Circularity for Climate

Tackling the Invisible Climate Risk

Reducing harmful refrigerant leakage through stewardship and value-chain collaboration

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Civic Futures Lab

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Disclaimers

Civic Futures Lab acknowledges the traditional owners and custodians of country throughout Australia and their continuing connection to land, waters and community. We pay our respects to the people, the cultures and the elders past, present and emerging.

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Circularity for Climate

WINNING GROUP

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Glossary

ACCC	Australian Competition and Consumer Commission
ARC	Australian Refrigeration Council
AREMA	Air-Conditioning and Refrigeration Equipment Manufacturers Association of Australia
CFC	Chlorofluorocarbon
CHF4	Cold Hard Facts 4
CO2-e	Carbon Dioxide Equivalent
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DCF	Designated Collection Facilities
DTS	Distributor Take-back Scheme
EA	Environment Agency
EOL	End-of-Life
GHG	Greenhouse Gas
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
LGAs	Local Government Authorities
ODP	Ozone Depletion Potential
ODS	Ozone-Depleting Substances
OPSGGMA	Ozone Protection and Synthetic Greenhouse Gas Management Act
PCS	Producer Compliance Scheme
RAC	Refrigeration and Air-Conditioning
RA / RRA	Refrigerants Australia / Refrigerants Reclaim Australia
ROCs	Regional Organisation of Councils
WEEE	Waste Electrical and Electronic Equipment

Executive Summary

This White Paper examines the environmental risks of refrigerant leakage from end-of-life refrigeration and air conditioning (RAC) equipment in Australia and how it contributes to greenhouse gas (GHG) emissions and ozone depletion, worsening climate change. The paper highlights the regulatory landscape in Australia, gathers latest research on circularity and refrigerant stewardship, identifies barriers to efficient refrigerant recovery, and presents compelling case studies, including Winning Group's voluntary removal and recycling program and AO Recycling in the UK. The paper outlines how improper disposal and low recovery rates of RAC equipment, especially refrigerators and freezers, are driving a hidden environmental crisis. It advocates for stronger value-chain collaboration, better end-of-life (EOL) management, enforcement and policy reforms to meet net-zero targets and boost circular economy efforts.

Key Findings

- **Recovery gaps:** Despite progress in phasing out ozone depleting substances and synthetic GHG in new appliances, data insights from Winning Group's removal and recycling program reveal that up to 65% of the discarded RAC equipment still contains gases which contribute to global warming and ozone depletion.
- **Climate impact:** Based on our case study insights, each RAC equipment responsibly recovered, prevents up to 235 KG of CO2-e from entering the atmosphere, highlighting the importance of refrigerant recovery.
- **Circular economy:** Enhancing refrigerant recovery aligns with NSW's Circular Economy Policy and supports broader decarbonisation goals by reducing waste and fostering resource efficiency. Enhancing circularity could reduce Australian emissions by 165 million tonnes CO2-e annually by 2040.

Barriers to Effective Stewardship

- **Regulatory hurdles:** Inconsistent enforcement of the Ozone Protection Act 1989 undermines recovery efforts. Strengthened enforcement and clearer regulations are essential.
- **Stewardship efficacy:** The Refrigerant Reclaim Australia (RRA) rebate system plays a critical role in incentivising recovery, but current settings only partially offset the real costs of collection and treatment. In the absence of a broader, mandatory stewardship framework, achieving comprehensive recovery remains challenging, while specialised skills and equipment requirements continue to limit efficiency.
- **Public awareness:** Low consumer engagement and awareness of refrigerant recovery programs limit participation. Educational campaigns and convenient disposal options could help.

Case Study: Winning Group's Value-Chain Collaboration

- Winning Group has provided a free appliance removal and recycling program to customers since 2005. This program now collects and recycles packaging, mattresses and old appliances including refrigerators, dryers and air conditioners, recovering harmful refrigerants and promoting high-value material recycling, with significant environmental, social and economic benefits including:
  - **Environmental benefits:** The program reduces landfill waste, prevents leakage of harmful substances at kerbside and CO2 emissions.
  - **Social benefits:** Raises awareness about recycling and e-waste management and prevents health risks associated with improper disposal of ODS.
  - **Economic benefits:** Creates jobs, reduces costs for councils and increases recovery of valuable materials.

Recommendations for Action

- To enhance refrigerant recovery efforts, the paper recommends the following actions:
  - **Federal Government:** Include RAC equipment on the Minster's Priority List for Stewardship, expand e-waste programs, integrate refrigerant recovery into climate policies, and collaborate to co-design a national strategy.
  - **State & Territory Governments:** Strengthen enforcement of refrigerant recovery laws, offer consumer incentives, and standardise refrigerant management practices.
  - **Local Governments & Ecosystem Partners:** Revise collection practices, increase consumer participation, and support public education campaigns.
  - **Industry:** Manufacturers, brand and retailers should expand take-back / removal programs and adopt standards for safe refrigerant handling and recycling.
- Circularity for Climate supports the development of a mandatory, co-regulated, whole-of-appliance product stewardship scheme in which refrigerant capture is a priority outcome, alongside increased material recovery and repair. Scheme design should include eco-modulated fees to incentivise circular product design and in-home collection services to minimise refrigerant leakage during transport and dismantling. Aligning refrigerant stewardship with a broader scheme approach will maximise climate, resource recovery, and economic benefits.

Introduction

Over 62 million pieces of refrigeration and air conditioning equipment are installed across Australia, and this number is rapidly growing. This surge is driven by factors like population increase, commercial expansion, and rising temperatures. The 2024 *Cold Hard Facts 4* (CHF4) report reveals substantial growth in the RAC industry between 2016 and 2022, with a diverse range of equipment, from domestic refrigerators to large industrial chillers. This increased demand for new products inevitably leads to a rise in end-of-life equipment. The cooling economy analysis indicates that annually, 3.4 million devices containing over 2,500 tonnes of refrigerant reach their end of life in Australia, including 150 tonnes from domestic refrigerators and freezers. The CHF4 report highlights anecdotal evidence suggesting that a significant number of domestic refrigerators, some as old as 25, 30, or even 40 years, remain in use, often repurposed as "beer fridges."[1]

These factors, coupled with regulatory measures targeting environmental concerns, particularly regarding outdated RAC equipment containing harmful, ozone-depleting substances (ODS) and greenhouse gases that contribute to climate change, highlight the importance of proper refrigerant recovery during decommissioning.

Effective recovery from older equipment requires the use of specialised tools, trained and accredited personnel to ensure safe and compliant handling. As the volume of RAC systems requiring end-of-life management continues to grow, this presents significant challenges for stakeholders across the resource recovery value chain.

Efforts to address the mounting ODS crisis are being pursued through national and international regulatory measures including the Australian Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 and the Kigali Amendment under the Montreal Protocol, an international agreement to gradually reduce the consumption and production of potent greenhouse gases such as hydroflurocarbons (HFCs), emphasising the transition to more environmentally friendly alternatives in manufacturing of cooling devices.

Despite progress in reducing ODS and synthetic greenhouse gases in new appliances, gaps in disposal efforts are leading to an overall increase in greenhouse gas emissions[2]. More than 80% of the refrigerant is estimated to have still been in end-of-life (EOL) stationary equipment equipment in 2022, including domestic refrigerators and freezers, stationary air conditioners and self-contained equipment employed in the refrigerated cold food chain. More stringent end-of-life management is required to ensure these materials are recovered and recycled through official channels.

Addressing these issues is critical, especially given the increase in refrigerant bank volume and the persistent use of high-GWP refrigerants like R404A and R134a despite of bans. Effective refrigerant recovery is essential to meeting NSW's climate goals and transitioning to a zero-carbon circular economy. Furthermore, the manufacturing sector could further benefit from enhanced circular material recovery from appliance waste more broadly.

According to PwC, transitioning to a circular economy in Australia could generate $210 billion in economic benefits by 2047[3]. However, to methodically move away from the 'take, make, dispose' model for materials and embrace circular business models of 'reuse, repurpose, repair and recycle', a reimagining of markets, a systemic infrastructure shift and joined-up thinking not previously achieved in "business-as-usual" supply chains is required. Recreating a circular economy from our current economic base and social norms requires both new policy and regulatory approaches, but also new business models and market incentives. Both are essential to achieving a thriving circular economy, environment and society.

While the private sector has begun the complex task of formulating and executing strategies to avoid and reduce emissions, CEOs and executive teams face the challenge of building specialised knowledge, capabilities and advanced tools to assess, monitor, and demonstrate the effectiveness of their efforts. Circular economy practices are still emerging in the Australian context, and a significant capability gap persists due to limited case studies linking circular solutions to decarbonisation outcomes. Addressing this gap is critical for enhancing industry value chains, meeting NSW's climate objectives and transitioning to a zero-carbon circular economy.

To address this essential gap in the market, Circularity for Climate was launched through a Sustainability Partnership between NSW EPA and Civic Futures Lab, to support NSW Sustainability Leaders committed to testing and investing in circular strategies. Over a six-month intensive sprint, Circularity for Climate worked with Winning Group to define and measure the impact of their refrigerant recovery and RAC circularity programs and the opportunities and barriers to scaling circular solutions in order to drive significantly greater decarbonisation outcomes across national supply chains.

The recommendations in this white paper align with the NSW EPA Climate Change Policy and Action Plan 2023–26 which sets a clear direction for reducing emissions in NSW by 2050; along with the NSW Circular Economy Policy Statement: *Too Good To Waste*, which emphasises the importance of effective waste management and material recovery. This white paper highlights how improvements to the current end-of-life management practices of RAC equipment will contribute to the broader objectives of the NSW EPA to mitigate climate change impacts and support a transition to a low-carbon, circular economy. This alignment ensures that our proposed reforms not only address immediate environmental concerns but also support long-term policy goals for climate resilience, community well-being and sustainability. Whilst the paper focuses on NSW, it has broader application and relevance across all states and territories.

This white paper signifies a pivotal moment in our partnership with Winning Group, showcasing a range of opportunities to enhance government policy to accelerate industry investment in circular solutions to deliver new abatement and circular opportunities across a range of sectors.

[1] Department of Climate Change, Energy, the Environment and Water (2023, February 1). Cold Hard Facts 2022

[2] Department of Climate Change, Energy, the Environment and Water (2023, February 1). Cold Hard Facts 2022

[3] https://www.pwc.com.au/assurance/esg/building-a-more-circular-australia.pdf

The Case for Change

According to the report CHF4 (2024) the total size of Australia's 'refrigerant bank' in 2022 was approximately 55,027 tonnes, with more than 80% of the refrigerant estimated to have still been in EOL equipment including domestic refrigerators and freezers, stationary air conditioners and self-contained equipment employed in the refrigerated cold food chain. The Australian Refrigeration Council estimates that only 30-40% of refrigerant is recovered from EOL domestic fridges and freezers[4].

[4] Australian Refrigeration Council, 2023

Leakage During Disposal Process

Refrigerants are some of the most potent greenhouse gases. Achieving success in refrigerant recovery lies in a more effective and efficient increase in the reclamation and destruction of refrigerants. With the continuous expansion of the existing HFC bank, particular attention is required on appropriate storage, handling, transport and processing. Whilst industry groups such as Refrigerant Reclaim Australia (RRA), Refrigerants Australia (RA), Australian Refrigeration Council (ARC) and the Air-Conditioning and Refrigeration Equipment Manufacturers Association of Australia (AREMA) have been rigorously tracking the import, sale, transfer and disposal of refrigerants, there are significant gaps in the recovery and destruction phase of the refrigerant lifecycle.

Deficiencies in the current system have been documented by several studies conducted over the past decade, however consistent and accurate data on disposal or recovery is difficult to ascertain across the States and Territories. We do know that the most common disposal pathways for EOL consumer appliances are[5]:

- Local Government waste disposal centres (Waste Transfer Stations and/or Landfill Operators)
- Service technician removal (new for old replacement)
- Kerbside collections
- Second-hand markets
- Scrap metal dealers
- Retail and manufacturer refrigerator takeback and/or buyback schemes
- Illegal disposal and dumping

Opportunities for enhancing recovery and recycling outcomes depend on improved data collection and reporting during the early stages of the collection, recycling and recovery lifecycle. By bolstering data tracking mechanisms early, stakeholders can glean valuable insights to refine recycling strategies and boost overall recovery rates.

Local Government Authorities Recovery Impediments

Local Government Authorities (LGAs) play a crucial role in the disposal lifecycle, overseeing the collection and disposal of electronic waste, including RAC equipment. While there is a commendable rate of refrigerant recovery through buyback and take-back schemes facilitated by retailers, manufacturers and LGAs; concerns persist regarding significant leakage during the disposal process, often attributed to:

- Improper handling or weather, resulting in damage to equipment which affects recovery potential;
- Scavengers and contractors operating outside official channels and without oversight or obligation to comply with the Act.

Scavengers are increasingly adept at retrieving RAC equipment from kerbside collections, subsequently selling these items to scrap metal merchants. Similarly, contractors have been known to bypass official channels and directly engage with scrap metal recyclers. Industry estimates that 20% to 30% of refrigerators are lost to scavengers and contractors[6].

These findings align with stakeholder views in the Stewardship Solutions for Whitegoods report (SSROC & PSCoE, 2025), which emphasise that in-home collection is the most effective way to ensure degassing occurs safely and consistently. Reliance on kerbside pick-ups exposes units to scavenging and weather damage, which significantly reduces recovery potential and undermines the business case for investment in degassing infrastructure.

[5] KPMG, 2014

[6] KPMG, 2014

The longer refrigeration units sit kerbside, the more likely they are to be damaged through metal scavenging, inadequate transport or collection, and wet weather. Once householders move these items to the kerb, local governments have limited influence over such factors. According to local government experts, it would be more effective for units to be collected and stored carefully at specified depots or transfer stations, then degassed in bulk (minimum 30-50 units), to maximise recovery and cost efficiency. Early intervention must come into play via proactive means to avoid this wastage and leakage, limiting the opportunity for poor practices to occur. For NSW and respective LGAs, enhancing the product stewardship model efficiencies are some of the biggest areas of opportunities for improvement.

Another recommendation for LGAs and Regional Organisation of Councils (‘ROCs’) is to encourage a more proactive RAC equipment collection regime which may include booking times for collection and more targeted RAC equipment pick-up. This mitigates opportunities for scavengers and illegal dumping to occur. Whilst increased services and facilities may incur additional costs, the intent is that a targeted campaign and focus on RAC e-waste as an area of concern will draw the sufficient attention required to seek funding and resources required to achieve optimal levels of circular practices.

Appliance retailers play a significant role in mitigating refrigerant loss within the e-waste cycle. While take-back and buyback programs prove effective in encouraging the replacement of RAC equipment with newer models, they often fail to address the gap when consumers discard old equipment without purchasing a new one. When discretionary effort is required by consumers to act more sustainably, participating in a fee for service recovery scheme is perceived to be more inconvenient and/or costly than alternative options. Additionally, limited awareness of the environmental consequences of improper disposal further hinders behaviour change. Consequently, it becomes increasingly difficult to motivate consumers to participate in safe collection, recovery, and recycling schemes, with many opting for easier, less sustainable alternatives such as kerbside disposal.

International E-waste Day, held annually on 14 October and initiated by the WEEE Forum, presents a vital opportunity to raise awareness about RAC recovery in Australia. By encouraging responsible disposal practices, we can reduce refrigerant emissions and make meaningful progress toward our circular economy goals.

While LGA collection initiatives bridge the deficiency in the take-back and buyback schemes, evidence suggests that due to limitations in collection and transport capabilities, practices may result in improper disposal and limited refrigerant recovery. Congruently, manufacturers and retailers are seeking to enhance their environmental stewardship and contribute more significantly to sustainable EOL management of appliances; however, in the absence of policy and regulation are not able to do so on a level playing-field.

Limitations of Current Product Stewardship Scope

A key step in establishing a system of proactive environmental, economic and social impact is the widespread adoption of product stewardship. Product stewardship necessitates manufacturers and retailers to manage the environmental, economic and social impact of products through their entire lifecycle, a key principle underpinning the circular economy.

According to the E-Product Stewardship in Australia Evidence Report[7], it is projected that e-waste will increase by 30% from 521,000 tonnes in 2019 to 674,000 tonnes in 2030, with temperature exchange equipment contributing to 123,000 tonnes of this total.

End-of-life RAC appliances represent a considerable proportion of the total e-waste produced in Australia.

At a national level, the Department of Climate Change, Energy, the Environment, and Water (DCCEEW) plays a crucial role in regulating the production and use of ozone-depleting substances and synthetic greenhouse gases. Industry associations and organisations such as RRA, RA, ARC and AREMA exist and work to promote responsible refrigerant management practices and support sustainable initiatives. However, the effectiveness of these efforts remains unclear, largely due to limited transparency and the need for deeper engagement with industry partners across the value chain. Circularity for Climate supports greater collaboration, shared data and coordinated action to strengthen accountability and improve outcomes across the refrigerant stewardship system.

Established in 1993, RRA is a not-for-profit product stewardship organisation that works with the Australian Government and industry to drive the collection, reclamation and safe disposal of used, contaminated and unwanted refrigerant. All importers of scheduled substances under the OPSGGMA, either in bulk or contained in equipment must participate in an approved product stewardship scheme as a condition of their import licence issued by DCCEEW. RRA currently is the only approved refrigerant product stewardship scheme in Australia. According to the RRA, there were over 500 collection points[8] distributed across Australia and in 2023, 484 tonnes of refrigerants were recovered, contributing to 1 million tonnes of CO2-e avoidance due to capture and proper management.

Importantly, RRA sets and applies national levy prices for the import and/or manufacture of refrigerant gases and determines the value of rebates offered for the return of recovered gases. RRA also determines the processes and disposal practices applied to the recovered gases which include storage, reclamation, sale and destruction.

With the rise of Hydrofluorocarbons (HFCs) and Hydrochlorofluorocarbons (HCFCs) as replacements for CFCs, attention has shifted to the potent greenhouse gas emissions associated with these substances. Managing the disposal of HFCs and HCFCs from end-of-life equipment is essential to mitigate their environmental impact and reduce contributions to global warming potential. Whilst the Australian Parliament makes it mandatory for the RAC industry to recover, return and safely dispose of harmful refrigerants – the remaining responsibility falls on the general public and households to correctly manage this form of e-waste.

[7] Department of Agriculture, 2021

[8] Refrigerant Reclaim Australia, 2024

In 2011, a group of stakeholders presented submissions to the ACCC during the scheme's re-authorisation process, noting that while RRA has played a critical role in refrigerant recovery, there remained significant opportunities to evolve its scope to achieve full product stewardship. Previous reviews outlined a series of structural reforms designed to enhance the scheme's effectiveness and alignment with future regulatory and environmental objectives. These proposed changes included:

- Ensuring comprehensive and balanced industry representation: Broaden representation across all parts of the RAC value chain so that the roles and responsibilities of manufacturers, installers and end-of-life managers are adequately reflected.

- Maintaining transparent operations: Enhance stakeholder confidence by co-developing clear performance metrics, strengthening transparency initiatives and incorporating periodic independent assessments as part of a continuous improvement approach.

- Establishing performance criteria: Define measurable benchmarks to assess progress toward environmental and industry objectives, particularly in relation to refrigerant recovery and emissions reduction.

- Independent assessment: Introduce regular independent reviews to evaluate performance, strengthen governance and ensure ongoing alignment with regulatory and environmental expectations.

- Taking comprehensive environmental responsibility: Expand the scheme's remit to address refrigerants across their full lifecycle, with a focus on preventing synthetic gas leakage during operation and at end of life.

- Incorporating design considerations: Work with manufacturers and other stakeholders to integrate design-for-environment principles, including sustainable materials, modularity and improved recovery pathways, to reduce impacts from the outset.

- Pilot collaboration with market leaders: Targeted pilot projects with market leaders across retail, manufacturing and recycling could demonstrate practical solutions to these challenges, build evidence for future regulatory design and accelerate progress through deeper value-chain collaboration.

Product stewardship plays a crucial role in addressing the environmental, economic, and social impacts of products throughout their lifecycle, particularly in the RAC industry. The ongoing risk of legacy refrigerants, with their significant greenhouse gas potential, underscores the importance of proper end-of-life management to mitigate global warming and climate impacts. Stronger enforcement measures and significant structural reforms are essential to fully integrate product stewardship principles and capture missed opportunities within the circular economy.

Accreditation and recognition are practical pathways to limit adverse practices and behaviours. This would normally require accreditation holders to adhere to established requirements and protocols. Participants would include importers, manufacturers, retailers, LGAs, recycling facilities and contractors. A regulated accreditation scheme ensures that participating organisations have been independently assessed as competent and compliant with product stewardship principles. Government oversight, such as NSW EPA enforcement, can incentivise the adoption of best practices and responsible behaviours within the industry; thereby offering consumers a reliable way to identify reputable schemes and dispose of end-of-life equipment safely and responsibly.

Nationally recognised product stewardship schemes are vital in accelerating the circular economy and this paper advocates for e-waste from RAC equipment to be included on the Minister's Priority List[9].

Manufacturers, importers, retailers, distributors and recyclers can play a crucial role in the establishment of product stewardship systems and value-chain collaboration as exemplified in the following two case studies.

[9] Department of Climate Change, Energy, the Environment and Water, 2022

Case Study 1

Winning Group Stewardship

Since 2005, Winning Group (which includes retail entities Appliances Online and Winning Appliances) has pioneered a free and convenient removal and recycling solution for old appliances in the electronics retail industry. The free service, provided to customers of Winning Group, has expanded and grown in sophistication over time, and according to industry benchmarking, is now the largest national retailer-managed and free for customers removal and recycling service for end-of-life appliances, mattresses and product packaging.

Through Winning Group's removal and recycling program, consumers have access to responsibly disposing their superseded and/or end-of-life appliances for free, including temperature exchange equipment such as refrigerators, dryers, hot water units and air conditioning units, regardless of whether the original appliance was purchased from the Winning Group. With this removal and recycling program, Winning Group helps prevent the leakage of harmful ODS and GHGs, proactively assisting in the reduction of emissions while also enabling high-value material recycling for remanufacturing; driving circularity and positive climate outcomes. Based on data insights from their refrigerant recovery program, up to 65% of the discarded RAC equipment still contains gases which contribute to global warming and ozone depletion and for each RAC unit responsibly collected and handled, up to 235 KG of CO_2-e are prevented to be released into the atmosphere from refrigerant recovery alone.

How it Works

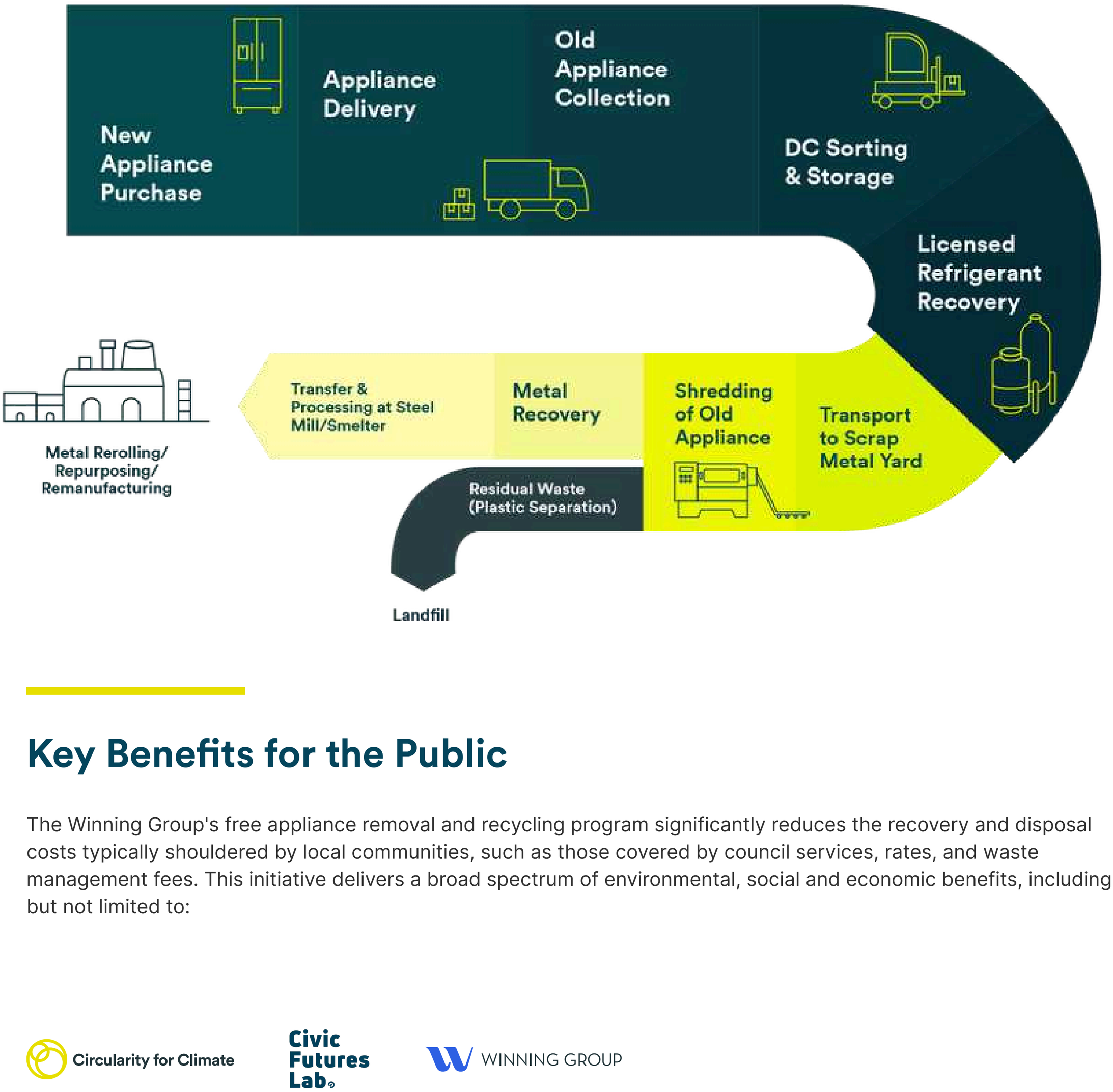
The following provides a high-level overview of the Winning Group appliance removal and recycling program, specifically focusing on refrigeration units:

1. Upon delivery of new appliances, Winning Group collects customers' superseded and end-of-life appliances, returning these to the nearest distribution centre (DC).

2. Once received at each DC, the units are sorted and separated by category (i.e. refrigerators, air conditioners, washing machines, dishwashers, vacuum cleaners etc). In the case of refrigerators, these are further segregated to enable ease of access by licensed ARCTick technicians.

3. Contracted licensed technicians attend each DC to recover global warming and/or ozone-depleting substances from old units.

4. Once the global warming and/or ozone-depleting substance is recovered from the units, Winning Group works with recycling transport partners to deliver the old appliances to licensed resource recovery sites across Australia.



Key Benefits for the Public

The Winning Group's free appliance removal and recycling program significantly reduces the recovery and disposal costs typically shouldered by local communities, such as those covered by council services, rates, and waste management fees. This initiative delivers a broad spectrum of environmental, social and economic benefits, including but not limited to:

Economic Benefits/Cost Savings

- **Job creation:** The program supports employment for licensed refrigerant handling technicians, drivers and workers at DCs and scrap metal yards.

- **Public cost savings:** By carrying the cost of customer's end-of-life appliance collection, ODS recovery and disposal, the program delivers significant economic benefits and savings to local councils and ratepayers.

- **Material circularity:** The recovery of valuable materials, especially metals contributes to economic benefits and significant opportunities exist to further such benefits through onshore reprocessing and value-adding in domestic manufacturing.

Social Benefits

- **Public health:** Safe recovery and proper disposal of ODS, harmful GHGs and other harmful materials prevent potential health risks associated with improper disposal.

- **Awareness and education:** The program raises awareness about the importance of recycling and proper e-waste management, fostering a culture of environmental responsibility among consumers and industry.

Environmental Benefits

- **Emissions reduction:** Based on FY24 data, the removal and recycling program prevents over 8,000 tonnes of CO2-e from entering the atmosphere annually; this includes harmful ODS. A description of the methodology used can be found in the Appendix.

- **Resource conservation:** Recycling metals from old appliances ensures the conservation of natural resources, reducing the need for new raw materials and the environmental impact of mining and processing.

- **Waste reduction:** The program diverts electronic waste from landfill and kerbside pollution, preventing leakage of harmful chemicals into soil and water, thereby protecting ecosystems and biodiversity.

- **Energy efficiency:** Encouraging the purchase of higher energy-efficient appliances helps reduce overall energy consumption, contributing to lower greenhouse gas emissions from RAC equipment.

Summary

The appliance removal and recycling program forms part of Winning Group's discretionary efforts to decarbonise its supply chain, as a pathway to delivering on the group's sustainability strategy and goals. The removal and recycling program, along with the associated refrigerant recovery program, support Scope 3 decarbonisation efforts, which are estimated to account for over 99% of their overall emissions.

However, the program faces operational and economic challenges due to the high degree of manual sorting and separation processes, weather exposure of degassing sites, and the limited availability of licensed technicians to remove ODS and harmful GHGs across Australia. Additionally, the absence of industry standards impedes the collection of accurate and consistent data, and limits transparency and clarity in the chain of custody among downstream value chain players, including rebate collections and the end-of-life destruction of ODS and harmful GHGs.

High costs of the refrigerant recovery program, increase Winning Group's operational costs and hinder expansion of other additional environmental stewardship programs. Currently, the national refrigerant recovery scheme provides no direct financial incentives or rebates to Winning Group, with the program fully funded and offered complimentary to consumers as part of the Winning Group's commitment to addressing climate change.

By championing a holistic approach to refrigerant recovery and material circularity, Winning Group has laid the groundwork for a more sustainable trajectory in the refrigeration sector. Deeper collaboration across the value chain is paramount to mitigating further environmental harm and strengthening industry stewardship to drive resource efficiency, thereby safeguarding the interests of both present and future generations.

Case Study 2

UK Refrigerator Recovery and Recycling Value-Chain Collaboration

In the UK, the disposal and recycling of refrigerators are governed by a robust legal framework designed to mitigate environmental impacts and promote product stewardship. Key mandatory regulations include the Waste Electrical and Electronic Equipment (WEEE) Regulations, the F-Gas Regulation, and the Environmental Protection Act 1990. These laws ensure that hazardous materials, such as refrigerants, are managed responsibly, and valuable resources are recovered to support the circular economy. For further details on these regulations see Appendix E. These regulations place the onus on manufacturers, importers, and retailers to ensure that their products are properly recycled at the end of their life cycle. WEEE requires that refrigerators be processed at facilities meeting stringent environmental standards, ensuring that hazardous materials, such as refrigerants and oils, are safely extracted and managed.

Manufacturers and importers must register with a Producer Compliance Scheme (PCS) and contribute financially to the collection, treatment, and recycling of electrical goods. Retailers and distributors have the option to provide an in-store take-back service or join the Distributor Take-back Scheme (DTS), a collective compliance initiative that funds the establishment and operation of designated collection facilities (DCF) where consumers can dispose of their old appliances.

Value-Chain Collaboration

In the UK, value-chain collaboration is key to advancing sustainable waste management, particularly for waste electrical and electronic equipment. By partnering across the product life cycle, from manufacturers to recyclers, refrigerants are properly collected (including from insulation foam) and materials like those from old refrigerators are efficiently recycled and repurposed, reducing environmental impact. The partnership between AO Recycling and Volution Group exemplifies how sectors can collaborate to turn waste into valuable resources, strengthening the circular economy and driving both innovation and economic growth.

Product Stewardship and the WEEE Directive in Practice

Product stewardship is a fundamental concept within the WEEE Regulations, which hold manufacturers and retailers accountable for the environmental impacts of their products throughout their entire lifecycle, including end-of-life disposal. Under these regulations, producers are required to finance the collection, treatment, and recycling of electrical appliances. This approach supports a circular economy, where materials are systematically recovered and reused, minimizing waste and environmental harm.

Retailers and distributors are crucial players in this system. They are obligated to either provide a take-back service for old appliances or participate in the DTS. The DTS is a mandatory, collective compliance initiative that ensures WEEE is collected at designated sites. Retailers who join the DTS contribute financially based on their market share, thus supporting the recycling infrastructure essential for managing electronic waste responsibly. Additionally, retailers are responsible for educating consumers on how and where they can recycle their old electronics, which enhances public participation in sustainable disposal practices.

Role of Local Government in the WEEE Directive

Local governments play a pivotal role in the execution of the WEEE Regulations. They are often tasked with establishing and managing designated collection facilities (DCFs), where consumers can drop off their old electrical and electronic equipment, including refrigerators, for recycling. These facilities are critical for ensuring that WEEE is collected and processed in an environmentally responsible manner.

Local authorities typically collaborate with Producer Compliance Schemes (PCS) and the DTS to facilitate the efficient collection and recycling of WEEE. They are also instrumental in raising public awareness about the importance of recycling electronic waste and providing guidance on proper disposal methods. By overseeing these collection points and educating the community, local governments ensure the effective implementation of the WEEE Regulations at the grassroots level, thereby reducing the environmental footprint of discarded electrical goods.

Advanced Refrigeration Recycling Infrastructure & Offtake Markets

AO Recycling operates one of the UK’s most advanced refrigerator recycling facilities, processing over 700,000 fridges annually, around 20% of the UK's total refrigerator disposal. AO Recycling’s operations are fully compliant with both the WEEE Regulations and the F-Gas Regulation, ensuring that hazardous substances such as refrigerants and oils are safely extracted and managed according to stringent UK environmental laws. The facility utilises cutting-edge technology to safely remove harmful gases and recover valuable materials, including metals, plastics, and insulation foam. By recycling these materials, AO Recycling not only mitigates environmental harm but also supports the circular economy by supplying raw materials for new products. Furthermore, the facility refurbishes and resells appliances that are still in good condition, thereby extending their lifecycle and reducing waste.

A key example of value-chain collaboration at AO Recycling is its partnership with Volution Group. Through this collaboration, materials recovered from recycled fridges, particularly polystyrene, are repurposed by Volution for use in ventilation systems, transforming unwanted fridges into products that contribute to healthy, fresh air. This partnership not only exemplifies the practical application of circular economy principles but also demonstrates how businesses can work together to create sustainable solutions across the value chain.

Summary

The UK's regulatory framework for the disposal and recycling of refrigerators is comprehensive, addressing both environmental protection and product stewardship. The WEEE Regulations, F-Gas Regulation and Environmental Protection Act collectively ensure that the environmental impact of discarded refrigerators is minimised. By mandating the recovery and recycling of hazardous materials and enforcing strict compliance measures, these regulations support a sustainable, circular economy. Industry partnerships are central to enabling equipment users, consumers and local governments, with responsible disposal, and play a pivotal role in the effective implementation of these regulations, ensuring that WEEE is managed responsibly and environmental benefits are realised for the broader community.

Barriers to Viable, Scalable RAC Recovery, Stewardship and Value-Chain Collaboration

Implementing and scaling a viable refrigerant recovery and stewardship program for RAC equipment faces several barriers. Addressing these issues is essential to reduce harmful emissions, align with climate goals and accelerate the circular economy.

Legislative Framework and Enforcement

Nationally, the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 provides a robust federal framework regulating the management of ODS and synthetic GHGs, including refrigerants. This legislation is mirrored and enforced at the state and territory level. For example, the NSW Protection of the Environment Operations Act 1997, alongside the NSW Ozone Protection Act 1989, mandates the responsible collection, handling, and disposal of refrigerants. Similarly, Queensland's Environmental Protection Act 1994, Victoria's Environmental Protection Act 1970, and equivalent laws across other states and territories, ensure businesses are held accountable for managing refrigerants in compliance with both state and federal regulations (for more details refer to Appendix A).

However, despite these legislative structures, enforcement remains inconsistent, with gaps in compliance leading to bad actors and free-riders undermining the integrity of the system. Strengthening enforcement mechanisms, ensuring nationwide uniformity in application, and addressing regulatory inconsistencies are critical to maintaining high environmental standards and achieving the objectives of a comprehensive recovery and stewardship scheme.

Stewardship Efficacy and Transparency

The efficacy and transparency of all product stewardship schemes, whether mandatory or not, is critical to achieving circularity and mitigating climate risk. RRA's levy and rebate system are critical for accountability in the RAC equipment and refrigerant recovery industries. While RRA provides financial incentives to encourage the return of recovered refrigerants for safe disposal, two major concerns have been identified:

- The current rebate contributes toward, but does not fully cover, the estimated $25 per unit cost of degassing. Collaborative pilot projects could provide valuable insight into how enhanced funding models and cost-sharing approaches might improve participation and outcomes.

- While the current scheme plays an important role in refrigerant recovery, addressing climate risk at scale will require stewardship solutions that extend beyond gas management. A co-regulated, whole-of-appliance model developed in collaboration with government, RRA and industry partners would enable more comprehensive environmental and economic outcomes.

Australia's refrigerant recovery rate is estimated to range between 35% and 61% per year, significantly lower than the UK's reported rate of 65% to 92%. While Australia's destruction rate of recovered refrigerants is high at 92%, ensuring substantial emissions abatement, gaps remain in the recovery process.

The destruction process highlights the critical value of effective refrigerant recovery schemes. Although an independent study by AHRI (2016) deemed the Refrigerant Reclaim Australia (RRA) rebate system effective, recent industry engagement has identified areas for improvement. Enhancements such as adopting a "full cost recovery" model could increase both efficacy and transparency.

As of the time of preparing this white paper, the most recent publicly available annual report from RRA is from FY2020, with the scheme last re-authorised by the ACCC in 2021 for a further 10 years. Although RRA has provided updated data specifically for this white paper, annual reports for FY2023 and FY2024 have not yet been published, and the latest publicly available recovery data referenced in the Cold Hard Facts 4 Report is from 2022. The lack of recent performance data presents a challenge in fully addressing the significant environmental risks and undermines the ability to meet the stewardship objectives. To effectively scale the recovery of harmful gases containing GHGs and ODS, improved data collection, enhanced governance, and greater transparency are critical for ensuring accountability and reinforcing the integrity of the stewardship scheme.

Consumer Awareness and Participation

Low consumer awareness and engagement can hinder the effectiveness of refrigerant recovery programs. Many consumers are unaware of the environmental impact of improper disposal or the available recovery and recycling programs. Increasing public awareness through educational campaigns and simplifying the return process for old equipment will boost participation rates, ensuring more widespread adoption and compliance.

Technological Barriers

Technological limitations in recovery and recycling processes affect the efficiency and effectiveness of refrigerant recovery programs. Innovations that improve the extraction, purification, and reuse of refrigerants are necessary. Investment in research and development to advance recovery technologies can overcome these barriers, making the processes more efficient and cost-effective, e.g. CSIRO refrigerant destruction technology PLASCON.

Non-Compliance and Absence of Enforcement

Non-compliance and the absence of robust enforcement mechanisms pose significant barriers to the success of an industry led refrigerant recovery scheme. Bad actors and free-riders, who evade regulations and avoid participating in the recovery process, contribute to ongoing environmental harm and financial imbalances within the system. Non-compliance across the refrigerant recovery value chain is estimated to result in significant volumes of avoidable emissions leakage, highlighting the climate risk of inadequate enforcement.

Addressing these barriers through stringent enforcement, transparent rebate systems, technological innovation and increased public awareness can significantly enhance the scalability and viability of refrigerant recovery schemes in Australia.

Call to Action: Strengthening Australia's Refrigerant Stewardship and Value-Chain Collaboration

Improper refrigerant disposal remains a significant environmental challenge that demands a coordinated, system-level response across government, industry and the wider value chain. Building on successful national and global models such as the Winning Group's program and the WEEE Directive, meaningful progress will require governments to go beyond enforcement and priority listings by co-designing regulatory frameworks with industry, embedding enforceable recovery and recycling standards, and establishing transparent cost-sharing mechanisms.

Strengthening collaboration between government, retailers, manufacturers, recyclers and RRA through joint pilots, shared data initiatives and co-designed policy solutions will build on existing efforts, reduce climate risks and unlock economic opportunities through improved circular practices.

The following actions are recommended to accelerate safe refrigerant recovery and recycling in Australia:

Federal Government:

1 **Stewardship priority:** Include RAC equipment on the Minister's Priority List for Product Stewardship to enable a nationally consistent scheme that supports whole-of-life refrigerant and appliance recovery.

2 **Expand e-waste programs:** Prioritise refrigerant-containing equipment under the Wired for Change initiative to unlock public and private investment in collection and recycling infrastructure, and consult industry on integrating these products into existing or new stewardship arrangements.

3 **Policy response to Cold Hard Facts 4 (2024) report:** Collaborate across the value chain to co-design and implement a national refrigerant recovery and destruction strategy, targeting emissions reduction, leakage prevention, and legacy bank management.

4 **Align GWP thresholds and stewardship policies with science:** Ensure national refrigerant policy, including GWP thresholds, phase-down schedules, and end-of-life requirements, reflects the latest international scientific guidance (e.g. IPCC AR6) and aligns with stewardship and recovery efforts. This is critical to minimise compliance confusion and improve investment certainty for low-GWP alternatives.

5 **Reform NGER and ASRS to close critical gaps:** by requiring actual data on leakage and end-of-life emissions, removing exemptions, and aligning with international best practice, to improve transparency, accountability, net zero credibility and alignment with international best practice.

6 **Integrate nature-related risks into stewardship strategy:** Leverage the policy shift signaled by the Nature Repair Bill 2023 to develop a lifecycle approach to refrigerant stewardship. This includes recognising the ecological risks of chemical leakage (including PFAS by-products) and aligning refrigerant policy with emerging biodiversity markets, integrated environmental disclosures, and nature-positive investment frameworks.

State & Territory Governments:

1 **Support consumer disposal options:** In partnership with industry, implement or expand programs to offer incentives or rebates that encourage consumers to dispose of refrigeration units responsibly, ensuring refrigerants are safely recovered.

2 **Strengthen regulatory enforcement:** Enhance mechanisms under the state and territory government's responsibility to enforce the Ozone Protection Act to ensure compliance, reduce the prevalence of bad actors and eliminate free-riders in the market. Regular inspections and increased penalties for non-compliance will drive better practices.

3 **Develop standardised guidelines:** Collaborate with other states and territories to develop and implement standardised guidelines for refrigerant management across all jurisdictions, ensuring consistent practices for recovery, storage and disposal.

4 **Engage stakeholders in climate action:** Establish and consult industry-sector advisory groups to ensure that climate actions related to refrigerant management are focused, impactful and supported by all stakeholders.

5 **Prioritise household appliances for end-of-life regulation:** Apply state-based product stewardship powers to develop enforceable standards for the recovery, recycling and disposal of household appliances, including refrigerant-containing units. The *NSW Product Lifecycle Responsibility Act 2025* provides a model for regulating products across their lifecycle and can inform nationally consistent approaches to reduce emissions, recover materials and address residual appliance waste.

Local Government and Regional Organisations of Councils (ROCs):

1. **Review and revise collection practices:** Re-evaluate the inclusion of refrigerant-containing appliances in kerbside collection programs, which can lead to improper disposal. Partner with industry take-back programs to ensure safe handling and recycling of these units.

2. **Incentivise participation in take-back programs:** Introduce incentives for consumers who participate in industry take-back programs, such as discounts on new appliances or local tax rebates, to increase participation and reduce the volume of improperly disposed refrigerant-containing appliances.

3. **Public education campaigns:** Support public education campaigns to raise awareness of the environmental risks of improper refrigerant disposal and provide clear guidance on safe disposal through local take-back programs or designated collection points.

Ecosystem Partners:

1. **Refrigerant Reclaim Australia (RRA):** Accurate data on the current state of refrigerant recovery is crucial for understanding the effectiveness of current strategies and areas for improvement in interventions. Regularly release updated performance data to guide policy decisions and industry practices.

2. **Product Stewardship Centre of Excellence (PSCE):** Support the development of a national framework for whole of product stewardship, including best practices for manufacturers, retailers, and recyclers. This framework should explore the potential to leverage and support existing extended producer responsibility programs.

Industry:

1. **Prioritise refrigerant leakage as a climate risk:** Business leaders must recognise that refrigerant leakage represents a significant climate risk, which will need to be disclosed under imminent Australian sustainability reporting standards. Companies should take immediate action to assess and mitigate refrigerant leakage within their operations.

2. **Support and expand take-back schemes:** Retailers, brands and manufacturers must actively participate in and expand take-back schemes to ensure the safe recovery and recycling of refrigerants. This is not only a compliance issue but also a critical element of corporate social responsibility and sustainability leadership.

3. **Mandatory climate disclosures:** Businesses should begin preparing for the integration of refrigerant management data into their Mandatory Climate Disclosures (MCD). Transparent reporting on refrigerant leakage, recovery rates, and mitigation strategies will be essential to meet upcoming regulatory requirements and demonstrate a commitment to reducing environmental impact.

4. **Implement industry standards:** Like other hazardous waste, industry must adopt and adhere to standards for the safe handling, storage, and recycling of refrigerants to ensure compliance and mitigate the impacts of legacy ODS refrigerants on the environment.

In Focus: Opportunities for New South Wales

As a leader in climate and circular economy policy, New South Wales has a unique opportunity to set the national standard for environmental stewardship when it comes to harmful, climate damaging, ozone-depleting refrigerants. By considering the recommendations outlined in this report, NSW EPA can further strengthen its position as a national leader in climate mitigation, through responsible end-of-life management of e-waste, specifically RAC equipment. The benefits for NSW include:

- **Reduce harmful emissions:** Implement and monitor robust end-of-life management practices for RAC equipment to significantly reduce the release of harmful emissions.
- **Support net-zero goals:** Effective end-of-life management aligns with the NSW government's decarbonisation objectives by reducing emissions associated with improper disposal, supporting the goal of net-zero emissions by 2050.
- **Accelerate the circular economy:** Enhancing the recovery and recycling of RAC equipment contributes to NSW circular economy objectives by reducing waste, conserving resources and promoting sustainable economic growth.

Increased Value-Chain Collaboration

Raising public awareness and education is vital to encourage improved outcomes and, whilst the RRA, ARC, RA and AREMA are actively promoting emissions reductions, a collaborative approach involving local government and other industry advocates will be required to effectively communicate with communities and stakeholders. Furthermore, incentives and rebates should be explored to mitigate further refrigerant leakage and climate risk. Engagement, education and enforcement measures should also be considered for metal recycling and scrap-metal facilities to ensure that best practices occur at all phases of the disposal lifecycle.

- Enhanced value-chain collaboration could further enable proper disposal of greater volumes of RAC equipment presenting an opportunity for NSW to save 47,201 tonnes of CO2-e of harmful, ozone-depleting substances from being released into the atmosphere every year, equating to annual savings of approximately $6 million[10] (based on NSW Treasury's carbon emissions value set at $126 per tonne for the purpose of preparing cost-benefit analyses).

- Establishment of a specialised whole of unit recovery infrastructure (such as AO Recycling featured in Case-study 2), presents an opportunity to reduce the cost of degassing (approximately $25 per domestic unit) and increase the value realised on materials recovered.

Going Further with Circular Value Chains

The National Waste Report (2022) revealed a national resource recovery rate of 63% and NSW ranks third behind South Australia and the Australian Capital Territory at 69%[11]. This highlights that despite being the most populous state, NSW has made commendable progress in waste management practices, underscoring the importance of continued efforts by the NSW EPA to enhance recycling and resource recovery initiatives.

In terms of material categories, metal recovery management stands out at an 87% recovery rate nationwide[12]. While the data is encouraging, a challenge looms for NSW as waste generation is projected to surge from the current 21 Mt to 31 Mt[13]; underscoring the critical need to enhance efforts in all aspects of circularity as resources and facilities are stretched.

In the publication Circular Economy Metrics , Case Studies for NSW, the concept of carbon dividends explains how efficient recycling of materials has potentially avoided up to 4 million tonnes of greenhouse gas emissions from the recycling of non-hazardous waste, of which aluminium and steel were by far the most recovered resource in terms of materials. More broadly, efficient material circularity benefits the economy as well as the environment , it is estimated that a 5% improvement in material efficiency would contribute over $10 billion to NSW's Gross State Product[14].

[10] NSW Treasury, 2023

[11] Department of Climate Change, Energy, the Environment and Water, 2022

[12] Department of Climate Change, Energy, the Environment and Water, 2022

[13] Circular Australia, 2024

[14] Circular Australia, 2022

NSW has already taken a positive stance towards driving a circular economy with the release of the Circular Economy Policy Statement, outlining principles and focus areas. Efforts towards reclamation, recovery, and recycling for end-of-life RAC equipment must align with these guiding circularity principles and maximise local reprocessing and remanufacturing of recyclable RAC components. Material circularity focuses on minimising waste and pollution by optimising material usage. Therefore, the management of RAC e-waste should encompass various materials present in RAC equipment, such as metals, plastics, foams, oils, and chemicals.

To continue driving change for NSW, this white paper presents a compelling case for further regulatory action. Aligning efforts with the NSW Waste and Sustainable Materials Strategy 2041 Stage 1: 2021-2027 highlighting compliance with relevant legislation such as the NSW Waste Avoidance and Resource Recovery Act 2001 and the Plastic Reduction and Circular Economy Act 2021 will strengthen the foundation for NSW's transition towards a circular economy.

Delivering on the NSW EPA Climate Action Plan with Circularity

This white paper and the Winning Group Case Study support the NSW EPA's Climate Change Action Plan by addressing several key actions.

Firstly, by monitoring emerging issues, trends, risks and opportunities in refrigerant recovery, this evidence-based white paper provides valuable insights to inform and plan for the transition to a decarbonised economy (Action 3). Additionally, it advocates for the development and implementation of tailored behavioural change programs to encourage safe refrigerant recovery, thereby reducing greenhouse gas emissions (Action 12). The paper also recommends strict enforcement actions against short-lived climate pollutants, reinforcing regulatory measures (Action 14).

Moreover, this strategy aligns with the EPA's efforts to develop greenhouse gas emission reduction targets and pathways for key industry sectors, providing a clear direction for regulatory efforts (Action 16). It also offers guidance on climate change mitigation for licensed industry sectors, including performance outcomes to be achieved (Action 17). Finally, by supporting innovation within the regulated community, this white paper and the Winning Group Case Study promote the adoption of best practices and technological advancements in refrigerant recovery (Action 19).

Delivering on the NSW EPA Climate Action Plan with Reform and Enforcement

The NSW Protection of the Environment Operations Act 1997, in conjunction with the Ozone Protection Act 1989, regulates the collection and management of ODS refrigerants. These laws align with the federal Ozone Protection and Synthetic Greenhouse Gas Management Act 1989, ensuring comprehensive control over the lifecycle of these substances. Effective enforcement is crucial to prevent the willful or negligent emission of ODS. However, non-compliance and inadequate enforcement result in bad actors and free-riders undermining the system's integrity. Strengthening enforcement mechanisms and ensuring consistent application of the laws are essential to maintaining environmental standards and achieving the scheme's objectives.

Summary of Potential Steps for NSW EPA to Address the Key Risks and Opportunities:

- **Quantify the scale of the problem:** Survey NSW LGs to develop the evidence base on the scale of refrigerant recovery challenges and risks including transport limitations, recovery and disposal costs, and circularity outcomes.

- **Address existing scheme efficacy:** Engage with Refrigerant Reclaim Australia and industry partners to address compliance and efficacy of the current stewardship model.

- **Enhance compliance:** Implement mandatory reporting and compliance measures in alignment with the NSW Protection of the Environment Operations Act 1997 and the Ozone Protection Act 1989; for both industry and public sector (covering both domestic and commercial refrigerators).

- **Mandate stewardship participation through new legislative powers:** Utilise the *NSW Product Lifecycle Responsibility Act 2025* to mandate industry participation in accredited stewardship schemes for e-waste, refrigerant recovery, and packaging. This will support the transition to closed-loop systems, drive higher recovery rates, and address persistent residual waste from end-of-life appliances.

- **Communication support to raise awareness of voluntary take-back schemes:** Support retailers, manufacturers and brands to optimise take-back and buyback schemes thereby increasing participation and awareness.

Factsheet

Refrigerant Emissions and Climate Impact

- 58.5 Mt CO2e emissions in 2022 from vapour compression technology and associated systems, accounting for approximately 12% of Australia's National Greenhouse Gas Inventory.
- Emissions decreased by 10% from 2016 (65.10 Mt CO2e) but still present significant climate risks.

  Of the total emissions:

  - 87% are indirect emissions from energy consumption.
  - 13% are direct emissions from refrigerant gas leakage.
- As Australia's energy grid decarbonises, direct emissions will form a larger proportion of total emissions.

  Breakdown of total emissions:

  - 51.6 Mt CO2e from energy-related emissions.
  - 6.9 Mt CO2e from refrigerant gas leakage during operations — excluding end-of-life emissions.

Urgent Policy Reform Indicators

- 3% increase in refrigerant bank volume from 2020 to 2022 due to rising heat pump usage.
- Emissions peaked in 2021 but are expected to decline with greater adoption of natural and low-GWP refrigerants.

  Significant uptake of:

  - R32 refrigerant.
  - Natural refrigerants like CO2 and hydrocarbons.
  - HFO/HFC blends such as R448A, R449A, R452A, and R513A.

  Persistent use of high-GWP refrigerants R404A and R134a, despite phase-down efforts:

  - R404A imports increased from 581 to 629 tonnes (2021-2022).
  - Stockpiles of high-GWP refrigerants continue to supply the market, undermining the HFC quota system.
  - 17-22% of new vehicles in 2022 still used HFO-1234yf instead of lower-GWP alternatives.

Annual Refrigerant Recovery Performance

Refrigerant Recovery Australia (RRA) prevented approximately **1 million tonnes of CO2e emissions annually** through the capture and destruction of ODS.

Recovery volumes in 2023 included:

- 6 tonnes of CFC “legacy” refrigerants, avoiding 50,962 t CO2e.
- 118 tonnes of HCFC (ODS), avoiding 209,844 t CO2e.
- 360 tonnes of HFCs, avoiding 826,386 t CO2e.

Global Warming Potential of Refrigerants

- The refrigerant types CO2, ammonia, propane and isobutane have low global warming potential and are considered environmentally friendly with minimal restrictions in place
- The refrigerant types R404A, R134a, R410A have high global warming potential and are subject to bans and restrictions (Montreal Protocol and Australian regulations).

Phase-Out Progress

High-GWP fluorinated refrigerants are being phased out under:

- Montreal Protocol.
- Australian Government legislation.
- Transition to natural refrigerants is essential to meet international and national climate targets.

Appendix A

Australia's Legislative Background and Net Zero Targets

Legislative Background

In Australia, the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 was introduced to better manage harmful refrigerants. This Act serves as the legislative mechanism through which Australia meets its obligations to phase out ODS and harmful GHGs under the Montreal Protocol and limits greenhouse gas emissions by controlling the use of synthetic greenhouse gases under the Kyoto Protocol. It regulates the import, export, manufacture, acquisition, use, storage, handling, and disposal of these substances, specifying the allowable limit of HCFC imports for each calendar year. State and territory environmental agencies play a critical role in enforcing compliance with the Act through their respective environmental protection frameworks.

In NSW, under the Ozone Protection Act 1989 and Clause 117 (Emission of Ozone Depleting Substances) of the Protection of the Environment Operations Act 1997 No 156, it is an offence to wilfully or negligently cause any controlled substance to be emitted into the atmosphere. An offence under Clause 117 carries special executive liability for corporations under Clause 169. Similarly, Queensland's Environmental Protection Act 1994 and Victoria's Environmental Protection Act 1970 mandate the safe management of refrigerants, ensuring that businesses comply with both state and federal regulations. These state-level laws are crucial levers to enforce proper handling, storage, and disposal of ODS and synthetic greenhouse gases, helping to safeguard the environment from their harmful effects.

Compliance and Enforcement

In Australia, state and territory environmental agencies play a crucial role in enforcing compliance with the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989. This responsibility is typically embedded within broader state and territory environmental legislation, which aligns with federal regulations. These local laws provide the legal framework for agencies to monitor and enforce the proper handling, storage, and disposal of ODS and synthetic greenhouse gases (SGGs). The following examples illustrate how state and territory agencies use their environmental protection laws to ensure businesses and individuals adhere to these regulations, thereby safeguarding the environment from the harmful effects of these substances.

New South Wales

Protection of the Environment Operations Act 1997

Part 5.7 – Environmental protection notices: This part empowers the NSW EPA to issue notices to individuals or businesses requiring them to take action to prevent or remedy environmental harm, including improper handling of ODS and SGGs.

Regulatory role of the NSW EPA: The NSW EPA monitors and enforces compliance with both state and federal environmental regulations, including those related to the management of ODS and SGGs. The EPA's role includes inspections and audits to ensure that businesses adhere to these regulations.

Waste Avoidance and Resource Recovery Act 2001

This Act promotes resource recovery and waste avoidance, which aligns with the proper disposal and recycling of ODS and SGGs. The NSW EPA enforces this Act, which includes the regulation of waste that may contain harmful substances such as ODS.

Queensland

Environmental Protection Act 1994

Section 319 – General environmental duty: This section mandates that a person must not carry out any activity that causes or is likely to cause environmental harm unless all reasonable and practicable measures are taken to prevent or minimize the harm. This can be applied to the handling and disposal of ODS and SGGs, as improper disposal could lead to environmental harm.

Environmental Protection Regulation 2008 (Queensland): This regulation includes specific requirements for the management of environmentally relevant activities, which can include the storage and handling of regulated substances like ODS and SGGs.

Victoria

Environmental Protection Act 1970

State Environment Protection Policy (Air Quality Management): This policy requires industries to manage emissions of substances that can deplete the ozone layer. Victoria's Environment Protection Authority (EPA) enforces these requirements, ensuring that businesses comply with both state and federal laws regarding ODS and SGGs.

EPA Victoria Guidelines: These guidelines provide businesses with best practices for managing ozone-depleting substances, emphasising compliance with the Ozone Protection Act at both the federal and state levels.

Net Zero Targets and Pathways

Australia's legislative commitment to Net Zero, supported by sectoral decarbonisation plans, mandates a reduction of greenhouse gas (GHG) emissions by 43% by 2030 from 2005 levels. In New South Wales (NSW), the government has set targets in alignment with this national commitment, aiming to cut emissions by 50% by 2030 and achieve Net Zero by 2050. The NSW Environment Protection Authority (EPA), a longstanding guardian and steward of the environment, is expanding its role in reducing and mitigating the impacts of climate change. To support this mission, the EPA has developed the Climate Change Policy and Climate Change Action Plan 2023–26, outlining key actions to guide its efforts. As the preeminent environmental regulator and policymaker, the EPA is focused on supporting industry transformation to achieve broader economic transition goals. This involves providing guidelines, resources and support to help industries adopt sustainable practices and significantly reduce emissions.

Unprecedented collaboration between government and industry is essential for achieving these ambitious targets. The EPA's Climate Change Action Plan recognises its critical role in enabling regulated industries to implement sustainable practices and reduce their environmental impact. To accelerate the transition to a zero-carbon circular economy, the NSW EPA emphasises that partnerships - built on deep listening, idea sharing and collaborative problem-solving - are vital. These partnerships ensure industries can effectively contribute to emission reduction goals, enhance their competitive advantage and support the broader societal shift towards sustainability.

With Australia on a firm path to reduce emissions, much of these reductions are projected to come from the energy sector by 2030, making the establishment of abatement pathways beyond this point crucial. It is broadly accepted that material use, a major factor in global warming, offers a significant lever for emissions reduction. However, The global circularity rate has fallen steadily from 9.1% in 2018 to 7.2% in 2023[15] (Circularity Gap Report, 2024) and Australia’s circularity rate remains well below the global average at 4%[16] according to CSIRO (2024).

Enhancing circularity could save Australia 165 Million Tonnes (Mt) CO_2-e annually by 2040 and therefore it offers vital reduction pathways. In this context, NSW's Circular Economy Policy acknowledges the extensive economic and environmental benefits of implementing circular practices and underscores how the government can support industry to realise these benefits including reducing material waste, lowering greenhouse gas emissions and fostering sustainable economic growth through resource efficiency and innovation. The NSW Waste and Sustainable Materials Strategy 2041 also supports these goals by promoting a circular economy approach to waste management, emphasising waste reduction, resource recovery, and innovation in material reuse.

[15] https://www.circularity-gap.world

[16] https://www.csiro.au/en/news/all/news/2024/march/new-report-reveals-australias-material-use-and-circular-rate

Appendix B

Quantifying the Climate and Environmental Impacts

The following data points underscore the critical importance of improving end-of-life management practices for RAC equipment to mitigate GHG emissions and reduce climate risks.

Impact on nature: The improper disposal of refrigerants poses significant threats to biodiversity. ODS and synthetic greenhouse gases released into the atmosphere contribute to climate change, affecting natural habitats and ecosystems. Additionally, the degradation of many fluorinated refrigerants into forever chemicals are highly persistent in waterways. The Intergovernmental Panel on Climate Change (IPCC) reports that climate change could lead to the extinction of up to 14% of terrestrial species by 2100 if global temperatures rise by 1.5°C. Effective recovery and management of these substances are crucial for reducing harmful emissions and protecting biodiversity.

Significant GHG emissions: The improper disposal of RAC equipment in Australia is estimated to release approximately 188,803 tonnes of CO2-e annually. Given that NSW accounts for about one-quarter of Australia's total emissions, this may equate to around 47,201 tonnes of CO2-e per year from improper RAC disposal in NSW (Department of the Environment, 2014; AdaptNSW, 2023). This estimate refers to a national emissions baseline from RAC equipment, based on current recovery rates. Comparative modelling in NSW shows that a mandatory, whole-of-appliance scheme could deliver ~3,900 tCO_2-e/yr emissions reductions by Year 5, highlighting the potential climate impact of scaling refrigerant recovery nationally (SSROC & PSCoE, 2025).

Low recovery rates: Only 30-40% of refrigerant is reportedly recovered from end-of-life domestic refrigerators and freezers. This low recovery rate leads to substantial emissions of GHGs and ODS, contributing significantly to climate change (Australian Refrigeration Council, 2023).

Ozone layer depletion: Inefficient recovery and recycling practices result in the emission of ODS such as Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs). These substances are potent GHGs with high global warming potential, exacerbating both ozone layer depletion and global warming (Department of Environment, Water, Heritage and the Arts, 2010).

Rising refrigerant bank: The total refrigerant bank in Australia was estimated at 54,100 tonnes in 2021. Without proper end-of-life management, the accumulated refrigerants can lead to significant GHG emissions if released into the atmosphere (Department of Climate Change, Energy, the Environment and Water, 2023).

Impact of HFCs and HCFCs: With the rise of HFCs and HCFCs as replacements for CFCs, managing the disposal of these substances is crucial. These refrigerants have high global warming potential, and their improper disposal can significantly increase the atmospheric concentration of GHGs (AHRI Project 8018 Final Report, 2016).

Refrigerant blowing agents in polyurethane foam: Older refrigerator models used R-11 (CFC-11) as a blowing agent for polyurethane foam insulation, with an estimated 316 grams of R-11 per refrigerator. R-11 has a high ozone depletion potential (ODP) and was replaced by HCFC-141b due to the Montreal Protocol. HCFC-141b, though still an ozone-depleting substance with an ODP of 0.12 and a global warming potential (GWP) of 725-2500, is also being phased out under the same protocol. Typically, the disposal of old refrigeration equipment does not include the recovery of refrigerant-blowing agents in polyurethane foam.

Cost of emissions: The "Cost Benefit Analysis of Product Stewardship for Domestic RAC Equipment at End of Life" report (prepared by KPMG for the Department of the Environment, 2014) highlighted that emission reduction benefits between mandatory and non-mandatory product stewardship schemes returned a $9.1m economic benefit under the mandatory scheme (between 2014-2024 NPV @ 7%).

Global Warming Potential (GWP): Common refrigerants used in RAC equipment, such as R-134a, have a GWP of 1,530 times that of CO_2[17]. This means that even small amounts of refrigerant released into the atmosphere can have a disproportionately large impact on global warming (Australian Refrigeration Council, 2023).

Unregulated emissions: A significant portion of refrigerant emissions occurs outside regulated channels, such as through illegal dumping and scavenging. These metal shredding operators are failing to ensure degassing before shredding, contributing to an overall increase in GHGs which poses a serious climate risk (Department of Climate Change, Energy, the Environment and Water, 2015).

Refrigerant leakage: Leakage during the disposal process is a major concern. Industry estimates suggest that 20-30% of refrigerants are lost to scavengers and contractors operating outside official channels, leading to uncontrolled GHG emissions (Department of Climate Change, Energy, the Environment and Water, 2015).

International commitments: Australia's commitments under the Kigali Amendment to the Montreal Protocol include phasing down the use of high-GWP refrigerants. Failure to manage end-of-life RAC equipment properly undermines these commitments and exacerbates climate risks (Department of Environment, Water, Heritage and the Arts, 2010).

PFAS in refrigerants: PFAS (per- and polyfluoroalkyl substances), known for their persistence and environmental risks, have increasingly become a concern in the refrigerant sector. Though not commonly used directly as refrigerants, PFAS compounds are present in the production processes of certain refrigerants like HFCs. The European Union is moving to phase out PFAS, including in certain refrigerant formulations. In NSW, regulations banning PFAS in specific applications, such as firefighting foams, reflect broader national efforts to manage PFAS contamination under the PFAS National Environmental Management Plan. The challenge of phasing out PFAS compounds must be addressed alongside the F-gas phase-out to mitigate both immediate and long-term environmental risks.

PFAS and TFA formation: The breakdown of certain refrigerants, such as R134a, poses significant environmental risks beyond their direct GWP. When R134a degrades, it can produce trifluoroacetic acid (TFA), a persistent PFAS compound, with an estimated yield of 7-20%. TFA has been identified as a widespread contaminant in drinking water and ecosystems globally, raising concerns about long-term environmental and public health impacts (Department of Climate Change, Energy, the Environment and Water, 2020). As the global stockpile of fluorinated refrigerants grows, the challenge shifts from a declining climate issue to an escalating problem of fluorinated waste, demanding robust disposal and management strategies to mitigate these risks (PFAS National Environmental Management Plan 2.0, 2020).

[17] IPCC 6th AR

Appendix C

EU Regulation and the Waste Electrical and Electronic Equipment Regulations (WEEE)

Waste Electrical and Electronic Equipment (WEEE) Regulations

The WEEE Regulations, first introduced in 2006 and updated in 2013, serve as the cornerstone of the UK's approach to recycling electrical and electronic equipment, including refrigerators. These regulations place the onus on manufacturers, importers, and retailers to ensure that their products are properly recycled at the end of their life cycle. The regulations require that refrigerators be processed at facilities meeting stringent environmental standards, ensuring that hazardous materials, such as refrigerants and oils, are safely extracted and managed.

Manufacturers and importers must register with a Producer Compliance Scheme (PCS) and contribute financially to the collection, treatment, and recycling of electrical goods. Retailers and distributors have the option to provide an in-store take-back service or join the Distributor Take-back Scheme (DTS), a collective compliance initiative that funds the establishment and operation of designated collection facilities (DCF) where consumers can dispose of their old appliances.

F-Gas Regulation (EU No 517/2014)

The F-Gas Regulation, a critical piece of legislation aimed at controlling emissions of fluorinated greenhouse gases (F-gases), plays a crucial role in the management of refrigerants found in refrigerators. These gases, if released into the atmosphere, contribute significantly to global warming. Although the regulation originated as an EU directive, it remains in force in the UK post-Brexit under retained EU law. The regulation mandates the proper recovery and destruction of F-gases during the disposal of refrigerators. Compliance with these regulations is essential to prevent the environmental harm associated with these potent greenhouse gases.

Enforcement of the F-Gas Regulation

The UK Environment Agency (EA) is responsible for enforcing the F-Gas Regulation. The agency conducts regular inspections and audits to ensure compliance. Companies that fail to adhere to the standards face legal action, financial penalties, and potential reputational damage. A notable enforcement action occurred in 2017 when the EA successfully prosecuted SRCL Ltd for improperly managing refrigerant gases. The company was fined £500,000, underscoring the seriousness with which these regulations are enforced and providing a compelling market signal.

Environmental Protection Act 1990

The Environmental Protection Act 1990 provides the overarching legal framework for waste management in the UK. It imposes a duty of care on all parties involved in the handling, treatment, and disposal of waste, including electrical appliances like refrigerators. This act mandates that hazardous substances, such as refrigerants, must be managed in a manner that prevents harm to the environment or human health.

Appendix D

Winning Group Case Study Avoided Emissions Methodology

To measure the environmental impact of its removal and recycling program, Winning Group engaged Terrascope, a carbon measurement and management platform and consultancy. Emissions from the removal and recycling program (intervention scenario) were compared against national averages for metals, packaging, mattresses, TVs and refrigerant disposal (reference scenario), using Greenhouse Gas Protocol methods and emission factors from Defra and National Greenhouse Accounts.

From this, it was found that for FY24 the program prevented over 8,000 tonnes of CO2e emissions, including from harmful ODS.

Savings were found across two different pathways:

- Lower and improved waste treatment emissions: refrigerant recovery and waste diverted from landfill avoids emissions associated with their disposal.
- Avoided virgin material production: recycling uses less energy and emits less CO2 than extracting and processing virgin materials.

Refrigerant recovery was identified as the most significant waste stream in terms of avoided CO2 emissions from improved waste treatment. Recovered refrigerants offered the highest emissions savings per kilogram of product and accounted for 29% of the total avoided emissions compared to the other waste types.

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