has reduced the potential on-site refrigerant emissions by approximately **17,500 tCO₂e**.
- Refrigerant destruction and remediation service providers such as **Cool-Safe, RefDestruct** and **A-Gas** can offer significant support for projects that remove old refrigerants, especially where large volumes of high GWP refrigerant is being replaced.
- **Mechanical expansion valves** have relatively low capital cost and are well suited to steady duties such as long-term stable storage applications, or where the system has limited annual operating hours.
- **Electronic expansion valves**, while significantly more expensive upfront, may deliver significant efficiency gains in systems with variable cooling demands.
- **Power draw analysis** across 14 refrigeration systems found that energy performance remained similar following replacement of R404A with R449A. While some systems showed small increases in electricity consumption and others showed small decreases, no consistent impact of refrigerant replacement on energy use was observed.
- **Environmental considerations** highlight that while R449A reduces GWP, it contains HFOs, which pose long-term ecological and phase-out risks.

Recommendations

Based on the findings of Workstream 2 the following recommendations are made for coolstore operators considering refrigerant replacement projects on their site(s):

- Discuss your situation with refrigeration destruction service providers to get customised guidance on the support they can offer. Some providers offer higher payments per kg to destroy high GWP refrigerants for larger quantities of refrigerant (refer to Appendix D).
- Consider carefully with your refrigeration contractor whether each coolstore justifies installation of electronic expansion valves, or whether mechanical valves are preferred due to their lower capital cost. Electronic valves do offer benefits, but those benefits are often insufficient to justify their higher up-front capital cost, particularly on single-purpose stable storage coolstores or duties with low annual run-hours. (Refer to Section 2.3).

1. Background

This section provides the background to the Workstream 2 pilot projects and supporting enquiries.

Key points:

- Workstream 2 involved a series of pilot projects across four Kiwifruit Post-Harvest Industry (KPHI) businesses where high GWP refrigerants were replaced with lower GWP refrigerant alternatives in 28 selected cool store refrigeration systems.
- The pilot projects aimed to investigate the real-world costs, challenges, practicalities and impacts of drop-in replacement refrigerants on efficiency and other performance of cool stores.
- To understand key financial drivers, enquiries were also made to:
 - Refrigerant destruction service providers regarding available support for refrigerant replacement projects.
 - Refrigeration contractors, regarding the key considerations when choosing between mechanical and electronic valves.

1.1 KPHI Decarbonisation Programme

Kiwifruit is the biggest horticulture industry in New Zealand, and New Zealand is the largest global exporter of kiwifruit by a wide margin. The industry faces headwinds to decarbonise with the main challenges being transport and cool storage.

The Kiwifruit Post-Harvest Industry (KPHI) working group is carrying out a programme of work, with support from MPI's Primary Sector Growth Fund (PSGF), to help address the cool storage decarbonisation challenge. The work aims to equip the New Zealand KPHI (and other related industries) with the knowledge required to determine the most cost-effective options to reduce greenhouse gas emissions liability at their sites.

The programme constitutes four workstreams as follows:

1. Use of natural refrigerants for new or replacement refrigeration systems.
2. Replacement of high Global Warming Potential (GWP) refrigerants with lower GWP refrigerants for existing systems.
3. Refrigerant leak mitigation and minimisation.
4. Programme management including stakeholder engagement, communication, knowledge sharing and administration.

1.2 Workstream 2

Workstream 2 involves a series of pilot projects carried out on existing refrigeration systems across four different KPHI businesses to replace high GWP refrigerant (R404A) with a so-called "drop-in" replacement lower GWP refrigerant (R449A).

The pilot projects aimed to investigate the real-world costs, challenges, practicalities and impacts of drop-in replacement refrigerants on efficiency and other performance of cool stores.

This report provides a summary of the key findings from the pilot projects and provides insights and guidance for cool store operators considering similar refrigerant replacement projects in future.

1.3 Overview of Refrigeration Systems in Pilot Projects

Table 1 provides a summary of the number of refrigeration systems that had their high GWP refrigerant replaced in the pilot projects, and how many cool stores those systems serve. The pilot projects were implemented across four stages, with the first pilots implemented in Feb 2025 and the last pilot implemented in Feb 2026.

Note: for the purpose of this study participating KPHI businesses have been anonymised.

Table 1: Count of refrigeration systems involved in pilot projects by KPHI business

KPHI business	Number of systems having refrigerant replaced	Programme stages in which work is completed
Post Harvest Operator A	19	1, 2, 3, 4
Post Harvest Operator B	2	1
Post Harvest Operator C	6	3
Post Harvest Operator D	1	4

1.4 Methodology and KPIs

Summary information was developed for each of the refrigeration systems that had their high GWP refrigerant replaced, based on verbal discussions with the relevant coolstore manager as well as a case study form completed by the coolstore manager.

The key performance indicators (KPIs) assessed were as follows:

- Power draw meter trends at a refrigeration system level (where available), used to determine total kWh of electricity used over an equivalent multi-day period of operation at full capacity before and after the refrigerant change. Equivalent periods were required to have relatively similar ambient temperature profiles (as determined by comparison of average cooling degree days with a 0°C basis).
- Details of what the old and new refrigerant were, as well as quantities recovered and used.
- Capital cost (excluding refrigerant costs, which were addressed separately to allow normalising).
- Qualitative comments on before and after ability of the affected coolstore(s) to provide the required product cooling, e.g., Were any significant issues observed with having sufficient capacity? Did this improve or worsen at all after the refrigerant replacement?
- Other learnings as were identified by each site.

1.5 Supporting Investigations

To supplement the information obtained directly through the pilot trials, DETA liaised with refrigerant destruction service providers and refrigeration contractors to better understand specific factors that were identified as having a strong influence over project financials, namely:

- What support can refrigerant destruction service providers offer to refrigerant replacement projects, and how do key parameters influence the level of support available?

- When should electronic valves be installed as part of a refrigerant replacement project, and when are mechanical valves more appropriate? What are the main issues to consider when making this decision?

The findings of these enquiries are included in Sections 2.2 and 2.3 below.

2. Workstream 2 Findings

This section provides the key findings of the Workstream 2 pilot projects and supporting enquiries. Tables summarising the pilot projects are provided in Appendix A.

2.1 Emissions Impact

The pilot projects involved recovery of 6,723 kg of R404A refrigerant from 28 refrigeration systems. Replacing the R404A with R449A reduced the potential on-site refrigerant emissions from refrigeration systems by approximately 17,500 tCO₂e.

This represents recovery of 35% of the total known R404A refrigerant charge identified by the 2024 DETA Kiwifruit Post-Harvest Refrigeration Survey, which covered 97% of the industry (by market share).

2.2 Refrigerant Destruction Service Providers

Refrigerant destruction service providers can offer financial or other support to coolstore operators who are removing significant quantities of high GWP refrigerant for destruction.

Cool-Safe, Refspecs / RefDestruct and A-Gas were each approached for a statement on what support they can offer and their responses are provided in Appendix D.

We recommend coolstore managers contact all major refrigerant destruction service providers when contemplating drop-in replacement projects to confirm what specific support they can offer to their project. High GWP refrigerants are expensive so getting the best deal to suit the particular needs of the project can significantly improve financial viability.

2.3 Mechanical vs Electronic Valves

Key points:

- Mechanical valves are commonly used for cool stores, particularly those that only do long-term stable storage duty as they are less expensive and are viewed as providing adequate performance in these simple duties.
- The greater versatility of electronic valves can give them significant efficiency benefit in cool stores that do varying duties, such as those that do both pre-cooling as well as long-term stable storage.
- Electronic valves may also be preferred for refrigerant replacement projects involving cool stores that struggle to deliver adequate cooling, to ensure the upgraded system runs at maximum performance.
- The systems in this study all involved replacing R404A with R449A but the above points also apply to direct expansion (DX) systems that use other refrigerants, as they are based on fundamental differences between how electronic and mechanical valves function.

Refrigerant expansion valves regulate the flow of refrigerant into the evaporator to maintain a target level of superheat in the vapour exiting the coil. This ensures the evaporator receives

enough refrigerant for effective heat exchange, while ensuring that only vapour – not liquid – returns to the compressor, preventing potential damage.

Mechanical expansion valves rely on temperature and pressure-driven physical forces to adjust refrigerant flow, whereas electronic valves use sensors and microprocessor-controlled stepper motors to respond precisely to real-time conditions. This active control allows electronic valves to maintain tighter superheat margins, improving energy efficiency and system responsiveness under varying load conditions.

Expansion valve selection is a key consideration in refrigerant drop-in replacement projects, with implications for both capital cost and system performance. This section summarises the technical differences between mechanical and electronic expansion valves (EEVs), and presents insights from pilot participants and industry contractors.

2.3.1 Technical Comparison

Table 2 provides a generalised comparison of mechanical valves and electronic valves for refrigerant replacement projects.

Table 2: Mechanical vs electronic valves comparison

Topic	Mechanical expansion valves (TXV)	Electronic expansion valves (EEV)
Project cost excluding refrigerant	Low. ~\$20k for a large coolstore (22 evaporators)	High. ~120k for a large coolstore (22 evaporators)
Formal name	Thermostatic expansion valve (TXV)	Electronic expansion valve (EEV)
Control mechanism	Temperature-sensing bulb that pushes on a spring to open or close the valve	Motorised valve, sensors and real-time controller to achieve a desired setpoint
Efficiency in constant load duties (e.g. long-term stable storage)	Good (potentially excellent if correctly set)	Excellent
Efficiency in varying load duties (e.g. dual-purpose systems)	Mediocre	Excellent
Likely modifications required if refrigerant is changed again in future	Replace valve or powerhead	Adjust settings in controls only

2.3.2 Industry Perspectives

Feedback from refrigeration contractors was mixed and context-dependent.

Excel Refrigeration highlighted several technical advantages of EEVs:

- *“Theoretical efficiency performances around 15% for use of EEV’s, especially at varying loads.*
- *Much finer control and automation ability to customise control logic.*
- *Ability to trend opening percentage for EEV potentially providing optimisation pathways. Trending will quickly tell you about a valve issue (i.e., valve stuck at 100% open) which you may not be aware of with a mechanical valve.*

- *Ability to complete refrigerant drop-ins without replacing thermostatic expansion valves. You can just reprogram an EEV for a new refrigerant. With how quickly refrigerant 'preferences' are changing this is seen as quite a large benefit."*

Some contractors meanwhile expressed scepticism about the cost-effectiveness of EEVs in retrofit scenarios, suggesting that the cost and complexity may often not be justified, and that funds may be better spent on new coolstores.

2.3.3 Real World Experience – Postharvest Operator A Trial

Postharvest Operator A provided the following insights into their views on mechanical vs electronic valves:

- Postharvest Operator A did a 3-month trial comparing electricity consumption of two coolstores, one having electronic valves and one having mechanical valves, but being otherwise similar. Their trial showed no significant difference between the energy efficiency of the two coolstores.
- They used two different refrigeration contractors to configure electronic valves on their coolstores but neither resulted in the electronic valves providing significant benefits vs mechanical valves.
- They found that the total installed cost of electronic valves has increased significantly since Covid. As a result, even if the electronic valves were achieving a 15% efficiency improvement, as some claim they can, it would still take a long time to pay off the higher capital cost vs mechanical valves.
- One factor favouring the use of electronic valves is that they offer better future-proofing for future refrigerant replacements. They can be easily reconfigured to suit new refrigerants, whereas mechanical valves typically require the valve to be replaced. However, Postharvest Operator A is now using a model of Danfoss mechanical valve that only needs its powerhead replaced to accommodate a new refrigerant, significantly reducing potential future costs.
- Based on the above, Postharvest Operator A is now using Danfoss mechanical valves as their default valve type for refrigerant replacement projects. They are only likely to consider electronic valves in applications where the cooling demand varies heavily between bin curing, avocados, kiwifruit storage and pre-cooling.

2.4 Environmental Implications of HFO-Based Refrigerants

The primary drop-in replacement refrigerant used in the pilot projects is R449A, which offers a 67% reduction in global warming potential (GWP) compared to R404A – 1282 versus 3943, respectively.

While this marks a step forward from a greenhouse gas emissions perspective, R449A contains hydrofluoroolefins (HFOs) such as R1234yf, which pose their own risks. If released into the environment, HFOs can degrade into PFAS “forever chemicals” such as trifluoroacetic acid (TFA). This raises long-term ecological concerns as TFA:

- Spreads via rainfall, accumulates in drinking water, soil, crops, animals and people.
- Is known to be rapidly accumulating globally, a fact that is primarily blamed on refrigerants.

- Has uncertain / contested long-term health effects.

This issue is common among many drop-in alternatives and has led to speculation that HFOs may eventually be phased out, likely beginning with Europe where there are already proposals to regulate the products that produce PFAS and TFA.

As such, HFO-based refrigerants should be viewed as transitional solutions to get old systems through to retirement, rather than as long-term replacements, especially when compared to more sustainable natural refrigerants.

2.5 Costs

Figure 1 provides a graphical summary of how pilot project costs varied depending on the number of evaporators in the system and on what expansion valve changes were made.

Note: Projects that required significant extra work (such as a project that included addition of a new compressor) were excluded from the analysis provided in this section, but are included in Figure 1 as “Non-Standard Projects”.

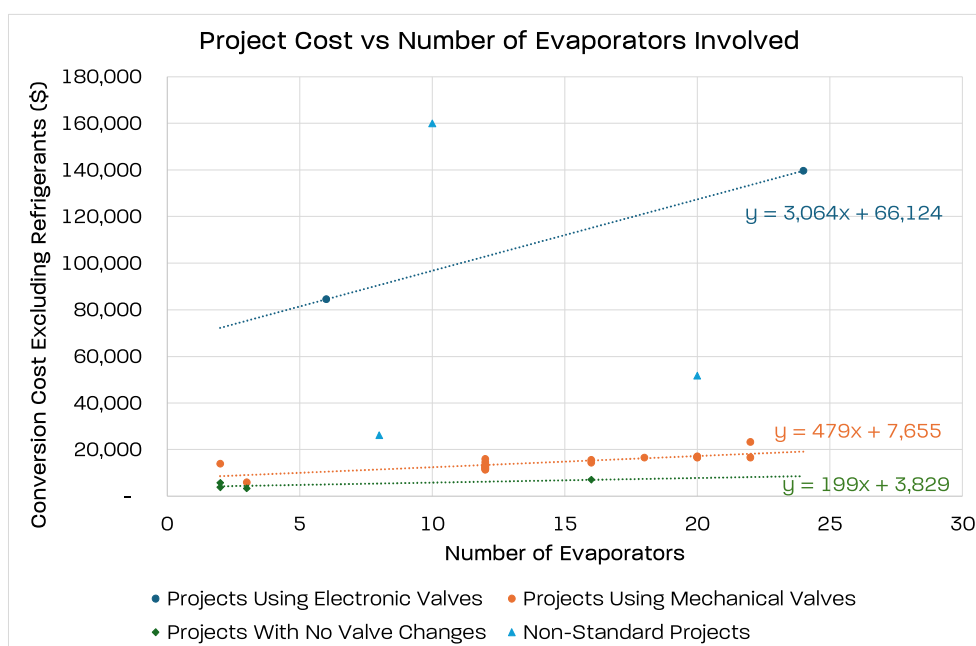


Figure 1: Summary of pilot project costs (excluding refrigerants).

Note: Trendlines are for indication only as actual costs depend on specific details of the system and changes required.

With reference to Figure 1 the following observations can be made:

- The median cost for projects using new electronic valves was \$112,000 based on 2 projects, with a median of 15 evaporators.

- The median cost for projects using new mechanical valves was \$14,400 based on 19 projects, with a median of 12 evaporators.
- The median cost for projects using existing expansion valves was \$4,700 based on 4 projects, with a median of 2.5 evaporators.

2.6 System Performance

2.6.1 Impact of Refrigerant Replacement on Energy Performance

Analysis was undertaken on 14 refrigeration systems where R404A was replaced with R449A and no known confounding factors were identified that would be expected to materially influence energy consumption. Systems affected by changes in operating practices, room usage, control strategies or other major modifications were excluded from this assessment. Appendix B provides summary graphs for the 14 systems of daily electricity consumption before and after the refrigerant replacement.

Across these systems, energy performance remained similar following refrigerant replacement. While individual systems exhibited small increases or decreases in daily electricity consumption, no consistent trend towards either improved or reduced energy performance was observed.

The magnitude of the observed changes was generally small relative to the influence of other operational and system factors. Site-specific changes such as coolstore utilisation, product loading, and evaporator fan speed settings were observed to have a greater impact on energy consumption than the refrigerant replacement itself.

These findings indicate that replacing R404A with R449A is unlikely to result in a material change in refrigeration system energy consumption in postharvest kiwifruit applications when no other significant system modifications are made.

2.6.2 Impact of Electronic Expansion Valves on Energy Performance

Pilot projects on 2x systems that upgraded from mechanical to electronic valves as part of the drop-in replacement work showed a statistically significant reduction in total plantroom power draw following the refrigerant change at the 99% confidence level¹. The mean power draw at the plantroom level reduced by 4% between two 9-day periods with comparable ambient temperatures and high load. This was for a plantroom where two of the three racks had their refrigerant replaced.

While a range of operational factors can influence refrigeration system power consumption, the result provides some support for the expectation that electronic expansion valves can contribute to improved energy performance.

The Postharvest Operator B coolstore manager responsible for this system provided the following comments regarding the observed reduction in power draw:

¹ Based on a Two-Sample Kolmogorov–Smirnov (K–S) Test.

- *“That’s not surprising but is interesting, also two out of the three racks have sub coolers which increase efficiency also.*
- *Our peak is May, since the fruit in these weeks is mid-long storing fruit. There would have to be more load on the racks in May than April. Due to driving precool temps a little lower and taking more heat out of pallets for static in these weeks since fruit is main pack.*
- *The use of electronic valves over mechanical is to gain more efficiency primarily.”*

2.7 Lessons

Table 3 provides a summary of key lessons identified through Workstream 2.

Table 3: Summary of the key lessons identified through Workstream 2

Topic	Lesson	Basis
Cool-Safe support	Disproportionally greater support for projects that destroy more refrigerant. Liaise with Cool-Safe to confirm specifics for each project.	Feedback from Cool-Safe. Refer Section 2.1 for further detail.
Mechanical vs electronic expansion valves	Expansion valve choice is a major driver of total project cost. The higher cost of electronic valves may not always be justified, particularly for simple long-term stable storage duties and/or where annual operating hours are low.	High cost of electronic valves can result in long payback times. Refer Section 2.3 for further detail.
Mechanical expansion valves	Some brands (e.g. Danfoss) offer mechanical valve models that allow the user to swap out just the powerhead if they need to change to a new refrigerant.	Feedback from cool store manager in case study response form.
Refrigerant leaks	Slow refrigerant leaks may not be identified by typical refrigerant gas detectors.	Feedback from cool store manager in case study response form.
Reusing existing mechanical valves	Change out R404A mechanical valves for mechanical valves specifically designed for R449A if time allows as they provide improved stability of operation.	Only one site attempted to reuse existing mechanical valves and in all three cases where they did so, they noted on their case study forms that they would recommend replacing the valves next time.

3. Recommendations

Based on the findings of Workstream 2 the following recommendations are made for coolstore operators considering refrigerant replacement projects on their site(s):

- Discuss your situation with refrigeration destruction service providers to get customised guidance on the support they can offer. Some providers can offer a higher payment per kg to destroy high GWP refrigerants if the quantities to be destroyed are larger (refer to Appendix D).
- Consider carefully with your refrigeration contractor whether each coolstore requires electronic expansion valves, or whether mechanical valves are likely to be preferred due to their lower cost. Electronic valves do offer benefits, but those benefits are often insufficient to justify their higher up-front cost on simple or low run-hour duties (Refer to Section 2.3).
- Treat drop-ins as a compromise solution that can be used to get old systems through to retirement, but not as an ideal permanent solution. They still carry risk of significant emissions, they may degrade into forever chemicals if leaked, and they are therefore likely to be phased out at some unknown point in future (Refer to Section 2.4).

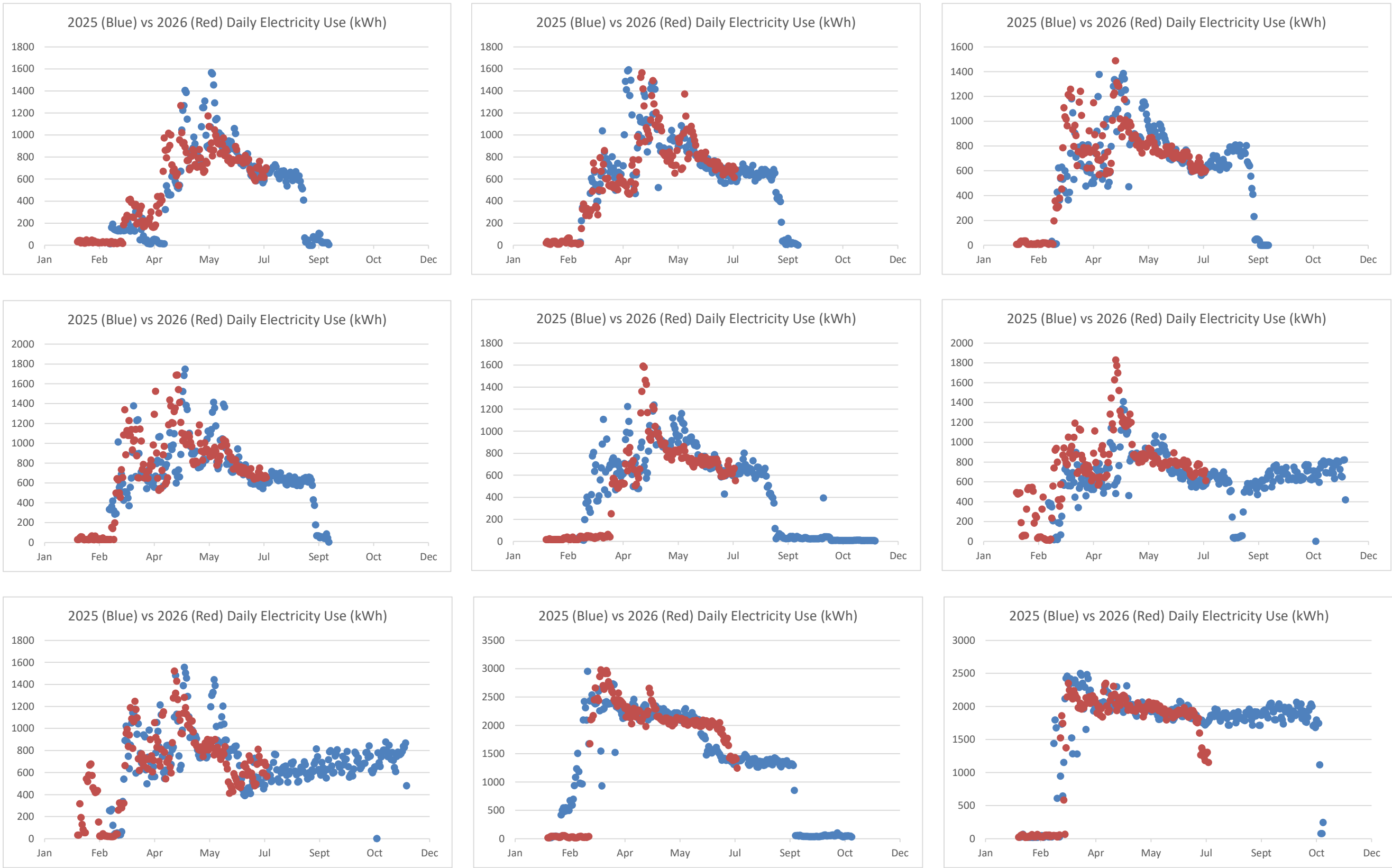
Appendix A: Case Studies Summary Table

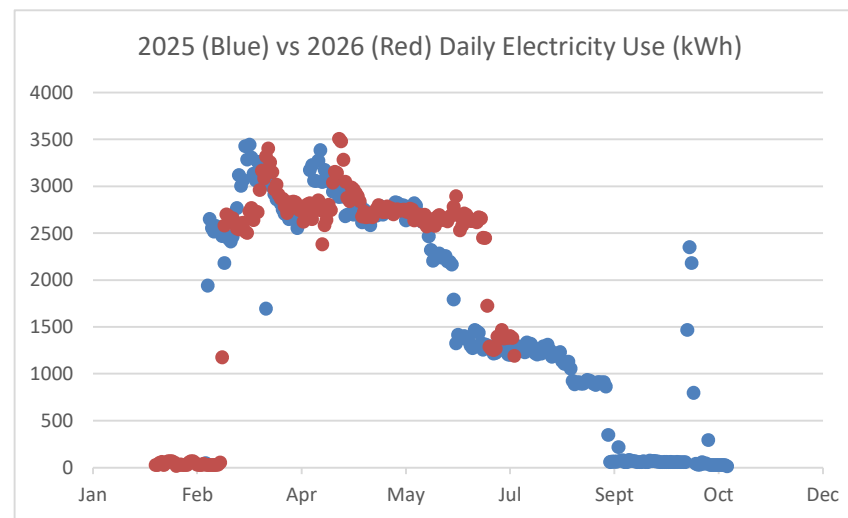
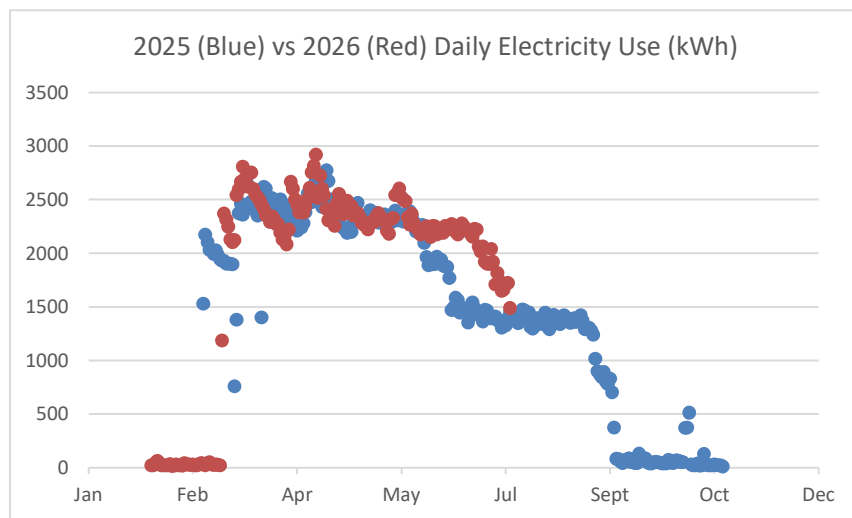
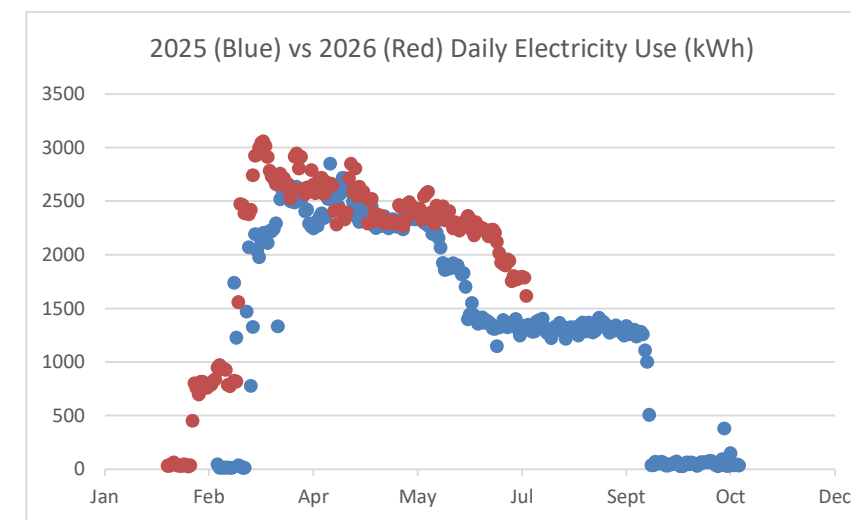
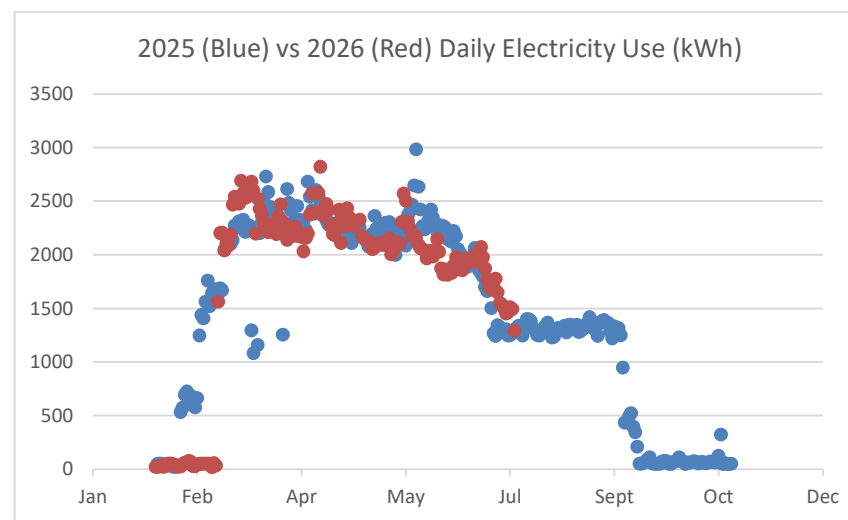
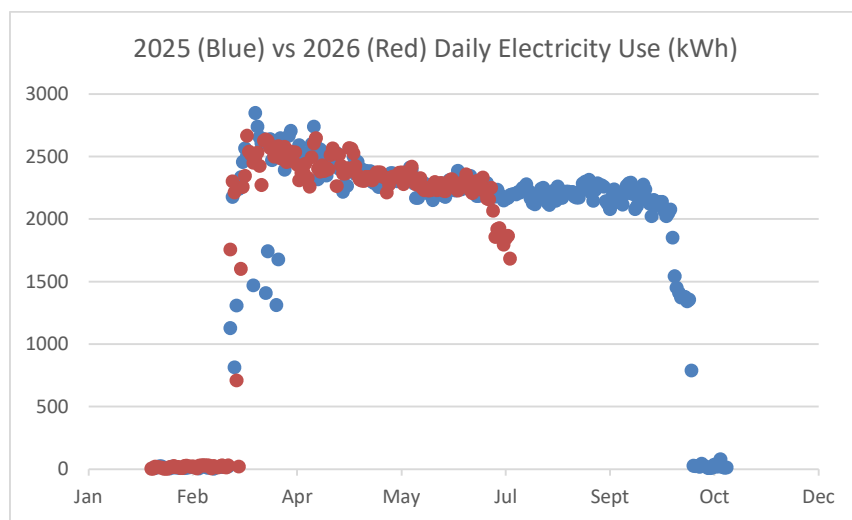
Ref	Case Study Description	No. Compressors	No. Evaporators	Old Refrigerant	Qty Expected (kg)	Qty Recovered (kg)	New Refrigerant	Qty Used (kg)	Valve Changes	Other Changes	Total Cost Excluding Refrigerants	Include in Cost Trend	Power Trend Analysis Results
A1.1	Post Harvest Operator A, Site A1, Coolstore 2	Before: 2, After: 3	10	R404A	218	250	R449A	293.8	Mechanical replaced with electronic	Added a compressor and condenser to give more capacity for precooling	\$160,000	N - Includes addition of a new compressor	Not comparable due to extra compressor
A1.2	Post Harvest Operator A, Site A1, Coolstore 23	3	22	R404A	305	343	R449A	339	Mechanical replaced with mechanical		\$23,272	Y	8% mean power draw increase for system
B1.1	Post Harvest Operator B, Site B1, Plantroom 4, Rack 1, Stores 15-17	3	6	R404A	300	180	R449A	271.2	Mechanical replaced with electronic		\$84,508	Y	4% mean power draw decrease for plantroom where 2 out of 3 racks had refrigerant replaced
B1.2	Post Harvest Operator B, Site B1, Plantroom 4, Rack 3, Stores 11&12	3	24	R404A	300	300	R449A	361.6	Mechanical replaced with electronic		\$139,658	Y	
A2.1	Post Harvest Operator A, Site A1, Coolstore 14	2	12	R404A	218	175.52	R449A	203.4	Mechanical replaced with mechanical		\$11,653	Y	Full data not yet available
A2.2	Post Harvest Operator A, Site A1, Coolstore 8	3	12	R404A	218	255	R449A	248.6	Mechanical replaced with mechanical	Removed EPR Valves	\$12,468	Y	Full data not yet available
A2.3	Post Harvest Operator A, Site A1, Coolstore 12	2	12	R404A	218	241	R449A	248.6	Mechanical replaced with mechanical		\$12,983	Y	Full data not yet available
A2.4	Post Harvest Operator A, Site A1, Coolstore 9	2	12	R404A	218	194	R449A	248.6	Mechanical replaced with mechanical		\$11,832	Y	Full data not yet available
A2.5	Post Harvest Operator A, Site A1, Coolstore 10	2	12	R404A	218	253	R449A	248.6	Mechanical replaced with mechanical		\$12,316	Y	Full data not yet available
A3.1	Post Harvest Operator A, Site A1, Coolstore 11	3	12	R404A	218	303	R449A	282.5	Mechanical replaced with mechanical		\$13,328	Y	Full data not yet available
A3.2	Post Harvest Operator A, Site A1, Coolstore 22	3	22	R404A	305	382	R449A	350.3	Mechanical replaced with mechanical		\$16,621	Y	Full data not yet available
A3.3	Post Harvest Operator A, Site A1, Coolstore 21	3	20	R404A	270	370	R449A	327.7	Mechanical replaced with mechanical		\$17,083	Y	Full data not yet available
A3.4	Post Harvest Operator A, Site A1, Coolstore 20	3	20	R404A	270	364	R449A	327.7	Mechanical replaced with mechanical		\$16,773	Y	Full data not yet available
A3.5	Post Harvest Operator A, Site A1, Coolstore 19	3	18	R404A	240	381	R449A	316.4	Mechanical replaced with mechanical		\$16,586	Y	Full data not yet available

Ref	Case Study Description	No. Compressors	No. Evaporators	Old Refrigerant	Qty Expected (kg)	Qty Recovered (kg)	New Refrigerant	Qty Used (kg)	Valve Changes	Other Changes	Total Cost Excluding Refrigerants	Include in Cost Trend	Power Trend Analysis Results
A3.6	Post Harvest Operator A, Site A1, Coolstore 18	2	20	R404A	240	381	R449A	327.7	Mechanical replaced with mechanical		\$16,635	Y	Full data not yet available
A3.7	Post Harvest Operator A, Site A1, Coolstore 16 Store	2	12	R404A	240	220	R449A	214.7	Mechanical replaced with mechanical		\$14,594	Y	Full data not yet available
A3.8	Post Harvest Operator A, Site A1, Coolstore 16 Pre/Cool	1	2	R404A	200	71	R449A	79.1	Already existing electronic valves. Reprogrammed EVD's for R449A.		\$5,704	Y	Full data not yet available
A3.9	Post Harvest Operator A, Site A1, Coolstore 17	2	16	R404A	240	389	R449A	305.1	Mechanical replaced with mechanical		\$15,567	Y	Full data not yet available
C3.1	Post Harvest Operator C, Site C1, Coolstore I	3	20	R404A	220	169	R449A	226	Mechanical replaced with mechanical	New Liquidline and solenoids	\$51,671	N - Includes replacement of liquid line	1.8% increase in compressor power draw
C3.2	Post Harvest Operator C, Site C1, Pre Cooler 11, 12	2	2	R404A	150	31.4	R449A	158	Mechanical replaced with mechanical	Gave System Service - Oil, Suction, + liquid Line + Oil Filters	\$13,933	Y	17% increase in compressor power draw (but performance fixed)
C3.3	Post Harvest Operator C, Site C2, Room D	3	16	R404A	220	150	R449A	203	Already existing mechanical valves. Adjusted position for R449A.	Oil, filters, driers, suction felts	\$7,095	Y	7.5% increase in compressor power draw
C3.4	Post Harvest Operator C, Site C2, Pre Cooler 1, 2, 3	3	3	R404A	150	104	R449A	169	Already existing mechanical valves. Adjusted position for R449A.	Oil, filters, driers, suction felts	\$3,321	Y	10% decrease in compressor power draw
C3.5	Post Harvest Operator C, Site C2, Pre Cooler 4, 5	2	2	R404A	150	81	R449A	135	Already existing mechanical valves. Adjusted position for R449A.	Oil, filters, driers, suction felts	\$3,777	Y	7.3% decrease in compressor power draw
C3.6	Post Harvest Operator C, Site C2, Pre Cooler 6, 7, 8	3	3	R404A	150	90	R449A	169	Mechanical replaced with mechanical	Oil, filters, driers, suction felts	\$5,953	Y	7.3% decrease in compressor power draw
A4.1	Post Harvest Operator A, Site A1, Coolstore 27 Store	2	12	R404A	220	240	R449A	237.3	Mechanical replaced with mechanical		\$11,315	Y	Full data not yet available
A4.2	Post Harvest Operator A, Site A1, Coolstore 27 Pre/Cool	3	16	R404A	240	411	R449A	293.8	Mechanical replaced with mechanical		\$14,449	Y	Full data not yet available
A4.3	Post Harvest Operator A, Site A1, Coolstore 15	2	12	R404A	218	194	R449A	248.6	Mechanical replaced with mechanical		\$15,920	Y	Full data not yet available
D4.1	Post Harvest Operator D, Site D1, Coolstores 7E & 7F	2	8	R404A	150 to 200	200	R449A	200	Mechanical replaced with mechanical	Solenoid valves replaced, all filters replaced, new oil, replaced O-rings, relief valves, thread tape.	\$26,221	N - Solenoid valves had to be replaced	Site power monitoring at transformer level, not to a per system level

Appendix B: Impact of Refrigerant Replacement on Energy Performance – Electricity Use Graphs

The below graphs show total daily electricity consumption per refrigeration system for 14 systems in the pilot trials where there were no specifically identified confounding factors.





Appendix C: Individual Case Study Forms

Case Study Ref. A1.1
Workstream Stage 1
Case Study No. 1
Replacement Date Feb-Mar 2025
Company Post Harvest Operator A
Site Site A1

System & Refrigerants

Coolstore Name Coolstore 2
Store Ref Post Harvest Operator A, Site A1, Coolstore 2
Duty Coolstore - Capable of Pre Cooling Packed Kiwifruit (Temperature Drawdown)
Number of Compressors Before: 2, After: 3
Number of Evaporators 10
Old Refrigerant R404A Original Qty Estimated (kg) 218 Actual Qty Recovered (kg) 250.38
New Refrigerant R449A Quantity Used (kg) 293.8

Electricity Demand Impact

Power Monitoring Resolution Whole single coolstore, CSV extract
Power Draw Before (kW)
Power Draw After (kW)
Comments Large increase expected due to additional equipment
Cold year last year meant colder fruit to site so less pre-cooling load

Extent of Changes

Valve changes Mechanical replaced with electronic
Other changes Added a compressor and condenser to give more capacity for precooling
Other comments Coolstore 2 was chosen at short notice as had to be repaired so changed out refrigerant at the same time

Learnings / General Comments

Comments Existing mechanical valves were Alco. Replaced with EVD Ice Electronic Valve from Carel.
Went with electronic valves on this coolstore only because is used for precooling and want more capability.
Capital cost is high due to additional compressor and condenser being included.

Capital Costs Excluding Refrigerants

Total equipment & materials cost
Internal Labour Cost or Internal Labour hours
Contractor labour Cost
Other costs excl. refrigerants
Total cost excl. refrigerants \$ 160,000.00

Estimated electrical costs included in the above total Not provided

Case Study Ref. A1.2
Workstream Stage 1
Case Study No. 2
Replacement Date Feb-Mar 2025
Company Post Harvest Operator A
Site Site A1

System & Refrigerants

Coolstore Name	Coolstore 23			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 23			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	3			
Number of Evaporators	22			
Old Refrigerant	R404A	Original Qty Estimated (kg)	305	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	339	342.7

Electricity Demand Impact

Power Monitoring Resolution	Whole single coolstore, CSV extract
Power Draw Before (kW)	CS23 power draw 12 Apr-10 Jun 2024 mean 109 kW
Power Draw After (kW)	CS23 power draw 27 Apr-25 Jun 2025 mean 118 kW
Comments	Statistically significant increase in power draw after the refrigerant change at the 99% confidence level. The mean power draw at the coolstore level increased by 8% between two 60-day periods with comparable ambient temperatures and high load.

Extent of Changes

Valve changes	Mechanical replaced with mechanical
Other changes	
Other comments	Coolstore 23 was as planned for this trial

Learnings / General Comments

Comments	Existing mechanical valves were Alco. Replaced mechanical valves from Danfoss. One benefit of Danfoss mechanical valves is that you can swap out just the powerhead if need to change to a new refrigerant later
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Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$	15,000.00	
Internal Labour Cost			or Internal Labour hours
Contractor labour Cost			176
Other costs excl. refrigerants	\$	-	
Total cost excl. refrigerants	\$	23,272.00	
Estimated electrical costs included in the above total	\$	-	

Case Study Ref.	B1.1
Workstream Stage	1
Case Study No.	1
Replacement Date	Feb-2025
Company	Post Harvest Operator B
Site	Site B1

System & Refrigerants

Coolstore Name	Plantroom 4, Rack 1, Stores 15-17				
Store Ref	Post Harvest Operator B, Site B1, Plantroom 4, Rack 1, Stores 15-17				
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only				
Number of Compressors	3				
Number of Evaporators	6				
Old Refrigerant	R404A	Original Qty Estimated (kg)	300	Actual Qty Recovered (kg)	180
New Refrigerant	R449A	Quantity Used (kg)	271.2		

Electricity Demand Impact

Power Monitoring Resolution	Whole plantroom level power draw which supplies 3x racks. CSV extract. ~64 minutely data.
Power Draw Before (kW)	Whole plantroom 4 power draw 22-30 Apr 2024 mean 359 kW
Power Draw After (kW)	Whole plantroom 4 power draw 4-12 May 2025 mean 343 kW
Comments	Statistically significant reduction in plantroom power draw after the refrigerant change at the 99% confidence level. The mean power draw at the plantroom level reduced by 4% between two 9-day periods with comparable ambient temperatures and high load.

Extent of Changes

Valve changes	Mechanical replaced with electronic
Other changes	
Other comments	

Learnings / General Comments

Comments	Lower gas recovery than expected, most likely due to a shorter run and a lot less evaporators than other 2 stores.

Capital Costs Excluding Refrigerants

Total equipment & materials cost		
Internal Labour Cost		or Internal Labour hours
Contractor labour Cost		
Other costs excl. refrigerants		
Total cost excl. refrigerants	\$	84,507.60
Estimated electrical costs included in the above total	\$	5,174.57

Case Study Ref. B1.2
Workstream Stage 1
Case Study No. 2
Replacement Date Apr-2025
Company Post Harvest Operator B
Site Site B1

System & Refrigerants

Coolstore Name Plantroom 4, Rack 3, Stores 11&12
Store Ref Post Harvest Operator B, Site B1, Plantroom 4, Rack 3, Stores 11&12
Duty Coolstore - Capable of Static Cooling Packed Kiwifruit Only
Number of Compressors 3
Number of Evaporators 24
Old Refrigerant R404A Original Qty Estimated (kg) 300 Actual Qty Recovered (kg) 300
New Refrigerant R449A Quantity Used (kg) 361.6

Electricity Demand Impact

Power Monitoring Resolution Whole plantroom level power draw which supplies 3x racks. CSV extract. ~64 minutely data.
Power Draw Before (kW) Whole plantroom 4 power draw 22-30 Apr 2024 median 365 kW
Power Draw After (kW) Whole plantroom 4 power draw 4-12 May 2025 median 343 kW
Comments Statistically significant reduction in plantroom power draw after the refrigerant change at the 99% confidence level.
The median power draw at the plantroom level reduced by 6% between two 9-day periods with comparable ambient temperatures and high load.

Extent of Changes

Valve changes Mechanical replaced with electronic
Other changes
Other comments

Learnings / General Comments

Comments Even with the gas detectors have been losing refrigerant over time.
This rack had the expected amount of gas recovered, due to it being on a larger pipe run.

Capital Costs Excluding Refrigerants

Total equipment & materials cost
Internal Labour Cost or Internal Labour hours
Contractor labour Cost
Other costs excl. refrigerants
Total cost excl. refrigerants \$139,658.40

Estimated electrical costs included in the above total \$ 13,674.49

Case Study Ref. A2.1
Workstream Stage 2
Case Study No. 1
Replacement Date Aug-2025
Company Post Harvest Operator A
Site Site A1

System & Refrigerants

Coolstore Name Coolstore 14
Store Ref Post Harvest Operator A, Site A1, Coolstore 14
Duty Coolstore - Capable of Bins Curing or Static Cooling Packed Kiwifruit
Number of Compressors 2
Number of Evaporators 12
Old Refrigerant R404A Original Qty Estimated (kg) 218 Actual Qty Recovered (kg) 175.52
New Refrigerant R449A Quantity Used (kg) 203.4

Electricity Demand Impact

Power Monitoring Resolution Whole single coolstore, CSV extract
Power Draw Before (kW)
Power Draw After (kW)
Comments

Extent of Changes

Valve changes Mechanical replaced with mechanical
Other changes
Other comments System Pressure Tested and Serviced before charging.

Learnings / General Comments

Comments

Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$	9,100.00	
Internal Labour Cost	\$	2,552.50	or Internal Labour hours
Contractor labour Cost	-		
Other costs excl. refrigerants			
Total cost excl. refrigerants	\$	11,652.50	

Estimated electrical costs included in the above total \$ -

Case Study Ref. A2.2
Workstream Stage 2
Case Study No. 2
Replacement Date Aug-2025
Company Post Harvest Operator A
Site Site A1

System & Refrigerants

Coolstore Name	Coolstore 8			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 8			
Duty	Coolstore - Capable of Bins Curing or Static Cooling Packed Kiwifruit			
Number of Compressors	3			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	218	Actual Qty Recovered (kg) 255
New Refrigerant	R449A	Quantity Used (kg)	248.6	

Electricity Demand Impact

Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes

Valve changes	Mechanical replaced with mechanical			
Other changes	Removed EPR Valves			
Other comments	System Pressure Tested and Serviced before charging.			

Learnings / General Comments

Comments				
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Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$	9,500.00		
Internal Labour Cost	\$	2,328.33	or Internal Labour hours	59.2
Contractor labour Cost	\$	640.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	12,468.33		
Estimated electrical costs included in the above total	\$	-		

Case Study Ref.	A2.3
Workstream Stage	2
Case Study No.	3
Replacement Date	Sept-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 12			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 12			
Duty	Coolstore - Capable of Bins Curing or Static Cooling Packed Kiwifruit			
Number of Compressors	2			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	218	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	248.6	241

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	9,100.00		
Internal Labour Cost	\$	1,483.33	or Internal Labour hours	23.7
Contractor labour Cost	\$	2,400.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	12,983.33		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A2.4
Workstream Stage	2
Case Study No.	4
Replacement Date	Sept-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 9			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 9			
Duty	Coolstore - Capable of Bins Curing or Static Cooling Packed Kiwifruit			
Number of Compressors	2			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	218	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	248.6	194

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	9,100.00		
Internal Labour Cost	\$	2,091.67	or Internal Labour hours	16.3
Contractor labour Cost	\$	640.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	11,831.67		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A2.5
Workstream Stage	2
Case Study No.	5
Replacement Date	Sept-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 10			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 10			
Duty	Coolstore - Capable of Bins Curing or Static Cooling Packed Kiwifruit			
Number of Compressors	2			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	218	Actual Qty Recovered (kg) 253
New Refrigerant	R449A	Quantity Used (kg)	248.6	

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	9,100.00		
Internal Labour Cost	\$	1,215.83	or Internal Labour hours	
Contractor labour Cost	\$	2,000.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	12,315.83		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.1
Workstream Stage	3
Case Study No.	1
Replacement Date	Oct-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 11			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 11			
Duty	Coolstore - Capable of Bins Curing or Static Cooling Packed Kiwifruit			
Number of Compressors	3			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	218	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	282.5	303

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	9,500.00		
Internal Labour Cost	\$	1,307.50	or Internal Labour hours	
Contractor labour Cost	\$	2,520.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	13,327.50		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.2
Workstream Stage	3
Case Study No.	2
Replacement Date	Oct-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 22			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 22			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	3			
Number of Evaporators	22			
Old Refrigerant	R404A	Original Qty Estimated (kg)	305	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	350.3	382

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	12,103.96		
Internal Labour Cost	\$	3,236.67	or Internal Labour hours	
Contractor labour Cost	\$	1,280.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	16,620.63		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.3
Workstream Stage	3
Case Study No.	3
Replacement Date	Oct-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 21			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 21			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	3			
Number of Evaporators	20			
Old Refrigerant	R404A	Original Qty Estimated (kg)	270	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	327.7	370

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	11,686.60		
Internal Labour Cost	\$	1,636.67	or Internal Labour hours	
Contractor labour Cost	\$	3,760.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	17,083.27		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.4
Workstream Stage	3
Case Study No.	4
Replacement Date	Oct-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 20			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 20			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	3			
Number of Evaporators	20			
Old Refrigerant	R404A	Original Qty Estimated (kg)	270	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	327.7	364

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	11,686.60		
Internal Labour Cost	\$	1,766.67	or Internal Labour hours	
Contractor labour Cost	\$	3,320.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	16,773.27		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.5
Workstream Stage	3
Case Study No.	5
Replacement Date	Oct-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 19			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 19			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	3			
Number of Evaporators	18			
Old Refrigerant	R404A	Original Qty Estimated (kg)	240	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	316.4	381

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	11,157.24		
Internal Labour Cost	\$	1,708.33	or Internal Labour hours	
Contractor labour Cost	\$	3,720.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	16,585.57		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.6
Workstream Stage	3
Case Study No.	6
Replacement Date	Nov-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 18			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 18			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	2			
Number of Evaporators	20			
Old Refrigerant	R404A	Original Qty Estimated (kg)	240	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	327.7	381

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	11,574.60		
Internal Labour Cost	\$	4,060.00	or Internal Labour hours	
Contractor labour Cost	\$	1,000.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	16,634.60		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.7
Workstream Stage	3
Case Study No.	7
Replacement Date	Nov-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 16 Store			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 16 Store			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	2			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	240	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	214.7	220

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	10,322.52		
Internal Labour Cost	\$	1,871.67	or Internal Labour hours	
Contractor labour Cost	\$	2,400.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	14,594.19		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	A3.8
Workstream Stage	3
Case Study No.	8
Replacement Date	Nov-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 16 Pre/Cool			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 16 Pre/Cool			
Duty	Coolstore - Capable of Pre-Cooling or Static Cooling Packed Kiwifruit			
Number of Compressors	1			
Number of Evaporators	2			
Old Refrigerant	R404A	Original Qty Estimated (kg)	200	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	79.1	71

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Already existing electronic valves. Reprogrammed EVD's for R449A.			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	4,189.00		
Internal Labour Cost	\$	835.00	or Internal Labour hours	
Contractor labour Cost	\$	680.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	5,704.00		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref. A3.9
Workstream Stage 3
Case Study No. 9
Replacement Date Dec-2025
Company Post Harvest Operator A
Site Site A1

System & Refrigerants

Coolstore Name Coolstore 17
Store Ref Post Harvest Operator A, Site A1, Coolstore 17
Duty Coolstore - Capable of Static Cooling Packed Kiwifruit Only
Number of Compressors 2
Number of Evaporators 16
Old Refrigerant R404A Original Qty Estimated (kg) 240 Actual Qty Recovered (kg) 389
New Refrigerant R449A Quantity Used (kg) 305.1

Electricity Demand Impact

Power Monitoring Resolution Whole single coolstore, CSV extract
Power Draw Before (kW)
Power Draw After (kW)
Comments

Extent of Changes

Valve changes Mechanical replaced with mechanical
Other changes
Other comments System Pressure Tested and Serviced.

Learnings / General Comments

Comments

Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$	11,484.00	
Internal Labour Cost	\$	3,442.50	or Internal Labour hours
Contractor labour Cost	\$	640.00	
Other costs excl. refrigerants			
Total cost excl. refrigerants	\$	15,566.50	

Estimated electrical costs included in the above total \$ -

Case Study Ref. C3.1
Workstream Stage 3
Case Study No. 1
Replacement Date Oct-Nov 2025
Company Post Harvest Operator C
Site Site C1

System & Refrigerants

Coolstore Name	Coolstore I			
Store Ref	Post Harvest Operator C, Site C1, Coolstore I			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	3			
Number of Evaporators	20			
Old Refrigerant	R404A	Original Qty Estimated (kg)	220	Actual Qty Recovered (kg) 169
New Refrigerant	R449A	Quantity Used (kg)	226	

Electricity Demand Impact

Power Monitoring Resolution				
Power Draw Before (kW)	Comp 1 47.4, 50.8, 50.1 A / 2- 31.7,33.4,32.7 / 3-45.5,48.3,47 A			
Power Draw After (kW)	Comp 1- 49, 50, 50.5 / 2- 31.5,33.3,33 / 3- 46.5, 50.3, 506			
Comments	Store ran ok, make good cooling except I3, that had valves not working. Liquid Line kept breaking. Found 2 more leaks in evap coils when pressure testing. After Changes - The whole store rips down to temp. I3 Cycling perfectly.			

Extent of Changes

Valve changes	Mechanical replaced with mechanical
Other changes	New Liquidline and solenoids
Other comments	Oil Filters, Driers, Suction Felts changed. Replaced leaky receiver valve.

Learnings / General Comments

Comments	Suction Pressure - 278kpa, Discharge Pressure 1946 AFTER: 2.9 Bar Suction, Discharge Pressure 19.2 Bar All superheats between 7 and 8k. Was a big job to replace whole liquid line, but worth doing as leaks were occurring regularly.
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Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$	26,072.34	
Internal Labour Cost	\$	25,092.50	or Internal Labour hours
Contractor labour Cost			
Other costs excl. refrigerants	\$	506.00	
Total cost excl. refrigerants	\$	51,670.84	

Estimated electrical costs included in the above total \$ -

Case Study Ref. C3.2
Workstream Stage 3
Case Study No. 2
Replacement Date Oct-Nov 2025
Company Post Harvest Operator C
Site Site C1

System & Refrigerants

Coolstore Name Pre Cooler 11, 12
Store Ref Post Harvest Operator C, Site C1, Pre Cooler 11, 12
Duty Coolstore - Capable of Pre Cooling Packed Kiwifruit (Temperature Drawdown)
Number of Compressors 2
Number of Evaporators 2
Old Refrigerant R404A Original Qty Estimated (kg) 150 Actual Qty Recovered (kg) 31.4
New Refrigerant R449A Quantity Used (kg) 158

Electricity Demand Impact

Power Monitoring Resolution
Power Draw Before (kW) Comp 1 - 34.6,37,36.8 / 2-32,35,34 A
Power Draw After (kW) Comp 1 - 41.2, 45.9, 45.5 / 2 -35.5,38.2,38.8 A (Pulldown)
Comments Not making good cooling before, but running very stable now

Extent of Changes

Valve changes Mechanical replaced with mechanical
Other changes Gave System Service - Oil, Suction, + liquid Line + Oil Filters
Other comments Changed 2x tX Valves as old ones will not set

Learnings / General Comments

Comments Before Suction 68kpa, Discharge 1114kpa
Now (Pulldown Pressures Suction 4 Bar, Discharge 17.9
New Superheat Settings 6.4K on both valves

Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$	6,316.52	
Internal Labour Cost	\$	7,409.00	or Internal Labour hours
Contractor labour Cost			
Other costs excl. refrigerants	\$	207.00	
Total cost excl. refrigerants	\$	13,932.52	

Estimated electrical costs included in the above total \$ -

Case Study Ref.	C3.3
Workstream Stage	3
Case Study No.	3
Replacement Date	Oct-2025
Company	Post Harvest Operator C
Site	Site C2

System & Refrigerants				
Coolstore Name	Room D			
Store Ref	Post Harvest Operator C, Site C2, Room D			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	3			
Number of Evaporators	16			
Old Refrigerant	R404A	Original Qty Estimated (kg)	220	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	203	150

Electricity Demand Impact				
Power Monitoring Resolution				
Power Draw Before (kW)	Comp 1- 29,30,30, /2-30,30,30 /3-29,29,30			
Power Draw After (kW)	Comp 1 - 30,33,32 / 2-31,33,32 / 3-31,33,32			
Comments	Before the change, room ran reliably. After the change, the room still seemed roughly the same. Was quite short of refrigerant - This may be why current draws are higher.			

Extent of Changes				
Valve changes	Already existing mechanical valves. Adjusted position for R449A.			
Other changes	Oil, filters, driers, suction felts			
Other comments	Gave system a good vac (sub 500 micron vac)			

Learnings / General Comments				
Comments	If given the opportunity again - change the expansion valves for the correct refrigerant while the gas is out Adjust Superheat - All ranged from between 6-8k. Setting of superheat with 404a valves runningR449a is a lot more difficult. A lot better stability is achieved with the correct valves. All valves closed roughly 2 turns.			

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	674.77		
Internal Labour Cost	\$	6,188.00	or Internal Labour hours	
Contractor labour Cost				
Other costs excl. refrigerants	\$	232.00		
Total cost excl. refrigerants	\$	7,094.77		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	C3.4
Workstream Stage	3
Case Study No.	4
Replacement Date	Oct-2025
Company	Post Harvest Operator C
Site	Site C2

System & Refrigerants				
Coolstore Name	Pre Cooler 1, 2, 3			
Store Ref	Post Harvest Operator C, Site C2, Pre Cooler 1, 2, 3			
Duty	Coolstore - Capable of Pre Cooling Packed Kiwifruit (Temperature Drawdown)			
Number of Compressors	3			
Number of Evaporators	3			
Old Refrigerant	R404A	Original Qty Estimated (kg)	150	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	169	104

Electricity Demand Impact	
Power Monitoring Resolution	
Power Draw Before (kW)	Comp 1- 55,55,53 /2-25,25,25 /3-26,27,27 A
Power Draw After (kW)	Comp 1 - 48.9,47,48 / 2-23,25,24 / 3-23,23,22 A
Comments	Room ran well despite being short of gas, Runs well after full charge. Adjust Superheat

Extent of Changes	
Valve changes	Already existing mechanical valves. Adjusted position for R449A.
Other changes	Oil, filters, driers, suction felts
Other comments	Gave System a good vac (sub 500 micron)

Learnings / General Comments	
Comments	Next time change out R404a valves for R449 specific ones. All superheats between 6-8k

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	402.50		
Internal Labour Cost	\$	2,802.00	or Internal Labour hours	
Contractor labour Cost				
Other costs excl. refrigerants	\$	116.00		
Total cost excl. refrigerants	\$	3,320.50		
Estimated electrical costs included in the above total	\$		-	

Case Study Ref.

Workstream Stage

Case Study No.

Replacement Date

Company

Site

C3.5

3

5

Oct-2025

Post Harvest Operator C

Site C2

System & Refrigerants

Coolstore Name

Store Ref

Duty

Number of Compressors

Number of Evaporators

Old Refrigerant

New Refrigerant

Pre Cooler 4, 5

Post Harvest Operator C, Site C2, Pre Cooler 4, 5

Coolstore - Capable of Pre Cooling Packed Kiwifruit (Temperature Drawdown)

2

2

R404A

R449A

Original Qty Estimated (kg)

Quantity Used (kg)

150

135

Actual Qty Recovered (kg)

81

Electricity Demand Impact

Power Monitoring Resolution

Power Draw Before (kW)

Power Draw After (kW)

Comments

Comp 1- 41,43,43, /2-44,45,43 A

Comp 1 - 38,40,40 / 2-40,41,41 A

Room ran quite well before change - even though it was short of refrigerant.

After change, cooling very well.

Adjust Superheat

Extent of Changes

Valve changes

Other changes

Other comments

Already existing mechanical valves. Adjusted position for R449A.

Oil, filters, driers, suction felts

Gave System a good vac (sub 500 micron)

Learnings / General Comments

Comments

Next time change out R404a valves for R449 specific ones.

All superheats between 6-8k

Capital Costs Excluding Refrigerants

Total equipment & materials cost

Internal Labour Cost

Contractor labour Cost

Other costs excl. refrigerants

Total cost excl. refrigerants

\$

3,372.50

\$

404.00

\$

3,776.50

Estimated electrical costs included in the above total

\$

-

Case Study Ref.	C3.6				
Workstream Stage	3				
Case Study No.	6				
Replacement Date	Oct-2025				
Company	Post Harvest Operator C				
Site	Site C2				
System & Refrigerants					
Coolstore Name	Pre Cooler 6, 7, 8				
Store Ref	Post Harvest Operator C, Site C2, Pre Cooler 6, 7, 8				
Duty	Coolstore - Capable of Pre Cooling Packed Kiwifruit (Temperature Drawdown)				
Number of Compressors	3				
Number of Evaporators	3				
Old Refrigerant	R404A	Original Qty Estimated (kg)	150	Actual Qty Recovered (kg)	90
New Refrigerant	R449A	Quantity Used (kg)	169		
Electricity Demand Impact					
Power Monitoring Resolution					
Power Draw Before (kW)	Comp 1- 39,42,41 / 2-40,42,41 / 3-40,41,41				
Power Draw After (kW)	Comp 1 - 40,41,42 / 2-42,43,44 / 3-20,21,21				
Comments	Before change, precoolers ran well even though it was quite short of refrigerant. Afterwards, it ran well, very stable with new expansion valves.				
Extent of Changes					
Valve changes	Mechanical replaced with mechanical				
Other changes	Oil, filters, driers, suction felts				
Other comments	Gave System a good vac (sub 500 micron)				
Learnings / General Comments					
Comments	Well worth making the change to TX valves. All superheats between 6-8k				
Capital Costs Excluding Refrigerants					
Total equipment & materials cost	\$	2,390.93			
Internal Labour Cost	\$	3,562.50			
Contractor labour Cost					
Other costs excl. refrigerants					
Total cost excl. refrigerants	\$	5,953.43			
Estimated electrical costs included in the above total	\$	-			

Case Study Ref.	A4.1			
Workstream Stage	4			
Case Study No.	1			
Replacement Date	Dec-2025			
Company	Post Harvest Operator A			
Site	Site A1			
System & Refrigerants				
Coolstore Name	Coolstore 27 Store			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 27 Store			
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only			
Number of Compressors	2			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	220	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	237.3	240
Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				
Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			
Learnings / General Comments				
Comments				
Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	10,922.00		
Internal Labour Cost	\$	392.50	or Internal Labour hours	
Contractor labour Cost				
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	11,314.50		
Estimated electrical costs included in the above total		\$	-	

Case Study Ref. A4.2
Workstream Stage 4
Case Study No. 2
Replacement Date Dec-2025
Company Post Harvest Operator A
Site Site A1

System & Refrigerants

Coolstore Name	Coolstore 27 Pre/Cool			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 27 Pre/Cool			
Duty	Coolstore - Capable of Pre-Cooling or Static Cooling Packed Kiwifruit			
Number of Compressors	3			
Number of Evaporators	16			
Old Refrigerant	R404A	Original Qty Estimated (kg)	240	Actual Qty Recovered (kg) 411
New Refrigerant	R449A	Quantity Used (kg)	293.8	

Electricity Demand Impact

Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes

Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments

Comments				
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Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$	11,786.00	or Internal Labour hours	
Internal Labour Cost	\$	502.50		
Contractor labour Cost	\$	2,160.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	14,448.50		

Estimated electrical costs included in the above total \$ -

Case Study Ref.	A4.3
Workstream Stage	4
Case Study No.	3
Replacement Date	Dec-2025
Company	Post Harvest Operator A
Site	Site A1

System & Refrigerants				
Coolstore Name	Coolstore 15			
Store Ref	Post Harvest Operator A, Site A1, Coolstore 15			
Duty	Coolstore - Capable of Bin Curing or Static Cooling Packed Kiwifruit and Avocado's			
Number of Compressors	2			
Number of Evaporators	12			
Old Refrigerant	R404A	Original Qty Estimated (kg)	218	Actual Qty Recovered (kg)
New Refrigerant	R449A	Quantity Used (kg)	248.6	194

Electricity Demand Impact				
Power Monitoring Resolution	Whole single coolstore, CSV extract			
Power Draw Before (kW)				
Power Draw After (kW)				
Comments				

Extent of Changes				
Valve changes	Mechanical replaced with mechanical			
Other changes				
Other comments	System Pressure Tested and Serviced.			

Learnings / General Comments				
Comments				

Capital Costs Excluding Refrigerants				
Total equipment & materials cost	\$	10,922.00		
Internal Labour Cost	\$	758.33	or Internal Labour hours	
Contractor labour Cost	\$	4,240.00		
Other costs excl. refrigerants				
Total cost excl. refrigerants	\$	15,920.33		

Estimated electrical costs included in the above total	\$	-
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Case Study Ref.	D4.1
Workstream Stage	4
Case Study No.	1
Replacement Date	Feb-2026
Company	Post Harvest Operator D
Site	Site D1

System & Refrigerants

Coolstore Name	Coolstores 7E & 7F				
Store Ref	Post Harvest Operator D, Site D1, Coolstores 7E & 7F				
Duty	Coolstore - Capable of Static Cooling Packed Kiwifruit Only				
Number of Compressors	2				
Number of Evaporators	8				
Old Refrigerant	R404A	Original Qty Estimated (kg)	150 to 200	Actual Qty Recovered (kg)	200
New Refrigerant	R449A	Quantity Used (kg)	200		

Electricity Demand Impact

Power Monitoring Resolution	Site power monitoring is only available at a transformer level, not broken down to a coolstore level.
Power Draw Before (kW)	
Power Draw After (kW)	
Comments	

Extent of Changes

Valve changes	Mechanical replaced with mechanical
Other changes	Solenoid valves replaced, all filters replaced, new oil, replaced O-rings, relief valves, thread tape.
Other comments	

Learnings / General Comments

Comments	Comment from site/contractor: "The efficeincy should be very similar with the gas change been completed"

Capital Costs Excluding Refrigerants

Total equipment & materials cost	\$16,682.09	
Internal Labour Cost		or Internal Labour hours
Contractor labour Cost	\$9,539.40	
Other costs excl. refrigerants		
Total cost excl. refrigerants	\$ 26,221.49	

Estimated electrical costs included in the above total	\$ -
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Appendix D: Responses from Refrigerant Destruction Service Providers

Cool-Safe

Cool-Safe has provided the below statement regarding the support they can offer to projects that allow Cool-Safe to destroy high GWP refrigerants.

“The Trust for the Destruction of Synthetic Refrigerants operates Cool-Safe – New Zealand’s only accredited Product Stewardship Scheme for synthetic refrigerants. For the past 32 years, the Trust has been responsible for the removal of harmful ozone depleting gases and greenhouse gas emissions from refrigerants and enabled industry-led sustainability. The scheme is funded by our destruction activities – we receive New Zealand Carbon Units (NZUs) which reflect the removal of carbon when the refrigerant is permanently destroyed, ensuring the true environmental cost of these gases is recognised. This funding model allows Cool-Safe to return direct financial support to industry, making refrigerant recovery and replacement projects more viable.

In practice, Cool-Safe currently provides payments to operators of \$40 per kilogram of mixed waste refrigerant recovered and destroyed through its Bounty Buy-Back programme. Larger volumes of high Global Warming Potential (GWP) refrigerants, such as R404A and R507, generally attract a higher rate of financial returns, which creates a strong incentive for coolstore operators to coordinate replacements across multiple systems or sites under a single agreement. Through Cool-Safe’s Bulk Buy-Back programme, you will earn competitive buy-back rates for quantities of single stream refrigerants above 200 kilograms. Additional benefits offered are streamlined and no-cost logistics, and on-demand recovery vessels, reducing both cost and operational disruption directly to coolstore operators, and their HVACR contractors. Cool-Safe regularly reviews buy-back pricing to ensure the long-term sustainability of the programme and alignment with market conditions and recovery volumes.

For major projects, Cool-Safe will work with operators to develop customised support packages that deliver the best outcomes for both the business and the environment. Because every project is unique, coolstore operators are encouraged to engage with Cool-Safe early to explore the most effective options for their situation.

For more information or a confidential quotation, please contact: Megan Dinsdale-Jones – General Manager Operations for more information and a confidential quotation.
megan@Cool-Safe.org.nz”

Refspecs / RefDestruct

Refspecs has provided the below statement regarding the support they can offer to projects that allow RefDestruct to destroy high GWP refrigerants.

"Refspecs is working with Refdestruct to assist businesses with the retrofitting of the refrigeration plant from high GWP refrigerants to a lower GWP alternative. The contact at Refdestruct is James Heckler. Happy to introduce you if you have not already met James.

It's pretty simple - Refdestruct supply the 449a they need in exchange for the 404a they take out (we can also do it for R507), and we supply the recovery bottles for them to put the refrigerant in. They just have to pay for their contractor to do the replacement.

It is a 1 for 1 swap so if they use more R449a than the 404a they recover there will be a charge for the difference.

Key thing to point out with it is that the used refrigerant gets destroyed - so it is a permanent removal, unlike some other programs where it gets re-used, and will eventually leak to the atmosphere.

Unfortunately, we can't do anything with the R22 or any of the HCFCs or CFCs as there is no funding to make it work. As I mentioned, the age of a R22 HCFC or CFC plant would now be at the end of its economical life and a completely new approach will be required for these room. The construction of the room along with the structural steel will need to be thoroughly looked at to ensure it meets code and is suitable for any additional weight that a glycol or CO2 system may inflict on the structure. Many of these rooms were free standing with only a shad roof over them with no structural steel supporting the insulated panel.

If you had companies doing equipment changes and going from 404a/507a to an A2L or a natural refrigerant solution we could also do a deal to help support that - haven't got a formal position on that one as it hasn't come up yet - but keen to see what we could do in that space to help.

If a site has a major leak on an R134a system, this would be a good time to retrofit to R513a. This refrigerant will operate in an existing R134a plant with minimal adjustments offering a lower GWP of 631."

For more information, please contact: Craig McCall – Territory Manager – BOP.
craig@refspecs.co.nz

A-Gas

A-Gas has provided the below statement regarding the support they can offer to projects that allow A-Gas to destroy or reclaim high GWP refrigerants.

As I had said we are already working with the horticulture industry throughout New Zealand and offer some unique services and expertise to support their change overs.

A-Gas is a lifecycle refrigerant management company that specialises in supporting businesses transition to low GWP alternatives. We offer refrigerant recovery services including Rapid Recovery and Rapid Exchange. Rapid Recovery is a service that manages gas recovery end to end for the customer utilising specialised highspeed recovery equipment. Our trained technician can recover refrigerant up to ten times faster than traditional equipment. Our Rapid Exchange cylinders are free for our customers for the purpose of recovering gas themselves and returning it to A-Gas. We currently offer a bounty price of \$35.00 +GST and depending on the scope of project we can offer significantly better bounty prices or replacement gas. We also stock the new generation of refrigerants including HFO's, HFO/HFC mixes and industrial refrigerants such as CO2 and hydrocarbons. We are the only business in New Zealand that offer reclamation (recycling) services for F-Gases. This gives our customers the ability to keep critical plant running while they transition. A-Gas also have the only laboratory in New Zealand specifically set up to test refrigerant to AHRI700 standards. We offer our Refrigerant Health Checks so customers can confirm the refrigerant they are using meets spec and won't damage their system or effect it's efficiency.

Please see attached brochures.

In regards to the ETS. It does have an effect on what we can offer the market in regards to bounty and the possibility of replacement of replacement refrigerant. As NZU value is so volatile we will look at each project and put our best foot forward at the time.

For more information, please contact: Mitch Williamson – General Manager - NZ.
mitch.williamson@agas.com