Life cycle assessment

IN ACCORDANCE WITH ISO 14044 and ISO 14067

Colombier EcoBarrier™ To-Go Cups
Colombier Finland Oy

20.01.2023

Created with One Click LCA

GENERAL INFORMATION

MANUFACTURER

Table 1 Manufacturer information

Manufacturer	Colombier Finland Oy
Address	Harjuntie 101 Stockfors, 49270 Pyhtää,
Contact details	finland(at)colombier.com
Website	https://colombier.com

STANDARDS, SCOPE AND VERIFICATION

This study is a cradle-to-grave LCA, assessing the potential environmental impacts associated with one 8 oz Colombier EcoBarrier™ cup.

This includes extraction of raw materials from the environment through to manufacturing of the paperboard and coating raw materials, coating process, cup making process and the end-of-life to the point where the cup is disposed of and recycled. Production and maintenance of capital goods (i.e. used for manufacture of turbine components) have been excluded from the scope of this study.

Table 2 Standards used in the calculations

Reference standard	ISO 14040/14044 ISO 14067
Category of LCA	Third party verified LCA, Cradle-to-grave
LCA author	Susanna Kiviniemi, Greenstep Oy

The manufacturer has the sole ownership, liability, and responsibility for the LCA. The verification was done by Kristin Fransson (AFRY) and the verification statement can be found in Appendix 4.

PRODUCT

Table 3 Product info

Product name	Colombier EcoBarrier To-Go Cups
Place of production	Pyhtää, Finland
Period for data	2021, average batch of production

ENVIRONMENTAL DATA SUMMARY

Table 4 Environmental data summary

Functional unit	one 8 oz Cup
Functional unit mass	7.1 g
GWP-fossil, Cradle to Grave (gCO_2e)	8,49
GWP-total, Cradle to Grave (gCO_2e)	9,09

This study is valid for five years. After that the potential changes in the electricity production forms and their lowering impact on the carbon footprint should affect may cause these results to give an over estimation of the carbon footprint.

PRODUCT AND MANUFACTURER

ABOUT THE MANUFACTURER

Colombier is a forest industry converting and trading company. As a large fibre product converter Colombier shoulders its responsibility by pioneering new technologies and introducing products that save resources and improve recyclability. Innovations in barrier coating for food packaging are paving the way for plastic-free products that are recyclable and biodegradable.

PRODUCT DESCRIPTION

Colombier EcoBarrier™ technology utilises an aqueous dispersion process to create a water- and grease-resistant barrier on paper and board. The innovative and environmentally friendly product is an easily recyclable mono-material that replaces plastic in various packaging applications. Colombier EcoBarrier™ products are compliant with the European Union SUP-directive and fully recyclable in the regular wastepaper stream (PAP21).

Colombier EcoBarrier™ solutions contain inorganic pigments, bio-based organic materials, non-plastic polymers, and water. Colombier EcoBarrier™ is FDA and BfR compliant. It is designed to be used in direct food contact applications as primary packaging, The end-uses include flexible packaging, to-go cups, take-away food packaging, bags, pouches and more.

GOAL OF THE STUDY AND INTENDED AUDIENCE

The goal of the study was to prove the potential environmental benefits that the EcoBarrier™ has compared to similar to-go cups. The study is made partly as a comparative study. The whole life cycle assessment was made for the Colombier product, but the comparison didn't include the recycling of the products compared.

After the calculations the results could be communicated to Colombier's potential clients and investors.

SUBSTANCES, REACH - VERY HIGH CONCERN

The product does not contain any REACH SVHC substances in amounts greater than 0,1 % (1000 ppm).

PRODUCT LIFE-CYCLE

SYSTEM BOUNDARY

This LCA covers the whole life-cycle of the cups from raw material manufacturing to the end of life. No impacts are generated in the use phase as the cup is used single time and then disposed of. The stages of the life cycle are listed in the Table 5.

Table 5 The stages of the lifecycle

Colombier activities			Sub-contractor activities		Use phase	End of life stage			Beyond the system boundaries		
Raw materials	Transport	Coating of paperboard	Transport	Manufacturing of cups	Use of the cup	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling

MANUFACTURING OF CUPS

The environmental impacts considered for the product stage cover the manufacturing of raw materials used in the production as well as packaging materials and other ancillary materials. Also, fuels used by machines, and handling of waste formed in the production processes at the manufacturing facilities are included in this stage. The study also considers the material losses occurring during the manufacturing processes as well as losses during electricity transmission. Transportation impacts occurred from final products delivery to the site where the cups are formed, cover fuel direct exhaust emissions, environmental impacts of fuel production, as well as related infrastructure emissions.

On the first stage of the cup making, the ready-made cardboard is coated in the Colombier factory (see coating process description in page 6). After the coating process, the cardboard is delivered to the sub-contractor for cup manufacturing. LNG trucks and vessels are used in transportation from Colombier factory in Pyhtää, Finland to sub-contractor in Rostock-Düsseldorf, Germany. The cups are made in converter by sub-contractor. After that the cups are delivered to the final customers by conventional road transportation means.
The total manufacturing process is presented on Figure 1 and the Colombier Barrier coating process in Figure 2

PRODUCT USE

No impacts are caused in the product use phase.

PRODUCT END OF LIFE

The Colombier EcoBarrier™ To-Go cups can be recycled as cardboard. The calculations are made on the assumption that all cups go to recycling.

RESULTS OF SENSITIVITY ANALYSIS AND UNCERTAINTY ASSESSMENT

MANUFACTURING PROCESS

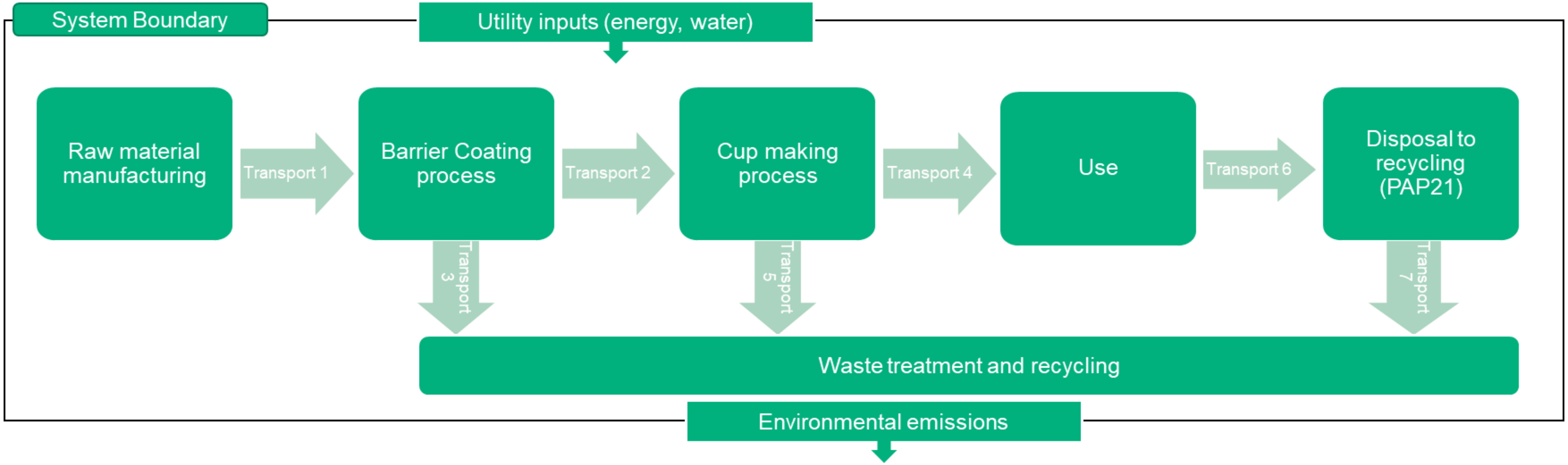

Figure 1 Manufacturing process of the cups

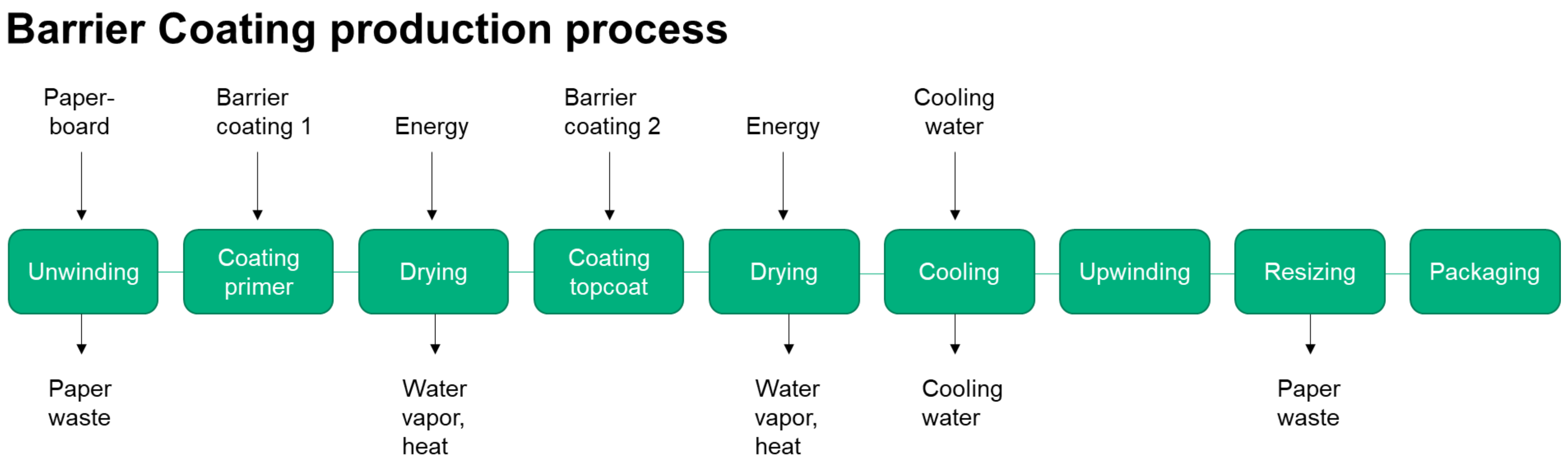

Figure 2 Barrier coating production process

Paperboard rolls are delivered to Colombier coating factory where the paperboard is coated with Colombier EcoBarrier™ coating that is water- and grease-resistant. The process includes the following steps. Fist the paperboard is unwound. After that the paperboard is coated with liquid primer which after the paperboard is dried. After that the liquid topcoat is applied to the paperboard which after the paperboard is again dried. The warm paperboard is then cooled and up-wound again for the delivery. The up-wound paperboard can be cut to size by the further processing demand, for example related to the different cup sizes. After that the paperboard is packed for transportation.

LIFE-CYCLE ASSESSMENT

CUT-OFF CRITERIA

The study does not exclude any hazardous materials or substances. The study includes all major raw material and energy consumption. All inputs and outputs of the unit processes, for which data is available for, are included in the calculation. There is no neglected unit process more than 1% of total mass or energy flows. The lifecycle stage specific total neglected input and output flows also do not exceed 5% of energy usage or mass. The calculations are made for a white cup and any printing by the customers are neglected from the calculations.

LOCATION, ESTIMATES AND ASSUMPTIONS

Allocation is required if some material, energy, and waste data cannot be measured separately for the product under investigation. In this study, allocation was made based on one batch information run in the factory. One batch produces 1 000 000 cups. The materials were divided by the batch cup amount. Electricity use and heating oil use was allocated based on the total production amount of cups at both Colombier factory and the subcontractor that is responsible of making the cups. Information about LPG use in the air dryers was batch specific measured information and allocated on the basis of cup amount per batch.

Colombier buys it's electricity from Oomi and the emissions are evaluated on the basis of the mixture provided by the electricity generator. Because Oomi tells only the portion of fossil and renewable energy in the electricity mix, the amount of different fossil and renewable energy sources were calculated on the Statistics Finland data. In addition, the driers use LPG and the factory uses heating oil in warming. The energy mix at the cup making process was assumed to be general electricity mix in Germany (dataset from ecoinvent).

The raw materials in the cup are totally made from virgin materials and no recycled materials can be used in the production. The dataset for packaging material kraft liner, is also calculated based on a process where only virgin fibre is used. The main raw material Food Service Board / Cupstock's emissions were received from the material provider. The calculations were made according to CEPI ten toes framework. The information about biogenic carbon emissions and land use and land use change are not mandatory according to the framework and the material provider has not added the information in their report. There for this calculation doesn't take those emissions from the Food Service Board / Cupstock into account. This might cause a significant deviation to the biogenic carbon and land use change emission information, and the author suggest caution when utilising information about the biogenic carbon and land use change emissions.

The benefits from the recycling are evaluated by closed-loop allocation procedure. The calculation is done based on the assumption that the cups and the kraft liner used in packaging are being recycled back to material. The datasets used in the calculation are for newsprint production. It is assumed that from one kg of kraft liner 0,0088 kg of secondary material is lost in the recycling. For cardboard the same relation is 0,57 kg/kg. The newsprint dataset was used to evaluate both burdens from the recycling and the benefits from the recycling.

100 % recovery rate is assumed in this case to be consistent with other similar LCA studies. At the moment the recovery rate of paper and cardboard packaging waste in Europe is about 80 % (Statista.com).

For the pallets a reuse scenario of 5 times was used in the calculation and the end-of-life benefits were assumed to be electricity (energy ratio converted to electricity 11 %) and heat (energy ratio converted to heat 62%).

For the packaging film the whole amount was assumed to be incinerated and the end-of-life benefits were assumed to be electricity (energy ratio converted to electricity 11 %) and heat (energy ratio converted to heat 62%).

The cups could be also composed or incinerated after use, but the preferred way to recycle the cups is to recycle them as material. Initial data and LCI are presented in appendix 1 (Confidential),

The data sources are presented in appendix 2.

LCA SOFTWARE AND BIBLIOGRAPHY

This LCA has been created using One Click LCA EPD Generator. The LCA have been prepared according to the reference standards and ISO 14040/14044 and ISO 14067. Ecoinvent and One Click LCA databases were used as sources of environmental data.

IMPACT ASSESSMENT CATEGORIES AND METHODS

The impact assessment too account on all the impact categories according to the ISO 14067 standard:

- GWP – total
- GWP – fossil
- GWP – biogenic
- GWP – dLUC

The IPCC fifth assessment report values for global warming potential were used in the impact assessment.

DATA QUALITY ASSESMENT

Appendix 3 provides a summary of the checks made in the LCA for data completeness, consistency and representativeness. The following important areas are identified for this LCA:

- Datasets for paperboard
- Datasets for styrene-acrolynite
- Energy use datasets
- Transport datasets

Appendix 3 provides further details of the results of the evaluation which indicates where there have been deviations and also gives an overall brief summary of consistency.

RESULTS OF UNCERTAINTY ASSESSMENT

The uncertainties related to this study are associated with the used average LCA datasets for the barrier coating chemicals. The raw material provider has not made their own LCA studies thus making it difficult to estimate how much their impacts vary from the general datasets used in this study. However, the chemicals represent 5 % of the total raw materials in the product. With 34,64 % variation in dataset the total uncertainty of all raw materials is +/- 6 %. This results to uncertainty of the total LCA results of +/- 2,6 %

ENVIRONMENTAL IMPACT DATA

The results of the LCA study are presented in Table 6. The results are presented for one 8 oz coffee cup. The production and transportation doesn't include flights. The information produced by the manufacturer of Food Service Board / Cupstock didn't include information about the biogenic climate impact and the results from the biogenic carbon should be used with caution.

Table 6 CORE ENVIRONMENTAL IMPACT INDICATORS of one coffee cup - ISO 14067 results in kgCO₂e

	Colombier activities				Sub-contractor activities			End of life stage			Sum of LCA	Beyond the system boundaries
Impact category	Raw materials	Transport	Coating of cardboard	Sum of Colombier activities	Transport	Manufacturing of cups	Transport	Transport	Waste processing	Disposal	SUM	Benefits of recycling
Fossil and biogenic GHG emissions and removals	3,46E-03	4,68E-04	2,31E-03	6,24E-03	1,30E-03	6,33E-04	2,70E-04	3,20E-05	6,20E-04	0,00E+00	9,09E-03	2,41E-03
Fossil GHG emissions and removals	3,45E-03	4,68E-04	1,13E-03	5,05E-03	1,30E-03	1,40E-03	2,70E-04	3,20E-05	4,30E-04	0,00E+00	8,49E-03	-1,21E-03
Biogenic GHG emissions and removals	4,67E-06	2,54E-07	1,09E-03	1,10E-03	9,60E-07	-7,86E-04	2,70E-04	2,40E-08	1,90E-04	0,00E+00	7,71E-04	3,52E-03
GHG emissions and removals occurring as a result of dLUC	8,42E-08	1,83E-07	1,83E-07	4,50E-07	4,00E-07	3,20E-06	9,60E-08	9,80E-09	1,30E-07	0,00E+00	4,28E-06	3,12E-05
Biogenic carbon in products	1,21E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Aircraft GHG emissions	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00

GHG=Greenhouse gas

dLUC=Direct land use change

CONCLUSIONS

The share of different stages of the manufacturing is presented in the Figure 3. The benefits from the recycling of the materials are not included in these numbers. The raw material extraction and processing produces 41 % of the total carbon footprint of the product. The Colombier coating process produces 13 % of the total emissions whereas the evaluated converter process (cup manufacturing) produces 17 %. The converter process is estimated based on the converter machines electricity consumption and that has a bigger uncertainty than the Colombier process. The transportation at different stages sums up to 24 % of the total products fossil CO2e emissions. The end of life covers 5 % of the total fossil CO2e emissions.

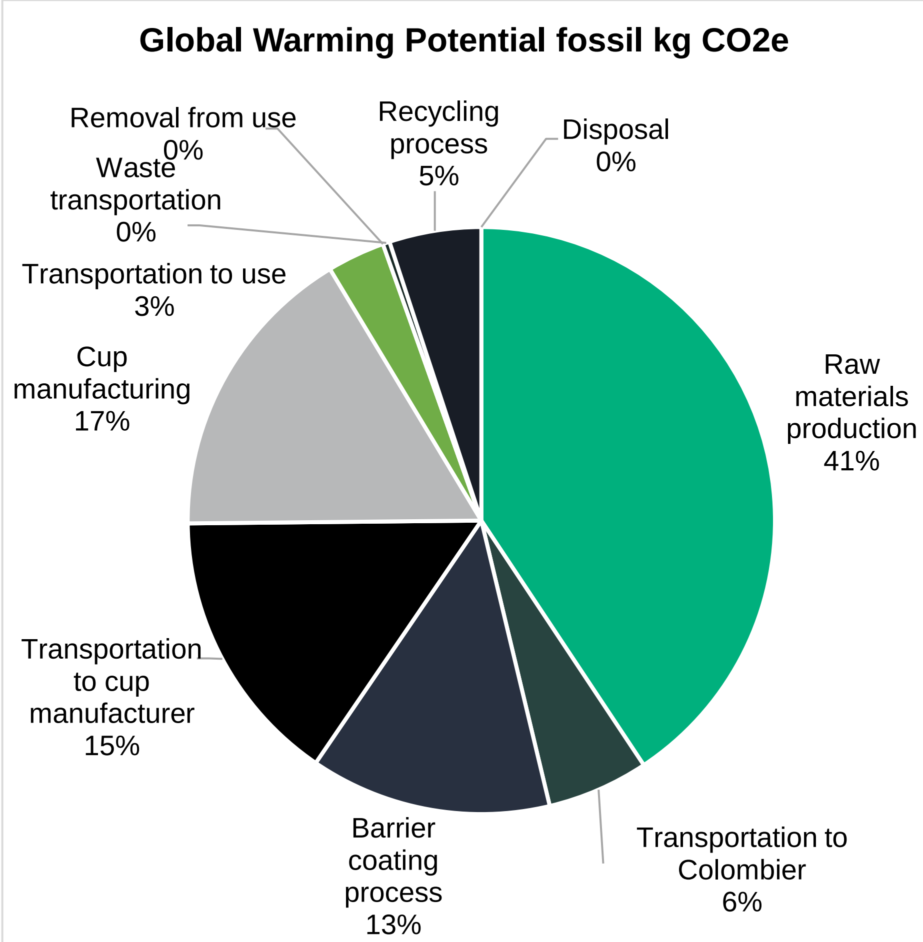

Figure 3 The share of fossil global warming potential in different life cycle stages.

The global warming of fossil sources from different lifecycle stages and the benefits and loads beyond the system boundary are shown in the Figure 4 and in Table 7 Amounts of global warming potential (fossil) in different lifecycle stages. Table 7.

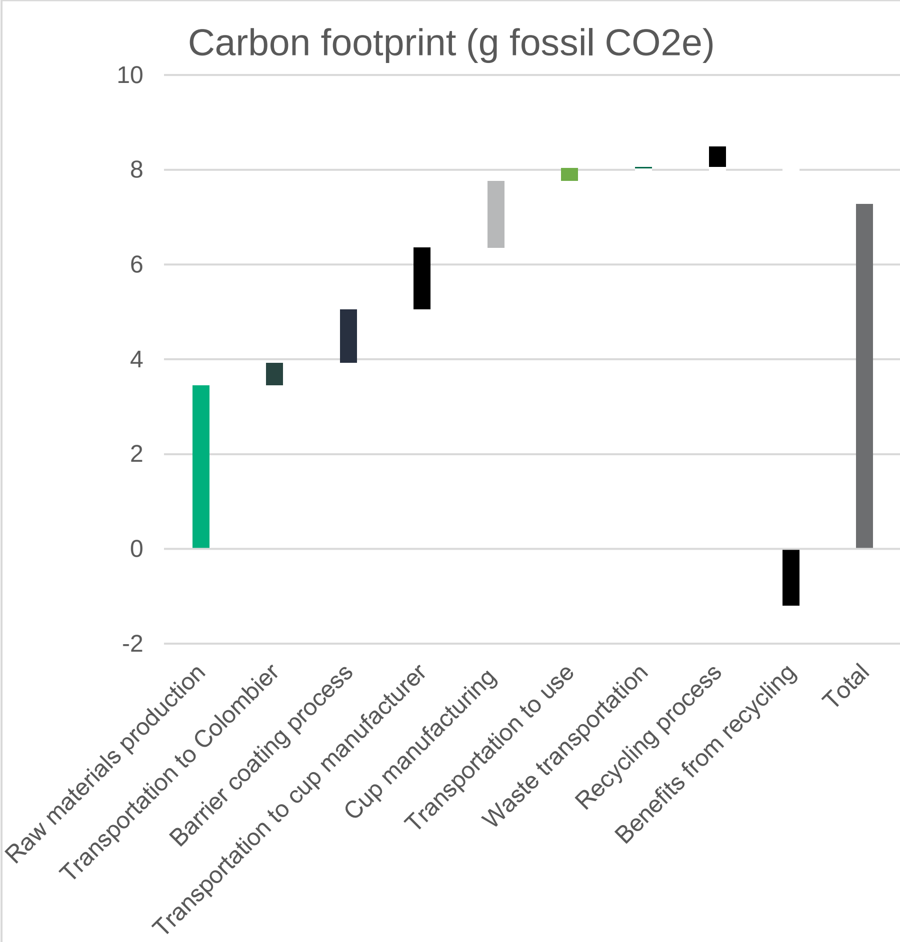

Figure 4 Amounts of global warming potential (fossil) in different lifecycle stages.

Table 7 Amounts of global warming potential (fossil) in different lifecycle stages.

Life cycle stage	**gCO2e**
Raw materials production	3,45
Transportation to Colombier	0,47
Barrier coating process	1,13
Transportation to cup manufacturer	1,30
Cup manufacturing	1,40
Transportation to use	0,27
Removal from use	0,00
Waste transportation	0.032
Recycling process	0,43
Disposal	0,00
Benefits from recycling	-1,21

If the benefits from the material recycling is neglected, the carbon footprint of the cup is 8,49 gCO_2e/cup. The recycling of the cup, as well as the energy recovery and recycling of the packaging waste of different life cycle stages lowers the carbon footprint to 7,29 gCO_2e/cup.

The total Global warming potential consists of greenhouse gases from fossil sources, biogenic sources, and greenhouse gases from direct land use change. The sum of those is presented in the Figure 5. As stated in the assumptions chapter the biogenic and land use change emissions from the cupstock was not stated at the manufacturers document, thus the total GWP of biogenic carbon might deviate from the reported number.

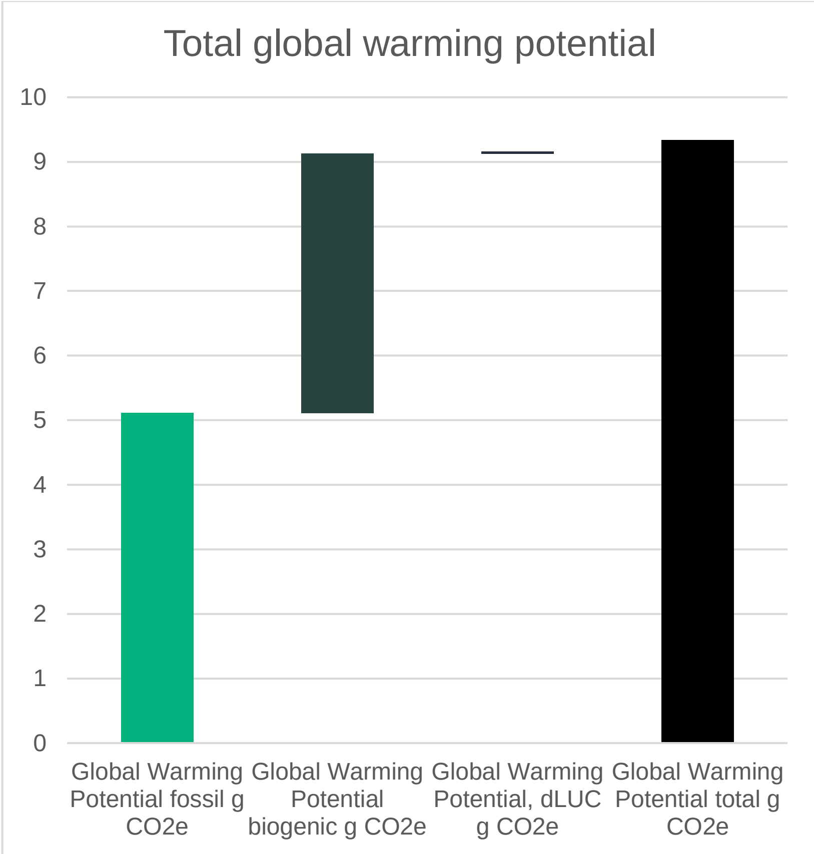

Figure 5. Total global warming potential divided between fossil, biogenic and dLUC.Table 8 Total global warming potential divided between fossil, biogenic and dLUC.

GWP fossil	8,49 gCO_2e
GWP biogenic	5,01 gCO_2e
GWP dLUC	0,004 gCO_2e
GWP total	9,09 gCO_2e

RESULTS OF SENSITIVITY ANALYSIS

As a result of the sensitivity analysis all the life cycle stages of the cup making are included in this study and no raw material streams or unit processes related straight to the cup making are neglected from the study.

The ancillary process where the coating machines are washed after use is also taken into account. However, the unit process where the washing water is pre-treated before the water is led to sewer was ruled out of the scope of the study. The water is treated by Axolot's process. The NaCl and other coagulants used in the process adds up to less than 1% of the total raw material use. The coagulated flock is treated as community waste and can be incinerated.

The sensitivity analysis showed that if the calculation of the emissions from the electricity production were done according to the general electricity mix in Finland instead of the actual electricity mix that is bought by Colombier the results from the electricity consumption would be 18,6 % higher in the total GWP the total result being 0,4 % higher. This option is shown as option 1 in the Table 9.

The option 2 where the electricity mix would remain as it is, but the light fuel oil would be changed to wooden pellets would increase the total GWP by 0,3%, but decrease the fossil emissions by 0,8 % and increase biogenic emissions by 19 %.

According to this analysis the electricity mix and the use of oil versus wooden pellets has a minor impact on the results. To support the most realistic results the use of the bought electricity mix is the best option. If the light fuel oil was to be replaced by wooden pellets in the future the impact can be estimated according to these calculations.

Table 9Table 9 Sensitivity analysis

Global Warming Potential		total kg CO2e	fossil kg CO2e	biogenic kg CO2e	dLUC kg CO2e
	As calculated	9,09E-03	8,49E-03	5,01E-04	4,28E-06
Difference	Option 1	3,29E-05	2,29E-05	3,62E-06	2,27E-06
	Option 2	2,80E-05	-6,80E-05	9,70E-05	4,19E-08
Difference %	Option 1	0,36 %	0,27 %	1 %	53 %
	Option 2	0,31 %	-0,80 %	19 %	1 %

LIMITATIONS AND RECOMMENDATIONS

The results are valid when we look at the GWP fossil results. The initial data provided by the cupstock producer did not include GWP of biogenic carbon or land use change which causes limitations to where this data can be utilized. It is recommended to redo the calculations in case new information about biogenic carbon emissions and land use change emissions can be received. Also, in case of significant process change, source of energy, location of factory changes the renewal of the calculations should be done.

CARBON HANDPRINT

Carbon Handprint is used to describe the climate benefits that can be gained from the use of the product. The Carbon Handprint is an LCA-based metric that describes the potential positive environmental impacts of a user's activities achieved by replacing a baseline product with the offered solution. For Handprint calculations the Colombier EcoBarrier™ To-Go Cup was compared to a conventional PE coated paper cup. The carbon handprint comparison is presented in the Figure 6.

The best comparable baseline carbon footprint's source was Huhtamäki's Life cycle analysis study, made by VTT in 2019 which was made in collaboration with D. The calculation was made for Stora Enso. The baseline products were 8 oz Paper cup PE coated and Paper cup compostable. No other similar studies with clear results could be found for comparison. The baseline study is fully compliant with ISO 14040 and ISO 14044 standards. The baseline study follows European Commission's product environmental footprint (PEF) category rules for intermediate paper products. Cut off was the chosen allocation method but circular footprint formula (CFF) was used to assess the impact of recycling rate. The baseline study assumed, similar to this LCA, that 100 % of the cups are recycled. However, they made the assumption that the wood fiber from the product can be recycled up to 7 times, and assumedly added the benefits from the recycling into the carbon footprint. The study considers biogenic carbon dioxide emissions carbon neutral and are not included in the assessment. The only emission from a biogenic source that is included in the assessment is methane from landfills, which is released into the atmosphere via degradation of formed fiber products.

The biggest difference between these two studies is in the recycling benefits evaluation. Therefore, the two different carbon footprints were comparable in regards of the lifecycle before the recycling part. The baseline and the Colombier cup's end-of-life positive impacts of recycling are not taken into account. The comparison is made based on GWP fossil.

Disclaimer: As the two studies have not been calculated simultaneously, results from the comparison/handprint are only indicative. There might be variations between the methodology and system boundaries between the two studies.

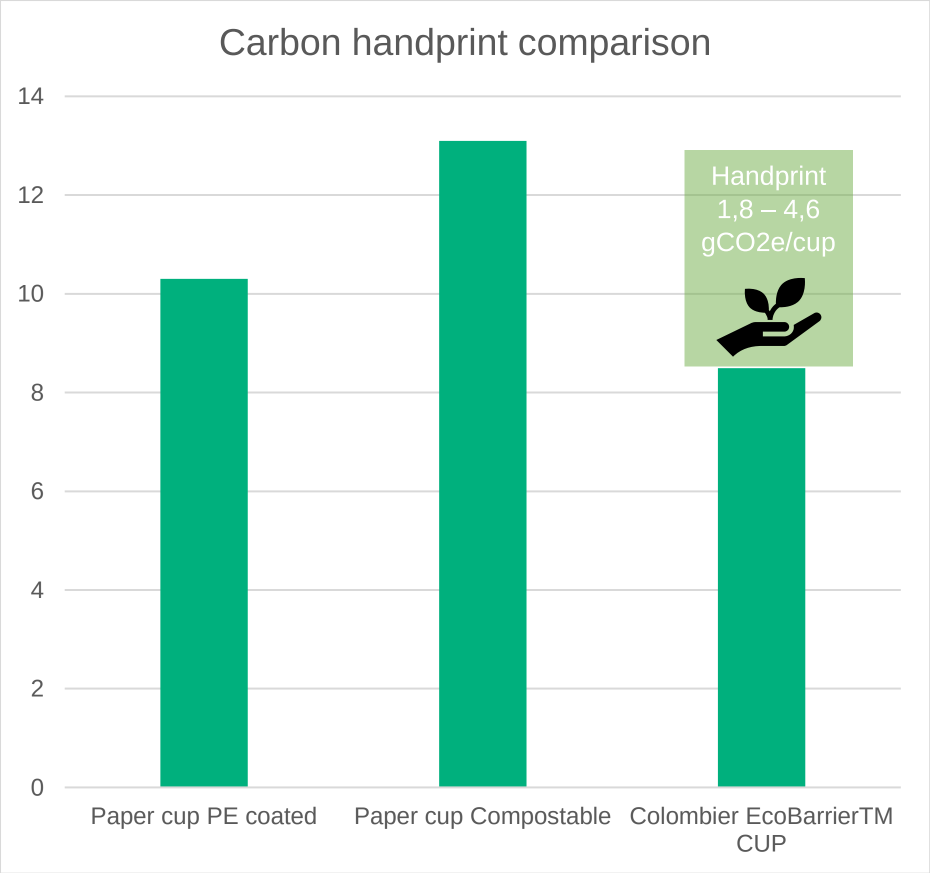

Figure 6 Carbon footprint comparison of different kinds of paper cups

Resulting handprint of the Colombier EcoBarrier™ To-Go Cup compared to the conventional PE coated paper cup is 1,8 gCO_2e/cup, the footprint being 18 % smaller. When compared to a compostable cup the handprint is 4,6 gCO_2e/cup, the footprint being 35 % smaller. The baseline study states that the compostable cups typically require a thicker lining to achieve leak-proofing, and some fossil-content, which increases their carbon footprint. This assumably plays to Colombier's benefit as the Colombier cups leak-proofing is done in a more efficient way.

REFERENCES AND BIBLIOGRAPHY

ISO 14040 (2006): Environmental Management - Life Cycle Assessment - Principles and Framework

ISO 14044 (2006): Environmental Management - Life Cycle Assessment – Requirements and Guidelines

ISO 14067 (2018): Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification

Environmental declaration for Food Service Board / Cupstock, date of issue 1.4.2022

Lifecycle analysis study, Taking a closer look at paper cups for coffee by Huhtamäki