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Ecodesign for Sustainable Products Regulation - preliminary study on new product priorities

Technical Report (draft)

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Contents

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Executive summary

Background. The European Union (EU) has assumed a leadership role on environmental sustainability by committing to achieving a circular economy and climate neutrality. To this end, and in the context of the EU Green Deal and Circular Economy Action Plan, 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 framework, ecodesign requirements can be set for specific product categories to significantly improve their circularity, energy performance, resource efficiency, and other environmental sustainability aspects. In addition, the ESPR proposal includes the possibility to set, when needed, "horizontal measures" (i.e., cross-cutting measures applicable to groups of products sharing common characteristics).

ESPR does not in itself lay down product rules, but rather enables these rules to be laid down in a second stage, via delegated acts (which will systematically be preceded by dedicated impact assessment and consultation). The proposal makes clear that a prioritisation exercise should therefore be carried out and – once ESPR is in place – the Commission should adopt and regularly update a Working Plan, setting out the list of product groups and horizontal measures for which action under ESPR is planned in the period covered by the working plan.

This Joint Research Centre (JRC) report aims to suggest a number of product groups and horizontal measures that may be suitable candidates for prioritisation under ESPR, once it enters into force.

The report focuses on 'new' priorities – i.e. products and horizontal measures 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, and a separate prioritisation exercise will be carried out for the latter category, 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. Both streams of work will together constitute a pool from which priorities for the first and then following working programmes will be drawn. Similarly, construction products and packaging were not addressed in this report, due to the interaction with the recent publication of the revised Construction Products Regulation and the revised Packaging and Packaging Waste Regulation.

This report serves as input to a public consultation process that is organised by the Commission. This consultation is 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 will have the opportunity to provide feedback on the findings of this 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. Targeted consultation of stakeholders and experts may be organised to complement the findings of this public consultation.

The results of consultations will be assessed and a factual summary report of the public consultation, followed by a more detailed synopsis report, will be published. The results will feed into the preparation of the first ESPR working plan, to be adopted only once ESPR is in force, in accordance with the relevant procedures it will set out.

Methodology. Building on the approach used for the Ecodesign and Energy Labelling Working Plan, on Article 16 of the ESPR proposal and on Annex 16 of the Impact Assessment accompanying the ESPR proposal, this report follows two broad steps:

> Step 1: Identification of potential end-use products, intermediate products and horizontal measures to be considered for first action under ESPR; and
>
> Step 2: Suggested prioritisation of the identified end-use 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 does not allow for a scientifically sound comparison.

To note: an additional complimentary assessment of the potential contribution to the EU's strategic autonomy has also been included, in order to assess whether certain dependencies in the supply chain of end-use or intermediate products could be mitigated by enhancing the circularity of these products under ESPR[1].

The report begins by selecting several product groups on the basis of their estimated environmental impacts, market relevance and the extent to which possibly relevant regulatory gaps exist[2]. In particular in relation to the latter, analysis of relevant policy gaps is 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 (such as, for tyres, the type-approval, tyre labelling or end-of-life vehicles legislation under revision[3], or for detergents, legislation that is currently under preparation[4]) – 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.

A distinction has been made between 'end-use products', such as e.g. furniture, that are sold directly to consumers and are ready for their intended use, and 'intermediate products', such as e.g. iron and steel, that are placed on the market as final products, but require further manufacturing and/or assembly processes before being ready for use as end-use 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 proportionality of costs related to the improvement potential, and preliminarily ranked.

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

It should be noted that, for the purposes of this report, horizontal measures and products (both end-use and intermediate) were investigated in parallel, and may overlap in terms of scope. This overlap will be addressed in the final decision on ESPR priorities. It should also be noted that, in the context of this report, the sets of products suggested for the proposed horizontal measures also include product groups that are not amongst the list of end-use and intermediate products 'shortlisted' as possible candidates for priority action under ESPR.

The results illustrated in this report are to be considered as preliminary: they do not bind the Commission, and are without prejudice to what may ultimately be prioritised for first action under ESPR or included in the first ESPR Working Plan, or undertaken under other EU policy frameworks. Their main purpose is providing a basis for the public consultation, to gather further information on the environmental and circularity characteristics of the relevant products, as well as to improve the understanding of their value chains and their potential for improvement.

End-use and intermediate products. From an initial list of 34 product groups referenced in recent policy documents, 19 products (12 end-use and 7 intermediate products) are first shortlisted based on environmental, market and policy considerations. The 19 shortlisted product groups (see Figure I) are then assessed in terms of environmental relevance (i.e., impacts and improvement potential) for ten 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 summarised in the fact sheets in Annex 5 of this report.

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[1] Furthermore, analysis on the quantification of the life cycle environmental impacts (related to the product groups prioritised in Step 2) and on the quantification of the potential savings (associated with the implementation of the horizontal measures identified in Step 1) has been initiated, and preliminary findings are included in the report (Annexes 6, 8,10, and 12). This will be further developed after the public consultation exercise. Preliminary environmental impacts, based on the modelling of EU consumption impacts (namely, the JRC "Consumption Footprint" indicator), have been estimated and compared against the Earth's capacity of sustaining environmental impacts (the so-called "Planetary Boundaries")(See Annex 6).

[2] Please note that regulatory measures still under preparation are also described in the product-specific datasheets (Annex 6), even if the regulatory gaps they are seeking to address cannot be considered filled until such measures are fully in place

[3] https://environment.ec.europa.eu/topics/waste-and-recycling/end-life-vehicles_en

[4] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13116-Detergents-streamlining-and-updating-the-EU-rules_en

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	80 bn EUR
CERAMIC PRODUCTS	Vitrified clay pipes and fittings, refractory products, expanded clay aggregates, household ceramics (e.g. tableware), sanitaryware, technical ceramics (aerospace, automotive, electronics, biomedical products industry), inorganic bonded abrasive	26 bn EUR
DETERGENTS	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	40 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. Composed of base fluids (80-75%) and additives (25-20%).	30 bn EUR
PAINTS	Coatings applied to buildings, their trim and fittings, and associated structures for decorative, functional and protective purpose. Includes also vehicle refinishes	17 bn EUR
TEXTILES and FOOTWEAR	Apparel and home/interior textiles consumed by households, and similar products consumed by government and business + footwear and technical textiles usually or also meant for consumers or specifically meant for industry. Excluded are: products for which textiles are not the dominant component and leather	175 bn EUR*
TOYS	The product group covers toys that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded: electronic toys	17 bn EUR
TYRES	Products included are cars (C1), tyres, vans (C2) tyres and heavy-duty vehicles (C3) tyres	45 bn EUR
ALUMINUM	Aluminium and its alloys	40 bn EUR
CHEMICALS	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, 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	500 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)	125 bn EUR
PULP, PAPER and BOARDS	Pulp, paper and board obtained by chemical, kraft, sulphite, mechanical and chemi- mechanical pulping, recovered paper processing and papermaking	95 bn EUR
PLASTICS and POLYMERS	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	405 bn EUR
NON-FERROUS METAL PRODUCTS	Intermediate products made of seven primary and secondary non-ferrous metals: copper, lead and/or tin, zinc and/or cadmium, precious metals, ferro-alloys, nickel and/or cobalt, carbon and graphite electrodes. Does not include aluminium	80 bn EUR

Figure I. Scope definition and market size in the EU of the 19 shortlisted product groups. * Includes leather footwear

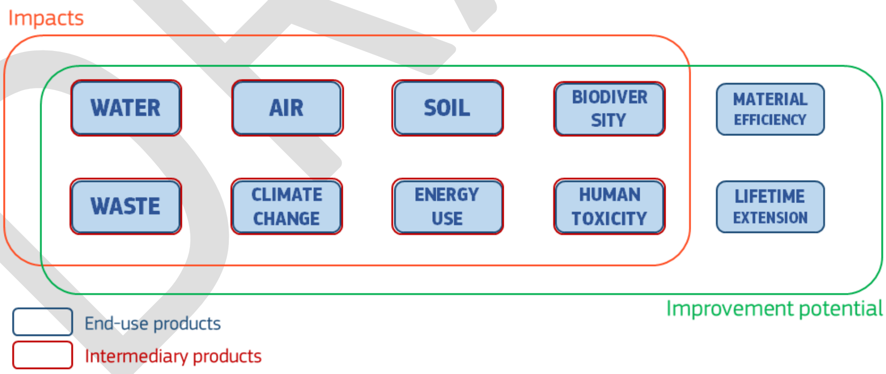

Figure II. Environmental categories considered for the assessment of products' environmental relevance.

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 environmental impacts and of the improvement potential. These scores range from 1 (very low) to 5 (very high). Figures III and IV below show the score of product groups for each environmental category and the total score, leading to a ranking of product groups. In addition to the analysis of environmental impacts and improvement potential, and the resulting ranking, the report assesses whether potential ESPR measures identified for each product group are already addressed by EU policies, and whether implementing such measures would entail disproportionate costs. However, at this stage, the analysis of the policy gaps and proportionality of costs does not affect the above-mentioned ranking.

In addition, a complementary assessment of the potential contribution to enhancing the EU's strategic autonomy is also conducted for each product group. A composite indicator is designed to cover (i) the use of critical materials, (ii) the use of fossil hydrocarbons (oil and gas) and (iii) use of materials with increased supply risk due to Russian's invasion of Ukraine. The assessment follows a similar ranking as for the environmental part, with a scale from 1 (very low) to 5 (very high). However, the resulting score on strategic autonomy is not used to rank products, as this would not follow the prioritisation criteria of ESPR proposal, but it is given as complementary information.

Preliminary assessment shows that the environmental impacts of end-use products included in the list represent more than one third of the impacts of the Climate Change impact category of the European Consumption Footprint indicator.

Horizontal measures. As outlined in the ESPR proposal, horizontal measures are intended to apply to two or more product groups which display sufficient technical similarities to allow a product aspect to be improved based on a common requirement(s).

Five aspects for possible horizontal measures were assessed in this report: "Durability", "Recyclability", "Lightweight design", "Post-consumer recycled content", and "Sustainable sourcing". After assessment, three of these aspects are retained for first consideration (see Figure V). The two others (Lightweight design and Sustainable sourcing) will be further elaborated before finalising the ESPR working plan. Each of these horizontal measures is accompanied by a suggested set of provisions, via which it could be concretely implemented, and by a set of proposed products to which it could be applied.

While feedback on the suggested provisions and products is sought via the public consultation exercise, it should be borne in mind that horizontal measures may be of particular relevance also for energy-related products, which are not covered in this report. Potential 'horizontal initiatives', largely on the same aspects, were also assessed in preparation of the Ecodesign and Energy Labelling working plan[5]. A separate assessment of energy-related products will be carried out and will consider also their relevance for horizontal measures.

[5] See SWD(2022) 101 final

Figure III. The 12 shortlisted end-use products.

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

Figure IV. The 7 shortlisted intermediate products.

Score	Product	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	HUMAN TOXICITY	STRATEGIC AUTONOMY
31	IRON & STEEL	5	5	2	2	4	5	5	3	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
25	CHEMICALS	3	3	3	3	3	4	4	2	5
23	PLASTICS	3	3	2	2	3	4	4	2	3
22	PULP & PAPER	3	2	3	3	2	4	4	1	2
19	GLASS	3	2	2	3	1	3	4	1	2

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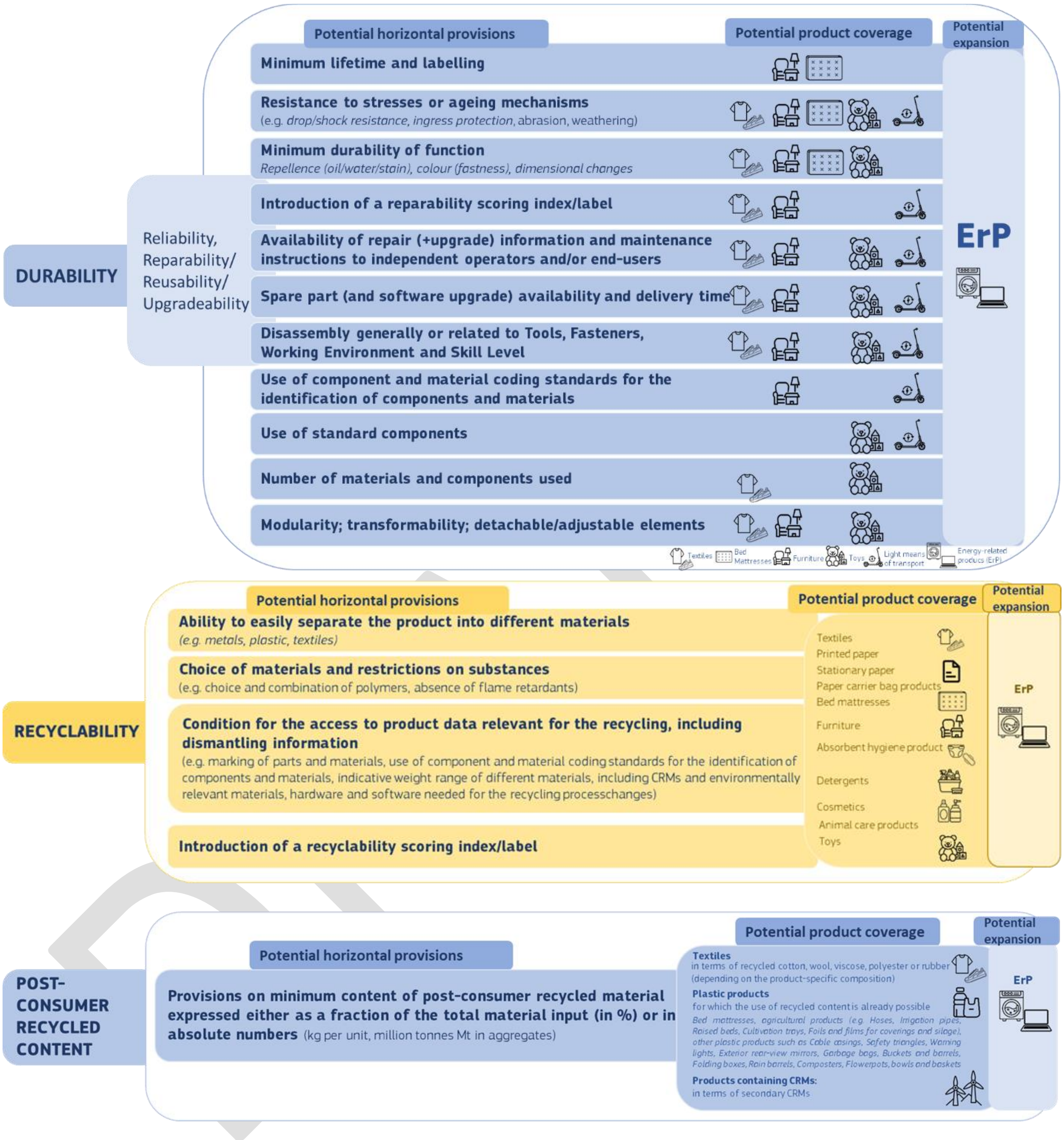
Figure V. Proposed horizontal measures, including potential provisions and potential product coverage. CRMs: critical raw materials



1 Introduction

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

In 2020, the EU's circular material rate was estimated at almost 13%, meaning that 13% of material resources used in the EU came from recycled materials (Eurostat, 2021). The remaining 87% of 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, 2018) – more than double - due to the expected growth in population (UN, 2019) and increase in Gross Domestic Product (OECD, 2018). 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 CO_2-eq. by 2060 (OECD, 2018). The EU's GHG emissions totalled 4 483 Mt in 2017, and in 2020 were 31% lower than GHG emission levels in 1990 (EEA, 2021).

EU legislation already addresses a number of sustainability aspects of products placed on the EU market. The Ecodesign Directive, 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 purchases, publishing, since 2008, criteria for Green Public Procurement for more than 20 products.

In this context, in March 2022, with the Communication on making sustainable products the norm (COM(2022) 140 final), the European Commission proposed the Ecodesign for Sustainable Products Regulation (ESPR). This proposal aims at creating a strong and coherent policy framework for sustainable products. Within the ESPR framework, minimum requirements can be set for specific product categories to significantly improve their circularity, energy performance and other environmental sustainability aspects. In addition, the ESPR proposal includes the possibility to set out, when needed, horizontal measures, i.e. cross-cutting measures applicable to groups of products sharing common characteristics. To implement this framework, the product-specific and horizontal measures will be developed on the basis of a working plan (WP), thus enabling prioritisation of the most relevant products and measures.

1.1 Study aims

This JRC Report aims at providing a preliminary ranking of the new product groups and horizontal measures that could be considered as a priority of the ESPR framework, in addition to the ones already identified in the Ecodesign and Energy Labelling Working Plan 2022-2024[6], in view of preparing the first ESPR Working Plan.

In this report, the relevance of a number of product groups and horizontal measures was evaluated in terms of their environmental sustainability and circularity impacts and improvement potential; economic weight; and policy coverage, in order to propose a preliminary ranking of potential ecodesign measures 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 should take place on the findings of this report, enabling the collection of further information and contributing to the first ESPR Working Plan.

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

1.2 Prioritisation and planning

1.2.1 Prioritisation in the Ecodesign and Energy Labelling Working Plan

Since the adoption of the first Ecodesign Directive (Directive 2009/125/EC), several ecodesign implementing measures have been adopted with the scope of setting sustainability requirements for Energy-related Products (ErP), especially with respect to the materials and energy consumed, expected emissions and waste and possibilities for reuse, recycling and recovery. In addition, the Energy Labelling Regulation (Regulation (EU) 2017/1369), sets out the basis for labelling energy-related products, providing standard information about energy efficiency — as well as the consumption of energy and other resources — to help consumers in purchase decisions. As both the Ecodesign Directive and the Energy Labelling Regulation establish framework, the Commission periodically sets out an indicative list of (energy-related) product groups which are considered as priorities for the adoption of implementing measures, i.e. a working plan. The latest study for the Ecodesign and Energy Labelling Working Plan 2022-2024 includes three main steps (tasks 2 – 4)[7]: (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. Summarily, tasks 2 – 4 involved the following:

- An initial list of products was generated to then be narrowed down using a qualitative scoring matrix.
- Selected products underwent analyses regarding sales stock, resource consumption and technical economic improvement potential, also including scope verification. The main specific aspects covered were: scope, policy measures and standards; market; usage; technologies; energy, materials, emissions and costs; savings potential.
- Some of the most relevant products/initiatives were subjected to complementary analyses, covering: further environmental impacts; route to market, existing regulatory coverage and feasibility; cost-effectiveness; and improved industrial competitiveness.

1.2.2 Prioritisation and planning in the ESPR proposal

Article 16(1) of the ESPR proposal 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' potential contribution to achieving the European Union's climate, environmental and energy efficiency objectives, the potential for improving products' circularity and environmental impacts, the absence or insufficiency of EU law, and the volume of sales and trade (see also Figure 2).

Annex 16 to the ESPR Impact Assessment focuses on methodological aspects and describes four main steps: (1) Prioritisation of the products; (2) Assessment of the products: (3) Definition of requirements: (4) Monitoring of results. The aim of (1) is to identify the order in which the products under its scope should be regulated by ESPR Delegated Acts, and suggests that the prioritisation study should follow the same approach as the one carried out for the elaboration of the Ecodesign and Energy Labelling Working Plan. It also provides a list of aspects to consider, indicates that stakeholders should be involved at every step and acknowledges that some aspects will be assessed qualitatively given that detailed assessment will be carried out in (2) Assessment of the products.

Figure 2 later in the text summarises how this report addresses the different criteria under Article 16 of the ESPR proposal.

[7] Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024

1.3 Methodology and structure of the study

This report addresses three types of possible ESPR measures: end-use products measures, intermediate products measures and horizontal measures. While end-use products are sold directly to consumers and are ready for their intended use, intermediate products are placed on the market as final products but requiring further manufacturing and/or assembly processes before being ready for use as end-products. Horizontal measures, as stated before, are cross-cutting measures applicable to groups of products sharing enough technical similarities.

Due to the inherent difference between product groups and horizontal measures, two distinct methodologies were applied to, on the one hand, end-use and intermediate products, and, on the other hand, horizontal measures (Figure 1).

Building on the three-step approach used for the Ecodesign and Energy Labelling Working Plan, on Article 16 of the ESPR proposal and on Annex 16 to the accompanying Impact Assessment, this Report follows these steps:

— Step 1 Identification of potential end-use products, intermediate products and horizontal measures to be considered for first action under ESPR (Section 2); and

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

These two steps will be followed by a stakeholder consultation and a final selection in the ESPR Working Plan, expected after the final adoption of ESPR, as explained in Section 1.4.

As illustrated in Figure 1, the horizontal measures proposed do not go through Step 2, i.e. the prioritisation process. Apart from the fact that the number of horizontal measures that can be proposed is already lower compared to the products case, the main reason for not prioritising is the difficulty to compare horizontal measures amongst themselves. While product-specific measures are comparable across the same impact categories and improvements, horizontal measures are not.

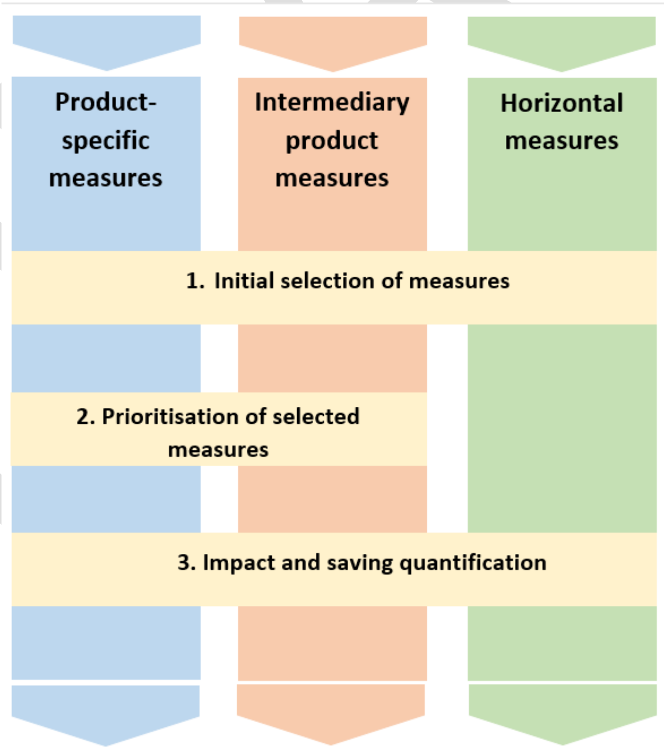


Figure 1. Overview of the methodology adopted for the preliminary Working Plan for the Ecodesign for Sustainable Products Regulation

The relationship between product-specific measures and horizontal measures is, at this stage, considered flexible, as a product group can be proposed as part of product-specific measure (i.e. to be regulated on its own) and under horizontal measures (i.e. included alongside other groups under a cross-cutting regulation). Ultimately, some aspects of a product group could be covered vertically, and others horizontally. In other words, the two types of measures proposed can act both exclusively and complementarily. In this report, the list of products to be covered by horizontal measures is indicative and will be further refined, together with the exact parameters to be considered for each measure.

With respect to the prioritisation process, Figure 2 summarises how this report addresses the different criteria under Article 16 of the ESPR proposal.

The first criterion mentioned in Art. 16(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). It should be noted that this criterion in Art. 16 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. 16(1) of the ESPR proposal refers to the "potential for improving the product aspects listed in Article 5(1) without entailing disproportionate costs". 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 the costs associated with the identified improvement measures were also sought and summarised for each product group. Further work after the stakeholder consultation will focus on refining these results, especially with respect to the evaluation of the proportionality of costs incurred by potential ESPR Delegated Acts.

Point (a)(i) in Art. 16(1) of the ESPR proposal refers to the criterion on "the absence or insufficiency of Union law or failure of market forces or self-regulation measures". 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 ESPR implementing measures.

Point (a)(ii) in Art. 16(1) of the ESPR proposal refers to "the disparity in the performance of products available on the market with equivalent functionality in relation to the product aspects listed in Article 5(1)". This criterion was taken into account when evaluating the products' potential for improvement on certain environmental aspects, although to a lesser extent than other criteria, due to the type and amount of information available in the literature. Further work after the stakeholder consultation will focus on improving the results for this criterion.

Point (b) in Art. 16(1) of the ESPR proposal refers to "the volume of sales and trade of the 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. 16(1) of the ESPR proposal refers to "the distribution of the environmental impacts, energy use and waste generation across the value chain, in particular whether they take place within the Union". 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 stage responsible for certain environmental impacts, and, to the extent possible, whether such life-cycle stages occur inside or outside the Union. This analysis could not be carried out for all product groups, due to the availability of information, but further analysis will focus on this aspect after the stakeholder consultation.

ESPR Art. 16 – 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, IN TERMS OF TEN ENVIRONMENTAL CATEGORIES	SECTION 3 (methodology) + **ANNEX 5 ("product fiches")**
POTENTIAL FOR IMPROVING PRODUCTS' CIRCULARITY AND ENVIRONMENTAL IMPACTS WITHOUT ENTAILING DISPROPORTIONATE COSTS	ANALYSIS OF IMPACTS AND IMPROVEMENT POTENTIAL FOR SHORTLISTED PGs	ANNEX 5 **("product fiches")**. **Sections: 'Improvement potential for ESPR' and 'Proportionality of costs'**
ABSENCE OR INSUFFICIENCY OF UNION LAW OR FAILURE OF MARKET FORCES OR SELF-REGULATION MEASURES TO ADDRESS THE OBJECTIVE PROPERLY	ANALYSIS OF EXISTING EU LEGISLATION ADDRESSING THE IDENTIFIED IMPROVEMENT POTENTIAL	ANNEX **5 ("product fiches"). Section: 'Policy gaps'**
DISPARITY IN THE PERFORMANCE OF PRODUCTS AVAILABLE ON THE MARKET WITH EQUIVALENT FUNCTIONALITY IN RELATION TO THEIR CIRCULARITY AND ENVIRONMENTAL IMPACTS	ANALYSIS OF IMPACTS AND IMPROVEMENT POTENTIAL FOR SHORTLISTED PGs	**ANNEX 5 ("product fiches"),** when relevant information could be found
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
THE DISTRIBUTION OF THE ENVIRONMENTAL IMPACTS, ENERGY USE AND WASTE GENERATION ACROSS THE VALUE CHAIN, AND WHETHER THEY TAKE PLACE WITHIN THE UNION	ANALYSIS OF IMPACTS AND IMPROVEMENT POTENTIAL FOR SHORTLISTED PGs	**ANNEX 5 ("product fiches"),** when relevant information could be found
THE NEED TO REGULARLY REVIEW AND ADAPT DELEGATED ACTS IN LIGHT OF TECHNOLOGICAL AND MARKET DEVELOPMENTS	NOT RELEVANT AT THIS STAGE	N/A

Figure 2. Criteria to be taken into account for the prioritisation and planning of products according to the current proposal 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. 16 of the ESPR proposal, where the first criterion is more general and related to policy objectives. PG: Product group. N/A: Not available

Finally, point (d) in Art. 16(1) of the ESPR proposal 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 work, and it is only applicable to the development of working plans after the first ones, 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 following working plans.

In addition to the analyses presented above, two additional complementary assessments were performed:

- The analysis of the potential contribution to the EU's strategic autonomy, in order to assess whether certain dependencies in the supply chain of end-use or intermediate products could be mitigated by enhancing the circularity of these products under ESPR. The findings of this analysis can be found in Sections 3.3.4; and
- The quantification of the life cycle environmental impacts related to the product groups prioritised in Step 2 and the quantification of the potential savings associated with the implementation of the horizontal measures identified in Step 1. Preliminary findings are included in the report (Section 4), which will be further developed after the public consultation exercise.

1.4 Public consultation and next steps

This report serves as input to an open public consultation process that is organised by the Commission. This consultation is 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 will have the opportunity to provide feedback on the findings of this 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. Targeted consultation of stakeholders and experts may be organised to complement the findings of this public consultation.

The results of consultations will be assessed and a factual summary report of the public consultation, followed by a more detailed synopsis report, will be published. The results will feed into the preparation of the first ESPR working plan, to be adopted only once ESPR is in force, and in accordance with the relevant procedures to be laid down in the framework.

In any case, the future ESPR working plan will cover both new products and energy-related products, and a separate prioritisation exercise will be carried out for the latter category, 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. Both streams of work will together constitute a pool from which priorities for the first and then following working programmes will be drawn. The potential inclusion of energy-related products for the horizontal measures identified in this report will be considered as well. Indeed, while this report suggests a number of possible 'new product' candidates for which the proposed horizontal measures could be considered – and on which public feedback is sought – these horizontal measures may also be of particular relevance for energy-related products (for which a separate assessment will be carried out).

2 Selection of end-use 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 (end-use 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 proposal, 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 and feed, medicinal products for human use, veterinary medicinal products, living plants, animals and micro-organisms, products of human origin and products of plants and animals relating directly to their future reproduction. This represents the scope of action of the ESPR.

However, 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 are currently covered by the Ecodesign Directive 2009/125/EC. While the ESPR will replace the Ecodesign Directive when the Commission proposal is adopted by the legislators, for the time being the Ecodesign Directive remains in force to ensure that work on energy-related products continues until the ESPR is adopted (EC, 2022a). For this, a new Ecodesign and Energy Labelling Working Plan for 2022-2024 was adopted in March 2022 together with a package of measures proposed in the Circular Economy Action Plan (EC, 2022b). Therefore, energy-related products are not considered within the scope of this preparatory document. It is envisaged that, when preparing the first ESPR WP, progress with the current Ecodesign and Energy Labelling Working Plan will be assessed, informing on the choice of the energy-related products to be prioritised in the 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 not considered within the scope of the first ESPR WP.

With regard to packaging products, there are already legislative instruments tackling their use and placing on the market in the EU, especially the Packaging and Packaging Waste Directive 94/62/EC. 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.

With regards to horizontal measures, Article 5.2 of the Commission's proposal for an ESPR outlines:

"where two or more product groups display technical similarities allowing a product aspect referred to in paragraph 1 to be improved based on a common requirement, ecodesign requirements may be established horizontally for those product groups".

Recital (42) further indicates "product aspects" (those in Article 5.1) as a determining factor for the potential establishment of horizontal measures:

(42) [...] the Commission should adopt a working plan, covering at least 3 years, laying down a list of product groups for which it plans 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 measures can deliver a number of benefits. Firstly, depending on how horizontal measures 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 end-use 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 3.

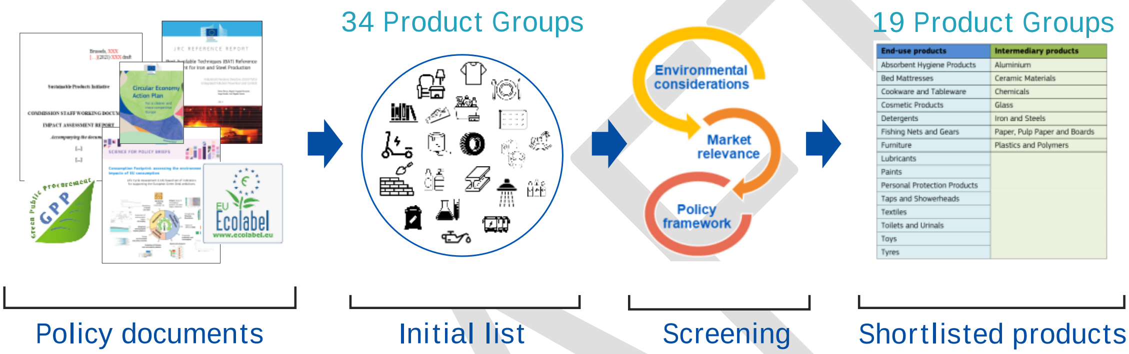


Figure 3. Overview of the methodology for the selection of relevant end-use and intermediate products

2.2.2.1 *Initial selection of end-use and intermediate products*

To develop an environmentally relevant initial long list of products to be potentially addressed by ESPR measures, 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[8];

— the Impact Assessment accompanying the ESPR proposal[9];

— Best Available Techniques (BAT) reference documents[10];

— EU Ecolabel[11] and EU GPP[12] criteria;

— other European ISO 14024 type I ecolabelling schemes[13];the Consumption Footprint indicator addressing household goods and mobility[14];

— Product Environmental Footprint Category Rules (PEFCRs)[15];

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8 COM(2020) 98 final. A new Circular Economy Action Plan For a cleaner and more competitive Europe
9 https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en
10 JRC IPPCB webpage
11 DG ENVIRONMENT EU Ecolabel criteria webpage
12 DG ENVIRONMENT EU GPP criteria webpage
13 Nordic Swan and Blue Angel were considered.
14 Castellani et al. (2019); Castellani et al. (2017)
15 https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm#final

— products with Environmental Product Declarations (EPD)[16].

Two lists were thus produced: one for end-use products and one for intermediate products.

2.2.2.2 Screening of end-use and intermediate products: selection criteria

The initial lists of (end-use 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. End-use 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 end-use 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 16(1)(b) of the ESPR proposal 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[17]), 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 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.

[16] https://www.environdec.com/all-about-epds/the-epd
[17] PRODCOM database DS-066341 available at https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=DS-066341&lang=en

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 regulated at EU level.

2.2.3 Initial selection: horizontal measures

The scope of a horizontal measure is determined by the aspect addressed by the measure. 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 measure.

2.3 Results and Discussion

2.3.1 Shortlisted end-use/ intermediate products

The initial list of products consisted of 34 product groups: 25 end-use products and 9 intermediate products. The complete initial list of products (and definitions) can be found in Annex 1, and represents a preliminary basket of products that fall under the first ESPR WP 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 2, the shortlisted products are presented in Table 1. In total, 12 end-use products and 7 intermediate products were shortlisted. The scope of the shortlisted product groups is presented in Figure 4, 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 4 are suitable, or whether these should be modified.

End-use products that were excluded as a result of the initial screening are Biofuels, Books and printed paper, Candles, Cotton buds, De-icers, Means of transportation (road), 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, Solid fuels and Means of transport (road), 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 environmental impacts related to their life cycle would already be covered by shortlisted intermediate products, such as Pulp and paper and Plastics. 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).

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

End-use products	Intermediate products	Not shortlisted products
Absorbent Hygiene Products	Aluminium	Biofuels
Bed Mattresses	Chemicals	Books and Printed Paper
Ceramic Products	Glass	Candles
Cosmetic Products	Iron and Steel	Cotton buds
Detergents	Paper, Pulp Paper and Boards	De-icers
Fishing Nets and Gears	Plastic and Polymers	Means of Transportation (road)
Furniture	Non-ferrous Metal Products	Office and Hobby Supply
Lubricants		Pest Control Devices
Paints and Varnishes		Sanitary Additives
Textiles and Footwear		Ski Wax
Toys		Solid Fuels and Firelighting Products
Tyres		Waste Containers for Separate Glass Collection
		Wet Wipes

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.

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 end-use products such as furniture, toys and construction 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
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
COSMETIC PRODUCTS	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)
CERAMIC PRODUCTS	Vitrified clay pipes and fittings are used for drains and sewers, but also tanks for acids and products for stables. Expanded clay aggregates, which 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, which cover tableware, artificial and fancy goods made of porcelain, earthenware and fine stoneware. Sanitary ware, which include lavatory bowls, bidets, wash basins, cisterns and drinking fountains. Technical ceramics, which supply aerospace and automotive industries (engine parts, catalyst carriers), electronics (capacitors, piezo-electrics), biomedical products (bone replacement), environment protection (filters) and many others. inorganic bonded abrasive is a tool where a synthetic abrasive is blended with a vitrified bond
DETERGENTS	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. 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. Paints and varnishes means coatings applied to buildings, their trim and fittings, and associated structures for decorative, functional and protective purpose. Note that vehicle refinishes are also included. Paints used in non-road vehicles (i.e. boats, ships, aircrafts…) or road marking paint are not included.
TEXTILES and FOOTWEAR	Apparel and home/interior textiles (e.g. bedlinen, towels, tablecloths, curtains etc.) consumed by households, and similar products consumed by government and business + footwear and technical textiles usually or also meant for consumers (such as truck covers, cleaning products) or specifically meant for industry. Excluded are: products for which textiles are not the dominant component (e.g. upholstery textiles, carpets mainly made of plastics, duvets, pillows) and leather
TOYS	The product group covers toys that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded: electronic toys
TYRES	Products included are cars (C1), tyres, vans (C2) tyres and heavy-duty vehicles (C3) tyres
ALUMINIUM	Aluminium and its alloys
CHEMICALS	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, 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	Intermediate products made of seven primary and secondary non-ferrous metals: copper, lead and/or tin, zinc and/or cadmium, precious metals, ferro-alloys, nickel and/or cobalt, carbon and graphite electrodes. Does not include aluminium
PLASTICS & POLYMERS	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
PULP & PAPER	Pulp, paper and board obtained by chemical, kraft, sulphite, mechanical and chemi- mechanical pulping, recovered paper processing and papermaking

Figure 4. Scope of shortlisted end-use and intermediate products

2.3.2 Horizontal measures

On the basis of the ESPR proposal, horizontal measures 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 measure, as well as its link with the product aspects listed in Article 5(1) of the ESPR proposal. In Table 3, the proposed horizontal measures are described in terms of potential horizontal provisions and potential products to be covered by such provisions.

The following tables illustrate the results of this section on horizontal measures.

Table 2. Definition of sustainability-related aspects included in proposed horizontal measures

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) reparability	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	(k) possibility of remanufacturing and recycling	Industrial process in which a product is produced from objects that are waste, products or components and in which at least one change is made to the product that affects the safety, performance, purpose or type of the product typically placed on the market with a commercial guarantee
Recycling	(k) possibility of remanufacturing and recycling	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 (EN 45555)
Lightweight design[18]	(i) resource use or 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
Post-consumer recycled content	(j) recycled content	The amount of post-consumer recycled material that goes into the manufacturing of a new product
Sourcing	(m) environmental impacts, including carbon and environmental footprint	The life-cycle phase involving the acquisition or extraction of the raw materials composing final or intermediate products

With regards to the product groups covered under horizontal measures, the primary point of consideration for their selection was technical similarity. More specifically, product groups under the same horizontal measure may still demonstrate technical differences, however their similarities are sufficient and such that they can all be subject to the same provisions (albeit with adjusted thresholds).

It must also be noted that, for the purposes of this report, horizontal measures and product-specific measures are studied in parallel, and overlap in terms of scope. This overlap will need to be considered before the finalisation of a working plan. Nevertheless, horizontal measures include product groups that are not proposed for product-specific measures (e.g. Light Means of Transport [LMT]). After assessment, three of Horizontal Measures are retained for first consideration (see Table 3). The two others (lightweight design and sustainable sourcing) will be further elaborated before drafting of the ESPR working plan (Table 4).

[18] Cordella et al 2020 https://link.springer.com/article/10.1007%252Fs11367-019-01608-8

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

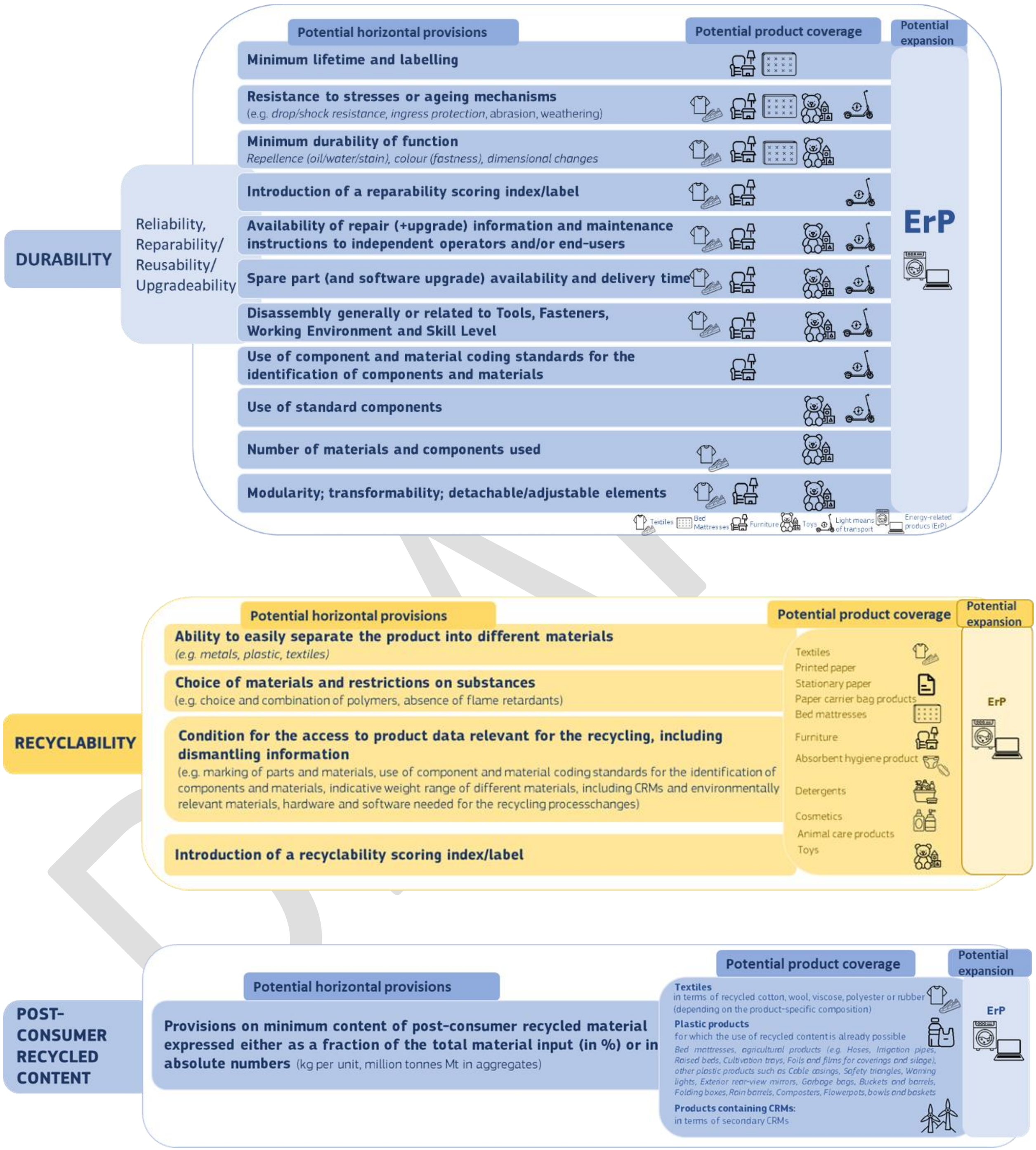

Table 4. Potential horizontal measures, to be further elaborated at a later stage before the drafting of the ESPR working plan

	Potential horizontal provisions	Potential product coverage
LIGHT-WEIGHT 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.**	Detergents Cosmetics Paints and varnishes Animal care products
SUSTAINABLE SOURCING	**Information / Labelling** **Traceability**	**Iron and steel** **Aluminium** **Plastic and polymers** **Chemicals** **Ceramic materials** **Glass** **Paper** **Pulp paper and board** **Precious metals**

2.3.2.1 Provisions associated with horizontal measures

This section lists and describes a range of potential provisions that are associated with various aspects contained in the proposed horizontal measures. 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 measures approach.

2.3.2.2 Horizontal measures for first consideration

2.3.2.2.1 Durability - Reliability

Durability measures 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. The durability measure proposed incorporates provisions which are related to reliability, reparability, reusability and upgradeability, as per the definitions provided in Table 2.

Minimum lifetime and labelling

A horizontal measure proposed under the Ecodesign frameworks would go beyond the consumer guarantees under existing EU legislation[19] and set the 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[20] or lifespan guarantees that consider the durability of the product.

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

[19] Under EU rules, the consumer guarantees are for a minimum of 2 years. Some jurisdictions such as Iceland and Norway also provide consumer rights for non-conforming products for a longer period of 5 years when the products are meant to last for a considerably longer time. See Directive (EU) 2019/771 of the European Parliament and of the Council of 20 May 2019 on certain aspects concerning contracts for the sale of goods

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

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).

Durability of function

This provision contributes to the "Fitness for use" of the products to which particular (given) functions are of interest. The scope would include those product families/groups for which a change in the duration of one or more of its functions could impair its intended use and/or result in users discarding them. A typical product family could be textiles.

Proxy examples of provisions are:

- repellence (oil/water/stains);
- flame retardance;
- colour fastness (light/rubbing/others);
- dimensional changes.

These elements should inform on how long a particular (given) product function would last under known use and/or aging effects.

Resistance to stresses or ageing mechanisms

This provision contributes to the "Fitness for use" of the products considered. The scope would include those product families/groups for which a degradation of the product (or its functional traits) could result in users discarding them or using additional resources.

Proxy examples of provisions are:

- drop/shock resistance;
- ingress protection;
- abrasion;
- biotic resistance (i.e., fungal);
- abiotic resistance (i.e., water, alkali, weathering);
- water resistance/permeability (gaseous/liquid).

These elements should define how long a particular product function would endure, after preparing and/or using the product under recommended operational conditions and it being submitted to known stresses and/or aging effects.

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: (see e.g. https://frame.work/)

— 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[21].

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

Examples of requirements linked to this provision include:

— 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.

[21] 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

2.3.2.2.4 Post-consumer recycled content

Inclusion of recycled content material in products is an important measure 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.

Minimum 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 a horizontal measure on post-consumer recycled content could help increase the efficiency of ESPR Delegated Acts.

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 ESPR measures on recycled content.

At this stage, the products eligible for an ESPR measure 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.

At present, for some materials, e.g., plastics, use of recycled materials is not economically advantageous, and boosting recycled content for such materials can be achieved by economic incentives or by setting binding requirements in products. 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 runs 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.

- Plastic products: This waste material is relevant for a measure 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 5. The thresholds for recycled content in the future ESPR measure are likely to differ depending on the polymer and the application types.

- Textile products: As in the case of plastics, the situation for textile waste is that, despite the large amount of waste generated, only very little is recycled back into products[22]. 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 6.

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

Table 5. Selected plastic polymers and their applications where recycled content can be used. Source: GIZ GmbH, 2021

Polymer	Input for recycling	Is recycling possible?	Where can recycled material be used?
Polyethylene Terephthalate 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 been 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

— Products containing critical raw materials (CRMs): For critical raw materials, the small quantity normally used in products and the difficulty in obtaining a homogeneous waste stream contribute to the low availability of recycled materials. Therefore, the market could be driven towards use of secondary materials by setting a horizontal measure on recycled content. Further analysis will evaluate which product groups are relevant in this sense.

Table 6. 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-consumer polyester	TRICORP case study
Knitted products	50% post-consumer cotton	WE case study
Jackets	5% post-consumer wool from discarded suits and 5% pre-consumer wool	Suitsupply case study

Source: own creation from ECAP, 2022

2.3.2.3 Horizontal measures to be further elaborated at a later stage

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 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 sourcing). 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 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 end-use and intermediate products

3.1 Specific aims

In Section 2, a total of 19 product groups (12 end-use products and 7 intermediate products) were shortlisted (out of the initial 34) 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 prioritisation under 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 end-use and intermediate products that were shortlisted in Section 2.

3.2 Methodology

In line with Article 16 of the ESPR proposal, the end-use 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. 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 strategic autonomy was also performed.

3.2.1 Assessment of the environmental relevance

Taking into account Article 16 of the ESPR proposal and Annex 16 to the ESPR Impact Assessment, the assessment of the environmental relevance of the shortlisted end-use 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 5). 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. 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.

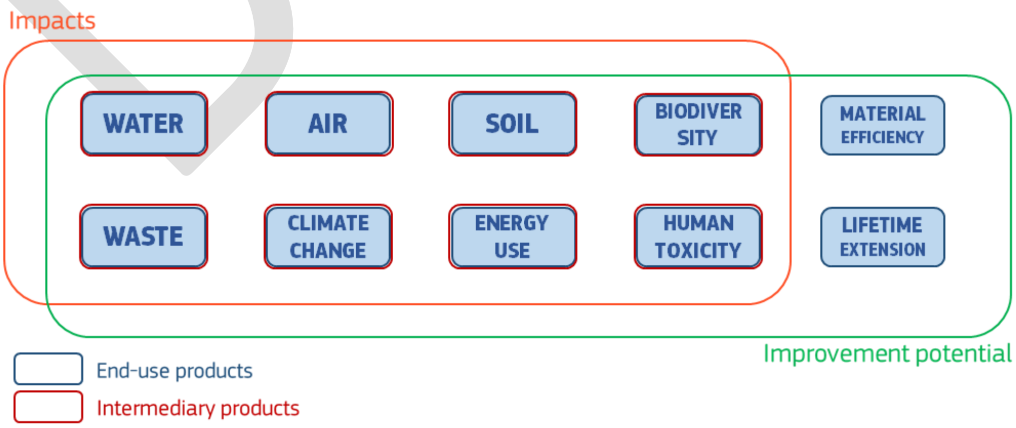

Figure 5. Environmental categories considered for the assessment of products' environmental relevance

For the first eight environmental categories (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 Table 7.

Table 7. Score assignment methodology for the environmental relevance of products, combining the information on products' environmental impacts and improvement potential

Categories	IMPACT RELEVANCE		IMPROVEMENT POT. RELEVANCE	SCORE
WATER, AIR, SOIL, WASTE, BIODIVERSITY, HUMAN TOXICITY, CLIMATE CHANGE, ENERGY USE	Low (EI)	+	Low (IP)	1
	Low (EI)	+	Medium (IP)	2
	Low (EI)	+	High (IP)	3
	Medium (EI)	+	Low (IP)	2
	Medium (EI)	+	Medium (IP)	3
	Medium (EI)	+	High (IP)	4
	High (EI)	+	Low (IP)	3
	High (EI)	+	Medium (IP)	4
	High (EI)	+	High (IP)	5

Categories	IMPROVEMENT POT. RELEVANCE	SCORE
MATERIAL EFFICIENCY, LIFETIME EXTENSION	Low (IP)	1
	Medium (IP)	2
	High (IP)	3

On the other hand, the environmental categories 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 proposal (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, 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 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 of the ESPR proposal (March 2022). 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. However, 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 it should be ESPR to implement such potential measures identified, as other existing legislative instruments could be preferred. Later stages of this work will focus on refining this analysis.

It must be noted that a different approach was needed for end-use products and intermediate products. For end-use 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 end-use 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 materials that will still undergo a remanufacturing phase to produce end-use 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 end-use 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 end-use products.

In light of this, the results for end-use 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 analyses were based on publicly available data only, and new data were not generated in this analysis. Examples of literature/data used are: life-cycle assessment studies, other environmental analysis, economic analysis, scientific articles and reports, statistics, databases, industry reports, surveys, 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 16(1)(a)(i) of the ESPR proposal. To this end, the main potential measures identified in the assessment of environmental relevance were compared to existing policy requirements. As a result of this analysis, products for which a comprehensive regulatory framework already exists that tackles the main environmental impacts and improvement potential were not proposed to be prioritised further.

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 the work for such policy initiatives is still ongoing, and it is not possible, at this stage, to predict the results in terms of new provisions and potential overlaps with future ESPR Delegated Acts. Nevertheless, coherence between regulatory proposals and risk of over-regulating certain aspects will be taken into account for the final ESPR Working Plan.

3.2.1.2 *Proportionality of costs*

The aim of this analysis was to evaluate whether the implementation of the main potential measures identified in the assessment of environmental relevance would entail disproportionate costs, as required by Article 16(1)(a) of the ESPR proposal. To this end, relevant literature was researched and analysed. The result 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. This analysis is preliminary at this stage, and will be refined in the next stages of the process.

3.2.2 Complementary analysis - Strategic autonomy

Open strategic autonomy (COM(2021) 66 final) emphasises the EU's ability to make its own choices and shape the world around it through leadership and engagement, 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 as also highlighted in the JRC Raw Material Information System (RMIS)[23].

Since the publication of the ESPR proposal on 30 March 2022, strategic autonomy of the Union has gained increasing importance, especially given the recent geopolitical context with Russia's invasion of Ukraine. The question of the extent to which ESPR Delegated Acts can contribute to EU strategic autonomy has thus gained significant relevance.

Hence, the goal of this section is to include such strategic autonomy aspects in the overall assessment, considering for instance the potential supply risks of the materials embedded in intermediate or final groups of products. The assessment is based on the Critical Raw Materials list, published by the EC in 2020 (COM(2020) 474 final). Critical raw materials (CRMs) for the EU economy are those with a very high import reliance and external supply concentration from third countries often with a low governance. Critical raw materials, hence, are associated with high supply risk, low resilience, and low strategic autonomy. However, the proposed methodology goes further than a compilation of the presence of CRMs based on the product's bill of materials (BoM). It is also proposed to consider the recent geopolitical developments and their consequences mainly in terms of crude oil and gas supply but also in terms of direct raw material supply from both Russia and Ukraine.

This assessment contributes to the understanding on how relevant are shortlisted products concerning strategic autonomy. However, it should not be understood as part of the formal selection and prioritisation criteria, since it is not specifically quoted within Art. 16 of the ESPR proposal.

3.2.2.1 *Inventory and data collection*

3.2.2.1.1 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 BoM has been established. A maximum of four raw or intermediate materials per product group are inventoried, with a particular focus on the presence of CRMs. For each product group, the potential presence of one or two CRMs in the product groups (according to the EC CRMs 2020 list[24]) 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 hydrocarbons like crude oil or petroleum-derivate products. It allows the methodology to capture the current context regarding energetic products market. The inventory table for each product group is available in Annex 3.

[23] JRC-RMIS, open strategic autonomy : https://rmis.jrc.ec.europa.eu/?page=autonomy-b2cea8

[24] European Commission (2020). Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability. COM(2020) 474 Final. https://ec.europa.eu/transparency/documents-register/detail?ref=COM(2020)474&lang=en

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.

In addition, the materials considered in the analysis are the ones which are directly used in the manufacture of the product, including the first raw materials needed to obtain the intermediate or finished products (e.g., bauxite minerals for aluminium alloys production). However, since the assessment is product-oriented and not process-oriented, the materials entering the whole production ecosystem are not considered. For instance, natural graphite used for electrodes and refractory materials in electric arc furnaces for steelmaking has not been assessed since the use of graphite is part of the process and does not directly enter in the composition of the product. The link between the ecodesign of the product (e.g., with a potentially high recycled content) and the potential material efficiency gains related to the process parts is not easy to assess.

3.2.2.1.2 Information collected for each of the materials

For each of the materials embedded in the different product groups (see the inventory list in Annex 3), the following parameters are addressed:

- For critical raw materials:
  - Supply risk (according to the CRMs 2020 list) of the targeted material.
  - Share of the demand for the material embedded in the product group compared to the total EU demand for this material.
  - Specific material grade used in the product group (oxides, minor alloys grade, specific high-quality or metallurgical grade).
  - Share of the EU supply coming from Russia and/or Ukraine.
- For other materials:
  - Whether the product group derives from fossil fuel hydrocarbons, such as crude oil and gas (y/n).
  - Share of the demand for the material embedded in the product group compared to the total EU demand for this material.
  - Share of the EU supply coming from Russia and/or Ukraine.

3.2.2.2 Selected criteria for the evaluation

To perform an evaluation of the potential of shortlisted product groups for achieving EU strategic autonomy, a composite indicator was designed according to three main criteria captured by the elements listed below: (i) Criticality of the materials embedded in the product group; (ii) Non-energy use of fossil hydrocarbons in the product group; (iii) Geopolitical context by considering the share coming from Russia/Ukraine.

These three criteria are then aggregated to assign each product a maximum score of 14 points. The product groups assessed were then ranked and compared according to these criteria. To ensure alignment with the other assessments dealing with environmental impact, the score is then reshaped to follow a three-level classification (1, 2, 3). To distinguish this analysis from the environmental aspects, the resulting score for the strategic autonomy will be kept separate and not summed up with the environmental score. Please note that the 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, qualitative information on the improvement potential measures with respect to strategic autonomy is reported.

3.2.2.2.1 Criteria 1: Critical raw materials embedded in the product group

The criticality of the supply (based on the CRMs list) was addressed with a total score of maximum 3 points per CRM (total score = 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" material grade: 3 points/CRM.

3.2.2.2.2 Criteria 2: Crude oil and petroleum products (non-energy use)

The fact that the materials used in the product groups comes from fossil hydrocarbons (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

3.2.2.2.3 Criteria 3: Geopolitical context (2022)

The geopolitical context focusing on the invasion of Ukraine was evaluated with a total score of 4 points (1 point per CRM element and non-CRM element). The proposed algorithm is the following:

— If Russia and/or Ukraine represent a share ≥ 5% in the EU supply mix: 1 point/material

To ensure alignment with the other assessments dealing with environmental impact, the score is then reshaped to follow a five-level classification (score maximum = 5 points).

3.3 Results and Discussion

3.3.1 Assessment of environmental relevance of shortlisted product groups

As explained in previous sections, the 19 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 'factsheets' for each of the end-use and intermediate products, illustrating the background information behind the assigned scores and listing the potential measures that future ESPR Delegated Acts could consider.

While the detailed results of the assessment of the environmental relevance are presented in Annex 5, the final environmental scoring of end-use products is presented in Table 8 (Section 3.3.1.1) while intermediate products are presented in Table 9 (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'. Stakeholders are invited to read carefully those '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 8 and Table 9 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 end-use products.

3.3.1.1 End-use 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 43 points, 13 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, material efficiency and lifetime extension, due to the large impacts caused by sourcing, producing, using and discarding materials, but also due to the large improvement potential in all these aspects, 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 of course. This represents a significant 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), and harmonised collection systems across the EU (EC, 2020; Palm et al., 2014). 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). Finally, large improvement potential could also be identified in sustainable sourcing of primary materials (especially cotton), and energy efficiency measures (see Annex 5 or full details).

Table 8. Environmental assessment of the 12 end-use products shortlisted.

Product	Score	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	HUMAN TOXICITY	MATERIAL EFFICIENCY	LIFETIME EXTENTION
TEXTILES and FOOTWEAR	43	5	2	4	4	5	5	5	3	5	5
FURNITURE	30	1	3	3	3	4	3	3	2	3	5
CERAMICS PRODUCTS	30	3	3	3	3	3	4	4	1	3	3
TYRES	30	3	4	3	3	3	3	3	2	3	3
DETERGENTS	28	4	2	1	4	3	3	3	2	3	3
BED MATTRESSES	26	1	3	1	2	5	3	3	2	3	3
LUBRICANTS	24	2	2	2	2	2	3	3	2	3	3
PAINTS	24	3	3	2	3	3	2	2	2	3	1
COSMETICS	23	4	2	1	4	3	2	1	2	3	1
TOYS	22	1	1	1	1	3	2	2	3	3	5
FISHING GEARS	21	4	1	1	4	3	2	1	1	3	1
ABSORBENT HYGIENE PRODUCTS	18	2	1	2	2	4	2	2	1	1	1

The next highest-scoring product groups were Furniture, Ceramic Products and Tyres, each one with an overall score of 30.

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 component, potentially saving on new resources, and therefore having an effect on other categories such as air, soil and biodiversity.

Ceramic Products was found to have an overall medium improvement potential (across almost all categories). However, many categories had a high impact, such as soil, climate change and energy consumption. This is due to the impacts related to the extraction of raw materials (for the impacts to soil), and the high energy consumption for the firing of the end-use products. Potential ESPR measures could address minimum content of material with sustainability certification maximum energy consumed during manufacturing, and minimum energy consumption from low carbon sources, in addition to circularity measures such as minimum content of recycled materials, durability and reliability measures and availability of spare parts (for some applications, such as toilets and urinals), that have the potential to indirectly affect other categories as well.

Tyres represent a special case among the assessed products. Indeed, while showing a high relevance with respect to impacts on soil, biodiversity and climate change, in terms of microplastics release, potential measures are still being identified by the sector. It is essential to develop testing methods or standards to measure and estimate tyres' abrasion. While the situation is expected to change in the future, available studies/technologies cannot confirm high savings at this moment. 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 CO_2 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.

Detergents and Bed mattresses scored 28 and 26, respectively. The main improvement potential identified for Detergents lies in sustainability certifications for the raw materials, packaging solutions towards more circularity, especially in terms of refillable solutions, lightweight design, and potential bans on secondary packaging (when and if relevant). 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, lifetime extension and energy use. On the other hand, 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 refurbishing and recycling, and minimum recycled content.

Lubricants, Paints, Cosmetics and Toys obtained a total environmental score between 24 and 22, 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.

Fishing gears and Absorbent Hygiene Products are the two product groups at the bottom of the ranking list, scoring 21 and 18, respectively. Indeed, Fishing gears showed relevance in terms of water effects, biodiversity and waste generation; 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.

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 product group (e.g. textiles), and not over a unit of the product group (e.g. a t-shirt). 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 higher than other products, despite being a much narrower product group and with a much 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 end-use 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 is not clear at this stage. Therefore, the list of potential measures presented in the individual factsheets for the shortlisted end-use products should be looked at as indicative only.

Finally, it should also be mentioned that some product groups are very wide and include a variety of products with partly different functions, such as the case of Textiles and Footwear, Furniture, Detergents, Cosmetics, or Toys, whose definition is much less granular than Bed mattresses or Tyres for example. While it can be expected that an ESPR Delegated Acts cannot address, for example, all textiles, and while the impacts and improvement potential of a cotton T-shirt are different to those of a wool sweater, the scoring results can still be considered representative of the whole product group. Further work on prioritised products will establish the adequate granularity for each prioritised product group, and later preparatory studies on individual product groups will retain or not the product group scopes considered in this study (and presented in Figure 4).

3.3.1.2 Intermediate products

Iron and steel, Non-ferrous metal products and Aluminium were the top three scoring groups among the intermediate products, where Iron and steel was at the top with a score of 31 points, Non-ferrous metal products with a score of 27, and Aluminium with 26.

Iron and steel as an intermediate product scored the highest possible (5 points) in four out of the eight categories, reaching high impacts and high improvement potential in water and air effects, climate change, and life cycle energy consumption. In waste generation, 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 raw materials, 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.

Table 9. Environmental assessment of the 8 intermediate products shortlisted.

Score	Product	WATER	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	HUMAN TOXICITY
31	IRON & STEEL	5	5	2	2	4	5	5	3
27	NON-FERROUS METAL PRODUCTS	3	2	3	2	5	4	5	3
26	ALUMINIUM	1	4	4	3	4	4	4	2
25	CHEMICALS	3	3	3	3	3	4	4	2
23	PLASTICS	3	3	2	2	3	4	4	2
22	PULP & PAPER	3	2	3	3	2	4	4	1
19	GLASS	3	2	2	3	1	3	4	1

Non-ferrous metal products scored second (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 end-use 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). In their vision towards 2050, the European non-ferrous metal association Eurometaux envisages to focus on a holistic management of metals value chains, from mines to products to secondary loops; a precondition for this is a detailed metal-by-metal spatial and temporal information about stocks and flows (Eurometaux, 2015).

Aluminium scored third among the intermediate products, with 26 points. Aluminium showed large impacts and improvement potential in terms of 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 would reduce the GHG emissions by 11 times (Moya Rivera et al., 2015).

Chemicals and Plastic and polymers scored fourth and fifth, with 25 and 23 points, respectively. These two products 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 shared aspects to decrease the environmental footprint of chemicals and plastics. For chemicals, this could be achieved by scaling-up more sustainable 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. Likewise, for Plastics is also related with diverging from fossil fuels consumption, both as energy and 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 (e'.g. reusable and/or recyclable plastics). Measures for Chemicals and Plastics could comprise setting a cap on GHG emissions or energy use per ton of materials; or introducing minimum share of low carbon sources energy used; or sourcing raw materials via certified sustainable practices; and/or require a share of recycled content as input material. 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.

Finally, Pulp and paper and Glass close the priority list, with 22 and 19 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).

3.3.2 Policy gaps

This step assessed whether, for a certain product group, the existing policy framework is addressing the areas where large 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. In addition, Table 9 summarises the aspects covered by existing legislation and the main improvement potential not currently regulated. 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. This would be further analysed at a later stage, also taking into account the input from stakeholders. Also, it should be made clear that the third column in Table 9 ("improvement potential not regulated") should not be seen as a proposal for ESPR measures, but rather as areas to be further investigated because potentially holding relevant improvement potential.

All packaging used for end-use products are covered by the Packaging and Packaging Waste Directive[25] (PPWD), therefore this information was not repeated in each factsheet. The PPWD covers both packaging design and packaging waste management in order to prevent the production of packaging waste and to promote the reuse and recycling of packaging waste across the EU. While the PPWD ensures that packaging can only be placed on the market if designed in such a way as to permit its reuse or recovery (including recycling), there is no product- or material-specific minimum % of recyclability in force. The EC is currently examining how to improve packaging design for reuse and promote high-quality recycling. In this respect, the

[25] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste (OJ L 365, 31.12.1994, p. 10–23)

recent proposal for a revised Packaging and Packaging Waste Regulation[26] (PPWR) sets the basis for mandatory requirements on recycled content and recyclability for plastic packaging.

Similarly, all intermediate products are covered by the Emission Trading System (ETS), currently under revision.

Overall, all products show improvement potential measures that go beyond current policy requirements. Textiles and Footwear, Furniture, Bed Mattresses Lubricants, Absorbent Hygiene Products and Toys are covered by REACH[27] and CLP[28] (currently under revision), but otherwise no sectorial legislation exists at the moment addressing their environmental performance. Moreover, Ceramic Products are covered by the Industrial Emission Directive, which regulates maximum levels of emissions during production (see also next paragraph on intermediate products). 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 dosage requirements, aspects such as maximum limit of water and energy consumption during manufacturing, sustainability certifications for the raw materials, refillable packaging, product-to-packaging ratio and 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 at this stage. Rather, the developments of the revision of the Detergents Regulation will be taken into account at a later stage, together with the stakeholder input.

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 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 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 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 (such as, for tyres, the type-approval, or end-of-life legislation under revision) or legislation under preparation (such as for detergents). The decision on the optimum policy instrument will be taken after the current consultation has concluded (and before final decisions are taken regarding their possible inclusion in the ESPR working plan).

All assessed intermediate products are under the Industrial Emission Directive, each one with a specific Commission Implementing Decision 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 Commission Implementing Decisions apply to EU installations, which should comply with the BAT-AELs in order to obtain their operation permit. The BAT-AELs focus primarily on emissions to water and air, and, to a lesser extent, to the waste produced. It should be highlighted that, as in the case for end-use products, the potential ESPR measures identified in this study (and reported in the factsheets in Annex 5)

[26] Proposal for a revision of EU legislation on Packaging and Packaging Waste. Available here

[27] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

[28] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures (OJ L 353, 31.12.2008, p. 1–1355)

relate to EU conditions, i.e. to what ecodesign measures could be set under ESPR. Therefore, the improvement potential for the environmental categories of water effects, air effects and soil effects was evaluated as ‘low’ for all product groups, since – as mentioned above – these aspects have been the focus of the Industrial Emission Directive since 2010. While the aspects of climate change and circularity (e.g. inclusion of secondary, recycled, materials) are currently not addressed by the Industrial Emission Directive, a proposal for a revision tabled by the European Commission aims to bring it into line with the EU's zero pollution ambition, energy, climate and circular economy policy goals under the European Green Deal. Nevertheless, ESPR could still regulate environmental aspects of intermediate products placed on the EU market, that is, also imported products, which currently escape the Industrial Emission Directive. Indeed, a large share of Iron and steel, Non-ferrous metals, Aluminium and Plastics and polymers is produced outside the EU (see also Section 3.3.4).

All in all, at this stage no product is excluded from the priority list.

3.3.3 Proportionality of costs

This section aimed at estimating, based on available data and information in the literature, whether potential ESPR measures in the areas where the main improvement potential was identified could result in disproportionate costs, in line with Art. 16.1.a of the ESPR proposal. A detailed cost assessment was out of the scope of this prioritisation study, but will be addressed at a later stage for the products on the first ESPR Working Plan.

The analysis suggested that none of the products investigated would entail the risk of involving disproportionate costs. Most of the potential ESPR measures identified focus on reducing the use of water, chemicals, energy, and material in general. Therefore, the investment costs borne by industries to make a change would be outbalanced by the benefits provided by such measures, and would be paid-off by the 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 2 000 million EUR (P&G, 2020). For textiles, an up-front investment of 17.3 million EUR 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 feedstocks, achieving 20% reduction in product defects, which was estimated to save 220-440 million EUR 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). On the other hand, some of the measures are 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 as the cost of electricity is higher than that of natural gas (CEPI, 2021), although geopolitical factors can influence this point.

At this stage, no product was excluded from the priority list.

Table 10. Regulated aspects and improvement potential aspects not currently regulated in the EU for the 12 shortlisted end-use products

TEXTILES

Regulated aspects

Emissions during production.
Fibre names and labelling.
Separate collection of textiles waste.
EU Ecolabel criteria (voluntary).
GPP criteria (voluntary).

Potential ESPR requirements

- Minimum recycled content in product and in packaging.
- Maximum limit of water consumption during production.
- Maximum limit of chemical consumption during production.
- Design for reliability, recyclability and durability.
- Design for minimising water consumption during use.
- Maximum limit of fertilisers, pesticides and insecticides.
- Minimum content of material with sustainability certification.
- Maximum level of GHG emissions.
- Limiting the number of materials used in a single product.
- Use of components and material coding standards.
- Use of design techniques that ease non-destructive disassembly and re-assembly.
- Availability of guarantees specific to remanufactured clothing.
- Use of modular design.
- Maximum level of energy consumed.
- Restricting the use of certain materials or manufacturing practises.
- Minimum durability and reliability.

FURNITURE

Regulated aspects

EU Ecolabel criteria (voluntary).
GPP criteria (voluntary).

Potential ESPR requirements

- Minimum recycled content.
- Design for disassembly and repair, re-use, refurbishing and recycling.
- Minimum content of raw material with sustainability certification.
- Design ensuring the durability.
- Limiting the number of materials used in a single furniture product.
- Design techniques that ease non-destructive disassembly and re-assembly
- Compatibility with commonly available spare parts.
- Minimum durability and reliability.
- Availability of spare parts.
- Use of components and material coding standards.
- Minimum percentage of energy use from low carbon sources.

TYRES

Regulated aspects

Emissions during production.
Fuel efficiency, wet/ice grip, external rolling noise and suitability for severe snow use.
Efficient management of tyres

Potential ESPR requirements

- Recycling and recycled content target.
- Reliable testing measures for abrasion.
- Re-trading tyres for waste reduction.
- Upgrading the rolling resistance.
- Sustainable sourcing for rubber.

CERAMICS

Regulated aspects

Environmental impact
Specific regulations, such as floor covering Commission Decision (EU) 2021/476 and building COMMISSION STAFF WORKING DOCUMENT (2016) 180

Potential ESPR requirements

- Maximum limit of water consumption.
- Design for minimising water consumption during use.
- Design for reliability and disassembly.
- Minimum recycled content.
- Sourcing of raw materials from certified sustainable practices.
- Maximum weight per item.
- Minimum percentage of energy use from low carbon sources.
- Minimum service life for plaster moulds.
- Technical lifetime and resistance to stress.
- Availability of spare parts.
- Maximum level of GHG emissions
- Maximum energy consumed during manufacturing

DETERGENTS

Regulated aspects

Emissions to water.
Information related to dosage.
Labelling of ingredients.
Environmental and human health risk assessment.
EU Ecolabel criteria (voluntary).

Potential ESPR requirements

- Availability of spare parts and refills.
- Maximum limit of water and energy consumption.
- Minimum content of biodegradable substances/materials.
- Prohibition of secondary packaging in certain cases.
- Maximum level of product-to-packaging ratio.
- Minimum content of material with sustainability. certification.
- Mandatory design of refillable packaging ratio.
- Design for minimising water consumption during use.
- Minimum cleaning performance at low temperature.

BED MATTRESSES

Regulated aspects

EU Ecolabel criteria (voluntary).
GPP criteria (voluntary).

Potential ESPR requirements

- Design for disassembly, refurbishing and recycling.
- Minimum content of materials with sustainability certification.
- Minimum recycled content.
- Minimum durability.
- Maximum level of GHGs emitted.
- Maximum energy consumed during manufacturing.
- Minimum percentage of energy use from low carbon footprint sources

Table 9 (continued). Regulated aspects and improvement potential aspects not currently regulated in the EU for the 12 shortlisted end-use products

LUBRICANTS

Regulated aspects

Emissions during production (under revision).
Waste collection and disposal.
Separate collection of textiles waste.
EU Ecolabel criteria (voluntary).

Potential ESPR requirements

- Maximum level of GHG emissions.
- Minimum percentage of recycled oil in lubricant.
- Design to determine a maximum coefficient on friction.
- Design to ease reuse.
- Minimum durability
- Minimum percentage of energy use from low carbon sources

COSMETICS

Regulated aspects

Protection of human health.
Use of nanomaterials.
Ban of animal testing.
Ban and restriction of certain hazardous substances.
Information on the packaging.
Use and justification of claims used in the cosmetic products.
Environmental and human health risk assessment.
EU Ecolabel criteria (voluntary).

Potential ESPR requirements

- Prohibition of secondary packaging in certain cases.
- Maximum limit of water consumption.
- Maximum energy consumed during manufacturing.
- Mandatory design of refillable packaging.
- Maximum level of product-to-packaging ratio.
- Availability of refills and spare parts.
- Design for minimising water consumption during use.
- Minimum content of material with sustainability certification.
- Minimum content of biodegradable substances/materials

FISHING GEARS

Regulated aspects

Labelling (plastic nature) and informational (e.g. share of plastic/metal/rubber) requirements.
Waste delivery to harbours.
Use of fishing gears, characteristics, construction limitations and prohibitions.

Potential ESPR requirements

- Design of traps and pots with effective escape mechanism with biodegradable mechanisms.
- Design to allow the traceability of components.
- Design to facilitate separation of recyclable materials.
- Minimum recycled content.

PAINTS

Regulated aspects

Emissions of VOCs.
Environmental and human health risk assessment.
Ambient air quality assessment and management.
Waste management.
EU Ecolabel criteria (voluntary).

Potential ESPR requirements

- Minimum packaging-to-product ratio.
- Design for reliability.

TOYS

Regulated aspects

Safety of use.
Ban and restriction of certain hazardous substances.
Waste management.

Potential ESPR requirements

- Minimum recycled content.
- Design for minimum reliability and durability.
- Sourcing of materials from certified sustainable practices.
- Design to facilitate reuse, repair, refurbishing and recycling
- Availability of spare parts.
- Minimum percentage of energy use from low carbon sources

AHP

Regulated aspects

Safety of use.
Labelling requirements on plastic composition.
Environmental and human health risk assessment.
EU Ecolabel criteria (voluntary).

Potential ESPR requirements

- Minimum recycled content.
- Design for disassembly
- Minimum content of material with sustainability certification.
- Design for recyclability.

3.3.4 Strategic autonomy

The outcome of the evaluation regarding strategic autonomy gives three product groups with the maximum score (5): Tyres, Iron and steel as well as Chemicals. These products combined a high share of critical raw materials used (e.g., tyres group represents 75% of the natural rubber end market, coking coal for steel uses 82% of the EU supply) with often high import reliance on Russia/Ukraine for both CRMs and hydrocarbons-based products. The high score of the category Chemicals is explained by the broadness of the scope which includes organics and inorganics compounds, fertilisers and polymers. Regarding the CRMs, a huge majority of them are used mainly for chemical applications such as: Phosphorus, Phosphate rock, Bismuth, Silicon metal, Titanium, Antimony, Platinum-group elements, Rare-Earth elements, Borate or Fluospar.

A second category of products ranked with a score of 4 or 3. This is the case for Aluminium (manufactured from bauxite and potentially silicon metal which are both listed as CRMs) but also Plastics and polymers. This latter intermediate product group accounts for around 10% of the crude oil end use for which the import reliance is very high. Still, 80% of the total supply is used for energetic applications, even though this share should decrease in the future, increasing the share of plastics compounds as an end-use application for crude oil.

The other products may contain specific materials which are at risk from a supply point of view, for instance the kaolin clay used for Ceramic products or paper products is partly sourced from Ukraine, or are mainly manufactured with oil-based derivates. However, they do not combine enough high or medium scores in all of the three subcategories to reach a critical threshold. Besides, it should be noted that a score of 1 or 0 does not mean that there is very little or no risk of supply shortage, 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 strategic autonomy is more limited than for categories that rank highly (with a score of 3 or 4).

Table 11 and Figure 6 compile the obtained results of the 'strategic autonomy' assessment.

Table 11. Final ranking of the product groups according to the "strategic autonomy" criteria

Products groups' name	Ranking	Relevance
Tyres	5	Very high
Iron and Steels	5	
Chemicals	5	
Non-ferrous metal products (excl. Aluminium)	4	High
Plastics & Polymers (incl surface treated)	3	
Aluminium & Al-alloys	3	
Paints	3	
Glass	2	Medium
Ceramic products	2	
Lubricants	2	
Paper, Pulp paper and boards	2	
Bed Matresses	2	
Detergents	2	
Absorbent Hygiene Products	1	Moderate
Fishing nets / gear	1	
Textiles	1	
Cosmetics	1	
Furniture	1	

NB: Elements in bold are intermediate products. A score of from 5 to 3 indicates a high relevance regarding strategic autonomy aspects while 2, 1 and 0 indicate a medium, low, or no relevance respectively.

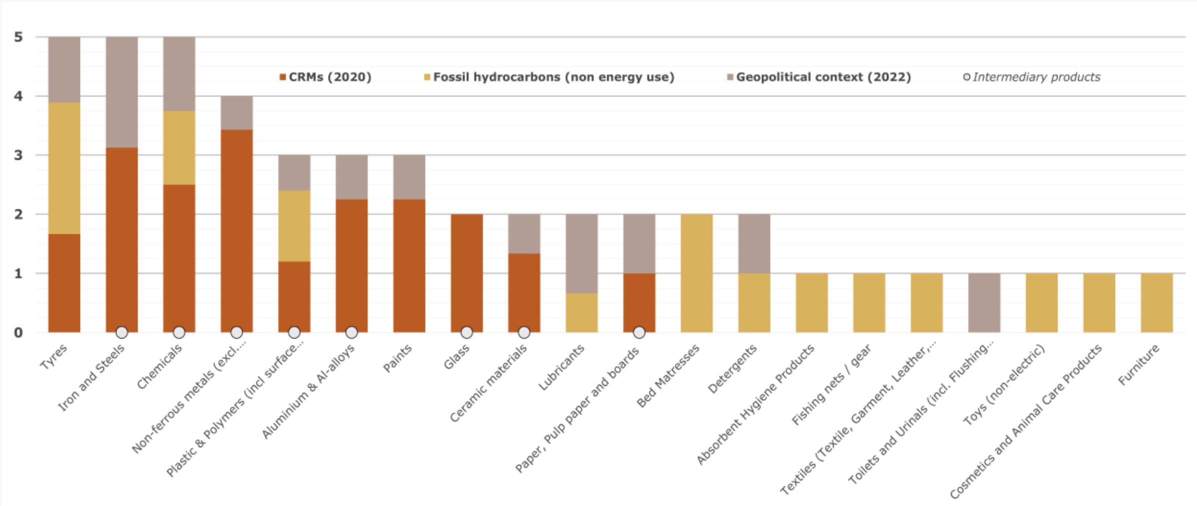

Figure 6: Strategic Autonomy scores for intermediate and final products' groups

4 Impacts quantification and savings evaluation

4.1 Specific aims

This section intends to discuss the results on the environmental impacts of prioritised end-use products and intermediate products and the savings expected from the implementation of ESPR horizontal measures. The below sections aim at addressing the following questions:

- What is the contribution of prioritised end-use products and intermediate products to the overall Consumption Footprint, in the context of the Planetary Boundaries?
- What are the potential benefits of the implementation of the ESPR horizontal measures?

The total impacts of the prioritised end-use products and intermediate products were compared to the overall EU Consumption Footprint, based on data extracted from the Consumption Footprint Platform (EC-JRC, 2022).

The Consumption Footprint method is used in Section 4 to quantify the expected environmental impacts that the ESPR measures 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 prioritized products against the impacts of the overall EU consumption and the Planetary Boundaries, thereby going beyond the scope in Section 3 as providing both a macro-scale and absolute sustainability perspectives. Additional details on the Consumption Footprint and the Planetary Boundaries are reported in Section 4.2.1.

In addition to the relevance assessment (Section 3), the Consumption Footprint allows to consistently assess the impacts of end-use products along their entire supply chain (considering same system boundaries for all assessed products). The Consumption Footprint also allows to estimate 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 of the prioritization 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.

4.2 Environmental impacts and contributions of prioritised end-use and intermediate products

4.2.1 Methodology

The contribution of prioritised end-use products[29] and intermediate products[30] was evaluated from a life-cycle assessment (LCA)[31] perspective, and it was related to the environmental impacts of the Consumption Footprint and to the Planetary Boundaries (as an absolute reference), as further detailed in Annex 6.

The Consumption Footprint focuses on 16 midpoint impact categories[32] (defined in the Environmental Footprint method (EC, 2021), as recommended by the EC for life-cycle assessment of products and organisations), and aims at quantifying the environmental impacts of apparent consumption. The apparent consumption corresponds to the overall environmental impacts of domestic production (plus imports and

[29] The list of end-use prioritized products assessed in Section 4 includes: textiles, lubricants, furniture, tyres, detergents, paints, bed mattresses, cosmetic products, absorbent hygiene products, toys (non-electric), and ceramic products.

[30] The list of intermediate products assessed Section 4 in includes: iron and steel, aluminium, chemicals (including industrial cleaning chemicals), plastic and polymers, glass and paper, pulp paper and boards.

[31] 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.

[32] 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.].

minus exports) in the whole EU and at EU Member State level (Sala & Sanyé Mengual, 2022)[33].
The resulting environmental impacts were compared with the so-called “planetary boundaries”. Planetary boundaries describe Earth’s capacity to bear environmental impacts (i.e., “Earth’s carrying capacity”). 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 use of the Environmental Footprint method allows the planetary boundaries framework to be employed as an absolute sustainability reference. A set of LCA-based planetary boundaries adapted to the 16 impact categories of the Environmental Footprint were developed by the JRC for this purpose (Sala et al., 2020). Comparing the per-capita impacts of consumption with the per-capita planetary boundary for each impact category, indicates the current situation in relation to a safe operating space for humanity[34].
Additionally, to understand the main contributors to the total impacts for each impact category, the contribution of each prioritised end-use product and intermediate product to the respective total impacts (i.e., total impacts of all prioritised end-use products and total impacts of all intermediate products) was calculated.

The potential plastic leakage due to the consumption of tyres and textiles (two of the prioritised end-use products) was also quantified following the “Plastic Leak Project method” (Peano et al., 2020). 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. For these reasons, these results should be considered as preliminary. Further details on the assessment and results of plastic leakages are provided in Annex 7.

4.2.2 Preliminary results and discussion

Results underline how, for some impact categories, the impact of prioritised end-use products is close to (e.g., resource use, fossils) or transgresses (e.g., freshwater ecotoxicity and climate change) the safe operating space for humanity at the EU level related to the planetary boundaries. In the case of the resource use minerals and metals and resource use fossils impact categories, only the impacts related to intermediate products are higher than the safe operating space. ESPR measures could be useful to reduce the overall Consumption Footprint, by lowering the impacts of prioritised products and bringing them within planetary boundaries’ safe thresholds. Further results on the contribution of prioritised end-use products and intermediate products related to the overall Consumption Footprint in the context of planetary boundaries are provided in Annex 8.

When the total impacts of the different prioritised end-use products are analysed[35], results indicate that the most relevant ones (i.e., exhibiting the highest impacts) are furniture, textiles and detergents, followed by cosmetic and animal care products and paints. Firstly, both textiles and furniture encompass a broader number of representative products compared to other categories (for model details, see Annex 9)[36]. Secondly, these high contributions could be associated with large consumption intensities[37] (such as in the case of furniture and detergents) or high unitary impacts (such as in the case of textiles). On average, the textiles prioritised end-use product contributes to 26% of the impacts of all end-use products[38]; whilst the furniture and detergents end-use products contribute on average to 28% and 22% of the total end-use impacts,

[33] 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.

[34] 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).

[35] For instance, in the case of “furniture”, the impacts of this product were compared to the total impacts of all end-use prioritized products for each impact category (i.e., impacts_furniture/impacts_all_end_use_products [%]).

[36] In the analysis presented in Section 4, the “textiles” product included several clothes (e.g. t-shirt, jeans) and footwear types (e.g., fashion footwear, waterproof and work footwear); whilst the “furniture” product included various types of furniture (e.g., bedroom wooden furniture, furniture of plastics, upholstered seats).

[37] Consumption intensities are used in this study to indicate the amount of consumed procuts by an average EU citizen in a given year (calculated for that product as its apparent consumption: production – export + import).

[38] For instance: for each impact category, the contribution (%) of textiles to the total impacts of all end-use products was calculated. The average of these contributions amounted to 27%.

respectively. When textiles, furniture and detergents are considered together, their impacts cover on average 76% of all the prioritized end-use products' impacts (Figure 11; Annex 10). This broadly confirms the results illustrated in Section 3.3, as textiles, 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 end-use products, since they have the lowest consumption intensities compared to the other end-use products.

Concerning intermediate products, iron and steels, aluminium and chemicals have the highest contributions to the total environmental impacts of all intermediate product[39] (Figure 12; Annex 10). Firstly, these high contributions could be explained considering that the consumption intensities, and the calculation of the impact factors for such products, were based on available statistics (such as the Eurostat database) and datasets (such as Ecoinvent datasets), due to the lack of comparable representative products[40] (Annex 9). Secondly, these high contributions could be explained by their consumption intensities, being one order of magnitude larger than those of the other analysed products[41]. Additional results and details concerning the most impactful end-use and intermediate products are provided in Annex 10.

4.3 Potential benefits of horizontal measures

4.3.1 Methodology

Estimating and quantifying the impacts and savings in terms of horizontal measures is a complex exercise. In particular, the main challenges are attributable to: (i) the grouping of various products within the scope of the horizontal measures; (ii) a proper definition of ambitions' levels for each provisions under each horizontal measure, 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 12.

In the quantification analysis presented in this section, the following horizontal measures were considered: "Lightweight design", "Durability", "Recyclability" and "Post-consumer recycled content"[42]. The potential savings associated to the implementation of specific horizontal measures were assessed for the four abovementioned horizontal measures, and for three improvement 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 default values (i.e., 10%, 30% and 50%) when relevant literature data were missing. This range can be associated with a "stringency range" or ambition of the proposed provisions. A summary of each horizontal measure, its related metric and improvement scenarios is provided in Table 19 in Annex 12.

Based on the Consumption Footprint indicator, the calculation of the environmental impacts of the prioritised end-use and intermediate products allowed the estimation of the potential benefits of applying each horizontal measure. Table 20 (Annex 13) presents a summary of the products for which the horizontal measures have been applied (compared to the full list of products considered and described in Table 19 in Annex 12). It must be noted that, since the benefits for some products have not been calculated (e.g., due to the lack of impacts' data at the level of each life cycle stage of a product), a potential underestimation effect of the savings could be present in the results of the present study. The calculation of the environmental savings of a product was performed at the life-cycle stage level, since some measures have effects on specific aspects of the life cycle of products (e.g., end of life). Further methodological details on the quantification of savings due to horizontal measures are provided in Annex 12.

[39] 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 47%.

[40] Further details on the main constraints and challenges related to the analysis described in Section 4.2.1 and Section 4.2.2 are presented in Annex 11.

[41] As an example, consumption intensity for iron and steel: 2.6E+11kg; consumption intensity for chemicals: 8.2E+10kg; average consumption intensity for all other intermediate products: 2.5E+10kg.

[42] Excluding the "Sustainbale sourcing" measure, due to the lack of data availability to properly modelling it and considering how this measure would be mostly related to "informational" aspects, rather than "design" aspects (that are instead prelevant for instance in the case of the Durability horizontal measure).

4.3.2 Preliminary results and discussion

The methodological approach described in Section 4.3.1 enabled the calculation of savings related to the application on the horizontal measures. Preliminary results suggest that Durability has the potential to deliver the highest savings compared to all other measures. For instance, such savings would ensure that the "uncertainty threshold" of the planetary boundaries of the climate change and ecotoxicity freshwater impact categories is not crossed (Figure 14, Annex 13). Durability measures would also have a positive effect in reducing the environmental impacts of the consumption of the products in scope across all impact categories. When compared to planetary boundaries for Ecotoxicity, all scenarios would be sufficient to not cross the "uncertainty area". Further results on the evaluation of savings due to horizontal measures are provided in Annex 13, and complemented in Annex 14 (further details on methods and assumptions) and Annex 15 (results for the impact categories not included in Annex 13).

The exercise of estimating environmental savings linked to the implementation of horizontal measures presented several challenges. In particular, results were especially influenced by the lack of quantitative data and by the challenging excercize of linking the proposed provisions under the measures with specific improvement potential. Solving the challenges presented would require a deeper analysis into each of the horizontal measure, whereby the product scope can be further specified, and an appropriate ambition level for the provisions could be explored allowing for a higher accuracy in the estimation of expected benefits[43]. For this reason, as described in Section 4.3.1, default scenarios were deployed. 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 measure.

Furthermore, the approach adopted for calculating the savings does not quantitatively account for the presence of potential trade-off effects on other horizontal measures (either increasing the total savings or decreasing the total savings)[44]. Additional details on the main constraints and challenges related to the analysis described in Section 4.3.1 and Section 4.3.2 are presented in Annex 11.

[43] For instance, in the case of a horizontal measure such as Post-consumer recycled content, the link between provisions and improvement potentials cold 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 measures, such as Durability, the association is more complex and would require a deeper analysis.

[44] 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.

5 Conclusions

This JRC Report provides a preliminary proposal of the new product groups and horizontal measures that should be considered as a priority of 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, and a separate prioritisation exercise will be carried out for the latter category, 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. Both streams of work will together constitute a pool from which priorities for the first and then following working programmes will be drawn.

In this report, the relevance of a number of product groups and horizontal measures was evaluated in terms of impacts and improvement potential on the basis of a number of parameters: environmental sustainability and circularity, economic weight, existing policy coverage, proportionality of costs, and contribution towards an EU strategic autonomy. This exercise resulted in a proposal for a preliminary ranking of future ESPR Delegated Acts. The level of impacts associated with the proposed 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, twelve end-use products (Textiles and footwear, Furniture, Ceramic products, Tyres, Detergents, Bed mattresses, Lubricants, Paints, Cosmetics, Toys, Fishing gears, and Absorbent hygiene products, see Table 8), seven intermediate products (Iron and steel, Non-ferrous metal products, Aluminium, Chemicals, Plastic and polymers, Pulp and paper, and Glass, see Table 9) and three horizontal measures (Durability, Recyclability, Recycled content, see Table 3), are proposed to be prioritised for the next steps of preparation of the first ESPR Working Plan, with two additional horizontal measures (Lightweight design and Sustainable sourcing) undergoing further developments.

Textiles and footwear, Furniture, Ceramic products and Tyres were the product groups resulting as most relevant from the environmental perspective according to the methodology applied in this report. 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 strategic autonomy, except for Tyres.

Similarly, Iron and steel, Non-ferrous metal products, and Aluminium 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 lay mainly in the areas of waste generation, climate change and energy consumption. At the same time, these products showed medium or high relevance in terms of contribution towards strategic autonomy.

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

When compared to the Consumption footprint, the prioritised end-use products represent between the 18% and the 73% 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 prioritised end-use products suggested that the highest impacts were associated with freshwater ecotoxicity, particulate matter and climate change, with the former transgressing the "uncertainty area" of the associated planetary boundary. Among prioritised end-use products, when Textiles, Furniture and Detergents are considered together, their impacts cover on average 76% of all end-use prioritized products impacts, considering all the 16 impact categories under examination. While these results are aligned with the ranking previously mentioned, it should be noted that they include only a measure of the relevance of the impacts of the products, whereas the prioritisation analysis include both the impacts caused to the environment and the improvement potential available to make products more sustainable.

Horizontal measures constitute cross-cutting measures that can cover groups of product categories demonstrating a degree of technical similarity. The horizontal measures proposed for the ESPR Working Plan would include a number of provisions which focus on improving material efficiency for key product groups (such as Textiles and footwear, Light means of transport, Toys, Bed mattresses), as well as on setting information requirements for the sourcing and traceability of raw materials. Horizontal measures 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 measures.

Regarding the assessment of environmental savings associated with the implementation of horizontal measures, the application of Durability-related measures would result in the highest savings for all the impact categories assessed, compared to the other horizontal measures assessed (i.e., Lightweight design, Recyclability or Post-consumer recycled content).

5.1 Final remarks and next steps

This JRC Report provides a preliminary proposal of end-use products, intermediate products and horizontal measures that should be addressed in the first ESPR Working Plan. Nevertheless, the results illustrated in this report should be considered as preliminary, and will be subject to stakeholder consultation.

Further analysis is planned in the next months in order to refine the results, incorporating the feedback that will be received from stakeholders. To this end, feedback from stakeholders will be key to pave the way to an agreed, evidence-based priority list for the first ESPR Working Plan.

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List of abbreviations and 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
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 Sustainble Products Regulation
ETS	Emission Trading System
EU	European Union
FEU	Eutrophication – freshwater
FRD	Resource Use – fossil
GHG	Greenhouse Gas(es)
HDPE	High-Density Polyethylene
HM	Horizontal Measure
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
PEFCRs	Product Environmental Footprint Category Rules
PET	Polyethylene Terephthalate
PLP	Plastic Leak Method
PM	Particulate Matter

POF	Photochemical ozone formation
PP	Polypropylene
PPWD	Packaging and Packaging Waste Directive
PS	Polystyrene
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

List of Figures

List of Tables

List of Boxes

Annexes

Annex 1. Initial list of products

Table 12 Definitions of the product groups included in the initial selection of end-use products and intermediate products

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
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. Sanitaryware are lavatory bowls, bidets, wash basins, cisterns and drinking fountains. Technical ceramics supply aerospace and automotive industries (engine parts, catalyst carriers), electronics (capacitors, piezo-electrics), biomedical products (bone replacement), environment protection (filters) and many others. inorganic bonded abrasive is a tool where a synthetic abrasive is blended with a vitrified bond.
Chemicals	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, 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.

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	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
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).
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. Composed of base fluids (80-75%) and additives (25-20%). Base fluids can be fossil base fluids (mineral oils, synthetic oils, re-refined mineral oils) which account for >95% of the market or vegetable base oils (in EU mostly rapeseed and sunflower) which account for <5% of the market (2015 data) and also mixtures of them, mostly mineral-synthetic, and vegetable-synthetic.

Means of transportation (road)	This group includes: 2-wheel vehicles, Bicycles, Buses, Cycle trailers, Electrically power-assisted cycles, Heavy duty vehicles, L-category vehicles, Light commercial vehicles, Light electric vehicles, Rail transport, Self-balancing vehicles, Taxis, Waste collection vehicles.
Non-ferrous metal products (excl. aluminium)	This includes seven primary and secondary non-ferrous metals: copper, lead and/or tin, zinc and/or cadmium, precious metals, ferro-alloys, nickel and/or cobalt, carbon and graphite electrodes
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. Paints and varnishes means 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.
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.
Plastic 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.
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 firefighting products	The product group comprises barbeque charcoal, briquettes, firelighters, firewood, pellets and wood chips.
Textiles	Apparel and home/interior textiles (e.g. bedlinen, towels, tablecloths, curtains etc.) consumed by households, and similar products consumed by government and business (e.g. uniforms and workwear used by all public and private sectors, bedlinen and towels etc. consumed by hotels, restaurants, healthcare services etc.) + footwear 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 are not the dominant component (e.g. upholstery textiles, carpets mainly made of plastics, duvets, pillows) and leather.
Toys	The product group covers toys that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded: 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

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[45]).
Wood-based panels	Wood-based panels such as particleboards, oriented-strand board, fibreboard, rigidboard and flexboard, softboard, hardboard, particleboard pallets and pallet block (BREF)

[45] 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 2. Screening of products

End-use products

Table 13 Results of the screening assessment for all end-use products initially listed. Green shading indicates products that were shortlisted. Red shading indicates products that were not shortlisted.

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	Perez-Arribas et al. 2021
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

Ceramic Products	26 billion EUR in 2020	High - resource depletion - air pollution - climate change - energy consumption	Partly regulated - BAT-AELs for ceramics - REACH	Shortlisted	JRC, 2007; European Commission; CerameUnie
Cosmetics	80 billion EUR in 2021	High - water impacts - microplastics - biodiversity	Partly regulated - Cosmetic Products Regulation	Shortlisted	Faraca et al., 2021; 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	40 billion EUR in 2022	High - water pollution - microplastics - biodiversity effect	Partly regulated - Detergent Products Regulation	Shortlisted	AISE, 2021
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[46]	High - microplastics - biodiversity effect	Partly Regulated - Single Use Plastic Directive - Regulation No 1224/2009 Community control system for ensuring compliance with rules of the Common Fisheries Policy - Directive 2019/883 on port reception facilities for the	Shortlisted	CEAP, 2018; Statista; EMR, 2022

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

			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
Means of transportation (road)	394 billion EUR in 2015	High - climate change - air emissions - water emissions	Regulated: - ETS - Regulation 2019/631 and Regulation 2019/1242 on CO2 emissions - Car labelling directive 1999/94 - EU strategy for low-emission mobility + road safety policies	Not shortlisted because of the extensive regulatory framework	Rodriguez Quintero et al., 2022; Allied Market Research
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

Textiles and footwear	175 billion EUR in 2021[47]	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	15 billion EUR in 2015	High - waste generation - use of resources	Partly regulated - EU Toy Safety Directive	Shortlisted	TIE
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

[47] The market value includes leather footwear.

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 end-use products are indirectly covered by the Packaging and Packaging Waste Directive

Intermediate products

Table 14 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	High - energy consumption - biodiversity - air and water pollution	Partly regulated - BAT-AELs for Non-Ferrous Metals, Aluminium - ETS -Taxonomy	Shortlisted	JRC, 2016 ; European Aluminium
Chemicals	500 billion EUR in 2020[48]	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

[48] 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
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	125 billion EUR in 2021	High - energy consumption - climate change - air and water pollution	Partly regulated - BAT-AELs for Ferrous metals, Iron and steel production - ETS - Taxonomy	Shortlisted	Eurofer
Paper, pulp paper and boards	95 billion EUR in 2021	High - energy consumption - biodiversity - water and air pollution	Partly regulated - BAT-AELs for paper - New EU Forest Strategy of 2030	Shortlisted	CEPI, 2022
Plastic 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) - ETS - Taxonomy	Shortlisted	Eurometaux
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 3. Inventory for strategic autonomy assessment

Table 15: List of materials considered in the simplified "Bill of Materials" for each product group. The product groups in bold are intermediate products.

	#1	#2	#3	#4
Product group name	CRM1	CRM2	other (strategic) material #1	other (strategic) material #2
Tyres	Natural rubber	-	Synthetic rubber	Carbon black
Iron and Steel	Coking coal	Niobium	Vanadium	Chromium
Chemicals	Phosphorus	Phosphate rocks	Fossil hydrocarbons	-
Non-ferrous metal products (excl. Aluminium)	Magnesium	Titanium	Copper	Cobalt
Plastic & Polymers	Titanium	Barite	Crude oil	-
Aluminium & Al-alloys	Bauxite	Silicon metal	Fluorspar	Scandium
Paints	Titanium	Barite	Talc	Cobalt
Glass	REEs	Borate	Lithium	Silica sand
Ceramic products	Yttrium	Borate	Kaolin clay	Zirconium
Lubricants	Lithium	Natural graphite (flake)	fMineral oil	-
Paper, Pulp paper and boards	Barite	-	Kaolin clay	Talc
Bed Mattresses	Natural rubber	-	PU foam	-
Detergents	Phosphate rock	-	Sodium salts	Chemicals (organic compounds)
Absorbent Hygiene Products	-	-	Natural cellulose fibres (cotton)	Synthetic fibres
Fishing nets / gear	-	-	Synthetic fibres	-
Textiles (Textile, Garment, Footwear)	-	-	Natural cellulose fibres (cotton)	Synthetic fibres (from crude oil)
Toys (non-electric)	Natural rubber	-	Plastics	-
Cosmetics	-	-	Talc	Sodium salts
Furniture	Natural rubber	-	Natural teak wood	Sapele wood

Annex 4. Assessment of environmental relevance: environmental categories considered

Table 16 Environmental categories considered in the assessment of environmental relevance for end-use products and intermediate products. Please note that for intermediate products the categories "material efficiency" and "lifetime extension" were not evaluated.

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 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 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 does 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 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 air effects, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends does 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 does 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 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 biodiversity effects, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends does 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 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 waste generation, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends does 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 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 GHG emissions, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends does 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 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 lifetime energy consumption, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends does 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 does 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 does 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. Lightweighting. 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 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 material efficiency, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends does 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 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 lifetime extension, but the issues caused so far have not been significant. These issues are currently being addressed. Technology and market trends does 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. Individual product group assessments

Reading guidelines for the products' factsheets

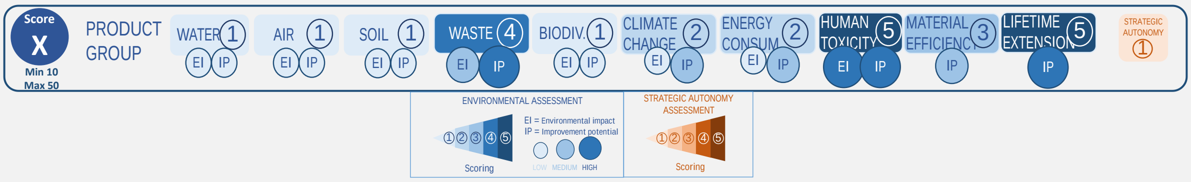
Below is the general structure of the assessments that were carried out for each of the shortlisted end-use and intermediate products, as explained in Section 3 of the report. The aim of this template is to give an overview of the aspects that were considered in the assessment.

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 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:



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

Explanation of main 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]

Explanation of main improvement potential 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).

Potential measures under ESPR:

List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to water effects

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

Explanation of main 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]

Explanation of main improvement potential 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).

Potential measures under ESPR:

List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to air effects

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

Name of the Product Group
Explanation of main 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] Explanation of main improvement potential identified 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 : List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to soil effects
Biodiversity Effects [scoring in brackets 1-5] Impact: [Low/Medium/High] Explanation of main impacts identified related to biodiversity including deforestation, effects on animal population, reduction of ecosystem resilience, surface affected. Environmental Improvement potential: [Low/Medium/High] Explanation of main improvement potential identified related to biodiversity including deforestation, effects on animal population, reduction of ecosystem resilience, surface affected. Potential measures under ESPR :List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to biodiversity effects
Waste Generation & Management [scoring in brackets 1-5] Environmental Impact: [Low/Medium/High] Explanation of main 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] Explanation of main improvement potential 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. Potential measures under ESPR :List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to waste generation and management
Climate Change [scoring in brackets 1-5] Environmental Impact: [Low/Medium/High] Explanation of main impacts identified related to life cycle GHG emissions and related effects. Improvement potential: [Low/Medium/High] Explanation of main improvement potential identified related to life cycle GHG emissions and related effects. Potential measures under ESPR :List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to climate change
Life Cycle Energy consumption [scoring in brackets 1-5] Environmental Impact: [Low/Medium/High] Explanation of main 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] Explanation of main improvement potential identified related to the energy efficiency of products, electricity

Name of the Product Group

consumption, energy recovery, fuel consumption, gas consumption and related effects.

Potential measures under ESPR :List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to energy consumption

Human Toxicity [scoring in brackets 1-5]
Environmental Impact: [Low/Medium/High]

Explanation of main impacts identified related to human toxicity (cancer and non-cancer 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]

Explanation of main improvement potential identified related to human toxicity (cancer and non-cancer 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 :List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to human toxicity. This section is normally empty because it's not in the scope of ESPR to regulate aspects related to human toxicity

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

Explanation of main improvement potential identified 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.

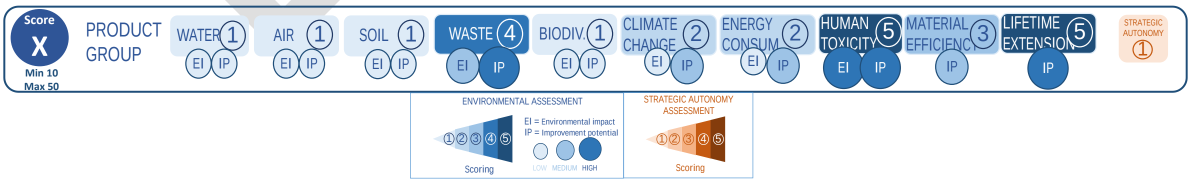
Potential measures under ESPR :List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to material efficiency

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

Explanation of main improvement potential identified related to measures such as durability, reparability, reusability, upgradability, reliability, ease of maintenance, or remanufacturing.

Potential measures under ESPR :List of the possible performance and/or information requirements that could be set by ESPR Delegated Acts with respect to lifetime extension

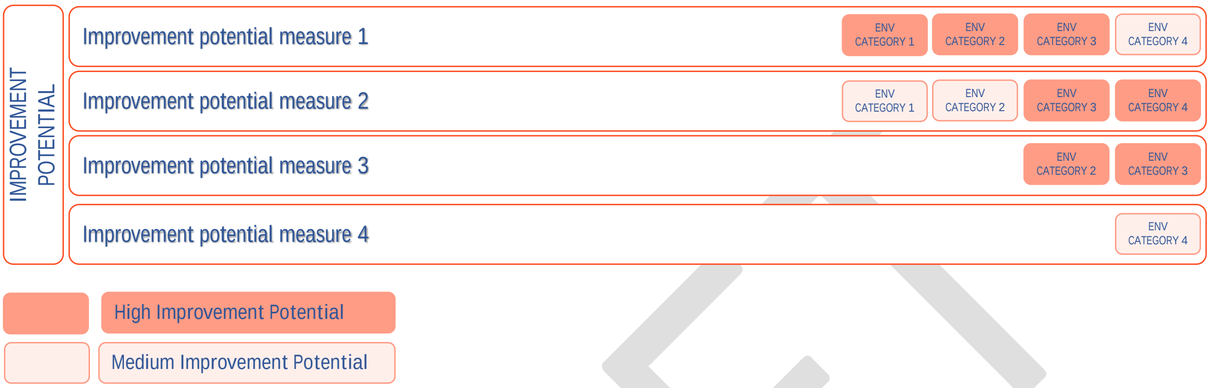
Final environmental score [scoring in brackets]



Strategic autonomy score [scoring in brackets 1-5]

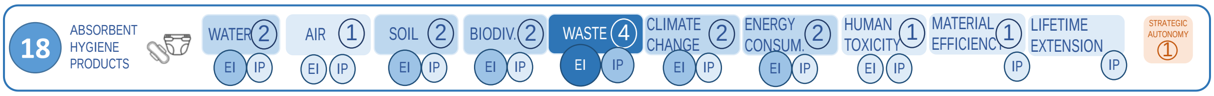
For products with a strategic autonomy score of 3, 4 and 5 points, an explanation of the improvement potential is given

Policy Gaps
This box summarises whether the PG's current policy framework is addressing the areas where improvement potential was identified. It presents the areas where there are gaps and these gaps are compared with the

Name of the Product Group
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 This summary helps guide the decision to prioritise or not the product under ESPR, but the final choice of measures and their exact definition can only be made after the full preparatory study and impact assessment are done. The potential measures identified here are therefore purely indicative. 
Proportionality of Costs This box provides available evidence to answer the question on whether potential measures identified above would entail disproportionate costs.
Additional notes and list of references

End-use products

Box 1. Factsheet for Absorbent Hygiene Products

<table>
<tr><th>ABSORBENT HYGIENE PRODUCTS</th></tr>
<tr><td></td></tr>
<tr><td>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.</td></tr>
<tr><td>Water Effects [2]
Environmental impact: Medium

AHP material production consumes water, potentially polluting it. In general, water emissions from material production used in AHP are P, Zn, Adsorbable Organically bound Halogens (AOX), and Organically bound Chlorine (OX), among others ([1]). These water emissions occur for all types of hygiene products, disposable or reusable. Nevertheless, the majority of currently used AHP are disposable products made of plastic that can damage wastewater treatment infrastructures, 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]).

Improvement potential: Low

There is a considerable improvement potential either by recycling (several studies at research level and three industrial sites on place), by replacing the plastic content with other materials or by substituting the single-use AHP by reusable products ([4]). Water emissions during the production of AHP components are reduced by means of abatement techniques as listed in several BREF documents consulted, just of application in Member States (MS) though ([5, 6]). Other measures to lower the impact of disposable AHP in water is through consumer awareness in relation to how to dispose AHP and which reusable options are available in the market. The main action is to provide information accompanying the products as these aspects are difficult to regulate ([1]).

Potential measures under ESPR:

- performance requirements on design for disassembly to enable the separation of recyclable parts

- performance requirements on maximum limit of water consumption per kg or unit of product (or component)

- information requirement on water consumption during production per kg or unit of product</td></tr>
<tr><td>Air Effects [1]

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 AHP component production are reduced by means of abatement techniques as listed in several BREF documents consulted and mandatory for MS ([5, 6]).

Potential measures under ESPR:

- information requirement on air pollution during production per unit of product</td></tr>
<tr><td>Soil Effects [2]
Environmental impact: Medium

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</td></tr>
</table>

environmental burdens respectively (4). 'Resource Use – fossils' also ranked 2nd for baby nappies with a 23% share of the total environmental burdens (4). Single-use AHP are composed of plastic materials (70-100% of their composition) and, depending on the product, natural resources such as fluff pulp and man-made cellulose (20-30%) (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 new-born baby until they cease to use them (2.5 years) (3).

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 are measures to apply (1) to AHP.

Potential measures under ESPR:

- performance requirement on minimum content of material with sustainability* certification per kg or unit of product (or component)
- performance requirement on minimum recycled content
- performance requirement on design for disassembly to increase material recovery
- performance requirement on design for recyclability
- information requirement on sourcing of materials from certified sustainable practices
- information requirement on how to correctly use and dispose of the product

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). 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 are measures to apply (1). Besides biodiversity management plans to mitigate impacts or promote increased biodiversity from manufacturing of the intermediates and final AHP could have an impact.

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability* certification per kg or unit of product (or component)
- performance requirement on minimum recycled content
- information requirement on sourcing of materials from certified sustainable practices
- information requirement on how to correctly use of the product

Waste Generation & Management [4]
Environmental impact: High

The End-of-Life (EoL) of AHP is an environmentally impactful LCA stage. The predominant EoL for AHP waste streams is incineration or landfilling (7). Landfilling can occur under controlled (municipal waste; landfills) or uncontrolled conditions (dumping, littering) (7), ending in many instances in the marine environment as the location of microplastic release.

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]).

Improvement potential: Medium

The reduction of waste production 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. In this regards, the exploration of waste management systems is under way due to the conditions to fulfil to make this type of options competitive ([1]). Design for recycling measures can play a role so that consumers can separate the parts that can be recycled. Content of recycled material is normally not used by the producers, however future investigations could explore how to make that possible, e.g. in layers of the product not in contact with the skin of the user.

Potential measures under ESPR:

- performance requirements on design for disassembly to enable the separation of recyclable parts
- performance requirements on design for recyclability to reduce multimaterial products
- performance requirement on minimum recycled content per kg of product.
- information requirement on recycled content per kg of product
- information requirement on how to correctly use and dispose of the product

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 contrast, 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 production while the switch to reusable products would also highly contribute. LCA results are to be considered in conjunction with other sources of information on environmental aspects, particularly where gaps exist in the available LCA studies. Methods to be applied might differ among countries or depending on industrial prospects ([1]).

Potential measures under ESPR:

- performance requirement on maximum level of CO_2 emissions during production, per kg of product or component
- information requirement on CO_2 emissions per kg of product

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

Measures listed as BAT could lead to a reduction of GHG emission in production while the switch to a certain percentage of reusable products has shown resources' savings ([1]).

Potential measures under ESPR:

- performance requirement on maximum level of energy consumption during production, per kg of product or component

- information requirement on energy consumption during production, per kg of product

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 for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).

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]). 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]). Hence, in the current scenario, recycled content in AHP products can only be present in the packaging which is not in direct contact with the final product ([1]). Nevertheless, however this 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) and of cleaner recycled materials develops ([1]).

On the other hand, AHP substitution with alternative products has been suggested as a way of decreasing environmental impacts but this frequently implies a trade-off in different impact categories ([7]). The future potential for improvement could also reside within substituting current single-use versions by reusable products ([4]). The highest improvement potential is the recyclability of certain sections of used AHP ([4]).

Potential measures under ESPR:

-

- performance requirements on design for recyclability to reduce multi-material products

- performance requirement on minimum recycled content per kg of product

- information requirement on recycled content per kg of product

Lifetime extension [1]

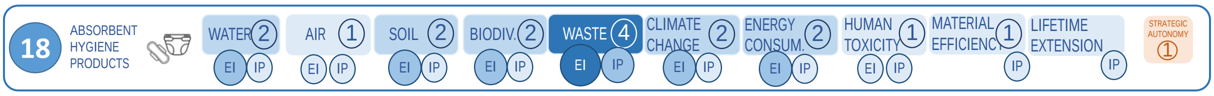
Improvement potential: Low

The lifetime of disposable or single-use AHP cannot be extended. Recycled materials is currently not used in AHP due to sanitary and hygiene reasons, however this 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) and of cleaner recycled materials develops ([1]).

Potential measures under ESPR:

ABSORBENT HYGIENE PRODUCTS
- performance requirement on minimum reliability (e.g. resistance to wetting, no leakage due to movements) - information requirement on how to correctly use and dispose of the product

Final score [18]



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 standards 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]). However, with respect to biobased AHP, there is no policy strategy or legislation specifically dedicated on the EU level. Such legislative gap may be linked to a technical problem of the use of biobased materials in this type of products. It is therefore necessary to develop a regulation that takes into account the state of the art.

With respect to bio-based components, at the moment of writing of this report, the EC has proposed a Regulation to tackle EU-driven deforestation and forest degradation ([54]), 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.

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	Minimum recycled content	SOIL	WASTE	BIODIVERSITY	
	Design for disassembly to increase material recovery	SOIL	WASTE		
	Minimum content of material with sustainability certification per kg or unit of product (or component)	SOIL		BIODIVERSITY	
	Design for recyclability	SOIL	WASTE		MATERIAL EFFICIENCY

ABSORBENT HYGIENE PRODUCTS

INFORMATION REQUIREMENTS	
Sourcing of materials from certified sustainable practices	SOIL, BIODIVERSITY
Recycled content per kg of product	MATERIAL EFFICIENCY, WASTE
How to correctly use and dispose of the product	BIODIVERSITY, SOIL, WASTE

Proportionality of Costs

There are no conclusive indications in the available literature on the costs related to the potential ESPR measures proposed in this product fiche. There exist three ISO type I ecolabelling schemes in the EU which certify the superior environmental performance of ecolabelled products with respect to the rest of the market. If prioritised under the final Working Plan, the development of the performance requirement will have to take in due account that the costs implied shall not lead to disproportionate costs.

Additional notes and list of references

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

(1) Faraca, G., M.N. Pérez Camacho, Z. Pérez Arribas, M.A. Kowalska, and O. Wolf, Revision of EU Ecolabel Criteria for Absorbent Hygiene Products Technical Report v. 2.0., Technical report, The EU Joint Research Centre., May 2022.

(2) 'Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the Reduction of the Impact of Certain Plastic Products on the Environment', Official Journal of the European Union, Vol. 155, June 12, 2019, pp. 1–19.

(3) Cabrera, A., and R. Garcia, The Environmental & Economic Costs of Single-Use Menstrual Products, Baby Nappies & Wet Wipes: Investigating the Impact of These Single-Use Items across Europe. November 2019.

(4) Pérez Arribas, Z., M.A. Kowalska, M.N. Pérez Camacho, G. Faraca, G. Tosches, D. Sinkko, and O. Wolf, Revision of EU Ecolabel Criteria for Absorbent Hygiene Products Preliminary Report., The EU Joint Research Centre., September 2021.

(5) Suhr M., Klein G., Kourti I., Gonzalo M.R., Giner Santonja G., Roudier S., Delgado Sancho L., Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board, Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control), 2015.

(6) European Commission (2007) Reference document on best available techniques in the production of polymers.

(7) Velasco Perez, M., P.X. Sotelo Navarro, A. Vazquez Morillas, R.M. Espinosa Valdemar, and J.P. Hermoso Lopez Araiza, 'Waste Management and Environmental Impact of Absorbent Hygiene Products: A Review', Waste Management & Research: The Journal for a Sustainable Circular Economy, Vol. 39, No. 6, June 2021, pp. 767–783.

(8) Environment Agency. (2008). Using science to create a better place. An updated life cycle assessment study for disposable and reusable nappies. UK.

(9) Technology and Operations management (2016). The Ecological Impact Of Feminine hygiene Products. MBA students Perspectives.

(10) Safety of Baby Diapers. ANSES Revised Opinion. Collective Expert Appraisal Report., Scientific edition, French Agency for food, environmental and occupational health and safety (ANSES), January 2019.

(11) DE-UZ 208. Nappies, Feminine Hygiene and Incontinence Products (Absorbent Hygiene Products, AHP), Edition 2021, Blue Angel. The German Ecolabel. 2021.

(12) Nordic Ecolabelling for Sanitary Products, Nordic Swan, June 14, 2016.

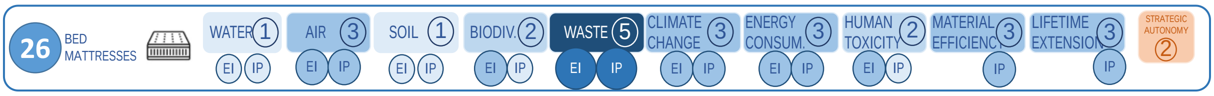
(13) Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on Medical Devices. Amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and Repealing Council Directives 90/385/EEC and 93/42/EEC', The Official Journal of the European Union, Vol. 60, No. 117, May 5, 2017.

(14) Webinar series co-hosted by the Menstrual Health Alliance of India, the African Coalition for Menstrual Health Management, MH Day and the Reproductive Health Supplies Coalition.

(15) Khoo, S. C., Phang, X. Y., Ng, C. M., Lim, K. L., Lam, S. S. and Ma, N. L., 'Recent technologies for treatment and recycling of used disposable baby diapers', Process Safety and Environmental Protection, Vol. 123, Elsevier, 2019, pp. 116-129.

Box 2. Factsheet for Bed Mattresses

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[49] 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 water consumption per kg or unit of product (or component)

- performance requirement on minmum content on of materials with sustainability certification per kg or unit of product (or component);

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

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 design for disassembly to increase material recovery to avoid air pollution due to raw material extraction

- performance requirement on minimum content of materials with sustainability certification per kg or unit of product (or component)

- performance requirement on minimum recycled content per unit of mattress manufactured

- performance requirement of maximum level of GHGs emitted during manufacturing by product

- performance requirement of maximum energy consumed during manufacturing by product

- performance requirement on minimum percentage of energy use per kg of product from low carbon

[49] Polyurethane

BED MATTRESSES
footprint sources - performance requirement on design to facilitate bed mattress disassembly - performance requirement on design to facilitate refurbishing and recycling - performance requirement on minimum durability of the product (during normal conditions of use) - information requirement on how to use the product to increase durability to avoid air pollution due to raw material extraction - information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components) - information requirement on sourcing of materials from certified sustainable practices - information requirement of level of GHGs emitted during manufacturing by product - information requirement of percentage of energy use per kg of product from low carbon sources - information requirement on expected lifetime of the product, and/or on how often to substitute/replace the product - information requirement for treatment facilities on how to disassembly, recycle and disposal
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 per unit of product (or component)
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 per unit of product (or component)
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). Up to 95% of the materials in a mattress can be recycled in some way (3).

BED MATTRESSES

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]).

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]). Considering a life-cycle approach, requirements on design stage are crutial to ease dissasembly, recovery and recycling processes wich have a direct impact on reducing the percentage of bed mattresses that end in landfills. The hotspots that need to be improved are the low cost of landfilling, the low quality of the materials arising from mattresses, the need to store end-of-life mattresses in a clean and dry place, the current mattress designs preventing easy disassembly and the low treatment capacity of the facilities ([6]).

Potential measures under ESPR:

- performance requirement on design to facilitate bed mattress disassembly

- performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction

- performance requirement on minimum recycled content per unit of mattress manufactured

- performance requirement on design to facilitate refurbishing and recycling

- performance requirement on minimum durability of the product (during normal conditions of use)

- information requirement on how to use the product to increase durability to avoid air pollution due to raw material extraction

- information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components)

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

- information requirement for treatment facilities on how to disassembly, recycle and disposal

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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 allows a 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]), 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 minimum content of materials with sustainability certification per kg or unit of product (or component)

- performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction

- performance requirement on design to facilitate bed mattress disassembly

- performance requirement on minimum recycled content per unit of mattress manufactured

- performance requirement on design to facilitate refurbishing and recycling

BED MATTRESSES

- performance requirement on minimum durability of the product (during normal conditions of use)

- performance requirement on a maximum level of GHGs emitted during manufacturing by product

- performance requirement on maximum energy consumed during manufacturing by product

- performance requirement on minimum percentage of energy use per kg of product from low carbon footprint sources

- information requirement on how to use the product to increase durability to avoid air pollution due to raw material extraction

- information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components)

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

- information requirement on the level of GHGs emitted during manufacturing by product

- information requirement on the percentage of energy use per kg of product from low carbon footprint sources

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

- information requirement for treatment facilities on how to disassembly, recycle and disposal

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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).

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).

Potential measures under ESPR:

- performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction

- performance requirement on design to facilitate bed mattress disassembly

- performance requirement on minimum content of materials with sustainability certification per kg or unit of product (or component)

- performance requirement on minimum recycled content per unit of mattress manufactured

- performance requirement on design to facilitate refurbishing and recycling

- performance requirement on minimum durability of the product (during normal conditions of use)

- performance requirement on a maximum energy consumed during manufacturing by product

- performance requirement on minimum percentage of energy use per kg of product from low carbon footprint sources

- information requirement on how to use the product to increase durability to avoid air pollution due to raw material extraction

- information requirement on how to use the product to avoid premature substitution/replacement (or of its components)

BED MATTRESSES
- information requirement on the percentage of energy use per kg of product from low carbon footprint sources - information requirement on expected lifetime of the product. And/or on how often to substitute/replace the product - information requirement for treatment facilities on how to disassembly, recycle and disposal
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[50] 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 [3] Improvement potential: Medium The potential for improvement of bed mattresses lies in design for disassembling and recovery of materials due to the findings that suggest that the major impacts of a mattress lifecycle are associated with production of the components which are then used to manufacture mattresses ([3]). Mattresses may contain recycled materials, such as recycled textiles used as part of the mattress filling and springs made of recycled metals ([5]). Up to 95% of the materials in a mattress can be recycled in some way ([3]). The proportion of recycled steel in spring mattresses can reach up to 80% ([3]). At least 85 % of the bed mattresses mass can be readily recycled through simple disassembly ([6]). It can be observed that recycling rather than landfilling allows a significant environmental benefit, reducing GHG emissions by 45 % ([6]). Potential measures under ESPR: - performance requirement on design to facilitate bed mattress disassembly - performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction - performance requirement on minimum durability of the product (during normal conditions of use) - performance requirement on design to facilitate refurbishing and recycling - Information requirement on how to use the product to increase durability to avoid air pollution due to raw material extraction - Information requirement for treatment facilities on how to disassembly, recycle and disposal
Lifetime extension [3]

[50] Polybrominated diphenyl ethers

BED MATTRESSES

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]).

Potential measures under ESPR:

- performance requirement on minimum durability of the product (during normal conditions of use)

- performance requirement on design to facilitate refurbishing and recycling

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

- information requirement on how to use/maintain the product to avoid its premature substitution/replacement (or of its components)

- information requirement on how to use the product to increase durability to avoid air pollution due to raw material extraction

- information requirement for treatment facilities on how to disassembly, recycle and disposal

Final score [27]

Strategic autonomy score: [2]

Policy Gaps

There is an absence of specific mandatory regulation related to environmental matter 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, at the moment of writing of this report, the EC has proposed a Regulation to tackle EU-driven deforestation and forest degradation ([54]), 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 policy gaps which are not currently regulated are the design for disassembling 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 end their useful life in landfills and promoting the design for disassembling and recovery of materials ([3]). The hotspots that need to be improved are the low cost of landfilling, the low quality of the materials arising from mattresses, the need to store end-of-life mattresses in a clean and dry place, the current mattress designs preventing easy disassembly and the low treatment capacity of the facilities ([6]).

Summary of potential measures to reduce environmental impacts

BED MATTRESSES

Group	Requirement	Air	Waste	Climate change	Energy use	Material efficiency	Lifetime extension
PERFORMANCE REQUIREMENTS	Design for disassembly to increase material recovery to avoid air pollution due to raw material extraction	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
	Minimum content of materials with sustainability certification per kg or unit of product (or component)	AIR		CLIMATE CHANGE			
	Design to facilitate bed mattress disassembly	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
	Minimum recycled content per unit of mattress manufactured	AIR	WASTE	CLIMATE CHANGE	ENERGY USE		
	Design to facilitate refurbishing and recycling	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	Minimum durability of the product (during normal conditions of use)	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	Maximum level of GHGs emitted during manufacturing by product	AIR		CLIMATE CHANGE			
	Maximum energy consumed during manufacturing by product	AIR		CLIMATE CHANGE	ENERGY USE		
	Minimum percentage of energy use per kg of product from low carbon footprint sources	AIR		CLIMATE CHANGE	ENERGY USE		
INFORMATION REQUIREMENTS	How to use the product to increase durability to avoid air pollution due to raw material extraction	AIR	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	How to use and maintain the product to avoid its premature substitution/replacement (or of its components)	AIR	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
	Sourcing of materials from certified sustainable practices	AIR		CLIMATE CHANGE			
	Level of GHGs emitted during manufacturing by product	AIR		CLIMATE CHANGE			
	Percentage of energy use per kg of product from low carbon footprint sources	AIR		CLIMATE CHANGE	ENERGY USE		
	Expected lifetime of the product, and/or on how often to substitute/replace the product	AIR	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
	For treatment facilities on how to disassembly, recycle and disposal	AIR	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION

Proportionality of Costs

Data related to the costs associated to possible circularity and environmental measures of bed mattresses are very scarce. In general, high costs can be attributed to disposal of the bed mattress to landfill. For these reasons, promoting the circularity of bed mattresses could reduce the number of old bed mattresses disposed of via landfill, and, thus, the associated costs.

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.

Box 3. Factsheet for Ceramic products

CERAMIC PRODUCTS

Scope: 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. Sanitaryware are lavatory bowls, bidets, wash basins, cisterns and drinking fountains. Technical ceramics supply aerospace and automotive industries (engine parts, catalyst carriers), electronics (capacitors, piezo-electrics), biomedical products (bone replacement), environment protection (filters) and many others. inorganic bonded abrasive is a tool where a synthetic abrasive is blended with a vitrified bond.

Water Effects [3]

Environmental impact: Medium

Water is a very important raw material but the amount used varies greatly between sectors and processes. Process waste water is generated mainly when clay materials are flushed out during the manufacturing process and equipment cleaning. The waste water in the process mostly shows turbidity and colouring owing to the very fine suspended particles of glaze and clay minerals (1). From a chemical point of view, these are characterised by the presence of: suspended solids: clays, frits and insoluble silicates in general; dissolved anions: sulphates; suspended and dissolved heavy metals: e.g. lead and zinc; boron in small quantities; traces of organic matter (screen printing vehicles and glues used in glazing operations) (4).

Average water consumption per square metre of manufactured tiles is around 20 L Milling the body composition consumes about 60% of the water used (5)

Regarding toilets and urinals, the impacts, in terms of water consumption, associated with the use phase outweigh those occurring in the other life cycle phases of the product. In the use phase, the impacts of water and sewage treatment are generally equally significant, with the exception of eutrophication impacts which are significantly higher for sewage treatment than for water treatment (15). Water consumption due to toilets and urinals in the EU is equal to 18 870 million m3/year (16), which represents 25% of domestic water in EU-27 (17).

Improvement potential: Medium

In terms of improvement potential, new developments in dry milling and granulation systems are leading to reconsider the dry route as an interesting alternative for the production of ceramic tiles with low environmental costs. In the dry method, water consumption is significantly reduced (by 74%) since it negates the need to prepare a slurry, thermal energy consumption and CO_2 direct emissions are reduced by 78%, while electricity consumption is reduced by 36%. (5)

Water-efficient toilets may use as less as 4 litres per flush compared to average toilets that use about 11 litres per flush. However, taking into account user behaviour, a reasonable estimate for water consumption saving potential is around 20% of water used (16)

Potential measures under ESPR:

- performance requirement on maximum limit of water consumption per kg/ton of product during production

- performance requirement on design for minimising water consumption during use of the product (toilets and urinals)

- performance requirement on minimum recycled content per tonne of product to avoid water consumption due to raw material extraction;

CERAMIC PRODUCTS
- information requirement on water consumption per kg/ton of product - information requirement on recycled content per ton of input material - information requirement on how to use/maintain the product (toilets and urinals)
Air Effects [3] Environmental impact: Medium The manufacturing of ceramics products lead to significant emissions to the air (1): dust formation in the processing of dry materials; Fluoride, Hydrofluoric acid and Fluorine compounds released during drying, calcining and firing; Sulphur oxides (mainly SO_2) in flue-gases is closely related to the sulphur content of the raw material (pyrite), and of the fuel (combustion of solid fuels and fuel oils; Nitrogen oxides mainly produced during combustion of fuels (mainly solid or liquid types) or organic additives at high temperatures (especially>1200 ºC) and by excess oxygen; Carbon monoxide from the combustion of organic matter in the ceramic body, especially under low oxygen conditions; volatile organic compounds during early heating process from organic matter coming from raw materials and additives and Hydrochloric acid (HCl) emissions from raw materials and additives. The main source of particulate matter emissions is the handling of raw materials (4) Improvement potential: Medium In terms of improvement potential, the impact of the manufacturing process, mainly deriving from dust generation and firing processes, could be reduced on one hand with control techniques to reduce fugitive particulate matter emissions (4) and on the other, decreasing fuel consumption, thus reducing air emission pollutants such as sulphur oxides, nitrogen oxides, hydrofluoric acid, and hydrochloric acid, and their associated environmental impacts. Combination of measures such as heat recovery from the burners of the kiln, lighting system improvements, and transport minimization are the most effective for environmental impact reduction (6). Alternative strategies such as *reshoring* or *nearshoring* could contribute to minimise transport, reduce climate change warming potential and reduce risk in resource-Intensive supply chains (14). It has to be considered that some of these measures are already partially in place. Potential measures under ESPR: - performance requirement on minimum recycled content per tonne of product to avoid air pollution due to raw material extraction - performance requirement on design for disassembly to increase recycling (pipes and sanitaryware) - performance requirement on the sourcing of raw materials from certified sustainable practices (if aplicable) - performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution - information requirement on recycled content per ton of input material - information requirement on the sourcing of raw materials from certified sustainable practices - information requirement on the percentage of energy use from low carbon source - information requirement on how to correctly dose additives to increase durability and avoid air pollution due to raw material extraction - information requirement on how to maintain the product to increase durability to avoid air pollution due to new products acquisition - information requirement on how to repair the product to increase durability to avoid air pollution due to new products acquisition
Soil Effects [3] Environmental impact: High A vast range of raw materials is consumed by the ceramic industry. These include the main body forming materials, involving high tonnages, and various additives, binders and decorative surface-applied materials

which are used on a lesser scale (1).

Raw material extraction for ceramic products require mining and quarrying operations with irreversible impacts characterised by the destruction of land, of its productive potential, of the vegetation cover and of the animal populations located within the more or less immediate surroundings. These operations entail the total modification of the surface as well as have important physical, chemical and biological limitations that make it difficult to reintroduce the original vegetation. These significant environmental impacts linger far beyond the time needed to carry out the actual operations (7).

Improvement potential: Low

Nevertheless, with careful planning and management, it is possible to minimize the effect on soil.

Potential measures under ESPR:

- performance requirement on minimum content of material with sustainability certification per kg or unit of product (or component)

Biodiversity Effects [3]
Environmental Impact: Medium

One of the biggest negative impacts of quarrying on the environment is the damage to biodiversity with the potential of destroying habitats and the species they support. Even if the habitats are not directly removed by excavation, they can be indirectly affected and damaged by changes to ground water or surface water that causes some habitats to dry out or others to become flooded or noise pollution that can have a significant impact on some species and affect their successful reproduction (10).

Improvement potential: Medium

Nevertheless, with careful planning and management, it is possible to minimize the effect on biodiversity. (10).

Potential measures under ESPR:

- performance requirement on minimum content of material with sustainability certification per kg or unit of product (or component)

- performance requirement on minimum recycled content per unit/tonne of product

- information requirement on recycled content per ton of input material

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

Waste Generation & Management [3]
Environmental impact: Medium

Quarrying involves the production of significant amounts of waste, generally inert and non-hazardous, however, there is still potential for damage to the environment, particularly with water contamination. Suspended particles may imbalance freshwater ecosystems. Large amounts of solids can also exacerbate flooding, if it is dumped on the flood plains. Lastly, the accumulation of waste by-products will still need to be stored and managed somewhere that will not affect the environment in an adverse manner (10).

From the manufacturing of ceramic products process, waste mainly consists of (1): sludge from the process waste water treatment facilities involved in cleaning body preparation, glaze preparation and application equipment, and also from wet grinding; broken material from shaping, drying, firing among other treatments; dust arises from off-gas cleaning units; used plaster moulds from shaping processes; used sorption agents (granular limestone, limestone dust) arise from flue-gas cleaning systems; packaging waste and solid residues, e.g. ashes arise from firing with solid fuels.

Improvement potential: Medium

The potential for improvement lies in addressing recycling and the internal reuse of products, including sludge, dust or fired broken ware as raw material (4) as well as increasing the lifespan of plaster moulds. It has to be considered that some of these measures are already partially in place.

CERAMIC PRODUCTS
Potential measures under ESPR: - performance requirement on minimum service life for plaster moulds - performance requirement on minimum recycled content per kg or unit of ceramic product - performance requirement on design for extended product lifetime - performance requirement on maximum weight per item (light-weight design) - information requirement on to use/maintain the product to avoid its premature substitution/replacement - performance requirement on availability of spare parts (for selected applications) - performance requirement on design for disassembly to increase recycling, for selected applications (e.g. pipes and sanitaryware) - information requirement on recycled content per ton of input material - information requirement on how to correctly dose additives to increase the lifetime of the product - information requirement on how to repair the product
Climate Change [4] Environmental impact: High The ceramics industry is responsible for emitting a substantial amount of greenhouse gases ([11]), mainly associated with the use of energy in the kiln and spray dryer. The greenhouse gas (GHG) emissions of the global ceramic production is estimated at more than 400 Mt CO_2/year, which have increased steadily from economic growth ([12]). Improvement potential: Medium The improvement potential strategies to reduce the impact of greenhouse gas emissions from ceramics manufacturing are among others ([4]): replace inefficient kilns and install new, adequately sized tunnel; improving thermal insulation of kilns to reduce heat loss or using high-velocity burners to obtain a higher combustion efficiency and heat transfer. It has to be considered that some of these measures are already partially in place. Potential measures under ESPR: - performance requirement on a maximum level of GHG emissions during manufacturing by mass of product - performance requirement on minimum percentage of energy use from low carbon sources - performance requirement on minimum recycled content per unit tonne of product - performance requirement on design for disassembly to increase recycling (pipes and sanitaryware) - information requirement on the GHGs emitted during manufacturing by mass of product - information requirement on recycled content per ton of input material - information requirement on the percentage of energy use from low carbon source - information requirement on how to correctly dose additives to increase durability - information requirement on how to use/maintain the product to increase durability - information requirement on how to repair the product to increase durability - information requirement on GHGs emitted during manufacturing by mass of product
Life Cycle Energy consumption [4] Environmental impact: High Depending on the type of product, the share of energy costs in the total production costs generally varies between 17 and 30 % with maximum values up to 40 % ([1]). Firing and drying are the hot spots for most

CERAMIC PRODUCTS
environmental impacts considered due to high energy requirements and emissions of acid gases. Improvement potential: Medium The highest energy consumption (90%) occurs in heating, so that energy improvements need to focus on these areas (5). Some options to reduce energy consumption are heat recovery (13) or the dry method (5). Potential measures under ESPR: - performance requirement on a maximum energy consumed during manufacturing by mass of product - performance requirement on the technical lifetime and resistance to stress of product - information requirement on the energy consumed during manufacturing by mass of product - information requirement on the technical lifetime of product
Human Toxicity [1] Environmental impact: Low Workplace exposure to fine airborne particulate in the form of silica dust (SiO_2), deriving from silica sands and feldspar (4). Improvement potential: Low The sector, in compliance with the BREF approved in 2007, has taken measures to reduce the risk of exposure to particulate matter, so there is not much room for improvement in this area, at least in EU. 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 potential for improvement lies in addressing recycling and the internal reuse of products, including sludge, dust or fired broken ware as raw material (4) as well as increasing the lifespan of plaster moulds. It has to be considered that some of these measures are already partially in place. Regarding sanitaryware, and potentially tableware, light-weight design measures could increase the material efficiency of this product groups, however trade-off should be considered as light-weight design may influence negatively the durability of the product. Potential measures under ESPR: - performance requirement on maximum weight per item produced (light-weight design), whenever possible - performance requirement on availability of spare parts (for toilets and urinals) - performance requirement on minimum recycled content per unit tonne of product - performance requirement on design for disassembly to increase recycling (pipes and sanitaryware) - performance requirement on design for reliability - performance requirement on minimum service life for plaster moulds - performance requirement on technical lifetime and resistance to stress of product; - information requirement on recycled content per ton of input material - information requirement on how to correctly dose additives to increase durability - information requirement on how to use/maintain the product to increase durability - information requirement on how to repair the product to increase durability

CERAMIC PRODUCTS

Lifetime extension [3]

Improvement potential: Medium

Even considering the large scope of this product group, it can be concluded that subsequent treatments and the addition of auxiliary materials are aimed at increasing the durability of products. But trade-offs need to be found so that improved lifetime extension does not lead to increased environmental impact.

The lifetime of sanitaryware is generally quite high, but it could be further extended by better maintenance during the use phase, but also by improving the repair of this product, especially with respect to the cistern mechanisms. Indeed, key repair pieces could be unavailable or out of the market after some years from the purchase of the toilet.

Potential measures under ESPR:

- performance requirement on availability of spare parts (for toilets and urinals)
- performance requirement on design for reliability
- performance requirement on technical lifetime and resistance to stress of product
- information requirement on how to correctly dose additives to increase durability
- information requirement on how to use/maintain the product to increase durability
- information requirement on how to repair the product to increase durability
- information requirement on technical lifetime of product

Final score [30]

Strategic autonomy score [2]

Policy Gaps

The environmental impact of the ceramic industry is covered at installation level in the EU by the Industrial Emissions Directive, which establishes best available techniques (BAT) for the ceramic manufacturing industry (from 2007). The BAT for the ceramic industry are currently under review as of 2019. In addition to this, some of the end-use ceramic products fall under specific (voluntary) regulations environmentally relevant, such as Commission Decision (EU) 2021/476 establishing the EU Ecolabel criteria for hard covering products, and Green Public Procurement criteria for office building design, construction and management (Commission staff working document SWD(2016) 180 final, currently under revision). At the moment of writing of this report, the Commission has proposed a revised Construction Products Regulation, which should create a harmonised framework to assess and communicate the environmental and climate performance of construction products

Environmental aspects not currently addressed by EU legislation relate to raw material extraction (mining and quarrying) in terms of impact on biodiversity and soil, re-use measures for ceramic waste (such as fired broken ware) as raw material, measures to improve heat recovery and combustion efficiency to reduce energy consumption and greenhouse gas emissions.

Summary of potential measures to reduce environmental impacts

CERAMIC PRODUCTS		
PERFORMANCE REQUIREMENTS	Maximum limit of water consumption per kg or unit of product during production	WATER
	Design for minimising water consumption during use of the product	WATER
	Design for reliability	MATERIAL EFFICIENCY, LIFETIME EXTENSION
	Minimum recycled content per unit/tonne of product	BIODIVERSITY, MATERIAL EFFICIENCY, WATER, AIR, WASTE, CLIMATE CHANGE
	Design for disassembly	AIR, WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	Sourcing of raw materials from certified sustainable practices	AIR, BIODIVERSITY
	Maximum weight per item (light-weight design)	WASTE, MATERIAL EFFICIENCY
	Minimum percentage of energy use from low carbon sources	AIR, CLIMATE CHANGE
	Minimum service life for plaster moulds	MATERIAL EFFICIENCY, WASTE
	Technical lifetime and resistance to stress of product	MATERIAL EFFICIENCY, LIFETIME EXTENSION, WASTE, ENERGY USE
	Availability of spare parts	WASTE, MATERIAL EFFICIENCY, LIFETIME EXTENSION
	Maximum level of GHG emissions during manufacturing	CLIMATE CHANGE
	Maximum energy consumed during manufacturing	ENERGY USE
INFORMATION REQUIREMENTS	Water consumption during production per kg or unit of product	WATER
	Recycled content per ton of input material	BIODIVERSITY, WATER, AIR, WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	Sourcing of raw materials from certified sustainable practices	BIODIVERSITY, AIR
	Percentage of energy use per kg of product from low carbon sources	AIR, CLIMATE CHANGE
	How to correctly dose additives to increase durability and avoid air pollution	AIR, WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY, LIFETIME EXTENSION
	How to use/maintain the product	WATER, AIR, WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY, LIFETIME EXTENSION
	How to repair the product	LIFETIME EXTENSION, AIR, WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	GHGs emitted during manufacturing by mass of product	CLIMATE CHANGE
	Energy consumption during manufacturing by mass of product	ENERGY USE
	Technical lifetime of product	LIFETIME EXTENSION, ENERGY USE

Proportionality of Costs

The sector has been working for years to reduce the emission of particulate matter into the atmosphere, but further efforts in innovation are needed to decouple production from fossil fuel consumption in order to reduce the emission of other pollutants into the air. Measures related to climate change and energy consumption potentially involve a change in essential parts of the ceramics production process which entail large investments. Data on costs associated to circularity measures for ceramic products are very scarce.

Additional notes and list of references

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

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Box 4. Factsheet for Cosmetic Products

COSMETICS

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, toothpaste, 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[51], 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. musks), preservatives (e.g. parabens) and UV filters ([4]). These substances are usually small molecules with a polar tendency, which WWTP[52] were not designed to treat and for which they therefore have low removal efficiencies ([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 ([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[53] 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 have been associated with important coral bleaching events([12]). Their occurrence in marine systems is expected to rise considering the foreseen temperature rise as well as the increase in populations inhabiting coastal areas (1.2–5.2 billion people by 2080) ([11]). The 'forever chemicals' PFAS[54] are used in cosmetics as components of surfactants ([13]). Cosmetics also represent 2% of the global release of primary microplastics to the world oceans ([14]), can represent up to 10% of the product weight and several thousand microbeads per gram of product ([16]). Production also accounts for a large part of the water impacts of cosmetics: the saponification process used for the manufacturing of cosmetics ingredients results in large amounts of water and many chemicals being used ([15]), and water is the main ingredient of all cosmetic products ([18]). Finally, the use phase of rinse-off products contributes to 40-50% of the water use during the product life cycle ([17]). Improvement potential: Medium The improvement potential is mainly related to restricting or banning toxic and polluting compounds, as biodegradable and less toxic alternatives are usually available and are gaining momentum ([17, 19]). Indeed, the green cosmetics market has experienced a 15% annual growth rate ([21]). For example, product innovations include formulations free from silicones, sulphates, parabens, mineral oils, preservatives and fragrances ([17,19,20]). The surfactants can also be selected so that the product is biodegradable: chemicals that degrade rapidly are quickly removed from the environment. 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, big European associations have voluntarily discontinued the use of synthetic, solid plastic particles used for exfoliating and cleansing (known as microbeads) ([23]), resulting in a 98% reduction in the use of plastic microbeads in rinse-off cosmetics between 2012 and 2017 ([18]). Another potential improvement measure lies in reducing the water use during production of cosmetic products: mapping the water usage

[51] Personal care products (PCPs) are a diverse group of common household substances used for health, beauty and cleaning purposes ([4]).
[52] Waste water treatment plants.
[53] Either organic (absorb UV radiation, e.g. methylbenzylidene camphor) or inorganic micropigments (reflect UV radiation, e.g. ZnO, TiO2).
[54] Perfluoroalkyl and Polyfluoroalkyl Substances.

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]). 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]).

Potential measures under ESPR:

- performance requirement on maximum limit of water consumption per kg or unit of product

- performance requirement on minimum content of biodegradable substances/materials [expressed e.g. as a % over the total weight of the product], for selected applications

- performance requirement on design for minimising water consumption during use of the product

- information requirement on how to correctly dose the product to serve its function (to avoid overdosage)

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

- information requirement on the presence in the product of non-biodegradable microplastics and/or microbeads

Air Effects [2]
Environmental impact: Medium

Impacts to air of cosmetics is mainly due to the VOC content in deodorants, hair products and, to a lower extent, perfumes ([25]), that contribute to a poor indoor air quality ([26]), and the significance of these products has recently grown, as historically dominant sources of VOCs like road transport and fuel evaporation decline ([27]). In 2000, cosmetics represented 57% of the use of VOC in aerosol cans produced in Europe, but VOCs were also used as solvents (ethanol, acetone, ...) to dissolve components and to make products liquid or applicable, in addition to being used as humectants, preservatives (e.g. phenoxyethanol) or fragrances (e.g. terpenes or limonene) ([25]).

Improvement potential: Low

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]). 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, and promoting fragrance-free products ([25]). However, changes in the formulations usually lead 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]).

Potential measures under ESPR:

- performance requirement on the mandatory design of refillable packaging to avoid air pollution due to raw material extraction avoid air pollution due to raw material extraction

- information requirement on how to correctly dose the product to increase durability and avoid air pollution due to raw material extraction

Soil Effects [1]
Environmental impact: Low

The main impacts to soil are driven by land use due to the sourcing of bio-based (or oleo-) surfactants, a key ingredient of cosmetics that, either of bio- or fossil-origin, can represent 20-40% of the product in shampoos and shower gel ([17,47]). Bio-based ingredients are becoming a rising trend in the cosmetic market ([31]), and bio-based surfactants originate mainly from palm and coconut oil ([17,24]). However, available studies did not find any scientific basis for their environmentally superiority over fossil alternatives, as the benefits from renewable ingredients are offset by the intensive land-use, often in South-East Asia ([10,29]).

Improvement potential: Low

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 certification schemes for the sourcing of some ingredients ([10,30]).

Potential measures under ESPR:

- performance requirement restriction on maximum area land used for the cultivation of raw material per kg or unit of product

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

Biodiversity Effects [4]
Environmental impact: High

Impacts on biodiversity are mainly due to deforestation caused by the sourcing of some ingredients, especially bio-based surfactants, which derive from palm and coconut oil. 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]). 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 six commodities linked to the destruction and degradation of forest ([32]), and cosmetic products are the second biggest user of palm oil after food, accounting for 18% of global palm oil use when merged with detergents ([33]).

Improvement potential: Medium

As bio-based ingredients are on the rise ([17,31,34]), potential improvement measures lie in strict sustainability requirements for the palm and other vegetable oil sourcing ([10,30,20]). The main and strictest certification scheme to date is the Roundtable for Sustainable Palm Oil – RSPO ([36,37]), which sets a 'No deforestation, no peat and no exploitation' strategy, and represents 19% of the global palm oil supply ([38]).

Potential measures under ESPR:

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

- performance requirement on minimum content of biodegradable substance/materials

- performance requirement on prohibition of secondary packaging in certain cases;

- performance requirement on mandatory design of refillable packaging;

- information requirement on presence of non-biodegradable microplastics and/or microbeads;

Waste Generation & Management [3]
Impact: Medium

The main impacts in terms of waste generation are related to the disposal of cosmetics packaging. 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]). 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: 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 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]). Cosmetics companies are increasingly using recycled paper and cardboard for packaging, rather than virgin materials ([18]). 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

COSMETICS

introduced refillable packaging in the fields of hair care, lotions/moisturisers, soaps, and perfumes, while some companies are investing in compostable packaging ([18]). 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]). To ensure that only 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 ([10,17,20]). 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]).

Potential measures under ESPR:

- performance requirement on the mandatory design of refillable packaging
- performance requirement on the availability of refills
- performance requirement on the maximum level of product-to-packaging ratio
- performance requirement on minimum packaging volume, for certain applications
- performance requirement on availability and compatibility of spare parts and (refillable) containers
- performance requirement on the prohibition of secondary packaging***, in certain cases
- 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

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 through the CO_2 emissions emitted when clear cutting forests to make space for palm trees ([35]).

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 companies 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]).

Potential measures under ESPR:

- performance requirement on availability of refills
- performance requirement on availability of spare parts
- performance requirement on the mandatory design of refillable packaging
- performance requirement on the maximum level of product-to-packaging ratio
- performance requirement on maximum energy consumed during manufacturing
- information requirement on the percentage of recycled content in product packaging
- information requirement on presence of non-biodegradable microplastics and/or microbeads
- information requirement on energy consumption during manufacturing by mass of product

COSMETICS
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 a maximum energy consumed during manufacturing by mass of product - performance requirement on the mandatory design of refillable packaging - information requirement on the energy consumed during manufacturing by mass of product - information requirement on percentage of recycled content in product packaging
Human Toxicity [2] 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 Alternatives to conventional chemicals that are less toxic to humans are available, as demonstrated by the strict chemical requirements in some European ecolabels, which also prohibit microplastic content ([10,20]). With respect to VOC, 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 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 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. 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 the mandatory design of refillable packaging
- performance requirement on the availability of refills
- performance requirement on the availability of spare parts
- performance requirement on the maximum level of product-to-packaging ratio
- performance requirement on the prohibition of secondary packaging***, in certain cases
- Information requirement on the percentage of recycled content in product packaging

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]). Cosmetic products based on natural ingredients may have a short shelf life, which cannot be increased without introducing preservatives ([17]).

Potential measures under ESPR:

- performance requirement on minimum shelf-life of the product
- information requirement on how to correctly dose, use and dispose of the product (if applicable)

Final score [23]

Strategic autonomy score [1]

Policy Gaps

In Europe, the substances used in cosmetic products are subjected to the application of the REACH regulation. This implies that, for each substance in a cosmetic formulation, environmental and human health risk assessment should be conducted.

The Cosmetics Products Regulation ([51]) has a number of aims, such as making cosmetics sold in the EU safer 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. 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 packaging: 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 human health and the environment from the risks that can be posed by chemicals, and applies also to cosmetics. 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. Some CRMs, phthalates and heavy metals compounds are restricted under REACH. The Classification, Labelling and Packaging (CLP) Regulation ([53]) 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 communication. With respect to bio-based chemicals, there is no policy strategy or legislation specifically dedicated to the bio-based chemicals and materials sectors. However, at the moment of writing of this report, the EC has proposed a Regulation to tackle EU-driven deforestation and forest degradation ([54]), 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

COSMETICS

deforestation-free products are allowed on the EU market. Finally, Regulation 655/2013 ([59]) regulates the use and justification of claims used in cosmetic products.

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

Summary of potential measures to reduce environmental impacts

Type	Measure	Impacts
PERFORMANCE REQUIREMENTS	Prohibition of secondary packaging in certain cases	BIODIVERSITY, WASTE, MATERIAL EFFICIENCY
	Maximum limit of water consumption per kg or unit of product	WATER
	Maximum energy consumed during manufacturing	CLIMATE CHANGE, ENERGY USE
	Mandatory design of refillable packaging	MATERIAL EFFICIENCY, CLIMATE CHANGE, BIODIVERSITY, WASTE, ENERGY USE
	Maximum level of product-to-packaging ratio	WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	Availability of refills	CLIMATE CHANGE, WASTE, MATERIAL EFFICIENCY
	Design for minimising water consumption during use of the product	WATER
	Minimum content of material with sustainability certification per kg or unit of product (or component)	BIODIVERSITY
	Minimum content of biodegradable substances/materials	BIODIVERSITY, WATER
	Availability and compatibility of spare parts	CLIMATE CHANGE, WASTE, MATERIAL EFFICIENCY
INFORMATION REQUIREMENTS	Presence of non-biodegradable microplastics and/or microbeads	BIODIVERSITY, CLIMATE CHANGE, WATER
	Water consumption during production per kg or unit of product	WATER
	Percentage of recycled content in product packaging	ENERGY USE, CLIMATE CHANGE, WASTE, MATERIAL EFFICIENCY
	How to correctly dose the product to avoid overdosage	WASTE, WATER
	Energy consumption during manufacturing by mass of product	ENERGY USE, CLIMATE CHANGE

Proportionality of Costs

Little information could be found on the costs involved in potential measures addressing the main potential improvement measures identified above. However, cosmetics companies are already switching to biodegradable formulations that are less harmful for the aquatic environment ([17]). Moreover, some companies are already acting upon the goals of the EU Green Deal, by committing to net zero emissions and to ambitious recyclability and recycling content measures ([44,50]). One company reported that reducing the energy use during production by 19% per unit of production could save hundreds of millions of dollars, while achieving zero manufacturing waste to landfill led to savings of USD 2 000 million([44]).

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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Box 5. Factsheet for Detergent Products

DETERGENT PRODUCTS

Scope: 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

Water Effects [4]
Environmental impact: High

The category Personal Care Products (PCP) includes the compounds used in detergent products[55], 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 disinfectants (e.g. triclosan), fragrances (e.g. musks), insect repellents, preservatives (e.g. parabens) and biocides ([4]). 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]). Some fragrances have been detected in 83–90% of WWTP[56] 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[57] are used in detergents as components of surfactants ([11]). Finally, detergents make a relatively small contribution to microplastics discharge ([12]).

Improvement potential: Medium

The improvement potential is mainly related to restricting or banning toxic and polluting compounds, as biodegradable and less toxic alternatives are usually available and are gaining momentum ([9]). For example, manufacturers have been producing phosphate-free laundry and dishwasher detergents since 2014 ([13,16,22]), and fragrance-free products are also available ([9]). The surfactants can also be selected so that the product is biodegradable: 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]). Another way to reduce the chemical load to the environment is indirectly, via a lower or correct dosage, and companies offer monodose solutions (e.g. capsules) or clear dosage directions as a potential solution. For example, reducing the dosage by 20% brings environmental savings for terrestrial ecotoxicity (19%) and freshwater ecotoxicity (15%) ([9,18]). Moreover, the design of detergent capsules' film is of utmost importance to avoid microplastics discharge ([14]), and biodegradable film options exist ([38]). Finally, 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]). The impacts during the consumer use phase can be tackled by innovative product designs that require less water during use, e.g. concentrated formulas ([9]).

Potential measures under ESPR:

- performance requirement on minimum detergents concentration [expressed as a % over the total weight of the product].

- performance requirement on maximum limit of water consumption per kg or unit of product

- performance requirement on minimum content of biodegradable substances/materials [expressed as a % over the total weight of the product], for selected applications. This may also be covered by the revised Detergents Regulation

- performance requirement on design for minimising water consumption during use of the product

[55] Personal care products (PCPs) are a diverse group of common household substances used for health, beauty and cleaning purposes ([4]).
[56] Waste water treatment plants.
[57] Perfluoroalkyl and Polyfluoroalkyl Substances.

DETERGENT PRODUCTS

- performance requirement on minimum cleaning performance of the product at low temperature

- information requirement on how to correctly use (focus on dosing) and dispose the product (if applicable). This may also be covered by the revised Detergents Regulation

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

- information requirement on the presence in the product of non-biodegradable microplastics. This may also be covered by the revised Detergents Regulation

- information requirement on cleaning performance of the product at low temperature

Air Effects [2]
Environmental impact: Medium

VOC, which are used for solvent, preservation, fragrance and disinfection properties, normally constitute ~10% of detergent products but up to 50-80% for furniture and shoe maintenance, and they significantly affect indoor air quality ([42,57]). In 2000, detergents represented 20% of the use of VOC in aerosol cans produced in Europe ([57]). 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 ([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, especially if used in combination with mechanical devices such rugs or cloths ([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]).

Potential measures under ESPR:

- performance requirement on minimum detergents concentration (% over the total weight of the product).

- performance requirement on the mandatory design of refillable packaging. This may also be covered by the revised Detergents Regulation

- information requirement on how to correctly dose the product to increase durability and avoid air pollution due to raw material extraction

- information requirement on how to correctly use (focus on dosing) and dispose the product (if applicable). This may also be covered by the revised Detergents Regulation

Soil Effects [1]
Environmental impact: Low

The main impacts to soil are driven by natural land transformation and agricultural land occupation due to the sourcing of bio-based (or oleo-) surfactants ([15]), a key ingredient of detergents that, either of bio- or fossil-origin, can represent 30% of the product ([16]). Bio-based surfactants originate mainly from palm and coconut oil ([15,25]). However, available studies did not find any scientific basis for their environmentally superiority over fossil alternatives, as the benefits from renewable ingredients are offset by the intensive land-use, often in South-East Asia ([15,25,26]).

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

DETERGENT PRODUCTS
through certification schemes or organic farming ([28]). Potential measures under ESPR: - performance requirement restriction on maximum area of land used for the cultivation of raw material per kg of detergent - performance requirement on minimum content on raw material with sustainability* certification per kg of detergent
Biodiversity Effects [4] Environmental impact: High Impacts to biodiversity are mainly due to deforestation caused by the sourcing of some ingredients, especially surfactants (which can represent 30% of the product ([16])), that derive from palm and coconut oil. 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 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 one of the six commodities linked to the destruction and degradation of forest ([30]), and detergent products are estimated to represent 18% of global use when merged with cosmetics ([31]). Improvement potential: Medium As bio-based ingredients are on the rise ([15,23,54]), potential improvement measures lie in strict sustainability requirements for the palm and other vegetable oil sourcing([19,20,21]). The main and strictest certification scheme to date is the Roundtable for Sustainable Palm Oil – RSPO ([32,33]), which sets a 'No deforestation, no peat and no exploitation' strategy, and represents 19% of the global palm oil supply ([34]). There are big brands on the market that have included 100% RSPO-certified ingredients in their products ([24]). Potential measures under ESPR: - performance requirement on minimum content on raw material with sustainability* certification per kg of detergent - performance requirement on minimum content of biodegradable substances/materials. This may also be covered by the revised Detergents Regulation - performance requirement on mandatory design of refillable packaging ratio. This may also be covered by the revised Detergents Regulation - information requirement on presence of non-biodegradable microplastics and/or microbeads. This may also be covered by the revised Detergents Regulation
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

DETERGENT PRODUCTS

recycled content, and the implementation of lightweight and refillable solutions. In terms of recyclability and recycled content, many companies[58] 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[59] committed to increase the use of recycled plastics in EU products to 10 million tonnes by 2025 ([52]). 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 ([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]). Refillable options are less available on the market, but some ecolabels are pioneering in this direction ([19,20,21]), as this measure would ensure high savings in terms of waste generation.

Potential measures under ESPR:

- performance requirement on minimum detergents concentration (% over the total weight of the product)

- performance requirement on the mandatory design of refillable packaging. This may also be covered by the revised Detergents Regulation

- performance requirement on the availability of refills

- performance requirement on the availability of spare parts

- performance requirement on the maximum level of product-to-packaging ratio

- performance requirement on prohibition of secondary packaging in certain cases

- information requirement on the percentage of recycled content in product packaging.

- information requirement on how to correctly dose the product to avoid overdosage. This may also be covered by the revised Detergents Regulation

- information requirement on how correctly to use (focus on dosing) and dispose the product (if applicable). This may also be covered by the revised Detergents Regulation

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]), but also through the CO_2 emissions emitted when clear cutting forests to make space for palm trees ([27]).

Improvement potential: Medium

The main potential improvement measure directly related to detergents to reduce CO_2 emissions 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 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]). Finally, companies have pledged to reduce by half the CO_2

[58] 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.

[59] 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

DETERGENT PRODUCTS

emissions per tonne of production, although it is not clear through what measures ([24,38]) – presumably by switching to low-CO_2 emissions sources of energy. Further improvement potential exists, as companies reduced their CO_2 emissions during production in 2020 by 60% compared to 2005 use, and pledge to reach net zero emissions by 2040 ([38,40]).

Potential measures under ESPR:

- performance requirement on minimum detergents concentration [expressed as a % over the total weight of the product]

- performance requirement on the minimum cleaning performance of the product at low temperature

- performance requirement on the maximum level of product-to-packaging ratio

- performance requirement on availability of spare parts

- performance requirement on prohibition of secondary packaging in certain cases

- performance requirement on availability of refills

- performance requirement on mandatory design of refillable packaging. This may also be covered by the revised Detergents Regulation

- performance requirement on maximum energy consumed during manufacturing

- Information requirement on the cleaning performance of the product at low temperature.

- information requirement on energy consumption during manufacturing by mass of product

- information requirement on presence of non-biodegradable microplastics and/or microbeads

- information requirement on percentage of recycled content in product packaging

- information requirement on how to correctly use (focus on dosing) and dispose the product (if applicable). This may also be covered by the revised Detergents Regulation

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Life Cycle Energy consumption [3]
Environmental impact: Medium

Fossil fuel depletion has been identified as the main hotspot throughout the life cycle of detergent products, due to the energy use, especially during the use phase to heat up the water ([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 the five investigated countries 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]). 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 the minimum cleaning performance of the product at low temperature.

- performance requirement on the maximum energy consumed to produce 1 kg of product

- information requirement on the cleaning performance of the product at low temperature

- information requirement on the energy consumed to produced 1 kg of product

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Human Toxicity [2]
Environmental impact: Medium

Due to use of detergents, people can be exposed to endocrine disrupting (ED) substances, such as PFAS, which are moreover toxic to reproduction, and other compounds with carcinogenic, mutagenic and toxic to reproduction (CRMs) properties ([11]). Other ingredients such as fragrances and some biocides can lead to allergic skin and respiratory reactions. Moreover, VOC, which are used for solvent, preservation, fragrance and disinfection properties, can constitute up to 30% of some detergent products ([42]).

Improvement potential: Low

Alternatives to conventional chemicals that are less toxic to humans are available, as demonstrated by the strict chemical requirements in some European ecolabels ([19,20,21]). 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 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 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]). 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 entails higher likelihood of acute effects due to higher concentration in the product Recyclability of packaging and inclusion of recycled material content is also possible, and a potential that is still largely untapped. Companies 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 minimum detergents concentration (% over the total weight of the product)

- performance requirement on the mandatory design of refillable packaging. This may also be covered by the revised Detergents Regulation

- performance requirement on the availability of refills

- performance requirement on the availability of spare parts (for the packaging)

- performance requirement on the maximum level of product-to-packaging ratio

- performance requirement on prohibition of secondary packaging in certain cases

- performance requirement on mandatory design for minimising water consumption during use of the product

- performance requirement on minimum cleaning performance of the product at low temperature

- information requirement on the percentage of recycled content in product packaging.

- information requirement on cleaning performance of the product at low temperature

- information requirement on how to correctly use (focus on dosing) and dispose the product (if applicable). This may also be covered by the revised Detergents Regulation

Lifetime extension [3]
Improvement potential: Medium

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. Further solutions could be product innovations that maintain the house, dish

DETERGENT PRODUCTS
or clothes clean for longer. Potential measures under ESPR: - information requirement on how to correctly use (focus on dosing) and dispose the product (if applicable). This may also be covered by the revised Detergents Regulation - information requirement on cleaning performance of the product at low termperature - performance requirement on the availability of spare parts (for the packaging) - performance requirement on availability of refills - performance requirement on mandatory design of refillable packaging. This may also be covered by the revised Detergents Regulation - performance requirement on minimum cleaning performance of the product at low temperature;
Final environmental score [33]

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 limits the presence of surfactants based on their biodegradability; it requests suppliers to clearly indicate dosage information for standard conditions on the package labelling; and it sets the rules for the labelling of ingredients. 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 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. Some CMRs, phthalates and heavy metals compounds are restricted under REACH. 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 communication. With respect to bio-based chemicals, there is no policy strategy or legislation specifically dedicated to the bio-based chemicals and materials sectors. However, at the time of writing this report, the EC has proposed a regulation to contrast EU-driven deforestation and forest degradation ([55]), 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. Finally, Regulation 655/2013 ([59]) regulates the use and justification of claims used in cosmetic products. Given the extensive regulatory framework for chemical safety, ESPR measures would not target such area. The improvement potential for ESPR lies in performance requirement for maximum levels of water and air emissions and energy consumption during the production of detergent products, depending on the product category. Moreover, measures related to soil and biodiversity impacts would lie in mandatory sustainability** certifications for the sourcing of bio-based materials. Finally, to minimize waste generation of packaging, ESPR measures could lie in implementing refilling options and ensuring the availability of spare parts. Measures on recycled content and recyclability of the packaging are not in the scope of ESPR, as these lie in the recently proposed Packaging and Packaging Waste Regulation.
Summary of potential measures to reduce environmental impacts

DETERGENT PRODUCTS

Requirement type	Requirement	Impact categories
PERFORMANCE REQUIREMENTS	Availability of spare parts	LIFETIME EXTENSION, WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	Maximum limit of water consumption per kg or unit of product	WATER
	Minimum content of biodegradable substances/materials	BIODIVERSITY, WATER
	Prohibition of secondary packaging in certain cases	CLIMATE CHANGE, WASTE, MATERIAL EFFICIENCY
	Maximum level of product-to-packaging ratio	WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	Availability of refills	LIFETIME EXTENSION, CLIMATE CHANGE, WASTE, MATERIAL EFFICIENCY
	Minimum content of material with sustainability certification per kg or unit of product (or component)	BIODIVERSITY
	Mandatory design of refillable packaging ratio	LIFETIME EXTENSION, BIODIVERSITY, WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	Maximum energy consumed during manufacturing	CLIMATE CHANGE, ENERGY USE
	Design for minimising water consumption during use of the product	MATERIAL EFFICIENCY, WATER
	Minimum cleaning performance of the product at low temperature	LIFETIME EXTENSION, MATERIAL EFFICIENCY, WATER, ENERGY USE, CLIMATE CHANGE
	Minimum detergent concentration as percentage over the total weight of the product	MATERIAL EFFICIENCY, CLIMATE CHANGE, WASTE, WATER
	Percentage of recycled content in product packaging	WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
INFORMATION REQUIREMENTS	Presence of non-biodegradable microplastics and/or microbeads	BIODIVERSITY, CLIMATE CHANGE, WATER
	Water consumption during production per kg or unit of product	WATER
	Percentage of recycled content in product packaging	WASTE, CLIMATE CHANGE, MATERIAL EFFICIENCY
	How to correctly use (focus on dosing) and dispose the product	LIFETIME EXTENSION, MATERIAL EFFICIENCY, CLIMATE CHANGE, WASTE, WATER
	Energy consumption during manufacturing by mass of product	CLIMATE CHANGE, ENERGY USE
	Cleaning performance of the product at low temperature	LIFETIME EXTENSION, MATERIAL EFFICIENCY, WATER, ENERGY USE, CLIMATE CHANGE

Proportionality of Costs

Little information could be found on the costs involved in potential measures addressing the main potential improvement measures identified above. Indications suggest that the market for most detergent products is at a mature stage, with most opportunities for growth in the development of 'green' or 'natural' chemicals and multifunctional products ([16]). Moreover, many companies are already acting upon the goals of the EU Green Deal, by committing to net zero emissions, and a circular economy, by committing to ambitious recyclability and recycling content measures ([24,38,40]). One company reported that reducing the energy use at during production by 19% per unit of production could save hundreds of millions of dollars, while achieving zero manufacturing waste to landfill led to savings of USD 2 000 million ([24]). However, an analysis of the business impacts of the CSS revealed potential losses for the detergent sector in terms of revenue and jobs, with potentially disproportionate costs for small and medium enterprises ([56]). Finally, A.I.S.E. reported that more than 12 200 million products have been sold since 2011 with a sustainability mark ([38]), confirming the relevance of the green market for detergent products.

Additional notes and list of references

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

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DETERGENT PRODUCTS

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Box 6. Factsheet for Fishing Nets and Gear

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 gear are abandoned in the marine environment, trapping wildlife and degrading the marine ecosystems ("ghost fishing") ([4]). 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]).

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 design for reliability (e.g. resistance to weathering, release of fibres and microplastics)

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

- performance requirement on minimum content of biodegradable materials (as % over the total weight of the product)

- information requirement on how to correctly use the product to reduce losses at the sea

Air Effects [1]
Environmental impact: Low

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:

- performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction

- performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction

- information requirement on how to correctly use the product to reduce losses at the sea to avoid air pollution due to raw material extraction

Soil Effects [1]

FISHING NETS & GEARS

Environmental impact: Low

No available evidence could be found.

Improvement potential: Low

The potential for improvement of fishing gear lies in preventing gear loss.

Potential measures under ESPR:

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

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Biodiversity Effects [4]
Environmental impact: High

Commercial fishing nets and gear abandoned, lost or discarded causes 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 improvement of 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 persist in the ocean indefinitely. 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 allow the traceability of fishing gear components

- information requirement on how to correctly use the product to reduce losses at the sea

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Waste Generation & Management [3]
Environmental impact: Medium

Abandoned gear makes up at least 10% of marine litter (between 0.5 million tonnes and 1 million tonnes per year) ([4]). The majority of 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 with other waste streams (e.g. packaging).

Improvement potential: Medium

The potential for improvement of fishing gear lies in preventing gear loss, designing and manufacturing traceable fishing gear, 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 persist in the ocean indefinitely.

FISHING NETS & GEARS
Potential measures under ESPR: - performance requirement on design to allow the traceability of fishing gear components - performance requirement on design to facilitate separation of recyclable materials at end-of-life of fishing nets and gears - performance requirement on minimum recycled content per unit of fishing net and gear produced - performance requirement on design to ensure harmless of fishing nets and gears in case they are lost - information requirement on how to correctly use the product to reduce losses at the sea - information requirement on technical lifetime of fishing gear - information requirement on how to separate recyclable materials at end-of-life of fishing nets and gears - information requirement on minimum recycled content per unit of fishing net and gear
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: - performance requirement on the technical lifetime and resistance to stress of fishing gear - performance requirement on the design of fishing gear with characteristics that facilitate its traceability - performance requirement on the use of component and material coding standards for the identification of components and materials in fishing gear - information requirement on the technical lifetime of fishing gear
Life Cycle Energy consumption [1] Environmental impact: Low Fishing is a highly energy-intensive food production method, relying mostly on fuel-based engines. Its fuel consumption is significantly conditioned 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 is helpful in reducing fuel consumptions. 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: - performance requirement on the technical lifetime and resistance to stress of fishing gear

FISHING NETS & GEARS
- information requirement on the technical lifetime of fishing gear
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 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 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 persist in the ocean indefinitely ([10]). Fishing gear might have non-recyclable parts or organic fouling, which require removal to allow for potential recycling ([10]). Contrastingly, 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 to allow the traceability of fishing gear components - performance requirement on design to ease separation of recyclable materials at end-of-life of fishing nets and gears - performance requirement on minimum recycled content per unit of fishing net and gear produced - performance requirement on design to ensure harmless of fishing nets and gears in case they are lost - information requirement on technical lifetime of fishing gear - information requirement on how to separate recyclable materials at end-of-life of fishing nets and gears - information requirement on minimum recycled content per unit of fishing net and gear
Lifetime extension [1] Improvement potential: Low 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 and dismantling (e.g. colour coding); reusing and repurposing of different materials currently used and modular design to facilitate repair, reuse and recycling ([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]).

FISHING NETS & GEARS

Potential measures under ESPR:

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

- performance requirement on design for reliability (e.g. resistance to weathering, release of fibres and microplastics)

- performance requirement on design to facilitate repair and recycling

- information requirement on how to correctly use the product to reduce losses at the sea

Final score [21]

Strategic autonomy score [1]

Policy Gaps

Fishing net & 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]), existing advocacy to adopt appropriate fishing gear best management practices ([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	Design of traps and pots with effective escape mechanisms with biodegradable mechanisms that allow traps to be deactivated if lost	WATER	BIODIVERSITY		MATERIAL EFFICIENCY
	Design to allow the traceability of fishing gear components	WATER	BIODIVERSITY	WASTE	MATERIAL EFFICIENCY
	Design to facilitate separation of recyclable materials at end-of-life of fishing nets and gears			WASTE	MATERIAL EFFICIENCY
	Minimum recycled content per unit of fishing net and gear produced			WASTE	MATERIAL EFFICIENCY

FISHING NETS & GEARS

INFORMATION REQUIREMENTS		
	How to correctly use the product to reduce losses at the sea	WATER, BIODIVERSITY, WASTE
	Technical lifetime of fishing gear	WASTE, MATERIAL EFFICIENCY
	How to separate recyclable materials at end-of-life of fishing nets and gears	WASTE, MATERIAL EFFICIENCY
	Minimum recycled content per unit of fishing net and gear	WASTE, MATERIAL EFFICIENCY

Proportionality of Costs

Data on costs associated to circularity measures for fishing gears could not be found, especially related to measures for a more sustainable approach at the product design stage coupled with the setting of consumption reduction targets.

Additional notes and list of references

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

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Box 7. Factsheet for Furniture

FURNITURE

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 water consumption per kg or unit of product (or component)

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

Air Effects [3]
Environmental impact: Medium

Furniture 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 the extraction.

Potential measures under ESPR:

- performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction

- performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction

- performance requirement on minimum content of raw material with sustainability certification per unit of product

- performance requirement on design to facilitate the further separation of recyclable materials

- performance requirement on design ensuring the durability of furniture

FURNITURE
- performance requirement on minimum recycled content per piece of furniture - performance requirement on sourcing of materials from certified sustainable practices - performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products - performance requirement on compatibility with commonly available spare parts in furniture products - performance requirement on minimum durability of the product (under normal conditions of use) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - performance requirement on minimum percentage of energy use from low carbon sources - information requirement on how to maintain the product to increase durability to avoid air pollution due to new products acquisition - information requirement on how to repair the product to increase durability to avoid air pollution due to new products acquisition - information requirement on content of raw material with sustainable certification per product to ease sustainable purchasing - information requirement on recycled content per piece of furniture - information requirement to ease disassembly - information requirement on percentage of recycled materials in furniture components - information requirement on sourcing of materials from certified sustainable practices - information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components) - information requirement on minimum percentage of energy use from low carbon sources
Soil Effects [3] Environmental impact: Medium The main effects of furniture life-cycle on the soil is strictly related to the sourcing of raw materials like forestry products (wood, wood-based, rattan, bamboo), plastic and metals. Especially the 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 per unit of product - performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction - performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction - performance requirement on design to facilitate the further separation of recyclable materials - performance requirement on design ensuring the durability of furniture

FURNITURE
- performance requirement on minimum recycled content per piece of furniture - performance requirement on sourcing of materials from certified sustainable practices - performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products - performance requirement on compatibility with commonly available spare parts in furniture products - performance requirement on minimum durability of the product (under normal conditions of use) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - performance requirement on minimum percentage of energy use from low carbon sources - information requirement on content of raw material with sustainable certification per product to ease sustainable purchasing - information requirement on how to maintain the product to increase durability to avoid air pollution due to new products acquisition - information requirement on how to repair the product to increase durability to avoid air pollution due to new products acquisition - information requirement on recycled content per piece of furniture - information requirement to ease disassembly - information requirement on percentage of recycled materials in furniture components - information requirement on sourcing of materials from certified sustainable practices - information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components) - information requirement on minimum percentage of energy use from low carbon sources
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 sustainable source 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 biodiversity impacts associated to the extraction. Potential measures under ESPR: - performance requirement on minimum content of raw material with sustainability certification per unit of product - performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction - performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction - performance requirement on design to facilitate the further separation of recyclable materials;

FURNITURE
- performance requirement on design ensuring the durability of furniture - performance requirement on minimum recycled content per piece of furniture - performance requirement on sourcing of materials from certified sustainable practices - performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products - performance requirement on compatibility with commonly available spare parts in furniture products - performance requirement on minimum durability of the product (under normal conditions of use) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - performance requirement on minimum percentage of energy use from low carbon sources - information requirement on content of raw material with sustainable certification per product to ease sustainable purchasing - information requirement on how to maintain the product to increase durability to avoid air pollution due to new products acquisition - information requirement on how to repair the product to increase durability to avoid air pollution due to new products acquisition - information requirement on recycled content per piece of furniture - information requirement to ease disassembly - information requirement on percentage of recycled materials in furniture components - information requirement on sourcing of materials from certified sustainable practices - information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components) - information requirement on minimum percentage of energy use from low carbon sources
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 ([12]). 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 ([12]). Furniture waste in the EU accounts for more than 4% of the total municipal solid waste stream. Additionally, household furniture alone represents between 2% and 5% of municipal solid waste in the EU-28 ([12]). Impacts at end of life vary considerably depending on what materials are used in the furniture. Recycling of furniture components or recovering energy from furniture waste is often complicated due to difficulties in separating components ([10]). 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

FURNITURE

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 design ensuring the durability of the furniture
- performance requirement on design to facilitate furniture disassembly
- performance requirement on minimum recycled content per piece of furniture
- performance requirement on design to facilitate the further separation of recyclable materials
- performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction
- performance requirement limiting the number of materials used in a single furniture product
- performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products
- performance requirement on compatibility with commonly available spare parts in furniture products
- performance requirement on minimum durability of the product (under normal conditions of use)
- performance requirement on minimum reliability (e.g. resistance to stress or weathering)
- performance requirement on design to facilitate reuse, repair, refurbishing and recycling
- performance requirement on availability of spare parts for the product
- performance requirement on design for use of components and materials coding standards for the identification of components and materials
- information requirement on how to maintain the product to increase durability avoiding air pollution due to new products acquisition
- information requirement on how to repair the product to increase durability to avoid air pollution due to new products acquisition
- information requirement on recycled content per piece of furniture
- information requirement to ease disassembly
- information requirement on percentage of recycled materials in furniture components
- information requirement of expected lifetime of the product (under normal conditions of use)
- information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components)

Climate Change [3]
Environmental impact: Medium

In 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]). 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]). 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. 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 used 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]).

FURNITURE
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. Potential measures under ESPR: - performance requirement on minimum content of raw material with sustainability certification per unit of product - performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction - performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction - performance requirement on design to facilitate the further separation of recyclable materials - performance requirement on design ensuring the durability of furniture - performance requirement on compatibility with commonly available spare parts in furniture products - performance requirement on minimum durability of the product (under normal conditions of use) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - performance requirement on minimum percentage of energy use from low carbon sources - performance requirement on the sourcing of materials from certified sustainable practices - performance requirement on a minimum percentage of recycled materials in furniture components - performance requirement on the use of design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products - information requirement on the sourcing of materials from certified sustainable practices - information requirement on the percentage of recycled materials in furniture components - information requirement on content of raw material with sustainable certification per product to ease sustainable purchasing - information requirement on how to maintain the product to increase durability to avoid air pollution due to new products acquisition - information requirement on how to repair the product to increase durability to avoid air pollution due to new products acquisition - information requirement on recycled content per piece of furniture - information requirement to ease disassembly - information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components) - information requirement on minimum percentage of energy use from low carbon sources
Life Cycle Energy consumption [3] Environmental impact: Medium Most of the energy consumption is related to the manufacture the product, particularly in injection-moulded plastics and wood-based panels due to the use of elevated temperatures and pressures ([10]). Surface coating operations also have some significant environmental impacts due to high-temperature curing processes ([10]). Currently the use of engineered wood-based components has also grown considerably in the building sector ([1]). Injection-moulded plastics and wood-based panels have a significant impact in terms of energy consumption due to the use of elevated temperatures and pressures when manufacturing.

FURNITURE
Improvement potential: Medium The improvement potential of the furniture sector lies in 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 minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction - performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction - performance requirement on design to facilitate the further separation of recyclable materials - performance requirement on design ensuring the durability of the furniture - performance requirement on minimum recycled content per piece of furniture - performance requirement on the use of design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products - performance requirement on the compatibility with commonly available spare parts in furniture products - performance requirement on minimum durability of the product (under normal conditions of use) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - performance requirement on minimum percentage of energy use from low carbon sources - information requirement on how to maintain the product to increase durability avoiding air pollution due to new products acquisition - information requirement on how to repair the product to increase durability avoiding air pollution due to new products acquisition - information requirement on recycled content per piece of furniture - information requirement on design for ease disassembly - information requirement on percentage of recycled materials in furniture components - information requirement on sourcing of materials from certified sustainable practices - information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components) - information requirement on minimum percentage of energy use from low carbon sources
Human Toxicity [2] Environmental impact: Medium The production and use phase of the furniture 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 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).

FURNITURE

Material efficiency [3]
Improvement potential: Medium

The potential for improvement in furniture sector lies in moving away from cheaper materials and poor product design and increase the recycled content, the reuse of components, and design for disassembly/reassembly, repair, reuse, remanufacture and recycling ([6]). The use of eco-innovation strategies in the furniture design phase ([17]) and the reduction of harmful substances using low emission materials ([13]) would ease the recycling of used products.

Potential measures under ESPR:

- performance requirement on minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction

- performance requirement on design to facilitate the further separation of recyclable materials

- performance requirement on design ensuring the durability of the furniture

- performance requirement on design to facilitate furniture disassembly to increase material recovery to avoid air pollution due to raw material extraction

- performance requirement on minimum recycled content per piece of furniture

- performance requirement on sourcing of materials from certified sustainable practices

- performance requirement on limiting the number of materials used in a single furniture product

- performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products

- performance requirement on compatibility with commonly available spare parts in furniture products

- performance requirement on minimum reliability (e.g. resistance to stress or weathering)

- performance requirement on design to facilitate reuse, repair, refurbishing and recycling

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

- information requirement on recycled content per piece of furniture

- information requirement for ease disassembly

- information requirement on percentage of recycled materials in furniture components

- information requirement on sourcing of materials from certified sustainable practices

Lifetime extension [5]
Improvement potential: High

The potential for improvement in furniture sector lies in moving away from lower quality materials and weak 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]). Circular economy interventions have the potential to help counter these trends, with repair, refurbishment and remanufacture allowing value recovery, economic growth and job creation within the European furniture industry, while saving on resources and the environment. However, realising these economic, environmental and social benefits will require the adoption of appropriate demand and supply chain levers, to support a meaningful change across the industry ([12]). There is room for improvement in the re-use targets ([13]).

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]).

Potential measures under ESPR:

FURNITURE
- performance requirement on minimum durability of the product (under normal conditions of use) - performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products - performance requirement on design ensuring the durability of the furniture - performance requirement on compatibility with commonly available spare parts in furniture products - performance requirement on minimum reliability (e.g. resistance to stress or weathering) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - performance requirement on the use of component and material coding standards for the identification of components and materials - information requirement on how to maintain the product to increase durability avoiding air pollution due to new products acquisition - information requirement on how to repair the product to increase durability avoiding air pollution due to new products acquisition - information requirement on expected lifetime of the product (under normal conditions of use) - information requirement on how to use and maintain the product to avoid its premature substitution/replacement (or of its components)
Final environmental score [30]

Strategic autonomy score [1]
Policy Gaps The absence of a specific regulation promoting furniture ecodesign principles is an issue. There are only voluntary schemes in place like ecolabel and green public procurement criteria and 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. Thus, standardisation activities are being carried out in the framework of WG10 which will cover a complete furniture circularity package, considering the most relevant aspects of the products listed in Article 5 of the European Commission's regulatory proposal (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). For wooden furniture or furniture made from raw materials from trees, whereas existing timber legislation could be considered applicable, they have been found to be based on voluntary agreements, such as the FLEGT Regulation (16). With respect to bio-based components/products, at the moment of writing of this report, the EC has proposed 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 allowed on the EU market. The gaps that need to be addressed are related to moving away from cheaper materials and poor product design and 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 the impacts associated with the extraction. In addition, a mandatory but simple extended producer responsibility

FURNITURE

(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).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS	Minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
PERFORMANCE REQUIREMENTS	Design for disassembly to increase material recovery to avoid air pollution due to raw material extraction	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
PERFORMANCE REQUIREMENTS	Minimum content of raw material with sustainability certification per unit of product	AIR	SOIL	BIODIVERSITY		CLIMATE CHANGE			
PERFORMANCE REQUIREMENTS	Design to facilitate the further separation of recyclable materials	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
PERFORMANCE REQUIREMENTS	Design ensuring the durability of the furniture	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Minimum recycled content per piece of furniture	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
PERFORMANCE REQUIREMENTS	Sourcing of materials from certified sustainable practices	AIR	SOIL	BIODIVERSITY		CLIMATE CHANGE		MATERIAL EFFICIENCY	
PERFORMANCE REQUIREMENTS	Limiting the number of materials used in a single furniture product				WASTE			MATERIAL EFFICIENCY	
PERFORMANCE REQUIREMENTS	Design techniques that ease non-destructive disassembly and re-assembly of specific components in furniture products	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Compatibility with commonly available spare parts in furniture products	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Minimum durability of the product (under normal conditions of use)	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Minimum reliability (e.g. resistance to stress or weathering)				WASTE			MATERIAL EFFICIENCY	LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Design to facilitate reuse, repair, refurbishing and recycling	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Availability of spare parts for the product	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Use of component and material coding standards for the identification of components and materials				WASTE			MATERIAL EFFICIENCY	LIFETIME EXTENSION
PERFORMANCE REQUIREMENTS	Minimum percentage of energy use from low carbon sources	AIR	SOIL	BIODIVERSITY		CLIMATE CHANGE	ENERGY USE		
INFORMATION REQUIREMENTS	How to maintain the product to increase durability avoiding air pollution due to new products acquisition	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
INFORMATION REQUIREMENTS	How to repair the product to increase durability to avoid air pollution due to new products acquisition	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
INFORMATION REQUIREMENTS	Content of raw material with sustainable certification per product to ease sustainable purchasing	AIR	SOIL	BIODIVERSITY		CLIMATE CHANGE			
INFORMATION REQUIREMENTS	Recycled content per piece of furniture	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
INFORMATION REQUIREMENTS	Ease disassembly	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
INFORMATION REQUIREMENTS	Percentage of recycled materials in furniture components	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
INFORMATION REQUIREMENTS	Sourcing of materials from certified sustainable practices	AIR	SOIL	BIODIVERSITY		CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
INFORMATION REQUIREMENTS	Expected lifetime of the product (under normal conditions of use);				WASTE				LIFETIME EXTENSION
INFORMATION REQUIREMENTS	How to use and maintain the product to avoid its premature substitution/replacement (or of its components)	AIR	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
INFORMATION REQUIREMENTS	Minimum percentage of energy use from low carbon sources	AIR	SOIL	BIODIVERSITY		CLIMATE CHANGE	ENERGY USE		

Proportionality of Costs

Very little data could be found with respect to costs incurred by possible ecodesign-related measures. Some companies have committed to ambitious circularity goals, and some have already started improving the circularity of the products put on the market (20). The number of products complying with the EU Ecolabel criteria are, as of 2022, 1548 (21).

Additional notes and list of references

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

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(14) Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of eco-design requirements for energy-related products (recast)

(15) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

(16) Forest Law Enforcement, Governance and Trade, COM (2003) 251 final

(17) Proposal for a Regulation of the European Parliament and of the Council on the making available on the Union market as well as export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010, COM(2021) 706 final

(18) New European Standardization Committee for Furniture Circularity, Tayfun Avdan (European Committee for Standardization)

(19) New EU Eco/design Proposals: Case Studies to Illustrate their Potential Impact. European Environmental Bureau, Final Report (November 2022)

(20) Ikea – A world without waste (last accessed 20.01.2023)

(21) EU Ecolabel facts and figures (last accessed 20.01.2023)

Box 8. Factsheet for Lubricants

<table>
<tr><th>LUBRICANTS</th></tr>
<tr><td>
</td></tr>
<tr><td>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. Composed of base fluids (80-75%) and additives (25-20%).</td></tr>
<tr><td>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[60] 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 lubricants remains a big challenge ([20]). Also, for partial loss[61] and accidental loss[62] 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 minimum content of biodegradable substances (as % over the total weight of the products), for selected applications

- information requirement on how to correctly dose the product to serve its function

- information requirement on how to correctly use the product to reduce losses/spillages</td></tr>
<tr><td>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]). Lubricant-related particulate emissions account for up to 35 % of total particulate emissions of engines, whereas the amount of NOx emissions depends on the type of oil used, due to the different content of additives and aromatic compounds ([1]).During the use phase. In degradation due to use, lubes can generate hazardous secondary chemicals such as PAHs, carbon monoxide, CMRs ([1]).</td></tr>
</table>

[60] 'total loss' means that the lubricant is fully released to the environment during use
[61] '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
[62] '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

LUBRICANTS

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 design for re-refining to avoid air pollution due to the recovery of waste oils

- performance requirement on minimum recycled content per unit of product (packaging) to avoid air pollution due to raw material extraction

- information requirement on how to correctly dose the product to increase durability and avoid air pollution due to raw material extraction

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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 (by use in open systems or by accidental spills) into the environment during use, spills, or disposal in the soil by consumers. Lubricant oil pollution causes serious damage to soils, 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 ([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]).

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 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]). Also, 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]).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])

Potential measures under ESPR:

- performance requirement on minimum biodegradable raw materials quantity per kg of lubricant for certain applications

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Biodiversity Effects [2]
Environmental impact: Medium

The production phase of vegetable-based oils leads to deforestation, negative effects on animal populations and indirect land use change. 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 production phase of fossil-based oils has been found to cause the reduction of the ecosystem resilience ([1, 2]). Moreover, the release (by use in open systems or by accidental spills) into the environment during use is very detrimental to ecosystems ([16]).

Improvement potential: Low

The potential for improvement of bio-based lubricants lies in targeting their sustainable production, 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 (725 645 thousand m3 wood were estimated to be harvested in the EU in 2017), which represent very delicate and important ecosystems ([6,11]). However, the development of a common biodegradable base stock that could replace conventional lubricants 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 biodegradable raw materials quantity per kg of lubricant for certain applications

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) 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 oil is a secondary raw material that for lubricants substitutes virgin oil, contributing to a lower EU demand of primary raw materials. 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 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%. 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 for minimum quantity of feedstock used that can be used as re-defined oil (depending on the type of lubricant manufactured)

- performance requirement on design to determine a maximum coefficient on friction in order to increase efficiency

LUBRICANTS
- performance requirement on design to ease reuse of lubricants - information requirement on how to use lubricants efficiently
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, 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 4 times smaller than mineral oils (18), while greenhouse emissions of synthetic oils are almost twice higher than those of mineral base oil (1). However, the inclusion of CO2 emissions due to indirect land use change has the potential to make biological substitutes worse than their conventional counterparts (3). However, available data (from 2015) indicate that vegetable base oils (in EU mostly rapeseed and sunflower) account for <5% of the lubricant market (1). It is important to mention that 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 for 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 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 a maximum level of GHG emissions by kg or liter of product - performance requirement on minimum percentage of recycled oil in lubricant production - performance requirement on design to ease reuse of lubricants - performance requirement on minimum durability of lubricants (under normal conditions of use) - performance requirement on minimum percentage of energy use from low carbon sources - information requirement on the level of GHG emissions by kg or liter of product - information requirement on percentage of recycled oil in lubricant production - information requirement on how to use lubricant efficiently - information requirement on how to dose and use the product - information requirement on how often to substitute/replace the product - information requirement on how to use the product to avoid its premature substitution/replacement (or of its components) - information requirement on minimum percentage of energy use from low carbon sources
Life Cycle Energy consumption [3] Environmental impact: Medium In general, vegetable oil has lower energy consumption during potential 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). 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 may be used in order to optimize energy efficiency (20).

LUBRICANTS

Improvement potential: Medium

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 oils ([1]).

Potential measures under ESPR:

- performance requirement on a minimum percentage of recycled oil in lubricant production
- performance requirement on a maximum level of GHG emissions by kg or liter of product
- performance requirement on design to ease reuse of lubricants
- performance requirement on minimum durability of lubricants (under normal conditions of use)
- performance requirement on minimum percentage of energy use from low carbon sources
- information requirement on the percentage of recycled oil in lubricant production
- information requirement on the level of GHG emissions by kg or liter of product
- information requirement on how to use lubricant efficiently
- information requirement on how to dose and use the product
- information requirement on how often to substitute/replace the product
- information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)
- information requirement on minimum percentage of energy use from low carbon sources

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

Re-refined oil is a secondary raw material that for lubricants substitutes virgin oil, contributing to a lower EU demand of primary raw materials, and especially of fossil resources. For the treatment of waste lubricant oils (WLO), 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).

Currently, 82% of collectable WLO is collected in the EU. Of this, 61% is treated by re-refining (material valorisation), while 24% of collected WLO is processed to produce fuels and 11% is used for energy recovery in cement, lime, steel and power plants (7). The improvement potential lies in mandatory and ambitious targets for WLO collection at the EU level, mandatory EPR schemes, and quantitative targets promoting re-refining (material valorisation) (7). Finally, there is room for improvement in developing methods for detecting and preventing used oil contamination with toxic constituents that complicates the recycling process. Another way to improve the material efficiency of lubricants is by reducing the amount of natural resources used for production. This can be achieved by e.g. designing a lower coefficient of friction, which increases efficiency and consumes less power, thus achieving more with fewer resources (17).

Potential measures under ESPR:

- performance requirement on design to determine a maximum coefficient on friction in order to increase efficiency
- performance requirement on design to ease reuse of lubricants
- performance requirement on minimum percentage of recycled oil in lubricant production
- performance requirement on minimum durability of lubricants (under normal conditions of use)
- information requirement on how to use lubricants efficiently
- information requirement of percentage of recycled oil in lubricant production

Lifetime extension [3]

Improvement potential: Medium

Lifetime extension reduces in a significant way the energy consumption and the global warming related impacts of the use phase of non-renewable lubes, when 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).Oil in equipment should not be changed unless it has reached the end of its useful life. This is typically not the case, because the oil 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 use (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 result, in this case, is less lubricant purchased and less used lubricant to be disposed of (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, one the biggest challenges facing the automotive industry is to improve fuel economy, and to limit pollutants, CO_2 emissions and natural resources use. Better fuel efficiency and consequently lower emissions will require new materials, new lubricants and low-emission fuel (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 durability of [PGs] (under normal conditions of use)
- performance requirement on minimum percentage of recycled oil in lubricant production

Performance requirement on design to determine a maximum coefficient on friction in order to increase efficiency

- performance requirement on design to ease reuse of lubricants

LUBRICANTS

- information requirement on expected lifetime of the product
- information requirement on how to correctly dose and use the product
- information requirement on how often to substitute/replace the product
- information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)
- information requirement of percentage of recycled oil in lubricant production
- information requirement on how to use lubricants efficiently

Final score [24]

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]), the revision of which is currently ongoing. Waste oils are covered by the Waste Framework Directive ([9]). The BAT Reference Document for 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.

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 plant/based oils. However, at the moment of writing this report, the EC has proposed a Regulation to tackle EU-driven deforestation and forest degradation ([15]), 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, lubricants produced from animal oils and greases are not covered from the proposed regulation.

Finally, there are missing policies that could set collection and recycling targets for waste lubricant oils, and prioritise regeneration and provision of consumer information to improve separate collection. This may change in the future as, in view of Article 21(4) of the Waste Framework Directive, by 31 December 2022, the Commission shall examine data on waste oils provided by Member States in accordance with Article 37(4) with a view to considering the feasibility of adopting measures for the treatment of waste oils, including quantitative targets on the regeneration of waste oils and any further measures to promote the regeneration of waste oils.

Summary of potential measures to reduce environmental impact

LUBRICANTS					
PERFORMANCE REQUIREMENTS	Maximum level of GHG emissions by kg or liter of product	CLIMATE CHANGE	ENERGY USE		
	Minimum percentage of recycled oil in lubricant production	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	Design to determine a maximum coefficient on friction in order to increase efficiency			MATERIAL EFFICIENCY	LIFETIME EXTENSION
	Design to ease reuse of lubricants	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	Minimum durability of lubricants (under normal conditions of use)	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	Minimum percentage of energy use from low carbon sources	CLIMATE CHANGE	ENERGY USE		
INFORMATION REQUIREMENTS	Level of GHG emissions by kg or liter of product	CLIMATE CHANGE	ENERGY USE		
	Percentage of recycled oil in lubricant production	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	How to use lubricants efficiently	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
	Expected lifetime of the product				LIFETIME EXTENSION
	How to correctly dose and use the product	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
	How often to substitute/replace the product	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
	How to use the product to avoid its premature substitution/replacement (or of its components)	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
	Minimum percentage of energy use from low carbon sources	CLIMATE CHANGE	ENERGY USE		

Proportionality of Costs

High costs could be expected from requirements to improve the separate collection of lubricant oils. This is because the collection system represents a challenge for most Member States, including countries who have already well implemented management systems (5). Moreover, the maximization of regeneration targets for lubricants is limited by the wide variety of physicochemical characteristics of the collected oils, the handling, segregating and storage of different types of WLO by producers (5). Nonetheless, no disproportionate costs may be expected on the lifetime extension improvement potential. In fact, a longer use of the oil contributes to less liquid waste and cost savings may occur as labour efforts can be used more effectively elsewhere, and fewer shutdowns are expected thanks to oil changes (1). Moreover, material efficiency measures such as designing lubricants with a lower coefficient of friction can increase efficiency and consume less power (including fuel economy and electrical consumption), thus achieving monetary savings (17). Moreover, design of lubricants that operate for extended periods of time (e.g. through proper base fluid and additive selection) would lead to less lubricant purchased, less used lubricant disposed, less maintenance labor, and ultimately, less financial resources spent (17). Finally, avoiding release to the environment by biodegradable total loss lubricants or minimising accidental spills would save on the enormous remediation costs needed to restore e.g. the aquatic environment (6).

Additional notes and list of references

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

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(4) Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (IED).

(5) C.T. Pinheiro, V.R. Ascensao, C.M. Cardoso, M.J. Quina, L.M. Gando-Ferreira (2017), An overview of waste lubricant oil management system: Physicochemical characterization contribution for its improvement, Journal of Cleaner Production 150

(6) Paulina Nowak, Karolina Kucharska and Marian Kaminski. Ecological and Health Effects of Lubricant Oils Emitted into the Environment (2019). International journal of environmental and public health.

(7) European Commission. Oko-institut e.V. Study to support the Commission in gathering structured information and defining of

reporting obligations on waste oils and other hazardous waste (2018)

([8]) Directive 2010/75/EU of the European Parliament and the Council on industrial emissions.

([9]) Directive 2008/98/EC of the European Parliament and of the Council on waste

([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

([12]) International Sustainability and Carbon Certification. https://www.iscc-system.org/

([13]) Roundtable on Sustainable Palm Oil. https://www.rspo.org/

([14]) Roundtable on Sustainable Biomaterials. https://rsb.org/

([15]) Proposal for a Regulation of the European Parliament and of the Council on the making available on the Union market as well as export from de Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010, COM(2021) 706 final

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Box 9. Factsheet for Paints and Varnishes

PAINTS AND VARNISHES

Scope: Products falling under the scope of the Directive 2004/42/EC (known as the "Paints Directive") for paints and varnishes. Paints and varnishes mean 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. Paints used in non-road vehicles (i.e. boats, ships, aircrafts...) or road marking paint are not considered under the scope.
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, for instance a recent study estimates that microplastic release represents 7.4 Mt/year (range from 5.2 to 9.8 Mt/year) ([1]). Paints can release microplastics to the environment during the application, wear and tear or removal of a paint itself. It can also be related to the unused paint or the end-of-life of the painted object ([2]). 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 microplastic release from paints is currently being investigated with a study on 'Cost-benefit analysis of policy measures reducing unintentional release of microplastics' to be published by the end of 2022 ([4]). Potential measures under ESPR: - performance requirement on design for reliability (e.g. resistance to release of microplastics) - information requirement on the presence in the product/possible release of non-biodegradable microplastics
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 the production of titanium dioxide (TiO_2) production is of particular relevance ([6]). 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 however still affects human health due to the use of paint preservation agents needed ([10]). Potential measures under ESPR: - performance requirement on design for reliability to reduce particulate matter release during use of the product - information requirement on how to correctly dose the product to increase durability and avoid air pollution due to raw material extraction - information requirement on the presence in the product/possible release of non-biodegradable microplastics
Soil Effects [2]

PAINTS AND VARNISHES
Environmental impact: Medium Terrestrial ecotoxicity, acidification and land occupation are significant at the production stage of paints and varnishes raw materials (binders, oils, pigments...). It is reported that for indoor and outdoor paints, acidification is the third most relevant impact category due to raw materials processing, in particular titanium dioxide, TiO_2 ([6]). Improvement potential: Low Application of BAT for the raw material production shall be put in place, while special care shall be given for the avoidance of 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. Potential measures under ESPR: - performance requirement for increased durability of paints in the design phase - information requirement on how to use paints and varnishes efficiently - performance requirement restriction on maximum area land use for the cultivation of raw material per kg of paints and varnishes produced - information requirement on the presence in the product/possible release of non-biodegradable microplastics.
Biodiversity Effects [3] Environmental impact: High Biodiversity effects from the production of paints could not be assessed however as paints are a source of microplastics (at different life cycle stages going from wear and tear to incorrect waste management), there is a potential negative effect to seas and oceans biodiversity. Paints has been selected as the third source of microplastics in seas and oceans which also relates to bioaccumulation as a potential harm to species. Improvement potential: Low Current strategies to minimise effect on biodiversity are uncertain however some can be tackled in the same way as microplastic reduction e.g. increasing the durability of paints at the design phase, avoid leachates and/or spillages and use paints in an efficient way. Potential measures under ESPR: - performance requirement restriction on maximum area land use for the cultivation of raw material per kg of paints and varnishes produced - information requirement on the presence in the product/possible release of non-biodegradable microplastics
Waste Generation & Management [3] Environmental impact: Medium Waste from paint utilisation is classified as hazardous waste and can be the paints itself while also 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 a 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

PAINTS AND VARNISHES
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 minimum packaging-to-product ratio - performance requirement on design for reliability (e.g. resistance to release of microplastics) - information requirement on the presence in the product/possible release of non-biodegradable microplastics - information requirement on expected lifetime of the product - information requirement on how to correctly dose and use the product - information requirement on how to use the product to avoid its premature substitution/replacement - information requirement on how to dispose of the product to reduce environmental impacts - Information requirement on how to clean painting tools in order to reduce environmental impacts
Climate Change [2] Environmental impact: Medium Some sources claim climate change is the most harmful impact category in the life cycle of paints [6, 12], being raw materials acquisition, use and end-of-life of paints, the three more 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 climate change related to raw material production (binders, oils, pigments...). Special care shall be given for the avoidance of cross-media effects [10, 11]. Potential measures under ESPR: - performance requirement on a maximum level of GHG emissions during manufacturing by mass of product - information requirement on the GHGs emitted during manufacturing by mass of product
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, it has been taken into account in the climate change and other sections, thus is decided to give a lower impact in this section. Particular cases shall be studied to shed more light to the variety of products in this group. Improvement potential: Low Improve 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: - performance requirement on a maximum energy consumed during manufacturing by mass of product - information requirement on a maximum energy consumed during manufacturing by mass of product
Human Toxicity [2] 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 substances, SVHC (Substances of Very High Concern), CMRs (Chemicals that cause cancer, gene mutations or reproductive toxicity), 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 source of toxicity which shall be avoided by paint formulation free of those harmful compounds. A way to assess the risk of the 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 a clear evidence ([14, 15]).

Due to the environmental legislation on the use of solvents, the paint sector moved 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 can. Without protection, 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 in order to minimise hazardous compounds. Good plant hygiene is the main practice in order to control the sources of contamination 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 of pipes and could ultimately lead to stopping production ([20]).

At the user level, by March 2022, there were over 30 000 paints and varnishes 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 for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).

Material efficiency [3]

Improvement potential: Medium

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 left over paint rather than the recycling of the pots. Recycling of paint pots does appear to be possible in the trade sector as it requires specialist equipment and is not suitable for the consumer market. The recovery of energy appears to be a favoured route to dispose of paint pots, for example using them as fuel in cement kiln furnaces. This has the advantage of eliminating any hazardous substances if the air pollutant control are in place (filtration or any other abatement techniques) ([10]).

Potential measures under ESPR:

- performance requirement on minimum packaging-to-product ratio
- performance requirement on design for reliability (e.g. resistance to release of microplastics)
- information requirement on the presence in the product/possible release of non-biodegradable microplastics
- information requirement on expected lifetime of the product
- information requirement on how to use the product to avoid its premature substitution/replacement
- information requirement on how to dispose of the product to reduce environmental impacts

PAINTS AND VARNISHES

- information requirement on how to clean painting tools in order to reduce environmental impacts

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 not one only test to study the durability of a paint. The performance of a paint 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 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. 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 nanoparticles of silver 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 need careful assessment. There is some evidence of an inherent health risk posed by exposure to nanoparticles ([10]).

Potential measures under ESPR:

- performance requirement on minimum reliability (e.g. resistance to water, adhesion, abrasion, weathering)
- information requirement on expected lifetime of the product
- information requirement on how to correctly dose and use the product
- information requirement on how to use the product to avoid its premature substitution/replacement

Final score [24]

Strategic autonomy score [3]

Relevance: Many raw materials used in the production of paints and varnishes are identified as critical raw materials (minerals and polymers) thus the pre-screening for strategic autonomy rated this product with a medium relevance.

Potential gains for strategic autonomy: The extension of the life time of paints and recovery of un-used paints are measures to be implemented as much as possible in order to minimise the need for new products.

Policy Gaps

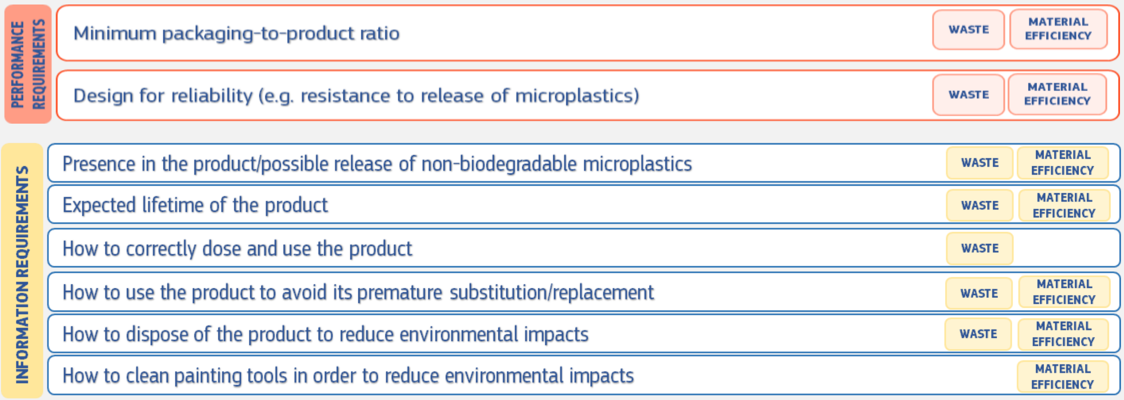
There is an absence of a specific and mandatory regulation promoting ecodesign principles in water-based paints. At the moment, there are only voluntary schemes in place, like the EU ecolabel (Commission Decision C(2014) 3429) and Green Public Procurement (SWD(2017) 484 final) criteria.

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 decorative paints and varnishes and vehicle refinishing products and amends Directive 1999/13/EC.

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 safety; the Waste Framework Directive 2019/1004/EC; and Council Directive 96/62/EC on ambient air quality assessment and management.

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. The Commission's proposal to amend the list of substances restricted under Annex XVII of REACH is expected to prevent the release of 500 000 tonnes of microplastics over 20 years. Paints are included in the on-going drafted proposal ([19]).

Summary of potential measures to reduce environmental impacts



Proportionality of Costs

No cost data could be found related to the application of the potential measures identified above, such as air and water pollution control, life time extension, recycling of unused paints or novel waste management processes reported. Some measures are already being implemented by major paint producers, but improvements remain to be done, and current market forces seem to support the abovementioned requirements. As of September 2022, almost 36 000 paint products are awarded with EU Ecolabel ([22]).

Additional notes and list of references

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

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PAINTS AND VARNISHES
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([15]) Moro et al., 2010. Effects of low-level exposure to xenobiotics present in paints on oxidative stress in workers. Science of The Total Environment, Volume 408, Issue 20, 2010, pp 4461-4467.
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([20]) CEPE and AISE, 2018. The need for a holistic approach on in-can preservatives (available upon request).
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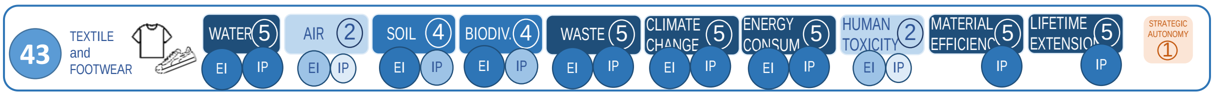
([22]) EU Ecolabel facts and figures (last accessed 20.01.2023)

Box 10. Factsheet for Textiles and footwear

TEXTILES AND FOOTWEAR



Scope: Apparel and home/interior textiles (e.g. bedlinen, towels, tablecloths, curtains etc.) consumed by households, and similar products consumed by government and business (e.g. uniforms and workwear used by all public and private sectors, bedlinen and towels etc. consumed by hotels, restaurants, healthcare services etc.) + footwear 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 are not the dominant component (e.g. upholstery textiles, carpets mainly made of plastics, duvets, pillows) and leather.

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]). As regards the footwear industry, water consumption reached 29 000 million m^3 of freshwater withdrawal ([56]). Dividing this industry according to footwear material, synthetic polymer shoes has the highest impact on water consumption, 48% compared to 31% for leather shoes and 21% for textile shoes ([57]). Moreover, it was estimated that about 20 % of global water pollution is caused by dyeing and finishing 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 ~40% of clothes ([13,15,18])), which requires huge quantities of water (estimated at 2.6% of global water use ([13])), fertilisers and pesticides ([2,14,15]), and is usually grown is dry areas where other commodities grow with difficulties ([12]). 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]): laundering clothes, especially synthetic (~55% of total clothes ([4,5,18])), represents the second cause of primary microfibers released into the environment in the world, and accounts for 35% of microfibers release ([5,6]).

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]). Incorporating recycling cotton in the production of textiles, on the other hand, avoids 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]), recycled cotton is still an emerging fabric ([9,25]), and its use impacts the quality of the yarn and the garment([11]). The environmental impacts of cotton can be drastically reduced also when sourcing it from organic farming, which it uses less water and pollutes less ([10]): it was estimated that organic cotton consumes 79% less water than conventional cotton ([12]). More than 100 brands have committed to the '2025 Sustainable Cotton Challenge' to achieve 50% of cotton from sustainable sources ([16]). 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 decrease by ~60% when using machine controllers ([4]). Finally, several initiatives exist to fight microfibers releases from 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:

TEXTILES AND FOOTWEAR
- performance requirement on minimum recycled content in textiles and footwear - performance requirement on maximum limit of water consumption related to the production of cotton - performance requirement on maximum limit of water consumption per kg or unit of product - performance requirement on maximum limit of chemical consumption related to the production of one kg or unit of product - performance requirement on design for performance requirement on design for reliability (shed-resistance to release of microplastics) - performance requirement on design for minimising water consumption during the use of the product - performance requirement on maximum limit of fertilisers, pesticides and insecticides to the production of cotton - performance requirement on minimum content of material with sustainability* certification per kg or unit of textiles and footwear - performance requirement on design ensuring easy recyclability of the product at the end of its useful life - performance requirement on design ensuring the durability of the textile products or footwear - performance requirement on minimum percentage of recycled content in product packaging - performance requirement for use of design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items - performance requirement on use of standard components for those parts that are prone to breaks - performance requirement of use of modular design in clothing items - performance requirement on restricting the use of certain materials or manufacturing practises - performance requirement on minimum durability of the product (during under normal conditions of use) - performance requirement on minimum reliability (e.g. resistance to shrinkage/weathering) - performance requirement for use of component and material coding standards for the identification of components and materials for reuse or recycling - information requirement on water consumption during production per kg or unit of product - information requirement on the possible release of non-biodegradable microplastics - information requirement on how to manage the textile or footwear at the end of its lifetime - information requirement on percentage of recycled content in product packaging - information requirement on GHG emissions associated to the washing and drying operations of a clothing item - information requirement on energy consumption associated to the washing and drying operations of a clothing item - information requirement on how to use the product to avoid its premature substitution/replacement (or its components)
Air Effects [2] Environmental impact: Medium The air emissions linked to textile products are VOC[63] produced during coating, lamination, printing, dyeing and finishing ([22]); formaldehyde originated during coating, laminating, finishing and printing ([22]); dust emissions,

[63] Volatile organic components

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]).

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.

Potential measures under ESPR:

- performance requirement on minimum recycled content in textiles and footwear reducing air pollution due to the decrease of raw material extraction

- performance requirement on design to reduce particulate matter release during production stage of the product

- information requirement on how to use the product to increase durability to avoid air pollution for new product production

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]). Projections show that at the current pace, by 2030 the fashion industry will increase by 35% its use of land for cotton cultivation, forest for cellulosic fibres, and grassland for livestock([3]). Cotton cultivation is also linked to large use of fertilisers, pesticides and insecticides ([2]): around 5% of pesticides and 14% of insecticides sold are destined for use on cotton ([23]). It has been showed that improper application pesticides has led to an increase in pest resistance and to the reduction of crop yields due to resistance ([4]).

Improvement potential: Medium

Reuse and recycling have the potential of reducing the production of new items, and therefore the cultivation of cotton. A scenario assuming an increase of 15% in recycling and 12% in reuse of EU textile waste should decrease land occupation by 10%, and land transformation by 6% ([4]). However, the utilisation rate of recycled cotton fibres is still low, especially in China, the largest producer of textiles ([25]). The pressure on land use can be reduced by switching to organic cotton, which does not use pesticides; however, organic crop yields is generally lower and can lead to increased land use ([4,24]). Flax and hemp could be viable alternatives to cotton fibres, given their higher yields, durability and strength ([4]). Finally, regenerative practices[64] improve soil health, increase the soil's water retention capacity and reduce reliance on fertilisers and pesticides ([26]).

Potential measures under ESPR:

- performance requirement on minimum recycled content in textiles and footwear

- performance requirement on maximum limit of chemical consumption related to the production of one kg or unit of product

- performance requirement on design for reliability (shed-resistance to release microplastics)

- performance requirement on design for minimising water consumption during the use of the product

- performance requirement on maximum limit of fertilisers, pesticides and insecticides to the production of

[64] Regenerative agriculture is a conservation and rehabilitation approach to food and farming systems.

TEXTILES AND FOOTWEAR
cotton - performance requirement on maximum limit of water consumption related to the production of cotton - performance requirement on minimum content of material with sustainability* certification per kg or unit of textiles and footwear - performance requirement on design ensuring easy recyclability of the product at the end of its lifetime - performance requirement on design ensuring the durability of the textile products or footwear - performance requirement on minimum percentage of recycled content in product packaging -performance requirement on use of design techniques that ease non-destructive disassembly and re-assembly of specific contents in clothing items -performance requirement on use of standard components for those parts that are prone to breaks - performance requirement of use of modular design in clothing items - performance requirement on restricting the use of certain materials or manufacturing practises - performance requirement on minimum durability of the product (during under normal conditions of use) - performance requirement on minimum reliability (e.g. resistance to shrinkage/weathering) - performance requirement for use of component and material coding standards for the identification of components and materials for reuse or recycling - information requirement on the possible release of non-biodegradable microplastics - information requirement on how to manage the textile or footwear at the end of its lifetime - information requirement on percentage of recycled content in product packaging - information requirement on how to use the product to avoid its premature substitution/replacement (or its components)
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 and fashion products facilitates ([29, 30]). Biodiversity impacts are especially high for cashmere ([26]). Improvement potential: Medium Improvement potential related to increased used of sustainable sourcing of fibres and reuse and recycling options, which have 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 ~0.4% ([8]). 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, 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 material with sustainability* certification per kg or unit of textiles and footwear - performance requirement on minimum recycled content in textiles and footwear

TEXTILES AND FOOTWEAR

- performance requirement on maximum limit of water consumption related to the production of cotton

- performance requirement on maximum limit of water consumption per kg or unit of product

- performance requirement on maximum limit of chemical consumption related to the production of one kg or unit of product

- performance requirement on design for performance requirement on design for reliability (shed-resistance to release of microplastics)

- performance requirement on design for minimising water consumption during the use of the product

- performance requirement on maximum limit of fertilisers, pesticides and insecticides to the production of cotton

- performance requirement on design ensuring easy recyclability of the product at the end of its useful life

- performance requirement on design ensuring the durability of the textile products or footwear

- performance requirement on minimum percentage of recycled content in product packaging

- performance requirement for use of design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items

- performance requirement on use of standard components for those parts that are prone to breaks

- performance requirement of use of modular design in clothing items

- performance requirement on restricting the use of certain materials or manufacturing practises

- performance requirement on minimum durability of the product (during under normal conditions of use)

- performance requirement on minimum reliability (e.g. resistance to shrinkage/weathering)

- performance requirement for use of component and material coding standards for the identification of components and materials for reuse or recycling

- information requirement on possible release of non-biodegradable microplastics

- information requirement on how to manage the textile or footwear at the end of its lifetime

- information requirement on percentage of recycled content in product packaging

- information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)

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 30 % of garments are over-produced and disposed of without being worn even once to preserve the exclusiveness of the brand ([27]). On the other hand, cut-offs during production are responsible for about 20 % of the industry's fabric waste ([3]). With respect to post-consumer waste, discarded textiles equal to 5 million tonnes textile waste/year in the EU ([1]), with total reported separate collection in 13 EU countries at around 2 million tonnes per year ([36]). 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]). As regards the footwear industry, the waste generated depends on the kind of shoe manufactured. In the case of leather waste, the material with the greatest negative impact on the life cycle of a footwear ([57,61]), the total amount generated per pair fabricated is about 90g. This means an amount of approximately 0.5 million tons of waste ([60]).

Improvement potential: High

There is high untapped potential with respect to the end-of-life of textiles ([31,35]). Companies can adopt circular business models to ensure that waste and overproduction are avoided, e.g. by shifting towards on-demand

TEXTILES AND FOOTWEAR
production, lending, renting, repair and resale ([35,62]). In particular, the global second-hand fashion market is estimated at 130 000 million USD, and 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]). 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. For example, while the share of recycled polyester reached 14% in 2019, it is not yet advancing at the speed and scale required, also due to the low prices of fossil-based polyester([8]). While most recycled polyester on the market is currently based on plastic bottles – the value of polyester fibres in discarded textiles is currently being lost ([8]). The market share of recycled cotton, polyamide, man-made cellulose fibres, and wool is still low ([8]). In all cases, the fact that used textiles are normally defined as waste is a significant barrier to the market for reuse and recycling. Moreover, 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 (eg 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 minimum recycled content in textiles and footwear - performance requirement on design ensuring easy recyclability of the product at the end of its useful life - performance requirement on design ensuring the durability of the textile products or footwear - performance requirement on maximum limit of chemical consumption related to the production of one kg or unit of product - performance requirement on design for reliability (shed-resistance to release of microplastics) - performance requirement on design for minimising water consumption during the use of the product - performance requirement on minimum percentage of recycled content in product packaging - performance requirement on limiting the number of materials used in a single product - performance requirement on use of component and material coding standards for the identification of components and materials in clothing items - performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items - performance requirement on use of standard components for those parts that are prone to breaks - performance requirement of use of modular design in clothing items - performance requirement on restricting the use of certain materials or manufacturing practises - performance requirement on minimum durability of the product (during under normal conditions of use) - performance requirement on minimum reliability (e.g. resistance to shrinkage/weathering) - performance requirement for use of component and material coding standards for the identification of components and materials for reuse or recycling - information requirement on how to manage the textile or footwear at the end of its lifetime - information requirement on the possible lifetime of the textile or footwear - information requirement on minimum recycled content in textiles and footwear - information requirement on possible release of non-biodegradable microplastics - information requirement on percentage of recycled content in product packaging; - information requirement on how to use the product to avoid its premature substitution/replacement (or of

TEXTILES AND FOOTWEAR

its components)

Climate Change [5]
Environmental impact: High

The fashion industry is responsible for 10 % of annual global carbon emissions, and expected to increase by 50% by 2030 ([26,27,40]). 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 mainly related to the production of materials (38% of the textiles' supply chain GHG emissions ([41])), especially polyester (the most commonly used fibre) or PVC in the case of the footwear industry ([59]), via carbon-intensive processes ([1]), as well as synthetic inputs used for the cultivation of cotton ([41]), the energy-intensive processes of dyeing and finishing products (29%) ([12,41]) and the energy used for laundering the items during the use phase (20%) ([41]).

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 energy efficiency measures and switching to renewable sources of energy, and to a minor extent to reductions in cut-off waste ([43]): 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]). 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 cut around 50% of GHG emissions from farming ([41,43]). With respect to brands' operations, improvement potential measures include: energy efficiency measures for heating, ventilation and air conditioning-related equipment, using recycled materials for packaging, reducing e-commerce returns through technological improvements on predicting size and fit and consumer behavioural change to reduce purchases with an intent to return, and reduce overproduction ([43]). 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 circular business models such as on-demand production, lending, renting, and repair could achieve larger reductions. Finally, reduced washing and drying of textile products in the use phase are expected to save 186 million tonnes of CO_2 ([43]).

Potential measures under ESPR:

- performance requirement on maximum level of GHG emissions by kg of product or item of clothing produced.

- performance requirement limiting the number of materials used in a single product

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

- performance requirement on the use of design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items

- performance requirement on the use of standard components for those parts that are prone to breaks

- performance requirement on the availability of guarantees specific to remanufactured clothing items

- performance requirement on the use of modular design in clothing items

- performance requirement on design ensuring easy recyclability of the product at the end of its useful life

- performance requirement on design ensuring the durability of the textile products or footwear

TEXTILES AND FOOTWEAR
-performance requirement on maximum level of energy consumed by kg of product or item of clothing produced - performance requirement on restricting the use of certain materials or manufacturing practises - performance requirement on minimum durability of the product (during under normal conditions of use) - performance requirement on minimum reliability (e.g. resistance to shrinkage/weathering) - performance requirement for use of component and material coding standards for the identification of components and materials for reuse or recycling - performance requirement on maximum limit of water consumption related to the production of cotton - performance requirement on maximum limit of water consumption per kg or unit of product - performance requirement on design for minimising water consumption during the use of the product - performance requirement on minimum content of material with sustainability* certification per kg or unit of textiles and footwear- information requirement on the GHG emissions associated to the production of a clothing item - information requirement on the percentage of recycled content in product packaging - information requirement on the GHG emissions associated to the washing and drying operations of a clothing item - information requirement on how to manage the textile or footwear at the end of its lifetime - information requirement on energy consumed associated to the production of a clothing item - information requirement on energy consumption associated to the washing and drying operations of a clothing item - information requirement on how to use product to avoid its premature substitution/replacement (or of its components)
Life Cycle Energy consumption [5] Environmental impact: High The production of textile products uses a significant amount of energy for spinning, weaving, dyeing or giving the fabrics strength and shine ([2,3]). 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]). 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]). Potential measures under ESPR: - performance requirement on maximum level of energy consumed by kg of product or item of clothing produced - performance requirement restricting the use of certain materials or manufacturing practises (in certain applications) - performance requirement limiting the number of materials used in a single product (in certain applications) - performance requirement on the use of component and material coding standards for the identification of components and materials in clothing items

- performance requirement on the use of design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items
- performance requirement on the use of standard components for those parts that are prone to breaks
- performance requirement on the availability of guarantees specific to remanufactured clothing items
- performance requirement on the use of modular design in clothing items
- performance requirement on minimum recycled content in textiles and footwear
- performance requirement on design for minimising water consumption during the use of the product
- performance requirement on design ensuring easy recyclability of the product at the end of its useful life
- performance requirement on design ensuring the durability of the textile products or footwear
- performance requirement on minimum recycled content in product packaging
- performance requirement on minimum durability of the product (during under normal conditions of use)
- performance conditions on minimum reliability (e.g. resistance to shrinkage/weathering)
- information requirement on the energy consumed associated to the production of a clothing item
- information requirement on the energy consumption associated to the washing and drying operations of a clothing item
- information requirement on how to manage the textile or footwear at the end of its lifetime
- information requirement on the GHG emissions associated to the production of a clothing item
- information requirement on the percentage of recycled content in product packaging
- information requirement on the GHG emissions associated to the washing and drying operations of a clothing item
- information requirement on how to use product to avoid its premature substitution/replacement (or of its components)

Human Toxicity [2]
Environmental impact: Medium

Human toxicity impacts are related to the pesticides use in cotton cultivation, which has been associated with impacts on the health of workers and surrounding populations ([4]), and air-borne fibre fragment emissions in factories and their health implications on workers ([8]), in addition to the impacts of microfibers release during laundering which may enter the food chain and affect human health ([27]). 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 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]). 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. 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]).

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]). 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]). Finally, 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]).

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 textiles value chain includes little or no reuse or recycling ([1]). Product design solutions have the potential to change this figures. 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 recycled content in textiles and footwear
- performance requirement on design ensuring easy recyclability of the product at the end of its useful life
- performance requirement on design ensuring the durability of the textile products or footwear
- performance requirement on design for reliability (shed-resistance to release of microplastics)
- performance requirement on design for minimising water consumption during the use of the product
- performance requirement on minimum percentage of recycled content in product packaging
- performance requirement on limiting the number of materials used in a single product
- performance requirement on use of component and material coding standards for the identification of components and materials in clothing items
- performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items
- performance requirement on use of standard components for those parts that are prone to breaks
- performance requirement on availability of guarantees specific to remanufactured clothing items
- performance requirement of use of modular design in clothing items
- performance requirement on restricting the use of certain materials or manufacturing practises
- performance requirement on minimum durability of the product (during under normal conditions of use)
- performance requirement on minimum reliability (e.g. resistance to shrinkage/weathering)
- performance requirement for use of component and material coding standards for the identification of components and materials for reuse or recycling
- information requirement on how to manage the textile or footwear at the end of its lifetime
- information requirement on the possible lifetime of the textile or footwear
- information requirement on percentage of recycled content in product packaging

Lifetime extension [5]
Improvement potential: High

Products of fast fashion usually have a short lifetime, and European consumers purchased 40% more

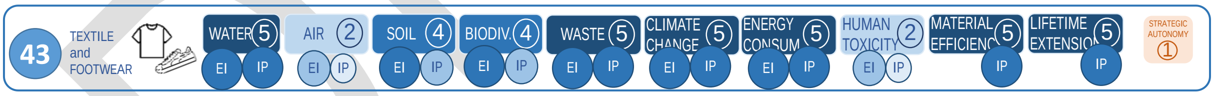
TEXTILES AND FOOTWEAR

clothing in 2012 compared to 1996, but wore it for a duration half as long. Better quality and sustainable material is part of the solution, but this is inseparable from consumer awareness ([27]). 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 on average, the GHG emissions would be 44 % lower ([31]). This could be achieved by measures that ensure and increase the durability of the items and the resistance to shrinkage/weather ([31]). On the other hand, studies estimate that resale will become twice as big as fast fashion by 2030([26]). It was studied that repair, re-commerce, rental and refurbishment models can extend average product life by 1.35, 1.7, 1.8 and 2 times ([43]).

Potential measures under ESPR:

- performance requirement on minimum durability of the product (during under normal conditions of use)
- performance requirement on minimum reliability (e.g. resistance to resistance to shrinkage/weathering)
- performance requirement on the use of component and material coding standards for the identification of components and materials for reuse or recycling
- performance requirement on design for reliability (shed-resistance to release of microplastics)
- performance requirement on design ensuring the durability of the textile products or footwear
- performance requirement on design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items
- performance requirement on use of standard components for those parts that are prone to breaks
- performance requirement on availability of guarantees specific to remanufactured clothing items
- performance requirement of use of modular design in clothing items
- performance requirement on restricting the use of certain materials or manufacturing practises
- information requirement on expected lifetime of the product
- information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)
- information requirement on possible lifetime of the textile or footwear

Final environmental score [43]



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 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

TEXTILES AND FOOTWEAR

European standards relating to textiles and clothing, relating to performance for certain types of textile products and to self-declared environmental claims[65]. 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 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]).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS

Minimum recycled content in textiles and footwear	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Maximum limit of water consumption related to the production of cotton	WATER		BIODIVERSITY		CLIMATE CHANGE			
Maximum limit of water consumption per kg or unit of product	WATER		BIODIVERSITY		CLIMATE CHANGE			
Maximum limit of chemical consumption related to the production of one kg or unit of product	WATER	SOIL	BIODIVERSITY	WASTE				
Design for reliability (shed-resistance to release of microplastics)	WATER	SOIL	BIODIVERSITY	WASTE			MATERIAL EFFICIENCY	LIFETIME EXTENSION
Design for minimising water consumption during the use of the product	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Maximum limit of fertilisers, pesticides and insecticides to the production of cotton	WATER	SOIL	BIODIVERSITY					
Minimum content of material with sustainability* certification per kg or unit of textiles and footwear	WATER	SOIL	BIODIVERSITY		CLIMATE CHANGE			
Design ensuring easy recyclability of the product at the end of its useful life	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Design ensuring the durability of the textile products or footwear	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Maximum level of GHG emissions by kg of product or item of clothing produced					CLIMATE CHANGE			
Limiting the number of materials used in a single product				WASTE			MATERIAL EFFICIENCY	
Use of component and material coding standards for the identification of components and materials in clothing items				WASTE			MATERIAL EFFICIENCY	
Use of design techniques that ease non-destructive disassembly and re-assembly of specific components in clothing items	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Use of standard components for those parts that are prone to breaks	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION

65 CEN/TS 16822:2015

TEXTILES AND FOOTWEAR

	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Availability of guarantees specific to remanufactured clothing items							X	X
Use of modular design in clothing items	X	X	X	X	X	X	X	X
Maximum level of energy consumed by kg of product or item of clothing produced					X	X		
Restricting the use of certain materials or manufacturing practises	X	X	X	X	X	X	X	X
Minimum durability of the product (during under normal conditions of use)	X	X	X	X	X	X	X	X
Minimum reliability (e.g. resistance to resistance to shrinkage/weathering)	X	X	X	X	X	X	X	X
Use of component and material coding standards for the identification of components and materials for reuse or recycling	X	X	X	X	X	X	X	X

INFORMATION REQUIREMENTS

	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Water consumption during production per kg or unit of product	X							
Possible release of non-biodegradable microplastics	X	X	X	X				
How to manage the textile or footwear at the end of its lifetime	X	X	X	X	X	X		
Possible lifetime of the textile or footwear								X
GHG emissions associated to the production of a clothing item					X	X		
Percentage of recycled content in product packaging	X	X	X	X	X	X	X	
GHG emissions associated to the washing and drying operations of a clothing item	X				X	X		
Energy consumed associated to the production of a clothing item					X	X		
Energy consumption associated to the washing and drying operations of a clothing item	X				X	X		
Expected lifetime of the product				X				X
How to use the product to avoid its premature substitution/replacement (or of its components)	X	X	X	X	X	X		X

Proportionality of Costs

Water conservation and reuse programs can have large benefits through decreased costs of purchased water and reduced costs for treatment of wastewaters, leading to short pay-back periods ([19]). Measures to reduce the usage of water and chemicals during dyeing have been found to have a pay-back period of about 2-3.5 years ([4]) and estimated cost savings of nearly $500,000 ([20]). A case study on 33 factories found that with an up-front investment of 17.3 million USD, resulted on average in 9% of water saved and 6% of energy saved, with a payback time for the whole program of only 14 months ([21]). On the other hand, certification and monitoring of organic crop cultivation is a costly procedure, which may ultimately offset the economic benefits due to less use of chemicals and higher returns from organic crop sales ([4]). Estimations identified that a circular economy for fashion can address the 500 000 millions USD of value lost annually due to clothing underutilisation and the lack of recycling, while supporting the creation of safe, healthy conditions for textile workers and users ([26]). Finally, textile-to-textile recycling can be worth more than 100 000 millions USD ([32]).

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

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Box 11. Factsheet for Toys

TOYS

Scope: The product group covers toys that consist of plastic, foam, silicone, rubber, textile, fur, leather, metal, paper, cardboard, wood, bamboo, or wood-based boards. Excluded: electronic toys (because falling these fall under the Ecodesign Directive for which the Ecodesign and Energy Labelling Workingplan 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 design for disassembly to enable the separation of recyclable parts
- information requirement on water consumption during production per kg or unit of product

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 minimum recycled content per kg or unit of product (or component) to avoid air pollution due to raw material extraction
- performance requirement on design for disassembly to increase material recovery to avoid air pollution due to raw material extraction
- information requirement on how to use the product to increase durability to avoid air pollution for new product production

Soil 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.

TOYS
Potential measures under ESPR: - performance requirement on minimum recycled content in toys - performance requirement on minimum content on raw material with sustainability certification
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 on raw material with sustainability certification
Waste Generation & Management [3] Environmental impact: Medium 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, more than 40 million toys end up as waste each year. In UK, 1/3 of parents have admitted to throw away toys in good working order ([17]). 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. For businesses making new toys, thinking about the materials that go into those toys is vital to eliminate waste and pollution. 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 minimum recycled content in toys - performance requirement on design ensuring the durability of toys - performance requirement on design to facilitate the recyclability of the toy at the end of its useful life; - performance requirement on design for reliability - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - information requirement on how to disassembly at the end of the lifetime to enable recycling - information requirement on minimum recycled content per toy unit/mass - information requirement on technical lifetime - information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)
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.

TOYS
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 the sourcing of materials from certified sustainable practices - performance requirement on the technical lifetime and resistance to stress of product - performance requirement on minimum percentage of energy use from low carbon sources - performance requirement on minimum recycled content in toys - performance requirement on design for reliability - performance requirement on minimum reliability (e.g. resistance to stress, abrasion, impact) - performance requirement on minimum durability (under normal conditions of use) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product - performance requirement on design ensuring the durability - information requirement on minimum recycled content per toy - information requirement on minimum percentage of energy use from low carbon sources - information requirement on the technical lifetime of product - information requirement on the sourcing of materials from certified sustainable practices - information requirement on how to disassembly at the end of the lifetime to enable recycling - information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)
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: - performance requirement on the sourcing of materials from certified sustainable practices - performance requirement on the technical lifetime and resistance to stress of product - performance requirement on minimum percentage of energy use from low carbon sources - performance requirement on minimum recycled content in toys - performance requirement on design for reliability - performance requirement on minimum reliability (e.g. resistance to stress, abrasion, impact) - performance requirement on minimum durability (under normal conditions of use) - performance requirement on design to facilitate reuse, repair, refurbishing and recycling - performance requirement on availability of spare parts for the product

TOYS
- performance requirement on design ensuring the durability - information requirement on the technical lifetime of product - information requirement on minimum percentage of energy use from low carbon sources - information requirement on the sourcing of materials from certified sustainable practices - information requirement on minimum recycled content per toy unit/mass - information requirement on how to disassembly at the end of the lifetime to enable recycling; - information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)
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) 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 to specify that toys should comply with general chemicals 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). 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. For example, replacing synthetic fibres with natural ones having lower life-cycle impacts, thus reducing the environmental impact of component production (11). Considering the currently low implementation of material efficiency aspects in toy products, the potential for improvement of toys lies in the use of renewable materials and sharing models and including upgradeability, reuse or end of life management, including recycling for other applications, when producing

TOYS

toys.

Potential measures under ESPR:

- performance requirement on design ensuring the durability of toys
- performance requirement on minimum recycled content in toys
- performance requirement on design to facilitate reuse, repair, refurbishing and recycling at the end of its useful life
- performance requirement on design for reliability
- performance requirement on minimum reliability (e.g. resistance to stress, abrasion, impact)
- performance requirement on minimum durability (under normal conditions of use)
- information requirement on how to disassembly at the end of the lifetime to enable recycling
- information requirement on technical lifetime
- information requirement on minimum recycled content per toy

Lifetime extension [5]

Improvement potential: High

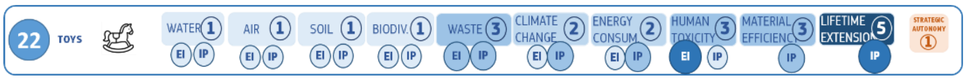
Toys generally end up as waste when a child's interests change or when get broken, with an average lifespan of six months. 40% of toys that are gifted during the holiday season get broken in a matter of months (5). This short lifespan of toys is due mainly to the fact that children rapidly change their 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. 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 durability of the product (under normal conditions of use)
- performance requirement on minimum reliability (e.g. resistance to stress, abrasion, impact)
- performance requirement on design to facilitate reuse, repair, refurbishing and recycling
- performance requirement on availability of spare parts for the product
- performance requirement on design for reliability
- performance requirement on design ensuring the durability
- information requirement on how to use the product to avoid its premature substitution/replacement (or of its components)
- information requirement on technical lifetime

Final score [21]



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

TOYS

chemical substances, thus some toxic and banned additives are sometimes found in plastic toys also on regulated markets ([6]). This Directive is under revision.

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 Rapporteur believes 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, including, where relevant, the availability of necessary software ([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 ([17]).

Summary of potential measures to reduce environmental impacts

PERFORMANCE REQUIREMENTS					
Minimum recycled content	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Design for reliability	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Sourcing of materials from certified sustainable practices		CLIMATE CHANGE	ENERGY USE		
Minimum reliability (e.g. resistance to stress, abrasion, impact)	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Minimum durability (under normal conditions of use)	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Design to facilitate reuse, repair, refurbishing and recycling;	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Availability of spare parts for the product	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
Design ensuring the durability	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Minimum percentage of energy use from low carbon sources		CLIMATE CHANGE	ENERGY USE		

TOYS

INFORMATION REQUIREMENTS					
How to disassembly at the end of the lifetime to enable recycling	WASTE	CLIMATE CHANGE	ENERGY USE		
Sourcing of materials from certified sustainable practices		CLIMATE CHANGE	ENERGY USE		
Technical lifetime	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
How to use the product to avoid its premature substitution/replacement (or of its components)	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
Minimum percentage of energy use from low carbon sources		CLIMATE CHANGE	ENERGY USE		
Minimum recycled content per toy	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	

Proportionality of costs

The implementation of the Toys Safety Directive has been laborious and implied significant investment from manufacturers ([14]). However, no data could be found on possible costs incurred by potential ecodesign requirement on design for durability, recyclability and recovery.

Additional notes and list of references

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

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Box 12. Factsheet for Tyres

TYRES

Water Effects [3]

Environmental impact: Medium

The emission of microplastics from tyres occurs during the use-phase (mechanical abrasion) ([3]). 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]). 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]).

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])

Potential measures under ESPR:

- performance requirement on design for reliability (resistance to release of microplastics); this may also be covered by Type-Approval Regulation in preparation (Euro 7)

- performance requirement on maximum level of water consumption during the production of 1 kg of product

- performance requirement on minimum recycled content; this could also be potentially covered by Type-Approval Regulation in revision

- performance requirement on design for durability to set a maximum limit of emission of microplastics per product unit

- performance requirement on design for reliability to set a limit to microplastic release

- performance requirement on design for disassembly to increase recycling

- performance requirement on design for disassembly to increase material recovery

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

- performance requirement on design to allow tyre re-treading

- performance requirement on design to facilitate the recyclability of the tyre at the end of its useful life

- performance requirement on minimum level of rolling resistance of tyres

- performance requirement on minimum percentage of recycled rubber in new tyres

- performance requirement on minimum durability (under normal conditions of use)

- performance requirement on percentage of recycled rubber in new tyres

- information requirement on the potential release of non-biodegradable microplastics during use: this may also be covered by measures in preparation under Tyre Labelling and Type-Approval Regulation

- information requirement on maximum level of water consumption during the production of 1 kg of product

- information requirement on how to choose more sustainable tyres to reduce microplastics

- information requirement on how to use the product to reduce microplastics

TYRES
- information requirement on how to maintain the product to increase durability - information requirement on how to disassembly the product at the end-of-life - information requirement on minimum content of raw material with sustainability certification per unit of product (or component) - information requirement on how to use tyres efficiently (i.e. to avoid its premature substitution/replacement) - information requirement on percentage of recycled rubber in new tyres - information requirement on how often to substitute/replace tyres
Air Effects [4] Environmental impact: High 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 particulate 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). 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). Potential measures under ESPR: - performance requirement on design for durability to set a maximum limit of emission of microplastics per product unit; this may also be covered by Type-Approval Regulation in preparation (Euro 7) - performance requirement on design for reliability to set a limit to microplastics release; this may also be covered by Type-Approval Regulation in preparation (Euro 7) - performance requirement for minimum recycled content per product unit to avoid air pollution due to raw material extraction; this could also be potentially covered by Type-Approval Regulation in revision - performance requirement on design for disassembly to increase recycling - performance requirement on design for disassembly to increase material recovery - performance requirement on minimum content of raw material with sustainability certification per unit of product - performance requirement on design to allow tyre re-treading - performance requirement on design to facilitate the recyclability of the tyre at the end of its useful life - performance requirement on maximum level of GHG emissions by tyre produced - performance requirement on minimum level of rolling resistance of tyres - performance requirement on minimum percentage of recycled rubber in new tyres - performance requirement on minimum durability (under normal conditions of use) - performance requirement on percentage of recycled rubber in new tyres - information requirement on potential release of non-biodegradable microplastics during use - information requirement on how to choose more sustainable tyres to reduce microplastics; this may also

TYRES

be covered by measures in preparation under the Tyre Labelling Regulation

- information requirement on how to use the product to reduce microplastics; this may also be covered by measures in preparation under the Tyre Labelling Regulation

- information requirement on how to maintain the product to increase durability; this may also be covered by measures in preparation under the Tyre Labelling Regulation

- information requirement on how to return the product at end-of-life

- information requirement on how to disassembly the product at the end-of-life

- information requirement on minimum content of raw material with sustainability certification per unit of product (or component)

- information requirement on how to use tyres efficiently (i.e. to avoid its premature substitution/replacement)

- information requirement on GHGs emitted during the production of a single tyre

- information requirement on percentage of recycled rubber in new tyres

- information requirement on how often to substitute/replace tyres

Soil Effects [3]
Environmental impact: Medium

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).

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)

Potential measures under ESPR:

- performance requirement on design for durability to set a maximum limit of emission of microplastics per product unit; this may also be covered by Type-Approval Regulation in preparation (Euro 7)

- performance requirement on design for reliability to set a limit to microplastics release; this may also be covered by Type-Approval Regulation in preparation (Euro 7)

- performance requirement on minimum content of raw material with sustainability certification per unit of product, this could also be potentially covered by Type-Approval Regulation in revision

- performance requirement on minimum recycled content

- performance requirement on design for disassembly to increase recycling

- performance requirement on design for disassembly to increase material recovery

- performance requirement on design to allow tyre re-treading

- performance requirement on design to facilitate the recyclability of the tyre at the end of its useful life

- performance requirement on minimum level of rolling resistance of tyres

- performance requirement on minimum percentage of recycled rubber in new tyres

TYRES

- performance requirement on minimum durability (under normal conditions of use)

- performance requirement on percentage of recycled rubber in new tyres

- information requirement on how to choose more sustainable tyres to reduce microplastics; this may also be covered by measures in preparation under the Tyre Labelling Regulation

- information requirement on how to use the product to reduce microplastics

- information requirement on minimum content of raw material with sustainability certification per unit of product (or component)

- information requirement on potential release of non-biodegradable microplastics during use

- information requirement on how to maintain the product to increase durability

- information requirement on how to disassembly the product at the end-of-life

- information requirement on how to use tyres efficiently (i.e. to avoid its premature substitution/replacement)

- information requirement on percentage of recycled rubber in new tyres

- information requirement on how often to substitute/replace tyres

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.

Land use change may directly occur also as result of resources (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, being the main EU sourcing countries, 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]).

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]), as well as an environmentally sustainable approach to sourcing.

Potential measures under ESPR:

- performance requirement on design for durability to set a maximum limit of emission of microplastics per product unit, this may also be covered by Type-Approval Regulation in preparation (Euro 7)

- performance requirement on design for reliability to set a limit to microplastics release; this may also be covered by Type-Approval Regulation in preparation (Euro 7)

- performance requirement on minimum content of raw material with sustainability certification per unit of product (or component)

- performance requirement on minimum recycled content

- performance requirement on design for disassembly to increase recycling

- performance requirement on design for disassembly to increase material recovery

TYRES
- performance requirement on design to allow tyre re-treading - performance requirement on design to facilitate the recyclability of the tyre at the end of its useful life - performance requirement on minimum level of rolling resistance of tyres - performance requirement on minimum percentage of recycled rubber in new tyres - performance requirement on minimum durability (under normal conditions of use) - performance requirement on percentage of recycled rubber in new tyres - information requirement on how to choose more sustainable tyres to reduce microplastics; this may also be covered by measures in preparation under the Tyre Labelling Regulation - information requirement on how to use the product to reduce microplastics - information requirement on minimum content of raw material with sustainability certification per unit of product (or component) - information requirement on the potential release of non-biodegradable microplastics during use: this may also be covered by measures in preparation under tyre labelling and type-approval regulation - information requirement on how to maintain the product to increase durability - information requirement on how to disassembly the product at the end-of-life - information requirement on how to use tyres efficiently (i.e. to avoid its premature substitution/replacement) - information requirement on percentage of recycled rubber in new tyres - information requirement on how often to substitute/replace tyres
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 Producers 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 CO2e 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 design to allow tyre re-treading - performance requirement on design to facilitate the recyclability of the tyre at the end of its useful life - performance requirement on design for reliability (resistance to release of microplastics)

TYRES
- performance requirement on design for durability to set a maximum limit of emission of microplastics per product unit; this may also be covered by type-approval regulation in preparation (Euro 7) - performance requirement on design for reliability to set a limit to microplastics release; this may also be covered by type-approval regulation in preparation (Euro 7) - performance requirement for minimum recycled content per product unit to avoid air pollution due to raw material extraction; this could also be potentially covered by type-approval regulation in revision - performance requirement on design for disassembly to increase recycling - performance requirement on design for disassembly to increase material recovery - performance requirement on minimum level of rolling resistance of tyres - performance requirement on minimum percentage of recycled rubber in new tyres - performance requirement on minimum durability (under normal conditions of use) - performance requirement on percentage of recycled rubber in new tyres - information requirement on how to use tyres efficiently - information requirement on potential release of non-biodegradable microplastics during use - information requirement on how to choose more sustainable tyres to reduce microplastic ; this may also be covered by measures in preparation under the tyre labelling regulation - information requirement on how to use the product to reduce microplastic; this may also be covered by measures in preparation under the tyre labelling regulation - information requirement on how to maintain the product to increase durability; this may also be covered by measures in preparation under the tyre labelling regulation - information requirement on how to return the product at end-of-life - information requirement on how to disassembly the product at the end-of-life - information requirement on percentage of recycled rubber in new tyres - information requirement on how often to substitute/replace 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. 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 drive 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 minimum level of rolling resistance of tyres, this may also be covered by

TYRES
measures in preparation under the Tyre Labelling Regulation and Type-Approval Regulation - performance requirement on a maximum level of GHG emissions by tyre produced, - performance requirement on a minimum percentage of recycled rubber in new tyres - performance requirement on design to allow tyre re-treading - performance requirement on design to facilitate the recyclability of the tyre at the end of its useful life - performance requirement on design for reliability (resistance to release of microplastics) - performance requirement on design for durability to set a maximum limit of emission of microplastics per product unit; this may also be covered by type-approval regulation in preparation (Euro 7) - performance requirement on design for reliability to set a limit to microplastics release; this may also be covered by type-approval regulation in preparation (Euro 7) - performance requirement for minimum recycled content per product unit to avoid air pollution due to raw material extraction; this could also be potentially covered by type-approval regulation in revision - performance requirement on design for disassembly to increase recycling - performance requirement on design for disassembly to increase material recovery - performance requirement on minimum durability (under normal conditions of use) - performance requirement on percentage of recycled rubber in new tyres - performance requirement on minimum content of raw material with sustainability certification per unit of product - performance requirement on maximum level of GHG emissions by tyre produced - information requirement on the level of rolling resistance of tyres, this may also be covered by measures in preparation under the Tyre Labelling Regulation and Type-Approval Regulation - information requirement on the GHGs emitted during the production of a single tyre - information requirement on the percentage of recycled rubber in new tyres - information requirement on how to choose more sustainable tyres to reduce microplastics - information requirement on how to maintain the product to increase durability - information requirement on how to disassembly the product at the end-of-life - information requirement on minimum content of raw material with sustainability certification per unit of product (or component) - information requirement on how to use tyres efficiently (i.e. to avoid its premature substitution/replacement) - information requirement on how often to substitute/replace tyres
Life Cycle Energy consumption [3] Environmental impact: Medium 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 a minimum level of rolling resistance of tyres; this may also be covered by

TYRES

measures in preparation under the Tyre Labelling Regulation and Type-Approval Regulation

- performance requirement on a maximum level of GHG emissions by tyre produced

- performance requirement on a minimum percentage of recycled rubber in new tyres

- performance requirement on design to allow tyre re-treading

- performance requirement on design to facilitate the recyclability of the tyre at the end of its useful life

- performance requirement on design for reliability (resistance to release of microplastics)

- performance requirement on design for durability to set a maximum limit of emission of microplastics per product unit; this may also be covered by type-approval regulation in preparation (Euro 7)

- performance requirement on design for reliability to set a limit to microplastics release; this may also be covered by type-approval regulation in preparation (Euro 7)

- performance requirement for minimum recycled content per product unit to avoid air pollution due to raw material extraction; this could also be potentially covered by type-approval regulation in revision

- performance requirement on design for disassembly to increase recycling

- performance requirement on design for disassembly to increase material recovery

- performance requirement on minimum durability (under normal conditions of use)

- performance requirement on percentage of recycled rubber in new tyres

- performance requirement on maximum level of GHG emissions by tyre produced

- information requirement on the level of rolling resistance of tyres, this may also be covered by measures in preparation under tyre labelling and type-approval regulation

- information requirement on the GHGs emitted during the production of a single tyre

- information requirement on the percentage of recycled rubber in new tyres

- information requirement on how to choose more sustainable tyres to reduce microplastics

- information requirement on how to maintain the product to increase durability

- information requirement on how to disassembly the product at the end-of-life

- information requirement on how to use tyres efficiently (i.e. to avoid its premature substitution/replacement)

- information requirement on how often to substitute/replace tyres

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 because of tyres/brakes wear, process that releases particles of all the sizes involved in the 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 humans 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 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.

TYRES
Material efficiency [3] Improvement potential: Medium 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]). It is essential developing testing methods or standards to measure tyre abrasion and durability; improving wet grip to reduce wet braking distances and measuring rolling resistance, wet grip, external rolling noise and other parameters in accordance with reliable, accurate and reproducible methods ([1]). Data shows that in the EU28+4, a total of over 4 million tonnes of used tyres were generated in 2019, and of this total approximately 3.5 million tonnes comprised ELT (3% was used in civil engineering applications; 52% was recycled; 40% was used for co-incineration and the remaining 5% went either to stock or unknown uses) ([23]). Recycling also provides substantial benefits in a number of other environmental categories. In addition to that ELT rubber has a positive market value ([23]). Ambitious recycling and recycled content targets could drive the demand for recycled rubber and materials from tyres ([24]). Innovation enables recovery of tyre component materials ([26]). Potential measures under ESPR: - performance requirement on design to allow tyre re-treading - performance requirement on design for reliability (resistance to release of microplastics) - performance requirement on minimum recycled content - performance requirement design for disassembly to increase recycling - performance requirement on design for disassembly to increase material recovery - performance requirement to facilitate the recyclability of the tyre at the end of its useful life - performance requirement on minimum level of rolling resistance of tyres - performance requirement on minimum percentage of recycled rubber in new tyres - performance requirement on percentage of recycled rubber in new tyres - information requirement on how to use tyres efficiently - information requirement on percentage of recycled rubber in new tyres
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]. 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 durability of tyres (during under normal conditions of use - performance requirement on design for reliability (resistance to release of microplastics, abrasion, weathering, impact) - performance requirement on design for durability to set a maximum limit of emission of microplstics per product unit - performance requirement on design for reliability to set a limit to microplastics release

TYRES

- performance requirement on design to allow tyre re-treading

- performance requirement on minimum level of rolling resistance of tyres

- information requirement on the potential release of non-biodegradable microplastics during use

- information requirement on expected lifetime of tyres; this may also be covered by measures in preparation under Tyre Labelling Regulation

- information requirement on how often to substitute/replace tyres

- information requirement on how to use/maintain the product to avoid its premature substitution/replacement

- information requirement on how to choose more sustainable tyres to reduce microplastics

- information requirement on how to use the product to reduce microplastics

- information requirement on how to maintain the product to increase durability

- information requirement on how to use tyres efficiently

- information requirement on level of rolling resistance of tyres

Final environmental score [30]

Strategic autonomy score [5]

Relevance: Tyres rate high in the pre-screening for strategic autonomy: this is mainly due to the fact that the product group demands an extremely large share (75%) of the EU demand of one critical raw material (natural rubber) for which the EU is fully dependant (100% import reliance). Moreover, tyre manufacturing depends on synthetic rubber (in case of substitution of natural rubber) and carbon black that also are supplied by Russia and Ukraine.

A key method to improve strategic autonomy would be replacement of natural rubber. Examples of research are use of natural rubber from dandelion and synthetic rubber: biomimetic synthetic rubber with optimized abrasion behaviour (BISYKA).

Potential gains for 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. These options could be analysed in a possible preparatory study.

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
    - Commission proposal for Euro 7

TYRES
2. Tyre labelling [Regulation (EU) 2020/740](https://eur-lex.europa.eu/eli/reg/2020/740/oj):
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 but does not avoid direct side-effects such as particulate matter release and/or (micro) plastic pollution contribution to different environmental compartments. Work is in progress to tackle both abrasion and mileage via the setting of minimal requirements or via information requirements (i.e. labelling): a study will provide the necessary testing methods, thus enabling the setting of legislative requirememnts. 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). It must be noted that type approval legislation is prepared in the context of the UNECE initiatives for sustainable development goals (https://unece.org/wp29-introduction): UN Regulations contain provisions (for vehicles, their systems, parts and equipment) related to safety and environmental aspects. They include performance-oriented test requirements, as well as administrative procedures. The latter address the type approval (of vehicle systems, parts and equipment), the conformity of production (i.e. the means to prove the ability, for manufacturers, to produce a series of products that exactly match the type approval specifications) and the mutual recognition of the type approvals. Specific work on tyre abrasion (and mileage) is ongoing in UNECE. These 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]). With respect to sourcing of tyre materials, there is no legislation specifically dedicated to this. However, at the moment of writing this report, the EC has proposed 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. 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. 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 improvement potential measures

TYRES

PERFORMANCE REQUIREMENTS (IMPROVEMENT POTENTIAL)

Design for reliability (resistance to release of microplastics)	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Maximum level of water consumption during the production of 1 kg of product		WATER							
Minimum recycled content	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Design for durability to set a maximum limit of emission of microplastics per product unit	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
Design for reliability to set a limit to microplastics release	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
Design for disassembly to increase recycling	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Design for disassembly to increase material recovery	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Minimum content of raw material with sustainability certification per unit of product	AIR	WATER	SOIL	BIODIVERSITY		CLIMATE CHANGE			
Design to allow tyre re-treading	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Design to facilitate the recyclability of the tyre at the end of its useful life	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Minimum level of rolling resistance of tyres	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	LIFETIME EXTENSION
Maximum level of GHG emissions by tyre produced	AIR					CLIMATE CHANGE	ENERGY USE		
Minimum percentage of recycled rubber in new tyres	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
Minimum durability (under normal conditions of use)	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
Percentage of recycled rubber in new tyres	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	

INFORMATION REQUIREMENTS (IMPROVEMENT POTENTIAL)

Potential release of non-biodegradable microplastics during use	AIR	WATER	SOIL	BIODIVERSITY	WASTE				
Maximum level of water consumption during the production of 1 kg of product		WATER							
How to choose more sustainable tyres to reduce microplastics	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
How to use the product to reduce microplastics	AIR	WATER	SOIL	BIODIVERSITY	WASTE				LIFETIME EXTENSION
How to maintain the product to increase durability	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
How to disassembly the product at the end-of-life	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		
Minimum content of raw material with sustainability certification per unit of product (or component)	AIR	WATER	SOIL	BIODIVERSITY		CLIMATE CHANGE			
How to use tyres efficiently (i.e. to avoid its premature substitution/ replacement)	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
Level of rolling resistance of tyres						CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION
GHGs emitted during the production of a single tyre	AIR					CLIMATE CHANGE	ENERGY USE		
Expected lifetime of tyres					WASTE				LIFETIME EXTENSION
Percentage of recycled rubber in new tyres	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE	MATERIAL EFFICIENCY	
How often to substitute/replace tyres	AIR	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE		LIFETIME EXTENSION

Proportionality of Costs

Cost data on potential ecodesign measures for tyres could not be found. Once methods will be available, minimal requirements will be proposed within the type approval framework and labelling via the tyre labelling legislation. There is a demand for ELT granulate and powder and it is treated by the market as a legitimate product with a positive value. If ELT rubber were not available, the market would need to seek other alternatives to fulfil the need ([23]).

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

Box 13. Factsheet for Aluminium

ALUMINIUM

Scope: Aluminium and its alloys.

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. 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:

- information requirement on the water consumption during production

Air Effects [4]
Environmental impact: High

Air emissions from the production of primary aluminium include a high range of pollutants (particles, metals, HCl, HF, fluorides, NOx, SO2, CO, CO_2, PFCs[66], NMVOC[67], PAH[68], PCDD/F[69] 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 minimum recycled content per tonne of product to avoid air pollution due to reducing bauxite extraction

- performance requirement on the sourcing of raw materials from certified sustainable practices (if aplicable)

- performance requirement on minimum percentage of energy use from low carbon sources to reduce air

[66] Polyfluorocarbon
[67] Non-methane volatile organic compounds
[68] Polycyclic aromatic hydrocarbons
[69] Polychlorinated dibenzo-dioxins and polychlorinated dibenzo-furans

ALUMINIUM
pollution - performance requirement on maximum level of GHG emissions during manufacturing - information requirement on recycled content per ton of input material - information requirement on the sourcing of raw materials from certified sustainable practices - information requirement on the percentage of energy use from low carbon source
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]). In 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]). 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]). However, aluminium, is the third most common element in the Earth's crust ([7]). The EU consumption is higher than the production and illustrate 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 recycled content in aluminium - performance requirement on minimum content of bauxite with sustainability certification - performance requirement on sourcing of raw materials from certified sustainable practices - information requirement on minimum recycled content in 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. Also the disposal by dams or lagoons of dangerous waste. 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:

ALUMINIUM

- performance requirement on minimum content of bauxite with sustainability certification

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]).

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]).

Potential measures under ESPR:

- performance requirement on minimum recycled content in aluminium
- information requirement on minimum recycled content in aluminium

Climate Change [4]
Environmental impact: High

The main environmental impact of primary aluminium production is climate change where GHGs (and PFCs such as CF4 and C2F6) 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]).

Primary aluminium production is energy intensive, therefore CO_2 emissions of the industry highly depend on the primary fuel for electricity generation ([5]).

Improvement potential: Medium

Measures listed as BATs could lead to a reduction of around 10% of GHG emission ([7]). The refining industry's environmental performance in Europe show that the GHG emissions of the refining process decreased by 14% between 2010 and 2018 ([12]).

Potential measures under ESPR:

- performance requirement on the sourcing of raw materials from certified sustainable practices
- performance requirement on a maximum level of GHG emissions by ton of material
- performance requirement on minimum percentage of energy use from low carbon sources
- performance requirement on maximum energy consumed during manufacturing
- information requirement on the sourcing of raw materials from certified sustainable practices
- information requirement on percentage of energy use per kg of product from low carbon sources

Life Cycle Energy consumption [4]
Environmental impact: High

One of the key reasons for high environmental emissions from the smelting process in primary production is the energy consumed which can be significantly reduced by altering the energy generation source ([3]). 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

ALUMINIUM

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 energy consumed by ton of material
- performance requirement on minimum percentage of recycled content in input material
- information requirement on the percentage of energy consumed by ton of material
- information requirement on percentage of recycled content in input material

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 select 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 for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).

Final score [26]

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 of the aluminium alloys manufactured, other critical raw materials can be used which is the case of e.g. silicium metal or magnesium both also identified as CRMs.

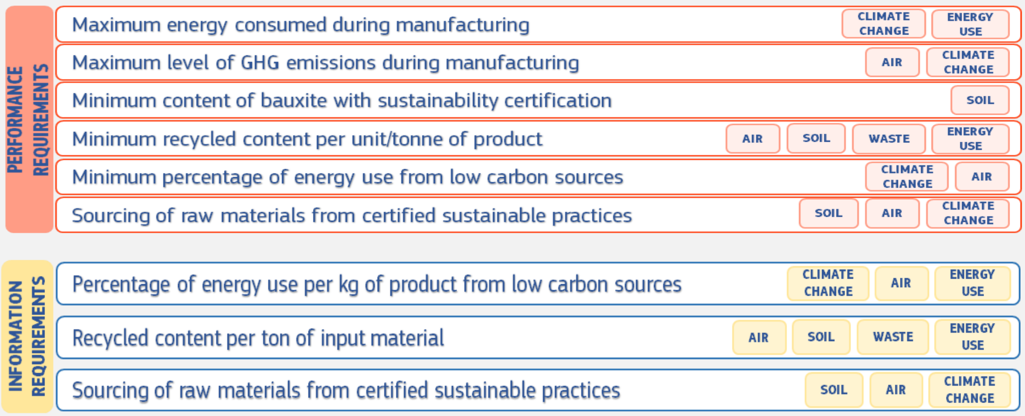
Potential gains for strategic autonomy: Aluminium is one of the metal with highest recyclability potential. Still, the current recycling rate at end-of-life represents only 51% while the recycled content is much more limited and represented only 12% in 2020. These figures clearly show an important untapped 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 Commission Implementing Decision 2012/134/EU ([2]), which are however regulating

ALUMINIUM
only EU installations. The industry moreover falls under the Directives on GHG emissions trading and REACH. Aluminium 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). Also worth mentioning is the Carbon Border Adjustment Mechanism (CBAM), a system being designed by the European Union to prevent the import of carbon-intensive materials (including aluminium) that have been manufactured in a carbon intensive way ([16]). 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 only indirectly via the Directive on GHG emissions trading. Increased recycling is also not fostered via legislation at the moment. Absence of a specific and mandatory regulation promoting ecodesign principles in aluminium. There are only voluntary schemes in place like ecolabel and green public procurement criteria.

Summary of potential measures to reduce environmental impacts



Proportionality of Costs

Some ecodesign measures are already being taken up by the sector, with room for expansion: the European demand for aluminium has grown over the past few decades at a rate of 2.4% per annum. This increase is mainly supported by the rise of recycling, whose growth was at the same time about 5% per annum ([12]). In 2021, European primary aluminium production (EU27+EFTA+UK) was forecast to increase by 3.1%. Unfortunately, during the 4th quarter of 2021, the energy price surge affected several European smelters, and production growth in 2021 decreased by 1.9% ([15]).

Worldwide, recycled aluminium is estimated to account for around one third of all aluminium production, while in Europe, recycled aluminium represented more than half of all aluminium production, indicating that recycling is proportionally a more important source of aluminium in Europe than globally, with a potential to increase mainly in eastern and southern Europe ([7, 12]).

There are huge environmental benefits for aluminium recycled in comparison with primary aluminium. First, the harmful environmental influence of the heat refining in comparison with cold recycling process. Also, it has been shown the interest of recycling by sector rather than in blend ([11]). However, cost data related to potential ecodesign measures are very scarce.

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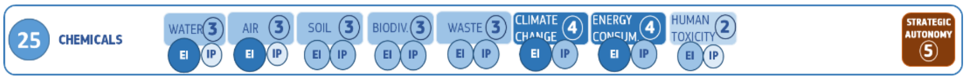
Box 14. Factsheet for Chemicals

CHEMICALS

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, 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.
Water Effects [3] Environmental impact: High 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]). Europe is the second largest producer of chemicals in the world ([2]) and where higher prevention and control measurements are in place thus the emission of water pollutants nearly halved since 2007 within the EU-27 ([3]). For instance, the European chemical sector saw a fall of over 64% in nitrogen (N) and 70% in phosphorous (P) emissions to water between 2007 and 2019 whereas the total organic carbon (TOC) emissions to water nearly halved (2007-2019). The Chemical Oxygen Demand (COD) of European wastewaters is 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]). There are also pollutants such as PFAS[70] and ED[71] 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 (a full spectrum of illnesses and the related societal and economic costs) ([11]). ED result in harmful effects in both humans and wildlife, shall as well be restricted ([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 (not under ESPR scope). Improvement potential: Low The implementation of Best Available Technologies (BAT), between 2004 and 2007, 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]). However, there is still a significant impact on water consumption and pollution with a considerable room for improvement in relation to water efficiency and abatement of pollutants. There are innovations and new technologies still to be applied in areas to where chemical production has shifted in recent years and where lower implementation of BAT and further measures to tackle and avoid pollution are still to be the norm ([4]). Specific measures in relation to PFAS are being prepared under REACH. Research is on-going in order to substitute them with safe chemicals. It is the intention of the Commission to revise the REACH regulation in ways that will make their use only allowed when they are essential for society ([11]), (the latter term remaining to be defined for use in law). Whereas in relation to ED, strengthen workers' protection and perform

[70] 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

[71] 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

CHEMICALS

environmental risk assessments are measures to avoid them [12]. According to the Chemicals Strategy for Sustainability [1] several measures are to be proposed such as the creation of a legally binding hazard identification of ED, the banning of ED in consumer products as soon as they are identified and the introduction of EDs as a category of substances of very high concern (SVHC). All in all, these are measures related to chemical safety which ESPR excludes as chemical legislation address them. ESPR can only tackle measures directly related to the design of an intermediate chemical product.

Potential measures under ESPR:

- performance requirements on maximum limit of water consumption per kg or unit of chemical product
- information requirement on water consumption during production per kg or unit of chemical product

Air Effects [3]
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].

The strong bond between carbon and fluorine, providing PFAS their properties, also causes a concern making them persistent [11]. PFAS also have the property of the mobility in the environment due to the nature of their short-chains. On the other hand, ED are less common as air emissions [12].

Improvement potential: Low

For instance dust and emissions to air from chemical production are reduced by means of abatement techniques and application of BAT [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]. However this is not always the case. Specific measures in relation to PFAS are being prepared under REACH. Research is ongoing to ban them and substitute them with safe chemicals. Their use shall only be allowed when they are essential for society [11].

Potential measures under ESPR:

No measures are envisaged under ESPR for air effects, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR because it would overlap with existing chemicals legislation).

Soil Effects [3]

Environmental impact: Medium

Chemical production often uses raw materials from natural resources which are then processed in intermediates chemicals. Mines and large production sites are common in the chemical industry however medium and smaller enterprises can also be in charge of the manufacturing of intermediate chemicals at small scales. A large variety of sites and locations may have different effects on soil. Other source of pollution to soil are accidental emissions. Accidental releases from the chemical industry have an impact on the environment. The number of accidental pollutant releases to water and air decreased around 50% over the period 2007-2019 [5].

For instance, production of silicon carbide (as any other operation involving pet cokes) can cause major soil pollution. The storage of coke, grinding, charge mixing, mineral oils, heavy metals and furnace terrain containing PAHs, mineral oils, heavy metals can be sources of pollution to soil [8].

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

CHEMICALS

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]).

The aforementioned measures refer either to chemical safety which is tackled by chemical legislation (not under ESPR scope) or to the control of pollutant emissions also under other legislative initiatives.

The implementation of responsible sourcing programmes and traceability standards for raw materials are measures that could be applied to chemicals, as well as the use of recycled materials at industry level or the waste disposed of to landfill.

Potential measures under ESPR:

- performance requirement on the sourcing of raw materials from certified sustainable practices
- performance requirement on minimum post industrial recycled content per ton of product
- performance requirement on minimum recycled content on intermediate bulk containers
- performance requirement on design for minimum recyclability of intermediate bulk containers
- information requirement on the sourcing of raw materials from certified sustainable practices
- information requirement on how to correctly use and dispose of the product
- information requirement on maximum waste send to landfill per ton of product

Biodiversity Effects [3]

Environmental impact: Medium

Pollution is a key driver of biodiversity loss and has a harmful impact on our health and environment. Biodiversity is suffering from the release of nutrients, chemical pesticides, pharmaceuticals or hazardous chemicals ([1]).

Improvement potential: Medium

Measures such as the storage of raw materials indoor and reduction of water usage in combustion furnaces helps 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 be applied to chemicals.

Potential measures under ESPR:

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

Waste Generation & Management [3]

CHEMICALS

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. The tendency of the sector is to reuse all by-products to reduce waste generation and in consequence save resources. In this line, the EU-27 chemical waste production from the chemical industry fell by nearly one third since 2007. Resource efficiency provides economic and ecological benefits, while it is also reflected in the amount of waste produced ([3]).

The total amount of industrial waste generated by the chemical industry varies between 8 and 16 million metric tonnes (2007-2019) of which slightly less than 40% is hazardous waste. The global economic recession in 2008-2009 resulted clearly in a reduced amount of waste. This amount increased over the period 2009 till 2013. The lower amount of waste generated in 2014 till 2016, while there was an increase of the production index, indicated a further improvement of the resource efficiency, but this trend did not continue as high amounts of mainly non-hazardous waste were reported in 2017 and 2018 ([3]).

Improvement potential: Medium

Measures for improvement involve prevention, novel process to avoid residues, resource efficiency, recycling and reuse of by-products ([3]). 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]).

Potential measures under ESPR:

- performance requirement on minimum post industrial recycled content per ton of chemical to reduce raw material consumption and waste generation

- information requirement on how to correctly use and dispose of the chemical product (if not covered by other mandatory measures i.e. for non-hazardous chemicals)

- performance requirement on minimum recycled content of intermediate bulk containers (this may also be covered by measures in preparation under specific mandatory initiatives such as Packaging and Packaging Waste Directive[72])

- performance requirement on design for recycling for minimum recyclability of intermediate bulk containers (this may also be covered by measures in preparation under specific mandatory initiatives such as Packaging and Packaging Waste Directive[73])

- information requirement on maximum waste sent to landfill per ton of chemical

Climate Change [4]

Environmental impact: High

The chemical sector is the largest industrial consumer of both oil and gas, as well as the largest industrial energy consumer overall. However, it is the third industry subsector in terms of direct CO_2 emissions, behind cement and iron and steel ([2]). The emissions due to combustion decreased less, resulting in an overall decrease of the GHG emissions in the chemical sector around 50%, mainly in the period 1997-2013. Since 2013, no significant reductions of GHG emissions were observed. From 1990 up to 2019 there was a decoupling of chemical production and GHG emissions in Europe ([2]), with a 47% increase of chemical production and a decrease of nearly 54% in the GHG emissions (145 million tonnes of CO_2) ([13]).

Improvement potential: Medium

To reduce GHG emissions, attention has to be paid to resources and processes where innovations plays the main role. There are many examples to decouple from fossil fuels, with projects where the energy source is

[72] Proposal for a revision of EU legislation on Packaging and Packaging Waste, https://environment.ec.europa.eu/publications/proposal-packaging-and-packaging-waste_en

[73] Proposal for a revision of EU legislation on Packaging and Packaging Waste, https://environment.ec.europa.eu/publications/proposal-packaging-and-packaging-waste_en

CHEMICALS

renewable. For instance the production of ammonia using solar and wind energy, with plans to scale up by 2030 ([14, 15]).

Potential measures under ESPR:

- performance requirement on minimum percentage of energy use per kg of chemical from low carbon footprint sources

- information requirement on the percentage of energy use per kg of chemical from low carbon footprint sources

Life Cycle Energy consumption [4]
Environmental impact: High

Only the production of primary chemicals such as ethylene, propylene, benzene, toluene, mixed xylenes, ammonia and methanol already accounts for two-thirds of energy consumption in the chemical and petrochemical sector ([16]).

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.

The whole processes efficiency shall 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 shall not to be forgotten ([1]).

Potential measures under ESPR:

- performance requirement on a maximum level of energy consumed per ton of a chemical produced

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[74], respiratory sensitizers, chemicals toxic to specific organs or bioaccumulative species. In this line the EC, published the Chemicals Strategy for Sustainability, from which the need to accelerate development of Safe and Sustainable by Design Chemicals was underlined ([1, 17]) to overcome the issue.

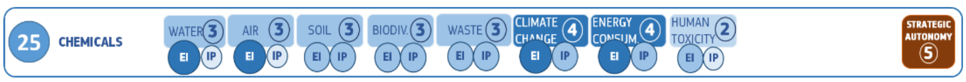
Improvement potential: Low

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 for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR because it would overlap with existing chemicals legislation).

Final score [25]



[74] Carcinogenic, mutagenic and reprotoxic chemicals

CHEMICALS

Strategic autonomy score [5]

Relevance: The high score of the category chemicals is explained by the broadness of the scope which includes organics and inorganics compounds, fertilisers and polymers. Regarding the CRMs, a huge majority 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). Even if not in the scope of the assessment, the manufacturing process for chemicals requires an extensive use of catalysts. It should be noted that Platinum-group elements, Rare-Earth elements such as Cerium or Praseodymium, as well as e.g. Tungsten are key materials in the manufacturing of chemicals and chemical products.

Regarding fossil hydrocarbons, approximately 20% of the imported crude oil is used for chemical purposes including both fertilizers product (10%) and plastics (10%).

Potential gains for 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 measure 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.

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]) which is increasingly becoming a model for safety standards worldwide. The European framework comprises nearly 40 legislative instruments including the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)[75] and, the Regulation on the Classification and the Labelling and Packaging of hazardous substances (CLP)[76].

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]).

Although the EU's approach to chemicals management has been effective in reducing human and environmental exposures to certain problematic substances, ongoing and emerging health and environmental concerns call for a strengthening of the legal framework to rapidly respond to scientific findings, making it more coherent, simple and predictable for all actors. In particular, the REACH and CLP Regulations should be reinforced as EU's cornerstones for regulating chemicals, and be complemented by coherent approaches to assess and manage chemicals in existing sectorial legislation, especially that regulating consumer products ([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.

With respect to bio-chemicals, at the moment of writing this report the EC has proposed 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.

Potential ESPR measures will not address chemical safety. However, there are complementary, potential measures that could be considered under ESPR such as requirements on water, waste and energy

[75] Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals. OJ L 396, 30.12.2006.
[76] Regulation (EC) No 1272/2008 on the Classification, Labelling and Packaging of Substances and Mixtures. OJ L 353, 31.12.2008.

CHEMICALS

performance, recycled content and recyclability of intermediate bulk containers, post industrial recycled content of chemical products to reduce raw material use and indirectly emissions or 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.

Summary of potential measures to reduce environmental impacts

Requirements	Measure	Impacts
PERFORMANCE REQUIREMENTS	Minimum post industrial recycled content per ton of product	SOIL, WASTE
PERFORMANCE REQUIREMENTS	Minimum recycled content of intermediate bulk containers	SOIL, WASTE
PERFORMANCE REQUIREMENTS	Design for minimum recyclability of intermediate bulk containers	SOIL, WASTE
PERFORMANCE REQUIREMENTS	Minimum percentage of energy use per kg of product from low carbon footprint sources	CLIMATE CHANGE
PERFORMANCE REQUIREMENTS	Maximum energy consumed during manufacturing	ENERGY USE
PERFORMANCE REQUIREMENTS	Sourcing of raw materials from certified sustainable practices	SOIL, BIODIVERSITY
INFORMATION REQUIREMENTS	Sourcing of raw materials from certified sustainable practices	SOIL, BIODIVERSITY
INFORMATION REQUIREMENTS	How to correctly use and dispose of the product	SOIL, WASTE
INFORMATION REQUIREMENTS	Maximum waste send to landfill per ton of product	SOIL, WASTE
INFORMATION REQUIREMENTS	Percentage of energy use per kg of product from low carbon footprint sources	CLIMATE CHANGE

Proportionality of Costs

Although the proposed measures imply an investment in innovation, in the long term, they could in help in some cases to reduce costs derived from savings in water, energy and raw materials.

Despite the potential of increment of recycling rates for raw chemicals and the promotion of low carbon energy sources to decrease the cost of chemical production in certain cases, in most cases recycling and low carbon energy sources increase the production costs. Nevertheless, recycling and low carbon energy sources help a more sustainable way of manufacturing, allowing for the reduction of the consumption of natural resources, indirectly helping to the minimisation of pollutant emissions to the environment([17]).

Additional notes and list of references

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CHEMICALS
back into our liveshttps://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF (10) United Nation Foundation, 2018. Why Biodiversity is Essential for Sustainable Development | unfoundation.org) (11) EC, 2020. PFAS - Chemicals. COMMISSION STAFF WORKING DOCUMENT Poly- and perfluoroalkyl substances (PFAS). (12) EC, 2018. Endocrine disruptors. Towards a comprehensive European Union framework on endocrine disruptors. (13) IEA, 2021. Ammonia Technology Roadmap Towards more sustainable nitrogen fertiliser production. (14) Example green electricity. (15) Example green hydrogen. (16) IEA, 2021. Primary chemical production in the Sustainable Development Scenario, 2000-2030. (17) EC, 2022. Caldeira C., Farcal R., Garmendia Aguirre, I., Mancini, L., Tosches, D., Amelio, A., Rasmussen, K., Rauscher, H., Riego Sintes J., Sala S. Safe and Sustainable by Design chemicals and materials - Framework for the definition of criteria and evaluation procedure for chemicals and materials. EUR 31100 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-53264-4, doi:10.2760/487955, JRC128591 (18) Proposal for a Nature Restoration Law, June 2022: https://environment.ec.europa.eu/publications/nature-restoration-law_en (19) Chemicals strategy: high-level roundtable adopts joint report on enforcement and compliance of chemical legislation, November 2021: https://environment.ec.europa.eu/news/chemicals-strategy-high-level-roundtable-adopts-joint-report-enforcement-and-compliance-2021-11-26_en

Box 15. Factsheet for Glass

GLASS

Scope: Products included: container glass, flat glass, continuous filament glass fibre, domestic glass, special glass, mineral wool, high temperature insulation wools and frits.

Water Effects [3]

Environmental impact: Medium

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 (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). The water use can be decreased by 90% if closed-loop systems are used for the recycling of water (3).

:

- performance requirement on minimum recycled content in the product

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption

- performance requirement on minimum percentage of recycled content in input material

- information requirement on the amount of sand extracted per kg of product

- information requirement on percentage of recycled content in input material

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

Air Effects [2]

Environmental impact: Low

The glass industry represent 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). However, these compounds are not so pollutant compared to other sectors, such as non-ferrous metals.

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 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.

Potential measures under ESPR:

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption

GLASS

- performance requirement on the sourcing of raw materials from certified sustainable practices

- performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution

- performance requirement in minimum recycled content in the product

- performance requirement on minimum content of raw material with sustainability certification per kg or unit of product

- performance requirement on minimum percentage of recycled content in input material

- information requirement on percentage of recycled content in input material

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

- information requirement on the percentage of energy use from low carbon source

- information requirement on amount of sand extracted per kg of product

- information requirement on level of energy consumed by ton of material

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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]).

Potential measures under ESPR:

- performance requirement on minimum recycled content in glass

- performance requirement on minimum content of raw material with sustainability certification per kg or unit of product

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption

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

- performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution

- performance requirement on minimum percentage of recycled content in input material

- information requirement on amount of sand extracted per kg of product

- information requirement on percentage of recycled content in input material

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

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Biodiversity Effects [3]
Environmental impact: Medium

The increasing volume of sand extracted, often 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]).

GLASS
Improvement potential: Medium The improvement potential lies in avoiding or reducing 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 standards and best practices ([6,8]). Potential measures under ESPR: - performance requirement on minimum content of raw material with sustainability certification per kg or unit of product - performance requirement on minimum recycled content in the product - performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption - performance requirement on sourcing of raw materials from certified sustainable practices - performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution - performance requirement on minimum percentage of recycled content in input material - information requirement on amount of sand extracted per kg of product - information requirement on percentage of recycled content in input material - information requirement on sourcing of raw materials from certified sustainable practices
Waste Generation & Management [2] 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 not possible. Improvement potential: Low 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]). Potential measures under ESPR: - performance requirement on minimum recycled content in glass, depending on the type of glass produced
Climate Change [3] 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 and dissociation of carbonate raw material ($CaCO_3$ and dolomite) used in the batch ([5,7,10]). 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]). Improvement potential: Medium Measures to prevent and control 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), 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]). 1 tonne of recycled glass is estimated to save 60% of CO2 emissions ([12]) Reuse of glass products (especially containers) can be increased by durable and resistant design, which may however increase the product weight ([13,14,15]).

GLASS

Potential measures under ESPR:

- performance requirement on minimum percentage of recycled content in input material

- performance requirement on the sourcing of raw materials from certified sustainable practices

- performance requirement on minimum recycled content in the product

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption

- performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution

- performance requirement on minimum content of raw material with sustainability certification per kg or unit of product'

- performance requirement on maximum level of energy consumed by ton of material

- information requirement on percentage of recycled content in input material

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

- information requirement on the amount of sand extracted per kg of product

- information requirement on percentage of energy use from low carbon source

- information requirement on level of energy consumed by ton of material

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]).

Improvement potential: High

Possible measures identified in the literature are batch preheating, waste heat recovery, reduce batch wetting to a minimum, use of novel mixers, selective batching, use of electric furnaces (which result in lower energy losses), and more. Innovations in heating and melting such as oxy-fuel furnaces can reduce energy losses by 20-30% ([4,7]).

Potential measures under ESPR:

- performance requirement on a maximum level of energy consumed by ton of material

- performance requirement on minimum percentage of recycled content in input material

- performance requirement on minimum recycled content in the product

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption

- performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution

- information requirement on the level of energy consumed by ton of material

- information requirement on percentage of recycled content in input material

- information requirement on percentage of energy use from low carbon sources

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.

GLASS

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:

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 [19]

Strategic autonomy score [2]

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 Directives on GHG emissions trading and REACH. 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 unsustainable (from a water quality, water quantity and biodiversity point of view) sand mining; however, this comes with difficulties since sand mining mostly occurs outside the EU. Solutions for energy savings are currently incentivised only indirectly via the Directive on GHG emissions trading. Increased recycling is also not fostered via legislation at the moment.

Summary of potential measures to reduce environmental impacts

	Measure	Water	Air	Soil	Biodiversity	Climate change	Energy use
PERFORMANCE REQUIREMENTS	Minimum recycled content in the product	WATER	AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	ENERGY USE
PERFORMANCE REQUIREMENTS	Minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption	WATER	AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	ENERGY USE
PERFORMANCE REQUIREMENTS	Sourcing of raw materials from certified sustainable practices		AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	
PERFORMANCE REQUIREMENTS	Minimum percentage of energy use from low carbon sources to reduce air pollution		AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	ENERGY USE
PERFORMANCE REQUIREMENTS	Minimum content of raw material with sustainability certification per kg or unit of product		AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	
PERFORMANCE REQUIREMENTS	Minimum percentage of recycled content in input material	WATER	AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	ENERGY USE
PERFORMANCE REQUIREMENTS	Maximum level of energy consumed by ton of material					CLIMATE CHANGE	ENERGY USE
INFORMATION REQUIREMENTS	Amount of sand extracted per kg of product		AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	
INFORMATION REQUIREMENTS	Percentage of recycled content in input material	WATER	AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	ENERGY USE
INFORMATION REQUIREMENTS	Sourcing of raw materials from certified sustainable practices	WATER	AIR	SOIL	BIODIVERSITY	CLIMATE CHANGE	
INFORMATION REQUIREMENTS	Percentage of energy use from low carbon source		AIR			CLIMATE CHANGE	ENERGY USE
INFORMATION REQUIREMENTS	Level of energy consumed by ton of material		AIR			CLIMATE CHANGE	ENERGY USE

Proportionality of Costs

Most of the measures for improvement identified for the glass industry are very expensive measures as they involve change in the type of furnace, change of energy source or sustainable sand extraction. However, the benefits provided by such measures could outstand the costs. Measures for improving the control of glass feedstock was estimated to save 220-440 million USD yearly in terms of reduction of defects and energy savings ([7]).

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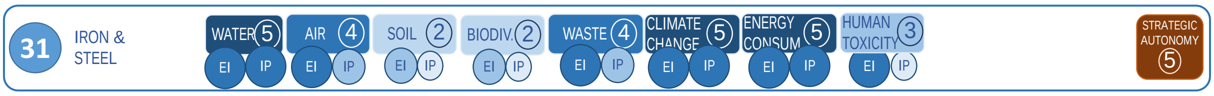
Box 16. Factsheet for Iron and Steel

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%, the material is defined as cast iron).

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 aim is 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 minimum recycled content in the product

- performance requirement on maximum limit of water consumption per kg of product

- information requirement on the water consumption during production

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:

IRON AND STEEL

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption

- performance requirement on the sourcing of raw materials from certified sustainable practices (if aplicable)

- performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution

- performance requirement on maximum level of GHG emissions during manufacturing

- performance requirement on material production to maximize the internal recirculation of carbon and iron steel bearing dusts

- information requirement on percentage of recycled content in input material

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

- information requirement on the percentage of energy use from low carbon sources

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Soil Effects [2]

Environmental impact: Medium

The biggest source of metal and mineral depletion is the 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]). 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:

- performance requirement on design for the development of a plan for the prevention and control of leaks and spillages

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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. In the closure and after-closure phase. 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 in order 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:

IRON AND STEEL
- performance requirement on design for the development of a plan for the prevention and control of leaks and spillages
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 slurried 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 sector ([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]). Adopting material efficiency strategies to reduces 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 minimum reuse of waste sand during the extraction process - performance requirement on material production to maximize the internal recirculation of carbon and iron bearing dusts during the extraction process - performance requirement on minimum recycled content in the product - information requirement on minimum recycled content in the product
Climate Change [5] Environmental impact: High Iron and steel is 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 Potential for energy efficiency improvements will likely soon be exhausted. Thus, innovation in the upcoming decade will be crucial to commercialise new low-emissions processes, including those that integrate carbon capture, utilization, and storage (CCUS) and hydrogen. 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 reduces 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 COeq) versus the total raw material demand (>620 Mt COeq) within Europe ([23]). On the other hand, it has been estimated that decarbonisation technologies could result in a decrease of CO_2

IRON AND STEEL

emission, 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 GHG emissions by ton of material
- performance requirement on the sourcing of raw materials from certified sustainable practices
- performance requirement on minimum percentage of energy use from low carbon sources
- performance requirement on material production to maximize internal recirculation of carbon and iron bearing dusts;
- information requirement on percentage of energy use per kg of product from low carbon sources
- information requirement on the sourcing of raw materials from certified sustainable practices

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 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's 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 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]).

Potential measures under ESPR:

- performance requirement on a maximum level of energy consumed by ton of material
- performance requirement on sourcing of raw materials from certified sustainable practices
- performance requirement on minimum recycled content per unit/tonne of product
- information requirement on the level of energy consumed by ton of material
- performance requirement on minimum percentage of recycled content in input material
- information requirement on percentage of recycled content in input material
- information requirement on sourcing of raw materials from certified sustainable practices
- information requirement on percentage of energy used per kg of product from low carbon sources

IRON AND STEEL

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])

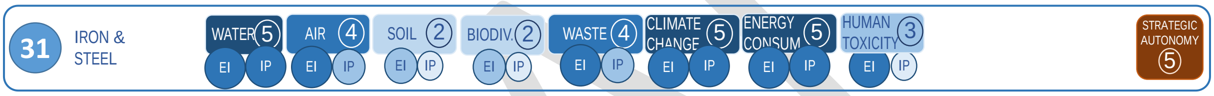
Improvement potential: Low

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 for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).

Final score [31]



Strategic autonomy score [5]

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]). Also worth mentioning is the Carbon Border Adjustment Mechanism (CBAM), a system being designed by the European Union to prevent the import of carbon-intensive materials (including iron and steel) that have been manufactured in a carbon intensive way ([26]).

Nevertheless, a sustainable approach is 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 and reducing human toxicity by addressing the coal gasification-shaft furnace-electric furnace (CSE) steelmaking technology. 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

IRON AND STEEL

PERFORMANCE REQUIREMENTS

Requirement	Impact categories
Minimum reuse of waste sand during the extraction process	WASTE
Material production to maximize the internal recirculation of carbon and iron bearing dusts	CLIMATE CHANGE, AIR, WASTE
Maximum limit of water consumption per kg or unit of product	WATER
Minimum recycled content per unit/tonne of product	WATER, AIR, WASTE, ENERGY USE
Minimum percentage of energy use from low carbon sources	CLIMATE CHANGE, AIR
Sourcing of raw materials from certified sustainable practices	ENERGY USE, AIR, CLIMATE CHANGE
Maximum level of GHG emissions during manufacturing	AIR, CLIMATE CHANGE
Maximum energy consumed during manufacturing	ENERGY USE

INFORMATION REQUIREMENTS

Requirement	Impact categories
Water consumption during production per kg or unit of product	WATER
Recycled content per ton of input material	AIR, WASTE, ENERGY USE
Sourcing of raw materials from certified sustainable practices	ENERGY USE, AIR, CLIMATE CHANGE
Percentage of energy use per kg of product from low carbon sources	CLIMATE CHANGE, AIR, ENERGY USE

Proportionality of Costs

Considering that steel will also be an integral ingredient for the energy transition with solar panels, wind turbines, dams and electric vehicles all depending on it to varying degrees ([8]), the next decade will be crucial in the Net Zero Emissions by 2050 Scenario for Governments and the iron and steel industry to work together providing a market for near-zero-emissions steel, adopting policies for mandatory CO_2 emissions reductions, expanding international co-operation and developing supporting infrastructure. Based on the above reasoning, it is worth the effort to make the steel industry more sustainable, understanding that sustainable sourcing and process efficiency are key aspects. Research shows that efficiency in the steelworks through process integration (water reuse, by-products recycling, energy saving) is possible, for example, via "smart applications" ([25]). Hence not only cost savings but actually resource consumption (thus sourcing) are reduced, though not at negligible cost ([25]).In other words, environmental improvement potentials might present trade-offs with product costs. For example, reducing CO_2 emissions, with respect to 2015, by 15 – 90% (depending on the pool of technological options considered), could imply an increase of the steel cost per tonne ranging 35 – 100% ([24]).

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

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Box 17. Factsheet for Non-Ferrous Metals

NON-FERROUS METALS PRODUCTS (Ex. Al)

Scope: This group includes intermediate products made of seven primary and secondary non-ferrous metals: copper, lead and/or tin, zinc and/or cadmium, precious metals, ferro-alloys, nickel and/or cobalt, carbon and graphite electrodes.

Water Effects [3]
Environmental impact: High

Production of non-ferrous metals is often a water intensive industrial process. For the production of 1 kg of gold, 260000 litres of water are consumed, for instance ([1]). 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])

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:

- performance requirement on minimum recycled content in the product

- performance requirement on maximum limit of water consumption per kg of product

- information requirement on the water consumption during production

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

NON-FERROUS METALS PRODUCTS (Ex. Al)

The emissions of sulphur dioxide in copper, lead, zinc and nickel have been 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]).

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:

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption
- performance requirement on the sourcing of raw materials from certified sustainable practices
- performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution
- information requirement on percentage of recycled content in input material
- information requirement on the sourcing of raw materials from certified sustainable practices
- information requirement on the percentage of energy use from low carbon sources

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Soil Effects [3]
Environmental impact: High

The development of a mining project necessarily modifies the local natural environment Therefore, the 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 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. Room for improvement appears to be low in this sector.

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability certification per kg or unit of product

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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]). 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

NON-FERROUS METALS PRODUCTS (Ex. Al)

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.

Potential measures under ESPR:

- performance requirement on minimum content of raw material with sustainability certification per kg or unit of product

Waste Generation & Management [5]
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).

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. Batteries, which accounted for more than 80% of the refined lead used in the EU-27 in 2012, are recycled with very high efficiency. 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).

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 material production to facilitate the recyclability of non-ferrous metals in final products

- performance requirement on material production to facilitate disassembly of products made from non-ferrous metals

- performance requirement on minimum recycled content in the product

- information requirement on minimum recycled content in the product

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 18000 tCO_{2eq} (1).

Improvement potential: Medium

NON-FERROUS METALS PRODUCTS (Ex. 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]). Potential measures under ESPR: - performance requirement on a maximum level of GHG emissions by ton of material - performance on minimum percentage of energy use from low carbon sources - performance requirement on the sourcing of raw materials from certified sustainable practices - information requirement on the sourcing of raw materials from certified sustainable practices - Information requirement on percentage of energy use per kg of product from low carbon sources
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 33000 MJ ([1]). The production of 1 tonne of zinc requires 37500 MJ ([13]). The production of 1 tonne of gold requires 200000 GJ ([1]). Improvement potential: High The nonferrous metals industry, overall, can save more than 20% in energy consumption. The recycling of nonferrous 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. 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

NON-FERROUS METALS PRODUCTS (Ex. Al)

energy efficient) ([10]).

Potential measures under ESPR:

- performance requirement on a maximum level of energy consumed by ton of material
- performance requirement on material production to facilitate the recyclability of non-ferrous metals in final products
- performance requirement on material production to facilitate the disassembly of non-ferrous metals in final products
- performance requirement on minimum percentage of energy use from low carbon sources
- performance requirement on minimum percentage of recycled content in input material
- information requirement on the level of energy consumed by ton of material
- information requirement on percentage of recycled content in input material

Human Toxicity [3]
Environmental impact: High

Non-ferrous metals can have a significant impact on human health. 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 for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).

Final score [27]

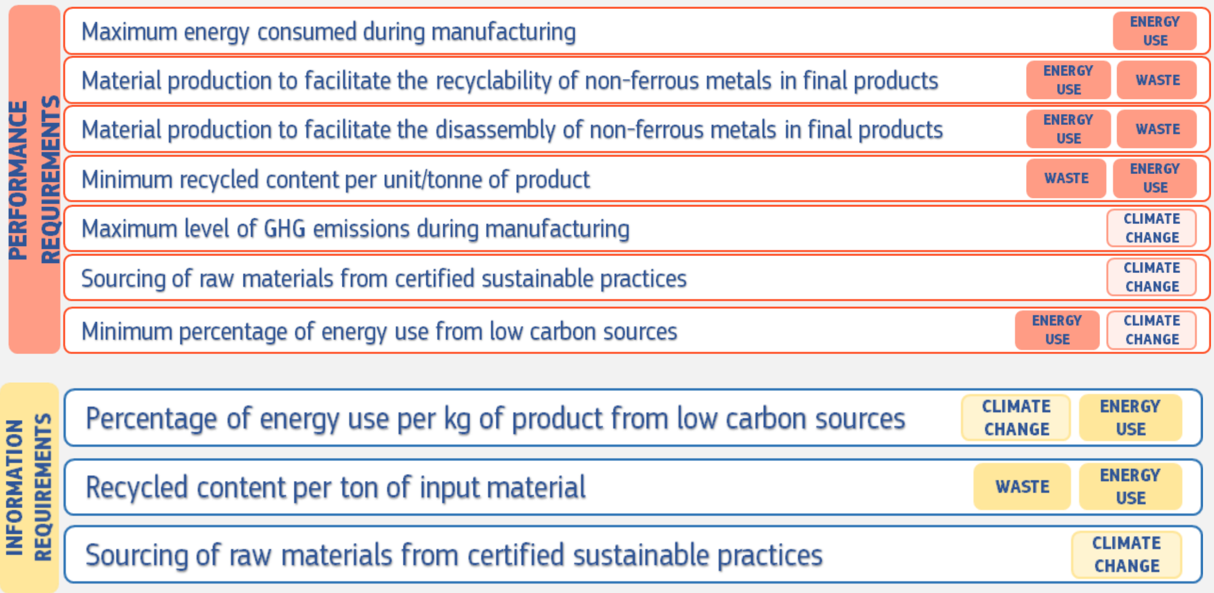
Strategic autonomy score [4]

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.

Summary of potential measures to reduce environmental impacts



Proportionality of Costs

The non-ferrous metals manufacturing industry accounted for 1.25% of EU manufacturing in 2010 and its turnover now reaches EUR 120 billion (1.8%). The sector directly employs more than 500000 people. Regarding the demand side, the EU is one of the biggest consumers of non-ferrous metals worldwide (10).

Many of the improvement areas identified are related to enhancing collection and recovery of materials. High energy costs are also a key driver of the value of recovery and recycling, which are substantially less energy intensive than the smelting of ores.

The cost of environmental compliance with measures identified in this industry is seen as a concern from the industry, especially in comparison with third countries, where the industry often is subjected to less regulation and does not face similar costs – for instance in emerging economies such as China, India and Russia (16).

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Box 18. Factsheet for Plastic and Polymers

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.

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, 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 water and which are understood to be assumed by the sector.

Potential measures under ESPR:

- performance requirement on minimum recycled content in the product
- performance requirement on maximum limit of water consumption per kg of product
- performance requirement on maximum limit of emission of microplastics per ton of product
- performance requirement on minimum recycled content per unit/tonne of product
- performance requirement on plastic production to facilitate their recyclability
- performance requirement on plastic production to ease the re-use of plastics and polymers
- information requirement on the water consumption during production
- information requirement on recycled content per ton of input material

Air Effects [3]

Environmental impact: Medium

Emissions of Sulphur ad 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 ([1]). 75 000 tonnes of microplastics are released into the environment, including to air, each year in the EU ([8]).

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, 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 atmosphere and which are understood to be assumed by the sector.

Potential measures under ESPR:

PLASTICS AND POLYMERS
- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption - performance requirement on the sourcing of raw materials from certified sustainable practices - performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution - performance requirement to set a maximum limit of emission of microplastics per ton of product - performance requirement on maximum level of GHG emissions during manufacturing - information requirement on percentage of recycled content in input material - information requirement on the sourcing of raw materials from certified sustainable practices - information requirement on the percentage of energy use from low carbon sources
Soil Effects [2] Environmental impact: Medium At the production phase, spillages and mismanagement of liquid/solid waste can impact on 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 recycled content in plastic and polymers
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]). 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

PLASTICS AND POLYMERS
environment and which are understood to be assumed by the sector Potential measures under ESPR: - performance requirement on design to ease the re-use of plastics and polymers
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]) 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 plastic production to facilitate their recyclability - performance requirement on plastic production to ease the disassembly of products made of plastic - performance requirement on plastic production to ease the re-use of plastics and polymers - performance requirement on maximum limit of emission of microplastics per ton of product - performance requirement on minimum recycled content per unit/tonne of product - information requirement on how to recycle plastic or polymer - information requirement on recycled content per ton of input material
Climate Change [4] Environmental impact: High Plastic refining 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]). 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 a maximum level of GHG emissions by ton of material - performance requirement on the sourcing of raw materials from certified sustainable practices - performance requirement on minimum percentage of energy use from low carbon sources

PLASTICS AND POLYMERS

- performance requirement on plastic production to facilitate their recyclability
- information requirement on the sourcing of raw materials from certified sustainable practices
- information requirement on percentage of energy use per kg of product from low carbon sources
- information requirement on how to recycle plastic or polymer

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 fossil based and 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 a maximum level of energy consumed by ton of material
- information requirement on the level of energy consumed by ton of material
- performance requirement on minimum percentage of recycled content in input material
- performance requirement on minimum percentage of energy use from low carbon sources
- information requirement on percentage of recycled content in input material

Human Toxicity [2]

Environmental impact: Medium

At production phase, occupational exposure in the extraction of raw materials, 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 designing plastics to reduce toxicity.

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]

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 use for energy purpose, around 10% of the crude oil is used by 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 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.

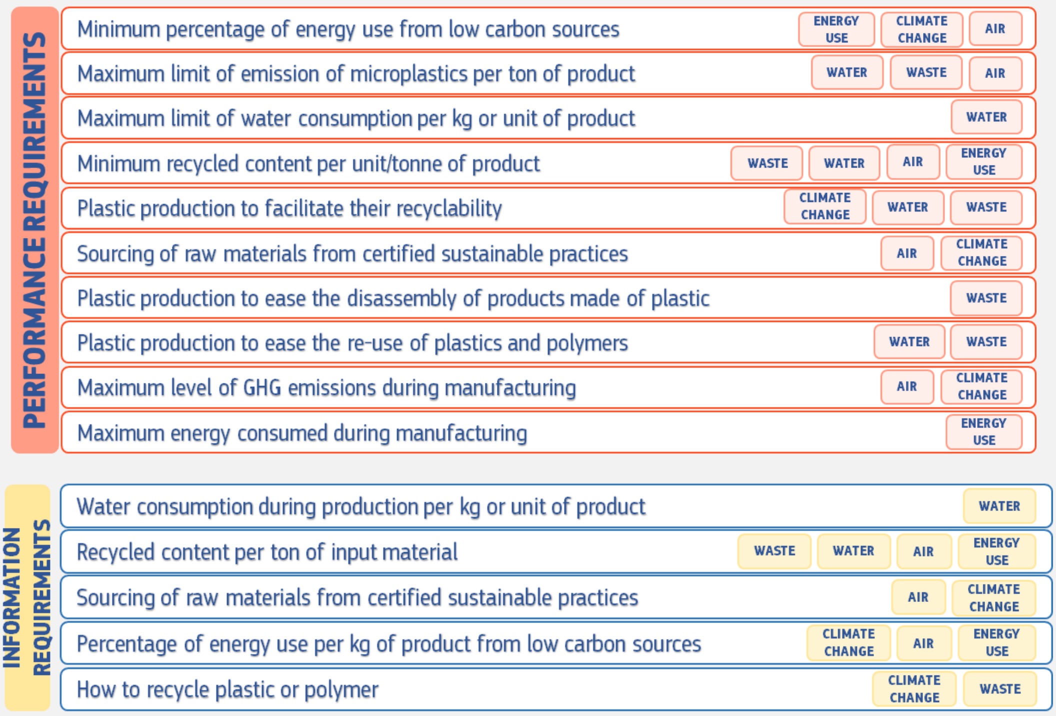
Policy Gaps

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 plastic, the Commission has proposed 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.

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 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



Proportionality of Costs

UN Environment estimated the natural capital cost of plastics, from environmental degradation, climate change and health, to be about USD 75 billion annually with 75% of these environmental costs occurring at the manufacturing stage ([14]). Although the proposed measures imply an investment in innovation, the benefits they bring recommend their consideration.

Additional notes and list of references

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

([1]) BREF for the production of polymers. Article 16(2) of Council Directive 96/61/EC

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Box 19. Factsheet for Pulp, Paper and Boards

PULP, PAPER AND BOARDS

Scope: pulp, paper and board obtained by chemical, kraft, sulphite, mechanical and chemi- mechanical pulping, recovered paper processing and papermaking.

Water Effects [3]
Environmental impact: Medium

The pulp and paper (P&P) 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 circuitsv([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 bleached pulp is a requirement ([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 water consumption per kg of product

- performance requirement on minimum content of material with sustainability* certification per kg or unit of product

- performance requirement on minimum account of recovered paper used per kg of pulp, pulp paper and board

- performance requirement on minimum account of agricultural residues used as raw materials per kg of paper and cardboard

- performance requirement on minimum amount of wood chips used per kg pulp, pulp paper and board

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

- performance requirement on minimum percentage of recycled content in input material

- information requirement on the water consumption during production

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

- information requirement on percentage of recycled content in input material

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]).

PULP, PAPER AND BOARDS

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.

Potential measures under ESPR:

- performance requirement on minimum recycled content per ton of input material to reduce air pollution decreasing raw material consumption

- performance requirement on the sourcing of raw materials from certified sustainable practices

- performance requirement on minimum percentage of energy use from low carbon sources to reduce air pollution

- information requirement on percentage of recycled content in input material

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

- information requirement on the percentage of energy use from low carbon sources

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 material with sustainability* certification per kg or unit of product

- performance requirement on minimum amount of recovered paper used per kg of pulp, pulp paper and board

-performance requirement on minimum amount of agricultural residues used as raw materials per kg of paper and cardboard

- performance requirement on minimum amount of wood chips used per kg of pulp, pulp paper and board

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

- performance requirement on minimum percentage of recycled content in input material

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

- information requirement on percentage of recycled content in input material

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 material with sustainability* certification per kg or unit of product
- performance requirement on minimum amount of recovered paper used per kg of pulp, pulp paper and board
- performance requirement on mononym amount of agricultural residues used as raw materials per kg of paper and cardboard
- performance requirement on minimum amount of wood chips used per kg of pulp, pulp paper and board
- performance requirement on sourcing of raw material from certified sustainable practices
- performance requirement on minimum percentage of recycled content in input material
- information requirement on sourcing of raw materials from certified sustainable practices
- information requirement on percentage of recycled content in input material

Waste Generation & Management [2]
Environmental impact: Low

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

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]). 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]). Since 2000 the majority of paper waste for recycling is exported to Asia. 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 minimum amount of recovered paper used per kg of pulp, pulp paper and board
- performance requirement on minimum amount of agricultural residues used as raw materials per kg of paper and cardboard
- performance requirement on minimum amount of wood chips used per kg of pulp, pulp paper and board
- performance requirement on minimum percentage of recycled content in input material
- information requirement on percentage of recycled content in input material

Climate Change [4]
Environmental impact: Medium

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).

Potential measures under ESPR:

- performance requirement on a maximum level of GHG emissions by ton of material

- performance requirement on the level of GHG emissions by ton of material

- performance requirement on the sourcing of raw materials from certified sustainable practices

- performance requirement on minimum content of material with sustainability* certification per kg or unit of product

- performance requirement on minimum amount of recovered paper used per kg of pulp, pulp paper and board

- performance requirement on minimum amount of agricultural residues used as raw materials per kg of paper and cardboard

- performance requirement on minimum amount of wood chips used per kg of pulp, pulp paper and board

- performance requirement on maximum level of energy consumed by ton of material

- performance requirement on minimum percentage of recycled content in input material

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

- information requirement on the level of energy consumed by ton of material

- information requirement on percentage of recycled content in input material

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), and in 2020 it was estimated to represent 4% of total EU consumption (15).

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.

Potential measures under ESPR:

- performance requirement on a maximum level of energy consumed by ton of material

- performance requirement on minimum percentage of recycled content in input material

- performance requirement on minimum account of recovered paper used per kg of pulp, pulp paper and board

- performance requirement on minimum account of agricultural residues used as raw materials per kg of paper and cardboard

PULP, PAPER AND BOARDS

- performance requirement on minimum amount of wood chips used per kg pulp, pulp paper and board
- performance requirement on maximum level of GHG emissions by ton of material
- performance requirement on level of GHG emissions by ton of material
- information requirement on the level of energy consumed by ton of material
- information requirement on percentage of recycled content in input material

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 for human toxicity, since the related impacts mainly refer to chemical safety (excluded from the scope of ESPR).

Total environmental score [22]

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. At the moment of writing this report, the Commission has proposed a Regulation on land use, forestry and agriculture, which should set an overall EU target for carbon removals by natural sinks ([19]). Moreover, the Commission has proposed a Regulation to tackle EU-driven deforestation and forest degradation ([8]), 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 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]).

Policy gaps moreover exist with respect to the large energy use of the sector and to the impacts to biodiversity caused by wood harvesting. Please note that at the moment of writing of this report, the Commission has proposed (i) a Directive on energy efficiency ([22]) to implement energy efficiency as a priority across all sectors and remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy; and (ii) a Regulation to contrast EU-driven deforestation and forest degradation ([8]).

Summary of potential measures to reduce environmental impacts

PULP, PAPER AND BOARDS

Type	Requirement	Water	Soil	Biodiversity	Waste	Climate change	Energy use
PERFORMANCE REQUIREMENTS	Maximum limit of water consumption per kg of product	WATER					
	Minimum content of material with sustainability* certification per kg or unit of product	WATER	SOIL	BIODIVERSITY		CLIMATE CHANGE	
	Minimum amount of recovered paper used per kg of pulp, pulp paper and board	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE
	Minimum amount of agricultural residues used as raw materials per kg of paper and cardboard	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE
	Minimum amount of wood chips used per kg of pulp, pulp paper and board	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE
	Maximum level of GHG emissions by ton of material					CLIMATE CHANGE	ENERGY USE
	Level of GHG emissions by ton of material					CLIMATE CHANGE	ENERGY USE
	Sourcing of raw materials from certified sustainable practices	WATER	SOIL	BIODIVERSITY		CLIMATE CHANGE	
	Maximum level of energy consumed by ton of material					CLIMATE CHANGE	ENERGY USE
	Minimum percentage of recycled content in input material	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE
INFORMATION REQUIREMENTS	Water consumption during production	WATER					
	Sourcing of raw materials from certified sustainable practices	WATER	SOIL	BIODIVERSITY		CLIMATE CHANGE	
	Level of energy consumed by ton of material					CLIMATE CHANGE	ENERGY USE
	Percentage of recycled content in input material	WATER	SOIL	BIODIVERSITY	WASTE	CLIMATE CHANGE	ENERGY USE

Proportionality of Costs

In general, improvement potential measures identified for energy and CO_2 emission savings are estimated to have low to medium costs with relatively short payback periods ([13]). For example, heat recovery measures in mechanical pulping were estimated to have a payback period of few months ([23]). On the other hand, some of the measures are particularly expensive: for example, full electrification does not seem economically viable in the foreseeable future, as it is particularly CAPEX-intensive (due to the need to replace current assets) and as the cost of electricity is higher than that of natural gas ([15]) (although geopolitical factors can influence this point).

Improvement potential measures associated with the management of by-products (e.g. incineration of residues) were estimated to have an investment cost proportional with the energy savings delivered ([13]).

Additional notes and list of references

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(14) CEPI (2016), Making industry transformation happen in Europe?, Stakeholder discussion paper

(15) CEPI (2021) Fit for 55' package: how to unleash the European pulp and paper industry's decarbonisation potential?, Position paper

(16) Commission Implementing Decision 2014/687/EU of 26 September 2014 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the production of pulp, paper and board

(17) Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC

(18) COM(2021) 572 final, New EU Forest Strategy for 2030

(19) COM/2021/554 final, Proposal for a Regulation of the European Parliament and of the Council amending Regulations (EU) 2018/841 as regards the scope, simplifying the compliance rules, setting out the targets of the Member States for 2030 and committing to the collective achievement of climate neutrality by 2035 in the land use, forestry and agriculture sector, and (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review

(20) Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814

(21) Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')

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Annex 6 Assessing the contribution of prioritised end-use products and intermediate products related to the Consumption Footprint and the Planetary Boundaries

The system boundaries of the Consumption Footprint include the following life-cycle stages:

(a) Components manufacture (examples of activities/processes included: production and processing of raw materials; transport of the materials for the manufacturing plant; etc.);

(b) Manufacturing (examples of activities/processes included: assembling of components; etc.);

(c) Packaging (examples of activities/processes included: manufacture and transport of packaging; final disposal of packaging, etc.);

(d) Logistics (examples of activities/processes included: transport of the packaged product from factory to retail/distribution centre; etc.);

(e) Use (examples of activities/processes included: transport of the packaged product from retail/distribution centre to the final consumer; consumption of energy and water from/to use the product; in the case of appliances, use of detergents and salt; etc.);

(f) End-of-life (examples of activities/processes included: sorting of waste; recycling; incineration; landfill; etc.).

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).

The environmental impacts of the current consumption of end-use and intermediate products were evaluated (for the 16 impact categories) and for the EU-27 (concerning the year 2018) by considering the consumption intensity and the environmental impacts of their life cycle, as described by Equation A7.1.

$$Environmental\ impacts\ of\ product\ \left(\frac{impact}{year}\right) = Consumption\ intensity\ \left(\frac{unit}{year}\right) * Environmental\ impact\ intensity\ \left(\frac{impact}{unit}\right) \quad (A7.1)$$

For each impact category, the total impacts of the prioritised end-use products and intermediate products were compared to the overall Consumption Footprint, based on data extracted from the Consumption Footprint Platform (EC-JRC, 2022). The contribution of end-use products was assessed by identifying the share of the Consumption Footprint for which they are responsible, since the impacts of these products consider the entire life cycle as in the Consumption Footprint. Meanwhile, intermediate products can only be assessed independently as they are not comparable with end-use products. Intermediate products consider only the initial life-cycle stages of a product life cycle (i.e., components manufacture and manufacturing), and they would double-count for the impacts of representative products. As a result, it is not possible to identify the share of the Consumption Footprint for which they are responsible (Figure 7).

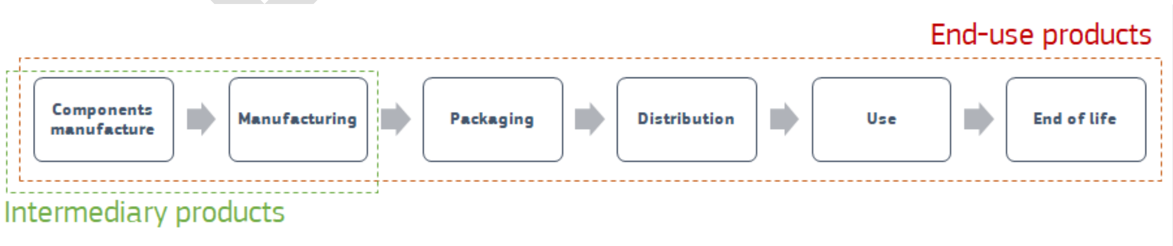


Figure 7. System boundaries for the assessment of the environmental impacts of end-use and intermediate products

The resulting environmental impacts for the 16 impact categories of the prioritised end-use products, the intermediate products and the overall Consumption Footprint 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).

To model the consumption intensities and environmental impacts of the end-use products and intermediate products under exam, several data sources were employed, as described in detail in Annex 9.

It is worth to mention that in the present assessment:

- The product “rubber” is partially addressed:
    - (i) in the category ‘plastic and polymers’ and modelled according to PRODCOM (Eurostat, 2023) “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 Annex 9;
    - (ii) in the end-use product ‘tyres’ for which the model includes PRODCOM codes of several types of tyres (e.g., pneumatic tyres for buses, motor cars, etc.).
- Concerning non-ferrous metal products, the present study includes the intermediate product ‘aluminium’ to be intended as a proxy for those materials.
- The end-use products “fishing gear”, as well as the intermediate product “non-ferrous metal products (excluding aluminium)” were not included in the calculations as it was not possible to model their consumption intensities and/or impact factors (e.g., due to data gaps, lack of available proxies, etc.).

Annex 7 Analysis of the potential plastic leakage associated with the prioritised end-use products

Methodological approach

The estimations of microplastics and macroplastics releases presented in this report followed the approach suggested by the "Plastic Leak Project method" (PLP) (Peano et al. 2020). The approach was applied to the consumed plastic mass for the tyres and textiles products, estimated as described in Annex 9. Environmental releases to water and soil, as well as the amount of littered items being recollected were estimated. Considering that the Environmental Footprint currently does not cover microplastics and macroplastics releases, these estimates were included as a potential approach to cover such gap. The estimation of microplastics and microplastics releases reported in the present study refer to the amount of new products (i.e., tyres and textiles) consumed each year, rather than to the total amount of products in use in that year.

Additionally, the EU Commission is currently assessing and estimating microplastics releases to the environment from several sources (including tyres and textiles), in the context of a Staff Working Document Impact Assessment report. Such report is currently not publicly available, and its results therefore could not be compared with those of the present study.
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.

The potential plastic leakage due to the consumption of tyres and textiles (two of the prioritised end-use products) was quantified following the Plastic Leak Project method (henceforth called the "PLP method"; Peano et al., 2020). Insights related to plastic leakages and the related environmental impacts are currently beyond the scope of the Consumption Footprint, although these issues 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). 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 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). 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).

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 a "number of bottles" metric being released, assuming a bottle of average weight (i.e., 23.9 g) as the reference. A visual description of the pathways leading to the environmental impacts of the plastic being released from tyres and textiles is described in Figure 8.

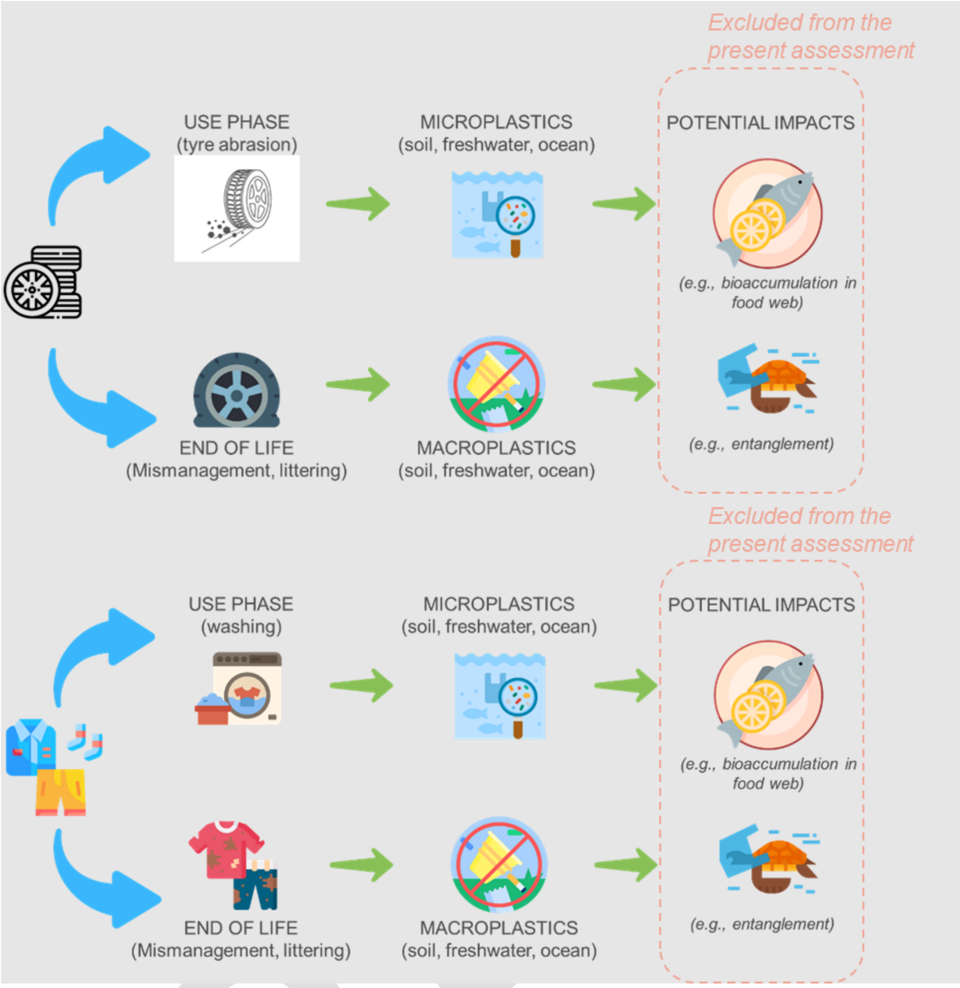


Figure 8. Micro- and macro-plastics generation and potential impacts due to the consumption of tyres and textiles

Preliminary results

Table 17 summarises the amount of microplastic and macroplastic emissions and the related releases to the environment or redirection toward end-of-life pathways.

Table 17. Estimated micro- and macroplastic generation and release to the environment for tyres and textiles.

Estimated quantities		Tyres	Textiles
Consumption [kg]		6.49E+09	8.82E+09
Microplastics generation [kg]		2.11E+04	8.11E+06
Microplastics	Release to Water [kg]	3.58E+03	3.97E+06
	Number of water bottles (0.5L)	1.50E+05	1.66E+08
	Release to Soil [kg]	1.45E+04	8.98E+05
	Number of soil bottles (0.5L)	6.08E+05	3.76E+07
	Recollected (Incineration) [kg]	2.95E+03	3.25E+06
Macroplastics generation [kg]		1.17E+08	5.30E+07
Macroplastics	Release to Water [kg]	1.83E+07	8.31E+06
	Number of water bottles (0.5L)	7.65E+08	3.48E+08
	Release to Soil [kg]	6.56E+07	2.98E+07
	Number of soil bottles (0.5L)	2.75E+09	1.25E+09
	Release to Environment (unspecified) [kg]	3.28E+07	1.49E+07
	Number of environment (unspecified) bottles (0.5L)	1.37E+09	6.24E+08

Note: the estimations are based on the "PLP method" (Peano et al., 2020). Microplastics refer to small plastic debris of less than 5 mm in diameter; macroplastics refer to plastic debris larger than 5mm in diameter. Each release was converted to a "number of bottles" by considering an average weight (23.9 g) of a bottle.

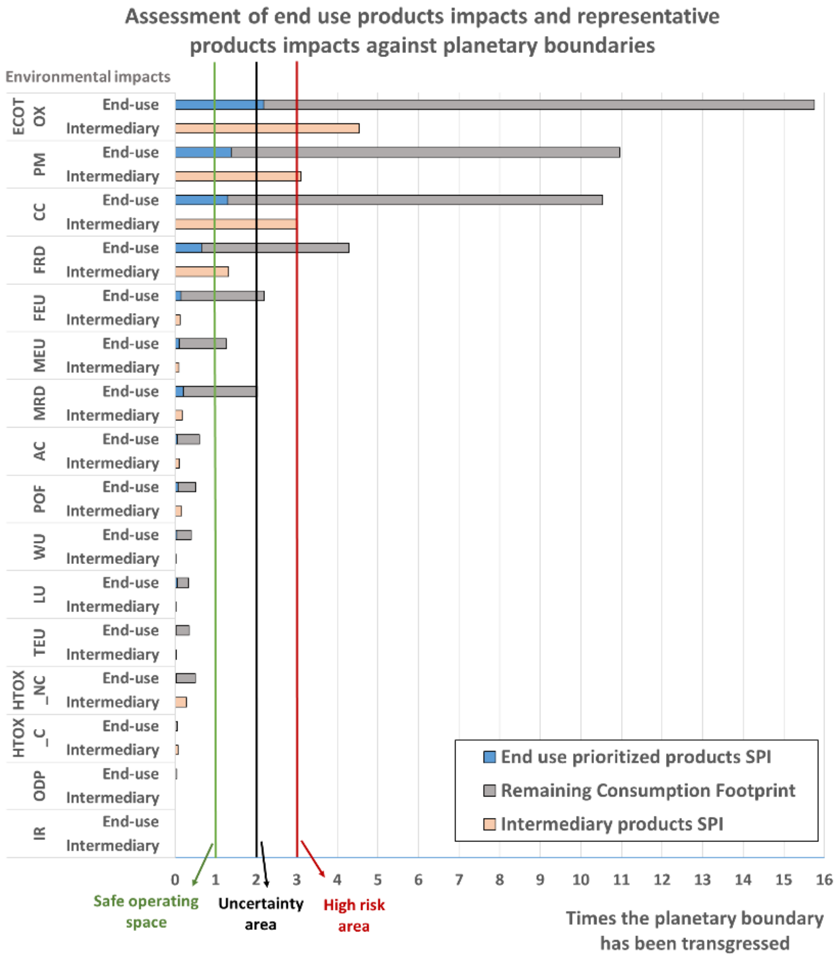
According to the PLP method, the release of microplastics was addressed based on the estimated consumption of tyres and textiles, whilst the macroplastics releases were calculated based on the total waste generated from the two sectors (assuming an amount of waste being generated from tyres equal to 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)). Results presented in Table 17 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 macroplastics releases to the environment are around four orders of magnitude higher than the releases of microplastics for tyres, and one order of magnitude higher for textiles. Macroplastics releases to the environment are higher for tyres than for textiles; instead, the microplastics releases are two orders of magnitude higher for textiles (during the use phase). The cumulative microplastic and macroplastic releases from both tyres and textiles would amount to a total of 31 ktonnes (to water), a total of 96 ktonnes (to soil) and a total of 48 ktonnes (to environment unspecified). Overall results indicate that the total plastic releases to the environment for the two prioritised end-use products under assessment would be equal to 175 ktonnes (0.18 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.

Annex 8 Additional results on the contribution of prioritised end-use products and intermediate products related to the overall Consumption Footprint, in the context of planetary boundaries

Results of the assessment of the impacts of prioritised end-use and intermediate products related to the overall Consumption Footprint and in the context of planetary boundaries are reported in Figure 9. The blue part of the 'end-use' bar represents the share of the products prioritised in this work. The longer the bar, the bigger the impact that may be partly reduced by ESPR measures.

The environmental impact of intermediate products is always larger than the environmental impact of prioritised end-use products. This is mainly related to the larger scope of the consumption for intermediate products: the consumption footprint and the assessment of end-use products focus on the consumption by end users, whilst the data on consumption of intermediate products reflect the overall consumption of such products by the entire economy (i.e., without differentiating the type of users), leading to a broader scope. On the other hand, intermediate and final products have a different coverage of life-cycle stages for the estimation of environmental impacts. The assessment of end-use products (as in the Consumption Footprint) considers the entire life cycle of products and, specifically, includes the burdens and benefits of end of life (e.g., recycling, incineration). Considering recycling activities result in the avoided environmental impacts associated to the displaced virgin material in the market, whilst incineration activities result in the avoided impacts associated to the produced electricity that substitutes the conventional electricity mix. These avoided environmental impacts contribute to decreased environmental impacts of end-use products. On the contrary, such burdens and benefits are not covered in the assessment of the intermediate products which consider only the impacts associated with the main production process until the factory gate and thereby excluding end of life management (and potential avoided impacts).[77]

[77] For instance, in the case of the intermediate product "Aluminium", the total impacts were derived by multiplying an estimated consumption intensity (EuropeanAlumnium, 2022; Annex 10) with the impacts associated with aluminium production (Ecoinvent, 2022; Annex 10). The aluminium production impacts consider a process that starts when all the inputs (mainly liquid aluminium and metal scraps) enter the cast house and ends when finished aluminium leaves the cast house, therefore excluding the burdens and benefits of downstream stages.

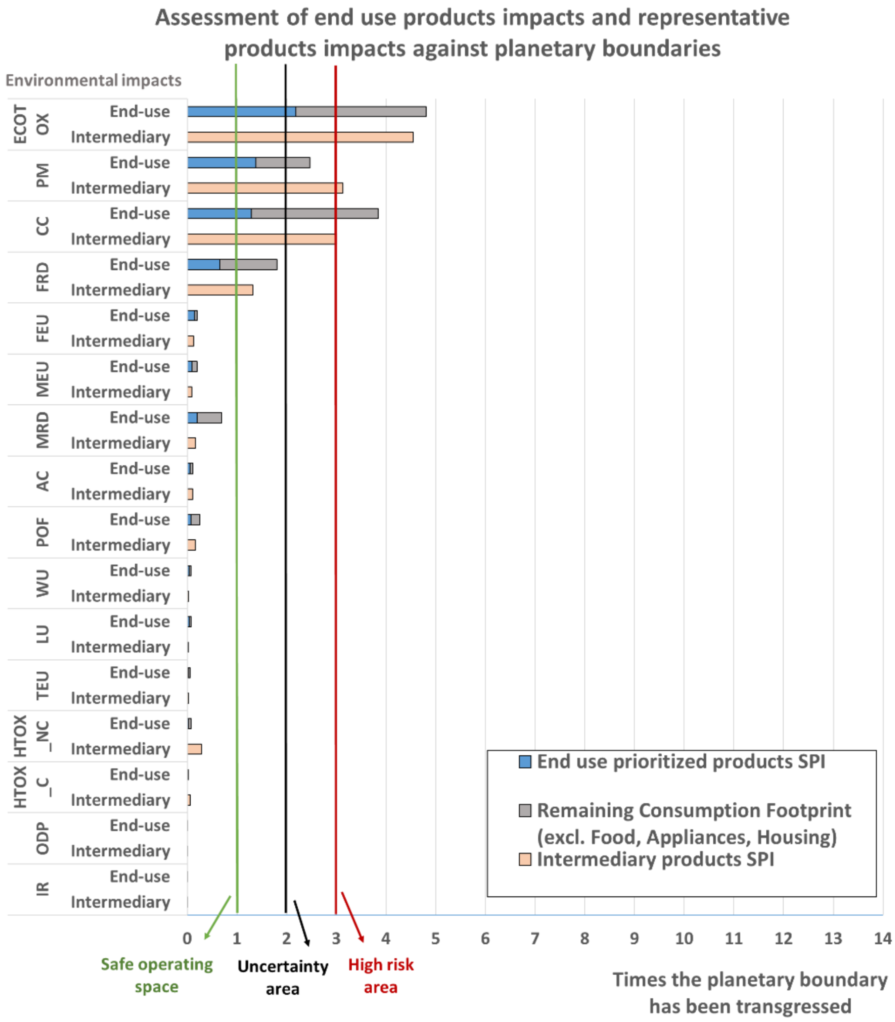


Note: CC = climate change; ODP = ozone depletion; HTOX_nc = human toxicity non-cancer; HTOX_c = human toxicity, cancer; PM = particulate matter; IR = ionising radiations; POF = photochemical ozone formation; AC = acidification; TEU = eutrophication, terrestrial; FEU = eutrophication, freshwater; MEU = eutrophication, marine; LU = land use; ECOTOX = ecotoxicity freshwater; WU = water use; FRD = resource use, fossil; MRD = resource use, minerals and metals

Figure 9. Impacts of prioritised end-use and intermediate products against the Planetary Boundaries and contribution of end-use products within the Consumption Footprint.

The prioritised end-use products represent between 3.2% (in the case of ozone depletion) and 21.1% (human toxicity cancer) of the impacts of the overall consumption[78]. When excluding the impact of food, appliances and housing from the scope of the Consumption Footprint (these not being considered in the Working Plan of the EPSR), the prioritised end-use products represent between 18.4% (ozone depletion) and 72.9% (freshwater eutrophication) of the impacts of the overall consumption (Figure 10).

[78] For this calculation, the overall impacts of the Consumption Footprint were considered for the assessment of the overall consumption. Although paints, tyres and lubricants are not representative products of this indicator, their overall impact was not considered as additional to the consumption footprint since these products are consumed in the life cycle of the representative products and considering them separately would lead to double counting.



Note: Impact categories acronyms are provided in Figure 9.

Figure 10. Impacts of prioritised end-use and intermediate products against the Planetary Boundaries and contribution of end-use products within the Consumption Footprint excluding impacts for the areas of consumption, food and appliances.

Annex 9 Modelling background information

For the different prioritized end-use products and intermediate products, the environmental impact was quantified considering both the consumption intensity and the unitary environmental impact per product. The present study leveraged the available representative products of the Consumption Footprint indicator (Sala & Sanyé-Mengual, 2022), and complemented the with ad-hoc models. Table 18 details the data sources employed for estimating the consumption intensity and the environmental impacts of the different products (both end-use and intermediate).

Table 18. 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, 2023): - Sum of the apparent consumptions for several PRODCOM codes of "Iron" and "Steel". The apparent consumption of each PRODCOM code "i" for EU27 2018 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$ - The categories and families of PRODCOM codes related to "Iron" and "Steel" were analysed and a subset of relevant codes was selected (i.e., codes identified as intermediate iron and steel). 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").	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). 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]	Based on literature data: - The consumption intensity was derived from European Aluminium (EuropeanAluminium, 2022).	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). The environmental impact for this product was derived as the impact of the following dataset: - Aluminium, wrought alloy {RER}| aluminium production, primary | APOS, U
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, phoshoric 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 and organo-metallic compounds. The consumption intensities were modelled by considering PRODCOM data (Eurostat, 2023): - Sum of the apparent consumptions for several PRODCOM codes of "Chemicals". The apparent consumption of each PRODCOM code "i" for EU27 2018 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$ The categories and families of PRODCOM codes related to "Chemicals" were analysed and a subset of relevant codes was selected by mapping the PRODCOM codes with the chemicals in the abovementioned scope.	A selection of the Ecoinvent datasets (Ecoinvent, 2022) based on the chemicals' scope was performed. These datasets were then characterized with the EF3.0 method. Production-related datasets (i.e., "{RER} | production | APOS, U") were prioritized. 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.

Product [category]	Consumption intensity	Environmental impact
Plastic & Polymers [intermediate]	PRODCOM data (Eurostat, 2023) of semifinished products (Amadei et al., 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 and colleagues.	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). The environmental impact for this product was derived as the weighted average of the following dataset related to polymers' production: - Polyvinylchloride, bulk polymerised {RER}| polyvinylchloride production, bulk polymerisation | APOS, U - Polyethylene terephthalate, granulate, amorphous {RER}| production | APOS, U - Polyethylene, high density, granulate {RER}| production | APOS, U - Polyethylene, low density, granulate {RER}| production | APOS, U - Polystyrene foam slab {RER}| production | APOS, U - Polystyrene, general purpose {RER}| production | APOS, U - Polypropylene, granulate {RER}| production | APOS, U The impact of each of the Ecoinvent datasets listed above was weighted by the respective polymer consumption in the EU. The shares of the polymers' consumptions were derived from Kawecki et al. (2018): PVC (19.9%), PET (8.6%), HDPE (17.1%), LDPE (18.2%), EPS (3.9%), PS (4.8%), PP (27.5%).
Glass [intermediate]	PRODCOM data (Eurostat, 2023): - 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: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$ - The categories and families of PRODCOM codes related to "Glass" were analysed and a subset of relevant codes was selected (i.e., codes identified as intermediate ceramic products). 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").	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). 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 "Graphic papers" (derived from Euro-Graph, 2022) and "Tissue paper" (derived from EuropeanTissue, 2022) were considered.	Consumption footprint (EC, 2022): - 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

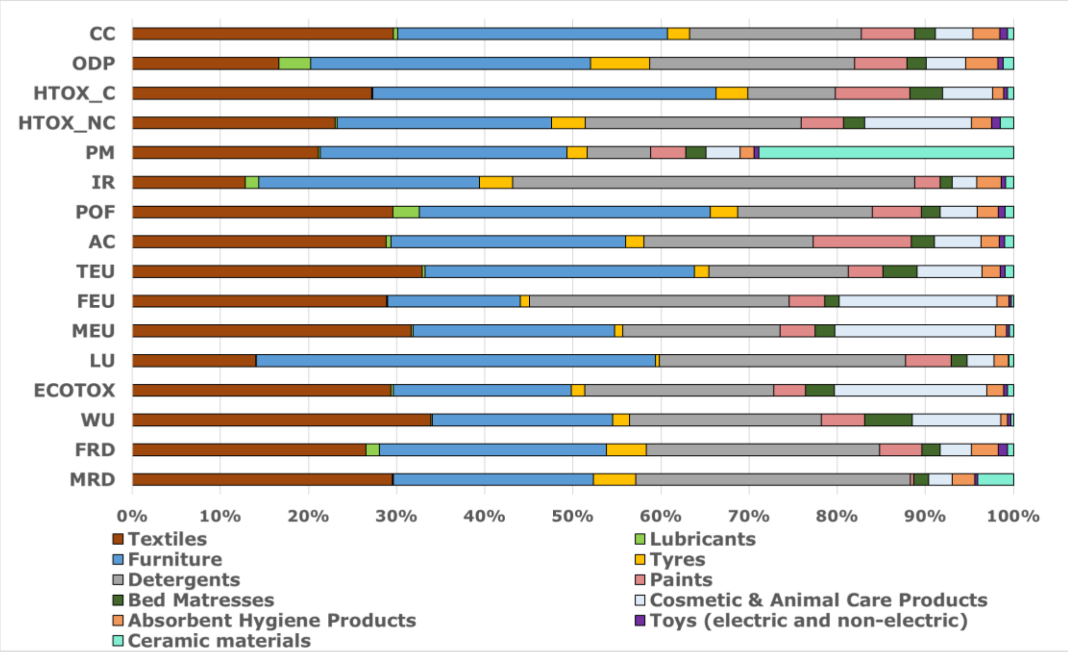
Product [category]	Consumption intensity	Environmental impact
		representative product "Toilet Paper".
Textiles [end use]	Consumption footprint (EC, 2022): - The consumption intensities of the representative products clothes (T-shirt, jeans, blouse, trousers, plastic articles of apparel and clothing accessories) and footwear (5 types, depending on use: fashion, waterproof and work, sports, casual, sandals) were considered.	Consumption footprint (EC, 2022): - 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.
Lubricants [end use]	PRODCOM data (Eurostat, 2023): - 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: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$ - The categories and families of PRODCOM codes related to "Lubricants" were analysed and a subset of relevant codes was selected (i.e., codes identified as intermediate ceramic products). 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").	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). The environmental impact for this product was derived as the impact of the following dataset: - Lubricating oil {RER}| production | APOS, U
Furniture [end use]	Consumption footprint (EC, 2022): - 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, 2022): - 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.
Tyres [end use]	PRODCOM data (Eurostat, 2023): - 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: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$ - The categories and families of PRODCOM codes related to "Tyres" were analysed and a subset of relevant codes was selected (i.e., codes identified as intermediate ceramic products). 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").	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). 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.
Detergents [end use]	Consumption footprint (EC, 2022): - 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, 2022): - The aggregated impacts of the representative products all-purpose cleaners and sanitary cleaners (500mL), detergents for dishwashers (tablet), hand dishwashing detergents (650mL), laundry detergents

Product [category]	Consumption intensity	Environmental impact
		liquid (650mL) and laundry detergents powder (dose), were considered.
Paints [end use]	PRODCOM data (Eurostat, 2023): - 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: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$ - The categories and families of PRODCOM codes related to "Paints" were analysed and a subset of relevant codes was selected (i.e., codes identified as intermediate ceramic products). 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").	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). The environmental impact for this product was derived as the average impact of the following datasets: - Alkyd paint, white, without solvent, in 60% solution state {RER}| alkyd paint production, white, solvent-based, product in 60% solution state | APOS, U - Alkyd paint, white, without solvent, in 60% solution state {RER}| market for alkyd paint, white, without solvent, in 60% solution state | APOS, U - Alkyd paint, white, without water, in 60% solution state {RER}| alkyd paint production, white, water-based, product in 60% solution state | APOS, U - Alkyd paint, white, without water, in 60% solution state {RER}| market for alkyd paint, white, without water, in 60% solution state | APOS, U
Bed mattresses [end use]	Consumption footprint (EC, 2022): - The consumption intensity of the representative product bed mattresses (mix of 3 types) was considered.	Consumption footprint (EC, 2022): - The impact of the representative product bed mattresses (mix of 3 types) was considered.
Cosmetic and Animal Care Products [end use]	Consumption footprint (EC, 2022): - The consumption intensities of the representative products bar soap, liquid soap (255mL), shampoo (255mL) and hair conditioner (255mL), were considered.	Consumption footprint (EC, 2022): - The aggregated impacts of the representative products bar soap, liquid soap (255mL), shampoo (255mL) and hair conditioner (255mL), were considered.
Absorbent Hygiene Products [end use]	Consumption footprint (EC, 2022): - The consumption intensities of the representative products baby diaper, sanitary pad, tampon and breast pad were considered.	Consumption footprint (EC, 2022): - The aggregated impacts of the representative products baby diaper, sanitary pad, tampon and breast pad were considered.
Toys (electronic and non-electric) [end use]	Consumption footprint (EC, 2022): - The consumption intensities of the representative product toys (product group: plastic products) was considered.	Consumption footprint (EC, 2022): - The impact of the representative product toys (product group: plastic products) was considered.

Product [category]	Consumption intensity	Environmental impact
Ceramic products [end use]	PRODCOM data (Eurostat, 2023): - Sum of the apparent consumptions for several PRODCOM codes of "Ceramics". The apparent consumption of each PRODCOM code "i" for EU27 2018 was calculated as: $Production_{code\_i}$ + $Import_{code\_i}$ - $Export_{code\_i}$ - The categories and families of PRODCOM codes related to "Ceramics" were analysed and a subset of relevant codes was selected (i.e., codes identified as ceramic product, including: refractory products, ceramic tiles and flags, bricks, tiles and construction products, ceramic household and ornamental articles, ceramic sanitary fixture, ceramic insulators and insulating fittings and other ceramic products). 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").	Ecoinvent datasets (Ecoinvent, 2022) characterized with the EF3.0 method. All calculations were performed on the SimaPro software (SimaPro, 2022). The environmental impact for this product was derived as the impact of the following datasets: - Manufacturing: the dataset "Ceramic tile {CH}| production | APOS, U". This dataset was employed to model the manufacturing process of ceramic product. This dataset was selected in place of the equivalent "Ceramic tile {RoW}| production | APOS, U" as Switzerland could represent a better proxy for ceramics production in the EU, considering that only 18% of ceramics are imported (according to the United Nations COMTRADE database on international trade). - Distribution: the distribution was modelled according to the PEF scenario from factory to final client. In particular, 18% of international supply chain (according to the import share) and 82% local supply chain. The international supply chain was modelled as 100km by trucj (outside of EU) (dataset "Transport, freight, lorry >32 metric ton, EURO4 {RoW}| transport, freight, lorry >32 metric ton, EURO4 | APOS, U") and 18000km by ship (dataset "Transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship | APOS, U"). The local supply chain was modelled as 1200km by truck (inside EU) (dataset "Transport, freight, lorry >32 metric ton, EURO4 {RER}| transport, freight, lorry >32 metric ton, EURO4 | APOS, U"). - End-of-life: the end-of-life was modelled considering 100% landfill of inert waste (including transport to the end-of-life landfill of inert waste; dataset: "Inert waste {Europe without Switzerland}| treatment of inert waste, sanitary landfill | APOS, U").

Annex 10 Contribution of the different end-use priority products and intermediate products to their overall impacts

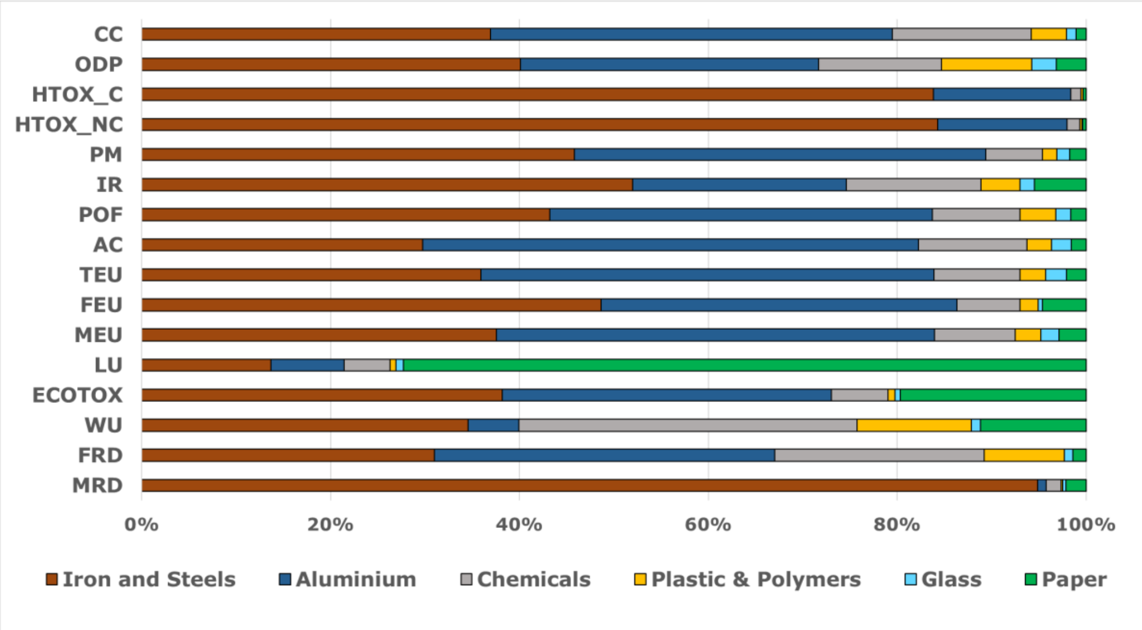
Among the different prioritised end-use products (Figure 11), the most relevant ones are textiles, furniture and detergents, followed by cosmetic and animal care products and paints. Ceramic products also exhibit a certain relevant for the particulate matter impact category, representing 29% of the total impacts of all end-use products in this impact category. This could be explained by the relevant dust emissions occurring during the handling of the raw materials (in particular, of PM2.5) during the production process. More details on the modelling on ceramic products are provided in Annex 10.



Note: Impact category acronyms are provided in Figure 9.

Figure 11. Role of prioritised end-use products in their overall impact.

When intermediate products are considered (Figure 12), the most relevant are iron and steel, aluminium and chemicals. These three product categories covered 87% of the total impacts of all intermediate products (on average for all the 16 impact categories). In particular, iron and steels have the highest contribution (47% on average) for the impacts of all impact categories. By contrast, plastic and polymers and glass amounted to 3% and to 1.2% of all impacts respectively (on average for all the 16 impact categories), since their consumption intensities are the lowest among of all the intermediate products analysed. Notably, paper products covered 72% of all impacts in the land use impact category because of the environmental effects of such products in this impact category, whilst covering an average of 4% of the total impacts in the remaining impact categories.



Note: Impact category acronyms are provided in Figure 9.

Figure 12. Role of intermediate products in their overall impact.

In general, the results provided for end-use and intermediate products in Figure 11 and Figure 12 broadly confirm the findings provided in Table 7 and Table 8 related to the assessment of their environmental relevance (Section 3). In particular, Textiles, Furniture and Detergents ranked first, second and fifth, respectively, in the assessment of their environmental relevance, whilst Iron and Steels and Aluminum ranked first and third, respectively. Nevertheless, few exceptions can be identified, mainly with respect to the product group Ceramics and Tyres, ranking as the third-highest and fourth-highest end-use products in Table 7, whilst having a minor role in Figure 11 (besides the contribution of Ceramics materials in the particulate matter impact category).

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, Table 7, both environmental impacts and improvement potential are considered, whereas (ii) for analysis of the end-use products' relevance (Figure 11), only the environmental impacts of such products are considered.

In addition, the scope of the products considered in Section 3.3.1 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), 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 end-use-products. For example, the product group "Textiles" was considered in the assessment of environmental relevance (Section 3.3.1) as apparel and home textiles consumed by households and business as well as footwear and technical textiles (Annex 2). On the other hand, for the analysis of the end-use products' environmental impacts, the product group Textiles was modelled by means of several representative products (i.e., T-shirts, jeans, blouses, trousers, plastic articles of apparel and clothing accessories, and five types of footwear; Annex 9). 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 that ESPR measure would address, should all prioritised products in Section 3.3.1 be retained (in line with the scope of the analysis of the present report).

Annex 11 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 intermediate products are limited to cradle-to-gate system boundaries. For the modelling, the consumption intensities, and the calculation of the impact factors for such products were based on available statistics (such as the Eurostat database) and datasets (such as Ecoinvent datasets) (Annex 9). In some cases (e.g., intermediate products such as Paper, pulp paper and boards), literature data were needed 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). 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 measures

This exercise presented several challenges, and this report illustrates the current advancements concerning this quantification. Firstly, there is a lack of quantitative data. As reported in Table 19, 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 measures should be also analysed in the context of potential trade-offs, as current results focus on single specific horizontal measures (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 measures (either increasing the total savings or decreasing the total savings)[79]. Horizontal measures proposed for products currently classified as "intermediate products" (e.g. "paper products" or "plastic products" in Table 19) 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 measures 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.

[79] 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.

Annex 12 Quantification of savings for each horizontal measure

Table 19 presents the metrics used and the improvement scenarios considered for each horizontal measure (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[80].

The end-use products and intermediate products for which the default scenarios (i.e., 10%, 30% and 50% improvements) were used and the respective horizontal measures can be found in Annex 9.

Based on the Consumption Footprint indicator, the calculation of the environmental impacts of the prioritised end-use and intermediate products allows the estimation of the potential benefits of applying such measures 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 measures have effects on specific aspects of the life cycle of products (e.g., end of life). Equation A12.1 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 (CI_i), and the benefit level (by HM and scenario) and the environmental impact of each life-cycle stage (j) of the product (i).

$$Product\ impact_{i,HM,s} = CI_i * \sum_{j=0}^{n} \left(1 - benefit_{HM,i,j,s}\right) * environmental\ impact_{i,j} \quad \text{[Eq. A12.1]}$$

A detailed description of the calculation methods for individual horizontal measures is available in Annex 15.

Table 19. Summary of horizontal measures and the related metrics and improvement scenarios.

Horizontal Measure	Metric	Improvement scenarios (classification)
Lightweight design		
– Detergents; Cosmetics; Paints and varnishes; Animal Care Products	Materials saved by reducing the primary packaging / product mass (or functional unit) ratio	5% (low benefits) – 10% (medium benefits) – 20% (high benefits)[81]
Durability		
– Textiles (clothes and footwear)	Increased lifetime expressed in %	10% (low benefits) - 30% (medium benefits) - 50% (high benefits)[82]
– Bed Mattresses	Increased lifetime expressed in %	TBD
– Furniture	Increased lifetime expressed in %	40% (low benefits) - 60% (medium benefits) - 80% (high benefits)[83]

[80] 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.

[81] Ponstein et al. (2019); Golsteijn and Vieira (2020).

[82] Assumptions based on: Cooper et al. (2013); Beton et al. (2014).

Horizontal Measure	Metric	Improvement scenarios (classification)
– Toys	Increased lifetime expressed in %	10% (low benefits) - 30% (medium benefits) - 50% (high benefits) (default)
– LMT	N/A	N/A
Recyclability		
– Bed mattresses	Increased recycling (% increased recycling rate)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits) (default)
– Textiles	Increased recycling (% increased recycling rate)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits) (default)
– Absorbent hygiene products	Increased recycling (% increased recycling rate)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits (default)
– Printed paper, stationery paper, and paper carrier bag products	Increased recycling (% increased recycling rate)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits (default)
– Furniture;	Increased recycling (% increased recycling rate)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits (default)
– Toys	Increased recycling (% increased recycling rate)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits (default)
Post-consumer recycled content		
- Textiles	Post-consumer recycled content (% used in manufacture)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits
– Plastic products	Post-consumer recycled content (% used in manufacture)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits)
– Products containing CRMs: in terms of secondary CRMs	Post-consumer recycled content (% used in manufacture)	10% (low benefits) - 30% (medium benefits) - 50% (high benefits)
Sustainable sourcing		
– Iron and Steel; Aluminium, Plastic and polymers; Chemicals; Ceramic products; Glass; Paper, pulp paper and board; Precious metals	N/A as the proposed measure is limited to ensure traceability and information requirements	N/A as indirect benefits from traceability and information requirements are challenging to estimate at this stage

Note: 1) For LMT, improvements cannot be modelled as these products are out of the model scope. 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. 2) Different sets of improvement scenarios for the same horizontal measures 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.

[83] Assumptions based on: Russell et al. (2022).

Annex 13 Additional results on results on the evaluation of savings due to horizontal measures

The results of the calculation of the environmental impacts savings due to the application of the horizontal measures are reported in the following sections. In Table 20 is reported a summary of the products for which the horizontal measures have been applied, compared to what is presented in Table 19. It must be noted that, since the benefits for some products have not been calculated, the results presented in the following annexes subsequently represent an underestimation of the savings. This could be improved if products labelled as "excluded" in Table 20 would be added in the calculations.

Table 20. Summary of the products for which the evaluation of savings due to horizontal measures has been calculated.

Horizontal Measure	Product	Comment
Lightweight design	Detergents	Calculated. The calculation was based on the Representative Product employed to model "Detergents" (Annex 9).
	Cosmetics	Calculated. The calculation was based on the Representative Product employed to model "Cosmetic and Animal Care Products" (Annex 9).
	Paints and varnishes	Excluded. This product was not calculated due to lack of impacts' data at the level of life cycle stages.
	Animal Care Products	Calculated. The calculation was based on the Representative Product employed to model "Cosmetic and Animal Care Products" (Annex 9).
Durability	Textiles (clothes and footwear)	Calculated. The calculation was based on the Representative Product employed to model "Textiles" and "Footwear" (Annex 9).
	Bed Mattresses	Excluded. Based on Table 19..
	Furniture	Calculated. The calculation was based on the Representative Product employed to model "Furniture" (Annex 9).
	Toys	Calculated. The calculation was based on the Representative Product employed to model "Toys" (Annex 9).
	LMT	Excluded. Based on Table 19.
Recyclability	Bed mattresses	Calculated. The calculation was based on the Representative Product employed to model "Bed Mattresses" (Annex 9).
	Textiles	Calculated. The calculation was based on the Representative Product employed to model "Textiles" and "Footwear" (Annex 9).
	Absorbent hygiene products	Calculated. The calculation was based on the Representative Product employed to model "Absorbent hygiene products" (Annex 9).
	Printed paper, stationery paper, and paper carrier bag products	Excluded. Intermediate products were not calculated due to lack of impacts' data at the level of life cycle stages.
	Furniture	Calculated. The calculation was based on the Representative Product employed to model "Furniture" (Annex 9).
	Toys	Calculated. The calculation was based on the Representative Product employed to model "Toys" (Annex 9).
Post-consumer recycled content	Textiles	Calculated. The calculation was based on the Representative Product employed to model "Textiles" and "Footwear" (Annex 9).
	Plastic products	Calculated. The calculation was based on the Representative Product employed to model "Plastics Products" (Annex 9).
	Products containing CRMs: in terms of secondary CRMs	Excluded. This product category was excluded as it is too broad to properly estimate savings per life cycle stage.
Sustainable sourcing	All products listed in Table 19 (Iron and Steel; Aluminium,	Excluded. No calculation was performed for this horizontal measure due to lack of available knowledge about indirect

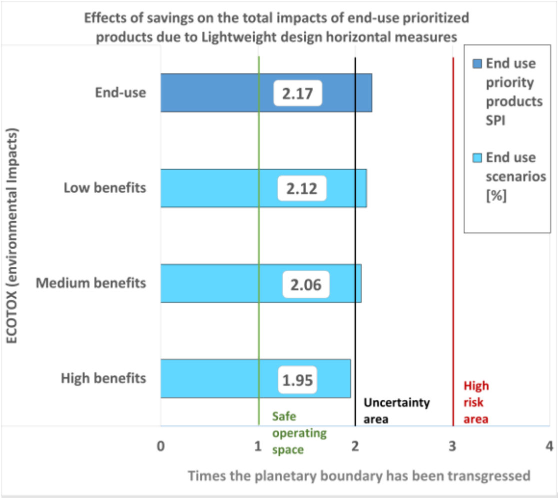
Horizontal Measure	Product	Comment
	Plastic and polymers; Chemicals; Ceramic products; Glass; Paper, pulp paper and board; Precious metals)	benefits from traceability, and since information requirements were recognized to be challenging to estimate.

<u>Savings due to the implementation of horizontal measures on Lightweight design</u>

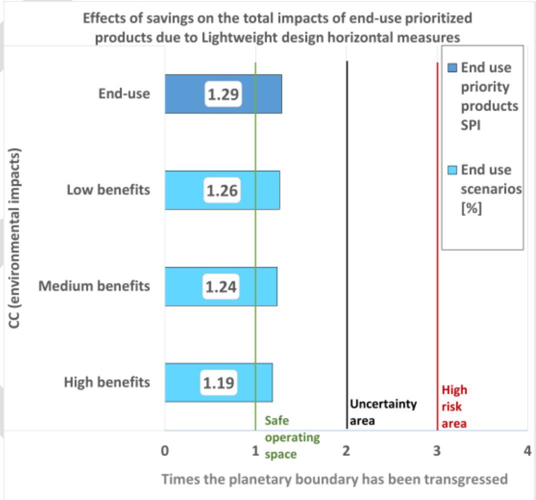
As discussed in Section 4 and Annex 14, the savings in terms of the environmental impacts of the prioritised end-use products due to horizontal Lightweight design measures were calculated considering an expected benefit for the entire life cycle apart from the direct resource use during the consumption phase. The calculations of the results related to the Lightweight design measures were performed on the products listed in Table 19. The results of the three scenarios (i.e., "low benefits", "medium benefits" and "high benefits") are presented in Figure 13 targeting the four impact categories with the highest impacts compared to the planetary boundaries (results associated with the other impact categories are presented in Annex 15). The scenarios evaluate the expected impact of the consumption of the prioritised end-use products considering the environmental benefits of the implemented horizontal measures.

Figure 13. Effect of the savings on the impacts of three scenarios (i.e., “low benefits”, “medium benefits” and “high benefits”) related to Lightweight design, compared to the total impacts of the consumption of the prioritised end-use products (“base scenario”) for Freshwater ecotoxicity (ECOTOX), Climate change (CC), Particulate matter (PM) and Resource use fossil (FRD) compared to the respective planetary boundary

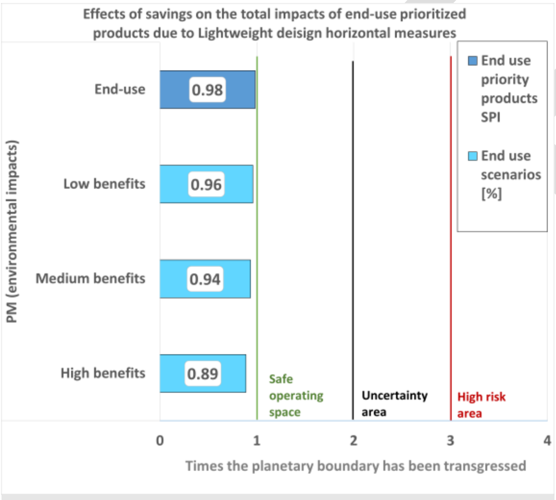
Freshwater ecotoxicity (ECOTOX)



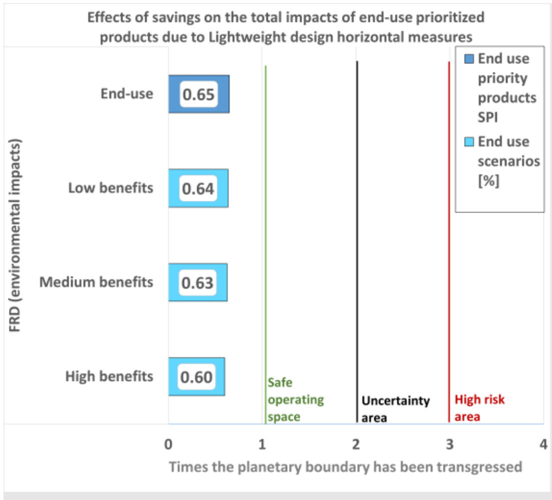
Climate change (CC)



Particulate matter (PM)



Resource use fossil (FRD)



Lightweight design would have a positive effect in reducing the environmental impact of the consumption of prioritised end-use products across all impact categories. However, the benefits of the application of this horizontal measure would be limited when compared with the "base scenario". Expected improvements could reach up to 10% for the different categories examined in Figure 13 ("high benefits" scenario, in the case of freshwater ecotoxicity). This is related to the narrow scope of this horizontal measure, for which this report suggests only implementing for Detergents and Cosmetics (Table 20)

When compared to the planetary boundaries, the environmental benefits would be particularly relevant for the impact category of Ecotoxicity (Figure 13). Only in the case of Ecotoxicity the "high benefits" scenario would ensure that the "uncertainty area" of the planetary boundaries is not crossed. By contrast, in the case of Climate Change, savings due to the implementation of the Lightweight Design measures would not be sufficient to avoid transgressing the "Safe operating space".

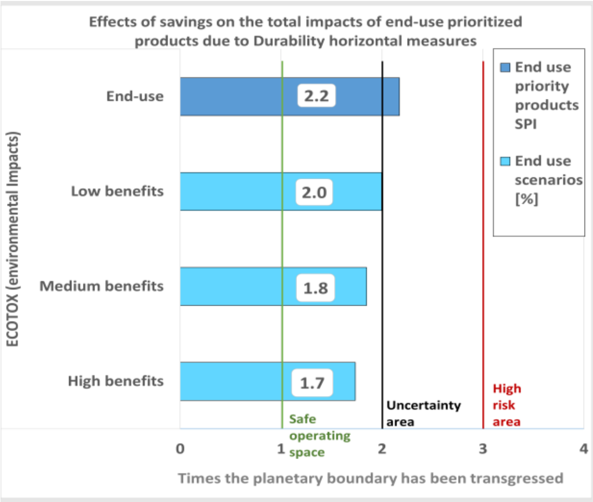
The Lightweight design measures were modelled on products included under the "Household goods" area of consumption. In the case of household goods products, the use phase represents on average 22% of the total life cycle impacts excluding the end-of-life stage (being the second most relevant stage, after components manufacture which accounts for 50% 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 Lightweight design measures are put into practice.

Savings due to the implementation of horizontal measures on Durability

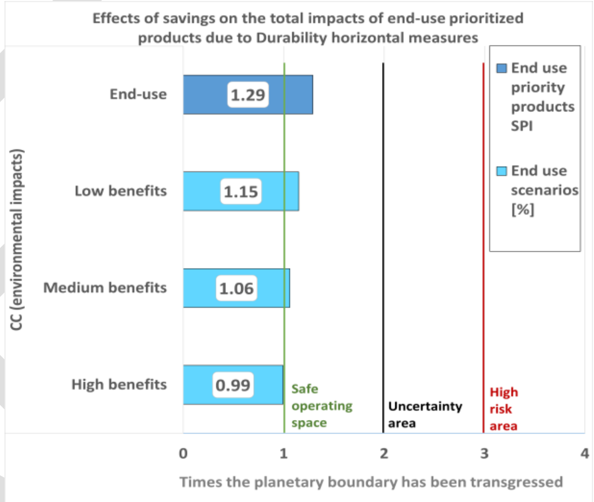
As discussed in Section 4 and Annex 14, the savings in terms of the environmental impacts of the prioritised end-use products due to Durability horizontal measures were calculated based on an increased product lifetime expressed in percentage (%). Changes in lifespan affect all life-cycle stages apart from use as the impact of these stages are allocated to a year based on the lifespan. The calculations of the results related to the Durability measures were performed on the products for which the collected data on the horizontal measures' expected savings were deemed more robust (i.e., "Textiles (clothes and footwear)"; "Furniture" and "Toys"). The results of the three scenarios (i.e., "low benefits", "medium benefits" and "high benefits") are presented in Figure 14 targeting the four impact categories with the highest impacts compared to the planetary boundaries (results associated with the other impact categories are presented in Annex 15). The scenarios evaluate the expected impact of the consumption of the prioritised end-use products considering the environmental benefits of the implemented horizontal measures.

Figure 14. Effect of the savings on the impacts of three scenarios (i.e., "low benefits", "medium benefits" and "high benefits") related to Durability, compared to the consumption of the prioritised end-use products ("base scenario") for Freshwater ecotoxicity (ECOTOX), Climate change (CC), Particulate matter (PM) and Resource use fossil (FRD) compared to the respective planetary boundary

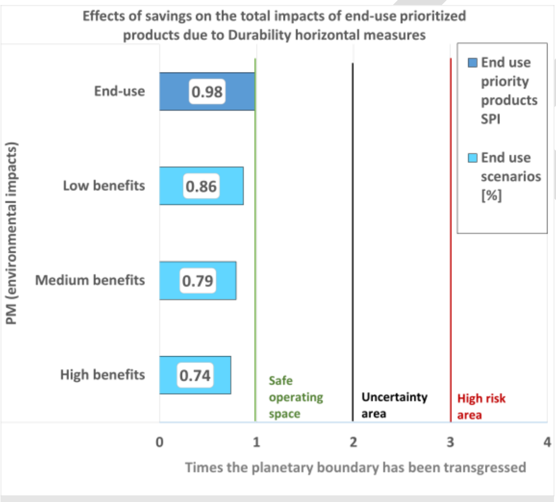
Freshwater ecotoxicity (ECOTOX)



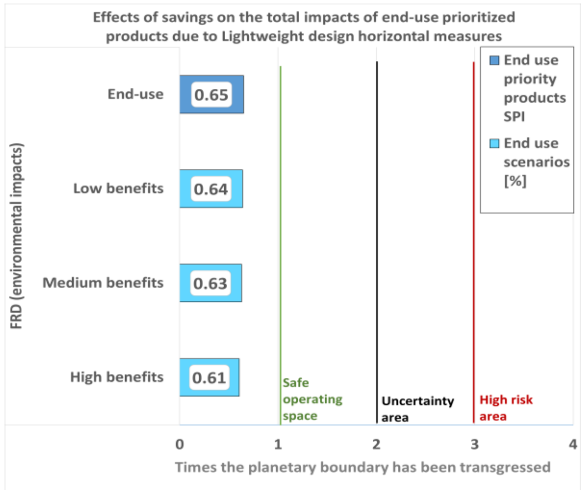
Climate change (CC)



Particulate matter (PM)



Resource use fossil (FRD)



Durability measures would have a positive effect in reducing the environmental impacts of the consumption of end-use products across all impact categories. Compared to Lightweight design, the benefits of the application of the Durability horizontal measures are higher when compared with the "base scenario"). Expected improvements could reach up to 25% for the different categories examined in Figure 14 ("high benefits" scenario, in the case of Particulate matter). These effects could be explained by the broader scope of this horizontal measure (compared for instance to Lightweight design), covering several textiles products (clothes and footwear), furniture types and toys.

When compared to the planetary boundaries, the environmental benefits would be particularly relevant for the impact categories of Particulate matter and Climate Change (Figure 14). For Ecotoxicity, all scenarios would be sufficient to not cross the "uncertainty area" in the context of planetary boundaries. In the case of Climate Change, savings associated with Durability measure would also be sufficient to avoid transgressing the "Safe operating space" only for the "high benefits" scenario.

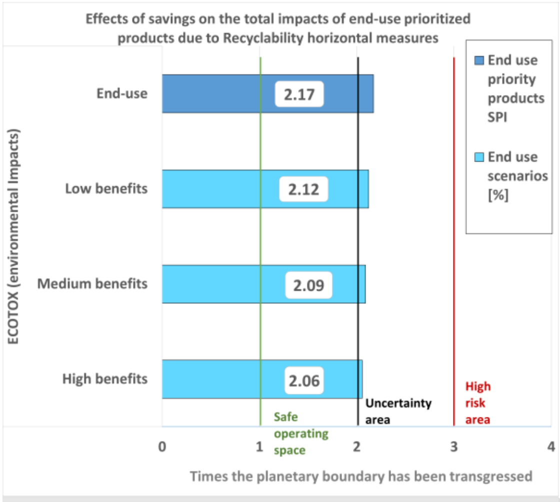
As for the Lightweight design measures, the Durability measures were applied to all life-cycle stages (excluding the use phase) of products listed in Table 19 ((i.e. textiles, furniture and toys, which are included under the "Household goods" area of consumption). In the case of household goods products, the use phase represents on average 22% of the total life-cycle impacts excluding the end-of-life stage (being the second most relevant stage, after components manufacture which accounts for 50% 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 measures are put into practice, together with the assumed lifespan of products for which a Durability measure has been calculated.

Savings due to the implementation of horizontal measures on Recyclability

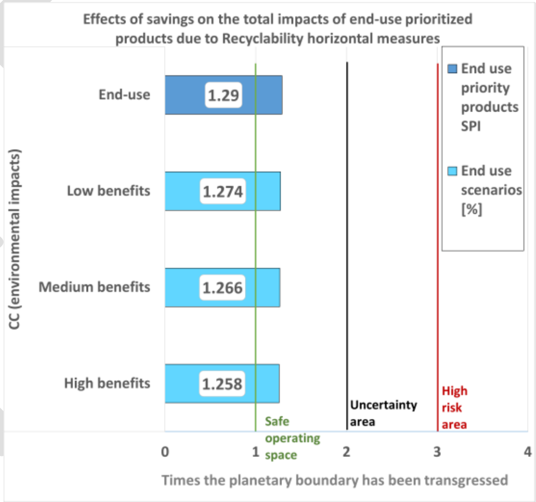
As discussed in Section 4 and Annex 14, the savings in terms of the environmental impacts of the prioritised end-use products due to Recyclability horizontal measures were calculated considering how a different recycling rate could influence the contribution to the impact of non-recycling pathways. A different (i.e. higher, according to Table 19) recycling rate could result in higher benefits at the end of life, considers the avoided impacts of the material that is being recycled. The calculations of the results related to the Recyclability measures were performed on the end-use products listed in Table 19, therefore excluding "Printed paper, stationery paper, and paper carrier bag products" (classified as intermediate products in the present study). The results of the three scenarios (i.e, "low benefits", "medium benefits" and "high benefits") are presented in Figure 15 targeting the four impact categories with the highest impacts compared to the planetary boundaries (results associated with the other impact categories are presented in Annex 15). The scenarios evaluate the expected impact of the consumption of the prioritised end-use products considering the environmental benefits of the implemented horizontal measures.

Figure 15. Effect of the savings on the impacts of three scenarios (i.e., "low benefits", "medium benefits" and "high benefits") related to Recyclability, compared to the total impacts of the consumption of the prioritised end-use products ("base scenario") for Freshwater ecotoxicity (ECOTOX), Climate change (CC), Particulate matter (PM) and Resource use fossil (FRD) compared to the respective planetary boundary

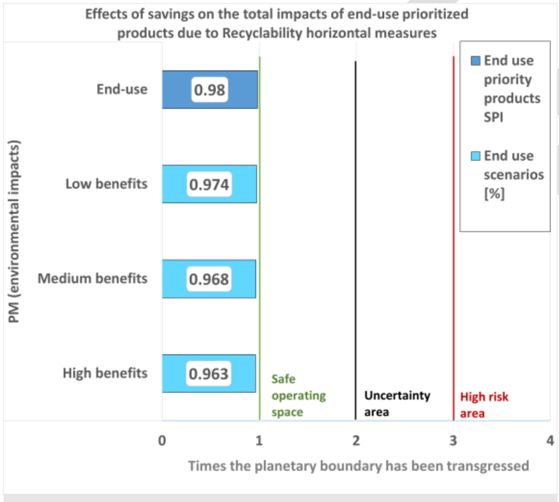
Freshwater ecotoxicity (ECOTOX)



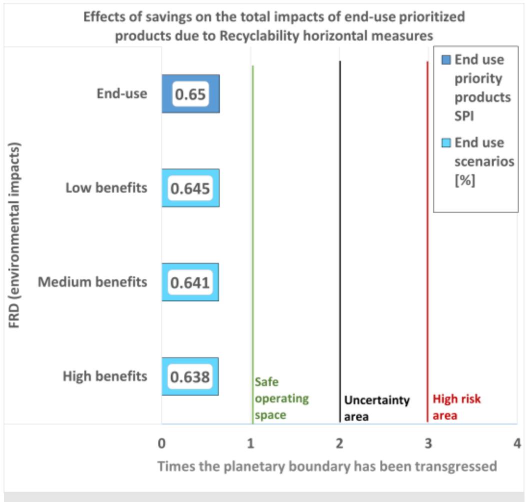
Climate change (CC)



Particulate matter (PM)



Resource use fossil (FRD)



Recyclability would have a positive effect in reducing the environmental impact of the consumption of prioritised end-use products across all impact categories. The benefits of the application of the Recyclability horizontal measure would be limited across all impact categories, and lower than the benefits of Lightweight design and Durability measures. Expected improvements could reach up to 5% for the different categories under examination in Figure 15 ("high benefits" scenario, in the case of freshwater ecotoxicity).

When compared to planetary boundaries, the environmental benefits would be similar for all impact categories (Figure 15). None of the scenarios related to Recyclability measures would ensure that the "uncertainty area" is not crossed (e.g., as it is can be seen in the case of freshwater ecotoxicity and climate change in Figure 15).

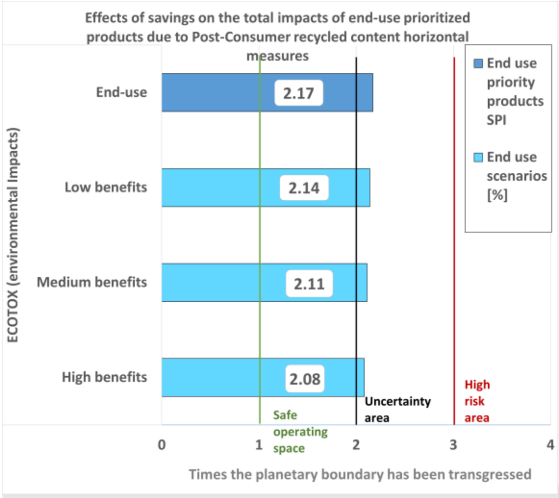
As for the Lightweight design measures and Durability measures, Recyclability measures were modelled on products included in the "Household goods" area of consumption. The importance of recycling compared to incineration and landfill in the current management options of the products assessed by the Recyclability 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., clothes, 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 measures on Recyclability (Table 19) should envision higher increases in recycling rates to achieve more significant savings.

Savings due to the implementation of horizontal measures on Post-consumer recycled content

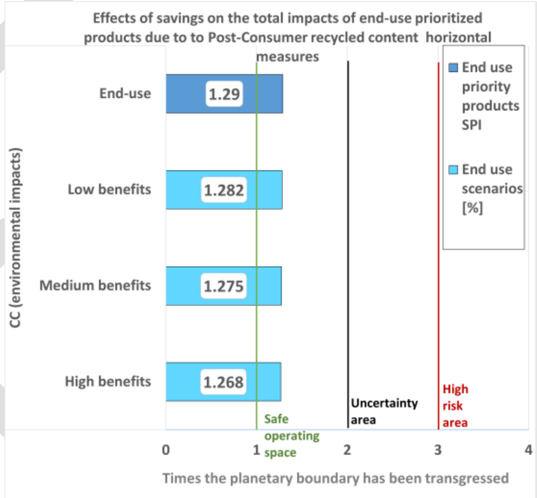
As discussed in Section 4 and Annex 14, the savings on the environmental impacts of the prioritised end-use products due to Post-consumer recycled content horizontal measures were calculated following the same approach as for assessing Recyclability, considering the benefits of recycled content simulating the benefit that would entail at the end of life. The calculations of the results related to the Recyclability measures were performed on the end-use products listed in Table 19. The product "Plastic products" was therefore excluded since it is categorised as intermediate products in the present study. Additionally, the product "Products containing CRMs: in terms of secondary CRMs" was not included in the assessment due to a lack of specific data on impacts and consumption and the lack of a corresponding representative product within the context of the Consumption Footprint. The results of the three scenarios (i.e., "low benefits", "medium benefits" and "high benefits") are presented in Figure 16 targeting the four impact categories with the highest impacts compared to the planetary boundaries (results associated with the other impact categories are presented in Annex 15). The scenarios evaluate the expected impact of the consumption of the prioritised end-use products considering the environmental benefits of the implemented horizontal measures.

Figure 16. Effect of the savings on the impacts of three scenarios (i.e., “low benefits”, “medium benefits” and “high benefits”) related to Post-consumer recycled content, compared to the total impacts of the consumption of the prioritised end-use products (“base scenario”) for Freshwater ecotoxicity (ECOTOX), Climate change (CC), Particulate matter (PM) and Resource use fossil (FRD) compared to the respective planetary boundary

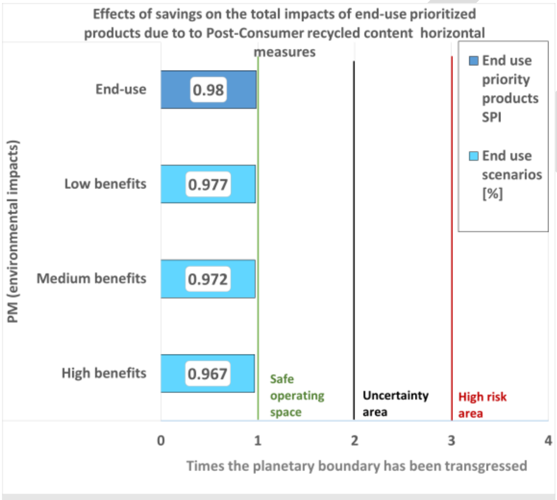
Freshwater ecotoxicity (ECOTOX)



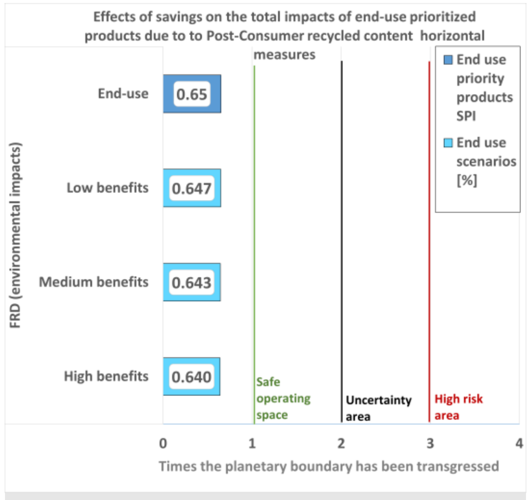
Climate change (CC)



Particulate matter (PM)



Resource use fossil (FRD)



Post-Consumer recycled content measures would have a positive effect in reducing the environmental impacts of the consumption of prioritised end-use products across all impact categories. Similarly to the Recyclability measures, the benefits of the application of the Post-consumer recycled content horizontal measures would however be limited across all impact categories, and lower than the benefits of Lightweight design and Durability measures. Expected improvements could reach up to 4% for the different categories under examination in Figure 16 ("high benefits" scenario, in the case of freshwater ecotoxicity).

When compared to planetary boundaries, the environmental benefits would be similar for all impact categories. All scenarios related to Post-consumer recycled content measures would not ensure that the "uncertainty area" is not crossed (e.g. as it is can be seen in the case of freshwater ecotoxicity and climate change)

As for the Lightweight design measures, Durability measures and Recyclability measures, the Post-consumer recycled content measures were modelled on products included in the "Household goods" area of consumption. Results of the application of Post-consumer recycling measures manifest a similar behaviour compared to Recyclability measures, due to the common calculation approach, although they are lower than the latter due to the fewer products under consideration (i.e., only textile products for Post-consumer recycled content measures compared to textile products, furniture, toys and bed mattresses for Recyclability measures).

As described in Annex 14, due to the structure of the Consumption Footprint model, the quantification of the savings related to Post-consumer Recycled content followed the same approach as for assessing Recyclability, assuming that the benefits due to a recycled content simulate the benefits at the end-of-life. 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. In fact, current models for several representative products employed in the calculations of the Post-consumer recycled content savings (e.g., clothes, footwear, sleeping bags, plastic apparel and clothing articles) propose a recycling share in the range of 0-11% 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, plastic household articles and hair related products (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 measures on Recyclability (Table 19) should envision higher increases in recycling rates to achieve more significant savings.

Comparison of the results for all horizontal measures

To provide an overview of the benefits of all horizontal measures, a summary of the results is provided in Table 21. Looking at the table, it is evident how Durability represents the horizontal measure leading to the highest savings compared to all other measures. These savings are particularly relevant moving from the "base scenario" towards the "high benefits" scenario: in this case, such benefits would be sufficient to avoid crossing the "uncertainty threshold" of the planetary boundaries (as noticeable for instance from the 19.9% savings in the case of freshwater ecotoxicity). Lightweight design measures would allow for visible savings (on average, 11.2% across all impact categories in the case of "high benefits"), although lower than Durability ones. On the other hand, both Recyclability and Post-Consumer recycled content measures result in savings on average no higher than 5.3% (for the "high benefits" scenario in the case of Recyclability) and no higher than 4.1% (for the "high benefits" scenarios in the case of Post-consumer recycled content).

Table 21. Summary of the results of the application of the horizontal measures (namely: “Lightweight design”, “Durability”, “Recyclability” and “Post-consumer recycled content”) for all impact categories of the Environmental Footprint. For each column (i.e., impact category) a colour coded has been applied across the various horizontal measures, to differentiate between those having the highest benefits (in green) from those having the lowest benefits (in red).

Measure	Class of benefits	CC	ODP	HTOX_c	HTOX_nc	PM	IR	POF	AC	TEU	FEU	MEU	LU	ECOTOX	WU	**FRD**	**MRD**
Lightweight design	Low	-2.0%	-1.8%	-3.3%	-2.2%	-2.4%	-1.4%	-2.1%	-2.2%	-2.3%	-2.4%	-2.8%	-4.7%	-2.5%	-7.5%	-1.7%	-3.2%
	Medium	-4.0%	-3.6%	-6.5%	-4.4%	-4.9%	-2.9%	-4.2%	-4.3%	-4.6%	-4.9%	-5.7%	-9.4%	-5.1%	-15.0%	-3.4%	-6.4%
	High	-7.9%	-7.2%	-13.1%	-8.9%	-9.8%	-5.7%	-8.4%	-8.6%	-9.2%	-9.8%	-11.4%	-18.8%	-10.1%	-30.0%	-6.8%	-12.7%
Durability	Low	-10.7%	-8.3%	-13.3%	-8.5%	-12.3%	-7.3%	-10.8%	-10.2%	-10.2%	-6.9%	-8.8%	-17.7%	-8.0%	-9.4%	-9.3%	-15.7%
	Medium	-17.7%	-12.9%	-20.9%	-13.9%	-19.7%	-11.1%	-17.9%	-17.2%	-17.2%	-12.4%	-15.2%	-22.4%	-14.9%	-16.4%	-15.5%	-22.9%
	High	-22.9%	-16.4%	-26.6%	-17.9%	-25.2%	-14.0%	-23.2%	-22.3%	-22.5%	-16.5%	-20.0%	-26.1%	-19.9%	-21.6%	-20.1%	-28.4%
Recyclability	Low	-1.2%	-0.6%	-2.4%	-1.0%	-1.0%	-0.6%	-0.8%	-1.1%	-1.3%	-0.9%	-1.2%	-0.3%	-2.4%	-1.5%	-0.8%	-0.2%
	Medium	-1.8%	-1.1%	-3.1%	-1.5%	-1.6%	-1.0%	-1.3%	-1.7%	-1.9%	-1.5%	-2.1%	-0.4%	-3.8%	-3.0%	-1.4%	-0.2%
	High	-2.5%	-1.5%	-3.8%	-2.1%	-2.1%	-1.4%	-1.8%	-2.3%	-2.5%	-2.1%	-2.9%	-0.5%	-5.3%	-4.4%	-1.9%	-0.3%
Post-consumer recycled content	Low	-0.6%	-0.4%	-2.1%	-0.6%	-0.7%	-0.4%	-0.5%	-0.8%	-1.0%	-0.6%	-0.8%	-0.1%	-1.4%	-0.9%	-0.5%	-0.1%
	Medium	-1.1%	-0.8%	-2.8%	-1.1%	-1.2%	-0.7%	-0.9%	-1.4%	-1.6%	-1.2%	-1.6%	-0.2%	-2.7%	-2.3%	-1.1%	-0.2%
	High	-1.6%	-1.2%	-3.5%	-1.6%	-1.7%	-1.1%	-1.3%	-1.9%	-2.2%	-1.7%	-2.3%	-0.2%	-4.1%	-3.6%	-1.6%	-0.2%

Note: the results for each “benefits” scenario (i.e., “low benefits”, “medium benefits” and “high benefits”) and each impact category, have been calculated as the percentage variation with respect to the corresponding “base scenario” impacts.

Annex 14. Modelling information for the quantification of savings due to horizontal measures

Calculating the savings due to Lightweight Design

The savings related to Lightweight design affect the amount of material employed in the product. Since the environmental impact is calculated for a functional unit based on "1 piece" of the product, the benefit is expected to influence the entire life cycle apart from the direct resource use during the consumption phase (e.g., energy or water consumption).

The benefits will be calculated following the approach described in Annex 13 for the affected products. Specific benefits based on literature or default scenarios will be used.

Calculating the savings due to Durability Measures

In the case of Horizontal Measures for Durability, the following approach was employed to calculate the savings of improvement scenarios. The calculations of the savings related to the Durability measures affected the lifespan of the product and the improvement level was assumed as an expansion of such lifespan (Equation A14.1). 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 22.

$$Product\ impact_{i,HM,s} = CI_i * \sum_{j=0}^{n} \frac{Lifespan_i}{(1+benefit_{HM,i,j,s}) * Lifespan_i} * environmental\ impact_{i,j} \quad \text{[Eq. A14.1]}$$

Table 22. Summary of lifespan assumed for each representative product employed in the calculations of the savings due to Durability Measures.

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
Hair-related (combs, hairpins)	5	Own modelling assumptions based on literature information
Sandals	5	Own modelling assumptions based on literature information
Household plastic articles (incl. table- and kitchenware)	2.5	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

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 (Equation A14.2) summarizes the calculation approach.

$$Product\ impact_{i,HM,s} = CI_i * \left(environmental\ impact_{i,excl.end\ of\ life} + (1 - Recycling_{rate,i} * Benefit_{HM,s}) * environmental\ impact_{i,EoL\ non\ recycling} - (Recycling_{rate,i} * Benefit_{HM,s}) * environmental\ impact_{i,components\ manufacture}\right) \quad \text{[Eq. A14.2]}$$

Calculating the savings due to Post-Consumer Recycled content

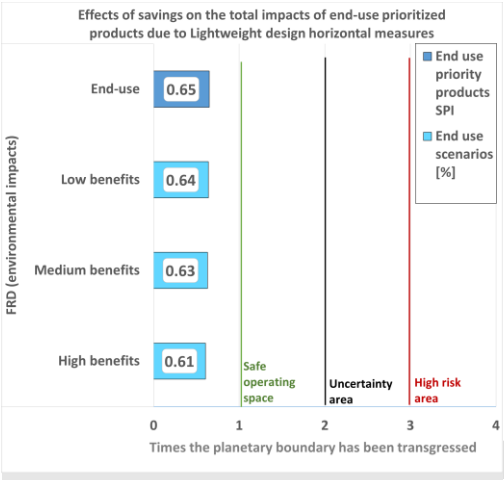
The quantification of the savings related to Post-Consumer Recycled content followed the same approach as for assessing Recyclability. In the Consumption Footprint model, benefits of recycling are considering only at the end of life and recycled materials are considering as input 0 (regarding the material). 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.

Annex 15. Quantification of savings due to horizontal measures – Additional results

In this annex, the results of the implementation of the horizontal measures for the impact categories not included in Annex 13 are provided.

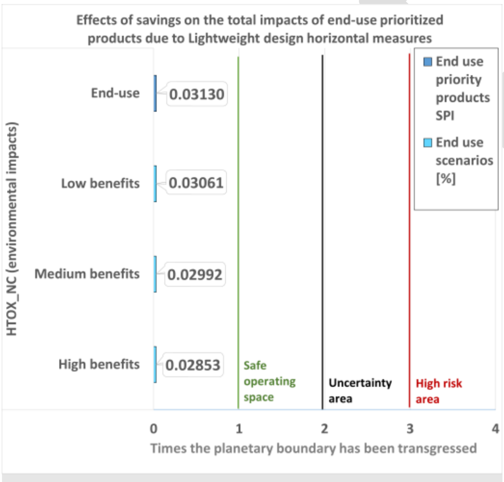
Figure 17. Savings associated to the Lightweight design horizontal measures compared to planetary boundaries.

Ozone depletion (ODP)

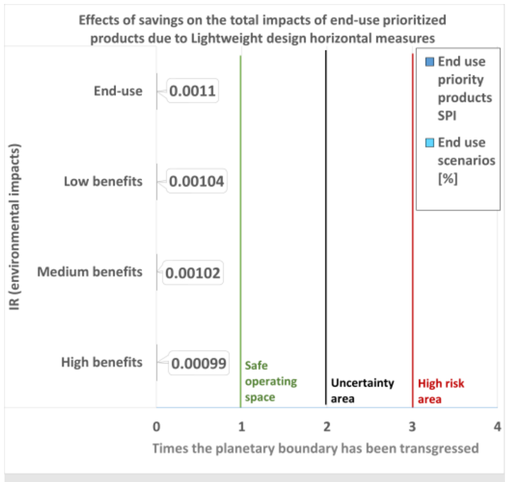


Human toxicity - cancer (HTOX_c)

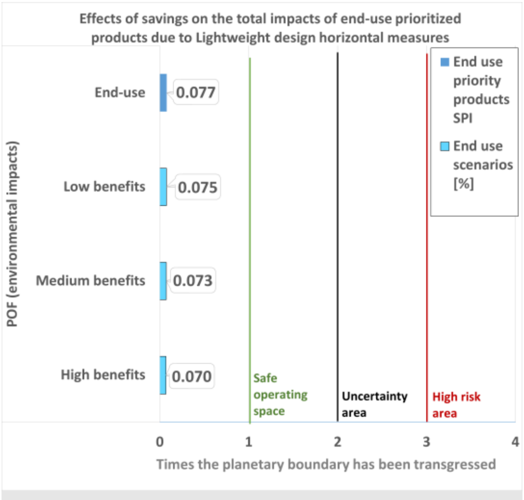
Human toxicity – non-cancer (HTOX_nc)



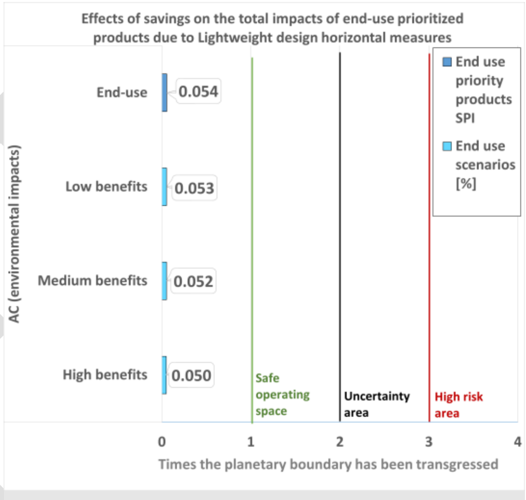
Ionising radiations (IR)



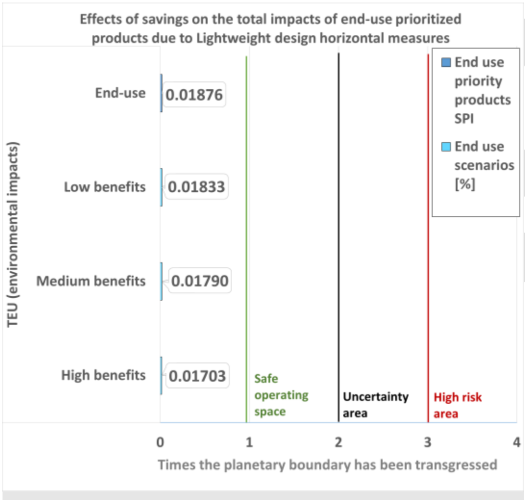
Photochemical Ozone Formation (POF)



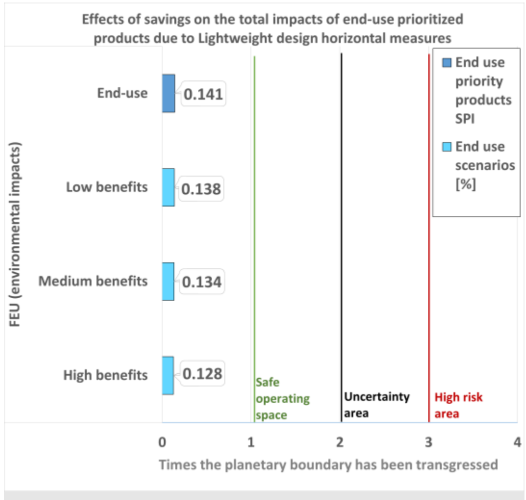
Acidification (AC)



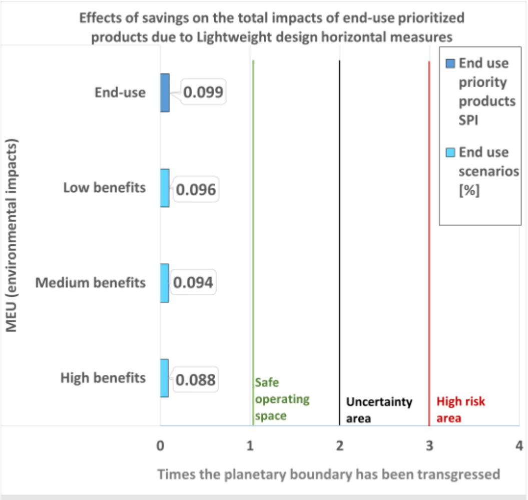
Eutrophication terrestrial (TEU)



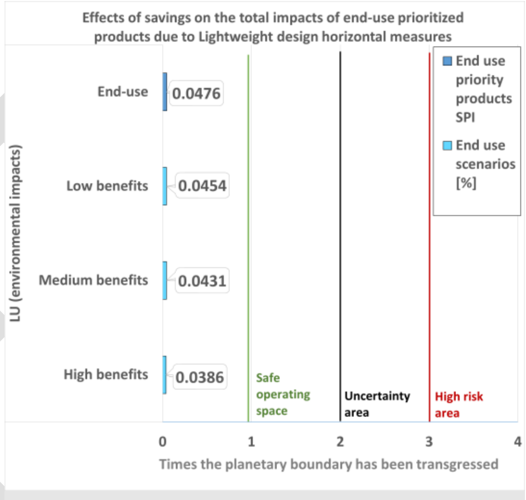
Eutrophication freshwater (FEU)



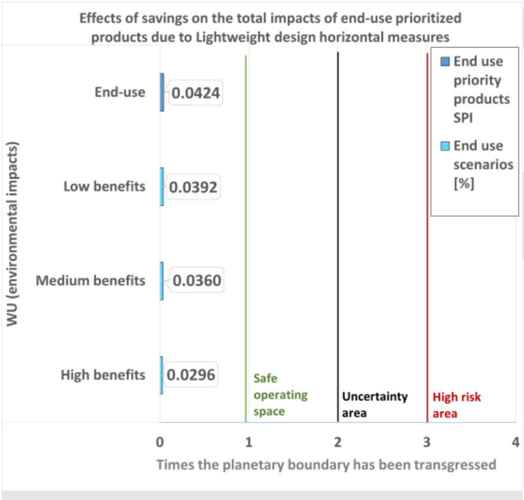
Eutrophication marine (MEU)



Land use (LU)



Water use (WU)



Resource use – minerals and metals (MRD)

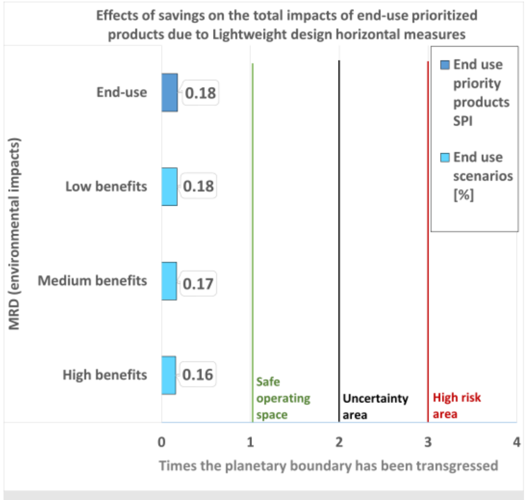
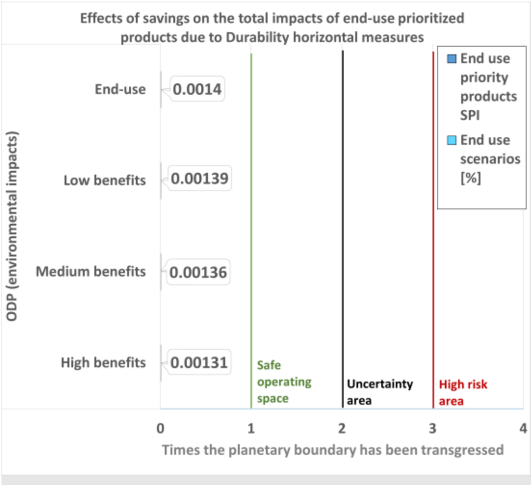
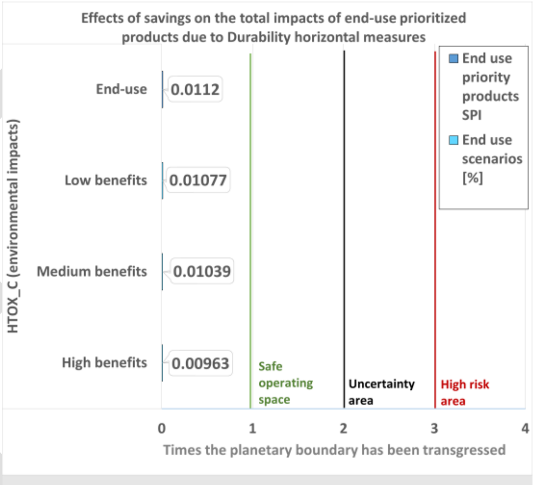


Figure 18. Savings associated to the Durability horizontal measures compared to planetary boundaries.

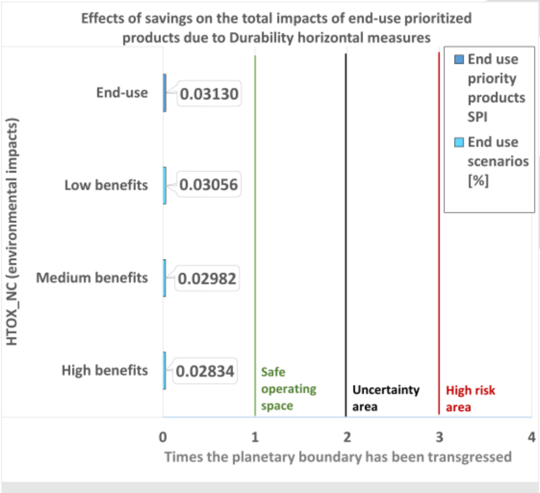
Ozone depletion (ODP)



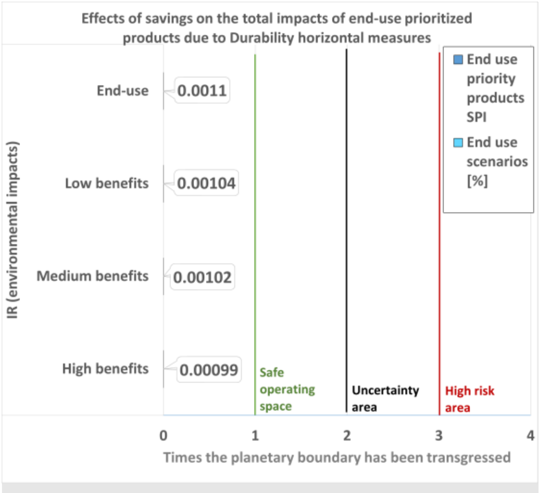
Human toxicity - cancer (HTOX_c)



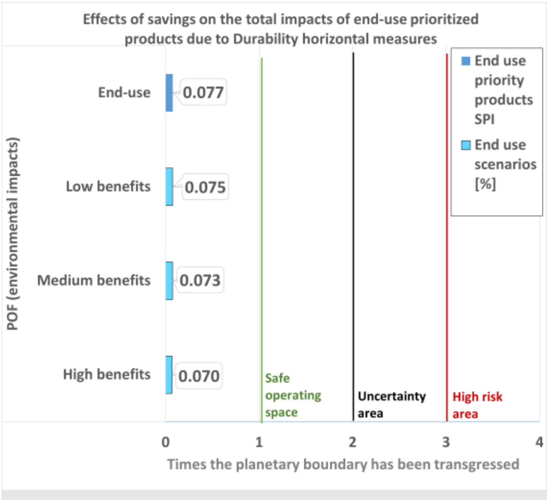
Human toxicity – non-cancer (HTOX_nc)



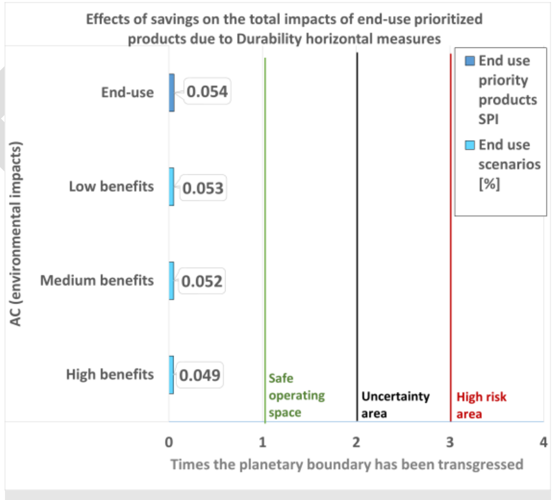
Ionising radiations (IR)



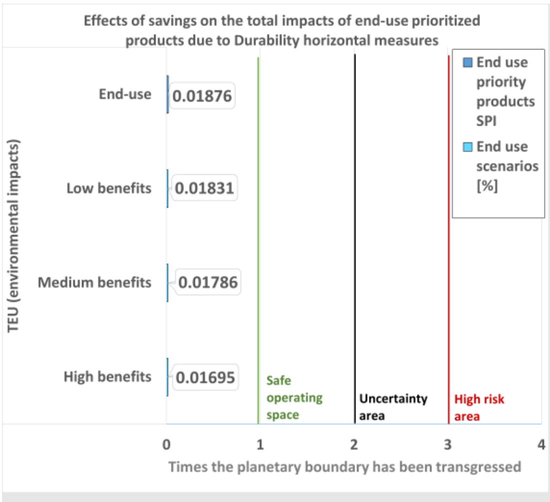
Photochemical Ozone Formation (POF)



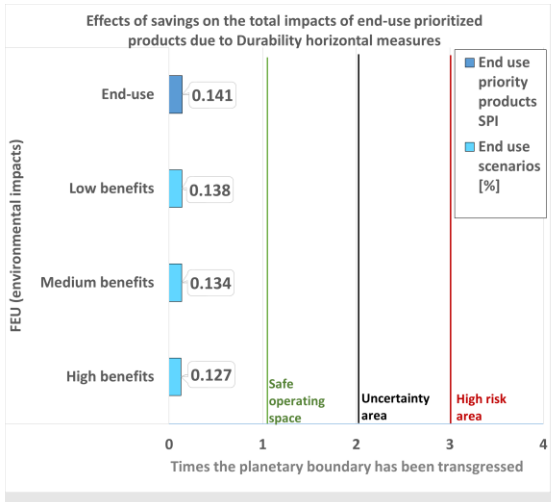
Acidification (AC)



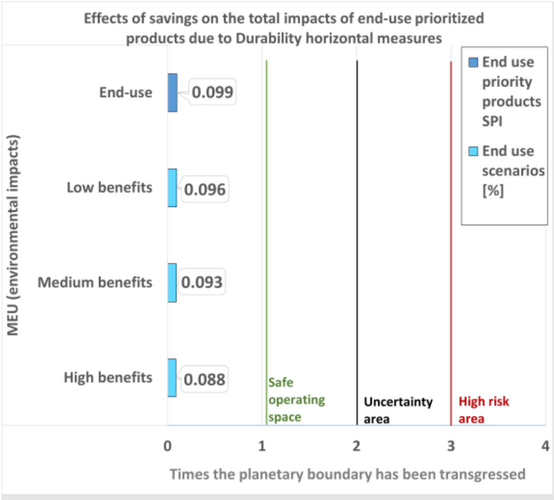
Eutrophication terrestrial (TEU)



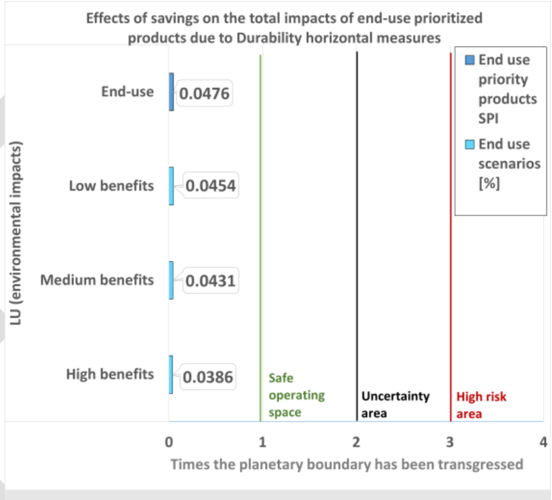
Eutrophication freshwater (FEU)



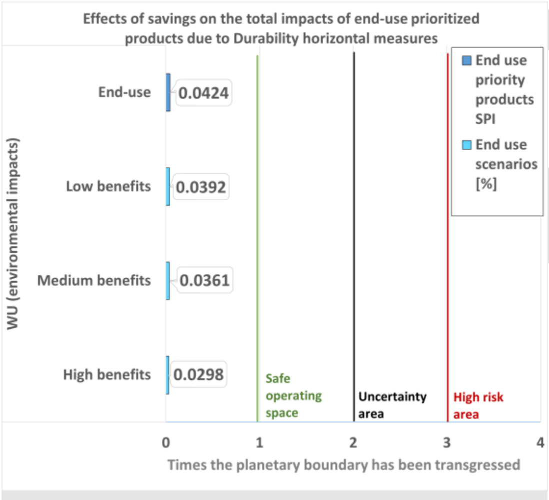
Eutrophication marine (MEU)



Land use (LU)



Water use (WU)



Resource use – minerals and metals (MRD)

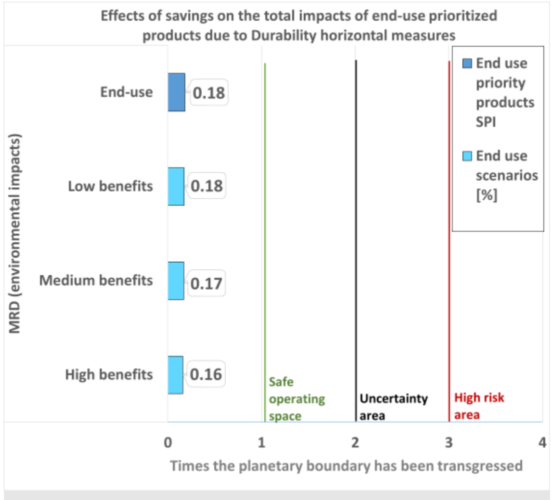
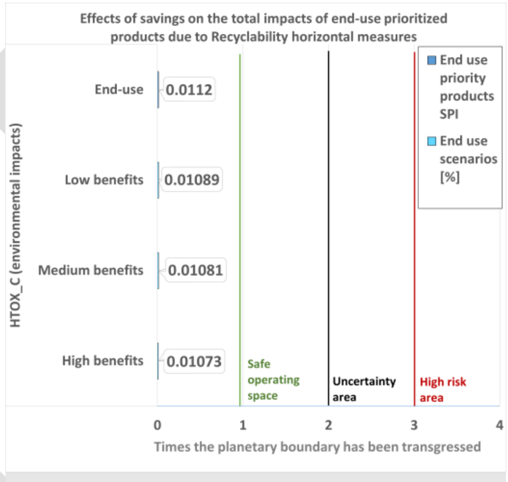


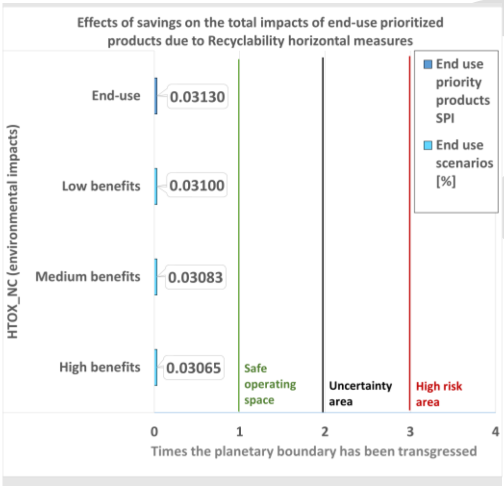
Figure 19. Savings associated to the Recyclability horizontal measures compared to planetary boundaries.

Ozone depletion (ODP)

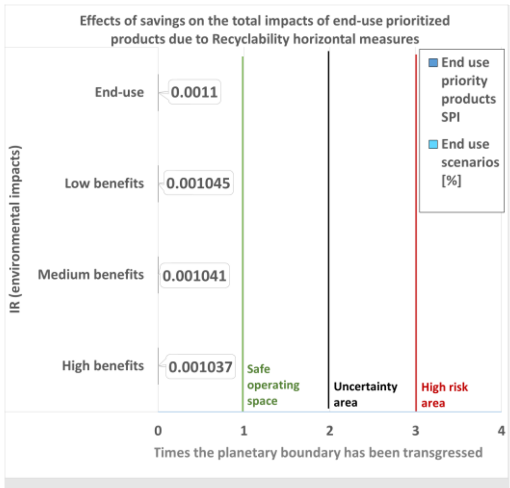
Human toxicity - cancer (HTOX_c)



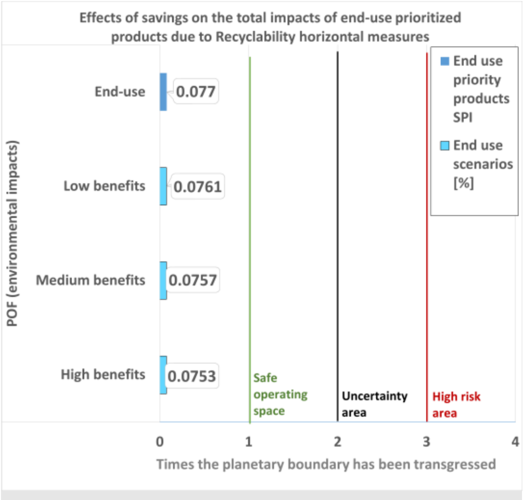
Human toxicity – non-cancer (HTOX_nc)



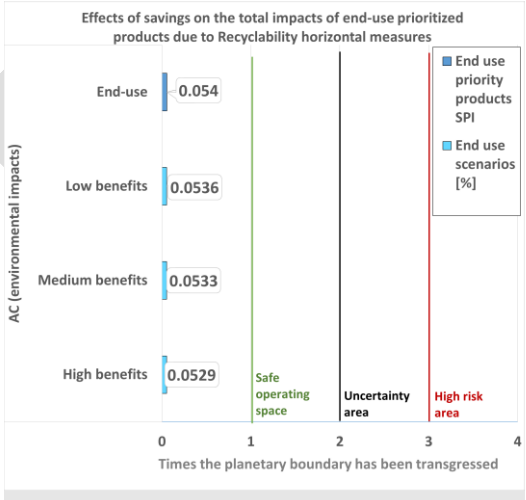
Ionising radiations (IR)



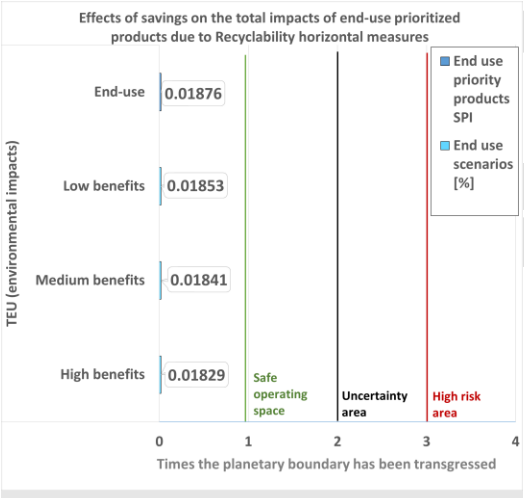
Photochemical Ozone Formation (POF)



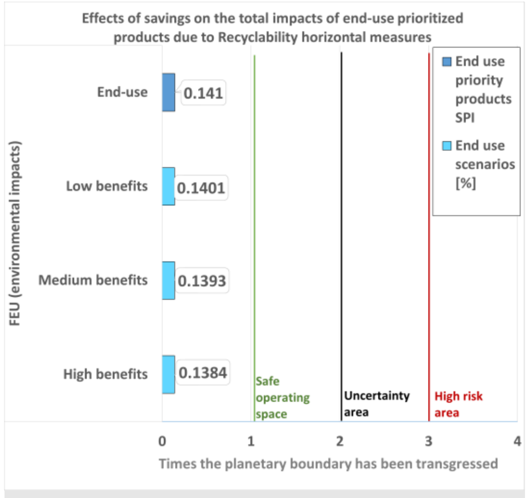
Acidification (AC)



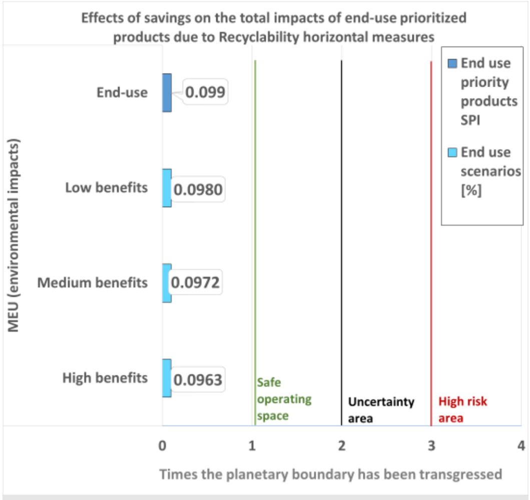
Eutrophication terrestrial (TEU)



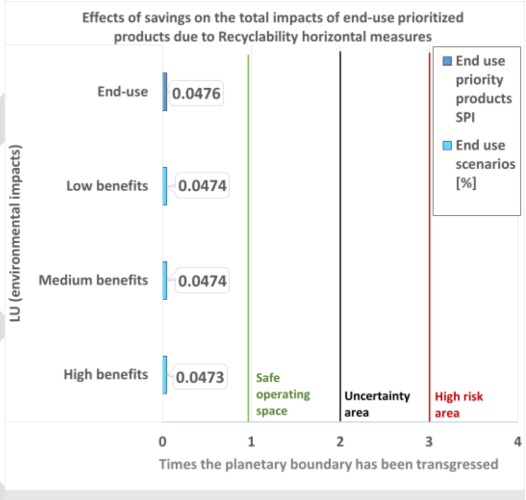
Eutrophication freshwater (FEU)



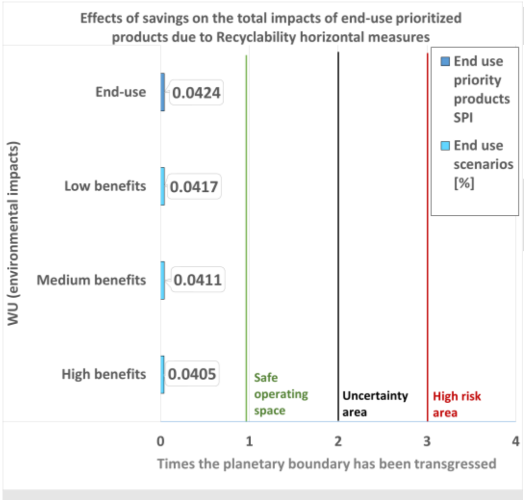
Eutrophication marine (MEU)



Land use (LU)



Water use (WU)



Resource use – minerals and metals (MRD)

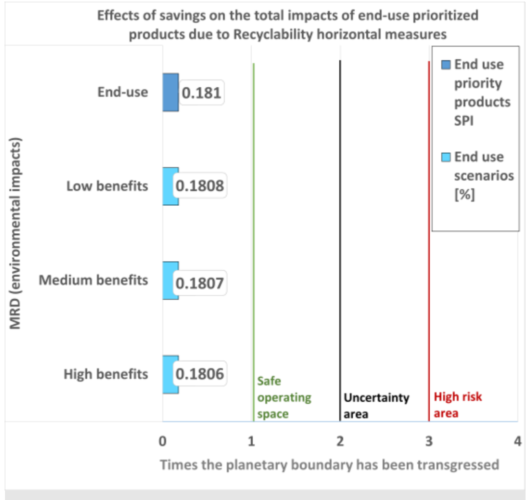
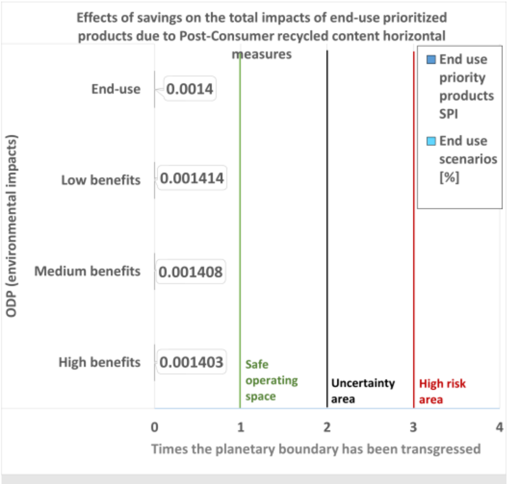
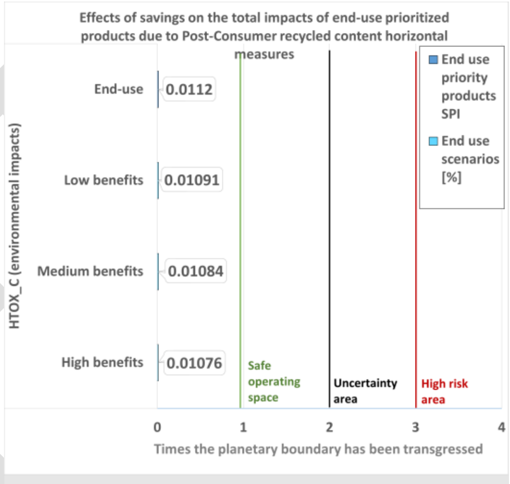


Figure 20. Savings associated to the Post-consumer recycled content horizontal measures compared to planetary boundaries.

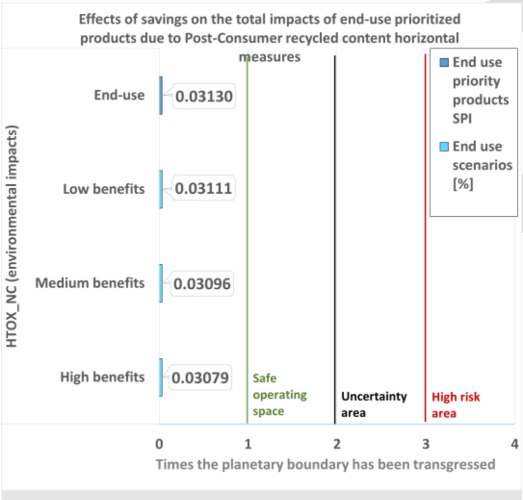
Ozone depletion (ODP)



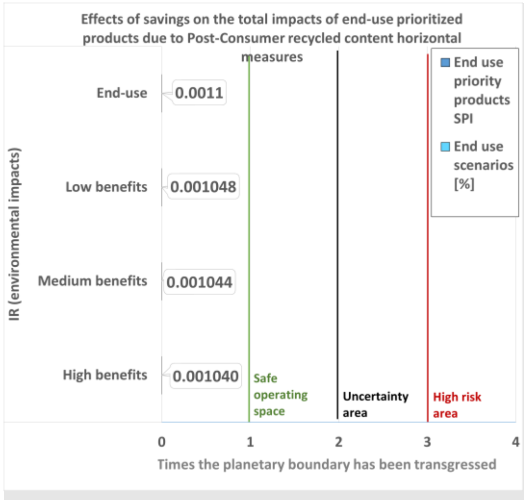
Human toxicity - cancer (HTOX_c)



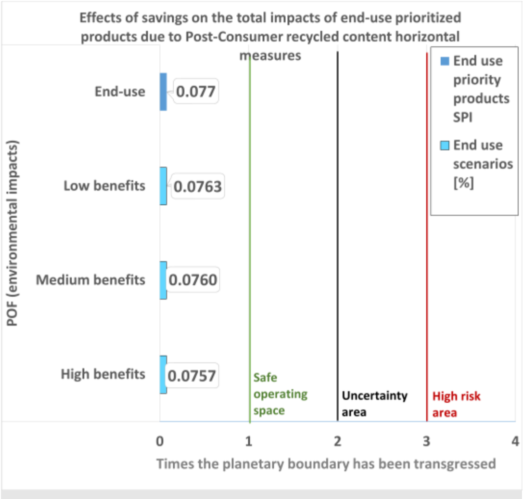
Human toxicity – non-cancer (HTOX_nc)



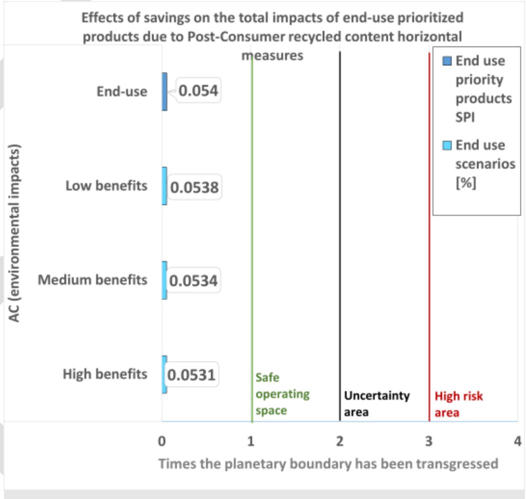
Ionising radiations (IR)



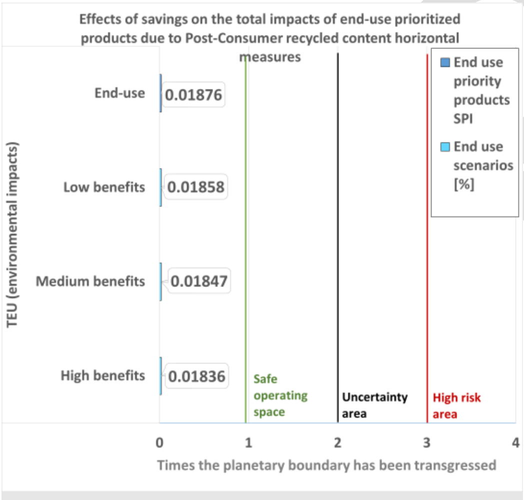
Photochemical Ozone Formation (POF)



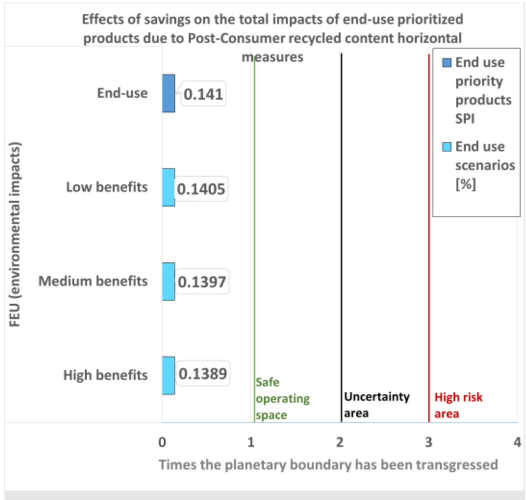
Acidification (AC)



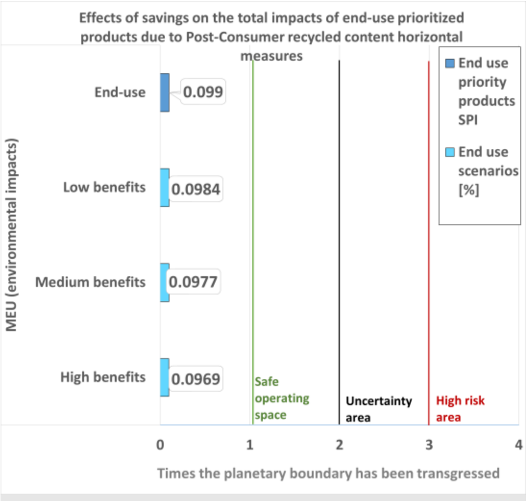
Eutrophication terrestrial (TEU)



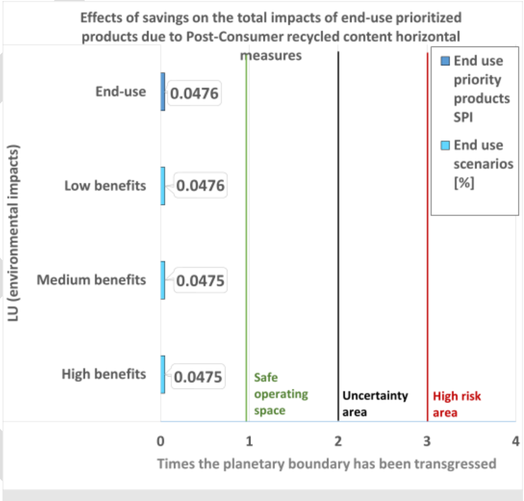
Eutrophication freshwater (FEU)



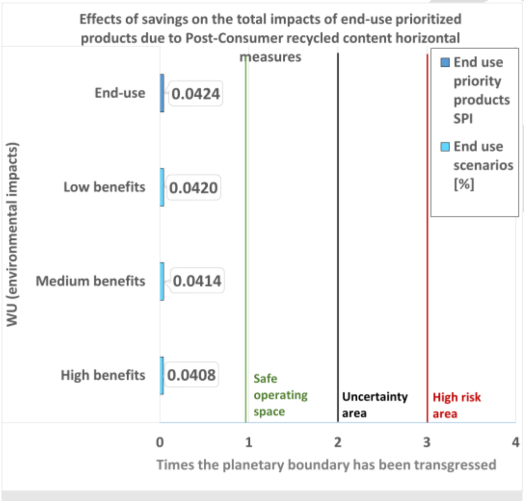
Eutrophication marine (MEU)



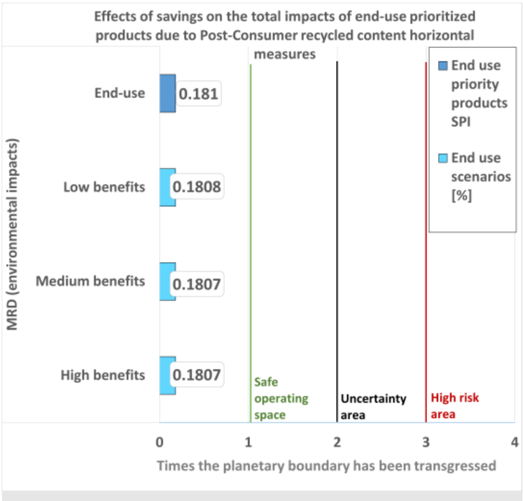
Land use (LU)



Water use (WU)



Resource use – minerals and metals (MRD)



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