WP1 | R potential, waste generation and waste management of outdoor products in the Alpine region (D1.3.2)

MAPPING THE STATE OF ALPINE SOLUTIONS FOR CIRCULAR PRODUCTS

PART 6

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Co-funded by the European Union through the Interreg Alpine Space programme.

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This report is an outcome (Deliverable 1.3.2) of the Interreg Alpine Space project ASTER (https://www.alpine-space.eu/project/aster/).

This project is co-funded by the European Union through the Interreg Alpine Space programme.

It provides insights and results from work package 1 (WP1) and structures the understanding in the testing and implementation phases in WP2 and WP3 of the project.

Innsbruck **2026**

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1 Introduction

The Outdoor Consumer Report 2021 across 19 European countries finds that 81% of respondents engaged in at least one outdoor activity in the past 12 months, with hiking, running, and cycling among the most common activities. Additionally, 55% purchased at least one outdoor product during that period, most frequently apparel (38%), footwear (37%), and equipment (12%). (Deloitte & Outdoor by ISPO, 2021)

At the same time, the Alpine region is home to well-known outdoor brands (Table 1). These brands develop and sell footwear, equipment, and apparel for all kinds of outdoor activities (e.g., biking, hiking, running).

Table 1: Examples of outdoor companies and their brands in the Alpine region - sorted alphabetically

Company	Brand (s)	Headquarter	Type of products	Outdoor sports	Link
Calzaturificio S.C.A.R.P.A. S.P.A	Scarpa	Asolo, Italy	Footwear	Hiking, trail running, climbing, ski touring, lifestyle	www.scarpa.com
Fischer Sports GmbH	Fischer, Löffler	Ried im Innkreis, Austria	apparel, footwear, equipment	Skiing, ski touring, Nordic walking, cross country skiing, running, biking	www.loeffler.at www.fischersports.com
Maloja Clothing GmbH	maloja	Rimsting, Germany	Apparel	Biking, running, cross country skiing, skiing, ski touring	www.maloja.com
Mammut Sports Group AG	Mammut	Seon, Switzerland	apparel, footwear, equipment	Hiking, climbing, trail running, lifestyle, biking	www.mammut.com
Martini Sportswear GmbH	Martini Sportswear	Annaberg, Austria	Apparel	Ski touring, cross country skiing, hiking, biking, (trail) running	www.martini-sportswear.com
Oberalp AG	Salewa, Dynafit, Pomoca,	Bolzano, Italy	apparel, footwear,	Hiking, ski touring, lifestyle,	www.oberalp.com

	Wild Country, Evolv, LaMunt		equipment	biking, trail running, climbing	
SAS Picture Organic Clothing	Picture	Cebazat, France	apparel, equipment	Ski & snowboard, hiking, lifestyle, surfing, mountain biking	www.picture-organic-clothing.com
Schöffel Sportbekleidung GmbH	Schöffel	Schwabmünchen, Germany	apparel	Hiking, biking, lifestyle, skiing, ski touring	www.schoeffel.com
Schwanhäuser Industrie Holding GMBH & CO. KG	Deuter, Ortovox, Maier Sports, Gonso	Heroldsberg, Germany	Apparel, equipment	Hiking, Biking, Ski touring, skiing, climbing, camping, lifestyle	www.schwan-stabilo.com
VAUDE Sport GmbH & Co. KG	VAUDE	Tettnang, Germany	apparel, footwear, equipment	Biking, hiking, ski touring, camping, lifestyle	www.vaude.com

Outdoor products are mainly composed of various types of plastic and textiles. Due to the concentration of outdoor manufacturers and the use of such products in the Alpine region, establishing a circular economy for such products is a high priority. This is particularly important in terms of reducing greenhouse gas emissions and resource consumption. So-called R strategies are often used to implement a circular economy and to put appropriate measures in place:

- R0 Refuse
- R1 Rethink
- R2 Reduce
- R3 Reuse
- R4 Repair
- R5 Refurbish
- R6 Remanufacture
- R7 Repurpose
- R8 Recycle
- R9 Recover

The ASTER project seeks to analyse and highlight effective strategies to enhance the circularity of outdoor products. As part of this effort, a comprehensive background paper was developed outlining the “R Strategies” and explaining how they are applied within the project framework. The paper is available at the following link: https://doi.org/10.13140/RG.2.2.22431.21920

The aim of this report is to provide the ASTER project's subsequent work packages with basic information. Specifically, it aims to analyse the outdoor market and the types and compositions of outdoor products, and to derive possibilities for recycling from this analysis. Furthermore, the current situation of waste management for outdoor products in alpine regions is examined. Additionally, the implementation of R-Strategies and the obstacles to their implementation are examined. This report does not cover the topic of laws or legislation, as a separate deliverable (D 1.2.1) is allocated for that.

2 Methods

Extensive research was conducted to provide a comprehensive overview of waste generation, waste management practices, and R-Strategies related to outdoor products in the Alpine region. This chapter outlines the general methodology applied to achieve the report's objectives. The legal framework governing waste management for outdoor products in the Alpine region is covered in Deliverable 1.2.1 of the ASTER project.

Waste potential of outdoor products

The study aims to quantify the waste generated by outdoor products and to categorise this waste by product type and material. Outdoor products are not recorded as a distinct waste fraction in official waste statistics, as they are typically disposed of through residual waste, bulky waste or separate textile waste streams. As a result, official statistics (e.g. BMUV Department T II 1 (2023); Environment Agency Austria (2025)) do not provide specific data on waste quantities from outdoor products. Activity 1.3 tested this hypothesis by examining how outdoor products are managed in the Alpine region, as outlined below.

To address this lack of data, an alternative approach was adopted: sales data for outdoor sports equipment was analysed to estimate future waste generation. To obtain sales figures, representatives from the outdoor sector were contacted. The challenge lay in obtaining specific figures for the Alpine region. As Chapter 3 shows, data was only available at a national level or for Europe as a whole. An evaluation of the available sales figures revealed the most relevant product categories. These categories and their material composition are examined in more detail in the third chapter. Information on typical material compositions in outdoor products were obtained from internet searches, and a review of the scientific literature was performed on potential for fibre-to-fibre recycling. Based on this research, the relevant material compositions of outdoor products are described along with options for separating and recycling them. Additionally, the relevance and current status of the presented technologies are assessed.

Waste management practices of outdoor products

To assess how waste from outdoor products is currently managed in the Alpine region, a questionnaire was developed. The questionnaire, which is provided in Annex 1, consisted of 16 questions grouped into the following sections:

- waste fractions in which outdoor product waste in collected in the alpine countries,
- waste quantities collected in these fractions,
- waste collection systems relevant for outdoor product waste,
- treatment, recycling and reuse of these fractions in the relevant countries, and
- specifically, the treatment and reuse of separately collected used clothing.

The questionnaire was distributed in July 2025 to all project partners in Austria, Italy, Germany, Slovenia, and France to gather insights into existing waste management practices for outdoor products in the Alpine region. The questionnaire responses were supplemented with literature research on this specific topic, as well as information on the European perspective.

R-potentials of outdoor products

To provide an overview of R-Strategies applied in the outdoor sector, a comprehensive desk research was carried out using online sources, industry and sector reports, and scientific literature. In addition, three interviews with outdoor brands and one interview with a sustainability expert in the outdoor market were conducted.

The interviews addressed topics such as sustainability in the outdoor market, circular economy approaches, and challenges related to implementing sustainability measures. The interview guide consisted of 15 questions and is included in Annex 2. All interviews were conducted via the online video conferencing system BigBlueButton, recorded, and subsequently analysed using the software Read AI.

The aim of the research was to establish which of the 10 R-Strategies (R0 - refuse, R1 - rethink, R2 - reduce, R3 - reuse, R4 - repair, R5 - refurbish, R6 - remanufacture, R7 - repurpose, R8 - recycling and R9 – recovery, see chapter 1) are already being applied in practice in the outdoor industry, and if so, to what extent. The research also aimed to investigate which strategies have the potential to make the industry more sustainable in the future. Additionally, successful implementations by companies are presented as examples of innovative practices. The challenges that the industry is facing when implementing R-Strategies are also discussed.

3 Waste Potential of outdoor products

3.1 Outdoor sports market

As part of the research for the ASTER project, an examination was performed of the market for outdoor sports goods and its development, to gain an overall understanding of the industry. No market and sales data specifically for the Alpine region could be found and thus the following information refer to the EU as a whole or to individual countries.

In the scope of this report, outdoor sports goods are defined as all apparel, footwear and equipment that are primarily produced to conduct outdoor activities but can also be used for (urban) lifestyle/leisure or performance purposes (according to Deloitte & Outdoor by ISPO (2021))

Market overview

From 2019 to 2022 the European outdoor wholesale market showed a clear trajectory of resilience and recovery (Figure 1). In 2019, the total sell-in value reached about €5.8 billion with moderate growth of +0.5 % in value and +2.3 % in volume versus 2018, reflecting stable pre-pandemic demand (EOG, 2019). The COVID-19 pandemic in 2020 and 2021 caused a marked downturn: total wholesale value fell by −9.5 % to around €5.3 billion (2020), with declines across most product categories and regions (EOG, 2020). By 2022, total wholesale value climbed to approximately €6.1 billion, representing an ~11.5 % increase, while volumes continued to grow, reaching nearly 265 million units (+~6.3 %), indicating sustained market expansion across Europe (EOG, 2022).

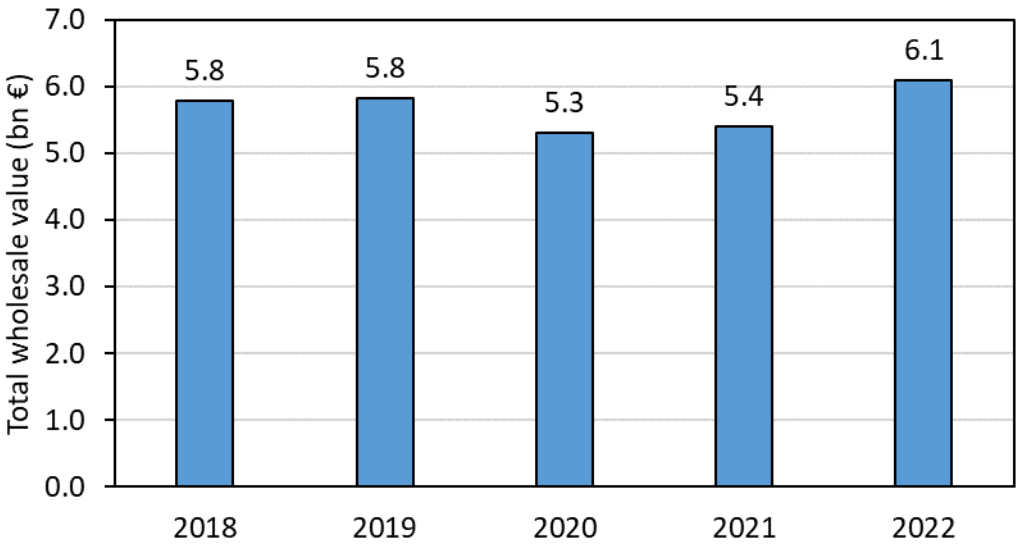

Figure 1: Summary of the European Outdoor Group (EOG) State of Trade wholesale market data for 2019–2022 (Data: EOG (2019, 2020, 2022))

The Austrian market experienced a slight "sideways movement" following the peaks of the pandemic years. For the 2022/2023 season (ending August 31, 2023), total sell-in sales to Austrian retailers amounted to €596 million, a decrease of 4%. Despite this slight decline, outdoor products remain a stable economic factor, accounting for 25% of total sales in the Austrian sports retail sector (VSSÖ, 2023).

Regional and Key Market Insights

Germany is the largest single market, holding a 21.2% value share of the total European Market in 2022 (Figure 2). France follows with 16.2%, and the UK/Ireland region holds 14.0%. Regional growth rates in 2022 were highest in Eastern Europe (+13.1%) and the DACH region (+12.0%), followed by Scandinavia (+11.6%) and Southern Europe (+11.4%) (EOG, 2022).

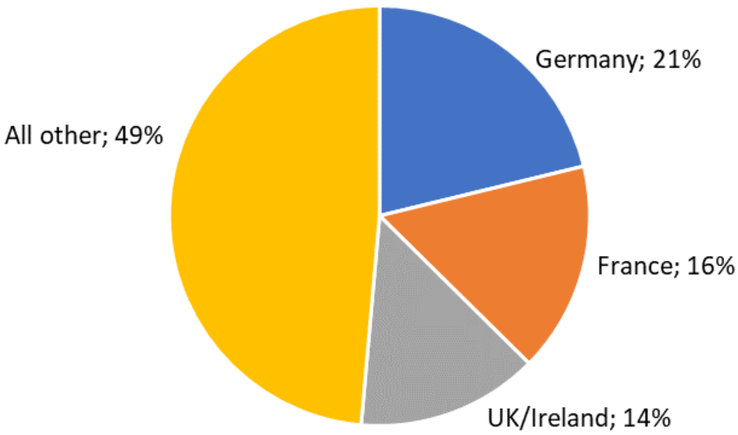

Figure 2: Key markets and their market share in 2022 (Data:EOG (2022))

Product Category Analysis

Across Europe, all major product categories recorded value growth in 2022 (Table 2). Apparel remained the largest segment representing an increase of 4% compared to the previous year. Footwear showed the strongest growth among the major categories, rising by 12%.

Table 2: Product category analysis – comparison of sell-in units 2021 and 2022 (Data: EOG (2022))

Product category	Units 2021	Units 2022	Change %
Apparel	129,188,505	134,699,950	4%
Footwear	37,238,822	42,126,594	12%
Climbing Equipment	7,637,927	7,717,322	1%
Backpacks & Luggage	22,524,427	23,603,760	5%
Tents	4,029,898	4,070,604	1%
Sleeping Bags & Mats	10,058,784	10,369,880	3%
Outdoor Accessories	38,549,590	42,362,187	9%
Total	249,227,953	264,950,297	

3.2 Types of products

The initial aim of the ASTER project was to evaluate the composition and quantities of waste produced by the outdoor industry. However, as discussed in Chapters 2 and 3, official waste statistics do not separately categorize data on waste from this specific sector. Most of their waste is disposed of as residual, bulky or textile waste (when separately collected).

To estimate the quantity and composition of the waste from outdoor products, an indirect approach based on the evaluation of sales figures for outdoor products was chosen. Data was researched at the EU level, and data for Austria was provided by the Association of Austrian sporting goods manufacturers and retailers (Verband der Sportartikelerzeuger und Sportartikelhändler Österreichs, VSSÖ). However, no specific data for the Alpine region overall is available.

Figure 3 presents EU sales data, showing that apparel is the most important product category in the outdoor products market, following footwear.

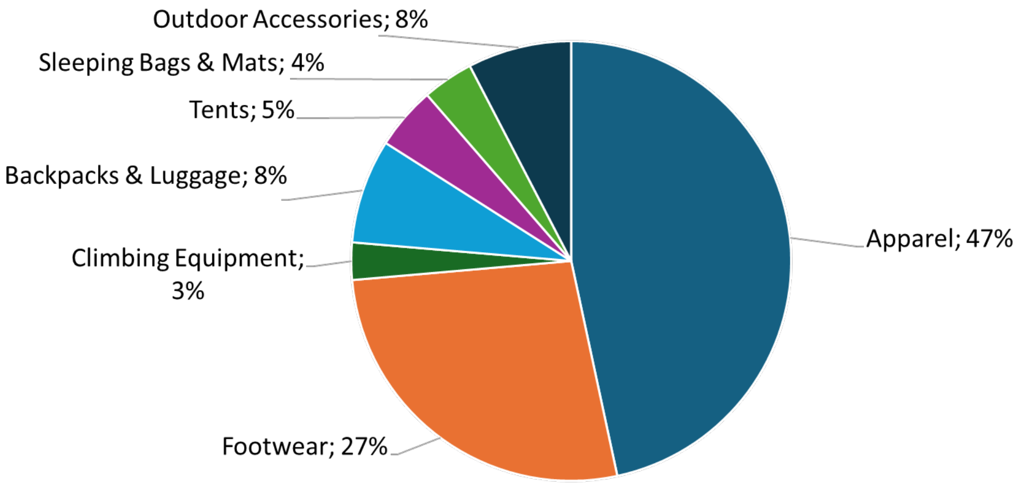

Figure 3: Share of each product group in total EU sales of 6.1 bn euros in 2022 (Data: EOG (2022))

Austrian sales figures show a similar distribution across product groups as the European Outdoor Group's figures for Europe. Clothing is also the most important product group in Austria (Figure 4).

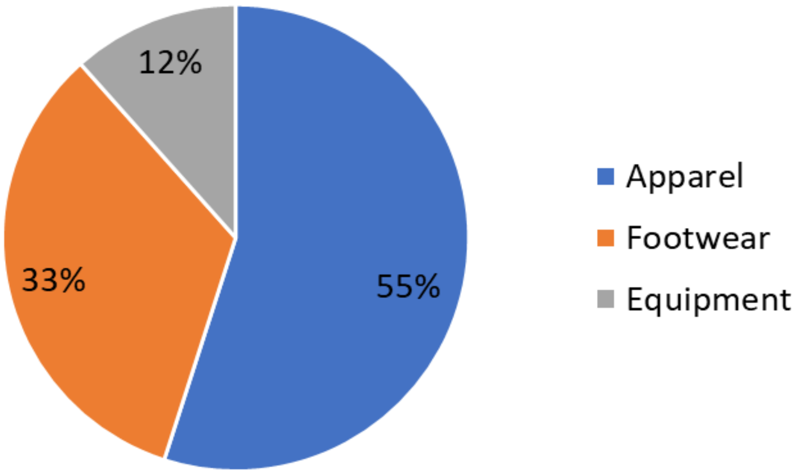

Figure 4: Sales of different outdoor products in Austria (2.7 million pieces sold) in 2023/24 (Data: VSSÖ (2024)

However, unlike the data available at the European level, the Austrian sales figures provide a more detailed insight into the individual product groups and the relative volumes of individual product types. A closer examination of the apparel product group reveals that shirts (27%), jackets (25%) and trousers (25%) are its most important products (Figure 5).

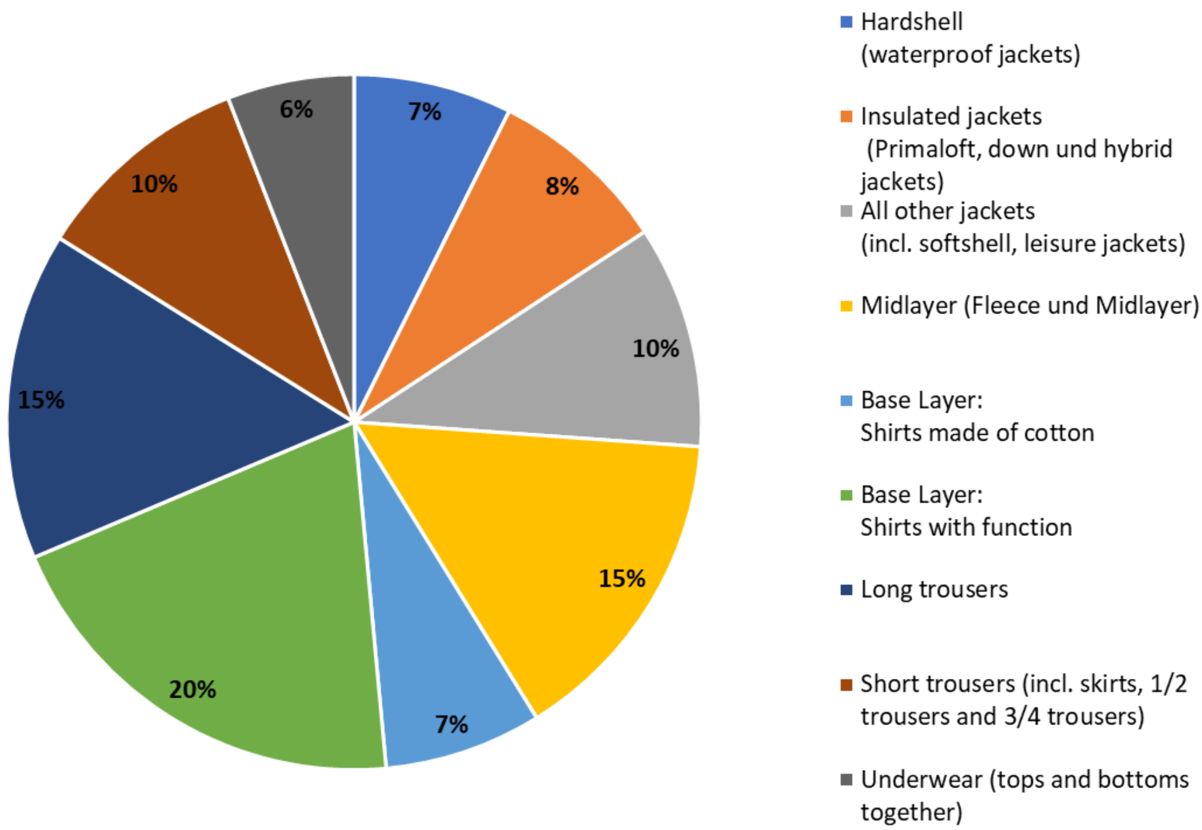

Figure 5: Sales of different types of outdoor apparel in Austria in 2023/24 (1.5 million pieces sold) (Data:VSSÖ (2024)).

Based on these sales figures it can be summarized that outdoor apparel is the most important product group, accounting for around 50% of sales. This is followed by footwear, accounting for around 30%, leaving an estimated 10–25% for other products such as backpacks, luggage, outdoor accessories, tents, sleeping bags, mats, and climbing equipment.

Within the outdoor apparel category, the most important products are shirts, jackets and trousers, each accounting for around 25%. The remaining 25% is divided between mid-layers and underwear. In a different breakdown, two-thirds of clothing is upper body clothing (jackets, mid-layers and shirts).

3.3 Overproduction, unsold textiles and pre-consumer waste

The previous chapters examined which outdoor products are sold and which could later be collected as post-consumer waste. Besides this type of waste, additional sources include waste generated during production, and manufactured products that are returned or remain unsold (see Table 3). However, no specific data are available for outdoor products in this context. In the textile industry overall, only limited information is available - for example, on the quantity of unsold textiles. It is estimated, that between 4% and 9% of all textile products placed on the European market are destroyed without being used. This equates to between 264,000 and 594,000 tonnes of textiles being destroyed each year (ETC-CE, 2024b).

Table 3: Glossary of products subject to product destruction (ETC-CE (2024b), adapted from Roberts et al. (2023))

Term		**Description**
Returned products		Products which have been sold but have been returned by the customer to the retailer under their right to return. These products may be fully functional or damaged.
Unsold	Overstock	Products that are produced but have never been sold. These come straight from the production line.
	Obsolete products	Products for which there is no longer any demand.
	Damaged products	Products that have been damaged in transit or storage.
	Recalled/defective products	Products taken off the market due to a defect or quality issues.

Pre-consumer textile waste refers to the waste generated during the manufacturing process of textiles before the product reaches the consumer. This includes scraps, excess fabric, off-cuts, and damaged materials produced at various stages such as spinning, weaving, cutting, and sewing (Haq & Alam, 2023). The textile and apparel industry in Vietnam - for example, the world's third-largest apparel exporter and second-largest footwear exporter - generates approximately 250,000 tonnes of pre-consumer textile waste each year (GiZ, 2025).

3.4 Material compositions of outdoor products

This chapter introduces the most important types of fibres and polymers found in outdoor textiles. The following table provides an overview of the most commonly used materials, their basic properties, areas of application and sustainability and environmental characteristics (Table 4).

Table 4: Key characteristics of fibre and polymer types commonly found in textile-based outdoor products (in alphabetic order)

Fibre / Polymer	Physical and Performance Properties	Common Applications in Outdoor Products	Sustainability and Environmental Aspects	Processing and Blends
Cellulose (cotton, flax, hemp, regenerated cellulosics such as viscose, lyocell)	Hydrophilic; moisture absorbing; breathable; moderate tensile strength; low elasticity; biodegradable	Apparel fabrics, linings, blended textiles	Renewable (plant-based); biodegradable; cotton associated with high water and land use; regenerated fibres require chemical processing; recycling via mechanical or dissolution-based routes	Natural fibres harvested and spun; regenerated fibres produced via dissolution and regeneration; frequently blended with polyester or elastane
Down (natural insulation)	Very low density; high loft; high warmth-to-weight ratio; highly compressible; insulation performance decreases when wet; biodegradable	Insulated jackets, sleeping bags, insulated trousers, gloves	Animal-derived; biodegradable; associated with animal welfare considerations; reuse and mechanical recycling possible	Cleaned, sterilised and sorted by cluster size; used as loose fill in quilted constructions; not melt-processable
Polyamides (Nylon 6, Nylon 66)	High tensile strength; high abrasion resistance; low moisture absorption; good elasticity; thermoplastic	Apparel fabrics, ropes, webbing, backpacks, tents	Fossil-based; durable; chemical recycling established for Nylon 6 (limited for Nylon 66); potential microfibre release	Produced by melt spinning; compatible with coatings and laminates; often blended with elastane or other fibres
Polyester (mainly polyethylene terephthalate, PET)	High strength; good dimensional stability; low moisture absorption; fast drying; UV resistant; thermoplastic	Apparel, fleece fabrics, fillings, ropes, webbing, laminates	Fossil-based (major share); recycled PET available (primarily bottle-derived); textile-to-textile recycling limited at commercial scale; potential microfibre release	Produced by melt spinning; commonly blended with cotton; suitable for thermo-mechanical recycling when a monomaterial
Polyolefins (polyethylene (PE), polypropylene (PP))	Low density; hydrophobic; chemical resistant; variable mechanical strength (grade-dependent); thermoplastic	Ropes, technical fabrics, laminates, foam components	Fossil-based; chemically stable; recycling often via thermo-chemical routes; separation required between PE and PP grades	Produced by melt or solvent processing; different grades (e.g., LDPE, HDPE, UHMWPE) not typically processed together; rarely used in fibre blends
Polyurethane (PU)	Properties range from flexible to rigid; elastic; abrasion resistant; water-resistant in coatings/films; used as foam, film or coating	Coatings, membranes, foams, footwear components	Fossil-based; chemically diverse; recycling feasible mainly for PU-rich streams (e.g., glycolysis); separation required in composite textiles	Produced via reaction of diisocyanates and polyols; applied as coatings, laminates or foams; frequently combined with other polymer types
Synthetic insulation (polyester-based)	Low density; thermal insulation via crimped microfibres; retains insulation performance under wet conditions; lower compressibility than down; thermoplastic	Insulated jackets, sleeping bags, insulated trousers, gloves	Fossil-based (primarily polyester); non-biodegradable; recycling limited due to composite constructions; potential microfibre release	Produced via melt spinning of fine polyester fibres; fibres crimped and formed into battings or loose fill; typically enclosed between fabric layers
Wool	Hygroscopic; thermally insulating; breathable; elastic; biodegradable; moderate abrasion resistance	Apparel (base layers, insulation layers), blended fabrics	Renewable (animal-based); biodegradable; mechanical recycling established at industrial scale; chemical recycling not feasible	Harvested, cleaned and spun; frequently blended with synthetic fibres to improve durability

Explanation of terminology used in relation to textiles

The following explanations are intended to introduce the terminology used in relation to textiles for outdoor activities. They are listed in alphabetical order. It is to be noted that these explanations are not meant to be technically accurate but are offered to aid understanding by the reader.

Coating

A polymer in liquid form (solution, emulsion, dispersion) is applied on fabric surfaces. Examples include silicones, polyurethane, polyvinyl chloride and polyacrylates.

Fabric

Two-dimensional sheet produced through the interlacement of fibres. There are three main types: woven, knit and nonwoven. For the first two, fibres are first twisted into yarns, which are then interlaced to form fabrics. For nonwovens (e.g., felt), fibres are directly interlaced, i.e., without first twisting them into yarns.

Fibre

For the textiles sector, fibres are defined as materials possessing long, thin physical forms of length-to-diameter ratio exceeding 1000:1, with diameters of between 6–80 μm (Sinclair, 2015). Their lengths vary, from about 30 mm (cotton) to about 80 mm (wool) up to about 1200 m (silk). Manufactured fibres can be made to any desired length. Fibres shorter than ca. 12 mm can typically not be used to produce yarns in industrial operations.

The bulk of textile fibre materials are polymers, i.e., made up of multiple repetitions of one or more fundamental molecular units, linked together into long chains. The fundamental molecular units (monomers) in most textile polymers are composed of the elements carbon (C), oxygen (O), and hydrogen (H). Some polymer types contain monomers with nitrogen (N) or other elements, in addition to C, H, O.

Natural fibres: Polymers that occur naturally as fibres in the environment (plants or animals), and only need to be harvested and cleaned before use. Examples include cotton (composed of the polymer cellulose) and wool (composed of the protein keratin).

Manufactured fibres: Polymers not found to occur naturally as fibres in the environment. Two sub-categories are defined.

- Synthetic: The polymer is first synthesized and then converted to fibres. Typical examples are nylon and polypropylene. The raw materials for synthesis may be derived from renewable or non-renewable resources.
- Regenerated: The polymer occurs naturally in the environment, and is extracted and converted to fibres. Typical examples are viscose and lyocell, where the polymer cellulose extracted from wood through pulping operations is converted to fibres.

Laminate

Polymeric film bonded to a fabric surface through application of adhesives or heat, combined with pressure.

Membrane

Thin, flexible polymeric films inserted between layers of fabric, typically to act as barriers against wind and/or liquid water. Whereas films are typically impermeable, membranes are designed to be semi-permeable or selectively permeable. Examples of materials used to make membranes include polytetrafluoroethylene (PTFE/ePTFE) (Gore-Tex™), polyurethane (PU) (e.g., Sympatex™), polyester (PES), polyethylene (PE/HDPE) and polypropylene (PP).

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Table 5 shows a list of the fibres/polymers most commonly found in textiles related to outdoor activities, together with examples of their typical applications.

Table 5: An alphabetized list of the fibre/polymer types most frequently reported as components in textile-related products for outdoor activities, as collected from academic literature and internet searches of product descriptions.

Fibre/Polymer	**Apparel**	**Footwear**	**Climbing equipment**	**Backpacks**	**Tents**	**Sleep systems**
Cellulose (including cotton)	Fabric	Fabric (upper, sole)	—*	Fabric	Fabric	Fabric
Down or feathers	Filling**					Filling
Polyamides (mainly nylon 6 or nylon 66)	Fabric	Fabric	Ropes Webbing	Fabric	Fabric	Fabric
Polyester (mainly polyethylene terephthalate, PET)	Fabric Filling	Fabric	Ropes Webbing	Fabric	Fabric Laminates	Fabric Filling
Polyolefins (Polyethylene, Polypropylene)	Fabric Laminates	Sole components Fabric	Ropes	Fabric	Fabric	Foam
Polyurethane	Coating Fabric Films	Coating Leather Rubber	Coating	—	Not typical	Foam
Wool	Fabric	Fabric	—	Fabric	Fabric	Fabric

* The symbol “—” indicates that mentions of the fibre/polymer were not found in the specific products.

** Fillings are typically introduced as insulation to improve thermal comfort.

3.5 Recyclability of outdoor textiles

The circular economy strategy for the management of textile waste prioritizes maximum use of undamaged goods, repair of damaged goods, and repurposing of unrepairable goods, above recycling (EU, 2025; FMCEEMIT, 2024). Therefore, the available options for recycling described below, adapted from the report of Duhoux et al. (2021), are to be understood as being performed on non-reusable goods that cannot be repaired or repurposed.

3.5.1 Categories of recycling operations

It is to be noted that all non-textile components such as buttons and zippers need to be removed before any recycling operations.

<u>Mechanical recycling</u>

Textiles are deconstructed through mechanical actions such as cutting, tearing, shredding, unravelling or milling. The fibres recovered may directly be used in the construction of new textiles – woven, knit or nonwovens.

- \+ Technologically established and commercial-scale operations exist e.g., for recycling of wool.
- \+ Material agnostic, i.e., all fibre types can be processed in principle.
- \+ Presence of colorants, finishing agents need not influence fibre recovery and reuse.
- \+ If waste textiles are colour sorted, the textiles produced from recovered fibres do not need to be dyed, which reduces the material and energy input into the recycling.
- – The presence of elastomeric fibres (e.g., spandex, elastane), coatings or laminations, can interfere with fibre recovery
- – Fibre lengths tend to be reduced during deconstruction, which affects yield of reusable fibres as well as quality of the produced textiles.

<u>Thermomechanical recycling</u>

This option is available only for thermoplastic polymers such as polyamides (e.g., nylons) or polyester (e.g., polyethylene terephthalate). Fibres recovered from waste textiles are heated to beyond their melting point and processed into fibres.

- \+ Technology established for recycling of certain waste streams, specifically conversion of waste drink bottles to fibres.
- – Presence of colorants and finishing agents may interfere with melt processability.
- – Mixtures of different polymer types often cannot be processed together.

<u>Thermochemical recycling</u>

The waste is subjected to high temperatures under low oxygen levels (gasification) or no oxygen (pyrolysis) to generate gas and oil. These products can be used for heat and power generation or converted to chemical intermediates usable as feedstock for the chemical industry.

- \+ Technology is established and commercial-scale operations exist for heat/power generation.
- \+ Waste composed of a diverse mixture of fibre types can be processed, purity requirements of the waste are not very high, the ageing of textiles has little impact, and waste from other sectors can also be mixed in.
- – Extensive fractionation and purification steps may be required for recovery of chemical intermediates.
- – Potential for emission of greenhouse gases.

Chemical recycling

Also termed “monomer recycling”, it involves treatments of fibres to break down the polymer structures to their constituent monomers under combined action of (as required) heat, pressure, and cleaving agents. In principle, the recovered monomers can be repolymerized back to the original polymer and then fibres can be produced anew.

+ Technology is established and commercial-scale operation is established for selected polymer types e.g., nylon 6, from fishing nets.
+ Relatively insensitive to factors that interfere in other recycling strategies (polymer ageing, presence of colorants).
– Repolymerization requires high purity of the recovered monomers, and thus extensive purification processes may be needed.
– The recycling of polymers with more than one monomer (e.g., nylon 66) has so far been found difficult to establish, due to the need for purification steps.

Physicochemical recycling

It involves the dissolution of polymer in a suitable solvent (ideally without any degradation), which is then recovered by reprecipitation in non-solvent, and processed into fibres.

+ Technology is available and has been demonstrated for selected polymer types in commercial-scale operations e.g., for recovery of cellulose from post-industrial waste.
– Fibre degradation due to ageing, the presence of colorants, may limit solubility of the polymer and thus reduce recovery.
– Recovery and reuse of the solvent may be important for economic and environmental sustainability, which may require extensive purification of the solvent after use.

A large proportion of textile articles are made not of a single fibre type but of more than one fibre type in intimate mixtures, such as:

- more than more than one fibre type mixed together in yarns e.g., polyacrylonitrile, wool and elastane,
- coating or lamination of one polymer type on a fabric made of another e.g., polyurethane on nylon
- interspersing one polymer type as membrane or fibrous filling between layers of fabrics of other polymer types e.g., polyester membranes or fibres in between layers of polyethylene fabrics.

3.5.2 Separation processes

The recycling strategies described above cannot be performed on an indiscriminate mixture of multiple polymer types. Thus, the collected textile waste needs to be sorted according to polymer type and, often, the polymer of interest needs to be separated from other polymer types present in the waste.

Instrumental technologies for the automated sorting of textile waste have been demonstrated on a commercial scale (see for example European Commission (2026)). The following strategies are described in the academic literature for separation and isolation of individual polymers, but information on their commercial-scale demonstration or implementation is not available.

Note that the removal of any non-textile components (e.g., buttons, zippers) is a necessary first step before any separation or recycling process and is thus not elaborated on in this section. The following information relates only to separation of textile components made of diverse polymer types.

Physical separation

Differences in physical properties (e.g., density, surface energy, polarizability) may be used as the basis for separating different fibre types, The options include froth flotation (Kökkılıç et al., 2022), by exploiting differences in wetting behaviour (Khoo et al., 2024), electrostatic or tribo-electrostatic separation (Achouri et al., 2025; Istrefi & Hutter, 2023), and density separation (Hajidela, 2025).

The efficacy of these methods depends on the particle size of shredded fibres, relative humidity and moisture content in fibres. Further, the waste may need to be subjected to more than one cycle of operation to separate complex mixtures. The presence of adhesives, glues and coatings may detract from the separation, and thus a separate step may be necessary to remove such components by treatments with solvents, detergents etc.

Chemical / Physicochemical / Biotechnological Separation

Both chemical and biotechnological modes of separating mixtures of diverse polymer types rely on selective depolymerization of one polymer type. As example, mixtures of cellulose with polyester may be separated through selective depolymerization of the cellulose or of the polyester through chemical or biotechnological means (Abid et al., 2023; Gritsch et al., 2023; Leenders et al., 2025; Villar et al., 2024). The nondegraded polymer (i.e., fibres) may be reutilized directly or subjected to a separate recycling step (e.g., thermomechanical or physicochemical) and the reaction products of the depolymerized fibre, in principle, may be recovered for repolymerization or for use as raw material in other processes; or discarded as waste.

The physicochemical mode of separation focuses on selective dissolution of individual polymer (i.e., fibre) types without causing significant damage to the targeted fibre/polymer or any of the other fibre/polymer types present in the textile. Examples include the use of solvents (dimethylformamide, dimethylsulfoxide, combinations of 2-methyltetrahydrofuran with dimethylsulfoxide) for selective removal of elastane/spandex through dissolution (Vonbrül et al., 2024); glycols, aliphatic alcohols, cyclic carbonates and carboxylic acids as solvents for nylons (Tonsi et al., 2025); and ionic liquid-based solvents for cellulosics (Jungbluth & Beuermann, 2025). Dissolution processes are typically followed by reprecipitation to recover the dissolved polymer for reuse.

3.5.3 Separation and recycling of fibres/polymers most common in outdoor textiles

Table 4 lists the most frequently reported types of fibre and polymer found in textiles for outdoor products. In the following section, potential methods for separating and recycling them are described. It should be noted that most descriptions are derived from academic literature, and their industrial/commercial feasibility remains unclear. There exist only limited examples of fibre-to-fibre recycling being performed on a commercial-scale.

Cellulose

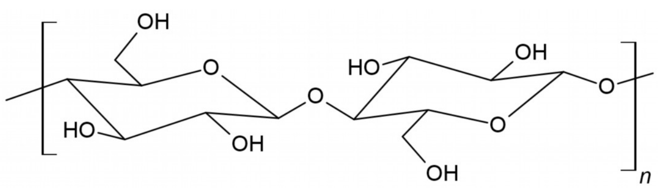

Figure 6: Chemical structure of cellulose

Cellulose is the polymer that makes up the native fibre cotton and is the major constituent in other native fibres such as flax and hemp etc. Wood pulp, composed of cellulose, may be converted to fibre or film forms, and the materials so produced are termed regenerated cellulosics. Examples include viscose and lyocell.

No chemical mode of recycling exists for cellulose, as it has not been found possible yet to synthesize the polymer to any acceptable degree of chain lengths. Thus, apart from mechanical processes, the primary modes of recycling involve dissolution and regeneration of the polymer through any of the technologies employed for producing regenerated fibres (viscose, lyocell, ionic liquids). Other solvents are also under investigation such as “deep eutectic solvents”. An emerging trend is to employ the biotechnological approach of cultivating cellulose producing bacteria on waste from textile and other sectors, and to harvest the cellulose for use in the manufacture of regenerated fibres (Jungbluth & Beuermann, 2025).

Down or feathers

Down and feathers from ducks and geese are employed as filling material to improve thermal insulation. There exist industrial processes for their recovery and recycling – predominantly through mechanical means. The quantity of recycled down/feathers in 2024 was in the region of 6000 tonnes, which constitutes about 1% of the total production (Textile Exchange, 2025). Synthetic polymers may also be used in the manufacturing insulating fillers, with polyethylene terephthalate (PET) being a typical example. The recyclability of PET is described below.

Polyamides (nylons)

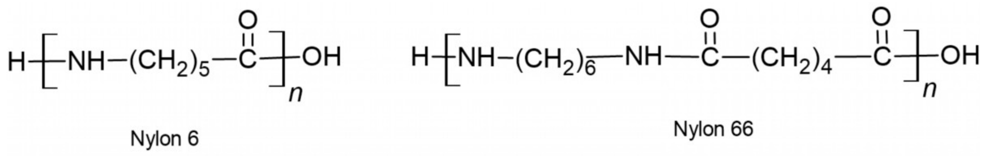

Figure 7: Chemical structures of nylon 6 and nylon 66

Only aliphatic polyamides (nylons) are discussed in this section as they are found in greater proportions than aromatic polyamides in textiles related to outdoor activities.

Although a range of aliphatic polyamides are available, two varieties predominate: nylon 6 and nylon 66 – shown in Figure 7. In principle, there exist options for hydrolytic depolymerization of both varieties: with water (under acidic, neutral or alkaline conditions), polyols or ammonia; but in practice, commercial scale operations exist only for recovery of nylon 6 waste through depolymerization (Duhoux et al., 2021; Textile Exchange, 2025). The recovery of nylon 66 through depolymerization is hampered by the challenges in separation and purification of the constituent monomers (adipic aid and hexamethylene diamine) to the high degrees required for reuse. The recovery of nylon 6 waste is also limited to monomaterials, such as used fishing nets. About 0.2 million tonnes of recycled polyamide is reported to have been produced in 2024, constituting 2.3% of total polyamide fibre production (Textile Exchange, 2025).

The solvents available for separation and isolation of nylons from textile waste through selective dissolution include: fluorinated solvents, organic and inorganic acids, polyols, aliphatic and aromatic alcohols, polar organic solvents and mixtures of aliphatic alcohols and salts (Tonsi et al., 2025); but commercial scale operations for separation and isolation of aliphatic nylons are not known at the present time.

Polyester

The polymer type commonly found is poly(ethylene terephthalate) or PET. Biobased polyesters such as poly(lactic acid) and poly(hydroxy alkanoates) constitute very minor proportions (estimated at 0.01% of total polyester production); and although recycled polyester accounts for about 12% of total polyester production, it stems primarily (about 98%) from recycling of bottles (Textile Exchange, 2025). Therefore, the information presented here will focus on PET and on recycling avenues for fibres.

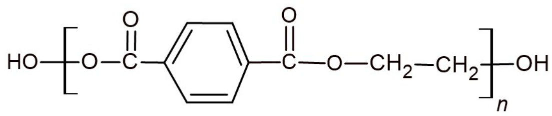

Figure 8: The chemical structure of poly(ethylene terephthalate), PET

The processes for chemical recycling of PET, chemical structure shown in Figure 8, typically focus on depolymerization through cleavage of ester linkages (O-C=O) to yield the constituent monomers or their derivatives (Zhu et al., 2025). The hydrolytic agents range from acids, alkalis, neat water, alcohols, polyols, ammonia and organic amines. The process temperatures are typically high (up to 250°C) and are performed under greater than ambient pressures. The hydrolysis products may be used for synthesis of PET again, or as raw material in other processes. Biotechnological processes that use enzymes for hydrolysis of the polymer are also under investigation, as they offer the advantage that process conditions (temperature, pressure) are milder than for chemical processes.

Chemical depolymerization processes cannot typically be employed for separation of polyester from other fibre/polymer types in blends since the high temperatures and pressures damage other fibre/polymer types. An exception is alkaline hydrolysis to separate PET from cotton or other cellulosics, since the process conditions do not cause damage to cellulose. Selective dissolution as a means of separation is possible, but the solvents employed for such purpose (e.g., hexafluoroisopropanol, dimethyl sulfoxide) present challenges with respect to worker and environment safety.

At the present time, polyester recycling is mainly through thermo-mechanical recycling of monomaterials, and the waste material processed is typically drink bottles (Textile Exchange, 2025). In other words, textile fibre-to-fibre recycling of polyester is not known to occur on a commercial scale to any significant extent as yet.

Polyolefins (polyethylene, polypropylene)

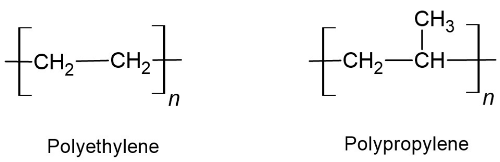

Figure 9: The structures of polyolefins: polyethylene (PE) and polypropylene (PP)

The polyolefins predominantly found in outdoor sports equipment are polyethylene (PE) and polypropylene (PP). Three grades of PE are employed: low density (LDPE), high density (HDPE), and ultra-high molecular weight (UHMWPE), which exhibit the same chemical structure but differ in degree of chain branching and polymer chain lengths. For that reason, the three grades of PE cannot typically be processed together in thermomechanical operations. Among polypropylenes, the polymers used in different applications (e.g., films vs. fibres) typically differ only in polymer chain lengths, but that may also prevent PP from different product categories from being processed together. Mixtures of PP and PE also cannot typically be processed together due to differences in their chemical structures as well as physical properties (e.g., melting point). Therefore, the routes for recycling of polyolefins typically involve pyrolysis, gasification, or other degradative reactions to obtain fuel, monomers for repolymerization, or chemicals for other processes and products (Zou et al., 2023).

Polyurethane

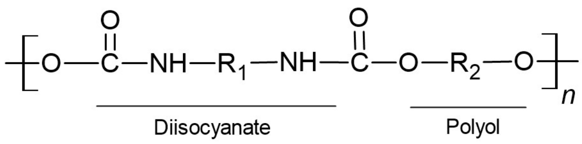

Figure 10: General structure of a polyurethane.

Polyurethanes comprise a diverse set of polymers with the common feature of diisocyanate and polyol monomers connected by urethane linkages. By changing the chemical structure of either monomer (i.e., of R1 and R2 in Figure 10), and addition of other substances (e.g., chain extenders, crosslinkers), the properties of the polymer can be modulated over a broad range in terms of mechanical performance (from highly flexible to rigid), interactions with water (hydrophilic to hydrophobic), resistance to chemical agents, electric and thermal insulation behaviour, and light stability (Souza et al., 2021). This diversity in range of properties allows for use of polyurethane in form of fibres, films, foams and coatings.

The broad diversity in chemical structures and physical forms of polyurethanes used in goods for outdoor sports and leisure activities makes it difficult to encapsulate all modes of recycling. But in broad terms, the strategies to recycle polyurethane include mechanical, thermomechanical and chemical processes. The chemical processes target hydrolysis of ester, urea or urethane linkages in acidic or alkaline media, with glycols, ammonia, or phosphoric acid; with glycolysis being favoured in industrial scale operations (Rossignolo et al., 2024; Simón et al., 2018). However, it should be noted that such options are feasible for polyurethane-only or polyurethane-rich products. For products containing polyurethane intermingled with other polymer types, such as in apparel, separation processes become very critical to the efficacy of recycling. The solvents typically investigated for separation through selective dissolution or depolymerization involve solvents such as dimethyl sulfoxide and dimethyl acetamide, but these efforts have been limited so far to laboratory-scale, and no industrial-scale operations exist at the present time.

Wool

Wool is typically found in apparel among outdoor products, and mechanical recycling is most commonly practiced for valorisation of wool from waste textiles, with major commercial-scale operators found in Italy, China, and India (McNeeley & Liu, 2025). Together, they account for about 80 thousand tonnes (or 7%) of the annual consumption. As a protein fibre, other recycling options, such as: depolymerization and repolymerization, or dissolution and regeneration, are not feasible. Protein properties emanate from the combination of amino acid sequences, chain folding, 3D structures of folded units and assembly of multiple units; and reproducing them through chemical processes is not possible.

Other materials and polymer types

Materials such as leather, rubber and other polymer types such as ethylene vinyl acetate, aromatic polyamides, polyacrylonitrile, polytetrafluoroethylene and polyvinyl fluoride are also found, to differing extents, in outdoor apparel and gear. In a majority of cases, industrial scale recycling is performed through mechanical operations (e.g., shredding, grinding) where the end products are used in the manufacture of other items. Chemical recycling avenues are being explored at the laboratory scale, but no industrial scale operations are available at the present time.

3.6 Concluding remarks

The sales data show that outdoor apparel is the company's core product category, generating about 50% of total revenue. Footwear follows at roughly 30%, while the remaining 10–25% comes from other items such as backpacks, luggage, accessories, tents, sleeping bags, mats, and climbing equipment.

Within outdoor apparel, shirts, jackets, and trousers are the leading products, each contributing around 25% of category sales. The remaining 25% is split between mid-layers and underwear. Overall, approximately two-thirds of clothing sales come from upper-body garments, including jackets, mid-layers, and shirts.

Outdoor textiles are characterized by high material diversity, functional layering and performance-oriented design. Across product categories such as apparel, backpacks, tents, ropes and insulation systems, a limited number of fibre and polymer types dominate. The most relevant materials are **polyester (mainly PET)** and **polyamides (Nylon 6 and Nylon 66)** in outer fabrics and load-bearing components; **cellulosic fibres** (cotton and regenerated cellulose) and **wool** in apparel; **polyolefins (PE, PP)** in ropes and technical components; and **polyurethane (PU)** in coatings, membranes and foams. Insulation systems are based either on **down** or on **polyester-based synthetic fillings**.

From a circular economy perspective, these materials differ substantially in their recyclability and current level of industrial implementation.

Polyester (PET) is the most widely used synthetic fibre globally and is therefore highly relevant for outdoor textiles. Thermo-mechanical recycling of PET is technologically established and operates at commercial scale; however, the dominant feedstock remains post-consumer beverage bottles rather than textile waste. Textile-to-textile recycling of PET fibres is still limited, primarily due to contamination, blends (e.g., polycotton), colour variability and the presence of coatings or elastomeric fibres. Chemical depolymerization routes exist and are technically feasible, but large-scale implementation for mixed textile waste remains limited.

Polyamides, particularly Nylon 6, show comparatively strong potential for circularity. Chemical depolymerization of Nylon 6 is commercially established for relatively pure waste streams such as fishing nets. In contrast, Nylon 66 recycling at monomer level remains more complex due to purification challenges. In blended apparel fabrics or coated constructions, separation remains the primary technical barrier.

Cellulosic fibres (cotton and regenerated cellulose) are renewable and biodegradable. Mechanical recycling is practiced but typically leads to fibre shortening and downcycling. Dissolution-based regeneration processes offer potential for higher-value recycling, particularly for cotton-rich streams, yet they require effective separation from synthetics and removal of finishes and contaminants.

Wool is recycled at industrial scale via mechanical processes, particularly in established regional clusters. However, recycling is largely limited to fibre reprocessing and is sensitive to fibre degradation and contamination.

Polyolefins (PE, PP) and **polyurethane** present more significant challenges. Although thermoplastic in nature, polyolefins used in different grades are often incompatible in melt processing, and mixed-material constructions complicate recovery. Recycling pathways frequently involve thermo-chemical routes such as pyrolysis. Polyurethane, due to its chemical diversity and frequent use in coatings, laminates and foams, is difficult to separate from textile substrates; recycling is feasible mainly for PU-rich waste streams.

Insulation materials illustrate the contrast between natural and synthetic systems. Down can be cleaned and mechanically reused, supporting material longevity strategies. Synthetic polyester-based insulation is technically recyclable in principle but is typically embedded in multi-layer constructions that hinder separation.

Overall, the main technical challenge in outdoor textiles is not the absence of recycling technologies at polymer level, but the **complexity of product design**: fibre blends, multilayer laminates, coatings, membranes and functional finishes impede sorting and material recovery. Established recycling pathways today include mechanical wool recycling, thermo-mechanical PET recycling (primarily bottle-based), and chemical recycling of Nylon 6 in selected streams. Automated sorting technologies are emerging, yet fibre-level separation of complex blends remains limited at scale.

To improve circularity, several developments are necessary:

(1) **Design for recycling**, including reduction of material diversity, avoidance of incompatible blends, and easier separation of coatings and components;

(2) **Expansion of textile-to-textile recycling infrastructure**, particularly for polyester and polyamide;

(3) **Scaling of selective dissolution and depolymerization technologies** for blended fabrics;

(4) **Improved collection and sorting systems**, supported by fibre identification technologies;

(5) Greater integration of durability, repairability and reuse strategies in product design.

Advancing sustainability in the outdoor sector will therefore require coordinated progress in material selection, product design, separation technologies and industrial-scale fibre-to-fibre recycling. While individual polymer recycling technologies are technically available, achieving meaningful circularity depends on aligning material performance requirements with end-of-life recoverability from the outset of product development.

4 Management of waste from outdoor products in the alpine region

The management of waste derived from outdoor products specifically - apparel, footwear, and equipment - presents a complex challenge within the circular economy framework of the Alpine Space. This region, comprising Austria, France, Germany, Italy, Slovenia, and Switzerland, represents a significant market for outdoor goods due to its geographical orientation towards mountain sports and tourism. However, the end-of-life (EoL) stage of these products is currently fragmented across various municipal and private waste management systems.

It is hard to find outdoor products as a distinct category of waste stream in national statistics. Instead, the most relevant outdoor products, such as apparel and footwear are generally classified under textiles, while hard equipment (e.g., skis, helmets, tents), depending on size and material composition, often falls into the categories of bulky waste or mixed municipal waste. The following analysis of waste management for outdoor products therefore relies mainly on data available for textile waste management.

4.1 Waste streams containing waste from outdoor products

The generation of waste from outdoor activities enters the waste management system through three primary channels: the mixed municipal waste stream (residual waste), the bulky waste stream, and the separately collected fraction of used textiles and clothing. The destination of an item is largely determined by its condition, size, and the consumer's intent to discard or donate.

4.1.1 Textile waste and other waste from outdoor products collected in residual waste, bulky waste and separately collected used textiles/clothing

Waste from outdoor products is heterogeneous. It includes used outdoor clothing and footwear (classified as textiles) but also outdoor equipment, such as backpacks, tents, sleeping bags, protective gear, poles, skis, etc. Some of this equipment is made of textiles while others are rigid equipment containing plastics, metals, etc.

In general, textile waste is defined to include clothing and footwear, accessories (such as belts, scarves, headgear), household textile waste (e.g., bed linen, towels, mattresses), and also technical textile waste, e.g., geotextiles, protective textiles and tents.

This definition fits outdoor apparel (e.g., waterproof jackets and hiking trousers), footwear, and parts of outdoor equipment such as tents, sleeping bags and protective textile gear. However, not all components of the outdoor waste stream are textile waste.

Waste from outdoor products is therefore collected via the following streams:

1. **"Unmixed" Textile Waste (Separate Collection):** This stream consists primarily of used clothing and footwear collected via street containers, recycling centres, or in-store take-back schemes. This is the primary route for items that the consumer believes are still wearable or reusable.
2. **Mixed Municipal Waste (Residual Waste):** This stream contains varying proportions of textiles, plastics and other materials. Dirty, worn-out, or destroyed clothing, as well as non-recyclable products, are directed to this stream.
3. **Bulky Waste:** Larger items that do not fit in regular bins, such as mattresses, large camping furniture, and specific sports equipment (e.g., skis, poles), are collected as bulky waste.

4.1.2 Estimation of textile waste quantities in Alpine countries

Estimating the specific amount of waste originating from outdoor products is difficult. Waste from outdoor products is mixed with other waste categories such as general textiles or sports equipment, and there are no specific waste codes. Therefore, this report uses estimations of general textile waste as the baseline to understand the scale of the issue in the Alpine region.

European Overview: At the EU level, it is estimated that around 6.95 million tonnes of textile waste were generated in 2020, equating to approximately 16 kg per person. Of this, only 4.4 kg per person were separately collected, meaning the majority (11.6 kg per person) was disposed of in mixed household waste to be incinerated or landfilled (ETC-CE, 2024a).

Country-Specific Estimates in the Alpine Region

Based on the report cited above (ETC-CE, 2024a), and supplemented with data from Switzerland (BAFU, 2021, 2023), the situation in the Alpine region is illustrated in the following graphic (Figure 11).

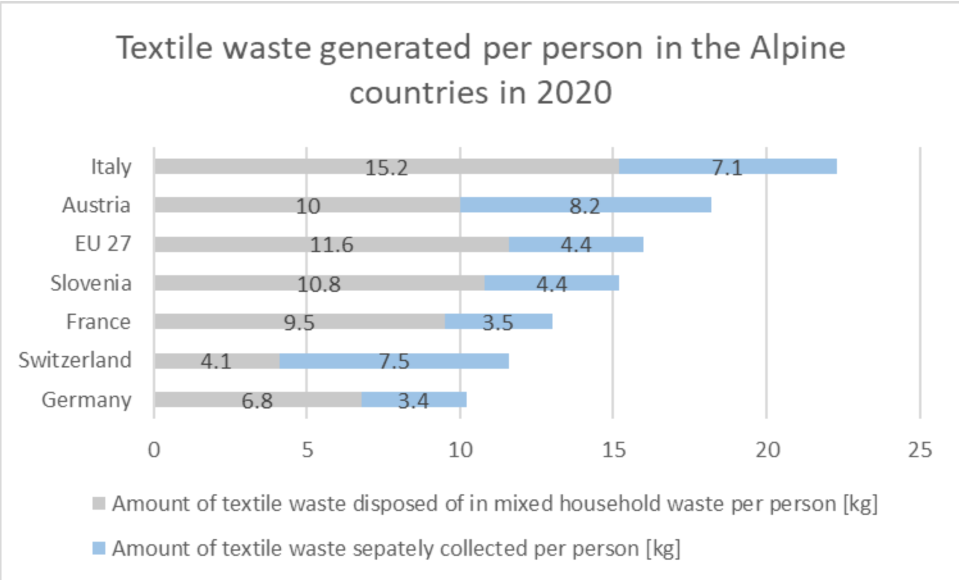

Figure 11: Textile waste generated per person in the Alpine countries in 2020 (BAFU, 2021, 2023; ETC-CE, 2024a)

Taking into account the population of the countries (Eurostat, 2026), the following amounts of textile waste can be estimated (Figure 12).

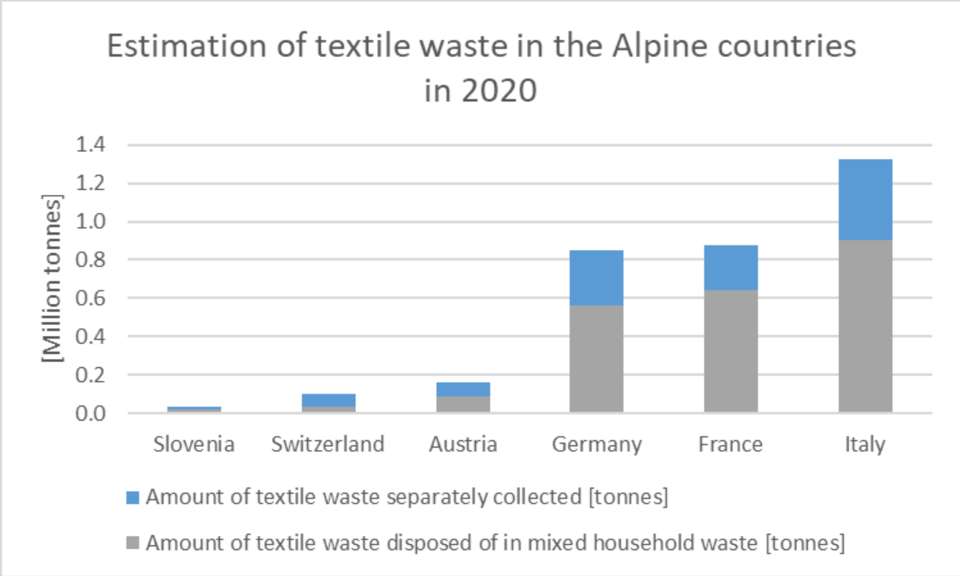

Figure 12: Estimation of textile waste in the Alpine countries in 2020 (BAFU, 2021, 2023; ETC-CE, 2024a; Eurostat, 2026)

Based on these figures, it can be estimated that a combined total of about 3.35 million tonnes of textile waste were generated across the respective countries in 2020. Of this, approximately one third was collected separately, while the remaining two thirds ended up in mixed waste streams. Using the figure of approximately 16 kg of textile waste generated per person at EU level in 2020 (ETC-CE, 2024a), and the Alpine Space Programme's figure of over 80 million inhabitants living in the Alpine region, it can be estimated that around **1.28 million tonnes of textile waste** were generated **in the Alpine region**.

The following figures were collected by the ASTER project partners using the questionnaire (see Chapter 2, 'Methods'). Due to the use of different data sources, and in some cases the need to make estimates due to a lack of data availability, the figures do not always correspond to those presented above. This once again highlights the difficulty of collecting consistent data on this topic.

- **Austria:** In 2023, textile waste amounted to approximately 213,000 tonnes. Notably, 75% of this was found in mixed waste streams (residual and bulky), leaving only 25% (approx. 47,000 tonnes) collected separately as "unmixed" used textiles (Environment Agency Austria, 2025)
- **France:** France has a quite robust data set due to its Extended Producer Responsibility (EPR) schemes. In 2023, approximately 270,000 tonnes of textile waste were collected separately. However, the total textile waste generation is estimated at 1.7 million tonnes annually, meaning the vast majority still leaks into other streams. (Ageneau et al., 2023; Refashion, 2024)
- **Germany:** Germany collects between 1 and 1.2 million tonnes of used clothing and home textiles separately per year. However, residual waste analysis reveals that an additional 373,500 to 514,600 tonnes of textile waste end up in household bins annually. (Naji et al., 2023)
- **Italy:** Data from the Italian Institute for Environmental Protection and Research ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) indicates that over 160,000 tonnes of municipal textile waste were separately collected in 2022, representing about 2.7 kg per capita. The Northern macro-region of Italy collects the largest quantities (80,000 tonnes), which is relevant for the Alpine Space cooperation area. However, separate collection was only active in 76% of municipalities as of 2022, indicating growth potential. (Squitieri et al., 2024)
- **Slovenia:** In 2023, separately collected textile waste amounted to roughly 4,081 tonnes. This is a small fraction compared to the estimated 17,000 to 26,000 tonnes of textile waste generated annually, suggesting that the majority ends up in mixed municipal waste. (Statistical Office of the Republic of Slovenia, 2024)

4.2 Current collection system for relevant waste streams

The efficiency of recovering outdoor products depends heavily on the infrastructure for collection. The Alpine countries utilize a mix of municipal collection systems for refuse, and private or charitable systems for collection of reusable textiles.

4.2.1 Municipal collection of residual and bulky waste

The collection of residual and bulky waste is predominantly a municipal responsibility, carried out by public waste disposal companies or contracted private firms.

Residual Waste: In all Alpine countries, residual waste is collected directly from households (door-to-door). Based on ETC-CE (2024a) and supplemented with data from Switzerland (BAFU, 2023) the share of textiles and shoes in mixed municipal waste fraction in the Alpine region can be illustrated as follows (Figure 13):

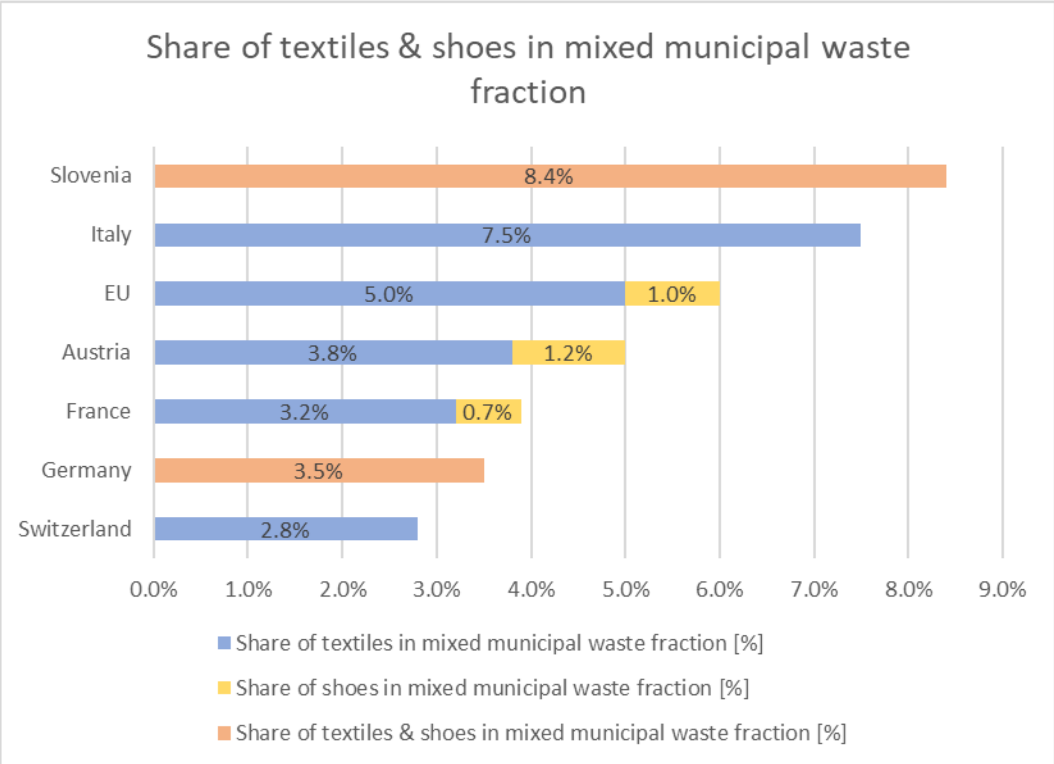

Figure 13: Share of textiles & shoes in mixed municipal waste fraction (BAFU, 2021, 2023; ETC-CE, 2024a; Eurostat, 2026)

The figures for EU countries ETC-CE (2024a) are based on waste composition analyses (WCAs) carried out by individual countries. Some countries reported the shares of textiles and shoes separately, while others indicated that their figures included both. Please note that the WCAs were not carried out using a standardised methodology. Therefore, these figures should be treated with caution and are only estimates.

The figures show that between 3% and 8% of textile waste (a total of approximately 2.3 million tonnes) still ends up in residual waste in countries belonging to the Alpine region. This means that this textile waste is lost to material recycling. Further efforts must be made in future to enable the separate collection of non-reusable textile waste for later recycling. At present, non-reusable textiles are not collected separately.

Bulky Waste: Bulky waste refers to large items that cannot be collected as part of the regular door-to-door collection services directly from households. Therefore, municipalities often provide drop-off locations or arrange for these items to be collected on specific days. Examples of bulky waste include furniture, mattresses, large appliances and carpets. Larger components of outdoor equipment, such as skis and tents, also fall into this category. However, it is difficult to determine how much outdoor equipment ends up in this waste stream, as data on the composition of bulky waste is rarely available. In Austria, for example, it is estimated that almost 20% of the approximately 300,000 tonnes of bulky waste collected in 2023 was textile waste, including mattresses (6.4%), carpets (6.2%) and recyclable textiles (6.2%) (Environment Agency Austria, 2025).

The critical issue with these mixed waste streams is that, once outdoor products enter residual or bulky waste, they are generally considered contaminated or too damaged for high-value recovery and are destined for energy recovery (incineration) or landfill.

4.2.2 Separate collection of used textiles/clothing

Separate collection is essential for the reuse and recycling of used textiles. According to the Waste Framework Directive, separate textile collection has been mandatory across the EU since 1 January 2025. Currently, this is mostly carried out via municipal recycling centres and private containers, but only reusable clothing should be placed in these. Until separate collection systems are in place to enable these materials to be recycled, tattered or heavily soiled textiles should be disposed of in residual waste bins.

In the Alpine region, **Bring-Banks and containers** are the primary system for collecting reusable textiles, utilising street containers. **Recycling centres and in-store take-back schemes** play a secondary role. The following paragraphs present some country-specific information:

- **Austria:** Collection is carried out by charitable organizations and private companies via containers at publicly accessible locations or waste collection centres. (Environment Agency Austria, 2023)
- **France:** The collection system is structured under the Refashion eco-organization (Extended Producer Responsibility (EPR)). There are approximately 44,000 collection points (terminals, recycling centres, charities) nationwide. (Refashion, 2024)
- **Germany:** The majority (75.6%) of separately collected textiles are gathered via used clothing containers managed by commercial and non-profit collectors. (Naji et al., 2023)
- **Italy:** The collection occurs through roadside containers, though efficiency varies by region, with the North performing best. (Squitieri et al., 2024)
- **Slovenia:** Street containers are managed by organizations like Humana, Caritas, and municipal companies.
- **Switzerland:** Around half of all used textiles are collected by TEXAID, a third by Tell-Tex, and the rest by smaller organisations such as Caritas, Textura and the Swiss Red Cross. Used textiles from households are now almost exclusively collected in containers (over 99%). Occasional street collections still take place. In-store collections, on the other hand, are becoming increasingly popular. Customers can return their used clothing to various retailers, who then pass the textiles on to collection organisations. (Faist et al., 2024)

Specific Systems for Outdoor Products While general textile collection is widespread, specific schemes for outdoor products are emerging but limited.

- **France:** France is a leader in this area thanks to its specific EPR regulations. The 'Sports and Leisure Goods' (Articles de Sport et de Loisirs – ASL) EPR scheme, which is managed by Ecologic, specifically targets sports equipment (Ecologic, 2026). Outdoor retailer Decathlon, for example, works with various EPR schemes, including ASL for sports equipment, EEE (Équipements Électriques et Électroniques / Electrical and Electronic Equipment) for products containing electrical outlets or electronic components, furniture for items such as cots and air mattresses, TLC (Textiles, Linge de maison, Chaussures / Textiles, Household Linen, Footwear), batteries and packaging. Decathlon stores act as collection points to facilitate the recovery of this type of waste (https://sustainability.decathlon.com/the-end-of-life-of-our-products).

- **Germany, Austria, Italy:** There are no government-mandated separate systems solely for outdoor products. However, private sector initiatives are growing. Retailers like Globetrotter and Bergzeit (Germany/Austria) and brands like Salewa (Italy), Vaude (Germany) offer take-back systems or second-hand departments for used gear (https://www.globetrotter.de/secondhand, https://reuse.bergzeit.de; www.salewa.com/en-gb/blog-second-life, https://secondhand.vaude.com/second-hand).
- **Slovenia:** There are no specific schemes for outdoor products; these items rely on general second-hand shops and "swap shops".

4.3 Current treatment of relevant waste streams

The treatment of waste from outdoor products varies depending on the collection stream. Outdoor gear can become unusable and damaged when collected with mixed waste, while separately collected items enter a complex global sorting and trade network.

4.3.1 Incineration and landfilling

Waste collected in residual and bulky streams is almost exclusively destined for disposal. The method of disposal - incineration or landfill - depends on national infrastructure and policy.

- **Incineration with Energy Recovery:** In Germany, Austria and Switzerland, and increasingly in France, incineration is the standard for residual waste.
  - **Austria:** In 2023, 97% of textile waste in mixed waste streams was incinerated with energy recovery (thermal and electrical). Only about 3% was landfilled. (Environment Agency Austria, 2025)
  - **Germany:** Most textiles in residual waste are thermally recovered (burned). (Naji et al., 2023)
  - **France:** Textiles in residual waste generally end up incinerated with energy recovery in UIOM (Household Waste Incineration Units) or landfilled in ISDND (Non-Hazardous Waste Storage Facilities), if incineration capacity is unavailable.
- **Landfilling:** While the EU aims to reduce landfilling, it remains a significant route in some parts of the Alpine region.
  - **Slovenia:** Statistics indicate that more than 99% of mixed municipal waste is landfilled (Statistical Office of the Republic of Slovenia, 2024).
  - **Italy:** Italy generally faces challenges with landfill reliance in certain regions, though Northern Italy (Alpine space) typically has better waste-to-energy infrastructure.

As stated above (refer to Chapter 4.1.2), it is estimated that, across the EU, 11.6 kg of textiles per person end up in mixed household waste (residual waste) each year (ETC-CE, 2024a). Combined with the Alpine Space Programme's figure of more than 80 million inhabitants living in the Alpine region, this amounts to **about 930 000 tonnes of textile waste lost to incineration or landfill each year in the Alpine region**.

4.3.2 Reuse of separately collected used textiles

Based on figures showing that an average of 4.4 kg of textile waste per person is collected separately each year in the EU (ETC-CE, 2024a), and considering that the population of the Alpine region is around 80 million, it can be estimated that **around 350,000 tonnes of textile waste are collected separately in the Alpine region each year**.

Reuse is the highest priority in the waste hierarchy after prevention, and the management of separately collected textiles is a market-driven global industry. The first step in the treatment process is sorting and separating the collected clothes.

Sorting and Separation: Due to labour costs, collected textiles are sent to sorting plants, often located outside the country where they are collected.

- **Techniques:** Sorting is predominantly manual. Semi-automatic sorting uses hand scanners to support manual sorting and determine the material compositions. Automatic sorting, which uses near-infrared technology (NIR) technology, is mostly used for low-value, non-reusable fractions and sorts by material types and colours. However, it is not yet the industry standard for reusable goods. Only visible impurities are removed by hand. In the sorting facilities often only the products with the highest resale value (‘cream products’) that can be sold directly are sorted out. The remaining used clothing is usually exported for further sorting and recycling. In advanced facilities (e.g., in Germany or Austria), deeper sorting is carried out (“Fine screening”). There, workers separate items into up to 300 categories based on quality, type, and material.
- **Sorting Locations:** As sorting is currently mostly manual, making it expensive, most sorting of waste from the Alpine region takes place abroad. Austria for example exports over 80% of its collected used clothing for sorting, as domestic capacity is limited to "cream" (high value) sorting (Environment Agency Austria, 2025). Similarly, Germany exports unsorted textiles to neighbouring countries like Poland and the Netherlands, where sorting costs are lower. Also in Switzerland, most of the sorting (around 98%) takes place abroad. Almost 60% is traded within Western Europe, around a third goes to Eastern Europe, while only around 3% is exported to countries outside Europe for sorting. (Faist et al., 2024) France has domestic sorting centres (55 facilities) but also exports significant volumes, mainly to Eastern Europe, North and West Africa and Southeast Asia (Refashion, 2025). In Italy, sorting facilities are not necessarily located near the areas where waste is collected, but rather in areas where industrial development and expansion has occurred. Classic examples of this include the districts of Campania and Prato.

Reuse Markets and Quantities

- **Domestic Reuse:** A small fraction of collected textiles remains in the country of origin. In Austria, around 8% of the separately collected used clothing is reused domestically, either sold in shops (physically or online) or given away free of charge to people in need. (Environment Agency Austria, 2023) In France, ~12% is reused domestically through networks such as Emmaüs, Le Relais, or local thrift stores. (Refashion, 2025)
- **Export Markets:** The business model relies on export. Approximately 30 to 35% of French collected textiles is reused in other EU countries, particularly through second-hand platforms or wholesalers and approximately 50% is exported outside the EU, mainly to North and West Africa and Southeast Asia, where it is resold on local markets. (Refashion, 2025) Germany is a major export hub, shipping over 500,000 tonnes annually to EU and non-EU destinations (ETC-CE, 2024a)

Current Problems in the Reuse Sector

The reuse sector is currently facing a severe structural crisis, described by Italian operators as "completely unsustainable". The economic viability of collecting outdoor and fashion textiles depends entirely on the high value of the reusable fraction ("cream" goods), but this value is collapsing due to several factors:

1. **Reduced Quality (Fast Fashion):** The rise of fast fashion has drastically lowered the quality of incoming goods. More items found in containers are made of low-grade synthetics unsuitable for reuse, increasing the volume of non-reusable waste that sorters must pay to dispose of. This is for example also relevant for outdoor "leisure" wear which mimics technical gear but lacks durability.
2. **Geopolitical Instability:** The war in Ukraine closed Russian and Eastern European markets, which have been traditional outlets for warm clothing (including outdoor jackets).
3. **Market Restrictions:** Destination countries in Asia and Africa are increasingly imposing bans or restrictions on used clothing imports to protect local industries.

Financial Pressure: Sorting facilities are under pressure due to increasing collection volumes resulting from mandatory collection regulations, as well as declining demand and prices for sorted goods. The volume of non-reusable fractions now often exceeds 50%, creating a bottleneck where storage facilities are saturated and incineration costs for residues are rising. As a result, large operators such as SOEX in Germany have had to deal with insolvency or restructuring proceedings. TEXAID Germany – part of the Swiss organisation TEXAID, one of Europe's largest companies for the collection, sorting and recycling of used textiles with locations in Germany, Austria, Bulgaria, Hungary and the USA – had to file for insolvency in June 2025.

4.3.3 Recycling of separately collected used textiles

When reuse is not possible, recycling is the next option. However, true fibre-to-fibre recycling for outdoor products is currently minimal. Most relevant is currently **mechanical recycling** which normally involves shredding textiles into fibres for "downcycling" applications. Common products include:

- Insulation materials for the construction industry,
- Wiping rags for industrial use,
- Filling materials for automotive upholstery and mattresses.

It reduces fibre length and quality, limiting its use in high-performance outdoor apparel unless blended with virgin fibres.

Estimated Amounts Recycling rates for textiles in general are low.

- **France:** About 35% of collected textiles are sent for "recycling," but this includes downcycling (Refashion, 2025).
- **Germany:** About 27% of separately collected material is recycled (Naji et al., 2023).
- **Austria:** About 4% of the separately collected textiles treated in Austria were materially recovered for the production of cleaning rags, the manufacture of insulation material or for applications in the automotive industry.
- **Switzerland:** Around 28% the collected used textiles are of low quality and recycled. (Faist et al., 2024)
- At the **European level**, less than 1% of textile waste is recycled into new fibres (closed-loop). The majority of what is classified as "recycling" is actually **downcycling** processing into cleaning rags, insulation materials, or padding for the automotive industry.

Challenges Specific to Outdoor Products Outdoor products present unique hurdles for recycling:

- **Material Blends:** Outdoor apparel often mixes materials (e.g., poly-cotton blends, elastane for stretch) which disrupt recycling processes. Elastane is particularly problematic for chemical recycling technologies.
- **Multi-Layer Construction:** Jackets often involve membranes (e.g., PTFE), glues, and laminates that are difficult to separate.
- **Hard Parts:** Zippers, buttons, and eyelets must be removed (pre-processing), which is currently a costly manual process.
- **Chemicals:** Durable Water Repellent (DWR) coatings and other finishes can contaminate recycling streams.

4.4 Concluding remarks

The analysis of the waste management practices for outdoor products in the Alpine region shows that the system is unbalanced and does not yet align with the principles of sustainability and the circular economy. Several challenges have been identified:

Firstly, a significant proportion of textile waste, including outdoor apparel, continues to end up in residual and bulky waste streams. Once these materials are mixed with municipal waste, they are effectively lost for high-value recovery and are predominantly incinerated or sent to landfill. Secondly, even within the separately collected fraction, reuse markets are under severe economic pressure. Declining product quality, geopolitical disruptions, and increasing trade restrictions are undermining the financial viability of the sorting and reuse sector. Thirdly, material recycling is largely limited to downcycling applications and true fibre-to-fibre recycling rates remain low. Finally, the complex material blends, multi-layer constructions, chemical finishes and hard components of outdoor products present additional technical barriers, complicating sorting and recycling processes.

For the Alpine region to move decisively towards sustainability and circularity, developments are required at several levels.

1. Strengthening separate collection and diverting textiles from residual waste

Although separate collection of textiles is mandatory in the EU since 2025, its implementation is still inconsistent. The priority must be to significantly reduce the proportion of textiles disposed of in mixed municipal waste. This requires:

- expanding and harmonising collection infrastructure across municipalities, particularly in regions with low participation rates;
- Improving public awareness of the correct disposal routes for worn-out (non-reusable) textiles.
- Developing dedicated collection channels for non-reusable textiles to ensure they are not automatically directed to incineration.

Without improving capture rates, investments in recycling infrastructure will not reach their full potential.

2. Stabilising and transforming the reuse sector

Reuse remains environmentally preferable to recycling, yet the sector is currently economically fragile. To stabilise it, policy and market measures must:

- Adjust Extended Producer Responsibility (EPR) schemes to ensure sufficient financial support for sorting and reuse operators, particularly for non-reusable fractions.
- Incentivise higher product durability and repairability to counteract the declining quality of incoming goods.
- Promote domestic and regional second-hand markets to reduce dependence on volatile export destinations.

For outdoor products in particular, repair services, refurbishment models, rental systems, and certified second-hand platforms should become standard components of business models rather than niche initiatives.

3. Scaling automated sorting and material identification

High-quality recycling requires precise knowledge of material composition. Current manual sorting processes are labour-intensive, costly, and insufficient to handle increasing volumes. The next development step must therefore include:

- Large-scale deployment of automated fibre-sorting technologies (e.g., NIR-based systems), further refined to better detect blends and multi-layer constructions.
- Integration of digital product information systems, such as Digital Product Passports under the revised EU Ecodesign framework, to provide reliable data on fibre composition, coatings, and chemical treatments.
- Harmonised labelling standards to enable machine-readable identification of materials.

Only by combining technological innovation with regulatory standardisation can sorting efficiency and recycling quality be significantly improved.

4. Expanding regional recycling capacities and closing the loop

Currently, mechanical recycling dominates, but mostly in the form of downcycling applications. In order to achieve a true circular economy, the Alpine region and Europe as a whole must take the following measures:

- Invest in industrial-scale fibre-to-fibre recycling facilities, including chemical recycling for polyester and polyamide, both of which are important materials for outdoor clothing.
- Develop pre-treatment processes that can handle elastane blends, laminated fabrics, and DWR-coated materials.
- Promote cross-border cooperation within the Alpine region to increase recycling volumes and ensure the economic viability of advanced recycling facilities.

Public–private partnerships and targeted innovation support are essential for bridging the gap between pilot projects and commercial use.

5. Redesigning outdoor products for circularity

Ultimately, end-of-life solutions such as recycling cannot compensate for products that are not designed with circularity in mind. It must be emphasised that the above suggestions are a lower priority than the other R-strategies (Refuse, Rethink, Reduce, Reuse, Repair and Repurpose). Outdoor brands must therefore increasingly implement the following:

- Mono-material constructions where technically feasible.
- Principles for ease of disassembly to facilitate the removal of zips, membranes and hard parts.
- Reduced use of problematic additives and hazardous chemicals.
- Clear traceability of materials throughout the value chain.

Further details can be found in chapter 5.

The recyclability of products in 10–20 years' time is determined by design decisions made today. Therefore, eco-design must become a central strategy for of the outdoor industry.

In summary, the transition to sustainability and a circular economy in the Alpine outdoor sector requires systemic change. This requires

- product design to be fundamentally changed,
- collection systems to capture more material,
- the reuse sector to be economically stabilised,
- automated sorting and digital transparency to be expanded, and
- regional capacities for fibre-to-fibre recycling to be created.

If these changes are implemented in a coordinated manner, the Alpine region - given its strong outdoor market and high level of environmental awareness - could take a leading role in providing circular solutions for outdoor products. However, without decisive action, there is a risk that increasing collection volumes will overwhelm existing systems and further widen the gap between circularity goals and practical implementation.

5 R potential – developments, current practices and challenges

5.1 Developments and current practices on R strategies of outdoor products

Extensive desktop research and interviews were conducted with companies involved in the Alpine outdoor sports sector (e.g., manufacturers, brands) - to learn their perspectives on R strategy implementation, and future directions of developments (see also Chapter 2). This chapter presents current examples of R-Strategy implementations in the areas of Refuse, Rethink, Reduce, Reuse, Repurpose and Recycle. It is not intended to be an authoritative, exhaustive list but rather an illustration of the diversity of measures employed to mitigate environmental impact and improve circularity of products. Note that it is not possible to determine whether any of the cited examples is a better strategy than another, as it is difficult to evaluate the overall impact of a single strategy in absolute terms

5.1.1 Refuse

PFAS

Per- and polyfluoroalkyl substances (PFAS) are used to make outdoor clothing and equipment water- and dirt-repellent. However, this group of substances is hazardous to health and the environment. Consequently, the industry is trying to avoid using them in its products. Most manufacturers have recognised the harmful nature of PFAS and are developing alternatives. The examples listed below are therefore just a sample, as many manufacturers are developing PFAS alternatives or have already adopted them.

Examples:

- DEUTER “Made without PFAS”: https://www.deuter.com/de-en/deuter/blog/pfas-und-pfc_EN
- VAUDE: https://www.vaude.com/int/en/blog/post/vaude-withdraws-completely-on-pas.html
- GORE-TEX ePE membrane: https://www.gore-tex.com/en_uk/technology/new-products
- Jack Wolfskin: https://www.jack-wolfskin.co.uk/information-pfc/
- Toray Dermizax^{TM} PFAS free variations: https://www.sportstextiles.toray/en/brand/dermizax/
- prAna: https://www.prana.com/sustainability/preferred-fibers-and-materials.html
- Keen footwear: https://www.keenfootwear.de/en/blogs/keen-blog/what-is-pfas-free
- Houdini sportswear: https://houdinisportswear.com/en-eu/sustainability/pfas-free-clothing
- Ortovox: https://www.ortovox.com/at-en/navigation/0197f3655b497caeadefc87571c99703
- Picture Organic Clothing: https://www.picture-organic-clothing.com/en_ES/news/unchanged-since-2017-we-are-still-pfc-free
- Fjällräven: https://www.fjallraven.com/us/en-us/about/sustainability/sustainable-materials/
- Patagonia: https://eu.patagonia.com/gb/en/our-footprint/pfas.html
- EXPED: https://www.exped.info/en/sustainability/without-pfas

Rental

Rental models are viewed within the industry as a forward-looking approach to the circular economy, but are currently difficult to implement in the apparel sector. Experts see potential for rental models primarily in specialized mountain sports clothing for short-term users (e.g., ski clothing), but point to high customer expectations regarding material performance, which complicates implementation.

Examples:

- Intersport Rent: https://www.intersportrent.at/skirent/equipment/skiwear
- Dropkid: https://dropkid.de/en/
- Rossignol “Rent your ski outfit: https://www.rossignol.com/nl-en/rent-your-ski-outfit.html
- Gore-Tex outerwear on demand: https://www.gore-tex.com/products/rentals

- VAUDE: https://rent-business.vaude.com/
- EcoSki rental: https://ecoski.co.uk/ski-wear-rental

5.1.2 Rethink

Modularity

Modularity refers to the way a system is built from discrete, separable components ("modules") that can be independently assembled, disassembled, and recombined to create different configurations. Modular garments are defined as clothing that can be taken apart into components like sleeves, collars or body panels that attach via standard interfaces such as zippers or buttons, enabling flexibility in form and function. This reflects the core modularity idea - breaking down a whole into smaller, interchangeable units with well-defined interfaces - which allows for flexibility, customization and potential sustainability benefits by extending product lifecycles (Zhang et al., 2024).

The term 'modularity' is often used to refer to three-layer systems. The 3-layer clothing system helps regulate body temperature and protect against weather. The base layer sits next to the skin and wicks away sweat to keep you dry. The middle layer provides insulation and keeps body heat in. The outer layer protects against wind, rain, and other environmental conditions.

Examples:

- STELLAR EQ, The Stellar SystemTM: https://stellarequipment.com/eu/our-systems/mens-stellar-system
- Beretta, Clothing Layering System: https://estore.beretta.com/en-pl/lookpage/clothing-layering-system
- Helly Hansen, The Arctic Patrol Modular Parka 2.0: https://www.hellyhansen.com/journal/arctic-patrol-modular-parka-design-evolution
- Helly Hansen, Unisex HH Archive Modular Padded Top Coat: https://www.hellyhansen.com/en_at/hh-arc-modular-padded-top-coat-54505?color=634832&qu=modular&ct=autosuggest_top_product

Mono-materials

Companies are focusing on products made from mono-materials (e.g., 100% polyester or polypropylene), as these are, in principle, significantly easier to recycle than blended fabrics. Some brands are developing dedicated product lines specifically designed around this principle.

Examples:

- Schöffel, Circ Collection: https://www.schoeffel.com/de/en/circularity?_billing_country_selection=DE
- FreyZein® mono-material technology: https://www.freyzein.com/technology
- The North Face DryVent™ Mono: https://www.thenorthface.com/en-gb/innovation/technologies/dryvent-mono
- Haglöfs, ROC Mono Proof Jacket Men: https://www.haglofs.com/at/aktivitaten/bergsport/roc-mono-proof-jacket-men-6061422C5
- Helly Hansen, Women's Ellie Puffy Parka: https://www.hellyhansen.com/de_at/w-ellie-puffy-parka-53108
- Napapijri, Rivalto Mono-Material Jacket: https://www.napapijri.com/en-ie/products/rivalto-mono-material-jacket-np0a4icpn2d?country=IE

5.1.3 Reduce

On-demand production

On-demand textile production aims to prevent overproduction by only manufacturing garments after a customer place an order, instead of mass-producing stock in advance. This made-to-order model is expected to eliminate excess inventory and reduce textile waste and unnecessary use of resources, because no items are produced that might never be sold. By avoiding season-based stock and large inventories, brands can significantly cut down on production overshoots that often lead to discounting or disposal, making fashion and sportswear more sustainable and responsible.

Examples:

- RE-ATHLETE: https://re-athlete.de/pages/uber-uns
- MADE Custom Apparel: https://madeoutdoor.com/pages/sustainability

Strategies for Reducing Material Waste in Manufacturing

Outdoor brands are increasingly optimizing material usage to reduce waste by improving product design and manufacturing processes. One key approach involves refining patterns and cutting layouts so that fabrics are used more efficiently, minimizing cut-offs during production. In addition, companies adjust technical production parameters, such as fabric widths or component dimensions, to better match product designs and avoid unnecessary surplus material. Another strategy is the systematic reuse of unavoidable production scraps by incorporating them into new products or secondary materials. Furthermore, collaboration across supply chains allows companies to share resources and coordinate material usage more effectively (Suston, o.J.).

Examples:

- Deuter, Infiniti series: https://www.deuter.com/ie-en/infiniti
- Mammut cut material use in their Dream Series sleeping bags by 33%, making four bags from one 20-meter fabric panel with nearly zero waste: https://sustonmagazine.com/outdoor-brands-seeking-zero-waste/
- Fjällräven, Samlaren Collection, jackets, bags and caps made from leftover fabrics and redesigned with new colour combinations: https://www.fjallraven.com/eu/en-gb/clothes/samlaren-collection/
- Rab, Second Stitch, Rab fixes damaged gear using leftover fabric pieces (end of life fabric roll ends, re-used and offcut materials) instead of matching new fabric: https://rab.equipment/us/service-centre/second-stitch?
- Picture Organic Clothing, reusing scraps from the manufacturing process for linings in some products (e.g. jackets and sleeping bags): https://eco.picture-organic-clothing.com/en/materials/

5.1.4 Reuse

Re-use platforms

Reuse of outdoor products means using outdoor equipment or items again—either for the same purpose or a new one—instead of throwing them away or recycling them. The goal is to extend the product's life and reduce waste.

The main motivation for buying second-hand outdoor gear among German and Austrian outdoor enthusiasts is cost savings (88 % of respondents) and ecological reasons, with a clear majority citing sustainability as important when choosing used items. About 36 % reported that roughly just 10 % of their outdoor clothing was bought second-hand, while around one-fifth said 10–20 % and 15 % said 20–30 % of their gear came from online second-hand platforms, showing that only a modest share of their wardrobes is reused today. Among product categories, used backpacks, rain/hard shell jackets, fleece jackets and softshell jackets were particularly common in the second-hand market (Bergzeit, 2023).

There are large online platforms for buying or selling outdoor products, but some retailers and brands also offer this service.

Examples:

- Bergzeit Re-use, clothing and equipment: https://reuse.bergzeit.at/

- Vinted: https://www.vinted.com/
- Sellpy: https://www.sellpy.com/
- Shpock: https://www.shpock.com/
- Patagonia, worn wear: https://wornwear.patagonia.com/

Take back systems

Brands are launching pilot projects in which they take back used products, recondition them, and offer them again as 'second life' items. For example, customers receive discounts or vouchers for their next purchase when they return used items.

Examples:

- LÖFFLER Second Life (German): https://www.textilzeitung.at/green/news/nachhaltigkeits-konzept-second-life-bei-loeffler-der-schluessel-zu-mehr-kunden-16717
- The North Face "Renewed": https://www.thenorthfacerenewed.com/
- Vaude, Second Hand: https://secondhand.vaude.com/second-hand
- Arc´teryx resale: https://www.resale.arcteryx.com/pages/about
- SALEWA Second Life Initiative: https://www.salewa.com/en-gb/blog-second-life
- KEEN, reuse of shoes, boots and sandals: https://re.keenfootwear.com/about
- D_b_™, take-back and re-sell of bags: https://lostfound.dbjourney.com/pages/about

5.1.5 Repair

Repair is an established service in the outdoor industry, and many brands maintain dedicated in-house departments for this purpose. Repair services are usually limited to a brand's own products, although some companies also repair items from other brands. Within the industry, repair is increasingly being used as a marketing and communication tool, even though it has often existed for decades as part of standard customer service. One key limitation of repair services, however, is economic viability: when products are severely damaged, companies may opt to offer store credit instead of carrying out repairs that would be disproportionately expensive.

In addition, modular concepts are being developed that enable the replacement of individual components to improve repairability.

Examples:

- LÖFFLER Repair Service: https://www.loeffler.at/en/loeffler-world/repair-service/
- Rab Repair Service: https://rab.equipment/eu/service-centre/choose-a-repair
- Patagonia, worn wear repair tour: https://eu.patagonia.com/de/de/wornwear/snow-events.html
- Patagonia, repair service: https://eu.patagonia.com/gb/en/repairs/
- Berghaus, repairhaus: https://www.berghaus.com/repairs.list
- Osprey, all mighty guarantee: https://www.osprey.com/customer-support/all-mighty-guarantee
- DYNAFIT Care & Repair Centre: https://www.dynafit.com/en-at/care-repair-center
- Komperdell repair service: https://www.komperdell.com/en/Service/3-Years-Free-Repair-Service/
- Ortovox, repair service and tutorials: https://www.ortovox.com/at-en/navigation/019bbcb4821776989674413f329971de
- Mammut, repair and care: https://www.mammut.com/ie/en/repair-and-care
- Vaude, repair: https://www.vaude.com/int/en/blog/post/repair.html
- Schöffel, service factory: https://www.schoeffel.com/bl/en/dynamic/service_factory?_billing_country_selection=NL
- Martini Sportswear, repair and care: https://www.martini-sportswear.com/de/Entdecke-Martini/Die-Marke/Reparaturservice

5.1.6 Repurpose

Repurposing involves transforming old or discarded materials into new products. For example, FREITAG upcycles used truck tarpaulins, car seat belts, and other industrial waste into durable bags and accessories. Similarly, Mammut mechanically recycles leftover polyester rope scraps, breaks them into fibres, and blends them with recycled PET (rPET) - without using additional chemicals - to produce long-lasting insulation that keeps wearers warm and protected.

Examples:

- Mammut, Loopinsulation: https://www.mammut.com/at/de/mammut-loopinsulation
- Freitag, bags: https://freitag.ch/en_AT/mission
- Cotopaxi, deadstock fabrics to produce products: https://www.cotopaxi.com/pages/sustainable-by-design
- Smartwool, Second Cut™, using old socks to make new pairs: https://www.smartwool.co.uk/uk/second-cut
- 66° North, jacket crafted from leftover Polartec fleece fabrics from last year's products: https://66north.com/blogs/66-blog/66north-kria-ss24?_pos=1&_sid=6f3825e35&_ss=r
- TEW Gear, Afterlife Projects, collect used and damaged gear and turn it into new items such as tote bags, bucket hats and dog bandanas:
  - https://trewgear.com/pages/afterlife-upcycled-projects
  - https://trewgear.com/collections/upcycled-items
- reride, Bags made from upcycled kitesurfing sails:
  - https://reridestore.com/en-eu/blogs/blog/recycled-bags
  - https://reridestore.com/en-eu
- AKU, outdoor shoe partially made with recycled materials: https://www.aku.com/en/blogs/my-aku-1/scarpa-omnia-outdoor-citta

5.1.7 Recycling

Use of recycled materials in the production of new products

Some manufacturers incorporate recycled materials into their products, but genuine textile-to-textile recycling is not yet common (see Chapter 3). Instead, recycled inputs often come from sources like used fishing nets or PET bottles, which doesn't constitute true textile recycling. In the case of PET bottles, downcycling is more likely, as plastics approved for food use are used in the production of clothing.

Despite these measures, scaling textile-to-textile recycling remains a major challenge, as there is often still a lack of profitable supply chains, necessary infrastructure, and investment (see also chapter 3). In addition, the high costs of sustainable materials and the complexity of blended fabrics make widespread implementation difficult.

Examples:

- Vaude, Sustainable Outdoor gear made from recycled scrap tires: https://www.vaude.com/nl/en/blog/post/sustainable-outdoor-gear-made-from-recycled-waste-tires.html
- Aquafil's Econyl® from nylon waste: https://econyl.aquafil.com/
- Netplus® from fishing nets: https://bureo.co/
- Patagonia Netplus® collection: https://www.patagonia.com/netplus/
- Ryzon, Econyl® products: https://ryzon.net/de-int/collections/econyl
- Rossignol, ski made from recycled material: https://www.rossignol.com/ca-en/essential-ski.html
- REPREVE® circular polyester: https://repreve.com/our-products/circular-polyester
- PRIMALOFT® ReRun insulation: https://sustonmagazine.com/primaloft-rerun-textile-to-textile-insulation/

Solutions for material disassembly

Some companies offer technologies that can improve textile recycling through solutions for the disassembly of mixed materials.

Examples:

- Climatex, DualCycle, textile technology that uses a dissolvable weave structure to keep different fibres separate so blended fabrics: https://www.climatex.com/dualcycle
- Climatex, Stitchlock, dissolvable sewing thread: https://www.climatex.com/stitchlock
- Resortecs, Smart Stitch™, heat dissolvable threads: https://resortecs.com/technology/
- Peak Performance, The R&D Helium Loop Anorak: https://www.peakperformance.com/ie/rd-helium-loop

Recycling of shoes

Recycling technologies exist that can break down all types of footwear into their raw components—such as foam, rubber, and textiles—which can then be reused to create new products, including industrial materials, sports flooring, furniture, and even new shoes

- FastFeetGrinded: https://www.fastfeetgrinded.eu/
- NIKE GRIND: https://www.nikegrind.com/about/

5.1.8 Further circular economy strategies

Digital product pass and transparent supply chains

The Digital Product Passport (DPP) is a structured, digital data set that documents key product-related information over the entire lifecycle - from materials and manufacturing to use, repair, recycling and end-of-life handling. For textiles, this means capturing and linking data such as material composition, origin of fibres and fabrics, production processes, sustainability attributes (e.g., resource use, recyclability) and potentially environmental impacts in a machine-readable, accessible format. The DPP is being developed as part of the EU Ecodesign for Sustainable Products Regulation (ESPR) and is intended to increase transparency and traceability in complex supply chains, support circular economy goals (like reuse and recycling), and help companies and consumers make more informed decisions. Some manufacturers are already implementing this and showing initial results by disclosing their supply chains.

Examples:

- LÖFFLER Supply Chain Transparency: https://www.loeffler.at/en/wp-content/uploads/sites/5/2024/03/LOFFLER-Nachhaltigkeitsbericht-2023-Kurzversion_EN.pdf
- Vaude, Tracking VAUDE products worldwide for selected products: https://www.vaude.com/nl/en/blog/post/transparent-supply-chain.html
- Bergans, digital product pass for 2025 collection: https://www.trimco-group.com/newsroom/starting-with-the-end-bergans-of-norway-takes-different-approach-to-digital-product-passport
- CIRPASS-2 project to demonstrate functioning DPP: https://cirpass2.eu/
- PASSAT supports Austrian companies in implementing the digital product passport: https://digitaler-produkt-pass.at/

Product Environmental Footprint

The Product Environmental Footprint (PEF) is a science-based, life-cycle assessment (LCA) methodology developed under guidance from the European Commission to measure the environmental impacts of products - including clothes and footwear - in a consistent and comparable way across the European Union. It evaluates a product's environmental footprint across its full life cycle: from raw material extraction through production, transport, use (including durability and repairability), and end-of-life. The method applies 16 environmental impact indicators such as climate change potential, water use, land use, and ecotoxicity

Examples:

- Product Environmental Footprint: https://pefapparelandfootwear.eu/

5.2 Challenges in the implementation of R strategies

The transition from linear to circular business models in the outdoor industry is widely recognized as essential for advancing sustainability goals. However, the practical implementation of R-Strategies remains fraught with significant challenges. While concepts like textile-to-textile recycling and rental models are frequently highlighted as promising pathways toward a circular economy, their large-scale realization is constrained by economic, technological, organizational, and regulatory barriers. Companies face complex trade-offs between sustainability ambitions and market pressures, as well as resource conflicts, cultural resistance, and data management complexities. At the same time, external factors - including high material costs, technological limitations in recycling blended fabrics, regulatory uncertainty linked to frameworks such as the Corporate Sustainability Reporting Directive (CSRD), insufficient infrastructure, and volatile consumer demand - further complicate progress. Together, these internal and external obstacles illustrate that the shift toward circular R-Strategies is not merely a technical transformation, but a systemic change that challenges existing value chains, mindsets, and market structures.

Internal barriers

- Resource conflicts (time & money): Sustainability projects require substantial time and financial resources. Smaller sustainability departments often compete with much larger departments for budgets. In addition, there is constant tension between sustainability goals and market pressure related to costs and time-to-market.

- Corporate culture and mindsets: In long-established companies, outdated ways of thinking often persist, as linear business models ("buy, make, profit") have been successful for decades. It takes courage and persuasion to pursue new approaches, especially when they do not immediately lead to economic success.

- Alignment between marketing and corporate sustainability: There is often friction between marketing and sustainability teams. The challenge lies in finding the right balance between pride in achievements and necessary modesty ("What are we allowed/required to communicate?"). Marketing concepts are still frequently prioritized over sustainability strategies.

- Complexity of data management: Collecting and processing large volumes of sustainability data (e.g., for digital product passports) places significant strain on internal systems.

External barriers

- High material costs: Sustainable material options, particularly high-quality recycled fibres (such as nylon), are significantly more expensive than conventional fossil-based materials. This directly affects product profitability.

- Technological limitations and blended fabrics: While mono-materials (e.g., 100% polyester) are relatively easy to recycle, recycling blended fabrics—often necessary for performance sportswear - is technologically extremely challenging. There is a lack of scalable production methods and profitable supply chains for textile-to-textile recycling.

- Regulatory uncertainty and bureaucracy: Companies complain about a flood of EU regulations (CSRD, Supply Chain Directive, Ecodesign Regulation), which often lead to legal uncertainty. Laws are also criticized for being difficult to implement in practice or for being changed or overturned shortly before coming into force.

- Lack of infrastructure and standards: There is no comprehensive infrastructure for the collection and sorting of used textiles. In addition, inconsistent calculation methods (e.g., surface area vs. weight share for recycled content) hinder product comparability in the market.

- Consumer behaviour and market dynamics: Consumers' willingness to pay for sustainable products is difficult to assess. At the same time, global crises (wars, inflation, post-COVID excess inventories) make it harder to focus strategically on circular economy initiatives, as companies act more cautiously in uncertain times.

- Lack of internalization of external costs: Current market prices often fail to reflect environmental costs (e.g., climate damage or chemical contamination), making conventional products appear artificially cheaper.

6 Final conclusions

This report provides an overview of waste potential, waste management practices, and circular economy opportunities for outdoor products in the Alpine region. The analysis demonstrates that the outdoor sector represents both a significant economic market and an emerging environmental challenge, particularly due to the increasing volumes of textile-based products and their complex material compositions.

The outdoor market in Europe has shown steady growth in recent years, with apparel representing the largest product category, followed by footwear and other equipment such as backpacks, tents, and climbing gear. Sales data indicate that outdoor apparel alone accounts for roughly half of the market, highlighting its central importance for both consumption and potential for waste generation. At the same time, the Alpine region hosts numerous well-known outdoor brands and is characterized by a high level of outdoor activity participation, which further increases the demand for such products. Consequently, significant quantities of outdoor products eventually enter the waste stream.

However, one of the key findings of this report is the lack of precise data regarding waste from outdoor products. These products are not recorded as a distinct category in waste statistics and are instead dispersed across several waste streams, primarily residual municipal waste, bulky waste, and separately collected used textiles. As a result, estimating the quantities and composition of outdoor product waste requires indirect approaches, such as analysing market sales data and broader textile waste statistics. Based on these estimates, textile waste generation in the Alpine region is substantial, with a large share still entering mixed waste streams rather than being separately collected.

Current waste management systems in the Alpine countries show that the majority of textile waste, including outdoor products, is still lost to incineration or landfill. While separate collection systems for used textiles exist and have expanded in recent years, especially due to new EU requirements, a large proportion of textiles continues to be disposed of in residual waste. Once materials enter these mixed waste streams, high-quality recovery is generally no longer possible. Even within separately collected textile streams, reuse remains the primary destination, while true material recycling plays only a minor role.

From a material perspective, outdoor products pose particular challenges for circularity. Outdoor textiles are typically composed of a wide range of natural and synthetic fibres such as polyester, polyamide, cellulose-based fibres, wool, polyolefins, and polyurethane. These materials are often combined in complex blends or multilayer constructions, including coatings, laminates, membranes, and insulation systems. While recycling technologies exist for several individual polymers - such as mechanical recycling of wool, thermomechanical recycling of polyester, and chemical recycling of nylon 6 - the mixed-material design of many outdoor products significantly complicates separation and recovery processes. As a result, fibre-to-fibre recycling of outdoor textiles is currently limited and rarely implemented at industrial scale.

The analysis of R-Strategies in the outdoor sector shows that several circular approaches are already being explored by companies, including repair services, second-hand platforms, take-back schemes, and design improvements aimed at easing separation of different polymer types. Nevertheless, important barriers remain. These include technical challenges related to product design and material complexity, insufficient recycling infrastructure for textile-to-textile recycling, limited data on product flows, and economic pressures in the reuse and sorting sector.

Overall, the findings highlight that improving circularity in the outdoor sector will require coordinated action across the entire product lifecycle. Key priorities include designing products for easier recycling, reducing material complexity, expanding collection and sorting systems, and scaling up recycling technologies for textile waste. At the same time, strategies that extend product lifetimes - such as repair, reuse, and refurbish - will remain essential. Only through the combined development of these measures can the outdoor industry move towards a more sustainable and circular system for managing outdoor products in the Alpine region.

Acknowledgments

The authors would like to thank the Verband der Sportartikelerzeuger und Sportartikelhändler Österreichs (Association of Austrian Sports Goods Manufacturers and Retailers) for their cooperation and for providing the sales figures for this report. We would also like to thank all of the outdoor brands and experts who were interviewed for their valuable contributions to the report, and for agreeing to be interviewed.

Reference to other Deliverables

This work package consists, beside this report, of six other reports that provide additional information and deeper insights into the ASTER project:

- **Input paper on R-strategies | Definitions and Understanding. A guideline through the Activities:** https://www.alpine-space.eu/wp-content/uploads/2026/02/R-strategies-and-their-use-in-ASTER_V3.pdf
- **Deliverable 1.1.1 | Mapping circular & textile actors in the Alps:** https://www.alpine-space.eu/wp-content/uploads/2026/04/D111-Mapping-circular-and-textile-actors-in-the-Alps.pdf
- **Deliverable 1.1.2 | Mapping economic flows & gaps in the Alps:** https://www.alpine-space.eu/wp-content/uploads/2026/04/D112-Mapping-economic-flows-and-gaps-in-the-Alps.pdf
- **Deliverable 1.2.1 | Regulations and economic policies for waste prevention and management in the Alps:** https://www.alpine-space.eu/wp-content/uploads/2026/04/D121-Regulations-and-economic-policies-for-waste-prevention-and-management-in-the-Alps.pdf
- **Deliverable 1.2.2 | Mapping institutional dynamics in the Alps:** https://www.alpine-space.eu/wp-content/uploads/2026/04/D122-Mapping-institutional-dynamics-in-the-Alps.pdf
- **Deliverable 1.3.1 | Methods – R-potential, waste generation and waste management of outdoor products in the Alpine region:** https://www.alpine-space.eu/wp-content/uploads/2026/05/D131-Methods_R-potential-waste-generation-and-waste-management.pdf

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Use of artificial intelligence (AI) tools

AI tools (ChatGPT, DeepL, NotebookLM, Read AI) were used to a limited extent in the preparation of the report, after which the content was reviewed and corrected as required. Full responsibility for the content lies with the authors.

ANNEX 1

Questionnaire to survey the management of outdoor products in the Alpine region

1. Waste categories in which outdoor product waste is collected and waste quantities

Which waste categories in your country contain outdoor product waste (apparel, footwear, equipment)?

How much textile waste is collected annually in your country? And in which waste categories is it collected?

How much mixed municipal waste (residual waste) is collected annually in your country? What percentage of the residual waste is textile waste?

How much bulky waste is collected annually in your country? What percentage of the bulky waste is textile waste? Bulky waste is defined as non-hazardous material not able to fit in regular waste bin containers (e.g., mattresses, sporting goods).

How much used clothing is collected separately in your country annually?

Is it possible to quantify the amount of outdoor product waste (apparel, footwear, equipment) collected annually? If so, how much is collected? If not, why not?

2. Waste collection

How is textile waste in mixed waste (residual and bulky waste) currently collected in your country?

Are there separate collection systems for used clothing for re-use in your country?

Are there any specific collection schemes in place to collect outdoor product waste (apparel, footwear, equipment) for reuse (e.g., take back systems or collection systems of specific companies)?

3. Waste treatment, recycling and reuse

How is textile waste, that is collected within the mixed waste categories (residual and bulky waste), currently treated in your country?

Are there any treatment or recycling facilities or reuse initiatives for non-textile waste from the outdoor industry (e.g., take-back systems for equipment, etc.)?

How is the waste that is not reused or recycled disposed in your country? Is it incinerated (technology? energy recovery?) or landfilled (type of landfill?)?

3.1 Treatment and reuse of separately collected used clothing

How is separately collected used clothing currently treated in your country? Are there recycling/sorting facilities for this type of waste in your country? Or is the waste exported for recycling (if so, where and for what treatment?)

If applicable, how is separately collected clothing currently sorted in your country, by machine and/or by hand? Is it sorted by fibre type or by resale value or by other means?

Where does the sorting take place (in your country, in the EU, outside the EU?)?

What proportion of separately collected used clothing is actually reused in your country? What proportion is reused in other EU countries and what proportion is reused outside the EU?

ANNEX 2

Questionnaire for outdoor brands

1. Could you please briefly introduce yourself and describe your role in your company?
2. What specific goals is your company currently pursuing in the area of circular economy and carbon neutrality?
3. Are there any products or product lines that have been specifically designed for recyclability, durability or multifunctional use? If so, what characterises these products?
4. What standards or certifications do your products meet in terms of sustainability?
5. How do you ensure that your supply chain is environmentally and socially responsible?
6. Do you offer second-hand products or rental models? Are there take-back systems or recycling programmes? How do your customers respond to these?
7. What options do you offer for repairing products?
8. What measures do you take to reduce production waste and emissions during manufacturing?
9. Are you currently working on developing new, environmentally friendly materials or manufacturing processes? Do you avoid using harmful substances (PFAS/PFC)?
10. What technologies or innovations do you see as key to the circular economy in your industry?
11. What specific impact do current or planned EU regulations have on your product development and choice of materials? (e.g., digital product passport or extended producer responsibility)
12. What experience have you had with the cost-effectiveness of sustainability measures?
13. What internal or external obstacles do you encounter when implementing sustainable concepts?
14. What trends or developments do you expect to see in the next 5–10 years in the field of sustainable outdoor products?
15. Is there anything else you would like to add on the subject of sustainability or 5R?

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