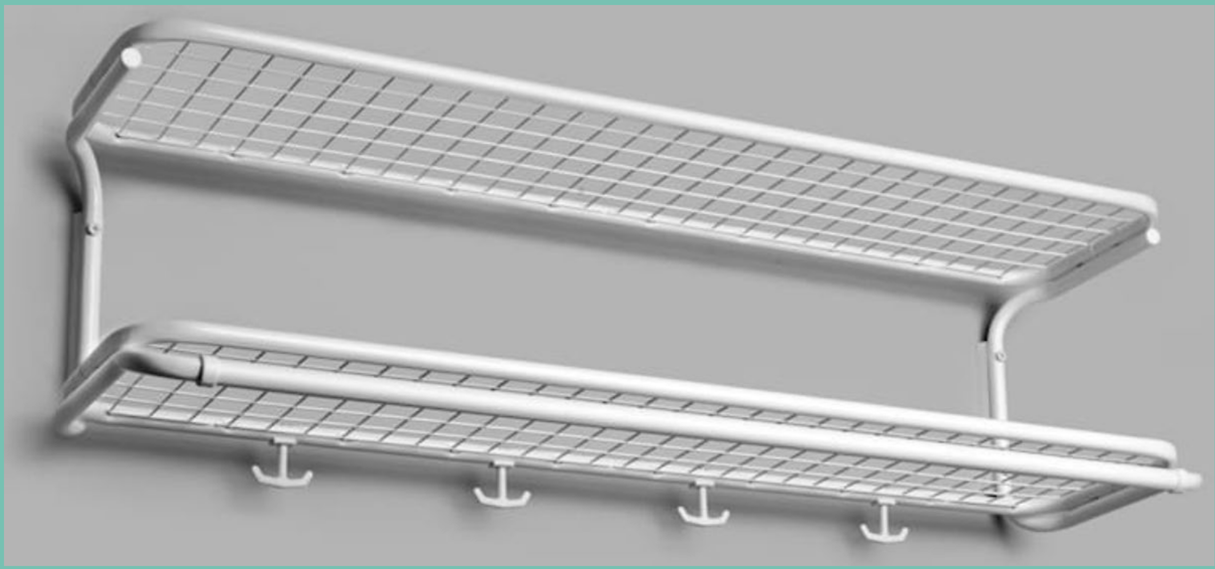

Reused Classic rack

Appendix to report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi

by Essem

Title: Reused Classic shelf – Appendix to report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi by Essem
Date: 25/09/2023
Ordered by: Essem
Report number: 1651
Name and location of database: SimaPro@192.168.15.21\Default\(MiljogiraffUpdate100; 1651 LCA Återbrukad Classic hylla Essem)
LCA practitioner: Sofia Lindroth, Miljögiraff AB

Miljögiraff

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Ordered by: Essem
Essem Design aims to develop, manufacture and market sustainable, functional and well-designed hallway furnishings for private and public spaces in a global marketplace.

Issued by: Miljögiraff AB
Miljögiraff is an environmental consultant specialising in product Life Cycle Assessment and Life Cycle Design. We believe that combining analysis and creativity is necessary to meet today's challenges. Therefore, we provide Life Cycle Assessment to evaluate environmental aspects and design methods to develop sustainable solutions.

We create measurability in environmental work based on a life cycle perspective on ecological aspects. The LCA methodology establishes the basis for modelling complex systems of aspects with a credible assessment of potential environmental effects.

Miljögiraff is part of a global network of experts in sustainability metrics piloted by PRé Sustainability.

Abbreviations and expressions

Clarification of expressions and abbreviations used in the report

CO_2 eq – Carbon dioxide equivalents
EPD – Environmental Product Declaration
GWP – Global Warming Potential
ISO – International Organization for Standardisation
IPCC – Intergovernmental Panel on Climate Change
LCA – Life Cycle Assessment
LCI – Life Cycle Inventory Analysis
LCIA – Life Cycle Impact Assessment
PCR - Product Category Rules
RER – The European region
RoW – Rest of the world
GLO – Global
APOS – Allocation at the point of substitution (system model in ecoinvent)
Cut-off in ecoinvent – Allocation cut off by classification (system model in ecoinvent)
Cut-off in general – Environmental impact that contributes insignificantly to the overall results.

Environmental aspect - An activity that might contribute to an environmental effect, for example, "electricity usage".

Environmental effect - An outcome that might influence the environment negatively (Environmental impact), for example, "Acidification", "Eutrophication", or "Climate change".

Environmental impact - The damage to a safeguarding object (i.e., human health, ecosystems, health, and natural resources).

Life Cycle Inventory (LCI) data – Inventory of input and output flows for a product system

Abstract

Life Cycle Assessment (LCA) is a standardized method for quantifying the potential environmental impact of a product or service throughout its entire lifecycle. This report presents a complementary appendix to r*eport 1282 Life Cycle Assessment of Classic, Mama & Nostalgi (Lindroth & Coleho, 2023)* by evaluating the environmental impact of producing a Reused Classic shelf. As all methodological details and documentation in accordance with ISO 14040/44 are available in the original report, this study should be used in conjunction with it.

The Reused Classic shelf is made from 91% reused components by weight, reusing the steel tube rack, grid net, and steel tube brackets. The environmental impact assessment covers the entire lifecycle, with key processes including collection, disassembly, surface treatment, and reassembly.

The findings illustrate the effectiveness of **component reuse, product design for disassembly, and local supplier networks** in minimizing environmental impact. By leveraging these strategies, the reused *Classic* shelf achieves a total lifecycle climate impact of **3.45 kg CO_2-eq**, highlighting the potential for sustainable product development through remanufacturing and reuse. This indicates that the Reused Classic shelf achieves a **71% reduction in climate impact** compared to the conventional Classic shelf.

The cradle-to-grave climate impact of the reused Classic shelf is 2.9 kg CO_2-eq, with the majority (84%) originating from virgin material production, surface treatment of reused components, and product packaging. Sensitivity analyses highlight the influence of surface treatment processes on climate impact results were it is important to obtain more specific data onwards. Additionally, the impact of transportation distances for surface treatment was assessed, showing that increasing transport from 8-24 km to 500 km results in a 60% increase in climate impact, emphasizing the importance of local suppliers. Despite this, the reused shelf still maintains a significantly lower environmental footprint than the conventional alternative.

Essem manufactures products that can last for decades, which is why a circular economy (e.g. reuse, repair, remanufacturing, recycling) of the products has a potential to lower the environmental impact of the products lifecycles. The Reused Classic demonstrates this effectively. The overall result shows that a Reused Classic rack from Essem can be produced to a significantly lower environmental impact than more conventional products. Thanks to a product design that enables disassembly and remanufacturing, and having local suppliers the total lifecycle climate impact result for the Reused Classic becomes 3,45 kg CO2 eq.

1 Background

Life cycle assessment (LCA) is a standardised method to quantify the potential environmental impact of a product or service from a holistic perspective. With its holistic perspective, LCA avoids the so-called burden-shifting from one part of the lifecycle to another or across impact categories. LCA results provide an understanding of a product’s life cycle burdens and hotspots and allow for identifying opportunities to mitigate adverse effects.

This report presents a complimentary scenario to the study report **1282 Life Cycle Assessment of Classic, Mama & Nostalgi** (Lindroth & Coleho, 2023) and should be used together with this report as all documentation in regard to ISO 14040/44 standard exist in that report**.** The scenario presented here is the environmental impact of the production of a reused Classic shelf.

1.1 Reused Classic rack

Below in the figure is a picture of the Classic rack. The difference between the Reused Classic and the Classic rack assessed in report - 1282 Life Cycle Assessment of Classic, Mama & Nostalgi – is that brackets and shelfs are made from reused components while rest of the parts for the racket is made in the same way.

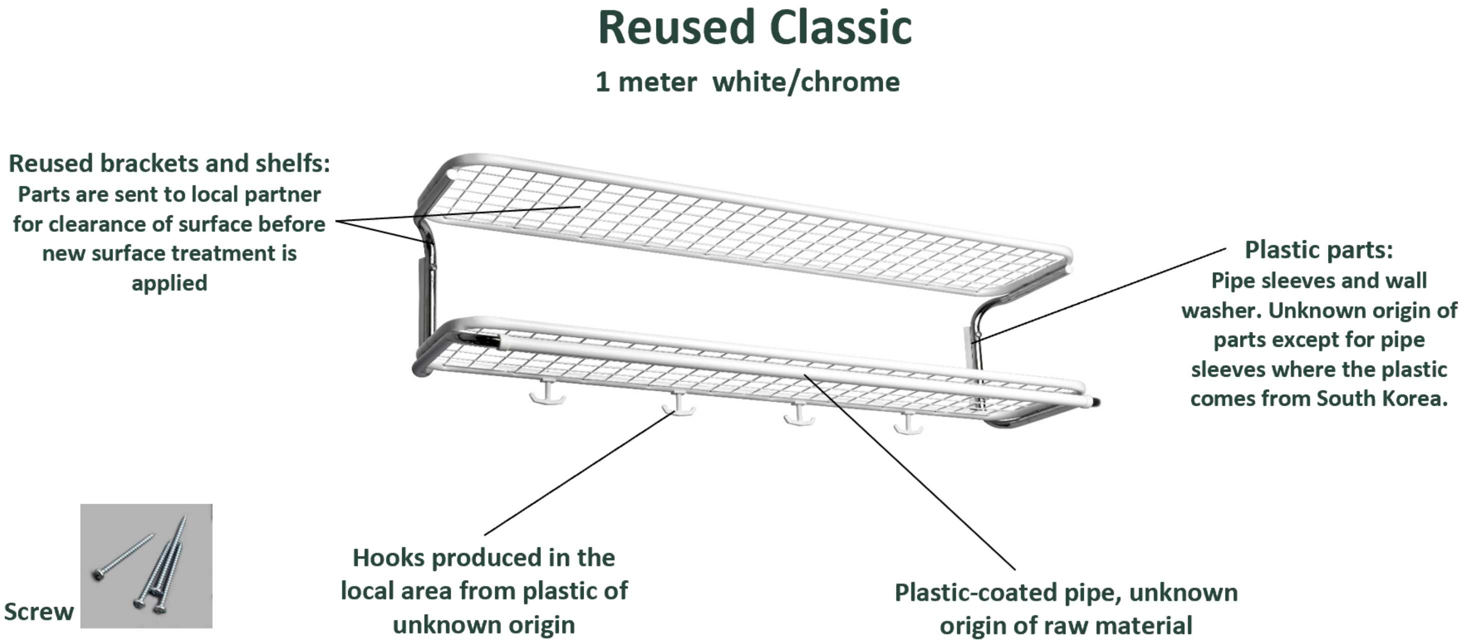


Figure 1 Picture of the product and description of components and their origin

1.2 Updates regarding goal and scope

Updates regarding goal and scope from study 1282 Life Cycle Assessment of Classic, Mama & Nostalgi (Lindroth & Coleho, 2023) are:

- **Newer version of SimaPro:** The life cycle impact assessment (LCIA) was calculated using the LCA software SimaPro 10 instead of SimaPro 9.4 (PRé Sustainability, 2024) developed by PRé Consultants.
- **Newer version of background data from ecoinvent:** For data referring to processes beyond the control of the core production, the ecoinvent database 3.10 instead of ecoinvent 3.9 is used. Ecoinvent is one of the world's leading databases with consistent, open, and updated Life Cycle Inventory Data (LCI) (Ecoinvent, 2024).
- **Updated impact methods** (EPD International, 2024).
- **System boundaries regarding reuse & allocation of reuse:** Processes linked to reuse of the Classic shelf is added, which regards additional transport for collection, dismantling processes and additional surface-treatments. See how the system boundary differs for a reused Classic shelf in Figure 1 below. As the figure shows, the reused components are allocated the environmental burden from collection and remanufacturing.
- Excluded processes in regard to reused rack and cut-off principles: Any packaging of reused racks to Essem (can vary and is unknown how this is currently managed)

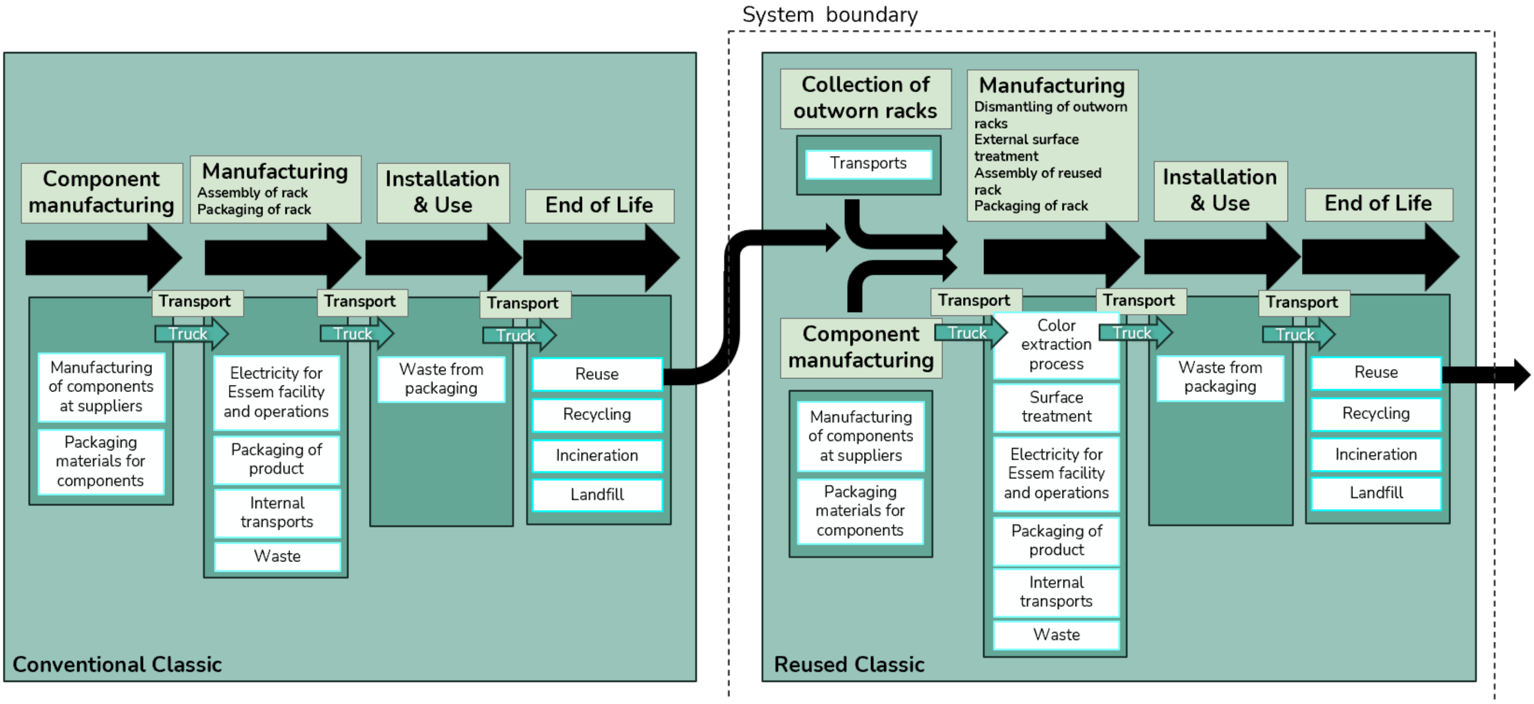


Figure 2 System boundary and included processes for reused Classic shelf

2 Life Cycle Inventory (LCI)

The inventory chapter for the reused Classic racket describes the lifecycle steps that differ from the more conventional Classic racket. These steps are raw material/component manufacturing (modules A1 + A2) and core manufacturing (module A3). All other lifecycle steps are similar to the conventional Classic rack and its documentation can be found in report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi (Lindroth & Coleho, 2023).

2.1 Product content declaration for reused Classic rack

Below in the table is the product content for the Reused Classic. As can be seen, the difference between the more conventional Classic rack and the reused Classic rack is that the components steel tube rack, grid net, and steel tube brackets are reused. By this, 91% of the product by weight is reused.

Table 1: Content declaration 1 meter Reused Classic

Product components	**Weight (kg)**	**% of total weight**	**Reused component (Yes/No)**	**Post-consumer recycled content in original component (%)**
Steel tube rack	1,672	48%	**Yes**	
Grid net	0,788	23%	**Yes**	**80%**
Steel tube bracket	0,666	19%	**Yes**	
Plastic coated steel tube	0,257	7%	No	
Plastic tube sleeve	0,002	0%	No	
Plastic anchor hook	0,016	0%	No	
Plastic wall bracket	0,028	1%	No	
Plastic end plug	0,002	0%	No	
Chrome coating	0,004	0%	No	
Screw	0,016	0%	No	
Total	**3,451**	**100%**	**3 components and 91% of product weight is reused**	**18%**
Packaging components	**Weight (kg)**	**Post-consumer recycled content (%)**	**Biogenic content (%)**	**Biogenic content (kg C)**
Cardboard	0,456	91%	100%	0,21
Total	**0,456**	**91%**	**100%**	**0,21**

Equation 1 Biogenic carbon content according to EN 16449

$$\text{Biogenic carbon content} = \text{Biogenic carbon fraction} \bullet \frac{\text{Wet density of the biomass} \bullet \text{Wet volume of the biomass}}{1 + \frac{Moisture\ percentage}{100}}$$

Standard Values:
Moisture: 10% for cardboard
Biogenic Carbon fraction: 50% for cardboard

2.2 Description of production process and main assumptions

Below is a description of the manufacturing process of the reused rack and the main assumptions that have been made regarding this process:

- **Transport for collection** (assumed to be the same as delivery to the customer, module A4 in previous LCA).
- **Disassembly** (same process as assembly assumed, e.g. same electricity consumption).
- **Plastic components are currently sent for incineration** (their waste treatment are allocated to the previous life cycle)
- **Brackets and shelves (two of each) are sent for paint removal.** This is done at Färgavbränning in Anderstorp, where an oven burns off the old coating. They use biogas for the ovens.
- **Brackets and shelves are then sent back to Essem** from Färgavbränning.
- **Brackets and shelves are sent to a supplier for surface treatment**. We assume the worst-case scenario—chrome plating (chrome plating applies only to the brackets, as the shelves are always powder-coated). However, it is more likely that they will be powder-coated.
- **Brackets and shelves are sent back to Essem again.**
- **Newly manufactured components include:** plastic-coated tubes and plastic details (wall brackets, plugs, tubes, and hooks), as well as screws.
- **The shelf is reassembled and packaged for the customer.**

2.3 Input data references

Table 2 shows the supplier contacts that have supplied the sources for data input.

Table 2 Input data references

Supplier	**Färgavbränning**
Contact	Färgavbränning were contacted via Magdalena Holm at Essem, contact magdalena@essem.se

2.4 Raw material (A1 + A2)

This section describes all the different raw materials needed for the manufacturing of the different products. Essem mainly buys finished components from suppliers that are sent to Essem for assembly and packaging. Therefore, module A1 mainly consists of component production and it A2 its transport to Essem. Below is the component composition of the Reused Classic rack. As mentioned, the components steel tube rack, grid net, and steel tube brackets are reused while the rest of the components are the same as in study report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi (Lindroth & Coleho, 2023). This section mainly describes the production processes linked to the reused Classic shelf, for all the components that are the same as in a Conventional Classic racket and for the general manufacturing steps at Essem that also applies to the Reused Classic racket, documentation can be found in report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi.

Table 3 Component composition and their transport to Essem

Component/Material	Quantity in final product (pcs.)	Weight of one component (kg)	Supplier & Origin	Transport type	Transport distance (km)	Comment
Steel tube rack	4	0,418	Reused	Truck 16t, diesel	400	The customers are mainly located in Sweden. Therefore, a general transport distance of 400 km has been assumed for collection of all reused components. Only transport of reused components is considered in the calculation since the component comes “burden-free” as production of the component is allocated to the lifecycle were it was first used.
Grid net	2	0,394	Reused	Truck 16t, diesel	400	
Steel tube bracket	2	0,333	Reused	Truck 16t, diesel	400	
Plastic coated steel tube	1	0,257	Teka AB, Alingsås	Truck 16t, diesel	113	The product consists of 90,99% steel, and the rest is mainly Polypropylen. There is no specific information about the origin of the materials so GLO market datasets has been used. There is no waste in production given from supplier so an assumption of 10% waste of steel wire has been assumed by Miljögiraff.

						The tubes comes packaged as 5 meter long tubes i package of 30psc. For this, 0,10 kg plastic and 3 kg wood is needed.
Plastic tube sleeve	2	0,001	Nylanders El & Plast AB, Anderstorp	Truck 16t, diesel	2	The tube sleeve is made of an LDPE, with the origin from South Korea.
Plastic anchor hook	4	0,004	By Småland AB, Anderstorp	Truck 16t, diesel	4	The anchor hook is made of Nylon 6 with an unknown origin, therefore a RoW dataset has been used for the material.
Plastic wall bracket	2	0,014	Nylanders El & Plast AB, Anderstorp	Truck 16t, diesel	2	The wall bracket is made of PP, no specific information about the origin has been given so a RoW market dataset has been selected.
Plastic end plug	2	0,001	Ackurat Industriplast AB, Lammhult	Truck 16t, diesel	76	The end plug is made of an LDPE, with the origin from Denmark. Packaged as 1000 pcs/plastic bag, 10 plastic bags/box. One plastic bag is 0,222 kg, and one cardboard box is 0,6kg. Cardboard packaging falls under cut-off.
Screw	8	0,002	Mattssons i Anderstorp AB, Anderstorp	Truck 16t, diesel	1	No specific data about the screw production has been given, therefore a GLO market stainless steel- and a GLO market wire drawing process has been to represent the screw production used as a conservative assumption. Packaged in cardboard, 0,241kg Per box 4500 pcs / box. This means that packaging falls under cut-off.
Coating – powder coating	1	0,031	Leba, Hillerstorp	Truck 16t, diesel	23 x 2	Coating occurs at an external company, Leba, a powder coating company in Hillerstorp, 23 km from Essem. The data used in ecoinvent 3.9 is in m2, which is why is has been calculated to kg by information in the dataset about density. There is a EPD for the coating powder, EPD-VDL-20230164-IAG1-DE, but since this EPD does not contain all indicators needed the

						EPD has only been used to check if results for the general dataset has been reasonable which they are.
Coating – chrome coating	1	0,004	Leba, Hillerstorp	Truck 16t, diesel	23 x 2	Coating occurs at an external company, Leba, a powder coating company in Hillerstorp, 23 km from Essem.

The reused parts are retrieved from racks that are sent to Essem and that Essem disassembles. The parts that will be reused are sent to the supplier Färgavbränning which removes any surface treatment that is left on the outworn components. No specific data has been given by the supplier as they do not wish to declare information about their production process, but they answered that they have ovens that burn the existing surface treatment away and which are powered with biogas. Therefore, the dataset "*Energy and auxilliary inputs, metal working machine {RER}| energy and auxilliary inputs, metal working machine, with process heat from natural gas | Cut-off, U"* has been used to represent the process conducted by Färgavbränning. Here, input of electricity has been changed to Swedish residual mix and gas has been changed to biogas. Färgavbränning is located 1,8km from Essem, which is why a transport back-and-forth is added. The transport is represented with the dataset *"Transport, freight, lorry 3.5-7.5 metric ton, EURO6 {RER}| transport, freight, lorry 3.5-7.5 metric ton, EURO6 | Cut-off, U*" in ecoinvent.

2.5 Manufacturing (A3)

After the reused components have been sent back to Essem again, they are assembled together with new components into the finished racket and packaged before sent out to customer. This is done in the same way as for the Conventional Classic rack assessed in report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi (Lindroth & Coleho, 2023). Hence, the energy consumption and waste in production that occurs for all products are the same for the reused Classic rack.

3 Result of Life cycle impact assessment (LCIA)

In this section, the results from the different environmental impact assessment methods will be presented. The LCIA method follows the standard for Construction Products EN 15804:2012+A2:2019/AC:2021 (CEN, 2021). EN 15804:2012+A2:2019/AC:2021 uses the impact categories and characterization factors of the LCIA methods used in Environmental Footprint 3.1 (EF 3.1), with the only difference that biogenic carbon dioxide uptake is calculated as -1 and biogenic carbon dioxide emissions as +1, where EF 3.1 calculates this as 0 and 0, respectively.

In addition to the climate impact indicator required in EN 15804:2012+A2:2019/AC:2021, the PCR for Construction Products requires reporting of climate impact with the GWP-GHG indicator, where the characterization factor for biogenic carbon dioxide is set to zero. This is calculated with the IPCC 2021 GWP 100 method.

The results are presented in the following order:

1. Environmental footprint midpoint using the EF 3.1 method, adapted to EN 15804:2012+A2:2019/AC:2021
2. Environmental footprint endpoint using the EF 3.1 method, adapted to EN 15804:2012+A2:2019/AC:2021
3. Climate impact using the GWP-GHG indicator
4. Use of resources and energy using the CED 1.12 method and inventory results based on the list of aspects required by the PCR

Note that the LCIA results are relative expressions, which means that they do not predict impacts on category endpoints or the exceeding of thresholds, safety margins or risk.

Sankey diagrams are used to display the results as flow diagrams where the thickness of the arrows reflects the relative amount of that flow. All the nodes cannot be displayed simultaneously due to the vast amounts of background data. Therefore, only processes that contribute to a minimum of 3%-4% of total impacts are shown in the diagram.

3.1 Environmental Footprint Midpoint

Table 29 shows the result per functional (or declared) unit according to the LCIA method Environmental footprint 3.1 midpoint level.

Table 4: Environmental footprint midpoint results per functional unit

Impact category	Unit	A1-C4	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
GWP Fossil	kg CO_2 eq	3,31E+00	2,14E+00	1,53E-01	4,45E-01	2,74E+00	2,97E-01	6,37E-02	0,00E+00	6,55E-02	1,43E-01	0,00E+00	-3,69E+00
GWP Biogenic	kg CO_2 eq	6,16E-02	3,77E-02	2,77E-05	-1,42E-01	-1,04E-01	5,37E-05	1,65E-01	0,00E+00	1,19E-05	1,43E-04	0,00E+00	-6,67E-03
GWP LULUC	kg CO_2 eq	7,11E-02	1,71E-02	5,07E-05	5,37E-02	7,09E-02	9,85E-05	9,77E-05	0,00E+00	2,17E-05	6,27E-06	0,00E+00	-2,67E-03
GWP Total	kg CO_2 eq	3,44E+00	2,19E+00	1,53E-01	3,57E-01	2,71E+00	2,97E-01	2,29E-01	0,00E+00	6,55E-02	1,43E-01	0,00E+00	-3,70E+00
ODP	kg CFC11 eq	6,38E-08	3,99E-08	3,04E-09	1,24E-08	5,53E-08	5,90E-09	1,07E-09	0,00E+00	1,30E-09	2,21E-10	0,00E+00	-1,60E-08
AP	mol H+ eq	1,36E-02	1,01E-02	3,18E-04	1,95E-03	1,24E-02	6,18E-04	4,47E-04	0,00E+00	1,36E-04	7,62E-05	0,00E+00	-1,27E-02
EP - Freshwater	kg P eq	9,15E-04	6,16E-04	1,03E-05	2,38E-04	8,64E-04	2,01E-05	1,82E-05	0,00E+00	4,44E-06	7,74E-06	0,00E+00	-1,41E-03
EP - Marine	kg N eq	3,77E-03	2,39E-03	7,64E-05	9,49E-04	3,42E-03	1,48E-04	1,41E-04	0,00E+00	3,28E-05	3,37E-05	0,00E+00	-3,11E-03
EP – Terrestrial	mol N eq	3,62E-02	2,47E-02	8,24E-04	6,93E-03	3,25E-02	1,60E-03	1,43E-03	0,00E+00	3,54E-04	3,38E-04	0,00E+00	-3,27E-02
POCP	kg NMVOC eq	1,21E-02	8,02E-03	5,28E-04	1,76E-03	1,03E-02	1,03E-03	4,15E-04	0,00E+00	2,27E-04	1,05E-04	0,00E+00	-1,12E-02
ADPE	kg Sb eq	2,72E-05	2,24E-05	4,97E-07	1,96E-06	2,49E-05	9,65E-07	1,11E-06	0,00E+00	2,13E-07	3,03E-08	0,00E+00	-1,94E-06
ADPF	MJ	9,73E+01	9,48E+01	1,78E-01	1,53E+00	9,65E+01	3,47E-01	3,41E-01	0,00E+00	7,66E-02	2,40E-02	0,00E+00	-3,32E+01
WDP	m3 depriv.	2,03E+00	1,56E+00	8,92E-03	4,17E-01	1,99E+00	1,73E-02	1,84E-02	0,00E+00	3,83E-03	5,23E-03	0,00E+00	-2,68E-01
PM	disease inc.	2,21E-07	1,57E-07	1,12E-08	1,83E-08	1,87E-07	2,18E-08	5,62E-09	0,00E+00	4,82E-09	1,81E-09	0,00E+00	-2,51E-07
IR	kBq U-235 eq	6,60E+00	6,55E+00	2,78E-03	3,92E-02	6,59E+00	5,41E-03	3,28E-03	0,00E+00	1,20E-03	2,28E-04	0,00E+00	-1,42E-01
ETP – FW	CTUe	3,95E+01	3,07E+01	5,85E-01	4,97E+00	3,63E+01	1,14E+00	1,53E+00	0,00E+00	2,51E-01	3,26E-01	0,00E+00	-3,13E+02
HTP - C	CTUh	8,33E-08	7,64E-08	1,08E-09	1,64E-09	7,91E-08	2,10E-09	1,45E-09	0,00E+00	4,65E-10	1,89E-10	0,00E+00	-1,19E-06
HTP - NC	CTUh	4,24E-08	2,88E-08	1,35E-09	7,01E-09	3,72E-08	2,62E-09	1,62E-09	0,00E+00	5,79E-10	3,76E-10	0,00E+00	-1,25E-08
Land use, SQP	Pt	5,34E+01	3,98E+01	1,30E+00	8,70E+00	4,98E+01	2,52E+00	3,20E-01	0,00E+00	5,57E-01	1,79E-01	0,00E+00	-2,70E+00
GWP-GHG	kg CO2 eq	3,45E+00	2,20E+00	1,53E-01	5,23E-01	2,88E+00	2,97E-01	6,39E-02	0,00E+00	6,55E-02	1,43E-01	0,00E+00	-3,70E+00

Acronyms	GWP: Global Warming Potential, LULUC: Land Use and Land Use Change, ODP: Ozone Depletion Potential, AP: Acidification Potential. EP: Eutrophication Potential, POCP: Photochemical Ozone Creation Potential, ADPE: Abiotic Depletion Potential – Elements, ADPF: Abiotic Depletion Potential – Fossil Fuels, WDP: Water Scarcity Footprint, PM: Particulate Matter, IRP: Ionizing Radiation - Human Health, ETP-FW: Ecotoxicity Potential – Freshwater, HTP-C: Human Toxicity Potential – Cancer, HTP-NC: Human Toxicity Potential – Non-Cancer, SQP: Soil Quality Potential Index, GWP-GHG: Global Warming Potential, Greenhouse Gases
Legend	A1-C4: Sum of impacts inside system boundary, A1: Raw Material, A2: Raw Material Transport, A3: Manufacturing, A1-A3: Sum of A1-A3, A4 Transport to Customer, A5: Installation, C1: Deconstruction, C2: Waste Transport, C3: Waste Processing, C4: Disposal, D: Reuse, Recovery, Recycling Potential

Disclaimer 1: The results of the environmental impact indicators Abiotic depletion for fossil and non-fossil resources, Water depletion potential, Ecotoxicity-freshwater, Human toxicity-cancer, Human toxicity-non-cancer and Land use shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

Disclaimer 2: The indicator GWP-GHG includes all greenhouse gases included in GWP-total but excludes biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. This indicator is thus equal to the GWP indicator originally defined in EN 15804:2012+A1:2013.

Disclaimer 3: The use of the results of modules A1-A3 without considering the results of module C is discouraged.

Disclaimer 4: The indicator Ionising radiation deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

Disclaimer 5: The results of the impact categories abiotic depletion of minerals and metals, land use, human toxicity (cancer), human toxicity, noncancer and ecotoxicity (freshwater) may be highly uncertain in LCAs that include capital goods/infrastructure in generic datasets, in case infrastructure/capital goods contribute greatly to the total results. This is because the LCI data of infrastructure/capital goods used to quantify these indicators in currently available generic datasets sometimes lack temporal, technological and geographical representativeness. Caution should be exercised when using the results of these indicators for decision-making purposes.

3.2 Environmental Footprint Endpoint

The environmental footprint endpoint shows the contribution of each environmental impact category to the total environmental impact. The result tells that the Reused Classic shelf have highest impact in the environmental impact categories climate change and use of fossil resources. This is linked to the energy required for processing throughout the lifecycle, from raw material extraction to core processing. The impact category human toxicity, cancer, is due to the supply chain of the virgin steel used in the newly produced component plastic coated steel tube. The impact category ionising radiation has to do with the electricity use from nuclear.

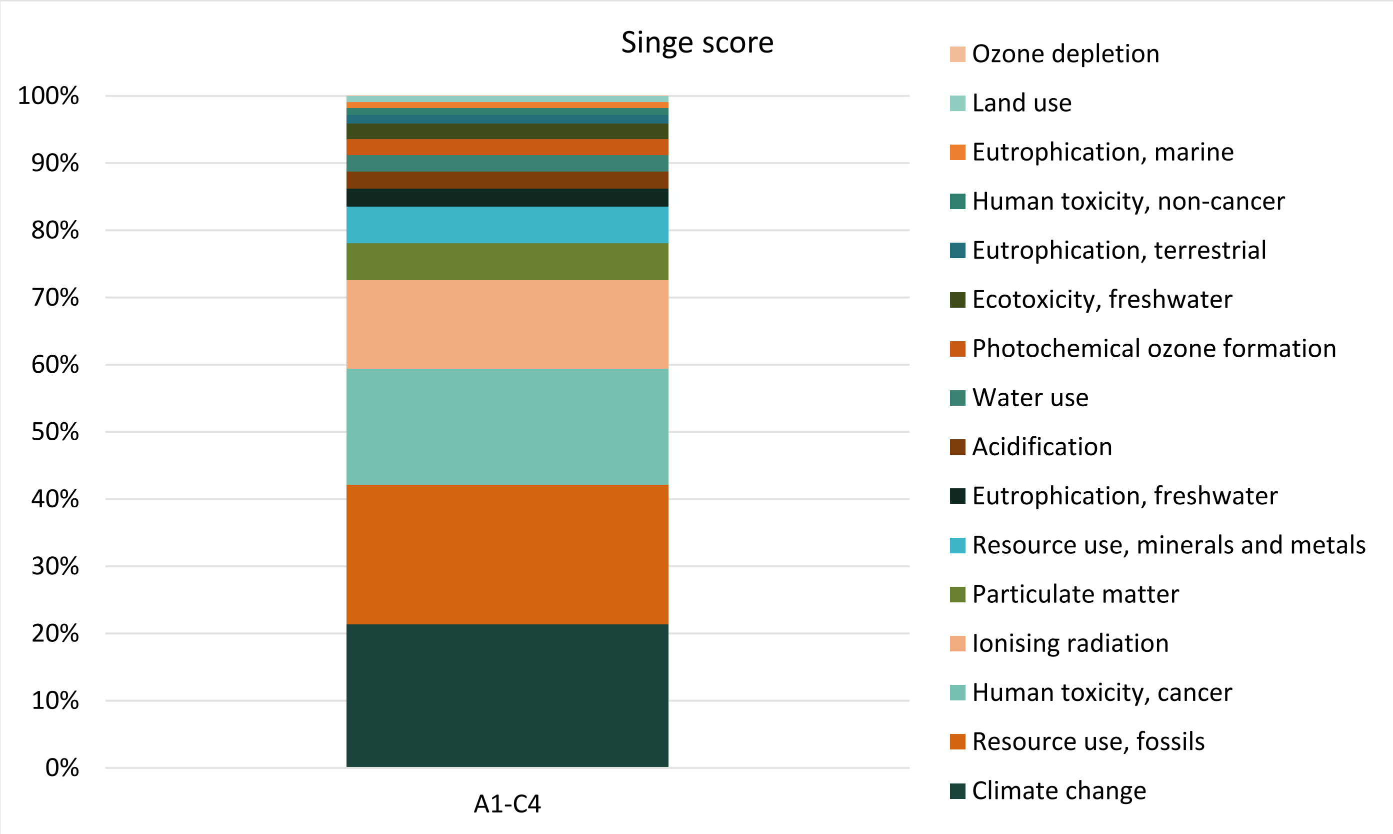


Figure 3: Share of environmental impact per impact category

When all impact categories are weight together, the total environmental impact for the product is divided over the lifecycle as the figure below shows.

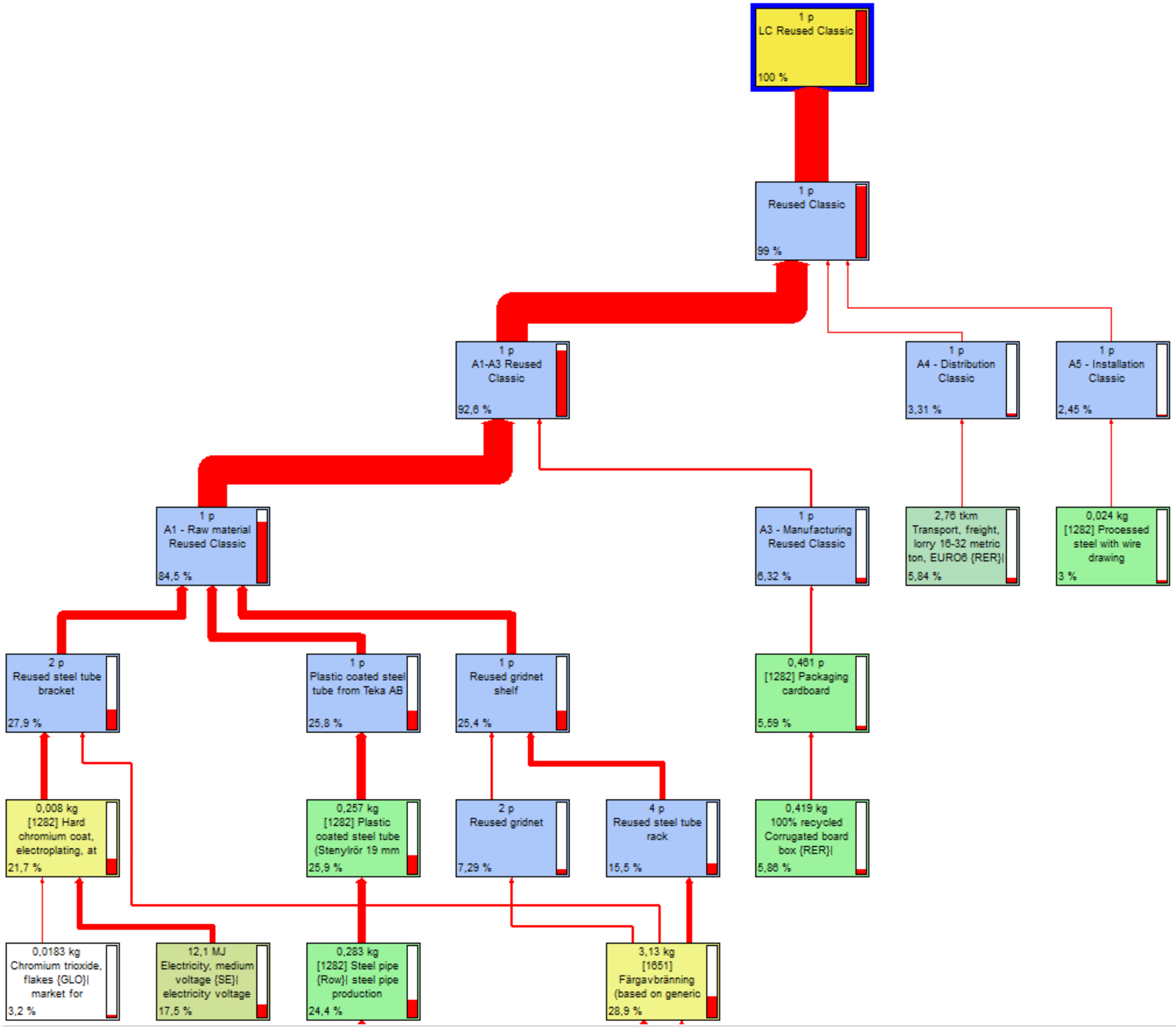
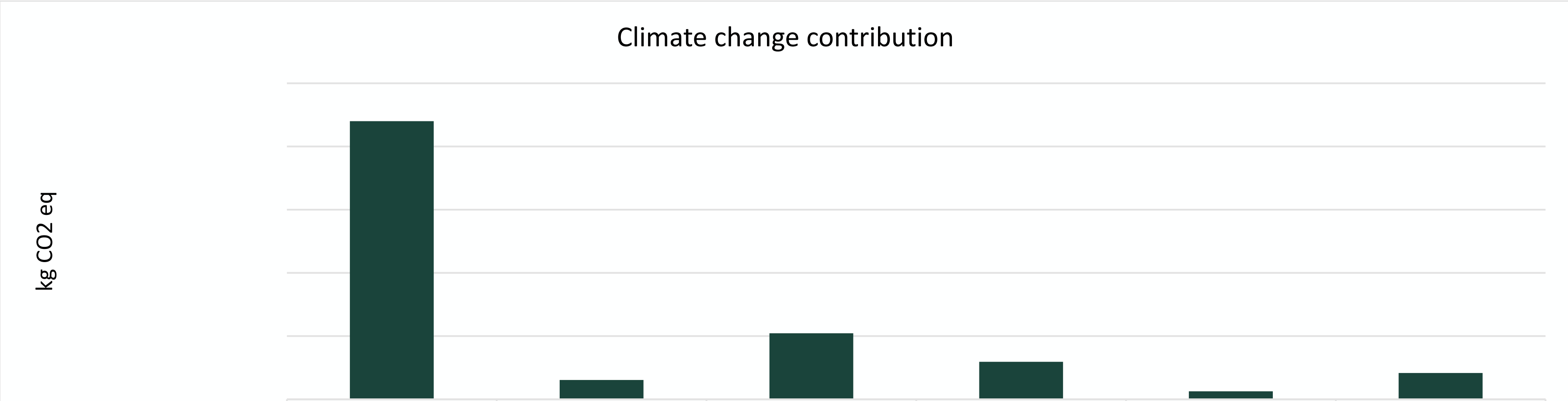


Figure 4: Sankey diagram over share of environmental impact contributions per module and per declared unit (EF3.1 single score, cut off 3%)

3.3 Climate impact (GWP-GHG)

The total climate impact over the life cycle is 3,44 kg CO2 eq and its distribution over the lifecycle is shown in the figures below. The Sankey diagram shows all processes that contribute more than 3% to the total climate impact.



	Raw material and component production	Transport of raw materials	Product assembly and packaging	Product distribution	Installation and use of product	End-of-life
GWP-GHG (EN15804)	2,20	0,15	0,52	0,30	0,06	0,21

Figure 5: Climate impact according to GWP-GHG

As can be seen in Figure 7, the hotspot for the climate impact is the production and remanufacturing of components for the Reused Classic. The component with the highest impact is “plastic coated steel tube” which is based on virgin sources and 7% of total product weight and 25% of total climate impact. The remanufacturing of the reused components that stands for 91% of the product weight, stands for 28% of total climate impact and here it is the different surface treatments of them that contribute to the result. The packaging used to package the product to customer stands for 13% of total lifecycle impact.

Reused Classic rack

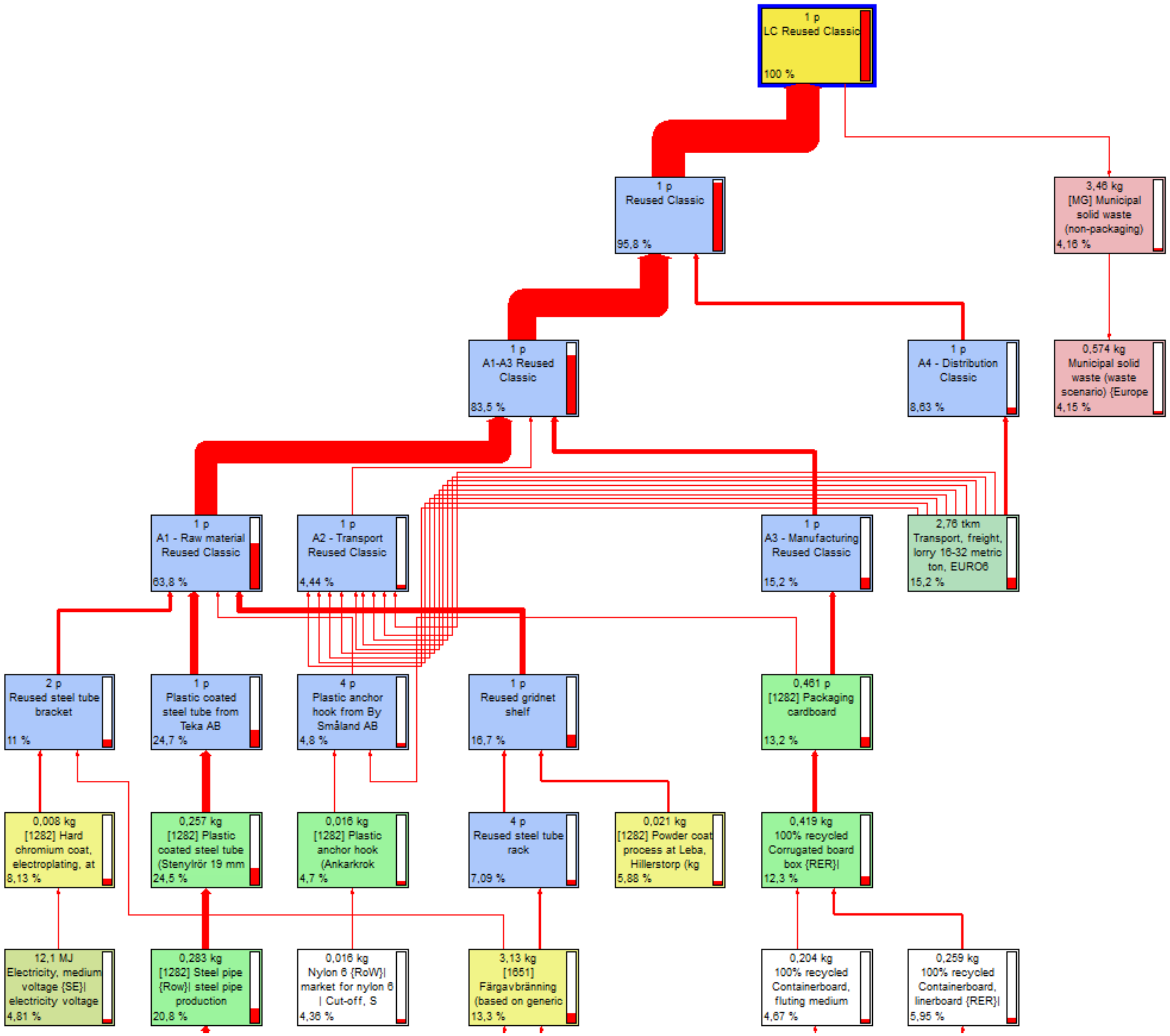


Figure 6: Sankey diagram over life cycle climate impact per declared unit, GWP-GHG (cut-off 3%)

3.4 Use of resources and energy CED 1.12

The consumption of resources in terms of energy is measured as primary energy demand with the method Cumulative Energy Demand 1.12. The calculations are done according to option B as described in annex 3 of the PCR.

Table 5: Use of resources and energy for module A-D, per declared unit

Para- meter	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
PERE	MJ	1,28E+01	3,69E-02	6,96E+00	**1,98E+01**	7,16E-02	1,19E-01	0,00E+00	1,58E-02	3,77E-03	0,00E+00	-6,44E-01
PERM	MJ	0,00E+00	0,00E+00	7,14E+00	**7,14E+00**	0,00E+00	-7,14E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	MJ	1,28E+01	3,69E-02	1,41E+01	**2,69E+01**	7,16E-02	-7,02E+00	0,00E+00	1,58E-02	3,77E-03	0,00E+00	-6,44E-01
PENRE	MJ	1,12E+02	2,29E+00	6,66E+00	**1,21E+02**	4,44E+00	7,55E-01	0,00E+00	9,80E-01	1,80E-01	0,00E+00	-4,19E+01
PENRM	MJ	2,21E+00	0,00E+00	0,00E+00	**2,21E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-2,21E+00	0,00E+00	0,00E+00
PENRT	MJ	1,14E+02	2,29E+00	6,66E+00	**1,23E+02**	4,44E+00	7,55E-01	0,00E+00	9,80E-01	-2,03E+00	0,00E+00	-4,19E+01
SM	kg	6,30E-01	0,00E+00	4,15E-01	**1,05E+00**	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	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
NRSF	MJ	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
FW	m3	3,48E-02	3,23E-04	1,59E-02	**5,10E-02**	6,28E-04	7,54E-04	0,00E+00	1,39E-04	2,20E-04	0,00E+00	-1,23E-02
Abbrevi- ations	PERE = use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total Use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total Use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = use of net fresh water											

3.5 Waste production and output flows

The production of waste in terms of final waste and the output of materials for recycling, is measured from the calculation of selected inventory results with our own method[1]. Final waste and output flows, refers to flows that are leaving the system of the LCA. In this LCA only elementary flows (substances) are actually leaving the system.

Table 6: Waste production for module A1-D, per declared unit

Indicator	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
Hazardous waste	kg	0	0	0	0	0	0	0	0	0	0	0
Non-Hazardous waste	kg	0	0	0	0	0	0	0	0	0	0	0
Radioactive waste	kg	0	0	0	0	0	0	0	0	0	0	0

Table 7: Output flows for module A-D, per declared unit

Indicator	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
Components for reuse	kg	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Material for recycling	kg	0,20	0,00	0,00	0,20	0,00	0,34	0,00	0,00	2,67	0,00	0,00
Materials for energy recovery	kg	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Exported energy, electricity	kg	0,02	0,00	0,00	0,02	0,00	0,43	0,00	0,00	0,76	0,00	0,00
Exported energy, thermal	kg	0,05	0,00	0,00	0,05	0,00	1,00	0,00	0,00	1,77	0,00	0,00

[1] EPD (2018) EN15804 v3

4 Interpretation

This section covers the key aspects of the results, sensitivity analyses, scenario analyses and an evaluation of the model and underlying data.

The quantitative impact assessment results are interpreted to understand the possibilities of reducing environmental impact most efficiently.

4.1 Key aspects of results

Similarly to the conventional Classic, Reused Classic has the highest impact in climate change potential and use of fossil resources as the product consists of mainly steel but also plastics. The difference between conventional Classic and Reused Classic will be further assessed in the interpretation chapter.

Looking at the impact category climate change (according to GWP-GHG), the lifecycle impact (A1-C4) for the product is 3,44 kg CO2 eq. Producing new components and remanufacturing of reused components stands for 64% of total climate impact and is divided according to the figure below. As can be seen, the component that is virgin – plastic coated steel tube – have the highest impact and for reused components it is the different surface treatments that contributes to the result. Plastic coated steel tube stands for 7% of total product weight and 25% of total climate impact. The remanufacturing of the reused components that stands for 91% of the product weight, stands for 28% of total climate impact and here it is the different surface treatments of them that contribute to the result.

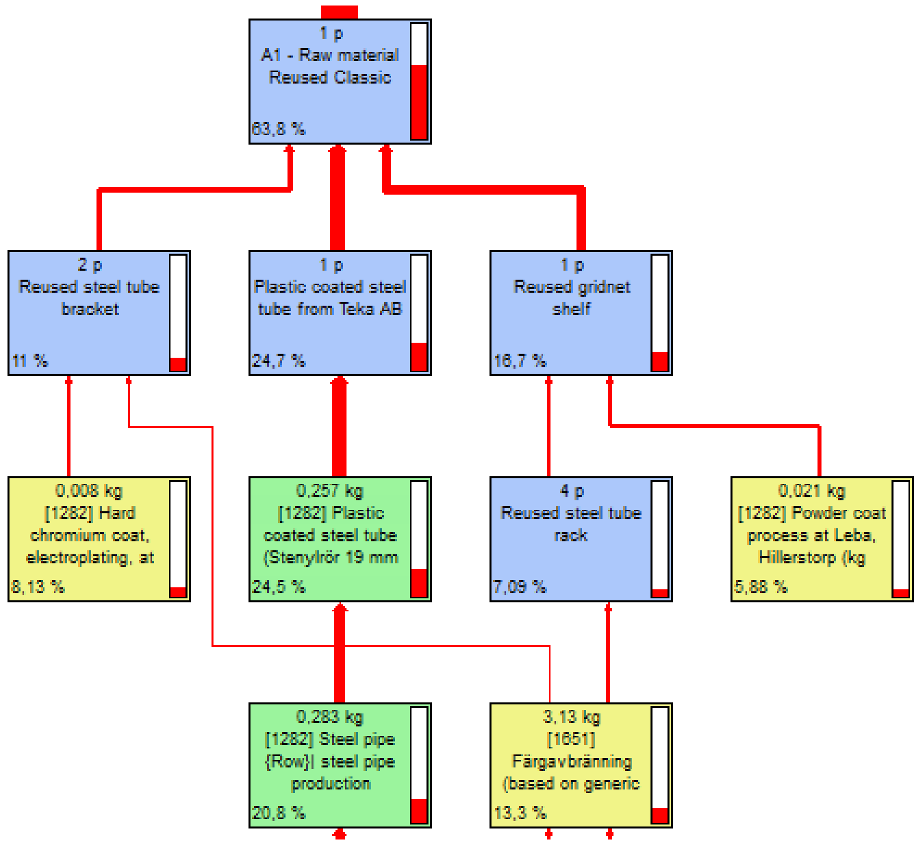


Figure 7 Climate impact (GWP-GHG) from components (Sankey with 5% cut-off)

Other aspects of the lifecycle that contribute to the result are the packaging material used in manufacturing (13% of total impact) and distribution of the product (9% of total impact).

Looking at the total climate impact divided per component (including all lifecycle steps), the result becomes as indicated in the figure below. The component with the highest weight carries more burden from other lifecycle steps which is why the grid net shelfs becomes the component with the highest impact, followed by plastic-coated pipe.

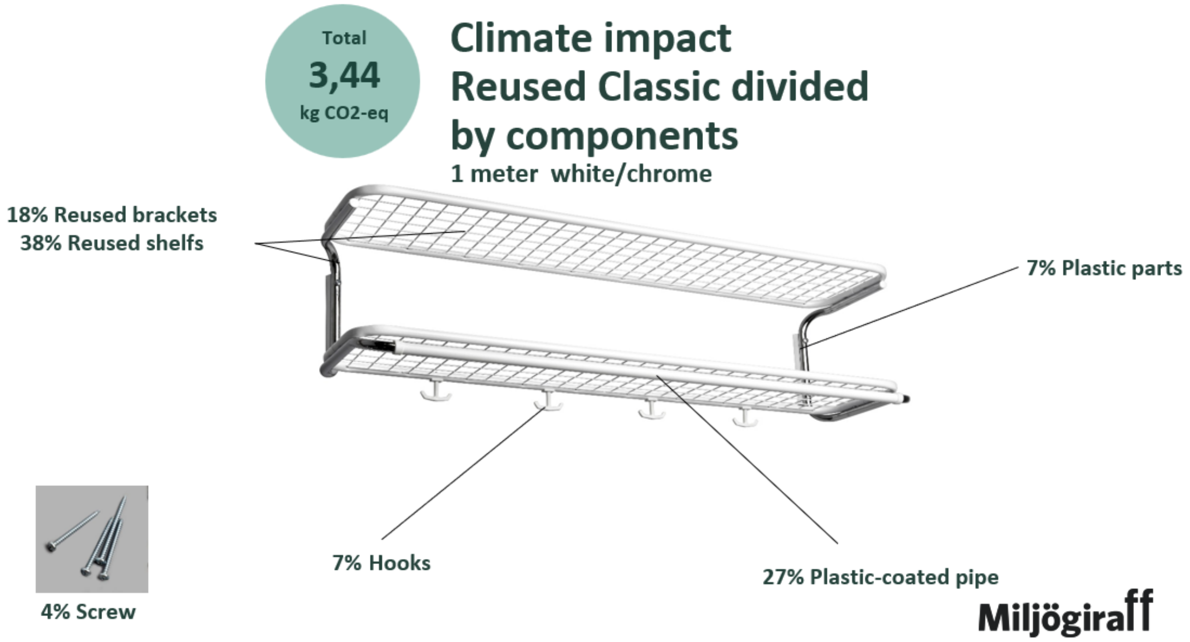


Figure 8 Climate impact GWP-GHG

4.2 Sensitivity analysis

LCA provides a holistic perspective on the entire system. To succeed in this ambitious goal, certain simplifications, and value-based choices to cover the entire system are required. By changing these choices, one can, based on the result, assess its relevance and whether there is a reason to revise the assumptions or choices that have been made.

In this study the different product variations have been in focus for the sensitivity analysis. A sensitivity check has also been made for the process delivered by Färgabränning since this is represented with generic data in the analysis and contributes to 13% of total climate impact result.

Product variations Reused Classic

This LCA and EPD covers product variations for Classic hat rack. The declared product is the worst-case for any variation of the product. More specifically the declared product is an 1m Classic hat rack chromed brackets. The product variations are mainly:

- Coated or chromed brackets
- Length of the rack, from 1m and above

For product variations longer than 1 meter, it is only the shelfs that requires more materials since the brackets remains in the same proportions. Therefore the 1-meter option becomes the worst case scenario for the product.

How the result would look like if the brackets were coated instead of chromed is shown in the figure below. As can be seen, if the brackets are coated instead of chromed, the result is 3,3 kg CO2 eq which is a 4% difference. How other impact categories are affected are shown in the table below.

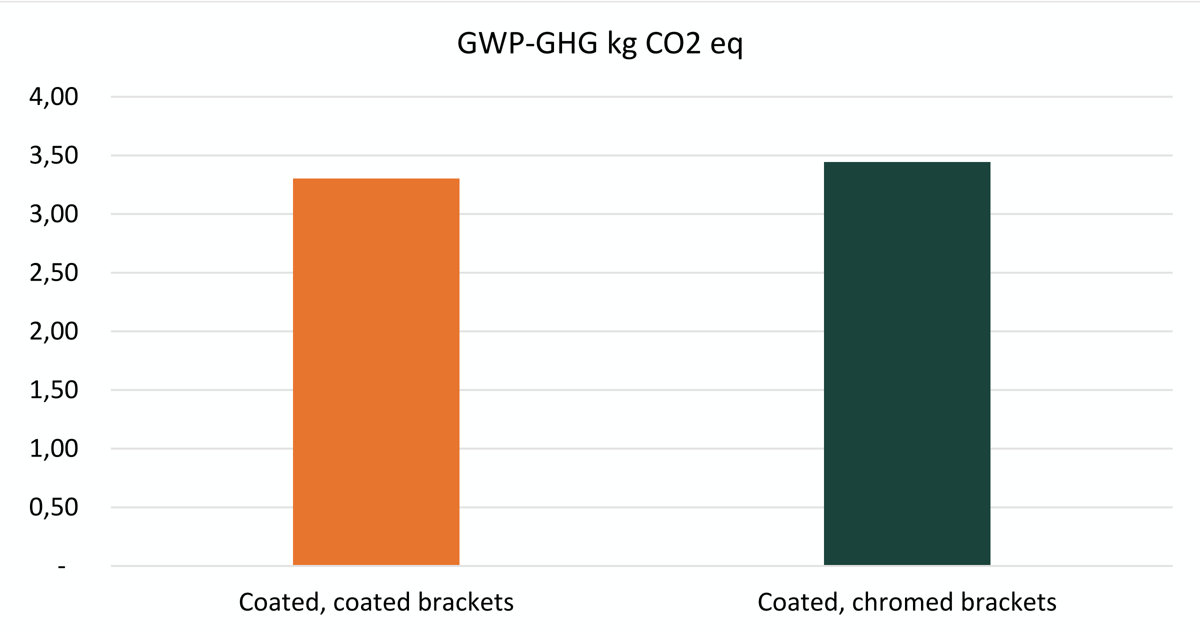


Figure 9 Product variations for the brackets of Classic

Table 8 How a coated bracket Classic preforms compared to a rack with chromed brackets for other impact categories

Impact category	Coated, coated brackets
Acidification	-11%
Ecotoxicity, freshwater	-3%
Particulate matter	-14%
Eutrophication, marine	-11%
Eutrophication, freshwater	-4%
Eutrophication, terrestrial	-13%
Human toxicity, cancer	-7%
Human toxicity, non-cancer	-9%
Ionising radiation	-44%
Land use	-25%
Ozone depletion	-2%
Photochemical ozone formation	-7%
Resource use, fossils	-40%
Resource use, minerals and metals	-28%
Water use	-21%

Datarepresentation for Färgavbränning
Due to lack of data from the supplier Färgavbränning, generic data have been used to represent the process for burning away old surface treatment on reused components. No specific data has been given by the supplier as they do not wish to declare information about their production process, but they answered that they have ovens that burn the existing surface treatment away and which are powered with biogas. Therefore, the dataset "*Energy and auxilliary inputs, metal working machine {RER}| energy and auxilliary inputs, metal working machine, with process heat from natural gas | Cut-off, U"* has been used to represent the process conducted by Färgavbränning. Here, input of electricity has been changed to Swedish residual mix and gas has been changed to biogas.

This dataset is assumed to be a relative uncertain representation but with no further information and no other generic data that could be representative it is assumed to be good enough. To see how the result would change if natural gas were used in the dataset instead, this sensitivity check assesses this case.

The result is then as indicated in the figure below. If natural gas instead of biogas is used as energy source in the generic data that represents Färgavbrännings process, the result would increase from 3,44 kg CO2 eq to 4,34 kg CO2 eq, a 26% increase. How the process for Färgavränning is currently represented gives a climate impact (GWP-GHG) which is 0,146 kg CO2 per kg processed material.

This sensitivity check shows that obtaining specific data about Färgavbrännings process is critical for a more robust result. Especially data about energy consumption and source is of importance for the result.

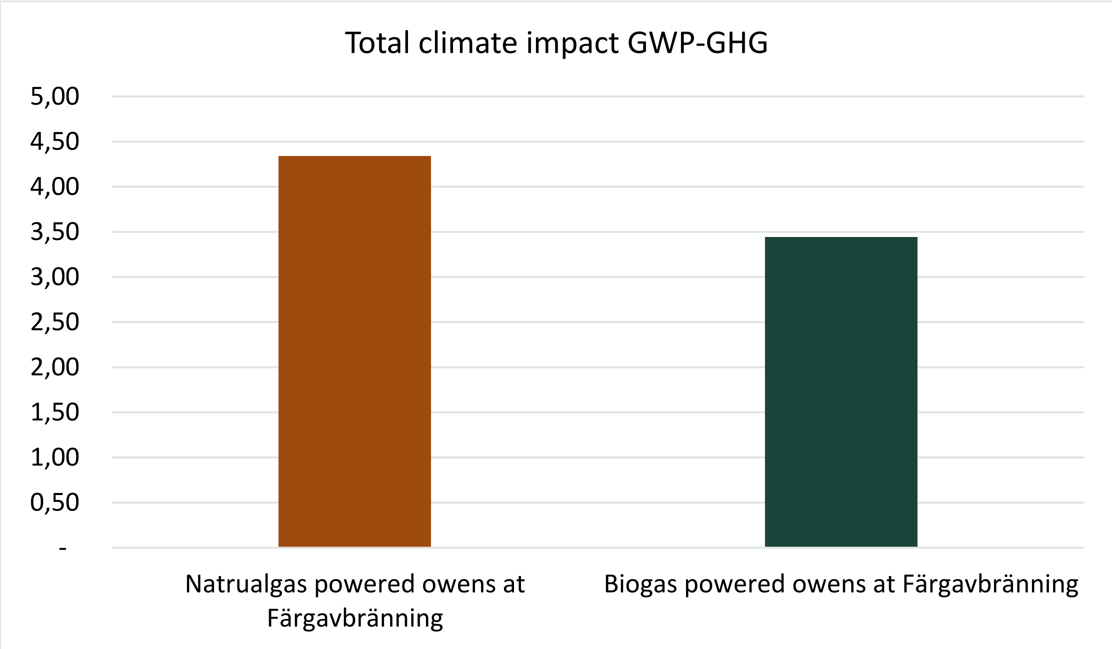


Figure 10 Total climate impact with different energy sources at Färgavbränning

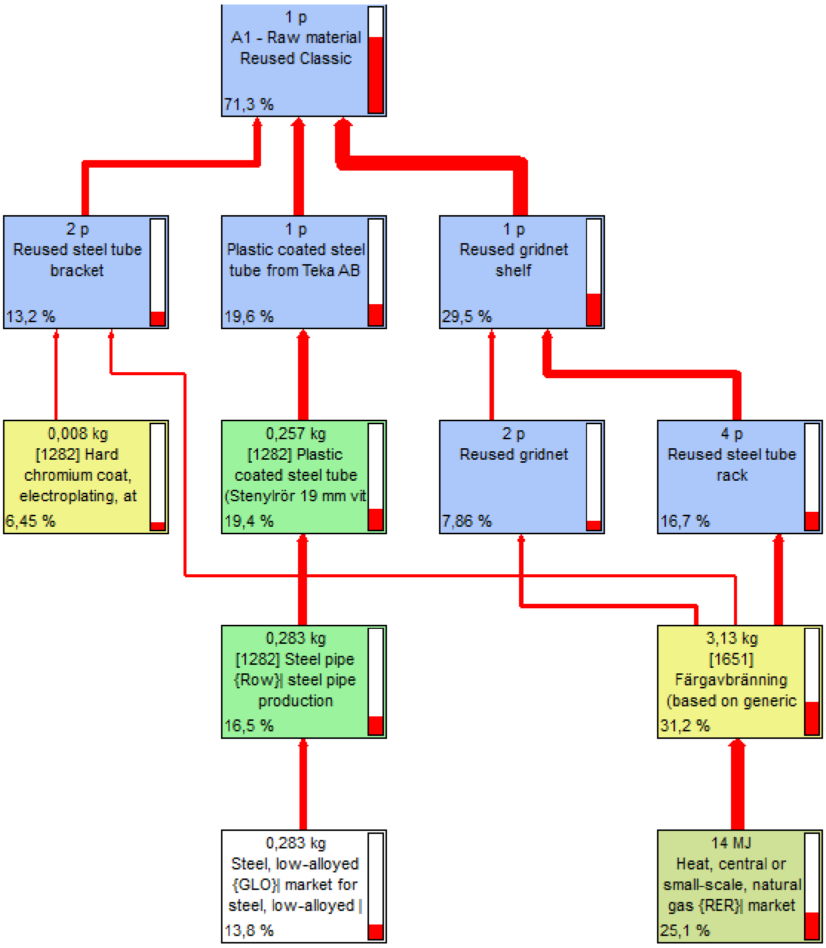


Figure 11 Relative contribution to total climate change impact with other energy source at Färgavbränning

4.3 Scenario analysis

The scenario analysis assessed two scenarios which are comparison of the reused racket to the conventional racket and what would happen to the result of the reused racket if suppliers for surface treatment were to be moved.

Comparison of conventional and reused Classic
Comparing the result of the Reused Classic to the result for the conventional Classic, the result becomes as indicated below.

Total climate impact for the conventional Classic is 12,0 kg CO2 eq over the lifecycle compared to 3,4 kg CO2 eq for Reused Classic. By this, the Reused Classic has achived a reduction of 71% of climate impact over the lifecycle compared to the more conventional production of the Classic rack.

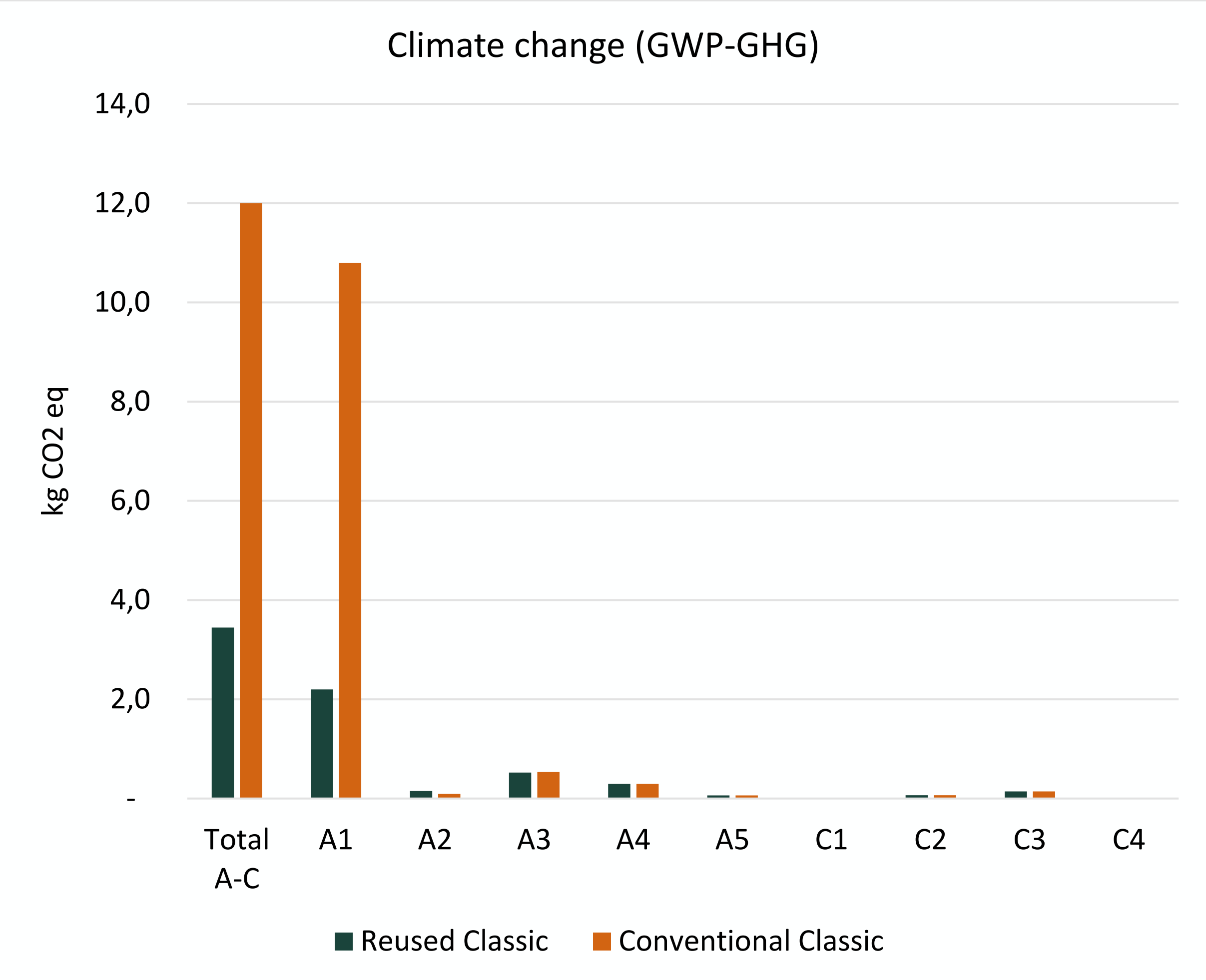


Figure 12 Comparison of Reused Classic and conventional Classic

As can be seen, the result for the Conventional Classic has changed some from the report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi (Lindroth & Coleho, 2023) and this is explained due to the updates regarding goal and scope found in chapter 1.2 and then the update of background data.

Change of location for surface treatment

Essem have suppliers for surface treatments in the close-by area. This scenario assesses what will happen to the result if transport distances for the surface treatment were to be changed.

Table 9 Data input to scenario

	Powdercoating + chromium coating	Removal of old surface treatment
Current distance from Essem (km)	23	2
Scenario new distance (km)	500 (single way)	500 (singe way)

The figure below shows the result for the scenario. The scenario shows that if suppliers for surface treatment were to be located 500km from Essem, the total climate impact for the products lifecycle would increase with 60% to 5,53 kg CO2 eq from 3,45 kg CO2 eq. This scenario highlights the importance of having local suppliers for the additional services required for Resused Classic. Although, both cases below have a significant lower climate impact then a conventional Classic rack.

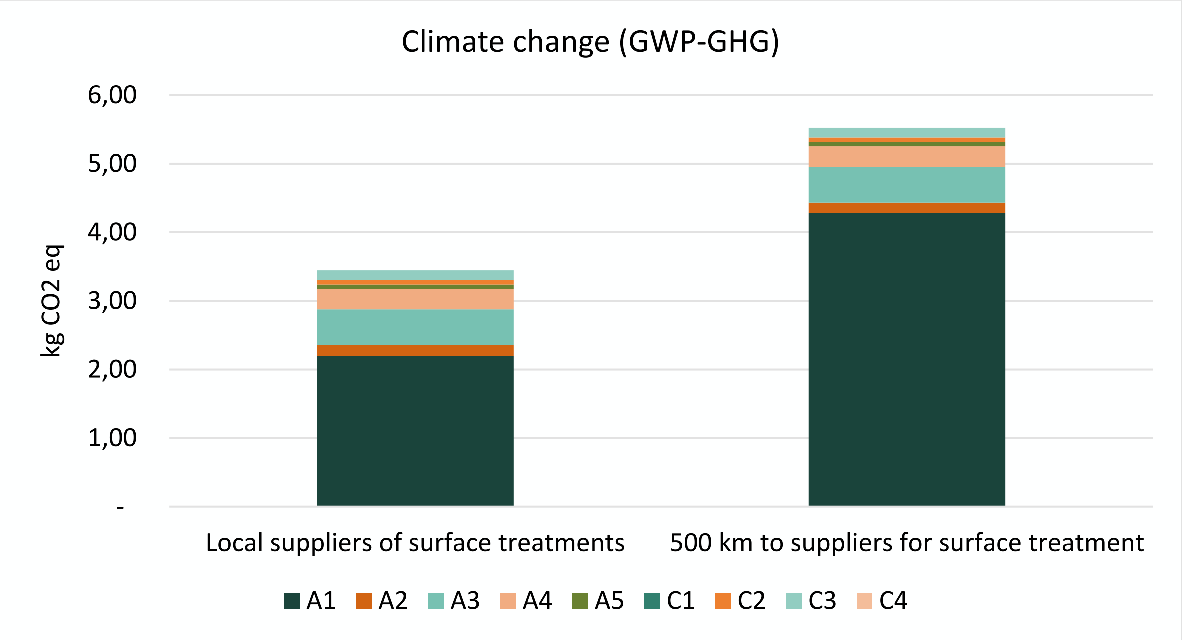


Figure 13 Scenario for transport distance to surface treatment suppliers.

5 Conclusions and recommendations

This section will summarise the conclusions from the study in terms of highlighting the most important aspects of the results and the interpretation. Recommendations will be presented in suggestions of how to mitigate the hot spots, how to communicate the results and how to reduce the uncertainties of the study.

The environmental impact of Reused Classic from Essem from a cradle-to-grave perspective mainly comes from the production of **virgin raw materials/components, surface treatment for reused components and product packaging**. The cradle-to-gate impact is 2,9 kg CO2 eq and hence about 84% of total climate impact.

Important impact categories for Classic are "Climate change potential" and "Resource use, fossil resources". This is linked to the energy required for processing throughout the lifecycle, from raw material extraction to core processing.

The sensitivity analysis shows that the product variations for the products (mainly coated or non-coated options) do not significantly change the climate impact result and that chromed brackets is the variation with the highest impact.

Another sensitivity check shows that obtaining specific data about the process for extracting old surface treatment on reused components at Färgavbrännings is critical for a more robust result. The data used to represent Färgavbränning stands for about 13% of total climate impact result and it is manly the energy consumption and source that influence this result.

In a scenario where the result of the Reused Classic is compared to the result for the conventional Classic, the comparison shows that the Reused Classic shelf has achived a reduction of 71% of climate impact over the lifecycle. This scenario demonstrates how effective reuse of componetns is to lower the enviornmental impact of a product that has the potential to be reused.

In another scenario analysis the importance of having local suppliers for the additional services required for Resused Classic was demonstrated. Currently Essem has teamed up with local suppliers for surface treatment which are located within a radius of less than 25 km. A scenario assessing what would happen if the transport to surface treatment increased to 500km showed an increase with 60% to 5,53 kg CO2 eq from 3,45 kg CO2 eq. Although with this increased transportation need, the climate impact result would still be lower than a conventional Classic rack.

The overall result shows that a Reused Classic rack from Essem can be produced to a significantly lower environmental impact than more conventional products. Thanks to a product design that enables disassembly and remanufacturing, and having local suppliers the total lifecycle climate impact result for the Reused Classic becomes 3,45 kg CO2 eq.

5.1 Recommendation on how to mitigate the hot spots

Essem manufactures products that can last for decades, which is why a circular economy (e.g. reuse, repair, remanufacturing, recycling) of the products has a potential to lower the environmental impact of the products lifecycles. The Reused Classic demonstrates this effectively. Reuse of further components and having more recycled materials in virgin components could further lower the impact of the product.

To mitigate the environmental impact, one would have to improve the information about the critical materials and obtain more specific data of Färgavbrännings process.

5.2 How to communicate the results

The study and report were carried out following the ISO standard for Life cycle assessments. According to ISO, LCA studies for external communication need to be summarised in a third party report (ISO, 2006):

"When results of the LCA are to be communicated to any third party (i.e. interested party other than the commissioner or the practitioner of the study), regardless of the form of communication, a third-party report shall be prepared. The third-party report can be based on study documentation that contains confidential information that may not be included in the third-party report. The third-party report constitutes a reference document, and shall be made available to any third party to whom the communication is made."

This appendix report together with report 1282 Life Cycle Assessment of Classic, Mama & Nostalgi (Lindroth & Coleho, 2023) can be used as a third-party report or as a basis for the development of such a report.

For enhanced robustness and transparency, it is advisable to conduct a critical review and obtain a verification statement. A critical review may assist in discovering errors or more reasonable assumptions, as well as generally ensuring the integrity of a study, in addition to preventing abuse and unsubstantiated claims, hence increases the LCA's robustness and the confidence in its findings and recommendations (Rosenbaum & Olsen, 2018). Overall, a critical review gives credibility to the study results.

6 Bibliography

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