The Carbon Footprint of Carton Packaging 2023

Carbon footprint statement prepared by RISE (Research Institutes of Sweden) Bioeconomy and Health Unit on behalf of Pro Carton

RISE

Carbon footprint statement prepared by RISE (Research Institutes of Sweden) Bioeconomy and Health Unit on behalf of Pro Carton

Contents

PRO CARTON
PACKAGING FOR A BETTER WORLD

Foreword

March 2023

Pro Carton, the European Association of Cartonboard and Carton Manufacturers is pleased to present the carbon footprint for carton packaging. The carbon footprint has been calculated using latest methodologies and data. The method applied is in accordance with the frameworks set out in CEPI's "Framework for Carbon Footprints for Paper and Board Products, April 2017" and the subsequent CITPA "Guidelines for calculating carbon footprints for paper-based packaging, March 2018". As recommended by these documents, the total carbon footprint value calculated covers the cradle-to-grave carbon impact of carton packaging, taking account of fossil and biogenic greenhouse gas (GHG) emissions and removals and emissions from direct land use change (dLUC). Carbon contained within the product when it is first placed on the market is also quantified.

The carbon footprint statement was compiled and written by RISE (Research Institutes of Sweden) and the raw data and calculations were verified by ifeu (Institut für Energie- und Umweltforschung) based in Heidelberg, Germany.

Cradle-to-grave carbon footprint of cartons, kgCO_2e per tonne of cartons

	Fossil GHG emissions	Biogenic GHG emissions	GHG removals	Direct land-use	Total
2021	852kgCO_2e	1,014kgCO_2e	-1,626kgCO_2e	9kgCO_2e	**249kgCO_2e**

It is encouraging to note that the analysis shows that the cradle-to-grave fossil GHG emissions for cartons was reduced by 17% in 2021 compared to the last calculation covering the calendar year 2018 (2021: 852kgCO_2e versus 2018: 1,025kgCO_2e). If the total carbon footprint is considered, including fossil GHG emissions, biogenic GHG emissions, GHG removals and direct land-use, then the reduction is increased to 24% (2021: 249kgCO_2e versus 2018: 326kgCO_2e).

The analysis of the 2021 footprint is more complete than in previous iterations of the analysis, with additional inputs included in the modelling of the cartonboard production (in particular, inclusion of the impact of binders) and in the modelling of the carton conversion process (in particular, inclusion of the impact of adhesives for lamination, inclusion of the impact of varnish, and inclusion of the impact of gravure printing ink). Together, these additional items account for nearly 12% of the fossil GHG emissions.

A detailed analysis of the carbon footprint reveals that:

- **The fossil GHG emissions across the entire life cycle are 852kgCO_2e per tonne of cartons**
  - The unit processes that together constitute the production of cartonboard accounts for 86% of the total fossil GHG footprint. Of these unit processes, the most important contributing item is emissions arising from the combustion of fossil fuels at the pulp and paper mills. Also important are emissions arising from purchased grid electricity at the mills, emissions arising from the production of non-fibre inputs at the mills (process chemicals and functional additives), emissions associated with the production of purchased fuels and emissions associated with production of purchased pulp. Emissions associated with the transport of raw materials (wood, paper for recycling, and non-fibre inputs) to the mill also contribute.
  - The unit process which together constitute the converting of cartonboard into cartons account for 18% of the total fossil GHG footprint. Of these unit processes, the most important contributing item is the emissions associated with the production of purchased electricity consumed at the converting process. Emissions associated with the production of other constituents of the cartons (inks, varnish, glues, etc) are also important, along with emissions arising from fuels consumed onsite for the print drying process and for space heating.
  - Emissions associated with the delivery of cartonboard from the mill to the converter account for 5% of the total fossil GHG footprint.
  - Due to the credit received for avoided emissions arising from the energy recovery process, there is a net credit for the end-of-life processes (accounting for -9% of the total fossil GHG footprint).
- **The biogenic emissions across the life cycle are 1,014kgCO_2e per tonne of cartons**
  - Biogenic emissions arising from the combustion of biofuels at the pulp and paper mills account for the majority of the biogenic emissions (79%). This is predominantly from the combustion of internally generated biofuels such as black liquor, plus some small emissions from purchased biofuels.
  - Emissions from end-of-life processes account for just 18% of the Biogenic emissions. However, it should be remembered that carton packaging achieves a high recycling rate. No end-of life emissions occur within the boundaries of the analysis for the proportion of cartons that are recycled (although emissions will occur in the life cycles of subsequent products that are manufactured from the recovered fibres – the implications of this are investigated in the uncertainty analysis).
- **The emissions due to land-use (dLUC) are just 9kgCO_2e per tonne of cartons**
  - The dLUC emissions mostly arise from the production of non-fibre inputs rather than inputs of fibres from the forest, reflecting the fact that the fibres used in cartonboard production are sourced from sustainably managed forests. Forests in Europe are growing, deforestation (and emissions of greenhouse gases associated with deforestation) is not an issue that is relevant to the carton supply chain in Europe, as more trees are planted than harvested through sustainable forest management.
  - The dLUC emissions in the life cycle for cartons are primarily associated with the production of inks used in the converting process, as the extraction of specific minerals required for e.g. ink formulations may lead to localised land-use changes that result in a net release of emissions to the environment.
- **The GHG removals across the life cycle are -1,626kgCO_2e per tonne of cartons**
  - 96% of these removals relate to the CO_2 flows from the atmosphere into the forests during the growth phase of the wood that provides fibres and internal bioenergy at the pulp and paper mills.
  - The remaining removals relate to CO_2 flows from the atmosphere into biomass used for purchased biofuels and/or non-fibre natural and renewable raw materials (e.g. starches).
- **These emissions and removals can be summed to give us a total GHG footprint across the entire life cycle of 249kgCO_2e per tonne of cartons.**
- In addition, the carbon content of the product when first placed on the market is 1,609kgCO_2e per tonne of cartons. In line with the CITPA methodology, this value is provided as additional information only, and should not be subtracted from the total carbon footprint.

The improvements in fossil GHG emissions of 17% compared to the 2018 figures are significant. The main drivers for these reductions have been improved resource efficiency during the converting process and investments in energy efficiency and renewable energy sources at the cartonboard mills and converting operations. Further investments in resource and energy efficiency and renewable energy sources should see continued reductions in the coming years.

Horst Bittermann
Director General

Winfried Muehling
Director Marketing & Communications

Carbon footprint summary

Studied product name and description: this carbon footprint statement relates to average European cartons (cut, creased and printed), produced from average European cartonboard. An average mix of recycled (white lined chip (WLC)) and virgin (folding box board (FBB)) and solid bleached board/solid unbleached board (SBB/SUB)).

Unit of analysis and reference flow: 1 tonne of converted cartons

Type of inventory: "Cradle-to-grave"

Information gathered from: 1st January 2021 **to:** 31st December 2021

Date of issue: February 2023

GHG's included in the inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs) are all accounted for, expressed in CO_2 equivalents (CO_2e).

Approach: The methodology applied is based on the sector specific guidance prepared by CITPA (the International Confederation of Paper and Board Convertors in Europe): *"Guidelines for calculating Carbon footprints for paper-based packaging 2022",* which are in turn based on CEPI's *"Framework for Carbon Footprints for Paper and Board Products, April 2017".* In 2022, the CEPI and CITPA frameworks were subject to an independent peer review by ifeu – Institute for Energy and Environmental Research Heidelberg GmbH, Heidelberg, Germany. This review found the methods to be compatible with the requirements of the "Product Life Cycle Accounting and Reporting Standard" of the Greenhouse Gas Protocol by the World Resources Institute (WRI) (known as the "Product Standard").

Inventory version: 2023 footprint calculation, version 1

Previous inventories: The previous version of the carbon footprint covering data from the calendar year 2018 was published by Pro Carton in 2019 and is available on request. Calculations prior to this were based on the previous version of the CITPA methodology, and only covered fossil GHG emissions and cradle-to-gate boundaries.

Biogenic carbon emissions and removals: It might be expected that the overall biogenic flows of CO_2 equivalents across the life cycle (including those flows leaving the system as carbon contained in the recovered fibres) would add up to close to zero (i.e. that the biogenic carbon entering the system is completely balanced with the biogenic carbon leaving the system). The fact that there is not be an exact balance reflects some of the difficulties in quantifying biogenic GHG emissions and removals. The imbalance reflects two aspects of the calculations:

1) As cartons achieve a high recycling rate, this means that a proportion of the original carbon removals (which are contained in the product when it is first placed on the market) are carried through to the life cycle of subsequent products outside the boundaries of this analysis. In line with the CITPA methodology, a cut-off method is applied for the share of the material that is sent for recycling. This means that the impacts associated with reprocessing the cartons sent for recycling and any credits associated with avoided production of virgin materials are allocated to the products which incorporate the recycled content, rather than to the carton system. It also means that the emissions from the final waste management of the products produced from recycled cartons are outside of the boundaries of this analysis.

2) There may be differences in the assumptions in the background data regarding the carbon content (and therefore the biogenic GHG removals) of wood and wood chips compared to the carbon content of biofuels used at the mill and the carbon content of paper in the energy recovery processes (and therefore the biogenic emissions arising from these processes).

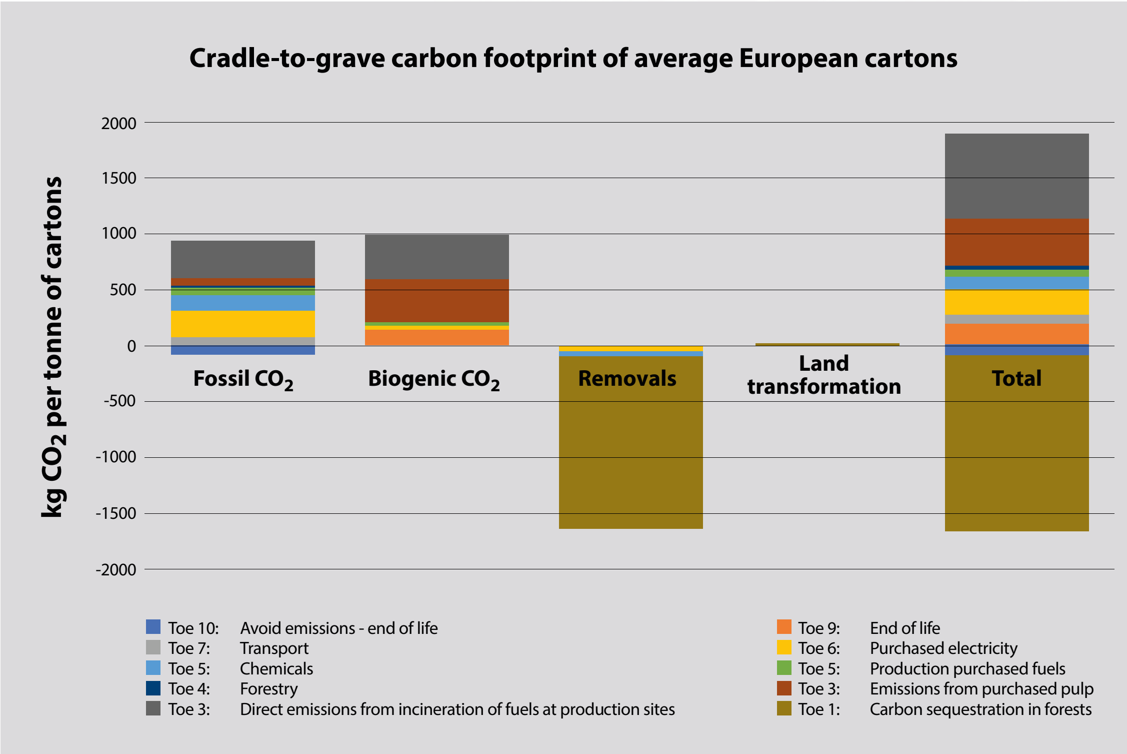
   Therefore, the results calculated and presented relating to biogenic GHG emissions and removals should be considered not as an accurate mapping of the flows but as informative of where in the life cycle biogenic removals and emissions occur and the likely scale of these compared to fossil GHG emissions and removals."

Results:

The table below summarises the cradle-to-gate and cradle-to-grave emissions and removals, according to the category of emissions/removals i.e., according to fossil GHG emissions, biogenic GHG emissions, GHG removals and emissions due to direct land-use. The table below also shows that total, which is the sum of all categories of emissions and removals. The chart overleaf provides the breakdown of each category of emissions and removals according to the CEPI 10 toes classification.

Boundaries considered	Fossil emissions kgCO_2e/ tonne of cartons	Biogenic emissions kgCO_2e/ tonne of cartons	Removals kgCO_2e/ tonne of cartons	Direct land-use kgCO_2e/ tonne of cartons	Total **kgCO_2e/ tonne of cartons**
Cradle-to-gate total	929	828	-1,619	9	148
Cradle-to-grave total	852	1,014	-1,626	9	249

Carbon footprint summary



This chart provides the breakdown of each category of emissions and removals according to the CEPI 10 toes classification.

Additional information:

Paper and board products are based on a renewable raw material, using the capacity of forests to bind CO_2 from the atmosphere as the starting point. According to the European GHG inventory, forests of the EU-28 are a net carbon sink, with net CO_2 removals by forests having increased by over 19% between 1990 and 2014. Subsequently, paper and board products store carbon. Recycling of paper and board products keeps this CO_2 from returning to the atmosphere. Landfill of paper and board product should be avoided whenever possible. The preferred end of life treatment is material recovery and if it is not an option, then energy recovery is the second preference.

Carbon contained in the product when first placed on the market: 1,609 $kgCO_2e$/tonne of cartons.

Contact:

For further information or questions regarding this carbon footprint statement, please contact **Winfried Muehling, Pro Carton (muehling@procarton.com)**

RI.
SE

PRO CARTON
PACKAGING FOR
A BETTER WORLD

Supporting information

Boundary setting

Figure 1. summarises the boundaries of a carbon footprint of paper and board products according to the CEPI framework applied.

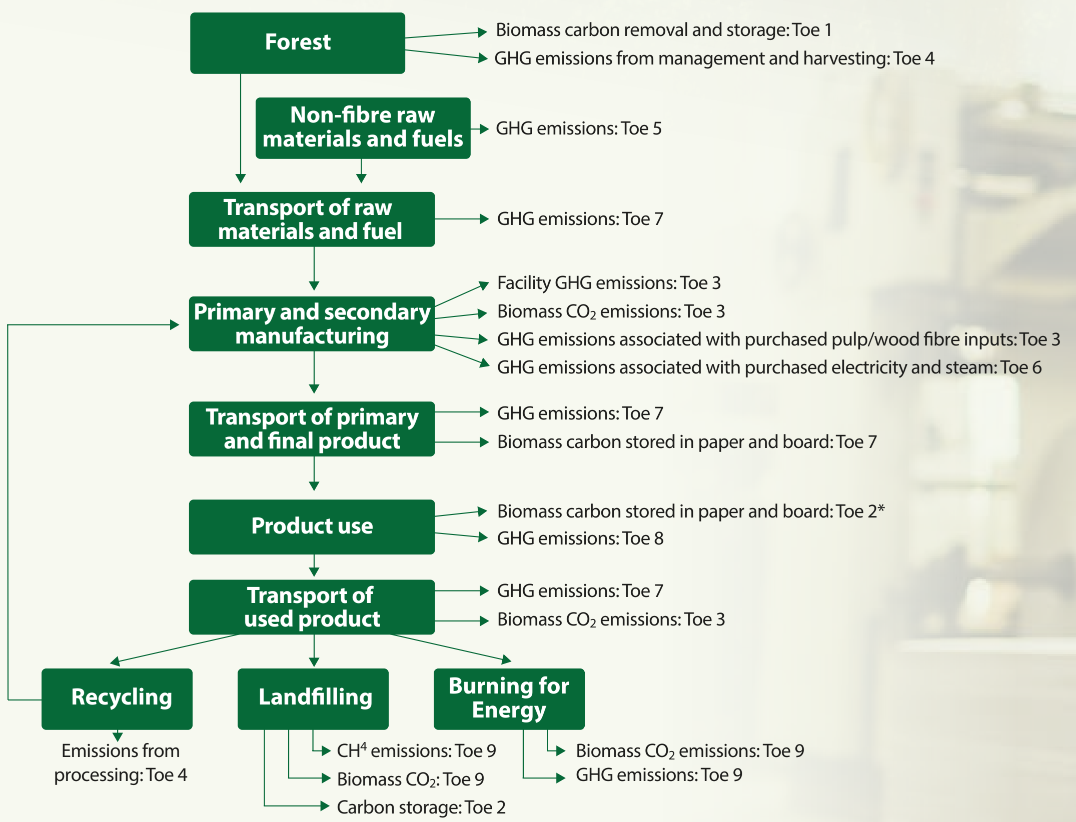


Fig .1 Elements of a carbon footprint from the CEPI framework[1]

[1] CEPI (2017) Framework for the development of Carbon Footprints For Paper and Board Products, www.cepi.org

All relevant processes are included, with the exception of the transport of the cartons between the convertor and the filler, and transport and management of process wastes arising at the paper mill and the converting plant that are sent for treatment off-site. These are excluded due to the fact that data for external process waste treatment are not always available and, as the vast majority of the process wastes from board production are recovered and recycled for other industrial or agricultural processes, these processes need to be considered together with which emissions would be avoided by the treatment. In many cases, it may be more appropriate to consider the residue streams as by-products of the board manufacturing process. Including treatment of process waste will be reconsidered when more reliable information becomes available in future.

For calculating land-use change impacts, emission factors are taken directly from the secondary databases applied.

Allocation

Data presented relates to the production of 1 tonne of net saleable product (i.e. 1 tonne of converted (cut, creased and printed) cartons. When a cartonboard mill also produces and sells energy from combined heat power (CHP), only fuels and subsequent emissions to air allocated to paper production are included in the carbon footprint. No allocation is made for emissions relating to sold by-products (as opposed to co-products). Sold by-products can include for example tall oil, bark, turpentine, etc.

As average European cartons are manufactured from a combination of virgin and recycled grades of cartonboard, the footprint is calculated considering the ratio of activities belonging to virgin and recycled cartonboard production. No further allocation of activities belonging to virgin fibre production and recycled fibre production is made, nor are any credits taken into account for use of recycled fibre.

Avoided emissions from end-of-life treatment are included – for example, incineration with energy recovery avoids emissions associated with grid electricity production and heat production from primary fuel sources. However, for material recycling at end-of-life the cut-off method has been applied (i.e., only the emissions associated with collecting the waste material are allocated to the system. Any impacts (or credits) from the recycling process are not allocated to the system.)

Data collection and quality

Primary data has been collected for the gate-to-gate inputs and outputs to the cartonboard production processes. Data was collected from mills representing:

- 53% of European production of White Lined Chip (WLC) – cartonboard manufactured primarily from recovered fibres:
- 93% of European production of Folding Box Board (FBB) and 62% of European production of Solid Bleached Board/Solid Unbleached Board (SBB/SUB) – cartonboard grades manufactured primarily from primary fibres:

Primary data was also collected from converting sites representing 8% of European production of cartons.

This primary data has been processed and checked by life cycle assessment practitioners and technical experts from the mills and converting plants, and it is subsequently deemed to be of high quality as it is within the companies' control and it represents a significant share of the production capacity for cartonboard. Primary data has also been gathered for distances and modes of transport for the delivery of pulp wood and chippings used for virgin fibre production, for the delivery of paper for recycling for recycled fibre production, the delivery of purchased pulp, the delivery of non-fibre inputs to the papermills, and the delivery of cartonboard from the mills to the converting sites. For purchased pulp, primary data has also been collected wherever possible. Primary data covers 56% of the purchased pulp, with the remainder being covered by secondary datasets. For purchased electricity, where possible information has been collected from the cartonboard mills and the converting plants regarding their specific electricity products and appropriate emission factors have been applied. Where information relating to specific electricity products was not available, emission factors for national grid electricity mixes have been applied.

RI.SE

PRO CARTON
PACKAGING FOR A BETTER WORLD

Supporting information

Inventory

The carbon emission factors for background processes have been selected, in order of preference, from the ELCD , Ecoinvent , Gabi and KCL databases. Where national grid electricity mixes have been considered, emission factors for purchased electricity are sourced from Ecoinvent.

Uncertainty

The carbon footprint results presented here are deemed to be representative of the likely GHG emissions associated with the production of the studied product. The allocation methods chosen mean that the models are as close to reality as possible. Efforts have been made to minimise uncertainties.

However, some key sources of uncertainty in this analysis should be recognised:

- The carbon emission factors applied for background processes. Primary data has been used to determine the emission factors applied where possible for purchased electricity and for 56% of the purchased pulp. For other background processes (emissions from the production of fuels, chemicals, inks and other inputs, emissions from modes of transport, emissions from end-of-life processes, etc), as is common in life cycle studies and carbon footprint calculations, average carbon emission factors have been applied. The analysis could be improved by obtaining emission factors for specific suppliers of chemicals, fuels, etc. However, as the manufacturing of cartonboard is energy intensive, and the emissions from the pulp and papermill are based on primary data, the uncertainty associated with emission factors applied for background processes is not anticipated to be overly influential for the results achieved and conclusions drawn.
- The end-of-life profile considered – the end-of-life profile for paper and board products varies considerably by end-use application and from country-to-country. It is impossible to know the exact end-of-life profile on a product-by-product basis. Therefore, the end-of-life profile considered in this analysis is based on consideration of the average recycling rate for fibre-based packaging, with the remaining material assumed to be sent for incineration with energy recovery. Efficient collection and recycling systems for cartons are in place in Europe. Industry wide efforts to further increase recycling rates to 90% by 2030 are in place. Changing the proportions of material sent to landfill, incineration and material recycling could significantly influence the end-of-life emissions (Toe 9) and avoided emissions (Toe 10) calculated.
- Methodological choices – in particular, the application of the cut-off method to the proportion of cartons that are recycled has a significant influence on the results achieved. It means that the carbon that has been removed from the atmosphere (recorded in Toe 1) and is subsequently contained within the product when it is placed on the market is carried over from the original product system to subsequent product systems. The release of this carbon at the end-of-life of the subsequent product systems is outside of the scope of the current analysis. It could therefore be argued that the carbon emissions from the end-of-life of the secondary products should be allocated at least in part to the first product placed on the market. In this case, the biogenic emissions associated with average European cartons would be considerably increased.

  The influence of end-of-life modelling choices is illustrated in the table below, which contrasts the results considering the baseline scenario investigated with the results considering 100% incineration with energy recovery and 100% landfilling of the cartons at end-of-life. In both the sensitivity scenarios, effectively all carbon contained within the product is released back into the atmosphere within the system boundaries, rather than being carried over into subsequent product systems.

Scenario	Fossil emissions kgCO_2e/ tonne of cartons	Biogenic emissions kgCO_2e/ tonne of cartons	Removals kgCO_2e/ tonne of cartons	Direct land-use kgCO_2e/ tonne of cartons	Total **kgCO_2e/ tonne of cartons**
Baseline scenario - Cradle-to-grave total	852	1,014	-1,626	9	249
Sensitivity scenario 1 – 100% of end-of-life cartons to incineration with energy recovery	499	1,860	-1,658	9	710
Sensitivity scenario 2 – 100% of end-of-life cartons to landfill	939	1,809	-1,620	9	1,136

The table shows that the results achieved, and the conclusions drawn, are particularly sensitive to these end-of-life considerations and approaches.

The results of the sensitivity scenarios also demonstrate that cartons store carbon. The recycling of paper and board products delays this carbon from returning to the atmosphere and forming carbon dioxide. Subsequently, the recycling of cartons at end-of-life should be encouraged and pursued. When recycling is not possible or the fibres can no longer be recovered, incineration with energy recovery is always a preferable option compared to landfilling of paper and board products.

[2] European Commission's "European Reference Life Cycle Data System" v. 3.2, http://lca.jrc.ec.europa.eu
[3] The ecoinvent database v.3.3 from the ecoinvent Centre, also known as the Swiss Centre for Life Cycle Inventories, is a joint initiative of institutes and departments of the Swiss Federal Institutes of Technology Zürich (ETH Zurich) and Lausanne (EPFL), of the Paul Scherrer Institute (PSI), of the Swiss Federal Laboratories for Materials Testing and Research (Empa), and of the Swiss Federal Research Station Agroscope Reckenholz-Tänikon (ART), http://www.ecoinvent.org/.
[4] GaBi database from PE INTERNATIONAL, http://www.ikpgabi.uni-stuttgart.de/english/index_e.html
[5] KCL EcoData, calculated for CITPA, http://www.kcl.fi

Assurance statement

Nature of the assurance

This product GHG inventory has been subject to third party reasonable assurance. The assurance was performed by Frank Wellenreuther ifeu (Institut für Energie- und Umweltforschung)

Frank Wellenreuther is an LCA expert with more than 15 years of experience in the field of packaging and paper life cycle assessments. He has compiled similar inventory datasets and carbon footprints for paper based products than the one reviewed. Ifeu is an independent and non-profit scientific research and consultancy institute. Neither ifeu nor Frank Wellenreuther personally have an affiliation to RISE, Pro Carton or any single members of this association.

Assurance procedures

The third party reasonable assurance has been commissioned on the 13th of January 2023. A draft report has been made available the same day. On a meeting between the report's author and the assurance provider on the 17th of January 2023 the report was presented and discussed. The final slightly amended report has been sent to the reviewer on the 22nd of February 2023.

The applied CITPA methodology as well as the underlying cartonboard production dataset have been separately critically reviewed by Frank Wellenreuther of ifeu, as well. Thus, the inventory data and applied methodology have been checked for plausibility and appropriateness to a very detailed degree. The calculations were followed through to check they were correct, and the additional sensitivity scenarios are much appreciated.

Assurance opinion

Based on the procedures performed, in the assurance provider's opinion, the product GHG inventory is reasonably stated.

Carbon footprint statement prepared by RISE (Research Institutes of Sweden) Bioeconomy and Health Unit on behalf of Pro Carton

The Carbon Footprint of Carton Packaging 2023

Published in March 2023 by **Pro Carton**
info@procarton.com

For further information, please see
www.procarton.com