RPS REPORT

Improving stewardship for large household appliances

Economic modelling

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REPORT

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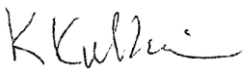
Kapil Kulkarni		4 April 2025

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Contents

Tables

Figures

EXECUTIVE SUMMARY

Background and purpose

This report provides a summary of high level financial, environmental and social impact modelling of three potential options to improve whole-of-life outcomes for large household appliances in New South Wales.

Presently, recovery pathways for large household appliances do not fully recover materials and harmful gases contained in these appliances, which include refrigerators, freezers, washing machines, dryers and dishwashers. While much of the volume of these large household appliances is collected at the kerbside, current practices and market conditions lead to a large proportion of collected materials being sent to landfill or for energy recovery, and a large volume of harmful gases leak into the atmosphere, contributing to ozone depletion and global warming from greenhouse gas emissions (GHG). Moreover, consumers currently do not have significant opportunities to repair, reuse or refurbish large household appliances.

In light of these issues, the Product Stewardship Centre of Excellence (the Centre), Southern Sydney Regional Organisation of Councils (SSROC) and the NSW Environment Protection Authority (NSW EPA) are investigating stewardship pathways for large household appliances, including whitegoods.

Stewardship approaches are designed to improve the whole-of-life management of products by keeping valuable materials recirculating in the economy in their highest value uses and minimising the environmental impacts of products throughout production, consumption and end-of-life management. Stewardship also involves producers of the products taking ownership of funding and facilitating these outcomes.

The Centre, SSROC and NSW EPA commissioned RPS to model the high level financial, environmental and social implications of different scheme design options (Economic Model). The modelling estimated the net impacts of each option, to inform potential future investigations into how these scenarios could be funded and what their benefits might be.

Approach and scheme options

The Modelling considered three options to address one or more of the scheme objectives outlined below, relative to a Base Case where the problems outlined below continue.

Problems in Base Case	Scheme objectives for Options
• Inconsistent handling of refrigerant gas which, if not managed responsibly, results in harmful gasses being released into the atmosphere, including greenhouse gas (GHG) emissions, chlorofluorocarbons and hydrochlorofluorocarbons • Council and ratepayers bearing the cost of end-of-life management without being able to directly influence the factors that drive this cost • Limited material recovery, which is focused primarily on metals, with the glass and plastic being sent to landfill • Limited opportunities for repair, reuse and refurbishment.	1. Transfer the collection and recycling costs and responsibility to producers, importers and retailers 2. Increasing recycling 3. Increasing material and gas recovery 4. Providing accessibility/convenience of collection 5. Increasing repair/reuse/refurbishment 6. Educating and informing consumers 7. Investing in research & development 8. Providing data transparency and robust governance

The options assumed that the Scheme achieves improved stewardship outcomes through a regulatory product stewardship approach. A regulatory approach involves government introducing regulations and regulatory oversight to ensure the achievement of stewardship outcomes. Such an approach can be co-designed in consultation with industry.

The practical implication of assuming a regulatory approach is that the modelling assumes full participation by industry, in that effectively every brand that imports products into Australia contributes to funding through a levy and that their funding is proportional to the mass of appliances they sell.

In contrast, a voluntary approach is highly likely to lead to free riding and less than full participation; and stakeholder interviews conducted as part of this Project showed universal support for a regulatory approach due to the issue of free riders.

The modelling considered the three Scheme options outlined below.

Option 1	Option 2	Option 3
Transfer costs to producers	**Uplift material & gas**	**Uplift including repair**
• Move to a common industry program and transfer the costs of end-of-life management of large household appliances to producers • No explicit initiatives to improve recycling, recovery, repair, reuse or refurbishment outcomes.	• Producers directly invest in and/or provide incentives to uplift recycling, gas and material recovery outcomes, through on or more of the following: – A mandated target to achieve these outcomes or incur a penalty cost – Rebates to Scheme approved collectors and recyclers – Direct investment in recycling capacity owned by the industry to improve pathways for more costly or difficult to recycle materials, such as problematic plastics – Buyback of materials or gas reclaimed.	• Same measures as Option 2 to address recycling, gas and material recovery outcomes • Address key barriers related to repair/reuse/refurbishment, including: – Introducing mandates to right of repair, providing a legal right for product owners to freely modify and repair large household appliances – Better labelling about repairability/durability – Stimulating the development of markets for spare parts – Apprenticeship programs in collaboration with government.

Results

The table below summarises the results of the modelling.

	Unit	Option 1	Option 2	Option 3
		Transfer costs to producers	Uplift material & gas	Uplift incl. repair
Diversion and material recovery (by Year 5)				
Collection for recycling/repair	%	90%	95%	95%
Net material recovery rate from recycling	%	59%	84%	80%
Illegal dumping	Tonnes/yr	802	402	402
Environmental and social benefits (by Year 5)				
Repaired/reused/refurbished	Tonnes/yr	minimal	minimal	4,958
Landfill reduced	Tonnes/yr	0	5,317	5,317[3]
Landfill airspace depletion avoided[2]	m^3/yr	0	40,677	40,677[3]
Incremental employment within circular economy[4]	FTE/yr	0	149	496
GHG emissions reduced[1]	tCO_2-e/yr	0	3,872	3,901
Financial implications				
Scheme levy (per average household appliance)	$/appliance[2]	$36.60	$47.84	$49.02
Percentage of retail price	%[2]	2.58%	3.37%	3.45%

[1] Including through recycling, avoiding the emissions embedded in materials recovery, as well as repair/reuse/refurbishment, avoiding the embodied emissions in new product manufacture

[2] The modelling is based on an 'average large appliance', with an average weight of 65kg and costing $1,256 ex GST

[3] Although the results show the same estimated landfill diversion outcomes for Option 2 and Option 3, the latter is expected to deliver greater long-term diversion outcomes. The current modelling does not capture these long-term effects and focuses on the first 5 years of the Scheme.

[4] These jobs would be distributed across Australia. Jobs would be predominantly concentrated in manufacturing regions, including in NSW and Victoria.

The results show that:

- The cost to the industry to assume financial responsibility for the end-of-life management of large households applies is an estimated $37 per appliance, which is expected to be:
  - Banded according to category/size (e.g., large fridge, small fridge, large washing machine, etc.)

  - Approximately 3% of the retail price
- For an additional $11.14 per appliance levy, Option 2 is estimated to:
  - Significantly lift net material and gas recovery
  - Significantly reduce illegal dumping
  - Provide significant environmental and social benefits in terms of avoided landfill, employment associated with the circular economy and GHG emission reductions
- For a further $1.18 per appliance levy, Option 3 is estimated to:
  - Stimulate a repair/reuse/refurbishment economy
  - Further substantially improve employment within the circular economy.

While these results relate to a NSW scheme, a national scheme would be expected to achieve proportionately higher environmental and social outcomes but with a similar levy, because the additional costs are spread over a larger base of sales, with potentially greater economies of scale and scope.

Conclusions and recommendations

The Economic Modelling assessed the implications of three regulatory options to address the current problems associated with the stewardship of large household appliances. Overall, the results show that transferring financial responsibility to the industry would require industry to incur an estimated levy of $35 per appliance. However, this is expected to be banded according to appliance category and size.

The size of the levy reflects the cost already being incurred to collect large household appliances at end-of-life. Councils are primarily responsible for incurring this existing cost burden. Due to the already relatively high cost base, options 2 and 3 achieve marginal improvements upon this base at relatively modest uplifts to the estimated levy requirements. While the levy increments in these options are modest, they are expected to provide substantial environmental and social benefits in terms circular economy, GHG emission reduction and employment outcomes.

The current barriers and opportunities to achieving these outcomes appear to be that:

- Only the metal materials are being recovered commercially from large household appliances with plastic and glass going to landfill
- Despite a large proportion of appliances being collected for recycling, the refrigerant gas reclamation rate is very low
  - This means that harmful gases are being leaked at the kerbside or further downstream in the collection and recycling pathway
- High labour costs in Australia are a likely impediment to repair/reuse/refurbishment.

Potential actions that are likely to be effective in addressing these barriers and opportunities include:

- Requiring stewards to collectively provide improved collection/take-back pathways
- Enforceable minimum standards for collectors and recyclers of large household appliances around responsible gas handling and material recovery
- Investment in capacity to process the recovered glass and plastic
- Rebates for degassing
- Delivering education and awareness to consumers
- Introducing mandates to right of repair, providing a legal right for product owners to freely modify and repair products large household appliances
- Better labelling about repairability/durability
- Stimulating the development of markets for spare parts
- Apprenticeship programs in collaboration with government.

These are actions that a common industry program can implement or, in the absence of a scheme, government agencies or regulators through refinements to policy and funding settings. In practice, the most effective approach is likely to be a model that combines a regulated industry stewardship program with government policy and funding. Without a regulatory framework, producers are likely to be reluctant to participate in an industry program due to concerns about free riding and competitive disadvantage. Lack of regulation is therefore a fundamental obstacle to the establishment of an effective product stewardship scheme. As such, the modelling assumes a regulatory approach.

The effects, costs and benefits of these mechanisms should be investigated through future, more detailed and targeted analyses.

1 INTRODUCTION

1.1 Background and report purpose

This report is part of research by the Product Stewardship Centre of Excellence (the Centre), Southern Sydney Regional Organisation of Councils (SSROC) and the NSW Environment Protection Authority (NSW EPA) to investigate stewardship pathways for large household appliances, including whitegoods.

Large household appliances, which include refrigerators, freezers, washing machines, dryers, and dishwashers, contain recoverable material and harmful gases. The existing collection and recovery paths lead to a low base of material and gas recovery. The low base of materials recovery is a barrier to Australia achieving its circular economy goals and the leakage of harmful gases into the atmosphere contributes to global warming from greenhouse gas emissions (GHG), as well as ozone depletion. Moreover, consumers currently do not have significant opportunities to repair, reuse or refurbish large household appliances.

Stewardship approaches are designed to improve the whole-of-life management of products by keeping valuable materials recirculating in the economy in their highest value uses and minimising the environmental impacts of products throughout production, consumption and end-of-life management. Stewardship also involves producers of the products taking ownership of funding and facilitating these outcomes.

The funding and financing of these outcomes is an important consideration for the industry, government and consumers, who all have a role to play in the development of product stewardship schemes. Appropriate funding models balance financial sustainability, cost of living impacts, stability of funding for stewardship outcomes and minimisation of adverse competitive impacts. As such, modelling the funding and financing approaches provides important information for future scheme development activities.

The overall project features several inputs in addition to the economic modelling and includes: key person interviews with relevant stakeholders; roundtable meetings with producers, brands, retailers and service providers; and a desktop review of legislative and regulatory instruments from around the world.

1.2 RPS scope, intended use and limitations

The Centre, SSROC and NSW EPA commissioned RPS to model the high level financial, environmental and social implications of different scheme design options (Economic Model). This report summarises the results of that modelling.

The modelling estimated the net impacts of each option, to inform potential future investigations into how these scenarios could be funded and what their benefits might be.

This report also provides some recommendations on what the observed barriers and opportunities are to improving environmental outcomes, including any potential refinements to policy and funding settings (e.g., degassing rebates, landfill levy waivers, public or private sector funding etc.).

The modelling is intended to provide an evidence-base for future scheme development. The information in this report is designed to inform industry and government on the potential merits of stewardship approaches and their funding implications, including the potential for regulatory, co-regulatory or voluntary product stewardship.

The modelling was performed at a coarse level of detail using several simplifications, which have been documented in this report, to make the modelling feasible. This was sufficient for the intended purposes. However, future modelling should include more detailed assumptions and analyses.

Moreover, the modelling is not a cost-benefit analysis (CBA), regulatory impact assessment or economic impact assessment in alignment with the requirements of government agency policy processes. However, it provides a basis for, and some information to support, such future analyses and processes if required.

2 OPTIONS MODELLED

2.1 Problem definition

The Project aims to address key problems relating to large household appliance whole-of-life impacts in NSW. These include:

- Inconsistent handling of refrigerant gas which, if not managed responsibly, results in harmful gasses being released into the atmosphere, including greenhouse gas (GHG) emissions, chlorofluorocarbons and hydrochlorofluorocarbons
- Council and ratepayers bearing the cost of end-of-life management without being able to directly influence the factors that drive this cost
- Limited material recovery, which is focused primarily on metals, with the glass and plastic being sent to landfill
- Limited opportunities for repair, reuse and refurbishment.

2.2 Scheme objectives

This modelling estimated the financial, environmental and social implications of a number of Scheme options. To identify options to model, RPS first clarified scheme objectives with SSROC and the Centre, which were agreed as the following:

1. Transfer the collection and recycling costs and responsibility to producers, importers and retailers
2. Increasing recycling
3. Increasing material and gas recovery
4. Providing accessibility/convenience of collection
5. Increasing repair/reuse/refurbishment
6. Educating and informing consumers
7. Investing in research & development
8. Providing data transparency and robust governance.

These objectives provided a basis for developing options that are likely to achieve one or more of a subset of these objectives. The modelling estimated the implications of each of these options relative to business as usual (BAU), referred to as the ‘Base Case’.

The following subsections describe the Base Case and the options. Each option assumes a Scheme is implemented and operational for the year 2026-27. The estimated levy for each option is the average levy required to fund Scheme cashflows between 2026-27 and 2031-32 (i.e., over a 5-year period).

2.3 Base Case

The Base Case represents the status quo and what is expected to continue to occur without intervention. In this scenario, the problem statement outlined in Section 2.1 would continue. This would include sub-optimal outcomes in terms of gas and material recovery, limited opportunities for repair/reuse/refurbishment and councils bearing the costs of end-of-life management with no direct influence on whole-of-life management.

In the Base Case, the following barriers limit improved stewardship outcomes:

- Only the metal materials are being recovered commercially from large household appliances with plastic and glass going to landfill
- Despite a large proportion of appliances being collected for recycling, the refrigerant gas reclamation rate is very low
  - This means that harmful gases are being leaked at the kerbside or further downstream in the collection and recycling pathway

- High labour costs and low availability of spare parts in Australia are likely impediments to repair/reuse/refurbishment.

2.4 Assumed regulatory approach

The modelling of the following options implicitly assumes that the Scheme achieves improved stewardship outcomes through a regulatory product stewardship approach. A regulatory approach involves government introducing regulations and regulatory oversight to ensure the achievement of stewardship outcomes. Such an approach can be co-designed in consultation with industry.[1]

The practical implication of assuming a regulatory approach is that the modelling assumes full participation by industry, in that effectively every brand that imports products into Australia contributes to funding through a levy and that their funding is proportional to the mass of appliances they sell.

A voluntary approach is highly likely to lead to free riding and less than full participation[2]; and stakeholder interviews conducted as part of this Project showed universal support for a regulatory approach due to the issue of free riders. Since a smaller proportion of the industry would contribute to a voluntary approach than a regulatory approach, the funding contribution for participating companies would be higher.

2.5 Option 1 – Move to a common program and producer pays

Option 1 involves moving to a common industry program and transferring the costs of end-of-life management of large household appliances to producers, defined as the brands of large household appliances that are importing these appliances into the Australian market. Option 1 does not include any initiatives to improve recycling, recovery or repair/reuse/refurbishment outcomes. As such, the option addresses the problem of an external party (i.e., local councils and recyclers) bearing the costs of sub-optimal stewardship outcomes but does not address the outcomes themselves.

Nonetheless, transferring cost responsibility is an important first step for stewardship. It creates incentives for the party who puts the subject goods on market and therefore has the ability to improve stewardship outcomes. However, in the absence of specific Scheme objectives to improve stewardship, transferring costs alone is likely to be ineffective.

2.6 Option 2 – Uplift recycling, gas and material recovery

Option 2 expands on Option 1 by uplifting recycling, gas and material recovery. This option assumes that producers directly invest in and/or provide incentives to uplift these outcomes. While the modelling did not include an explicit assumption about the form of these investments/incentives, examples would include:

- A mandated target that is monitored and enforced, which compels industry to achieve these outcomes or incur a penalty cost
- Rebates to Scheme approved collectors and recyclers who can demonstrate verified responsible collection and recycling
- Direct investment in recycling capacity owned by the industry to improve pathways for more costly or difficult to recycle materials, such as problematic plastics
- Buyback of materials or gas reclaimed.

It should be noted that these examples are not mutually exclusive. For example, a mandated target is often complemented by rebates.

The Economic Modelling assumes that Option 2 achieves the following:

[1] Co-regulation is another alternative. Under co-regulation, government and regulators provide the framework and targets for stewardship outcomes, while industry has some flexibility on how to achieve these outcomes.

[2] Free riding refers to the situation where a producer who does not contribute funding benefits from the stewardship outcomes being financially supported by the participating producers, who are contributing funding.

- A 5 per cent increase in appliances collected for recycling between 2026-27 and 2031-32, increasing linearly every year
- An increase in the material recovery rate from 58 to 80 per cent over 5 years
- A 50 per cent reduction in illegal dumping between 2026-27 and 2031-32, reducing linearly every year
- A 50 per cent reduction in gas leakage between 2026-27 and 2031-32, reducing linearly every year
- Recyclers recover glass and plastic as well as the metals, increasing the net material recovery rate from 59 to 84 per cent.

Option 2 addresses key barriers related to gas and material recovery by:

- Requiring stewards to collectively provide improved collection/take-back pathways
- Enforceable minimum standards for collectors and recyclers of large household appliances around responsible gas handling and material recovery
- Investment in capacity to process the recovered glass and plastic
- Rebates for degassing and investment in degassing businesses to stimulate competition
- Delivering education and awareness to consumers.

2.7 Option 3 – Option 2 with uplift repair/reuse/refurbishment

Option 3 expands on Option 2 by also uplifting repair/reuse/refurbishment outcomes. As with Option 2, the modelling did not include an explicit assumption about how the Scheme would achieve this. However, the same examples are likely to be effective here, such as mandated targets, rebates and direct investment.

The Economic Modelling assumes that Option 2 achieves the following:

- 5 per cent of appliances reaching end of first use are either repaired, reused or refurbished by 2030-31, increasing linearly every year
- A 50 per cent reduction in illegal dumping between 2026-27 and 2031-32, reducing linearly every year
- A 50 per cent reduction in gas leakage between 2026-27 and 2031-32, reducing linearly every year
- Recyclers recover glass and plastic as well as the metals, increasing the net material recovery rate from 59 to 80 per cent.

In addition to the initiatives in Option 2, Option 3 addresses key barriers related to repair/reuse/refurbishment, including:

- Introducing mandates to right of repair, providing a legal right for product owners to freely modify and repair large household appliances
- Better labelling about repairability/durability
- Stimulating the development of markets for spare parts
- Apprenticeship programs in collaboration with government.

3 APPROACH

3.1 Definition of large household appliances

The modelling adopts the same definition of large household appliances as adopted by Randell Environmental Consulting (2021).[3] As such, it includes the following applies:

- Dishwashers
- Kitchen equipment (e.g., large furnaces, ovens, cooking equipment)
- Washing Machines (including combined dryers)
- Dryers (wash dryers, centrifuges)
- Household Heating & Ventilation (e.g., hoods, ventilators, space heaters)
- Fridges (including combi-fridges)
- Freezers
- Air Conditioners (household installed and portable)
- Other cooling equipment (e.g., dehumidifiers, heat pump dryers)
- Microwaves (including combined, excl. grills).

As the modelling at this stage is at a high level, the model worked with units of an 'average large appliance'.[4] In practice, this unit represents the average weight, material composition and gas content of a large household appliance. As such, the modelling did not model the pathways and impacts of each individual type of household appliance separately. Future, more detailed, modelling should do this.

3.2 Analytical steps

The modelling was completing using the three analytical steps summarised in Figure 3-1.

Figure 3-1: Key analytical steps

The following subsections describe each of these steps.

Material flows analysis

The first step in the approach to the Economic Modelling is understanding the pathways large household appliances take after they reach end-of-life, including the mass of:

[3] However, the modelling excludes the sub-category of Professional cooling equipment (e.g., large air conditioners, cooling displays), because it relates to appliances that are not used in households.

[4] This modelling adopts a very simple definition of an average large appliance that fits the available data, being one with an average weight, volume and price typical of modern day appliances sold at retailers presently, and with a gas content typical of the sorts of appliances currently collected at end of life. More detailed modelling should consider the effects of differences between modern day and legacy products.

- Appliances collected for recycling
- Appliances sent directly to landfill
- Appliances illegally dumped
- Material recovered from appliances
- Gas reclaimed
- Appliances repaired/reused/refurbished.

The modelling estimated these pathways for each option, as well as the Base Case, and used the assumptions outlined in Section 3.3.

Financial and funding analysis

For the financial aspect, the modelling required assumptions about the incremental net costs and revenues associated with changing these pathways, specifically:

- Diverting more appliances away from recycling in options 2 and 3
- Recovering more material and gas in options 2 and 3, relative to the Base Case
- Reducing illegal dumping in options 2 and 3
- Increasing the number of appliances repaired/reused/refurbished in Option 3.

This aspect of the modelling also required estimating the funding requirements to provide sufficient cashflow to fund and finance these outcomes. The funding was estimated as a levy, expressed as $ per tonne and $ per appliance.

Environmental and social impacts analysis

The improvement of stewardship outcomes is also expected to deliver environmental and social benefits, including:

- A reduction in material going to landfill
- A reduction in GHG emissions and ozone depleting substances
- Job creation, as recycling and repair/reuse/refurbishment has a higher employment density compared to landfill.

This report includes a quantitative and qualitative assessment of these outcomes, using the assumptions outlined in Section 3.3.

3.3 Key assumptions

Table 3-1 outlines the key assumptions used by the modelling.

Table 3-1: Funding model cost assumptions

General parameters		
Consumer inflation	2.5%	• Mid-range of Reserve Bank of Australia (RBA) target band
Material stocks and flows		
Sales of household appliances in NSW (2024-25)	1,950,615 appliances 29,845 tonnes	• Randell Environmental Consulting (2021) estimate for Australia • Factored by NSW proportion of Australian population (31%)
Sales growth (CAGR)	1.8%	• Derived from Randell Environmental Consulting (2021)
Weight of household appliances reaching EOL (2024-25)	9.8kg per capita	• Derived from Randell Environmental Consulting (2021)
Waste generation growth	1.8%	• Proportionate to sales
Baseline collection for recycling rate	90%	• Bontinck (2021)
Baseline repair/reuse/refurbishment	Negligible	• Stakeholder consultation
Baseline illegal dumping	1% of waste generated	• Derived from Randell Environmental Consulting (2021)
Refrigerant gas reclaim rate	21%	• Combining estimates from BRODRIBB ET AL. (2024) on size of refrigerant bank, release rate based on waste generation rate (see above), and rate of reclamation of gas by Refrigerant Reclaim Australia (RRA) also from BRODRIBB ET AL. (2024)
Baseline materials recovered	Ferrous and non-ferrous metals only, residual sent to landfill	• Stakeholder consultation
Collection and recycling costs		
Collection costs	$400 per tonne	• Calculated based on commercial day rates for truck hire and 2-person collection team, and the assumed items and average weight of items collected in a day in a metro area[1] • Benchmarked against overall kerbside hard rubbish collection cost estimated by Chambers (2007), inflated to today's prices, recognising that these are likely to be lower due to an aggregated pick-up model • Further benchmarked against quoted take-back prices,[2] recognising that these are less relevant as they are part of a broader service provided by brands
Degassing costs	~$400 per tonne	• Stakeholder consultation
Processing cost	~$270 per tonne	• Stakeholder consultation • Based on weight delivered to weighbridge
Net cost of recovering additional glass	$250 per tonne	• Based on approximate cost of co-mingled material sorting from prior RPS models and an assumed nil ($0 per tonne) value of the recovered glass due to relatively low quality

Net cost of recovering additional plastics	$700 per tonne	• Based on approximate cost of using advanced recycling methods (e.g., plastics-to-oil) from prior RPS models for problematic plastics that do not have an established processing pathway in Australia
Illegal dumping costs		
Cost to clean up illegal dumping	$1,050 per tonne	• Synergies Economic Consulting (2014), inflated to today's prices
Repair/reuse/refurbishment costs		•
Net cost per tonne to repair/reuse/refurbish	$1,467 per tonne ($110 per appliance)	• Calculated based on international data on the viability of e-waste refurbishment business model costs and profitability • Key assumptions: – Refurbished appliances sell for between ~15-50% of a new unit's price[3] – The international experience shows that refurbishment models for white goods can be viable, particularly if operated as a social enterprise (Lechner and Reiman, 2015) – However, refurbishment is a labour-intensive process with approximately two-thirds of the cost being labour (ibid) – Australia has significantly higher wages by global standards, approximately 50% higher than Europe – A similar business model in Australia would be expected to incur a loss of ~$110 per appliance, factoring in take-back costs and the wage premium
Environmental and social benefits		
Emissions embodied in large household appliances and temperature exchange equipment (Abated through repair/reuse/refurbishment)	7.9 tCO2-e per tonne	• Derived from Bontinck (2019) • Repair/reuse/refurbishment leads to the avoidance of these emissions as it displaces new product manufacture
Emissions abatement by diverting from landfill to recycling	2.0 tCO2-e per tonne	• Derived from Bontinck (2019)
Landfill airspace depletion avoided	7.6 m^3/tonne	• Based on assumed average appliance volume of 0.5 m^3 and average weight of 66kg calculated based on Randell Environmental Consulting (2021)
Job uplift from repair/reuse/refurbishment	100 FTE/tonne processed	• Derived from O'Connell (2013); US EPA (2002) • Noting that this is a labour-intensive process
Job uplift from recycling	30 FTE/tonne processed	• Derived from O'Connell (2013); US EPA (2002)

[1] Regional and rural collections are likely to have a higher cost

[2] https://www.miele.com.au/domestic/disposal-of-old-appliances-669.htm

[3] https://www.greengooding.com/blog/what-is-the-price-difference-between-refurbished-and-new

4 RESULTS

4.1 Key results

Table 4-1 summarises the key results of the Economic Modelling.

Table 4-1: Key results

	Unit	Option 1	Option 2	Option 3
		Transfer costs to producers	Uplift material & gas	Uplift incl. repair
Diversion and material recovery (by Year 5)				
Collection for recycling/repair	%	90%	95%	95%
Net material recovery rate from recycling	%	59%	84%	80%
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GHG emissions reduced[1]	tCO_2-e/yr	0	3,872	3,901
Financial implications				
Scheme levy (per average household appliance)	$/appliance[2]	$36.60	$47.84	$49.02
Percentage of retail price	%[2]	2.58%	3.37%	3.45%

[1] Including through recycling, avoiding the emissions embedded in materials recovery, as well as repair/reuse/refurbishment, avoiding the embodied emissions in new product manufacture

[2] The modelling is based on an 'average large appliance', with an average weight of 65kg and costing $1,256 ex GST

[3] Although the results show the same estimated landfill diversion outcomes for Option 2 and Option 3, the latter is expected to deliver greater long-term diversion outcomes. The current modelling does not capture these long-term effects and focuses on the first 5 years of the Scheme.

[4] These jobs would be distributed across Australia. Jobs would be predominantly concentrated in manufacturing regions, including in NSW and Victoria.

4.2 Observations

The results show that:

- The cost to the industry to assume financial responsibility for the end-of-life management of large households applies is an estimated $37 per appliance, which is expected to be:
  - Banded according to category/size (e.g., large fridge, small fridge, large washing machine, etc.)
  - Approximately 3% of the retail price
- For an additional $11.14 per appliance levy, Option 2 is estimated to:
  - Significantly lift net material and gas recovery
  - Significantly reduce illegal dumping
  - Provide significant environmental and social benefits in terms of avoided landfill, employment associated with the circular economy and GHG emission reductions
- For a further $1.18 per appliance levy, Option 3 is estimated to:
  - Stimulate a repair/reuse/refurbishment economy
  - Further substantially improve employment within the circular economy.

While these results relate to a NSW scheme, a national scheme would be expected to achieve proportionately higher environmental and social outcomes but with a similar levy, because the additional costs are spread over a larger base of sales, with potentially greater economies of scale and scope.

5 CONCLUSIONS AND RECOMMENDATIONS

The Economic Modelling assessed the implications of three regulatory options to address the current problems associated with the stewardship of large household appliances. Overall, the results show that transferring financial responsibility to the industry would require industry to incur an estimated levy of $35 per appliance. However, this is expected to be banded according to appliance category and size.

The size of the levy reflects the cost already being incurred to collect large household appliances at end-of-life. Councils are primarily responsible for incurring this existing cost burden. Due to the already relatively high cost base, options 2 and 3 achieve marginal improvements upon this base at relatively modest uplifts to the estimated levy requirements. While the levy increments in these options are modest, they are expected to provide substantial environmental and social benefits in terms circular economy, GHG emission reduction and employment outcomes. For example:

- For an additional $11.14 per appliance levy, Option 2 is estimated to:
  - Lift net material and gas recovery from 50 (in Option 1) to 84 per cent by Year 5
  - Reduce illegal dumping from 804 (in Option 1) to 402 tonnes by Year 5
  - Reduce GHG emission by 3,872 tCO_2-e per year by Year 5
  - Create incremental employment within the circular economy of 149 FTE
- For a further $1.18 per appliance levy, Option 3 is estimated to:
  - Lift net material and gas recovery from 50 (in Option 1) to 80 per cent by Year 5
  - Reduce illegal dumping from 804 (in Option 1) to 402 tonnes by Year 5
  - Reduce GHG emission by 3,901 tCO_2-e per year by Year 5
  - Create incremental employment within the circular economy of 496 FTE.

While these results relate to a NSW scheme, a national scheme would be expected to achieve proportionately higher environmental and social outcomes but with a similar levy, because the additional costs are spread over a larger base of sales, with potentially greater economies of scale and scope.

The current barriers and opportunities to achieving these outcomes appear to be that:

- Only the metal materials are being recovered commercially from large household appliances with plastic and glass going to landfill
- Despite a large proportion of appliances being collected for recycling, the refrigerant gas reclamation rate is very low
  - This means that harmful gases are being leaked at the kerbside or further downstream in the collection and recycling pathway
- High labour costs in Australia are a likely impediment to repair/reuse/refurbishment.

Potential actions that are likely to be effective in addressing these barriers and opportunities include:

- Requiring stewards to collectively provide improved collection/take-back pathways
- Enforceable minimum standards for collectors and recyclers of large household appliances around responsible gas handling and material recovery
- Investment in capacity to process the recovered glass and plastic
- Rebates for degassing
- Delivering education and awareness to consumers
- Introducing mandates to right of repair, providing a legal right for product owners to freely modify and repair products large household appliances
- Better labelling about repairability/durability
- Stimulating the development of markets for spare parts
- Apprenticeship programs in collaboration with government.

These are actions that a common industry program can implement or, in the absence of a scheme, government agencies or regulators through refinements to policy and funding settings. In practice, the most effective approach is likely to be a model that combines a regulated industry stewardship program with government policy and funding. Without a regulatory framework, producers are likely to be reluctant to participate in an industry program due to concerns about free riding and competitive disadvantage. Lack of regulation is therefore a fundamental obstacle to the establishment of an effective product stewardship scheme. As such, the modelling assumes a regulatory approach.

The effects, costs and benefits of these mechanisms should be investigated through future, more detailed and targeted analyses.

REFERENCES

Chambers, D. (2007). *Kerbside Hard Waste Collection: Issues and Opportunities*. Zero Waste SA.

Brodribb, P., McCann, M., Dewerson, G., Franjić, J. and Anderson, G. (2024). *Cold Hard Facts 4*. Report prepared for the Department of Climate Change, Energy, the Environment and Water (DCCEEW). Canberra.

O'Connell, M. W., Hickey, S. W., & Fitzpatrick, C. (2013). Evaluating the sustainability potential of a white goods refurbishment program. *Sustainability Science*, *8*, 529-541.

Bontinck, P. A., Bricout, J., Grant, T., & Legoe, G. (2021). *E-product stewardship in Australia: Evidence report.* Report Prepared for the Commonwealth Department of Agriculture, Water and the Environment (DCCEEW) by Iceni Group and Lifecycles. Sydney, Australia.

Randell Environmental Consulting (2021). *Victorian e-waste material flow analysis*. Report prepared for Sustainability Victoria in associated with Blue Environment.

Synergies Economic Consulting (2014). *Cost-benefit analysis of the implementation of landfill disposal bans in Queensland.*

US EPA (2002). *Resource conservation challenge: campaigning against waste.* EPA 530-F-02-033