Life Cycle Assessment of Tasmania's Container Refund Scheme

Undertaken by Lifecycles for TasRecycle

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1 Introduction

1.1 Background

The Tasmanian Container Refund Scheme (CRS) is a litter reduction initiative that was introduced by the Tasmania Government. Participants can collect and return their empty drink containers to refund points across Tasmania for a 10 cent refund on each item.

The CRS provides consumers with multiple ways to participate, with 49 refund points across Tasmania, including on King and Flinders Islands. There are two main types of refund points, which are:

- Reverse vending machine (RVM)

  Self-service machines that users feed containers into. The machine will then read the drink container barcode and either accept or reject the container based on its eligibility for a refund. Refund types include donation, vouchers and electronic refund.

- Depots

  A staffed refund point with automated counting machines that is ideal for larger loads. Refund types include donation, cash and electronic refund.

This life cycle assessment (LCA) aims to establish a robust baseline for the environmental benefits of diverting recyclable waste from becoming litter or landfill. This information will then be used to develop a tool for the public to understand the impact of the scheme in the hope it will motivate greater participation in the scheme.

1.2 Life cycle assessment

Life cycle assessment (LCA) is a methodology for assessing the full ‘cradle-to-grave’ environmental benefits of products and processes by assessing environmental flows (i.e. impacts) at each stage of the life cycle. LCA aims to include all important environmental impacts for the product system being studied. In doing so, LCA seeks to avoid shifting impacts from one life cycle stage to another, or from one environmental impact to another.

The framework and principles of LCA are described in the international standard ISO 14040 (International Organization for Standardization, 2006). The general structure of the LCA framework is shown in Figure 1. Each stage of the LCA interacts with the other stages which makes LCA an inherently iterative process. The specific requirements for LCA are defined by ISO 14044.

- The first stage (**goal and scope**) describes the reasons for the LCA, scenarios, boundaries, indicators and other methodological approaches used.
- The second stage (**inventory analysis**) builds a model of the production systems involved in each scenario and describes how each stage of the production process interacts with the environment.
- The third stage (**impact assessment**) assesses the inventory data against key indicators to produce an environmental profile of each scenario.
- The final stage (**interpretation**) analyses the results and undertakes systematic checks of the assumptions and data to ensure robust results.

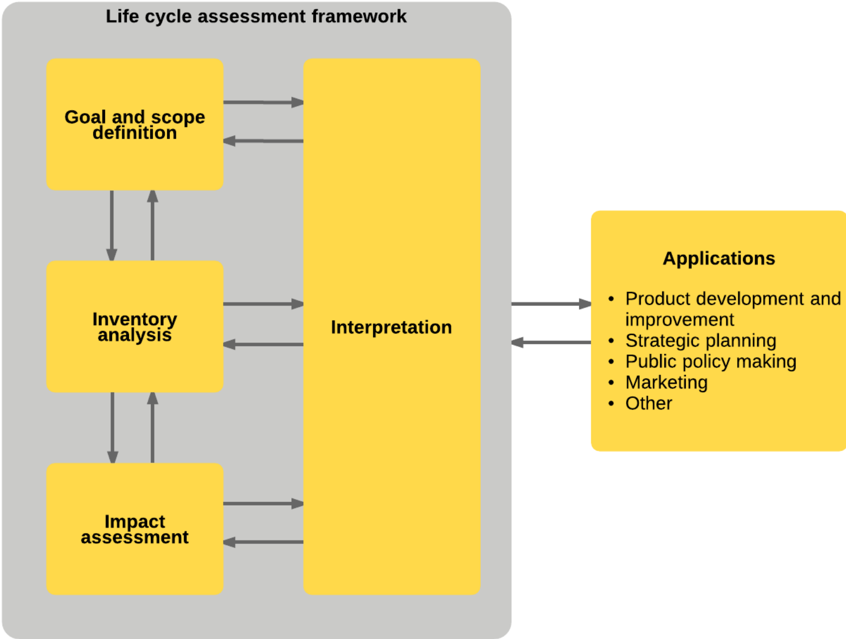

Figure 1: Framework for life cycle assessment

Life cycle assessment tries to measure the exchange between human activity, the 'technosphere', and the natural world, the 'biosphere'. This occurs either through the extraction of natural resources or via the emissions of pollutants to the air, water and ground. The measurement is undertaken at the level of the system that is being analysed, which is then further broken down into a series of unit processes that lead to the delivery of the functional unit. The functional unit is ultimately the basis upon which the system surrounds, as defined in the ensuing goal and scope section.

A single unit process is illustrated in Figure 2 which includes the flows to and from the 'biosphere' as well as flows to and from the 'technosphere'.

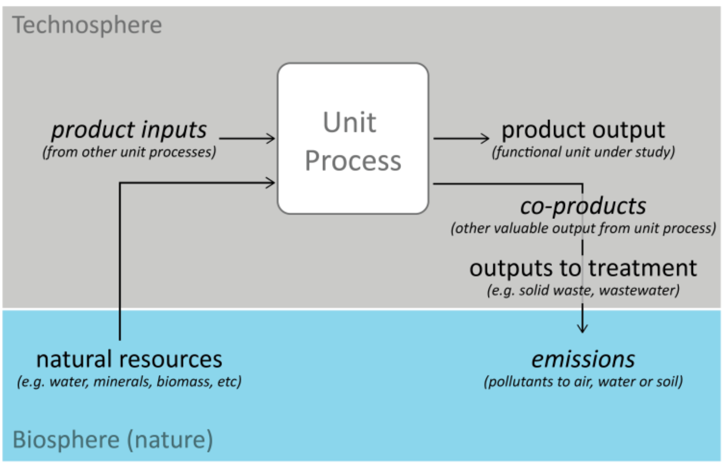

Figure 2: Inputs and outputs of a unit process in LCA

Unit processes are linked to create a system that produces the functional unit of the study, as illustrated in Figure 3. They can be categorised into foreground unit processes and background unit processes.

Foreground processes are those for which specific data is collected for the study. This includes primary data collected from facilities, secondary data from published papers and modified background processes from existing LCA databases.

Background processes are those for which data are typically sourced from pre-existing databases. The background data are either less important to the study outcomes or are already well-characterised in the existing data sets and therefore do not warrant specific modelling. In some instances, background unit processes may be modified to better reflect the conditions of the study.

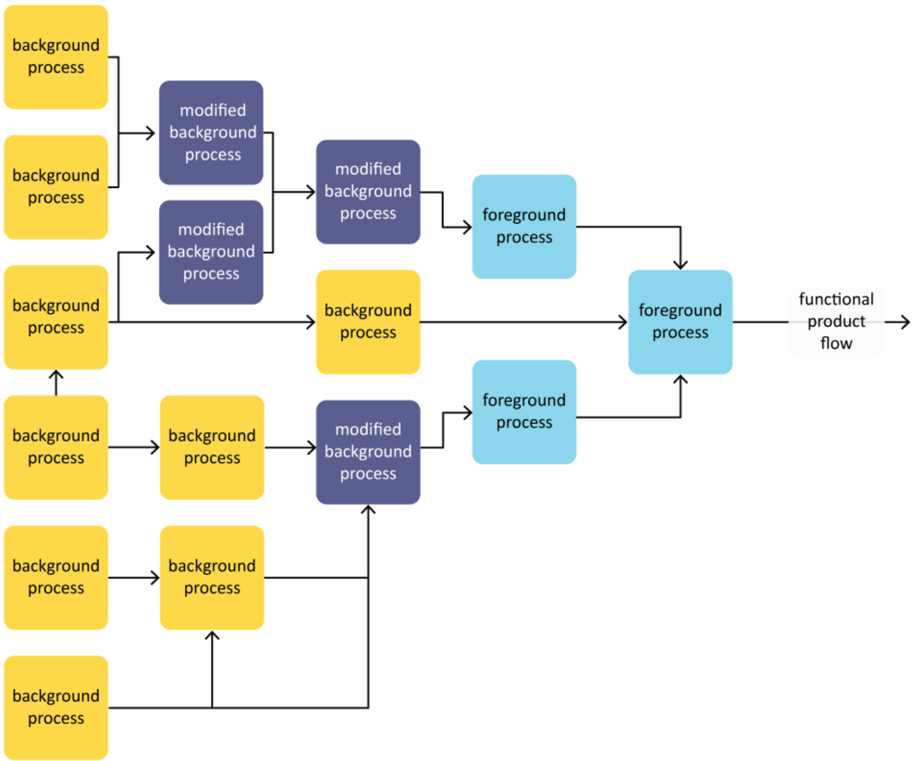

Figure 3: Linking unit processes in an LCA to produce the functional unit

2 Goal and scope

2.1 Reason for the study

The goal of this LCA is to establish a robust baseline life cycle assessment of the Tasmanian CRS. The baseline will be used to assess potential strategies for improving the implementation of the scheme. In addition, the results of the LCA will be used as a basis for the development of a metric system that can be used to demonstrate the associated environmental benefits of material recovery through the scheme to a broader audience.

It should be noted that this LCA is not a marginal analysis of the benefits of CRS over kerbside recycling schemes nor an assessment of the preference for any packaging material. The environmental benefits are calculated as those flowing directly from the actions of scheme participants without measuring any counter-factual consequences of recycling via kerbside, littering or landfilling of the packaging.

2.2 Intended audience

The audience for the report will be the TasRecycle organisation and the general public. The environmental impact factors produced in this report will be used to assist in the development of an interactive online tool for estimating the public benefits of participating in the scheme, as well as for the external marketing and communication of the scheme.

2.3 Calculation approach

in this LCA, the environmental benefits of recycling activities are calculated and connected to individual actions of Tasmania’s CRS participants. The results from the study are being used to describe to Tasmanians what the outcome is when they recycle their drink containers through the CRS without reference to what else could be done with the container (a zero baseline). With this in mind, all activities modelled start from the point where the consumer decides to participate in the CRS and relate only to activities of the scheme and the impacts and benefits derived from that point forward.

The total environmental impact of the recycling as part of the CRS is calculated by first determining the impacts of the scheme collection process and downstream processing of recyclables; and then subtracting the impacts related to the avoided virgin material production. When this calculation results in a negative value, it is interpreted as an environmental benefit. However, this benefit should not be considered an absolute saving, as no baseline scenario is defined. Instead, it represents the environmental benefits directly attributable to material recovery achieved through the CRS.

2.4 Functional unit

The functional unit is the basis for comparison of alternatives in LCA. It describes the service delivered by the processes being studied. In this study, the service is the management of drink containers from the Tasmanian CRS.

The functional unit is defined as:

"The management of 1000 drink containers returned through the Tasmanian CRS."

2.5 System boundary

The system boundary describes the process steps included in the LCA. Figure 4 shows the system boundary of this study.

The system boundary includes:

- Transportation of the containers from user to refund point; from refund point to bulk-up point; from bulk-up point to recycling.
- Electricity consumption at all refund points and bulk-up points
- Recycling process for production of secondary materials
- Displacement of virgin material supply chain

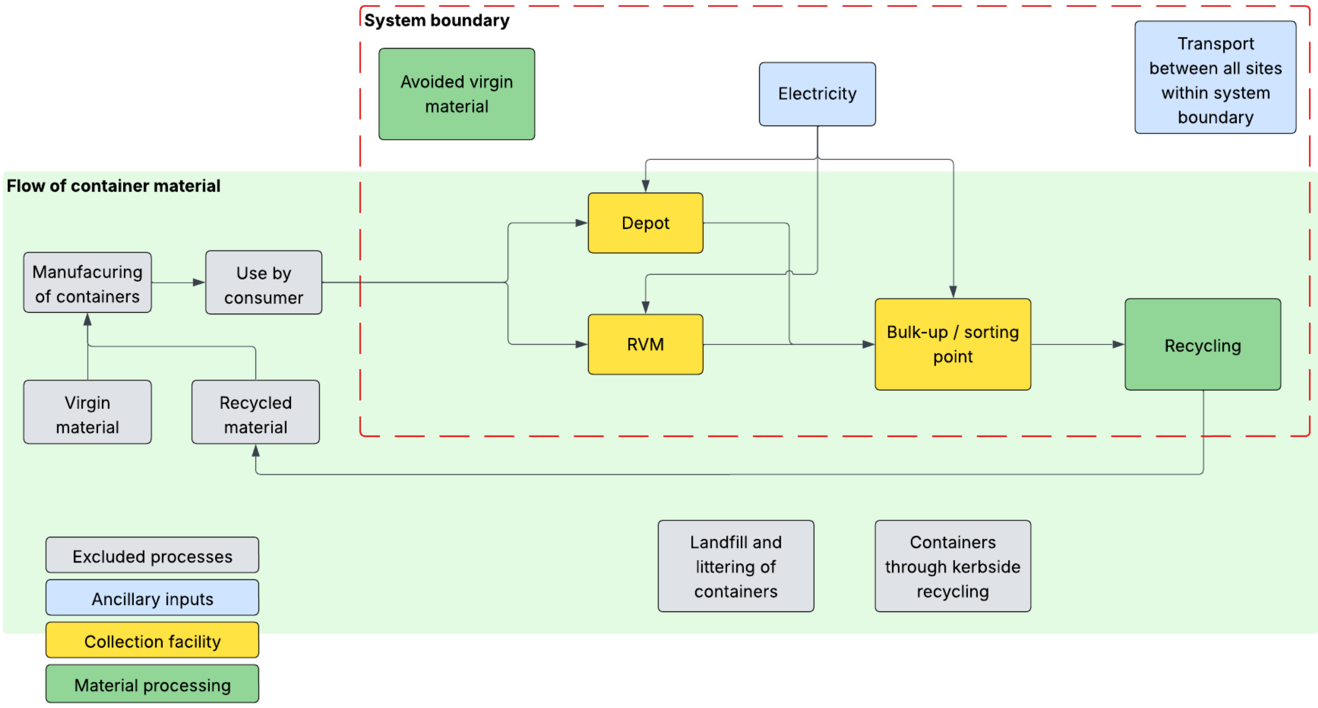

Figure 4: System boundaries of current study

For this study, the alternative fate of the drink containers was not considered. While certain activities such as kerbside recycling, littering, and landfill are likely be avoided through the implementation of the Tasmanian CRS, their displacement is not included.

Any excluded flows must fall below the cut-off threshold for this study (below 1% of any impact category included in the LCA). For this reason, materials other than aluminium, glass, PET, HDPE, LPB and steel were excluded as these materials only make up a small portion of the total mix (0.001%). Besides this, infrastructure associated with refund points such as signage, bins, concrete pads etc was not included as they would be long-lasting and therefore below the cut-off threshold.

2.6 Allocation procedures

In this LCA the main allocation issue relates to the allocation of the recycling credit between the product system that generates the container and the product system that utilises the recycled material as secondary material input.

The GHG protocol for product carbon footprints (Bhatia, 2011) suggest two options for dealing with recycling credits. The first (for strong recycling markets) is the 0/100 method, which provides 100% of the credit to the recycling at the end of a product life. The second is the 100/0 method, where 100% of the benefit of recycling is applied to the secondary product. This is for weak recycling markets where new products made from recycled content need to be specified.

The most common drink container materials (glass, PET and aluminium) are all considered as strong recycling markets. Therefore, we have applied the 0/100 method. This also fits the premise of the study, which is to calculate the benefits derived from material recovery through operation of the CRS scheme.

2.7 Data quality requirements

Data quality was assessed for all input data to the LCA and ranked in terms of its fitness for purpose.

The key data quality criteria for the study are:

- Reliability
- Time-related coverage
- Geographical coverage
- Technology coverage

The indicators of data quality are shown in Table 1 for each of the criteria. All major data points in the LCA above 5% net contribution to climate change impacts will be assessed according to these criteria.

Table 1: Data quality assessment framework

	Poor	Fair	Good	Very good
Reliability	Non-qualified estimate	Qualified estimate	Modelled data	Primary measured data
Time-related coverage	From past production >10 years old	From past production >5 years old and less than 10 years old	From past production >2 years old and less than 5 years old	From current production data <2 years old
Geographical coverage	From distinctly dissimilar region	From global average	From similar region	From region of interest
Technology coverage	From old or dissimilar technology	Generic technology average	From technology specific to region	From actual technology used

2.8 Impact assessment categories and characterisation models

The impact assessment stage relates the inventory flows to the indicators chosen for the LCA. This is done by classifying which flows relate to each impact category and then selecting a characterisation model that quantifies the relationship of each inventory type to the indicator in question. The calculation of the category indicator results is the sum of all inventory flows multiplied by their relevant characterisation factors. The list of indicators considered in summarised in Table 2.

Table 2: Impact categories assessed and their related characterisation model

Indicator	Description	Characterisation model
Climate change	Measured in kg of carbon dioxide equivalence. This is governed by the increased concentration of gases in the atmosphere that trap heat and lead to increasing global temperatures. These gases are principally carbon dioxide, methane and nitrous oxide.	IPCC 2021 model based on 100-year timeframe
Particulate matter	Measure in grams of $PM_{2.5}$. This impact category looks at the respiratory health impacts from particulate matter for PM_{10} and $PM_{2.5}$. This is one of the most dominant immediate risks to human health as identified in the global burden of disease.	TRACI V2.1
Water volume	Measured as litres of water consumed.	Water consumption only, no characterisation applied
Fossil fuel depletion	Measured in MJ of Net Calorific Value (NCV) This impact category measures the amount of the quantification of the specific energy of combustion for fossil fuels.	CML-IA V4.8

The reason these indicators were selected was due to relatability of the impact categories to a generalised audience with assumed minimal understanding of environmental science. The indicators needed to be familiar enough for the results to be relatable for all levels of comprehension. This is why climate change and fossil fuel depletion were both chosen despite being correlated impacts. Water volume has been used instead of water scarcity as the latter is less tangible for consumers to understand in a simple online calculator.

2.9 Critical review

An independent critical review of the study was undertaken by Blue Environment and the critical review statement is provided in Appendix C.

2.10 Data requirements

To ensure that the results produced by this LCA are of a reputable standard, the quality of the input data must be of sufficient standard. The data used must be the most recent and relevant as possible. This LCA is focused on the collection and processing of resources within Tasmania, therefore, where possible specific regional data for the state should be used, and where unavailable, sourced from other regions within Australia. Any inputs related to technology must be within the relevant timeframe of the CRS. Data which has been sourced externally must be consistent and representative with sources clearly referenced for reproducibility.

3 Life cycle inventory

While hundreds of background processes contribute to the analysis, the most important processes are described in the life cycle inventory (LCI), particularly those affecting the results or those that have been modified from the original source to better represent Tasmanian data.

3.1 Container numbers and distribution

Initial data on the refund points and number of collected containers was provided by TasRecycle. This included 45 operational refund point locations between 1 August and 31 October 2025. The aggregated data is summarised in Table 3 and Table 4.

Mobile collection points, over-the-counter refund points and container collection services were excluded from the LCI as these were largely temporary arrangements and collect minimal volumes.

Table 3: Breakdown of transaction by refund point types (1 Aug to 31 Oct 2025)

Refund Point Type	Transactions	Containers returned
Depot	12,738	4,585,932
RVM	227,865	22,505,472
Total	240,602	27,091,404

Table 4: Breakdown of materials in collections (1 Aug to 31 Oct 2025)

Material	Number of containers	Percentage of total
Glass	4,021,938	15%
Aluminium	16,637,367	61%
PET	5,866,669	22%
HDPE	28,064	<1%
Liquid paper board	519,790	2%
Steel	17,218	<1%
Other materials	358	<1%

Table 5. Average masses for the different container types and number of collection points per type.

Item	Assumption	Input	Source
Aluminium can	Mass	14.2g	TasRecycle
Glass bottle	Mass	202g	TasRecycle
HDPE bottle	Mass	48.2g	TasRecycle
PET bottle	Mass	32.6g	TasRecycle
Liquid paperboard carton	Mass	16.6g	TasRecycle
Steel container	Mass	40g	TasRecycle
Reverse vending machine	Units	41	TasRecycle
Depots	Units	4	TasRecycle

3.2 Assumptions energy consumption

Assumptions are an essential part of LCA in circumstances where data has not been supplied or specific information is unable to be obtained. Assumptions are used to fill in the data gaps in order to produce the most complete model possible. Table 6 sets out several assumptions made during this LCA and are considered to have minimal influence on the outcome of the study. Assumptions can be easily adjusted in the model if more information becomes available or if any changes are made to the scope of the assessment.

Table 6. Energy consumptions for the collection points and bulk-up locations.

Ite,	Assumption	Value	Source
RVM energy consumption	Energy	13,254 kWh/month	TasRecycle
Depot energy consumption	Energy	1,536 kWh/month	TasRecycle
Bulk-up point energy consumption	Energy	15,215 kWh/month	Estimation based on previous studies

3.3 Transport

There are multiple transport legs included in the system boundary (see Figure 5). Containers are first dropped off by consumers at the refund points. Glass from refund points in northern and northwestern regions is consolidated at a northern bulk-up facility, while lightweight materials go to a northern sorting site. In the south, glass is sent to a southern bulk-up facility. Lightweight materials are bulked up in the south before being transferred to a northern processing facility. Bulk-up transport from Flinders Island and King Island was excluded from the transport assumptions. Aluminium is recycled in South Korea, PET and HDPE are recycled in Victoria, LPB is recycled in Spain and steel is recycled in Thailand. Assumptions made around transport are shown in Table 7 to Table 9.

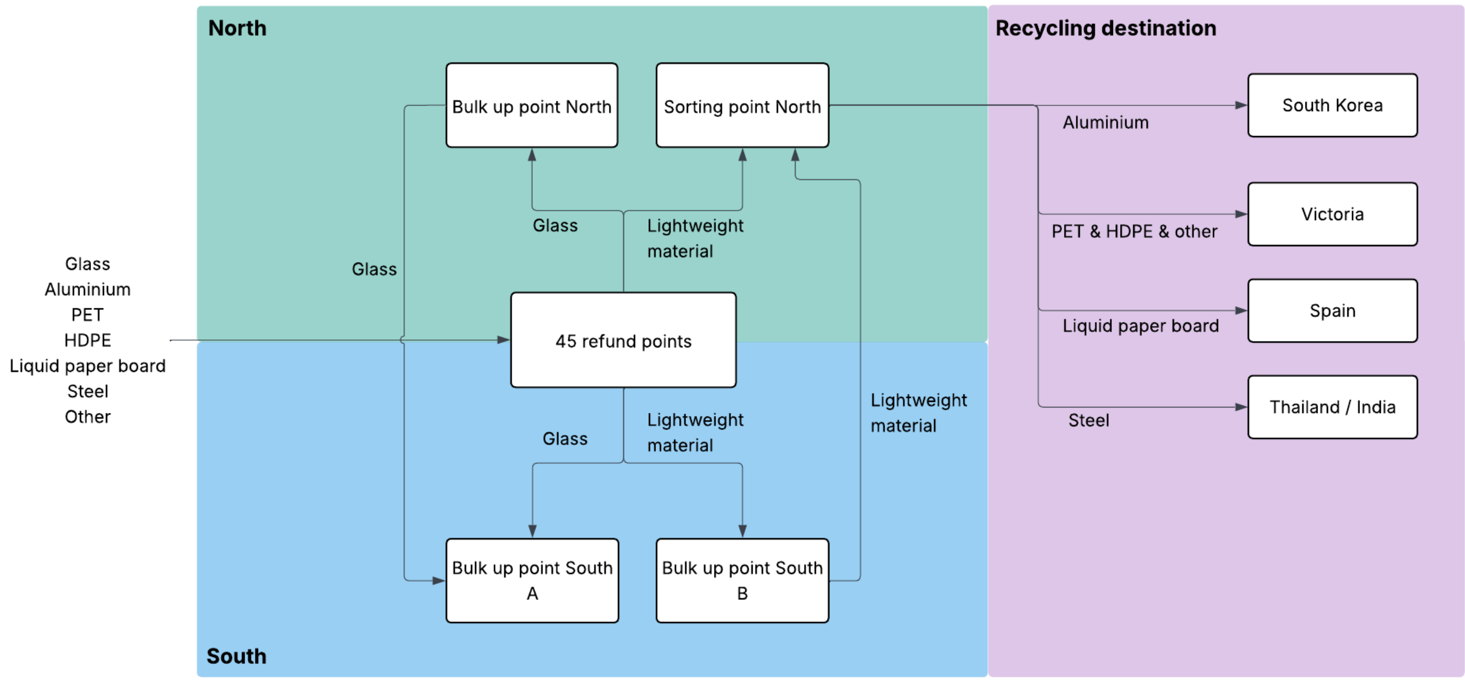

Figure 5: Overview of transport location of Tasmanian CRS

Table 7: Consumer transport – assumed distances to refunds points based on refund point type and location, source: TasRecycle

Refund Point Location	Trip distance	Co-located in a shopping district	Co-located with a single business	Stand-alone location
Dedicated trip %	**-**	**10%**	**50%**	**80%**
Metro RVM	4 km	0.4 km	2 km	3.2 km
Regional RVM	8 km	0.8 km	4 km	6.4 km
Depot	12 km	1.2 km	6 km	9.6 km

Table 8: Distances assumed for container collection and transport to bulk up locations. Average load based on truck type and weight of containers collected per trip. Load factor based on percentage of trip carrying load. Maximum volume of 'garbage truck' assumed to be 24 m3. Source: TasRecycle

Truck type	Material	Average load	Load factor
Unit	**-**	**MT**	**-**
Garbage truck	Lightweights (Aluminium, PET, HDPE, LPB, Steel)	0.81	0.5
Garbage truck	Glass	4	0.5
Prime mover	Lightweights (Aluminium, PET, HDPE, LPB, Steel)	7	1
Prime mover	Glass	20	1

Table 9: Distances assumed for transport between bulk-up locations and recycling destinations. Source 'Country recycling': TasRecycle, source 'Sea transport': sea-distances.org, source 'Land transport': google.maps

Material type	Country recycling	Sea transport (km)	Land transport (km)
		km	**km**
Aluminium	South Korea	5,308	154
PET	Victoria	246	120
HDPE	Victoria	246	120
Other Materials	Victoria	246	120
Liquid paper board	Spain	9,501	154
Steel	Thailand	4,698	154
Glass	Tasmania	0	20

3.4 Recycling inventory data

Data regarding recycling processes for all the different material types are taken from different sources. More details on the inputs for all different recycling processes are displayed in Table 10 to Table 15.

Table 10: Life cycle inventory for aluminium recycling process

Recycling of aluminium (per ton)				
Process	**Item**	**Amount**	**Unit**	**Comment / source**
Avoided product	Aluminium, primary, ingot {UN-OCEANIA}| aluminium production, primary, ingot | Cut-off, S	0.95	t	Ecoinvent v3.11 process, clean quality of aluminium is assumed to result in high yield of aluminium.
Materials	Aluminium, wrought alloy {SK}| treatment of aluminium scrap, post-consumer, prepared for recycling, at remelter | Cut-off, U	1	t	Ecoinvent v3.11 process, regionalized to South Korea.

Table 11: Life cycle inventory for glass (glass to sand) recycling process

Recycling of glass (glass to sand, per ton)				
Process	**Item**	**Amount**	**Unit**	**Comment / source**
Avoided product	Silica sand {RoW}| silica sand production | Cut-off, U	0.95	t	(Tushar et al., 2023)
Materials / fuels	Diesel	9.2	MJ	(Tushar et al., 2023)
Electricity / heat	Electricity	1.5	kWh	(Tushar et al., 2023)
Final waste flows	Waste, unspecified	0.05	t	(Tushar et al., 2023)
	Water	1.1	t	(Tushar et al., 2023)

Table 12: Life cycle inventory for steel recycling process; for part of the steel packaging, the tin coating is removed during the detinning process, however, most steel is shredded without detinning

Recycling of steel (per ton)				
Process	**Item**	**Amount**	**Unit**	**Comment / source**
Avoided product	Pig iron, at plant/GLO U/AusSD U	0.91	t	(Grant et al., 2003; Grant et al., 2001)
Materials / fuels	Steel/tinplate shred & detinning	0.23	t	(Grant et al., 2003; Grant et al., 2001)
	Steel/tinplate shredding	0.72	t	(Grant et al., 2003; Grant et al., 2001)

Table 13: Life cycle inventory for PET recycling process

Recycling of PET (per ton)				
Process	**Item**	**Amount**	**Unit**	**Comment / source**
Avoided product	Polyethylene terephthalate, granulate, bottle grade {RoW} | polyethylene terephthalate production, granulate, bottle grade | Cut-off, U	0.9	t	Ecoinvent v3.11 process.
Materials / fuels	Polyethylene terephthalate, flakes, food grade, recycled {AU-VIC }| treatment of waste polyethylene terephthalate, food grade, recycling | Cut-off, U	1.0	t	Ecoinvent v3.11 process, regionalized to Victoria, Australia and adjusted to reflect processing of 1kg of PET waste.

Table 14: Life cycle inventory for LPB recycling process

Recycling of liquid paper board (per ton)				
Process	**Item**	**Amount**	**Unit**	**Comment / source**
Avoided product	Paper, woodfree, coated {RoW}| market for paper, woodfree, coated | Cut-off, S	0.75	t	Ecoinvent v3.11 process.
Materials / fuels	Graphic paper, 100% recycled {RER}| graphic paper production, 100% recycled | Cut-off, U	1.0	t	Ecoinvent v3.11 process.
Waste treatment	waste treatment, inert waste, at landfill/AU U	0.20	t	
	waste treatment, mixed paper, at landfill/AU U	0.05	t	

Table 15: Life cycle inventory for HDPE recycling process

Recycling of HDPE (per ton)				
Process	**Item**	**Amount**	**Unit**	**Comment / source**
Avoided product	Polyethylene, high density, granulate {RoW}| polyethylene production, high density, granulate | Cut-off, U	0.94	t	Ecoinvent v3.11 process.
Materials / fuels	Polyethylene, high density, granulate, recycled {RoW}| polyethylene production, high density, granulate, recycled | Cut-off, U	1.0	t	Ecoinvent v3.11 process, regionalized to Victoria, Australia and adjusted to reflect processing of 1kg of HDPE waste.

4 Results

4.1 Impact assessment results

The impact assessment stage relates the inventory flows to the indicators chosen for the LCA. This is done by classifying which flows relate to which impact indicator and then selecting a characterisation model that quantifies the relationship of each inventory type to the indicator in question.

The LCIA results produced by this study are relative expressions and therefore do not predict impacts on category endpoints, nor the exceeding of thresholds and safety margins or risks.

The impact assessment results are presented in Table 16. The results show that the recovery of 1000 containers through Tasmania's CRS results in negative emissions in all impact categories assessed. For the results presented in this section, a negative value indicates environmental benefits, i.e. the benefits related to the recycling of 1000 containers through Tasmania's CRS is 152.7 kgCO2-eq.

In Section 5.1, the results are further investigated using a contribution analysis to investigate the sources of impacts and benefits for each impact category.

Table 16: Results for climate change, fossil fuel depletion, water volume and particulate matter related to the recycling of 1000 containers through the Tasmanian CRS

Impact category	Per 1000 Containers	Unit
Climate Change	-152.7	kg CO2 eq
Fossil fuel depletion	-1327.4	MJ NCV
Water volume	-6375.4	L
Particulate matter	-78.3	g PM2.5

The LCIA results produced by this study are relative expressions and therefore do not predict impacts on category endpoints, nor the exceeding of thresholds and safety margins or risks.

5 Interpretation

The interpretation step examines the results through a series of analyses and checks to better understand the results of the LCA, and to ensure any conclusions drawn from the LCA are robust and well supported by the data. The interpretation stage is divided in two sections:

- a contribution analysis, which is used to assess the relative contribution of each life cycle stage to the overall result
- a series of sensitivity analyses, which are used to increase the robustness of conclusions from the LCA and provide further insights into the observed environmental impacts.

5.1 Contribution analysis

For the contribution analysis, the environmental impacts and benefits are broken down into the following categories: consumer transport, CRS transport, CRS energy consumption, recycling transport, recycling processes, avoided virgin aluminium, avoided virgin PET, avoided sand (from glass recycling) and avoided other. Environmental impacts are shown in yellow, while environmental benefits related to displacement of virgin material are shown in green. The overall net result is shown in orange.

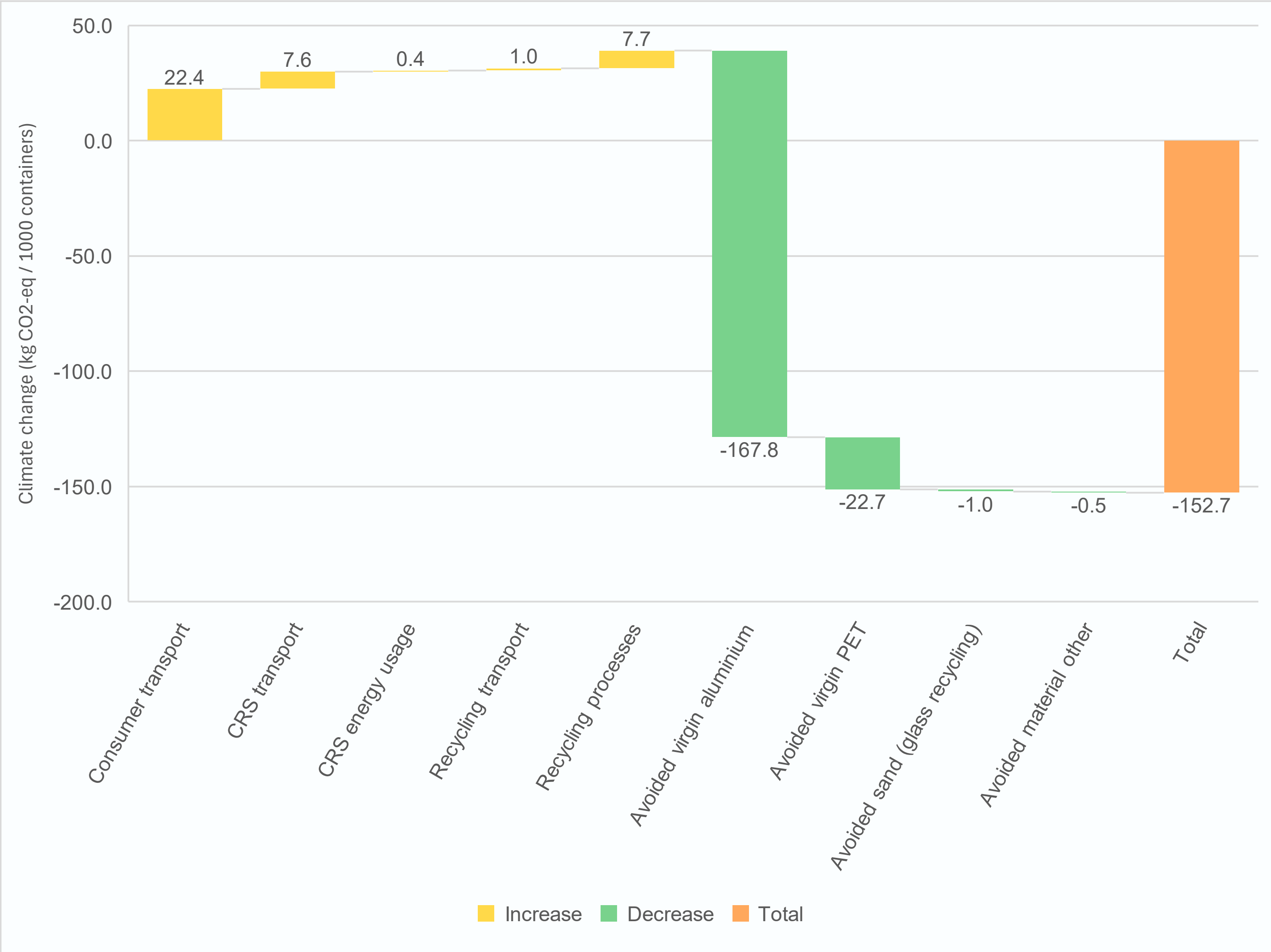

Figure 6: Climate change - Contribution analysis related to returning 1000 containers

The climate change contribution analysis is presented in Figure 6. The results show that the main environmental benefit of recycling comes from avoiding the production of virgin aluminium. Recycling aluminium cans reduces the demand for virgin aluminium and avoids the highly energy-intensive smelting processes. This leads to substantial climate benefits, particularly because aluminium cans make up approximately 61% of the total container mix.

PET containers account for a further 22% of the mix and therefore also make a significant contribution to the overall climate benefits.

The energy and material inputs related to recycling processes contribute a significant part of the environmental burdens. The contributions of the different materials and their recycling processes are discussed in more detail in Chapter 5.3.

Consumer transport is the largest contributor to the climate impact and is relatively high compared to other transport types. This is because consumers typically return only a small number of containers per trip, whereas CRS and recycling transport move containers in bulk. In addition, recycling transport largely relies on sea freight, which generally has a lower emission factor than road or rail transport.

Overall, energy consumption contributes only a minor share to the total environmental impact.

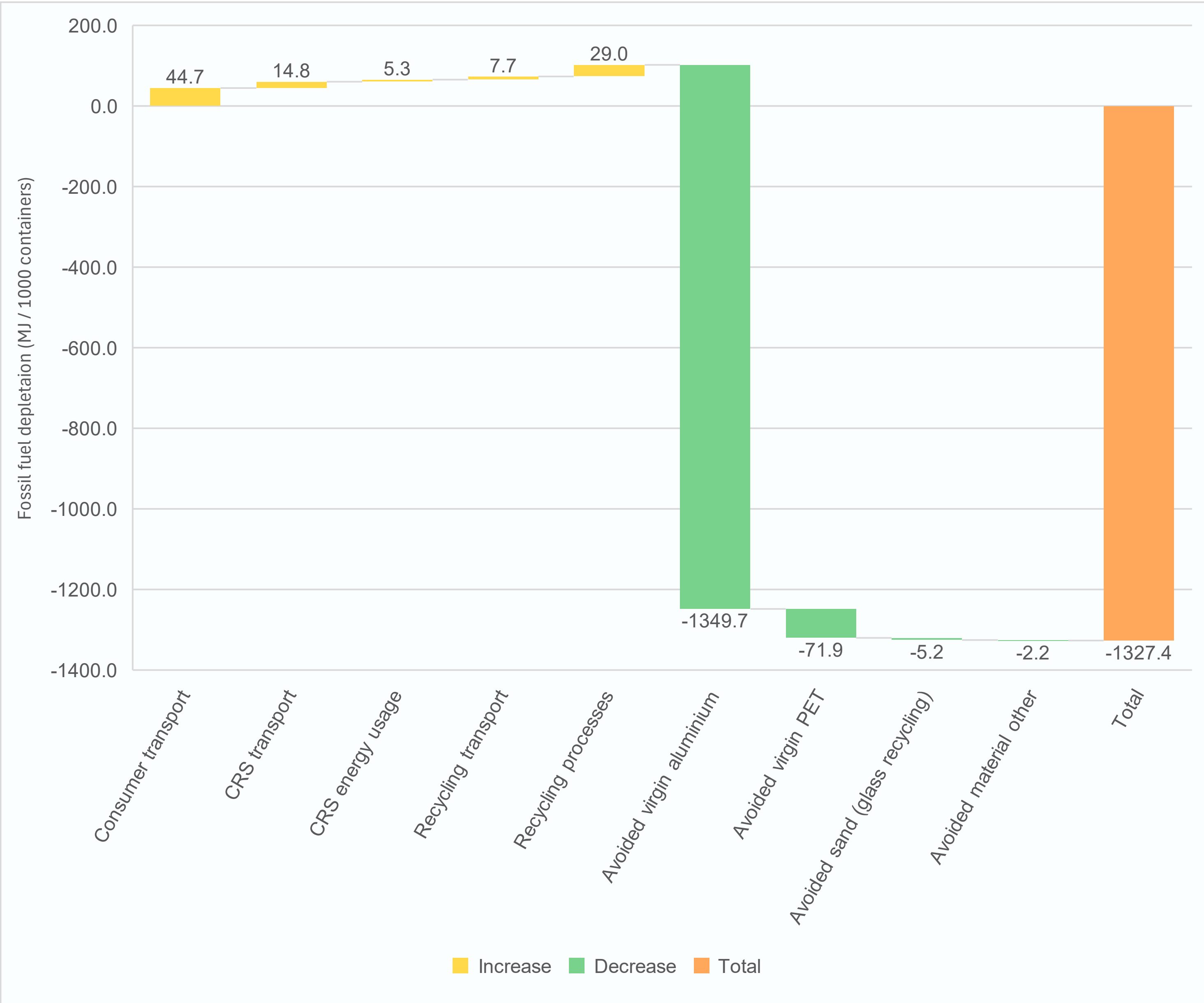

Figure 7: Fossil fuel depletion - Contribution analysis related to returning 1000 containers

Figure 7 shows that fossil fuel depletion follows a similar pattern to climate change. Consumer transport is the main contributors to environmental burdens, followed by recycling processes. The largest environmental benefits result from avoiding the production of virgin aluminium, with the avoidance of virgin PET being the second most important contributor.

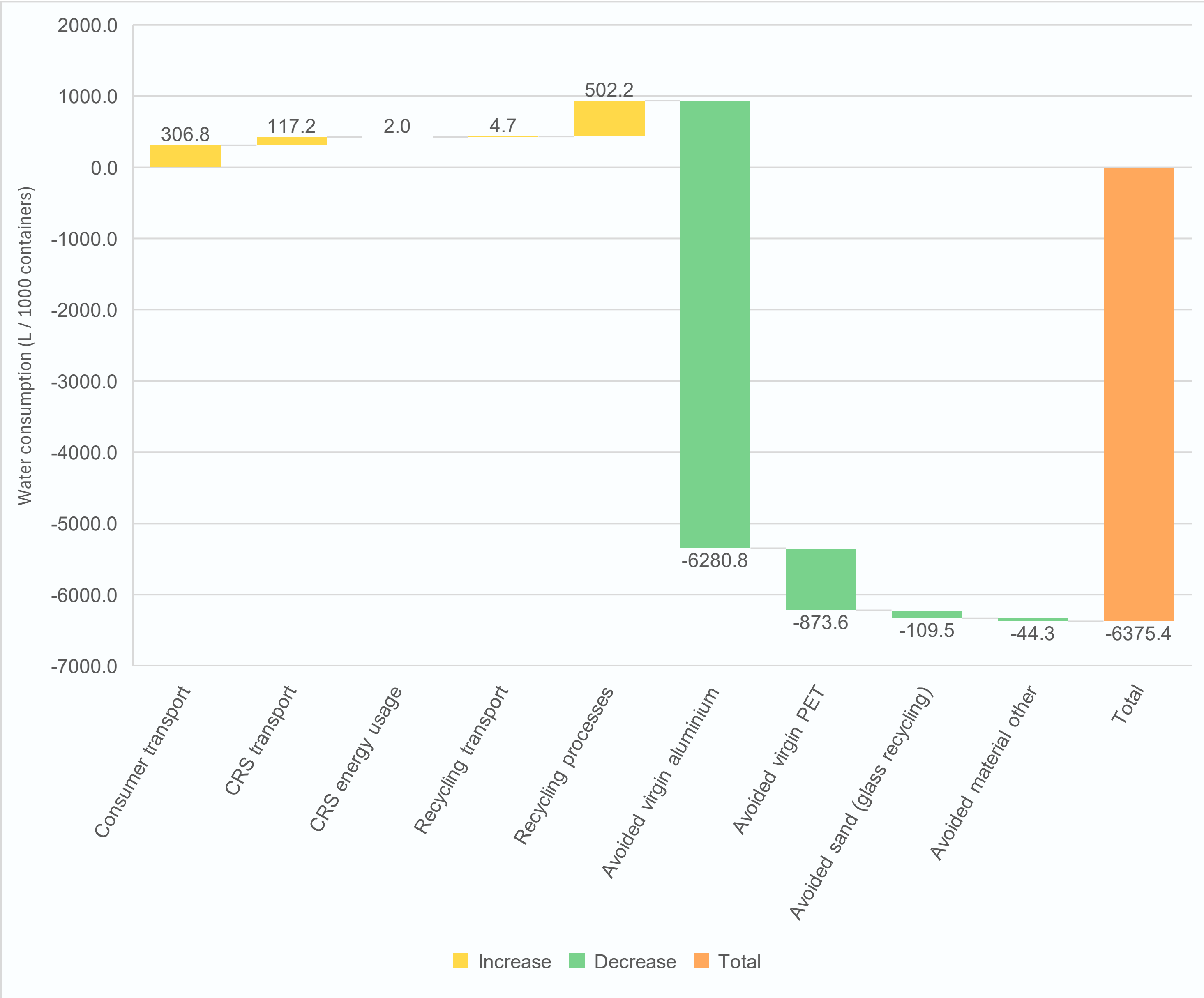

Figure 8: Water consumption - Contribution analysis related to returning 1000 containers

Figure 8 shows the direct water use impacts resulting from the CRS. As in the other impact categories, the main environmental benefits come from avoiding the production of virgin aluminium and PET. For virgin aluminium, water use is primarily associated with the conversion of bauxite to alumina and with energy generation. For virgin PET, water consumption mainly occurs during raw material extraction and refining. The largest contribution to water use comes from the recycling processes themselves, where water is primarily used for washing and cooling.

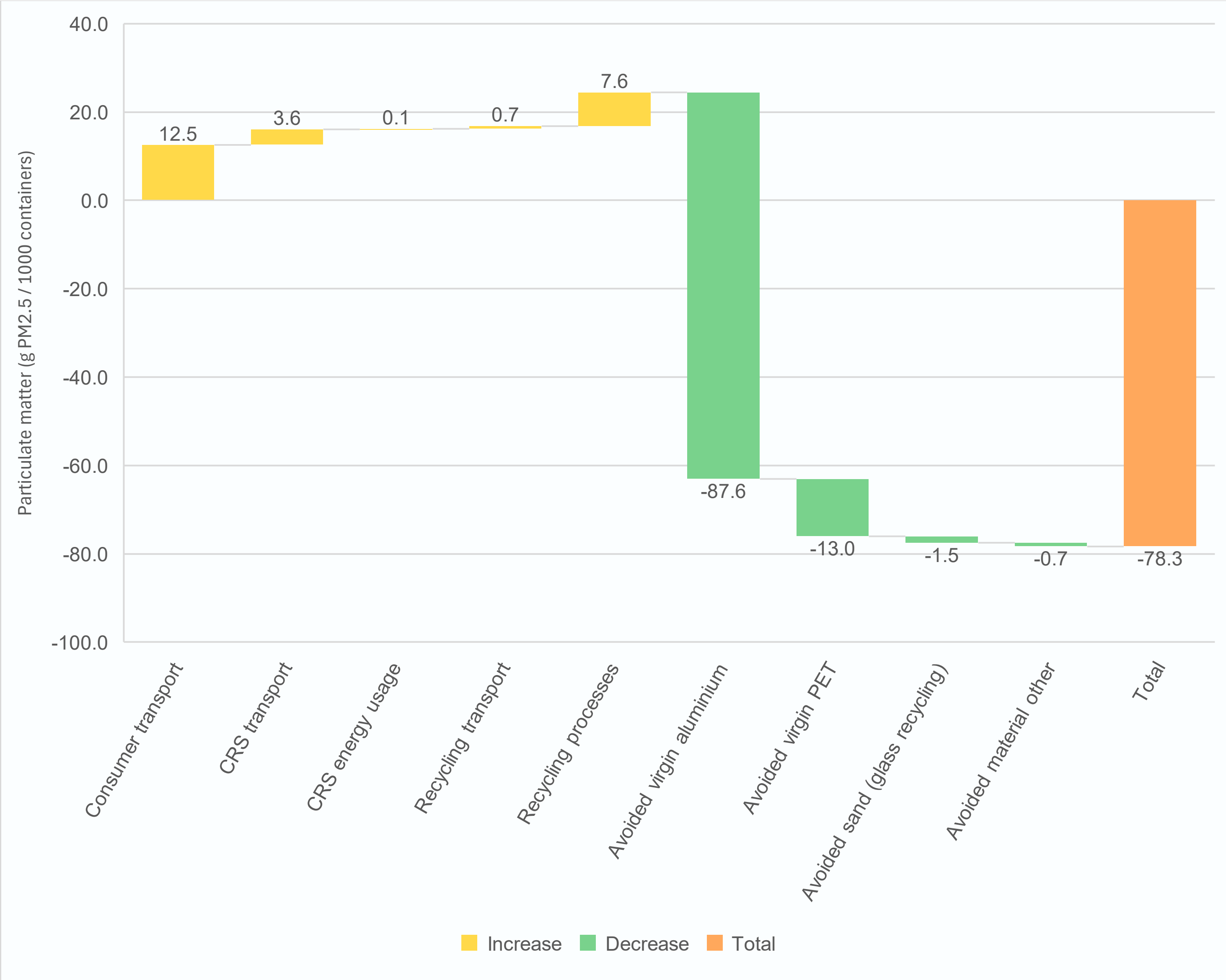

Figure 9 Particulate matter - Contribution analysis related to returning 1000 containers

Particulate matter emissions follow the same pattern as the climate impact. This is because both are largely driven by the same primary sources, mainly the combustion of fossil fuels. Consumer transport is the largest contributor, followed by recycling processes and CRS transport. The greatest environmental benefits come from avoiding the production of virgin aluminium, followed by avoided PET and sand production.

5.2 Impacts by material

Table 17 shows the impact of the aluminium, PET and glass per kilogram for the four different impact categories. The other materials are not included here as these only make up a small portion of the total mixture, but can be found in Appendix B.

Table 17: Impacts per kilogram of material

	Consumer transport	CRS transport	CRS energy usage	Recycling transport	Recycling processes	Avoided material	Total
Climate change				kg CO2 eq			
Aluminium	0.79	0.26	0.031	0.080	0.79	-19	-17
PET	0.34	0.26	0.014	0.023	0.070	-3.2	-2.5
Glass (glass to sand)	0.055	0.11	0.0022	0.0034	0.0012	-0.033	0.14
Fossil fuel depletion				MJ NCV			
Aluminium	1.58	0.51	0.38	0.43	2.7	-155	-150
PET	0.69	0.51	0.16	0.32	0.64	-10	-7.9
Glass (glass to sand)	0.11	0.22	0.026	0.052	0.0029	-0.17	0.24
Water volume				Litres			
Aluminium	11	4.0	0.14	0.37	49	-723	-659
PET	4.7	4.0	0.060	0.11	6.5	-124	-108
Glass (glass to sand)	0.76	1.7	0.010	0.017	0.007	-3.7	-1.1
Particulate matter				g PM2.5			
Aluminium	0.44	0.12	0.0070	0.066	0.84	-10	-8.6
PET	0.19	0.12	0.0031	0.0080	0.028	-1.8	-1.5
Glass (glass to sand)	0.031	0.053	0.00049	0.00088	0.00025	-0.049	0.036

Consumer transport has the highest impact for aluminium, followed by PET and then glass, across all impact categories. Travel distances are allocated to materials based on the number of containers returned for each material type. Since aluminium has the lowest mass per container, followed by PET and then glass, aluminium has the highest impact per kilogram. CRS energy usage is allocated in the same manner and therefore follows a similar pattern.

Glass and lightweight materials are transported separately, all impact related to glass transport is allocated to glass. CRS transport distances for lightweight materials are allocated based on mass, resulting in similar transport-related impacts for aluminium and PET.

The impact related to recycling transport is calculated using the distance and mass of each material. The logic behind this is that the emission for transport depends not only on the distance, but also on the transported mass. For example, if one kilogram of aluminium is transported for 5308 km over sea, this will receive a transport value of 5308 kgkm. The LCA model will take this value and relate a certain amount of emissions to it. Aluminium has the highest impact as it is transported over the largest distance. It should be noted here that no mass is included in consumer transport as this is assumed to be negligible compared to the other contents of the vehicle. Only the distance travelled is accounted for. Additionally, specific models have been developed for Tasmanian CRS transport, incorporating Tasmania-specific truck loads.

The aluminium and PET recycling processes contribute a significant portion of the total impact. Impacts related to glass recycling processes are low since these only consist of sorting and crushing into sand.

5.3 Sensitivity analysis

5.3.1 Container mix composition

The relative percentages (or fractions) of container material types supplied and returned in the CRS may vary in the future. Accordingly, a sensitivity analysis was conducted to understand how this uncertainty affects the results. The aluminium fraction was varied by ±4% to maintain a consistent total number of containers. The glass and PET fractions were reduced by 2% when aluminium was increased and vice versa when aluminium was decreased. It is assumed that bulk transport is unaffected by this change.

Table 18: Result of sensitivity analysis on container mix composition

Impact category	Unit	Baseline	Aluminium frac 4% increase	Aluminium frac 4% decrease
Climate change	kg CO2 eq	-153	-161	-144
Energy depletion	MJ	-1327	-1407	-1248
Water volume	L	-6375	-6666	-6085
Particulate matter	g PM2.5	-78	-82	-74

Increasing the aluminium fraction will provide an improvement for all impact categories and vice versa for decreasing the aluminium fraction because the environmental benefits related to aluminium are the highest out of all dominant materials (see Table 17). When increasing the aluminium, the environmental benefits increase with 5-6% for all impact categories and the opposite happens when decreasing the aluminium fraction.

5.3.2 Transport to bulk-up locations

A sensitivity analysis was undertaken on the distance travelled to the bulk-up locations because there is some uncertainty in these numbers. The distance travelled was varied by ±10%. Results are shown in Table 19.

Table 19: Result of sensitivity analysis on transport distances to bulk-up locations

Impact category	Unit	Baseline	Bulk-up transport 10% increase	Bulk-up transport 10% decrease
Climate change	kg CO2 eq	-153	-152	-153
Energy depletion	MJ	-1327	-1326	-1329
Water volume	L	-6375	-6364	-6387
Particulate matter	g PM2.5	-78	-78	-79

Increasing and decreasing the distances travelled to the bulk-up locations by 10% slightly changes the overall results, but the differences are minimal. The impact of the transport on the overall impact is only a small portion, changing this number will therefore not significantly change the outcome.

5.3.3 Consumer transport

The consumer transport contributes a significant portion to the overall impact. Therefore, a sensitivity analysis was conducted on the percentage of dedicated trips for each location type to obtain the lowest and highest expected consumer transport distances. Table 20 shows the dedicated trip percentages for the high and low scenarios. Table 21 shows the related environmental impacts.

Table 20: Values used for sensitivity analysis on consumer transport distances

Location Type	Unit	Dedicated trip high	Dedicated trip low
Co-located in a shopping district	%	15%	5%
Co-located with a single business	%	60%	40%
Stand-alone location	%	90%	70%

Table 21: Result of sensitivity analysis on consumer transport distances

Impact category	Unit	Baseline	Consumer transport high	Consumer transport low
Climate change	kg CO2 eq	-153	-149	-158
Energy depletion	MJ	-1327	-1320	-1338
Water volume	L	-6375	-6326	-6445
Particulate matter	g PM2.5	-78	-76	-81

Consumer transport is one of the biggest contributors to the environmental burdens. Varying the distances to the highest and lowest expected values results in a variation of approximately ± 3% for climate change and particulate matter and ± 1% for fossil fuel depletion and water volume, with respect to the baseline. This shows that the model is reasonably robust to these changes.

5.4 Data quality assessment

The quality of key datapoints was assessed and is reported in Table 22, showing that the most critical aspects of the model were modelled from good or very good quality data.

Table 22: Data quality assessment

	Approximate % Climate change Contribution	**Reliability**	**Time-related coverage**	**Geographical coverage**	**Technology coverage**	**Comment**
Aluminium recycling	<5%	Good	Fair	Fair	Good	Ecoinvent database v3.11
Virgin aluminium offset	>70%	Good	Good	Good	Very good	Ecoinvent database v3.11
PET recycling	<5%	Good	Fair	Fair	Good	Ecoinvent database v3.11
Virgin PET offset	>5%	Good	Fair	Fair	Good	Ecoinvent database v3.11
Glass recycling	<5%	Very good	Very good	Very good	Very good	Tushar et al. (2023).
Sand offset	<1%	Good	Good	Fair	Good	Ecoinvent database v3.11
Consumer transport distance	<10%	Good	Good	Good	Good	Source: TasRecycle
CSR transport distances	<5%	Very good	Very good	Very good	Very good	Source: TasRecycle
Transport type	<5%	Very good	Very good	Very good	Very good	Source: TasRecycle

5.5 Equivalence metrics

To communicate the benefits of the Tasmanian CRS, a table of metrics was developed using familiar activities which can be analogous with the results of this LCA more easily. The impact and corresponding metric are displayed in Table 23, step by step calculations on the numbers can be found in Appendix A.

Table 23: Equivalence metrics, per 1000 containers

Impact	Metric	Result	Source
Reduction in CO2 emissions	Kilometres of driving	795.3	National Transport Commission (Australian average)
	Tasmanian cars on the road for one year	0.07799	Australian Bureau of Statistics
Energy depletion	Hours of TV use	1035	Average of 125cm (49") TVs on the market
	Tasmanian homes powered for one year	0.01767	Australian Bureau of Statistics
Water use	Hours of showering	11.81	Australian Gov - Department of Climate Change, Energy, the Environment and Water
	Olympic pools filled	0.002550	Measurements Olympic pool: 50m x 25 x 2m
Particulate matter	kg of wood in wood heater	7.831	(AusGov)

Climate change impact is typically calculated and presented in kilograms of carbon dioxide equivalent (kg CO2-eq), which scales in the influence of other greenhouse gas emissions that have greater or lesser influence on global warming compared to CO_2 such as methane or nitrous oxide. Creating metrics that are analogous with CO_2 is innately difficult due to the variables associated with emission and absorption rates. One relatable metric chosen was the number of kilometres driven by a passenger car. The National Transport Commission calculated the emissions produced by an averaged sized passenger vehicle to be 0.192 kg per km on average (Hopkins, 2025). This will vary depending on the type of car, driving behaviour, fuel quality, and a multitude of other factors but is accurate for an unknown audience that represents the variability of these influences. Another metric chosen to represent the climate change impact is number of Tasmanian cars on the road. The average annual emissions related to driving one car in Tasmania are 1958 kg (ABS, 2020). Using the results from the LCA it was calculated that the environmental benefits related to 1000 containers returned is 152.7 kgCO_2-eq, which is comparable to avoiding 795.3 km of driving or the removal of 0.07799 Tasmanian cars per year.

Fossil fuel depletion is a measure of the amount of energy available by the combustion of fossil fuels, which is why it is presented in megajoules (MJ). To make this a relatable number, the metric chosen is hours of television watched. As TVs are sold in a variety of sizes, the energy consumption of a 49-inch LCD TV was chosen as it is middle of the range between 100-150W of power. Additionally, another metric that was looked at was Tasmanian households powered for one year. According to the Australian Bureau of statistics, an average Tasmanian household consumes 7324 kWh annually (ABS, 2014). The results from the LCA show that the benefits related to fossil fuel depletion equate to 1327 MJ for every 1000 containers returned. Assuming an efficiency of 35.1% for converting fossil energy into electricity (Saddler et al., 2004), this is equals 129.4 kWh, which is comparable to avoiding 1035 hours of TV usage or avoiding powering 0.01767 Tasmanian households for one year.

The third category of water volume is the amount of water used. As it is difficult to envision large amounts of water by volume, the metric of minutes showering was chosen to aide with conceptualisation. A water efficient showerhead dispenses 9 litres of water per minute of showering (AustralianGov, Accessed 2025). Another metric chosen was the number of Olympic pools (2500 m3) filled with water. Using the results from the LCA, it was calculated that the benefits for every 1000 containers returned equate to 6375 litres of water, which is comparable to avoiding 11.81 hours of showering or removing 0.002550 Olympic pools.

The final category is the quantity of fine particles that are less than 2.5 microns in size produced by a given process. These particles are of concern to the environment as well as human health because they can be inhaled and absorbed directly into tissue and the blood stream with adverse consequences (NSW Government, 2020). Their impact is difficult to conceptualise because these particles are impossible to see with the human eye. To achieve a communicable format, kilograms of wood in a wood fired heater was chosen as the metric because woodsmoke is a common source of PM2.5 particles. On average, burning 1 kg of wood results in the emission of 10 g of PM2.5 particles (AusGov). Using the results from the LCA it was calculated that the benefits for every 1000 containers returned equate to 78.31 g of PM2.5 emitted, which is the same amount produced by the burning of 7.831 kg of firewood.

6 Conclusion

The results from this LCA show there are substantial benefits associated with the recycling of common drink containers. The results have been quantified for the communication of these benefits to the Tasmanian public.

The main contributors to the overall environmental burden are consumer transport and the recycling processes. Burdens related to consumer transport could be reduced by adding more refund points. While this would likely increase energy consumption, it would probably improve the overall impact because energy consumption is currently low. Recycling processes are difficult for TasRecycle to improve because these are conducted by external parties. An improvement could be achieved by transporting materials to closer recycling facilities; however, transport does not have a major impact and this would therefore not significantly reduce the overall burden. The main benefits arise from avoiding virgin aluminium and PET production.

The model is shown to be robust for variations in the transport distances to bulk-up locations. Differences in consumer behaviour (fraction of aluminium and consumer transport) may result in some variation of the overall impact but this variation will be limited.

7 Limitations

The limitations of this assessment relate to the use of background and literature data to represent processes when primary data is unavailable. The details of the limitations are provided below:

- Collection and transportation procedures: certain assumptions were made regarding consumer transport distances and the distances to recycling destinations.
- Energy consumption of refund and bulk-up points: Assumptions had to be made on energy usage during active and idle time of the refund sites and bulk-up points.
- Various assumptions made regarding the masses of containers: Average container masses were used.
- Consumer return behaviour: Assumptions were made on number of items returned per trip, frequency of trip, etc.

The variable masses and composition of containers on the market make definitive impact assessments difficult as the sorting process is limited by this diversity. However, it is unlikely that more detailed information would have a significant influence on the overall impacts across the categories as care was taken to ensure the most complete dataset available was utilised.

Note this is not a consequential study and does not represent the marginal benefits of implementing the CRS on top of the pre-existing kerbside program. The calculation also makes no assessment of impacts of avoided littering or landfill disposal of drink containers.

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Appendix A.

Metrics calculations

Climate change			
			Source / calcs
Climate change result	-152.7	kg CO2eq / 1000 containers	
Kilometres of driving			
Transport emission	0.1920*	kg CO2eq / km	NTC
Kilometres of driving	-795.3	km / 1000 containers	-152.7 / 0.1920
Tasmanian cars per year			
Average distance driven in Tasmania passenger cars	10200	km / year	ABS
Emission one Tasmanian car	1958	kg CO2eq / year	10200 x 0.1920
Tasmanian cars	-0.07799	cars/1000 containers	-152.7 / 1958

* Average of inner metro areas (181 g/km) and rural areas (202 g/km) in Australia.

Fossil fuel depletion			
			Source / calcs
Fossil fuel depletion results	-1327	MJ / 1000 containers	
Conversion efficiency MJ to kWh	35.1%*		(Saddler et al., 2004)
Electricity generated	129.4	kWh / 1000 containers	1327 x 35.1% / 3.6
Hours of TV watched			
Average power usage TV	125	W	Reviewed sites selling TVs
Hours of TV use	-1035	hours / 1000 containers	-129.4 x 1000 / 125
Tasmanian households powered			
Average energy consumption Tasmanian household	7324	kWh / year	ABS
Tasmanian households powered	-0.01767	Households / 1000 containers	-129.4 / 7324

* Assumed all electricity is generated from natural gas.

Water use			
			Source / calcs
Water use results	-6375	L / 1000 containers	
Hours of showering			
Average waterflow shower	9	L/minute	AU government
Hours of showering	-11.81	hours / 1000 containers	-6375 / 9 / 60
Olympic pools filled			
Volume olympic pool	2500000	L	50m x 25m x 2m
Olympic pools filled	0.002550	pools / 1000 containers	-6375 / 2500000

Particulate matter			
			Source / calcs
Particulate matter results	-78.31	g PM2.5 / 1000 containers	
Wood in wood heater			
Particulate matter emissions from burning wood	10	g / kg wood	AU government
Wood in wood heater	-7.831	kg / 1000 containers	-78.31 / 10

Appendix B.

	Consumer transport	CDS transport	CDS energy usage	Recycling transport	Recycling processes	Avoided material	Total
Climate change				kg CO2 eq			
Aluminium	0.79	0.26	0.02	0.08	0.79	-19.31	-17.36
PET	0.34	0.26	0.01	0.02	0.07	-3.21	-2.50
Glass (glass to sand)	0.06	0.11	0.00	0.00	0.00	-0.03	0.14
HDPE	0.23	0.26	0.00	0.02	0.36	-2.68	-1.80
LPB	0.67	0.26	0.01	0.12	0.80	-0.96	0.91
Steel	0.28	0.26	0.01	0.07	0.20	-1.33	-0.51
Fossil fuel depletion				MJ NCV			
Aluminium	1.58	0.51	0.20	0.43	2.69	-155.31	-149.90
PET	0.69	0.51	0.09	0.32	0.64	-10.18	-7.93
Glass (glass to sand)	0.11	0.22	0.01	0.05	0.00	-0.17	0.23
HDPE	0.46	0.51	0.06	0.32	2.56	-9.01	-5.10
LPB	1.35	0.51	0.17	0.45	2.41	-4.20	0.69
Steel	0.56	0.51	0.07	0.43	2.16	-17.12	-13.39
Water volume				Litres			
Aluminium	10.84	4.03	0.08	0.37	48.51	-722.77	-658.95
PET	4.70	4.03	0.03	0.11	6.54	-123.63	-108.21
Glass (glass to sand)	0.76	1.74	0.01	0.02	0.01	-3.65	-1.13
HDPE	3.18	4.03	0.02	0.11	16.02	-162.00	-138.62
LPB	9.24	4.03	0.06	0.55	104.83	-112.97	5.74
Steel	3.84	4.03	0.03	0.34	0.82	-10.21	-1.16
Particulate matter				g PM2.5			
Aluminium	0.441	0.123	0.004	0.066	0.837	-10.077	-8.607
PET	0.191	0.123	0.002	0.008	0.028	-1.839	-1.487
Glass (glass to sand)	0.031	0.053	0.000	0.001	0.000	-0.049	0.036
HDPE	0.130	0.123	0.001	0.008	0.368	-1.341	-0.712
LPB	0.376	0.123	0.003	0.112	0.436	-2.077	-1.027
Steel	0.156	0.123	0.001	0.059	0.042	-0.674	-0.293

Appendix C.

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Critical review statement – Life Cycle Assessment of Tasmania's Container Refund Scheme

30 January 2026

This critical review statement reports the results of the critical review process of the life cycle assessment (LCA) study identified below. The reviewed report documents the LCA conducted on the Tasmanian container deposit scheme 'Recycle Rewards'.

Life cycle assessment report details

- **Title of the study** – Life Cycle Assessment of Tasmania's Container Refund Scheme.
- **LCA commissioner** – TasRecycle.
- **LCA practitioners** – Anna Boyden and Roos Visser at Lifecycle Pty Ltd.
- **Reviewed version of the (final) report** – Version provided on 30 January 2026 (version 2.0).
- **Reviewer** – Kyle O'Farrell (Director | Blue Environment)

Description of the review process

Kyle O'Farrell undertook this LCA report critical review. The review process consisted of:

- Review of the 16 January 2026 version of the report (v1.2), followed by the issue of the critical review report (version 1) on 27 January 2026.
- Review of the 29 January 2026 version of the report (v2.0), followed by the issue of the critical review report (version 2) on 30 January 2026.
- Review of the 30 January 2026 version of the report (unchanged at v2.0), followed by the issue of the critical review report (version 3) on 30 January 2026.

As no non-compliances or other major issues were identified in the 30 January 2026 version of the LCA report, the final review report was then issued to Lifecycles and TasRecycle, and this critical review statement was prepared.

The 3 versions of the LCA report reviewed were:

- Boyden A. & Visser R. (2025a), ***Life Cycle Assessment of Tasmania's Container Refund Scheme (version 1.2)***, Lifecycles, Melbourne, Australia – as provided to Blue Environment on 16 January 2026.
- Boyden A. & Visser R. (2025b), ***Life Cycle Assessment of Tasmania's Container Refund Scheme (version 2.0)***, Lifecycles, Melbourne, Australia – as provided to Blue Environment on 29 January 2026.
- Boyden A. & Visser R. (2025c), ***Life Cycle Assessment of Tasmania's Container Refund Scheme (version 2.0)***, Lifecycles, Melbourne, Australia – as provided to Blue Environment on 30 January 2026.

The review was undertaken with reference to relevant guidance provided in the following standards and guidelines:

- ISO, 2006a. International Standard ISO 14040:2006 *Environmental management - Life cycle assessment - Principles and framework*.
- ISO, 2006b. International Standard ISO 14044:2006 *Environmental management - Life cycle assessment - Requirements and guidelines*.

Summary elements of the review process are:

- The review has been undertaken in line with the requirements of the LCA standards ISO 14040:2006 and ISO 14044:2006.
- The review was undertaken at the end of the study.
- The review included a limited assessment of the LCI model, based on the summary outputs provided in the reviewed report.
- The review did not include an assessment of individual datasets. However, it did include an assessment of data incorporated into the modelling (as provided in the report), and the consistency of the LCI outputs with other similar LCA reports, to which it was found to be consistent.

For brevity, the detailed review comments on the 30 January 2026 report, are not provided in this critical review statement, but are detailed in the final version of the critical review report (version 3 – dated 30 January 2026).

Statement of conformance

The reviewed LCA report (version 2.0 dated 30 January 2026) is considered to meet requirements of the LCA standards ISO 14040:2006 and ISO 14044:2006.

Yours sincerely

Kyle O'Farrell
Director