SUSTAINABILITY IN HARD GOODS

A GUIDE TO ACCELERATED SUSTAINABILITY WORK IN NON-TEXTILE OUTDOOR PRODUCTS AND SUPPLY CHAINS

EUROPEAN
OUTDOOR
GROUP

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EDITORIAL INFORMATION

About this report

This document is a first response to the expressed need of hard goods brands, to better understand and integrate sustainability aspects into their core business, processes, and practices.

The content of this document is inspired by discussions and questions raised in the European Outdoor Group (EOG) Hard Goods Roundtables on sustainability, which started in 2017 and have been a part of the EOG sustainability agenda at the two annual European tradeshows since then. At the roundtables, a gap between the different parts of the outdoor sector has been identified in terms of consumer awareness and available tools for sustainability. Now we see that the demand for sustainable solutions are raising generally, but there is still uncertainty and some lack of specific sustainability tools for many hard goods materials, technologies and processes. In this document, Peak Innovation and EOG offers an overview of sustainability topics to consider, relevant available tools and best practice cases showing some efforts and gains in the field of hard goods sustainability. The document includes:

- Considerations for specific materials and processes
- Sustainability tools and standards
- Legislation considerations
- Circular economy aspects

It is important to state however, that this present document does not prescribe certain tools or solutions over others. Neither does it claim to be a scientific description of all environmental and/or social benefits or challenges in outdoor hard goods. The principle reasons for a non-prescriptive approach is a lack of available and peer reviewed data, as well as the vast diversity of hard goods as product category with related multitude of materials/processes.

Important note for the reader

The definition of hard goods in this document covers a vast array of product types, which comprise an almost innumerable different materials, treatments and manufacturing technologies. This complexity of hard goods products makes it impossible to provide an in-depth look at all sustainability aspects of each of these individual materials in a short and comprehensive format. This document is therefore not designed to give a full overview of all the issues that relate to the use every material in hard goods, but rather to give practical advice, guidelines and tools which will enable readers to understand the challenges and improve sustainability in their product lifecycle. A few areas have deliberately not been included in this document – specifically electronics, textile/leather materials and ceramics are not covered. Wood and wood treatments are only very briefly mentioned. If you have interest in these areas, please contact EOG sustainability staff for further dialogue. See Appendix 1 for details on included and excluded product groups in EOG hard goods definitions and this document. This document is a 'living document'. It is a representation of the current knowledge at the time of writing. Therefore, we proactively invite input, feedback, and improvement suggestions from experts, to keep readers up to date with the latest findings and information.

The document will be re-disseminated following relevant updates.


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ABOUT THE EUROPEAN OUTDOOR GROUP (EOG)

We are the voice of the European outdoor sector. Our vision is to do global, profitable business in a way that gives back more than we take — from nature and from people.

We undertake a wide range of activities, including market insights, corporate social responsibility and sustainability initiatives, outdoor retail collaboration, organising and supporting industry events and trade fairs, and representing our sector and its interests to the European Commission, NGOs, formal institutions, and other stakeholders. Recognising the need for a cohesive, cross border approach to representation of the outdoor sector, the European Outdoor Group was founded in 2003 by 19 of the world's largest outdoor companies. The association has grown steadily to include retailers, national associations, and technology providers. Now totalling over 100 members, the combined strength of our members delivers an extremely powerful force to represent the European outdoor industry in a constructive and positive manner.

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CHAPTER 7. SUGGESTED

1. INTRODUCTION

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Climate change and sustainable development are two of the most important issues affecting our society today. Global consumption is increasing, placing higher demands on our planet's resources (Figure 1).

We already consume 1.7 times more than can be sustainably produced, irreversibly depleting valuable natural resources and spreading waste, and it is predicted that if current trends continue, by the year 2050, consumption levels will be three times higher than the planet can provide [United Nations, 2020] [European Union, 2014]. The impact of this is that the demand for raw materials is expected to double over the next 40 years [OECD, 2019] and as a result, by 2050, annual waste generation is projected to increase by 70% [Kaza, Yao, Bhada-Tata, & Van Woerden, 2018].

As companies that promote the enjoyment of the planet through outdoor activities, it is even more important that our products and processes are optimized to reduce the total environmental impact over the course of each product's lifecycle, from design through to disposal.

The production of any hard goods article has an associated environmental and social impact. It is commonly estimated that over 80% of a product's environmental impact is determined during the design phase . Although this figure is debatable, it is true that during the design phase, the majority of the product's lifecycle is determined, from its construction, expected shelf-life, serviceability and reparability during use and how it should be treated when it is time for disposal.

Often, when products are designed, the focus is given to functionality, economic viability, and novelty. However, products that break down too quickly or cannot be repaired or recycled at the end of life are not sustainable. At the other end of the spectrum, using persistent or hazardous substances for increased functionality and to prolong the lifespan of a product often increase the burden on society and ecosystems. Addressing these issues directly in the design phase can positively influence the whole of the product life cycle, and thus the environmental impact of a product can be vastly reduced.

It is very important to consider any hard goods product from a systems perspective - that is to look at the product not solely from the product's functionality, but from a position which takes into account the whole of the life cycle, from the production of the raw materials to fill the supply chain, through production, including related emissions and human impacts, and the product's end of life (Figure 2).

Reading advice

Depending on your current needs, you can choose which sections in this document to read. All sections are linked in the PDF version for quick access from the Table of Contents, or in the text where referred.

If you work in a SME company and find sustainability a daunting and time-consuming task, we recommend starting by reading and applying the methods in 7. Sustainability with limited resources. If you want to start with a foundation of basic understanding, we recommend reading Appendix 2: Sustainability and Circularity basics.

We hope you find good use of this document.

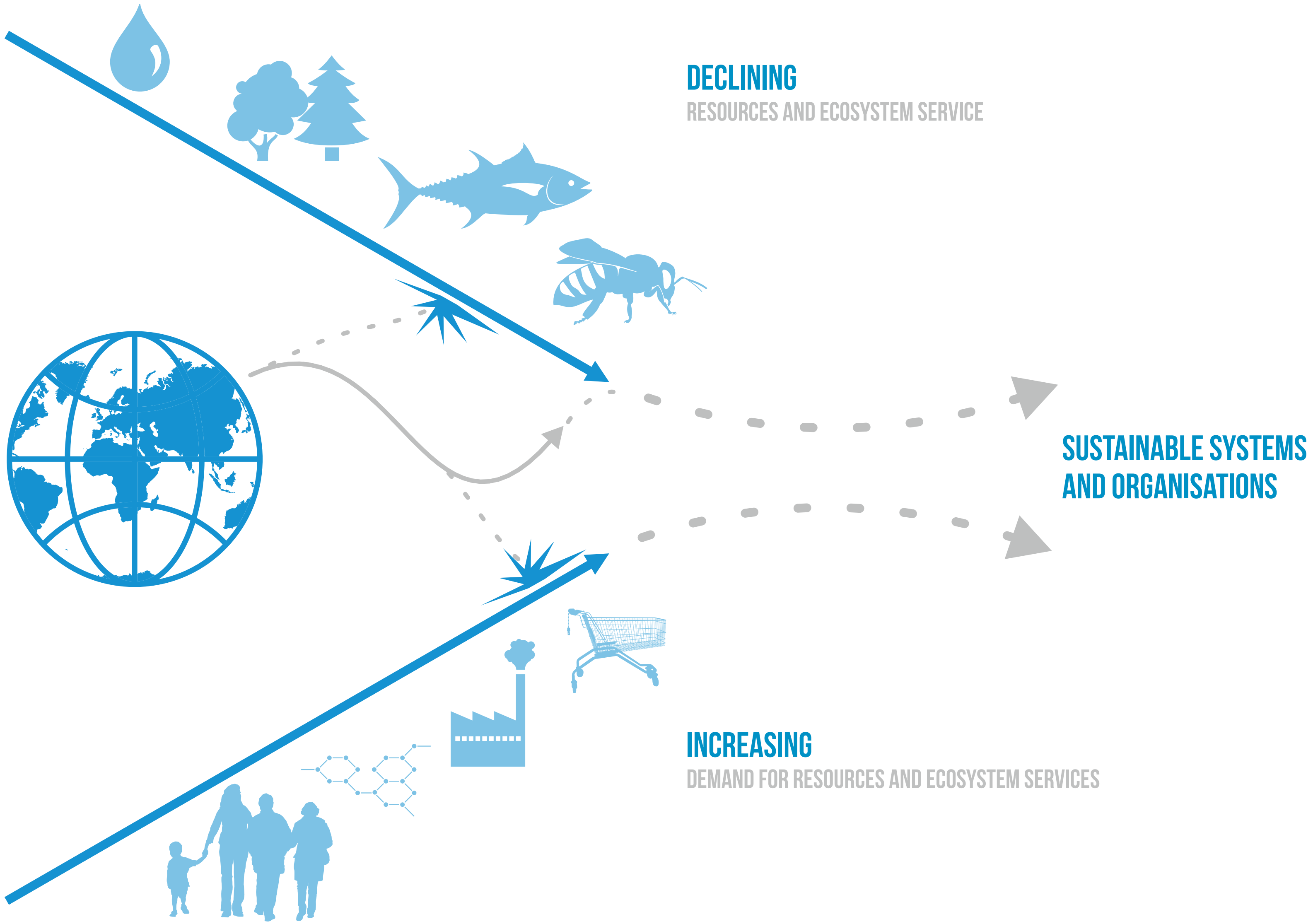

Figure 1: The resource funnel

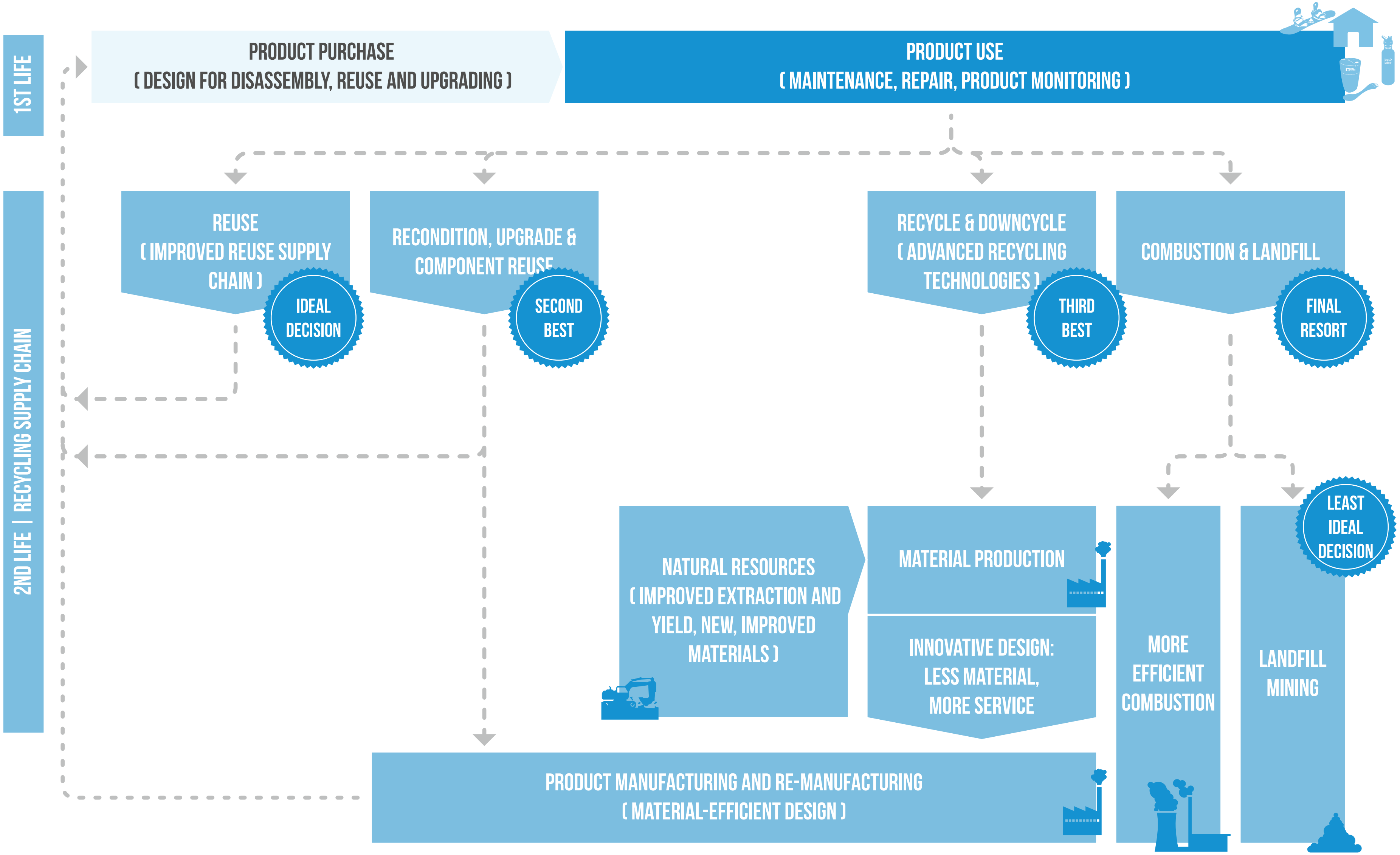

Figure 2: The outdoor hard goods lifecycle

2. MATERIALS USED IN HARD GOODS

Material use in hard goods is varied, but most materials fall into one of five main categories - metals, plastics, composites, natural materials, and adhesives. In addition to this, there are various surface treatments that are commonly used, including anodizing, metal plating, metallisation of polymer surfaces and the use of paints and inks.

Materials used in packaging are not included specifically in this document, but a similar thought process can be applied to how they should be considered from a sustainability aspect; further information can be found in section 4. Packaging and sustainability.

Quantifying Material Impacts

There are many different parameters which can be used to compare different materials from a sustainability perspective. In the same way that a table of mechanical properties can be used to select the best material for a part, environmental factors can be used to select the best material from an environmental impact perspective.

The chart shows a range of embodied energy and carbon footprint for each material, where lowest embodied energy values are using 100% recycled material and highest values are using 0% recycled.

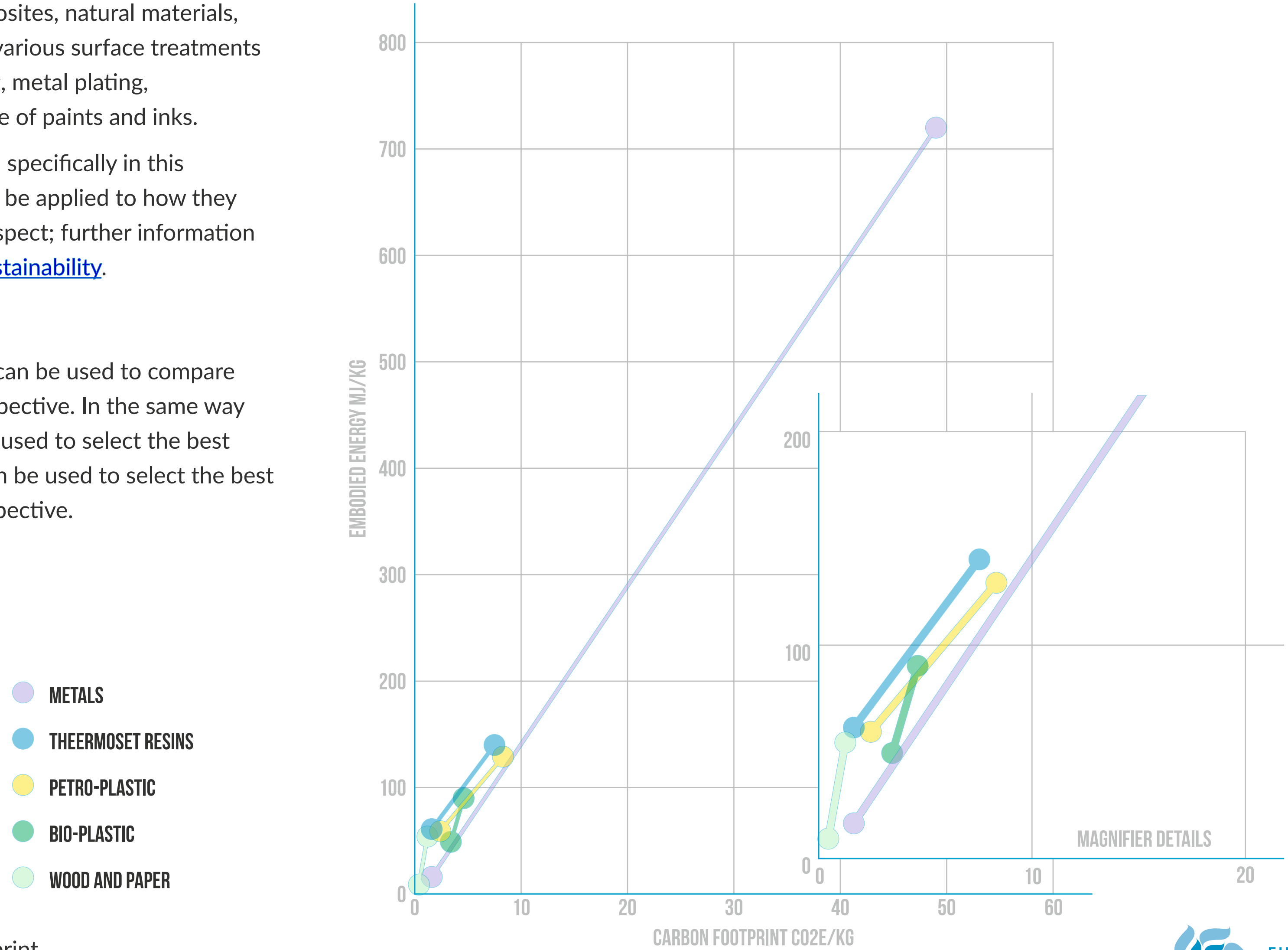

Figure 3: Embodied energy and carbon footprint

The two most used indicators, based on lifecycle energy consumption and emissions, are embodied energy and carbon footprint (Figure 3).

Embodied energy is the sum of all the energy required to produce any goods or services. The embodied energy can be determined for any product at any stage of its lifecycle, by cumulating the energy from raw material extraction, transport, manufacture, assembly, installation, disassembly, deconstruction and/or decomposition as well as human and secondary resources. It gives an indication of how much energy is used to produce a material, so minimizing this reduces the total impact from an energy perspective.

Energy inputs usually cause greenhouse gas emissions, and these can be calculated as a **Carbon Footprint**, as a function of **Global Warming Potential (GWP)**. A Carbon Footprint measures the total greenhouse gas (GHG) emissions caused directly and indirectly by an individual, organization or product. Like embodied energy, it is summed over the whole lifecycle. There are many different greenhouse gases emitted over a product lifecycle, and these have different abilities to trap heat in the atmosphere – different global warming potential (GWP). To account for these differences, emissions are commonly aggregated into a common unit of measurement: carbon dioxide equivalents (Co_2e).

This unit combines the emissions of carbon with the effect of other CO_2e gases, including methane, nitrous oxide, and other greenhouse gases, based on their global warming potential. The GWP describes how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, often either 20 or more commonly 100 years, relative to carbon dioxide, then these can be summed to determine to total carbon footprint.

Embodied energy and carbon footprint values considered together are useful in deciding whether a product contributes to or mitigates global warming. Often, these values are used to compare the amount of energy produced or saved by a product during use to the amount of energy consumed in producing it, whilst simultaneously minimizing the GHG emissions. With the exception of outdoor stoves and battery-operated devices like headlamps, the fossil energy use and savings potential during use of outdoor hard goods is generally very small. Because of this, embodied energy values are good indicators of total carbon footprint for most hard goods products.

2.1. Metals

Steel and aluminium are the two most encountered metals in the outdoor hard goods sector. Titanium can be found in applications where strength and light weight is important and other metals and alloys are also used for specific applications.

Metal production from virgin material is a highly specialized industrial activity, so outdoor equipment manufacturers are reliant on their metallic raw materials and components coming from a few major producers. The result is that end-users frequently have little insight into the processes related to the production of the metal. As low-volume purchasers, hard goods manufacturers represent only a small part of the global metal supply chain, so it can be difficult to try and steer and influence the sustainability of the processes and production, so there is an assumed level of trust in these high tier suppliers, and their compliance with sustainability standards.

Production

Metals have a large and diverse global supply chain which exposes many sustainability challenges. Primary production of metals is based on extraction and refining of metal-containing ores from the earth's crust. In addition to the fact that metal ores are finite resources, mining often occurs in sensitive areas, leading to issues including biodiversity loss, environmental issues, human rights, health and safety, and the preservation of rights of indigenous people.

The refining of the ore to produce pure aluminium, iron or steel generates large amounts of waste material and emissions, and is also highly energy intensive, which means that on a whole production of primary metal is considered to be an unsustainable process, from an economic, social and environmental standpoint. (Figure 4) For every tonne of aluminium produced, over 4 tonnes of bauxite ore are needed, which generates over 10 tonnes of waste rock, and three tonnes of toxic red mud. [Marin & Bournay, 2009]

The chart shows a range of embodied energy and carbon footprint for each material, where lowest material, lowest embodied energy values are using 100% recycled material and highest values are using 0% recycled.

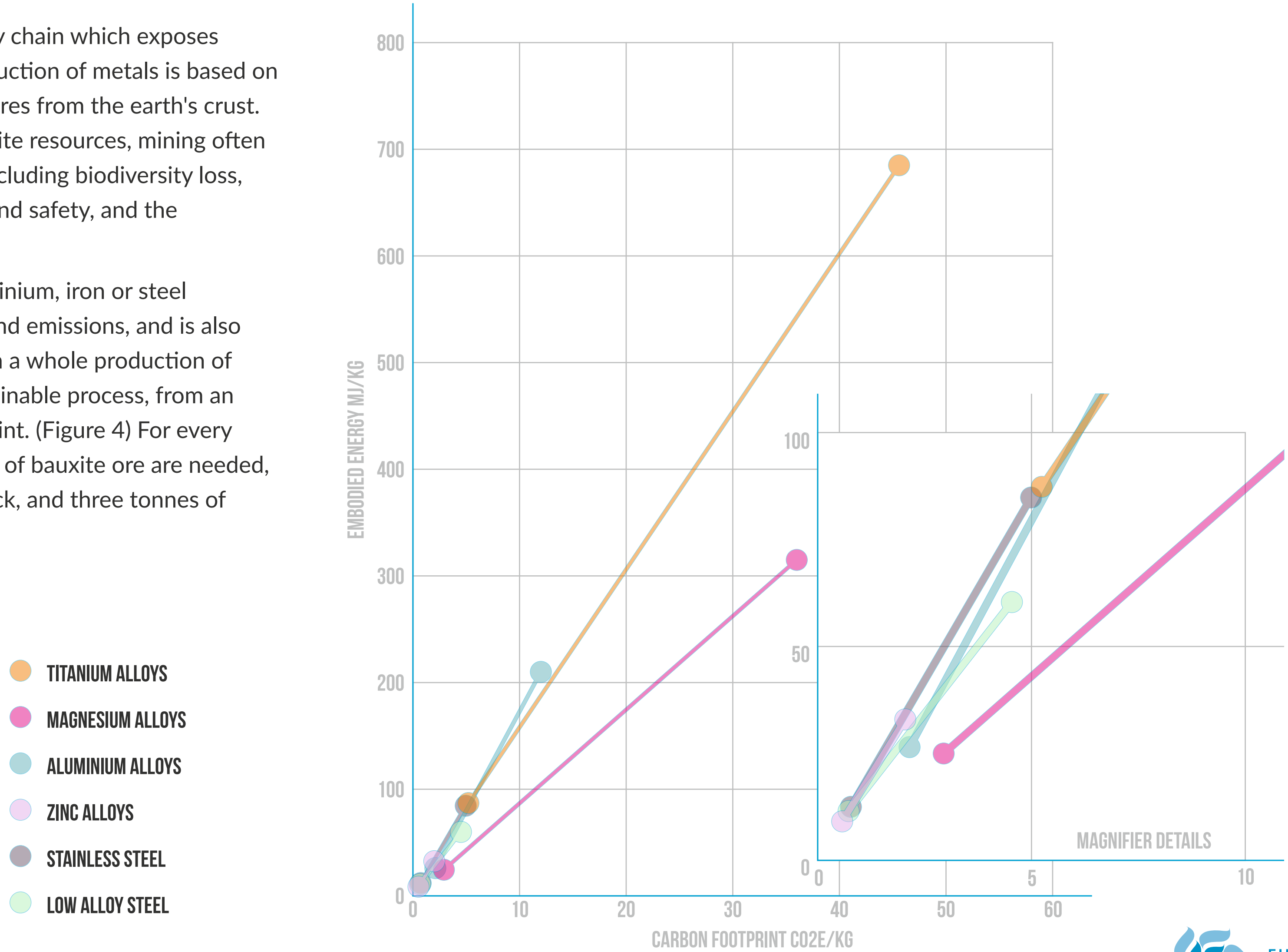

Figure 4: Carbon footprint - metals

Bulk metal is not the final form for most applications, so various conversion processes are required to produce rolled, extruded or cast form, which can then be converted into finished products. These processes are energy intensive, generate emissions, and in certain cases also involve the use of aggressive chemicals which require careful management. The energy requirements for processes varies according to complexity, from around 4 MJ/kg for a simple forging process, to 50 MJ/kg for a vapour deposition process. The carbon footprint for such processes follows the energy requirements, so a more complex procedure generates more emissions than a simple one. (Table 1)

SHAPING PROCESS	AVERAGE ENERGY MJ/KG	AVERAGE CO_2 FOOTPRINT KG/KG
CASTING	10	0.5
ROUGH ROLLING, FORGING	4	0.2
EXTRUSION, FOIL ROLLING	15	0.75
WIRE DRAWING	30	1.5
METAL POWDER FORMING	25	1.25
VAPOUR PHASE PROCESSES	50	2.5

Table 1: Carbon footprints in metal processing

Durability is a key factor behind the selection of a metal for any product. Although the embodied energy of metals, considering extraction, melting and processing, is high, metal products tend to have a long service life. This may mean that energy consumption related to a metal product's total service life is still lower than a petro-based plastic alternative. Of equal importance, manufacturing something only once, instead of twice or even three times during a certain time, is of course less resource consuming, contributing to improved sustainability.

Safety considerations

When personal safety is prioritized, especially under the EU Personal Protection Equipment (PPE) directive (89/686/EEC), some products may be required to have their lifespan restricted to meet safety requirements. When correctly selected for purpose, metals provide durability, strength and are often used when safety is a key product requirement, for example in climbing equipment. Although metals do not degrade to generate harmful products during use, they can be subject to corrosion and wear, which can render them unfit for purpose.

For components which are safety critical, although limiting the lifespan is the easiest solution, other possibilities may exist. One way of extending life could be to work with regulators or standard bodies to implement authorized controls verifying that safety can be continuously assured, in conjunction with supplier services, such as service intervals and refurbishment. For metal parts that are not directly safety critical, effort should be made to ensure that the user can service or replace individual metal parts, to minimise the processing that is required for the production of a complete product.

End of Life

Whilst the disposal of bulk metal waste to landfills today presents only a limited risk for the environment through the potential leaching of alloying elements and surface treatments, it still represents an enormous waste of resources on a global scale, which should be integrated in circular material flows. Metal recycling is therefore an obvious route to improve sustainability.

Metals can, in theory, be recycled infinitely and suffer no quality degradation during reprocessing, if the quality of scrap material used in the recycling process is carefully controlled.

The environmental benefits of using recycled materials are clear, from the conservation of non-renewable resources, to saving energy, avoiding emissions and reducing waste. Steel recycling is common practice. For stainless steels, the recycling rate is over 80%, however consumer goods sectors have a lower recycling rate of around 60% [Outokumpu, 2020].

For aluminium, recycling is less common, even though using recycled aluminium instead of virgin material can give a reduction of up to 95% in energy use, and 80% in greenhouse gas emissions. Due to lower processing temperatures, mixed aluminium alloys cannot be recycled into high quality extrusion or rolling grades. Most recycled aluminium ends up in cast alloys which are least sensitive to impurities.

It is important that the metal is recoverable from waste, especially when used as a part of a larger product. To achieve this, consideration for disassembly and separation of materials at end of use is needed during the design stages of a new product. Ease of separation of materials by type makes the recycling process more efficient and prevents contamination and subsequent waste of materials.

The European consumer involvement in recycling is currently limited to sorting packaging materials. Products are generally returned at end of use as whole units, to recycling stations, municipal recycling bins or return systems within an Extended Producer Responsibility (EPR) programme. It is key to clearly communicate the correct return policy to the end-user, so that the product is handled correctly at the end of use. After product return, it is important to have a process in place for separation and materials recycling. Whilst a single material product is relatively easy to sort for recycling, most products today contain a number of mixed materials, such as titanium buckles on plastic ski boots, or steel edges embedded in a composite ski, which requires a more complex separation procedure. Component parts, especially metals which have high recycling value, need to be an integrated part of the circular economy.

Standards for Metals

International environmental standards for metal production are still relatively few. For the aluminium and steel industries, new standards are developing through Responsible Steel and the Aluminium Stewardship Initiative. Both covering a wide scope of sustainability aspects in the supply chain, from extraction to finished raw material, including specific issues like social challenges of conflict free mining and smelting, and the minimization of the environmental impact from chemicals used in production facilities (Figure 5).

- Responsible Steel launched the first version of the Responsible Steel standard in late 2019. It is designed to support the responsible sourcing and production of steel, based on twelve sustainability principles covering environmental, social, and economic issues related to steel production. The standard is still in development, during 2020 focusing on the inclusion of input material streams and GHG emissions.
  https://www.responsiblesteel.org/

- The Aluminium Stewardship Initiative (ASI) currently provides two different, complementary certifications, setting good practice requirements that support responsible mining, refining and smelting practices and encouraging recycling. The ASI Performance Standard V2 defines environmental, social and governance principles and criteria with the aim to address sustainability issues in the aluminium value chain, and the ASI Chain of Custody Standard V1 provides the requirements for creating a chain of custody material. With these standards, the ASI promotes responsible sourcing of the supply chain and provides guidance to downstream users, promoting correct handling of waste to ensure that valuable materials remain in circulation.
  https://aluminium-stewardship.org/

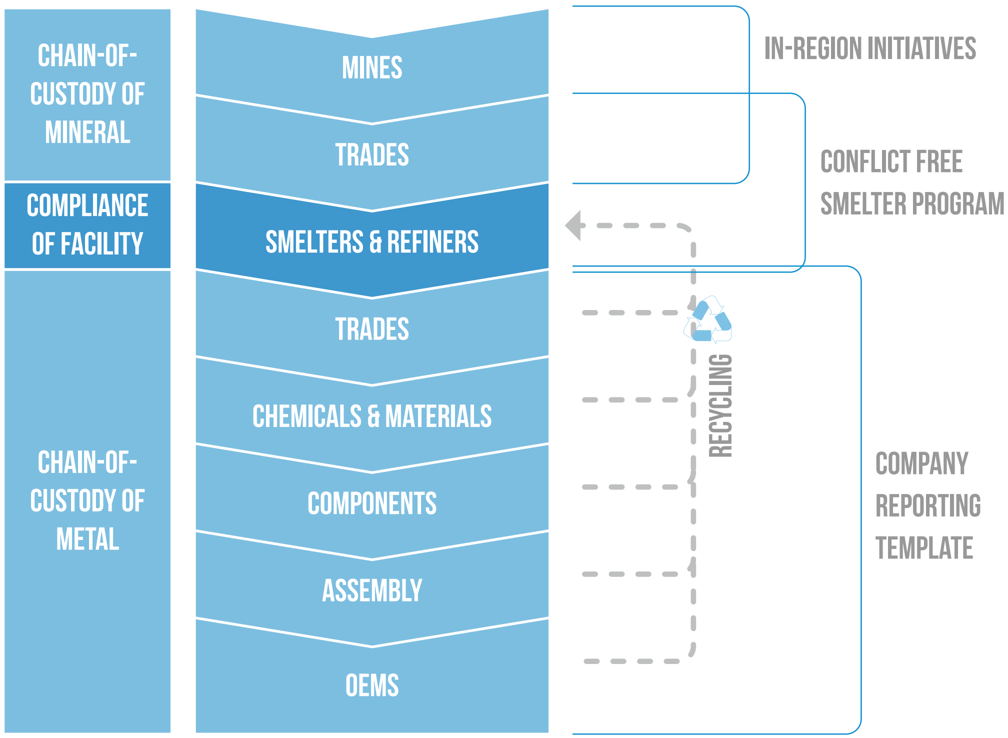

Figure 5: Metal traceability standards

Aluminium

Aluminium is the second most used metal after iron, with a steady growth over the last decades, and is expected to continue growing through a broad range of applications. The versatility and lightweight properties of aluminium has made it a common material in outdoor hard goods, e.g. climbing equipment, cookware and tent poles. Aluminium products generally have a long lifespan, but the production is energy intensive and generates large amounts of greenhouse gas emissions. Environmental and material stewardship is needed when resources are finite and to be able to fulfil global climate agreements and meet demand from social development. The transition towards a circular economy that emphasize on use of renewable energy and reuse and recycling of materials is developing globally.

Aluminium has a very high embodied energy in its virgin form, due to the vast amounts of energy required to extract and convert the metal from ore form into pure metal. Production of one kilogram of primary aluminium requires up to 200 MJ of energy. When recycling aluminium from scrap metal, only 5% of this energy is needed, saving not only energy, but also drastically reducing its carbon footprint by 80%. [Rankin, 2012]

Recycled aluminium already represents 36 percent of aluminium metal supply in Europe, and Europe has a good record in recycling rates: 90% of the aluminium used in the construction and automotive sectors is recycled, and around 60% of aluminium packaging enters a recycling stream. There is little information however on recycling rates from other sources, including outdoor goods. Nonetheless, a growing barrier to the recycling of aluminium is the availability of scrap. Aluminium products have a long lifespan; on average they are in use for 50 years in construction and 15 years in transport, which means that the amount of aluminium reaching its end-of-life and becoming available as post-consumer scrap is limited [European Aluminium, 2020].

Not all scrap is of equal value however – different grades of aluminium contain different alloying elements, and when these are combined in mixed-alloy scrap, it is very hard to recreate high quality recycled material with a precise composition. The mixed-alloy scrap can still be re-used, but is generally reprocessed as cast product, which should be considered a “downgrading” as the quality and control of elemental composition is less critical. It can also be mixed with high content of virgin material to dilute unwanted alloys, which limits the climate winnings and resource effectiveness of recycled material.

Better and more widely applied sorting routines and techniques down to alloy grade/grade family will enable higher quality aluminium recycling. A few technologies exist but have not been widely economically viable yet due to high demand for lower grade cast aluminium and a lack of material traceability in the value chain. Cooperation between brands, manufacturers, downstream collectors/recyclers and upstream product/material suppliers is needed, to share material data and collect specific alloy products at end of use for closed-loop recycling to high-grade (and high-value) aluminium.

To make sure that the trend of increasing use of recycled aluminium continues, it is important that all aluminium containing products can be easily recycled at the end of life. Considering the specialty applications in hard goods, it is potentially interesting to try and set up closed-loop recycling streams, such that the improved separation streams can increase the functionality of the recycled material. More information on how to achieve products that can be more easily recycled can be found in 7.2. Designing for Sustainability

In connection to this document, a master's thesis on circular economy and aluminium hard goods products in the European outdoor industry has been produced. It examines the opportunities and challenges the outdoor industry has in developing circular products and how the Aluminium Stewardship Initiative (ASI) is encouraging a circular economy through their standards. The thesis is a standalone addition to this document which aims to widen the understanding of aluminium use and promote efforts towards a circular economy.

Steel

The heading of steel covers a wide range of iron-based metals, from simple iron-carbon alloys to complex stainless-steel grades containing alloying additions of amongst others, chromium, nickel and molybdenum.

The embodied energy in steels is highly dependent on the production method. Virgin steels are produced by the basic oxygen process, where coal and iron ore are heated to produce steel. Recycled steels and stainless steels are most often produced using an electric arc furnace, where electrical energy is used to re-melt scrap metal, before secondary processes are used to control the final composition.

Even though the energy requirements of recycling steel scrap are high, there is still a large saving, around 60-80%, in both embodied energy and in greenhouse gas emissions when compared to the virgin materials . Like the case for aluminium, scrap availability and quality are main barriers to increase steel recycling. Although technically viable and with a high content of recycled stainless steel in production, it is currently not possible on a global level to produce a specific grade of stainless steel from 100% scrap material due to availability, sorting and marking limitations for specific grades.

Titanium

The production of pure titanium metal is highly complex and energy intensive. Most primary titanium is produced by the Kroll process, where titanium chloride reacts with magnesium to form pure titanium metal. The production process requires the use of fluorinated acids and other harmful chemicals which must be carefully controlled, and it also has very high energy requirements. New methods of production which are less energy intensive are under development, but these have yet to reach full scale implementation [Norgate, Jahanshahi, & Rankin, 2007].

Scrap titanium and its alloys can be recycled by re-melting and then combining with high-purity virgin material. However, the scrap needs to be of high quality with low impurity content to avoid contaminating the final material. The recycling process reduces the amount of energy required per tonne of material, although precise figures are hard to obtain.

Titanium scrap of unknown source is usually combined with other low-grade scrap and recycled as ferrotitanium for the steel industry. The amount of titanium waste in post-consumer products is, however, very small compared to industrial scrap, which creates potential challenges for the development of worthwhile recycling streams [Takeda & Okabe, 2019].

2.2 Plastics

Plastics are ubiquitous in our everyday lives. They have in recent times developed a bad reputation, largely due to the inadequate or incorrect disposal of plastic products, leading to problems such as microplastic contamination and ocean pollution. As a direct result of this, plastics have become the focus of a number of upcoming regulations, for example, the EU restriction starting in 2021 on single-use plastics, which are responsible for the majority of plastic pollution in today's society.

However, plastics are not all inherently bad – they present solutions for products where alternative materials would not meet functional requirements. Plastics have a range of properties which make them perfect candidates for specific applications – it is hard to imagine, for example, a climbing helmet made from metal or wood. The key to sustainable use of plastics in products is choosing the right plastic for the right application, and to make sure that at the end of its life it is disposed in the right way to build circular material flows.

Plastics used in Hard Goods

The plastics used in hard goods are wide-ranging and cover a lot of different properties, requirements and applications. The durability of most plastics, seen as an advantage during use, also translates to a long lifetime as waste. The current situation of a less than 100% recycling rate means that there are both drawbacks and advantages to the use of plastics from a sustainability perspective. Not all plastics are created equal, and some plastics require the use of harmful chemicals in their manufacture. To the extent possible, these should be avoided where alternatives with similar performances are available. Plastics with high chemical load include ABS, PVC, PS, PC and PU.

Most commonly available and used plastics are petro-based (synthetic) in origin, so their production is highly resource consuming, and they have high levels of embodied energy with correspondingly high emissions (Figure 6). Bio-based (natural) plastics are increasing in popularity, and different families and grades are becoming available. These also have a relatively high embodied energy as there is a large amount of energy input required from agricultural vehicles and processing, however they have a much lower total carbon footprint, mainly because they are produced from renewable resources rather than from the use of fossil feedstock.

"USE THE RIGHT PLASTIC IN THE RIGHT PLACE AND DISPOSE OF IT IN THE RIGHT WAY"

The chart shows a range of embodied energy and carbon footprint for each material, where lowest embodied energy values are using 100% recycled material and highest values are using 0% recycled.

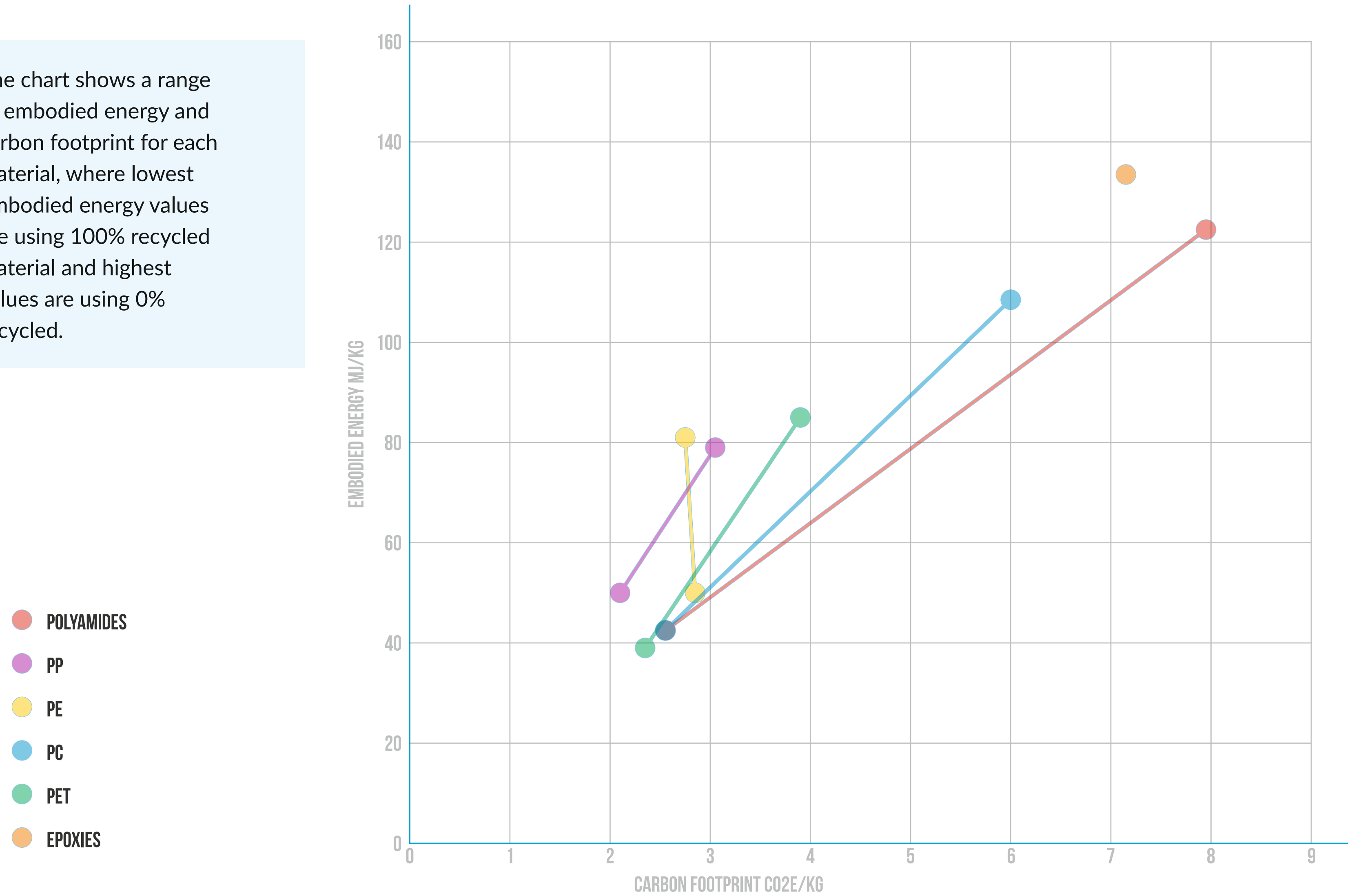

Figure 6: Carbon footprint - plastics

With careful selection and consideration, there is potential to reduce the environmental impact of petro-based plastic products by replacing them with more sustainable options. Bio-based plastics are discussed in detail in 2.3. What are Bioplastics?.

Plastics are often chosen over alternative materials as they are light weight, cheap, and have a wide range of mechanical, thermal, and electrical properties. They are easy to form into a wide range of shapes, which increases their versatility. If the design and application of plastic products is done well, plastic components can have a long lifespan and a relatively low environmental impact. Their light weight can reduce energy consumption in transportation and can provide users with the desired functionality.

Production

Plastics are man-made materials, derived from organic materials such as cellulose, natural gas and of course crude oil. Today, most plastics used have petrochemical origins - the lighter fractions of crude oil, especially naphtha, are the primary starting compounds to produce many of today's commonly used plastics.

Polymers are produced in a reactor, through the processes of polymerisation or polycondensation. In this, monomers, like building blocks, are combined to form a polymer chain or network. The properties of the polymer are controlled by how these monomers are linked, and how any are added to the chain. There are many different types of plastics, and they can be grouped into two main polymer families:

- **Thermoplastics** are plastics which soften on heating and then harden again on cooling. These properties are reversible, so thermoplastics can be reheated, reshaped and frozen repeatedly. This means that most thermoplastics are mechanically recyclable, however with each recycling process, the chains break down and the properties are gradually lost. Some of the most common types of thermoplastic are polypropylene (PP), polyethylene (PE), polyvinylchloride (PVC), polystyrene (PS), polyethylene terephthalate (PET) and polycarbonate (PC).
- **Thermosets, including elastomers,** are plastics which never soften once they have been moulded. During processing, strong covalent bonds are formed between the chains of the polymer, changing it from a low viscosity liquid to a high melting point solid. This process is known as curing, and depending on polymer type, is catalysed by heat, a catalyst compound, or energy sources such as UV light. Thermosets are generally stronger and more heat resistant than thermoplastics, which enables them to be used in specialist applications, but leads to complications in recycling, as they cannot be remoulded as easily as thermoplastic materials, and are more commonly ground down and used as filler materials. Thermosets have wide ranging applications from barrier coatings in cans and packaging, as components of paints and surface coatings, and of course, as a binder in the production of composite

materials. Some common types of thermosets include epoxy and polyester resins, polyurethane, silicones and vulcanised rubber.

A note on Fluorinated Plastics

Fluorinated plastics such as PTFE are used widely for specialty purposes like low friction, heat stability and oil- or water repellence. They are incredibly stable compounds, but due to their stability are persistent in ecosystems, so they accumulate in the environment and additionally present a potential harm to human health. Some fluorinated compounds are already being restricted by REACH and other bodies, and these restrictions will broaden over the coming years. From a sustainability perspective, all fluorinated materials should be avoided whenever possible, at all stages of the product lifecycle. Fluorinated substances are often used in manufacturing processes, for example as high-performing lubricants and emulsifiers, so it is important to identify where they are used to enable a controlled phase-out without unpleasant surprises. Good chemical management practices are useful to identify and substitute chemicals and materials of concern – read more in 6.6. Chemicals Management.

Additives in Plastics

Although each plastic has its own native properties, these can be tailored to fit specific requirements through blending different polymers together and using additives. These substances are commonly used to improve functionality and increase durability. Despite their usefulness, there is potential for contamination of soil, air and food due to migration of such additives, and they may also be released during recycling processes.

Additives carry out various functions:

- **Functional additives:** stabilizers, antistatic agents, flame retardants, plasticizers, lubricants, slip agents, curing agents, foaming agents, biocides, etc.
- **Colorants:** pigments, soluble azo colorants, etc.
- **Fillers:** mica, talc, kaolin, clay, calcium carbonate, barium sulphate
- **Reinforcements:** glass fibres, carbon fibres or natural fibres

In nearly all cases, except for some flame retardants, additives do not form part of the polymer chains. This means that they are not bound into the material, increasing the risk that under certain circumstances they can migrate into the surroundings.

There are concerns about the health and environmental impact from certain additives used in plastic production. Certain phthalates, e.g. Bisphenol A, and some flame retardant or lubricant additions are regarded as particularly problematic [Hahladakis & et al., 2018].

Not all additives have a negative environmental impact, however it is important to identify the use of any additive that may cause harm and substitute it or eliminate its use. A starting point is to identify if an additive is really required. If it is not necessary, then elimination solves the problem, however if it is critical to product function, then understanding of what it is, and what is does is key to addressing the sustainability. Chemical management is a key tool to address this, and in

many cases, harmful additives may be readily substituted for more sustainable and less hazardous alternatives. Appendix 3 provides an overview of additives, functions and risk areas. ECHA have a developed a guide on the use of various additives which can be used to estimate related exposure.
https://echa.europa.eu/plastic-additives-initiative

Recycling of Plastics

Large volumes of plastic wastes are generated per year, mainly since around 40% of plastic products have a lifespan of less than one month, leading to severe environmental issues if it not handled correctly [Achilias & et al., 2007]. At the end of a plastic product's life, it is therefore vitally important that it is disposed of correctly. When dumped outside of a waste stream, plastic will break down with wear and UV damage into small parts known as microplastics, which are a growing concern related to plastic use. Microplastics (according to the current definition, any piece of plastic smaller than 5 mm) do not just cause pollution on land but enter global waters in various ways and can be found everywhere from drinking water supplies to the depths of the oceans. Microplastic debris is generated from the effects of friction, UV radiation and chemical breakdown during use. In addition, spills of plastic pellets from plastic manufacturing comprise a significant part of the plastic waste problem, which means it is also important to have good control of production processes to ensure minimized microplastic pollution [Galloway & Lewis, 2016].

Many plastics are recyclable, but there are a few practical factors to consider when designing a plastic product for recyclability. The Global Plastics Outreach Alliance determines if a plastic product is considered recyclable by whether it meets the following conditions:

- The product must be made with a plastic that is collected for recycling, has market value and/or is supported by a legislatively mandated program.
- The product must be sorted and aggregated into defined streams for recycling processes.
- The product can be processed and reclaimed/recycled with commercial recycling processes.
- The recycled plastic becomes a raw material that is used in the production of new products.

Recycling of Plastics - Why is it important?

There are two main routes for improving the sustainability of plastics at the end of life: material recycling and energy recovery.

- Material recycling saves valuable finite resources and saves energy.
- Energy recovery reduces landfill waste and provides energy.

Most thermoplastics can in theory, be recycled, however there are some key criteria which must be met for a product to be successfully recycled.

- Not all plastics are compatible, and contamination of the recycling stream can lead to a reduction in quality or even the rejection of recycled material.

- Some plastic waste is generated in low volume (e.g. PS) or is difficult to process (e.g. PP moulded furniture) which means that it is uneconomical to recycle.
- Recycling is not conducted in the same way between different countries and even within countries so what is available in one place is not necessarily available elsewhere.
    - For a product to be labelled as recyclable, according to ISO 14021 the product must have the possibility to actually be recycled at the location it is being used (e.g. not at one specific global location where that particular material is processed.)

One big difference in the recycling of plastics in comparison to metals is that each time a plastic is recycled, it loses some functionality, through break-down of the chemical chain, and contamination. This means that a plastic can only be recycled a few times, and after that, is usually either sent to landfill or used for energy recovery, depending on the country. In textiles this challenge has been taken on, in innovation efforts towards chemical depolymerisation and re-building polymers, but so far only a handful industrial-scale recycling plants exist for polyamide and polyester.

Whereas products made from a single material are preferred from an end-of-life perspective, in many cases, to perform specific functions, a combination of different types of plastics or materials is needed. Separating mixed scrap plastic is possible, however it is important to avoid using plastics with similar densities together in a single product, as the density is a key parameter to facilitate the separation of incompatible materials during mechanical shredding or crushing, or during the subsequent water- based washing process. When the densities of different plastics and additives combinations are similar, automated separation techniques are inadequate, and recycling is not always possible. It is not sufficient only to look at plastic type when designing – the use of additives can create issues with recycling. The colouring of a part with a 4% pigment can raise density by 0.03 g/cm^3 which may cause overlaps of polymer densities, and the use of additives/fillers such as calcium carbonate, talc, etc. in concentrations that alter the density can cause, for example an HDPE plastic to sink in water or alter the properties of the regrind. Both these situations are undesirable and should be avoided. Recyclability by design provides useful information on how to handle the use of plastics in products and packaging to maximize recyclability https://www.recoup.org/download/747/recyclability-by-design-2020.

Recycling of plastic materials is almost always environmentally preferable to incineration. However, in cases where speciality plastic products are not produced in a sufficient quantity, or are contaminated with other materials, the energy and resources used in a recycling process may be more than those required to produce new plastics. In such cases energy recovery may be a viable option. Energy recovery by incineration is preferable to landfill, as the high calorific value of the plastics can be used to generate energy, thus recovering some of the embodied energy present in the material, while at the same time not adding to landfill masses and potential chemical leaches over long periods.

Clear messages are needed to communicate to users how they should dispose of the product regarding separation of materials, recycling and reuse.

Plastic Standards

The diversity of plastics means that there are many standards covering different parts of the production processes or for dedicated applications. Most of these are highly specific and go beyond the scope of this report. One interesting standard which is of relevance to producers of plastic products, or anyone involved in design work and other activities where environmental aspects of plastics need to be considered is the ISO standard ISO 17422:2018. This is a standard intended primarily for other writers of standards on how to consider the environmental impact of plastics, but provides valuable information and guidance on how to minimise adverse environmental impacts from the manufacture of plastic products, whilst ensuring that the product remains fit-for purpose; https://www.iso.org/standard/70028.html

There are some standards considering the recycled content of plastic materials, these have primarily been developed for the textile industry, but can also be applied to other industries.

- Recycled Claim Standards (RCS) is an international, voluntary, full product standard to verify the presence and amount of recycled material in a final product. This happens through input and chain-of-custody verification from a third party. Different levels are available, for example, 100% recycled content or blended products https://textileexchange.org/integrity/
- The Global Recycled Standard (GRS) provide verification of recycled materials, and then tracks the material through to the final product. Built on the RCS standards, the GRS includes additional social, environmental and chemical processing requirements https://textileexchange.org/integrity/

2.3. What are Bioplastics?

The term “bioplastics” or “biopolymers” includes several different types of plastics with quite diverse properties. The main two categories within bioplastics are bio-based and biodegradable plastics (Figure 7). One material may be part of both, but often that is not the case. There are many questions about feedstock and farming, biodegradation, recyclability and availability to be answered for a more comprehensive understanding of these materials.

Bio-based plastics

Bio-based plastics are plastics which are fully or partially derived from biomass - renewable biological sources. For any claim on bio-based materials, the percentage of bio-based content should always be controlled and clearly communicated, as there are no general requirements of minimum levels. A plastic product containing only a small percentage of bio-based content can still be referred to as a “bio-based plastic”, leading to risks of a greenwash discussion. The majority of bio-based plastics have their origin from food-based biomass including corn, sugar cane, cellulose and potatoes, but other resources such as residues and wastes (sludge, methane gas, carbon dioxide, etc.)

can be used which is especially interesting from a circular economy and resource-use aspect. Forestry by-products are also a growing source for bio-based content. Bio-based plastics are relatively new (i.e. less than 30 years) and are starting to become more widespread but have not fully penetrated the market yet. There are two different streams to bio-based plastics: one type is identical to classical petro-based plastics, such as polyethylene (PE) produced from the processing of sugar cane, which can be used as a direct replacement to the petro alternative (drop-in). The second type are novel bio-based plastics such as PLA, which is processed from starch (from corn, potato, cassava, sugarcane or sugar beet pulp) into lactic acid and then into polylactic acid.

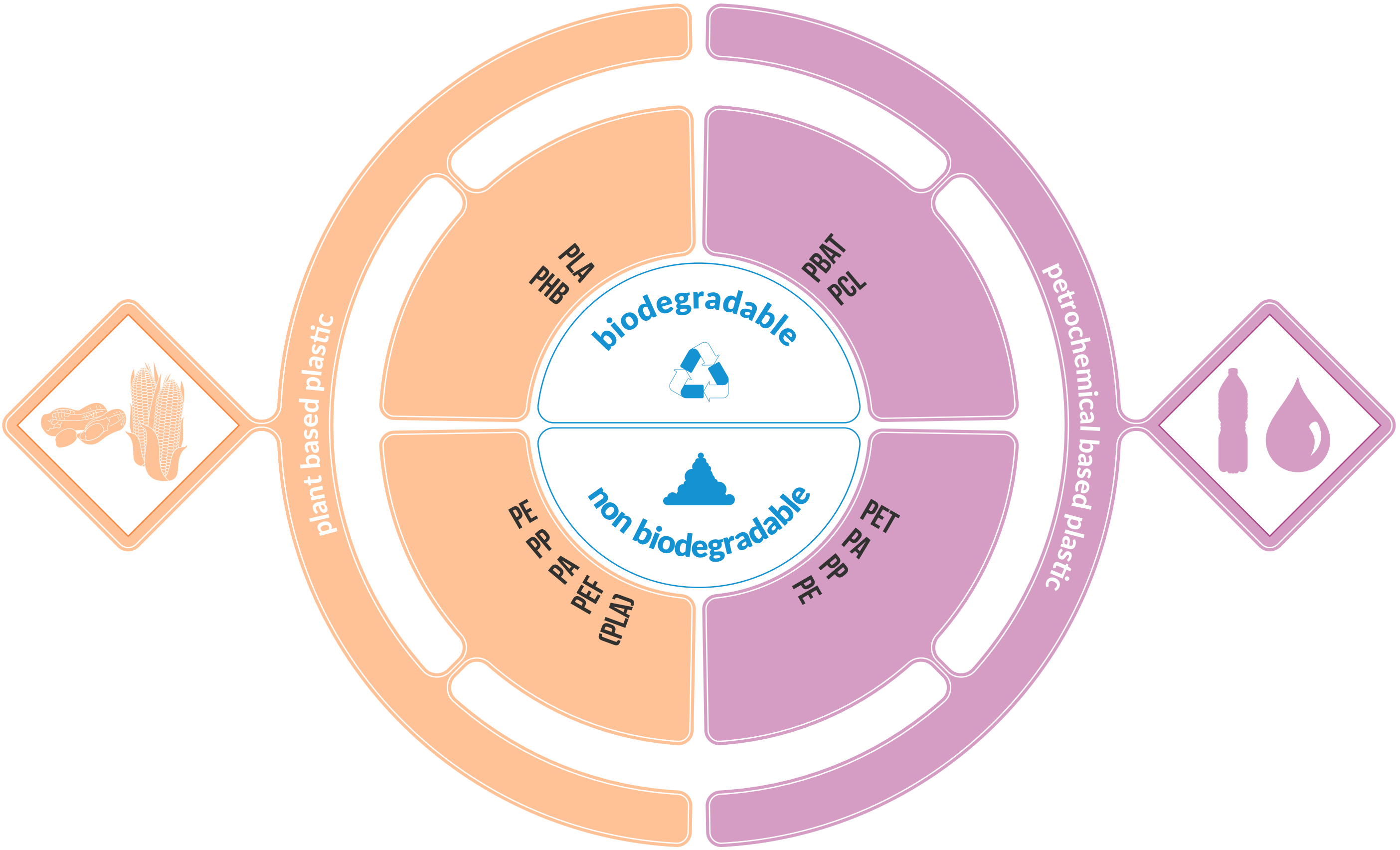

Figure 7: The bioplastics landscape

The chart shows arange of embodied energy and carbon footprint for each material. For petro-based plastics, the lowest embodied energy values are using 100% recycled material and highest values are using 0% recycled. For the shown bio-based plastics, no recycled content is available today.

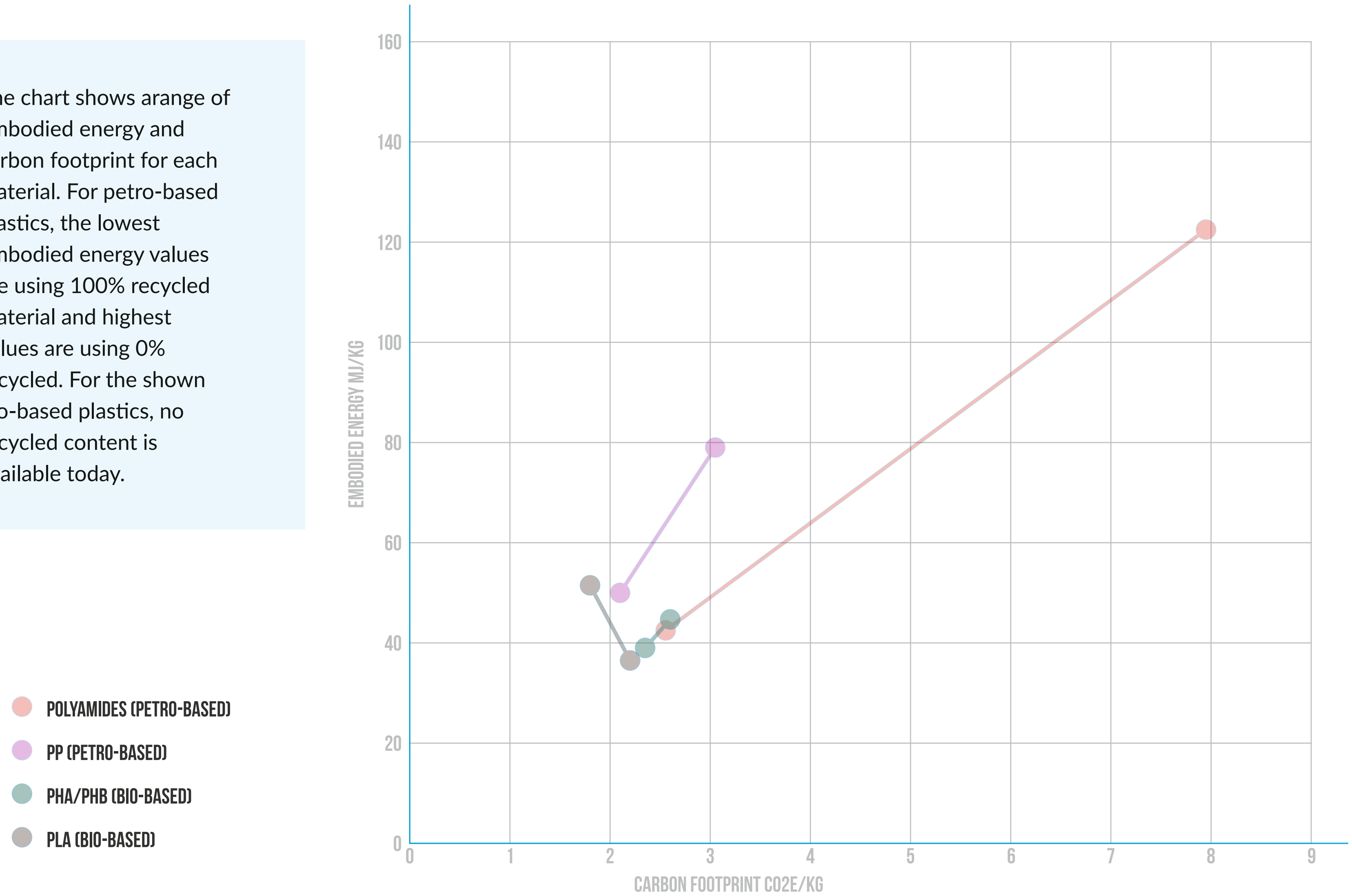

Figure 8: Carbon footprint – comparison between bio-based and petro-based plastics

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Bio-based plastics are not automatically low environmental impact, as their sustainability must be considered from a systems perspective and raw materials are only part of the overall process. Carbon footprint is one aspect, where bio-based plastics average better than petro-based counterparts, but from a carbon perspective a recycled petro-based plastic can be equally good or better (Figure 8). There is a risk that “bio-based” conveys the potentially misleading message that these materials are “harmless” to the environment, which is not always the case, so care must be taken when bio-based materials are used that any claims of sustainability are substantiated. Most bioplastics are synthesised into polymers that do not readily break down in nature and hence need end-of-use solutions similar to petro-based plastics, such as recycling. For claims on biodegradability, read section below on Biodegradable plastics.

Benefits of bio-based plastics

There are two main advantages of bio-based plastics compared to petro-based plastics

- Fossil fuels are a finite resource, so by using renewable resources for plastic production, which regenerate on an annual basis, consumption of finite resources is decreased.
- Growth of biomass sequesters carbon, which, when combined with the reduction in fossil fuel use leads to lower GHG emissions, and even the potential for carbon neutrality

Standards for bio-based plastics

It is important for producers and consumers to have confidence in the materials they are using. Biomass content of plastics can be certified, which provide assurance that the plastic used has a certain bio-based content.

- Plastics (or products) can be certified as bio-based by indicating the biomass carbon content in materials. This can be determined through radiocarbon analysis (bio-based carbon content) and analyses of hydrogen, oxygen and nitrogen (bio-based content) as specified in EN 16785-1:2015. In Europe, the independently assessed “Bio-based content certification scheme” uses this standard to validate the amount of biomass in a bio-based product and issues certificates to validate biobased claims. https://www.european-bioplastics.org/bioplastics/standards/labels/
- An equivalent certification exists in the USA under the USDA's BioPreferred program. https://www.biopreferred.gov/BioPreferred/

Agricultural Considerations for Bio-Based Plastics

Whilst bio-based plastic solutions are often directly compared to petro-based plastics from a sustainability perspective, the sustainability of the raw materials for bio-based plastics is often overlooked. Increased production of bio-based feedstock for plastics can raise issues with land-use and other agricultural practices which must then be coupled to the plastic lifecycle. Agricultural practices involve the use of machinery and farm equipment, which are often fossil-fuel intensive, and crop treatments may involve toxic pesticides and chemical fertilizers, intensive irrigation causing soil erosion, loss of biodiversity, and indirect land use changes, all of which can have negative implications for the surrounding environment and communities. The tendency towards monoculture for biomass crops exacerbates these issues further.

Standards and certifications covering agricultural practices are discussed in Standards for Natural Materials.

Biodegradable plastics

Biodegradable plastics are plastics which can be degraded by microorganisms such as fungi and bacteria into water, carbon dioxide (or methane) and biomass under specified conditions. The time taken for a plastic to be broken down is highly dependent on its composition and degradation conditions. Any claim regarding biodegradability or compostability must be backed by documentation on conditions and breakdown data.

'Biobased' does not equal 'biodegradable'

Biodegradation is not related to the type of resource used to produce the plastic but is linked to its chemical structure. Fully biomass-based plastics may be non-biodegradable, and some petro-based plastics can biodegrade. It is important to understand the distinctions between terms applied to "bio" materials, to be able to accurately and honestly market products.

Compostable materials are a sub-set of biodegradable materials, which are defined by specific conditions and timeframe under which they will biodegrade. All compostable plastics are biodegradable, but not all biodegradable plastics would be considered compostable (Figure 9).

Oxo-degradable materials are a stand-alone category, not to be confused with biodegradability (Figure 9). They are conventional plastics mixed with an additive which enables it to mimic biodegradation, by fragmenting into smaller and smaller pieces. But since these do not break down at the molecular level like true biodegradable plastics, they result in microplastic wastes, which remain in the environment until they degrade naturally, a process which takes thousands of years.

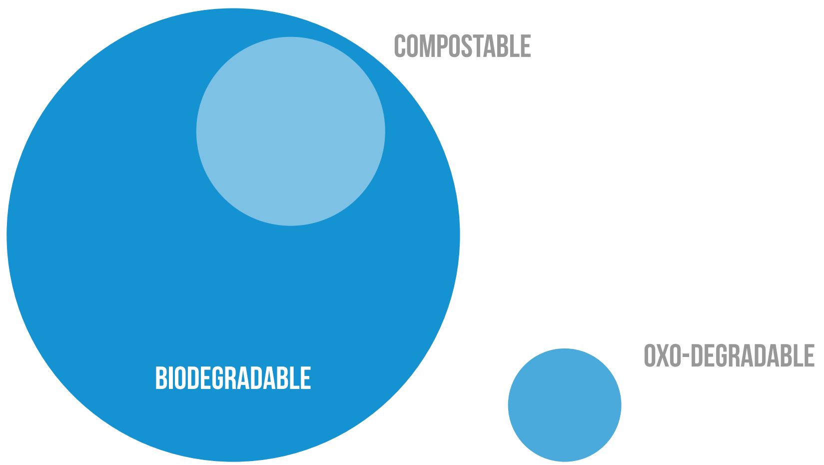


Figure 9: Degradability in plastics

Biodegradable and compostable materials often require the use of specialist industrial facilities which provide optimum conditions for decomposition to occur - in the absence of these conditions, the material will not start to degrade. Claiming that a plastic is “biodegradable” or “compostable” without any further context is misleading to consumers, and in fact not allowed under the EUs marketing laws. If a material or product is advertised to be biodegradable or compostable, information about the timeframe, the level of biodegradation, and the required surrounding conditions should be provided to the consumer.

Standards for biodegradable plastics

There are several standards for testing biodegradation and compostability of plastics. The organisation European Bioplastics recommend aiming for compostability, referring to standards EN 13432 (packaging), EN 14995 (plastics), ASTM 6400 (plastics) or AST; 6868 (paper coating). For consumer communication, there are also corresponding compostability certifications/labels by international institutes TÜV AUSTRIA BELGIUM and DIN CERTCO. If compostability is not preferred, standards for biodegradability in various non-compost media such as soil, sludge and seawater are also available. An overview of plastic biodegradability and standards can be found in the report “A Review of Standards for Biodegradable Plastics” [Kjeldsen, Price, Lilley, & Guzniczak, 2019].

2.4. Other Materials, Treatments and Processes

Composites

A composite is a material made from two or more different materials that, when combined, are stronger than those individual materials by themselves. Common composite combinations include carbon or glass fibres embedded in a polymer matrix, but natural fibre composites, such as jute or flax are increasing in popularity.

The sustainability profile of composites is highly related to which materials, or combination of materials are used. A large part of environmental impact is associated with the energy required for the materials production and the lack of end-of-life recyclability of thermosetting composites. There are also chemical ingredients and process auxiliaries with risk profiles to consider, such as bisphenols and isocyanates. Conventional composites can only be recycled through pyrolysis and solvolysis techniques, which can separate the fibres and resins for reuse, or mechanical recycling, which produces a by-product which can be used as a filler or reinforcement in other material.

The choice of resins for composites has increased rapidly over the past few years and alternatives to the traditionally used polyester or conventional epoxy resins, such as bio-based or recyclable epoxies are starting to become more commonplace in the market. They can offer a more sustainable option to the traditional materials, by reducing the use of petro-based feedstock and greatly improving the end-of-life options for a product. Thermoplastic resins with properties similar to the thermosets are also becoming more common, offering improved formability and recyclability.

The majority of bio-based resins have similar recyclability issues to conventional composites; however, their production has been shown to have a lower environmental impact when compared to petro-based resins in many cradle-to-gate studies as the original resource production has vastly reduced GHG emissions.
https://entropyresins.com/sustainability/life-cycle-assessment/

Various companies have now successfully developed completely recyclable epoxy resins and thermoplastic resins to enable a composite material where it is possible to separate all materials and repurpose them.

Eco Impact Calculator for Composites by composites industry association EuCIA is a tool for assessing the environmental impact of different conventional composites. New bio-epoxies and recyclable resins are too recent to be included in such tools, so data from suppliers are required in order to assess and compare these to the traditional materials to quantify the benefits.
http://ecocalculator.eucia.eu/

Natural Materials

Natural materials include wood, bamboo and other cellulosic materials. Stone and ceramics are also natural materials, but are not often used in the hard goods sector, so are not considered herein. Bio-based plastics may fall into this category depending on their origin, but for the purpose of this report are considered in the section 2.3. What are bioplastics?

Woods, grasses and plants that are used for making fibres have a strong claim to be sustainable materials as they are completely renewable. The biomass forms part of the carbon cycle, and therefore natural materials do not directly contribute to the greenhouse effect. In many cases, the materials can also be sourced locally, reducing transportation requirements, and supporting local communities. Correctly managed and responsibly sourced natural materials can therefore represent very low-impact material solutions for products where they are suitable.

Although responsible agriculture and forestry can result in these materials having a very low environmental impact, poor management can lead to a multitude of sustainability issues, from social impacts such as displacement of people, child labour to health risks due to widespread use of chemicals and pesticides, and ecosystem challenges from extensive land use. Poor agricultural practices can lead to issues with nutrient depletion, or to the other extent, eutrophication. Spraying and spreading of chemicals can affect biodiversity and cause irreparable damage to land and water resources and harvesting and forestry operations can be fossil intensive and cause land-use change and high levels of GHG emissions.

Post-processing of natural materials, for example, sawing, or transformation into fibres for composite materials often include industrial processes that need to be controlled. Surfaces are often treated or laminated with petro-based materials or metals which can be difficult to separate and recover.

Standards for Natural Materials

There are many different standards covering sustainable and good agricultural practices. Most standards apply to farming and focus on the production of foodstuffs; however, others are applicable to the production of feedstock material.

- SAN, an NGO network focused on helping drive sustainability in agriculture has developed a Sustainable Agriculture standard, in cooperation with the Rainforest Alliance. This standard focuses on 4 principles, Effective Planning and Management, Biodiversity Conservation, Natural Resource Conservation and Improved Livelihoods and Human Wellbeing. https://www.sustainableagriculture.eco/blog/2017/11/9/is-saving-water-enough-5tss3
- Two examples of certifications addressing sustainable agricultural practices in the feedstock production: The International Sustainability and Carbon Certification (ISCC)'s “ISCC Plus” certificate and the Institute for Agriculture and Trade Policy's Working Landscapes Certificate (WLC) program. These standards address biodiversity conservation, soil and water conservation, limiting and phasing out chemical usage, and the promotion of safe and healthy working conditions. https://www.iscc-system.org/process/iscc-documents-at-a-glance/iscc-system-documents/ https://www.iatp.org/documents/working-landscapes-certificates-program-information
- Forest Stewardship Council (FSC) - A non-profit, non-governmental organisation (NGO) established in 1993 which promotes the responsible management of forests globally. FSC certification provides assurance to customers that their products are sustainably manufactured from wood which has been harvested from forests that are responsibly managed, socially beneficial, environmentally conscious, and economically viable. https://www.fsc.org/en
- PEFC Forest certification is a method to promote the sustainable management of forests and ensures that forest-based products reaching the marketplace have been sourced from sustainably managed forests. https://www.pefc.org/

2.5. Surface Treatments and Finishing

Metals and plastics can both be treated to adapt their surface properties. This can be done to improve appearance, including decoration and reflectivity, to improve mechanical properties, such as hardness and wear resistance, increase corrosion prevention or to prepare the surface for other treatments, such as painting or photosensitive coatings, or to increase adhesive properties.

Plastics can even be metallised, which gives the surface metallic properties, whist retaining the advantages of a plastic substrate.

Surface treatments are often conducted in wet environments, so if the processes are not carefully controlled, the chemicals used have a large potential to cause harm to the environment through contamination of surface and ground waters, and to the surrounding land.

Other processes are aerosol based, which can give rise to toxic emissions.

The EU reference document on the best available techniques for the surface treatment of metals and plastics, highlights four focus points to consider for improving sustainability of surface treatments [European Commission, 2006]:

- minimisation of the consumption of raw materials, energy and water
- minimisations of emissions by process management and pollution control
- minimisation of waste production and its management
- improvement of chemical safety and reduction of environmental accidents.

Chemical management techniques are useful in assessing the environmental impact of various treatments. Conducting a full inventory of which chemicals are involved in you processes, then following the management steps to eliminate, substitute or make the exposure to substances as safe as possible. Read more in 6.6 Chemicals Management.

An example of surface treatments is the use of inks to print labels, graphics and logotypes on to products. As for any process, it is important to assess the whole lifecycle of the process, for example a water-based ink containing natural dyes may need significantly more energy to dry on plastic or metal substrate than on a substrate such as corrugated paper, which in some cases could render a solvent based solution more favourable [European Printing Ink Association, 2013].

There is no single surface treatment which can be categorised as sustainable. The most appropriate solution will need to be assessed for a particular process or product, taking all the relevant factors into account.

3.1. Klean Kanteen: Chemicals

Substitution tools for chemicals safety

By introducing a chemical hazard assessment tool, Klean Kanteen has taken control of the ingredients in their products and can proactively substitute chemicals of high concern with safer options.

About Klean Kanteen

With the focus on finding an alternative to plastic BPA bottles, Klean Kanteen was founded in 2004 and has produced and sold stainless steel bottles since then. Today they have a variety of reusable food and beverage containers such as water bottles, cannisters, coffee mugs etc. Based in Chico, northern California, Klean Kanteen has become an international brand with distribution in more than 40 countries. In 2012 Klean Kanteen became a B Corporation, certified by the non-profit B Lab. The company is also a 1% for the Planet member as a Business for Good™ member.

In 2018 Klean Kanteen launched a new exterior finish called Klean Coat™, a durable powder coating finish that replaced their spray paint-coating. A powder coating is not a unique material for their type of products, but this was their first material that came about through a product development project where they were using a chemical hazard assessment tool, GreenScreen.

Klean Kanteen's road to chemical hazard assessment

Chemical safety was the driving reason behind why Klean Kanteen was invented. From the beginning it was about finding a safe, durable alternative to single-use plastic water bottles and the concern for material safety and the concern for how the materials that they used could affect human and environmental health.

In 2012 Klean Kanteen was introduced to Biz NGO work group (a collaboration between non-profit regulatory agencies, companies and academics). Through Biz-NGO they found the guide to safer chemicals, which took their understanding of chemicals to a new level and it was a good resource for them to be able to develop their own thoughts about how to achieve safer materials.
https://www.bizngo.org/safer-chemicals/guide-to-safer-chemicals

The focus then became to avoid all types of chemicals of high concern in their materials. They started working with a restricted substances lists, figuring out what substances to avoid and asking the factories to review and make sure that they are not using those substances.

This was however not a very efficient way for Klean Kanteen to manage and avoid harmful chemicals, they wanted to move from just restricting certain substances to actually knowing what is in their materials. They then started to ask their factories to provide a chemical inventory for all the product materials that they considered using. Once the chemical information was received, they needed to figure out what to do with it and how to determine whether a chemical is safe or not and determine which one is better than the other (Figure 10).

The search for a tool then started, something that could help them assess the level of hazard presence in different coating options and help them to determine one chemicals hazard level from another so they could decide whether a material was good for them, based on its hazard level rating.

The preference was to find a tool accessible at a relatively low-cost and that they could use without having toxicologists in their company, and it was here that GreenScreen - Chemical hazard assessment tool came into the picture (more about GreenScreen Below and in 6.6. Chemicals Management section).

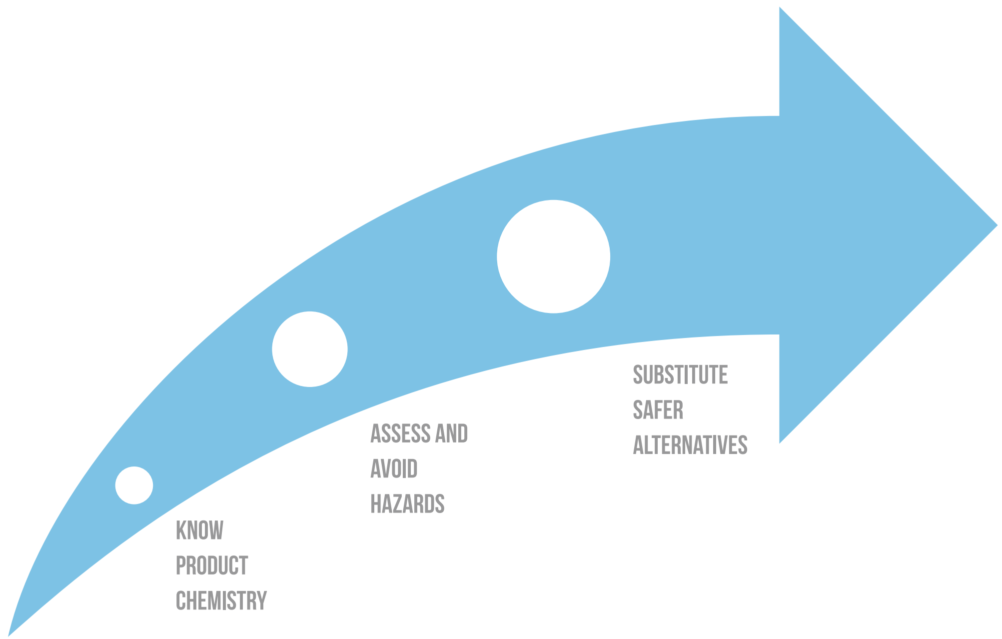


Figure 10: The material selection process

Two parallel processes merged into one.

To be able to realize the implementation of the chemical hazard assessment, the Klean Kanteen sustainability team needed something to apply it to. At that time, the Klean Kanteen product development team was working on a project, replacing the paint that they used. They wanted a stronger coating to match the durability of a long-lasting bottle.

This project became the catalyst for rolling out the new chemical hazard assessment approach. It was it was not intended at the start of both projects, but at the end they value added each other.

Effect so far

By the end of 2018, around of 75% percent of Klean Kanteen's materials (by weight) were made up of chemicals with Benchmark (BM) 3 or higher, meaning that they have a low to moderate total hazard assessment.

- BM-U - Benchmark U: Unspecified Due to Insufficient Data
- BM-1 - Benchmark 1: Avoid - Chemical of High Concern
- BM-2 - Benchmark 2: Use but Search for Safer Substitutes
- BM-3 - Benchmark 3: Use but Still Opportunity for Improvement
- BM-4 - Benchmark 4: Prefer - Safer Chemical

Out of the remaining 25% there are some BM-U (Benchmark Unknown). These are chemicals that do not have a classification yet and are or not listed on any chemical hazard lists. If any of those chemicals become a primary ingredient in a Klean Kanteen material, then they will add resources to have it classified.

Risks and Rewards

There are always risks involved when implementing new tools, introducing new materials, or challenging old ways of working. But there is also a big risk in doing nothing and be left behind when the rest of the business around you is progressing. Below are some bullets/key learnings from Klean Kanteen's process in introducing chemical hazard assessment into their business

- There are many good, accessible, and low-cost tools for chemicals management available. As a brand you need to know the chemistry of your chosen materials so you actively can search for safer alternatives. There are good tools out there that can help you with this.
- You do not have to be a chemist or a toxicologist. Use the information and resources provided by OIA, EOG, and similar organisations, they can point you in the right direction.
- There is no reason to hold back the change. You just need to have the mindset of what you want to accomplish.
- The barriers are much lower today than just a few years ago. It is also getting much easier to get the suppliers onboard as they are getting approached by other brands as well. Do not be afraid to ask your suppliers questions. Just

to have those conversations with your suppliers will get you started.

- Make sure upper management is onboard. You will need the right resources to push the project forward.
- Piloting the idea on an existing development project as soon as you reach to a point where feel comfortable and when you know that you have the suppliers with you.

The Future

Since 2019 Klean Kanteen are Climate Neutral certified (see section Climate tools). Their focus for 2020/2021 is to continue to weigh the different scenarios and options for reducing their emissions. This will happen by integrating climate work in the whole of Klean Kanteen's business processes through the collaboration of multiple departments.

About GreenScreen

GreenScreen® for Safer Chemicals is a chemical hazard assessment method for collecting and analysing chemical information, to determine if a substance poses a Hazard to human or environmental health.

Developed by the non-profit Clean Protection Action, GreenScreen allows manufacturers to identify chemicals of high concern and make decisions to replace them with safer alternatives to move towards safer chemistry in the final product.

GreenScreen also contains a List Translator, a way to identify chemicals of high concern by scoring them on a scale from high concern (1) to safer chemical (4), based on information from over 40 hazard lists.

- The List Translator: A way to screen out known hazardous chemicals,
- GreenScreen® for Safer Chemicals: To be used to identify safer alternatives of chemicals

https://www.greenscreenchemicals.org/

Based on an interview with Danielle Cresswell and Michael Duffy at Klean Kanteen in May 2020, and GreenScreen presentation for EOG Hard Goods Roundtable 2019.

3.2. Light My Fire: Bioplastics

From petro- to bio-based products in less than 2 years

Through an intense 2-year dialogue with their producers, Light My Fire managed to change all their products to contain up to 96% bio-based content by 2019.

About Light my Fire

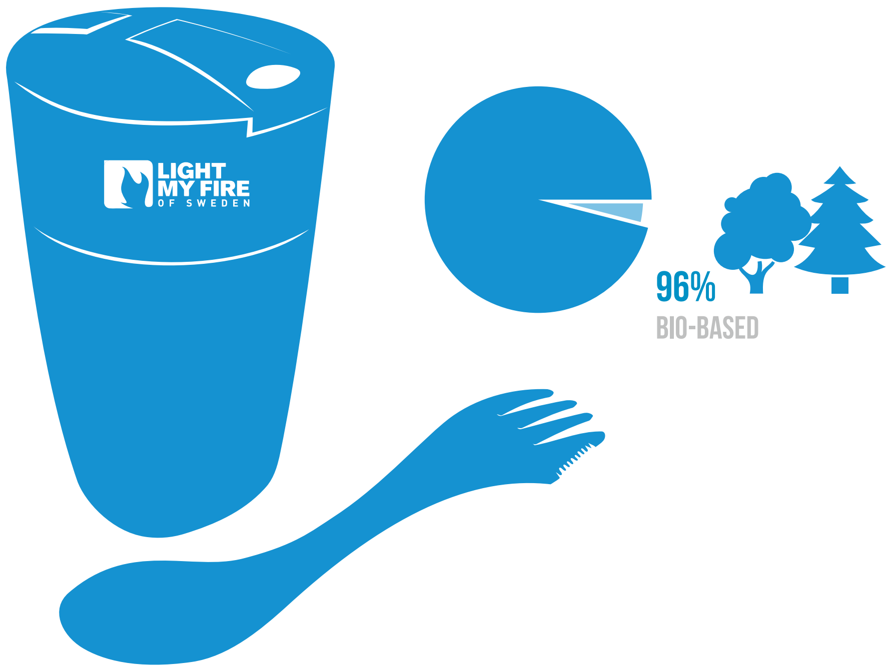
Light my Fire (LMF) is a Swedish company, founded in 1995, specializing in outdoor accessories with colour, design, and functionality, for use in the city as well as in the wild.

Their biggest product range are their meal kits with the Spork (spoon and fork in combination) as the star in the collection. The majority of their products are produced in Sweden. As of January 2019, the company's entire product line has transitioned to bio-based plastics, derived from renewable crops including corn, sugar cane and tree cellulose.

Light my Fire's road to bio-based plastics

Sustainability has been a part of Light My Fire in various ways since their very first product, the Maya Sticks. The sticks are pieces of fatwood pine, cultivated in Latin America, and with their 60-70% resin content they burn even when wet. Not only was it an easy way make a fire, but the sticks were also completely natural, produced from waste (the stumps left from felled pine trees) by locals in Guatemala with whom they started a fair-trade production.

Some years later LMF realized that there was more potential in the outdoor field. Most outdoor cutlery and flatware at that time were in plain colours and many things were also single use. So, the palette of colour cutleries designed for lasting a long time were born.



In 2009, LMF started to investigate what things could be problematic from a sustainability point of view with their products. Quickly they realized that shipping and their use of petro-based plastic were two key areas. The work towards bio-based plastics then started with a pilot project on how they could use a blend of corn and wood in their spork. A lot of tests were conducted, but the materials at that time did not live up to LMF's standards and they also felt that the market was not ready and they were afraid that their customers would question the origin of the bio-based plastic even though they didn't question the origin of the conventional plastics they used.

LMF started to dig deeper into the problems of conventional plastics, all the problems they cause and got an understanding on how important is was for them to convert to bio-based plastic. In 2017 LMF decided to stop waiting and start acting. They set a goal for the entire product range, to consist of bio-based plastics by 2019. The decision was not based on customer surveys or market research, it was all about acting and taking responsibility for an environmental problem.

The search for answers

As bio-based plastics are still in their infancy, a difficult part for LMF in their journey towards bio-based plastics has been to find answers. What are the risks with the new materials substituting petro-based plastics, are there materials that are more sustainable than others? For every question asked, they got different answers depending on who they were asking. The way for LMF to tackle the lack of information has been to lean against available certifications, asking the producers a lot of questions, and thoroughly evaluate the answers. But also, seeking outside help by publishing a full overview of all product materials and suppliers used for their products. If there is incorrect or incomplete information, external competences can react and start a dialogue with LMF for mutual learning. It also opens up to a library of solutions for others wanting to go biobased.

The biggest challenges & Lessons Learned

- **Shop around:** Take the time and dare to look around; do not stick with one material and one supplier, find alternatives. It is tempting to stick with a supplier that is easy to cooperate with, but their material might not be the best for you.
- **Tests take time:** Do not underestimate the test-phase, it can be a cumbersome process. When introducing new materials, the suppliers can only help you with the information they have, be prepared to do a lot of work yourself. For LMF this took a lot of extra time and increased costs.
- **The journey within the company:** Initiating and pulling though a process like this creates a great pride and commitment within the company. It creates energy that spills over to other parts of the business and can be valuable for the company overall.
- **Listen to many sources:** No one has all the answers, and no one has the total overview of all the information. Try to identify and talk to as many knowledgeable persons as you can, and try to get their input on your challenges

- **Simple communication:** Complex things are hard to communicate, and the plastic jungle is no exception. Too much information can be deterrent and confusing, plastics are complicated so make it as simple as possible.

The Future

The bio-based plastic project has been a learning journey and huge amounts of hands-on knowledge has been acquired by LMF. To take this to the next level and deepen the sustainability work even more, they are now aiming for to become climate positive within a few years. Since LMF own their production facilities, working with the raw materials will be a good way for them to reach that goal.

About Bioplastics

Produced from renewable biomass sources, such as vegetable fats and oils, corn starch, sugar cane, tree cellulose, recycled food waste etc. bio-based plastics provide a way replace petro-based polymers while providing a product with properties like conventional plastic. The bio-content in LMF's different products varies from 15% to 96,3%. To produce them, LMF currently use 3 types of bio-based plastics:

- Terralene: A mix of certified sugarcane and wood fibre waste from certified European wood https://fkur.com/en/
- Ecozen: Made from European GMO-free corn. https://www.skchemicals.com/
- Dryflex Green: Certified sugarcanes in two different densities https://www.hexpoltpe.com/en/

Based on an interview with Calill Odqvist Jagusch, CEO at Light My Fire, May 2019, and "Little handbook of plastics" by LMF, available at www.lightmyfire.com.

3.3. Burton Snowboards: Biocomposites

Reducing the carbon footprint by introducing bio-based epoxy

Burton managed to decrease their carbon footprint by 19% for their snowboards in part by introduction of a bio-based epoxy into their entire snowboard range.

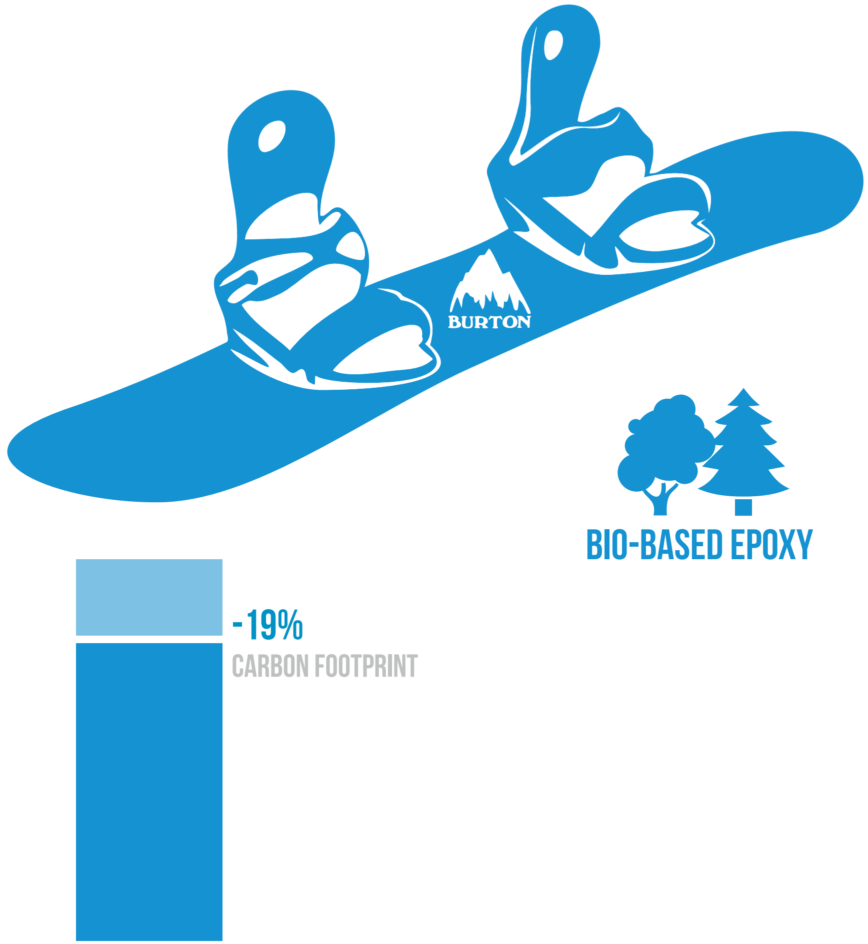
About Burton

Burton Snowboards was founded in Vermont 1977 by Jake Burton Carpenter. They have been one of the key players in growing snowboarding from a backyard hobby to a world-class sport. In addition to snowboards, Burton produce apparel, accessories, bags, and protection gear.

They are a Certified B Corp®, a bluesign(R) member and working towards 100% PFC-free textiles in 2022.

Burton's road to bio-based epoxy

Sustainability has in some ways been a part of Burton's work for many years, however not always in a structured way. In the beginning they worked with eliminating materials that they thought had a negative environmental impact but without really understanding what the ultimate impact of making that choice was.



EUROPEAN OUTDOOR GROUP

In 2012, Burton founded their sustainability department and with this department in place their work became more structured and they started to concentrate their efforts on identifying real targets for sustainability. Shortly after that they started to use life cycle assessment to create models for the exchange between product lifecycle and related ecosystems (Figure 11). The life cycle assessment work impacted their overall way of working, with an increased focus to find areas where they could make measurable differences in their sustainability. From that work came the idea of setting concrete sustainability targets. One of those targets was to reduce their carbon footprint by 20% across all hardgoods product lines. That goal and the underlying baseline LCA were made in 2017, with a five-year plan. The overall carbon footprint target was broken down and projects created to drive Innovation that would result in a decreased carbon footprint.

LCA for a new material - a challenging task

At the same time as Burton started to use the LCA to measure their footprint, they also started to discuss to introduce a bio-based epoxy into their boards. To do this, they needed to make sure that it really was making a difference, and not just telling their customers “we're using a bio-material and it's much better, just trust us”. This meant that they needed to get the LCA-data for the bio-epoxy, to show that they were actually reducing their carbon footprint.

Since the bio-based epoxy was a brand-new material and the common LCA software and databases did not have the specific carbon emission data for it, they needed to work closely with the company producing the bio-based epoxy to have them to produce the data so it could be

Figure 11: LCA view of hard goods

incorporated into Burton's own LCA model to show what the actual impact was on their snowboards.

With impact data in place, Burton started introducing the bio-based epoxy in some of the boards in one of their snowboard lines, Family Tree (a backcountry focused snowboard line) to start with. Within a year all boards in the Family Tree line were made from bio-based epoxy and around twelve months later, all Burton snowboards were made with bio-based epoxy.

The biggest challenges & Lessons Learned

- **Product performance:** Burton had to make sure that the level of product performance would not be impaired if they changed to new material. For the bio-based epoxy it took quite a few rounds of tweaks and changes to the process to be able to get a product that met their standards. So therefore, a small-scale start is always advisable when changing a material.
- **Cost:** Be aware that new Innovations (and supply chain innovations) are often more expensive in the beginning. But when rolling it out over more products, and/or more industry players start using it, the cost comes down.
- **Use the right metrics:** When measuring the carbon footprint, Burton measure CO2 per product unit instead of total CO2 footprint, meaning that a year with lower production does not make their product footprint lower.
- **In-house knowledge:** It is valuable to measure your sustainability progress yourself, and not to use external resources. By doing this you get a deeper understanding of what really contributes to the impacts, and by having the insight skill set allows you to play around with things a lot quicker and have results much faster.
- **Stick with the goals:** When you have decided on your goals, stay with them, continue to drive towards them rather than reassess even if you see that you will not reach them on time. Be honest, transparent and share your goals with your customers to bring them along on your journey. This builds that customer trust.

The Future

Burton has been looking into an epoxy that enables snowboard recycling and has collaborated with the epoxy manufacturer to adapt their product for snowboard manufacturing. This epoxy contains of a new type of hardener that in combination with a specific chemical can be dissolved back into a thermoplastic, enabling the other materials to be separated and reclaimed. So far, the actual recycling process has only been done on a pilot scale. Burton is now waiting for a functioning recycling facility to be planned before they introduce the new material to their range of snowboards.

They will also be continuing the work with their suppliers to increase their solar electricity installations. This especially in areas where the energy is produced from non-renewable sources.

About Bio-Based Epoxy

Burton is currently using a bio-based epoxy manufactured by Entropy Resins. The epoxy replaces around 30% of the petroleum-based carbon with bio-based carbon from plant material. The raw materials used are primarily sourced as a waste stream from the production of biodiesel that also uses recycled or reclaimed materials as its raw material source, such as used frying oils from the food industry. This reduces the carbon footprint from production by up to 33% compared with conventional epoxies.

Based on an interview with David Grace, Hardgoods Project and Validation Manager at Burton, May 2020.

4. PACKAGING AND SUSTAINABILITY

Packaging is an important part of a sustainable product. Packaging serves several functions, generally during a very limited time compared to that of the total lifetime of the product. It is obviously important that if a product strives to be as sustainable as possible, then its packaging must fulfil the same criteria. The focus of this report is not a detailed view on packaging design, materials and processes, as a full report of its own would be required. However, there are some general design suggestions which are applicable to packaging to improve sustainability:

Minimized, or non-existent! If the product itself can be sold and transported without individual packaging, with only the shipping packaging required, it will be less resource intense than when additional material is used and then disposed of.

Re-usable: Can the packaging be re-used or repurposed as something else? If the packaging can have its life extended to a longer use phase before disposal, then it will be more sustainable, especially if avoids another product having to be manufactured in its place. An example could be a stove packaged in a protective pouch which can serve as storage inside a rucksack.

Circular: not in shape, but adhering to the circular economy concept: can any packaging material be fully recycled, composted or biodegraded? Can recycled or repurposed materials be used?

Sustainable packaging is therefore:

- Sourced from materials that are hazard free throughout the whole product lifecycle
- Optimized to minimise materials and energy use, and manufactured using clean technologies and best practices
- Affordable and reaching set performance and cost standards
- Transported efficiently using only renewable energy sources
- Recycled, recovered, and utilized in closed loop cycles

Handy tools for Sustainable Packaging Development

The Australian packaging covenant organisation (APCO) published their updated Sustainable Packaging Guidelines in 2019, offering useful thinking points for how to design and implement sustainable packaging.
https://www.packagingcovenant.org.au/documents/item/1091

The Packaging Consortium has also produced a Sustainability Checklist which guides packaging designers through the design of sustainable packaging, covering aspects of packaging in the circular economy.
http://www.pac.ca/ePromos/promos/pac0945/pac0935-checklist-structural.pdf

5. LEGISLATION

Legislation affecting sustainability differs between countries and regions. Focus here is on relevant EU directives, but other legislation has been included where it offers an advantage or opportunity to EU organisations.

5.1. Chemical Regulations

REACH, the Registration, Evaluation, Authorisation and Restriction of Chemicals is a European Union regulation, addressing the production of and use of chemical substance, based on their potential impacts on both human health and the environment. All companies manufacturing or importing chemical substances into the EU in quantities of one tonne or more per year are required to register these substances with the **European Chemical Agency, (ECHA)**. The substances are then evaluated to assess if they present a risk to human health or the environment, and restrictions or authorisations applied accordingly.
https://ec.europa.eu/environment/chemicals/reach/reach_en.htm

In 2007, **REACH** introduced the "no data, no market" principle, and the EU has implemented bans for those which are regarded as harmful and continues to analyse and place restrictions on further additives. To date, approximately 23 000 different substances have been registered within REACH. In combination with the **European Chemical Agency, ECHA**, a Candidate List of **Substances of Very High Concern (SVHC)** has been developed. This is a list of pre-restricted substances that may be subjected to future restrictions and regulations. The list contains, as of early 2020, around 200 substances. Monitoring of this list is a good way to stay ahead of incoming chemical legislation. Early identification and proactive substitution of hazardous substances often give competitive advantages when legislation catches up with the scientific reality.

In most regulatory systems worldwide, chemicals of concern are regulated based on their hazards and unacceptable risks they may pose on humans and environment. International regulations may vary in detail, but they have a common baseline to regulate hazardous chemicals according to certain criteria:

- Chemical identity (CAS)
- Persistence (biodegradability)
- Bioaccumulation
- Potential for long-range environmental transport (mobility)
- Adverse effects to humans (mutagenicity, carcinogenicity or adverse effects on the reproductive, developmental, endocrine, immune or nervous systems)
- Adverse effects to the environment

A framework to assess chemicals is a crucial part of generating the information required to develop regulations based on scientifically validated data. These criteria enable a baseline to be reached, however the criteria do not fulfil all future needs to assess for green chemistry principles. Moving towards future targets for chemical production and use with reduced environmental impact requires an even more comprehensive evaluation of substances and of mixtures. The evaluation also needs to become much more efficient in terms of time, material resources and cost. Generic assessments of groups/families of similar substances as well as high throughput techniques for scientific studies may meet this vision and is how tools such as GreenScreen and ToxNot operate.

Not all chemical regulations involve bans or restrictions. For example, Proposition 65, **(Prop 65)** the Safe Drinking Water and Toxic Enforcement Act of California, is a regulation for consumer communication. It aims to protect the state's drinking water sources from being contaminated with chemicals known to cause cancer, birth defects or other reproductive harm by offering Californian consumers full information on hazardous substances. Businesses are required to clearly mark products with warnings about exposure, based on a list of chemicals provided by the Californian government. For a more proactive approach, the list can also be used for identifying substances to substitute for a less harmful product and simplified consumer communication without big warning tags.
https://oehha.ca.gov/proposition-65/proposition-65-list

5.2. Energy Directives

In 2019, the EU updated its energy policy to try and fulfil its commitments to the Paris agreement through implementing the Clean energy for all Europeans package. These regulations do not apply directly to the manufacturing industry, but the concept behind them can be taken further by individual companies. The directives focus on reduction in energy use, improvement in efficiency of infrastructure to minimise energy losses and a requirement to increase the level of renewable energy used.
https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en

Of course, different countries obtain their energy supplies from different sources. The global energy mix is heavily reliant on fossil fuels, which are responsible for incredibly greenhouse gas emissions. Within the EU, the Renewable Energy Recast has set a target that 32% of energy must be from renewable sources by 2030. Individual consumers of electricity in many locations can however already choose to be provided with electricity from renewable sources, often at only a minimal premium compared to the standard mix. Choosing to switch to renewable energy suppliers is an easy way to reduce emissions. Renewable energy generation sources emit little to no greenhouse gases or pollutants into the air. This means a smaller carbon footprint and an overall positive impact on the natural environment.
https://ec.europa.eu/jrc/en/jec/renewable-energy-recast-2030-red-ii

5.3. Waste Directives

In 2018, the EU adopted a waste directive which establishes legally binding targets for recycling up to 2035. The waste management directives focus on sustainable material management and in particular a shift towards a circular economy in combination with renewable energy use and long-term economic competitiveness.
https://www.consilium.europa.eu/en/press/press-releases/2018/05/22/waste-management-and-recycling-council-adopts-new-rules/

Most hard goods products will end up in municipal waste at the end of their useful life. Municipal waste covers standard household waste, including bulky waste, but also some waste from industry, office buildings, institutions and small businesses. The contents of public litter containers also fall under municipal waste. The composition of municipal waste and how it is sorted differs from region to region, and facilities for recycling vary widely according to location. On a European level, in 2016, 55% of municipal waste was recycled. By 2035, this must increase to 65%. In addition, a landfill reduction target sets minimum requirements for all extended producer responsibility (EPR) schemes.

Prevention of waste is generally better than managing waste. Waste handling presents several potential challenges such as landfill, recycling energy requirements, use of process chemicals and different types of pollution. Hence, minimising waste at all levels of a product lifecycle is a very effective way to improve a product's total environmental impact (Figure 12).

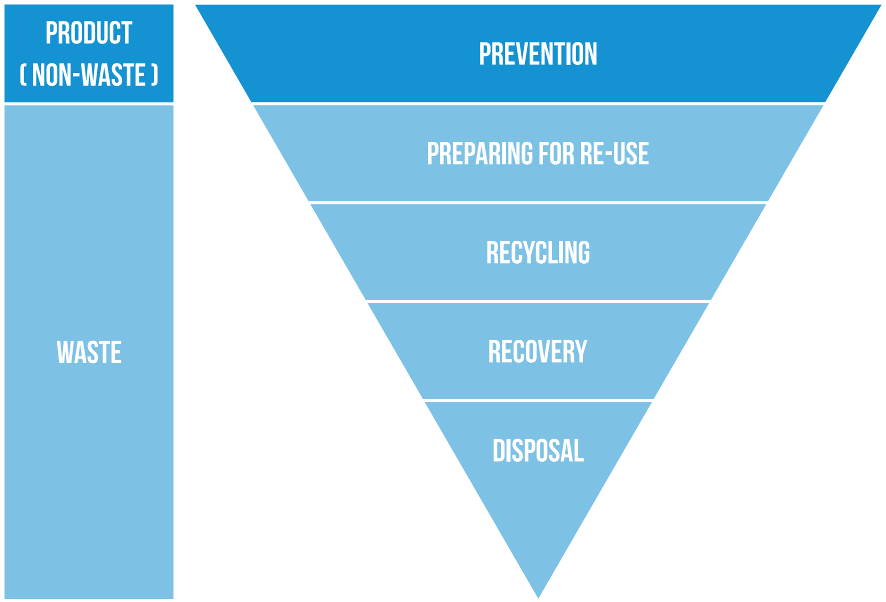


Figure 12: The waste pyramid

5.4. EU Circular Economy action plan

The EU has developed a circular economy action plan to help address the waste directive. This focuses on sustainable material management, with a view to protect, preserve and improve the quality of the environment and to protect human health by ensuring responsible utilisation of natural resources. Emphasis is placed on improving energy efficiency, with a focus on the shift to locally sourced, renewable energy sources. https://ec.europa.eu/environment/circular-economy/

The focus on circularity highlights the need for additional measures on sustainable production and consumption, looking at the full life cycle of a product, and trying to preserve resources and "close the loop". Efficient use of resources brings cost savings and reduces total greenhouse emissions around the whole circle, for producers, consumers and waste handlers.

The status of material use in the EU is that only 12% of the materials used by EU industry come from recycling [Eurostat, 2016]. Between 1970 to 2017, the annual global extraction of materials tripled and it continues to grow. More than 90% of global biodiversity loss and water stress comes from resource extraction and processing [The International Resource Panel, 2019]. The need to incorporate more recycled materials and to minimise resource use is key to achieve sustainability. Aside from material aspects, EU industry accounts for 20% of the EU's emissions [European Commission, 2019]. Reduction in energy use combined with renewable energy sourcing are key aspects to achieving emissions targets, such as reduction in greenhouse gas emissions laid out in the Kyoto Protocol, in order to comply with the Paris agreement to limit global warming to below 1.5C.

5.5. The future: Green transformation

In 2019, the EU presented the European Green Deal. This aims to promote efficient use of resources and a shift to a circular economy, with the additional goal to restore biodiversity and cut pollution. As part of this strategy, a Circular Economy Action plan has been proposed in March 2020, within which is a sustainable products policy, to prioritise reducing and reusing materials before recycling them, ensuring that products considered environmentally harmful do not reach the EU market.

Companies will be asked to substantiate their environmental claims using Product and Organisation Environmental Footprint methods, and it is expected that these methods will be integrated into the EU Ecolabel criteria, expanding them to include durability, recyclability and recycled content. False green claims will also be tackled as part of this initiative. The sustainable product policy may not initially be applicable to non-textile outdoor hard goods as the primary outdoor-related focuses will be on electronics, information-and communication technologies (ICT) and textiles. However, high impact intermediary products such as steel and chemicals are also targeted and further groups will be identified. Further, the overall goals, aims and guidelines are relevant to the whole outdoor industry.
https://ec.europa.eu/info/priorities/european-green-deal_en

5.6. Application of legislations outside of the EU

UK

At the time of writing, it is unclear what effect the UK leaving the EU will have on existing and future environmental legislation.

Environmental policies are devolved issues, so England, Scotland, Wales and Northern Ireland are all free to set their own policies, including minimum standards. In an initial phase, at least until the end of the withdrawal period, EU law will continue to be applied. Exactly how these policies will be implemented and enforced is unclear. Whilst there is a strong possibility that the UK will align with the EU on environmental standards, applying EU standards or new UK standard if these exceed the requirements of the EU standards, will minimise any risk associated with policy changes and the ability to trade with the EU.

Non-EU Member European States

Iceland, Liechtenstein, Norway and Switzerland are not members of the EU, but are associated with it via the European Free Trade Association (EFTA). As EFTA members these countries have a coordinated trade policy, and EU related legislation is generally applicable.

Rest of the World

Outside Europe, sustainability requirements vary markedly between different countries. A few countries (e.g. Japan, Korea and USA) have progressive legislation that in parts is equal or surpasses EU policy, whereas many other countries place less emphasis on sustainability, in particular the environmental aspect, and rather focus on economic aspects.

Adhering to the most restrictive legislation possible in regards to environment, working conditions and product safety sets the base line for sustainability high and has the added benefit that a product will be able to be sold or produced anywhere without legal issues when expanding to new markets.

6. SUSTAINABILITY TOOLS

Practical sustainability work entails different issues, actions and initiatives in different companies and products, and as such, each company has its own internal requirements for sustainability. There are a range of general sustainability tools which can be adapted to work for individual requirements, covering the different aspects of sustainability, including eco-design, waste, responsible sourcing, chemical management through to safe working environments, labour and human rights.

6.1. Tools

Tools for sustainability work range over a broad spectrum from guidelines, checklists and indexes through assessment and analysis methodology to specific standards and labels concerning specific issues. Many of these tools can be used both as internal support in work, and where third-party control is part of the system, also as an external validator for external communication.

Some tools apply on a holistic level, looking at the organisation, its management and processes, whereas others are much more specific and apply to individual chemical components in a product. General tools and approaches are described here, and specific tools can be found in the relevant sections of the document and summarised in the appendix.

Numerous third-party standards or labels covering various aspects of sustainability exist - these are most frequently provided to an organisation or a specific manufacturing site, certifying that it operates to an expected standard for a specific material flow, product or site.

Standards are often accompanied by a verification or certification process, which checks whether a company, product or activity complies with the requirements and responsibilities laid out in the standard.

For instance, meeting set emission levels, preventing the use of child labour or the validation of responsible supply chains. Many standards follow the iterative Plan-Do-Check-Act management method for continuous improvement, which is important for sustainability objectives as requirements and enabling technologies are evolving all the time (Figure 13).

The application of standards and labels are voluntary but using them provides assurance to end-users that the product they are purchasing reaches a certain level of quality, safety, reliability and sustainability.

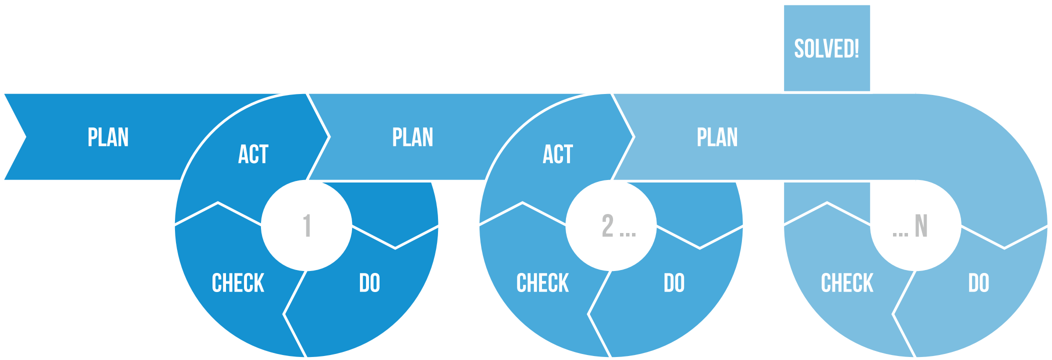


Figure 13: The plan-do-check-act process

6.2. Environmental Management Standards

Tools for environmental management are available in a multitude of shapes and sizes, from simple checklists and ecolabels to full-fledged management systems. The ISO 14000 series is a family of standards from the International Standards Organisation (ISO) related to environmental management, which forms the backbone for many of the environmental management tools that are out there. These standards cover a wide range of topics, with the aim to help organisations to minimize how their operations negatively affect the environment, and to help them comply with applicable laws, and environmental regulations and requirements.

Within the ISO 14000 series, a few standards are highly relevant to hard goods, notably:

- **ISO 14001** is an Environmental Management System (EMS) which gives organizations a systematic approach for measuring and improving their environmental impact. https://www.iso.org/standard/60857.html
- **ISO 14006** Environmental management systems - Guidelines for incorporating ecodesign https://www.iso.org/standard/72644.html
- **ISO 14020** to **14025** Environmental labels and declarations. Includes rules for third-party ecolabels and Environmental Product Declarations, (EPD). Information about EPDs: https://www.environdec.com/
- **ISO 14040** to **14049** Environmental management - Life cycle assessment; are the main standards relating to life cycle assessment (LCA). LCA is widely regarded as the gold standard in assessing and confirming product sustainability, and can be used to identify problem areas, strengths and weaknesses, and can be used as a comparative tool to assess the effect of making changes to a product process, material or life cycle step. https://www.iso.org/standard/37456.html https://www.iso.org/standard/72357.html

The **Eco-Management and Audit Scheme (EMAS)** is the EU's voluntary environmental resources management instrument. The registration process is independently verified by external assessors, which means that is a highly credible and respected scheme. It is based on the ISO 14001: 2014 requirements but adds elements to ensure that an even higher level is achieved. It also requires a commitment to continual improvement, and compliance checks are conducted on an annual basis. https://ec.europa.eu/environment/emas/index_en.htm

6.3. Social Responsibility tools

Large parts of the outdoor industry today have a setup where production takes place outside a brand's direct control, by several tiers of suppliers in a global, complex supplier network. Taking full social responsibility within one's whole value chain has proven to be a big task. To address this challenge, tools have been developed for both general management practices and specific topics/industries. In the background are the UN Universal Declaration of Human Rights and other work by UN such as the Global Compact and Agenda 2030, where a large part of the goals touch on social responsibility. Below are a few of the most referred or relevant tools from an outdoor hard goods perspective, often used in company code of conducts and by supporting organisations. Besides the standards and signed codes of conduct, direct on-the-ground control mechanisms with audits and grievance systems for workers are generally needed to ensure that agreed working conditions are fulfilled. This work is sometimes done by a brand themselves, but often performed by external consultants or industry support organisations.

ILO labour standards are today the most referred international standards when it comes to principles and rights for workers. International Labour Organisation (ILO) is a UN agency for social justice and workers' rights. Most other standards, tools and organisations refer to ILO when it comes to fundamental rights for workers. Examples of tools referring to ILO from the textile outdoor sector are Fair Labour Association (FLA) and Fair Wear Foundation (FWF). Most corporate Code of Conducts also refer to ILO standards for fundamental workers' rights.
https://www.ilo.org/global/standards/lang--en/index.htm

ISO 26000 is an often referred-to standard on social responsibility in a wider sense. It is not a management system standard and it cannot be used for certification, but rather provides guidelines and a common understanding of social responsibility through the focus on 7 core subjects (Figure 14).
https://www.iso.org/iso-26000-social-responsibility.html

SA8000 is a social certification standard, developed by Social Accountability International, applicable to factories and organizations. It is an auditable standard, measuring social performance in eight areas important to social accountability in workplaces, combined with a commitment to continuous improvement. Elements of the Standard include a focus on the elimination of child labour and forced labour. It promotes a safe and equitable working environment, with adequate remuneration.
https://sa-intl.org/programs/sa8000/

Figure 14: ISO 26000: Social responsibility

The Responsible Sport Initiative (RSI) is a platform helping sporting goods companies to implement unified corporate and social responsibility standards based on the air Factories Clearinghouse (FFC) system. They have piloted the work in the bicycle sector and are ready to expand to other sports/outdoor hard goods areas. The RSI is managed by the World Federation of the Sporting Goods Industry (WFSGI) and incorporates their common Code of Conduct.
https://www.wfsgi.org/activities
https://www.wfsgi.org/news/wfsgi-cr-position-papers

The Higg Facility Social & Labor Module (Higg FSLM) is a recently released tool dedicated to promoting safe and fair social and labour conditions for value chain workers globally, at this point mostly directed towards textile but possible to adjust for hardgoods if there is interest. It enables manufacturing facilities to measure their social impacts across the value chain. It also assesses the efficacy of social management programs. The Higg FSLM is appropriate for any tier of manufacturing.
https://apparelcoalition.org/higg-facility-tools/

6.4. Carbon Footprint tools

The task of reducing carbon footprint in line with the Paris agreement is complex, but there are some tools which offer an easy way in, to get going and start making climate-smart decisions.

In early 2020, the **1.5°C Business Playbook** was launched. It is designed to guide companies and organizations to reduce emissions and develop a climate strategy which aligns with the ambition to limit global warming to below 1.5°C above pre-industrial levels. The tool provides 36 key solutions to help halve emissions at least every 10 years, based on a 4-pillar strategy to shift business focus to zero-carbon solutions:

1. Reduce your own emissions
2. Reduce your value chain emissions
3. Integrate climate in business strategy
4. Influence climate action in society

https://bit.ly/playbookforprint

Climate Neutral Now is an initiative by the United Nations Framework Convention on Climate Change to address how to improve a climate footprint through a 3-step method with emphasis on direct action:

1. Measure greenhouse gas emissions/carbon footprint.
2. Reduce these as much as possible through your own actions.
3. Compensate those emissions which cannot be currently avoided.

https://unfccc.int/climate-action/climate-neutral-now

Science Based Targets initiative (SBTi) champions science-based target (SBT) setting to boost companies' transition to the low-carbon economy. The objective is supporting companies and organisations to set targets for their climate footprint and publicly disclose them for easy follow-up. They have developed a simplified target-setting process for small and medium-sized companies (SMEs). SBTi is a collaboration between CDP, World Resources Institute (WRI), the World Wide Fund for Nature (WWF), and the United Nations Global Compact (UNGC).
https://sciencebasedtargets.org/

Climate Neutral is a label/certification which assures that a company has taken steps to measure, offset and set reduction goals for its carbon emissions, resulting in a net-zero carbon emission.
https://www.climateneutral.org/

Carbon offsets

Whilst the primary approach to climate action always should be to reduce emissions as far as possible through reduction in company and product lifecycle processes, any remaining GHG emissions can be offset via a range of carbon offsetting possibilities, accelerating GHG mitigation efforts elsewhere. If you choose a carbon offsetting process, make sure that the method chosen is sustainable also from other perspectives. E.g. avoiding monocultures, invasive species and respecting indigenous land and its residents. The **UN Clean Development Mechanism (CDM)** certifies some emission reductions (CERs), a type of carbon credit. Another similar credit system is the **Gold Standard**, supported by international NGO's like WWF. Many organisations offer a similar service on a smaller scale – check the credibility of the offsetting system before engaging in it.
https://cdm.unfccc.int/
https://www.goldstandard.org/

Tools to measure and validate product carbon footprints

When it comes to the carbon footprint for an outdoor hard goods company, the materials and processes to make a product usually stand for a vast majority. This means that **product carbon footprints (PCFs)** are crucial to assess the full climate impact of a company and its supply chain. Life cycle assessment (LCA) is the basic methodology to make these assessments, together with databases on carbon emissions for materials and processes and standards to ensure a verifiable result. Below are four standards which are often referred to in PCF work.

- **PAS 2050** was introduced by British Standards Institute (BSI) in 2008 with the aim of providing a consistent internationally applicable method for quantifying product carbon footprints. PAS 2050 has been applied by many companies worldwide.
  http://www.bsigroup.com/PAS2050
- **The GHG Protocol** product standard was introduced in 2011. was released in 2011 and in addition to providing requirements to quantify the GHG inventories of products, also includes requirements for public reporting and is now the basis for many climate initiatives.
  http://www.ghgprotocol.org/standards
  A comparison between PAS 2050 and The GHG Protocol can be viewed here:
  https://ghgprotocol.org/sites/default/files/standards_supporting/GHG%20Protocol%20PAS%202050%20Factsheet.pdf
- **ISO 14067:2018** specifies principles, requirements and guidelines for the quantification and reporting of the carbon footprint of a product (CFP), consistent with International Standards on life cycle assessment (LCA) (ISO 14040 and ISO 14044).
  https://www.iso.org/standard/71206.html.

- **Carbon Trust Standard** is an independent certification awarded by The Carbon Trust, which certifies that an organisation reaches certain standards regarding energy use and greenhouse gas emissions, water use and waste management and disposal. https://www.carbontrust.com/

6.5. Product and supply chain tools

Materials form the basis of any product, and before making any decisions to address sustainability, it is important to know your baseline. Do you actually know all of what has actually gone into your product? You can control the processes that you are responsible for, but you should recognize that before a material or semi-finished product arrives at your facility, it may have undergone processes that you may not be aware of.

A starting point to have a complete understanding of your product is to develop a complete **Bill of Materials (BOM)** or composition/ingredient list for your product. This is fundamental for making deeper assessments of materials and formulations.

For each part and sub-part in the BOM, a full chemical inventory is recommended for deeper insight, focusing on identifying each substance, material and processing aid that are used.

These two steps are important to help you consider not just the materials you have in the product itself, but all the materials and chemicals that are involved in processes throughout the entire supply chain. There are many ways to develop a full picture of the chemicals and materials used in your product. Some information may be easily available to you, whereas other information will require some investigative work. In the table on next page, you can find a basic set of tools that are highly useful in your investigations.

A complete material inventory can be used as the basis for a basic life cycle analysis, to identify any potential hotspots from an environmental or societal perspective, and to try and find suitable substitutions. Such an analysis can often lead to surprising cost benefits and moving to more sustainable options leads to economic sustainability in the long-term.

Chemical inventory management can take many forms, it is discussed further in 6.6. Chemicals Management section below.

Traceability tools

At some point most supply chains get too long and complex for a complete search by the brand themselves. Gathering information on Tier 2-3 supplier's ingredients and sources, where you provide less than a percent of their business, may just seem like an impossible task.

To tackle this obstacle effectively and aggregate data for products and supply chains, traceability tools have been developed to support brands. Data can be used both for internal assessments and for consumer communication, in some cases the tools themselves have a consumer interface which can be unlocked to show selected data. Some of the listed tools below have been developed for, or in collaboration with, textile brands in outdoor, sports and fashion.

They are however tools which can be used in a multitude of complex supply chains, with some adjustments or in some cases right away depending on your products and materials.

Supplier agreement/contracts can be used to regulate some of the information flow needed for your risk management. Make sure to include your chemical, environmental, and facility management approach in the agreement and specify how potentially sensitive information will be handled, for increased trust.

A Non-disclosure Agreement (NDA) is sometimes needed to obtain information about suppliers, chemical products that are used, their ingredients and process parameters, especially from suppliers who have a proprietary treatment or technology which they may be wary of sharing. If you consider openness and trust a way of supplier collaboration, it may not be the first thing to offer but is a good way to encourage the sharing of potentially sensitive information. Other possibilities include involving a neutral third assessment party, which can verify and validate without disclosing all information.

Requesting a **Full Chemical Inventory** from all your suppliers is highly recommended. This will give your brand a clear picture of what your suppliers use to make your materials and products. Obtaining a full list is not always an easy task, especially when suppliers are reluctant to share potentially sensitive information. When complete, is should be updated on a regular basis. See 6.6. Chemicals Management section for further details.

A **Code of Conduct (CoC)** can be part of, or an appendix to, a supplier agreement or exist as a parallel document. In the CoC general guidelines for governance and stakeholder interaction are communicated, as well as specific game rules for environmental and social sustainability. Chemical, environmental, and facility management approach should be expressed in the CoC, as well as social aspects like human rights and working conditions.

A **Safety Data Sheet (SDS)** is mandatory documentation supplied for all chemical products with hazardous content. The standardized format is often used as a declaration for mixtures without hazard classifications. SDS should be available for all the chemicals involved in any chemical processes, including added cross-linkers, process boosters and other auxiliaries. Your supplier should be able to provide these for any substances used. Relevant additional information may be available in the form of a **Technical Data Sheet (TDS)** or **Process Data Sheet (PDS)** for the chemical product.

The **CAS number** is an international registration/identification for every chemical substance which is registered in a national or international register. They are the most common references when searching databases and should always be noted when investigating a substance.

Basic toolbox for materials and chemicals investigations in the supply chain.

- **Higg index Facility Environmental Module (FEM)** is part of the Higg index suite of tools which was developed by the Sustainable Apparel Coalition (SAC). It gives manufacturing units the possibility to make preformatted self-assessments which can be securely shared with selected customers. Many textile brands and their suppliers in the outdoor industry are already using Higg index, and there are already some hard goods parts manufacturers who have entered the system and made their self-assessment available. As the name implies, this tool is more about the actual facility than attributed to specific products, so it doesn't give specific product data that can be communicated to a consumer directly. Higg also has a Product Footprinting tool which was recently released, but its relevance for hard goods is yet to be assessed.
https://apparelcoalition.org/higg-facility-tools/
- **Sourcemap** builds a visual map of the supplier network for a product, where specific questions can be asked, and transactions can be recorded from raw material to finished goods. It can be used to identify unknown suppliers and make geographical risk assessments. Sourcemap has been used in various industries such as food, textile and jewellery.
https://www.sourcemap.com/
- **Provenance** is a blockchain-based assurance system where the integrity of an ingredient or material origin can be traced through complex transaction chains. It is highly adaptable to type of product and requested informati on and has a consumer-facing interface for sharing information and storytelling, to build credibility.
https://www.provenance.org/
- **TrusTrace** is a blockchain-based product traceability tool used in fashion and textile outdoor industries. It works by asking questions to suppliers within the system, adding traceability to the responses and aggregating results throughout the product value chain down to batch level. Transaction traceability is available. A module for consumer communication has been developed. Their system can be adopted for use in other supply chains than textile with a few engaged development partners.
https://trustrace.com/

6.6. Chemicals Management

Chemicals, whether they end up in your product or are used as process aids during production, are a source of potential environmental and health hazards.

Whereas some chemicals are relatively harmless, others present much greater risks, and identifying what and where these risks manifest themselves is key to being able to address sustainability. Undesirable chemicals can be found throughout the whole production process, from raw material extraction and processing, such as in polymer processing aids, or washing, etching and pickling treatments of metals, to finishing processes like painting, gluing and printing.

Different chemicals have different exposure routes, such as to the environment through air emissions, water effluents or solid wastes, or to workers during production, and even to final users of the product. Risks are also present at the end-of-life, especially if the product is not handled as intended.

Whilst the best approach to risk with chemicals use is to try and eliminate the use of the substance in the first place, there are cases where this is not possible. In this case, substitution should be considered, along with engineering and administrative control of the substance and ensuring that the best possible measures to protect workers, the environment and others who may be exposed are taken.

A solid chemicals management approach is key to identify potential risks and hazards and take action. There are many different levels on which chemicals management can be applied:

1. **Legal** – The bare minimum as required under national legislations and restrictions.
2. **Reactive and monitoring** – Looking at potential developments and addressing them before they become legislated e.g. SVHC, policies, ECHA News.
3. **Proactive** – Using RSL/MRSL and own statements – Identification and removal of chemicals that are not harmful enough to earn a place on the SVHC lists, but that are not as safe as desired.
4. **Best-in-class** – Based on progressive certifications and substitution tools – Replacement of all chemicals which have a notable impact and their substitution with less-harmful alternatives.
5. **Innovative** – Cutting-edge searching for Green Chemistry and Biomimicry solutions – Stand out by having a product that minimizes or eliminates the use and generation of hazardous substances totally and focusses on naturally inspired solutions.

Sustainable thinking goes beyond the first, legal level of chemicals management, as legislation sets the "allowed worst case" rather than progressive development. To develop and produce sustainable products, it is important to think about the impact of what goes into your product, so different types of chemical management tools will be needed.

Tools for chemicals management

Below you can find examples of tools to use in your chemicals management work. There is no one-tool-fits-all approach – as you build your chemicals management approach you will likely use different tools in different stages, and some of them in parallel to cover all bases. It also depends on company structure, type of products and supplier network, which approach is most effective and what tools will work best for you. Take some time to go through your options, and if it is overwhelming seek advice from an expert in the field to get started.

Inventory

An inventory of all chemicals used in the production of your product is a solid starting point for any chemicals management work. Creating the inventory is a good start for a deeper supplier dialogue on chemistry. It is less work than may be anticipated and when done, can easily be updated at a reasonable interval. It should include a list of CAS numbers to categorize and identify any substances of potential concern and links

to Safety Data Sheets (SDS) to each substance. If a supplier is reluctant to open their inventory to you, you can use a non-disclosure agreement (NDA) to ensure confidentiality. The inventory itself can readily be built by internal resources, but for deeper assessments of your inventory findings and suggestions for further work you may need external expert support. A chemicals inventory template with quick-assessment functionality is available from the POPFREE team – contact joel.svedlund@peakinnovation.se for more information.
www.popfree.se

Lists

There are many chemical lists available for assessing hazardous substances. Some are open and free to use, whereas others are linked to memberships or services. Not all lists are alike, you need to decide on your own ambition level to find a suitable list approach. The list is a passive tool – you need to set up a process for it to activate substitution work, and auditing is necessary for full compliance.

There are two main types of lists – restriction lists decide what cannot be used, and positive lists decide what can only be used. Restriction lists are mostly used today, but within a few services (e.g. Bluesign®, Cradle to Cradle®) there are positive lists governing their approval of materials. The lists below are restriction lists.

- **Restricted Substance Lists (RSL)**: A restriction list determining what is prohibited or needs threshold values in the textile product. An example of a publicly available RSL is the AFIRM RSL, used in textile industry.
https://www.afirm-group.com/2020_RSL_ENGLISH
- **Manufacturing Restricted Substance Lists (MRSL)**: A restriction list determining what is prohibited or restricted in the manufacturing processes. It extends further than the RSL since it also looks at process chemicals in production. Example of a widely spread MRSL is the ZDHC MRSL. Another is the BSSL, used by Bluesign® members. Both used in textile industry.
https://www.roadmaptozero.com/input
- **ChemSec** has an informative article about setting up an RSL/MRSL.
http://textileguide.chemsec.org/act/setting-up-an-rsl/
- **SINList** from ChemSec is one of the most referenced lists globally when using a precautionary approach, containing approx. 1000 substances (April 2020) which have shown health and environmental concerns in scientific studies.
https://sinlist.chemsec.org/
- **ECHA Chemicals search** contains all registered chemicals within the REACH regulation, currently approx. 23 000 CAS numbers, with data on hazard classes and regulatory information.
https://echa.europa.eu/search-for-chemicals
- **SVHC Candidate list** of very high concern for authorisation is a list of approx. 200 substances (April 2020) that will be evaluated for restrictions in REACH, and hence a good monitoring tool to be ahead of legislation.

- **California Prop65 List**: Contains chemicals known to cause cancer or birth defects or other reproductive harm. These substances must also be clearly declared on any product sold in California. https://oehha.ca.gov/proposition-65/proposition-65-list

Tools, Service Providers, and Certification Bodies

A few service providers have packaged tools and additional assessment work into external chemical management services. Depending on your needs and the scope for your chemical work, some examples of the tools available are given below.

- **Greenscreen®**: A software tool that reviews chemicals by CAS number providing an assessment of the health of the chemical by a grading system. It includes chemistry for textile and many other industry sectors. There is a "light" version of the tool called Greenscreen® List Translator. https://www.greenscreenchemicals.org/
- **ChemSec**: A non-profit international chemistry watchdog, offering a set of tools for chemicals management and substitution. They manage SIN List, SIN Producers and SINimilarity for identification of hazardous chemicals, and Marketplace for finding alternatives. https://chemsec.org/
- **OECD Substitution and Alternative Assessment toolbox**: The Organization for Economic Cooperation and Development (OECD) has useful resources for substitution work, including a list of available tools which can be filtered according to requirements. http://www.oecdsaatoolbox.org/Home/Tools
- **The Swedish Centre for Chemical Substitution** – A Swedish governmental initiative for progressive substitution work, managed by the research institute RISE. Website contains information resources on chemical assessment and substitution methodology, with a guide for successful substitution.

  https://www.ri.se/en/substitutionscentrum
- **Toxnot** is a software platform for chemicals documentation in the supply chain, compliance, hazard assessment and disclosure. There is a free subscription alternative which offers good initial support. https://toxnot.com/
- **ToxServices**: International consultant specializing in services for vetting chemistry, from compliance to progressive circular chemistry. https://toxservices.com/
- **Higg MSI**: A materials impact database, part of the Higg index suite. Mainly textile focus but contains both metals and some polymers. Chemical load is intended to be part of the material evaluation, but as of April 2020 the chemistry part is still under development and has limited information/scoring impact. https://msi.higg.org/page/msi-home

- **PRIO database** by Swedish Chemicals Agency (Kemikalieinspektionen) is a web-based tool that can help you to preventively reduce health and environmental risks from chemical substances.
https://www.kemi.se/prioguiden/english/start
- **12 Principles of Green Chemistry** – ACS – a framework to learn about green chemistry, and designing or improving materials, products, processes, and systems. It focusses on eliminating the most harmful aspects of chemical production and improving process efficiency through using biocatalysts and lower reaction temperatures.
https://www.acs.org/content/acs/en/greenchemistry/principles/12-principles-of-green-chemistry.html

7. SUSTAINABILITY WITH LIMITED RESOURCES

Terms like eco-design, design for sustainability, carbon footprinting and life cycle thinking may sound technical and complex when you start to consider the sustainability of a product. The common theme here is that the entire life cycle should be considered when looking at improving any product. The broad nature of outdoor hard goods, their materials and various product uses does add some complexity when looking at the sustainability of products. Each product must be considered from an individual standpoint. And of course, sustainability needs to be balanced with other important product considerations, such as:

- Safety features
- Branding requirements
- Regulatory information
- Function and durability

Some trade-offs may be necessary in order to fulfil all of these requirements, but by taking a systematic approach to sustainability, the negative impact of your product can be reduced as much as possible whilst still reaching the highest level of quality and functionality.

There are numerous tools to address sustainability and the right approach will depend on what targets or objectives your organization has set. For instance, if your goal is to reduce the carbon footprint of your organization, then looking at improving embedded carbon or improvement to transport efficiency may be more relevant than design for recycling. Ideally, all can be taken into consideration at the same time, to address all parts of the lifecycle, but in the real world where time and money are limited, it can be wise to identify your first priorities and target them in a first step.

7.1. How do I choose a tool?

- Ask yourself what you and your brand care about most. It can be driven by brand communication priorities (e.g. surf boards and sea water quality), but also because of inherent risks in the materials, processes, or geography of your operations.
  - Environmental or social impacts? On a global or local scale?
  - Which are the most urgent environmental or health risks to handle?
  - Where do the biggest sustainability risks lie in a longer perspective?
- How are you going to address what you are measuring?
  - How will you weight the factors against each other to make a decision?
  - Is reduction in the use of toxic chemicals worth twice as much as a reduction in energy?
- How much certainty will you need to be credible?
  - It is easy to make a quick estimate of impacts, but to be able to communicate and qualify statements on

sustainability, you need to back up claims with evidence.

Design priorities can often be changed depending on which sustainability tools you look at, so it may be worth investigating various systems and seeing which one fits best with your organization.

One way to do this effectively is via a workshop, where you can invite colleagues from different business sections to get together and discuss the different requirements for a product or product line from an organization perspective.

Brainstorming of this type helps to identify product needs and wants and can often identify where even small changes can lead to great improvements in sustainability. If workshop support is needed, an external consultant could help to facilitate such a discussion, or you can use a simple guiding tool like the three below (many other alternatives are available online):

- EcoDesign Strategy Wheel http://wikid.io.tudelft.nl/WikID/index.php/EcoDesign_strategy_wheel
- Circular Design Guide https://www.circulardesignguide.com/
- MethodKit for Sustainable Organisations https://methodkit.com/shop/methodkit-for-sustainable-organizations/

7.2. Designing for Sustainability

When designing a new product, or analysing an existing product to improve its sustainability, it is important to consider the potential environmental impacts of the product at all stages of its lifecycle. It is only a small step from designing for form and function to including design for sustainability.

Introduction to designing for sustainability

- **Design for reducing embedded carbon**, e.g. Substituting 60% recycled Aluminium into a product using 100% virgin Al can reduce the material-based carbon footprint by up to 90%.
- **Design for recyclability**
  - Prioritize between requirements (needs) and wishes (nice to haves) and choose materials strictly based on the needs to minimize complexity.
  - Consider the recyclability of all materials used in your product.
  - Minimize the number of different materials used in a single product.
  - Consider how different parts are joined. E.g. using snaps from a similar material instead of screws will reduce the time taken to dismantle the product and increase the likelihood of it being recycled or re-used.

- Avoid layering materials without a separation strategy or making separation of different components difficult.
- Avoid mixing types of plastics, especially where plastics of similar densities are used together.
- Avoid using dark coloured plastics as they are hard to recycle.
- If labels are required, see if they can be fixed in such a way that they are easily removable, e.g. using water-soluble adhesives.

- **Design for recycled content**
  - Consider incorporating recycled material into the product BOM. A product does not have to be 100% recycled material; most materials can incorporate various levels of recycled fractions with little-to-no loss in performance.
  - Introduce recycled materials in non-critical parts to get used to how the materials behave, and then spread them further throughout the product line.
  - The inclusion of a small percentage of recycled material can result in a large reduction in environmental footprint and can be gradually increased over time as qualities improve.
  - Ask your supplier if the materials you use are available in recycled form or look to start including a small recycled fraction in your product.
- **Design for transport efficiency**
  - Can the product be designed so that it can be packed more efficiently, by interlocking or stacking to minimize the amount of air that needs to be transported, improving efficiency, and reducing transport related emissions.
  - Can packaging be minimized so that the product is shelf-ready on delivery and reduces the pre-consumer waste generated.
- **Design for longevity**
  - Minimize product obsolescence by different ways to increase the useful life of a product, for example including serviceable parts which can be replaced, repaired and upgraded.
  - Investigate how other business models, e.g. rental or leasing, where ownership of the product stays within the company, would affect view of value creation and longevity/upgradeability.

- **Design for low-impact materials**

  Step-by-step guide:

  1. Define your product and design requirements. Based on function, identify constraints and objectives – differentiate between needs and wants.
  2. Screen materials using these constraints.
  3. Eliminate unsuitable materials that do not fulfil the function.
  4. Rank materials based on objectives. Include chemical screening to identify any hidden risks and seek documentation on functionality.
  5. Make final selection.

7.3. Lifecycle Checklist

The sustainability of a hard goods product is closely linked to the chemicals and materials used in its construction. When considering how sustainable any individual product is, an excellent starting point is an examination of the product's lifecycle. A life-cycle assessment is the gold-standard in assessing the sustainability of a product, but conducting a full LCA is time-consuming and costly, and is not a feasible option for most companies on all their different product lines.

However, it is possible to gain an overview of the potential sustainability hot-spots by asking a series of questions about the product which encourage thinking about what impacts occur on each of the aspects of sustainability throughout each part of the product's lifecycle from conception to the end of the product's life. It is easy to overlook the impact on social and economic sustainability so remember to take these into account. An example checklist can be found on the following pages.

LC STAGE	PRIMARY QUESTIONS

RAW MATERIALS AND RESOURCES	Make an inventory of all the chemicals and materials in your product – do not forget process chemicals and packaging materials
	• Gather information on them – For each identified material/chemical ask:
	  • What is its function?
	  • Do you really need it?
	  • Is it hazardous?
	  • Is there a better alternative?
	    • Can you increase the recycled content?
	    • Is there a bio-based alternative and could it replace the petro-based option?
	• Identify where each substance comes from
	  • Can the supply chain sustainability be verified?
	• For materials sourced directly from suppliers – how can you verify that their processes are sustainable?
	• Are social sustainability practices being followed?
	  • No child labour, forced labour and safe and equitable working conditions

PRODUCTION	Gather information on processes and parameters
	• For each process:
	  • Is this the most efficient process?
	  • Can material waste be reduced?
	  • Are there large distances involved in the supply chain?
	    • Can transportation be reduced or made more efficient?
	  • Can you reduce energy and water consumption?
	  • Is my energy supplied from renewable sources?
	• Are there any wastes or emissions which are hazardous to others?
	  • What happens to the effluents and emissions?
	• For production at suppliers – how can I verify that their processes are sustainable?
	• Are social sustainability practices being followed?
	  • No child labour, forced labour and safe and equitable working conditions

LC STAGE	PRIMARY QUESTIONS

USE	Is the product as fit for purpose as possible?
	• Can its longevity be increased?
	    • What is the expected life? Is this reasonable?
	• Can the user service or repair it if it breaks?
	• Are spare parts available?
	    • Think outside the box – can the user make their own spare parts – 3D printing or use commonly available objects?
	    • Can the product be returned for repair?

END OF USE	When the product reaches the end of use, what is most likely to happen to it?
	• Can it be re-purposed for another use or user?
	    • Are there parts that can be used in other products without re-processing?
	• Can it be recycled?
	    • Has the product been designed to be easily dismantled into its components by material type?
	    • Does the user know what to do with each part?
	    • Can you make the process easier?
	    • Would a take-back scheme be beneficial to add value to a particular recycling stream?
	• Does the user know how it is meant to be disposed of correctly?
	    • Check that communication is clear and the product parts are correctly labelled

RESIDUALS	Due to the nature of outdoor hard goods, it is inevitable that some products or parts thereof will end up in nature – being lost, damaged or worn down.
	• Have you ensured that to current knowledge the risk to the environment from your product is minimised?
	    • Do the materials decompose?
	    • Are any hazardous degradation products generated?
	    • Would small parts cause harm to the environment – animals, plants etc.?

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APPENDIX 1: EOG HARDWARE CATEGORIES AND REPORT SCOPE

EOG HARDWARE CATEGORIES	EXCLUSIONS IN THIS REPORT
The categories have been defined in the annual EOG market survey work. All apparel and most footwear are already excluded from hardware as they are separate product categories.	Exclusion of hardware mainly relate to textile and electronics specific materials, processes, tools and supply chains which are not covered in this report. List of excluded product types below.

• Backpacks & Luggage
  ○ Backpacks
  ○ Luggage
  ○ Pack & Luggage Accessories
• Climbing Equipment
  ○ Carabiners
  ○ Chalkbags & Chalk
  ○ Climbing Devices
  ○ Climbing Other
  ○ Climbing Shoes
  ○ Crampons
  ○ Crash Pads
  ○ Harnesses
  ○ Helmets
  ○ Ice Axes
  ○ Quickdraws
  ○ Rock Protection
  ○ Ropes
  ○ Slings
  ○ Snow & Ice Protection
  ○ Via Ferrata Equipment
• Outdoor Accessories
  ○ Camping Furniture
  ○ Cooking, Eating & Hydration
  ○ Lighting
  ○ Miscellaneous Accessories
  ○ Navigation equipment
  ○ Poles
  ○ Snow Safety & Equipment
• Sleeping Bags & Mattresses
  ○ Mattresses
  ○ Sleeping Accessories
  ○ Sleeping Bags Down
  ○ Sleeping Bags Synthetic
• Tents
  ○ Non-Portable Tents
  ○ Portable Tents
  ○ Tarps & Sun Protection
  ○ Tent Accessories
	• Apparel and Footwear
	• Backpacks and Luggage
	  ○ Backpacks
	  ○ Luggage
	  ○ Pack & Luggage Accessories
	• Climbing Equipment
	  ○ Chalkbags and chalk
	  ○ Climbing shoes
	  ○ Harnesses
	  ○ Ropes
	  ○ Slings
	• Outdoor Accessories
	  ○ Lighting
	  (no electronics in report, but structural hard goods materials are covered)
	  ○ Miscellaneous Accessories
	  (High variety of products in this category. Some sections of the report may be of relevance due to the types of materials used)
	  ○ Navigation equipment
	  (no electronics in report, but structural hard goods materials are covered)
	  ○ Water treatment
	  (not included in this report but structural hard goods materials are covered)
	• Sleeping Bags & Mattresses
	  ○ Sleeping Accessories
	  ○ Sleeping Bags Down
	  ○ Sleeping Bags Synthetic
	• Tents
	  ○ Non-Portable Tents
	  ○ Portable Tents
	  ○ Tarps & Sun Protection

APPENDIX 2: SUSTAINABILITY AND CIRCULARITY BASICS

Sustainability

Sustainability is the ability to co-exist continuously in a context of societal and ecological systems. There are many different definitions and paradigms used to define sustainability, but all have a common theme: to become sustainable, we have to develop processes for long-term economic, social and environmental well-being. These three focal points are considered in sustainability circles as pillars, known informally as people, profits and planet, (the 3Ps, or triple bottom line).

One of the risks when trying to address sustainability is narrowing down initiatives and actions aimed at only one of these pillars (or just a part of one pillar), providing a benefit to one aspect, but which does not increase sustainability as a whole. In an extreme case, this can lead to greenwashing, giving an illusion of sustainability whilst hiding other, less sustainable practices.

Separating the three pillars of sustainability is impossible, as they are highly entwined, and any change to one will have an impact on the

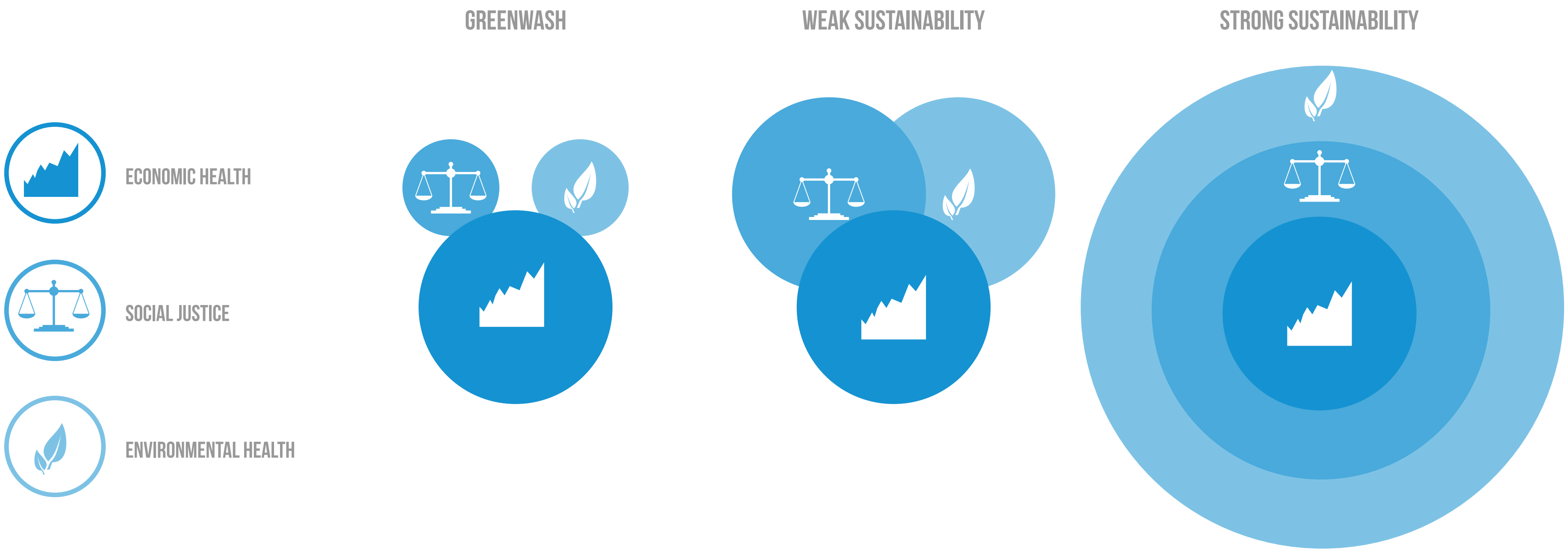

Figure 15: From weak to strong sustainability

others. Strong sustainability starts with a healthy planet, which provides a solid base to achieve sustainability on social and economic fronts, yet to ignore social and economic challenges can negate any environmental benefits (Figure 15). The challenge faced by us today is which steps to make to ensure that we are following the right path to become a truly sustainable society.

The concept of **The Planetary Boundaries** represent nine environmental limits within which humanity needs to remain to develop and thrive today, and for years to come. These boundaries lack a social and economic dimension, so to develop a stronger picture of how sustainability can be achieved on all fronts, need to be considered in combination with the minimal social standards, for example by UN in the Sustainable Development Goals. The wedding cake model (Figure 16) or Doughnut Economy model (link below) are two attempts to integrate planetary boundaries with societal and economic aspects for a broader picture of priorities and impacts.

https://www.stockholmresilience.org/research/planetary-boundaries.html

https://www.kateraworth.com/doughnut/

https://www.stockholmresilience.org/research/research-news/2016-06-14-how-food-connects-all-the-sdgs.html

The Natural Step describes this model in a relatively concise manner based on four general sustainability principles. In the sustainable society, nature is not subject to systematically increasing:

- Concentrations of substances extracted from the Earth's crust
- Concentrations of substances produced by society
- Degradation by physical means

And in that society...

- People are not subject to conditions that systematically undermine their capacity to meet their needs

The four principles is part of the Framework for Strategic Sustainable Development (FSSD) – more info:

http://www.alliance-ssd.org/framework-for-strategic-sustainable-development-fssd/

https://thenaturalstep.org/

The wedding cake model, sorting the 17 UN Global Goals into a Strong sustainability model for priority. Numbers in figure are references to corresponding Global Goal https://www.globalgoals.org/.

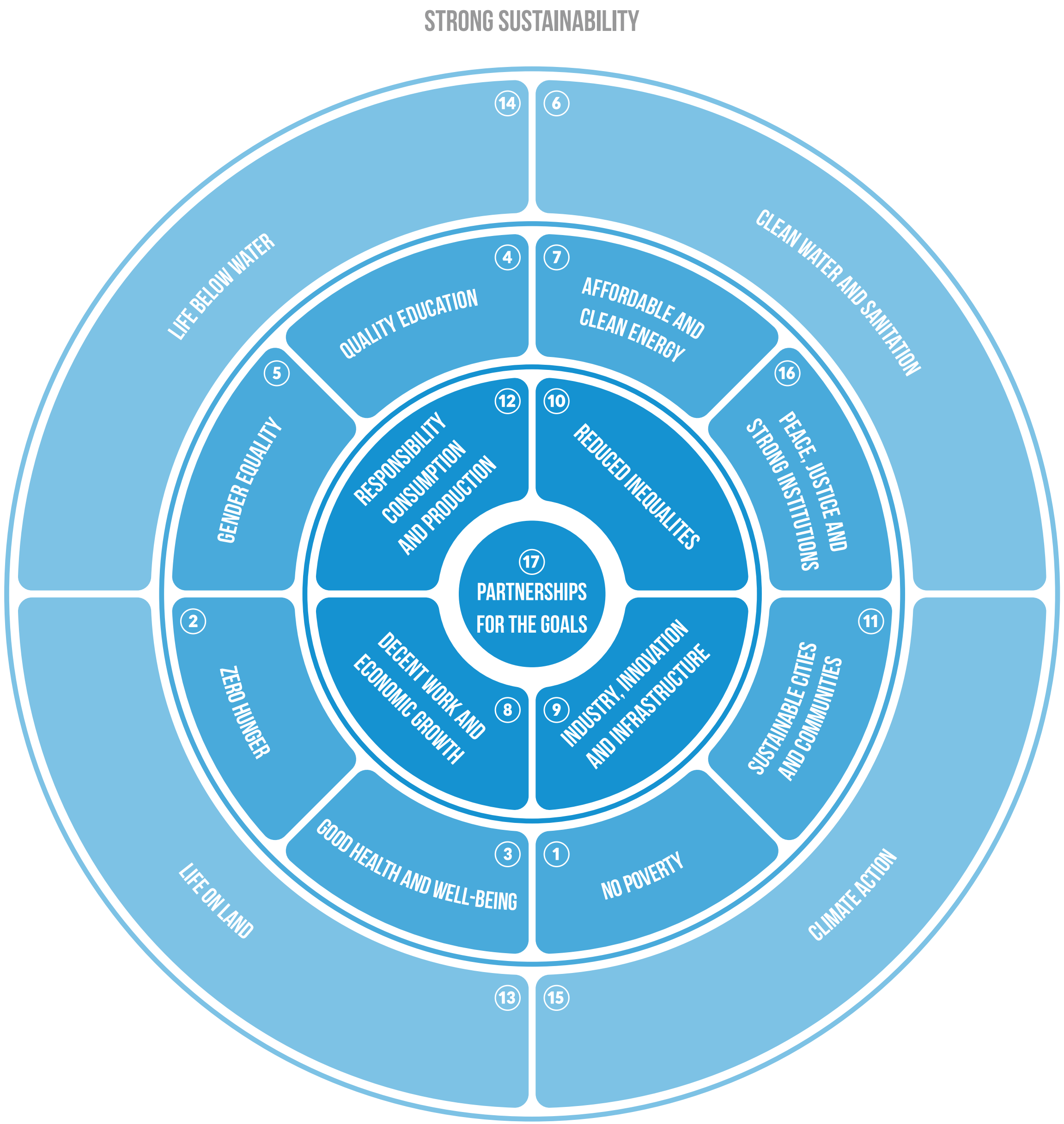

Figure 16: The wedding cake model

Linear vs Circular economy

For the longest time, our economy has been linear. This means that raw materials were used to make a product, and at the end of life, the entire product was disposed of as waste. In our current industrial system, there are attempts to fix the flaws of the linear economy, for example with the introduction of large-scale recycling which provide loops back into the material flows. Although an improvement on the traditional linear system, to ensure that our resources can handle the demands of our consumption, the whole material-based economy must become truly circular: preventing waste by managing material and chemical resources in closed loops use during production, extending the useful life of our products, and altering how a product is treated at the end of life by including possibilities for full repurposing and re-use of all products as raw materials for future products.

The circular economy model is based on three main principles:

- Design out waste and pollution
- Keep products and materials in use
- Regenerate natural systems

https://www.ellenmacarthurfoundation.org/circular-economy/concept

To achieve circularity, products must be designed to last, using high-quality materials and repairable designs. They also have to be optimized for a cycle of disassembly and reuse so that it is easy to transform them, renew them or use the materials for other products (Figure 17). To complement the efforts to design out all pollution and allow natural systems to regenerate, an important step is to ensure that energy requirements should be fulfilled from renewable sources; avoiding resource depletion and reducing the emission of greenhouse gases associated with the combustion of fossil fuels. Circular chemistry is a cornerstone of successful implementation, looking towards green chemistry and closed-loop processes to use substances that would otherwise affect environment and health negatively.

Dematerialisation is a key concept in circularity, which can apply on both economic and material levels. For products, this means using less, or even no material to deliver the same level of functionality as an alternative product. Dematerialisation is not just limited to the product - the whole production process can be dematerialised, through reducing waste and minimising resource use. A change in mentality to view waste as a design flaw can be useful in starting the change to a circular economy. Dematerialisation is also a part of new business modelling, offering services rather than products through sharing, rental and experience-based offers rather than focusing on physical products.

https://kenniskaarten.hetgroenebrein.nl/en/kenniskaart/circular-economy/

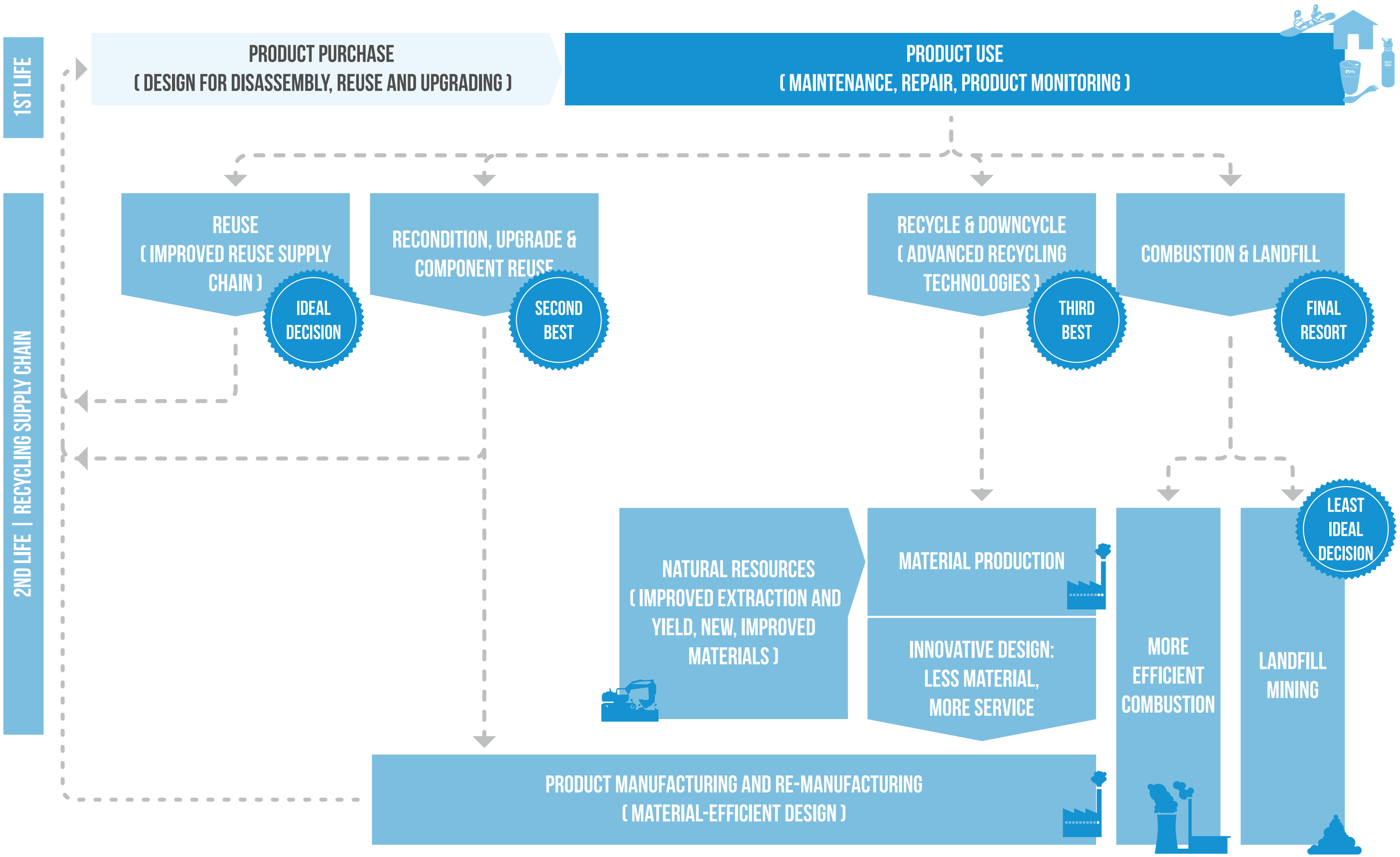

Figure 17: The outdoor hard goods lifecycle

APPENDIX 3: SUSTAINABILITY TOOLBOX

The toolbox below includes a few selected tools in various sustainability areas. More tools are mentioned in the report and many others are available online or through support organisations. New tools are rapidly developed when a sustainability topic comes into focus, why this landscape can be tough to navigate at times. You are welcome to contact EOG's sustainability resources for further dialogue at responsibility@europeanoutdoorgroup.com, if you are trying to address a specific sustainability issue or want to assess the relevance of a tool you have discovered.

INITIATIVE	DESCRIPTION/LINK
AGENDA 2030 AND THE GLOBAL GOALS	Agenda 2030 with the 17 UN Global Goals is one of the most important frameworks for sustainable development internationally, referred to by governments, NGOs and industry players. The goals have a deadline year 2030, creating a sense of urgency and convergence among governments and all types of organisations. www.globalgoals.org
Future-Fit Foundation FUTURE-FIT BUSINESS BENCHMARK	Future-Fit Business Benchmark is a tool for continuous assessment and improvement of sustainability and "future-fitness", with a sustainable future as benchmark. The system considers both mitigation of negative impacts and additions of positive impacts, in a quest to reach beyond the extra-financial break-even point. https://futurefitbusiness.org/
Certified B Corporation CERTIFIED B CORPORATIONS	Certified B Corporations is a certification of businesses that meet the highest standards of verified social and environmental performance, public transparency, and legal accountability to balance profit and purpose. B Corps are accelerating a global culture shift to redefine success in business and build a more inclusive and sustainable economy. https://bcorporation.net/
ISO ISO 26000:2010	ISO 26 000 is an international social responsibility standard which provides guidance on what social responsibility is and helps businesses and organizations to implement principles into effective actions. It is not built for certification, but there are assurance/reporting systems based on this standard. https://www.iso.org/iso-26000-social-responsibility.html

EUROPEAN OUTDOOR GROUP

INITIATIVE	DESCRIPTION/LINK
HIGG INDEX	Higg Index is a suite of tools currently aimed towards the textile and apparel industry with many outdoor brands as members. Hard goods-oriented tools are considered as development. The facilities module is applicable to textile/hard goods mixed brands, the brand module is largely applicable to non-textile brands and the materials sustainability index contains information on some materials commonly used in the hard goods branch. https://portal.higg.org/
SA8000	The SA8000® Standard is the leading social certification standard for factories and organizations across the globe. SA8000 measures social performance in eight areas important to social accountability in workplaces and is built on a requirement for continuous improvement in all areas of the Standard. https://sa-intl.org/programs/sa8000/
PEFC	PEFC is a forest certification which promotes sustainable management of forests and ensures that forest-based products reaching the marketplace have been sourced from sustainably managed forests. https://www.pefc.org/
FSC	FSC provides a variety of standards from forest management to chain of custody certification. These provide credible assurance that products are sourced from environmentally and socially responsible origins. https://fsc.org/en
CARBON TRUST ASSURANCE	Carbon Trust Assurance is an international independent certification body for carbon footprints, following the PAS 2060 standard developed by BSI and Carbon Trust. Ensuring robustness of carbon accounting, strength of carbon management plans and credible offsets. https://www.carbontrust.com/

INITIATIVE	DESCRIPTION/LINK
CLIMATE NEUTRAL CERTIFICATION	Climate Neutral is an independent non-profit organization offering a label that guides consumers in their purchases toward brands that take climate action. Certified brands show that immediate climate action is possible and proving that consumers care. Impacts are measured in tonnes of carbon that are measured, offset, and reduced. www.climateneutral.org
CARBON FOOTPRINT CALCULATOR	Carbon Footprint offers online Carbon Calculation Tools to help raise awareness, measure emissions, reduce costs and engage staff in carbon management programmes. The software is a leading & authoritative calculation package which is easy to use. https://www.carbonfootprint.com/calculator.aspx
THE CANDIDATE LIST	Candidate List of substances of very high concern for Authorisation by the European Chemicals Agency (ECHA) is the first step in the procedure for authorisation or restriction of use of a chemical. It is possible to avoid nasty surprises and stay ahead of any future regulations by monitoring the list, which contains 209 chemicals as of June 2020. https://echa.europa.eu/candidate-list-table
SIN LIST	The Substitute It Now (SIN) List registers hazardous chemicals that are used in products and manufacturing processes. Substitute It Now (SIN) can be used in chemicals management for substituting hazardous chemicals before the legislators register them in their systems. https://sinlist.chemsec.org/
THE PROPOSITION 65 LIST	The Proposition 65 List requires the state of California to maintain and update a list of chemicals known to the state to cause cancer or reproductive toxicity, and for companies to inform consumers in California about exposure to any chemical on the list. Although specific to California, the list can be used to help identify chemicals of concern. https://oehha.ca.gov/proposition-65/proposition-65-list

INITIATIVE	DESCRIPTION/LINK
THE CHEMICAL FOOTPRINT PROJECT	The Chemical Footprint Project is a program of Clean Production Action to develop the use of chemical footprinting, a tool to identify and measure the use of chemicals of high concern throughout a supply chain. This can then be used to evaluate performance and create a benchmark measure the reduction in the use of harmful chemicals towards safer alternatives. https://www.chemicalfootprint.org/
GREENSCREEN®	GreenScreen is a tool for chemical hazard assessment. The GreenScreen benchmark scores can be used to identify chemicals of concern to human health and the environment, select safer alternatives, and to track and communicate progress towards elimination. GreenScreen criteria and guidance are fully transparent and available for anyone to use. They also have a certification program. https://www.greenscreenchemicals.org/
MATERIALWISE	MaterialWise is a tool from Chem Forward, based on the Pharos chemicals assessment platform, to screen a chemicals list or inventory against lists of hazardous and restricted substances.. https://www.materialwise.org/
SWEDISH CENTRE FOR CHEMICAL SUBSTITUTION	The Swedish Centre for Chemical Substitution acts as a node to promote substitution of hazardous chemicals and identify better alternatives for products and processes. The work focuses on consumer products and small and medium sized enterprises (SME). https://www.ri.se/en/substitutionscentrum
GLOBAL RECYCLED STANDARD	Global Recycled Standard is an international, voluntary, full product standard that sets requirements for third-party certification of recycled content, chain of custody, social and environmental practices and chemical restrictions. Currently most used in textile but possible to adapt to other material streams. https://textileexchange.org/integrity/

INITIATIVE	DESCRIPTION/LINK
RECYCLED CONTENT STANDARD	Recycled Content Standard (RCS) verifies the presence and amount of recycled material in a final product. This happens through input and chain-of-custody verification from a third party. It allows for the transparent, consistent and comprehensive independent evaluation and verification of recycled material content claims on products. https://textileexchange.org/integrity
THE CIRCULAR DESIGN GUIDE	The Circular Design Guide by Ellen MacArthur Foundation and IDEO provides numerous resources, such as worksheets, and flowcharts to help designers to develop products that fulfil the requirements of the circular economy https://www.circulardesignguide.com
CIRCIT	CIRCit is a Nordic research project developing tools for business model transformation, product development and business operations to fit into the circular economy model. http://circitnord.com
CRADLE TO CRADLE CERTIFIED™	Cradle to Cradle Certified™ is a globally recognized measure of safer, more sustainable products made for the circular economy. The standard is rooted in the Cradle to Cradle® design principles with material assessment in 5 different categories, to assure material health, circularity and social fairness. https://www.c2ccertified.org

APPENDIX 4: ADDITIVES IN PLASTICS - OVERVIEW

ADDITIVE FUNCTION	CLASSIFICATION	DESCRIPTION	EXAMPLES OF RISK SUBSTANCES
IMPROVING PROCESSABILITY	Plasticizers	Improve the fluidity of plastics during processing and flexibility at room temperature. Used extensively in polyvinyl chloride (PVC) molding	Many Phthalates are on substitution lists
	Lubricants	Prevent the adhesion of plastics to the surface of metal molds and to each other, improves the fluidity of plastics, and reduces friction during processing	PFAS-based lubricants, PTFE-based lubricants. Siloxanes D4-D6 as silicone building blocks Many Phenol based lubricants are endocrine disruptors
	Blowing Agents	Used in foam molding, decompose through heat and compression to produce carbon dioxide, water, nitrogen, and other gases	Azodicarbonamide, known as the yoga-mat chemical, was banned in the EU in 2005 for food contact applications, but is still used in other plastic products, PFAS are often used outside of Europe as foaming agents
	Catalysts	Often metal compounds or complexes to speed up production processes	Antimony trioxide, commonly used in PET production is carcinogenic. Organotin compounds, used in PU foam and silicone production, are linked to several types of toxicityto marine life.
SURFACE MODIFIER	Antistatic agents	Prevent static electrification of electrical insulators. Classified into coating agents and blending agents. Surfactants are used	Nickel and cyclic aromatic compounds are found on restricted lists
	Antifriction agents	Reduce the surface friction coefficient.	PFAS-based substances
	Adhesion-improving agents	Improve the adhesiveness of the surface of plastics.	PFAS-based surfactants may be used, as well as strong oxidizers (e.g. elemental fluorine) and cross-linking agents such as isocyanates or phenols
	Anti-fog additives	Hydrophobic surfaces permit condensation, leading to loss of translucency. Surfactants prevent fogging	PFAS-based substances

ADDITIVE FUNCTION	CLASSIFICATION	DESCRIPTION	EXAMPLES OF RISK SUBSTANCES
MATERIAL PROTECTANTS	Antioxidants	Prevent oxidation, deterioration and radical formation caused by heat during processing.	Aromatic compounds and other common antioxidants such as azines and azoles are suspected carcinogens and endocrine disruptors
	Light stabilizers	Prevent oxidation caused by light during the service life of a plastic product	Octocrylene (OC) and BM-DBM are currently listed for evaluation by ECHA for suspected PBT/vPvB properties
	Ultraviolet-absorbing agents	Prevent the breakage of molecular bonds by UV light and the generation of radicals	Four benzotriazole UV stabilizers are listed SVHC due to persistent, bioaccumulative and toxic (PBT) properties
	Thermo-stabilizers	Prevent thermal degradation of polymers when exposed to high temperatures	Lead or metal salt blends
PROPERTY IMPROVERS	Flame Retardants	Reduce combustibility of plastics	Brominated substances - POPs
	Fillers/reinforcement material	Fibres and powders improve the strength of plastics. E.g. mica, talc, kaolin, clay, calcium carbonate, barium sulphate	Nanoparticulate matter
FUNCTIONALIZING AGENTS	Colorants	Pigments of inorganic or organic origin can be used to colour plastics and improve light resistance	Azo dyes, heavy metal pigments
	Biocides	Antiseptic additives to prevent bacterial or fungal growth	Triclosan is toxic to aquatic life and metal salts from e.g. silver and copper are also considered risk substances to water-living organisms.

Based on data from these three sources:

https://www.naturskyddsforeningen.se/sites/default/files/dokument-media/rapporter/Plastic-Report.pdf
http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2019)10&doclanguage=en
https://echa.europa.eu/documents/10162/13630/expo_plastic_addives_guide_en.pdf/ef63b255-6ea2-5645-a553-9408057eb4fd

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