From:	[redacted]
To:	SingleUse
Subject:	Print cup submission
Date:	Monday 14 November 2022 15:59:30
Attachments:	2022-11-11 Cup Print Letter to Minster Smyth_Environmental Levy on Disposable Paper Cups.pdf Ramboll_LCA_Executive_Summary[3].pdf Ramboll_Ireland_LCA_Context[3].pdf LCA Single Use Multiple Use Infographic[5].pdf ~WRD0001.jpg

From: [redacted]@oireachtas.ie>
Sent: Monday 14 November 2022 14:57
To: [redacted]@per.gov.ie>; 'Minister Of State (PER)' [redacted]@per.gov.ie>
Cc: [redacted]@decc.gov.ie>; [redacted]@decc.gov.ie>
Subject: FW: Latte levy, Environmental and Industrial impacts, including Alternative Proposals

CAUTION: This email originated from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

From: [redacted]@cupprint.com>
Sent: Friday 11 November 2022 16:02
To: [redacted]@oireachtas.ie>
Subject: Latte levy, Environmental and Industrial impacts, including Alternative Proposals

Dear Minister Smyth,

Please find attached a letter highlighting our concerns on draft regulations to introduce an environmental levy on single-use paper cups.

We would like to bring to your attention the critical impacts the legislation will bring on both the environment and industry, along with some constructive, alternative solutions, which we have previously presented to the Joint Committee on Environment and Climate Action, in the spirit of a truly circular economy.

In summary, we feel that government has failed to both carry out appropriate impact assessment, to the standards required by European law, or engage with industry to gain adequate market data upon which to base legislative decisions.

We would welcome the opportunity to brief yourself and your department further on these matters and would be grateful if you could confirm receipt of attached.

Yours sincerely,

On behalf of

[redacted] (General Manager Huhtamaki Cup Print Ltd.) & [redacted] (Head of Operations and Finance, Huhtamaki Cup Print Ltd.)

[redacted]
Digital Marketing Specialist

Ballymaley Business Park, Ennis, Co. Clare, Ireland, V95 NN60
[redacted]
cupprint.com

#YourBrandOutThere

Office Hours 0900 - 1700 Monday - Thursday. Closed at 1600 on Fridays.

Cup Print will be closing for seasonal holidays on December 22nd 2022, reopening January 3rd 2023

Cup Print

Huhtamaki Cup Print Ltd.
Unit 4, Ballymaley Business Park,
Ennis, Co Clare

November 11th 2022
065 686 8633

Minister of State for the Department of Public Expenditure and Reform, with responsibility for Public Procurement and eGovernment;and at the Department of the Environment, Climate and Communications with special responsibility for Communications and Circular Economy

Leinster House, Kildare Street, Dublin 2

RE: Latte levy, Environmental and Industrial impacts, including Alternative Proposals

Dear Minister Smyth,

In relation to the ongoing public consultation concerning the proposed regulations to be issued under section 11 of the Circular Economy Act 2022 (**"the Draft Regulations"** and **"the 2022 Act"** respectively), Cup Print (based in Ennis, Co. Clare), would like to bring to your attention some critical, detrimental impacts to both the environment and industry if the proposed levy on renewable and recyclable single-use paper cups (as outlined in the Draft Regulations) is implemented, and wishes to propose some constructive alternative solutions.

As you may be aware, Cup Print has engaged rigorously with many stakeholders, including officials from the Department of the Environment, Climate and Communications, and members of the Oireachtas Joint Committee on Environment and Climate Action, over the last six months during the legislative process undertaken to adopt the 2022 Act into law, in order to highlight our concerns with the so-called *"latte levy"* and to advocate for a more environmentally and economically efficient approach, in the spirit of a true circular economy.

Overall, as promoters of renewable, recyclable and environmentally performant paper packaging products, including European-certified recyclable and compostable paper coffee cups, we are supporters of a circular economy and welcome the principles set out in the 2022 Act. However, despite constructive communications with several Government Ministers and the Joint Committee on Environment and Climate Action and the Department, we are disappointed with the proposals set out in the Draft Regulations, both for the renewable fibre packaging industry and for the promotion of circularity itself.

We have outlined some of these concerns below.

- **According to European legislation, waste treatment cannot be limited to mere waste volume reduction but needs first and foremost to achieve *"the best overall environmental outcome"*** as stated in at Article 4(2) of the Waste Directive (Directive 2008/98). The Government and the Department of the Environment, Climate and Communications should encourage options that deliver the best overall environmental outcomes, using life-cycle thinking and appropriate ISO 14040 and 14044-compliant Life Cycle Analysis to match the principles of a truly circular economy. Article 4.2

states clearly that "*when applying the Waste Hierarchy, Member States shall take measures to encourage the options that deliver the **best overall environmental outcome**. This may require specific waste streams departing from the hierarchy where this is **justified by life-cycle thinking** on the overall impacts of the generation and management of such waste*." In other words, within the inverted pyramid of *"reduce/reuse/recycle"*, if informed analysis demonstrates that *"recycle"* delivers a better overall environmental outcome than *"reuse"*, then policymakers should choose this option.

- **The latte levy will not achieve "the best overall environmental outcome"**, as required as a matter of European Union law, because the 2022 Act has been passed into law without the completion of an appropriate impact assessment. In particular, a scientific Life Cycle Analysis (LCA)[i] to determine whether reusables have a greater environmental impact than single-use, paper-based packaging, has not been conducted. We have presented to the Joint Committee a primary-data-based study, which found that reusable tableware emits 2.8 times more CO^2 and demands 3.4 times more freshwater consumption compared to single-use products, due to the energy-consuming washing and drying phases required. This report was carried by European LCA experts Ramboll[ii], who have also completed work for the European Commission on the Single Use Packaging Directive. It should be noted that their study is based on primary research data and has been independently reviewed and completed to ISO 14040/140444 standards. We have enclosed a copy of the updated Executive Summary of the report and a summary infographic. Additionally, following a desktop study, Ramboll has confirmed this LCA is applicable to the Irish context, with case study research completed on Ireland-specific data, which corroborated the findings of the primary study (see document also enclosed).

- **The legislation will result in a substantial increase of plastic in circulation,** achieving the exact opposite outcome to that which the 2022 Act seeks to achieve. The effect of the levy will be to replace renewable, recyclable and environmentally performant products with non-renewable, non-recyclable (i.e., ceramic, tableware glass) or not-yet-recycled plastic products. As seen in other markets in Europe, it is extremely likely that reusable plastic cups will be the primary replacement of renewable paper-based cups, contributing to a substantial increase in plastic products compared to the current situation – entirely contrary to the goal of plastic-reduction legislation. Distributors have stocks of cheap, nominally reusable *"dishwasher safe"* 100 percent plastic cups in warehouses, ready to sell as a replacement for paper coffee cups. According to trial implementation feedback, these nominally reusable plastic cups are on average discarded after 35 to 50 washing cycles in a Quick Service Restaurant (QSR) context, with rates of non-return averaging 80% for in-store consumption and 50% for takeaway. You have stated that you will legislate to address this, but how you will approach this problem is not clear; for example, taking a price or a plastic grade specification approach? Furthermore, despite promised engagement with stakeholders, there is no available information as to who will regulate and police this issue. Nor is there any information on how the government will prevent the market from being flooded with flimsy plastic cups, which will neither solve litter issues nor help Ireland to achieve its plastic reduction targets.

- **Paper cups are not waste**, but a valuable secondary raw material used in the truly circular paper value chain to provide many different new products (such as cardboard and egg boxes, drinks carriers or household paper roll cores). This legislation sets a dangerous precedent for other recyclable and renewable-fibre single-use items, and we anticipate that in due course an outright ban on single-use cups will be proposed (in addition to an extension of the levy model to other single-use food packaging products such as cold drink cups and takeaway containers). You have publicly stated this objective on several occasions and that outright ban on single-use cups for hot drinks could follow within one year of implementation of the initial levy. The levy therefore has implications for all food packaging, by making no distinction between renewable, valuable, recyclable fibre packaging or 100 percent plastic items, despite the radically different roles that these two categories of product have to play in a circular economy.

- **The levy is disproportionate, as well as discriminatory** on one product in one market. Paper cups of all types represent just 0.0003 of waste in Ireland. According to the Government's own National Litter Pollution Monitoring System data for 2021[iii], all categories of *"drinks cups"* represent just 1.7 percent of litter. In contrast, other items not legislated for that are more prolifically littered, such as 100 percent plastic sweet-related litter at 9.5 percent, have not been targeted by the 2022 Act. Additionally, according to the Environment Protection Agency, the largest contributor to total waste in Ireland is the construction sector, which contributed 8.8 million tonnes of waste in 2019, compared to 1.1 million tonnes of waste accounting for all types of packaging. Moreover, Ireland has indigenous manufacture of certified compostable cups for an Irish population equipped with brown bins dedicated to composting. The proposed latte levy will conflict with this existing waste treatment scheme. We are very concerned that no rational basis for the specific, and apparently arbitrary, targeting of our industry has been identified by the Government.

- **The levy will unnecessarily limit the freedom of enterprises** and impose costs on the full value-chain, including consumers. We are concerned about the significant commercial impacts and operational complexities that lie ahead for vendors once this levy is implemented. These distinct impracticalities of the levy during an exceptionally challenging time for the restaurant industry point to a lack of engagement by the Government with industry stakeholders to identify solutions. It also indicates that, in preparation of the Draft regulations, little research was undertaken to examine how workable the levy would be in practice for the very stakeholders it affects. Our specific concerns are as follows:

  i) In the context of inflation, the levy will impact both consumers and operators, with a proportionally greater negative impact on smaller vendors who will require investment in energy-consuming, on-premises washing and drying equipment, and face sizeable drop-offs in footfall and lost add-on sales.

  ii) A study by Ecuity in the UK suggests[iv] a minimum 8.4 percent loss of drinks sales on the implementation of a 25p levy and a 6 percent uptake in reusables following a levy. A maximum of 6 percent of customers availing of incentives currently in place for bringing reusables has been reported by vendors (with an average of below 3%), suggesting that no significant behavioral change will follow. In the Regulatory Impact Assessment[v] (RIA) issued by the Department of the Environment, Climate and Communications for the Public Consultation, market estimations used have vastly overestimated the current percentage share of reusables in the Ireland takeaway market at 25%, when they are currently running at <3%. The RIA also overestimates the takeaway market size at 633M cups p.a. (472 paper + 161 reusable) and in general lacks credible primary data. In summary, the RIA report cannot deliver adequate evidence-based justification for legislators to proceed with a levy based on such fundamentally flawed premises.

  iii) A study by RBB Economics[vi] in France during 2021 showed a Quick Service Restaurant (QSR) burger outlet switching from single-use packaging to multiple use tableware, would see operating costs (water, electricity, detergent, equipment etc.) increase by 270 percent, to approx. €30,000 per annum and an average refurbishment cost impact of €140,000 per QSR outlet. Smaller outlets (e.g., bakeries and family-owned cafés) are likely to suffer the most, due to the proportionally larger impact of these costs on their businesses.

Cup Print

In response to these concerns, we are calling for implementation of the following measures, which we would respectfully urge the Government to consider:

- **Alternative legislative mechanisms** to help Ireland meet its obligations to reduce waste and meet targets, notably for plastic reduction (which are not in fact specifically referenced in the 2022 Act) and a focus on the most prolifically littered items. Other EU states have demonstrated this more effective approach by reducing plastic waste and plastic littering, in compliance with the Single-Use Plastic Directive, using decreasing plastic thresholds. For example, France introduced a 15 percent plastic maximum allowed in cups in 2022 and 8 percent in 2024. Italy set a maximum 10 percent plastic threshold for cups. These measures have delivered a better plastic waste and litter reduction for those Member States and have not needlessly taxed consumers in the midst of a cost-of-living crisis.

- Officials should promote renewable, recyclable options that deliver the **best overall environmental outcomes (in compliance with European Union law)** and reduce Ireland's reliance on fossil fuel resources. The bottom line is, that all paper cups can and should be recycled. Operators in Ireland have made great efforts to serve certified recyclable (Waste Path 13 / DIN ISO EN 13430) or certified compostable (to Cré / EN13432 Standards) products that can and are being industrially composted in Ireland. In addition to this, many jurisdictions have re-enabled paper cup recycling for traditional, PE-lined paper cups. Irish fibre waste for recycling is generally exported to other EU countries or to the UK. Materials recycling facilities in these jurisdictions accept all types of paper cups for recycling and are actively seeking volumes of paper cups, so there are pathways to circularity if paper cups are added to recycling lists.

- **Modulating Extended Producer Responsibility ("EPR") fees** to tackle waste according to the priority environmental and littering impact. Packaging manufacturers understand they will be required to pay higher EPR. Ideally, EPR would contribute towards more meaningful circular waste pathways and infrastructure that delivers circularity across a spectrum of recyclable items. The levy is intended to create a behavioral change, seemingly to be followed by outright prohibition. This entails consumer taxation that is designed to be temporary and does not contribute towards infrastructure. The same shortfalls in enabling circularity would exist following prohibition of one specific single-use item. An opportunity to enable circularity for all recyclable fibre packaging items, under consistent methods of treatment, is being missed.

- **The Government should increase its investment in segregated collection** and engagement with Local Authorities (especially regarding street furniture), sorting and recycling pathways. This is something that Ireland desperately needs, and Irish industry is already making progress in collecting data to demonstrate the volume of items processed for composting and is enabling pathways to recycling facilities so that paper cups can be recycled into valuable, in-demand fibre materials that demonstrate true circularity.

- **Deploying collecting schemes for paper-based recyclable products** whether the recycling occurs in Ireland, or in other EU countries and the UK.

- **Upgrading composting schemes** through increased efficiency targets and financial support

- Finally, we urge the Department to establish and support initiatives to foster **education and communication** on collecting and recycling.

The approach that the Government has taken with the plastics industry has created incentives to recycle (e.g., via Deposit Return Schemes), with no levies or punitive actions in place for either consumers or vendors of plastic bottles or caps (even though these are more prolifically littered than drinks cups). The fibre packaging industry and operators would welcome similar positive engagement with the Government in order to achieve circularity for renewable, recyclable, organic fibre packaging.

The industry stands ready to engage with Government officials and put its shoulder to the wheel in order to implement changes to help Ireland meet its EU packaging waste and plastic reduction targets. We urge the Government to ensure that the best environmental outcome is achieved by avoiding greater unnecessary - and harmful - energy consumption, a consumer taxation, costs and negative impacts on businesses; and instead focus on plastic reduction and collaborate with industry to identify solutions and work towards greater infrastructure that puts Ireland at the forefront of circularity.

We are all responsible in playing our part and ensuring that the best environmental outcome is delivered, while also preventing unintended consequences of the proposed levy that would have a detrimental impact on Ireland's environmental goals.

We would greatly welcome the opportunity to brief you and your Department further on this matter and look forward to continued and constructive engagement on the issue.

Yours sincerely,

[redacted]

[redacted]
General Manager
Huhtamaki Cup Print Ltd.
Ennis, Co. Clare

[redacted]

[redacted]
Head of Operations & Finance
Huhtamaki Cup Print Ltd.
Ennis, Co. Clare

Appendix

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[i] European Commission International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Provisions and Action Steps
[ii] Comparative Life-Cycle Assessment (LCA) Single-Use and Multiple-Use Dishes Systems for In-Store Consumption in Quick Service Restaurants by Ramboll (Publicly available via European Paper Packaging Alliance)
[iii] National Litter Pollution Monitoring System Report 2021 (Tobin Consulting Engineers)
[iv] Economic Analysis of a Takeaway Paper Cup Levy, March 2018 (Ecuity: Higgins, Jackson and Baumerte)
[v] RIA Single Use Disposable Cups Oct 2022
[vi] RBB Economics, The economic effects of Decree no.2020-1724 (2021): findings on economic impact of reusables - an assessment of the economic impact of the French law

About Cup Print
Est. 2010, Cup Print is Europe's largest sustainable paper cup manufacturer, producing both certified compostable (EN 13432 / Cré) and the world's first and only recyclable paper cups certified in accordance with the DIN ISO EN 13430 standard for processing via regular mixed card & paper path 13. Cup Print employs over 200 people in their 100 percent certified renewable energy, BRCGS AA-rated High Hygiene facility in Ennis, Co. Clare and holds both PEFC and FSC certification for responsibly sourced renewable fibre. In 2018 Cup Print joined forces with global sustainable fibre packaging leader, Huhtamaki.

Intended for

EPPA - European Paper Packaging Alliance

Document type

Updated Executive Summary

Date

November 2021

COMPARATIVE LIFE-CYCLE ASSESSMENT (LCA)

SINGLE-USE AND MULTIPLE-USE DISHES SYSTEMS FOR IN-STORE CONSUMPTION IN QUICK SERVICE RESTAURANTS

RAMBOLL Bright ideas. Sustainable change.

COMPARATIVE LIFE-CYCLE ASSESSMENT (LCA) SINGLE-USE AND MULTIPLE-USE DISHES SYSTEMS FOR IN-STORE CONSUMPTION IN QUICK SERVICE RESTAURANTS

Project name	**EPPA – Italy – Comparative LCA Study**
Project no.	**330001928**
Recipient	**EPPA - European Paper Packaging Alliance, The Hague, The Netherlands**
Document type	**Updated Executive Summary**
Version	**Final report**
Date	**05/11/2021**
Prepared by	**Joachim Aigner and Francesco Mauro**
Approved by	**Emiliano Micalizio**

Disclaimer
Due to an extensive GaBi database update, the results for the EU reference model have changed. Therefore, this report includes updated results for the EU baseline scenario and additional sensitivity scenarios that were outside of the scope of the peer-reviewed LCA study. These results are clearly marked and disclosed at the end of this report.

The database update includes, among other things:

- Global energy mix and production data updates;
- Update of the treatment plant models/parameters;
- Updated global supply chains / mixes;
- Further expanded regionalization of land use and water consumption elementary flows
- Energy update: All energy-related datasets, such as electricity, thermal energy, fuels and the like, have been upgraded in line with the latest available, consistent international energy trade and technology data.

Updates of LCA databases, including both, larger annual as well as smaller updates throughout the year, are a means to ensure correctness, accuracy and timeliness of the datasets included. Such updates may include specific updates of dataset regarding the quantities or types of their inputs and outputs as well as updates regarding the characterisation factors used to translate these inputs and outputs into the impact categories of an assessment method (e.g. ReCiPe).
The 2021 update of GaBi included major updates on chemicals as well as the metal depletion category of ReCiPe[1]. This update therefore affects in particular the impacts created by chemicals in the metal depletion impact category and let to substantial changes of the impact of chemicals used in detergent and rinse agent for the washing process of multiple-use items. However, the major change is due to one chemical (potassium hydroxide), which accounts for more than one third of the detergent quantity.
Although obtained through unchanged methodology and calculation process, this updated executive summary and disclosed results were not part of the original study and are not subject to a third-party review.

[1] https://sphera.com/wp-content/uploads/2020/04/Details-and-Reasons-for-Changes.pdf

EXECUTIVE SUMMARY

Ramboll has been appointed by the European Paper Packaging Alliance (EPPA[2]) as technical consultant for conducting a comparative Life Cycle Assessment (LCA) study between a single use dishes system and equivalent multiple-use dishes in Quick Service Restaurants (hereafter "QSRs") in accordance with ISO standards 14040 and 14044 as a basis for discussion with authority representatives on the current legal developments within the European Union plus the United Kingdom regarding circular economy and waste prevention.

In particular, EPPA wishes to provide policy makers with information to support the application of the 2008 Waste Directive, so that "*when applying the waste hierarchy, Member States shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste."* (Directive 2008/98/EC, article 4§2)

Ramboll conducted a Comparative Life Cycle Assessment study for the European Paper Packaging Alliance regarding *single-use and multi-use dishes systems in quick service restaurants*. The study was issued in December 2020 after the completion of a Critical Review conducted by TUV (Critical review report is dated 16/12/2020).

However, during 2021 update of GaBi databases (used for the above-mentioned study) ware issued and EPPA asked Ramboll to update the results of the study accordingly.

This assessment is embedded in an ongoing debate around the environmental performance of single-use and multiple-use products, and it is focused on a systemic approach (comprehensive dishes options for in-store consumption in QSR) which is used to reflect both systems and compare equal functions of single-use and multiple-use product items in an average.
The main goal of the LCA study is to use a systems-based approach to **compare the environmental performance of single-use and multiple-use dishes options for in-store consumption in QSR in Europe.**

The functional unit was the in-store consumption of foodstuff and beverages with single-use or multiple-use dishes (including cups, lids, plates, containers and cutlery) in an *average* QSR for 365 days in Europe in consideration of established facilities and hygiene standards as well as QSR-specific characteristics (e.g. peak times, throughput of served dishes).

For the comparative assessment, two fundamentally distinct systems are taken into consideration:

- the current system in QSRs based on single-use (disposable) products made of paperboard with a polyethylene (PE) content < 10% w/w (also referred to as single-use product system), accounting for regulatory implications in 2023 (e.g. targets for separate waste collection and end of life (EoL) recycling);
- an expected (hypothetical) future system in the near future based on equivalent multiple-use products (also referred to as multiple-use product system) and respective processes and infrastructure for washing operations (in-store or sub-contracted).

[2] EPPA is an association representing suppliers and manufacturers of renewable and sustainable paper board and paper board packaging for Food and Foodservice Industry. They include, e.g., Seda International Packaging Group, Huhtamaki, AR Packaging, Smith Anderson, CEE Schisler Packaging Solut ons, Stora Enso, Metsä Board, Mayr-Melnhof Karton, WestRock, Iggesund/Holmen, Reno De Med ci and Paper Machinery Corporation.

The distinctive feature of this study compared to other assessments within this field of research are the following:

- **Approach**: the main goal of the LCA study is to compare for the first time through a system approach the environmental performance of single-use and multiple-use dishes options for in-store consumption in QSR in Europe and not focused on the environmental performance of a single product;
- **Robustness and reliability of the investigated system**: the incorporation of representative data and information with regards to the functional unit, inventory data as well assumptions around the systems.
  Primary data and information (reflected in the functional unit) for single-use system are obtained from EPPA members' which market shares cover more than 65% of QSRs in Europe. This is particularly relevant since previous LCA studies based on secondary data for paper upstream processes are not anymore representing state-of-the art for the investigated single-use system.

The geographical scope of the baseline comparison is Europe (EU-27 + UK). This geographical boundary is reflected in the assumptions around the systems (e.g. recycling rates) and background datasets (e.g. electricity from grid) as inventory data for the manufacturing stage of certain products will be site-specific or representing average production scenarios (e.g. global, EU).

The comparative LCA study has taken into account the use of **7 different food and beverage containers**:

- A cold cup;
- A hot cup;
- A wrap/clamshell or plate/cover or tray;
- A fry bag/basket/fry carton;
- A salad bowl with lid;
- A cutlery set;
- An ice-cream cup.

Other food containers/packaging (i.e. shovel for coffee, placemat, drinking straw) are not included in the LCA study.

In total, the comparative LCA assessment incorporates the life cycles of:

- **10 different single-use product items** made of paperboard (if coated, PE content is < 10% w/w); and
- **14 different multiple-use product items** (represented in different scenarios and sensitivity analyses) with 2 dishes set options: one set made of polypropylene (PP; one acrylic plastic item), and one set combining PP, ceramic, glass and steel for sensitivity analyses.

For the **baseline scenarios** the following key assumptions have been made:

<u>Single-use system:</u>

- Paper manufacturing refers to the respective geographical context of the paper mill or manufacturer from which primary data is used and is considered representative for EU-average supply chain;
- Products are made solely from virgin paper;
- Intermediate transport from paper producers to converters is modelled according to primary data provided by converters;

- Paper converting stage is modelled based on primary data obtained from converters located in representative European countries;
- Production paper wastes during converting (i.e. post-industrial wastes) are materially recycled as indicated in primary information obtained from converters;
- Types and amounts of packaging materials (cardboard and PE foils) for all single-use product items (except for wooden cutlery) are based on primary data from converters;
- End-of-life (paper products):
    - 30% paper recycling and 70% incineration with energy recovery for paper;
    - Transport of waste from QSR to incineration facility is assumed to be 100 km

<u>Multiple-use system:</u>

- PP manufacturing in Europe;
- Average reuse PP rate of 100 reuses is considered. Reuse rates also include potential replacement reasons such as damages, stains, theft or loss. The latter reasons are considered to be relatively important in QSRs as higher volumes of product items are involved than in regular restaurants;
- Dishwashing process:
    - An average scenario for in-house dishwashers is used to reflect different grades of devices' efficiencies;
    - Internal washing is assumed with a separate drying module because of hygienic requirements and increased efforts for drying of PP products based on literature information, 30% of total energy demand of washing and drying comes from drying; thus energy demands for washing reported in literature were increased by +30% if the device does not perform sufficient drying for PP products;
    - State-of-the-art detergent and rinse agent compositions are assumed;
    - Average rewashing rate for all items of 5% is considered, this assumption is made to avoid persistent residues that might remain after washing;
    - Production of simplified dishwashers is considered (generic assumption of two additional devices to be installed inside a QSR to perform in-house washing; ten-year lifetime of the dishwasher).
- End-of-life (PP products):
    - 30% material recycling and 70% incineration with energy recovery;
    - Transport of waste from QSR to waste treatment facility is assumed to be 100 km.

For the EoL assumption of the baseline scenarios it should be noted that generic plastic packaging shows EU average recycling figures (about 40%)[3] lower than paper packaging (about 85%[4]). For data symmetry reasons in the comparison and due to the lack of product-specific recycling rates, 30% material recycling and 70% incineration with energy recovery are assumed for both baseline scenarios, provided that appropriate sorting of post-consumer waste fractions is facilitated at the EoL stage. Sensitivity analyses are performed for 0% recycling and 100% incineration with energy recovery and for 70% material recycling and 30% incineration with energy recovery for both systems.

The aggregated total impacts of the baseline systems are summarised in the following Table 1.

[3] https://ec.europa.eu/eurostat/databrowser/view/ten00063/default/table?lang=en
[4] https://ec.europa.eu/eurostat/databrowser/view/ten00063/default/table?lang=en

Table 1: Life cycle impact assessment results of the baseline comparison of the single-use and multiple-use systems.

ReCiPe 2016 (H) Indicator	Single-use system - Baseline Scenario	Multiple-use system - Baseline Scenario
Climate change, default, excl. biogenic carbon [kg CO2 eq.]	8912	24645
Fine Particulate Matter Formation [kg PM2.5 eq.]	5.2	11.5
Fossil depletion [kg oil eq.]	2813	9605
Freshwater Consumption [m3]	60	202
Freshwater Eutrophication [kg P eq.]	2.9	0.6
Ionizing Radiation [kBq Co-60 eq. to air]	2110	1302
Metal depletion [kg Cu eq.]	55	180
Stratospheric Ozone Depletion [kg CFC-11 eq.]	0.010	0.009
Terrestrial Acidification [kg SO2 eq.]	22	37

These results for the baseline scenario are[5]:

- For **Climate Change**, the single-use system shows very significant climate change benefits (i.e. impacts of multiple-use baseline scenario are 177% higher than in the single-use baseline scenario).
- For **Fine Particulate Matter Formation**, the single-use system shows very significant environmental benefits (i.e. impacts of multiple-use baseline scenario are 124% higher than in the single-use baseline scenario).
- For **Fossil Depletion**, there are very significant benefits for the single-use system (i.e. impacts of multiple-use baseline scenario are 241% higher than in the single-use baseline scenario).
- For **Freshwater Consumption**, there are very significant environmental benefits for the single-use system (i.e. impacts of multiple-use baseline scenario are 235% higher than in the single-use baseline scenario).
- For **Freshwater Eutrophication**, there are very significant benefits for the multiple-use system (i.e. impacts of multiple-use baseline scenario are 81% lower than in the single-use baseline scenario).

[5] Terminology used for interpretation based on relative difference in % based on the respective indicated single-use system as reference value (e.g. baseline scenario): <5%: **marginal** difference (i.e. uncertainty threshold); 5 to 10%: **minor** difference; 10-20%: **noticeable** difference; 20-30%: **moderate** difference; 30-50%: **significant** difference; >50%: **very significant** difference

- For **Ionizing Radiation**, there are significant environmental benefits for the multiple-use system (i.e. impacts of multiple-use baseline scenario are 38% lower than in the single-use baseline scenario).
- For **Metal Depletion**, there are very significant environmental benefits for the single-use system (i.e. impacts of multiple-use baseline scenario are 226% higher than in the single-use baseline scenario).
- For **Stratospheric Ozone Depletion**, there are noticeable environmental benefits for the multiple-use system (i.e. impacts of multiple-use baseline scenario are 13% lower than in the single-use baseline scenario).
- For **Terrestrial Acidification**, there are very significant environmental benefits for the single-use system (i.e. impacts of multiple-use baseline scenario are 65% higher than in the single-use baseline scenario).

The comparison of the single-use and multiple-use systems shows that the **environmental hotspots predominantly occur in different life cycle phases in the two systems**: for the single-use system, major impacts are generated during the upstream production of the items whereas the main contributor to the impacts of the multiple-use system is the use phase, i.e. the washing of items. To test decisive assumptions in the systems, several sensitivity scenarios were analysed. Uncertainties of the method and the results were considered.

For the **sensitivity analysis** and respective scenarios only one parameter or assumption has been changed per system in order to maintain transparency and ensure traceability of results. The following sensitivity analyses have been performed:

1. <u>Single-use system</u>: Different recycling rates of post-consumer paperboard (0%; 70%);
2. <u>Multiple-use system</u>: Different recycling rates of post-consumer PP items (0%; 70%);
3. <u>Multiple-use system</u>: Varied demand for multiple-use items (30% higher; 30% lower);
4. <u>Multiple-use system</u>: Optimised washing scenario;
5. <u>Multiple-use system</u>: External washing with band transport dishwasher;
6. <u>Multiple-use system</u>: Alternative multiple-use items (dishes made from ceramic (500 or 250 reuses), glass (500 or 250 reuses), stainless steel (1000 reuses) and PP (100 reuses);
7. <u>Both systems</u>: Different EoL allocation approach for avoided energy and material production (50:50)

Under consideration of identified uncertainties and sensitivities of impact results, the following **conclusions** can be drawn from the comparative assessment[5]:

- For **Climate Change**, the single-use system shows very significant benefits considering the comparison of the baseline scenarios. When including the different sensitivity scenarios, only in cases where very efficient dishwashing processes are implemented either through solely using efficient hood-type dishwashers or in an external dishwashing scenario do the environmental benefits for the single-use system become smaller and range from very significant to minor. Therefore, the environmental benefits for the single-use system in terms of climate change impacts are consistent throughout all considered scenarios.
- For **Fine Particulate Matter Formation**, the single-use system shows very significant environmental benefits in the baseline comparison. Minor benefits for the multiple-use system are only identified when optimised or external washing scenarios are compared to

single-use system scenarios representing 0% post-consumer paperboard recycling and/or a different allocation assumption for EoL credits. Therefore, the comparison between the single-use and the multiple-use system is dependent on underlying assumptions.

- For **Fossil Depletion**, there are very significant benefits for the single-use system in the baseline comparison. Minor environmental benefits for the single-use system may occur in cases where very efficient dishwashing processes are implemented either through solely using efficient hood-type dishwashers or in an external dishwashing scenario. Therefore, the environmental benefits for the single-use system in terms of fossil depletion impacts are consistent throughout all considered scenarios.
- For **Freshwater Consumption**, there are very significant environmental benefits for the single-use system considering the baseline comparison. Moderate environmental benefits for the multiple-use system are only identified when optimised or external washing scenarios are compared to single-use system scenarios representing 0% post-consumer paperboard recycling and/or a different allocation assumption for EoL credits.
- For **Freshwater Eutrophication**, there are exclusively very significant benefits for the multiple-use system in the baseline and the different scenarios. Therefore, the environmental benefits for the multiple-use system in terms of freshwater eutrophication impacts are consistent throughout all considered scenarios.
- For **Ionizing Radiation**, there are significant environmental benefits for the multiple-use system in the baseline comparison. Only noticeable environmental benefits for the multiple-use system are identified when increased post-consumer paper recycling and full crediting at the EoL stage is assumed. Therefore, the environmental benefits for the multiple-use system in terms of ionizing radiation impacts are consistent throughout all considered scenarios.
- For **Metal Depletion**, there are very significant environmental benefits for the single-use system in the baseline comparison. However, moderate environmental benefits for the multiple-use system are identified when external washing is assumed. Therefore, the comparison between the single-use and the multiple-use system for the potential metal depletion impact is dependent on underlying assumptions.
- For **Stratospheric Ozone Depletion**, there are noticeable environmental benefits for the multiple-use system in the baseline comparison. Very significant environmental benefits for the multiple-use system are identified for the hypothetical scenarios entailing optimised or external washing processes. Therefore, the environmental benefits for the multiple-use system in terms of stratospheric ozone depletion impacts are consistent throughout all considered scenarios.
- For **Terrestrial Acidification**, there are very significant environmental benefits for the single-use system in the baseline comparison. Noticeable environmental benefits for the multiple-use system are only identified when optimised or external washing scenarios are compared to single-use system scenarios representing 0% post-consumer paperboard recycling and/or a different allocation assumption for EoL credits. Therefore, the comparison between the single-use and the multiple-use system for the potential terrestrial acidification impact is dependent on underlying assumptions.

These results are partly in contrast to other LCA studies found in literature screening that are mainly product-focused and often reveal clearer environmental advantages for multiple-use items compared to their single-use equivalents as long as a certain minimum number of reuses is considered. This difference can largely be explained by the fact that previous studies are mainly relying on secondary data (in particular concerning the paper upstream value chain) whereas the study at hand implemented primary data to a large extend, in particular for the environmental hotspots of paper production and conversion in the single-use system. However, for the multiple-use system, data is based on literature information and conventions combined with selected industry and expert inputs where possible. This is due to the fact that the multiple-use system presents a hypothetical future scenario for which no primary data exists (i.e. specific functioning of QSRs is mainly based on conventions) and, as regards the upstream production of multiple-use items, no primary data is available in the context of this LCA study.

This study is not intended to present or interpret environmental impacts on a product level. Modelling choices, data quality and assumptions are to be seen in the light of the overarching goal and systems perspective. As a consequence, the impact result may not be used for product development, production process improvement, or any product-related decisions.

The geographical location of production and use is potentially crucial and in particular the energy mix at the location of production and use has significant influence on the associated environmental impacts. Consequently, the geographical context is also a decisive factor for the results of this study. Due to the geographical scope of the study (i.e. Europe), European averages are used for important (background) processes such as the electricity mix and pulp production. In particular for the multiple-use system, where major impacts are generated by the use of electricity for the washing process, the selection of another geographical scope could significantly change the results and comparative assertion.

In the light of a potential introduction of multiple-use systems it needs to be borne in mind that this also constitutes a paradigm shift of the environmental monitoring and management. **While the single-use system is characterised by rather centralised large, industrialised operators with continuous environmental improvement systems in place, the environmental implications of a hypothetical multiple-use system may be characterised by decentralised and less organised actors.** This shift may cause a lack of both environmental management systems and data availability and reliability to steer further environmental strategies.

The results of the study also point to further need for research and investigation of relevant parameters and processes, amongst others related to certain impact categories in LCA methods as well as further need for research on the assumptions, conventions and parameters relating to current and hypothetical multiple-use system.

<u>External review</u>
This executive summary is based on an ISO-compliant full LCA report that was subject to a third-party review.

EXECUTIVE ANNEX

Quick Service Restaurants (QSRs) are at the core of utilized product items and accompanying processes (e.g. transport, dishwashing) in this assessment. Therefore, it is crucial that the established functioning of a QSR restaurant is maintained despite the fundamental change related to the use of reusable food and beverage containers for in-store consumption. In line with the goal and envisaged systems approach of this assessment and current or hypothetical future operations in QSRs being in the foreground of this assessment, this LCA seeks to differentiate between upstream, core, and downstream processes which are inextricably linked to the functional unit (see Figure 1).

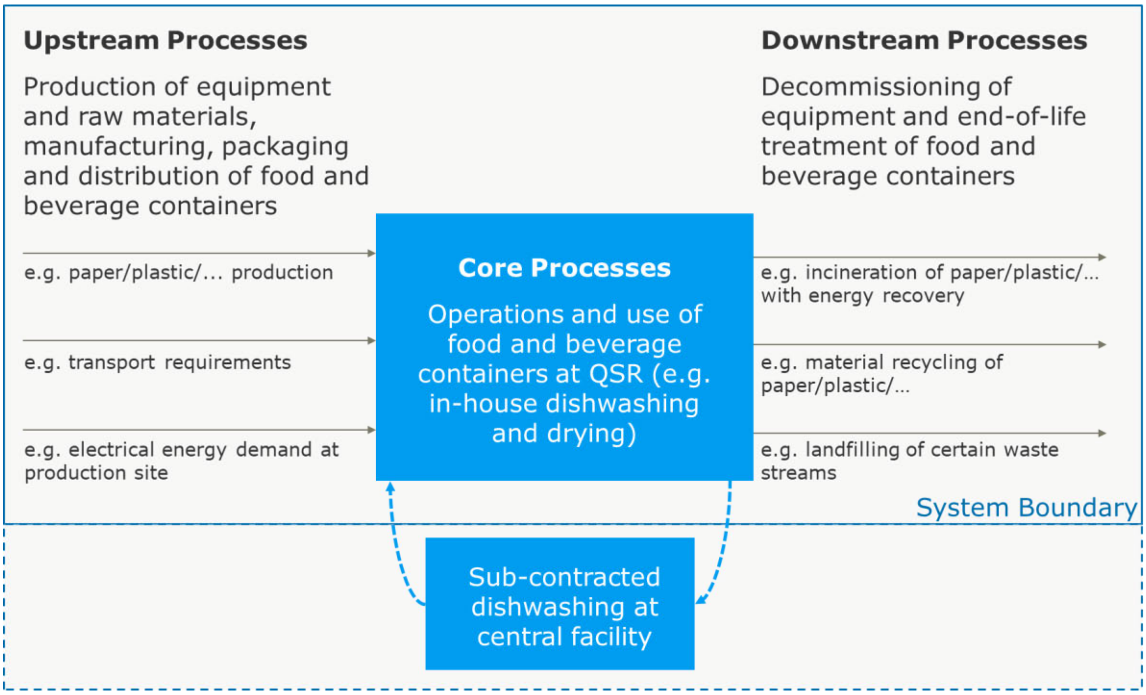

Figure 1: Schematic system boundary and differentiation between upstream, core, and downstream processes from the perspective of a QSR (Source: own depiction)

As outlined above, the comparison of the single-use and multiple-use systems shows that the environmental hotspots predominantly occur in different life cycle phases in the two systems: for the single-use system, major impacts and credits are generated during the upstream production and EoL treatment of the items whereas the main contributor to the impacts of the multiple-use system is the use phase, i.e. the washing of items. Hence, further details on the respective important life-cycle stages are provided here.

Further details on the production and EoL treatment phases of the single-use system

Primary LCI data for pulp and paper products are obtained from several producers located in countries representative for the pulp and paper market situation in Europe. Hence, the entire raw material production and processing phase for paper products is represented by using primary data (only exceptions are background processes such as chemicals, auxiliary materials, electricity, thermal energy). To this end, the primary information indicated in Table 2 is implemented in the assessment.

Table 2: Primary data for paper making implemented in the assessment

Process name	Classification	Source	Geographical coverage	Reference value	Reference year
Chemical pulp (softwood)	Primary data	Confidential	Finland	1 t dry chemical pulp	2019
PE-coated paperboard (different variants and specifications)	Primary data	Confidential	Finland	1 t board	2020
Thin greaseproof paper with soy-based coating	Primary data	Confidential	Austria	1 t paper	2020
High-brightness cartonboard	Primary data	Confidential	Austria	1 t cartonboard	2019
Brown kraft cartonboard	Primary data	Confidential	Slovenia	1 t cartonboard	2019

For this assessment it is assumed that all single-use products are entirely made of virgin paper. In this regard it is important to remember that actually a significant share of some paper products listed above comes from post-industrial paper waste. Consequently, this assumption reflects a conservative approach and avoids the risk of double counting of the credits associated with energy or material recovery at the EoL stage. In line with this approach, EoL credits are assigned based on the assumption that an equivalent virgin paper product is displaced in the market by the recovered material.
The production stage of single-use product items (i.e. converting stage) is modelled based on primary data obtained from converters based in Germany, Finland, and France. Wooden cutlery marks the only exemption, for which only secondary data is implemented. To this end, the primary information indicated in Table 3 is implemented in the assessment.

Table 3: Primary data for paper converting implemented in the assessment

Process name	Classification	Source	Geographical coverage	Reference value	Reference year
Hot drink cup	Primary data	Huhtamaki	Finland	1 t dry weight product	2018
Cold drink cup	Primary data	Seda	Germany	1000000 pcs	2020
Clamshell	Primary data	Seda	Germany	1000000 pcs	2020
Fry bag	Primary data	Seda	Germany	1000000 pcs	2020
Salad box	Primary data	Seda	Germany	1000000 pcs	2020
Clip on Lid	Primary data	Seda	Germany	1000000 pcs	2020
Ice Cream Cup	Primary data	Seda	Germany	1000000 pcs	2020
Paper wrap	Primary data	CEE Schisler	France	1000 pcs	2019
Paper fry bag	Primary data	CEE Schisler	France	1000 pcs	2019

In order to represent an appropriate recycling scenario as well as to account for environmental credits of recycling, primary gate-to-gate inventory data of a dedicated recycling process for plastic (PE)-coated as well as uncoated paperboard products is implemented. For the subsequent environmental credits from material recycling, inventory data of the manufacturing of intermediate paper products until the point of substitution through respective material outputs of the recycling process are implemented as indicated in Table 4.

Table 4: Industry statistics and secondary data for avoided pulp production

Industry statistics for the resulting shares of avoided pulp products per ton of recovered pulp (in total 100 %)	Provider process	Data classification	Source	Geographical coverage
49 %	Market for sulfate pulp, bleached	Secondary data	Ecoinvent 3.6	Europe (RER)
2 %	Market for sulfate pulp, unbleached	Secondary data	Ecoinvent 3.6	Europe (RER)
2 %	Sulfite pulp production, bleached*	Secondary data	Ecoinvent 3.6	Europe (RER)
24 %	Thermo-mechanical pulp (TMP) production*	Secondary data	Ecoinvent 3.6	Europe (RER)
24 %	Chemo-thermomechanical pulp (CTMP) production*	Secondary data	Ecoinvent 3.6	Europe (RER)

* implemented data is adjusted to reflect energy efficiency gains in the industry

Further details on the use phase (including washing) of the multiple-use system

Two types of commercial dishwashers are considered suitable to be used (and installed) in QSRs in an in-house washing scenario: undercounter and hood-type dishwashers. Both types of dishwashers show different ranges of efficiencies in terms of energy, water and chemicals demand. For the baseline scenario it is assumed that already installed devices in QSRs will be maintained until their end of life and will be supplemented by new devices. To reflect the different options of dishwashers in QSRs and the different levels of efficiencies, an average washing scenario is assumed for the baseline comparison. Given the board geographical scope of this assessment (EU average) this assumption is further justified. This average washing scenario consists of two options of undercounter dishwashers (conservative and optimised performance) and two options of hood-type dishwashers (conservative and optimised performance), resulting in four options with different demands for electricity, water and chemicals. Due to limited existing experience with washing processes of multiple-use items in QSRs and limited data availability for washing demands on a per item-basis, each option is weighted equally to define an overall average washing scenario for the in-house washing process. These four options along with their LCI data and the resulting overall average used for the baseline comparison are summarised in Table 5. The two undercounter dishwasher options presented in Table 5 possess dedicated plastic washing and drying programmes that ensure plastic items are completely dry. The reported energy demands are therefore considered sufficient for drying PP products in a QSR context. Literature information identified for the hood-type dishwashers focuses on ceramic products only. Thus, it must be assumed that plastic item washing and drying in QSRs requires additional energy for a dedicated drying process. According to literature data, drying accounts for approximately

30% of the overall energy demand for washing and drying[6]. Therefore, energy demands reported in literature for the two hood-type devices are assumed to reflect 70% and are increased by 30% to model in-house dishwashing of plastic-based multiple-use items.

Table 5: Technical specifications of dishwashers for the inhouse washing scenario (LCI data).

	Undercounter dishwasher		Hood-type dishwasher		Average washing process
	Conservative	Optimised	Conservative	Optimised	
Reference year	2011	2020	2011	2017	
Energy demand* [kWh/item]	0.043	0.027	0.024	0.014	0.027
Water demand [l/item]	0.80	0.23	0.16	0.08	0.318
Combined detergents and rinse demand [g/item]**	0.80	0.20	0.50	0.17	0.417
Source	Based on (Rüdenauer *et al.*, 2011); (CIRAIG, 2014)	Based on Miele[7]; (CIRAIG, 2014; Paspaldzhiev *et al.*, 2018)	Based on (Rüdenauer *et al.*, 2011); (Paspaldzhiev *et al.*, 2018)	Based on (Antony and Gensch, 2017)	

* including assumption for energy demand for drying

** 90% of the total is detergent demand, 10% rinse agent demand

Baseline comparison and sensitivity analyses results

The following paragraphs show the results of the baseline comparison per impact category, including details on the distribution of impact over different life cycle stages. In addition, results of the sensitivity analyses for the respective impact categories are provided.

[6] 30% is an approximation based on: 26% reported by EC, JRC (2007), Best Environmental Pract ce in the tourism sector; 33% reported for Meiko Flight Conveyor Dishwasher by Slater (2017), Energy Efficient Flight Conveyor Dishwashers; 32% reported for Hobart Flight Conveyor Dishwasher by Slater (2017), Energy Efficient Flight Conveyor Dishwashers.

[7] Source: Miele Webs te (accessed 26.10.2020), commercial dishwashers: https://www.miele.co.uk/profess onal/product-selection-commercial-dishwashers-429.htm

a) Climate Change

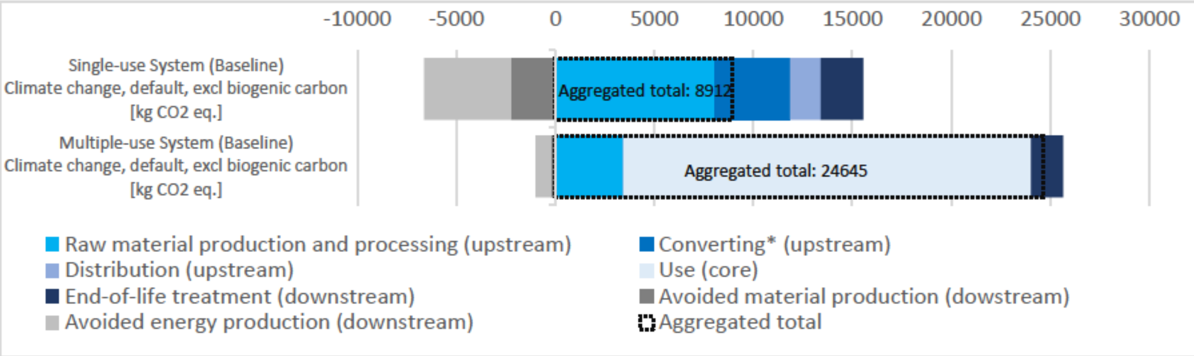

Figure 2: Baseline comparison results for the impact category Climate Change (excl. biogenic carbon) in kg CO_2 eq.

<u>Single-use system</u>

The potential climate change impacts of the single-use system are largely driven by paper manufacturing (about 90% of the aggregated total and half of the positive impact contributions, i.e. from raw material stage until EoL treatment). Next to paper manufacturing, the electricity demand for converting plays an important role in this category (assumed as EU-28 average grid mix). While paper manufacturing adds significant climate impacts, it is important to bear in mind that the total climate change impact is also significantly affected by the assigned climate change credits through material recycling and incineration with energy recovery (i.e. calculated negative impacts due to assumed avoidance of primary production of pulp or energy). Avoided climate change impacts through recycling and energy recovery correspond to about 75% of the aggregated total. The resulting climate change credits are, in turn, mainly associated with the avoided energy production, i.e. avoided production of electricity and thermal energy from natural gas in Europe.

<u>Multiple-use system</u>

The single main contributor to climate change impact in the multiple-use baseline scenario is the electricity demand of the washing process. Overall, the use phase accounts for 83% of the total aggregated impact. Another 14% are generated from the upstream production of multiple-use products and 7% from the EoL treatment of the item, although again a credit of 4% is associated with EoL treatment (credits for material and energy).

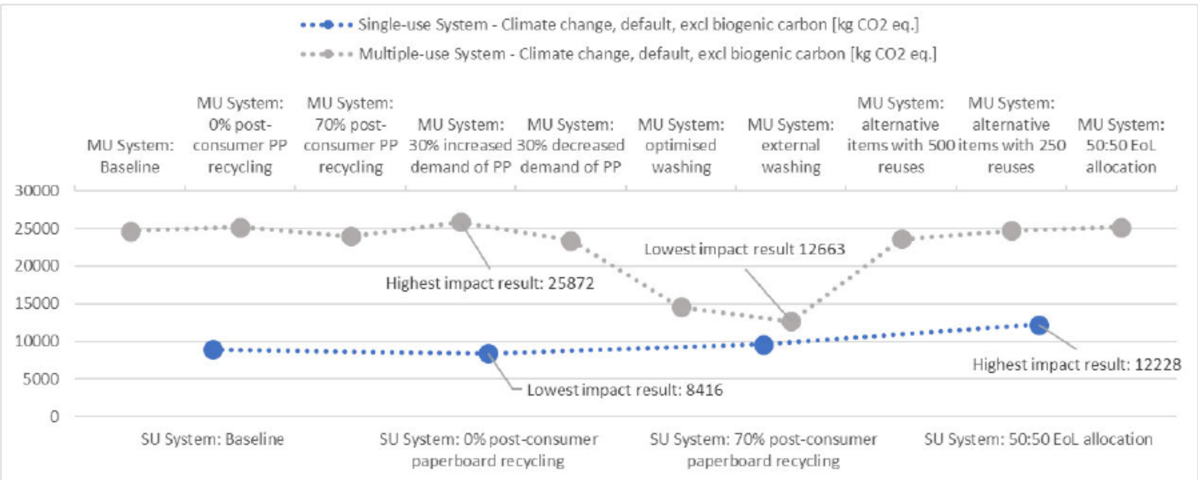

Figure 3: Summary of aggregated results for the impact category Climate Change of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, the single-use system predominantly and on average shows **very significant** climate change benefits, apart from a scenario where very efficient dishwashing processes are implemented either through solely using efficient hood-type dishwashers or in an external dishwashing scenario. Only in these cases do the relative differences in climate change impacts become smaller (i.e. ranging from **significant benefits** for the single-use system to **minor benefits** for the single-use system).

b) Fine Particulate Matter Formation

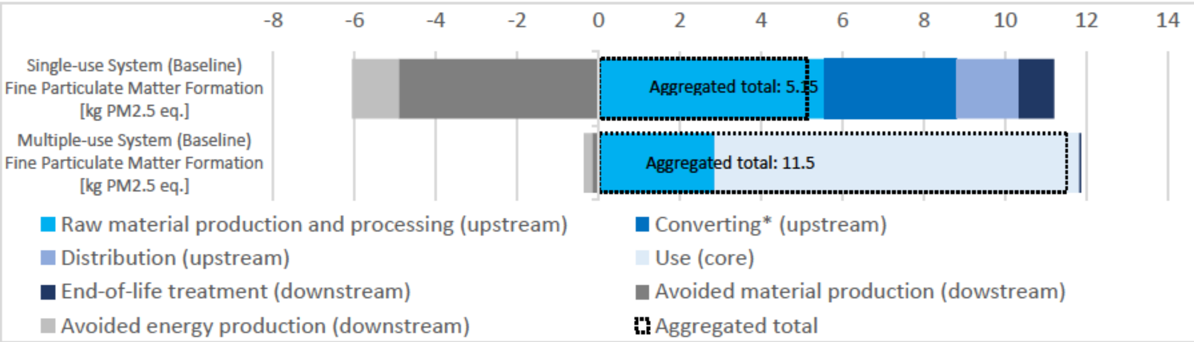

Figure 4: Baseline comparison results for the impact category Fine Particulate Matter Formation in kg PM2.5 eq.

Single-use system

Next to significant contributions from the paper manufacturing stage (both paper-based products as well as cardboard for packaging), converting (more than 60% of the aggregated total) and transport emissions during final distribution of single-use product items to QSR locations (about 30% of the aggregated total) are the main contributors to the total impacts associated with the baseline scenario of the single-use system. The resulting aggregated total impact is, again, significantly affected by the credits associated with material recycling and energy recovery. Overall, the incorporated credits are as high as the aggregated impacts of the single-use system in this category.

Multiple-use system

Similarly to the climate change impact category, 79% of the aggregated total for fine particulate matter are associated with the washing process, dominated by its electricity demand (i.e. EU-28 average grid mix). Upstream multiple-use items cradle-to-gate production accounts for 23% of the aggregated total impact.

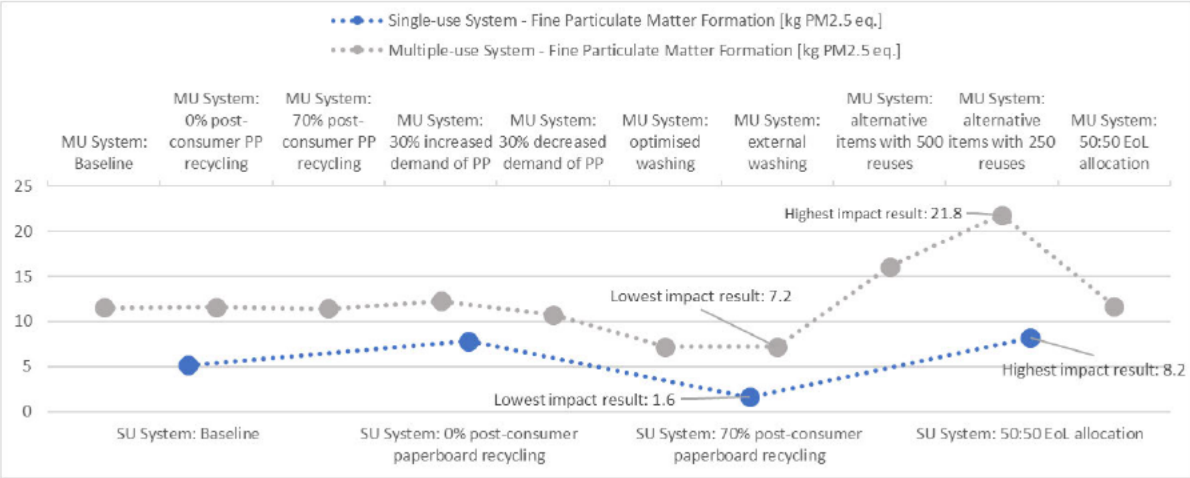

Figure 5: Summary of aggregated results for the impact category Fine Particulate Matter Formation of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, the majority of the considered scenarios confirm the tendency of the baseline comparison, i.e. on average the single-use system shows **very significant** environmental benefits for fine particulate matter formation. **Minor** benefits for the multiple-use system are only identified when optimised or external washing scenarios are compared to single-use system scenarios representing 0% post-consumer paperboard recycling and/or a different allocation assumption for EoL credits.

c) Fossil Depletion

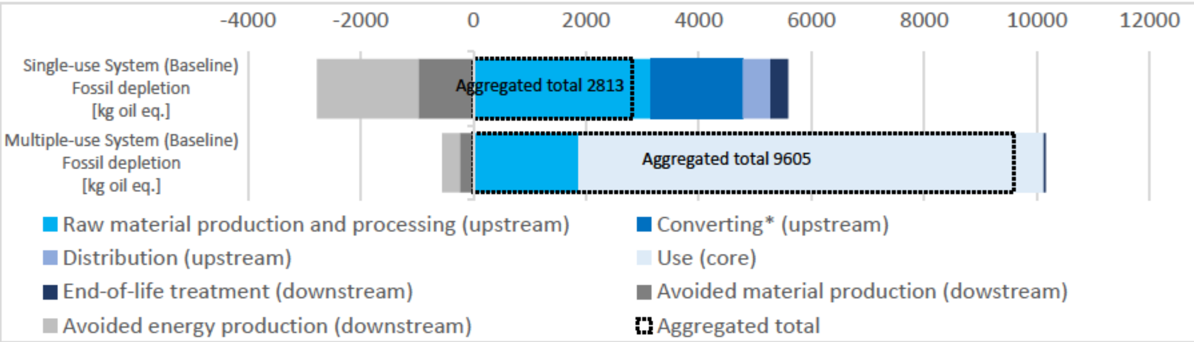

Figure 6: Baseline comparison results for the impact category Fossil depletion in kg oil eq.

Single-use system

The largest contributors to the baseline scenario of the single-use system are paper manufacturing and electricity demand for converting which is based on the EU-28 average grid mix. However, these contributions are again significantly counteracted by credits from material recycling and energy recovery, together corresponding to about 50% of the total positive impact contributions (see contributions from upstream, core, and EoL treatment).

Multiple-use system

With regard to the baseline scenario of the multiple-use system, fossil depletion is dominated by the electricity demand (i.e. EU-28 average grid mix) for washing and the washing phase accounts for 86% of the aggregated total impact. Upstream multiple-use items production is responsible for 19% of the aggregated total impact to fossil depletion.

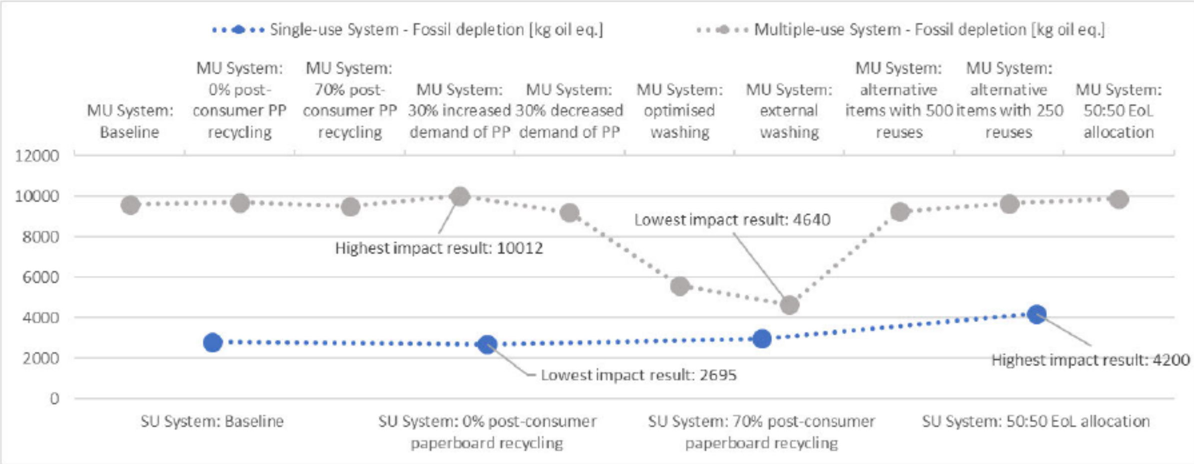

Figure 7: Summary of aggregated results for the impact category Fossil Depletion of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, reported results mainly and on average suggest **very significant** benefits for the single-use system with regard to fossil depletion. Only when assuming an efficient external washing scenario in combination with a different assumption concerning the EoL stages of both systems, the relative difference between the two systems becomes smaller (i.e. ranging from **very significant** benefits for the single-use system to **noticeable** benefits for the single-use system).

d) Freshwater Consumption

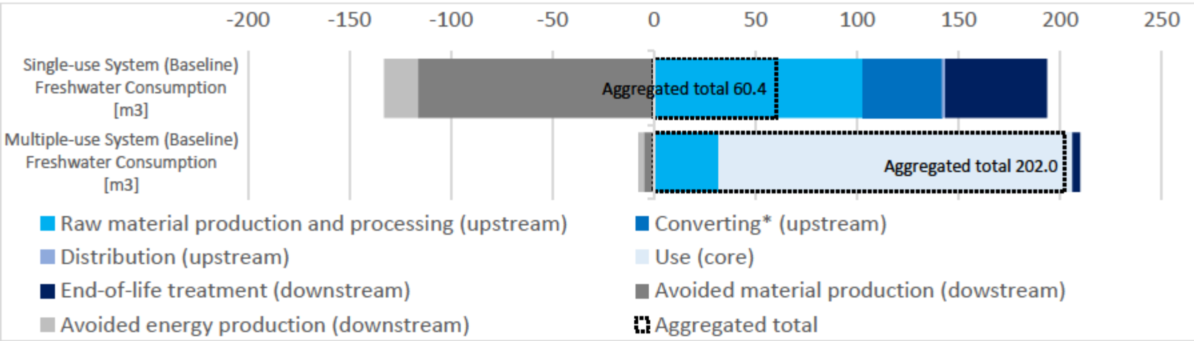

Figure 8: Baseline comparison results for the impact category Freshwater Consumption in m³

Single-use system

Paper manufacturing and electricity demand for converting and the paper incineration process (see contribution from End-of-life treatment) are significant contributors in the baseline scenario of the single-use system. Despite the relatively high impact from the actual incineration process, freshwater consumption credits associated with energy recovery and recycling more than outweighs these impacts (in particular credits from avoided primary production of bleached sulphate pulp).

Multiple-use system

The main contributor to freshwater consumption in the baseline scenario of the multiple-use system is the water demand of the washing process. However, the net effect is rather small as a most of the water is only used temporarily and made available again through a wastewater treatment process. Other significant contributions to freshwater consumption arise again from electricity demand of the washing process and upstream items production as well as from chemicals production for the washing process.

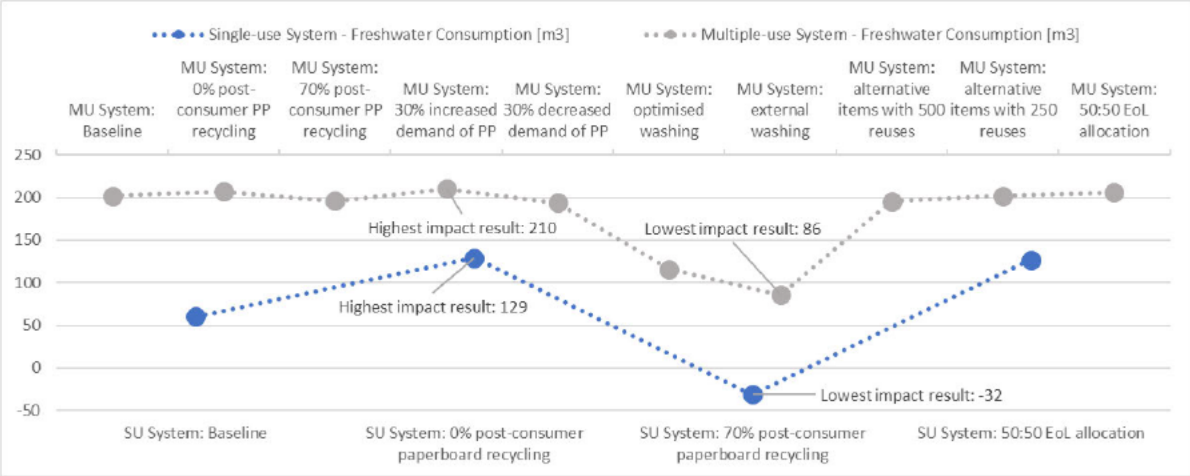

Figure 9: Summary of aggregated results for the impact category Freshwater Consumption of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, the comparison between the single-use and the multiple-use system is dependent on underlying assumptions. However, there is a tendency that on average the single-use system shows **very significant** environmental benefits in terms of freshwater consumption. **Moderate** environmental benefits for the multiple-use system are solely identified in hypothetical situations where the effects of post-consumer paper recycling are less prevalent (i.e. 0% post-consumer recycling and/or different EoL allocation assumption) and optimised or external washing is fully adopted. In general, it is important to bear in mind inherent uncertainties relating to the adopted impact assessment method and, in particular, the freshwater consumption indicator.

e) Freshwater Eutrophication

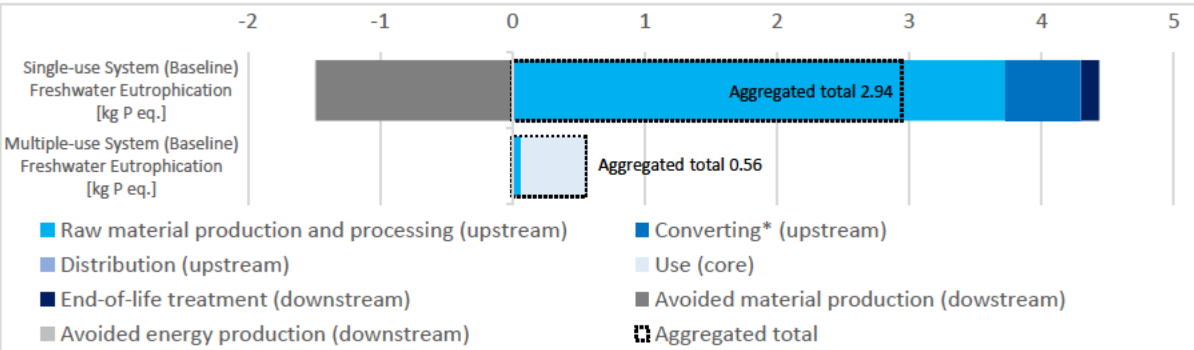

Figure 10: Baseline comparison results for the impact category Freshwater Eutrophication in kg P eq.

<u>Single-use system</u>

The resulting impact of the baseline scenario of the single-use system is predominantly influenced by paper manufacturing. Credits from avoided primary production of pulp contributes significant credits (i.e. negative impacts) to this impact category.

Multiple-use system

The single main contributor to freshwater eutrophication in the baseline scenario of the multiple-use system is wastewater treatment as a result of the washing process (see use phase). Combined with the contributions from the electricity demand of the washing process and the production of chemicals for the detergent, 89% of the aggregated total impact are generated by the use phase of the multiple-use system. The upstream production of items is another significant contributor with a share of 12% of the total aggregated impact.

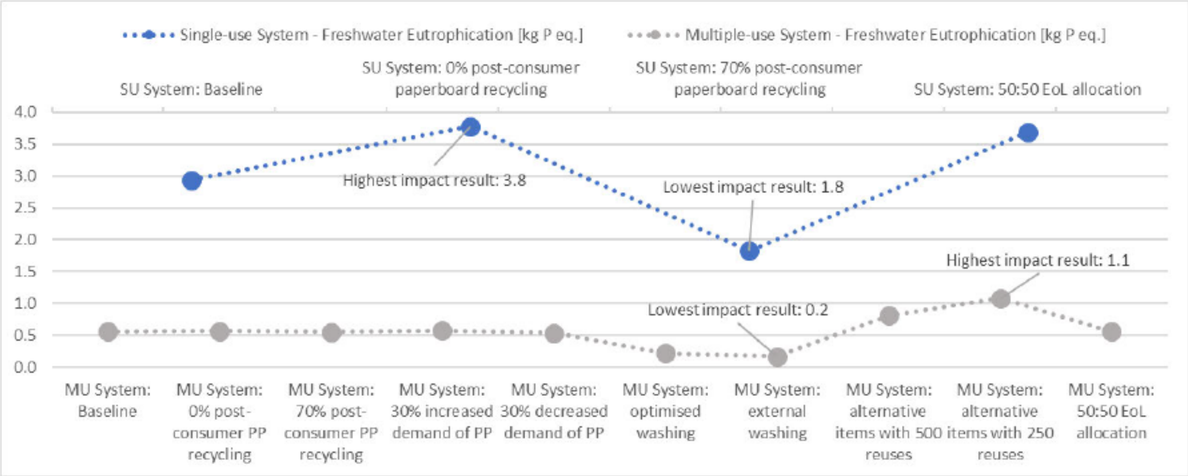

Figure 11: Summary of aggregated results for the impact category Freshwater Eutrophication of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, reported results exclusively suggest **very significant** benefits for the multiple-use system with regard to freshwater eutrophication.

f) Ionizing Radiation

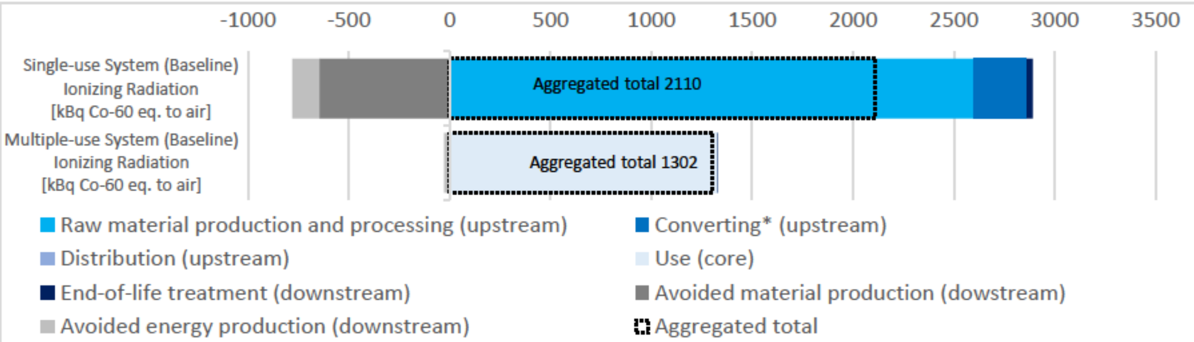

Figure 12: Baseline comparison results for the impact category Ionizing Radiation in kBq Co-60 eq. to air

Single-use system

The resulting impact in the baseline scenario of the single-use system is almost entirely affected by both the paper manufacturing and subsequent credits from material recycling. The latter corresponds to almost 40% of the aggregated total.

Multiple-use system

In the baseline scenario of the multiple-use system, ionizing radiation is dominated by the electricity demand (i.e. EU-28 average grid mix) of the washing process in the use phase, which accounts for almost 102% of the aggregated total impact. Around 2% of these impacts are offset due to the credits from EoL treatment.

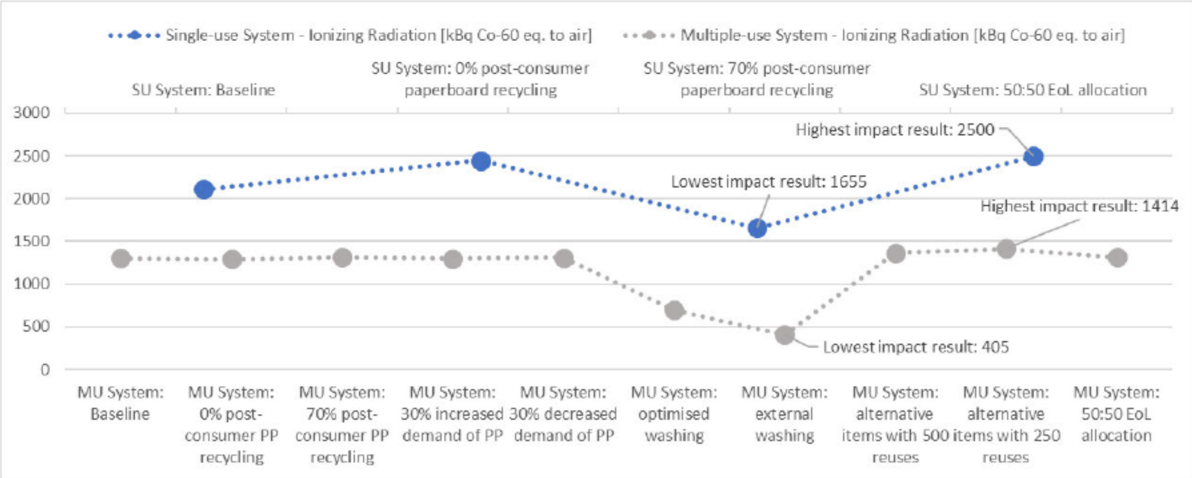

Figure 13: Summary of aggregated results for the impact category Ionizing Radiation of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, there are on average **significant** environmental benefits for the multiple-use system with regard to ionizing radiation. Only **noticeable** environmental benefits for the multiple-use system are identified when increased post-consumer paper recycling and full crediting at the EoL stage is assumed.

g) Metal Depletion

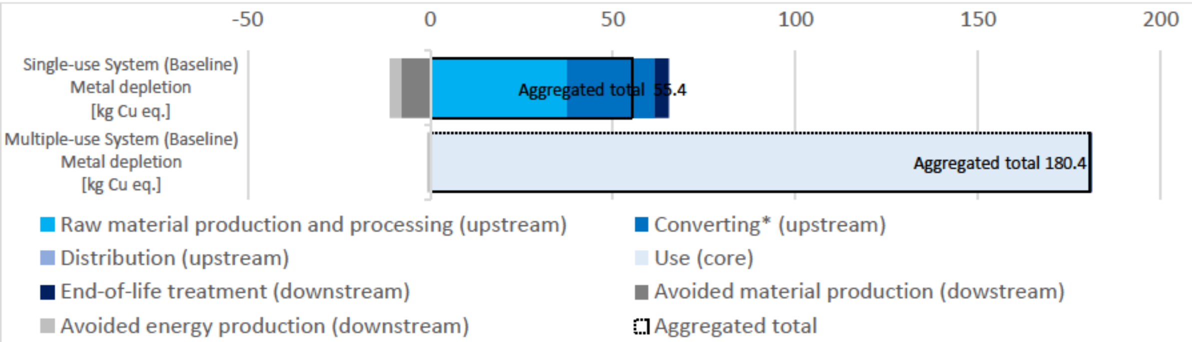

Figure 14: Baseline comparison results for the impact category Metal Depletion in kg Cu eq.

<u>Single-use system</u>

The main contributors in the baseline scenario of the single-use system are chemicals/fillers and varnishes/paints during paper manufacturing and converting. Noteworthy credits are resulting from energy recovery and material recycling (corresponding to about 20% of the aggregated total).

<u>Multiple-use system</u>

The predominant contributor to metal depletion in the baseline scenario of the multiple-use system are the chemicals used in detergent and rinse agent for the washing process of multiple-use items. This is due to one specific chemical (potassium hydroxide), which accounts for more than one third of the detergent quantity. Electricity demand is the second largest contributor, making up for about 16% of the total impact.

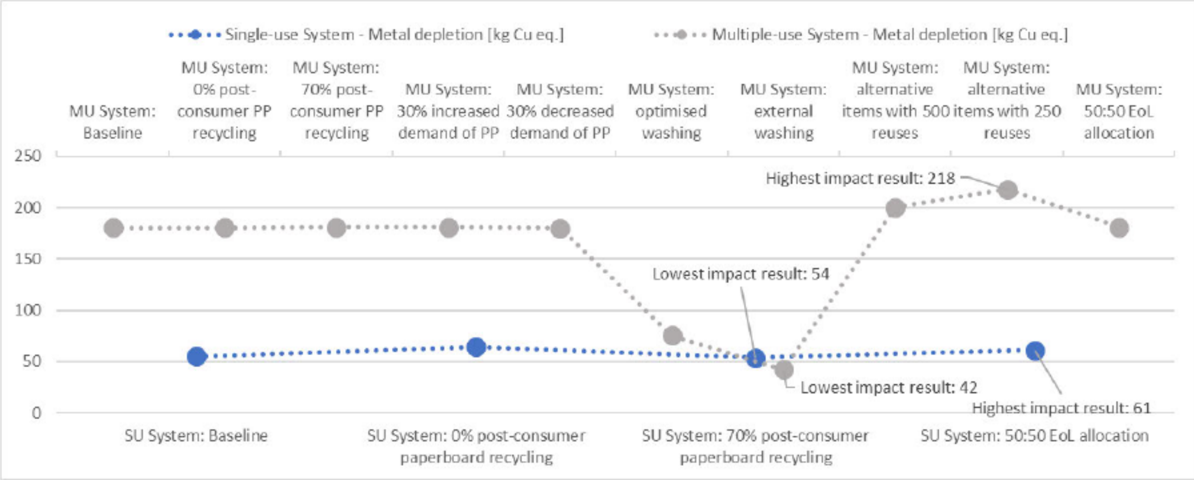

Figure 15: Summary of aggregated results for the impact category Metal Depletion of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, the multiple-use system shows on average **very significant** environmental benefits with regard to metal depletion. However, **moderate** environmental benefits are shown for the single-use system when external washing is assumed.

h) Stratospheric Ozone Depletion

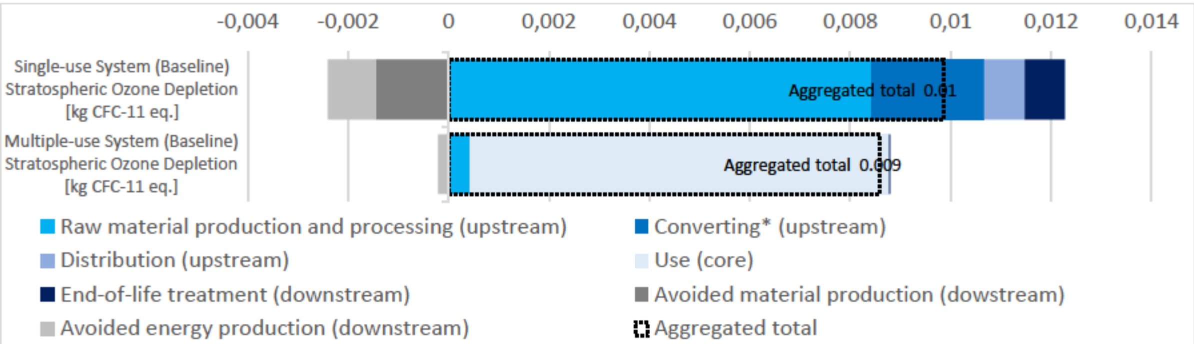

Figure 16: Baseline comparison results for the impact category Stratospheric Ozone Depletion in kg CFC-11 eq.

Single-use system

Looking at the baseline scenario of the single-use system, this impact category is almost entirely influenced by certain paper manufacturing processes. Credits from recycling and energy recovery are less significant in this category compared to other impact categories.

Multiple-use system

With regard to the baseline scenario of the multiple-use system, the stratospheric ozone depletion is again dominated by the electricity demand of the washing process, followed by municipal wastewater treatment and the production of chemicals for washing. Thus, the use phase generates 97% of the total aggregated impact.

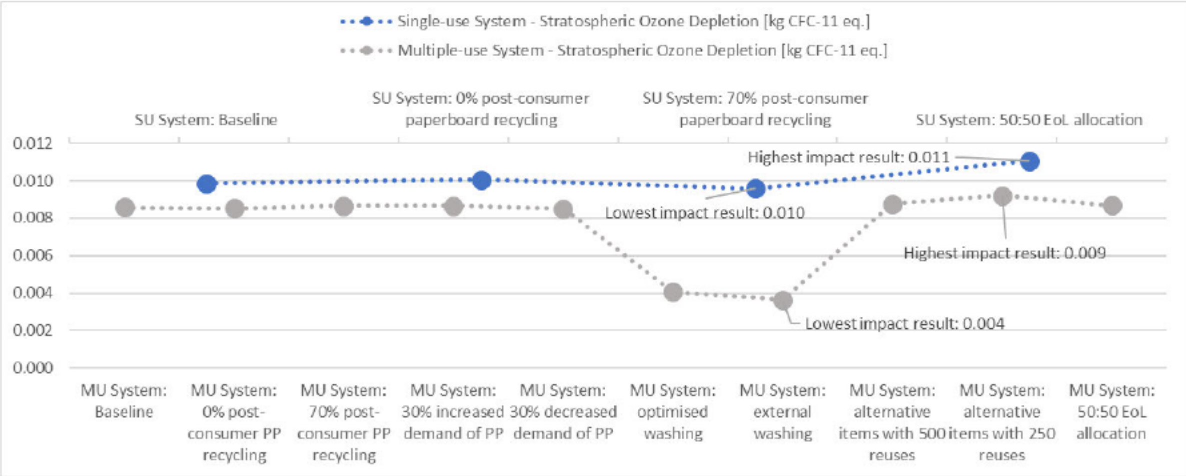

Figure 17: Summary of aggregated results for the impact category Stratospheric Ozone Depletion of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, the multiple-use system on average shows **moderate** environmental benefits in terms of stratospheric ozone depletion. **Very significant** environmental benefits for the multiple-use system are identified for the hypothetical scenarios entailing optimised or external washing processes.

i) Terrestrial Acidification

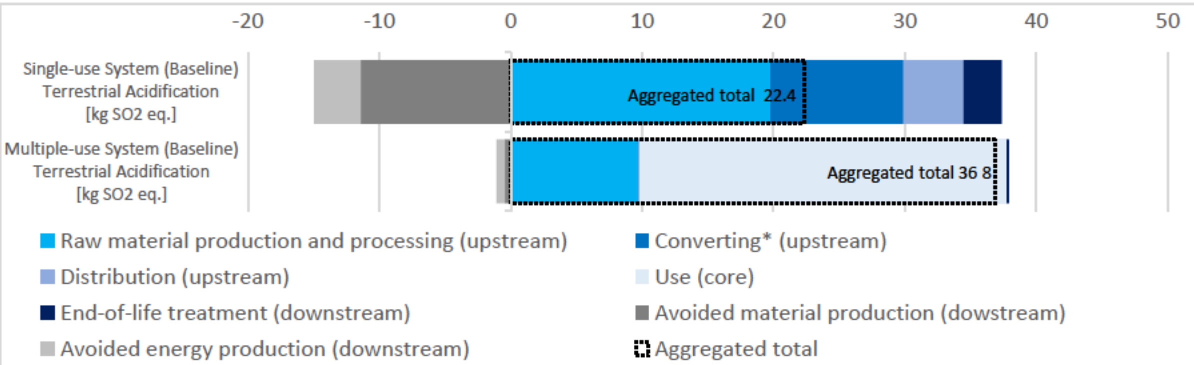

Figure 18: Baseline comparison results for the impact category Terrestrial Acidification in kg SO_2 eq.

Single-use system

The largest contributors in the baseline scenario of the single-use system are paper manufacturing and electricity demand for converting. These contributions are again significantly counteracted by credits from recycling and energy recovery (corresponding to almost 70% of the aggregated total).

Multiple-use system

With regard to the baseline scenario of the multiple-use system, terrestrial acidification is dominated by the electricity demand of the washing process. The use phase is responsible for 77% of the aggregated total impact. 25% of the impact on terrestrial acidification stem from the upstream production of multiple-use items and around 3% credits are generated through their EoL treatment.

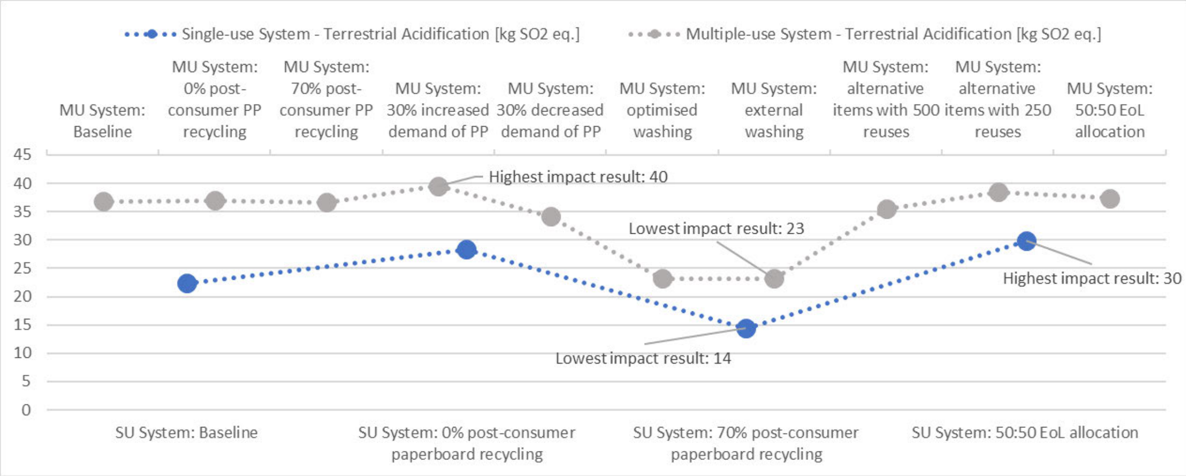

Figure 19: Summary of aggregated results for the impact category Terrestrial Acidification of all scenarios within both systems (the order from left to right follows the sequence of the respective report sections).

In summary, the single-use system on average shows **significant** environmental benefits with regard to terrestrial acidification. **Noticeable** environmental benefits for the multiple-use system are solely identified in situations where the effects of post-consumer paper recycling are less prevalent (i.e. different allocation assumption and/or no post-consumer paperboard recycling) and optimised or external washing is fully adopted.

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DESKTOP ASSESSMENT RELATED TO COMPARATIVE LCA PERFORMED FOR QUICK SERVICE RESTAURANTS

IRISH CONTEXT EVALUATION

RAMBOLL Bright ideas. Sustainable change.

DESKTOP ASSESSMENT RELATED TO COMPARATIVE LCA PERFORMED FOR QUICK SERVICE RESTAURANTS IRISH CONTEXT EVALUATION

Project name	**EPPA – Italy**
Recipient	**EPPA - European Paper Packaging Alliance, The Hague, The Netherlands**
Version	**Memo report for Ireland**
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[1] 'Comparative LCA: Single-use and Multiple-use dishes systems for in-store consumption in Quick Serv ce Restaurants', December 2020, p. 182

CONTENTS

ABBREVIATIONS

EoL	End-of-Life
EPPA	European Paper Packaging Alliance
EU	European Union
FU	Functional Unit
IE	Ireland
ISO	International Standardization Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
MU	Multiple-Use
PP	Polypropylene
QSR	Quick service restaurant
SU	Single-Use
UK	United Kingdom

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1. INTRODUCTION

Ramboll was appointed by the European Paper Packaging Alliance (EPPA) as technical consultant for conducting a desktop assessment to identify peculiarities of Irish context (hereinafter IE) that can have significant impacts on the results of a Comparative Life Cycle Assessment (LCA) between a single use dishes system and equivalent multiple-use dishes system in Quick Service Restaurants (referred to EU average + UK) in accordance with ISO standards 14040 and 14044 conducted in 2020 on behalf of EPPA (Ramboll, 2020[2]). The functional unit of the performed Comparative LCA was:

> *in-store consumption of foodstuff and beverages with single-use or multiple-use dishes (including cups, lids, plates, containers and cutlery) in an average QSR for 365 days in Europe in consideration of established facilities and hygiene standards as well as QSR-specific characteristics (e.g., peak times, throughput of served dishes).*

To this aim, Ramboll carried out a dedicated desktop assessment (including literature review and a web-based research) to identify peculiarities of Irish context that can have significant impacts on LCA results, and performed a specific assessment related to the variation of the parameters for which figures of Irish context are comparable/different with the ones utilized in the EU Comparative LCA study (Ramboll, 2020), considering baseline scenario and sensitivity analyses.

Results of this assessment are summarized in this Memo report that includes a qualitative evaluation of the possibility to consider main conclusions of EU Comparative LCA study (Ramboll, 2020) representative also of the Irish context.

<u>Note</u>: This study is not intended as a Life Cycle Assessment and the adopted methodology does not follow any applicable ISO standard. In addition, qualitative results are not subject to a third-party review.

[2] 'Comparative LCA: Single-use and Multiple-use dishes systems for in-store consumption in Quick Serv ce Restaurants', December 2020, p. 182.

2. EUROPEAN LCA STUDY - SUMMARY OF APPROACH AND ASSUMPTIONS

As mentioned before, in 2020 Ramboll was appointed by the European Paper Packaging Alliance (EPPA) as technical consultant for conducting a comparative Life Cycle Assessment (LCA) study between a single use dishes system and equivalent multiple-use dishes in Quick Service Restaurants (hereafter "QSRs") in accordance with ISO standards 14040 and 14044 (Ramboll, 2020) as a basis for discussion with authority representatives on the current legal developments within the European Union plus the United Kingdom regarding circular economy and waste prevention.

This assessment was embedded in an ongoing debate around the environmental performance of single-use and multiple-use products, and it was focused on a systemic approach (comprehensive dishes options for in-store consumption in QSR) which was used to reflect both systems and compare equal functions of single-use and multiple-use product items in an average. Below approach and assumptions of the EU Comparative LCA Study (Ramboll, 2020) are summarized.

The main goal of the EU Comparative LCA study (Ramboll, 2020) was to use a systems-based approach to **compare the environmental performance of single-use (SU) and multiple-use (MU) dishes options for in-store consumption in QSR in Europe.**

The functional unit was the in-store consumption of foodstuff and beverages with single-use or multiple-use dishes (including cups, lids, plates, containers and cutlery) in an *average* QSR for 365 days in Europe in consideration of established facilities and hygiene standards as well as QSR-specific characteristics (e.g., peak times, throughput of served dishes).

For the comparative assessment, two fundamentally distinct systems were taken into consideration:

- the current system in QSRs based on single-use (disposable) products made of paperboard with a polyethylene (PE) content < 10% w/w (also referred to as single-use product system), accounting for regulatory implications in 2023 (e.g., targets for separate waste collection and end of life (EoL) recycling);
- an expected (hypothetical) future system in the near future based on equivalent multiple-use products (also referred to as multiple-use product system) and respective processes and infrastructure for washing operations (in-store or sub-contracted).

The distinctive feature of this study compared to other assessments within this field of research were the following:

- **Approach**: the main goal of the EU Comparative LCA study (Ramboll, 2020)was to compare through a system approach the environmental performance of single-use and multiple-use dishes options for in-store consumption in QSR in Europe, and not focused on the environmental performance of a single product
- **Robustness and reliability of the investigated system**: the incorporation of representative data and information with regards to the functional unit, inventory data as well assumptions around the systems – primary data and information (reflected in the functional unit) for single-use system were obtained from EPPA members.

In addition, an **extensive sensitivity analysis was carried out:** 12 scenarios analysed (9 for MU system; 3 for SU system), including: different recycling rates, different washing scenarios, different EoL allocation approaches

The geographical scope of the baseline comparison was Europe (EU-27 + UK). This geographical boundary was reflected in the assumptions around the systems (e.g., recycling rates) and background datasets (e.g., electricity from grid) as inventory data for the manufacturing stage of certain products will be site-specific or representing average production scenarios.

The EU Comparative LCA study (Ramboll, 2020) considered the use of **7 different food and beverage containers**:

- A cold cup
- A hot cup
- A wrap/clamshell or plate/cover or tray
- A fry bag/basket/fry carton
- A salad bowl with lid
- A cutlery set
- An ice-cream cup.

In total, the EU Comparative LCA study (Ramboll, 2020) incorporated the life cycles of:

- **10 different single-use product items** made of paperboard (if coated, PE content is <10% w/w); and
- **14 different multiple-use product items** (represented in different scenarios and sensitivity analyses) with 2 dishes set options: one set made of polypropylene (PP; one acrylic plastic item), and one set combining PP, ceramic, glass and steel for sensitivity analyses.

For the **baseline scenarios** the following key assumptions were made:

<u>Single-use system:</u>

- Paper manufacturing refers to the respective geographical context of the paper mill or manufacturer from which primary data is used and is considered representative for EU-average supply chain
- Products are made solely from virgin paper
- Intermediate transport from paper producers to converters is modelled according to primary data provided by converters
- Paper converting stage is modelled based on primary data obtained from converters located in representative European countries
- Production paper wastes during converting (i.e., post-industrial wastes) are materially recycled as indicated in primary information obtained from converters;
- Types and amounts of packaging materials (cardboard and PE foils) for all single-use product items (except for wooden cutlery) are based on primary data from converters
- EoL (paper products): 30% paper recycling and 70% incineration with energy recovery for paper

Multiple-use system:

- PP manufacturing in Europe
- Average reuse PP rate of 100 reuses is considered. Reuse rates also include potential replacement reasons such as damages, stains, theft or loss. The latter reasons are considered to be relatively important in QSRs as higher volumes of product items are involved than in regular restaurants
- Dishwashing process:
  - An average scenario for in-house dishwashers is used to reflect different grades of devices' efficiencies
  - Internal washing is assumed with a separate drying module because of hygienic requirements and increased efforts for drying of PP products based on literature information, 30% of total energy demand of washing and drying comes from drying; thus, energy demands for washing reported in literature were increased by +30% if the device does not perform sufficient drying for PP products
  - State-of-the-art detergent and rinse agent compositions are assumed
  - Average rewashing rate for all items of 5% is considered, this assumption is made to avoid persistent residues that might remain after washing
  - Production of simplified dishwashers is considered (generic assumption of two additional devices to be installed inside a QSR to perform in-house washing, ten-year lifetime of the dishwasher).
- EoL (PP products): 30% material recycling and 70% incineration with energy recovery

For the EoL assumption of the baseline scenarios it should be noted that generic plastic packaging shows EU average recycling figures (about 40%)[3] lower than paper packaging (about 85%[4]). For data symmetry reasons in the comparison and due to the lack of product-specific recycling rates for QSRs, 30% material recycling and 70% incineration with energy recovery were assumed for both baseline scenarios, provided that appropriate sorting of post-consumer waste fractions is facilitated at the EoL stage. Sensitivity analyses were performed for 0% recycling and 100% incineration with energy recovery and for 70% material recycling and 30% incineration with energy recovery for both systems.

The following sensitivity analyses - only one parameter or assumption was changed per system in order to maintain transparency and ensure traceability of results - were performed:

- Single-use system: Different recycling rates of post-consumer paperboard (0%; 70%);
- Multiple-use system: Different recycling rates of post-consumer PP items (0%; 70%);
- Multiple-use system: Varied demand for multiple-use items (30% higher; 30% lower);
- Multiple-use system: Optimised washing scenario;
- Multiple-use system: External washing with band transport dishwasher;
- Multiple-use system: Alternative multiple-use items (dishes made from ceramic (500 or 250 reuses), glass (500 or 250 reuses), stainless steel (1000 reuses) and PP (100 reuses);

[3] https://ec.europa.eu/eurostat/databrowser/view/ten00063/default/table?lang=en
[4] https://ec.europa.eu/eurostat/databrowser/view/ten00063/default/table?lang=en

- Both systems: Different EoL allocation approach for avoided energy and material production (50:50)

External review

Assumption described above are summarized from the ISO-compliant full LCA report that was subject to a third-party review, conducted by TÜV NORD CERT Umweltgutachter GmbH (date of review - 16th December 2020). The study was updated in 2021 due to an extensive GaBi database update (the updated version of the study was not subject to a third-party review).

Full description is available in the LCA report.

3. EVALUATION OF GEOGRAPHICAL-SPECIFIC PARAMETERS

The main scope of the assessment is to **identify peculiarities of Irish context that can have significant impacts on LCA results** and highlight similarities and differences. The shift of geographical location from the European average situation (assessed in the EU Comparative LCA study (Ramboll, 2020)) to the Irish context could influence different *life cycle stages/parameters*. To this aim the performed assessment investigated all life cycle stages (considering SU and MU systems), as described below:

- **Upstream**, that includes raw material production, processing and converting of SU paperboards, as well as raw material production, processing, and manufacturing of MU product items.
- **Distribution** of product items, which includes transport from converter or manufacturers to QSRs.
- **Use stage** (relevant only for MU system), which includes washing, drying at QSRs and wastewater treatment.
- **End of life** (downstream), which includes SU and MU items recycling and incineration.
- **Avoided material** (pulp and PP granulate when recycling)**.**
- **Avoided energy production** (thermal and electrical energy when incinerating).

As a preliminary assessment, Ramboll identified the *life cycle stages/parameters* that are geographically dependent (i.e., the *life cycle stages/parameters* have been classified as Geography-dependent: affected by the geographical scope of the study (considering the location of QSRs); or not geography-dependent: not affected by the geographical scope of the study (considering the location of QSRs)). To this aim the following information have been used as references:

- The EU Comparative LCA study (Ramboll, 2020), and in particular:
  - The entire body of literature utilised, and the main assumptions considered.
  - The baseline results.
  - The contribution analyses (i.e., how much each life cycle stage contribute to overall results in each impact category).
  - The sensitivity analyses (i.e., how much the variation of selected key parameters affect the overall results).
- Results of a specific desktop-assessment related to Irish context.

The following table includes a summary of *life cycle stages/parameters* and the categorization (e.g., affected/not affected by the geographical scope of the study).

Table 1: Parameters from the EU study that could be affected by a shift of the geographical scope withing the EU context

life cycle stages/parameters		Affected/not affected by geographical scope of the study		Classification
		SU system	MU system	
Upstream	All processes in the Raw material extraction and manufacturing stage	**Not affected**: Site-specific manufacturing by EPPA members and partners	**Not affected**: Site-specific manufacturing in other countries	**Not-geography dependent**
Distribution	Distribution of items	**Affected**	**Affected**	**Geography-dependent**
Use stage	Demand of MU items	***Not applicable***	**Not affected**: It only depends on QSR size, which is set to an average value not dependent from the geographical context	**Not-geography dependent**
	Number of reuses (rotations)	***Not applicable***	**Not affected**: this value has been considered from literature studies at average level, and therefore it does not depend on site-specific situation	**Not-geography dependent**
	Energy grid mix in the Use stage	***Not applicable***	**Affected**: washing and drying effects depend on electrical grid mix of the country	**Geography-dependent** (only for MU)
	Energy consumption rate in the Use stage	***Not applicable***	**Not affected**: consumption rate of dishwasher is retrieved from average EU values in literature, and therefore no country-specific boundaries could be evaluated	**Not-geography dependent**
End of Life	Type of treatment in the EoL stage	**Affected**: recycling/incineration shares depend on country statistics	**Affected**: recycling/incineration shares depend on country statistics	**Geography-dependent**
	Avoided material production	**Not affected**: EU average database set is the only one available (background data)	**Not affected**: EU average database set is the only one available (background data)	**Not-geography dependent**
	Avoided energy production	**Affected**: when incinerating wastepaper, energy credited should be adapted to the geographical scope	**Affected**: when incinerating plastic waste, energy credited should be adapted to the geographical scope	**Geography-dependent**

Based on the performed preliminary assessment, the following parameters have been identified as geographically dependent:

1. Distribution of items.
2. Energy grid mix in the Use stage (relevant for MU system only).
3. Type of treatment in the EoL stage.
4. Avoided energy production.

BOX #1: Preliminary comments on the identified geographical dependent parameters

As anticipated at § 2 the comparison of the single-use and multiple-use systems showed that the **environmental hotspots predominantly occur in different life cycle phases in the two systems**: for the single-use system, major impacts are generated during the upstream production of the items whereas the main contributor to the impacts of the multiple-use system is the use phase, i.e., the washing of items.

Based on the above, it is expected that the geographical shifting of the study might determine:

- potentially limited differences on SU system (if compared to EU scope), since the geographical shifting does not affect the main environmental hotspot, i.e., the upstream phase, due to the well-established paper production and converting in specific EU countries (as explained in detail in the following paragraph 3.1.1).
- potentially relevant differences on MU system (if compared to EU scope), since the geographical shifting could affect the main environmental hotspot, i.e., the use phase. These differences are expected relevant only in case the environmental impact emissions of the electrical grid mix of the investigated geography are significatively different of EU ones.

3.1 Irish-specific context

To retrieve Irish-specific features that could affect the *life cycle stages/parameters* described above an in-depth analysis of this context has been performed, using the following sources of information:

- Scientific literature.
- Press releases (in the form of journal/websites).
- LCA databases.
- Statistics from official sources.

The following paragraphs analyses each life cycle stage, providing information related to all parameters identified and reported in **Table 1**, including those classified as not affected by the geographical scope of the study.

3.1.1 Upstream

In the upstream life cycle stage, the geographical location for raw material production of items, either SU or MU items, might have an influence on relative environmental impacts for this life cycle stage.

According to the results of the performed desktop assessment, **assumptions for the upstream made for the EU average situation of the previous study could be considered identical for the Irish context.** This conclusion is based on the followings:

- For SU: The focus of the analysis is on items manufactured by EPPA members and partners, with their specific properties and characteristics. The raw material production and processing stage entails countries like Finland and Austria, while converting data refers to production sites in countries like Germany, Finland and France. According to the Best Available Techniques Reference Document for the Production of Pulp, Paper and

Board issued by EU Commission[5], these countries reflect very well the European pulp and paper production market, while no data referring to IE are reported. Accordingly, it should be considered that the production sites would remain the same also when shifting the scope of the study to Irish context.

- For MU: According to figures reported by PlasticsEurope[6], the 6 largest European countries (Germany, Italy, France, Poland, Spain and United Kingdom) represent almost 70% of converters plastic demand, while Ireland has a very limited share (<1%). For this reason, the approach adopted for the EU Comparative LCA study (Ramboll, 2020) (using database sets for PP production at the EU average level) can be deemed as valid also for the Irish context.

3.1.2 Distribution

In the distribution life cycle stage, the geographical set in Ireland would imply different routes of distribution as well as means of transport. Distribution assumed in the EU study would remain valid for Ireland, but an additional transport route for both systems to Ireland is required. Roll-on/roll-off ship is assumed here for a transport route between the major port in EU (Rotterdam) and the major port of Ireland (Dublin), which corresponds to about 1300 km sea distance[7].

Consequently, **changes for both SU and MU are expected for the Irish-specific context**. Note that SU system needs a greater number of items with respect to MU system (MU items are expected to be reused 100 times, thus an higher number of SU items is required to provide the same function), thus it is expected that this parameter will affect more the SU system.

3.1.3 Use stage (MU)

In the use stage, which is relevant only for the MU system, there are different parameters potentially affecting the results. However, some of these can be deemed not dependent from the geographical scope of the study, in particular:

- The demand of MU items only depends on QSR size, which is set to an average value which is assumed to be the same regardless of the reference country.
- The number of reuses of MU items is retrieved from literature studies and set equal to an average value, and therefore it does not depend on site-specific situation.
- The energy consumption rate of dishwashers is retrieved from average EU values in literature, and therefore no country-specific boundaries could be evaluated.

For all these three parameters, there are no indications from literature of country-specific values.

Instead, the geographical context could be a decisive factor for the environmental impacts of electrical consumption. In the use stage, major impacts are generated by the electricity demand of the washing process, and the selection of another geographical scope could change the results and the comparative assertion. By shifting the washing and drying process in Ireland, its electrical grid mix should be assumed.

[5] https://eippcb.jrc.ec.europa.eu/s tes/default/files/2019-11/PP_revised_BREF_2015.pdf

[6] https://plasticseurope.org/wp-content/uploads/2021/12/Plast cs-the-Facts-2021-web-final.pdf

[7] http://www.shiptraff c.net/2001/05/sea-distances-calculator.html

Differences between the EU-28 electricity grid mix used in the model in the previous EU study and the Irish (IE) electricity grid mix are shown in **Figure 1**[8]. It is evident that when shifting to Ireland, two different categories can be found[9]:

- Impact categories where IE grid mix has lower emissions than EU-28 grid mix: Particulate matter formation, Freshwater consumption, Freshwater eutrophication, Ionizing radiation, Metal depletion, Terrestrial acidification.
- Impact categories where IE grid mix has higher emissions than EU-28 grid mix: Climate Change, Fossil depletion, Ozone depletion.

To evaluate differences between the EU study and the Irish-specific context, emissions factors for IE electricity grid mix for all impact categories are applied to the MU system.

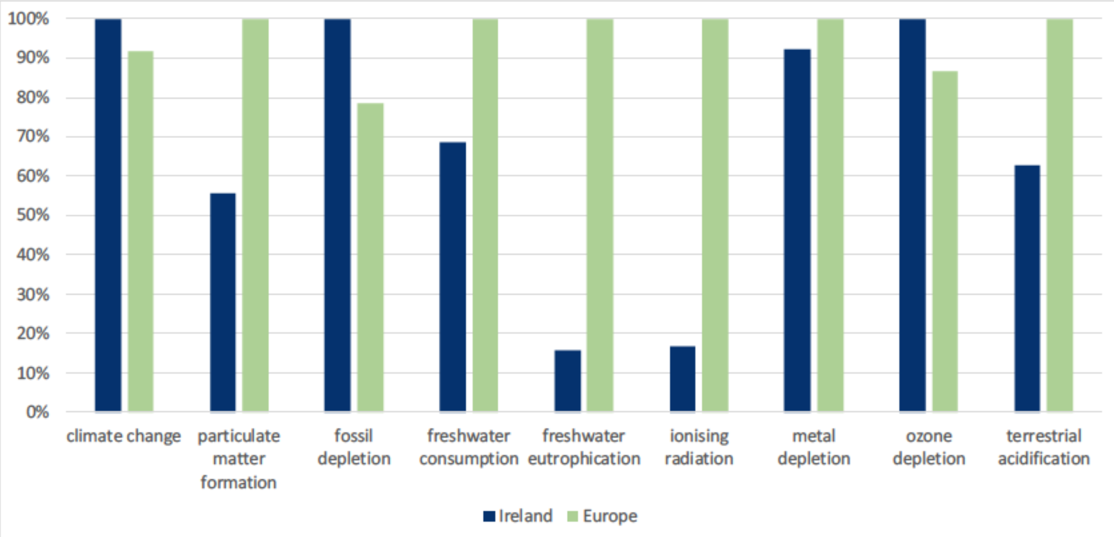


Figure 1: Relative differences between environmental impact emissions of EU-28 electrical grid mix and IE electrical grid mix (ReCiPe 2016 (H) impact categories)

According to the most updated data from Eurostat[10], the comparison between European and Irish energy mix (see **Table 2**) shows that Irish energy mix is characterised by:

- higher share of fossils sources;
- lower share of renewables sources;
- absence of nuclear energy;
- lower share of solid fossil fuels.

[8] The electricity grid mix w th associated highest impact for each category is set to 100%, and the other electricity grid mix is normalized to this value, to facil tate the visualization and the difference between the impact results.

[9] The selection of the environmental impact categories for ReCiPe 2016 (H) methodology is made by considering the same categories of the previous EU study.

[10] https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2a.html

Table 2: Energy mix for European Union and Ireland in 2020. Source: Eurostat.

Energy source	European energy mix	Irish energy mix
Total petroleum products (including crude oil)	34.5%	45.9%
Natural gas	23.7%	32.8%
Renewable energy	17.4%	12.7%*
Nuclear energy	12.7%	0%
Solid fossil fuels	11.5%	8.6%
Other	0.2%	0%
*It derives almost completely from wind farms production[11]		

It must be noted that, due to the complexity of the investigated system, the charts of **Figure 1** do not directly reflect the environmental burdens in each category associated with the different energy grid mix and cannot be directly used as indicators of different environmental performances of the two geographical contexts.

3.1.4 EoL treatment

A symmetric approach was used in the EU study, by considering 30% recycling and 70% incineration (due to the lack of product-specific recycling rates for QSRs, see previous chapter). When shifting to the Irish context, country-specific statistics might be considered. REPAK, a recyclers association in Ireland comprising 3400 members, reported[12] in 2020 that about 379,000-ton waste from backdoor sector (i.e., commercial sector) was recycled.

For MU: REPAK reported[12] about 30% recycling rate in Ireland.

For SU: REPAK reported[12] high recycling rate (about 79%) in Ireland, which is in line with paper and cardboard packaging recycling rate in the EU in 2018 retrieved from EUROSTAT, which indicates 82.9% recycling rate[13].

Since symmetrical recycling and incineration rates might be assumed (as in the previous EU study), and since the same recycling rate for plastics (30%) is reported in Ireland, **assumptions for the EoL treatment made for the EU average situation of the previous study could be considered applicable for the Irish context.**

3.1.5 Avoided material production

It is not methodologically possible to evaluate Irish-specific avoided material production, as a shift to Ireland would assume database sets for chemical and mechanical pulps for Ireland for the SU system, and database sets for PP granulate production for Ireland for the MU system. However, no country-specific database set is available for these materials.

[11] https://www.iea.org/countries/ireland

[12] Source REPAK, 2020, Adapting to change, Annual report 2020 (page 33-34), available at: https://repak.ie/images/uploads/reports/Repak_AR_Web_2020.pdf

[13] Source: https://ec.europa.eu/eurostat/databrowser/view/ENV_WASPACR__custom_1226307/default/table?lang=en EU-28 countries, year 2018, waste category "paper and carboard packaging"

Consequently, for both SU and MU, **assumptions for the avoided material production for the EU average situation of the previous study could be considered identical for the Irish context**.

3.1.6 Avoided energy production

The avoided energy production depends on the electricity grid mix. Therefore, by shifting the focus to Ireland, the IE electrical grid mix should be considered. This shift affects both SU and MU systems – for the relative difference between the two electricity grid mixes, see **Figure 1**.

Consequently, **changes for both SU and MU are expected for the Irish-specific context**.

4. RESULTS AND CONCLUSIONS

Based on the evaluation of Irish specific context, a limited number (4 of 9, see **Table 1**) *life cycle stages/parameters* is geographic-dependant; in addition, one of these parameters (EoL treatment) can be considered (as explained in paragraph **3.1.4**) not affected by Irish context. The following potential impacts of Irish context on the EU results are expected (considering SU and MU systems):

- Distribution: it affects both systems; however, this parameter affects more the SU system, since a higher number of items is required, thus higher number of trips are expected from manufacturing and converting plants (located in different EU countries) to Ireland.
- Energy grid mix: it affects MU system only (since no use stage is applicable to SU system).
- Avoided energy production: it affects both systems.

To evaluate if the Irish context might determine significant variation of the results of the Comparative Life Cycle Assessment related to EU context, Ramboll considered:

A. the expected effects on each impact category when shifting from EU scenario to Irish scenario.

   To this aim a Rapid Impact Assessment Matrix (RIAM)[14] method – adopted in the framework of Environmental Impact Assessment – has been applied to each identified geographically dependent parameter, to provide an accurate and independent score for each impact category.

   The following rating have been assigned for each geographical dependant parameters:

      not affected.

      (=) negligible differences.

      (+) low increase; (++) medium increase; (+++) significant increase.

      (-) low reduction; (--) medium reduction; (---) significant reduction.

B. the contribution of each parameter on overall results in each impact category.

   To this aim, the contribution analyses of the EU Comparative LCA study (Ramboll, 2020) have been used as reference. For dealing with negative values, the approach suggested in the PEFCR is taken[15]: the percentage impact contribution for any life cycle stage is calculated by using absolute values (i.e., the minus sign is ignored). This procedure allows to consider the relevance of any credits (e.g., from avoided emissions at EoL) to be identified. Consequently, the total impact score is recalculated including the converted negative scores and set to 100%. Percentage impact contribution for any life cycle stage is assessed to this new total impact score.

Results of this assessment are reported in **Table 3.**.

[14] The Rap d Impact Assessment Matrix (RIAM) method is widely adopted in the framework of Environmental Impact Assessment. In RIAM impact significance is modelled as a mult criteria problem, in wh ch the complex nature of the concept is broken down into smaller, more accessible attributes (cr teria) for the decision-makers to work with. Evaluating the significance of impacts this way is a widely used approach in the l terature on environmental decision-making, when constructing systematic methods for impact evaluation (Bojórquez-Tapia et al., 1998; Cloquell-Ballester et al., 2007; European Commiss on, 1999; Thompson, 1990).

[15] PEFCR Gu dance, available at https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf

Table 3 Effect of different parameters on each impact category when shifting from EU scenario to Irish scenario for SU system, together with contribution of the parameter to overall results.

Impact category	Parameters	SU system		MU system	
		A Effects of geographical shifting (1)	B Contribution of the parameter to results of the EU Comparative LCA study (Ramboll, 2020) (2)	A Effects of geographical shifting (1)	B Contribution of the parameter to results of the EU Comparative LCA study (Ramboll, 2020) (2)
Climate change, default, excl. biogenic carbon	Distribution	(+)	~ 7 %	(=)	~ 7 %
	Energy grid mix	Not applicable		(+)	~ 70 %
	Avoided energy production	(-)	~ 20 %	(=)	~ 3 %
Fine Particulate Matter Formation	Distribution	(++)	~ 9 %	(=)	~ 9 %
	Energy grid mix	Not applicable		(--)	~ 70 %
	Avoided energy production	(+)	~ 7 %	(=)	~ 2 %
Fossil depletion	Distribution	(+)	~ 6 %	(=)	~ 6 %
	Energy grid mix	Not applicable		(++)	~ 70 %
	Avoided energy production	(-)	~ 20 %	(=)	~ 3 %
Freshwater Consumption	Distribution	(=)	< 1%	(=)	< 1%
	Energy grid mix	Not applicable		(--)	~ 70 %
	Avoided energy production	(+)	~ 6 %	(=)	< 1%

Freshwater Eutrophication	Distribution	(=)	< 1%	(=)	< 1%
	Energy grid mix	Not applicable		(--)	~ 9 %
	Avoided energy production	(+)	< 1%	(=)	< 1%
Ionizing Radiation	Distribution	(=)	< 1%	(=)	< 1%
	Energy grid mix	Not applicable		(---)	~ 90 %
	Avoided energy production	(+)	~ 4 %	(=)	< 2%
Metal depletion	Distribution	(=)	~ 2 %	(=)	< 1%
	Energy grid mix	Not applicable		(-)	~ 15 %
	Avoided energy production	(=)	~ 4 %	(=)	< 1%
Stratospheric Ozone Depletion	Distribution	(=)	~ 6 %	(=)	~ 6 %
	Energy grid mix	Not applicable		(+)	~ 70 %
	Avoided energy production	(-)	~ 7 %	(-)	< 1%
Terrestrial Acidification	Distribution	(+)	~ 9 %	(=)	~ 9 %
	Energy grid mix	Not applicable		(--)	~ 70 %
	Avoided energy production	(+)	~ 7 %	(-)	< 1%

(1): (+) low increase; (++) medium increase; (+++) significant increase; (-) low reduction; (--) medium reduction; (---) significant reduction; (=) negligible differences; not affected

(2): The parameters indicated as "Distribution" and "Avoided energy production" correspond to a life cycle stage, then to calculate their contribution the entire life cycle stage is considered. Instead, the parameter "energy grid mix" only partially correspond to the "use stage" life cycle stage. Thus, to calculate is contribution, only the effect of energy grid mix on the use stage is considered.

On this basis, the following conclusion - related to the shifting from EU context to Irish context – could be drawn:

Climate change (if compared with EU scenario)

- SU: marginally lower environmental impacts.
- MU: slightly higher environmental impacts.

No significant effects on the main conclusion are expected for this impact categories due to the geographical shifting (IE scenario) both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario, the single-use system showed "very significant benefits" for climate change, and
  - according to the sensitivity analysis, the results were "consistent throughout all considered sensitivity scenarios".

Fine Particulate Matter Formation (if compared with EU scenario)

- SU: slightly higher environmental impacts.
- MU: moderately lower environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (IE scenario) both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario, the single-use system showed "very significant benefits" for fine particulate matter formation, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependant on the geographical scope (optimised or external washing, 0% post-consumer paperboard recycling and/or a different allocation assumption for EoL credits).

Fossil depletion (if compared with EU scenario)

- SU: marginally lower environmental impacts.
- MU: considerably higher environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (IE scenario) both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario, the single-use system showed "very significant benefits" for fossil depletion, and
  - according to the sensitivity analysis, the results were "consistent throughout all considered sensitivity scenarios".

Freshwater Consumption (if compared with EU scenario)

- SU: marginally higher environmental impacts.
- MU: considerably lower environmental impacts.

The reduction of environmental impacts of MU system for Freshwater Consumption category derives from different factors, including the reference energy mix of Irish context. Irish grid mix determines lower impacts on this impact category[16] (if compared with EU average one). However main conclusions (i.e., the single-use system determine environmental benefits) might be considered confirmed both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario, the single-use system showed "very significant benefits" for freshwater consumption, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependant on the geographical scope (optimised or external washing, 0% post-consumer paperboard recycling and/or a different allocation assumption for EoL credits).

Freshwater Eutrophication (if compared with EU scenario)

- SU: no variation environmental impacts.
- MU: marginally lower environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (IE scenario) both for the baseline and investigated scenarios of the sensitivity analysis since:

  - according to the baseline results for EU scenario, the multiple-use system showed "very significant benefits" for freshwater eutrophication, and
  - according to the sensitivity analysis, the results were "consistent throughout all considered sensitivity scenarios.

Ionizing Radiation (if compared with EU scenario)

- SU: no variation environmental impacts.
- MU: considerably lower environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (IE scenario) both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario, the multiple-use system showed "significant benefits" for ionizing radiation, and
  - according to the sensitivity analysis, the results were "consistent throughout all considered sensitivity scenarios".

Metal depletion (if compared with EU scenario)

[16] Due to marginal shares of nuclear and hydro energy sources of Ireland energy grid mix, wh ch are energy sources that can determine significant impacts on this category.

- SU: no variation environmental impacts.
- MU: marginally lower environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (IE scenario) both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario, the multiple-use system showed "noticeable benefits" for metal depletion, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependant on the geographical scope (utilisation of alternative MU items made of ceramic, glass, and steel).

<u>Stratospheric Ozone Depletion (if compared with EU scenario)</u>

- SU: marginally lower environmental impacts.
- MU: slightly higher environmental impacts.

It can be expected from shifting to IE scenario that the results of the two systems are comparable, both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario the multiple-use system showed "noticeable benefits" for stratospheric ozone depletion, and
  - the sensitivity analysis the results were "consistent throughout all considered sensitivity scenarios".

<u>Terrestrial Acidification (if compared with EU scenario)</u>

- SU: slightly higher environmental impacts.
- MU: moderately lower environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (IE scenario) both for the baseline and investigated scenarios of the sensitivity analysis, since:

  - according to the baseline results for EU scenario, the single-use system showed "very significant benefits" for terrestrial acidification, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependant from the geographical scope (optimised or external washing, 0% post-consumer paperboard recycling and/or a different allocation assumption for EoL credits).

These conclusions could be further confirmed with a quantitative assessment by means of a Life Cycle Assessment study.

SINGLE-USE VS MULTIPLE-USE

EPPA
European Paper Packaging Alliance

This LCA meets ISO standards and has been independently assessed by Germany's TÜV (technischer Überwachungsverein).

SINGLE-USE PAPER PACKAGING: THE EVIDENCE-BASED ENVIRONMENTAL SOLUTION.

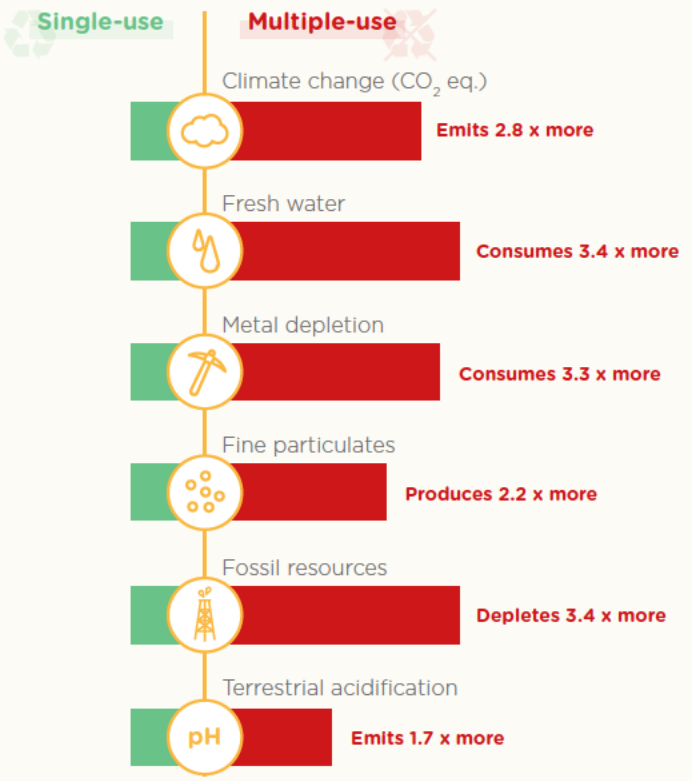
Reusing tableware seems intuitively better for the environment. Considering all impacts, however, this is often not the case.

Thanks to a certified and 3rd party reviewed comprehensive Life Cycle Assessment (LCA) study carried out by Ramboll, an independent Danish consultancy, the science is now challenging the common misconception that reusable food and drink packaging is more sustainable than single-use paper packaging. In 6 of 9 categories, including climate change and water usage, single-use paper products performed better than reusable tableware.

Reusable packaging requires industrial **washing systems** that consume **energy, water** and **detergents**. Unlike paper-based single-use products, which are **renewable, recyclable** and use **less energy** and **fresh water** – an increasingly scarce resource.

Ramboll's LCA study clearly shows that single-use paper-based systems have a "very significant" environmental advantage over multiple-use systems in real-world conditions.

Compared to paper-based single-use, a PP plastic multiple-use system:



Both systems are equally considered at a 30% recycling rate. Results are similar for a traditional ceramic, glass and metal tableware set, also tested. Multiple-use systems perform better only in ionizing radiation (1.6 times fewer kBq Co-60 eq. to air) and freshwater eutrophication (4.8 times fewer kg P eq.), with only a minimal advantage for ozone depletion.

If the studied multi-use system was introduced across Europe, it would be equivalent to an annual extra:

1 million petrol cars.

750,000 people's freshwater needs.

The **advantages of paper-based items** become even clearer when the recycling rate of restaurants increases, especially when looking at the levels of **freshwater consumption**, which is **increased from 3,4 to 228 times** when the recycling reaches 70% and can improve further as the recycling rate increases.

This LCA study accounts for the comprehensive use of 24 different food and beverage containers used in Quick Service Restaurants, including:

cold and hot cups · salad bowls · ice-cream cups · fry bags · clamshells, plates, trays · cutlery sets

Find further details on the Ramboll LCA study here. Results updated August 2021.
For further information, contact mail@eppa-eu.org or visit https://www.eppa-eu.org/