Report for KeepCup

Reusable coffee cups life cycle assessment and benchmark

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EDGE

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Executive Summary

KeepCup is one of the world's best-known designers, manufacturers and sellers of reusable plastic and glass coffee cups. The company's mission is "to encourage the use of reusable cups", and in doing so help move society away from their disposable alternatives. To be consistent with the sustainability focus of that mission, it is important that KeepCup also takes steps to understand and manage the environmental footprint of its own products.

If everyone in Australia switched to KeepCups rather than using disposable cups, the amount of carbon emissions that would be saved in a year would be equivalent to approximately 100,000 hours of flight time for a Boeing 747.

Approach

As such, Edge Environment (Edge) was commissioned to assess the environmental footprint of three KeepCup designs, and compare them with:

Two single-use cups (compostable and paperboard); and

Two multi-use cups (bamboo and polypropylene).

The study quantifies and compares the cradle-to-grave impacts (raw materials, transport, manufacture, customer use and end of life disposal) following the life cycle assessment (LCA) methodology outlined in ISO 14040:2006. The study was conducted for KeepCups assembled in Melbourne, Los Angeles and London for the following markets: Australia, New Zealand, Singapore and China, North America and Europe.

The cups were compared in terms of the environmental impact to deliver one year of coffee drinking. Light, medium and heavy use intensities were assessed, modelled as 1, 2 or 3 coffees per day respectively, or 250, 500 or 750 coffees per year.

In-depth analysis of the environmental impact was conducted using three primary indicators: Carbon emissions; energy use; and water use.

Additional indicators reported on acidification, eutrophication, fossil fuel depletion, land occupation and toxicity.

This study was conducted taking a conservative approach towards KeepCup in the benchmark with its competitors, mainly due to the lack of available data to characterise other cups in the market. For this reason, the comparison with competitors must be seen in the light that: (i) the competitors do not represent other specific products (e.g. brands) in the market; (ii) that the impacts of KeepCups are more complete than the impacts of the competitors.

KeepCup's Impacts: Usage

The total environmental impact shows that on average, KeepCup has lower impact than the benchmark when considering light, medium or heavy use in all markets assessed. The results for KeepCup's carbon footprint were similar, coming out as 88% lower than compostable cups and only marginally (4%) lower than reusable bamboo cups.

On average, using a KeepCup has lower impact than using single use cups and reusable cups made of polypropylene and bamboo.

These advantages are present even for light users. In that scenario – drinking one cup of coffee a day – compostable cups' carbon footprint overtakes that of all KeepCups after only 10 days, and after 24 days for paper cups. Considering KeepCups are typically used for years, this amounts to significant lifetime carbon savings.

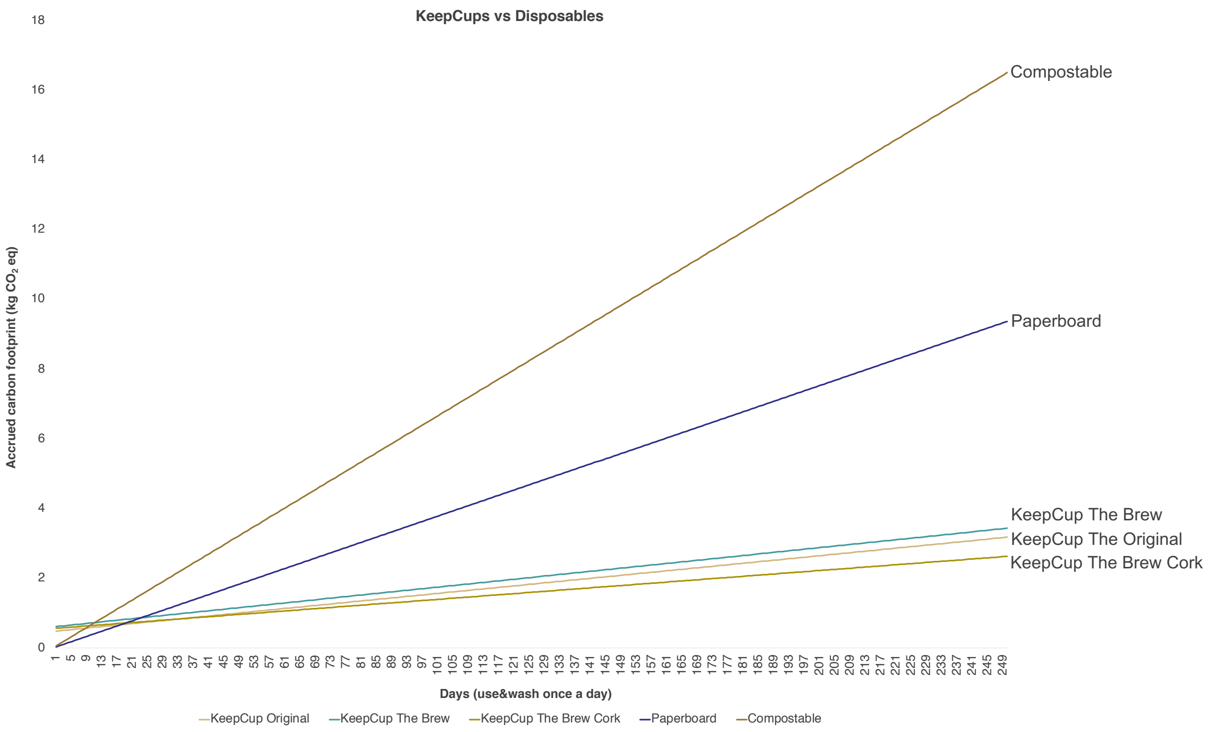


Figure 1 – Carbon footprint comparison over time for KeepCups and disposable cups archetypes (based on a light use profile and average of regions).

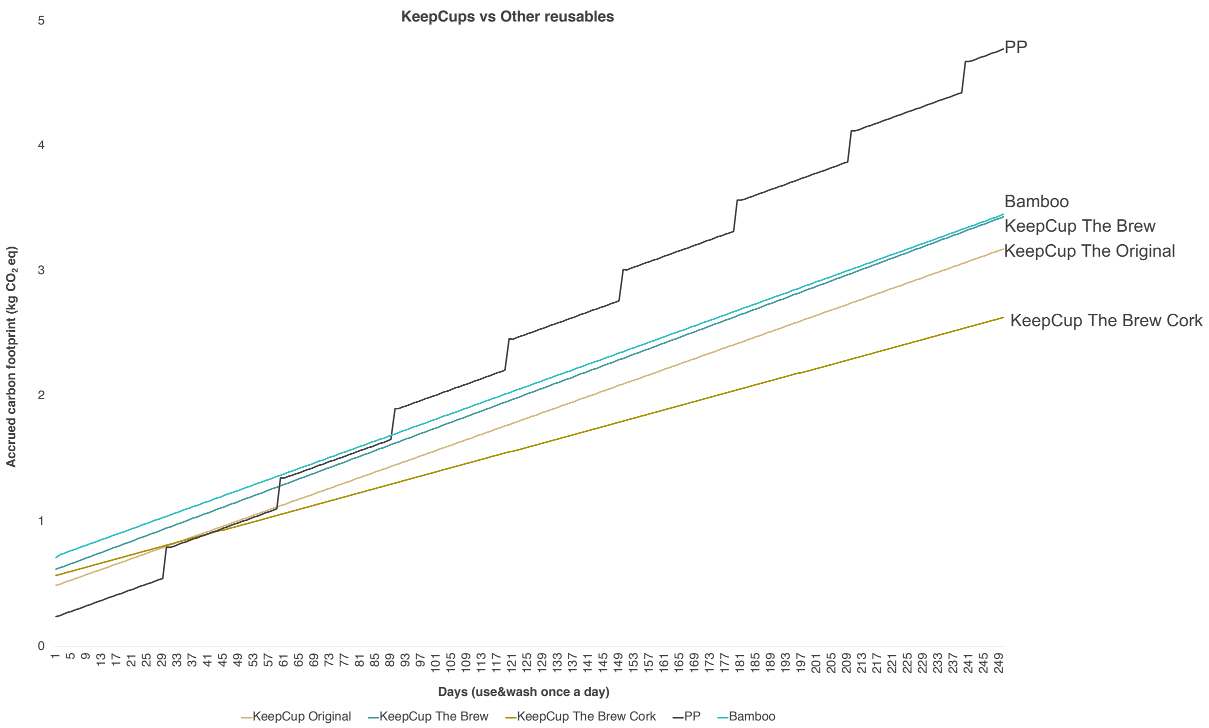


Figure 2 - Carbon footprint comparison over time for KeepCups and reusable cups archetypes (based on a light use profile and average of regions).

KeepCup's Impacts: Manufacturing and Assembly

Manufacturing is the second most important life cycle stage after use, which is to be expected given the typically long lifetime and high usage rates of KeepCup's products. Approximately 8% of a

KeepCup's lifetime carbon emissions are embodied in the cup itself, along with 11% of the energy and 1% of water use.

- The most relevant parts in terms of embodied carbon emissions are:
- The plastic (41%) or the glass cup (53-59%) depending on the KeepCup type;
- The lid (29-35%); and
- The band (14-18% for the silicon band, but only 5% for the cork band).

The assembly stage is the third most important component in the life cycle of KeepCups. Notably, the carbon footprint of KeepCups made in the UK is 15-30% higher than of those made in Australia, largely due to energy supplied by onsite PV panels for the Melbourne facility.

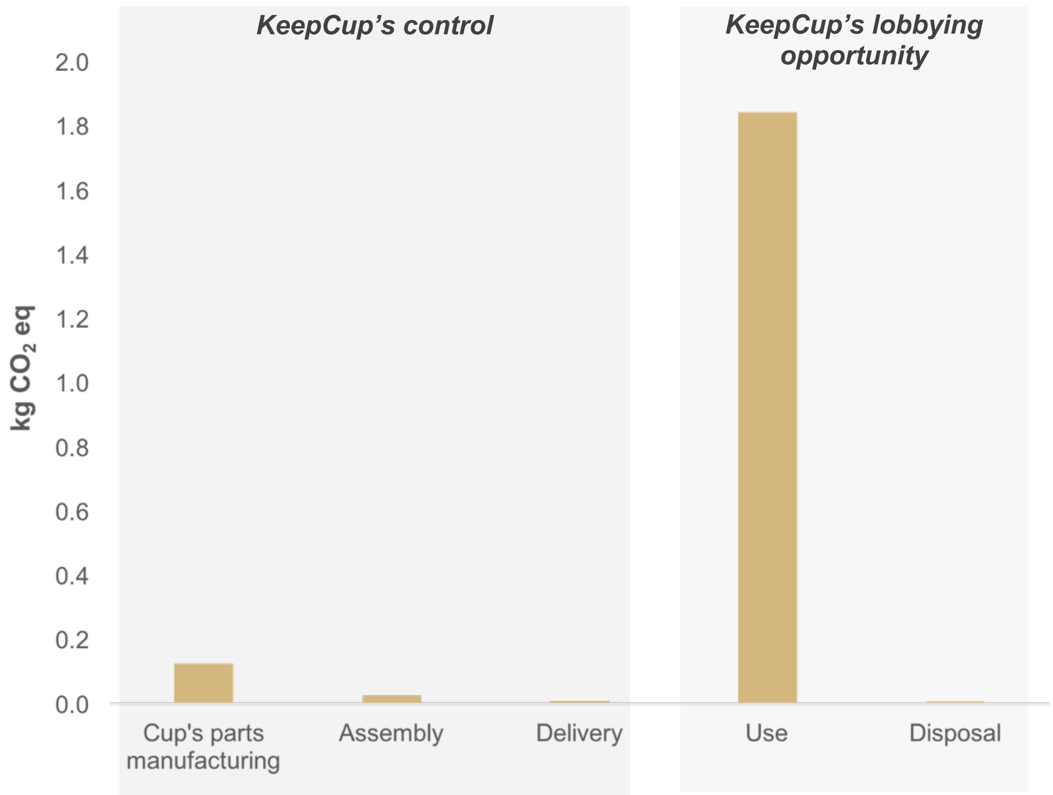


Figure 3 – Carbon footprint and impact reduction opportunity for KeepCup across its markets.

Opportunities for Lowering KeepCup's Impacts

KeepCup has the lowest environmental impact of the cup options assessed. However, there is still significant room for improvement, especially in influencing the main hotspot which is the use stage influencing user behaviour through education and communication:

- **Washing the cups:** to encourage hand washing over dishwashing, and to promote energy and water efficiency techniques, as well as the purchase of water and energy efficient dishwashers[1].
- **Replacement of parts:** KeepCup facilitates replacement of cup parts. This prevents KeepCup users from having to buy an entirely new cup in case of damage or loss, which in turn extends the cups' lifespan and reduces the impact of using KeepCups.

[1] The Australian government for example has relevant information in the "Your Energy Savings" and "Your Water Servings" websites, including the Water Efficiency Labelling and Standards Scheme where consumers can compare different products according to their water use.

- **Recycling of used cups:** KeepCup should always encourage recycling of their products at their end of life to reduce the overall impact, and align with their mission to reduce plastic wastage. This could encompass not only educating and encouraging consumers, but also lobbying for infrastructure to increase coverage and scope of recycling services; and continued consideration of recyclability in the design of cups.

To back up its re-use and recyclability potential, could KeepCup include pre-paid "return to sender when you're done" on the box the cup is delivered

There are also several, wider opportunities for KeepCup to reduce the environmental impact of its cups across different life cycle stages. These include:

- **Choice of materials:** glass cups are shown to have a higher impact than plastic cups, while the cork band has lower carbon footprint than the silicone band. Considering the relative small, and at this stage uncertain environmental difference between reusable cups of other materials (e.g. bamboo), it is arguably in KeepCup's interest to explore alternative cup materials and evaluate different combinations of parts to build the lowest impact cup.

We recommend that KeepCup continue to explore better cup materials and designs, to stay competitive in the reusable cup market segment.

- **Material efficiency:** there may be potential to redesign the product to reduce the amount of material needed, particularly for the glass cup.
- **Recycled materials:** KeepCup should evaluate the possibility of incorporating recycled glass (waste from the processes or post-consumer waste) as a raw material to reduce the impact of material extraction and processing.
- **Energy efficiency:** there is likely to be potential to reduce embodied impacts by incorporating further energy efficiency technologies and more efficient processes into the assembly phase. Alternative, less energy-intensive processes to those currently employed to manufacture the cup parts could also be explored.
- **Renewable energy:** the Melbourne facility is the only that has its own photovoltaic system, which is shown to significantly reduce the impacts of Australian assembly vs. that undertaken in the UK. It would therefore be sensible to consider extending the roll out of renewable energy generation technologies to other facilities.
- **Shrink the supply chain:** reducing the transport distance of cup parts between the point of manufacture and the assembly plants would reduce the carbon footprint and energy requirements of the life cycle.

Communicating the Results of this Study

Following relevant guidelines in the Australia[2], the UK[3] and the United States[4], Edge recommends that KeepCup base its public-facing statements on sentences such as:

> *"An independent life cycle assessment has demonstrated that using KeepCup has the lowest environmental impacts compared disposable cups" rather than "KeepCup saves the environment".*
>
> *"KeepCup offers an alternative, reusable cup with a low environmental footprint, and with no risk of driving deforestation" rather than "KeepCup saves trees".*

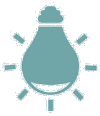
While KeepCup's products have lower environmental impacts than their key peers, there are still actions for all stakeholders across the life cycle to reduce them. This is particularly relevant to KeepCup's customers, who are likely to be a relatively engaged and motivated audience.

Carbon emissions were highlighted by KeepCup at the onset of the study as one of the key impacts to focus on and assess. This was supported by the LCA results, which showed that carbon emissions are a big differentiator for KeepCup when comparing performance to their disposable peers. Given the status of climate change as arguably the main environmental challenge of our time, this presents an opportunity for KeepCup to forcefully advocate for the use and reuse of KeepCups as a means of cutting emissions.

The carbon savings from one person that uses a KeepCup instead of single use cup for their coffee for one year include:

205 km driven

5 trees growing for 1 year



750 LED downlights for 1 year

Communicating the results of this study would show a level of transparency on the properties of KeepCup products and whole-of-life responsibility of KeepCup that is unmatched on the market. A good example of this is the part replacement program and the clarity on the end of life of cup materials. KeepCup can use its potential divulgation to generate momentum in the sector for better clarification on what the lifespans of reusable cups and what is the end of life of different cup materials that are tangible for consumers (e.g. the impossibility for most cup users to compost a compostable material). These are seemingly small factors in product design and in the information that is paid to the costumer but that enable the public to make informed and impactful decisions on their own footprint.

Another aspect of raising the bar in terms of transparency and holistic life cycle information would be to expand cup assessments from single issue and life cycle stage focus, such as bamboo cups are made from natural materials, to include considerations of how bamboo fibre and melamine composites can be recycled, if at all.

Note: To claim ISO compliance with regards to LCA, this study must undergo third party expert critical review to support a comparative assertion intended to be disclosed to the public.

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[2] https://www.ngina.com.au/Attachment?Action=Download&Attachment_id=184

[3] https://www.gov.uk/government/publications/make-a-green-claim/make-an-environmental-claim-for-your-product-service-or-organisation

[4] http://sinsofgreenwashing.com/findings/the-seven-sins/index.html

Closing Knowledge Gaps

Some of the story emerging from this study remains untold. Some data on benchmark cups remain gaps and we assumed zero impact where there was insufficient data to characterise the impacts, meaning we have likely underestimated the impact of for example bamboo cups. It is likely in KeepCup's interest to work towards refining benchmark data and closing data gaps, to explore alternative options for sourcing more specific information on raw materials and manufacturing of bamboo cups.

KeepCup could consider indirectly challenging other cup providers by being completely transparent and open about its own environmental performance and initiatives. KeepCup could even consider putting out a challenge to other cup manufacturer to tell their story and provide their information and data for customers and clients to make informed decisions.

KeepCup is invested in its mission to reduce waste to landfill or littering the environment. There are data gaps in science concerning the end of life impacts of plastics, and as such methodologies such as life cycle assessment cannot properly account for them.

KeepCup could take a proactive role in clarifying what its contribution to "the plastic problem" is by aligning with research initiatives such as the recently launched Medellin Declaration on Marine Litter in Life Cycle Assessment and Management, or potentially commissioning its own studies to support the agenda.

Disclaimer

The results presented in this study are based on realistic models of typical cup life cycles. As with any model, different assumptions will lead to different outcomes. It is important to understand the working of the model, the scope and the limitations before applying these results to other situations.

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1 Introduction

One billion single-use hot beverage cups are sent to landfill annually in Australia alone. Single-use cups, often use for take-away drinks, are commonly made of either polystyrene or biopolymer foams, lined paperboard or biopolymers. These materials are not typically recycled, and while biopolymer cups are often compostable, facilities rarely exist to do so and most end up in landfill.

KeepCup was born from a concern about the environmental footprint of the use of disposable cups in a Melbourne café. Therefore, it comes as no surprise that the environmental footprint of KeepCup products is of high interest for the company. While sustainability is central to KeepCup's mission, its environmental credentials are also a crucial market differentiator, and a lever for helping to disrupt the take-away market.

Since 2009, KeepCups has sold over three million cups across 65 countries, with warehouses in the United Kingdom and United States. Customers can be individuals buying a cup from a retailer or online, or businesses using KeepCups as a branded product for their company employees or clients.

Questions remain, however, over the environmental performance of KeepCup's reusable cups compared with other reusable cup types and single-use cups, when assessed across the full life cycle. Many of KeepCup's customers are highly engaged on environmental issues and are therefore thought to be interested in and sensitive to this issue.

This study assesses the environmental impacts from the manufacturing, use and disposal of KeepCups to identify hotspots and opportunities to reduce impacts. The results, alongside a comparison with other conventional cups, aim at further supporting KeepCup's environmental claims.

This study is conducted using Life Cycle Assessment (LCA), which is the leading standardised method to measure the environmental impacts of a product over its lifetime, including raw material extraction, manufacture, distribution, use and disposal.

The target audience for this study includes key clients (e.g. corporations, universities, government) and the wider public and private consumers. A key objective is to present the study and results on two distinct levels:

- Practical and plainly explained for use in external communications, sales and marketing.
- Rigorous and transparent in terms of method, data and interpretation, satisfying demanding scientific scrutiny if required.

1.1 KeepCup life cycle assessment

The first part of the study aims at understanding the main environmental hotspots and improvement opportunities in KeepCup's global supply and distribution chain. The study assesses three KeepCup products: the "Original" plastic cup, the "Brew" glass cup and the "Cork" edition – a glass cup with a cork band. It covers the cups three key markets: Europe, Australia/Asia and the United States.

1.2 Assessing and comparing cup impacts

The second part of the study benchmarks KeepCup's environmental performance with four competing product archetypes. The benchmark cups include:

- Two single-use cups – disposable paper cup with plastic lid and compostable cups; and
- Two reusable cups – bamboo based cups and polypropylene cup with plastic lids.

1.3 Study goal and scope

KeepCup commissioned Edge to undertake a comparative study of the environmental credentials of various cup options using LCA. The purpose of the study is to:

- Establish the method and data for the development of LCA tools for KeepCup;
- Profile the key environmental impacts of KeepCup product life cycles in key markets;
- Provide KeepCup with a critical assessment of the environmental performance of their products;
- Identify life cycle opportunities for improvement and recommendations for use of KeepCups to minimise environmental impacts; and
- Benchmark conventional cup types against KeepCup with consideration of their properties and functions.

The scope of the study includes:

- LCA of three KeepCup products: The Original, the Brew and the Cork edition;
- Three markets: Australia, Europe, and the United States.
- Benchmark LCA using generic data of four conventional cups:
  - Two single-use cups: paper cup with plastic lid, compostable cups; and
  - Two reusable cups: bamboo based cups and polypropylene cup with plastic lids.
- The LCA of the three KeepCups are based on a 12-month period of typical manufacturing and operations; and
- Assessment of multiple environmental impacts using best practice international data and assessment methods.

This report describes:

- The LCA method used;
- The life cycle stages of the cups studied;
- The data on raw materials, manufacturing inputs, distribution and use of the cups;
- Comparative results for each cup type, showing their environmental impact during their assumed lifespan;
- Sensitivity analyses exploring key parameters and methodological choices; and
- Interpretation of the results and recommendations for further actions and communication of the results.

The study intends to support comparative assertions intended to be disclosed to the public

2 LCA methodology

LCA is an internationally standardised analytical framework for identifying and quantifying the impact of resource use and emissions (e.g. greenhouse gases) from the “cradle” to the “grave” of a system. The general impacts to be considered include resource depletion, human health and ecological consequences. For example:

- Emissions of greenhouse gases affecting human health and causing loss of ecosystem services through the effects of global warming and climate change;
- Depletion or pollution of scarce freshwater resources necessary for human consumption, food production systems and to sustain ecosystems; and
- Use of finite resources such as fossil fuels limiting the available pool for future generations.

The study follows the ISO 14040 and ISO 14044 guidelines, that is, it:

- Identifies the goal and scope of the cups and life cycle to be reviewed;
- Identifies the energy, water and materials used, pollution emitted and waste generate through the life cycle, by life cycle stage;
- Assesses the potential resource use, human and ecological impacts of those uses and emissions, acknowledging the uncertainties and assumptions used;
- Compares those impacts for the selected cups; and
- Highlights any significant results and implications.

Considering the study compares KeepCup with competing products, for ISO compliance the study and comparative results must be critically reviewed before public disclosure.

Details on the methodology and on the LCA standards that inform it are provided in Appendix A.

2.1 LCA software platforms

The life cycle model was created in a leading international LCA software tool SimaPro® (PRé, The Netherlands). SimaPro® is a platform that links LCA background databases with environmental impact assessment methods, making it possible to calculate impacts from an inventory model (see Figure 4).

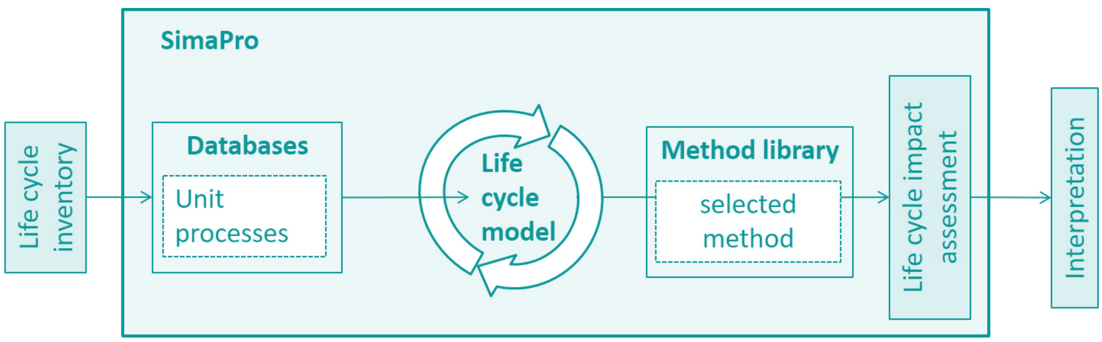

Figure 4 – Use of SimaPro in LCA.

2.2 LCA scope

2.2.1 KeepCup archetypes

KeepCup manufactures plastic cups with silicone bands, glass cups with silicone bands and glass cups with cork bands (Figure 5). All three types of cups were assessed for their 12 oz (340 ml) version (see Table 1). The lifespan of the cups indicated was estimated by KeepCup.

Table 1 – Products assessed (as specified by KeepCup).

Cup	Cup Material	Band Material	Typical uses[5]
The Original	Polypropylene	Silicone	Multiuse – 4 years
The Brew	Tempered glass	Silicone	Multiuse – 4 years
The Brew – Cork edition	Tempered glass	Cork	Multiuse – 4 years

Figure 5 – KeepCups included in this study.

2.2.2 Benchmark cups

Edge and KeepCup screened the market for KeepCup's main competing cups and shortlisted the four cups described in Table 2 and presented in Figure 6. These cup archetypes do not represent any specific products on the market as they were modelled with data available from mixed third-party data sources. The lifespan of the reusable cups indicated was estimated by KeepCup.

Data requirements and inventory for benchmark cups are given in Section 3.1.2.

[5] Includes replacement of parts. See Table 16 for replacement rates.

Table 2 – Benchmark cup types.

Cup	Material	Typical uses
Bamboo cup	Melamine and bamboo	Multiuse – 4 years
PP cup	Polypropylene	Multiuse – 30 uses
Compostable cup	Polylactic acid	Single-use
Paperboard cup	Paperboard with polyethylene lining	Single-use

Bamboo cup **PP cup** **Compostable cup** **Paperboard cup**

Figure 6 – Examples of benchmark cups.

2.2.3 System boundaries

For every KeepCup and benchmark, the LCA includes raw materials and energy required to manufacture the cups, deliveries, washing (if reusable) and disposal at end of life. Diagrams describing the cups' life cycle are provided in Figure 7 to Figure 9.

Due to higher data quality, KeepCup was modelled with higher level of detail and includes transport between component manufacturer and assembly plants and replacement of parts (Figure 7). Benchmark cups were modelled after data retrieved from third party sources, such as manufacturers websites. These publicly available data are limited and formed a more incomplete inventory. The exclusions do not refer to processes that are out of scope but rather processes that could not be quantified due to lack of data. Details on exclusions is provided in section 3. Data quality and completeness are discussed in section 2.3.2.

2.2.4 Functional unit

To compare the life cycle environmental impacts of the cups, a common functional unit is required. The functional unit chosen for this project is one year of coffee drinking.

To that end, the available data has been sourced, then normalised to determine the number of cups needed to provide the uses required, the material inputs and outputs for that number of cups, and their total impacts.

Three use intensities were defined depending on the number of coffees drank per day

- Light use: 1 coffee per day, 250 coffees per year[6].
- Medium use: 2 coffees per day, 500 coffees per year.
- Heavy use: 3 coffees per day, 750 coffees per year.

The lifespan of the cups was kept constant regardless of the number of uses. This is because how often a cup is used is not the only use-related factor influencing lifespan. There is also how the cups are handled and cared for, how they are transported and stored, etc.. There is no depth in currently available data to differentiate the lifespan further.

[6] Assuming 250 working days.

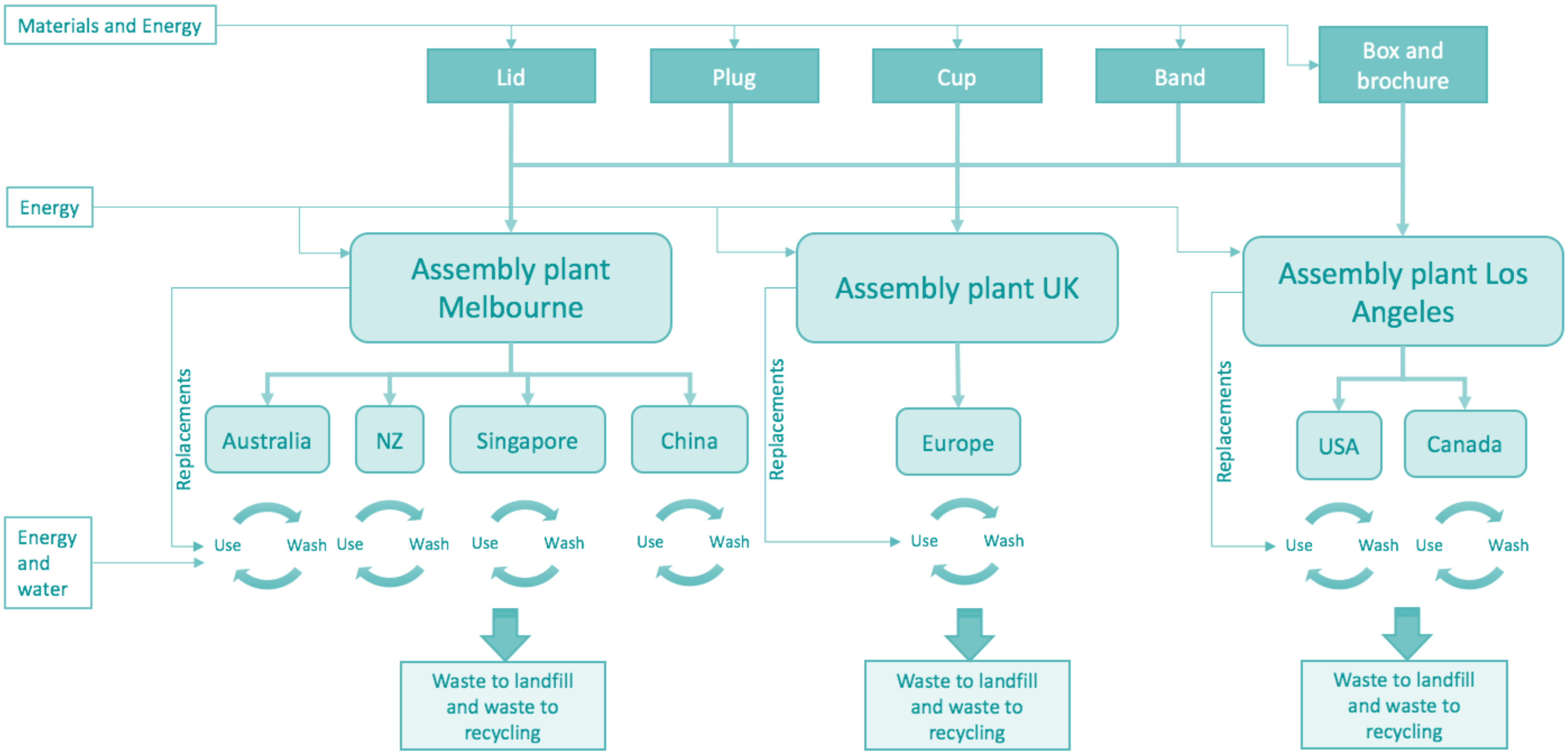

Figure 7 - Life cycle of KeepCups. The white boxes indicated foreground data collected for basic material and energy flows. The filled boxes represent modelled operations and processes.

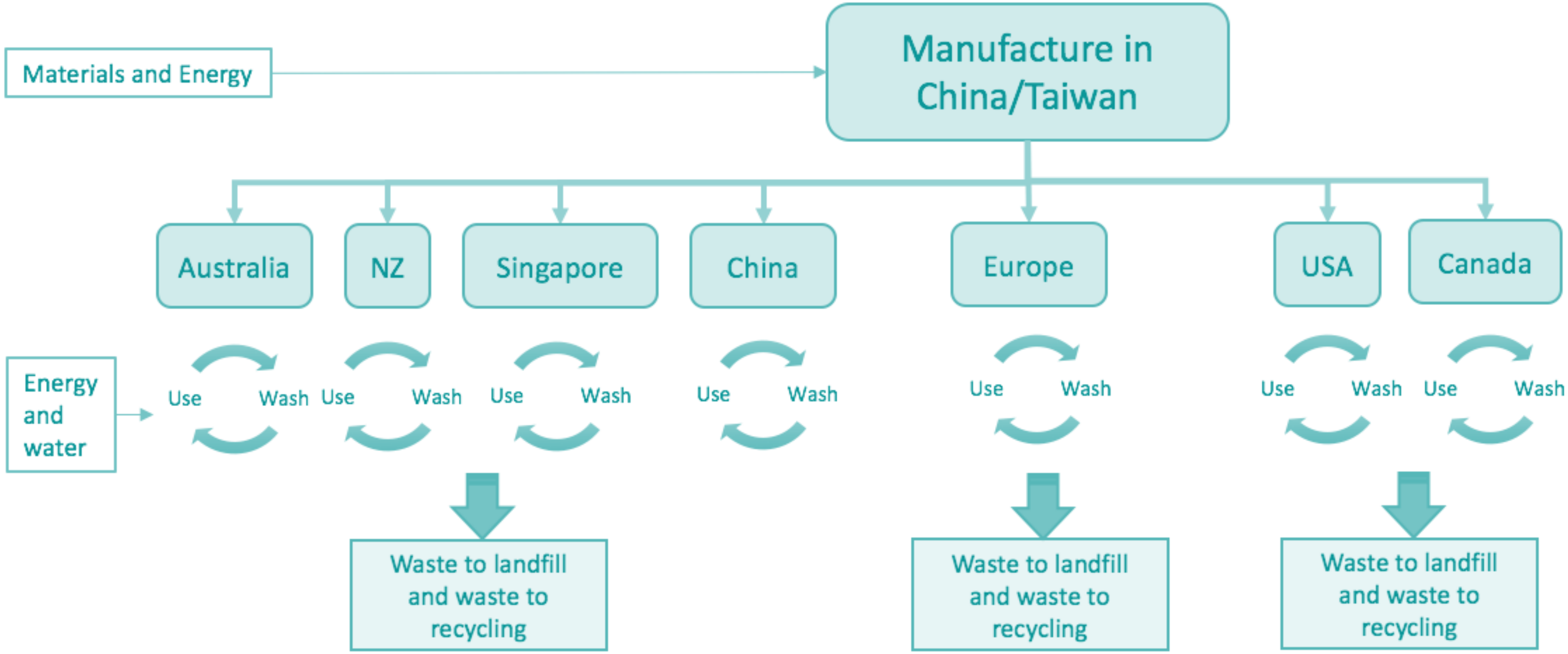

Figure 8 - Life cycle of benchmark reusable cups made of bamboo and polypropylene. The white boxes indicated foreground data collected for basic material and energy flows. The filled boxes represent modelled operations and processes.

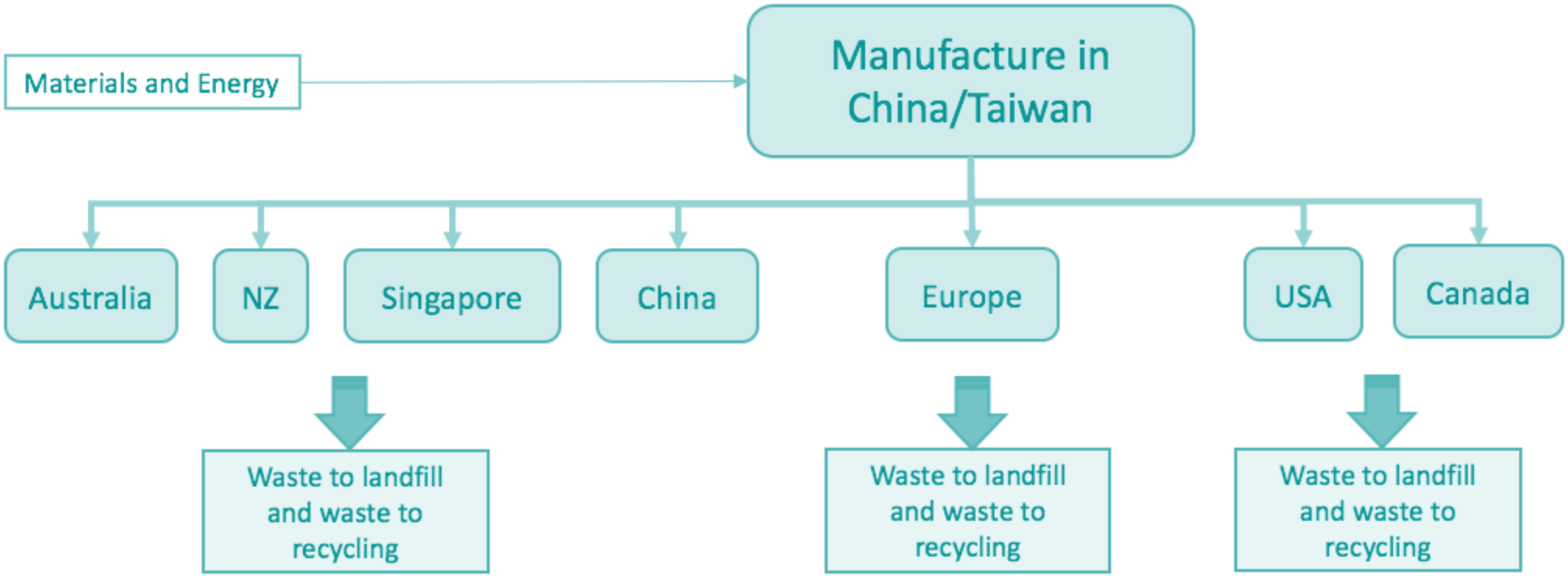

Figure 9 - Life cycle of benchmark single-use cups made of cardboard and compostable materials. The white boxes indicated foreground data collected for basic material and energy flows. The filled boxes represent modelled operations and processes.

Table 3 shows the number of cups required per year for each use intensity scenario. For reusable cups (i.e. KeepCup, bamboo and PP), a portion of the cup or cups is allocated to each year of service. For example, 0.250 or 25% of a KeepCup is used per year, assuming the typical life span is 4 years.

Table 3 – Number of cups required per use profile.

Cup	Light use	Medium use	Heavy use
KeepCup #1 Original	0.250	0.250	0.250
KeepCup #2 Brew	0.250	0.250	0.250
KeepCup #3 Brew Cork	0.250	0.250	0.250
Bamboo cup	0.250	0.250	0.250
PP (Polypropylene)	8.33	16.7	25.0
Compostable cup	250	500	750
Paperboard Cup	250	500	750

2.2.5 Geographical scope

The geographical scope of the study follows the cup production and dispatch to the customer from Melbourne/Australia, Los Angeles/USA and London/UK (Table 4).

Table 4 – Cups origin and key markets including in the study.

Origin	Markets
Melbourne, Australia	Australasia and Asia (Australia, New Zealand, Singapore and China)
Los Angeles, USA	North America (Canada and USA)
London, United Kingdom	Europe

2.2.6 Time boundary

The data sourced from KeepCup was generally for the calendar year 2016. Raw data was based on KeepCup's estimates and measurements for production practices, product specification sheets, and surveys of cup users.

2.2.7 Co-product allocation

The cup life cycle produces several co-products with economic value, including:

- Retired cups or cup parts; and
- Packaging for recycling.

Each of these co-products can be inputs into other product life cycles, e.g. recycled into production of new cups or other products; therefore, there's normally an allocation of impacts according to their economic value. However, in this study, retired cups or cup parts were not considered because they are recycled internally (allocation not necessary); while the value of recycled packaging was considered negligible (See Appendix A).

2.2.8 Biogenic carbon in benchmark paper cups and bamboo cups

Forests are an important sink for carbon in this cycle because they help to offset carbon dioxide emissions and other greenhouse gases that would otherwise contribute to climate change.

In the LCA of land-based products, the use of land and its attributes is part of the life cycle. Hence, LCA can include, and in some cases shall include, shifts in carbon stocks in soil and biomass that are the responsibility of the product being analysed. Losses in carbon stocks due to land-use change (LUC) imply the emission of CO_2 when forests are not harvested sustainably. In this study, it was assumed that all trees and crops grown for cup materials are grown sustainably and don't result in emissions from land use change or deforestation (More details in Appendix A).

2.3 Background data sources

We used ecoinvent v3.2, the world's leading database with several thousand Life Cycle Inventory (LCI) datasets. *ecoinvent* is developed and provided by the Swiss Centre for Life Cycle Inventories. For processes taking place in Australia, we used data from the Australian Life Cycle Inventory (AusLCI) database, which included representative practices of the Australian industry and energy mixes.

Data used for the purposes of modelling was selected based on the following criteria:

- **Relevance:** Information from appropriate sources, data and methods in relation to the primary product data was used.
- **Completeness:** Data was used if it provided a significant contribution to the products' life cycle impacts.
- **Consistency:** Only data that enabled meaningful comparisons in life cycle impact assessment (LCIA) information was used.
- **Accuracy:** Only accurate data was used to reduce bias and uncertainty as far as is practical.
- **Transparency:** Published data was used as far as practical to disclose information to allow third party scrutiny.

These data sources are further detailed in Appendix C.

2.3.1 Exclusion of small amounts

This study has been conducted with the attempt to capture and include all inputs and outputs. It is, however, common practice in LCA/LCI protocols to propose exclusion limits for inputs and outputs that fall below a threshold percentage of the total impact. These impacts can be smaller than the error range associated with the inventory data itself. Exclusion of small amounts in background data used in this study follows the standard approach of *ecoinvent* modelling.

Exclusion of small amounts in the foreground data consisted not on a cut-off delineation but on system boundary setting. Impacts associated with capital equipment and buildings are typically insignificant in LCIs. For this project, capital equipment and buildings were excluded from the assessment scope, as previous studies (Frischknecht, et al., 2007) have demonstrated their immateriality.

The impacts of employees are also excluded from inventory impacts on the basis that if they were not employed for this production or service function, they would be employed for another. It is also difficult to accurately determine the proportion of overall employee impacts to allocate to their work at KeepCup and benchmark cups.

2.3.2 Data requirements and quality

The data quality requirements for the study were set to the following:

- The data sourced from KeepCup shall be representative of the year 2016 and be assumed to reasonably represent the typical operations of the Australian, US and UK factories the foreseeable future beyond this period.
- The foreground data shall be sourced from KeepCups' manufacturing.
- The background data shall be sourced from nationally relevant databases or adapted to regional conditions as far as practical.
- The background data shall be representative of contemporary technology and practices.

The data requirements for the LCA are summarised in Table 5.

Table 5 – Data requirements.

Component	Data related to cups	Data source	Data quality
Raw materials	Source and quantities used for manufacturing and repairing cups	KeepCup staff Manufacturer publicly available data	KeepCup: Good (primary data) Benchmarks: Good. (extended literature research and laboratory test of bamboo cup composition)
Transport to manufacturing site	Transport mode and distance (fuel consumption)	KeepCup staff ecoinvent 3.2 standard market mix distances	KeepCup: Good (primary data) Benchmarks: Unknown or not applicable.
Manufacturing of cups	Material use, energy, emissions, waste and recycling	KeepCup staff ecoinvent 3.2 standard processes	KeepCup: Good (primary data) Benchmarks: Low (unknown specific operations, assumptions-based)
Cup distribution	Transport modes and distance	KeepCup staff	KeepCup: Good (primary data) Benchmarks: Average (assumed same end markets as KeepCup for comparability)
Use	Frequency and type of washing Energy and water use to wash cups	Survey by KeepCup staff ecoinvent 3.2. standard fuel consumptions	KeepCup: Good (primary data from public survey) Benchmarks: Average (not applicable to disposables and reusables assumed same as Keep Cup for comparability)
End of life	Secondary use and waste disposal	Scenarios developed by Edge	KeepCup: Good (primary data from public survey) Benchmarks: Good (extended literature research)

The heat maps in Table 6 and Table 7 show the gaps in data availability and in data quality, respectively.

Table 6 – Data completeness map.

	Raw material requirements and provision	Manufacture and Assembly energy	Manufacture and Assembly wastage	Deliveries	Replacement of parts	Washing regime	Recycling/ Composting rates
KeepCup							
Bamboo cup							
PP cup							
Compostable cup							
Paperboard cup							

No data	Incomplete	Complete

Table 7 – Data quality map.

	Raw material requirements and provision	Manufacture and Assembly energy	Manufacture and Assembly wastage	Deliveries	Replacement of parts	Washing regime	Recycling/ Composting rates
KeepCup							
Bamboo cup							
PP cup							
Compostable cup							
Paperboard cup							

Low	Average	High

3 Life cycle inventory

This section describes the data, data sources, assumptions and quality, for both the raw materials and the processes used at each stage of the cup life cycle.

The following sections specify the inventory for KeepCup and its benchmarks. All LCI data is provided in Appendix B. Background unit processes for all inputs and outputs are provided in Appendix C.

3.1 Raw materials and manufacture

This section outlines the main material, energy and transport inputs and outputs of the life cycle stages from extraction of raw materials to the cup assembly gate. This includes the extraction of resources from nature and man-made materials, their transformation into the materials used in the cups, the manufacture of the cups and cup parts and their assembly, if applicable. Intermediate transport is included as:

- Resources from nature to raw materials – market averages, embedded in background data;
- Raw materials to cup parts - market averages, embedded in background data;
- Cup parts to assembly (for KeepCup only) – actual transport distances and modes from supplier to KeepCup's facilities.

3.1.1 KeepCup

Cup parts

KeepCups are designed in modules: a lid with an over-mould, a plug to seal the lid opening, a cup, and a band which can be silicone or cork-based (see Figure 10). The detailed composition of the parts for 12oz The Original, The Brew and The Brew Cork cups are provided in Table 8 of Appendix B.

The manufacture of lids, silicone bands and plastic cups is done by injection moulding of the materials. The glass cups are blown moulded and the cork bands are press moulded.

The lid, plug and plastic cups are produced in Australia, while the silicone band and glass cup are produced in China, and the cork band in Portugal.

Assembly

The parts are packed into cardboard boxes and then transported to plants in Melbourne, Los Angeles in the USA or London in the United Kingdom, where the cups are assembled and packed into retail boxes. The transport distances between part production site and assembly sites are provided in (

Table 10). Overland distances were estimated on GoogleMaps^{TM} (Google, 2017). Sea distances were calculated on sea-distances.org (Sea-Distances.org, 2017).

The LA and UK assembly plants use grid electricity, but the Melbourne plant has its own photovoltaic system. The inventory also considers the wastage of parts due to defect or breakage, as well as the disposal of wasted parts. Wastage rates vary between 0.1% and 0.6%, depending on the part and material (

Table 10).

Figure 10 – Parts of a KeepCup (not at scale): A – Lid for plastic cup, B – Lid for glass cup, C – Plug, D – Silicone Band, E – Cork band, F – Glass cup, G – Plastic cup.

3.1.2 Benchmarks

The main data source for benchmark cups is research conducted by Edge into product specifications, since there was not access to primary data directly from the manufacturers. Data was retrieved from third-party environmental performance studies, manufacturer's websites and third-party online stores. Parts, materials and quantities are presented in Table 18 and Table 20.

The life cycle database used to model the material supply (ecoinvent) contains average transport distances of products in the market. For instance, ecoinvent data for plastic will include an average distance for plastic between the points of manufacture and transformation.

Modelling assumptions

The following assumptions were made to fill in data gaps in the inventory of cup materials:

- The same lid to cup mass ratio of the compostable cup applied to the cardboard cup and the PP cup;
- The same lid to cup and band to cup mass ratio of The Original KeepCup applied to the bamboo cup;
- The bamboo cup and the PP cup are manufactured by injection moulding;
- 3% of the cardboard's cup weight is polyethylene for the lining.

These assumptions reflect the author's own judgement.

Exclusions

The following data is present in the KeepCup inventory but excluded from benchmark life cycle models due to lack of information:

- Manufacturing energy of the disposable cups;

- Assembly energy of the reusable cups;
- Wastage rates and wasted outputs during assembly;
- Packaging for transport (secondary packaging);
- Intermediate transport steps between manufacture of cup parts and cup assembly, if applicable (e.g. cup part production and assembly at the same location).

3.2 Distribution

3.2.1 KeepCup

KeepCups are distributed to several destinations in three main markets from the assembly plants:

- Melbourne to Australia, New Zealand and Asia;
- Los Angeles to North America;
- And London to Europe.

The sales share of each cup from an assembly plant to the different destinations in its regional market is given in Table 11 to Table 21. A main city was considered per market as the endpoint to the shipping. Small transportation steps (plant to port/airport and local distribution) were excluded.

The shipping uses overland truck transport and air shipping (online and samples only) or sea shipping (remaining sales). The shares of sale types leaving each assembly plant are also provided in Table 12.

The distances of each distribution route were estimated on GoogleMaps™ (Google, 2017) and on sea-distances.org (Sea-Distances.org, 2017). The average distance and transportation mode for each regional market were then calculated as a weighted average across sales types (included the different transport methods) and across destinations (Table 13).

3.2.2 Benchmarks

Because there was no first-hand data on the distribution of benchmark cups, the same destination markets were assumed. The assumed departure point for distribution for all cups is in China and Taiwan. These countries were suggested by the literature review as most likely provenances of either the cups or their raw materials.

The shares going to each market are the average of the three KeepCups, since they compete equally against all versions of KeepCup in this study. Cups were assumed to travel by road and ship (conservative assumption). The distances travelled by each mode are provided in Table 21.

3.3 Use

3.3.1 Cleaning

KeepCup collected data on washing habits of KeepCup users through an open survey with 2,430 respondents. The survey aimed to determine the share of users that adopt machine washing, rinsing or handing washing as the usual cleaning method for their KeepCup (Table 14). KeepCup assumed that figures for The Original and The Brew are the same, while the machine-washing rate is lower for The Brew Cork owners since the cork band is mostly recommended to clean up by hand[7].

The washing rates for The Original/The Brew cups were applied to the bamboo and the PP cups.

Data on the energy and water use of each cleaning option was collected from literature and is provided in Table 15.

3.3.2 Replacement of cup parts

KeepCup users have the option to replace retired cup parts. Part replacement was included in the inventory (rates indicated in Table 16).

3.3.3 End of life: Recycling and disposal

KeepCup collected recycling rates data through an open survey with 2,430 respondents (Table 17).

Different End of Life (EOL) options were modelled for KeepCup cups and its benchmarks based on waste management statistics in Australia, Europe and North America [8]. It was assumed that the cups would be used and disposed of in commercial properties or public spaces, such as offices, shopping centres, or train stations.

Each EOL process includes the energy and material inputs required to dispose of or recycle the cup waste, as well as any direct emissions arising from the waste processing.

The LCI includes an end of life scenario of each material in each broad geographical region. The end of life scenario is defined by the uptake rate of recycling, composting, landfill and waste to energy. These rates were estimated through a literature review and correspond to the fate of waste disposed by the public, mostly household waste. This excludes pathways available to industrial waste, which often offer more options. For instance, composting is often not available to household waste but it can be part of waste management services in other settings.

The process of landfilling includes the operations and emissions during the products residence time in landfill. The release of biogenic carbon of paper and bamboo cups and of cork bands in landfill was included as per the corresponding *AusLCI* or *ecoinvent* processes.

Recycling and waste to energy conversion include the sorting and pre-processing of waste, but exclude the actual conversion into a new product, which was considered to fall in the boundaries of another life cycle.

[7] “Soft cloth and water”

[8] See Appendix E for the background research.

4 Life cycle impact assessment

This LCA step converts the inventoried data into flows of resources and pollutant releases into measurable and communicable impact indicators. Life cycle impact indicators translate quantities of such flows into substances and those substances are grouped according to the impacts they cause and standardised against a reference substances.

For example, 1 kWh of electricity used in the life cycle emits several types of greenhouse gases in different amounts. The greenhouse gases are aggregated in reference to the impacts cause by carbon dioxide (CO_2, the reference substance) and added up to form the climate change impact indicator.

4.1 Impact assessment methods

The environmental impact assessment was based on leading international assessment methods with a well-established and recognised scientific models. The life cycle impacts reported are:

- Climate change: based on the International Panel for Climate Change 100-year global warming potentials[9] - indicates the cumulative effect of greenhouse gas emissions on the climate.
- Energy use[10] - indicates the cumulative non-renewable and renewable energy use across the life cycle.
- Water use, based on water depletion indicator[11] - indicates the cumulative water uses across the life cycle. This indicator does not reflect impact on water availability.
- The full suite of ReCiPe indicators at at the characterisation and weighted level.

The ReCiPe method is an internationally well accepted method covering a wide range of environmental issue. It is recognized as a leading and comprehensive approach to calculate life cycle environmental impacts. ReCiPe was developed in the Netherlands by a consortium including the University of Leiden, the Dutch environmental authorities and private consultancy.

4.1.1 Weighting

Some of the results presented and used in support of the analysis are weighted [12]. This means that the different impact indicators that ReCiPe includes are normalised into unitless impacts and then affected by a weight. The weight reflects the relative importance that each environmental impact has been given by a group of experts.

Weighting is useful in analysing hotspots and trade-offs in life cycles, even though it adds subjectivity to the results.

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[9] Hierarchist ReCiPe (v1.12) midpoint method.

[10] Cumulative energy demand method.

[11] Hierarchist ReCiPe (v1.12) midpoint method.

[12] The set of weights are not the original weights of the ReCiPe method, but were retrieved from an Australia-specific study (Bengtsson, Howard, & Kneppers, 2010).

4.2 Mandatory statements

- ISO 14044 does not specify any specific methodology or support the underlying value choices used to group the impact categories; and
- The value-choices and judgements within the grouping procedures are the sole responsibilities of the commissioner of the study (e.g. government, community, organization, etc.).

5 Results and Discussion

5.1 How does KeepCup compare to other cups?

The charts in Figure 10 to Figure 12 report on the greenhouse gas emissions, water use and energy use of KeepCups and benchmark cups for one year of using. The results are averaged across the three markets. Three scenarios are shown: 250 coffees per year (light use), 500 coffees per year (medium use) and 750 coffees per year (heavy use). This data includes making, transporting, washing and disposing of cups, and excludes the preparation of beverages.

The key findings of this comparison are:

- A year of drinking coffee from KeepCups has lower life cycle greenhouse gas emissions, energy use and water use than doing so in single-use cups in terms of energy use and climate change. However, due to water consumption in washing, single-use cups have lower water use impact, specifically when recommended hand-wash, such as for KeepCups with cork bands.
- Although with significant gaps and based on assumptions, KeepCups' life cycle greenhouse gas emissions, energy use and water use are lower than PP cups' (due to PP's shorter lifespan) and slightly lower than bamboo cups', depending on the KeepCup and the region.
- Bases on the data that was available for this study, using the KeepCup Original and the KeepCup Brew Cork seems to carry lower climate change and energy use impacts than using the other assessed reusable cups, bamboo and PP. The reason why The Brew doesn't show the same trend is the glass cup and the fact that it was assumed to be washed in the dishwasher more often than The Brew Cork.

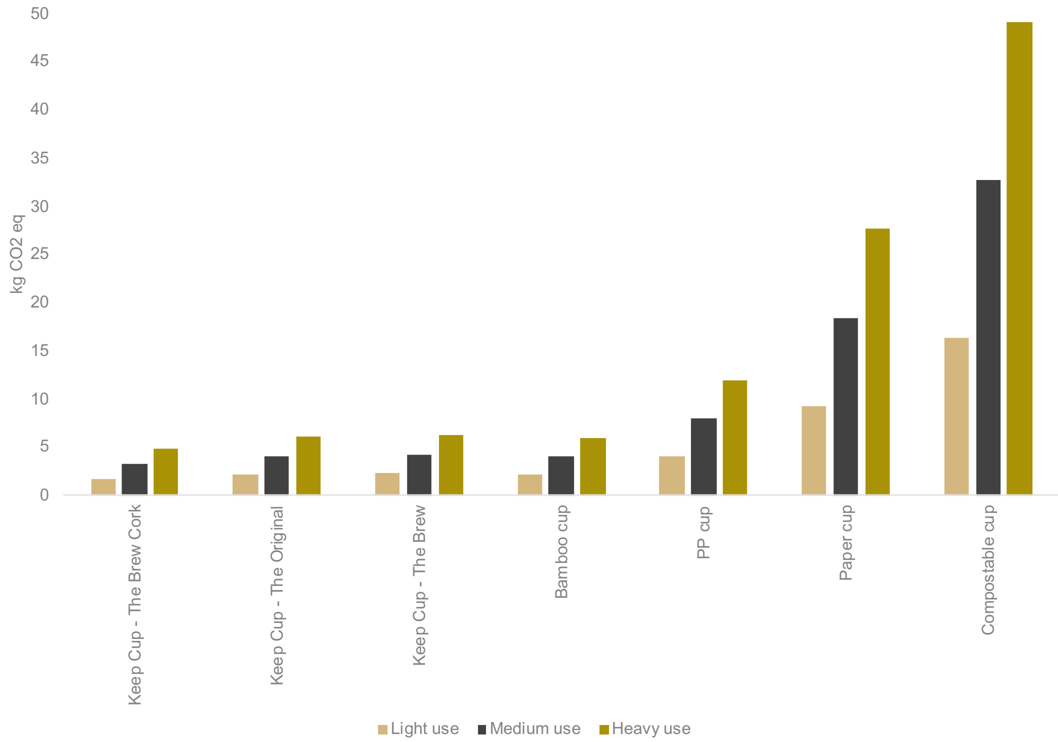

Figure 11 – Climate change impacts of a year of coffee drinking under different use intensities and different cups. Light Use = 250 coffees. Medium use – 500 coffees. Heavy use = 750 coffees.

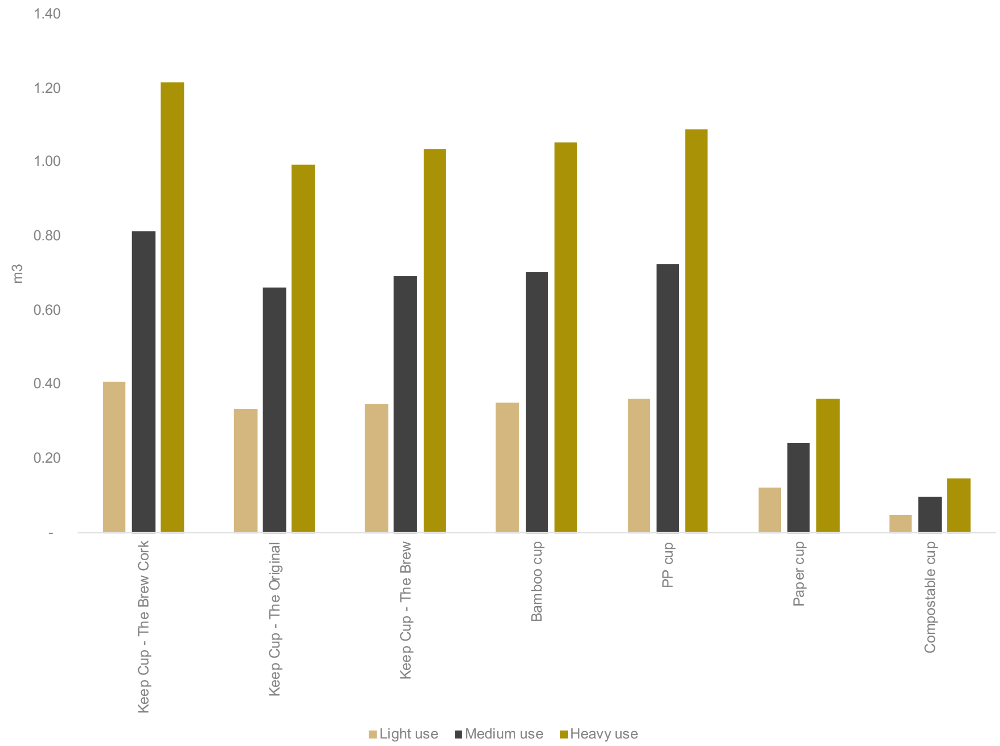

Figure 12 – Water use of a year of coffee drinking under different use intensities and different cups. Light Use = 250 coffees. Medium use – 500 coffees. Heavy use = 750 coffees

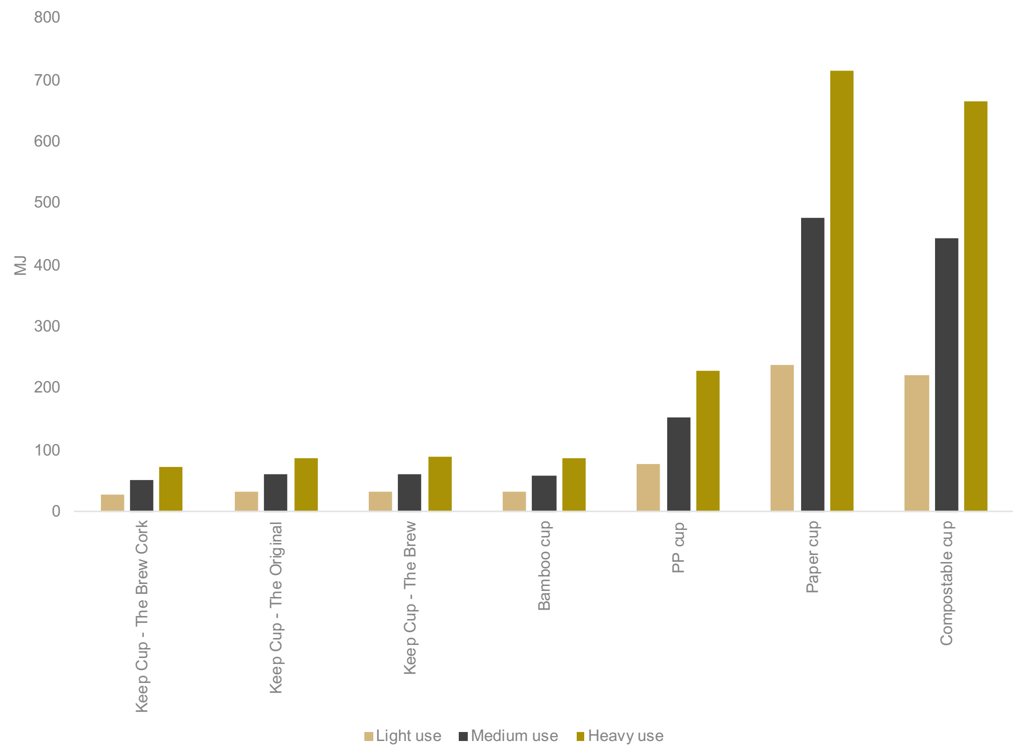

Figure 13 – Energy use of a year of coffee drinking under different use intensities and different cups.

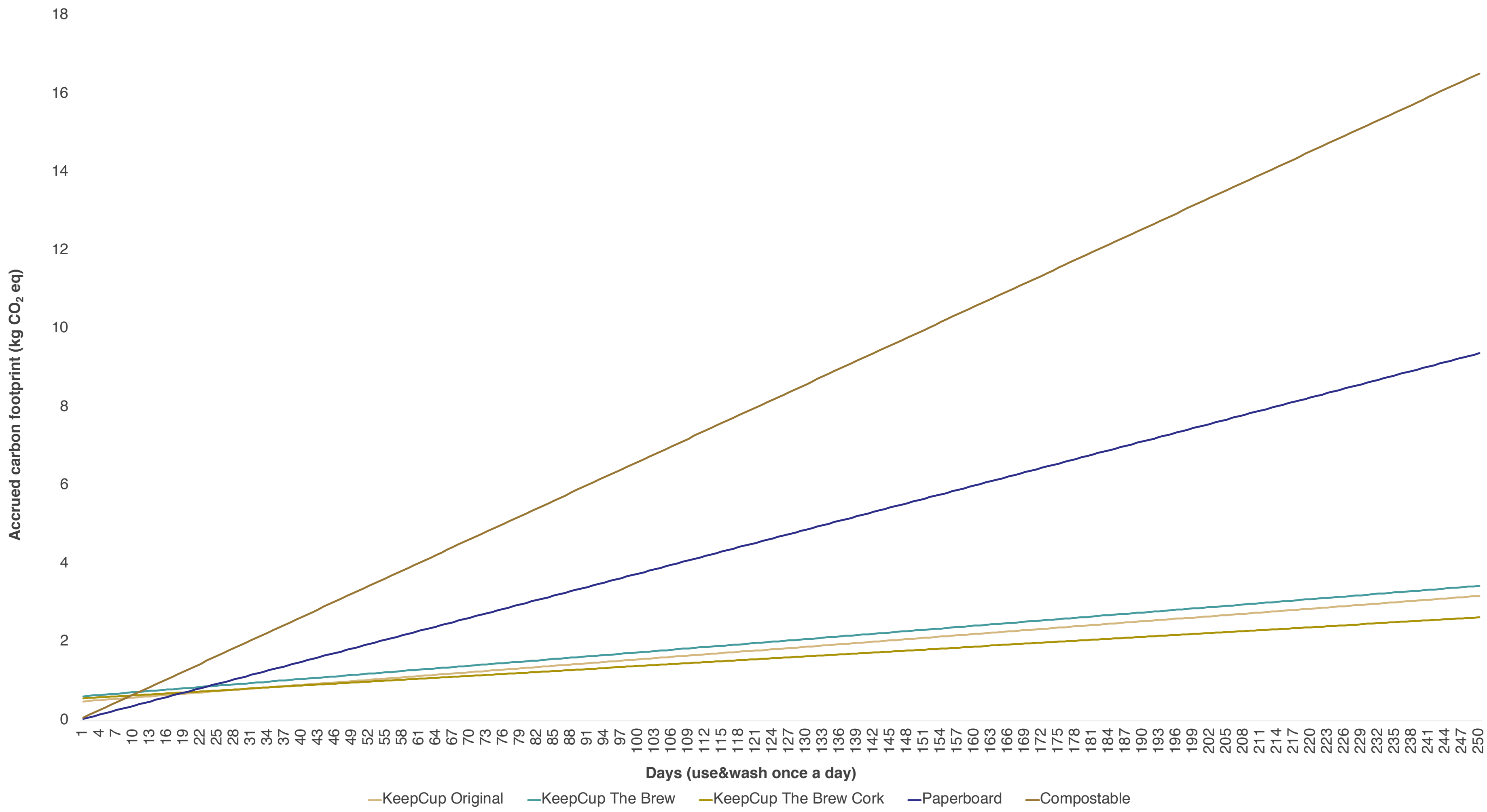

Figure 14 – Carbon footprint comparison over time for KeepCups and disposable cups (based on a light use profile and average of regions).

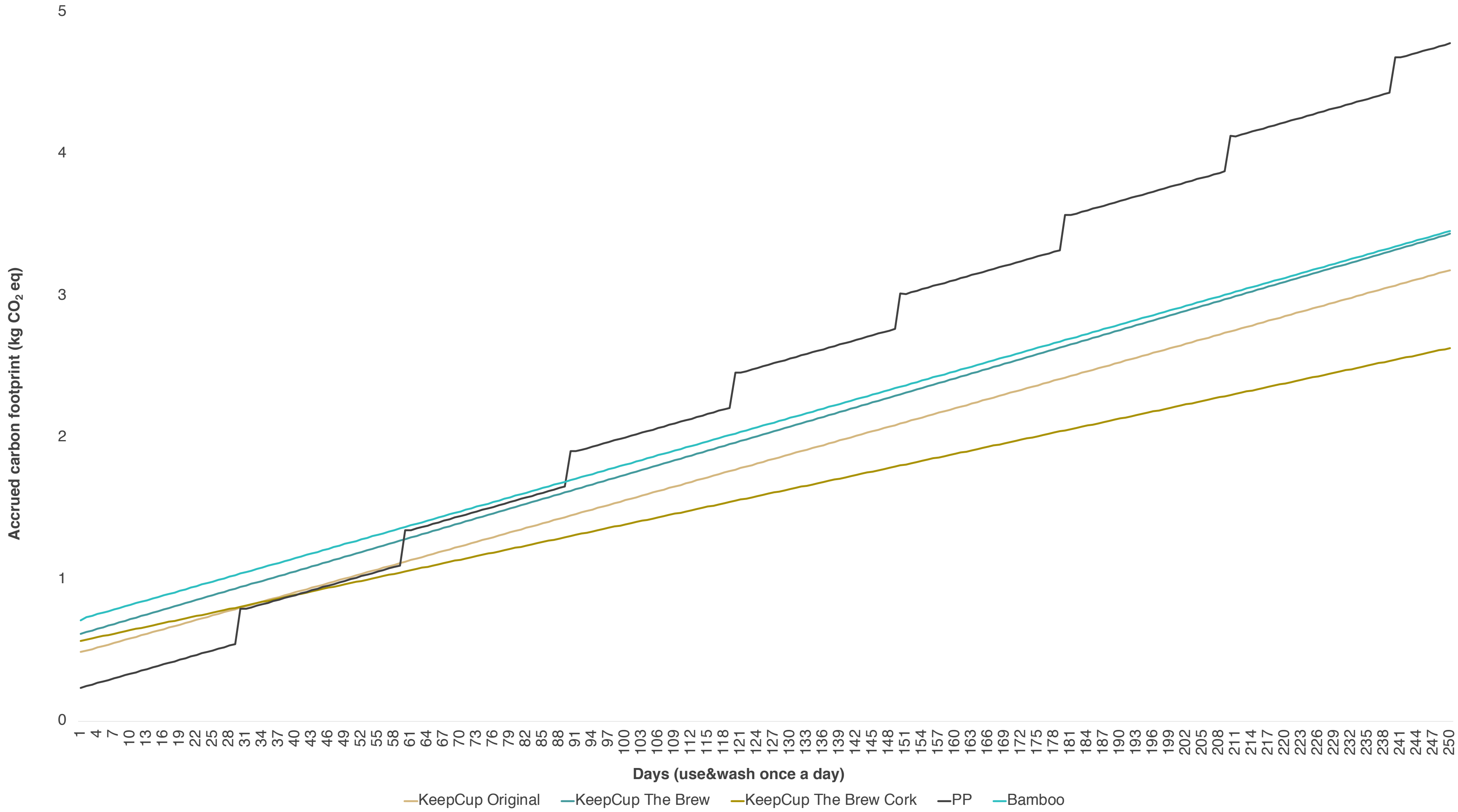

Figure 15 - Carbon footprint comparison over time for KeepCups and reusable cups (based on a light use profile and average of regions).

The timelines in Figure 14 show the accrued carbon footprint of the different cups in function of the number of coffees drank. This chart shows breakeven points when the initial impact of

Even though reusable cups have a higher manufacturing impact, the cumulative greenhouse gas emissions of manufacturing and disposing of single-use cups for each coffee dose, leads to higher impacts on climate change over time.

After 24 days, all KeepCups have a lower impact than a paper cup every day with only one coffee a day. After 10 days, one use per day, all KeepCups have a lower impact than compostable cups (Figure 13)

5.2 What are the hotspots in the life cycle of KeepCups?

The charts in Figure 16 to Figure 18 shows the carbon footprint, energy use and water use of an average KeepCup across the three assembly sites, at the factory gate.

The main driver of the climate change impact of a KeepCup at the factory gate is manufacturing the cup, from 29% to 38% of the total carbon footprint. The second main driver is the lid.

The glass cup has an life cycle greenhouse gas emissions, energy use and water use significantly higher (>50%) than the plastic cup in terms of climate change impact and energy use.

The silicone band has an impact close to twice the impact of the cork band when looking at climate change and energy use. However, the water use of making a cork band is lower than that of making a silicone band.

As a result of these differences in materials and their origins, The Original KeepCup has lower carbon footprint and energy use, followed by The Brew Cork. The Brew Cork requires less water than the other two KeepCup types.

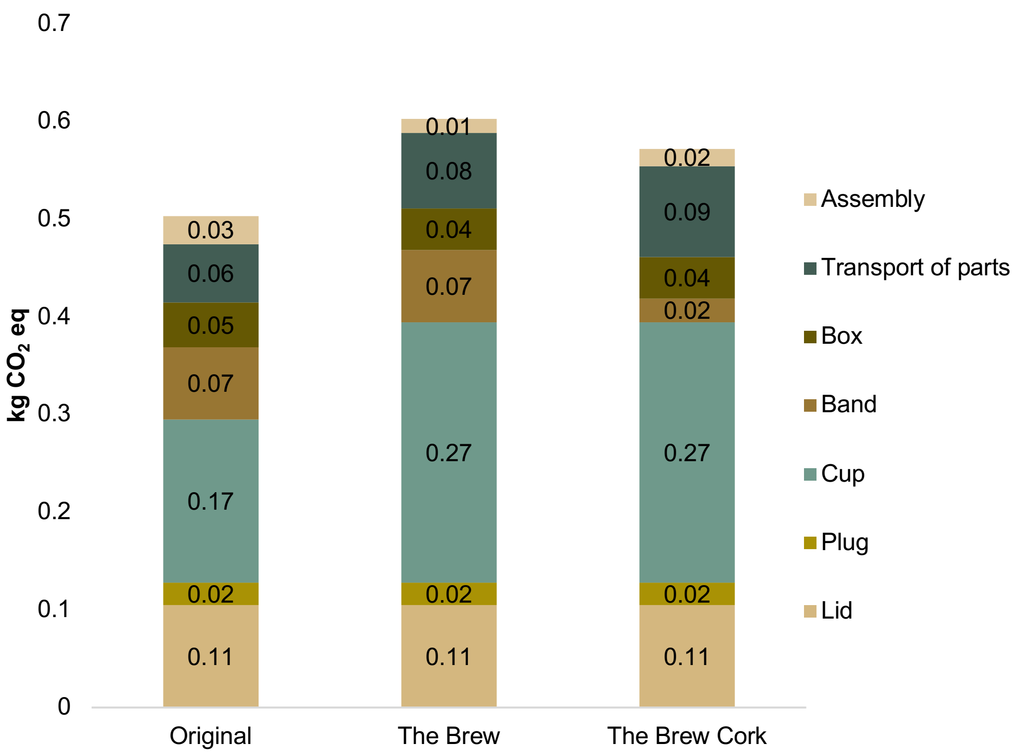

Figure 16 - Cradle to gate climate change impact of the three KeepCups, average across geographic zones.

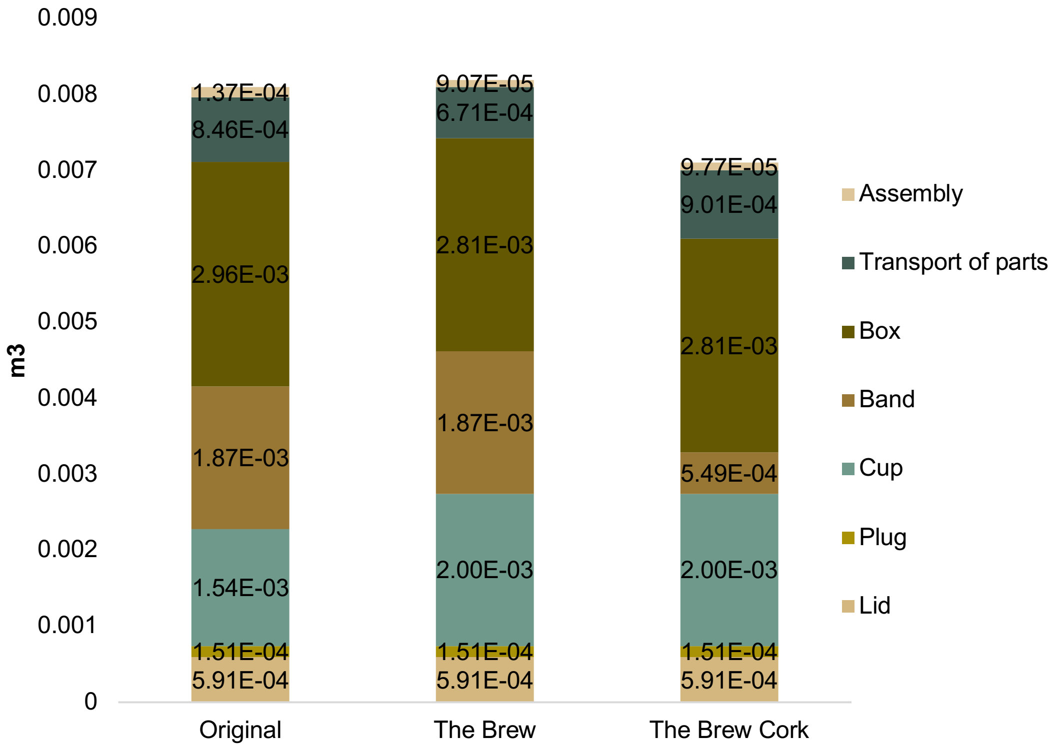

Figure 17 - Cradle to gate water use impact of the three KeepCups, average across geographic zones.

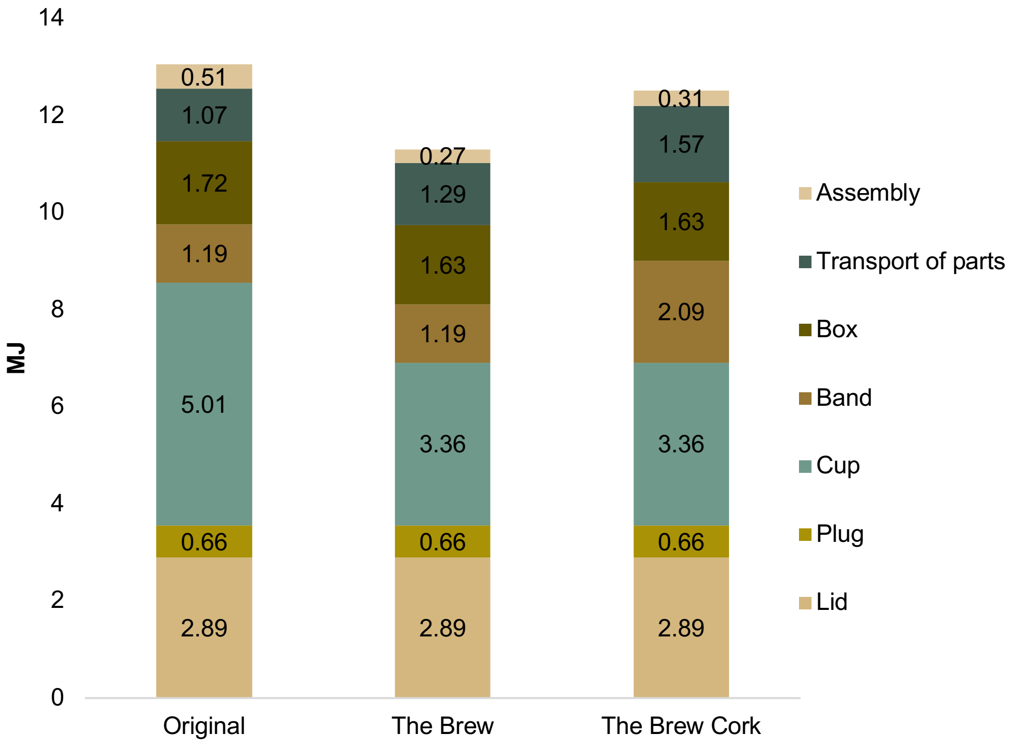

Figure 18 - Cradle to gate energy use of the three KeepCups, average across geographic zones.

Manufacture is a small part of the life cycle greenhouse gas emissions, energy use and water use of KeepCups. The charts below show the contribution to the carbon footprint, water use and energy use of the different stages of a KeepCup's life cycle: making the cup, delivering it to the market, using it and disposing of it. These figures are the average for all KeepCups and all three assembly plants.

Figure 19 shows that the use stage, which includes washing and replacements, is the biggest impact driver in a year of coffee drinking with KeepCups: 91% of the footprint, 99% of the energy use and 88% of the energy use.

By contrast, manufacturing and assembly constitute 7% of the footprint, 1% of the water use and 10% of the energy use.

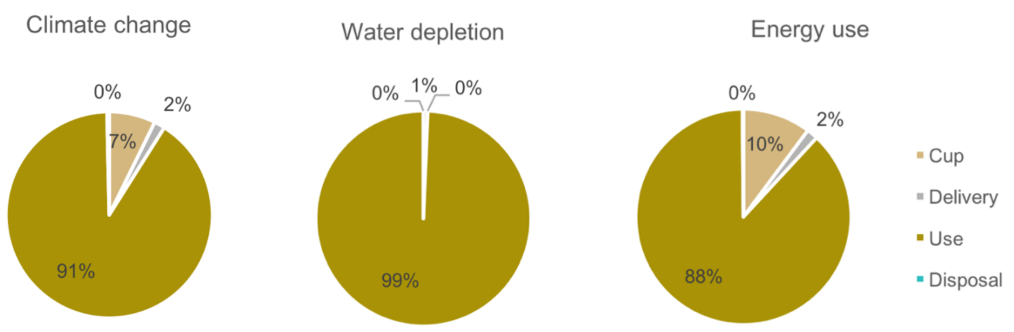

Figure 19 – Contribution of the life cycle stages of a KeepCup to the impact on climate change, water depletion and energy use. This profile corresponds to one year of coffee drinking, with one coffee per day.

In sum, the main impact of the KeepCup life cycle lies away from KeepCup's direct control: use phase. However, the manufacturing stage has the second biggest impact on the KeepCup's life cycle greenhouse gas emissions, energy use and water use.

5.3 Are there differences between KeepCups made in different places?

If we exclude usage and look only to the point the cups are packed and ready for delivery, cups made in different assembly plants have very similar footprints (Figure 20)

Cups made in LA have slightly higher footprint, due to the differences in the electricity mix and the transportation of parts. The largest difference between two keep cups made in different locations is 3%. It makes therefore sense to globally speak of environmental impact of KeepCup at the factory gate.

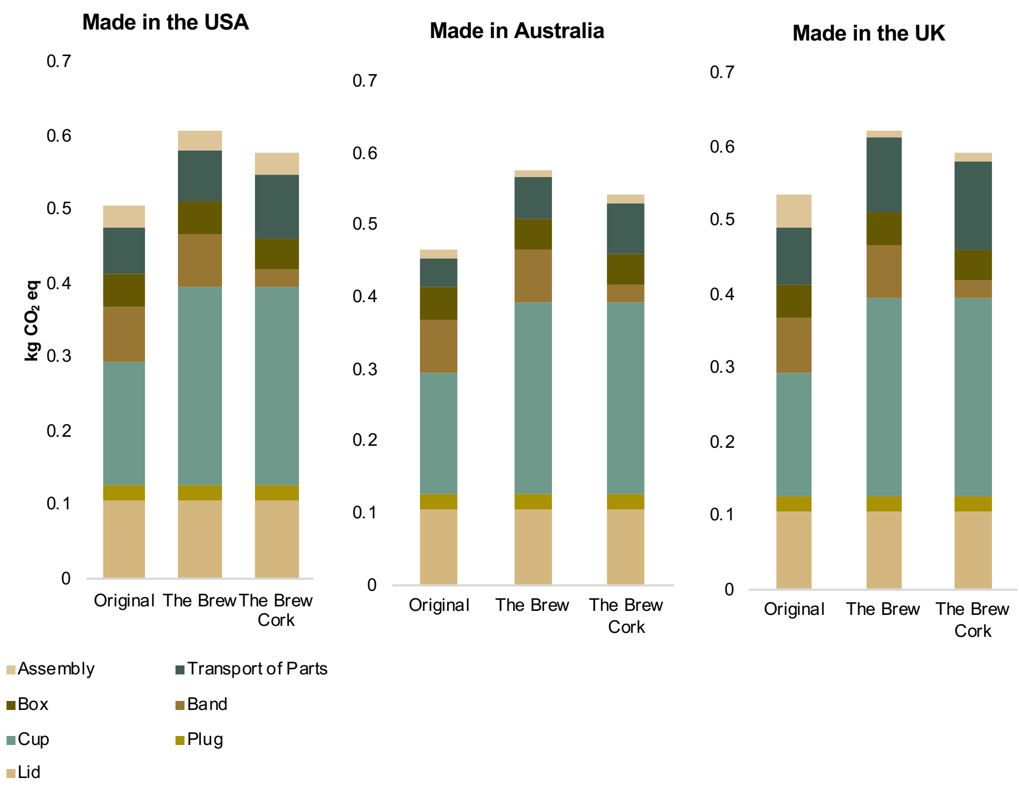

Figure 20 – Difference in carbon footprint between KeepCup's manufactured in the three different plants. The charts show the impact from cradle-to-gate only, i.e. before the cups leave the factories.

Looking at the whole life cycle (Figure 21, Figure 22 and Figure 23 below), there are slight differences in the impacts of KeepCups used in different regions. Because the use stage is so important, this is mostly due to the impact of the energy produced in each region and required to clean each cup in the way each cup is washed.

For instance, the reason why the Australian-made Brew Cork has a lower impact than the other cups used in that market is because it needs to be hand washed, which means there is no coal-based electricity involved in the washing to run the dishwasher. Because the electricity mix in the other regions is relatively cleaner, there are less embedded emissions in the energy required for washing. Hence, it matters less how the cup is washed. This can be seen in the small difference between The Original in North America and The Original in Europe.

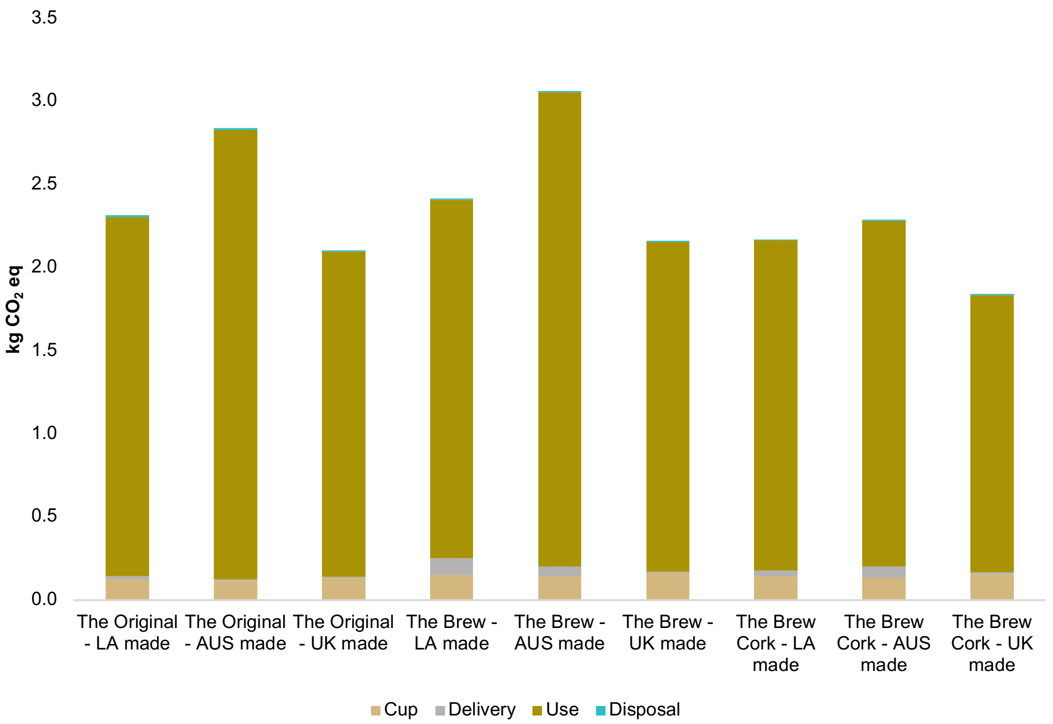

Figure 21 – Climate change impact over the life cycle of a cup for each cup and region.

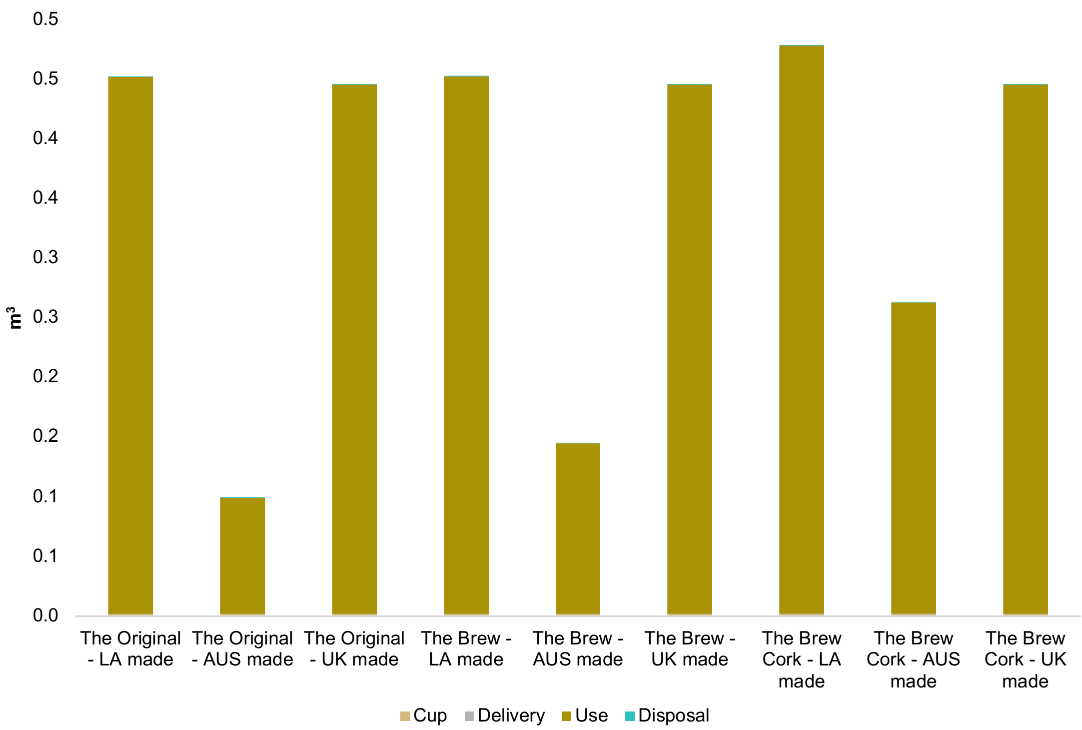

Figure 22 – Water use over the life cycle of a cup for each cup and region

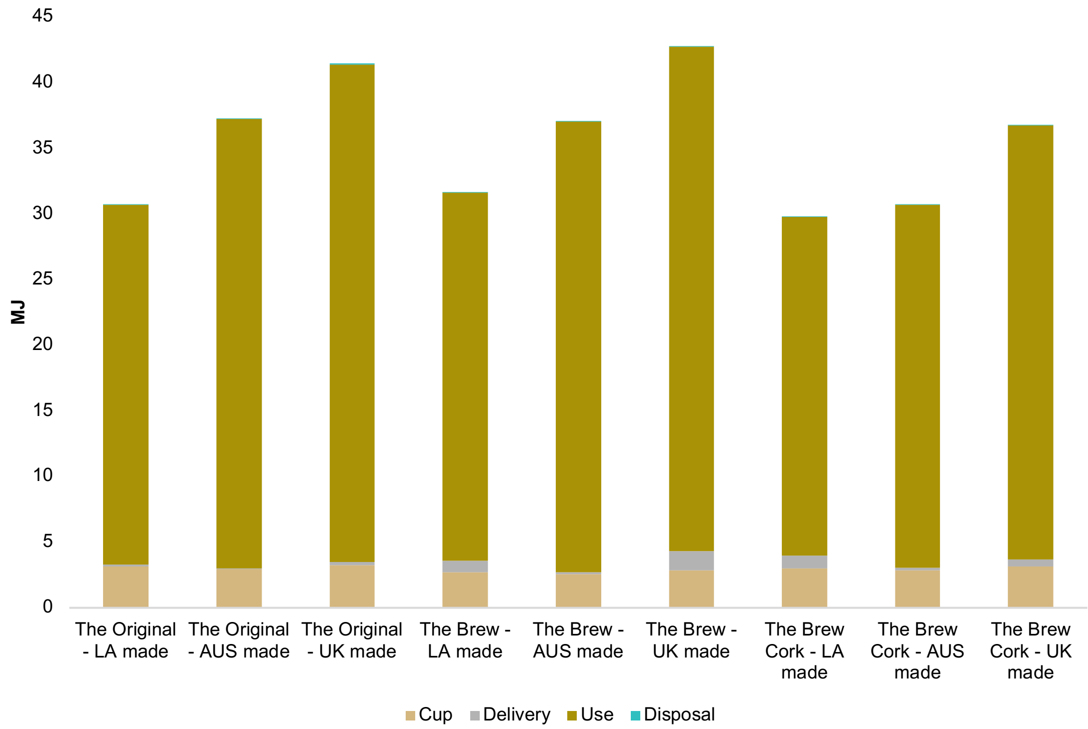

Figure 23 – Energy use over the life cycle of a cup for each cup and region.

5.4 What is the overall impact of all cups assessed?

The charts in Figure 25 and Figure 25 display the overall impact of drinking one coffee per day during one year different world regions.

The first chart shows a range of impact categories weighted according to their relative relevance. This chart demonstrates that:

- The impact on climate change is the foremost issue in all cups' life cycles.
- Depletion of fossil fuel is an issue that stands out in all cups, particularly those that are plastic based: PP cup and The Original KeepCup.
- Using compostable cups stand out for their toxicity impact to terrestrial, freshwater and marine environments and well to humans. Using paper cups results in a significant demand for agricultural land and impacts freshwater and marine ecotoxicity, has well as toxicity to humans.

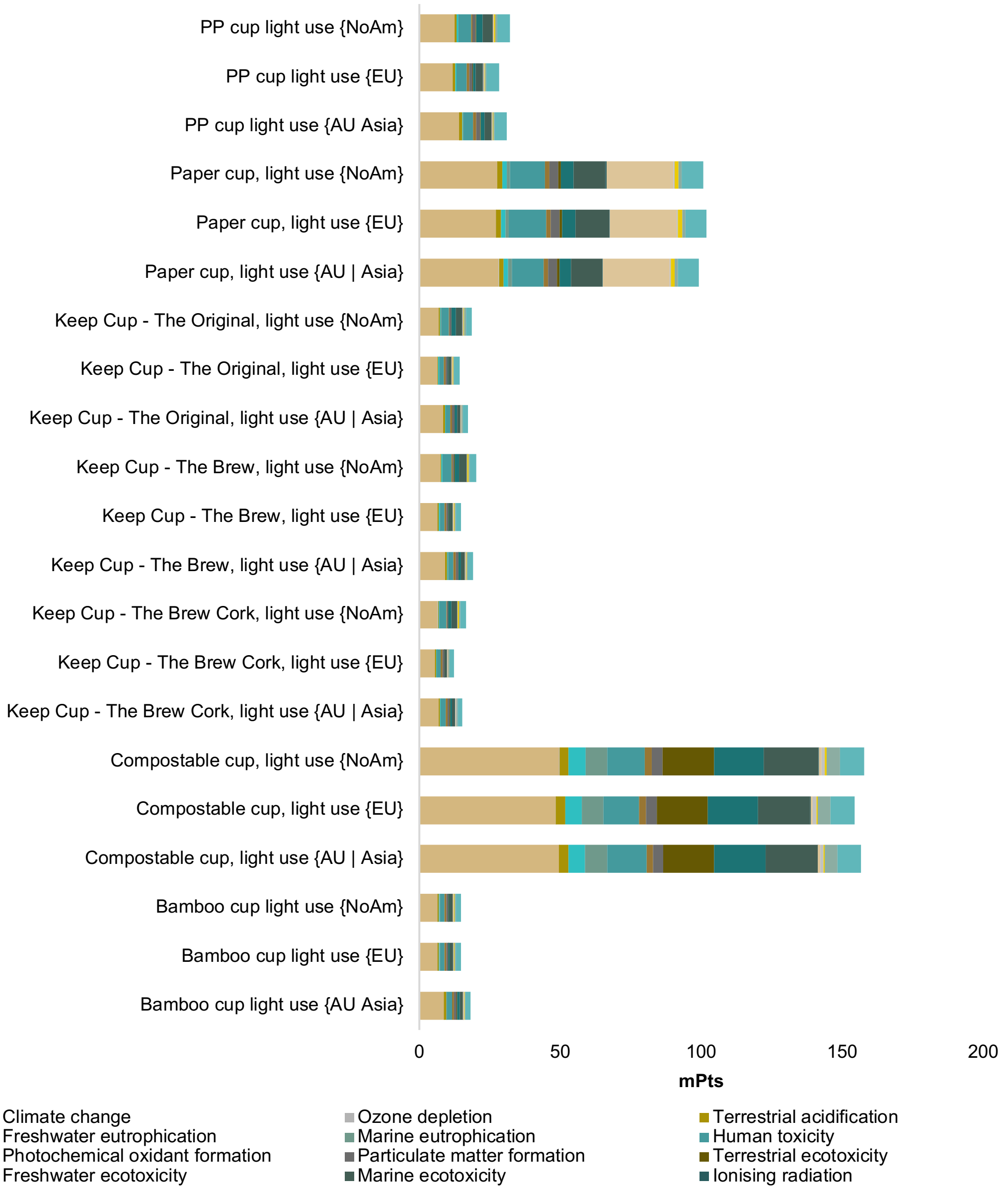

Figure 24 – Weighed midpoint impacts of all assessed cups in all geographic regions. This example is for 250 cups of coffee (i.e. 1 year of light use).

The indicators reported in Figure 25 reflect damage that all impacts assessed in this LCA have on human health[13], ecosystem and resource reserves.

The biggest concerns hailing from using disposable cups are split between damages to human health and to resource stocks. This relates to the recurrent need to replace and process materials after single usage and the emissions of pollutants associated with those activities.

The main issue in the life cycle of reusable cups, including KeepCup, is resource depletion, due to energy and material use.

These findings corroborate that using disposable cups are more impactful than reusable cups, and that using KeepCups is overall impact-leaner than all other cups.

[13] This does not include direct health effects to users of the cups (e.g. exposure to BPA).

There are small differences between the same cup used in different regions, but no pattern to single out a trend in regional impacts.

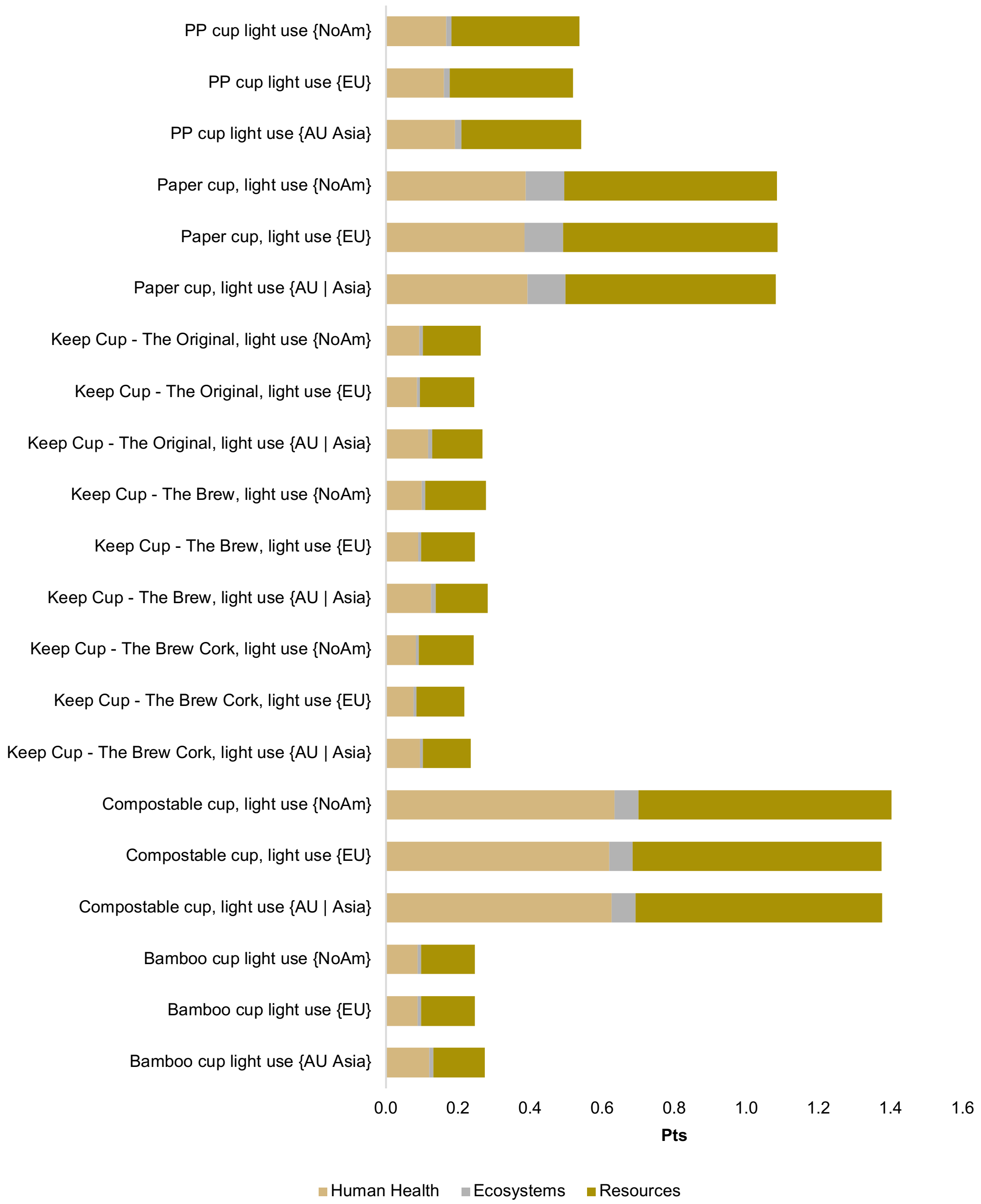

Figure 25 – Endpoint impacts of all assessed cups across different geographic regions. This example is for 250 cups of coffee (i.e. 1 year of light use).

5.5 Implications of taking a conservative approach

Whenever needed, the assumptions made on this study have been conservative towards KeepCup:

- Pessimistic estimations on KeepCup's life cycle, such as durability, recycling and distribution; and

- Assuming zero impact for life cycle stages or data gaps with high uncertainty, such as manufacturing impacts, on the benchmark cups.

Thus, the results and findings from the study should be framed as statements of trends rather than of absolute results, to not provide a false sense of accuracy.

5.6 How confident are we in these results?

Two aspects come to play in the robustness of these results: data fitness and uncertainty.

Data fitness, or quality, for all cups covered in this study is described in Section 2.3.2. We can conclude from it that:

- The profile of KeepCups is robust because data is complete and of good quality (first hand production data and surveys);
- The profile of the benchmark cups is of variable robustness, because data had to be collected from third-party sources and the life inventories are incomplete;
- The lifespans of the reusable cups are based on estimates;
- The most robust results on the benchmark cups pertain to single-use cups, since these have a simpler, better documented manufacturing processes and life cycles; and
- Because the profiles of other reusable cups are based on weak data, it cannot be confidently affirmed that the indicative results of lower impact are sufficiently confident to communicate publicly.

Uncertainty refers to all the variation in the data, regardless of its quality, that we overcome by using averages to represent our model. For example: distribution of a KeepCup in Europe includes travel distances as short at from London to domestic markets to from London to Finland; this range is represented in the model as a weighted average of the sales volumes that reach each market.

The variability in the results per life cycle stage is shown in Figure 26. The error bars indicate the lowest and highest possible footprint of each life cycle stage. The variability in the footprint of the cups is driven by the different materials (glass vs plastic cup and cork vs silicone band). In the assembly, it depends on the location. These two aspects have been discussed in the previous sections.

Most variability falls out of KeepCups direct control, as it sits in the washing of the cups (use stage). The best-case scenario is if all cups were rinsed. The worst-case scenario is if all cups were sold in Victoria (where electricity is mostly coal-based) and all KeepCup users opted for dishwashing them. This is an unlikely burden to fall on KeepCups, as their market is diverse enough to include lower-carbon electricity grids and because KeepCup users prefer different cup-cleaning habits.

The sensitivity analysis presented is merely illustrating the extreme ranges of impact from individual use, to guide where most effort, from a scientific life cycle perspective, should be focussed – consumer behaviour, grid electricity transformation and advocacy for renewable energy and energy efficiency in washing equipment.

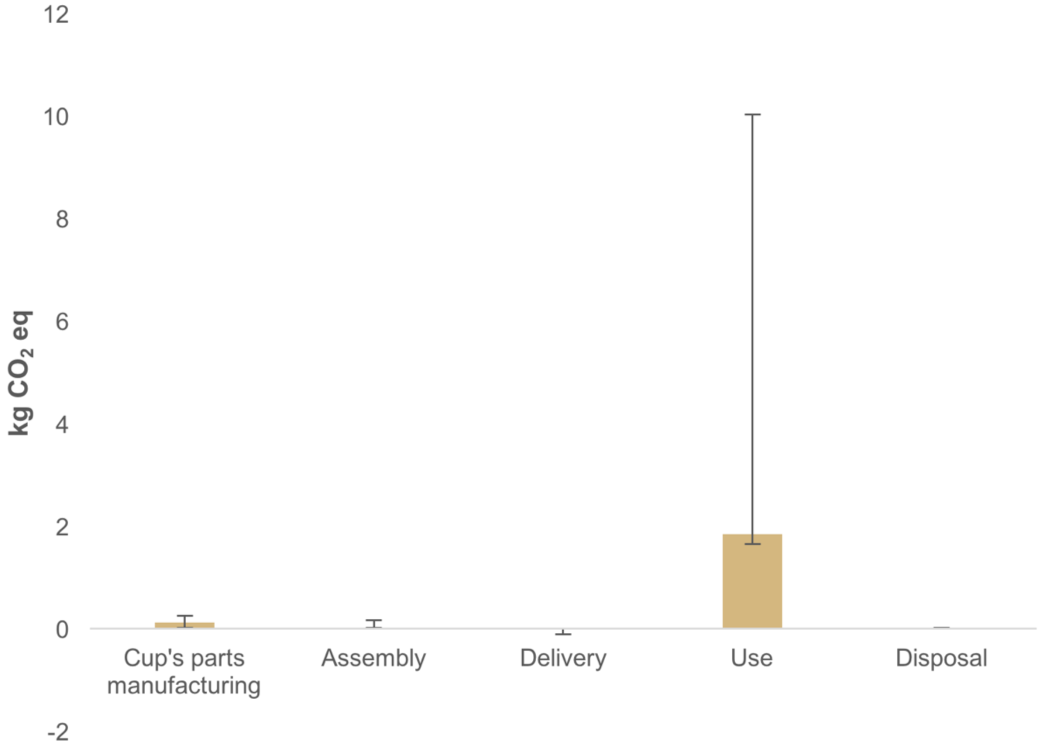

Figure 26 – Range of variation in the carbon footprint of each life cycle stage for a year of coffee drinking with 1 coffee a day (light use profile).

The chart below (Figure 27) shows the influence of the lifespan estimates on the comparison between cups. The bars show the cradle to grave climate change impact for 250 uses in Australasia and Asia calculated with modified lifespans relative to those used in the study. The lifespan of KeepCups and the bamboo cup were reduced to 2 years, from four. The lifespan of the PP cup is increased from 30 uses to 250 uses.

The variation in impact does not overlap with the variation in lifespan because usage (washing) rather than manufacture and disposal contribute the most to the climate change impact of these cups. Halving the lifespan of the KeepCups and the bamboo cup leads to a cradle to gate climate change impact increase between 5% and 9%. Increasing the lifespan of the PP cup by 89% decreases the same impact by 37%.

These figures also suggest also that the comparative assertions made in the previous sections are only fickle if KeepCup has largely overestimated the lifespan of certain cups in relation to each other.

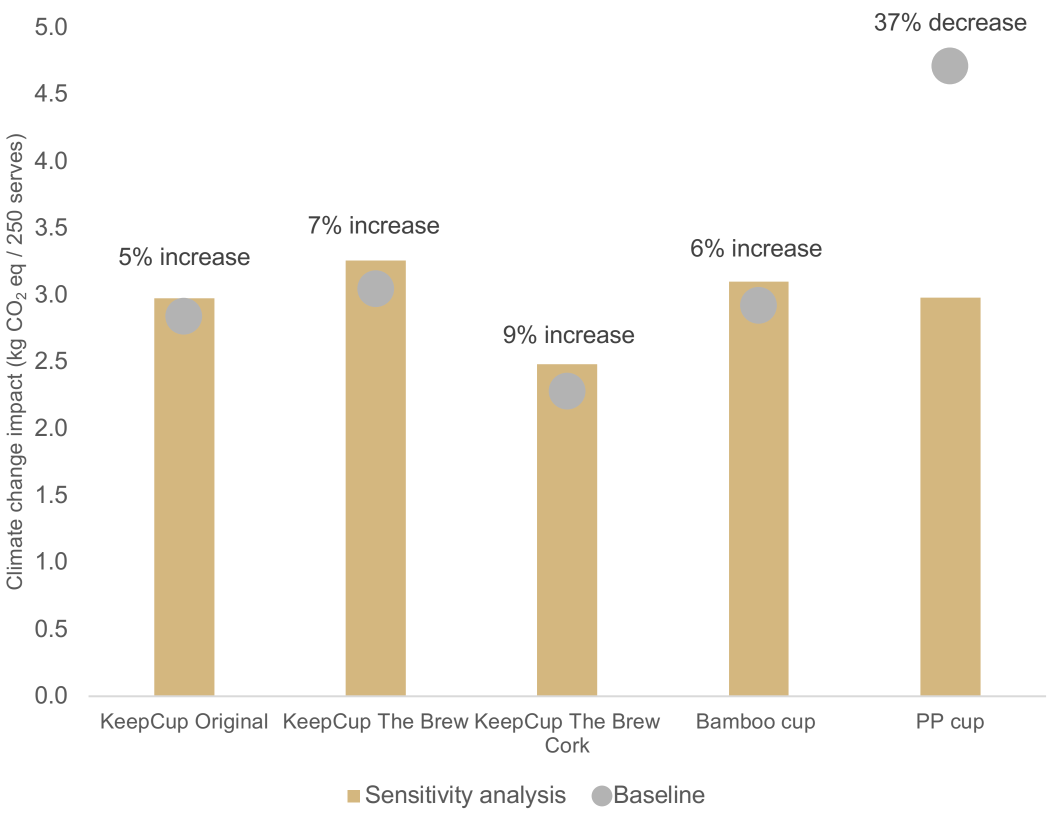

Figure 27 – Cradle to grave climate change impact of reusable cups with modified lifespans (bars) against the baseline results (dots). The scenario analysed is light use in the Australasia – Asia region. The modified lifespans are 2 years instead of 4 for KeepCup and the bamboo cup and 1 year instead of 30 uses for the PP cup.

6 Recommendations

6.1 Lowering environmental impacts for KeepCup products

The main impacts of KeepCup fall outside the company's control – i.e. during the use stage. While this limits KeepCup's influence to some extent, there is still an important opportunity to advocate for better outcomes in that stage. The manufacturing of parts and assembly are the second and third most important impacts and both are more within KeepCup's control (Figure 28).

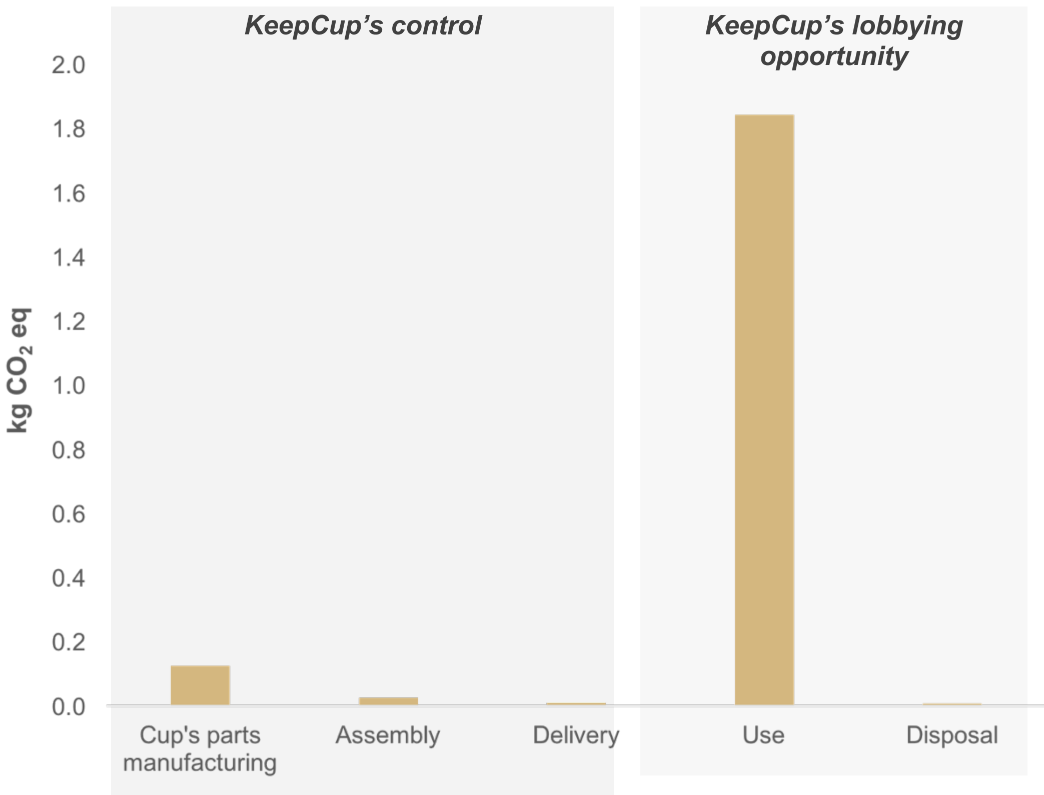

Figure 28 – Carbon footprint over the life cycle of an average KeepCup.

Cup materials and parts:

- **Choice of materials:** as observed, glass cups have a higher impact than plastic cups, while the cork band has lower carbon footprint than the silicone band. Considering the relative small and at this stage uncertain environmental difference between reusable cups of other materials (e.g. bamboo), it is arguably in KeepCup's interest to explore alternative cup materials, evaluate different combinations of parts to build the lowest impact cup, and communicate the differences to the consumers, providing them with the opportunity to choose according to their material and environmental preferences.
- **Recycled materials:** to evaluate the possibility of incorporating recycled glass (waste from the processes or post-consumer) as a raw material to reduce the impact of material extraction and processing.

Assembly:

- **Energy efficiency:** to incorporate energy efficiency technologies or techniques to reduce the amount of energy consumed during assembly.
- **Renewable energy:** now, the Melbourne plant is the only that has its own photovoltaic system, and its impact associated with the assembly is considerably lower than for example the UK. KeepCup could consider the possibility of incorporating renewable energy in its other plants.

Use stage:

The use stage has the higher environmental impact of KeepCup, so it is very important for the company to influence consumer behaviour through education and communication. The areas to be addressed should be:

- **Cleaning of the product:** To encourage hand washing over dishwashing can reduce the use of energy in the household. In order to maintain a low water use when handwashing, KeepCup should also encourage water efficiency techniques, such as avoiding rinsing or using a sink plug instead of letting the tap run continuously[14];
- **To promote the use of water and energy efficient dishwashers:** Australia has the Water Efficiency Labelling and Standards (WELS), which allows consumers to compare the water efficiency of different products[15].
- **Replacement of parts:** the replacement of parts instead of disposing a KeepCup could increase the life of the product and therefore reduce the need for new raw material extraction and energy use in the manufacturing and assembly processes. KeepCup should encourage this replacement among its consumers, providing them with information on the relevance of the practise and facilitating the process of obtaining new parts.
- **Recycling of the product:** KeepCup should always encourage an increase in recycling of their products in order to reduce the overall impact, and also since the company has the mission to reduce waste plastic. Educating consumers on the importance of recycling is key for KeepCup, as well as having the adequate infrastructure and logistics to stack and recycle the product.
- **Repurposing KeepCups:** The obvious implication of the modular nature of KeepCups, is that KeepCup users not wanting to replace faulty or damaged parts can still use functioning cup parts. Encouraging users to repurpose viable cup parts would decrease the impact from disposal.

6.2 Communication opportunities and use of study in public domain

KeepCup should consider commissioning a third-party critical review of the LCA study before the results are used to support a comparative assertion intended to be disclosed to the public in order to ascertain compliance with the appropriate ISO standards.

It is also important for KeepCup to consider the Australian Competition & Consumer Commission, to comply with legislation regarding environmental claims. A summary of the points the company should focus on is presented in Figure 29 below. For the UK, the

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[14] Australian Government (n.d.). Use water efficiently. Available at: http://yourenergysavings.gov.au/water/water-home-garden/water-efficiency-home/use-water-efficiently

[15] Database available: https://wels.agriculture.gov.au/wels-public/search-product-load.do?src=menu

Department for Environmental Food & Rural Affairs has a similar checklist, while in the USA the “Seven Sins of Greenwashing” are very popular (Appendix D).

According to those institutions, Edge recommends that KeepCup use statements such as:

> *“An independent life cycle assessment has demonstrated that using KeepCup has the lowest environmental impacts compared with functionally equivalent alternatives” rather than “KeepCup saves the environment”.*
>
> *“Drinking one cup of coffee a day – compostable cups’ carbon footprint overtakes that of all KeepCups after only 10 days, and after 24 days for paper cups. Considering KeepCups are typically used for years, this amounts to significant lifetime carbon savings.”*
>
> *“If everyone in Australia switched to KeepCups rather than using disposable cups, the amount of emissions that would be saved in a year would be equivalent to over 100,000 hours of flight time for a Boeing 747 in terms of greenhouse gas emissions[16].” rather than “KeepCup are climate friendly”.*

- ✓ **Avoid using terms like ‘safe’ and ‘friendly’ and unqualified pictures or graphics.** At best they are unhelpful and encourage skepticism; at worst they are misleading.
- ✓ **Spell out exactly what is beneficial about a product in plain language** that consumers can understand.
- ✓ **Link the environmental benefit to a specific part of the product or its production process**, such as extraction, transportation, manufacture, use, packaging or disposal.
- ✓ **Make sure any claims you make about your product can be substantiated.** Think about how you would answer a query regarding the environmental benefits you are claiming about your product. For example, what scientific authority could you use to justify the basis of your claim?
- ✓ **Explain how a product’s characteristic is beneficial to the environment**. For example, explain that a phosphate-free product is less damaging in river systems because phosphate promotes algal growth, which can clog up rivers.
- ✓ **Avoid giving the impression that your product is completely environmentally benign if it is not.**
- ✓ **Use the claim only in an appropriate context or setting.** For example, do not claim that a product is not tested on animals if it is a product that would never be tested on animals anyway.

Figure 29 - Checklist for green marketing. Source: Australian Competition & Consumer Commission, Green Marketing and Trade Practices Act.

How and where to communicate will also be important for KeepCup. International consumer studies suggest that claims on a product are very important, in fact in 2014, 51% of Millennials reported checking the product packaging for sustainability claims before making a purchase[17]. Although a claim is a great start, the same study suggests that it needs to be accompanied by a marketing strategy to reinforce the message and make sure it is reaching the desired market.

There is a broad scope of opportunities to communicate and help deliver the improvement opportunities confirmed in this study. Edge suggests considering the following communication platforms/media:

- Website content, fact sheets and calculators for consumers seeking in-depth information.

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[16] Carbon Independent (2015) http://www.carbonindependent.org/sources_aviation.html

[17] Nielsen, 2014. The Sustainability Imperative. New insights on consumer expectations.

- In cup box information brochure for new and existing clients to appropriately use the cup, with a focus on their choices in cleaning the cup specifically.
- Media release to reach and reinforce the message with new and existing clients and audiences.
- Events planning and guidelines for life cycle optimised beverage solutions.
- Environmental certifications through for example Good Environmental Choice Australia (GECA), Cradle to Cradle, or other suitable eco-labelling programme.
- Café owner and barista manuals and guidelines to educate and empower them to do the right thing by the environment.
- Conference presentations and dissemination of the work through academic journal articles.
- Advocacy on public policy and procurement guidelines to influence decision making and planning for infrastructure and regulatory upgrades and changes.
- Sales presentations and material for sales staff to ensure they optimise the opportunity to hit the right sustainability strategy and targets owned by your customers.

In preparing this report, we considered the guidelines by the Australian Competition and Consumer Commission (ACCC), and other guidelines on environmental marketing. Although the results are robust and defensible, they are complex, and care needs to be taken when placing them in the public domain.

If these results are to be used for any comparative assertion in the public domain (e.g. that plastic cups are better than paper cups), they require critical peer review. We have therefore taken care to prepare this report for peer review, including compliance with ISO 14040, the international benchmark for this type of assessment.

Australian Competition & Consumer Commission

6.3 How to improve this study – Closing the Knowledge Gaps

Some of the story emerging from this study remains untold. Some data on benchmark cups remain gaps and we assumed zero impact where there was insufficient data to characterise the impacts, meaning we have likely underestimated the impact of for example bamboo cups. It is likely in KeepCup's interest to work towards refining benchmark data and closing data gaps, to explore alternative options for sourcing more specific information on raw materials and manufacturing of bamboo cups in particular.

KeepCup is invested in its mission to reduce waste to landfill or littering the environment. There are data gaps in science concerning the end of life impacts of plastics, and as such methodologies such as life cycle assessment cannot properly account for them.

KeepCup could take a proactive role in clarifying what its contribution to "the plastic problem" is by aligning with research initiatives such as the recently launched Medellin Declaration on Marine Litter in Life Cycle Assessment and Management, or potentially commissioning its own studies to support the agenda.

There is also an opportunity for the coffee cup market to provide more data and details on the respective life cycles of cups. KeepCup is through this report attempting to catalyse more transparency by disclosing their information and LCA, and to provide very conservative representations for the rest of the market.

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Appendix A - LCA standards and Approach

There is a range of complementary or otherwise largely compatible LCA standards and guidelines available. The leading initiatives are set out below, in order of generality.

ISO14040 and ISO14044

ISO14040 describes the principles and framework for the LCA. It does not describe the LCA technique in detail, nor does it specify methodologies for the individual phases of the LCA.

ISO14044 specifies requirements and provides guidelines for LCA: definition of the goal and scope of the LCA; the LCI phase; the LCIA phase; the life cycle interpretation phase; reporting and critical review of the LCA; limitations of the LCA; relationship between the LCA phases; and conditions for use of value choices and optional elements.

Footprint or market effect – Attributional and consequential LCA

LCA can be applied to answer one of the following questions at a time:

- What is the footprint of my product based on the current life cycle; or
- What is the effect on the additional offer/demand of a certain product in the market?

Given KeepCup's requirements, our analysis looks to answer the first question, which is known as an attributional perspective of LCA –an accounting based method looking at the here and now. This is a standardised modelling approach that assesses a product against its interaction with the environment, based mainly in physical exchanges.

An alternative pathway to LCA modelling is the consequential approach, which is best suited to answer questions such as "what is the effect on the additional offer/demand of a certain product in the market?" In consequential LCA, market models are employed to establish displacement and substation sequences in the market.

See Table 8 for a summary of the four main differences between the two approaches.

Table 8 – Difference between attributional and consequential LCA (Brander, Tipper, Hutchinson, & Davis, 2009).

	Attributional	Consequential
Application	Understanding the total emissions directly associated with a life cycle	Understanding the change in emissions resulting from a purchasing or policy decision that leads to a change in output of a product
System boundary	Processes and flows directly involved in the life cycle	Processes and flows directly and indirectly affected by the marginal output of the life cycle
Data and uncertainty	Balanced relationships between flows, low uncertainty	Modelling of market effects, high uncertainty

Allocation to waste products

The co-product approach allocates environmental impacts to both the cup and the co-product life cycle, in proportion to their economic value.

In this study, we did not allocate/share any of the environmental impacts to the co-products resulting from cup manufacturing, because co-products are recycled internally (allocation not necessary).

The ratios of economic allocation for recovered waste products was screened for recycling of plastic, composting of compostable materials and energy recovery:

- Allocation of impacts to recycled plastic considered losses from the plastic recycling stream (not all plastic is recycled, there is a loss in each life cycle the plastic is recycled) and the decrease in value (recycled plastic is worth less than virgin plastic/resin). This resulted in an allocation of 21% of the burden to the scrap.
- Allocation of impacts to compost from compostable cups assumed the price of compost to be $0.4/kg and the price of the cups to be $0.12. This is a conservative approach that uses the lowest compostable cup price (that of compostable cups, rather than bamboo cups) which decreases the impacts of the cups. A 54% mass loss during composting was assumed. The resulting allocation factor to compost is 3%, which was considered negligible.
- Also negligible is the value of low grade heat generated from waste combustion. The estimation considered a thermal energy production rate of 8.15 MJ/kg from plastic which is sold at $0.01/MJ.

The cups life cycles include the negative impacts associated with waste generated, including recycling operations and used materials disposed in landfill.

Treatment of biogenic carbon

Trees and bamboo have a natural ability to concentrate and store carbon. Through photosynthesis, plants absorb CO_2 from the atmosphere. Carbon accounts for around 50% the dry weight of a tree. When trees and bamboo are harvested, and manufactured into products such as fibres or pulp, this carbon remains stored for the life of the product, and can continue to reside in the wood for a considerable time once the product's service life ends, depending on how it is disposed. Only when a tree or wood product decays or is burned does the carbon return to the atmosphere. When plant-based products degrade in landfill, it takes hundreds of years to break down into both carbon dioxide (CO_2) and methane (CH_4), resulting in a temporary carbon sink, removing CO_2 from the atmosphere. This temporary removal of carbon dioxide from the atmosphere results in a delay of climate warming impact. In this study, cups are considered short-lived products and LCA guidelines do not recommend including temporary storage due to methodological uncertainties.

When timber is harvested outside a sustainable forestry scheme (e.g. compliant with the Forest Stewardship Council (FSC) certification requirements), it can be assumed that deforestation occurred and that the biomass stock in the forest will not be replenished. This is due to a land use (e.g. forest to cropland) or due to poorly managed land use (e.g. forest can regrow but not fully). In either case, there is a change in the carbon stock of that area and the lost carbon is accounted for as a CO_2 emission (see Figure 30).

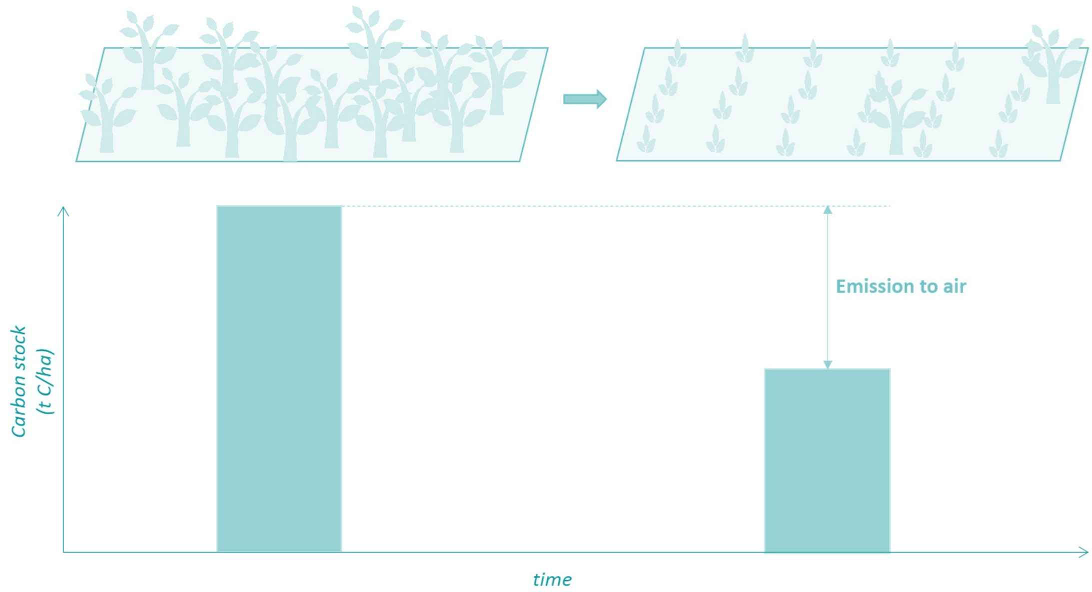

Figure 30 – Loss of carbon stocks in land due to LUC/deforestation.

The carbon that is lost is the carbon stock of the removed biomass. Part of that carbon stock is preserved in the wood product during its lifetime. A share of that stock, however, is assumed to be immediately lost through biomass burning and degradation.

If, on the other hand, timber is harvested sustainably, it can be assumed that there is a cycle with carbon neutrality, the carbon lost through harvest is re-absorbed through re-growth. Only the emissions from biomass that is immediately burned/degraded are considered.

In this study, it was assumed that all trees and crops grown for cup materials are grown sustainably and don't result in emissions from land use change or deforestation.

Appendix B – Life cycle inventory data

KeepCup

Table 9 – Inventory of Keep Cup parts.

KeepCup	Component	Mass (kg)	Materials
The Original	Lid	0.021	Low density polyethylene
	Plug	0.006	Low density polyethylene
	Cup	0.049	Polypropylene
	Band	0.014	Silicone #7
	Retail Box	0.026	Cardboard - Forest Stewardship Council certified
	Insert Brochure	0.004	100% recycled paper – Forest Stewardship Council certified
The Brew	Lid	0.018	Synthetic rubber – thermoplastic oleifin and high density polypropylene blend
	Lid over-mould	0.009	Thermoplastic rubbers
	Plug	0.006	Low density polyethylene
	Glass Cup	0.220	Tempered soda lime glass
	Band	0.014	Silicone #7
	Retail Box	0.025	Cardboard - Forest Stewardship Council certified
	Insert Brochure	0.004	100% recycled paper – Forest Stewardship Council certified
The Brew - Cork	Lid	0.018	Synthetic rubber – thermoplastic oleifin and high density polypropylene blend
	Lid over-mould	0.009	Thermoplastic rubbers
	Plug	0.006	Low density polyethylene
	Cup	0.220	Tempered soda lime glass
	Band	0.014	Cork, glue
	Retail Box	0.025	Cardboard - Forest Stewardship Council certified
	Insert Brochure	0.004	100% recycled paper – Forest Stewardship Council certified

Table 10 – Assembly of Keep Cup. All units per cup.

	Input/Output	Unit	The Original	The Brew	The Brew - Cork
Parts in	Lid	p	1.001	1.001	1.001

	Input/Output	Unit	The Original	The Brew	The Brew - Cork
	Plug	p	1.001	1.001	1.001
	Cup	p	1.001	1.062	1.062
	Band	p	1.021	1.021	1.003
	Retail Box	p	1.003	1.003	1.003
	Insert Brochure	p	1.003	1.003	1.003
	Boxes for parts	kg	0.032	0.021	0.030
Melbourne Assembly	Electricity (PV)	kWh	0.0009	0.0009	0.0009
	Transport of parts (truck)	kgkm	15.9	31.7	32.5
	Transport of parts (ship)	kgkm	159	2,475	2,756
Los Angeles Assembly	Electricity (grid)	kWh	0.1	0.1	0.1
	Transport of parts (truck)	kgkm	15.9	31.7	32.5
	Transport of parts (ship)	kgkm	2,037	3,632	4,213
United Kingdom Assembly	Electricity (grid)	kWh	0.05	0.05	0.05
	Transport of parts (truck)	kgkm	15.9	31.7	32.5
	Transport of parts (ship)	kgkm	3249	6439	7053
Waste	Plastic (recycling)	kg	0.000	0.000	0.000
	Glass (recycling)	kg	0.000	0.014	0.014
	Cork (landfill)	kg	0.000	0.000	0.000
	Paper and cardboard (recycling)	kg	0.033	0.021	0.030

Table 11 - Sales shares from assembly plants to their regional markets per KeepCup.

Origin	The Original	Sales share	The Brew	Sales share	The Brew - Cork	Sales share
Melbourne	NSW/Sydney	35.8%	VIC/Melbourne	36.4%	VIC/Melbourne	30.7%
	VIC/Melbourne	34.6%	NSW/Sydney	24.2%	China/Shanghai	26.7%
	WA/Perth	13.6%	China/Shanghai	16.7%	NSW/Sydney	17.3%
	QLD/Brisbane	12.3%	QLD/Brisbane	12.1%	New Zealand	16.0%
	Singapore	3.70%	WA/Perth	10.6%	QLD/Brisbane	9.33%
Los Angeles	USA/Texas	31.9%	USA/California	35.2%	USA/California	62.8%
	Canada/BC	26.4%	Canada/Alberta	32.4%	Canada/ Alberta	16.3%
	USA/California	22.2%	USA/Washington	21.1%	USA/Washington	15.1%
	Canada/Alberta	11.1%	USA/NY	5.63%	USA/NY	3.49%
	USA/Washington	8.33%	USA/Wisconsin	5.63%	USA/Texas	2.33%
UK	UK	45.9%	UK	60.9%	UK	60.0%
	Germany	14.9%	Finland	13.0%	Germany	18.7%
	Netherlands	17.6%	Germany	13.0%	Slovakia	9.33%

Origin	The Original	Sales share	The Brew	Sales share	The Brew - Cork	Sales share
	Spain	10.8%	Ireland	7.25%	Czech Republic	6.67%
	Finland	10.8%	The Netherlands	5.80%	Ireland	5.33%

Table 12 – Sales shares per order type for each KeepCup leaving the Melbourne, LA and UK assembly plants.

Origin		The Original	The Brew	The Brew - Cork
Melbourne	Online/ Samples	8%	17%	14%
	Cafes/Retails & Distributors	31%	61%	81%
	Branded - Cafes/Retails & Distributors	18%	0%	0%
	Branded - Corporate	42%	22%	5%
Los Angeles	Online/ Samples	8%	29%	13%
	Cafes/Retails & Distributors	45%	64%	81%
	Branded - Cafes/Retails & Distributors	0%	0%	0%
	Branded - Corporate	47%	7%	6%
UK	Online/ Samples	13%	12%	12%
	Cafes/Retails & Distributors	59%	65%	86%
	Branded - Cafes/Retails & Distributors	3%	0%	0%
	Branded - Corporate	25%	23%	2%

Table 13 – Distances by road, sea and air between KeepCup assembly plants and regional markets. A cup will either travel by airplane or ship but not both.

Origin	Destination	Distance travelled by truck (km)	Distance travelled by airplane (km)	Distance travelled by ship (km)
Melbourne	NSW/Sydney	876	714	1,078
	VIC/Melbourne	100	-	-
	WA/Perth	3,418	2,725	3,113
	QLD/Brisbane	1,667	1,376	2,000
	Singapore	-	6,070	7,115
	China/Shanghai	-	8,064	9,617
	New Zealand	-	2,575	2,759
Los Angeles	Canada/BC	2,803	2,373	-
	Canada/Alberta	3,034	2,217	-
	USA/Texas	2,005	1,725	-

Origin	Destination	Distance travelled by truck (km)	Distance travelled by airplane (km)	Distance travelled by ship (km)
	USA/California	300	-	-
	USA/Washington	4,300	3,698	-
	USA/NY	4,489	3,940	-
	USA/Wisconsin	3,303	2,753	-
UK	UK	100	-	-
	Germany	874	736	696
	The Netherlands	508	379	391
	Spain	1,710	1,260	1,309
	Finland	2,502	1,939	2,324
	Slovakia	1,839	1,446	-
	Czech Republic	1,358	1,115	-

Table 14 – Washing rates of KeepCup users per cup and cleaning method.

Cup	Machine wash	Rinse	Hand wash
The Original	17%	16%	67%
The Brew	17%	16%	67%
The Brew Cork	5%	20%	72%

Table 15 – Water and energy use for each cleaning option. All units per cup.

Method	Input	Amount	Assumptions and references
Dishwashing	Water (l)	0.3	Assumed 15l/load and 50 cups/load (Gall, 2016)
	Electricity (kWh)	0.025	Assumed 1.23 kWh/load and 50 cups/load (Gall, 2016)
Handwashing (warm)	Water (l)	0.5	Assumed a tap debit of 14.6 l/min and a 2 second rinse (Western Water, 2015).
	Natural gas heating (MJ)	0.084	Assumed natural gas needed to heat water from 25° to 65°
Rinsing (cold)	Water (l)	0.5	Assumed a tap debit of 16.5 l/min and a 15 second rinse (Australian Government, 2017)

Table 16 – Average replacement of KeepCup components per cup per year in the different markets.

Component	Australasian and Asian markets	European market	North American market
Lid	0.006	0.003	0.004
Plug	0.007	0.003	0.006
Cup	0.001	0.001	0.005
Glass Cup	0.004	0.005	0.002
Band	0.003	0.002	0.003
Cork Band	0.012	0.011	0.005

Table 17 – Percentage of KeepCup owners that recycle KeepCup parts in different regions.

Component	Australasian and Asian markets	European market	North American market
Lid	50%	50%	50%
Plug	50%	50%	50%
Cup	50%	50%	50%
Band	0%	0%	0%
Cork Band	0%	0%	0%

Benchmark cups

Table 18 – Benchmark reusable cup parts and materials. All units per cup.

<table>
<tr><th>Cup</th><th>Component</th><th>Quantity</th><th>Unit</th><th>Materials</th><th>Reference</th></tr>
<tr><td rowspan="4">Bamboo Cup</td><td>Lid</td><td>0.008</td><td>kg</td><td>Silicone</td><td>Loughborough University, 2017</td></tr>
<tr><td>Cup</td><td>0.099</td><td>kg</td><td>Melamine resin (56.6%), bamboo fibre (36.2%) and pigments and fillers[18] (7.2%)</td><td>Alternativa3, 2017
Lab testing</td></tr>
<tr><td>Band</td><td>0.018</td><td>kg</td><td>Silicone</td><td>Channel Distribution, 2017</td></tr>
<tr><td>Retail gift box</td><td>0.045</td><td>g</td><td>Cardboard</td><td>Ecoffee Cup, 2017</td></tr>
<tr><td rowspan="2">Plastic cup</td><td>Lid</td><td>0.014</td><td>kg</td><td>Polypropylene</td><td rowspan="2">Pladerer, Meissnet, Dinkel, & Dehoust, 2008</td></tr>
<tr><td>Cup</td><td>0.042</td><td>kg</td><td>Polypropylene</td></tr>
</table>

[18] Titanium dioxide and calcium carbonate.

Table 19: Known inputs to the production of bamboo fibre (van der Lugt & Vogtlander, 2015).

Input	Amount	Unit
Petrol for plantation machinery	0.20	MJ
Electricity	0.93	kWh
Transport	15.11	km

Table 20 - Benchmark single-use cup parts and materials. All units per cup.

Cup	Component	Quantity	Unit	Materials	References
Compostable cup	Lid	0.004	kg	PLA	BioPak, 2017
	Cup	0.013	kg	Paperboard with PLA lining	
Cardboard	Lid	0.003	kg	Polystyrene	Assumption
	Cup	0.009	kg	Paperboard with polyethylene lining	Dinkel, 2004Meissnet, Dinkel, & Dehoust, 2008;

Table 21 – Sales shares and transport distances to each end market destinations for benchmark cups.

Destination	Sales share	Distance travelled by truck (km)	Distance travelled by ship (km)
NSW/Sydney	8.7%	-	8,045
VIC/Melbourne	11.4%	-	9,095
WA/Perth	2.7%	-	6,719
QLD/Brisbane	3.8%	-	7,302
Singapore	0.4%	-	3,356
China/Shanghai	4.9%	-	780
New Zealand	1.8%	-	9,390
Canada/BC	2.97%	3,844	10,964
Canada/Alberta	6.74%	1,004	9,847
USA/Texas	3.86%	2,007	10,964
USA/California	13.55%	-	10,964
USA/Washington	5.02%	4,246	10,964
USA/NY	1.03%	4,491	10,964
USA/Wisconsin	0.63%	3,304	10,964
UK	18.8%	-	9,390
Germany	5.2%	-	19,085
Netherlands	2.6%	-	18,757
Spain	1.2%	-	16,312
Finland	2.7%	-	20,744

Destination	Sales share	Distance travelled by truck (km)	Distance travelled by ship (km)
Slovakia	1.1%	665	15,070
Czech Republic	0.8%	855	15,070

Appendix C - Background data

The following background data sources were used to model the product life cycles from cradle-to-grave/cradle-to-gate:

- **ecoinvent v3.2:** The ecoinvent Centre holds the world's leading database with consistent and transparent, up-to-date LCI data. The ecoinvent v3 database contains LCI data from various sectors such as energy production, transport, building materials, production of chemicals, metal production, and fruit and vegetables. The entire database consists of over 10,000 interlinked datasets, each of which describes an LCI on a process level.
- **Australian National Life Cycle Inventory Database (AusLCI):** A major initiative currently being delivered by the Australian Life Cycle Assessment Society (ALCAS). The aim is to provide and maintain a national, publicly-accessible database with easy access to authoritative, comprehensive and transparent environmental information on a wide range of Australian products and services over their entire life cycle.
- **AusLCI shadow database:** ALCAS have developed a "shadow database" to provide consistent, quality background data to the AusLCI database. This shadow database fills most of the gaps in the supply chain as AusLCI is being developed. The shadow database is based on the ecoinvent unit process database, but with a number of adjustments to bring the data more in line with the Australian industrial environment.
- **Australasian Unit Process LCI:** The main Australasian database in SimaPro, which has been developed for use with LCA in Australia over the past 12 years. The original database was developed as part of a project funded by the four state-based environmental protection authorities', the commonwealth government and the Cooperative Research Centre for Waste Management and Pollution Control. The project partners were the University of New South Wales and the Centre for Design at RMIT University. The database has been added to over time by different public projects and its upkeep is coordinated by Life Cycle Strategies.

A SimaPro file and map is available upon request.

Table 22 – Background data processes.

Input/output	Unit process
Materials	
Polypropylene	Polypropylene, granulate {GLO}| market for | Alloc Def, U
Polypropylene (Australia)	polypropylene, PP, at factory gate/AU U
Glass	Tempering, flat glass {GLO}| market for | Alloc Def, U Flat glass, uncoated {GLO}| market for | Alloc Def, U
LPDE	Polyethylene, LDPE, granulate, at plant/AU U
LDPE (Australia)	Polyethylene, LDPE, granulate, at plant/AU U
Synthetic rubber	Synthetic rubber, at plant/RER U/AusSD S
Silicone	Silicone product {GLO}| market for | Alloc Def, U
Cork composite	Cork slab {PT}| production | Alloc Def, U Polyurethane, flexible foam {RoW}| production | Alloc Def, U
PLA	Polylactide, granulate, at plant/GLO U/AusSD U
Paperboard	Solid bleached board, SBB, at plant/RER U/AusSD U
LDPE film	Packaging film, low density polyethylene {GLO}| market for | Alloc Def, U
Polystyrene	Polystyrene, general purpose {GLO}| market for | Alloc Def, U
Cardboard	Corrugated board, mixed fibre, single wall, at plant/RER U/AusSD U
Paper	Graphic paper, 100% recycled {RER}| production | Alloc Def, U
Bamboo fibres	Diesel, burned in building machine {GLO}| market for | Alloc Def, U

Input/output	Unit process
	Transport, freight, lorry, unspecified {GLO}| market for | Alloc Def, U Electricity, low voltage {CN}| market group for | Alloc Def, U
Melamine	Melamine-urea-formaldehyde resin, at plant/US
Calcium carbonate	Limestone, crushed, washed {RoW}| market for limestone, crushed, washed | Alloc Def, U
Titanium dioxide	Titanium dioxide {RoW}| market for | Alloc Def, U
Injection moulding	Injection moulding {GLO}| market for | Alloc Def, U Adapted to regional electricity mix, if applicable and as per system diagrams
Injection moulding (Australia)	Injection moulding/RER U/AusSD U
Blow moulding	Blow moulding {GLO}| market for | Alloc Def, U
Electricity	
New South Wales	electricity, low voltage, New South Wales/AU S
Western Australia	electricity, low voltage, western Australia/AU S
Queensland	electricity, low voltage, Queensland/AU S
Victoria	electricity, low voltage, Victoria/AU S
New Zealand	Electricity, New Zealand, low volage/NZ S
China	Electricity, medium voltage {CN}| market group for | Alloc Def, U
Taiwan	Electricity, medium voltage {TW}| market for | Alloc Def, U
Singapore	Electricity, low voltage {SI}| market for | Alloc Def, U
Canada	Electricity, low voltage {Canada without Quebec}| market group for | Alloc Def, U
USA	Electricity, low voltage {US}| market group for | Alloc Def, U

Input/output	Unit process
British Columbia	Electricity, low voltage {CA-BC}| market for | Alloc Def, U
California	Electricity, at eGrid, CAMX, 2010/kWh/RNA
Czech Republic	Electricity, low voltage {CZ}| market for | Alloc Rec, U
Germany	Electricity, low voltage {DE}| market for | Alloc Def, U
Great Britain	Electricity, low voltage {GB}| market for | Alloc Def, U
Ireland	Electricity, low voltage {IE}| market for | Alloc Def, U
The Netherlands	Electricity, low voltage {NL}| market for | Alloc Def, U
Slovakia	Electricity, low voltage {SK}| market for | Alloc Def, U
Spain	Electricity, low voltage {ES}| market for | Alloc Def, U
Transport	
Truck transport	Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}| market for | Alloc Def, U
Sea shipping	Transport, freight, sea, transoceanic ship {GLO}| market for | Alloc Def, U
Air transport	Transport, freight, aircraft {GLO}| market for | Alloc Def, U
Truck transport (Australia)	Transport, lorry 16-32t, EURO5/RER U
Sea shipping (Australia)	Shipping, Domestic Freight/AU S
Air transport (Australia)	air freight domestic/AU U
Water	
New South Wales	tap water, at user, New South Wales/AU S
Western Australia	tap water, at user, Western Australia/AU S

Input/output	Unit process
Queensland	tap water, at user, Queensland/AU S
Victoria	electricity, low voltage, Victoria/AU S
New Zealand	Water, drinking, Auckland, reticulated/NZ U
Europe	Tap water {Europe without Switzerland}| market for | Alloc Def, U
Canada	Tap water {CA-QC}| market for | Alloc Rec, U
Other regions	Tap water {RoW}| market for | Conseq, U
Heat	
Heat from natural gas	Heat, central or small-scale, natural gas {GLO}| market group for | Alloc Def, U
Heat from natural gas (Australia)	Energy, from natural gas/AU U
Waste treatment	
Polypropylene disposed of in landfill	Waste plastic, mixture {CH}| treatment of, sanitary landfill | Alloc Def, U
Paper and paperboard disposed of in landfill	Waste graphical paper {RoW}| treatment of, sanitary landfill | Alloc Def, U
Glass disposed of in landfill	Waste glass {CH}| treatment of, inert material landfill | Alloc Def, U
Cork disposed of in landfill	Waste wood, untreated {CH}| treatment of, sanitary landfill | Alloc Def, U
Polypropylene disposed of in landfill (Australia)	Disposal, polypropylene, 15.9% water, to sanitary landfill/CH U/AusSD S
Paper and paperboard disposed of in landfill (Australia)	Disposal, paper, 11.2% water, to sanitary landfill/CH U/AusSD S
Glass disposed of in landfill (Australia)	Disposal, glass, 0% water, to inert material landfill/CH U/AusSD U
Cork disposed of in landfill (Australia)	Disposal, wood untreated, 20% water, to sanitary landfill/CH U/AusSD U

Input/output	Unit process
Mixed inert and organic material disposed of in landfill	Disposal, municipal solid waste, 22.9% water, to sanitary landfill/CH U/AusSD S
Resource recovery for recycling and WTE	Sorting for recycling and WTE PP/AU U
Resource recovery of paper and paperboard	Recycling paper & board, kerbside /AU U, adapted to delete avoided production
Composting	Compost, at plant/CH U/AusSD U

Appendix D – Additional life cycle impact assessment results

Cradle-to-gate - Midpoint

- Most of impact profiles are similar, with the exception of ozone depletion, agricultural land occupation and urban land occupation. Plastic or glass cups are the biggest contribution to most of the impacts, including Climate change, acidification, eutrophication, photochemical oxidation or fossil depletion.
- The retail box has a major impact on land focused impacts. The cork band in the case of The Brew Cork is also relevant in agricultural land occupation.
- The silicone is the biggest contribution to ozone depletion impact.
- The plug has a very limited impact across the different categories, not a rare situation given its weight compared to other parts.

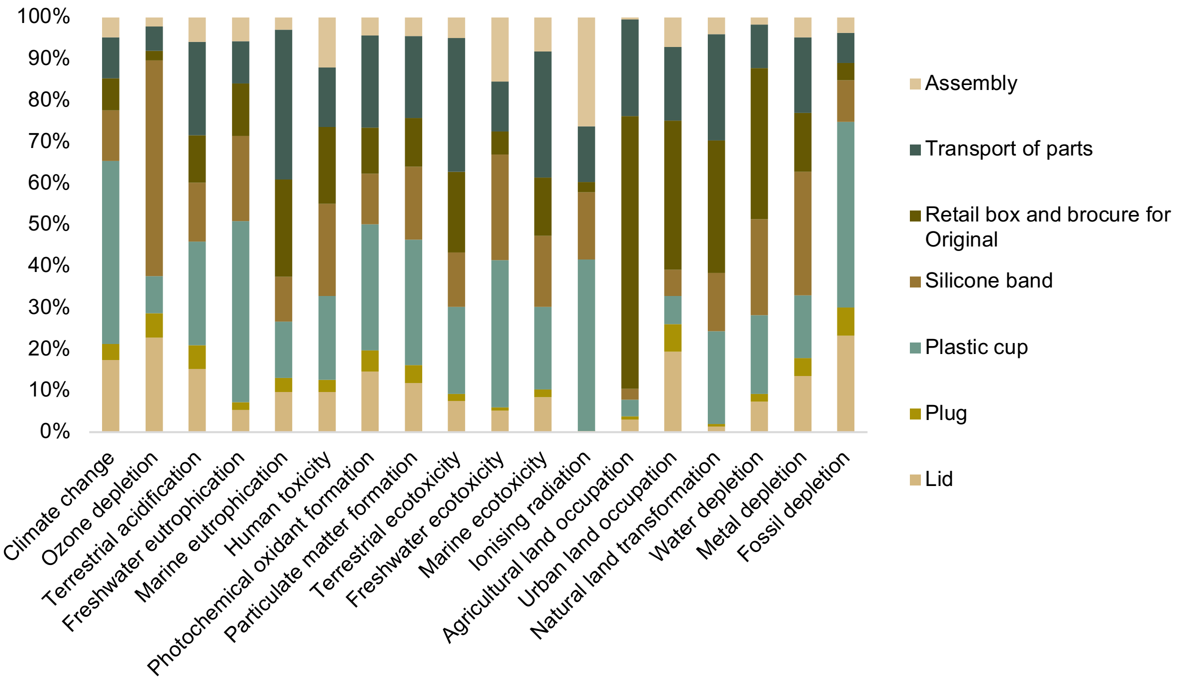

Figure 31 - Cradle to gate impacts comparison for the KeepCup Original.

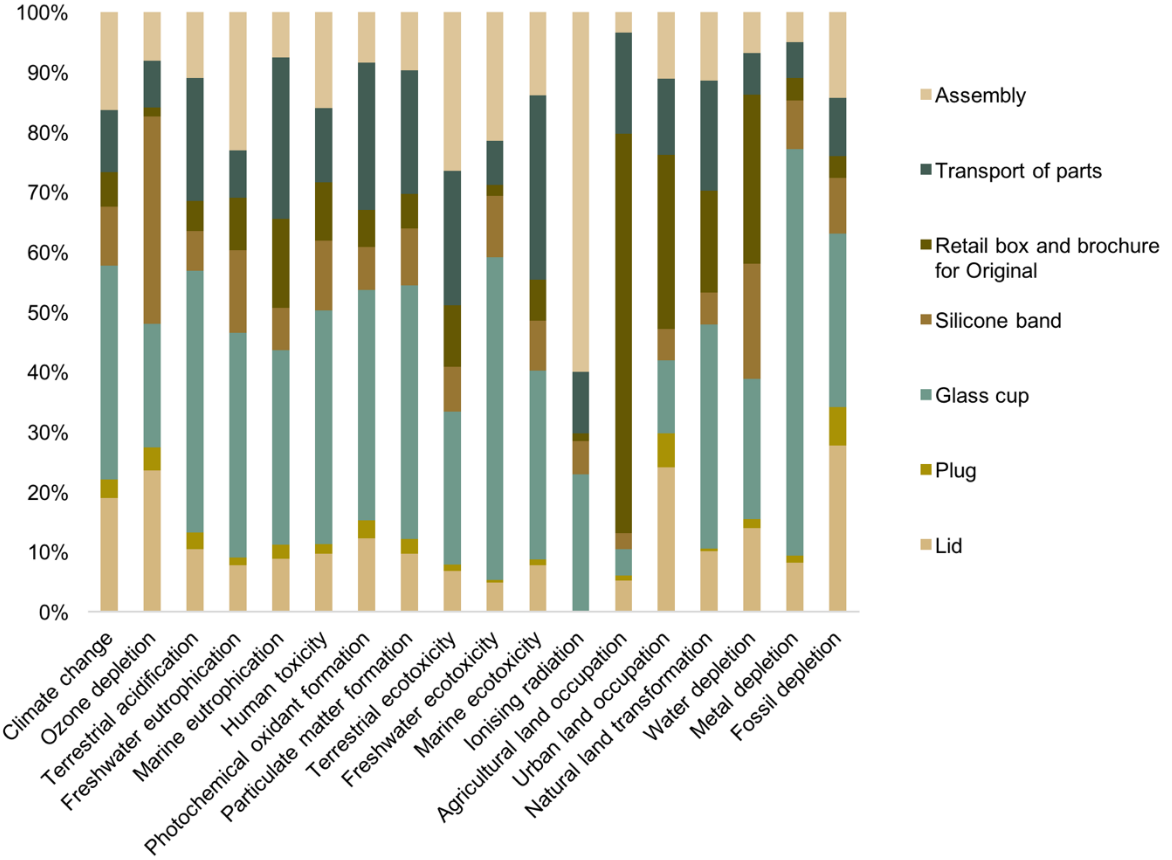

Figure 32 - Cradle to gate impacts comparison for the KeepCup The Brew.

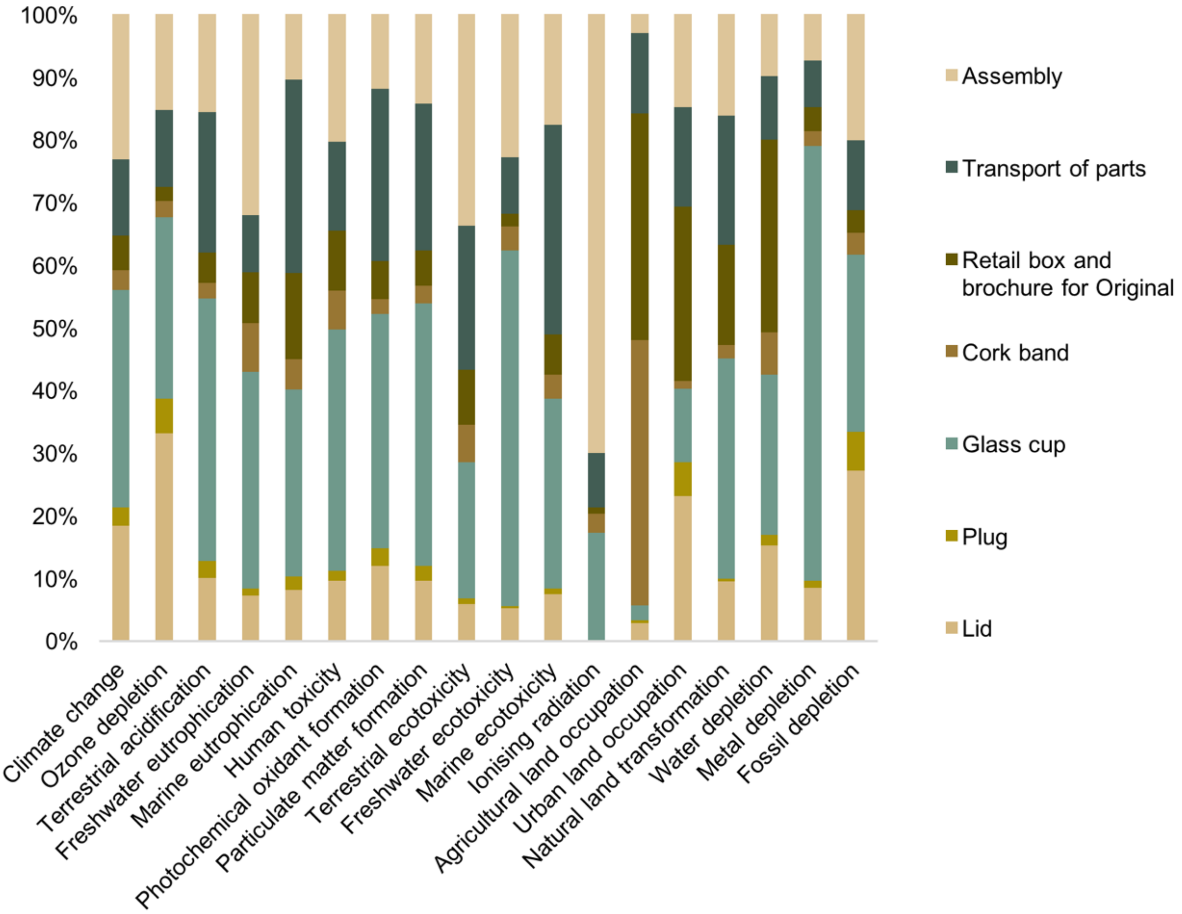

Figure 33 - Cradle to gate impacts comparison for the KeepCup The Brew Cork.

Cradle-to-cradle – Weighted impacts

We defined three use intensities depending on the number of coffees drank per day

- Light use: 1 coffee per day, 250 coffees per year[19]
- Medium use: 2 coffees per day, 500 coffees per year
- Heavy use: 3 coffees per day, 750 coffees per year

When considering the full life cycle of the cup from the manufacturing of the cup to its disposal, the use phase has the main impact, from 49% (agricultural land occupation) to 99% (Water depletion). This is based on a light use scenario.

[19] 250 working days.

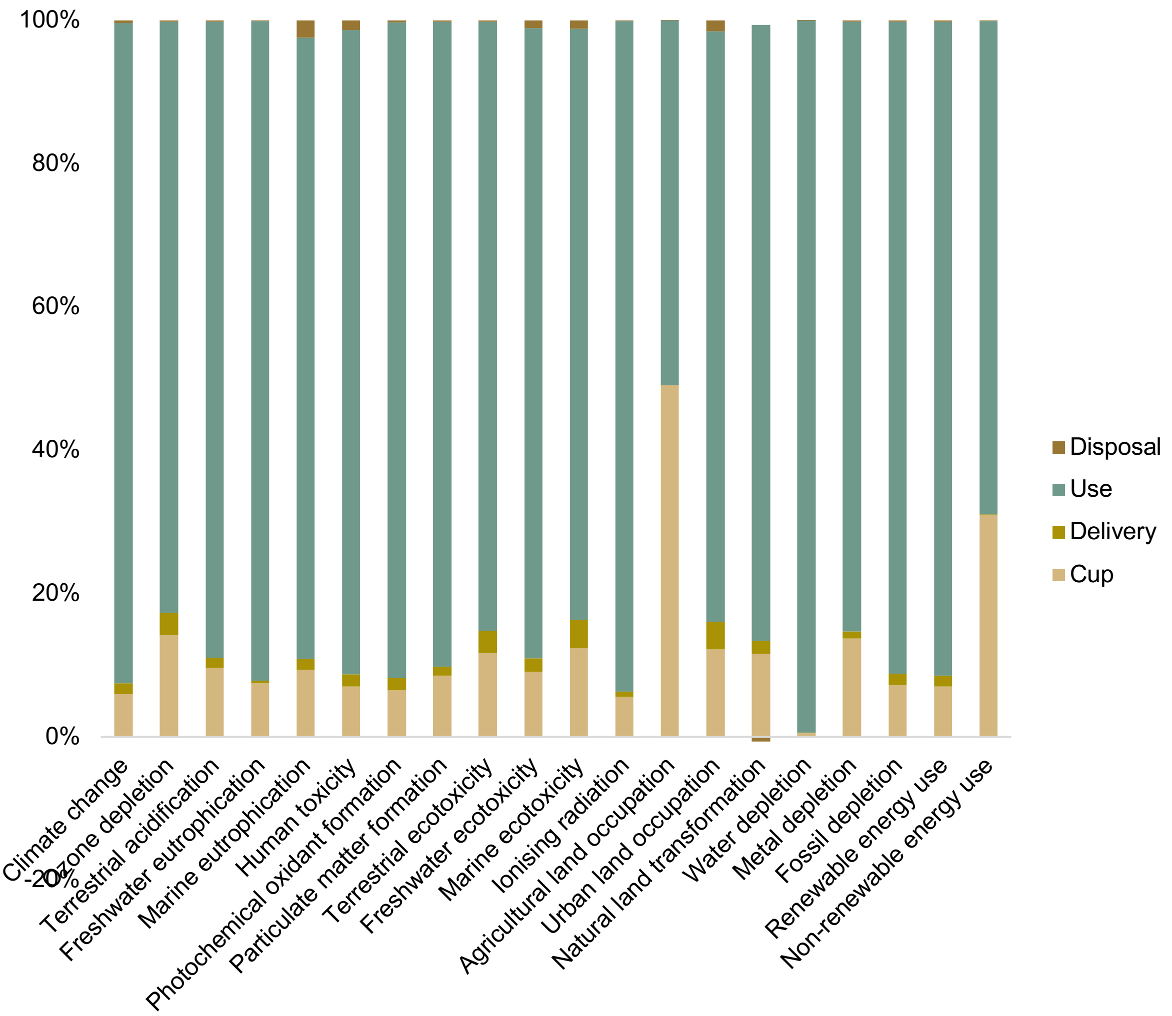

Figure 34 – Impact profile over the life cycle of KeepCups (average across all regions and cups) for light use.

KeepCup parts in detail

Glass vs plastic cup

- Aggregated impact: glass cup's impact is twice the plastic cup's impact
- Main impact is climate change for both cups. The plastic cup climate change impact is two third of the glass cup one.
- The plastic cup impact sits both in the material and injection moulding process. For the glass cup, the raw material is responsible for the cup footprint.

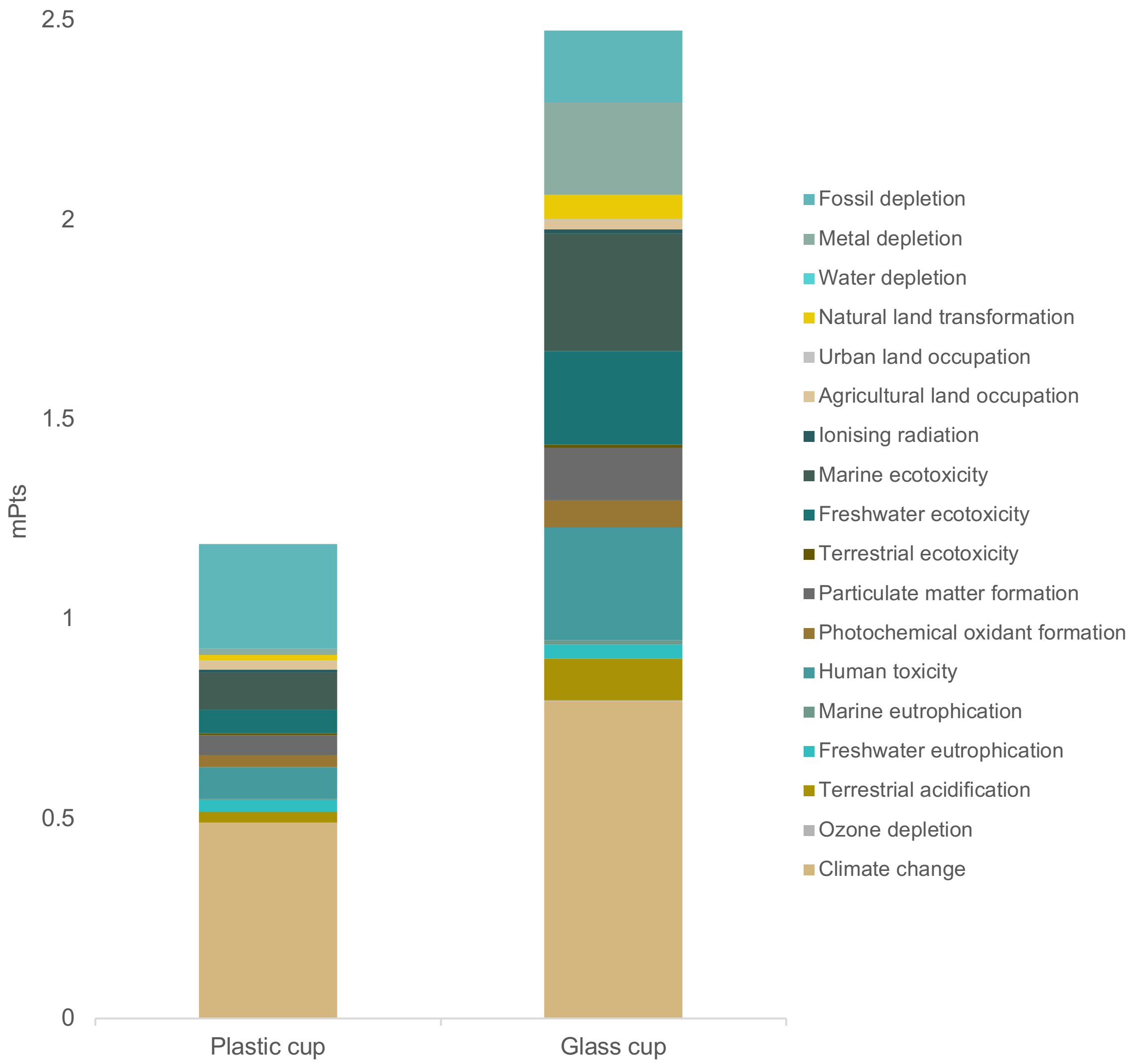

Figure 35 – Weighted environmental impacts for glass and plastic cups (regional average).

Cork vs Silicone band

- Aggregated impact is similar for both bands.
- Main impact for cork is land occupation and transformation (62%) due to the cork production
- 35% of the aggregated impact of the silicone band is Climate change. The silicone production is responsible for 60% of this impact, almost 40% for electricity use for moulding.

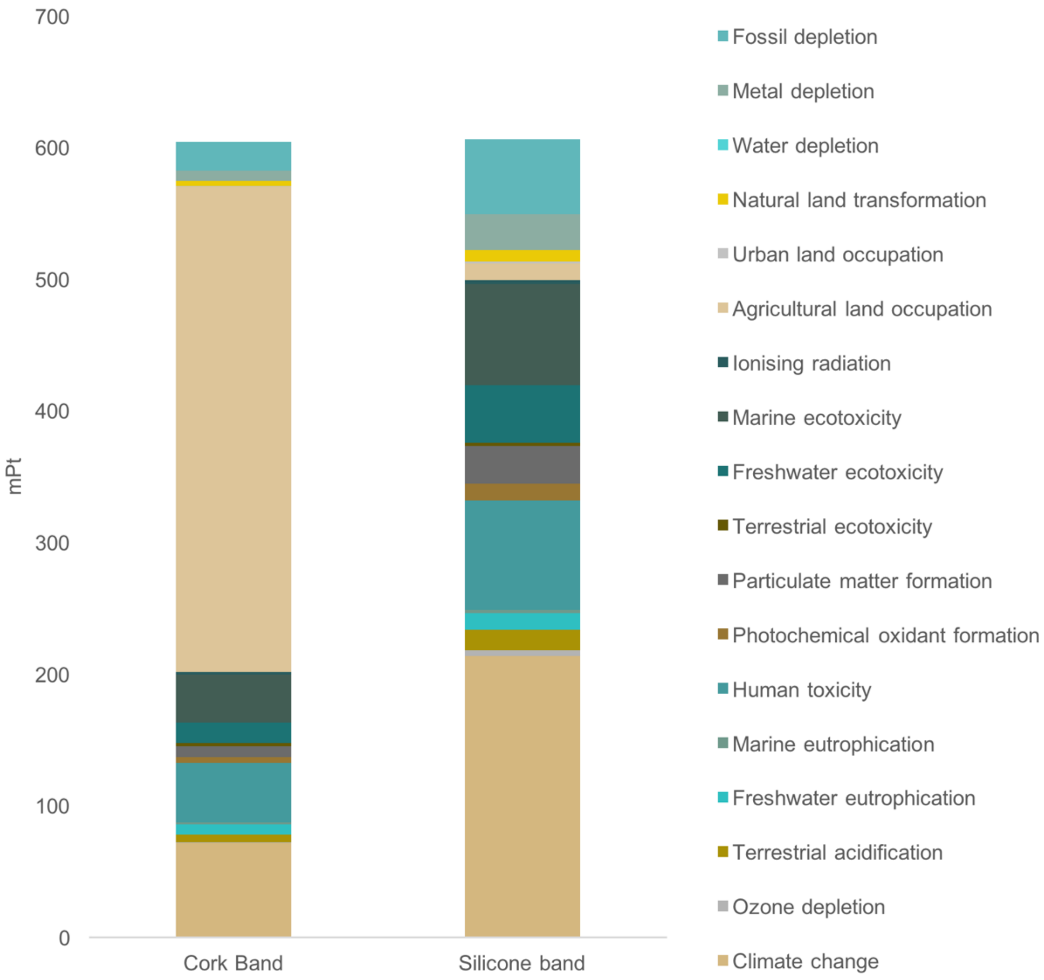

Figure 36 – Weighted environmental impacts for cork and silicone bands (in mPt) (regional average).

Appendix E – End of life data literature research and assumptions

Mass Divertion % to Waste Treatment

	Australia			Europe				North America			
	Recycling	Composting	Landfill	Recycling	Composting	WTE	Landfill	Recycling	Composting	WTE	Landfill
Packaging glass	0.0%	0.0%	100.0%	0.00%	0.0%	0.0%	100.00%	0%	0.0%	0.0%	100.0%
PP	37.2%	0.0%	62.8%	29.70%	0.0%	39.5%	30.80%	8.80%	0.0%	12.0%	79.2%
Silicone	0.0%	0.0%	100.0%	0.0%	0.0%	23.0%	77.00%	0.0%	0.0%	12.0%	88.0%
Cork	0.0%	0.0%	100.0%	0.0%	0.0%	23.0%	77.00%	0.0%	0.0%	12.0%	88.0%
Paper with polyethylene lining	10.0%	0.0%	90.0%	21%	0.0%	23.0%	56.00%	10.0%	0.0%	12.0%	78.0%
Bamboo/starch composite	0.0%	0.0%	100.0%	0.0%	0.0%	23.0%	77.00%	0.0%	0.0%	12.0%	88.0%
PLA	0.0%	0.0%	100.0%	0.0%	0.0%	23.0%	77.00%	0.0%	0.0%	12.0%	88.0%
Paper with PLA lining	0.0%	0.0%	100.0%	0.0%	0.0%	23.0%	77.00%	0.0%	0.0%	12.0%	88.0%

Mass Divertion Reference

	Australia			Europe				North America			
	Recycling	Composting	Landfill	Recycling	Composting	WTE	Landfill	Recycling	Composting	WTE	Landfill
Tempered glass	#3 (pp.43)	#9	Calculated	#8 (pp.1)	#13		Calculated	#5 (pp.5)	#11		Calculated
PP	#2 (pp.5)	#9	Calculated	#7 (pp.24)	#13	#7 (pp.24)	#7 (pp.24)	#11 (pp.8)	#11	#11 (pp.2)	#11 (pp.2)
Silicone		#9	Calculated		#13	#16	Calculated		#11	#11 (pp.2)	Calculated
Cork	#6	#9	Calculated		#13	#16	Calculated	#14	#11	#11 (pp.2)	Calculated
Paper with polyethylene lining	#4 (pp.4)	#9	Calculated	#4 (pp.4)	#13	#16	Calculated	#4 (pp.4)	#11	#11 (pp.2)	Calculated
Bamboo/starch composite	#10	#9	Calculated	#15	#13	#16	Calculated		#11	#11 (pp.2)	Calculated
PLA	#10	#9	Calculated	#15	#13	#16	Calculated		#11	#11 (pp.2)	Calculated
Paper with PLA lining	#12	#9	Calculated	#12	#13	#16	Calculated	#12	#11	#11 (pp.2)	Calculated

Notes
AUS: No household composting collection for non-garden waste by councils in Australia. 38% houeshold have green bin collection services for garden waste only. Reference #9
EUROPE: Biodegradable waste does not include materials other than garden or food. Recycling rate in Europe is for biowaste is composted at 25%. Reference #13
NORTH AMERICA: No household composting collection for non-garden or non food waste in United States. Yard trimmings represent almost all compost waste. Reference #11 (pp.8)
Silcone Rubber/Silicone: No evidence this is a MRF recoverable recyclable so at 0% in all regions
Cork: Only recyclable at collection points, no MRF recovery in Australian and North America, assuming same for Europe

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Uncertainty

	Australia			Europe				North America			
	Recycling	Composting	Landfill	Recycling	Composting	WTE	Landfill	Recycling	Composting	WTE	Landfill
Tempered glass	(1,3,3,1,1)	/	(1,3,3,1,1)	(1,2,2,2,1)	/	/	(1,2,2,2,1)	(1,3,3,2,1)	/	/	(5,5,5,5,5)
PP	(1,3,1,1,1)	/	(1,3,1,1,1)	(1,2,1,2,1)	/	(1,2,1,2,1)	(1,2,1,2,1)	(1,3,2,3,1)	/	(1,3,2,3,1)	(1,3,2,3,1)
Silicone	/	/	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)
Cork	/	/	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)
Paper with polyethylene lining	(1,3,5,1,1)	/	(1,3,5,1,1)	(1,3,5,2,1)	/	(5,5,5,5,5)	(5,5,5,5,5)	(1,3,5,5,1)	/	(5,5,5,5,5)	(5,5,5,5,5)
Bamboo/starch composite	/	/	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)
PLA	/	/	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(5,5,5,5,5)
Paper with PLA lining	(3,3,1,3,1)	/	(3,3,1,3,1)	/	/	(5,5,5,5,5)	(5,5,5,5,5)	/	/	(5,5,5,5,5)	(3,3,1,3,1)

Indicator score	1	2	3	4	5 (default)
Reliability	Verified data based on measurement	Verified data based on assumptions or non-verified based on measurements	Non-verified qualified estimate	Qualified estimate (i.e. industry expert)	Non-qualified estimate
Completeness	Completely representative	Representative of more than 50% of sites	Representative of less than 50% of sites or greater than 50% for short periods	Representative from one relevant site or some sites over short period	Unknown or representatively small
Temporal correlation	Less than 3 years old	Less than 6 years old	Less than 10 years old	Less than 15 years old	Unknown or data greater than 15 years old
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	From slightly similar region	Unknown or from distinctively different region
Further technical correlation	Data from enterprises, processes and materials under study	Identical technology from different enterprise	Data from processes and materials under study from different technology	Data on related processes or materials	Lab-scale testing or from different technology