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LIFE CYCLE INVENTORY REPORT
SINGLE-USE PAPER-BASED TABLEWARE FOR QUICK SERVICE RESTAURANTS

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APPENDICES

1. INTRODUCTION AND SCOPE OF WORK

Ramboll has been appointed by the European Paper Packaging Alliance (hereafter "EPPA" or the Client) as technical consultant for conducting a Life Cycle Inventory (LCI) study related to the production of three specific paper grades and their converting into single-use paper tableware utilised in Quick Service Restaurants (QSRs).

EPPA is an association representing suppliers and manufacturers of paper board and paper board packaging for Food and Foodservice Industry[1]. To the aim of this project, not only EPPA members but also part of their suppliers outside EPPA have been involved for the data collection.

A Life Cycle Inventory (LCI) study involves the collection and analysis of data for quantities of inputs and outputs of a product system. An LCI quantifies the raw materials and energy flows (inputs) into a product system, as well as the environmental releases (outputs) associated with that system.

The inventories analysed in this report, focused on material production and converting phases only, includes all stages of such processes, such as raw material extraction, transport of raw materials, materials processing, transport of intermediate materials, manufacture, and disposal or recycling of waste generated in operations. The purpose is to provide primary LCI data exploitable for the development of LCA studies, where these data can be used to evaluate potential environmental impacts and explore improvement opportunities.

This LCI report is focused on the production of three specific paper grades and their converting into single-use paper tableware utilised in QSRs, specifically:

1. **Converted virgin fiber bleached food service board, coated**: this represents the pulp and paper making of virgin fiber bleached board and subsequent converting into the following tableware:
    - Hot drink cup (PE content < 10 % w/w) for serving of hot drinks,
    - Lid for Hot drink cup for spillover protection,
    - Cold drink cup (PE content < 5 % w/w) for serving of cold drinks and shakes,
    - Lid for Cold drink cup for spillover protection,
    - Ice cream cup (PE content < 5 % w/w) for serving of cold desserts, and
    - Salad box (incl. lid) for serving of salads.
2. **Converted partially recycled food service board**: this represents the pulp and paper making of partially recycled cartonboard and subsequent converting into the following tableware:
    - Clamshell for serving of burgers, and
    - Fry box for serving of fries.
3. **Converted oil-resistant bleached food service paper with barrier:** this represents the pulp and paper making of virgin-fibre oil and grease-resistant bleached paper with organic barrier coating and subsequent converting into the following tableware:
    - Wrap for serving of burgers, and
    - Fry bag for serving of French fries.

[1] That includes, e.g., Seda International Packaging Group, Sonoco Products Company, Burgo Group, Ahlstrom-Munksjö Oyj, CEE Schisler Packaging Solutions, Huhtamaki Oyj, Mayr-Melnhof Karton AG, McDonald's Corporation, Medac S.r.l., Metsä Board, Novolex, Paper Machinery Corporation, Reno De Medici, and Restaurants Brands International Inc.

Detailed descriptions of the systems studied, and technical features of tableware are given in the next sections of the report.

External judgment and review

This LCI study has been subjected to:

1. External QA/QC process by Michael Sturges, from RISE Research Institutes of Sweden / RISE Innventia AB, Sweden – a senior life cycle assessment expert with specific experience of environmental studies relating to pulp and paper making, as well as packaging and food service sectors.
2. External third-party review by Frank Wellenreuther, ifeu - Institut für Energie- und Umweltforschung Heidelberg gGmbH, Germany – a senior life cycle assessment practitioner with specific experience of environmental studies relating to packaging systems. The Critical Review Statement is reported in **Appendix 2**.

1.1 Objectives

The objective of this Life Cycle Inventory (LCI) is to quantify and report inputs and outputs for the production of the abovementioned three paper grades and their converting into the listed tableware, from a gate-to-gate standpoint. The final aim is to provide LCI data for use in life cycle studies.

Therefore, this report focuses on the material production and converting stages, aiming at providing data for LCA practitioners to perform LCA studies using primary data from industry players. The data could be also used to inform current and future environmental decision-making processes.

1.2 System Boundaries and declared units

The system boundaries of the LCIs are gate-to-gate (see **Figure 1**), including transport of raw materials to mills, pulp and paper making process, distribution to converters and converting into tableware, and refer to the following declared unit: **One tonne of converted net saleable paperboard into tableware for QSRs.**

The following different types of paper grades are considered:

1. Converted virgin fibre bleached food service board, coated (cold and hot cups, lids, ice cream cup, salad box)
2. Converted partially recycled food service board (clamshell, fry box)
3. Converted oil-resistant bleached food service paper with barrier (wrap, fry bag)

The gate-to-gate life cycle inventories for each paper grade presented in this report in **Chapter 4** are calculated, as follows:

- Primary data among pulp and papermakers (which include transport routes for raw materials) is collected along with the production volumes (annual production of a specific paper grade); then, weighted averages are calculated for the data collected for 1 air dry tonne (1.000 kg) of net saleable paper product for each paper grade, before conversion.
- Primary data among converters (which include transport routes from papermakers and converting sites) is collected along with their production volumes (annual converted paper products); then, weighted averages of converted products are calculated among the data collected for one tonne (1.000 kg) of printed and converted paper product for each paper grade.
- Weighted averages of the three paper grades for one tonne (1.000 kg) of net saleable paper products (calculated in point 1) are scaled to the average input required for the converting process and then summed up with the weighted averages of the converted products (calculated in point 2). This final aggregated life cycle inventories are reported in **Chapter 4**.

The life cycle inventories include data about transport routes for pulpwood to pulp/papermakers, for pulp products from producers to pulp/papermakers, for input recovered paper from recyclers to pulp/papermakers, and for output paper products from papermakers to converting sites.

Manufacturing sites are not disclosed for confidentiality reasons, as well as details of various processes inside the sites. The following flows are excluded:

- Emissions related to production of internally consumed resources and internal fuels;
- Exportation of energy to external and/or thermal grid ;
- Transportation of chemicals;
- Transport of waste to treatment facilities.

To complete a full cradle-to-gate analysis, LCA practitioners must add the processes/entries reported in red in **Figure 1**. Suggestion of ecoinvent datasets to be used to complete a full cradle-to-gate analysis that reflects average technical standards and geographical footprint of EPPA members are reported in **Appendix 1.**

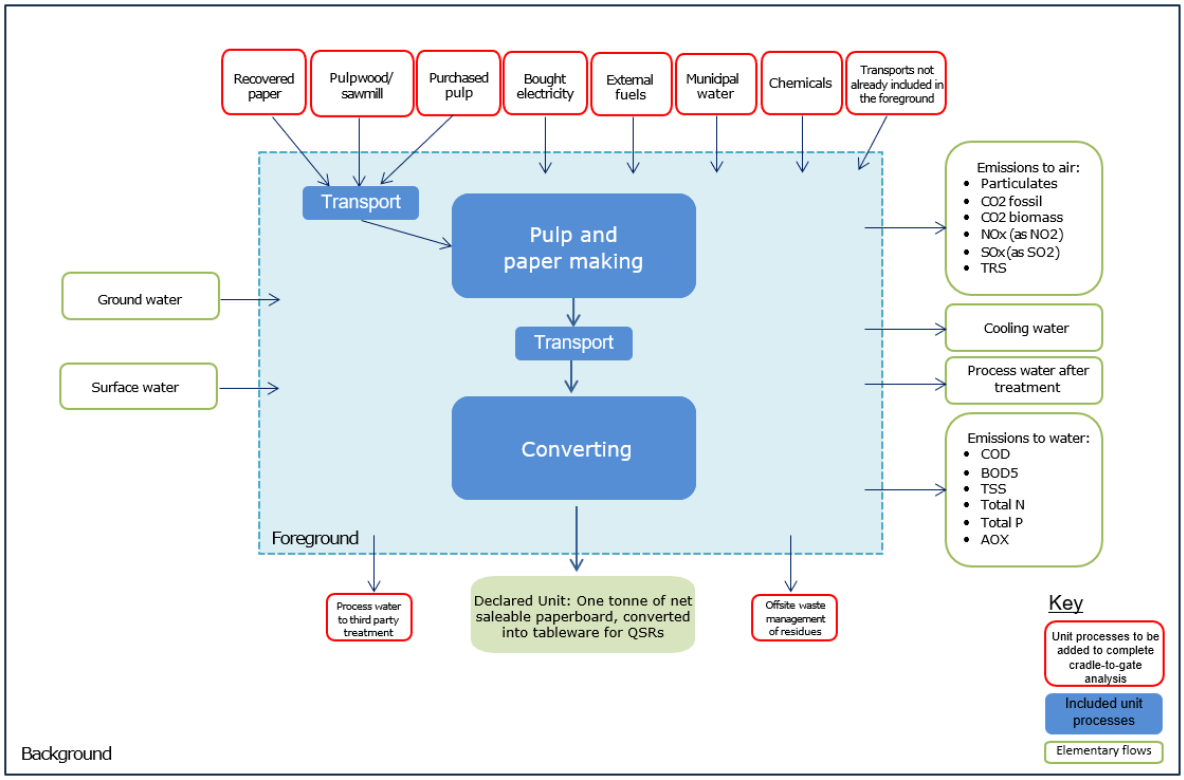

Figure 1 LCIs System boundaries

Figure 1 offers an overview of the system boundaries under analysis. In situations where the facility generates surplus energy (like electricity or steam) that it subsequently sells, the system is viewed as having dual functions (i.e., production of corrugated base paper and energy generation). This corresponds to a multifunctional situation. In this context, a subdivision principle is adopted where only the inputs and outputs related to paper production are reported in the life cycle inventory. No allocation has been designated to by-products like tall oil, turpentine, and wood/bark chips, indicating that the reported inputs and outputs also include the production of these by-products (conservative approach). For paper facilities that manufacture multiple paper grades or market pulp, allocating inputs and outputs across different paper grades or pulp becomes essential. The technical facility staff and LCA practitioners of the data providers, responsible for completing the questionnaire, performed this allocation with reference to the products under analysis.

When the total mass of non-fibre inputs was below 1% of the paper weight and the relative category is not present in the majority of the collected LCIs and the input is not included in the "Mandatory company-specific data" reported in Annex 4-III of the PEFCR for intermediate paper products (JRC, 2020), then this was not considered. This cut-off approach is based on general rule for LCI in the pulp and papermaking industry. As a general rule, these other non-fibre inputs could have been omitted from the study as insignificant. However, for completeness all non-fibre inputs for which data was reported by more than 6 facilities have been included in the inventory.

2. PRODUCTION PROCESSES AND PRODUCTS DESCRIPTION

2.1 Description of the investigated production processes

2.1.1 Pulp and paper making

The generic pulp and paper making process consists of several stages, described as follow. This process can change slightly depending on whether the paper is made from virgin wood fibers, recycled fibers, or a blend of both:

a) Wood Preparation (for virgin fibres): pulping process starts with debarking the logs that have been obtained from sustainably managed forests, using mechanical or chemical processes. The wood is then chipped into small pieces for further processing.

b) Wastepaper preparation (for recycled fibres): If the paper is produced starting from recycled paper, the wastepaper is collected, sorted, and then shredded into small pieces. It is then mixed with water in a pulper to create a slurry. Ink particles and other contaminants are removed using floatation deinking and cleaning processes.

c) Pulping: The chips are cooked in a digester using chemical processes under high pressure and temperature. This process breaks down the lignin in the wood that holds the cellulose fibres together to create pulp.

d) Washing and Screening: The pulp undergoes a washing stage to remove chemicals and residual lignin. The pulp is screened to remove any larger pieces of remaining wood or other debris.

e) Bleaching (if applicable): To remove any further remaining lignin and produce a white pulp, a bleaching process is used. This step is particularly critical for papers that need a high degree of whiteness.

f) Papermaking: The refined pulp is mixed with water to form a dilute suspension that is then drained on a paper machine, typically a Fourdrinier or cylinder mold machine. This forms a continuous mesh of random fibre, which is then pressed and dried using steam-heated rollers called dryers. and compress the fibres together to form a solid sheet of paper.

g) Finishing: Once the paper is dried and calendered, it may be coated with low density polyethylene (if needed), and is then wounded into large reels. From the reel, paper is cut and packaged for distribution.

h) Auxiliary activities integral to paper production, such as on-site water and solid waste management, on-site generation of electricity for internal use, and production of heat or steam.

The system boundaries established for the life cycle inventories of paper grades includes all operations within the operation of the pulp and paper facility. As a result, all inputs and outputs - including those interacting with the technosphere[2] and the biosphere[3] - linked with the above-mentioned processes fall within the inventory.

[2] Technosphere "describes inputs and outputs of technological systems, such as energy and material consumption" (source: https://doi.org/10.1021/acs.est.1c07438).
[3] Biosphere "gives interactions with the natural environment such as the consumption of natural resources or emissions to soil, water or air" (source: https://doi.org/10.1021/acs.est.1c07438) .

2.1.2 Converting

The generic converting process consists of several stages, described as follow. This process can change slightly depending on the type of paper used and the desired tableware:

a) Printing and coating: paper is printed with artwork or branding. This can be done through several methods such as flexography or offset printing. A food-safe coating can also be applied to make the tableware resistant to food and liquids.

b) Cutting and folding: once printed, the paper is fed through a die cutter. This machine uses custom-designed dies to cut the paper into the shapes needed for the tableware items like clamshells or cups. The die-cut shapes are then formed into the final product by sealing the side seam, often using heat. The finished products are inspected, both visually and sometimes using automated systems, to ensure they meet quality standards. They are then counted, stacked, and packaged ready for distribution.

The system boundaries established for the life cycle inventories of paper grades includes all operations within the operation of the converting facility. As a result, all inputs and outputs - including those interacting with the technosphere and the biosphere - linked with the above-mentioned processes fall within the inventory.

2.2 Description of the products related to the three specific paper grades used in QSRs

2.2.1 Converted virgin fibre bleached food service board, coated (cold and hot cups, lids, ice cream cup, salad box)

The following tableware are made of Virgin-fibre bleached board with PE coating on the reverse side and are actually considered in the LCI for the converting process of this paper into tableware for QSRs:

1. Hot drink cup (PE content < 10 % w/w) for serving of hot drinks,
2. Lid for Hot drink cup for spillover protection,
3. Cold drink cup (PE content < 5 % w/w) for serving of cold drinks and shakes,
4. Lid for Cold drink cup for spillover protection,
5. Ice cream cup (PE content < 5 % w/w) for serving of cold desserts, and
6. Salad box (incl. lid) for serving of salads.

Figure 2 Example of single-use paper-based cold drink cups and lid made of virgin-fibre bleached board with PE coating on the reverse side.

Figure 3 Example of single-use paper-based hot drink cups and lid made of virgin-fibre bleached board with PE coating on the reverse side.

Figure 4 Example of single-use paper-based ice cream cups made of virgin-fibre bleached board with PE coating on the reverse side.

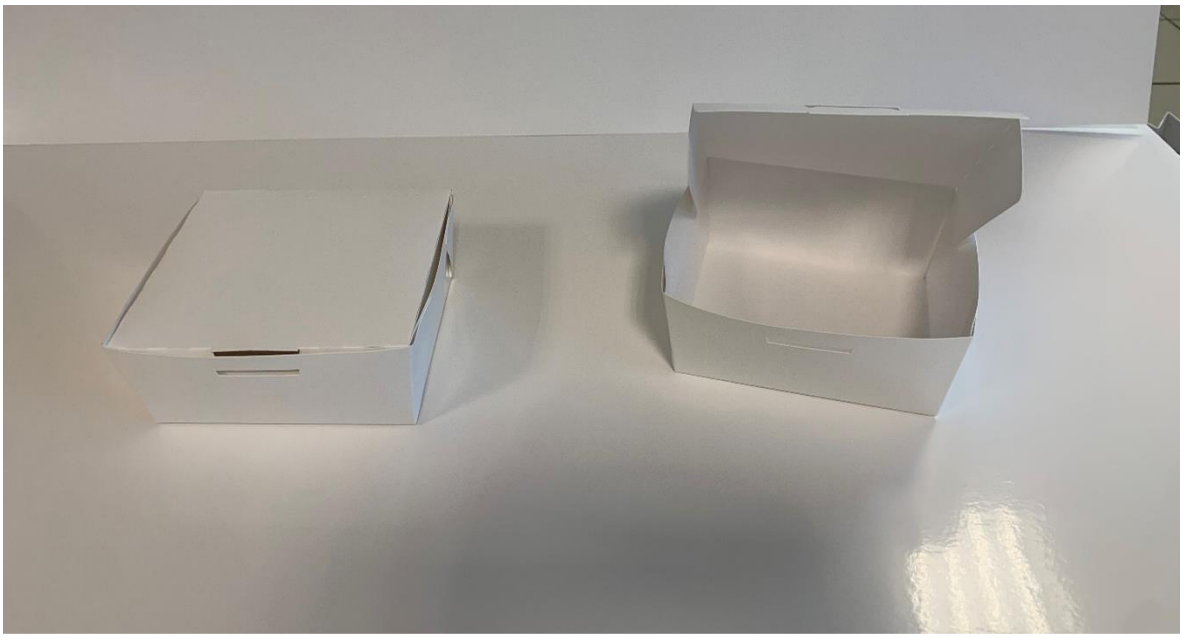

Figure 5 Example of single-use paper-based Salad box (incl. lid) made of virgin-fibre bleached board with PE coating on the reverse side.

2.2.2 Converted partially recycled food service board (clamshell, fry box)

The following tableware are made of Partially recycled cartonboard and are actually considered in the LCI for the converting process of this paper into tableware for QSRs:

1. Clamshell for serving of burgers, and
2. Fry box for serving of french fries.

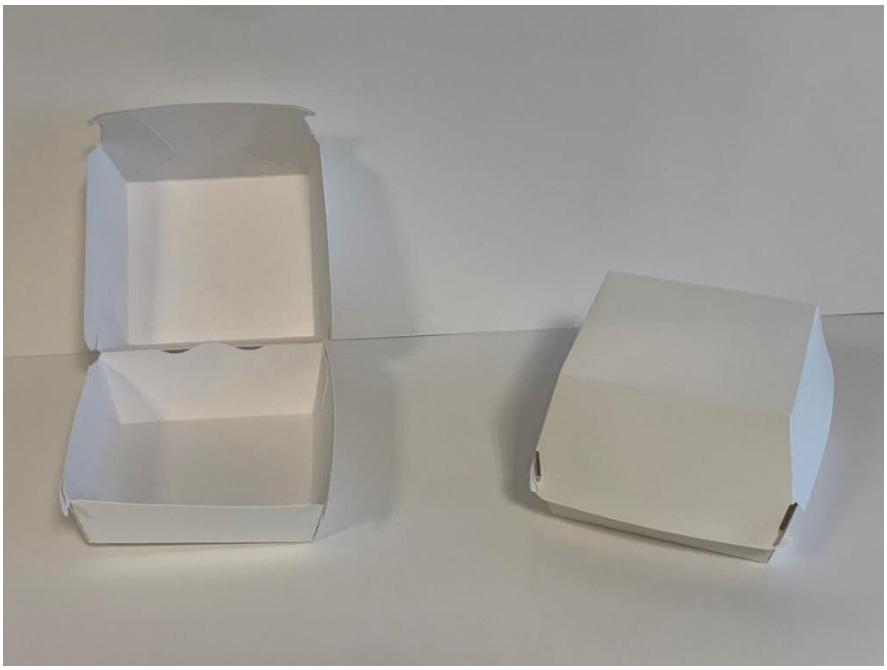

Figure 6 Example of single-use paper-based Clamshell for serving of burgers made of partially recycled cartonboard.

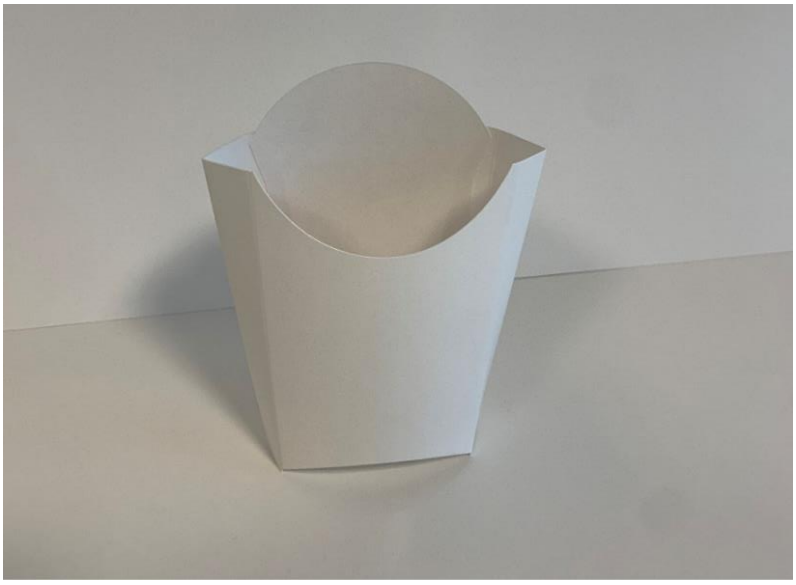

Figure 7 Example of single-use paper-based Frybox for serving French fries made of partially recycled cartonboard.

2.2.3 Converted oil-resistant bleached food service paper with barrier (wrap, fry bag)

The following tableware are made of Virgin-fibre oil and grease-resistant bleached paper with organic barrier coating and are actually considered in the LCI for the converting process of this paper into tableware for QSRs:

- Wrap for serving of burgers, and
- Fry bag for serving of french fries.

Figure 8 Example of single-use paper-based Fry bag for serving of fries (left) and Wrap for serving burgers (right) made of Virgin-fibre oil and grease-resistant bleached paper with organic barrier coating.

3. DATA DESCRIPTION

3.1 Data collection for pulp and paper making processes

Data collection was executed through the distribution of questionnaires to paper manufacturing companies (data providers). These questionnaires sought specifics about the inflow and outflow within either integrated pulp and paper facilities or non-integrated facilities. The questionnaire included essential inputs and outputs involved in the papercraft and pulping processes, along with auxiliary processes like on-site energy generation and wastewater management. Prior to distribution to the industry, the questionnaire was subjected to the external QA/QC review. The questionnaires were distributed in the course of 2023, and the provided data is indicative of production scenarios in 2022.

For each paper grade, data representative of the market condition and technology application for the year 2022 was collected. This gathered data was subjected to the external QA/QC review, subsequently organized into a weighted average representative of the production of each paper grade during 2022.

3.2 Data collection for converting processes

To collect relevant data associated with the converting processes, it was designed a comprehensive questionnaire covering the main inputs and outputs of these processes. Before these questionnaires were distributed to the industry, were subjected to the external QA/QC review.

3.3 Material inputs by data providers

Data has been provided in terms of raw materials (e.g., pulpwood), chemicals, packaging and other ancillary inputs materials. The pulpwood input has been reported as bone-dry solid wood under bark. In this study they are reported as softwood or hardwood. The pulpwood used to produce paper grades has been indicated as being all sourced from sustainable managed forests and delivered through a certified chain-of-custody system (PEFC or similar). The input of recovered paper has been reported as total weight including moisture and other materials, which are discarded from the pulp as rejects during the pulping.

Data for chemicals and other non-fibre components which may be employed within the procedure or as additives have been collected. A variety of inputs are consolidated in accordance with their role within the facility. Functional additives, primarily starch, serve to influence the properties of the paper. Process additives ensure a smoothly running paper production process or contribute to enhanced production. Water treatment additives encompass those used across all water treatment operations on-site. Other additives, although in very limited quantities, are still utilized and considered in the assessment. Depending on the paper type, facilities may also laminate the board and apply a plastic coating. In the converting process, cold glue and small amounts of hot melt and inks are used.

Data related to the materials used to package paper products for the shipment from papermakers to converters (e.g., corrugated boxes or plastic film wrappings) have been collected, even though they form a relatively small component of the input. Data pertaining to the use of pallets (for logistics) has been neglected, since the pallets could be reused several times and no consistent information was collected among data providers.

3.4 Material outputs and waste treatment

All residues are reported based on their wet weight and classified according to their fundamental characteristics. Residues are only documented when they exit the system boundaries, that is,

when they are taken off-site for treatment. Given that the facilities are treated as black boxes[4], considerations regarding energy and emissions linked with the internal (on-site) management of residues are already incorporated within the gate-to-gate inventory data. Residues of the recycled paper mills that are mainly rejects from the pulp preparation, it is assumed that about a third is due to rejected materials associated with the previous use of the paper (e.g., staples, paper clips, tags, adhesive labels, unrecovered fibres). The remaining two thirds is assumed to be material not associated with the previous use of the paper (e.g., foreign items such as textiles, plastic packaging, glass, sand and grit, etc)[5].

3.5 Energy inputs and outputs

Fuel inputs to the sites have been collected and reported. The lower calorific heat values have been used to calculate energy from volume or mass of fuel. Fossil fuel and biomass fuel consumptions are reported as separate entities. The energy for the sites refers to energy directly used for the processes of pulp/papermaking or converting and auxiliary processes such as wastewater treatment. Energy distributed externally in forms as electricity or steam is not reported. In the LCI, the production sites are handled as a black box, and energy recovery is achieved, for example, via the combustion of black liquor and bark derived from the inbound wood at production sites for primary fiber-based paper production. This inherent energy is already included in the LCIs.

3.6 Water inputs and outputs

When paper facilities use water, they in general do not consume this water during the production process. Post-usage water is typically re-introduced into rivers, lakes or seas in the form of cooling water or treated effluent water. A portion of water may evaporate during the drying phase of paper production. Notably, discourse around water stresses its impact when consumed, and this is best understood in the context of local water availability rather than the volume of water directed into the facilities. Consequently, a more appropriate indicator to gauge water impact would be the net difference between the intake and return of water to rivers or lakes, equating to water consumed as opposed to water intake.

3.7 Transports

The transport distances of wood raw materials from the harvesting/production sites (i.e., pulpwood), purchased pulps and recovered paper used as input of the LCIs to the facilities, as well as those of paper from paper making facilities to converting facilities, have been reported specifying the means of transport (such as trucks, rail or ships). Distances and tonnages of materials delivered have been used to calculate the total t*km for delivery of materials by each mode of transport. Transport of residues and waste is not reported.

3.8 Emissions to air

Emissions to air from the sites have been reported. For dust, TRS (H2S), NOx and SOx the figures from the paper facilities are mostly based on measurements. For CO_2, the figures reported are based on emissions reported to authorities if provided, or if these were not provided, they are based on calculations and reported separately for fossil and biomass origin. When not available, air emission figures are calculated from reported figures for consumption of different fuels. In this case, emission factors from different sources, such as IPCC and ecoinvent, were used for the calculations for fossil fuels. For biofuels, the following factors were applied: black liquor 110 kgCOe2 per GJ; wood, bark and wood chips 125 kgCO2e per GJ; biogas 55

[4] A "black box" is a system in LCA where inputs/outputs could not be detailed and reported for each facility, due to confidentiality reasons. Inputs and outputs are therefore reported as average data, weighted between the facilities by using production volumes.
[5] This assumption was adopted from the approach reported in FEFCO (2022)

kgCO2e per GJ. These emission factors were based on literature data (FEFCO, 2022). Emissions from fuel combustion (transport, electricity generation for the public grid) outside the facility are not included in the data.

Table 1 Default factors for calculating emissions to air from fossil fuels

	unit	natural gas	oil heavy	oil light/diesel	coal
CO2 (fossil) 1*	kg/GJ	56	78	74	95
CO 1*	g/GJ	2.1	7	4	100
Particulates, < 2.5 µm 2*	g/GJ	0.2	35	0.1	20
Particulates, > 2.5 µm, and < 10µm 2*	g/GJ	-	5	-	20
Particulates, > 10 µm 2*	g/GJ	-	10	-	10
NOx (as NO_2) 2*	g/GJ	18	100	50	200
SOx (as SO_2) 2*	g/GJ	0.55	400	47	500
Ecoinvent dataset name and ID-number		natural gas, burned in industrial furnace >100kW, RER, [MJ] (#1363)	heavy fuel oil, burned in industrial furnace 1MW, non-modulating, RER, [MJ] (#1589)	light fuel oil, burned in industrial furnace 1MW, non-modulating, RER, [MJ] (#1601)	hard coal, burned in industrial furnace 1-10MW, RER [MJ] (#848)

1* Source Intergovernmental Panel on Climate Change (extracted from Emission Factors Database, IPPC Guidelines version 2006)
2* ecoinvent Centre, ecoinvent data v2.2 Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent data v2.0, 2007, Swiss Centre for Life Cycle Inventories, PSI, Duebendorf, CH, www.ecoinvent.org, 2012

3.9 Emissions to water

Water used in the facilities is treated before it is released as effluent to a recipient. The substances in the effluent after wastewater treatment are reported. Some facilities have wastewater treatment, while others send their effluent water to an external treatment facility. The volume of effluent water is reported separately for treated process water and thermally polluted effluent (e.g., cooling water).

3.10 Data Quality

Data quality check was performed during the whole data collection process. In addition, an external QA/QC process review of data was performed by an external expert.

The following check procedure were considered:

- mass balance check procedure.
- water balance check procedure.

- fuel emissions check procedure.
- plausibility and consistency check against applicable benchmark (e.g., literature review, best practices, sector guidelines, sector LCIs database).

Only primary data that met the requirement of this multiple check was considered adequate and therefore included in this report.

The following data quality requirements were considered during the data collection and the compilation of this report:

- **Time-related coverage:** Primary inventory in this report is referred to the reference year 2022.
- **Geographical coverage:** Primary data refer to each facility and converting sites located in the EU context. In particular:
    - Pulpwood and purchased pulp production facilities are located in EU Nordic countries (Finland and Sweden)
    - Papermaking facilities for "Converted virgin fibre bleached food service board, coated" are located in EU Nordic countries (Finland and Sweden)
    - Papermaking facilities for "Converted partially recycled food service board" and "Converted oil-resistant bleached food service paper with barrier" are located in EU states, such as Austria, Italy and Spain
    - Converting facilities are located in different EU countries, such as Germany, Italy, Finland, France, Spain, Poland and Ireland

  According to figures and data reported by the *Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board*, this situation is considered representative of the EU context.
- **Technological coverage:** Primary data covers state-of-the-art of pulp and paper production and converting.
- **Precision:** Representative and precise primary data is used to the extent possible.
- **Completeness:** Completeness of data is achieved through iterative process of data collection via interviews and questionnaires.
- **Representativeness:** The degree to which data and assumptions reflects an average EU situation is addressed under time-related, geographical, and technological coverage.
- **Consistency:** Data was checked for consistency and only meeting the requirements for consistency check, as well as external expert judgment, it was included in this report.

4. RESULTS

Table 2 shows the calculated inputs and outputs for the production of One tonne of converted net saleable paperboard into tableware for QSRs for the three different paper grades presented in the report. All data refer to the declared units.

Table 2: Life cycle inventories for the production of One tonne of converted net saleable paperboard into tableware for QSRs for the three different paper grades presented in the report.

		Converted virgin fibre bleached food service board, coated	Converted partially recycled food service board	Converted oil-resistant bleached food service paper with barrier
PRODUCT	**tonne net saleable product**	**1**	**1**	**1**
RAW MATERIAL				
Wood consumption	as bone dry weight (= 45% of transported total wet weight)			
Pulpwood, Hardwood (birch)	t	1.18	0	0
Pulpwood, Softwood (spruce, pine)	t	0.22	0	0.01
Sawmill residues softwood	t	0.24	0	0.00
Recovered paper	as wet weight			
Mixed grades	t	0.0287	0.8469	0.0028
Purchased pulp consumption	as bone dry weight			
Purchased Bleached CTM pulp	t	0	0.0116	0
Purchased Bleached kraft pulp, Hardwood	t	0.0289	0	0.2810
Purchased Bleached kraft pulp, Softwood	t	0.0195	0.0106	0.5712
Purchased Bleached sulphite pulp	t	0	0	0.0148
Purchased Unbleached pulp	t	0	0.0805	0
TRANSPORT OF RAW MATERIALS				
Wood				
Transport, Wood with boat	t*km	654	0	0
Transport, Wood with rail	t*km	1027	0	0
Transport, Wood with truck	t*km	378	0	0
Recovered paper				
Transport, Recovered paper with rail	t*km	0	61	0
Transport, Recovered paper with truck	t*km	0	22	0
Purchased pulp				
Transport, Purchased pulp with boat	t*km	131	0	2471
Transport, Purchased pulp with truck	t*km	7	21	1294
TRANSPORT TO CONVERTING				
Transport, paperboard to converting with boat	t*km	93	56	21

Transport, paperboard to converting with truck	t*km	2202	1620	1441
ENERGY INPUTS				
Bought electricity	GJ	5.932	0.826	4.482
Fossil fuels				
Diesel oil	GJ	0	0.006	0
Heavy fuel oil	GJ	0.577	0	0
Light fuel oil	GJ	0.001	0	0
LPG	GJ	0.052	0	0.074
Natural gas	GJ	1.478	6.110	6.801
Total fossil fuels	GJ	2.11	6.12	6.87
Renewable fuels				
Biofuel (bark, scrap wood)	GJ	0.37	0	0
Total renewable fuels	GJ	0.37	0	0
Total fuel	GJ	2.48	6.12	6.87
WATER				
Input total	m^3	74.57	8.87	20.76
Ground water	m^3	0	6.46	0.79
Municipal water	m^3	0	0.04	0.07
Surface water	m^3	74.56	2.38	19.90
PROCESS CHEMICALS AND ADDITIVES, DRY MASS				
Al as (Al2(SO4)3)	kg	4.37	0	0
Binders	kg	8.11	12.61	0
Biocides	kg	0	0.10	0
CaCO3 (Calcium carbonate)	kg	24.36	18.64	0
CaO (Calcium oxide)	kg	7.09	0	0
Carboxymethyl Cellulose	kg	0	0	62.27
CO2 (carbon dioxide, liquid)	kg	3.54	0	0
Defoamer	kg	0	0.004	0
Fillers	kg	8.23	2.48	1.29
Glue, cold and hot melts	kg	45.87	2.35	34.51
H2O2, peroxide	kg	8.16	0	0
H2SO4	kg	14.50	0	0
Lubricants (oil and grease)	kg	0	1.05	0
Minerals (e.g., clay)	kg	20.12	122.76	4.01
NaClO3 (Sodium chlorate)	kg	18.96	0	0
NaOH (sodium hydroxide)	kg	28.88	0.53	0.04
NH3 (ammonia)	kg	0	0.04	0
Oxygen, O2	kg	10.65	0	0
Plastics coating	kg	75.17	0	0
Polymer and retention agents	kg	0	0.13	0
Sizing agents	kg	1.44	0	2.37

Starch, modified	kg	11.82	0.30	0.87
Starch, potato	kg	0	0	0.12
Starch, unspecified	kg	9.21	0.90	15.57
Starch, wheat	kg	3.52	74.44	0.70
Varnish for printing	kg	4.35	4.60	0
Water-based ink	kg	2.24	2.54	12.84
PACKAGING				
Corrugated board for packaging	kg	2.02	2.25	4.81
Plastics for packaging	kg	0.09	1.50	0.04
EMISSIONS TO AIR				
CO (carbon monoxide)	kg	0.09	0.01	0.0002
CO2 (biomass)	kg	46.18	0	0
CO2 (fossil)	kg	131.76	328.47	390.04
Nitrogen oxides	kg	1.0434	0.0890	0.1231
Particulates	kg	0.0985	11.2679	0.0004
Sulfur oxides	kg	0.0795	0.0027	0.00004
TRS	kg	0.0667	0	0.0107
EMISSIONS TO WATER				
Water output	m^3			
Water output to freshwater after onsite treatment	m^3	49.82	7.37	19.94
Water output to municipal wastewater treatment plant	m^3	23.16	0.78	0.65
Total water out	m^3	72.99	8.15	20.59
Water in – water out	m^3	1.58	0.72	0.18
Waterborne emissions				
AOX	kg	0.06	0.00098	0
BOD5	kg	1.08	0.02	0.18
COD	kg	11.46	0.62	0.91
Suspended solids	kg	1.59	0.14	0.22
TOC	kg	0.48	0.19	0.10
Total Nitrogen	kg	31.30	0.05	6.22
Total Phosphorous	kg	4.10	0.004	0.82
RESIDUES	wet weight			
Ashes	kg	12.11	0	0.01
Ink residues	kg	0	0.51	0.00026
Lubricants and oil	kg	0	0.07	0.0038
Mixed waste to incineration (with energy recovery)	kg	0.37	0	0
Paper for recycling	kg	299.86	242.16	77.63
Plastics for recycling	kg	0.57	0.00	0

Rejects, other[6]	kg	0	69.54	0
Rejects, paper related[7]	kg	0	34.77	0
Sludges	kg	22.73	16.77	14.01

[6] Material not associated with the previous use of the paper (e.g., foreign items such as plastic packaging, glass, sand and grit)
[7] Rejects associated with the previous use of the paper (e.g., staples, paper clips, tags, adhesive labels, unrecovered fibres)

5. REFERENCES

FEFCO - European Federation of Corrugated Board Manufacturers, 2021. European database for corrugated board life cycle studies. Available at: https://www.fefco.org/lca

JRC, Join Research Centre, 2020. PEFCR for intermediate paper products, 2020.

IPCC, Intergovernmental Panel on Climate Change. Emission Factors Database, IPPC Guidelines version 2006.

ecoinvent Centre, ecoinvent data v2.2 Sachbilanzen von Energiesystemen. Final report No. 6 ecoinvent data v2.0, 2007, Swiss Centre for Life Cycle Inventories, PSI, Duebendorf, CH, www.ecoinvent.org, 2012

APPENDIX 1
ECOINVENT MAPPING

This appendix reports suggestion of ecoinvent datasets to be used to complete a full **cradle-to-gate** analysis for material production and converting of analysed paper grades and related tableware that reflects average technical standards and geographical footprint of EPPA members. The suggested datasets are retrieved from ecoinvent 3.9.1.

CATEGORY	ECOINVENT 3.9.1 DATASET
PRODUCT	
RAW MATERIAL	
Wood consumption	
Pulpwood, Hardwood (birch)	pulpwood, hardwood, measured as solid wood under bark (SE, hardwood forestry, birch, sustainable forest management)
Pulpwood, Softwood (spruce, pine)	50% pulpwood, softwood, measured as solid wood under bark (SE, softwood forestry, spruce, sustainable forest management) + 50% pulpwood, softwood, measured as solid wood under bark (SE, softwood forestry, pine, sustainable forest management)
Sawmill residues softwood	wood chips, wet, measured as dry mass (Europe without Switzerland, wood chips production, softwood, at sawmill)
Recovered paper	
Mixed grades	market for waste paperboard, sorted (GLO, market for waste paperboard, sorted)
Purchased pulp consumption	
Purchased Bleached CTM pulp	chemi-thermomechanical pulp (RER, chemi-thermomechanical pulp production)
Purchased Bleached kraft pulp, Hardwood	sulfate pulp, bleached (RER, sulfate pulp production, from hardwood, bleached)
Purchased Bleached kraft pulp, Softwood	sulfate pulp, bleached (RER, sulfate pulp production, from softwood, bleached)
Purchased Bleached sulphite pulp	sulfite pulp, bleached (RER, sulfite pulp production, bleached)
Purchased Unbleached pulp	sulfate pulp, unbleached (RER, market for sulfate pulp, unbleached)
TRANSPORT OF RAW MATERIALS	
Wood	
Transport, Wood with boat	transport, freight, sea, container ship (GLO, market for transport, freight sea, container ship)
Transport, Wood with rail	transport, freight train (RER, market group for transport, freight train)
Transport, Wood with truck	transport, freight, lorry >32 metric ton, EURO5 (RER, market for transport, freight, lorry >32 metric ton, EURO5)

Recovered paper	
Transport, Recovered paper with rail	transport, freight train (RER, market group for transport, freight train)
Transport, Recovered paper with truck	transport, freight, lorry >32 metric ton, EURO5 (RER, market for transport, freight, lorry >32 metric ton, EURO5)
Purchased pulp	
Transport, Purchased pulp with boat	transport, freight, sea, container ship (GLO, market for transport, freight sea, container ship)
Transport, Purchased pulp with truck	transport, freight, lorry >32 metric ton, EURO5 (RER, market for transport, freight, lorry >32 metric ton, EURO5)
TRANSPORT TO CONVERTING	
Transport, paperboard to converting with boat	transport, freight, sea, container ship (GLO, market for transport, freight sea, container ship)
Transport, paperboard to converting with truck	transport, freight, lorry >32 metric ton, EURO5 (RER, market for transport, freight, lorry >32 metric ton, EURO5)
ENERGY INPUTS	
Bought electricity for LCI 1[8]	• 28% electricity, high voltage (FI, market for electricity, high voltage) • 28% electricity, high voltage (SE, market for electricity, high voltage) • 44% electricity, medium voltage (RER, market group for electricity, medium voltage)
Bought electricity for LCI 2[9] and 3[10]	electricity, medium voltage (RER, market group for electricity, medium voltage)
Fossil fuels	
Diesel oil	diesel, low-sulfur (RER, market group for diesel, low-sulfur)
Heavy fuel oil	heavy fuel oil (RER, market group for heavy fuel oil)
Light fuel oil	light fuel oil (RER, market group for light fuel oil)
LPG	liquefied petroleum gas (Europe without Switzerland, market for liquefied petroleum gas)
Natural gas	natural gas, high pressure (Europe without Switzerland, market group for natural gas, high pressure)
Biofuel (bark, scrap wood)	wood chips, dry, measured as dry mass (RER, market for wood chips, dry, measured as dry mass)
WATER	
Input total	
Ground water	Water, well, in ground (resources from water, unspecified) (elementary)
Municipal water	tap water (RER, market group for tap water)
Surface water	Water, river (resources from water, unspecified) (elementary)
PROCESS CHEMICALS AND ADDITIVES, DRY MASS	
Alum (Al2(SO4)3)	aluminium sulfate, powder (RER, market for aluminium sulfate, powder)
Binders	latex (RER, market for latex)
Biocides	50% dithiocarbamate-compound (GLO, market for dithiocarbamate-compound) + 50% triazine-compound, unspecified (GLO, market for triazine-compound, unspecified)

[8] Converted virgin fibre bleached food service board, coated. Since the paper for this LCI is produced in Finland and Sweden (see section 3.10 for details), the share of electricity related to these countries has been equally divided to reflect an average energy mix.
[9] Converted partially recycled food service board
[10] Converted oil-resistant bleached food service paper with barrier

CaCO3 (Calcium carbonate)	50% calcium carbonate, precipitated (RER, market for calcium carbonate, precipitated + 50% Calcium (resources from ground, unspecified) (elementary)
CaO (Calcium oxide)	quicklime, milled, loose (CH, market for quicklime, milled, loose)
Carboxymethyl Cellulose	carboxymethyl cellulose, powder (GLO, market for carboxymethyl cellulose, powder)
CO2 (carbon dioxide, liquid)	carbon dioxide, liquid (RER, market for carbon dioxide, liquid)
Defoamer	ethoxylated alcohol (AE3) (RER, market for ethoxylated alcohol (AE3))
Fillers	kaolin (GLO, market for kaolin)
Glue, cold and hot melts	ethylene vinyl acetate copolymer (RER, market for ethylene vinyl acetate copolymer)
H2O2, peroxide	hydrogen peroxide, without water, in 50% solution state (RER, market for hydrogen peroxide, without water, in 50% solution state)
H2SO4	sulfuric acid (RER, market for sulfuric acid)
Lubricants (oil and grease)	lubricating oil (RER, market for lubricating oil)
Minerals (e.g., clay)	50% clay (CH, market for clay) + 25% calcium carbonate, precipitated (RER, market for calcium carbonate, precipitated) + 25% Calcium (resources from ground, unspecified) (elementary)
NaClO3 (Sodium chlorate)	sodium chlorate, powder (RER, market for sodium chlorate, powder)
NaOH (sodium hydroxide)	sodium hydroxide, without water, in 50% solution state (RER, market for sodium hydroxide, without water, in 50% solution state)
NH3 (ammonia)	ammonia, anhydrous, liquid (RER, market for ammonia, anhydrous, liquid)
Oxygen, O2	oxygen, liquid (RER, market for oxygen, liquid)
Plastics coating	polyethylene production, low density, granulate (GLO, market for polyethylene production, low density, granulate)
Polymer and retention agents	retention aid, for paper production (RER, market for retention aid, for paper production)
Sizing agents	alkylketene dimer sizing agent, for paper production (RER, market for alkylketene dimer sizing agent, for paper production)
Starch, modified	50% potato starch (GLO, market for potato starch) + 50% maize starch (GLO, market for maize starch)
Starch, potato	potato starch (GLO, market for potato starch)
Starch, unspecified	50% potato starch (GLO, market for potato starch) + 50% maize starch (GLO, market for maize starch)
Starch, wheat	maize starch (GLO, market for maize starch
Varnish for printing	acrylic varnish, with water, in 53% solution state (RER, market for acrylic varnish, with water, in 53% solution state)
Water-based ink	printing ink, offset, without solvent, in 47.5% solution state (RER, market for printing ink, offset, without solvent, in 47.5% solution state
PACKAGING	
Corrugated board for packaging	corrugated board box (RER, market for corrugated board box)
Plastics for packaging	packaging film, low density polyethylene (GLO, market for packaging film, low density polyethylene)
EMISSIONS TO AIR	
CO (carbon monoxide)	Carbon monoxide, fossil (emissions to air, unspecified) (elementary)
CO2 (biomass)	Carbon dioxide, non-fossil (emissions to air, unspecified) (elementary)
CO2 (fossil)	Carbon dioxide, fossil (emissions to air, unspecified) (elementary)
Nitrogen oxides	Nitrogen oxides (emissions to air, unspecified) (elementary)

Particulates	22.24% Particulate Matter, < 2.5 um (emissions to air, unspecified) (elementary) + 12.33% Particulate Matter, > 2.5 um and < 10um (emissions to air, unspecified) (elementary) + 65.43% Particulate Matter, > 10 um (emissions to air, unspecified) (elementary)
Sulfur oxides	Sulfur oxides (emissions to air, unspecified) (elementary)
TRS	Sulfur dioxide (emissions to air, unspecified) (elementary)
EMISSIONS TO WATER	
Water output	
Water output to freshwater after onsite treatment	Water (emissions to water, unspecified) (elementary)
Water output to municipal wastewater treatment plant	Water (emissions to water, unspecified) (elementary)
Waterborne emissions	
AOX	AOX, Adsorbable Organic Halogen (emissions to water, unspecified) (elementary)
BOD5	BOD5, Biological Oxygen Demand (emissions to water, unspecified) (elementary)
COD	COD, Chemical Oxygen Demand (emissions to water, unspecified) (elementary)
Suspended solids	Suspended solids, unspecified (emissions to water, unspecified) (elementary)
TOC	TOC, Total Organic Carbon (emissions to water, unspecified) (elementary)
Total Nitrogen	Nitrogen (emissions to water, unspecified) (elementary)
Total Phosphorous	Phosphorus (emissions to water, unspecified) (elementary)
RESIDUES	
Ashes	ash from paper production sludge (Europe without Switzerland, market for ash from paper production sludge)
Ink residues	waste paint (Europe without Switzerland, market for waste paint)
Lubricants and oil	waste mineral oil (Europe without Switzerland, market for waste mineral oil)
Mixed waste to incineration (with energy recovery)	e.g., treatment of municipal solid waste, incineration (DE)
Paper for recycling	*burden free in the cut-off method*
Plastics for recycling	*burden free in the cut-off method*
Rejects, other	municipal solid waste (RER, market group for municipal solid waste)
Rejects, paper related	municipal solid waste (RER, market group for municipal solid waste)
Sludges	sludge from pulp and paper production (Europe without Switzerland, market for sludge from pulp and paper production)

APPENDIX 2
CRITICAL REVIEW STATEMENT

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Critical review statement: LIFE CYCLE INVENTORY REPORT SINGLE-USE PAPER-BASED TABLEWARE FOR QUICK SERVICE RESTAURANTS

Frank Wellenreuther

ifeu - Institute for Energy and Environmental Research

Heidelberg, March 2024

Contents

1 Background

European Paper Packaging Alliance (EPPA) is an association representing suppliers and manufacturers of paper board and paper board packaging for Food and Foodservice Industry. EPPA aims to provide LCI data for use in life cycle studies for products manufactured by member companies of EPPA. For the study under review three paper grades converted into tableware for Quick Service Restaurants (QSRs) are selected. EPPA commissioned Ramboll for the collection of data and the creation of the LCI dataset.

Prior to the critical review step, the LCI study has been subjected to an external QA/QC process by Michael Sturges from RISE.

2 Critical review

2.1 Review process

The review process began at an advanced stage of the project timeline. The following table lists the key dates of the critical review process:

17.01.2024	Commissioning of critical review by EPPA represented by Armando Mariano
22.01.2024	Kick-off call between Ramboll, Michael Sturges and critical reviewer
25.01.2024	NDA between critical reviewer and EPPA
07.02.2024	Provision of LCI data: 'EPPA 2024, Life Cycle Inventories_v01.xlsx' by Ramboll
12.-13.02.2024	First review of LCI data by critical reviewer
14. & 19.02.2024	Provision of exemplary LCI from data providers and draft report: 'EPPA 2024, Data provider LCIs_v01.xlsx' 'EPPA LCI report_draft.docx' by Ramboll
22.02.2024	First review of draft report and exemplary LCI from data providers by critical reviewer
26.02.204	Modification to report by Ramboll, regarding water output results by Ramboll
02.-03.03.2024	Second review of LCI data and report by critical reviewer
03.03.2024	Delivery of draft critical review statement to Ramboll by critical reviewer
06.03.2024	Finalisation of LCI report by Ramboll Finalisation of critical review statement by critical reviewer

2.2 Documents and files for review

The documents shared for review are:

- EPPA 2024, Life Cycle Inventories_v01.xlsx
- EPPA 2024, Data provider LCIs_v01.xlsx
- EPPA LCI report_draft.docx
- EPPA LCI report_DRAFT CONFIDENTIAL_05.03.24
- Table 'EMISSIONS TO WATER' (in email from 26.02)

The authors of the draft report are Francesco Castellani, Giovanni F. Cardamone, Iacopo Del Vecchio, Alessia Abeti and Selina Scheer from Ramboll.

2.3 Scope review

2.3.1 Products

The paper grades and their converting are:

1. Virgin fibre bleached food service board, coated
    - Converted into various cups and salad boxes
2. Partially recycled food service board
    - Converted into clamshells for burgers and fry boxes for fries
3. Oil-resistant bleached food service paper with barrier
    - Wraps for Burgers and fry bags for fries

The products are well presented, incl. photographs, in the report. The production processes are explained transparently and divided into the two main production steps of production and converting. Both steps consist of several subprocesses which are clearly explained facilitating an easy understanding which data have had to be collected.

2.3.2 System boundaries

The system boundaries are reported to be gate-to-gate, including transport of raw materials to mills, pulp and paper making process, distribution to converters and converting into tableware. A figure of the system boundaries is provided.

Allocation between different paper grades at the same plant has been conducted by the original data providers. This is considered to be a valid and practical approach. No allocation for by-products like tall oil or turpentine is applied. This is considered to be a conservative approach and approved by the reviewer.

A cut-off rule is applied regarding non-fibre inputs with a mass below 1% of the paper weight if the input is not included in the list of mandatory data inputs reported in Annex 4-III of the PEFCR for intermediate paper products. This is

considered a common and valid approach when creating LCI datasets of paper products.

2.3.3 Declared unit

The declared unit is 'one tonne of converted net saleable paperboard into tableware for QSRs'.

The choice of declared unit is considered appropriate regarding the objectives of this LCI study.

2.4 Data review

Pulp and paper making data were collected from paper manufacturing companies. Converting data were collected from the converting industry. For both process steps data collection questionnaires were developed and subjected to a external QA/QC process by Michael Sturges of RISE. Exemplary, filled-in data questionnaires for different steps and products have been provided for the review process. The data questionnaires are considered to be comprehensive and appropriate for the task to collect the relevant data.

Both the sample data and the completed LCI data sets were analysed in the course of the review by means of cross-checks and plausibility checks and the data quality is considered to be very high.

Assumptions and determinations (f.e. choice of lower calorific heat values, emission factors for fossil fuels taken from Ecoinvent and IPCC, those for biofuels are taken from the FEFCO LCI report) as well as exclusions (f.e. production of multi-use pallets or transport of waste) regarding all inputs and outputs/emissions have been reviewed and are considered to be valid and transparently described in the report and the LCI data sheet.

2.5 Results review

Comprehensive inventory lists are presented for each product. The inputs and outputs are unmistakably named and necessary additional information is provided in a transparent way (f.e wet weight / dry weight of paper and pulp or onsite/offsite treatment of water outputs).

3 Conclusion

The LIFE CYCLE INVENTORY REPORT - SINGLE-USE PAPER-BASED TABLEWARE FOR QUICK SERVICE RESTAURANTS is considered to deliver comprehensive and robust LCI data for application in ISO compliant life cycle assessment studies. All data have been collected as primary data to a very high detail. The report is transparently written, the data quality of the LCI data is very high and the data are considered easy to apply even for less experienced practitioners.

The additional suggestions for appropriate background datasets from the Ecoinvent database in Appendix 1 of the report for use in a cradle-to-gate LCA are considered helpful and comprehensive.

Heidelberg, 2024-03-06

Frank Wellenreuther, ifeu gGmbH