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ORIGINAL PAPER

Evaluating Circular Economy Aspects in the EU Ecolabel Criteria

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Abstract
The EU Ecolabel encompasses a range of requirements that support a reduction in environmental impacts from a product's life cycle perspective and that can help the transition towards a circular economy. This study analyses the level of circularity of the EU Ecolabel by assessing how the product-group-specific criteria of the EU Ecolabel integrate circular economy requirements. Following the Material Circularity Indicator, the study identified key concepts related to the circular economy and classified them into three groups: extension of product service time, material circularity and resource efficiency. This classification system was then used to analyse existing requirements for different EU Ecolabel products. The EU Ecolabel product groups, namely, electronic equipment, hard coverings and textile products, were selected according to the priority areas of the circular economy promoted by the European Commission. The analysis indicates a trend towards enhancing the circular approach in setting the EU Ecolabel criteria despite a heterogeneous distribution of the circular economy requirements among the product groups analysed some of which are influenced by the nature of the product group itself. Some circular economy aspects such as durability, substance restrictions, energy efficiency and provision of information have been integrated into the EU Ecolabel criteria. Although the EU Ecolabel criteria include requirements on the use of recycled materials, strengthening requirements on by-product use and recyclability would enhance material circulation. More requirements on upgradability, reparability and multifunctionality would also enhance the service time of products. Finally, requirements for water and material efficiency would increase product resource efficiency.

Keywords Ecolabel · Circular economy · Green public procurement · Management · Marketing · Consumption

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Introduction

Ecolabels are key to foster environmentally friendly behaviour and purchasing choices among consumers. They provide clear, credible, and easily recognizable information on the environmental impact of products and services. By labelling products that meet specific environmental standards, consumers gain more awareness of issues such as resource conservation, pollution reduction, and sustainable practices [21]. This increased awareness helps consumers make more informed decisions and understand the benefits of choosing eco-friendly products. Ecolabels simplify the decision-making process for consumers in selecting products that align with their environmental values [35].

However, in a market flooded with various products and ecolabels, to prevent the risk of greenwashing, it is important for consumers to select products with ecolabels that are based on rigorous assessments and compliance with strict criteria, which are often developed by independent or governmental bodies [23]. This process builds trust and confidence among consumers, who regard these labels as reliable indicators of a product's environmental performance. In fact, being reassured that a product has been independently verified as environmentally friendly encourages consumers to prefer these products over non-labelled alternatives [6].

The European Ecolabel can play a significant role in fostering environmentally friendly behaviour. By covering a wide range of product categories and ensuring high environmental standards, the European Ecolabel can help consumers across the EU to make choices that contribute to sustainability. Its credibility and rigorous criteria provide consumers with confidence in their purchasing decisions, while its recognition can help to normalize and promote sustainable consumption practices throughout Europe [29].

The European Commission (EC) has also been proactive in promoting the circular economy through various policies and initiatives. Launched in 2015 and updated in 2020, the Circular Economy Action Plan outlines measures to make sustainable products the norm in the EU [50, 51]. It includes actions to reduce waste, enhance product durability and reparability, and promote recycling. In addition to recognising the crucial role that consumers and businesses play in driving the transition to a circular economy, a key objective of the Action Plan is the transparency and availability of information on product sustainability. Ecolabels, such as the EU Ecolabel, are seen as essential tools for providing this information, helping consumers identify products that meet high environmental standards, reducing environmental impacts and promoting resource efficiency during the consumption phase [43].

Transitioning to a resource-efficient circular economy requires better practices in the design, production, and consumption of products [37]. Both private and public purchasers play a critical role in driving this change through market influence. However, this shift requires consumers to have access to information and recommendations, as well as access to products with superior environmental performance [61]. Additionally, options for more efficient consumption modes need to be made available.

The EU Ecolabel, a well-established Type I ecolabel, is valued by consumers in the EU countries. It is crucial to understand how the EU Ecolabel influences consumption patterns and product design towards a circular economy and to explore ways to further strengthen its impact [39].

The circular economy describes an economic system where natural resources are used efficiently and their value is maintained within the economy for as long as possible. This

approach emphasizes two key aspects: the service life of products and the circulation of materials [26]. To achieve this transformation, citizens and authorities are need to be provided with the right incentives, such as appropriate pricing signals and comprehensive environmental information, so that they can then choose products and services with lower environmental impacts [25]. The EU Ecolabel is specifically designed to guide incremental progress toward sustainability highlighting the most environmentally friendly options available in the market. However, as suggested by [28] its level of integration with the circular economy has still not been investigated sufficiently.

This study thus aims to analyse how the product-group-specific criteria of the EU Ecolabel integrate circularity and to present ideas on how to further develop the criteria so that they contribute to the circular economy. The criteria documents for awarding the EU Ecolabel to specific product groups were, thus, analysed to identify requirements that support the circular economy by extending product service life and enhancing material circulation.

The structure of this paper is as follows: Section 2 provides an overview of the literature on ecolabelling schemes and outlines our research questions. Section 3 describes the methodology used to carry out the analysis and the results are reported in Section 4. Section 5 critically analyse the key findings, comparing them with other significant papers in the literature. Finally, the paper concludes with a discussion on the study's contributions and limitations.

Literature Review and Research Question

Scholars and technicians have mainly concentrated on how environmental labels can impact and steer consumers' purchasing decisions towards more sustainable products. The body of academic research is abundant with studies exploring these topics from various perspectives and employing diverse methodologies, even though, as proved by the EU (2923), only 38% of EU citizens recognize the EU Ecolabel.

According to [9] consumers' trust in government and environmental NGOs to provide credible environmental information encourages consumers' use of ecolabels sponsored by these entities, and consumers do not differentiate between certified and uncertified ecolabels if they trust the product/brand. Adopting ecolabels based on scientific and robust methodologies is crucial to ensuring reliability for consumers. Nevertheless, the large number and variety of existing ecolabels have led to consumer confusion in recent years. In fact, [31] highlight that some ecolabels apply different awarding formats and criteria in combinations and hybrid forms that are not recognized by the ISO or any other commonly observed classification approach. Although [10] claimed that the EU Ecolabel criteria are too complex, it is important to maintain challenging and robust criteria to ensure high environmental quality among products bearing the EU Ecolabel. In fact, in 2020, the Commission carried out a study of more than 150 environmental claims for a wide range of products and found that more than 53% of them were too "*vague*, *misleading or unfounded*", and that 40% were not supported by adequate technical and scientific evidence.

Preziosi et al. 38 highlighted how third-party certified ecolabels, i.e., the EU Ecolabel ensure hotel compliance with specific environmental performance criteria and offer reliable communication to their guests. The authors confirmed the positive relationship between

the implementation of green practices and increased market awareness and loyalty towards green hotels.

Surveys and experimental studies have mainly highlighted the positive effects of ecolabels on respondents' choices [19]. [53] examined the effectiveness of ecolabels in informing sustainable consumption using eye tracking glasses. However, consumer revealed preferences for ecolabelled products were much lower than their stated preferences, highlighting that ecolabels receive little attention and awareness from consumers.

As reported by [46] the EU Ecolabel integrates the life cycle thinking perspective within its criteria, thus fostering the adoption of one of the most important circular economy principles. In fact, as shown by [7] green supply chain management plays a pivotal role in improving organisations' performance.

An initial attempt to integrate life cycle thinking within the EU Ecolabel criteria was made by [2] although it was limited to the carbon footprint. The importance of also using even the life cycle perspective in the definition of Digital Product Passport was also suggest by [57]. The authors identify life cycle assessment (LCA) as the consistent tool that should be used to communicate environmental impact. Thus, the same methodology might be applied to identify the ecolabel criteria to support circularity, transparency, and traceability in the circular economy.

The strong connection between the EU Ecolabel and the LCA was also indirectly shown by [4] who used EU Ecolabel background reports as data for the life cycle inventory.

Despite the attention given to sustainability labelling [63], the direct integration of the circular economy within ecolabel criteria has not been investigated in depth. By investigating the level of ecotoxicity due to chemicals included in products bearing EU Ecolabel, [49] showed that EU Ecolabel methods are relevant for ranking chemicals. [3] focused on the indirect evaluation of the "embodied pollution" of the natural stone working chain claiming the inadequacy of the EU Ecolabel criteria to identify the environmental impact of the transport of material between the different workstations of the same company. Even without specifically analysing the criteria, [20] recognised the crucial role of the EU Ecolabel criteria in prompting EU product energy efficiency policies. [54] assessed the presence of longevity criteria in Blue Angel, a German ecolabel, and found that, while longevity criteria are present in half of the Blue Angel criteria sets, but in most cases were not very comprehensive.

Focusing specifically on material efficiency in the life cycle of products, [5] analysed the state of implementation of material efficiency requirements for products as set out in existing EU Ecolabel criteria. The authors revealed a broad range of material efficiency aspects, some of which are influenced by the nature of the product group itself. Criteria such as design for durability, recyclability, availability of spare parts, reversible disassembly and provision of information were broadly integrated into the EU Ecolabel criteria. However, they felt that additional material efficiency requirements such as the minimum lifetime of products should be looked into further.

Nevertheless, as mentioned by [55] material efficiency is just one of the circular economy principles. In fact, a circular economy is underpinned by several core principles that collectively redefine how to approach the life cycle of products and services [41]. Products and processes should be designed to prevent waste and pollution from being created in the first place [34]. This involves considering the entire lifecycle of a product, from the extraction of raw materials to the end of its useful life. The value of products and materials is maintained for as long as possible through strategies such as reuse, repair, refurbishment,

and recycling [8]. This principle aims to keep materials circulating within the economy, reducing the need for virgin resources. This includes ensuring that products are durable, easy to repair, upgradeable, and multifunctional. Products are designed for recyclability, ensuring that materials can be effectively reprocessed at the end of their life cycle, while efficient use of resources throughout the products' lifecycle is emphasized.

From a circular perspective, the EU Ecolabel does not explicitly regulate "remanufacturing" as a business model. Instead, it operationalises circularity through product-level criteria that make remanufacturing, refurbishment, and reuse technically feasible. Requirements related to durability, reparability, disassembly, and availability of spare parts create the technical conditions under which products can remain in use longer or re-enter production cycles.

By incorporating these criteria ecolabels can promote sustainable production and consumption patterns helping consumers identify products that have a lower environmental impact and are designed for longevity and recyclability [45].

Regarding social criteria, their role is present but more constrained and uneven across product groups. The EU Ecolabel incorporates social aspects primarily through baseline requirements related to health, safety, and, in some sectors, labour conditions in supply chains. A clear example can be found in the textile product group, where criteria include references to working conditions along the supply chain and restrictions on hazardous substances that affect both workers and end users.

For businesses, adherence to ecolabel criteria can drive innovation, improve brand reputation, and open up new market opportunities [22]. This then highlights a commitment to sustainability, which is increasingly important to consumers, investors, and regulators. Ecolabels can also encourage industry-wide shifts towards more sustainable practices, as companies strive to meet these standards to remain competitive [33].

Ecolabels play a crucial role in the transition to a circular economy, where products and materials are kept in use, waste is designed out, and natural systems are regenerated. This alignment with circular economy principles ensures that ecolabels contribute to long-term sustainability and resource conservation [40].

Considering these aspects and that the EU Ecolabel is considered one of the tools to promote circular economy, we formulated our research question as follows:

RQ: What is the level of circularity of the product-group-specific environmental criteria of the EU Ecolabel?

Materials and Methods

To analyse to what extent circular economy aspects are recognised by the EU Ecolabel and how this could be potentially improved, a clearer understanding is needed of what is meant by the term "circular economy", and then to use this definition to screen against a defined number of EU Ecolabel product groups.

Definition and Classification of Circular Economy Aspects

The analysis of circular economy aspects entails addressing a broad spectrum of concepts. An economy is circular where natural resources are efficiently used and where their value is kept in the economy for as long as possible. Although it is a relatively new term in policy making, from the perspective of material flows, it is a culmination of various different schools of thought. The interdisciplinary nature of the circular economy adds another layer of complexity in achieving a common definition. It intersects with multiple fields, including environmental science, economics, engineering, and social sciences. Each of these disciplines has its own perspectives and terminologies, leading to a fragmented understanding of what actually constitutes a circular economy. Furthermore, the concept of the circular economy is still evolving, with new theories, models, and practices continuously emerging. This ongoing evolution makes it difficult to settle on a definitive definition [42].

The lack of a common framework or set of standards for measuring circularity also contributes to this difficulty. Without standardized metrics, it is challenging to objectively assess and compare circular economy initiatives. This lack of common metrics means that different organizations and countries may develop their own definitions and criteria, indicators, methodologies and metrics, leading to inconsistencies and difficulties in comparing results [32].

A large body of analytical work that fed into the EC's analysis, as well as broader development and awareness-raising work on the circular economy, has been led and carried out by the UK-based, non-for-profit Ellen MacArthur Foundation [13], whose comprehensive definition emphasise the circular economy as a systemic approach. Its focus is essentially on three inherent attributes: the service life of products, material circulation and resource efficiency. In terms of measurement, the Ellen MacArthur Foundation has developed several tools and frameworks to help organizations assess their level of circularity. One of the key measurement tools is the Material Circularity Indicator (MCI) [14].

The MCI assesses how restorative the material flows of a product are within the circular economy framework. The MCI generates a score that reflects the circularity of a product or material. A higher MCI indicates a greater degree of circularity, meaning that the product is better designed so that it keeps materials in use, reduces waste, and minimizes the need for mining raw materials. While covering the different life cycle stages, these indicators provide a quantifiable measure of how well a product or system adheres to circular economy principles (see Table 1).

These indicators have been developed for use in product design decisions, and may also be used for internal reporting, procurement decisions and the rating of companies. In this study, we considered them as a useful starting point for assessing "product circularity" (or "restorativity") in ecolabelling criteria, as suggested by Suikkanen and Nissinen 56.

Products Included in the Analysis

The development of criteria under the EU Ecolabel follows a structured, science-based and multi-stakeholder process designed to ensure both environmental relevance and market applicability. It begins with a preparatory phase in which the product group is analysed from a life-cycle perspective. The aim is to focus criteria on the stages where improvements can generate the greatest environmental benefits, while also considering technical feasibility and market conditions. Based on this analysis, draft criteria are developed, then discussed

Table 1 Product circularity indicators

Life Cycle Stage	Indicators for Circularity
Product Design	No explicit indicators for product design. The Material Circularity Indicator stemming from each of the life cycle stages can be used to design and redesign products.
Production Process	Input from reused feedstock and recycled feedstock, taking into consideration recycling efficiency.
Consumption	Product use duration (reuse, redistribution, repair, maintain). Product use intensity (e.g., shared consumption business models).
End of Life	Amount of material collected for recycling. Amount of material going to landfill and energy recovery. Amount of material or components going for reuse.

extensively with stakeholders through formal consultations. This iterative dialogue is essential to balance environmental ambition with economic and technical feasibility, and it often leads to several revisions of the criteria.

According to the EU Ecolabel website, as of March 2024, the EU Ecolabel applied to 25 different product groups with 2,743 valid licences covering 95,758 products and services available on the market.

However, according to the EC 11, a number of sectors face specific challenges in the context of the circular economy, because of the specificities of their products or value-chains, their environmental footprint or their dependency on material from outside Europe. These sectors need to be addressed to ensure that the interactions between the various phases of the cycle are fully considered throughout the value chain. More recently, in the new Circular Economy Action Plan (EC, 12, the EC claimed that the sustainability challenge posed by key value chains requires urgent, comprehensive and coordinated actions. In particular, the priority areas should form an integral part of the sustainable product policy framework outlined by the EC in its main tools such as the EU Ecolabel.

We, thus, merged the priority areas of the circular economy identified by the EC with the categories covered by the EU Ecolabel to select the product groups to be analysed. According to the EC 12, there are several priority areas: electronics and ICT equipment, batteries and vehicles, packaging, plastics, textiles, construction and demolition, food, water and nutrients. Of these categories, three are also covered by the EU Ecolabel.

The area of electronics and ICT equipment is covered by the EU Ecolabel for electronic equipment, which awards eco-friendly electronic devices such as televisions, computer monitors and signage displays. The EU Ecolabel guarantees that electronic displays are energy efficient, repairable and contain a limited quantity of hazardous substances. In addition, the criteria require a minimum of recycled content as well as easy product dismantling to ensure that parts can be recovered and recycled (EU, 16.

With respect to construction and demolition, the products included in the EU Ecolabel coverings group include high-quality floors, roofs, tiles, vertical surfaces and other covering products for private and professional use with a reduced environmental impact and low health risks for consumers and workers. The EU Ecolabel for hard covering products

includes certified eco-friendly and sustainable alternative products to conventional hard covering products such as tiles, slabs, panels, vanity tops and kitchen worktops.

The EU Ecolabel guarantees that these hard covering products comply with strict criteria for reduced impacts caused by the quarrying of raw materials, limited emissions of pollutants, and the restricted use of hazardous substances. Manufacturers are also encouraged to use renewable energy and to reuse/recycle their production waste (EU, 17.

Finally, the EU Ecolabel for textile products covers various groups such as textile clothing and accessories, interior textiles, fibres, yarn, fabric and knitted panels. The EU Ecolabel for textile products ensures a more sustainable fibre production, a less polluting production process, strict restrictions on the use of hazardous substances, and a long-lasting final product (EU, 15.

We did not take into account the remaining priority sectors because they are not covered by the EU Ecolabel. In particular, plastic and packaging are not dealt separately within the categories of the Ecolabel regulated groups, but are often specifically affected by individual criteria within the different product categories. Batteries, vehicles, food, water and nutrients are not included among the categories currently in force.

Results

In accordance with the approach presented in the methodology, the circular economy requirements that products must fulfil to be awarded the EU Ecolabel were categorised and cross-checked with the EU Ecolabel product groups criteria.

Electronic Equipment

The Ecolabel criteria regarding electronic displays are set out in Commission Decision 2020/1804, which will be valid until 2028. As of March 2026, 1 license and 3 products have been certified.

The criteria for awarding the EU Ecolabel to electronic displays are divided into six categories: energy consumption, restricted substances, reparability and commercial guarantee, end-of-life management, corporate social responsibility and information criteria.

With respect to energy consumption, these criteria ensure direct energy savings, but also durability through power management requirements which reduce the heat generated by the device and consequently the stress on the components.

The use of classified hazardous substances, with a focus on plasticisers and flame retardants, is restricted. The criteria also include activities to reduce supply chain fluorinated GHG emissions.

The requirements also include design criteria for repairs and upgrades. Spares must be easily available and replaceable by the end user, using tools normally available on the market. The availability of commercial guarantees is also mandatory.

Material selection and information to improve recyclability are part of the end-of-life management criteria. Plastics must be recyclable which means that no paints, glues and coatings can be used. Waste managers should have access to information on the disposal and recovery of plastic materials. The content of recycled materials is also subject to regulation. In fact, the product should be made of at least 10% recycled plastic.

Finally, information should provide advice on the environmental use and disposal of products and on how to prolong the lifetime of the product. Optional labels with text boxes can be added to the product reporting information on energy efficiency, restriction of hazardous substances, repairability, recyclability and recycled content.

In summary, 8 out of 13 circular economy requirements are present in the EU Ecolabel criteria for electronic equipment. While the extension of product service time is ensured by the above criteria, material circularity and resource efficiency criteria need to be defined more clearly. There are currently no requirements in terms of the management of the waste generated in the production process, including by-product use. Lastly, despite the strong focus on energy efficiency, the criteria lack performance standards for water and material efficiency (Table 2).

Hard Covering Products

The criteria currently in force to obtain certification are contained in the European Commission Decision 2021/476 and will be valid until 2028. As of March 2026, 9 licenses and 5,089 products have been certified. Given the heterogeneity of the category, the legislation divides the criteria into two distinct types: (i) criteria common to all hard roofing products; (ii) criteria based on the type of material, i.e., natural stone, agglomerated stone based on resin binders, ceramic or fired clay and precast concrete or compressed earth based on hydraulic binders or alternative cements.

The common criteria include requirements for industrial and construction mineral extraction, restricted substances, VOC emissions, fitness for use, user information and environmental management systems.

The second section of criteria differs from the first by the use of a scoring system for each type of material. A maximum number of points is attributed to each criterion, and a minimum score is required to obtain certification, given by the sum of points obtained for each criterion.

For natural stone products, the EU Ecolabel sets requirements for energy consumption and material efficiency at quarries and a quarry landscape impact ratio. At the transformation plant, the criteria cover energy consumption, water and wastewater management, reuse of process waste and transportation distance.

Energy consumption, recycled/secondary material content, resin binder content and reuse of process waste are the criteria set for agglomerated stone products. For ceramic and fired clay products, fuel consumption for drying and firing, CO_2 emissions, process water consumption, emissions of dust, HF, NOx and SOx to air, wastewater management and reuse of process waste are the requirements of this category. For precast concrete products or compressed earth blocks based on hydraulic binders or alternative cements, clinker factors, CO_2 emissions, dust emissions, NOx and SOx to air, recovery and responsible sourcing of raw materials, energy consumption and environmentally innovative product designs have been identified.

In summary, 11 out of 13 circular economy requirements are present in the EU Ecolabel criteria for hard coverings. Contrary to the electronic equipment criteria, in this case the extension of the product service time is less covered, while material circularity and resource efficiency criteria provide almost a full coverage for all circular economy requirements. In fact, the only missing requirement is related to recyclability, although there are common

Table 2 Requirements relevant to circular economy in the EU Ecolabel criteria for electronic equipment

Criteria for electronic equipment	Extension of product service time				Material circularity						Resource efficiency		
	Durability	Reparability	Upgradability	Multi functionality	Recyclability	Non-toxic cycles	Recycled content	Production recycling	By-product utilisation	End of life	Water	Energy	Material
Energy consumption	X											X	
Restricted substances						X							
Reparability and commercial guarantee	X	X	X										
End-of-life management					X		X			X			
Corporate social responsibility													
Information criteria	X	X			X	X	X			X		X	

criteria for end-of-life management. However, as regards the extension of product service time, the EU Ecolabel criteria do not only cover recyclability and upgradability, which seems understandable for a product such as hard coverings (Table 3).

Textile Products

Current criteria relating to textile products are set out by Commission Decision 2017/1392 and are valid until the end of 2025. As of March 2026, 106 licenses and 11,528 products have been certified. Due to the wide range of materials and substances that fall within this category, the criteria are divided into six sections, each with its own reference sub-criteria: textile fibres, components and accessories, chemicals and processes, fitness for use, corporate social responsibility and supporting information.

In terms of textile fibres, components and accessories, the EU Ecolabel sets criteria for organic and recycled content, wastewater treatment, substance restrictions, air emissions and the use of by-products. In addition to the classic restricted substance list, for chemicals and processes the EU Ecolabel also requires performance standards for energy efficiency and treatment of emissions to air and water. Dimensional changes during washing and drying, colour fastness to washing, perspiration, wet rubbing, dry rubbing and light, wash resistance and absorbency of cleaning products, fabric resistance to pilling and abrasion and durability of function are the requirements for the section on fitness for use. Information on the Ecolabel may contain text boxes with claims such as “more sustainable fibre production”, “less polluting production processes”, “restrictions on hazardous substances” or “tested for durability”.

In summary, 5 out of 13 circular economy requirements are present in the EU Ecolabel criteria for textile products. Only the durability requirement is considered for the extension of the product service time. There is no mention of recyclability, use of by-product and also end-of-life management nor of water consumption and material efficiency despite the massive use of water in the textile sector (Table 4).

Discussion

This study has assessed the types of requirements that have been set with the EU Ecolabel criteria that are in line with the circular economy. Three product categories have been analysed: electronic equipment, hard coverings and textile products, and we have crosschecked requirements for extending the service life of products, enhancing material circulation and boosting resource efficiency.

The circular economy is very much about ensuring that materials are kept in circulation for as long as possible [22]. By setting requirements on the use of recycled feedstock and components, the EU Ecolabel can play a role in steering towards this direction. Current EU Ecolabel criteria include requirements on the use of recycled materials in product compositions as well as in packaging. In addition to existing requirements on the use of secondary raw materials and recycling, strengthened requirements on by-product use in manufacturing and the reuse of components would enhance material circulation. In contrast, remanufacturing is not addressed and requirements relating to dismantling are only found for some product groups. The requirements for the separability of materials can be met, but it is difficult to

Table 3 Requirements relevant to circular economy in the EU Ecolabel criteria for hard coverings

Criteria for hard coverings	Extension of product service time				Material circularity						Resource efficiency		
	Durability	Reparability	Upgradability	Multi functionality	Recyclability	Non-toxic cycles	Recycled content	Production recycling	By-product utilisation	End of life	Water	Energy	Material
Common criteria	X					X				X			
Natural stone								X	X		X	X	X
Agglomerated stone						X	X	X	X			X	
Ceramic and fired clay								X			X	X	
Precast concrete				X			X	X	X			X	

Table 4 Requirements relevant to circular economy in the EU Ecolabel criteria for textile products

Criteria for textile products	Extension of product service time				Material circularity						Resource efficiency		
	Durability	Reparability	Upgradability	Multi functionality	Recyclability	Non-toxic cycles	Recycled content	Production recycling	By-product utilisation	End of life	Water	Energy	Material
Textile fibres						X	X		X				
Components and accessories						X	X		X				
Chemicals and processes						X						X	
Fitness for use	X												
Corporate Social Responsibility													
Supporting information	X					X							

determine which chemicals remain after the recycling process. Given that ecolabelling aims to reduce the dangers of hazardous chemicals, ecolabelled products should in theory lead to recycled materials with lower quantities of hazardous substances [33].

The EU Ecolabel provides good quality products through durability, quality and warranty requirements. In addition to durability requirements, a product's service time can be extended through repair and upgrading. Thus, more requirements could be set for these two areas, as well as for multifunctionality. In fact, although the concept of multifunctionality is not frequently discussed in the literature of the circular economy, we believe that multifunctional products can play a significant role in increasing product use. By setting criteria for remanufacturing, the EU Ecolabel may extend the product service time.

The analysis indicates a trend towards enhancing the circular approach in setting the EU Ecolabel criteria. In fact, the older publication time of the criteria, the fewer the circular economy requirements. Five requirements for textile products were released in 2014, eight for electronic equipment in 2020 and eleven in 2021 for hard coverings. This may indicate the increased attention given by the EC on including circular requirements within the ecolabel criteria.

When setting out criteria in the future, we believe that the EU Ecolabel should consider how additional circular economy requirements could fit into the ecolabelling criteria. These could include setting requirements for incoming chemicals which would increase the possibility of reuse and recycling and also better communication of the circularity of product life cycles. The EU Ecolabel should focus on requirements for renewable, recycled and sustainable raw materials, strict chemical requirements, reduced use of resources and energy, quality and lifetime requirements as well as requirements for product design, dismantling and reparability and optimum waste handling.

Most labels adopt the Relevance (R), Potential (P), and Steerability (S) approach in defining the product-specific requirements, where relevance identifies the extent of the environmental problem for the product group; potential determines what can be done about the problem; and steerability identifies how much influence the ecolabel can have. By integrating the principles of the "circular approach" with the RPS assessment process, the EU Ecolabel can strive for continuous improvement ensuring the inclusion of relevant and feasible aspects of the circular economy within the product group.

The credibility of the scheme hinges on the traceability and verifiability of the information provided by license applicants. The ecolabel, therefore, serves as a means of verifying and substantiating company claims related to circular economy practices, such as the use of secondary raw materials and reparability. Ecolabels play a critical role in green marketing strategies by providing consumers with reliable information on the environmental impact of products. These labels certify that a product meets specific environmental standards, helping consumers make informed purchasing decisions. By adhering to recognized ecolabel criteria, companies can demonstrate their commitment to sustainability and differentiate their products in the marketplace. [44].

In terms of green marketing, ecolabels are a powerful tool for building brand credibility. When consumers see a credible ecolabel, they are more likely to trust that the product genuinely adheres to environmentally friendly practices. This trust can translate into increased customer loyalty and a stronger competitive advantage, as more consumers seek out products that align with their environmental values. Additionally, ecolabels facilitate transparency and accountability. Companies that pursue ecolabel certification often have

to disclose detailed information on their production processes, materials used, and overall environmental impact. This transparency is critical for building consumer trust and can help companies establish a reputation for honesty and integrity in their green marketing efforts.

Ecolabels help companies avoid the risk of greenwashing, which is the practice of making misleading claims about the environmental benefits of a product [59]. Greenwashing can severely damage a company's reputation if consumers discover that the claims are unfounded. By obtaining certification from an established ecolabeling organization, companies can provide third-party validation of their environmental claims, reducing the likelihood of being accused of greenwashing. This independent verification assures consumers that the product's environmental benefits are real and not exaggerated [60].

Life Cycle Assessments (LCAs) can be used to set ecolabel criteria by providing a comprehensive analysis of the environmental impacts associated with a product throughout its life cycle, from extracting the raw material to disposal, thus avoiding the risk of circularwashing as suggested by [30]. LCAs also facilitate the comparison of different products and materials, enabling the establishment of benchmark criteria that represent best practices within an industry [47]; [48]. By employing an LCA, organizations can establish scientifically robust criteria that reflect the true environmental impacts of products. This involves quantifying factors such as energy consumption, greenhouse gas emissions, water usage, and waste generation. LCAs can thus highlight the most significant environmental aspects and potential hotspots, guiding the development of criteria that target these critical areas for improvement [58]. By comparing the environmental performance of various products, an LCA helps define what constitutes a more sustainable option, setting a high standard for ecolabel certification [18].

The social circular economy is an extension of the traditional circular economy concept which integrates social considerations and emphasise social values and positive social impacts alongside environmental sustainability [27]. The EU Ecolabel criteria also include requirements related to corporate social responsibility. The criteria for ecolabel certification however could be expanded to include specific social circular requirements as suggested by [52]. Certifications could require companies to adhere to fair labour practices, provide safe working conditions, and support local communities. This would entail ensuring that workers receive fair wages, prohibiting child and forced labour, and promoting gender equality and diversity in the workplace. Social circular criteria can also emphasize the importance of social enterprises and community-based initiatives. Ecolabel schemes could prioritize products and companies that actively contribute to local economies, support social enterprises, or engage in community development projects. This would encourage businesses to adopt practices that create shared value for both the environment and society [36]. Transparency and stakeholder engagement are also crucial in integrating social circular criteria within ecolabel schemes. Companies seeking ecolabel certification should be required to provide transparent reporting on their social and environmental practices, enabling consumers and stakeholders to make informed decisions. Additionally, involving stakeholders such as workers, local communities, and social organizations in the certification process can help ensure that the criteria are relevant and address real social needs [1].

The evolution of EU product policy has significantly expanded the scope of mandatory requirements, particularly through the Ecodesign for Sustainable Products Regulation and the revised Energy Labelling Regulation. In product groups such as mobile phones, these instruments now include criteria that were historically typical of voluntary ecolabels. As

mandatory policies become more comprehensive, the "space for differentiation" of eco-labels shrinks. If regulation already covers durability, repairability, and energy performance in a robust way, the EU Ecolabel must either become significantly more ambitious or risk becoming marginal. In some product groups, this could indeed lead to a situation where eco-label criteria are no longer justified, particularly if they do not provide additional, meaningful information or incentives. Therefore, rather than concluding that circular economy aspects should not be addressed by eco-labelling, it is more accurate to argue that their role must be redefined. Eco-labels should avoid duplication, focus on areas where regulation is not yet mature, and act as instruments of policy anticipation and integration, rather than compliance verification.

Conclusions

The EU Ecolabel is a key tool that can steer consumer and producer choices through a market-based approach. Many decisions are taken in the product design phase and the criteria can influence and provide a benchmark for product developers and designers. The current EU Ecolabel criteria include requirements promoting the circulation of materials such as recyclability, recycled content, and recycling both in the production and at the end-of-life. Some criteria already stipulate the separation of materials to facilitate separate collection and recycling treatment. The EU Ecolabel promotes the use of secondary raw materials in products and packaging through percentage requirements on recycled input or residues. The criteria include promoting the extension of product service time through good quality products with requirements on durability, warranties and the availability of replacement parts.

However, these requirements are not homogenously distributed among the product groups which create discrepancies in the contribution to circular economy and in the reduction of environmental impacts. For this reason, the EU Ecolabel may transfer good examples from product groups, where a circular approach has already been well applied, to other product groups. It can also strengthen requirements on the use of by-products, secondary components, multi-functionality, modularity, separability, repair and upgrade in setting new criteria. In contrast, our analysis of the EU Ecolabel criteria showed the strong role of chemical-criteria in promoting non-toxic cycles.

In addition to prolonging product lifespan and improving material reuse, the circular cconomy emphasizes new consumption and production methods. These methods include shared-use business models, which increase a product's use by enabling multiple consumers to use it during its lifecycle, and remanufacturing, which restores end-of-life products to like-new condition, often with a warranty. As suggested by [24] In the development of the Ecolabel criteria, the EU Ecolabel could potentially include incentives for innovations in these areas.

Lastly, by embedding LCAs within ecolabel criteria, the methodologies and metrics used for assessment become more standardized, reducing variability and increasing trust in the results. This standardization can alleviate concerns regarding the complexity and comparability of LCA results, which is often a barrier to its broader use [62].

There are some limitations in this study. Our analysis only included those product groups that were within the priority areas of the circular economy. Only a partial overview of circular economy requirements in the EU Ecolabel standard was thus obtained. Future research

could extend the analysis, not only to other EU Ecolabel product groups, but also to other ecolabels such as Blue Angel or Nordic Swan. This comparison should not be limited to highlighting similarities or differences, but, above all to checking the robustness of the criteria, maybe using the PEF methodology. We did not cross-check the EU Ecolabel criteria either with other EU policies and initiatives indirectly related to the circular economy or with circular business models. Future research could evaluate the ways in which the EU Ecolabel could best use its steering role in pushing ecologically sound models such as sharing economy and product-service development. Lastly, a comparative analysis between products bearing the EU Ecolabel and comparable non-labelled products should be carried out both from a technical perspective to assess differences in durability and lifetime and from the LCA perspective to evaluate the environmental impact and to ensure continuous improvements in defining the criteria.

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Data Availability All data and information used in this work are public and available on the official EU Ecolabel website.

Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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