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E-POSTA

KARADENİZ İHRACATÇI BİRLİKLERİ ÜYELERİNE SİRKÜLER
2024/752

Sayın üyemiz,

T.C. Ticaret Bakanlığının bir yazısına atfen, Türkiye İhracatçılar Meclisinden alınan 10/12/2024 tarih 125-3007 sayılı yazıda;

Sürdürülebilir Ürünler için Ekotasarım (Ecodesign for Sustainable Products-ESPR) Tüzüğü'nün 28 Haziran 2024 tarihli AB Resmi Gazetesi'nde yayınlandığı ve 18 Temmuz 2024 tarihi itibariyle yürürlüğe girdiği, tüzük kapsamında genel çerçevesi çizilen eko-tasarım kuralları doğrultusunda, Komisyon tarafından yetki devrine dayanan mevzuatlar ile ürün gruplarına yönelik eko-tasarım kurallarının belirlenmesi ve söz konusu ürün gruplarına ve eko-tasarım kurallarına ilişkin Avrupa Komisyonu tarafından bir çalışma takvimi yayımlandığı, Avrupa Komisyonu Ortak Araştırma Merkezi (Joint Research Center-JRC) tarafından söz konusu Tüzüğe ilişkin olarak 13 Kasım 2024 tarihinde yayımlanan raporda, ESPR kapsamında potansiyel eylemler için belirli ürün gruplarının ve yatay gerekliliklerin uygunluğunun; çevresel etkiler ve iyileştirme potansiyeli, pazar uygunluğu, AB'deki politika kapsamı, maliyet yansımaları gibi çeşitli parametreler temelinde değerlendirildiği, analiz sonucunda, on bir nihai ürünün (tekstil ve ayakkabı, mobilya, lastik, yatak şilteleri, deterjanlar, boyalar ve vernikler, yağlayıcılar, kozmetikler, oyuncaklar, balıkçılık ekipmanları, emici hijyen ürünleri), yedi ara ürünün (demir ve çelik, ticari kimyasallar, demir dışı, alüminyum olmayan metal ürünler, alüminyum, plastik ve polimerler, kağıt hamuru ve kağıt, cam) ve üç yatay gerekliliğin (dayanıklılık, geri dönüştürülebilirlik, geri dönüştürülmüş içerik) potansiyel öncelikler olduğunun aktarıldığı, bir örneği ekte yer alan rapor, JRC'nin ESPR için yeni ürün önceliklerine ilişkin nihai analizini temsil etmekte olduğu, gösterilen sonuçlar nihai kararlar olmamakla birlikte, Komisyonun önümüzdeki dönemdeki çalışmalarını desteklemesinin beklendiği ifade edilmektedir.

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Ecodesign for Sustainable Products Regulation: Study on new product priorities

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Abstract

The Ecodesign for Sustainable Products Regulation (ESPR) recently entered into force with the aim of making sustainable products the norm.

In this report, the relevance of a number of product groups and horizontal requirements for potential action under ESPR was evaluated on the basis of several parameters: environmental impacts and improvement potential, market relevance, policy coverage in the EU, cost reflections, and contribution towards an EU Open Strategic Autonomy.

As a result of the analysis, eleven final products (Textiles and footwear, Furniture, Tyres, Bed mattresses, Detergents, Paints and varnishes, Lubricants, Cosmetics, Toys, Fishing gears, Absorbent hygiene products), seven intermediate products (Iron and steel, Commodity chemicals, Non-ferrous, non-aluminium metal products, Aluminium, Plastic and polymers, Pulp and paper, Glass) and three horizontal requirements (Durability, Recyclability, Recycled content) are identified as potential priorities for the next steps of preparation of the first ESPR Working Plan.

This report represents the JRC's final analysis of new product priorities for the ESPR. However, the results illustrated are not final decisions: they do not bind the Commission, and are without prejudice to what may ultimately be prioritised for first action under ESPR, included in the first ESPR Working Plan, or undertaken under other EU policy frameworks.

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Executive summary

Policy context

The Ecodesign for Sustainable Products Regulation (ESPR) recently entered into force as Regulation (EU) 2024/1781 with the aim of creating a strong and coherent policy framework to make sustainable products the norm in the EU. This JRC report assesses a number of product groups and horizontal requirements that *may* be suitable priorities under ESPR. Together with other elements – such as the requirements and priority list of products set out in Article 18 of the ESPR, considerations relating to availability of resources and the political priorities of the new Commission – it will feed into reflections for the preparation of the first **ESPR Working Plan**, to be adopted by the Commission within 9 months from the entry into force of ESPR, following consultation of the members of the Ecodesign Forum.

Key conclusions

In this report, the relevance of a number of product groups and horizontal requirements was evaluated and scored in terms of impacts and improvement potential on the basis of several parameters: environmental sustainability and circularity, market relevance, existing and planned policy coverage, cost reflections, and contribution towards an EU Open Strategic Autonomy. This exercise resulted in a list of potential priority products (final and intermediate) and horizontal requirements for future ESPR action.

As a result of the analysis, eleven final products (highest to lowest score: Textiles and footwear, Furniture, Tyres, Bed mattresses, Detergents, Paints and varnishes, Lubricants, Cosmetics, Toys, Fishing gears, and Absorbent hygiene products), seven intermediate products (Iron and steel, Commodity chemicals, Non-ferrous, non-aluminium metal products, Aluminium, Plastic and polymers, Pulp and paper, and Glass) and three horizontal requirements (Durability, Recyclability, Recycled content), show potential for prioritisation in the first ESPR Working Plan.

According to the methodology applied in this report, Textiles and Footwear, Furniture, and Tyres were the final products that emerged as the most relevant from an environmental perspective. These products showed high relevance in terms of impact for several environmental categories as well as medium/high relevance in terms of improvement potential currently unexploited, especially with respect to increased material efficiency. These products showed, however, lower relevance in terms of contribution to Open Strategic Autonomy (except for Tyres, which showed high relevance).

Similarly, Iron and steel, Commodity chemicals, and Non-ferrous, non-aluminium metal products were the three product groups with the highest environmental relevance among the intermediate products. While their relevance was very high in terms of impacts for many environmental categories, the improvement potential identified was mainly related to the areas of waste generation, climate change and energy consumption. These products also showed medium or high relevance in terms of contribution towards Open Strategic Autonomy.

Main findings

Final and intermediate products

- From an initial list of 33 product groups, 18 products (11 final and 7 intermediate products) were shortlisted based on environmental, market and policy considerations. Those products were then assessed and ranked based on their environmental relevance (i.e., impacts and improvement potential) for 10 environmental categories: water effects; air effects; soil effects; biodiversity effects; waste generation and management; climate change; life-cycle energy consumption; human toxicity; material efficiency; and lifetime extension.
- The potential contribution of the final and intermediate products to the EU's Open Strategic Autonomy was also evaluated, in order to assess whether certain dependencies in the supply chain of final or intermediate products could be mitigated by enhancing the circularity of these products under ESPR. However, the assessment on Open Strategic Autonomy is not used to rank products, as it is included in ESPR Art.18 as additional assessment but not part of the prioritisation criteria.
- The level of impacts associated with the proposed priority products was quantified and compared to the overall Consumption Footprint and the planetary boundaries, showing that the products suggested as a priority represent a relevant share of impacts (between 15% and 81% of the impacts of the overall consumption).

Horizontal requirements

- As outlined in the ESPR, where two or more product groups display technical similarities that can be improved by common ecodesign requirements, such requirements may be established horizontally for those product groups.
- The horizontal requirements proposed in this report include a number of provisions that focus on improving material efficiency for key product groups (such as Textiles and footwear, Light means of transport, Toys, Bed mattresses) by performance and/or information requirements.
- Horizontal requirements were analysed in terms of expected improvement potential, and some insights regarding their comparative benefits could be drawn, notably the high impact reduction potential of a Durability requirement.

Related and future JRC work

The results of this report **do not bind the Commission: they are without prejudice to what may ultimately be prioritised for first action under ESPR, included in the first ESPR Working Plan, or undertaken under other EU policy frameworks**. Products selected for inclusion in the first Working Plan will be the focus of ad-hoc Preparatory Studies, which will investigate from scratch the feasibility of setting ecodesign requirements and the detailed definition of such requirements. This will be complemented by dedicated impact assessments and consultations.

Extended executive summary

Background. The European Union (EU) has assumed a leadership role on environmental sustainability by committing to achieving a more circular economy and full climate neutrality. To this end, and in the context of the EU Green Deal (2019) and the new Circular Economy Action Plan (2020), in March 2022 the European Commission proposed the **Ecodesign for Sustainable Products Regulation** (ESPR) with the aim of creating a strong and coherent policy framework to make sustainable products the norm in the EU. Under the ESPR, now in force as Regulation (EU) 2024/1781, ecodesign requirements can be set for specific product groups to significantly improve their circularity, energy performance, resource efficiency, and other environmental sustainability aspects.

ESPR is a framework regulation, and it enables product design rules to be laid down in a second stage, via Delegated Acts, which will systematically be preceded by dedicated impact assessments and consultations. Once established via Delegated Acts, ecodesign requirements will become mandatory for the placing on the market of the products in question in the EU. The ESPR text makes clear that a prioritisation exercise should therefore be carried out and that the Commission should adopt and regularly update a **Working Plan**, to be adopted within 9 months from the entry into force of ESPR, setting out the list of **product groups** that shall be prioritised for the establishment of ecodesign requirements. This includes estimating timelines for their establishment, as well as listing the product groups and product aspects to be prioritised for the establishment of **horizontal ecodesign requirements**, which are also possible under ESPR, and represent cross-cutting measures applicable to groups of products sharing common characteristics.

This Joint Research Centre (JRC) report aims at assessing a number of product groups and horizontal requirements that *may* be suitable candidates for prioritisation under the first ESPR working plan.

The report focuses on **'new' priorities** – i.e., products and horizontal requirements that are not currently within the scope of the Ecodesign Directive 2009/125/EC, now repealed, which covered energy-related products. The first ESPR Working Plan can however cover both new products and energy-related products. Construction products and packaging were also not addressed in this report, as these are expected to be covered by requirements laid down under the Construction Products Regulation and the soon-to-be-adopted Packaging and Packaging Waste Regulation.

A preliminary version of this report[1] (hereafter, Preliminary Report) served as input to a **public consultation process** that was organised by the Commission in spring 2023. This consultation was comprised of a Call for Evidence document, outlining the background and aims of the exercise, and an online questionnaire, via which the general public and interested stakeholders had the opportunity to provide feedback on the findings of the preliminary version of this report, share views and expertise with the Commission, fill information gaps and ensure the planning for meaningful action to reduce the environmental impacts of products. The results of the public consultation were assessed and a factual summary report was published[2]. The results of this analysis led to a revision of the Preliminary Report, as reflected in the current document.

[1] Available at: https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2023-01/Preliminary%20ESPR%20WP%20Report_MERGED_CLEAN_.pdf

[2] Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13682-New-product-priorities-for-Ecodesign-for-Sustainable-Products/public-consultation_en

This report represents the JRC's **final analysis of new potential product priorities** for the ESPR. Together with several other elements – such as the requirements and priority list of products set out in Article 18 of the ESPR, the considerations relating to availability of resources and the political priorities of the new Commission – it will feed into the preparation of the first ESPR Working Plan, to be adopted by the Commission within 9 months from the entry into force of ESPR, following consultation of the members of the Ecodesign Forum also foreseen under ESPR.

Methodology. Building on the approach used for the 2020-2024 Ecodesign and Energy Labelling Working Plan, on Article 18 of ESPR and on Annex 16 of the Impact Assessment accompanying the Commission's proposal for ESPR, this Final Report follows two main steps:

Step 1: Identification of potential final products, intermediate products and horizontal requirements relevant to be considered for first action under ESPR;

Step 2: Assessment and scoring of the identified final and intermediate products, based on considerations of estimated environmental impacts and improvement potential, amongst others. This step is not applied to horizontal measures, as the diversity of possible provisions and product coverage makes a scientifically sound comparison very challenging.

To note: an additional complimentary assessment of the potential contribution to the EU's Open Strategic Autonomy has also been included, in order to assess whether certain dependencies in the supply chain of final or intermediate products could be mitigated by enhancing the circularity of these products under ESPR[3]*. The EU's Open Strategic Autonomy refers to the ability to act autonomously (i.e., without being dependent on other countries) in important policy areas, reflecting its strategic interests and values. Strengthening the resilience and sustainability of the EU economy while de-risking its supply chains is a pillar of the EU's drive towards Open Strategic Autonomy.*

The analysis presented within this Final Report is based on a selection of several product groups, on the basis of their estimated environmental impacts, market relevance and the extent to which possibly relevant regulatory gaps exist[4]. In particular in relation to the latter, analysis of relevant policy gaps is and will be an ongoing exercise, and decisions on optimum means of addressing such gaps – i.e., whether through Delegated Acts under ESPR, or via other existing or upcoming EU legislation[5] – will be made taking into account the regulatory situation after the conclusion of the current exercise and before adoption of the first ESPR Working Plan, as well as when preparing ecodesign measures and when adopting them.

A distinction has been made between '**final products**', such as Furniture, that are sold directly to consumers and are ready for their intended use, and '**intermediate products**', such as Iron and steel, that are placed on the market, but require further manufacturing and/or assembly processes

[3] In fact, Art. 18(1) of the ESPR states that "*The Commission shall also strive to assess the potential contribution of those products to the functioning of the internal market and to the Union's economic resilience*"

[4] Please note that regulatory measures still under preparation are also described in the product-specific datasheets (Annex 5), even if the regulatory gaps they are seeking to address cannot be considered filled until such measures are fully in place.

[5] Such as, for tyres, the type-approval, tyre labelling or end-of-life vehicles legislation under revision , or, for detergents, legislation that is currently being discussed with the European Parliament and the Council under the ordinary legislative procedure (see https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13116-Detergents-streamlining-and-updating-the-EU-rules_en)

before being ready for use as final products. The identified product groups are then evaluated based on criteria such as their environmental impacts and the improvement potential for ESPR, as well as policy gaps and reflections on costs related to the improvement potential, and preliminarily ranked.

On the basis of the product aspects listed in Article 5 of the ESPR, a number of **horizontal requirements** are also identified, with the aim of addressing certain key sustainability dimensions in a cross-cutting way, for more than one product group at a time. While this approach entails the harmonisation of definitions, principles, regulatory formulations and verification procedures, the actual ecodesign requirements could differ and be adapted to the characteristics of each product group within the horizontal measure.

It should be noted that, for the purposes of this report, horizontal requirements and products (both final and intermediate) were investigated in parallel, and may overlap in terms of scope. As such, choices are to be made between regulating a product on its own, through product-specific measures, or as part of a larger horizontal measure focussing on one product aspect. For example, Textiles and footwear could be addressed either by a product-specific measure, a horizontal requirement, or both approaches in a way that the measures complement each other by addressing different types of provisions. Furthermore, the sets of products suggested for the proposed horizontal requirements also include product groups that are not amongst the list of final and intermediate products ‘shortlisted’ as possible candidates for priority action under ESPR.

The results illustrated in this Final Report do not constitute final decisions to regulate the products prioritised, but will feed into future Commission decisions on the Working Plan and Preparatory Studies ahead of future Delegated Acts. In this sense, they do not bind the Commission: they are without prejudice to what may ultimately be prioritised for first action under ESPR, included in the first ESPR Working Plan, or undertaken under other EU policy frameworks. In fact, the Commission is required to take other aspects into account, when defining first priorities under ESPR – including the obligation to prioritise the products listed in Article 18 of the ESPR[6] for the first ESPR Working Plan.

Final and intermediate products. From an initial list of 33 product groups referenced in recent policy documents, 18 products (11 final and 7 intermediate products) are first shortlisted based on environmental, market and policy considerations. The 18 shortlisted product groups (see **Figure I**) are then assessed in terms of environmental relevance (i.e., impacts and improvement potential) for 10 impact categories addressing the main climate, environmental and energy objectives of the EU: water effects; air effects; soil effects; biodiversity effects; waste generation and management; climate change; life-cycle energy consumption; human toxicity; material efficiency; and lifetime extension (see **Figure II**). The analysis for the individual product groups is reported in the product fiches in Annex 5 and summarised in Section 3.3.1.

[6] These are: *iron & steel; aluminium; textiles, notably garments and footwear; furniture, including mattresses; tyres; detergents; paints; lubricants; chemicals; energy related products, the implementing measures for which need to be revised or newly defined; ICT products and other electronics.*

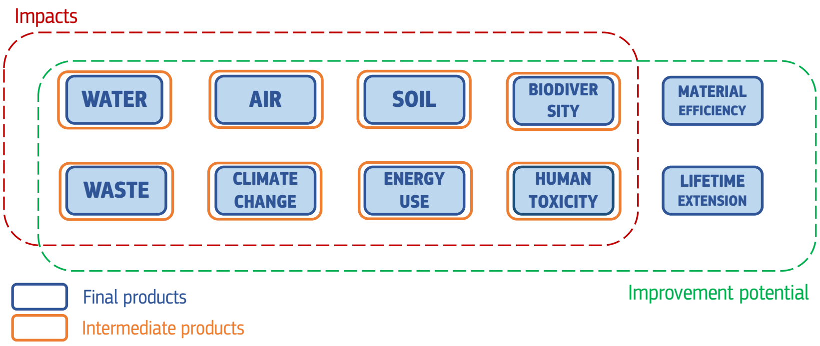
Figure I. Scope definition and market size in the EU of the 18 shortlisted product groups.

PRODUCT GROUP NAME	PRODUCT GROUP SCOPE	EU MARKET SIZE
ABSORBENT HYGIENIC PRODUCTS	Any article whose function is to absorb and retain human fluids such as urine, faeces, sweat, menstrual fluid or milk, excluding textile products. Products included are: baby diapers, panty-liners, menstrual pads, breast pads, tampons, incontinence products.	**6 bn** EUR
BED MATTRESSES	Products consisting of a cloth cover that is filled with materials and that can be placed on an existing supporting bed structure or designed for free standing in order to provide a surface to sleep or rest upon for indoor use.	**10 bn** EUR
COSMETICS	Any substance or mixture intended to be placed in contact with the external parts of the human body, or with the teeth and the mucous membranes of the oral cavity, with a view to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition or correcting body odours.	**88 bn** EUR
DETERGENTS	Any substance and mixture falling under the scope of the Detergents Product Regulation. Products included are: laundry detergents, dishwasher detergents, hard surface cleaning products (i.e. all purpose cleaners, kitchen cleaners, window cleaners, sanitary cleaners), hand dishwashing detergents.	**41 bn** EUR
FISHING GEARS	Any item or piece of equipment that is used in fishing or aquaculture to target, capture or rear marine biological resources or that is floating on the sea surface, and is deployed with the objective of attracting and capturing or of rearing such marine biological resources	**2,4 bn** EUR
FURNITURE	Free-standing or built-in units whose primary function is to be used for the storage, placement or hanging of items and/or to provide surfaces where users can rest, sit, eat, study or work, whether for indoor or outdoor use.	**140 bn** EUR
LUBRICANTS	Product capable of reducing friction, adhesion, heat, wear or corrosion when applied to a surface or introduced between two surfaces in relative motion, or is capable of transmitting mechanical power.	**30 bn** EUR
PAINTS	Products falling under the scope of the Directive 2004/42/EC for paints and varnishes, and vehicle refinishing products.	**17 bn** EUR
TEXTILES and FOOTWEAR	Textiles: Any raw, semi-worked, worked, semi-manufactured, manufactured, semi-made-up or made-up product which is exclusively composed of textile fibres, regardless of the mixing or assembly process employed, as well as a product containing at least 80% textile fibres by weight. Includes apparel textiles, home/interior textiles and technical textiles. Footwear: in line with Directive 94/11/EC, all articles with applied soles designed to protect or cover the foot. Excluded are: protective footwear covered by Regulation (EU) 2016/425	**175 bn** EUR
TOYS	Products for use in play by children under 14 that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded are: products listed in Annex 1 of Toys Safety Directive, electric and electronic toys.	**18 bn** EUR
TYRES	Products included are cars (C1), tyres, vans (C2) tyres and heavy-duty vehicles (C3) tyres	**45 bn** EUR
ALUMINUM	Aluminum and its alloys.	**40 bn** EUR
COMMODITY CHEMICALS	Large volume inorganic chemicals – ammonia, acids and fertilisers: ammonia, nitric acid, sulphuric acid, phosphoric acid and hydrofluoric acid, phosphorus-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers). Large volume inorganic chemicals – solids and others industry: soda ash, titanium dioxide, carbon black (rubber and speciality grades), synthetic amorphous silica (pyrogenic silica, precipitated silica, and silica gel). Large volume organic chemicals: lower olefins by the cracking process, aromatics such as benzene/toluene/xylene (BTX), oxygenated compounds such as ethylene oxide, ethylene glycols and formaldehyde, nitrogenated compounds such as acrylonitrile and toluene diisocyanate, halogenated compounds such as ethylene dichloride and vinyl chloride monomer (VCM), sulphur and phosphorus compounds and organo-metallic compounds.	**760 bn** EUR
GLASS	Products included: container glass, flat glass, continuous filament glass fibre, domestic glass, special glass, mineral wool, high temperature insulation wools and frits.	**30 bn** EUR
IRON and STEEL	Iron and steel. Steel is an alloy of iron and carbon, where the carbon content can range up to 2% (when the carbon content is over 2%, the material is defined as cast iron).	**130 bn** EUR
NON-FERROUS METAL PRODUCTS, NON-AL.	Products made of six primary and secondary non-ferrous metals: Copper and its alloys; Lead and tin; Zinc and cadmium; Precious metals: gold (electronics), silver (industrial applications), platinum, palladium, rhodium, iridium, ruthenium and osmium (the platinum group metals, mainly used as catalysts); Ferro-alloys: bulk ferro-alloys and special ferro-alloys; Nickel and cobalt. Does not include aluminum.	**80 bn** EUR
PAPER, PULP and BOARDS	Pulp, paper and board obtained by chemical, kraft, sulphite, mechanical and chemi- mechanical pulping, recovered paper processing and papermaking	**115 bn** EUR
PLASTICS and POLYMERS	Polymeric material that has the capability of being moulded or shaped, usually by the application of heat and pressure. It usually contains polymers and additives that give additional properties to the mixture. The scope is plastic basic materials, synthetic rubbers and hydrocarbons containing oxygen	**405 bn** EUR

Source: JRC own elaboration.

In order to rank the shortlisted product groups, a score has been attributed to each product group for each impact category, based on the relevance of the impacts and of the improvement potential, the score ranging from 1 (very low) to 5 (very high). **Figure III** and **IV** below show the score of product groups for each environmental category and the total score, leading to a **final ranking of product groups**. Since the assessment of environmental relevance differed for final products and intermediate products in terms of environmental aspects considered, results are presented separately and cannot be compared between each other. The analysis also addressed products' improvement potential, and listed examples of possible potential measures identified for each product group, assessing whether they are already dealt with by existing EU policies. In **Figure V**, the 11 shortlisted final products are presented, together with current coverage through environmental legislation and examples for potential ecodesign requirements. These examples for potential ecodesign requirements are illustrative and can by no means be understood as pre-determination of future legislation; their aim is rather to identify areas of interest for a specific product group.

Figure II. Environmental aspects considered for the assessment of products' environmental relevance.



Source: JRC own elaboration

In addition, to assess the potential contribution of the listed products to enhancing the **EU's Open Strategic Autonomy**, a composite indicator is designed to cover (i) the use of critical raw materials, (ii) the use of fossil feedstock (oil and gas), (iii) energy-related consumption during manufacturing and use stages, and (iv) product groups or associated material targeted by EU import restrictions or sanctions. The assessment follows a similar approach as applied for the environmental part, with a scale from 1 to 5 indicating the relevance of the product group with regards to EU Open Strategic Autonomy objectives (results are included in Figures III and IV). However, the resulting score on Open Strategic Autonomy is not used to rank products, as it is included in ESPR Art.18 as additional assessment but not part of the prioritisation criteria of Art. 18 of ESPR.

Horizontal requirements. As outlined in the ESPR, where two or more product groups display one or more similarities allowing a product aspect (as referred to in Art. 5(1) of the ESPR) to be effectively improved based on common ecodesign information or performance requirements, such requirements may be established horizontally for those product groups.

Five aspects for possible horizontal requirements were considered in this report: "Durability" (which includes "Reparability"), "Recyclability", "Lightweight design", "Post-consumer recycled content", and "Sustainable sourcing". After consideration, three of these aspects are proposed for action under ESPR (see **Figure VI**). The two others ("Lightweight design" and "Sustainable sourcing") were initially considered as proposals but then discarded in the course of the study, and not further elaborated as not mature enough. Each of these horizontal requirements is accompanied by a set of suggestions for potential provisions, via which they could be concretely implemented, and by a potential set of products to which they could be applied.

While feedback on the suggestions for potential provisions and products was sought via the public consultation exercise held in 2023, it is worth noting that horizontal requirements may be of particular relevance also for energy-related products, which are not covered in this Final Report. Potential 'horizontal initiatives', largely on the same aspects, were also assessed in preparation of the Ecodesign and Energy Labelling Working Plan. Energy-related products are referenced in the horizontal requirements proposals as potentially relevant (in Table V), however additional assessment (outside the scope of this study) would be required for their inclusion.

Figure III. The 11 shortlisted **final products**.

Score	Product	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	HUMAN TOXICITY	MATERIAL EFFICIENCY	LIFETIME EXTENTION	STRATEGIC AUTONOMY
42	TEXTILES and FOOTWEAR	5	3	4	4	5	5	5	3	5	3	1
30	FURNITURE	1	3	3	3	4	3	3	2	3	5	1
30	TYRES	3	4	3	3	3	3	3	2	3	3	4
28	BED MATTRESSES	1	3	1	2	5	3	3	2	5	3	1
26	DETERGENTS	4	2	2	3	3	3	3	2	3	1	1
24	PAINTS	3	3	2	3	3	2	2	2	3	1	1
24	COSMETICS	4	2	1	4	3	2	1	2	3	1	1
23	LUBRICANTS	2	2	2	2	2	3	2	2	3	3	2
23	TOYS	1	1	1	1	4	2	2	3	3	5	1
21	FISHING GEARS	4	1	1	4	3	2	1	1	3	1	1
19	ABSORBENT HYGIENE PRODUCTS	3	1	2	2	4	2	2	1	1	1	1

Source: JRC own elaboration

Figure IV. The 7 shortlisted **intermediate products**.

Score	Product	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	HUMAN TOXICITY	STRATEGIC AUTONOMY
30	IRON & STEEL	5	4	2	2	4	5	5	3	5
28	COMMODITY CHEMICALS	4	4	3	3	3	5	4	2	5
27	NON-FERROUS METAL PRODUCTS	3	2	3	2	5	4	5	3	4
26	ALUMINIUM	1	4	4	3	4	4	4	2	3
23	PLASTICS	3	3	2	2	3	4	4	2	3
21	PULP & PAPER	3	2	3	3	2	3	4	1	2
20	GLASS	2	2	2	3	2	4	4	1	3

Source: JRC own elaboration

Figure V. Summary of the main product environmental aspects already regulated in the EU (left-hand column) for the 11 shortlisted final products, and exemplary list of possible improvement measures for such products (right-hand column), in accordance with Annex I to ESPR. Non-exhaustive lists. For further information see Section 3.2.1.1 and Annex 5.

IMPORTANT: The examples for potential ecodesign requirements are of illustrative nature and can by no means be understood as pre-determination of future legislation. Assessment of the appropriate ecodesign requirements to set for a given product group will start once the product group in question has been included in an ESPR working plan.

TEXTILES and FOOTWEAR

Environmental aspects regulated in the EU

- Emissions from EU production of textiles
- Mandatory due diligence for cotton
- Separate collection of textile waste
- Voluntary labelling of energy consumption from low carbon sources

Examples of potential ecodesign requirements

- Maximum limit of microplastics release
- Minimum content of raw materials with sustainability certification
- Maximum amount of life cycle waste generated
- Safe, easy and non-destructive access to recyclable components
- Use of easily recyclable materials or combination of materials
- Minimum recycled content
- Maximum number of materials and components used
- Adequate and standard sizing and fitting of the product
- Maximum level of carbon footprint
- Maximum level of life cycle energy consumption
- Minimum reliability

FURNITURE

Environmental aspects regulated in the EU

- Emissions from EU production of main materials (plastics, steel, glass)
- Mandatory due diligence for wood
- Carbon emissions of main materials
- Voluntary labelling of energy consumption from low carbon sources

Examples of potential ecodesign requirements

- Emissions from the production of furniture
- Minimum content of raw materials with sustainability certification
- Minimum recycled content
- Safe, easy and non-destructive access to recyclable components
- Use of easily recyclable materials or combination of materials
- Maximum number of materials and components used
- Compatibility with commonly available tools and spare parts
- Minimum reliability
- Availability and affordability of spare parts
- Use of standards components
- Minimum share of energy use from low carbon sources
- Availability of guarantees and information

TYRES

Environmental aspects regulated in the EU

- Emissions from EU production of rubber
- Type approval
- Mandatory due diligence for rubber
- Waste prevention and recycling targets

Examples of potential ecodesign requirements

- Minimum content of raw materials with sustainability certification
- Ease of upgrading, re-use, remanufacturing and refurbishment
- Minimum recycled content
- Maximum level of carbon footprint
- Minimum content of sustainable renewable materials

BED MATTRESSES

Environmental aspects regulated in the EU

- Emissions from EU production of main materials
- Mandatory due diligence for rubber and wood
- Waste prevention and recycling targets

Examples of potential ecodesign requirements

- Maximum amount of life cycle waste generates
- Minimum content of raw material with sustainability certification
- Safe, easy and non-destructive access to recyclable components
- Minimum recyclability and recycled content
- Maximum level of carbon footprint
- Minimum reliability
- Availability of info long after the product is sold

DETERGENTS

Environmental aspects regulated in the EU

- Emissions from EU production of chemical ingredients
- Mandatory due diligence for palm oil and soy
- Recyclability and recycling content of packaging
- Push for refillable packaging
- Chemical safety

Examples of potential ecodesign requirements

- Emissions from production of detergent products
- Minimum content of raw material with sustainability certification
- Maximum level of carbon footprint
- Minimum share of energy use from low carbon sources
- Efficiency of the product at low energy consumption
- Minimum content of sustainable renewable materials
- Lightweight design
- Maximum product-to-packaging ratio
- Availability of spare parts

Source: JRC own elaboration

Figure V (continues). Summary of the main product environmental aspects already regulated in the EU (left-hand column) for the 11 shortlisted final products, and exemplary list of possible improvement measures for such products (right-hand column), in accordance with Annex I to ESPR. Non-exhaustive lists. For further information see Section 3.2.1.1 and Annex 5.

IMPORTANT: The examples for potential ecodesign requirements are of illustrative nature and can by no means be understood as pre-determination of future legislation. Assessment of the appropriate ecodesign requirements to set for a given product group will start once the product group in question has been included in an ESPR working plan.

PAINTS and VARNISHES

Environmental aspects regulated in the EU

- Emissions of EU production of some ingredients of paints
- Recyclability and recycling content of packaging
- Chemical safety

Examples of potential ecodesign requirements

- Emissions from production of paints and varnishes
- Maximum level of life cycle release of microplastics and nanoplastics
- use of easily recyclable materials
- Maximum product to packaging ratio
- Minimum reliability
- Maximum material footprint of the product

COSMETICS

Environmental aspects regulated in the EU

- Emissions of EU production of chemical ingredients
- Presence of microplastics
- Mandatory due diligence on palm oil and soy
- Recyclability and recycling content of packaging
- Push for refillable packaging
- Chemical safety

Examples of potential ecodesign requirements

- Emissions from production of cosmetics products
- Minimum content of raw material with sustainability certification
- Restrictions of secondary packaging
- Maximum amount of product remaining in the packaging
- Maximum level of carbon footprint
- Maximum product to packaging ratio
- Lightweight design
- Mandatory minimum use of renewable materials
- Minimum content of sustainable raw materials

LUBRICANTS

Environmental aspects regulated in the EU

- Recyclability and recycling content of packaging
- Chemical safety

Examples of potential ecodesign requirements

- Minimum content of sustainable renewable materials
- Maximum product to packaging ratio
- Maximum level of carbon footprint
- Minimum reliability

TOYS

Environmental aspects regulated in the EU

- Toys safety
- Mandatory due diligence rules o wood.
- Waste prevention and recycling targets

Examples of potential ecodesign requirements

- Safe, easy and non-destructive access to recyclable parts
- Use of easily recyclable materials or combination of materials
- Ease of upgrading, re-use, remanufacturing and refurbishment
- Maximum number of materials and components used
- Minimum recycled content
- Maximum level of carbon footprint
- Minimum content of sustainable renewable materials
- Maximum product to packaging ratio
- Minimum reliability
- Availability and affordability of spare parts
- Availability of guarantees and information

FISHING GEARS

Environmental aspects regulated in the EU

- Marking and identification of fishing gears
- Restrictions on the use of specific fishing gears

Examples of potential ecodesign requirements

- Use of component and material coding standards
- Design of traps and pots with effective escape mechanisms with biodegradable mechanisms
- Use of easily recyclable materials or combination of materials
- Minimum content of biodegradable materials
- Design for lighter weight
- Use of standard components
- Design to facilitate repair
- Availability of information

AHP

Environmental aspects regulated in the EU

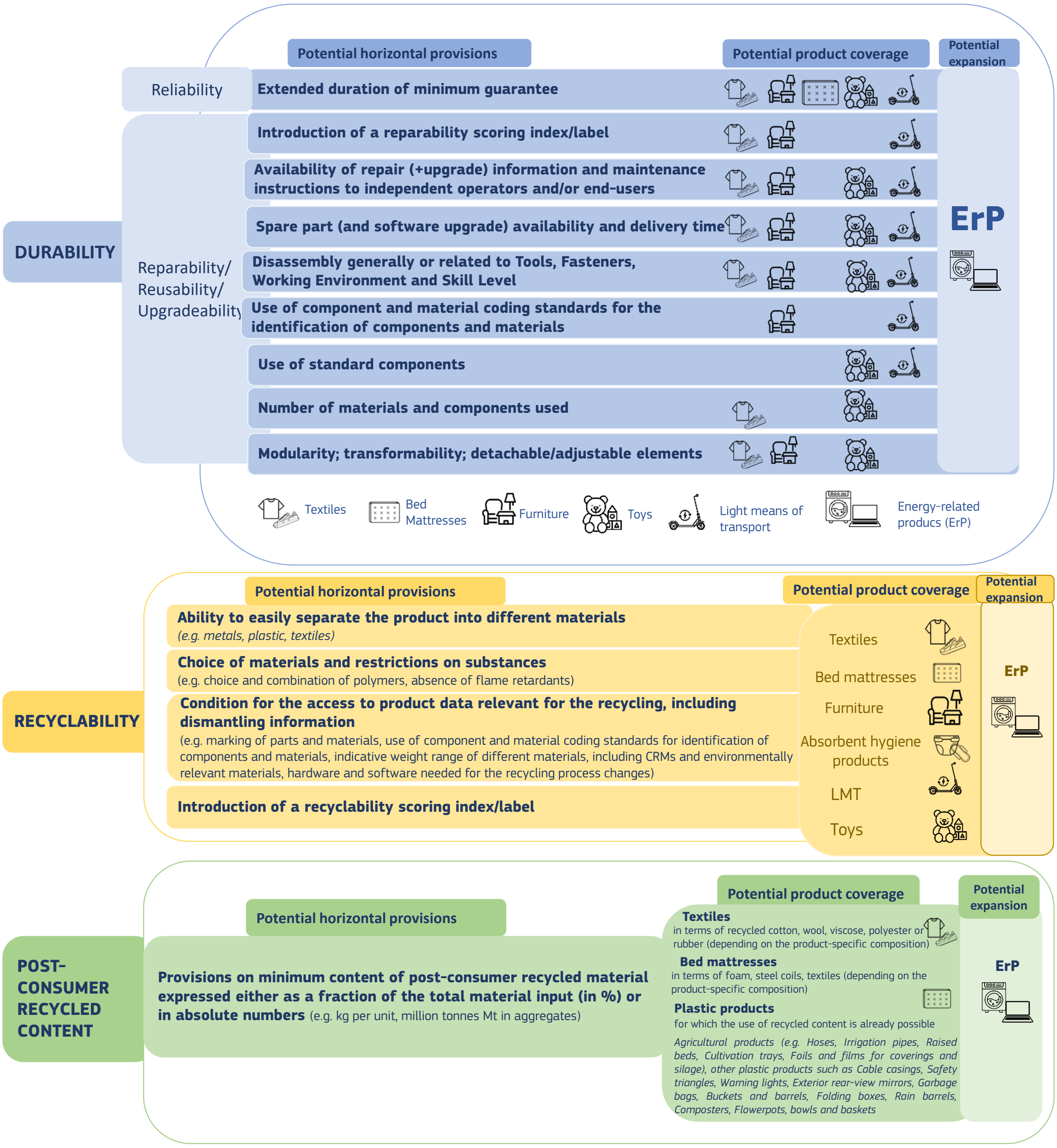
- Emissions of EU production of fluff pulp and viscose

Examples of potential ecodesign requirements

- Emissions from production of AHP
- Use of easily recyclable materials or combination of materials
- Minimum recycled content
- Maximum number of materials and components used
- Safe, easy and non-destructive access to recyclable parts
- Use of component and material coding standards

Source: JRC own elaboration

Figure VI. Proposed horizontal requirements, including suggestions for potential provisions and product coverage. CRMs: critical raw materials; ErP: Energy-related products; LMT: Light means of transport



Source: JRC own elaboration

Quantification of environmental impacts. With current EU consumption patterns leading to impacts beyond the limits of the planet for several Planetary Boundaries, the ESPR is expected to bring positive changes not only in making the products more sustainable but also in shaping better consumption patterns. In this respect, a quantitative estimation was performed relying on the Life Cycle Assessment-based Consumption Footprint model, which is used to support EU policy-making. Although food is one of the major areas of consumption contributing to the overall EU footprint, the estimation conducted in this report shows that the products suggested as a priority in this Final Report (which exclude food) still represent a relevant share of impacts. However, the behaviour of consumers is expected to play a key role that may reduce the effectiveness of the ESPR implementation due to possible demand led rebound effects – i.e., increased product efficiency that leads to higher demand for that product. Such effects should be considered and mitigated when preparing future Delegated Acts. Moreover, a quantitative estimation of the potential effects of horizontal requirements on final products shows benefits up to 28%, with durability making a key contribution (see Section 4.3.3 and Annex 8 for details). Such benefits will depend on the ambition of the requirements to be set in future Delegated Acts and will contribute to bringing the EU consumption patterns and the associated Consumption Footprint to stay within the limits imposed by the Planetary Boundaries.

The results of this Final Report identify 11 final products, 7 intermediate products and three horizontal requirements as potential priorities for the setting of ecodesign criteria under ESPR, given their relevance in terms of environmental impacts, improvement potential, Open Strategic Autonomy, and the extent to which such products are covered by EU policies. This Final Report will feed into reflections on the first ESPR Working Plan, which will consider also additional aspects, including the list of products set out in Art. 18 of ESPR, consultation with stakeholders and Member States, and the political priorities of the new Commission. Products selected for the first Working Plan will be the focus of ad-hoc Preparatory Studies that will investigate from scratch the feasibility of setting ecodesign requirements and the detailed definition of such requirements. This will be complemented by dedicated impact assessments and stakeholder consultations.

1 Introduction

In recent years, the European Union has assumed a leadership role on environmental sustainability. In particular, the European Union (EU) has committed to achieving a more circular economy (EC, 2015 and 2020a) and full climate neutrality by 2050 (EC, 2019a); however, we are not there yet.

In 2022, the EU's circular material use rate was estimated at 11.5%, meaning that 11.5% of material resources used in the EU came from recycled materials (Eurostat, 2023). The remaining material resources came from mining and harvesting. However, while the intensity of the global economy in terms of materials use is expected to decline, global use of materials was projected to rise from 79 billion tonnes in 2011 to 167 billion tonnes in 2060 (OECD, 2019) – more than double - due to the expected growth in population (UN, 2019) and increase in Gross Domestic Product (OECD, 2019). The global generation of solid waste management was estimated at 2 000 million tonnes in 2016, expected to grow to 3 400 million tonnes by 2050 (The World Bank, 2018). In the EU, 225.7 million tonnes of municipal waste were generated in 2020, representing a 1% increase compared to 2019 and 14% increase compared to 1995 (Eurostat, 2022). Moreover, more than half of global greenhouse gas (GHG) emissions were estimated to be related to materials management activities, which are expected to rise to 50 billion tonnes CO2-eq. by 2060 (OECD, 2019). The EU's GHG emissions totalled 3,119 million tonnes of CO2-equivalents in 2020 (EEA, 2023; The World Bank, 2023), and preliminary 2022 estimates indicate that EU-wide net GHG emissions stood at 31% below 1990 levels, with a 2% decline of GHG emissions compared with 2021 (EEA, 2023).

EU legislation already addresses a number of sustainability aspects of products placed on the EU market. The Ecodesign Directive[7], in particular, sets out EU-wide minimum mandatory environmental requirements, especially in terms of energy efficiency, for a number of products, such as household appliances, information and communication technologies or engineering. In some cases, the Energy Labelling Regulation (Regulation EU/2017/1369) complements those ecodesign requirements with mandatory labelling requirements. Often, sectorial legislation also addresses some environmental aspects of products, e.g., the Detergents Regulation (Regulation EC/648/2004) or the Single Use Plastics Directive (Directive EU/2019/904). Moreover, the EU Ecolabel Regulation (Regulation EC/66/2010) sets out voluntary requirements to identify environmental excellence in the market, empowering consumers to make informed choices and play an active role in the green transition. Finally, the European Commission has developed guidance in the area of public procurement, publishing, since 2008, criteria for Green Public Procurement for more than 20 products.

In this context, the Ecodesign for Sustainable Products Regulation (ESPR) recently entered into force[8]. This Regulation aims at creating a strong and coherent policy framework for sustainable products. While the ESPR is a framework Regulation, future Delegated Acts will establish minimum requirements for specific product groups to significantly improve their circularity, energy performance and other environmental sustainability aspects. In addition, the ESPR includes the possibility to set out, when needed, horizontal requirements, i.e., cross-cutting requirements applicable to groups of products sharing common technical characteristics. To implement such requirements, delegated acts

[7] Directive 2009/125/EC.

[8] Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC.

will be developed on the basis of a Working Plan (WP), thus enabling the prioritisation of the most relevant products and horizontal requirements.

1.1 Study aims

This JRC Report aims at recommending a ranking of the new product groups and horizontal requirements that – in addition to the energy-related products already identified in the Ecodesign and Energy Labelling Working Plan 2022-2024[9] – will feed into reflections on the priorities for regulation under ESPR, and in particular for inclusion in the first ESPR Working Plan.

In this report, the relevance of a number of product groups and horizontal requirements was evaluated in terms of environmental sustainability and circularity impacts and improvement potential; economic weight; and current coverage by EU policies, in order to propose a suggested ranking of products recommended for regulation under ESPR. This report thus represents the first step towards reducing the negative life-cycle environmental impacts of products under the new ESPR framework.

A consultation process has taken place on the findings of an earlier version of this report[10], hereafter Preliminary Report, enabling the collection of additional information and further contributing to the preparation of the first ESPR Working Plan. This consultation was comprised of a Call for Evidence document, outlining the background and aims of the exercise, and an online questionnaire, via which the general public and interested stakeholders had the opportunity to provide feedback on the findings of the Preliminary Report, share views and expertise with the Commission, fill information gaps and ensure that the correct action to reduce the environmental impacts of products is planned.

The results of the public consultation were assessed and a factual summary report of the public consultation was published[11]. A brief overview of the results of the public consultation is also presented in Section 1.4 of this report.

The results of the consultation were analysed, leading to a revision of the preliminary study on new product priorities. The JRC has considered all comments submitted as part of the public consultation on the study on new product priority, being it questionnaire responses or position papers. Based on such feedback, whenever stakeholders' contribution could be verified by published studies and data, the JRC has carried out further research, and revised the product fiches (Annex 5 of the report) as well as the proposal for horizontal requirements.

This report represents the JRC's final analysis of new product priorities for the Ecodesign for Sustainable Products Regulation, and will feed into the preparation of the first ESPR working plan, to be adopted 9 months after the entry into force of the ESPR, in accordance with the relevant procedures set out in that Regulation.

1.2 Prioritisation and planning in the ESPR

Article 18(1) of the ESPR text lists the criteria that should be taken into account by the Commission when prioritising the products to be covered by ecodesign requirements. These include the products'

[9] Communication from the Commission 2022/C 182/01

[10] Available at this link

[11] Available at this link

potential contribution to achieving the European Union's climate, environmental and energy efficiency objectives, taking into account:

(a) the potential for improving products' circularity and environmental impacts (in turn taking into account (i) the absence or insufficiency of EU law, as well as (ii) disparities in the performance of relevant products available on the market);

(b) the volume of sales and trade (see also);

(c) the distribution of the climate and environmental impacts, energy use, resource use and waste generation across the value chain; and

(d) the need to regularly review and adapt measures adopted, in light of technological and market development.

In addition, Article 18(1) stipulates that "*the Commission must strive to assess the potential contribution of the prioritised products to the functioning of the internal market and to the Union's economic resilience*".

With respect to horizontal requirements, Article 18(2) states that "*the Commission must take into consideration the benefits of having such requirements imposed on a range of products and product groups in the same Delegated Act*".

It should also be noted that Article 18(5) requires the Commission to prioritise the following products in the first ESPR Working Plan: "*iron & steel; aluminium; textiles, notably garments and footwear; furniture, including mattresses; tyres; detergents; paints; lubricants; chemicals; energy related products, the implementing measures for which need to be revised or newly defined; ICT products and other electronics*". If a decision is taken not to include any of these products, or to include product groups outside this list, the Commission will need to justify why.

The analysis in this Final Report was carried out before the ESPR entered into force and in particular before Article 18 was finally drafted and the list of priority products introduced. Nevertheless, the analysis corresponds largely to the prioritisation criteria of Article 18, as **Figure 2** shows.

1.3 Methodology and structure of the study

This report addresses three types of possible ecodesign requirements: final products requirements, intermediate products requirements and horizontal requirements. While final products are goods placed on the market and ready for use or consumption, intermediate products require further transformation such as mixing, coating or assembling to make it suitable for customers. Components are products intended to be incorporated into other products. Finally, horizontal requirements, as stated earlier, are cross-cutting requirements applicable to groups of products sharing enough technical similarities.

Due to the inherent difference between product groups and horizontal requirements, two distinct methodologies were applied to, on the one hand, final and intermediate products, and, on the other hand, horizontal requirements (**Figure 1**). The structure and methodology of this study builds on the three-step approach used for the Ecodesign and Energy Labelling Working Plan and on the methodological aspects described in Annex 16 to the Impact Assessment accompanying the ESPR proposal from March 2022 (COM(2022) 142 final).

With respect to the Ecodesign Directive and the Energy Labelling Regulation, the latest study for the Ecodesign and Energy Labelling Working Plan 2022-2024 includes three main steps (tasks 2 – 4) [12]: (2) identification of the product groups and horizontal initiatives; (3) preliminary analyses of the product groups and horizontal initiatives based on the Methodology for Ecodesign of Energy-Related Products (MEErP); and (4) complementary analyses for selected products and recommendations for the Working Plan. In addition, Annex 16 to the Impact Assessment[13] to the ESPR proposal described four main steps: (1) Prioritisation of the products; (2) Assessment of the products: (3) Definition of requirements: (4) Monitoring of results.

Building on the above, this Report follows these steps:

— Step 1: Identification of potential final products, intermediate products and horizontal requirements to be considered for first action under ESPR (Section 2); and

— Step 2: Suggested prioritisation of the identified final and intermediate products, based on considerations of estimated environmental impacts and improvement potential, amongst others (Section 3).

These two steps have been informed by the results of the stakeholder consultation carried out in 2023, and will feed into the development of the first ESPR Working Plan, expected 9 months after the entry into force of ESPR, as explained in Section 1.4.

As illustrated in **Figure 1**, the horizontal requirements proposed do not go through Step 2, i.e., the prioritisation process. Apart from the fact that the number of horizontal requirements proposed in this report is already lower compared to the products case, the main reason for not prioritising them is the difficulty in comparing horizontal requirements against one another. While product-specific requirements are comparable across the same impact categories and improvements, horizontal requirements are not.

The relationship between products and horizontal requirements is considered, at this stage, flexible, as a product group can be proposed as part of product-specific Delegated Act (i.e., to be regulated on its own) and under horizontal requirements (i.e., included alongside other groups under a cross-cutting Delegated Act), logically not with overlapping or conflicting requirements. Ultimately, some aspects of a product group could be covered vertically, and others horizontally. In other words, the two approaches to ecodesign requirements can act both exclusively and complementarily.

With respect to the prioritisation methodology, **Figure 2** summarises how and where this report addresses the different prioritisation criteria listed in Article 18 of the ESPR text.

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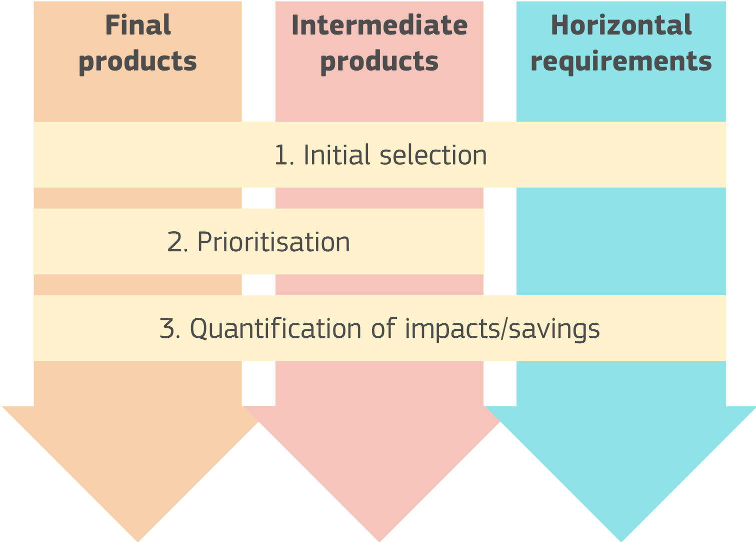
12 Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024

13 Available at this link

Figure 1. Overview of the methodology adopted in this report.



Source: JRC own elaboration

The first and overarching criterion mentioned in Art. 18(1) is the "*potential contribution of products to achieving Union climate, environmental and energy objectives*". In this report, this criterion was considered first when selecting product groups for the initial list of products (Step 1), which represented a preliminary basket of products that have recently been considered in different policy documents because of their environmental relevance, and, most importantly, by carrying out an analysis of their environmental impacts and expected improvement potential in terms of ten environmental categories (Step 2). As a complementary analysis, the contribution of the prioritised product groups to the crossing of the planetary boundaries[14] was estimated in Section 4.2 of the report. It should be noted that this criterion in Art. 18 is of a more general nature and refers to the EU policy objectives. The remaining criteria should not be seen as sub-criteria of this first one, but rather as more technical criteria that, if fulfilled, can be considered as fulfilling this first one.

Point (a) in Art. 18(1) of the ESPR refers to the "*potential for improving the product aspects without entailing disproportionate costs*"[15]. To address this point, the potential for improving the environmental performance of each product group in Step 2 was analysed in terms of ten environmental categories. Technology state of the art solutions for reducing products' environmental impacts were considered for each product group, as well as the expected room for manoeuvre for ESPR Delegated Acts. Information on potential costs associated with the identified improvement measures were also sought and related considerations were summarised in Section 3.3.3, although it was very challenging to find such cost data, and the reflections presented in this report will have to be revisited at the time of preparatory studies. For horizontal requirements, potential

[14] Planetary boundaries describe the Earth's capacity to bear environmental impacts (i.e., "Earth's carrying capacity").

[15] Products aspects are listed in Article 5 and are: durability; reliability; reusability; upgradability; repairability; the possibility of maintenance and refurbishment; the presence of substances of concern; energy use and energy efficiency; water use and water efficiency; resource use and resource efficiency; recycled content; the possibility of remanufacturing; recyclability; the possibility of the recovery of materials; environmental impacts, including carbon footprint and environmental footprint; expected generation of waste.

environmental savings of the proposed requirements were quantified, and the estimates are presented in Section 4.3.

Point (a)(i) in Art. 18(1) of the ESPR refers to the criterion on "*the absence or insufficiency of Union law, or failure of market forces or of self-regulation measures to address the objective properly*". This criterion was addressed preliminarily in Step 1, and to a more comprehensive extent in Step 2, by analysing existing and upcoming EU legislation regulating the main improvement potential aspects identified for each product group, thus giving an indication of the room for manoeuvre for the potential ecodesign requirements.

Point (a)(ii) in Art. 18(1) of the ESPR refers to "*the disparity in the performance of products available on the market that have equivalent functionality in relation to the product aspects*". This criterion was taken into account when evaluating the products' potential for improvement on certain environmental aspects to the extent that the information was available in the literature, which was often very scarce.

Point (b) in Art. 18(1) of the ESPR refers to "*the volume of sales and trade of those product within the Union*". This criterion was considered in Step 1, when shortlisting products from an initial long list to a shorter list containing products for further assessment in terms of their environmental relevance. Indeed, the economic relevance of a product group was one of the main criteria used to shortlist products, thus making sure that only market relevant product groups were retained.

Point (c) in Art. 18(1) of the ESPR refers to "*the distribution across the value chain of the climate and environmental impacts, energy use, resource use and waste generation*". This criterion was addressed in Step 2 when analysing the environmental impacts of the shortlisted product groups, where information was retrieved on the life-cycle stages responsible for certain environmental impacts.

Point (d) in Art. 18(1) of the ESPR refers to "*the need to regularly review and adapt delegated acts adopted pursuant to Article 4 in light of technological and market developments*". This aspect is not relevant to this report, and it is only applicable to the development of working plans after the first one, as it refers to the possibility that product groups identified as priority in a working plan were not eventually addressed by ESPR Delegated Acts, thus leaving them for action to future working plans, as well as the possibility to update ecodesign requirements on existing Delegated Acts due to possible update to technical progress.

Art. 18 also states that "*The Commission shall also strive to assess their potential contribution to the functioning of the internal market and to the **Union's economic resilience***". In line with that, this study presents an analysis of the potential contribution to the EU's Open Strategic Autonomy, in order to assess whether certain dependencies in the supply chain of final or intermediate products could be mitigated by enhancing the circularity of these products under ESPR. The findings of this analysis can be found in Section 3.3.5.

In addition, this study also presents a complementary assessment to quantify the life-cycle environmental impacts related to the product groups prioritised in Step 2 as well as the potential savings associated with the implementation of the horizontal requirements identified in Step 1. The findings in this respect (Section 4), were further developed following the 2023 public consultation exercise.

Figure 2. Criteria to be taken into account for the prioritisation and planning of products according to Article 18 of the Ecodesign for Sustainable Products Regulation (ESPR), and how and where such criteria were addressed by this report. Different blue boxes indicate the different criteria listed in Art. 18 of the ESPR proposal, where the first criterion is more general and related to policy objectives. env.: environmental; hor. req.: horizontal requirements; PG: Product group. n.a.: not available.

ESPR Art. 18 – Prioritisation and planning	This Report – How it is addressed	This Report – Where it is addressed
POTENTIAL CONTRIBUTION TO UNION CLIMATE, ENVIRONMENTAL AND ENERGY EFFICIENCY OBJECTIVES	ANALYSIS OF IMPACTS AND IMPROVEMENT POTENTIAL FOR SHORTLISTED PGs; CONTRIBUTION TO PLANETARY BOUNDAIRES	SECTION 3.2 (methodology); SECTION 4.2 (env. impacts); ANNEX 5 (product fiches)
(a) POTENTIAL FOR IMPROVING PRODUCTS' ASPECTS (reported in Art.5) AND ENVIRONMENTAL IMPACTS WITHOUT ENTAILING DISPROPORTIONATE COSTS	ANALYSIS OF IMPACTS AND IMPROVEMENT POTENTIAL FOR SHORTLISTED PGs	ANNEX 5 (product fiches); SECTION 3.3.3 (reflections on potential costs); SECTION 4.3 (potential benefits of hor. req.)
(i) ABSENCE OR INSUFFICIENCY OF UNION LAW OR FAILURE OF MARKET FORCES OR OF SELF-REGULATION MEASURES TO ADDRESS THE OBJECTIVE PROPERLY	ANALYSIS OF EXISTING EU LEGISLATION ADDRESSING THE IDENTIFIED IMPROVEMENT POTENTIAL	ANNEX 5 (product fiches); SECTION 3.3.2 (policy gaps)
(ii) DISPARITY IN THE PERFORMANCE OF PRODUCTS AVAILABLE ON THE MARKET THAT HAVE EQUIVALENT FUNCTIONALITY IN RELATION TO THE PRODUCT ASPECTS	ANALYSIS OF IMPACTS AND IMPROVEMENT POTENTIAL FOR SHORTLISTED PGs	ANNEX 5 (product fiches), when relevant information could be found
(b) THE VOLUME OF SALES AND TRADE OF THE PRODUCT WITHIN THE UNION	ANALYSIS OF MARKET RELEVANCE WHEN SCREENING THE INITIAL LIST OF PRODUCTS	SECTION 2.3 (methodology); ANNEX 2 (screening of products)
(c) THE DISTRIBUTION ACROSS THE VALUE CHAIN OF THE CLIMATE AND ENVIRONMENTAL IMPACTS, ENERGY USE, RESOURCE USE AND WASTE GENERATION OF THE PRODUCT	ANALYSIS OF IMPACTS AND IMPROVEMENT POTENTIAL FOR SHORTLISTED PGs	ANNEX 5 (product fiches), when relevant information could be found
(d) THE NEED TO REGULARLY REVIEW AND ADAPT DELEGATED ACTS IN LIGHT OF TECHNOLOGICAL AND MARKET DEVELOPMENTS	NOT RELEVANT AT THIS STAGE	n.a.

Source: JRC own elaboration based on Regulation (EU) 2024/1781

1.4 Open public consultation

The public consultation was open for input between 31 January and 12 May 2023. The questionnaire comprised the following sections:

- An introductory section that collected information about the demographic profile of the respondents.
- Three thematic sections that gathered opinions about 1) end-use products 2) intermediate products and 3) horizontal measures. All three sections included general questions, as well as questions per product group/horizontal measure.
- A final section where the survey participants could submit general comments and upload supplementary documents.

The open public consultation (OPC) on 'New Product Priorities for Ecodesign for Sustainable Products' aimed at:

- gathering the views of the general public and interested stakeholders on what the first priorities under the future Ecodesign for Sustainable Products Regulation (ESPR) should be;
- refining the findings of the preliminary version of this study – which identified several product groups and horizontal measures that may be suitable candidates for prioritisation under the ESPR, once it enters into force;
- closing information gaps;
- helping build consensus on future action under the ESPR; and
- helping prepare for a smooth implementation once ESPR enters into force.

While the factual summary on the results of the public consultation is available online, the paragraphs below give a brief overview of the stakeholders' feedback.

1.4.1 Questionnaire statistics

The questionnaire developed for the purpose of the OPC consisted of several single-select, multiple-choice questions. The responses to the questionnaire thus enabled the analysis of the results via basic statistics. 447 stakeholders responded to the questionnaire, providing interesting insights on how stakeholders reacted to the Preliminary Report.

The vast majority of questionnaire respondents was from the EU (89%), with contributions also from non-EU countries, especially Japan (3% of respondents), United States (2%), the UK (1%), Norway (1%), Australia (1%) and Switzerland (1%). Within the EU, Belgium, France, Germany and Italy represented more than 70% of respondents.

Industry stakeholders were the most frequently represented stakeholders, making up 73% of the questionnaire respondents. NGOs provided 7% of the questionnaire responses, while public authorities provided 3%.

When asked about their sector, over two thirds of industry stakeholders came from sectors related to the products identified in JRC's preliminary study (69%). 15% represent Textiles and Footwear, 7% Chemicals and 6% Plastic and Polymers. The other 31% of industry stakeholders came from sectors related to products not identified in the preliminary study, notably 6% from the energy-related products sector, 5% from the construction products sector and 4% from the packaging sector.

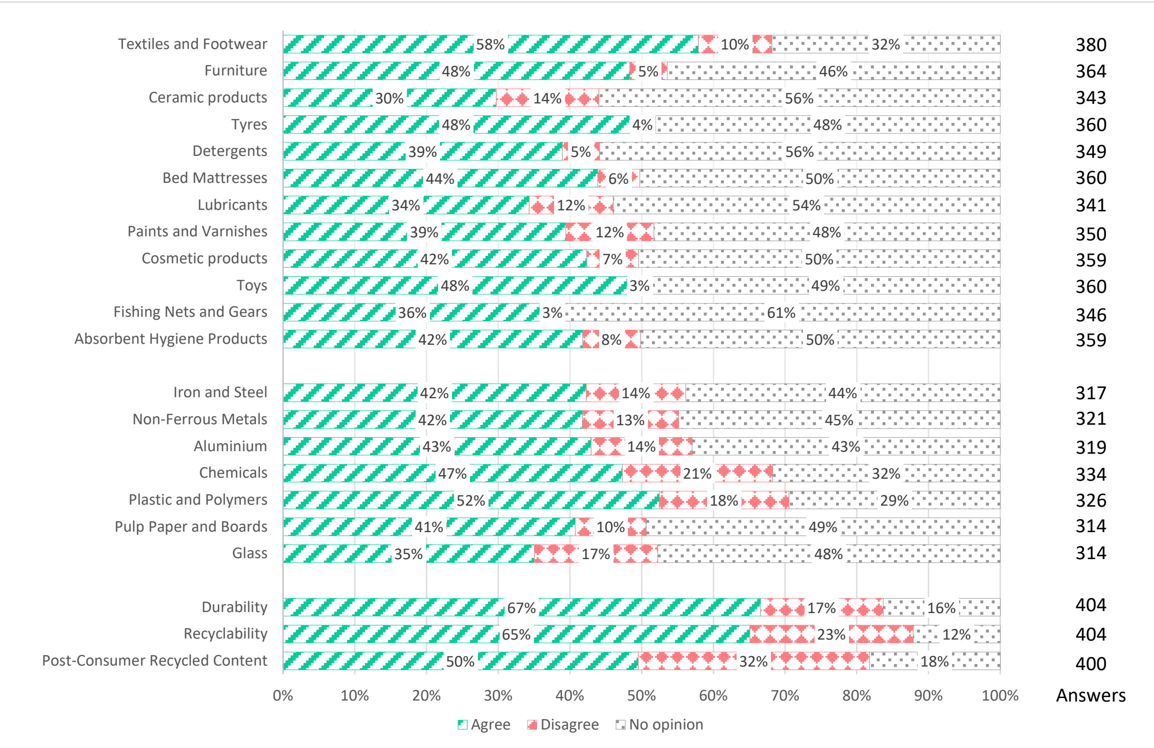
With respect to the market dimension, 36% of industry stakeholders declare they are active on the worldwide market, 32% in the EU market, and 10% in local, regional and non-EU markets respectively. 50% of industry stakeholders represent medium sized enterprises, 17% large enterprises, 17% small enterprises, and 16% micro enterprises.

It should be noted that, due to the design of the questionnaire, which permitted respondents to answer as many sections as they wished (including on only one single product group, if this was their only area of interest), a significant number of “no answer” responses were generated. This may be because respondents were not answering questions on products which fell outside of their field of competence or interest. As such, “no answer” responses were filtered out of the analysis conducted and are therefore not reflected in the results summarised here. On the contrary, “no opinion” responses, when available, were always considered. Furthermore, it is possible that some respondents interpreted the various product scopes in ways that differed from those product scopes outlined in the JRC’s preliminary study, as they were not repeated in the questionnaire.

1.4.2 Opinion of stakeholders on the products and horizontal measures for the working plan

In the questionnaire, stakeholders were asked, for each product and horizontal measure analysed in the preliminary study, whether they agreed with the identification of such product/horizontal measure for potential first action under ESPR. The results of the responses can be seen in **Figure 3**.

Figure 3. Opinion of stakeholders (agree /no opinion/disagree) on the final products, intermediate products and horizontal measures identified for the working plan. HM: horizontal measures.



Source: JRC own elaboration

The results suggest that stakeholders in general largely agree on the identified product groups and horizontal measures. In all cases, the number of stakeholders agreeing was always much higher than the stakeholders disagreeing. This suggests that no product, among the ones identified in the preliminary study, was rejected by stakeholders.

The final products with the highest percentage of agreement were:

- Textiles and footwear (58% stakeholders agreed, 10% disagreed, 32% no opinion)
- Furniture (48% stakeholders agreed, 5% disagreed, 46% no opinion)
- Tyres (48%, stakeholders agreed, 4% disagreed, 48% no opinion)
- Toys (48%, stakeholders agreed, 3% disagreed, 49% no opinion)
- Bed mattresses (44%, stakeholders agreed, 6% disagreed, 50% no opinion)

The intermediate products with the highest percentage of agreement were:

- Plastics & polymers (52% stakeholders agreed, 18% disagreed, 29% no opinion)
- Chemicals (47% stakeholders agreed, 21% disagreed, 32% no opinion)
- Aluminium (43% stakeholders agreed, 14% disagreed, 43% no opinion)

The Horizontal Measures with the highest percentage of agreement were:

- Durability (67% agreed, 17% disagreed, 16% no opinion)
- Recyclability (65% agreed, 23% disagreed, 12% no opinion)

1.4.3 Products considered having highest priority

In the questionnaire, stakeholders were asked to rate, for each product analysed in the preliminary study, their priority as low, medium, or high importance. The results of the responses can be seen in **Figure 4**.

The products which received the highest share of high priority answers were:

Final products:

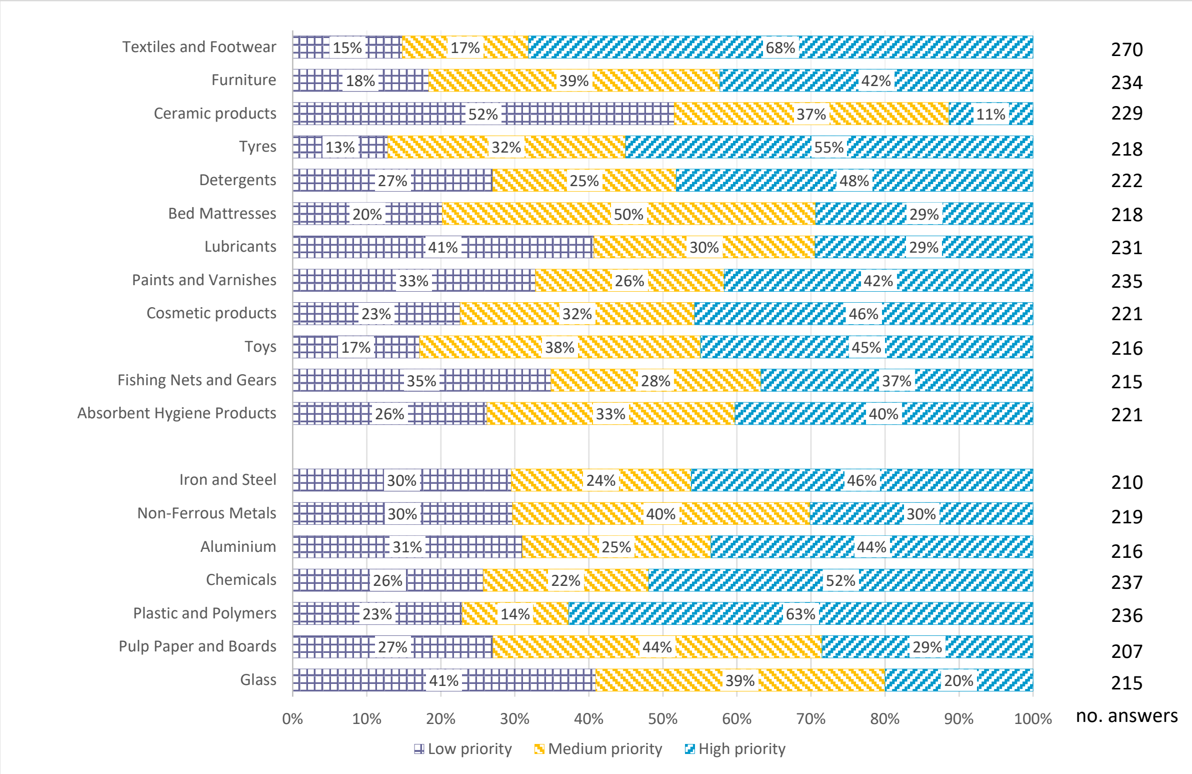
- Textiles and footwear (68% of the stakeholders)
- Tyres (55%)
- Detergents (48%)

Intermediate products:

- Plastics and polymers (63%)
- Chemicals (52%)

The results suggest that stakeholders agree overall with the product ranking presented in the Preliminary Report, with some notable exceptions such as Toys, Ceramic products, Cosmetics, Lubricants, Absorbent hygiene products and Plastics and polymers.

Figure 4. Share of stakeholders assigning Low/Medium/High priority to final and intermediate products (questionnaire responses - not considering the "no answer" option). Values on the right-side of the graph represent the number of answers received for each product.



Source: JRC own elaboration

1.5 Changes compared to the Preliminary Report

This Final Report sees several changes compared to the Preliminary Report published in January 2023. Some of these changes are related to the differences in the final adopted text of the ESPR, compared to the proposal published by the Commission in March 2022. Some other changes are related to the feedback received as part of the Open Public Consultation and the additional evidence shared by stakeholders on a number of topics. Also, recent regulatory developments in the context of other Union policies were taken into account. Although the main structure and methodology of the report has remained the same, the further research that was conducted led to some changes in the results and in the way results are presented. The main changes in this Final Report, compared to the Preliminary Report, can be found in **Annex 1**.

2 Selection of final products, intermediate products and horizontal measures

2.1 Specific aims

In the context of the Ecodesign Directive, the first step for developing a WP is the identification of product groups and horizontal measures for further analysis. The aim of this phase was thus to identify a first long list of (final and intermediate) products and horizontal measures to be considered as possible priorities under the ESPR framework.

2.2 Methodology

2.2.1 Scope

According to Article 1(2) of the ESPR, the Regulation should apply to all physical goods that are placed on the market or put into service, including components and intermediate products, with the exception of:

— "*food as defined in Article 2 of Regulation (EC) No 178/2002;*

— *feed as defined in Article 3(4) of Regulation (EC) No 178/2002;*

— *medicinal products as defined in Article 1(2) of Directive 2001/83/EC;*

— *veterinary medicinal products as defined in Article 4(1) of Regulation (EU) 2019/6;*

— *living plants, animals and micro-organisms;*

— *products of human origin;*

— *products of plants and animals relating directly to their future reproduction;*

— *vehicles as referred to in Article 2(1) of Regulation (EU) No 167/2013, in Article 2(1) of Regulation (EU) No 168/2013 and in Article 2(1) of Regulation (EU) 2018/858, in respect of those product aspects for which requirements are set under sector-specific Union legislative acts applicable to those vehicles*".

In addition, Article 5(5) of the ESPR states that "*products whose sole purpose is to serve defence or national security shall be excluded from product groups*", meaning that ecodesign requirements cannot be set on products with the sole function of defence or national security.

This represents the scope of action of the ESPR. Nevertheless, there are a few sectors that, although included in the ESPR scope, are considered outside the scope of this report. These sectors are: energy-related products, construction products, and packaging.

Energy-related products have until now been covered by the Ecodesign Directive 2009/125/EC. While the ESPR replaces the Ecodesign Directive, work on energy-related products will continue uninterrupted, in line with the priorities set out in the Ecodesign and Energy Labelling Working Plan for 2022-2024, adopted in March 2022[16]. Therefore, energy-related products are not considered within the scope of this report. It is envisaged that, when preparing the first ESPR WP, progress with the Ecodesign and Energy Labelling Working Plan for 2022-2024 will be assessed, informing on the choice of the energy-related products to be prioritised in the first ESPR WP.

The package of measures adopted in March 2022 included a proposal for a revised Construction Products Regulation, which will create a harmonised framework to assess and communicate the environmental and climate performance of construction products (EC, 2022c). As stated in the Communication of 30 March 2022 on making sustainable products the norm, given the need to manage the close links between the environmental and structural performance, including health and safety, environmental sustainability requirements for construction products that are not energy-related products will be primarily dealt with under the revised Construction Products Regulation. For this reason, construction products are considered outside the scope of the first ESPR WP, and thus, of this report. In relation to cement, Art. 18(5) of the ESPR states that "*where there is an absence of adequate performance requirements and information requirements concerning the environmental footprint and carbon footprint of cement under the construction products Regulation, the Commission shall set ecodesign requirements for cement in a delegated act adopted pursuant to Article 4 not earlier than 31 December 2028 and not later than 1 January 2030*".

With regard to packaging products, there are already legislative instruments tackling their use and placing on the market in the EU, especially the newly adopted Packaging and Packaging Waste Regulation. Moreover, as packaging products vary greatly depending on the product category in which they are used, it is envisaged not to treat them as products per se in the context of the ESPR framework. Instead, the circularity aspects of packaging should be the focus when developing product-specific ESPR rules. In light of this, packaging was not considered as a specific product group in this report, but measures related to the interaction of packaging with the product it contains were taken into account when evaluating the improvement potential of specific products.

With regards to horizontal measures, Article 5(7) of the ESPR outlines:

"*Where two or more product groups display one or more similarities allowing a product aspect to be effectively improved based on common information requirements or performance requirements, horizontal ecodesign requirements may be set for those product groups ('horizontal ecodesign requirements'). When considering whether to set horizontal ecodesign requirements, the Commission shall also take into account the positive effects of those requirements towards reaching the objectives of this Regulation, in particular the ability to cover a wide range of product groups in the same delegated act. The Commission may supplement the horizontal ecodesign requirements through the setting of ecodesign requirements for a specific product group*".

Recital (49) further indicates "product aspects" (those in Article 5.1) as a determining factor for the potential establishment of horizontal measures:

"*(49) […] Based on the process followed for prioritisation under Directive 2009/125/EC, the Commission should adopt a working plan covering at least three years and laying down a list of*

16 In the case of the energy-related products listed in Art. 79 of ESPR, regulation/review will take place in line with rules of Directive 2009/125/EC. For all other energy-related products, regulation will take place under ESPR.

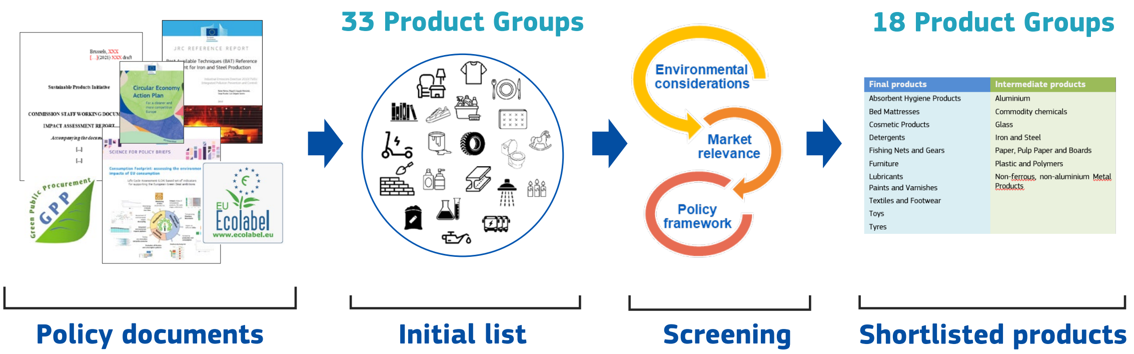
product groups for which it intends to adopt delegated acts, as well as the product aspects for which it intends to adopt delegated acts of horizontal application".

Regulating products in groupings via horizontal requirements can deliver a number of benefits. Firstly, depending on how horizontal requirements are structured, sustainability aspects can be addressed in a harmonised manner with common definitions and provisions, and regulation reviews can take place in a more systematic way. Secondly, the regulatory scope in terms of products can be expanded by considering a range of products which are very similar but which, in isolation, might never have qualified as sufficiently relevant for regulation. Aggregation of such products into one measure might significantly contribute to sustainability improvements. For example, a horizontal measure on "Post-consumer recycled content" can allow for establishing provisions on minimum level of post-consumer recycled content across a range of product groups without the need to address the same provision in each product-specific measure.

2.2.2 Selection and shortlisting of final and intermediate products

The work described in this section entailed the development of an initial list of products which was then shortlisted according to environmental, market and policy considerations, as shown in **Figure 5**.

Figure 5. Overview of the methodology for the selection of relevant final and intermediate products.



Source: JRC own elaboration

2.2.2.1 Initial selection of final and intermediate products

To develop an environmentally relevant initial long list of products to be potentially addressed by ecodesign requirements, several documents were researched that addressed the environmental aspects of specific products, in specific, or in generic terms. The main documents investigated were:

— the Circular Economy Action Plan[17];

— the Impact Assessment accompanying the ESPR proposal[18];

17 COM(2020) 98 final. A new Circular Economy Action Plan For a cleaner and more competitive Europe.

18 https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en

— Best Available Techniques (BAT) reference documents[19];

— the EU Ecolabel[20] and EU GPP[21] criteria;

— other European ISO 14024 type I ecolabelling schemes[22];

— the Consumption Footprint indicator addressing household goods and mobility[23];

— Product Environmental Footprint Category Rules (PEFCRs)[24];

— products with Environmental Product Declarations (EPD)[25].

Two lists were thus produced: one for final products and one for intermediate products.

2.2.2.2 *Screening of final and intermediate products: selection criteria*

The initial lists of (final and intermediate) product groups were reduced to shortlists by individually screening the products based on environmental, market and policy considerations. First, products were screened based on their market relevance, as explained in Section 2.2.2.2.1. Then, the products' main environmental impacts were identified, as well as the existing policy framework addressing such impacts. Only the products with higher market relevance and substantial environmental impacts not currently regulated were retained for the next phase. The other products were screened out. Final products whose main environmental impacts would be indirectly addressed by a shortlisted intermediate product were also screened out. Products not shortlisted should not be seen as not relevant; they are just considered to have lower priority compared to the short-listed products.

The outcome of this exercise was thus a list of shortlisted final and intermediate products that will be further assessed in the next sections.

2.2.2.2.1 Market relevance

The product groups were investigated to select only the ones covering a significant proportion of the European market, in line with Article 18(1)(b) of the ESPR and as carried out in the Ecodesign Directive.

To this aim, market data for the EU were retrieved from available literature such as statistics (e.g. Eurostat), databases (e.g. PRODCOM[26]), reports, scientific articles, industry annual reports, and other available studies. Market data in terms of units were compared against the threshold of 200 000 units/year, in line with Article 15(2)(a) of the Ecodesign Directive 2009/125/EC. Therefore, products with an EU market size below 200 000 units/year were excluded. Market data in terms of monetary value were compared against an indicative threshold of EUR 100 million/year. Therefore, products with an EU market size below EUR 100 million/year were excluded. In the absence of a suitable

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19 JRC EIPPCB webpage

20 DG ENVIRONMENT EU Ecolabel criteria webpage

21 DG ENVIRONMENT EU GPP criteria webpage

22 Nordic Swan and Blue Angel were considered.

23 Castellani et al. (2019); Castellani et al. (2017)

24 https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm#final

25 https://www.environdec.com/all-about-epds/the-epd

26 PRODCOM database DS-066341 available at https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=DS-066341&lang=en

reference in other similar exercises, a threshold of EUR 100 million was chosen as an indicator for products with higher relevance, since the majority of products on the list have a market size of the order of magnitude of billions of euros.

In few cases, only US-specific or global data could be found for the market size of a specific product. In such cases, Gross Domestic Product (GDP) data were used to derive an estimation of EU consumption, as an indicator of affordability for the EU compared to the US or the world. For example, global data were rescaled to EU conditions by dividing the global consumption by the global GDP and multiplying it by the European GDP. GDP factors for the US, the EU and the world were retrieved from The World Bank (2021 data).

2.2.2.2.2 Main environmental impacts

The aim of this category was to provide an overview of the environmental impacts associated with a product group. For each product group on the initial list, information on the main impacts was gathered based on relevant literature sources.

The environmental information obtained represents an indication of the size of the main environmental impacts of selected products, and whether it entails few or many impact categories.

2.2.2.2.3 Policy framework

In this category, existing product-specific policy instruments addressing (even partly) a product's environmental impacts were researched and listed. At this stage, which serves to retain products that are considered relevant for the ESPR, Commission proposals and policy initiatives in preparation were not taken into account. These aspects were instead taken into account at a later stage, which focused on the policy gaps of the shortlisted products. This preliminary analysis of the policy framework was used to evaluate whether a product's environmental impacts are already exhaustively addressed at EU level.

2.2.3 Initial selection: horizontal requirements

The scope of a horizontal requirements is determined by the aspect addressed by the requirement. Products grouped in one measure demonstrate technical similarities in the sense that similar provisions can be applied to them due to their design characteristics. The benefits of such an approach is that key sustainability aspects can be addressed in a harmonised manner across a number of relevant products. This includes the harmonisation of definitions, principles, regulatory formulations and verification procedures. The actual requirements could of course differ and be adapted to the characteristics of each product category within the horizontal measure.

> *Example: Some provisions related to the aspect of reparability are similar across product groups which may be diverse in their function and application: a provision for spare part availability, for instance, could be defined and formulated in the same way for both textiles and for furniture, even though the element of years of availability could differ amongst the two but could be set in the same horizontal requirement.*

2.3 Results and discussion

2.3.1 Shortlisted final/intermediate products

The initial list of products consisted of 33 product groups: 24 final products and 9 intermediate products. The complete initial list of products (and definitions) can be found in **Annex 2**, and represents a preliminary basket of products that fall under ESPR's scope and that have recently been considered in different policy documents because of the products' environmental relevance.

While the results of the individual screening of the initial product groups in terms of market relevance, environmental impacts and policy framework can be found in **Annex 3**, the shortlisted products are presented in **Table 1**. In total, 11 final products and 7 intermediate products were shortlisted. The scope of the shortlisted product groups is presented in **Figure 6**, and these products will be further assessed in Section 3. It is important to bear in mind that the product group scopes represent the scope of the analysis in this report, but should not be seen as final scopes for the future ESPR Delegated Acts. Rather, it will be up to later preparatory studies to analyse whether the scopes presented in **Figure 6** are suitable, or whether these should be modified.

Final products that were excluded as a result of the initial screening are Biofuels, Books and printed paper, Candles, Cotton buds, De-icers, Office and hobby supply, Pest control devices, Sanitary additives, Ski wax, Solid fuels and firelighting products, Waste containers for separate glass collection, and Wet wipes. Some of these products, e.g. Biofuels and Solid fuels, are characterised by high environmental impacts across different environmental categories (e.g. climate change, particulate matter formation, resource depletion); however, these products are currently comprehensively regulated, including environmental aspects. Other products, such as Cotton buds and Wet wipes, have significant environmental impacts over fewer environmental categories (e.g. water pollution and waste generation), but there currently exists policies that tackle such impacts (the Single Use Plastics Directive in the case of cotton buds and wet wipes). Other products, such as Books and printed paper and Office and hobby supply, were not shortlisted in order not to duplicate work, since the main

Table 1. Initial list of products: shortlisted (final & intermediate) and not-shortlisted.

Final products	Intermediate products	Not shortlisted products
Absorbent hygiene products	Aluminium	Biofuels
Bed mattresses	Commodity chemicals	Books and printed paper
Cosmetic products	Glass	Candles
Detergents	Iron and steel	Ceramic products
Fishing nets and gears	Paper, pulp paper and boards	Cotton buds
Furniture	Plastic and polymers	De-icers
Lubricants	Non-ferrous, non-aluminium metal products	Office and hobby supply
Paints and varnishes		Pest control devices
Textiles and footwear		Sanitary additives
Toys		Ski wax
Tyres		Solid fuels and firelighting products
		Waste containers for separate glass collection
		Wet wipes

Source: JRC own elaboration

environmental impacts related to their life cycle would already be covered by shortlisted intermediate products, such as Pulp and paper and Plastics and polymers. The remaining products were filtered out because of their lower and region-specific market relevance. These correspond to five product groups (Candles, De-icers, Sanitary additives, Ski wax and Waste containers).

It is important to clarify that retaining a product group in the short list for prioritisation does not mean that such product is not regulated or not comprehensively regulated at EU level. Rather, it means that the combination of its market relevance, its environmental impacts and the existing related regulations deserve a deeper analysis. As mentioned earlier, policy gaps for the shortlisted products will be addressed in Section 3.3.2, which also considered Commission proposals and policy initiatives in preparation. At that stage, shortlisted products can be excluded based on the already comprehensive regulatory framework in the EU.

Figure 6. Scope of shortlisted final and intermediate products.

ABSORBENT HYGIENIC PRODUCTS (AHP)	Any article whose function is to absorb and retain human fluids such as urine, faeces, sweat, menstrual fluid or milk, excluding textile products. Products included are: baby diapers, panty-liners, menstrual pads, breast pads, tampons, incontinence products. Excluded products are: wet wipes, make-up remover wipes, cotton swabs.
BED MATTRESSES	Products consisting of a cloth cover that is filled with materials and that can be placed on an existing supporting bed structure or designed for free standing in order to provide a surface to sleep or rest upon for indoor use
COSMETICS	Any substance or mixture falling under the scope of Regulation (EC) No 1223/2009, intended to be placed in contact with the external parts of the human body, or with the teeth and the mucous membranes of the oral cavity, with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition or correcting body odours. Products included are e.g. toilet soaps, shower preparations, shampoos, hair conditioning products, shaving products, deodorants, toothpaste, skin-care products, sunscreens, decorative cosmetics (the list is not exhaustive)
DETERGENTS	Any substance and mixture falling under the scope of the Detergents Product Regulation. Products included are: laundry detergents, dishwasher detergents, hard surface cleaning products (i.e. all purpose cleaners, kitchen cleaners, window cleaners, sanitary cleaners), hand dishwashing detergents
FISHING GEARS	Any item or piece of equipment that is used in fishing or aquaculture to target, capture or rear marine biological resources or that is floating on the sea surface, and is deployed with the objective of attracting and capturing or of rearing such marine biological resources
FURNITURE	Free-standing or built-in units whose primary function is to be used for the storage, placement or hanging of items and/or to provide surfaces where users can rest, sit, eat, study or work, whether for indoor or outdoor use. Bed frames, legs, bases and headboards are included in the scope. Not included are: bed mattresses, streetlights, railings and fences, ladders, clocks, playground equipment, stand-alone or wall-hung mirrors, electrical conduits, road bollards and building products such as steps, doors, windows, floor coverings and cladding
LUBRICANTS	Product capable of reducing friction, adhesion, heat, wear or corrosion when applied to a surface or introduced between two surfaces in relative motion, or is capable of transmitting mechanical power. Lubricants are typically composed of base fluids (80-75%) and additives (25-20%). Base fluids can be fossil, vegetable-based or a mixture
PAINTS	Products falling under the scope of the Directive 2004/42/EC for paints and varnishes, and vehicle refinishing products. Paints and varnishes refer to coatings applied to buildings, their trim and fittings, and associated structures for decorative, functional and protective purpose. Vehicle refinishes are used for the coating of road vehicles as defined in Directive 70/156/EEC, or part of them, carried out as part of vehicle repair, conservation or decoration outside of manufacturing installations.
TEXTILES and FOOTWEAR	Textiles: Any raw, semi-worked, worked, semi-manufactured, manufactured, semi-made-up or made-up product which is exclusively composed of textile fibres, regardless of the mixing or assembly process employed, as well as a product containing at least 80% textile fibres by weight, in line with the Textile Labelling Regulation. This includes apparel textiles, home/interior textiles and technical textiles. Excluded are personal protective equipment according to Regulation (EU) 2016/425, apparel textiles identified as medical devices or as an accessory for medical devices according with Regulation (EU) 2017/745, leather and fur. Footwear: in line with Directive 94/11/EC, all articles with applied soles designed to protect or cover the foot. Excluded are: protective footwear covered by Regulation (EU) 2016/425. Excluded are: footwear containing any electric or electronic components; toy footwear.
TOYS	Products for use in play by children under 14 that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded are: products listed in Annex 1 of Toys Safety Directive, electric and electronic toys.
TYRES	Products included are cars (C1), tyres, vans (C2) tyres and heavy-duty vehicles (C3) tyres
ALUMINUM	Aluminum and its alloys
COMMODITY CHEMICALS	Large volume inorganic chemicals – ammonia, acids and fertilisers: ammonia, nitric acid, sulphuric acid, phosphoric acid and hydrofluoric acid, phosphorus-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers). Large volume inorganic chemicals – solids and others industry: soda ash (called sodium carbonate, including sodium bicarbonate), titanium dioxide (from the chloride and sulphate process routes), carbon black (rubber and speciality grades), synthetic amorphous silica (pyrogenic silica, precipitated silica, and silica gel). Large volume organic chemicals: lower olefins by the cracking process (e.g. ethylene), aromatics such as benzene/toluene/xylene (BTX), oxygenated compounds such as ethylene oxide, ethylene glycols and formaldehyde, nitrogenated compounds such as acrylonitrile and toluene diisocyanate, halogenated compounds such as ethylene dichloride (EDC) and vinyl chloride monomer (VCM), sulphur and phosphorus compounds and organo-metallic compounds.
GLASS	Products included: container glass, flat glass, continuous filament glass fibre, domestic glass, special glass, mineral wool, high temperature insulation wools and frits
IRON & STEEL	Iron and steel. Steel is an alloy of iron and carbon, where the carbon content can range up to 2% (when the carbon content is over 2%, the material is defined as cast iron)
NON-FERROUS METAL PRODUCTS	Products made of six primary and secondary non-ferrous metals: Copper and its alloys; Lead and tin; Zinc and cadmium; Precious metals: gold (electronics), silver (industrial application), platinum, palladium, rhodium, iridium, ruthenium and osmium (the platinum group metals, mainly used as catalysts); Ferro-alloys: bulk ferro-alloys and special ferro-alloys; Nickel, cobalt
PAPER & PULP	Pulp, paper and board obtained by chemical, kraft, sulphite, mechanical and chemi- mechanical pulping, recovered paper processing and papermaking
PLASTICS & POLYMERS	Polymeric material that has the capability of being moulded or shaped, usually by the application of heat and pressure. It usually contains polymers and additives that give additional properties to the mixture. The scope is plastic basic materials, synthetic rubbers and hydrocarbons containing oxygen

Source: JRC own elaboration

In terms of intermediate products, only Wood-based panels were not shortlisted, mainly because the related environmental impacts would be addressed by regulation of a number of final products such as furniture, toys and construction products.

The Preliminary Report also addressed and shortlisted Ceramic products as final products. However, further analysis on the scope of Ceramic products revealed that most of them are construction products, which, as explained in Section 2.2.1, are out of the scope of this study. Out of the ceramic non-construction products, some of them could be classified as final products, e.g. tableware, and some others as intermediate products. Splitting Ceramic products into final and intermediate decreased their market relevance, and Ceramic products were thus not addressed further in this Final Report.

2.3.2 Horizontal requirements

On the basis of the ESPR proposal, horizontal requirements are measures based on **product aspects** with a finite scope of a number of product groups that demonstrate technical similarities vis-à-vis the provisions that can be applied to them. Each horizontal measure proposed may constitute a delegated act in itself, or act as an umbrella assessment under which more targeted delegated acts may be established. Either option would serve the objectives of ensuring a systematic and harmonised consideration of such aspects across product groups by establishing similar provisions for all and adapting the thresholds for those provisions to specificities of the covered products, while achieving an efficient policy-making process.

In **Table 2**, definitions are provided for each aspect proposed as a horizontal requirements, as well as its link with the product aspects listed in Article 5(1) of the ESPR. In **Table 3**, the proposed horizontal requirements are described in terms of potential horizontal provisions and potential products to be covered by such provisions.

Table 2. Definition of sustainability-related aspects included in considered horizontal requirements.

Aspects	Link with ESPR Art.5	Definition
Durability	(a) durability	Ability to function as required, under specified conditions of use, maintenance and repair, until a limiting event prevents its functioning (EN 45552)
Reliability	(b) reliability	Probability that a product functions as required under given conditions, for a given duration without a limiting event (EN 45552)
Repair	(e) repairability	Process of returning a faulty product or waste to a condition where it can fulfil its intended use (EN 45554)
Upgrading	(d) upgradability	Process of enhancing the functionality, performance, capacity, or aesthetics of a product (EN 45554)
Reuse	(c) reusability	Process by which a product or its parts, having reached the end of their first use, are used for the same purpose for which they were conceived (EN 45554)
Remanufacturing	(l) possibility of remanufacturing	Actions through which a new product is produced from objects that are waste, products or components and through which at least one change is made that substantially affects the safety, performance, purpose or type of the product (ESPR Art. 2(16))

Aspects	Link with ESPR Art.5	Definition
Recycling	(m) recyclability	Recovery operation of any kind, by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes excluding energy recovery (Directive 2008/98/EC[27] and EN 45555)
Lightweight design	(j) resource use and resource efficiency	The reduction of the quantity of materials in a product (or vis-à-vis its packaging) without compromising its ability to meet its minimum functional requirements (Cordella et al, 2020)
Post-consumer recycled content	(k) recycled content	The amount of post-consumer recycled material that goes into the manufacturing of a new product
Sourcing	(o) environmental impacts, including carbon footprint and environmental footprint	The life-cycle phase involving the acquisition or extraction of the raw materials composing final or intermediate products

Source: JRC own elaboration

With regards to the product groups covered under horizontal requirements, the primary point of consideration for their selection was **technical similarity**. More specifically, product groups under the same horizontal requirements may still demonstrate technical differences, however certain similarities mean they can still be subject to the same type of provisions (albeit with adjusted thresholds). For instance products relevant to measures on Reparability, Reusability and Upgradeability are groups which are 'complex products'[28], as their intrinsic characteristics deem them appropriate for a component-based assessment.

It must also be noted that, for the purposes of this report, horizontal requirements and product-specific requirements are studied in parallel, and overlap in terms of scope. For example, textiles can be addressed either by a product-specific requirements, a horizontal requirements, or both approaches in a way that the requirements complement each other by addressing different types of provisions. As such, choices are to be made between regulating a product on its own, through product-specific measures, or as part of a larger horizontal measure focussing on one product aspect.

Furthermore, the sets of products suggested for the proposed horizontal requirements also include product groups that are not amongst the list of products 'shortlisted' as possible candidates for priority action under ESPR (e.g. Light Means of Transport [LMT]).

After assessment, three horizontal requirements are retained for first consideration (see **Table 3**). The two others (lightweight design and sustainable sourcing) were initially considered but then discarded in the course of the study, and not further elaborated as not mature enough (**Table 4**).

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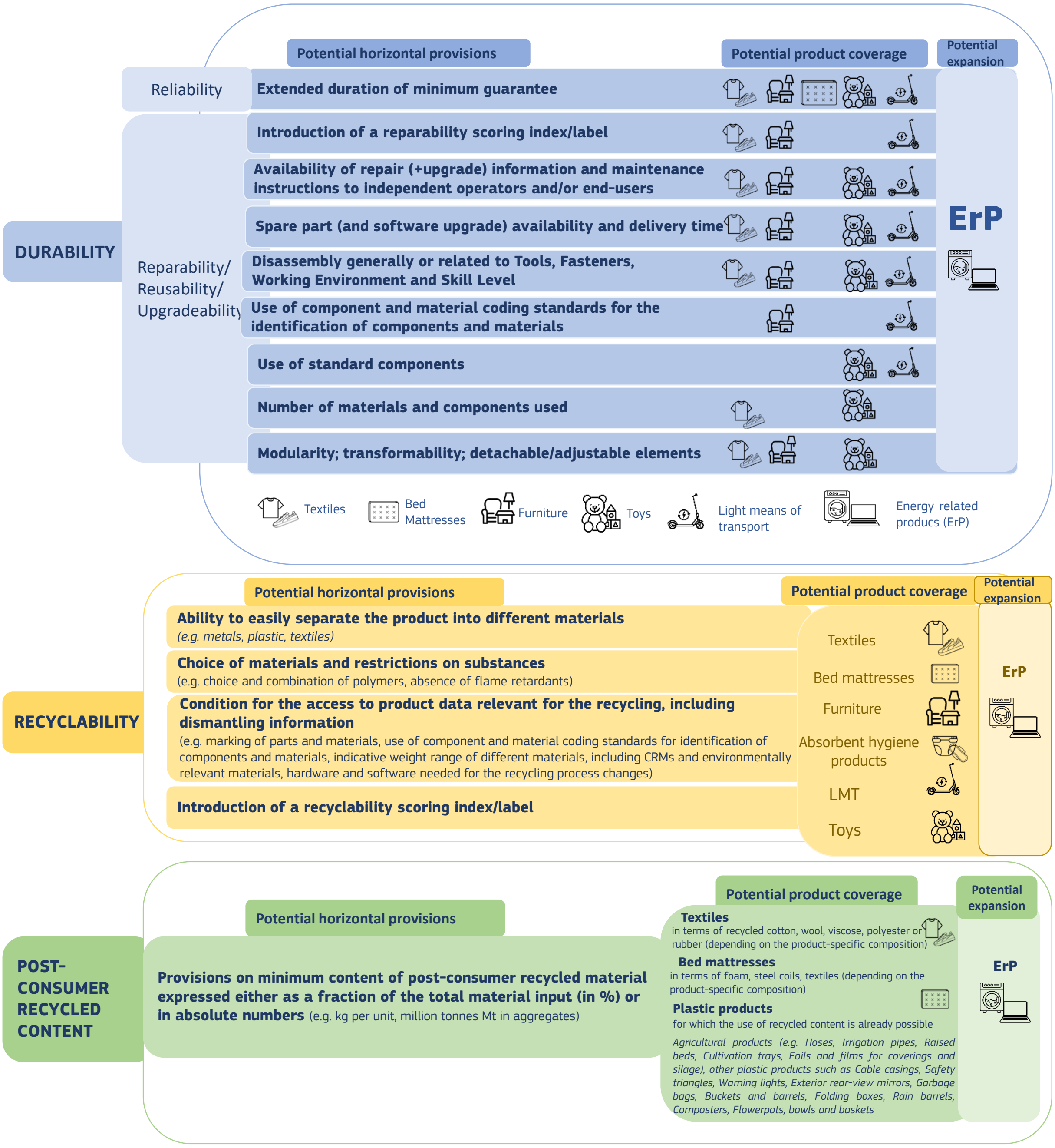
27 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

28 According to the Commission proposal in COM/2022/666 for a regulation on Community designs, a 'complex product' means a product that is composed of multiple components which can be replaced, permitting disassembly and reassembly of the product.';

Table 3. Proposed horizontal requirements for first consideration, including potential provisions, proposed product coverage and potential product scope expansion.

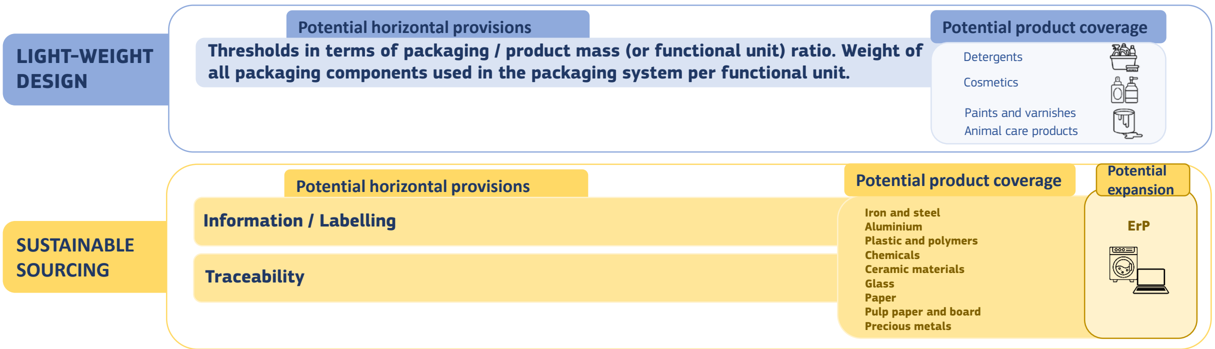


Source: JRC own elaboration

2.3.2.1 Provisions associated with horizontal requirements

This section lists and describes a range of potential provisions that are associated with various aspects contained in the proposed horizontal requirements. They are presented in a way which allows for harmonisation (or for selection depending on the product scope) in order to acquire the benefits of a horizontal requirements approach. Not all following provisions described have the same potential to be addressed horizontally, as it very much depends on the product scope, i.e. what is the level of technical similarity that the products demonstrate.

Table 4. Potential horizontal requirements, initially considered but not further elaborated.



Source: JRC own elaboration

For instance, for reasons described in the dedicated section 2.3.2.2.1 below, addressing reliability horizontally has challenges and limitations, meaning that the policy-making efficiency of developing a horizontal requirement on this aspect would depend on the ability to accommodate product-specific considerations under the same Act; differences would not only be present in terms of level of ambition or limit values, but also on the very metrics of reliability.

2.3.2.2 Horizontal requirements for first consideration

2.3.2.2.1 Durability – Reliability

Durability requirements are especially beneficial for products with significant life-cycle environmental impacts in the extraction and production phases compared to the use phase, such as consumer electronics, as well as "passive" products that have very limited impacts in the use phase, such as furniture. Durability requirements refer to provisions which are related to reliability, reparability, reusability and upgradeability, as per the definitions provided in **Table 2**.

Requirements related to reliability can vary, ranging from minimum threshold or informational requirements on lifetime, durability of function, and resistance to stresses and ageing mechanisms. Further details about these requirements are described below. However, the potential for horizontal reliability requirements horizontally is expected to be challenging and limited to grouping products with very similar technical characteristics. The low potential is assumed for the following reasons:

— Most approaches of assessing reliability are dependent on product-specific characteristics, including a product specific functional analysis (as per EN 45552:2020). For example, resistance to stresses can differ;

— Even if a metric of reliability can be applicable for a number of different product groups, functionalities and environmental conditions to which they are exposed often differ;

— Most reliability metrics require test methods and standards in order to ensure a level-playing field for product comparison and compliance verification. These are also expected to be product-specific.

Nevertheless, proxies with the potential to enable lifetime extension can still be considered at horizontal level, such as the establishment of an extended duration of guarantee, either as a minimum or an informational requirement.

Table 5 provides examples of reliability-related provisions in existing legislation, demonstrating the diversity among products, with the exemption of minimum duration of commercial guarantee.

Table 5. Examples of reliability-related requirements in EU legislation.

Product group	Reliability-related requirements
Ecodesign – Mobile phones	Accidental drops resistance, scratch resistance, dust/water protection, battery endurance
Ecodesign – Vacuum Cleaners	Hose durability (oscillations); operational motor lifetime
Energy Labelling - Household Dish-washers	Information on minimum duration of commercial guarantee
Energy Labelling - Refrigerators	Information on minimum duration of commercial guarantee
Energy Labelling – Household Washing machines and Household washer-dryers	Information on minimum duration of commercial guarantee
Energy Labelling - Electronic dis-plays	Information on minimum duration of commercial guarantee
EU Ecolabel - Bed mattresses	Minimum Guarantee; Loss of height %; Loss of firmness %
EU Ecolabel - Textile products	Water repellent functionality; Wash cycle functionality; Fabric smooth-ness grade
EU Ecolabel - Footwear	Flex resistance; tear strength; abrasion resistance; Colour fastness
EU Ecolabel - Electronic displays	Minimum Guarantee
EU Ecolabel - Wood-based floor coverings	Extended product guarantee; Resistance to indentation; Thickness swelling; Impact resistance; Wear resistance; Locking strength; Thick-ness of top layer, Wood hardness
EU Ecolabel - Furniture	Durability class based on EN 350 ; Extended product guarantee
EU Ecolabel - Road lighting	Control gear failure; Ingress protection (IP); specific rated lifetime

Source: JRC own elaboration

Minimum lifetime and labelling

Such requirement would set harmonised rules regarding the products' life expectancy.

There are various approaches that could be followed in this context, from the information requirements, labelling on the minimum (technical) lifespan[29] or lifespan guarantees that consider the durability of the product.

Regulating "durability" as a horizontal requirement needs the use of different parameters (e.g. number of years/hours/cycles, kilometres, Mean Time Before Failure) and different testing methods per product group.

Also, there is no standard for accurately assessing product lifespans. The definition of the lifespan of the products (in absolute terms), followed by a definition of the test methods and reporting standards would need to be put in place. Alternatively, a mandatory usage meter on specific products groups could be regulated to provide objective information on the product lifetime throughout its use; it could count the number of hours of use (e.g., in TVs, smartphones, laptops) or the cycles of use (e.g., for washing machines, dishwashers).

[29] The time period under which the product functions for its intended purpose.

2.3.2.2.2 Durability – Reparability/Reusability/Upgradability

Introduction of a Reparability Scoring Index / Label

A reparability score is the result of the following steps:

- identification of priority parts;
- identification of relevant parameters influencing reparability (existing for ErP/electronics);
- scoring system and aggregation.

The product scope is proposed based on whether the characteristics of a product family are compatible with the above-mentioned principles. This means that if a product family is composed of some parts/components for which some distinct parameters influencing reparability can be identified, then a product can be proposed as relevant for reparability.

Availability of repair (+upgrade) information and maintenance instructions to independent operators and/or end users

Examples of information are the following:

- a disassembly map or exploded view;
- wiring and connection diagrams, as required for failure analysis;
- electronic board diagrams, to the level of detail needed to replace parts;
- list of necessary repair and test equipment;
- technical manual of instructions for repair;
- diagnostic fault and error information;
- component and diagnosis information;
- instructions for software and firmware (including reset software);
- information on how to access data records of reported failure incidents stored on the device;
- the procedure for authorisation of part replacement, in cases where remote notification or authorisation of serial numbers are necessary for the full functionality of the spare part and the device;
- how to access professional repair (internet webpages, addresses, contact details).

Furthermore, the process for registration of independent/professional repairers should be specified and harmonised: “the process for professional repairers to register for access to information; to accept such a request, the manufacturers, importers or authorised representatives may require the professional repairer to demonstrate that…”

Spare part (and software upgrade) availability and delivery time

The following parameters are relevant for spare part availability:

- definition of spare parts list;

- duration: “manufacturers, importers or authorised representatives shall make available to [end-users/independent operators] at least the following spare parts, for a minimum period from [X] month after the date of placement on the market until [Y] years after the date of end of placement on the market: [parts]”;
- method of availability: “the list of spare parts concerned and the procedure for ordering them shall be publicly available on the free access website of the manufacturer, importer or authorised representative, from [X] month after placing the first unit of a model on the market and until the end of the period of availability of these spare parts”;
- delivery time: “manufacturers, importers or authorised representatives shall ensure the delivery of the spare parts within [X] working days after having received the order”;
- maximum price of spare parts: “manufacturers, importers or authorised representatives shall indicate an expected maximum pre-tax price at least for spare parts” (either in Euro or as % of indicative purchasing price of the product);
- software update availability;
- availability of the procedure for authorisation of part replacement.

Disassembly generally or related to Tools, Fasteners, Working Environment and Skill Level

The following options are proposed (based on EN 45554:2020):

- General provision (when specification is non-applicable): “manufacturers shall ensure that joining, fastening or sealing techniques do not prevent the disassembly for repair or reuse purposes (of the following components)”.
- Specification based on:
    - fasteners: “fasteners shall be [removable or reusable]”;
    - tools: “the process for replacement shall be feasible with [no tool, a tool or set of tools that is supplied with the product or spare part, or basic tools, or with commercially available tools]”;
    - working environment: “the process for replacement shall, as a minimum, be able to be carried out in a [workshop environment or use environment]”;
    - skill level: “the process for replacement shall, as a minimum, be able to be carried out by [Expert or layman or generalist].”

Use of component and material coding standards for the identification of components and materials

The following specifications can apply:

- “Plastic components heavier than X g shall be marked by specifying the type of polymer with the appropriate standard symbols or abbreviated terms set between the punctuation marks ‘>’ and ‘<’ as specified in available standards. The marking shall be legible.”
- Additionally, there could be labelling of every main component with a title and QR code leading to a spare part provider.
- Coloured wires.

Use of standard components / Compatibility with commonly available spare parts

Examples of provisions:

- Common battery within the same product family.
- Port harmonisation.
- Use of shared solutions, fittings, and parts.
- Use of standardised materials and recommended colours.
- Use of standardised components to secure interchangeability. This could either occur within a brand (e.g., lighting port used by various Apple products), across multiple (two or more) brands (e.g., use of USB c connector), or even within brand proprietaries.

Reusability/Upgradeability-specific provisions

Reusability and Upgradability are concepts closely related to Reparability, in the sense that all design-related reparability provisions aiming at ease of disassembly act in a synergic manner to increase reusability and upgradability. Nevertheless, there are still some types of provisions that are more distinctly specific to reusability and upgradability:

- modular design (the product is built from individually distinct functional units), transformability;
- detachable elements;
- adjustable sizing, customisable surfaces, changing fabric;
- data deletion and reset options.

2.3.2.2.3 Recyclability: ease and quality of recycling

Ability to easily separate the product into different materials (e.g. metal, plastic, textile)

Example of requirements linked to this provision include:

- avoiding connections that enclose a material permanently (such as inserts into plastic).

Methods such as moulding inserts into plastic, rivets, staples, press-fit, bolts, bolt and nut, brazing, welding and clinching make it harder to separate the different materials. These processes mentioned are typically used for tightly enclosing one material into another and it is therefore recommended to avoid them to facilitate recycling[30].

Choice of materials and restrictions on substances (e.g. choice and combination of polymers; homogeneous fibres)

Examples of requirements linked to this provision include:

[30] Polyce project (2021) Design for Recycling: Guidance for designers: https://www.polyce-project.eu/wp-content/uploads/2021/04/PolyCE-E-book-Circular-Design-Guidelines-2.pdf

— avoiding the use of coatings on plastics such as painting, lacquering, plating, galvanising, vacuum-metallisation, since it can change the density of the plastic;

— avoiding moulding different material types together by 2K or xK processes (different plastic materials injected into the same mould, or overmoulding, or in-mould labelling) such as moulding a thermoplastic elastomer onto PP (e.g., toothbrush);

— avoiding hazardous substances that cause material streams not to meet the requirements to be recycled and reused in new products in the future;

— avoiding design choices hindering recycling (e.g., multilayers, use of carbon black).

Examples of choice of materials can also be applicable to the primary packaging of products (e.g., cosmetic products) that are currently collected by urban waste management systems. Primary packaging of products shall be designed to facilitate effective recycling by avoiding potential contaminants and incompatible materials that are known to impede separation or reprocessing or to reduce the quality of recyclate.

Access to product data relevant for recycling, including dismantling information

Examples of requirements linked to this provision include:

— marking of parts and materials, use of component and material coding standards for the identification of components and materials, access to information, hardware and software needed for the recycling process;

— making available, on a free-access website, the dismantling information needed to access any of the product components referred to in point 1 of Annex VII to Directive 2012/19/EU; this dismantling information shall include the sequence of dismantling steps, tools or technologies needed to access the targeted components;

— providing information on the indicative weight range at component level of specific CRMs and environmentally relevant materials.

Recyclability information to consumers / recyclability claims

Examples of requirements linked to this provision include:

— including a sentence or a pictogram in relation to product disposal;

— providing guidance to consumers about product dismantling (if necessary before the recycling);

— providing information on the recyclability of the product.

2.3.2.2.4 Post-consumer recycled content

Inclusion of recycled content material in products is an important requirement that is directly linked to the decoupling of economic development from natural resource use and reduction of material dependencies, while at the same time fostering EU Open Strategic Autonomy and resilience. The aspect of recycled content, in general, is highlighted in the ESPR, while the European standard EN

45557[31] distinguishes between pre-consumer recycled content (referring to material that was generated by the same manufacturing process) and post-consumer recycled content (recovered from waste generated by finished products). The consideration of post-consumer recycled content is proposed here as priority, considering that the use of pre-consumer recycled content is already a usual practice in the industry, whereas the utilisation of post-consumer waste valorises waste as a resource (BIO Intelligence Service, 2013).

Requirements for recycled content may be introduced for a certain material (paper, cotton, plastic, etc.) on a sector-specific basis or based on average figures. In any case, for a specific material, a unified target is not possible at intermediate level, and differentiation by types of end-use applications is needed. Therefore, the consideration of a horizontal requirements on post-consumer recycled content could help increase the efficiency of ESPR requirements.

This provision has the potential to be set in terms of average minimum recycled content for a certain product group at Member State level, similar to what is proposed under the Single Use Plastic Directive. Alternatively, the minimum recycled content provision could be set as a mass balance content at factory level (for a certain product group). A market analysis, combined with the input from key stakeholders, will be important at the time of drafting ecodesign requirements on recycled content.

At this stage, the products eligible for an ecodesign requirement setting a minimum content of post-consumer recycled material have been preliminarily defined by looking at which products in the market already show presence of recycled content, and for which products regulatory intervention is needed.

Stakeholder input related to such measures highlights challenges associated with establishing post-consumer recycled content requirements. Relevant considerations raised include the question of availability of waste material itself, the need for that material to be of appropriate quality, and the establishment of an appropriate verification method. At present, for some materials, e.g., plastics, use of recycled content is not economically advantageous, and boosting recycled content for such materials can be achieved by economic incentives or by setting binding requirements in products. A synergic effect contributing to the availability of quality recycled content could be achieved with the establishment of recyclability requirements as described in section 2.3.2.2.3 above. However, the exact structure of the provision will need to be carefully drafted as the availability of waste materials suitable for recycling relies on the quantity of waste generated for those materials. At the same time, the political agenda is also focused on waste prevention (be it reuse, increased lifetime, etc.), which is a measure that could run contrary to that of recycled content (simply because the consequence of waste prevention is that less waste is available for recycling). While this is not yet the reality in Europe, boosting the use of recycled materials in products should not be achieved by producing more waste, but rather by extracting the most from the waste material. This is especially the case for some materials like plastics, textiles and critical raw materials for which, because of flaws in their supply chains, the use of recycled content is at present suboptimal. Finally, with regards to verification procedures, further research should focus on paper trail, tracing or laboratory test alternatives (European Commission, 2021).

[31] EN 45557:2020 General method for assessing the proportion of recycled material content in energy-related products.

Considering the aforementioned challenges and product-specific considerations, an alternative policy pathway could be the initial establishment of mandatory information requirements at **horizontal level** accompanied by a minimal post-consumer recycled content use requirement. This policy mix may not directly lead to high environmental benefit, but could prepare the ground, in terms of setting supply chain and verification infrastructure, for more ambitious minimum threshold requirements as follow-up measure. A similar approach was discussed in the context of technical proposals for recycled plastic content targets in new passenger cars and light commercial vehicles (European Commission, 2023).

The following product scope under this requirement is proposed for first consideration:

- Plastic products: This waste material is relevant for a requirement on minimum content of recycled material because, despite the large amount of plastic waste generated, only a small amount is recycled back into products (either for the same or a different application). It is important to stress here that this section addresses plastics individually and not plastic generally, as there are different polymer materials on the market with different properties and whose recycling must be kept isolated from the other polymers. The main polymers High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Polypropylene (PP), Polyethylene Terephthalate (PET) and Polystyrene (PS) are used in a great variety of products; however, when recycled, secondary polymers may only be used for selected applications, as shown in **Table 6**. Another source lists the following as plastic products that contain recycled plastics already today (2018 data): park benches, safety triangles, vacuum cleaners equipment parts, hangers, folding boxes, warning lights, backpacks, sport shoes, composters, rain barrels, raised beds, irrigation pipes, hoses, flower tubes, flower pots and bowls, hanging baskets, and cultivation pallets (Delvaux, 2022). The thresholds for recycled content in the future ecodesign requirements are likely to differ depending on the polymer and the application types.

- Textile products: As in the case of the aforementioned products containing plastic, the situation for textile waste is that, despite the large amount of waste generated, only very little is recycled back into products[32]. A measure on minimum recycled content for textiles has thus the potential for great environmental improvement. However, it is important to be aware that recycled content in textile products is a very complicated and immature field. This is especially the case for products made out of fibre blends (e.g. cotton with polyester and elastane), as it makes recycling very complex. The use of recycled fibres may also lead to trade-offs with other product aspects, primarily related to durability. Successful case studies on the use of recycled materials in textiles are summarised in **Table 7**.

[32] The Ellen MacArthur Foundation estimated that less than 1% of textile waste is recycled back into new textile fibres (Ellen MacArthur Foundation, 2017).

Table 6. Selected plastic polymers and their applications where recycled content can be used.

Polymer	Input for recycling	Is recycling possible?	Where can recycled material be used?
High-Density Polyethylene (HDPE)	Canisters/barrels Waste cuttings Natural foil Household bottles and cases Trash bins	100% recyclable if single-origin HDPE is used	Packaging
Low-Density Polyethylene (LDPE)	Transport packaging Shrink hoods Brickyard plastic films Tyre films Pellet bags Agricultural film (e.g. silage cover films, stretch films) Strips and hoses for irrigation Protective foil for varnishing, canvas covers Waste cuttings Granulate bags Coiled nodules	100% recyclable if single-origin LDPE is used	Garbage and carrier bags Agricultural foils
Polystyrene (PS) Polypropylene (PP)	Big bags Woven and unwoven fabric PP/PET strapping bands Multiwall sheets PP/PS plant trays and flowerpots PP buckets Cases and hard plastics Packing belts PP/PS cups and packaging	Recyclable; recycled PP has only become available in significant quantities recently	Automotive industry Flowerpots Park benches
Polyethylene Terephthalate (PET)	PET bottles Blisters Foil Flakes Packing belts	100% recyclable if single-origin PET is used	Packaging, including food packaging or bottles for cleaning agents and cosmetics New PET bottles Foils Textile fibres

Source: GIZ GmbH, 2021

2.3.2.3 Horizontal requirements initially considered but not further elaborated

2.3.2.3.1 Lightweight design

Thresholds in terms of packaging / product mass (or functional unit) ratio. Weight of all packaging components used in the packaging system per functional unit.

This horizontal provision aims to minimise waste production by reducing primary packaging. The weight/utility ratio (WUR) could be used as an indicator. The WUR is already applied at a voluntary

Table 7. Examples of textile recycled content in textile products.

Type of textile product	Recycled content	Reference
Denim jeans	17-20% recycled cotton	ASOS case study; JBC case study
Bed sheets	15% post-consumer cotton and 35% pre-consumer cotton	Blycolin case study
Workwear aprons	10% post-consumer cotton and 30% pre-consumer cotton	HAVEP case study
Jackets	43% post-consumer polyester	Moodstreet case study
Workwear t-shirts, polo shirts and blouses	30% post-consumer textiles (mixed PET & cotton), 20% pre-consumer cotton	Schijvens case study
T-shirts	10% post-consumer cotton, 40% pre-consumer cotton and 50% post-industrial PET	TRICORP case study
Knitted products	50% post-consumer cotton	WE case study
Jackets	5% post-consumer wool from dis-carded suits and 5% pre-consumer wool	Suitsupply case study

Source: JRC own elaboration from ECAP, 2022

level (e.g. Commission Decision (EU) 2017/1216 of 23 June 2017 establishing the EU Ecolabel criteria for dishwasher detergents). In this case, the use of packaging is expressed per wash (g/wash).

2.3.2.3.2 Sustainable sourcing

Some product families/groups can be manufactured on the basis of materials and intermediate products with different level of circularity (i.e. use of virgin vs. secondary raw materials) and different levels of environmental impacts (i.e. carbon and environmental footprint associated to material). This proposed horizontal measure focus on the provision of information and labelling as well as ensuring traceability of materials across the supply chain that could be applied through a common methodological approach and criteria applicable to different intermediated product groups.

Information / Labelling

A horizontal provision on information/labelling can provide information to users of intermediate products and/or directly to consumers on the sourcing of raw materials including, if applicable, their secondary raw material content and/or on the environmental footprint associated with their sourcing. A horizontal approach would be beneficial as it would allow a more harmonised approach among different product groups. An interesting example comes from the EU Ecolabel for lubricants.

Traceability

Intermediate materials that are sourced from supply chains with relevant environmental impacts could be requested to ensure traceability and comply with minimum requirements. The implementation of traceability requirements can be facilitated by the creation of the digital product passport, established under this regulation, that will provide the digital tool to electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers.

2.3.2.4 Trade-offs

Horizontal measures are addressing design aspects that often act in a synergic manner. For instance, design aspects that facilitate repair, also facilitate reuse and upgrade. At the same time, they also pose trade-offs, both amongst each other (e.g. reliability versus reparability) and in relation to other sustainability aspects (e.g. durability versus recyclability). Some representative examples are the following:

— Durability vs material use: Durable design might require additional material (or materials with a higher energy/material intensity) and resource consumption. Alternatively, or in addition, there might be higher energy content requirements for more durable products throughout their life cycles, e.g. for additional protective covers.

— Reliability vs modularity: Durable design might interfere with design strategies for modularity, reparability or recyclability. For example, if part of the design strategy of a product is to gain improved reliability by making it more robust and water/dustproof, e,g. using certain sealing techniques (e.g., embedded batteries), this could make other aspects more difficult, such as the replacement of parts by users, product repair, or easy disassembly for recycling.

— Durability vs use phase impacts: When considering durability, the overall trade-off between longer lifetime (reducing impacts related to the manufacturing and disposal of new products) and reduced environmental impacts of new products (due to energy and resource efficiency gains of the latest products) needs to be considered over a certain period of total usage time. LCA-based methods and product replacement modelling can assist in determining an optimal lifetime for a product (Bakker et al, 2014).

— Circularity vs presence of chemicals: Legacy chemicals and pollutants may deem remanufacturing, recyclability or the use of recycled content less desirable or feasible. For instance, durable furniture enables longer lifetime, however potentially compromising criteria related to chemical substances (Dalhammar et al, 2020)

— Recycled content and durability: the inclusion of recycled materials may hinder other products important quality such as durability

— Durability strategies might involve higher investment costs, e.g. due to more/higher quality material, additional components, costs for spare parts and repairs. According to Cordella et al. (2021), a more durable design of smartphones, for example, is – at least presently - normally associated with higher-end products with higher purchase prices, although it is also implemented in some products in the medium price range.

Thus, a proper balance needs to be found, with the positive impact of durability measures being one possible route to reducing the environmental impact of products among many other options, and these in turn need to be evaluated in Impact Assessments with socio-techno-environmental impacts. This can entail the identification of alternative design strategies (e.g. towards durability, or towards reparability), followed by an analysis of measures which benefit one aspect over another, and measures which can be compatible with both strategies. Unless there is evidence that a strategy of favouring only one design aspect is always environmentally preferable, measures of various aspects should be systematically considered in the design of products (Cordella et al, 2020). Stakeholder consultation is also integral towards arriving at an optimal policy mix.

3 Prioritisation across shortlisted final and intermediate products

3.1 Specific aims

In Section 2, a total of 18 product groups (11 final products and 7 intermediate products) were shortlisted (out of the initial 33) based on an initial screening that considered the market relevance, the main environmental impacts and the existing policies for such products. These products were then examined further in order to identify which ones could be best candidates for potential prioritisation for the first ESPR WP. The analysis presented in this section aims at developing and applying a methodology that allows the ranking – and thus the suggestion for prioritisation – of the final and intermediate products that were shortlisted in Section 2.

3.2 Methodology

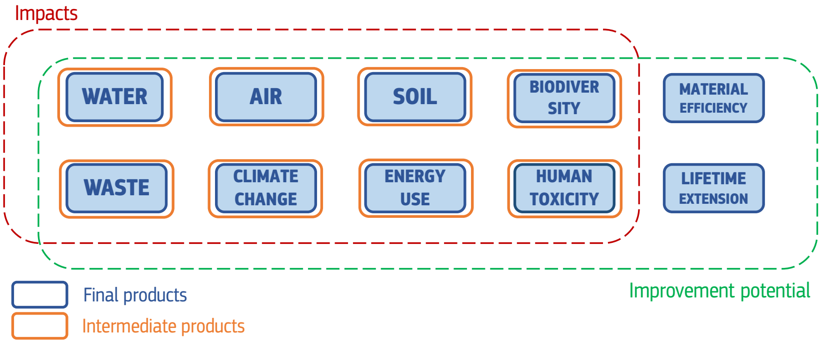
In line with Article 18 of the ESPR, the final and intermediate products that were shortlisted according to Section 2.2 were further assessed, scored and ranked in terms of their environmental impacts and improvement potential across different environmental aspects. Examples of potential performance and information requirements that could possibly be covered by ESPR were proposed. In addition, existing policy gaps and expected costs associated with the improvement potential were analysed. Finally, an analysis of the contribution of the shortlisted products towards EU Open Strategic Autonomy was also performed.

3.2.1 Assessment of the environmental relevance

Taking into account Article 18 of the ESPR and Annex 16 to the Impact Assessment accompanying the ESPR proposal, the assessment of the environmental relevance of the shortlisted final and intermediate products took into account the following environmental aspects: **water effects; air effects; soil effects; biodiversity effects; waste generation and management; climate change; life-cycle energy consumption; human toxicity; material efficiency; and lifetime extension** (see **Figure 7**). These categories were selected as the ones addressing the main climate, environmental and energy objectives of the EU. These categories include and go beyond the 16 midpoint environmental categories recommended by the EC for the Environmental Footprint (EF) method (EC, 2021), for example with respect to waste generation, biodiversity impacts or lifetime extension, although in a qualitative way. As explained in the next paragraphs, while for final products all environmental aspects were assessed, material efficiency and lifetime extension were not considered for intermediate products.

In any case, it is important to underline the difference between products' impacts that are multi-faceted and double-counted. For instance, while the same finite emissions of particulate matter cannot contribute to both impacts on water and impacts on air to the same extent, fossil fuel combustion can be considered to contribute to both air pollution and climate change simultaneously without that constituting double-counting. More details on the environmental aspects used for the assessment as well as their correspondence with the Environmental Footprint impact categories can be found in **Annex 4**.

Figure 7. Environmental aspects considered for the assessment of products' environmental relevance.



Source: JRC own elaboration

For the first eight environmental aspects (water effects, air effects, soil effects, biodiversity effects, waste generation, climate change, life-cycle energy consumption, and human toxicity), both the environmental impacts and the improvement potential of each product group were considered. Environmental impacts and improvement potential were evaluated, for each environmental category, considering the whole life cycle of the product. Environmental impacts were assessed globally, considering the full supply chain of the products. Nevertheless, the improvement potential, while referring to the (global) impacts identified, is linked to the European situation and to the type of intervention the ESPR could effect.

In particular, for each product group, the relevance of the environmental impacts and improvement potential for each environmental category were classified as Low, Medium, or High based on the following:

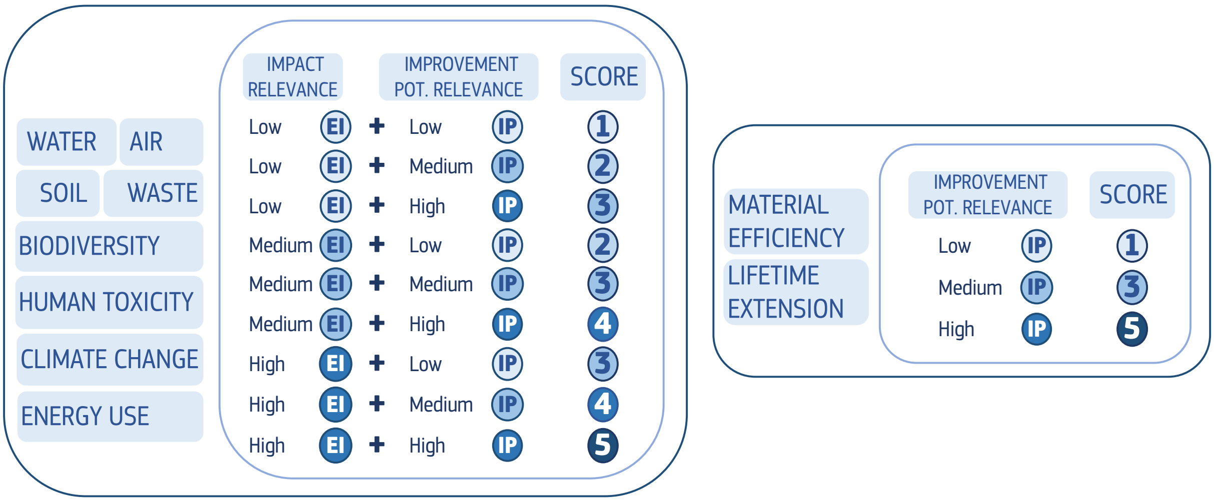
— Low relevance: the product group does not show any particular relevance in terms of impacts to that environmental category; the improvement potential for ESPR is marginal; technology and market trends do not suggest that impacts or the improvement potential may change in the near future.

— Medium relevance: the product group shows some relevance in terms of impacts to that environmental category; impacts caused are relevant but are being addressed; some improvement potential can be identified for ESPR and foreseen to give modest but tangible results; technology and market trends suggest that impacts or the improvement potential may change little in the near future.

— High relevance: the product group shows significant relevance in terms of impacts to that environmental category; impacts caused are significant and are not being sufficiently addressed; some or significant improvement potential is available for ESPR with clear links to environmental savings; technology and market trends suggest that impacts may continue in the near future, or the improvement potential may increase in the near future.

The relevance of the environmental impacts of a product group to a specific impact category and the related improvement potential were combined into a 5-point-based score, as described in **Figure 8**.

Figure 8. Score assignment methodology for the environmental relevance of products, combining the information on products' environmental impacts (EI) and improvement potential (IP).



Source: JRC own elaboration

On the other hand, the environmental aspects material efficiency and lifetime extension were assessed in terms of improvement potential only, in order to evaluate the extent to which a product group has potential for circularity measures such as durability, reuse, repair, recycling, recycled content and lightweight design, which have been listed in the ESPR (Article 5(1)) as aspects which should be addressed by ecodesign requirements. For each product group, the score of each environmental category was aggregated in a total score, which enabled the ranking of products.

To evaluate the environmental impacts and improvement potential for a certain environmental category, and thus to assign it a specific score, the analysis included both a **bottom-up** and **top-down approach**. This allowed the identification, for each product group, of the product's environmental hotspots (bottom-up analysis, i.e., which environmental aspects are more relevant in the product's life cycle in terms of impacts and potential improvement) as well as its overall contribution to the environmental categories in absolute terms (top-down analysis, i.e., whether the product's life cycle contributes substantially to those environmental categories globally). Indeed, the scores obtained enable a ranking which is relative to the shortlisted products, and would be different if additional or different products were considered.

It is important to underline that the analysis of the **improvement potential** was two-fold:

— a first analysis focused on the broad improvement potential that could be identified for a specific product group for the EU, including emerging technologies or measures that are likely to be covered by other legislation;

— a second analysis focused on 'Potential measures under ESPR', tailoring the improvement potential to the scope of possible action of the ESPR and preliminarily proposing potential performance and information requirements that could be possible under ESPR Delegated Acts, on the basis of Art. 5, Art. 7 and Annex I to the ESPR.

While the first analysis serves the objective of collecting available information and presenting the state-of-the-art situation for a specific product group, the estimation of the improvement potential as Low, Medium or High was based on the second analysis only, i.e., on what ESPR can be expected to deliver. The list of examples of potential performance and information requirements is based on the **product parameters listed in Annex I to the ESPR**, which have been targeted to the specific characteristics of the product under analysis. Therefore, for each product group, only a sub-list of the product parameters from Annex I is proposed.

It can often happen that one potential ESPR requirement can bring savings across different environmental areas. For example, incorporating recycled content material avoids (at least partially) the production of virgin materials, which is often associated with higher resource consumption. Also, the environmental aspects Waste generation, Material efficiency and Lifetime extension are interconnected by definition, and a potential ESPR measure affecting one of these will unavoidably bring savings to the other two. To avoid repetition, the proposed ESPR measures were reported under the main environmental aspect concerned only. Nevertheless, a **summary table** (in each product fiche) specifies which ESPR requirements have the potential to bring savings across more than one environmental aspect. In any case, it should be born in mind that the list of performance and information requirements identified at this stage is preliminary and focused at comparing and prioritising product groups. Such proposal also does not consider nor conclude on whether ESPR should implement the potential measures identified, or on whether other existing legislative instruments could be preferred.

It must be noted that a different approach was needed for final products and intermediate products. For **final products**, the whole life cycle (from raw material extraction to end-of-life) was considered during the environmental assessment and a 5-point-based score was given for the 10 environmental categories listed above. The maximum possible score for final products is thus 50.

For **intermediate products**, only the first eight environmental categories were considered in the assessment: material efficiency and lifetime extension categories were not included. This is due to the fact that intermediate products put on the market are products that will still undergo a manufacturing phase to produce final products, which will then be used and discarded. Therefore, only the raw material extraction and manufacturing phases of intermediate products were evaluated in the assessment. Indeed, a prerequisite for the assessment of material efficiency and lifetime extension strategies is an understanding of specific final products and their application. Thus, considering the wide and varied applications associated with intermediate products, material efficiency and lifetime extension were not included in the assessment, as these are only applicable to the use and end-of-life stages. The maximum possible score for intermediate products is thus 40. In any case, many (if not all) intermediate products are covered in the shortlisted final products, which means that the impacts related to the use and end-of-life stages of intermediate products are considered, in this methodology, within the final products.

In light of this, the results for final products and intermediate products will be presented separately and **not compared between each other**. Moreover, the difference in the maximum possible score will have to be considered for the interpretation of the results.

The analysis of products throughout this report, including the product fiches in **Annex 5**, has been carried out at the level of product groups. However, the product group scope presented in this report may not necessarily reflect the product group scope of future Delegated Acts, should the product be retained in the first ESPR Working Plan. For some products that rank in the top-three positions and that are considered as having a heterogeneous scope, i.e., Textiles and Footwear, Furniture, and Commodity Chemicals, this report presents an **analysis of the possible granularity** of the product into more homogeneous product sub-groups, i.e., a more granular grouping of products serving a specific function, e.g., furniture seats or furniture surfaces. For such product groups, **Annex 6** presents an analysis of possible sub-classification, based on existing sub-classifications used in policy documents, groupings used by the sector, classification used for statistical purposes (e.g., NACE), and other classifications, when relevant. The analysis also includes a reflection on which potential ecodesign requirements could be applied to which product sub-groups. Based on this, the analysis recommends whether it is considered feasible to split a product group into two or more Delegated Acts. Nevertheless, the granularity analysis presented in this report is to be considered as a preliminary assessment, with its only aim being to provide guidance on the most suitable policy option for grouping products. It will need to be further substantiated by a product-specific Preparatory Study, impact assessment and consultation with stakeholders.

The analyses were based on publicly available data only, and new data were not generated. Examples of literature/data used are: life-cycle assessment studies, other environmental analyses, economic analyses, scientific articles and reports, statistics, databases, industry reports, surveys, conference proceedings, and more.

3.2.1.1 Analysis of policy gaps

The aim of this analysis was to describe which of the potential measures identified in the assessment of environmental relevance are already addressed by EU legislation, and which are currently unregulated or partly regulated in the EU, as required by Article 18(1)(a)(i) of the ESPR. To this end, the EU policy landscape was analysed for each product group under analysis in a specific section titled 'Policy analysis'. In addition, the potential measures that in the assessment of environmental relevance were identified as having a score of Medium and High were compared to existing requirements in EU policies. As a result of this analysis, products for which a comprehensive regulatory framework already exists that tackles the main environmental impacts and improvement potential see a list of potential ESPR measures much shorter than other, less regulated, products. This may or may not influence the final score and ranking of products, since ultimately the score is defined by the potential for environmental savings, and not the number of requirements that could be set by ESPR.

Legislative proposals and ongoing revisions of existing regulations were acknowledged in the analysis, and the new regulatory elements foreseen by such proposals/revisions were considered in the study and compared with the main potential measures identified. It is important to bear in mind that since the work for such policy initiatives is still ongoing, it is not possible, at this stage, to predict the results in terms of new provisions and potential overlaps with possible future ecodesign requirements. Coherence between regulatory proposals and risk of over-regulating certain aspects will be taken into account for the final ESPR Working Plan or in preparatory studies, depending on the decision process of these policy initiatives. National legislation has not been addressed.

3.2.1.2 Reflections on potential costs

The aim of this analysis was to carry out an initial evaluation with regards to potential disproportionate costs associated with the implementation of main potential measures identified in the assessment of environmental relevance. To this end, relevant literature was researched and analysed. The desired outcome of this analysis is an estimation of whether, for a specific product, the costs associated with its improvement potential measures would be disproportionate or would be outweighed by the benefits delivered by that measure. To the extent possible, data were sought that could link a specific improvement measure with the costs born by it, although in many cases this was not possible. A more specific analysis is expected to be carried out as part of the Preparatory Study for the product groups that will be retained in the final ESPR Working Plan, as well as in Impact Assessments accompanying product-specific Delegated Acts.

3.2.2 Complementary analysis – Open Strategic Autonomy

Polycrisis and reshaped geopolitical order challenge the European Union's ambition to achieve EU climate neutrality by 2050 and keeping its resource consumption within planetary boundaries. The COVID-19 pandemic, Russia's unprovoked invasion of Ukraine, the associated energy crisis, and emerging threats of trade wars underscore the necessity of ensuring Europe's sovereignty and resilience. This involves mitigating dependencies and minimizing exposure to potential supply disruptions across strategic value chains.

To achieve this aim, the EU has developed the concept of Open Strategic Autonomy which refers to the ability to act autonomously (i.e., without being dependent on other countries) in important policy areas, reflecting its strategic interests and values. It builds on the importance of openness, recalling the EU's commitment to open and fair trade with well-functioning, diversified and sustainable global value chains Strengthening the resilience and sustainability of the EU economy while de-risking its supply chains is a pillar of the EU's drive towards Open Strategic Autonomy. Since the publication of the ESPR proposal on 30 March 2022, the path towards Open Strategic Autonomy of the Union has gained increasing political importance especially within the EU policy agenda and associated initiatives developed by the European Commission. The question of the extent to which ESPR Delegated Acts can contribute to EU Open Strategic Autonomy has thus gained significant relevance.

Art. 18 of the ESPR dealing with prioritisation and planning explicitly refers to the contribution to the functioning of the internal market and to the Union's **economic resilience**. In addition, recital (5) of the ESPR as well as the Annex I listing the list of product parameters highlight the importance to consider strategic and critical raw materials[33], material footprint and resource and energy efficiency. Finally, Art. 5 states that resource security shall be taken into account when setting ecodesign requirements. Economic resilience was already touched upon by some ecodesign requirements in the past, and we can cite for example provisions on circularity of selected critical raw materials contained in the Regulation (EU) 2019/424 on ecodesign requirements for servers and data storage products. The MEErP methodology has been recently reviewed by the JRC [34] and the methodology now contains a specific step where Critical Raw Materials potentially contained in product groups can explicitly be analysed in preparatory studies. This methodological upgrade should lead to more systematic consideration of Critical Raw Materials in upcoming preparatory studies and Ecodesign regulations.

The goal of this section is to analyse several criteria (beyond the only presence of critical raw materials) related to Open Strategic Autonomy aspects in the overall assessment for prioritisation of product. Open Strategic Autonomy is a broad, multi-faceted concept which can be declined at product-specific level with the aim of lowering supply dependencies for materials, intermediate and finished goods placed on the EU Market[35]. The section below presents the main aspects considered within this prioritisation exercised and detail the adopted methodology to classify the candidate products.

This assessment contributes to the understanding of how relevant are shortlisted products with regards to EU Open Strategic Autonomy and seek to identify the potential for improvement within each of the product in synergies with ecodesign aspects such as circularity or environmental footprint.

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33 See adopted Critical Raw Materials act, Regulation (EU) 2024/1252.

34 Reports and revised EcoReport tool available: https://susproc.jrc.ec.europa.eu/product-bureau/product-groups/521/documents

35 See Maury et al. (2023): From critical raw materials identification and circularity analysis to enhancement of EU strategic autonomy: a product policy contribution. In: Concordi conference proceedings.

However, it should not be understood as part of the formal selection and prioritisation criteria, since the ESPR lies in setting a framework related to ecodesign requirements, while Open Strategic Autonomy is not specifically quoted within Art. 18 of the ESPR.

3.2.2.1 Criteria associated to EU Open Strategic Autonomy considered in the study

The proposed assessment focuses on four main criteria listed below and related to the EU's Open Strategic Autonomy, particularly concerning potential supply risks for materials used in the product group under evaluation. Facing significant supply risks may lead to two potential effects on products: supply disruptions and price volatility. These factors are important as they can hinder the EU's competitiveness and resilience.

1. Product group containing critical and strategic raw materials

The importance of securing a sustainable supply of critical raw materials to reduce strategic dependencies is highlighted by the CRMs Act - Regulation (EU) 2024/1252. CRMs for the EU economy are those with a very high import reliance and external supply concentration from third countries often with low governance standards. As a result, CRMs are associated with high supply risk, low resilience, and reduced EU Open Strategic Autonomy. Similarly, a focus is made on strategic raw materials, for whose projected demand growth compared to current levels of supply, combined with the difficulties of scaling up production, resulting in potential supply shortage in the near future.

Therefore, evaluating the significant content of critical or strategic raw materials in a product group's composition is crucial. This assessment captures the potential risk of supply disruption and indicates in a first approach, the untapped potential regarding the recovery these CRMs at the product's end-of-life (EoL).

2. Product group derived from or manufactured using fossil feedstock (non-energy use)

Beyond CRMs, given the import reliance exceeding 95% for crude oil and petroleum product consumed in the EU (Eurostat, 2023), particular attention should be paid to materials manufactured from petrochemicals feedstock (crude oil, (liquid) natural gas or petroleum-derivates). While petrochemicals feedstock accounts for around 16% of the global oil demand, it is rapidly becoming the largest driver of this demand due the decarbonisation transition for energy and mobility sectors. As the supply of fossil feedstock for non-energy purposes becomes increasingly important, it is captured with specific criteria in the assessment.

3. Product group associated with substantial energy-related consumption during manufacturing and use phases

The high-energy prices currently faced by the EU and associated market volatility, are impacting EU industrial competitiveness and may lead to a loss of domestic production capacities. This situation could cause the relocation of EU-based energy-intensive industries to third countries where more affordable but more CO2-intensive energy sources are available. According to the EC (2022)[36], the Energy Intensive Industries (EII) ecosystem covers chemicals, steel, paper, plastics, mining, extraction

[36] Fiche on Energy intensive industries, July 2022: link

and quarrying, refining, cement, wood, rubber, non-ferrous metals, glass, and ceramics. These sectors target upstream activities enabling the production of intermediate products used in end sectors. Consequently, the vulnerabilities of such industries would affect the resilience of numerous value chains, making them more exposed to supply shocks. Therefore, whether the product group originates from energy intensive industry or not is selected as an additional criterion for the assessment. Additionally, when dealing with energy-related consumption, whether the product is an energy-related product (ErP) or not is relevant to integrate in the assessment. Energy savings through ErPs are important for EU energy security so that ecodesign of such product may allow to reinforce energy efficiency and contribute in fine to lower EU energy dependencies.

4. Product group (or material composing it) targeted by potential trade sanctions or import bans

Lastly, it is relevant to consider the material composition in light of the nature of materials or components that might be potentially banned from the EU or subject to import restrictions. This might be the case to materials and products banned from the EU market due to their intrinsic consequences (from an environmental or geopolitical perspective), such as contributions to deforestation and forest degradation worldwide (Regulation (EU) No 995/2010), or due to their origin from conflict areas under sanction regimes (Regulation (EU) 2017/821). The most emblematic case is the products and materials under the sanctions list against Russia after February 2022. The inclusion of materials, semi-finished, or finished products in such sanctions might lead to supply disruptions when reliance to the targeted country or geographical area is high. For these reasons, this criterion has been added to the assessment.

3.2.2.2 Inventory and data collection (simplified Bill of Materials)

3.2.2.2.1 Scope of the analysis and simplified Bill of Materials

For each of the shortlisted product groups on the list presented in **Table 1** a simplified Bill of materials (BoM) is established. A maximum of four raw or intermediate materials per product group are inventoried, with a particular focus on the presence of strategic and critical raw materials. For each product group, the potential presence of one or two CRMs in the product groups (according to the EC CRMs 2023 list) is analysed. Moreover, one or two additional elements depending on the composition and complexity of the product group are listed to increase the completeness of the inventory. These elements can be additional CRMs (in the event that more than two make up the product group), non-critical raw materials (e.g., silica sand or sodium salts) or intermediate products such as specific chemical compounds, natural or synthetic fibres. Particular attention has been paid in instances when these materials come from fossil feedstock like crude oil or petroleum-derivate products. The inventory table for each product group is available below in **Table 8**.

It should be noted that in the event that more than two CRMs make up a product group, these “additional” CRMs are listed in the inventory table as material number 3 or 4 but are not assessed as supplementary CRMs. This happens mainly in the case of intermediate products that can be manufactured with several different CRMs depending on the end market. For example, for glass products, rare-earth elements and borate have been considered as CRM 1 and CRM 2 while lithium (for which the supply risk is lower) has been listed as “material 3” but is not included in the calculation score to avoid having a simple addition of CRMs materials contributing to the final score.

In addition, the materials considered in the analysis are the ones which are directly used in the manufacture of the product, including the raw materials needed to obtain the intermediate or finished products (e.g., bauxite for aluminium alloys production). Additionally, the materials entering the whole production ecosystem can be considered when they play a significant role in the process. It is particularly the case of coking coal for steel making or Palladium group metals (PGMs) used as catalysts during chemical manufacturing. However, it should be noted that the link between potential ecodesign improvements of the product (e.g., with a potentially high recycled content) and the consequence in terms of material efficiency gains related to the processing stage is not easy to assess.

3.2.2.2.2 Information collected for each of the materials

For each of the materials embedded in the different product groups (see the inventory list in **Table 8**), the following parameters are addressed with reference to the criteria (see Section 3.2.2.1) they pertain to:

— For critical raw materials:

  - Supply risk (according to the CRMs 2023 list) of the targeted material [criterion 1].
  - Share of the EU material demand ending in the product group [criterion 1]
  - Specific material grade used in the product group (oxides, minor alloys grade, specific high-quality or metallurgical grade). [criterion 1]
  - Potential import restrictions or trade sanction affecting the materials (only if the product groups represents a significant share of the demand, i.e. ≥10%) [criterion 4]

— For other materials:

  - Whether the product group derives from fossil feedstock, such as crude oil and gas [criterion 2]
  - Share of the EU material demand ending in the product group [criterion 2]
  - Potential import restrictions or trade sanction affecting the materials [criterion 4]

— For the entire product group:

  - Whether the product groups is directly manufactured within the Energy intensive industries' ecosystem or is considered as energy-related product [criterion 3]
  - Potential import restrictions or trade sanctions applying directly to the product groups (on top of the potential targeted materials within the product) [criterion 4]

3.2.2.3 Algorithms for the scoring methodology

To perform an evaluation of the potential of shortlisted product groups for achieving EU Open Strategic Autonomy, a composite indicator is designed according to the list of parameters and the four associated criteria listed above.

These criteria are aggregated to assign each product a maximum score of 15 points according to the algorithm listed below. The product groups are then ranked and compared according to these criteria. To ensure alignment with other assessments dealing with environmental impact, the score is reshaped to follow a five-level classification rounded down to the nearest whole number. In practice, this means that the highest-ranking product groups are attributed a score of 5, with other product groups scaled accordingly. The obtained score over five for each product is rounded down, except for

Table 8. Simplified Bill of materials for the listed product groups.

	Product group	Critical Raw Materials: CRM1	Critical Raw Materials: CRM2	Other materials: Material 1	Other materials: Material 2
Final products	ABSORBENT HYGIENIC PRODUCTS			Natural fibres (cellulose)	Synthetic fibres
	BED MATTRESSES			PU foam	Natural rubber
	COSMETICS			Talc	Chemicals (organic compounds)
	DETERGENTS	Phosphate rock		Sodium salts	Chemicals (organic compounds)
	FISHING GEARS			Synthetic fibres	
	FURNITURE	Aluminium/Bauxite		Natural teak/spapele wood	Synthetic fibres
	LUBRICANTS	Lithium	Natural graphite (flake)	Mineral oil	
	PAINTS	Cobalt		Talc	Crude oil
	TEXTILES and FOOTWEAR			Natural fibres (e.g. cotton)	Synthetic fibres
	TOYS			Plastics	Natural rubber
	TYRES			Natural rubber	Carbon black
Intermediate products	ALUMINUM	Aluminium/Bauxite	Magnesium	Fluorspar	Scandium
	COMMODITY CHEMICALS	Platinum Group Metals	Fluorspar	Crude oil	
	GLASS	Rare Earth Elements	Borate	Feldspar	Silica sand
	IRON and STEEL	Coking coal	Niobium	Vanadium	Chromium
	NON-FERROUS METAL PRODUCTS, NON-AL.	Copper	Titanium	Nickel	Cobalt
	PAPER, PULP and BOARDS	Baryte		Kaolin clay	Talc
	PLASTICS and POLYMERS	Baryte	Antimony	Crude oil	Additives

Note: Colour legend related to material: purple: the share of the EU material demand ending in the product group represents ≥50%; light blue: ≥10%; grey: <10%. When a material or a product is underlined, it means a substantial share of this material is likely to be targeted by EU import restrictions or sanctions.

Source: JRC own elaboration

the product ranking the lowest. Since all products score at least 1 point, a final mark of zero out of five is not possible; therefore the score is rounded up to 1 (minimum score).

To distinguish this analysis from the environmental aspects, the resulting score for the Open Strategic Autonomy will be kept separate and not summed up with the environmental score, as it represents both a geopolitical and economical perspective rather than an environmental one. Please note that the Open Strategic Autonomy score does not only include the potential improvements that could be realised e.g. by increasing circularity or diversifying the supply mix. Nevertheless, considering parameters such as the quality grade or the share of the total EU demand ending in the product group can give qualitative information on the improvement potential for circularity measures with respect to Open Strategic Autonomy.

Algorithm for criteria 1: critical and strategic materials

The criticality of the supply (based on the CRMs list 2023) was addressed with a total score of maximum 3 points per CRM (total score for the criterion 1 = 2 x 3 points maximum). The proposed algorithm is the following:

— If the material is critical and the share of the demand is ≥ 10%: 1 point/CRM; if the material is critical and the share of the demand is ≥ 50%: 2 points/CRM; if the material requires a specific "high-quality" grade (such as aerospace grade or high purity): 3 points/CRM.

Algorithm for criteria 2: Fossil feedstock for materials

The fact that the materials used in the product groups come from fossil feedstock (e.g. oil-based products) is evaluated with a total score of 4 points (2 points maximum per element). The proposed algorithm is the following:

— If the material is derived from crude oil: 1 point/material; if the share of the demand in the product group represents ≥ 10% of EU demand for that material: 2 points/material.

Algorithm for criteria 3: Energy-related consumption for manufacturing and use stages

The energy intensive energy ecosystems is evaluated with a yes/no criterion, awarding a total score of 1 point. Similarly, the fact that the product is an energy-related one is accounted for with one additional point. Hence, the evaluation is carried out as follows:

— If the product group stems from sectors encompassed within the energy-intensive industry ecosystems, 1 point is given to the product group;

— If the product group is an energy-related product, 1 point is given to the product group.

Algorithm for criteria 4: Trade sanctions/import bans

Supply restrictions due to trade sanctions or import bans related to geopolitical or environmental aspects are evaluated with a focus on the geopolitical context, particularly the invasion of Ukraine. The evaluation has a total score of 5 points: 1 point per CRM element and non-CRM element, plus 1 additional point if the product group itself is targeted by restrictions. **Table 8** highlights by underlining them the elements considered in the evaluation.

It should be noted that when only partial restrictions applied to the product group the additional point is not awarded. For instance, copper products are only partially targeted with sanction against Russia (only copper wires), the same applies to aluminium with only several finished aluminum products included in the sanction packages. Additionally, if the product group is targeted by import restrictions but its market share in the EU is not significant, the point is not awarded. This is the case for cosmetic chemicals: the fact that chemicals composing the cosmetics (as materials) may be targeted by sanction is accounted for, but no supplementary point is given become import restriction on cosmetics (finished products) produced in Russia is expected to have a very minor effect on the EU economy.

Hence, the proposed algorithm is the following:

— If the material is targeted by restrictive import measures more particularly Council Regulation (EU) 2024/1428 on sanctions against Russia or Regulation (EU) 2023/1115 on deforestation-free products: 1 point/material

— If the whole product group itself is targeted by restrictive import measures: 1 supplementary point is awarded.

3.3 Results and discussion

3.3.1 Assessment of environmental relevance of shortlisted product groups

As explained in previous sections, the 18 product groups shortlisted as a result of the initial screening were assessed in terms of environmental relevance for 10 different environmental categories, taking into account the products' impacts and potential for improvement. To this end, **Annex 5** presents the results of the assessments organised in individual 'product fiches' for each of the final and intermediate products, illustrating the background information behind the assigned scores and listing the potential measures that future Preparatory Studies could consider for a deeper analysis in advance of a product-specific ESPR Delegated Act.

While the detailed results of the assessment of the environmental relevance are presented in **Annex 5**, the final environmental scoring of final products is presented in **Table 9** (Section 3.3.1.1); intermediate products are presented in **Table 10** (Section 3.3.1.2). In particular, **Annex 5** gathers the detailed results of the assessment for each shortlisted product group in individual 'product fiches', which are the basis for the ranking proposed in the next Sections.

As mentioned in Section 3.2.1, it is important to bear in mind that the scores reported in **Table 9** and **Table 10** represent a relative ranking, meaning that they can only be compared between products in the same table. This means that a score of '28' in the case of intermediate products should be interpreted differently than the same score for final products.

3.3.1.1 Final products

The top scoring product groups according to the assessment methodology described in Section 3.2.1 resulted to be, by far, **Textiles and footwear**, which obtained a total environmental score of 42 points, 12 points higher than the second highest-scoring product group. This result does not come as a surprise since the 2020 Circular Economy Action Plan, the Textiles Strategy and the 2021 update of the EU Industrial Strategy already identified textiles as a key product value chain with an urgent need for action and a strong potential for the transition to sustainable and circular production, consumption and business models. Textiles obtained the highest score in water effects, waste generation, climate change, energy consumption, and material efficiency, due to the large impacts caused by sourcing, producing, using and discarding materials. Microplastics release is also a concerning problem, and state-of-the-art methodology (as reported in **Box 3**) suggests the current levels of consumption of textiles to lead to a total amount of plastic (both as macro- and micro-plastic) pollution of around 50 kilotonnes of plastics - equivalent to 20 million plastic chairs, which would be enough to sit together all population of Portugal and Austria for a joint gathering. The improvement potential for textiles also scored high for almost all environmental aspects, and especially in terms of circularity, which is still largely untapped. Indeed, reuse and recycling of used textiles could bring significant savings in terms of water use and pollution, biodiversity, climate change and energy use, in addition to reducing waste generation. This represents a significant

Table 9. Environmental assessment of the 11 final products shortlisted.

Score	Product	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	HUMAN TOXICITY	MATERIAL EFFICIENCY	LIFETIME EXTENTION
42	TEXTILES and FOOTWEAR	5	3	4	4	5	5	5	3	5	3
30	FURNITURE	1	3	3	3	4	3	3	2	3	5
30	TYRES	3	4	3	3	3	3	3	2	3	3
28	BED MATTRESSES	1	3	1	2	5	3	3	2	5	3
26	DETERGENTS	4	2	2	3	3	3	3	2	3	1
24	PAINTS	3	3	2	3	3	2	2	2	3	1
24	COSMETICS	4	2	1	4	3	2	1	2	3	1
23	LUBRICANTS	2	2	2	2	2	3	2	2	3	3
23	TOYS	1	1	1	1	4	2	2	3	3	5
21	FISHING GEARS	4	1	1	4	3	2	1	1	3	1
19	ABSORBENT HYGIENE PRODUCTS	3	1	2	2	4	2	2	1	1	1

Source: JRC own elaboration

improvement potential, since textiles' current value chain include little or no reuse and recycling (EEA, 2019). Solutions towards increased recycling include reducing the complexity of materials used to produce textiles and textile products, adopting product passports and materials labelling at the design stage (Ellen MacArthur Foundation, 2017). Also, measures that ensure and increase the durability of the items and the resistance to shrinkage/weather could double the average product life, which was estimated to save 44% of GHG emissions (Ellen MacArthur Foundation, 2017). However, measures related to reuse, recycling, and durability should go hand in hand with information requirements to boost consumer awareness, in order to avoid undesired rebound effects. Finally, large improvement potential could also be identified in sustainable sourcing of primary materials, decarbonisation, and energy efficiency measures (see **Annex 5** for full details).

Furniture exhibited a high improvement potential in terms of waste generation and lifetime extension, which could be improved by performance requirements on design for durability, design for reliability (e.g. resistance to stress or weathering), design for disassembly, design for refurbishing and/or recyclability, availability of spare parts and mandatory minimum recycled content materials. These circularity measures have the potential to extend the lifetime of the product or its components, potentially saving on new resources, and therefore having an effect on other categories such as air, soil and biodiversity.

Tyres represents a special case among the assessed products. Indeed, Tyres show a high relevance with respect to impacts on soil, biodiversity and climate change in terms of microplastics release. With the state-of-the-art estimation methodologies (reported in **Box 3**) the current levels of consumption of tyres would lead to a total amount of plastic (both as macro- and micro-plastic) pollution of around 116 kilotonnes of plastics, equivalent to 46 million plastic chairs, which would be enough to sit together almost all population of Spain (estimated at 48.6 million people as of 1 January 2024 - Eurostat, 2024). However, potential solutions to microplastics release are still being identified by the sector. It is in fact essential to develop testing methods or standards to measure and estimate tyres' abrasion. According to Euro 7 Regulation, Article 15, "*the Commission shall adopt delegated acts setting out abrasion limits for tyres types relying on the work of the UN WP.29. Where the UN WP.29 has not adopted uniform provisions by 1 July 2026 for C1 class tyres, by 1 April 2028 for C2 class tyres and by 1 April 2030 for C3 class tyres, the Commission shall develop a method for the measurement of tyre abrasion and shall define abrasion limits for tyres based on existing state-of-the-art methods*". Therefore, the improvement potential for Tyres in impacts to soil, biodiversity and climate change was evaluated as medium, although an untapped potential for improvement, not yet identified, may be discovered. When it comes to the collection of used tyres, 40 % is currently destined for co-incineration. However, it has been estimated that recycling of EOL tyres could save 700 kg of CO2 per tonne of tyres. Further research should be carried out in the areas of re-treading, emerging uses for end-of-life tyres rubber, recycling and recycled content targets and sustainable sourcing and deforestation-free supply chains.

Bed mattresses and **Detergents** scored 28 and 26, respectively. Potential measures for Bed mattresses focused on reducing waste generation and, therefore, increasing material efficiency and lifetime extension, in particular related to design for disassembly, design to facilitate recycling, and minimum recycled content. The main improvement potential identified for Detergents lies in sustainability certifications for the raw materials, packaging volume that is not excessive and that is lightweight. For example, it was estimated that refillable designs in home cleaning products could save 80-85% of current GHG emissions caused by packaging and transport (Ellen MacArthur Foundation, 2021). Innovative products that are effective at low temperatures can moreover bring large savings in water use, material efficiency, waste generation, and energy use. Yet, it should also be noted that the European Parliament and the Council of the European Union proposed several new sustainability requirements in its amendments to the proposal for a revision of the Detergents Regulation. The final choice of whether Detergents should be retained in the first ESPR Working Plan may depend on the final text of the revised Detergent Regulation, which cannot be anticipated at the moment.

Paints, **Lubricants**, **Cosmetics** and **Toys** obtained a total environmental score between 24 and 23, and represent product groups which are relevant for prioritisation under the ESPR, but to a lesser extent than the products discussed above, either because of a relative lower environmental impact (compared to the other products analysed), improvement potential, or both. Paints, Lubricants and Cosmetics are mixtures, whose main impacts occur to water, air and soil due to the sourcing of their ingredients and their dissipative use (especially for Lubricants and Cosmetics). Paints are also a large contributor to microplastics pollution, however the improvement potential is estimated to be low, given that technologies are still being developed by the sector. Waste reduction potential mainly lays within measures to be set on their packaging, excluding recyclability and recycled content aspects that are addressed by the soon-to-be-adopted revised Packaging and Packaging Waste Regulation. Toys, on the other hand, includes complex products characterised by large waste generation due to low durability and reliability, but also due to discarding of the products as the age of the user increases. Main improvement potential measures lies thus in design for reliability and design for disassembly, upgrading and recycling. In addition, circular business models that rethink the way we consume toys have the potential to reduce the environmental impacts associated with this product group.

Fishing gears and **Absorbent hygiene products** close the ranking list, with a score of 21 and 19, respectively. Indeed, Fishing gears showed relevance in terms of water effects, biodiversity, waste generation and material efficiency; however, all the other environmental categories showed a very low relevance. On the other hand, Absorbent hygiene products, while showing medium-to-high impacts in almost all categories, did not show significant improvement potential for ESPR, mainly due to the nature of the product group, which is single-use and with high hygienic standards to allow for recycled content measures (at least in the short term).

It is important to bear in mind that the total environmental score obtained for the different product groups implicitly **includes the size of the market** of the product group, or, in other words, the assessment was carried out over the whole product group (e.g. Textiles and Footwear), and not over a unit of the product group (e.g. a t-shirt or a pair of shoes). Therefore, products with a larger market share may be expected to obtain higher scores. However, products with a lower market share are not necessarily at the very bottom of the ranking. For example, Lubricants scores as high as, or even higher than, other products, despite being a product group and with a smaller consumption intensity. In this regard, it should also be highlighted that while the improvement potential addressed in this analysis is linked to the products' impacts, which are global, the identified potential measures relate to what can be feasible to be regulated under ESPR. This means that, for each environmental category, the estimation of the relevance of the improvement potential (Low/Medium/High, as explained in Section 3.2.1) targeted measures that can be implemented in the EU, and specifically via ESPR delegated acts. However, this does not necessarily mean that only impacts occurring in the EU would be addressed; on the contrary, as the Delegated Acts would apply to final products placed on the EU market, limits set to e.g. emissions of pollutants during production would have to be respected regardless of the country where the production takes place. Nevertheless, it is important to highlight that how ESPR requirements would be formulated would be clarified at a later stage, should the product be retained in the ESPR workplan, via a preparatory study and stakeholder consultations. Therefore, the list of potential measures presented in the individual factsheets for the shortlisted final products should be looked at as indicative only.

This Final Report does not include the product group **Ceramics**, compared to the Preliminary Report. After analysing the contributions of the open public consultation, ceramics was excluded from the list of final products given the fact that according to Eurostat data, two thirds of ceramic products fall inside the category of construction products, which is excluded from the scope of ESPR working plan. In addition to that, within ceramics, there are products that can be considered final as tableware, however others can be identified as intermediate, which is the case of refractory bricks (65% are sold to steel industry). Thus, the market share of ceramics is significantly lower than the other products analysed. This situation considerably reduces both the impact and the potential for improvement of this group of products and they are therefore left out of the analysis.

3.3.1.2 Intermediate products

Iron and steel, Commodity chemicals, and (Non-ferrous, non-aluminium) metal products were the top three scoring groups among the intermediate products, where Iron and steel was at the top with a score of 30 points, Commodity chemicals obtained a score of 28, and Non-ferrous, non-aluminium metal products a score of 27 (**Table 10**).

Iron and steel as an intermediate product scored maximum points in three out of the eight categories investigated, due to high impacts and high improvement potential in water effects, climate

Table 10. Environmental assessment of the 7 intermediate products shortlisted.

Product	Score	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	HUMAN TOXICITY
IRON & STEEL	30	5	4	2	2	4	5	5	3
COMMODITY CHEMICALS	28	4	4	3	3	3	5	4	2
NON-FERROUS METAL PRODUCTS	27	3	2	3	2	5	4	5	3
ALUMINIUM	26	1	4	4	3	4	4	4	2
PLASTICS	23	3	3	2	2	3	4	4	2
PULP & PAPER	21	3	2	3	3	2	3	4	1
GLASS	20	2	2	2	3	2	4	4	1

Source: JRC own elaboration

change, and life cycle energy consumption. In waste generation and air effects, Iron and steel scored High only in terms of impacts, whereas its improvement potential was estimated as Medium. Only in soil effects and biodiversity categories, Iron and steel showed a Medium relevance in terms of impacts and a Low relevance in terms of improvement potential. For this product, water impacts could be reduced by water consumption optimisation (e.g. by recirculation techniques), whereas air impacts could be addressed by substitution of polluting raw materials with less polluting ones, de-dusting operations, recycling targets and waste recovery, among others. Climate change impacts could be mitigated by means of novel low-emissions processes, including those that integrate carbon capture, utilisation, and storage (CCUS) and hydrogen, and by adopting material efficiency strategies to reduce losses and optimise steel use throughout the value chain. Energy use could be reduced by the collection of data on energy intensity to enable better performance assessments and comparisons, raw material substitution, increasing production from scrap, natural gas-based DRI (direct reduced iron) and hydrogen-based DRI techniques.

Commodity chemicals scored second, with 28 points. This product group showed large impacts and large-medium improvement potential in terms of climate change and energy consumption. Efficiency, innovation and alternative sourcing (both raw materials and energy) are shared aspects to decrease the environmental footprint of chemicals. This could be achieved by scaling-up more sustainable process-related technologies and sourcing (thus decoupling even further GHG emission from energy consumption in EU) and by optimising the processes by digital means, including necessarily skilling up the associated workforce. Measures for Commodity chemicals could comprise setting a cap on GHG emissions or energy consumption; or introducing mandatory minimum shares of low carbon sources for the energy used; or sourcing raw materials via certified sustainable practices. These performance requirements should be accompanied by the associated information requirements, which would make users aware of the data behind them, in order to allow informed choices and usages. Water and air effects also showed large impacts, especially due to process emissions, and the improvement potential was estimated as Medium for these categories due to the untapped potential from imported products, which are not covered by the emission limits of the Industrial Emission Directive.

Non-ferrous, non-aluminium metal products scored third (27 points) with high impacts and high improvement potential in waste generation and energy consumption. Waste generation could be reduced by increasing the circularity of materials that are used in final products, which, by avoiding mining, would reduce also the impacts related to water, air, and soil pollution. The amount of recycled content in new products is moderately high already today, which can contain 40% of recycled copper, 30% of recycled zinc, and 35% of recycled lead (Feil et al, 2019). The European non-ferrous metal association Eurometaux indicates that in 2050 this sector can be secured with a dedicated horizontal industry strategy, contributing to the climate-neutral transition (Wyns et. al, 2019).

Aluminium scored fourth among the intermediate products, with 26 points. Aluminium showed large impacts and improvement potential in terms of waste, climate change and energy consumption, air and soil pollution. Improvement potential measures could target maximum limits for energy consumption and GHG consumption during manufacturing, recycled content, and sustainability certifications for the sourcing of raw materials. In particular, incorporating secondary materials during manufacturing was identified as a key improvement potential measure, which could reduce the GHG emissions by 11 times (Moya Rivera et al., 2015).

Plastics and polymers scored fifth, with 23 points. This product group showed large impacts and medium improvement potential in terms of climate change and energy consumption. Efficiency, innovation and alternative sourcing (both raw materials and energy) are aspects that can decrease the environmental footprint of plastics. This is also related with diverging from fossil fuels consumption, both as energy and as material source. Circularity and efficiency can be boosted by reducing its consumption, via less plastic production and wastage, as well as by shifting towards more sustainable sources and alternative designs such as reusable and/or recyclable plastics, e.g. avoiding polymer mixes or the use of additives/colorants that prevent reuse or recycling. Similarly to the case of Commodity chemicals, measures for Plastics and polymers could comprise setting a cap on GHG emissions or energy consumption; or introducing minimum share of low carbon sources for the energy used; or sourcing raw materials via certified sustainable practices; and/or require a share of recycled content as input material.

Finally, **Pulp and paper** and **Glass** close the priority list, with 21 and 20 points, respectively. For these intermediate products, circularity options are already quite established during production. For example, 56% of the total paper fibre production in EU in 2021 came from recycled fibres (CEPI, 2022), while for the glass sector, the great majority of internally generated glass waste is already recycled back to the furnace (Scalet et al., 2013). Further improvement is more dependent on waste management strategies and amount of waste generated rather than alternative design.

3.3.2 Policy gaps

This step assessed whether, for each product group, the existing policy framework is addressing the areas where large or medium improvement potential was identified, thereby confirming or not whether a certain product group is a suitable candidate for prioritisation under ESPR. Also in this case, detailed information for all product groups investigated is presented in the individual factsheets in **Annex 5**. This includes, for each product, a dedicated section on policy analysis as well as a summary table where examples of possible performance and/or information requirements are compared with measures existing in current EU policies (proposal regulations under revision have not been considered, nor have national legislation), to show the potential of the requirement, should it be considered for future Delegated Acts. In addition, **Table 11** summarises the aspects covered by existing legislation and lists examples of possible ecodesign measures holding potential for ESPR (right-hand column "examples of potential ecodesign requirements"). The list should not be seen as a proposal for ESPR measures, as its main objective is to illustrate the improvement potential for different product groups, identifying areas to be further investigated by future studies.

It is important to underline that at this stage of the process, no conclusion is drawn on whether ESPR is the right legislative instrument to tackle specific environmental aspects, as this is a political aspect which should be analysed in a holistic way considering the nature of promising requirements, how this fits under the scope of other existing policies as well as future Commission priorities.

The EU has in place a comprehensive regulatory framework that targets environmental impacts horizontally as well as in a product-specific way (for some products and/or some environmental impacts). Some of these policies are important to be considered for the prioritisation of products, to carefully identify the scope of action of ESPR, ensure consistency and avoid over-regulation.

All packaging used for final products are covered by the soon-to-be-adopted revised Packaging and Packaging Waste Regulation (PPWR), therefore this information was not repeated in each product fiche, nor in **Table 11**. The PPWR covers both packaging design and packaging waste management in order to prevent the generation of packaging waste and to promote the reuse and recycling of packaging waste across the EU. The new PPWR ensures that packaging can only be placed on the market if designed in such a way as to permit its reuse or recycling, in addition to mandatory requirements on recycled content and recyclability for plastic packaging. Overall, all products show improvement potential measures that go beyond current policy requirements. Textiles and footwear, Furniture, Bed mattresses, Lubricants, Toys, and Absorbent hygiene products were the product groups with the least policy coverage, since no sectorial legislation exists at the moment that addresses their environmental performance. The products with the highest policy coverage (in terms of environmental requirements) are Detergents and Cosmetics, especially because of the Detergents Regulation and the Cosmetic Product Regulation that set bans and restrictions on specific substances based on environmental or human health considerations, labelling and dosage requirements. It should be mentioned that the Detergents Regulation is currently under revision, with the aim of clarifying and simplifying the rules that allow for innovative products and sustainable new practices; reducing the burden for manufacturers, providing clear information to consumers, and optimising the protection of human health and the environment. While such revision has the potential to address some sustainability aspects, especially in terms of biodegradable and less toxic alternatives as well as availability of refills and dosage requirements, aspects oriented to increase water and energy efficiency, GHG emissions, sustainability certifications for the raw materials, product-to-packaging ratio and packaging light-weight design may not be addressed. While it could be possible to address circularity aspects by horizontal measures (see Section 2.3.2), Detergents is not proposed to be excluded from the priority list of final products. Nevertheless, it is recommended to follow closely the developments of the revision of the Detergents Regulation when drafting the final ESPR Working Plan.

With respect to Tyres, its current legislative framework addresses aspects related to the environmental control of the installation through the Industrial Emission Directive, while safety is addressed in Regulation (EU) 2019/2014 related to vehicles, where Tyres are considered as a component of the same (EC, 2019c). However, it is in Regulation (EU) 20/20/740 on the labelling of tyres (EC, 2020b) where environmental performance is regulated from an energy perspective. Aspects such as fuel efficiency, wet/ice grip, external rolling noise are currently addressed and the need to

Table 11. Summary of the main product environmental aspects already regulated in the EU (left-hand column) for the 11 shortlisted final products, and exemplary list of possible improvement measures for such products (right-hand column), in accordance with Annex I to ESPR. Non-exhaustive lists. For further information see Annex 5.

IMPORTANT: The examples for potential ecodesign requirements are of illustrative nature and can by no means be understood as pre-determination of future legislation. Any discussion of ecodesign requirements will start once the decision is taken for a specific product group to be addressed through an ESPR Delegated Act.

Product	Environmental aspects regulated in the EU	Examples of potential ecodesign requirements
TEXTILES and FOOTWEAR	• Emissions from EU production of textiles • Mandatory due diligence for cotton • Separate collection of textile waste • Voluntary labelling of energy consumption from low carbon sources	• Maximum limit of microplastics release • Minimum content of raw materials with sustainability certification • Maximum amount of life cycle waste generated • Safe, easy and non-destructive access to recyclable components • Use of easily recyclable materials or combination of materials • Minimum recycled content • Maximum number of materials and components used • Adequate and standard sizing and fitting of the product • Maximum level of carbon footprint • Maximum level of life cycle energy consumption • Minimum reliability
FURNITURE	• Emissions from EU production of main materials (plastics, steel, glass) • Mandatory due diligence for wood • Carbon emissions of main materials • Voluntary labelling of energy consumption from low carbon sources	• Emissions from the production of furniture • Minimum content of raw materials with sustainability certification • Minimum recycled content • Safe, easy and non-destructive access to recyclable components • Use of easily recyclable materials or combination of materials • Maximum number of materials and components used • Compatibility with commonly available tools and spare parts • Minimum reliability • Availability and affordability of spare parts • Use of standards components • Minimum share of energy use from low carbon sources • Availability of guarantees and information
TYRES	• Emissions from EU production of rubber • Type approval • Mandatory due diligence for rubber • Waste prevention and recycling targets	• Minimum content of raw materials with sustainability certification • Ease of upgrading, re-use, remanufacturing and refurbishment • Minimum recycled content • Maximum level of carbon footprint • Minimum content of sustainable renewable materials
BED MATTRESSES	• Emissions from EU production of main materials • Mandatory due diligence for rubber and wood • Waste prevention and recycling targets	• Maximum amount of life cycle waste generates • Minimum content of raw material with sustainability certification • Safe, easy and non-destructive access to recyclable components • Minimum recyclability and recycled content • Maximum level of carbon footprint • Minimum reliability • Availability of info long after the product is sold
DETERGENTS	• Emissions from EU production of chemical ingredients • Mandatory due diligence for palm oil and soy • Recyclability and recycling content of packaging • Push for refillable packaging • Chemical safety	• Emissions from production of detergent products • Minimum content of raw material with sustainability certification • Maximum level of carbon footprint • Minimum share of energy use from low carbon sources • Efficiency of the product at low energy consumption • Minimum content of sustainable renewable materials • Lightweight design • Maximum product-to-packaging ratio • Availability of spare parts

Source: JRC own elaboration

Table 11 (continues). Summary of the main product environmental aspects already regulated in the EU (left-hand column) for the 11 shortlisted final products, and exemplary list of possible improvement measures for such products (right-hand column), in accordance with Annex I to ESPR. Non-exhaustive lists. For further information see Annex 5.

IMPORTANT: The examples for potential ecodesign requirements are of illustrative nature and can by no means be understood as pre-determination of future legislation. Any discussion of ecodesign requirements will start once the decision is taken for a specific product group to be addressed through an ESPR Delegated Act.

PAINTS and VARNISHES

Environmental aspects regulated in the EU
- Emissions of EU production of some ingredients of paints
- Recyclability and recycling content of packaging
- Chemical safety

Examples of potential ecodesign requirements
- Emissions from production of paints and varnishes
- Maximum level of life cycle release of microplastics and nanoplastics
- use of easily recyclable materials
- Maximum product to packaging ratio
- Minimum reliability
- Maximum material footprint of the product

COSMETICS

Environmental aspects regulated in the EU
- Emissions of EU production of chemical ingredients
- Presence of microplastics
- Mandatory due diligence on palm oil and soy
- Recyclability and recycling content of packaging
- Push for refillable packaging
- Chemical safety

Examples of potential ecodesign requirements
- Emissions from production of cosmetics products
- Minimum content of raw material with sustainability certification
- Restrictions of secondary packaging
- Maximum amount of product remaining in the packaging
- Maximum level of carbon footprint
- Maximum product to packaging ratio
- Lightweight design
- Mandatory minimum use of renewable materials
- Minimum content of sustainable raw materials

LUBRICANTS

Environmental aspects regulated in the EU
- Recyclability and recycling content of packaging
- Chemical safety

Examples of potential ecodesign requirements
- Minimum content of sustainable renewable materials
- Maximum product to packaging ratio
- Maximum level of carbon footprint
- Minimum reliability

TOYS

Environmental aspects regulated in the EU
- Toys safety
- Mandatory due diligence rules o wood.
- Waste prevention and recycling targets

Examples of potential ecodesign requirements
- Safe, easy and non-destructive access to recyclable parts
- Use of easily recyclable materials or combination of materials
- Ease of upgrading, re-use, remanufacturing and refurbishment
- Maximum number of materials and components used
- Minimum recycled content
- Maximum level of carbon footprint
- Minimum content of sustainable renewable materials
- Maximum product to packaging ratio
- Minimum reliability
- Availability and affordability of spare parts
- Availability of guarantees and information

FISHING GEARS

Environmental aspects regulated in the EU
- Marking and identification of fishing gears
- Restrictions on the use of specific fishing gears

Examples of potential ecodesign requirements
- Use of component and material coding standards
- Design of traps and pots with effective escape mechanisms with biodegradable mechanisms
- Use of easily recyclable materials or combination of materials
- Minimum content of biodegradable materials
- Design for lighter weight
- Use of standard components
- Design to facilitate repair
- Availability of information

AHP

Environmental aspects regulated in the EU
- Emissions of EU production of fluff pulp and viscose

Examples of potential ecodesign requirements
- Emissions from production of AHP
- Use of easily recyclable materials or combination of materials
- Minimum recycled content
- Maximum number of materials and components used
- Safe, easy and non-destructive access to recyclable parts
- Use of component and material coding standards

Source: JRC own elaboration

find methods to measure the emission of microplastics is also mentioned, always in terms of labelling. Prospective work on tyres in the current Ecodesign and Energy Labelling Working Plan (EC, 2022b) includes informational and labelling requirements on retreading and abrasion mileage, respectively, subject to having suitable testing methods available. According to Euro 7 Regulation, Article 15, "*the Commission shall adopt delegated acts setting out abrasion limits for tyres types relying on the work of the UN WP.29. Where the UN WP.29 has not adopted uniform provisions by 1 July 2026 for C1 class tyres, by 1 April 2028 for C2 class tyres and by 1 April 2030 for C3 class tyres, the Commission shall develop a method for the measurement of tyre abrasion and shall define abrasion limits for tyres based on existing state-of-the-art methods*". The aspects that remain to be covered are the recycling of end-of-life tyres (ELT) as ELT granulate and powder, emerging uses for ELT rubber, sustainable sourcing of raw materials, as well as finding reliable, accurate and reproducible methods to measure and reduce tyre's abrasion.

As substantiated in the previous paragraphs, in particular for Detergents and Tyres there is no clear indication on the best way to address policy gaps – i.e. whether through Delegated Acts under ESPR, or inclusion under already existing legislation.

All assessed intermediate products are also regulated under the Industrial Emission Directive, determining the emission levels associated with the best available techniques for emissions to air and/or water (Best Available Technologies Associated Emission Levels – BAT-AELs). The Industrial Emission Directive was recently revised to increase the focus on energy, water and material efficiency and reuse, in addition to promoting the use of safer, less toxic or non-toxic chemicals in industrial processes. The BAT-AELs apply to EU large installations, which should comply with such limits in order to obtain their operation permit. Given the focus of the Industrial Emission Directive on the EU since 2010, the improvement potential for the environmental categories of water effects, air effects and soil effects was evaluated as 'Low' for those product groups that are primarily produced in the EU. This was not the case for products that, although consumed in the EU, are mainly produced outside the EU, such as Textiles and Footwear, but also some of the Commodity Chemicals, whose consumption in the EU relies 100% on imports, and Absorbent Hygiene Products, for the production of fluff pulp and viscose which take place mainly in the US and Asia, respectively (see more detailed information in **Annex 5**). In fact, the potential for ESPR lies in targeting also imported products, which fall outside the scope of the Industrial Emission Directive.

In light of the above, no product was excluded from the priority list; nevertheless, the list of potential ESPR measures was revised and adapted in order to ensure no overlaps with existing regulation.

3.3.3 Reflections on potential costs

This section presents the considerations of an initial analysis that was carried out to estimate, based on available data and information in the literature, whether the potential ESPR measures proposed for individual product groups could result in disproportionate costs. A detailed cost assessment was out of the scope of this prioritisation study, but will be addressed at a later stage by dedicated Preparatory Studies, for the products that will be retained in the final ESPR Working Plan.

Most of the potential ESPR measures identified focus on reducing the use of water, chemicals, energy, and materials in general. Therefore, the investment costs borne by industries to make a change are expected to lead to benefits provided by such measures, and could be offset by the resulting savings in water, chemicals, energy and materials. For example, it was found that for the cosmetic and detergent sector, achieving zero manufacturing waste to landfill could lead to a saving of EUR 2 000 million (P&G, 2020). For Textiles and footwear, a case study on 33 factories found that an up-front investment of EUR 17.3 million resulted on average in 9% of water saved and 6% of energy saved, with a payback time for the whole program of 14 months (Greer et al., 2015). New technologies such as laser-induced breakdown spectroscopy can improve the control of glass feedstock, achieving 20% reduction in product defects, which was estimated to save EUR 220-440 million yearly, in addition to provide energy savings (Furszyfer Del Rio et al., 2022). Also, heat recovery measures in mechanical pulping were estimated to have a payback period of few months (Kramer et al., 2019). Investment returning is important to make sure that consumers do not see a disproportionate raise of products' prices.

Costs should also be accounted for in terms of the avoided costs to society, for example as avoided environmental degradation or avoided process. For example, for Plastics and polymers, cost estimates in terms of environmental degradation, climate change and health, are in the range of EUR 75-139 billion annually, with 75% of these environmental costs occurring at the manufacturing stage, although estimates are not very recent (UNEP, 2014; Lord, 2016). The waste management costs that could be avoided thanks to the reduction of waste generation should also be considered. This is important for product groups for which there is still no recycling technology established in the market, like Absorbent hygiene products. The total typical charge to landfill one tonne of municipal waste in the EU was estimated to range from EUR 17.50 in Lithuania to up to EUR 155.50 in Sweden, while incineration ranges from EUR 46 in Czech Republic to EUR 174 in Germany (Zero Waste Europe, 2021). Thus, reducing the amount of waste generated will also lead to financial benefits in addition to the environmental ones, which need to be balanced with the other costs and benefits of such measures.

Still, some of the improvement measures identified for ESPR were found to be particularly expensive: for example, full electrification of the pulp and paper sector does not seem economically viable in the foreseeable future, as it is particularly CAPEX-intensive and the cost of electricity is higher than that of natural gas (CEPI, 2021), although geopolitical factors can influence this aspect. For Iron and steel, environmental improvement potentials might present trade-offs with product costs. For example, reducing CO2 emissions, with respect to 2015, by 15 – 90% (depending on the pool of technological options considered), could imply a 35 – 100% increase of the steel cost per tonne (European Commission, 2022f). For Textiles and footwear, energy efficiency measures are estimated to require high up-front costs with possibly a long pay-back (Sadowski et al., 2021).

For Commodity chemicals, the Processes4Planet Partnership[37], funded under Horizon Europe, estimated that EU-wide investments needed to develop the first commercial low-carbon and circular technologies are in the range of EUR 218-238 billion, and additional investments in the order of trillions are needed to fully deploy these technologies across the EU (considering electric-power production, supply chains and transport) (Processes4Planet, 2021). The P4P Partnership also estimated that ensuring the operation of industrial plants based on low-carbon technologies will require an average additional investment of EUR 3.9-5.5 billion per year (European Commission, 2022e; European Commission, 2023). Driven by massive infrastructure needs in ammonia and methanol production, investments may be in the order of 2.7-3.2 trillion EUR by 2050, 7-9 times the current requirements (Center for Global Commons, 2022). The production cost of net-zero olefins and aromatics could be 50-200% higher than their fossil-based counterparts in 2050 (Center for Global Commons, 2022). Additional cost analysis will be needed, considering the perspectives of the different

[37] P4Planet is a European co-programmed public-private Partnership established between A.SPIRE – as the private entity – and the European Commission in the context of the Cluster 4 (Digital, Industry and Space) of Horizon Europe funding programme. The Partnership's aim is to transform the European process industries to achieve circularity and overall climate neutrality at the EU level by 2050 while enhancing their global competitiveness.

actors involved, should Commodity Chemicals be retained in the final Working Plan, as the little available data seem to suggest that costs can be disproportionate. Moreover, it should be pointed out that at this stage it was not possible to retrieve information on the expected costs incurred by potential ESPR measures other than climate change-related measures: possible ecodesign requirements related to other environmental aspects may incur lower costs.

Although not in terms of cost data, the number of products complying with the EU Ecolabel criteria may be an indicator of what improvement potential could be achieved by the market at a cost effective way. The EU Ecolabel is the EU-wide voluntary labelling scheme that is awarded to products that comply with strict environmental criteria. As of March 2024, 95 758 products have been awarded the EU Ecolabel (European Commission, 2024), indicating encouraging trends despite the potential cost impacts relating with fulfilling strict environmental criteria. Similarly, marketing products as 'environmentally friendly' can be a source of revenue for companies. For example, the market for most detergent products is considered at a mature stage since 2015, with most opportunities for growth laying in the development of 'green' or 'natural' chemicals and multifunctional products (Medyna et al., 2015).

In general, however, it must be said that information available on the potential costs related to specific requirements are very scarce in the literature. More in-depth analysis and stakeholder engagement would allow for carefully assessing the economic consequences of possible ESPR measures on different actors of the value chain and the society, including small and medium enterprises. This may form part of a Preparatory Study and Impact Assessment for the products which will be finally selected for the final ESPR Working Plan. In light of this, no product was excluded from the priority list at this stage.

3.3.4 Analysis of granularity

Some of the product groups prioritised in this report are very wide and include a variety of products with partly different functions, such as the case of Textiles and Footwear, Furniture, or Commodity Chemicals, whose definition is much less granular than Bed mattresses or Tyres, for example. This heterogeneity may potentially make it challenging to regulate product design aspects in one Delegated Act. In addition, Textiles and Footwear, Furniture, and Commodity Chemicals rank in the top positions of **Table 9** and **Table 10**, potentially making them as suitable candidates for the first ESPR Woking Plan: Textiles and Footwear and Furniture rank 1st and 2nd of final products, respectively, and Commodity Chemicals ranks 2nd of intermediate products. Their relevance is also confirmed by the ESPR text in itself, which specifies that these product groups should be prioritised by the Commission in the first Working Plan. **Annex 6** presents the results of the granularity assessment, organised into a one-page infographic.

Based on existing classifications used in policy documents, groupings used by the sector, classifications used for statistical purposes (e.g., NACE), and others, when relevant, **Annex 6** suggested a possible grouping for the three analysed product groups. For final products, i.e., Textiles and footwear and Furniture, the approach suggested is to group the products in the scope according to their functionality, instead of taking a material or an application approach. For Commodity chemicals, its intermediate nature hinders a function-based classification. Instead, it is suggested to group the products in the scope according to the classification used in the Industrial Emission Directive.

The results of the analysis suggest that for Textiles and footwear and for Commodity chemicals it is recommended to split the scope of the product groups into more homogeneous sub-sets for possible

ESPR Delegated Acts. In particular, Textiles and footwear are suggested to be split into Apparel, Home textiles, Technical textiles and Footwear. Commodity chemicals are suggested to be split into Large volume inorganic chemicals – ammonia, acids, and fertilisers, Large volume inorganic chemicals – solids and other industries, and Large volume organic chemicals, although a possible sub-division could also be into Large volume inorganic chemicals and Large volume organic chemicals, similarly to the approach that is being considered within the framework of the Industrial Emission Directive.

For Furniture, the analysis suggested a categorisation of the product group into Storage, Seats, and Surfaces. Nevertheless, it is not recommended to split the group into three Delegated Acts, since the heterogeneity could in principle be addressed by setting different thresholds targeting each of the product sub-groups, to be identified and verified based on the same methodological approach. Alternatively, the group of Furniture could be addressed by horizontal, furniture-wide, ecodesign requirements.

These results are to be considered as a preliminary assessment, with the only aim of providing guidance on the most suitable policy option for grouping products, and will need to be further substantiated by a product-specific Preparatory Study and consultation with stakeholders, retaining or not the sub-division proposed in **Annex 6**.

3.3.5 Open Strategic Autonomy

Table 12 and **Figure 9** compile the obtained results of the assessment on Open Strategic Autonomy.

The outcome of the evaluation regarding Open Strategic Autonomy gives two product groups with the maximum score (5): Iron and steel as well as Commodity chemicals. These products combined a high share of critical raw materials used (e.g., coking coal for steel uses 82% of the EU supply, PGMs catalysers for chemicals) with often substantial import reliance on Russia and thus materials potentially targeted by sanctions (pig iron, coking coal, steel products). The high score of the category Commodity chemicals is also explained by the broadness of the scope which includes organic and inorganic compounds endings in extensive end sectors such as fertilisers, plastics, paints and coating, adhesives or synthetic fibres. Both sectors are energy-intensive and face challenges regarding the supply of affordable energy.

A second category of products ranked with a score of 4 or 3. This is the case for non-ferrous, non-aluminium metals, containing particularly sub-categories such as copper, nickel or titanium intermediate products. Product with high relevance (score of 3) are following: Aluminium and Aluminium alloys (manufactured from bauxite and CRMs alloying elements such as silicon metal or Magnesium) but also Plastics and polymers. This latter intermediate product group accounts for around 10% of the EU crude oil end-use for which the import reliance coupled with price volatility are relevant parameters to consider when dealing with EU Open Strategic Autonomy. Glass is also ranking high particularly thanks to the presence of CRMs entering in the composition of special type glass (e.g. with rare-earth elements thin layer).

Tyre products are notable as the first non-intermediate product group in this ranking. Although natural rubber (its main material) is not included anymore in the 2023 list of critical raw materials, its supply risk may increase in the short term due to entry onto force of the deforestation-free regulation. Substituting natural rubber with synthetic rubber (styrene-butadiene) could exacerbate supply disruptions, particularly because of sanctions against Russia, a major producer of synthetic rubber. Furthermore, tyres as final goods, as well as carbon black, a material predominantly used in the tyre industry, were included in the 10th sanctions package against Russia from February 2023. Finally, Tyres are energy-related products so that the energy consumed during use phase is accounted for in the evaluation.

The other products may contain specific materials which are at risk from a supply point of view, for instance the kaolin clay used for paper products is partly sourced from Ukraine, or are mainly manufactured with oil-based derivate. However, they do not combine enough high or medium scores in all of the three subcategories to reach a critical threshold.

Finally, it should be noted that a score of 1 or 2 does not mean that there is very little or no risk of supply shortage of the product or associated materials, but from a comparative point of view these products represent a lower risk than the others. Hence, the relevance of obtaining significant gains in the future in terms of Open Strategic Autonomy is more limited than for categories that rank higher.

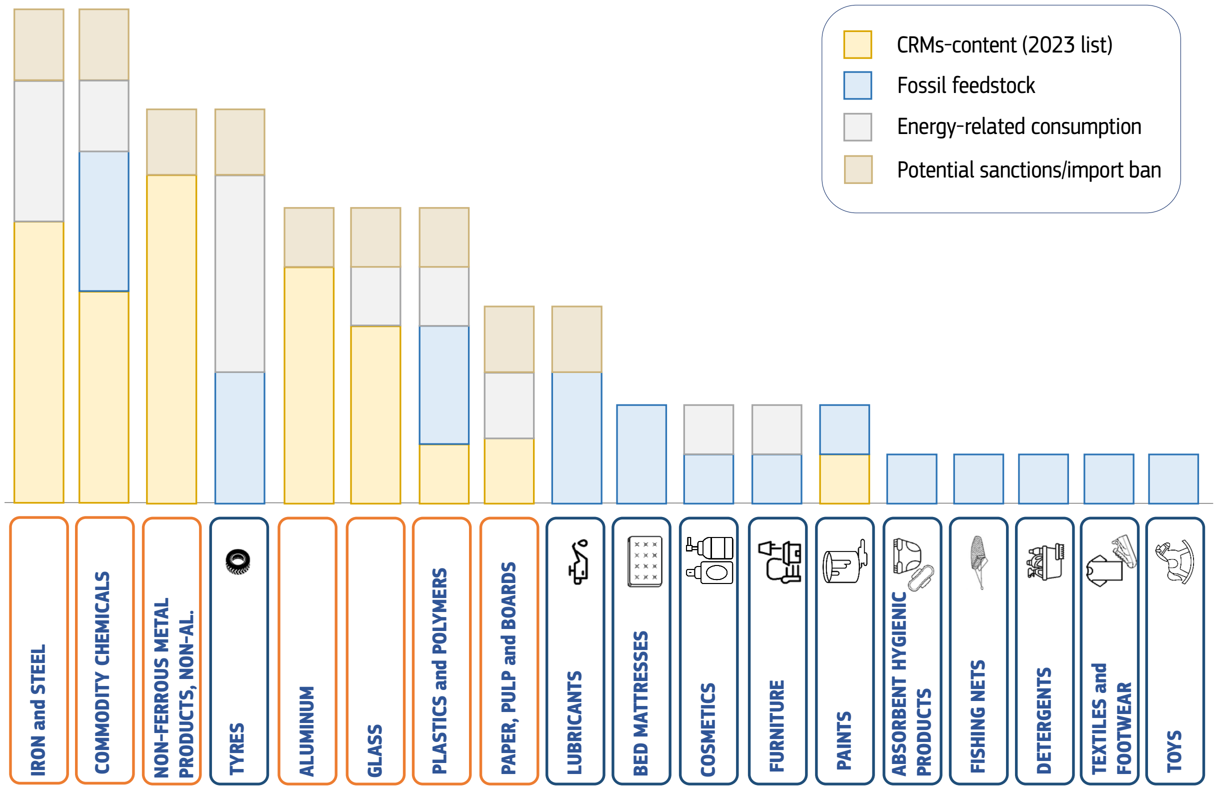
Table 12. Final ranking of the product groups according to the Open Strategic Autonomy criteria.

		Critical Raw Materials content	Fossil feedstock	Potential sanctions / Import ban	Energy-related consumption	Total	Final Strategic Autonomy score
Final products	ABSORBENT HYGIENIC PRODUCTS		1			1	1
	BED MATTRESSES		2			2	1
	COSMETICS		1	1		2	1
	DETERGENTS		1			1	1
	FISHING NETS		1			1	1
	FURNITURE		1	1		2	1
	LUBRICANTS		2		1	3	2
	PAINTS	1	1			2	1
	TEXTILES and FOOTWEAR		1			1	1
	TOYS		1			1	1
	TYRES		2	3	1	6	4
Intermediate products	ALUMINUM	4			1	5	3
	COMMODITY CHEMICALS	3	2	1	1	7	5
	GLASS	3		1	1	5	3
	IRON and STEEL	4		2	1	7	5
	NON-FERROUS METAL PRODUCTS, NON-AL.	5			1	6	4
	PAPER, PULP and BOARDS	1		1	1	3	2
	PLASTICS and POLYMERS	1	2	1	1	5	3

Note: Elements in bold are intermediate products. A score of from 5 to 3 indicates a high relevance regarding Open Strategic Autonomy aspects while 2, 1 and 0 indicate a medium, moderate or low relevance respectively.

Source: JRC own elaboration

Figure 9. Open Strategic Autonomy scores for intermediate and final products' groups. Orange outline boxes indicate intermediate products.



Source: JRC own elaboration

4 Quantification of the potential environmental savings associated to the prioritised products

4.1 Specific aims

This section intends to put into perspective the potential effects of the ESPR implementation, focusing on the environmental impacts of prioritised final products and intermediate products and the savings expected from the implementation of ESPR horizontal requirements. The quantitative analysis in this section employs the EU Consumption Footprint (Sanyé Mengual & Sala, 2023), which is a headline indicator of the new monitoring framework of the circular economy[38], as well as of the 8th Environment Action Programme[39] and the EU Sustainable Development Goals[40].

The Consumption Footprint method is used in this section to quantify the expected environmental impacts that the ESPR requirements would address, should all prioritised products in Section 3.3.1 be retained. Furthermore, the Consumption Footprint analysis allows to assess the environmental impacts of these prioritised products against the impacts of the overall EU consumption and the Planetary Boundaries[41], thereby going beyond the scope in Section 3 as providing both a macro-scale and absolute sustainability perspectives. The Planetary Boundaries (Rockstrom et al., 2009; Steffen et al., 2015) are also employed in this section as a reference of the limits of the planet, which are ambitioned by the 8th Environment Action Programme[42] and the European Green Deal[43]. Additional details on the Consumption Footprint and the Planetary Boundaries are reported in Section 4.2.1.

In fact, the Consumption Footprint is based on Life Cycle Assessment (LCA) (Sanyé Mengual et al., 2023) thereby consistently assessing the impacts of final products along their entire supply chain (considering same system boundaries for all assessed products). The Consumption Footprint also allows estimating the overall environmental impacts and the relative contribution of the different prioritised products. It should be considered that results in the following sections do not account for social aspects and that the products' scope in the Consumption Footprint may be defined differently compared to the one in the prioritisation exercise (Section 3). For these reasons, the analysis proposed in Section 3 and Section 4 should be viewed as complementary, as their results can be compared only to a certain extent.

With this quantitative approach, the following questions are explored in this section:

— What are the impacts of the EU consumption of products in the context of the Planetary Boundaries? And how relevant is the scope of the prioritised products in that context?

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38 https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework

39 https://www.eea.europa.eu/en/topics/at-a-glance/state-of-europes-environment/environment-action-programme/8th-eap-indicator-based-progress-2023

40 https://ec.europa.eu/eurostat/web/products-catalogues/w/ks-05-24-072

41 The Planetary Boundaries framework addresses nine main ecological processes by using different control variables along the cause-effect chain of environmental effects. Sala et al. (2020) adapted the Planetary Boundaries framework to the 16 impact categories of the Environmental Footprint method, which is the recommended method by the European Commission (EC, 2021), including the expansion of the framework to impacts on human health and resource depletion.

42 https://environment.ec.europa.eu/strategy/environment-action-programme-2030_en

43 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

— What are the potential benefits of the implementation of the ESPR horizontal requirements? How much are these expected to bring current environmental impacts within the Planetary Boundaries?

Additional ESPR aspects are addressed along the chapter in devoted boxes, including the potential role of rebound effects, the quantification of macro- and micro-plastics litter generation, and examples of the potential benefits of ESPR requirements for prioritised products.

4.2 Methodology

4.2.1 Quantification of the environmental impacts of prioritised products

This quantitative exercise follows an LCA[44] perspective employing the bottom-up Consumption Footprint model[45] developed by the EC-JRC to assess the environmental impacts of EU consumption and production of a selection of products. This bottom-up model is based on a series of representative products from five areas of consumption (namely food, housing, mobility, household goods, and appliances). For each representative product, the environmental impacts of the consumption are quantified combining consumption statistics with the environmental impact of the entire life cycle following a process-based LCA model. The Consumption Footprint indicator aims at quantifying the environmental impacts of apparent consumption. The apparent consumption corresponds to the overall environmental impacts of domestic production and trade balance (plus imports and minus exports) in the whole EU and at EU Member State level (Sala & Sanyé Mengual, 2022)[46]. Further details are provided in **Annex 7**.

The Consumption Footprint is assessed by means of 16 midpoint impact categories[47] (defined in the Environmental Footprint method (EC, 2021), as recommended by the European Commission for life-cycle assessment of products and organisations). The impact categories of the Environmental Footprint method can be complemented by other metrics, e.g. circularity indicators (Wiedmann et al., 2022). The use of the Environmental Footprint method can also be combined with the Planetary Boundaries framework as an absolute sustainability reference. Planetary Boundaries represent limits describing the Earth's capacity to bear human-induced environmental impacts (i.e., "Earth's carrying capacity") for a number of environmental areas[48]. When the "safe operating space" for humanity is crossed, the planet's biophysical subsystems and processes could shift to a new state with potential negative consequences for humans (Rockstrom et al., 2009). The analysis presented in this section uses a set of LCA-based Planetary Boundaries adapted by the JRC to the 16 impact categories of the Environmental Footprint (Sala et al., 2020). Comparing the per-capita impacts of consumption with

[44] According to the definition reported in the ISO standard (ISO, 2006a,b), LCA is the compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product system throughout its life cycle.

[45] https://web.jrc.ec.europa.eu/policy-model-inventory/explore/models/model-consumption-footprint

[46] In the Consumption Footprint, five areas of consumption are assessed (namely: food, mobility, housing, household goods, and appliances) building on the specific life-cycle assessment of more than 160 representative products.

[47] Namely: climate change [kg CO_2 eq.]; ozone depletion [kg CFC-11 eq.]; human toxicity, cancer [CTUh]; human toxicity, non-cancer [CTUh], particulate matter [disease incidences]; ionizing radiation, human health [kBq U_{235} eq.]; photochemical ozone formation, human health [kg NMVOC eq.]; acidification [mol H^+ eq.]; eutrophication, terrestrial [mol N eq.]; eutrophication, freshwater [kg P eq.]; eutrophication, marine [kg N eq.]; land use [points - pt]; ecotoxicity, freshwater [CTUe]; water use [m^3 water eq. of deprived water]; resource use, fossils [MJ] and resource use, minerals and metals [kg Sb eq.].

[48] These areas include: 'climate change', 'biosphere integrity', 'land-system change', 'freshwater use', 'biogeothermal flows', 'ocean acidification', 'atmospheric aerosol loading', 'stratospheric ozone depletion' and 'novel entities'.

the per-capita Planetary Boundary for each LCA impact category indicates the current situation of EU consumption and production in relation to a safe operating space for humanity[49]. In this chapter, results are illustrated in terms of four impact categories: climate change, water use, resource use – fossils, and resource use – minerals and metals. While the results for all 16 impact categories are available in **Annex 8**, these four categories were selected for the main text due to their relevance in current circular economy strategies.

The analysis is vastly based on available data from the Consumption Footprint Platform (EC-JRC, 2024) and underpinning data (e.g., consumption statistics from Eurostat). Additional modelling was performed to quantify the environmental impacts of the current consumption of the intermediate products[50] and final products[51] prioritised in Section 3. For this purpose, consumption statistics were compiled and LCA modelling performed as detailed in **Annex 7 – Table 5** and **Annex 7 – Table 6**. The **environmental impacts of the scope of ESPR and of the scope of this report** were quantified, and compared to the EU Consumption Footprint 2022 (EC-JRC, 2024) and the Planetary Boundaries per capita for the EU (as in Sanyé Mengual and Sala, 2023).

4.2.2 Quantification of the environmental savings of horizontal requirements

This section quantifies the **potential benefits associated to the implementation of the horizontal requirements** proposed in Section 2.3.2. These requirements have been only modelled for shortlisted final products as the nature of the proposed horizontal requirements refer to life cycle stages that are not possible to be addressed for intermediate products: use phase and end of life phase (see also Section) 3.2.1. Therefore, the baseline for this assessment is the environmental impact of the scope associated to the horizontal requirements proposed in this report.

Estimating and quantifying the impacts and savings of horizontal requirements is a complex exercise. In particular, the main challenges are attributable to: (i) the grouping of various products within the scope of the horizontal requirements; (ii) a proper definition of ambitions' levels for each provision under each horizontal requirement, and the linking of such ambitions with specific improvement potentials for the calculation of environmental savings. Therefore, a range of improvement scenarios were examined and different metrics to express these improvements were used, as described in this section as well as in **Annex 7**.

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[49] The ratio between a certain impact in a given impact category and the related planetary boundary, allowed to calculate how many times the planetary boundary was transgressed. In the context of the present report, thresholds were set to indicate a "safe operating space" (when impacts transgressed the planetary boundary once), an "uncertainty area" (when impacts transgressed the planetary boundary twice) and a "high risk area" (when impacts transgressed the planetary boundary three times).

[50] The list of intermediate products assessed in Section 4 includes: iron and steel, aluminium, commodity chemicals, plastic and polymers, glass and paper, pulp paper and boards. Further methodological details are provided in Annex 7. The intermediate product 'non-ferrous metals' has not been modelled separately in the analysis of this section, as it being partially covered by 'iron and steel' and 'aluminium' (as an example, 'copper coatings', 'zinc coatings' and 'ferro alloys' are included in the calculation of the 'iron and steels' intermediate product).

[51] The list of final prioritised products assessed in Section 4 includes: Textiles and footwear, Lubricants, Furniture, Tyres, Detergents, Paints, Bed mattresses, Cosmetics, Absorbent hygiene products, Toys. Further methodological details are provided in Annex 7.

In the quantification analysis presented in this section, the following horizontal requirements were considered: “Durability” (DUR), “Recyclability” (REC) and “Post-consumer recycled content” (PRC). The following expected benefits were modelled in this exercise (**Figure 10**):

— **Durability (DUR)**: horizontal requirements to improve the durability of products aim to extend their lifetime. As a result, the impact per product for a given year of consumption will decrease proportionally for the different life cycle stages of the product. This does not necessarily hold true for the use phase, which might remain equal or even increase the impact due to, e.g., additional transportation associated to a second-hand marketing channel.

— **Recyclability (REC)**: Increasing the recyclability of a product is expected to increase the quantity of recycled material in the market that can be then used for a new product thereby substituting and reducing the consumption of virgin material. Benefits of this action are therefore associated to a reduced demand of virgin material, the less impactful production of recycled materials compared to virgin ones, and a ‘saving’ due to the substitution of virgin material in the market.

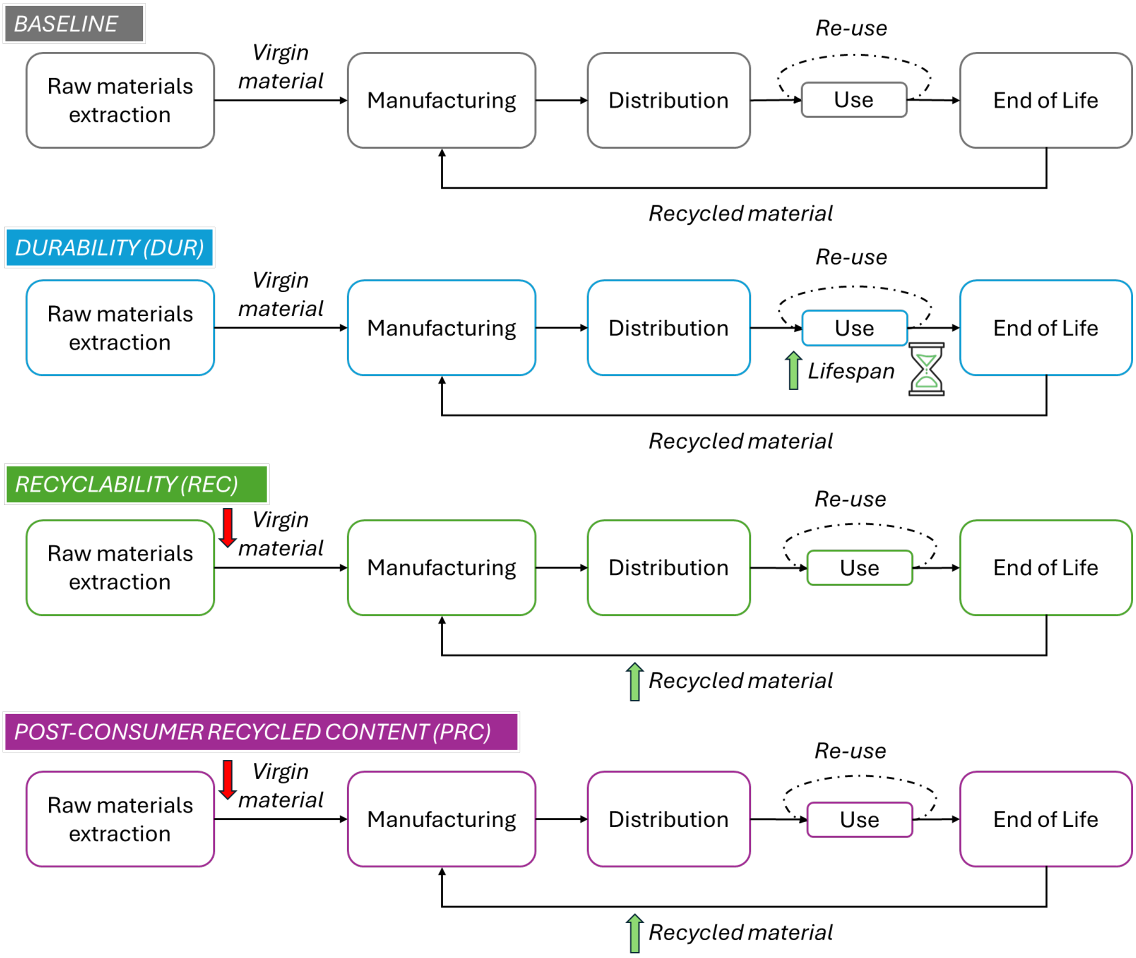
— **Post-consumer recycled content (PRC)**: Increasing the post-consumer recycled content in a product will increase the use of recycled material for a new product thereby substituting and reducing the consumption of virgin material. Benefits of this action are therefore associated to a reduced demand of virgin material, the less impactful production of recycled materials compared to virgin ones, and the savings generated by the substitution of virgin material in the market.

Modelling the benefits of recycling considers a credit of substituting virgin material in products. In LCA modelling, the system boundaries need to be defined to understand which stakeholder in the supply-chain considers the credit of such an action to prevent double-crediting and, therefore, overestimation of the savings. In this modelling exercise, the credit associated to the recycled material is attributed to the recycling facility instead of the final user. As a result, the credit of avoided virgin material is allocated to the horizontal requirement of ‘recyclability’ and not considered for ‘post-consumer recycled content’. For example, printed paper may be manufactured employing post-consumer recycled paper. Similarly, water bottles or outdoor/sportswear clothes may be manufactured employing a certain amount of post-consumer recycled plastics/fibres together with virgin ones.

The potential improvement associated to the implementation of specific horizontal requirements were assessed for three ambition scenarios, i.e. a “low benefit” scenario, a “medium benefit” scenario, a “high benefit” scenario. The range of the estimated improvement scenarios was set either (i) based on existing literature or (ii) based on a set of default values (i.e., 10%, 30% and 50%) when relevant literature data were missing. This range can be associated with the possible saving potential of the proposed provisions. A summary of each horizontal requirement, its related metric and improvement scenarios is provided in **Annex 7 – Table 7**.

Based on the Consumption Footprint indicator, the calculation of the environmental impacts of the prioritised final products allowed the estimation of the potential benefits of applying each horizontal requirement. **Annex 7** provides a summary of the products for which the horizontal requirements have been applied. The calculation of the environmental savings of a product was performed at the life-cycle stage level, since some requirements have effects on specific aspects of the life cycle of products (e.g., end of life). It should be noted that the benefits could not be calculated for all prioritised final products, due to the lack of impacts’ data at the level of individual life cycle stages of a product. Therefore, a potential underestimation effect of the savings could be present in the results section. Further methodological details on the quantification of savings due to horizontal requirements are provided in **Annex 7**.

Figure 10. Overview of the modelled benefits of the horizontal requirements.



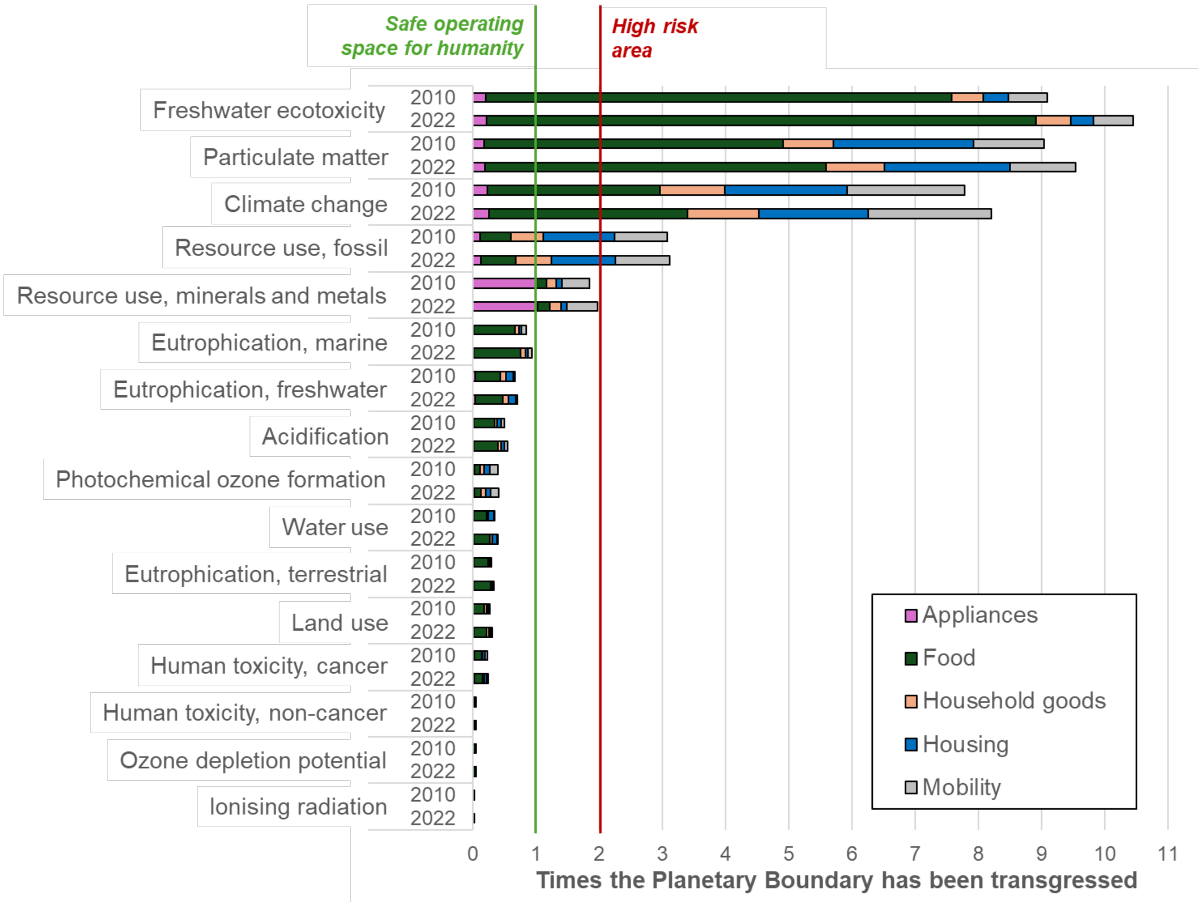
Source: JRC own elaboration

4.3 Results and discussion

4.3.1 What are the environmental impacts of EU consumption?

When the Consumption Footprint of the EU average consumer is compared with the per-capita Planetary Boundaries (as adapted for the Environmental Footprint method, **Figure 11**), five impact categories are beyond the safe operating space for humanity including climate change. Therefore, the EU levels of consumption (how much is consumed) as well as patterns (what is consumed) are transgressing the limits of our planet, negatively contributing to the current triple planetary crisis (Hellweg et al., 2023): climate change, biodiversity loss and pollution. The ESPR is a supply-side policy measure that will contribute to mitigate the current impacts of EU consumption by decreasing the environmental impacts of the products available in the EU market. In the context of the many other product-related EU policy initiatives, the ESPR has a production and trade perspective thereby regulating not only products manufactured within the EU territory but also those imported from third countries that aim to be sold in the EU.

Figure 11. EU consumption footprint per capita (2010, 2022) by area of consumption compared against the Planetary Boundaries per capita, by impact category of the Environmental Footprint.



Source: Sanyé Mengual et al. (2024)

4.3.2 How important is the scope of ESPR and the Working Plan in terms of environmental impact?

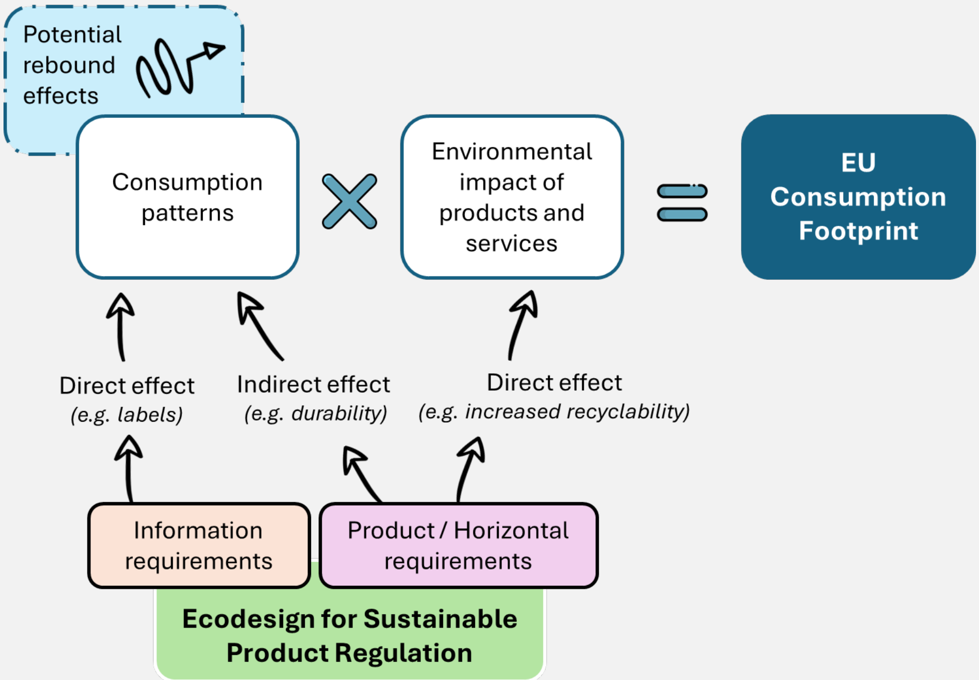
Although the ESPR expands the scope of the current Ecodesign Directive, it excludes specific sectors of the economy such as food and feed (see Section 2.2.1). Furthermore, the ESPR complements existing EU legislation focusing on specific sectors and product groups, thereby being excluded from the ESPR scope such as feed, medicinal products, living plants, etc., as specified in the legal text and detailed in Section 2.2.1. To demonstrate the potential role of the ESPR and its effects to the overall EU Consumption Footprint, a comparison of the scope of the ESPR and the environmental impact method adopted in this report (intended to support the Working Plan) has been performed. Four impact categories of the Environmental Footprint have been selected to display the results, including climate change, freshwater ecotoxicity, resource use (fossil fuel/petroleum, minerals and metals). These categories have been selected due to the sensitivity to circularity measures as well as due to how they transgress the Planetary Boundaries. **Annex 8 – Figure 8.1** and **Annex 8 – Figure 8.2** details the assessment of all the impact categories of the Environmental Footprint method.

Box 1. The relevance of consumer behaviour

The EU Consumption Footprint has increased between 2010 and 2022 for all the impact categories assessed in the Environmental Footprint (**Figure 11**), with an overall increase of 9% for the Single Score – an aggregated indicator for all impact categories of the Environmental Footprint (Sanyé Mengual et al., 2024). This illustrates a clear gap between EU environmental policy implementation and the impacts of EU consumption and production. Population growth of 1.4% for the period 2010-2022 might only explain a partial contribution to this increase. Therefore, major effects are observed from the lifestyles and consumption patterns of EU citizens. On the one hand, consumption intensity continues to increase, e.g. increase number of clothes purchased per capita associated to fast fashion trends. On the other hand, consumer patterns might lean towards unsustainable options due to a range of consumer preferences, e.g. identity creation. In relation to this second element, there has been a limited progress in sustainable options in the market, e.g. known impacts of products still not being addressed by companies. The ESPR will tackle directly this last point delimiting specific requirements that will become mandatory in the EU market, therefore fostering an improvement of the **environmental profile of products**.

However, addressing the impact of individual products is limited to improving their eco-efficiency, which might be offset due to changes in consumption patterns that can perpetuate the observed increasing trends in consumption patterns and, therefore, lead to an increasing EU consumption footprint. These effects can be partly explained by **rebound effects** caused by specific mechanisms that react to sustainability-oriented actions, including those of economic nature (e.g., increased consumption, switch of expenditure among areas of consumption) and those associated to behavioural effects (e.g., moral licensing, motivational crowding) (Guzzo et al., 2024). Therefore, the behaviour of consumers becomes key in an effective implementation of the ESPR that mitigates potential rebound effects. The ESPR strives to have **positive effects on future consumption patterns** both directly (e.g., via information requirements) and indirectly (e.g., via product requirements that extend the lifespan and might reduce the demand of consumers for products).

Figure 12. Rebound effects in the context of the EU Consumption Footprint



Source: JRC own elaboration

Compared to the 2022 EU Consumption Footprint, the ESPR scope represents between 26% and 109% of the environmental impacts[52], depending on the category (**Figure 13**). Note that the impact associated to intermediate products can lead to impacts beyond the EU Consumption Footprint as some intermediate products are then devoted to products consumed within the economy (e.g., machinery, infrastructure) rather than by the final consumer. Beyond the legislative scope, this report has focused on a list of product groups for prioritisation for the first ESPR Working Plan. The prioritised products represent between 18% and 57% of the EU Consumption Footprint[53] and between 22% and 61% of the ESPR scope's environmental impacts[54], depending on the impact category (**Figure 13**). Additionally, to understand the main contributors to the total impacts for each impact category, the contribution of each prioritised final product and intermediate product to the respective total impacts (i.e., total impacts of all prioritised final products and total impacts of all intermediate products) was calculated (**Annex 8 – Figure 8.3** and **Annex 8 – Figure 8.4**). When the total impacts of the different prioritised final products are analysed[55], results indicate that the most relevant ones (i.e., exhibiting the highest impacts) are furniture, textiles and footwear, and detergents, followed by cosmetics and paints and varnishes. This broadly confirms the results illustrated in Section 3.3, as Textiles and footwear, Furniture and Detergents scored first, second and fifth, respectively, in the assessment of environmental relevance. By contrast, both lubricants and toys amount on average to 1% of the impacts of all final products, since they have together with bed mattresses the lowest consumption intensities compared to the other final products. Concerning intermediate products, results indicate that the most relevant ones (i.e., exhibiting the highest impacts) are 'Iron and steel' and aluminium, followed by 'commodity chemicals' and 'paper, pulp paper and boards'[56] (**Annex 8 – Figure 8.4**). The modelling approach employed in this section to derive the environmental impacts related to tyres differ from the one considered in Section 3.3. As further detailed in **Annex 7**, the environmental impacts associated to tyres were estimated combining consumption intensities from Eurostat and Ecoinvent datasets (characterized according to the Environmental Footprint 3.1 method). As no agreement has been reached yet on a proper methodological approach to assess microplastics impacts in LCA, impacts due to microplastic releases from tyres were not considered in the results of Section 4.

It should be also noted that, in general, the results presented in Section 4 refer solely to environmental impacts, whereas those illustrated in Section 3.3 also include improvement potentials. Further the scope of the representative products considered in the results of Section 4 reflects the products scope outlined in Section 3 to a minor or larger extent, depending on the product (see **Annex 7** for additional details).

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52 Considering all the 16 impact categories of the EF, the range would be between 20% and 199% - as available in Annex 7.

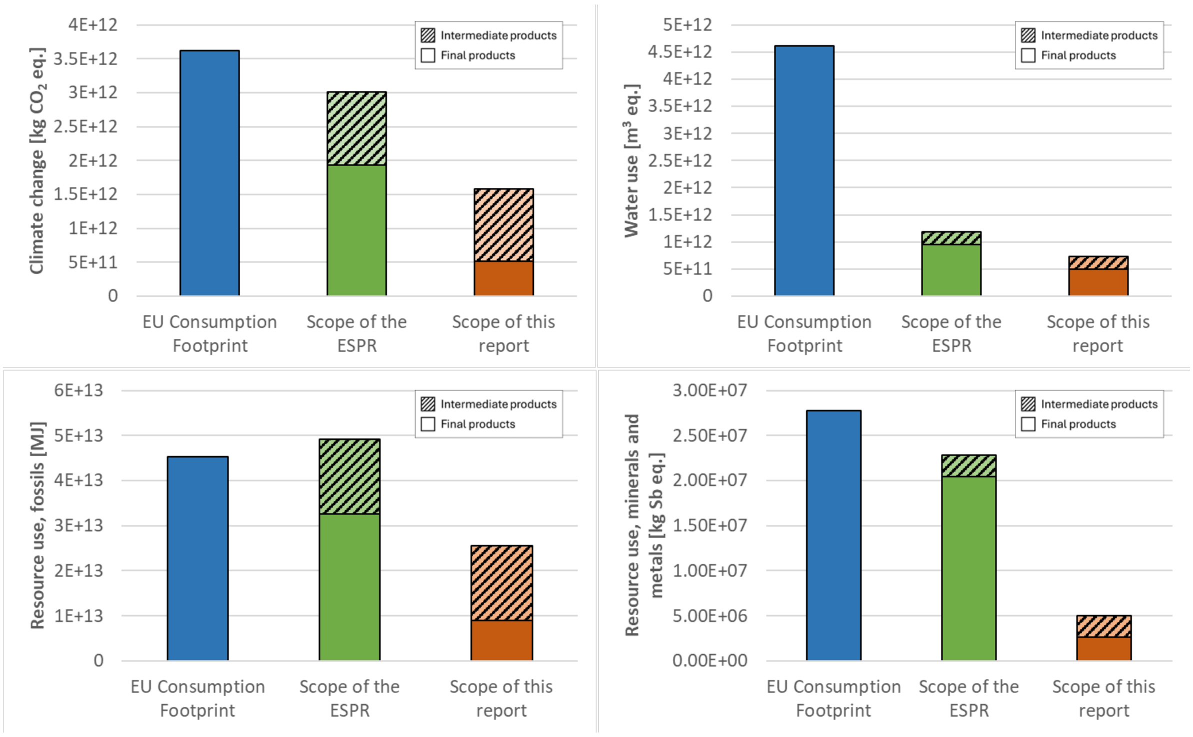
53 Considering all the 16 impact categories of the EF, the range would be between 6% and 176% - as available in Annex 7.

54 Considering all the 16 impact categories of the EF, the range would be between 22% and 88% - as available in Annex 7.

55 For instance, in the case of Furniture, the impacts of this product were compared to the total impacts of all final prioritised products for each impact category (i.e., impacts_furniture/impacts_all_end_use_products [%]).

56 For instance: for each impact category, the contribution (%) of iron and steels to the total impacts of all intermediate products was calculated. The average of these contributions amounted to 46%.

Figure 13. Comparison of the EU Consumption Footprint, the scope of ESPR and the scope of this report in terms of environmental impact (2022).



Source: JRC own elaboration

4.3.3 What are the potential benefits of ESPR horizontal requirements on final products?

The methodological approach described in Section 4.3.1 enabled the calculation of savings related to the application of horizontal requirements proposed in Section 2.3.2 on the final products prioritised for the Working Plan. **Figure 14** compares the environmental impacts of the final products prioritised in this report (baseline for 2022) with the impact resulting from the implementation of the following horizontal requirements: 'durability' (DUR), 'recyclability' (REC), and 'post-consumer recycled content' (PRC). In addition, the results are compared against the Planetary Boundaries. The results in **Figure 14** represent the "medium benefits" scenario (see Section 4.2.2), with error bars displaying variability in the results when the scenario is calculated for "low benefits" or "high benefits" scenarios instead. The results for all environmental footprint impact categories are reported in **Annex 8 – Figure 8.5** and **Annex 8 – Figure 8.6**.

Results suggest that the implementation of horizontal requirements will have a positive effect on the environmental impacts of the consumption of the prioritised final products (see **Figure 14** or EF impact categories that exhibit the greatest impact). When all the horizontal requirements are applied, considering the "medium benefit" scenario, environmental impacts could be reduced up to 25% (water use), depending on the impact category (**Figure 14**). When assessing instead all the 16 impact categories of the EF, a positive effect as high as 28% would be observable for the "medium benefit" scenario, in the case of 'Human toxicity – cancer'. The same impact category would exhibit a 20% and a 34% positive effect for "low benefits" and "high benefits" scenarios, respectively.

For some impact categories, the implementation of the horizontal requirements would mean bringing the impacts of the prioritised final products from transgressing the Planetary Boundaries to returning to the safe operating space for humanity (such as for climate change). However, a better understanding on the actual improvement potential that can be achieved by ESPR will be decisive on such milestone. Among the different horizontal requirements, **durability has the potential to deliver the highest savings** compared to the other two requirements.

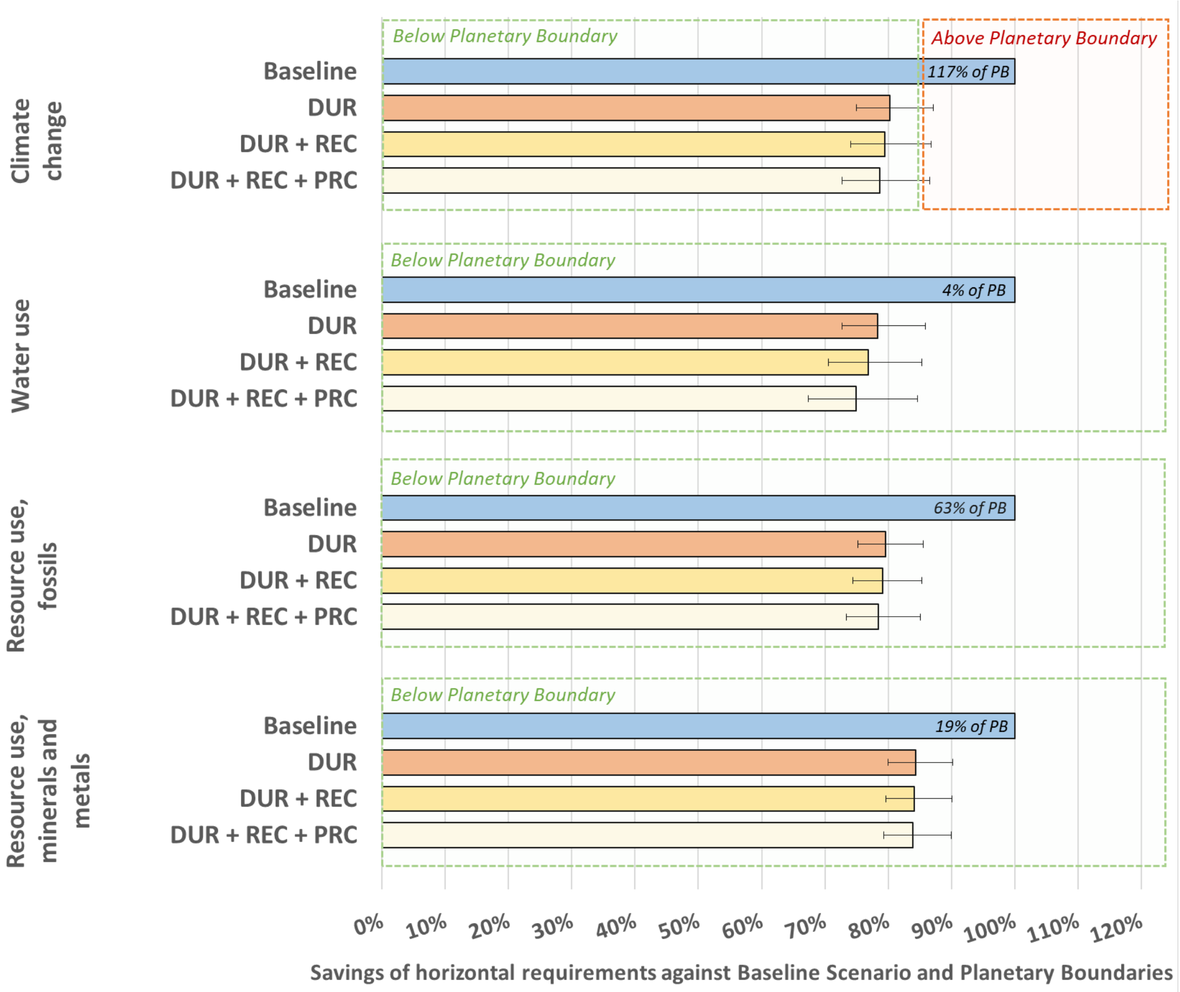
The exercise of estimating environmental savings linked to the implementation of horizontal requirements presented several challenges. In particular, results were especially influenced by the lack of quantitative data and by the exercise of linking the proposed provisions under the requirements with specific improvement potential. Solving the challenges presented would require a deeper analysis into each of the horizontal requirements, whereby the product scope can be further specified, and an appropriate improvement potential for the provisions could be explored allowing for a higher accuracy in the estimation of expected benefits[57]. For this reason, as described in Section 4.2.2, default scenarios were deployed. Therefore, it must be noted that for scenarios such as durability, (which was assumed to take place due to the introduction of a circularity policy mix) a 1:1 link to specific provisions is not necessarily attributable. For instance, the employed quantification approach on durability is not linked to individual provisions such as "spare part availability", or "water resistance"[58]. It should also be highlighted that the achievable savings are strongly dependant on consumer behaviour rather than product design alone (since a consumer can decide whether to discard a product, potentially off-setting savings), which demonstrates the importance of incentivising business models where retailers buy second hand products from established businesses. In the case of intermediate products, the lack of specific data concerning the impacts of each life-cycle stage prevented a precise assessment of the savings associated to horizontal requirement. Furthermore, the approach adopted for calculating the savings does not quantitatively account for the presence of potential trade-off effects on other horizontal requirements (either increasing the total savings or decreasing the total savings)[59]. Additional details on the main constraints and challenges related to this analysis are presented in **Annex 7**.

57 For instance, in the case of a horizontal measure such as Post-consumer recycled content, the link between provisions and improvement potentials could be readily established: a certain level of recycled content required via a regulatory provision will result in a similar level of recycled content, comparable to that which is actually used in the manufacturing of the covered products. For other horizontal requirements, such as Durability, the association is more complex and would require a deeper analysis.

58 As a consequence, the quantification approach proposed was not affected by variations/additions/removal of certain provisions compared to the preliminary draft report (see section 1.5). If the pool of specific provisions slightly changes, it can be considered that the same lifetime extension levels are maintained, which in turn yields the same quantified impacts/savings (as described in Annex 7).

59 For example, a right balance between “reliability-related” provisions and “reparability-related” ones is important to avoid that the former could be detrimental to the latter and vice-versa.

Figure 14. Assessment of horizontal requirements implementation on the prioritised final products: comparison of environmental impacts for the baseline, implementing 'durability' (DUR), implementing 'durability' and 'recyclability' (DUR + REC), and implementing all horizontal requirements ('durability', 'recyclability', and 'postconsumer recycled content') (DUR+REC+PRC) – and assessment against the Planetary Boundaries (consumption data for 2022).



Note: The results represent the "medium benefits" scenario, with error bars displaying the variability in the results when the scenario is changed to "low benefits" and "high benefits" scenarios. The results for all environmental footprint impact categories are reported in Annex 8 – Figure 8.5 and Annex 8 – Figure 8.6.

Source: JRC own elaboration.

Box 2. Product requirements: examples of potential environmental savings for Textiles and footwear and Furniture

The definition of product requirements by product group will be defined in product-specific Delegated Acts, for which an impact assessment will be performed, quantifying the expected sustainability impacts of the proposed requirements. This Box provides some examples of potential types of requirements and their effects on the environmental impacts for the product groups Textiles and footwear and Furniture. Note that these examples are based on assumptions without the goal to anticipate future requirements and their expected effect. Also, the quantification is based on the Consumption Footprint model, while specific LCA models will be developed for the purposes of future ESPR Delegated Act. The provided scenarios are based on Castellani et al. (2019) and further details are provided in **Annex 7**. Additional results for all impact categories in the case of the Textiles and footwear product group are provided in **Annex 8 – Figure 8.7**, **Figure 8.8** and **Figure 8.9**; whilst results for the Furniture product group are provided in **Annex 8 – Figure 8.10**, **Figure 8.11**, and **Figure 8.12**.

Examples of requirements and their potential effect for the product group Textiles and footwear

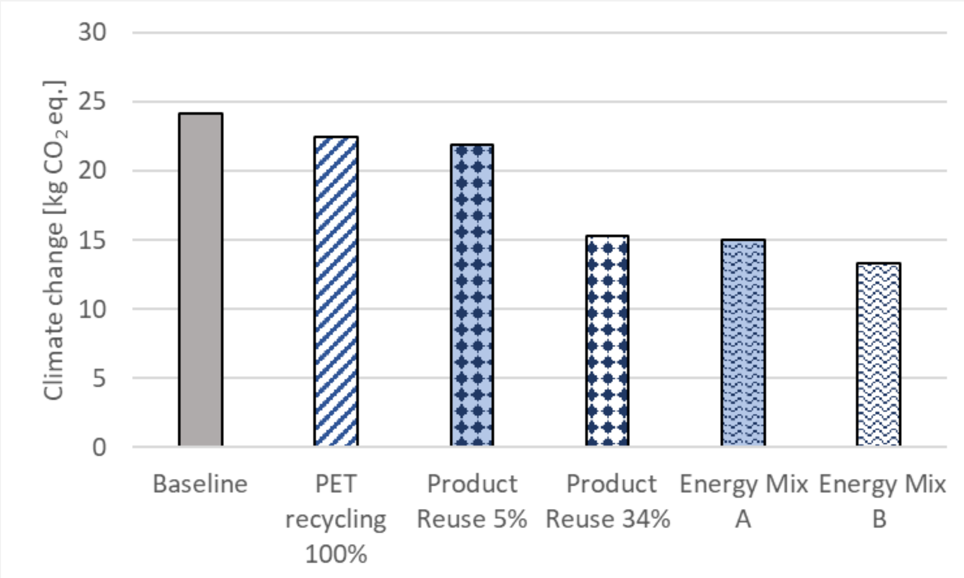
Three different types of requirements were modelled for the product group Textiles and footwear showing mainly positive effects in the environmental impact of the consumption of clothes:

— **Performance requirement for a minimum recycled content for synthetic fibres** (polyester) for apparel (both textile and clothes): Substituting virgin PET by recycled PET could reduce the environmental impacts of the current consumption of apparel up to 13%, depending on the impact category. This will have a positive effect on the production phase reducing the extraction of raw materials and, particularly, of fossil resources.

— **Performance requirement on ease of re-use of apparel**: Expanding the lifespan of clothes through second-hand options could have a positive effect along the entire life cycle of the product, with environmental benefits up to 44% (water use). The effect of this requirement would depend on the ambition level, with higher reuse rates leading to larger benefits. Note that the benefit, however, depends on an effective substitution of new clothes by the expansion of the second-hand market and behavioural effects (e.g. buy second-hand clothes in addition to new ones).

— **Performance requirement on minimum share of energy consumption from low carbon sources**: A major hotspot of impacts in the life cycle of clothing is the consumption of electricity in the production phase of clothes. An energy mix with a greater presence of renewable energy sources would have mainly positive effects (most efficient requirement in climate change), but it could also lead to potential trade-offs with other impact categories such as resource use minerals and metals – which depend on the type of renewable energy being implemented (i.e., the reduction in emissions would come at the expenses of the increased material use for developing more wind and solar energy). Prevention measures of trade-offs would be then recommended. Further details on the two energy mixes tested (namely: 'Energy Mix A' and 'Energy mix B') are provided in **Annex 7**.

Figure 15. Examples of requirements and their potential effect for the product group Textiles and footwear.

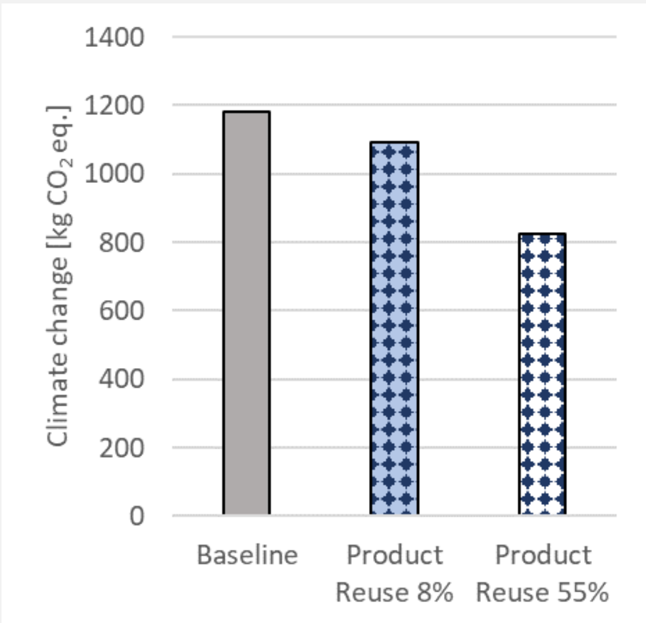


Source: JRC own elaboration

Example of requirements and their potential effect for the product group Furniture

— **Performance requirement on ease of re-use of furniture**: Expanding the lifespan of furniture through second-hand options could have a positive effect along the entire life cycle of the product, with environmental benefits up to 54% (water use). The effect of this requirement would depend on the ambition level with higher reuse rates leading to larger benefits. Note that the benefit, however, depends on an effective substitution of new furniture by the expansion of the second-hand market and behavioural effects (e.g. buy second-hand furniture *in addition* to new furniture).

Figure 16. Example of requirements and their potential effect for the product group Furniture.



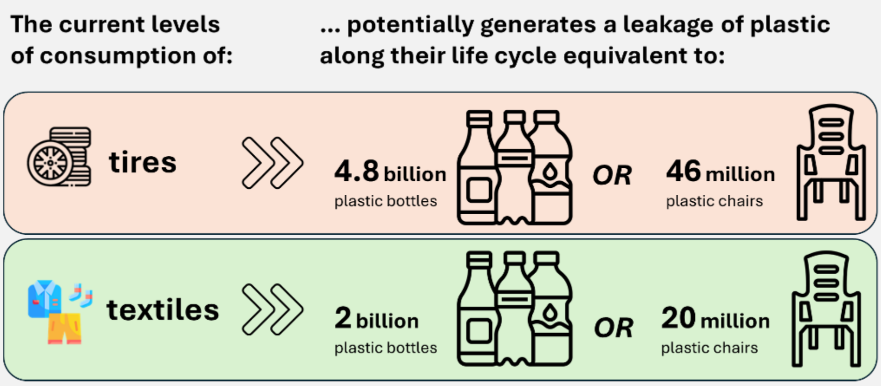
Source: JRC own elaboration

Box 3. Emerging environmental impacts: the emission of macro- and micro-plastics litter along the life cycle of products

The EU is taking policy action on plastics[60] to mitigate plastic pollution and associated marine litter, being the core goal to accelerate the transition to a circular plastics economy. Examples of these actions are the EU Plastics Strategy, the Single Use Plastic Directive or the Packaging and Packaging Waste Regulation. To provide a context of the relevance of this issue, the **potential plastic leakage due to the consumption of tyres and textiles** (two of the prioritised final products in this report) was quantified following the "Plastic Leak Project method" (Peano et al., 2020). It must be considered that the analysis of microplastics/macroplastics releases is an emerging scientific field and estimations presented in this study are influenced by data limitations and by a lack of available approaches for their quantification.

With the state-of-the-art estimation methodologies, the current levels of consumption of tyres would lead to a total amount of plastic (both as macro- and micro-plastic) pollution equivalent to 46 million plastic chairs (equivalent to around 116 kilotonnes of plastics). Tyres lead to the emission of plastic particles during the use of vehicles (tyre wear and tear emitted due to the friction between the tyre and the road) that end up in the environment. At the same time, textiles made of synthetic fibres can emit micro-plastics during the washing process in washing machines (it is worth noting that such emissions into water could eventually be mitigated by the addition of specific filters in new washing machines[61]). In the case of textiles, the current levels of consumption of textile products would lead to a total amount of plastic (both as macro- and micro-plastic) pollution equivalent to 20 million plastic chairs (equivalent to around 50 kilotonnes of plastics). Both products are also associated to the emission of plastic pellets during their production phase and become macro-litter at the end of their life due to the direct littering by consumers or the mismanagement of waste (particularly, when waste is transported to third countries with less strict waste management requirements). Further details on the assessment and results of plastic leakages are provided in **Annex 7** and **Annex 8**, respectively.

Figure 17. Potential plastic leakage due to the consumption of tyres and textiles.



Source: JRC own elaboration

[60] https://environment.ec.europa.eu/topics/plastics_en

[61] https://www.europarl.europa.eu/doceo/document/E-9-2020-001371_EN.html

5 Conclusions

This JRC Report provides the assessment of new product groups and horizontal requirements that can be considered as potential priorities for the ESPR framework, and that are not currently within the scope of the existing Ecodesign Directive 2009/125/EC, which covers energy-related products. The future ESPR working plan will however cover both new products and energy-related products, taking into account (amongst other aspects) the progress made in implementing the Ecodesign and Energy Labelling Working Plan 2022-2024, also adopted in March 2022.

In this report, the relevance of a number of product groups and horizontal requirements was evaluated in terms of impacts and improvement potential on the basis of a number of parameters: environmental sustainability and circularity, market relevance, existing and planned policy coverage, cost reflections, and contribution towards an EU Open Strategic Autonomy. This exercise resulted in a list of potential priority products (final and intermediate) and horizontal requirements for future ESPR Delegated Acts. The level of impacts associated with the potential priority products was quantified and compared to the overall Consumption Footprint and the planetary boundaries. Moreover, different scenarios were evaluated for possible environmental savings brought by potential ESPR measures.

As a result of the analysis, eleven final products (Textiles and footwear, Furniture, Tyres, Bed mattresses, Detergents, Paints and varnishes, Lubricants, Cosmetics, Toys, Fishing gears, and Absorbent hygiene products, see Table 9), seven intermediate products (Iron and steel, Commodity chemicals, Non-ferrous, non-aluminium metal products, Aluminium, Plastic and polymers, Pulp and paper, and Glass, see Table 10) and three horizontal requirements (Durability, Recyclability, Recycled content, see Table 3), show potential for prioritisation in the first ESPR Working Plan.

According to the methodology applied in this report, Textiles and Footwear, Furniture, and Tyres were the product groups that emerged as the most relevant from the environmental perspective. These products showed high relevance in terms of impact for several environmental categories as well as medium/high relevance in terms of improvement potential currently unexploited, especially with respect to increased material efficiency. These products showed, however, lower relevance in terms of contribution to Open Strategic Autonomy, except for Tyres, which showed high relevance.

Similarly, Iron and steel, Commodity chemicals, and Non-ferrous, non-aluminium metal products were the three product groups with the highest environmental relevance among the intermediate products. While their relevance was very high in terms of impacts for many environmental categories, the improvement potential identified was mainly related to the areas of waste generation, climate change and energy consumption. These products also showed medium or high relevance in terms of contribution towards Open Strategic Autonomy.

An analysis of existing policies regulating the environmental impacts of the identified final and intermediate products revealed that there are still many aspects that are currently not addressed in EU law, and ecodesign requirements for these products could contribute towards reducing the negative life-cycle environmental impacts of those products.

When compared to the Consumption footprint, the products in scope of this report represent between 15% and 81% of the impacts of the overall consumption (depending on the environmental category), confirming that the priority list would address a relevant part of EU impacts related to products. When assessed against the Planetary Boundaries, results for identified final products suggested that the highest impacts were associated with climate change, water use and resource use (both mineral and metals and fossil fuels), with the former transgressing the “safe operating space” of the associated planetary boundary. Among the prioritised final products, the combined impact of Textiles, Furniture and Detergents taken together covers, on average, the 85% of all the impacts of final products, and considering all the 16 impact categories under examination. While these results are aligned with the ranking mentioned above, it should be noted that they focus on assessing the products' environmental impacts. By contrast, the prioritisation analysis also includes the improvement potential to make products more sustainable.

Horizontal requirements constitute cross-cutting measures that can cover groups of product categories that demonstrate a certain degree of technical similarity. The horizontal requirements identified as potential priorities in this report include a number of provisions that focus on both improving material efficiency for key product groups (such as Textiles and footwear, Light means of transport, Toys, Bed mattresses) by performance or information requirements. Horizontal requirements were analysed in terms of expected improvement potential, and some insights regarding their comparative benefits can be drawn, notably the high impact reduction potential of a Durability measure. However, due to their wider scope and focus, they were neither scored nor ranked against each other or against other types of requirements.

Regarding the assessment of environmental savings associated with the implementation of potential horizontal requirements, the application of Durability-related requirements would result in the highest savings for all the impact categories assessed, compared to the other horizontal requirements assessed (i.e. Recyclability or Post-consumer recycled content). Altogether, horizontal requirements could reduce up to 25% the environmental impacts of the consumption of prioritized final products within this report. The level of ambition of the future requirements (to be defined in the possible future Delegated Acts) will determine the overall benefits of the ESPR, with current 'medium benefits' scenario highlighting the potential role of ESPR to bring impacts within Planetary Boundaries (for the associated scope). For this purpose, the impact assessment to be performed in view of potential future Delegated Acts should provide a specific quantification for the scope and ambition of the requirements. This study provided an overall estimation for horizontal requirements and exemplify potential product-level requirements for Textiles and footwear and Furniture. Overall, the ESPR is a product policy that can have a positive effect on the two main elements of the EU Consumption Footprint: the impacts of products in the market, by setting requirements and making sustainable products the norm, and the consumption patterns of EU citizens, by facilitating sustainable patterns that decrease over-consumption (e.g., by providing information to consumers and making products durable and repairable).

5.1 Final remarks and next steps

The results of this Report identify 11 final products, 7 intermediate products and three horizontal requirements as potential priorities for the setting of ecodesign criteria under ESPR, given their relevance in terms of environmental impacts, improvement potential, Open Strategic Autonomy, and the extent to which such products are covered by EU policies. This Final Report will feed into reflections on the first ESPR Working Plan, but its results do not bind the Commission, and are without prejudice to what may ultimately be prioritised for first action under ESPR, included in the first ESPR Working Plan, or undertaken under other EU policy frameworks. In this respect, it should be noted that the Commission will also be required to take other aspects into account, when defining first priorities under ESPR – including the obligation to consider prioritising the products listed in Article 18 of the

ESPR text[62] in the first ESPR Working Plan, available resources and the political priorities of the new Commission.

[62] These are: *iron & steel; aluminium; textiles, notably garments and footwear; furniture, including mattresses; tyres; detergents; paints; lubricants; chemicals; energy related products, the implementing measures for which need to be revised or newly defined; ICT products and other electronics.*

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List of abbreviations and definitions

Abbreviations	Definitions
AC	Acidification
BAT	Best Available Technique
BAT-AELs	Best Available Technologies Associated Emission Levels
BoM	Bill of Materials
CC	Climate Change
CF	Consumption Footprint method
Commodity chemical	(aka bulk chemical) chemicals produced in large quantities
CRMs	Critical Raw Materials
EC	European Commission
ECOTOX	Freshwater Ecotoxicity
EF	Environmental Footprint
ELT	End-of-Life Tyres
EPD	Environmental Product Declarations
ErP	Energy-Related Products
ESPR	Ecodesign for Sustainable Products Regulation
ETS	Emission Trading System
EU	European Union
FEU	Eutrophication – freshwater
FRD	Resource Use – fossil
GHG	Greenhouse Gas(es)
HDPE	High-Density Polyethylene

Abbreviations	Definitions
HTOX_c	Human toxicity – cancer
HTOX_nc	Human toxicity – non-cancer
IR	Ionising radiation
JRC	The European Commission Joint Research Centre
LCA	Life Cycle Assessment
LDPE	Low-Density Polyethylene
LMT	Light Means of Transport
LU	Land use
MEErP	Methodology for Ecodesign of Energy-related Products
MEU	Eutrophication, marine
MRD	Resources use – minerals and metals
MTBF	Mean Time Before Failure
ODP	Ozone depletion
OSA	Open Strategic Autonomy
PEFCRs	Product Environmental Footprint Category Rules
PET	Polyethylene Terephthalate
PLP	Plastic Leak Method
PM	Particulate Matter
POF	Photochemical ozone formation
PP	Polypropylene
PPWR	Packaging and Packaging Waste Regulation
PS	Polystyrene

Abbreviations	Definitions
RMIS	JRC Raw Material Information System
SDG	Sustainable Development Goal
SUP	Single-Use Plastics
TEU	Eutrophication – terrestrial
WP	Working Plan
WU	Water Use
WUR	Weight/utility ratio

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Annexes

Annex 1. Changes compared to the Preliminary Report

This Final Report sees several changes compared to the Preliminary Report published in January 2023. Some of these changes are related to the differences in the final adopted text of the ESPR compared to the proposal published by the Commission in March 2022. Some other changes are related to the feedback received as part of the Open Public Consultation and the additional evidence shared by stakeholders on a number of topics. Also, regulatory developments of other Union policies were taken into account. Although the main structure and methodology of the report has remained the same, the further research that was conducted led to some changes in the results and in the way results are presented. The following paragraphs describe the main changes that can be found in this Final Report, compared to the Preliminary Report.

Changes related to the final ESPR text

One of the main changes in the final ESPR text is related to the **scope** of the ESPR. In fact, the final ESPR text, compared to the Commission proposal from March 2022, excludes additional products, and in particular "*vehicles as referred to in Article 2(1) of Regulation (EU) No 167/2013, in Article 2(1) of Regulation (EU) No 168/2013 and in Article 2(1) of Regulation (EU) 2018/858, in respect of those product aspects for which requirements are set under sector-specific Union legislative acts applicable to those vehicles*".

The Preliminary Report included vehicles, under the name of Means of transport (road), in the initial selection of final products, although such products were not shortlisted for the final ranking. In this Final Report, Means of transport (road) has been excluded since the beginning. The exclusion of vehicles from the ESPR does not affect the proposal of horizontal requirements for light means of transport, which are not part of the exclusion set by ESPR.

Changes to the proposal for final and intermediate products

Thanks to the feedback from stakeholders obtained as part of the Open Public Consultation, as well as further research and evidence available in the literature, some changes were made to the scores and ranking of final and intermediate products:

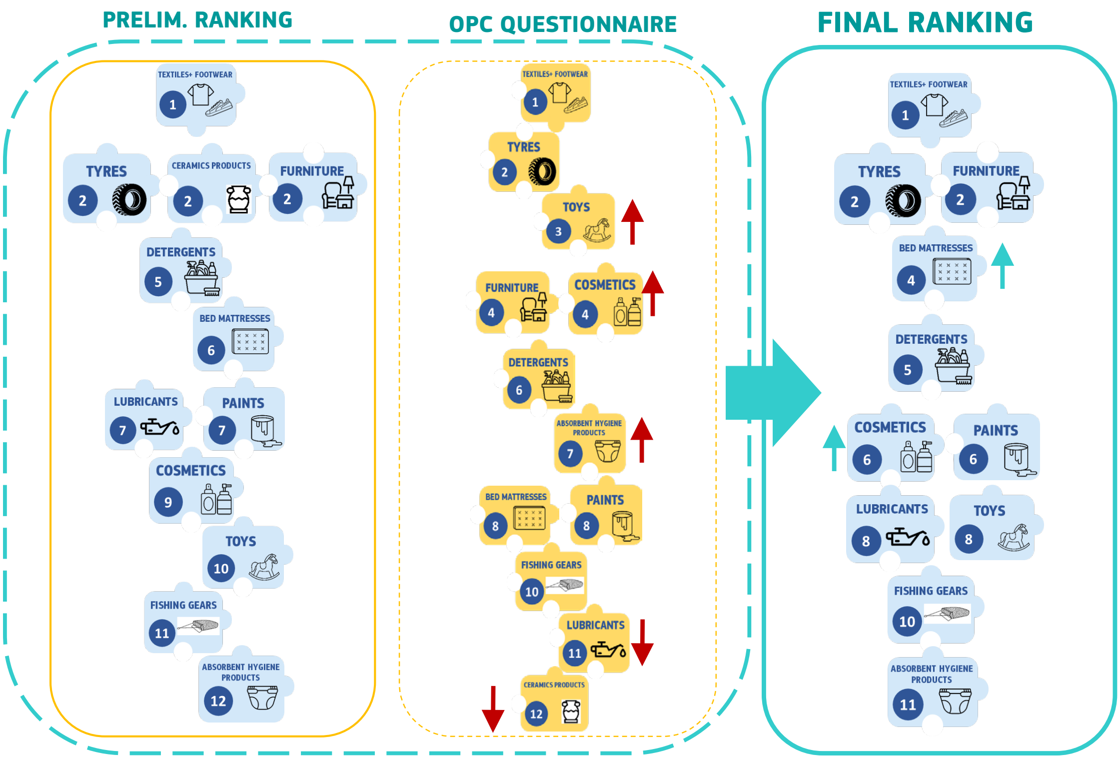
- The **scope of some product groups** was changed to align it with other pieces of legislation. This involved Textiles and footwear, Detergents and Absorbent hygiene products (as final products), and Commodity Chemicals (previously Chemicals) and Non-ferrous metal products (as intermediate products).
- Changes in the **scores** affected the following **final products**: Textiles and footwear (from 43 in the Preliminary Report to 42 in this Final Report), Bed mattresses (from 26 to 28), Detergents (from 28 to 26), Cosmetics (from 23 to 24), Lubricants (from 24 to 23), Toys (from 22 to 23), Absorbent hygiene products (from 18 to 19).
- The **ranking of final products** was affected by the following changes: Bed mattresses ranks 4th in this Final Report (instead of 6th in the Preliminary Report), Cosmetics ranks 7th (instead of 9th), Lubricants ranks 8th (instead of 7th), Toys ranks 9th (instead of 10th), Absorbent hygiene products ranks 10th (instead of 11th). The final ranking as well as its comparison with the preliminary ranking and the results of the Open Public Consultation is shown in **Figure 1.1**.

- Regarding **Ceramics products**, after analysing the contributions of the open public consultation, this product group is excluded from the list of final products given the fact that according to Eurostat data, two thirds of ceramic products fall inside the category of construction products, which is excluded from the scope of ESPR working plan. In addition to that, within ceramics, there are products that can be considered final as tableware, however others can be identified as intermediate, which is the case of refractory bricks (65% are sold to steel industry). Thus, the market share of ceramics is significantly lower than the other products analysed. This situation considerably reduces both the impact and the potential for improvement of this group of products and they are therefore left out of the analysis.

- Changes in the **scores** affected the following **intermediate products**: Commodity chemicals (previously Chemicals, from 25 in the Preliminary Report to 28 in this Final Report), Pulp and paper (from 22 to 21), Glass (from 19 to 20).

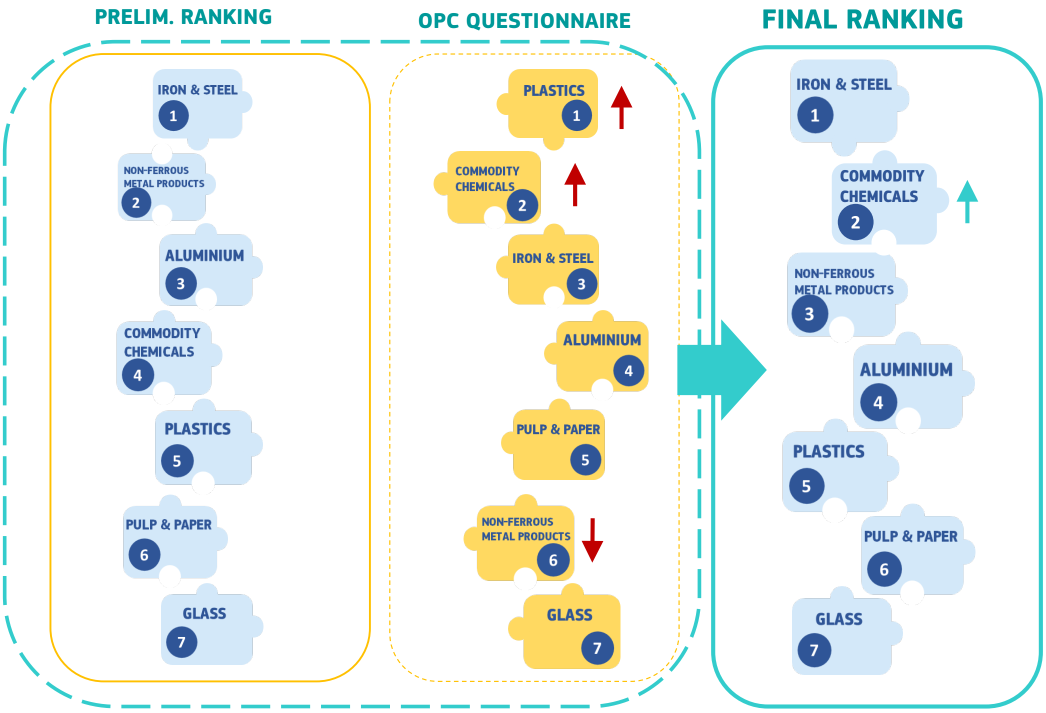
- The **ranking of intermediate products** was affected by the following changes: Commodity chemicals (previously Chemicals) ranks 2nd in this Final Report (instead of 4th in the Preliminary Report), Non-ferrous metals ranks 3rd (instead of 2nd), Aluminium ranks 4th (instead of 3rd). The final ranking as well as its comparison with the preliminary ranking and the results of the Open Public Consultation is shown in **Figure 1.2**.

Figure 1.1. Comparison between the preliminary ranking, the results of the Open Public Consultation and the final ranking of final products



Source: JRC own elaboration

Figure 1.2. Comparison between the preliminary ranking, the results of the Open Public Consultation and the final ranking of intermediate products



Source: JRC own elaboration

Changes to the proposal for horizontal requirements

With regards to horizontal requirements, changes to the Preliminary Report were made in order to reflect expanded research, stakeholder input via the open public consultation and regulatory developments (both of the ESPR itself and other pieces of Union legislation). Those are summarised below:

- **Durability**: the scope of the horizontal measure was re-considered and updated to reflect product-specific challenges associated with the majority of reliability-related provisions, specifically those related to resistance to stresses or ageing mechanisms and minimum durability of function. The challenges and rationale of the changes is presented in detail in Section 2.3.2.
- **Recyclability**: the initial scope of the Recyclability horizontal requirement included a number of product groups for which recyclability can be addressed at packaging level, specifically detergents, cosmetics, animal care products. The report was since updated to reflect the publication of the revised on Packaging and Packaging Waste Regulation, which addresses (among other aspects) recyclability of packaging. Furthermore, the product groups of stationary paper and printed paper were also removed, due to the challenge of addressing its recyclability horizontally with the other products in scope, as it depends on paper applications, expected lifetime (see JRC Final Technical Report EU Ecolabel Criteria for printed paper, stationery paper, and paper carrier bag products).

- **Post-consumer Recycled Content**: the initial scope of the horizontal requirement included “Products containing CRMs”. This product family was later removed to reflect the publication of Regulation (EU) 2024/1252, i.e., the European Critical Raw Materials Act, which contains provisions related to recycled content (including for permanent magnets), thus already covering an important part of CRM scope. Additionally, a significant number of other key CRM-related products (Carrara et al, 2023) are out of scope of the ESPR framework.
- **Quantification of Horizontal Requirements**: the quantification of horizontal requirements was refined to reflect the updated scope for each of them.

Other changes

The following changes are also present in this Final Report:

— The **proposal of potential measures under ESPR** (illustrated in the product fiches of Annex 5) was modified. First of all, the wording of the potential measures proposed in the product fiches was aligned with the wording used for the product parameters described in Annex I to the ESPR. Moreover, the list of potential measures was better streamlined across the environmental aspects used for the assessment of environmental relevance, ensuring that the repetition of measures between environmental aspects is minimised.

— In order to clarify the potential role of possible ESPR Delegated Acts in the EU regulatory landscape, a **new summary table** can be found in the product fiches (Annex 5 of this report). The summary table highlights, for each performance and information requirement proposed, the environmental aspects for which there would be direct or indirect improvement potential, existing Union law related to the requirement, and what could be addressed by ESPR.

— The product fiche sections on the proportionality of costs, previously included in the individual product fiches in Annex 5, have been merged into one section that is presented and discussed in Section 3.3.3.

— For Textiles and footwear, Furniture and Commodity chemicals, Annex 6 presents the analysis of the possible **granularity** of such product groups. These products were selected because characterised by a high heterogeneity of products within their scope, and because of their ranking in the top positions (among the first three product groups). The granularity analysis has the main objective of informing of possible sub-division of the product group into smaller sub-groups that could be addressed by separate Delegated Acts. Nevertheless, the proposed sub-group classification will have to be further analysed by a dedicated Preparatory Study, should the product be retained in the final Working Plan, and consulted with relevant stakeholders.

Annex 2. Initial list of products

Table 2.1. Definitions of the product groups included in the initial selection of final products, intermediate products and horizontal requirements

Product group	Scope description
Absorbent hygiene products	Any article whose function is to absorb and retain human fluids such as urine, faeces, sweat, menstrual fluid or milk, excluding textile products. Products included are: baby diapers, panty-liners, menstrual pads, breast pads, tampons, incontinence products. Excluded products are: wet wipes, make-up remover wipes, cotton swabs.
Aluminium	Aluminium and its alloys
Bed mattresses	Products consisting of a cloth cover that is filled with materials and that can be placed on an existing supporting bed structure or designed for free standing in order to provide a surface to sleep or rest upon for indoor use
Biofuels	The product group comprises liquid and gaseous biofuels for transport (road, sea and air) as well as fuels for heating and industrial use.
Books and printed paper	Products included are any printed paper product that consists of at least 90% by weight of paper, paperboard, or paper-based substrates, except for books, that shall consist of at least 80% by weight of paper or paperboard of paper-based substrates (paper printed books, brochures and leaflets, printed paper products, advertising material, catalogues). Inserts, covers and any printed paper part of the final printed paper shall be considered to form part of the printed paper product.
Candles	The product group covers taper candles, pillar candles, tea light candles, graveyard candles, garden candles, candles for decoration and oil candles/-lamps
Ceramic products	The scope considered is the same as that of the BREF with the exception of the uses related to construction. Thus, ceramic products include the following sectors: **Vitrified clay pipes** and fittings are used for drains and sewers, but also tanks for acids and products for stables. **Refractory products** are usually applied in industries like the metals, the cement, the petrochemical and the glass industries to increase the energy efficiency of their processes. **Expanded clay aggregates** are porous ceramic products used as loose material in garden and landscape design (e.g. embankment fillings in road construction, substrates for green roofs, filter and drainage fillings). **Household ceramics** covers tableware, artificial and fancy goods made of porcelain, earthenware and fine stoneware. **Sanitary ware** are lavatory bowls, bidets, wash basins, cisterns and drinking fountains. **Technical ceramics** supply aerospace and automotive industries (engine parts, catalyst carriers), electronics (capacitors, piezoelectrics), biomedical products (bone replacement), environment

Product group	Scope description
	protection (filters) and many others. **Inorganic bonded abrasive** is a tool where a synthetic abrasive is blended with a vitrified bond.
Commodity Chemicals	**Large volume inorganic chemicals – ammonia, acids and fertilisers**: ammonia, nitric acid, sulphuric acid, phosphoric acid and hydrofluoric acid, phosphorus-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers); as defined by the relative Best Available Techniques Reference Document (BREF) ([5]). **Large volume inorganic chemicals – solids and others industry**: soda ash (called sodium carbonate, including sodium bicarbonate), titanium dioxide (from the chloride and sulphate process routes), carbon black (rubber and speciality grades), synthetic amorphous silica (pyrogenic silica, precipitated silica, and silica gel); as defined by the relative BREF[63] ([8]). **Large volume organic chemicals**: lower olefins by the cracking process (e.g. ethylene), aromatics such as benzene/toluene/xylene (BTX), oxygenated compounds such as ethylene oxide, ethylene glycols and formaldehyde, nitrogenated compounds such as acrylonitrile and toluene diisocyanate, halogenated compounds such as ethylene dichloride (EDC) and vinyl chloride monomer (VCM), sulphur and phosphorus compounds and organo-metallic compounds; as defined by the relative BREF ([7]).
Cosmetics	Any substance or mixture falling under the scope of Regulation (EC) No 1223/2009, intended to be placed in contact with the external parts of the human body, or with the teeth and the mucous membranes of the oral cavity, with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition or correcting body odours. Products included are e.g. toilet soaps, shower preparations, shampoos, hair conditioning products, shaving products, deodorants, toothpaste, skin-care products, sunscreens, decorative cosmetics (the list is not exhaustive).
Cotton buds	No standard definition is provided. A cotton bud stick typically refers to a short stick with a small amount (or wad) of cotton at one or both of its ends, often used for personal hygiene, especially for the cleaning of ears or the application of make-up. In this case refers to a single-use, plastic containing version of the product. Exclusion of cotton buds intended for medical use
Detergents	Any substance and mixture falling under the scope of the Detergents Product Regulation. Products included are: laundry detergents, dishwasher detergents, hard surface cleaning products (i.e. all purpose cleaners, kitchen cleaners, window cleaners, sanitary cleaners), hand dishwashing detergents

[63] With the exception of inorganic phosphates, which are excluded from this product fiche, due to their use in food and feed (excluded from the scope of ESPR) and in detergents (proposed as a final product for the Working Plan)

Product group	Scope description
De-icers	De-icers are used to remove ice and snow on flat areas, preventing further ice formation or maintaining friction on for example runways at airports, roads, tunnels and foundation walls. They may be either liquid or solid (granulate). According to composition, de-icing salt can be divided into inorganic, organic, and mixed types.
Fishing nets & gear	Any item or piece of equipment that is used in fishing or aquaculture to target, capture or rear marine biological resources or that is floating on the sea surface, and is deployed with the objective of attracting and capturing or of rearing such marine biological resources
Furniture	Free-standing or built-in units whose primary function is to be used for the storage, placement or hanging of items and/or to provide surfaces where users can rest, sit, eat, study or work, whether for indoor or outdoor use. The scope extends to domestic furniture and contract furniture items for use in domestic or non-domestic environments. Bed frames, legs, bases and headboards are included in the scope. Not included are: bed mattresses, streetlights, railings and fences, ladders, clocks, playground equipment, stand-alone or wall-hung mirrors, electrical conduits, road bollards and building products such as steps, doors, windows, floor coverings and cladding.
Glass	Products included: container glass, flat glass, continuous filament glass fibre, domestic glass, special glass, mineral wool, high temperature insulation wools and frits.
Iron and steel	Iron and steel. Steel is an alloy of iron and carbon, where the carbon content can range up to 2% (when the carbon content is over 2%, the material is defined as cast iron). Steel products considered under scope include group 72 (iron and steel) and group 73 (articles of iron or steel) of the Combined Nomenclature (CN codes).
Light means of transport (LMT)	Monowheels, e-scooter, e-bikes, e-mopeds, up to L2e (No 168/2013 classification)
Lubricants	Product capable of reducing friction, adhesion, heat, wear or corrosion when applied to a surface or introduced between two surfaces in relative motion, or is capable of transmitting mechanical power. Lubricants are typically composed of variable concentrations of base fluids (80-75%) and additives (25-20%).. Base fluids can be fossil based (mineral oils, semi- or fully synthetic oils, re-refined mineral oils) or vegetable oil based as well as also mixtures of them, mostly mineral-synthetic and vegetable-synthetic, but also a small proportion may be water based. Lubricants also assist with cleaning machinery from wear metals and deposits, prolonging their life.
Non-ferrous metal products (excl. aluminium)	This group includes intermediate products made of six primary and secondary non-ferrous metals:

Product group	Scope description
	1. Copper and its alloys (e.g., with Zn, Sn, Ni, Al and other metals) 2. Lead and tin. 3. Zinc and cadmium. 4. Precious metals: gold (electronics), silver (industrial applications), platinum, palladium, rhodium, iridium, ruthenium and osmium (the platinum group metals, mainly used as catalysts). 5. Ferro-alloys: a. Bulk ferro-alloys (i.e., ferro-chrome, ferro-silicon together with silicon metal, ferro-manganese, silico-manganese and ferro-nickel), b. Special ferro-alloys (i.e., ferro-titanium, ferro-vanadium, ferro-tungsten, ferro-niobium, ferro-molybdenum, ferro-boron, alloyed or refined ferro-silicon, silicon metal and ternary/quaternary alloys). 6. Nickel and cobalt
Office and hobby supplies, stationery	The product group comprises writing instruments, paint, glue, tape and erasers for office and hobby, not falling under Toy Directive Scope. Electronic products are excluded.
Paints	Products falling under the scope of the Directive 2004/42/EC (known as the "Paints Directive") for paints and varnishes, and vehicle refinishing products. • **Paints and varnishes** refer to coatings applied to buildings, their trim and fittings, and associated structures for decorative, functional and protective purpose. • Note that **vehicle refinishes** also fall under the scope of the "Paints Directive". Vehicle refinishes are used for the coating of road vehicles as defined in Directive 70/156/EEC, or part of them, carried out as part of vehicle repair, conservation or decoration outside of manufacturing installations. Not included: paints used in non-road vehicles (i.e., boats, ships, aircrafts…) or road marking paint.
Paper, pulp paper and boards	Pulp, paper and board (chemical, kraft, sulphite, mechanical and chemi- mechanical pulping, recovered paper processing and papermaking.
Pest control	Non-toxic agents and techniques to control or destroy noxious articulates and rodents. Traps and electroacoustic devices are excluded from the scope.
Plastics and polymers	Polymeric material that has the capability of being moulded or shaped, usually by the application of heat and pressure. It usually contains polymers and additives that give additional properties to

Product group	Scope description
	the mixture. The scope is plastic basic materials, synthetic rubbers and hydrocarbons containing oxygen.
Sanitary additives	Sanitary additives to reduce odour nuisance and gas formation in mobile toilets such as those used in camping vehicles and sport boats, at construction sites, highway restrooms, big events, on coaches, planes, trains and passenger ships
Ski wax	Glide wax products for all types of skis and boards intended for use on snow.
Solid fuels and fire-fighting products	The product group comprises barbeque charcoal, briquettes, fire-lighters, firewood, pellets and wood chips.
Textiles and footwear	**Textiles:** Any raw, semi-worked, worked, semi-manufactured, manufactured, semi-made-up or made-up product which is exclusively composed of textile fibres, regardless of the mixing or assembly process employed, as well as a product containing at least 80% textile fibres by weight, in line with the Textile Labelling Regulation (Regulation (EU) No 1007/2011). This includes apparel textiles, home/interior textiles and technical textiles usually or also meant for consumers (such as truck covers, cleaning products) or specifically meant for industry (automotive, construction, medical, agriculture, etc). Excluded are: products for which textiles fibres accounts for less than 80% by weight[64] (e.g. upholstery textiles, carpets mainly made of plastics, duvets, pillows), personal protective equipment according to Regulation (EU) 2016/425, apparel textiles identified as medical devices or as an accessory for medical devices according with Regulation (EU) 2017/745, leather and fur. **Footwear:** in line with Directive 94/11/EC, all articles with applied soles designed to protect or cover the foot. Excluded from the scope are: protective footwear covered by Regulation (EU) 2016/425 ([66]), footwear containing any electric or electronic components; toy footwear.
Toys	The product group covers products for use in play by children under 14 (hereinafter referred to as toys) that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded are: products listed in Annex 1 of Toys Safety Directive as well as electronic toys (because falling these fall under the Ecodesign Directive for which the Ecodesign and Energy Labelling Workingplan 2022 2024 applies).
Tyres	Products included are cars (C1) tyres, vans (C2) tyres and heavy-duty vehicles (C3) tyres

[64] See, in this regard, Articles 3(1)(a) and 2(2)(a) of the Textile Labelling Regulation (EU) 1007/2011

Product group	Scope description
Waste containers for separate glass collection	It includes containers made out of recycled plastic.
Wet wipes	Wet wipes for personal care and domestic use excluding industrial ones (EU Commission guidelines[65]).
Wood-based panels	Wood-based panels such as particleboards, oriented-strand board, fibreboard, rigidboard and flexboard, softboard, hardboard, particleboard pallets and pallet block.

[65] Commission guidelines on single-use plastic products in accordance with Directive (EU) 2019/904 of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment, 2021/C 216/01

Annex 3. Screening of products

Final products

Table 3.1. Results of the screening assessment for all final products initially listed

Product group	**EU market size** (in billion EUR or units or tonnes)	**Environmental considerations**	**Policy coverage(*)**	**Final decision**	**References**
Absorbent hygiene products	59 000 million units and 6 billion EUR in 2020	High - use of resources - waste generation - air and water emissions	Partly regulated - BAT-AELs for pulp - Single Use Plastic Directive	Shortlisted	Pérez-Camacho et al., 2023
Bed mattresses	10 billion EUR in 2022	High - use of resources - waste generation	No mandatory regulation of environmental relevance	Shortlisted	Cordella and Wolf, 2013; Statista, 2023
Biofuels	20 billion EUR in 2019	High - climate change - air emissions - land use	Regulated: - RED I, II	Not shortlisted because of the extensive regulatory framework	Nordic Swan Ecolabel, Background document; Fortune Business insight
Books and printed paper	37 billion EUR in 2020	High - air emissions - energy use - chemical use	Partly regulated - BAT-AELs for pulp - BAT-AELs for solvents	Not shortlisted. Main impacts addressed under the 'Pulp, paper and board' intermediate product	PRODCOM
Candles	1,5 billion EUR in 2020	Medium - human toxicity - use of resources	No mandatory regulation of environmental relevance	Not shortlisted. - Seasonal use - Not uniform use across EU MS	PRODCOM

Product group	**EU market size** (in billion EUR or units or tonnes)	**Environmental consider-ations**	**Policy coverage(*)**	**Final decision**	**References**
Ceramic products	26 billion EUR in 2020	High - resource depletion - air pollution - climate change - energy consumption	Partly regulated - BAT-AELs for ceramics - REACH	Not Shortlisted because 2/3 of ceramic products fall inside the category of construction products.	JRC, 2007; European Commission; Cera-meUnie
Cosmetics	88 billion EUR in 2022	High - water impacts - microplastics - biodiversity	Partly regulated - Cosmetic Products Regulation	Shortlisted	CosmeticsEurope
Cotton buds	96 billion units in 2017	High - waste generation - microplastics - biodiversity effect	Partly regulated - BAT-AELs for pulp - Single Use Plastic Directive	Not shortlisted. The main impacts of the product are regulated by the Single Use Plastic Directive (EU) 2019/904.	Research and Markets, 2018
Detergents	41 billion EUR in 2020	High - water pollution - microplastics - biodiversity effect	Partly regulated - Detergent Products Regulation	Shortlisted	AISE, 2021, EC, 2023
De-icers	75 million EUR in 2018	Medium - human toxicity - biodiversity effect	No mandatory regulation of environmental relevance	Not shortlisted. Low market relevance	Nordic Swan ecolabelling, Background document; Marketsandmarkets
Fishing nets & gear	2,4 billion EUR in 2020[66]	High - microplastics - biodiversity effect	Partly Regulated - Single Use Plastic Directive - Regulation No 1224/2009 Community control system for ensuring compliance with rules	Shortlisted	CEAP, 2018; Statista; EMR, 2022

[66] The market value includes fishing equipment, not only fishing gears.

Product group	**EU market size** (in billion EUR or units or tonnes)	**Environmental considerations**	**Policy coverage(*)**	**Final decision**	**References**
			of the Common Fisheries Policy - Directive 2019/883 on port reception facilities for the delivery of waste from ships		
Furniture	140 billion EUR in 2021	High - human toxicity - use of resources - waste generation	No mandatory regulation of environmental relevance	Shortlisted	Donatello et al., 2014; European Environment Bureau, 2017 ; EFIC, 2022
Lubricants	4.3 million tonnes in 2017; 30 billion EUR in 2021	High - waste generation - use of resources - water pollution	Partly regulated - Waste Framework Directive	Shortlisted	EC, 2020; Vidal-Abarca Garrido et al., 2018; UEIL, 2022
Office and hobby supplies, stationery	7 billion EUR in 2020	Low - chemical use	No mandatory regulation of environmental relevance	Not shortlisted. Not included because low impacts that are nevertheless covered by another shortlisted (intermediate) product: pulp paper and board.	PRODCOM
Paints	17 billion EUR in 2022	High - human toxicity - microplastics - water pollution	Partly regulated - Paints Directive	Shortlisted	Jiannis et al. 2013; CEPE, 2022

Product group	**EU market size** (in billion EUR or units or tonnes)	**Environmental considerations**	**Policy coverage(*)**	**Final decision**	**References**
Textiles and footwear	175 billion EUR in 2021[67]	High - water pollution - waste generation - microplastics - climate change	Partly covered: - REACH - Regulation 1007/2011 on labelling	Shortlisted	Euratex, 2022; Statista; CEC, 2021 (Eurostat data)
Toys	18 billion EUR in 2022	High - waste generation - use of resources	Partly regulated - EU Toy Safety Directive	Shortlisted	TIE,2023
Tyres	45 billion EUR in 2021	High - microplastics - air pollution - biodiversity	Partly regulated - Regulation (EU) 2020/740 on the labelling of tyres with respect to fuel efficiency and other parameters	Shortlisted	Techsciresearch
Pest control	409 million EUR in 2020	Medium - indoor air quality	No mandatory regulation of environmental relevance	Not shortlisted. Low market relevance	PRODCOM
Sanitary additives	Market size unknown but estimated to be low.	Low - water and soil pollution	No mandatory regulation of environmental relevance	Not shortlisted Product discarded for low relevance.	
Ski wax	8 billion EUR in 2020	Medium - human toxicity	No mandatory regulation of environmental relevance	Not shortlisted. Market dependent on the EU country and not-equally distributed.	Nordic Swan Ecolabelling, Background Document; Business Research, 2022
Solid fuels and firefighting products	3 billion EUR in 2019	High - climate change - air emissions - use of resources	Regulated: - RED I, II	Not shortlisted because of the extensive regulatory framework	Nordic Swan Ecolabel, Background document; Fortune Business insight

[67] The market value includes leather footwear.

Product group	EU market size (in billion EUR or units or tonnes)	Environmental considerations	Policy coverage(*)	Final decision	References
Waste containers for separate glass collection	6 million EUR in 2017	Low - noise pollution	No mandatory regulation of environmental relevance	Not Shortlisted low size of the market	Grand View Research
Wet wipes	3 billion EUR in 2018	Medium - waste generation - water pollution and littering	Regulated - SUP Directive	Not shortlisted. The main impacts of the product are regulated by the Single Use Plastic Directive (EU) 2019/904.	Faraca et al., 2021; The Insight Partners, 2020

(*) all final products are indirectly covered by the revised Packaging and Packaging Waste Regulation

Intermediate products

Table 3.2. Results of the screening assessment for all intermediate products initially listed

Product group	EU market size (in billion EUR or units or tonnes)	Environmental considerations	Policy coverage(*)	Final decision	References
Aluminium	40 bn EUR in 2019 (annual turnover)	High - energy consumption - biodiversity - air and water pollution	Partly regulated - BAT-AELs for Non-Ferrous Metals, Aluminium - ETS, CBAM - Taxonomy	Shortlisted	JRC, 2016 ; European Aluminium

Product group	EU market size (in billion EUR or units or tonnes)	Environmental considerations	Policy coverage(*)	Final decision	References
Commodity chemicals	760 billion EUR in 2022[68]	High - energy consumption - water pollution - use of resources	Partly regulated - BAT-AELs for Large Volume Inorganic Chemicals, Large Volume Inorganic Chemicals, Production of Large Volume Organic Chemicals, Manufacture of Organic Fine Chemicals - REACH, CLP	Shortlisted	Cefic, 2023
Glass	30 billion EUR in 2022	High - air pollution - climate change - energy consumption	Partly regulated - BAT-AELs for glass - REACH	Shortlisted	Grand View Research; Glass for Europe
Iron and steel	130 billion EUR in 2022 (annual turnover)	High - energy consumption - climate change - air and water pollution	Partly regulated - BAT-AELs for Ferrous metals, Iron and steel production - ETS, CBAM - Taxonomy	Shortlisted	Eurofer, 2023
Paper, pulp paper and boards	115 billion EUR in 2022 (annual turnover)	High - energy consumption - biodiversity - water and air pollution	Partly regulated - BAT-AELs for paper - New EU Forest Strategy of 2030	Shortlisted	CEPI, 2023
Plastics and polymers	405 billion EUR in 2021	High - climate change - water pollution - microplastics	Partly regulated - BAT-AELs for plastic and polymers - Single Use Plastic Directive	Shortlisted	Plastics Europe, 2022
Non-ferrous metal products	80 billion EUR in 2022	High - climate change - energy consumption	Partly regulated - BAT-AELs for Non-ferrous metals (excluding Aluminium)	Shortlisted	Eurometaux

[68] The market value may include more products than those included in the scope of this report

Product group	EU market size (in billion EUR or units or tonnes)	Environmental considerations	Policy coverage(*)	Final decision	References
			- ETS - Taxonomy		
Wood-based panels	16 850 million EUR in 2016	High - air pollution - use of resources	Regulated: - BAT-AELs Wood-based panel production - Deforestation Regulation	Not shortlisted Due to policy coverage and main impacts addressed in final products: furniture, construction products (excluded), toys	Grand View Research

(*) all intermediate products are under Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community (the EU Emission Trading System)

Annex 4. Assessment of environmental relevance: environmental categories considered

Table 4.1. Environmental categories considered in the assessment of environmental relevance for final products and intermediate products. Please note that for intermediate products the categories "material efficiency" and "lifetime extension" were not evaluated. PG: product group.

Water effects	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: Preserving & Restoring Ecosystems & Biodiversity. The Circular Economy Action Plan: Address the presence of microplastics in the environment. Plastics Strategy: Prevention of Microplastics release. Zero Pollution Strategy Targets 2030: reduce 30% microplastics released into environment.
	Link with PEF impact categories	Ecotoxicity for Aquatic freshwater. Eutrophication – Aquatic. Resource depletion – Water. Ozone depletion. Acidification.
	Aspects to consider during evaluation	Water Consumption. Water Emissions. Freshwater pollution. Intentionally and unintentionally added microplastics. Microplastics leakage. Oceans pollution. PBT substances (Persistent, Bioaccumulative and Toxic). vPvB substances (very Persistent, very Bioaccumulative). Metals. Arsenic. Biocides. Nitrates. Phosphates. Sulphur Compounds. Nitrogen Compounds.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of water consumption, water emissions or other water effects. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on water consumption, water emissions or other water effects, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to water consumption, water emissions or other water effects. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on water consumption, water emissions or other water effects in the

		near future. Significant improvement potential available.
Air effects	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: Preserving & Restoring Ecosystems & Biodiversity. 8th Environment Action Programme thematic priorities: Decoupling economic growth from resource use and environmental degradation. Zero Pollution Strategy Targets 2030: reduce 55% health impacts of air pollution.
	Link with PEF impact categories	Ozone Depletion. Ionising Radiation. Photochemical ozone formation. Sky quality. Particulate Matter.
	Aspects to consider during evaluation	Air Emissions. Ammonia. Sulphur Compounds. Nitrogen Compounds. Carbon monoxide. VOCs. Chlorine. Bromine. Fluorine. Arsenic. Ionising Radiations. Microwaves. Ozone Depleting Substances.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of air effects. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on air effects, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to air effects. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on air effects in the near future. Significant improvement potential available.
Soil effects	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: Preserving & Restoring Ecosystems & Biodiversity. 8th Environment Action Programme thematic priorities: Decoupling economic growth from resource use and environmental degradation.

	Link with PEF impact categories	Eutrophication – Terrestrial. Resource depletion - Mineral/Fossil. Land Use. Acidification.
	Aspects to consider during evaluation	Exploitation of natural resources. Nitrogen compounds. Sulphur Compounds. Ammonia. Fertilisers. Surface affected. Indirect land use change. Microplastics.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of soil effects. Technology and market trends does not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on soil effects, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to soil effects. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on soil effects in the near future. Significant improvement potential available.
Biodiversity effects	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: Preserving & Restoring Ecosystems & Biodiversity. 8th Environment Action Programme thematic priorities: Decoupling economic growth from resource use and environmental degradation. Zero Pollution Strategy Targets 2030: reduce 55% ecosystems where air pollution threatens biodiversity.
	Link with PEF impact categories	
	Aspects to consider during evaluation	Deforestation. Effects on animal population. Reduction of ecosystem resilience. Surface affected. Indirect land use change.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of biodiversity effects. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on biodiversity effects, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.

	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to biodiversity effects. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on biodiversity effects in the near future. Significant improvement potential available.
Waste generation	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	Plastics Strategy: Curbing plastic waste and littering. Zero Pollution Strategy Targets 2030: reduce 50% plastic sea litter + 30% residual municipal waste.
	Link with PEF impact categories	
	Aspects to consider during evaluation	Waste avoidance. Hazardous waste. WEEE. Municipal waste. Packaging waste. Food waste. Plastic litter/Microplastics. Waste export. Waste oils.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of waste generation. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on waste generation, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to waste generation. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on waste generation in the near future. Significant improvement potential available.
Climate Change	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: Increasing EU's Climate Ambition. 8th Environment Action Programme thematic priorities: Reduction of GHG emissions + Reducing vulnerability to Climate Change + Reducing key Environmental and Climate pressures.
	Link with PEF impact categories	Climate change. Land use.
	Aspects to consider during evaluation	Life cycle GHG emissions.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of GHG emissions. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.

	Priority level 2. Medium relevance. (2p)	The PG has some relevance on GHG emissions, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to GHG emissions. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on GHG emissions in the near future. Significant improvement potential available.
Life cycle Energy consumption	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: Increasing EU's Climate Ambition. EU Energy Efficiency Goals.
	Link with PEF impact categories	Resource depletion.
	Aspects to consider during evaluation	Energy Efficiency of products. Electricity consumption. Fuel consumption. Gas consumption.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of lifetime energy consumption. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on lifetime energy consumption, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to lifetime energy consumption. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on lifetime energy consumption in the near future. Significant improvement potential available.
Human Toxicity	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: Zero Pollution Ambition for Toxic-free environment. 8th Environment Action Programme thematic priorities: Pursuing a Zero-pollution ambition and toxic free environment. Chemicals Strategy, Substances that require special attention: endocrine disruptors & harmful and persistent substances.
	Link with PEF impact categories	Human Toxicity - cancer effects. Human Toxicity - non cancer effects.

	Aspects to consider during evaluation	Heavy Metals. Endocrine disruptors PFAS: Per- and polyfluoroalkyl substances. Persistent, mobile and toxic substances. Substances of Very High Concern (SVHC). Chemicals that cause cancer, gene mutations or reproductive toxicity. Respiratory sensitisers. Chemicals toxic to specific organ. Bioaccumulative chemicals.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of use of human toxicity. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential in the use of human toxicity.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on use of human toxicity, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen in the use of human toxicity.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to use of human toxicity. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on use of human toxicity in the near future. Significant improvement potential available.
Material efficiency	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: mobilising industry for Clean and Circular Economy. The Circular Economy Action Plan. 8th Environment Action Programme thematic priorities: Transition to a Circular Economy. Plastics Strategy: A vision for a Circular Plastics Economy.
	Link with PEF impact categories	Resource depletion.
	Aspects to consider during evaluation	Depletion of minerals and fossil fuels. Recyclability. Recycled content. Minimisation of manufacturing waste. Material recovery. Energy recovery. Lightweight. Use of renewable materials. Product as a Service.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of material efficiency. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on material efficiency, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.

	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to material efficiency. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on material efficiency in the near future. Significant improvement potential available.
Lifetime extension	Why is this category relevant? Is the category addressed in any of the key EU Policy & Strategy documents?	EU Green Deal: mobilising industry for Clean and Circular Economy. The Circular Economy Action Plan. 8th Environment Action Programme thematic priorities: Transition to a Circular Economy. Plastics Strategy: A vision for a Circular Plastics Economy.
	Link with PEF impact categories	Resource depletion.
	Aspects to consider during evaluation	Durability. Reparability. Reusability. Upgradability. Reliability. Ease of maintenance. Remanufacturing.
	Priority level 1. Low or no relevance. (1p)	The PG has not shown any particular relevance in terms of lifetime extension. Technology and market trends do not suggest that this may change in the near future. Marginal improvement potential.
	Priority level 2. Medium relevance. (2p)	The PG has some relevance on lifetime extension, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends do not suggest that this may change in the near future. Some improvement potential can be foreseen.
	Priority level 3. High relevance. (3p)	There is evidence that the PG has caused significant issues related to lifetime extension. The issues are currently not being addressed or addressed incorrectly. Market and technology trends suggest that the PG may cause significant issues on lifetime extension in the near future. Significant improvement potential available.

Annex 5. Product fiches

Reading guidelines for the product fiches

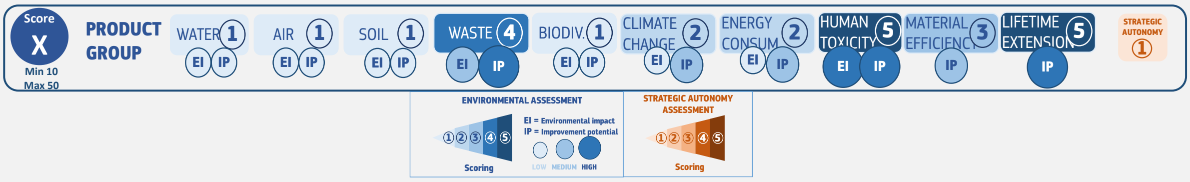
Below is the general structure of the assessments that were carried out for each of the shortlisted final and intermediate products, as explained in Section 3 of this Final Report. The aim of this template is to give an overview of the aspects that were considered in the assessment.

Name of the Product Group

Environmental Assessment

Environmental Impacts (EI) and improvement potential (IP) related to 10 impact categories were analysed for each product group and a score of relevance was as low, medium or high. This section presents a visual summary of these (through small, medium or large circles with EI or IP), plus: the individual [1-5] impact category score; the total score [10-40]; and the scoring for Open Strategic Autonomy (not counted in the total score). For ease of use, this summary is also presented just after the *Final Environmental Score* section

Subsequently, an example with explanatory legend:



For a full description of the methodology used in the product fiches, the reader is redirected to Section 3.2.1 of the main report as well as Annex 4.

Water Effects [scoring in brackets 1-5]
Environmental Impact: [Low/Medium/High]

This section refers to global impacts. Explanation of main global impacts identified related to water: water consumption, water emissions (metals, NPK, PBT substances, microplastics, etc.) and water effects (including ecotoxicity for aquatic fresh water, aquatic eutrophication, water resource depletion, acidification).

Improvement potential: [Low/Medium/High]

This section refers to improvement potential within the EU. Explanation of main improvement potential identified for the EU related to water: water consumption, water emissions (metals, NPK, PBT substances, microplastics, etc.) and water effects (including ecotoxicity for aquatic fresh water, aquatic eutrophication, water resource depletion, acidification).

Potential measures under ESPR:

Indicative list of possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to water effects. The wording of the proposed requirements is aligned with Annex I to the ESPR.

Air Effects [scoring in brackets 1-5]
Environmental Impact: [Low/Medium/High]

This section refers to global impacts. Explanation of main global impacts identified related to air pollution: air emissions (NH_3, S compounds, N compounds, CO, VOCs, halogens, etc.) and air effects (including ozone depletion, ionising radiation, photochemical ozone formation, sky quality, particulate matter).

Improvement potential: [Low/Medium/High]

This section refers to improvement potential within the EU. Explanation of main improvement potential identified for the EU related to air pollution: air emissions (NH_3, S compounds, N compounds, CO, VOCs, halogens, etc.) and air effects (including ozone depletion, ionising radiation, photochemical ozone formation, sky quality, particulate matter).

Name of the Product Group
Potential measures under ESPR: **Indicative** list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to air effects. The wording of the proposed requirements is aligned with Annex I to the ESPR.
Soil Effects [scoring in brackets 1-5] **Environmental Impact: [Low/Medium/High]** **This section refers to global impacts.** Explanation of main global impacts identified related to soil: soil emissions (S, NPK, ammonia, microplastics, etc.) and soil effects (including mineral/fossil resource depletion, land use, terrestrial eutrophication, acidification). **Improvement potential: [Low/Medium/High]** **This section refers to improvement potential within the EU.** Explanation of main improvement potential identified for the EU related to soil: soil emissions (S, NPK, ammonia, microplastics, etc.) and soil effects (including mineral/fossil resource depletion, land use, terrestrial eutrophication, acidification). **Potential measures under ESPR :** **Indicative** list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to soil effects. The wording of the proposed requirements is aligned with Annex I to the ESPR.
Biodiversity Effects [scoring in brackets 1-5] **Impact: [Low/Medium/High]** **This section refers to global impacts.** Explanation of main global impacts identified related to biodiversity including deforestation, effects on animal population, reduction of ecosystem resilience, surface affected. **Environmental Improvement potential: [Low/Medium/High]** **This section refers to improvement potential within the EU.** Explanation of main improvement potential identified for the EU related to biodiversity including deforestation, effects on animal population, reduction of ecosystem resilience, surface affected. **Potential measures under ESPR:** **Indicative** list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to biodiversity effects. The wording of the proposed requirements is aligned with Annex I to the ESPR.
Waste Generation & Management [scoring in brackets 1-5] **Environmental Impact: [Low/Medium/High]** **This section refers to global impacts.** Explanation of main global impacts identified related to waste avoidance, hazardous waste, WEEE (Waste from Electrical and Electronic Equipment), municipal waste, packaging waste, food waste, plastic litter/microplastics, waste export, waste oils. **Improvement potential: [Low/Medium/High]** **This section refers to improvement potential within the EU.** Explanation of main improvement potential identified for the EU related to waste avoidance, hazardous waste, WEEE (Waste from Electrical and Electronic Equipment), municipal waste, packaging waste, food waste, plastic litter/microplastics, waste export, waste oils. **Potential measures under ESPR:** **Indicative** list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to waste generation and management. The wording of the

Name of the Product Group
proposed requirements is aligned with Annex I to the ESPR. Measures proposed refer to the generation of waste across all life cycle stages.
Climate Change [scoring in brackets 1-5] **Environmental Impact: [Low/Medium/High]** **This section refers to global impacts.** Explanation of main global impacts identified related to life cycle GHG emissions and related effects. **Improvement potential: [Low/Medium/High]** **This section refers to improvement potential within the EU.** Explanation of main improvement potential identified for the EU related to life cycle GHG emissions and related effects. **Potential measures under ESPR:** **Indicative** list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to climate change. The wording of the proposed requirements is aligned with Annex I to the ESPR.
Life Cycle Energy consumption [scoring in brackets 1-5] **Environmental Impact: [Low/Medium/High]** **This section refers to global impacts.** Explanation of main global impacts identified related to the energy efficiency of products, electricity consumption, energy recovery, fuel consumption, gas consumption and related effects. **Improvement potential: [Low/Medium/High]** **This section refers to improvement potential within the EU.** Explanation of main improvement potential identified for the EU related to the energy efficiency of products, electricity consumption, energy recovery, fuel consumption, gas consumption and related effects. **Potential measures under ESPR:** **Indicative** list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to energy consumption. The wording of the proposed requirements is aligned with Annex I to the ESPR.
Human Toxicity [scoring in brackets 1-5] **Environmental Impact: [Low/Medium/High]** **This section refers to global impacts.** Explanation of main global impacts identified related to human toxicity (carcinogenic and non-carcinogenic effects), and related impacts from heavy metals, endocrine disruptors, PFAS (Per- and polyfluoroalkyl substances), persistent, mobile and toxic substances, Substances of Very High Concern (SVHC), gene mutations or reproductive toxicity, respiratory sensitisers, chemicals toxic to specific organ, bio-accumulative chemicals. **Improvement potential: [Low/Medium/High]** **This section refers to improvement potential within the EU.** Explanation of main improvement potential identified for the EU related to human toxicity (carcinogenic and non-carcinogenic effects), and related impacts from heavy metals, endocrine disruptors, PFAS (Per- and polyfluoroalkyl substances), persistent, mobile and toxic substances, Substances of Very High Concern (SVHC), gene mutations or reproductive toxicity, respiratory sensitisers, chemicals toxic to specific organ, bio-accumulative chemicals. **Potential measures under ESPR:** **Indicative** list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with to human toxicity. This section is normally empty because it's not in the scope of ESPR to regulate aspects related to human toxicity.

Name of the Product Group

Material efficiency [scoring in brackets 1-5] (only improvement potential/not for intermediate products)
Improvement potential: [Low/Medium/High]

This section refers to improvement potential within the EU. Explanation of main improvement potential identified for the EU related to material efficiency and in particular to depletion of minerals and fossil fuels, recyclability, recycled content, minimisation of manufacturing waste, material recovery, lightweighting or use of renewable materials.

Potential measures under ESPR:

Indicative list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to material efficiency. The wording of the proposed requirements is aligned with Annex I to the ESPR. Measures proposed refer to requirements that can improve the resource efficiency of products, and not only of waste generation.

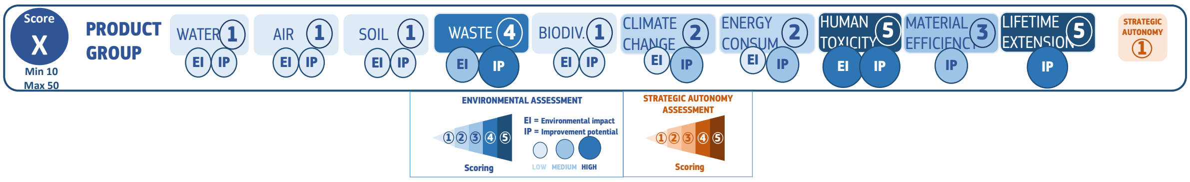
Lifetime extension [scoring in brackets 1-5] (only improvement potential/not for intermediate products)
Improvement potential: [Low/Medium/High]

This section refers to improvement potential within the EU. Explanation of main improvement potential identified for the EU related to measures such as durability, reparability, reusability, upgradability, reliability, ease of maintenance, or remanufacturing.

Potential measures under ESPR:

Indicative list of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with direct improvement with respect to lifetime extension. The wording of the proposed requirements is aligned with Annex I to the ESPR.

Final environmental score [scoring in brackets]



Open Strategic Autonomy score [scoring in brackets 1-5]

For products with a Open Strategic Autonomy score of 3, 4 and 5 points, an explanation of the improvement potential is given.

Policy Gaps

This box summarises the current EU regulatory landscape addressing the areas where improvement potential was identified. It presents the areas where there are gaps and these gaps are compared with the scope / type of requirements that ESPR can potentially cover. If existing legislation is currently under revision, a note is added.

Summary of potential measures to reduce environmental impacts

Two tables (one for performance requirements and one for information requirements) summarise the improvement potential measures characterised by Medium or High potential. Each measure is compared to the existing EU regulatory background and the potential for ESPR.

These summary tables help guide the decision to prioritise or not the product under ESPR, but the final choice of measures and the exact definition of ecodesign requirements can only be made after the full preparatory

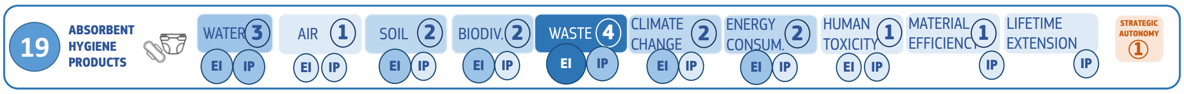
Name of the Product Group
study and impact assessment are done. The potential measures identified here are therefore purely indicative.
Additional notes and list of references

Final products

Product fiche 1. Absorbent Hygiene Products

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension**, and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

ABSORBENT HYGIENE PRODUCTS



Scope: any article whose function is to absorb and retain human fluids such as urine, faeces, sweat, menstrual fluid or milk, excluding textile products. Products included are: baby diapers, panty-liners, menstrual pads, breast pads, tampons, incontinence products. Excluded products are: wet wipes, make-up remover wipes, cotton swabs.

Water Effects [3]

Environmental impact: Medium

The production of the materials used in the manufacturing of AHP consumes water, potentially polluting it. In general, water emissions from the production of materials used in AHP (such as fluff pulp and man-made cellulose fibres) are P, Zn, Adsorbable Organically bound Halogens (AOX), and Organically bound Chlorine (OX), among others ([1]). The cultivation and production of cotton (the main material for tampons) also involves the consumption of water. The plastic content in AHP can also contribute to marine litter (1 288 tonnes; top 5 by mass of waste found) and, ultimately, are a source of microplastics due to fragmentation ([2, 3]). For baby diapers, it is estimated that the production process to cover a child's needs until 2.5 years of age uses 34 000 kg of water ([23]).

Improvement potential: Medium

Water emissions during the production of AHP materials and components can be reduced by means of abatement techniques as mandated by several BAT reference documents, which establish mandatory limits for EU installations for pollutants such as AOX, P, and Zn[69] ([5,6]). However, AHP are composed of different materials, often characterised by a global and complex supply chain that escape the requirements of the IED: 75-85% of world fluff pulp originate from south east US, with the EU accounting only for 5% of global production ([1,27]), while the main producers of man-made cellulose fibres are China, India, the US, Japan and South Africa ([1]). Other measures to lower the impact of AHP to water is through consumer awareness, by providing information on how to dispose of AHP (no flushing nor littering) ([1]). Examples in the nonwoven industry show that eutrophication and water consumption can be significantly reduced for the raw material production ([26]).

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- performance requirement on maximum level of life cycle emissions to water (e.g. for AOX, P, and Zn)
- information requirement on life cycle water consumption
- information requirement on the level of life cycle emissions to water

Air Effects [1]

[69] AOX: adsorbable organically bound halideas; P: Phosporus; Zn: Zinc

ABSORBENT HYGIENE PRODUCTS

Environmental impact: Low

Emissions to air occur during the manufacturing of AHP components and include SOx, NOx or CO ([1]). According to life cycle assessment studies, the impact categories particulate matter and photochemical ozone formation were ranked 3rd and 4th for baby nappies and 4th and 5th for sanitary towels, respectively ([4]).

Improvement potential: Low

Air emissions during the production of AHP materials and components can be reduced by means of abatement techniques as mandated by several BAT reference documents ([5, 6]). As stated for *Water effects*, most of the materials composing AHP are originate from outside the EU, thus escaping the requirements of the IED ([1,27]).

Potential measures under ESPR:

- performance requirement on maximum level of life cycle emissions to air (e.g. for NOx, SOx and CO)

- information requirement on the level of life cycle emissions to air

Soil Effects [2]

Environmental impact: Medium

In general, petroleum-based materials represent around 70% of the share of the AHP industry raw materials use, whereas renewable-based raw materials account for around 30% of the used materials ([26]), although there are examples of AHP which are 100% made of plastic ([1]). Consequently, this results in the net consumption of mostly non-renewable resources. As an example, it takes over 1,500 litres of crude oil to produce enough single-use nappies for a newborn baby until they cease to use them (2.5 years) ([3]). The renewable part of AHP is normally fluff pulp that is produced from wood fibres. The share of this component is lower for diapers (24% is fluff pulp) than for feminine products (47%) ([4]), and it is estimated that 200–400 kg of wood pulp are needed for disposable diapers used by a single baby in a year ([24]). Moreover, the cultivation of cotton, used especially in tampons, is one of the most intensive users of agrochemicals worldwide ([1]). According to a life cycle assessment, the impact categories 'Resource Use – fossils' and 'Resource Use – Minerals and metals' ranked 2nd and 1st for sanitary towels, with 17% and 19% shares of the total environmental burdens respectively ([4]). 'Resource Use – fossils' also ranked 2nd for baby nappies with a 23% share of the total environmental burdens ([4]).

Improvement potential: Low

The implementation of responsible sourcing programmes and traceability standards for materials such as fluff pulp, man-made cellulose fibres, cotton or plastics used in AHP can ensure high soil quality by implementing best agricultural practices for the use of fertilizers and pesticides, irrigation, tillage, soil management, and the protection of the surrounding environment ([1,26]). In terms of certification schemes to demonstrate the sustainable sourcing of wood fibres, the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) are the two most prominent private schemes worldwide, with a total area of certified forests of 435.5 million ha in 2020 (both schemes, after correcting for double-certified forest areas) ([28]). Looking at production forest area, 39% of it is certified ([29]). North America and Europe represent around 85% of certified forests (2017 data). With respect to cotton, the cultivation of organic cotton reduces the emission of greenhouse gases and avoids the use of pesticides, which benefits both the environment and the health of farmers and local communities.

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability* certification

- information requirement on sourcing of raw materials from certified sustainable practices

Biodiversity Effects [2]

Environmental impact: Medium

Wood pulp and man-made cellulose fibre production are both sources of deforestation, soil impoverishment, and can lead to high depletion of natural resources ([4]). The cultivation of cotton, used especially in tampons, is one of the most intensive users of agrochemicals worldwide ([1]). Meanwhile, the extraction and production of plastics may affect biodiversity through impacts such land and ocean occupation and resources consumption. Besides, according to the SUP Directive, AHP are among the top 5 products found at beaches thus causing a negative impact on the habitat of great number of flora and fauna ([2]).

Improvement potential: Low

The implementation of responsible sourcing programmes for materials such as fluff pulp, man-made cellulose fibres, cotton or plastics used in AHP can ensure that the impacts on biodiversity are reduced by protecting highly biodiverse and high carbon stock areas ([1,26]). This is a measure that can be taken up by the industry, as in 2017 65% of the nonwoven industry used sustainability certification as a key element in the decision-making of raw material sourcing ([26]). As stated for *Soil effects*, sustainably-certified forests amounted to 39% of production forest area ([29]), 85% of it being located in Europe or North America. Other measures to lower the impact of AHP to (water) biodiversity is through consumer awareness, by providing information on how to dispose of AHP (no flushing nor littering) ([1]). This aspect is indirectly addressed by the Single Use Plastic Directive, which however applies only to baby diapers (and not to all AHP included in the scope of this fiche).

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability* certification

- information requirement on sourcing of raw materials from certified sustainable practices

Waste Generation & Management [4]

Environmental impact: High

The global production of absorbent hygiene products was estimated at 45 million tonnes in 2019, which can be assumed almost totally converted into waste after one single use ([31]).The waste generation within the EU-28 during 2017 of single-use menstrual products, baby nappies and wet wipes was equivalent to 15.3 kg per inhabitant per year (7.83 million tonnes) representing a 4% of the total residual municipal solid waste (MSW) ([3]). Baby nappies is the predominant group, both in terms of manufacture (average of >5.5 million tonnes per year in the EU28 for 2009-2019) and waste generation (in 2017, 6.73 million; 2.9% of municipal solid waste) ([3]). In any case, the share of AHP in MSW is generally higher for municipalities with a high level of separate waste collection, such as Finland (8.2% of MSW) and Sweden (9.4%) ([16]). These data do not account for manufacturing waste, for which little data could be found: according to ([18]), 30 000 tonnes per minute of industrial AHP waste is generated globally from manufacturing plants. Outside the EU, baby diapers may represent the third largest fraction of MSW, as it is in Malaysia ([23]). As the global AHP market has been growing and is currently forecast to increase by around 6 % per year to 2029([16]), the waste generation can be expected to grow as well.

The End-of-Life (EoL) of AHP is an environmentally impactful LCA stage. AHP are quite complex (a product can be composed of around 16 separate functional components - with different material composition - in a complex engineering system), which makes their recycling challenging ([16]). The hygiene and odour problems add complexity and costs to recycling options ([16]). The predominant EoL for AHP waste streams is incineration or landfilling ([7]), despite AHP include a significant portion of organic materials. In the EU, it is estimated that 87% of AHP is landfilled and 13% incinerated ([17]). Landfilling can occur under controlled (municipal waste; landfills) or uncontrolled conditions (dumping, littering) ([7]), ending in many instances in the marine environment, potentially causing microplastic release. A few emerging technology options for recycling of the cellulose and polymer fractions in AHP do exist in Europe in the Netherlands and in Wales ([16]). AHP normally include a significant share of polymers ([4]), and only a small share of the disposable diapers on the market are biodegradable ([16]). While the so-claimed green AHP available on the market focus on biobased options, a Swedish study found that the amount of biobased carbon, either biobased plastics such as polylactide (PLA) or cellulose, in “green diapers” in Sweden is between 20–53% ([21]). Even in such cases, the full decomposition of such AHP has been questioned, also in the case of industrial composting ([18,19]). In terms of manufacturing waste, the sector reports a raw material efficiency (fibres, polymers and binders) of 92% in 2017, an overall stable performance over the last decade ([26]).

Improvement potential: Medium

ABSORBENT HYGIENE PRODUCTS

In the past 20 years, advances in the construction of AHP have led to their weight dropping by more than 50 %, while simultaneously improving their performance ([18]). Thanks to innovative technologies, it is possible to manufacture a sanitary towel that is 20% thinner than the previous generation ([26]). This may imply that the amount of waste has been reduced, even though the fundamental role played by user behaviour does not allow for a direct correlation. The reduction of waste generation from AHP can be achieved by replacing the use of disposable with reusable products, i.e. modifying consumer patterns in favour of reusable options such as baby nappies made of textiles or reusable menstrual products as the menstrual cup or menstrual underwear ([1]). Nevertheless, waste from the use of disposable AHP is not likely to be avoided as disposables are still mostly used (for example, reusable diapers currently have less than 15 % of current global markets) ([20]). Some diaper companies developed hybrid diaper products by combining both characteristic of cloth and disposable diaper material, which could help in decreasing the high waste generation while conserving the convenience (from a parental point of view) of disposable options ([23]). Circular solutions for disposable AHPs require strict hygienisation, thus leaving recycling as the almost only possibility for circular solution. Technically, recycling of the plastic and cellulose fractions of AHP is possible, but there are very few actual examples for their implementation ([16]). In Italy, about 900 000 tonnes of AHPs end up in landfills and/or incineration plants every year. The first recycling process with an industrial capacity for AHP waste operates in Treviso (Italy) (10 000 tonnes of AHP waste annually). The process involves an autoclave process for sterilising AHPs, which are then separated into individual streams of reusable plastics and a combination of cellulose and superabsorbent polymers, both of which have some, even if currently limited, commercial value. From 500 kg of waste materials and 500 kg of body fluids, the system can recover 350 kg of sterilised cellulose and SAPs and a separate stream of 150 kg of sterilised plastics. The sterilized cellulose can be used as a viscose fibre as well as in applications such as seedbed mats, cat litter and paper, while the superabsorbent polymers can be used in products such as industrial absorbers and pet mats. The sterilised plastics recycled into hard plastic products such as pallets and furniture ([22]). While this process could be replicated in more municipalities and MSs, it should be noted that efficient recycling also requires changes in waste collection systems, i.e., the separate collection of the used AHP, which poses problems due to hygiene and odour issues ([16]) as well as high investments cost ([25]). This was confirmed by a 2019 survey on the circularity of AHP, which however also pointed out to a lack of social acceptance and a lack of markets for secondary materials due to the absence of End of Waste criteria ([22]). According to a report by the EEA ([16]), extended producer responsibility can be an efficient tool to enhance the circularity of AHP ([16]). However, such solutions cannot be implemented within the framework of the ESPR. At this stage, design for recycling measures can play a role so that consumers can separate the parts that can be (effectively) recycled, even if such measures would need to be combined with separate collection or MSW sorting. Content of recycled material is normally not used by the AHP producers due to high safety standards ([1,25]), however future innovative solutions could explore how to make that possible, e.g. in layers of the product not in contact with the skin. For example, recycled PET could be used in AHP, and many nonwovens industries have pledged an uptake of more than 300,000 tonnes of rPET by 2025 ([26]). Currently, one company recycles 7 million PET bottles daily and processes the purified rPET into nonwovens ([26]). For biodegradable AHP, the only example found of a biodegradation process is located in Berlin, where waste diapers, kitchen waste and charcoal are converted into a high-nutrient black fertile soil, although it is possible only for 100% bio-based diapers ([23]). Some examples for novel materials used in biodegradable diapers can be silk, wool, leaves (pineapple, sisal), seeds (cotton, kapok, coir) or grass (bamboo, bagasse) ([25]).

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated

- performance requirement on design for the use of easily recyclable materials or combination of materials

- performance requirement on the maximum number of materials and components used

- performance requirement on safe, easy and non-destructive access to recyclable/compostable components

- performance requirement on the use of component and material coding standards for the identification of components and materials

- performance requirement on minimum recycled content

- information requirement on recycled content

- information requirement on how to disassemble, recycle and dispose of the product (for users and/or treatment facilities)

- information requirement on the coding standards for the identification of components and materials

- information requirement on how to correctly use, store and dispose of the product

- information requirement on maximum amount of waste sent to landfill

Climate Change [2]

Environmental impact: Medium

The use of single-use nappies by an average child (<2.5 years) would result in a global warming potential (GWP) of approximately 550 kg of CO_2 equivalents (circa 3.3 million tonnes of CO_2 equivalents per year in the EU-28) ([8]) while a single year of menstruation for an average menstruating woman amounts to a GWP of 5.3kg of CO_2 equivalents (circa 0.245 million tonnes of CO_2 equivalents per year in the EU-28) ([9]). In fact, climate change was found to be the most relevant impact category regarding the share of the total environmental burdens for baby nappies (26%) while it ranked 2nd for sanitary towels (15%) ([1]).

Improvement potential: Low

Measures listed as BAT could lead to a reduction of GHG emission in baby diaper production while the switch to reusable products would also highly contribute to lower the GHG impact([1]). The sector is engaged in reducing its carbon footprint, and a large portion of the sector sets yearly targets to reduce the carbon footprint, with an average yearly reduction target of 3.3% ([26]). Switching to renewables such as wind, solar or hydro is a way to reduce the carbon footprint of the energy usage. The average proportion of renewable electricity consumed by the nonwoven sector is reported as 31%, a good starting point that can be improved further, as few actors can achieve 100% energy from renewable sources ([26]). Weight reduction per unit production can significantly decrease the CO_2 emissions since around 85% of CO_2 emissions from a finished product come from the raw material production, as opposed to extrusion, conversion and transportation ([26]). Nevertheless, the nonwovens' average weight has been reduced by 17% since 2005 (from ~41 gsm[4] to ~34 gsm[4], average values), suggesting that additional weigh reduction might be challenging ([26]). Despite currently only very few examples are operating at industrial scale, it was found that recycling of AHP can reduce CO_2 emissions by 71% compared to landfill/incineration ([25]).

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint

- performance requirement on minimum share of energy consumption from low carbon sources

- performance requirement on minimum content of sustainable renewable materials

- information requirement on carbon footprint

- information requirement on the share of energy consumption from low carbon sources

- information requirement the content of sustainable renewable materials

Life Cycle Energy consumption [2]

Environmental impact: Medium

The production of AHP is an energy intensive process, namely the manufacturing of precursor materials and the final manufacturing site ([1]).

Improvement potential: Low

Energy efficiency has multiple motivators as the environmental perspectives are often combined with potential financial benefits. In fact, a significant part of the nonwoven industries have set targets to reduce their energy intensity with an average of 2% reduction per year ([26]). Digitalization and intelligent production can enhance productivity and quality, with examples of 15-25% in total energy consumption reduction ([26]).

Potential measures under ESPR:

ABSORBENT HYGIENE PRODUCTS
- performance requirement on maximum level of energy consumption - information requirement on energy consumption
Human Toxicity [1] **Environmental impact: Low** Some studies claimed that hazardous ingredients were detected within AHP (tampons, menstrual pads and baby nappies) ([1, 10]). In any case, it is important to clarify that the presence of some compounds in trace levels does not mean that they present a health risk to consumers, as this is very well regulated in the EU. Chemical traces may come from different sources in the daily environment that may be difficult to track. Moreover, the EU industry's standards with respect to consumer safety are very high ([1]). **Improvement potential: Low** The improvement potential is mainly related to a high degree of monitoring and control during the production phase of AHP in order to minimise hazardous compounds. A specific regulation aligned with voluntary labels could also increase consumer reliability on such products ([1]). **Potential measures under ESPR:** No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts
Material efficiency [1] **Improvement potential: Low** There are studies on novel technologies to recover resources from AHP waste streams (cellulose & plastics, bio-hydrogen and biomass boiler pellets production) ([1,4]). However, recycling still seems unfeasible unless changes occur in current waste management infrastructures and processes ([1]), especially with regards to economic viability ([7]). Improvements could be foreseen if AHP were designed in a modular way, thus making possible to separate recyclable parts from non-recyclable ones ([23]). Furthermore, even if technically feasible, conventional AHP manufacturers do not incorporate recycled material content (open loop) due to low traceability and potential presence of undesired substances. Recycled content materials in AHP could compromise the fitness for use and/or safety of the products ([1, 4]). In the current scenario, recycled content in AHP products is only present in the packaging which is not in direct contact with the final product ([1]), although recycled PET could be used in AHP, and many nonwovens industries have pledged an uptake of more than 300,000 tonnes of rPET by 2025 ([26]). The role of recycled content in AHP may change in the future as the availability of new technologies (e.g. binding recycled content in inner layers of the product not in contact with the user) develops and the properties of recycled materials further improve ([1]). Improvements in material efficiency for AHP can be fostered in terms of recycling of pre-consumer waste generated during AHP production/assembling, and on maximum weight of products to limit resource consumption ([1,18,26]). On the other hand, AHP substitution with alternative reusable products has been suggested as a way of decreasing environmental impacts but this frequently implies a trade-off in different impact categories ([4,7,25]), besides being linked to user behavior. The highest improvement potential is the recyclability of certain sections of used AHP ([4]). **Potential measures under ESPR:** - performance requirement on maximum weight or volume of the product and/or its packaging - performance requirement on maximum product to packaging ratio - performance requirement on lightweight design (e.g. integration of functions within the materials, use of lower density or high-strength materials and hybrid materials) - performance requirement on minimum amount of by-products/process residues/off-specs recovered
Lifetime extension [1]

ABSORBENT HYGIENE PRODUCTS

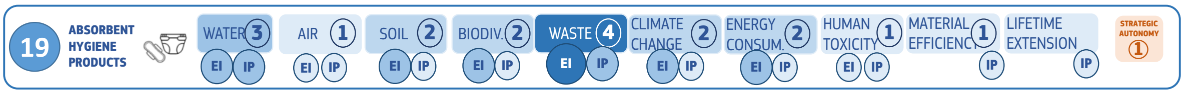
Improvement potential: Low

The lifetime of disposable or single-use AHP cannot be extended. Recycled materials are currently not used in AHP due to sanitary and hygiene reasons, however this may change in the future as new technologies (e.g. binding recycled content in inner layers of the product not in contact with the user) become available and properties of recycled materials further improve ([1]). The improvement potential for lifetime extension of AHP lies in products that are fit for their use and do not lead to sub-optimal performance of products, and on clear guidance for the disposal of the product, in order to avoid waste leakage that escapes municipal waste management and could otherwise be recovered.

Potential measures under ESPR:

- performance requirement on minimum reliability (e.g. resistance to wetting, no leakage due to movements)

Final score [19]



Open Strategic Autonomy score [1]

Policy Gaps

There are no specific regulations on AHP. However, there is a proposal for a CEN Workshop for AHP in relation to test methods for analysing trace chemicals, thus it is an initiative on the chemical safety of AHP.

Several AHP voluntarily apply for the CE mark for medical devices, thus being regulated as such by Regulation (EU) 2017/745 ([13]). However, this Regulation focuses on aspects related to safety rather than environmental ones. The Directive on Single-Use Plastic Products (EU) 2019/904, derived from the Circular Economy Action Plan, mentions and targets AHP specifically because they are single-use plastic products that are in the top 10 marine litter items, imposing labelling requirements on AHP plastic composition but not in relation to performance ([2]). There are other cross-sectorial and non-specific regulations affecting, for example, AHP components (chemicals; REACH 1907/2006/EC); packaging (packaging; Regulation 1272/528/EC) or life-cycle stages (Waste Framework Directive 2019/1004/EC). There are ISO Type I Ecolabels (EU Ecolabel; Nordic Swan and Blue Angel) ([1, 11, 12]) while other pieces of legislation partially regulate AHP indirectly ([2, 13]).

Currently, there is a specific ISO standard under development for menstrual products only (disposable and reusable). The closest applicable standard is ISO/DIS 13485 Medical devices – Quality management systems. National standards can be found for some countries ([14]).

With respect to bio-based components, the Commission has adopted a Regulation to tackle EU-driven deforestation and forest degradation ([30]), which should apply equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market. Nevertheless, environmental sustainability requirements related to e.g. sourcing of the raw material are not included in the deforestation-free products regulation.

Technical circularity potential for single-use plastic AHP is currently limited, given constraints on recycling and recycled content incorporation across the supply-chain. For this type of products, measures on the extraction of raw materials and manufacturing stages could yield the highest environmental improvements. Regulatory options for ESPR to explore could be sustainable* sourcing of materials and design to enable the separation of certain components for recycling. In any case, environmental improvements for this product group largely rely on users' behaviour.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT		Related Union Law	What could be addressed by ESPR
maximum limit of life cycle water consumption	WATER		Industrial Emission Directive	IED covers the production of fluff pulp and viscose, but not other life cycle stages or final AHP production in and outside the EU
maximum level of life cycle emissions to water (e.g. AOX, P, Zn)	WATER		Industrial Emission Directive	IED covers the production of fluff pulp and viscose, but not other life cycle stages or final AHP production in and outside the EU
maximum amount of life cycle waste generated		WASTE	Waste Framework Directive (WFD)-	WFD incentivizes waste prevention but does not have a product-specific approach
maximum weight or volume of the product and/or its packaging		WASTE	-	Full potential of the requirement
use of easily recyclable materials or combination of materials	WATER	WASTE	Waste Framework Directive	WFD sets recycling targets in the EU. But does not have a design approach in and outside the EU
maximum number of materials and components used		WASTE	-	Full potential of the requirement
safe, easy and non-destructive access to recyclable/compostable components		WASTE	-	Full potential of the requirement
use of component and material coding standards for the identification of components and materials		WASTE	-	Full potential of the requirement
minimum recycled content	WATER	WASTE	Packaging and Packaging Waste Regulation	Focuses only on plastic packaging and not on the product. Packaging for AHP is excluded because 'contact sensitive'

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT		Related Union Law	What could be addressed by ESPR
life cycle water consumption	WATER		-	Full potential of the requirement
level of life cycle emissions to water	WATER		-	Full potential of the requirement
recycled content		WASTE	-	Full potential of the requirement
how to disassemble, recycle and dispose of the product (for users and/or treatment facilities)	WATER	WASTE	-	Full potential of the requirement
maximum amount of waste sent to landfill		WASTE	-	Full potential of the requirement
coding standards for the identification of components and materials	WATER	WASTE	-	Full potential of the requirement
how to correctly use, store and dispose of the product	WATER	WASTE	Single Use Plastic Directive	Does not apply to baby diapers or incontinence products

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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Product fiche 2. Bed Mattresses

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

BED MATTRESSES

Scope: Products consisting of a cloth cover that is filled with materials and that can be placed on an existing supporting bed structure or designed for free standing in order to provide a surface to sleep or rest upon for indoor use.

Water Effects [1]

Environmental impact: Low

The effect on water, acidification, is of less importance and is mainly arising from the production of the main core materials (PUR[70] foam, latex foam and steel) ([3]).

Improvement potential: Low

The potential for improvement of bed mattresses lies in the selection of more eco-friendly materials, both in sourcing and production ([5]), tracing the origins of natural rubber and ensuring deforestation-free supply chains to be able to demonstrate that the products are not tainted by deforestation or land grabbing ([7]).

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- information requirement on life cycle water consumption

Air Effects [3]

Environmental impact: Medium

The extractive industry is the main source of air pollutants ([4]). Smog– is mainly associated with emissions of CxHy, SO_2 and NOx from the production of steel, synthetic rubber, PUR foam and cotton ([3]). The manufacturing and extractive industry sector was the principal source of all heavy metal emissions, except nickel, and was responsible for 63% of lead, 55% of cadmium, 44% of mercury, and 36% of arsenic emissions ([4]).

Improvement potential: Medium

The potential for improvement of bed mattresses lies in the selection of more eco-friendly materials, both in sourcing and production and the promotion of best industrial practises ([5]).

Potential measures under ESPR:

- performance requirement on maximum level of life cycle emissions to air
- performance requirement on minimum content of sustainable renewable materials
- information requirement on the level of life cycle emissions to air
- information requirement on content of sustainable renewable materials

[70] Polyurethane

BED MATTRESSES
Soil Effects [1] **Environmental impact:** Low The effect on soil is of lower importance and is mainly arising from the production of the main core materials (PUR foam, latex foam and steel) ([3]). **Improvement potential:** Low The potential for improvement of bed mattresses lies in the selection of more eco-friendly materials, both in sourcing and production ([5]), tracing the origins of natural rubber and ensuring deforestation-free supply chains to be able to demonstrate that the products are not tainted by deforestation or land grabbing ([7]). **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [2] **Environmental impact:** Medium The use of natural latex may appear more environmentally friendly. However, evidence suggests that extending rubber tree plantations to produce natural latex could have negative impacts on local ecosystems, biodiversity and food production ([3]). **Improvement potential:** Low The potential for improvement of bed mattresses lies in the selection of more eco-friendly materials, both in sourcing and production ([5]), tracing the origins of natural rubber and ensuring deforestation-free supply chains to be able to demonstrate that the products are not tainted by deforestation or land grabbing ([7]). **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability certification - information requirement on sourcing of raw materials from certified sustainable practices
Waste Generation & Management [5] **Environmental impact:** High The highest impacts were registered for waste production: this was mostly attributed to disposal of the bed mattress to landfill ([3]). One of the most critical aspects of the life cycle of a mattress is the disposal of the product after its useful lifespan ([5]). In the EU, more than 30 million mattresses annually reach their end of life and it is estimated that 60 % go to landfill and 40 % are incinerated. Assuming an average unit weight of 24 kg, mattresses thus account for more than 700 000 tonnes of waste. ([8]) Up to 95% of the materials in a mattress can be recycled in some way ([3]). At least 85 % of the bed mattresses mass can be readily recycled through simple disassembly ([6]). Recycling end-of-life mattresses reduces landfill disposal ([6]). Approximately one quarter of the weight of discarded mattresses consists of polyurethane ([9,10]). The EU27 mattresses market is forecast to grow from USD 5.87 billion in 2016 to around USD 8.96 billion in 2026 ([11]). the growing healthcare and hospitality sectors and the rising purchasing power of people in Europe which allows them to replace them more frequently than in the past ([12]). **Improvement potential:** High The potential for improvement of bed mattresses lies in reducing the percentage of bed mattresses that end their useful life in landfills and promoting the design for disassembling and recovery of materials ([3]). Reuse options are limited for mattresses due to hygiene concerns and low consumer demand. Some initiatives for refurbishing them have been identified ([1]), but the associated health risks and liabilities remain a major challenge ([8]). Considering a life-cycle approach, requirements on design stage are crucial to ease disassembly, recovery and recycling processes which have a direct impact on reducing the percentage of bed mattresses that end in landfills. A design issue relevant to recycling is the avoidance of hazardous substances,

in order to avoid the contamination of recycling loops by legacy substances. Mattresses may contain carcinogens and other hazardous components, particularly in the PU foam, adhesives and flame retardants. These substances include polybrominated diphenyl ethers (PBDE), formaldehyde, and antimony trioxide, among other ([8]). Especially for multilayer products, design for recycling should consider reversible connections. Layers that are connected to one another should be easily to disassemble – glued connections and composite materials make recycling more difficult ([13]). Two major hotspots that need to be improved are the low quality of the recycled materials arising from mattress recycling, and the current mattress designs preventing easy disassembly ([6]).

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated
- performance requirement on maximum amount of life cycle hazardous waste generated
- performance requirement on safe, easy and non-destructive access to recyclable components
- performance requirement on the use of easily recyclable materials or combination of materials
- performance requirement on minimum recycled content - information requirement on recycled content
- information requirement on how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities)
- information requirement on amount of waste sent to landfill

Climate Change [3]
Environmental impact: Medium

Production of the raw materials (PUR foam, latex foam and steel) have the largest impacts in terms of carbon footprint. Also energy use at storage site and at retail store are to be considered ([3]). Recycling end-of-life mattresses reduces the need for virgin materials to be extracted and therefore decreases greenhouse gas emissions ([6]). It can be observed that recycling rather than landfilling delivers significant environmental benefit, reducing GHG emissions by 45 % ([6]).

Improvement potential: Medium

The potential for improvement of bed mattresses lies in the selection of more eco-friendly materials, both in sourcing and production ([5]), considering the use of recycled materials and also tracing the origins of natural rubber and ensuring deforestation-free supply chains to be able to demonstrate that the products are not tainted by deforestation or land grabbing ([7]). Decreasing the impacts due to the manufacture and the storage of the mattress is another option ([5]).

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- performance requirement on minimum content of sustainable renewable materials
- information requirement on carbon footprint
- information requirement on share of energy consumption from low carbon sources
- information requirement on the content of sustainable renewable materials

Life Cycle Energy consumption [3]
Environmental impact: Medium

Energy use mainly arise from the production of the main core materials: PUR foam, latex foam and Steel. Product delivery and energy use during storage could be significant sources of environmental impacts ([3]). Recycling end-of-life mattresses reduces the need for virgin materials to be extracted and therefore decreases the energy-intensive production of new mattresses or other products ([6]).

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Improvement potential: Medium The potential for improvement of bed mattresses lies in boosting the energy performance (5) and also in the selection of more eco-friendly materials, both in sourcing and production (5), tracing the origins natural rubber and ensuring deforestation-free supply chains to be able to demonstrate that the products are not tainted by deforestation or land grabbing (7). Using sustainable materials like natural latex, organic cotton (that often have lower embodied energy compared to synthetic alternatives) and recycled steel reduces the energy required for raw material extraction and processing. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - information requirement on life cycle energy consumption
Human Toxicity [3] **Environmental impact: Medium** Human toxicity arises from the production of steel, synthetic rubber, PUR foam and cotton. Synthetic mattresses often have fire resistant treatments added to them during manufacture in order to conform to safety standards. PBDEs[71] are frequently mentioned as the most typical treatment, have a toxic effect and are often associated with poor health (3). **Improvement potential: Low** The potential for improvement of bed mattresses lies in the selection of more eco-friendly materials, both in sourcing and production and the promotion of best industrial practises (5). Increasing the proportion of recycled steel (spring mattresses) to 80% significantly reduce toxicity indicators (3). **Potential measures under ESPR:** No measures are envisaged under ESPR for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).
Material efficiency [5] **Improvement potential: High** The bed mattresses industry has significant potential for improvement in terms of lightweight design, product versus packaging ratio, and the recovery of by-products, process residues, and off-spec materials. By adopting lightweight design techniques and innovative materials, manufacturers can reduce the overall weight of mattresses, which decreases transportation emissions and material usage. Optimizing the product versus packaging ratio by using minimal, eco-friendly packaging can further reduce waste and improve sustainability. Enhancing the recovery and reuse of by-products, process residues, and off-spec materials through advanced recycling technologies and circular economy practices can minimize waste and promote resource efficiency **Potential measures under ESPR:** - performance requirement on maximum product to packaging ratio - performance requirement on minimum amount of by-products/process residues/off-specs recovered - information requirement on product to packaging ratio - information requirement on amount of by-products/process residues/off-specs recovered

[71] Polybrominated diphenyl ethers

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Lifetime extension [3]

Improvement potential: Medium

The real life of a mattress can range from less than 10 years, due to hygienic reasons, to 20-35 years (depending on product quality and on user behaviour). Improving the technical performance ensures that an adequate durability of the mattress could be worthy of further consideration ([5]). Design for disassembling and recovery of materials would also extend the lifetime of the resources/materials used in bed mattresses ([3]).

Market analysis shows that global demand for organic mattresses increased by 9.2 % in 2021 over 2020, growing to 1.9 million units. Worldwide sales of organic mattresses are expected to increase at a CAGR of 8.2 % and reach a market value of USD 13.87 billion by the end of 2032 ([8])

Potential measures under ESPR:

- performance requirement on minimum reliability

- performance requirement on availability of information (e.g. maintenance instructions) long after the product is sold

- information requirement on condition for use and maintenance of the product

- information requirement of expected lifetime of the product, and/or on how to substitute/replace the product or its component

- information requirement on resistance to stresses or ageing mechanisms

Final score [28]

Open Strategic Autonomy score: [1]

Policy Gaps

No specific mandatory regulation related to environmental matters is in place for this product group. The environmental impact of bed mattresses is partially covered by Commission Decision 2014/391/EU, establishing the (voluntary) ecological criteria for the award of the EU Ecolabel for bed mattresses, and of the related assessment and verification requirements. The EU Ecolabel is a voluntary scheme to identify the environmental excellence in the market. In addition to that, voluntary Green Public Procurement criteria exist for bed mattresses (within the product group 'Furniture', Commission Staff Working Document 283 final). The Circular Economy Action Plan does not mention directly bed mattresses, but this product group is indirectly affected by the EU Strategy for Sustainable Textiles. With respect to bio-based components, the Commission has adopted a Regulation to tackle EU-driven deforestation and forest degradation, which should apply equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market. Nevertheless, environmental sustainability requirements related to e.g. sourcing of the raw material are not included in the deforestation-free products regulation.

The policy gaps which are not currently regulated are the design for disassembly and recovery of materials and the diversion from landfill ([5]). The potential for improvement of bed mattresses lies in reducing the percentage of bed mattresses that are disposed in landfills and promoting the design for disassembling and recovery of materials ([3]). Mattresses are voluminous, multilayer products made of a diverse and often very complex range of materials. Currently, nearly half of the weight of the 50 million mattresses discarded annually consists of PU foams and aluminium and steel coils and frames. Both PU and metals are valuable materials for which mature recycling technologies are available. Market outlets for mechanically recycled PU are, however, limited. The collection of more mattresses for material recovery, driven by the implementation of EPR schemes and chemical recycling technologies, such as chemolysis for recovering polyols from PU

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foam, would offer a good opportunity for increasing the circularity of a significant and challenging waste product stream ([8]). The hotspots that need to be improved are promoting high quality recycling of the materials arising from waste mattresses, reducing substances that hinder recycling, decreasing the use of virgin fossil-based materials and design for disassembly ([6]).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA							Related Union law	What could be addressed by ESPR
maximum level of life cycle emissions to air	AIR							Industrial Emission Directive	IED covers the production of main materials (steel, plastics), but not other life cycle stages or production outside the EU
minimum content of raw material with sustainability certification				CLIMATE CHANGE				Regulation on deforestation-free products	The Deforestation-free Regulation focuses on wood. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated			WASTE					Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
maximum amount of life cycle hazardous waste generated			WASTE					Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
safe, easy and non-destructive access to recyclable components			WASTE					-	Full potential of the requirement
use of easily recyclable materials or combination of materials	AIR		WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	Waste Framework Directive	WFD sets recycling targets in the EU but does not have a design approach in and outside the EU
minimum recycled content	AIR		WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	-	Full potential of the requirement
maximum level of carbon footprint				CLIMATE CHANGE	ENERGY USE			EU Emission Trading System	EU ETS covers the production of main materials, but not other life cycle stages nor production in non-EU countries
minimum share of energy consumption from low carbon sources				CLIMATE CHANGE				Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA						Related Union law	What could be addressed by ESPR
								labelling but not mandatory requirements
minimum content of sustainable renewable materials	AIR		CLIMATE CHANGE				Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
maximum level of life cycle energy consumption				ENERGY USE			-	Full potential of the requirement
maximum product to packaging ratio		WASTE	CLIMATE CHANGE		MATERIAL EFFICIENCY		-	Full potential of the requirement
minimum amount of by-products/process residues/off-specs recovered		WASTE			MATERIAL EFFICIENCY		-	Full potential of the requirement
minimum reliability (e.g. resistance to stresses)	AIR	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	-	Full potential of the requirement
availability of information long after the product is sold						LIFETIME EXTENTION	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA		Related Union Law	What could be addressed by ESPR
level of life cycle emissions to air	AIR		-	Full potential for the requirement
content of sustainable renewable materials	AIR	CLIMATE CHANGE	-	Full potential for the requirement
sourcing of raw materials from certified sustainable practices		CLIMATE CHANGE	-	Full potential for the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA							Related Union Law	What could be addressed by ESPR
recycled content			WASTE					Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for the product information requirements
how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities.)	AIR		WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement
amount of waste sent to landfill			WASTE					-	Full potential for the requirement
carbon footprint				CLIMATE CHANGE	ENERGY USE			-	Full potential for the requirement
share of energy consumption from low carbon sources				CLIMATE CHANGE				Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
life cycle energy consumption					ENERGY USE			-	Full potential for the requirement
product to packaging ratio						MATERIAL EFFICIENCY		-	Full potential for the requirement
amount of by-products/process residues/off-specs recovered						MATERIAL EFFICIENCY		-	Full potential for the requirement
condition for use and maintenance of the product	AIR		WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement
expected lifetime of the product, and/or on how to substitute/replace the product or its component							LIFETIME EXTENSION	-	Full potential for the requirement
resistance to stresses or ageing mechanisms (reliability)							LIFETIME EXTENSION	-	Full potential for the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

(1) Commission Decision 2014/391/EU of 23 June 2014 establishing the ecological criteria for the award of the EU Ecolabel for bed mattresses.

(2) European ECOLABEL Bed Mattresses. LCA and criteria proposals. Final report for EC. Available at: https://ec.europa.eu/environment/archives/ecolabel/pdf/bed_mattresses/bed_mattresses_report.pdf

(3) EU Eco label for Bed Mattresses. The Greek LCA study - Establishment of ecological criteria. JRC, 2013, Revision of the EU Ecolabel criteria for bed mattresses. Background report and proposal for criteria revision.

(4) Sources and emissions of air pollutants in Europe. EEA 2021

(5) Rapport de synthese PROPILAE (PROjet PILote pour l'Affichage Environnemental) des produits d'ameublement.

(6) Green best practices community. European Commission. Treatment of mattresses for improved recycling of materials.

(7) Mightyearth. European Parliament's vote to include rubber in legislation aimed at ending deforestation in EU supply chains.

(8) Headhache fractions in mixed municipal waste. ETC CE Report 2023/3

(9) Chapman, A. and Bartlett, C., 2012, A Business Case for Mattress Recycling in Scotland - A Business Case for investment in infrastructure, Zero Waste Scotland, Stirling, Scotland.

(10) Recyc Matelas Europe, nd., 'Recyc Matelas Europe Chiffres Clé' (https://recyc-matelas.fr/comprendre-le-recyclage-chiffres-cle.html) accessed 7 September 2022

(11) Bonafide Research & Marketing Pvt. LTD., 2022, 'Europe Mattress Market Outlook, 2027' (https://www.bonafideresearch.com/product/201119933/Europe-Mattress-Market-Outlook) accessed 7 September 2022.

(12) Statista, 2022, 'Mattresses - EU-27' (https://www.statista.com/outlook/cmo/furniture/bedroom-furniture/mattresses/eu-27) accessed 7 September 2022.

(13) Barner, L., Herbst, J., O'Shea, M., Speight, R., Mansfield, K. and Zhanying, Z., 2021, Mattress Recycling - Scoping study, Queensland University of Technology, Brisbane, Queensland, Australia.

(14) Fact.MR, 2022, 'Organic Mattress Market' (https://www.factmr.com/report/organic-mattress-market) accessed 15 September 2022.

Product fiche 3. Cosmetic Products

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

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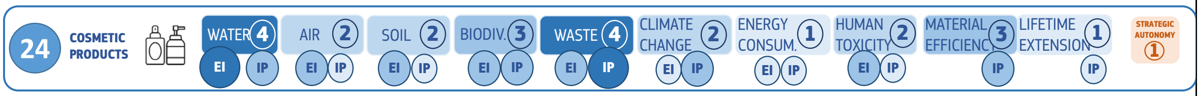

Scope: any substance or mixture falling under the scope of Regulation (EC) No 1223/2009, intended to be placed in contact with the external parts of the human body, or with the teeth and the mucous membranes of the oral cavity, with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition or correcting body odours. Products included are e.g. toilet soaps, shower preparations, shampoos, hair conditioning products, shaving products, deodorants, toothpastes, skin-care products, sunscreens, decorative cosmetics (the list is not exhaustive).

Water Effects [4]

Environmental impact: High

The category Personal Care Products (PCP) includes the compounds used in cosmetic products[72], which are ubiquitous micro-pollutants* of rising concern for the aquatic environment ([1]) and which are among the most commonly detected compounds in surface water throughout the world ([2,3]). These include antimicrobial substances (e.g. triclosan), fragrances (e.g. some musks), preservatives (e.g. parabens) and UV filters ([4]). Some of these substances are small polar molecules , for which waste water treatment plants (WWTP) were not designed to treat, and are therefore, not efficiently removed([8]). The antimicrobials triclosan and triclocarban are persistent and bioaccumulative and are among the top 10 most commonly detected organic waste water compounds in terms of frequency and concentration in some jurisdictions ([5,6,7]). Some fragrances contain harmful phthalates and have been detected in 83–90% of WWTP effluents and in approximately 50% of surface waters ([9]). UV filters[73] enter the environment either indirectly via WWTP effluent or directly from sloughing off while swimming ([9]). Most of them are toxic to the aquatic environment, bioaccumulative or endocrine disruptors (ED) ([8,10,22]), and in some studies have been associated with coral bleaching events ([12]), although other sources do not list cosmetic products as one of the main causes of coral bleaching ([72]). Their occurrence in marine systems is expected to increase considering the increase in populations inhabiting coastal areas (1.2–5.2 billion people by 2080) and expected rise in costal tourism ([11]). The 'forever chemicals' PFAS[74] can occur in cosmetic products, mostly unintentionally via the degradation of other ingredients, contamination from the production processes or via the migration from containers/packaging; however, it was estimated that 1.4% of European cosmetic products, mostly decorative cosmetics, use PFAS as skin conditioning, film forming, solvent and surfactant ([73,74]). No data could be found on the use of PFAS in non-EU cosmetic products. Cosmetics also represent 2% of the global release of primary microplastics to the world oceans ([14]), and in some cases microplastics can make up to 10% of the product weight equalling several thousand microbeads per gram of product ([16]). In addition, water consumption plays a crucial role in all life cycle stages of cosmetic products: from growing raw materials to manufacturing processes (e.g. distillation), equipment cleaning, sanitation and packaging production ([66]). Water is also the main ingredient of all cosmetic products ([15,18]): often, the amount of water is higher than that of other ingredients, accounting for more

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[72] Personal care products (PCPs) are a diverse group of common household substances used for health, beauty and cleaning purposes ([4]).

[73] Either organic (absorb UV radiation, e.g. methylbenzylidene camphor) or inorganic micropigments (reflect UV radiation, e.g. ZnO, TiO_2).

[74] Perfluoroalkyl and Polyfluoroalkyl Substances.

than 2/3 of the volume of a formula ([66]). For example, a regular cream contains from 60 to 80% of water, a lotion up to 90%, and a shower gel or shampoo up to 95% ([66]). Finally, the use phase of rinse-off products was found to contribute to 40-50% of the water use during the product life cycle ([17]).

Improvement potential: Medium

While the regulatory framework in the EU (especially via the Cosmetic Product Regulation ([51]) and REACH ([52])) ensures the protection of human health and the environment from the risks that can be posed by chemicals present in cosmetic products, biodegradable and less toxic ingredients are gaining momentum in the EU ([17, 19]), in conjunction with greener and more sustainable product initiatives from EU businesses. In particular, the green cosmetics market has experienced a 15% annual growth rate ([21]), and product innovations include formulations free from silicones, sulphates, parabens, mineral oils, preservatives and fragrances ([17,19,20]). Triclosan and triclocarban are already restricted in the EU in cosmetic products, and can only be used below a threshold assessed as safe by the SCCS ([64]). Several phthalates are also prohibited from use in cosmetics by the Cosmetics Regulation, as also are several UV filters ([51]). The surfactants can also be selected so that the product is biodegradable: chemicals that degrade rapidly are quickly removed from the environment. While the Cosmetics Regulation does not establish requirements on the biodegradability of cosmetics ingredients, the biodegradability restrictions laid down by the Detergents Regulation are likely to have influenced the composition of cosmetic products, since the raw material suppliers are often the same for cosmetics and detergents. Products are available on the market that are almost fully biodegradable ([17, 20]), also with respect to microplastics: given the availability of alternative biodegradable materials, the European Cosmetic industry association has recommended to their members to discontinue the use of synthetic, solid plastic particles used for exfoliating and cleansing (known as microbeads) in certain applications ([23]), resulting in a 98% reduction in the use of plastic microbeads in rinse-off cosmetics between 2012 and 2017 ([18]). This voluntary initiative has been followed up by legislation, with the recent adoption of Commission Regulation 2023/2055 on synthetic polymer microparticles ([68]), which covers both rinse-off and leave-on cosmetic products. Another potential improvement measure lies in reducing the water use during production of cosmetic products: mapping the water usage along the cosmetics value chain, changes in overflow controls, and changes in the water treatment system can reduce water consumption by 7-65% over the years ([18]). Innovation in ingredients formulation can also lead to decreased water usage during production, and savings of 61-77% were reported ([15]). Refillable packaging can lead to improved sustainability also in terms of water consumption: examples from one company show that transitioning one leave-on cream to refillable packaging achieved savings of 600,000 l of water per year ([63]). Finally, the impacts during the consumer use phase can be tackled by innovative product design that requires less water during use, e.g. concentrated formulas or 'two-in-one products' ([18]), even if the actual benefits are closely linked to consumer behaviour, or no-rinse formulas, which could possibly save 460 l of water per bottle of conditioner ([67]). As regards information requirements, some of the biggest European companies are already joining up to develop a simple A-B-C-D scoring system for cosmetic products in order to enable consumers to make environmentally informed choices ([61,62]). This information, if displayed on all products, could support consumers in making more sustainable choices, since it was estimated that 65% of global consumers care about a reduced water footprint of their products ([63]).

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- performance requirement on maximum level of life cycle emissions to water
- information requirement on life cycle water consumption
- information requirement on the level of life cycle emissions to water
- information requirement on water consumption

Air Effects [2]

Environmental impact: Medium

The main impacts of cosmetics to air is linked to the volatile organic compounds (VOC) content in deodorants, hair products and, to a lower extent, perfumes, which contribute to poor indoor air quality ([25,26]). VOCs are typically used: 1) as solvents for incorporating other ingredients in the formulation; 2) as propellants in

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sprayable products; 3) as preservatives (since various alcohols also support product preservation); 4) as fragrance raw materials in order to create the products' scents. Recent studies on the contribution of cosmetics to the overall VOC emissions could not be found. An old study quantified that cosmetics represented 57% of the use of VOC in aerosol cans produced in Europe ([25]). While this study cannot be seen representative of today's situation, additional sources of VOCs not included in the study are VOCs used as solvents (ethanol, acetone, …) to dissolve components and to make products liquid or applicable, and VOCs used as humectants, preservatives (e.g. phenoxyethanol) or fragrances (e.g. terpenes or limonene). In addition, the study referred to EU conditions, which are expected to be associated with less emissions compared to globally. Finally, the significance of VOC emissions from cosmetics is expected to grow, as historically dominant sources of VOCs like road transport and fuel evaporation decline ([27]). **Improvement potential: Low** VOC emissions from cosmetic products have been discussed in 2011 during the revision of Directive 2004/42/EC (the 'VOC Paints Directive')., but it was concluded that "[…] regulating a very wide range of different products would deliver only modest potential emission reductions and this would come with significant implementation problems, as well as with increased administrative burden and costs". In order to avoid or reduce VOC in cosmetic products, two main alternatives can be taken into consideration. Alternative application packaging may reduce or eliminate the VOC used to extract the product from the can, e.g. via powder, tablets or granulate form ([25]) or via mechanical pump sprays that don't require the presence of pressurised VOCs, provided that they can accommodate formulation requirements without loss of effectiveness or efficacy of the product. Due to given application requirements, in many cases a complete change of the application form is not possible, however this is also linked to market strategies, and formats that have been historically not the norm, such as deodorants in cream or solid form, are now widely available in the market. A second alternative to low or no VOCs is via new formulations, substituting e.g. acetone-based solvents with water- or oil-based formulations, or using glycerine-based humectants (provided that such alternatives do not provide a worse environmental profile), and promoting fragrance-free products ([25]). However, changes in the formulations usually lead to side-effects such as increased need for preservatives due to high-water content or more expensive raw materials due to the absence of fragrances ([25]), suggesting that a more in-depth, life cycle-oriented analysis should be performed. **Potential measures under ESPR:** - performance requirement on maximum level of emissions to air (e.g. VOCs) - information requirement on the level of life cycle emissions to air
Soil Effects [2] **Environmental impact: Medium** Cosmetics and personal care products often rely on natural raw materials and inputs, such as coconut oil, cocoa for cocoa butter and soy for producing glycerine ([63]). The main impacts to soil are driven by land use due to the sourcing of surfactants which, either of bio- or fossil-origin, can make up to 20-40% of the product (for example in shampoos and shower gels) ([17,47]). Bio-based ingredients are becoming a rising trend in the cosmetic market ([31]), with bio-based surfactants originating mainly from palm and coconut oil ([17,24]). However, available studies did not find any scientific evidence for their environmental superiority over fossil alternatives, as the benefits of renewable ingredients depend on the location of their cultivation while they can be offset by the intensive land-use or land-use change impacts ([10,29]). For example, an analysis of the life-cycle impacts of natural glycerine based on Brazilian soybean, natural glycerine based on European soybean, and synthetic glycerin showed that synthetic glycerine performs best in terms of land-use, but worst in terms of climate change and fossil fuel use ([63]). Natural glycerine based on European soybean performs better than its Brazilian counterpart in terms of climate change and fossil use, but relatively worse in terms of land-use ([63]). Thus life-cycle impacts across several parameters should always be assessed and balanced on a case-by-case basis. **Improvement potential: Low**

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The improvement potential for bio-based ingredients lies in clear and ambitious requirements for bio-based products that reduce their impact from a life-cycle perspective ([30]), for example through robust certification schemes for the sourcing of some ingredients ([10,30]). **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability** certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [3] **Environmental impact: Medium** Impacts on biodiversity are mainly due to deforestation caused by the sourcing of some ingredients, especially bio-based ingredients, especially those deriving from palm and coconut oil, soy for producing glycerine ([63]). Between 1972 and 2015, palm oil was responsible for 2–3% of forest loss in Central America and West Africa, 47% in Malaysia, and 16% in Indonesia ([35]), with the latter countries being the major producers of palm oil worldwide. The negative impact is due to the clearing of tropical forests, drainage of peatland, and the use of fire in land clearing and resulting smoke-haze which affects downstream water quality and freshwater species diversity ([35]). Palm oil has been classified as one of the seven commodities linked to the destruction and degradation of forest ([32]), and cosmetic products together with detergents are the second biggest user of palm oil after food, accounting for 18% of global palm oil use ([33]). On the other hand, synthetic ingredients are associated to environmental concerns such as deforestation and resource (petroleum) depletion ([71]). As mentioned for water effects, cosmetics make a relatively small contribution to microplastic discharge, which could negatively affect the aquatic fauna ([14]). **Improvement potential: Medium** As bio-based ingredients are on the rise ([17,31,34]), potential improvement measures lie in strict sustainability requirements for the sourcing of palm and other vegetable oils ([10,30,20]). The recently adopted Deforestation-free Products Regulation establishes that palm oil (and its derivatives and by-products) forcedly would need to be sourced from deforestation-free lands. However, additional requirements could be set on the sourcing of palm oil and palm oil derivatives ingredients used in cosmetic products ([10]). The main and strictest certification scheme to date for palm oil is the Roundtable for Sustainable Palm Oil – RSPO ([36,37]), which represents 41% of the global crude palm oil output ([38]), but many others exist. RSPO-certified products were found to have a 20% lower biodiversity impact than non-certified products ([65]). Requirements over the presence of microplastics and microbeads in cosmetics are not necessary thanks to the recently adopted Regulation 2023/2055 ([68]). Finally, emphasis could be placed on cosmetic products that minimize the use of consumables like cotton buds and discs that are known to place a risk on aquatic fauna or cause problems to waste water treatment plants (e.g. face masks, tonic water, make up remover towels). **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability** certification information requirement on sourcing of raw materials percentage of materials sourced from certified sustainable practices - performance or information requirement on product design to minimize the use of consumables, for selected applications only
Waste Generation & Management [4] **Environmental impact: Medium** The main impacts in terms of waste generation are related to the disposal of cosmetics packaging. The global beauty and personal care industry was estimated to produce around 120 billion units of packaging each year ([63]). While packaging was not identified as an environmental hotspot for rinse-off products, it can represent 20-50% of impacts in many environmental categories for leave-on products ([17]). This is mainly due to the presence of secondary packaging, e.g. a cardboard box around a face cream, which becomes waste right after purchase ([10]). For cosmetic products with a high packaging to formula ratio, manufacture and disposal

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of packaging can account for up to 90% of a product's footprint ([63]). Packaging is mainly made of plastics ([17,39]), whose potential for recycling remains largely unexploited ([40]). Finally, companies report that the amount of waste generated during production is of significant concern ([18]). **Improvement potential: High** The main potential improvement measures lie in the avoidance of secondary packaging, and improving the recyclability of the packaging used, the introduction of recycled content, and the implementation of light-weight and refillable solutions to save on materials ([18]). For this, clear design for recycling measures can be adopted, such as negative lists for combining packaging materials ([10, 42]). Simpler packaging designs (with fewer materials, fewer components, and detachable components) are easier to recycle; however, recyclability is complex: it varies across regions and even between cities ([63]). Cosmetics companies are increasingly using recycled paper and cardboard for packaging, rather than virgin materials ([18]). In any case, measures addressing recycled content and recyclability in plastic packaging have been proposed by the revised Packaging and Packaging Waste Regulation, and therefore fall outside the scope of ESPR ([69]). Several companies have introduced consumer incentives (e.g. free products or vouchers) for returning packaging that can be refilled and/or reused ([18]). A number of companies have introduced refillable packaging in the fields of hair care, lotions/moisturisers, soaps, and perfumes, while some companies are investing in compostable packaging ([18]). In fact, it was estimated that 75% of global consumers seek out refillable/reusable packaging ([63]). However, it must be mentioned that some products cannot be refillable due to risks of bacterial contamination, but also aerosols, which are not refillable according to the EU Aerosol Products Directive for safety reasons. Also, a good packaging design can help consumers avoid wasting or over-using product by creating containers that deliver the correct dosage ([10,63]). Examples of concentrated product formulations demonstrated their potential for saving on materials required for packaging and transport ([18]): savings of 25% on raw materials and of 35% on transport are possible ([41]), although the benefits of these measures are highly dependent on consumer behaviour. In addition, innovative formulations can be developed for consumers to require less resources when using the product, e.g. water, energy, cotton pads, etc. ([63]). To ensure that the minimum amount of packaging is used, some ecolabels use a product-utilisation ratio requirement, as a measure of the mass of packaging over the weight of the product sold, or do not allow secondary packaging to be used (i.e. cardboard boxes over product packaging) ([10,17,20]). This approach could be replicated, with different levels of ambition, for the ESPR. Finishing processes should also be assessed, as some finishing processes for packaging, including several metallization processes, generate high environmental impacts. Their use should be carefully considered during packaging design, e.g. reducing the amount of decorated surface or choosing less impactful finishing processes ([63]). Cutting production waste is also possible: examples of improvement measures are technologies to monitor waste generation and refillable and reusable boxes for transporting ingredients ([18]). Finally, a type of waste that is often overlooked is Point of Sale materials (POSM), i.e. marketing items used to display and/or advertise cosmetic products. Mis-targeted and unused POSM generate large quantities of waste, whose lifetime could be extended both in terms of durability of materials and potential use across multiple campaigns ([63]). **Potential measures under ESPR:** - performance requirement on maximum amount of life cycle waste generated - performance requirement on refillable packaging - performance requirement on the availability of refills - performance requirement on the maximum amount of product remaining in the packaging - performance requirement on the restriction of secondary packaging*** (for selected products only) - information requirement on the amount of life cycle waste sent to landfill - information requirement on the percentage of recycled content in product packaging information requirement on how to correctly dose the product to avoid overdosage
Climate Change [2] **Environmental impact: Low**

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Climate change impacts of cosmetic products are mainly linked to the energy use at production sites and the energy needed to heat the water in the use phase ([17,18]), but also CO_2 emissions linked to deforestation and land-use change e.g. to cultivate oil palm trees ([35]). Initial, high-level estimates place the cosmetic industry's contribution to global GHG emissions anywhere between 0.5% to 1.5%, even though this estimation should be considered with caution as it is based on a limited number of companies (2020 estimate) ([63]). **Improvement potential: Medium** The main potential improvement measure to reduce CO_2 emissions from the production of cosmetics is to switch to renewable sources of energy and energy efficiency measures ([18]), with some major players in the sector pledging to reach net zero emissions by 2040 ([44]). Energy savings could be achieved via production plant design, e.g. highly effective ventilation systems, ventilated exterior wall cladding, using LED lighting, making the most of natural daylight by installing solar tubes or combining natural climate control systems with heat recovery ([18]). Additional savings could be obtained through packaging design. For example, it was estimated that if refillable designs and models were to be applied to all bottles in home cleaning products as well as beauty and personal care, packaging and transport savings would represent an 80–85% reduction in GHG emissions compared to today's single-use bottles ([43]), while concentrated products could cut the need for transportation, and thus related GHG emissions, by 35% ([41]). Finally, the mode of transport can also play a role, as switching from trucks to intermodal rail transport could save 1 200 tonnes CO_2 emissions/year ([45]). With regards to information requirements, some European companies are already joining up to develop a simple A-B-C-D scoring system for cosmetic products in order to enable consumers to make environmentally informed choices ([61,62]). This information, if displayed on all products, could enable more informed consumer choices, since it was estimated that 69% of global consumers are influenced by a reduced carbon footprint of their products ([63]). **Potential measures under ESPR:** - performance requirement on maximum level of carbon footprint - performance requirement on minim energy consumption from low-carbon energy sources - performance requirement on minimum content of sustainable renewable materials - information requirement on carbon footprint - information requirement on the share of energy consumption from low carbon sources - information requirement the content of sustainable renewable materials
Life Cycle Energy consumption [1] **Environmental impact: Low** Energy use at production sites can be high for some ingredients and some cosmetic products ([46]). For rinse-off products, the energy needed to heat the water in the use phase can be the main contribution in almost all impact categories ([47]). **Improvement potential: Low** Energy savings during production could be achieved via energy efficient production equipment and adaptation of production methods, together with improved design of production installations, e.g. highly effective ventilation systems, ventilated exterior wall cladding, using LED lighting, making the most of natural daylight by installing solar tubes or combining natural climate control systems with heat recovery ([18]). The use of recycled material in packaging would also result in energy savings ([43]). However, no measures are envisaged for the energy consumption during the use phase, given the high dependency to local climate conditions. **Potential measures under ESPR:** - performance requirement on maximum life cycle energy consumption - information requirement on the life cycle energy consumption
Human Toxicity [2]

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Environmental impact: Medium Personal care products emit volatile organic compounds, including alcohols and fragrance compounds, which are potentially harmful if inhaled in large amounts ([26]). Facially applied personal care products, such as moisturisers, have the potential to deliver enhanced VOC doses via inhalation due to the close proximity of the nose and mouth to the emission source ([26]). Micro- and nano-plastic particles originating from use of cosmetic products (representing 2% of the global release of primary microplastics ([14])) cannot be captured by most WWTP and, once in the sea, organic contaminants (eg PCBs) may be adsorbed to them. Once they enter the food chain of fish and birds, microplastics may pass on to humans ([16]). However, while plastic particles have been found in human blood ([49]), there are no published data indicating the transfer of chemicals to humans from ingested plastic, other than trace quantities of phthalates, as well as clear conclusions on the extent of the effects to human health ([16]). **Improvement potential: Low** Some alternatives are available for chemicals that are less toxic to humans, as demonstrated by the strict chemical requirements in some European ecolabels ([10,20]). With respect to VOCs, it was found that products marketed as “green” generally emit the same volatile compounds as regular products, and at comparable emission rates ([26]). New formulations or alternative application methods can significantly reduce the amount of VOC emissions ([25]). **Potential measures under ESPR:** No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.
Material efficiency [3] **Improvement potential: Medium** The main improvement potential for cosmetics to save on materials lies in the recyclability of the packaging used, the introduction of recycled content, and the implementation of light-weight and refillable solutions without jeopardising consumer safety. Recyclability of packaging and inclusion of recycled material content is especially important, as its potential is still largely untapped. Companies have already committed to 100% recyclable, reusable or compostable plastic packaging, and a minimum of 20-50% by volume of recycled plastic materials by 2025 ([50]). The savings brought by refillable solutions are almost fully unexploited ([43]). Finally, significant savings can be obtained by measures banning secondary packaging ([10]). **Potential measures under ESPR:** - performance requirement on maximum weight or volume of the product and/or its packaging - performance requirement on maximum product to packaging ratio - performance requirement on lightweight design (e.g. use of lower density or high-strength materials) - information requirement on maximum product to packaging ratio
Lifetime extension [1] **Improvement potential: Low** The improvement potential of lifetime extension for cosmetics is low, and mostly linked to user behaviour. Clear indications on dosage requirements could help inform consumers on using the products sparingly ([10]), although this is already required by the Cosmetics Product Regulation. Cosmetic products based on natural ingredients may have a short shelf life, which cannot be increased without introducing preservatives ([17]). Improvement potential also exists with respect to standardised components for spare parts availability, e.g. droppers and sprayers with standardised inlet so that this can be substituted if it gets broken, but also design of the packaging that releases only the dosage that is needed for the use of the product, thus avoiding overconsumption. **Potential measures under ESPR:**

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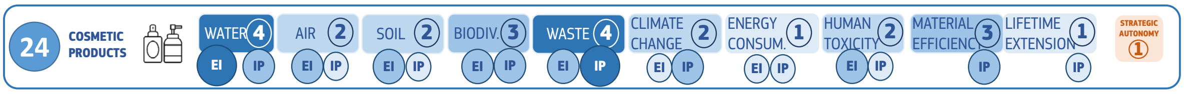
- performance requirement on minimum reliability (e.g. guaranteed efficiency) - performance requirement on availability and affordability of spare parts - performance requirement on the characteristics and availability of consumables needed for proper use - performance requirement on the use of standard components - information requirement on how to correctly dose, use and dispose of the product (if applicable
Final score [24]



Open Strategic Autonomy score [1]

Policy Gaps

The Cosmetics Products Regulation ([51]) ensures the highest safety of cosmetic products placed on the EU market by providing strict safety requirements for protecting human health, simplifying procedures for companies and regulatory authorities in the sector, updating the rules to take account of the latest technical and scientific developments, including the possible use of nanomaterials, and banning animal testing[75]. The Regulation also includes lists of substances which are prohibited, restricted or authorised for use in cosmetics, as well as the mandatory information that should appear on the cosmetic product label or packaging, such as the name and the address of the responsible person, the contents, precautions for use and the list of ingredients. The REACH ([52]) regulation ensures the protection of the environment from the risks that can be posed by chemicals, and applies also to cosmetic ingredients; however, protection to human health is regulated via the Cosmetic Products Regulation (and not via REACH). Ingredients of cosmetic products need to comply with the Classification, Labelling and Packaging (CLP) Regulation ([53]), which lays down rules on how to determine whether a substance or mixture displays properties that lead to a classification as hazardous, as the starting point for hazard communication, now also including hazard classes for endocrine disruptors and PMT/vPvB. However, cosmetic products in their finished state are not regulated by the CLP Regulation. Cosmetic ingredients are also subject to the recently adopted Regulation 2023/1115 tackling EU-driven deforestation and forest degradation ([54]), which applies to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market (this is of high relevance for palm oil and its derivative, extensively used in cosmetic products). Cosmetic ingredients are also subject to the ABS Regulation ([70]), which brings the EU in line with the international commitments to contribute to the conservation of biological diversity and the sustainable use of its components. Finally, Regulation 655/2013 ([59]) regulates the use and justification of claims used in cosmetic products.

Given the extensive regulatory framework for chemicals' safety, ESPR measures would likely not target such area. The improvement potential for ESPR lies in performance requirement for maximum levels of life cycle water, air emissions and energy consumption, depending on the product category. Moreover, measures related to soil and biodiversity impacts could lie in mandatory sustainability** certifications for the sourcing of bio-based materials. Finally, to minimize waste generation of packaging, ESPR measures could lie in banning secondary packaging*** and implementing mandatory refilling options. Measures on recycled content and recyclability of the packaging are not in the scope of ESPR, as these are expected to be addressed by the recently proposed Packaging and Packaging Waste Regulation.

[75] Animal testing is banned in cosmetics since 2013.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT					Related Union Law	What could be addressed by ESPR
maximum limit of life cycle water consumption	WATER					Industrial Emission Directive	IED covers the production of chemical ingredients, but not cosmetic products, other life cycle stages or production outside the EU
maximum level of life cycle emissions to water	WATER					Industrial Emission Directive	IED covers the production of chemical ingredients, but not cosmetic products, other life cycle stages or production outside the EU
minimum content of raw material with sustainability certification		BIODIVERSITY				Regulation on deforestation-free products	The Deforestation-free Regulation only covers addresses wood, rubber, cattle, coffee, cocoa, palm oil and soy. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated			WASTE			Waste Framework Directive	WFD incentivizes waste prevention but does not have a product-specific approach
refillable packaging and availability of refills	WATER		WASTE	CLIMATE CHANGE	MAT EFF.	Packaging and Packaging Waste Regulation	PPWR incentivises refill, but does not set mandatory obligations to offer refill solutions
maximum amount of product remaining in the packaging			WASTE		MAT EFF.	-	Full potential of the requirement
restriction of secondary packaging	WATER	BIODIVERSITY	WASTE	CLIMATE CHANGE	MAT EFF.	-	Full potential of the requirement
maximum level of carbon footprint		BIODIVERSITY		CLIMATE CHANGE		Emission Trading System	ETS covers the production of some chemical ingredients (acids and bulk organic chemicals), but not cosmetic products, other life cycle stages or production outside the EU

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT				Related Union Law	What could be addressed by ESPR
minimum share of energy consumption from low carbon sources			CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product-specific and does not address production outside the EU. It includes voluntary labelling, but not mandatory requirements
minimum content of sustainable renewable materials	BIODIVERSITY		CLIMATE CHANGE		Renewable Energy Directive II	RED II sets sustainability requirements for biomass but not mandatory minimum use of renewable materials
maximum weight or volume of the product and/or its packaging		WASTE		MAT EFF.	-	Full potential of the requirement
maximum product to packaging ratio		WASTE	CLIMATE CHANGE	MAT EFF.	-	Full potential of the requirement
lightweight design (e.g. use of lower density or high-strength materials)		WASTE		MAT EFF.	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT			Related Union Law	What could be addressed by ESPR
life cycle water consumption	WATER			-	Full potential of the requirement
life cycle emissions to water	WATER			-	Full potential of the requirement
sourcing of raw materials from certified sustainable practices		BIODIVERSITY		-	Full potential of the requirement
amount of life cycle waste sent to landfill			WASTE	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT	Related Union Law	What could be addressed by ESPR
recycled content in product packaging	WASTE	Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for information requirements
carbon footprint	CLIMATE CHANGE	-	Full potential of the requirement
share of energy consumption from low carbon sources	CLIMATE CHANGE	Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
content of sustainable renewable materials	CLIMATE CHANGE	-	Full potential of the requirement
maximum product to packaging ratio	MAT. EFF	-	Full potential of the requirement

Additional notes and list of references

* Micro-pollutants are defined as anthropogenic chemicals that occur in the (aquatic) environment well above a (potential) natural background level due to human activities but with concentrations remaining at trace levels (i.e. up to the microgram per litre range) ([60])

** please note that in this context 'sustainable' does not include the social dimension

*** 'secondary packaging' means packaging which can be removed from the product without affecting its characteristics, e.g. a cardboard box around a plastic bottle.

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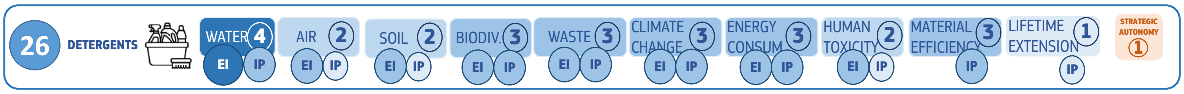
[74] European Chemicals Agency, 2023, Annex to the ANNEX XV RESTRICTION REPORT - PROPOSAL FOR A RESTRICTION for Per- and polyfluoroalkyl substances (PFASs)

Product fiche 4. Detergent Products

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

DETERGENT PRODUCTS



Scope: Any substance and mixture falling under the scope of the Detergents Product Regulation. Products included are (non-exhaustive list): laundry detergents, dishwasher detergents, hard surface cleaning products (i.e. all purpose cleaners, kitchen cleaners, window cleaners, sanitary cleaners), softeners/fabric enhancers, hand dishwashing detergents.

Water Effects [4]

Environmental impact: High

The category Personal Care Products (PCP) includes the compounds used in detergent products[76], which are ubiquitous micro-contaminants of rising concern for the aquatic environment ([1]), and are among the most commonly detected compounds in surface water throughout the world ([2,3]). These include fragrances (e.g. musks), preservatives (e.g. parabens, isothiazolinones). Some detergents are also disinfectants, containing a biocidal active substance such as triclosan[77]. Some fragrances have been detected in 83–90% of WWTP[78] effluents and approximately 50% of surface waters ([8]). Biocides show a combination of high toxicity, poor degradability and bioaccumulation ([9]). In many countries, households are the main point sources of nutrients discharge, causing eutrophication, and detergents accounted for approximately one third of the phosphorus in global sewage influents worldwide in 2010 ([10]). The 'forever chemicals' PFAS[79] can be used in detergents, as components of surfactants, such as in formulations and spray ([11,78]). However, their use in the EU is estimated by ECHA to be in the order of 21-30 tonnes per year in consumer mixtures (which includes also antifog agents, not considered with the scope of this product group), thereby suggesting that the use of PFAS is not the norm in the detergents market ([59]). In the EU, PFAS have been recently tackled by a restriction proposal that may result in a ban of the manufacture, use and placing on the EU market of around 10 000 PFAS ([77]), therefore leaving PFAS outside the ESPR scope. Finally, detergents make a relatively small contribution to microplastics discharge ([12]), whose addition to the product formulation is addressed by the recent restriction adopted within the framework of REACH ([60]).

Improvement potential: Medium

While the regulatory framework in the EU (especially via the Detergent Products Regulation ([44]), REACH ([46]) and CLP ([47])) ensures the protection of human health and the environment from the risks that can be posed by chemicals present in detergents, biodegradable and less toxic alternatives are gaining momentum in the EU ([9]). For example, the concentration of phosphate in detergent products has decreased drastically in the last two decades ([58]), and manufacturers have been producing phosphate-free laundry and dishwasher detergents since 2013 ([13,16,22]). Fragrance-free products are also available ([9]). The use of biocides such as triclosan in detergents are regulated in the EU under the Biocidal Products Regulation, which ensures high levels

[76] Personal care products (PCPs) are a diverse group of common household substances used for health, beauty and cleaning purposes (**4**).

[77] Triclosan is persistent and bioaccumulative and is among the top 10 most commonly detected organic waste water compounds in terms of frequency and concentration ([5,6,7]).

[78] Waste water treatment plants.

[79] Perfluoroalkyl and Polyfluoroalkyl Substances.

DETERGENT PRODUCTS
of protection of human and animal health, and of the environment ([73]). Surfactants used in detergents in the EU are subject to strict biodegradability requirements since 2005 ([44]): chemicals that degrade rapidly are quickly removed from the environment. Eco-friendly products can be found that are almost fully biodegradable ([19,20,21,22]), and the biodegradability aspect of detergents in the EU is addressed by the Detergent Regulation, including its revised proposal, and therefore falls outside the scope of the ESPR. In relation to fabric softeners, recent research efforts have focused on reducing the concentration of surfactants in softener formulations to mitigate their environmental impact ([68]). Studies have demonstrated the possibility of halving the concentration of cationic surfactants while maintaining the overall physicochemical properties and performance of the formulations ([69]). Another way to reduce the chemical load to the environment is indirectly, via a lower or correct dosage. For example, reducing the dosage by 20% brings environmental savings for terrestrial ecotoxicity (19%) and freshwater ecotoxicity (15%) ([9,18]). Given the importance of this aspect, mandatory dosage instructions are being set by the Detergents Regulation for consumer laundry and consumer automatic dishwasher detergents, so that the scope of ESPR on this topic is still to be seen. Moreover, companies offer monodose solutions (e.g. capsules), and their design is of utmost importance to avoid microplastics discharge ([14]), and biodegradable film options exist ([38]). Water use during the production phase can also be reduced: for example, some brands claim to have reduced, in recent years, the water used per unit of production by 27% ([24]). Furthermore, the major impacts during the consumer use phase can be tackled by innovative product designs that require less water during use, e.g. concentrated formulas ([9]). Liquid detergent products can contain 81-84% by weight of water ([36]), a scarce resource whose use can be optimised in detergents via more concentrated products, accompanied by clear dosage instructions. No data could be found with respect to the improvement potential for water consumption during manufacturing of the products. While it is expected that solutions like mapping the water usage along the value chain, changes in overflow controls, and changes in the water treatment system can reduce water consumption during manufacturing of detergents, it is recommended to look at this aspect more in depth. **Potential measures under ESPR:** - performance requirement on maximum limit of life cycle water consumption - performance requirement on maximum level of life cycle emissions to water - performance requirement on maximum limit of microplastics release - information requirement on life cycle water consumption - information requirement on the level of life cycle emissions to water - information requirement on the possible release of non-biodegradable microplastics
Air Effects [2] **Environmental impact: Medium** VOC, which are used for aerosol, solvent, preservation, fragrance and disinfection properties, can constitute up to 30% of the formulation of detergent products (e.g. for glass cleaners), but normally do not exceed 10% of the formulation of the product (e.g. for bathroom and WC cleaners and for floor cleaners), and they significantly affect indoor air quality ([42,57]). The content of VOC is also linked to the product form (solid or liquid) ([42]). While it is reasonable to expect that VOC emissions have decreased recently, their significance may grow as historically dominant sources of VOCs like road transport and fuel evaporation decline ([82]). Dust can also be an issue during the production of powder detergent, potentially affecting indoor air quality in manufacturing sites. Other impacts to air of detergents occur during the transport phase, which has impacts in terms of ozone depletion due to the use of fossil fuels, and during the use phase, especially for laundry detergents and dishwasher detergents, with impacts in terms of particle matter and ozone depletion due to the energy use ([9]). Moreover, particulate matter formation also occurs during the production of the plastic packaging for detergents ([15]). **Improvement potential: Low** In order to avoid or reduce VOC in detergents, two main alternatives can be taken into consideration. Alternative application packaging may reduce or eliminate the VOCs used to extract the product from the can, e.g. via powder, tablets or paste form ([57]). Due to given application requirements, in many cases a complete change of the application form is not possible; however, this is also linked to market strategies. A second

alternative to low or no VOC is via new formulations, e.g. using low- or no-VOC solvents, avoiding high-VOC fragrances such as terpene or not using VOC for preserving functions ([57]). Air impacts can be reduced indirectly via reducing the use of energy during the use phase ([16]) and via innovative packaging that is lightweight and refillable. For example, some ecolabels use a weight-utility ratio as a measure of the mass of packaging used to deliver the reference dosage for a detergent, in order to limit the amount of packaging produced and used and, indirectly, also the transport ([19,20,21]). While the Packaging and Packaging Waste Regulation sets measure to incentivise the use of refillable packaging, it does not set mandatory obligations for the availability of refills.

Potential measures under ESPR:

- performance requirement on maximum level of life cycle emissions to air

- information requirement on the level of life cycle emissions to air

Soil Effects [2]

Environmental impact: Medium

The shift towards the use of bio-based surfactants is a relevant trend to consider, since they are normally believed to have lower environmental impacts than their fossil-based counterpart ([15,23,54]). Surfactants, either of bio- or fossil-origin, can represent 30% of the product (e.g. 15-40% in laundry detergents) ([16]). Bio-based surfactants originate mainly from palm and coconut oil ([15,25]), and can be used as complete or partial substitutes for chemical surfactants and generally exhibit similar or even superior characteristics, especially at lower temperatures ([74]).However, the main impacts to soil associated with bio-based surfactants are driven by natural land transformation and agricultural land occupation due to their sourcing ([15]). Moreover, available studies did not find any scientific evidence for their environmentally superiority over fossil alternatives, as the benefits from renewable ingredients can be offset by the intensive land-use or land-use change, often in South-East Asia ([15,25,26]), especially without robust sustainability criteria being enforced. On the other hand, synthetic surfactants are associated to environmental concerns such as deforestation and resource (petroleum) depletion ([67]).

Improvement potential: Low

As bio-based chemicals are on the rise ([15,23,54]), the improvement potential lies in clear and ambitious requirements for bio-based products that reduce their impact from a life-cycle perspective([27]), for example through certification schemes or organic farming ([28]) that preserve and improve soil quality via management practices and principles.

Potential measures under ESPR:

- performance requirement on minimum content on raw material with sustainability* certification (for selected ingredients only)

- information requirement on sourcing of raw materials from certified sustainable practices

Biodiversity Effects [3]

Environmental impact: Medium

Biodiversity impacts incurred by detergents are mainly related to deforestation and land-use change caused by the sourcing of certain palm or coconut oil-derived ingredients, especially surfactants (which can represent 30% of the product ([16])). Between 1972 and 2015, palm oil has been responsible for 2–3% of forest loss in Central America and West Africa, 47% in Malaysia, and 16% in Indonesia ([29]). The negative impact of palm cultivation is due to the clearing of tropical forests, drainage of peatland, and the use of fire in land clearing and resulting smoke-haze which affects downstream water quality and freshwater species diversity ([29]). Palm oil has been classified as the first of seven commodities linked to EU-driven deforestation (34%) ([30]). Detergent products and cosmetics are estimated to represent 18% of the global use of palm oil ([31]). As mentioned for water effects, detergents make a relatively small contribution to microplastics discharge, which could negatively affect the aquatic fauna ([12]).

Improvement potential: Medium

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As bio-based ingredients are on the rise ([15,23,54]), potential improvement measures lie in strict sustainability requirements for the sourcing of palm and other vegetable oils ([19,20,21]). The recently adopted Deforestation-free products regulation establishes that palm oil (and its derivatives and by-products) forcedly would need to be sourced from deforestation-free lands. However, there are additional sustainability requirements that could be set on the sourcing of palm oil and palm oil derivatives and other bio-based ingredients used in detergent products ([9]). The main and strictest certification scheme to date for palm oil is the Roundtable for Sustainable Palm Oil – RSPO ([32,33]), which represents 41% of the global crude palm oil output ([34]). RSPO-certified products were found to have a 20% lower biodiversity impact than non-certified products ([61]). There are currently brands on the market that have included 100% RSPO-certified ingredients in their products ([24]). **Potential measures under ESPR:** - performance requirement on minimum content of raw materials with sustainability* certification - information requirement on minimum content of raw materials with sustainability* certification
Waste Generation & Management [3] **Environmental impact: Medium** The main impacts in terms of waste generation are related to the disposal of the detergents packaging. Packaging represents up to 65% of a product's environmental impacts, depending on the detergent product, packaging and environmental impact considered ([15]). Packaging is mainly made of plastics ([9,15,16,17,18,36]), whose potential for recycling remains largely unexploited ([37]). Finally, company reports suggest that in some cases waste generation during production has increased by 51% in recent years ([38]). **Improvement potential: Medium** The main potential improvement measures lie in the recyclability of the packaging used, the introduction of recycled content, and the implementation of lightweight and refillable solutions. In terms of recyclability and recycled content, many companies[80] have committed to ambitious results: 100% plastic packaging being recyclable, reusable or compostable, and a minimum of 20% by volume of recycled plastic materials by 2025 ([38]). In 2021, the recycled plastic packaging ratio was ~14% as an average over 900 companies, while the ratio of recyclable plastic packaging was ~82% ([38]). However, no standards exist at the moment for the definition of recyclable packaging. Other companies reported having doubled their use of recycled materials in packaging compared to 2010, and seek to source 50% of the plastic packaging materials from secondary sources ([24]), while the Circular Plastics Alliance[81] committed to increase the use of recycled plastics in EU products to 10 million tonnes by 2025 ([52]). In any case, measures addressing recycled content and recyclability in plastic packaging have been proposed by the recently adopted Packaging and Packaging Waste Regulationand therefore fall outside the scope of ESPR. Another aspect is the potential packaging minimisation via concentrated formulations, and available studies reported that detergents in concentrated form would cut down the energy and materials required for packaging, production and transport ([15,35]): 2x, 4x, and even 8x concentrated products can be found on the market, although the benefits of these measures are highly dependent on consumer behaviour ([9]). To ensure that only the minimum amount of packaging is used, some ecolabels use a weight-utility ratio requirement, as a measure of the mass of packaging used to deliver the reference dosage for a detergent ([19,20,21]). This approach could be replicated, with a different level of ambition, for the ESPR. Refillable options are available on the market, and currently represent 2% of the market, with a potential of 2% annual growth for the next decade ([83]). Refillable options may include empty packages that are brought to and refilled at refill stations, or the sale of products packed in less intensive packages that can be transferred by the consumer into the original (empty) packaging. In any case, it must be mentioned that for some detergent product categories, legislative or regulatory provisions prohibit reuse due to health

[80] A.I.S.E., the International Association for Soaps, Detergents and Maintenance Products, represents over 900 companies supplying household and professional cleaning products and services across Europe.

[81] The Circular Plastics Alliance (CPA) was launched with the support of the European Commission in 2018 as a voluntary platform to deliver on the circular economy for plastics

or safety requirements of the consumer. Aerosols, for example, are not refillable according to the EU Aerosol Products Directive for safety reasons. In any case, it is expected that the refill of detergents will be dealt with in the context of the revision of the Detergents Regulation and the CLP Regulation; the room for measures to be set under ESPR is therefore still to be seen.

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated
- performance requirement on refillable packaging and availability of refills
- information requirement on how to correctly use, store (focus on dosing) and dispose the product (to the extent that this aspect will not be covered by the revised Detergents Regulation)
- information requirement on recycled content in product packaging
- information requirement on maximum amount of life cycle waste sent to landfill

Climate Change [3]

Environmental impact: Medium

Climate change has been identified as one of the most relevant impact categories for detergent products. This is due mainly to the energy needed to heat the water in the use phase, and to a lower extent to the manufacture of the product, packaging, and transportation ([15,35]). It was estimated that 85% of the amount of carbon needed annually for the production of chemicals and derived products (including detergents) is generated from fossil fuel-based resources, 10 % by biomass and only 5 % by recycling ([63]), although it was not possible to retrieve the extent of the contribution of detergent products. In addition, CO_2 emissions also occur due to land transformation, which induces carbon losses (in this case expressed as CO_2 emmissions), especially when converting to intensive agricultural uses (as palm oil cultivation) being the magnitude dependent on the previous status or condition of the transformed land (e.g. greater impact in peat-like soils than in extensively exploited lands) ([27,75]). This is important to be mentioned, since palm oil and palm oil derivatives are an important ingredient in detergents.

Improvement potential: Medium

The main potential CO_2 emission improvement measure directly related to detergents during their use phase is product innovation for a cleaning efficiency at lower temperatures, so that no/less energy is needed to heat up the water ([40]). It was estimated that cold-wash laundry from two brands have helped save 15 million tons of CO_2 ([40]). Additional savings could be obtained through packaging design. For example, it was estimated that if refillable designs and models were to be applied to all bottles in home cleaning products as well as beauty and personal care, packaging and transport savings would represent an 80–85% reduction in GHG emissions compared to today's single-use bottles ([39]). With respect to emissions during production, the Charter for Sustainable Cleaning, which covers ~90% of detergents production output in Europe, reported a 42% reduction of CO_2 emissions during production since 2005 ([62]). Further improvement potential exists, as some companies pledge to reach net zero emissions by 2040 ([24,38,40]). To reduce the dependency on fossil fuels during production of chemicals (in general, but also including chemicals used in detergent products), three sources of renewable carbon have been identified that can substitute the utilisation of fossil carbon that is extracted from the ground: biomass, recycling, and Carbon Capture and Utilisation (captured CO_2, from industrial processes or the atmosphere) ([63]). It was estimated that with these three renewable carbon sources combined, it should be possible to maintain current production intensity without the need for any additional fossil carbon ([63]). To foster these sources in detergents production, policy options include direct financial incentives, comprehensive carbon management strategies and supporting market access for products based on renewable carbon, among others ([63]); however, these fall outside the scope of action of ESPR, which could nevertheless focus on minimum share of energy from low carbon sources and minimum content of renewable ingredients. In any case, it should be also considered that as the EU energy grid decarbonises (reaching at least 42.5% of renewables by 2030), the GHG impact of the use phase will also decrease, making the impact of raw materials and the design of detergents and their raw materials (chemicals) a bigger contributor to the overall carbon footprint ([64]).

Potential measures under ESPR:

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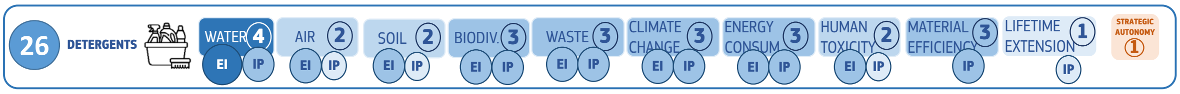
- performance requirement on maximum level of carbon footprint - performance requirement on minim share of energy consumption from low-carbon energy sources - performance requirement on minimum content of sustainable renewable materials - information requirement on carbon footprint - information requirement on the share of energy consumption from low-carbon energy sources - information requirement on the content of sustainable renewable materials
Life Cycle Energy consumption [3] **Environmental impact: Medium** For some detergents, the use phase (washing) accounts for 60-90% of the carbon footprint, linked to the temperature used for washing ([70]). For this reason, fossil fuel depletion has been identified as the main hotspot throughout the life cycle of some detergent products, due to the energy use during the use ([24]). **Improvement potential: Medium** The main potential improvement measure directly related to detergents to reduce energy use during the use phase is product innovations for a cleaning efficiency at lower temperatures, so that no/less energy is needed to heat up the water ([40]). It was estimated that a reduction of the average wash temperature by 3 °C in five investigated countries (Belgium, France, Denmark, Italy and the UK) could reduce the energy consumption for laundry washing by 1 300 GWh/yr, corresponding to the electricity consumption of a city of more than 180 000 inhabitants in a year ([41]). However, it is important to stress that consumer behaviour plays a key role in decreasing the energy consumption during the use phase (temperature of washing, load of washing, frequency of washing, etc.), and can neutralise the potential benefits. Some improvement potential also lies at the production site, as some companies reported having reduced energy use per unit of production by 19% since 2010 ([24]). A report estimated that the energy use of 900 EU companies was reduced in 2020 by 50% compared to 2005 use ([38]). **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - performance requirement on efficiency of the product at low energy consumption - information requirement on life cycle energy consumption - information requirement on the efficiency of the product at low energy consumption
Human Toxicity [2] **Environmental impact: Medium** Globally, detergents can contain endocrine disrupting (ED) substances, and other compounds with carcinogenic, mutagenic and reprotoxic (CRMs) properties, such as phenolic compounds ([11,79,80]). Other ingredients such as some fragrances, preservatives (e.g. MIT) and biocidal active substances in case that the detergent is also a disinfectant can lead to allergic/irritant skin and respiratory reactions. Moreover, VOC, which are used for solvent, preservation, fragrance and disinfection properties, can constitute up to 10% of some detergent products (up to 30% for certain applications such as glass cleaning and dry cleaning) ([42]). Exposure to VOCs has been associated with various adverse effects on the respiratory, nervous, and cardiovascular systems, as well as allergic sensitization/irritation and carcinogenicity, with the severity depending on the duration and level of exposure ([76]). **Improvement potential: Low** Detergent products on the EU market are regulated by means of REACH and CLP Regulation, which effectively ensure the protection of human health and the environment from the risks that can be posed by chemicals ([46,47]), for example restricting the use of CMRs in detergent products. The recently revised CLP Regulation now also includes new hazard classes on substances that are endocrine disruptors, persistent, mobile and toxic (PMT), very persistent and very bioaccumulative (vPvB), and very persistent and very mobile (vPvM). Finally,

DETERGENT PRODUCTS
PFAS have been recently tackled by an EU restriction proposal that may result in a ban of the manufacture, use and placing on the EU market of around 10 000 PFAS, including in detergents ([77]). Alternatives to conventional chemicals with a less toxic profile are available on the EU market, as demonstrated by the strict chemical requirements in some European ecolabels ([19,20,21,81]). Alternative application packaging may reduce or eliminate the need for VOC used in the product ([57]), even though, due to application requirements, in many cases a complete change of the application form is not possible; however, this is also linked to market strategies. **Potential measures under ESPR:** No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.
Material efficiency [3] **Improvement potential: Medium** The main potential improvement related to an increased material efficiency of detergents lies in clear dosage requirements, or monodose designs, as confirmed by the recent tablets trend for laundry and dishwasher detergents ([38]). Concentrated products would also reduce the need for materials ([15,35]), and are growing in the market ([43]). One of the main innovations in the field of compaction is through the use of enzymes and polymers which have a high performance with low concentrations in the formula whilst securing equivalent cleaning performance of detergent products ([65]). However, information to consumers is important in this case to avoid using concentrated products as per normal usage (as in ready-to-use or diluted) and also to reduce potential harm under accidental exposure/contact. The former case would lead to overdosing, thus inefficient use with potential environmental implications, while the latter may entail higher likelihood of acute effects due to higher concentration in the product (assuming that higher concentration would trigger a more severe CLP classification). Recyclability of packaging and inclusion of recycled material content is also possible, and a potential that is still largely untapped. Some major player in the EU have already committed to 100% plastic packaging being recyclable, reusable or compostable, and a minimum of 20-50% by volume of recycled plastic materials by 2025 ([24,38]). Finally, the savings brought by refillable solutions are almost fully unexploited ([39]). **Potential measures under ESPR:** - performance requirement on maximum weight or volume of the product and/or its packaging - performance requirement on maximum product to packaging ratio - performance requirement on lightweight design (e.g. use of lower density or high-strength materials) - information requirement on product to packaging ratio
Lifetime extension [1] **Improvement potential: Low** The lifetime of detergents can be extended by dosing the products appropriately, without overdosing. In this sense, clear dosage indications or monodose designs can help consumers ([38]), even though this measure remains linked to user behaviour, and are already established by the Detergent Product Regulation. Improvement potential also exists with respect to standardised components for spare parts availability, e.g. sprayers with standardised inlet so that this can be substituted if it gets broken, but also design of the packaging that releases only the dosage that is needed for the use of the product, thus avoiding overconsumption. Further solutions could be product innovations that maintain the house, dish or clothes clean for longer. **Potential measures under ESPR:** - performance requirement on minimum reliability(guaranteed efficiency) - performance requirement on availability and affordability of spare parts (for selected products, e.g. spray dispensers)

DETERGENT PRODUCTS

- performance requirement on the characteristics and availability of consumables needed for proper use
- performance requirement on the use of standard components
- information requirement on cleaning performance of the product at low temperature

Final environmental score [26]



Open Strategic Autonomy score [1]

Policy Gaps

The Detergents Regulation (44) sets a number of requirements to reduce the impacts to water: it limits P-compounds in domestic laundry and dishwasher detergents; it allows only surfactants that are fully (aerobically) biodegradable to be included in detergents; it requests suppliers to clearly indicate dosage information for standard conditions on the label; and it sets the rules for the labelling of ingredients. Moreover, the proposal for a revised Detergent Regulation puts larger focus on the biodegradability of detergents and on labelling requirements, especially for refills (66). The REACH (46) Regulation ensures the protection of human health and the environment from the risks that can be posed by chemicals, and applies also to ingredients of detergents. According to REACH, companies must demonstrate how the substance can be safely used, and they must communicate the risk management measures to the users. If the risks are unmanageable, authorities can ban, restrict or make hazardous substances subject to a prior authorisation. The Classification, Labelling and Packaging (CLP) Regulation (47) ensures a high level of protection of health and the environment by determining whether a substance or mixture displays properties that lead to a hazardous classification, as the starting point for hazard communication, now also including hazard classes for endocrine disruptors and PMT/vPvB. With respect to bio-based chemicals, the Commission has recently adopted a regulation to counter EU-driven deforestation and forest degradation (55), which applies equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are placed on the EU market. Finally, Regulation 655/2013 (59) regulates the use and justification of claims used in detergents.

Given the extensive regulatory framework for chemical safety, ESPR measures would likely not target such area. The improvement potential for ESPR lies in performance requirement for maximum levels of life cycle consumption of water and air emissions and energy consumption, depending on the type of product. Moreover, measures related to soil and biodiversity impacts would lie in mandatory sustainability** certifications for the sourcing of bio-based raw materials. Measures on recycled content and recyclability of the packaging are likely not to be in the scope of ESPR, as these are likely to be addressed by the recently adopted Packaging and Packaging Waste Regulation. Finally, several performance requirements proposed within this fiche address the improvement potential identified in the use phase, mainly related to a minimum cleaning performance and a maximum dosage allowance at set usage conditions, as well as availability of refills and of standardised components and spare parts. Despite being conditional to correct user behaviour (ensuring proper use), information requirements will support consumers in actively engaging in the behavioural changes necessary to reduce our environmental footprint.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT						Related Union law	What could be addressed by ESPR
maximum limit of life cycle water consumption	WATER						Industrial Emission Directive	IED covers the production of chemical ingredients, but not detergent products, other life cycle stages or production outside the EU
maximum level of life cycle emissions to water	WATER						Industrial Emission Directive	IED covers the production of chemical ingredients, but not detergent products, other life cycle stages or production outside the EU
maximum limit of microplastics release	WATER		BIODIVERSITY				Microplastics Regulation	Does not address unintentional release of microplastics
minimum content of raw material with sustainability certification			BIODIVERSITY				Regulation on deforestation-free products	The Deforestation-free Regulation only covers addresses wood, rubber, cattle, coffee, cocoa, palm oil and soy. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated				WASTE			Waste Framework Directive	WFD incentivizes waste prevention but does not have a product-specific approach
refillable packaging and availability of refills	WATER		BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	Packaging and Packaging Waste Regulation	PPWR incentivises refill, but does not set mandatory obligations to offer refill solutions
maximum level of carbon footprint			BIODIVERSITY		CLIMATE CHANGE	ENERGY USE	EU Emission Trading System	EU ETS covers the production of some chemical ingredients (acids and bulk organic chemicals), but not other life cycle stages or production outside the EU
minimum share of energy consumption from low carbon sources					CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product-specific and does not address production outside the EU. It includes voluntary labelling, but not mandatory requirements

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT					Related Union law	What could be addressed by ESPR
minimum content of sustainable renewable materials	BIODIV ERSITY		CLIMATE CHANGE			Renewable Energy Directive II	RED II sets sustainability requirements for biomass but not mandatory minimum use of renewable materials
maximum level of life cycle energy consumption			CLIMATE CHANGE	ENERGY USE.		Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU, but not outside the EU. Also, EED is not product-specific
efficiency of the product at low energy consumption			CLIMATE CHANGE	ENERGY USE		-	Full potential of the requirement
maximum weight or volume of the product and/or its packaging		WASTE			MAT EFF.	-	Full potential of the requirement
maximum product to packaging ratio		WASTE	CLIMATE CHANGE		MAT EFF.	-	Full potential of the requirement
lightweight design (e.g. use of lower density or high-strength materials)		WASTE			MAT EFF.	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT			Related Union law	What could be addressed by ESPR
life cycle water consumption	WATER			-	Full potential of the requirement
life cycle emissions to water	WATER			-	Full potential of the requirement
possible release of non-biodegradable microplastics	WATER	BIODI VERSITY		Microplastics Regulation	Does not address unintentional release of microplastics
sourcing of raw materials from certified sustainable practices		BIODI VERSITY		-	Full potential of the requirement
amount of life cycle waste sent to landfill			WASTE	-	Full potential of the requirement

INFORMATION REQUIREMENTS	**ENVIRONMENTAL ASPECT**								**Related Union law**	**What could be addressed by ESPR**
how to correctly use, store (focus on dosing) and dispose the product	WATER		BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
recycled content in product packaging	WATER		BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE			Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for information requirements
carbon footprint					CLIMATE CHANGE				-	Full potential of the requirement
share of energy consumption from low carbon sources					CLIMATE CHANGE				Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
content of sustainable renewable materials					CLIMATE CHANGE				-	Full potential of the requirement
life cycle energy consumption						ENERGY USE			-	Full potential of the requirement
efficiency of the product at low energy consumption					CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
maximum product to packaging ratio							MAT EFF.		-	Full potential of the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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Product fiche 5. Fishing Nets and Gear

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

FISHING NETS & GEARS

Scope: any item or piece of equipment that is used in fishing or aquaculture to target, capture or rear marine biological resources or that is floating on the sea surface, and is deployed with the objective of attracting and capturing or of rearing such marine biological resources.

Water Effects [4]

Environmental impact: High

Fishing gears containing plastic are a serious problem in the context of marine litter, posing severe risks to marine ecosystems, as a significant proportion of the fishing gear placed on the market is not collected for treatment ([1]). Fishing nets and gears are abandoned in the marine environment; as an example, 5.7% of all fishing nets, 8.6% of traps and pots, and 29% of all fishing lines used globally are abandoned, lost or discarded ([4]). Fishing-related items represent 27% of total marine litter in the EU ([1]). In addition, fishing gears and nets are a significant source of microplastics in the oceans due to their constant use and shedding of microfibers, as well as accidental loss or abandonment. Synthetic materials (e.g., nylon, polypropylene, polyester) are the primary sources of microplastics in fishing gears and nets ([22]). In the Mediterranean seafloor 68% of the debris are fishing lines, 18% are nets, 12% are ropes and 0.2% are pots ([23]).

Improvement potential: Medium

The potential for improvement of fishing gear lies in preventing gear loss ([4]), designing and manufacturing traceable fishing gear, marking its key components (ropes, net panels, traps, and tracking buoys). Other areas of work include the design and the manufacture of fishing gear that becomes harmless if it is lost at sea, using as much biodegradable materials in fishing gear as possible to ensure that lost gear will not persist in the ocean indefinitely and training sessions to improve fishermen's skills on how to repair and maintain netting ([9]).

Potential measures under ESPR:

- performance requirement on the use of component and material coding standards for the identification of components and materials.

- information requirement on conditions for use and maintenance of the product to reduce losses at the sea.

- information requirement on the possible release of non-biodegradable microplastics.

Air Effects [1]

Environmental impact: Low

Fishing gear consists of various synthetic polymers (e.g., nylon, polyethylene, polypropylene) ([19]), as well as metals, among other materials. The main impact is related to the extraction of raw materials.

Improvement potential: Low

The potential for improvement of fishing gear lies in addressing an environmentally sustainable approach to sourcing of raw materials (plastic, metal, among others).

Potential measures under ESPR:

FISHING NETS & GEARS
No specific measures have been defined that directly cover air effects. However, measures defined in other environmental areas may also benefit this environmental area.
Soil Effects [1] **Environmental impact: Low** The main impact on beaches is related to the release of microplastics, where fishing rope and net are considered the largest sources ([20]). **Improvement potential: Low** The potential for improvement of fishing gear lies in preventing gear loss. **Potential measures under ESPR:** No specific measures have been defined that directly cover soil effects. However, measures defined in other environmental areas may also benefit this environmental area.
Biodiversity Effects [4] **Environmental impact: High** Commercial fishing nets and gear abandoned, lost or discarded cause passive and enormous, non-specific harm ("Ghost fishing") to marine and coastal ecosystems ([3, 4, 5]). Most of the marine litter classed as an elevated risk for entanglement is fishing-related items ([5]). Fishing gear litter may continue to persist for a prolonged time (years to decades), with mortal or sub-lethal effects to marine biota through entanglement, physical damage, smothering, or ingestion ([3, 4]). Beyond physical detrimental impacts, potentially toxic elements (e.g., lead) and/or microplastics could be released, the latter acting as vector priming pollutants bioaccumulation ([3, 5]). Ghost fishing is non-specific, affecting both plants and animals ([4]). Observable effects demonstrate severe impacts on cetaceans, seabirds and the totality of turtle species ([3, 4]). The quantification of these impacts is difficult given their scale, their diffusivity and their trans-boundary nature ([5, 10]). **Improvement potential: Medium** The potential for improving fishing gear lies in preventing gear loss ([4]), addressing the design and the manufacture of fishing gear that becomes harmless if it is lost at sea, including as much biodegradable materials in fishing gear as possible to ensure that lost gear will not indefinitely persist in the ocean. Designers and producers should design traps and pots with effective escape mechanisms and include biodegradable mechanisms that allow the traps to become disabled if they are lost; and collaborate with fishermen to research and test improved gear designs. Although not all materials used in fishing gear can be easily substituted with others because of legal considerations, there are, however, parts of fishing gear that could potentially be replaced with more environmentally friendly substitutes ([10]). **Potential measures under ESPR:** - performance requirement for the design of traps and pots with effective escape mechanisms with biodegradable mechanisms that allow traps to be deactivated if lost. - performance requirement on design to ensure harmless of fishing nets and gears in case they are lost (e.g., including biodegradable materials). - information requirement on conditions for use and maintenance of the product to reduce losses at the sea.
Waste Generation & Management [3] **Environmental impact: Medium** A recent study estimated that nearly 2% of all fishing gear is lost to the ocean annually ([18]). Abandoned gear makes up at least 10% of marine litter (between 0.5 million tonnes and 1 million tonnes per year) ([4]). Most of the EU marine litter that reaches the coast is plastic, with fishing-related items representing 27% ([1]). Assuming that 15% of the plastic consumption is used in fishing nets and gear, plastic waste from fishing

and aquaculture entering the European seas ranges from 9 888 tonnes to 22 685 tonnes per year (3). These estimated waste generation rates are not as significant as other waste streams (e.g., packaging).

Improvement potential: Medium

It has been observed that mechanical recycling of fishing gear is difficult due to their high degradation, energy recovery being often the best solution (21). The potential for improvement of fishing gear lies in preventing gear loss, designing and manufacturing traceable fishing gear, reducing the combination of materials and polymers in their design, as well as reducing their complex disassembly, marking its key components (ropes, net panels, traps, and tracking buoys) and including as much biodegradable materials in fishing gear as possible to ensure that lost gear will not indefinitely persist in the ocean.

Potential measures under ESPR:

- performance requirement on the use of easily recyclable materials or combination of materials.
- performance requirement on the maximum number of materials and components used.
- performance requirement on the use of standard components.
- performance requirement on the use of component and material coding standards for the identification of components and materials.
- performance requirement on safe, easy and non-destructive access to recyclable components.
- performance requirement on design to facilitate repair.
- performance requirement on availability of information (e.g. repair and maintenance instructions, product data, long after the product is sold (no discontinuing of availability of information).
- performance requirement on minimum reliability (e.g., resistance to weathering).
- performance requirement on minimum recycled content.
- performance requirement on minimum content of biodegradable materials.
- information requirement on conditions for use and maintenance of the product to reduce losses at the sea.
- information requirement on how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities).
- information requirement of expected lifetime of the product, and/or on how to substitute/replace the product or its component.
- information requirement on recycled content

Climate Change [2]

Environmental impact: Medium

Either active (commercial) or passive (ghost) fishing results in disturbance of marine ecosystems. When this happens, carbon (C) that has been stored in coastal and marine environments, known as blue carbon, can be re-suspended and released. This can contribute to ocean acidification, thus affecting the ability of oceans to act as a C sink (6). It is estimated that bottom trawling 1.3% of the global ocean floor could induce C release of 1.47 Pg as aqueous carbon dioxide (CO_2), which equates to 15-20% of the atmospheric CO_2 absorbed annually by the ocean (6). Additionally, it has been estimated that as much as 1.02 billion tons of CO_2 per year are released into the water column from fisheries affected degraded coastal ecosystems (6).

Improvement potential: Low

The potential for improvement of fishing gear lies in preventing gear loss, designing and manufacturing traceable fishing gear, and marking its key components (ropes, net panels, traps, and tracking buoys).

Potential measures under ESPR:

No specific measures have been defined that directly cover climate change. However, measures defined in other environmental areas may also benefit this environmental area.

FISHING NETS & GEARS
Life Cycle Energy consumption [1] **Environmental impact: Low** Fishing is a highly energy-intensive food production method, relying mostly on fuel-based engines. The total fuel consumption is significantly impacted by the nets and gear used and the resistance that these offer against ship navigation ([7]). **Improvement potential: Low** The potential for improvement of fishing gear lies in the total resistance of the net; due to the fact that fuel consumption is related to this issue, it is clear that reducing net resistance will contribute to reduce fuel consumption. Passive gear is mentioned as an alternative to reduce energy consumption ([7]). By modernising fishing gear, a potential improvement, expressed as fuel savings, of 15% is estimated ([7]). However, this improvement would be marginal when accounting for the total energy use pool, since in many countries it represents less than 1% ([8]). **Potential measures under ESPR:** No specific measures have been defined that directly cover life cycle energy consumption. However, measures defined in other environmental areas may also benefit this environmental area.
Human Toxicity [1] **Environmental impact: Low** Lead leakage from fishing gear has been reported but no further data on specific toxicological impacts on humans are available. Fishing gear should not have, as manufacturing requirement, hazardous chemicals that pose a significant risk to human or environmental health. **Improvement potential: Low** The potential for improvement of fishing gear lies in preventing gear loss, designing and manufacturing traceable fishing gears, with its key components (ropes, net panels, traps, and tracking buoys) marked. **Potential measures under ESPR:** No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.
Material efficiency [3] **Improvement potential: Medium** The potential for improvement of fishing gear lies in designing and manufacturing products that are recyclable and do not include mixed polymers, and therefore are easily dismantled so recyclable components can be separated from non-recyclable components. This will require work on the traceability of the material, higher costs and potential reduction of the technical performance/specifications of the fishing nets and gear due to manufacturing materials substitution ([9, 10]). There is also some room for improvement in designing and manufacturing fishing gear that becomes harmless if it is lost at sea, including as much biodegradable materials in fishing gear as possible to ensure that lost gear will not indefinitely persist in the ocean ([10]). Fishing gear might have non-recyclable parts or organic fouling, which require removal to allow for potential recycling ([10]). Some stakeholders advocate manufacturing fishing gear that is traceable (marking), recyclable (unmixed polymers and easy to dismantle) and not harmful if lost at sea (biodegradable) ([4]). **Potential measures under ESPR:** - performance requirement on design for lighter weight.
Lifetime extension [1] **Improvement potential: Low**

FISHING NETS & GEARS

Fishing nets and gear imply a significant cost for fishermen. This acts in favour of extending their lifetime and also reinforces the understanding that losses tend to be unintentional. For this reason, the potential for improvement of fishing gear lies in circularity options leading to lifetime extension such as facilitating disassembly (e.g., colour coding); reusing and repurposing of different materials currently used and modular design to facilitate repair and reuse ([9]). Other areas of work include designing and manufacturing traceable fishing gear, marking its key components (ropes, net panels, traps, and tracking buoys), and training sessions to improve fishermen's skills on how to repair and maintain netting ([9]).

Potential measures under ESPR:

No specific measures have been defined that directly cover lifetime extension. However, measures defined in other environmental areas may also benefit this environmental area.

Final score [21]

Open Strategic Autonomy score [1]

Policy Gaps

Fishing nets and gears are prioritized under the Circular Economy Action Plan (CEAP), which targeted to reduce for marine litter of 30% by 2020 and aimed at timely implementing the Directive on Single Use Plastics (SUP) (EU) 2019/904 to tackle the problem of marine plastic pollution ([1]). Further work aimed at quantifying the threshold for marine litter under this context, highlighting the difficulty of doing so ([12]). SUP Directive sets labelling (plastic nature) and informational (e.g., share of plastic/metals/rubber) requirements for fishing nets and gear placed in the market ([1]).

Directive (EU) 2019/883 ([13]) regulates the procedure to deliver waste to port facilities, including reporting the mass of fishing gear waste and an indirect fee system removing the incentive for ships to discharge their waste at sea. Regulation (EU) No 1224/2009 stablishes the Community Control System for ensuring compliance with the rules of the Common Fisheries Policy, which dictates how fishing gear can be used, empowers Member States for verification (type, number and characteristics) and instructs what to do in case of lost gear ([14]). Regulation (EU) No 1380/2013 made possible to take measures for the conservation and sustainable exploitation of marine biological resources, including technical measures on fishing gears such as rules on their use, characteristics, construction limitations and prohibitions ([15]). The Regulation (EU) 2019/1241 amended the two former and provided further technical measures concerning the operation of fishing gear to ensure marine protection ([16]). This highlights a whole trail and comprehensive regulatory efforts towards marine environment protection. Despite them, environmental impacts associated with *ghost fishing* still occur ([4]), and therefore continued advocacy to adopt appropriate fishing gear best management practices is needed ([17]).

Policy gaps can be related to preventing gear loss. In that sense, the areas of work include targeting consumption reduction, fishing gear circularity potential (traceability, recyclability, reparability or disassembly), sustainability (use of biodegradable materials), and waste management (composition or amounts generated).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT				Related Union law	What could be addressed by ESPR
use of component and material coding standards for the identification of components and materials	WATER		WASTE		Regulation (EU) No 1224/2009	It refers to the adoption of rules for the marking and identification of fishing gear, but no reference is made to material and component standards.
design of traps and pots with effective escape mechanisms with biodegradable mechanisms that allow traps to be deactivated if lost	WATER	BIODIVERSITY	WASTE		Regulation (EU) 2019/1241	It sets restrictions on the use of specific fishing gears, but no reference is made to specific design requirements.
design to ensure harmless of fishing nets and gears in case they are lost (e.g., including biodegradable materials)		BIODIVERSITY	WASTE		Regulation (EU) 2019/1241	It sets restrictions on the use of specific fishing gears, but no reference is made to specific design requirements.
use of easily recyclable materials or combination of materials	WATER	BIODIVERSITY	WASTE	MATERIAL EFFICIENCY	Directive on Single Use Plastics (SUP) (EU) 2019/904	SUP refers to the development of standards for preparing for re-use and recyclability, but no requirements are set.
maximum number of materials and components used			WASTE		Directive on Single Use Plastics (SUP) (EU) 2019/904	SUP refers to the development of standards for preparing for re-use and recyclability, but no requirements are set.
safe, easy and non-destructive access to recyclable components	WATER		WASTE	MATERIAL EFFICIENCY	Directive on Single Use Plastics (SUP) (EU) 2019/904	SUP refers to the development of standards for preparing for re-use and recyclability, but no requirements are set.
minimum recycled content	WATER	BIODIVERSITY	WASTE	MATERIAL EFFICIENCY	Directive on Single Use Plastics (SUP) (EU) 2019/904	SUP Directive only refers to fishing gears containing plastic. Fishing gears made of other materials are not covered.

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT				Related Union law	What could be addressed by ESPR
	WATER	BIODIVERSITY	WASTE	MATERIAL EFFICIENCY		
minimum content of biodegradable materials		BIODIVERSITY	WASTE		-	Full potential of the requirement
design for lighter weight			WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
use of standard components			WASTE		-	Full potential of the requirement
minimum reliability (e.g., resistance to stresses or aging mechanisms)	WATER	BIODIVERSITY	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
design to facilitate repair			WASTE		Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach.
availability of information (e.g. repair and maintenance instructions, product data, long after the product is sold)			WASTE		-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT			Related Union Law	What could be addressed by ESPR
	WATER	BIODIVERSITY	WASTE		
conditions for use and maintenance of the product to reduce losses at the sea	WATER	BIODIVERSITY	WASTE	Regulation (EU) No 1224/2009 Regulation (EU) No 1380/2013	It only indicates that lost gear should be retrieved and instructs what to do in case of lost gear, but does not provide preventive measures to reduce losses. Conditions on use are required; however, the focus is not on reducing losses.

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT				Related Union Law	What could be addressed by ESPR
possible release of non-biodegradable microplastics	WATER	BIODI VERSITY	WASTE		-	Full potential of the requirement
how to disassemble, recycle and re-turn or dispose the product (for users and/or treatment facilities)			WASTE		Directive (EU) 2019/883	Although it regulates the proce-dure to deliver waste to port facili-ties, no relevant information ac-companies the product.
recycled content	WATER	BIODI VERSITY	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
expected lifetime of the product, and/or on how to substitute/replace the product or its component			WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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(14) Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006. (OJ L 343, 22.12.2009, p. 1–50). Available at: http://data.europa.eu/eli/reg/2009/1224/oj.

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Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

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Scope: free-standing or built-in units whose primary function is to be used for the storage, placement or hanging of items and/or to provide surfaces where users can rest, sit, eat, study or work, whether for indoor or outdoor use. The scope extends to domestic furniture and contract furniture items for use in domestic or non-domestic environments. Bed frames, legs, bases and headboards are included in the scope. Not included are: bed mattresses, streetlights, railings and fences, ladders, clocks, playground equipment, stand-alone or wall-hung mirrors, electrical conduits, road bollards and building products such as steps, doors, windows, floor coverings and cladding.

Water Effects [1]

Environmental impact: Low

The majority of furniture is made of wooden-based materials. The assessment of water depletion in the life cycle of furniture is characterised by high uncertainties mainly because it depends on many variables, like types of trees, cultivation techniques/conditions, and local climate ([7]). Additionally, available data are affected by a high degree of uncertainty, especially for the forestry phase ([8]). The difficulty in assessing water depletion impacts for wood products is observed also by Klein et al. ([9]).

Improvement potential: Low

Due to high uncertainty in assessing water depletion impacts, possible improvement potential are low.

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption - performance requirement on maximum level of life cycle emissions to water

- information requirement on water consumption during production per kg or unit of product

- information requirement on the level of life cycle emissions to water

Air Effects [3]

Environmental impact: Medium

Wood-based products, including furniture, play a significant role in our everyday lives. However, the production and delivery processes of these products can have significant environmental impacts, including resource consumption, emissions, and waste generation ([23]).

Furniture can contain substances like biocidal products, flame retardants, adhesives, resins, paints, varnishes, inks, dyes, plasticisers and foaming agents, which affect the indoor environment releasing mainly VOC ([10]). VOC emitted from furniture are one of the factors affecting air quality and human health ([11]).

The use of hazardous substances in manufacture, such as surface coating operations have some significant environmental impacts due to chemicals used during processes ([10]).

Improvement potential: Medium

The improvement potential of the furniture sector lies in addressing the composition of furniture elements, reducing the addition of harmful substances, using low emission materials and low VOC emission furniture ([13]). In addition to that the design for disassembly and repair, re-use and recycle would lead to an increase of the lifespan and a decrease of the need of virgin materials and the air impacts associated to their extraction.

Opting for finishes and adhesives that are low in volatile organic compounds (VOCs) or are water-based can yield significant environmental benefits. This choice translates to minimized indoor air pollution during manufacturing and product use (23)

Potential measures under ESPR:

-performance requirement on maximum level of life cycle emissions to air

-information requirement on the level of life cycle emissions to air

Soil Effects [3]

Environmental impact: Medium

The main life-cycle effects of furniture on soil are related to the sourcing of raw materials like forestry products (wood, wood-based, rattan, bamboo), plastic and metals. Especially forestry products have a direct impact on soil, land use change, and soil degradation, which are related to their management (10).

Improvement potential: Medium

The improvement potential of the furniture sector lies in sourcing of legal timber for furniture production (13) In addition to that the design for disassembly and repair, re-use and recycle would lead to an increase of the lifespan and a decrease of the need of virgin materials and the soil impacts associated to the extraction.

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability certification
- information requirement on sourcing of raw materials from certified sustainable practices

Biodiversity Effects [3]

Environmental impact: Medium

The effect on biodiversity for furniture is strictly related to the use of forestry products (wood, rattan, bamboo), because an unsustainable production of these specific materials negatively affect biodiversity (10). Currently, the majority of the furniture market does not assure that forestry materials come from forests sustainably managed.

Improvement potential: Medium

The improvement potential of the furniture sector lies in sourcing of legal and sustainably sourced timber for furniture production (13) In addition to that the design for disassembly and repair, re-use and recycle would lead to an increase of the furniture lifespan and thus a decrease of the need of virgin materials and ultimately reduced biodiversity impacts associated to the extraction.

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability certification
- information requirement on sourcing of raw materials from certified sustainable practices

Waste Generation & Management [4]

Environmental impact: Medium

In EU Member States each year, 10 million tonnes of furniture are discarded, the majority of which is inadequately disposed of. One of the main problems with this high number, is the elimination of new furniture that is not sold, indicating significant overproduction (19). According to the European Federation of Furniture Manufacturers' statistics, 80% to 90% of the EU furniture waste in the municipal solid waste stream is incinerated or sent to landfill, with less than 10% recycled (6).

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Underinvestment in reuse, repair and remanufacturing infrastructure limits the potential for furniture being managed in accordance with the principles of the waste hierarchy or the circular economy ([6]). Each year, 10.5 million tons of furniture are produced, 10 million tons of furniture waste are generated accounting for more than 4% of municipal solid waste in the European Union ([24]).

Impacts at end of life vary considerably depending on what materials are used in the furniture. From an environmental perspective, recycling wood waste to manufacture particleboard is more favourable than generating energy through incineration. Furthermore, employing a cascading approach to avoid waste throughout the product life cycle results in lower environmental impacts such as reusing wood waste residue compared to using primary wood ([25]).Furniture waste estimated to be generated in Germany was 3.6 Mt, or 43 kg/person/yr, of which 1.7 Mt, or 20 kg/person/yr, is collected separately in bulky waste. Similar trends can be expected in many other EU countries ([22]).

By facilitating product recycling and designing products with easy disassembly for component reuse or material recycling, companies can effectively manage the end stages of their products' lifecycles. This approach not only contributes to a circular economy but also underscores a commitment to minimizing waste and environmental impact ([23]). Circular economy interventions have the potential to help, with repair, refurbishment and remanufacture allowing value recovery, economic growth and job creation within the European furniture industry ([6]) In cooperation with furniture manufacturers and the recycling industry, standards for the ecodesign of specific pieces of furniture need to be developed at EU level that facilitate repair, separation of different materials and recycling ([22]). An increased and cross-sectoral use of recycled materials in the production of furniture strengthens the circular economy by creating better market opportunities for recycled products, therewith improving the economic viability of recycling processes ([22]).

Improvement potential: High

The improvement potential of the furniture sector lies in reducing waste generation. Eradicating, for example, the problem of overproduction could save another 23,000 tonnes of CO_2eq per year in the EU furniture market ([19]). More can be invested in reuse, repair and remanufacturing infrastructure ([12]). A mandatory but simple extended producer responsibility (EPR) system, with gradually increasing targets for 'preparing for reuse' and separate recycling targets, would provide the most certainty in terms of positive outcomes ([6]). There is room for improvement in the reuse targets and addressing the composition of furniture elements that generate low- chemical waste ([13]). Designing for longer lifetimes, more durable components or ease of maintenance would imply lower long-term lifetime costs ([13]). Design for disassembly and repair is also important ([13]).

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated
- performance requirement on maximum amount of life cycle hazardous waste generated
- performance requirement on safe, easy and non-destructive access to recyclable components
- performance requirement on the use of easily recyclable materials or combination of materials
- performance requirement on ease of upgrading, re-use, remanufacturing and refurbishment
- performance requirement on minimum recycled content
- performance requirement on the maximum number of materials and components used
- information requirement on recycled content
- information requirement on how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities)
- information requirement on amount of waste sent to landfill

Climate Change [3]

Environmental impact: Medium

The impact of furniture production on climate change varies across different stages of the production process. During the raw material extraction phase, logging for wood contributes to deforestation and habitat loss, which significantly reduces forests' capacity to sequester carbon and leads to increased atmospheric CO2 levels. Additionally, the machinery used in logging and transporting raw materials often relies on fossil fuels, resulting in further carbon emissions. Soil disturbance during logging also releases carbon stored in the soil into the atmosphere. In the manufacturing stage, furniture production is energy-intensive, with much of this energy coming from fossil fuels, leading to substantial carbon emissions. Transportation of raw materials to factories and finished products to retailers or consumers relies heavily on vehicles powered by fossil fuels, which emit significant amounts of CO2. During the usage phase, the environmental impact of furniture is influenced by its lifespan. Furniture with a short lifespan necessitates frequent replacements, leading to higher overall production rates and associated emissions. Finally, at the end-of-life stage, furniture often ends up in landfills where decomposing organic materials release greenhouse gas.

In the framework of the Paris Agreement, the furniture sector can contribute to the goal of limiting the global warming to 2 ◦C by 2050 ([10]). n a net-zero energy building, the impact of furniture represents about 10% of impacts on global warming ([13]). In particular, the material selection can play an important role in mitigating climate change ([14, 15]). Climate change impacts are highest where the furniture is manufactured using aluminium, and lowest where wood is used – despite the latter using considerably more material on a weight basis ([6]). The furniture sector accounts for approximately 8–10 % of global greenhouse gas emissions. With each year, millions of trees are harvested to meet the industry's voracious demand, leading to deforestation rates that average 15 billion trees annually ([23]). In the case, for example, of sales of office chairs and desks in the EU, they are associated with greenhouse gas emissions of more than 2 Mt CO_2 eq per year. Raw materials and components have biggest impact on total GHG emissions (38.4–90.1 per cent); processing and assembling can also have impact on greenhouse gas emissions (8–58 per cent); packaging and transportation have a minor role (1–8 per cent) ([27]). According to studies, it is possible to improve the carbon footprint by up to 10% by increasing, for example, the proportion of recycled metals ([19]).

Improvement potential: Medium

The improvement potential of the furniture sector lies in sourcing of legal timber for furniture production ([13]); using recycled materials instead of virgin material to decrease the impact on Climate Change ([14, 15]). Wood materials from sustainable harvesting practices, present a significant opportunity for emission reduction ([10]). In addition to that the design for disassembly and repair, re-use and recycle would lead to an increase of the lifespan and lower demand for virgin materials. Transitioning to renewable energy sources, such as harnessing solar power for both manufacturing and distribution processes, stands as a promising strategy. Not only to reduce greenhouse gas emissions, but also to shift away from fossil fuel dependency ([23])

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- performance requirement on minimum content of sustainable renewable materials
- information requirement on carbon footprint
- information requirement on the share of energy consumption from low carbon energy sources
- information requirement the content of sustainable renewable materials

Life Cycle Energy consumption [3]

Environmental impact: Medium

Energy consumption in the furniture industry significantly impacts the environment throughout its life cycle. During the extraction and processing of raw materials like wood, metal, and plastics, substantial energy is required, often derived from non-renewable sources, leading to high carbon emissions and environmental degradation. Manufacturing processes, including cutting, shaping, assembling, and finishing, are energy-intensive. The transportation of raw materials to factories and finished products to markets also consumes considerable fossil fuels.

The application of the ecodesign parameters results in reduction of the use of raw material by 30%, in a reduction in waste by 49% and in allowing a reduction in energy by 36% due to simplification of the productive process ([26]). Most of the energy consumption is related to the manufacture the product, particularly in

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injection-moulded plastics and wood-based panels due to the use of elevated temperatures and pressures ([10]). Energy needed for surface treatment is remarkably high and it has a significant effect on the overall use of electricity in production ([27]). Manufacturing of coatings and coating process are very energy intensive ([27]). Surface coating operations have some significant environmental impacts due to high-temperature curing processes ([10]). **Improvement potential: Medium** The improvement potential of the furniture sector lies in implementing renewable energy sources and using different materials to plastic and metals to decrease the energy consumption during manufacturing. Increasing product durability, the reuse of components, and design for disassembly/reassembly, repair and reuse ([6]) would lead to an increase in the lifespan and a reduction of the need of virgin materials and the energy for their production. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - information requirement on life cycle energy consumption
Human Toxicity [2] **Environmental impact: Medium** The production and use phase of the furniture can expose humans to several harmful substances like biocidal products, flame retardants, adhesives, resins, paints/varnishes/inks/dyes, plasticisers and foaming agents ([10]). **Improvement potential: Low** The improvement potential of the furniture sector lies in addressing the composition of furniture elements, reducing the addition of harmful substances, using low emission materials and establishing low VOC emission furniture ([13]). **Potential measures under ESPR:** No measures are envisaged under ESPR for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).
Material efficiency [3] **Improvement potential: Medium** The furniture industry holds substantial potential for improvement in terms of material efficiency across several sustainability fronts. Light-weighting designs through innovative materials and construction techniques can reduce material usage and transportation emissions. Increasing the product versus packaging ratio by minimizing packaging materials and optimizing packaging design can lower waste generation. Enhancing the recovery and reuse of by-products, process residues, and off-spec materials from manufacturing processes can contribute to a circular economy approach.. **Potential measures under ESPR:** - performance requirement on maximum weight or volume of the product and/or its packaging - performance requirement on maximum product to packaging ratio - performance requirement on minimum amount of by-products/process residues/off-specs recovered - information requirement on product to packaging ratio - information requirement on amount of by-products/process residues/off-specs recovered
Lifetime extension [5] **Improvement potential: High**

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The potential for improvement in furniture sector lies in moving away from lower quality materials and non-circular product design and increase product durability, the reuse of components, and design for disassembly/reassembly, repair and reuse ([6]). There is great potential for improving circularity ([18]) There is room as well as for improvement in the re-use targets ([13]). Material life extension represents a crucial strategy, focusing on extending the lifespan of materials through recycling or reuse. This approach reduces the demand for new raw material extraction and mitigates disposal impacts associated with landfills or incineration ([25]). The durability of products can dramatically influence the environmental impacts of furniture products ([16]). Some estimates show that a one-year extension of the lifespan of office desks and tables from 15 to 16 years could save 65,000 tonnes of CO_2eq each year, which would be equivalent to burning more than 60 million litres of diesel fuel ([19]). In addition the choice of material may impact the product lifespan, as Furniture made of wood, such as chairs and kitchen furniture, as well as metal furniture are likely to have longer lifetimes than plastic and composite furniture ([22]). **Potential measures under ESPR:** - performance requirement on minimum reliability (e.g. product's guaranteed lifetime) -performance requirement on availability and affordability of spare parts (design for repair and maintenance) - performance requirement on compatibility with commonly available tools and spare parts - performance requirement on the use of standard components - performance requirement on the maximum number of materials and components used - performance requirement on availability of information (e.g. repair and maintenance instructions) long after the product is sold (no discontinuing of availability of information) - performance requirement on availability of guarantees specific to remanufactured or refurbished products - information requirement on condition for use and maintenance of the product - information requirement of expected lifetime of the product, and/or on how to substitute/replace the product or its component - information requirement on resistance to stresses or ageing mechanisms - information requirements on whether specialised tools are needed for repair
Final environmental score [30]

Open Strategic Autonomy score [1]
Policy Gaps There is no specific regulation promoting furniture ecodesign and circularity principles. However, several voluntary schemes are in place for example ecolabel and green public procurement criteria as wells as some European Directives affecting specific components like LEDs, displays, etc. but not include bio-based components [14]. After the publication of the Circular Economy Action Plan, some industries started working on specific ecodesign features, but any action is still far from in place. Furthermore, standardisation activities are being carried out in the framework of CEN/TC207/WG10 'Requirements and tools for furniture circularity' which will cover many aspects of furniture circularity ([18]). There is no self-regulation or industry voluntary agreement in place. Regarding wood waste from this product group, although it has been analysed as a stream, no specific criteria have been defined on the current situation for its recycling in the EU [15]. Examples of durability standards are EN 12520 (for seating furniture and tables), EN 15828 (for hardware/functional fittings) or EN 12720 (for surfaces) ([18]).

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For wooden furniture or furniture made from timber, whereas the existing timber legislation could be considered applicable, they have been found to be based on voluntary timber trade agreements, such as the FLEGT Regulation (16). With respect to bio-based components, the Commission has adopted a Regulation to tackle EU-driven deforestation and forest degradation (17), which should apply equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are entering the EU market. Nevertheless, environmental sustainability requirements related to e.g. sourcing of the raw material are not included in the deforestation-free products regulation. The gaps that need to be addressed are related to moving away from low quality materials and non-circular product design as well as increasing the recycled content, the reuse of components, and design for disassembly/reassembly, repair, reuse, remanufacture and recycling (6). The design for reducing harmful additives, for disassembly and repair, for reuse and recycling would increase the lifespan and decrease the need for virgin materials and thus lower impacts associated with their extraction. In addition, a mandatory but simple extended producer responsibility (EPR) system, with gradually increasing targets for 'preparing for reuse' and separate recycling targets, would provide the most certainty in terms of positive outcomes (6). Aspects such as improving durability and reliability, ease of repair and maintenance, ease of refurbishment, remanufacturing and upgradability as well as ease of recycling of materials must be addressed.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA							Related Union law	What could be addressed by ESPR
maximum level of life cycle emissions to air	AIR							Industrial Emission Directive	IED covers the production of main materials used in furniture (plastics, steel, glass...), but not other life cycle stages or production outside the EU
minimum content of raw material with sustainability certification		SOIL	BIODIVERSITY		CLIMATE CHANGE			Regulation on deforestation-free products	The Deforestation-free Regulation focuses on wood. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated				WASTE				Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
maximum amount of life cycle hazardous waste generated				WASTE				Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
safe, easy and non-destructive access to recyclable components				WASTE				-	Full potential of the requirement
use of easily recyclable materials or combination of materials	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	LIFETIME EXTENTION	Waste Framework Directive	WFD sets recycling targets for materials in the EU but does not have a design approach in and outside the EU
ease of upgrading, re-use, remanufacturing and refurbishment				WASTE				-	Full potential of the requirement
minimum recycled content	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	LIFETIME EXTENTION	-	Full potential of the requirement
maximum number of materials and components used				WASTE				-	Full potential of the requirement
maximum level of carbon footprint			BIODIVERSITY		CLIMATE CHANGE	ENERGY USE		Emission Trading System	EU ETS covers the production of main materials used in furniture, but

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA								Related Union law	What could be addressed by ESPR
										not other life cycle stages, nor production in non-EU countries
minimum share of energy consumption from low carbon sources			BIODIVERSITY		CLIMATE CHANGE				Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
minimum content of sustainable renewable materials	AIR				CLIMATE CHANGE				Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
maximum level of life cycle energy consumption					CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
maximum product to packaging ratio				WASTE	CLIMATE CHANGE		MATERIAL EFFICIENCY		-	Full potential of the requirement
minimum amount of by-products/process residues/off-specs recovered				WASTE			MATERIAL EFFICIENCY		-	Full potential of the requirement
minimum reliability (e.g. resistance to weathering, strength stress, etc.)	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	-	Full potential of the requirement
availability and affordability of spare parts				WASTE				LIFETIME EXTENTION	-	Full potential of the requirement
compatibility with commonly available tools and spare parts				WASTE				LIFETIME EXTENTION	-	Full potential of the requirement
use of standard components				WASTE				LIFETIME EXTENTION	-	Full potential of the requirement

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA	Related Union law	What could be addressed by ESPR
maximum number of materials and components used	LIFETIME EXTENTION	-	Full potential of the requirement
availability of information long after the product is sold	LIFETIME EXTENTION	-	Full potential of the requirement
availability of guarantees specific to remanufactured or refurbished products	LIFETIME EXTENTION	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA								Related Union Law	What could be addressed by ESPR
possible release of non-biodegradable microplastics	AIR	SOIL							-	Full potential for the requirement
level of life cycle emissions to air	AIR								-	Full potential for the requirement
content of sustainable renewable materials	AIR				CLIMATE CHANGE				-	Full potential for the requirement
condition for use and maintenance of the product to reduce release of non-biodegradable microplastics	AIR	SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement
sourcing of raw materials from certified sustainable practices		SOIL	BIODI VERSITY						-	Full potential for the requirement
recycled content				WASTE					Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for the product information requirements

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA								Related Union Law	What could be addressed by ESPR
how to disassemble, recycle and re-turn or dispose the product (for users and/or treatment facilities.)	AIR	SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement
amount of waste sent to landfill				WASTE					-	Full potential for the requirement
carbon footprint			BIODI VERSITY		CLIMATE CHANGE	ENERGY USE			-	Full potential for the requirement
share of energy consumption from low carbon sources			BIODI VERSITY		CLIMATE CHANGE				Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
life cycle energy consumption						ENERGY USE			-	Full potential for the requirement
product to packaging ratio							MATERIAL EFFICIENCY		-	Full potential for the requirement
amount of by-products/process residues/off-specs recovered							MATERIAL EFFICIENCY		-	Full potential for the requirement
condition for use and maintenance of the product	AIR	SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement
expected lifetime of the product, and/or on how to substitute/replace the product or its component								LIFETIME EXTENSION	-	Full potential for the requirement
resistance to stresses or ageing mechanisms								LIFETIME EXTENSION	-	Full potential for the requirement
whether specialised tools are needed for repair								LIFETIME EXTENSION	-	Full potential for the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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(15) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

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(17) Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010 (Text with EEA relevance) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1115&qid=1687867231461

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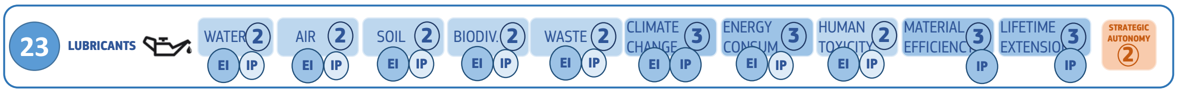
Product fiche 7. Lubricants

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

LUBRICANTS



Scope: Product capable of reducing friction, adhesion, heat, wear or corrosion when applied to a surface or introduced between two surfaces in relative motion, or is capable of transmitting mechanical power. Lubricants are typically composed of variable concentrations of base fluids (80-75%) and additives (25-20%). Base fluids can be fossil based (mineral oils, semi- or fully synthetic oils, re-refined mineral oils) or vegetable oil based as well as also mixtures of them, mostly mineral-synthetic and vegetable-synthetic, but also a small proportion may be water based. Lubricants also assist with cleaning machinery from wear metals and deposits, prolonging their life.

Water Effects [2]

Environmental impact: Medium

The impacts of fossil-based lubricants on water pollution are most significant in the manufacturing and use stages due to: total and partial loss of lubes, accidental loss (spillages), combustion, and, at the end-of-life phase, in the case of improper waste management ([1, 2]). When entering the aquatic environment, lubricant oils produced from crude oil are a very significant threat to aquatic ecosystems, potentially creating a film of oil on the water surface which can reduce the exchange of oxygen and the access of light to the depth of the water, leading to metabolic disturbances of aquatic organisms and oxygen starvation area in the bottom parts of the reservoir ([6]). It was estimated that one litre of petroleum-based lubricating oils can contaminate one million litres of drinking water ([6]).

Improvement potential: Low

The improvement potential is related to the use phase by using less ecotoxic, more biodegradable base oils and additives, especially for total loss lubricants[82] used in open systems such as those used in forest harvesting (725 645 thousand m3 wood were estimated to be harvested in the EU in 2017, whose open chain system for harvesting release lubricant oils) ([6,11]). In Germany and Scandinavia, there are about 80 brands of lubricants produced on the basis of vegetable oils ([6]). However, the development of a common biodegradable base stock that could replace conventional lubricant remains a big challenge ([20]). Also, for partial loss[83] and accidental loss[84] lubricants, the risk of spillages should be minimised by e.g. providing enough information to the user ([2]). For example, the EU Ecolabel criteria for lubricants include mandatory information to be displayed on the packaging related to avoiding any spillage of unused product to the environment ([11]).

Potential measures under ESPR:

performance requirement on maximum limit of life cycle water consumption

- performance requirement on maximum level of life cycle emissions to water

[82] 'total loss' means that the lubricant is fully released to the environment during use

[83] 'partial loss' means that the lubricant is partially released to the environment during use and the non-released part can be recovered for re-processing, recycling or disposal

[84] 'accidental loss' means that the lubricant is used in a closed system and can be released to the environment only incidentally and, after use, can be recovered for re-processing, recycling or disposal

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- information requirement on life cycle water consumption - information requirement on life cycle emissions to water
Air Effects [2] **Environmental impact: Medium** The use of fossil fuel lubricants is a significant cause of air pollution due to their combustion generating VOC, sulphur and nitrogen compounds and their production has a significant impact on ozone depletion and photochemical oxidation ([1]). Research has demonstrated that lubricants indeed have a significant impact on PM emissions. A developed method for estimating the contribution of oil to mean PM, within a 95 % confidence interval, indicated that 13 %-37 % of PM could be attributed to lubricants ([22]), The amount of NOx emissions depends on the type of lubricant used, due to the different content of additives and aromatic compounds ([1]). During the use phase, the degradation of lubricants can generate hazardous secondary chemicals such as PAHs, carbon monoxide and CMRs ([1]). Non-engine lubricants, such as hydraulic fluids, industrial oils, and metalworking fluids, impact air quality primarily through the release VOCs, mist, and aerosols, due to high-temperature applications that may cause thermal decomposition. **Environmental impact: Low** The improvement potential is related to the use phase by using less ecotoxic, more biodegradable base oils and additives, especially for total loss lubricants used in open systems, that are fully released to the environment during use ([6,11]). In Germany and Scandinavia, there are about 80 brands of lubricants produced on the basis of vegetable oils ([6]). However, the development of a common biodegradable base stock that could replace conventional lubricants remains a big challenge ([20]). **Potential measures under ESPR:** - performance requirement on minimum content of sustainable renewable materials - information requirement the content of sustainable renewable materials
Soil Effects [2] **Environmental impact: Medium** The main effects of the lubricants in the soil correspond to the use phase and the end-of-life stage, due to the release into the environment during use (e.g open systems), spills, or incorrect disposal by consumers. Lubricant oil pollution causes serious damage to soil, causing changes in the forms and distribution of organic matter, in the range of carbon, water, nitrogen, and phosphorus, thus altering the proper functioning of the ecosystem. Mineral oil can clog pores in the soil, resulting in reduced aeration and water infiltration. The presence of petroleum compounds may reduce or limit the permeability of soils, and, consequently, cause the degradation of soils due to oxygen deficit ([16]). It was estimated that approx. 50% of all traditional lubricants are released into the environment during use, spills, or disposal ([1]). For bio-based lubricants, impacts can be on land use and indirect land use change depending on the renewable base oil used ([1, 2]). However, available data (from 2015) indicate that vegetable base oils (in EU mostly rapeseed and sunflower) account for <5% of the lubricant market ([1]).t The global market size for biolubricants was USD 2.20 billion in 2019 and is projected to reach USD 2.46 billion by 2025, at a compound annual growth rate of 4.1% between 2020 and 2025 ([23]). **Improvement potential: Low** The improvement potential is related to the use phase by using less ecotoxic, more biodegradable base oils and additives, especially for total loss lubricants used in open systems, that are fully released to the environment during use ([6,11]). In Germany and Scandinavia, there are about 80 brands of lubricants produced utilising vegetable base oils ([6]). However, the development of a common biodegradable base stock that could replace conventional fossil base oils remains a big challenge ([20]). Also, for partial loss and accidental loss lubricants, the risk of spillages with severe adverse impacts should be minimised by e.g. providing enough information to the user ([2]). For example, the EU Ecolabel criteria for lubricants include mandatory information to be displayed on the packaging related to avoiding any spillage of unused product to the environment ([11]).For bio-based lubricant oils, sustainable agricultural best practices during the cultivation of the biomass

would bring considerable environmental benefits to the soil health ([2]). However, available data (from 2015) indicate that vegetable base oils (in EU mostly rapeseed and sunflower) account for <5% of the lubricant market ([1]) The global market size for biolubricants was USD 2.20 billion in 2019 and is projected to reach USD 2.46 billion by 2025, at a compound annual growth rate of 4.1% between 2020 and 2025 ([23]).

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability* certification

- information requirement on sourcing of raw materials from certified sustainable practices

Biodiversity Effects [2]

Environmental impact: Medium

The production phase of vegetable-based oils can lead to deforestation, negative effects on animal populations and indirect land use change. The global market size for biolubricants was USD 2.20 billion in 2019 and is projected to reach USD 2.46 billion by 2025, at a compound annual growth rate of 4.1% between 2020 and 2025 ([23]).The production phase of fossil-based oils has been found to cause the reduction of the ecosystem resilience ([1, 2]). The substantial increase in lubricant oil spillage and inefficient lubricant oil recycling techniques mainly harm the ecosystem. As per estimates, 50% of lubricant oil dispose of into the environment and 95% of this disposed lubricant which put adverse impacts on human lives and the ecosystem ([24]).

Improvement potential: Low

The potential for improvement of bio-based lubricants lies ensuring truly sustainable production and third party certification along supply chains, e.g. following the “Sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass” derived from the REDII Directive. However, available data (from 2015) indicate that vegetable base oils (in EU mostly rapeseed and sunflower) account for <5% of the lubricant market ([1]). Moreover, using less ecotoxic, more biodegradable base oils and additives, especially for total loss lubricants used in open systems, would avoid important impacts to the ecosystems where the release occurs ([6,11]). For example, open systems such are used in forest harvesting which represent very delicate and important ecosystems ([6,11]). However, the development of a common biodegradable base stock that could replace conventional lubricant remains a big challenge ([20]). Finally, for partial loss and accidental loss lubricants, the risk of (hazardous) spillages should be minimised by e.g. providing enough information to the user ([2]). For example, the EU Ecolabel criteria for lubricants include mandatory information to be displayed on the packaging related to avoiding any spillage of unused product to the environment ([11]).

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability* certification

- information requirement on sourcing of raw materials from certified sustainable practices

Waste Generation & Management [2]

Environmental impact: Medium

Only a part of used lubricant oils will reach its end-of-life, due to the unavoidable losses which occur during the use phase of lubricants. For example, engine oil used in vehicles is partly burned during driving, or process oils which are converted into products. For the collectable waste oils, it should be taken into account that waste lubricant oil (WLO) from fossil based lubricants are hazardous waste whose impact will depend on the treatment pathways followed: re-refining to base oils, processing to fuels, application as fuel (energy valorization/recovery) in the cement/lime/steel industry or hazardous waste incineration([7]). Collectable WLO in the EU corresponds to about 47% ([7]). The remaining part is released into the environment during use, spills, or disposal ([2]). About 38% of the lubricant oils placed on the market in the EU was collected as waste oil, which corresponds to a collection rate of collectable WLO of about 82% ([7]). Of the collected WLO, it was estimated that around 61% was sent to re-refining to produce re-refined base oil([7]). Re-refined base oil is a secondary raw material substitutes virgin base oils in lubricants, contributing to a lower EU demand of primary raw materials and thus lowering their environmental impacts. Another 24% of collected WLO is processed to produce fuels and the remaining 11% is used for energy recovery in cement, lime, steel and power

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plants. For the treatment of waste oils, regeneration resulting in re-refined base oil is considered to be the best practice, in particular with regard to the circular economy and waste hierarchy ([7]).

Improvement potential: Low

Collectable WLO which is not currently collected is estimated at 16%. Collection rates of waste oils vary greatly between Member States. In 2018 they ranged between 38 and 100% of the collectable oils ([25]). For this, mandatory and ambitious targets for WLO collection at the EU level and mandatory EPR schemes with defined requirements could help to increase the collection of WLO and minimise the risk of pollution (especially to water and soil) ([7]). More potential for improvement lies in focusing on methods of material valorisation of WLO in order to produce second raw material (base oil) with lower impacts at the production phase ([1]). To implement this, quantitative targets for WLO regeneration have been identified as a determining factor ([7]). Nevertheless, it is important to consider that most lubricants cannot be reused because of degradation and contamination occurring during the use stage, such as a very high content of ash, carbon residues, asphaltenes, materials, metals, water, and other ([17,21])

Potential measures under ESPR:

- performance requirement on ease of upgrading, re-use, remanufacturing and refurbishment
- performance requirement on minimum recycled content
- information requirement on how to correctly use, store and dispose of the product
- information requirement on recycled content

Climate Change [3]

Environmental impact: Medium

The impacts of lubricant oils to climate change occur mainly during the use phase, due to the combustion of the oil, and during raw material extraction and manufacturing/blending, due to the large amount of energy required. Mineral oils are characterised by a higher impact in terms of climate change ([1]). Bio-based oils can have a global warming potential four times smaller than mineral oils if sourced sustainably ([18]), while greenhouse emissions of synthetic oils are almost twice as high as those of mineral base oil ([1]). However, the inclusion of CO_2 emissions due to indirect land use change has the potential to make biological substitutes worse than their conventional counterparts ([3]). At the same time available data (from 2015) indicate that vegetable base oils (in EU mostly rapeseed and sunflower) account for <5% of the lubricant market ([1]). The global market size for biolubricants was USD 2.20 billion in 2019 and is projected to reach USD 2.46 billion by 2025, at a compound annual growth rate of 4.1% between 2020 and 2025 ([23]) It is important to mention that from a life-cycle perspective, the use of lubricant oil in the automotive sector can also have indirect benefits as appropriate lubricant formulations can reduce the engine friction, thus improving fuel economy ([1]).

Improvement potential: Medium

The main potential for improvement of lubricants related to climate change lies in modern re-refining technologies, than can reduce CO_2 emissions by more than 50% as compared to the conventional production of fossil base oil ([2]). Currently (2020 data), the collection rate of collectable WLO is at 82% ([7]); of this 82%, around 61% is sent to re-refining to produce re-refined base oil([7]). Potential measures could also include switching to bio-based lubricant oils, however this should be thoroughly assessed taking into account all factors (including indirect land use change) ([3]).

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- performance requirement on minimum content of sustainable renewable materials
- performance requirement on minimum content of raw material with sustainability certification
- information requirement on carbon footprint

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- information requirement on the share of energy consumption from low carbon energy sources - information requirement the content of sustainable renewable materials
Life Cycle Energy consumption [2] **Environmental impact: Medium** In general, vegetable oil has lower energy consumption during production than mineral and synthetic oils ([2]). For example, it was found that the energy needs for the raw material extraction/production, processing and use for bio-based oils in aluminium rolling is 9 times smaller than for mineral oil ([19]). However, available data (from 2015) indicate that vegetable base oils (in EU mostly rapeseed and sunflower) account for <5% of the lubricant market ([1]). The global market size for biolubricants was USD 2.20 billion in 2019 and is projected to reach USD 2.46 billion by 2025, at a compound annual growth rate of 4.1% between 2020 and 2025 ([23]). In addition, the energy use during production of synthetic oils is higher than for mineral oils ([1]). However, the use of lubricants can contribute to minimize the energy use of several processes and equipment, since they are often used in order to optimize energy efficiency or avoid process energy losses e.g. as heat/friction ([20]). **Improvement potential: Low** The main potential for improvement to reduce energy consumption lies in modern re-refining technologies for waste lubricant oils (WLO), which has a much lower energy consumption than extraction and processing virgin oils ([2]). Currently (2020 data), the collection rate of collectable WLO is at 82% ([7]); of this 82%, around 61% is sent to re-refining to produce re-refined base oil([7]). In addition, energy recovery for WLO would also be preferable than disposal, especially if replacing coal ([1]). However, re-refining technologies can save about 8 % of the energy content of the used oil compared to combusting the oil for heating purposes ([20]). Potential measures could also include switching to bio-based lubricant base oils ([1]). **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - information requirement on life cycle energy consumption
Human Toxicity [2] **Environmental impact: Medium** Lubricants may contain heavy metals, PBTs, vPvB, CMRs, SVHC, respiratory and skin sensitisers, and bioaccumulative chemicals. The bio-based lubricant system scores higher than the petroleum-based lubricant system on human toxicity, mainly at the production stage in some studies. In degradation due to use, lubricants can generate hazardous secondary chemicals such as PAH, carbon monoxide, other CMRs. Occupational exposures to metalworking fluids may cause a variety of health effects ([1, 2]). **Improvement potential: Low** The potential for improvement of lubricants lies in putting in place mechanisms to make available appropriate disposal and separation at both, end-consumer and industrial levels, since approximately 50% of all traditional lubricants are released into the environment during use, spills, or disposal ([2]). In addition to that, lubricating oils used in open cutting systems, such as chainsaws or harvesters in forestry work, should contain only biodegradable components, avoiding the use of fossil fuel lubricants ([6]). **Potential measures under ESPR:** No measures are envisaged under ESPR for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).
Material efficiency [3] **Improvement potential: Medium** The improvement potential of the lubricant industry relies on lightweight design, the optimisation of the product versus packaging ratio, and the recovery of by-products, process residues, and off-spec materials.

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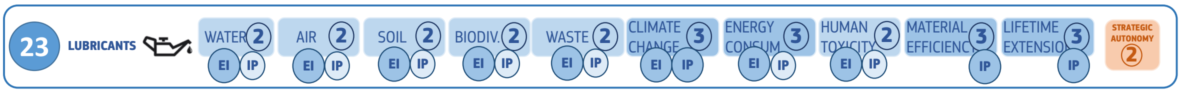
By developing advanced formulations that require less material while maintaining performance, the industry can reduce the weight and volume of lubricants used. Optimizing packaging by using lightweight, recyclable materials and minimizing excess packaging can reduce waste and lower transportation emissions. Additionally, implementing more effective recovery and recycling processes for by-products and off-spec materials during production can minimize waste and promote resource efficiency. **Potential measures under ESPR:** - performance requirement on maximum weight or volume of the product and/or its packaging - performance requirement on maximum product to packaging ratio - performance requirement on minimum amount of by-products/process residues/off-specs recovered - information requirement on product to packaging ratio - information requirement on amount of by-products/process residues/off-specs recovered
Lifetime extension [3] **Improvement potential: Medium** Lifetime extension reduces in a significant way the lifecycle energy consumption and the lifecycle global warming related impacts of non-renewable lubes, due to being assessed taking into account a larger lifetime period. Durability is especially significant when the lubricants are ALL (accidental loss lubricants) which means that they work in closed systems and losses are due to degradation or accidental spills ([1]). Lubricants in equipment should not be changed unless they have reached the end of their useful life. This is typically not the case, because the lubricant is often changed based on an arbitrary time criteria or because of contaminants such as water or dirt. These contaminants can normally be removed with the proper equipment. Less frequent oil changes also reduce the chances of accidental spills ([1]). Among the available lubricant oils, synthetic oils can have higher impacts in the production phase, however the characteristics of these lubricants allow a longer life of the lubricant and require less oil changes, leading to a decrease of environmental impacts during the use phase ([2]). Finally, through proper base fluid and additive selection, it is possible to formulate lubricant products that operate for extended periods of time under proper maintenance without needing to be changed. The results, in this case, are lower lubricant demand and lower waste generation ([17]). However, it is important to state that the use of lubricants can contribute to maximise the lifetime of the machineries they are used in, minimizing wear and maintenance ([20]). For automotive applications, novel lubricants can play a role in solving the automotive industry's challenges with regard to improve fuel economy, limit pollutants, CO_2 emissions and natural resources use. [20]). Finally, condition monitoring and proactive maintenance are critical tools for achieving significant improvement in the performance of mechanical components and extended lubricant life ([20]). **Potential measures under ESPR:** - performance requirement on minimum reliability - information requirement on condition for use and maintenance of the product - information requirement of expected lifetime of the product
Final score [23]

Open Strategic Autonomy score [2]
Policy Gaps The environmental impacts of the lubricants industry to air are regulated in the EU by the Industrial Emissions Directive ([8]). Waste oils are covered by the Waste Framework Directive ([9]). The BAT Reference Document for

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the Refining of Mineral Oil and Gas is relevant for lubricants. Also, the BAT Reference Document on Surface Treatment of Metals and Plastics has a chapter on "minimisation and optimisation of coating from previous mechanical treatments – oil and grease". In 2018, a review on the implementation of EU waste legislation was published, including waste oils. The EU Ecolabel criteria for lubricants ([11]) aim to promote products that have a limited impact on the aquatic environment, contain a limited amount of hazardous substances and perform as well as or better than a conventional lubricant available on the market. In 2017, about 4.3 million tonnes of lubricant and industrial oils were placed on the EU market. The 1.64 million tonnes of waste oils collected in the EU28 in 2017 represent 38% of this amount and is 82% of the theoretically collectable waste oil (~2 million tonnes) 12 . Unavoidable losses of oil, estimated to be 2.3 million tonnes, occur during use, mostly due to burning in engines or by being disposed with other waste. It is estimated that about 18% of collectable waste oils are lost due to burning in small waste oil burners, due to illegal conversion into fuels and, to a limited extent, via direct releases into the environment. Such activities have a direct and deleterious impact on water, soil and air quality, are illegal, contrary to the waste hierarchy and may result in unfair competition with legal waste operators, thereby requiring intensified efforts in terms of collection and enforcement to avoid them ([25]). Regarding bio/based lubricants, there is no policy strategy or legislation specifically dedicated to this product group, and only a few voluntary sustainable certification schemes (ISCC ([12]), RSPO ([13]), and RSB ([14]) among others) have been elaborated to minimise the environmental impacts relating to the cultivation of the renewable oils. With respect to bio-based components, the Commission has adopted a Regulation to tackle EU-driven deforestation and forest degradation (), which should apply equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market. Nevertheless, environmental sustainability requirements related to e.g. sourcing of the raw material are not included in the deforestation-free products regulation. Nevertheless, lubricants produced from animal oils and greases are not covered from the proposed regulation. Collection rates of waste oils vary greatly between Member States. In 2018 they ranged between 38 and 100% of the collectable oils. Based on the analysis of existing waste oil management systems and collection schemes in the EU (and beyond) and of the best practices applied, and on the limited information on waste oil collection and regeneration in the EU Member States, a number of measures to increase the quantity and the quality of waste oils collected could be considered ([25]). Regeneration - depending on the specific technology and context - is superior or comparable to treatment to fuel and superior to direct energy recovery, from a societal cost perspective. This analysis shows that Member States should promote options that deliver the best overall environmental outcome. For waste oil management, this means encouraging the development of installations making use of the best performing and most advanced regeneration technologies ([25]).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA			Related Union law	What could be addressed by ESPR
maximum level of carbon footprint	CLIMATE CHANGE			-	Full potential of the requirement
minimum share of energy consumption from low carbon sources	CLIMATE CHANGE			Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
minimum content of sustainable renewable materials	CLIMATE CHANGE			Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
minimum content of raw material with sustainability certification	CLIMATE CHANGE			Regulation on deforestation-free products	The Deforestation-free Regulation focus on wood. Sets mandatory due diligence rules, but not sustainability certification
maximum product to packaging ratio	CLIMATE CHANGE	MATERIAL EFFICIENCY		-	Full potential of the requirement
maximum weight or volume of the product and/or its packaging	CLIMATE CHANGE	MATERIAL EFFICIENCY			
minimum amount of by-products/process residues/off-specs recovered		MATERIAL EFFICIENCY		-	Full potential of the requirement
minimum reliability	CLIMATE CHANGE		LIFETIME EXTENTION	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA			Related Union Law	What could be addressed by ESPR
content of sustainable renewable materials	CLIMATE CHANGE			-	Full potential for the requirement
sourcing of raw materials from certified sustainable practices	CLIMATE CHANGE			-	Full potential for the requirement
carbon footprint	CLIMATE CHANGE			-	Full potential for the requirement
share of energy consumption from low carbon sources	CLIMATE CHANGE			Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
product to packaging ratio		MATERIAL EFFICIENCY		-	Full potential for the requirement
amount of by-products/process residues/off-specs recovered		MATERIAL EFFICIENCY		-	Full potential for the requirement
condition for use and maintenance of the product	CLIMATE CHANGE		LIFETIME EXTENSION	-	Full potential for the requirement
expected lifetime of the product			LIFETIME EXTENSION	-	Full potential for the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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([10]) COM/2018/656 on the implementation of EU waste legislation, including the early warning report for Member States at risk of missing the 2020 preparation for re-use/recycling target on municipal waste.

([11]) Commission Decision (EU) 2018/1702, of 8 November 2018, establishing the EU Ecolabel criteria for lubricants

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(14) Roundtable on Sustainable Biomaterials. https://rsb.org/

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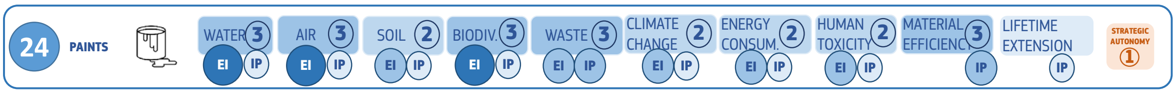
([25]) Report from the Commission to the European Parliament and the Council Circularity of mineral and synthetic lubrication and industrial waste oil management in the EU. COM/2023/670 final

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

PAINTS AND VARNISHES



Scope: Products falling under the scope of the Directive 2004/42/EC (known as the "Paints Directive") for paints and varnishes, and vehicle refinishing products.

- **Paints and varnishes** refer to coatings applied to buildings, their trim and fittings, and associated structures for decorative, functional and protective purpose.
- Note that **vehicle refinishes** also fall under the scope of the "Paints Directive". Vehicle refinishes are used for the coating of road vehicles as defined in Directive 70/156/EEC, or part of them, carried out as part of vehicle repair, conservation or decoration outside of manufacturing installations.

Not included: Paints used in non-road vehicles (i.e., boats, ships, aircrafts…) or road marking paint.

Water Effects [3]

Environmental impact: High

Paints have a high impact on water pollution, with a particular effect on microplastic release, which has been largely overlooked. Paints can release microplastics to the environment during application, wear and tear, or removal. It can also be related to the unused paint or the end-of-life of the painted object ([2]). In 2019 approximatively 21% (around 0.5 million tonnes) of plastic polymers used in different types of paints across the EU leaked into the environment in the form of microplastics, out of which 28 000 tonnes coming from the architectural sector where released into water/oceans and 93 000 into land ([1]).

Paint production has a major dependency on water use as water is the liquid medium used. In addition, a large volume of water is used in the manufacturing process ([3]).

Improvement potential: Low

Reduction of water pollution due to unintentional microplastic release from paints was investigated with a study on 'Cost-benefit analysis of policy measures reducing unintentional release of microplastics' ([4]). The preliminary analysis concluded that further assessment of the emission profile and suitable alternatives are needed to identify the most effective and efficient measures ([1]).

Potential measures under ESPR:

No specific measures have been defined that directly cover water effects. However, measures defined in other environmental areas may also benefit this environmental area.

Air Effects [3]

Environmental impact: High

Paints and varnishes application, drying and wear and tear affect the environment air quality and human health releasing VOCs and particulate matter (PM) which ultimately impacts ozone formation ([5, 6, 7, 8]). The importance of VOCs from paints is regulated through the 'Paints Directive' ([9]). PM emissions due to titanium dioxide (TiO_2) production, which is used as a white pigment, is of particular relevance ([6]). Although further studies are needed to fully determine its cytotoxic and genotoxic potential, TiO_2 is classified as 2B-type carcinogen ("possibly carcinogenic to humans") by the International Agency for Research on Cancer (IARC) ([23])

PAINTS AND VARNISHES
Improvement potential: Low The current use of water-based paints replacing solvent-based paints helps to reduce the environmental impact corresponding to VOC and PM. Water-based paints present lower VOC emission factors (11 g VOC/kg paint) compared to solvent-based paints (80 g VOC/kg paint) ([24]). However it still affects human health due to the use of paint preservation agents needed ([10]). **Potential measures under ESPR:** No specific measures have been defined that directly cover air effects. However, measures defined in other environmental areas may also benefit this environmental area.
Soil Effects [2] **Environmental impact: Medium** Terrestrial ecotoxicity, acidification and land occupation are significant at the production stage of paints and varnishes raw materials (e.g., binders, fillers, oils, pigments). **Improvement potential: Low** Application of BAT for the raw material production shall be put in place, while special care shall be given to avoid cross-media effects ([10, 11]). Storage of raw materials indoors and avoid humid areas while preventing the leachates to soil are measures to take into consideration. A reduction in the use of lead- and zinc-based anti-corrosion paints will reduce the potential leakage of heavy materials into the soil ([25]). **Potential measures under ESPR:** No specific measures have been defined that directly cover soil effects. However, measures defined in other environmental areas may also benefit this environmental area.
Biodiversity Effects [3] **Environmental impact: High** Biodiversity effects from the production of paints could not be assessed. However, given that paints are a source of microplastics (e.g., in 2019 0.5 million tonnes of microplastics where leaked into the environment in the EU ([1]), there is a potential negative effect to water bodies' biodiversity. Unintentional microplastic release in water/oceans relates to bioaccumulation as a potential harm to species. **Improvement potential: Low** Strategies to minimise effects on biodiversity are uncertain. However, some can be tackled in the same way as microplastic reduction, e.g., increasing the reliability of paints at the design phase, avoiding leachates and/or spillages and using paints in an efficient way. **Potential measures under ESPR:** No specific measures have been defined that directly cover biodiversity effects. However, measures defined in other environmental areas may also benefit this environmental area.
Waste Generation & Management [3] **Environmental impact: Medium** Waste from paint utilisation is classified as hazardous waste. Paint waste includes the paints itself as well as contaminated packaging and utensils. Mixed opinions are found in relation to the recyclability of packaging waste from paints ([12, 13]). **Improvement potential: Medium** The main measure to apply is the establishment of separate waste collection measures where paints and contaminated items could be efficiently disposed. In the production phase, the principal BAT conclusion for the raw materials for paints production industry relate to cost-effective choice of feedstock, based on e.g., LCA considerations, with as low as practical level of harmful impurities. This would reduce consumption of

raw materials and energy, reduce waste generation, and provide the lowest environmental burden at the production sites ([11]).

Some companies reported the implementation of waste reduction strategies with the ambition of 100% reusable waste by 2030, showing progress figures such as waste reuse over 50% (reduction compared with 2018 baseline) and 40% reduction in waste per ton since 2011 ([16]) There are also pilot programmes for the recovery of raw materials from other industries in a circular economic approach: an example is the extraction from paper sludge of a chemical as an alternative to calcium carbonate ([21]).

Potential measures under ESPR:

- performance requirement on maximum level of life cycle release of microplastics and nanoplastics
- performance requirement on maximum amount of life cycle waste generated
- performance requirement on maximum amount of life cycle hazardous waste generated
- performance requirement on use of easily recyclable materials
- information requirement on the presence in the product/possible release of non-biodegradable microplastics

Climate Change [2]

Environmental impact: Medium

Some sources claim climate change is the most harmful life cycle impact category of paints ([6, 12]), with raw materials acquisition, use and end-of-life of paints, being the three most relevant life cycle stages.

It is reported that the three biggest contributors to the environmental impact of a paint are: binders, TiO_2 pigment and paint plant energy in production/formulation. In fact, about one quarter of the overall environmental impact of the paint is related to the paint manufacturing process (specifically operating formulation plant), while the remaining 75% of the impact is within the paint manufacturer's supply chain ([10]).

Improvement potential: Low

Application of BAT are measures to take into account to reduce the raw material production's adverse impacts on climate change (e.g., binders, oils, pigments). Special attention shall be given to avoid cross-media effects ([10, 11]).

Potential measures under ESPR:

No specific measures have been defined that directly cover climate change. However, measures defined in other environmental areas may also benefit this environmental area.

Life Cycle Energy consumption [2]

Environmental impact: Medium

The energy use is highly dependent on the characteristics of the final product ([11]). Although the impact is in general high, this has been taken into account in the climate change and other sections, thus it was decided to assign a lower impact in this section. Particular cases shall be studied to shed more light into the variety of products in this group.

Improvement potential: Low

Improving the overall energy efficiency of the paint plant energy consumption by using BAT is the main measure to apply. Nevertheless, limitations towards final product type variety apply ([11]).

Potential measures under ESPR:

No specific measures have been defined that directly cover energy consumption. However, measures defined in other environmental areas may also benefit this environmental area.

Human Toxicity [2]

PAINTS AND VARNISHES

Environmental impact: Medium

There is a number of chemicals which are considered to be of particular concern within the paints industry as a large number of traditional paint ingredients are toxic or harmful ([10]). Paints can contain heavy metals, EDs (endocrine disruptors), PFAS (per- and polyfluoroalkyl substances), persistent, mobile and toxic (PMT) substances, SVHC (Substances of Very High Concern), CMRs (chemicals that cause cancer, gene mutations or are toxic to the reproductive system), respiratory sensitizers, chemicals toxic to specific organs and bioaccumulative chemicals ([10]). Not only the production can be harmful if specific measures are not in place, but home application is also a potential source of exposure to toxic compounds which shall be avoided by formulating paints free of those harmful compounds. A way to assess the potential risk of chemicals in paints is to determine their impact based on the release of a standard amount into the environment ([11]). There are studies that suggest that paint exposure increases the risk of certain illness; however, conclusions found do not show clear evidence ([14, 15]).

Due to the environmental legislation on the use of solvents, the paint sector transitioned to water-based products and, thereby, significantly reduced the emissions of volatile organic compounds in the atmosphere. Water-based products require protection against the development of micro-organisms in the packaging. Without such preservation, the product would deteriorate and become waste within a few days ([20]).

Improvement potential: Low

The improvement potential can be related to a high degree of monitoring and control during the production phase of paints and varnishes to minimise hazardous compounds. Good plant hygiene is the main practice to control contamination sources and therefore to minimise the use of in-can preservatives. However, the use of biocides in plant hygiene cannot be entirely stopped. If not controlled appropriately, microbes can also form biofilms ('fouling') which would end blocking pipes and could ultimately lead to stopping production ([20]).

At the user level, by September 2023, there were almost 36 000 paint and varnish products awarded with EU Ecolabel with proven lower concentrations of hazardous chemicals, such as the mentioned biocides and for so relatively minimised impacts on human toxicity. This demonstrates that there is space for improvement in the whole market ([17]).

Potential measures under ESPR:

No measures are envisaged under ESPR that primarily aim to improve for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.

Material efficiency [3]

Improvement potential: Medium

A reduction in the product to packaging ratio could reduce the use of materials in the packaging. While products with a lower product to packaging ratio are desirable, it could also be counterproductive due to a potential higher waste generation if the products are partially consumed. Research on user behaviour would be required.

Used paint pots present a recycling challenge as they invariably contain leftover paint inside. It appears that the composition of paint pots (both steel and plastic) enables them to be readily recycled. However, containers are very unlikely to be in a sufficiently clean condition for this to be achieved. In some countries, spent paint pots are sent to landfill with efforts directed towards the reuse of leftover paint rather than the recycling of the pots. Recycling of paint pots does appear to be possible in the trade sector as it requires special equipment and is not suitable for the consumer market. Energy recovery appears to be a favoured route to dispose paint pots, e.g., by using those as fuel in cement kiln furnaces. This has the advantage of eliminating any hazardous substances if the air pollutant control is in place (e.g., filtration or any other abatement techniques) ([10]).

Potential measures under ESPR:

- performance requirement on a maximum material footprint of the product.

- performance requirement on minimum amount of by-products/process residues/off-specs recovered.

PAINTS AND VARNISHES
- performance requirement on maximum product to packaging ratio. - performance requirement on minimum reliability (e.g., resistance to water, adhesion, abrasion, weathering). - information requirement on product to packaging ratio. - information requirement on amount of by-products/process residues/off-specs recovered. - information requirement on the material footprint of the product.

Lifetime extension [1]

Improvement potential: Low

The lifetime of a paint/varnish can be checked through several testing procedures, such as resistance to water, adhesion, abrasion or weathering ([18]). However, there is no single universal test to study the different performance aspects of a paint. The durability performance can be investigated based on the overall amount that is necessary to use for painting a certain surface (and reach a predefined painting quality) and the time that is needed until the next repaint ([10]).

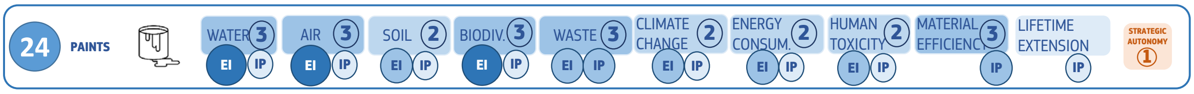
A paint with good performance characteristics will require the use of a small amount of paint to achieve a quality coating and need less frequent repainting. Using less paint results in a lower environmental impact related to the paint production, along with the release of air pollutants during application and the treatment of waste ([10]).

The use of nanoparticles and other nanomaterials offers potential performance enhancements in a wide variety of consumer products. Especially novel nanoparticles within the paint sector are beginning to make an impact in several areas, including increasing drying rate, dirt resistance, better humidity tolerance and water resistivity. The use of silver nanoparticles as a biocide and antibacterial agent is seen as a particular application of interest in paints. The risk associated with the inclusion of nanoparticles within paints requires careful assessment. There is some evidence of an inherent health risk posed by exposure to nanoparticles ([10]).

Potential measures under ESPR:

No specific measures have been defined that directly cover lifetime extension. However, measures defined in other environmental areas may also benefit this environmental area.

Final score [24]



Open Strategic Autonomy score [1]

Policy Gaps

There is an absence of a specific and mandatory regulation promoting ecodesign principles in water-based paints. At the moment, there are only voluntary schemes in place, like the EU ecolabel (Commission Decision C (2014) 3429) – technical criteria currently under revision - and Green Public Procurement (SWD (2017) 484 final) criteria.

Directive 2004/42/EC (known as the 'Paints Directive') lays down the restrictions of emissions of volatile organic compounds due to the use of organic solvents (in can) in decorative paints and varnishes and vehicle refinishing products and amends Directive 1999/13/EC. The BREF for Large Volume Inorganic Chemicals – Solids and Others (LVIC-S) industry (2017) provides BAT to avoid emissions to air and water only in the manufacturing stage of specific paint-related substances and for selected pollutants.

Other regulations of relevance for paints and varnishes are Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH); Regulation (EC) 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP); Regulation 2012/528/EC concerning the making available on the market and use of biocidal products; Directive 2001/95/EC on general product

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safety; the Waste Framework Directive 2019/1004/EC; and Directive 2008/50/EC on ambient air quality and cleaner air for Europe. Regulation 305/2011 on construction products requires information on the emission of formaldehyde, volatile organic compounds (VOCs) in general and any dangerous substances, dangerous particles, or greenhouse gases into the indoor environment. The Circular Economy Action Plan 2020 addresses the presence of microplastics in the environment, while the European Strategy for Plastics in a Circular Economy 2018 also looks at the prevention of microplastics release. In January 2019, ECHA proposed a wide-ranging restriction on microplastics in products placed in the EU/EEA market to avoid or reduce their release to the environment. However, the Commission Regulation (EU) 2023/2055 that amends the list of substances restricted under Annex XVII of REACH does not include the application of microplastics in paints, as intended microplastics would be permanently incorporated in a solid matrix, which is one of the exemptions of the Regulation. It introduces reporting requirements for certain paints ([19]).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT		Related Union law	What could be addressed by ESPR
maximum level of life cycle release of microplastics and nanoplastics	WASTE		Microplastics Regulation	Does not address unintentional release of microplastics
maximum amount of life cycle waste generated	WASTE		Waste Framework Directive	WFD incentivises waste prevention but does not have a product specific approach.
maximum amount of life cycle hazardous waste generated	WASTE		Waste Framework Directive	WFD incentivises waste prevention but does not have a product specific approach.
use of easily recyclable materials	WASTE		Waste Framework Directive	WFD sets recycling targets in the EU but does not have a design approach in and outside the EU.
maximum material footprint of the product	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
minimum amount of by-products/process residues/off-specs recovered	WASTE	MATERIAL EFFICIENCY	Industrial Emission Directive	IED covers the production of some ingredients of paints and varnishes in the EU but not outside the EU.
maximum product to packaging ratio	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
minimum reliability (e.g., resistance to water, adhesion, abrasion, weathering).	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT		Related Union law	What could be addressed by ESPR
presence in the product/possible release of non-biodegradable microplastics	WASTE		Regulation 2023/2055 (REACH restriction on synthetic polymer microparticles)	The REACH restrictions only introduces reporting requirements for certain paint products on intentionally added microplastics, but not consumer information on non-intentionally added
how to correctly use, store and dispose the product (for users and/or treatment facilities)	WASTE		-	Full potential of the requirement
amount of life cycle waste generated	WASTE		-	Full potential of the requirement
amount of life cycle hazardous waste generated	WASTE		Regulation 1272/2008 (CLP)	Required label for paints and varnishes containing lead in a specific quantity; but no reference to waste per se.
use of easily recyclable materials	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
product to packaging ratio	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
amount of by-products/process residues/off-specs recovered	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement
material footprint of the product	WASTE	MATERIAL EFFICIENCY	-	Full potential of the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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Product fiche 9. Textiles and footwear

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

TEXTILES AND FOOTWEAR

Scope: **Textiles:** Any raw, semi-worked, worked, semi-manufactured, manufactured, semi-made-up or made-up product which is exclusively composed of textile fibres, regardless of the mixing or assembly process employed, as well as a product containing at least 80% textile fibres by weight, in line with the Textile Labelling Regulation (Regulation (EU) No 1007/2011). This includes apparel textiles, home/interior textiles and technical textiles usually or also meant for consumers (such as truck covers, cleaning products) or specifically meant for industry (automotive, construction, medical, agriculture, etc). Excluded are: products for which textiles fibres accounts for less than 80% by weight[85] (e.g. upholstery textiles, carpets mainly made of plastics, duvets, pillows), personal protective equipment according to Regulation (EU) 2016/425, apparel textiles identified as medical devices or as an accessory for medical devices according with Regulation (EU) 2017/745, leather and fur. **Footwear:** in line with Directive 94/11/EC, all articles with applied soles designed to protect or cover the foot. Excluded from the scope are: protective footwear covered by Regulation (EU) 2016/425 ([66]), footwear containing any electric or electronic components; toy footwear.
Water Effects [5] **Environmental impact: High** Textiles (clothing, footwear and household textiles) represent the fourth highest pressure category in terms of water use ([1,17]): indeed, in 2015, the global textiles and clothing industry was responsible for the consumption of 79,000 million m^3 of water ([2]), with 92% of the water consumed outside the EU ([1]). Moreover, it was estimated that about 20 % of global water pollution is caused by dyeing and finishing of textile products ([1]): dyeing can indeed require up to 150 l water/kg fabric ([3]), while finishing techniques such as giving the fabrics strength and shine are very water and chemicals intense ([2]). In developing countries, where most of the production takes place, the wastewater is often discharged unfiltered into waterways ([3]). The water consumption of textiles is also due to the cultivation of cotton (used in ~25% of clothes ([118])). The water consumption of cotton however depends on the location and on whether cotton is irrigated or not. The International Cotton Advisory Committee estimated that the irrigated area for cotton is 45% (of the global area used for cotton), and that the irrigation water use is around 2% of total irrigation water for global uses, even if the ICAC acknowledged that irrigation data were the most difficult to get ([81]). Also, the production of polyester fibres and the treatment of knitted fabrics generate wastewater with a high load of heavy metals such as antimony, and with a high hydrocarbon oil index, respectively ([116]). However, the use phase of textiles is estimated as having the largest environmental footprint in the lifecycle of clothes, owing to the water and chemicals used in washing, and the release of microfibers into water ([4]). Microfibres are released throughout the textile value chain, from the production phase to the end-of-life phase: during the manufacturing stages, microplastics are released into the atmosphere and into the wastewater produced ([4,118]); laundering clothes, especially synthetic (~63% of total clothes ([118])), represents the second cause of primary microfibers released into the environment in the world, and accounts for 35% of microfibers release ([5,6]), and current patterns indicate that emissions of microplastics from textiles are projected to rise by approximately 22% by the year

[85] See, in this regard, Articles 3(1)(a) and 2(2)(a) of the Textile Labelling Regulation (EU) 1007/2011

2030 ([119]). Despite the biodegradability of natural fragmented fibres, their potential risk is still under evaluation, as their widespread release into aquatic systems can still lead to ecological disruptions, especially if associated with harmful substances ([120,121]). For footwear, it is estimated that the production of footwear for EU consumption requires around 1,200 million m^3 of blue water (i.e. surface water or groundwater) and 4,000 million m^3 of green water (i.e. rain water) ([67]). The global freshwater consumption for footwear (all life cycle stages considered) reached 29,000 million m^3 of water, 41% of which is consumed during footwear manufacturing, 20% each for raw material processing and footwear assembly and 18% for raw material extraction ([56]). According to the same study, synthetic polymer shoes take up the highest water consumption, 48%, compared to 31% for leather shoes and 21% for textile shoes ([56]). For leather shoes, the tanning process accounts for around 40% of the total impacts of leather shoes production ([56]). Leather shoes accounted for 25% of global footwear production, compared to 57% of synthetic shoes and 18% of textile shoes (2016 data).

Improvement potential: High

One of the main measures to reduce impacts to water is via reusing and recycling textiles. Indeed, it was estimated that at least 16,000 million l water could be saved thanks to reuse and reselling of used clothes ([7]), although the real savings depend on whether consumers will really replace new clothes with reused ones, as shown in ([44]). Incorporating recycling cotton in the production of textiles can reduce the use of blue water, fertilizers and pesticides during cultivation and the use of water, dyes, wetting agents, softener, and other related products during dyeing ([7]). However, while 12.5% of the global fashion market has committed to using recycled fibres ([8]), it is not yet advancing at the speed and scale required: the share of recycled polyester reached 14% in 2019 (mainly from PET bottles) ([8,111]), while the market share of recycled cotton, polyamide, man-made cellulose fibres, and wool is still low ([8,118]). Moreover, the use of mechanically recycled fibres impacts the quality of the yarn and the garment, therefore needs to be blended with virgin materials and dyed ([11]). With respect to organic vs conventional cotton, different studies provide different results: according to ([82]) and ([83]), the cultivation of organic cotton is able to save 87-88% irrigation water compared to conventional cotton; other publications, however, report that organic cotton consume 10% more water than conventional one ([12,84,85]). More, updated, and reliable studies are needed before taking any conclusion on this aspect. Water conservation programs can decrease water use during manufacturing, by using efficient washing equipment, avoiding excessively long washing circles and reusing water for more than one process ([19]). Water use savings are expected to be ~30% and more for some processes, e.g. 70% for dyeing by intermittent rinsing ([19]). Reducing the consumption of chemicals, replacing them with enzymes, and using dye controllers also can result in significant improvement, e.g. 25% less water use by replacing chemicals with enzymes ([4]). Moreover, it was estimated that chemicals used in dyeing could be decreased by ~60% when using machine controllers ([4]). Finally, several initiatives exist to fight microfibers releases from synthetic textiles, resulting for example into guidance for product development, in addition to innovative microfiber free materials ([8]). Designing clothing that uses non-toxic dyes and more shed-resistant or safely biodegradable fabrics helps avoid the leakage of hazardous substances and microfibers into the environment ([26]).

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- performance requirement on maximum level of life cycle emissions to water
- performance requirement on design for resistance to stresses or ageing mechanisms
- information requirement on life cycle water consumption
- information requirement on life cycle emissions to water
- information requirement on the possible release of non-biodegradable microplastics

Air Effects [3]

Environmental impact: High

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The air emissions linked to textile products are VOC[86] produced during coating, lamination, printing, dyeing and finishing ([22]); formaldehyde originated during coating, laminating, finishing and printing ([22]); dust emissions, mainly for singeing, fabric production, drying, curing and heat fixation ([22]); particulate matter and other air pollutants related to the large use of energy during production and laundering of textiles – for example, it is estimated that Chinese textile factories produce about 3 billion tons of soot every year by burning coal for energy to make clothes ([20]). In the case of the footwear industry, air pollution is related to the incineration of leather waste ([60]) and PVC, which is often used as an alternative to leather footwear, which can lead to the formation of dioxins and non-methane volatile organic compound ([59]). The use of synthetic textiles is associated with microplastics release, and especially from activities such as mechanical drying of clothes, dressing, folding clothes, wear and tear and, potentially, wind abrasion ([89,90,91,92,93,94]). Microplastic fibres from textiles are mobile and have been detected in outdoor dust, atmospheric samples from the open ocean, in remote locations and are suspected to remain in the convective plume surrounding the body (Thomas, 2008), within an individual's personal cloud, thus increasing inhalation exposure to ambient microplastics when seated and clothing mediated exposure of chemical additives and particulates ([89,91,92,95,96,97]). The number of publications on microplastics in the atmosphere rose from fewer than ten in 2015 and 2016 to more than 100 in 2022, demonstrating the growing concern about the subject within the scientific community ([98]). **Improvement potential: Low** Measures to abate emissions of VOC, formaldehyde and dust include wet scrubbers and condensation ([22]). For these measures there is still some improvement potential, as it was reported that only 16% of EU textiles making installations uses abatement techniques for VOC ([22]). Switching to renewable sources of energy would decrease the air emissions related to energy derived from fossil sources. With respect to microplastics release from synthetic textiles, it has been found that it can be influenced by fabric type, particle size, fabric loading, bonding, wear of the clothing item and fibre construction (being of woven or knit construction), in addition to the intensity of the activity carried out on the textile itself ([89,99,100,101]), suggesting that some improvement potential can be associated with changes in the design of synthetic textiles. However, although design guidelines are being developed ([8]), the estimation of the benefits is unknown at this stage. Recycling of PVC footwear, as opposed to its incineration, is a recommended practice to reduce emissions of plastic footwear to the environment ([69]). The reduction of emissions of pollutants during the manufacturing stage could be addressed through the use of air filters installed in the exhausters of the painting booths ([59]). **Potential measures under ESPR:** - performance requirement on maximum level of life cycle emissions to air - information requirement on the level of life cycle emissions to air
Soil Effects [4] **Environmental impact: High** Clothing, footwear and household textiles represent the second highest pressure category on land use ([1]). The majority of pressures on land use come from outside the EU (93 %) and are largely a consequence of cotton cultivation ([1]). Cotton cultivation uses 2.5% of global agricultural land, but is linked to large use of fertilisers, pesticides and insecticides ([2,15]): around 3% of fertilisers, 5% of pesticides and 14% of insecticides sold globally are destined for use on cotton ([23,81]). It has been showed that improper application of pesticides has led to an increase in pest resistance and to the reduction of crop yields ([4]). With respect to synthetic fibres, the production of plastic polymers releases gaseous pollutants which can enter the soil directly through acid rain or atmospheric deposition, in addition to incorrect chemical storage or direct discharge of waste into the soil ([105]). Other sources of pollution to soil are accidental emissions (spillages) during chemical production, which can have a significant impact on the environment ([106]). Moreover, the microplastics release from synthetic textiles can have an impact on soil via outdoor deposition and dust ([96]).

[86] Volatile organic components

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Improvement potential: Medium Reuse and recycling have the potential of reducing the production of new items, and therefore the cultivation of cotton and the production of polyester fibres, although the real savings depend on whether consumers will really replace new clothes with reused ones, as shown in ([44]). A study assuming an increase of 15% in recycling and 12% in reuse of EU textile waste showed a decrease in land occupation by 10%, and land transformation by 6% ([4]). However, the utilisation rate of recycled fibres is still low, especially in China, the largest producer of textiles ([25]). The use of organic cotton can reduce the use of pesticides; however, organic crop yields is generally lower and can lead to increased (up to 3.5x) land use ([4,24,114]). An increased use of natural fibres such as flax and hemp could also help reducing the pressure on the environment, given their high yields, durability and strength ([4]). Finally, regenerative cultivation practices[87] can improve soil health, increase the soil's water retention capacity and reduce reliance on fertilisers and pesticides ([26]). All in all, the potential for action for ESPR will need to be tailored to the specific environmental and climate situations of different exporting countries. **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [4] **Environmental impact: High** The fashion industry is a major player in biodiversity impacts through deforestation and degradation of natural habitats; pollution of air, water, and soil; and contribution to climate change ([26, 27]). Examples of impacts are the use of chemicals with high concern for the environment due to their capacity to spread globally and bioaccumulate ([28]), microfibers released into the environment (35% of total primary microfibres release) ([5]), and the spread of invasive alien species due to long-range transport of raw materials that fashion products facilitates ([29, 30]). Biodiversity impacts are usually considered very high for cashmere([26]), due to the impacts that the (increasingly high) population of goats have on rangeland degradation ([86]). However, an increasing number of studies challenges this view, as it is difficult to isolate the effects of livestock from climate and other factors that influence ecosystem conditions, and defining rangeland degradation and its underlying causes remains controversial ([87,88]). **Improvement potential: Medium** The conservation and restoration of biodiversity is of great importance to the EU and globally, as it is declared in the United Nations Biodiversity Framework ([80]). The UN Biodiversity Framework sets out 25 targets, and its target 10 aims to 'ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably, in particular through the sustainable use of biodiversity, including through a substantial increase of the application of biodiversity friendly practices, such as sustainable intensification, agroecological and other innovative approaches, contributing to the resilience and long-term efficiency and productivity of these production systems, and to food security, conserving and restoring biodiversity and maintaining nature's contributions to people, including ecosystem functions and services' ([80]). In the context of textiles, this is important to agricultural practices related to the production of natural fibres as well as man-made cellulose fibres. Improvement potential related to increased used of sustainable sourcing of fibres and reuse and recycling options has the potential to help gradually decouple the sector's growth from its impacts on biodiversity ([26,33]). However, recycled fibres are still emerging: for example, the market share of recycled man-made cellulose fibres is estimated at ~0.5% ([8,118]). Several initiatives exist to fight microfibers releases from textiles, resulting for example into guidance for product development, in addition to innovative microfibre free materials ([8]). Designing clothing that uses non-toxic dyes and more shed-resistant or safely biodegradable fabrics helps avoid the leakage of hazardous substances and microfibres into the environment ([26]). Finally,

[87] Regenerative agriculture is a conservation and rehabilitation approach to food and farming systems.

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producing fibres and materials regeneratively helps establish healthy agro-ecosystems, reverse land degradation, and minimise GHG emissions and pollution ([26]). **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Waste Generation & Management [5] **Environmental impact: High** In 2015, the global textiles and clothing industry was responsible for 92 million tons of waste, both in the supply chain and at the end of the product's life ([2,34]). Industry's waste is significantly affected by overproduction patterns: it was estimated that 4-9 % of garments are over-produced and disposed of without being worn even once to preserve the exclusiveness of the brand ([67]). On the other hand, cut-offs during production are responsible for about 20 % of the industry's fabric waste ([3]). In 2019, the EU-27 generated 12.6 Mt of textile waste; 11% was post-industrial waste, 3% was pre-consumer waste, and 86% was post-consumer waste ([115]). Research has also shown that poor fit and sizing issues are just as important as wear and tear for clothing disposal in the EU ([72,118]): approximately one-third of clothing is discarded due to problems with fit and sizing ([73]). Fit is also important factor in returned goods, a growing problem due to the rise of internet shopping ([74]). 87% of textile waste is landfilled or incinerated after its final use, and less than 1% of all clothing is recycled back into apparel, as most of the material being recycled is cascaded into lower-value applications such as cleaning cloths, insulation material, and mattress stuffing ([31]). Within this landscape, wool garments seem to be an exception, since industrial-scale mechanical recycling of post-consumer wool clothes is available already today in the UK and in Italy ([76,77]). As regards the footwear industry, household consumption of footwear in Europe in 2020 is estimated to amount to 2.7 kg of shoes per capita ([67]), which stayed relatively constant over the last decade. This means that the past decade saw a total cumulative consumption of over 12 million tonnes shoes (around 1.2 million tonnes per year). Household expenditure for footwear in 2021 represented 0.8% of total household expenditure ([68]). A previous study from 2018 estimated that Europe consumes 2.1 pairs of shoes per year per capita, compared to the almost 7 pairs in the US and almost 2 pairs in China ([56]). It is estimated that the production of all footwear purchased by EU households in 2020 used around 53 million tonnes of primary raw materials ([67]). Synthetic shoes represent more than half of the impacts in terms of resource depletion, mainly due to polyethylene and polyester production and the overall large number of synthetic shoes produced ([56]). The waste generated during manufacturing depends on the kind of shoe manufactured. In the case of leather shoes, the material with the greatest negative impact on the life cycle of a footwear ([57,61]), the total pre-consumer waste generated per pair shoes is about 90g. This means an amount of approximately 0.5 million tons of waste ([60]). The recycling of PVC footwear involves mainly mechanical recycling, composed by the separation, grinding, washing and reprocessing of the PVC to make new plastic footwear. The reduced mechanical properties of recycled PVC can be improved vis the addition of stabilisers, to reach the same quality as virgin PVC ([69]). However, the economic viability of mechanical PVC recycling depends on the availability of a large, homogeneous and source-separated waste stream ([69]). Post-consumer footwear waste is normally not separately collected in the EU to be repurposed for reuse/recycling. In the absence of a recycling technology at scale, incineration is often the ultimate End-of-Life option. **Improvement potential: High** There is high untapped potential with respect to the end-of-life of textiles ([31,35]). Better fit, more correct labelling of fit, is a design problem with the potential for major improvements both in terms of environmental impact and for the individual consumer. This includes everything from updated measurements of EU's population, better systems, better grading (especially of large sizes) and better and more correct labelling, which have the potential to reduce waste of items that may not even been worn ([73,75]). Companies can adopt circular business models to ensure that waste and overproduction are avoided, e.g. by shifting towards on-demand production, lending, renting, repair and resale ([35,62]). In fact, clothes, footwear and other textile products are mainly repairable, upgradeable and throughout history they have been objects for repair and adaptation to the user and changes in taste and body measurements. While little is repaired today, some studies claim it is not because items cannot be repaired, but because it costs less to buy new, and because the item value for the owner is too small ([79]). In terms of reuse, the global second-hand fashion market is estimated at EUR

130,000 million, and is expected to grow a 127% by 2026, especially via online resale ([38]). Product design, e.g. reducing the complexity of materials used to produce textiles, could enhance durability, thus postponing the end-of-life of the product, and allow easier recycling solutions ([31]). Recycling of PVC footwear, as opposed to its incineration, is a recommended practice to reduce the use of non-renewable resources ([59]). Techniques associated with improving the design and materials use in the manufacture of shoes are of particular interest, as the management of post-consumer waste is a major issue in this sector ([57]). Some brands committed to no production waste sent to landfill by 2023 ([42]). While the sector is keen on increasing the uptake of recycled fibres, several barriers exist, and the use of recycled fibres in recent years has been of 14% for polyester, 7% for wool, 2% for polyamide, 1% for cotton, and 0.5% for man-made cellulose fibres such as viscose ([8,118]). Most recycled polyester on the market is currently based on plastic PET bottles, and its availability is constrained by (increasing) competition with other sectors such as packaging ([111]). At the same time, by using recycled PET as the main source for recycled synthetic fibres, the value of polyester fibres in discarded textiles is currently being lost ([8]). In any case, increased recycling of textiles cannot decrease the overall environmental burden of the sector if textiles' production and consumption continues to grow ([107]). Moreover, the fact that used textiles are normally defined as waste is a significant barrier to the market for reuse and recycling. The definition of what is textile waste is not harmonised among different EU countries, which hinders trades and possibly decreases the possibility of reusing certain textile streams ([39]). For unsold items, existing alternatives to resource destruction (e.g. incineration) are: recycling of the material (eg. fibres) to be part of another product; donations to non-EU countries; enhanced selling efforts across the value chain (Business-Business, Business-Consumers); and/or switching to on-demand models ([35,37]).

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated
- performance requirement on safe, easy and non-destructive access to recyclable components
- performance requirement on the use of easily recyclable materials or combination of materials
- performance requirement on the use of component and material coding standards for the identification of components and materials
- performance requirement on minimum recycled content
- performance requirement on use of easily recyclable materials
- performance requirement on the maximum number of materials and components used
- performance requirement on adequate and standard sizing and fitting of the product
- information requirement on recycled content
- information requirement on how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities)
- information requirement on the coding standards for the identification of components and materials
- information requirement on maximum amount of waste sent to landfill

Climate Change [5]

Environmental impact: High

The fashion industry is said to be responsible for 2-8 % of annual global carbon emissions ([26,56,111,118]). The upstream value chain of clothing, footwear and household textiles consumed in the EU is the fifth highest GHG emission pressure category, and only 25% of the emissions take place inside the EU ([1]). Emissions are mostly related to the production phase, accounting for around 80% of the value chain of textiles ([67,71]). Textiles made from natural fibres, such as cotton, generally have the lowest climate impact, while those made from synthetic fibres (especially nylon and acrylic) generally have a higher climate impact because of their fossil fuel origin and the energy consumed during production ([4,67]). Textile production processes are responsible for a large share of the impacts, with knitting and weaving estimated to contribute to 50% of the GHG emissions. The use phase (washing, drying and ironing) accounts for approx.. 14% of the climate change impacts of textiles ([4,67]). Footwear approximately represents one-fifth the impact of the apparel industry, accounting for 1.4% of global climate impacts (2016 data) ([56]) Of the 121 million tonnes CO_{2eq} generated for the resource extraction, production, washing, drying, and waste incineration of textiles and footwear, 20% is attributable to footwear only (so, around 24 million tonnes CO_{2eq})([67]). The manufacturing step of footwear accounts for around 40% of such impacts ([56]), especially PVC ([59]), via carbon-intensive processes ([1]). The raw material extraction and the assembly phases account for around 20% of CO_{2eq} missions (each phase) ([56]). Raw material processing accounts for more than 10% of CO_{2eq} emission, whereas transport and disposal have a much lower contribution ([56]).

Improvement potential: High

According to estimations, the textiles sector should decrease its GHG emissions by ~50% in order to stay on the 1.5-degree pathway ([43]): 60% of the accelerated abatement potential is expected to lie in decarbonising upstream operations, 20% in brands' own operations and 20% in encouraging sustainable consumer behaviour ([43]). Several players on the market have committed to a goal of reducing 30% CO_2 emissions from textile fibre and material production by 2030, with a vision of achieving net-zero emissions by 2050 ([8,42]). Measures related to decrease the textiles' upstream impacts on climate change include maximising material and energy efficiency, scaling up recycled materials, and switching to renewable sources of energy ([43,111]). Material efficiency measures lie in improved design, material selection and improved manufacturing methods. Recycled materials include polyester, nylon and cotton; GHG savings could be achieved if their use in textile production could be increased, although barriers in terms of costs, availability and quality need to be addressed ([111]). Combined, these material efficiency and use of recycled materials could reduce climate change impacts by 6% ([111]). Measures related to cotton cultivation have been found to achieve unclear results, with studies finding that climate change impacts for conventional and organic cotton can be considered similar taking into account the high variability within the same kind of cultivation ([4,12]), and other studies concluding that improved farming practices and reduced synthetic inputs in cotton cultivation can achieve GHG savings ([41,43]): more and updated studies are needed to be more conclusive regarding the climate impacts of organic vs. conventional cotton ([112]). Variations in the impacts of cotton production can be due to tillage practices, rate of synthetic fertiliser use, harvesting equipment and similar ([112]). In general, however, there is a lack of data for conventional as well as for new and alternative fibres ([112]). Possible energy efficiency improvements were estimated at 20% for polyester production, 5% for spinning and knitting operations, 30% for heating, ventilation and air conditioning-related equipment and 20% in sewing through new technologies and equipment upgrades ([43]), although another study estimated a lower saving potential at 6% overall ([111]). Switching to renewable energy across the whole textile value chain was estimated to possibly deliver 40% savings ([111]). Individual processes can have different GHG reduction potential: for synthetic fibres, the abatement of emissions of N_2O (a potent greenhouse gas) for the adipic acid route has been developed, and its implementation in the production of PA66 (a synthetic polymer) can improve its climate impact ([112]); dope dyeing of synthetic fibres can result in 90% fewer emissions than batch dyeing ([111]). An analysis across over 44 Italian manufacturers of machinery for the textile industry found that innovation was able to reduce carbon footprint by between around 20% in knitting to by more than 80% in weaving and other ([114]). Improving textiles' end-of-life also has a high potential of reducing the GHG emissions of the sector. A scenario assuming an increase of 15% in recycling and 12% in reuse of EU textile waste should reduce climate change impact by 8% ([4]), while the savings from circular business models such as on-demand production, lending, renting, repair, technological improvements on predicting size and fit , and reduce overproduction should be better studied, but are expected to be promising. Finally, reduced washing and drying of textile products in the use phase are expected to save 186 million tonnes of CO_2 ([43]), but this is very much linked to consumer behaviour.

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- performance requirement on minimum content of sustainable renewable materials
- information requirement on carbon footprint
- information requirement on the share of energy consumption from low carbon energy sources
- information requirement the content of sustainable renewable materials

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Life Cycle Energy consumption [5] **Environmental impact: High** Almost all life-cycle stages of the apparel textiles have a significant energy consumption ([117]). In particular, some processes are highly energy-demanding, like the extraction of raw materials, specifically in the cases of synthetic fibres, and production processes such as spinning, knitting, weaving, dyeing or giving the fabrics strength and shine ([2,3,118]). Regardless of the type of fibres used, the manufacturing stages cover about 70-80% of the total life-cycle energy consumption of textiles ([122,123]). Moreover, the use phase of textiles has large environmental impacts in the lifecycle of clothes owing to the energy used in washing, tumble drying and ironing ([4]). Electricity in the footwear industry is used to move everything that makes use of motor, which can include, in the case of synthetic shoes, lathes for machining injection dies; injection molding machines; mill, conveyor belt and sieve; conveyor belt for production and assembly of footwear, painting equipment, etc ([59]). Heat is used, in the case of synthetic shoes, for the process of casting aluminum for the production of blocks in which the injection molding take place ([59]). The energy consumption largely varies according to the country where the textile/footwear production process occurs ([118]). **Improvement potential: High** Energy efficiency measures can be applied throughout the textiles' supply chain: in polyester production (the most used fibre in textiles), for spinning and knitting operations, in sewing through new technologies and equipment upgrades, for heating, ventilation and air conditioning-related equipment during production and in shops([43]). Reuse practices have the potential to avoid new energy consumption for the production of new items, while recycling has lower saving potential due to the energy needs for the recycling operations ([18,44]). Finally, lower washing temperatures can result in large savings: an EU-wide average reduction of 3°C of the wash temperature can reduce the average laundry energy consumption by 11%, compared to the 18% if it was reduced by 5°C ([54]). Increased efficiency in the use of electricity during production can be achieved through the use of capacitor banks as well as through the preventive maintenance of the motors) ([59]). **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - information requirement on life cycle energy consumption
Human Toxicity [2] **Environmental impact: Medium** Human toxicity impacts from textiles occur for different reasons. Pesticides use in cotton cultivation has been associated with impacts on the health of workers and surrounding populations ([4]). Air-borne fibre fragment emissions in factories have health implications on workers ([8]). Antimony is used as a catalyst in the polymerisation process of polyester fabrics (not in the EU where it is banned, but production of textiles largely takes place outside the EU) ([102]), and can escape from polyester clothing during skin contact with perspiration ([103,104]). The impacts of microfibers release during laundering pose different health outcomes as particulates <100 μm are inhaled and move into the nasopharyngeal airways; smaller PM 10 particles move into the thoracic region; PM 2.5 are able to penetrate into the deeper alveolar areas of the lung and are associated with various diseases ([89]). Microfibers can also carry toxic substances on their surface or within their materials ([50]). Moreover, of the 3,500 substances that are used in textile production, 750 have been classified as hazardous for human health ([1]). These are toxic and persistent chemicals, such as water repellents or dyes currently used in non-EU textile processing for performance or aesthetic purposes ([31]). Example of harmful substances are chlorinated solvents, azo dyes, chlorobenzenes, phthalates, perfluorinated chemicals, formaldehydes and chlorinated paraffins ([55]). In addition, PVC is often used as a substitute for leather, which generates dioxins in its life cycle. Dioxins are persistent and bioaccumulative endocrine disrupting chemicals and therefore pose a serious threat to human health ([58,59]). Harmful substances could be released when apparel textiles are landfilled and incinerated. Degradation of textiles in landfills was estimated to release about 2,000 tonnes of hazardous substances annually in the EU ([118]). For footwear, it was estimated that global production and consumption of footwear is responsible for 514,000 disability-adjusted life years** (DALYs)([56]). Such impacts are attributable mainly to the manufacturing stage (38% of impacts), raw material extraction (23%), assembly (18%) and raw material processing (16%). Packaging production, transport and

disposal contribute to a much lower extent [56]. It is also worth noting, in the case of leather industry, the toxicity of the chromium salts used in approximately 90% of the world's tanning production, which are carcinogenic. Nevertheless, synthetic shoes are expected to generate more impacts than leather shoes in terms of human health [56]. PVC, which is often used as a substitute for leather, generates dioxins in its life cycle [58,59]. Moreover, PVC footwear requires the use of stabilisers, which may be in the form of heavy metals such as lead and cadmium, and plasticizers, mainly the phthalates [59].

Improvement potential: Low

Shifting to safe chemistry in the fashion industry's value chain protects the health of ecosystems and people [26]. Colouring methods are being developed that eliminate the use of hazardous chemicals, therefore reducing the potential harm to people and the environment [26,45]. Schemes like the EU Ecolabel, Nordic Swan, Blue Angel and Zero Discharge of Hazardous Chemicals' Manufacturing Restricted Substances List have proven successful at preventing toxic substances from entering the value chain [46,47,48]. Alternatives exist to the use of antimony as catalyst in polyester fabrics, and it seems that Asia is switching to antimony alternatives [104]. Further potential lies in developing alternatives to conventional chemicals and processes that do not have harmful environmental effects [26]. When it is unavoidable to use toxic substances, measures are being developed that extracts chemicals during recycling processes, eliminating them from the final garment [49,59]. Increasing fabric resistance to shedding or finding alternative materials that can safely biodegrade if they leak into the environment can be some of the measures to prevent microfibers formation [51,52]. Recent developments see the increased use of environmentally-friendly materials for inks, solvents and chemical additives, such as water-based inks to replace solvent-based inks and the use of Dioctyl adipate plasticizer as substitute for Dioctyl Phthalate [59]. For the stabilisers used in the footwear industry, the situation has improved drastically in the last decades, as the use of lead stabilisers was reduced by 68% in PVC production [70].

Potential measures under ESPR:

No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts

Material efficiency [5]

Improvement potential: High

The textiles value chain includes little or no reuse or recycling [1]. Product design solutions have the potential to change this figure. For example, reducing the complexity of materials used to produce textiles, and textile products themselves, would allow more and easier recycling technologies [31]. Material recovery would also benefit from adopting product passports and materials labelling at the design stage [31]. Harmonised collection systems across the EU, highly specialised personnel sorting textile waste, and a revised definition of textile waste could increase the share of textile waste reused or recycled [39,53]. The impacts arising from the destruction of unsold goods could be addressed by on-demand models, recycling of the material and reuse in non-EU countries [35,37].

Potential measures under ESPR:

- performance requirement on minimum amount of process residues
- information requirement on maximum product to packaging ratio
- information requirement on amount of process residues
- information requirement on lightweight design

Lifetime extension [3]

Improvement potential: Medium

The lifespan of apparel textile is affected by many factors related to the specific type of apparel textiles, the intrinsic physical properties of the product, and the behaviour of the users [118]. Products of fast fashion usually have a short lifetime, and European consumers purchased 40% more clothing in 2012 compared to

1996, but, over the last 20 years, the use time of clothes decreased by 36%, with each garment used an average of seven or eight times ([27,31,67,110]). The lack of a direct measurement method often does not allow a better understanding of this important parameter ([118]). Increasing the lifetime of textile products can be achieved by using it for longer or reselling it for reuse by someone else. Estimates show that if the number of times a garment is worn is doubled, the GHG emissions would be 44-50 % lower ([31,112]), assuming that extending the textile lifetime leads to reduced consumption of new textile – which may however not be the case as it is highly dependent on user behaviour. In a life cycle perspective, the garment life length is a crucial aspect for reducing the environmental load also from the fibres, so it is essential that the fibres do not negatively influence the garment life length ([112]). This could be achieved by measures that ensure and increase the durability of the items and the resistance to shrinkage/weather, colour fastness, and resistance to abrasion ([31]). While it comes with high variability of results, surveys found that 8-72% of all reasons for consumers discarding clothes are linked to (functional) changes of garments, including holes or tears, worn-out appearance, loss of elasticity or shape, stains, colour changing or fading ([79,118]). At the same time, 88 % out of 27,498 EU-27 citizens indicated that apparel should be made to last longer ([124]). Nevertheless, there are studies arguing that the short lifespan of textile products cannot be resolved through a purely material approach, as obsolescence is not the result of a quality defect, but rather of a psycho-social process, influenced by aesthetic developments and fashion trends ([78]). At the same time, studies estimate that resale will become twice as big as fast fashion by 2030 ([26]). A study suggests that repair, re-commerce, rental and refurbishment models can extend average product life by 1.35, 1.7, 1.8 and 2 times ([41]). However, 11% of survey respondents rated reparability as important when purchasing apparel items such as coats or jackets ([118]). Nevertheless, caution should be paid to the so-called 'rebound effect'***, and the fact that consumers' belief that their purchases are 'impact free' does not lead to them making as many purchases as they please, or buying them in addition to new items. In fact, the results of another study showed that the impacts from rental systems can even be higher than normal use of the garment, depending on the number of times the garment is worn and the type of delivery system (results related to the use of a pair of jeans, only in terms of global warming potential) ([109]). On the other hand, the study confirmed that impacts brought by extending the lifetime can be ~1/3 compared to buying a new garment, underlying the importance of better quality and design ([109]). Still, the overall environmental burdens of the textile sector cannot be reduced if consumers buy new garments in addition to extending the lifetime of the garments they already own ([108,109]).

Potential measures under ESPR:

- performance requirement on minimum reliability (e.g. resistance to stresses or ageing mechanisms, minimum amount of wear and wash before changes in the shape, colour, appearance)

- performance requirement on availability and affordability of spare parts (design for repair and maintenance)

- performance requirement on compatibility with commonly available tools and spare parts

- performance requirement on the use of standard components

- information requirement on condition for use and maintenance of the product

- information requirement of expected lifetime of the product

- information requirement on resistance to stresses or ageing mechanisms

Final environmental score [42]

Open Strategic Autonomy score [1]

Policy Gaps

The production of textiles, clothing, and footwear has one of the most complex global value chains, with most products on the internal EU market manufactured outside the EU, often in countries with lower labour and environmental standards ([2]). In the EU, the level of emissions from the textile industry is regulated via

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the Industrial Emission Directive (IED), which is however only addressing EU installations. Non-EU production, which is expected to cover the vast majority of textile products, is not covered by the IED. The Textile Regulation (EU) No 1007/2011 aligns laws in all EU countries on fibre names and related labelling and marking of the fibre composition of textile products, including an obligation to state the full fibre composition of textile products at all stages of industrial processing and commercial distribution. The EU also lays down European standards relating to textiles and clothing, relating to performance for certain types of textile products and to self-declared environmental claims[88]. No recycling targets are set at the moment for textile waste; however, the revised EU Waste Framework Directive (WFD) requires that as of 2025 MS shall establish systems for the separate collection of textile waste, with specific recycling targets to be set by the end of 2024. Regarding bio-based fibres, the EC has recently proposed a Regulation to tackle EU-driven deforestation and forest degradation ([63]), which should apply equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market. The Personal Protective Equipment Regulation (EU) 2016/425 lays down requirements for the design and manufacture of protective clothing, garments and footwear, however it does not address their environmental performance. The EU has also a voluntary EU ecolabel for textiles, establishing criteria such as limited use of substances harmful to health and environment, reduction in water and air pollution, extension of the lifetime of clothes (e.g. resistance to shrinking during washing and drying and colour resistance to perspiration, washing, wet and dry rubbing and light exposure) ([46]). Finally, the EU Green Public Procurement criteria for textiles facilitate the inclusion of green requirements in public tender documents that Member States and public authorities can implement to the extent to which they themselves wish ([56]).

[88] CEN/TS 16822:2015

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT						Related Union Law	What could be addressed by ESPR
maximum limit of life cycle water consumption	WATER						Industrial Emission Directive	IED covers the production of textiles, but not other life cycle stages or textiles production outside the EU
maximum level of life cycle emissions to water	WATER						Industrial Emission Directive	IED covers the production of textiles, but not other life cycle stages or textiles production outside the EU
minimum content of raw material with sustainability certification	WATER	SOIL	BIODIVERSITY		CLIMATE CHANGE		Regulation on deforestation-free products	The Deforestation-free Regulation only addresses wood, rubber, cattle, coffee, cocoa, palm oil and soy. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated				WASTE			Waste Framework Directive	WFD incentivizes waste prevention but does not have a product-specific approach
safe, easy and non-destructive access to recyclable components				WASTE			-	Full potential of the requirement
use of easily recyclable materials or combination of materials	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	Waste Framework Directive	WFD sets recycling targets in the EU. But does not have a design approach in and outside the EU
use of component and material coding standards for the identification of components and materials				WASTE			-	Full potential of the requirement
minimum recycled content	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
maximum number of materials and components used				WASTE			-	Full potential of the requirement
adequate and standard sizing and fitting of the product				WASTE			-	Full potential of the requirement

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT									Related Union Law	What could be addressed by ESPR
maximum level of carbon footprint				BIODIVERSITY		CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
minimum share of energy consumption from low carbon sources				BIODIVERSITY		CLIMATE CHANGE				Renewable Energy Directive II	RED II is not product-specific and does not address production outside the EU. It includes voluntary labelling, but not mandatory requirements
minimum content of sustainable renewable materials				BIODIVERSITY		CLIMATE CHANGE				Renewable Energy Directive II	RED II sets sustainability requirements for biomass but not mandatory minimum use of renewable materials
maximum level of life cycle energy consumption						CLIMATE CHANGE	ENERGY USE			Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU, but not outside the EU. Also, EED is not product-specific
minimum amount of process residues					WASTE			MAT EFF.		Industrial Emission Directive	IED covers the production of textiles in the EU, but not outside the EU
minimum reliability (e.g. resistance to stresses or ageing mechanisms)	WATER		SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFET. EXT.	-	Full potential of the requirement
availability and affordability of spare parts (design for repair and maintenance)					WASTE				LIFET. EXT.	-	Full potential of the requirement
compatibility with commonly available tools and spare parts					WASTE				LIFET. EXT.	-	Full potential of the requirement
use of standard components									LIFET. EXT.	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT	Related Union law	What could be addressed by ESPR
life cycle water consumption	WATER	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT									Related Union law	What could be addressed by ESPR
life cycle emissions to water	WATER									-	Full potential of the requirement
possible release of non-biodegradable microplastics	WATER		SOIL	BIODI VERSITY	WASTE					Microplastics Regulation	Does not address unintentional release of microplastics
sourcing of raw materials from certified sustainable practices			SOIL	BIODI VERSITY						-	Full potential of the requirement
amount of life cycle waste sent to landfill					WASTE					-	Full potential of the requirement
recycled content	WATER		SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
how to disassemble, recycle and return or dispose the product	WATER		SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
coding standards for the identification of components and materials	WATER		SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
carbon footprint						CLIMATE CHANGE				-	Full potential of the requirement
share of energy consumption from low carbon sources						CLIMATE CHANGE				Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
content of sustainable renewable materials						CLIMATE CHANGE				-	Full potential of the requirement
life cycle energy consumption							ENERGY USE			-	Full potential of the requirement
maximum product to packaging ratio (including for e-commerce)								MATERIAL EFFICIENCY		-	Full potential of the requirement
amount of process residues								MATERIAL EFFICIENCY		-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT									Related Union law	What could be addressed by ESPR
condition for use and maintenance of the product	WATER		SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential of the requirement
expected lifetime of the product	WATER		SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential of the requirement
resistance to stresses or ageing mecha-nisms	WATER		SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE.		LIFETIME EXTENSION	-	Full potential of the requirement

Additional notes and list of references

The benefits of reuse and recycling of textiles are mainly due to the avoidance of the manufacturing of new products ([18]). Therefore, low replacement rates can eliminate the benefits, e.g. when buying a second-hand item *in addition* to a new one. While this is true for all products, fashion and feelings greatly influence the user behaviour for textiles.

* please note that in this context 'sustainable' does not include the social dimension

** DALY is a time-based measure that combines years of life lost due to premature mortality (YLLs) and years of life lost due to time lived in states of less than full health, or years of healthy life lost due to disability (YLDs). One DALY represents the loss of the equivalent of one year of full health. Using DALYs, the burden of diseases that cause premature death but little disability (such as drowning or measles) can be compared to that of diseases that do not cause death but do cause disability (such as cataract causing blindness).

*** The rebound effect is a well-known phenomenon in which resource efficiency gains, caused by a new technology or organizational practice, are not achieved or they remain smaller than expected for external reasons ([108,109])

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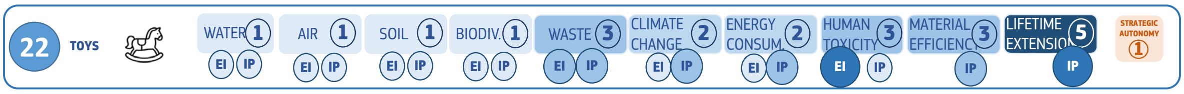
Product fiche 10. Toys

Please note that the sections on ‘*Environmental impacts*’ refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on ‘*Improvement potential*’ refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

TOYS



Scope: The product group covers products for use in play by children under 14 (hereinafter referred to as toys) that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded products listed in Annex 1 of Toys Safety Directive as well as electronic toys (because falling these fall under the Ecodesign Directive for which the Ecodesign and Energy Labelling Working plan 2022-2024 applies).

Water Effects [1]

Environmental impact: Low

A 90 % of toys sold in today's market are made from plastic ([18]). It takes about 185 litres of water to make a kilogram of plastic ([12]). It is estimated that 1402 tonnes of the plastic children’s toys sold last year in the UK will end up littered within 50km of the coastline in the UK at the end of their life ([16]).

Improvement potential: Low

The potential for improvement of toys lies in addressing the waste prevention, redesigning not only how toys are made and played with, but also toy ownership ([17]), via circular business models that consider the product as a service.

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- performance requirement on maximum level of life cycle emissions to water
- information requirement on life cycle water consumption
- information requirement on life cycle emissions to water

Air Effects [1]

Environmental impact: Low

A 90 percent of toys sold in today's market are made from plastic ([18]). Emissions of Sulphur and Nitrogen Oxides, particulate matter and Volatile Organic Compounds during extraction and processing of raw materials (petroleum), the production of additives and the manufacture of the polymers. Emissions of volatile organic compounds ([19]).

Improvement potential: Low

The potential for improvement of toys lies in addressing the development of control technologies in the production phase of fossil based plastics ([19]).

Potential measures under ESPR:

- performance requirement on maximum level of life cycle emissions to air
- information requirement on the level of life cycle emissions to air

Soil Effects [1]

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Environmental impact: **Low** The main impact is related to the extraction of raw materials, mainly plastics (20), metals, wood and textiles. **Improvement potential:** **Low** The potential for improvement of toys lies in addressing an environmentally sustainable approach to sourcing. **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [1] **Environmental impact:** **Low** The main impact is related to the extraction of raw materials, mainly plastics (20), metals, wood and textiles. **Improvement potential:** **Low** The potential for improvement of toys lies in addressing an environmentally sustainable approach to sourcing. **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Waste Generation & Management [4] **Environmental impact:** **High** A key problem for circularity in toys comes with consumerism itself. In UK, 1/3 of parents have admitted to throw away toys in good working order (17). Manufacturers of many consumer products design them for rapid consumption and short lifespans (29). This quick turnover has significant consequences for the volume of waste being generated (27). Toys waste generation rate (manufacturing and End-of-Life) is high. It is estimated that by 2023 over 1 million tons of toy plastic waste will be produced globally (5). As much as 80% of all toys end up in landfill, incinerators, or the ocean. In France alone, around 100 000 tonnes of toys become waste every year. Most of them end up in landfills or are incinerated while only 4% are reused (28). The most common materials found in children's toys and gadgets are plastics (23). the breakdown of plastic into micro- and nanoplastics by ultra-violet sunlight is a widespread and well documented problem (30), that can release additives in plastics into the environment (31). The improper disposal of toys and gadgets containing plastics likely contributes to this problem. During the manufacture of toys and gadgets, most plastics are mixed with various additives, to improve their performance, engender flexibility, enhance product durability, and/or add a level of flame retardancy (24). In Europe, it has been reported that more banned chemicals have been found more frequently in toys than in any other product type (32). Some of the most common current or historic additives include some chemicals of concern that hinder recycling. **Improvement potential:** **Medium** The potential for improvement of toys lies in re-designing not only how toys are made, but also toy ownership. Together, these are critical steps towards a circular economy. Reuse models and toy subscription services are emerging to enable toys to be used by more people. Repair and reuse possess a strong potential for circular economy. 76 % of non-electronic toys brought to repair cafés can be repaired successfully (33) Research shows that consumers favour products that can easily be repaired, but their willingness to pay (more) for such products depends on what it is and the way information on its reparability is presented (27). For businesses making new toys, thinking about the materials that go into those toys is vital to eliminate waste and pollution. The sustainable toy market, or toys made from biodegradable and/or recycled materials, is

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expected to see rapid growth in the coming years. This will be a result of a widening interest of toy manufacturers in utilising used and recycled materials rather than dwindling virgin resources ([27]). The long-term success of circular business models relies on new toys being designed and made for a circular economy ([17]). The management of toy-related waste can be improved significantly.

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated
- performance requirement on maximum amount of life cycle hazardous waste generated
- performance requirement on safe, easy and non-destructive access to recyclable components
- performance requirement on the use of easily recyclable materials or combination of materials
- performance requirement on ease of upgrading, re-use, remanufacturing and refurbishment
- performance requirement on minimum recycled content
- performance requirement on the maximum number of materials and components used
- information requirement on recycled content
- information requirement on how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities)
- information requirement on amount of waste sent to landfill

Climate Change [2]

Environmental impact: Low

The main impact of toys is related to the production of the raw materials from which toys are made of, mainly plastic ([20]), metal, wood and textiles.

Improvement potential: Medium

The potential for improvement of toys lies in addressing an environmentally sustainable approach to sourcing, for example, decoupling the production of plastic from fossil fuel consumption ([20]) and promoting re-use of toys, via circular business models that consider the product as a service.

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- performance requirement on minimum content of sustainable renewable materials
- information requirement on carbon footprint
- information requirement on the share of energy consumption from low carbon energy sources
- information requirement the content of sustainable renewable materials

Life Cycle Energy consumption [2]

Environmental impact: Low

The energy demand of the production of raw materials is one of the key impacts ([19]).

Improvement potential: Medium

The potential for improvement of toys lies in addressing an environmentally sustainable approach to sourcing, decoupling production from fossil feedstock ([20]), and redesigning not only how toys are made and played with, but also toy ownership ([17])

Potential measures under ESPR:

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- performance requirement on maximum level of life cycle energy consumption - information requirement on life cycle energy consumption - information requirement on the share of energy consumption from low carbon energy sources

Human Toxicity [4]

Environmental impact: High

A significant share of toys are composed of plastic, which might contain chemical substances harmful to humans (6), for example phthalate and chlorinated paraffin plasticizers, polybrominated, diphenyl ether (PBDE) flame retardants, bisphenols (monomers in polycarbonate plastics), colorants and stabilizers containing metals, and biocides (7). Other toys of potential concern are those that can stick to hands or being easily ingested (i.e. chalk, crayons), which might contain potentially toxic elements (e.g. Cr, Sb). Toys made of plastic, paper, and wood turned out to have the highest average Cr and Sb total concentrations (279 mg kg1 and 18.0 mg kg1) respectively. The presence of these substances do not seem to be directly related to location of purchase or cost, which suggest the manufacturing process and materials used for it as main contributors (8).

According to alerts from the Safety Gate (rapid alert system for dangerous non-food products of the European Commission), in 2018, toys were the category with the most notifications, covering the 31% of all notifications for non-food products. A search on "chemical risk" from 2005 to 2020 has returned more than 6000 results, including many children's items contaminated with PTEs and/or organic contaminants (8).

Improvement potential: Low

The potential for improvement of toys lies in ensuring a high level of protection of children against risks caused by chemical substances in toys. So, the use of dangerous substances, in particular substances that are classified as carcinogenic, mutagenic or toxic for reproduction (CMR), and allergenic substances and certain metals, should be subject to careful attention (3). This is addressed in the Toy Safety Directive 2009/48/EC as well as in the Commission proposal for a Toy Safety Regulation (COM(2023)462).

However, chemical composition data for (plastic) toys are scarce, since manufacturers often do not disclose this information and toy composition databases are currently not available. It is therefore in particular necessary to complete and update the provisions on chemical substances in toys and to ensure that toys comply with the applicable legislation (6).

Potential measures under ESPR:

No measures are envisaged under ESPR for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).

Material efficiency [3]

Improvement potential: Medium

The toy industry uses one of the highest amount of plastic per unit of revenue (10). The most common materials found in children's toys and gadgets are plastics (23).Due to their properties, around 90% of the total sales are plastic toys (5). However, despite the material efficiency potential of plastic materials, toys are generally produced as 'disposable' items. A growing share of studies suggest that the integration of circular economy principles in the toy sector is beneficial. (11).

During the manufacture of toys, most plastics are mixed with various additives, to improve their performance, engender flexibility, enhance product durability, and/or add a level of flame retardancy. Some of the most common current or historic additives include some chemicals of concern under the REACH Regulation or are substances banned by the Stockholm Convention (24)

The toys industry has substantial potential for improvement in sustainability through lightweight design, optimizing the product versus packaging ratio, and enhancing the recovery of by-products, process residues, and off-spec materials. By innovating with lightweight, durable materials, toy manufacturers can reduce material usage and transportation emissions. Streamlining packaging by minimizing excess materials and using eco-friendly, recyclable options can significantly lower waste and improve the product-to-packaging

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ratio. Implementing advanced recycling and recovery processes for manufacturing by-products and off-spec items can further reduce waste and promote a circular economy **Potential measures under ESPR:** - performance requirement on maximum weight or volume of the product and/or its packaging - performance requirement on maximum product to packaging ratio - performance requirement on minimum amount of by-products/process residues/off-specs recovered - information requirement on product to packaging ratio - information requirement on amount of by-products/process residues/off-specs recovered
Lifetime extension [5] **Improvement potential: High** A key problem for circularity in toys comes with consumerism itself. In UK, 1/3 of parents have admitted to throw away toys in good working order (17). Manufacturers of many consumer products design them for rapid consumption and short lifespans (29). Toys generally end up as waste when a child's interests change or when get broken, with an average lifespan of six months. 40% of toys that are gifted during the holiday season get broken in a matter of months (5). This short lifespan of toys is due mainly to the fact that children rapidly change their interests and activities. The phrase "play and then forget" could probably apply to more than 90% of toys (17). The potential for improvement of toys lies in increasing this short average lifetime in terms of durability and reliability. Repair, refurbishment and upgrading operations play a key role in the durability of toys, always considering the trade offs involved. 76 % of non-electronic toys brought to repair cafés can be repaired successfully (33) Research shows that consumers favour products that can easily be repaired, but their willingness to pay (more) for such products depends on what it is and the way information on its reparability is presented (27). Some toy manufacturers are rethinking the future of their business, redesigning not only how toys are made and played with, but also toy ownership (17). **Potential measures under ESPR:** - performance requirement on minimum reliability - performance requirement on availability and affordability of spare parts (design for repair and maintenance) - performance requirement on the characteristics and availability of consumables needed for proper use and maintenance - performance requirement on compatibility with commonly available tools and spare parts - performance requirement on the use of standard components - performance requirement on the maximum number of materials and components used - performance requirement on availability of information long after the product is sold - performance requirement on availability of guarantees specific to remanufactured or refurbished products - information requirement on condition for use and maintenance of the product - information requirement of expected lifetime of the product, and/or on how to substitute/replace the product or its component - information requirement on resistance to stresses or ageing mechanisms - information requirements on whether specialised tools are needed for repair
Final score [23]

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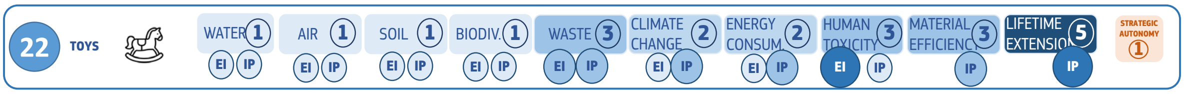

Open Strategic Autonomy score [1]

Policy Gaps

Chemicals in toys are regulated by the Toy Safety Directive 2009/48/EC (3), under which the usage of more than 70 substances is restricted or prohibited. However, existing regulations usually focus on particular chemicals (e.g., phthalates, brominated flame retardants and metals), not covering the broad range of chemical substances, thus some toxic and banned additives are sometimes found in plastic toys also on regulated markets (6). This Directive is under revision and the Commission has adopted a proposal for a Toy Safety Regulation (COM(2023)462). Toys are often rather complex of mixtures of plastics; rubber and silicone, among others. Each type of material may also be a mixture of various components, including some with chemicals or elements which are substances of very high concern regulated under the REACH, included on the SIN list; or even banned under the Stockholm Convention. As the movement towards a circular economy encourages recycling, there is a risk that these legacy substances are reincorporated into the newly manufactured products(8).

As explained above, current regulatory framework is focused mainly on safety and the environmental concerns presented by toys are addressed by horizontal environmental legislation applying to electrical and electronic toys, namely Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment and Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE). In addition, environmental issues on waste are regulated by Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006, those on packaging and packaging waste by Directive 94/62/EC of the European Parliament and of the Council of 20 December 1994 and those on batteries and accumulators and waste batteries and accumulators by Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 (3).

The European Parliament have officially acknowledged this and other aspects requiring attention (14). Consequently, further work is ongoing, suggesting as option consolidating all applicable chemical limits values under the same legal instrument (15). Amongst others, circular aspects relate to consumers' access to information and its impact on durability/reparability, including possible trade-off with safety (9). The Chemical Strategy for Sustainability highlights the need to introduce or reinforce provisions to take into account the combination effects of chemicals, including for toys. In terms of sustainability, the European Parliament has argued that the Toy Safety Directive revision could be an occasion to introduce sustainable labelling for toys, as also requested by some Member States. This would provide the consumer at the time of purchase with clear and easily understandable information on estimated lifetime, degree of reparability and availability of spare parts, options for repairing the toy (15).Beyond the regulation of chemicals, thus, strategies to address (over-) consumption and/or lifestyles should be considered when designing approaches to Chemicals of Concern (CoCs). With these findings, policy should put focus on supporting the development of fundamentally different chemistries to known CoCs, while future research is needed to better understand plastic composition, exposure patterns and toxicity (6).

For wooden toys or toys with wooden components, whereas existing timber legislation could be considered applicable, they have been found to be based on voluntary agreements, such as the FLEGT Regulation (21). However, at the moment of writing this report, the EC has proposed a Regulation to tackle EU-driven deforestation and forest degradation (22), which should apply equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market.

Despite the extensive regulatory framework around the different aspects mentioned above for toys, this sector has considerable room for improvement, in line with the above, increasing the implementation of material efficiency aspects in toy products, the use of renewable materials and including upgradeability, reuse or end of life management when producing toys. There is also potential for improvement in increasing the short average lifetime in terms of durability and reliability. Some toy manufacturers are rethinking the future of their business, redesigning not only how toys are made and played with, but also toy ownership

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([17])The sustainable toy market was valued at about USD 18.9 billion in 2020 and is expected to reach USD 59.6 billion by 2030. The demand for sustainable toys will also increase the global demand for biobased and recycled plastics. It is expected that value of the recycled plastic market will rise to $76 billion, or just more than 11 % of the expected market, by 2029 as more toy and gadget manufacturers turn towards sustainable production ([27]).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA				Related Union law	What could be addressed by ESPR
maximum amount of life cycle waste generated	WASTE				Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
maximum amount of life cycle hazardous waste generated	WASTE				Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
safe, easy and non-destructive access to recyclable components	WASTE				-	Full potential of the requirement
use of easily recyclable materials or combination of materials	WASTE	CLIMATE CHANGE	ENERGY USE	LIFETIME EXTENTION	Waste Framework Directive	WFD sets recycling targets in the EU but does not have a design approach in and outside the EU
ease of upgrading, re-use, remanufacturing and refurbishment	WASTE				-	Full potential of the requirement
minimum recycled content	WASTE	CLIMATE CHANGE	ENERGY USE	LIFETIME EXTENTION	-	Full potential of the requirement
maximum number of materials and components used	WASTE				-	Full potential of the requirement
maximum level of carbon footprint		CLIMATE CHANGE			EU Emission Trading System	EU ETS covers the production of some main materials (e.g. plastics), but not other life cycle stages production in non-EU countries
minimum share of energy consumption from low carbon sources		CLIMATE CHANGE			Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
minimum content of sustainable renewable materials		CLIMATE CHANGE			Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA					Related Union law	What could be addressed by ESPR
							labelling but not mandatory requirements
maximum level of life cycle energy consumption			ENERGY USE			-	Full potential of the requirement
maximum product to packaging ratio	WASTE	CLIMATE CHANGE		MATERIAL EFFICIENCY		-	Full potential of the requirement
maximum weight or volume of the product and/or its packaging	WASTE	CLIMATE CHANGE		MATERIAL EFFICIENCY			
minimum amount of by-products/process residues/off-specs recovered	WASTE			MATERIAL EFFICIENCY		-	Full potential of the requirement
minimum reliability	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	-	Full potential of the requirement
availability and affordability of spare parts	WASTE				LIFETIME EXTENTION	-	Full potential of the requirement
compatibility with commonly available tools and spare parts	WASTE				LIFETIME EXTENTION	-	Full potential of the requirement
use of standard components	WASTE				LIFETIME EXTENTION	-	Full potential of the requirement
availability of information long after the product is sold					LIFETIME EXTENTION	-	Full potential of the requirement
availability of guarantees specific to remanufactured or refurbished products					LIFETIME EXTENTION	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA					Related Union Law	What could be addressed by ESPR
content of sustainable renewable materials		CLIMATE CHANGE				-	Full potential for the requirement
sourcing of raw materials from certified sustainable practices		CLIMATE CHANGE				-	Full potential for the requirement
recycled content	WASTE					Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for the product information requirements
how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities.)	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement
amount of waste sent to landfill	WASTE					-	Full potential for the requirement
carbon footprint		CLIMATE CHANGE				-	Full potential for the requirement
share of energy consumption from low carbon sources		CLIMATE CHANGE				Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
life cycle energy consumption			ENERGY USE			-	Full potential for the requirement
product to packaging ratio				MATERIAL EFFICIENCY		-	Full potential for the requirement
weight or volume of the product and/or its packaging				MATERIAL EFFICIENCY			
amount of by-products/process residues/off-specs recovered				MATERIAL EFFICIENCY		-	Full potential for the requirement
condition for use and maintenance of the product	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA	Related Union Law	What could be addressed by ESPR
expected lifetime of the product, and/or on how to substitute/replace the product or its component	LIFETIME EXTENSION	-	Full potential for the requirement
resistance to stresses or ageing mechanisms	LIFETIME EXTENSION	-	Full potential for the requirement
whether specialised tools are needed for repair	LIFETIME EXTENSION	-	Full potential for the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

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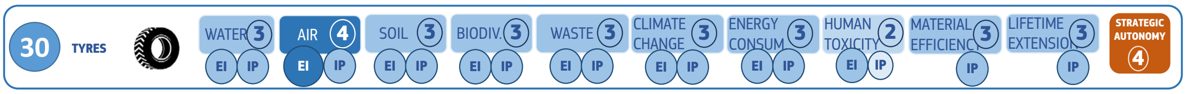

Scope

The product group covers C1 tyres, C2 tyres and C3 tyres that are placed on the market. Requirements for re-treaded tyres apply once a suitable testing method to measure the performance of such tyres is available. The following products are excluded: off-road professional tyres; tyres designed to be fitted only on vehicles registered for the first time before 1 October 1990; T-type temporary-use spare tyres; tyres whose speed rating is less than 80 km/h; tyres whose nominal rim diameter does not exceed 254 mm or is 635 mm or more; tyres fitted with additional devices to improve traction properties, such as studded tyres; tyres designed only to be fitted on vehicles intended exclusively for racing.

Water Effects [3]

Environmental impact: Medium

The modern tire is a highly complex feat of engineering comprised mainly of blends of styrene-butadiene rubber, polybutadiene rubber and natural rubber (i.e. polymer/elastomer 40–50 %) and strengthened and compounded with inorganic fillers (e.g. carbon black, silica 30–35 %) To this are added a range of chemicals in the form of emollients (hydrocarbons, ~15 %), additives (antioxidants, plasticizers, 5–10 %) and vulcanization agents (2–5 %). Formulations vary between manufacturers and models in efforts to optimise tires that perform according to the desired properties of wear resistance, rolling resistance and wet traction in different driving conditions (e.g. summer vs. winter tires). Within the emollients, additives and vulcanization agents are numerous chemicals that fall within the groups of organics (e.g. benzothiazoles, phthalates and polycyclic aromatic hydrocarbons, 6PPD) and trace metals (predominantly zinc, but also copper, lead and cadmium [29]

The rubber industry is considered one of the industries producing water pollution. Water was the most used resource to wash raw materials because the cup lumps are quite dirty. A huge amount of water is required. High water consumption results in large amounts of wastewater. This wastewater contains high levels of organic contamination and may affect the ecosystem and aquatic animals in the water source. The highest water consumption in block rubber manufacturing was found in the rubber cleaning process[31]

Tire microplastics from synthetic rubber tires are a major contributor of microplastic pollution to the environment [27]. Variously termed as tire wear particles (TWP), tire and road wear particles (TRWP), and end-of-life tires (ELTs) to differentiate between possible compositions and sources in the environment, these rubber particles have been described as a major contributor to plastic pollution in the world's aquatic habitats [29]

Moreover, road tyre wear has been identified as the greatest contributor to the unintentional release of microplastics to surface waters, with 94 000 out of a total of 176 000 tonnes per year) ([5]). The emission of microplastics from tyres occurs during the use-phase (mechanical abrasion) ([3]). It has been estimated that 5-10% of total plastic ending up in the ocean is from tyre wear and tear ([7]). The estimated per capita emission ranges from 0.23 to 4.7 kg per year, with a global average of 0.81 kg per year ([8]). Recent research has demonstrated that tires are a source of previously unrecognized chemicals, some are highly toxic to aquatic organisms, and many of which are currently unknown or poorly described. Roads can represent hot spots of tire pollutants and effective pathways of pollutants to aquatic, terrestrial, atmospheric, and groundwater resources. Storm water is considered a significant pathway for tire wear particles to enter aquatic systems [27] The distribution of tire-road-wear-particles (TRWPs) from German roads estimates that between 12 and 20% of the TRWPs was found to be released to surface waters, 66–77% being transported to road banks and soils near roads and finally, 5% of TRWPs went into the fine air-fraction. Chemicals commonly used in

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tire manufacturing, such as aniline, 1-octanethiol, 6PPD and benzothiazole, and their derivates, have been shown to be toxic and have on many occasions be found to be present in tires, tire particles and leachate [28] **Improvement potential: Medium** The potential for improvement of tyres lies in addressing the unintentional release of microplastics from tyre abrasion by both setting minimal requirements for new tyres to be placed on the market and by using information tools to orient consumer choice towards more sustainable tyres (e.g. by using "mileage" as associated indicator). Both strategies require developing reliable, accurate and reproducible test methods (possibly becoming standards) to measure tyre abrasion and durability, including for re-treaded tyres([1]) There is also room for improvement by addressing raw materials extraction with a sustainable approach. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle release of microplastics and nanoplastics - performance requirement on design for resistance to stresses or ageing mechanisms - performance requirement on maximum limit of life cycle water consumption - performance requirement on minimum level of rolling resistance of tyres - information requirement on the level of life cycle emissions to water
Air Effects [4] **Environmental impact: High** In general, tire rubber consists of synthetic and/or natural rubber (40–60 %), fillers and reinforcing agents like carbon black and silica (20–25 %), process or extender oils (12–15 %), vulcanization agents like Zn and thiazoles (1–2 %), and other additives such as preservatives and processing aids (5–10 %). Tires contain approximately 50:50 ratio of natural to synthetic rubber. Global dependence on tires produced from petroleum-based compounds, synthetic materials, heavy metals, and added chemicals, represents a persistent and complex environmental problem with only partial, and often-times ineffective, solutions. Extrapolating from an estimated 3 billion tires produced annually, tire manufacture may produce as much as 729 million kg particulate matter [27]. Petroleum fractions are employed as end-products or starting materials for producing new sets of materials. The chemical processing, of petrochemical products generate massive pollutants that cause adverse effects on human health and the surrounding environment The emission of oil industry pollutants such as particulate matter, volatile organic compounds (VOCs), polycylic aromatic hydrocarbons (PAHs), NOx, SOx, CO, CH4, and CO2 contain unacceptable dosages that cause severe human diseases, acid rain, ozone layer depletion, and overall become a significant threat to the survival of our planet[30]. In addition to taht, tyres are a significant source of particulate matter emission via microplastics released from tyres abrasion. The size of these particles ranges from 10 nm down to several 100 µm ([4]) and, via fragmentation and degradation throughout time, is likely that these particles size can even be reduced further. In air, 3-7% of the parti culate matter (PM2.5) is estimated to consist of tyre wear and tear ([8]). The PM2.5 particles can stay in the air for days or weeks, travelling more than 1000 km ([8]), which highlights the transboundary nature of this impact (delocalisation). Tire microplastics from synthetic rubber tires are a major contributor of microplastic pollution to the environment[27]. Between 360,000 to 540,000 tonnes of microplastics are released from tyres as a consequence of the friction of tyres on road surfaces. Passenger cars make up the largest source of tyre wear particle emissions [32] **Improvement potential: Medium** The potential for improvement of tyres lies in addressing the unintentional release of microplastics from tyre abrasion by both setting minimum requirements for new tyres to be placed on the market and by using information tools to orient consumer choice towards more sustainable tyres (e.g. by using "mileage" as associated indicator). Both strategies require developing reliable, accurate and reproducible testing methods to measure tyre abrasion and durability, including for re-treaded tyres ([1]).

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There is also room for improvement by addressing raw materials extraction with a sustainable approach. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle emissions to air - performance requirement on maximum level of life cycle release of microplastics and nanoplastics - performance requirement on design for resistance to stresses or ageing mechanisms - information requirement on the level of life cycle emissions to air -information requirement on the possible release of non-biodegradable microplastics
Soil Effects [3] **Environmental impact: Medium** In general, tire rubber consists of synthetic and/or natural rubber (40–60 %). Tires contain approximately 50:50 ratio of natural to synthetic rubber. Tire production begins with acquisition of natural rubber for the tread, textiles and steel for the cord and belts, and chemicals such as carbon black, silicon dioxide, and clay. A significant environmental impact of tire production is from the cultivation of natural rubber which involves clearing native, diverse forests for growing monocultures of rubber trees. This type of agriculture is an especially important cause of deforestation in Asia and Africa. High resolution maps of southeast Asia show that rubber tree cultivation accounted for at least 4 million ha of deforestation since 1993, 2 million ha of which was lost since 2000, including 1 million ha of rubber plantations that have been established in high biodiversity areas.[27)] Furthermore, soil is the main compartment receiving tyres road wear particles, thus also microplastics and any other potential pollutant present. (e.g. polycyclic aromatic hydrocarbons; heavy metals) ([9]). This does not only occur via direct addition to soil or water [(9)] but also via atmospheric deposition ([10]). A large proportion of tear wear particles are retained in wastewater systems, road banks and in soil close to roads ([9]). The accumulation of these particles may result not only in diffuse pollution, but also in impaired soil functionality (physical and biological properties) ([10]). Tire microplastics from synthetic rubber tires are a major contributor of microplastic pollution to the environment[(27)] . **Improvement potential: Medium** The potential for improvement of tyres lies in addressing the unintentional release of microplastics from tyres 'abrasion by both setting minimal requirements for new tyres to be placed on the market and by using information tools to orient consumer choice towards more sustainable tyres (e.g. by using "mileage" as associated indicator). Both strategies require developing reliable, accurate and reproducible testing methods to measure tyre abrasion and durability, including for re-treaded tyres ([1]) There is also room for improvement by addressing raw materials extraction with a sustainable approach **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability certification - performance requirement on maximum level of life cycle release of microplastics and nanoplastics - performance requirement on design for resistance to stresses or ageing mechanisms - information requirement on sourcing of raw materials from certified sustainable practices - information requirement on the possible release of non-biodegradable microplastics
Biodiversity Effects [4] **Environmental impact**: **High** Tyre wear particles carry associated potential toxic effects, capable of compromising mainly aquatic and soil-related organisms ([10 & 11]), as these are the compartments where these particles accumulate ([9]). This dynamic

also may imply land use change, since polluted environments could cease having the functionality required for their prior intended use.

A significant environmental impact of tire production is from the cultivation of natural rubber which involves clearing native, diverse forests for growing monocultures of rubber trees(27) Land use change may directly occur also as result of resources (natural rubber) demand (12). For example, the increase of rubber cultivation in Southeast Asia since 2000 implied the loss of 3 million ha of forest (12). Rubber is essential for tyres manufacturing and EU is a key global player (17). In fact, natural rubber is part of the fourth EU's critical raw materials list, with the main EU sourcing countries being Indonesia (31%), Thailand (18%) and Malaysia (16%) (13). The global consumption of natural rubber for tyres and tyre products is forecasted to increase from 9,125,000 tonnes in 2020 to 11,720,000 tonnes in 2030 (14).

High resolution maps of southeast Asia show that rubber tree cultivation accounted for at least 4 million ha of deforestation since 1993, 2 million ha of which was lost since 2000, including 1 million ha of rubber plantations that have been established in high biodiversity areas (27)

Improvement potential: Medium

The potential for improvement of tyres lies in addressing the unintentional release of microplastics from tyre abrasion by both setting minimum requirements for new tyres to be placed on the market and by using information tools to orient consumer choice towards more sustainable tyres (e.g. by using "mileage" as associated indicator). Both strategies require developing reliable, accurate and reproducible testing methods to measure tyre abrasion and mileage, including for re-treaded tyres (1)

In addition to that there is room for improvement in terms of an environmentally sustainable approach to sourcing..

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability certification
- information requirement on sourcing of raw materials from certified sustainable practices

Waste Generation & Management [3]

Environmental impact: Medium

Globally, approx. 60% of End-of-Life tyres (ELT) are recovered, with >40% ELT used to produce secondary raw materials (SRM) (15). In the EU, landfill of ELT was prohibited in 2006 by the European Directive 1999/31/EC. This implied higher recovery rates in following years (e.g. 95% across EU27 by 2008). This management is carried out under a Producer Responsibility scheme promoted by the Tyre industry. From the total ELT mass (3.26 million tonnes) in the EU28 in 2018, 94% were collected and treated for material recovery (61.75%) and energy recovery (32.85%) (16). From the SRM, 94% was used again in the economy (17), in sectors such as construction, automotive and civil engineering applications (17). Energy recovery occurs mainly in cement kilns and, in a lower extent in power plants. For each tonne of ELT processed into rubber and used as infill in artificial turf pitches, there is a reduction of 700 kg of CO_2e compared to co-incineration of ELT (23) so there is room for improvement in recycling tyres. In addition, there is a demand for ELT granulate and powder and it is treated by the market as a legitimate product with a positive value, so if ELT rubber were not available, the market would need to seek other alternatives to fulfil the need (23). Innovation is enabling recovery of tyre component materials from ELTs (26).

Improvement potential: Medium

The potential for improvement of tyres lies in emerging uses for end-of-life tyres (ELT) rubber, including use in asphalt and devulcanisation. Fully closed-loop recycling of ELT rubber into new tyres is not yet commercially feasible for techno-economic reasons, but the existing markets retain the value of rubber by utilising its properties (23). Re-treading tyres (a substantial part of the market for heavy-duty vehicle tyres) contributes to waste reduction (1).

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated

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- performance requirement on safe, easy and non-destructive access to recyclable components
- performance requirement on ease of upgrading, re-use, remanufacturing and refurbishment
- performance requirement on minimum recycled content
- performance requirement on use of easily recyclable materials or combination of materials
- information requirement on how to correctly use, store and dispose of the product
- information requirement on recycled content
- information requirement on how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities)
- information requirement on condition for use and maintenance of the product to reduce release of non-biodegradable microplastics (tyres)

Climate Change [4]

Environmental impact: High

In 2015, 22% of European Union total GHG were attributed to road transport, with rolling resistance accounting for 20-30% of fuel consumption ([1]). These emissions are accounted as emissions from transport and are measured through type approval and regulated in road vehicle CO_2 legislation. Minimum rolling resistance requirements are set through vehicle type approval and purchase of more efficient tyres is promoted through tyre labelling.

In general, tire rubber consists of synthetic and/or natural rubber (40–60 %), fillers and reinforcing agents like carbon black and silica (20–25 %), process or extender oils (12–15 %), vulcanization agents like Zn and thiazoles (1–2 %), and other additives such as preservatives and processing aids (5–10 %) Each tire life cycle stage has multiple impacts on climate and acidification from energy use and production of CO2, ozone depletion, photochemical oxidation, and eutrophication from NOx production and use of PO43− in manufacturing. Using the Intergovernmental Panel on Climate Change (IPCC) methodology, each tire requires over 333,000 kg CO2 Eq during production while 2116 kg of CO2 Eq are recovered by recycling a tire ([27])

Increased rubber cultivation could induce land use change. It has been estimated that conversion of intact forest to rubber will generate carbon losses of 141.5 tonnes of carbon per ha in dense forest and 51.5 tC per ha in open forest ([18]). Within the EU, road transport is the main demand driver for natural rubber consumption, accounting for 1/5 of the annual harvest in several producer countries ([19]).

Improvement potential: Medium

The potential for improvement of tyres lies in: improving the rolling resistance of tyres while safeguarding other vital tyre characteristics ([1]);; addressing sourcing of rubber with an environmentally sustainable approach). Rubber consumption may be reduced by replacing it with other materials. Examples of research are use of natural rubber from dandelion and synthetic rubber: biomimetic synthetic rubber with optimized abrasion behaviour (BISYKA).

Potential measures under ESPR:

- performance requirement on a maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- performance requirement on minimum content of sustainable renewable materials
- information requirement on carbon footprint
- information requirement on share of energy consumption from low carbon sources
- information requirement on content of sustainable renewable materials

Life Cycle Energy consumption [3]

Environmental impact: Medium

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One of the most energy-intensive manufacturing processes in the rubber industry is producing tires. Energy-intensive processes include producing steam and compressed air, cooling and powering industrial equipment Four kinds of energy sources are used: 1. electricity to operate the factory's machinery, 2. steam for vulcanizing tires, 3. bituminous coal as a fuel for producing steam and 4. gasoline for building the tire structure. According to the value chain analysis, the most energy consumed is 0.0041 tons or 4.1 kg of steam used in the tire curing process, followed by electricity. Steam is the most energy-intensive component of tire production ([31]). Energy (fuel) consumption in the use phase is significant and is directly associated with rolling resistance([1]). **Improvement potential: Medium** The potential for improvement of tyres lies in reducing the rolling resistance of tyres to contribute significantly to the fuel efficiency of road transport ([1]) and providing end-users tools to take cost-effective and environmentally friendly purchasing decisions to get more fuel-efficient tyres. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - information requirement on life cycle energy consumption
Human Toxicity [2] **Environmental impact: Medium** Microplastics might reach humans via food chain, yet the extent, magnitude and effects are still unknown. Given this, the main human exposure route, with validated scientific evidences, is by inhalation of airborne particles ([20]). This mainly occurs due to tyre orbrake wear releasing particles of a wide size distribution which can be inhaled and impactthe respiratory function ([20]). Tyre wear and tear has been estimated to contribute 3-7% to the PM2.5 particle size pool ([8]). These particles might contain toxicants such as heavy metals and/or organic pollutants (e.g. PAH), which could affect human health ([20]). The toxic potential of organic components in tyre wear and tear has been demonstrated in human lung cells ([22]). **Improvement potential: Low** The potential for improvement of tyres lies in addressing the unintentional release of microplastics and other toxicants from tyre abrasion after developing reliable, accurate and reproducible test methods or standards to measure tyre abrasion and mileage ([1]); this may also be covered by measures in preparation under the Tyre Labelling Regulation and Type-Approval Regulation.
Material efficiency [3] **Improvement potential: Medium** The tire industry has significant potential for improvement in utilizing by-products, process residues, and off-specs recovered in production. Typically, tire manufacturing generates rubber scrap, curing bladders, off-spec tires, and scrap materials from steel and fabric. Good practises can emphasize recycling and reprocessing these materials; for example, scrap rubber is often ground into powder for reuse, and off-spec tires are reprocessed for other applications **Potential measures under ESPR:** - performance requirement on minimum amount of by-products/process residues/off-specs recovered - information requirement on the amount of by-products/process residues/off-specs recovered
Lifetime extension [3] **Improvement potential: Medium** The lifespan of a tyre depends on a range of factors, such as the wear resistance of the tyre, including the compound, tread pattern and structure, road conditions, maintenance, tyre pressure and driving behaviour [1].

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The potential for improvement of tyres lies in developing minimum durability requirements for new tyres to be placed on the market and by using information tools to orient consumer choice towards more durable tyres (e.g. by using “mileage” as associated indicator). Lifetime extension potential lies also in promoting re-treaded tyres ([1]), providing end-users tools, when purchasing tyres, to be able to compare retreaded and new tyres and making green procurement possible (e.g. for fleets of trucks or buses).

Potential measures under ESPR:

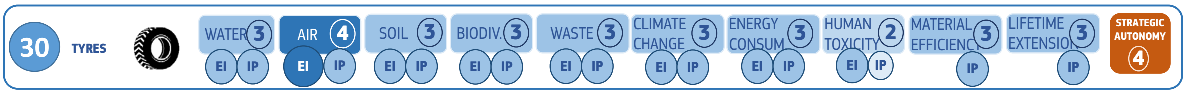
- performance requirement on minimum reliability (resistance to stresses or ageing mechanisms)

- performance requirement on availability of guarantees specific to remanufactured or refurbished products

- information requirement on condition for use and maintenance of the product

- information requirement on resistance to stresses or ageing mechanisms

Final environmental score [30]



Open Strategic Autonomy score [4]

Relevance: Tyre products are notable as the first non-intermediate product group in the ranking. Although natural rubber (its main material) is not included anymore in the 2023 list of critical raw materials, its supply risk may increase in the short term due to entry into force of the deforestation-free regulation (reg. 2023/1115).

Substituting natural rubber with synthetic rubber (styrene-butadiene) could exacerbate supply disruptions, particularly because of sanctions against Russia, a major producer of synthetic rubber. Furthermore, tyres as final goods, as well as carbon black, a material predominantly used in the tyre industry, were included in the 10th sanctions package against Russia from February 2023.

Finally, tyres are energy-related products so that the energy consumed during use phase is accounted for in the evaluation.

Potential gains for Open Strategic Autonomy: tyres manufacturing is currently relying mainly on primary raw materials but tyres are characterised by significant untapped potential for circularity. Tyres are usually well collected and recovered. Re-treading is a method used to extend tyre lives. Industrial innovative initiatives concerning substantial share of recycled content are currently under development for natural rubber and to a lesser extent carbon black. These options could be analysed in a possible preparatory study. Labelling options for energy performance is already implemented via “Rolling resistance” classes.

Policy Gaps

The environmental impact of the tyres industry is partially covered at installation level in the EU by the Industrial Emissions Directive, through iron and steel production and production of polymers BREFs In addition to this, the environmental performance of tyres is largely covered under a number of legislations that combine these aspects with “safety” needs, as combining both together is extremely challenging.

The regulation in force includes:

1. Type approval:
   - REGULATION (EU) 2019/2144
   - Commission Delegated Regulation (EU) 2015/208
   - Regulation (EU) 2018/858
   - Regulation (EC) No 661/2009
   - Euro 7 Regulation
2. Tyre labelling [Regulation (EU) 2020/740](#):

TYRES

The aspects covered and labelled within the Tyre Regulation ([1]) are fuel efficiency, wet/ice and snow grip, external rolling noise. Existing Regulations address the efficient management of tyres, mostly from an energy perspective and in terms of labelling. This is environmentally desirable, as it reduces impacts associated with their use.

Work is in progress to tackle microplastic release. In fact, according to Euro 7 Regulation, article 15, the Commission shall adopt delegated acts setting out abrasion limits for tyres types relying on the work of the UN WP.29. Where the UN WP.29 has not adopted uniform provisions by 1 July 2026 for C1 class tyres, by 1 April 2028 for C2 class tyres and by 1 April 2030 for C3 class tyres, the Commission shall develop a method for the measurement of tyre abrasion and shall define abrasion limits for tyres based on existing state-of-the-art methods. Work is in progress also to promote the use of retreaded truck and bus tyres by labelling them (type approval aspects are already regulated for all retreaded tyres).

Other aspects, which are not currently regulated and need to be addressed, are: Fully closed-loop recycling of ELT rubber into new tyres is not yet commercially feasible for techno-economic reasons, but the existing markets retain the value of rubber by utilising its properties ([23]). Indirect impacts such as land use change might occur, normally in third-countries, as a result of an EU critical raw materials (rubber) sourcing. Ambitious recycling and recycled content targets are necessary to drive the demand for recycled rubber and materials from tyres ([24]).

Natural rubber is included among the products covered by the Regulation to tackle EU-driven deforestation and forest degradation, which applies equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market. As indicated in the EuRIC MTR [(25)], the harmonization of end-of-waste criteria for ELTs and the regulation of the sustainable design of tyres, among other measures, should be considered.

There are numerous regulations relating to tires, chemicals, manufacturing, raw materials, use of tires on roads, waste handling, safety and Polycyclic Aromatic Hydrocarbons in different life cycle stages of a tire. However, none directly target the contribution of tire wear particles and their chemical constituents to the environment. Priority should be given to addressing complex mixtures like tire wear particles that disperse in the environment so that we better understand their mixture effects and transformative products [(28)]

The indications above show that the potential for improvement in tyre performance is being addressed through multiple approaches and not only in terms of its energy impacts as part of a vehicle.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA									Related Union law	What could be addressed by ESPR
maximum level of life cycle release of microplastics and nanoplastics	WATER	AIR	SOIL							Euro 7 Regulation	Tyres abrasion limits if uniform provisions have not been adopted by UN WP.29
design for resistance to stresses or ageing mechanisms (minimum reliability)	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	Type approval Regulation	Does not apply a sustainability approach
maximum level of life cycle water consumption	WATER									Industrial Emission Directive	IED covers the production of rubber, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to water	WATER									Industrial Emission Directive	IED covers the production of rubber, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to air		AIR								Industrial Emission Directive	IED covers the production of rubber, but not other life cycle stages or production outside the EU
minimum content of sustainable renewable materials		AIR				CLIMATE CHANGE				Renewable Energy Directive II	REDII sets sustainability requirements for biomass but not mandatory minimum use of renewable materials
minimum content of raw material with sustainability certification	WATER		SOIL	BIODIVERSITY		CLIMATE CHANGE				Regulation on deforestation-free products	The Deforestation-free Regulation focuses on rubber. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated					WASTE					Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
safe, easy and non-destructive access to recyclable components					WASTE					-	Full potential of the requirement
ease of upgrading, re-use, remanufacturing and refurbishment					WASTE					Type approval Regulation	Does not apply a sustainability approach

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA									Related Union law	What could be addressed by ESPR
use of easily recyclable materials or combination of materials	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	Waste Framework Directive	WFD sets recycling targets in the EU but does not have a design approach in and outside the EU
minimum recycled content	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENTION	-	Full potential of the requirement
maximum level of carbon footprint				BIODIVERSITY		CLIMATE CHANGE	ENERGY USE			-	Full potential of the requirement
minimum share of energy consumption from low carbon sources				BIODIVERSITY		CLIMATE CHANGE				Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
maximum level of life cycle energy consumption							ENERGY USE			Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU but not outside the EU. Also, EED is not product specific
minimum amount of by-products/process residues/off-specs recovered								MATERIAL EFFICIENCY		-	Full potential of the requirement
availability of guarantees specific to remanufactured or refurbished products									LIFETIME EXTENTION	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA			Related Union Law	What could be addressed by ESPR
possible release of non-biodegradable microplastics	WATER	AIR	SOIL	-	Full potential for the requirement
life cycle water consumption	WATER			-	Full potential for the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA									Related Union Law	What could be addressed by ESPR
Level of life cycle emissions to water	WATER									-	Full potential for the requirement
level of life cycle emissions to air		AIR								-	Full potential for the requirement
content of sustainable renewable materials		AIR				CLIMATE CHANGE				-	Full potential for the requirement
condition for use and maintenance of the product to reduce release of non-biodegradable microplastics	WATER	AIR	SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	-	Full potential for the requirement
sourcing of raw materials from certified sustainable practices			SOIL	BIODI VERSITY		CLIMATE CHANGE				-	Full potential for the requirement
how to correctly use, store and dispose of the product	WATER	AIR	SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	Type approval Regulation	Does not apply a life cycle approach
recycled content					WASTE					Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for the product nor information requirements
how to disassemble, recycle and return or dispose the product (for users and/or treatment facilities.)					WASTE					-	Full potential for the requirement
Carbon footprint						CLIMATE CHANGE				-	Full potential for the requirement
share of energy consumption from low carbon sources				BIODI VERSITY		CLIMATE CHANGE				Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
life cycle energy consumption							ENERGY USE			Type approval Regulation	Does not apply a life cycle approach
amount of by-products/process residues/off-specs recovered								MATERIAL EFFICIENCY		-	Full potential for the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA									Related Union Law	What could be addressed by ESPR
condition for use and maintenance of the product	WATER	AIR	SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION	Type approval Regulation	Does not address sustainability aspects
resistance to stresses or ageing mechanisms									LIFETIME EXTENSION	-	Full potential for the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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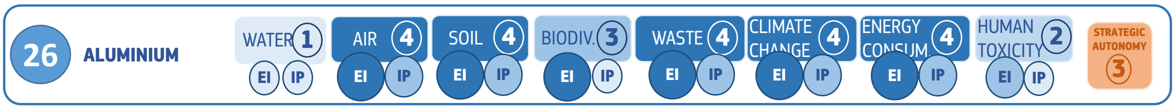
Intermediate products

Product fiche 12. Aluminium

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

ALUMINIUM



Scope: Aluminium and its alloys.

Based on its end-use applications in Europe, aluminium could be categorized as follows: transport vehicles (40 %), realisation of structural components in the construction industry (24%), production of recyclable packaging (19%), manufacture of electrical components (19%) and to produce industrial machinery and equipment (6%) ([20]).

Water Effects [1]

Environmental impact: Low

The production of **primary aluminium** is a dry process where the discharge of waste water is usually limited to cooling water, rainwater run-off from surfaces and roofs, and seawater from scrubbing pot room ventilation gases. The production of alumina from bauxite is carried out in a closed system to eliminate emissions to water ([1]). The bauxite residue (red mud) might also be produced during alumina refining from bauxite in the form of a red slurry, which comprises emissions to surface water and groundwater ([21]).

The production of **secondary aluminium** is also a dry process where major water utilisation is related to wet systems used for air pollution control. This water is often purified and recirculated within the system ([1]). Consumption of water for the production of primary aluminium is reported to be of 0.2-10 m^3 per tonne of aluminium. Emissions are < 0.03 kg/tonne for suspended solids and < 0.02 kg/tonne for dissolved fluoride ([1]).

Improvement potential: Low

The European sector, in compliance with the BREF approved in 2017, has taken measures to reduce the risk of water emissions with room for improvement in this area in sites where this regulation is not mandatory ([2]).

Potential measures under ESPR:

No specific measures have been defined that directly cover water effects. However, measures defined in other environmental areas may also benefit this environmental area.

Air Effects [4]

Environmental impact: High

ALUMINIUM
Air emissions from the production of primary aluminium include a high range of pollutants (particles, metals, HCl, HF, fluorides, NOx, SO_2, CO, CO_2, PFCs[89], NMVOC[90], PAH[91], PCDD/F[92] including dusts and noise and odours) ([1]). These emissions result in a number of impacts such as photochemical ozone creation potential and acidification ([3]). Regarding the production of secondary aluminium, there are potential emissions of dust and PCDD/F from poorly operated furnaces and poor combustion ([1]). **Improvement potential: Medium** Dust and emissions to air during the aluminium production are reduced by means of abatement techniques which can provoke cross-media effects as water use or waste production ([1]). The use of bag filtering is recommended for primary aluminium production while secondary aluminium air emissions are reduced by means of uncontaminated scrap use (i.e., free of substances such oils, paints, etc.), optimisation of the combustion conditions and also use of filtration systems (bag filters) ([1]). **Potential measures under ESPR:** - performance requirement on the maximum level of life cycle emissions to air. - information requirement on the level of life cycle emissions to air.
Soil Effects [4] **Environmental impact: High** Generally aluminium is comprised of two basic sources: (i) primary (domestic production from alumina contained in the bauxite mineral) and (ii) secondary (recycled from metal scrap). It can also be acquitted through (iii) imports of ingot and semi-fabricated products ([4, 5]). On average, 100 tonnes of bauxite can produce around 40-50 tonnes of alumina (aluminium oxide), which can then produce 20 to 25 tonnes of aluminium ([1]). The majority of primary aluminium produced in Europe is obtained from imported bauxite (Guinea, Australia, Jamaica, Brazil, or Sierra Leone for instance), forcing to classify aluminium as a critical raw material for the European economy ([4], [6]). Aluminium in the form of bauxite was included in the 2023 list of critical raw materials ([22]). However, aluminium is the third most common element in the Earth's crust ([7]). The EU consumption is higher than the production and illustrates that the EU is greatly dependent on imports of bauxite ([7]). Mining of bauxite for primary production of aluminium is the main process causing soil degradation. EU extraction of bauxite is very limited being approximately 1.5 % of the global total, of which 60 % is produced by Greece ([7]). Significant hazards happen from bauxite mining due to soil erosion and sedimentation, noise, dust, the release of minerals and naturally occurring impurities ([1]). The main impacts are resource depletion, land use and eutrophication (terrestrial). **Improvement potential: Medium** The implementation of responsible sourcing programs and traceability standards for primary production of aluminium are measures to apply ([8]). In relation to secondary production, the increase of its production is the more appropriate way to overcome the issues related to mining. This is already the case as it is reported that recycled aluminium in Europe represented more than half of all aluminium production ([7]). **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability certification

[89] Polyfluorocarbon

[90] Non-methane volatile organic compounds

[91] Polycyclic aromatic hydrocarbons

[92] Polychlorinated dibenzo-dioxins and polychlorinated dibenzo-furans

ALUMINIUM
- information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [3] **Environmental impact: High** Biodiversity can be impacted by bauxite mining and the management of the refining waste. The operation (construction, management and maintenance) of extractive waste facilities can disturb or destroy the initial natural habitat of local species during the operational phase, as well as the disposal of dangerous waste in dams or lagoons. Local flora and fauna are disturbed by the deposits of extractive refining waste on land ([2]). Air and water missions can also influence the biodiversity at the local level ([1]). **Improvement potential: Low** Bauxite mining companies usually establish biodiversity management plans to mitigate impacts or prevent loss of biodiversity ([9]). **Potential measures under ESPR:** No specific measures have been defined that directly cover biodiversity effects. However, measures defined in other environmental areas may also benefit this environmental area.
Waste Generation & Management [4] **Environmental impact: High** There are large amounts of solid waste, such as undissolved bauxite generated during the extraction of alumina ([5]) for primary aluminium production. It is estimated that around 2-2.5 tons of solid waste are generated per ton of primary aluminium produced ([10]). The bauxite residue, generated during alumina refining from bauxite, represents a major challenge for its sustainable disposal and recovery: (i) high volume, (ii) high alkalinity, and (iii) trace radioactive elements, among others. ([21]) **Improvement potential: Medium** There are management alternatives for the reduction of the waste generated in the production of primary and secondary aluminium as explained in the BREF document. If BATs cannot be applied, aluminium can also be produced from secondary sources, thus reducing the amount of waste released in aluminium production. The improvement potential lies on secondary aluminium sources (recovery from closed-loop at production/fabrication and especially end-of-life ([1])). In Europe, recycling rates are already significant. In the automotive and building sectors, 90% of the aluminium is recycled, and around 75% in the case of aluminium cans ([20]). **Potential measures under ESPR:** - performance requirement on minimum recycled content - performance requirement on maximum amount of life cycle waste generated - information requirement on recycled content
Climate Change [4] **Environmental impact: High** The main environmental impact of primary aluminium production is climate change where GHGs (and PFCs such as CF_4 and C_2F_6) are generated as a result of the anode effects during electrolysis. Both PFCs have a global warming potential much higher than CO_2 ([5]). At European level, the average CO_2 emission from the fuel consumption for primary aluminium is around 3.5 tCO_2 per tonne of aluminium, while for secondary aluminium is around 0.265 tCO_2/t Al ([7]). In 2021, European aluminium production emissions accounted for 24 $MtCO_2$, representing the 2.3% of the emissions from the global aluminium industry: primary production represented 74%, followed by recycling (14%) and semis production (12%) ([20]).

ALUMINIUM
Primary aluminium production is energy intensive, therefore CO_2 emissions of the industry highly depend on the primary fuel used for electricity generation ([5]). Indirect emissions from the electricity consumed during smelting represent an important share of the GHG emissions ([20]). **Improvement potential: Medium** Measures listed as BATs could lead to a reduction of around 10% of GHG emissions ([7]). The refining industry's environmental performance in Europe shows that the GHG emissions of the refining process decreased by 14% between 2010 and 2018 ([12]). To reduce direct emissions resulting from aluminium production, alternative such as using electric or hydrogen-powered furnaces are being considered for future application, as well as Carbon Capture and Storage (CCS) technologies. However, these alternatives require further research and testing to confirm they are appropriate for aluminium production. In smelting, the substitution of carbon anodes by inert anodes could contribute to reduce emissions (reduction potential of 95%), but this alternative also will need to be scaled up from pilot to commercial use, not expected until 2035 ([20]). As aluminium does not lose its original properties when recycled, the use of recycled aluminium appears as a CO_2 emission mitigation strategy: the process of recycling aluminium only represents 5% of the energy required to produce primary aluminium ([24]). According to the International Energy Agency ([19]), the potential to increase the collection rate of aluminium is modest as it is already high, around 70%. **Potential measures under ESPR:** - performance requirement on a maximum level of carbon footprint. - performance requirement on minimum share of energy consumption from low-carbon sources. - information requirement on the level of carbon footprint. - information requirement on share of energy consumption from low-carbon sources.
Life Cycle Energy consumption [4] **Environmental impact: High** Aluminium production is a high energy intensive industrial process: to produce a metric tonne of primary aluminium in Europe, 20.3 MWh are required. The most energy intensive processes are smelters processes and alumina refining, with an energy demand of 14.5 MWh and 5 MWh of energy per tonne of material produced, respectively ([20]). On the contrary, the process of recycling aluminium only represents 5% of the energy required to produce primary aluminium ([24]). It is also worth mentioning that a considerable amount of process heat is being consumed during alumina production through the Bayer process. The alteration of the process heat generation source would be highly beneficial to reduce environmental burdens associated with it ([3]). **Improvement potential: Medium** Recycling aluminium (secondary production) saves 95% of the energy needed for primary production ([1, 7, 12]) although the production route for secondary aluminium is also much more diverse and fragmented compared to primary aluminium ([7]). Material efficiency strategies can help maximise the collection of post-consumer scrap to enable greater secondary production and reduce the total amount of metal used while delivering the same services ([13]). **Potential measures under ESPR:** - performance requirement on a maximum level of life cycle energy consumption. - information requirement on the level of life cycle energy consumption.
Human Toxicity [2] **Environmental impact: Medium** At production phase, occupational exposure in the extraction of raw materials and refining of alumina to dust and noises are fairly common. Other chemical hazards include alumina and bauxite dusts, caustic soda, and

diesel exhaust fumes. LCA have shown human toxicity non-cancer and cancer effects derived from the aluminium industry [3, 12].

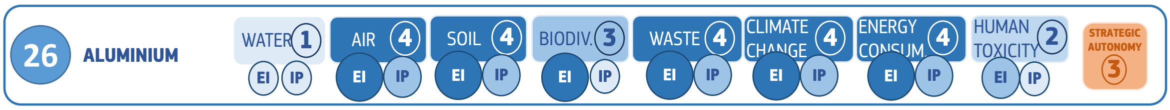
Improvement potential: Low

The presence of adequately equipped on-site emergency response and medical personnel is therefore highly desirable. Noise is a ubiquitous hazard throughout aluminium refineries, and noise-induced hearing loss remains an unfortunate but still prevalent occupational illness for refinery workers. Aggressive hearing conservation programs are essential. Vibrating hand tools are frequently used within refineries, with hand–arm vibration syndrome occasionally manifesting in the workforce [14]. There are many well-studied and characterized occupational health hazards and risks within the primary aluminium production industry. On the basis of various environmental and technical factors, some of these risks may, in selected circumstances, also extend to local communities — although the evidence for this is less clear [14].

Potential measures under ESPR:

No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.

Final score [26]



Open Strategic Autonomy score: [3]

Relevance: The main raw material entering in the composition of aluminium and aluminium alloys manufacturing is bauxite, which is identified as a critical raw material (the EU import reliance for bauxite was 87% in 2020). Depending on the aluminium alloys manufactured, other critical raw materials can be used, which is the case of e.g., silicon metal or magnesium, both identified as CRMs.

Potential gains for Open Strategic Autonomy: Aluminium is one of the metals with highest recyclability potential. Still, the current recycling rate at end-of-life represents only 51%, while the recycled content is much more limited and represented only 12% in 2020. These figures clearly show an important untapped potential for circularity that would allow decreasing aluminium supply risk for the EU.

Policy Gaps

The environmental impacts to air of the aluminium industry are regulated in the EU by the Industrial Emissions Directive and in the Commission Implementing Decision 2016/1032 [2], which are however regulating only EU installations, without considering other life cycle stages (other than production) and the production outside the EU. It is important to consider the recent approval (April 2024) of the revision of the Industrial Emissions Directive, pending to be published in the Journal of the European Union; the revised IED will have a stronger focus on efficiency and reuse of energy, water and materials in the industrial sector.

The industry moreover falls under the Directives on REACH and GHG emissions trading; EU ETS introduces a carbon price on the emissions of alumina refining and primary aluminium installations, and on certain aluminium transformation and recycling plants. Also worth mentioning is the Carbon Border Adjustment Mechanism (CBAM), a system designed by the European Union to promote the import of products in some of the most carbon-intensive sectors (including aluminium) by non-EU businesses with high climate standards, ensuring a balanced treatment of these imports and encouraging non-EU producers to join EU's climate efforts [16].

The EU Taxonomy's supplementing regulation 2021/2139 defines technical screening criteria only for the manufacture of aluminium of certain NACE codes. Aluminium final products subject to specific legislation are: packaging products (Directive 94/62/EC), vehicles (Directive 2000/53/EC) and electrical and electronic products (Directive 2011/65/EU).

ALUMINIUM
Policy gaps moreover exist with respect to regulating unsustainable (from a water quality, water quantity and biodiversity point of view) bauxite mining, especially since this mostly occurs outside the EU. Solutions for energy savings are incentivised via the Directive on GHG emissions trading, where installations covered by the energy audit obligation under the Energy Efficiency Directive have to implement the recommendations of the energy audit or otherwise their free ETS allocation is reduced by 20%. Increased recycling is also not fostered via legislation at the moment. There is no specific and mandatory regulation promoting ecodesign principles in aluminium. For instance, for product specific legislation, the regulation proposal on circularity requirements for vehicle design and on management of end-of-life vehicles only indicates that setting recycled content targets for aluminium is an option that will be assessed in the future ([17]). The proposal for the revision of the Packaging and Packaging Waste Directive (PPWD) aims to promote the use of recycled content in packaging, also considering aluminium. However, it does not provide specific targets but an indication to consider setting targets. It includes recycling targets ([18]). The Critical Raw Materials Act (Regulation 2024/1252) includes in its lists of strategic and critical raw materials bauxite, alumina and aluminium. Although it refers to the implementation of circularity measures in the form of national programmes, it does not provide specific targets.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT					Related Union law	What could be addressed by ESPR
maximum level of life cycle emissions to air	AIR			CLIMATE CHANGE		Industrial Emission Directive; Decision (EU) 2016/1032 on BAT for NFM industries	IED covers the production of aluminium but not other life cycle stages, or production outside the EU.
minimum recycled content		SOIL	WASTE	CLIMATE CHANGE	ENERGY CONSUMP	Packaging and Packaging Waste Regulation (PPWR)	Although it considers setting recycled content targets also in aluminium packaging, it does not set specific targets. It only refers to packaging.
maximum amount of life cycle waste generated			WASTE			Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach.
minimum content of raw material with sustainability certification		SOIL		CLIMATE CHANGE		-	Full potential of the requirement
maximum level of carbon footprint				CLIMATE CHANGE	ENERGY CONSUMP	Directive 2023/959 - EU Emission Trading System (ETS); CBAM	EU ETS and CBAM cover production but not other life cycle stages, and only CO_2 and PFCs.
minimum share of energy consumption from low-carbon sources				CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements.
maximum level of life cycle energy consumption				CLIMATE CHANGE	ENERGY CONSUMP	Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU but not outside the EU. Also, EED is not product specific.

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT					Related Union law	What could be addressed by ESPR
	AIR	SOIL	WASTE	CLIMATE CHANGE	ENERGY CONSUMP		
level of life cycle emissions to air	AIR			CLIMATE CHANGE		-	Full potential of the requirement
recycled content		SOIL	WASTE	CLIMATE CHANGE	ENERGY CONSUMP	Packaging and Packaging Waste Regulation (PPWR) Critical Raw Material Act (Regulation 2024/1252)	Although the PPWR considers setting recycled content targets also in aluminium packaging, it does not set specific targets. It only refers to packaging. The CRM Act only refers to delegated acts to provide information on relevant waste volumes and their strategic raw material content.
sourcing of raw materials from certified sustainable practices		SOIL		CLIMATE CHANGE		-	Only voluntary standards (e.g., Aluminium Stewardship Initiative Standard, etc.). Full potential of the requirement
level of carbon footprint				CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement
share of energy consumption from low-carbon sources				CLIMATE CHANGE		Renewable Energy Directive II	It only includes a voluntary labelling.
level of life cycle energy consumption				CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement

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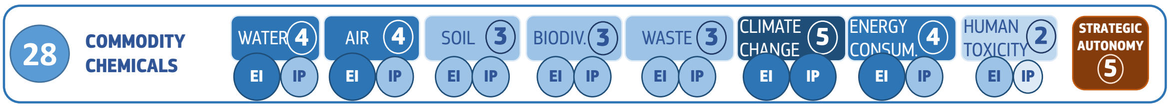
Product fiche 13. Commodity Chemicals

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

COMMODITY CHEMICALS



Scope: **Large volume inorganic chemicals – ammonia, acids and fertilisers**: ammonia, nitric acid, sulphuric acid, phosphoric acid and hydrofluoric acid, phosphorus-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers); as defined by the relative Best Available Techniques Reference Document (BREF) ([5]). **Large volume inorganic chemicals – solids and others industry**: soda ash (called sodium carbonate, including sodium bicarbonate), titanium dioxide (from the chloride and sulphate process routes), carbon black (rubber and speciality grades), synthetic amorphous silica (pyrogenic silica, precipitated silica, and silica gel); as defined by the relative BREF[93] ([8]). **Large volume organic chemicals**: lower olefins by the cracking process (e.g. ethylene), aromatics such as benzene/toluene/xylene (BTX), oxygenated compounds such as ethylene oxide, ethylene glycols and formaldehyde, nitrogenated compounds such as acrylonitrile and toluene diisocyanate, halogenated compounds such as ethylene dichloride (EDC) and vinyl chloride monomer (VCM), sulphur and phosphorus compounds and organo-metallic compounds; as defined by the relative BREF ([7]).

Note on consistency with other product groups: The product group 'Commodity Chemicals' includes the main (in volume) chemical products. These chemical products are often used as a precursor or ingredient in the manufacturing of other, more complex, chemical products and materials. This fiche focuses only on the production of the above mentioned Commodity Chemicals from raw material extraction to their placing on the market as intermediate product. Other product fiches presented in the report may originate from or contain chemical ingredients that are included in Commodity Chemicals. For example, the product group Commodity Chemicals includes olefins such as ethylene, which is mostly used for the production of polyethylene, which is covered in the product group 'Plastic and polymers'. While consistency must be ensured between the requirements proposed for the two product groups, no overlap is envisaged, since ethylene and polyethylene are two different products, and polyethylene is only one of the uses of ethylene.

Water Effects [4]

Environmental impact: High

In Europe, the chemical industry uses large amount of water, with one study estimating 11 % of freshwater use for the chemical and petroleum refining industries, although it is not clear what is exactly included in the scope ([44]). Globally, the industry as a whole uses 5 – 10 % of the freshwater resource ([44]). For reference, the global volume of renewable freshwater was estimated at around 37 000 000 m^3/year in 2015 ([47]), although availability varies considerably locally and regionally according to geological and climatic factors ([48]). In addition, the production of chemicals is, on a global level, one of the most polluting, energy and resource-intensive sectors while it is closely integrated with other energy-intensive sectors and processes ([1]). The EU is the second largest producer of chemicals in the world in terms of sales, only after China, and the commodity chemicals in the scope of this product group accounted for around 43% of total chemical sales in 2022 (EUR 325 billion) ([2]).

[93] With the exception of inorganic phospates, which are excluded from this product fiche, due to their use in food and feed (excluded from the scope of ESPR) and in detergents (proposed as a final product for the Working Plan)

COMMODITY CHEMICALS
Water is a valuable resource that is globally under pressure: over 50% of global catchment areas and reservoirs displays deviations from normal conditions, showing considerably dry conditions ([56]). Worldwide, 32 countries are experiencing water stress (defined as "proportion of total water resources used") of between 25 and 70 per cent; 22 countries experience it above 70 per cent and are considered to be seriously stressed; in 15 countries, this figure rises to above 100 per cent, and of these, four have water stress above 1,000 per cent ([57]). In the EU only 40% of surface water bodies stands in good ecological status, and 35% is in good chemical status ([53,54]). The chemical industry contributes to such pressure as it leads to the release of pollutants to water, including total organic carbon (TOC) and compounds that contain nutrients such as nitrogen and phosphorous, which can cause eutrophication, and heavy metals such as Cd, Pb, Hg and Ni, which also have detrimental impacts on the environment and human health ([55]). For example, in the U.S., petroleum and chemical manufacturing industries account for 31% of all toxic releases to water ([58]). Manufacturing of organic chemicals can release millions of tonnes of pollution in the form of discharges of benzene, salts, nitrogen compounds, phosphate, oil and grease, volatile organic compounds, suspended solids, and metals like aluminium, zinc, and lead into waterways ([7,59]). The industry of inorganic chemicals is a very large discharger of toxic pollution such as salts and inorganic substances (including halogen and phosphorus compounds), acidifying and alkalising substances, metals and heavy metals, dioxins, PCBs, and suspended solids ([5,59]). Water consumption is generally very high during production of commodity chemicals, since it is used as a heat transfer agent for cooling or heating, feedstock for boiler plants, carrying agent for transport of insoluble materials, solvent, washing/cleaning agent, air contaminant abatement fluid, etc ([8]). There are also pollutants such as PFAS[94] and endocrine disruptors[95] with a high impact on human and animal health. PFAS have been reported as contaminants of soil and water (including drinking water) not only in EU but globally, with a large number of people affected. (For a full spectrum of illnesses and the related societal and economic costs, see ([11])). Exposure to endocrine disruptors results in harmful effects in both humans and wildlife ([12]). These pollutants can be generated in industrial installations, however its impacts mainly refer to chemical safety which is tackled through existing and under development chemical legislation. For example, new hazard classes are being established under the revision of the CLP Regulation for endocrine disruptors, persistent, bioaccumulative and toxic substances, and persistent, mobile and toxic substances. **Improvement potential: Medium** The implementation of Best Available Technologies (BAT), as control measures for water pollution from the chemical industry has showed its effectiveness with the widespread of the significant reductions in the emissions of N, P and organic pollutants in Europe ([3,5,6,7,8]). In the EU, the emissions of nitrogen showed a 64%-fall in nitrogen, while phosphorous emissions to water fell by 70%, whereas the total organic carbon (TOC) emissions to water nearly halved in the period 2007-2019 ([3]). The Chemical Oxygen Demand (COD) of European wastewaters is also continuing a slow decrease following the improvement between 2004 and 2007 when most of the chemical manufacturing sites implemented Best Available Technologies (BAT) ([3]). Unfortunately, this situation is not extended worldwide where certain locations present high pollution from emissions to water from the chemical industry and due to absence of measures to reduce water use and pollution ([4]). In fact, the BAT established according to the Industrial Emission Directive only affect EU installations, thus leaving industrial emissions occurring outside the EU not regulated to the same extent, even though the majority of the extraction and processing of raw materials for the production of chemicals occur outside the EU. China is by far the top producer of chemicals (in sales (EUR), 2021 data) ([2]). For example, phosphoric acid is mostly (80% of global production) produced by wet process from phosphate rock, which is a critical raw material with 82% EU import reliance, with Morocco, Algeria and Russia as the main EU suppliers, whereas elemental phosphorus has an EU import reliance of 100%, with Kazakhstan, Vietnam and China as the main

[94] Per- and polyfluoroalkyl substances are a group of widely used man-made organic chemical substances containing alkyl groups on which all or many of the hydrogen atoms have been replaced with fluorine. COMMISSION STAFF WORKING DOCUMENT Poly- and perfluoroalkyl substances (PFAS) https://ec.europa.eu/environment/pdf/chemicals/2020/10/SWD_PFAS.pdf

[95] Endocrine Disruptors are a wide range of chemicals, both natural and man-made, which alter the functioning of the endocrine (hormonal) system. More information: https://ec.europa.eu/info/news/endocrine-disruptors-questions-and-answers-2018-nov-07_en

COMMODITY CHEMICALS

EU suppliers [23,24]. 90% of EU uses of elemental phosphorus is for chemicals [24]. The titanium ore used for the production of titanium dioxide, even if not a critical material due to its low grade (compared to Titanium metal), also faces a very high EU import reliance (100% in 2023), with Norway, South Africa and Canada as the main EU suppliers [23,25]. This suggests that for many chemicals included in the scope proposed for this product group, water emissions from industrial production are not regulated to the same extent as EU installations.

Specific measures in relation to PFAS exist under REACH, and additional restrictions are being prepared under REACH, with a far-reaching restriction possibly proposed by 2025 [22]. Research is on-going in order to substitute them with safer chemicals, and ESPR is likely to make use of any results obtained in this research field.

Finally, substantial improvements can be expected in terms of water consumption. The EU-funded EU4WATER (Economically and Ecologically Efficient Water Management in the European Chemical Industry) project focused on stimulating a paradigm shift in the chemical industry to create a breakthrough in industrial water treatment and management [44]. The project, finalised in 2016, has addressed crucial process industry needs to overcome bottlenecks and barriers for an integrated and energy efficient water management, and, through case studies, could develop water management strategies able to cut water use by 20-40% and wastewater production by 30-70%, while ensuring 60% direct economic benefits [45]. Typical water saving measures involve water meters and monitoring systems to identify leaks and overflows, however it is thanks to innovative process design that sizeable, long-term savings can be achieved – requiring a significant investment which can be paid back thanks to the cost savings in water use [46]. The United Nations proposed in 2018 to rely on nature-based solutions to address many of the world's water challenges, via an ecosystem approach that promotes greater resource productivity aiming to reduce waste and avoid pollution, including through reuse and recycling, and is restorative and regenerative by design [49]. Finally, there are innovations and new technologies still to be applied in areas where chemical production has shifted in recent years and where lower implementation of BAT and further measures to tackle and avoid pollution are still the norm [4].

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption

- performance requirement on maximum level of life cycle emissions to water (e.g. N, P, AOX – adsorbable organically bound halides, etc.)

- information requirement on life cycle water consumption

- information requirement on life cycle emissions to water (e.g. N, P, AOX, etc.)

Air Effects [4]

Environmental impact: High

Chemical production influences air quality and pollution despite efforts made by industry. Examples are the production of ammonia, hydrogen fluoride, or phosphoric acid, with high levels of dust emissions [5].

Between 2007 and 2019, the chemical industry achieved a 40% reduction in its acidifying emissions such as sulphur oxides (SO_x), nitrogen oxides (NO_x) and ammonia (NH_3), together with their reaction products [3]. Of particular toxicity are the emissions of volatile organic compounds (VOC) which are ozone precursors thus being a key environmental issue in the organic fine chemical production [6].

Improvement potential: Medium

Dust and other emissions to air from chemical production can be reduced by means of abatement techniques and application of Best Available Technologies [5,6,7,8]. An example is the reduction of VOC from chemical production achieved through changes in the solvent used, process optimization, and higher levels of solvent recycling [3]. These measures, implemented in the EU thanks to the Industrial Emissions Directive, together with the compromise by the chemical sector, helped to reduce emissions of NOx, SOx and non-methane VOCs by over 27%, 50% and 36%, respectively, since 2009 [67]. As mentioned in the "Improvement potential" section for Water Effects, non-EU processes escape the regulatory net of the Industrial Emission Directive, and requirements on air pollution set at the level of products placed on the EU market can give the opportunity to reduce air emissions worldwide.

COMMODITY CHEMICALS
Potential measures under ESPR: - performance requirement on maximum level of life cycle emissions to air (e.g. S, N, VOC, dust etc.) - information requirement on the level of life cycle emissions to air
Soil Effects [3] **Environmental impact: Medium** Chemical production often uses raw materials from natural resources as a starting point for their manufacturing. Mines and large production sites are common in the chemical industry, for which permits and safety measures vary depending on the country. Mining introduces significant environmental hazards, ranging from soil and water pollution to the disruption of ecosystems and the release of potentially deleterious substances into the soil medium ([61]). Chemical production sites may result in different effects on soil, such as the global conversion of forests, grasslands, and peatlands for mining, or industrial uses ([60]). Moreover, gaseous pollutants released to the atmosphere during production of commodity chemicals can enter the soil directly through acid rain or atmospheric deposition, in addition to incorrect chemical storage or direct discharge of waste into the soil ([62]). Other sources of pollution to soil are accidental emissions (spillages) during chemical production, which can have a significant impact on the environment which could need decades to recover and restore the contaminated site, especially in installations not equipped with strict safety measures and procedures ([61]). **Improvement potential: Medium** Preventive and optimisation measures are to be put in place to limit and avoid soil pollution. As an example, to avoid pollution of the subsoil and groundwater by acidic and contaminated phosphogypsum leachate and run-off (process water and rainwater), preventive measures such as seepage collection ditches, intercept wells, natural barriers and lining systems are necessary. Furthermore, to prevent or minimise pollution of the surrounding area and water systems, it is necessary to make provisions for any effluent overflow ([5]). Apart from safe storage and little or no water use, measures to prevent soil and groundwater pollution can be applied regarding a traditional furnace set-up. These measures include: retain fluid from the storage area; retain fluid at the bottom of the furnace terrain in combination with a system to collect drainage water, and a groundwater monitoring system; fluid tight floor at the desulphurisation unit and at the waste water treatment unit; and/or fluid tight foil lining at the bottom of the waste water basins ([8]). Advanced accident-prevention systems, and human and institutional infrastructure should be established to prevent chemical spills, including major industrial accidents. In the EU, such measures have decreased the number of accidental pollutant releases to water and air around 50% over the period 2007-2019 for commodity chemicals ([5]). The aforementioned measures refer either to chemical safety which is tackled by chemical legislation (not under ESPR scope as primary objective) or to the control of pollutant emissions also under other legislative initiatives but applicable in the EU only (e.g., IED). Finally, implementation of responsible sourcing programmes and traceability standards for raw materials are measures that could be applied to the production of commodity chemicals. **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [3] **Environmental impact: Medium** Pollution is a key driver of biodiversity loss and has a harmful impact on human health and environment. Biodiversity is suffering from the release of nutrients, chemical pesticides, or hazardous chemicals ([1]). Mining of raw materials had a major impact on biota since ancient times ([62]), and can lead to the disruption of ecosystems and the release of potentially deleterious substances into the soil medium ([61]). In addition, accidental spillages can drastically affect the biodiversity of contaminated sites, with the degree of environmental degradation being dependent on the ecotoxicity, persistence, and volume of chemicals released and the physical and biological nature of the habitats polluted ([62]). For example, the impacts from accidental spills

of ethyl benzene into the Roanoke River (U.S.) caused the death of 13000+ fish and macroinvertebrates for around 11 km (63).

Improvement potential: Medium

Measures mentioned in previous sections for Water, Air and Soil effects will also have an indirect (positive) contribution for a healthy biodiversity. Measures such as the storage of raw materials indoor and reduction of water usage in combustion furnaces can help reducing soil or groundwater pollution (5, 6, 7, 8). Measures such as the development of biodiversity plans helping to protect specific areas of high interest can be put in place. Actions to restore degraded ecosystems, in particular those with the most potential to capture and store carbon and to prevent and reduce the impact of natural disasters (9) are to be put in place. Some examples may include increase of vegetation along watercourses and setting natural connections back into the landscape for species survival (10). The aforementioned measures refer to the control of pollutant emissions under other legislative initiatives and to specific biodiversity measures as in the proposed new law to restore ecosystems (Nature Restoration Law) (18), which are out of the scope of ESPR. The implementation of responsible sourcing programmes and traceability standards for raw materials are measures that could ensure reduced impact on the environment, especially for alternative bio-based feedstock, now on the rise for the chemical industry.

Potential measures under ESPR:

- performance requirement on content of raw material with sustainability* certification

- information requirement on the sourcing of raw materials from certified sustainable practices

Waste Generation & Management [3]

Environmental impact: Medium

Waste produced within the chemical sector can be hazardous and non-hazardous with a huge variety depending of the specific chemical being produced. Examples of solid waste produced by the industry are spent catalyst and catalyst support, spent purification media (which are used to remove impurities such as water or unwanted by-products, e.g. activated carbon, molecular sieves, filter media, desiccants, ion exchange resins), unwanted compounds produced by side-reactions, product separation and refinement, process residues, spent reagents, and off-specification products (7). Global data on the total amount of industrial waste generated by the chemical industry could not be found. In the US, official data are available only for toxic-release inventory waste managed by sector, which for the chemical industry was 7 million tonnes in 2020 (68). In the EU, the amount of waste from the chemical industry was 11.57 million tonnes, although it was not possible to know how much of this comes from the commodity chemicals included in the scope of this fiche (64). The generation of both hazardous and non-hazardous waste in the chemical industry has been increasing by 21% in the period 2012-2018, and decreasing in the period 2018-2020 (latest official data available), most likely due to the COVID-19 pandemic (64). The amount of generated waste in the EU is marginally decoupling from the total gross value added by the chemical industry during this period (64). The share of total generated waste categorised as hazardous remained stable at about 50% (5.8 million tonnes per year) between 2012 and 2020 (64). The tendency of the sector is to recover what is possible, for example catalysts based on precious metals, whose recovery is economically viable, either on or off site, compared to sending them for disposal (7). Some process residues are also economically viable to be recovered, e.g. heavy organic residues from distillation columns such as tars and waxes, which can be used as a feedstock for another process or as a fuel (7). Some organic solvents may also be valuable to recover/reuse, or to use a fuel to capture the calorific value (7). With respect to the packaging that contains and transports the chemical, intermediate bulk containers (IBCs) are industrial, usually HDPE-made, containers (the "bottle") housed within a tubular steel cage that is attached to a pallet (69). Such containers are usually reusable and have an expected lifetime of 5 rotations* before being sent to recycling (69). A study evaluating the environmental impacts of IBC estimated that on average 43% of the IBCs are discarded and sent to material recovery, with the remaining 57% being washed and reused (69).

Improvement potential: Medium

The reduction of generated waste can be an indicator of a higher process and production efficiency (industrial symbiosis) (21), and is an international priority recognised in the Rio+20 United Nations Conference on Sustainable Development in 2015 via target 12.4: "*By 2020, achieve the environmentally sound management* *of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks* […]" ([65]).. Measures for improvement involve prevention, novel process to avoid residues, resource efficiency technologies, recycling and reuse of by-products, spent catalysts, process residues and off specification problems ([3]). In particular, reusing materials and resources is imperative towards the transition to a circular economy, provided that the recycled materials are sourced and treated in a sustainable way ([21]). In this regards, CEFIC has estimated that over 50% of waste – equal to 4.4 million tons – was recovered in 2019 ([67]). There are opportunities to shift from traditional production and use of chemicals to chemicals as a service which could optimise the use of expertise and ensure resource efficiency during the entire life cycle ([1]). Moreover, the choice of one chemical over another one for a certain product application has the potential to influence the disposal option for that product application once it reaches its end-of-life. For example, there can be chemicals impeding recycling processes ([20]). Since (large) chemical companies have a huge variety of products for various sectors, it is important that they have an overview of which products could negatively impact the circularity potential of their use cases/applications. Knowledge and transparency of a company's product portfolio is the starting point for improving the environmental sustainability of chemicals in products ([21]). Material efficiency in the chemical industry is also one of the principles underpinning the Safe and Sustainable by Design (SSbD) framework ([66]). The SSbD is a voluntary approach to guide the innovation process for chemicals and materials, and aims to reduce raw materials use in production processes and to generate less waste. The application of the SSbD in the production of chemicals could decouple waste generation from the gross value added of the goods produced by the chemical industry. Finally, with respect to the packaging used by the industry, the newly adopted Packaging and Packaging Waste Regulation prescribes minimum mandatory re-use targets for plastic intermediate bulk container used within the EU, at a minimum rate of 40% by 2030 and 70% by 2040. The revised Regulation also addresses aspects such as the recyclability of all packaging placed on the market as well as specific recycled content. Additional measures specific to intermediate bulk containers for commodity chemicals could be investigated during a potential Preparatory Study.

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated

- performance requirement on minimum fraction of by-products/process residues/off-specs recovered

- information requirement on how to correctly use, store and dispose of the product (for non-hazardous chemicals, since information about hazardous chemicals is covered by existing EU legislation)

- information requirement on maximum amount of life cycle waste sent to landfill

- information requirement on the impacts on the recyclability of the final products for some applications of the commodity chemical, in order to facilitate transparency along the value chain

Climate Change [5]

Environmental impact: High

The global chemical sector is the third largest emitter in terms of direct CO_2 emissions, only behind cement and iron and steel ([32]). The industry generates about 5% of global CO_2 emissions, and consumes 14% of all oil and 8% of all gas supply as feedstock and fuel and is, therefore, one of the largest consumers of fossil carbon supply for material use, accounting for 723 Mt of pure carbon (equivalent to 2,655 Mt of CO_2) ([32,41,70,74]). The global CO_2 emissions from the chemical sector have shown an overall increasing trend since 2010, although with differences depending on the country and the specific commodity chemical under focus (for example, the global CO_2 emissions from ammonia production have been stable at around 400 Mt CO_2 emissions/year) ([32]). In China, the chemical industry's carbon emissions have fluctuated and increased since 2005, reaching a peak in 2015, and decreasing steadily until a 18% decrease in 2020 compared to 2015 levels, in line with China's response to global climate change ([71]). In the U.S., the chemical manufacturing sector reported emissions of around 200 million tonnes of $CO_{2\text{-eq}}$ for 2022, a 6% increase since 2013 ([72]). In the EU, total GHG emissions from the chemical industry showed a fluctuating trend, resulting in an overall strong decrease since 1995 ([3,73]). GHG emissions decreased by around 50%, in the period 1997-2012, showed a historical minimum in 2020, and slightly increased in 2021. Between 2012 and 2021, GHG emissions from the chemical sector decreased by 9% compared to 2012 levels, while the gross value added of the chemical industry increased by 23% ([73]), suggesting a decoupling of the GHG emissions from chemicals production. However, given the current and future stress on phasing out fossil fuels from other industrial sectors, the chemical industry is expected to become the largest driver of global oil consumption by 2050 ([74]).

CO_2 emissions can occur due to combustion of fuels for heat or power generation, or they can be process-related ([3]). The EU Member States' annual GHG inventory indicates that 67% of GHG emissions from the chemical industry comes from fuel combustion, while 33% were linked to industrial processes and product use, but this can vary across Member States ([73]). Process-related GHG emissions have experienced the most significant decrease in the EU since 2012 (15%); for example, nitrous oxide emissions related to the production of nitric acid fell significantly due to the implementation of abatement techniques ([73]). Among the chemical products included in this product group, ammonia production is the largest single contributor to the chemical industry's Scope 1 and 2 emissions[96] (0.37 Gt of CO_{2eq} or 45% of the Scope 1 and 2 emissions produced by the primary chemical intermediates industry today) and is predicted to be by far the largest growing chemical by 2050 ([43]).

Improvement potential: High

In the case of the chemical industry, the focus should be on how it could achieve net-zero emissions, rather than on its decarbonisation, since fossil fuels are largely used as raw materials to provide carbon and/or hydrogen to the final products ([74]). According to the IEA, in order to achieve the Net Zero Emissions by 2050 Scenario**, by 2030 we should see an 18% CO_2 emission reduction compared to 2022, despite an increase in production ([32]). To decouple CO_2 emissions from production, chemical industry will need to achieve technological innovation, efficiency gains and higher recycling rates. Examples of the levers that have the highest potential for emissions reductions are steam generation, heat integration, electricity procurement and energy efficiency during production ([36]). Moreover, important steps are being taken to deploy low-emissions chemicals production technologies, with special focus on three technologies: carbon capture, utilisation and storage (CCUS), the use of electrolytic hydrogen and direct electrification (mainly when the required process heat is below 200 °C) ([32,35,42]). A couple of known small-scale CCUS projects on high-value chemicals plants have been developed in China, with one methanol plant with a production capacity of 110kt ([32]). The European Union is also very active on the topic, with 66 planned CCUS facilities and 6 in operations (Jan 2023 data), and issued around EUR 1.5 billion to CCUS projects under the latest Innovation Fund round, and over EUR 500 million to CO2 transport and storage projects under its Connecting Europe Facility programme ([75,76]). France estimates that CCUS technologies in the French chemical industry can account for -24 Mtonnes CO_{2eq} ([35]). With respect to the use of electrolytic hydrogen, the European Union accounts for the largest number of electrolysis projects for ammonia and methanol production ([32,43]), and ammonia especially has the potential to be produced in large volumes using low-emission hydrogen. Electrolysis is one of the technologies with the largest growth potential for ammonia, expected to represent 67-80% of ammonia production by 2050 ([42,43]) (the first EU plant is under construction in Denmark ([33,34])). In addition, methanol is expected to play a central role both as a means of recycling carbon at end-of-life and in the production of olefins and aromatics from renewable sources of carbon and green hydrogen ([43]). Finally, on the direct electrification of energy sources, several projects in Europe and the US are looking into electrifying steam crackers, one of the key units for producing high-value chemicals ([42]). The current projects are all at relatively low technology readiness levels, from concept to small pilot, although some plants have scaled up to demonstration in 2023 to achieve commercialisation in 2024 ([33]). With respect to process-related emissions, improvements can be achieved by reducing N_2O emissions from the production of nitric acid and glyoxylic acid ([35]). Finally, an interesting solution without hampering the industrial development is to make use of emitted CO_2 to efficiently convert it into e.g. new chemical feedstock ([26,27,28,29]). The CO_2 reduction to other chemicals can be done by different methods such as thermochemical, photochemical, and electrochemical pathways ([30]). Catalyzing the reduction of CO_2, however, is a challenging chemical process due to the myriad of possible products and complicated interconnected reaction pathways, and "business as usual" has not yielded a viable catalyst so far ([30]). It is reported that the reduction of CO_2 can lead to 17 different chemical/fuel products depending on

[96] Scope 1 emissions are direct emissions created by a company's activities, scope 2 emissions are indirect emissions from the consumption of the electricity or heat used by the company, scope 3 emissions are indirect emissions from all other activities in which the company is engaged

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the materials and/or methods employed, to e.g. methanol, acetaldehyde, dimethyl ether, methane, glycolaldehyde, hydroxyacetone, ethanol, acetone and ethylene ([31]). Note that, to make a significant impact, the demands for the output chemicals need to be higher than now ([38]). All in all, it has been estimated that 15% of available emerging abatement solutions have the potential to address 90% of the industry's scope 1 and 2 emissions ([37]). Finally, the carbon intensity of the chemical products can be reduced by making use of alternative bio-based feedstock, and the bio-based chemical turnover has increased by over 30% since 2009 ([67, 73,78]). Moreover, focus should be placed also on the carbon intensity of the energy used ([74]), since renewable energy still accounts for only 1% of the energy used for the production of chemicals, even if its share more than doubled in the period 2000-2020 ([3]). However, it has been discussed how the use of low-carbon electricity for commodity chemicals production might affect the pathway to full decarbonisation of other sectors, e.g., the power, transport, or aviation sectors ([74,77]), so that consequences will have to be analysed carefully.

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint

- performance requirement on minimum share of energy consumption from low carbon sources

- performance requirement on minimum content of sustainable renewable materials

- information requirement on the share of energy consumption from low carbon sources

- Information requirement on carbon footprint

- information requirement on the content of sustainable renewable materials

Life Cycle Energy consumption [4]

Environmental impact: High

The chemical sector is the second-largest global industrial energy consumer, as well as the largest energy user of all manufacturing industries globally and in the EU ([40,67]). The production of olefins, ammonia, aromatics and methanol alone accounts for more than 50% of energy consumption in the chemical and petrochemical sector ([16,40]). Significant environmental challenges are caused by the coal-based chemical industry, which is particularly prevalent in China, as emission intensities are considerably higher than in natural gas-based production. For example, methanol can be produced from coal at a low cost in China (IEA). Coal accounted for an estimated 36% of process energy used in primary chemical production in 2022. Most of the electricity consumed by the chemicals industry is used for drive and motor systems and is set to grow by 30% by 2030 ([40]). In the EU, efforts to reduce the energy consumption have resulted in -24% of total energy usage since 1990; however, the reduction in the period 2005-2020 was of -3% ([2,67]). Moreover, the specific energy consumption in the eU (i.e. energy consumption index/production index) dropped by 45%, suggesting that energy usage has decreased even though production volume has increased ([2]).

Improvement potential: Medium

The improvement potential of energy consumption shall be connected to the increment of energy efficiency by means of optimisation and improvement of the current procedures in combination with changes to avoid, when possible, energy–intensive processes followed by process innovation. Technologies exist to implement improvements that could significantly reduce energy use and help reach net zero carbon targets ([40]). Increased energy efficiency can be achieved both through incremental improvements to existing methods and step-changes resulting from switching to fundamentally more efficient methods (e.g. from coal- to natural gas-based processing) ([32]). Examples include process intensification, improved waste heat recovery, modern equipment, pump efficiency, improved steam system efficiency, combined heat and power, integrate gas turbines with cracking furnace ([38,40]). One example is ammonia production, for which preheating of combustion air, hydrogen recovery from the purge gas, indirect cooling of the ammonia synthesis reactor and use of smaller catalyst particles in ammonia converters have resulted in significant reductions in energy consumption (and CO_2 emissions) ([38,39]). Another example is benzene, which is conventionally produced from hydrocarbons by energy intensive catalytic conversion techniques, and experimental studies have explored the development of alternative efficient catalysts for high feed conversion and high yield of benzene ([38]). Other energy reduction possibilities are the integration of energy demand and supply, process re-design for reduc-

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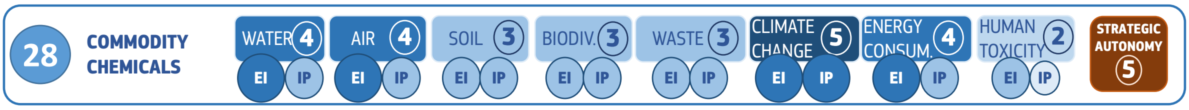
tion of energy demand, and green technologies for efficient supply of energy ([38]). The whole processes efficiency may also be optimised by means of digital technologies such as the internet of things, big data, artificial intelligence, smart sensors and robotics whereas re-skilling and up-skilling of the workforce involved in the production and use of chemicals also has a role ([1]). **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - performance requirement on efficiency of the product at low energy consumption - information requirement on life cycle energy consumption - information requirement on the efficiency of the product at low energy consumption
Human Toxicity [2] **Environmental impact: Medium** Production of chemicals is a source not only of environmental emissions but health hazardous substances such as heavy metals, ED, PFAS, CMR[97], respiratory sensitizers, chemicals toxic to specific organs or bioaccumulative species. With this in mind, the European Commission published the Chemicals Strategy for Sustainability, which stresses the need to accelerate the development of Safe and Sustainable by Design Chemicals ([1, 17]). **Improvement potential: Low** The improvement potential lies in designing new chemicals in a safe and sustainable way ([1, 17]), as well as in better risk management measures and operational conditions that limit the emissions and exposure to hazardous substances. **Potential measures under ESPR:** No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.
Final score [28]

Open Strategic Autonomy score [5] **Relevance:** The high score of the category chemicals is explained by the broadness of the scope which includes organic and inorganic compounds. Regarding the CRMs, many of them are used mainly for production of chemicals such as: phosphorus (94% of the EU supply used for chemicals and agro-chemical), phosphate rock (90% for fertilizers and detergents), bismuth (62% for chemicals), silicon metal (54% for chemical application), antimony (43%), or fluorspar (21% for fluorochemicals and fluoropolymers). Most of all, the manufacturing process for chemicals requires an extensive use of catalysts composed of Platinium group metals or Rare-Earth elements like Cerium or praseodymium. These are key materials for the manufacturing of chemicals and chemical products.

[97] Carcinogenic, mutagenic and reprotoxic chemicals

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Regarding fossil feedstock (hydrocarbons), approximately 20% of the imported crude oil is used for chemical purposes including both fertilizers product (10%) and plastics (10%). Chemicals as well as fossil feedstock are also targeted by sanctions against Russia, as specified in the EU's fifth package of restrictive measures. Finally, the energy price volatility appears as one (if not the main) factor hindering EU chemical industry competitiveness. Given that Chemical industry is an energy-intensive sector, EU industrial stakeholders face considerable expenses due to energy costs and potential supply risks -for e.g. natural gas- influenced by geopolitical factors. Therefore, finding an affordable, secure, and environmentally sustainable energy source is the industry's ultimate goal. **Potential gains for Open Strategic Autonomy:** Due to the broadness of the scope, determining one mitigation measure regarding all kind of chemicals appears quite challenging. Some chemicals are dissipated in the environment during use phase or EoL and cannot be recovered. Also, a non negligible part of chemicals consumed in the EU is imported from third countries while an important part of chemicals manufactured in the EU are exported, which complicates the implementation of circular measures such as mandatory recycling rate or recycled content. According to Eurostat, imports of chemicals into the EU increased from €172 billion in 2011 to €271 billion in 2021 while exports reached €459 billion in 2021. A strong focus on improving energy efficiency of the sector might help to ensure resilience of the sector, preventing relocation to outside of the EU where highly carbon intensive energy sources are more affordable.
Policy Gaps The EU already has one of the most comprehensive and protective regulatory frameworks for chemicals, supported by the most advanced knowledge base globally ([1]). The European framework comprises more than 40 legislative instruments (see, e.g., EUCLEF[98]) including the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)[99] and, the Regulation on the Classification and the Labelling and Packaging of hazardous substances (CLP)[100], recently revised. As the Chemicals Strategy for Sustainability summarises, a pathway towards implementation of actions to support innovation for safe and sustainable chemicals, strengthen the protection of human health and the environment, simplify and strengthen the legal framework on chemicals, build a comprehensive knowledge base to support evidence-based policy making, and set the example of sound management of chemicals globally, is needed ([1]). The complexity of EU's chemicals legislation has been acknowledged before, meaning that some SMEs may not fully understand their legal obligations, this still happening nowadays ([19]). In this line, information requirements to overcome this limitation would be appropriate either under ESPR or another regulatory tool. Potential ESPR measures will not address chemical safety as primary objective. However, there are complementary, potential measures that could be considered under ESPR such as requirements on water, waste and energy performance, on recycled content of chemical products to reduce raw material use andemissions, or on sourcing of raw materials from certified sustainable practices. Whether the ESPR is the most appropriate and effective regulatory tool to make progress in these areas has not been addressed yet.

[98] EUCLEF - ECHA (europa.eu)

[99] Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals. OJ L 396, 30.12.2006.

[100] Regulation (EC) No 1272/2008 on the Classification, Labelling and Packaging of Substances and Mixtures. OJ L 353, 31.12.2008.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT							Related Union Law	What could be addressed by ESPR
maximum limit of life cycle water consumption	WATER							Industrial Emission Directive	IED covers the production of chemicals, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to water (e.g. N, P, AOX)	WATER							Industrial Emission Directive	IED covers the production of chemicals, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to air (e.g. S, VOC, dust)		AIR						Industrial Emission Directive	IED covers the production of chemicals, but not other life cycle stages or production outside the EU
minimum content of raw material with sustainability certification			SOIL	BIODI VERSITY				Regulation on deforestation-free products	The Deforestation-free Regulation only addresses wood, rubber, cattle, coffee, cocoa, palm oil and soy. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated					WASTE			Waste Framework Directive	WFD incentivizes waste prevention but does not have a product-specific approach
minimum fraction of by-products/process residues/off-specs recovered	WATER	AIR	SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
maximum level of carbon footprint				BIODI VERSITY		CLIMATE CHANGE	ENERGY USE	Emission Trading System	ETS covers the production of some chemical ingredients (acids and bulk organic chemicals), but not all chemicals in this scope, other life cycle stages or production outside the EU
minimum share of energy consumption from low carbon sources				BIODI VERSITY		CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product-specific and does not address production outside the EU. It includes voluntary labelling, but not mandatory requirements

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT							Related Union Law	What could be addressed by ESPR
minimum content of sustainable renewable materials				BIODIVERSITY		CLIMATE CHANGE		Renewable Energy Directive II	RED II sets sustainability requirements for biomass but not mandatory minimum use of renewable materials
maximum level of life cycle energy consumption							ENERGY USE	Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU, but not outside the EU. Also, EED is not product-specific
efficiency of the product at low energy consumption						CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT							Related Union Law	What could be addressed by ESPR
level of life cycle water consumption	WATER							-	Full potential of the requirement
level of life cycle emissions to water	WATER							-	Full potential of the requirement
level of life cycle emissions to air		AIR						-	Full potential of the requirement
sourcing of raw materials from certified sustainable practices			SOIL	BIODIVERSITY				-	Full potential of the requirement
how to correctly use, store and dispose of the product (for non-hazardous chemicals)	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	REACH	REACH requires information only on hazardous chemicals
amount of life cycle waste sent to landfill					WASTE			-	Full potential of the requirement
impacts on the recyclability of the final products for some applications of the commodity chemical	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
carbon footprint						CLIMATE CHANGE		-	Full potential of the requirement
share of energy consumption from low carbon sources						CLIMATE CHANGE		Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT		Related Union Law	What could be addressed by ESPR
content of sustainable renewable materials	CLIMATE CHANGE		-	Full potential of the requirement
life cycle energy consumption		ENERGY USE	-	Full potential of the requirement
efficiency of the product at low energy consumption	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement

Additional notes and list of references

* 'rotation' is intended here as the cycle that reusable packaging accomplishes from the moment it is placed on the market together with the product it is intended to contain, protect, handle, deliver or present, to the moment it is ready to be reused in a system for re-use with a view to it being supplied again to end users together with another product, in line with the Revised Packaging and Packaging Waste Regulation.

** The Net Zero Emissions by 2050 Scenario (NZE Scenario) is a normative scenario that shows a pathway for the global energy sector to achieve net zero CO_2 emissions by 2050. This scenario also meets key energy-related Sustainable Development Goals (SDGs), in particular universal energy access by 2030 and major improvements in air quality. It is consistent with limiting the global temperature rise to 1.5 °C (with at least a 50% probability), in line with emissions reductions assessed in the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report.

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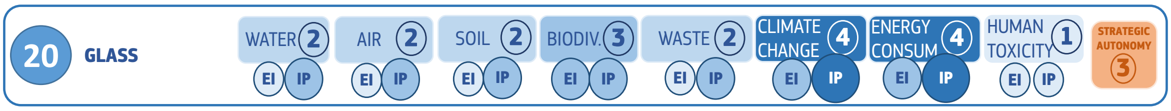
Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

GLASS



Scope: Products included: container glass, flat glass, continuous filament glass fibre, domestic glass, special glass, mineral wool, high temperature insulation wools (HTIW) and frits.

The main application of glass is packaging glass, with a production of is ~25 million tonnes/year (~60% of glass production), followed by flat glass, with 10 million tonnes/year (~25 % of glass production) ([18,20,23]). 97% of packaging glass is used by the food and beverage industry ([23]). For flat glass, 80% is used in buildings, 15% in automotive and 5% in solar and other applications ([20]).

Water Effects [2]

Environmental impact: Low

Impacts to water are mainly caused by sand mining, which is causing the collapse of river banks, river and coastal erosion in some areas on Southeast Asia ([1]). However, despite sand is one of the largest resources extracted and traded by volume ([1,7]), it is estimated that the glass industry represents <1% of the 50 billion tonnes of sand extracted yearly, the remaining 99% being used for construction purposes ([2]). Impacts on surface water quality arising from cleansing the sand from clay and silt particles are not high ([3]). Groundwater quality can be affected by the use of polyacrylamide and acid mine runoff from sand mines, but there not have been documented cases of contamination of groundwater aquifers ([3]). Silica sand mining can be a water-intensive industry ([3]).

Improvement potential: Medium

The improvement potential is mainly related to limiting illegal sand mining practices and implementing existing standards and best practices and using recycled materials to prevent and mitigate the impacts to rivers and coasts ([6]). This relates to non-EU production, since sand extraction is strictly regulated in the EU, including the rehabilitation of the quarries at the end of the extraction permit period. The water use during production can be decreased by 90% if closed-loop systems are used for the recycling of water ([3]).

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- performance requirement on maximum level of life cycle emissions to water
- information requirement on life cycle water consumption
- information requirement on the level of life cycle emissions to water

Air Effects [2]

Environmental impact: Low

The glass industry represents a significant potential for dust emissions due to the use of powdered, granular or dusty raw materials and the crushing and sorting of cullets ([4]). Moreover, melting activities release pollutants such as particular matter, SO_2, CO_2, NO_x, HCl, HF and heavy metals ([4, 5]).

Improvement potential: Medium

Dust emissions can be reduced by a correct design of the facilities and the use of filters and sealed areas. NO_x formation can be reduced by minimizing combustion air supply to the furnaces or by running furnaces

GLASS
under slightly reducing conditions. Innovations in heating and melting such as oxy-fuel furnaces can reduce the amount of flue gases by 60–70% ([16]). SO_x emissions can be reduced with dry or semi-wet scrubbers or bag filters ([4]). Emissions of heavy metals can be reduced using high-efficiency dust abatement techniques ([4]). These measures are already partly taken up by EU installations, although differences in performance can be identified. Non-EU installations do not have to comply with the Industrial Emission Directive, therefore the emission of air pollutants during glass production can be expected higher than EU standards. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle emissions to air - information requirement on the level of life cycle emissions to air
Soil Effects [2] **Environmental impact: Low** Sand and gravel extraction are one of the major sustainability challenges of the 21st century, especially in terms of resource depletion ([6,7,8]), which is addressed in a following section. However, while the glass manufacturing industry is one of the largest end-user industries of the silica sand market, it represents <1% of total sand extraction ([2,9]). **Improvement potential: Medium** The improvement potential lies in avoiding or reducing consumption; using alternative materials such as recycled materials; and reducing the impacts through implementing existing standards and best practices ([6]), especially for non-EU installations that are not regulated by the Industrial Emission Directive. **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [3] **Environmental impact: Medium** Globally, the volume of sand extracted illegally from riverine and marine ecosystems results in river and coastal erosion, threats to freshwater and marine fisheries, removals of habitats, changes to the vegetation structure of riparian zones and changes to the downstream sedimentation, as well as the ecology, and the livelihoods of the 3 billion people who live along rivers ([6,7,8]). However, it is estimated that the glass industry represents <1% of total sand extraction ([2]). **Improvement potential: Medium** The improvement potential lies in reducing sand consumption to a quantity which is within the volume 'replenished' by the system; using alternative materials such as recycled materials; and reducing the impacts through implementing existing EU standards and best practices ([6,8]). This is especially relevant for non-EU installations that are not regulated by the Industrial Emission Directive. **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability certification - information requirement on sourcing of raw materials from certified sustainable practices
Waste Generation & Management [3] **Environmental impact: Low** Most activities of the glass industry produce relatively low levels of waste and, in most of the glass industry sectors, the great majority of internally generated glass waste is recycled back to the furnace([4]). However, in some cases related to special applications, quality requirements may make the use of recycled material

GLASS

not possible. Recycling of glass is relatively high in the EU, although with variations depending on the glass application. One ton of glass cullet is said to replace 1.2 tons of virgin raw materials ([4,20]).

For the packaging sector, 80% of glass packaging put on the EU market is collected for recycling, 91% of which is recycled back into bottles and jars, and on average a glass container made in Europe contains 52% post-consumer recycled glass ([22,24]), even though packaging glass recycling rate is < 35% on a global scale ([27]). Waste generation for packaging waste made of glass is projected to remain relatively stable and not set to grow significantly (+3% by 2030 compared to 2018)([19]). For the flat glass sector, glass cullet represents 26% of the raw materials' input that goes into European flat glass furnaces ([4,20]).

Improvement potential: Medium

There is improvement potential for some of the glass sectors such as the mineral wool and frits sectors, which show a wide variation in the amount of waste recycled to the furnace, ranging from nothing to almost 100 % for some stone wool plants ([4]). However, such improvement potential is very much linked to the availability of waste management facilities to collect and recycle waste non-packaging glass, for example end-of-life building glass ([20]). In fact, despite its recyclability, end-of-life building glass is almost never recycled into new glass products; instead it is often crushed together with other building materials and put into landfills or recovered together with other C&D waste, probably due to its inert characteristics and the little share of glass fraction in C&D ([25,26]). A proper collection and recycling system could turn what currently has a low market value to a valuable glass-making raw material ([25]). For packaging glass, reuse of glass products (especially containers) can be increased by durable and resistant design, which may however increase the product weight ([13,14,15]).

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated
- performance requirement on minimum fraction of by-products/process residues/off-specs recovered
- performance requirement on minimum recycled content
- information requirement on life cycle waste sent to landfill
- information requirement on the fraction of by-products/process residues/off-specs recovered
- information requirement on recycled content

Climate Change [4]

Environmental impact: Medium

Glass manufacturing is a significant emitter of GHGs, especially CO_2 (at least 86 million tonnes CO_2 every year ([11])), generated by fossil fuels combustion (roughly 75% of CO_2 emissions) and dissociation of carbonate raw material ($CaCO_3$ and dolomite) used in the batch (roughly 25% of CO_2 emissions) ([5,7,10,20]). In the EU, CO_2 emissions from the glass industry represents ~2% of the verified emissions of all stationary installations of the EU, and approximately 6% of industrial emissions (not including combustion) ([7,20]). Compared to China, world leader in flat glass manufacturing with over 50% of the world's installations, EU installations emit far less CO_2 with a reduced energy consumption. In equivalent size and when using the same amount of cullet, a Chinese float plant emits on average 90% more CO_2 ([20]) for the same production.

Improvement potential: High

Measures to reduce GHG emissions include increasing energy efficiency, use of low carbon content fuels or biofuels (although currently their supply would be insufficient to meet demand's needs ([20])), waste heat recovery and maximizing cullet use (to decrease fuel usage – in the range of 12-18% – and to limit the use of carbonate raw materials) ([5]). CO_2 emissions can also be reduced by CO_2 capture for large oxy-fuel furnaces ([21]), or electric melting, although such technologies are not available at viable economic costs for all glass manufacturing processes ([20]). Recycling of glass cullets can also decrease GHG emissions during production: 1 tonne of recycled glass is estimated to save 60% of CO_2 emissions ([12]). Carbon capture, storage and utilization are also expected to play a key role in some cases, e.g. -85% CO_2 emissions from flat glass industry compared to 2018 emissions ([20]). It has to be noted however that some glass manufacturing processes operates continuously 24/7 for uninterrupted periods of 16 to 20 years. During this period, only limited upgrades to plants can be realised so as to keep furnaces hot and to minimize energy waste ([20]).

In the case of flat glass manufacturing, the industry has already succeeded in cutting its CO_2 emissions per tonne of melted glass by 43% since 1990 ([20]). This was made possible by improving furnaces' design, construction and operations, including a certain share of glass cullets, and phasing out fuel oil-fired plants ([20]). While the processes used for glass manufacturing are application-specific, it could be studied if feasible to apply these solutions to the whole glass sector. It is expected that future incremental improvements could contribute to 7 percentage points additional emission reduction per tonne of flat glass produced ([20]). To go beyond this, major evolutions will be needed in infrastructures, science and society.

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- information requirement on carbon footprint
- information requirement on the share of energy consumption from low carbon sources

Life Cycle Energy consumption [4]

Environmental impact: Medium

Glass making is energy intensive and the choices of energy source, heating technique and heat recovery method are central to the design of the furnace ([4]). More than half of energy consumption in the glass production process is for the melting process of the raw materials ([21]). For the case of flat glass, EU installations have a reduced energy consumption compared to world's production leader China. In equivalent size and when using the same amount of cullet, a Chinese float plant consumes 32% more energy for the same production ([20] based on 2007 data from [21]).

Improvement potential: High

Possible measures identified in the literature are improved process control, batch preheating, waste heat recovery, reduce batch wetting to a minimum, use of novel mixers, selective batching, increased furnace size, use of electric furnaces (which result in lower energy losses), regenerative heating, oxy-fuel technology, increased use (up to 100%) of cullet, reduction of reject rates, and more ([4,7,21]). Innovations in heating and melting such as oxy-fuel furnaces or electric melting can reduce energy losses by 20-30% ([4,7]), although such technologies are not available at viable economic costs for all glass manufacturing processes ([20]). Use of recycled glass reduces the energy consumption, since glass cullets melt at lower temperature than the raw materials ([18]). As a general rule, 10% extra cullet results in a 2.5 – 3% reduction of the furnace energy consumption ([21]).

Potential measures under ESPR:

- performance requirement on a maximum level of energy consumption
- information requirement on energy consumption

Human Toxicity [1]

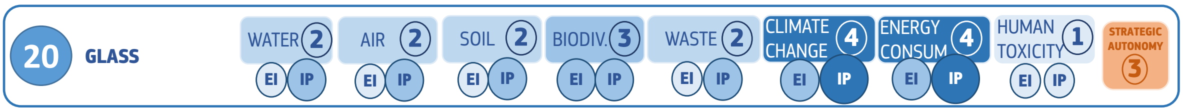
Environmental impact: Low

Dust emissions may represent an occupational health and safety (OHS) issue ([4]). Some factories use Cr-containing refractories, which under certain conditions release Cr(VI) compounds, which are highly soluble, toxic and carcinogenic.

Improvement potential: Low

Dust emissions can be reduced by a correct design of the facilities and the use of filters and sealed areas ([4]). Options exist to reduce the amount of Cr-containing refractories by development and redesign ([4]).

Potential measures under ESPR:

GLASS
No measures are envisaged under ESPR for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).
Total environmental score [20]

Open Strategic Autonomy score [3]
Policy Gaps The environmental impacts to air of the glass industry are regulated in the EU by the Industrial Emissions Directive and in Commission Implementing Decision 2012/134/EU ([17]), which are however regulating only EU installations. The industry, moreover, falls under the Directive on Emissions Trading System (ETS) and the REACH Regulation. Glass end-use products subject to specific legislation are: packaging products (Directive 94/62/EC), vehicles (Directive 2000/53/EC) and electrical and electronic products (Directive 2011/65/EU). Policy gaps exist with respect to regulating non-EU sand mining; however, this comes with difficulties related to regulating non-EU activities. Solutions for energy savings are currently incentivised only indirectly via the ETS Directive. Increased recycling is also not fostered via legislation at the moment, with the exception of glass packaging.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT							Related Union Law	What could be addressed by ESPR
maximum limit of life cycle water consumption	WATER							Industrial Emission Directive	IED covers the production of glass, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to water	WATER							Industrial Emission Directive	IED covers the production of glass, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to air (e.g. SO_2, NOx, particulate matter)		AIR						Industrial Emission Directive	IED covers the production of glass, but not other life cycle stages or production outside the EU
minimum content of raw material with sustainability certification	WATER		SOIL	BIODIVERSITY				Regulation on deforestation-free products	The Deforestation-free Regulation only addresses wood, rubber, cattle, coffee, cocoa, palm oil and soy. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated					WASTE			Waste Framework Directive	WFD incentivizes waste prevention but does not have a product-specific approach
minimum fraction of by-products/process residues/off-specs recovered	WATER		SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
minimum recycled content	WATER		SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
maximum level of carbon footprint				BIODIVERSITY		CLIMATE CHANGE	ENERGY USE	Emission Trading System	ETS covers the production of glass, but not other life cycle stages or production outside the EU
minimum share of energy consumption from low carbon sources				BIODIVERSITY		CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product-specific and does not address production outside the EU. It includes voluntary labelling, but not mandatory requirements

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT	Related Union Law	What could be addressed by ESPR
maximum level of life cycle energy consumption	CLIMATE CHANGE; ENERGY USE	Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU, but not outside the EU. Also, EED is not product-specific

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT	Related Union Law	What could be addressed by ESPR
level of life cycle water consumption	WATER	-	Full potential of the requirement
level of life cycle emissions to water	WATER	-	Full potential of the requirement
level of life cycle emissions to air	AIR	-	Full potential of the requirement
sourcing of raw materials from certified sustainable practices	SOIL; BIODIVERSITY	-	Full potential of the requirement
amount of life cycle waste sent to landfill	WASTE	-	Full potential of the requirement
recycled content	WASTE	-	Full potential of the requirement
fraction of by-products/process residues/off-specs recovered	WASTE	-	Full potential of the requirement
carbon footprint	CLIMATE CHANGE	-	Full potential of the requirement
share of energy consumption from low carbon sources	CLIMATE CHANGE	Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
life cycle energy consumption	ENERGY USE	-	Full potential of the requirement

Additional notes and list of references

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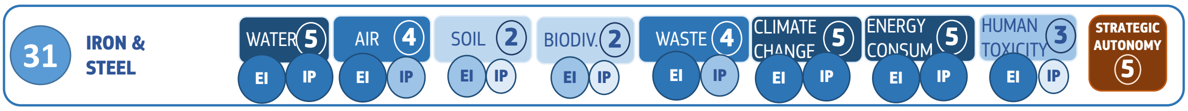
Product fiche 15. Iron and Steel

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

IRON AND STEEL



Scope: Iron and steel. Steel is an alloy of iron and carbon, where the carbon content can range up to 2% (when the carbon content is over 2.11%, the material is defined as cast iron).

Steel products considered under scope include group 72 (iron and steel) and group 73 (articles of iron or steel) of the Combined Nomenclature (CN codes).

Iron and steel's wide-ranging applications encompass the following sectors ([28-34]):

- The construction sector, accounting for more than 50% of the total demand, with infrastructure and buildings making up 24% and 28% of this share, respectively.
- The transportation sector accounts for 11% of EU steel demand. This sector can be disaggregated into three subcategories: light vehicles (LDV, LCV), which accounts for 8% of demand; heavy vehicles and buses (HCV), which accounts for 1%; and other transportation, which accounts from the remaining 2%.
- Industrial machinery accounts for 20% of overall demand, with mechanical machinery making up 15% and electrical machinery accounting for 4%.
- The metal goods sector represents 17% of total demand, of which 3% are domestic appliances and 1% is packaging; the remaining 13% is not further specified metal goods, such as racks, hangers, carts, and similar products.

Water Effects [5]

Environmental impact: High

Water consumption is the third resource most used in steel production after metal ore (iron) and fuel. The steel plant poses a serious risk to the water environment ([11]). For one ton of cast steel produced, there was over 100 m^3 of water used along the whole process while the wastewater produced was of 8.5 m^3 ([10]). Steel production is a source of freshwater and marine eutrophication as well as freshwater and marine ecotoxicity ([10]).

Improvement potential: High

There seems to be a considerable improvement potential in water efficiency with new technologies in the market developed by ArcelorMittal with recirculation rates of up to 98% at several facilities. Techniques and initiatives used include tailings thickening and water recirculation ([13]). The same company is part of the SpotView project which aims to develop and demonstrate innovative, sustainable and efficient technology and processes which optimise the use of natural resources, especially water, in three industrial sectors: dairy, pulp and paper and steel ([14]).

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption.

- performance requirement on minimum content of raw material with sustainability certification.

- information requirement on the life cycle water consumption.

- information requirement on the sourcing of raw materials from certified sustainable practices.

IRON AND STEEL
Air Effects [5] **Environmental impact: High** Iron and steel industry is a source of NOx, SO_2, CO and dust emissions ([9]). The main air emissions in the steel industry are dust, nitrogen oxides (NOx) and sulphur oxides (SOx), being dust the most visible of these environmental impacts ([13]). Due to use of organic resins and chemical binders, casting processes are known to emit low quantities of HAPs including benzene, toluene and phenol ([15]). Dust emissions from foundries are a major issue because they are generated in almost all process steps ([9]). Melting practice and sand consumption in moulding and core preparation stages result in emissions of dust with different composition and sizes. Fine and ultrafine particulates can easily reach the lung alveoli and result in respiratory and cardiovascular effects and silica sand dust is regarded as highly toxic ([16, 17]) Furthermore, presence of chemicals including PCDD/Fs, polycyclic aromatic hydrocarbons (PAHs), benzo[a]pyrene creates additional toxic risks ([15]). Emissions to air from steel plants are of high environmental significance. Air emissions include: dusts, PM_{10}, metals (As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Se, Tl, V, Zn), pollutants (HCl, HF, NOx, SO_2, CO, CO_2, CH_4, NMVOC, PAH, BaP, PCDD/F, PCBs) ([9]). The key environmental issues for iron casting process were identified as solid waste generation, air emissions including hazardous air pollutants and energy consumption ([15]). **Improvement potential: Medium** The improvement potential of this sector lies in de-dusting operations (secondary de-dusting systems), minimization of binders and resins consumption, use of high calorific value coke (decrease dust emissions as a result of reduced coke consumption)([15]), as well as decoupling of fossil fuel consumption. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle emissions to air. - information requirement on the level of life cycle emissions to air.
Soil Effects [2] **Environmental impact: Medium** The biggest source of metal and mineral depletion is iron consumption ([10]). Soil can be also polluted from the operations in the steel manufacturing process. In the coke oven gas treatment plant, tar and other organic compounds (e.g. BTX) are recovered from coke oven gas. Spillage or leakage of these compounds may cause a soil pollution hazard, depending on local soil conditions. Furthermore, spillage or leakage of coal water may also cause a soil pollution hazard ([9]). In other cases, if the scrapyard is unpaved and uncovered, contamination of soil may arise from the storage of scrap contaminated by mineral oil/emulsions or other compounds. If the yard for slag processing is unpaved and the raw slag contains free CaO, alkaline water may enter the soil ([9]). **Improvement potential: Low** The improvement potential of this sector lies in storing of the scrap according to different criteria (e.g., size, alloys, degree of cleanliness) or storing of scrap with potential release of contaminants to the soil on impermeable surfaces with drainage and collection system, applying a roof which can reduce the need for such a system ([9]). Other measures consist of the development of a plan for the prevention and control of leaks and spillages, use of oil-tight trays or cellars, prevention and handling of acid spillages and leakages ([3]). All these measures are already partially put in place by the sector. **Potential measures under ESPR:** No specific measures have been defined that directly cover soil effects. However, measures defined in other environmental areas may also benefit this environmental area.
Biodiversity Effects [2] **Environmental impact: Medium**

Biodiversity can be impacted by the management of extractive waste. The operation (construction, management and maintenance) of extractive waste facilities can disturb or destroy the initial natural habitat of local species during the operational phase. For example, when depositing extractive waste in the sea, the local benthic fauna is destroyed during operation; when depositing extractive waste on land, the local flora and fauna are disturbed. Emissions from these facilities can also influence the biodiversity at the local level ([18]).

Improvement potential: Low

The improvement potential of this sector lies in implementing appropriate closure plans and measures (e.g., putting back the topsoil to promote revegetation) and extending the monitoring programme to control the environmental impact within and around the steel manufacturing site to the extractive waste deposition areas ([18]). All these measures are already partially put in place by the sector.

Potential measures under ESPR:

No specific measures have been defined that directly cover biodiversity effects. However, measures defined in other environmental areas may also benefit this environmental area.

Waste Generation & Management [4]

Environmental impact: High

The key environmental issues for iron casting process were identified as solid waste generation, air emissions including hazardous air pollutants and energy consumption ([15]). Common extractive residues generated during mineral processing include powdery or slurred materials such as tailings. The relative amount of extractive residues generated during mineral processing is usually closely linked to the type of mineral resources processed, the mineral processing and the ore grade ([18]). In 2018, the production of ferrous metal wastes from mining and quarrying for hazardous and non-hazardous waste total was 320,000 tonnes in EU-27 ([19]). The metal industry remains one of the most important waste generating sectors ([15]).

Improvement potential: Medium

The improvement potential of this sector lies in applying on-site recovery and external reuse of waste sand techniques (reducing the solid waste generation the overall environmental impact of the process could be decreased by 60-90%) ([15]). In order to achieve a relatively small proportion of total residues requiring disposal, process optimisation, including maximising the internal recirculation of carbon and iron-bearing dusts can be applied ([9]). Given that recycling routes for steel are already well-established and end-of-life collection rate is around 85%, the potential to increase steel's recycling rate is quite modest ([27]). Adopting material efficiency strategies to reduce losses and optimise steel use throughout the value chain can curb demand growth and thus help the subsector get on track with the Net Zero Emissions by 2050 Scenario.

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated.

- performance requirement on minimum recycled content.

- information requirement on the amount of life cycle waste generated.

- information requirement on minimum recycled content.

Climate Change [5]

Environmental impact: High

Iron and steel are the second industry subsector in terms of direct CO_2 emissions. The iron and steel industry is highly intensive in energy and materials ([6, 7]). The specific energy intensity of steel production varies by technology and region. Global steel sector emissions were estimated to be 2.6 $GtCO_2$ in 2006, including direct and indirect emissions ([6]). Among heavy industries, the iron and steel sector ranks first when it comes to CO_2 emissions, and second when it comes energy consumption ([20,21]).

Improvement potential: High

IRON AND STEEL

Potential for energy efficiency improvements will likely soon be exhausted. Thus, innovation in the upcoming decade will be crucial to commercialise new low-emission processes, including those that integrate carbon capture, utilization, and storage (CCUS) and hydrogen ([20,21]). An option to produce near zero emission steel consists of using scrap-based electric arc furnace (EAF) production powered with zero emission electricity (however, scrap availability is limited), as well as other innovative primary production routes ([27]). Short-term CO_2 emissions reductions can be achieved largely through energy efficiency improvements and increased scrap collection to enable more scrap-based production. However, longer-term reductions will require the adoption of new direct reduced iron (DRI) and smelting reduction technologies that facilitate the integration of low-carbon electricity (directly or through electrolytic hydrogen) and CCUS, as well as material efficiency strategies to optimise steel use. The groundwork for commercialising these technologies needs to be laid in the next decade. Adopting material efficiency strategies to reduce losses and optimise steel use throughout the value chain can curb demand growth and thus help the subsector get on track with the Net Zero Emissions by 2050 Scenario ([20,21]).

Iron climate-friendly sourcing practices could reduce CO_2 emissions by, at least by 10%, for a number of processes inherent to extraction and processing stage; this is significant given the magnitude of total CO_2 equivalent emissions (>223 Mt CO_2eq) versus the total raw material demand (>620 Mt CO_2eq) within Europe ([23]). On the other hand, it has been estimated that decarbonisation technologies could result in a decrease of CO_2 emissions, with respect to 2015, ranging approximately from 15 – 90% depending on the pool of technological options considered ([24]).

Potential measures under ESPR:

- performance requirement on a maximum level of carbon footprint.

- performance requirement on minimum share of energy consumption from low-carbon sources.

- information requirement on the level of carbon footprint.

- information requirement on share of energy consumption from low-carbon sources.

Life Cycle Energy consumption [5]

Environmental impact: High

The iron and steel industry is highly intensive in energy and materials ([6, 7]). The key environmental issues for iron casting process were identified as solid waste generation, air emissions including hazardous air pollutants and energy consumption ([15]). Among heavy industries, the iron and steel sector ranks first when it comes to CO_2 emissions, and second when it comes to energy consumption ([20,21]). The steel sector is currently the largest industrial consumer of coal, which provides around 75% of its energy demand. Coal is used to generate heat and to make coke, which is instrumental in the chemical reactions necessary to produce steel from iron ore.

Electricity consumption had a major impact on the process' total fossil fuel depletion and greenhouse gas emissions. The results of the analysis indicated that the use of alternative fuels could reduce greenhouse gas emissions, but the use of charcoal increased other impact categories such as land use and total energy demand. Pollution prevention methods related to raw material substitution in iron-making processes should be applied to reduce the environmental impacts of the iron and steel industry ([10]).

Improvement potential: High

The improvement potential lies in collecting data on energy intensity for each separate steel production route; this is especially needed to account for variability among routes and enable better performance assessments and comparisons. Increased industry participation and government co-ordination are both integral to improve data collection and reporting. Through increasing production from scrap, natural gas-based DRI and hydrogen-based DRI, coal's share of energy consumption in the subsector falls to just below 60% by 2030 in the Net Zero Emissions by 2050 Scenario. Using clean scrap can reduce energy consumption by 10 to 15% ([15]). Scrap-based steel production (also referred to as secondary or recycled production) can be valuable in reducing energy demand and CO_2 emissions, as it is considerably less energy-intensive than primary production from iron ore ([8]). Pollution prevention methods related to raw material substitution in iron-making processes reduce the environmental impacts of the iron and steel industry ([10]).

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Potential measures under ESPR:

- performance requirement on a maximum level of life cycle energy consumption.

- information requirement on the level of life cycle energy consumption.

Human Toxicity [3]

Environmental impact: High

The most significant environmental impact was damage to human health, which was related to coke consumption in the blast furnace and iron ore consumption in the sinter plant ([10]). Melting practice and sand consumption in moulding and core preparation stages result in emissions of dust with different composition and sizes. Fine and ultrafine particulates can easily reach the lung alveoli and result in respiratory and cardiovascular effects and silica sand dust is regarded as highly toxic ([16, 17])

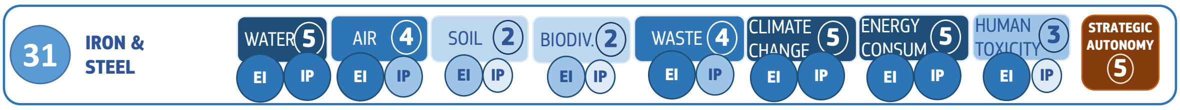
Improvement potential: Low

The improvement potential of this sector lies in addressing the coal gasification-shaft furnace-electric furnace (CSE) steelmaking technology that has recently become a sustainable topic of great concern, due to its environmental and economic benefits ([12]). De-dusting operations (secondary de-dusting systems), minimization of binders and resins consumption, use of high calorific value coke (decrease dust emissions as a result of reduced coke consumption) ([15]).

Potential measures under ESPR:

No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.

Final score [31]



Open Strategic Autonomy score [5]

Iron and steel products combines a high share of critical raw materials demand used in the product, like 82% of the EU demand for coking coal ending in Steel industry, with substantial share of materials targeted by sanctions such as pig iron, coking coal, steel products(see EU's "12th package" of restrictive measures). Steel alloying elements such as Niobium and Vanadium are also classified as CRMs.

Potential improvements: Shifting production route from blast furnace to electric arc furnaces can improve both material and energy efficiency. However, the availability of good quality scrap in the EU is a prerequisite for a performing secondary route. The supply and consumption of natural graphite (CRMs) in the electrodes of the electric arc furnace should also be monitored to not shift from a supply dependency (coking coal) to another (graphite). Finally, hydrogen might play a role in the long term by substituting coking coal as a reducing agent in the blast furnace route. At the moment, most of the alloying elements are dissipated and not functionally recycled. The situation can be improved, dealing with better EoL management and segregation of quality scrap.

Policy Gaps

The environmental impact of the iron and steel industry is covered at installation level in the EU by the Industrial Emissions Directive ([22]) as well as the iron and steel production BREF ([4]). The EU ETS introduces a carbon price on the emissions for the production of pig iron and steel (primary or secondary fusion) including continuous casting.

Also worth mentioning is the Carbon Border Adjustment Mechanism (CBAM), a system designed by the European Union to promote the import of products in some of the most carbon-intensive sectors (including iron

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and steel) by non-EU businesses with high climate standards, ensuring a balanced treatment of these imports and encouraging non-EU producers to join EU's climate efforts ([26]). However, other life cycle stages other than production are not covered by current legislation. Both EU ETS and CBAM only cover CO_2. The EU Taxonomy's supplementing regulation 2021/2139 defines technical screening criteria only for the manufacture of iron and steel of certain NACE codes. A sustainable approach is also needed in terms of water efficiency (focusing on water recirculation techniques); air emissions reduction through de-dusting operations, minimization of binders and resins consumption and use of high calorific value coke; waste generation reduction by on-site recovery and re-use of waste and maximising the internal recirculation of carbon and iron-bearing dusts; climate change mitigation with new low-emissions processes, including those that integrate carbon capture, utilization, and storage (CCUS) and hydrogen and adopting material efficiency strategies to reduce losses and optimise steel use throughout the value chain; energy use by the collection of data on energy intensity to enable better performance assessments and comparisons, raw material substitution, increasing production from scrap, natural gas-based DRI and hydrogen-based DRI. Recycling measures will be especially important in emerging economies as greater amounts of steel-containing products begin to reach the end of their lifetimes.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT					Related Union law	What could be addressed by ESPR
Maximum limit of life cycle water consumption	WATER					Industrial Emissions Directive	IED covers the production of iron and steel but not other life cycle stages, or production outside the EU.
maximum level of life cycle emissions to air		AIR		CLIMATE CHANGE		Industrial Emissions Directive; Decision (EU) 2012/135 on BAT for iron and steel production	IED covers the production of iron and steel but not other life cycle stages, or production outside the EU.
minimum content of raw material with sustainability certification	WATER	AIR		CLIMATE CHANGE		-	Full potential of the requirement
maximum amount of life cycle waste generated			WASTE			Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach.
minimum recycled content	WATER		WASTE	CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement
maximum level of carbon footprint				CLIMATE CHANGE	ENERGY CONSUMP	Directive 2023/959 - EU Emission Trading System (ETS); CBAM	EU ETS and CBAM cover production but not other life cycle stages, and only CO_2.
minimum share of energy consumption from low-carbon sources				CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements.
maximum level of life cycle energy consumption				CLIMATE CHANGE	ENERGY CONSUMP	Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU but not outside the EU. Also, EED is not product specific.

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT					Related Union law	What could be addressed by ESPR
life cycle water consumption	WATER					-	Full potential of the requirement
level of life cycle emissions to air		AIR		CLIMATE CHANGE		-	Full potential of the requirement
sourcing of raw materials from certified sustainable practices	WATER			CLIMATE CHANGE		-	Full potential of the requirement
amount of life cycle waste generated	WATER		WASTE			-	Full potential of the requirement
recycled content			WASTE	CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement
level of carbon footprint				CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement
share of energy consumption from low-carbon sources				CLIMATE CHANGE		Renewable Energy Directive II	It only includes a voluntary labelling.
level of life cycle energy consumption				CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement

Additional notes and list of references

* please note that in this context 'sustainable' does not include the social dimension

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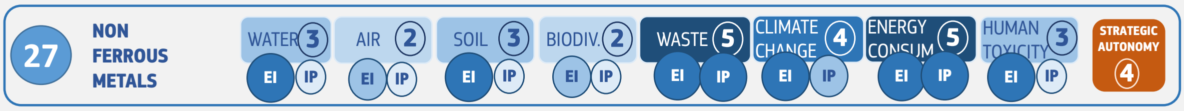
Product fiche 16. Non-Ferrous Metals

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

NON-FERROUS METALS PRODUCTS (Excl. Al)



Scope: This group includes intermediate products made of six primary and secondary non-ferrous metals:

1. **Copper and its alloys** (e.g., with Zn, Sn, Ni, Al and other metals): refined copper results in a copper cathode; when melted, alloyed and processed, semi-fabricated products include wires (mainly) rods, profiles, sheets, tubes, etc. Their main applications are electrical engineering (mainly), vehicles, construction, plumbing, machinery, aircraft, etc.[4]. Nearly 70% of the copper produced globally is used for electrical/conductivity applications; in Europe, 65% [17]. In vehicles, only 8% is used in vehicles, both globally and in Europe ([18]).
2. **Lead and tin:** *refined lead* is largely consumed in the battery industry (85% of the refined lead metal); other uses of lead include lead metal in rolled and extruded products (e.g., lead sheets). *Tin* is mainly used for soldering, as well as for tin plating (i.e., as a protective coating for other metals), chemical applications (e.g., marine antifouling paints), glass manufacturing, among others ([4, 26]).
3. **Zinc and cadmium**: *Zinc* is the third most used non-ferrous metal (behind aluminium and copper); it is mainly used in galvanising (60%), but also in the production of alloys (e.g., brass), as metal coating, among others (e.g., batteries, construction, chemical industry) ([4, 23]). *Cadmium*'s main uses are (i) electroplated cadmium coatings, (ii) nickel-cadmium batteries, (iii) some pigments and stabilisers for plastics, (iv) alloys for specialised thermal and electrical conductivity applications, electrical contact alloys and nuclear control rods, and (v) for solar cells in small amounts [4].
4. **Precious metals:** gold (electronics), silver (industrial applications), platinum, palladium, rhodium, iridium, ruthenium and osmium (the platinum group metals, mainly used as catalysts).
5. **Ferro-alloys:**
    a. *Bulk ferro-alloys* (i.e., ferro-chrome, ferro-silicon together with silicon metal, ferro-manganese, silico-manganese and ferro-nickel), mainly used in steelmaking and steel/iron foundries.
    b. *Special ferro-alloys* (i.e., ferro-titanium, ferro-vanadium, ferro-tungsten, ferro-niobium, ferro-molybdenum, ferro-boron, alloyed or refined ferro-silicon, silicon metal and ternary/quaternary alloys), with diverse uses (e.g., aluminium and chemical industry, mainly silicon products) [4].
6. **Nickel and cobalt:** *primary nickel* is mostly used in alloys, particularly on stainless steel; other uses are electroplating, foundries, catalysts, batteries, coinage, etc. It is found in transportation products, electronic equipment, chemicals, construction materials, petroleum products, aircraft and aerospace parts and equipment, and durable consumer goods. *Cobalt* is used in alloys: superalloys for aircraft engines, magnetic alloys for powerful permanent magnets, hard metal alloys for cutting tool materials, cemented carbides, wear- or corrosion-resistant alloys, and electro-deposited alloys to provide wear- and corrosion-resistant metal coatings; it is also used as chemicals in rechargeable batteries, as pigments in the glass, ceramics and paint industries, catalysts in the petroleum industry, paint dryers, etc. [4].

Aluminium is not included on this Factsheet (see Factsheet on Aluminium).

Water Effects [3]

Environmental impact: High

Production of non-ferrous metals is often a water intensive industrial process, E.g., for the production of 1 kg of gold, 260 000 litres of water are consumed ([1]); for tin, mining and beneficiation are the main drivers for water consumption, with around 151 500 litres of water per tonne of refined tin [22]; for zinc, 71 000 litres of water are consumed for the production of 1 tonne of zinc in Europe [23] However, the most significant water effect in the non-ferrous metal mining industry is acid mine drainage, inorganic chemical water pollution resulting from the oxidation of sulphide-containing minerals, mainly pyrite and pyrrhotite [2].

In mining operations, contaminants can percolate down to aquifers, contaminating drinking water supplies. Pollutants can also contaminate drinking water supplies if they are exposed to water pipes. Wastewaters arising from various process stages are likely to contain soluble and insoluble metal compounds, oil and organic material. Rainwater runoff may become contaminated through contact with material stockpiles or airborne contaminants [3].

The demand for some non-ferrous metals is expected to exponentially increase. For instance, in terms of global clean energy technology and infrastructure, it is forecasted that the copper, cobalt and nickel demand by 2030 will be 3-14 times higher than in 2021 [21].

Improvement potential: Low

A BREF on this industry is available since 2017 [4]. EU mining and manufacturing companies in this sector have taken measures to reduce consumption of water and the risk of emissions to water. Room for improvement appears to be low in this sector.

What ESPR can potentially cover:

No specific measures have been defined that directly cover water effects. However, measures defined in other environmental areas may also benefit this environmental area.

Air Effects [2]

Environmental impact: Medium

Although the air pollution problems of non-ferrous metals mining and beneficiating industries are smaller than other metallurgical industries [2], their emissions cannot be considered negligible. Different air effects can be associated to each of non-ferrous metal.

Emissions of sulphur dioxide, nitrogen oxide and other acidifying compounds that cause acid rain can occur from all steps of metal processing [3]. The production of copper, for instance, causes the emission of sulphur dioxide from the roasting and smelting of sulphidic concentrates. It can also produce flue-gases from the various furnaces in use. There is also potential for the formation of polychlorinated dibenzo-p-dioxins due to the presence of small amounts of chlorine in the secondary raw materials. Similar air emissions can be expected in the production of lead, zinc and nickel [4].

Diffuse emissions and dust are also typical of non-ferrous metal production. In the case of lead, emissions of dust and metals can come from roads, storage areas and old waste deposits. In zinc, diffuse emissions can arise from roasting and calcining. In cobalt, they come from grinding operations, and to a lesser extent from hydrometallurgical operations [4]

For the production of carbon and graphite, the main impacts are the emissions of tars and PAH from the complex mixtures of binder and impregnation pitches, sulphur dioxide from coke and fuels and VOCs from impregnating agents. Ionising radiations are also a potential emission from the production of non-ferrous metals [5].

Improvement potential: Low

The emissions of sulphur dioxide in copper, lead, zinc and nickel have been effectively addressed by the EU smelters, which now achieve on average a 98.9 % fixation of the sulphur and produce sulphuric acid and liquid sulphur dioxide [4].

Cadmium production is closely controlled to prevent diffuse emissions and remove dust to a very high standard. Less than 2% of the exposure of the general population to cadmium is due to emissions to the environment from cadmium-bearing products in their total life cycle [4].

NON-FERROUS METALS PRODUCTS (Excl. Al)
Mining and production of precious metals often use hazardous reagents such as HCl, HNO_3, Cl_2 and organic solvents. Advanced processing techniques are already used to contain these materials and the small scale of production allows these techniques to be used effectively to minimise and abate potential emissions ([4]). **Potential measures under ESPR:** No specific measures have been defined that directly cover air effects. However, measures defined in other environmental areas may also benefit this environmental area.
Soil Effects [3] **Environmental impact: High** The development of a mining project necessarily modifies the local natural environment. Therefore, mining of non-ferrous metals results in geomechanical, hydrological, and chemical transformations ([6]). In zinc production, for instance, the leaching of calcine and other material produces liquor that contains iron. The removal of iron results in the production of significant quantities of solid waste that contain a variety of metals ([4]). Gold mining releases a considerable amount of waste, which is responsible for soil or water pollution. Lead particles can be accumulated in plants or soils which remain unchanged, thus, leading to deforestation ([5]). Soils around non-ferrous smelteries were found to be heavily contaminated with heavy metals worldwide, which not only degrades the quality of the surrounding ecosystem, atmosphere, water bodies, and soil but also threatens the human health. In China, smelting of non-ferrous metals has become the leading industry responsible for the most severe pollution by releasing large amounts of cadmium, copper, lead, and zinc into soil ([7]). **Improvement potential: Low** A BREF on this industry is available since 2017([4]). EU mining and manufacturing companies in this sector have taken measures to reduce the risk of impacts on soil. Innovation plays an important role to reduce the impact of non-ferrous metals, e.g., the need for platinum group metals is being reduced in electrolysers thanks to the use of innovative catalysts ([21]). Room for improvement appears to be low in this sector. **Potential measures under ESPR:** No specific measures have been defined that directly cover soil effects. However, measures defined in other environmental areas may also benefit this environmental area.
Biodiversity Effects [2] **Environmental impact: Medium** The effects on biodiversity of non-ferrous metal production is fundamentally related to mining operations and to potential leakages during manufacturing processes. Copper, for instance, is a threatening element for the marine environment and species and is harmful for deforestation ([5]), as well as in terms of freshwater eutrophication due to phosphorous and phosphate emissions to water, associated with wastewater treatment and diesel combustion ([20]). Organic tin can spread through water and can cause harm to aquatic ecosystems. They are very toxic to fungi, algae and phytoplankton ([4]). **Improvement potential: Low** A BREF on this industry is available since 2017 ([4]). EU mining and manufacturing companies in this sector have taken measures to reduce the risk of impacts on biodiversity. Room for improvement appears to be low in this sector. However, some activities related to land regeneration could be implemented, e.g., replanting native species of trees and reintroducing wildlife in mined areas to restore wetlands and biodiversity ([19]) **Potential measures under ESPR:** No specific measures have been defined that directly cover biodiversity effects. However, measures defined in other environmental areas may also benefit this environmental area.
Waste Generation & Management [5]

NON-FERROUS METALS PRODUCTS (Excl. Al)

Environmental impact: High

Non-ferrous metal industry produces a large amount of waste. Low metal content in the mined ore means that waste from the ore enrichment process constitutes 80%–90% of the total amount of processed material. Approximately 98% of the rock mined in such facilities finds its way to mine and metallurgical spoil heaps and to sedimentation ponds at various stages of mining and preparation processes ([6]). As an example, for the production of 1 tonne of gold, 1 270 000 t of waste are produced ([1]). Iron residue and sulphuric acid result as waste from zinc production ([23]).

Improvement potential: High

The improvement potential of waste-related issues in the non-ferrous metal industry relies on the capacity of increasing the collection and recycling of materials along the value chain. Copper, for instance, can be recovered from the majority of its applications and returned to the production process without loss of quality. It has been estimated that 95% of copper scrap is recycled.. For zinc and nickel, recovery rates of 80% have been reached ([4]). The amount of recycled content in new products is also high today: copper products>40%, zinc products>30%, lead products >35% ([8]). For the production of special high grade zinc production, Waelz oxide – an enriched flue dust resulting from steel re-melting facilities – is the most widely used secondary raw material ([23]).

In their vision for a 2050 Sustainable Europe, the European non-ferrous metal association Eurometaux states that manufacturing processes need to maximise the use of primary materials by enhancing the management of resources into products that can be reused or recycled. A condition for this vision is a detailed metal-by-metal spatial and temporal information about stocks and flows. This would be part of a holistic management of metals value chains, from mines to products to secondary loops. Automated mining process, integrated value chain approaches and industrial symbiosis are also seen as areas for further development ([9]).

Embedding intelligence in products through smart materials can make full traceability possible. This technology would allow knowing where and when materials were sourced and manufactured as well as their composition. Designing smart materials that facilitate design for disassembly would help achieve a fully circular economy ([10]).

Potential measures under ESPR:

- performance requirement on maximum amount of life cycle waste generated.

- performance requirement on maximum amount of life cycle hazardous waste generated.

- performance requirement on minimum level of recovery of materials.

- performance requirement on minimum recycled content.

- performance requirement on minimum content of raw material with sustainability certification.

- information requirement on amount of waste sent to landfill.

- information requirement on recycled content in the product.

- sourcing of raw materials from certified sustainable practices.

Climate Change [4]

Environmental impact: High

The production of non-ferrous metals is very energy-intensive. Therefore, it has a significant impact on climate change. In 2016, the world's non-ferrous metal industry produced 1.06 billion tons of CO_2 and was responsible for 3% of global CO_2 emissions ([11]).

The production of 1 tonne of copper results in 2.5-8.5 tCO_{2eq} ([12]). The production of 1 tonne of zinc results in 2.6 tCO_{2eq} ([13]). The production of 1 tonne of gold results in 18,000 tCO_{2eq} ([1]). The production of 1 tonne of refined tin results in 6.6 tCO_{2eq}, mainly coming from the smelting and refining processes ([22]).

Improvement potential: Medium

NON-FERROUS METALS PRODUCTS (Excl. Al)
For the low-carbon development of the non-ferrous metals industry, the reduction of energy consumption in non-ferrous metals production is mainly through the increase in the proportion of clean energy and upgrading of industrial technologies ([14]). Copper smelting enterprises also accelerated the pace of technology transformation and upgrade, and adopted advanced smelting technology. The lead and zinc enterprises adopted advanced smelting technology with clean, energy savings and environmental protection features. The breakthrough in technology has resulted in a decrease in energy consumption and remarkably improved CO_2 emission performance ([14]). Big-data analysis across the value chain, grid technologies, and captive low-carbon primary production are valuable avenues to pursue. Innovations allowing flexible manufacturing processes are needed to reach the objective of almost exclusively relying on renewable energy, especially for energy intensive smelters ([10]). In addition, the use of recycled material in the manufacturing of products can significantly reduce the energy required, e.g., there is a reduction of 80-90% in the energy required when using recycled copper without losing its properties ([20]), recycled nickel only requires around 25% of the energy required to produce Class I nickel. In addition, recycling processes for most non-ferrous metals are well-established. While some of them reach a high collection rate (e.g., gold at 86% and nickel at 60%), others have a lower one (e.g., copper at 46% and cobalt at 32%) ([21]). In Europe, 90% of rolled zinc is recycled at end of life, while only 30% of global gold production is recycled; secondary tin accounts for 15% of world production ([25]). **Potential measures under ESPR:** - performance requirement on a maximum level of carbon footprint. - performance requirement on minimum share of life cycle energy consumption from low-carbon sources. - performance requirement on maximum level of life cycle emissions to air. - information requirement on the level of carbon footprint. - Information requirement on share of life cycle energy consumption from low carbon sources. - information requirement on the level of life cycle emissions to air.
Life Cycle Energy consumption [5] **Environmental impact: High** The production of non-ferrous metals is energy-intensive and so production costs are very sensitive to energy costs ([9]). This industry has therefore always regarded the reduction of energy consumption as a vital priority ([4]). The non-ferrous metals industry is highly energy-dependent. The energy consumption of the primary processing of non-ferrous products accounts for a considerable proportion in the industrial chain ([14]). The production of 1 tonne of copper requires 33 000 MJ ([1]). The production of 1 tonne of zinc requires 37 500 MJ ([13]). The production of 1 tonne of gold requires 200 000 GJ ([1]). **Improvement potential: High** The non-ferrous metals industry, overall, can save more than 20% in energy consumption. The recycling of non-ferrous metals is of great importance for increasing resource supply and reducing energy consumption ([15]). In the ferro-alloys industry, the reduction of the overall energy consumption is in most cases only possible using an efficient energy recovery system. The recovered energy can be transferred into electrical energy or used as heat for various purposes. CO-rich exhaust gas from closed furnaces can also be used as secondary fuel or as a raw material for chemical processes ([4]). Replacing fossil fuels with renewable energy resources might be a solution to reduce these environmental burdens. Solar industrial process heating systems are already in operation for mining industries in Chile, South Africa and Oman ([5]). However, the issues around energy encompass among others the intermittent nature of renewables and the difficulty to store energy in a cost-effective way. Renewable sources of energy are often distrusted by energy-demanding sectors such as non-ferrous metals, in particular because of unreliability of supply. The difficulty to find cost-efficient technologies for energy storage poses other problems.

NON-FERROUS METALS PRODUCTS (Excl. Al)

Small production units — whose relevance is expected to grow in the future — are not resource efficient enough compared to larger plants. Reducing energy costs, investing in energy efficiency, acting as a virtual battery or as a grid stabiliser and pressuring for competitive prices for renewables are other possible actions ([10]).

The sector could also act as grid stabiliser: as an energy-intensive industry, it could in theory regulate to a certain extent its demand of energy to stabilise, when needed, the overall grid. Interruptability clauses in energy supply contracts and the storage of energy in times of weak demand can help the non-ferrous metals sector support energy demand management. Furthermore, the sector can also partner with renewable energy experts to facilitate the transition to renewable sources of energy. It could also put pressure on electricity producers to gain access to renewable energy at competitive prices. Increasing energy efficiency can be achieved both directly (in the production of non-ferrous metals) or indirectly (e.g., by making buildings more energy efficient) ([10]).

Potential measures under ESPR:

- performance requirement on a maximum level of life cycle energy consumption.

- information requirement on the level of life cycle energy consumption.

Human Toxicity [3]

Environmental impact: High

Non-ferrous metals can have a significant impact on human health. Metals and alloys have to suffer corrosion to release metal ions ([24]). Lead is of great environmental concern and many lead compounds are classified as toxic. General policy is normally to restrict emissions to the lowest practicable levels given the state of technology. Recycling is normally conducted whenever appropriate and economic ([4]).

Tin as single atoms or molecules is not very toxic to organisms; the toxic form is the organic form. Organic tin compounds can stay in the environment for long periods of time ([4]).

The critical effect of cadmium in human beings is renal tubular dysfunction. The tubular damage is irreversible at advanced stages, so prevention is more important than diagnosis. The long biological half-life of cadmium can lead to a continuous increase in renal levels over many years and so past exposure is often more important than present exposure. Chronic exposure to cadmium can cause kidney, hypertension, and bone loss, and excessive intake of lead can damage the nervous and blood systems ([7]).

Improvement potential: Low

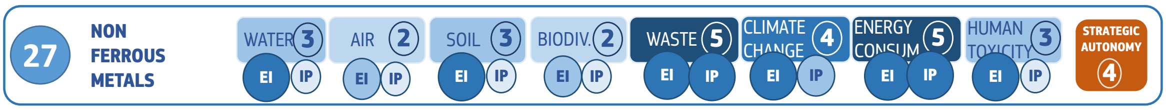
Most control measures are concerned principally with human and animal exposure. Measures to protect children living in the vicinity of smelting plants are of particular significance. In recent years several new technologies have been developed and implemented which offer more efficient methods of smelting lead concentrates. These processes have also reduced emissions to the environment. Existing processes have been improved using state-of-the-art control and abatement systems ([4]).

Dusts can contain toxic components and the continuous monitoring of dust is important not only for compliance assessment but also to assess whether any failures of the abatement plants have taken place ([4]).

Potential measures under ESPR:

No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts.

Final score [27]



Open Strategic Autonomy score [4]

NON-FERROUS METALS PRODUCTS (Excl. Al)
Some of the non-ferrous metals are under the scope of the Critical Raw Materials Act (CRM) and classified as critical raw materials. The list includes copper, cobalt, nickel (battery grade), Titanium (including aerospace grade), Platinum Group Metals and silicon metal.
Policy Gaps The EU environmental regulations are the most far reaching and ambitious compared to other developed and developing economies. These are generally still setting up their environmental framework and their environmental policies tend to focus on other environmental topics ([16]). Potential policy gaps in this sector include ([10]): ▪ Lack of level-playing field across regions in terms of environmental and social standards. ▪ Enhancing transparency in the global pricing of raw material. ▪ A true intra-European level playing field with harmonised environmental standards. ▪ Developing full potential of the Energy Union to decrease energy costs. ▪ Addressing urban mine challenge to ensure scrap is correctly collected and sorted. ▪ Discouraging the exports of scrap. ▪ Adapting regulation to facilitate recycling. Some of the non-ferrous metals are already partially covered by some existing legislations, such as the Critical Raw Materials Act (2023), the Construction Products Regulation (CPR), and/or product specific legislation: the Batteries Regulation, the End-of-Life Vehicles Directive (ELVD), and alike. ESPR aims to complement the existing ones and provide a regulatory framework for those non-ferrous metals or other provisions that are not regulated yet.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT			Related Union law	What could be addressed by ESPR
maximum level of life cycle emissions to air		CLIMATE CHANGE		Industrial Emissions Directive Decision (EU) 2016/1032 on BAT for NFM industries	IED covers the production of aluminium but not other life cycle stages, or production outside the EU.
minimum content of raw material with sustainability certification	WASTE	CLIMATE CHANGE		-	Full potential of the requirement
maximum amount of life cycle waste generated	WASTE			Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach.
maximum amount of life cycle hazardous waste generated	WASTE			Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach.
minimum recycled content	WASTE	CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement
minimum level of recovery of materials	WASTE	CLIMATE CHANGE	ENERGY CONSUMP	Critical Raw Materials (CRM) Act; Batteries Regulation	The CRM Act only covers non-ferrous metals that are classified as critical raw materials (i.e. copper, cobalt, nickel (battery grade), Platinum Group Metals and silicon metal) The Batteries Regulation sets minimum recovery targets only for cobalt, copper, lead, lithium and nickel in batteries.
maximum level of carbon footprint		CLIMATE CHANGE	ENERGY CONSUMP	Directive 2023/959 - EU Emission Trading System (ETS)	EU ETS cover production but not other life cycle stages.

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT		Related Union law	What could be addressed by ESPR
minimum share of life cycle energy consumption from low-carbon sources	CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements.
maximum level of life cycle energy consumption	CLIMATE CHANGE	ENERGY CONSUMP	Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU but not outside the EU. Also, EED is not product specific.

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT			Related Union law	What could be addressed by ESPR
level of life cycle emissions to air		CLIMATE CHANGE		-	Full potential of the requirement
amount of waste sent to landfill	WASTE			-	Full potential of the requirement
recycled content in the product	WASTE	CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement
level of carbon footprint		CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement
share of life cycle energy consumption from low-carbon sources		CLIMATE CHANGE		Renewable Energy Directive II	It only includes a voluntary labelling.
level of life cycle energy consumption		CLIMATE CHANGE	ENERGY CONSUMP	-	Full potential of the requirement

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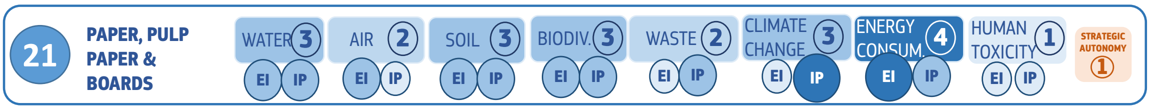
Product fiche17. Paper, Pulp Paper and Boards

Please note that the sections on '*Environmental impacts*' refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on '*Improvement potential*' refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

PAPER, PULP PAPER AND BOARDS



Scope: pulp, paper and board obtained by chemical, kraft, sulphite, mechanical and chemi- mechanical pulping, recovered paper processing and papermaking.

According to Cepi, the Confederation of European Paper Industries, 41% of paper produced in the EU is for case materials, 21% for packaging, 12% for uncoated paper, 10% for sanitary and household applications, 7% for coated paper. 4% for newsprint and 5% for other paper and board,

Water Effects [3]

Environmental impact: Medium

The pulp and paper industry is one of the largest users of water, especially surface water (1), used as dispersion and transporting medium for the fibres; as heat exchanger fluid; as sealant in the vacuum systems; for the production of steam and as a lubricant agent; among others (2). The industry has been discharging chlorinated organics into the aquatic environment in the 1990s, however these emissions have been drastically reduced, although only in the EU. Other emissions of concern are chemical additives like chelating agents (EDTA, DTPA), nutrients (N and P) that cause eutrophication in receiving water bodies, and the discharge of suspended solids (3).

Improvement potential: Medium

The industry has made a lot of progress to clean and reduce the water used in the paper industry, for example closing up water circuits (3). However, in regions with scarce water resources or a dry climate, further reduction of water usage is essential, especially in terms of water savings. Closure of water circuits does come with drawbacks such as increased corrosion and accumulation of salts in process waters (3). A reduction of water pollutants discharge is possible and has occurred in Europe, but continues to remain a challenge especially because the effluent flow from mills is large(3). Cleaner technologies can be used for some applications, such as unbleached pulps or chlorine-free processes when pulp needs to be bleached (4), and some EU actors are leading this take-up. An EU project is currently looking at developing and demonstrating innovative, sustainable and efficient technology and processes which optimise the use of natural resources, especially water, in three industrial sectors, including pulp and paper (26)

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- performance requirement on maximum level of life cycle emissions to water
- information requirement on the life cycle water consumption
- information requirement on the level of life cycle emissions to water

Air Effects [2]

Environmental impact: Medium

In the past, chemical pulp mills have caused serious emissions of sulphur (acidification). Mills are important sources of air pollutants such as dust, NO_X, SO_2, CO and H_2S in some cases, mostly because of the on-site power plants, boilers or combined heat and power plants needed to produce energy (3).

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Improvement potential: Low In recent years, sulphur air emissions have especially been reduced by substantial progress in process technology ([3]). Air emissions levels in general have decreased in the EU, especially thanks to the Industrial Emissions Directive. However, different mills show different performances, suggesting that there is some improvement potential. Moreover, the IED applies to EU installations, leaving significant room for improvement for non-EU installations and related emissions to air. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle emissions to air - information requirement on the level of life cycle emissions to air
Soil Effects [3] **Environmental impact: Medium** Effects to soil from the pulp and paper industry refers mainly to wood harvesting from the forest, which, if performed unsustainably, causes loss of minerals and risk of flooding/erosion to the area, especially in mountain and coastal forests ([5]). **Improvement potential: Medium** The management regime of forests can increase the protective role of forests (including protective forests) for soil conservation ([5]). It is reported that 39% of production forests is certified under a Sustainable Forest Management (SFM) scheme. North America and Europe represent 85% of certified forests, whereas Russia, China and Mediterranean Europe show the largest area of uncertified forests in the Northern hemisphere ([6]). **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [3] **Environmental impact: Medium** Forest biodiversity is decreasing at an alarming rate due to forest loss, degradation and fragmentation. The sector of wood-based products is estimated to contribute to around 8% of EU-driven deforestation ([7,8]). The relative contribution of the pulp industry is not known. **Improvement potential: Medium** The use of more sustainable raw materials such as timber taken from controlled zones subjected to periodic reforestation, seasonal crops and recovered paper ([4]). SFM should ensure biodiversity conservation ([9]); and the current 39% of SFM production forest shows that improvements are possible. The use of alternative feedstock, including agricultural residues, for the manufacture of paper and cardboard have been tested with good results: different cereal straws, or sugarcane bagasse, among others, have been or continue to be used for the industrial manufacture of paper, mainly fluting and liner papers for the production of corrugated cardboard and, to a lesser extent, for other applications such as writing paper ([4,10]). Also, increased use of wood chips instead of roundwood are an important contribution to circular economy ([11]), and able to decrease the biodiversity impacts caused by deforestation **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Waste Generation & Management [2] **Environmental impact: Low**

PAPER, PULP PAPER AND BOARDS
The sector is not associated with high level of waste, also because some of the waste/residues that result from the production process may be regarded as a by-product according to Waste Framework Directive ([12]). **Improvement potential: Medium** The paper sector has the highest recycling rate in Europe, 81.6%, compared to other material fractions, and industries have teamed up in an alliance to raise the overall recycling rate to 90% by 2030 (for packaging applications only) ([27]). In this respect, a dedicated standard exist, EN 643, that contains requirements specifically for paper for recycling grades intended for deinking. The standard sets out a list of grades that are predominantly used for deinking. In these grades, paper products that are not suitable for deinking count towards the percentage of unwanted material. Solutions to increase the amount of paper and cardboard waste that is effectively recycled include positive and negative lists for substances and material combinations that can be used in the product ([29]), but it is to be seen how this can be implemented at intermediate product level. The paper sector uses a large amount of recycled fibres, 56% of the total fibre production in EU in 2021 ([11]). The recycled content in products depend on their final application, ranging from around 90% recycled content in newspapers to 15% in some graphic grades ([11]). Available studies suggest that pulp fibres for cardboard can be recycled up to 25 times ([28]). By-products from the pulp and paper sector are mostly reused as renewable fuels, as soil improvers or as raw materials for other industries or their conversion into added value products for other users ([3]). New concepts in the sector aim at a best possible usage and energetic recovery of most residues generated on-site, if possible recycling also the ashes, e.g. in the construction or cement industry or using ash for soil stabilisation ([3]). **Potential measures under ESPR:** - performance requirement on maximum amount of life cycle waste generated - performance requirement on minimum recycled content - performance requirement on the use of easily recyclable materials or combination of materials/substances - performance requirement on the use of component and material coding standards for the identification of components and materials - information requirement on recycled content - information requirement on the coding standards for the identification of components and materials - information requirement on maximum amount of waste sent to landfill
Climate Change [3] **Environmental impact: Low** Despite its high energy consumption, the pulp and paper industry is one of the least CO_2 intensive industrial sectors in Europe and worldwide. This is due to the large utilisation of biomass as a primary energy source, which is considered as carbon-neutral by the Intergovernmental Panel on Climate Change ([13]). The European pulp and paper industry has a direct emission of about 37 million tonnes of CO_2 per year, which accounts for less than 1 % of the EU total emissions ([3]). The CO_2 emissions are mainly caused by combustion processes: producing the electricity and heat needed for the processes. Indirect emissions are mainly caused by purchased electricity ([3]). **Improvement potential: High** Examples of improvement measures are: general measures (e.g. energy management systems, process integration, new equipment, etc.), increasing on-site use and production of energy from biomass residues (fuel switch) and expanding the adoption of combined heat and power (CHP) technology, retrofitting the existing mills with energy-efficient technologies (e.g. BATs), development and growth of new bio-based products from renewable solutions ([13]). These measures could cut direct CO_2 emissions by ~60% by 2050 ([14]). However, the sector has already reduced its direct and indirect CO_2 emissions by around 25% compared to 2010 levels ([11]). Increased electrification of the pulp and paper industry could also be an option to decarbonise the sector ([15]). The energy consumption (and related GHG emissions) for recovered paper pulp is 2-8 times less than the one for virgin paper product, depending on the application ([13]), so that any measure related to incentivising the use of recovered paper has a positive effect in decreasing the GHG emissions from this sector.

PAPER, PULP PAPER AND BOARDS

Potential measures under ESPR:

- performance requirement on maximum level of carbon footprint
- performance requirement on minimum share of energy consumption from low carbon sources
- information requirement on carbon footprint
- information requirement on the share of energy consumption from low carbon sources

Life Cycle Energy consumption [4]

Environmental impact: High

The pulp and paper industry is the fourth largest industrial user of energy and the second industrial electricity consumer in Europe ([15]). The energy required for paper production is comparable to that of cement or steel ([3]). In 2014, this sector consumed 31 659 ktoe (equivalent of 1 325.5 PJ), accounting for 11.5 % of final industrial energy consumption in the EU ([13]). About 93 % of the total energy consumption by the European pulp and paper sector is as heat power, used mainly for the generation of pressurised steam, and about 7 % as electricity ([13]).

Improvement potential: Medium

The sector is the largest user and producer of renewable energy sources ([3]), and biomass fuel in EU accounts for 60% of the industry's fuel ([15]). On-site waste is frequently used for producing electricity and heat ([15]). However, non-European plants may not do the same (pulp and paper from EU represents around one fourth of global production) ([3]). Some energy efficiency measures identified are: high-temperature heat recovery boilers and continuous digesters in chemical pulping, heat recovery and high-efficiency grinding in mechanical pulping, dry sheet forming in papermaking ([3]). Incineration of residues and heat recovery from de-inking effluent are also possible measures ([3]). EU's primary energy consumption has already decreased by 6% since 2010. Another way to reduce the energy consumption of the sector is via incorporating recovered fibres, since the energy consumption for recovered paper pulp is 2-8 times less than the one for virgin paper product, depending on the application ([13]).

Potential measures under ESPR:

- performance requirement on maximum level of life cycle energy consumption
- information requirement on life cycle energy consumption

Human Toxicity [1]

Environmental impact: Low

The use of chemicals in pulp and paper making has decreased compared to the levels in the 1990s. The main chemicals used are sulfite salts caustic soda and sodium sulphide ([3]).

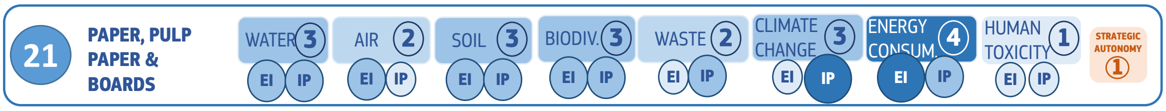
Improvement potential: Low

Improvement measures include the substitution of potentially harmful substances with less harmful alternatives and preventing or reducing the adverse effects of the generation and management of waste ([3]).

Potential measures under ESPR:

No measures are envisaged under ESPR that primarily aim to improve human toxicity, since the related impacts mainly refer to chemical safety (which is covered by other legislation). However, improved human health impacts could be secondary/indirect benefits of measures targeting other environmental impacts

Total environmental score [21]



PAPER, PULP PAPER AND BOARDS
Open Strategic Autonomy score [1]
Policy Gaps The environmental impacts to air of the pulp and paper industry are regulated in the EU by the Industrial Emissions Directive and in Commission Implementing Decision 2014/687/EU ([16]) and by Directive 2016/2284 ([17]) on national emission ceilings for certain atmospheric pollutants, which are however regulating only EU installations. Imported goods are not regulated under these aspects. The 'New EU Forest Strategy for 2030' ([18]), defines the priorities of European forest management in the coming years, promoting the reuse and recycling of long-lived wood-based materials rather than the harvest of virgin wood coming from sustainably managed forests, without however setting binding requirements to the industries. April 2023 saw the adoption of the Regulation on land use, forestry and agriculture, which should set an overall EU target for carbon removals by natural sinks ([19]). Moreover, the new Regulation 2023/1115 tackles EU-driven deforestation and forest degradation ([8]), and applies equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market. The GHG emissions from the pulp and paper industry are regulated by the Emission Trading System Directive ([20]), which sets an emissions reduction ambition of -40% by 2030 compared to 1990 levels. At the moment of writing this report, the Commission has proposed a new target of -55% of GHG emissions by 2030 compared to 1990 levels ([21]). Finally, the Energy Efficiency Directive ([22]) implements energy efficiency as a priority across all sectors, removes barriers in the energy market ,and overcomes market failures that impede efficiency in the supply and use of energy

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT							Related Union Law	What could be addressed by ESPR
maximum limit of life cycle water consumption	WATER							Industrial Emission Directive	IED covers the production of pulp and paper, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to water	WATER							Industrial Emission Directive	IED covers the production of pulp and paper, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to air (e.g. SO_2, NOx, particulate matter)		AIR						Industrial Emission Directive	IED covers the production of pulp and paper, but not other life cycle stages or production outside the EU
minimum content of raw material with sustainability certification	WATER		SOIL	BIODI VERSITY				Regulation on deforestation-free products	The Deforestation-free Regulation sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated					WASTE			Waste Framework Directive-	WFD incentivizes waste prevention but does not have a product-specific approach
minimum recycled content	WATER		SOIL	BIODI VERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
use of easily recyclable materials or combination of materials/substances	WATER		SOIL	BIODIVE RSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
use of component and material coding standards for the identification of components and materials					WASTE			-	Full potential of the requirement
maximum level of carbon footprint				BIODI VERSITY		CLIMATE CHANGE	ENERGY USE	Emission Trading System	ETS covers the production of pulp and paper, but not other life cycle stages or production outside the EU
minimum share of energy consumption from low carbon sources				BIODI VERSITY		CLIMATE CHANGE		Renewable Energy Directive II	RED II is not product-specific and does not address production outside the EU. It includes voluntary labelling, but not mandatory requirements

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL ASPECT		Related Union Law	What could be addressed by ESPR
maximum level of life cycle energy consumption	CLIMATE CHANGE	ENERGY USE	Energy Efficiency Directive	EED sets maximum energy consumption targets in the EU, but not outside the EU. Also, EED is not product-specific

INFORMATION REQUIREMENTS	ENVIRONMENTAL ASPECT							Related Union Law	What could be addressed by ESPR
level of life cycle water consumption	WATER							-	Full potential of the requirement
level of life cycle emissions to water	WATER							-	Full potential of the requirement
level of life cycle emissions to air		AIR						-	Full potential of the requirement
sourcing of raw materials from certified sustainable practices			SOIL	BIODIVERSITY				-	Full potential of the requirement
amount of life cycle waste sent to landfill					WASTE			-	Full potential of the requirement
recycled content					WASTE	CLIMATE CHANGE		-	Full potential of the requirement
use of easily recyclable materials or combination of materials/substances					WASTE			-	Full potential of the requirement
the coding standards for the identification of components and materials	WATER		SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement
carbon footprint						CLIMATE CHANGE		-	Full potential of the requirement
share of energy consumption from low carbon sources						CLIMATE CHANGE		Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
life cycle energy consumption							ENERGY USE	-	Full potential of the requirement

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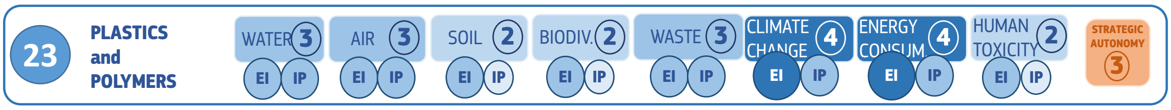
Product fiche 18. Plastic and Polymers

Please note that the sections on ‘*Environmental impacts*’ refer to **global impacts** (i.e., happening in or affecting all parts of the world), while the sections on ‘*Improvement potential*’ refer to the **EU dimension,** and the potential that the Ecodesign for Sustainable Products Regulation can aim for.

PLASTICS AND POLYMERS



Scope: Plastic is a polymeric material that has the capability of being moulded or shaped, usually by the application of heat and pressure. It usually contains polymers and additives that give additional properties to the mixture. The scope is plastic basic materials, synthetic rubbers and hydrocarbons containing oxygen.

According to Plastics Europe, 44% of plastics produced in the EU is used for packaging applications, 18% for building and constructions, 8% for automotive, 7% for electrical and electronics, 7% for household, leisure and sports, 4% for agriculture, farming and gardening, and the remaining 12% for other applications ([20]).

Water Effects [4]

Environmental impact: Medium

It takes about 185 litres of water to make a kilogram of plastic ([12]). The production phase (manufacture of refined petroleum products, chemicals and chemical products) is related to water consumption and also to water pollution ([4]). Waste waters with the potential for high loads of organic compounds ([1]).

Globally, 5 to 13 million tonnes of plastics — 1.5 to 4 % of global plastics production — end up in the oceans every year ([7]). Around 80% of marine litter is plastic ([4]). By 2050, there will be more plastics, by weight, in the oceans than fish, if the current ‘take, make, use, and dispose’ model continues ([12]).

Improvement potential: Medium

The improvement potential focuses on reducing the production of plastics in general, minimising the use of single-use plastics and designing plastics to reduce microplastics release and to facilitate their recycling. The production process is under the polymer production BREF, in force since 2007, which establishes a set of general and specific measures to minimise the emission of pollutants into the water and which are understood to be assumed by the sector.

Potential measures under ESPR:

- performance requirement on maximum limit of life cycle water consumption
- performance requirement on maximum level of life cycle emissions to water
- performance requirement on maximum level of life cycle release of microplastics and nanoplastics
- information requirement on life cycle water consumption
- information requirement on life cycle emissions to water
- information requirement on the possible release of non-biodegradable microplastics

Air Effects [3]

Environmental impact: Medium

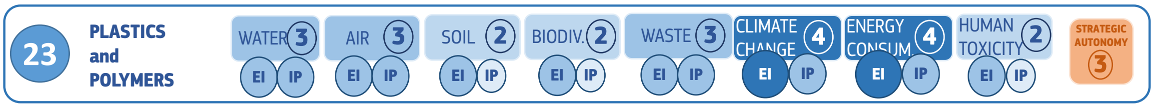
Air impacts relate to emissions of Sulphur and Nitrogen Oxides, particulate matter and Volatile Organic Compounds during extraction and processing of raw materials (petroleum), the production of additives and the manufacture of the polymers([1]). 75 000 tonnes of microplastics are released into the environment, including to air, each year in the EU ([8]).

PLASTICS AND POLYMERS
Improvement potential: Medium The improvement potential focuses on reducing the production of plastics in general, minimising the use of single-use plastics, designing plastics with reduced microplastics release and to facilitate their recycling. The production process is under the polymer production BREF, in force since 2007, which establishes a set of general and specific measures to minimise the emission of pollutants into the atmosphere and which are understood to be assumed by the sector. **Potential measures under ESPR:** - performance requirement on maximum level of life cycle emissions to air - performance requirement on maximum level of life cycle release of microplastics and nanoplastics - performance requirement on minimum content of sustainable renewable materials - information requirement on the level of life cycle emissions to air - information requirement the content of sustainable renewable materials - information requirement on the possible release of non-biodegradable microplastics
Soil Effects [2] **Environmental impact: Medium** At the production phase, spillages and mismanagement of liquid/solid waste can impact soil. Microplastics are an emerging source of soil and freshwater pollution that could have a long-term damaging effect on terrestrial ecosystems globally through adverse effects on organisms ([12]). **Improvement potential: Low** The improvement potential focuses on reducing the production of plastics in general, minimising the use of single-use plastics and designing plastics to reduce microplastics release and to facilitate their recycling, given the fact that the production process is under the polymer production BREF, in force since 2007, which establishes a set of general and specific measures to minimise the emission of pollutants into the soil and which are understood to be assumed by the sector. **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Biodiversity Effects [2] **Environmental impact: Medium** The whole production cycle of plastics may affect biodiversity through physical impacts. To date, research on marine plastic pollution has reached three main conclusions. First, plastic breaks into smaller pieces that can now be found in the most far-flung corners of the globe, including the deepest area of the ocean. Second, attached to these plastic pieces are a mix of toxic chemicals that are harmful to humans and animals, known as persistent organic pollutants. Third, plastic harms aquatic animals through ingestion at all levels of the food chain, and humans in turn ingest plastic through a variety of pathways. Plastic pollution can reduce the metabolic rates, reproductive success, and survival of zooplankton that transfer the carbon to the deep ocean ([11]). Plastics pollution is the second most significant threat to the future of coral reefs, after climate change. The impact of plastic on marine species, including ingestion by turtles, birds, fish and mammals, is well documented. Many of the chemicals additives used in plastics have proven adverse effects on fisheries and their habitats ([12]). Microplastics are an emerging source of soil and freshwater pollution that could have a long-term damaging effect on terrestrial ecosystems globally through adverse effects on organisms, such as soil-dwelling invertebrates and fungi are transferred to agricultural lands from urban sewage sludge used as farm manure, with potentially direct effects on soil ecosystems, crops and livestock or through the presence of toxic chemicals ([12]).

PLASTICS AND POLYMERS
Improvement potential: Low The improvement potential focuses on reducing the production of plastics in general, minimising the use of single-use plastics and designing plastics to reduce microplastics release and to facilitate their recycling, given the fact that the production process is under the polymer production BREF, in force since 2007, which establishes a set of general and specific measures to minimise the emission of pollutants into the environment and which are understood to be assumed by the sector **Potential measures under ESPR:** - performance requirement on minimum content of raw material with sustainability* certification - information requirement on sourcing of raw materials from certified sustainable practices
Waste Generation & Management [3] **Environmental impact: Medium** Around 25.8 million tonnes of plastic waste are generated in Europe every year ([5]). Reuse and recycling of end-of-life plastics remains very low. Demand for recycled plastics today accounts for only around 6 % of plastics demand in Europe improve ([2]) Leakage and spills from transport of virgin plastic around the world is one of the most common form of plastic pollution ([11]) Large quantities of spent solvents and non-recyclable waste ([1]). Marine litter damage activities such as tourism, fisheries and shipping ([4]). Accounting for all uses, more PET plastic is produced and consumed than any other single type of plastic. Most PET plastic is used only once and then thrown away. Only about 11% of the PET and polyester produced has ever been recycled, and nine times out of ten it is recycled for just one more use ([17]) About 70% of all plastics ever produced between 1950 and 2015 have become waste while 30% still remain in use; For that wasted plastic, only 9% has ever been recycled (usually only once) with 12% incinerated and 79% of all plastics discarded in landfills and the natural environment ([18]). **Improvement potential: Medium** The improvement potential lies in designing plastics and plastic products easier to recycle; expand and improve the separate collection of plastic waste, to ensure quality inputs to the recycling industry and create viable markets for recycled and renewable plastics ([2]). Reduce reliance on single-use plastics other than for essential non-substitutable functions. Improve waste management practices around the world. Raise consumer awareness about the multiple benefits of recycling ([13]). **Potential measures under ESPR:** - performance requirement on maximum amount of life cycle waste generated - performance requirement on maximum amount of life cycle hazardous waste generated - performance requirement on the use of easily recyclable materials or combination of materials - performance requirement on minimum recycled content - information requirement on recycled content
Climate Change [4] **Environmental impact: High** Plastic production is among the most greenhouse gas-intensive industries in the manufacturing sector—and the fastest growing. By 2050, the accumulation of greenhouse gas emissions from plastic could reach over 56 gigatons (10–13 % of the entire remaining carbon budget). Plastic is the second-largest and fastest growing source of industrial greenhouse gas emissions. It is calculated that 1.89 Mt CO2e are emitted per Mt plastic resin produced, taking into account that the electricity and heat in the processes are produced by the combustion of fossil fuels. Emissions per ton of virgin plastic produced are estimated to be 3.6 times higher compared to recycling as of 2017. This gap is estimated to widen to as much as 48 times higher by 2050, as efficiency in both plastic production and recycling improves ([11]). Plastics alone are expected to account for nearly 15% of the remaining budget of greenhouse gas emissions by 2050 to withstand the

PLASTICS AND POLYMERS
global temperature rise below 1.5 °C ([15]). The plastics industry emissions of greenhouse gas emissions, currently equivalent to about 200 coal-fired power plants, will continue to grow until plastics account for at least 10% to 15% of the entire fossil carbon budget by 2050 ([19]) **Improvement potential: Medium** The improvement potential focuses on decoupling the production of plastic from fossil fuel consumption ([11]), reducing the production of plastics in general, minimising the use of single-use plastics and designing plastics to facilitate their recycling. **Potential measures under ESPR:** - performance requirement on maximum level of carbon footprint - performance requirement on minimum share of energy consumption from low carbon sources - performance requirement on minimum content of sustainable renewable materials - information requirement on carbon footprint - information requirement on the share of energy consumption from low carbon energy sources - information requirement the content of sustainable renewable materials
Life Cycle Energy consumption [4] **Environmental impact: High** One of the key environmental issues of the polymer sector is the energy demand ([1]). Extraction of raw materials and processing of naphtas, and the chemical synthesis of polymers and additives have high energy consumption. Still today, most plastic materials are produced from oil or gas ([11]). **Improvement potential: Medium** The improvement potential, in the long term, lies in decoupling plastics production from fossil feedstock. Which means that, in the future, the vast majority of plastics will be produced from alternative feedstock, such as recycled oils or secondary plastics, responsibly sourced biomass, or even CO_2 ([11]). **Potential measures under ESPR:** - performance requirement on maximum level of life cycle energy consumption - information requirement on life cycle energy consumption
Human Toxicity [2] **Environmental impact: Medium** At production phase occupational exposure and potential human health impacts are due to the extraction of raw materials and manufacturing of polymers and additives. From wellhead to store shelves to water and food systems, the plastic lifecycle poses risks not only for the environment, but also for human health ([11]). Some plastics contain toxic chemical additives, including persistent organic pollutants (POPs), which have been linked to health issues such as cancer, mental, reproductive, and developmental diseases. It is difficult to recycle some plastics without perpetuating these chemicals ([12]). **Improvement potential: Low** The improvement potential lies in considering, in the design stage of plastic and polymers, the reduction of substances that increase the toxicity of this product group. **Potential measures under ESPR:** No measures are envisaged under ESPR for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).
Final score [23]

PLASTICS AND POLYMERS



Open Strategic Autonomy score [3]

Relevance: Plastics are mainly obtained from oil-derivate sources. In 2020, the EU mainly depended on Russia for imports of crude oil, natural gas and solid fossil fuels, followed by Norway for crude oil and natural gas ([15]). While 80% of the crude oil extracted worldwide is today uses for energy purpose, around 10% of the crude oil is used by the petro-chemical industry to manufacture polymers/plastics compounds. Considering the urgent need of decarbonising the energy sources, the share of crude oil used for plastics and chemicals production is expected to increase dramatically in the coming years.

Potential gains for Open Strategic Autonomy: Plastic recycling is today a reality in Europe. However, only 35% of the plastic reaching end-of-life is today going to recycling, representing a very important untapped potential in term of circularity of the value chain ([16]). A higher recycled content share is the plastics manufactured in Europe would allow to decrease the dependency EU is facing in term of crude oil imports.

Policy Gaps

Plastics are an important material in our economy and daily lives, which could however be associated with negative effects on the environment and human health. Thus, the EU is taking action through the EU's plastic strategy, as a part of the circular economy action plan aiming at tackling plastic pollution and marine litter to accelerate the transition to a circular and resource-efficient plastics economy. Specific rules and targets apply to certain areas, including single-use plastics, plastic packaging, microplastics, and soon bio-based, biodegradable and compostable plastics.

With respect to bio-based components, the Commission has adopted a Regulation to tackle EU-driven deforestation and forest degradation ([16]), which should apply equally to all commodities and to products produced inside as well as outside the EU, requiring companies to put in place and implement due diligence systems to ensure that only deforestation-free products are allowed on the EU market. Nevertheless, environmental sustainability requirements related to e.g. sourcing of the raw material are not included in the deforestation-free products regulation.

Despite the EU's efforts to develop the framework for action in the previous paragraph, the plastics sector has considerable room for improvement in decoupling plastic production from fossil fuel feedstock and in reducing the production of plastics in general, minimising the use of single-use plastics and designing plastics to reduce microplastics release and to facilitate their recycling.

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA					Related Union law	What could be addressed by ESPR
maximum level of life cycle release of microplastics and nanoplastics	WATER	AIR				Microplastic regulation	Does not address unintentional release of microplastic
maximum level of life cycle water consumption	WATER					Industrial Emission Directive	IED covers the production, but not other life cycle stages or production outside the EU
maximum level of life cycle emissions to water	WATER					Industrial Emission Directive	IED does not cover the production outside the EU
maximum level of life cycle emissions to air		AIR				Industrial Emission Directive	IED covers the production, but not other life cycle stages or production outside the EU
minimum content of sustainable renewable materials		AIR		CLIMATE CHANGE		Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
minimum content of raw material with sustainability certification				CLIMATE CHANGE		Regulation on deforestation-free products	The Deforestation-free Regulation only addresses wood, rubber, cattle, coffee, cocoa, palm oil and soy. Sets mandatory due diligence rules, but not sustainability certification
maximum amount of life cycle waste generated			WASTE			Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
maximum amount of life cycle hazardous waste generated			WASTE			Waste Framework Directive	WFD incentivises waste prevention but does not have a product-specific approach
use of easily recyclable materials or combination of materials	WATER	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	Waste Framework Directive	WFD sets recycling targets in the EU but does not have a design approach in and outside the EU

PERFORMANCE REQUIREMENTS	ENVIRONMENTAL AREA					Related Union law	What could be addressed by ESPR
minimum recycled content	WATER	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for the product information requirements
maximum level of carbon footprint				CLIMATE CHANGE	ENERGY USE	EU-Emission Trading System	EU-ETS covers the production, but not other life cycle stages or the production in non-EU countries
minimum share of energy consumption from low carbon sources				CLIMATE CHANGE		Renewable Energy Directive II	REDII is not product-specific and does not address production outside the EU. It includes voluntary labelling but not mandatory requirements
minimum content of sustainable renewable materials		AIR		CLIMATE CHANGE		-	Full potential of the requirement
maximum level of life cycle energy consumption					ENERGY USE	-	Full potential of the requirement
minimum amount of by-products/process residues/off-specs recovered			WASTE			Industrial Emission Directive	IED does not cover the production outside the EU and does not have a product specific approach
minimum reliability	WATER	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	-	Full potential of the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA	Related Union Law	What could be addressed by ESPR
life cycle water consumption	WATER	-	Full potential for the requirement
level of life cycle emissions to water	WATER	-	Full potential for the requirement

INFORMATION REQUIREMENTS	ENVIRONMENTAL AREA	Related Union Law	What could be addressed by ESPR
possible release of non-biodegradable microplastics	WATER, AIR	-	Full potential for the requirement
level of life cycle emissions to air	AIR	-	Full potential for the requirement
content of sustainable renewable materials	AIR, CLIMATE CHANGE	-	Full potential for the requirement
sourcing of raw materials from certified sustainable practices	CLIMATE CHANGE	-	Full potential for the requirement
recycled content	WASTE	Packaging and Packaging Waste Regulation	PPWR sets minimum recycling content obligations for plastic packaging only. No obligations for the product information requirements
carbon footprint	CLIMATE CHANGE, ENERGY USE	-	Full potential for the requirement
share of energy consumption from low carbon sources	CLIMATE CHANGE	Renewable Energy Directive II	RED II includes voluntary labelling, but not mandatory requirements
life cycle energy consumption	ENERGY USE	-	Full potential for the requirement

Additional notes and list of references

* please note that in this context ‘sustainable’ does not include the social dimension

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Annex 6. Analysis of granularity

FURNITURE PRODUCT GROUP GRANULARITY

In order to address the concept of **granularity** within the **furniture** product group, different approaches have been analysed to assess the most suitable aspects for dividing such a large group.

Inspiration has been taken from the classification adopted by ECOLABEL (1)and consumption footprint (2) as well as from those established by CEN (3) and Taxation and Customs Union (4) proposed by the industry, through the Open Public Consultation.

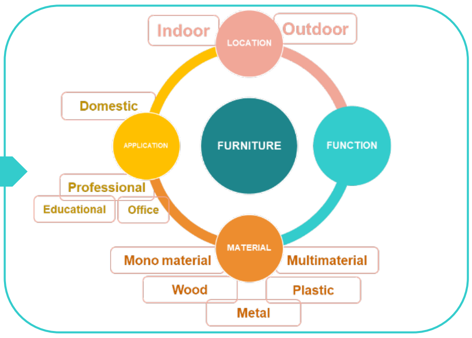
The analysis of the different instruments mentioned above shows that the most relevant aspects to consider when subdividing this category are:

The **location** of the furniture, which makes it possible to differentiate between indoor and outdoor furniture.

The **application**, which distinguishes between domestic and professional, and within the latter category we can find educational or office use, among others.

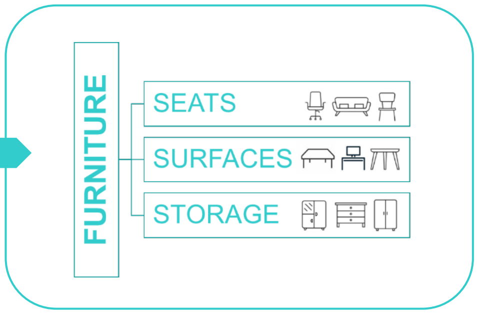
The **material** from which the furniture is made, which is mostly grouped into wood (or wooden based), plastic, textile, metal and glass.

Moreover, the **function** for which the furniture is designed, which establishes three main groups: seating, surfaces and storage.



In this preliminary study on granularity, the **furniture function approach** will be adopted for the subdivision of this product group. Classifying according to the function of the furniture allows to establish more effective requirements to **extend the life** of the furniture, as well as to fight against **planned obsolescence**, in an industry where the throwaway culture is gaining ground.

As a result, furniture is suggested to be divided into:



If we consider the requirements proposed in Annex 5 for furniture products, we observe that all of them are potentially applicable to the three categories adopted. This can be achieved either via three category specific Delegated Acts, as well as via one furniture Delegated Act which would have different threshold for each category.

Once the granularity according to the function has been set, a second level of analysis by material can be made, which makes it possible to work with provisions that are more focused on circularity.

Material column shows the applicability of the requirement according to the composition of the product *(G for glass, M, for metals, P for plastic, T for textiles and W for wood)*

Requirement	Category
safe, easy and non-destructive access to recyclable components	
ease of upgrading, re-use, remanufacturing and refurbishment	
minimum recycled content	
minimum content of raw material with sustainability certification	
use of easily recyclable materials or combination of materials	
minimum reliability	
compatibility with commonly available tools and spare parts	
availability and affordability of spare parts	
minimum share of energy consumption from low carbon sources	
condition for use and maintenance of the product	
expected lifetime of the product, and/or on how to substitute/replace the product or i component	

(1) EU Ecolabel; (2) EU Consumption Footprint; (3) CEN/TC207Furniture; (4) Taxation and Customs Union

TEXTILE and FOOTWEAR PRODUCT GROUP GRANULARITY

In order to address the concept of **granularity** within the **textiles and footwear** product group, different approaches have been analysed to assess the most suitable aspects for dividing such a large group.

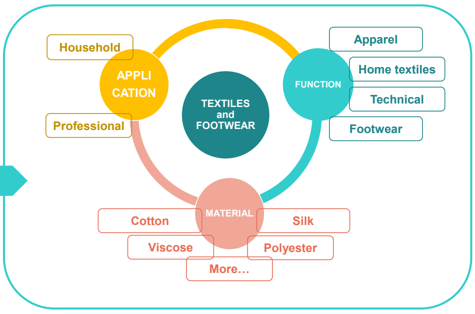
Inspiration has been taken from the classifications used by the Textile Labelling Regulation ([1]), the Communication 'EU Strategy for Sustainable and Circular Textiles' ([2]), the EU ECOLABEL ([3,4]), the Annual Single Market Report 2021 ([5]), the EU Consumption Footprint ([6]), the Product Environmental Footprint Category Rules ([7]), three JRC reports ([8,9,10]), as well as from the classification used by the industry ([11]) and that established by CEN ([12]), the Taxation and Customs Union codes ([13]), and ProdCom codes ([14]).

The analysis of the above mentioned documents suggests that the most relevant aspects to consider when subdividing textiles and footwear are:

The **material** of the textiles and footwear, which can include materials such as cotton, polyester, viscose, silk, leather, polyamide, etc.

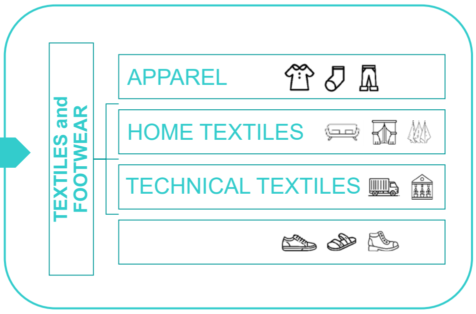
The **application**, which can distinguish between household and professional, with the latter including e.g. automotive, medical and agro applications.

The **function** for which the product is designed.



In this preliminary analysis on the granularity of textiles and footwear, the **function approach** is suggested to be adopted for the subdivision of this product group. Such classification also in principle allows to establish more targeted requirements that can take into account any effect on the functionality of the product group, for example for product aspects such as durability, reliability and inclusion of recycled content.

As a result, textile and footwear is suggested to be divided into **APPAREL, HOME TEXTILES, TECHNICAL TEXTILES**



If we consider the requirements proposed in Annex 5 for Textiles and Footwear, we can observe two types of approaches. Requirements related to **resource consumptions and emissions** could be set for the four proposed categories at once, establishing a unique methodology but with different limit thresholds depending on the category. Requirements more related to the **design of the product** (use and number of certain materials, recyclability, recycled content, durability and reliability) could need an approach that is more specific to the product category under analysis.

Considering the above, it seems that the most viable way for ESPR to address the product group 'Textiles and footwear' is via four category-specific Delegated Acts.

Requirement	Category (Apparel)	Category (Home textiles)	Category (Technical textiles)	Category (Footwear)
Limit on water life cycle emissions and consumption	✓	✓	✓	✓
Content of raw material with sustainability certification	✓	✓	✓	✓
Maximum amount of life cycle waste generated and process residues	✓	✓	✓	✓
Safe, easy, non-destructive access to recyclable components	✓	✓	✓	✓
Use of coding standards, number of materials/components used	✓	✓	✓	✓
Recycled content	✓	✓		
Standard sizing and fitting of the product	✓			
Maximum level of carbon footprint	✓	✓	✓	✓
Life cycle energy consumption and share of low carbon energy sources	✓	✓	✓	✓
Maximum product to packaging ratio (including for e-commerce)	✓			✓
Minimum content of sustainable renewable materials	✓	✓	✓	✓
Minimum durability and reliability	✓	✓	✓	✓
Availability and affordability of spare parts	✓	✓		✓
Compatibility with commonly available tools and spare parts and use of standard components			✓	✓

([1]) Textile Labelling Regulation; ([2]) EU Strategy for Sustainable and Circular Textiles; ([3,4]) EU Ecolabel; ([5]) Annual Single Market Report 2021; ([6]) EU Consumption Footprint; ([7]) Product Environmental Footprint Category Rules; ([8,9,10]) JRC reports; ([11]) industry classification; ([12]) CEN; ([13]) Taxation and Customs Union codes; ([14]) ProdCom codes.

Commodity chemicals as defined in this report (Annex 5, Box 14) is a very heterogeneous product group, for which ESPR could encounter difficulties to regulate it under one Delegated Act.

The scope of the product group commodity chemicals in this report contains chemical products that are listed in Annex I to the Industrial Emission Directive 2010/75/EU. In particular, the scope of commodity chemicals include:

large volume inorganic chemicals – ammonia, acids and fertilisers ([1]);

large volume inorganic chemicals – solids and others industry ([2]);

large volume organic chemicals ([3]).

The industry uses a somewhat different classification, which however can still be reflected to the three groupings above: basic inorganics and petrochemicals (in addition to polymers, specialty chemicals and consumer chemicals, that are however outside of the scope of Commodity Chemicals) ([4]).

Due to the large variety of chemical products included in the scope, and given that these are intermediate products, with multiple applications into final products, it does not seem viable that ESPR addresses 'Commodity Chemicals' in one Delegated Act. Instead, an approach of **three Delegated Acts**, each of them focusing on a specific product category, in line with the IED, seems to better meet the needs of ESPR.

It is to be noted that, under the Industrial Emission Directive, a new Best Available Technique Reference Document (BREF) is being developed for the product group Large Volume Inorganic Chemicals (LVIC). Although the precise scope of the LVIC BREF (e.g. in terms of chemical sub-sectors/products/processes to be covered) has not yet been defined, such document is meant to address key environmental issues associated with the processes covered by the BREFs (i) and (ii) in the list above. Therefore, a feasible option may be for ESPR to address the product Commodity Chemicals via two Delegated Acts, one for inorganic and the other one for organic chemicals. At this stage, it is not possible to draw a clear conclusion on the matter.

If we consider the requirements proposed in Annex 5 for Commodity Chemicals, we can observe that requirements such as '*minimum content of raw material with sustainability certification*', and '*minimum share of energy consumption from low carbon sources*' are measures that are less dependent on the type of product (LVIC-AAF, LVIC-S and LVOC), and could potentially be set **horizontally**. The same could be said for information requirements, not reported in the table below. On the opposite, requirements such as '*minimum fraction of by-products/process residues/off-specs recovered*', '*minimum content of sustainable renewable materials*'. and '*efficiency of the product at low energy consumption*' are measures that are **highly dependent on the final application** of the chemical products, thereby demanding a narrower scope of the intermediate product under analysis. Finally, the remaining requirements shown in the table below could benefit from establishing a **unique methodology**, but would nevertheless require a deep knowledge of the intermediate products and their application into final products.

Performance requirements	Category		
Maximum limit on water life cycle emissions and consumption	LVIC AAF	LVIC S	LVOC
Maximum level of life cycle emissions to water and air	LVIC AAF	LVIC S	LVOC
Minimum content of raw material with sustainability certification	LVIC AAF	LVIC S	LVOC
Maximum amount of life cycle waste generated	LVIC AAF	LVIC S	LVOC
Minimum fraction of by-products/process residues/off-specs recovered	LVIC AAF	LVIC S	LVOC
Maximum level of carbon footprint	LVIC AAF	LVIC S	LVOC
Minimum share of energy consumption from low carbon sources	LVIC AAF	LVIC S	LVOC
Minimum content of sustainable renewable materials	LVIC AAF	LVIC S	LVOC
Maximum level of life cycle energy consumption	LVIC AAF	LVIC S	LVOC
Efficiency of the product at low energy consumption	LVIC AAF	LVIC S	LVOC

([1]) Large volume inorganic chemicals – ammonia, acids and fertilisers; ([2]) Large volume inorganic chemicals – solids and others industry; ([3]) Large volume organic chemicals.

Annex 7. Environmental impact assessment – methodological overview

Quantification of the environmental impacts based on the Consumption Footprint

The Consumption Footprint model

The Consumption Footprint models the environmental impact of the consumption patterns of EU citizens (and Member States) combining consumption statistics with the LCA model of 164 representative product from the five most impact areas of consumption (food, mobility, housing, household goods, and appliances) (Sanyé Mengual et al., 2023). Each area of consumption is composed of a 'Basket of representative products' structured in product groups. For each product group, a set of representative products is modelled considering their apparent consumption (and upscaled to the overall consumption of the product group) and the environmental impacts along their life cycle. The aggregated impact of the consumption of the different representative products integrated the overall EU consumption footprint, as in the following equation: Assessing the contribution of prioritised final products and intermediate products related to the Consumption Footprint and the Planetary Boundaries

$$EU\ Consumption\ Footprint\left(\frac{impact}{year}\right) = \sum_{i=0}^{n} Consumption\ intensity\ \left(\frac{unit}{year}\right) * Environmental\ impact\ intensity\ \left(\frac{impact}{unit}\right)$$

The evaluation of the environmental impacts of the life cycle of representative products is conducted following the same modelling principles. The system boundaries of the Consumption Footprint include the following life-cycle stages:

- Components manufacture (including for instance the production and processing of raw materials; the transport of the materials for the manufacturing plant; etc.);
- Manufacturing (including for instance the assembling of components; etc.);
- Packaging (including for instance the manufacture and transport of packaging; the final disposal of packaging, etc.);
- Logistics (including for instance the transport of the packaged product from factory to retail/distribution centre; etc.);
- Use (including for instance the transport of the packaged product from retail/distribution centre to the final consumer; the consumption of energy and water from/to use the product; in the case of appliances: the use of detergents and salt; etc.);
- End-of-life (including for instance the sorting of waste; recycling; incineration; landfill; etc.).

The Environmental Footprint 3.1 method is used for the impact assessment of the life cycle of the products. This includes the following 16 midpoint impact categories are included: freshwater ecotoxicity (ECOTOX), particulate matter (PM), climate change (CC), resource use – fossil (FRD), eutrophication – freshwater (FEU), eutrophication, marine (MEU), resources use – minerals and metals (MRD), acidification (AC), photochemical ozone formation (POF), water use (WU), land use (LU), eutrophication – terrestrial (TEU), human toxicity – non-cancer (HTOX_nc), human toxicity – cancer (HTOX_c), ozone depletion (ODP), ionising radiation (IR).

Data regarding the overall Consumption Footprint was extracted from the Consumption Footprint Platform (EC-JRC, 2024).

Quantifying the environmental impact of ESPR and Working Plan scope based on individual final products and intermediate products

The environmental impacts of the current consumption of final and intermediate products were evaluated (for the 16 impact categories) and for the EU-27 (concerning the year 2022) by considering the consumption intensity and the environmental impacts of their life cycle, as described by the below equation. This is performed for the individual 16 Environmental Footprint impact categories under assessment.

$$Environmental\ impacts\ of\ product\ \left(\frac{impact}{year}\right) =$$

$$Consumption\ intensity\ \left(\frac{unit}{year}\right) * Environmental\ impact\ intensity\ \left(\frac{impact}{unit}\right)$$

ESPR scope: Impacts related to the whole ESPR scope were modelled considering the following elements. Regarding covered final products, the following life cycle stages of the EU Consumption Footprint were included:

- The whole life cycle impacts for the products under the ‘Appliances’ basket of products – wile energy-related products are excluded from this initial Working Plan, these are considered as part of the ESPR scope for future action;
- The ‘use’ phase impacts for the products under the ‘Housing’ basket of products – which then covers the energy and water used associated to household goods and appliances (on the contrary construction materials are excluded);
- The ‘use’ phase’ impacts for the products under the ‘Mobility’ basket of products – while vehicles are excluded, fuels are part of the ESPR scope;
- The whole life cycle impacts for the products under the ‘Household goods’ basket of products;
- The ‘packaging’ phase impacts for the products under the ‘Food’ basket of products – with packaging being part of the ESPR scope.

The ESPR scope also considered the list of intermediate products assessed in this study (namely: ‘Iron and steel’, ‘Commodity chemicals’, ‘Aluminium’, ‘Plastics and polymers’, ‘Paper, pulp paper and boards’, ‘Glass’).

Working Plan scope: Impacts related to the scope of this study (proposing products for consideration for the first Working Plan) includes those impacts associated to:

— Final products: Textiles, Lubricants, Furniture, Tyres, Detergents, Paints, Bed mattresses, Cosmetics, Absorbent hygiene products, Toys.

— Intermediate products: ‘Iron and steel’, ‘Commodity chemicals’, Aluminium, ‘Plastics and polymers’, ‘Paper, pulp paper and boards’, Glass.

Modelling the environmental impact of intermediate and final products: The impacts of the life cycle of intermediate and final products were modelled following the approach of the Consumption Footprint.

For intermediate products, the impacts associated with components manufacture and manufacturing were modelled based on consumption intensities estimates and manufacturing impacts (as detailed in **Table 7.2**). The total consumption intensities were corrected to the final products, to avoid double-counting for the impacts of representative products (e.g., impacts related to aluminium already accounted in the product-specific final life cycles, were not considered in the assessment of the intermediate aluminium impacts). Additionally, the impacts associated with the end-of-life of intermediate products were included in the analysis as detailed in **Table 7.1**. The modelling considered when possible the potential final applications of each intermediate product (not already covered by the final products under scope) and the associated fate after use, once the end-of-life stage is reached. Due to the lack of available Ecoinvent dataset, proxies were selected to model specific impacts in the case of certain intermediate products as detailed in **Table 7.1** For all intermediate products it was considered that not all the intermediate products manufactured in a given year could reach the end-of-life in the same year (due to the presence of a stock).

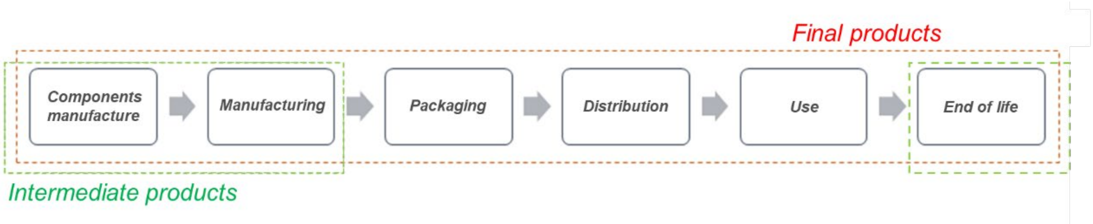
To model the end-of-life of the intermediate product 'Plastics & polymers', data from Amadei and Ardente (2022) and Amadei et al. (2022) were retrieved. In particular, the model considered the end-of-life fate of Polypropylene (PP) and polyethylene (PE) as these represent the two most commonly consumed polymers in the EU. These two polymers were considered as proxy for the whole intermediate product, considering a share of 66% for PP and 34% for PE (calculated from Amadei and Ardente, 2022). It must be noted that the production of monomers is included within the scope of 'Commodity chemicals', whilst the production of polymers is included within the scope of 'Plastics & polymers'. To avoid double counting, the supply chain impacts associated to the share of polymers being employed in plastic final products were not included within 'Commodity chemicals' but rather in the 'Plastics & polymers' intermediate product.

To model the end-of-life of the intermediate product 'Commodity chemicals', a thorough assessment of the potential end-of-life of each chemical under scope was performed, following the various system boundaries of the chemical according to its final purposes (from the chemicals perspective, as detailed in Abbate et al., 2024). Most chemicals reach the end-of-life as embedded components in final products and are not typically separated and recovered via dedicated technologies. For instance, Ammonia is a component of fertilisers, which hamper the possibility to properly track the end-of-life of the Ammonia separated from the rest of the composition of the fertiliser itself. Further, other chemicals act as reagents withing reactions employed for the final product manufacturing, which implies that the chemicals is not found in the final product in its original form.

To avoid double counting (i.e., end-of-life impacts related to final products in scope in which chemicals might be already embedded) and due to the complexity of estimating the end-of-life fate of each product-specific application of the various intermediate chemicals under scope, the end-of-life impacts (and credits) after use were not considered in the present study. However, it was accounted for the impacts related to the losses of chemicals during the manufacturing stage, which typically refer to losses in water and to the associated wastewater treatment impacts. Such estimate was possible as at this stage chemicals are not yet embedded in any final products. The percentage of losses during reactions were estimated to be 10%, while the related final destination to different environmental compartments, and efficiency of removal of the chemicals in the wastewater treatment plant were retrieved from the Best Available Technique Reference documents (BREF) for the three macro groups of chemicals: Large volume inorganic chemicals (BREF, 2007a), basic inorganic chemicals (BREF, 2007b), and large volume organic chemicals (BREF, 2006). Further details are provided in **Table 7.1**.

An overview of the life cycle considered for final products and intermediate products is provided in **Figure 7.1**.

Figure 7.1. System boundaries for the assessment of the environmental impacts of final and intermediate products



Source: JRC own elaboration.

It is worth to mention that in the present assessment:

— Rubber is partially addressed: (i) in the category 'Plastics and polymers' and modelled according to PRODCOM (Eurostat, 2024) "22292130 – Self-adhesive strips of plastic with a coating consisting of unvulcanised natural or synthetic rubber, in rolls of a width <= 20 cm" following the approach described in **Table 7.2**; (ii) in the final product 'tyres' for which the model includes PRODCOM codes of several types of tyres (e.g., pneumatic tyres for buses, motor cars, etc.);

— Concerning the intermediate product Non-ferrous metals, the present study includes the intermediate products Iron and steel and Aluminium. In the present analysis, the scope of Non-ferrous metals is partially covered by these two intermediate products (as an example, 'copper coatings', 'zinc coatings' and 'ferro alloys' are included in the calculation of the Iron and steel intermediate product);

— The final product Fishing nets and gear was not included in the calculations as it was not possible to model its consumption intensities and/or impact factors (e.g., due to data gaps, lack of available proxies especially to model impacts related to the various life cycle stages impacts, lack of suitable entries in Eurostat to model their consumption intensities, etc.). For instance, in the case of Fishing nets and gear, literature data are not yet available to ensure a proper end-of-life modelling particularly on lost fishing gears in sea;

— For the final product Textiles and footwear, the impacts associated with the life cycle of leather were excluded from the assessment as out of the scope of the present study.

Table 7.1. Details on the estimates of end-of-life environmental impacts for intermediate products (dataset reported below refer to Ecoinvent datasets; Ecoinvent, 2022).

Intermediate product	Recycling	Incineration	Landfill
Iron and steel	- Share: 94% (EUROFER, 2023). - Recycling efficiency: 87% (WorldSteel, 2019; Pardo, 2012). - Recycling impacts dataset: "Iron scrap, sorted, pressed {RoW}| sorting and pressing of iron scrap | APOS, U" - Recycling credits dataset: "Steel, low-alloyed, hot rolled {RER}| production | APOS, U"	- Share: 0% (EUROFER, 2023).	- Share: 6% (EUROFER, 2023). - Landfill impacts dataset: "Scrap steel {Europe without Switzerland}| treatment of scrap steel, inert material landfill | APOS, U"
Aluminium	- Share: 94% (EUROFER, 2023). - Recycling efficiency: 90% (International-Aluminium, 2024). - Recycling impacts dataset: "Aluminium, wrought alloy {RER}| aluminium production, primary | APOS, U" - Recycling credits dataset: "Iron scrap, unsorted {RER}| treatment of aluminium scrap, post-consumer. Prepared for recycling at refiner | APOS, U"	- Share: 0% (EUROFER, 2023).	- Share: 6% (EUROFER, 2023). - Landfill impacts dataset: "Waste aluminium {Europe without Switzerland}| treatment of, sanitary landfill | APOS, U"
Commodity chemicals	Not considered. Most of the chemicals used in the manufacturing process are internally recovered and reused for the process. Most chemicals reach the end-of-life as embedded components in final products and are not typically separated and recovered via dedicated technologies. As an example (BREF, 2007a): silica products are used as ingredients for many types of products and preparations and their direct recycling is, therefore, typically not a viable option.		Impacts associated to landfilling after wastewater treatment of chemicals during the chemicals production life cycle stage. Impacts associated with end-of-life landfilling of chemicals were not considered. - Losses to water during manufacturing: 10% of the mass (own assumption) - Concentration of chemicals in wastewater: 0.07kg/m3 (BREF, 2006) - Impacts for wastewater treatment: "Wastewater, average {Europe without Switzerland}| treatment of wastewater, average, capacity 1E9l/year | APOS, U" - Efficiency of wastewater treatment: 95% (BREF, 2006) - Landfilling of organic chemicals under scope (71% of the total chemicals): "Refinery sludge {Europe without Switzerland}| treatment of refinery sludge, sanitary landfill | APOS, U" - Landfilling of organic chemicals under scope (29% of the total chemicals): "Inert waste {Europe without Switzerland}| treatment of inert waste, sanitary landfill | APOS, U"

Intermediate product	Recycling	Incineration	Landfill
Plastics and polymers	- Share: 25% (Amadei and Ardente, 2022). - PP and PE Recycling efficiency: 67% (Amadei et al., 2022). - PP Recycling impacts dataset: “Polyethylene terephthalate, granulate, amorphous, recycled {Europe without Switzerland}| polyethylene terephthalate production, granulate, amorphous, recycled | APOS, U” - PP Recycling credits dataset: “Polypropylene, granulate {RER}| production | APOS, U” - PE Recycling impacts dataset: “Polyethylene high density, granulate, recycled {Europe without Switzerland}| market for polyethylene, high density, granulate, recycled | APOS, U” - PE Recycling credits dataset: “Polyethylene, high density, granulate {RER}| production | APOS, U”	- Share: 39% (Amadei and Ardente, 2022). - PP incineration impacts dataset: “Waste polypropylene {Europe without Switzerland}| treatment of, municipal incineatino with fly ash extraction | APOS, U” - PE incineration impacts dataset: “Waste polyethylene {Europe without Switzerland}| treatment of waste polyethylene, municipal incineration | APOS, U”	- Share: 37% (Amadei and Ardente, 2022). - Landfill impacts dataset: “Waste plastic, mixture {Europe without Switzerland}| treatment of waste plastic, mixture, sanitary landfill | APOS, U”
Glass	- Share: 54% (ClosetheGlassLoop, 2023). - Recycling efficiency: 92% (ClosetheGlassLoop, 2023). - Recycling impacts dataset: “Glass cullet, sorted {RoW}| treatment of waste glass from unsorted public collection, sorting | APOS, U” - Recycling credits dataset: “Flat glass, uncoated {RER}| production | APOS, U”	- Share: 25% (Eurostat, 2024); applying to the non-recycled amount, the share of municipal waste being incinerated. - Incineration impacts dataset: “Waste glass {Europe without Switzerland}| treatment of waste glass, municipal incineration | APOS, U”.	- Share: 21% (Eurostat, 2024); applying to the non-recycled amount, the share of municipal waste being landfilled. - Landfill impacts dataset: “Waste glass {CH}| treatment of, inert material landfill | APOS, U”
Paper, pulp paper and boards	- Share: 71% (EPRC, 2022). - Recycling efficiency: 65% (EPRC, 2024). - Recycling impacts dataset: “Waste paper, unsorted (waste treatment) {RER}| graphic paper production, 100% recycled | APOS, U” - Recycling credits dataset: Pulp production tissue paper dry (manufacturing life cycle stage for the ‘tissue paper’ product of the Consumption Footprint).	- Share: 16% (Eurostat, 2024); applying to the non-recycled amount, the share of municipal waste being incinerated. - Incineration impacts dataset: “Waste graphical paper {Europe without Switzerland}| treatment of waste graphical paper, municipal incineration | APOS, U”.	- Share: 13% (Eurostat, 2024); applying to the non-recycled amount, the share of municipal waste being landfilled. - Incineration impacts dataset: “Waste graphical paper {Europe without Switzerland}| treatment of waste graphical paper, sanitary landfill | APOS, U”.

For the different prioritised final products and intermediate products, the environmental impact was quantified considering both the consumption intensity and the unitary environmental impact per product, as indicated in **Table 7.2**. The present study leveraged the available representative products of the Consumption Footprint indicator (Sala and Sanyé-Mengual, 2022), which were complemented with ad-hoc models. **Table 7.2** details the data sources employed for estimating the consumption intensity and the environmental impacts of the different products (both final and intermediate). Consumption intensities in **Table 7.2** refer to EU27 2022, whilst environmental impacts refer to the year 2022 and were calculated according to the EF3.1 method. The categories and families of PRODCOM codes related to each product in **Table 7.2** (e.g., Iron and Steel, Aluminium, etc.) were analysed to retrieve a subset of relevant codes (i.e., codes identified as representative for the products Iron and Steel, Aluminium, etc.). For calculating the apparent consumption expressed as mass (i.e., kg), the unit of each PRODCOM code was corrected if needed (e.g., in case the unit of a PRODCOM code was expressed as "pieces/year", it was multiplied by its unitary weight expressed as "kg/piece").

Table 7.2. Details on the estimates of consumption intensities and environmental impacts for each product under study.

Product [category]	**Consumption intensity**	**Environmental impact**
Iron and Steel [intermediate]	PRODCOM data (Eurostat, 2024): - Sum of the apparent consumptions for several PRODCOM codes of “Iron” and “Steel”. The apparent consumption of each PRODCOM code “i” for EU27 2022 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.1 method. All calculations were performed on the SimaPro software (SimaPro, 2024). The environmental impact for this product was derived as the average of the impacts of the following two datasets: - Cast iron {RER}| production | APOS, U - Steel, low-alloyed, hot rolled {RER}| production | APOS, U
Aluminium [intermediate]	PRODCOM data (Eurostat, 2024): - Sum of the apparent consumptions for several PRODCOM codes of “Aluminium”. The apparent consumption of each PRODCOM code “i” for EU27 2022 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.1 method. All calculations were performed on the SimaPro software (SimaPro, 2024). The environmental impact for this product was derived as the impact of the following dataset: - Aluminium, wrought alloy {RER}| aluminium production, primary | APOS, U
Commodity chemicals [intermediate]	The assessment of this product category was carried out by considering the following chemicals in scope: - Large volume inorganic chemicals: ammonia, nitric acid, sulphuric acid, phosphoric acid and hydrofluoric acid. - Basic inorganic chemicals: caustic soda and soda ash (called sodium carbonate, including sodium bicarbonate), titanium dioxide (from the chloride and sulphate process routes), synthetic amorphous silica (pyrogenic silica, precipitated silica, and silica gel). - Large volume organic chemicals: lower olefins by the cracking process (such as ethylene, propylene, butadiene, isoprene, etc.), aromatics such as benzene, toluene, xylene (BTX), oxygenated compounds such as ethylene oxide, ethylene glycols and formaldehyde, nitrogenated compounds such as acrylonitrile and toluene diisocyanate, halogenated compounds such as ethylene dichloride (EDC) and vinyl chloride monomer (VCM), sulphur and phosphorous compounds, organometallic compounds, methanol. The consumption intensities were modelled by considering PRODCOM data (Eurostat, 2024).	A selection of the Ecoinvent datasets (Ecoinvent, 2022) based on the chemicals’ scope was performed. These datasets were then characterized with the EF3.1 method. Production-related datasets (i.e., “{RER} | production | APOS, U”) were prioritised. By considering the chemicals in scope, an association between the characterized impacts and the related consumption intensity was performed (e.g., the calculated consumption intensity of “ammonia” from PRODCOM data was mapped with the corresponding impact factor derived from Ecoinvent datasets for “ammonia”). When multiple datasets were available for the same chemical, the average impact was calculated.
Plastics & polymers [intermediate]	PRODCOM data (Eurostat, 2024) of semifinished products (Amadei and Ardente, 2022): - Sum of the apparent consumptions of the PRODCOM codes listed under “Semi-finished products” in the supplementary material (Table SM8) of the study of Amadei et al. (2022), recalculated for the year 2022.	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.1 method. All calculations were performed on the SimaPro software (SimaPro, 2024). The environmental impact for this product was derived as the weighted average of the following dataset related to polymers’ production (66% PP, 34% PE): - Polyethylene, high density, granulate {RER}| production | APOS, U

Product [category]	Consumption intensity	Environmental impact
		- Polypropylene, granulate {RER}| production | APOS, U The weights were derived considering the relative significance fo PE and PP in the polymer's consumption in EU, according to Amadei and Ardente (2022).
Glass [intermediate]	PRODCOM data (Eurostat, 2024): - Sum of the apparent consumptions for several PRODCOM codes of "Glass". The apparent consumption of each PRODCOM code "i" for EU27 2018 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.1 method. All calculations were performed on the SimaPro software (SimaPro, 2024). The environmental impact for this product was derived as the impact of the following dataset: - Flat glass, uncoated {RER}| production | APOS, U
Paper, Pulp paper and boards [intermediate]	Based on literature data: - Consumption intensities for 2022 for "Graphic papers" (derived from Euro-Graph, 2022) and "Tissue paper" (derived from EuropeanTissue, 2022) were considered.	Consumption footprint (EC-JRC, 2024): - Impacts of life cycle stage "1 Components manufacture Pulp production_Graphic paper" of representative product "Newsprint". - Impacts of life cycle stage "1 Pulp production_Tissue paper dry" of representative product "Toilet Paper".
Textiles and footwear [final]	Consumption footprint (EC-JRC, 2024): - The consumption intensities of the representative products clothes (T-shirt, jeans, blouse, trousers, plastic articles of apparel and clothing accessories) and footwear (5 types, depending on use: fashion, waterproof and work, sports, casual, sandals) were considered.	Consumption footprint (EC-JRC, 2024): - The aggregated impacts of the representative products clothes (T-shirt, jeans, blouse, trousers, plastic articles of apparel and clothing accessories) and footwear (4 types, depending on use: fashion, waterproof and work, sports, casual, sandals) were considered. Note that while the EF impact assessment method shows some limitations for assessing specific aspects of bio-based textiles, comparing fossil- and bio-based options are out of the scope of this prioritization exercise.
Lubricants [final]	PRODCOM data (Eurostat, 2024): - Sum of the apparent consumptions for several PRODCOM codes of "Lubricants". The apparent consumption of each PRODCOM code "i" for EU27 2018 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.1 method. All calculations were performed on the SimaPro software (SimaPro, 2024). The environmental impact for this product was derived as the impact of the following dataset: - Lubricating oil {RER}| production | APOS, U
Furniture [final]	Consumption footprint (EC-JRC, 2024): - The consumption intensities of the representative products bedroom wooden furniture, kitchen furniture, upholstered seat, non-upholstered seat (wooden seat), dining room furniture (wooden table) and furniture of plastics were considered.	Consumption footprint (EC-JRC, 2024): - The aggregated impacts of the representative products bedroom wooden furniture, kitchen furniture, upholstered seat, non-upholstered seat (wooden seat), dining room furniture (wooden table) and furniture of plastics were considered.

Product [category]	Consumption intensity	Environmental impact
Tyres [final]	PRODCOM data (Eurostat, 2024): - Sum of the apparent consumptions for several PRODCOM codes of “Tyres”. The apparent consumption of each PRODCOM code “i” for EU27 2018 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$	Ecoinvent datasets (Ecoinvent, 2024) characterized with the EF3.1 method. All calculations were performed on the SimaPro software (SimaPro, 2024). The environmental impact for this product was derived as the impact of the following dataset: - Synthetic rubber {RER}| production | APOS, U - Steel, low-alloyed, hot rolled {RER}| production | APOS, U A share was applied to each of the above datasets based on the model “Used tyre {GLO}| production | APOS, U”, that indicates a share of 24% steel and 76% rubber.
Detergent products [final]	Consumption footprint (EC-JRC, 2024): - The consumption intensities of the representative products all-purpose cleaners and sanitary cleaners (500mL), detergents for dishwashers (tablet), hand dishwashing detergents (650mL), laundry detergents liquid (650mL) and laundry detergents powder (dose), were considered.	Consumption footprint (EC-JRC, 2024): - The aggregated impacts of the representative products all-purpose cleaners and sanitary cleaners (500mL), detergents for dishwashers (tablet), hand dishwashing detergents (650mL), laundry detergents liquid (650mL) and laundry detergents powder (dose), were considered.
Paints and varnishes [final]	PRODCOM data (Eurostat, 2024): - Sum of the apparent consumptions for several PRODCOM codes of “Paints”. The apparent consumption of each PRODCOM code “i” for EU27 2018 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$	Ecoinvent datasets (Ecoinvent, 2024) characterized with the EF3.1 method. All calculations were performed on the SimaPro software (SimaPro, 2024). The environmental impact for this product was derived as the weighted average impact of the following datasets: - Acrylic varnish, without water, in 87.5% solution state {RER}| acrylic varnish production, product in 87.5% solution state | APOS, U - Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | APOS, U Insights on the market share of paints were derived from Statista (2023). A proxy was created using the two life cycle impacts of the only Ecoinvent paints-related datasets currently available. The weights were calculated based on those provided by Statista (2023): 76% for acrylic and 24% for alkyd paint.
Bed mattresses [final]	Consumption footprint (EC-JRC, 2024): - The consumption intensity of the representative product bed mattresses (mix of 3 types) was considered.	Consumption footprint (EC-JRC, 2024): - The impact of the representative product bed mattresses (mix of 3 types) was considered.
Cosmetic products [final]	Consumption footprint (EC-JRC, 2024):	Consumption footprint (EC-JRC, 2024):

Product [category]	Consumption intensity	Environmental impact
	- The consumption intensities of the representative products bar soap, liquid soap (255mL), shampoo (255mL) and hair conditioner (255mL), were considered.	- The aggregated impacts of the representative products bar soap, liquid soap (255mL), shampoo (255mL) and hair conditioner (255mL), were considered.
Absorbent Hygiene Products [final]	Consumption footprint (EC-JRC, 2024): - The consumption intensities of the representative products baby diaper, sanitary pad, tampon and breast pad were considered.	Consumption footprint (EC-JRC, 2024): - The aggregated impacts of the representative products baby diaper, sanitary pad, tampon and breast pad were considered.
Toys [final]	Consumption footprint (EC-JRC, 2024): - The consumption intensities of the representative product toys (product group: plastic products) was considered.	Consumption footprint (EC-JRC, 2024): - The impact of the representative product toys (product group: plastic products) was considered.

Quantification of savings for each horizontal requirements examined in the present study

Table 7.3 presents the metrics used and the improvement scenarios considered for each horizontal requirements (indicating the products for which a default improvement scenario was used). It must be noted that the percentages selected in the improvement scenarios are indicative, and, due to their use as input for the modelling of benefits, may lead to underestimated results. This could be explained considering:

— The lack of data, and the challenge of associating a certain ambition level for the suggested provisions with specific savings.

— That the percentages for the improvement scenarios were selected considering the direct benefits of improved design for the products in scope. Wider and indirect effects (such as those related to change of consumer behaviour or market responses) were not considered. This is aligned with the principle sustainable design, stating that it creates the necessary conditions for benefits albeit not being sufficient alone for reaching such benefits[101].

Further, lifetime extension scenarios, which were assumed to take place due to circularity policy mix, are not necessarily attributed 1:1 to specific provisions. For instance, the employed quantification approach on the lifetime extension is not linked individually to provisions such as "spare part availability", or "water resistance". As a consequence, the quantification approach proposed is not affected by variations/additions/removal of certain provisions. If the pool of specific provisions slightly changes, it can be considered that the same lifetime extension levels are maintained, which in turn yields the same quantified impacts/savings (as described in the below **Table 7.3**). The final products and intermediate products for which the default scenarios (i.e., 10%, 30% and 50% improvements) were used and the respective horizontal requirements can be found in Table 8. Based on the Consumption Footprint indicator, the calculation of the environmental impacts of the prioritised final and intermediate products allows the estimation of the potential benefits of applying such requirements through the ESPR. The calculation of the environmental impact of a product considering the benefit of the applied horizontal measure was performed at the life-cycle stage level, since some requirements have effects on specific aspects of the life cycle of products (e.g., end of life). The below equation summarises the calculation, where the environmental impact of a product (i) considering a given horizontal measure (HM) and scenario of benefits (s) depends on the consumption intensity of the product (CIi), and the benefit level (by HM and scenario) and the environmental impact of each life-cycle stage (j) of the product (i).

$$Product\ impact_{i,HM,s} = CI_i * \sum_{j=0}^{n} \left(1 - benefit_{HM,i,j,s}\right) * environmental\ impact_{i,j}$$

The results of the horizontal requirements were calculated cumulatively: the benefits of recyclability requirements were calculated on top of those of durability requirements, whilst the benefits of post-consumer recycled content requirements were calculated on top of durability and recyclability ones. Results were presented with regard to the “medium benefits”, accompanied by a range of variability

101 For example, designing solely towards an increased recyclability would contribute to an increased recycling rate of products in scope only to a certain extent, although to properly capture the full potential of increased recycling, it would be necessary to consider wider market transformations, such as correct disposal and collection, the presence of the appropriate recycling infrastructure, or the economic viability of recycling processes.

calculated from “low benefits” and “high benefits” results. The resulting environmental impacts for the various horizontal requirements were compared with the so-called “Planetary Boundaries”. The concept of the Planetary Boundaries was proposed in 2009 by a group of Earth system and environmental scientists, aiming to provide a reference point for assessing the “sustainability of consumption”. The group wanted to define a "safe operating space for humanity" for the international community, including governments at all levels, international organisations, civil society, and the private sector, as a precondition for sustainable development. The framework is based on the scientific evidence that human actions have become the main driver of global environmental change since the Industrial Revolution. The "safe operating space" is defined as the threshold to maintain the Holocene state. When this threshold is crossed, the planet's biophysical subsystems and processes could shift to a new state with potential negative consequences for humans (Rockstrom et al., 2009).

Table 7.3. Summary of horizontal requirements and the related metrics and improvement scenarios.

Horizontal Requirement	**Metric**	**Product analysed**	**Improvement scenarios (classification)**	**Comments – Calculation approach**
Durability	Increased lifetime expressed in %	Textiles and footwear	10% (low benefits) - 30% (medium benefits) - 50% (high benefits)[102]	Based on the Representative Product employed to model "Textiles" and "Footwear".
		Bed Mattresses	10% (low benefits) - 30% (medium benefits) - 50% (high benefits) (default)	Based on the Representative Product employed to model "Bed Mattresses".
		Furniture	40% (low benefits) - 60% (medium benefits) - 80% (high benefits)[103]	Based on the Representative Product employed to model "Furniture".
		Toys	10% (low benefits) - 30% (medium benefits) - 50% (high benefits) (default)	Based on the Representative Product employed to model "Toys".
Recyclability	Increased recycling (% increased recycling rate)	Bed mattresses	10% (low benefits) - 30% (medium benefits) - 50% (high benefits) (default)	Based on the Representative Product employed to model "Bed Mattresses".
		Textiles and footwear	10% (low benefits) - 30% (medium benefits) - 50% (high benefits) (default)	Based on the Representative Product employed to model "Textiles" and "Footwear".
		Absorbent hygiene products	10% (low benefits) - 30% (medium benefits) - 50% (high benefits (default)	Based on the Representative Product employed to model "Absorbent hygiene products".
		Furniture	10% (low benefits) - 30% (medium benefits) - 50% (high benefits (default)	Based on the Representative Product employed to model "Furniture".
		Toys	10% (low benefits) - 30% (medium benefits) - 50% (high benefits (default)	Based on the Representative Product employed to model "Toys".
Post-consumer recycled content	Post-consumer recycled content	Textiles and footwear	10% (low benefits) - 30% (medium benefits) - 50% (high benefits	Based on the Representative Product employed to model "Textiles" and "Footwear".

[102] Assumptions based on: Cooper et al. (2013); Beton et al. (2014).

[103] Assumptions based on: Russell et al. (2022).

Horizontal Requirement	Metric	Product analysed	Improvement scenarios (classification)	Comments - Calculation approach
	(% used in manufacture)	Bed mattresses	10% (low benefits) - 30% (medium benefits) - 50% (high benefits	Based on the Representative Product employed to model "Bed Mattresses".

Note: Where no literature or data was available to make an estimation of improvement potential, the default values of 10%, 30% and 50% for improvements were used, wherever indicated. Different sets of improvement scenarios for the same horizontal requirements were aggregated under "low benefits", "medium benefits" and "high benefits" categories. For instance, an improvement scenario of 10% for durability of textiles and an improvement scenario of 40% for durability of furniture would both be classified as a "low benefits" durability improvement scenario – these ranges of benefits were defined based on literature when available.

Modelling information for the quantification of savings due to horizontal requirements

Calculating the savings due to Durability Requirements

In the case of Horizontal Requirements for Durability, the following approach was employed to calculate the savings of improvement scenarios. The calculations of the savings related to the Durability requirements affected the lifespan of the product and the improvement level was assumed as an expansion of such lifespan, as illustrated by the below equation. The expansion of lifespan affected the environmental impact per life cycle stage apart from the use phase. Baseline lifespan used in the model are reported in **Table 7.4**.

$$Product\ impact_{i,HM,s} = CI_i * \sum_{j=0}^{n} \frac{Lifespan_i}{(1 + benefit_{HM,i,j,s}) *\ Lifespan_i} * environmental\ impact_{i,j}$$

Table 7.4. Summary of lifespan assumed for each representative product employed in the calculations of the savings due to Durability Requirements.

Representative product	Lifespan (years)	Reference
Toys	10	Own modelling assumptions based on literature information
Plastic articles of apparel and clothing	7.5	Own modelling assumptions based on literature information
Sandals	5	Own modelling assumptions based on literature information
Furniture of plastics	15	Own modelling assumptions based on literature information
Bedroom wooden furniture	15	Castellani et al. (2019), according to EU Ecolabel background reports
Kitchen furniture	15	Castellani et al. (2019)
Upholstered seat	15	Castellani et al. (2019)
Non-upholstered seat (wooden seat)	15	Castellani et al. (2019)
Wooden table	15	Castellani et al. (2019)
Work and waterproof footwear	1	Castellani et al. (2019), according to the related Product Environmental Footprint Category Rules (PEFCR)
Sport footwear	1	Castellani et al. (2019), according to the related PEFCR
Leisure footwear	1	Castellani et al. (2019), according to the related PEFCR
Fashion footwear	1	Castellani et al. (2019), according to the related PEFCR
T-shirt	1	Castellani et al. (2019), according to the related PEFCR
Women blouse	1	Castellani et al. (2019), according to the related PEFCR
Men trousers	1	Castellani et al. (2019), according to the related PEFCR
Jeans	1	Castellani et al. (2019), according to the related PEFCR

Source: JRC own elaboration

Calculating the savings due to Recyclability

The quantification of the savings related to Recyclability considers the effect at the end-of-life stage. A different recycling rate influences the contribution to the impact of non-recycling pathways at the end of life and the modelled benefit of recycling, which considers the avoided impacts of the material that is being recycled (considering the respective recovery rate in this impact factor). The following equation summarizes the calculation approach.

$$Product\ impact_{i,HM,s} = CI_i * \big(environmental\ impact_{i,excl.end\ of\ life} + \big(1 - Recycling_{rate,i} * Benefit_{HM,s}\big) * environmental\ impact_{i,EoL\ non\ recycling} - \big(Recycling_{rate,i} * Benefit_{HM,s}\big) * environmental\ impact_{i,components\ manufacture}\big)$$

Calculating the savings due to Post-Consumer Recycled content

The quantification of the savings related to Post-Consumer Recycled content followed the same approach as for assessing Recyclability. In the Consumption Footprint model, benefits of recycling are considering only at the end of life and recycled materials are considering as input 0 (regarding the material). Such approach was implemented to prevent double counting by defining a clear actor benefiting from the credits. However, in this exercise the benefits of recycled content were assumed to be simulating the benefits at the end of life. The potentials savings related to Post-Consumer Recycled content for plastics were not calculated as the final products for which environmental impacts have been calculated (such as toys) do not correspond to the plastic products proposed as target for this horizontal measure (i.e., agricultural products, cable casings, safety/warning signs, barrels, etc.).

Main constraints and challenges for the impacts' quantification and savings' evaluation

Modelling of intermediate products

The intermediate products such as Iron and steel, Aluminium, etc. were modelled by employing dedicated assumptions due to the lack of comparable representative products. The modelling employed in the Consumption Footprint for its representative products consider their entire life cycle, while for intermediate products impacts associated with production, manufacturing and end-of-life management were considered in the present analysis. Consumption intensities, and the calculation of the impact factors for such intermediate products were based on available statistics (e.g., Eurostat database) and datasets (e.g., Ecoinvent datasets). In some cases (e.g., intermediate products such as Paper, pulp paper and boards), literature data were employed to properly capture the full consumption intensity. Additionally, for some of the consumption intensities gathered from the Eurostat database, a unit conversion was necessary to adapt the available data to the scope of the present work (e.g., data related to tyres expressed in "pieces" needed to be converted to "kg" by assuming unitary weights). The main challenge related to the modelling end-of-life fate of intermediate products and the associated impacts was related to the potential wide array of final products applications in which intermediate products might be employed. As a consequence, proxies were created adopting best available estimates and datasets and considering potential final applications of intermediate products under exam and how these could be handled at the end-of-life. In the case of chemicals, it was not possible to assess impacts associated with end-of-life management due to the very numerous final applications and the uncertainty associated to their management and proper impacts modelling estimates. These assumptions should be taken into consideration when analysing the results for the intermediate products as they may introduce a significant level of uncertainty in the estimation of the impacts of such products.

Estimating the savings associated to horizontal requirements

This exercise presented several challenges, and this report illustrates the current advancements concerning this quantification. Firstly, there is a lack of quantitative data: only a limited number of studies were found in the literature to refine the definition of improvement scenarios. Furthermore, these studies are usually focused on product improvement (e.g., weight difference) or on an individual impact category (e.g., Climate Change), limiting the potential evaluation of trade-offs among environmental impacts. Secondly, there are some impact assessment limitations. For example, reducing the use of sand for glass production cannot be modelled, as "sand" is not a "resource use" addressed in the resource use impact categories of the Environmental Footprint. Thirdly, specific considerations of specific life-cycle stages could affect the remaining life cycles. The Consumption Footprint is in fact calculated for a given year and the environmental impacts of products are allocated to a given year. For example, changes in lifespan affect all life cycle stages apart from use, as the impacts of these stages are allocated to a year in the Consumption Footprint (such allocation is based on the lifespan). In other approaches, lifespan variability could affect only primary stages (e.g., higher demand for materials) or the use phase (e.g., longer use of the product). Furthermore, the savings associated with the implementation of horizontal requirements should be also analysed in the context of potential trade-offs, as current results focus on single specific horizontal requirements (e.g., Durability scenario). Therefore, the approach adopted for calculating these savings does not quantitatively account for the presence of any potential side effect on other horizontal requirements (either increasing the total savings or decreasing the total savings)[104]. Horizontal requirements proposed for products currently classified as "intermediate products" (**Table 7.3**) could not be properly assessed or analysed due to data constraints, especially concerning data availability for the impacts for each life-cycle stage. To calculate the savings associated with horizontal requirements for such products, it would be necessary to (i) provide a breakdown at a "representative" product level for each intermediate group (e.g., one or more representative plastic products to map the "plastic products" intermediate group) and (ii) to establish a dedicated life-cycle model for each "representative" product, enabling a detailed impact assessment for each life-cycle stage.

Savings due to the implementation of product requirements - examples for clothes and furniture product groups

The modelling of specific product requirements has been performed as example for two product groups: clothes and furniture. This modelling exercise leverage on available scenarios reported in detail in the design of the Consumption Footprint model regarding the area of consumption of household goods (Castellani et al., 2019). The modelled scenarios with specific requirements have been updated considering the consumption intensity of 2022 and updating the environmental assessment to the Environmental Footprint 3.1 method.

This annex provides an overview of the scenarios (Castellani et al., 2019):

— Scenarios for the product group Textiles and footwear:

- Performance requirement for a minimum recycled content:

  This scenario models a requirement where polyester used in synthetic textile made from virgin PET is substituted by 100% recycled PET pellets. This represents a closed-loop type of recycling where virgin material is substituted by recycled alternatives.

- Performance requirement for a minimum re-use:

  This scenario models that the lifespan of clothes is extended with a second life through a re-selling process (second-hand shopping), which leads to a re-use of the product prior to reaching the end of life. The scenarios considers that 34% of EU citizens are keen to buy clothes in second-hand market channels.

[104] For example, in the case of the prioritised end-use product tyres, a horizontal measure aimed at boosting tyres' recycled content could in principle (positively) affect savings associated with horizontal measures such as increased lightweight or sustainable sourcing and (negatively) affect savings associated with horizontal measures such as durability. This does not imply the exclusion of these potential trade-offs from the performed study, but rather aims at acknowledging them and appraising them qualitatively. The complexity of a quantitative analysis of potential trade-offs would require a more exhaustive and detailed evaluation, relying on stakeholder engagement and, fundamentally, containing the agreed political choices which would constrain and define the scenarios.

Scenario of low requirement: A scenario of low requirement models that 15% of people keen to use second-hand channels buys clothes instead of buying new clothes. This leads to modelled requirement of 5% of re-use (15% of 34%).

Scenario of high requirement: A scenario of low requirement models that 100% of people keen to use second-hand channels buys clothes instead of buying new clothes. This leads to modelled requirement of 34% of re-use (100% of 34%).

- Performance requirement on minimum share of energy consumption from low carbon sources:

  This scenario models the benefits due to the reduction of the impact of the electricity used in manufacturing of textiles, by using more environmentally sustainable energy mixes, including a higher share of electricity from renewable sources.

  Scenario A: in this scenario, all the electricity used in the production phases of textiles (e.g., spinning, texturizing, knitting, dyeing, etc.) are modelled with the Ecoinvent dataset related to an average European electricity mix (in place of the ones of the baseline results, representing real conditions/geographies of the textiles production sites).

  Scenario B: in this scenario, all the electricity used in the production phases of textiles (e.g., spinning, texturizing, knitting, dyeing, etc.) are modelled with the Ecoinvent dataset related to an average European electricity mix, adapted to the expected mix for the gross electricity generation by source in the year 2030 as described in EC (2016) (in place of the ones of the baseline results, representing real conditions/geographies of the textiles production sites).

— Scenarios for the product group 'Furniture':

- Performance requirement on ease for re-use:

  This scenario models that the lifespan of furniture is extended with a second life through a re-selling process (second-hand shopping), which leads to a re-use of the product prior to reaching the end of life. The scenarios considers that 56% of EU citizens are keen to buy furniture in second-hand market channels.

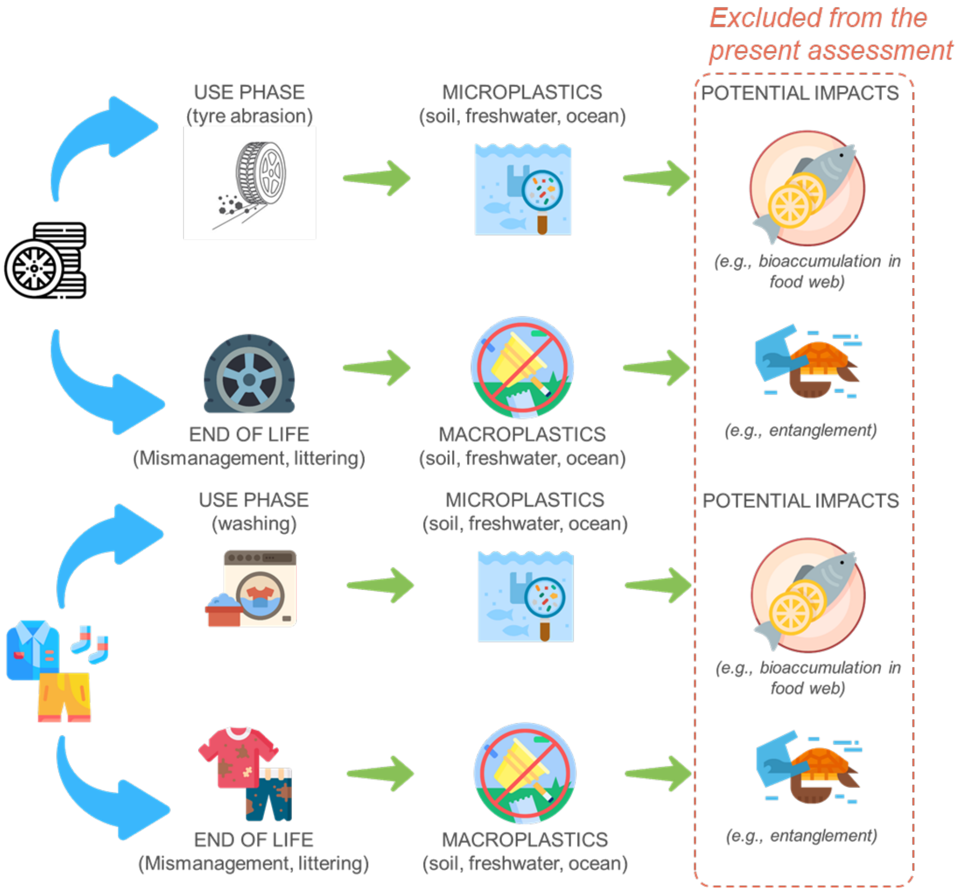
  Scenario of low requirement: A scenario of low requirement models that 15% of people keen to use second-hand channels buys furniture instead of buying new furniture. This leads to modelled requirement of 8% of re-use (15% of 56%).

  Scenario of high requirement: A scenario of low requirement models that 100% of people keen to use second-hand channels buys furniture instead of buying new furniture. This leads to modelled requirement of 56% of re-use (100% of 56%).

Analysis of the potential plastic leakage associated with the prioritised final products – Contribution of prioritised final products

Plastic pollution and associated environmental impacts have recently been recognised as a key research topic not only for the achievement of UN Sustainable Development Goal (SDG) number 14 (UNEP, 2015) but also within the context of several ambitious EU policies: the European Strategy for plastics in a Circular Economy (EC, 2018), the European Green Deal (EC, 2019a) and the Single-Use Plastics (SUP) Directive (EC, 2019b). A visual description of the pathways leading to the environmental impacts of the plastic being released from tyres and textiles is described in **Figure 7.2**. However, insights related to plastic leakages and the related environmental impacts are currently beyond the scope of the Consumption Footprint as this is not an impact modelled in the Environmental Footprint method. To cover this gap, estimations of microplastics and macroplastics releases were added to the analysis.

Figure 7.2. Micro- and macro-plastics generation and potential impacts due to the consumption of tyres and textiles



Source: JRC own elaboration.

The potential plastic leakage due to the consumption of tyres and textiles (two of the prioritised final products) was quantified following the Plastic Leak Project method (henceforth called the "PLP method"; Peano et al., 2020). In the context of the PLP method, a series of specific approaches have been proposed to model the losses and release of plastics to the environment at different life-cycle steps and considering different sources. In the PLP method, different environmental compartments of release are also considered, as well as any potential redistribution among such compartments (i.e., a distinction is made between "initial release" and "final release"). The framework covers both microplastics (i.e., small plastic debris of less than 5 mm in diameter) and macroplastics (i.e., plastic debris larger than 5 mm in diameter).

The approach was applied to the consumed plastic mass for the tyres and textiles products, as examples of final prioritised products with a relevant role in the generation of micro- and macro-plastics along their life cycle. The PLP method estimation included environmental releases to the environment of microplastics (end compartment of emission being water and soil), as well as of macroplastics, i.e. littering or mismanagement of the product at their end of life. The analysis presented in this section considers solely the final release to three environmental compartments (expressed in kg): releases to soil, releases to water and releases to the environment (unspecified) (this compartment describes a release related to an unspecified environmental compartment; this flow was aggregated in the present analysis to the losses to the water environmental compartment).

Note that, when accounting for the final release, it is considered that a share of emitted plastic is re-collected and returned to the end-of-life pathways (e.g., incineration).

The estimation of microplastics and microplastics releases reported in the present study refers to the potential plastic leakage associated to the amount of new products (i.e., tyres and textiles) consumed in 2022, rather than to the total amount of products present in the stock. Overall, it must be considered that the analysis of microplastics/macroplastics releases and the related findings presented in this study are influenced by data limitations and by a lack of available approaches for their quantification. These results should therefore be considered as preliminary, and could be revised when more robust data and approaches would be available.

According to the PLP method, the release of microplastics was addressed based on the estimated consumption of tyres and textiles, whilst the macroplastics releases were calculated based on the total waste generated from the two sectors (assuming an amount of waste being generated from tyres equal to 54% of the total consumption; and assuming an amount of waste being generated from textiles equal to 65% of the total consumption, based on Amadei and Ardente, 2022).

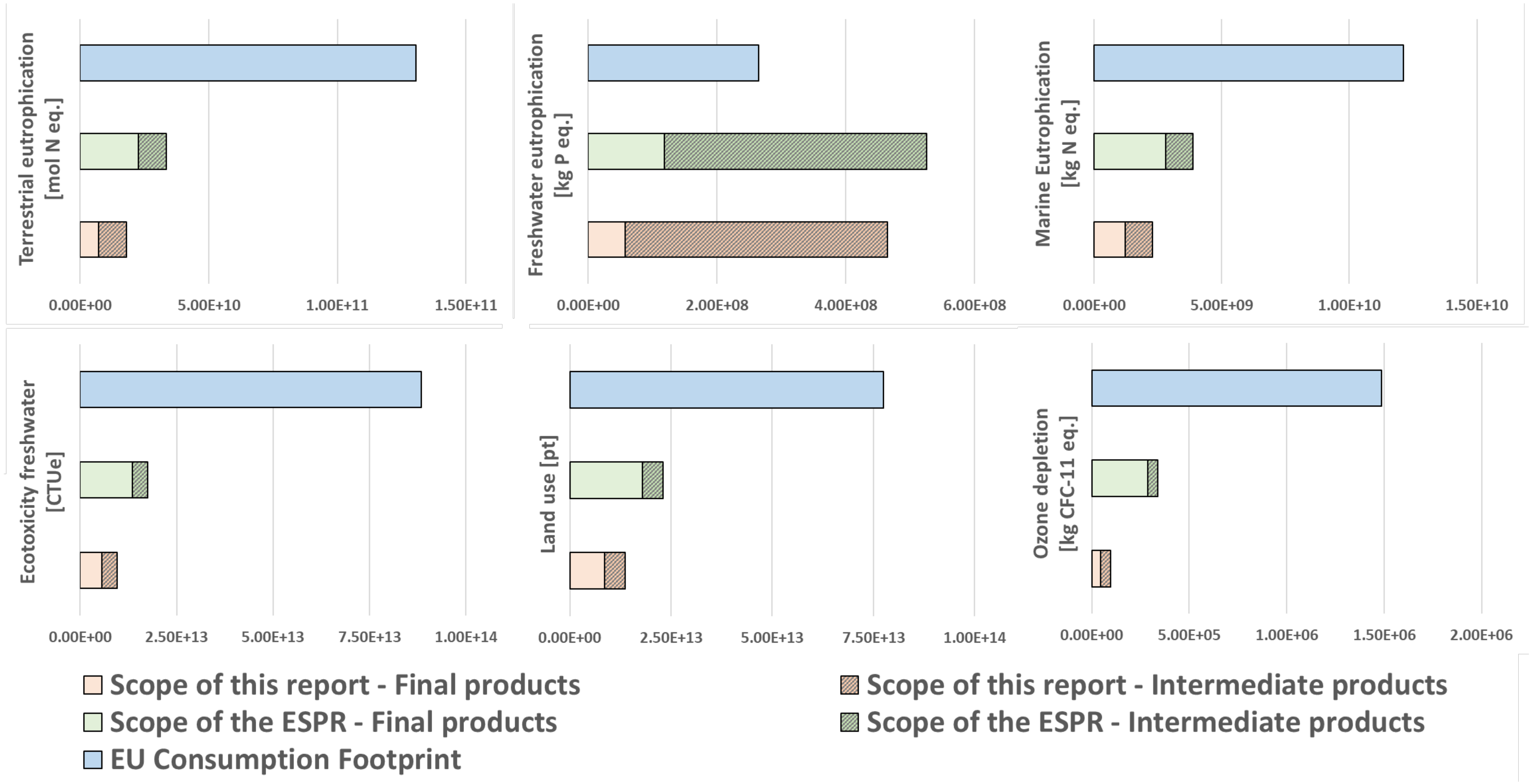
With the aim of providing a reference to daily-life objects, the amount of plastic in the final releases to each environmental compartment were then converted to (i) a “number of bottles” metric being released, assuming a bottle of average weight (i.e., 23.9 g) as the reference; and (ii) a “number of plastic chairs” being release, assuming a chair of average weight (i.e., 2.5kg) as reference.

Annex 8. Environmental impact assessment – results overview

Additional results on the contribution of final products and intermediate products related to the overall Consumption Footprint

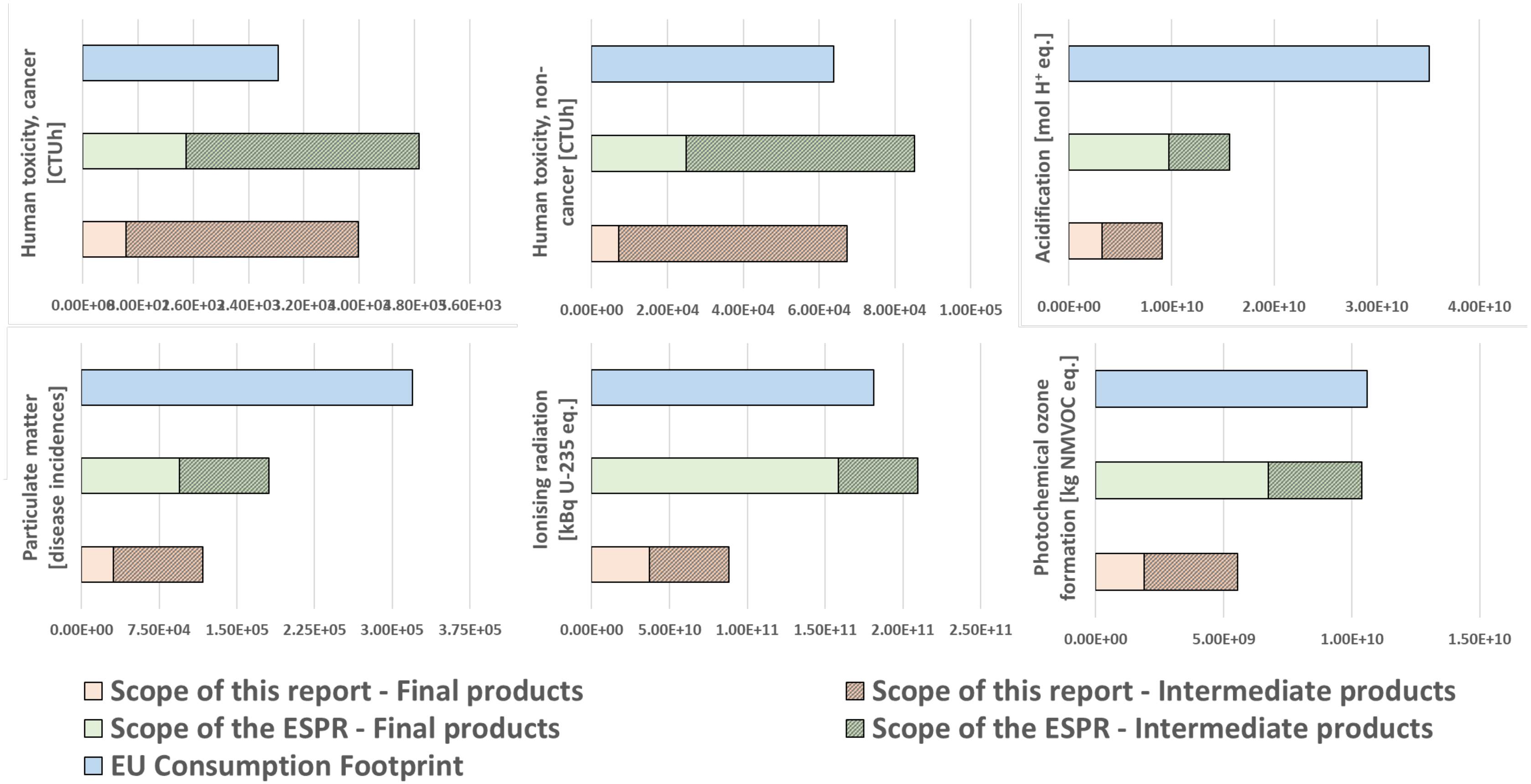
Results of the assessment of the impacts of prioritised final and intermediate products related to the overall Consumption Footprint and the ESPR scope not provided in the main report (i.e., the 12 remaining EF impact categories beside Climate Change, Water Use, 'Resource use, fossils' and 'Resource use, minerals and metals') are illustrated in **Figure 8.1** and **Figure 8.2**.

Figure 8.1. Impacts of working plan scope, EPSR scope for final and intermediate products and Consumption Footprint impacts (Part 1/2).



Source: JRC own elaboration

Figure 8.2. Impacts of working plan scope, EPSR scope for final and intermediate products and Consumption Footprint impacts (Part 2/2).



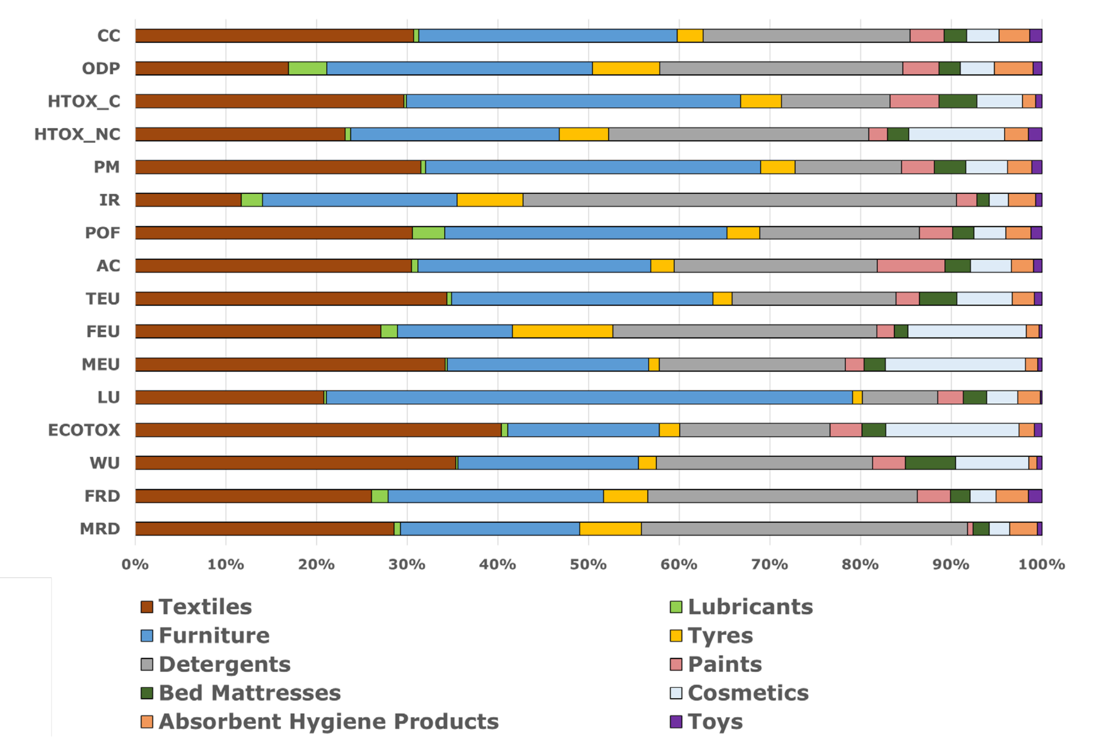
Source: JRC own elaboration

Contribution of the different final priority products and intermediate products to their overall impacts

Among the different prioritised final products (**Figure 8.3**), the most relevant ones are textiles, furniture and detergents. These three products represent on average around 85% of the total impacts across all impact categories, also due to their significant consumption intensities that contribute to more than 62% of the total consumption intensities of all final products. Despite being lower also cosmetic, paints and tires share a significant amount of impacts across all impact categories: overall around 14% on average.

Figure 8.3. Role of prioritised final products in their overall impact.

Note: CC = climate change; ODP = ozone depletion; HTOX_nc = human toxicity non-cancer; HTOX_c = human toxicity, cancer; PM = particulate matter; IR = ionising radiations; POF = photochemical ozone formation; AC = acidification; TEU = eutrophication, terrestrial; FEU = eutrophication, freshwater; MEU = eutrophication, marine; LU = land use; ECOTOX = ecotoxicity freshwater; WU = water use; FRD = resource use, fossil; MRD = resource use, minerals and metals.



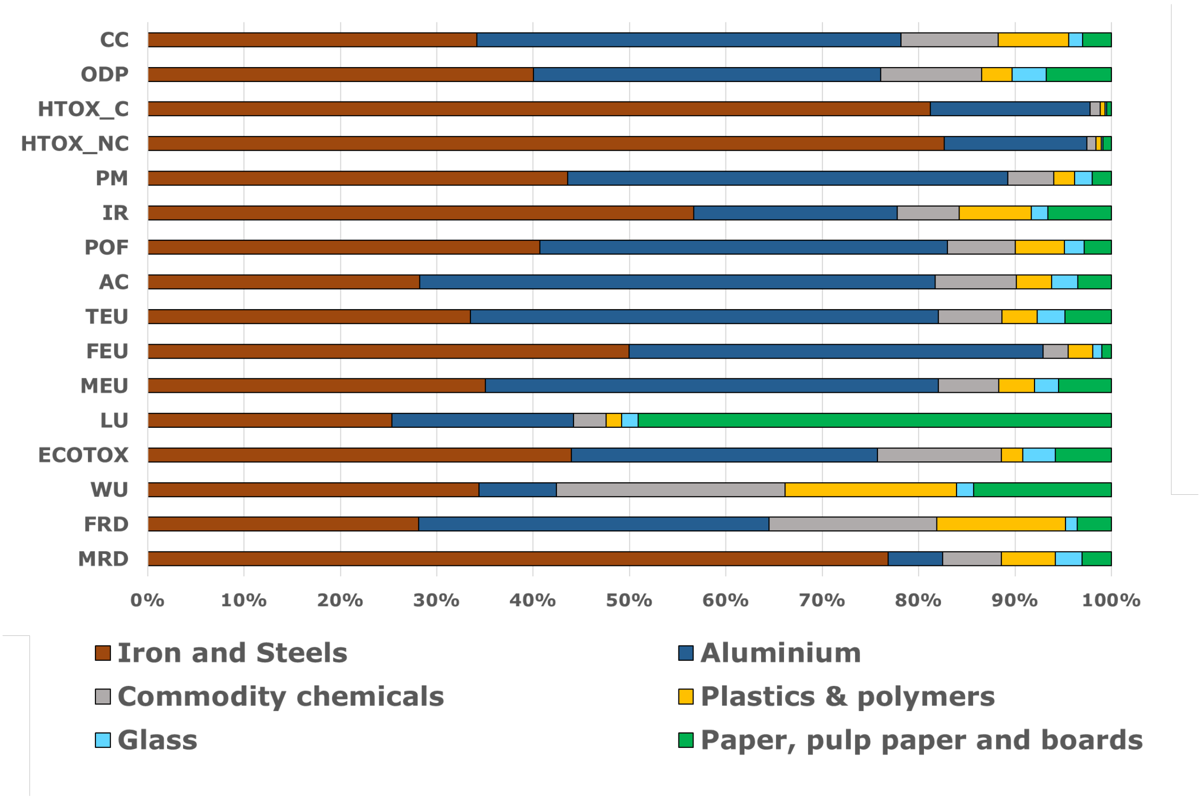
Source: JRC own elaboration

When intermediate products are considered (**Figure 8.4**), the most relevant are Iron and steel, Aluminium and Commodity chemicals. These three products covered 86% of the total impacts of all intermediate products (on average for all the 16 impact categories). In particular, Iron and steel have the highest contribution (46% on average) for the impacts of all impact categories. By contrast, Plastic and polymers, Glass and Paper, pulp paper and boards amounted together to 14% of all impacts respectively (on average for all the 16 impact categories), since their consumption intensities cover only around 21% of the total consumption of all intermediate products analysed.

In general, the results provided for final products in Section 1.4.3 of the main report broadly confirm the findings provided in **Figure 8.3**. In particular, Textiles and footwear, Furniture and Detergents ranked first, second and fifth, respectively, in the assessment of their environmental relevance. Nevertheless, few exceptions can be identified, such as Tyres, ranking as the second-highest final products in Section 1.4.3 of the main report, whilst having a minor role in **Figure 8.3**.

This should not be seen as an inconsistency, as it mainly highlights the differences of the two approaches: (i) in the assessment of environmental relevance (Section 3.3.1 of the main report) both environmental impacts and improvement potential are considered, whereas (ii) for analysis of the final products' relevance (**Figure 8.3**), only the environmental impacts of such products are considered.

Figure 8.4. Role of intermediate products in their overall impact.



Source: JRC own elaboration

In addition, the scope of the products considered in Section 3.3.1 of the main report differed in most cases from the scope of the products considered in the current section. In the assessment of the products' environmental relevance (Section 3.3.1 of the main report), a qualitative analysis is performed. Such analysis is characterized by a broader scope compared to the specific data needed for calculating the environmental impacts of final-products. For example, the product group Textiles and footwear was considered in the assessment of environmental relevance (Section 3.3.1 of the main report) as apparel and home textiles consumed by households and business as well as footwear and technical textiles. On the other hand, for the analysis of the final products' environmental impacts, the product group Textiles and footwear was modelled by means of several representative products (i.e., T-shirts, jeans, blouses, trousers, plastic articles of apparel and clothing accessories, as well as a total of five types of footwears). This indicates that the results obtained with the two methodologies can be compared only to a certain extent. Notwithstanding the above-mentioned differences, the Consumption Footprint method is here used to quantify the expected environmental impacts of products under scope (i.e., in line with the scope of the analysis of the present report).

Savings due to the implementation of horizontal requirements – additional results

As discussed in Annex 7 the savings in terms of the environmental impacts of the prioritised final products due to the implementation of horizontal requirements were calculated cumulatively. First, Durability savings were estimated. Secondly, recyclability savings were estimated on top of Durability ones. Thirdly, savings due to the application of post-consumer recycled content measured were added.

Savings associated with the Durability horizontal requirements were calculated based on an increased product lifetime expressed in percentage. Savings associated with the Recyclability horizontal requirements were calculated considering how a different recycling rate could influence the contribution to the impact of non-recycling pathways. Savings associated with the Post-consumer recycled content horizontal requirements were calculated following the same approach as for assessing Recyclability, considering the benefits of recycled content as simulating the benefit that would entail at the end of life. For each horizontal measure, calculations were performed for the products listed in **Table 7.3**. The results for the "medium benefit" scenario were presented in specific bar-charts dedicated to each impact category of the EF3.1 method. Results for the "low benefits" and "high benefits" scenarios were added to the graphs in form of error bars, to highlight the minimum/maximum potential range of the achievable savings. The scenarios evaluate the expected impact of the consumption of the prioritised final products considering the environmental benefits of the implemented horizontal requirements.

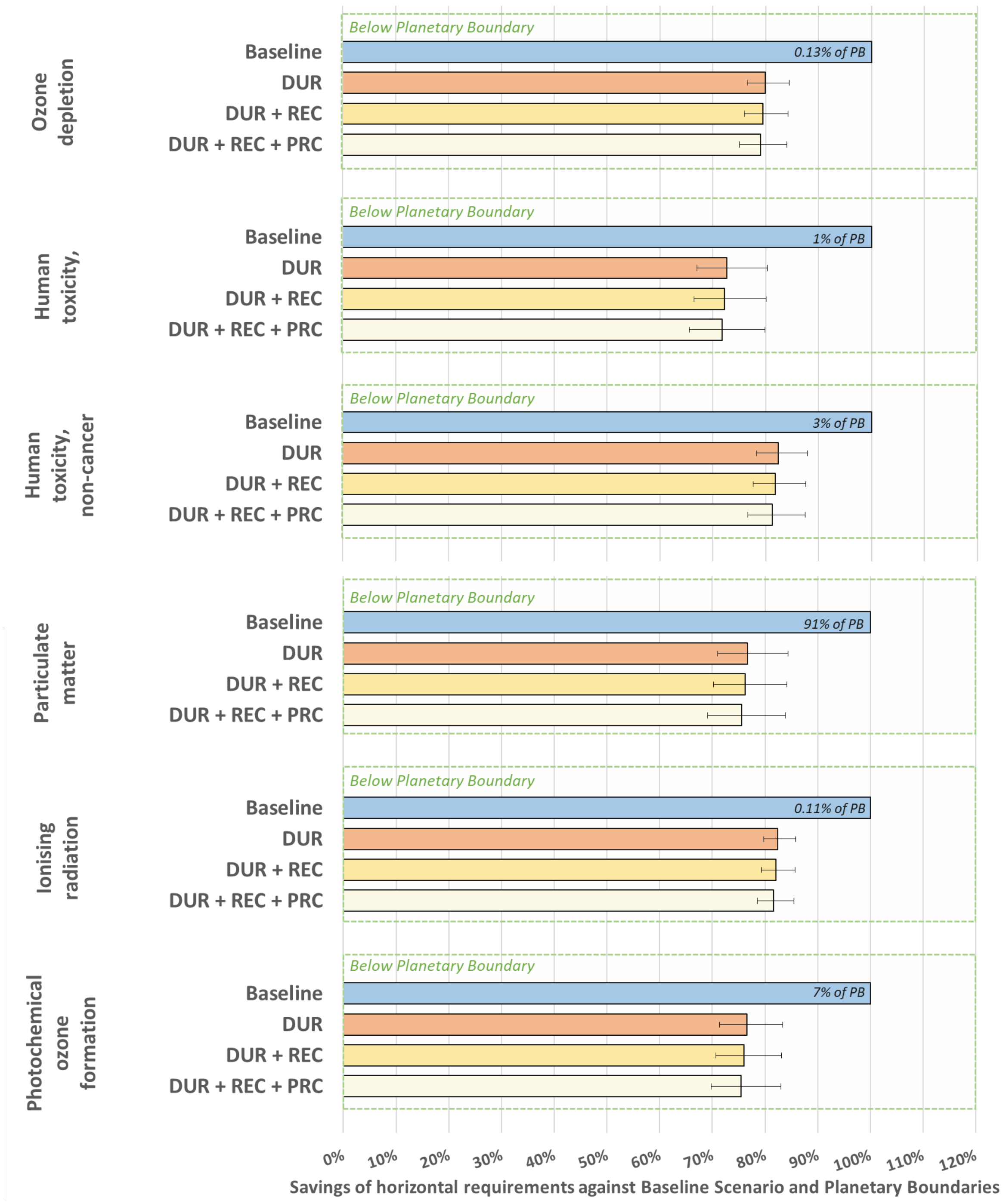
With regards to the Durability horizontal measure, changes in lifespan affect all life-cycle stages apart from use as the impact of these stages are allocated to a year based on the lifespan. The results of the three scenarios (i.e., "low benefits", "medium benefits" and "high benefits") were than compared to the planetary boundaries and especially the "safe operating space" threshold. If this threshold is surpassed, planet's biophysical subsystems and processes could shift to a new state with potential negative consequences for humans. The results for the application of the horizontal requirements are provided in **Figure 8.5** and **Figure 8.6** (illustrating the impact categories not provided in the main report i.e., the 12 remaining EF impact categories beside Climate Change, Water Use, 'Resource use, fossils' and 'Resource use, minerals and metals').

Durability requirements would have a positive effect in reducing the environmental impacts of the consumption of final products across all impact categories. Expected improvements could reach up to 33% ("high benefit") for the different categories examined (especially significant in the case of the land use, particulate matter and 'human toxicity, cancer' impact categories). In the case of the "medium benefits" scenario, savings compared to the baseline results would be around 26% across all impact categories analysed. In the case of Climate Change, savings associated with Durability measure would also be especially relevant as they would ensure that the "Safe operating space" is not surpassed for the "medium benefits" and "high benefits" scenarios. The Durability requirements were applied to all life-cycle stages (excluding the use phase) of products listed in Table 8 (these products are included in the 'Household goods' area of consumption of the Consumption Footprint; EC-JRC, 2024). In the case of household goods products, the use phase represents on average 21% of the total life-cycle impacts excluding the end-of-life stage (being the second most relevant stage, after components manufacture which accounts for 49% of total impacts). The importance of the use phase for the household goods products could therefore have a role in limiting the maximum savings potentially achievable when durability requirements are put into practice, together with the assumed lifespan of products for which a Durability measure has been calculated.

The addition of Recyclability horizontal requirements on top of Durability ones, would have a positive effect in reducing the environmental impact of the consumption of prioritised final products across all impact categories. However, expected improvements could only reach up to 2% (for the "medium benefit" scenario for the different categories under examination compared to the implementation of Durability requirements alone (3% for the "maximum benefit" scenario). As for the Durability measure, Recyclability requirements were modelled on products included in the 'Household goods' area of consumption. The importance of recycling compared to incineration and landfill in the current management options of the products assessed by the Recyclability horizontal measure, could have a limiting role concerning the maximum achievable savings. In fact, current models for several representative products employed in the calculations of the Recyclability savings (e.g., Textiles and footwear, Absorbent hygiene products, Furniture) propose a recycling share in the range of 0-10% compared to incineration and landfill. Recycling share is intended as the amount of plastic waste which is recycled at the end of life (i.e., not incinerated nor landfilled). The highest recycling share are related to toys and furniture of plastics (32.5%). This aspect could strongly influence the maximum achievable savings as the improvement scenarios are applied to a low recycling share (e.g., a 50% improvement to a 10% recycling share, would lead to a recycling share equal to 15%). Results could also imply that the proposed Horizontal requirements on Recyclability should envision higher increases in recycling rates to achieve more significant savings.

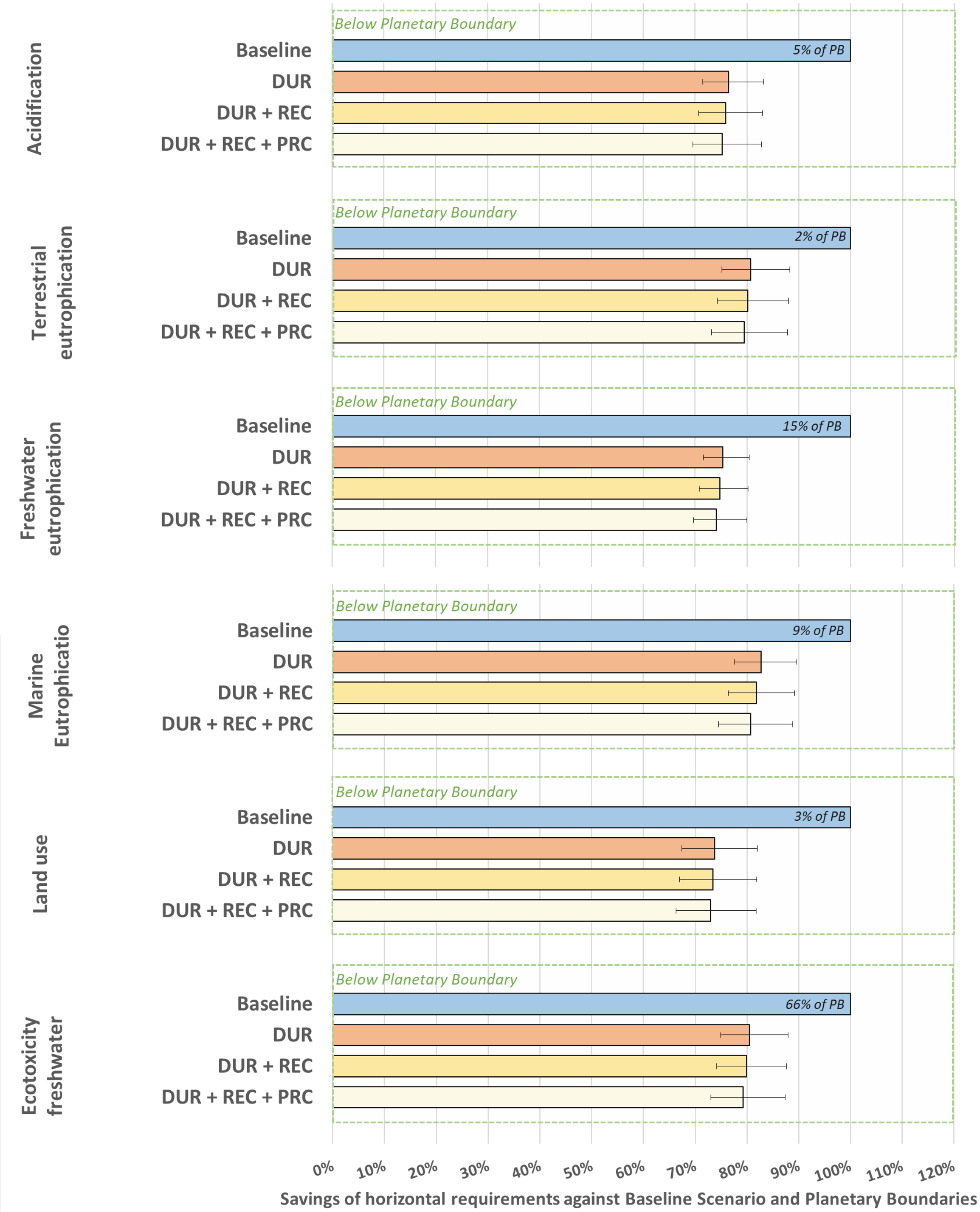
The implementation of Post-Consumer recycled content requirements on top of Recyclability and Durability ones, would have a positive effect in reducing the environmental impacts of the consumption of prioritised final products across all impact categories. The implementation of this measure would lead to similar additional benefits compared to the ones of Recyclability, up to around 3% ("medium benefits" scenario) improvement compared to the scenario when only Durability and Recyclability are implemented (5% improvement for the "high benefits" scenario). This result suggests how a combination of various horizontal measure could improve the maximum achievable savings and might be preferable to the application horizontal requirements individually, although certain horizontal requirements might have greater savings potentials than others. In fact, in the case of the present analysis, most of the benefits are attributable to the application of the Durability horizontal measure. As discussed for Recyclability, the importance of recycling compared to incineration and landfill in the current management options of the products assessed by the Post-consumer recycled content horizontal measure, could have a limiting role concerning the maximum achievable savings.

Figure 8.5. Savings associated with horizontal requirements' implementation and comparison with Planetary Boundary 'Safe operating space' (Part 1/2).



Source: JRC own elaboration.

Figure 8.6. Savings associated with horizontal requirements' implementation and comparison with Planetary Boundary 'Safe operating space' (Part 2/2).

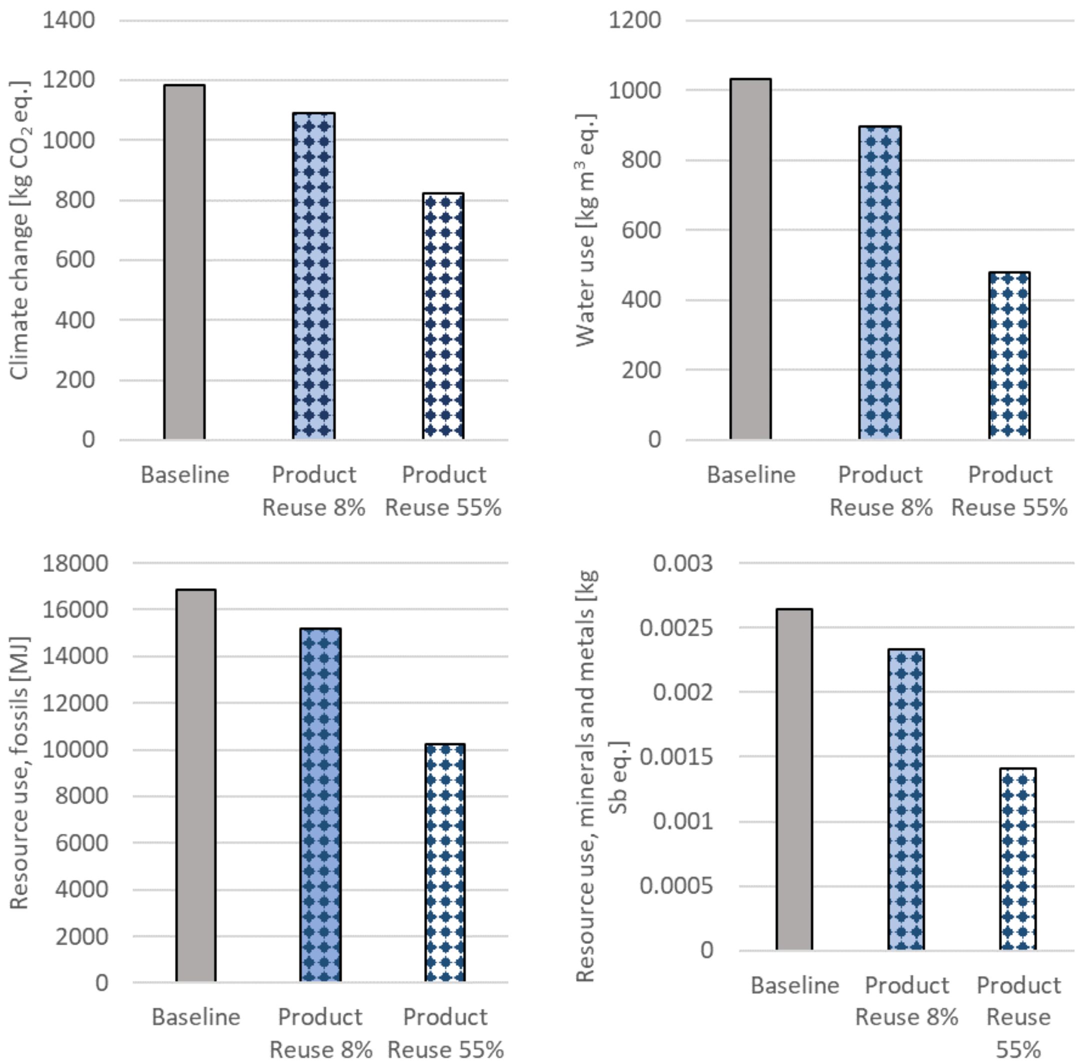


Source: Own elaboration.

Analysis of the potential savings related to product requirements associated to the product group Textiles and footwear and Furniture – Results

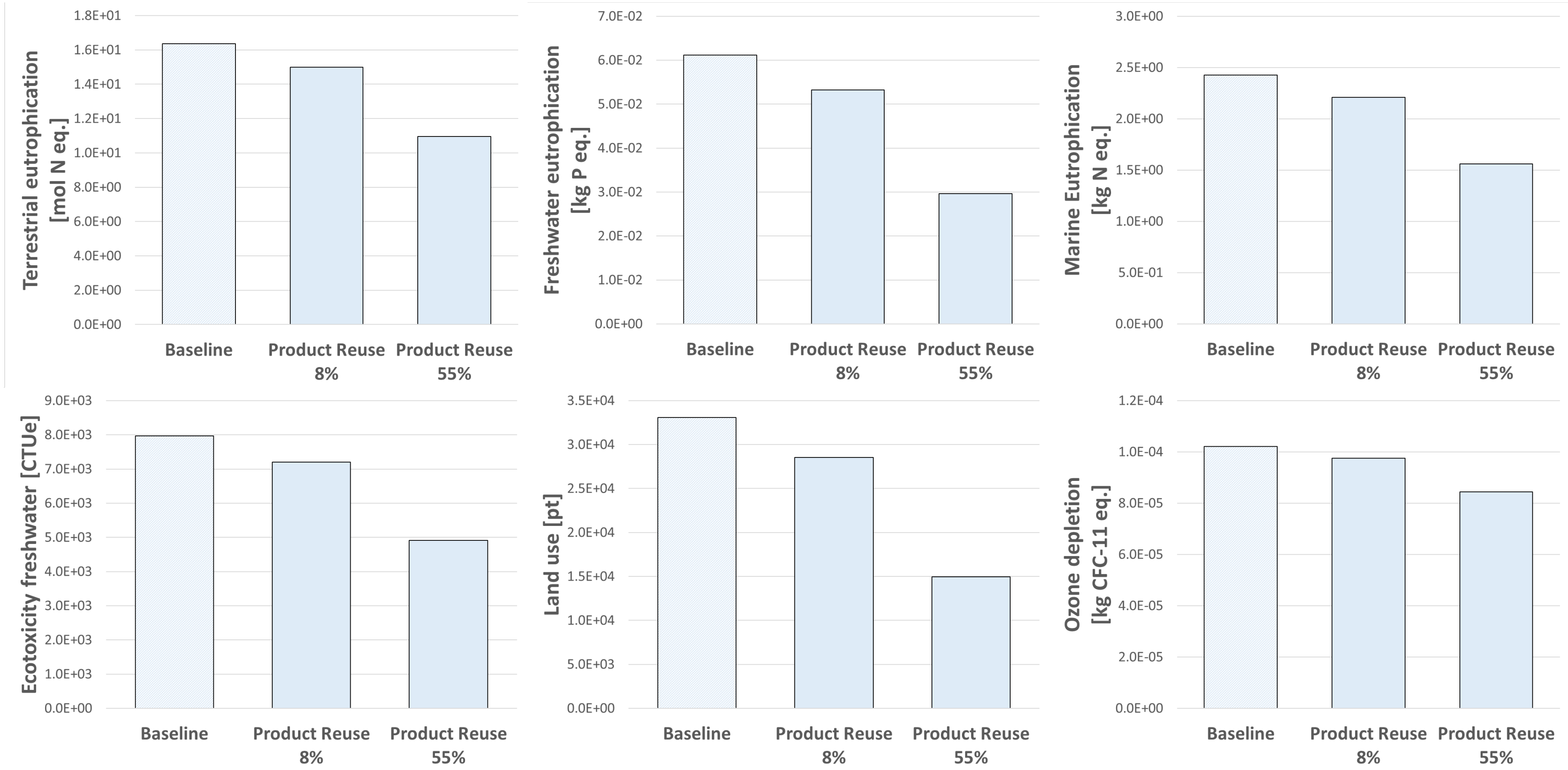
The results associated to the potential savings related to product requirements associated to the product group Textiles and footwear and Furniture are presented in this section, covering all the 16 impacts categories of the EF. The results on product-specific requirements for Furniture are detailed in **Figure 8.7**, **Figure 8.8** and **Figure 8.9**. The results on product-specific requirements for Textiles and footwear are provided in **Figure 8.10**, **Figure 8.11** and in **Figure 8.12**.

Figure 8.7. Savings associated with product-specific requirements for furniture products (Part 1/3).



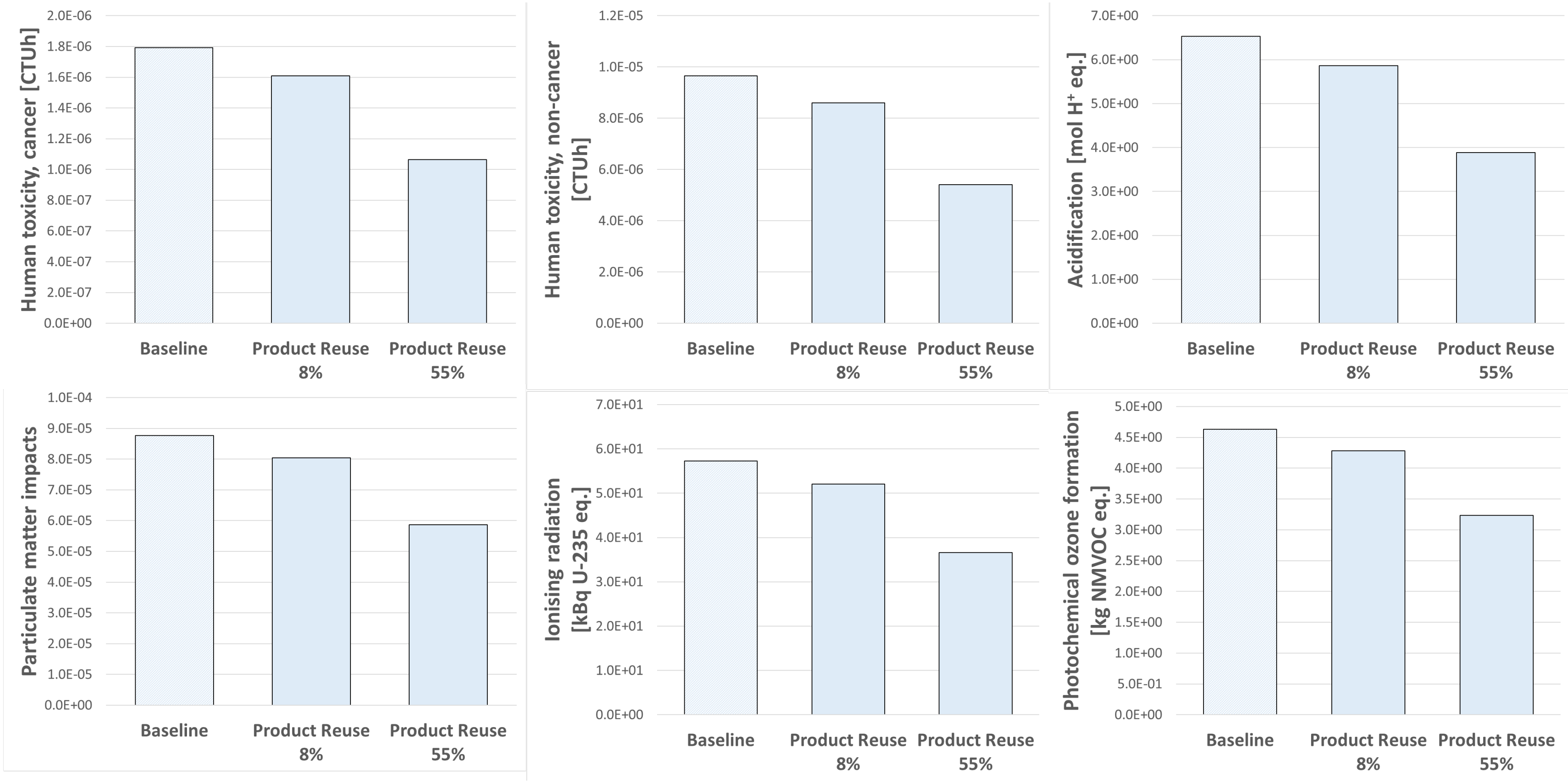
Source: JRC own elaboration.

Figure 8.8. Savings associated with product-specific requirements for furniture products (Part 2/3).



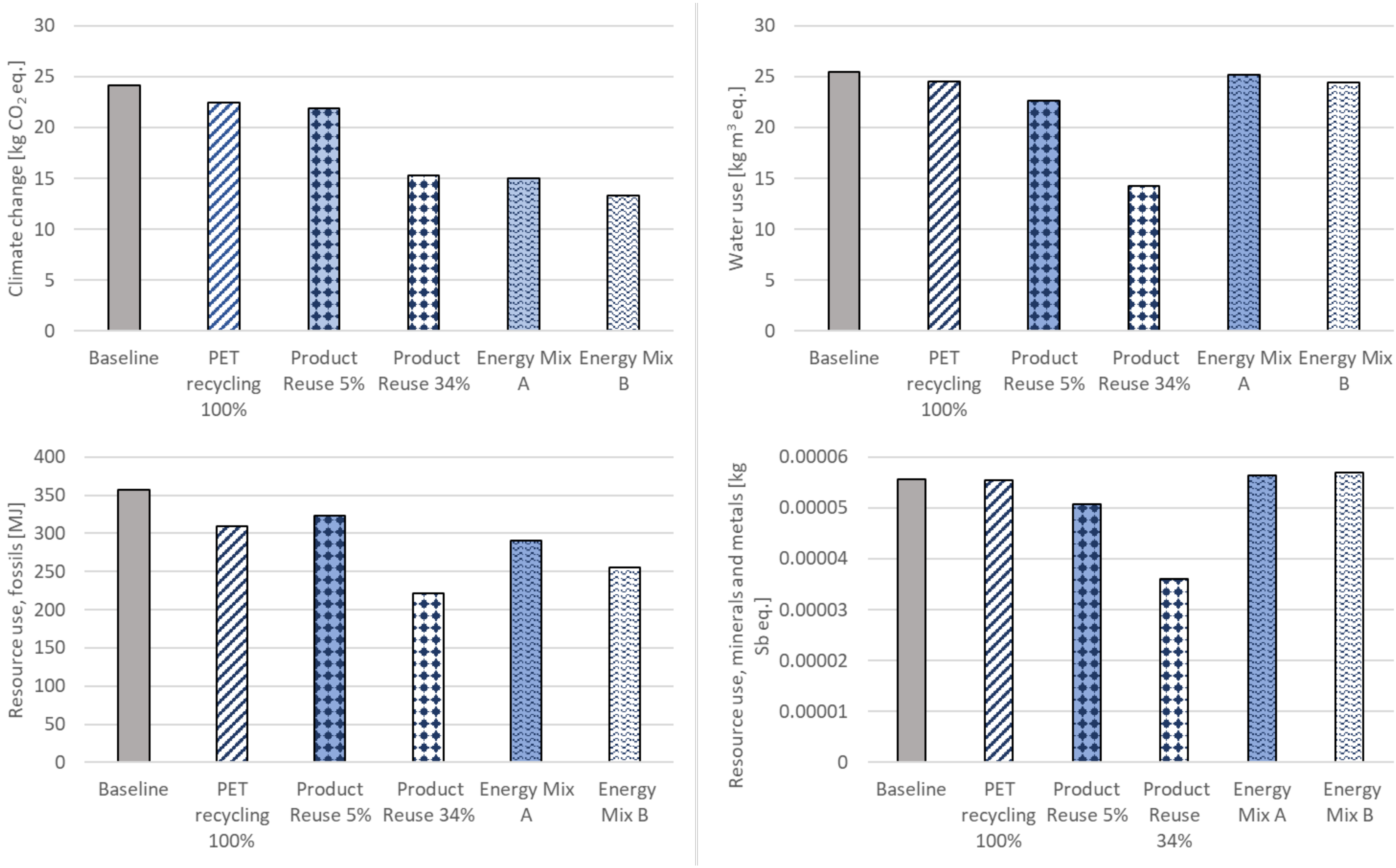
Source: JRC own elaboration.

Figure 8.9. Savings associated with product-specific requirements for furniture products (Part 3/3).



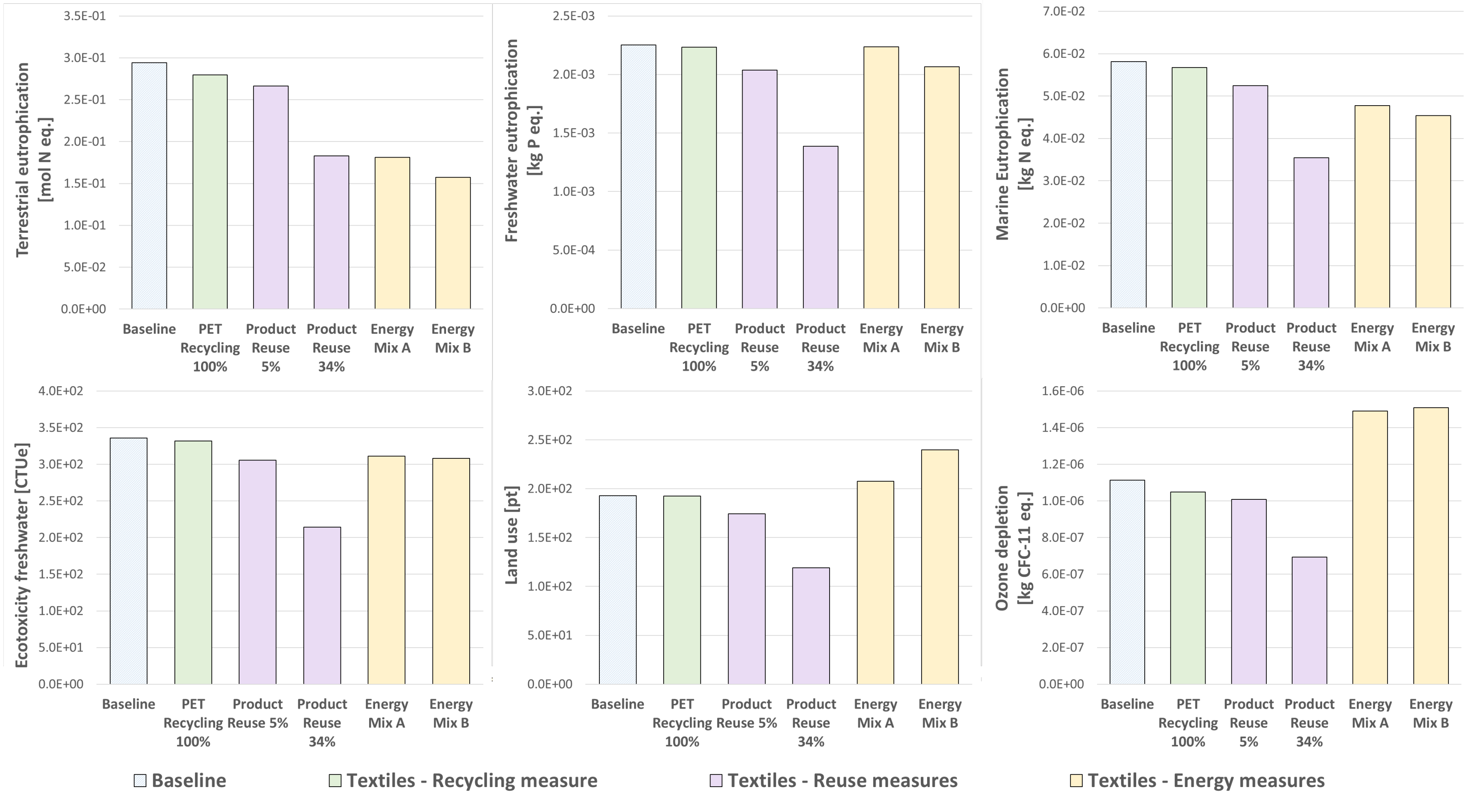
Source: JRC own elaboration.

Figure 8.10. Savings associated with product-specific requirements for Textiles and footwear products (Part 1/3).



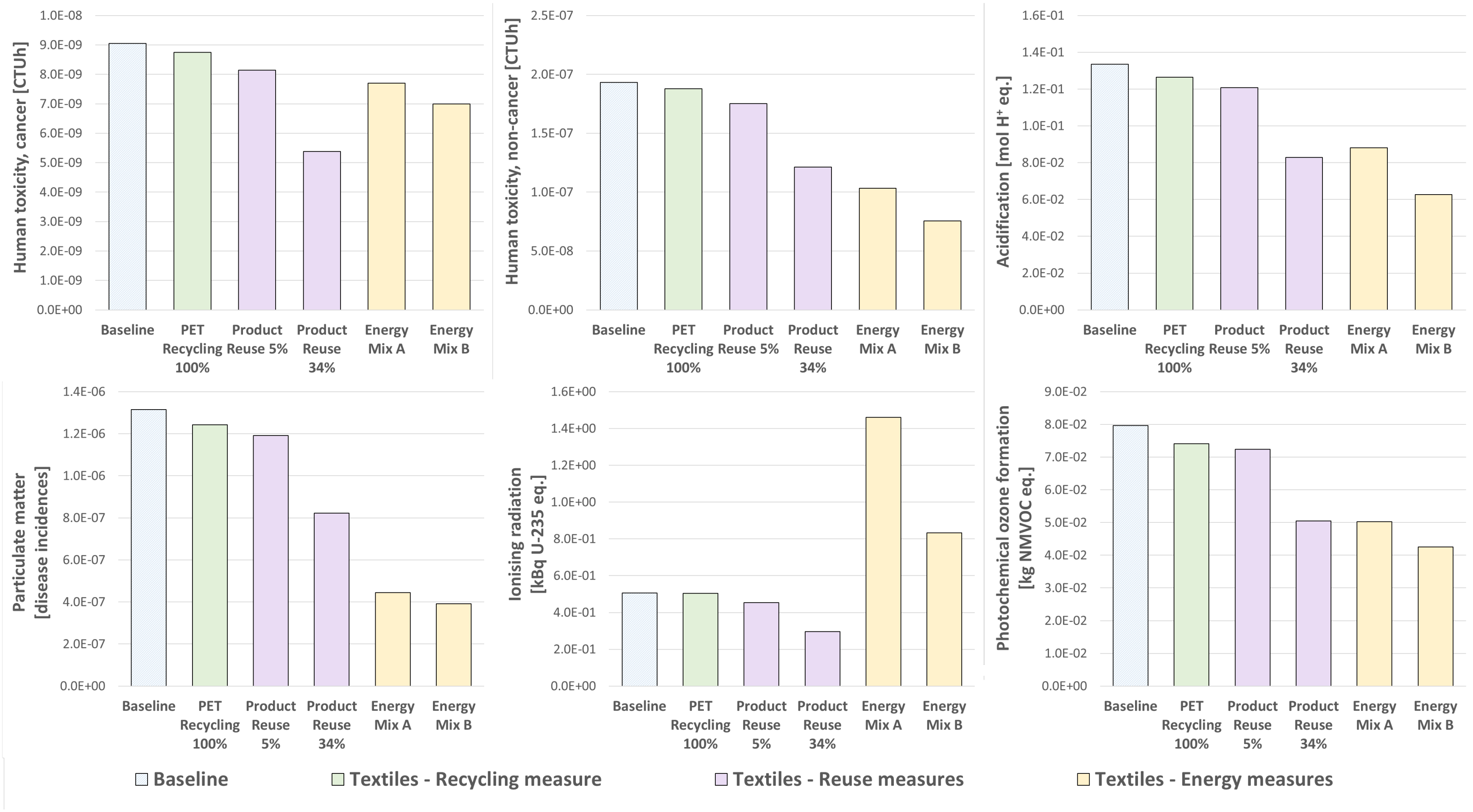
Source: JRC own elaboration.

Figure 8.11. Savings associated with product-specific requirements for textiles products (Part 2/3).



Source: JRC own elaboration.

Figure 8.12. Savings associated with product-specific requirements for textiles products (Part 3/3).



Source: JRC own elaboration

Analysis of the potential plastic leakage associated with the prioritised final products: Contribution of prioritised final products – Results

Table 8.1 summarises the amount of microplastic and macroplastics emissions and the related releases to the environment or redirection toward end-of-life pathways.

Table 8.1. Estimated micro- and macroplastic generation and release to the environment for tyres and textiles (plastic losses are expressed in ktonnes = million kg).

Consumption [ktonne]	**Tyres**	**Textiles**
	6431	7558
Total micro and macroplastics losses to water [ktonne]	51	23
Total micro and macroplastics losses to soil [ktonne]	65	26
Equivalent number of plastic bottles lost in the environment	*4.8E+09*	*2.1E+09*
Equivalent number of plastic chairs lost in the environment	*4.6E+07*	*2.0E+07*

Note: the estimations are based on the "PLP method" (Peano et al., 2020). Each release was converted to a "number of bottles" by considering an average weight (23.9 g) of a plastic bottle and to a "number of chairs" by considering an average weight (2.5kg) of a plastic chair.

Results presented in **Table 8.1** are particularly sensitive to the assumed amount of waste generated from the consumption of tyres and textile products, as this represents the input mass to the PLP method for the estimation of the macroplastic releases (which contributes to a higher amount of plastic releases compared to microplastics). Results indicate that the cumulative microplastic and macroplastic releases from both tyres and textiles would amount to a total of would be equal to 165 ktonnes (0.17 megatonnes). As context, global plastic emissions are estimated at 6.2 megatonnes of macroplastics and 3.0 megatonnes of microplastics (Ryberg et al., 2019). Other recent studies suggest for the EU27 in 2018, a yearly total amount of plastic being lost in the range of 1-3 megatonnes (adapted to EU-27 2018 from Kawecki and Nowack (2019) and from Hsu et al. (2021), respectively). When translating such values into daily products, these releases would represent hundreds of millions of water bottles or tens of millions of plastic chairs.

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