Life Cycle Assessment of

- EPDM membranes for roofing
- EPDM membranes for lining and geomembranes
- EPDM membranes for Facade waterproofing, Air Sealing & Damp Proof Course applications

By SealEco

Title: Life Cycle Assessment of EPDM roof sealing systems from SealEco
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MILJÖGIRAFF

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Ordered by: SealEco AB

SealEco is a manufacturer of EPDM membranes and offers innovative water- and weather protection solutions for increased service life of buildings and other types of constructions. Our offer also includes lining of ponds, tanks and geomembranes for water and waste containment. SealEco provides tailor-made sealing solutions for the building envelope and lining applications, improving efficiency and durability with environmental benefits.

Issued by: Miljögiraff AB

Miljögiraff is an environmental consultant specialising in Life Cycle Assessment and Ecodesign. We believe that a combination of 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 – Allocation cut off by classification (system model in ecoinvent)

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

1 Introduction

This report presents the total environmental footprint for 5 different products produced by SealEco from a life cycle perspective using the ISO 14040 standard approach.

The purpose of the LCA method is to quantify the environmental impact from a holistic perspective and to use this understanding to find the most effective opportunities to mitigate adverse effects and avoid burden shifting from one part of the lifecycle to another.

The studied products are 5 different EPDM membranes with different applications.

1.1 Reading guide to the report

Readers of this report can choose different parts to read, depending on their time availability:

- 5 minutes
    - Section 7 gives the briefest summary of the most relevant conclusions and recommendations.
- 10 minutes
    - Section 7, and section 6 gives some more nuance/depth, including interpretation and sensitivity analysis that underpins the conclusions
- 20 minutes
    - Section 7, section 6 and section 5 presents detailed results and flowcharts/diagrams for the different impact categories
- >30 minutes
    - For in-depth detail and transparent documentation on the modelling of each part of the life cycle, see section 4 (“Life Cycle Inventory”)
    - For information about methodology, scope and functional unit, see sections 2 (“Life Cycle Assessment”) and section 3 (“Goal and Scope”)

1.2 The sustainability challenges

The industrial and natural systems depend on a stable Earth system. Steffen et al. (Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, 2015) describe nine processes that determine the resilience and stability of the Earth system, such as climate change, water use, and land use. Crossing these boundaries increases the risk of abrupt and irreversible environmental change, while staying within the boundaries represents a safe operating space for a sustainable society, see Figure 1.

In LCA, the effect of a product system on the environment and on human health is quantified. These quantifications are divided into different impact categories that represent different types of environmental impact. Note that the division into categories in LCA is done according to a somewhat different logic compared to the planetary boundaries.

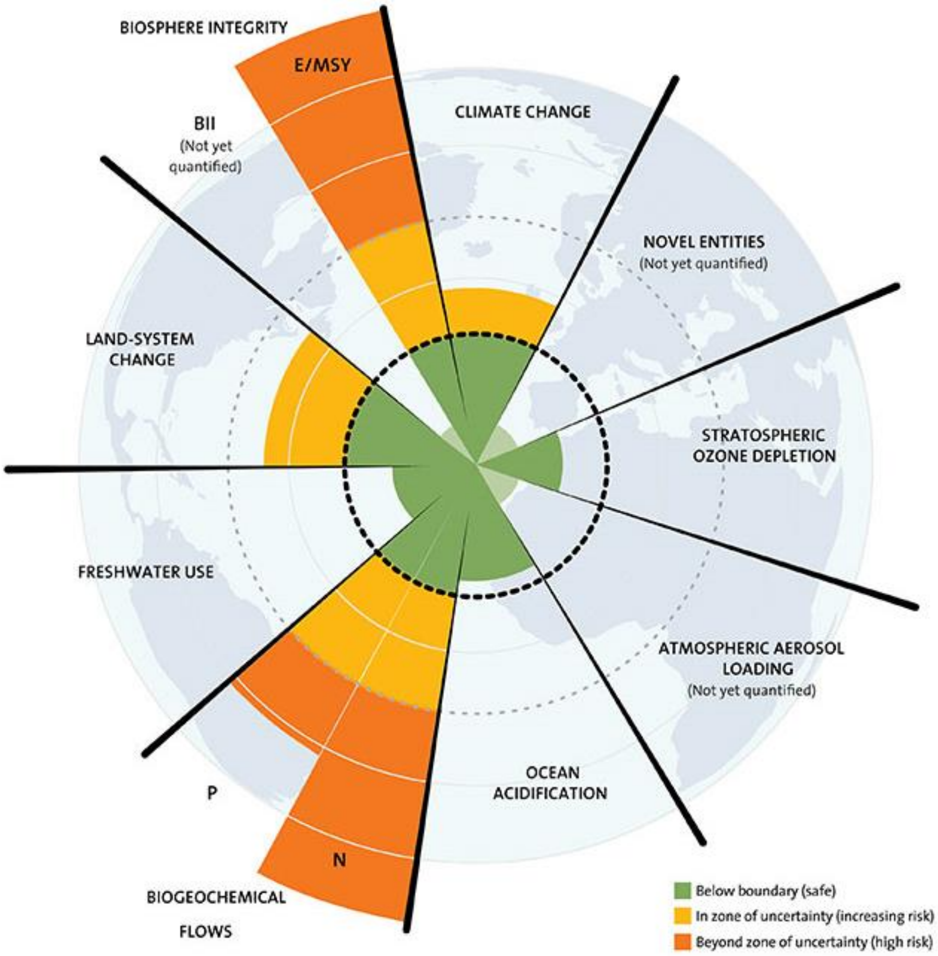

Figure 1: Show the state of the planetary boundaries, where the green area represents a safe operating space. From J. Lokrantz/Azote based on Steffen et al. 2015.

One of the most important environmental impacts is climate change. IPCC (IPCC, 2021) shows that the available space for mitigating radical climate change is ever-shrinking, necessitating decisive action in all parts of society. Figure 2 shows the projected temperature changes due to greenhouse gas emissions in the coming century, in 5 different scenarios where only the most ambitious one results in a temperature increase within 2°C. Keeping the temperature rise below 1.5 ° C is the ambition stipulated by the Paris Agreement 2016.

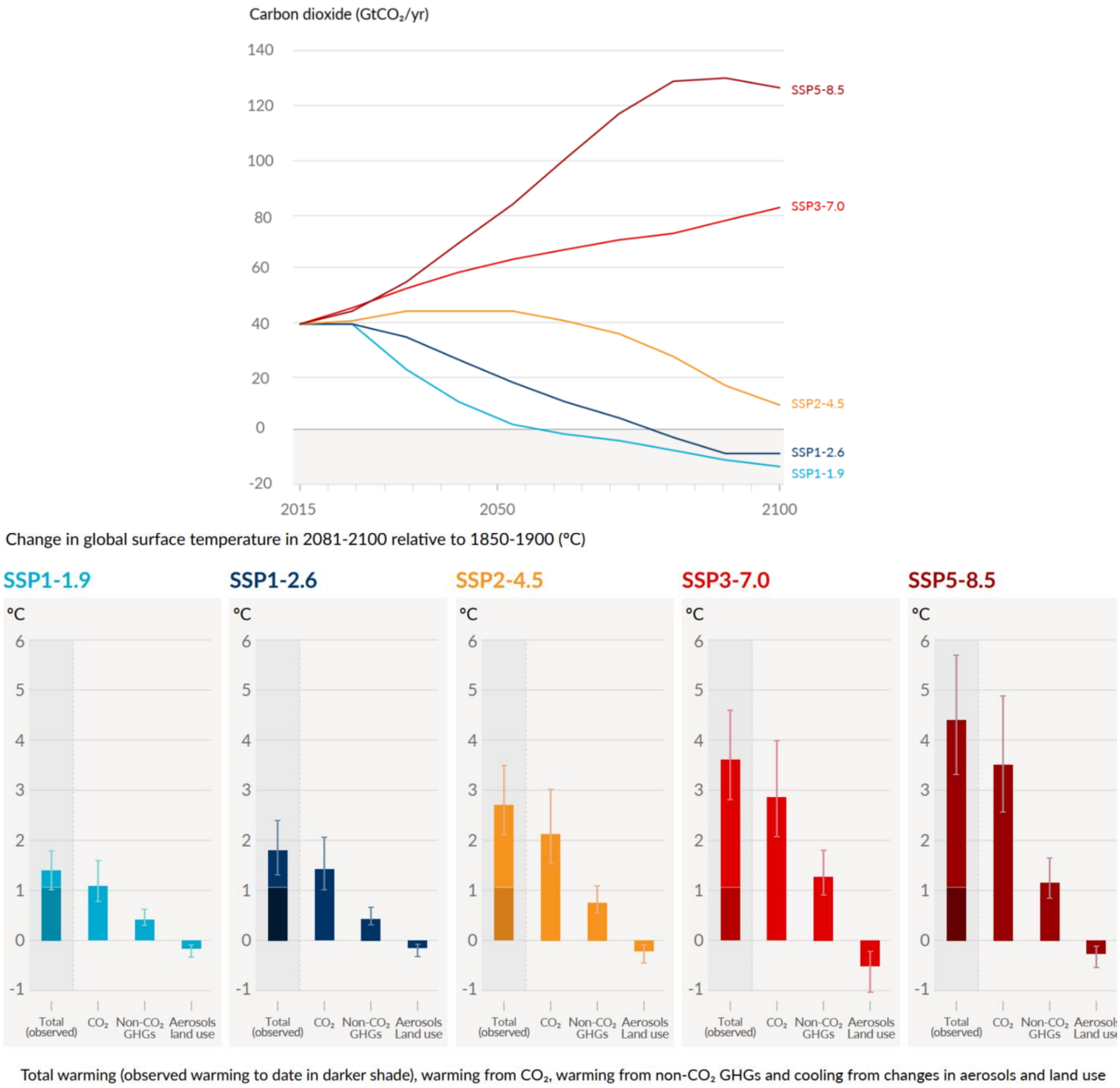

Figure 2: Future annual emissions of CO_2 (top) and contribution to global surface temperature increase from different emissions, with a dominant role of CO_2 emissions (bottom) across five illustrative scenarios (Image from IPCC (IPCC, 2021))

2 Life Cycle Assessment (LCA)

2.1 LCA Methodology background

The importance of understanding the potential environmental impact in connection with the manufacture and use of products is constantly increasing. LCA is the accepted and scientific method that exists to create this understanding. LCA forms a basis for the development of strategy, management and communication of environmental issues related to products.

The purpose of LCA is to provide a basis that describes the environmental impact in such a way that it provides conditions for change and measures in the analysed life cycle that can contribute to a more sustainable development. LCA provides a comprehensive basis for environmental impact as all incoming and outgoing flows of environmental significance during a product's life cycle are measured. (see Figure 3).

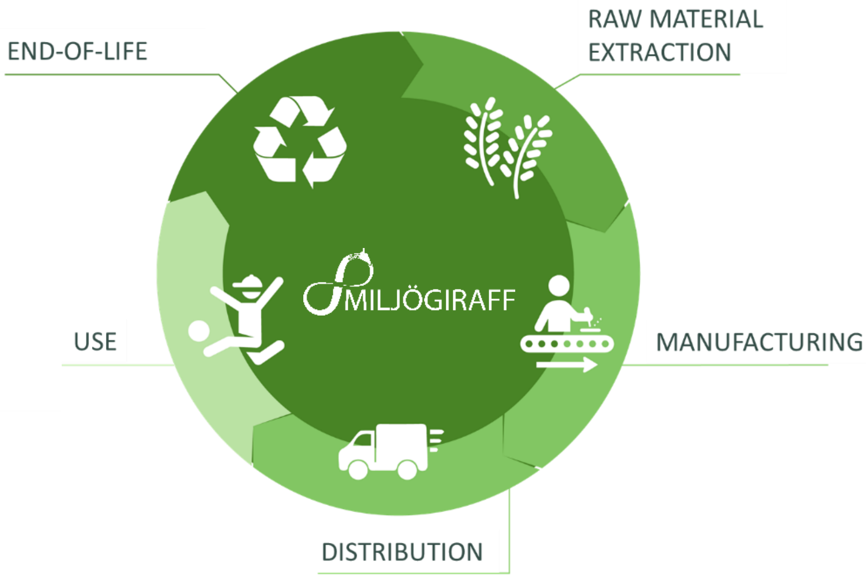

Figure 3: The Life Cycle concept, starting from raw material extraction, manufacturing, and distribution, followed by use and end-of-life.

Miljögiraff combines the confidence and objectiveness of the strong and accepted ISO standard with the scientific and reliable LCI data from ecoinvent and with the world-leading LCA software SimaPro for calculation and modelling (see Figure 4.).

Figure 4: ISO standard combined with reliable data from ecoinvent and the LCA software SimaPro.

2.2 ISO 14040

In 1997, the European Committee for Standardization published their first set of international guidelines for the performance of LCA. This ISO 14040 standard series has become widely accepted amongst the practitioners of LCA and is continuously being developed along with progressions within the field of LCA (Rebitzer et al., 2004). The guidelines for LCA are described in two documents; ISO 14040, that contains the main principles and structure for preforming an LCA, and ISO 14044, which includes detailed requirements and recommendations. Furthermore, a document containing the format for data-documentation (ISO/TS 14048), as well as technical reports with guidelines for the different stages of an LCA (ISO/TR 14049 and ISO/TR 14047), are available in this standard series.

This LCA follow the “Book-keeping“ LCA approach which is defined as attributional LCA in the ISO 14040 standard.

The environmental management method Life Cycle Assessment (LCA) is used in this study. The LCA has been performed according to the ISO 14040 series standards.
ISO 14040: 2006 - Principles and framework
ISO 14042: 2006 - Life Cycle Impact assessment
ISO 14044: 2006 - Guiding

There are four phases in an LCA study; the goal and scope definition phase, the inventory analysis phase, the impact assessment phase and the interpretation phase. Below is a conceptual picture of this in Figure 5.

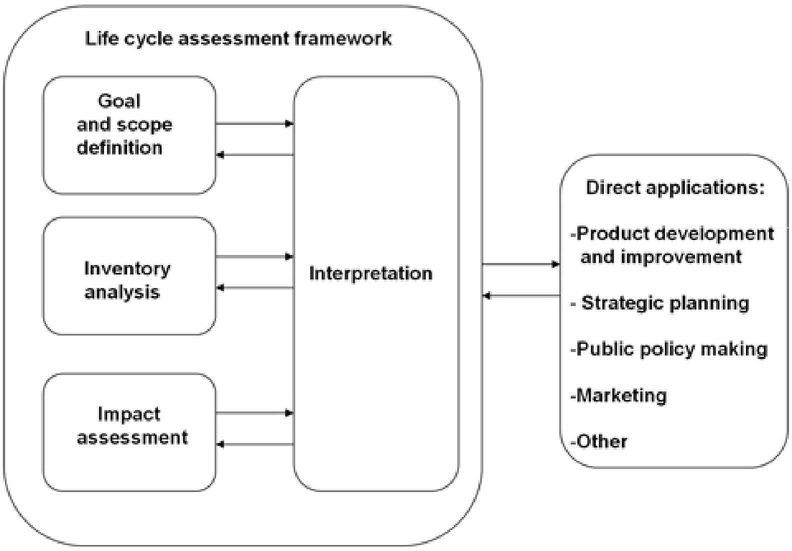

Figure 5. The four phases of the Life Cycle Assessment

2.2.1 Goal and scope definition

The first phase is the definition of goal and scope. The goal and scope, including system boundary and level of detail, of an LCA depends on the subject and the intended use of the study. The depth and the breadth of LCA can differ considerably depending on the goal of a particular LCA.

2.2.2 Inventory analysis (LCI)

The life cycle inventory analysis phase (LCI phase) is the second phase of LCA. It is an inventory of input/output data with regard to the system being studied. It involves the collection of the data necessary to meet the goals of the defined study.

2.2.3 Impact assessment (LCIA)

The life cycle impact assessment phase (LCIA) is the third phase of the LCA. The purpose of LCIA is to provide additional information to help assess a product system's LCI results so as to better understand their environmental significance. Mandatory steps in the lifecycle impact assessment are classification and characterisation. An optional step is weighting. The LCIA-method is explained in more details in 0.

Classification and characterisation
The process of determining what effects an environmental aspect can contribute to is called classification, e.g. that the use of water contributes to the environmental effect of water depletion. Characterisation in turn means defining how much an environmental aspect contributes to the environmental impact category to which it is classified, e.g. the use of 1 tonne of river water contributes a factor of 0.5 to water depletion. Evaluating how critical it is in a specific area depends on the current environmental impact, the pressure from resource consumption and the ecosystem's carrying capacity. This is done through normalisation.

Weighting
To compare between different environmental effects and to identify "hot spots", so-called *weighting* is applied. The calculated environmental effects are weighted together to form an index called a "*single score*" which describes the total environmental impact.

Because weighting involves subjective weighting (e.g. by an expert panel) it is recommended for internal communication only. Otherwise, there is a risk of mistrust if the choice of weighting method used leads to results that emphasise the "upsides" and hide the "downsides" of the analysed product. For external communication, only *Single issues* should be communicated.

2.2.4 Interpretation

The life cycle interpretation phase of an LCA or an LCI study comprises several elements:

- identification of the significant issues based on the results of the LCI and LCIA phases of LCA
- an evaluation that considers completeness, sensitivity and consistency checks
- conclusions, limitations, and recommendations.

The interpretation of the results in this study is done by first identifying the aspects that contribute the most in each individual environmental effect category. After that, the sensitivity of these aspects are evaluated, and the completeness and consistency of the study are assessed. Conclusions and recommendations are then based on the results and a clear understanding of how the LCA was conducted with any subsequent limitation.

Evaluation of the results

The objectives of the evaluation element are to establish and enhance confidence in, and the reliability of, the results of the LCA or the LCI study, including the significant issues identified in the first element of the interpretation. The evaluation should use the following three techniques:

- Completeness check
  The objective of the completeness check is to ensure that all relevant information and data needed for the interpretation are available and complete. If any relevant information is missing or incomplete, the necessity of such information for satisfying the goal and scope of the LCA shall be considered. This finding and its justification shall be recorded.
- Sensitivity check
  The objective of the sensitivity check is to assess the reliability of the final results and conclusions by determining how they are affected by uncertainties in the data, allocation methods or calculation of category indicator results, etc.
- Consistency check
  The objective of the consistency check is to determine whether the assumptions, methods and data are consistent with the goal and scope.

2.3 Environmental product declaration

An Environmental Product Declaration (EPD) is defined by (ISO) 14025 as a Type III declaration that "quantifies environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function."

EPDs are primarily intended to facilitate business-to-business communication, although they may also be of benefit to consumers who are environmentally focused when choosing goods or services.

As shown in Figure 6 several standard documents are used when creating an EPD.

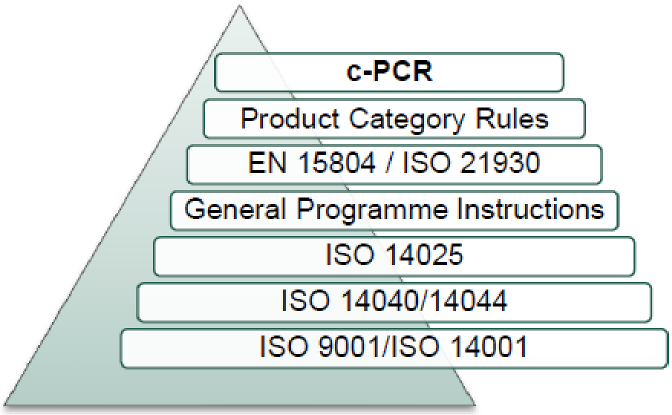

Figure 6, shows the hierarchy of standards used to create and EPD according to the International EPD system.

2.3.1 General Program Instructions (GPI)

General Program Instructions constitutes the General Programme Instructions (GPI) of the International EPD® System. It forms the basis of the overall administration and operation of a programme for Type III environmental declarations according to ISO 14025.

2.3.2 Product Category Rules (PCR)

Product Category Rules (PCRs) provide guidance that enables fair comparison among products of the same category. PCRs include the description of the product category, the goal of the LCA, functional units, system boundaries, cut-off criteria, allocation rules, impact categories, information on the use phase, units, calculation procedures, requirements for data quality, and other information. The goal of PCRs is to help develop EPDs for products that are comparable to others within a product category. ISO 14025 establishes the procedure for developing PCRs and the required content of a PCR, as well as requirements for comparability.

2.3.3 EN15804:2012+A2:2019

EN15804:2012+A2:2019 standard provides core product category rules for all construction products and services. It provides a structure to ensure that all Environmental Product Declarations (EPD) of construction products, construction services and construction processes are derived, verified and presented in a harmonised way.

2.4 System boundary

The system boundary determines which modules and activities are included within the LCA. The selection of the system boundary shall be consistent with the goal of the study. A system boundary is chosen to include all contributing processes for the system while facilitating the modelling and analysis of the system. Therefore, there may be reasons to exclude activities that contribute insignificantly to the environmental effects (so-called "cut-off"). However, the omission of life cycle stages, processes, inputs, or outputs is permitted only if it does not significantly change the study's overall conclusions. It should be clearly stated if decision to skip life cycle stages, processes, inputs, or outputs are made and the reasons and implications for their exclusion must be explained.

When the life cycle is defined by the system boundary the environmental aspects included and the data used to represent the different aspects is in detail described under the

Life cycle inventory (LCI) part.

Figure 7 shows all the life cycle stages included in an LCA, divided into modules A-D.

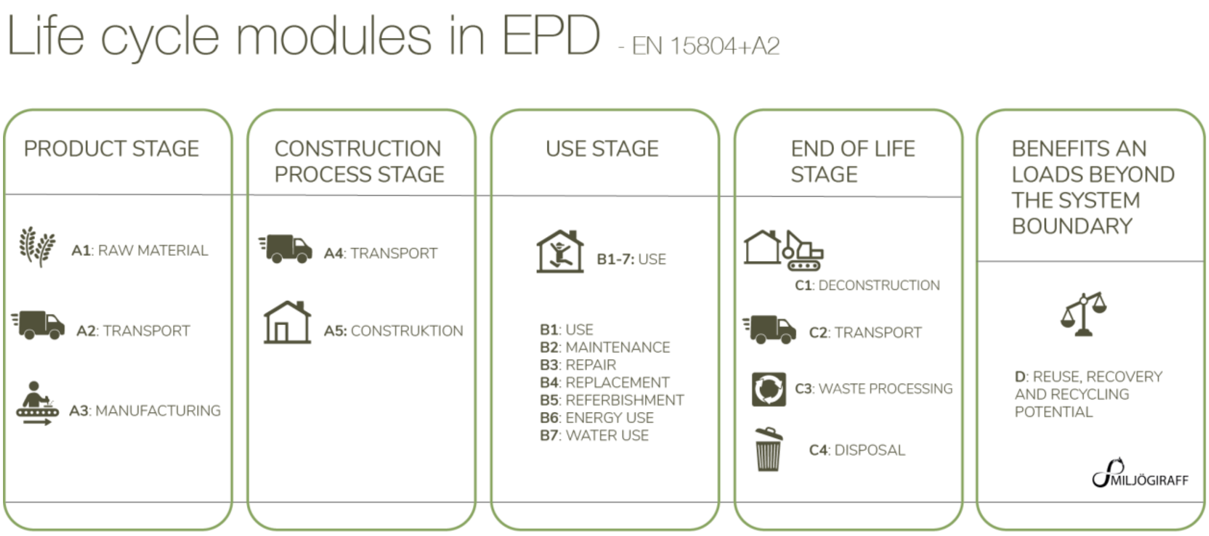

Figure 7: General summary of the modules included in an LCA, based on EN 15804.

In this LCA, boundaries with other systems, and the allocation of environmental burdens between them, are based on the recommendations of the international EPD system[1], which are also in line with the requirements and guidelines of the ISO14040/14044 standards. Following these recommendations, the Polluter Pays (PP) allocation method is applied (see Figure 8). For allocation of environmental burdens when incinerating waste, all processes in the waste treatment phase, including emissions from the incineration, are allocated to the life cycle in which the waste is generated. Subsequent procedures for refining energy or materials to be used as input in a following/receiving process are allocated to the next life cycle.

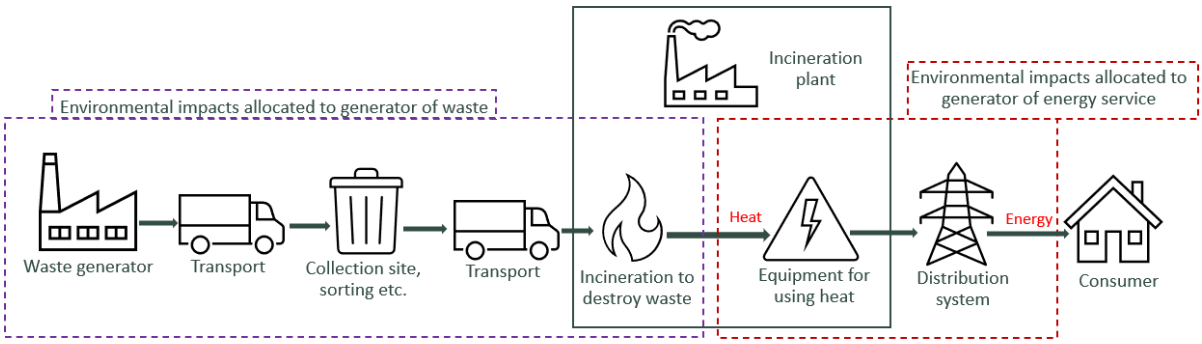

Figure 8: Allocation of environmental impacts between two life cycles according to the PP allocation method. Here in regard to incineration of waste and resulting energy products.

In the case of recycling, environmental burdens are accounted for outside of the generating life cycle. They have thus been allocated to the subsequent life cycle, which uses the recycled materials as input.

Avoided materials due to recycling are typically not considered in the main scenario, this in accordance to the International EPD system's recommendation of the Polluter Pays Principle. In other words, only if the generating life cycle uses recycled material as input material will it account for the benefits of recycling.

[1] EPD (Environmental Product Declarations) by EPD International®

Avoided material from recycling is included in the total environmental impacts and is represented with the D-module, as recommended in EN15804.

2.4.1.1 D-module

Module D aims to describe consequences or benefits that can be related to material and energy recovery as well as reuse outside the system boundary. Recycled material or energy has the potential to replace primary resources that would otherwise have been used in new production if the recycled material has not been available, this benefit is calculated with the d-module. For products that contain recycled material as raw material, the recycled proportion is deducted to avoid double counting.

The following formula has been used to calculate the potential consequences of recycling the product:

$$e_{module\ D1} = \sum_i \left(M_{MR\ out}\Big|_i - M_{MR\ in}\Big|_i\right) \cdot \left(E_{MR\ after\ EoW\ out}\Big|_i - E_{VMSub\ out}\Big|_i \cdot \frac{Q_{R\ out}}{Q_{Sub}}\Big|_i\right)$$

Equation 1 describes how the potential benefit of recycling of material and energy has been calculated.

- MMR out = The amount of material that leaves the product system and will be reused / recycled in subsequent systems.
- MMR in = The amount of material that has previously been recycled and that enters the product system as raw material from previous systems as secondary material.
- EMR after EoW out = Specific emissions and consumed resources that arise in material treatment processes up to recycling.
- EVMSub out = Specific emissions and consumed resources that arise during the acquisition and pre-treatment of primary materials in the manufacturing process.
- QR out = Quality of the recycled material at replacement.
- QSub = Average quality of primary material that the recycled material substitutes.

2.5 Cut-off

It is common to scan for the most important factors (a "cut off" of 95% is a minimum) to avoid putting time and effort on irrelevant parts of the life cycle. In general, LCA focuses on the essential material and energy flows, while the flows that can be considered negligible are excluded. By setting cut-off criteria, a lower limit is defined for the flows to be included. Flows below the limit can be assumed to have a negligible impact and are thus excluded from the study. For example, cut-off criteria can be determined for inflows concerning mass, energy, or outflows, e.g., waste.

2.6 Allocation

The study shall identify the processes shared with other product systems, as co-products, and deal with them according to the stepwise procedure presented below:

- **Step 1**: Wherever possible, the allocation should be avoided by dividing the unit process into two or more sub-processes and collecting the input and output data related to these sub-processes or expanding the product system to include the additional functions related to the co-products.
- **Step 2**: Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying

physical relationships between them; i.e., they should reflect how the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system.
- **Step 3**: Where physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way that reflects other relationships between them. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.

When other allocation methods are used, it should be documented and assessed whether it may be significant to the results.

2.7 Data requirements (DQR)

General LCI databases contain a large amount of third party reviewed LCI data compiled according to the ISO 14048 standard. Certified LCI data forms a basis for a robust and transparent study. However, it is crucial to understand that specific producers may differ considerably from general practice and average data.

The LCI data can be either specific or general. Specific data means that all data concerning material, energy and waste are specifically modelled for the conditions at the manufacturing facility and the technology used. Generic
data means that material or energy are represented using average LCI data from ecoinvent 3.8.

Specific data
1. Environmental Product Declarations (type III)
2. Collected data (web format, site visits and interviews).
3. Reported data (EMS, Internal data systems or spreadsheets)

Selected generic data
1. Close proxy with data on a similar product
2. Statistics
3. Public documents

Generic data
1. Public and verified libraries with LCI data
2. Trade organisations libraries with LCI data
3. Sector-based IO data, national

2.8 Limitations

Practitioners can only achieve the broad scope of analysing the entire life cycle of a product using a holistic approach at the expense of simplifying some aspects. Thus, the following limitations must be taken into account as summarised by Guinée et al. (J. Guinée et al., 2002):

- Localised aspects are typically not addressed, and LCA is not a local risk assessment tool
- LCA is typically a steady-state approach rather than a dynamic approach
- LCA does not include market mechanisms or secondary effects on technological development
- Processes are considered linear, both in the economy and the environment, meaning that impact increases linearly with increased production.
- LCA focuses on environmental aspects and excludes social, economic, and other characteristics

LCA involves several technical assumptions and value choices that are not purely science-based

3 Goal and Scope

3.1 The aim of the study

The study's goal is to find metrics for the environmental impact for 5 different EPDM membrane systems from a life cycle perspective. Three of the EPDM systems are for roofing, one is a geomembrane system and one is for cladding and Damp proof course system.
The goal is a report that describe the results in a transparent and reproducible way according to the standards and method described under 2 Life Cycle Assessment (LCA). The goal is also to interpreted the result in such a way that effective recommendations for mitigating the environmental impact can be found and implemented by SealEco.

The purpose of the LCA study is product development to mitigate the environmental burden of the products and external communication of the environmental performance through an Environmental Product Declaration (EPD).

The intended audience is Business to Business customers.

3.2 Standards and frameworks

The standards and frameworks that has been followed in this LCA are presented in Table 1.

Table 1: Standards and framework conformance.

Standards conformance
ISO 14040 and 14044 (ISO, 2006)
General program instructions for the International EPD System 4.0 (EPD International, 2021b)
PCR 2019:14 version 1.11 (EPD International, 2021a)
EN15804:2012+A2:2019

3.3 Scope of the Study

The scope of an LCA specifies the functions (performance characteristics) of the system being studied.

3.3.1 Name and Function of the Products

The studied products are EPDM membrane sealing systems used to make different surfaces in a construction waterproof.

The five products are:

3.3.1.1 CladSeal EXT

CladSeal EXT consists of a product range of EPDM strips and accessories with properties that provide a seal against water, moisture and air tightness. The CladSeal system has been developed for weather-resistant seals around window frames, facades, sill insulation or weather protection for other types of building structures and for damp proof course (DPC)

Figure 9 show a picture of the product CladSeal EXT. For more information about the product and its life cycle see 4 Life cycle inventory (LCI).

Figure 9, shows a picture of the product CladSeal EXT.

3.3.1.2 *ElastoSeal*

ElastoSeal EPDM geomembrane remains elastic regardless of age and temperature and has a high resistance to root penetration. It is not exposed to cracking from stresses, so-called "stress cracking", and does not have a yield strength like thermoplastic materials. ElastoSeal EPDM can be installed exposed or covered with soil or water. It has a good ability to withstand mechanical impact from pressure or movement.

Figure 10 shows a picture of the product ElastoSeal. For more information about the product and its life cycle see 4 Life cycle inventory (LCI).

Figure 10, shows a picture of the product ElastoSeal

3.3.1.3 Prelasti S

Prelasti is an unreinforced EPDM rubber membrane for waterproofing flat or low-slope roofs. Prelasti can be installed loosely laid under ballast of, for example, gravel, tiles or green roof, but can also be glued to the substrate or attached mechanically. The Prelasti membrane is prefabricated to the desired size by welding. Size and shape can be adapted to each roof. The prefabricated joints are and remain 100% waterproof.

Figure 11 shows a picture of the product Prelasti S. For more information about the product and its life cycle see 4 Life cycle inventory (LCI).

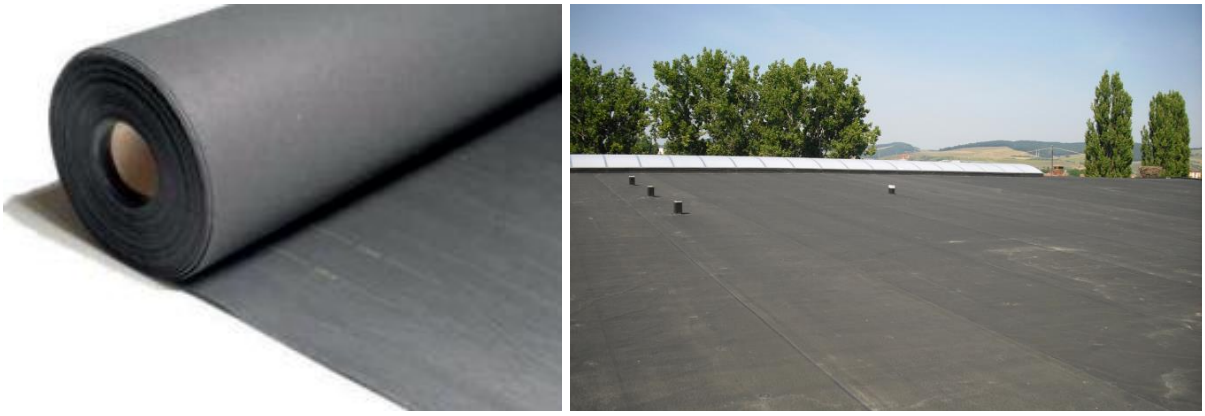

Figure 11, shows a picture of the product Prelasti S

3.3.1.4 Prelasti Fleece

The application of Prelasti Fleece is identical as the the Prelasti S membrane. Prelasti Fleece is laminated with a polyester fleece backing.

Figure 12 shows a picture of the product Prelasti Fleece. For more information about the product and its life see 4 Life cycle inventory (LCI).

Figure 12, shows a picture of the product Prelasti Fleece

3.3.1.5 Prelasti FR

The application of Prelasti FR is identical to the Prelasti S membrane. Prelasti FR is more fire retardant and meets Brooft 1,2,4 for different roof build ups.

Figure 13 shows a picture of the product Prelasti FR. This product is used to make roofs waterproof. For more information about the product and its life cycle see 4 Life cycle inventory (LCI).

Figure 13, shows a picture of the product Prelasti FR

3.4 The Functional Unit and reference flow

The primary purpose of a functional unit is to provide a reference to which the result and the input and output data are normalised to. For this study, **the functional unit used is 1m2.**

The different membranes are offered in different thicknesses, the most common thicknesses with corresponding weight can be seen in Table 2.

Table 2, show the most common thickness and weight per 1m2 for the five different products.

Product	Area (m2)	Thickness (mm)	Weight (kg)
CladSeal	1	0,75	0,941
ElastoSeal	1	1,0	1,111
Prelasti S	1	1,2	1,307
Prelasti Fleece	1	2,3	1,618
Prelasti FR	1	1,44	1,437

3.5 System Boundary

The system boundary for the study is defined as **Cradle to gate with options.**
The studied system includes the production of raw material (A1), transport of raw material (A2), and manufacturing (A3), Distribution A4, end of life (C) is included, and the potential secondary effects of reuse and recycling (D). The use phase (B) is not included due to many different functionalities and installation methods that will give different results.

Figure 14 shows an overview of the model. The dotted lines (inside the system boundary) indicate aspects that have been included and excluded.

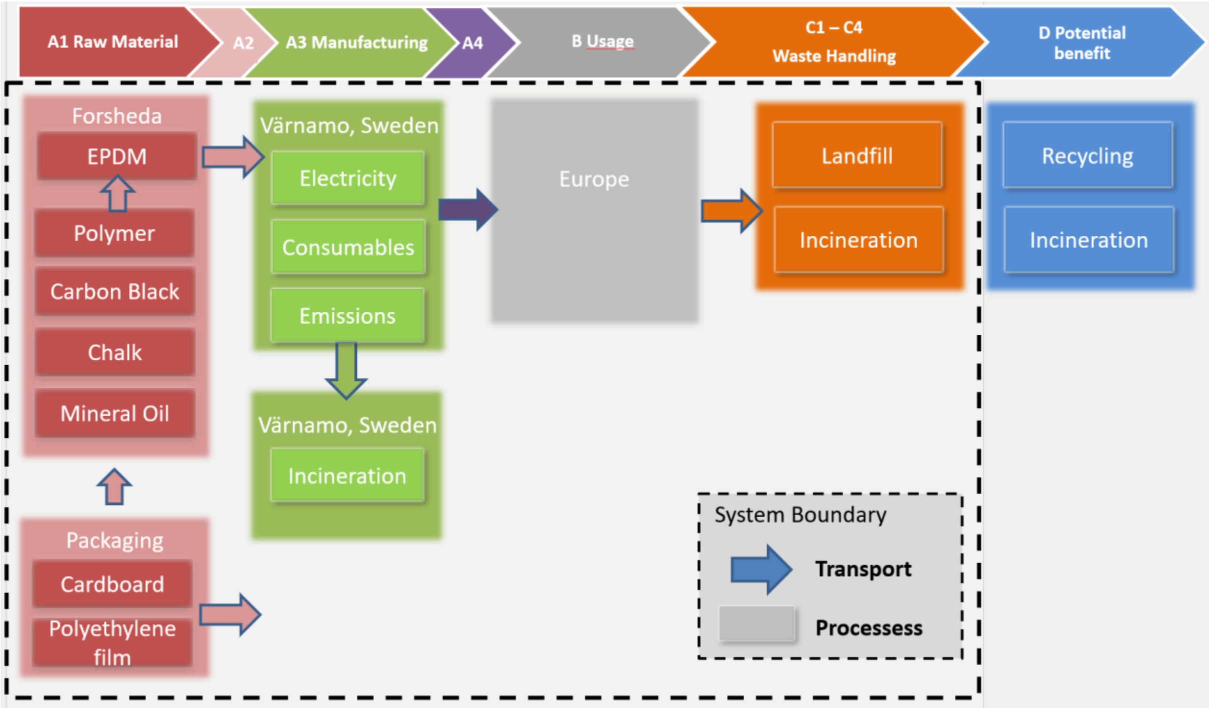

Figure 14: System boundaries for the model of the product system.

3.6 Excluded parts and "cut-off"

To ensure that all relevant environmental impacts were represented in the study, the following cut-off criteria were used:

Mass relevance - If the flow was less than 1% of the cumulative mass of all the inputs and outputs of the LCI model.
Energy relevance - If the flow was less than 1% of the cumulative energy of all the inputs and outputs of the LCI model.
Environmental relevance - If the flow met the above criteria for exclusion yet was thought to have a potentially significant environmental impact. The environmental relevance was evaluated with experience and relevant external research on similar products. If an excluded material significantly contributed to the overall LCIA, more information was collected and evaluated in the system.

The sum of the neglected material flows did not exceed 5% of mass or 1% of energy.

In addition to cut-off of material- and energy flows, also life cycle stages can be excluded if they are deemed to be of low relevance or do not cause any negative environmental effects.

An overview of processes that are excluded in this study are presented in Table 3.

Table 3: Overview of aspects that are excluded.

Excluded processes
Usage of the product

3.7 Allocation

In this report, no allocation in specific data was done.

3.8 Method of Life Cycle Impact Assessment (LCIA)

The LCIA methods are chosen to give a comprehensive and multifaceted picture of the environmental effects of the product's life cycle. In total, 19 different environmental effect categories will be used to provide different perspectives on the environmental burden.

The life cycle impact assessment (LCIA) was made with the LCA software SimaPro[2]. This software contains several well recognised and scientific LCIA-methods. The methods, impact categories, and indicators used are listed below. The methodology is further described in chapter 5.

Environmental Footprint (EF) 3.0 method is the most recently updated and comprehensive method for calculating the environmental effect categories recommended by the PCR. Furthermore, Environmental Footprint 3.0 is especially harmonised with the demands from EN 15804:2012+A2:2019. More information about the impact assessment method can be found in Appendix 1.

For calculating climate change potential, the method **IPCC 2021 GWP 100 years** is used. This is the most established method for calculating climate change potential. The category indicator is Global Warming Potential (GWP).

The **CML method** is the reference for impact categories used in the international EPD system (EPD International, 2021b). It has two different sub-methods, CML 2001 baseline[3] and CML-IA non-baseline, to handle variations in different PCRs. The version is version 4.7 (Aug 2016).

3.8.1 Environmental effect categories and Environmental indicators

The General Program Instructions (EPD International, 2021b) and the Product Category Rules of EPDs are the primary basis for choosing which environmental effect categories to include. The methods used to calculate the relevant environmental effect categories in this study are summarised in Table 4 and Table 8.

Table 4: Impact categories, indicators and methods used in the study. The chosen indicators follow the standard for Construction products EN 15804:2012+A2:2019.

Impact category	Abbreviation	Category indicator	Method
Climate Change-total	GWP total	kg CO_2 equivalents	CML 2001 baseline version 4.7 (IPCC 2013 GWP 100)
Climate Change-fossil	GWP fossil	kg CO_2 equivalents	CML 2001 baseline version 4.7 (IPCC 2013 GWP 100)
Climate Change-biogenic[4]	GWP biogenic	kg CO_2 equivalents	CML 2001 baseline version 4.7 (IPCC 2013 GWP 100)

[2] SimaPro Version 9.3 described at support.simapro.com

[3] CML-IA Characterisation Factors - Leiden University (universiteitleiden.nl)

[4] Removals of biogenic CO2 into biomass (with the exclusion of biomass of native forests) and transfers from previous product systems shall be characterised in the LCIA as –1 kg CO2 eq./kg CO2 when entering the product system. Emissions of biogenic CO2 from biomass and transfers of biomass into subsequent product systems (with the exclusion of biomass of native forests) shall be characterized as +1 kg CO2 eq./kg CO2 of biogenic carbon, see EN ISO 14067:2018, 6.5.2. (Swedish Standard Institute, 2020)

Climate Change-land use and land use change	GWP luluc	kg CO_2 equivalents	CML 2001 baseline version 4.7 (IPCC 2013 GWP 100)
Ozone-depleting gases	ODP20	CFC 11-equivalents	CML 2001 baseline version 4.7
Acidification potential (fate not included)')	AP	mol H+ eq	EF 3.0 based on ReCiPe 2008
Eutrophication aquatic freshwater	EP	kg P equivalents / kg	EF 3.0 based on ReCiPe 2008
Eutrophication aquatic marine	EP	kg N equivalents / kg	EF 3.0 based on ReCiPe 2008
Eutrophication aquatic terrestrial	EP	mol N equivalents / kg	EF 3.0 based on ReCiPe 2008
Photochemical ozone creation potential	POCP	kg NMVOC eq./ kg	EF 3.0 based on ReCiPe 2008
Abiotic resource depletion, elements	ADPe	kg Sb eq / kg	EF 3.0 based on ReCiPe 2008
Abiotic resource depletion, fossil fuels	ADPf	MJ	EF 3.0 based on ReCiPe 2008
Water Depletion	WD	m3	AWARE 1.01

Table 5: Additional environmental impact indicators and methods used in the study. SS-EN 15804:2012+A2:2019 (E).

Impact category	Indicator	Unit	Method
Particulate Matter emissions	Potential incidence of disease due to PM emissions (PM)	Disease incidence	EF 3.0 based on ReCiPe 2008
Ionising radiation, human health	Potential Human exposure efficiency relative to U235 (IRP)	kBq U235 eq.	EF 3.0 based on ReCiPe 2008
Eco-toxicity (freshwater)	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	CTUe	EF 3.0 based on ReCiPe 2008
Human toxicity, cancer effects	Potential Comparative Toxic Unit for humans (HTP-c)	CTUh	EF 3.0 based on ReCiPe 2008
Human toxicity, non-cancer effects	Potential Comparative Toxic Unit for humans (HTP-nc)	CTUh	EF 3.0 based on ReCiPe 2008
Land-use related impacts/Soil quality	Potential soil quality index (SQP)	dimensionless	EF 3.0 based on ReCiPe 2008

Table 6: Information on biogenic content.

Biogenic carbon content (1 kg = 44/12 kg CO2)	Unit per FU or DC
Biogenic carbon content in the product	Kg C
Biogenic carbon content in the accompanying packaging	Kg C

Unit conversion for LCIA results.

Some methods report the LCIA results in different units then EF 3.0. Below some common unit conversions can be seen:

Acidification: 1.31 to report kg SO2,eq as mol H +,eq
Eutrophication: 0.33 to report kg PO_4^{-3},eq. Kg P,eq
Photochemical Ozone Creation Potential: 1.69 to report kg C2H4,eq as kg NMVOC,eq

Table 7: Resource use to be declared in the study.

Resource	Unit
Use of renewable primary energy excluding primary energy resources used as raw material (PERE)	MJ
Use of renewable primary energy resources used as raw material (PERM)	MJ
Total use of renewable primary energy (PERT)	MJ
Use of non-renewable primary energy excluding primary energy resources used as raw material (PENRE)	MJ
Use of non-renewable primary energy resources used as raw material (PENRM)	MJ
Total use of non-renewable primary energy (PENRT)	MJ
Use of recycled or recycled materials (secondary materials)	Kg
Use of renewable secondary fuels	MJ
Use of non-renewable secondary fuels	MJ
Net use of freshwater	m3

Table 8: Waste materials to be declared in the study.

Rest materials	Unit
Hazardous waste	Kg
Non-hazardous waste	Kg
Radioactive waste, disposed/stored	Kg
Outputs, secondary materials and exported energy	
Material for reuse	Kg
Recycling material	Kg
Material for energy recovery	Kg
Exported energy	MJ

3.9 Data requirements (DQR)

The data quality and representativeness will be assessed in part 6.2 Data quality assessment based on the guidelines established in the EN 15804:A2 standard.
The following data quality requirements are used for all the central LCI data. The more peripheral aspects may deviate from the DQI based on the rule for "cut off".

- Geographical coverage: **The processes included in the data set are well represented for the geography stated in the "location" indicated in the metadata**
- Technology presentiveness: **Average technology or BAT**[5]

[5] BAT (Best Available Technology or Best Available Techniques) signifies the latest stage in development of activities, processes and their method of operation which indicate the practical suitability of particular techniques as the basis of emission

- Time related coverage: **2014 and after**
- Multiple output allocation: **Physical causality**
- Substitution allocation: Not applicable
- Waste treatment allocation: Not applicable
- Cut-off rules: **Less than 1% environmental relevance**
- System boundary: **Second order (material/energy flows including operations)**
- The boundary with nature: **Agricultural production is part of the production system**

3.10 Assumptions

Assumptions that are general to the entire LCA are:

- Choice of transport model: all transportation with lorry have been assumed to be with emissions standard Euro 5.
- Transport distances have been based on Google Maps for road transportation and a port routing tool (e.g. Sea Distances or Port World) for sea transports. Possible deviating routes have not been included in the calculations.

Specific assumptions are presented in the section for the life cycle inventory, see chapter 4 Life cycle inventory (LCI).

3.11 Type of critical review, if any

A critical review will be carried out according to the International Standards ISO 14040 and 14044 (ISO 2006 b,c) as well as the applied PCR. The LCA will be reviewed according to the following five aspects outlined in ISO 14040. It is assessed whether:

- the methods used to carry out the LCA are consistent with this International Standard and in line with the applied PCR.
- the methods used to carry out the LCA are scientifically and technically valid
- the data used are appropriate and reasonable in relation to the goal of the study
- the interpretations reflect the limitations identified and the goal of the study, and
- the study report is transparent and consistent.

A critical review is necessary to allow for external communication and comparison with results from other studies. This is a public study with comparative assertions. The EPD and this underlying LCA report are reviewed by a third party, Dr Hudai Kara of Metsims Sustainability Consulting, www.metsims.com.

This LCA report was internally reviewed by Marcus Bernhard.

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limit values, linked to environmental regulations, such as the European Industrial Emissions Directive (IED, 2010/75/EU). In determining whether operational methods are BAT, consideration is given to economic feasibility and the availability of techniques to carry out the required function. The BAT concept is closely related to BEP (Best Environmental Practice), which is the best environment-friendly company practice.

4 Life cycle inventory (LCI)

In the life cycle inventory, the product system is defined and described. Firstly, the material flows and relevant processes required for the product system are identified. Secondly relevant data (i.e. resource inputs, emissions and product outputs) for the system components are collected and their amounts related to the defined functional unit.

4.1 Product content declaration

This part describes all the different components, packaging materials and substances of very high concern.

All products are different types of EPDM. The EPDM polymer is manufactured by the same raw material but in different relations for other characteristics of the material. The finished EPDM material with fillers is manufactured by the supplier Trelleborg AB in Forsheda, Sweden and is transported to SealEco in Värnamo, Sweden. At SealEco the finished EPDM is then calendared and cut before a vulcanisation process.

Table 9 show the raw material input and amount per the FU 1m2 with the thickness and weight given in Table 2 . All materials will be further described under 4.3.

Table 9: Content declaration in kg per 1m2 for the five studied products.

Product components	CladSeal EXT	ElastoSeal	Prelasti Fleece	Prelasti FR	Prelasti S
EPDM polymer	0.208	0.318	0.441	0.478	0.411
Carbon black	0.301	0.470	0.397	0.239	0.452
Chalk	0.199	0	0	0	0.165
Mineral oil	0.199	0.273	0.220	0.072	0.206
Magnesium Hydroxide	0	0	0.441	0.532	0
Aliphatic resin	0.015	0.022	0.066	0.072	0.037
Zinc oxide	0.010	0.014	0.035	0.022	0.019
Stearic	0.002	0.003	0.004	0.005	0.004
Sulphur	0.003	0.004	0.004	0.006	0.005
CBS	0.003	0.005	0.008	0.008	0.006
TBBS	0.001	0.002	0.002	0.003	0.002
Total Weight					
	0.941	1.111	1.618	1.437	1.307
Packaging materials					
Cardboard core	0,012	0,012	0,057	0,012	0,012
PE Foil	0,005	0,005	0,006	0,005	0,005
Substances of Very High Concern (SVHC)					
None					

SVHC and the Candidate List of SVHC are available via the European Chemicals Agency[6].

4.2 Input data references

Table 10 shows the contact at SealEco that have supplied specific data input concerning raw material, transport and manufaturing.

Table 10: List of supplier contacts

Name	Jan Wullerman
e-mail	jan.wulleman@sealeco.com
Phone number	
Position in company	
Supplier	Trelleborg
Name	Carl Cumming
e-mail	Carl.cumming@trelleborg.com
Phone number	0768814060
Position in company	

[6] Candidate List of substances of very high concern for Authorisation - ECHA (europa.eu)

4.3 Raw material (A1 + A2)

This part describes all the different raw materials needed for the manufacturing of the EPDM polymer used as raw material for all studied products. All raw materials come from Germany and is transported 975km by truck to Trelleborg mixing facility in Forsheda, Sweden. The finished material for each product is then transported 15km by truck to SealEco facility in Värnamo. Sweden.

4.3.1 EPDM polymer

Ethylene Propylene Diene Monomer (EPDM) is a copolymer of ethylene, propylene, and a small amount of non-conjugated diene monomers (3 – 9 percent) which provide cross-linking sites for vulcanisation . EPDM elastomers have excellent heat, ozone/weathering, and aging resistance. They also exhibit excellent electrical insulation, compression set, and low temperature properties, but only fair physical strength properties.

The EPDM polymer will be represented with polyethylene and polypropylene with a global market dataset. The global market dataset is used because no specific data concerning the origin could be found and means that the source of the polymer will be distributed according to the world market production 2021.

Table 11 show details on how the material EPDM polymer is modelled.

Table 11, shows details on how EPDM polymer is modelled.

EPDM polymer	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
60%	Polyethylene, high density, granulate {GLO}| market for | Cut-off	0	0	Global
40%	Polypropylene, granulate {GLO}| market for | Cut-off	0	0	Global

4.3.2 Chalk

Chalk is a soft, white, porous, sedimentary carbonate rock. It is a form of limestone composed of the mineral calcite. Chalk as filler will increase the stiffness and hardness of the EPDM.

Table 12 show details on how the material Chalk is modelled.

Table 12, shows details on how Chalk is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin

Chalk	Calcium carbonate, precipitated {RER}| calcium carbonate production, precipitated | Cut-off	0	0	Europe

4.3.3 Carbon black

Carbon black is a fine carbon powder produced by the incomplete combustion of heavy petroleum products. Carbon black is added to polypropylene because it absorbs ultraviolet radiation, which otherwise causes the material to degrade.

Table 13 show details on how the material Carbon black is modelled.

Table 13, shows details on how carbon black is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
Carbon black	Carbon black {GLO}| production | Alloc Def	0	0	Europe

4.3.4 Mineral oil

Mineral oil is added to improve the viscosity of the EPDM.

Table 14 show details on how the mineral oil is modelled.

Table 14, shows details on how mineral oil is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
Mineral oil	Lubricating oil {RER}| market for lubricating oil | Cut-off	0	0	Europe

4.3.5 Magnesium hydroxide

Magnesium hydroxide is added to make the EPDM flame retardant.

Table 15 show details on how magnesium hydroxide is modelled.

Table 15, shows details on how magnesium hydroxide is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
Magnesium hydroxide	Magnesium oxide {GLO}| market for | Cut-off	0	0	Global

4.3.6 Aliphatic resin

Aliphatic resin is a glue product that is added as additive to improve tack and peel strength of the final product.

Table 16 show details on how the material aliphatic resin is modelled.

Table 16, shows details on how aliphatic resin is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
Aliphatic resin	Polyurethane adhesive {GLO}| polyurethane adhesive production | Cut-off	0	0	Global

4.3.7 Zinc oxide

Zinc oxide additive protect from solar radiation and decreases its oxidation rate.

Table 17 show details on how zinc oxide is modelled.

Table 17, shows details on how zinc oxide is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
Zinc oxide	Zinc oxide {RER}| production | Alloc Def	0	0	Europe

4.3.8 Stearic

Stearic acid is added as lubrication in the plastic molding process.

Table 24 show details on how stearic acid is modelled.

Table 18, shows details on how stearic acid is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
Stearic acid	Stearic acid {GLO}| stearic acid production | Cut-off	0	0	Europe

4.3.9 Sulphur

Sulphur is added as an antioxidant to react with and decompose polymer peroxide to inert substances.

Table 19 show details on how sulphur is modelled.

Table 19, shows details on how sulphur is modelled.

	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
Sulphur	Sulfur {GLO}| market for | Cut-off	0	0	Global

4.3.10 CBS

CBS is an organic oil-based material used as an accelerator when producing rubber. Its molecular formula is C13H16N2S2 and the CAS number is 95-33-0. Its composition is 80% active ingredient and 20% rubber binder. The total sulphur content is 19,5%.

No good representation is found for CBS, therefore a general dataset for organic chemicals will be used. CBS stand for around 0,5% of the total material composition for the five products, and could fall under the cut off criteria, but it is evaluated that a general representation will give a more robust result and avoids an underestimate of the environmental burden.

Table 20 show details on how CBS is modelled.

Table 20, shows details on how CBS is modelled.

CBS	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
80%	Chemical, organic {GLO}| market for | Cut-off	0	0	Global
20%	Sulfur {GLO}| market for | Cut-off	0	0	Global

4.3.11 TBBS

TBBS is also an organic oil-based material used as an accelerator when producing rubber. Its molecular formula is C11H14N2S2, and the CAS number is 95-31-8. Its composition is 80% active ingredient and 20% rubber binder. The total sulphur content is 21%.

No good representation is found for TBBS, therefore a general dataset for organic chemicals will be used. CBS stand for around 0,2% of the total material composition for the five products, and could fall under the cut off criteria, but it is evaluated that a general representation will give a more robust result and avoids an underestimate of the environmental burden.

Table 21 show details on how TBBS is modelled.

Table 21, shows details on how TBBS is modelled.

TBBS	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
79%	Chemical, organic {GLO}| market for | Cut-off	0	0	Global
21%	Sulfur {GLO}| market for | Cut-off	0	0	Global

4.3.12 Fleece

For Prelasti Fleece a layer of fleece is added to the finished EPDM. This fleece textile is made by polyethylene and bought finished from a supplier in France and transported 1809km by truck to Värnamo, Sweden. The fleece textile has a density of 0,3227kg per m2 and one square meter will be added to the rest of the finished product.

The transportation of the fleece adds 45g of cardboard box packaging per m2 of fleece raw material.

Table 21 show details on how the polyethylene fleece is modelled.

Table 22, shows details on how polyethylene fleece is modelled.

Polyethylene fleece	LCI data representation in ecoinvent 3.8	Recycled content (%)	Biogenic content (%)	Geographical origin
	Fleece, polyethylene {RER}| production | Cut-off, U	0	0	Europe

4.3.13 Raw material packaging

The finished raw material is sent to SealEco in Värnamo, Sweden in a cardboard box and wrapped in PE foil. In total the weight packaging per m2 is 0,005kg PE foil and 0,012kg cardboard box. The cardboard box is manufactured by Scandicore Nordenspapperindustrier in Borås, Sweden and transported 92km by truck to Trelleborg mixing facility in Forsheda, Sweden. The PE-foil is manufactured by Trioplast in Smålandsstenar, Sweden and is transported 30km by truck to Forsheda, Sweden.

Table 23 show details on how the raw material packaging is modelled.

Table 23, show details on how the raw material packaging is modelled.

Raw material packaging	LCI data representation in ecoinvent 3.8	Amount in kg per m2 product	Recycled content (%)	Biogenic content (%)	Geographical origin
PE foil	Packaging film, low density polyethylene {RER}| production | Cut-off	0,005	0	0	Global
Cardboard box	Corrugated board box {RER}| production | Cut-off	0,012	41	100	Global

4.4 Manufacturing (A3)

In this chapter, the activities carried out by SealEco are presented. All activities are presented per the manufacturing of 1m2 of the different products.

All products go through the same manufacturing process, a flow diagram can be seen in

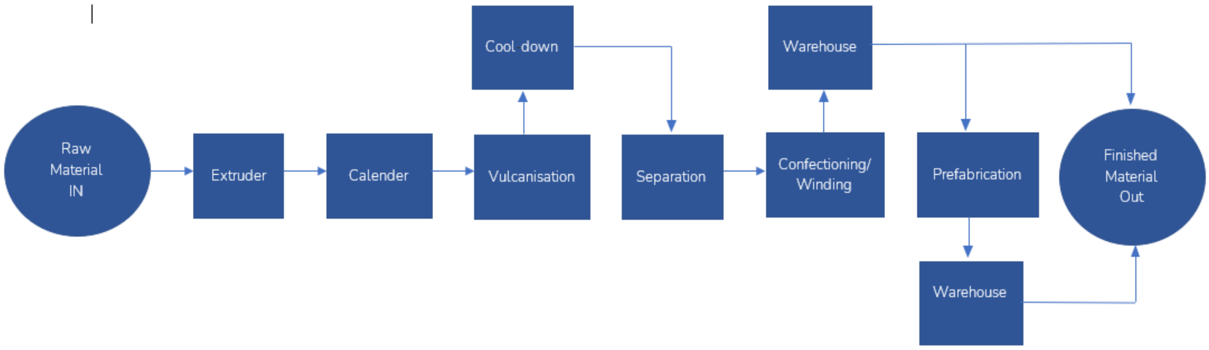


Figure 15, show a flow diagram of the manufacturing process. (In Swedish)

First the compound from the supplier is run through a calendar machine, to get the right dimension on the order.
Secondly the product is moved to the vulcanisation furnaces. Vulcanisation is a chemical process in which the rubber is heated with sulphur, accelerator and activator at 140–160°C. The process involves the formation of cross-links between long rubber molecules to achieve improved elasticity, resilience, tensile strength, viscosity, hardness and weather resistance.

After vulcanisation the product is checked and packaged according to specific customer order.

4.4.1 Energy

Energy demand per product is calculated from the total energy demand for manufacturing all types of products in 2021 and then divided by the total m2 manufactured. Because of the similar manufacturing process for all types of products the generalisation with the same energy demand should give a plausible result for all products.

Table 24: Energy use in production of 1m2 finished product.

Energy type	Energy source	LCI data representation	Amount (kWh, kg, m^3)	Certificate?	Comment
Electricity	Swedish energy grid	*Residual mix Electricity, low voltage {Nordic}| market for | Cut-off	0,427989	No	GPI 4.0 stipulates to use Nordic residual mix if the electricity have no origin certified.

- This mix is created by Miljögiraff according to the energy mix of the Nordic residual mix defined by Grexel 2020. The mix is 55% fossil, 37% nuclear and 8% percent renewable. The residual mix is the remaining electricity mix after certified electricity is removed.

4.4.2 Direct emissions

The gases from the vulcanisation process are cleaned by filters but some emissions are released to the air.

Table 25: Direct emissions to air per finished 1m2

Emission	Amount (mg)	Compartment (Air, water, ground)
Hydrocarbon	1,74	Air
Dust particles	0,58	Air

4.4.3 Consumables

Textile fabrics are reused after cleaning. They are used around 40 times before discarded.

Oil for hydraulic and gear boxes are used in manufacturing.

Transport distance for the consumables have been estimated.

Table 26: Consumables used in production per 1m2.

Type of consumable	Material	Amount (kg)	LCI data representation in ecoinvent 3.8	Transport type	Transport distance (km)
Fabric	Cotton fabric	0,002	Textile, knit cotton {GLO}| market for | Cut-off	Truck	150
Oil	Oil	0,00000255	Lubricating oil {RER}| market for lubricating oil | Cut-off	Truck	150

4.4.4 Packaging

Table 27: Packaging used for product per finished 1m2.

Type of Packaging	Material	Amount (kg)	LCI data representation in ecoinvent 3.8	Transport type	Transport distance (km)
PE Foil	LDPE	0,005	Packaging film, low density polyethylene {RER}| production | Cut-off	Truck	43
Cardboard core	Cardboard	0,012	Core board {RER}| production | Cut-off	Truck	137
Euro pallet	Wood	1 pallet per 1020m2	EUR-flat pallet {RER}| market for EUR-flat pallet | Cut-off, U		

4.4.5 Internal transports

There are internal trucks for maintenance and transport of raw material.

Table 28: Internal transports in fuel per finished 1m2.

Transport type	type of fuel	Amount in litre
Truck	Diesel	0,00006

4.4.6 Manufacturing waste

When the product is cut to the preferred size before vulcanisation all material can be internally recycled and is therefore not added to this part.

After vulcanisation 2,8% of the finished products is discarded due to quality issues. Stena Recycling transport the waste to the closest waste management plant in Torsvik, 55km from the manufacturing site. The quantity depends on the density described under 3.3.1, an average is documented in Table 29.

Also, raw material packaging and consumables is externally handled and transported to the same waste management plant.

Table 29: Manufacturing waste types and treatment

Waste type	Waste transport type	Waste transport distance (km)	Waste quantity in average (kg)	Waste treatment
Finished product	Truck	55	0,035	Incineration
Soiled textile	Truck	55	0,002	Incineration
PE foil	Truck	55	0,005	Incineration
Cardboard box	Truck	55	0,012	Recycling

4.5 Transport of finished goods (A4)

The finished products are loaded on a truck and transported to warehouses in the main markets of Sweden, Netherlands and Belgium. Sweden, Netherlands and Belgium are not the sole markets of the SealEco products but stands for a majority and gives a good representation. The transport of finished products is the same for all products.

The transportation from the warehouses is assumed to be the same for the three main markets and estimated to 75km on average.

Table 30: Distribution of products

Market	Market percentage	Road transport type	Road transport distance (km)	Comment
Sweden	45,5	Diesel Truck 16-32t	0+75	
Netherlands	36,3	Diesel Truck 16-32t	1080+75	

Belgium	18,2	Diesel Truck 16-32t	1150+75	

4.6 End-of-Life (C1-C4)

The end-of-life phase handles the product and the material it consists of after its use. The final handling includes dismantling of the product, transport to a facility for waste treatment, any energy and materials used for preparation for waste treatment and final waste treatment. If the material is recycled or reused into a new product, the environmental aspects of the processing of the secondary material are allocated to the life cycle of the new product.

The End-of-Life scenario is set as an average of handling construction waste in Sweden, Netherlands and Belgium according to Eurostat (EuroStat, 2020). Vulcanised rubber cannot be recycled as conventional recycling for plastics. There are ways of recycling vulcanised EPDM but they are not widely used. Following the recommendation of the International EPD system the situation today stipulates the End-of-Life scenario. So even if it is plausible that recycling of EPDM will increase in the future when the products manufactured today are discarded, this will not be in the main End-of-Life scenario. However, different End-of-Life scenarios will be investigated in the interpretation of the result.

The strong attachment to the underlaying surface makes sorting of the EPDM as an individual material harder when deconstructing a building or a roof. In turn, this make landfill a more plausible End-of-Life scenario as mixed waste is not suited for energy recovery.

It is assumed that 75% of the products are manually dismantled and can therefore be sorted. The other 25% will be part of mixed construction waste that ends up at a landfill for inert material. Even if the material is sorted out it is not guaranteed that the material is energy recovered. A large portion of construction waste is sent to landfill in all the countries where the End-of-Life occur as can be seen in the EuroStat (EuroStat, 2020). The portion of Landfill and energy recovery are distributed according to the stats.

Table 31: End of life scenarios for the product.

Location	Recycling %	Incineration %	Landfill %
Sweden	0	70	30
Netherlands	0	70	30
Belgium	0	70	30

4.6.1 End-of-Life Packaging

The packaging consists of PE-foil and a cardboard box. Due to other material composition and time they will be sent to disposal, these will not follow the same disposal scenario as the product. Instead, it will be assumed that the plastic is sent to incineration and the cardboard box to recycling. The assumption is a little simplification but due to the very small amount it is considered to be negligible. The potential benefit from the material and energy recovery is also added to module D.

4.6.2 Dismantling (C1)

The EPDM membranes are fixed to the surface they are protecting by means of adhesives or mechanical fixations. In both cases the product can be separated from the surface with manual labour with force or screwdriver. In both cases no environmental aspects occur or is considered so small it falls under the cut-off of the study.

4.6.3 Transport to waste management (C2)

The waste from the dismantled construction and the packaging is assumed to be transported 30km to the closest waste management plant by truck.

Table 32: Transport to waste management site

Road transport type	Road transport distance (km)	Comment
Truck	30	Assumption

4.6.4 Waste treatment (C3)

Neither for the incineration or landfill of the waste any previous waste treatment is needed.

4.6.5 Final disposal (C4)

Table 33 show the amount and treatment of the final disposal of the waste. The amount is set as an average for the five products but are individually calculated in the result.

Table 33, show the final disposal of the waste.

Type of final disposal	Amount in average (kg)	LCI data representation in ecoinvent 3.8	Comment
Incineration	0,88	Waste rubber, unspecified {Europe without Switzerland}| treatment of waste rubber, unspecified, municipal incineration | Cut-off	
Landfill	0,38	Inert waste, for final disposal {CH}| treatment of inert waste, inert material landfill | Cut-off	

4.7 Benefits from material recycling or energy recovery (D)

4.7.1 Benefits from End-of-Life waste

The benefits from energy recovery are calculated according to 2.4.1.1. The avoided type of heat is based on the biggest source of heat for each specific country. For Belgium it is gas with 42% of the heat (Brian Vad Mathiesen, 2015), for Netherland it is gas with 92% of all heat from gas and for Sweden it is biomass.

Energy allocation is assumed to be 50% of the energy is converted to electricity and 50% to heat.

Assuming 80% energy efficiency in incineration, the assumption is that global average incineration is likely somewhat lower than Swedish CHP plants with efficiency 90-93% without flue gas condensation (Rydegran, 2021).

The ratio of energy will be divided according to market distribution described in 4.5.

Total energy recovered will be calculated as:
*Material sent to incineration * Energy content * Energy Allocation * Energy efficiency * Market distribution*

Table 34 show the result for the product CladSeal EXT, but every product will be individually calculated in the result.

Table 34: Benefits from energy recovery of product CladSeal EXT

Benefit	LCI data representation in ecoinvent 3.8 (avoided activity)	Material sent to incineration (weight * incineration rate)	Energy content of waste LHV (MJ/kg)	Total energy recovered in kWh
Energy recovery EPDM, production of electricity Belgium	Electricity, medium voltage {BE}| market for | Cut-off	0,88	42,1	2,02
Energy recovery EPDM, production of electricity Netherlands	Electricity, medium voltage {NL}| market for | Cut-off	0,88	42,1	4,02
Energy recovery EPDM, production of electricity Sweden	Residual mix Electricity, low voltage {Nordic}| market for | Cut-off	0,88	42,1	5,04
Energy recovery EPDM, production of heat Belgium	Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler condensing modulating >100kW | Cut-off, U	0,88	42,1	2,02
Energy recovery EPDM, production of heat Netherlands	Heat, district or industrial, natural gas {Europe without Switzerland}| heat production, natural gas, at boiler condensing modulating >100kW | Cut-off, U	0,88	42,1	4,02

Benefit	LCI data representation in ecoinvent 3.8 (avoided activity)	Material sent to incineration (weight * incineration rate)	Energy content of waste LHV (MJ/kg)	Total energy recovered in kWh
Energy recovery EPDM, production of heat Sweden	Heat, district or industrial, other than natural gas {SE}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	0,88	42,1	5,04

5 Life cycle impact assessment (LCIA)

5.1 Method for impact assessment

The methods chosen for assessing the life cycle impact are called **Environmental Footprint 3.0, CML 2001** and **IPCC 2021 GWP 100.**

In sections 5.1.1-5.1.4 follow some theory behind the modelling and calculations carried out for this report.

5.1.1 Classification and characterisation

The process of determining what effects an environmental aspect can contribute to is called classification, e.g. that the use of water contributes to the environmental effect of water depletion. Characterisation in turn means defining how much an environmental aspect contributes to the environmental impact category to which it is classified, e.g. the use of 1 tonne of river water contributes a factor of 0.5 to water depletion. Evaluating how critical it is in a specific area depends on the current environmental impact, the pressure from resource consumption and the ecosystem's carrying capacity. This is done through normalisation.

5.1.2 Weighting

To compare between different environmental effects and to identify "hot spots", so-called *weighting* is applied. The calculated environmental effects are weighted together to form an index called a "*single score*" which describes the total environmental impact.

Because weighting involves subjective weighting (e.g. by an expert panel) it is recommended for internal communication only. Otherwise, there is a risk of mistrust if the choice of weighting method used leads to results that emphasise the "upsides" and hide the "downsides" of the analysed product. For external communication, only *Single issues* should be communicated.

5.1.3 LCIA method Environmental Footprint 3.0

The method Environmental Footprint 3.0 divides the total environmental impact of the life cycle into 19 different categories. The method provides the opportunity for results at both the so-called midpoint and endpoint level. Midpoint means that each environmental impact category is characterised as a common unit. At the endpoint level, each category is awarded points based on the quantity calculated at the midpoint level. This provides an estimation of how serious the environmental effect is, where a higher score indicates a more serious environmental effect. In endpoint, all categories can also be weighted relative each other and added to generate a point for the entire life cycle. The endpoint level can then provide a total assessment of the environmental impact, which provides an opportunity to assess the various environmental impact categories against each other and to compare the total environmental impact with other products. The different environmental impact categories are described in more detail in Appendix 1.

5.1.4 Single issues

In contrast to weighted results which are the combined results from many different environmental effect categories, *single issues* focus on just one issue. It is important to break out some single issues that are relevant for the analysed product both considering the environment and marketing. All the different environmental effect categories will still be accounted for in the weighted result.

IPCC 2021 is the successor of the IPCC 2013 method, which was developed by the Intergovernmental Panel on Climate Change. It contains the climate change factors of IPCC with a timeframe of 100 years and calculates the single issue of climate change potential.

5.1.5 Description relevant environmental effect categories

Acidification – EF impact category that addresses impacts due to acidifying substances in the environment. Emissions of NOx, NH3 and SOx lead to releases of hydrogen ions (H+) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.

Climate change - All inputs or outputs that result in greenhouse gas emissions. The consequences include increased average global temperatures and sudden regional climatic changes. Climate change is an impact affecting the environment on a global scale.

Ecotoxicity, freshwater – Environmental footprint impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure and function of the ecosystem. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem.

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).

Eutrophication – Nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilised farmland accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass. Three EF impact categories are used to assess the impacts due to eutrophication: Eutrophication, terrestrial; Eutrophication, freshwater; Eutrophication, marine.

Human toxicity – cancer: Impact category that accounts for adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to cancer.

Human toxicity - non cancer: Impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to noncancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.

Ionising radiation, human health – EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.

Land use: The land use impact category reflects the damage to ecosystems due to the effects of occupation and transformation of the land. Although there are many links between the way land is used and the loss of biodiversity, this category concentrates on the following mechanisms:

1. Occupation of a certain area of land during a certain time;
2. Transformation of a certain area of land.

Both mechanisms can be combined, often occupation follows a transformation, but often occupation occurs in an area that has already been converted (transformed). In such cases, the transformation impact is not allocated to the production system that occupies an area.

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

Ozone depletion – EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. CFCs, HCFCs, Halons).

Particulate matter formation – Fine Particulate Matter with a diameter of smaller than 10 µm (PM10) represents a complex mixture of organic and inorganic substances. PM10 causes health problems as it reaches the upper part of the airways and lungs when inhaled. Secondary PM10 aerosols are formed in air from emissions of sulphur dioxide (SO2), ammonia (NH3), and nitrogen oxides (NOx) among others (World Health Organisation, 2003). Inhalation of different particulate sizes can cause different health problems.

Photochemical ozone formation – EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NOx) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.

Resource use, fossil: Impact category that addresses the use of non-renewable fossil natural resources (e.g. natural gas, coal, oil).

Resource use, minerals and metals: Impact category that addresses the use of non-renewable abiotic natural resources (minerals and metals).

Water use – It represents the relative available water remaining per area in a watershed, after the demand of humans and aquatic ecosystems has been met. It assesses the potential of water deprivation, to either humans or ecosystems, building on the assumption that the less water remaining available per area, the more likely another user will be deprived (see also http://www.wulca-waterlca.org/aware.html).

5.2 Results

In this part, the result from the different environmental impact assessment methods will be presented. First, the results from the method Environmental Footprint 3.0 (EF), Midpoint and Endpoint are presented, second from the method IPCC GWP 2013 100 and third the 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 5-6% of total impacts are shown in the diagram.

Result structure:

- 5.2.1 CladSeal EXT
- 5.2.2 ElastoSeal
- 5.2.3 Prelasti S
- 5.2.4 Prelasti Fleece
- 5.2.5 Prelasti FR
- 5.3 Comparison all products

5.2.1 Results CladSeal EXT

5.2.1.1 Environmental Footprint Midpoint

Table 35 shows the result per FU according to the LCIA method Environmental footprint 3.0 midpoint level.

Table 35: Environmental footprint midpoint results

Impact category		Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
GWP	Fossil	kg CO_2 eq	2.48E+00	2.45E-03	3.79E-01	2.92E+00	1.06E-01	0.00E+00	4.77E-03	0.00E+00	2.09E+00	-2.05E+00
	Biogenic	kg CO_2 eq	-3.78E-02	2.09E-06	-2.90E-02	-9.57E-02	9.01E-05	0.00E+00	4.07E-06	0.00E+00	2.31E-04	-1.06E-02
	LULUC	kg CO_2 eq	1.15E-03	9.63E-07	1.45E-03	2.79E-03	4.15E-05	0.00E+00	1.87E-06	0.00E+00	1.18E-05	-8.79E-04
	Total	kg CO_2 eq	2.45E+00	2.45E-03	3.52E-01	2.83E+00	1.06E-01	0.00E+00	4.78E-03	0.00E+00	2.09E+00	-2.06E+00
ODP		kg CFC11 eq	6.68E-07	5.67E-10	1.84E-08	6.91E-07	2.45E-08	0.00E+00	1.10E-09	0.00E+00	5.00E-09	-1.60E-07
AP		mol H+ eq	1.24E-02	9.95E-06	1.01E-03	1.37E-02	4.29E-04	0.00E+00	1.94E-05	0.00E+00	3.14E-04	-4.59E-03
EP- Freshwater[7]		kg PO_4^{-3} eq	1.96E-03	5.84E-07	3.43E-04	2.38E-03	2.52E-05	0.00E+00	1.14E-06	0.00E+00	1.97E-05	-2.26E-03
EP - Freshwater		kg P eq	5.29E-04	1.58E-07	9.27E-05	6.42E-04	6.81E-06	0.00E+00	3.07E-07	0.00E+00	5.33E-06	-6.12E-04
EP - Marine		kg N eq	2.14E-03	3.00E-06	5.40E-04	2.78E-03	1.29E-04	0.00E+00	5.83E-06	0.00E+00	1.22E-04	-1.20E-03
EP – Terrestrial		mol N eq	2.22E-02	3.27E-05	2.78E-03	2.57E-02	1.41E-03	0.00E+00	6.37E-05	0.00E+00	1.32E-03	-1.28E-02
POCP		kg NMVOC eq	1.19E-02	1.00E-05	5.80E-04	1.27E-02	4.32E-04	0.00E+00	1.95E-05	0.00E+00	3.27E-04	-3.20E-03
ADPE[8]		kg Sb eq	2.89E-05	8.52E-09	5.27E-07	2.98E-05	3.67E-07	0.00E+00	1.66E-08	0.00E+00	1.18E-07	-2.60E-06
ADPF[11]		MJ	7.48E+01	3.71E-02	6.31E+00	8.23E+01	1.60E+00	0.00E+00	7.21E-02	0.00E+00	3.36E-01	-4.01E+01
WSF[11]		m3 depriv.	1.73E+00	1.11E-04	3.95E-01	2.16E+00	4.78E-03	0.00E+00	2.16E-04	0.00E+00	2.40E-02	-3.78E-01
PM		disease inc.	1.67E-07	2.12E-10	6.17E-09	1.76E-07	9.12E-09	0.00E+00	4.12E-10	0.00E+00	1.73E-09	-2.43E-08
IR[9]		kBq U-235 eq	7.32E-01	1.91E-04	1.88E-01	9.26E-01	8.21E-03	0.00E+00	3.71E-04	0.00E+00	1.57E-03	-8.94E-01
ETP – FW[11]		CTUe	5.39E+01	2.89E-02	4.58E+00	5.93E+01	1.25E+00	0.00E+00	5.63E-02	0.00E+00	3.42E+00	-2.46E+01
HTP - C[11]		CTUh	2.03E-09	9.37E-13	1.24E-10	2.21E-09	4.04E-11	0.00E+00	1.82E-12	0.00E+00	2.59E-11	-3.76E-10
HTP - NC[11]		CTUh	3.76E-08	3.04E-11	2.01E-09	4.03E-08	1.31E-09	0.00E+00	5.92E-11	0.00E+00	1.41E-09	-1.11E-08
SQP[11]		Pt	1.46E+01	2.55E-02	3.62E+00	2.11E+01	1.10E+00	0.00E+00	4.96E-02	0.00E+00	1.95E-01	-1.53E+01

[7] For the impact category Eutrophication, freshwater, the result per unit kg P is used as basis for calculating the result per unit kg PO_4^{-3} eq, using the factor 3,07

[8] **Disclaimer:** The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

[9] **Disclaimer:** This impact category 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.

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
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										
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, **B1:** Use, **B2:** Maintenance, **B3:** Repair, **B4:** Replacement, **B5:** Refurbishment, **B6:** Operational Energy Use, **B7:** Operational Water Use, **C1:** Deconstruction, **C2:** Waste Transport, **C3:** Waste Processing, **C4:** Disposal, **D:** Reuse, Recovery, Recycling Potential										

5.2.1.2 Results Climate change

Table 36 show the climate change potential expressed as kg CO2 eqv. Calculated with the method IPCC 2021 GWP 100. Figure 16, show a Sankey diagram on how the emissions of CO2 eqv. is distributed throughout the life cycle. Cut off 5%.

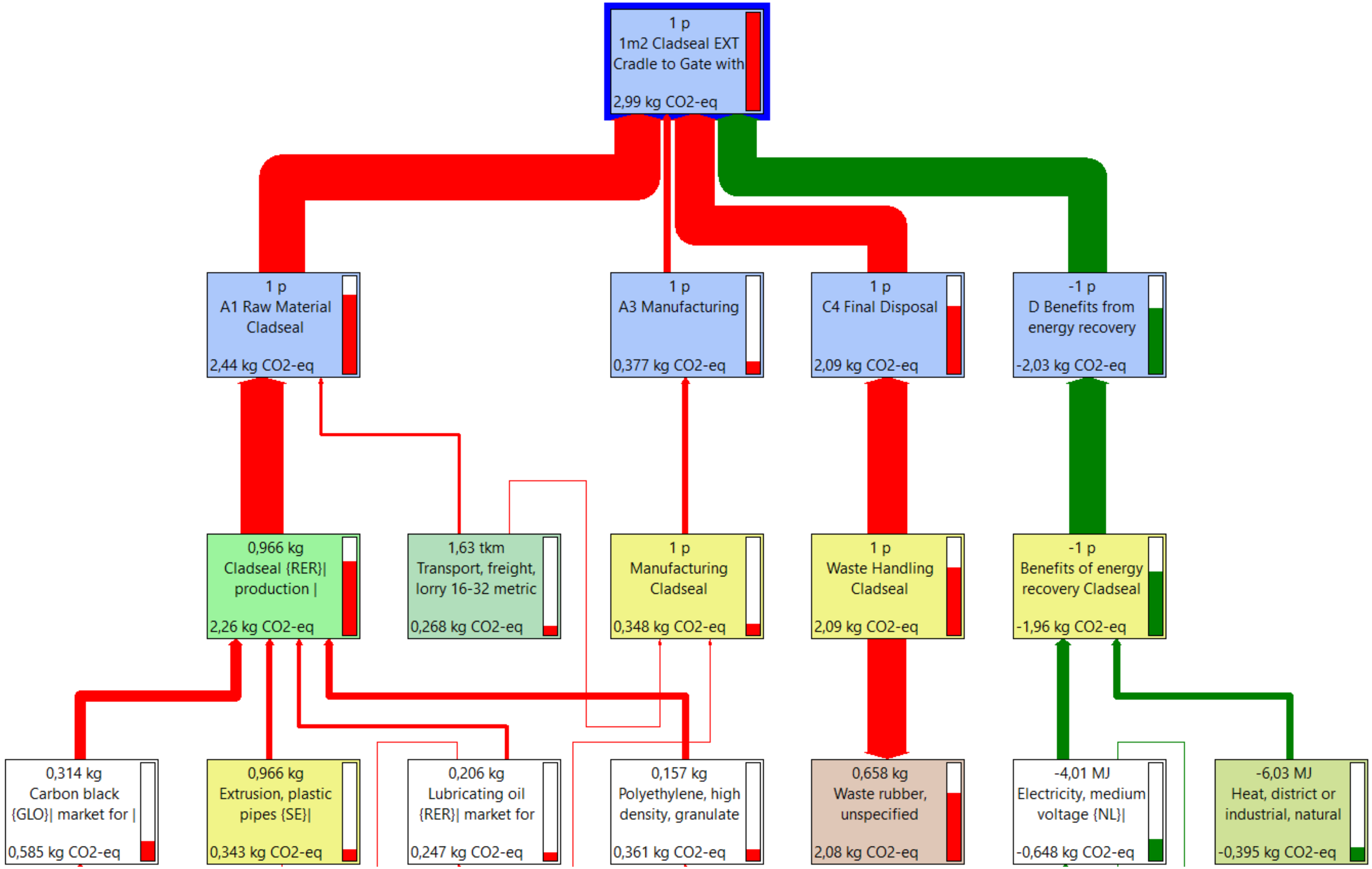


Figure 16, show a Sankey diagram on how the emissions of CO2 eqv. is distributed throughout the life cycle. Cut off 5%.

Table 36, show the result from the method IPCC 2021 GWP 100 concerning climate change potential.

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
GWP-GHG[10]	kg CO_2 eq.	2.44E+00	2.43E-03	3.77E-01	2.87E+00	1.05E-01	0.00E+00	4.73E-03	0.00E+00	2.09E+00	-2.03E+00

5.2.1.3 Use of resources

Table 37 show the use of resources

Table 37, show the use of resources.

Results per 1m² of finished product with a thickness of 0,75mm											
Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	2.26E+00	5.22E-04	7.43E-01	3.58E+00	2.25E-02	0.00E+00	1.02E-03	0.00E+00	1.52E-02	-4.67E+00
PERM	MJ	0.00E+00	0.00E+00	2.53E-03	2.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.06E-01
PERT	MJ	2.26E+00	5.22E-04	7.46E-01	3.58E+00	2.25E-02	0.00E+00	1.02E-03	0.00E+00	1.52E-02	-4.78E+00
PENRE	MJ	4.23E+01	3.93E-02	6.60E+00	5.02E+01	1.70E+00	0.00E+00	7.66E-02	0.00E+00	3.64E-01	-4.25E+01
PENRM	MJ.	3.71E+01	0.00E+00	2.50E-03	3.71E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	7.94E+01	3.93E-02	6.60E+00	8.73E+01	1.70E+00	0.00E+00	7.66E-02	0.00E+00	3.64E-01	-4.25E+01
SM	kg	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

[10] The indicator 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 almost equal to the GWP indicator originally defined in EN 15804:2012+A1:2013.

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
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
FW	m^3	1.21E-02	6.83E-06	2.07E-02	3.28E-02	2.94E-04	0.00E+00	1.33E-05	0.00E+00	3.02E-03	-8.52E-03
Acronyms		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 re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water									

5.2.1.4 Waste production and output flows

Table 38 show waste production.

Table 38 show waste production

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Hazardous waste disposed	kg	0.00E+00	0.00E+00	1.75E-03	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	0.00E+00	0.00E+00	2.40E-02	2.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.57E-01	0.00E+00

Radioactive waste disposed	kg	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

Table 39 show output flows.

Table 39 show output flows

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Components for re-use	kg	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
Material for recycling	kg	0.00E+00	0.00E+00	1.20E-02	1.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02	7.00E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	3.30E-02	3.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.58E-01	6.58E-01
Exported energy, electricity	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

Exported energy, thermal	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

5.2.1.5 Biogenic carbon content

Table 40 show the biogenic carbon content of the product and the packaging.

Table 40 show the biogenic carbon content of the product and the packaging.

Results per 1m² of finished product with a thickness of 0,75mm		
BIOGENIC CARBON CONTENT	Unit	QUANTITY
Biogenic carbon content in product	kg C	0.00E+00
Biogenic carbon content in packaging	kg C	3.60E-02

Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO_2.

5.2.1.6 Environmental Footprint Endpoint

The environmental footprint endpoint shows an assessment of the total environmental burden based on all environmental effect categories included in EF 3.0 impact assessment method. Figure 17 shows the contribution of each environmental impact category to the total environmental impact. Figure 18 show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 5%.

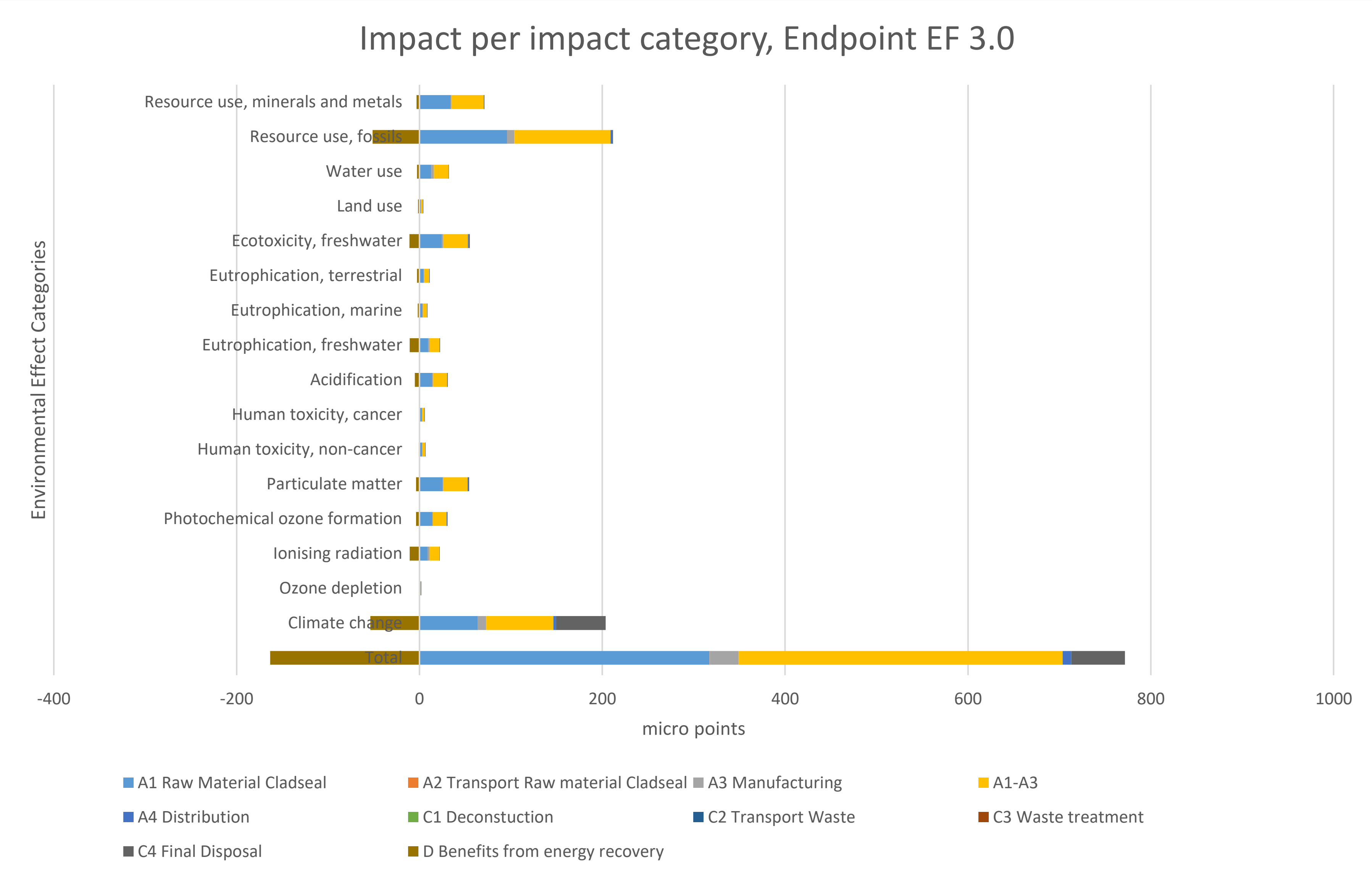


Figure 17: Share of environmental impact per impact category

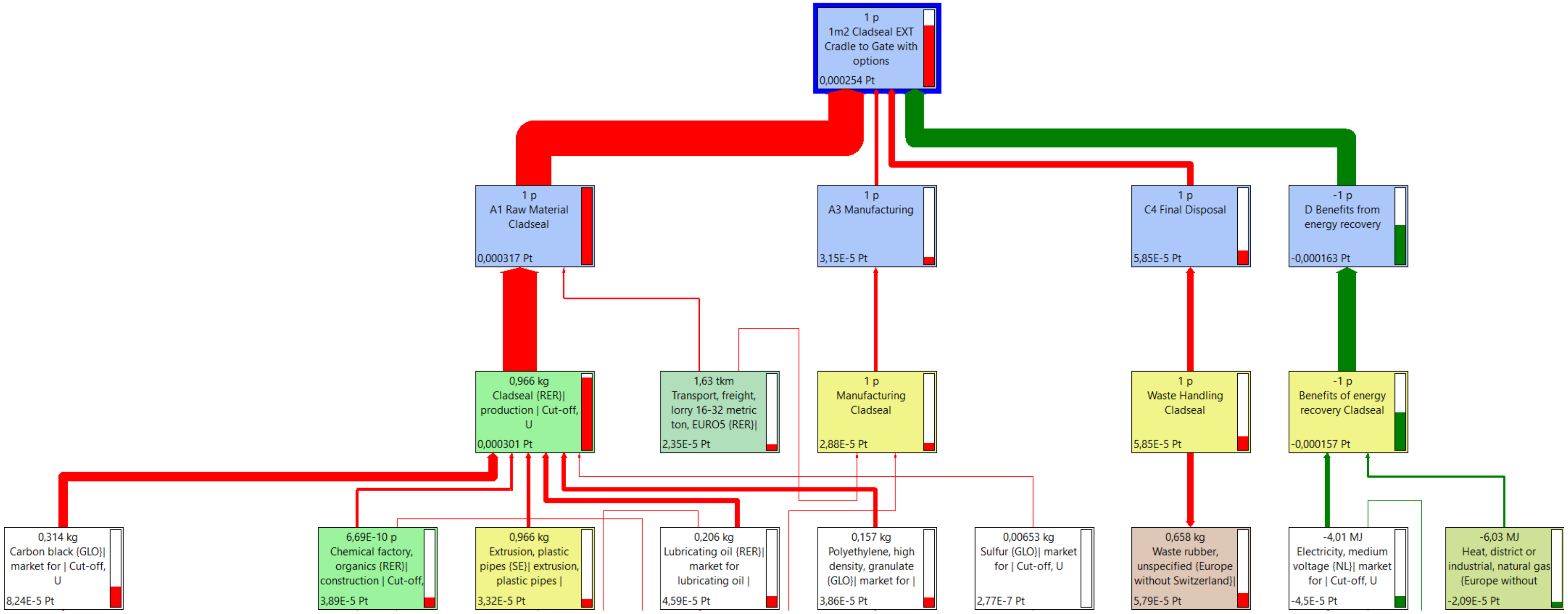


Figure 18, show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 5%.

5.2.2 Results ElastoSeal

5.2.2.1 Environmental Footprint Midpoint

Table 41 shows the result per FU according to the LCIA method Environmental footprint 3.0 midpoint level.

Table 41: Environmental footprint midpoint results

Impact category		Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
GWP	Fossil	kg CO_2 eq	3.32E+00	2.89E-03	3.94E-01	3.72E+00	1.25E-01	0.00E+00	5.62E-03	0.00E+00	2.47E+00	-2.42E+00
	Biogenic	kg CO_2 eq	-4.27E-02	2.46E-06	-2.90E-02	-7.17E-02	1.06E-04	0.00E+00	4.79E-06	0.00E+00	2.73E-04	-1.29E-02
	LULUC	kg CO_2 eq	1.52E-03	1.13E-06	1.45E-03	2.97E-03	4.90E-05	0.00E+00	2.21E-06	0.00E+00	1.39E-05	-1.03E-03
	Total	kg CO_2 eq	3.28E+00	2.89E-03	3.67E-01	3.65E+00	1.25E-01	0.00E+00	5.63E-03	0.00E+00	2.47E+00	-2.43E+00
ODP		kg CFC11 eq	9.63E-07	6.68E-10	1.85E-08	9.83E-07	2.89E-08	0.00E+00	1.30E-09	0.00E+00	5.90E-09	-1.89E-07
AP		mol H+ eq	1.69E-02	1.17E-05	1.02E-03	1.79E-02	5.06E-04	0.00E+00	2.28E-05	0.00E+00	3.71E-04	-5.41E-03
EP- Freshwater[11]		kg PO_4^{-3} eq	2.46E-03	6.88E-07	3.43E-04	2.81E-03	2.97E-05	0.00E+00	1.34E-06	0.00E+00	2.33E-05	-2.67E-03
EP - Freshwater		kg P eq	6.66E-04	1.86E-07	9.28E-05	7.59E-04	8.04E-06	0.00E+00	3.62E-07	0.00E+00	6.29E-06	-7.21E-04
EP - Marine		kg N eq	2.85E-03	3.53E-06	5.40E-04	3.40E-03	1.53E-04	0.00E+00	6.87E-06	0.00E+00	1.44E-04	-1.42E-03
EP – Terrestrial		mol N eq	2.96E-02	3.86E-05	2.79E-03	3.24E-02	1.67E-03	0.00E+00	7.51E-05	0.00E+00	1.56E-03	-1.50E-02
POCP		kg NMVOC eq	1.62E-02	1.18E-05	5.83E-04	1.68E-02	5.10E-04	0.00E+00	2.30E-05	0.00E+00	3.85E-04	-3.77E-03
ADPE[12]		kg Sb eq	3.50E-05	1.00E-08	5.29E-07	3.56E-05	4.34E-07	0.00E+00	1.95E-08	0.00E+00	1.40E-07	-3.06E-06
ADPF[11]		MJ	1.04E+02	4.36E-02	6.31E+00	1.11E+02	1.89E+00	0.00E+00	8.50E-02	0.00E+00	3.97E-01	-4.73E+01
WSF[11]		m3 depriv.	2.15E+00	1.31E-04	3.95E-01	2.54E+00	5.65E-03	0.00E+00	2.54E-04	0.00E+00	2.84E-02	-4.45E-01
PM		disease inc.	2.40E-07	2.49E-10	6.19E-09	2.46E-07	1.08E-08	0.00E+00	4.85E-10	0.00E+00	2.03E-09	-2.85E-08
IR[13]		kBq U-235 eq	9.17E-01	2.24E-04	1.88E-01	1.10E+00	9.70E-03	0.00E+00	4.37E-04	0.00E+00	1.85E-03	-1.05E+00
ETP – FW[11]		CTUe	6.88E+01	3.41E-02	4.61E+00	7.34E+01	1.47E+00	0.00E+00	6.63E-02	0.00E+00	4.04E+00	-2.90E+01
HTP - C[11]		CTUh	2.76E-09	1.10E-12	1.26E-10	2.88E-09	4.77E-11	0.00E+00	2.15E-12	0.00E+00	3.02E-11	-4.43E-10
HTP - NC[11]		CTUh	4.85E-08	3.58E-11	2.02E-09	5.06E-08	1.55E-09	0.00E+00	6.97E-11	0.00E+00	1.66E-09	-1.31E-08

[11] For the impact category Eutrophication, freshwater, the result per unit kg P is used as basis for calculating the result per unit kg PO_4^{-3} eq, using the factor 3,07

[12] **Disclaimer:** The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

[13] **Disclaimer:** This impact category 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.

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
SQP[11]	Pt	1.86E+01	3.00E-02	3.62E+00	2.23E+01	1.30E+00	0.00E+00	5.84E-02	0.00E+00	2.31E-01	-1.80E+01
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										
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, **B1:** Use, **B2:** Maintenance, **B3:** Repair, **B4:** Replacement, **B5:** Refurbishment, **B6:** Operational Energy Use, **B7:** Operational Water Use, **C1:** Deconstruction, **C2:** Waste Transport**, C3:** Waste Processing, **C4:** Disposal**, D:** Reuse, Recovery, Recycling Potential										

5.2.2.2 Results Climate change

Table 42 show the climate change potential expressed as kg CO2 eqv. Calculated with the method IPCC 2021 GWP 100.

Table 42, show the result from the method IPCC 2021 GWP 100 concerning climate change potential.

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
GWP-GHG[14]	kg CO_2 eq.	3.25E+00	2.86E-03	3.92E-01	3.65E+00	1.24E-01	0.00E+00	5.57E-03	0.00E+00	2.47E+00	-2.39E+00

Figure 19 show how the climate change potential is distributed throughout the life cycle using a Sankey diagram. Only the environmental aspects contributing with more than 5% of the total is visible in the Sankey diagram.

[14] The indicator 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 almost equal to the GWP indicator originally defined in EN 15804:2012+A1:2013.

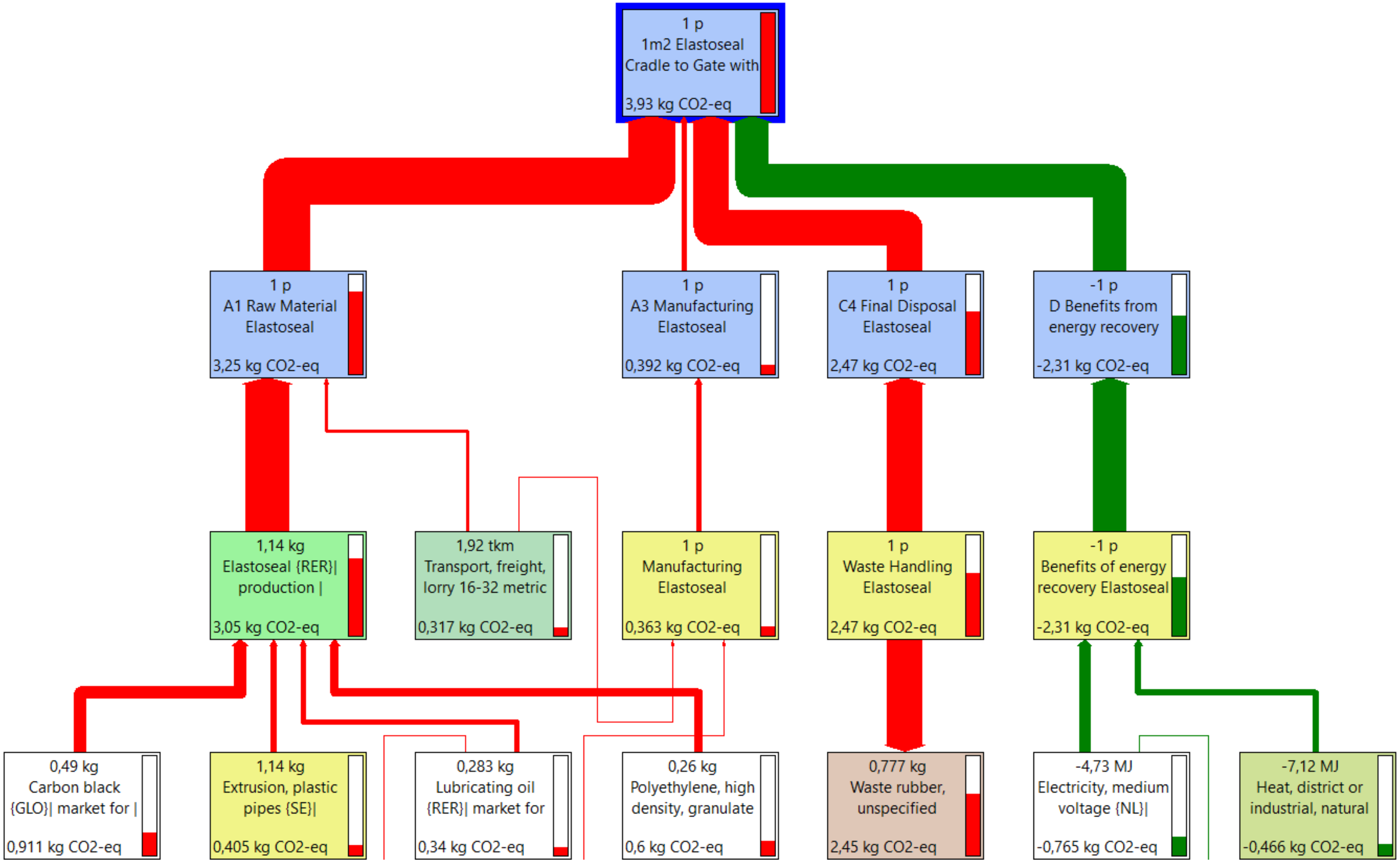


Figure 19, show a Sankey diagram on how the emissions of CO2 eqv. is distributed throughout the life cycle. Cut off 5%.

5.2.2.3 *Use of resources*

Table 43 show the use of resources

Table 43, show the use of resources.

Results per 1m² of finished product with a thickness of 1,00mm											
Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	2.76E+00	6.15E-04	7.43E-01	3.58E+00	2.66E-02	0.00E+00	1.20E-03	0.00E+00	1.80E-02	-5.30E+00
PERM	MJ	0.00E+00	0.00E+00	2.90E-03	2.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.06E-01
PERT	MJ	2.76E+00	6.15E-04	7.46E-01	3.58E+00	2.66E-02	0.00E+00	1.20E-03	0.00E+00	1.80E-02	-5.19E+00
PENRE	MJ	6.84E+01	4.63E-02	6.60E+00	4.48E+01	2.00E+00	0.00E+00	9.02E-02	0.00E+00	4.29E-01	-4.84E+01
PENRM	MJ.	4.25E+01	0.00E+00	2.86E-03	4.25E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.11E+02	4.63E-02	6.60E+00	8.73E+01	2.00E+00	0.00E+00	9.02E-02	0.00E+00	4.29E-01	-4.84E+01
SM	kg	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
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
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
FW	m^3	1.46E-02	7.31E-06	2.07E-02	3.53E-02	3.16E-04	0.00E+00	1.42E-05	0.00E+00	3.57E-03	-9.38E-03
Acronyms		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 re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water									

5.2.2.4 Waste production and output flows

Table 44 show waste production.

Table 44 show waste production

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Hazardous waste disposed	kg	0.00E+00	0.00E+00	1.75E-03	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	0.00E+00	0.00E+00	2.40E-02	2.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+00	0.00E+00
Radioactive waste disposed	kg	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

Table 45 show output flows.

Table 45 show output flows

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Components for re-use	kg	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
Material for recycling	kg	0.00E+00	0.00E+00	1.20E-02	1.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02	7.00E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	3.30E-02	3.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.82E-01	7.82E-01
Exported energy, electricity	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
Exported energy, thermal	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

5.2.2.5 Biogenic carbon content

Table 46, shot the biogenic carbon content of the product and the packaging.

Table 46, shot the biogenic carbon content of the product and the packaging.

Results per 1m² of finished product with a thickness of 1,00mm		
BIOGENIC CARBON CONTENT	Unit	QUANTITY
Biogenic carbon content in product	kg C	0.00E+00
Biogenic carbon content in packaging	kg C	3.60E-02

Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO_2.

5.2.2.6 Environmental Footprint Endpoint

The environmental footprint endpoint shows an assessment of the total environmental burden based on all environmental effect categories included in EF 3.0 impact assessment method. Figure 20 show the contribution of each environmental impact category to the total environmental impact. Figure 21 show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

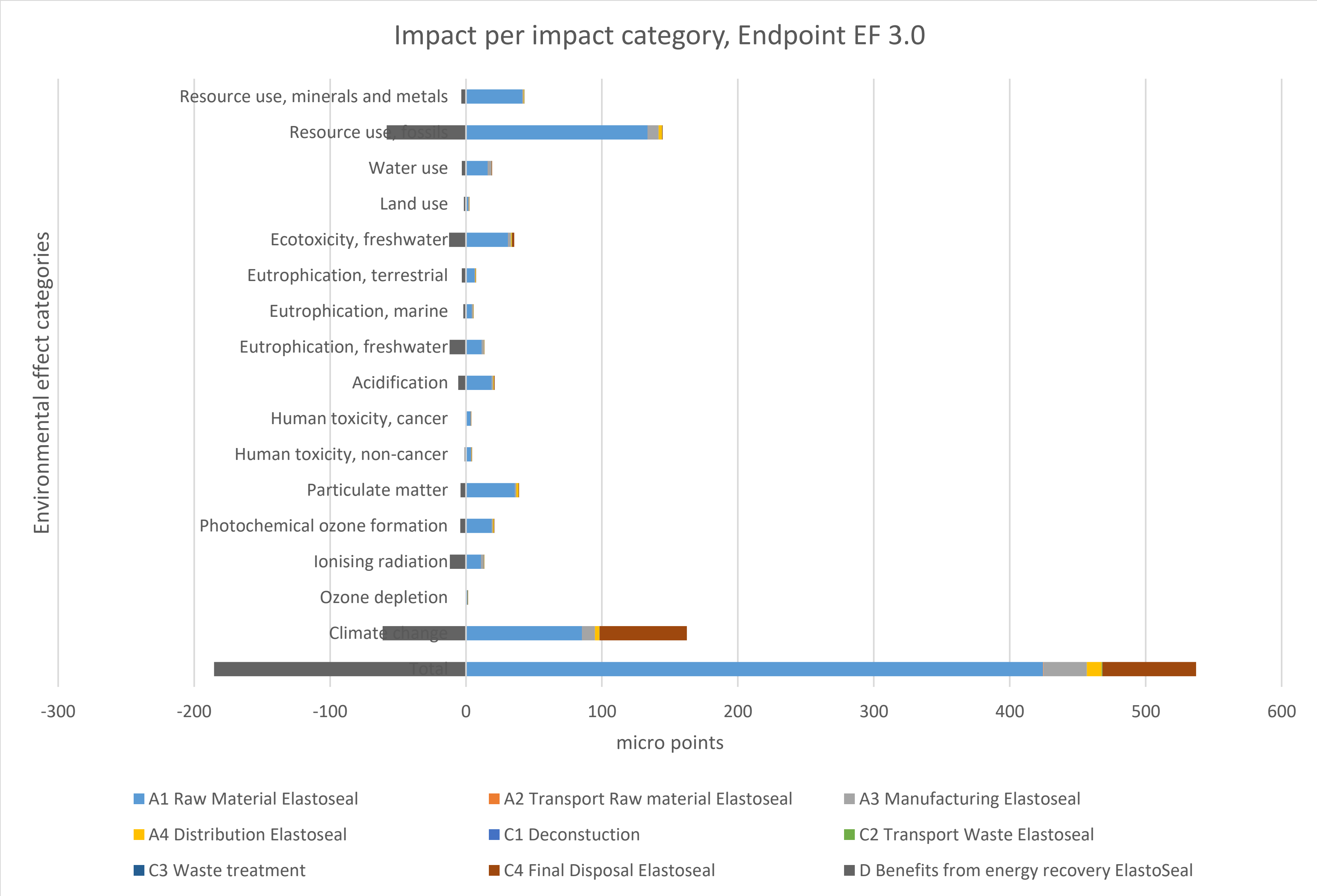


Figure 20: Share of environmental impact per impact category

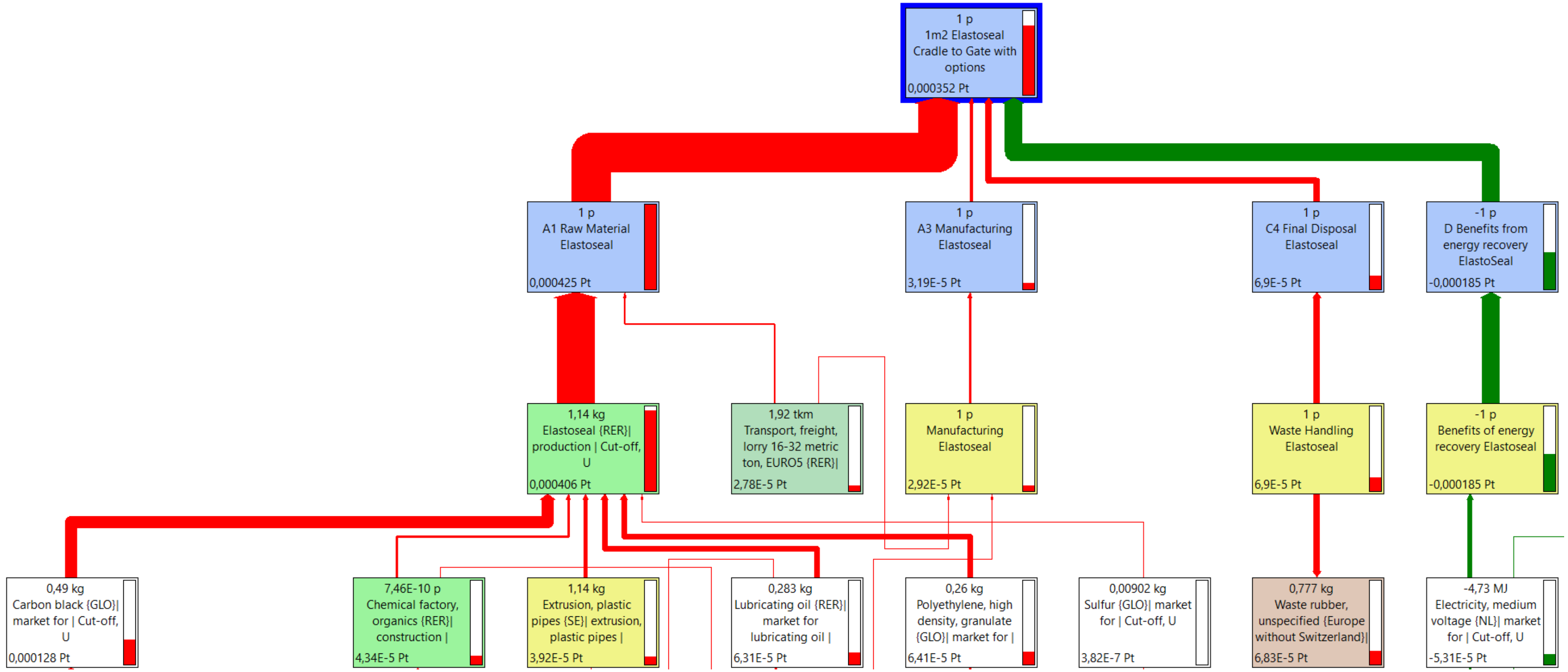


Figure 21, show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

5.2.3 Results Prelasti S

5.2.3.1 Environmental Footprint Midpoint

Table 47 shows the result per FU according to the LCIA method Environmental footprint 3.0 midpoint level.

Table 47: Environmental footprint midpoint results

Impact category		Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
GWP	Fossil	kg CO_2 eq	3.79E+00	3.39E-03	3.94E-01	4.18E+00	1.47E-01	0.00E+00	6.60E-03	0.00E+00	2.90E+00	-2.82E+00
	Biogenic	kg CO_2 eq	-4.91E-02	2.89E-06	-2.90E-02	-7.80E-02	1.25E-04	0.00E+00	5.63E-06	0.00E+00	3.21E-04	-1.56E-02
	LULUC	kg CO_2 eq	1.73E-03	1.33E-06	1.45E-03	3.18E-03	5.77E-05	0.00E+00	2.59E-06	0.00E+00	1.64E-05	-1.20E-03
	Total	kg CO_2 eq	3.74E+00	3.40E-03	3.67E-01	4.11E+00	1.47E-01	0.00E+00	6.61E-03	0.00E+00	2.90E+00	-2.84E+00
ODP		kg CFC11 eq	9.30E-07	7.85E-10	1.85E-08	9.50E-07	3.40E-08	0.00E+00	1.53E-09	0.00E+00	6.94E-09	-2.21E-07
AP		mol H+ eq	1.86E-02	1.38E-05	1.02E-03	1.96E-02	5.96E-04	0.00E+00	2.68E-05	0.00E+00	4.36E-04	-6.30E-03
EP- Freshwater[15]		kg PO_4^{-3} eq	2.39E-03	6.71E-07	2.85E-04	2.67E-03	2.90E-05	0.00E+00	1.31E-06	0.00E+00	2.27E-05	-2.59E-03
EP - Freshwater		kg P eq	7.78E-04	2.18E-07	9.28E-05	8.71E-04	9.46E-06	0.00E+00	4.25E-07	0.00E+00	7.40E-06	-8.42E-04
EP - Marine		kg N eq	3.27E-03	4.15E-06	5.41E-04	3.81E-03	1.80E-04	0.00E+00	8.07E-06	0.00E+00	1.69E-04	-1.65E-03
EP – Terrestrial		mol N eq	3.35E-02	4.53E-05	2.79E-03	3.63E-02	1.96E-03	0.00E+00	8.82E-05	0.00E+00	1.84E-03	-1.75E-02
POCP		kg NMVOC eq	1.61E-02	1.39E-05	5.83E-04	1.67E-02	6.01E-04	0.00E+00	2.70E-05	0.00E+00	4.53E-04	-4.40E-03
ADPE[16]		kg Sb eq	4.14E-05	1.18E-08	5.30E-07	4.19E-05	5.11E-07	0.00E+00	2.30E-08	0.00E+00	1.65E-07	-3.58E-06
ADPF[11]		MJ	1.13E+02	5.13E-02	6.31E+00	1.19E+02	2.22E+00	0.00E+00	9.98E-02	0.00E+00	4.68E-01	-5.52E+01
WSF[11]		m3 depriv.	2.58E+00	1.54E-04	3.95E-01	2.98E+00	6.65E-03	0.00E+00	2.99E-04	0.00E+00	3.34E-02	-5.17E-01
PM		disease inc.	2.57E-07	2.93E-10	6.20E-09	2.63E-07	1.27E-08	0.00E+00	5.70E-10	0.00E+00	2.39E-09	-3.31E-08
IR[17]		kBq U-235 eq	1.02E+00	2.64E-04	1.88E-01	1.20E+00	1.14E-02	0.00E+00	5.13E-04	0.00E+00	2.18E-03	-1.22E+00
ETP – FW[11]		CTUe	8.18E+01	4.00E-02	4.61E+00	8.64E+01	1.73E+00	0.00E+00	7.79E-02	0.00E+00	4.75E+00	-3.37E+01
HTP - C[11]		CTUh	3.81E-09	1.30E-12	1.26E-10	3.94E-09	5.61E-11	0.00E+00	2.52E-12	0.00E+00	3.52E-11	-5.17E-10
HTP - NC[11]		CTUh	6.25E-08	4.21E-11	2.02E-09	6.46E-08	1.82E-09	0.00E+00	8.19E-11	0.00E+00	1.95E-09	-1.52E-08

[15] For the impact category Eutrophication, freshwater, the result per unit kg P is used as basis for calculating the result per unit kg PO_4^{-3} eq, using the factor 3,07

[16] **Disclaimer:** The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

[17] **Disclaimer:** This impact category 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.

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
SQP[11]	Pt	2.03E+01	3.52E-02	3.62E+00	2.39E+01	1.53E+00	0.00E+00	6.86E-02	0.00E+00	2.71E-01	-2.08E+01
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										
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, **B1:** Use, **B2:** Maintenance, **B3:** Repair, **B4:** Replacement, **B5:** Refurbishment, **B6:** Operational Energy Use, **B7:** Operational Water Use, **C1:** Deconstruction, **C2:** Waste Transport, **C3:** Waste Processing, **C4:** Disposal, **D:** Reuse, Recovery, Recycling Potential										

5.2.3.2 Results Climate change

Table 48 show the climate change potential expressed as kg CO2 eqv. Calculated with the method IPCC 2021 GWP 100.

Table 48, show the result from the method IPCC 2021 GWP 100 concerning climate change potential.

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
GWP-GHG[18]	kg CO_2 eq.	3.71E+00	3.36E-03	3.93E-01	4.10E+00	1.46E-01	0.00E+00	6.55E-03	0.00E+00	2.90E+00	-2.79E+00

Figure 22 show how the climate change potential is distributed throughout the life cycle using a Sankey diagram. Only the environmental aspects contributing with more than 5% of the total is visible in the Sankey diagram.

[18] The indicator 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 almost equal to the GWP indicator originally defined in EN 15804:2012+A1:2013.

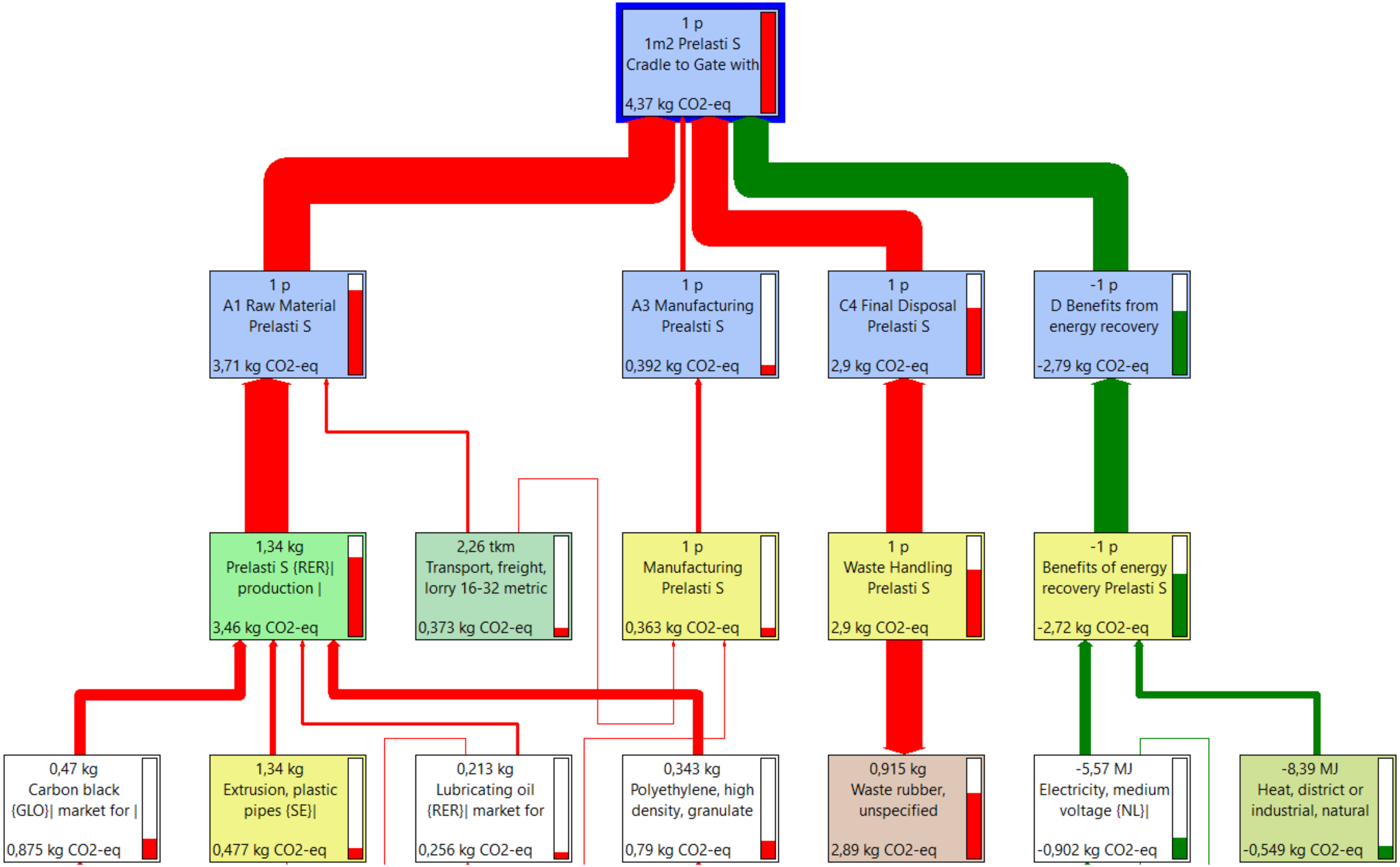


Figure 22, show a Sankey diagram on how the emissions of CO2 eqv. is distributed throughout the life cycle. Cut off 5%.

5.2.3.3 Use of resources

Table 49 show the use of resources

Table 49, show the use of resources.

Results per 1m² of finished product with a thickness of 1,20mm											
Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.19E+00	7.23E-04	7.42E-01	3.93E+00	3.13E-02	0.00E+00	1.41E-03	0.00E+00	2.11E-02	-6.37E+00
PERM	MJ	0.00E+00	0.00E+00	3.52E-03	3.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.06E-01
PERT	MJ	3.19E+00	7.23E-04	7.46E-01	3.93E+00	3.13E-02	0.00E+00	1.41E-03	0.00E+00	2.11E-02	-6.53E+00
PENRE	MJ	6.80E+01	5.44E-02	6.60E+00	7.47E+01	2.36E+00	0.00E+00	1.06E-01	0.00E+00	5.05E-01	-5.85E+01
PENRM	MJ.	5.16E+01	0.00E+00	3.48E-03	5.16E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.20E+02	5.44E-02	6.60E+00	1.26E+02	2.36E+00	0.00E+00	1.06E-01	0.00E+00	5.05E-01	-5.85E+01
SM	kg	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
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
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
FW	m^3	1.67E-02	8.59E-06	2.07E-02	3.73E-02	3.72E-04	0.00E+00	1.67E-05	0.00E+00	4.20E-03	-1.16E-02
Acronyms		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 re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water									

5.2.3.4 Waste production and output flows

Table 50 show waste production.

Table 50 show waste production

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Hazardous waste disposed	kg	0.00E+00	0.00E+00	1.75E-03	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	0.00E+00	0.00E+00	2.40E-02	2.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E+00	0.00E+00
Radioactive waste disposed	kg	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

Table 51show output flows.

Table 51 show output flows

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Components for re-use	kg	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
Material for recycling	kg	0.00E+00	0.00E+00	1.20E-02	1.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02	7.00E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	3.30E-02	3.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.20E-01	9.20E-01
Exported energy, electricity	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
Exported energy, thermal	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

5.2.3.5 Biogenic carbon content

Table 52, show the biogenic carbon content of the product and the packaging.

Table 52, show the biogenic carbon content of the product and the packaging.

Results per 1m² of finished product with a thickness of 1,20mm		
BIOGENIC CARBON CONTENT	Unit	QUANTITY
Biogenic carbon content in product	kg C	0.00E+00
Biogenic carbon content in packaging	kg C	3.60E-02

Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO_2.

5.2.3.6 Environmental Footprint Endpoint

The environmental footprint endpoint shows an assessment of the total environmental burden based on all environmental effect categories included in EF 3.0 impact assessment method. Figure 23 shows the contribution of each environmental impact category to the total environmental impact. Figure 24 show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

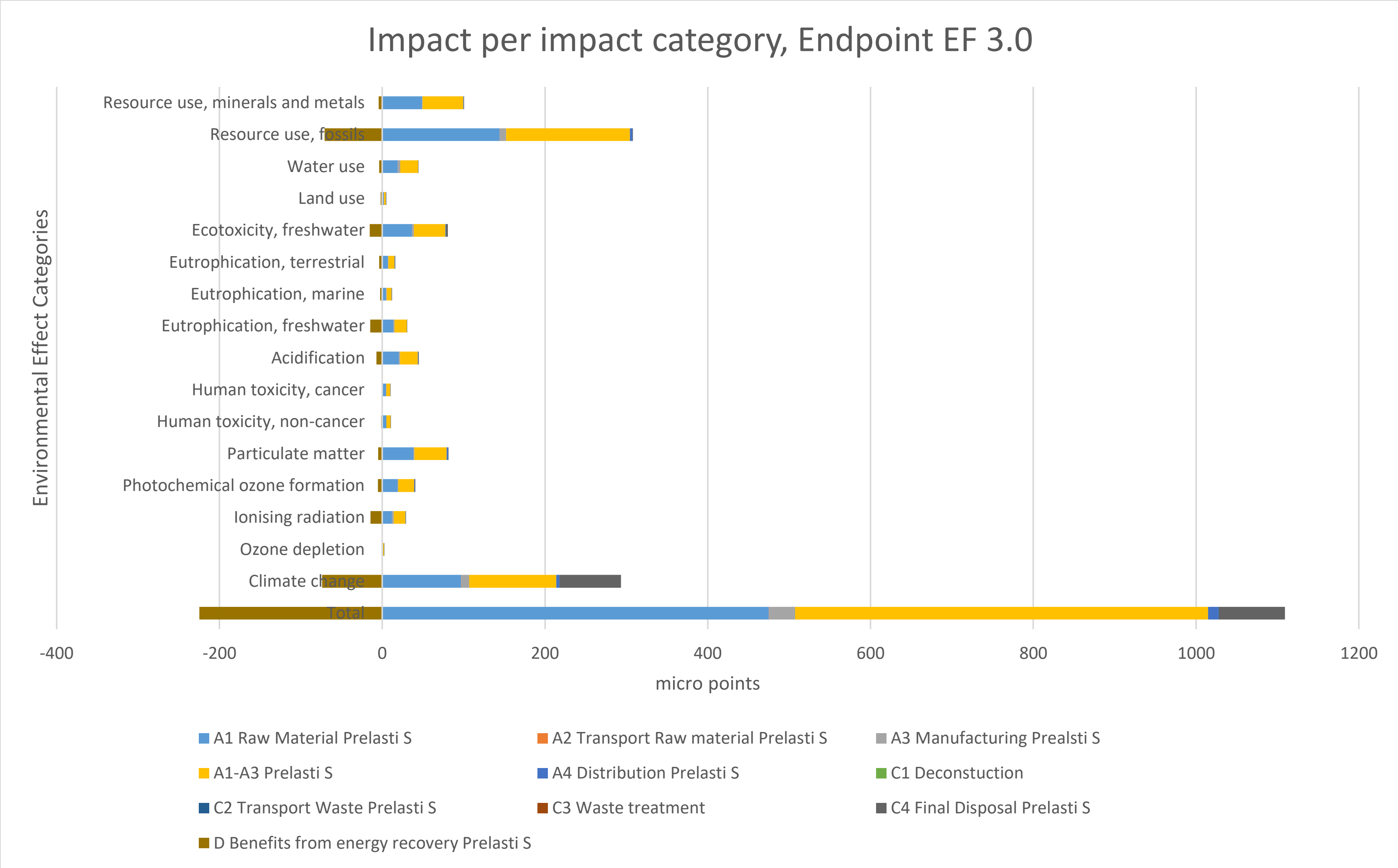


Figure 23: Share of environmental impact per impact category

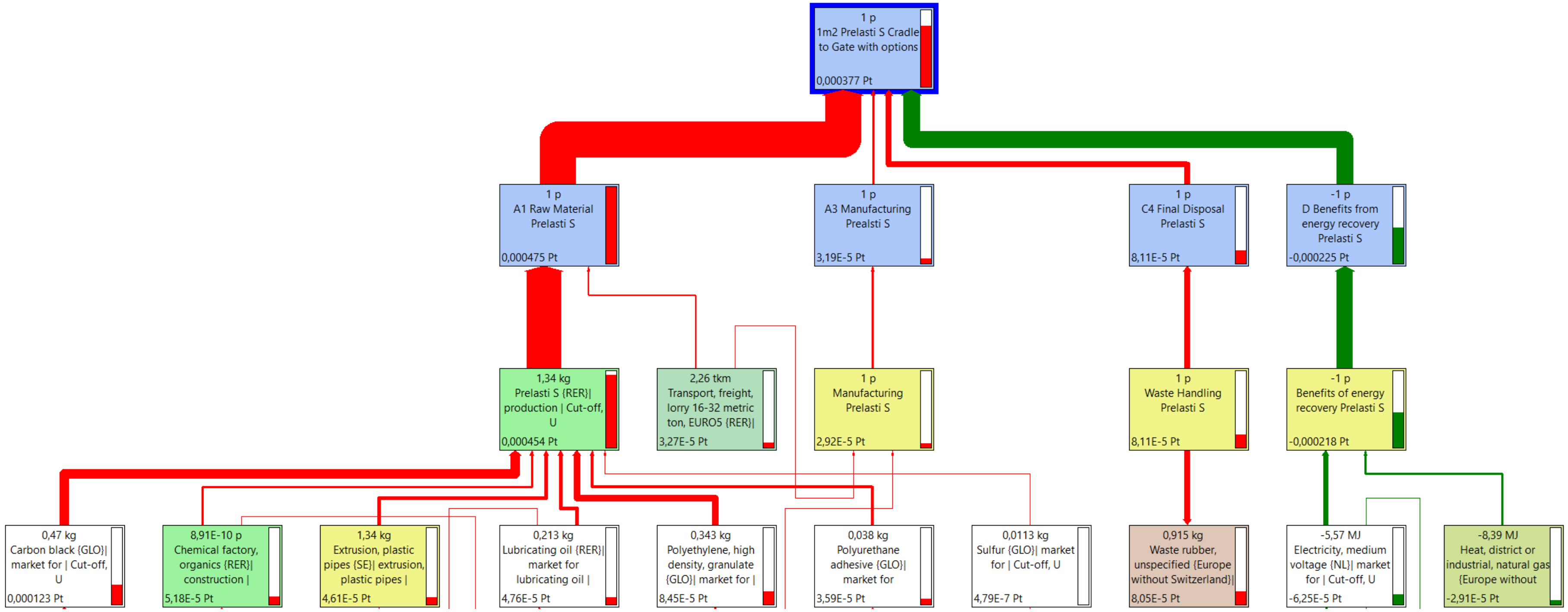


Figure 24, show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

5.2.4 Results Prelasti Fleece

5.2.4.1 Environmental Footprint Midpoint

Table 53 shows the result per FU according to the LCIA method Environmental footprint 3.0 midpoint level.

Table 53: Environmental footprint midpoint results

Impact category		Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
GWP	Fossil	kg CO_2 eq	6.37E+00	6.41E-02	4.37E-01	6.88E+00	1.81E-01	0.00E+00	8.13E-03	0.00E+00	3.44E+00	-3.52E+00
	Biogenic	kg CO_2 eq	-5.63E-02	6.23E-05	-2.90E-02	-8.52E-02	1.55E-04	0.00E+00	6.93E-06	0.00E+00	3.25E-04	-1.10E-02
	LULUC	kg CO_2 eq	3.57E-03	2.31E-05	1.45E-03	5.05E-03	7.12E-05	0.00E+00	3.19E-06	0.00E+00	1.62E-05	-1.63E-03
	Total	kg CO_2 eq	6.32E+00	6.42E-02	4.10E-01	6.80E+00	1.82E-01	0.00E+00	8.14E-03	0.00E+00	3.44E+00	-3.53E+00
ODP		kg CFC11 eq	1.15E-06	1.53E-08	1.87E-08	1.19E-06	4.20E-08	0.00E+00	1.88E-09	0.00E+00	6.92E-09	-2.76E-07
AP		mol H+ eq	2.88E-02	2.68E-04	1.02E-03	3.00E-02	7.36E-04	0.00E+00	3.30E-05	0.00E+00	4.85E-04	-7.90E-03
EP- Freshwater[19]		kg PO_4^{-3} eq	3.73E-03	1.23E-05	2.85E-04	4.03E-03	3.58E-05	0.00E+00	1.61E-06	0.00E+00	2.23E-05	-3.23E-03
EP - Freshwater		kg P eq	1.22E-03	3.99E-06	9.29E-05	1.31E-03	1.17E-05	0.00E+00	5.23E-07	0.00E+00	7.27E-06	-1.05E-03
EP - Marine		kg N eq	5.44E-03	8.16E-05	5.43E-04	6.07E-03	2.22E-04	0.00E+00	9.93E-06	0.00E+00	1.99E-04	-2.10E-03
EP – Terrestrial		mol N eq	5.46E-02	8.93E-04	2.82E-03	5.83E-02	2.42E-03	0.00E+00	1.09E-04	0.00E+00	2.15E-03	-2.20E-02
POCP		kg NMVOC eq	2.55E-02	2.87E-04	5.90E-04	2.64E-02	7.42E-04	0.00E+00	3.32E-05	0.00E+00	5.43E-04	-5.51E-03
ADPE[20]		kg Sb eq	5.89E-05	1.47E-07	5.33E-07	5.96E-05	6.30E-07	0.00E+00	2.83E-08	0.00E+00	1.61E-07	-4.54E-06
ADPF[11]		MJ	1.70E+02	1.00E+00	6.32E+00	1.77E+02	2.74E+00	0.00E+00	1.23E-01	0.00E+00	4.61E-01	-6.86E+01
WSF[11]		m3 depriv.	3.60E+00	3.44E-03	3.95E-01	4.00E+00	8.21E-03	0.00E+00	3.68E-04	0.00E+00	3.00E-02	-6.48E-01
PM		disease inc.	5.03E-07	7.54E-09	6.25E-09	5.16E-07	1.56E-08	0.00E+00	7.01E-10	0.00E+00	3.03E-09	-4.27E-08
IR[21]		kBq U-235 eq	1.15E+00	5.06E-03	1.88E-01	1.34E+00	1.41E-02	0.00E+00	6.32E-04	0.00E+00	2.17E-03	-1.52E+00
ETP – FW[11]		CTUe	1.47E+02	7.81E-01	4.65E+00	1.52E+02	2.14E+00	0.00E+00	9.59E-02	0.00E+00	4.28E+00	-4.22E+01
HTP - C[11]		CTUh	9.37E-09	2.16E-11	1.30E-10	9.52E-09	6.93E-11	0.00E+00	3.11E-12	0.00E+00	1.48E-10	-6.51E-10
HTP - NC[11]		CTUh	1.46E-07	8.56E-10	2.05E-09	1.49E-07	2.25E-09	0.00E+00	1.01E-10	0.00E+00	2.55E-09	-1.91E-08

[19] For the impact category Eutrophication, freshwater, the result per unit kg P is used as basis for calculating the result per unit kg PO_4^{-3} eq, using the factor 3,07

[20] **Disclaimer:** The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

[21] **Disclaimer:** This impact category 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.

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
SQP[11]	Pt	2.71E+01	1.14E+00	3.63E+00	3.18E+01	1.88E+00	0.00E+00	8.44E-02	0.00E+00	2.93E-01	-2.67E+01
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										
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, **B1:** Use, **B2:** Maintenance, **B3:** Repair, **B4:** Replacement, **B5:** Refurbishment, **B6:** Operational Energy Use, **B7:** Operational Water Use, **C1:** Deconstruction, **C2:** Waste Transport**, C3:** Waste Processing, **C4:** Disposal**, D:** Reuse, Recovery, Recycling Potential										

5.2.4.2 Results Climate change

Table 54 show the climate change potential expressed as kg CO2 eqv. Calculated with the method IPCC 2021 GWP 100.

Table 54, show the result from the method IPCC 2021 GWP 100 concerning climate change potential.

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
GWP-GHG[22]	kg CO_2 eq.	6.23E+00	6.36E-02	4.35E-01	6.73E+00	1.80E-01	0.00E+00	8.06E-03	0.00E+00	3.44E+00	-3.48E+00

Figure 25 show how the climate change potential is distributed throughout the life cycle using a Sankey diagram. Only the environmental aspects contributing with more than 5% of the total is visible in the Sankey diagram.

[22] The indicator 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 almost equal to the GWP indicator originally defined in EN 15804:2012+A1:2013.

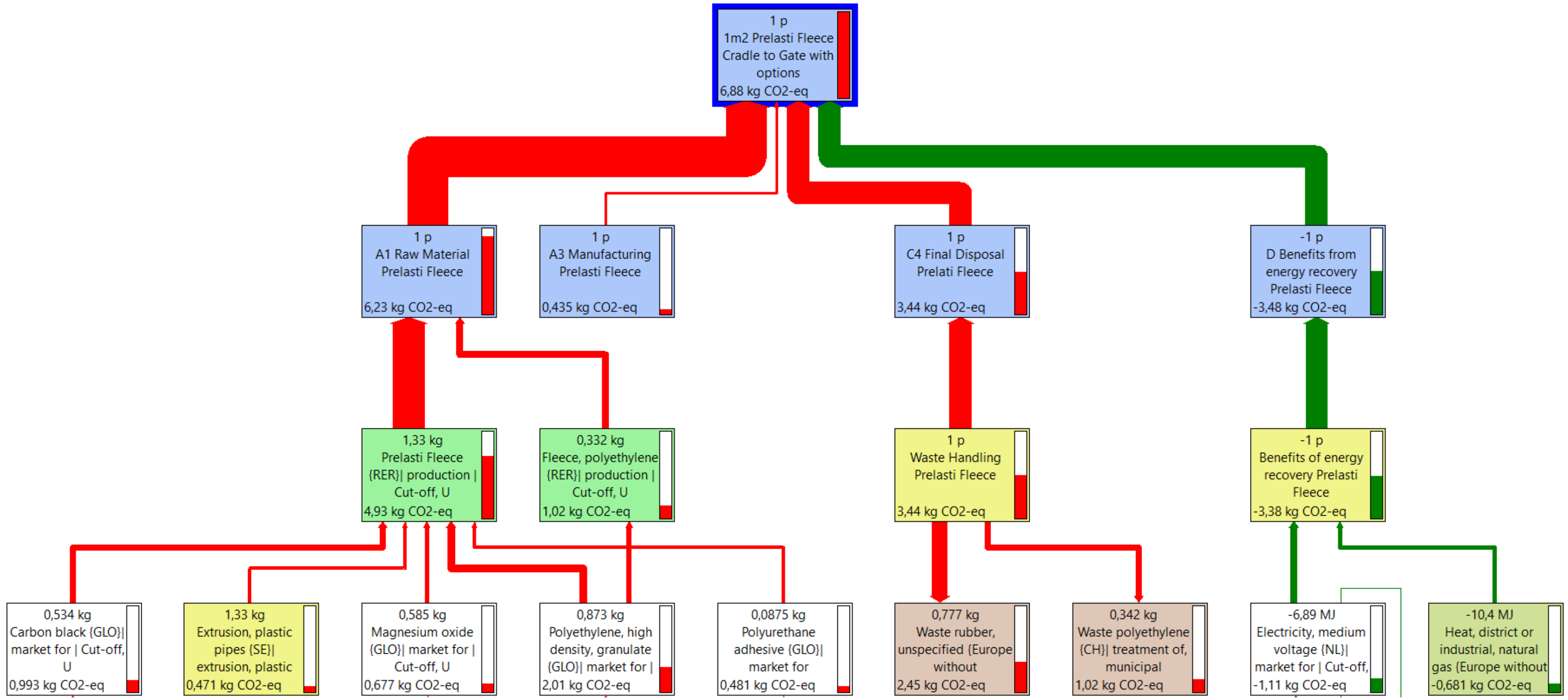


Figure 25, show a Sankey diagram on how the emissions of CO2 eqv. is distributed throughout the life cycle. Cut off 6%.

5.2.4.3 Use of resources

Table 55 show the use of resources

Table 55, show the use of resources.

Results per 1m² of finished product with a thickness of 2,30mm											
Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D

PERE	MJ	4.88E+00	1.27E-02	7.42E-01	5.63E+00	3.86E-02	0.00E+00	1.73E-03	0.00E+00	2.08E-02	8.28E+01
PERM	MJ	0.00E+00	0.00E+00	4.34E-03	4.34E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.12E-01
PERT	MJ	4.88E+00	1.27E-02	7.46E-01	5.64E+00	3.86E-02	0.00E+00	1.73E-03	0.00E+00	2.08E-02	-8.30E+00
PENRE	MJ	1.17E+02	1.06E+00	6.61E+00	1.25E+02	2.91E+00	0.00E+00	1.30E-01	0.00E+00	4.97E-01	-7.27E+01
PENRM	MJ.	6.37E+01	0.00E+00	4.29E-03	6.37E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.81E+02	1.06E+00	6.61E+00	1.89E+02	2.91E+00	0.00E+00	1.30E-01	0.00E+00	4.97E-01	-7.27E+01
SM	kg	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
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
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
FW	m^3	2.86E-02	2.23E-04	2.07E-02	4.95E-02	5.05E-04	0.00E+00	2.26E-05	0.00E+00	3.95E-03	-1.51E-02
Acronyms		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 re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water									

5.2.4.4 Waste production and output flows

Table 56 show waste production.

Table 56 show waste production

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Hazardous waste disposed	kg	0.00E+00	0.00E+00	1.75E-03	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	0.00E+00	0.00E+00	1.08E-01	1.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00
Radioactive waste disposed	kg	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

Table 57 show output flows.

Table 57 show output flows

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Components for re-use	kg	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

Material for recycling	kg	0.00E+00	0.00E+00	5.70E-02	5.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02	7.00E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	3.30E-02	3.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E+00	1.11E+00
Exported energy, electricity	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
Exported energy, thermal	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

5.2.4.5 Biogenic carbon content

Table 58, show the biogenic carbon content in the product and the packaging.

Table 58, show the biogenic carbon content in the product and the packaging.

Results per 1m² of finished product with a thickness of 2,30mm		
BIOGENIC CARBON CONTENT	Unit	QUANTITY
Biogenic carbon content in product	kg C	0.00E+00
Biogenic carbon content in packaging	kg C	1.04E-01

Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO_2.

5.2.4.6 Environmental Footprint Endpoint

The environmental footprint endpoint shows an assessment of the total environmental burden based on all environmental effect categories included in EF 3.0 impact assessment method. Figure 26 shows the contribution of each environmental impact category to the total environmental impact. Figure 27 show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

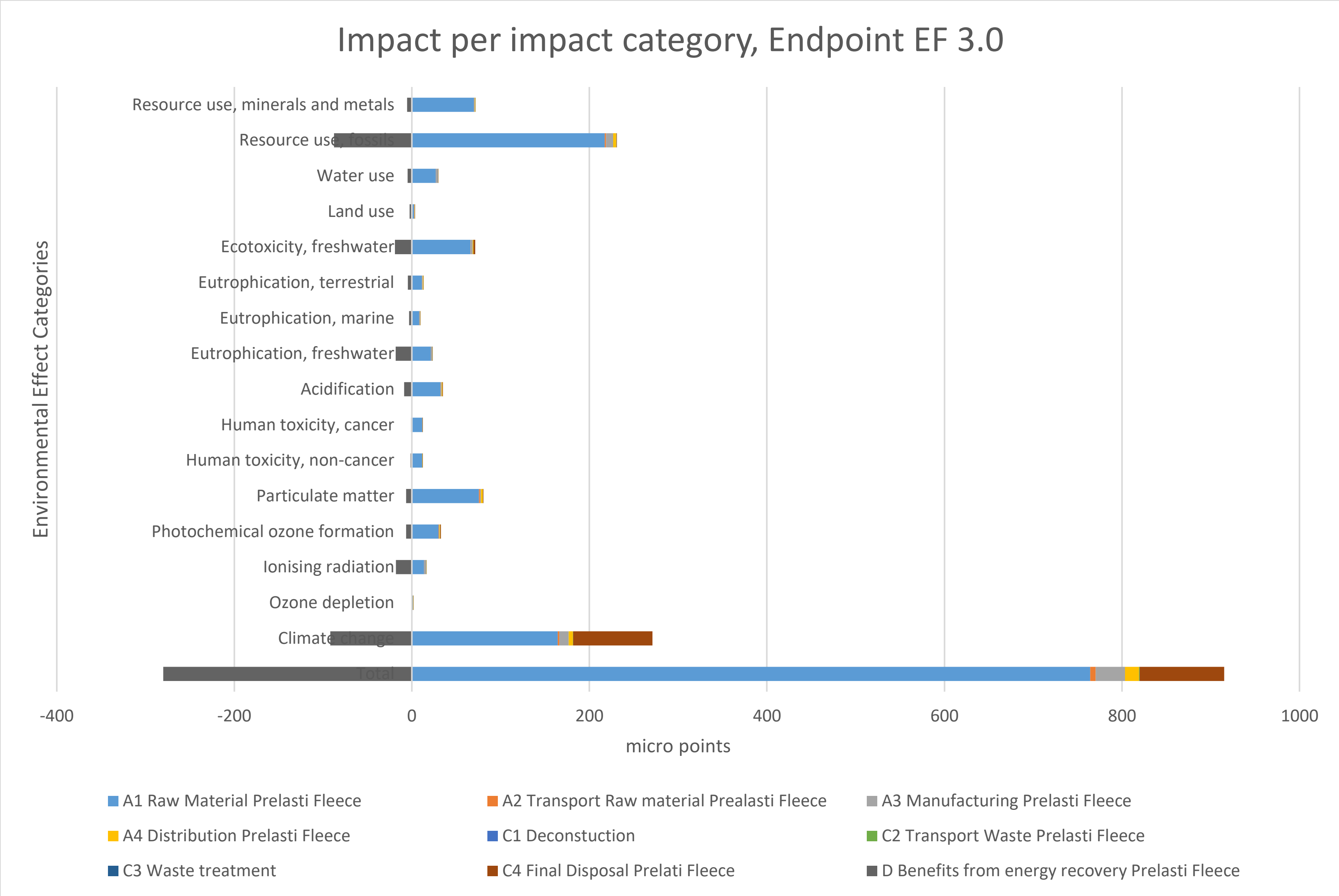


Figure 26: Share of environmental impact per impact category

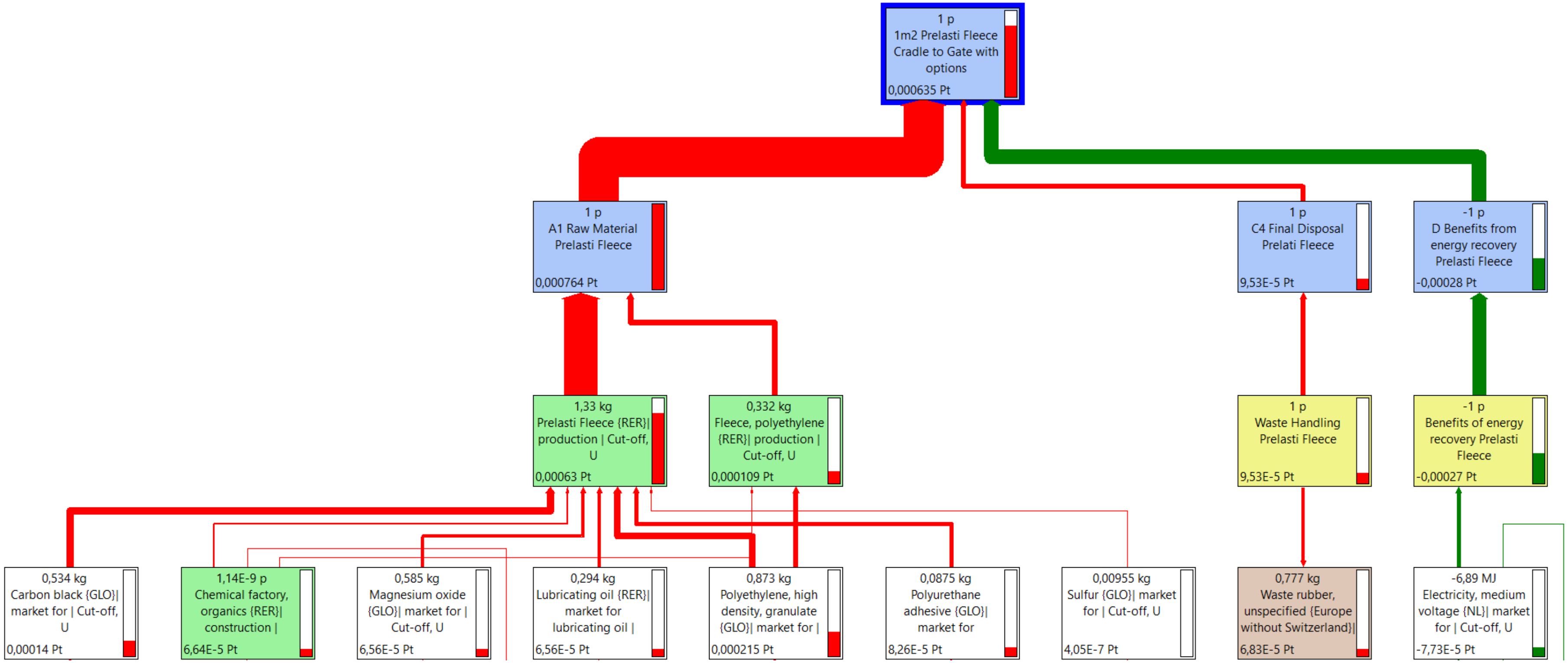


Figure 27, show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

5.2.5 Results Prelasti FR

5.2.5.1 Environmental Footprint Midpoint

Table 59 shows the result per FU according to the LCIA method Environmental footprint 3.0 midpoint level.

Table 59: Environmental footprint midpoint results

Impact category		Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
GWP	Fossil	kg CO_2 eq	4.21E+00	3.72E-03	4.23E-01	4.63E+00	1.61E-01	0.00E+00	7.25E-03	0.00E+00	3.19E+00	-3.10E+00
	Biogenic	kg CO_2 eq	-5.04E-02	3.17E-06	-2.90E-02	-7.94E-02	1.38E-04	0.00E+00	6.18E-06	0.00E+00	3.53E-04	-1.74E-02
	LULUC	kg CO_2 eq	1.84E-03	1.46E-06	1.45E-03	3.30E-03	6.34E-05	0.00E+00	2.85E-06	0.00E+00	1.80E-05	-1.31E-03
	Total	kg CO_2 eq	4.16E+00	3.73E-03	3.96E-01	4.56E+00	1.62E-01	0.00E+00	7.26E-03	0.00E+00	3.19E+00	-3.12E+00
ODP		kg CFC11 eq	5.88E-07	8.62E-10	1.87E-08	6.07E-07	3.74E-08	0.00E+00	1.68E-09	0.00E+00	7.63E-09	-2.42E-07
AP		mol H+ eq	1.75E-02	1.51E-05	1.02E-03	1.85E-02	6.55E-04	0.00E+00	2.94E-05	0.00E+00	4.79E-04	-6.90E-03
EP- Freshwater[23]		kg PO_4^{-3} eq	2.63E-03	7.36E-07	2.85E-04	2.92E-03	3.19E-05	0.00E+00	1.43E-06	0.00E+00	2.50E-05	-2.84E-03
EP - Freshwater		kg P eq	8.58E-04	2.40E-07	9.29E-05	9.51E-04	1.04E-05	0.00E+00	4.67E-07	0.00E+00	8.13E-06	-9.24E-04
EP - Marine		kg N eq	3.42E-03	4.55E-06	5.42E-04	3.96E-03	1.97E-04	0.00E+00	8.86E-06	0.00E+00	1.86E-04	-1.81E-03
EP – Terrestrial		mol N eq	3.40E-02	4.97E-05	2.81E-03	3.68E-02	2.16E-03	0.00E+00	9.68E-05	0.00E+00	2.02E-03	-1.92E-02
POCP		kg NMVOC eq	1.32E-02	1.52E-05	5.88E-04	1.38E-02	6.61E-04	0.00E+00	2.96E-05	0.00E+00	4.98E-04	-4.82E-03
ADPE[24]		kg Sb eq	4.03E-05	1.29E-08	5.34E-07	4.09E-05	5.61E-07	0.00E+00	2.52E-08	0.00E+00	1.81E-07	-3.92E-06
ADPF[11]		MJ	9.92E+01	5.63E-02	6.32E+00	1.06E+02	2.44E+00	0.00E+00	1.10E-01	0.00E+00	5.14E-01	-6.05E+01
WSF[11]		m3 depriv.	2.95E+00	1.69E-04	3.95E-01	3.34E+00	7.31E-03	0.00E+00	3.28E-04	0.00E+00	3.67E-02	-5.66E-01
PM		disease inc.	3.38E-07	3.21E-10	6.24E-09	3.45E-07	1.39E-08	0.00E+00	6.25E-10	0.00E+00	2.63E-09	-3.62E-08
IR[25]		kBq U-235 eq	1.01E+00	2.89E-04	1.88E-01	1.20E+00	1.25E-02	0.00E+00	5.63E-04	0.00E+00	2.40E-03	-1.34E+00
ETP – FW[11]		CTUe	1.05E+02	4.39E-02	4.67E+00	1.10E+02	1.91E+00	0.00E+00	8.55E-02	0.00E+00	5.22E+00	-3.70E+01
HTP - C[11]		CTUh	7.69E-09	1.42E-12	1.28E-10	7.82E-09	6.17E-11	0.00E+00	2.77E-12	0.00E+00	3.85E-11	-5.66E-10
HTP - NC[11]		CTUh	1.15E-07	4.62E-11	2.04E-09	1.17E-07	2.00E-09	0.00E+00	8.99E-11	0.00E+00	2.15E-09	-1.67E-08

[23] For the impact category Eutrophication, freshwater, the result per unit kg P is used as basis for calculating the result per unit kg PO_4^{-3} eq, using the factor 3,07

[24] **Disclaimer:** The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.

[25] **Disclaimer:** This impact category 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.

Impact category	Unit	A1	A2	A3	A1-A3	A4	C1	C2	C3	C4	D
SQP[11]	Pt	1.86E+01	3.87E-02	3.63E+00	2.23E+01	1.68E+00	0.00E+00	7.53E-02	0.00E+00	2.98E-01	-2.27E+01
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										
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, **B1:** Use, **B2:** Maintenance, **B3:** Repair, **B4:** Replacement, **B5:** Refurbishment, **B6:** Operational Energy Use, **B7:** Operational Water Use, **C1:** Deconstruction, **C2:** Waste Transport**, C3:** Waste Processing, **C4:** Disposal**, D:** Reuse, Recovery, Recycling Potential										

5.2.5.2 Results Climate change

Table 60 show the climate change potential expressed as kg CO2 eqv. Calculated with the method IPCC 2021 GWP 100.

Table 60, show the result from the method IPCC 2021 GWP 100 concerning climate change potential.

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
GWP-GHG[26]	kg CO_2 eq.	4.12E+00	3.69E-03	4.21E-01	4.54E+00	1.60E-01	0.00E+00	7.19E-03	0.00E+00	3.19E+00	-3.06E+00

Figure 28 show how the climate change potential is distributed throughout the life cycle using a Sankey diagram. Only the environmental aspects contributing with more than 5% of the total is visible in the Sankey diagram.

[26] The indicator 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 almost equal to the GWP indicator originally defined in EN 15804:2012+A1:2013.

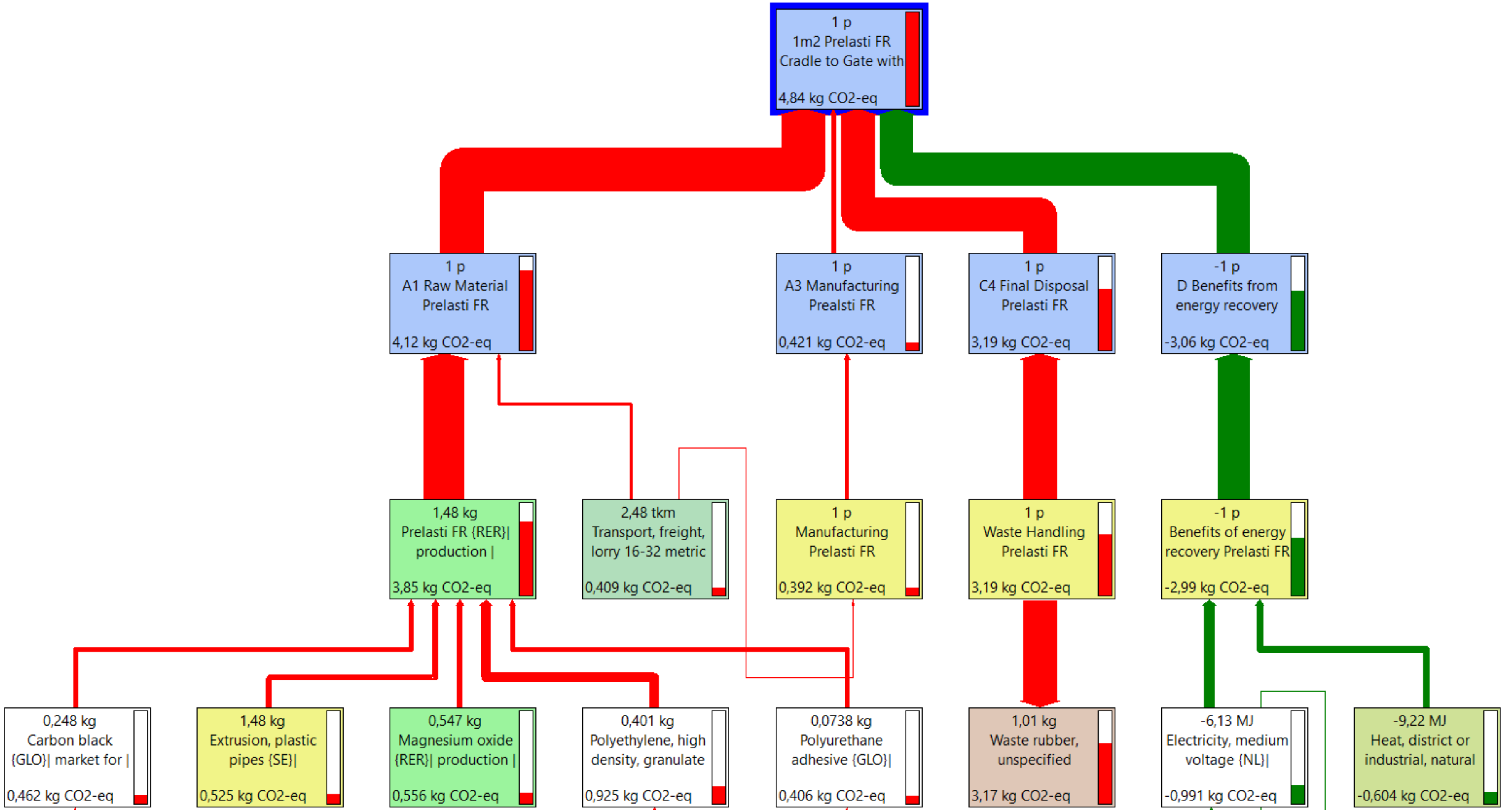


Figure 28, show a Sankey diagram on how the emissions of CO2 eqv. is distributed throughout the life cycle. Cut off 5%.

5.2.5.3 Use of resources

Table 61 show the use of resources

Table 61, show the use of resources.

Results per 1m² of finished product with a thickness of 1,44mm											
Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
PERE	MJ	3.53E+00	7.93E-04	7.42E-01	4.27E+00	3.44E-02	0.00E+00	1.54E-03	0.00E+00	2.32E-02	-7.14E+01
PERM	MJ	0.00E+00	0.00E+00	3.87E-03	3.87E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-01
PERT	MJ	3.53E+00	7.93E-04	7.46E-01	4.27E+00	3.44E-02	0.00E+00	1.54E-03	0.00E+00	2.32E-02	-7.15E+00
PENRE	MJ	4.87E+01	5.98E-02	6.60E+00	5.54E+01	2.59E+00	0.00E+00	1.16E-01	0.00E+00	5.55E-01	-6.42E+01
PENRM	MJ.	5.67E+01	0.00E+00	3.83E-03	5.67E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	1.05E+02	5.98E-02	6.61E+00	1.12E+02	2.59E+00	0.00E+00	1.16E-01	0.00E+00	5.55E-01	-6.42E+01
SM	kg	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
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
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
FW	m^3	1.91E-02	1.04E-05	2.07E-02	3.98E-02	4.50E-04	0.00E+00	2.02E-05	0.00E+00	4.62E-03	-1.27E-02
Acronyms		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 re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water									

5.2.5.4 Waste production and output flows

Table 62 show waste production.

Table 62 show waste production

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D
Hazardous waste disposed	kg	0.00E+00	0.00E+00	1.75E-03	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-hazardous waste disposed	kg	0.00E+00	0.00E+00	2.40E-02	2.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E+00	0.00E+00
Radioactive waste disposed	kg	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

Table 63 show output flows.

Table 63 show output flows

Indicator	Unit	A1	A2	A3	Total A1-A3	A4	C1	C2	C3	C4	D

Components for re-use	kg	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
Material for recycling	kg	0.00E+00	0.00E+00	1.20E-02	1.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02	7.00E-03
Materials for energy recovery	kg	0.00E+00	0.00E+00	3.30E-02	3.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E+00	1.02E+00
Exported energy, electricity	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
Exported energy, thermal	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

5.2.5.5 Biogenic carbon content

Table 64, show the biogenic carbon content in the product and packaging.

Table 64, show the biogenic carbon content in the product and packaging.

Results per 1m² of finished product with a thickness of 1,44mm		
BIOGENIC CARBON CONTENT	Unit	QUANTITY
Biogenic carbon content in product	kg C	0.00E+00

Biogenic carbon content in packaging	kg C	3.60E-02

Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO_2.

5.2.5.6 Environmental Footprint Endpoint

The environmental footprint endpoint shows an assessment of the total environmental burden based on all environmental effect categories included in EF 3.0 impact assessment method. Figure 29 shows the contribution of each environmental impact category to the total environmental impact. Figure 30 show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

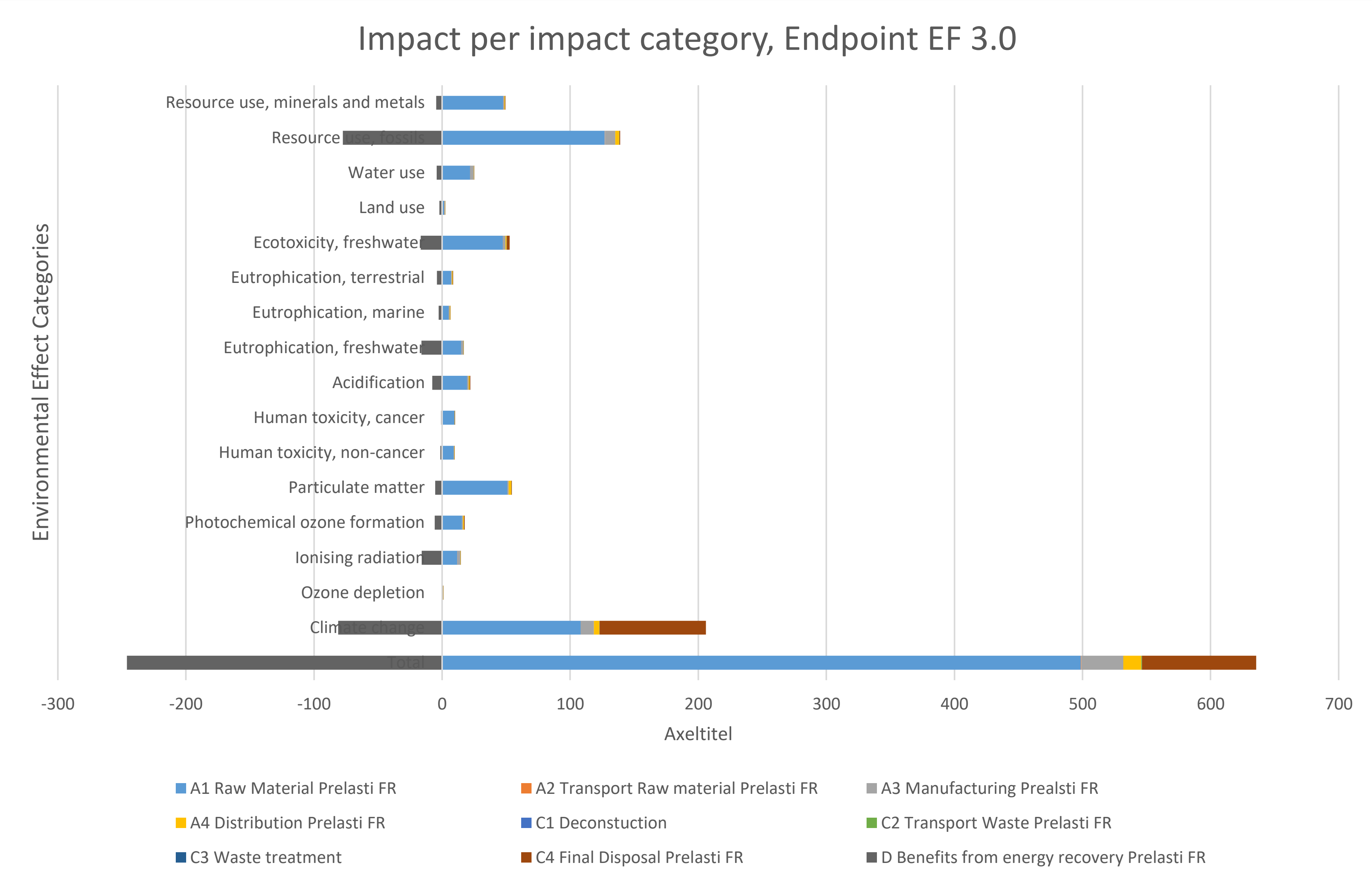


Figure 29: Share of environmental impact per impact category

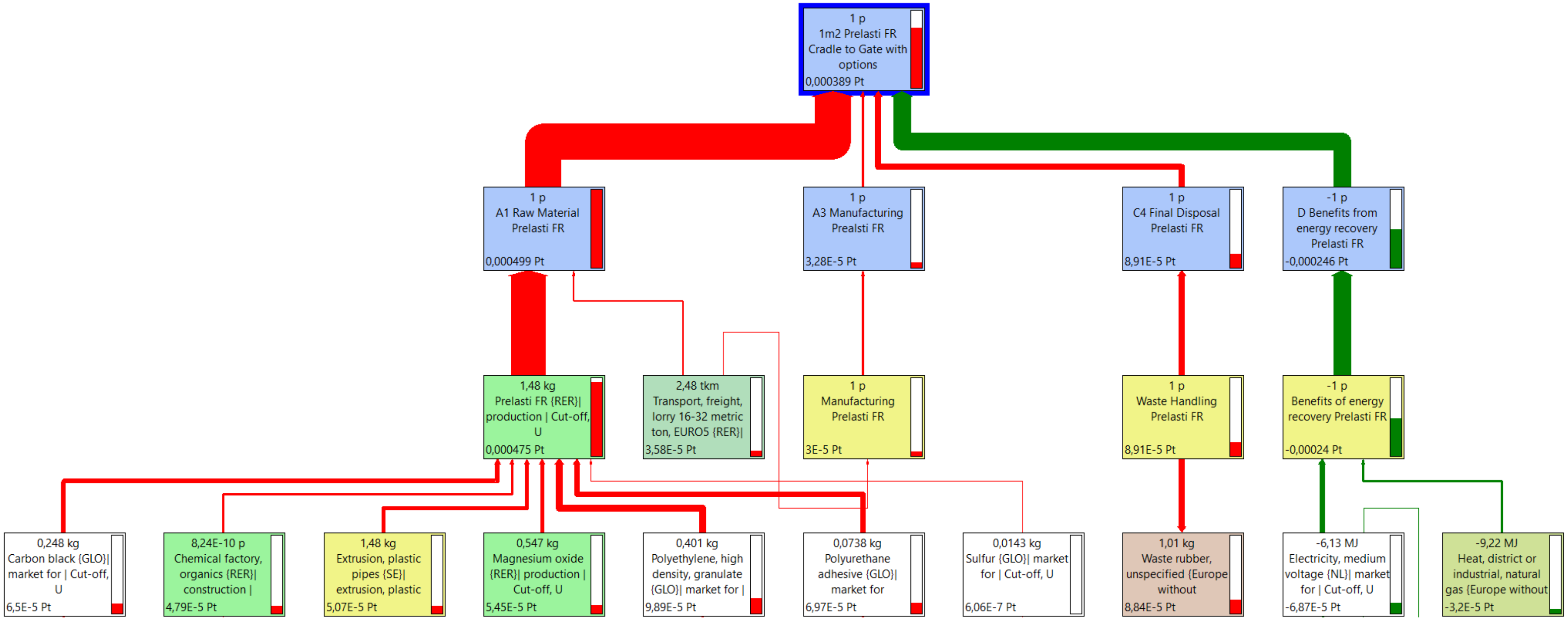
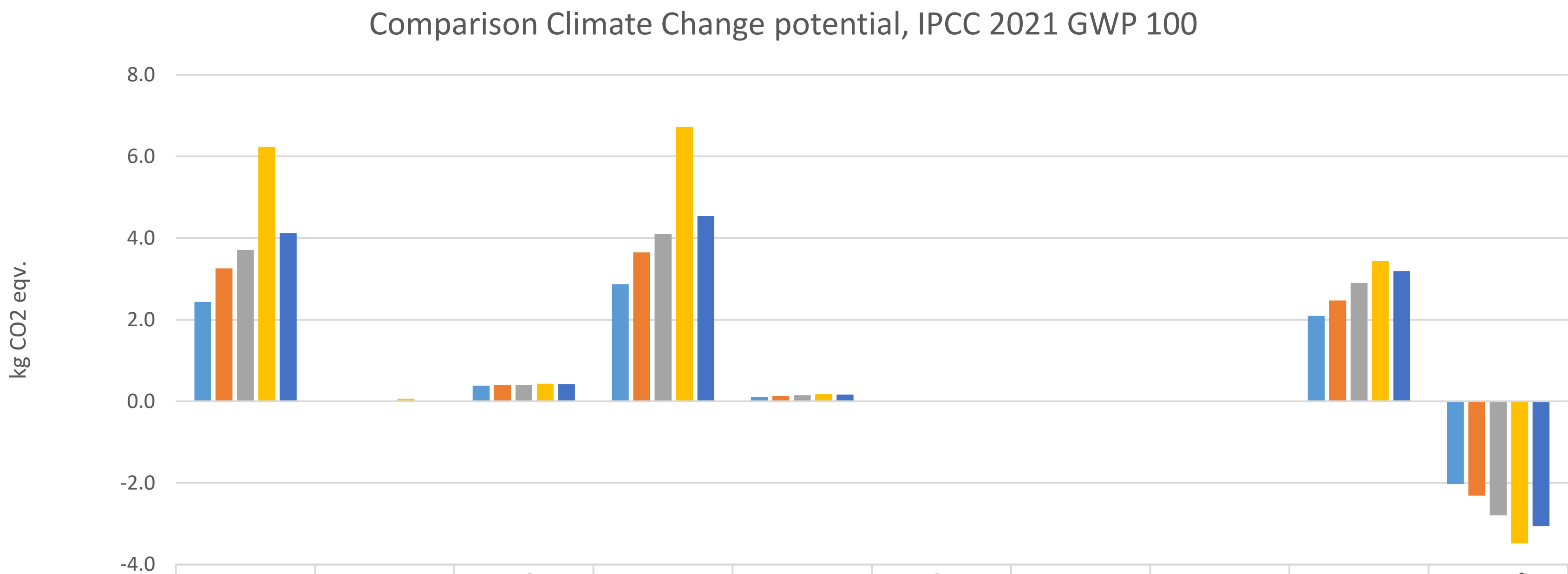


Figure 30, show how the total environmental burden is distributed on the included environmental aspects. Calculated with Environmental Footprint 3.0, cut off 6%.

5.3 Comparison all products

This part compares the different products with each other first from a Climate change perspective, Figure 31 calculated with IPCC 2021 GWP 100 and Figure 32 after that from a total environmental burden perspective calculated with EF 3.0 Endpoint level.

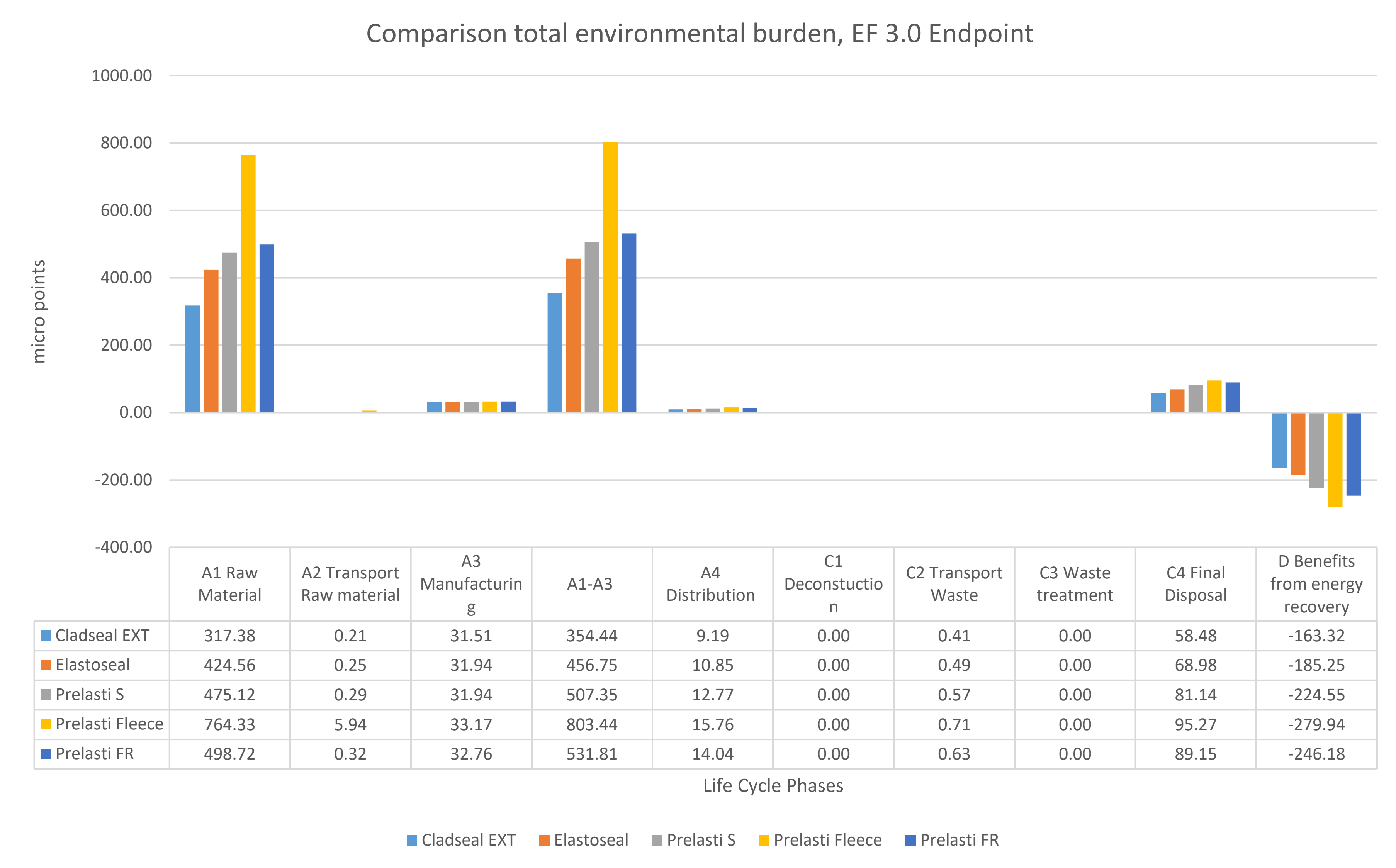


	A1 Raw Material	A2 Transport Raw material	A3 Manufacturing	A1-A3	A4 Distribution	C1 Deconstuction	C2 Transport Waste	C3 Waste treatment	C4 Final Disposal	D Benefits from energy recovery
Cladseal EXT	2.4	0.0	0.4	2.9	0.1	0.0	0.0	0.0	2.1	-2.0
Elastoseal	3.3	0.0	0.4	3.7	0.1	0.0	0.0	0.0	2.5	-2.3
Prealsati S	3.7	0.0	0.4	4.1	0.1	0.0	0.0	0.0	2.9	-2.8
Prelasti Fleece	6.2	0.1	0.4	6.7	0.2	0.0	0.0	0.0	3.4	-3.5
Prelasti FR	4.1	0.0	0.4	4.5	0.2	0.0	0.0	0.0	3.2	-3.1

Life Cycle Phases

Cladseal EXT Elastoseal Prealsati S Prelasti Fleece Prelasti FR

Figure 31, show a comparison of the Climate change potential expressed as kg CO2 equivalents calculated with IPCC 2021 GW 100.



	A1 Raw Material	A2 Transport Raw material	A3 Manufacturing	A1-A3	A4 Distribution	C1 Deconstuction	C2 Transport Waste	C3 Waste treatment	C4 Final Disposal	D Benefits from energy recovery
Cladseal EXT	317.38	0.21	31.51	354.44	9.19	0.00	0.41	0.00	58.48	-163.32
Elastoseal	424.56	0.25	31.94	456.75	10.85	0.00	0.49	0.00	68.98	-185.25
Prelasti S	475.12	0.29	31.94	507.35	12.77	0.00	0.57	0.00	81.14	-224.55
Prelasti Fleece	764.33	5.94	33.17	803.44	15.76	0.00	0.71	0.00	95.27	-279.94
Prelasti FR	498.72	0.32	32.76	531.81	14.04	0.00	0.63	0.00	89.15	-246.18

Figure 32, show a comparison of the total environmental burden expressed as micro points calculated with EF 3.0 Endpoint.

6 Interpretation

6.1 Sensitivity analysis

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

A1 Raw material is the life cycle phase with the highest environmental burden as can be seen in Figure 32. A part of that is the mixing facility in Forsheda owned by Trelleborg. Because no site-specific data could be obtained for this a number of assumptions had to be made based on generic data. The energy and water consumption are taken directly from the ecoinvent 3.8 process for producing synthetic rubber in Europe (Synthetic rubber {RER}| production | Cut-off). It is also assumed that the energy used in the facility is non-certified and therefore represented with the Nordic residual mix according to GPI 4.0 recommendations. Both these are conservative choices and would likely mean an increase of environmental burden.

If the electricity would be considered certified from renewable sources that would decrease the total climate change potential for CladSeal EXT with 14%. So, this is a relevant assumption that should be double checked for an update of this analysis.

All transportation has also been assumed to be made with truck with the emissions standard Euro 5. If all transport where instead done with Euro 4 standard the total climate change potential for CladSeal would decrease with 0,1% and with Euro 6 it would decrease with 0,2%. The small change is also true looking at endpoint level with changes under 0,5%. The assumption is considered robust and no further investigation into the matter is necessary.

6.2 Data quality assessment

An evaluation of the model an underlying data is made by a data quality assessment which includes a completeness check, assessing validity of data and a consistency check.

The data is assessed according to the DQR defined in part 3.9. The data quality assessment is based on the requirements in the ISO 14044 standard and EN 15804 standard.

Table 65: Data quality assessment for the study.

Aspect	Notes
Data quality assessment scheme	The data quality level and criteria from the product category rules have been applied in this study
Geographical coverage	Upstream data: Good (Europe) Core module (A3): Very good (site-specific)
Technological representativeness	Upstream data: Good (Generic data based on plant averages) Core module (A3): Very good (site-specific)
Time-related coverage	Upstream data: Good

	Core module (A3): Very good (2021 data)
Validity	The technological and geographical coverage of the data chosen reflects the physical reality of the product system modelled.
Plausibility	The data used for the core process and some upstream processes have been checked for plausibility, using as reference EPDs for similar products.
Precision	Material and energy flow quantified based on generic data from the ecoinvent 3.8 database.
Completeness	Data accounts for all known sub-processes. All upstream processes were modelled using generic data from the ecoinvent 3.8 database, using country-specific datasets whenever available, otherwise using European datasets.
Consistency, allocation method, etc.	Allocation follows a physical causality in line with EN 15804.
Completeness and treatment of missing data	No data is found missing.
Final result of data quality assessment	Data quality as required in EN15804 is met.

6.3 Limitations

6.4 Uncertainty analysis

To assess the uncertainty of the result a Monte Carlo analysis can be performed. A Monte Carlo analysis quantitively assesses the probability of the result by re-calculating the result several times with different in-data variation each time. ecoinvent 3.8 data contain in-data interval, meaning that the input can vary between an interval of number distributed on different probability distributions, most common a lognormal distribution.

In total 71,8% of the in-data have an interval that is randomly changed in this interval in the Monte Carlo analysis. The Monte Carlo analysis then shows how the result deviates depending on the change in in-data. This indicates the probability of the result documented in 5.2.

The distribution of the results concerning climate change potential calculated with EF 3.0 method after 1000 calculations can be seen in Figure 33.

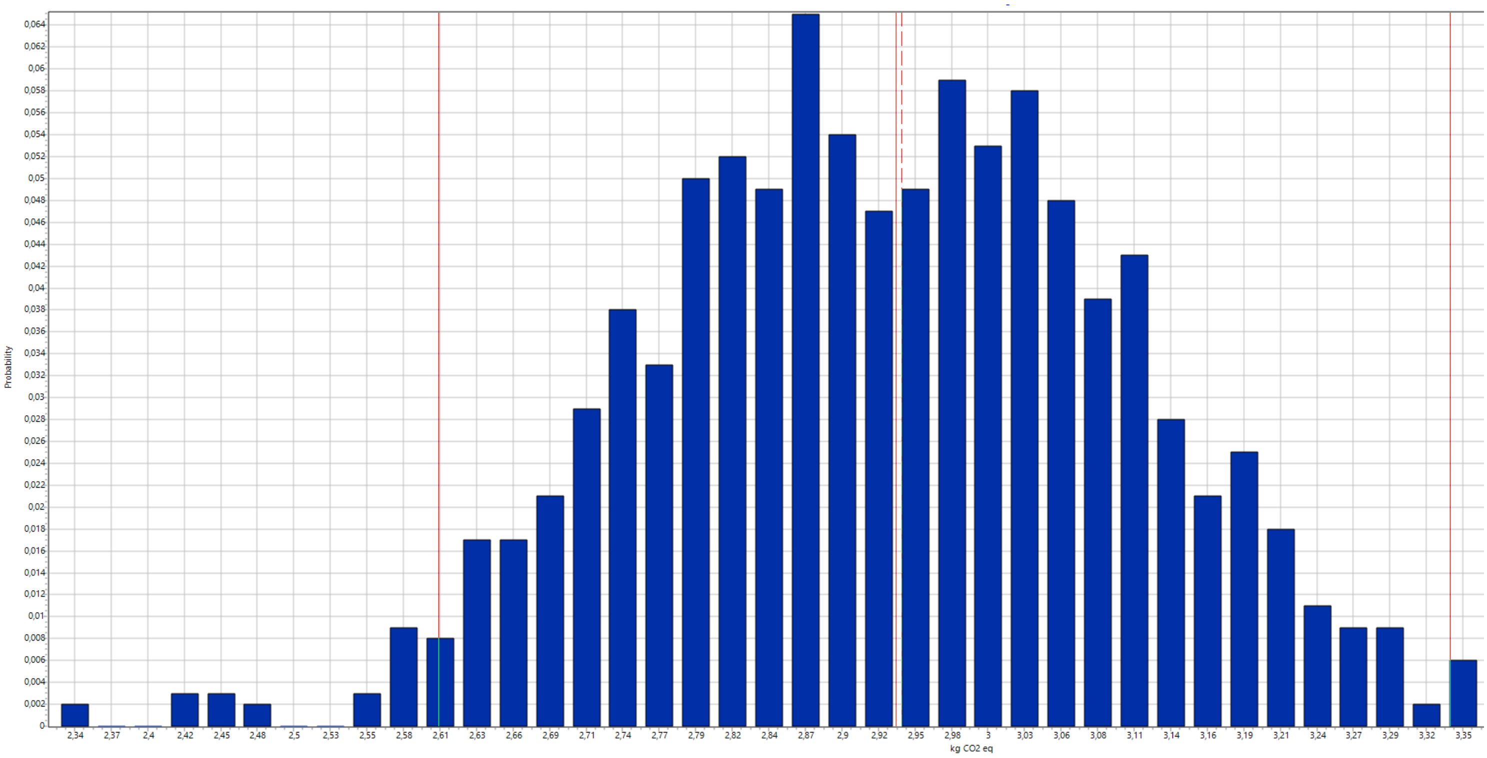


Figure 33, shows the distribution of results and their probability.

The result shows that the mean value is 2,94kg CO2 eqv, the median value is 2,94kg CO2 eqv. The standard deviation is 0,185kg CO2 eqv. or 6,3%. 2,5% of the result is lower than 2,61kg CO2 eqv and 2,5% is higher than 3,34kg CO2 eqv.

7 Conclusions and recommendations

7.1 Overall conclusions

As can be seen in Figure 31 and Figure 32 for all five products the dominating life cycle phase is A1 raw material extraction. What raw materials contribute most to the total is described under 7.1.1.

C4 Waste handling is the second biggest contributor to the overall environmental burden. The high percentage of fossil based raw material leads to emissions with high GWP when incinerated. How the different material is contributing to C4 waste handling burden and how a change in disposal scenario can change the result are described in detail under 7.1.3.

Manufacturing shows a small contribution to the total environmental burden, around 5%. Because of the high ability for SealEco to affect the manufacturing it is still interesting to go into detail to, this is done under 7.1.2.

Prelasti Fleece show the highest environmental burden, mainly because the higher amount of raw material needed for the production and the highest application thickness, but also because the raw material composition. Details concerning this can be seen in 7.1.1.

CladSeal EXT show the lowest environmental burden, this mainly because of the low thickness used in application which leads to low less raw material needed. This also give a lower environmental burden in transportation and C4 waste handling.

The climate change potential, use of fossil resources and particulate matter formation is considering to be the most relevant environmental effect categories looking at the results from EF 3.0 Endpoint for the different products. Considering that the products have a high percentage fossil based raw material this is expected.

7.1.1 Raw material

Looking into detail of the raw material phase give the opportunity to assess the environmental burden of each raw material individually and the energy needed for mixing the raw material. For CladSeal the raw material with the highest environmental burden and endpoint is carbon black with 27% of the burden in A1. The second biggest contributor is the energy used in manufacturing the finished raw material, this stands for 19,1%. The third biggest is the mineral oil with 15,2%.

To understand the environmental burden per raw material better the environmental burden of the same amount of raw material can help. Table 66 show the total environmental burden expressed as micro points (see chapter 5.1.2) and climate change potential for 1kg for each raw material individually.

Table 66, show the climate change potential and environmental burden calculated with EF 3.0 for 1kg of each raw material used in the five products.

Raw Material	Kg CO2 eqv.	micro points
Carbon black	1.879	0.262
Fleece	3.190	0.330
Chemical, organic (CBS, TBBS)	2.071	0.220

Chalk	0.382	0.054
Mineral Oil	1.238	0.224
EPDM polymer	4.784	0.490
Zinc oxide	0.776	0.082
Aliphatic resin	5.785	0.944
Stearic	0.531	0.061
Sulfur	0.137	0.042
Magnesium oxide	1.027	0.100

Table 66 show that the raw material with highest burden is the aliphatic resin, however, this is used in small amounts, around 1% of the raw material composition. The EPDM polymer, that is the mix of polyethylene and polypropylene that is the basis of the synthetic rubber, show the second highest environmental burden, and this is also used in higher amount (22% of the weight in CladSeal) which make a big potential to lower the environmental burden by lower the amount of this raw material. Chalk shows small environmental burden relative the other raw materials and is at the same time a raw material used in high amount (21% in CladSeal). CladSeal have the lowest environmental burden for the raw material and the highest amount of chalk.

Prelasti FR and Prelasti Fleece both have high percentage of magnesium hydroxide instead of chalk which leads to higher environmental burden per kg raw material.

Looking at the raw material used per kg material instead of 1m2 the environmental burden of the raw material composition for the different components is more apparent. This can be seen in Table 67 below.

Table 67, show the climate change potential per kg raw material.

Product	Unit	Kg CO2 eqv.
Raw Material CladSeal	1kg	2.6
Raw Material ElastoSeal	1kg	2.95
Raw Material Prelasti Fleece	1kg	3.9
Raw Material Prelasti FR	1kg	2.89
Raw Material Prelasti S	1kg	2.85

Prelasti fleece is the most material intensive product per m2, with a weight of 1,62kg per m2, this mostly because of the thickness of 2,3mm per m2. The weight is for example 72% more than CladSeal per m2 as can be seen in 3.4. Prelasti Fleece is also the product with the highest GWP per kg raw material, which make it with some margin the product with the highest environmental burden.

The importance of the raw material phase highlights the importance of not using more of the finished product than is needed. The thickness applied then becomes an important factor. For example, the most crucial factor for making CladSeal better per m2 than Prelasti Fleece is the lower thickness of the membrane and with that the lower amount of raw material needed per m2. If there is any opportunity to lower the thickness of the products this should be investigated by SealEco. It is however important to see the long-term environmental burden from a function perspective. If for instance CladSeal needs to be changed two extra time during the usage of the product due to bad functionality, it will be the worst choice of all the five membranes per m2.

7.1.2 A3 Manufacturing

Manufacturing show small relative burden to the other life cycle phases but considering the high ability to change this process for SealEco it is interesting to investigate in more detail. For manufacturing the electricity used stands for 72% of the total environmental burden. The second biggest is the textile used, that stands for 18%. Looking from a climate change perspective the numbers change and instead the electricity stands for 67% and the second biggest contributor is rubber waste handling of product waste, that stands for 24%.

The electricity is not certified which means that the residual mix for the Nordic market is used. This has a high GWP compared to the consumption mix, and the relative difference is even higher compared to electricity from renewable sources. If the electricity used came from certified wind power for example, instead of the non-certified electricity that is used today, the GWP from manufacturing would decrease from 0,347kg CO2 to 0,125kg CO2, a decrease with more than 60%. However, the certification of electricity do nothing to enhance the sustainability from a larger perspective. The same amount of emissions is only allocated to different users when electricity is certified, so even if the results look better for SealEco the emissions as a total in society have not changed. A more sustainable measure to decrease the burden from electricity usage is either to lower the energy use or to build the capacity to produce renewable energy, for example by solar cells or wind power plant.

The textile has relatively small environmental burden seen to the total but have a relevant part of the environmental burden from manufacturing. This is not from a climate change perspective but originate from the environmental effect categories Water Use, Eutrophication and Ecotoxicity. If the environmental burden is compared to paper, paper have a significantly lower environmental burden, but holds the downside that it is discarded after each use. Because of the high number of re-uses of the textile, this is considered to be the better option, based on a number of LCA:s assessing this (Johansson, 2021). So, textile is a viable option as long as it re-used at least more than ten times, preferably more of course.

The manufacturing process have a waste of 2,8%, this adds quite some environmental burden because the extra amount of raw material, transportation and waste that needs handling. For CladSeal EXT the total climate change potential decreases from 2,99kg CO2 eqv to 2,84kg CO2 eqv if there would be no waste at all, a decrease with around 5%. Even if a zero-waste scenario is very unlikely it shows the potential of waste reduction measures. The burden from the production waste comes from the extra raw material and the incineration of the waste. To lower the product waste is a relevant measure to lower the overall environmental burden for all products.

7.1.3 C4 Waste handling

Final waste disposal C4 has the second biggest environmental burden of all life cycle phases. Here 70% of the product waste is incinerated and emissions to air is released. Looking only at climate change potential 99,2% of the total climate potential comes from rubber incineration. Incineration of the polyethylene packaging stand for 0,7%, so almost all comes from the incineration part of the waste handling. The 30% of the material waste that is sent to landfill has barely any climate change potential or environmental burden. Landfill as a solution for final waste handling instead have the downside that it makes recycling impossible. Much of the climate change potential can be neutralized if the potential benefit of the energy recovery is added as can be seen in Figure 31 and Figure 32.

There are pilot cases of material recycling of EPDM material, and facilities for this are available. To calculate the potential benefits of using recycled EPDM instead of virgin raw material some rough assumptions had to be made, so the results should be seen as indication of the potential and not an exact result. Because there is no data on how much energy or material that is needed for the recycling process the same process as for plastic recycling will be used, that includes washing, sorting, grinding and extruding. A transport of 1000km will also be added that are representing the transport post-consumer to the recycling facility and then to SealEco. For CladSeal the climate change potential for A1 Raw material phase will then decrease from 2,4kg CO2 eqv. to 0,51kg CO2 eqv if recycled raw material is used instead of virgin. A decrease with almost 80%.

If also the product would be material recycled instead of energy recycled in C4 Waste handling the climate change potential decrease from 2,09kg to 0,2kg CO2 eqv. a 90% decrease in this life cycle phase.

If both these benefits are added together the total climate change potential A1 to C4 would decrease from 5,02kg CO2 eqv. to 1,2kg CO2 eqv. a decrease with 76% for CladSeal.

7.1.4 Transportation

In total CladSeal is transported 1,63tkm during its entire life cycle. All this transport is made by truck with the assumed emissions standard of Euro 5. In total this adds 0,268kg CO2 eqv. this is around 5% of the total climate change potential of the product. If this was done with train instead the climate change potential would be 0,064kg CO2 eqv instead a decrease of around 75%. This can decrease the total climate change potential of CladSeal with around 4%.

7.1.5 Packaging

The production and waste handling of the packaging stands for 0,056kg CO2 eqv during the life cycle. That is around 1% of the total.

7.2 Recommendation on how to mitigate the hot spots

From the conclusions in 7.1 some recommendations can be derived. The recommendations are in falling priority order:

1. Use recycled EPDM as raw material
2. Take measures to recycle or take back used EPDM
3. If possible, considering functionality, the products with low environmental burden should be recommended by SealEco.
4. Build infrastructure to generate renewable energy for manufacturing
5. Increase the relative amount of chalk, magnesium oxide and zinc oxide on the expense of EPDM polymer, carbon black and mineral oil
6. Lower the production waste
7. Use train for transportation

If 1,2,4, 6 and 7 is implemented it has the potential to lower the total climate change potential with 86% for CladSeal.
How and in which degree 3, 4 or 5 is possible cannot be evaluated my Miljögiraff, but both have the potential to lower the environmental burden of the product.

7.3 Internal follow-up procedures

For EPDs, internal follow-up procedures shall be established to confirm whether the information in the EPD remains valid or if the EPD needs to be updated during its validity period. The GPI state that the main parameters that may mandate an update shall be identified through a sensitivity analysis. The established procedure may or may not involve a contracted verifier. The follow-up shall be at least annually and should be made with a frequency that will allow for an acceptable coverage of changes that might occur.

The procedure should include how the organisation monitors any significant changes that have taken place in the information submitted as input data for the information in the EPD, such as raw material acquisition, transportation modes, manufacturing processes, changes in product design, or updated legislation. The follow-up procedure may be made part of an existing quality or environmental management system.

8 References

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9 Appendix list

Appendix 1, Methods for Impact Assessment

Classification and characterisation

Classification means that all categories of data are sorted into different categories of environmental effects (see Figure 34). Readymade methods for this have been used to evaluate environmental effects from a broad perspective and find the categories with the most potential impact. The most commonly used methods include Ecoindicator and EPS. These methods also include characterisation (and weighting, described below). In characterisation, the aim is to quantify each element's contribution to the different categories of environmental effect, respectively. To do this, each category of environmental effect is multiplied with characterisation factors that are specific for the data and the category of environmental effect. The result of the characterisation indicates what or which emissions lead to a significant environmental influence. Each of these characterisations represents the potential environmental influence that could arise if an element were released into the environment or if a resource was consumed. Classification and characterisation are where all items in the inventory are assigned to the effect it is likely to have on the environment.

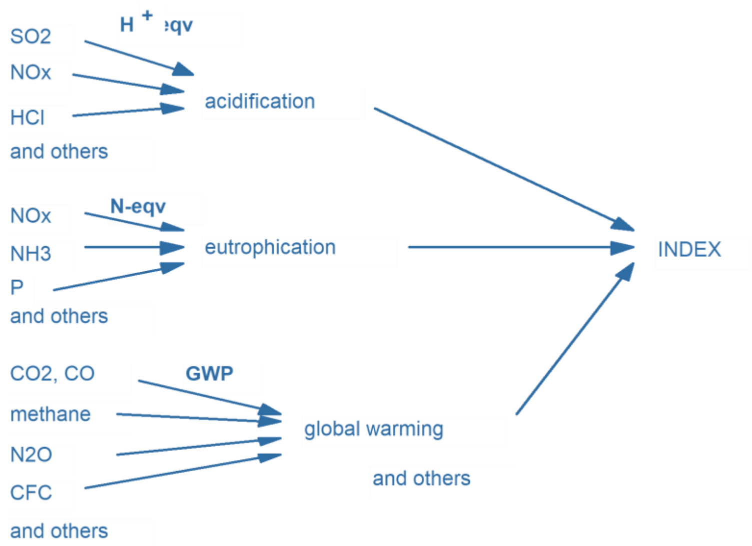

Figure 34: An illustration of the Impact Assessment of an LCA.

When this link is determined, we call it an environmental aspect. This environmental aspect has to be linked between the environment and the process before you can say that it is established and that the process is unsustainable. In the early stages of the Life Cycle Assessment, substances that were found in the inventory are assigned to environmental aspects. In order to contribute to the ultimate goal of sustainability, it is important to also describe the local and global environment. Environmental aspects that may have an impact are located and after that, the link to the inventory and the process path features may be analysed and established.

LCA impact categories vs planetary boundaries

It can be relevant to note that the impact categories described above do not have a one to one correlation with the planetary boundaries as described by Steffen et al. (Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, 2015). Table 68 maps the planetary boundaries to mid-point indicators in LCA (when possible) and classifies whether there is a high or low level of correspondence between the indicators.

Climate change, ozone depletion, eutrophication and human- and ecotoxicity are included in similar ways in the two frameworks (Böckin et al., 2020). However, the ILCD indicators of photochemical ozone creation potential and respiratory effects are meant to represent direct human health impacts. The corresponding planetary boundary is atmospheric aerosol loading, but this is instead mainly meant to represent effects on monsoon rains. Furthermore, acidification in ILCD represents impacts from e.g. nitrogen and sulphur oxides on land and water ecosystems, while ocean acidification in the planetary boundaries instead represents the effects of carbon dioxide being dissolved in oceans, thus lowering pH levels and affecting marine life. Moreover, the ILCD standard does not include an indicator that matches the planetary boundary of biospheric integrity, while the closest category can be said to be land use, since it is a driver of biodiversity loss. Lastly, there are some differences between land system change and freshwater use in the planetary boundaries and land use and water use in ILCD, while the planetary boundaries do not include a category for abiotic resource depletion.

Table 68: Planetary boundaries, by Steffen et al. (Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, 2015), and mid-point environmental impact indicators in LCA recommended by ILCD (Hauschild & Huijbregts, 2015). Adapted from (Tillman et al., 2020).

Planetary boundaries	Mid-point indicators in LCA as recommended by ILCD	Level of correspondence between impact categories
Climate change	Climate change	High level of correspondence
Stratospheric ozone depletion	Ozone layer depletion	
Biogeochemical flows (nitrogen and phosphorus cycles)	Freshwater, marine and terrestrial eutrophication	
Novel entities (chemical pollution)	Freshwater ecotoxicity	
	Human toxicity (cancer and non-cancer)	
Atmospheric aerosol loading	Photochemical ozone creation	Some correspondence
	Respiratory effects, inorganic	
Ocean acidification	Freshwater acidification	
Biospheric integrity (biodiversity loss)	Resources land use	
Land system change	Resources land use	
Freshwater use	Resources dissipated water	
-	Resources minerals and metals	No correspondence
-	Resources fossils	
-	Ionising radiation	

Weighting
The results of an LCA may depend on the method for impact assessment. There are several different models to assist in the assessment of the environmental impacts connected to the life cycle, e.g. ecological scarcity (ECO), the environmental theme method (ET), ECO indicator (EI), ReCiPe and the Environmental Priority Strategies in Product Design (EPS) method.

Using a weighting method implies that all of the data classes are weighted together so that only one number is expressed for the weighting method. The different data categories are weighed from some form of valuation principle. The basis of valuation could be either individual or a community's political and/or morality valuations. The weighting expresses the relation between values in the community and variations in nature. The more effect or deviation an environmental aspect has from the valuations, the higher the weighting value assigned to that environmental aspect.

The basis of the valuations used to develop weighting methods could be; political decisions, technical-financial conditions, nature conditions, health effects, panels or studies of behavioural patterns. In a weighting method, there is either one or a combination of valuation bases. Since the basis of valuations varies for each weighting method, a comparison between different methods will give a corresponding shift in the result.

The most commonly used weighting methods are collected in the book "The Hitch Hiker's Guide to LCA", written by Baumann & Tillman (Baumann & Tillman, 2004), and the most important are presented below:

Ecoindicator'99 is a weighting method based on the distance-to-target principle, and the target is established as environmental critical loads of 5 % ecosystem degeneration, or similar. Ecoindicator'99 weights are determined from three different cultural perspectives; hierarchist, egalitarian and individualist perspectives. Ecoindicator’99 is based on Goedkoop and Spriensma (Goedkoop & Spriensma, 1999).

EPS 2000 is based on the willingness-to-pay for avoiding damages on environmental safeguard subjects. The EPS method is especially suitable for the assessment of global impacts, such as climate change potential and resource depletion. The EPS indices are prepared by a group at the Chalmers University of Technology and a steering committee from the industry in Sweden.

Among the most common methods, however, are EF and ReCiPe and they deserve some more details, which are presented below.

The impact assessment methods EF 3.0 and ReCiPe 2008
While the Environmental Footprint method is used in this report, it is built on the foundation of the ReCiPe 2008 method, which is presented in detail here.

ReCiPe LCIA Methodology is a methodological tool used to quantitatively analyse the life cycle of products/activities. ISO 14040 and 14044 provide a generic framework. After the goal and scope have been determined and data collected, an inventory result is calculated. This inventory result is often a long list of emissions, consumed resources and sometimes other items. The interpretation of this list is difficult. An LCIA procedure, such as the ReCiPe method is designed to help with this interpretation. The primary objective of the ReCiPe method is to transform the long list of inventory results, into a limited number of indicator scores. These indicator scores express the relative severity of an environmental impact category. In ReCiPe indicators are determined on two levels:

- Eighteen midpoint indicators
- Three endpoint indicators

ReCiPe uses an environmental mechanism as the basis for the modelling. An environmental mechanism can be seen as a series of effects that together can create a certain level of damage to, for instance, human health or ecosystems. For climate change, we know that a number of substances increase radiative forcing. This means that heat is prevented from being radiated from Earth to space. As a result, more energy is trapped on Earth and temperature increases. As a result, we can expect changes in habitats for living organisms, resulting in the potential extinction of species. From this example, it is clear that the longer the chains of environmental mechanisms, the higher the uncertainties (see Figure 35). Radiative forcing is a physical parameter that can be relatively easily measured in a laboratory. The resulting temperature increase is less easy to determine, as there are many parallel positive and negative feedback. Our understanding of the expected change in habitat is also not complete, etc.

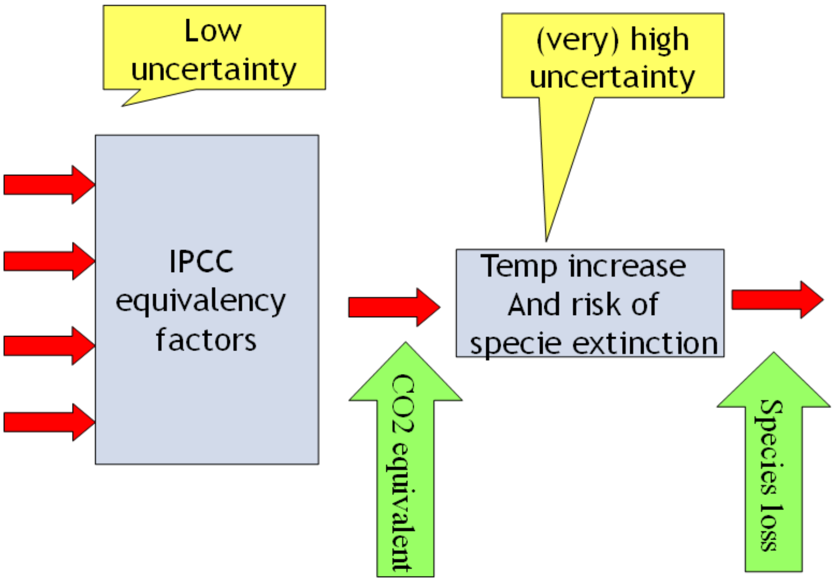

Figure 35: Example of a harmonised midpoint-endpoint model for climate change, linking to human health and ecosystem damage.

Hence, the obvious benefit of only taking the first step is the relatively low uncertainty. However, ReCiPe combines mid- and endpoints. Eighteen midpoint indicators are used, but three much more uncertain endpoint indicators are also calculated. The motivation to calculate the endpoint indicators is that the large number of midpoint indicators is difficult to interpret, partially as there are too many, partially because they have a very abstract meaning. How to compare radiative forcing with base saturation numbers that express acidification? The indicators at the endpoint level are intended to facilitate easier interpretation, as there are only three, and they have a more easily grasped meaning. The idea is that each user can choose at which level they wants to have the result:

- Eighteen robust midpoints, that are relatively robust, but not easy to interpret
- Three easy to understand, but more uncertain endpoints:
    - Damage to Human health
    - Damage to ecosystems
    - Damage to resource availability

The user can thus choose between uncertainty in the indicators on the one hand and uncertainty in the correct interpretation of indicators on the other hand. Figure 36 provides the overall structure of the method.

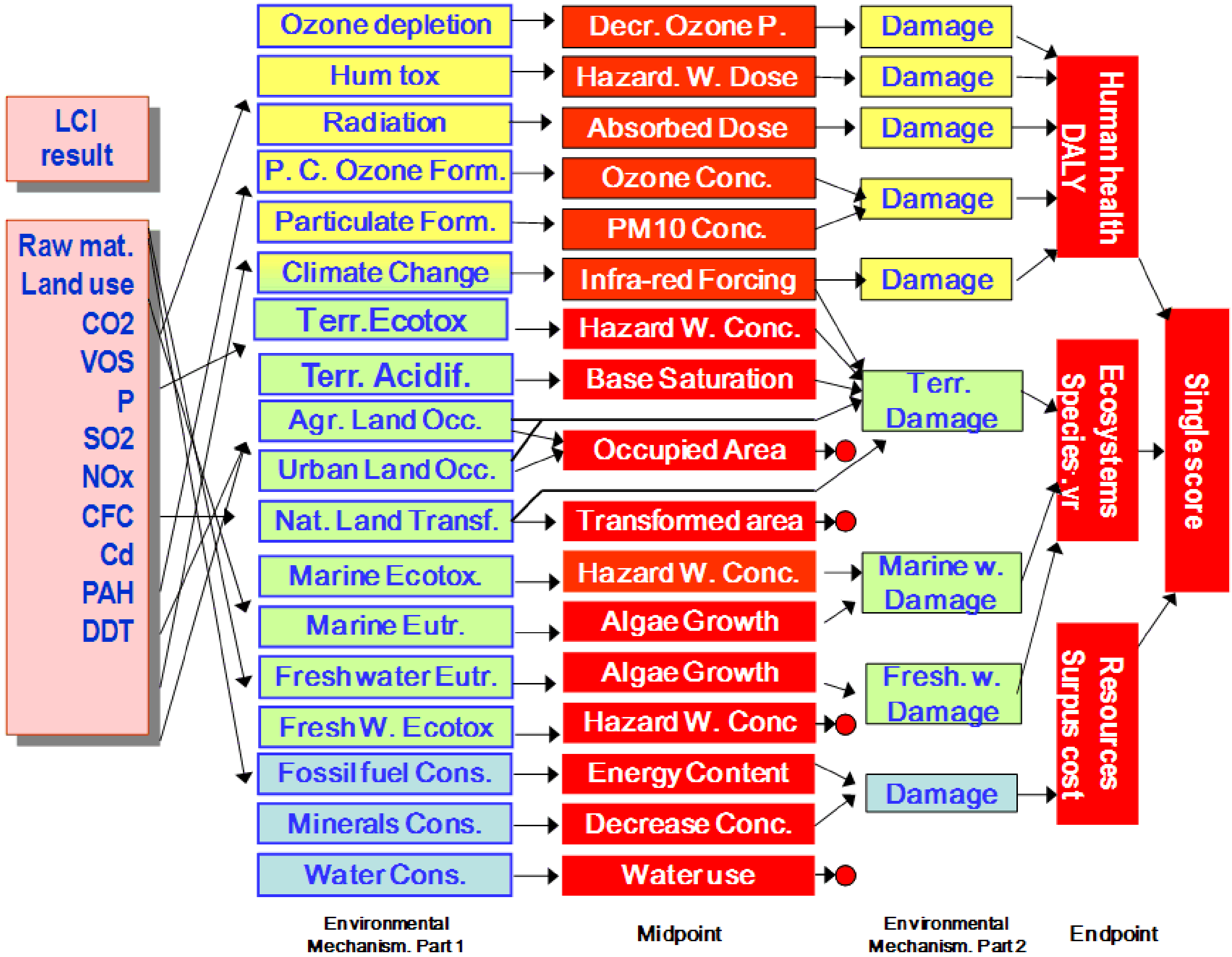

Figure 36: ReCiPe Characterisation links.

A closer description of the different environmental effect categories calculated with ReCiPe Method can be seen below:

Climate change: Climate change causes a number of environmental mechanisms that affect both the endpoint human health and ecosystem health. Climate change models are in general developed to assess the future environmental impact of different policy scenarios. For ReCiPe 2008, we are interested in the marginal effect of adding a relatively small amount of CO_2 or other greenhouse gasses, and not the impact of all emissions

Ozone layer: The characterisation factor for ozone layer depletion accounts for the destruction of the stratospheric ozone layer by anthropogenic emissions of ozone depleting substances (ODS). These are recalcitrant chemicals that contain chlorine or bromine atoms. Because of their long atmospheric lifetime they are the source of Chlorine and Bromine reaching the stratosphere. Chlorine atoms in chlorofluorocarbons (CFC) and bromine atoms in halons are effective in degrading ozone due to heterogeneous catalysis, which leads to a slow depletion of stratospheric ozone around the globe.

Ionising radiation: This describes the damage to Human Health related to the release of radioactive material into the environment.

Photochemical ozone formation: This category represents the potential of nitrogen oxides, carbon monoxide and volatile organic compounds to form ground level ozone, with consequent negative health effects.

Particulate matter formation: Fine Particulate Matter with a diameter of smaller than 10 µm (PM10) represents a complex mixture of organic and inorganic substances. PM10 causes health problems as it reaches the upper part of the airways and lungs when inhaled. Secondary PM10 aerosols are formed in air from emissions of sulphur dioxide (SO2), ammonia (NH3), and nitrogen oxides (NOx) among others (World Health Organisation, 2003). Inhalation of different particulate sizes can cause different health problems.

Acidification: Atmospheric deposition of inorganic substances, such as sulphates, nitrates, and phosphates, cause a change in acidity in the soil. For almost all plant species there is a clearly defined optimum of acidity. A significant deviation from this optimum is harmful to that specific kind of species and is referred to as acidification.

Eutrophication: Aquatic eutrophication can be defined as nutrient enrichment of the aquatic environment. Eutrophication in inland waters as a result of human activities is one of the major factors that determine its ecological quality. On the European continent, it generally ranks higher in the severity of water pollution than the emission of toxic substances. Aquatic eutrophication can be caused by emissions to air, water and soil. In practice, the relevant substances include phosphorus and nitrogen compounds emitted to water and soil as well as ammonia (NH3) and nitrogen oxide (NOx) emitted to air.

Toxicity: The characterisation factor of human toxicity and ecotoxicity accounts for the environmental persistence (fate) and accumulation in the human food chain (exposure), and toxicity (effect) of a chemical. Fate and exposure factors can be calculated by means of 'evaluative' multimedia fate and exposure models, while effect factors can be derived from toxicity data on human beings and laboratory animals.

Land occupation: The land use impact category reflects the damage to ecosystems due to the effects of occupation and transformation of the land. Although there are many links between the way land is used and the loss of biodiversity, this category concentrates on the following mechanisms:

1. Occupation of a certain area of land during a certain time;
2. Transformation of a certain area of land.

Both mechanisms can be combined, often occupation follows a transformation, but often occupation occurs in an area that has already been converted (transformed). In such cases, the transformation impact is not allocated to the production system that occupies an area.

Water depletion: Water is a scarce resource in many parts of the world, but also a very abundant resource in other parts of the world. Unlike other resources, there is no global market that ensures a global distribution. The market does not work over big distances as transport costs are too high. Extracting water in a dry area can cause significant damages to ecosystems and human health.

Depletion of abiotic resources: "Abiotic resources" are natural resources (including energy resources) such as iorn ore, crude oil and wind energy, which are regarded as non-living. Abiotic resource depletion is one of the most frequently discussed impact categories and there is consequently a wide variety of methods available for characterising contributions to this category. To a large extent, these different methodologies reflect differences in problem definition. Depending on the definition, this impact category includes only natural resources, or natural resources, human health and the natural environment, among its areas of protection. Note that the debate on the characterisation of depletion-related impact categories is not settled. (J. B. Guinée et al., 2002)

Appendix 2, IPCC 2013

Direct solar radiation heats the Earth. The heated crust emits heat radiation which is partially absorbed by gases, known as greenhouse gases, in the Earth's atmosphere. Some of this heat radiation radiates back to Earth and heats it. This natural greenhouse effect is essential for life on Earth. However, because of human activity, the presence of greenhouse gases in the atmosphere, such as carbon dioxide, methane, and nitrous oxide, have increased. This affects the natural radiation balance, which leads to global warming and climate changes.

The potential impact on the climate is calculated using the IPCC 2013 GWP 100 v.1.03, model Global Warming Potential, GWP. The impact of climate gases is expressed as carbon dioxide equivalents, CO2 eq. It is the most established scientific method. It has been implemented in other methods, such as GHG protocol and ReCiPe, but then with adaptions.

Appendix 3, Cumulative Energy Demand, CED

Cumulative Energy Demand (CED) is a method to calculate direct and indirect use of energy resources, commonly referred to as *primary energy*. Characterisation factors are given for the energy resources divided into five impact categories:

- Non-renewable, fossil
- Non-renewable, nuclear
- Renewable, biomass
- Renewable, wind, solar, geothermal
- Renewable, water

Some studies also add energy from waste as an indicator. This is not done here, since waste is not considered to be primary energy, and thus the input of energy resources may be less than the final energy (heat and electricity) delivered by the system.

Normalisation is not a part of this method. To get a total ("cumulative") energy demand, each impact category is given the weighting factor 1 (Frischknecht et al., 2007).

Appendix 4, ecoinvent

Ecoinvent is one of the world's leading databases with consistent, open, and updated Life Cycle Inventory Data (LCI). With several thousand LCI datasets in the fields of agriculture, energy supply, transport, biofuels and biomaterials, bulk and speciality chemicals, construction and packaging materials, basic and precious metals, metals, IT and electronics and waste management, ecoinvent offers the most comprehensive international LCI database.

Ecoinvent's high-quality LCI datasets are based on industrial data and have been compiled by internationally recognised research institutes and LCA consultants.

Appendix 5, LCA methodology and ISO 14040

LCA can assist in:

- identifying opportunities to improve the environmental performance of products at various points in their life cycle,
- informing decision-makers in industry, government, or non-government organisations (e.g., for strategic planning, priority setting, product or process design or redesign),
- the selection of relevant indicators of environmental performance, including measurement techniques,
- marketing (e.g., implementing an eco-labeling scheme, making an environmental claim, or producing an environmental product declaration).

Some terms that are used in the method require clarification:

- 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).

LCA addresses the environmental aspects and potential environmental impacts) (e.g., use of resources or environmental consequences of emissions) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling, and final disposal (i.e., cradle-to-grave).

A significant part of the environmental impact of a product depends on choices taken during the product development phase, e.g., materials, processes, or functionality. Therefore, the basic principles for abatement come from the discipline of cleaner technology and are defined in the concept of Integrated Product Policy (IPP) as:

"*All products cause environmental degradation in some way, whether from their manufacturing, use, or disposal. LCA management minimises these by looking at all phases of a product's life cycle and acting where it is most effective.*

The life cycle of a product is often long and complicated. It covers all the areas from the extraction of natural resources, through their design, manufacture, assembly, marketing, distribution, sale, and use to their eventual disposal as waste. At the same time, it also involves many different actors such as designers, industry, marketing people, retailers, and consumers. LCA management attempts to stimulate each part of these individual phases to improve their environmental performance. With so many different products and actors, there cannot be one simple policy measure for everything. Instead, there are a whole variety of tools - both voluntary and mandatory - that can be used to achieve this objective."

In 1997, the European Committee for Standardisation published their first set of international guidelines for LCA performance. This ISO 14040 standard series has become widely accepted amongst the practitioners of LCA and is continuously being developed along with progressions within the field of LCA (Rebitzer et al., 2004). The International Organization for Standardization describes the guidelines for LCA in two documents; ISO 14040, which contains the main principles and structure for performing an LCA, and ISO 14044, which includes detailed requirements and recommendations. Furthermore, ISO/TR 14048 includes the format for data documentation (ISO, 2002) as well as technical reports with guidelines for the different stages of an LCA in ISO/TR 14047 (ISO, 2012a) and ISO/TR 14049 (ISO, 2012b), are available in this standard series.

An LCA study has four phases: the goal and scope definition phase, the inventory analysis phase, the impact assessment phase, and the interpretation phase. Figure 37 shows a conceptual representation of this.

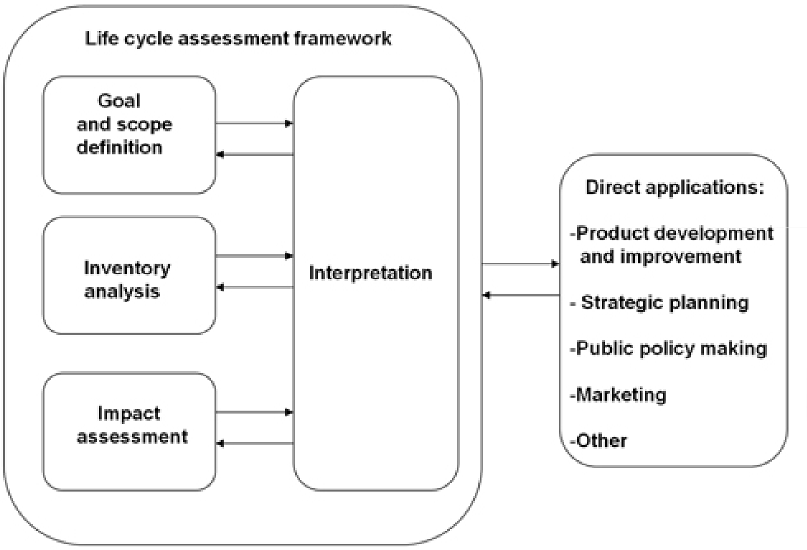

Figure 37: The four phases of the Life Cycle Assessment and some suggestions for how to apply the results and insights

1. The first phase is the definition of goal and scope. The goal and scope, system boundary, and level of detail of an LCA depend on the subject and the intended use of the study. The depth and the breadth of LCA can differ considerably depending on the goal of a particular LCA.

2. The life cycle inventory analysis phase (LCI) is the second phase of LCA. It is an inventory of input/output data concerning the system that is studied. It involves the collection of the data necessary to meet the goals of the defined study.

3. The life cycle impact assessment phase (LCIA) is the third phase of the LCA. The purpose of LCIA is to provide additional information to help assess a product system's LCI results to understand their environmental significance better.

Life cycle interpretation is the final phase of the LCA procedure. The results of the LCI, LCIA, or both are summarised and discussed as a basis for conclusions, recommendations, and decision-making according to the goal and scope definition.