LCA of Beverage and Food Packaging in Australia and New Zealand

On behalf of Tetra Pak

thinkstep anz

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Executive Summary

Goal and Scope

Tetra Pak Oceania engaged thinkstep-anz to carry out a Life Cycle Assessment (LCA) comparing the environmental performance of beverage/food cartons to other packaging choices available on the Australian and New Zealand markets in 2019/20. This study is intended for internal staff, customers, and other stakeholders.

This study considers a range of packaging size classes (from 200 mL to 2 L), product categories (long-life milk, fresh milk, juice, water, and food), and filling types (fresh and aseptic). The primary packaging materials considered include cartons, PET bottles, recycled PET (rPET) bottles, HDPE bottles, pouches, aluminium cans, tinplated steel cans, glass bottles and glass jars. Given that Tetra Pak does not manufacture these alternative packaging formats, 106 packages available in Australia and New Zealand in November/December 2019 were purchased from retailers, cleaned and weighed, with further detail added for 28 types of carton derived from Tetra Pak's design specifications.

The entire packaging life cycle and all packaging levels have been included within the scope of this study. The life cycle stages considered include material production, pack manufacture, filling, transport, and end-of-life. Impacts from refrigeration of chilled products were considered to be part of the life cycle of the chilled beverage/food product and therefore excluded from this study. The packaging levels considered include the primary packaging (consumer packaging), secondary packaging (a one-way shipper carton or reusable crate) and tertiary packaging (a pallet). The impact of coatings and printing inks were excluded from the study.

Carbon footprint (as measured by Global Warming Potential, or GWP) is used as a headline indicator within this report to simplify the analysis and interpretation. The results for other environmental indicators are documented in annexes and only discussed in the body of the report if they change the conclusions drawn from the carbon footprint alone.

Two packaging-related metrics are also reported: product-to-packaging ratio and the amount of plastic packaging per litre of product. The former metric is used to demonstrate the mass of packaging required per mass of product, while the latter metric focuses solely on the mass of plastic packaging required to deliver a fixed volume of product.

This study complies with international standards ISO 14044:2006 for LCA and ISO 14067:2018 for product carbon footprinting. As a comparative study, it has undergone a critical review by a panel of three independent experts.

Results: Product-to-Packaging and Plastic-per-Litre Ratios

This study shows that cartons have the second-highest product-to-packaging ratio of all packaging systems considered, after pouches. In general, cartons have a low plastic-per-litre ratio, with only glass, tinplated steel, and aluminium packaging having lower ratios; however, the amount of plastic per litre of product varies to a large degree between cartons depending on whether the carton is fresh or aseptic, and if it has a lid or straw.

Results: Carbon Footprint

Cartons were found to have the lowest – or lowest-equal – carbon footprint of all packaging systems included within this study across all sizes classes and product categories considered. This is due to a combination of their light weight, the relatively low impact of paperboard per kilogram, and the biogenic carbon sequestered in paperboard during tree growth (which may only be partly re-released at end-of-life for products in landfill).

Figure 1-1 and Figure 1-2 show the results for 1 L and 250 mL aseptic packaging systems, respectively. These two size classes were chosen to show the results for pouches and 100% recycled PET (rPET) bottles – the two packaging systems whose carbon footprint is most comparable to cartons.

The vertical axis in both charts shows GWP over a 100-year time horizon. Sequestration of biogenic carbon during tree/plant growth, releases of biogenic carbon from land use change (in the few cases where this occurs) and releases of biogenic carbon from end-of-life (EoL) of the packaging are combined in the “Consumer EoL” and “Shipper & Pallet Total” bars in the charts below, with all other bars showing the contribution from fossil carbon only.

The charts present an unweighted average of the carbon footprint results for all individual products included within a given size class, country, and packaging format (which includes long-life milk, juice, and water in these two charts). The red bars show the range of results found within a given category, reflecting different product masses within that category to deliver the same volume of beverage. A small deviation in range either indicates low variation due to better data (as is the case for cartons) or a smaller number of samples (as is the case for the glass jar and the pouch in the 250 mL category below). The dashed line over the PET and rPET bars shows the results for lightweight water bottles. These results have been presented separately as lightweight PET was only found in the water category.

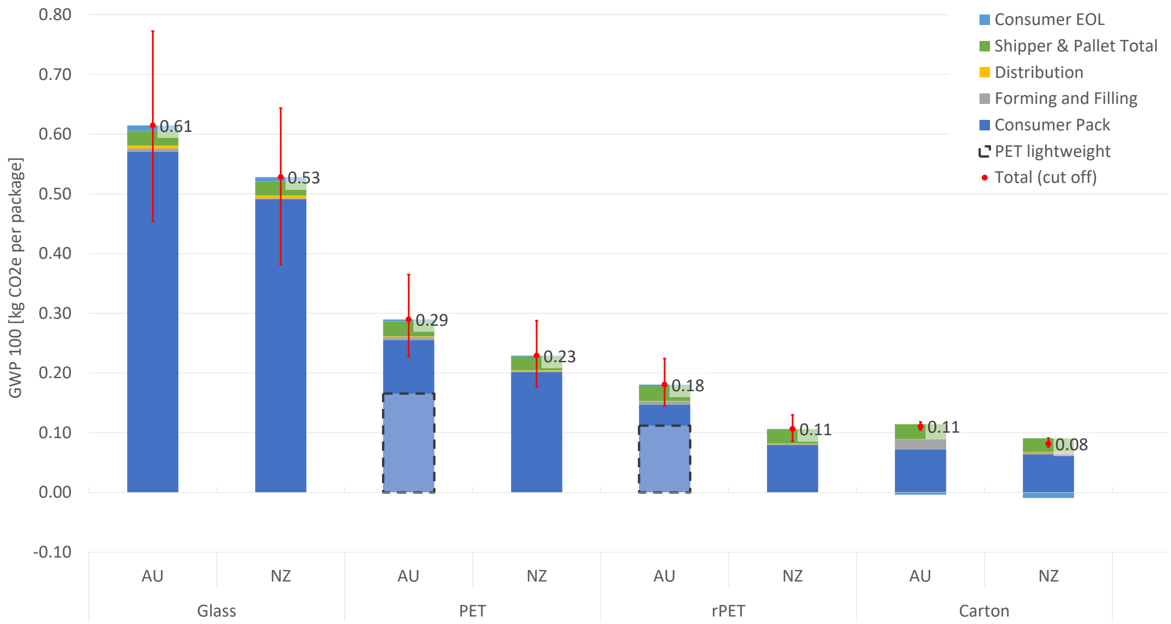

Figure 1-1: GWP of 1 L aseptic packaging system. Carton is equivalent to a Tetra Pak Aseptic 1 L.

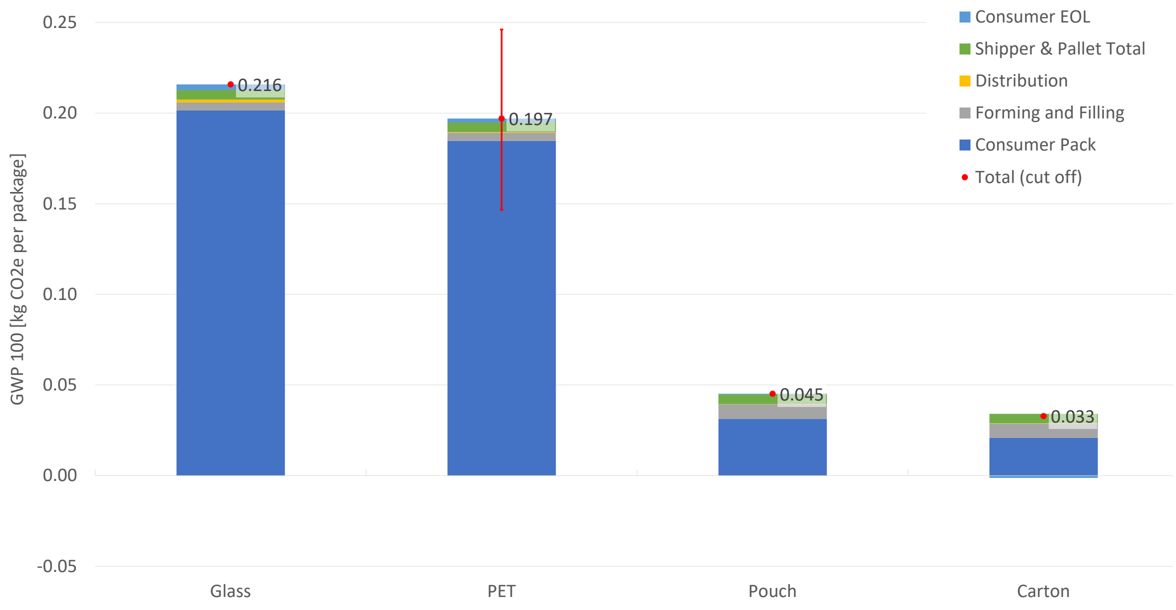

Figure 1-2: GWP of 250 mL aseptic packaging system (Australia only). Carton is equivalent to a Tetra Pak Aseptic Square 250 mL (with straw).

Figure 1-1 and Figure 1-2 show that cartons have the lowest carbon footprint of all packaging systems considered on average, though pouches and lightweight rPET bottles (made from 100% rPET, as is assumed in Figure 1-1) have a comparable carbon footprint. Glass and virgin PET have considerably higher carbon footprints. For glass, this is due to its high mass. For PET, this is due to a combination of its carbon footprint per kilogram of packaging material (for both charts) and its relatively high mass in smaller pack formats (250 mL format only).

Results: Other Environmental Impact Indicators

Analysis of other environmental impact indicators shows that cartons have lower impacts than glass bottles/jars, steel cans and virgin aluminium cans across all indicators in all packaging size classes considered by this study. Depending on the size class, lightweight PET/rPET water bottles (Australia) and rPET bottles (New Zealand) had comparable or lower impacts than cartons across several impact indicators considered in this study (particularly acidification, eutrophication, and photochemical ozone creation potential). In the categories where they were found, pouches were the best performing packaging format for many of the other environmental indicators (acidification, eutrophication, photochemical ozone creation potential and Water Scarcity Footprint) due to their light weight.

Sensitivity Analyses

Sensitivity analyses were used to test if the conclusions of this study would change with different input data and/or methodological choices. The analyses conducted considered:

- Carton end-of-life, specifically:
  - The share of cartons sent to landfill versus the share sent to recycling;
  - The proportion of recycling that occurs onshore; and
  - If sent to landfill, how much of the biogenic carbon in the carton degrades and how much of it is released to air as carbon dioxide and methane.
- Plastic bottle mass variation.
- End-of-life recycling allocation approach: cut-off versus substitution.
- Sourcing of virgin (primary) aluminium: global electricity mix versus hydro power.

The outcomes of these sensitivity analyses show that:

- Cartons continue to have the lowest – or lowest-equal – carbon footprint of all pack formats assessed, regardless of variation in the plastic bottle mass, sourcing of aluminium, or choice of end-of-life allocation method.
- If the worst possible case for cartons is considered at end of life (100% landfill, 0% landfill gas capture, 50% degradation of the paper in the carton laminate – equivalent to the degradation of uncoated paper), pouches, lightweight PET/rPET bottles, and rPET bottles can have lower carbon footprint than cartons. However, this scenario is the worst case for a single carton and does not represent market-average performance.

Conclusion

The results of this study indicate that cartons have the lowest – or lowest-equal – carbon footprint of the most commonly used beverage and food packaging systems available on the Australian and New Zealand markets in late 2019 across all considered size classes (from 200 mL to 2 L) and product categories (long-life milk, fresh milk, juice, water, and food). Pouches, lightweight PET and 100% recycled PET (rPET) can offer similar carbon footprints in some cases; however, all three packaging systems have higher plastic-per-litre ratios than cartons. Cartons have the second-highest product-to-packaging ratio of all packaging systems considered, after pouches. Australasian beverage and food producers who wish to minimise their carbon footprint should, therefore, strongly consider cartons as a preferred packaging choice.

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1. Goal of the Study

Tetra Pak is one of the world's leading suppliers of food and beverage packaging systems, with products to suit a wide variety of requirements. Several comparative life cycle assessment (LCA) studies of Tetra Pak products have already been completed across the European and North American markets, but no studies have so far looked at the Australian and New Zealand markets.

This study aims to conduct a robust and transparent LCA of Tetra Pak packaging systems in comparison to a range of competitive packaging systems for fresh milk, long-life milk, juice, water, and packaged food within the Australian and New Zealand markets. For a fair comparison different classes of packaging types are defined, according to performance, i.e. fresh and aseptic for beverages and aseptic for food, and to size from 200 mL to 2 L. Tetra Pak packaging are compared against alternative packaging options within those classes.

This study complies with international standards ISO 14044:2006 for LCA and ISO 14067:2018 for product carbon footprinting. It is primarily based on data from the 2019 calendar year.

This study intends to provide Tetra Pak with a factual basis with which it can make statements to current and potential clients about the environmental performance of its packaging when compared to other systems. These statements will focus on the carbon footprint of products and on packaging metrics such as the product-to-packaging ratio and the mass of plastic per litre of product. Other indicators are shown in Annex J but are not commented on in this report unless they change the conclusions drawn from the carbon footprint alone. Because the results from this study will be used to make public comparative assertions, this study has been critically reviewed by a panel of experts in both LCA and packaging, as required by ISO 14044:2006 and ISO 14067:2018. A critical review statement can be found in Annex A.

2. Scope of the Study

The following sections describe the general scope of the project. This includes the identification of the specific product systems assessed, the product functions, functional unit and reference flows, the system boundary, allocation procedures, and cut-off criteria of the study.

2.1. Product System(s)

The products analysed in this study include a range of packaging systems for a variety of beverages and food within the Australian and New Zealand markets. These systems cover a range of packaging size classes (from 200 mL to 2 L), product categories (long-life milk, fresh milk, juice, water, and food), and filling types (fresh and aseptic). The primary packaging materials considered include cartons, PET bottles, HDPE bottles, pouches, aluminium cans, tinplated steel cans, glass bottles and glass jars.

Data for the individual packages was obtained by weighing 106 packages available in Australia and New Zealand in November/December 2019, with further detail added for 28 types of carton derived from Tetra Pak's design specifications. All packages were purchased from retailers, disassembled, cleaned, dried, and weighed. Where possible, three different examples for each primary material (PET, glass, etc.) were weighed and an average weight was taken for each product category, size class and country. However, this was not possible for many material types as there was not a large enough range of options available in major supermarkets.

To simplify the presentation of results, packaging systems with the same volume, primary material, and country of purchase have been aggregated in the main body of this report. For example, Australian 1 L PET bottles for water, juice and long-life milk have been combined into one average Australian 1 L PET bottle. Results for fresh milk packaging are shown separately due to different carton composition and filling requirements.

The packaging size classes included are:

- 2 L aseptic beverage
- 2 L fresh milk
- 1 L aseptic beverage
- 1 L fresh milk
- 600 mL aseptic beverage
- 330 mL aseptic beverage
- 250 mL aseptic beverage
- 200 mL aseptic beverage
- 500 mL food (retorted)
- 400 mL food (retorted)

The following high-level assumptions per packaging material and described below:

- **Cartons** are manufactured from a multi-layer paperboard/plastic laminate that is produced in either Europe or Asia and distributed to Australia and New Zealand on either a roll or as blanks. Cartons are then formed and filled in-market.
- **Virgin PET bottles** are manufactured from plastic granulate manufactured in Asia and formed locally in Australia and New Zealand. Both the manufacturing of the pre-form and bottle blowing are assumed to occur in-market.

- **Recycled PET bottles** are assumed to be manufactured from plastic granulate that is captured and recycled in-market (i.e. within Australia and New Zealand). The pre-form and bottle blowing are both assumed to occur in-market.
- **Pouches** are manufactured in China and then transported to the country of purchase for filling.
- **Glass containers** are manufactured in the country of purchase using standard manufacturing techniques.
- **Tinplated steel cans (for food)** are manufactured from virgin steel (blast furnace route) using standard manufacturing techniques. It is assumed that cans are manufactured in-market from coils of rolled steel imported from Asia. The final can-making dataset used in this study is North American.
- **Aluminium cans (for beverages)** are manufactured from a combination of virgin aluminium (using the global production mix) and recycled aluminium using standard manufacturing techniques. Two scenarios are applied in this report: 0% recycled content (worst case) and 70% recycled content (best case). It is assumed that cans are manufactured in-market from coils of rolled aluminium purchased on the global market and imported from Asia. The final can-making dataset used in this study is European.

These assumptions do not necessarily reflect market-average performance for each packaging material (e.g. recycled plastic granulate is often imported and pre-forms can be manufactured offshore, particularly within New Zealand). Instead, a conservative approach has been used, which means that, where there is uncertainty, a choice has been made in a way that is designed to favour alternative packaging formats over cartons. In the case of aluminium, two scenarios were used due to significant variability within the aluminium supply chain which has a significant influence on the results.

2.2. Product Function(s) and Functional Unit

The functional unit of this study is based on one unit of consumer packaging, as delivered to the retailer and disposed of by the consumer. This means that this report includes multiple functional units due to the variety of packaging sizes assessed. A distinction is made between short-life (fresh) and long-life (shelf-stable) products. Furthermore, long-life products are divided into aseptically filled beverages and retorted food products. Within each of these categories, it is assumed that all packaging options fulfil the equivalent function of protecting the product and that there is no difference in shelf-life.

Comparisons are only made within the same size class – products of different size classes are not compared. The results are deliberately not normalised (e.g. to 1 L of beverage) because packaging suppliers optimise their packs to meet each given size class and consumers typically purchase packs that suit their consumption patterns. So, for example, a consumer who purchases a 2 L milk bottle is likely purchasing this instead of two 1 L bottles because they are more likely to consume the milk quickly. The packaging types weighed in each size class are shown in Table 2-1 and Table 2-2.

Cartons shown in the size class are all weighed averages taken from the Australian and New Zealand markets, except for the 400 and 500 mL aseptic food which are based on specifications for the Tetra Recart (with the Tetra Recart 390 mL scaled to 400 mL).This is due to the Tetra Recart not being available in these markets in late 2019 when the weighing was done.

Table 2-1: Packaging types weighed: 600 mL to 2 L

Size Class	Carton	PET	rPET	HDPE	HDPE Lightproof	Glass
2 L aseptic beverage	X[1]	X[1]		X[1]		
2 L fresh milk	X	X[2]	X[2]	X	X[2]	
1 L aseptic beverage	X	X	X			X
1 L fresh milk	X	X	X	X	X[2]	X
600 mL aseptic beverage	X	X	X			

1 Packaging type only weighed in Australia
2 Packaging type only weighed in New Zealand

Table 2-2: Packaging types weighed: 200 mL to 500 mL

Size Class	Carton	PET	Glass	Aluminium pouch	Aluminium can	Steel can
330 mL aseptic beverage	X[1]		X[1]		X[1]	
250 mL aseptic beverage	X[1]	X[1]	X[1]	X[1]		
200 mL aseptic beverage	X[2]			X[2]		
500 mL food (retorted)	X[3]		X			X
400 mL food (retorted)	X[3]			X[2]		X[2]

[1] Packaging type only weighed in Australia
[2] Packaging type only weighed in New Zealand
[3] Carton mass taken from Tetra Pak specifications for the Tetra Recart (400 mL scaled from 390 mL)

As well as analysing the environmental impacts of generic cartons versus other types of packaging, this study looks at the impacts of specific Tetra Pak cartons (see Section 5.7, Annex K, and Annex M). Table 2-3 and Figure 2-1 shows the Tetra Pak cartons studied, as well as their carton mass (not including straw/cap).

Table 2-3: Tetra Pak cartons analysed

Tetra Pak Product Class	Size	Carton mass (g)	Cap	Straw	Other information
Tetra Brik Aseptic Square	1 L	33.1	Yes	No	
Tetra Brik Aseptic Base	2 L	56.6	Yes	No	
	200 mL	8.0	No	Yes	
Tetra Brik Aseptic Edge	1 L	29.0	Yes	No	
	250 mL	9.9	Optional	Optional	
Tetra Brik Aseptic Slim	1 L	31.1	Yes	No	
	250 mL	9.3	No	Yes	
	200 mL	8.6	No	Yes	
Tetra Prisma Aseptic Square	1 L	35.3	Yes	No	
	330 mL	12.8	Yes	No	
	250 mL	33.1	No	Yes	
	200 mL	8.7	No	Yes	
Tetra Top	1 L	21.1	Yes	No	Bioplastic cap and neck
	500 mL	15.1	Yes	No	Bioplastic cap and neck
	330 mL	11.1	Yes	No	Bioplastic cap and neck
Tetra Rex	1 L	31.0	Optional	No	
	1 L (bio)	26.2*	Optional	No	Bioplastic film for laminate
	600 mL	22.5	Optional	No	
	600 mL (bio)	19.0*	Optional	No	Bioplastic film for laminate
Tetra Recart Midi	500 mL	20.5	No	No	Polypropylene film for laminate (for retorting)
	390 mL	16.9	No	No	Polypropylene film for laminate (for retorting)

* Fossil-derived polyethylene and bio-derived polyethylene are chemically identical and therefore have identical mass. The reduction in mass between the Tetra Rex fossil-derived and bio-derived products is due to lightweighting that occurred between product generations.

Tetra Brik Aseptic (TBA)

Tetra Prisma Aseptic (TPA)

Tetra Top

Tetra Rex
(weighed packs did not have a cap)

Tetra Recart

Figure 2-1: Tetra Pak cartons analysed

2.3. System Boundary

This is a cradle to grave analysis including material production, pack manufacture, filling, transport, and end-of-life. The packaging levels considered include the primary packaging (consumer packaging), secondary packaging (a one-way shipper carton or reusable crate) and tertiary packaging (a pallet). The impact of coatings and printing inks was excluded from the study. The impacts of those aspects were expected to be minimal compared to the impacts of the packaging materials. The impacts of production and distribution of the beverage or food contained within the consumer package is not within the system boundary. A summary of key inclusions and exclusions is provided in Table 2-4.

Plastic bottles have been assumed to be blow moulded onsite, with offsite blow moulding not included due to a previous LCA study showing that it does not have an effect on conclusions (Franklin Associates, 2015).

The forming and filling of cartons is included in the analysis, including sterilisation to make them aseptic (see Figure 2-2). Plastic and glass bottles are already formed when they reach the filling stage, so only need to be sterilised prior to being filled and sealed. Food packaging – Tetra Recart cartons, tinplated steel cans, glass jars, and retort pouches – are all assumed to be retorted (cooked) once filled and the retorting process provides the sterilisation required.

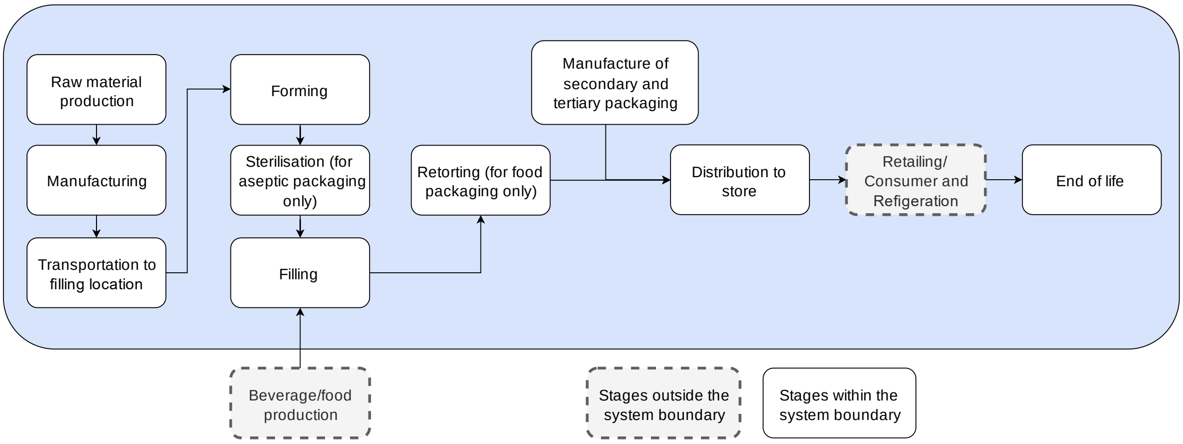

Figure 2-2: Flow diagram and system boundary

The Australian and New Zealand markets are considered in this LCA, with the major differences between the two being the electricity mix for forming/filling, transportation distances, and the methane capture rate for landfills.

Refrigeration impacts have been excluded, as this is assumed to be part of the beverage/food life cycle and therefore not part of the packaging life cycle. This exclusion will benefit heavier types of packaging, which have higher thermal mass, like glass. This methodological choice is supported by an LCA study done for Tetra Pak within the North American market, which shows that the inclusion of home refrigeration is largely irrelevant (Franklin Associates, 2015).

For biological materials which are sent to recycling (wood, paper, cardboard, bioplastics), the biogenic carbon that is sequestered when the material is produced is modelled as being released artificially as carbon dioxide to the atmosphere during the recycling process. This occurs due to the material leaving the system boundary to become part of another product system, in line with ISO 14067:2018 and supported by non-packaging standards such as EN 16485:2014 and ISO 21930:2017. From a carbon perspective, this makes recycling appear similar to incineration, with landfilling often appearing as preferential for biological materials, depending on the degradable organic carbon fraction (DOC_F) of the material and the landfill gas capture rate (see End-of-Life sensitivity analysis in 5.5.1.) However, as a generalisation, recycling of biogenic materials is likely to be environmentally preferable to landfilling because it keeps the biogenic carbon sequestered in a product.

Table 2-4: System boundaries

Included	Excluded
✓ Production and end-of-life of the components used in the consumer packaging ✓ Production and end-of-life of the components used in the display and shipment packaging ✓ Transportation of consumer, display, and shipment packaging from production facility to filling location ✓ Forming of cartons from laminated sheets and blowing/moulding of other packaging formats ✓ Filling of all packaging systems ✓ Retorting (cooking) for food packaging (considering the heating required for the packaging component, not the food) ✓ Transportation of consumer, display, and shipment packaging from filling to the retailer	× Coatings and printing inks are excluded from the study × Any product contained within the packaging × Intermediate packaging used in the transportation between the consumer packaging production facility and the filling location × Refrigeration of the filled packaging × Final transportation of packaging from the retailer to the consumer's home

2.3.1. Time Coverage

Data collection for this assessment occurred in November and December 2019. The reference year for this analysis is 2019.

2.3.2. Technology Coverage

This data used must be (and is) representative of the technologies available to packaging companies operating in Australia and New Zealand in late 2019. Tetra Recart is a notable exception, as this product was available not on the market in Australasia in 2019 and was instead assessed as a prospective new product.

2.3.3. Geographical Coverage

This LCA is intended to cover both the Australian and New Zealand markets, and uses geographically appropriate data wherever possible. Results are presented separately for Australia and New Zealand in all cases.

2.4. Allocation

2.4.1. Multi-output Allocation

Multi-output allocation is important for processes that produce two or more co-products and must follow the requirements of ISO 14044, section 4.3.4.2. Within this study, there are no significant cases of multi-output allocation in the foreground system. Allocation of background data (energy and materials) taken from the GaBi 2020 databases is documented online (Sphera, 2020).

2.4.2. End-of-Life Allocation

End-of-life allocation addresses the question of how to assign impacts from virgin production processes to material that is recycled and used in future product systems. This is important when a product system uses recycled content or is recycled at end-of-life. The approaches used follow the requirements of ISO 14044, section 4.3.4.3.

While there are many possible approaches to end-of-life allocation, there are two main approaches commonly used in LCA studies: the cut-off approach and the substitution approach (GHG Protocol, 2011). Each approach is described in Figure 2-3 and further defined in the next few sections.

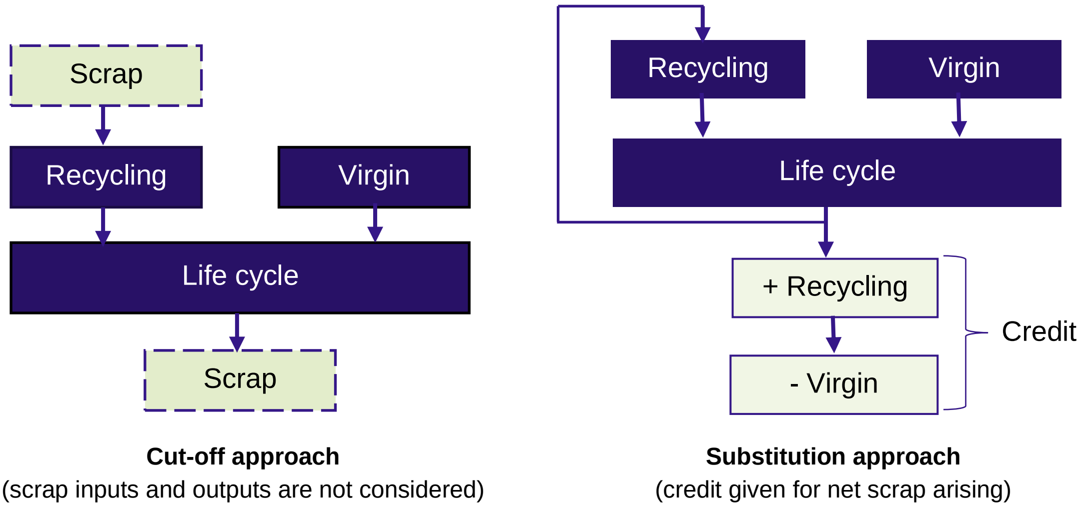

Figure 2-3: Flow diagrams for cut-off and substitution end-of-life allocation methods

This study uses the cut-off approach as the primary method, as the authors consider it to be the most appropriate for packaging materials given that are typically of relatively low economic value and often co-mingled within the municipal waste stream. The substitution approach is tested through sensitivity analysis in Section 5.5.3.

Cut-off approach (also known as 100:0 or recycled content approach)

Burdens or credits associated with material from previous or subsequent life cycles are not considered, i.e., they are “cut-off”. Therefore, the scrap input to the production process is considered to be burden-free and, equally, no credit is received for scrap available for recycling at end-of-life. This approach rewards the use of recycled content but does not reward end-of-life recycling.

Material recycling: Any open scrap inputs into manufacturing remain unconnected. The system boundary at end of life is drawn after scrap collection to account for the collection rate, which generates an open scrap output for the product system. The processing and recycling of the scrap is associated with the subsequent product system and is not considered in this study.

Energy recovery and landfilling: Any open scrap inputs into manufacturing remain unconnected. The system boundary includes the waste incineration and landfilling processes following the polluter-pays-principle. In cases where materials are sent to waste incineration, they are linked to an inventory that accounts for waste composition and heating value as well as for regional efficiencies and heat-to-power output ratios. In cases where materials are sent to landfills, they are linked to an inventory that accounts for waste composition, regional leakage rates, landfill gas capture as well as utilisation rates (flaring vs. electricity production). No credits for electricity or heat production are assigned.

Substitution approach (also known as 0:100, closed-loop approximation, recyclability substitution or end-of-life approach)

This approach is based on the idea that material that is recycled into secondary material at end-of-life will substitute for an equivalent amount of virgin material. Hence, a credit is given to account for this material substitution. However, this also means that burdens equivalent to this credit should be assigned to scrap used as an input to the production process, with the overall result that the impact of using recycled material is the same as using virgin material. This approach rewards end-of-life recycling but does not reward the use of recycled content.

Material recycling: Open scrap inputs from the production stage are subtracted from scrap to be recycled at end of life to give the net scrap output from the product life cycle. This remaining net scrap is sent to material recycling. The original burden of the primary material input is allocated between the current and subsequent life cycle using the mass of recovered secondary material to scale the substituted primary material, i.e., applying a credit for the substitution of primary material so as to distribute burdens appropriately among the different product life cycles. These subsequent process steps are modelled using industry average inventories.

Energy recovery: In cases where materials are sent to waste incineration, they are linked to an inventory that accounts for waste composition and heating value as well as for regional efficiencies and heat-to-power output ratios. A credit is assigned for electricity output using the regional grid mix. No credit is awarded for thermal energy.

Landfilling: In cases where materials are sent to landfills, they are linked to an inventory that accounts for waste composition, regional leakage rates, landfill gas capture as well as utilisation rates (flaring vs. electricity production). A credit is assigned for electricity output using the regional grid mix.

2.5. Cut-off Criteria

Inks and dyes have been excluded from this study due to their very low mass, and the fact that whole containers have been weighed, meaning that the ink/dye mass has already been captured with the base packaging materials. No other cut-off criteria have been defined for this assessment and all reported data have been incorporated and modelled using the best available LCI data. Where specific datasets are not available for a given input or process these have been modelled using proxy data.

2.6. Scenario Analyses

The baseline scenario for this study has been defined to best reflect the most realistic situation for the packaging systems. To account for areas of uncertainty, different methodological choices and future changes in technology and packaging design, several scenario analyses have been carried out:

- The substitution approach was performed as an alternative to the cut-off end-of-life modelling used in the baseline analysis.
- Carton end-of-life alternative scenarios include varying the DOC_F of the laminated paper between 0% (no degradation, i.e. behaves as plastic), 21% (baseline) and 50% (high degradation, i.e. behaves as paper), landfill gas collection at the landfill of between 0% and 90%, and setting the carton recycling to a minimum of 0% (no recycling) and a maximum of 80% (world best-practice).
- A wide range of different plastic and glass bottle masses were assessed to account for different degrees of light-weighting (i.e. reducing the mass of packaging per product delivered). This variation is shown graphically in the results section. Two size classes were chosen for further analysis because they contained light-weight packs whose GWP results were the closest to the cartons (see Section 5.5.2).
- Two scenarios for the recycled content of aluminium cans were considered (0% and 70% recycled content, which were considered to be the minimum and maximum values available in the market). Both were included to demonstrate the possible range of results in the best and worst-case scenarios. These results are shown in the main results section as two separate products (see Section 5.2.6)

2.7. Selection of LCIA Methodology and Impact Categories

The headline indicator for this report is carbon footprint, as measured using Global Warming Potential (GWP). Other environmental indicators have been considered to understand if there are environmental trade-offs, but are only discussed in the body of this report if they affect the conclusions.

The Global Warming Potential impact category is assessed based on the characterisation factors for GWP_{100} from the IPCC's Fifth Assessment Report (IPCC, 2014). This report and the modelling behind the results shown follow the requirements of ISO 14067 (ISO, 2018). Fossil carbon, biogenic carbon and carbon from land use charge are reported as a total in the body of this report to simplify the analysis, but are reported separately in Annex I and Annex J for compliance with ISO 14067.

Other impact categories considered are:

- Acidification potential (AP)
- Eutrophication potential (EP)
- Photochemical ozone creation potential (POCP)
- Abiotic depletion for non-fossil resources (ADPE)
- Abiotic depletion for fossil resources (ADPF)
- Water Scarcity Footprint (WSF)

Eutrophication, acidification, and photochemical ozone creation potentials were chosen because they are closely connected to air, soil, and water quality and capture the environmental burdens associated with commonly regulated emissions such as NO_x, SO_2, VOCs, and others. The abiotic depletion indicators are included to highlight stress placed on mineral resources (ADPE) and fossil resources (ADPF). Water Scarcity Footprint was chosen because of keen interest in water availability, particularly within the regions of Australia and New Zealand that experience water scarcity.

These impact categories follow the guidelines of the Product Category Rules (PCR) for cartons (IEPDS, 2011) and general packaging (IEPDS, 2019). All indicators from these PCRs are included; however, a more recent version of the indicator for Photochemical Ozone Creation Potential (POCP) has been applied in this analysis. For Water Scarcity Footprint, the reader should be aware that the use of generic and regionally unspecific background data for material manufacture makes it hard to draw conclusions from what is a highly regional impact category. The authors recommend considering the unregionalised Blue Water Consumption (BWC) alongside WSF indicator as this gives an idea of total withdrawal of water from watersheds globally for each product compared.

Table 2-5: Impact category descriptions

Impact Category	Description	Unit	Reference
Global Warming Potential (GWP100)	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare.	kg CO_2 equivalent	(IPCC, 2013)
Abiotic Resource Depletion (ADP elements, ADP fossil)	The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resources and non-renewable energy resources are reported separately. Depletion of mineral resources is assessed based on ultimate reserves.	kg Sb equivalent, MJ (net calorific value)	(van Oers, et al., 2002) (CML-IA baseline method, Jan 2016 update)

Impact Category	Description	Unit	Reference
Eutrophication Potential (EP)	Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.	kg PO_4^{3-} equivalent	(Guinée, et al., 2002) (CML-IA baseline method, Jan 2016 update)
Acidification Potential (AP)	A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.	kg SO_2 equivalent	(Guinée, et al., 2002) (CML-IA baseline method, Jan 2016 update)
Photochemical Ozone Creation Potential (POCP)	A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOC and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be injurious to human health and ecosystems and may also damage crops.	kg NO_x equivalent (human health)	(Huijbregts, et al., 2016)
Water Scarcity Footprint (WSF)	An assessment of water scarcity accounting for the net intake and release of fresh water across the life of the product system considering the availability of water in different regions.	Litres of water equivalent (H_2Oe)	(Boulay, et al., 2018)

Table 2-6: Other environmental indicators

Indicator	Description	Unit	Reference
Blue Water Consumption (BWC)	A measure of the net intake and release of fresh water across the life of the product system. This is not an indicator of environmental impact without the addition of information about regional water availability.	Litres of water	(Sphera, 2020)

It shall be noted that the above impact categories represent impact *potentials*, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) actually follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the functional unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

For an overall sustainability assessment of different packaging options, factors such as the potential of littering or breakdown into microplastics should also be considered. However, these are not covered by robust methodologies for Life Cycle Impact Assessment and are therefore excluded from the scope of this study.

As this study intends to support comparative assertions to be disclosed to third parties, no grouping or further quantitative cross-category weighting has been applied. Instead, each impact is discussed in isolation, without reference to other impact categories, before final conclusions and recommendations are made.

2.8. Interpretation to Be Used

The results of the LCI and LCIA are to be interpreted according to the Goal and Scope. As the headline indicator, GWP is assessed first. Other environmental indicators are only discussed insofar as the they alter the conclusions reached from the GWP results alone. The interpretation (Chapter 6) addresses the following topics:

- Evaluation of completeness, sensitivity, and consistency to justify the exclusion of data from the system boundaries as well as the use of proxy data.
- Conclusions, limitations, and recommendations.

Note that in situations where no product outperforms all alternatives in each of the impact categories, some form of cross-category evaluation is necessary to draw conclusions regarding the environmental superiority of one product over the other. Since ISO 14044 rules out the use of quantitative weighting factors in comparative assertions to be disclosed to the public, this evaluation will take place qualitatively and the defensibility of the results therefore depend on the authors' expertise and ability to convey the underlying line of reasoning that led to the final conclusion.

2.9. Data Quality Requirements

The data used to create the inventory model is as precise, complete, consistent, and representative as possible with regards to the goal and scope of the study under given time and budget constraints.

- Measured primary data are considered to be of the highest precision, followed by calculated data, literature data, and estimated data. The goal is to model all relevant foreground processes using measured or calculated primary data.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. The goal is to capture all relevant data in this regard.
- Consistency refers to modelling choices and data sources. The goal is to ensure that differences in results reflect actual differences between product systems and are not due to inconsistencies in modelling choices, data sources, emission factors, or other artefacts.
- Reproducibility expresses the degree to which third parties would be able to reproduce the results of the study based on the information contained in this report. The goal is to provide enough transparency with this report so that third parties are able to approximate

the reported results. This ability may be limited by the exclusion of confidential primary data and access to the same background data sources.

- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope. The goal is to use the most representative primary data for all foreground processes and the most representative industry-average data for all background processes. Whenever such data were not available (e.g., no industry-average data available for a certain country), best-available proxy data were employed.

An evaluation of the data quality with regard to these requirements is provided in Section 6.4 of this report.

2.10. Type and Format of the Report

In accordance with ISO 14040/44 requirements (ISO, 2006a; ISO, 2006b), this document aims to report the results and conclusions of the LCA completely, accurately and without bias to the intended audience. The results, data, methods, assumptions, and limitations are presented in a transparent manner and in sufficient detail to convey the complexities, limitations, and trade-offs inherent in the LCA to the reader. This allows the results to be interpreted and used in a manner consistent with the goals of the study.

2.11. Software and Database

The LCA model was created using the GaBi Software system for life cycle engineering, developed by Sphera Solutions, Inc. The GaBi 2020 LCI database provides the life cycle inventory data for the raw and process materials obtained from the background system.

2.12. Critical Review

As this study is intended to provide comparative assertions that may be made available to the public, ISO 14040/44 requires that it undergo a critical review. This critical review has been conducted by a panel of three experts:

- Rob Rouwette, Life Cycle Expert, start2see (Chair)
- Professor Gordon Robertson, Adjunct Professor, University of Queensland
- Dr Elspeth MacRae, Chief Innovation & Science Officer, Scion

The panel's Critical Review Statement can be found in Annex A. The panel has not viewed or reviewed the LCA models created in the GaBi LCA software for this project. The scope of their review is focused on this report and the confidential data which support it.

3. Life Cycle Inventory Analysis

3.1. Data Collection Procedure

In this project, data specific to Tetra Pak products (including pack specifications, site data and forming and filling data) were provided by Tetra Pak and modelled by thinkstep-anz in a modified version of Sphera's GaBi Packaging Calculator in GaBi 9. This data can be found in Section 3.10. Competitor products were physically weighed in both Australia and New Zealand (Annex H) and country-specific averages were calculated (Annex G).

Secondary packaging was observed in store and some samples were collected and weighed. This information can be found in Section 3.9.

3.2. Packaging Teardowns

3.2.1. Selection of Packs

Packs were purchased from major supermarkets in November and December 2019:

- Coles and Woolworths in Australia; and
- Countdown, Pak'nSave, and New World in New Zealand.

Packs were selected to represent a given category (e.g. Australian 1 L fresh milk packed in an HDPE bottle). The aim was to purchase three packs per category; however, there were not enough packs available to meet this aim in many cases. In cases where there were many different options, the packs that occupied the greatest shelf-frontage were selected, as these were assumed to be the highest-selling products in that category. Tetra Pak cartons were also purchased and weighed, allowing for a comparison to Tetra Pak specifications to check the accuracy of the process (as reported in Section 3.2.6).

3.2.2. Weighing Procedure

Consumer packaging was purchased, and its contents removed. Packages were thoroughly washed with warm soapy water, rinsed, and then left upside down to dry for 24 hours in a well-ventilated room. The cartons went through the same washing procedure, but these were taken apart after washing to separate components like caps and lids. When weighing, the inside of the packaging was checked to ensure that it was completely dry.

Weighing was done by Tetra Pak in Melbourne for Australian products and thinkstep-anz in Wellington for New Zealand products. Both organisations used Kern balances with 0.1g readability and 0.1g reproducibility. thinkstep-anz checked for outliers across both markets and a few packs were reweighed because of this process.

3.2.3. Scaling

Some of the products weighed did not come in sizes that matched the rest of their category. In these cases, scaling was used to estimate the mass of the pack if it were to be one of the standard sizes. Scaling was performed using one of three methods:

1. If there were two pack sizes of the same branded product (e.g. 600 mL and 1.5 L Coles water bottles), it was assumed that the packs scaled in mass linearly between the two sizes.
2. If there was only one pack size of a branded product, then it was assumed that the pack would scale in mass based on the scaling in size of a similar branded product of the same material class (e.g. the scaling of all glass bottles was based on the scaling ratio of Voss-branded glass water bottles).
3. For foil pouches and scaling where the volume changed by less than 10%, the component masses were all scaled linearly.

Only the main container (i.e., the bottle, pouch, can, or jar) was scaled as above. The cap was assumed to remain at a constant mass unless there were two samples of the same brand in different sizes that had different cap masses.

3.2.4. Product Composition Data (Size Class Averages)

The average product teardown values used for the results in Section 5.2 are presented in Table 3-1. An average of the consumer packs of the same size and primary material type was calculated for each market (e.g. Australian 1 L PET). Cartons are split into aseptic and refrigerated as aseptic cartons also include an aluminium barrier layer within the carton laminate. This same distinction is not made for other materials (PET, rPET, and glass) because there is no additional material present in the packaging for aseptic filling.

Average packs further disaggregated by beverage/food category (fresh milk, long-life milk, juice, water, and food) can be found in Annex G with results in Annex J. Raw data for all individual consumer packs weighed can be found in Annex H. Due to modelling constraints, if there are more than three plastic materials (not including cartons or other laminates) then the cap and ring component masses are summed together. As these components are injection-moulded from the same material, this would not influence the results. Where labels were made from different materials across a size class (e.g. from PET, LDPE, and paper), the average product assumes the most common material.

The size classes in Table 3-1 were determined after tearing down the packaging systems. As a result, different 'small volume' (<300 mL) size classes were chosen for Australia (250 mL) and New Zealand (200 mL) due to the packs available. PET and rPET packaging masses have been grouped together to create a single average because (1) these materials are nearly chemically identical, (2) the differences in bottle masses within the PET and rPET categories were larger than the differences between them, and (3) it provided a larger pool of bottles in the PET category, providing a fuller picture of the variability within this material category.

Table 3-1: Packaging teardown masses

Product size class and country	Packaging type	Component	Mass (g)	Material
1 L aseptic beverage and fresh milk (AU)	**Aseptic carton (aseptic only)**	Pack	34.8	Paper/PE/Al laminate
		Neck	1.1	HDPE
		Cutter	1.6	HDPE
		Cap	0.9	HDPE
	Refrigerated carton (fresh milk only)	Pack	28.4	Paper/PE laminate
	Glass	Pack	490.0	Glass
		Cap	12.1	Steel
		Label	2.0	LDPE
	Natural HDPE (fresh milk only)	Bottle	35.7	HDPE
		Cap	3.1	HDPE
		Ring	0.6	HDPE
		Label	1.0	Paper
	PET	Pack	38.3	PET
		Cap	2.8	HDPE
		Ring	0.9	HDPE
		Label	1.3	Paper
	Lightweight PET	Pack	19.3	PET
		Cap	2.5	HDPE
		Label	1.3	LDPE
	rPET	Pack	31.9	PET (100% recycled)
		Cap	2.8	HDPE
		Ring	0.9	HDPE
		Label	1.3	Paper
	Lightweight rPET	Pack	19.3	PET (100% recycled)
		Cap	2.5	HDPE
		Label	1.3	LDPE
	Aseptic carton (aseptic only)	Carton	30.2	Paper/PE/Al laminate
		Cap	2.9	HDPE
		Seal	0.2	Al/PE laminate
	Refrigerated carton (fresh milk only)	Carton	30.8	Paper/PE laminate
	Glass	Bottle	507.5	Glass
		Cap	2.0	Tin plated steel
		Label (plastic)	0.5	PET
		Seal	0.3	Laminate
	Natural HDPE (fresh milk only)	Bottle	29.1	HDPE
		Cap	1.6	HDPE
		Label	0.5	PP

Product size class and country	Packaging type	Component	Mass (g)	Material
1 L aseptic beverage and fresh milk (NZ)		Seal	0.3	Al/PE laminate
	Lightproof HDPE (fresh milk only)	Bottle	30.1	HDPE
		Cap	1.6	HDPE
		Label	0.6	PP
		Seal	0.3	Al/PE laminate
	PET	Pack	36.7	PET
		Cap	4.2	HDPE
		Label	1.4	LDPE
	rPET	Pack	36.7	PET (100% recycled)
		Cap	4.2	HDPE
		Label	1.4	LDPE
2 L aseptic beverage and fresh milk (AU)	**Aseptic carton (aseptic only)**	Pack	60.0	Paper/PE/Al laminate
		Cap	1.7	HDPE
		Neck	2.2	HDPE
		Ring	0.6	HDPE
	Refrigerated carton (fresh milk only)	Pack	61.0	Paper/PE laminate
		Cap	1.3	HDPE
		Neck	1.8	HDPE
	HDPE	Pack	54.8	HDPE
		Cap	3.6	HDPE
		Label	1.1	LDPE
	PET (aseptic only)	Pack	65.2	PET
		Cap	3.4	HDPE
		Ring	0.8	HDPE
		Label	1.7	Paper
2 L (NZ) (fresh milk only)	**Refrigerated carton (fresh milk only)**	Pack	61.0	Paper/PE laminate
		Cap	1.3	HDPE
		Neck	1.8	HDPE
	Natural HDPE	Pack	39.4	HDPE
		Cap	1.6	HDPE
		Label	0.6	PP
		Seal	0.3	Al/PE laminate
	Lightproof HDPE	Pack	43.8	HDPE
		Cap	1.7	HDPE
		Label	1.0	PP
		Seal	0.3	Al/PE laminate
	PET	Pack	54.8	PET
		Cap	2.5	HDPE
		Label	0.9	LDPE
	rPET	Pack	54.8	PET (100% recycled)

Product size class and country	Packaging type	Component	Mass (g)	Material
		Cap	2.5	HDPE
		Label	0.9	LDPE
600 mL aseptic beverage (AU)	**Aseptic carton**	Pack	22.0	Paper/PE/Al laminate
		Cap	1.2	HDPE
		Neck	1.6	HDPE
	PET	Pack	12.8	PET
		Cap	2.0	HDPE
		Label	0.5	LDPE
	rPET	Bottle	12.8	PET (100% recycled)
		Cap	2.0	HDPE
		Label	0.5	LDPE
330 mL aseptic beverage (AU)	**Aseptic carton**	Pack	16.0	Paper/PE/Al laminate
		Cap	1.4	HDPE
	Glass	Pack	245.7	Glass
		Cap	13.1	Steel
		Label	0.5	LDPE
	Aluminium can (0% recycled)	Pack	14.9	Aluminium (0% recycled)
	Aluminium can (70% recycled)	Pack	14.9	Aluminium (70% recycled)
330 mL aseptic beverage (NZ)	**Aseptic carton**[2]	Pack	16.0	Paper/PE/Al laminate
		Cap	1.4	HDPE
	Aluminium can (0% recycled)	Pack	12.6	Aluminium (0% recycled)
	Aluminium can (70% recycled)	Pack	12.6	Aluminium (70% recycled)
250 mL aseptic beverage (AU)	**Aseptic carton**	Pack	10.4	Paper/PE/Al laminate
		Straw	0.6	PP
	Glass	Pack	245.7	Glass
		Cap	13.1	Steel
		Label	0.5	LDPE
	PET	Pack	26.1	PET
		Cap	5.3	HDPE
		Label	0.5	LDPE
	Pouch	Pack	6.3	Al/PE laminate
200 mL aseptic beverage (NZ)	**Aseptic carton**	Paperboard	8.8	Paper/PE/Al laminate
		Straw	0.5	PP
	Pouch – straw	Pack	4.8	PE/Al/PET laminate
		Straw	0.4	PP
		Straw Wrapper	0.1	LDPE

Product size class and country	Packaging type	Component	Mass (g)	Material
	Pouch – lid	Pack	5.3	PE/Al/PET laminate
		Lid	3.6	HDPE
500 mL retorted food (AU)	**Carton**[1]	Pack	20.5	Paper/Al/PP laminate
	Glass	Pack	280.8	Glass
		Lid	8.1	Steel
		Label	1.2	Paper
	Steel can	Pack	52.9	Tin plated steel
		Lid	6.5	Tin plated steel
	Retort pouch	Pack	10.5	PP/Al/PET laminate
500 mL retorted food (NZ)	**Carton**[1]	Pack	20.5	Paper/PP/Al laminate
	Glass	Pack	279.7	Glass
		Lid	7.4	Steel
		Label	1.8	Paper
		Seal	0.1	Aluminium laminate
	Steel can	Pack	52.9	Tin plated steel
		Lid	6.5	Tin plated steel
400 mL retorted (NZ)	**Carton**[1]	Pack	17.2	Paper/PP/Al laminate
	Retort pouch	Pack	10.5	PP/Al/PET laminate
	Steel Can	Pack	48.5	Tin plated steel
		Label	2.2	Tin plated steel

1 No carton was found of this size class, so the corresponding Tetra Pak product packaging masses were used instead, refer to Table 3-2.
2 For the 330 mL aseptic NZ size class, the same carton was used as used in the 330 mL aseptic AU class.

3.2.5. Tetra Pak Products

Not all size classes analysed had cartons which could be purchased at the stores visited by the weighing teams. Table 3-2 shows the Tetra Pak product specifications used in place of weighed cartons.

Table 3-2: Tetra Pak products used in packaging teardown

Size class	Tetra Pak Product used
500 mL aseptic food (AU)	Tetra Recart Midi 500 mL
500 mL aseptic food (NZ)	
400 mL aseptic food (NZ)	Tetra Recart Midi 400 mL*

*The Tetra Recart 400 mL has been scaled from a Tetra Recart 390 mL

3.2.6. Tetra Pak Specifications Comparison

In Table 3-3, Tetra Pak product specifications were compared against weighed Tetra Pak products. This table accounts for the mass of the carton on its own as there is a wide variety of Tetra Pak cap options. As can be seen, there was variation in the carton mass between the specifications and the weighed cartons, with some weighed masses being heavier and others being lighter than the specification. As there was no obvious trend where the weighed masses were heavier than the specifications, it was determined that this variation is due to natural variability in the carton stock and not due to leftover product residue. It was therefore concluded that there was no need to adjust the pack masses to account for leftover product residue.

Table 3-3: Comparison of raw data with Tetra Pak specifications

Tetra Pak Product	Product	Carton mass (g)
Tetra Rex 1 L	**Tetra Rex Specifications**	**31.0**
	Meadow Fresh Farmhouse	30.5
	Naturalea Organic Milk	31.0
	Paul's Pure Organic	28.4
TBA Square 1 L	**TBA Specifications**	**33.2**
	Devondale	33.5
TBA Slim 1 L	**TBA Specifications**	**31.2**
	Liddells	30.2
TBA Slim 2 L	**TBA Specifications**	**56.8**
	Australia's Own	58.8
	Devondale	60.2

3.3. Manufacturing

3.3.1. Cartons

The body of a Tetra Pak carton is made from laminated paperboard (liquid packaging board). For aseptic beverage and food cartons, this laminate comprises paperboard, polyethylene, and aluminium (see Figure 3-1). Refrigerated (short life) cartons have a similar structure but there is no aluminium barrier layer. Tetra Recart cartons for food products are designed to be retorted (i.e. to have their filling cooked while inside the packaging, thereby sterilising it) and, as a result, use a laminate comprising paperboard, polypropylene (instead of polyethylene) and aluminium.

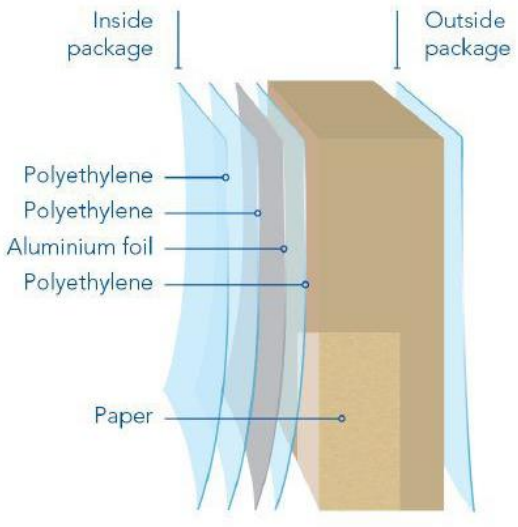

Figure 3-1: Layers of a Tetra Pak aseptic carton (source: Tetra Pak)

Liquid packaging board (marked “paper” in Figure 3-1) is a multi-layer paperboard with between one and five plies manufactured from virgin pulp using two different production routes: chemical pulp (kraft pulp) and CTMP (chemicalthermomechanical pulp). Kraft pulp is the most common and is used in the inner and outer layers of the board. Kraft pulp can come from softwood or hardwood trees, with hardwood kraft pulp typically reserved for the top (outer) ply as the shorter hardwood fibres provide a better printing surface. CTMP can be used in the middle layers, providing bulk and stiffness. The outer print surface of the board is always bleached for printing, though the inner layers are typically unbleached. The board can also consist of fillers, pigments, and binders.

Globally, Tetra Pak sources its liquid packaging board from Scandinavia, Brazil, and the USA. All pulp and paper is FSC certified. Tetra Pak Oceania sources its liquid packaging board from Scandinavia and Brazil only, with the bulk of supply coming from Scandinavia. In this analysis, we assume transport from Stockholm to the lamination plant.

Liquid packaging board is then bonded with plastic film and (optionally) aluminium foil to create a multi-layer laminate that is used to manufacture the finished carton. The aluminium layer is used in aseptic products to protect the contents from oxygen and light. The stages of carton manufacturing used for modelling are shown in Figure 3-2.

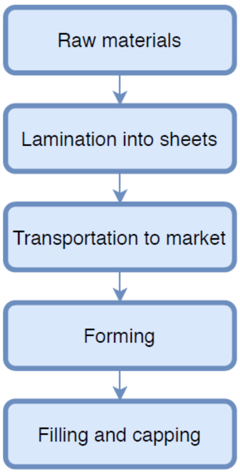

Figure 3-2: Carton manufacturing stages

Lamination for Tetra Pak Oceania's products occurs in facilities located in Europe and Asia. Each Tetra Pak product was modelled using site-specific lamination data from its respective manufacturing location (see Table 3-4 and Annex D for further information). Country-specific electricity grid mixes and natural gas mixes were used for each manufacturing country. It is assumed that all 'average' cartons and non-Tetra Pak cartons are manufactured in China, with the site lamination data assumed to be the same as the Tetra Pak global average. The layer composition is based on specifications provided by Tetra Pak in Annex D.

The carton type used for the results in Section 4 can be found in Table 3-4. It is important to note that the carton and other component masses used are collected from the packaging teardowns in Section 3.2 and that Tetra Pak's layer specifications only used to determine the relative layer thickness of the paperboard, plastic and aluminium layers. It has been assumed that the Tetra Top 500 mL specifications will be equivalent to a 600 mL aseptic carton. This is a conservative estimate because as the size increases, the only change to Tetra Top's relative layer thicknesses is an increase in paperboard thickness (not aluminium), which would lower the carbon footprint per kilogram of carton.

Table 3-4: Packaging category layer specifications

Packaging category	Tetra Pak product modelled
2 L aseptic	Tetra Brik Aseptic 2 L
2 L fresh milk	Tetra Rex 2 L
1 L aseptic	Tetra Brik Aseptic Edge 1 L
1 L fresh milk	Tetra Rex 1 L
600 mL aseptic	Tetra Top 500 mL
330 mL aseptic	Tetra Prisma Aseptic 330 mL
250 mL aseptic	Tetra Prisma Aseptic Straw 250 mL
200 mL aseptic	Tetra Prisma Aseptic Straw 200 mL
500 mL aseptic food	Tetra Recart Midi 500 mL
400 mL aseptic food	Tetra Recart Midi 400 mL

The primary life cycle inventory dataset used for this project is from the "European Database for Corrugated Board Life Cycle Studies" (FEFCO & CCB, 2015, as implemented in GaBi Databases 2020). This choice was made because it is a recent life cycle inventory dataset and its implementation directly within the GaBi Databases means that a full suite of environmental indicators could be applied. Given the significance of this choice to the overall results, comparisons have been made between this and other data sources in Annex F. The conclusion that can be drawn from this comparison is that the FEFCO/CCB data adequately represents the GWP of Tetra Pak Oceania's liquid packaging board and it is conservative for three of its four suppliers.

3.3.2. Plastics Manufacturing

The manufacturing process used for the manufacture of plastic components was defined based on the component type. To alter material characteristics (colour, strength, flexibility) some plastic components require an extra manufacturing step (compounding), where the granulate is re-melted and additives are added. A list of plastic components and manufacturing and compounding assumptions is presented in Table 3-5. All plastic granulate is assumed to have been produced in China. While granulate could be imported from other countries, China exports more plastics than any other country to both Australia and New Zealand (World Integrated Trade Solution, 2020). It is therefore considered a valid assumption for the purpose of this study. Additionally, the LCA databases used for this project do not have Australia- or New Zealand-specific plastic granulate datasets.

Table 3-5: Plastic manufacturing assumptions

Component	Manufacturing	Compounding
PET Bottle	Preform injection moulding and bottle blow moulding	No
HDPE Bottle	Blow moulding	No (unless lightproof)
Cap	Injection moulding	Yes
Lid	Injection moulding	Yes
Seal	Film metalized	No
Pull tab	Extrusion	Yes
Ring	Injection moulding	Yes
Label	Film thermoformed	No
Neck	Injection moulding	Yes
Straw	Extrusion	No
Cutter	Injection moulding	Yes

PET and HDPE bottles follow different manufacturing processes, as shown in Figure 3-3. For the purposes of this study, PET bottles are manufactured by first injection moulding a preform, which is then transported to the filling site (or nearby site) and blown into a bottle. HDPE bottles are blow moulded straight from granulate in one step. All steps for both PET and HDPE bottles are assumed to occur in the country of filling, though in practice some preforms are imported, particularly into the smaller New Zealand market.

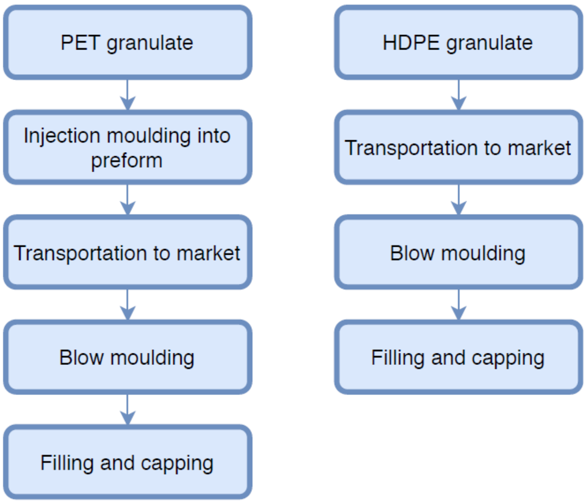

Figure 3-3: Manufacturing stage of PET and HDPE bottles

3.3.2.1. Recycled PET

Recycled PET bottles were assumed to have been mechanically recycled in the country of filling. GaBi processes were used for the granulation, washing and melting of waste PET in order to form new PET perform moulds.

3.3.3. Aluminium Pouches

Aluminium pouches are assumed to be manufactured in China and then transported to the country of purchase. An overview of the pouch manufacturing process can be seen in Figure 3-4. Acrylate was assumed to be the adhesive used and ethanol was the solvent, based on discussions with Tetra Pak. The solvent and adhesive used are not expected to have a significant impact on the GWP.

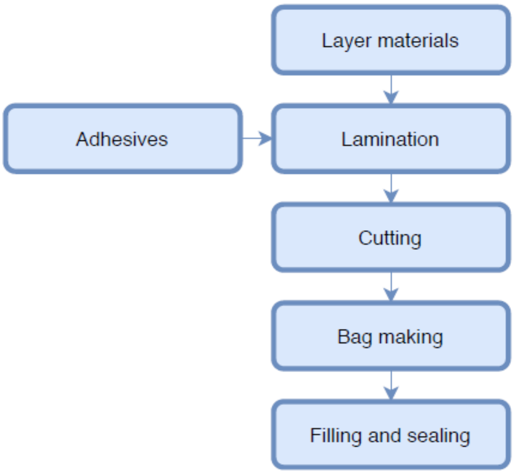

Figure 3-4: Aluminium pouch manufacturing

Two different types of pouch are considered within this study:

- **Aseptic beverage pouch:** This is a pouch with a polyethylene base layer and aluminium and PET barrier layers. It is not suitable for heating. The thickness of each layer (Table

3-6) is from literature (Lamberti & Escher, 2007) and was cross-checked with other work done by Tetra Pak.

- **Retort food pouch:** This is a pouch for food that is suitable for retorting (cooking) at approximately 120-130°C. Polypropylene is used as the base material, as polyethylene's melting point is too low for retorting. The thickness of each layer is shown in Table 3-7 and is assumed to be the same as the beverage pouch from (Lamberti & Escher, 2007) with polyethylene exchanged for polypropylene.

Table 3-6: Aseptic beverage pouch layer thickness

Layer Material	Thickness (μm)	Calculated Weight (gsm)
PET	12.0	16.6
Aluminium foil	8.0	21.6
Polyethylene	75.0	69.4

Table 3-7: Retort food pouch layer thickness

Layer Material	Thickness (μm)	Calculated Weight (gsm)
PET	12.0	16.6
Aluminium foil	8.0	21.7
Polypropylene	75.0	67.5

3.3.4. Aluminium Induction Seals

Aluminium induction seals were assumed to be a lamination of LDPE and aluminium, with acrylate as the adhesive used and ethanol as the solvent, based on discussions with Tetra Pak. The solvent and adhesive used are not expected to have a significant impact on results. The material layers were assumed to be the equal in thickness.

3.3.5. Glass Containers

Glass containers were manufactured in the country of purchase using standard manufacturing techniques, see Figure 3-5. The recycled content percentage for clear glass was estimated as 45% for New Zealand (figure supplied by O-I NZ) and 20% for Australia (from O-I Australia). The glass manufacturing process is shown in Figure 3-5.

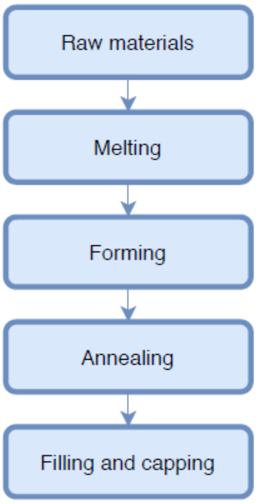

Figure 3-5: Glass container manufacturing

3.3.6. Cans (Steel and Aluminium)

The manufacturing process for tinplated steel cans (for food) and aluminium cans (for beverages) are shown below in Figure 3-6. Steel cans were assumed to be manufactured from primary (virgin) tin-plated steel (blast furnace route). Aluminium cans were assumed to be manufactured from either primary aluminium sourced on the global market (World Aluminium, 2017, as implemented in GaBi Databases 2020) or a combination of both primary and recycled aluminium. The recycled content of aluminium cans varies between suppliers and companies can request cans with up to 70% recycled content. Because of this variance, both 0% and 70% recycled content cans have been considered to provide worst- and best-case scenarios. Can-making was modelled using American and European can-making data, respectively.

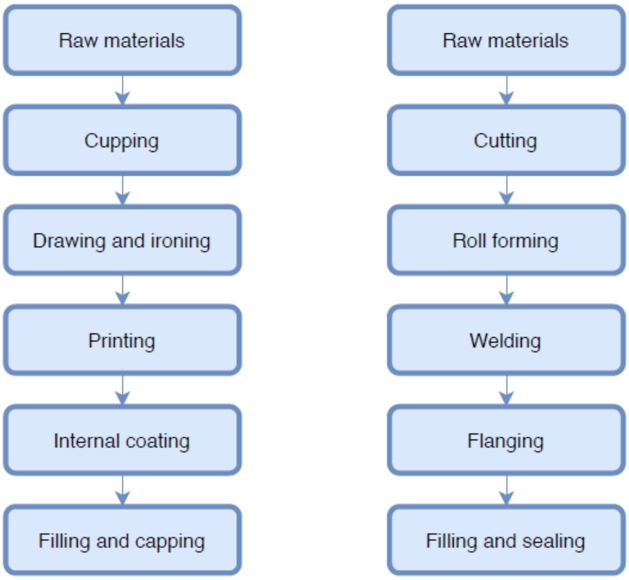

Figure 3-6: Aluminium can (left) and steel can (right) manufacturing stages

3.4. Transportation to Filling

Filling occurs in the country of sale, and transportation of the package from manufacturing site to filling site is included in the manufacturing stage. This was done due to some packaging solutions not being fully formed during the transportation to the filling site (e.g. PET bottles which are in preform moulds and cartons which can be in sheets).

The weight of the different packaging types was considered for the transport modelling.

3.5. Filling and Forming

Filling and the forming of the cartons occurs in the country of sale. Filling and forming data for Tetra Pak products and generic cartons were provided in the form of technical datasheets of various Tetra Pak forming and filling machines. From these datasheets, process inputs per 1,000 filled packages were calculated, based on the median number of packages filled per hour (see Table 7-1 in Annex B).

Other products' filling inputs were estimated using carton filling data and anecdotal information and were found to line up with previous work by thinkstep-anz (see Table 7-1 and Table 7-2 in Annex B). These estimates were conservative to attempt not to overestimate non-carton filling impacts. Aluminium pouches were assumed to have the same forming and filling impacts as cartons, as they need to be formed and heat sealed in a similar way to cartons. There is a degree of uncertainty with the filling impacts due to primary data not being available.

For simplicity, compressed air input is assumed to be at 7-bar at medium efficiency and is converted to electricity using a process conversion within GaBi. Fresh milk filling still uses hydrogen peroxide even though it is non-aseptic. This assumption was made because filling of the non-aseptic Tetra Rex still uses limited amounts of hydrogen peroxide. Steam is assumed to be produced by the combustion of natural gas.

All food packaging was assumed to be retorted instead of aseptic filling. The food is first filled into the pack and then both are heated to a temperature of approximately 130ºC to make both the food and the packaging sterile. This study includes the impacts of heating the packaging, but not the food itself as this is considered outside of the system boundary.

The energy required to heat the packaging was calculated by multiplying the mass of the packaging, the heat capacity of the predominant material (by mass) in the packaging and the increase in temperature required (from 20 ºC to 130 ºC) (Table 3-8). This calculates the theoretical minimum energy required to get the packaging material to the retorting temperature. Inefficiencies in the heating system are considered to be allocated to the food product as the heating of the packaging is not the goal of the retorting process.

Table 3-8: Energy required to bring packaging to retorting temperature

Size Class	Pack	Thermal energy required (MJ/pack)
500 mL retorted (food)	**Glass AU**	2.68E-02
	Glass NZ	2.66E-02
	Steel Can AU	3.20E-03
	Steel Can NZ	3.54E-03
	Carton AU	3.02E-03
	Carton NZ	3.02E-03
400 mL retorted (food) (NZ only)	**Steel Can NZ**	2.73E-03
	Pouch NZ	2.04E-03
	Carton NZ	2.54E-03

3.6. Distribution

After filling, the packaging is transported 400 km by truck to the retailer. The truck process is based on a Euro 0-6 mix 20-26 t gross weight (17.3 t payload) truck, with a utilisation rate of 55% (the GaBi default), i.e. most return trips are empty.

The weight of the different packaging types was considered for the transport modelling. The weight of the product contained within the packaging was excluded as this is assumed to be part of the product's life cycle, not the life cycle of the packaging.

3.7. Use

No use phase is modelled for packaging. Refrigeration of the packaging systems is not included, as a previous Tetra Pak LCA study has shown it to have effectively no impact on the results (Franklin Associates, 2015). If refrigeration were included, this would favour lighter weight products such as cartons and pouches due to the lower mass of packaging to be chilled.

3.8. End-of-Life

This section is broken into four parts:

- Waste processing in Australia and New Zealand.
- Recycling rates in Australia.
- Recycling rates in New Zealand.
- Recycling: onshore versus offshore.
- Landfill in Australia and New Zealand.

3.8.1. Waste processing in Australia and New Zealand

The vast majority of consumer packaging waste is collected through municipal kerbside collection systems in both Australia (Madden & Florin, 2019) and New Zealand (Wilson, et al., 2018). These systems typically have at least two bins: one for general rubbish (destined for landfill) and one for co-mingled recycling (destined for a Materials Recovery Facility). Some areas have more bins (for glass, food waste and/or garden waste) and some rural areas have no kerbside collection at all, though this makes up a small portion of overall waste collection by volume. Container deposit schemes are a rapidly growing part of the waste collection mix in Australia (Madden & Florin, 2019) and they have been under consideration in New Zealand for several years (Davies, 2017).

Recycling and landfill are the two main end-of-life pathways in both Australia and New Zealand. Energy recovery is very uncommon (Madden & Florin, 2019) and is excluded from this analysis for all primary packaging materials. (Incineration is included for wooden pallets as can be used in kilns and furnaces as a biomass fuel source.) As a result, this analysis is primarily concerned by the share of material going to recycling versus the share going to landfill.

Recycling of used packaging materials has been in a state of flux since 2018 when China's 'National Sword' policy banned the import of low-grade recyclables into the Chinese market. Prior to that, China had processed almost half of the world's recyclable waste (Katz, 2019). While many recyclables are still being exported to other countries at the time of writing, China's policy change has shifted attention in Australia and New Zealand toward local recycling opportunities. The Australian Government (2020) has announced a phased waste export ban, starting with a ban on the export of unprocessed glass from January 2021, mixed plastics from July 2021, single-resin plastics such as bottles from July 2022, and, finally, mixed paper and cardboard from July 2024. As a result, almost all packaging waste (except metals, which are a high-value waste stream) will have to be recycled domestically within Australia by 2024. While New Zealand does not yet have a formal timetable for phasing out exports, New Zealand faces the same challenges as Australia.

3.8.2. Recycling Rates in Australia

Table 3-9 presents the recycling and landfill rates applied for all packaging types included in this study. Recycling rates for most consumer packaging materials were based on data from the Australian Packaging Covenant Organisation's (APCO's) Packaging Material Flow Analysis 2018 (Madden & Florin, 2019). It is assumed that the recycling rate is equal to the reported recovery rate (i.e. all recovered materials are recycled) with the remainder being sent to landfill, due to the fact that less than 0.5% of packaging is sent to energy recovery in Australia (Madden & Florin, 2019). Shipper cartons (cardboard) are assumed to have a recycling rate of 90% as they are disposed of by supermarkets, not consumers.

Table 3-9: Recycling and landfill rates for packaging at end-of-life in Australia

Material Type	Recycling Rate	Landfill Rate
Glass	50%	50%
Paper/cardboard	72%	28%
Aluminium	72%	28%
Steel	44%	56%
PET	29%	71%
HDPE	29%	71%
Carton	10%	90%
Pouch	0%	100%

The APCO study does not provide data for laminated products such as cartons and pouches. This study assumes 100% of pouches are landfilled (due to their low value at end-of-life and complex layer structure) and that 90% of cartons are landfilled with the remaining 10% recycled.

This 10% recycling rate for cartons has been chosen for several reasons. First, cartons are accepted from container deposit systems and materials from these systems are exported to India and South Korea for recycling. Second, cartons have historically been exported as part of mixed paper bales from Material Recovery Facilities, though the Chinese National Sword has impacted this. Third, this recycling rate is broadly in line with a 15.3% rate in the USA in 2017 for "Total Paper and Paperboard Containers and Packaging" (which includes beverage cartons) (USEPA, 2019). Fourth, Tetra Pak's own analysis suggests a recycling rate of 26% for Australia in 2019, based on analysis of the percentage of cartons in mixed paper bales and the number returned through container deposit schemes versus the calculated total mass of cartons put onto the market in 2019. The effects of this assumption are tested using sensitivity analysis in Section 5.5.1.

3.8.3. Recycling Rates in New Zealand

A similar material flow analysis to the one commissioned by APCO does not exist for the New Zealand market. As a result, this report uses data from WasteMINZ (Yates, 2020). This is based on a waste audit of 875 households across New Zealand in 2019. Household waste was collected from bins at the kerbside with permission of the waste companies contracted to collect that waste (permission was not needed from the householders owing to the waste already being at the kerbside). Households included in the sample were deliberately chosen to represent both the diversity of waste collection systems across New Zealand (glass in co-mingled recycling, separate glass crate, etc.) and different socioeconomic demographics (using household income data for Statistics New Zealand meshblocks – the smallest geographic unit for which Statistics New Zealand collects data).

Table 3-10 includes the data applied within this study. The "Collected" column is based on data from the WasteMINZ study. The "Sorted" and "Recycled" columns are calculations applying the same losses as found in the APCO study for Australia (Madden & Florin, 2019). The only exceptions are for:

- Paper/cardboard, where APCO data has been used directly for all stages as this was not in scope of the WasteMINZ study.
- Glass, where APCO's sorting losses have been halved as many of New Zealand's councils' separate glass from the co-mingled recycling stream, improving yields. (Importantly, Auckland Council does not separate glass and it represents one-third of New Zealand's population.)
- Cartons, where the final recycling rate has been estimated by the authors of this report (as some councils, e.g. Southland, collect cartons with recyclables but don't recycle them). The rationale is similar to that for Australia in the previous section.
- Pouches, which is an estimate from the authors due to no collection infrastructure.

Table 3-10: Recycling and landfill rates for packaging at end-of-life in New Zealand

Material	Collected	Sorted	Recycled	Landfill	Note
Glass	88%	74%	69%	31%	APCO sorting losses have been halved due to different processes
Paper/cardboard	73%	72%	72%	28%	(Madden & Florin, 2019)
Aluminium	77%	69%	63%	37%	
Steel	77%	62%	56%	44%	
PET	81%	67%	67%	33%	
HDPE	86%	73%	73%	27%	
Carton	41%	40%	10%	90%	Recycling figure assumed and not based on the portion of waste collected or sorted
Pouch	0%	n/a	0%	100%	Authors' estimate

3.8.4. Recycling: Onshore Versus Offshore

Table 3-1 highlights the proportion of waste recovered for recycling that was recycled in-country in 2017/18, with the remainder being exported for recycling. Importantly, these percentages are for the period immediately *before* trade restrictions from the Chinese National Sword came into effect. Glass is the only material for which virtually all material is already recycled domestically (when use in road base and industrial applications is included alongside like-for-like recycling into container glass).

Table 3-11: Share of recycling processed domestically in 2017/18, prior to restrictions

Material	Australia	New Zealand
Plastic	54% (incl. 10% export post processing)	10%
Paper & card	57% (= 41% local use / 72% recovery)	40%
Aluminium cans	21% (= 15% local use / 72% recovery)	<5% (no large-scale facilities exist)
Steel cans	90% (= 44% local use / 49% recovery)	<5% (no large-scale facilities exist)
Glass	~100% (incl. use in road base, etc.)	~100% (incl. use in road base, etc.)
Cartons	~0% (no facilities yet)	~0% (no facilities yet)
Source	**Madden & Florin (2019)**	**Wilson, et al. (2018)**

Given that this analysis is intended to reflect current practice rather than past practice, and that the goal (certainly in the Australian context) seems to be a move toward no export of waste packaging materials across all categories (except for metals, where relatively high-value global markets exist), this analysis applies the following simplifying assumptions:

- Domestic recycling continues at the rate it was operating in 2017/18. That is, this analysis assumes that domestic recycling in 2017/18 is a good predictor of domestic manufacturing capacity. All domestically recycled material receives a credit under the substitution method used as a sensitivity analysis in section 5.5.3.
- Rather than exporting the remaining waste for recycling offshore, this analysis assumes that this material is instead now downcycled locally or stockpiled and leaves the system boundary with no credit or burden applied for this fraction of the waste stream (i.e. is cut-off). The final fate of this material is uncertain and therefore not modelled. It could be downcycled into another product (e.g. mixed plastics for making posts), incinerated with

or without energy recovery, landfilled, or exported to a country that will still accept it. Metals are an exception in that they are assumed to continue being exported, given that they have high material value and a largely except from trade restrictions. Cartons are also assumed to continue to be exported, solely because there are no facilities currently able to reprocess them in Australia or New Zealand. Importantly, this approach is conservative (i.e. disadvantages cartons) due to the additional transport impacts to relocate them to India, where recycling facilities do exist.

This approach is summarised in Table 3-12 and is applied in this analysis as the baseline scenario. Over time, it is likely that domestic recycling capacity will improve to account for the new material, though this may also require changes to the waste collection system to provide a higher quality feedstock for recycling (Madden & Florin, 2019). A sensitivity analysis which also considers offshore recycling for plastics and paper/cardboard is presented in Section 5.5.3.

Table 3-12: Share of recycling processed domestically and offshore, as used in this study

Material	Australia				New Zealand			
	Domestic recycling	Offshore recycling	Cut-off	Total	Domestic recycling	Offshore recycling	Cut-off	Total
Plastic	54%	0%	46%	100%	10%	0%	90%	100%
Paper & card	57%	0%	43%	100%	40%	0%	60%	100%
Aluminium cans	21%	79%	0%	100%	5%	95%	0%	100%
Steel cans	90%	10%	0%	100%	5%	95%	0%	100%
Glass	100%	0%	0%	100%	100%	0%	0%	100%
Cartons	0%	100%	0%	100%	0%	100%	0%	100%

3.8.5. Landfill in Australia and New Zealand

All consumer packaging materials which are not recycled are presumed to go to landfill. Bio-derived plastic components (injected moulded bio-HDPE and bio-LDPE film) are modelled to behave in the same way as their petroleum-based counterparts in landfill.

The time horizon considered within this study for landfill is 100 years. However, it should be noted that the DOC_F values below have been calculated from desktop bioreactor studies, which are designed to simulate an environment that degrades the material as completely as possible in anaerobic conditions. As such, applying a longer-term time horizon should not affect the results for biodegradable materials such as paper, as all biogenic carbon emissions will have already been accounted for.

3.8.5.1. Degradable Organic Carbon Fraction (DOC_F)

The degradable organic carbon fraction (DOC_F) is a fraction of the biogenic carbon in a material which will break down and be emitted to the atmosphere as gaseous compounds over time, in this case in a landfill. DOC_F values vary by material, as seen in Table 3-13. Of the landfill gases produced from decomposition, 50% forms methane and 50% forms carbon dioxide (Australian Government, 2019a).

Table 3-13 DOC_F values of packaging materials

Material Type	DOC_F	Source
Paper/cardboard	0.49	National Greenhouse Accounts (Australian Government, 2019a)
Wood	0.1	
Coated paper (in cartons)	0.21	(Eleazer, et al., 1997)

There is a significant level of uncertainty regarding the DOC_F of laminated paperboard and it could vary anywhere from 0% (assuming that the plastic and aluminium barrier layers on either side of the paperboard stop it from breaking down at all) to 50% (assuming the barrier layers fail over time and the paperboard behaves like uncoated paper in landfill). A value of 21% for coated paper (Eleazer, et al., 1997) was used as the base case in this study because it is one of the few experimental values available for coated paper. It aligns well with another value of 17.5% for coated paper (Micales & Skog, 1997).

Two different recycling rates were also chosen, to show how future changes in the recycling rate of cartons changes the GWP. The baseline recycling rate of cartons is 10%, but rates of 0% recycling (to align with pouches) and 80% recycling (to reflect world best-practice) were included as scenarios. A recycling rate of 80% is currently being achieved for used beverage cartons in Germany.

Both assumptions (the DOC_F and the carton recycling rate) were tested through scenario analysis in Section 5.5.1.

3.8.5.2. Methane Capture Rate

Methane capture rates for specific landfills can range from 0% (uncovered landfill with no gas collection) to near 100% (covered landfill with highly effective gas collection). Large, modern landfills in Australasia typically have high rates of gas collection, though older and smaller landfills can have limited or no gas collection. For landfills that do capture gas, instantaneous collection efficiencies can range from 50% to near 100% (Barlaz, et al., 2009). When weighted over the lifetime of the landfill, collection efficiencies range between 55% and 91% (Barlaz, et al., 2009).

The baseline results within this body of this report apply weighted national average gas collection rates for Australia and New Zealand. Lower and higher gas collection rates are tested through sensitivity analysis in Section 5.5.1.

For Australia, a weighted national average landfill gas collection rate of 36% has been applied. This is based on a historic forecast of the proportion of waste going to Australian landfills likely to have landfill gas collection by 2020 and assuming that the effectiveness of these collection systems is 85% (Hyder Consulting Group, 2007). This compares to the default regulatory minimum of 30% (Australian Government, 2019b).

For New Zealand, the weighted national average methane capture rate has been calculated as 53% by the authors, based on a list of landfills with/without landfill gas collection (Ministry for the Environment, 2019), the estimated population served by each landfill, and an assumed lifetime landfill gas collection effectiveness of 85% (Hyder Consulting Group, 2007).

In comparison, GaBi's standard landfill datasets assume a gas capture rate of 50% in Europe, and 64% in the United States (Sphera, 2020).

After capture, it is assumed that 25% of all landfill gas is flared with the remaining 75% used for energy recovery in an alternator/generator (Carre, 2011).

3.8.6. Credits

The default scenario involves cutting off recycling and not assigning any energy credits, as discussed in Section 2.5. In Section 6.3, a scenario analysis has been performed which compares the difference between using the cut-off method and the substitution method.

3.9. Secondary and Tertiary Packaging

To allow for a full assessment of the impacts of different packaging types, secondary and tertiary packaging was modelled. As this study is done on a consumer pack basis, the masses of each packaging type were divided by the number of consumer packs transported to get the impact per consumer pack. Masses for packaging types which are reused multiple times (e.g. pallets and HDPE milk crates) were divided by the number of use cycles to evenly allocate the burden of production. The number of consumer packs per secondary pack and the number of secondary packs per pallet was estimated based on observations and teardowns of secondary packaging.

3.9.1. Secondary Packaging

3.9.1.1. Fresh Milk Secondary Packaging

All consumer packs containing fresh milk are shipped in HDPE crates, which are reused multiple times, as specified in Table 3-14. The reusable HDPE crate mass was based on public data from a Viscount Plastics specification. This report assumes that each crate lasts 50 cycles before needing to be replaced. In practice, the number of use cycles typically assumed in LCA studies varies between 5 and 300 (for plastic pallets), with 50 being a common assumption (Deviatkin, et al., 2019).

Table 3-14: LCI data for fresh milk secondary packaging

Pack Type	Material	Mass (g)	Number of consumer packs	Use cycles	Number of secondary packs per pallet
1 L fresh milk	Reusable HPDE crate	1,575	16	50	36
2 L fresh milk	Reusable HPDE crate	1,575	9	50	36

To ensure proper hygiene, HDPE crates are washed between every cycle. Primary data for this washing cycle was obtained from a Tetra Pak client, found in Table 3-15.

Table 3-15: LCI inputs of washing of milk crates over an 11-hour shift

Input	Value	Unit
Number of crates washed	13,860	crates
Electricity	676	kWh
Detergent	20	L
Water	2,060	L
Rinse aid	6.5	L

3.9.1.2. Aseptic Container Secondary Packaging

Generalisations on aseptic secondary packaging were made based on teardowns of Australian and New Zealand secondary packaging. For the size class averages (e.g. taking 1 L carton or 1 L PET average), secondary packaging was assumed to be the same. While cartons are more space efficient due to their shape, it was decided to keep the mass of the secondary packaging and the number of consumer packs per secondary pack the same across all pack types in every size class, as a conservative assumption.

Table 3-16: Secondary packaging assumptions for each size class of aseptic containers

Aseptic container size	Material	Mass (g)	Number of consumer packs	Use cycles	Number of secondary packs per pallet
1 L	Corrugated board	230	12	1	36
2 L	Corrugated board	300	8	1	36
600 mL	Corrugated board	160	12	1	60
500 mL (Food)	Corrugated board	130	6	1	72
400 mL (Food)	Corrugated board	130	8	1	72
330 mL	Corrugated board	120	12	1	80
250 mL	Corrugated board	174	48	1	72
	LDPE film (6-pack)	15.6	48	1	72
200 mL	Corrugated board	174	48	1	72
	LDPE film (6-pack)	15.6	48	1	72

3.9.2. Tertiary Packaging

Wooden pallet mass and reuse cycle data was selected based on conversations with suppliers. The number of reuse cycles is uncertain, though it does affect all packaging systems equally as wooden pallets are assumed in all cases. This study assumes 10 reuse cycles, while other studies assume anywhere between 5 and 90 cycles (with 5, 10 and 30 cycles being most common) (Deviatkin, et al., 2019).

Table 3-17: Tertiary packaging assumptions

Pallet Material	Mass (g)	Use cycles
Softwood	25,000	10

3.9.3. Distribution

Secondary and tertiary packaging has the same distribution to market distance and methods as the consumer packaging.

3.9.4. Use

No life cycle impacts have been associated with the use of the packaging.

3.9.5. End-Of-Life

End-of-life assumptions made for secondary and tertiary packaging were the same as made for primary packaging, except for the cardboard recycling rate, which was adjusted to 88% due to a much higher level of cardboard box recycling at the distributor level (EPA, 2019). Wooden pallets used for tertiary packaging were split into 33.3% landfill, 33.3% downcycled and 33.3% incineration.

3.10. Background Data

3.10.1. Fuels and Energy

National averages for fuel inputs and electricity grid mixes were obtained from the GaBi 2020 databases. Table 3-18 shows the most relevant LCI datasets used in modelling the product systems. Electricity consumption was modelled using national grid mixes that account for imports from neighbouring countries/regions. Documentation for all GaBi datasets can be found at http://www.gabi-software.com/support/gabi/gabi-database-2020-lci-documentation/.

Table 3-18: Key energy datasets used in inventory analysis

Energy	Location	Dataset	Data Provider	Reference Year	Proxy?
Electricity	AU	AU: Electricity grid mix	Sphera	2017	No
Electricity	CN	CN: Electricity grid mix	Sphera	2017	No
Electricity	EU	EU-28: Electricity grid mix	Sphera	2017	No
Electricity	HU	HU: Electricity grid mix	Sphera	2017	No
Electricity	IN	IN: Electricity grid mix	Sphera	2017	No
Electricity	JP	JP: Electricity grid mix	Sphera	2017	No
Electricity	NZ	NZ: Electricity grid mix	Sphera	2017	No
Electricity	SG	SG: Electricity grid mix	Sphera	2017	No
Electricity	TW	TW: Electricity grid mix	Sphera	2017	No
Natural Gas	AU	AU: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	CN	CN: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	EU	EU-28: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	HU	HU: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	IN	IN: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	JP	JP: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	NZ	NZ: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	SG	SG: Thermal energy from natural gas	Sphera	2017	No
Natural Gas	TW	TW: Thermal energy from natural gas	Sphera	2017	No
Light fuel oil	AU	AU: Thermal energy from natural gas	Sphera	2017	No
Light fuel oil	CN	CN: Thermal energy from natural gas	Sphera	2017	No
Light fuel oil	EU	EU-28: Thermal energy from natural gas	Sphera	2017	No
Light fuel oil	IN	IN: Thermal energy from natural gas	Sphera	2017	No
Light fuel oil	JP	JP: Thermal energy from natural gas	Sphera	2017	No
Light fuel oil	NZ	NZ: Thermal energy from natural gas	Sphera	2017	No
Light fuel oil	MY	MY: Thermal energy from natural gas	Sphera	2017	No

3.10.1.1. Raw Materials and Processes

Data for upstream and downstream raw materials and unit processes were obtained from the GaBi 2020 database. Table 3-19 shows the most relevant LCI datasets used in modelling the product systems. Documentation for all GaBi datasets can be found at http://www.gabi-software.com/support/gabi/gabi-database-2020-lci-documentation/

Table 3-19: Key material and process datasets used in inventory analysis

Material/ process	Location	Dataset	Data Provider	Reference Year	Proxy?
PET	CN	CN: Polyethylene terephthalate granulate (PET via DMT)	Sphera	2019	No
PE film	CN	CN: Polyethylene Film (PE-LD) (without additives) (estimation)	Sphera	2019	No
LDPE	CN	CN: Polyethylene Low Density Granulate (LDPE/PE-LD) (estimation)	Sphera	2019	No
LLDPE	CN	CN: Polyethylene Linear Low Density Granulate (LLDPE/PE-LLD)	Sphera	2019	No
HDPE	CN	CN: Polyethylene high density granulate (HDPE/PE-HD)	Sphera	2019	No
PP	CN	CN: Polypropylene granulate (PP) (estimation)	Sphera	2019	No
OPP	DE	DE: Oriented Polypropylene film (OPP)	Sphera	2019	Yes
Bio-LDPE	EU-28	EU-28: Polyethylene Low Density Granulate (LDPE/PE-LD) (biobased from sugar cane)	Sphera	2019	No
Bio HDPE	EU-28	EU-28: Polyethylene Low Density Granulate (LDPE/PE-LD) (biobased from sugar cane)	Sphera	2019	Yes
Granulator	DE	DE: Granulator	Sphera	2018	No
Plastic washing	DE	DE: Washing (plastic recycling)	Sphera	2019	No
Pelletizing and compounding	DE	DE: Pelletizing and compounding	Sphera	2019	No
Compressed air	GLO	GLO: Compressed air 7 bar (medium power consumption)	Sphera	2019	No
Blow moulding	DE	DE: Polyethylene (HDPE/PE-HD) blow moulding	Sphera	2019	No
Water	EU-28	EU-28: Tap water from surface water	Sphera	2019	No
Injection moulding	GLO	GLO: Plastic injection moulding (parameterized)	Sphera	2019	No
Compounding	GLO	GLO: Compounding (plastics)	Sphera	2019	No
Plastic film	GLO	GLO: Plastic Film (PE, PP, PVC)	Sphera	2019	No
Plastic extrusion	GLO	GLO: Plastic extrusion profile (unspecific)	Sphera	2019	No
Ethanol	DE	DE: Ethanol	Sphera	2019	Yes

Material/ process	Location	Dataset	Data Provider	Reference Year	Proxy?
Acrylate	EU-28	EU-28: Acrylate sealing mass (EN15804 A1-A3)	Sphera	2019	Yes
Glass	EU-28	EU-28: Product of container glass (100% cullet)	Sphera	2019	Yes
Glass	EU-28	EU-28: Product of container glass (100% batch)	Sphera	2019	Yes
Kraftliner	EU-28	EU-28: Kraftliner (2015) - for use in cut-off EoL scenario cases ts/FEFCO	Sphera	2015	No
Testliner	EU-28	EU-28: Testliner (2015) - for use in cut-off EoL scenario cases ts/FEFCO	Sphera	2015	No
Aluminium ingot	GLO	GLO: Aluminium ingot mix IAI 2015	Sphera	2015	No
Aluminium foil	EU-28	EU-28: Aluminium foil	Sphera	2019	Yes
Tinplate	EU-28	EU-28: BF Tinplate coil	Sphera	2019	Yes
Steel part	DE	DE: Steel cold rolled coil <1,5mm	Sphera	2019	Yes
Nitrogen	EU-28	EU-28: Nitrogen (gaseous)	Sphera	2019	No
Carbon dioxide	DE	DE: Carbon dioxide highly pure	Sphera	2019	No
Hydrogen peroxide	EU-28	EU-28: Hydrogen peroxide mix	Sphera	2019	No

3.10.2. Waste Treatment Processes

Waste treatment datasets are shown in Table 3-20. Landfilling of paper, cardboard and wood used a dataset customised by thinkstep-anz which allows for the adjusting of the DOC_F and the landfill gas recovery rate.

Table 3-20: Waste treatment datasets

Material/ process	Location	Dataset	Data Provider	Reference Year	Proxy?
Wastewater treatment	GLO	GLO: Municipal wastewater treatment (sludge landfill, for regionalization)	Sphera	2019	No
Plastic landfill	EU-28	EU-28: Plastic waste on landfill	Sphera	2019	No
Plastic incineration	EU-28	EU-28: Plastic packaging in municipal waste incineration plant	Sphera	2019	No
Polypropylene incineration	EU-28	EU-28: Polypropylene (PP) in municipal waste incineration plant	Sphera	2019	No
Polyethylene incineration	EU-28	EU-28: Polyethylene (PE) in municipal waste incineration plant	Sphera	2019	No
Polyethylene terephthalate incineration	EU-28	EU-28: Polyethylene terephthalate (PET) in municipal waste incineration plant	Sphera	2019	No
Landfill of wood products	AU	AU: Landfill of wood products	Sphera	2012	No
Wood incineration	EU-28	EU-28: Wood (natural) in municipal waste incineration plant	Sphera	2019	No

Material/ process	Location	Dataset	Data Provider	Reference Year	Proxy?
Glass landfill	EU-28	EU-28: Glass/inert waste on landfill	Sphera	2019	No
Aluminium landfill	EU-28	EU-28: Inert matter (Aluminium) on landfill	Sphera	2019	No
Steel landfill	EU-28	EU-28: Inert matter (Steel) on landfill	Sphera	2019	No

3.10.3. Transportation

Average transportation distances and modes of transport are included for the transport of all materials to production and assembly facilities.

The GaBi 2020 database was used to model transportation. Transportation was modelled using the GaBi global transportation datasets. Fuels were modelled using the geographically appropriate datasets.

Table 3-21: Transportation and road fuel datasets

Mode / fuels	Geographic Reference	Dataset	Data Provider	Reference Year	Proxy?
Euro 6 truck, 20-26 t	GLO	Truck-trailer - diesel driven, Euro 0-6 mix, cargo – 20 - 26 t gross weight / 17.3t payload capacity. Utilisation 55%.	Sphera	2019	No
Rail	GLO	Rail transport cargo – average - average train, gross tonne weight 1000t / 726t payload capacity	Sphera	2019	No
Container ship	GLO	Container ship, 5,000 to 200,000 dwt payload capacity, ocean going	Sphera	2019	No
Diesel	AU	Diesel mix at filling station	Sphera	2019	No
Heavy fuel oil	AU	Heavy fuel oil at refinery (1.0wt.% S)	Sphera	2019	No

4. Life Cycle Inventory (LCI) Analysis

4.1. Packaging Metrics

Table 4-1 shows the packaging metrics for each size class. Pouches have the highest product-to-packaging ratio, while glass has the lowest (a higher ratio meaning that more volume is contained per gram of packaging). Cartons, HDPE and (r)PET have similar product-to-packaging ratios. Larger cartons have a low plastic ratio per litre, and this ratio increases as the volume decreases, or when the product contains a cap or straw. Glass, tin, and aluminium cans have lower plastic-per-litre ratios than cartons, while HDPE, (r)PET and pouches have higher plastic ratios.

Table 4-1: Size class packaging statistics

Size class	Packaging type	Pack Mass (g)	Product-to-packaging ratio (mL/g)	Plastic per litre of beverage/food (g/L)
1 L aseptic	**Glass AU**	504.09	1.98	2.00
	Glass NZ	548.96	1.82	0.54
	PET AU	43.44	23.02	40.42
	PET lightweight AU	22.65	44.16	21.57
	PET NZ	42.69	23.42	42.29
	rPET AU	43.44	23.02	40.42
	rPET lightweight AU	22.65	44.16	21.57
	rPET NZ	42.69	23.42	42.29
	Carton AU	38.40	26.04	10.20
	Carton NZ	33.25	30.08	8.68
1 L fresh milk	**Glass AU**	504.09	1.98	2.00
	Glass NZ	548.96	1.82	0.54
	PET AU	43.44	23.02	40.42
	PET lightweight AU	22.65	44.16	21.57
	PET NZ	42.69	23.42	42.29
	rPET AU	43.44	23.02	40.42
	rPET lightweight AU	22.65	44.16	21.57
	rPET NZ	42.69	23.42	42.29
	HDPE natural AU	40.30	24.81	39.30
	HDPE natural NZ	31.50	31.75	31.20
	HDPE lightproof NZ	32.60	30.67	32.30
	Carton AU	28.40	35.21	3.16
	Carton NZ	30.75	32.52	3.43
2 L aseptic	**PET AU**	70.97	28.18	34.66
	HDPE AU	59.50	33.61	29.75
	Carton AU	64.50	31.01	8.63

Size class	Packaging type	Pack Mass (g)	Product-to-packaging ratio (mL/g)	Plastic per litre of beverage/food (g/L)
2 L fresh milk	**PET NZ**	58.19	34.37	29.10
	rPET NZ	58.19	34.37	29.10
	HDPE natural AU	45.13	44.31	22.10
	HDPE natural NZ	41.93	47.69	20.82
	HDPE lightproof NZ	46.80	42.74	23.25
	Carton AU	64.10	31.20	4.95
	Carton NZ	64.10[1]	31.20[1]	4.95[1]
600 mL aseptic	**PET lightweight AU**	15.30	39.22	25.50
	rPET lightweight AU	15.30	39.22	25.50
	Carton AU	24.76	24.23	10.89
330 mL aseptic	**Glass AU**	259.27	1.27	1.52
	Aluminium Can - 0% Recycled AU	14.93	22.11	0.00
	Aluminium Can - 0% Recycled NZ	12.64	26.10	0.00
	Aluminium Can - 70% Recycled AU	14.93	22.11	0.00
	Aluminium Can - 70% Recycled NZ	12.64	26.10	0.00
	Carton AU	17.40	18.97	15.57
	Carton NZ	17.40[1]	18.97[1]	15.57[1]
250 mL aseptic (AU only)	**Glass AU**	177.90	1.41	2.80
	PET AU	32.00	7.81	127.20
	Pouch AU	6.25	40.00	22.89
	Carton AU	11.00	22.72	11.27
200 mL aseptic (NZ only)	**Pouch - lid NZ**	8.90	22.47	42.27
	Pouch - straw NZ	5.30	37.74	24.48
	Carton NZ	9.32	21.46	12.40
500 mL retorted (food)	**Glass AU**	290.10	1.72	0.00
	Glass NZ	288.32	1.73	0.20
	Steel Can AU	59.38	8.42	0.00
	Steel Can NZ	65.66	7.61	0.00
	Pouch AU	10.47	47.78	19.17
	Carton AU[2]	20.50	24.39	10.01
	Carton NZ[2]	20.50	24.39	10.01
400 mL retorted (food) (NZ only)	**Steel Can NZ**	50.60	7.91	0.00
	Pouch NZ	9.50	42.12	21.74
	Carton NZ[2]	17.23	23.22	10.16

[1] Australia teardown was used due to no carton found in New Zealand

[2] Specifications for the Tetra Recart Midi were used for the aseptic food cartons masses.

5. Life Cycle Impact Assessment

This chapter contains the results for the impact categories and additional metrics defined in Section 0. It shall be reiterated at this point that the reported impact categories represent impact potentials, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen functional unit (relative approach).

LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

5.1. Results Breakdown

Results in the following charts are broken down into five categories:

- Consumer Pack: This category includes the production of raw materials used in the consumer packs (except biogenic carbon sequestered, which is included in 'consumer end-of-life'), the manufacture of these materials into the consumer packs and the transportation of the packaging to the filling location.
- Consumer EOL: This category includes the end-of-life disposal of the consumer packs, including transportation of the package to landfill or recycling. Biogenic carbon sequestered by paper and cardboard is included in this category to show the net carbon sequestered or released and to avoid having negative numbers within the Consumer Pack category above.
- Forming and Filling: This category includes the process inputs required for the filling of consumer packages, including the sterilisation of aseptic packaging and heat for retorted packaging. For cartons, this category also includes process inputs required for their forming from a laminated roll (as forming and filling are done on the same line). For all non-carton materials, forming impacts (e.g. bottle blowing) are included in the Consumer Pack category.
- Distribution: This category includes transportation of the package after it has been filled from the filling location to retailer. Distribution of the product is excluded.
- Shipper and pallet total: This category is the sum of manufacture and end-of-life for all secondary and tertiary packaging included in the packaging system. This includes both the uptake and release of biogenic carbon.

5.2. Overall Results

This section contains results from the combined average of materials across the different product classes (milk, juice, water, and food). The 1 L and 2 L size categories are split into aseptic (all products) and fresh milk, due to fresh milk carton composition being different to the aseptic cartons (which contains an aluminium barrier).

Bars have been included to show the range of packaging masses which were collected. The range of values is high for the glass and PET consumer packs due to large differences in bottle design. These bars do not show standard deviation or standard error, which is their more common use. The masses of rPET and PET bottles have been aggregated to create an average mass which is used for both PET and rPET. Reduced plastic and glass bottle masses have been further analysed as a sensitivity analysis (Section 5.4).

5.2.1. 1 L Aseptic Beverage

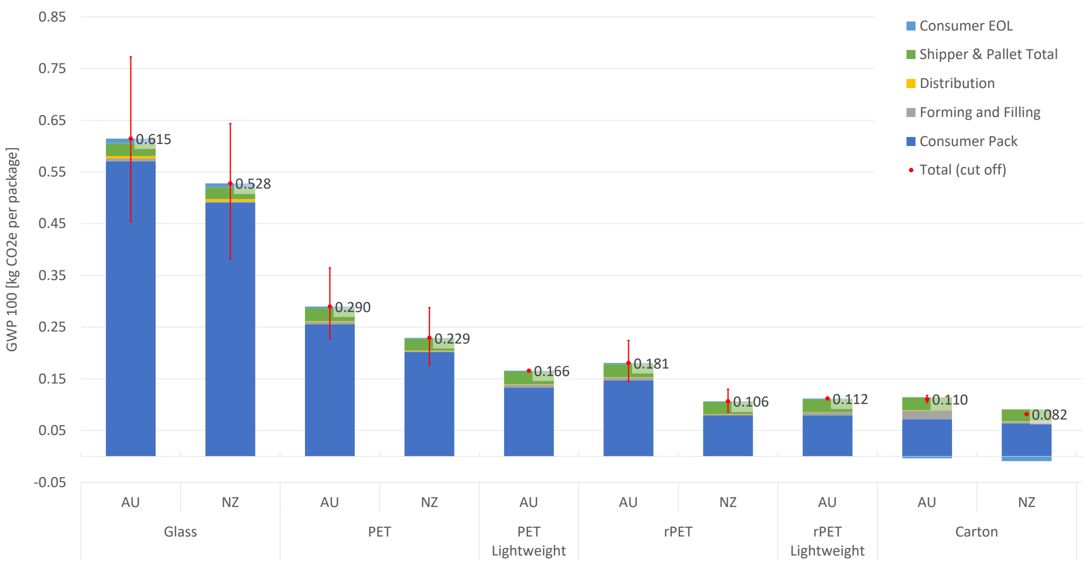

Figure 5-1: 1 L aseptic beverage GWP results

5.2.2. 1 L Fresh Milk

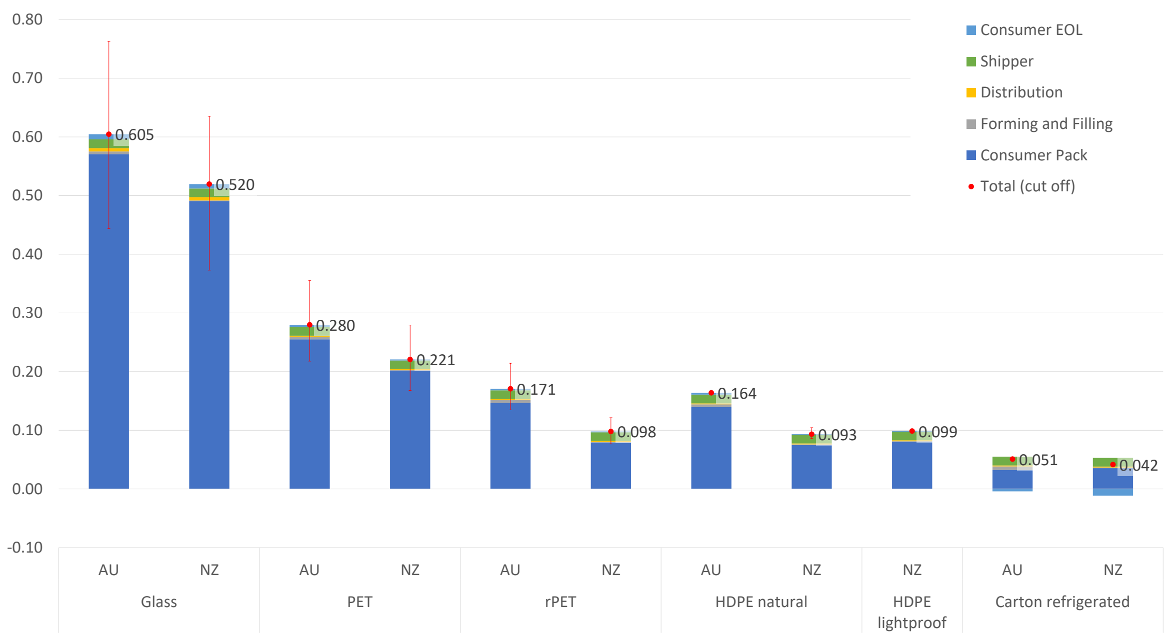

Figure 5-2: 1 L fresh milk GWP results

5.2.3. 2 L Aseptic Beverage (AU Only)

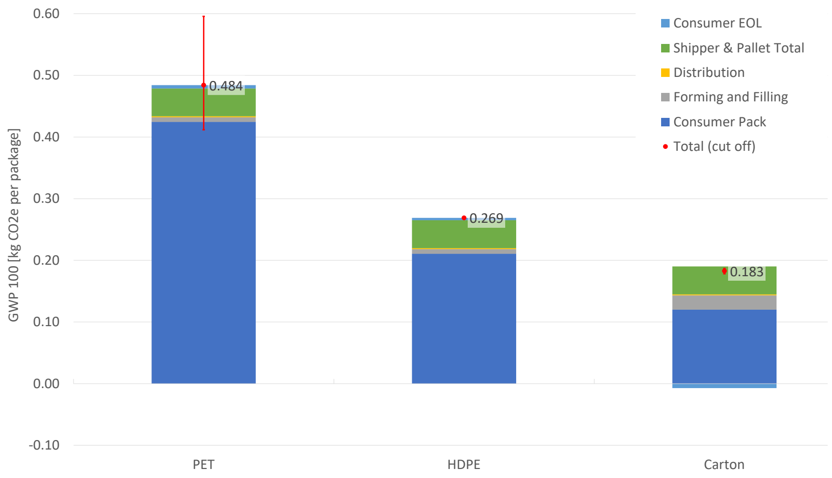

Figure 5-3: 2 L aseptic beverage GWP results

5.2.4. 2 L Fresh Milk

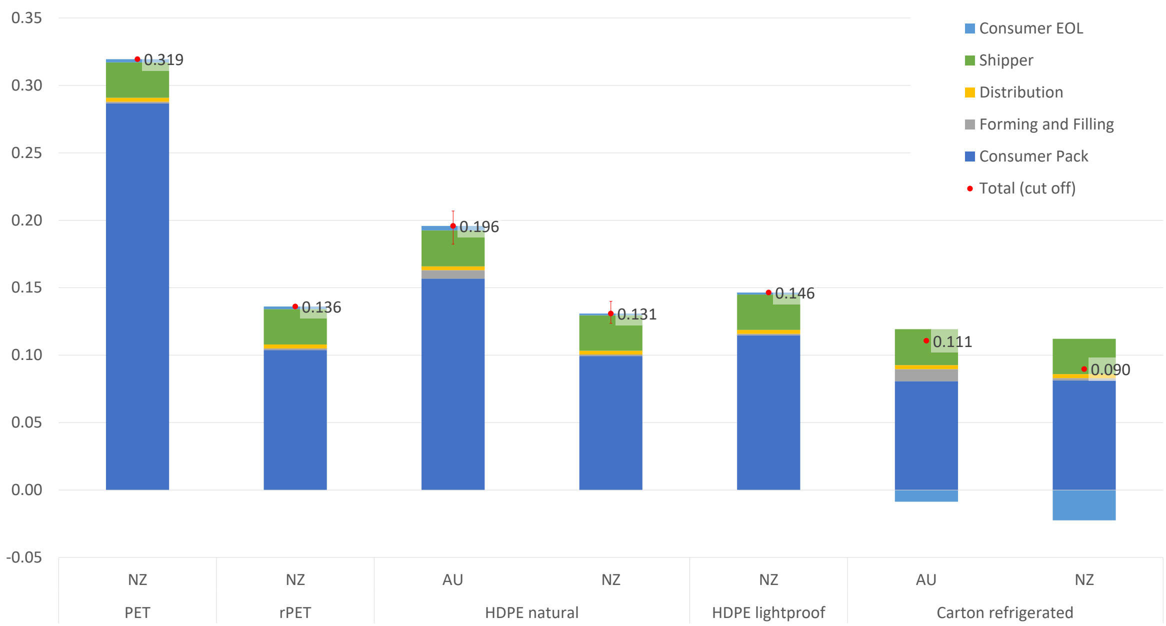

Figure 5-4: 2 L fresh milk GWP results

5.2.5. 600 mL Aseptic Beverage (AU Only)

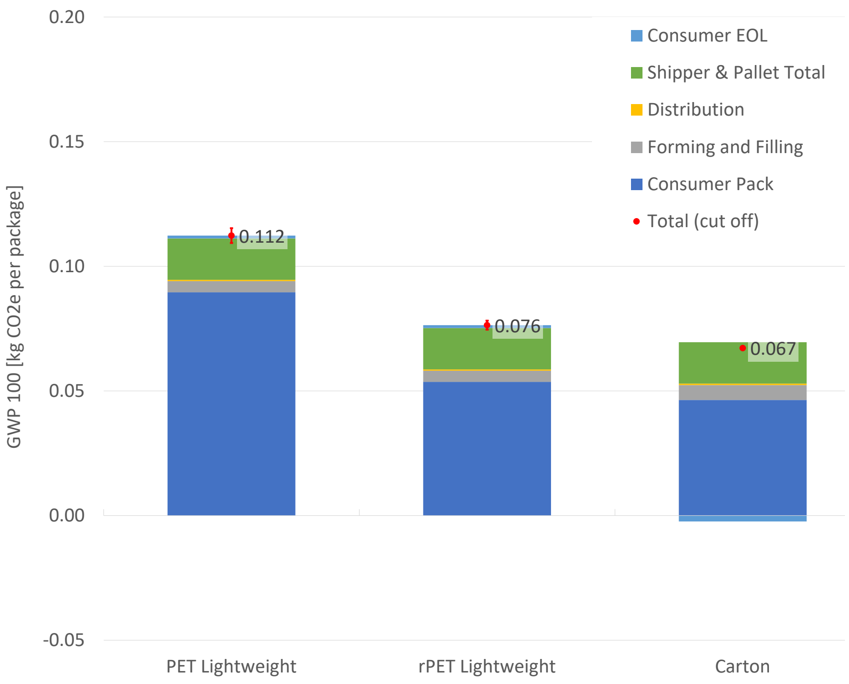

Figure 5-5: 600 mL aseptic beverage GWP results

5.2.6. 330 mL Aseptic Beverage

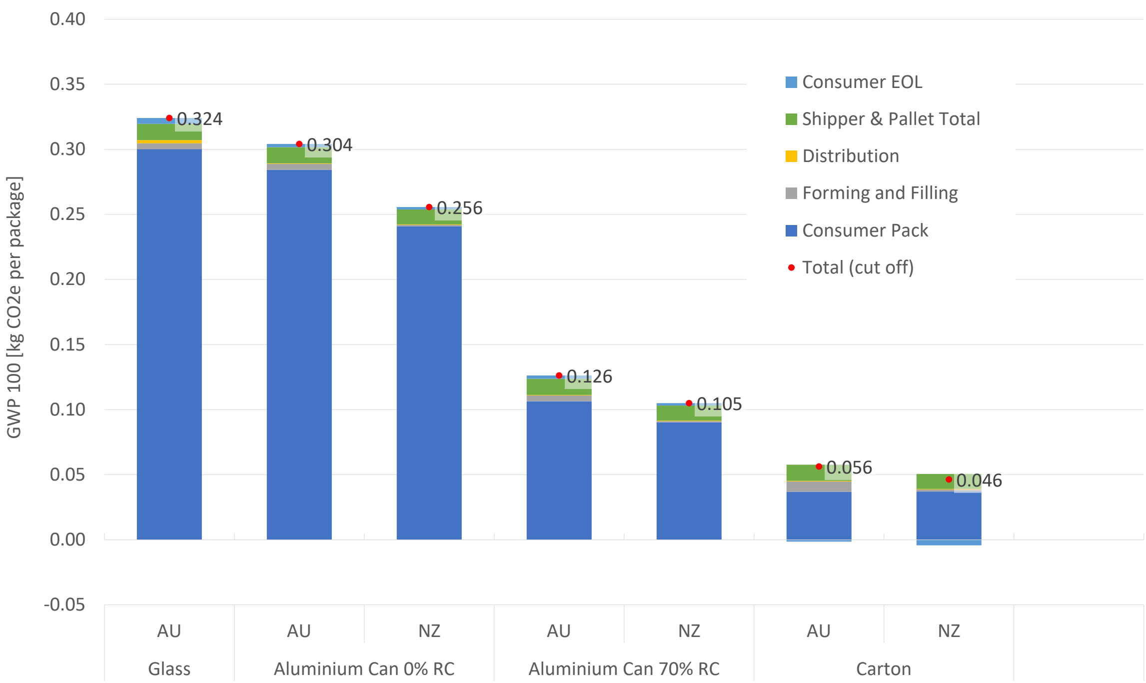

Figure 5-6: 330 mL aseptic beverage GWP results

5.2.7. 250 mL Aseptic Beverage (AU Only)

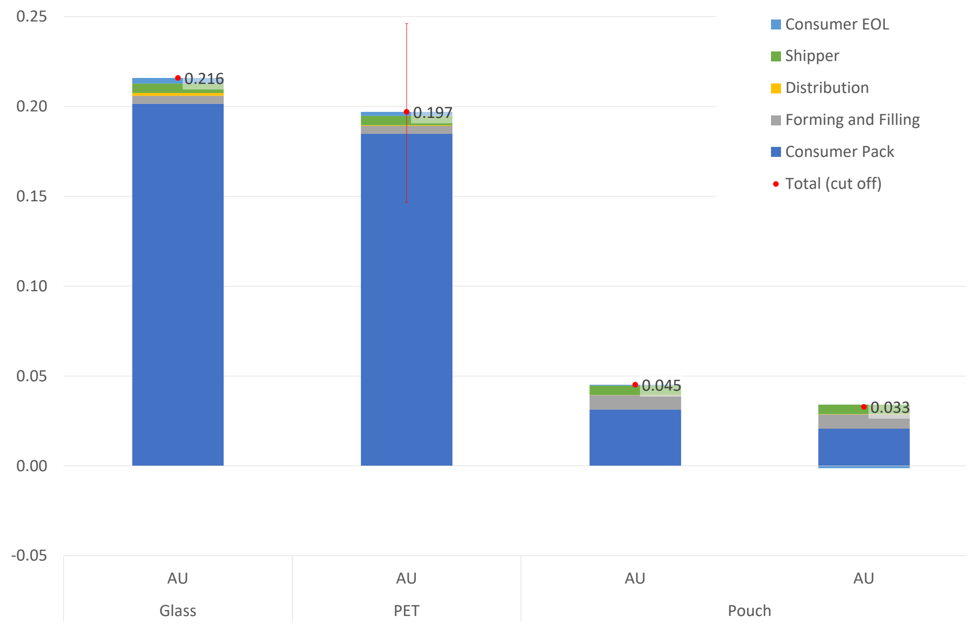

Figure 5-7: 250 mL aseptic beverage GWP results

5.2.8. 200 mL Aseptic Beverage (NZ Only)

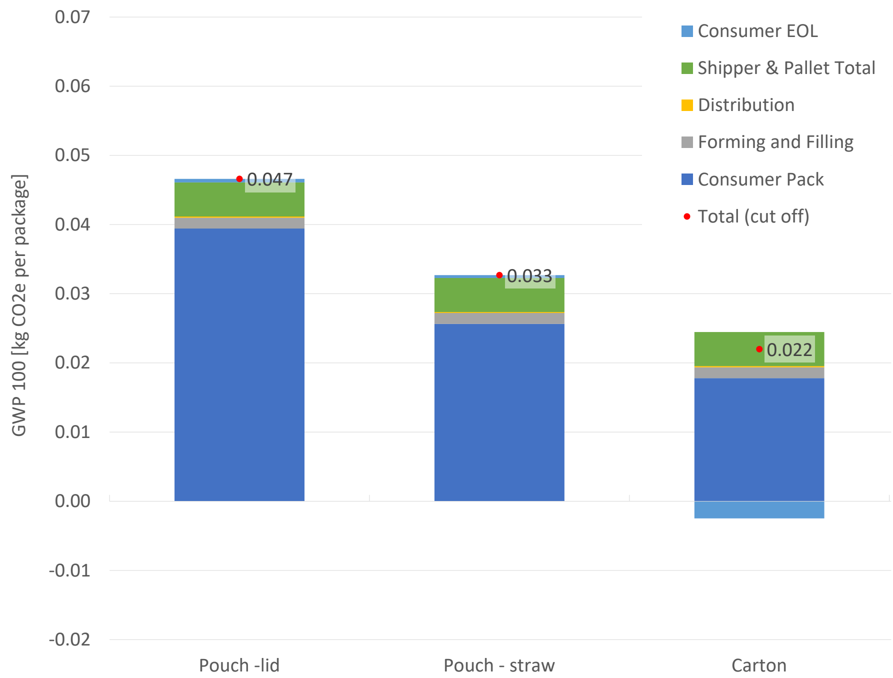

Figure 5-8: 200 mL aseptic beverage GWP results

5.2.9. 500 mL Aseptic Food

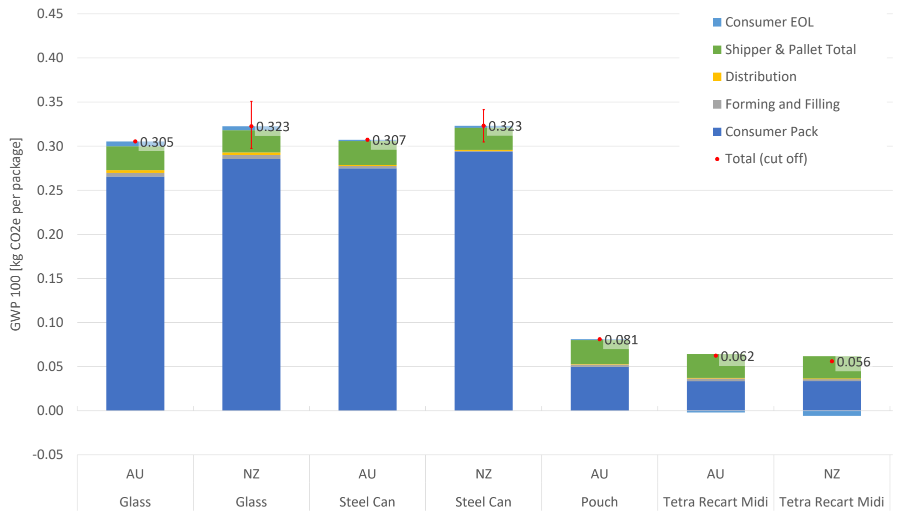

Figure 5-9: 500 mL aseptic food GWP results

5.2.10. 400 mL Aseptic Food (NZ Only)

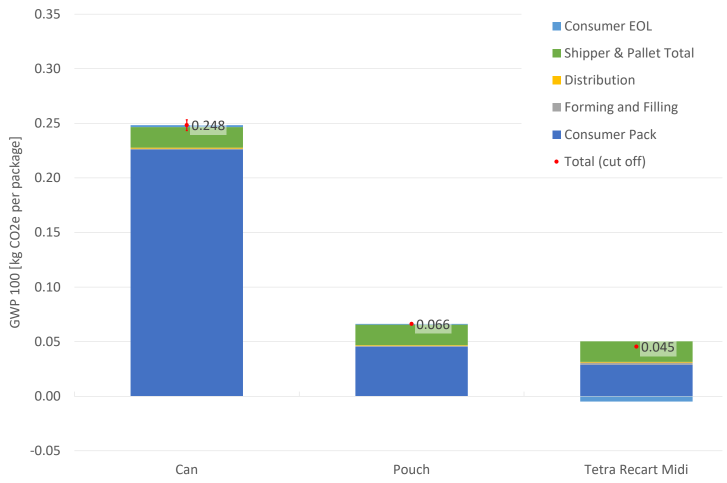

Figure 5-10: 400 mL aseptic food GWP results

5.3. Detailed Results

The detailed GWP results for each aggregated pack type are shown below in Table 5-1. These results are split into biogenic and fossil carbon in Annex I.

Table 5-1: Detailed GWP results (kg CO_2-e per package)

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
1 L aseptic	Glass AU	5.71E-01	5.35E-03	4.80E-03	8.80E-03	2.48E-02	6.15E-01
	Glass NZ	4.91E-01	1.80E-03	4.85E-03	7.48E-03	2.31E-02	5.28E-01
	PET AU	2.55E-01	5.35E-03	9.96E-04	3.48E-03	2.48E-02	2.90E-01
	PET NZ	2.02E-01	1.80E-03	9.86E-04	1.68E-03	2.31E-02	2.29E-01
	PET Lightweight AU	1.33E-01	5.35E-03	8.24E-04	1.58E-03	2.48E-02	1.66E-01
	rPET AU	1.47E-01	5.35E-03	9.85E-04	2.61E-03	2.48E-02	1.81E-01
	rPET NZ	7.92E-02	1.80E-03	9.86E-04	1.37E-03	2.31E-02	1.06E-01
	rPET Lightweight AU	7.94E-02	5.35E-03	8.24E-04	1.42E-03	2.48E-02	1.12E-01
	Carton AU	7.18E-02	1.66E-02	9.54E-04	-3.80E-03	2.48E-02	1.10E-01
	Carton NZ	6.34E-02	3.42E-03	9.11E-04	-9.19E-03	2.31E-02	8.16E-02
1 L fresh milk	Glass AU	5.71E-01	4.48E-03	5.56E-03	8.83E-03	1.50E-02	6.05E-01
	Glass NZ	4.91E-01	8.54E-04	5.61E-03	7.48E-03	1.47E-02	5.20E-01
	PET AU	2.55E-01	4.48E-03	1.75E-03	3.48E-03	1.50E-02	2.80E-01
	PET NZ	2.02E-01	8.54E-04	1.74E-03	1.68E-03	1.47E-02	2.21E-01
	rPET AU	1.47E-01	4.48E-03	1.74E-03	2.60E-03	1.50E-02	1.71E-01
	rPET NZ	7.92E-02	8.54E-04	1.74E-03	1.37E-03	1.47E-02	9.80E-02
	HDPE natural AU	1.40E-01	4.48E-03	1.72E-03	2.97E-03	1.50E-02	1.64E-01
	HDPE natural NZ	7.51E-02	8.54E-04	1.65E-03	9.77E-04	1.47E-02	9.33E-02
	HDPE lightproof NZ	8.04E-02	8.54E-04	1.66E-03	1.04E-03	1.47E-02	9.87E-02
	Carton AU	3.25E-02	5.96E-03	1.63E-03	-4.09E-03	1.50E-02	5.10E-02
	Carton NZ	3.54E-02	1.10E-03	1.65E-03	-1.14E-02	1.47E-02	4.16E-02
2 L aseptic	PET AU	4.25E-01	7.48E-03	1.61E-03	5.53E-03	4.50E-02	4.84E-01
	HDPE AU	2.11E-01	7.48E-03	1.52E-03	3.83E-03	4.53E-02	2.69E-01
	Carton AU	1.20E-01	2.32E-02	1.56E-03	-7.30E-03	4.53E-02	1.83E-01
2 L fresh milk	PET NZ	2.87E-01	1.20E-03	2.96E-03	2.35E-03	2.62E-02	3.19E-01
	rPET NZ	1.04E-01	1.20E-03	2.96E-03	1.89E-03	2.62E-02	1.36E-01
	HDPE natural AU	1.57E-01	6.27E-03	2.85E-03	3.30E-03	2.67E-02	1.96E-01
	HDPE natural NZ	9.93E-02	1.20E-03	2.82E-03	1.33E-03	2.62E-02	1.31E-01
	HDPE lightproof NZ	1.15E-01	1.20E-03	2.86E-03	1.52E-03	2.62E-02	1.46E-01
	Carton AU	8.07E-02	8.94E-03	3.00E-03	-8.62E-03	2.67E-02	1.11E-01
	Carton NZ	8.13E-02	1.65E-03	3.00E-03	-2.25E-02	2.62E-02	8.97E-02

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
600 mL aseptic	PET lightweight AU	8.96E-02	4.48E-03	5.24E-04	1.07E-03	1.66E-02	1.12E-01
	rPET lightweight AU	5.37E-02	4.48E-03	5.24E-04	9.58E-04	1.66E-02	7.62E-02
	Carton AU	4.64E-02	5.96E-03	6.02E-04	-2.48E-03	1.66E-02	6.71E-02
330 mL aseptic	Glass AU	3.00E-01	4.48E-03	2.44E-03	4.54E-03	1.24E-02	3.24E-01
	Aluminium Can - 0% Recycled AU	2.84E-01	4.48E-03	4.21E-04	2.49E-03	1.24E-02	3.04E-01
	Aluminium Can - 0% Recycled NZ	2.41E-01	9.47E-04	4.02E-04	1.87E-03	1.15E-02	2.56E-01
	Aluminium Can - 70% Recycled AU	1.06E-01	4.48E-03	4.21E-04	2.39E-03	1.24E-02	1.26E-01
	Aluminium Can - 70% Recycled NZ	9.03E-02	9.47E-04	4.02E-04	1.78E-03	1.15E-02	1.05E-01
	Carton AU	3.69E-02	7.93E-03	4.42E-04	-1.51E-03	1.24E-02	5.62E-02
	Carton NZ	3.71E-02	1.57E-03	4.42E-04	-4.38E-03	1.15E-02	4.62E-02
250 mL aseptic (AU only)	Glass AU	2.01E-01	4.48E-03	1.56E-03	3.10E-03	5.26E-03	2.16E-01
	PET AU	1.85E-01	4.48E-03	3.55E-04	2.18E-03	5.26E-03	1.97E-01
	Pouch AU	3.14E-02	7.93E-03	1.44E-04	4.62E-04	5.26E-03	4.52E-02
	Carton AU	2.07E-02	7.93E-03	1.83E-04	-1.28E-03	5.26E-03	3.28E-02
200 mL aseptic (NZ only)	Pouch - lid NZ	3.94E-02	1.57E-03	1.66E-04	4.91E-04	4.93E-03	4.66E-02
	Pouch - straw NZ	2.56E-02	1.57E-03	1.36E-04	3.86E-04	4.93E-03	3.27E-02
	Carton NZ	1.78E-02	1.57E-03	1.69E-04	-2.52E-03	4.93E-03	2.19E-02
500 mL retorted (food)	Glass AU	2.66E-01	4.13E-03	3.05E-03	5.50E-03	2.71E-02	3.05E-01
	Glass NZ	2.86E-01	4.19E-03	3.04E-03	4.48E-03	2.52E-02	3.23E-01
	Steel Can AU	2.75E-01	2.51E-03	1.15E-03	1.57E-03	2.71E-02	3.07E-01
	Steel Can NZ	2.94E-01	9.82E-04	1.20E-03	2.23E-03	2.52E-02	3.23E-01
	Pouch AU	4.99E-02	2.45E-03	7.44E-04	7.75E-04	2.71E-02	8.10E-02
	Carton AU	3.34E-02	3.11E-03	8.27E-04	-2.05E-03	2.71E-02	6.24E-02
	Carton NZ	3.37E-02	2.02E-03	8.27E-04	-5.75E-03	2.52E-02	5.60E-02
400 mL retorted (food) (NZ only)	Steel Can NZ	2.26E-01	8.70E-04	9.11E-04	1.73E-03	1.89E-02	2.48E-01
	Pouch NZ	4.54E-02	7.74E-04	5.71E-04	7.00E-04	1.89E-02	6.63E-02
	Carton NZ	2.89E-02	1.95E-03	6.35E-04	-4.88E-03	1.89E-02	4.55E-02

5.4. Results and Interpretation

Cartons were shown to have the lowest GWP across all average beverage and food systems analysed. Glass packaging had the highest GWP, with values 5 to 12 times higher than cartons. PET consumer packs generally had the second-highest GWP after glass, and the GWP of rPET was roughly half that of virgin PET. PET and rPET results varied by a large degree based on the mass of the pack (see Section 5.4.1 for further analysis). Lightweight rPET in Australia had a very similar GWP to cartons, though this product group is only available in the water category.

HDPE results were generally lower than PET, with lightproof HDPE being higher than natural. Aluminium cans with 0% recycled content were comparable to glass, and while much improvement was seen at 70% recycled content, the high recycled content cans still had a significantly higher GWP than cartons (approximately double). In categories where pouches were available, they had the lowest GWP after cartons – varying from 30% to 100% higher than the comparable carton. In the retorted food categories, steel cans had a high GWP – comparable to glass packs.

5.4.1. Consumer Packs

For all packaging systems, the production of the consumer pack has the largest impact on the GWP. The scale of this impact is dependent on the mass of the pack and the material it is made of.

Across all volumes and functions, cartons had the lowest GWP results. The magnitude of this benefit varied by the relative performance of other packaging types, as well as whether the carton was aseptic and therefore contains additional barrier layers. Taking into account the consumer end-of-life stage, where the long-term carbon sequestration of biogenic carbon occurs, the lightweight 600 mL and 1 L rPET packs in Australia were very similar to cartons, having near the same GWP.

In the size classes where they occur, pouches consistently have the second-lowest GWP. This is due to the fact that they are lightweight, with the highest product-to-packaging ratios of all packs considered in this study (see Table 4-1). This finding occurs even though they contain materials with high GWP per kilogram, such as aluminium and plastic. That being said, there are currently few or no recycling options for pouches in Australia and New Zealand.

Results from PET packaging range from being the highest among all measured packaging types to being one of the better performing packaging types, closely following cartons. This was largely due to wide ranges in the masses of the bottles. This can be seen in Figure 5-5 for 600 mL aseptic packaging – a category that includes water bottles. The lightweight PET/rPET bottles shown here were supermarket-brand water bottles, which had the highest product-to-packaging ratio of all studied packaging systems, excluding pouches. On the contrary, for 250 mL aseptic packaging, the impacts of PET are very high, comparable with the glass impacts, due to a low product-to-packaging ratio.

Glass packages have the highest GWP across all size classes due to how heavy the packs must be to remain intact during transportation. There is a wide range in their masses, due to differences in bottle design, which is shown by the large range for these packages.

5.4.2. Consumer End-of-Life

Consumer end-of-life impacts are dependent on the composition of the consumer pack and the country where the pack would be disposed. Plastics, glass, and aluminium are all inert materials which do not break down in a landfill and so have a low GWP impact at end-of-life.

Due to the biogenic carbon sequestered by the cartons being included in the consumer end-of-life category, all base scenario cartons have a negative GWP impact because some of the biogenic carbon remains sequestered in landfills for the 100-year time horizon considered in this study. This net sequestration is dependent on the amount of paper within the carton and the country where the packaging is landfilled. Australia has a lower landfill gas capture rate (on average) than New Zealand (see Section 3.8.5) and so more of the methane produced by cartons breaking down is able to escape into the atmosphere, increasing the GWP.

5.4.3. Forming and Filling

For most pack types, forming and filling has an insignificant impact. Exceptions to this rule include aseptic Australian cartons and pouches, which have lower consumer pack impacts, but relatively high forming and filling impacts due to the formation of these packs occurring in this stage. These impacts are more noticeable for Australian packs because they use the Australian electricity grid mix which is GWP intensive. Aseptic packs in general have higher forming and filling impacts than fresh milk packs due to the sterilisation requirements (see Annex B, Table 7-1 and Table 7-2).

5.4.4. Distribution

Distribution has a low relative impact on results, due to the low mass of most of the consumer packs and the exclusion of the beverage/food mass from the transportation impacts (as this is assumed to be part of the life cycle of the beverage/food itself).

5.4.5. Shipper and Pallet Total

The net GWP impacts for shippers and pallets were low for most pack types. The impacts were most significant for packaging types which had low overall impacts, like pouches, rPET and cartons. Due to the shipper and pallet assumptions being the same for all pack types, all GWP impacts in this category are the same within each size class. Because of this, changing the secondary or tertiary packaging values will not change the conclusions. As mentioned in Section 3.9, the assumption that the secondary and tertiary packaging will be the same for different pack types across a single size class is conservative; cartons are the most space efficient packaging type as there is little dead space between packs, which means that more cartons can fit on a single pallet.

5.4.6. Other Indicators

The results for other indicators are shown in Table 7-17 of Annex J, with a colour coding system used to highlight the cartons and how they performed relative to other packaging types.

For acidification potential, pouches are the best performer in the categories where they exist, with cartons having an impact about 60-90% higher, but still considerably lower than most other pack formats (glass, steel cans, aluminium cans). Lightweight rPET and PET water bottles in the Australian market also have a lower AP than cartons, though these packs are currently limited to the water category. rPET also has a lower AP than cartons in the New Zealand market, which is due to the highly renewable New Zealand electricity mix assumed for recycling, though it should be noted that all rPET bottles currently on the New Zealand market rely on imported granulate and/or imported bottle pre-forms and would not offer this level of performance today because New Zealand's only domestic recycler of food grade PET at the time of writing (Flight Plastics) does not produce bottle pre-forms. As such, the New Zealand rPET results should rather be interpreted as a possible future state for rPET.

Eutrophication potential and photochemical ozone creation potential behave in a similar way to AP, with pouches having the lowest potential impact in all categories where they exist, and with lightweight PET/rPET water bottles and New Zealand rPET all performing slightly better than cartons. For EP and POCP, cartons are outperformed in the 2L fresh category by all materials except glass, with impacts approximately 30-60% higher for than those of the other materials.

For abiotic depletion of fossil fuels, cartons are the best performer (i.e. have the lowest contribution) across the board, with the exception of the 600mL lightweight rPET water bottle in the Australian market.

For abiotic depletion of elements, the potential impact for cartons is very similar to the best performing pack materials, which were pouches, recycled PET and lightweight PET (in the water category) and considerably better than the worst performers (glass, virgin aluminium cans and virgin steel cans). The exception to this is in the 1L aseptic category where the carton is 50% higher than the lightweight rPET (which is only for water)

For the Water Scarcity Footprint (WSF), cartons offer the lowest footprint except for pouches, with cartons and pouches having similar results. A similar pattern is repeated for the blue water consumption indicator, though cartons do have slightly higher water consumption than recycled aluminium cans, lightweight PET/rPET water bottles, and the 2L aseptic HDPE bottle.

5.5. Sensitivity Analyses

Because of the large number of packaging size classes, sensitivity analyses have only been performed for three classes. The findings from these analyses are expected to translate well to all other size classes. These size classes (1 L, 250 mL, and 200 mL aseptic) have been selected due to the fact that they contain the packaging options where the second-lowest GWP (lightweight PET, rPET and pouch) is the closest to the carton GWP.

5.5.1. End-of-life (DOC_F, Landfill Gas Capture Rate and Carton Recycling)

Due to the DOC_F of the paperboard inside cartons being a large source of uncertainty, scenario analyses were performed for the potential range of different DOC_F values. 0% was selected as the lowest value, which assumes that the aluminium and plastic layers on either side of the paperboard manage to stop it from breaking down during the 100-year time horizon considered in this study. 50% was selected as the highest possible value, which is the approximate value for uncoated paper in landfill (Australian Government, 2019a). A value of 21% was used as the base case (Eleazer, et al., 1997). Different landfill gas capture rates were also included, ranging from 0% (no capture) to 90% (maximum likely capture rate when weighted over the life of the landfill). Two different recycling rates were also chosen, to show how future changes in the recycling rate of cartons changes the GWP. The baseline recycling rate of cartons is 10%, but scenarios of 0% and 80% recycling were included as scenarios.

The results for these analyses can be seen in Figure 5-11 to Figure 5-14. As expected, the GWP increases as the DOC_F increases, owing to greater amounts of methane produced in the landfill. Australian cartons have a greater increase in GWP as DOC_F increases due to Australian landfills having a lower methane capture rate than New Zealand landfills on average. The scenario with the highest GWP for cartons was 50% DOC_F with a 0% recycling rate and a 0% landfill gas collection rate. This represents a single carton that is put in a landfill without gas capture and it would likely only be achieved if the package was first ground to powder or delaminated – it does not represent market-average performance. The packaging system with the second lowest GWP for each size class is shown in green (rPET for the 1 L aseptic, and aluminium pouches for the 250 mL and 200 mL classes). It is important to note than for the vast majority of scenarios, the carton has a lower GWP than the second-best packaging system and that the worst-case scenario is an outlier.

Figure 5-15, Figure 5-16, Figure 5-17 and Table 5-2 show the GWP of the worst-case scenario (50% DOC_F, 0% recycling, 0% landfill gas capture) compared to the results from the other 1 L, 250 mL and 200 mL aseptic packages. These charts show that the worst-case GWP for cartons is higher than the GWP for the following pack formats: pouches, lightweight PET/rPET water bottles, and rPET bottles. Cartons always have a lower GWP than glass and PET, no matter which end-of-life assumptions are applied.

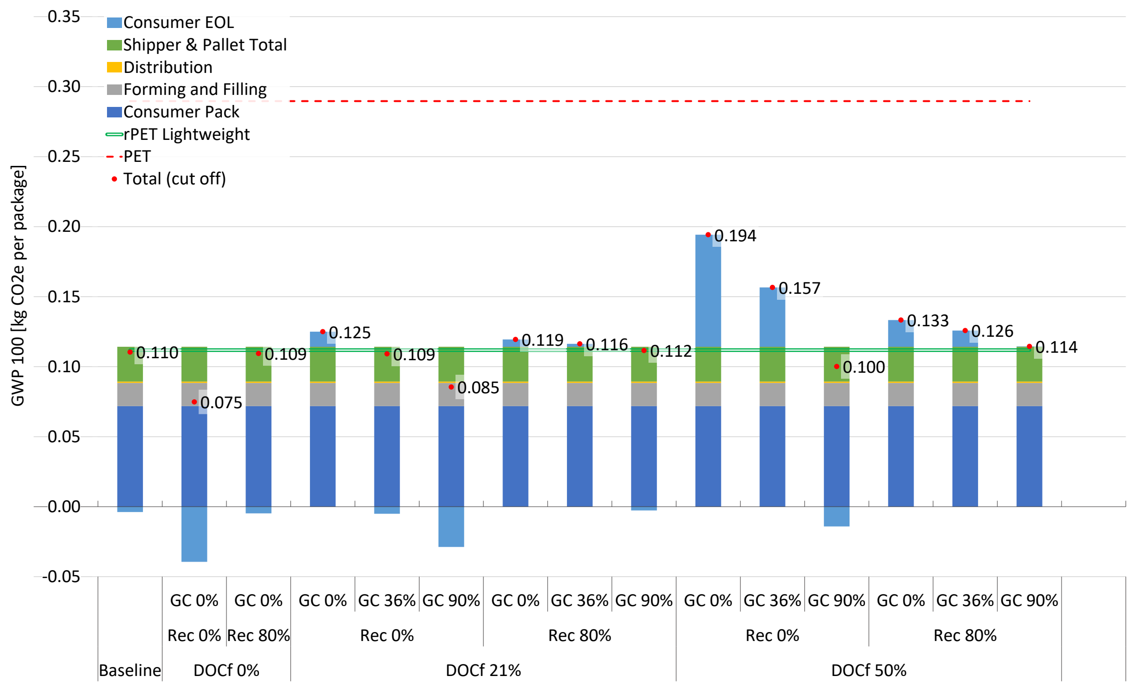

Figure 5-11: Australia 1 L carton DOC_F and recycling rate scenario analysis (GC= landfill gas collection)

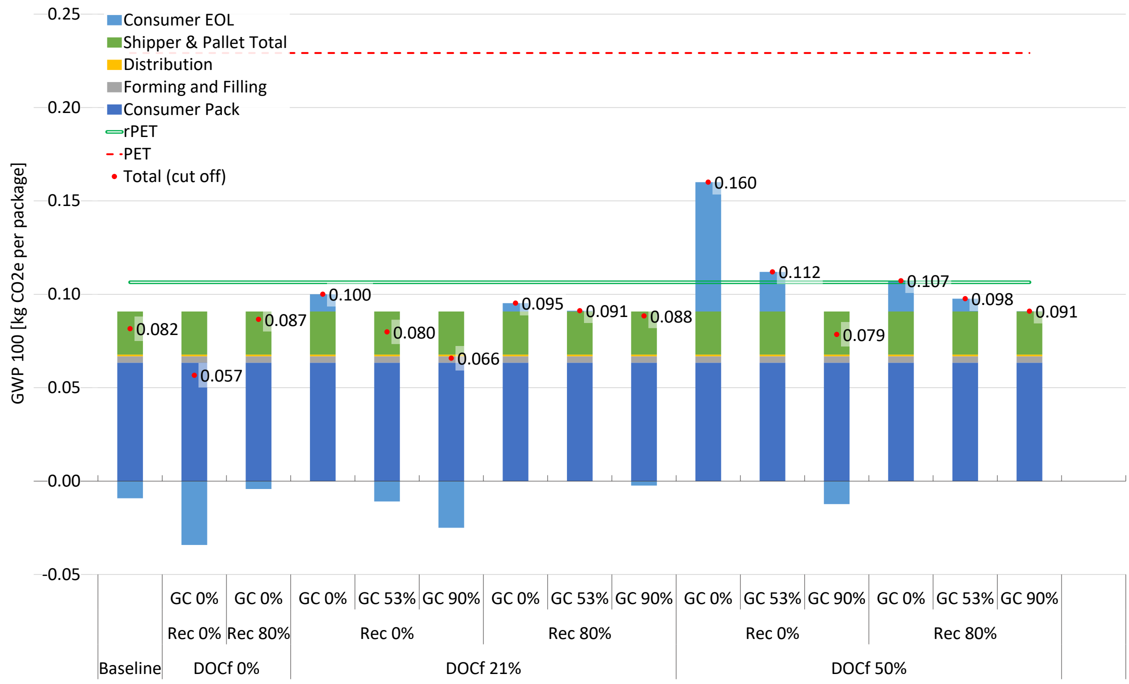

Figure 5-12: New Zealand 1 L carton DOC$_F$ and recycling rate scenario analysis (GC= landfill gas collection)

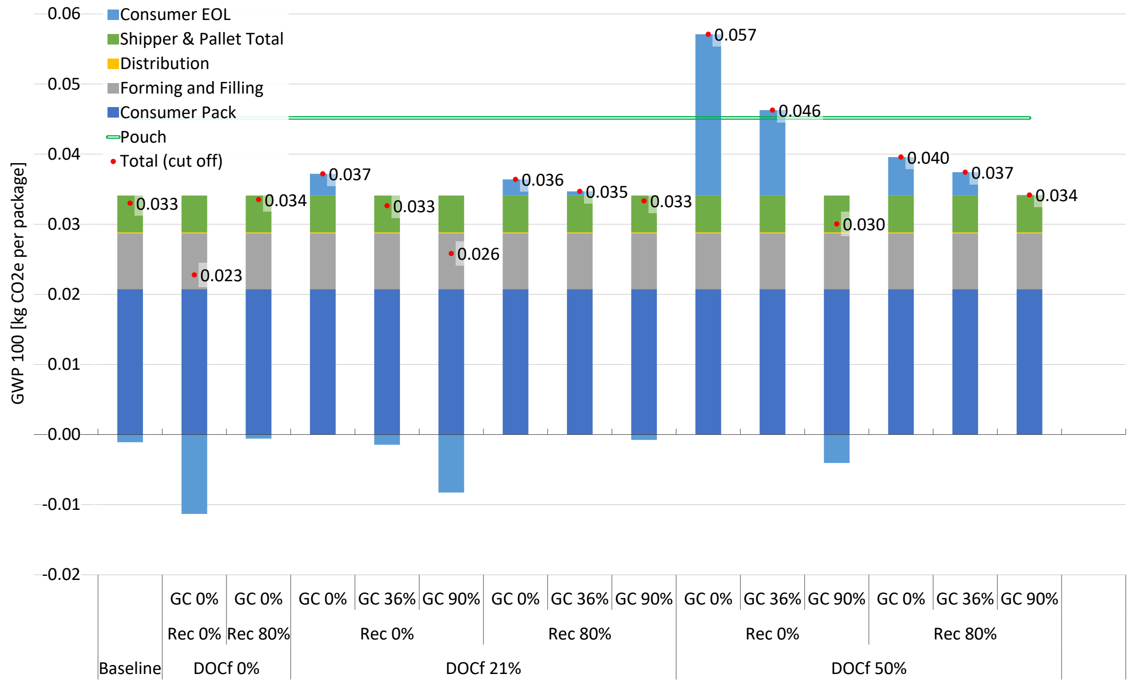

Figure 5-13: Australia 250 mL carton DOC$_F$ and recycling rate scenario analysis (GC= landfill gas collection)

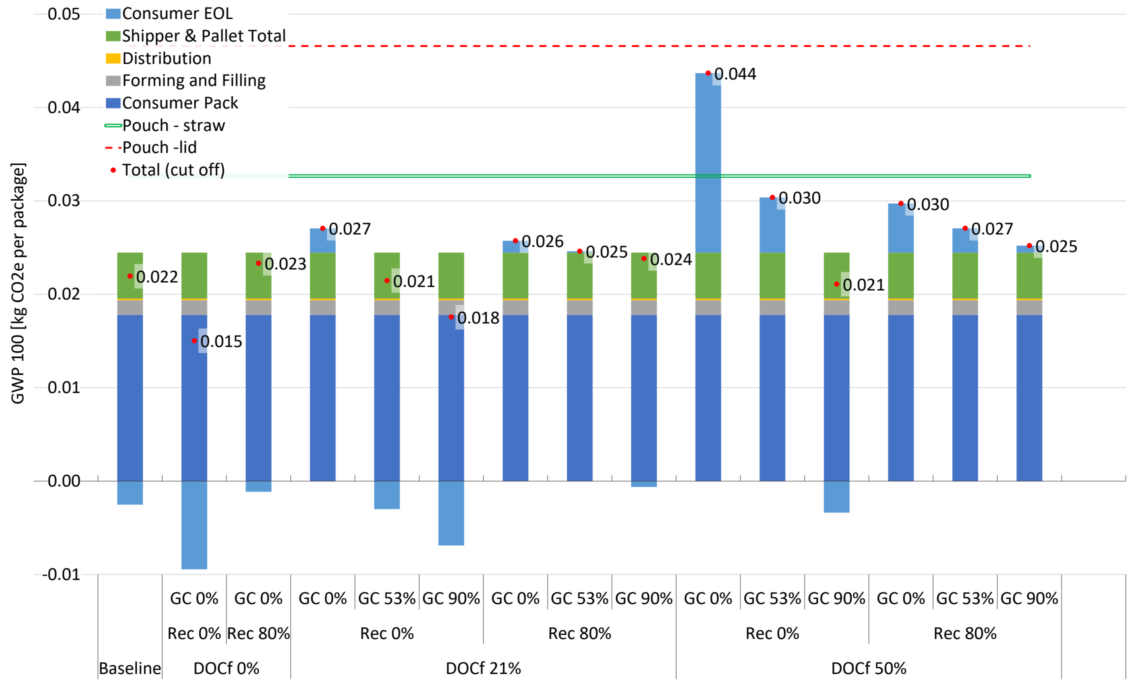

Figure 5-14: New Zealand 200 mL carton DOC$_F$ and recycling rate scenario analysis (GC= landfill gas collection)

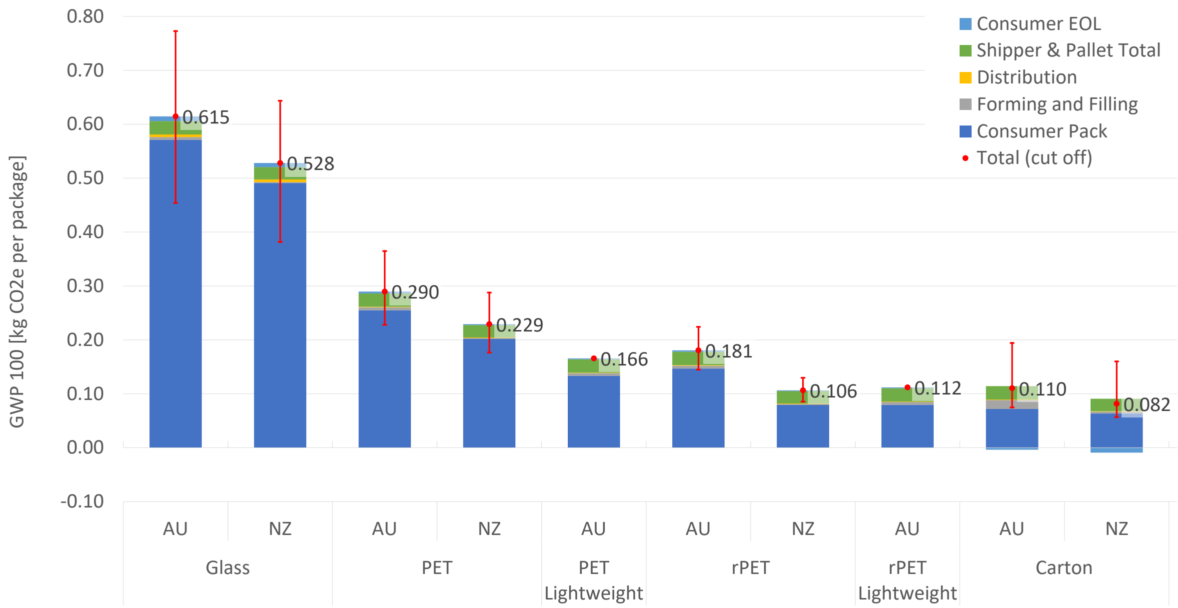

Figure 5-15: 1 L aseptic GWP with range of carton EOL scenarios

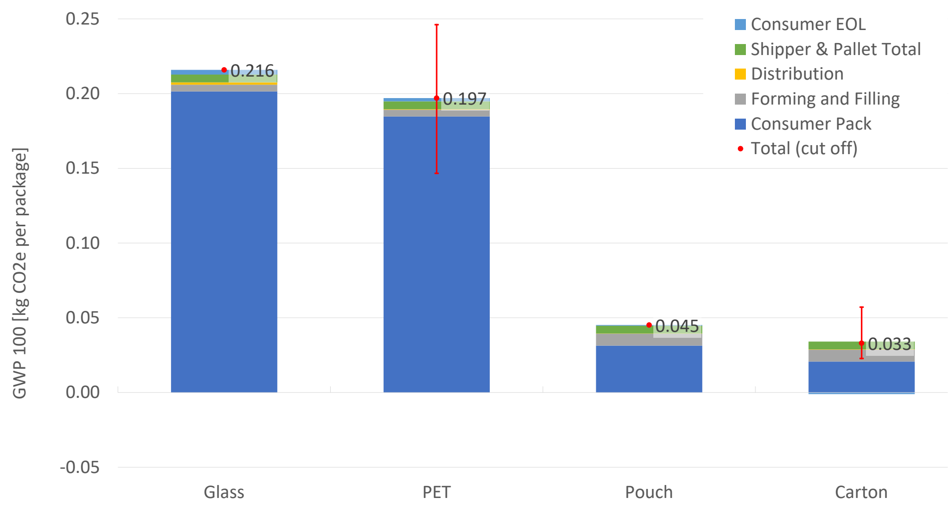

Figure 5-16: 250 mL (AU only) aseptic GWP with range of carton EOL scenarios

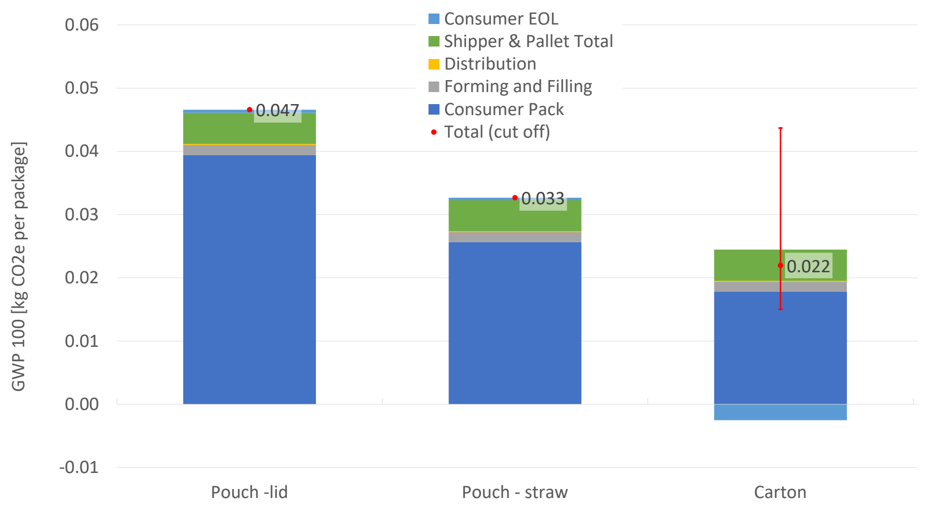

Figure 5-17: 200 mL (NZ only) aseptic GWP with range of carton EOL scenarios

Table 5-2: Worst case carton DOC_F and recycling rate GWP results (kg CO_2-e). Green shading indicates values have changed from default analysis.

	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
1L aseptic	Glass AU	5.71E-01	5.35E-03	4.80E-03	8.84E-03	2.48E-02	6.15E-01
	Glass NZ	4.91E-01	1.80E-03	4.85E-03	7.48E-03	2.31E-02	5.28E-01
	PET AU	2.55E-01	5.35E-03	9.96E-04	3.48E-03	2.48E-02	2.90E-01
	PET NZ	2.02E-01	1.80E-03	9.86E-04	1.68E-03	2.31E-02	2.29E-01
	PET Lightweight AU	1.33E-01	5.35E-03	8.24E-04	1.58E-03	2.48E-02	1.66E-01
	rPET AU	1.47E-01	5.35E-03	9.85E-04	2.61E-03	2.48E-02	1.81E-01
	rPET NZ	7.92E-02	1.80E-03	9.86E-04	1.37E-03	2.31E-02	1.06E-01
	rPET Lightweight AU	7.94E-02	5.35E-03	8.24E-04	1.42E-03	2.48E-02	1.12E-01
	Carton AU (baseline)	7.18E-02	1.66E-02	9.54E-04	-3.80E-03	2.48E-02	1.10E-01
	Carton Worst Case (DOC_F 50%, Recycling 0%, Gas capture 0%) AU	7.18E-02	1.66E-02	9.54E-04	8.00E-02	2.48E-02	1.94E-01
250 mL aseptic (AU only)	Glass AU	2.01E-01	4.48E-03	1.56E-03	3.12E-03	5.26E-03	2.16E-01
	PET AU	1.85E-01	4.48E-03	3.55E-04	2.18E-03	5.26E-03	1.97E-01
	Pouch AU	3.14E-02	7.93E-03	1.44E-04	4.62E-04	5.26E-03	4.52E-02
	Carton AU (baseline)	2.07E-02	7.93E-03	1.83E-04	-1.09E-03	5.26E-03	3.30E-02
	Carton Worst Case (DOC_F 50%, Recycling 0%, Gas capture 0%) AU	2.07E-02	7.93E-03	1.83E-04	2.30E-02	5.26E-03	5.71E-02
200 mL aseptic (NZ only)	Pouch – lid NZ	3.94E-02	1.57E-03	1.66E-04	4.91E-04	4.93E-03	4.66E-02
	Pouch – straw NZ	2.56E-02	1.57E-03	1.36E-04	3.86E-04	4.93E-03	3.27E-02
	Carton NZ (baseline)	1.78E-02	1.57E-03	1.69E-04	-2.52E-03	4.93E-03	2.19E-02
	Carton Worst Case (DOC_F 50%, Recycling 0%, Gas capture 0%) NZ	1.78E-02	1.57E-03	1.69E-04	1.92E-02	4.93E-03	4.37E-02

5.5.2. Plastic and Glass Bottle Mass Variation

Across the weighing of the consumer packs, it was found that there was a wide variation in the mass of plastic and glass bottles of the same size class. This range has been portrayed with bars which are the same as those seen in Section 5.2 and this analysis evaluates the results if the PET, rPET and glass bottles were their lowest measured value. This results in 1 L PET and rPET bottles weighing approximately 25% less than the 1 L PET average, glass bottles weighing approximately 30% less than the glass bottle average, and HDPE bottles weighing 10% less than the HDPE bottle average. The 1 L aseptic beverage and 1 L fresh milk categories have been included in this scenario analysis because these were the categories where the error bars showed the minimum weighed masses of some packaging types, being low enough to potentially be competitive with cartons. For 1 L aseptic, shown in Figure 5-18, it can be seen that rPET (including lightweight rPET in Australia) is now within 10% of the GWP of cartons. For 1 L fresh milk, cartons still have the lowest GWP by a significant margin. The 250 mL and 200 mL size classes have not been included in this category because the plastic packs in those categories had a GWP of more than 100% larger than the carton GWP.

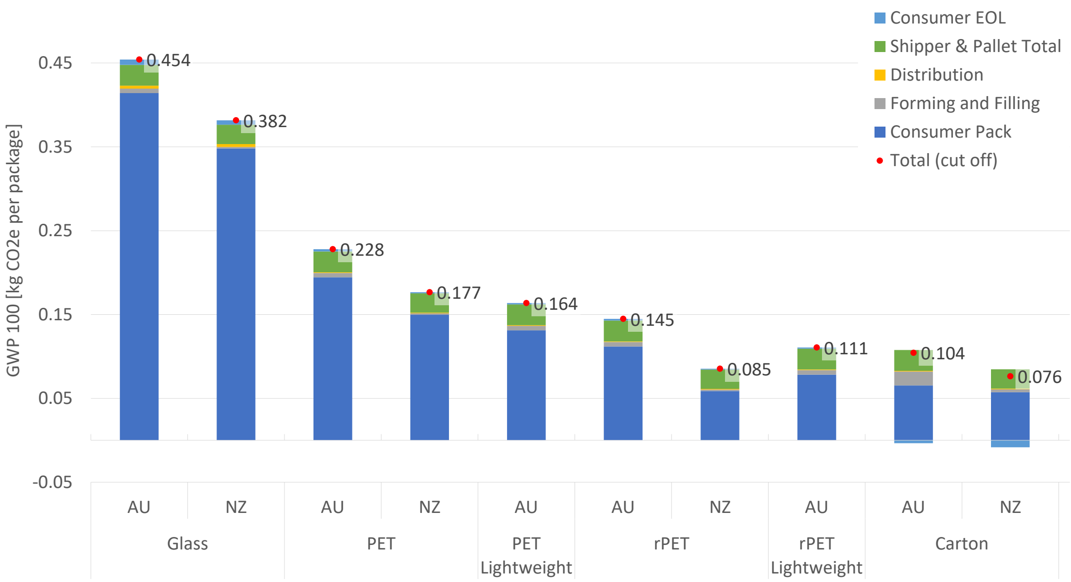

Figure 5-18: 1 L aseptic results - minimum plastic and glass bottle masses

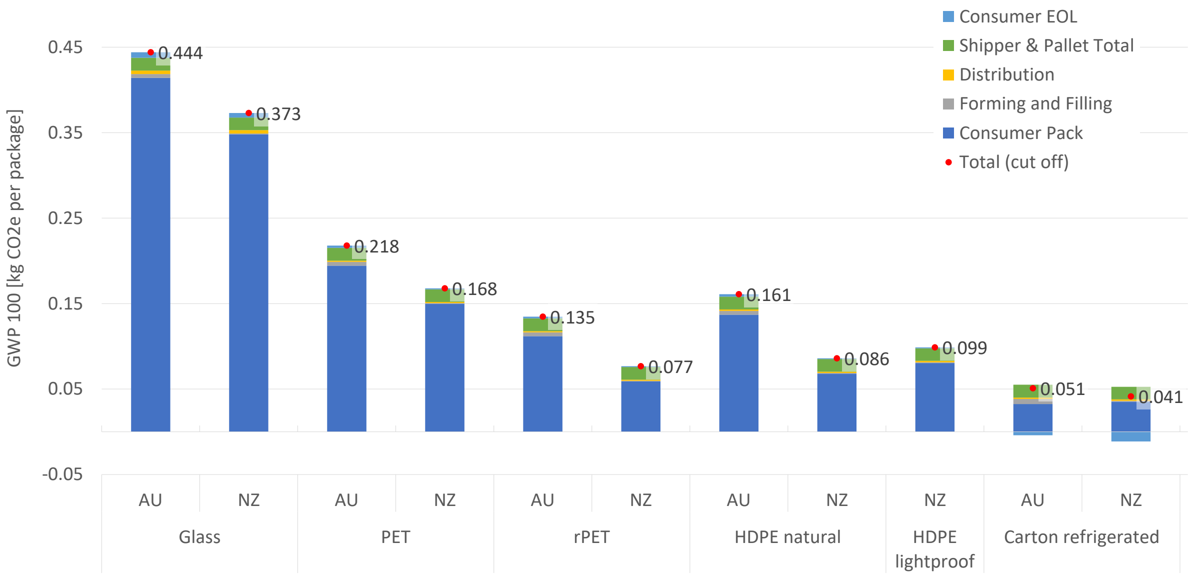

Figure 5-19: 1 L fresh milk results - minimum plastic and glass bottle masses

Table 5-3: Plastic and glass mass variation scenario analysis GWP results (kg CO_2-e)

	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
1L aseptic	Glass AU	4.14E-01	5.35E-03	3.48E-03	6.39E-03	2.48E-02	4.54E-01
	Glass NZ	3.48E-01	1.80E-03	3.44E-03	5.30E-03	2.31E-02	3.82E-01
	PET AU	1.94E-01	5.35E-03	7.59E-04	2.65E-03	2.48E-02	2.28E-01
	PET NZ	1.50E-01	1.80E-03	7.32E-04	1.25E-03	2.31E-02	1.77E-01
	PET Lightweight AU	1.31E-01	5.35E-03	8.12E-04	1.56E-03	2.48E-02	1.64E-01
	rPET AU	1.12E-01	5.35E-03	7.50E-04	1.99E-03	2.48E-02	1.45E-01
	rPET NZ	5.88E-02	1.80E-03	7.32E-04	1.02E-03	2.31E-02	8.54E-02
	rPET Lightweight AU	7.83E-02	5.35E-03	8.12E-04	1.40E-03	2.48E-02	1.11E-01
	Carton AU	6.55E-02	1.66E-02	8.70E-04	-3.46E-03	2.48E-02	1.04E-01
	Carton NZ	5.74E-02	3.42E-03	8.25E-04	-8.32E-03	2.31E-02	7.64E-02
1L fresh milk	Glass AU	4.14E-01	4.48E-03	4.03E-03	6.41E-03	1.50E-02	4.44E-01
	Glass NZ	3.48E-01	8.54E-04	3.98E-03	5.32E-03	1.47E-02	3.73E-01
	PET AU	1.94E-01	4.48E-03	1.33E-03	2.67E-03	1.50E-02	2.18E-01
	PET NZ	1.50E-01	8.54E-04	1.29E-03	1.27E-03	1.47E-02	1.68E-01
	rPET AU	1.12E-01	4.48E-03	1.33E-03	2.01E-03	1.50E-02	1.35E-01
	rPET NZ	5.88E-02	8.54E-04	1.29E-03	1.04E-03	1.47E-02	7.68E-02
	HDPE natural AU	1.37E-01	4.48E-03	1.69E-03	2.91E-03	1.50E-02	1.61E-01
	HDPE natural NZ	6.80E-02	8.54E-04	1.49E-03	8.84E-04	1.47E-02	8.59E-02
	HDPE lightproof NZ	8.04E-02	8.54E-04	1.66E-03	1.04E-03	1.47E-02	9.87E-02
	Carton refrigerated AU	3.25E-02	5.96E-03	1.63E-03	-4.09E-03	1.50E-02	5.10E-02
	Carton refrigerated NZ	3.51E-02	1.10E-03	1.63E-03	-1.13E-02	1.47E-02	4.14E-02

5.5.3. Recycling Allocation Method: Cut-off vs Substitution

The baseline scenario in this report uses the cut-off method for allocation of recycled materials between product life cycles. This means that the impacts of previous and future uses of recycled materials are not considered within the system boundary. The analysis in this section applies the substitution approach instead. As a general rule, the cut-off method favours products with high recycled content irrespective of the recycling rate at end-of-life, whereas the substitution method penalises products that do not produce enough recycled content at end-of-life to manufacture themselves again (i.e., products are penalised if they have a net deficit of recycled content over the full product life cycle).

Due to the changing recycling landscape in Australia and New Zealand (see Section 3.8.1) these analyses compare two substitution allocations to the baseline (cut-off) scenario:

1. The “Current Domestic Recycling” scenario provides credits for the share of recycling processed domestically (as seen in Table 3-12), while the share of recycling which has historically been processed overseas (except for steel and aluminium) has no credit as it is assumed to be stockpiled/downcycled (i.e. the cut-off method) (see Section 3.8.4). The overseas recycling of steel and aluminium continues to generate a credit as they

have high material value. The net result of this scenario is shown as a black triangle on the graphs below.

2. The “100% Domestic Recycling” scenario assumes that there is the capacity to process all recycling domestically and so provides credits for all recycled materials. This is a better-than-best-case scenario and represents domestic recycling capacity that did not exist at the time of writing, but which may be built within the next few years in response to waste export restrictions. The net result of this scenario is shown as a white square with a black border on the graphs below.

Figure 5-20, Figure 5-21 and Figure 5-22 show that there is essentially no change in results between allocation methods for cartons and pouches, i.e., the results for cartons and pouches are insensitive to the choice of recycling allocation method. This is expected because both cartons and pouches are manufactured from virgin materials and (currently) have low recycling rates at end-of-life. The biggest shift in results between the cut-off method and the substitution methods is for 100% rPET, whose carbon footprint increases considerably using the substitution method, bring its carbon footprint closer to that of virgin PET as more virgin material is needed to ‘top up’ the 100% recycled input than can be collected through current waste and recycling infrastructure.

In general, using the 100% Domestic Recycling substitution method results in PET packaging systems to have a lower carbon footprint than in the Current Domestic Recycling method because the systems gain more of a credit due to more material being recycled. This effect is more pronounced in the New Zealand systems due to (a) the higher recycling rate for PET in New Zealand compared to Australia, and (b) recycling of PET in New Zealand has a lower carbon footprint than in Australia due to the electricity grid being less carbon intensive. Other materials are not significantly impacted by either substitution method.

The outcome of this sensitivity analysis is that cartons have the lowest GWP of all packaging systems considered by this study, irrespective of which end-of-life allocation method is applied. Pouches have a comparable GWP to cartons in the categories where they exist.

Overall, use of either substitution method reinforces the conclusions of this study.

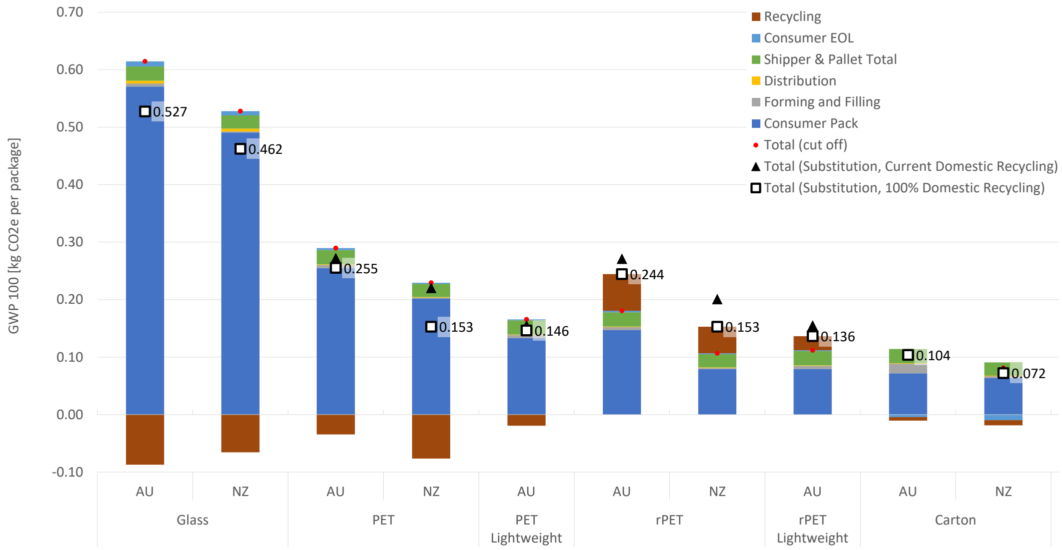

Figure 5-20: Results for 1 L aseptic packaging – substitution recycling methods

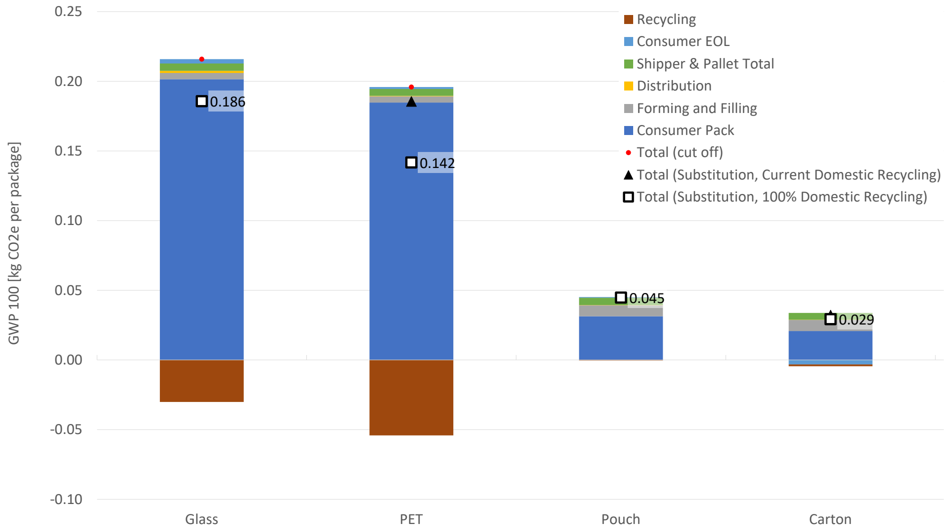

Figure 5-21: Results for 250 mL packaging (AU only) – substitution recycling methods

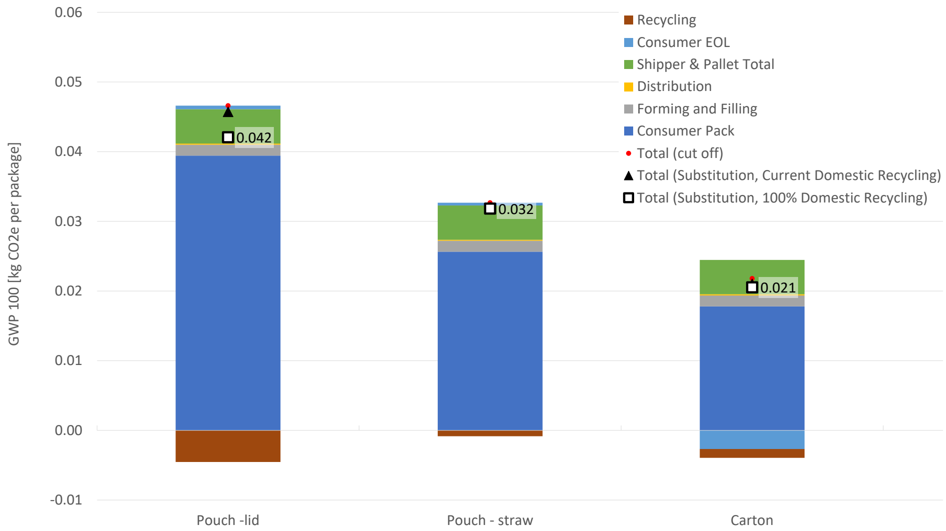

Figure 5-22: Results for 200 mL packaging (NZ only) – substitution recycling methods

Table 5-4: GWP results (kg CO2-e) – substitution recycling methods

	Packaging type	Total (cut-off)	Total (Substitution, Current Domestic Recycling)	Total (Substitution, 100% Domestic Recycling)
1L aseptic	**Glass AU**	6.15E-01	5.27E-01	5.27E-01
	Glass NZ	5.28E-01	4.62E-01	4.62E-01
	PET AU	2.90E-01	2.72E-01	2.55E-01
	PET NZ	2.29E-01	2.20E-01	1.53E-01
	PET Lightweight AU	1.66E-01	1.55E-01	1.46E-01
	rPET AU	1.81E-01	2.71E-01	2.44E-01
	rPET NZ	1.07E-01	2.01E-01	1.53E-01
	rPET Lightweight AU	1.12E-01	1.55E-01	1.36E-01

	Packaging type	Total (cut-off)	Total (Substitution, Current Domestic Recycling)	Total (Substitution, 100% Domestic Recycling)
	Carton AU	1.10E-01	1.05E-01	1.04E-01
	Carton NZ	8.11E-02	7.60E-02	7.21E-02
250 mL aseptic (AU only)	**Glass AU**	2.16E-01	1.86E-01	1.86E-01
	PET AU	1.97E-01	1.86E-01	1.42E-01
	Pouch AU	4.52E-02	4.50E-02	4.48E-02
	Carton AU	3.28E-02	3.22E-02	2.94E-02
200 mL aseptic (NZ only)	**Pouch - lid NZ**	4.66E-02	4.57E-02	4.24E-02
	Pouch - straw NZ	3.27E-02	3.24E-02	3.21E-02
	Carton NZ	2.19E-02	2.15E-02	2.09E-02

5.5.4. Aluminium Production

The carbon footprint of virgin (primary) aluminium varies significantly, primarily based on the electricity used for the electrolysis of alumina (World Aluminium, 2017). In the baseline scenarios within this report, virgin aluminium is assumed to be purchased from the global market (i.e. the electricity mix used is a global average weighted by the amount of aluminium produced). Figure 5-23 demonstrates the change in results if the primary aluminium with the lowest carbon footprint were used (produced using electricity from hydropower) for the 30% virgin aluminium used, with the remaining 70% being recycled aluminium. From the graph, it can be seen that even with best-case aluminium sourcing, aluminium cans still have a higher GWP than their respective cartons (>30%).

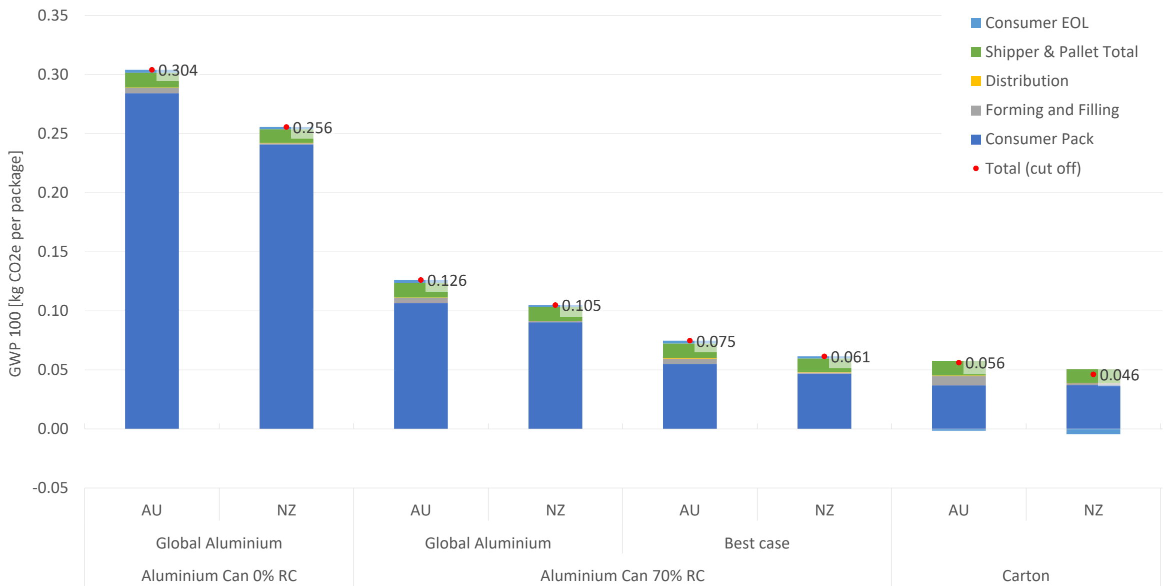

Figure 5-23: Results for 330 mL packaging – aluminium can scenario analysis (RC= Recycled Content)

Table 5-5: GWP results – aluminium can scenario analysis

Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
Aluminium Can - 0% Recycled AU	2.84E-01	4.48E-03	4.21E-04	2.49E-03	1.24E-02	3.04E-01
Aluminium Can - 0% Recycled NZ	2.41E-01	9.47E-04	4.02E-04	1.87E-03	1.15E-02	2.56E-01
Aluminium Can - 70% Recycled (baseline) AU	1.06E-01	4.48E-03	4.21E-04	2.39E-03	1.24E-02	1.26E-01
Aluminium Can - 70% Recycled (baseline)NZ	9.03E-02	9.47E-04	4.02E-04	1.78E-03	1.15E-02	1.05E-01
Aluminium Can - 70% Recycled (best-case) AU	5.50E-02	4.48E-03	4.21E-04	2.39E-03	1.24E-02	7.48E-02
Aluminium Can - 70% Recycled (best-case) NZ	4.68E-02	9.47E-04	4.02E-04	1.78E-03	1.15E-02	6.15E-02
Carton AU	3.69E-02	7.93E-03	4.42E-04	-1.51E-03	1.24E-02	5.62E-02
Carton NZ	3.71E-02	1.57E-03	4.42E-04	-4.38E-03	1.15E-02	4.62E-02

5.6. Comparison to Other Studies

The results from this study were compared to several other studies as a sense-check. Studies used for comparison in this section included two other critically reviewed studies and a peer-reviewed journal article. The full list of studies and packaging systems against which a comparison is made can be seen in Table 5-6.

Table 5-6: List of studies and packaging systems compared

Study	Material	Country	Specific packaging system
(Franklin Associates, 2015)	PET	US	PET bottle – preform*
	PET	CA	PET bottle – preform*
	Carton	US	Tetra Prisma Aseptic 1 L
	Carton	CA	Tetra Prisma Aseptic 1 L
	Pouch	US	Pouch 177 mL*
	Pouch	CA	Pouch 177 mL*
	Carton	US	Tetra Prisma Aseptic 180 mL*
	Carton	CA	Tetra Prisma Aseptic 180 mL*
(Stefanini, et al., 2020)	PET	IT	PET 1 L
	rPET	IT	rPET 1 L
(Institute for Energy and Environmental Research (IFEU), 2017)	PET	SE	Base scenarios DAIRY Sweden: PET bottle 1 L
	Carton	SE	Base scenarios DAIRY Sweden: Tetra Brik 1 L

Study	Material	Country	Specific packaging system
This study	PET	AU	1 L Aseptic PET AU
	PET	NZ	1 L Aseptic PET NZ
	rPET	AU	1 L Aseptic rPET AU
	rPET	NZ	1 L Aseptic rPET NZ
	Carton	AU	1 L Aseptic Carton AU
	Carton	NZ	1 L Aseptic Carton NZ
	Pouch	NZ	200 mL Aseptic Pouch – straw NZ
	Carton	NZ	200 mL Aseptic Carton NZ

* These packaging systems were different to the packaging systems used in this study and so were scaled to have equivalent volumes of the size classes in this study

For these comparisons, the cradle-to-grave GWP impacts of the consumer packs using the cut-off methodology were compared to other studies. For the packaging systems in this study the included modules were: in Consumer Pack, Forming and Filling and Consumer EOL (see Section 5.1). These modules were selected to keep the scope the same across all studies, with some modules (e.g. distribution and recycling and energy credits) from other studies being excluded as well.

Due to the fact this study was done on a per consumer pack basis, other studies were scaled in order to provide a carbon footprint per consumer pack. The Franklin Associates report had different consumer pack sizes; these were further scaled to make them contain the same volume.

Notable potential differences in teardowns, modelling assumptions, datasets used and end-of-life pathways between studies are noted below:

- Plastic granulate from China (used in this study) has a larger carbon footprint than plastic granulate from Europe and North America.
- The carbon footprint of rPET (when using a cut-off approach) is largely dependent on the carbon intensity of the electricity grid. The New Zealand electrical grid is lower carbon than the grid in both Italy and Australia, which leads to New Zealand rPET having a low GWP.
- Consumer pack mass is a major driver of the GWP, especially with variations in PET bottle design (as shown in this study). None of the PET bottles in the other studies analysed contained ‘lightweight’ PET bottles.
- The IFEU report assumed a 25% rPET content for PET bottles.
- End-of-life:
    - The IFEU report used the 50% allocation method for their baseline EOL scenario. This will not have a major impact on the carton results but will affect the PET bottle results due to their recycled content and recycling rate.
    - Europe and North America have different recycling, landfill and incineration rates compared to New Zealand and Australia, with both markets having higher waste incineration as well as higher carton recycling rates than in this study.
    - The DOC_F of the cartons was assumed to be 0% in the Franklin Associates study and 30% in the IFEU study.

Figure 5-24 shows the 1 L PET and rPET bottles and the 1 L cartons in this study compared with similar packaging systems from other studies. In general, the results from this study align with results from the other studies considered. Exceptions to this include the PET bottles from this study having slightly higher GWPs than the other PET bottles, which can be explained by the granulate used for this study coming from China, which has a higher GWP than PET granulate from Europe or North America. The New Zealand rPET bottle in this study has a lower GWP than the other rPET bottles due to the mechanical recycling of the PET granulate occurring in New Zealand, which has a low carbon electricity grid.

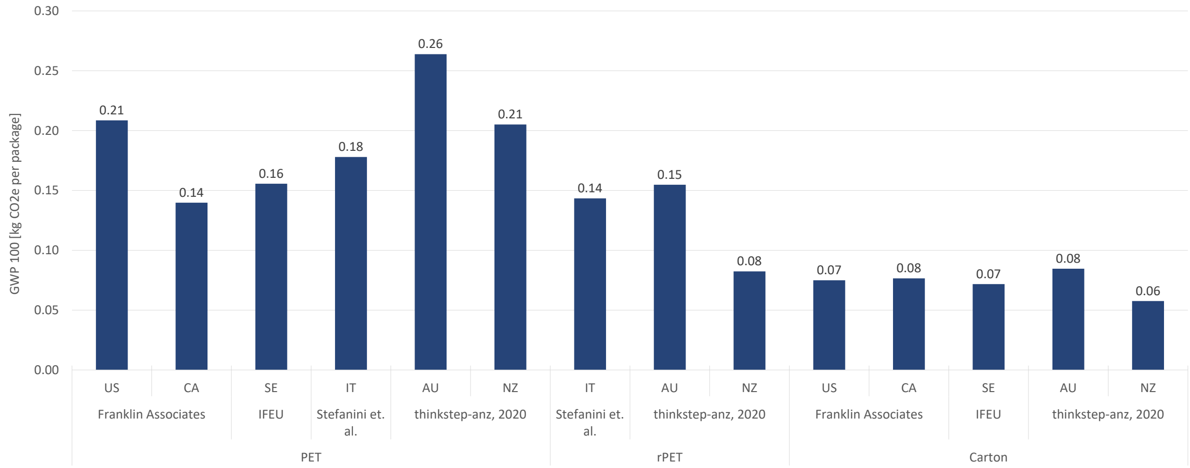

Figure 5-24: 1 L aseptic GWP comparison to other studies

Figure 5-25 shows the 200 mL pouches and cartons in this study compared with similar packaging systems from the Franklin Associates report (Franklin Associates, 2015). Results from this study align with the other results shown.

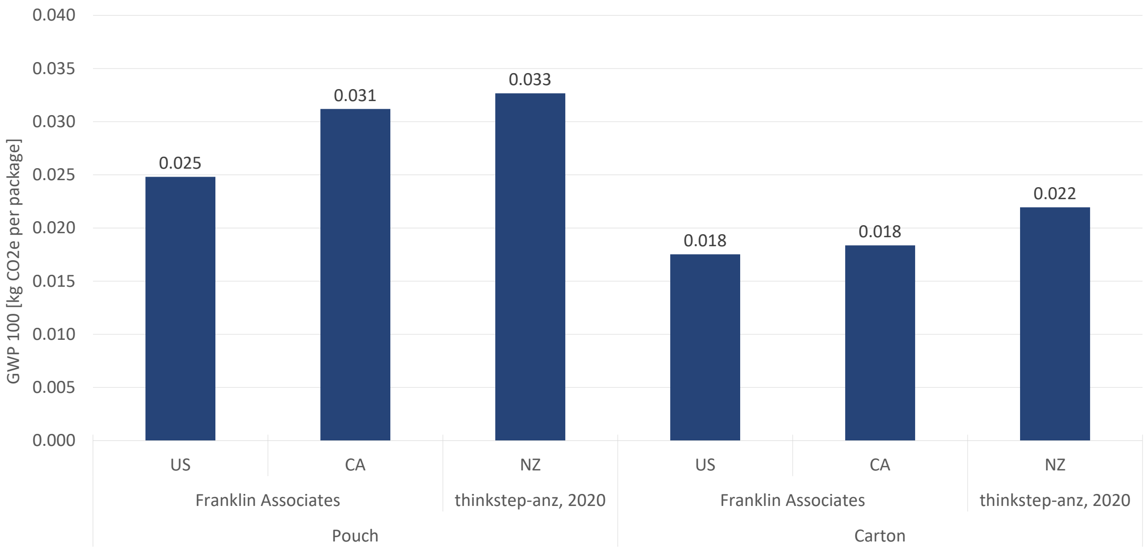

Figure 5-25: 200 mL aseptic GWP comparison to other studies

5.7. Tetra Pak Packages

Results for individual Tetra Pak cartons are shown in Table 5-7 with other indicators included in Annex M. A summary of the specifications of the cartons analysed can be found in Table 2-3, with a full list in Annex C (confidential). Looking at products within the same size class, the GWP results are similar between products, with a few notable exceptions. The Tetra Rex, which is used for fresh beverages (with a short shelf life) does not have an aluminium inner barrier layer and so has lower impact than the aseptic products of the same size class. The Tetra Rex also has a bio-based version, where the plastic layer of the carton is derived from sugarcane. The bio-based Tetra Rex cartons have better results than the standard Tetra Rex across all indicators, but this is largely due to the paperboard layer of the bioplastic carton having a lower density (in g/m^2) than in the standard carton, while the plastic/bioplastic layer have the same layer density across both products. This results in the Tetra Rex bio-based carton being lighter than the standard Tetra Rex. The Tetra Top line of products have bio-based plastic caps and necks from sugar cane, which results in them having a lower GWP but a higher Eutrophication Potential (EP) and Photochemical Ozone Creation Potential (POCP) than other aseptic products of the same size class. In the 1 L size class, the TPA Square and the TBA Square HC27 both have high GWP values relative to other TBA cartons in that size class due to the heavier cap.

Table 5-7: Tetra Pak product GWP results (kg CO_2-e)

Size class	Packaging type	Consumer Pack	Forming & Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
2L Tetra Pak products	TBA HC27 AU	1.08E-01	2.32E-02	1.53E-03	-5.62E-03	4.53E-02	1.72E-01
	TBA SC AU	1.12E-01	2.32E-02	1.54E-03	-5.55E-03	4.53E-02	1.76E-01
1L Tetra Pak products	TPA Square AU	7.71E-02	1.66E-02	9.61E-04	-3.42E-03	2.48E-02	1.16E-01
	TBA Square HC27 AU	7.20E-02	1.66E-02	9.44E-04	-3.09E-03	2.48E-02	1.11E-01
	TBA Slim HC AU	5.97E-02	1.66E-02	9.17E-04	-3.12E-03	2.48E-02	9.89E-02
	TBA Edge AU	5.21E-02	1.66E-02	8.89E-04	-3.10E-03	2.48E-02	9.13E-02
	Tetra Top AU	7.67E-02	7.61E-03	8.86E-04	-2.76E-02	2.48E-02	8.24E-02
	Tetra Rex AU	3.72E-02	5.96E-03	8.93E-04	-4.30E-03	2.48E-02	6.46E-02
	Tetra Rex Bio AU	3.69E-02	5.96E-03	8.53E-04	-1.38E-02	2.48E-02	5.47E-02
600 mL Tetra Pak products	Tetra Rex AU	2.70E-02	5.96E-03	5.83E-04	-3.13E-03	1.66E-02	4.70E-02
	Tetra Rex Bio AU	2.67E-02	5.96E-03	5.54E-04	-1.00E-02	1.66E-02	3.98E-02
500 mL Tetra Pak products	Tetra Top AU	5.82E-02	7.61E-03	8.37E-04	-1.99E-02	2.71E-02	7.39E-02
	Tetra Recart Midi AU	3.34E-02	3.11E-03	8.27E-04	-1.86E-03	2.71E-02	6.26E-02
330 mL Tetra Pak products	Tetra Top AU	5.17E-02	7.61E-03	4.44E-04	-1.95E-02	1.24E-02	5.27E-02
	Tetra Prisma AU	3.60E-02	7.93E-03	4.35E-04	-9.77E-04	1.24E-02	5.58E-02
250 mL Tetra Pak products	TBA Slim Straw AU	1.79E-02	7.93E-03	1.74E-04	-9.78E-04	5.26E-03	3.03E-02
	TPA Square Straw AU	1.95E-02	7.93E-03	1.81E-04	-1.03E-03	5.26E-03	3.18E-02
	TBA Edge Straw AU	2.04E-02	7.93E-03	1.77E-04	-9.21E-04	5.26E-03	3.29E-02
	TBA Edge Cap AU	3.05E-02	7.93E-03	1.97E-04	-7.59E-04	5.26E-03	4.32E-02

Size class	Packaging type	Consumer Pack	Forming & Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
200 mL Tetra Pak products	TPA Square Straw AU	1.97E-02	7.93E-03	1.74E-04	-8.28E-04	5.26E-03	3.22E-02
	TBA Slim Straw AU	1.62E-02	7.93E-03	1.63E-04	-8.05E-04	5.26E-03	2.88E-02
	TBA Slim Leaf AU	1.64E-02	7.93E-03	1.68E-04	-9.23E-04	5.26E-03	2.88E-02
	TBA Base AU	1.60E-02	7.93E-03	1.62E-04	-8.01E-04	5.26E-03	2.86E-02
	TBA Base Crystal AU	1.69E-02	7.93E-03	1.62E-04	-7.86E-04	5.26E-03	2.95E-02

6. Interpretation

6.1. Identification of Relevant Findings

6.1.1. Overview of Assessed Options

Tetra Pak packaging options were assessed against different packaging materials including PET bottles, HDPE bottles, pouches, aluminium cans, tinplated steel cans, glass bottles and glass jars.

Different classes of packaging types were defined, according to performance, i.e. fresh and aseptic for beverages and aseptic for food, and to size from 200 mL to 2 L. Tetra Pak packaging are compared against alternative packaging options within those classes.

6.1.2. Comparison of Tetra Pak Cartons with Other Packaging Options

For all size classes, cartons were shown to have the lowest GWP. For most size classes, the difference between cartons and other packaging options was significant. In most cases the packaging option with second-lowest GWP had 30-120% higher GHG emissions. The only exceptions were the lightweight 1 L water bottle where the GWP was essentially identical, and the lightweight 600 mL water bottle where the GWP was 14% higher than the carton.

Analysis of other impact categories shows that cartons have lower impacts than almost all of the other packaging types studied, across most size classes (see Section 5.4.6). Exceptions include the AP, EP and POCP indicators where pouches and in some cases rPET and lightweight PET/rPET had a lower impact.

6.1.3. Detailed Assessment of Tetra Pak Carton Components

Tetra Pak packages were also analysed as part of this report in more detail to identify the impact of the different materials used within a carton. These results show that impacts are similar for different Tetra Pak products with the same function and volume. Large caps and straws increased the impact of products, while cartons with bioplastics had lower GWP values, but higher AP and EP values. Cartons designed as short-life packaging had lower impacts in general due to not having an aluminium barrier layer.

6.1.4. Contribution of Life Cycle Stages to Overall Impacts

The consumer pack manufacturing stage had by far the largest contribution towards GWP. For the lower-impact products (small cartons and pouches), the impact from the secondary and tertiary packaging is relatively more significant at up to 40% of total GWP. The consumer end-of-life stage was insignificant for most packs, but was negative for all cartons (in some cases significantly) due to the sequestration of biogenic carbon. Forming and filling was insignificant except for smaller Australian aseptic cartons and pouches.

6.2. Assumptions and Limitations

The main assumptions used in the modelling for this report as well as the datasets used are described in detail in Section 3. Areas where the data used were of lower quality or where there were data gaps are summarised below:

- All generic cartons have been assumed to have come from China. This is a conservative approach as China’s national electricity mix is relatively carbon intensive compared to other regions.
- The supply chains for all competitor packs have been assumed based on current packaging trends and generic manufacturing data. Individual packaging manufacturers may have different material sources and different production efficiencies and therefore different results.
- Proxy European data was used in place of Chinese datasets where Chinese (or equivalent) could not be found. This includes, but is not limited to, materials such as glass, tinplated steel, aluminium foil, and steel used in lids. This is considered conservative as these materials were used for non-carton pack formats and, in general, European production has a lower GWP than Chinese production.
- There was a wide variation in the masses of plastic and glass bottles weighed during data collection. For the baseline scenarios an average was taken, with bars indicating the range of masses. A scenario analysis was undertaken which showed the impacts of the lightest bottles compared to the average carton. The results from this analysis showed that the minimum weighed mass did not affect the conclusions, except for the 1 L aseptic beverage size class where the difference between the rPET and the carton became less than 10%.
- Certain assumptions were made for the filling of non-carton packaging systems. These needed to be made because no primary data was available for these types of filling. The data used is consistent with previous thinkstep-anz work for other companies. To help counteract this uncertainty, the estimates made were conservative so as not to overestimate the impacts of a given packaging system.
- Raw materials for the non-carton packaging options are based on datasets available in the GaBi database as no primary data was available. The GaBi Database is based on industry data and provides a reliable proxy for primary data.
- Secondary and tertiary packaging data was based on teardowns and anecdotal information. The same assumptions were applied for all packaging materials within a size class so as not to benefit cartons.
- It was assumed that the DOC_F of laminated paper is 21%, based on a previous study (Eleazer, et al., 1997). There is uncertainty in this value and a sensitivity analysis was performed to assess its effect on the conclusions.
- There is some uncertainty around the methane capture rate in landfills. This has been discussed in Section 3.8.5.2 and tested through sensitivity analysis in Section 5.5.1.
- A low carton recycling rate (10%) was assumed for both nations, but this is a developing area and may change in the near future. Counterintuitively, an increased recycling rate would increase the GWP of cartons for the baseline scenario (due to artificial release when it leaves the system as opposed to being sequestered in the landfill). However, an increased recycling rate would decrease the GWP of the worst-case DOC_F scenario.
- The glass bottles assessed in the study were all clear glass bottles, as clear glass is typically used for water, milk and juice – the product categories considered in this study.

Recycling rates for amber and green glass are higher than that for clear glass in both Australia and New Zealand, meaning that the results cannot be applied to beer bottles or wine bottles (which are outside the scope of this report).

- There is relatively high uncertainty in the results for aluminium cans as aluminium is an electricity-intensive material to manufacture. This means that the impacts of primary aluminium can vary from approximately 5 kg CO_2e/kg to over 20 kg CO_2e/kg (World Aluminium, 2017). The global mix selected for this study is towards the higher end of that range, due to the prevalence of coal-fired electricity in the global aluminium production mix. Selecting a high recycled content (70%) as one scenario helps to counter this uncertainty.

6.3. Scenario Analyses

Scenario analyses were performed to compare results between different sets of assumptions or modelling choices. The carton DOC_F and recycling rate analysis (see Section 5.5.1) showed that variations in the DOC_F of laminated paper had a significant impact on results, especially in Australia where the landfill gas capture rate was lower. Increasing the recycling rate increased the GWP for the baseline scenario, but made uncertainty in the DOC_F less significant, due to fewer cartons making it to landfill. Taking the worst-case scenario from those modelled made the Australian 1 L and 250 mL aseptic beverage cartons as bad as the second lowest packaging system of that size class (rPET and pouch respectively).

Due to the variation in plastic and glass bottle masses, a sensitivity analysis was performed to determine if the results would be different if the lowest-mass bottles were used. These results showed that the lightest rPET bottle results were similar to the carton results for the 1 L aseptic results, while the 1 L fresh milk results still showed the carton having a significantly lower GWP.

Two ‘substitution’ end-of-life scenarios were analysed to assess the impact of using different end-of-life allocation methodology. Due to the low recycled content and current recycling rates of both cartons and pouches, these packaging types do not change significantly from the ‘cut-off’ scenario. However, the GWP of rPET increases significantly, as the amount of recyclable material recovered at end-of-life is insufficient to meet the 100% recycled content and a top-up of virgin material is required to manufacture the next bottle. The ‘substitution’ scenarios, therefore, does not change the findings reached in Section 6.1.

The virgin (primary) aluminium sourcing scenario (see Section 5.5.4) considered aluminium cans made from aluminium produced using hydropower electricity, which has a much lower carbon footprint than the global average for aluminium. This lowers the GWP of aluminium cans, but it still remains >30% higher than the GWP of cartons, so it does not change the findings reached in Section 6.1.

6.4. Data Quality Assessment

Data quality is judged by its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied) and representativeness (geographical, temporal, and technological).

To meet these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from the GaBi 2020 database were used. The LCI datasets from the GaBi 2020 database are widely distributed and used with the GaBi 9 Software. The datasets have been used in LCA models worldwide in industrial and scientific applications in internal as well as in many critically reviewed and published studies. In the process of providing these datasets they are cross-checked with other databases and values from industry and science.

6.4.1. Precision and Completeness

- ✓ **Precision:** As the majority of the relevant foreground data are measured data or calculated based on primary information sources of the owner of the technology, precision is considered to be high. All background data are sourced from GaBi databases with the documented precision. A notable area where precision is lower, though still acceptable in the view of the authors, is for manufacturing of non-carton packs as this data is based on industry-averages from the GaBi 2020 database.
- ✓ **Completeness:** Each foreground process was checked for mass balance and completeness of the emission inventory. No data were knowingly omitted, except for printing inks and dyes. Completeness of foreground unit process data is considered to be high. All background data are sourced from GaBi databases with the documented completeness.

6.4.2. Consistency and Reproducibility

- ✓ **Consistency:** To ensure data consistency, all primary data were collected with the same level of detail, while all background data were sourced from the GaBi databases.
- ✓ **Reproducibility:** Reproducibility is supported as much as possible through the disclosure of input-output data, dataset choices, and modelling approaches in this report. Based on this information, any third party should be able to approximate the results of this study using the same data and modelling approaches.

6.4.3. Representativeness

- ✓ **Temporal:** All primary data were collected for the year 2019. All secondary data come from the GaBi 2020 databases and are representative of the years 2016-2019. As the study intended to compare the product systems for the reference year 2019, temporal representativeness is considered very high.
- ✓ **Geographical:** All primary data were collected specific to the countries under study. Where possible, secondary data were used specific to the countries under study. Where country-specific or region-specific data were unavailable, proxy data were used. Assumptions had to be made on the supply chains of competitor packs, in these cases the decisions made have been in favour of benefitting the competitor (e.g. blow moulding PET preforms and HDPE granulate in New Zealand instead of China/Australia). Geographical representativeness is considered acceptable, particularly given the conservative approach applied.
- ✓ **Technological:** All primary and secondary data were modelled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used (a notable example is that a generic blow moulding

dataset was used as a proxy for the actual moulding process for HDPE milk bottles). Technological representativeness is considered high.

6.5. Model Completeness and Consistency

6.5.1. Completeness

All relevant process steps for each product system were considered and modelled to represent each specific situation. The process chain is considered sufficiently complete and detailed with regards to the goal and scope of this study.

6.5.2. Consistency

All assumptions, methods and data are consistent with each other and with the study's goal and scope. Differences in background data quality were minimised by exclusively using LCI data from the GaBi 2020 databases. System boundaries, allocation rules, and impact assessment methods have been applied consistently throughout the study.

6.6. Conclusions, Limitations, and Recommendations

6.6.1. Conclusions

The results of this study show that cartons are the consumer packaging solution with the lowest GWP (carbon footprint) for both beverages and food. rPET bottles, aluminium pouches and lightweight PET water bottles are the packaging types which have the closest GWP to cartons. The use of paperboard as the main component of the packaging is the main driver of a low GWP.

Assumptions have been made to model the manufacture and distribution of competitor packaging types where no primary data was available. These include assuming the material supply chain, location of manufacture and filling data. These estimations have been made based on underlying data and previous work by thinkstep-anz.

Following a Data Quality Assessment, the data used has been deemed to be of sufficient quality and representative of the packaging market in Australia and New Zealand in 2019. Where assumptions have been required, they have been justified in the Life Cycle Inventory (Section 3) and the most significant assumptions have been discussed in Section 6.2. This data, as well as the modelling used, provides results which are able to stand up to critical review and be used to make comparative claims about packaging.

With the current political and social climate, climate change is becoming an increasingly pressing issue. Both producers and consumers want to be sure that the products that they are making and using are packaged in a way which has the lowest effect on GWP. This study shows that food and beverage producers who are looking for a packaging solution with the lowest GWP should strongly consider cartons.

6.6.2. Limitations

This study does not support the following interpretation and conclusions:

- This study does not allow for comparisons of packaging solutions across different size classes.
- This study does not allow for comparisons between different brands of carton, as the same assumptions were used for both Tetra Pak and non-Tetra Pak cartons (with the only exception being that non-Tetra Pak cartons were assumed to be manufactured in China).
- This study is specific to the packaging options and technology available in Australia and New Zealand in 2019 and is not necessarily transferrable to other markets. Future changes in packaging technology and available packaging options may result in these results becoming out of date.
- The GWP_{100} indicator used (from the IPCC's Fifth Assessment Report) looks at Global Warming Potential across a 100-year timeframe, as required by ISO 14067:2018 as a base case. Considering shorter or longer-term timeframes may have different results.

6.6.3. Recommendations

The most significant area of uncertainty for this study is the DOC_F of the laminated paper within the cartons in landfill. This area is especially significant due to the (currently) low recycling rate within Australia and New Zealand assumed in this study, which results in a higher percentage of cartons being sent to landfill. A desktop bioreactor study on various cartons with holes pierced in the laminate layer (to simulate municipal comingled recycling where glass and other sharp objects may be present in the recycling stream) could be conducted to further refine the DOC_F value used.

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Annex A Critical Review Statement

START2SEE
LIFE CYCLE ASSESSMENTS

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thinkstep Ltd
Jeff Vickers
Technical Director

11 Rawhiti Road, Pukerua Bay
Wellington 5026
New Zealand

30 September 2020

Subject: Tetra Pak LCA critical review statement

Dear Jeff,

As the chair of the critical review panel, consisting of Elspeth MacRae, Gordon Robertson and myself, it gratifies me to present you with a positive critical review statement concerning the life cycle assessment study "LCA of Beverage and Food Packaging in Australia and New Zealand" that thinkstep completed for Tetra Pak Oceania.

With regard to the final report (version 1.5 of 9 September 2020), the review panel unanimously concludes that:

- The methods used to carry out the LCA are consistent with ISO 14040, ISO 14044 and ISO 14067
- The methods used to carry out the LCA are scientifically and technically valid
- The data used are appropriate
- The data sources used were appropriate, well documented, appeared to be generally reliable and reasonable in relation to the goal of the study
- The calculations and assumptions employed were generally clearly and carefully described
- The interpretations reflect the limitations identified and the goal of the study
- The study report is transparent and consistent
- The conclusions drawn from this study are consistent with other LCA results for the packaging systems.

It should be noted that panel members were not provided with comprehensive appendices with more detailed data and descriptions of the material inventories as these were confidential. Therefore, it was somewhat difficult for them to provide a thorough review of sections of the study results.

The panel considers the strengths of the report to be its comprehensive analysis of a large range of packaging formats, thereby providing a good coverage of key available packaging systems in the Australian and New Zealand market. Scenario analyses cover major choices and assumptions in the LCA, offering additional depth in results and strengthening of the conclusions. They also highlight one of the main limitations of the LCA: the presentation of results and conclusions associated with a large number of scenarios is intrinsically difficult to grasp in a condensed form.

Further potential for improvement of the study would be to consider additional environmental indicators, such as eco-toxicity and human toxicity. Finally, the critical review process of any future updates would benefit from a more relaxed timeline.

Please feel free to contact me should you have any further questions regarding our final review statement.

Yours sincerely,

....

Rob Rouwette
Director, start2see Pty Ltd

Chair of the review panel

....

Elspeth MacRae

Scion

Chief Innovation and Science officer

Packaging expert for the review panel

....

Dr. Gordon Robertson

Principal Consultant

Food | Packaging | Environment

Packaging expert for the review panel

Annex B Filling Data

Table 7-1: Filling inputs of consumer packs (per 1000 packs) - part 1

		2 L aseptic carton	1 L aseptic carton	2 L fresh carton	1 L fresh carton	400/500 mL food carton	330 mL aseptic carton	200/250 mL aseptic cartons and pouches
Electricity	kWh	23.25	16.60	9.13	6.09	2.27	7.19	8.06
Water	L	1.65	1.18	2.64	1.76	1.07	0.31	0.88
Nitrogen gas	m^3	0.00	0.00	0.00	0.00	1.41	0.00	0.00
Thermal energy[1]	MJ	1.56	1.11	0.00	0.00	7.22[2]	0.00	0.94
Hydrogen peroxide	L	0.63	0.45	0.18	0.12	0.35	0.40	0.15

Table 7-2: Filling inputs of consumer packs (per 1000 packs) - part 2

		2 L bottle (fresh)	1 L bottle (fresh)	2 L aseptic bottle	1 L aseptic bottle	400/500 mL aseptic food pack	330 mL aseptic pack	200/250 mL aseptic bottle
Electricity	kWh	6.36	4.54	6.36	4.54	2.26	4.42	4.42
Water	L	1.65	1.18	1.65	1.18	0.27	0.31	0.88
Nitrogen gas	m^3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal energy[1]	MJ	0.00	0.00	1.56	1.11	0.00[2]	0.00	0.00
Hydrogen peroxide	L	0.15	0.11	0.63	0.45	0.35	0.15	0.15

[1] Assumed to be from natural gas

[2] This does not include energy for retorting. See Table 3-8 for thermal energy required for retorting on a per pack basis

Annex C Lamination (Confidential)

Table 7-3: Site lamination data per 1000 m^2 of laminate

[Confidential information has been removed.]

Annex D Tetra Pak Carton Specifications (Confidential)

Table 7-4: Site lamination data per 1000 m^2 of laminate

[Confidential information has been removed.]

Annex E Tetra Pak Ink Safety (Confidential)

[Confidential information has been removed.]

Annex F Tetra Pak Paperboard GWP (Confidential)

Tetra Pak Oceania sources its paperboard from four mills: three in Sweden and one in Brazil. Most of the supply comes from Sweden, with a smaller share from Brazil, though all sources are used and there is no fixed split between them.

Figure 7-1 compares the GWP used in this study (in the top row) with GWP values from other studies. All GWP values exclude sequestration of biogenic carbon. Additionally, for its corporate greenhouse gas reporting, Tetra Pak collects greenhouse gas data from all major paper suppliers in its supply chain. These GWP factors are cradle to gate (i.e. scope 1, 2 and 3 greenhouse gas emissions) and are calculated from activity data collected for mill operations, chemical use, transport of wood to site, and production and transport of externally purchased pulp. The greenhouse gas impacts of forestry operations are based on data from the ecoinvent database. As can be seen, the FEFCO kraft paper data used in this study is representative of Tetra Pak's real supply chain.

Figure 7-1: GWP comparison across different paper types

Source	kg CO_2e/kg
"Kraftliner (2015) - for use in cut-off EoL scenario cases" (FEFCO & CCB, 2015, as implemented in GaBi Databases 2020) Reference year: 2015 Geographic scope: European Union **(Used in this study)**	0.462
European liquid paperboard (ACE, 2011) Reference year: 2009 Geographic scope: European Union	0.456
Brazilian liquid paperboard (Mourad, et al., 2012) Reference year: 2008 Geographic scope: Brazil	0.512
[Actual mill #1 – Confidential] Reference year: 2019 Geographic scope: Sweden	[Confidential; lower than FEFCO, ACE]
[Actual mill #2 – Confidential] Reference year: 2019 Geographic scope: Sweden	[Confidential; lower than FEFCO, ACE]
[Actual mill #3 – Confidential] Reference year: 2019 Geographic scope: Sweden	[Confidential; lower than FEFCO, ACE]
[Actual mill #4 – Confidential] Reference year: 2019 Geographic scope: Brazil	[Confidential; slightly higher than Mourad]

Annex G Packaging Composition by Product Category

Table 7-5: Composition of average pack by beverage/food category, country, size class, and material

Category	Component	Mass (g)	Material
Milk: NZ: 1L: HDPE natural	HDPE Bottle	29.1	HDPE
	Cap	1.6	HDPE
	Label	0.5	PP oriented
	Seal	0.3	Aluminium laminate
Milk: NZ: 2L: HDPE natural	HDPE Bottle	39.4	HDPE
	Cap	1.6	HDPE
	Label	0.6	PP oriented
	Seal	0.3	Aluminium laminate
Milk: AU: 1L: HDPE natural	HDPE Bottle	35.7	HDPE
	Cap	3.1	HDPE
	Ring	0.6	HDPE
	Label	1.0	Paper
Milk: AU: 2L: HDPE natural	HDPE Bottle	41.4	HDPE
	Cap	2.3	HDPE
	Ring	0.5	HDPE
	Label	0.9	Paper
Milk: NZ: 1L: HDPE lightproof	HDPE Bottle	30.1	HDPE
	Cap	1.6	HDPE
	Label	0.6	PP oriented
	Seal	0.3	Aluminium laminate
Milk: NZ: 2L: HDPE lightproof	HDPE Bottle	43.8	HDPE
	Cap	1.7	HDPE
	Label	1.0	PP oriented
	Seal	0.3	Aluminium laminate
Milk: NZ: 1L: PET	Bottle	43.7	PET
	Cap	3.1	HDPE
	Label	0.9	PET
Milk: NZ: 2L: PET	Bottle	54.8	PET
	Cap	2.5	HDPE
	Label	0.9	PET
Milk: AU: 1L: PET	Bottle	37.1	PET
	Cap	3.2	HDPE

Category	Component	Mass (g)	Material
	Ring	0.6	HDPE
	Label	1.3	Paper
Milk: AU: 2L: PET	Bottle	56.4	PET
	Cap	3.3	HDPE
	Ring	0.6	HDPE
	Label	1.7	Paper
Milk: NZ: 1L: rPET	Bottle	43.7	PET
	Cap	3.1	HDPE
	Label	0.9	PET
Milk: NZ: 2L: rPET	Bottle	54.8	PET
	Cap	2.5	HDPE
	Label	0.9	PET
Milk: NZ: 1L: Aseptic PET	Bottle	43.0	PET
	Cap	3.8	PET
	Label	3.9	PET
Milk: NZ: 1L: Carton	Carton	30.4	Carton laminate
	Lid	1.8	HDPE
	Seal	0.1	Al foil
Milk: AU: 1L: Carton	Carton	34.1	Carton laminate
	Cap	0.8	HDPE
	Neck	1.9	HDPE
	Ring	0.6	HDPE
Milk: NZ: 1L: Carton refrigerated	Carton	30.8	Carton laminate
Milk: AU: 1L: Carton refrigerated	Carton	28.4	Carton laminate
Milk: NZ: 1L: Glass	Bottle	360.6	Glass
	Cap	4.4	Steel
	Label (plastic)	1.2	PET
	Label (paper)	0.1	Paper
Milk: NZ: 2L: Carton	Carton	59.5	Carton laminate
	Cap	1.9	HDPE
	Neck	2.5	HDPE
	Ring	0.6	HDPE
Milk: NZ: 2L: Carton refrigerated	Pack	61.0	Carton laminate
	Cap	1.3	HDPE
	Neck	1.8	HDPE
Milk: AU: 2L: Carton refrigerated	Pack	61.0	Carton laminate
	Cap	1.3	HDPE
	Neck	1.8	HDPE

Category	Component	Mass (g)	Material
Milk: AU: 2L: Carton	Carton	59.5	Carton laminate
	Cap	1.9	HDPE
	Neck	2.5	HDPE
	Ring	0.6	HDPE
Juice: NZ: 1L: PET	Bottle	38.0	PET
	Lid	3.1	HDPE
	Label	2.5	Paper
	Seal	0.1	Aluminium laminate
Juice: AU: 2L: Carton	Pack	61.0	Carton laminate
	Cap	1.3	HDPE
	Neck	1.8	HDPE
Juice: AU: 250ml: PET	Bottle	26.1	PET
	Cap	5.3	HDPE
	Label	0.5	LDPE
Juice: AU: 1L: PET	Bottle	42.5	PET
	Cap	3.7	HDPE
	Label	1.1	LDPE
Juice: AU: 2L: PET	Bottle	82.8	PET
	Cap	3.6	HDPE
	Label	1.2	LDPE
Juice: AU: 2L: HDPE	HDPE Bottle	54.8	HDPE
	Cap	3.6	HDPE
	Label	1.1	LDPE
Juice: NZ: 1L: Carton	Carton	29.9	Carton laminate
	Lid	4.7	HDPE
	Cutter	0.2	HDPE
Juice: NZ: 200ml: Carton	Pack	8.7	Carton laminate
	Straw	0.5	PP
	Straw Wrapper	0.1	LDPE
Juice: AU: 250ml: Carton	Pack	10.4	Carton laminate
	Straw	0.6	PP
Juice: AU: 1L: Carton	Pack	37.0	Carton laminate
	Neck	1.9	HDPE
	Cutter	0.7	HDPE
	Cap	1.6	HDPE
Juice: AU: 2L: Carton refrigerated	Pack	61.0	Carton laminate
	Cap	1.3	HDPE
	Neck	1.8	HDPE
Juice: NZ: 1L: Glass	Bottle	562.3	Glass

Category	Component	Mass (g)	Material
	Lid	1.6	Steel
	Label	0.3	Paper
	Seal	0.1	Aluminium laminate
Juice: AU: 1L: Glass	Bottle	360.3	Glass
	Cap	5.4	Steel
	Label	2.0	LDPE
Juice: AU: 250ml: Glass	Bottle	172.9	Glass
	Cap	4.3	Steel
	Label	0.7	LDPE
Juice: NZ: 200ml: Pouch -lid	Pouch	5.3	Pouch
	Lid	3.6	HDPE
Juice: NZ: 200ml: Pouch - straw	Pouch	4.8	Pouch
	Straw	0.4	PP
	Straw Wrapper	0.1	LDPE
Juice: AU: 250ml: Pouch	Pouch	6.3	Pouch
Water: NZ: 1L: PET	Bottle	30.7	PET
	Cap	6.0	HDPE
	Label	0.8	LDPE
Water: AU: 600ml: PET lightweight	Bottle	12.8	PET
	Cap	2.0	HDPE
	Label	0.5	LDPE
Water: AU: 1L: PET	Bottle	31.3	PET
	Cap	1.3	HDPE
	Label	0.5	LDPE
Water: AU: 1L: PET lightweight	Bottle	19.1	PET
	Cap	1.7	HDPE
	Label	0.7	LDPE
Water: NZ: 1L: rPET	Bottle	30.7	PET
	Cap	6.0	HDPE
	Label	0.8	LDPE
Water: AU: 600ml: rPET lightweight	Bottle	12.8	PET
	Cap	2.0	HDPE
	Label	0.5	LDPE
Water: AU: 1L: rPET	Bottle	30.7	PET
	Cap	6.0	HDPE
	Label	0.8	LDPE
Water: AU: 1L: rPET lightweight	Bottle	19.1	PET
	Cap	1.7	HDPE

Category	Component	Mass (g)	Material
	Label	0.7	LDPE
Water: NZ: 1L: Glass	Bottle	597.6	Glass
	Cap	1.3	Steel
	Label	0.3	LDPE
Water: AU: 1L: Glass	Bottle	619.8	Glass
	Cap	21.1	Steel
Water: AU: 330ml: Glass	Bottle	245.7	Glass
	Cap	13.1	Steel
	Label	0.5	LDPE
Water: NZ: 330ml: Can	Can	12.6	Al can
Water: AU: 330ml: Can	Can	14.9	Al can
Water: AU: 1L: Carton	Pack	37.0	Carton laminate
	Neck	1.9	HDPE
	Cutter	0.7	HDPE
	Cap	1.6	HDPE
Water: AU: 600ml: Carton	Pack	22.0	Carton laminate
	Cap	1.2	HDPE
	Neck	1.6	HDPE
Water: AU: 330ml: Carton	Pack	16.0	Carton laminate
	Cap	1.4	HDPE
Food: NZ: 400g: Pouch	Foil	9.5	Aluminium laminate
Food: NZ: 500g: Glass	Container	280.2	Glass
	Lid	7.4	Steel
	Label	1.1	Paper
	Seal	0.0	LDPE
Food: NZ: 400g: Can	Can	48.5	Tin plate can
	Label	2.2	Paper
Food: NZ: 500g: Can	Can	55.8	Tin plate can
	Lid	7.1	Tin plate can
	Label	2.7	Paper
Food: AU: 500g: Can	Can	52.9	Tin plate can
	Lid	6.5	Tin plate can
Food: AU: 500g: Glass	Bottle	280.8	Glass
	Lid	8.1	Steel
	Label	1.2	Paper
Food: AU: 500g: Pouch	Foil	10.5	Pouch

Annex H Packaging Composition

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
NZ Fresh Milk 2L	HDPE	Meadow Fresh	HDPE Bottle	42.7	HDPE
			Cap	1.6	HDPE
			Label	1	PP oriented
			Seal	0.3	Aluminium laminate
NZ Fresh Milk 2L	HDPE	Value	HDPE Bottle	38.8	HDPE
			Cap	1.6	HDPE
			Label	0.4	Paper
			Seal	0.3	Aluminium laminate
NZ Fresh Milk 2L	HDPE lightproof	Anchor	HDPE Bottle	43.8	HDPE
			Cap	1.7	HDPE
			Label	1	PP oriented
			Seal	0.3	Aluminium laminate
NZ Fresh Milk 2L	HDPE	Countdown	HDPE Bottle	36.7	HDPE
			Cap	1.6	HDPE
			Label	0.5	Paper
			Seal	0.3	Aluminium laminate
NZ Fresh Milk 1L	HDPE	Meadow Fresh	HDPE Bottle	27.7	HDPE
			Cap	1.6	HDPE
			Label	0.6	PP oriented
			Seal	0.3	Aluminium laminate
NZ Fresh Milk 1L	HDPE	Value	HDPE Bottle	33.5	HDPE
			Cap	1.6	HDPE
			Label	0.4	Paper
			Seal	0.3	Aluminium laminate
NZ Fresh Milk 1L	HDPE lightproof	Anchor	HDPE Bottle	30.1	HDPE
			Cap	1.6	HDPE
			Label	0.6	PP oriented
			Seal	0.3	Aluminium laminate
NZ Fresh Milk 1L	HDPE	Countdown	HDPE Bottle	26.2	HDPE
			Cap	1.6	HDPE
			Label	0.4	Paper
			Seal	0.3	Aluminium laminate

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
NZ Fresh Milk 0.75L	rPET	Lewis Rd Creamery	Bottle	40.6	PET
			Cap	3.1	HDPE
			Label	0.6	PET
NZ Fresh Milk 0.75L	PET	Puhoi valley	Bottle	41.5	PET
			Cap	3	HDPE
			Label	1.1	PET
NZ Fresh Milk 1.5L	rPET	Lewis Rd Creamery	Bottle	48.5	PET
			Cap	2.5	HDPE
			Label	0.9	PET
NZ Fresh Milk 1L	Glass	Aunt Jean's	Bottle	360.6	Glass
			Cap	4.4	Steel
			Label (plastic)	1.2	PET
			Label (paper)	0.1	Paper
NZ Aseptic Milk 0.8L	PET	WDOM	Bottle	40.9	PET
			Cap	3.8	PET
			Label	3.9	PET
NZ Fresh Milk 1L	Carton	Naturalea	Carton	30.5	Carton laminate
NZ Aseptic Milk 1L	Carton	Vitasoy	Carton	29.4	Carton laminate
			Lid (white)	2.4	HDPE
			Lid (blue)	0.4	HDPE
			Seal	0.1	Aluminium laminate
NZ Fresh Milk 1L	Carton	Meadow Fresh Silver Top	Carton	31	Carton laminate
NZ Aseptic Milk 1L	Carton	Meadow Fresh UHT	Carton	31	Carton laminate
			Lid	1.9	HDPE
			Seal	0.1	Al foil
NZ Aseptic Milk 1L	Tetra Pak	Anchor	Carton	28.6	Carton laminate
			Lid	1.8	HDPE
			Seal	0.1	Aluminium laminate
NZ Aseptic Milk 1L	Carton	Countdown	Carton	31.5	Carton laminate
			Lid	1.7	HDPE
			Seal	0.1	Aluminium laminate
NZ Juice 1L	PET	NZ Orchard Gate	Bottle	40.8	PET
			Lid	3.8	HDPE
			Label	2.3	LDPE

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
NZ Juice 1L	PET	Just Juice	Bottle	28.7	PET
			Lid	3.1	HDPE
			Label	4	LDPE
NZ Juice 1L	PET	Keri Juice Co	Bottle	44.4	PET
			Lid	2.5	HDPE
			Label	1.1	Paper
			Seal	0.4	Aluminium laminate
NZ Juice 500mL	PET	Charlies	Bottle	31.9	PET
			Lid	3.5	HDPE
			Label	0.6	LDPE
NZ Juice 1L	Carton	Golden Circle	Carton	28.4	Carton laminate
			Lid	2.1	HDPE
			Cutter	0.3	HDPE
NZ Juice 1L	Carton	Nekta	Pack	31.3	Carton laminate
			Lid	7.2	HDPE
NZ Juice 1L	Carton	The Real Mccoy	Pack	35.2	Carton laminate
			Lid	4.3	HDPE
NZ Juice 750mL	Glass	Grapetiser	Bottle	478.8	Glass
			Lid	1.5	Steel
			Label	0.4	Paper
			Seal	0.2	Aluminium laminate
NZ Juice 750mL	Glass	Phoenix	Bottle	412.6	Glass
			Lid	1.6	Steel
			Label	0.2	Paper
NZ Juice 750mL	Glass	Bel Normande	Bottle	544.2	Glass
			Cork	8.7	Cork
			Cork Wire	5.1	Steel
			Label	1.7	Al foil
NZ Juice 200mL	Pouch	The Homegrown Juice Company	Pouch	5.3	Pouch
			Lid	3.6	HDPE
NZ Juice 200mL	Pouch	Charlies	Pouch	4.8	Pouch
			Straw	0.4	PP
			Straw Wrapper	0.1	LDPE
NZ Juice 250mL	Can	Remedy	Can	11.5	Al can
NZ Juice 250mL	Carton	Countdown	Pack	10.6	Carton laminate
			Straw	0.4	PP

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
			Straw Wrapper	0.1	LDPE
NZ Juice 250mL	Carton	V8	Pack	10.9	Carton laminate
			Straw	0.3	PP
			Straw Wrapper	0.1	LDPE
NZ Juice 400mL	PET- Coloured	The Homegrown Juice Company	Bottle	27.4	PET
			Lid	2	HDPE
			Label	1	LDPE
NZ Juice 250mL	Can	Remedy	Can	11.5	Al can
NZ Water 750mL	PET	Countdown	Bottle	22.4	PET
			Cap	6.1	HDPE
			Label	0.4	LDPE
NZ Water 750mL	rPET	Pump	Bottle	25.4	PET
			Cap	6.1	HDPE
			Label	0.9	LDPE
NZ Water 750mL	PET	H2Go	Bottle	22.5	PET
			Cap	5.6	HDPE
			Label	3.6	LDPE
NZ Water 500mL	PET - Coloured	ABCD	Bottle	25.2	PET
			Cap	2.9	HDPE
			Label	0.9	Paper
NZ Water 1	PET	Pure Dew	Bottle	29	PET
			Cap	6.1	HDPE
			Label	0.9	LDPE
NZ Water 1.25	PET	Countdown	Bottle	40.4	PET
			Cap	6.1	HDPE
			Label	0.6	LDPE
NZ Water 1.25	PET	Pump	Bottle	37.9	PET
			Cap	5.3	HDPE
			Label	1.2	
NZ Water 1.5	rPET	Pure NZ	Bottle	37.4	PET
			Cap	2.2	HDPE
			Label	0.6	LDPE
NZ Water 1.5	PET	Kiwi Blue	Bottle	37.6	PET
			Cap	2	HDPE
			Label	1.7	LDPE

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
NZ Water 500mL	Glass	Antipodes	Bottle	290.5	Glass
			Cap	1.5	Steel
			Label	0.2	LDPE
NZ Water 750mL	Glass	NZ Natural	Bottle	459.9	Glass
			Cap	1.4	Steel
			Label	0.4	LDPE
NZ Water 750mL	Glass	S.Pellegrino	Bottle	455.4	Glass
			Cap	1.1	Steel
			Label	0.5	LDPE
NZ Water 750mL	Glass	Perrier	Bottle(with paper label)	485.4	Glass
			Cap	1.5	St small part
NZ Water 355mL	Can	Vista	Can	13.6	Al can
NZ Food 400g	Pouch	Hansells	Foil	9.4	Pouch
NZ Food 375g	Pouch	Passage Foods	Foil	8.9	Pouch
NZ Food 375g	Pouch	Watties	Foil	9	Pouch
NZ Food 500g	Glass	Leggos	Container	276.3	Glass
			Lid	7.9	Steel
			Label	1.1	Paper
			Seal	0.1	LDPE
NZ Food 500g	Glass	Dolmio	Container	256.3	Glass
			Lid	7.9	Steel
			Label	1.4	Paper
NZ Food 525g	Glass	Heinz	Container	321.9	Glass
			Lid	6.5	Steel
			Label	0.7	Paper
NZ Food 400g	Can	Watties	Can	49.4	Tin plate can
			Label	2	Paper
NZ Food 400g	Can	Benedicts	Can	47.5	Tin plate can
			Label	2.3	Paper
NZ Food 535g	Can	Watties	Can	56.3	Tin plate can
			Lid	6.4	Tin plate can
			Label	2.6	Paper
NZ Food 505g	Can	Campbells	Can	59.8	Tin plate can
			Lid	7.7	Tin plate can
			Label	2.8	Paper
AU Milk 1L	Carton	Liddells	Carton	30.2	Carton laminate

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
			Cap	1.4	HDPE
			Neck	2.1	HDPE
			Seal	0.5	Aluminium laminate
AU Milk 1L	Carton	Devondale	Carton	33.5	Carton laminate
			Cutter	0.7	HDPE
			Ring	1.8	HDPE
			Neck	1.7	HDPE
AU Milk 2L	Carton	Australia's Own	Carton	58.8	Carton laminate
			Cap	1.6	HDPE
			Neck	1.9	HDPE
			Ring	0.7	HDPE
AU Milk 2L	Carton	Devondale	Carton	60.2	Carton laminate
			Cap	2.1	HDPE
			Neck	3	HDPE
			Ring	0.5	HDPE
AU Milk 1L	Carton	Woolworths - Lite	Carton	33.8	Carton laminate
			Cap	0.8	HDPE
			Neck	2	HDPE
			Ring	0.1	HDPE
AU Milk 750mL	PET	Paul's Farmhouse Gold Full Cream	Bottle	34.8	PET
			Cap	3.2	HDPE
			Ring	0.6	HDPE
			Label	1.3	Paper
AU Milk 1.5L	PET	Dairy Farmer's Milk	Bottle	49	PET
			Cap	3.2	HDPE
			Ring	0.5	HDPE
			Label	1.7	Paper
AU Milk 2L	HDPE	Pura Original Milk	HDPE Bottle	38.6	HDPE
			Cap	2.5	HDPE
			Ring	0.3	HDPE
			Label	0.8	Paper
AU Milk 2L	HDPE	Paul's Smarter White	HDPE Bottle	41.9	HDPE
			Cap	2.6	HDPE
			Ring	0.6	HDPE
			Label	0.8	Paper

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
AU Milk 1L	Carton	Paul's Pure Organic Unhomogenised Full Cream	Carton	28.4	Carton laminate
AU Milk 1L	HDPE	Pauls's Smarter While Milk 2% Fat	HDPE Bottle	35.2	HDPE
			Cap	3.1	HDPE
			Ring	0.6	HDPE
			Label	1.2	Paper
AU Milk 1L	HDPE	Coles Full Cream Milk - Dark Blue	HDPE Bottle	36.2	HDPE
			Cap	3	HDPE
			Ring	0.5	HDPE
			Label	0.8	Paper
AU Milk 1L	Carton	Coles Lite Milk	Carton	35	Carton laminate
			Cap	0.9	HDPE
			Neck	2	HDPE
			Ring	0.1	HDPE
AU Milk 1.5L	PET	Paul's Farmhouse Gold Full Cream	Bottle	50.8	PET
			Cap	3.3	HDPE
			Ring	0.6	HDPE
			Label	1.6	Paper
AU Milk 2L	HDPE	Coles Lite Milk	HDPE Bottle	43.8	HDPE
			Cap	1.7	HDPE
			Pull tab	0.6	HDPE
			Label	1.2	Paper
AU Juice 200mL	Carton	Heinz Golden Circle	Pack	9.5	Carton laminate
			Straw	0.5	PP
AU Juice 250 mL	Carton	Heinz Golden Circle	Pack	10.5	Carton laminate
			Straw	0.5	PP
AU Juice 250 mL	PET	Berri	Bottle	19	PET
			Cap	6.4	HDPE
			Label	0.3	LDPE
AU Juice 250 mL	PET	Bickfords's	Bottle	33.1	PET
			Cap	4.1	HDPE
			Ring	0.7	HDPE
			Foil	0.2	LDPE
AU Juice 350 mL	PET	Heinz	Bottle	33	PET
			Cap	3.6	HDPE
			Label	0.9	LDPE

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
AU Juice 200mL	Carton	Nudie	Pack	8.9	Carton laminate
			Straw	0.5	PP
AU Juice 250mL	Glass	Sunraysia	Bottle	172.9	Glass
			Cap	4.3	Steel
			Label	0.7	LDPE
AU Juice 200mL	Pouch	Sunraysia	Pouch	5	Pouch
AU Juice 1L	Glass	Sunraysia	Bottle	360.3	Glass
			Cap	5.4	Steel
			Label	2	LDPE
AU Juice 1L	PET	Nudie	Bottle	35.3	PET
			Cap	3.5	HDPE
			Label	1.1	LDPE
AU Juice 1L	PET	Boost	Bottle	49.7	PET
			Cap	3.9	HDPE
			Label	1.1	LDPE
AU Juice 2L	Carton	Mildura	Pack	61	Carton laminate
			Cap	1.3	HDPE
			Neck	1.8	HDPE
AU Juice 1L	Carton	Cawston Press	Pack	37	Carton laminate
			Neck	1.9	HDPE
			Cutter	0.7	HDPE
			Cap	1.6	HDPE
AU Juice 2L	HDPE	Daily Juice Co	HDPE Bottle	54.8	HDPE
			Cap	3.6	HDPE
			Label	1.1	LDPE
AU Juice 2L	PET	Charlie's	Bottle	82.8	PET
			Cap	3.6	HDPE
			Label	1.2	LDPE
AU Water 500mL	Carton	Carton & Co	Pack	19	Carton laminate
			Cap	1.2	HDPE
			Neck	1.6	HDPE
AU Water 375mL	Glass	Voss	Bottle	270.8	Glass
			Cap	13.1	Steel
			Label	0.5	LDPE
AU Water 800 mL	Glass	Voss	Bottle	508.1	Glass
			Cap	18.7	Steel

Product Category	Pack Material	Brand	Component	Component Mass (g)	Component's Primary Material
AU Water 325 mL	Aluminium can	Raw C	Can	14.7	Al can
AU Water 330mL	Carton	H2 CoCo	Pack	16	Carton laminate
			Cap	1.4	HDPE
AU Water 600mL	PET	Woolworths	Bottle	13.1	PET
			Cap	2.1	HDPE
			Label	0.4	LDPE
AU Water 1L with sports cap	PET	Woolworths	Bottle	31.3	PET
			Cap	1.3	HDPE
			Label	0.5	LDPE
AU Water 600mL	rPET	Coles	Bottle	12.5	PET
			Cap	1.9	HDPE
			Label	0.6	LDPE
AU Water 1.5L	rPET	Coles	Bottle	27.5	PET
			Cap	2.4	HDPE
			Label	1.2	LDPE
AU Water 1L	Carton	Raw C	Pack	37	Carton laminate
			Neck	1.9	HDPE
			Cutter	0.7	HDPE
			Cap	1.6	HDPE
AU Food 555g	Can	Heinz	Can	58.7	Tin plate can
			Lid	6.5	Tin plate can
AU Food 430g	Pouch	Heinz Soup	Foil	9	Pouch
AU Food 500g	Glass	Leggos Bolognese	Bottle	280.8	Glass
			Lid	8.1	Steel
			Label	1.2	Paper

Annex I GWP by Primary Material

The average GWP results split by size class, primary material (glass, PET, carton etc.) and country are shown in For the biogenic carbon (Table 7-7) the uptake and release are shown in the life cycle modules where they occur. In the total GWP results (Table 5-1) the biogenic carbon from the consumer packs (paperboard, paper labels) and filling and distribution are reported under "Consumer EoL". All carbon uptake and release from secondary and tertiary packaging (cardboard boxes and wooden pallets) is reported in "Shipper & Pallet Total".

Table 7-6 for fossil GWP, Table 7-7 for biogenic GWP, Table 7-8 for land use GWP and Table 7-9 for aviation GWP (Total GWP is found in Table 5-1 within the body of this report).

For the biogenic carbon (Table 7-7) the uptake and release are shown in the life cycle modules where they occur. In the total GWP results (Table 5-1) the biogenic carbon from the consumer packs (paperboard, paper labels) and filling and distribution are reported under "Consumer EoL". All carbon uptake and release from secondary and tertiary packaging (cardboard boxes and wooden pallets) is reported in "Shipper & Pallet Total".

Table 7-6: Fossil GWP results by primary material and size class (kg CO_2-e per consumer pack)

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
1 L aseptic	Glass AU	5.71E-01	5.34E-03	4.80E-03	8.03E-03	1.78E-02
	Glass NZ	4.91E-01	1.80E-03	4.85E-03	6.60E-03	1.78E-02
	PET AU	2.55E-01	5.34E-03	9.96E-04	2.43E-03	1.78E-02
	PET NZ	2.02E-01	1.80E-03	9.86E-04	1.10E-03	1.78E-02
	PET Lightweight AU	1.33E-01	5.34E-03	8.24E-04	1.29E-03	1.78E-02
	rPET AU	1.47E-01	5.34E-03	9.85E-04	2.40E-03	1.78E-02
	rPET NZ	7.92E-02	1.80E-03	9.86E-04	1.10E-03	1.78E-02
	rPET Lightweight AU	7.94E-02	5.34E-03	8.24E-04	1.29E-03	1.78E-02
	Carton AU	7.18E-02	1.66E-02	9.54E-04	3.12E-03	1.78E-02
	Carton NZ	6.33E-02	3.42E-03	9.11E-04	2.59E-03	1.78E-02
1 L fresh milk	Glass AU	5.71E-01	4.48E-03	5.56E-03	8.03E-03	9.92E-03
	Glass NZ	4.91E-01	8.52E-04	5.61E-03	6.59E-03	9.85E-03
	PET AU	2.55E-01	4.48E-03	1.75E-03	2.43E-03	9.92E-03
	PET NZ	2.02E-01	8.52E-04	1.74E-03	1.10E-03	9.85E-03
	rPET AU	1.47E-01	4.48E-03	1.74E-03	2.40E-03	9.92E-03
	rPET NZ	7.92E-02	8.52E-04	1.74E-03	1.10E-03	9.85E-03
	HDPE natural AU	1.40E-01	4.48E-03	1.72E-03	2.30E-03	9.92E-03
	HDPE natural NZ	7.51E-02	8.52E-04	1.65E-03	7.03E-04	9.85E-03
	HDPE lightproof NZ	8.04E-02	8.52E-04	1.66E-03	7.32E-04	9.85E-03
	Carton AU	3.24E-02	5.96E-03	1.63E-03	2.49E-03	9.92E-03
	Carton NZ	3.54E-02	1.10E-03	1.65E-03	2.69E-03	9.85E-03

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
2 L aseptic	PET AU	4.25E-01	7.48E-03	1.61E-03	3.98E-03	3.47E-02
	HDPE AU	2.11E-01	7.48E-03	1.52E-03	3.45E-03	3.47E-02
	Carton AU	1.20E-01	2.32E-02	1.56E-03	3.91E-03	3.47E-02
2 L fresh milk	PET NZ	2.87E-01	1.19E-03	2.96E-03	1.52E-03	1.75E-02
	rPET NZ	1.04E-01	1.19E-03	2.96E-03	1.52E-03	1.75E-02
	HDPE natural AU	1.57E-01	6.27E-03	2.85E-03	2.58E-03	1.76E-02
	HDPE natural NZ	9.93E-02	1.19E-03	2.82E-03	9.36E-04	1.75E-02
	HDPE lightproof NZ	1.15E-01	1.19E-03	2.86E-03	1.05E-03	1.75E-02
	Carton AU	8.06E-02	8.94E-03	3.00E-03	5.52E-03	1.76E-02
	Carton NZ	8.12E-02	1.65E-03	3.00E-03	5.41E-03	1.75E-02
600 mL aseptic	PET Lightweight AU	8.96E-02	4.48E-03	5.24E-04	8.72E-04	1.24E-02
	rPET Lightweight AU	5.37E-02	4.48E-03	5.24E-04	8.72E-04	1.24E-02
	Carton AU	4.64E-02	5.96E-03	6.02E-04	2.00E-03	1.24E-02
330 mL aseptic	Glass AU	3.00E-01	4.48E-03	2.44E-03	4.14E-03	9.27E-03
	Aluminium Can - 0% Recycled AU	2.84E-01	4.48E-03	4.21E-04	9.14E-04	9.27E-03
	Aluminium Can - 0% Recycled NZ	2.41E-01	9.46E-04	4.02E-04	7.14E-04	9.28E-03
	Aluminium Can - 70% Recycled AU	1.06E-01	4.48E-03	4.21E-04	9.14E-04	9.27E-03
	Aluminium Can - 70% Recycled NZ	9.02E-02	9.46E-04	4.02E-04	7.14E-04	9.28E-03
	Carton AU	3.69E-02	7.93E-03	4.42E-04	1.39E-03	9.27E-03
	Carton NZ	3.70E-02	1.57E-03	4.42E-04	1.34E-03	9.28E-03
250 mL aseptic (AU only)	Glass AU	2.01E-01	4.48E-03	1.56E-03	2.83E-03	4.37E-03
	PET AU	1.85E-01	4.48E-03	3.55E-04	1.81E-03	4.37E-03
	Pouch AU	3.14E-02	7.93E-03	1.44E-04	3.92E-04	4.37E-03
	Carton AU	2.07E-02	7.93E-03	1.83E-04	6.68E-04	4.37E-03
200 mL aseptic (NZ only)	Pouch - lid NZ	3.94E-02	1.57E-03	1.66E-04	4.11E-04	4.36E-03
	Pouch - straw NZ	2.56E-02	1.57E-03	1.36E-04	3.27E-04	4.36E-03
	Carton NZ	1.78E-02	1.57E-03	1.69E-04	7.55E-04	4.36E-03
500 mL retorted (food)	Glass AU	2.65E-01	4.13E-03	3.05E-03	4.60E-03	2.01E-02
	Glass NZ	2.86E-01	4.18E-03	3.04E-03	3.77E-03	2.01E-02
	Steel Can AU	2.75E-01	2.51E-03	1.15E-03	1.15E-03	2.01E-02
	Steel Can NZ	2.93E-01	9.81E-04	1.20E-03	1.22E-03	2.01E-02
	Pouch AU	4.99E-02	2.44E-03	7.44E-04	6.55E-04	2.01E-02
	Carton AU*	3.33E-02	3.11E-03	8.27E-04	1.71E-03	2.01E-02
	Carton NZ*	3.37E-02	2.02E-03	8.27E-04	1.71E-03	2.01E-02

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
400 mL retorted (food) (NZ only)	**Steel Can NZ**	2.26E-01	8.69E-04	9.11E-04	9.43E-04	1.51E-02
	Pouch NZ	4.53E-02	7.73E-04	5.71E-04	5.95E-04	1.51E-02
	Carton NZ*	2.88E-02	1.95E-03	6.35E-04	1.43E-03	1.51E-02

*No carton could be found for teardown, so the Tetra Recart was used as a proxy for comparison.

Table 7-7: Biogenic GWP results by primary material and size class (kg CO_2-e per consumer pack)

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
1 L aseptic	Glass AU	6.94E-04	7.06E-06	2.00E-04	-1.35E-04	6.83E-03
	Glass NZ	4.14E-04	8.36E-06	2.02E-04	2.51E-04	5.06E-03
	PET AU	-1.51E-03	7.06E-06	4.14E-05	2.51E-03	6.83E-03
	PET NZ	5.62E-04	8.36E-06	4.10E-05	-2.48E-05	5.06E-03
	PET Lightweight AU	2.80E-04	7.06E-06	3.43E-05	-2.88E-05	6.83E-03
	rPET AU	2.12E-04	7.06E-06	4.10E-05	-5.38E-05	6.83E-03
	rPET NZ	2.50E-04	8.36E-06	4.10E-05	-2.48E-05	5.06E-03
	rPET Lightweight AU	1.15E-04	7.06E-06	3.43E-05	-2.88E-05	6.83E-03
	Carton AU	-4.18E-02	1.48E-05	3.97E-05	3.49E-02	6.83E-03
	Carton NZ	-3.62E-02	1.90E-05	3.79E-05	2.44E-02	5.06E-03
1 L fresh milk	Glass AU	6.94E-04	4.55E-06	2.31E-04	-1.35E-04	5.07E-03
	Glass NZ	4.14E-04	5.64E-06	2.33E-04	2.51E-04	4.88E-03
	PET AU	-1.51E-03	4.55E-06	7.28E-05	2.51E-03	5.07E-03
	PET NZ	5.62E-04	5.64E-06	7.24E-05	-2.48E-05	4.88E-03
	rPET AU	2.12E-04	4.55E-06	7.24E-05	-5.38E-05	5.07E-03
	rPET NZ	2.50E-04	5.64E-06	7.24E-05	-2.48E-05	4.88E-03
	HDPE natural AU	-1.33E-03	4.55E-06	7.17E-05	1.92E-03	5.07E-03
	HDPE natural NZ	2.15E-04	5.64E-06	6.87E-05	-1.57E-05	4.88E-03
	HDPE lightproof NZ	2.48E-04	5.64E-06	6.91E-05	-1.64E-05	4.88E-03
	Carton AU	-3.98E-02	6.11E-06	6.76E-05	3.32E-02	5.07E-03
	Carton NZ	-4.31E-02	7.57E-06	6.85E-05	2.90E-02	4.88E-03
2 L aseptic	PET AU	-1.69E-03	9.88E-06	6.71E-05	3.16E-03	1.03E-02
	HDPE AU	3.79E-04	9.88E-06	6.32E-05	-7.35E-05	1.03E-02
	Carton AU	-6.95E-02	2.07E-05	6.49E-05	5.82E-02	1.03E-02
2 L fresh milk	PET NZ	7.94E-04	7.90E-06	1.23E-04	-3.45E-05	8.67E-03
	rPET NZ	3.28E-04	7.90E-06	1.23E-04	-3.45E-05	8.67E-03
	HDPE natural AU	-1.19E-03	6.37E-06	1.18E-04	1.78E-03	9.02E-03
	HDPE natural NZ	2.87E-04	7.90E-06	1.17E-04	-2.09E-05	8.67E-03
	HDPE lightproof NZ	3.58E-04	7.90E-06	1.19E-04	-2.35E-05	8.67E-03
	Carton AU	-8.56E-02	9.16E-06	1.25E-04	7.13E-02	9.02E-03
	Carton NZ	-8.56E-02	1.14E-05	1.25E-04	5.76E-02	8.67E-03
600 mL aseptic	PET Lightweight AU	1.89E-04	4.55E-06	2.18E-05	-1.95E-05	4.11E-03
	rPET Lightweight AU	7.84E-05	4.55E-06	2.18E-05	-1.95E-05	4.11E-03
	Carton AU	-2.71E-02	6.11E-06	2.50E-05	2.26E-02	4.11E-03

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
330 mL aseptic	Glass AU	3.56E-04	4.60E-06	1.01E-04	-6.92E-05	3.08E-03
	Aluminium Can - 0% Recycled AU	-2.12E-04	4.60E-06	1.75E-05	1.87E-07	3.08E-03
	Aluminium Can - 0% Recycled NZ	-1.80E-04	5.67E-06	1.67E-05	-1.23E-06	2.18E-03
	Aluminium Can - 70% Recycled AU	-3.16E-04	4.60E-06	1.75E-05	1.87E-07	3.08E-03
	Aluminium Can - 70% Recycled NZ	-2.67E-04	5.67E-06	1.67E-05	-1.23E-06	2.18E-03
	Carton AU	-1.75E-02	6.95E-06	1.84E-05	1.46E-02	3.08E-03
	Carton NZ	-1.75E-02	9.06E-06	1.84E-05	1.18E-02	2.18E-03
250 mL aseptic (AU only)	Glass AU	2.45E-04	4.60E-06	6.50E-05	-4.76E-05	8.67E-04
	PET AU	3.91E-04	4.60E-06	1.48E-05	-4.05E-05	8.67E-04
	Pouch AU	6.56E-05	6.95E-06	5.99E-06	-9.79E-06	8.67E-04
	Carton AU	-1.20E-02	6.95E-06	7.62E-06	1.01E-02	8.67E-04
200 mL aseptic (NZ only)	Pouch - lid NZ	7.36E-05	9.06E-06	6.90E-06	-1.00E-05	5.49E-04
	Pouch - straw NZ	5.18E-05	9.06E-06	5.66E-06	-8.10E-06	5.49E-04
	Carton NZ	-1.00E-02	9.06E-06	7.04E-06	6.76E-03	5.49E-04
500 mL retorted (food)	Glass AU	-1.53E-03	2.43E-06	1.27E-04	2.29E-03	6.85E-03
	Glass NZ	-1.32E-03	7.98E-06	1.26E-04	1.89E-03	4.88E-03
	Steel Can AU	3.83E-04	2.27E-06	4.78E-05	-1.99E-05	6.85E-03
	Steel Can NZ	-3.86E-03	3.48E-06	4.99E-05	4.81E-03	4.88E-03
	Pouch AU	1.02E-04	2.26E-06	3.09E-05	-1.64E-05	6.85E-03
	Carton AU*	-2.30E-02	3.11E-06	3.44E-05	1.92E-02	6.85E-03
	Carton NZ*	-2.30E-02	5.58E-06	3.44E-05	1.55E-02	4.88E-03
400 mL retorted (food) (NZ only)	Steel Can NZ	-3.08E-03	3.32E-06	3.79E-05	3.83E-03	3.66E-03
	Pouch NZ	9.26E-05	3.18E-06	2.38E-05	-1.49E-05	3.66E-03
	Carton NZ*	-1.94E-02	5.48E-06	2.64E-05	1.31E-02	3.66E-03

*No carton could be found for teardown, so the Tetra Recart was used as a proxy for comparison.

Table 7-8: Land use GWP results by primary material and size class (kg CO_2-e per consumer pack)

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
1 L aseptic	Glass AU	1.99E-04	1.41E-06	8.99E-08	1.12E-05	1.66E-04
	Glass NZ	1.62E-04	1.61E-06	9.09E-08	7.00E-06	1.66E-04
	PET AU	5.25E-05	1.41E-06	1.86E-08	1.78E-06	1.66E-04
	PET NZ	5.21E-05	1.61E-06	1.85E-08	8.08E-07	1.66E-04
	PET Lightweight AU	2.65E-05	1.41E-06	1.54E-08	9.48E-07	1.66E-04
	rPET AU	3.38E-05	1.41E-06	1.84E-08	1.76E-06	1.66E-04
	rPET NZ	3.75E-05	1.61E-06	1.85E-08	8.08E-07	1.66E-04
	rPET Lightweight AU	1.84E-05	1.41E-06	1.54E-08	9.48E-07	1.66E-04
	Carton AU	7.61E-05	4.13E-06	1.79E-08	2.00E-06	1.66E-04
	Carton NZ	6.62E-05	4.83E-06	1.71E-08	1.65E-06	1.66E-04
1 L fresh milk	Glass AU	1.99E-04	1.11E-06	1.04E-07	1.12E-05	8.18E-06
	Glass NZ	1.62E-04	1.31E-06	1.05E-07	7.00E-06	8.11E-06
	PET AU	5.25E-05	1.11E-06	3.28E-08	1.78E-06	8.18E-06
	PET NZ	5.21E-05	1.31E-06	3.26E-08	8.08E-07	8.11E-06
	rPET AU	3.38E-05	1.11E-06	3.26E-08	1.76E-06	8.18E-06
	rPET NZ	3.75E-05	1.31E-06	3.26E-08	8.08E-07	8.11E-06
	HDPE natural AU	3.08E-05	1.11E-06	3.23E-08	1.66E-06	8.18E-06
	HDPE natural NZ	2.69E-05	1.31E-06	3.09E-08	5.22E-07	8.11E-06
	HDPE lightproof NZ	3.22E-05	1.31E-06	3.11E-08	5.43E-07	8.11E-06
	Carton AU	5.86E-05	1.48E-06	3.05E-08	1.51E-06	8.18E-06
	Carton NZ	6.34E-05	1.73E-06	3.08E-08	1.63E-06	8.11E-06
2 L aseptic	PET AU	8.63E-05	1.98E-06	3.02E-08	2.93E-06	3.24E-04
	HDPE AU	4.40E-05	1.98E-06	2.84E-08	2.49E-06	3.24E-04
	Carton AU	1.25E-04	5.78E-06	2.92E-08	3.15E-06	3.24E-04
2 L fresh milk	PET NZ	7.35E-05	1.83E-06	5.53E-08	1.12E-06	1.44E-05
	rPET NZ	5.17E-05	1.83E-06	5.53E-08	1.12E-06	1.44E-05
	HDPE natural AU	3.42E-05	1.56E-06	5.33E-08	1.86E-06	1.45E-05
	HDPE natural NZ	3.55E-05	1.83E-06	5.28E-08	6.93E-07	1.44E-05
	HDPE lightproof NZ	4.61E-05	1.83E-06	5.36E-08	7.80E-07	1.44E-05
	Carton AU	1.30E-04	2.22E-06	5.62E-08	3.37E-06	1.45E-05
	Carton NZ	1.30E-04	2.60E-06	5.62E-08	3.29E-06	1.44E-05
600 mL aseptic	PET Lightweight AU	1.78E-05	1.11E-06	9.80E-09	6.40E-07	1.15E-04
	rPET Lightweight AU	1.23E-05	1.11E-06	9.80E-09	6.40E-07	1.15E-04
	Carton AU	4.94E-05	1.48E-06	1.13E-08	1.28E-06	1.15E-04

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
330 mL aseptic	Glass AU	1.05E-04	1.13E-06	4.56E-08	5.73E-06	8.66E-05
	Aluminium Can - 0% Recycled AU	8.43E-05	1.13E-06	7.89E-09	2.22E-07	8.66E-05
	Aluminium Can - 0% Recycled NZ	7.14E-05	1.31E-06	7.53E-09	2.34E-07	8.66E-05
	Aluminium Can - 70% Recycled AU	5.97E-05	1.13E-06	7.89E-09	2.22E-07	8.66E-05
	Aluminium Can - 70% Recycled NZ	5.06E-05	1.31E-06	7.53E-09	2.34E-07	8.66E-05
	Carton AU	3.44E-05	1.95E-06	8.27E-09	9.11E-07	8.66E-05
	Carton NZ	3.44E-05	2.29E-06	8.27E-09	8.75E-07	8.66E-05
250 mL aseptic (AU only)	Glass AU	7.01E-05	1.13E-06	2.93E-08	3.94E-06	2.38E-05
	PET AU	3.65E-05	1.13E-06	6.65E-09	1.33E-06	2.38E-05
	Pouch AU	1.48E-05	1.95E-06	2.70E-09	3.27E-07	2.38E-05
	Carton AU	2.17E-05	1.95E-06	3.43E-09	5.40E-07	2.38E-05
200 mL aseptic (NZ only)	Pouch - lid NZ	1.79E-05	2.29E-06	3.11E-09	3.34E-07	2.38E-05
	Pouch - straw NZ	1.19E-05	2.29E-06	2.55E-09	2.70E-07	2.38E-05
	Carton NZ	1.83E-05	2.29E-06	3.17E-09	4.88E-07	2.38E-05
500 mL retorted (food)	Glass AU	9.78E-05	6.09E-07	5.72E-08	6.39E-06	1.88E-04
	Glass NZ	9.70E-05	8.03E-07	5.69E-08	3.99E-06	1.88E-04
	Steel Can AU	1.17E-04	5.82E-07	2.15E-08	1.46E-06	1.88E-04
	Steel Can NZ	1.30E-04	6.91E-07	2.25E-08	1.26E-06	1.88E-04
	Pouch AU	1.90E-05	5.81E-07	1.39E-08	5.46E-07	1.88E-04
	Carton AU*	4.09E-05	7.48E-07	1.55E-08	1.10E-06	1.88E-04
	Carton NZ*	4.09E-05	8.82E-07	1.55E-08	1.10E-06	1.88E-04
400 mL retorted (food) (NZ only)	Steel Can NZ	1.00E-04	6.87E-07	1.71E-08	9.72E-07	1.41E-04
	Pouch NZ	1.73E-05	6.83E-07	1.07E-08	4.96E-07	1.41E-04
	Carton NZ*	3.48E-05	8.79E-07	1.19E-08	9.22E-07	1.41E-04

*No carton could be found for teardown, so the Tetra Recart was used as a proxy for comparison.

Table 7-9: Aviation GWP results by primary material and size class (kg CO_2-e per consumer pack)

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
1 L aseptic	Glass AU	7.32E-07	1.17E-08	2.94E-10	7.00E-09	3.13E-08
	Glass NZ	6.95E-07	4.83E-09	2.97E-10	4.44E-09	3.13E-08
	PET AU	2.90E-07	1.17E-08	6.10E-11	2.59E-09	3.13E-08
	PET NZ	1.85E-07	4.83E-09	6.05E-11	1.17E-09	3.13E-08
	PET Lightweight AU	1.50E-07	1.17E-08	5.05E-11	1.38E-09	3.13E-08
	rPET	2.81E-07	1.17E-08	6.04E-11	2.56E-09	3.13E-08
	rPET	1.43E-07	4.83E-09	6.05E-11	1.17E-09	3.13E-08

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
	rPET Lightweight AU	1.47E-07	1.17E-08	5.05E-11	1.38E-09	3.13E-08
	Carton AU	1.00E-07	3.56E-08	5.85E-11	3.55E-09	3.13E-08
	Carton NZ	8.74E-08	1.06E-08	5.59E-11	1.55E-05	3.13E-08
1 L fresh milk	Glass AU	7.32E-07	9.62E-09	3.41E-10	7.00E-09	1.65E-08
	Glass NZ	6.95E-07	2.78E-09	3.44E-10	4.44E-09	1.64E-08
	PET AU	2.90E-07	9.62E-09	1.07E-10	2.59E-09	1.65E-08
	PET NZ	1.85E-07	2.78E-09	1.07E-10	1.17E-09	1.64E-08
	rPET AU	2.81E-07	9.62E-09	1.07E-10	2.56E-09	1.65E-08
	rPET NZ	1.43E-07	2.78E-09	1.07E-10	1.17E-09	1.64E-08
	HDPE natural AU	1.57E-07	9.62E-09	1.06E-10	2.41E-09	1.65E-08
	HDPE natural NZ	5.90E-08	2.78E-09	1.01E-10	7.49E-10	1.64E-08
	HDPE lightproof NZ	7.01E-08	2.78E-09	1.02E-10	7.80E-10	1.64E-08
	Carton AU	5.92E-08	1.28E-08	9.97E-11	2.86E-09	1.65E-08
	Carton NZ	6.41E-08	3.62E-09	1.01E-10	3.10E-09	1.64E-08
2 L aseptic	PET AU	4.82E-07	1.63E-08	9.89E-11	4.24E-09	6.07E-08
	HDPE AU	2.34E-07	1.63E-08	9.31E-11	3.62E-09	6.07E-08
	Carton AU	1.62E-07	4.98E-08	9.57E-11	3.97E-09	6.07E-08
2 L fresh milk	PET NZ	2.68E-07	3.90E-09	1.81E-10	1.63E-09	2.92E-08
	rPET NZ	2.04E-07	3.90E-09	1.81E-10	1.63E-09	2.92E-08
	HDPE natural AU	1.75E-07	1.35E-08	1.75E-10	2.71E-09	2.94E-08
	HDPE natural NZ	7.79E-08	3.90E-09	1.73E-10	9.97E-10	2.92E-08
	HDPE lightproof NZ	1.01E-07	3.90E-09	1.75E-10	1.12E-09	2.92E-08
	Carton AU	1.40E-07	1.92E-08	1.84E-10	6.33E-09	2.94E-08
	Carton NZ	1.40E-07	5.44E-09	1.84E-10	6.21E-09	2.92E-08
600 mL aseptic	PET Lightweight AU	1.01E-07	9.62E-09	3.21E-11	9.30E-10	2.17E-08
	rPET Lightweight AU	9.92E-08	9.62E-09	3.21E-11	9.30E-10	2.17E-08
	Carton AU	6.52E-08	1.28E-08	3.69E-11	2.28E-09	2.17E-08
330 mL aseptic	Glass AU	3.73E-07	9.67E-09	1.49E-10	3.58E-09	1.63E-08
	Aluminium Can - 0% Recycled AU	1.49E-07	9.67E-09	2.58E-11	1.77E-03	1.63E-08
	Aluminium Can - 0% Recycled NZ	1.27E-07	3.01E-09	2.47E-11	1.31E-03	1.63E-08
	Aluminium Can - 70% Recycled AU	1.25E-07	9.67E-09	2.58E-11	1.77E-03	1.63E-08
	Aluminium Can - 70% Recycled NZ	1.06E-07	3.01E-09	2.47E-11	1.31E-03	1.63E-08
	Carton AU	4.84E-08	1.69E-08	2.71E-11	1.58E-09	1.63E-08
	Carton NZ	4.84E-08	4.74E-09	2.71E-11	1.52E-09	1.63E-08

Size class	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
250 mL aseptic (AU only)	Glass AU	2.58E-07	9.67E-09	9.58E-11	2.47E-09	7.38E-09
	PET AU	2.09E-07	9.67E-09	2.18E-11	1.93E-09	7.38E-09
	Pouch AU	5.79E-08	1.69E-08	8.83E-12	4.31E-10	7.38E-09
	Carton AU	2.82E-08	1.69E-08	1.12E-11	6.78E-10	7.38E-09
200 mL aseptic (NZ only)	Pouch - lid NZ	6.37E-08	4.74E-09	1.02E-11	4.49E-10	7.37E-09
	Pouch - straw NZ	4.58E-08	4.74E-09	8.35E-12	3.58E-10	7.37E-09
	Carton NZ	2.39E-08	4.74E-09	1.04E-11	8.61E-10	7.37E-09
500 mL retorted (food)	Glass AU	3.94E-07	4.98E-09	1.87E-10	3.98E-09	3.52E-08
	Glass NZ	3.92E-07	1.63E-09	1.86E-10	2.54E-09	3.52E-08
	Steel Can AU	2.95E-07	4.96E-09	7.04E-11	9.12E-10	3.52E-08
	Steel Can NZ	3.17E-07	1.57E-09	7.36E-11	8.19E-10	3.52E-08
	Pouch AU	6.72E-08	4.96E-09	4.56E-11	7.19E-10	3.52E-08
	Carton AU*	6.28E-08	6.13E-09	5.07E-11	1.95E-09	3.52E-08
	Carton NZ*	6.29E-08	2.73E-09	5.07E-11	1.95E-09	3.52E-08
400 mL retorted (food) (NZ only)	Steel Can NZ	2.44E-07	1.56E-09	5.59E-11	6.31E-10	2.64E-08
	Pouch NZ	6.10E-08	1.56E-09	3.50E-11	6.53E-10	2.64E-08
	Carton NZ*	5.34E-08	2.73E-09	3.90E-11	1.64E-09	2.64E-08

* No carton could be found for teardown, so the Tetra Recart was used as a proxy for comparison

Annex J GWP by Product Category

The average GWP results split by size class, product category (fresh milk, long-life milk, juice, water, and food), primary material (glass, PET, carton etc.) and country are shown in for Table 7-10 total GWP, Table 7-11 for fossil GWP, Table 7-13 for biogenic GWP, Table 7-14 for land use GWP and Table 7-14 for aviation GWP.

For the biogenic carbon (Table 7-12) the uptake and release are shown in the life cycle modules where they occur. In the total GWP results (Table 7-10) the biogenic carbon from the consumer packs (paperboard, paper labels) and filling and distribution are reported under “Consumer EoL”. All carbon uptake and release from secondary and tertiary packaging (cardboard boxes and wooden pallets) is reported in “Shipper & Pallet Total”.

The 1 L fresh milk results for PET and glass shown in this section are different from the 1 L fresh milk results shown in Section 5.3. This is because the fresh milk PET and glass packaging masses used in Section 5.3 are the average masses across the whole size class, from both aseptic beverages and fresh milk. The packaging masses in the results in this Annex are from the weighed masses from each product category.

Table 7-10: Total GWP results per beverage/food category (kg CO_2-e per consumer pack)

Product category	Packaging type	Consumer	Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
2 L fresh milk	PET AU	3.68E-01	6.27E-03	2.99E-03	4.95E-03	2.67E-02	4.09E-01
	HDPE natural AU	1.57E-01	6.27E-03	2.85E-03	3.30E-03	2.67E-02	1.96E-01
	Carton refrigerated AU	8.07E-02	8.94E-03	3.00E-03	-8.62E-03	2.67E-02	1.11E-01
	PET NZ	2.87E-01	1.20E-03	2.96E-03	2.41E-03	2.62E-02	3.19E-01
	rPET NZ	1.04E-01	1.20E-03	2.96E-03	1.95E-03	2.62E-02	1.36E-01
	HDPE lightproof NZ	1.15E-01	1.20E-03	2.86E-03	1.52E-03	2.62E-02	1.46E-01
	HDPE natural NZ	9.93E-02	1.20E-03	2.82E-03	1.33E-03	2.62E-02	1.31E-01
	Carton refrigerated NZ	8.13E-02	1.65E-03	3.00E-03	-2.25E-02	2.62E-02	8.97E-02
1 L fresh milk	PET AU	2.47E-01	4.48E-03	1.74E-03	3.42E-03	1.50E-02	2.72E-01
	HDPE natural AU	1.40E-01	4.48E-03	1.72E-03	2.97E-03	1.50E-02	1.64E-01
	Carton refrigerated - Cardboard box AU	3.25E-02	5.96E-03	8.71E-04	-4.12E-03	2.48E-02	6.00E-02
	Carton refrigerated - HDPE Crate AU	3.25E-02	5.96E-03	1.63E-03	-4.09E-03	1.50E-02	5.10E-02
	Glass NZ	3.60E-01	8.54E-04	4.42E-03	5.45E-03	1.47E-02	3.85E-01
	PET NZ	2.32E-01	8.54E-04	1.79E-03	1.94E-03	1.47E-02	2.51E-01
	rPET NZ	8.59E-02	8.54E-04	1.79E-03	1.57E-03	1.47E-02	1.05E-01

Product category	Packaging type	Consumer	Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
	HDPE lightproof NZ	8.04E-02	8.54E-04	1.66E-03	1.04E-03	1.47E-02	9.87E-02
	HDPE natural NZ	7.51E-02	8.54E-04	1.65E-03	9.77E-04	1.47E-02	9.33E-02
	Carton refrigerated - Cardboard box NZ	3.54E-02	1.10E-03	8.91E-04	-1.14E-02	2.31E-02	4.91E-02
	Carton refrigerated - HDPE Crate NZ	3.54E-02	1.10E-03	1.65E-03	-1.14E-02	1.47E-02	4.16E-02
1 L aseptic milk	PET NZ	2.50E-01	1.80E-03	1.06E-03	2.07E-03	2.31E-02	2.78E-01
	Carton NZ	5.95E-02	3.42E-03	9.03E-04	-9.01E-03	2.31E-02	7.79E-02
2 L juice	PET AU	5.37E-01	7.48E-03	1.75E-03	6.11E-03	4.53E-02	5.97E-01
	HDPE AU	2.11E-01	7.48E-03	1.52E-03	3.83E-03	4.53E-02	2.69E-01
	Carton AU	1.17E-01	2.32E-02	1.56E-03	-6.45E-03	4.53E-02	1.80E-01
1 L juice	Glass AU	4.13E-01	5.35E-03	3.68E-03	6.47E-03	2.48E-02	4.54E-01
	PET AU	2.84E-01	5.35E-03	1.03E-03	3.29E-03	2.48E-02	3.19E-01
	Carton AU	8.63E-02	1.66E-02	9.77E-04	-3.73E-03	2.48E-02	1.25E-01
	Glass NZ	5.41E-01	1.80E-03	5.30E-03	8.28E-03	2.31E-02	5.79E-01
	PET NZ	2.02E-01	1.80E-03	9.98E-04	2.22E-03	2.31E-02	2.30E-01
	Carton NZ	6.83E-02	3.42E-03	9.23E-04	-8.79E-03	2.31E-02	8.69E-02
250 mL juice	Glass AU	2.01E-01	4.48E-03	1.56E-03	3.10E-03	5.26E-03	2.16E-01
	PET AU	1.85E-01	4.48E-03	3.55E-04	2.18E-03	5.26E-03	1.97E-01
	Pouch AU	3.14E-02	7.93E-03	1.44E-04	4.62E-04	5.26E-03	4.52E-02
	Carton AU	2.07E-02	7.93E-03	1.83E-04	-1.28E-03	5.26E-03	3.28E-02
200 mL juice	Pouch - lid NZ	3.94E-02	1.57E-03	1.66E-04	4.91E-04	4.93E-03	4.66E-02
	Pouch - straw NZ	2.56E-02	1.57E-03	1.36E-04	3.86E-04	4.93E-03	3.27E-02
	Carton NZ	1.78E-02	1.57E-03	1.69E-04	-2.52E-03	4.93E-03	2.19E-02
1 L water	Glass AU	7.26E-01	5.35E-03	5.93E-03	1.11E-02	2.48E-02	7.74E-01
	PET AU	2.03E-01	5.35E-03	1.01E-03	2.33E-03	1.81E-02	2.30E-01
	PET Lightweight AU	1.33E-01	5.35E-03	9.23E-04	1.59E-03	1.81E-02	1.59E-01
	rPET AU	1.15E-01	5.35E-03	1.01E-03	2.06E-03	1.81E-02	1.42E-01
	rPET Lightweight AU	7.94E-02	5.35E-03	9.23E-04	1.42E-03	1.81E-02	1.05E-01
	Carton AU	7.80E-02	1.66E-02	9.77E-04	-3.84E-03	2.48E-02	1.17E-01
	Tetra Top AU*	7.67E-02	7.61E-03	8.86E-04	-2.78E-02	2.48E-02	8.23E-02
	Glass NZ	5.74E-01	1.80E-03	5.59E-03	8.72E-03	2.31E-02	6.13E-01
	PET NZ	1.72E-01	1.80E-03	1.05E-03	1.46E-03	1.77E-02	1.94E-01
	TPA Square NZ*	7.76E-02	3.42E-03	9.61E-04	-1.03E-02	2.31E-02	9.48E-02
	Tetra Top NZ*	7.72E-02	1.87E-03	8.86E-04	-3.22E-02	2.31E-02	7.08E-02

Product category	Packaging type	Consumer	Filling	Distribution	Consumer EOL	Shipper & Pallet Total	Total (cut-off)
600 mL water	PET AU	8.96E-02	4.48E-03	4.20E-04	1.06E-03	7.09E-03	1.03E-01
	rPET AU	5.37E-02	4.48E-03	4.20E-04	9.54E-04	7.09E-03	6.66E-02
	Carton AU	4.64E-02	5.96E-03	6.02E-04	-2.48E-03	1.66E-02	6.71E-02
330 mL water	Glass AU	3.00E-01	4.48E-03	2.44E-03	4.54E-03	1.24E-02	3.24E-01
	Aluminium Can - 0% Recycled AU	2.84E-01	4.48E-03	4.21E-04	2.49E-03	1.24E-02	3.04E-01
	Aluminium Can - 70% Recycled AU	1.06E-01	4.48E-03	4.21E-04	2.39E-03	1.24E-02	1.26E-01
	Carton AU	3.69E-02	7.93E-03	4.42E-04	-1.51E-03	1.24E-02	5.62E-02
	Aluminium Can - 0% Recycled NZ	2.41E-01	9.47E-04	4.02E-04	1.87E-03	1.15E-02	2.56E-01
	Aluminium Can - 70% Recycled NZ	9.03E-02	9.47E-04	4.02E-04	1.78E-03	1.15E-02	1.05E-01
	Carton NZ	3.71E-02	1.57E-03	4.42E-04	-4.38E-03	1.15E-02	4.62E-02
500 mL retorted food	Glass AU	2.66E-01	4.13E-03	3.05E-03	5.50E-03	2.71E-02	3.05E-01
	Steel Can AU	2.75E-01	2.51E-03	1.15E-03	1.57E-03	2.71E-02	3.07E-01
	Pouch AU	4.99E-02	2.45E-03	7.44E-04	7.75E-04	2.71E-02	8.10E-02
	Carton AU	3.34E-02	3.11E-03	8.27E-04	-2.05E-03	2.71E-02	6.24E-02
	Glass NZ	2.86E-01	4.19E-03	3.04E-03	4.48E-03	2.52E-02	3.23E-01
	Steel Can NZ	2.94E-01	9.82E-04	1.20E-03	2.23E-03	2.52E-02	3.23E-01
	Tetra Recart NZ*	3.37E-02	2.02E-03	8.27E-04	-5.75E-03	2.52E-02	5.60E-02
400 mL retorted food	Can NZ	2.26E-01	8.70E-04	9.11E-04	1.73E-03	1.89E-02	2.48E-01
	Pouch NZ	4.54E-02	7.74E-04	5.71E-04	7.00E-04	1.89E-02	6.63E-02
	Tetra Recart NZ*	2.89E-02	1.95E-03	6.35E-04	-4.88E-03	1.89E-02	4.55E-02

*No carton could be found for teardown, so a Tetra Pak product was used as a proxy for comparison.

Table 7-11: Fossil GWP results per beverage/food category (kg CO_2-e per consumer pack)

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
2 L fresh milk	PET AU	3.68E-01	6.27E-03	2.99E-03	3.46E-03	1.76E-02
	HDPE natural AU	1.57E-01	6.27E-03	2.85E-03	2.58E-03	1.76E-02
	Carton refrigerated AU	8.06E-02	8.94E-03	3.00E-03	5.52E-03	1.76E-02
	PET NZ	2.87E-01	1.19E-03	2.96E-03	1.52E-03	1.75E-02
	rPET NZ	1.04E-01	1.19E-03	2.96E-03	1.52E-03	1.75E-02
	HDPE lightproof NZ	1.15E-01	1.19E-03	2.86E-03	1.05E-03	1.75E-02
	HDPE natural NZ	9.93E-02	1.19E-03	2.82E-03	9.36E-04	1.75E-02
	Carton refrigerated NZ	8.12E-02	1.65E-03	3.00E-03	5.41E-03	1.75E-02
1 L fresh milk	PET AU	2.47E-01	4.48E-03	1.74E-03	2.36E-03	9.92E-03
	HDPE natural AU	1.40E-01	4.48E-03	1.72E-03	2.30E-03	9.92E-03
	Carton refrigerated - Cardboard box AU	3.24E-02	5.96E-03	8.71E-04	2.49E-03	1.78E-02

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
	Carton refrigerated - HDPE Crate AU	3.24E-02	5.96E-03	1.63E-03	2.49E-03	9.92E-03
	Glass NZ	3.60E-01	8.52E-04	4.42E-03	4.76E-03	9.85E-03
	PET NZ	2.32E-01	8.52E-04	1.79E-03	1.24E-03	9.85E-03
	rPET NZ	8.59E-02	8.52E-04	1.79E-03	1.24E-03	9.85E-03
	HDPE lightproof N	8.04E-02	8.52E-04	1.66E-03	7.32E-04	9.85E-03
	HDPE natural NZ	7.51E-02	8.52E-04	1.65E-03	7.03E-04	9.85E-03
	Carton refrigerated - Cardboard box NZ	3.54E-02	1.10E-03	8.91E-04	2.69E-03	1.78E-02
	Carton refrigerated - HDPE Crate NZ	3.54E-02	1.10E-03	1.65E-03	2.69E-03	9.85E-03
1 L aseptic milk	PET NZ	2.50E-01	1.80E-03	1.06E-03	1.34E-03	1.78E-02
	Carton NZ	5.94E-02	3.42E-03	9.03E-04	2.58E-03	1.78E-02
2 L juice	PET AU	5.37E-01	7.48E-03	1.75E-03	4.98E-03	3.47E-02
	HDPE AU	2.11E-01	7.48E-03	1.52E-03	3.45E-03	3.47E-02
	Carton AU	1.17E-01	2.32E-02	1.56E-03	5.24E-03	3.47E-02
1 L juice	Glass AU	4.13E-01	5.34E-03	3.68E-03	5.89E-03	1.78E-02
	PET AU	2.84E-01	5.34E-03	1.03E-03	2.69E-03	1.78E-02
	Carton AU	8.62E-02	1.66E-02	9.77E-04	3.29E-03	1.78E-02
	Glass NZ	5.41E-01	1.80E-03	5.30E-03	7.29E-03	1.78E-02
	PET NZ	2.02E-01	1.80E-03	9.98E-04	1.13E-03	1.78E-02
	Carton NZ	6.82E-02	3.42E-03	9.23E-04	2.60E-03	1.78E-02
250 mL juice	Glass AU	2.01E-01	4.48E-03	1.56E-03	2.83E-03	4.37E-03
	PET AU	1.85E-01	4.48E-03	3.55E-04	1.81E-03	4.37E-03
	Pouch AU	3.14E-02	7.93E-03	1.44E-04	3.92E-04	4.37E-03
	Carton AU	2.07E-02	7.93E-03	1.83E-04	6.68E-04	4.37E-03
200 mL juice	Pouch - lid NZ	3.94E-02	1.57E-03	1.66E-04	4.11E-04	4.36E-03
	Pouch - straw NZ	2.56E-02	1.57E-03	1.36E-04	3.27E-04	4.36E-03
	Carton NZ	1.78E-02	1.57E-03	1.69E-04	7.55E-04	4.36E-03
1 L water	Glass AU	7.26E-01	5.34E-03	5.93E-03	1.02E-02	1.78E-02
	PET AU	2.03E-01	5.34E-03	1.01E-03	1.88E-03	8.00E-03
	PET Lightweight AU	1.33E-01	5.34E-03	9.23E-04	1.29E-03	8.00E-03
	rPET AU	1.15E-01	5.34E-03	1.01E-03	1.88E-03	8.00E-03
	rPET Lightweight AU	7.94E-02	5.34E-03	9.23E-04	1.29E-03	8.00E-03
	Carton AU	7.80E-02	1.66E-02	9.77E-04	3.33E-03	1.78E-02
	Tetra Top AU*	4.84E-02	7.61E-03	8.86E-04	2.46E-03	1.78E-02
	Glass NZ	5.74E-01	1.80E-03	5.59E-03	7.74E-03	1.78E-02
	PET NZ	1.72E-01	1.80E-03	1.05E-03	9.56E-04	7.93E-03
	TPA Square NZ*	7.75E-02	3.42E-03	9.61E-04	2.99E-03	1.78E-02
	Tetra Top NZ*	4.89E-02	1.87E-03	8.86E-04	2.46E-03	1.78E-02

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
600 mL water	PET AU	8.96E-02	4.48E-03	4.20E-04	8.72E-04	3.04E-03
	rPET AU	5.37E-02	4.48E-03	4.20E-04	8.72E-04	3.04E-03
	Carton AU	4.64E-02	5.96E-03	6.02E-04	2.00E-03	1.24E-02
330 mL water	Glass AU	3.00E-01	4.48E-03	2.44E-03	4.14E-03	9.27E-03
	Aluminium Can - 0% Recycled AU	2.84E-01	4.48E-03	4.21E-04	9.14E-04	9.27E-03
	Aluminium Can - 70% Recycled AU	1.06E-01	4.48E-03	4.21E-04	9.14E-04	9.27E-03
	Carton AU	3.69E-02	7.93E-03	4.42E-04	1.39E-03	9.27E-03
	Aluminium Can - 0% Recycled NZ	2.41E-01	9.46E-04	4.02E-04	7.14E-04	9.28E-03
	Aluminium Can - 70% Recycled NZ	9.02E-02	9.46E-04	4.02E-04	7.14E-04	9.28E-03
	Carton NZ	3.70E-02	1.57E-03	4.42E-04	1.34E-03	9.28E-03
500 mL retorted food	Glass AU	2.65E-01	4.13E-03	3.05E-03	4.60E-03	2.01E-02
	Steel Can AU	2.75E-01	2.51E-03	1.15E-03	1.15E-03	2.01E-02
	Pouch AU	4.99E-02	2.44E-03	7.44E-04	6.55E-04	2.01E-02
	Carton AU	3.33E-02	3.11E-03	8.27E-04	1.71E-03	2.01E-02
	Glass NZ	2.86E-01	4.18E-03	3.04E-03	3.77E-03	2.01E-02
	Steel Can NZ	2.93E-01	9.81E-04	1.20E-03	1.22E-03	2.01E-02
	Tetra Recart NZ*	3.37E-02	2.02E-03	8.27E-04	1.71E-03	2.01E-02
400 mL retorted food	Can NZ	2.26E-01	8.69E-04	9.11E-04	9.43E-04	1.51E-02
	Pouch NZ	4.53E-02	7.73E-04	5.71E-04	5.95E-04	1.51E-02
	Tetra Recart NZ*	2.88E-02	1.95E-03	6.35E-04	1.43E-03	1.51E-02

*No carton could be found for teardown, so a Tetra Pak product was used as a proxy for comparison.

Table 7-12: Biogenic GWP results per beverage/food category (kg CO_2-e per consumer pack)

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
2 L fresh milk	PET AU	-1.81E-03	6.37E-06	1.24E-04	3.17E-03	9.02E-03
	HDPE natural AU	-1.19E-03	6.37E-06	1.18E-04	1.78E-03	9.02E-03
	Carton refrigerated AU	-8.56E-02	9.16E-06	1.25E-04	7.13E-02	9.02E-03
	PET NZ	7.94E-04	7.90E-06	1.23E-04	-3.45E-05	8.67E-03
	rPET NZ	3.28E-04	7.90E-06	1.23E-04	-3.45E-05	8.67E-03
	HDPE lightproof NZ	3.58E-04	7.90E-06	1.19E-04	-2.35E-05	8.67E-03
	HDPE natural NZ	2.87E-04	7.90E-06	1.17E-04	-2.09E-05	8.67E-03
	Carton refrigerated NZ	-8.56E-02	1.14E-05	1.25E-04	5.76E-02	8.67E-03
1 L fresh milk	PET AU	-1.52E-03	4.55E-06	7.24E-05	2.51E-03	5.07E-03
	HDPE natural AU	-1.33E-03	4.55E-06	7.17E-05	1.92E-03	5.07E-03
	Carton refrigerated - Cardboard box AU	-3.98E-02	6.11E-06	3.62E-05	3.32E-02	6.83E-03

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
	Carton refrigerated - HDPE Crate AU	-3.98E-02	6.11E-06	6.76E-05	3.32E-02	5.07E-03
	Glass NZ	3.21E-04	5.64E-06	1.84E-04	1.65E-04	4.88E-03
	PET NZ	6.43E-04	5.64E-06	7.43E-05	-2.81E-05	4.88E-03
	rPET NZ	2.71E-04	5.64E-06	7.43E-05	-2.81E-05	4.88E-03
	HDPE lightproof N	2.48E-04	5.64E-06	6.91E-05	-1.64E-05	4.88E-03
	HDPE natural NZ	2.15E-04	5.64E-06	6.87E-05	-1.57E-05	4.88E-03
	Carton refrigerated - Cardboard box NZ	-4.31E-02	7.57E-06	3.71E-05	2.90E-02	5.06E-03
	Carton refrigerated - HDPE Crate NZ	-4.31E-02	7.57E-06	6.85E-05	2.90E-02	4.88E-03
1 L aseptic milk	PET NZ	7.06E-04	8.36E-06	4.39E-05	-3.03E-05	5.06E-03
	Carton NZ	-3.56E-02	1.90E-05	3.76E-05	2.40E-02	5.06E-03
2 L juice	PET AU	1.15E-03	9.88E-06	7.28E-05	-1.12E-04	1.03E-02
	HDPE AU	3.79E-04	9.88E-06	6.32E-05	-7.35E-05	1.03E-02
	Carton AU	-7.06E-02	2.07E-05	6.48E-05	5.89E-02	1.03E-02
1 L juice	Glass AU	5.07E-04	7.06E-06	1.53E-04	-9.88E-05	6.83E-03
	PET AU	6.06E-04	7.06E-06	4.27E-05	-6.03E-05	6.83E-03
	Carton AU	-4.25E-02	1.48E-05	4.06E-05	3.54E-02	6.83E-03
	Glass NZ	2.39E-04	8.36E-06	2.20E-04	5.17E-04	5.06E-03
	PET NZ	-3.34E-03	8.36E-06	4.15E-05	4.38E-03	5.06E-03
	Carton NZ	-3.50E-02	1.90E-05	3.84E-05	2.35E-02	5.06E-03
250 mL juice	Glass AU	2.45E-04	4.60E-06	6.50E-05	-4.76E-05	8.67E-04
	PET AU	3.91E-04	4.60E-06	1.48E-05	-4.05E-05	8.67E-04
	Pouch AU	6.56E-05	6.95E-06	5.99E-06	-9.79E-06	8.67E-04
	Carton AU	-1.20E-02	6.95E-06	7.62E-06	1.01E-02	8.67E-04
200 mL juice	Pouch - lid NZ	7.36E-05	9.06E-06	6.90E-06	-1.00E-05	5.49E-04
	Pouch - straw NZ	5.18E-05	9.06E-06	5.66E-06	-8.10E-06	5.49E-04
	Carton NZ	-1.00E-02	9.06E-06	7.04E-06	6.76E-03	5.49E-04
1 L water	Glass AU	8.77E-04	7.06E-06	2.47E-04	-1.70E-04	6.83E-03
	PET AU	4.35E-04	7.06E-06	4.20E-05	-4.23E-05	1.01E-02
	PET Lightweight AU	2.80E-04	7.06E-06	3.84E-05	-2.88E-05	1.01E-02
	rPET AU	1.64E-04	7.06E-06	4.20E-05	-4.23E-05	1.01E-02
	rPET Lightweight AU	1.15E-04	7.06E-06	3.84E-05	-2.88E-05	1.01E-02
	Carton AU	-4.34E-02	1.48E-05	4.06E-05	3.62E-02	6.83E-03
	Tetra Top AU*	-5.45E-02	7.70E-06	3.68E-05	2.43E-02	6.83E-03
	Glass NZ	7.58E-04	8.36E-06	2.32E-04	-1.95E-05	5.06E-03
	PET NZ	4.74E-04	8.36E-06	4.35E-05	-2.16E-05	9.75E-03
	TPA Square NZ*	-4.06E-02	1.90E-05	4.00E-05	2.72E-02	5.06E-03
	Tetra Top NZ*	-5.45E-02	9.43E-06	3.68E-05	1.99E-02	5.06E-03

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
600 mL water	PET AU	1.89E-04	4.55E-06	1.75E-05	-1.95E-05	4.05E-03
	rPET AU	7.84E-05	4.55E-06	1.75E-05	-1.95E-05	4.05E-03
	Carton AU	-2.71E-02	6.11E-06	2.50E-05	2.26E-02	4.11E-03
330 mL water	Glass AU	3.56E-04	4.60E-06	1.01E-04	-6.92E-05	3.08E-03
	Aluminium Can - 0% Recycled AU	-2.12E-04	4.60E-06	1.75E-05	1.87E-07	3.08E-03
	Aluminium Can - 70% Recycled AU	-3.16E-04	4.60E-06	1.75E-05	1.87E-07	3.08E-03
	Carton AU	-1.75E-02	6.95E-06	1.84E-05	1.46E-02	3.08E-03
	Aluminium Can - 0% Recycled NZ	-1.80E-04	5.67E-06	1.67E-05	-1.23E-06	2.18E-03
	Aluminium Can - 70% Recycled NZ	-2.67E-04	5.67E-06	1.67E-05	-1.23E-06	2.18E-03
	Carton NZ	-1.75E-02	9.06E-06	1.84E-05	1.18E-02	2.18E-03
500 mL retorted food	Glass AU	-1.53E-03	2.43E-06	1.27E-04	2.29E-03	6.85E-03
	Steel Can AU	3.83E-04	2.27E-06	4.78E-05	-1.99E-05	6.85E-03
	Pouch AU	1.02E-04	2.26E-06	3.09E-05	-1.64E-05	6.85E-03
	Carton AU	-2.30E-02	3.11E-06	3.44E-05	1.92E-02	6.85E-03
	Glass NZ	-1.32E-03	7.98E-06	1.26E-04	1.89E-03	4.88E-03
	Steel Can NZ	-3.86E-03	3.48E-06	4.99E-05	4.81E-03	4.88E-03
	Tetra Recart NZ*	-2.30E-02	5.58E-06	3.44E-05	1.55E-02	4.88E-03
400 mL retorted food	Can NZ	-3.08E-03	3.32E-06	3.79E-05	3.83E-03	3.66E-03
	Pouch NZ	9.26E-05	3.18E-06	2.38E-05	-1.49E-05	3.66E-03
	Tetra Recart NZ*	-1.94E-02	5.48E-06	2.64E-05	1.31E-02	3.66E-03

*No carton could be found for teardown, so a Tetra Pak product was used as a proxy for comparison.

Table 7-13: Land Use GWP results per beverage/food category (kg CO_2-e per consumer pack)

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
2 L fresh milk	PET AU	7.52E-05	1.56E-06	5.59E-08	2.54E-06	1.45E-05
	HDPE natural AU	3.42E-05	1.56E-06	5.33E-08	1.86E-06	1.45E-05
	Carton refrigerated AU	1.30E-04	2.22E-06	5.62E-08	3.37E-06	1.45E-05
	PET NZ	7.35E-05	1.83E-06	5.53E-08	1.12E-06	1.44E-05
	rPET NZ	5.17E-05	1.83E-06	5.53E-08	1.12E-06	1.44E-05
	HDPE lightproof NZ	4.61E-05	1.83E-06	5.36E-08	7.80E-07	1.44E-05
	HDPE natural NZ	3.55E-05	1.83E-06	5.28E-08	6.93E-07	1.44E-05
	Carton refrigerated NZ	1.30E-04	2.60E-06	5.62E-08	3.29E-06	1.44E-05
1 L fresh milk	PET AU	5.09E-05	1.11E-06	3.26E-08	1.73E-06	8.18E-06
	HDPE natural AU	3.08E-05	1.11E-06	3.23E-08	1.66E-06	8.18E-06
	Carton refrigerated - Cardboard box AU	5.86E-05	1.48E-06	1.63E-08	1.51E-06	1.66E-04

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
	Carton refrigerated - HDPE Crate AU	5.86E-05	1.48E-06	3.05E-08	1.51E-06	8.18E-06
	Glass NZ	1.19E-04	1.31E-06	8.27E-08	5.05E-06	8.11E-06
	PET NZ	5.97E-05	1.31E-06	3.34E-08	9.16E-07	8.11E-06
	rPET NZ	4.23E-05	1.31E-06	3.34E-08	9.16E-07	8.11E-06
	HDPE lightproof N	3.22E-05	1.31E-06	3.11E-08	5.43E-07	8.11E-06
	HDPE natural NZ	2.69E-05	1.31E-06	3.09E-08	5.22E-07	8.11E-06
	Carton refrigerated - Cardboard box NZ	6.34E-05	1.73E-06	1.67E-08	1.63E-06	1.66E-04
	Carton refrigerated - HDPE Crate NZ	6.34E-05	1.73E-06	3.08E-08	1.63E-06	8.11E-06
1 L aseptic milk	PET NZ	6.29E-05	1.61E-06	1.98E-08	9.87E-07	1.66E-04
	Carton NZ	6.36E-05	4.83E-06	1.69E-08	1.65E-06	1.66E-04
2 L juice	PET AU	1.05E-04	1.98E-06	3.28E-08	3.67E-06	3.24E-04
	HDPE AU	4.40E-05	1.98E-06	2.84E-08	2.49E-06	3.24E-04
	Carton AU	1.25E-04	5.78E-06	2.92E-08	3.38E-06	3.24E-04
1 L juice	Glass AU	1.43E-04	1.41E-06	6.88E-08	8.14E-06	1.66E-04
	PET AU	5.61E-05	1.41E-06	1.92E-08	1.98E-06	1.66E-04
	Carton AU	8.31E-05	4.13E-06	1.83E-08	2.14E-06	1.66E-04
	Glass NZ	1.79E-04	1.61E-06	9.92E-08	7.74E-06	1.66E-04
	PET NZ	5.70E-05	1.61E-06	1.87E-08	8.31E-07	1.66E-04
	Carton NZ	6.66E-05	4.83E-06	1.73E-08	1.67E-06	1.66E-04
250 mL juice	Glass AU	7.01E-05	1.13E-06	2.93E-08	3.94E-06	2.38E-05
	PET AU	3.65E-05	1.13E-06	6.65E-09	1.33E-06	2.38E-05
	Pouch AU	1.48E-05	1.95E-06	2.70E-09	3.27E-07	2.38E-05
	Carton AU	2.17E-05	1.95E-06	3.43E-09	5.40E-07	2.38E-05
200 mL juice	Pouch - lid NZ	1.79E-05	2.29E-06	3.11E-09	3.34E-07	2.38E-05
	Pouch - straw NZ	1.19E-05	2.29E-06	2.55E-09	2.70E-07	2.38E-05
	Carton NZ	1.83E-05	2.29E-06	3.17E-09	4.88E-07	2.38E-05
1 L water	Glass AU	2.54E-04	1.41E-06	1.11E-07	1.41E-05	1.66E-04
	PET AU	3.99E-05	1.41E-06	1.89E-08	1.39E-06	3.14E-06
	PET Lightweight AU	2.65E-05	1.41E-06	1.73E-08	9.48E-07	3.14E-06
	rPET AU	2.65E-05	1.41E-06	1.89E-08	1.39E-06	3.14E-06
	rPET Lightweight AU	1.84E-05	1.41E-06	1.73E-08	9.48E-07	3.14E-06
	Carton AU	8.00E-05	4.13E-06	1.83E-08	2.15E-06	1.66E-04
	Tetra Top AU*	2.83E-02	1.96E-06	1.66E-08	1.62E-06	1.66E-04
	Glass NZ	1.89E-04	1.61E-06	1.05E-07	8.21E-06	1.66E-04
	PET NZ	4.56E-05	1.61E-06	1.96E-08	7.05E-07	3.09E-06
	TPA Square NZ*	7.25E-05	4.83E-06	1.80E-08	1.94E-06	1.66E-04
	Tetra Top NZ*	2.83E-02	2.26E-06	1.66E-08	1.62E-06	1.66E-04

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
600 mL water	PET AU	1.78E-05	1.11E-06	7.87E-09	6.40E-07	1.21E-06
	rPET AU	1.23E-05	1.11E-06	7.87E-09	6.40E-07	1.21E-06
	Carton AU	4.94E-05	1.48E-06	1.13E-08	1.28E-06	1.15E-04
330 mL water	Glass AU	1.05E-04	1.13E-06	4.56E-08	5.73E-06	8.66E-05
	Aluminium Can - 0% Recycled AU	8.43E-05	1.13E-06	7.89E-09	2.22E-07	8.66E-05
	Aluminium Can - 70% Recycled AU	5.97E-05	1.13E-06	7.89E-09	2.22E-07	8.66E-05
	Carton AU	3.44E-05	1.95E-06	8.27E-09	9.11E-07	8.66E-05
	Aluminium Can - 0% Recycled NZ	7.14E-05	1.31E-06	7.53E-09	2.34E-07	8.66E-05
	Aluminium Can - 70% Recycled NZ	5.06E-05	1.31E-06	7.53E-09	2.34E-07	8.66E-05
	Carton NZ	3.44E-05	2.29E-06	8.27E-09	8.75E-07	8.66E-05
500 mL retorted food	Glass AU	9.78E-05	6.09E-07	5.72E-08	6.39E-06	1.88E-04
	Steel Can AU	1.17E-04	5.82E-07	2.15E-08	1.46E-06	1.88E-04
	Pouch AU	1.90E-05	5.81E-07	1.39E-08	5.46E-07	1.88E-04
	Carton AU	4.09E-05	7.48E-07	1.55E-08	1.10E-06	1.88E-04
	Glass NZ	9.70E-05	8.03E-07	5.69E-08	3.99E-06	1.88E-04
	Steel Can NZ	1.30E-04	6.91E-07	2.25E-08	1.26E-06	1.88E-04
	Tetra Recart NZ*	4.09E-05	8.82E-07	1.55E-08	1.10E-06	1.88E-04
400 mL retorted food	Can NZ	1.00E-04	6.87E-07	1.71E-08	9.72E-07	1.41E-04
	Pouch NZ	1.73E-05	6.83E-07	1.07E-08	4.96E-07	1.41E-04
	Tetra Recart NZ*	3.48E-05	8.79E-07	1.19E-08	9.22E-07	1.41E-04

*No carton could be found for teardown, so a Tetra Pak product was used as a proxy for comparison.

Table 7-14: Aviation GWP results per beverage/food category (kg CO_2-e per consumer pack)

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
2 L fresh milk	PET AU	4.18E-07	1.35E-08	1.83E-10	3.69E-09	2.94E-08
	HDPE natural AU	1.75E-07	1.35E-08	1.75E-10	2.71E-09	2.94E-08
	Carton refrigerated AU	1.40E-07	1.92E-08	1.84E-10	6.33E-09	2.94E-08
	PET NZ	2.68E-07	3.90E-09	1.81E-10	1.63E-09	2.92E-08
	rPET NZ	2.04E-07	3.90E-09	1.81E-10	1.63E-09	2.92E-08
	HDPE lightproof NZ	1.01E-07	3.90E-09	1.75E-10	1.12E-09	2.92E-08
	HDPE natural NZ	7.79E-08	3.90E-09	1.73E-10	9.97E-10	2.92E-08
	Carton refrigerated NZ	1.40E-07	5.44E-09	1.84E-10	6.21E-09	2.92E-08
1 L fresh milk	PET AU	2.81E-07	9.62E-09	1.07E-10	2.51E-09	1.65E-08
	HDPE natural AU	1.57E-07	9.62E-09	1.06E-10	2.41E-09	1.65E-08
	Carton refrigerated - Cardboard box AU	5.92E-08	1.28E-08	5.34E-11	2.86E-09	3.13E-08

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
	Carton refrigerated - HDPE Crate AU	5.92E-08	1.28E-08	9.97E-11	2.86E-09	1.65E-08
	Glass NZ	5.00E-07	2.78E-09	2.71E-10	3.21E-09	1.64E-08
	PET NZ	2.16E-07	2.78E-09	1.09E-10	1.33E-09	1.64E-08
	rPET NZ	1.65E-07	2.78E-09	1.09E-10	1.33E-09	1.64E-08
	HDPE lightproof N	7.01E-08	2.78E-09	1.02E-10	7.80E-10	1.64E-08
	HDPE natural NZ	5.90E-08	2.78E-09	1.01E-10	7.49E-10	1.64E-08
	Carton refrigerated - Cardboard box NZ	6.41E-08	3.62E-09	5.46E-11	3.10E-09	3.13E-08
	Carton refrigerated - HDPE Crate NZ	6.41E-08	3.62E-09	1.01E-10	3.10E-09	1.64E-08
1 L aseptic milk	PET NZ	2.22E-07	4.83E-09	6.47E-11	1.43E-09	3.13E-08
	Carton NZ	8.17E-08	1.06E-08	5.54E-11	1.04E-05	3.13E-08
2 L juice	PET AU	6.06E-07	1.63E-08	1.07E-10	5.32E-09	6.07E-08
	HDPE AU	2.34E-07	1.63E-08	9.31E-11	3.62E-09	6.07E-08
	Carton AU	1.59E-07	4.98E-08	9.55E-11	5.98E-09	6.07E-08
1 L juice	Glass AU	5.36E-07	1.17E-08	2.25E-10	5.13E-09	3.13E-08
	PET AU	3.21E-07	1.17E-08	6.30E-11	2.88E-09	3.13E-08
	Carton AU	1.17E-07	3.56E-08	5.99E-11	3.74E-09	3.13E-08
	Glass NZ	7.70E-07	4.83E-09	3.25E-10	4.90E-09	3.13E-08
	PET NZ	1.92E-07	4.83E-09	6.12E-11	1.19E-09	3.13E-08
	Carton NZ	9.16E-08	1.06E-08	5.66E-11	2.96E-09	3.13E-08
250 mL juice	Glass AU	2.58E-07	9.67E-09	9.58E-11	2.47E-09	7.38E-09
	PET AU	2.09E-07	9.67E-09	2.18E-11	1.93E-09	7.38E-09
	Pouch AU	5.79E-08	1.69E-08	8.83E-12	4.31E-10	7.38E-09
	Carton AU	2.82E-08	1.69E-08	1.12E-11	6.78E-10	7.38E-09
200 mL juice	Pouch - lid NZ	6.37E-08	4.74E-09	1.02E-11	4.49E-10	7.37E-09
	Pouch - straw NZ	4.58E-08	4.74E-09	8.35E-12	3.58E-10	7.37E-09
	Carton NZ	2.39E-08	4.74E-09	1.04E-11	8.61E-10	7.37E-09
1 L water	Glass AU	9.24E-07	1.17E-08	3.64E-10	8.79E-09	3.13E-08
	PET AU	2.29E-07	1.17E-08	6.19E-11	2.01E-09	1.34E-08
	PET Lightweight AU	1.50E-07	1.17E-08	5.66E-11	1.38E-09	1.34E-08
	rPET AU	2.24E-07	1.17E-08	6.19E-11	2.01E-09	1.34E-08
	rPET Lightweight AU	1.47E-07	1.17E-08	5.66E-11	1.38E-09	1.34E-08
	TPA Square AU*	1.06E-07	3.56E-08	5.99E-11	3.79E-09	3.13E-08
	Tetra Top AU*	1.21E-07	1.66E-08	5.43E-11	2.79E-09	3.13E-08
	Glass NZ	8.17E-07	4.83E-09	3.43E-10	5.20E-09	3.13E-08
	PET NZ	1.59E-07	4.83E-09	6.41E-11	1.02E-09	1.33E-08
	TPA Square NZ*	8.39E-08	1.06E-08	5.89E-11	3.42E-09	3.13E-08
	Tetra Top NZ*	1.21E-07	5.76E-09	5.43E-11	2.78E-09	3.13E-08

Product category	Packaging type	Consumer Pack	Forming and Filling	Distribution	Consumer EOL	Shipper & Pallet Total
600 mL water	PET AU	1.01E-07	9.62E-09	2.58E-11	9.30E-10	5.10E-09
	rPET AU	9.92E-08	9.62E-09	2.58E-11	9.30E-10	5.10E-09
	Carton AU	6.52E-08	1.28E-08	3.69E-11	2.28E-09	2.17E-08
330 mL water	Glass AU	3.73E-07	9.67E-09	1.49E-10	3.58E-09	1.63E-08
	Aluminium Can - 0% Recycled AU	1.49E-07	9.67E-09	2.58E-11	1.77E-03	1.63E-08
	Aluminium Can - 70% Recycled AU	1.25E-07	9.67E-09	2.58E-11	1.77E-03	1.63E-08
	Carton AU	4.84E-08	1.69E-08	2.71E-11	1.58E-09	1.63E-08
	Aluminium Can - 0% Recycled NZ	1.27E-07	3.01E-09	2.47E-11	1.31E-03	1.63E-08
	Aluminium Can - 70% Recycled NZ	1.06E-07	3.01E-09	2.47E-11	1.31E-03	1.63E-08
	Carton NZ	4.84E-08	4.74E-09	2.71E-11	1.52E-09	1.63E-08
500 mL retorted food	Glass AU	3.94E-07	4.98E-09	1.87E-10	3.98E-09	3.52E-08
	Steel Can AU	2.95E-07	4.96E-09	7.04E-11	9.12E-10	3.52E-08
	Pouch AU	6.72E-08	4.96E-09	4.56E-11	7.19E-10	3.52E-08
	Carton AU	6.28E-08	6.13E-09	5.07E-11	1.95E-09	3.52E-08
	Glass NZ	3.92E-07	1.63E-09	1.86E-10	2.54E-09	3.52E-08
	Steel Can NZ	3.17E-07	1.57E-09	7.36E-11	8.19E-10	3.52E-08
	Tetra Recart NZ*	6.29E-08	2.73E-09	5.07E-11	1.95E-09	3.52E-08
400 mL retorted food	Can NZ	2.44E-07	1.56E-09	5.59E-11	6.31E-10	2.64E-08
	Pouch NZ	6.10E-08	1.56E-09	3.50E-11	6.53E-10	2.64E-08
	Tetra Recart NZ*	5.34E-08	2.73E-09	3.90E-11	1.64E-09	2.64E-08

*No carton could be found for teardown, so a Tetra Pak product was used as a proxy for comparison.

Annex K Tetra Pak Packaging Metrics

Table 7-15: Tetra Pak packaging metrics

Volume (L)	Packaging type	Pack Mass (g)	Product-to-packaging ratio (mL/g)	Plastic per litre of beverage/food (g/L)
1 L	TPA Square	39.3	25.5	11.4
	TBA SQ HC27	37.1	26.9	11.3
	TBA Slim HC	33.9	29.5	9.4
	TBA Edge	32.1	31.1	7.1
	Tetra Top	30.1	33.2	3.0
	Tetra Rex	31.0	32.3	3.5
	Tetra Rex Bio	26.2	38.2	0.0
2 L	TBA HC27	60.7	33.0	8.0
	TBA SC	62.0	32.3	8.7
600 mL	Tetra Rex	22.5	26.7	4.2
	Tetra Rex Bio	19.0	31.6	0.0
500 mL	Tetra Top	21.7	23.0	5.3
	Tetra Recart Midi	20.5	24.4	10.0
330 mL	Tetra Top	17.7	18.7	6.1
	Tetra Prisma	16.6	19.9	20.6
250 mL	TBA S Straw	9.9	25.4	9.6
	TPA SQ Straw	10.7	23.3	11.2
	TBA Edge Straw	10.2	24.5	10.9
	TBA Edge Cap	12.7	19.7	21.0
200 mL	TPA SQ Straw	9.3	21.5	12.4
	TBA S Straw	8.5	23.4	11.0
	TBA Slim Leaf	9.1	21.9	10.8
	TBA Base	8.4	23.7	10.7
	TBA Base Crystal	8.4	23.7	10.7

Annex L Other Indicators

Other indicators were also analysed during this assessment. Table 7-17 shows these results, with the cartons in each size class in bold and colour coded, as per the coding system seen in Table 7-16.

Table 7-16: Colour coding scheme used for other indicator results

Colour	Result relative to other results	Interpretation
Green	The carton is the lowest in that size class	Cartons are the lowest impact
Blue	The carton is within +/-10% of the lowest value (excluding cartons) in that size class	Insignificant difference
Yellow	The carton is between 10-50% higher than the lowest value in that size class	Notable difference
Red	The carton is more than 50% larger than the lowest value in that size class	Significant difference

Table 7-17: Other indicator results

Size Class	Packaging Type	AP [kg SO2 eq.]	EP [kg PO_4^{3-} eq.]	ADPF [MJ]	ADPE [MJ]	POCP [kg NOx eq.]	WSF [m³ world equiv.]	Blue water [kg]
1L aseptic AU	**Glass**	3.99E-03	4.99E-04	8.30E+00	4.84E-08	3.46E-03	3.84E-02	1.44E+00
	PET	1.17E-03	1.11E-04	5.14E+00	3.21E-08	7.64E-04	7.62E-02	1.54E+00
	PET Lightweight	6.83E-04	6.52E-05	2.87E+00	2.04E-08	4.33E-04	4.41E-02	9.68E-01
	rPET	8.09E-04	8.37E-05	2.20E+00	1.81E-08	5.35E-04	5.73E-02	1.08E+00
	rPET Lightweight	5.04E-04	5.20E-05	1.41E+00	1.35E-08	3.22E-04	3.48E-02	7.39E-01
	Carton	**8.06E-04**	**7.62E-05**	**1.78E+00**	**2.05E-08**	**4.69E-04**	**2.91E-02**	**9.92E-01**
1L aseptic NZ	**Glass**	3.72E-03	4.71E-04	7.36E+00	4.47E-08	3.34E-03	3.39E-02	1.35E+00
	PET	9.39E-04	8.86E-05	4.52E+00	3.01E-08	6.16E-04	6.40E-02	2.36E+00
	rPET	5.11E-04	5.65E-05	1.49E+00	1.61E-08	3.50E-04	4.23E-02	2.22E+00
	Carton	**6.65E-04**	**6.48E-05**	**1.46E+00**	**1.86E-08**	**3.93E-04**	**2.44E-02**	**1.13E+00**

Size Class	Packaging Type	AP [kg SO2 eq.]	EP [kg PO_4^{3-} eq.]	ADPF [MJ]	ADPE [MJ]	POCP [kg NOx eq.]	WSF [m³ world equiv.]	Blue water [kg]
1L fresh AU	Glass- Fresh	4.02E-03	4.91E-04	8.24E+00	4.20E-08	3.44E-03	3.41E-02	1.18E+00
	PET - Fresh	1.20E-03	1.03E-04	5.08E+00	2.58E-08	7.42E-04	7.19E-02	1.28E+00
	rPET- Fresh	8.37E-04	7.59E-05	2.14E+00	1.17E-08	5.14E-04	5.31E-02	8.19E-01
	HDPE natural	1.64E-03	8.12E-05	3.79E+00	1.62E-08	5.71E-04	4.18E-02	7.44E-01
	Carton refrigerated	**4.52E-04**	**4.73E-05**	**8.29E-01**	**8.62E-09**	**3.00E-04**	**1.33E-02**	**3.28E-01**
1L fresh NZ	Glass- Fresh	3.75E-03	4.63E-04	7.30E+00	3.83E-08	3.32E-03	2.96E-02	1.09E+00
	PET - Fresh	9.66E-04	8.06E-05	4.45E+00	2.37E-08	5.95E-04	5.97E-02	2.10E+00
	rPET- Fresh	5.38E-04	4.85E-05	1.43E+00	9.70E-09	3.29E-04	3.80E-02	1.96E+00
	HDPE natural	1.14E-03	4.90E-05	2.61E+00	1.20E-08	3.55E-04	2.56E-02	1.27E+00
	HDPE lightproof	1.19E-03	5.17E-05	2.74E+00	1.31E-08	3.73E-04	2.93E-02	1.56E+00
	Carton refrigerated	**4.71E-04**	**4.98E-05**	**8.25E-01**	**9.07E-09**	**3.16E-04**	**1.30E-02**	**4.22E-01**
2L aseptic AU	PET	1.90E-03	1.86E-04	8.56E+00	5.53E-08	1.27E-03	1.28E-01	2.65E+00
	HDPE	2.46E-03	1.38E-04	5.91E+00	3.70E-08	9.08E-04	7.24E-02	1.65E+00
	Carton	**1.35E-03**	**1.29E-04**	**3.00E+00**	**3.62E-08**	**7.84E-04**	**4.81E-02**	**1.74E+00**
2L fresh AU	HDPE natural	1.90E-03	9.47E-05	4.40E+00	1.88E-08	6.66E-04	4.94E-02	8.77E-01
	Carton refrigerated	**1.05E-03**	**1.04E-04**	**1.94E+00**	**1.91E-08**	**6.61E-04**	**2.87E-02**	**7.26E-01**
2L fresh NZ	PET - Fresh	1.31E-03	1.14E-04	6.28E+00	3.37E-08	8.44E-04	8.62E-02	2.96E+00
	rPET- Fresh	6.71E-04	6.62E-05	1.76E+00	1.28E-08	4.46E-04	5.38E-02	2.75E+00
	HDPE natural	1.55E-03	6.73E-05	3.56E+00	1.64E-08	4.87E-04	3.55E-02	1.70E+00
	HDPE lightproof	1.72E-03	7.57E-05	4.00E+00	1.91E-08	5.46E-04	4.30E-02	2.24E+00
	Carton refrigerated	**1.04E-03**	**1.03E-04**	**1.86E+00**	**1.89E-08**	**6.58E-04**	**2.73E-02**	**8.38E-01**

Size Class	Packaging Type	AP [kg SO2 eq.]	EP [kg PO_4^{3-} eq.]	ADPF [MJ]	ADPE [MJ]	POCP [kg NOx eq.]	WSF [m³ world equiv.]	Blue water [kg]
600ml AU	PET Lightweight	4.67E-04	4.46E-05	1.95E+00	1.39E-08	2.96E-04	3.03E-02	6.64E-01
	rPET Lightweight	3.47E-04	3.58E-05	9.66E-01	9.30E-09	2.22E-04	2.41E-02	5.10E-01
	Carton	**5.03E-04**	**4.82E-05**	**1.10E+00**	**1.33E-08**	**2.93E-04**	**1.75E-02**	**6.30E-01**
330ml AU	Glass	2.04E-03	2.55E-04	4.28E+00	2.51E-08	1.77E-03	1.92E-02	7.40E-01
	Can - 0% Recycled	1.55E-03	1.12E-04	2.98E+00	2.89E-08	7.93E-04	5.87E-02	1.53E+00
	Can - 70% Recycled	5.65E-04	5.12E-05	1.30E+00	1.50E-08	3.47E-04	2.60E-02	5.66E-01
	Carton	**3.96E-04**	**3.61E-05**	**9.02E-01**	**1.02E-08**	**2.22E-04**	**1.45E-02**	**5.25E-01**
330ml NZ	Can - 0% Recycled	1.31E-03	9.51E-05	2.51E+00	2.50E-08	6.69E-04	4.99E-02	1.38E+00
	Can - 70% Recycled	4.70E-04	4.35E-05	1.09E+00	1.33E-08	2.91E-04	2.22E-02	5.62E-01
	Carton	**3.74E-04**	**3.43E-05**	**8.33E-01**	**1.01E-08**	**2.10E-04**	**1.32E-02**	**6.23E-01**
250ml AU	Glass	1.42E-03	1.75E-04	2.94E+00	1.61E-08	1.22E-03	1.35E-02	4.75E-01
	PET	9.14E-04	7.58E-05	3.70E+00	1.95E-08	5.39E-04	5.18E-02	9.58E-01
	Pouch	1.33E-04	1.38E-05	7.62E-01	5.87E-09	8.60E-05	7.51E-03	3.37E-01
	Carton	**2.45E-04**	**2.21E-05**	**5.39E-01**	**5.51E-09**	**1.40E-04**	**8.95E-03**	**2.81E-01**
200ml NZ	Pouch - lid	2.31E-04	1.67E-05	9.18E-01	6.44E-09	1.07E-04	8.86E-03	4.73E-01
	Pouch - straw	1.04E-04	1.06E-05	5.92E-01	4.94E-09	6.34E-05	5.85E-03	3.89E-01
	Carton	**1.92E-04**	**1.76E-05**	**4.17E-01**	**4.78E-09**	**1.09E-04**	**7.02E-03**	**3.52E-01**
500ml AU	Glass	1.43E-03	1.99E-04	4.11E+00	2.98E-08	1.34E-03	2.26E-02	9.06E-01
	Can	7.91E-04	8.33E-05	3.06E+00	4.62E-08	5.53E-04	2.50E-02	1.28E+00
	Pouch	1.96E-04	2.78E-05	1.28E+00	1.40E-08	1.50E-04	1.40E-02	7.36E-01
	Tetra Recart Midi	**3.10E-04**	**4.64E-05**	**9.59E-01**	**1.49E-08**	**2.67E-04**	**1.39E-02**	**6.38E-01**
500ml NZ	Glass	2.13E-03	2.73E-04	4.37E+00	2.99E-08	1.92E-03	2.24E-02	9.33E-01

Size Class	Packaging Type	AP [kg SO2 eq.]	EP [kg PO_4^{3-} eq.]	ADPF [MJ]	ADPE [MJ]	POCP [kg NOx eq.]	WSF [m³ world equiv.]	Blue water [kg]
	Can	8.59E-04	9.11E-05	3.24E+00	4.91E-08	6.06E-04	2.60E-02	1.38E+00
	Tetra Recart Midi	**3.14E-04**	**4.70E-05**	**9.55E-01**	**1.49E-08**	**2.72E-04**	**1.35E-02**	**6.66E-01**
400ml NZ	**Can**	6.61E-04	7.00E-05	2.49E+00	3.76E-08	4.66E-04	2.00E-02	1.06E+00
	Pouch	1.66E-04	2.29E-05	1.10E+00	1.14E-08	1.25E-04	1.11E-02	6.41E-01
	Tetra Recart Midi	**2.63E-04**	**3.85E-05**	**7.82E-01**	**1.19E-08**	**2.26E-04**	**1.08E-02**	**5.43E-01**

Annex M Tetra Pak Products – Other Indicators

Size class	Packaging type	AP [kg SO2 eq.]	EP [kg PO_4^{3-} eq.]	ADPF [MJ]	ADPE [MJ]	POCP [kg NOx eq.]	WSF [m³ world equiv.]	Blue water [kg]
2L Tetra Pak products	**TBA HC27 AU**	1.25E-03	1.22E-04	2.87E+00	3.46E-08	7.34E-04	4.23E-02	1.60E+00
	TBA SC AU	1.29E-03	1.24E-04	2.98E+00	3.50E-08	7.49E-04	4.28E-02	1.61E+00
1L Tetra Pak products	**TPA Square AU**	8.43E-04	7.76E-05	1.97E+00	2.11E-08	4.80E-04	2.71E-02	1.01E+00
	TBA Square HC27 AU	8.12E-04	7.39E-05	1.89E+00	2.03E-08	4.55E-04	2.61E-02	9.71E-01
	TBA Slim HC AU	7.10E-04	6.82E-05	1.65E+00	1.87E-08	4.16E-04	2.42E-02	8.59E-01
	TBA Edge AU	6.18E-04	6.31E-05	1.44E+00	1.77E-08	3.82E-04	2.30E-02	8.21E-01
	Tetra Top AU	7.45E-04	3.56E-04	9.41E-01	1.92E-08	5.35E-04	1.80E-02	6.49E-01
	Tetra Rex AU	5.15E-04	6.12E-05	9.56E-01	1.57E-08	3.61E-04	1.75E-02	5.96E-01
	Tetra Rex Bio AU	4.42E-04	1.69E-04	5.92E-01	1.48E-08	3.60E-04	1.46E-02	5.04E-01
600 mL Tetra Pak products	**Tetra Rex AU**	3.79E-04	4.46E-05	7.04E-01	1.13E-08	2.64E-04	1.31E-02	4.31E-01
	Tetra Rex Bio AU	3.25E-04	1.22E-04	4.40E-01	1.06E-08	2.63E-04	1.09E-02	3.64E-01
500 mL Tetra Pak products	**Tetra Top AU**	5.82E-04	2.65E-04	8.51E-01	1.72E-08	4.16E-04	1.72E-02	6.31E-01
	Tetra Recart Midi AU	3.10E-04	4.64E-05	9.59E-01	1.49E-08	2.67E-04	1.39E-02	6.38E-01
330 mL Tetra Pak products	**Tetra Top AU**	4.86E-04	2.51E-04	5.96E-01	1.16E-08	3.40E-04	1.15E-02	3.85E-01
	Tetra Prisma AU	4.14E-04	3.47E-05	1.00E+00	9.78E-09	2.15E-04	1.28E-02	4.66E-01
250 mL Tetra Pak products	**TBA Slim Straw AU**	2.17E-04	2.02E-05	4.97E-01	5.10E-09	1.27E-04	7.82E-03	2.53E-01
	TPA Square Straw AU	2.36E-04	2.14E-05	5.36E-01	5.36E-09	1.35E-04	8.12E-03	2.62E-01
	TBA Edge Straw AU	2.46E-04	2.21E-05	5.44E-01	5.28E-09	1.42E-04	8.38E-03	2.68E-01
	TBA Edge Cap AU	3.86E-04	2.82E-05	7.81E-01	6.28E-09	1.85E-04	9.90E-03	3.10E-01
200 mL Tetra Pak products	**TPA Square Straw AU**	2.37E-04	2.05E-05	5.32E-01	5.16E-09	1.31E-04	8.83E-03	2.66E-01
	TBA Slim Straw AU	1.98E-04	1.83E-05	4.65E-01	4.74E-09	1.16E-04	7.50E-03	2.40E-01

Size class	Packaging type	AP [kg SO2 eq.]	EP [kg PO_4^{3-} eq.]	ADPF [MJ]	ADPE [MJ]	POCP [kg NOx eq.]	WSF [m³ world equiv.]	Blue water [kg]
	TBA Slim Leaf AU	2.02E-04	1.91E-05	4.65E-01	4.86E-09	1.20E-04	7.54E-03	2.40E-01
	TBA Base AU	1.96E-04	1.82E-05	4.60E-01	4.71E-09	1.15E-04	7.46E-03	2.38E-01
	TBA Base Crystal AU	2.09E-04	1.93E-05	4.71E-01	4.73E-09	1.23E-04	7.72E-03	2.41E-01

Annex N Relative GWP Results

The tables below present the GWP results relative to cartons (normalised to 100%) to show the difference between cartons and other pack formats. Table 7-18 and Table 7-19 present the results from the body of the report (i.e. the base case assumptions). Table 7-20 and Table 7-21 present the results after sensitivity analysis to demonstrate the worst-case for cartons.

Table 7-18: Relative results for Australia (base case analysis)

Packaging system	1L aseptic	1L fresh	2L aseptic	2L fresh	600ml	330ml	250ml	500ml	Second lowest GWP (by material)	Highest GWP (by material)
Carton AU	100%	100%	100%	100%	100%	100%	100%	100%		
Glass AU	557%	1185%				577%	658%	489%	**489%**	**1185%**
PET AU	262%	548%	265%				600%		**262%**	**600%**
PET lightweight AU	150%				167%				**150%**	**167%**
rPET AU	164%	333%							**164%**	**333%**
rPET lightweight AU	101%				114%				**101%**	**114%**
HDPE natural AU		322%	147%	177%					**147%**	**322%**
Aluminium can 0% RC AU						541%			**541%**	**541%**
Aluminium can 70% RC AU						224%			**224%**	**224%**
Pouch AU							138%	130%	**130%**	**138%**
Steel can AU								492%	**492%**	**492%**
Second lowest GWP (by category)	**101%**	**322%**	**147%**	**177%**	**114%**	**224%**	**138%**	**130%**		
Highest GWP (by category)	**557%**	**1185%**	**265%**	**177%**	**167%**	**577%**	**658%**	**492%**		

Table 7-19: Relative results for New Zealand (base case analysis)

Packaging System	1L Aseptic	1L Fresh	2L fresh	330ml	200ml	500ml	400ml	Second-lowest GWP (by material)	Highest GWP (by material)
Carton NZ	100%	100%	100%	100%	100%	100%	100%		
Glass NZ	647%	1117%				576%		**576%**	**1117%**
PET NZ	281%	473%	354%					**281%**	**473%**
rPET NZ	130%	209%	150%					**130%**	**209%**
HDPE natural NZ		201%	146%					**146%**	**201%**
HDPE lightproof NZ		213%	163%					**163%**	**213%**
Aluminium can 0% RC NZ				553%				**553%**	**553%**
Aluminium can 70% RC NZ				227%				**227%**	**227%**
Pouch NZ							146%	**146%**	**146%**
Pouch -lid NZ					212%			**212%**	**212%**
Pouch - straw NZ					149%			**149%**	**149%**
Steel can NZ						577%	546%	**546%**	**577%**
Second-lowest GWP (by category)	**130%**	**201%**	**146%**	**227%**	**149%**	**576%**	**146%**		
Highest GWP (by category)	**647%**	**1117%**	**354%**	**553%**	**212%**	**577%**	**546%**		

Table 7-20: Relative results for Australia (sensitivity analysis)

Packaging System	1L Aseptic Mass Variation	Total (Substitution, Current Domestic Recycling)	Total (Substitution, 100% Domestic Recycling)	250 mL Substitution, Current Domestic Recycling	250 mL Substitution, 100% Domestic Recycling	1L Aseptic Carton EOL Worst case	250ml Carton EOL Worst Case	Second-lowest GWP (by material)	Highest GWP (by material)
Carton AU	100%	100%	100%	100%	100%	100%	100%		
Glass AU	411%	502%	507%	578%	633%	310%	374%	**310%**	**633%**
PET AU	206%	259%	245%	578%	483%	146%	341%	**146%**	**578%**
PET Lightweight AU	148%	148%	140%			84%		**84%**	**148%**
rPET AU	131%	258%	235%			91%		**91%**	**258%**
rPET Lightweight AU	100%	148%	131%			56%		**56%**	**148%**
Pouch AU				140%	152%		78%	**78%**	**152%**
Second-lowest GWP (by category)	**100%**	**148%**	**131%**	**140%**	**152%**	**56%**	**78%**		
Highest GWP (by category)	**411%**	**502%**	**507%**	**578%**	**633%**	**310%**	**374%**		

Table 7-21: Relative results for New Zealand (sensitivity analysis)

Packaging System	1L Aseptic Mass Variation	1 L Substitution, Current Domestic Recycling	1 L Substitution, 100% Domestic Recycling	200 mL Substitution, Current Domestic Recycling	200 mL Substitution, 100% Domestic Recycling	1L Aseptic Carton EOL Worst case	200ml Carton EOL Worst Case	Second-lowest GWP (by material)	Highest GWP (by material)
Carton NZ	100%	100%	100%	100%	100%	100%	100%		
Glass NZ	468%	608%	641%			319%		**319%**	**641%**
PET NZ	216%	289%	212%			138%		**138%**	**289%**
rPET NZ	105%	264%	212%			64%		**64%**	**264%**
Pouch - lid NZ				213%	203%		104%	**104%**	**213%**
Pouch - straw NZ				151%	154%		73%	**73%**	**154%**
Second-lowest GWP (by category)	**105%**	**264%**	**212%**	**151%**	**154%**	**64%**	**73%**		
Highest GWP (by category)	**468%**	**608%**	**641%**	**213%**	**203%**	**319%**	**104%**		

Annex O Biogenic Carbon Sequestered

Table 7-22, Table 7-23 and Table 7-24 shows the biogenic carbon within consumer pack, Tetra Pak products and secondary/tertiary packaging respectively. All results are shown in grams of carbon on a per consumer pack basis.

Table 7-22: Biogenic carbon sequestered in consumer packs (g of carbon per consumer pack)

Consumer packs	Carbon sequestered (g/consumer pack)
1 L Aseptic Carton AU	11.4
1 L Aseptic Carton NZ	9.8
2 L Aseptic Carton AU	18.9
1 L Fresh Milk Carton AU	10.8
1 L Fresh Milk Carton NZ	11.7
2 L Fresh Milk Carton AU	23.2
2 L Fresh Milk Carton NZ	23.2
600 mL Aseptic Carton AU	7.4
330 mL Aseptic Carton AU	4.8
330 mL Aseptic Carton NZ	4.8
250 mL Aseptic Carton AU	3.3
200 mL Aseptic Carton NZ	2.7
500 mL Aseptic Carton AU	6.2
500 mL Aseptic Carton NZ	6.2
400 mL Aseptic Carton AU	5.3
400 mL Aseptic Carton NZ	5.3

Table 7-23: Biogenic carbon sequestered in Tetra Pak products (g of carbon per consumer pack)

Size class	Tetra Pak Product	Carbon sequestered (g/consumer pack)
2L Tetra Pak products	TBA HC27 AU	17.8
	TBA SC AU	17.8
1L Tetra Pak products	TPA Square AU	11.0
	TBA Square HC27 AU	10.2
	TBA Slim HC AU	9.9
	TBA Edge AU	9.5
	Tetra Top AU	14.4
	Tetra Rex AU	11.8*
	Tetra Rex Bio AU	11.2*
600 mL Tetra Pak products	Tetra Rex AU	8.6*
	Tetra Rex Bio AU	8.1*
500 mL Tetra Pak products	Tetra Top AU	10.1

Size class	Tetra Pak Product	Carbon sequestered (g/consumer pack)
	Tetra Recart Midi AU	6.2
330 mL Tetra Pak products	Tetra Top AU	8.8
	Tetra Prisma AU	3.8
250 mL Tetra Pak products	TBA Slim Straw AU	3.0
	TPA Square Straw AU	3.2
	TBA Edge Straw AU	2.9
	TBA Edge Cap AU	2.9
200 mL Tetra Pak products	TPA Square Straw AU	2.7
	TBA Slim Straw AU	2.5
	TBA Slim Leaf AU	2.8
	TBA Base AU	2.5
	TBA Base Crystal AU	2.5

*While the Tetra Rex Bio pack has a great percentage of biotic material, the standard Tetra Rex has more biogenic carbon due to having a heavier total mass.

Table 7-24: Biogenic carbon sequestered in secondary and tertiary packaging (g of carbon per consumer pack)

Size class	Secondary packaging (g/consumer pack)	Tertiary packaging (g/consumer pack)
1 L Aseptic Beverage AU	8.2	1.3
1 L Aseptic Beverage NZ	8.2	1.3
2 L Aseptic Beverage AU	16.1	2.0
1 L Fresh Milk AU	0.0*	1.3
1 L Fresh Milk NZ	0.0*	1.3
2 L Fresh Milk AU	0.0*	2.0
2 L Fresh Milk NZ	0.0*	2.0
600 mL Aseptic Beverage AU	9.3	1.6
330 mL Aseptic Beverage AU	4.3	0.6
330 mL Aseptic Beverage NZ	4.3	0.6
250 mL Aseptic Beverage AU	1.6	0.2
200 mL Aseptic Beverage NZ	1.6	0.2
500 mL Carton AU	7.0	1.0
500 mL Carton NZ	7.0	1.0
400 mL Carton AU	7.0	1.0
400 mL Carton NZ	7.0	1.0

*Fresh milk size classes used HDPE crates for secondary packaging

Annex P Secondary Packaging Assumptions by Product Category

The packaging assumptions used to generate the results in Annex J are shown in Table 7-25. These are slightly different from the assumptions used in the main body of the report, due to water packaging often having LDPE film as secondary packaging instead of a corrugated box. Tertiary packaging assumptions are the same as in the main body of this report.

Table 7-25: Secondary and packaging assumptions by product category

Product category	Pack Type	Material	Mass (g)	Number of consumer packs	Use cycles	Number of secondary packs per pallet
Fresh milk	1 L Bottle (HPDE crate)	Reusable HPDE crate	1,575	16	50	36
	2 L Bottle (HDPE crate)	Reusable HPDE crate	1,575	9	50	36
	1 L Carton (HPDE crate)	Reusable HPDE crate	1,575	16	50	36
	2 L Carton (HDPE crate)	Reusable HPDE crate	1,575	9	50	36
	1 L Carton (cardboard box)	Corrugated box	230	12	1	36
Aseptic milk	1 L Bottle	Corrugated box	230	12	1	36
	1 L Carton	Corrugated box	230	12	1	36
Water	1 L Bottle (PET)	LDPE	18	8	1	36
	1 L Carton	Corrugated board	230	12	1	36
	1 L Bottle (Glass)	Corrugated board	230	12	1	36
	600 mL Bottle	LDPE	10	12	1	60
	600 mL Carton	Corrugated board	160	12	1	60
	330 mL Carton	Corrugated board	120	12	1	80
	330 mL Bottle	Corrugated board	120	12	1	80
	330 mL Can	Corrugated board	120	12	1	80
Juice	2 L Carton	Corrugated board	300	8	1	36
	2 L Bottle	Corrugated board	300	8	1	36
	1 L Carton	Corrugated board	230	12	1	36
	1 L Bottle	Corrugated board	230	12	1	36
	250 mL Carton, pouch & bottle	LDPE film	15.6	48	1	72
		Corrugated board	174	48	1	72
	200 mL Carton, pouch & bottle	LDPE film	15.6	48	1	72
		Corrugated board	174	48	1	72
Food	500 mL Carton	Corrugated board	130	6	1	72
	500 mL Can	Corrugated board	130	6	1	72
	500 mL Jar	Corrugated board	130	6	1	72
	400 mL Carton	Corrugated board	130	8	1	72
	400 mL Can	Corrugated board	130	8	1	72
	400 mL Pouch	Corrugated board	130	8	1	72

Annex Q Review Panel Comments and Responses

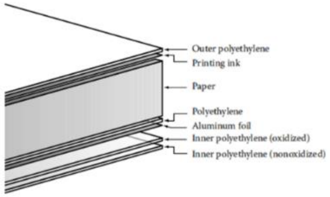
Table 7-26: Round 1 comments and responses

Section	Panel member	Comment	thinkstep-anz response
General comment	Elspeth MacRae	Would be very helpful to have a very clear and simply described description of where all the Tetra Pak packaging is made at the beginning and in summary. E.g.: a. Glass used for liquid products imported prefilling to Australia and NZ from China; b. metal cans imported prefilling from China; c. PET for bottles imported from China as a compound/formulation/sheet to Australia and NZ from China then blown into bottles and filled. d. Cartons (aseptic or non) imported to Australia and NZ as a premade roll to be assembled in country – from china using materials from Sweden etc. It would also make the impact of transport clearer as well.	An overview has been added in the body of the report. We haven't included in the Executive Summary for brevity.
	Elspeth MacRae	Summary needs description of boundaries used – for me they haven't included fully the materials used that I can see	Following further discussion by phone, a comment regarding coatings and ink has been added in the summary. An additional confidential annex (Annex E) has been included with further detail.
Packaging teardowns & plastics manufacturing	Elspeth MacRae	Clarify the coatings aspect for various products – looking at the pictures of Tetra Pak cartons they must have coatings and also printing inks which are relevant for release of materials into the environment through any route (not necessarily GHG related). Are these printed in Australia/NZ or elsewhere for example. This is also relevant in section 3.2. and 3.3.2.	We have now included a diagram of the laminate structure of the carton. As you say, the products are coated (typically in polyethylene) and then printed. We have noted that inks are excluded from the study also included information on the types of inks used in Annex E.
Packaging teardowns & plastics manufacturing	Elspeth MacRae	Consider microplastics impact and whether this and potential toxic chemicals release should be elevated in the report. This is also relevant in section 3.2. and 3.3.2.	Added a comment in Section 2.7, Impact Categories. Microplastics are excluded because there is not yet a robust, internationally accepted method to include them in an LCA study. Microplastics and litter need to be taken into account for an overall assessment of sustainability, in addition to the LCA results.

Section	Panel member	Comment	thinkstep-anz response
	Elspeth MacRae	Would be helpful NOT to call error bars that show the range error bars – maybe relabel as indicating range of measurements or something similar.	Reworded
2.7 Selection of LCIA Methodology	Elspeth MacRae	Why is GWP a 100 year time horizon? Is there any suggestion that a 10 year would be any different?- significantly? Biodegradability testing uses a 6month measure. Para on pg22 confusing and unclear regarding how bio and recent versus ancient carbon cycling works. (There will be a new EU authenticated recent carbon detection method coming in a couple of years)	GWP 100 was chosen to be in line with the requirement of ISO 14067 which specifies this as the impact category for product carbon footprints. While GWP100 is by far the most common, another method that could be applied is GWP20, i.e. 20-year time horizon. This would increase the impacts for cartons in landfill due to the higher characterisation factor for landfill.
3.8.3 Landfill?	Elspeth MacRae	I am uncertain regarding the selection of quantity going to landfill versus recycling – suspect much more in NZ landfill at least, also since it has been estimated that well under 50% of material goes to legal/council landfill. This includes glass etc – the WasteMINZ and PM science adviser rethink plastics have some figures of value perhaps.	We have spoken with WasteMINZ. They do have a dataset which is likely to be more representative of New Zealand conditions, but it was not fully published. We have now got access to the data and updated all modelling for New Zealand accordingly. Note that we have applied loss factors from APCO in Australia as the WasteMINZ study is at the point of kerbside collection.
Bioplastic	Elspeth MacRae	I assume NZ/Australia Tetra Pak have not been significantly substituting bioderived plastics in products? Versus biodegradable, as this has not featured in the document. (but does on Tetra Pak website). In addition the statement bioplastic in the Tetra Pak products table doesn't differentiate whether it is a bioderived plastic e.g. PE or a biodegradable plastic e.g. PLA. So I'm not quite clear whether the recent (todays C capture versus ancient c capture and hence circularity or addition to GHG atmosphere) carbon contents of the packaging are part of the analysis or not really – despite a statement on EOL which I think is just end of life of all products? So thinking more of recycling versus degradation?	All plastics are bioderived drop-in replacements. They are polyethylene derived from sugarcane from Braskem in Brazil. This means they are bio-based but not biodegradable. Tetra Pak does not use biodegradable polymers as this could compromise the food in the pack. The carbon uptake during plant growth and any greenhouse gas releases due to land use change are captured within the report.
6 Interpretation	Elspeth MacRae	It's clear that the aim is firstly define performance of classes of packaging then how does Tetra Pak compare within this in its class. I would have like this to be more clearly stated earlier (summary and overall objective) and also in interpretation, and logically spelt out even sub headed. Statements like increasing the impact – is that worse (e.g.	Additional information has been added to the Goal and Scope of the study. Interpretation section has been revised.

Section	Panel member	Comment	thinkstep-anz response
		more nasties)? Or better (e.g. lower GWP)… this section jumps around a lot in language.	
General comments	Elspeth MacRae	Overall it doesn't seem intuitive that transporting paperboard (to get the right weight formulation etc) to Australia/NZ for cartons is better than locally sourced…. I.e. transport emissions etc. maybe there is some way to address that	Tetra Pak and other carton manufacturers produce their laminates overseas. We have therefore tried to model their supply chain as it exists now. The European paperboard they source has a very low carbon footprint – considerably lower than many Australian paperboards, for example, which would balance out any impacts from shipping.
Results: Life Cycle Impact Assessment Fig. 1.1 Executive summary	Gordon Robertson	"For the plastic bottle mass variation, the lowest Australian 1 L rPET bottle mass had a carbon footprint equivalent to the respective carton in the 1 L aseptic beverage category." Can you add what these values are as clearly you are not using the average values from Figure 1-1 (0.154 and 0.101).	We have now separated the ultra-lightweight PET and rPET water bottles into new categories called PET Lightweight and rPET Lightweight. Hopefully, this is now clearer.
2.3 System boundary	Gordon Robertson	"Plastic bottles, glass bottles, and tinplated steel (tin) cans are already formed when they reach the filling stage, so only need to be filled and sealed." According to Table 2-1 and 2-2, glass, PET and HDPE were aseptically filled. I'm not sure that this was the case and should be checked. If it is correct, then the packages would have been sterilised prior to filling and this should be included to make a valid comparison with the aseptic cartons.	You are correct that the wording was unclear. All have been modelled with an aseptic cleaning stage first. The diagram and wording have been updated.
2.3.2 Technology coverage	Gordon Robertson	Technology Coverage – was Tetra Recart "available to packaging companies operating in Australia and New Zealand in late 2019."	No, it was not. Good point. We have updated the wording to clarify that Tetra Recart is an exception to this rule.
2.3.2 Technology coverage	Gordon Robertson	"Allocation of background data (energy and materials) taken from the GaBi 2020 databases." I looked at Sphera, 2020 but could not find any details concerning allocation of background data. Could you expand on this?	Each dataset has its own documentation on the GaBi website. You can either use the GaBi Data Search feature of go through the "GaBi Databases" link to find an index. Here is an example of a single documentation record: http://gabi-documentation-2020.gabi-software.com/xml-data/processes/df6a564c-f46e-4325-9689-022bbfe009db.xml More human-readable content can be found in the GaBi Modelling Principles, which you will find here: http://www.gabi-

Section	Panel member	Comment	thinkstep-anz response
			software.com/fileadmin/gabi/Modelling_Principles/Modeling_Principles_-_GaBi_Databases_2020_2.pdf
2.4.2 End of life allocation	Gordon Robertson	“the scrap input to the production process.” It would be helpful to define scrap which I presume is secondary, recycled material. During the manufacture of packaging materials, scrap or waste is produced but this is not what is meant by open scrap inputs. How is manufacturing scrap/waste treated in the LCA? Default of packaging calc and datasets.	In this context, it is scrap material that will be recycled (e.g. glass cullet for glass, baled plastic bottles for PET and HDPE). Manufacturing processes also have scrap outputs, but it is usually quite small amounts. These are recycled where possible and landfilled where not. The “scrap input” refers to the fact that 1kg of rPET might require an input of scrap PET bottles of, say, 1.1 kg to account for losses through the chain. In the cut-off method this scrap input is left open (i.e. treated as burden free). In the substitution approach we create an artificial closed loop between the packaging scrap at end-of-life and the input of scrap going into recycling for secondary materials. If there isn’t enough scrap produced to meet the demand posed by that product system then more virgin material is needed as a top up. We have included two diagrams to try to make the modelling approach clearer.
3.3 Manufacturing	Gordon Robertson	“It is assumed that all ‘average’ cartons and non-Tetra Pak cartons are manufactured in China.” “The site lamination data assumed to be the same as the Tetra Pak global average.” How valid are these assumptions?	The location chosen is likely to be a worst-case scenario, given the carbon intensity of the Chinese electricity grid. Site lamination data is valid given that Tetra Pak manufacture a significant portion of all cartons in Australasia.
3.3.2 Plastics manufacturing	Gordon Robertson	Suggest that after the first paragraph the composition of aseptic and non-aseptic cartons is included. What is the nature of the paperboard? Unbleached? Fully bleached? With CTMP? Also a diagram showing the structure of aseptic and non-aseptic cartons would be helpful (see example below):	Further detail and a diagram added following discussion with Tetra Pak. We have also included a comparison of the paperboard GWP used versus Tetra Pak Oceania’s actual suppliers given the importance of the paperboard to the overall results. See Annex F.

Section	Panel member	Comment	thinkstep-anz response
			
3.3.2 Plastics manufacturing	Gordon Robertson	“The carton layer specifications used for the results in Section 4 can be found in Table 3-4.” “The carton layer specifications used for the generic carton in each packaging cart “These layer specifications only determine the relative layer thickness of the paperboard, plastic and aluminium layers.” This section is confusing and incorrect words such as layer specifications are used; suggest a rewording for clarity.	Sections updated
3.3.2 Plastics manufacturing	Gordon Robertson	“All plastic granulate is assumed to have been produced in China.” How valid is this assumption? ExxonMobil in Singapore is a major supplier of HDPE granulate to Australasia.	This assumption is not hugely important to the results as the impact of plastic granulate manufacture does not change particularly much from market to market. A comment has been added for clarity.
3.3.3 Aluminium pouches	Gordon Robertson	“PET bottles are made into an injection moulded preform in China.” I disagree. Preforms have been manufactured in Australasia since at least 1978. Perhaps a statement could be inserted justifying this assumption, its negligible impact on the conclusions and stating the market reality in Australasia.	This was a mistake in the text. We do assume the preform is manufactured in market. This was an old assumption which we had since replaced but had failed to update the text accordingly. The text is now updated.
3.3.5 Glass containers	Gordon Robertson	“The recycled content percentage for flint glass was estimated as 45% for New Zealand (from O-I NZ) and 22.5% for Australia (O-I Australia). I assume that clear glass bottles were used in this study. Glass collected in Australasia is almost always mixed colours (mainly beer and wine bottles), meaning that most recycled glass (cullet) is used in amber and green bottles. Very few clear glass containers are made with post-consumer recycled glass unless the factory has an optical sorting facility which some do. Yet the glass industry claims an average recycled content across their total output. Also, soda-lime glass, not flint glass.	Yes, all bottles in this study are clear. When we used the term ‘flint’, we were referring to the colour of the glass rather than the glassmaking process. We have reworded this text to make it clearer. These values were sourced from major manufacturers directly. O-I is the only domestic glass maker in New Zealand, so we believe that figure is representative of NZ-made glass (they achieve higher recycled content for amber and green glass). Many of New Zealand’s councils separate glass at source, allowing O-I NZ to achieve higher recycled content. The recycled content in Australia is lower for the reasons you flag, though I

Section	Panel member	Comment	thinkstep-anz response
			believe the larger Material Recovery Facilities do have optical sorting. A note has been added in the limitation section.
Cans (Tin and Aluminium)	Gordon Robertson	“Tinplated steel cans (for food) and aluminium cans (for beverages) were modelled as being manufactured in China using standard manufacturing techniques and then transported to the country of purchase.” Cans have been manufactured in Australasia from rollstock for over 70 years. Perhaps a statement could be inserted justifying this assumption, its negligible impact on the conclusions and stating the market reality in Australasia.	Agreed. The wording of this part of the report has been revised to make it clearer.
Transportation to filling	Gordon Robertson	“cartons which are in sheets”- Aseptic Tetra Pak cartons are delivered in rolls; aseptic Combibloc cartons and gable top cartons are delivered as blanks.	Thank you. We have updated the wording.
Recycling	Gordon Robertson	According to Madden & Florin (p. 9), the local material utilisation rate in Australia is 36% for glass, 41% for paper, 22% for metal and 14% for plastic.	Our analysis has been updated to reflect this. Sensitivity analysis is used to determine the effect of increasing the recycling rate domestically.
Recycling	Gordon Robertson	“and Tetra Pak did not have sufficient data to calculate them.” I think this would be because cartons are not recycled in Australasia! There needs to be a comment about recycling of cartons in Australasia.	We have clarified the wording. As you say, there are no recycling facilities for cartons in Australasia. However, they are collected by numerous councils and by container deposit schemes. Typical end markets for recycling are India and South Korea.
Recycling	Gordon Robertson	Carton recycling was modelled differently.” Please elaborate.	Wording now altered
Recycling	Gordon Robertson	“to account for the increased difficulty of separating recyclable components.” The paper fibres are easily separated from the plastic/foil material in a hydrapulper and this is the standard global method of recycling aseptic cartons. The plastic/foil residue is typically either used for energy recovery or landfilled.	Wording now altered. The wording was outdated and had not been improved.
Fresh milk secondary packaging	Gordon Robertson	Table 3-10: LCI inputs of washing of milk crates over an 11-hour shift. The figure for water is difficult to accept: it works out at 148 mL per crate which seems to be too little to wash a crate.	The crate washer recycles the water.

Section	Panel member	Comment	thinkstep-anz response
Aseptic Container Secondary Packaging	Gordon Robertson	"all secondary packaging is assumed to be the same." PET bottles are typically shrink-wrapped.	We found a wide variety of secondary packaging used for different products. Corrugated board was selected for the average classes as it was seen to be most commonly used. Bottles in the water category use shrink-wrapping.
Fuels & energy	Gordon Robertson	Table 3-13: Key energy datasets used in inventory analysis. Since it has been assumed that all packaging materials come from China, what is the relevance of energy data sets from Japan, Singapore, Malaysia, etc?	These are the locations of Tetra Pak manufacturing facilities. Tetra Pak cartons are also looked at separately.
Raw Materials and Processes	Gordon Robertson	EU-28: Product of container glass (100% cullet) Assuming 100% cullet would underestimate the energy used to manufacture glass bottles. What does 100% batch mean in the following line?	Batch means 100% virgin feed. We have used these together to create glass with adjustable recycled material content.
Results breakdown	Gordon Robertson	Are you able to include more details about the rPET bottles? Was mechanical or chemical recycling assumed? Where was the data from?	Mechanical recycling facility using GaBi processes for granulation, washing and melting. Have added a section to explain this (3.3.2.1)
500 mL Aseptic Food & 400 mL Aseptic Food (NZ Only)	Gordon Robertson	Does Forming and Filling include retorting of cartons and cans?	Yes for cartons, no for cans due to the way our LCA model is set up.
Executive summary	Rob Rouwette	"The entire packaging life cycle and all packaging layers have been included within the scope of this study. The life cycle stages considered include material production, pack manufacture, filling, transport, and end-of-life. Impacts from refrigeration of chilled products were considered to be part of the life cycle of the chilled beverage/food product and therefore excluded from this study. The packaging layers considered include the primary packaging (consumer packaging), secondary packaging (a one-way shipper carton or reusable crate) and tertiary packaging (a pallet)." Check if refrigeration would impact on packaging. Use stage missing: equal functional performance?	A comment has been added to the section of the functional unit that all options are assumed to fulfil the same functional unit and that they don't have an impact on the shelf life. Refrigeration was not modelled. A previous study was referenced which has shown that it would have little impact on the results. (Franklin Associates, 2015)

Section	Panel member	Comment	thinkstep-anz response
Executive summary	Rob Rouwette	Two packaging-related metrics are also reported: “product-to-packaging ratio” and the “amount of plastic packaging per litre of product.” Careful in using this as an environmental indicator as it discriminates against plastics	The plastic to packaging metric is regarded as an inventory indicator and is not interpreted to be environmentally superior or worse.
Executive summary	Rob Rouwette	“This is due to a combination of their light weight, the relatively low impact of paperboard per kilogram, and the biogenic carbon sequestered in paperboard during tree growth.” Check: - impact of biogenic carbon sequestration - what if recycled cardboard is used? - end-of-life emissions / scenario	Biogenic carbon has been modelled. Even if recycled cardboard was used, it would have had carbon uptake which is embodied in the product. End-of-life emissions have been modelled. The revised version of the report has assumed a higher degradation rate within the landfill.
Executive summary	Rob Rouwette	Check: - EOL sequestration? - biogenic sequestration start of life?	Both have been modelled according to ISO 14067
Executive summary	Rob Rouwette	“how much of the biogenic carbon in the carton degrades” Check time horizon	The bioreactor studies used to calculate the DOC_F try to fully degrade the biogenic carbon within the sample (i.e. the time horizon is effectively indefinite, since the sample will no longer be reactive at the end of the test).
Executive summary	Rob Rouwette	“cartons have the lowest – or lowest-equal – carbon footprint of all beverage and food packaging systems available on the Australian and New Zealand markets in late 2019” Are these ALL systems available? Or ALL systems STUDIED?	This has been rephrased from “all” to the “most commonly used”.
Scope of the study	Rob Rouwette	“cleaned and weighed.” drying?	Included ‘dried’
Product function(s) and functional unit	Rob Rouwette	Title- The function does not include how the packaging protects the products and whether there are any differences in product shelf-life	Comment has been added.

Section	Panel member	Comment	thinkstep-anz response
Product function(s) and functional unit	Rob Rouwette	"weighed averages" - Why not provided by Tetra Pak? - Any differences in closures?	All packaging was weighed by the project team to provide consistent results for both cartons other pack types. Closures were the same for different sizes of different packaging options. They were also all weighed.
Product function(s) and functional unit	Rob Rouwette	Tetra Rex cap not included in results- why not?	The Tetra Rex's that were weighed in the study did not have caps - fixed wording.
System boundary	Rob Rouwette	"Plastic bottles, glass bottles, and tinplated steel (tin) cans are already formed when they reach the filling stage" This is not directly clear from the diagram. Please make the diagram clearer or use two diagrams	Diagram modified and second diagram included.
System boundary	Rob Rouwette	"Refrigeration impacts have been excluded, as this is assumed to be part of the beverage/food life cycle and therefore not part of the packaging life cycle. This exclusion will benefit heavier types of packaging, which have higher thermal mass, like glass."	Put forth to panel and accepted.
System boundary	Rob Rouwette	"In reality, recycling of biogenic materials is likely to be environmentally preferable to landfilling because it keeps the biogenic carbon sequestered in a product." Q: Does this mean you have done a sensitivity analysis?	Yes, see 5.5.1
Time coverage	Rob Rouwette	"2019 calendar year" Do you have 12 months of complete data, given that data collection took place before the end of the reporting period?	No, have fixed wording.
End-of-life allocation	Rob Rouwette	"The substitution approach is tested through sensitivity analysis in Section 5.5.3." We know that these are limited in their view. why not use a Module D approach, which uses a cut-off approach, but then shows the potential impacts and benefits beyond the system boundaries?	The Module D approach from EN 15804 can effectively be calculated as the difference between the cut-off results and the substitution results. We only give a credit for the net scrap under the substitution approach, which aligns with EN 15804. Thus, the substitution results are effectively the sum of modules A + C + D under EN 15804.

Section	Panel member	Comment	thinkstep-anz response
End-of-life allocation	Rob Rouwette	“regional leakage rates, landfill gas capture as well as utilisation rates (flaring vs. electricity production).” The parameters around landfill emissions could have an impact on end-of-life emissions of carton. As this is not the case for glass, a sensitivity analysis may be in order. A source for the data and details around percentages would be helpful too.	Added, see section 3.8.5.2 – sensitivity analysis in 5.5.1
Scenario Analyses	Rob Rouwette	Cartons end-of-life alternative scenarios include varying the DOCf of the laminated paper between 0% (no degradation, i.e. behaves as plastic), 17.5% (baseline) and 50% (high degradation, i.e. behaves as paper),” I like this sensitivity analysis. Could you add the landfill leakage rates; methane capture rates and methane utilisation rates (min-max range) to the sensitivity analysis? Or add as a separate analysis.	Added, see section 3.8.5.2 – sensitivity analysis in 5.5.1. Have changed baseline DOCF to 21%
Selection of LCIA Methodology and Impact Categories	Rob Rouwette	“The indicator is therefore included for reasons of completeness.” - If completeness is the aim, then why are toxicity indicators left out? - Can you comment on Microplastics and Marine Litter as newly relevant indicators?! Water Scarcity conclusion?	PCR does not include toxicity as required indicators. Toxicity excluded due to high uncertainty in data. Comments on microplastics and marine litter have been included. Water Scarcity Footprint now included.
Scaling	Rob Rouwette	Non-linear relationship between mass and volume of packaging- suggestion not to use linear scaling	We considered several different methods to scale the pack masses and applied the method that fit best with measured data for those packs where we had multiple size classes for the same brand. That said, there will be some uncertainty due to our scaling of pack masses.
Product Composition Data (Size Class Averages)	Rob Rouwette	“the average product assumes the most common material.” Check impact of label to see if this choice influences results. Topic for sensitivity analysis?	It does not influence results. Labels have a very low mass compared to the other components and the different materials were mostly different types of plastics which have similar environmental impacts
Product Composition	Rob Rouwette	Carton laminate- Check for additives and toxicity. BPA in polycarbonates as an example.	Toxicity was not included as an indicator. There is no polycarbonate or BPA present in any of the packs

Section	Panel member	Comment	thinkstep-anz response
Data (Size Class Averages)			assessed. As food and beverage packaging, all packaging materials must meet strict food safety requirements.
Tetra Pak Specifications Comparison	Rob Rouwette	TBA Slim 2 L- Up to 6% deviation measured. I think it would be prudent to include this variation in the conclusions	As the weighed packs were heavier than the Tetra Pak specifications, the results generated would have been conservative for the TBA Slim 2 L (as the pack is heavier and therefore has higher impacts).
Cartons	Rob Rouwette	"Country-specific"- If electricity mix is important to results, then a sensitivity analysis using a regional grid may be appropriate. Panel: Yet, production in China has been assumed? It isn't clear what happens in AU/NZ and what happens elsewhere	The location of carton manufacture being China is worst case scenario. Section 3.5 states where forming and filling takes place.
Cartons	Rob Rouwette	"Tetra Pak paperboard is sourced from Stockholm, Sweden and is FSC certified." Did you get paperboard manufacturing data from the Swedish supplier? In general, what data were used for the raw materials?	European data from FEFCO was used. This was compared to GWP emissions data from all paper mills supplying Tetra Pak Oceania and found to be conservative for all but one of the mills. A new annex has been added to show this data (see Annex F).
Aluminium induction seals	Rob Rouwette	"solvent and adhesive"- Could they have a POCP impact?	This is shown in the other indicator results
Distribution	Rob Rouwette	The distance would be highly variable. Also, if transport is important, then the results may vary depending on location (i.e. not all products would have to be transported over the same distance) Check impact of 50km.	We have shown that distribution is not a major impact on results, as we only consider the mass of the packaging (and not the product it contains) being shipped.
Transportation	Rob Rouwette	"9,000 km by container ship at sea for all materials except glass and paper products (for which local recycling is most common)." Plastics are not going to China or Asia as much, so a local scenario may be possible too. A local recycling scenario (for plastics) should be the default, as a conservative assumption	The approach has now been changed to assume local recycling as the default scenario, with the results updated accordingly.
Recycling	Rob Rouwette	"less than 0.5% of packaging is sent to energy recovery in Australia" So not modelled?	Correct. This was not modelled as it is not a relevant EOL scenario for packaging in Australia or New Zealand.
Recycling	Rob Rouwette	"New Zealand was assumed to have the same recycling rates as Australia" Elspeth has recent data for NZ. Cross-check rates with this study	We have calculated new recycling rates for New Zealand, based on WasteMINZ recycling collection

Section	Panel member	Comment	thinkstep-anz response
			data as well as the APCO sorting and recycling efficiency data.
Recycling	Rob Rouwette	Panel believes recycling rate for Carton is too high. Pouch seems implausible.	While there are no local facilities, some cartons are sent overseas to be recycled (to India and Korea). This choice doesn't affect the conclusions. As shown in section 5.5.1, the scenario with a DOCf of 21%, the default landfill gas capture rate (36% or 53%), and a recycling rate of 0% has a lower GWP than the baseline scenario (which is the same except it has a recycling rate of 10%). Pouch having 100% recycling rate was a typo and was meant to be 0% with 100% to landfill. This is now corrected.
Recycling	Rob Rouwette	"100% of pouches are landfilled"- swap values in the table (Tab 3.7)	Done
Recycling	Rob Rouwette	"Carton recycling was modelled differently to other recycling, in that the separation of the paperboard from the rest of the carton was modelled to account for the increased difficulty of separating recyclable components." How did you model this differently	This was incorrect, It was not modelled differently.
Recycling	Rob Rouwette	"Shipper cartons (cardboard)"- Do you have data on secondary and tertiary packaging for alternative packaging options?	We observed which secondary packaging was used via retail store visits, and we collected samples where feasible. When it comes to recycling rates, there is limited data on recycling rates from specific end-users. However, we do know that shippers will be sent to end-of-life at retailers. These retailers have large volumes of cardboard to dispose of and typically have strict environmental policies, which makes recycling the most likely scenario.
Degradable Organic Carbon	Rob Rouwette	"0.01"- This value is 0.10 in NGA 2019 (table 46)	This has been corrected.

Section	Panel member	Comment	thinkstep-anz response
Fraction (DOCf)			
Degradable Organic Carbon Fraction (DOCf)	Rob Rouwette	“There is a significant level of uncertainty regarding the DOCf of laminated paperboard andit could vary anywhere from 0% (assuming that the plastic and aluminium barrier layers on either side of the paperboard stop it from breaking down at all) to 50% (assuming the barrier layers fail over time and the paperboard behaves like uncoated paper in landfill). A value of 17.5% for coated paper (Micales, J & Skog, K, 1996) was used as the base case in this study because it is one of the few actual values available.” A sensitivity analysis assuming 50% is appropriate, as the barriers	Has been carried out. See section 5.5.1.
Aseptic container secondary packaging	Rob Rouwette	“For each size class, (e.g. taking 1 L PET average for water, juice and aseptic milk), all secondary packaging is assumed to be the same.” Fair assumption	n/a
End-of-life	Rob Rouwette	“33.3% landfill, 33.3% downcycled and 33.3% incineration.” Source for this scenario? Incineration is much higher than waste incineration %	This is an estimate from previous anecdotal conversations with suppliers. This doesn’t have an impact on results because: 1. recycling and incineration are very similar from a carbon perspective for wood (due to the methodology followed for biogenic carbon) 2. all packaging options of the same size class have the same tertiary packaging
Raw materials and processes	Rob Rouwette	“Table 3-14: Key material and process datasets used in inventory analysis” Needs to be clearly stated as a limitation (that the alternatives are based on literature data)	Comment has been included in section 6.2
Overall results	Rob Rouwette	“Error bars have been included to show the range of packaging masses which were collected; this is high for the glass and PET consumer packs due to large differences in bottle design. These bars do not show standard deviation or standard error, which is their more common use.” - This is confusing. Change error to a different word. - Real range in results would be useful, considering all variables.	The term ‘error bar’ has been changed.

Section	Panel member	Comment	thinkstep-anz response
		- The conclusions should be very clear to indicate variations, uncertainty, limitations, etc.	
500 mL aseptic food	Rob Rouwette	Large differences between AU/NZ	This was the case for PET, which has been removed now. Food PET and LDPE were removed as they serve a different purpose than cartons, tins, glass jars and pouches. (PET and LDPE contain condiments, while the others contain sauces, soups and stock used for cooking.)
Detailed results	Panel	A comparison against published studies would be very useful to benchmark the results	Done, in Section 5.6
Results and interpretation	Rob Rouwette	“lowest GWP”- This formulation is better than "Tetra Pak is better"	Changed
Consumer end-of-life	Rob Rouwette	“Due to the biogenic carbon sequestered by the cartons being included in the consumer end-of-life category, all base scenario cartons have a negative GWP impact because some of the biogenic carbon remains sequestered in landfills long-term.” Long-term is relative. Would this be the case over 10,000 years as considered in ecoinvent? A sensitivity analysis would be useful.	Yes, we believe so. The DOC_F values used are calculated from bioreactor studies which aim to simulate full degradation of biogenic carbon.
Shipper and pallet total	Rob Rouwette	“for smaller pack sizes”- How is pack size a factor? Smaller packs would mean smaller boxes or more packs per box, right? If you have used different assumptions for different pack types, then please provide these. Or did you use specific shipper and pallet data for each pack size?	Secondary packaging assumptions are shown in section 3.9 and these differ by pack size. Fixed wording.
Shipper and pallet total	Rob Rouwette	“Long-term is relative. Would this be the case over 10,000 years as considered in ecoinvent? A sensitivity analysis would be useful.” List as minor limitation	Listed as limitation
Other indicators	Rob Rouwette	“Annex 1” https://www.researchgate.net/publication/288600543_The_decomposition_of_paper_products_in_landfills references a newer study (Barlaz 2004), which indicates 21% decomposition for coated paper. It would be advisable to use a conservative factor (maybe even round it up to 25%) to increase robustness of the results.	After consultation, Fabiano Ximenes (the author of this paper) has suggested we use 21% and we have recalculated the results using this value.

Section	Panel member	Comment	thinkstep-anz response
Other indicators	Rob Rouwette	ODP and POCP indicators will be updated.	These indicators are now updated.
Other indicators	Rob Rouwette	"Acidification potential (AP) and Eutrophication potential (EP) results are the lowest for cartons in most size classes, except for size classes which have pouches. The difference between carton and pouch AP and EP is significant (>50%)." The results are obviously important, but it would make sense to add some key interpretation here as well. E.g. what causes the reduction in AP/EP? Which substances? From which processes? Based on foreground data or background data? Actual data or scenarios? etc.	The focus of our analysis is on carbon footprint. The AP and EP results are provided as a sensitivity check. We have not explored the reasons for these differences further.
Other indicators	Rob Rouwette	"the difference is always less than 50%"- That's a fairly large range, which potentially includes small differences. Here also, it would make sense to add some key interpretation. E.g. what causes the differences in ADPE/ADPF? Which substances? From which processes? Based on foreground data or background data? Actual data or scenarios? etc.	The wording has been improved. Further interpretation has not been added in this case because the focus of our analysis is on carbon footprint and the other results are provided as a sensitivity check.
Sensitivity analyses	Rob Rouwette	"two"- three?	Changed
DOCf and carton recycling	Rob Rouwette	"stop it from breaking down at all."- This probably has a time aspect to it. Can you outline what time horizon for emissions in landfill you have chosen?	100 years. Fixed wording.
DOCf and carton recycling	Rob Rouwette	Micales, J & Skog, K, 1996 https://www.researchgate.net/publication/288600543_The_decomposition_of_paper_product_in_landfills references a newer study (Barlaz 2004), which indicates 21% decomposition for coated paper. It would be advisable to use a conservative factor (maybe even round it up to 25%) to increase robustness of the results.	After consultation, Fabiano Ximenes (the author of this paper) has suggested we use 21% and we have recalculated the results using this value.
DOCf and carton recycling	Panel	"The baseline recycling rate of cartons is 10%"- may be optimistic	There is collection of Tetra Pak cartons in both Australia and New Zealand (collection rate is 40% in NZ – WasteMINZ, 2020). The sensitivity analysis in Section 5.5.1 shows that at the baseline DOC_F and methane capture rate, the recycling rate isn't a major factor.

Section	Panel member	Comment	thinkstep-anz response
DOCf and carton recycling	Rob Rouwette	“80% recycling were included as scenarios”-The 80% scenario would be valid for uncoated paper. 20% recycling would be more reasonable/useful for coated paper, creating a 0%-10%-20% recycling rate set of scenarios, which is more likely to display actual variation.	Left 80% as we wanted to show a range of potential recycling rates, rather than the smaller range of what is potentially happening now. 80% is world best-practice and is achieved today in Germany.
DOCf and carton recycling	Rob Rouwette	“due to Australian landfills having a lower methane capture rate than New Zealand landfills.” This varies from landfill to landfill; basically from 0% (no capture) to 94% for the most modern ones. This range should be included in the sensitivity analysis, as it shows the impact of local conditions on the results. 94% is based on Ximenes 2010: "In a recent report (Hyder Consulting, 2010) it was estimated that the collection efficiency of methane was between 68 to 94% at a modern landfill in Victoria." https://www.researchgate.net/publication/288600543_The_decomposition_of_paper_products_in_landfills	See section 3.8.3.2 for the assumptions regarding the methane capture rate. Section 5.5.1 includes a scenario analysis with a varied methane capture rate for cartons.
DOCf and carton recycling	Rob Rouwette	This graph is quite insightful and should inform the nuance (uncertainty) of the conclusions. E.g. - In the worst-case scenario for cartons, their GWP scores roughly equal to rPET's default scenario, 40% lower than PET's default scenario and 75% lower than glass's default scenario. - In our default (average) scenario for cartons, their GWP scores are x% lower than rPET's best-case (lightest?) scenario, x% lower than PET's best-case scenario and x% lower than glass's best-case scenario. Consider adding the default scenario for carton to each graph as well.	Added default scenario for PET and rPET on the graphs.
DOCf and carton recycling	Rob Rouwette	If easy to do: highlight the values that have changed from the default analysis.	Done
Plastic and glass bottle mass variation	Rob Rouwette	“Across the weighing of the consumer packs, it was found that there was a wide variation in the mass of plastic and glass bottles of the same size class.” Did I miss this in the description of the weighing process? This is quite important, so should be listed earlier and has to be part of the conclusions/interpretation.	Section 3.2.2
Plastic and glass bottle mass variation	Rob Rouwette	“44% less than the 1 L PET average”- This is a massive difference, which may make it difficult to generalise conclusions across all permutations.	Yes, the difference is very large due to lightweight PET water bottles, which are much lighter and thinner walled than PET bottles in other categories (juice, milk,

Section	Panel member	Comment	thinkstep-anz response
			etc.). After further discussion with the panel, we have separated out lightweight PET and rPET, which is only used in the water category, from "regular weight" PET and rPET.
Plastic and glass bottle mass variation	Rob Rouwette	"The 250 mL and 200 mL size classes have not been included in this category because the plastic packs in those categories had a GWP of more than 100% larger than the carton GWP." It won't change the direction of the conclusion, but it will affect the margin.	There isn't the same variation for pouches (relative to glass and PET), which are the product most comparable to cartons in these categories.
Assumptions and limitations	Rob Rouwette	This is a good list of key issues. The question beckons: what is the combined influence of all these issues. Individually they don't change the direction of the conclusions, but there is no reason why some or all of the variables could occur at the same time. Are you able to provide this spread?	Most of the issues listed in this seciton have a relatively small influence on the results. We have tested the sensitivity of the results to the most important variables. Yes, there could be interaction effects that cross areas; however, we have set the base case results to be conservative (i.e. to favour other pack formats, and to disadvantage cartons) wherever there was uncertainty.
Assumptions and limitations	Rob Rouwette	"sensitivity analysis was performed to assess its effect on the conclusions"- should say something here about sensitivity analysis	Added
Assumptions and limitations	Rob Rouwette	add landfill methane capture rates to the list of variables (0-94%)	A comment has been added to the assumptions. It was discussed already in Section 3.8.3.2
Limitations	Rob Rouwette	The data (and model) variability are probably an important limitation that should be taken into account when interpreting the results.	The use of secondary data for competitive pack formats is noted throughout the study. In general, we have tried to set the base case results to be conservative (i.e. to favour other pack formats, and to disadvantage cartons) wherever we were uncertain.
Limitations	Rob Rouwette	"The most significant area of uncertainty for this study is the DOCf of the laminated paper within the cartons in landfill." Perhaps for cartons, although other landfill parameters are also important. For glass and PET, mass per unit would be an area of uncertainty, not?	Glass and PET mass uncertainties added to limitations. That said, the environmental impacts associated with landfill of inert materials such as glass and PET are relatively small from a life cycle perspective.

Table 7-27: Round 2 comments and responses

Section	Panel member	Comment	thinkstep-anz response
Exec summary	Rob Rouwette	"Pouches were the best performing packaging format for many of the other environmental indicators," Please name the indicators.	Done
Exec summary	Rob Rouwette	"The analyses conducted considered". You also conducted an analysis for aluminium, which I think should be added here. I believe the choices you made regarding aluminium are reasonable, although it is possible that an aluminium producer that uses hydropower would challenge the conclusions regarding the 250 ml alu cans. If you wanted to strengthen the conclusions on this front, then a sensitivity analysis could be useful. Based on my high-level analysis, it wouldn't change any conclusions.	Done
Manufacturing	Elspeth MacRae	'Tinplated steel cans (for food) are manufactured from virgin steel (blast furnace route) using standard manufacturing techniques.' Where are they manufactured?	We have used a dataset for can-making from the USA. This is aggregated which means it reflects the US energy mix. The final can-making stage doesn't have a significant influence on the results Have changed the wording to make this clearer
Manufacturing	Elspeth MacRae	'Aluminium cans (for beverages) are manufactured from a combination of virgin aluminium (using the global production mix) and recycled aluminium using standard manufacturing techniques. Two scenarios are applied in this report: 0% recycled content (worst case) and 70% recycled content (best case).' Manufactured where?	We have used a dataset for can-making from Europe. This is aggregated which means it reflects the European energy mix. The final can-making stage doesn't have a significant influence on the results. We have changed the wording to make this clearer.

Erratum to Version 1.5

After the review panel submitted their review statement, it came to the authors' attention that there were some minor errors within the report which have been corrected in this version of the document. These do not affect the results in the main body of the report.

These errors (which have been corrected in this document) were:

- Table 3-16: Previous version did not state that the 250 mL and 200 mL secondary packaging included LDPE film which is used as wrapping around a 6-pack.
- Table 3-16: Previous version did not state that the 500 mL secondary packaging had 6 consumer packs per secondary packaging unit
- Table 3-16: Correction to the values provided for the 600 mL secondary packaging
- Annex I: Minor errors in the results tables (transposed rows and minor issues with the biogenic carbon)
- Annex J: Minor errors in the results tables (transposed rows and minor issues with the biogenic carbon)

List of Acronyms

ADP	Abiotic Depletion Potential
AP	Acidification Potential
AU	Australia
BWC	Blue Water Consumption
CML	Institute of Environmental Sciences at Leiden University
CTMP	Chemi-Thermo-Mechanical Pulp
DOC_F	Degradable Organic Carbon Fraction
ELCD	European Life Cycle Database
EoL	End-of-Life
EP	Eutrophication Potential
GaBi	Ganzheitliche Bilanzierung (German for holistic balancing)
GHG	Greenhouse Gas
GWP	Global Warming Potential
HDPE	High-Density Polyethylene
ILCD	International Cycle Data System
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LDPE	Low-Density Polyethylene
MRF	Materials Recovery Facility
NMVOC	Non-Methane Volatile Organic Compound
NZ	New Zealand
PET	Polyethylene Terephthalate
POCP	Photochemical Ozone Creation Potential
PP	Polypropylene
TBA	Tetra Brick Aseptic
TPA	Tetra Prisma Aseptic
VOC	Volatile Organic Compound
WSF	Water Scarcity Footprint

Glossary

Life cycle

A view of a product system as "consecutive and interlinked stages … from raw material acquisition or generation from natural resources to final disposal" (ISO 14040:2006, section 3.1). This includes all material and energy inputs as well as emissions to air, land and water.

Life Cycle Assessment (LCA)

"Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040:2006, section 3.2)

Life Cycle Inventory (LCI)

"Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle" (ISO 14040:2006, section 3.3)

Life Cycle Impact Assessment (LCIA)

"Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product" (ISO 14040:2006, section 3.4)

Life cycle interpretation

"Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations" (ISO 14040:2006, section 3.5)

Environmental Product Declaration (EPD)

"Independently verified and registered document that communicates transparent and comparable information about the life cycle environmental impact of products."

Product Category Rule (PCR)

"Defines the rules and requirements for EPDs of a certain product category."

Functional / Declared unit

"Quantified performance of a product system for use as a reference unit." (ISO 14040:2006, section 3.20)

Functional unit = LCA/EPD covers entire life cycle "cradle to grave".

Declared unit = LCA/EPD is not based on a full "cradle to grave" LCA, common in construction product EPDs.

Allocation

"Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems" (ISO 14040:2006, section 3.17)

Foreground system

“Those processes of the system that are specific to it … and/or directly affected by decisions analysed in the study.” (JRC, 2010, 97) This typically includes first-tier suppliers, the manufacturer itself and any downstream life cycle stages where the manufacturer can exert significant influence. As a general rule, specific (primary) data should be used for the foreground system.

Background system

“Those processes, where due to the averaging effect across the suppliers, a homogenous market with average (or equivalent, generic data) can be assumed to appropriately represent the respective process … and/or those processes that are operated as part of the system but that are not under direct control or decisive influence of the producer of the good….” (JRC, 2010, 97-98) As a general rule, secondary data are appropriate for the background system, particularly where primary data are difficult to collect.

Closed-loop and open-loop allocation of recycled material

“An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.”

“A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials.”

(ISO 14044:2006, section 4.3.4.3.3)

Critical Review

“Process intended to ensure consistency between a life cycle assessment and the principles and requirements of the International Standards on life cycle assessment” (ISO 14044:2006, section 3.45).

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