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DESKTOP ASSESSMENT RELATED TO COMPARATIVE LCA PERFORMED FOR TAKE-AWAY SERVICES IN QUICK SERVICE RESTAURANTS

FRENCH CONTEXT EVALUATION

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Project name	**DESKTOP ASSESSMENT RELATED TO COMPARATIVE LCA PERFORMED FOR TAKE-AWAY SERVICES IN QUICK SERVICE RESTAURANTS FRENCH CONTEXT EVALUATION**
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[1] 'COMPARATIVE LIFE CYCLE ASSESSMENT (LCA) SINGLE-USE AND MULTIPLE-USE TABLEWARE SYSTEMS FOR TAKE-AWAY SERVICES IN QUICK SERVICE RESTAURANTS', November 2022, p.148

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ABBREVIATIONS

EoL	End-of-Life
EPPA	European Paper Packaging Alliance
EU	European Union
FR	France
FU	Functional Unit
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 French context (hereinafter FR) that can have significant impacts on the results of a comparative Life Cycle Assessment (LCA) study related to single-use (SU) and multiple-use (MU) tableware systems for take-away services in Quick Service Restaurants (QSRs) (referred to EU average + UK), in accordance with ISO standards 14040 and 14044 conducted in 2022 on behalf of EPPA (Ramboll, 2022).

The functional unit of the performed Comparative LCA was:

> *Take-away services (drive through, on-the-go, click and collect, home delivery) of foodstuff and beverages with single-use or multiple-use tableware (including cups, lids, containers, cutlery, carriers and bags) in an average QSR for 365 days in Europe in consideration of established facilities and hygiene standards and take-away services specific characteristics (e.g., selling channels, distances, means of transport).*

To this aim, Ramboll carried out a dedicated desktop assessment (including literature review and a web-based research) to identify peculiarities of French 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 French context are comparable/different with the ones utilized in the EU Comparative LCA study (Ramboll, 2022), 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, 2022) representative also of the French 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 have not been subject to a third-party review.

2. EUROPEAN LCA STUDY - SUMMARY OF APPROACH AND ASSUMPTIONS

As mentioned before, in 2022 Ramboll was appointed by the European Paper Packaging Alliance (EPPA) as technical consultant for conducting a comparative Life Cycle Assessment (LCA) study related to single-use (SU) and multiple-use (MU) tableware systems for take-away services in Quick Service Restaurants (QSRs) (referred to EU average + UK), in accordance with ISO standards 14040 and 14044 (Ramboll, 2022), subjected to internal review conducted by two senior LCA experts of the international Ramboll Decarbonisation (GHG/LCA) Steering Committee and to external third-party review by a panel composed by three independent reviewers.

This comparative LCA study is focused on QSRs *Take-away services* that includes:

- **drive-through**: customers reach the restaurant and order food directly from their cars;
- **on-the-go**: customers reach the restaurant and take out their food;
- **click and collect:** similar to the on-the-go option, but booking the food online before reaching the restaurant;
- **home delivery:** customers buy food online and it is delivered by means of a courier.

This assessment was embedded in an ongoing debate around the environmental performance of single-use and multiple-use products. Consequently, there was already a quite mature body of knowledge concerning several products and applications from either category. However, previous studies adopted a rather product-focused approach in comparative assertions (i.e., comparing single-use cups with multiple-use cups). In these assessments less attention was given to the underlying systems and obtained functions from respective products. Next to taking into account previous findings this study sought to adopt a holistic perspective on the comparison of single-use (SU) and multiple-use (MU) products in QSRs.

The main goal of the EU Comparative LCA study (Ramboll, 2022) was to use a systems-based approach to **compare the environmental performance of single-use (SU) and multiple-use (MU) tableware options for take-away consumption in QSR in Europe.**

The functional unit was:

> ***Take-away services (drive through, on-the-go, click and collect, home delivery) of foodstuff and beverages with single-use or multiple-use tableware (including cups, lids, containers, cutlery, carriers and bags) in an average QSR for 365 days in Europe in consideration of established facilities and hygiene standards and take-away services specific characteristics (e.g., selling channels, distances, means of transport).***

The geographical scope of the baseline comparison is 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 was site-specific or representing average production scenarios (e.g., global, EU).

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

- current system for take-away services from QSRs based on single-use (disposable) products made of paperboard with a PE content < 10% w/w (also referred to as single-use product system) and related transport from/to QSRs;

- expected (hypothetical) system for take-away services from QSRs based on equivalent multiple-use products (also referred to as multiple-use product system) and respective processes and operations (transport from/to QSRs, inspection, washing at home and/or in-store, take-back system).

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

- A cold drink cup;
- A clip-on lid for the drink cup;
- A cup holder;
- A wrap/clamshell for burgers;
- A fry bag/basket/fry carton;
- A small bag for fries' transport;
- An ice-cream cup.
- A spoon (cutlery item) for the ice cream cup;
- Bag for delivery.

Other food containers/packaging (i.e., hot drink cups, salad bowls) are not included in the LCA study: items corresponding to less than 1% of total items used for take-away services (based on confidential QSRs data) are excluded.

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

- **8** different products for the single-use system, made of paperboard (if coated, PE content is < 10 % w/w);
- **6** different products for the multiple-use system, made of PP; and
- **3** products (cup holder, bags for transport of fries and delivery bag) considered for both single-use and multiple-use systems: even though these products are intended for single-use, it is understood from information gathered from relevant stakeholders that these items would not be replaced by equivalent function multiple-use items.

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 (with the exception of cup holder, bags for transport of fries and delivery bags considered for both single-use and multiple-use systems).
- 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.
- Four different take-away selling channels are considered:
    - Drive through, by means of EURO4[2] cars;
    - Delivery, on-the-go, and click and collect, all three by means of an equal share of EURO4 cars, scooters, bikes, public transport and by walking.
- Transport from QSR to point of consumptions is symmetrical for SU and MU systems. It is then excluded from the analysis.
- End-of-life (paper products):
    - 30% paper recycling, 60% incineration with energy recovery and 10% landfilling, based on an extensive analysis of literature data and taking into account regulatory aspects provided for EU legislation (see full report for details).
    - Transport of waste from QSR to incineration facility is assumed to be 100 km.
    - The baseline allocation approach is the system expansion methodology (i.e., the avoided burdens method).

Multiple-use system:

- PP manufacturing in Europe.
- Four different take-away selling channels are considered:
    - Drive through, by means of EURO4 cars[3];
    - Delivery, on-the-go, and click and collect, all three by means of an equal share of EURO4 cars, scooters, bikes, public transport and by walking.
- Transport from QSR to point of consumptions is symmetrical for SU and MU systems. It is then excluded from the analysis.
- An average scenario for preliminary washing is used to reflect different possible processes. It considers an equal share of handwashing, dishwashing, cold rinsing and dry wiping, and is applied to half of total items (50%) taken back to QSRs (with the exception of those bought by means of drive through, which are assumed to be returned directly after consuming food and beverages as conservative assumption).
- The phase of transport back to QSR is considered, being this exclusive of the MU system.
- For returning MU items to QSRs, a decentralized take-back mechanism is considered, where MU items are returned to collection points by consumers.
- For on-the-go, click and collect and delivery, it is assumed an average distance between QSR and point of consumption of 3 km (as reported by QSRs in specific data gathering questionnaires prepared by Ramboll). For drive through, as conservative assumption, it is assumed that food and beverages are consumed near the QSR and MU items are returned directly after consumption of food and beverages, covering a distance of 1 km.

[2] Due to lack of data related to the potential fleet of vehicles involved in the system, a conservative assumption is made by considering only EURO4 cars.

[3] Due to lack of data related to the potential fleet of vehicles involved in the system, a conservative assumption is made by considering only EURO4 cars.

- It is then assumed that trips for returning MU items to QSRs can provide a multifunctionality (i.e., a trip not only intended to return MU items, but also intended for other reasons external to the system boundaries), however multifunctionality may be highly affected by consumers' activities, decisions, and behaviour. There are limited studies that provide analytics on behaviour toward take-back program. In this study the impacts associated with these trips are only partially allocated to the system, assuming - in the baseline - that only 50% of consumers make the average distances described above specifically for returning the MU items. According to this scenario, 1/2 of trips for take-back are neglected (e.g., 1 out of 2 people return MU items in case of buying of another menu). Given the unpredictability of customers' behaviour more conservative scenarios have been also tested with sensitivity analysis.
- Average reuse rate of 50 reuses and average return rate of 50%[4] are considered as reported by confidential QSRs data (gathered by means of specific questionnaires prepared by Ramboll to assure reliability of potentially key figures). Reuse rate and return rate also include potential replacement reasons such as damages, stains, theft or loss.
- Washing, rinsing and drying processes are performed in-house (in QSRs) by means of hood-types dishwashers (as reported by confidential QSRs data); inputs to these processes are based on literature values for water, energy, detergent and rinse agent demand (per item basis). An average scenario for dishwashers is used to reflect different grades of devices' efficiencies;
- State-of-the-art detergent, rinse agent and softener compositions are assumed;
- Average rewashing rate for all items of 10% is considered: this assumption is to consider the presence of persistent residues that might remain after washing (Antony and Gensch, 2017). The presence of persistent residues is a peculiarity of take-away systems, since items could be returned in a long time frame (e.g., weeks) after food consumption, which leads to food/beverages encrustations. For this reason, the rewashing rate value has been increased to 10% (the original publication reports a 5% rewashing rate referring to items that are washed immediately after their use) to consider this further constraint of the system. However, the exact rate will depend on organisational structures in a QSR (e.g., time between serving of tableware and washing; pre-rinsing of tableware by hand, time frame before returning MU items).
- End-of-life (PP products):
    - 30% recycling, 60% incineration with energy recovery and 10% landfilling based on an extensive analysis of literature data and taking into account regulatory aspects provided for EU legislation (see full report for details).
    - Transport of waste from QSR to waste treatment facility is assumed to be 100 km.
    - The baseline allocation approach is the system expansion methodology (i.e., the avoided burdens method).
    - In addition, for MU system there is also a residual share of items disposed of within QSRs, which is represented by those items that are returned to QSRs but are no longer usable. For these items higher recycling rates are assumed considering that take-back systems are normally organized on purpose to

[4] These assumptions are based on primary data gathered from QSRs operators.

guarantee collection and recycling of items. Those MU items that are returned to QSRs are therefore assumed to be 70% recycled and 30% incinerated.

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

1. Parameters related to take-back system of MU items:
    a. S01: Increase in number of reuses (100 reuses).
    b. S02: Increase of return rate (70%).
    c. S03: Reduction of trips for take-back: 4 out of 5 people return MU items in case of buying of another menu.

    Customers' behaviour might represent a decisive factor when considering overall environmental performance of MU system. It is therefore worth considering a scenario where only 20% of consumers cover the full average distance to return MU items (i.e., 4/5 of trips for take-back are neglected) which appear a rather conservative assumption.
2. Parameters related to washing of MU items:
    a. S04: No preliminary washing at home.
    b. S05: Type of professional washing: External washing with band transport dishwasher.
3. Parameters and allocation methodology related to End-of-Life for SU and MU systems:
    a. S06: 30% recycling and 70% incineration.
    b. S07: 60% recycling, 30% incineration and 10% landfilling.
    c. S08: Eurostat data:
        i. SU: 82.9% recycling, 7.8% incineration and 9.3% landfilling
        ii. MU: 41.8% recycling, 33.5% incineration and 24.7% landfilling.
    d. S09: Cut-off 50:50 allocation approach.

<u>External review</u>

Assumption described above are summarized from the ISO-compliant full LCA report that was subject to subjected to:

1. Internal QA/QC conducted by two senior LCA experts of the international Ramboll *Decarbonisation (GHG/LCA) Steering Committee.*
2. External third-party review by a panel composed by the following reviewers:
    - Michael Sturges (lead panelist) - RISE Research Institutes of Sweden / RISE Innventia AB, Sweden – a life cycle assessment practitioner with specific experience of environmental studies relating to the packaging and food service sectors.
    - Prof. Umberto Arena – University of Campania "Luigi Vanvitelli", Italy - a chemical engineer with experience of packaging systems, including LCA studies on valorisation of paper and plastic waste streams.

- Frank Wellenreuther, ifeu - Institut für Energie- und Umweltforschung Heidelberg gGmbH, Germany – a life cycle assessment practitioner with specific experience of environmental studies relating to packaging systems.

Full description is available in the LCA report.

2.1 Peculiarities of the EU Comparative LCA study for take-away services in QSRs

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

- **Approach**: the main goal of the LCA study was to compare through a system approach the environmental performance of single-use and multiple-use tableware options for take-away 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 as assumptions around the systems.

  In order to have robust and reliable sources of data related to the potentially relevant parameters, Ramboll performed a specific data gathering (via datasheets, questionnaire) to QSRs operators related to the use stage in take-away systems, such as distribution channels repartition, type of washing and type of dishwashers, number of reuses of a product, return rates, means of transport and distances covered. Moreover, 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. Also, data from scientific papers in Q1 journal with high level of consistency have been incorporated for both SU and MU systems.
- **Extensive sensitivity analysis:** to test decisive assumptions in the systems, several sensitivity scenarios were analysed. The suggested sensitivity scenarios are based on both the contribution analysis of the baseline comparison and the identified variability regarding critical parameters. 9 scenarios have been analyzed (5 for MU system; 4 for both systems), including: different number of reuses, different return rate, different assumptions related to take-back system, different washing scenarios, different EoL shares, different EoL allocation approaches.

The geographical scope of the baseline comparison is 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 was site-specific or representing average production scenarios (e.g., global, EU).

It should be noted as of now that considerations regarding take-back system of MU items are affected by the unpredictability of customers' behaviour, which is in contrast with the science-driven nature of LCA, thus implying the need to make specific assumptions for the correct functioning of the system. These assumptions are clearly reported in this study to guarantee transparency of the assessment.

3. EVALUATION OF GEOGRAPHICAL-SPECIFIC PARAMETERS

The main scope of the assessment is to **identify peculiarities of French context that can have significant impacts on LCA results** and highlight similarities and differences. The shift of geographical location from the EU average situation (assessed in the EU Comparative LCA study (Ramboll, 2022)) to the French 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 pre-washing at home, washing and drying at QSRs, wastewater treatment and use phase transport (take-back system). For SU system, the use stage consists only in transport towards customer. However, since transport from QSR to point of consumptions is symmetrical for SU and MU systems, it was excluded from the analysis. For this reason, use stage is relevant only for MU system.
- **End of life** (downstream), which includes SU and MU items recycling, incineration and landfilling.
- **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, 2022), 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 French 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	• Raw material extraction and manufacturing stage • Converting stage	**Not affected**: Site-specific manufacturing by EPPA members and partners	**Not affected**: Site-specific manufacturing in different European countries (including France)	**Not-geography dependent**
Distribution	Transportation of items from production sites to QSRs	**Not affected**: distribution is assumed to represent an average distance from the location of the respective converter to a central location in Europe such as France, therefore not dependent from the specific geographical context	**Not affected**: distribution is modelled following the suggestion by Plastic LCA method (Nessi et al., 2021), considering production in Europe	**Not-geography dependent**
Use stage	Demand of MU items	***Not applicable***	**Not affected**: it depends on QSR size only, which is set to an average value not dependent from the geographical context	**Not-geography dependent**
	Number of reuses (rotations)	***Not applicable***	**Not affected**: it has been considered from literature studies at average level, and therefore it is not dependent from the geographical context	**Not-geography dependent**
	Use phase transport (take-back scheme)	***Not applicable***	**Potentially affected**: It has been considered from QSRs data and literature studies at average level, but could be affected by the geographical context	**Potentially geography-dependent** (only for MU)
	Energy grid mix in the Use stage (dishwashing and drying)	***Not applicable***	**Affected**: washing and drying impacts are affected by the local energy grid mix	**Geography-dependent** (only for MU)
	Energy consumption rate of dishwashing and drying systems	***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/landfilling shares depend on country statistics		**Geography-dependent**
	Avoided material production	**Not affected**: The study has been implemented using the only available database set that is referred to EU average		**Not-geography dependent**
	Avoided energy production	**Affected**: energy credited deriving from the incineration should be adapted to the local geography		**Geography-dependent**

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

1. Energy grid mix in the Use stage (relevant for MU system only).
2. Type of treatment in the EoL stage.
3. 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., mostly the use phase transport (take-back scheme) and, to a lesser extent, 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 differences on MU system (if compared to EU scope), since the geographical shifting might affect the main environmental hotspot, i.e., the use phase transport. These differences are expected relevant only in case the environmental impact emissions associated to the vehicles of the investigated geography (France) are significatively different to those of the EU ones

3.1 French-specific context

To retrieve French-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 valid for the French 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. Accordingly, it should be considered that the production sites would remain the same also when shifting the scope of the study to French 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. For this reason, the approach adopted for the EU Comparative LCA study (Ramboll, 2022) (using database sets for PP production at the EU average level) can be deemed as valid also for the French context.

3.1.2 Distribution

In the distribution life cycle stage, the geographical location 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 valid for the French context.** This conclusion is based on the followings:

- For SU, transport from converters to QSRs is assumed to represent an average distance from the location of the respective converter to a central location in Europe such as France or Germany (i.e., 400 km for converters based in FR, 800 km for converters based in DE, 2.700 km for converters based in FI). Therefore, these assumptions well reflect an average situation valid also for the French context.
- For MU, transport from producers to QSRs is modelled following the suggestion by Plastic LCA method (Nessi *et al.*, 2021), considering production in Europe and in particular:
    - 230 km by truck (>32 t, EURO 4);
    - 280 km by train (average freight train);
    - 360 km by ship (barge).

  Since this modelling is note dependent on a geography-specific situation, as it reflects an average scenario, and considering that France is the largest territorial country in EU 27 and located in a central position it can be considered as valid also for the French context.

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:

[5] https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/PP_revised_BREF_2015.pdf
[6] https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf

- The demand of MU items mainly 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, use phase transport and energy mix (associated to washing) require a more detailed analysis.

3.1.3.1 Use phase transport

The use phase transport (take-back scheme), which is the major contributor to overall impacts of MU system, has been considered from QSRs data and literature studies at average level. In particular, the following key assumptions have been made:

- Four different take-away selling channels are considered:
  - Drive through, by means of EURO4 cars[7];
  - Delivery, on-the-go, and click and collect, all three by means of an equal share of EURO4 cars, scooters, bikes, public transport and by walking.
- Transport from QSR to point of consumptions is symmetrical for SU and MU systems. It is then excluded from the analysis.
- The phase of transport back to QSR is considered, being this exclusive of the MU system.
- For returning MU items to QSRs, a decentralized take-back mechanism is considered, where MU items are returned to collection points by consumers.
- For on-the-go, click and collect and delivery, it is assumed an average distance between QSR and point of consumption of 3 km (as reported by QSRs in specific data gathering questionnaires prepared by Ramboll). For drive through, as conservative assumption, it is assumed that food and beverages are consumed near the QSR and MU items are returned directly after consumption of food and beverages, covering a distance of 1 km.
- It is then assumed that trips for returning MU items to QSRs can provide a multifunctionality (i.e., a trip not only intended to return MU items, but also intended for other reasons external to the system boundaries), however multifunctionality may be highly affected by consumers' activities, decisions, and behaviour. There are limited studies that provide analytics on behaviour toward take-back program. In this study the impacts associated with these trips are only partially allocated to the system, assuming - in the baseline - that only 50% of consumers make the average distances described above specifically for returning the MU items. According to this scenario, 1/2 of trips for take-back are neglected (e.g., 1 out of 2 people return MU items in case of buying of another menu). Given the unpredictability of customers' behaviour more conservative scenarios have been also tested with sensitivity analysis.

When shifting to another geographical context, two main conclusions can be drawn:

[7] Due to lack of data related to the potential fleet of vehicles involved in the system, a conservative assumption is made by considering only EURO4 cars.

1. On one hand, part of the assumptions would not vary, since they are based on average data from QSRs and literature (e.g., share of means of transport, distance between QSR and point of consumption) or because they strongly depend on consumers' activities, decisions, and behaviour.
2. On the other hand, a possible variation is related to the type of vehicles utilised, and especially the cars, which represent the majority of considered vehicles.

Modelling of passenger cars was implemented through Ecoinvent 3.8 database by considering an average Euro 4 car taking into account different car sizes (small, medium and large) and fuel types (petrol, diesel and natural gas). Euro 4 is considered a "robust" assumption as it represents an average scenario for vehicles fleet in Europe, by assuming a standard lifetime.

According to data from EUROSTAT, in 2020 the number of vehicles with an age between 10 and 20 years was the 47.4% of total vehicles[8] and according with 2021 data from European Automobile Manufacturers' Association (ACEA) the average age of passenger cars in European Union is 11.5 years[9]. Therefore, the Euro 4 standard appears to be a "robust" assumption.

When shifting to the French context, according to the same 2021 data from ACEA, the average age of passenger cars in France is 10.2 years[10], which is in line with the figure for EU. For this reason, it can be assumed that, when shifting from EU context to the French one, no significant variation in terms of impacts deriving from use phase transport (take-back scheme) are expected.

In addition, to test this assumption, a specific LCA comparison between Euro 4 and Euro 5 cars (in terms of impacts/km) has been made, as reported in **Table 2**. Results show that differences in all impact categories are negligible (less than 5%), with the unique exception of Particulate matter. Nevertheless, when taking into account the overall systems analysed in the LCA, this difference would not have an effect on the main conclusions of the study.

Table 2 Analysis of different environmental impacts with Euro 4 and Euro 5 passenger cars over a 1 km distance. Results are based on Ecoinvent 3.8 database.

Indicator	Euro 4 passenger car	Euro 5 passenger car	Unit	Percentage difference*
EF-Acidification	Confidential data	Confidential data	mol H+-Eq	-1%
EF-Climate change, total	Confidential data	Confidential data	kg CO2-Eq	2%
EF-Eutrophication, freshwater	Confidential data	Confidential data	kg P-Eq	0%
EF-Eutrophication, marine	Confidential data	Confidential data	kg N-Eq	-5%
EF-Eutrophication, terrestrial	Confidential data	Confidential data	mol N-Eq	-5%
EF-Ionising radiation, human health	Confidential data	Confidential data	kg U235-Eq	2%
EF-Ozone depletion	Confidential data	Confidential data	kg CFC-11-Eq	3%
EF-Particulate matter	Confidential data	Confidential data	disease incidence	33%
EF-Photochemical ozone formation - human health	Confidential data	Confidential data	kg NMVOC-Eq	-3%
EF-Resource use, fossils	Confidential data	Confidential data	MJ	2%

[8] Source : https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_CARAGE__custom_3881603/default/table?lang=en
Data refer to EU-27 + UK and have been elaborated excluding vehicles older than 20 years.

[9] https://www.acea.auto/files/report-vehicles-in-use-europe-january-2021-1.pdf

[10] https://www.acea.auto/files/report-vehicles-in-use-europe-january-2021-1.pdf

EF-Resource use, minerals and metals	Confidential data	Confidential data	kg Sb-Eq	0%
ReCiPe 2016 Midpoint (H)-Water consumption	Confidential data	Confidential data	m3	0%
*if the percentage difference is negative, Euro 4 cars have less environmental impacts than Euro 5 cars (and the other way around).				

Euro 6 vehicles have been introduced only recently in Europe (2015), and they cannot be representative for an average situation. Euro 7 standard regulation is not in use, and it will be applied in the future. In addition, Euro 6 and Euro 7 cars data are not available in Ecoinvent 3.8 database (which was the latest available version at the time of developing the LCA study) and therefore could not be implemented in the LCA model.

Regarding electric vehicles, according to ACEA the share of electric passenger cars in 2021 in EU is around 1.2% (considering all electric vehicle types, i.e., Battery electric, Plug-in hybrid, and Hybrid electric), while in France this value is even lower (0.6%) [11]. This means that the share of electric vehicles is still very low and not representative of an average share in EU, nor in France.

For all these reasons, even though Use phase transport is a geography-dependent parameter, it can be assumed that, when shifting from EU context to the French one, no significant variation on the results is obtained.

As mentioned before, it should be noted as of now that considerations regarding take-back system of MU items are affected by the unpredictability of customers' behaviour, which is in contrast with the science-driven nature of LCA, thus implying the need to make specific assumptions for the correct functioning of the system. These assumptions are clearly reported in this study to guarantee transparency of the assessment.

3.1.3.2 Energy grid mix

The environmental impacts associated with electrical consumption are dependent on the specific geographical context. In the use stage, 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 France, its electrical grid mix should be assumed.

Differences between the EU-28 electricity grid mix used in the model in the previous EU study and the French electricity grid mix are shown in **Figure 1**[12]. It is evident that when shifting to France, two different categories can be found:

- Impact categories where French grid mix has <u>lower emissions</u> than EU-28 grid mix: Acidification, Climate change, total, Eutrophication, freshwater, Eutrophication, marine, Eutrophication, terrestrial, Ozone depletion, Particulate matter, Photochemical ozone formation - human health, Resource use, minerals and metals and Water consumption.
- Impact categories where French grid mix has <u>higher emissions</u> than EU-28 grid mix: Ionising radiation, human health and Resource use, fossils.

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

[11] https://www.acea.auto/files/report-vehicles-in-use-europe-january-2021-1.pdf

[12] The electricity grid mix with associated highest impact for each category is set to 100%, and the other electricity grid mix is normalized to this value, to facilitate the visualization and the difference between the impact results.

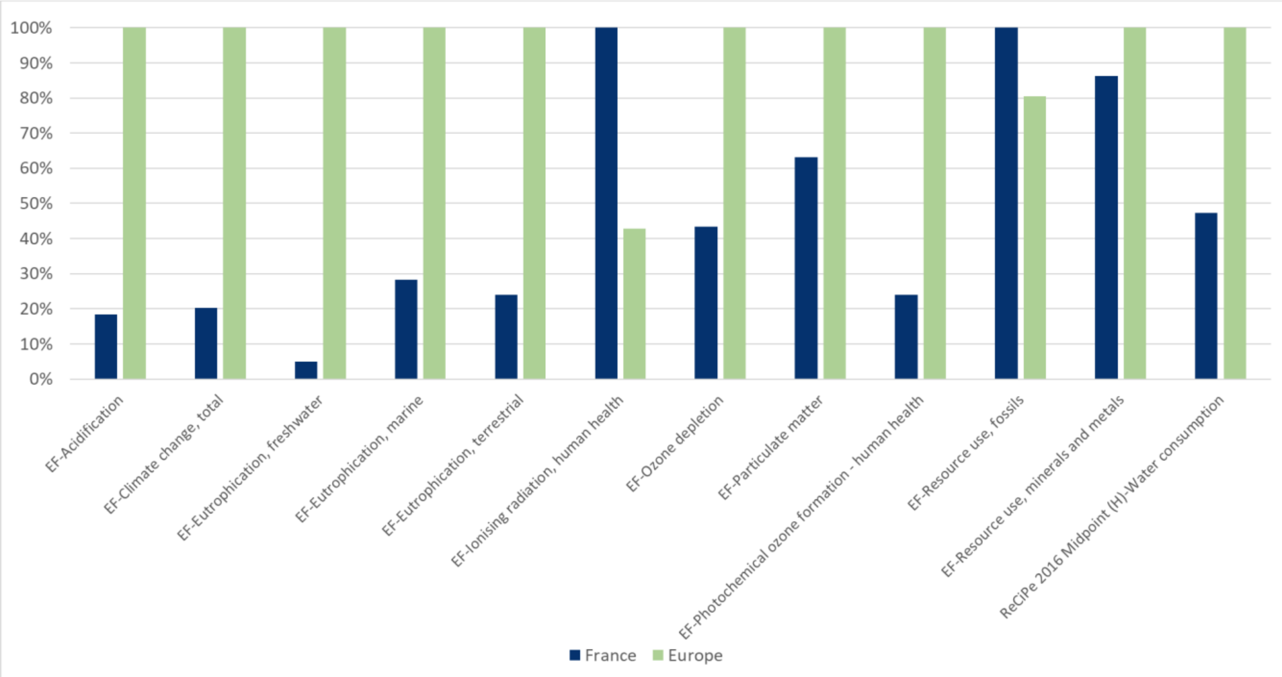

Figure 1: Relative differences between environmental impact emissions of EU-28 electrical grid mix and FR electrical grid mix

According to the most updated data from Eurostat[13], the comparison between European and French energy mix (see **Table 3**) shows that French energy mix is characterised by:

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

Table 3: Energy mix for European Union and France in 2020. Source: Eurostat.

Energy source	European energy mix	French energy mix
Total petroleum products (including crude oil)	34.5%	29.3%
Natural gas	23.7%	15.5%
Renewable energy	17.4%	12.7%
Nuclear energy	12.7%	41.1%
Solid fossil fuels	11.5%	3.1%
Other	0.2%	-1.7%*
*The negative value is reported by Eurostat to compensate uncertainties arising from reported data.		

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

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

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 comprehensive and in-depth analysis on EoL was carried out in the EU study. This was necessary because, if on one hand it is possible to estimate in a qualitative manner the fate of the focus waste streams, on the other hand it is difficult to determine the exact distribution of the shares of the focus waste streams over the different fates for several reasons:

- Specific data on the share of the focus waste streams discarded in public spaces versus those discarded at home was not found.
- Reliable data on the share of separately collected plastics and paper in public spaces was not found.
- Some data on the share of the focus waste streams which is collected separately from households has been identified but these are subject to considerable uncertainties.
- Data on the share of the focus waste streams generated from take-away orders but discarded in QSR is not available.

Given the uncertainties as presented above it should be also considered that shares of separately collected plastics and paper in public spaces across the EU will vary greatly due to differences in management of public waste among Member States.

The main publicly available data regarding recycling rate of waste streams is **data from Eurostat**[14], that refers to overall packaging waste streams (including Paper and Plastic packaging). When considering rates for the SU system, on the one side, Eurostat reports recycling rate for "paper and cardboard packaging", but it is clear that this value could be highly affected by cardboard share, which is associated to very high recycling rates, and it cannot be representative for the study. On the other hand, recycling rate for plastic packaging reported by Eurostat includes all types of polymers and both commercial/household streams, whose consideration does not completely reflect the context of this study.

Due to a lack of reliable and detailed material flow information on the current and future downstream pathways of disposed SU and MU items, assumptions are made concerning the end-of-life treatment. To do so, different sources have been examined. The more valuable information is derived from:

- Antonoupolous et al. (2021)[15]: the authors calculated the plastic waste statistics considering plants with primary data for Germany, France, Spain, Italy, Benelux, Scandinavia and Croatia, thus very representative for Europe. According with the authors, **PP waste sorting rate is indicated as equal to 57%, and re-manufacturing rate equal to 71%**. By multiplying these two figures, it can be obtained **an overall recycling share of 40.5%**, which is in line with figures reported by Eurostat.
- Picuno et al. (2021)[16] examined specific materials recycling rates when taking into account Deposit Refund System (DRS). For plastic recycling process (including DRS stream and specifically for separate collection), they estimated for two European countries (Germany and The Netherlands) **a sorting rate equal to 77%, and a re-**

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

[15] https://www.sciencedirect.com/science/article/pii/S0956053X21001999?via%3Dihub

[16] https://www.mdpi.com/2071-1050/13/12/6772

manufacturing rate equal to 73%. Therefore, **an overall recycling share of about 57%.**

For SU system no specific data regarding collecting and recycling have been identified.

For all these reasons, a symmetric approach was used in the EU study, by considering 30% recycling, 60% incineration with energy recovery and 10% landfilling based on an extensive analysis of literature data and taking into account regulatory aspects provided for by EU legislation (see full report for details).

When shifting to the French context, emerging regulations shall be taken into account, according to which the recycling rates shall be higher. However, as described for the EU context, it is not possible to determine the exact shares of waste treatments also at national level.

Nevertheless, the higher recycling rates have been considered in the sensitivity analysis of the EU study, where the share of recycling was doubled (from 30% to 60%), **and the share of incineration was halved** (from 60% to 30%). Even when doubling the recycling rates (and halving the incineration ones), **no significant effects on the main results and conclusions of the study were obtained.**

For this reason, even though EoL treatment is a geography-dependent parameter, it can be assumed that, when shifting from EU context to the French one, no variation on the results is obtained.

3.1.5 Avoided material production

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

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

3.1.6 Avoided energy production

The avoided energy production depends on the electricity grid mix. Therefore, by shifting the focus to France, the FR 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 French-specific context**.

4. RESULTS AND CONCLUSIONS

Based on the evaluation of French specific context, a limited number (4 out of 10, see **Table 1**) of *life cycle stages/parameters* is potentially geographically-dependent; however, two of these parameters (Use phase transport in the Use stage and EoL treatment) can be considered (as explained in paragraph **3.1.4**) not affected by French context. The following potential impacts of French context on the EU results are expected (considering SU and MU systems):

- Energy grid mix: it affects use phase of MU system only, since no use stage is applicable to SU system and production sites of SU items would remain the same also when shifting the scope of the study to French context
- Avoided energy production: it affects both systems.

To evaluate if the French context might determine significant variation on 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 French scenario.

   To this aim a Rapid Impact Assessment Matrix (RIAM)[17] 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 has been assigned for each geographical dependant parameters:

      not affected.

      (=) negligible differences.

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

      (-) low reduction; (--) medium reduction; (---) high 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, 2022) have been used as reference. For dealing with negative values, the approach suggested in the PEFCR is taken[18]: 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 4.** Interpretation of results should be carried out according to the following approach: the percentages reported in **Table 4** indicate how much the specific parameters weight on total impacts, while the ratings (+, -, etc.) provide a semi-quantitative indication on the effects of geographical shifting.

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

[18] PEFCR Guidance, available at https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf

For example:

- for the SU system in the "Climate Change, total" impact category, the contribution of the parameter "Avoided energy production" to the results of the EU Comparative LCA study is 12%, while the effect of geographical shifting on such parameter is medium reduction (indicated as "--"). In other words, for the SU system in the "Climate Change, total" impact category, there is a medium reduction of a parameter that weights 12% of total impacts due to geographical shifting.
- for the SU system in the Particulate Matter" impact category, due to geographical shifting, there is a low reduction of a parameter (avoided energy production) that weights 2% of total impacts and for the MU system for the same impact category there is a high reduction of the same parameter that weight 1 % of total impacts.

Table 4 Effect of different parameters on each impact category when shifting from EU scenario to French 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, 2022) (2)	A Effects of geographical shifting (1)	B Contribution of the parameter to results of the EU Comparative LCA study (Ramboll, 2022)(2)
Acidification	Energy grid mix (only use phase)	Not applicable		--	10 %
	Avoided energy production	--	9 %	---	4 %
Climate change, total	Energy grid mix (only use phase)	Not applicable		--	8 %
	Avoided energy production	--	12 %	--	5 %
Eutrophication, freshwater	Energy grid mix (only use phase)	Not applicable		--	31 %
	Avoided energy production	---	16 %	---	9 %
Eutrophication, marine	Energy grid mix (only use phase)	Not applicable		-	6 %
	Avoided energy production	--	4 %	---	2 %
Eutrophication, terrestrial	Energy grid mix (only use phase)	Not applicable		--	6 %
	Avoided energy production	--	6 %	---	2 %
	Energy grid mix (only use phase)	Not applicable		+++	36 %

Ionising radiation, human health	Avoided energy production	+++	15 %	-	11 %
Ozone depletion	Energy grid mix (only use phase)	Not applicable		-	3 %
	Avoided energy production	-	10 %	-	4 %
Particulate matter	Energy grid mix (only use phase)	Not applicable		-	3 %
	Avoided energy production	-	2 %	---	1 %
Photochemical ozone formation – human health	Energy grid mix (only use phase)	Not applicable		--	4 %
	Avoided energy production	--	6 %	--	2 %
Resource use, fossils	Energy grid mix (only use phase)	Not applicable		+	11 %
	Avoided energy production	+	14 %	---	6 %
Resource use, minerals and metals	Energy grid mix (only use phase)	Not applicable		=	3 %
	Avoided energy production	-	5 %	---	1 %
Water consumption (ReCiPe 2016 Midpoint (H))	Energy grid mix (only use phase)	Not applicable		-	18 %
	Avoided energy production	--	8 %	---	6 %

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

(2): The parameter indicated as "Avoided energy production" corresponds to a life cycle stage, then to calculate its 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.

In the EU Comparative LCA study (Ramboll, 2022), the analysis of relevant findings for the comparative assertion followed a consistent terminology[19] as presented in **Table 5**.

Table 5: Terminology for results interpretation

Relative difference in %	Terminologies in comparative assertion and interpretation of results
<5%	**marginal** *difference (i.e., uncertainty threshold)*
5-10%	**minor** *difference*
10-20%	**noticeable** *difference*
20-30%	**moderate** *difference*
30-50%	**significant** *difference*
>50%	**very significant** *difference*

This classification was used to present overall results. The interpretation was based on relative difference in %, where the system with associated highest impact for each category was set to 100% and the other system was normalized to this value.

On the basis of the results reported in **Table 4**, the following conclusion – related to the shifting from EU context to French context – could be drawn:

Acidification (if compared with EU scenario)

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

No significant effects on the main conclusion are expected for this impact categories due to the geographical shifting (FR 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 acidification, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Climate change, total (if compared with EU scenario)

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

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 "significant benefits" for climate change, total, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Eutrophication, freshwater (if compared with EU scenario)

- SU: moderately lower environmental impacts.

[19] The terminology used for interpretation is based on relative difference in %, where the system with associated highest impact for each category is set to 100% and the other system is normalized to this value.

- MU: moderately lower environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 "significant benefits" for Eutrophication, freshwater, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (external washing).

Eutrophication, marine (if compared with EU scenario)

- SU: marginally lower environmental impacts.
- MU: marginally 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 French context. French grid mix determines lower impacts on this impact category[20] (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 "moderate benefits" for Eutrophication, marine, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Eutrophication, terrestrial (if compared with EU scenario)

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

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 "significant benefits" for Eutrophication, terrestrial, and
  - according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Ionising radiation, human health (if compared with EU scenario)

- SU: moderately higher environmental impacts.
- MU: considerably higher environmental impacts.

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

[20] Due to marginal shares of nuclear and hydro energy sources of France energy grid mix, which are energy sources that can determine significant impacts on this category.

- according to the baseline results for EU scenario, the single-use system showed "minor benefits" for Ionising radiation, human health, and
- according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu) and external washing).

Ozone depletion (if compared with EU scenario)

- SU: no variation environmental impacts.
- MU: no variation in environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 Ozone depletion, and
- according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Particulate matter (if compared with EU scenario)

- SU: no variation in environmental impacts.
- MU: no variation in environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 stratospheric Particulate matter, and
- according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Photochemical ozone formation - human health (if compared with EU scenario)

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

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 Photochemical ozone formation - human health, and
- according to the sensitivity analysis, the results could be deemed "dependent on underlying assumptions" only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Resource use, fossils (if compared with EU scenario)

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

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 “significant benefits” for Resource use, fossils, and
- according to the sensitivity analysis, the results could be deemed “dependent on underlying assumptions” only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Resource use, minerals and metals (if compared with EU scenario)

- SU: no variation in environmental impacts.
- MU: no variation in environmental impacts.

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 Resource use, minerals and metals, and
- according to the sensitivity analysis, the results could be deemed “dependent on underlying assumptions” only when taking into account parameters not directly dependent on the geographical scope (4/5 trips to return MU items are neglected (i.e., 4 out of 5 people return MU items in case of buying of another menu)).

Water consumption (ReCiPe 2016 Midpoint (H)) (if compared with EU scenario)

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

No significant effects on the main conclusion are expected due to the geographical shifting (FR 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 “significant benefits” for Water consumption, and
- according to the sensitivity analysis, the results could be deemed “dependent on underlying assumptions” only when taking into account parameters not directly dependent on the geographical scope (external washing).

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