A Container Return System for New Zealand

Cost-benefit analysis

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Executive summary

This report presents the findings of an economic cost-benefit analysis (CBA) of a Container Return Scheme (CRS) in New Zealand.

The CBA relies on work completed by a Scheme Design Working Group, including financial modelling commissioned by the Working Group from PwC. That is, we largely take as given the design features, options and operations of a CRS based on expert input. We understand that changes to these factors might be made as further work progresses, but for the purposes of the CBA we did not make independent changes.

A peer review by Sense Partners has been completed, and the results presented reflect feedback given as part of that review. In addition, a commissioned review by NZIER and feedback received from a range of stakeholders has also been incorporated into the analysis, where available evidence allows.

This CBA essentially refreshes a previous CBA completed in 2016/17 for Auckland Council, which found benefits exceeded costs by a factor of around three and society would be better off by $184 million in present value terms, across a ten-year study period.

Relative to the previous work, this analysis extends the study period to 30 years, models two scenarios (i.e. a CRS with and without glass containers) and includes additional effects (e.g. emissions and machine-based return facilities).

Compared to a 'business as usual' situation of no CRS, a CRS that includes glass containers would result in society being better off to the tune of $1,089 million, in present value terms. In that scenario, benefits exceed costs by 49 per cent. Such a 'business as usual' counterfactual necessarily assumes that the existing pattern and volume of recycling and other factors affecting willingness to recycle remain unchanged throughout the study period. This may seem unrealistic but is the most tractable approach given our lack of knowledge around the future, particularly over a 30-year period. To attempt to predict likely outcomes in that time effectively reflects 'the pretence of knowledge' which can lead to less useful and potentially incorrect results.

The central estimate of the largest categories of benefits (welfare gain from reduced litter and increased recycling) is the average of two willingness to pay studies representing the midpoint of the two studies' results. Using only the lower of these two estimates would result in $73 million net benefit and applying only the higher estimate results in $2,105 million net benefit for the glass-in scenario. While acknowledging the large spread in estimated benefits and the well-rehearsed caveats around results using such estimating approaches, the studies represent the best available – though not perfect – information. We present the midpoint results with a range in brackets.

If glass containers were removed from the CRS design, society is made better off from introducing a CRS by $68 million and benefits exceed costs by 6 per cent. The glass-out willingness to pay benefit estimates range from a net loss of $60 million to a net benefit of $196 million for the glass-out scenario.

These results are largely robust to changes in the discount rate applied and the time period. However, the results for the glass-out scenario go from net positive to net negative when a 10-year study period is used due to the time profile of costs and benefits.

However, results are sensitive to the type of metric chosen to measure the litter, with item count causing the Benefit Cost Ratio (BCR) to decrease to 0.92 and increase to 1.97 if weight is used rather than the average of weight, item count and volume reported in the central scenario.

The glass-out scenario is also net negative when a 10 cent deposit level assumes lower household participation and litter reduction rates.

	Glass-in scenario	Glass-out scenario
Total benefits ($m, PV)	$3,316 ($2,300 to $4,332)	$1,258 ($1,130 to $1,386)
Total costs ($m, PV)	$2,227	$1,190
Net benefits ($m, PV)	$1,089 ($73 to $2,105)	$68 (-$60 to $198)
Benefit-cost ratio	1.49 (1.03 to 1.94)	1.06 (0.95 to 1.16)

While the cost and benefit categories were broadly consistent between this CBA and the previous 2016/17 work, some clear differences emerged as a result of better information, especially on the cost side. In particular:

- Operating costs are over six times higher than those estimated previously
- Scheme administration (i.e. Managing Agency) costs are around 15 times higher than those estimated previously
- Benefits from welfare gains to households due to less litter were proportionally about the same in both studies, but in absolute terms were considerably higher than previously estimated (i.e. all benefits grew at about the same rate as a result of growth in household numbers despite the inclusion of additional values that were not previously included)
- Benefits from welfare gains to households due to additional recycling were higher in absolute and relative terms, due to the inclusion of additional information on household willingness-to-pay
- The benefit associated with higher value recycled material due to a CRS is much lower in the current study, largely due to lower prices as well as the costs of exporting materials, which were not included previously.

The new information available for this study has led to more confidence in the robustness of cost and benefit estimates, but the results of the CBA should be seen as a further step in what is ultimately a journey to precise estimation.

As further information surfaces and key design features are settled (e.g. return facilities) additional updating of the results of this study will allow progress towards a 'true' estimate of the economic costs and benefits. Areas where there are existing gaps or where further exploration is likely to be useful are:

- Material flows
- Commercial arrangements, responses and costs
- The volume and composition of litter

- Return facility capacity, cost and operations. We have a possible source of data to use but need to establish the extent to which the data can be used, given its commercial sensitivity. In addition, we have developed alternatives to the 'lease' model used, but only to a rudimentary level.
- Possible household behaviour.

Introduction and background

CRS's have a range of objectives, meaning precise problem definition is elusive

Cost-benefit analysis (CBA) is usually motivated by a problem statement. While there is no single problem that CRS's are developed to address, a high-level problem statement relevant for this analysis is as follows:

A mismatch between private costs and social costs of disposal and recycling leads to excessive amounts of beverage containers being disposed into landfill or discarded as litter.

We acknowledge that the expression of the problem a CRS (as designed) could address is part of the wider policy development and consideration process, but we include a problem statement here for clarity and completeness.

This analysis follows previous work

In 2016, Auckland Council commissioned us to prepare a CBA of a proposed Container Deposit Scheme (CDS). Data from Auckland Council were combined with specialist advice and extrapolated to the national situation. The CDS modelled was 'generic' in nature, with a range of assumptions applied for tractability reasons.

The 2016 CBA indicated that society would be better off from the introduction of a CDS, relative to the status quo of no CDS. Benefits exceeded costs by a factor of around three, meaning society was better off by $184 million in present value terms, across the 10-year study period.

Subsequently, in September 2019 funding was provided by the Waste Minimisation Fund to *Design a Container Return Scheme for New Zealand* in particular, and a Working Group was put together to advise on scheme:

- design
- management
- governance
- financial implications.

A CBA of the resulting scheme, referred to as a Container Return Scheme (CRS), was part of the work programme of the Working Group. This report summarises the results of the CBA.

The work 'refreshes' rather than recreates the previous work...

This analysis updates the earlier study. The same basic benefit categories are used, while costs now include those related to carbon emissions. Similarly, the economic effects of introducing the CRS are measured against a counterfactual of no CRS, just like the previous analysis.

Where the two studies differ is the extent to which information is available on the factors summarised immediately above. In addition, more detailed and accurate information is available on consumption of containers and predicted recycling rates/volumes.

We proceed on the basis that readers are familiar with what a CRS is and have had considered relevant material produced by the Working Group and the consultants who assisted the group.

...and is informed by peer review

The CBA was peer reviewed by respected economics consultancy Sense Partners as part of the update process. The peer review identified three major areas where improvement is possible:

- a clearer specification of the problems a CRS would address and consideration of a broader range of options for addressing problems
- wider sensitivity testing of results
- more detailed analysis of litter reduction.

In addition, the peer review highlighted a calculation error where the benefit estimation for litter reduction and increased recycling components was understated, as well as other relatively minor issues that were either presentational in nature or questions of clarity.

As a result of the peer review, we:

- included a high-level problem statement (above)
- corrected the benefit calculation error, which meant that net benefits and the benefit-cost-ratio improved
- undertook additional sensitivity analysis, where the change with the most effect was for the assumed deposit level (modelled through changes to participation rates).

The suggested improvements relating to more detailed analysis of litter volumes and reduction (through a more dynamic rather than static approach) and greater options analysis were useful but were not addressed in this updated report.

In the case of litter volumes, we believe that the current treatment is sufficient and adequately represents a potential change relative to a 'status quo' or 'business as usual' scenario. While we agree that the possible use of a stock and flow approach could be beneficial, our assessment is that the degree of difficulty in accurately specifying relevant parameters would not necessarily result in more precise or realistic estimates of effect, even if time was available.

In respect of greater option identification, we consider this to be a question best dealt with through other avenues in the CRS examination process. That is, this is more a scope issue than an analytical one. We were asked to consider only the CRS option, as described by the Working Group. The underlying question of whether there are alternatives to a CRS to address the problems/achieve the objectives that might be preferred to a CRS (as designed) is a good question. However, it is not a question we were asked to answer in this analysis. To the extent that other options are feasible and are subject to the same set of criteria (e.g. objectives and principles) as applied in the CRS co-design process, examination of the options in a CBA framework could be useful for decision makers.

In addition, a commissioned review by NZIER and feedback received from a range of stakeholders has also been incorporated into the analysis, where available evidence allows.

What we modelled

Rather than a single scheme design, we were presented with a range of possibilities, each with potentially different cost and benefit implications. For reasons of tractability, we looked to simplify the modelling we undertook, which is described below.

Collection model

We model the capital and operating costs of three components of the Container Return Scheme (CRS):

- Managing Agency (MA) oversees the operation and administration of the scheme
- Material Consolidation Facility (MCF) collects, aggregates and bales returned containers for sale and processing
- Return Facilities (RF), point for consumers to return container for deposit refund.

Costs for the MA and MCFs were provided by the PwC financial model, which we understand may be subject to change. In the absence of information on the costs of the RF, which we recognise would be available during the implementation (procurement) stage of a CRS, we used international evidence. The RF are modelled as mix of Reverse Vending Machines (RVM) and manual facilities that have differing cost structures and capacity. The Working Group (WG) guidance was for a lease model to operate the RVMs, so we took that approach.

Scheme fees

The CRS fee is applied to all beverage containers, paid by the beverage producers and fully passed on to retailers and ultimately consumers. The only relevant aspect for the CBA is the demand response to the price increase, which is modelled as a one-off 6.5 per cent reduction in beverage sales in year one of the scheme. Refer to PwC (2020) financial model for details, which may be subject to change but gave the best guidance at the time of modelling.

Ideally, for an economic CBA, we would use estimates of the price elasticity of demand for different beverages to model the reduction in consumption as a result of a price rise due to the CRS. As indicated in the previous CBA, there are very little data in New Zealand on the relevant elasticities.

In addition, the bundling options available for beverages (particularly alcohol) make it extremely difficult to determine the price impact and consequently the consumption reduction. Moreover, it is not a classical increase in price as such (e.g. from a tax), as consumers have the possibility of recouping the additional payment (although that is not costless). Thus, the somewhat 'blunt' and possibly overstated consumption reduction explained above is used in this analysis.

Material flow changes

As a result of the CRS, beverage containers are diverted from kerbside refuse and recycling collections, and the quantity of beverage containers that become litter is reduced.

Key inputs to determine Business as Usual (BAU) and CRS material volumes and flows were provided by PwC and the WG:

- GS1 container sales data by beverage type and container material are used to establish consumption.
- WasteMINZ and Territorial Local Authority (TLA) data on the beverage container flows by material type in kerbside refuse and recycling collections across the country.
- Container consumption and disposal are modelled to grow at 2.03 per cent annually after the initial drop off of 6.5 per cent in consumption when the CRS is introduced.

The financial modelling assumes an initial total return rate of 60 per cent, increasing to 85 per cent by year five of the CRS. This is also modelled to correspond with an 85 per cent household participation rate once the CRS is fully operational.

In year one we model 60 per cent of kerbside refuse and recycling diverted into the CRS. In year five, when fully implemented, 85 per cent is diverted from kerbside into the CRS, and this rate continues for the modelling period.[1]

Table 1: Change in eligible containers in kerbside recycling and refuse during implementation (tonnes)

Category	**Year one (60% diversion)**				**Year five (85% diversion)**			
	Recycling		Refuse		Recycling		Refuse	
	BAU	CRS	BAU	CRS	BAU	CRS	BAU	CRS
Plastic	24,038	8,990	7,972	2,982	26,050	3,654	8,639	1,212
Liquid paperboard	1,462	547	2,930	1,096	1,585	222	3,175	445
Metal (Aluminium)	3,367	1,259	1,813	678	3,649	512	1,965	276
Glass	143,280	53,587	13,334	4,987	155,273	21,777	14,450	2,027
Total	172,147	64,383	26,049	9,742	186,557	26,165	28,230	3,959

Source: PwC financial model, Sapere analysis.
Note these figures represent the tonnes of eligible containers in the kerbside refuse and recycling streams.

The reduction in litter assumes that half the consumption quantity not accounted for in kerbside collections become litter and the other half goes to other sources, such as stockpile, commercial, transfer station and other refuse. This assumption is calibrated with litter collection data from Keep New Zealand Beautiful (KNZB).

[1] Note the actual change in volume is greater due to reduce demand from the CRS price being passed onto consumers.

Litter volumes reduce by 61 per cent once the CRS is fully implemented. 60 per cent of this reduction happens in year one and 100 per cent by year five.

Table 2: Change in litter volumes (tonnes)

Category	Year one (60% impact)		Year five (100% impact)	
	BAU	CRS	BAU	CRS
Plastic	1,761	1,042	1,909	692
Liquid paperboard	4,646	2,748	5,035	1,824
Metal (Aluminium)	2,001	1,184	2,169	786
Glass	57,218	33,838	62,007	22,466
Total	65,627	38,811	71,120	25,768

Source: Sapere analysis

A change in commercial (hospitality) volumes is not modelled due to lack of data.

Return rates modelled through assumed household participation rates

We did not assume that the CRS will achieve a set (85 per cent) rate of material recovery, as the details of the system implemented and how consumers react involves a high degree of uncertainty. Data limitations and uncertainty, particularly around commercial flows, mean we did not have visibility over what the assumed diversion would be displacing and thus could not calculate the net impact.

We applied assumptions to the areas where there was the best data, household kerbside collections and litter reduction. We use participation rates to assume the volume of material that is diverted from kerbside refuse and recycling schemes into the CRS. We feel this more conservative approach is appropriate given the inherent uncertainty and nature of supporting data available.

Table 3: Material inputs (tonnes) CRS and BAU

	Year one BAU	Year one CRS	Year five BAU	Year five CRS
Plastic	35,533	33,223	38,507	36,004
Liquid paperboard	13,685	12,795	14,830	13,866
Metal	9,183	8,586	9,952	9,305
Glass	271,050	253,431	293,738	274,645
Total material input	329,450	308,036	357,027	333,820

Source: Sapere analysis, PwC 2020 financial model. Note the base FY 2019 figures have been inflated by 2.03% for four years to get the year one figures as per PwC model inputs. The CRS flow represent the one off reduction in demand of -6.5%.

Table 4: Recovery of material flows CRS and BAU

	Year one BAU	Year one CRS	Year five BAU	Year five CRS
Total kerbside recycling	172,147	96,574	186,557	26,165
CRS recycling transferred from kerbside recycling	-	64,383	-	148,266
CRS recycling transferred from kerbside refuse	-	9,742	-	22,436
CRS recycling from litter	-	22,550	-	40,730
Total recovery	172,147	193,250	186,557	237,596
Total material input	329,450	308,036	357,027	333,820
Recovery rates	52%	63%	52%	71%

Source: Sapere analysis, PwC 2020 financial model

The table above captures only the flows where we have sufficient data to model changes brought about by the CRS. Modelling assumes a change in household participation rates transfers containers from kerbside collections into the CRS and international evidence on litter reduction from similar schemes also transfers from litter into the CRS. That is the table is restricted to the diversion of eligible containers from kerbside collections and from a reduction in litter. Due to unavailability of data and lack of a broader understanding of the 'journey' of commercial beverage containers, commercial flows are not able to be modelled and are therefore not included in the analysis.

Relevant costs and benefits

This analysis includes some costs and benefits that weren't considered previously and accounts for growth in households over time

The categories of costs and benefits included in this analysis are summarised in Table 5. Those cost or benefit categories marked with an asterisk were not included in the previous CBA.

A key difference between the previous analysis and this updated analysis is that the current exercise grows the number of households in line with historical trends into the future. The previous analysis made no such adjustment. The effect of this adjustment is to increase both costs (associated with household participation) but also benefits (associated with household willingness-to-pay for litter reduction and additional recycling).

Employment effects are not included, but are a qualitative feature of a CRS

In common with other proposals of this nature, claims are often made that employment opportunities arise from a CRS and that these opportunities are a benefit that should be included in any economic CBA. In general, economic CBA does not directly or explicitly include employment effects. This is the position that was taken in the previous CBA.

The opportunity cost of labour employed (i.e. the going wage rate) is implicitly included as part of the various cost elements while any beneficial effect that arises from the deployment of labour to produce goods or services would be captured in terms of the outputs of that labour process (e.g. in the scale of additional recycling, or reduced litter).

The rationale behind excluding employment effects is that labour resources used to undertake activities associated with a CRS would (or could) have been deployed elsewhere in the economy and is therefore a resource transfer rather than resource creation. However, where there is unemployment in the relevant catchment or for the relevant skill area, it is possible that the opportunity cost of labour employed could be low (perhaps even zero). [2]

In such cases the impact of employment could be viewed as positive (i.e. the output produced comes at very low or no cost). There may also be fiscal benefits if the labour that is to be used was previously receiving transfer payments from the government but would no longer do so following a CRS.

[2] The Treasury (2015) *"Guide to Social Cost Benefit Analysis."* p.17.

Lack of available data and the transfer nature of employment effects (i.e. labour deployed as part of a CRS would likely have been deployed elsewhere in the economy) means we do not include employment effects in the analysis.

We note, however, that the benefits associated with employment may be broader than just the market wage, with such "externalities" thought to include better civic engagement, enhanced social interactions and overall gains in self-esteem/well-being. Furthermore, in an environment where employment protection is paramount among government goals as a result of the COVID-19 pandemic, the extent to which a CRS is able to preserve employment that might otherwise have disappeared is positive economically, even if such effects are not amenable to inclusion in a CBA.

Measuring consumer welfare with willingness to pay

The major non-market benefit category relates to consumer welfare (see Table 5). In particular, people may perceive and value the aesthetics of cleaner public places due to less (beverage container) litter now and into the future (i.e. "bequest" benefits for future generations from less visible litter and litter going to landfill).

Two studies that sought to quantify/monetise such amenity benefits have been frequently cited in analysis of CRS[3] and other waste management projects.[4] PwC (2010) is an Australian study and Wardman et al., (2011) a similar United Kingdom based study. The PwC (2010) study also quantifies the value of increased recycling, as does the New Zealand based Covec (2007) study on willingness to pay for increased recycling.

Willingness-to-pay surveys have been accused of producing over-stated benefits, as respondents may not fully understand the context of the question. Perhaps more importantly, respondents can claim values that are greater than what they would actually pay as they don't believe there is a strong possibility that they will be faced with having to pay.

In the context of litter reduction, a particular question is whether the willingness to pay is predicated on the mechanism used to bring about the change in question. In particular, is adequate consideration given to the cost-effectiveness of particular options to reduce litter? Covec (2016) suggests that amenity values should only be included in analysis if a CRS is the most cost-effective policy to reduce litter and increase public space amenity and that further work should be done on optimal litter reduction measures.

While we agree further research would be helpful, we also acknowledge that analyses of this type often take place in an information-poor environment, and judgment is required. In other words, it is very rare for a CBA to take place with perfect information or complete certainty. Reliance on the best available evidence will always be required, and we believe that this is the case here. In addition, the objective of a CBA is to determine the extent to which society is made better off (if at all) as a result of

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[3] (NSW EPA, 2017) (Government of Western Australia, 2018) (ACT Government, 2018)

[4] such as Perry, Varua, & Hewitson, (2018)

a policy proposal, rather than to necessarily determine the least cost method of achieving a particular goal.

A further question that has been raised in relation to the type of direct consumer benefits under study here is whether they are additional to the other benefits. Covec (2007) questioned whether there is a benefit that households are receiving that is not accounted for elsewhere. Their view was that there is, and that including the consumer surplus (the difference between their willingness to pay and current costs of litter reduction) can be added to other avoided cost-related benefits.

We consider increased recycling benefits to be additional to those in respect of litter reduction, as we interpret litter reduction as relating to visual amenity (i.e. the presence of litter), while recycling is what happens to relevant litter once it is cleared (i.e. the appropriate disposal of beverage containers).

Table 5: Overview of costs and benefits

	Description	Calculation used	Source
Costs			
Household participation	Costs incurred by households for activity related to the CRS	Time required multiplied by time cost multiplied by proportion of participating households	NZTA Economic Evaluation Manual, Author's estimates
Infrastructure-capital	Asset costs for processing and collecting containers for MCFs	Estimated market cost of assets	SDWG, PwC (2020), Author's estimates
Infrastructure-operating	Transport, administration, handling and processing/staff costs for MCFs, collection facilities and Managing Agency	Cost per tonne for transport and handling Annual estimated labour and other costs	PwC (2020), Auckland Council
Labelling*	Costs to display information on containers, potentially including bar codes and value of refund	One-off cost based on product lines and daily cost for four days' work by design company	Hogg et al (2015), Eunomia
Exporting cost*	Costs associated with sending additional volumes of recyclate matter offshore	Price per tonne, by recyclate matter	PwC (2020)

	Description	Calculation used	Source
Benefits			
Welfare gain from additional recycling	The value households place on additional recycling as a result of a CRS	Willingness to pay per household multiplied by the net change in volumes for the relevant number of households. Updated to today's value and averaged across two sources used.	PwC (2010), Covec (2007)
Welfare gain from less litter	The value households place on the reduction in litter recycling as a result of a CRS	Willingness to pay per household multiplied by the net change in volumes for the relevant number of households. Updated to today's value and averaged across two sources used.	PwC (2010), Wardman et al, (2011)
Lower landfill costs	Avoided costs of landfill due to tonnes diverted from kerbside refuse	Diverted volume multiplied by cost per tonne of landfill	PwC (2020)
Value of material collected	Additional value due to better quality of material	Dollar value per tonne for relevant material type multiplied by respective volume	PwC (2020)

	Description	Calculation used	Source
Reduced litter clean-up costs-market-based	Lower costs of litter clean-up due to reduced volume of litter	Dollar cost per person multiplied by relevant litter reduction	Auckland Council, Author's calculations
Reduced litter clean-up costs-non-market-based	Avoided damage from marine litter and notional value of volunteers	Proportional reduction in litter multiplied by assumed value of time for volunteers; volume of litter reduction times cost of marine litter/tonne. Updated to today's value.	Beaumont et al (2019), NZTA Economic Evaluation Manual, Author's calculations
Reduced contamination	The lower level of contamination in landfills as a result of better quality/less-contaminating material ending up in landfills	Reduction in tonnage multiplied by landfill cost	PwC (2020), Author's estimates
Emissions*	Impact on carbon footprint as a result of CRS. Largest impact stems from replacing virgin material.	Net total of additional emissions from transporting material and reduced emissions from replacing virgin use and landfill emissions (due to paperboard)	NZTA Economic Evaluation Manual, UK Government (for emissions factors)
Lower collection costs	Savings from reduced burden of kerbside collection	Reduction in volume of kerbside refuse and recycling multiplied by cost saving per tonne	PwC (2020), Covec (2016)

* denotes categories not included in previous work

Estimated costs and benefits

This section presents the (quantified) estimates of the costs and benefits of the CRS, as proposed. The estimates are based on the core assumptions contained in Table 6. We highlight that, where value ranges are presented, we use the midpoint for modelling purposes.

Table 6: Core assumptions

Relevant factor	Value	Source
Discount rate	6%	Treasury (2015)
Study period	30 years	Author's estimate
Phase-in period to steady state	5 years	PwC (2020), SDWG
Average annual household growth	0.69%	Statistics New Zealand
Annual change in consumption	2.03%	PwC (2020)
Maximum household participation	85%	PwC (2020), previous estimate of likely participation

Participation costs ($772 million with glass, $417 million without glass)

Beverage containers must be sorted, stored and transported to return facilities. Thus, there are two elements to household participation costs: the additional time needed to sort and return/redeem the containers and the transportation costs to get to the return facility.

Household time ($446 million with glass, $241 million without glass)

As a result of the CRS, households are likely to spend additional to time sort, store and redeem containers. We assume that such trips will often be combined with other trips, such as weekly grocery shopping.

As indicated above, containers can be returned either at a depot, or by RVM. For this analysis, we assume 85 per cent of containers will be returned through RVMs and 15 per cent at depots.

Table 7: Household participation time variables (seconds per week) for RVMs

Weekly components	Low	High	Midpoint
Additional sorting and storing	30	60	45
Walk time	30	60	45
Wait time	10	30	20
Total	70	150	110
Seconds per container	3	5	4

Given the number of containers assumed to be redeemed per household, the figures above translate into households spending just over **two hours per year** participating via RVMs once the CRS is fully up and running, made up of around 1.25 hours per year putting containers into RVMs and 0.79 hours in additional sorting, storing, walking and wait time per year.

In the case of manual return facilities, we assume monthly to quarterly frequency (i.e. eight return trips per household per year). These trips are estimated to take five to 10 minutes per trip. Based on these figures and a test of likely container number thresholds to generate a trip, our best estimate of the time taken by households to use manual collection depots **is one hour per household per year**.

These time estimates are comparable to findings from overseas studies:

- Container deposit redemption time 1.6 minutes for RVM and 10 minutes for other refund points (Government of Western Australia, 2018).
- RVM is equivalent to 1.7 minutes. Return facility 5 minutes per transaction (PwC & WSC, 2011).

We used a household value of time of $10.63 per hour. This value is the same category of time cost used in the previous CBA, adjusted upwards (from $6.90 per hour) by the update factor contained in the NZTA Economic Evaluation Manual (EEM). Reflecting the information we have to hand and the assumption around CRS-dedicated trips being in the minority, the monetary value chosen is the lowest of those contained in the NZTA EEM. In effect, the opportunity cost of households' time is minimal, as sorting would occur at home and the redemption trip is, by and large, already being undertaken and hence does not crowd-out otherwise valuable time.

The present value of total time costs for household participation is estimated at $446 million, for the glass-in scenario and $241 million without glass. Costs for the glass-out scenario are scaled by a factor of 0.54 to reflect volume and weight.

Transport cost ($326 million with glass, $176 million without glass)

We combine vehicle operating costs (calculated by multiplying estimated additional kilometres travelled and cost per km given by Inland Revenue of $0.79) and the extra time travelling, a function of distance and speed multiplied by the NZTA EEM time costs of $10.63 per hour. Table 8 summarises the transport-related costs.

Underlying assumptions are set out further below.

Table 8: Breakdown of household transport costs (PV, $m)

Component	Glass in	Glass out
Vehicle operating costs	$230.3	$124.4
Time in car	$95.9	$51.8

We assume that 10 per cent of trips to both RVMs and manual return facilities are new trips, on the basis that:

- the origin of shopping trips is not always the household, e.g. people may shop on the way home from work
- households are not likely to make a trip for the sole purpose of returning containers unless they have a significant quantity (PwC & WSC, 2011).

Table 9: Distance and frequency assumptions for participation cost estimation

Depot type	Share of returns	Distance (km)	Average speed (km/h)	Time per trip (minutes)	New trips per year	Minutes per year
RVM	85%	5	30	10	2.6	26
Manual	15%	20	50	24	0.8	19

Capital costs ($47 million with glass, $37 million without glass)

Capital costs relate to the assets required for the MCFs only. We assume that two-thirds of assets cost is incurred in year zero and the remainder in year one.

Long-term assets have an asset life of 35 years, and terminal values[5] (of $0.83 million) are netted off capital costs at year 30. Short-term assets are replaced every four years, so costs reappear every four years (see Table 10).

[5] Terminal value refers to the estimated useful life of assets and therefore, when assets have an expected life that exceeds the time period of the analysis some residual value remains, which needs to be accounted for in the

The glass-out scenario represents 80 per cent of the glass-in scenario, to reflect the fixed nature of capital costs.

Table 10: Capital costs for MCF (PV, $m)

Capital costs	Glass in	Glass out	Asset life
Long term assets (balers, conveyors and silos)	$33.4	$26.7	35 years
Short term assets (conveyor belts)	$0.3	$0.2	4 years
Land	$5.7	$4.6	3.6ha at $150m^2
Cages	$8.0	$6.4	35 years

Source: PwC (2020)

Operating costs ($1,376 million with glass, $709 million without glass)

This category of costs is made up of operating expenses for the Managing Agency, MCF and return facilities.

Managing Agency costs total $361 million with glass, $289 million without glass

Table 11 outlines the Managing Agency operating costs for the initial implementation phase and the 'steady state' or ongoing yearly costs for the glass-in scenario.

The glass-out scenario results in costs of $289 million – 80 per cent of full cost due to volume reduction.

Table 11: Managing agency fixed costs (PV, $m)

Year	Zero	One	Ongoing
Admin and support services	-	$10.5	$8.4
Professional services	$8.7	$3.7	$2.2
Marketing and communication	-	$5.3	$4.2
Employee benefits	$0.2	$3.5	$3.5

analysis. In this case, the value of the estimated five remaining years of functional life of the assets are removed from the costs,

Other expenses	$1.6	$6.6	$6.6
Office lease	-	$0.1	$0.1

Source: PwC financial model

Material Consolidation Facilities costs total $512 million with glass and $148 million without glass

The Working Group (and previous work) signalled an intention to make use of existing facilities such as Community Recycling Centres (CRCs) and existing return points for recycling and existing Material Recovery Facilities (MRFs) that could be converted, expanded or contracted for the required services.

Nevertheless, there are still sizeable operating costs, reflecting the incremental volume of material that such facilities would face. There are transport and processing costs, which are based on cost per tonne multiplied by tonnage, as well as staff and utilities costs. Glass crushing costs are also included as we understand that local bottle-to-bottle processing is at capacity and any additional glass returned due to the CRS would need to be crushed.

Table 12 shows that total transport and processing costs are estimated to be $459 million with glass included. These costs reduce to $106 million without glass, due to volume and tonnage impacts. The glass cost per tonne figures are at the high end of ranges considered, possibly overstating true costs of glass transport and processing.

Table 12: Transport and processing costs, including glass

Category	Cost per tonne	Steady-state cost (PV, $m)	30-year cost (PV, $m)
Transport (plastic, metal, liquid paperboard)	$171	$7.0	$106.0
Transport glass	$112	$19.1	$287.8
Glass crushing	$90	$4.3	$64.9

Source: PwC Financial modelling final report July 2020, Sapere analysis

Staff and utilities costs are estimated at $53.6 million, when glass is included. These costs are reduced by 20 per cent for the glass-out scenario to $42 million, based on insights from financial modelling by PwC.

Table 13: Variable costs per MCF (PV, $m)

Category	Annual cost, glass in	Annual cost, glass out
Staff costs	$3.3	$2.6
Utilities costs	$0.6	$0.5

Source: PwC Financial modelling final report July 2020

Return facilities costs total $502 million with glass and $271 million without glass

The costs included in this category are population-based, with one facility for every 12,500 people. Based on a 2019 population of 4.9 million, 393 return facilities are included in the modelling. As indicated earlier, RVMs make up 85 per cent of facilities and the remaining 15 per cent are manual return facilities.

The model has the costs of leasing and maintaining the RVMs fixed, so the cost per container rapidly drops as throughput increases. In year one RVMs cost 4.5 cents per container, while by year five, when the system is fully implemented, the cost per container is 2 cents, and by year 30 the cost has reduced to 1.2 cents per container. The assumption for manual return facilities is a constant 2.3 cents per container.

RVMs are usually considered more efficient for the system. For example, they can reduce collection costs through compacting containers and automatically verify units, further reducing administrative costs (Edwards, Grushack, Elliot, Kelly, & Card, 2019).

The costs for return facilities have been estimated by reference to international evidence, applied to New Zealand with relatively little adaptation. Thus, there is more of a question about the validity of these estimates than is the case for others. We have sought to calibrate the model estimates with CRC financials and material volumes as a check, but doubt around the precision of these estimates remains.

Of note is the possibility of accessing proprietary knowledge on costs, subject to commercial sensitivity being maintained. This has not been included at this stage.

Reverse vending machines costs total $414 million with glass and $223 million without glass, based on the recommended lease model

The space, capital and operating expenses all differ across potentially suitable models. It is likely that a range of models would be used depending on the volumes expected at a return facility.

A lease model is proposed for the RVM return facilities. While there are many iterations that could eventuate, we make simplifying assumptions and rely on international experience to estimate the costs involved.

We estimate, based on publicly available information, lease costs would total $30 million per year. The inputs into that cost estimate follow.

Model specifications important for capital, space and participation costs

The newly launched Tomra R1 model enables over 100 empty beverage containers to be inserted into the machine at one time, meaning the household participation costs could be drastically reduced when compared to a single-feed machine.

The standard T-90 Tomra RVM has two chambers, meaning two machines would be required per location for a CRS including, glass, plastic, liquid paper board and metal cans. Two RVMs would also be required per site when glass is excluded. However, it is likely a model like the T-70 Trisort could be configured to mean only one machine is required in the glass-excluded scenario.

Glass

Including glass considerably reduces throughput capacity of RVMs as glass cannot be compacted, meaning the RVM needs to be emptied more frequently.

Capital cost estimates

In 2015, Zero Waste Scotland estimated that the upfront cost of a RVM would cost £30,000, development of the business case and scheme design resulted in a forecast of approximately 3,000 RVMs required, with upfront capital costs of approximately £60 million (Scottish Government, 2019).

A report prepared for British Glass indicates Tomra RVM model costs range from £19,000 to £25,000 with glass and £17,100 to £22,500 without glass. A lease for a standard model is estimated at £7,190 per year. Assumed functioning life of models ranges from five to seven years (Simpson, 2019).

Cost per machine

We convert to NZD at an exchange of 1.9 and produce a cost per machine range of $36,100 to $47,500 and a lease cost of $13,661 per RVM per year.

2200 RVMs required

The average density of RVMs in Europe is around 1 per 1,900 people. This is deemed appropriated for Scotland based on similar population densities (Hogg, et al., 2015). Using the assumption that 85 per cent of return facilities will be RVM and serve 85 per cent of the population results in an assumption of 2,200 RVMs required. This equates to 6.6 RVMs per return facility.

Without knowledge of the specification of the machines it is hard to determine if these assumptions are appropriate for the volumes of material modelled.

For the glass-out scenario we scale cost to 54 per cent based on the 10 per cent price difference in RVMs and an assumption that only 60 per cent of machines will be needed.

Manual facility costs total $88.6 million with glass and $47.8 million without glass

For manual return facilities, we assume the main costs are staff time, the value of the space required within the business and consumables such as bags and/or tags to link the containers back to a specific business.

We assume an average of these costs 2.7 cents per container, adjusting for income differences and inflation to an average of 2.3 cents per container (see Table 14). The Ontario and Scottish models are designed to encourage more adoption of RVM as this reduces the overall cost of the system, whereas the Australian estimate accounts for increased cost in remote locations.

Table 14: Manual return depot costs cents per container

Cost Element	Ontario (2019)	Scotland (2019)	Australia (2013)
Space Costs	0.264	-	-
Labour Costs	0.378	-	-
Container Costs	0.084	-	-
Total	0.73	1.5	6
PPP conversion	0.62	1.4	4.8

Source: (Edwards, Grushack, Elliot, Kelly, & Card, 2019; Scottish Government, 2019; Masden Jacob, 2013)

Again, we estimate the glass-out scenario costs at 54 per cent of the glass-in equivalent.

Welfare gain from increased recycling is $849 million with glass in and $225 million without glass

The welfare gain to households is proxied by their willingness to pay for additional recycling. This willingness to pay is expressed in terms of weight, which naturally places greater emphasis on glass containers. Hence, the significant differences between the glass-in and glass-out scenarios benefit estimates. We acknowledge that use of a weight measure might mean that some estimates could be mis-stated, but we were unable to source any evidence on which to base willingness-to-pay figures for alternative recycling measures, such as item counts.

Rather than rely on a single measure, we have used two separate studies and derived the estimated benefits using a simple average. The average willingness-to-pay value used in the modelling is $33.14 per household per year for increased recycling.

As indicated above, these studies reflect the best available – rather than ideal – information. Both studies are somewhat dated, and one reflects Australian household values, which can only be translated to New Zealand equivalents imperfectly. Further, the method used to produce values of willingness to pay is known to be subject to questions. Absent a more up-to-date and comprehensively designed study, these values remain the only plausible representation of household values. Setting aside the values due to questions on the actual size of the estimated effects would, in our view, result in a less complete picture of relevant costs and benefits.

The first method produces benefits of $1,331 million with glass and $353 million without glass

The first method, from PwC (2010), estimates households are willing to pay, on average, $2.77 per year for every 1 per cent increase in the weight of waste packaging recycled (PwC, 2010). This is adjusted for income differences and inflation to $2.72 per percentage point increase. The CRS increases the recycling rate by 19 per cent once fully implemented, which translates to households being willing to pay $53 per year for the increase in recycling, with glass included.

Excluding glass sees just a 5 per cent increase in the rate of recycling and, therefore, estimated benefits that are just under a third of the glass-in scenario, at $353 million.

The second method results in benefits of $367 million with glass and $97 million without glass

Covec (2007) used a survey to find that people were willing to pay $1.68/week to recycle paper, plastic and glass, which implied a surplus of $350/tonne (based on 4.8 kg per week). Using the EEM cost update factors to adjust the $6.90 figure used for the value of time to $10.63 per hour resulted in a value per tonne of $373, compared to $242 per tonne used in the previous analysis. This led to a willingness-to-pay figure of $13.50 per household per year and total benefits of $367 million. This method would seem to understate value as it does not include aluminium cans, which will be part of the CRS. Once fully implemented, the CRS increases recycling of beverage containers by 65,000 tonnes per year.

Removing glass reduces the benefit to $97 million, again highlighting the role weight plays in estimation of welfare gains.

Welfare gain from reduced litter is around $2,005 million with glass in and $783 million without glass

The approach to calculating the welfare gain is very similar to that used for estimates of the benefits of additional recycling, utilising willingness-to-pay data and averaging across two separate sources. Like the benefit estimates associated with additional recycling, litter benefits are weight-based. Further, the same caveats identified above in relation to additional recycling apply.

The first step was to estimate the proportion of litter explained by beverage containers. We used the 2019 Keep New Zealand Beautiful (KNZB) national litter audit and then calibrated assumptions on proportion of consumption that becomes litter with the 190,000 tonnes litter that was collected in 2016.

Table 15 indicates that the percentage of litter that beverage containers account for is 24 per cent, while the corresponding share when glass is excluded is 13 per cent. This figure was derived using an average of all the metrics available in the KNZB litter audit including weight, volume and item. [6]

Overseas evidence suggests that litter reduction due to CRS implementation produces an average of 61 per cent less container waste, from a range of 84 per cent to 35 per cent (Bottlebill.org; NSW EPA,

[6] Lids and caps are included as beverage container related litter. While the lids and caps are not directly part of the refund, given the evidence that CRS can reduce total litter supports their inclusion in the litter calculations.

2019; Boomerang Alliance, 2020; West, Angel, Kelman, & Lazarro, 2013). The average litter reduction based on composition and overseas evidence is 14.4 per cent for all containers. When glass containers are excluded, we conservatively use the lower bound, resulting in a 4.4 per cent reduction.

Table 15: Litter reduction due to CRS

Litter reduction	Current beverage container litter	Average (61%)	High (84%)	Low (35%)
Percentage litter from beverage containers	24%	14.4%	19.8%	8.2%
Percentage litter from beverage containers (no glass)	13%	7.8%	10.7%	4.4%
Total litter reduction (stadium effect)		47%	64%	30%

Source: KNZB litter audit 2019, Sapere analysis

While the average figures are slightly above estimated litter reduction from beverage containers in the previous CBA, they may still be understated given the possibility outlined in some of the overseas studies cited above that a CRS would reduce total litter rather than just beverage container litter, possibly due to behavioural biases such as the stadium effect, which we explain further below. We have not included such effects in the core modelling but investigate the impact in sensitivity testing.

Benefits of $1,472 million estimated in one study

An Australian study finds households are willing to pay, on average, $4.15 per one per cent point reduction in litter, or $41.50 per annum for a 10 per cent reduction in litter and $83.00 for a 20 per cent reduction (PwC, 2010). Equating to New Zealand dollar terms and adjusting for income differences and inflation results in a value of $4.08. A 14.4 per cent reduction in litter would result in households being willing to pay $59 per year.

This study has been used in the economic analysis of NSW and Western Australia CDS schemes.

Benefits of $2,538 million estimated in another study

A University of Leeds study for DEFRA found that people were willing to spend £3.95 per month on council tax for a 1 point improvement on a 10 point litter scale. On this basis, it is estimated that each household would be willing to spend an additional £47.40 on council tax per year to achieve a 1 point reduction of litter (Wardman, Bristow, Shires, Chintakayala, & Nellthorp, 2011).

Equating the £47.40 to New Zealand dollar terms, adjusting for income differences and inflation results in a value of $70.38. Translating that effective 10 per cent reduction in litter to the average of

14.4 per cent reduction in New Zealand results in an estimated willingness-to-pay of $102 per household per year for the reduction with glass in and $31 without glass.

Using benefit transfer, Marsden Jacob Associates estimate the willingness to pay using recalibrated study results from the United Kingdom to be between $67.78 and $81.37 per person per year in an Australian context.

Additional value from material recycled is $97 million with or without glass

The calculation process is essentially the same as that used in the previous CBA. The extra CRS material collected for recycling would have an additional market value. In addition, the value of existing collected materials would increase due to reduced cross-contamination (i.e. a CRS produces cleaner material than existing systems).

Table 16 contains the components used in the calculation of benefits. At the 'steady state' of the CRS almost $6.5 million a year in benefits would accrue that otherwise wouldn't.

Glass is not included in calculation as there are costs to crush regardless. Current bottle to bottle recycling is at capacity so increased material is considered a cost to crush rather than a benefit through sales of revenue-generating material. Investment in increased capacity could increase the value of collected glass.

Table 16: Value of CRS materials recovered, PV

Revenue per tonne	$/tonne	Tonnes CRS steady-state	Value, $m per year
Plastic	$315	8,521	$2.7
Liquid paperboard	$10	5,614	$0.06
Metal (Aluminium)	$1,250	2,932	$3.7

Source: PwC financial model

Reduced contamination of kerbside recycling $25.5 million with glass and $4.3 million without glass

Broken glass is a common contaminant. With the 85 per cent reduction in kerbside volumes, a plausible assumption is that the CRS reduces contamination rates at MRFs by half. Current contamination rates are reported to be around 12 per cent. The reduction in volume of contamination is multiplied by a conservative estimate of the landfill cost, $78 per tonne.

The glass-out scenario reduces benefits to $4.3 million.

Kerbside collection costs are $168 million lower with glass and $35 million lower without glass

The CRS reduces collection costs by removing cumbersome, low-value glass and plastic bottles from the waste stream, allowing for better productivity and efficiency in collection. The saving of $60 per tonne estimated by Covec (2016) and used in the previous CBA is multiplied by the difference in volume kerbside refuse and recycling with and without a CRS.

The glass-out scenario reduces these savings to $35 million.

Table 17: Reduction in kerbside collection costs

Category	Tonnes CRS steady-state	Savings $m per year
Change in kerbside refuse glass-in	24,271	$1.5
Change in kerbside recycling glass-in	160,392	$9.6
Total glass in CRS	184,663	$11. 1
Change in kerbside refuse glass-out	11,847	$0.7
Change in kerbside recycling glass-out	26,896	$1.6
Total glass out CRS	38,743	$2.3

Source: Sapere analysis

Avoided landfill costs are $29 million with glass and $14 million without glass

This is a simple calculation where tonnes of kerbside refuse diverted from landfill are multiplied by the $78 tonne landfill cost (see Table 18).

Table 18: Avoided landfill costs

Category	Tonnes CRS steady-state	Saving $m per year
Kerbside refuse diverted glass in	24,271	$1.9
Glass out CRS	11,847	$0.9

Source: Sapere analysis, PwC financial model

Reduced litter clean-up costs are $63.5 million with glass and $20 million without glass

This calculation is merely an update of the benefit estimated in the previous CBA report. Estimated litter clean-up costs in Auckland are in the order of $11 million per annum, which means average annual litter clean-up costs per person of $6.95, which is scaled to the national population.

The saving is reduced to $19.5 million with glass out.

Volunteer time savings are $3.9 million with glass and $1.2 million without glass

Again, this benefit is estimated by updating the value in the previous CBA for the new proportional reduction in litter (14.4 per cent for glass in), translating to hours spent by volunteers and multiplying by the updated NZTA EEM time costs of $10.63 per hour.

For the glass-out scenario the relevant reduction in litter is 4.4 per cent, lowering benefits to $1.2 million.

Avoided marine litter costs are $41 million with and without glass

Recent analysis showed the total economic cost of marine plastic pollution in 2011 is US$3,300 to US$33,000 per tonne in the ocean (Beaumont, et al., 2019). We conservatively use the lower figure and equate to New Zealand dollar terms adjusting for income differences and inflation to arrive at a figure of $4,616 per tonne of plastic. We assume 50 per cent of reduced litter would have entered waterways. This estimate is a more conservative adaptation of available evidence from Jambeck, et al., (2015) suggesting that 1.75 per cent of total production enters the ocean.

The estimated benefit is unaffected by the glass-in or glass-out scenarios, as glass is not responsible for marine plastic pollution.

Reduced emissions result in benefit of $38.5 million with glass and $40.5 million without glass

Greenhouse gas reductions arise from the increase in recycling as a result of the CRS and the reduced volumes going to landfill. This is offset by the increased emissions from transporting additional material to recycling destinations. Due to lack of detailed data we have used a coarse approach relying on the UK Government GHG Conversion Factors for Company Reporting (2018).

Most of the benefit is from increased recycling tonnage replacing virgin material in production. Glass is excluded from this emissions benefit category as local processing is at capacity and additional tonnes are crushed at unknown emissions cost, resulting in benefits increasing to $40.5 million if glass is excluded from the CRS.

Emissions associated with the collection/return, processing and disposal of materials included in the scheme is calculated. We have not been able to include embedded emissions associated with the required infrastructure in this calculation. We assume a cost of carbon $71.19 per tonne, based on NZTA Economic Evaluation Manual (EEM) updated for inflation. We understand this figure is being reviewed and is set to increase in the next update of the EEM.

As the approach is coarse and using emissions factors from a country with different GHG input fundamentals such as electricity generation mix, we have taken a conservative approach whenever a choice is required.

Table 19: Emissions categories ($ millions, 30 year PV 6% discount rate)

Emissions category	Glass in	Glass out
Household transport	$4.6	$2.5
Landfill	-$3.1	-$3.0
Recycling transport	$1.6	$0.4
Virgin material	-$42.2	-$42.2
Export of material	$2.9	$2.9
Decreased consumption	-$2.3	-$1.1
Total	**-$38.5**	**-$40.5**

Note: negative values are a reduction in total emissions compared to status quo and hence represent benefits

Household transport costs of $4.6 million with glass and $2.5 million without glass

We use the emission factor of 0.207kg CO2-e/km for a standard petrol vehicle and model an additional 14 million kilometres in year one and 21 million kilometres in year five once the CRS is in the steady state. These inputs result in costs of $0.3 million in year one and $0.5 million in year five. Costs for the glass-out scenario are scaled by a factor of 0.54 to reflect reduced volume and weight.

Table 20: Additional household travel from CRS

Return depot type	Distance (Km)	Trips per year	New trips	Km/year per household
RVM	5	26	10%	13
Manual	20	8	10%	16

Landfill emissions $3.1 million benefit

We calculate the change in emissions caused by a reduction in material going to landfill and an increase in material going to recyclers.

$$\Delta Emissions = Landfill\ BAU\ emssions - Landfill\ CRS\ emissions + Additional\ recycling\ emissions$$

- Landfill emissions BAU – no reduction in consumption.
- Landfill emissions CRS – consumption reduction, and 85 per cent diversion from refuse stream achieved after five years, 60 per cent in the first year.
- Additional tonnes recycled from litter and refuse – additional transport emissions.

For landfill, the emissions factors in the tables include collection, transportation and landfill emissions ('gate to grave'). Liquid paperboard is assumed to be 88 per cent carboard and 12 per cent plastic and aluminium.

Table 21: Emissions kg CO_2e per tonne

Material	Landfill	Closed-loop	Open-loop
Plastic	9	21.3842	21.3842
Liquid paperboard	1041.9017	21.3842	21.3842
Metal (Aluminium)	9	21.3842	21.3842
Glass	9	21.3842	21.3842

Source: UK Government GHG Conversion Factors for Company Reporting 2018

Increased recycling transport costs of $1.6 million with glass and $0.4 million without glass

For recycling, the transport from a return depot to a materials recovery facility is considered. This is in line with GHG Protocol Guidelines, with subsequent emissions attributed to recycled material production respectively.

Substitution of virgin material results in $42 million benefit

Only the additional recycling tonnages collected by the CRS system and reprocessed results in a net emissions reduction. The per tonne emissions of closed-loop recycling (the carbon saving from replacing virgin materials in production with recycled materials) is only relevant for plastic and aluminium, potentially for glass with expanded infrastructure.

Calculations used closed loop emission even though additional glass likely to be crushed as this method results in the smallest change in emissions.

Table 22: Emissions factors for virgin and recycled material (kg CO2e per tonne)

Material	Primary material production	Closed loop source (CL)	Open-loop source (OL)	Emissions change CL	Emissions change OL
Plastic	3,280	2373.6545	604.3039	906	2675.632533
Liquid paperboard	844	795.4032	-	49.0784	
Metal (Aluminium)	12,874	3012.5707	-	9861.0373	
Glass	895	529	19	366	876

Source: UK Government GHG Conversion Factors for Company Reporting 2018

Export of material cost $3 million

Increased tonnages from refuse and litter are multiplied by the containership average emissions rate 0.01614 kg CO2e per tonne kilometre (UK GHG, 2018). The distance is an average of Asian destinations in Table 20.

Table 23: Export rate of recycled material

Material	Rate	Tonnes once fully implemented
Plastic	90%	8,521
Liquid paperboard	60%	5,614
Metal (Aluminium)	95%	2,932
Glass	0%	47,934

Source: Tranche 1 p.19-23, Sapere analysis

Destination of material is assumed to be an average of the following Asian countries.

Table 24: Destination assumptions

Destination	Nautical miles	Kilometres
Malaysia	5,016	9,290
Vietnam	5,398	9,997
Thailand	5,739	10,629
Indonesia	3,508	6,497
Average	4,915	9,103

Source: sea-distances.org

Decreased consumption benefit of $2 million with glass and $1 million without glass

The CRS price increase is modelled to reduce sales of all beverage containers by 6.5 per cent. This is considered a one-off reduction in year one. We have not attempted to model the loss of consumer surplus from the reduction in consumption, as we do not have sufficient information on the demand curve for beverages. Moreover, at least some of the loss would be made up by consumption of other goods. Finally, we have not sought to model any public or personal health or other effects from reduced consumption of alcohol or sugar beverages, which would also tend to offset any loss of consumer surplus. The inverse with healthy beverages would also need to be considered.

Table 25: Emission reduction from demand response

Material	Tonnes	Emissions factor kgCO2e	CO2 tonnes	Monetised
Plastic	2,310	3,280	7,575	539,293
Liquid paperboard	890	844	661	47,059
Metal (Aluminium)	597	12,874	7,684	547,039
Glass	17,618	895	15,768	1,122,546

Total	21,414	-	31,689	2,255,936

Source: UK Government GHG Conversion Factors for Company Reporting 2018

Qualitative assessment

In addition to the effects outlined above, co-benefits also arise from a CRS. The major co-benefit relates to additional recycling of non-CRS materials as a result of CRS collection depots or hubs becoming a "drop-off" service. The key issue for such analysis was the ability to determine the extent to which whether any non-beverage container recycling that does take place at the "drop-off" was over and above what would have happened in the absence of a CRS.

Support for charitable objectives

Experience in South Australia suggests that voluntary and/or charitable organisations are able to capitalise on a CRS to boost their fundraising activities. Scouts in particular are frequently mentioned as major beneficiaries of a CRS. This can occur either in terms of such organisations establishing collection points or through the redemption of containers that are donated by others or sourced directly. In CBA terms the degree to which people voluntarily donate their containers to charitable organisations is effectively a transfer (i.e. it does not alter the resources available to the economy in any meaningful way). As such, a CBA does not account for such transactions. As discussed in relation to employment, where organisations establish operations to undertake other activities that have financial reward, these undertakings are captured in terms of resources invested (i.e. opportunity costs) and outputs from the activities (i.e. increased recycling and/or avoided costs of landfill). Separate consideration of such impacts would risk double-counting.

There may be some argument that revenue raising through a CRS means that volunteer or charitable organisations are better able to supply services or could reduce their reliance on other fundraising actions. The latter might give rise to the possibility of additional resources being made available to other charities (who might otherwise have given to the organisation who now has CRS-sourced revenue streams). In essence, this series of possibilities also represents wealth transfers from one party to another. To the extent that there is some additional well-being effect from the transfer, it is likely that it would be captured in the willingness-to-pay estimates summarised above. Again, our approach is to recognise the possibility of such effects, but not include such effects in the CBA.

Net impacts

This section compares the benefits to the costs over the study period of 30 years. To be of most use for decision-makers, the estimated costs and benefits are expressed in present value terms, using a discount rate of 6 per cent. A five-year phase-in period is assumed.

Glass-in scenario results in benefits outweighing costs, glass-out scenario result is sensitive to the range of willingness to pay values applied

Table 26 shows that the extent to which society is made better off from the CRS depends on whether glass containers are included or not. The inclusion of glass results in a net benefit to society of around $1,089 million and benefits exceed costs by 49 per cent. The result represents the midpoint of a range of willingness to pay benefits that deliver net benefit between $73 million and $2,105 million, meaning benefits exceed costs by 3 per cent to 94 per cent.

The central scenario of excluding glass means society is likely made better off to the tune of about $68 million and benefits exceed costs by 6 per cent. The range of values for the willingness to pay benefits mean excluding glass from the CRS could result in net costs to society of $60 million or benefits of $198 million.

We reiterate that these results are measured against a ‘business as usual’ scenario where there is no CRS; therefore, excluding glass containers means that no change is assumed in the return rates or methods of collection and disposal than is presently the case.

The relativity between the benefits and costs for the respective glass-in, glass-out scenarios highlights the predominance glass containers have with respect to gains in welfare from reduced litter and additional recycling, which are both calculated on a weight basis.

Total benefits with glass-out are just over 38 per cent of total benefits with glass-in (i.e. glass-in benefits are about 2.6 times glass-out benefits). Meanwhile, total costs with glass-out are just over half of total costs for the glass-in scenario (i.e. glass-in costs are about 1.87 times glass-out costs).

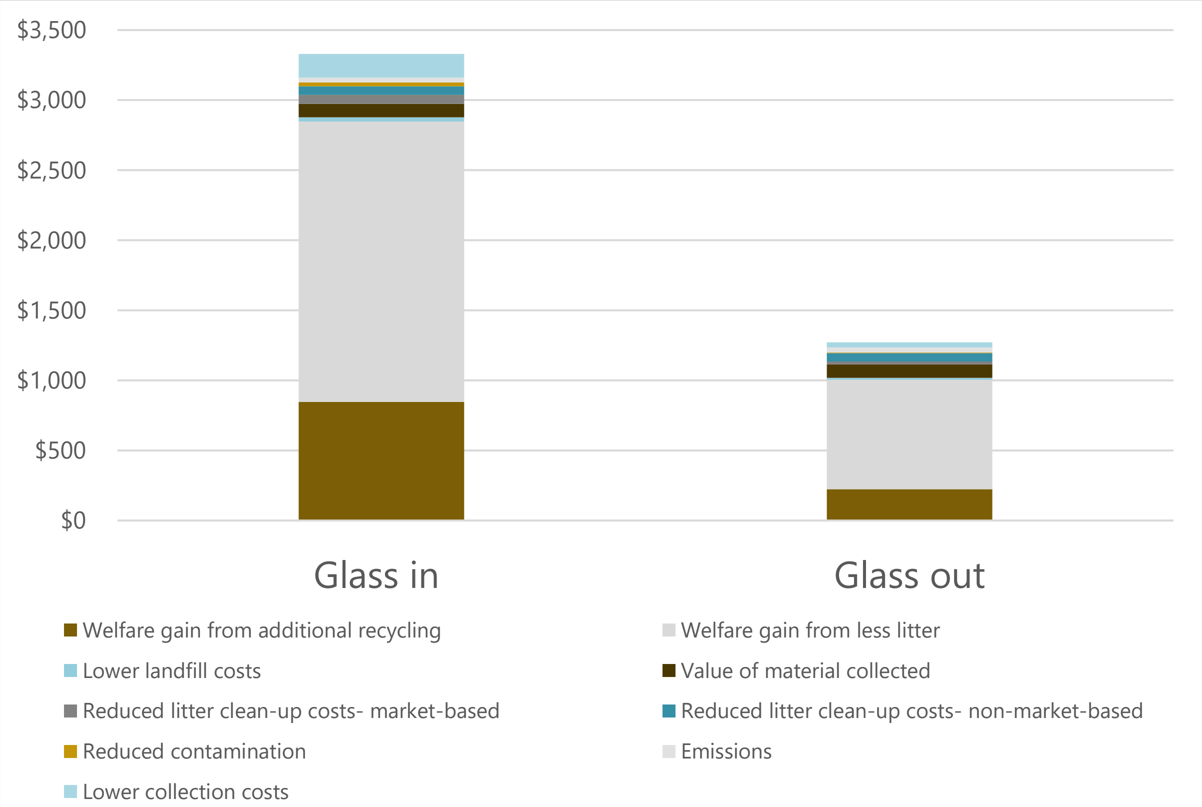
Table 26 Summary CBA results (PV, $m)

	Glass-in scenario	Glass-out scenario
Total benefits	$3,316 ($2,300 to $4,332)	$1,258 ($1,130 to $1,386)
Total costs	$2,227	$1,190
Net benefits	$1,089 ($73 to $2,105)	$68 (-$60 to $198)
Benefit-cost ratio	1.49 (1.03 to 1.94)	1.06 (0.95 to 1.16)

Gains in welfare responsible for 79-85 per cent of total benefits, depending on glass scenario

Figure 1 shows that the major benefit category is the welfare gain to households from a reduction in litter following the introduction of the CRS. On its own, this benefit category accounts for about 60 per cent of the total estimated benefits for the glass-in scenario and 61 per cent in the glass-out scenario. When combined with the welfare gain to households from additional recycling, the welfare gains account for 85 per cent and 79 per cent of total benefits for the respective glass-based scenarios.

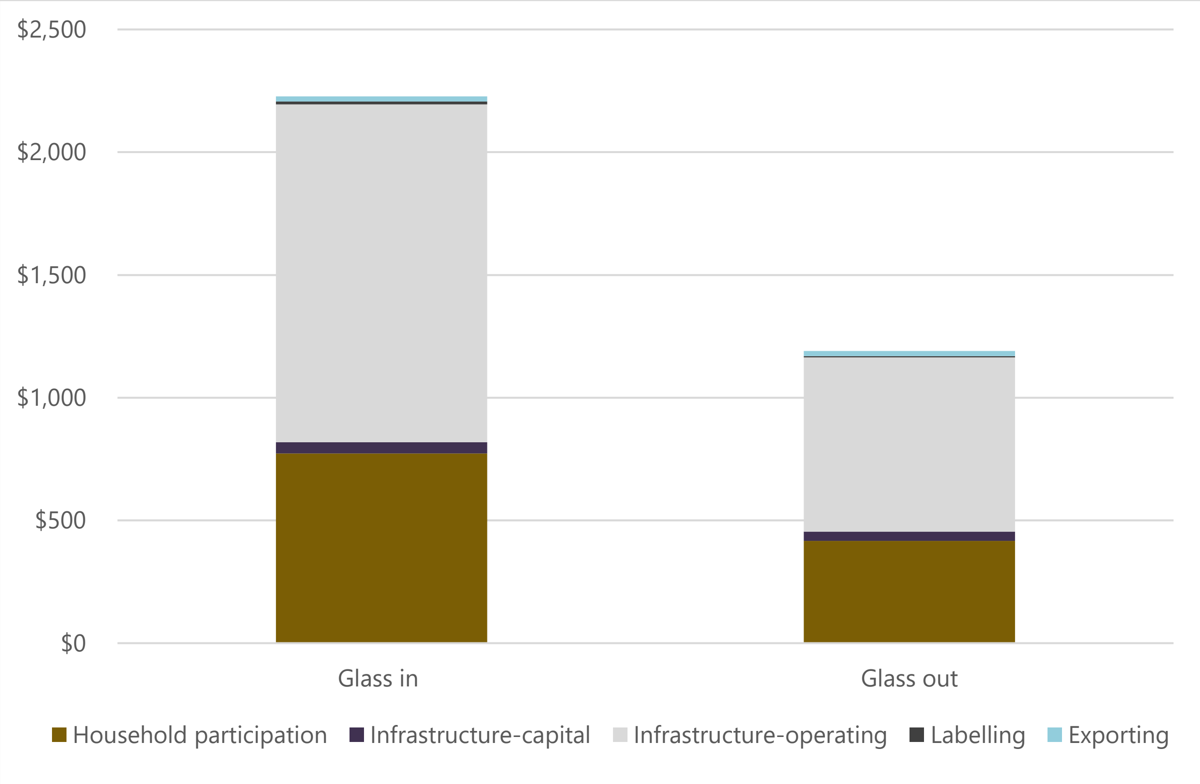
Figure 1: Composition of benefits (PV, $m)



Total costs are dominated by MCF and Collection Facility costs

Figure 2 shows the composition of costs for the glass-in and glass-out scenarios. The lion's share of costs relates to the operations of the MCF and collection depots (around 62 per cent of total costs including glass and 60 per cent when glass is excluded). Household participation costs represent around 35 per cent of total cost in both glass-related scenarios.

Figure 2: Composition of costs (PV, $m)



Basic results mainly robust to sensitivity analysis

We subjected the results above to changes in some key assumptions. While there is an array of possible changes, for simplicity we focus on changes to the:

- analysis time period
- discount rate
- method of measuring litter
- optimum bias
- litter reduction beyond beverage containers
- deposit level
- weight-based factors driving key benefit estimates.

We present effects on the benefit-cost ratios (BCRs) but can report additional values, if required.

Timing and discount rate changes

The following two tables outline the effect of separate changes to the relevant parameters. The effect of shortening the study period is to lower the BCR, while the opposite effect is observed for reducing the discount rate.

Both changes are largely immaterial. This is not surprising given the ongoing nature of both benefits and costs. That is, rather than being a capital-heavy undertaking with significant costs incurred close to inception and then falling away until asset renewal is required, the majority of costs are operational in nature and continue to be incurred over time, much like benefits which continue to accrue across time. Thus, any differential that might be brought about through the effect of timing and discounting is effectively nullified.

The one exception is the glass-out scenario in a 10-year study period, where the BCR is below one (indicating society is made worse off as a result of a glass-out CRS).

Table 27 Benefit-cost ratios for alternative time periods

Period	Glass in	Glass out
10 years	1.40	0.96
20 years	1.47	1.04
30 years	1.49	1.06
40 years	1.50	1.07
50 years	1.50	1.08

Table 28 Benefit-cost ratios for alternative discount rates

Discount rate	Glass in	Glass out
2%	1.52	1.10
4%	1.51	1.08
6%	1.49	1.06
8%	1.47	1.04
10%	1.45	1.01

BCR sensitive to litter metric used

Using the average beverage container litter reduction reported from jurisdictions with a CRS we investigate the relative impact of the chosen litter metric and associated willingness to pay for reductions The results of the sensitivity test are reported in Table 29, showing that if item count is used then the BCR dips below 1, meaning that the costs of a CRS outweigh the benefits. If weight is used as the metric to measure litter the BCR approaches 2, meaning benefits are almost twice the costs of the CRS. Our preferred average measure represents a practical middle ground.

Table 29: Willingness to Pay litter reduction benefit with different metrics and studies (glass in)

Litter metric	(PwC, 2010)		Wardman et al., (2011)		Average	
	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR
Average	$1,472	1.25	$2,538	1.73	$2,005	1.49
Item	$544	0.83	$938	1.01	$741	0.92
Weight	$2,265	1.61	$3,905	2.34	$3,085	1.97
Volume	$1,606	1.31	$2,769	1.83	$2,188	1.57

Litter can be measured with a variety of metrics ultimately; we could not determine the best litter metric to use as:

- weight places emphasis on heavier material.
- item count places more emphasis on small pieces of litter that may not be as noticeable.
- volume would place more emphasis on larger bulky containers.

Table 30: KNZB litter audit results

	Item count	Weight	Average volume	Average
Percent litter	9%	36%	26%	24%
Percent litter (glass out)	8%	10%	20%	13%

Source: KNZB litter audit 2019

Table 31: Total litter reduction by different metrics

Beverage litter reduction	Materials	Item	Weight	Volume	Average
Low (35%)	Glass in	3.1%	12.7%	9.0%	8.3%
	Glass out	2.8%	3.6%	7.0%	4.5%
Average (61%)	Glass in	5.3%	22.2%	15.8%	14.5%
	Glass out	4.9%	6.3%	12.3%	7.8%
High (84%)	Glass in	7.3%	30.5%	21.6%	19.8%
	Glass out	6.7%	8.6%	16.8%	10.7%

Stadium effect increases BCR

A simpler approach would be to apply the total litter reduction reported in jurisdictions with CRS in a blanket fashion. The reduction ranges from 30 per cent to 64 per cent, with an average of 47 per cent reported and could be associated with a "stadium effect".[7] The results for the glass-in scenario are presented in Table 32. The 30 per cent litter reduction using the PwC (2010) study results in households' willingness to pay of $122 per year for the litter reduction.

Table 32: CRS induced total litter reduction

Total litter reduction	(PwC, 2010)		Wardman et al., (2011)		Average	
	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR
30%	$3,055	1.96	$5,267	2.95	$4,161	2.46
47%	$4,786	2.74	$8,251	4.29	$6,519	3.52
64%	$6,517	3.51	$11,236	5.63	$8,877	4.57

Glass in analysis robust to recycling willingness to pay study applied

The availability of relevant studies of willingness to pay is extremely limited. We have found two studies and one is based on Australian households' willingness to pay. Arguably, the results of the Australian study could be ignored. We would support such an approach if a number of other relevant studies were available to draw from, but that is not the case. In our view, two data points are preferable to a single source, notwithstanding potential issues with the transfer of benefits from other jurisdictions. Table 33 shows the analysis is robust to either method for glass-in, with the biggest impact in the glass-in scenario due to the emphasis the use of weight puts on glass. The glass-out scenario results in a net cost to society if only the Covec (2007) study is applied.

Table 33: Recycling willingness to pay

	(PwC, 2010)		(Covec, 2007)		Average	
	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR
Glass in	$1,331	1.71	$366	1.27	$849	1.49

[7] Packaging Forum spokeswoman Lyn Mayes recognizes that when people see litter they could feel licensed to litter too. Meaning less littering of one type leads to less littering of all types known as a "stadium effect" (Woolf, 2018).

Glass out	$353	1.16	$97	0.95	$225	1.06

Accounting for optimism bias, the BCR falls below one with 40 per cent adjustment with glass and 10 per cent adjustment without glass

A response to the potential for households to overstate their willingness to pay for reduction in litter and increases in recycling is to allow for so-called optimism bias. Optimism bias has been known to reduce costs and inflate benefits. We model a range of bias values in relation to households' willingness to pay. Table 34 shows the glass-out scenario BCR dips below one with a 10 per cent optimism bias adjustment to willingness to pay values, while it takes a 40 per cent reduction in willingness to pay benefits for the glass-in scenario to result in net social costs.

Table 34: Optimism bias applied to WtP benefits measures

Optimism bias		0%	10%	20%	30%	40%
Glass in						
Recycling	$m 30 year PV	$849	$764	$679	$594	$509
Litter	$m 30 year PV	$2,005	$1,804	$1,604	$1,403	$1,203
BCR		1.49	1.36	1.23	1.10	0.98
Glass out						
Recycling	$m 30 year PV	$225	$202	$180	$157	$135
Litter	$m 30 year PV	$783	$705	$626	$548	$470
BCR		1.06	0.97	0.89	0.80	0.72

Deposit level and participation rate

We understand it is proposed that the initial recommended deposit will be 10 cents, and unless minimum targets are reached within defined time periods, this will increase to 20 cents. This approach would delay some of the benefits realised from the reduction in litter and landfill but also reduce household participation costs and initial capital costs (e.g. number of RVMs). An advantage of this approach is it is likely to provide a better understanding of the infrastructure required and the best mix of return facility types for higher participation rates.

A high-level analysis of the impact of adjusting the deposit level through a range from 10 cents to 30 cents was undertaken by adjusting the assumed participation rate, diversion from kerbside collections and the expected rate of litter reduction. The intuition behind this change is that the deposit level acts as a participation incentive so adjustments will impact participation costs and diversion (litter and kerbside refuse) rates.[8]

We change the participation assumption from a starting rate of 60 per cent and steady state of 85 per cent to starting rates of 50 and 70 per cent, and steady state rates of 75 and 95 per cent respectively, which adjusts household participation costs and timing of litter reduction benefits.

For the 10 cent deposit level we assume litter reduction is reduced to the lowest level reported from international experience (35 per cent), resulting in a lowering of the litter reduction rate from 14.4 per cent to 8.2 per cent (4.4 per cent to 2.5 per cent with glass out[9]). This decreases the BCR to 1.13 (0.79 glass out).

For a 30 cent deposit we correspondingly assume the highest rate of container litter reduction reported in international experience (84 per cent), resulting in a 19.8 per cent total litter reduction. This raises the BCR to 1.75 for the glass-in scenario. For glass-out we increase to the average rate of 61 per cent, which results in a 7.8 per cent total litter reduction and a BCR of 1.50.

Table 35 Benefit-cost ratios for alternative participation rates and diversion from kerbside

Steady state participation	Deposit level	Glass in BCR	Glass out BCR
75%	10 cents	1.14	0.78
85%	20 cents	1.49	1.06
95%	30 cents	1.75	1.50

For the 10 cent deposit test, net benefits reduce by $810 million ($314 million for glass-out) to $279 million (negative $246 million glass-out), with total benefits decreasing by $976 million ($393 million in glass-out scenario). The largest change is a $894 million ($357 million for glass-out scenario) reduction in the welfare gain from litter reduction. Of the $166 million decrease in costs, the largest change is a decrease in household participation costs of $117 million ($63 million for glass out).

There are also $9 million ($5 million glass out) savings from reduced manual depot costs as they are based on container throughput. For the 30 cent deposit test, net benefits increase by $710 million ($568 million glass-out), with total benefits increasing by $882 million ($651 million glass-out) again driven by the change in welfare gain from the associated litter reduction, emphasising the role of this parameter in driving the model's results.

Table 36: Summary with 75 per cent participation rate

	Glass-in 75%	Glass-in base	Glass-in 95%	Glass-out 75%	Glass-out base	Glass-out 95%

[8] There is no empirical evidence we are aware of to assess the deposit level and litter reduction association.
[9] Glass was already using the lowest reported litter rate so we adjust by the same relative change as the glass-in scenario shift of 43 per cent.

Total benefits	$2,340	$3,316	$4,198	$865	$1,258	$1,910
Total costs	$2,061	$2,227	$2,399	$1,111	$1,190	$1,273
Net benefits	$279	$1,089	$1,799	-$246	$68	$637
Benefit-cost ratio	1.14	1.49	1.75	0.78	1.06	1.50

Figure 3: Glass in deposit level sensitivity test ($m, 6 per cent discount rate)

Deposit level $0.30 **Litter reduction 19.8%**

Year	0	1	2	3	4	5	6	7	8	9	10	15	20	25	30
Participation rate		70%	80%	85%	90%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Litter timing		70%	80%	90%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total benefits	0	175	383	603	826	1,049	1,262	1,465	1,658	1,843	2,019	2,782	3,378	3,840	4,198
Total costs	54	176	300	423	546	668	784	895	1,000	1,101	1,197	1,613	1,940	2,197	2,399
Net benefits	-54	0	83	180	280	381	478	570	658	742	822	1,169	1,438	1,643	1,799
Benefit-cost ratio	**0.00**	**1.00**	**1.28**	**1.43**	**1.43**	**1.57**	**1.61**	**1.64**	**1.66**	**1.67**	**1.69**	**1.73**	**1.74**	**1.75**	**1.75**

Deposit level $0.20 **Litter reduction 14.4%**

Year	0	1	2	3	4	5	6	7	8	9	10	15	20	25	30
Participation rate		60%	70%	75%	80%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Litter timing		60%	70%	80%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total benefits	0	127	276	436	606	785	956	1,118	1,274	1,422	1,563	2,176	2,655	3,027	3,316
Total costs	54	174	288	401	515	628	736	838	936	1,029	1,118	1,503	1,805	2,042	2,227
Net benefits	-54	-47	-12	35	91	157	220	280	338	392	445	673	850	985	1,089
Benefit-cost ratio	**0.00**	**0.73**	**0.96**	**1.09**	**1.18**	**1.25**	**1.30**	**1.33**	**1.36**	**1.38**	**1.40**	**1.45**	**1.47**	**1.48**	**1.49**

Deposit level $0.10 **Litter reduction 8.2%**

Year	0	1	2	3	4	5	6	7	8	9	10	15	20	25	30
Participation rate		50%	60%	65%	70%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Litter timing		50%	60%	70%	80%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total benefits	0	85	180	284	395	513	636	753	864	971	1,072	1,513	1,859	2,130	2,340
Total costs	54	172	276	380	483	587	687	782	872	959	1,041	1,395	1,673	1,891	2,061
Net benefits	-54	-87	-96	-96	-88	-74	-51	-29	-8	12	32	118	186	239	279
Benefit-cost ratio	**0.00**	**0.49**	**0.65**	**0.75**	**0.82**	**0.87**	**0.93**	**0.96**	**0.99**	**1.01**	**1.03**	**1.08**	**1.11**	**1.13**	**1.14**

Figure 4: Glass out deposit level sensitivity test ($m, 6 per cent discount rate)

Deposit level $0.30 **Litter reduction 7.8%**

Year	0	1	2	3	4	5	6	7	8	9	10	15	20	25	30
Participation rate	70%	80%	85%	90%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	0%
Litter timing	70%	80%	90%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%
Total benefits	0	79	173	273	374	476	573	665	753	837	917	1,264	1,536	1,746	1,910
Total costs	40	114	181	248	313	378	439	497	552	605	655	872	1,040	1,171	1,273
Net benefits	-40	-35	-8	26	61	98	134	168	201	232	262	392	495	575	637
Benefit-cost ratio	**0.00**	**0.69**	**0.95**	**1.10**	**1.20**	**1.26**	**1.31**	**1.34**	**1.36**	**1.38**	**1.40**	**1.45**	**1.48**	**1.49**	**1.50**

Deposit level $0.20 **Litter reduction 4.4%**

Year	0	1	2	3	4	5	6	7	8	9	10	15	20	25	30
Participation rate		60%	70%	75%	80%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Litter timing		60%	70%	80%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total benefits	0	47	104	164	229	296	361	422	481	537	590	823	1,005	1,148	1,258
Total costs	40	113	175	237	298	358	415	470	522	571	618	819	975	1,097	1,190
Net benefits	-40	-66	-72	-73	-69	-62	-55	-48	-41	-34	-27	4	30	51	68
Benefit-cost ratio	**0.00**	**0.42**	**0.59**	**0.69**	**0.77**	**0.83**	**0.87**	**0.90**	**0.92**	**0.94**	**0.96**	**1.00**	**1.03**	**1.05**	**1.06**

Deposit level $0.10 **Litter reduction 2.5%**

Year	0	1	2	3	4	5	6	7	8	9	10	15	20	25	30
Participation rate		50%	60%	65%	70%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Litter timing		50%	60%	70%	80%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total benefits	0	32	67	105	146	190	235	278	319	358	395	558	686	787	865
Total costs	40	112	170	227	283	339	393	443	491	537	581	768	913	1,025	1,111
Net benefits	-40	-80	-103	-121	-137	-149	-158	-165	-173	-179	-186	-210	-227	-238	-246
Benefit-cost ratio	**0.00**	**0.28**	**0.40**	**0.46**	**0.52**	**0.56**	**0.60**	**0.63**	**0.65**	**0.67**	**0.68**	**0.73**	**0.75**	**0.77**	**0.78**

Containers per tonne adjustment

Adjusting the assumptions around containers per tonne has little bearing on the model, as the most significant calculations are not influenced by this conversion factor. The change does increase household participation costs and manual return depot costs as both of these are determined by the number of containers. Hence, the BCR reduces to 1.47 (from 1.49) for the glass-in scenario and 1.05 (from 1.06) following the changes.

Table 37: Containers per tonne conversions

	(000's) per tonne (PwC financial model 2020)	**(000's) per tonne (PwC & WSC, 2011)**
Plastic	24.230	24.607
Liquid paperboard	10.024	24.060
Metal (Aluminium)	60.770	66.821
Glass	3.711	4.784

High-level comparison with previous work and thoughts on limitations of current study

While the fundamental structure of the analysis is similar to previous work, this study contains more detail and nuance. Direct comparisons should therefore be avoided. Nevertheless, we offer the following comments on some clear differences between the results of the studies. For the current exercise:

- Operating costs are over six times higher than those estimated previously.
- Scheme administration (i.e. Managing Agency) costs are around 15 times higher than those estimated previously.
- Benefits from welfare gains to households due to less litter were proportionally about the same in both studies, but in absolute terms were around 50 per cent higher than previously estimated.
- Benefits from welfare gains to households due to additional recycling were higher in absolute and relative terms, due to the inclusion of additional information on household willingness-to-pay.
- The benefit associated with higher value recycled material due to a CRS is much lower in the current study, largely due to lower prices and increases in costs of exporting which were not included previously.

With both the previous work and the findings of this study in mind, we offer the following thoughts:

- *Data limitations hamper precision on cost side.*

There is a lack of detail in a range of areas. In particular, specificity around the return facilities and the associated costs of such options is most lacking (e.g. use of existing Community Recycling Centres, performance specifications of RVMs and the mix of capital and operating costs associated with the model most likely to be employed).

The dearth of data means a heavy reliance on assumptions and adaptation of overseas data was needed. The effect of this requirement is that we are unsure how close to the 'actual' costs our estimates are.

- *Further exploration is possible with additional time.*

Areas where there are existing gaps or where further exploration is likely to be useful are:

  - material flows
  - commercial arrangements, responses and costs
  - the volume and composition of litter
  - return facility capacity, cost and operations
  - possible household behaviour.
- *This report is a conversation starter and advancement towards a goal.*

This report should be seen as the first step in the walk towards a decision on a CRS. A CBA will never be the sole determinant of any decision, but rather is a contribution. It may be that the constraints discussed above are binding in nature, but at this stage we do not know for sure.

We are confident that this analysis advances knowledge around the economic costs and benefits of a CRS, but we caution against it being seen as the final word. Further consideration is needed.

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