D4.1 Guiding design principles

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LIST OF ABBREVIATIONS

CEAP	Circular Economy Action Plan
DPP	Digital Product Passport
EC	European Commission
EC-PB	European Commission - Product Bureau
EC-JRC	European Commission - Joint Research Centre
EEA	European Environment Agency
EP	European Parliament
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
GHG	Greenhouse Gas
OECD	Organization for Economic Co-operation and Development
SOTA	State of the Art
SSbD	Safe and Sustainable by Design
WP	Work Package

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SUMMARY

Deliverable 4.1 outlines the guiding principles for ecodesign within the BioFibreLoop Project, which focuses on the development of bio-based and sustainable technical textiles through innovative processes. The main objective of the deliverable is to provide clear guidelines to support the design of safe and environmentally sustainable products and processes, integrating the principles of circularity and sustainability at every stage of the project's lifecycle development.

This activity is framed within the regulatory context of the European Union, in particular the Ecodesign for Sustainable Products Regulation (ESPR). The ESPR is a key element of the EU's strategy to promote circular and sustainable products. One of its key tools is the Digital Product Passport (DPP), which ensures transparency by tracking materials, environmental impacts and recycling information throughout the entire product lifecycle.

The textile sector has been identified as a critical area due to its significant environmental impacts, including substantial waste, greenhouse gas emissions and resource consumption. The document emphasises the importance of designing textile products with improved durability, repairability and recyclability, and mandating the incorporation of a minimum level of recycled material. This is in line with the EU's broader strategy to move towards circular production and consumption models.

Ecodesign is closely linked to bio-based products, which offer the opportunity to reduce environmental impacts using renewable, and biodegradable materials. These materials can reduce carbon footprints and contribute to achieving circular economy goals. However, challenges remain, such as balancing the use of bio-based resources with food crop production and addressing performance limitations compared to fossil-based alternatives.

The development of Deliverable 4.1 is a collaborative effort between all the Project partners, who are actively contributing to tasks such as data collection, design specification definition and technological process refinement. By aligning with European regulatory requirements and best practices, this document aims to set a benchmark for sustainable design that can serve not only as a foundation for the BioFibreLoop Project, but also as a model for other research and innovation initiatives.

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1. Introduction

1.1. Aims and objectives

The EU BioFibreLoop project aims to improve the sustainability of the European textile industry, with a focus on outdoor, active and workwear applications. The project emphasizes circular and technical textiles made from biopolymers such as lignin, cellulosic materials and PLA, using bio-inspired non-toxic functionalisation. This eco-friendly functionalisation will be achieved by an innovative laser-based bio-inspired surface treatment. Circularity will be ensured through the exclusive use of bio-based materials derived from renewable and sustainable sources, designed for recycling and durability to minimise landfill waste.

The objective of Work Package 4 (WP4) is to carry out Life Cycle Assessments (LCA) and overall safety and sustainability assessments for the three product lines developed by the BioFibreLoop project. These assessments will verify the circularity of the products and their reduced impact on human health and the environment. Guided by the principles of the European Green Deal and the Safe and Sustainable by Design (SSbD) framework, WP4 aims to establish environmentally conscious design principles while addressing the negative impacts that products may have on different ecosystem compartments. By adopting a life-cycle approach, WP4 aims to demonstrate that the fabrics developed within the BioFibreLoop project will significantly reduce environmental impacts and health risks for both workers and consumers.

The aim of Task 4.1 is to develop a guideline, based on existing best practice and legislation, to define the objectives, scope and boundaries of the scheme to determine the evaluation parameters for the products developed in the BioFibreLoop project. It will also be the repository of design information to be considered by the technical and industrial partners when improving the BioFibreLoop technologies in WP1; examples of information to be collected will be material efficiency, minimisation of hazardous chemicals or materials, energy efficiency, use of renewable resources, end-of-life design.

The deliverable 4.1 “Guiding design principles” referred to the Task 4.1 and will set the goal, scope and system boundaries, as well as the assessment parameters for safe and sustainable BioFibreLoop process and products. In addition, it will summarise the design principles (e.g. material efficiency, minimisation of hazardous chemicals or materials, energy efficiency, use of renewable sources, end-of-life design) that the technical and industrial partners need to take into consideration when upgrading the BioFibreLoop technologies in WP1 “Technology upgrade: from flat master plate to roll continuous production”. The defined guidelines and procedures will be further matched with the specifications at material and process levels to allow the drafting of a roadmap for end-product manufacturing.

This document will be structured into two main sections. The first part, to be completed and published by month 6 (M6), will outline the foundational principles necessary for designing products in compliance with European legislation, while advancing the EU’s objectives of fostering sustainable and circular production, consumption, and business models. The second part, scheduled for delivery by month 12 (M12) at the conclusion of Task 4.1, will evaluate the practical implementation of these

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guidelines. Specifically, it will assess how the proposed principles have been adopted and applied by project partners in the development of prototypes during the first year of the project.

1.2. Framework for Ecodesign

Ecodesign means the integration of environmental sustainability considerations into the characteristics of a product and the processes taking place throughout the product's value chain. (EP, 2024).

This is the fundamental definition that will guide industrial decisions in the near future. Product design dictates up to 80% of a product's life-cycle environmental impact (COM(2022) 140). In 2022, only 11.5% of the materials consumed in the EU came from recycling (Eurostat, 2023), meaning the majority of materials were derived from extraction and harvesting. While the material use intensity of the global economy is expected to decrease, total material consumption is projected to increase significantly from 79 billion tonnes in 2011 to 167 billion tonnes in 2060 (OECD, 2019). Global solid waste generation, estimated at 2 billion tonnes in 2016, is expected to increase to 3.4 billion 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 an increase of 14% since 1995 (Eurostat, 2022). Furthermore, more than half of global greenhouse gas (GHG) emissions and 90% of biodiversity loss are linked to materials management activities, which are projected to reach 50 billion tonnes of CO_2 equivalent by 2060 (OECD, 2019; COM(2022) 140). The cumulative effect of EU rules on ecodesign and energy labelling enforced until 2022 has resulted in a 10% reduction in annual energy consumption by the products in scope, equivalent to the energy consumption of Poland (COM(2022) 140). This clearly indicates that the potential for reducing environmental impacts by extending these regulations is very large.

The Ecodesign for Sustainable Products Regulation (ESPR), which entered into force on 18 July 2024, is the cornerstone of the Commission's approach to more environmentally sustainable and circular products (EC, 2024a). This strategic initiative is the fruit of a long journey undertaken by the European Union. Its foundation lies in the European Green Deal, the growth strategy to transform the EU into a fair and prosperous society, with a modern, resource-efficient, and competitive economy that achieves net-zero greenhouse gas emissions by 2050 and decouples economic growth from resource use (COM(2022) 142).

The European Commission's 2020 industrial strategy for Europe underlines the need to move beyond traditional models, and revolutionize the design, production, use, and disposal of products. The purpose of this blueprint can be summarized as follows "Europe is embarking on a transition towards climate neutrality and digital leadership. The European industrial strategy aims to ensure that European industry can lead the way as we enter this new age" (EC, 2024b).

Another important step was the Circular Economy Action Plan (CEAP) which established a sustainable product policy framework with measures in three main areas: fostering sustainable product design; empowering consumers and public buyers; and promoting circularity in production processes (COM(2022) 142). At the same time, the so-called Safe and Sustainable by Design (SSbD) criteria for chemicals and materials were defined. The SSbD approach supports the design, development,

production and use of chemicals and materials by focusing on their functionality while avoiding or minimising harmful impacts on human health and the environment (Caldeira et al., 2022).

Within this wide regulatory framework, the ESPR aims to reduce the environmental impacts of products across their life cycle and to improve the functioning of the EU's internal market (Delre et al., 2024). The ESPR replaces the previous Ecodesign Directive 2009/125/EC and establishes a structure for setting ecodesign requirements on specific product groups, to improve circularity, energy performance, and other aspects of environmental sustainability for products placed on the EU market (EP, 2024).

The Regulation provides the Digital Product Passport (DPP), an important tool for making information available to actors along the entire value chain. This includes details on the product's origin, materials used, environmental impact, and disposal recommendations (Delre et al., 2024; EP, 2024).

1.3. Ecodesign and the textile sector

Textiles are the sector to which the European Commission is devoting a great deal of attention in order to support and carry out studies to assess the possibility of reducing the impact of products through better and more careful design (EC - JRC, 2024).

This emphasis reflects the sector's critical role as a product value chain with urgent needs and strong potential for transitioning to sustainable and circular production, consumption, and business models (COM(2022) 141). Global textile production almost doubled between 2000 and 2015, and the consumption of clothing and footwear is expected to increase by 63% by 2030, from 62 million tonnes now to 102 million tonnes in 2030 (COM(2022) 141). The European consumption of textiles has a major impact on environment, climate change as well as water and land use (EEA, 2022). In 2019, the EU-27 generated 12.6 million tonnes (Mt) of textile waste; 11% was post-industrial waste, 3% was a pre-consumer waste, and 86% was post-consumer waste (Delre et al., 2024). More than 8 Mt of post-consumer textile waste is incinerated or landfilled annually (Huygens et al., 2023). The separate collection of used and waste post-consumer textiles is estimated at 2.4 Mt yr^{-1}. In contrast, the sorting capacity is assessed to be lower (1.8 Mt yr^{-1}), leaving about 48% of the textiles exported to third countries following sorting in the EU (Huygens et al., 2023). Clothing represents the primary part of EU textile consumption (81%), mainly due to the so-called "fast fashion" trend, where garments are used for ever shorter periods before being discarded. This contributes to unsustainable patterns of overproduction and overconsumption (COM(2022) 141).

The EU Strategy for Sustainable and Circular Textiles aims to tackle fast fashion and textile waste by making textiles more durable, repairable, reusable, and recyclable (EC-PB, 2024). As fast fashion is linked to the increased use of fossil-fuel-based synthetic fibres, shifting to more sustainable business models will reduce both the dependency of clothing producers on fossil fuels, as well as their impacts on climate change and microplastic pollution (COM(2022) 141). A particular focus on textiles and footwear is evident in the very first standards of this legislative initiative, which aim to set new rules on ecodesign, circularity and recyclability, as already indicated in the Commission's Communication "On making sustainable products the norm" (Figure 1) (COM(2022) 140).

Figure 1 - Commission's Communication "On making sustainable products the norm" – Source: COM(2022) 140

The importance of textile sector is also evident by the fact that the 1st Milestone (to date in draft version) released by the JRC within the legal framework of the ecodesign Regulation is the "Preparatory study on textiles for product policy instruments". This document aims to provide a basis on which the European Commission can consider the development of ecodesign requirements, green public procurement criteria and revised EU Ecolabel criteria for textile products (Delre et al., 2024). To date, European legislation on the environmental aspects of the textile sector is already very extensive and covers the following areas:

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

The forthcoming EU Ecodesign for Sustainable Products Regulation (ESPR), which will come into force in 2026, introduces significant changes to improve sustainability across product categories. Key elements include:

1. Ban on the destruction of unsold textiles and footwear: The regulation will ban the destruction of unsold textiles and footwear, addressing environmental concerns related to waste. This ban may be extended to other product categories in the future.
2. Digital Product Passport: A "digital passport" will be introduced for products sold in the EU, providing consumers with accessible information on the environmental sustainability of a product. This will promote transparency and encourage informed purchasing decisions.

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3. Extended ecodesign requirements: Building on the current Directive (which focuses on energy products), the Regulation will cover diverse products such as textiles, furniture, tyres and electronics. It introduces requirements for durability, repairability, and recyclability to minimise environmental impacts and support circular economy principles.
4. Impact on fast fashion: The regulation targets the fast fashion sector, encouraging greater social and environmental sustainability and promoting durability and reusability in product design.
5. Timetable for implementation: The regulation will take effect two years after its adoption. Small and micro-enterprises will be exempted, while medium-sized enterprises will have to comply six years later.

Member States will harmonise penalties for non-compliance and companies will have to report annually on the disposal of unsold products where bans do not yet apply (EuNews, 2024).

The Joint Research Centre of the European Commission has recently published a report analysing the implementation of the ESPR (EC - JRC, 2024). This study assesses the relevance of different product groups and horizontal requirements for potential action under the ESPR, taking into account factors such as environmental impact and improvement potential, market importance, existing EU policy coverage, cost considerations and contributions to the EU's Open Strategic Autonomy. As a result of the analysis, from an initial list of 33 product groups, the JRC identified

- 11 final products (textiles and footwear, furniture, tyres, bed mattresses, detergents, paints and varnishes, lubricants, cosmetics, toys, fishing tackle, absorbent hygiene products);
- 7 intermediate products (iron and steel, basic chemicals, non-ferrous and non-aluminium metal products, aluminium, plastics and polymers, pulp and paper, glass);
- 3 horizontal requirements (durability, recyclability, recycled content).

The 18 product groups shortlisted as a result of the initial screening were assessed for environmental relevance in 10 different environmental categories, taking into account the products' impacts and potential for improvement. For each environmental aspect, the level of concern is expressed on a scale of 0 to 5, with 5 being the highest level of concern for the specific environmental category. The product groups with the highest scores were 'Textiles and footwear' with 42 points, 12 points more than the second highest-scoring product group (Figure 2); this highlights how the textile and footwear sector is concerned about their potential environmental impacts. The main environmental concerns for the textile sector relate to the following impact categories: water use and pollution, waste generation, microplastic release, climate change impacts, energy consumption, material inefficiency, due to the large impacts caused by sourcing, producing, use and disposal of textile materials (EC - JRC, 2024).

This outcome is not surprising, as the 2020 Circular Economy Action Plan, the Textiles Strategy, and the 2021 update of the EU Industrial Strategy had already identified textiles as a critical value chain with an urgent need for action and significant potential for transitioning to sustainable and circular production, consumption, and business models (EC - JRC, 2024).

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This analysis, together with other factors such as the requirements and priority product list set out in Article 18 of the ESPR, resource availability considerations, and the Commission's evolving political priorities, will contribute to the development of the first ESPR Working Plan. This plan, to be adopted by the Commission within nine months of the ESPR enforcement, will follow consultations with members of the Ecodesign Forum.

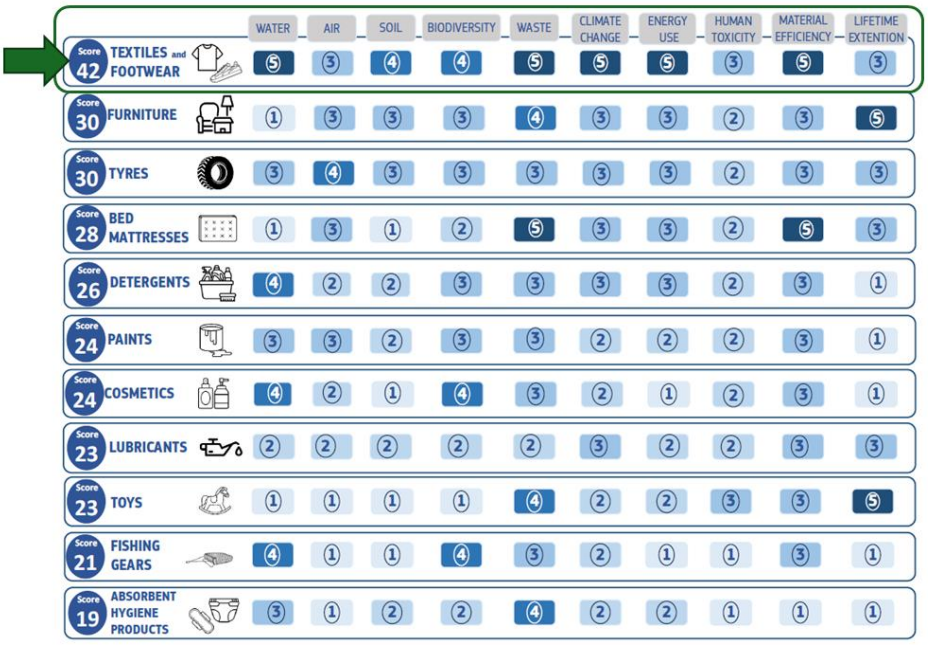

Figure 2 - Environmental assessment of the 11 final products selected – Source: EC - JRC, 2024

1.4. Ecodesign Requirements

The potential ecodesign requirements under the EU regulation could include measures targeting durability, repairability, recyclability, and overall sustainability. Specific examples might involve (EP, 2024):

- Product durability, reliability, reusability, upgradability, reparability, ease of maintenance and refurbishment;
- Restrictions on the presence of substances that inhibit the circularity of products and materials;
- Energy use or energy efficiency of products;
- Resource use or resource efficiency of products;
- Minimum recycled content in products;
- Ease of disassembly, remanufacturing and recycling of products and materials;
- Life-cycle environmental impact of products, including their carbon and environmental footprints;

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- Preventing and reducing waste, including packaging waste.

Figure 3 illustrates the key product aspects as defined in Article 5 “Ecodesign requirements” of the ESPR regulation (EP, 2024).

Figure 3 - Key product aspects under ESPR – Source: EC, 2024c

In detail, for the textile sector, ecodesign requirements emphasize critical aspects to promote eco-friendly product design, such as (EC - JRC, 2024):

- Setting maximum limits of microplastics release;
- Ensuing a minimum content of raw materials with sustainability certification;
- Minimizing life-cycle waste generation;
- Enabling safe, easy and non-destructive access to recyclable components;
- Using materials or combination that are easily recyclable;
- Defining minimum recycled content levels;
- Reducing the number of materials and components used;
- Standardizing product sizing and fitting of the product;
- Setting maximum level of carbon footprint;
- Setting maximum level of life cycle energy consumption;
- Guaranteeing minimum levels of product reliability.

The work that will take place within the activities of Deliverable 4.1 will therefore be based on requirements detailed above and incorporate any updates issued by the European Commission in the coming months.

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1.5. Ecodesign & Bio-based products

Bio-based products and ecodesign share the goal of reducing environmental impact and promoting a circular economy, contributing to sustainability through innovative materials and processes. Their interaction is based on complementary and mutually reinforcing principles. Bio-based materials, derived from renewable resources such as plants, algae or organic waste, are a viable alternative to conventional materials derived from petroleum.

Below are some of the characteristics of bio-based products that can help achieve the goals of ecodesign:

- Reduced carbon footprint, as they are able to absorb and store CO_2 during their life cycle, offsetting some of the emissions generated;
- Biodegradability and compostability: many bio-based products decompose naturally, helping to reduce waste;
- Renewability: Because they are made from biomass, they are more easily regenerated than fossil–based materials.
- Circular economy: Bio-based products encourage recycling and reuse, reducing dependency on non-renewable resources.
- Substitution of fossil materials: The use of renewable resources is a pillar of ecodesign.
- Efficiency of production processes: The production of bio-based materials often requires less energy and fewer resources than the production of conventional materials.

These characteristics make bio-based products key tools for implementing effective ecodesign, improving the sustainability of products without compromising their functionality. However, there are several challenges that need to be considered when promoting bio-based products. For example, despite the benefits, the use of bio-based materials could have an impact on land use: biomass production could compete with food crops or cause deforestation.

In addition, some bio-based materials do not yet have the same longevity as fossil materials, which affects overall sustainability and the cost of the product (Delre et al., 2024; EP, 2024; Müller-Carneiro et al., 2023).

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2. Contributions of partners and WP connections

Partners involved in T 4.1: NTT, DITF, NFA, VTT, NIL, FreyZein, BEES, Knopf, BAT, A-Nov, IDENER.NTT was responsible for coordinating the partners involved, collecting information on the products under study in the BioFibreLoop project, their composition and salient features. The information collected was then placed in the current European context, referring to existing legislation, sector literature and existing best practices. This work made it possible to define the fundamental aspects to be taken into consideration for a correct ecodesign. NTT's role is to coordinate the Task 4.1 and to plan, organise and manage the collection and processing of the data required to achieve the objectives of Task 4.1. NTT with other partners will contribute to the collection of data necessary for the definition of product ecodesign standards; in particular, DITF, NIL, FreyZein, BEES, Knopf, BAT, A-Novas technical partners, will contribute by providing information on the products studied and defined in the project.

NFA, IDENER, DITF and VTT will play a key role in data collection and processing, with overlapping contributions to Task 4.3 (data libraries for LCA and sustainability), Task 4.5 (Life Cycle and Circularity Assessment), and Task 4.6 (Overall safety and sustainability assessment). These tasks align in principles and objectives, ensuring consistent data use, harmonized methodologies, and integrated evaluations of safety, sustainability, and circularity. Figure 4 shows the links between Task 4.1 and the different WPs of the project.

As shown, Task 4.1 mainly receives input from WP1 activities, and the data collection and processing efforts in Tasks 4.3, 4.5, and 4.6, specifically concerning the Life Cycle Assessment (LCA) and overall safety and sustainability of the products developed in the Project. The outcomes of Task 4.1 directly impact on WP1 by influencing decisions on the design and composition of the materials developed in the project, which subsequently affect WP5 activities.

Furthermore, the information and decisions defined in Task 4.1 will be useful for the communication and dissemination activities (WP6) of the Project to highlight and demonstrate BioFibreLoop's commitment and focus on environmental issues and its contribution to reducing the environmental impact of bio-based textile products.

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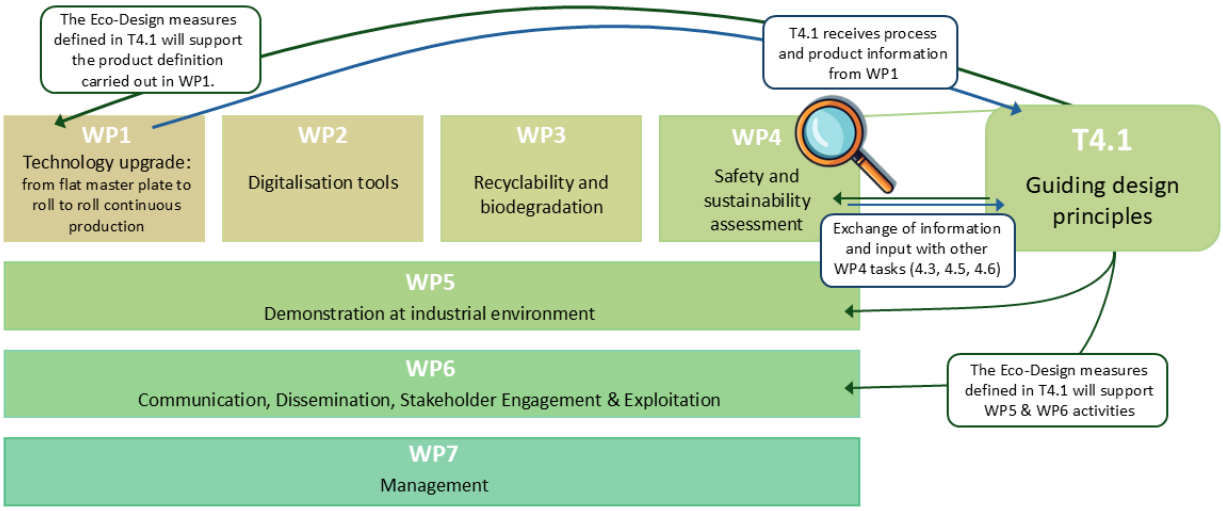

Figure 4 - Links between Task 4.1 and Project WPs (NTT elaboration)

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3. Technical/scientific activities

3.1. Activity performed: Research & Benchmark

The BioFibreLoop project focuses on circular and technical textiles made from three biopolymers (lignin, cellulosic material, PLA) with bio-inspired non-toxic functionalisation (Figure 5). Such an environmental-friendly will be achieved by a developed bio-inspired laser-based surface functionalisation. After end-of-life, functionalised biopolymers will be recycled using dissolution-based physical recycling for cellulosic material, mechanical and thermomechanical processes for PLA and lignin-based textile materials.

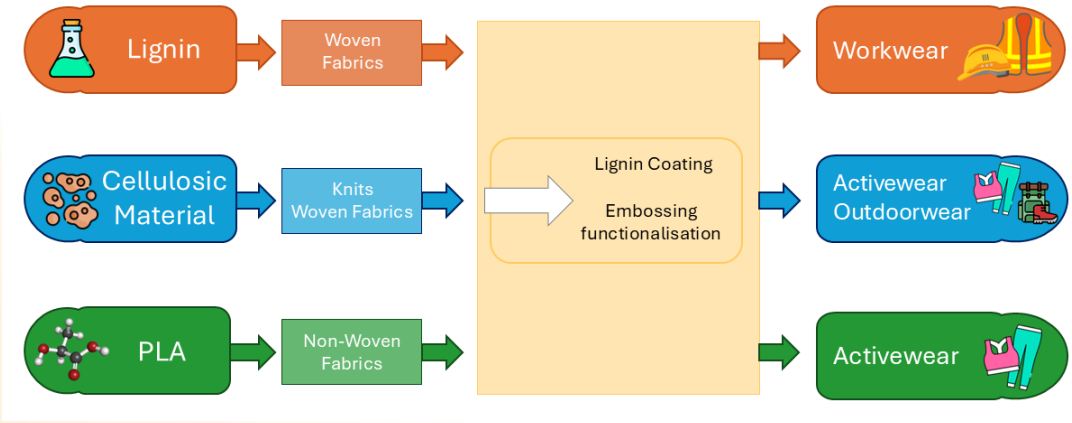

Figure 5 - Graphical representation of product development in the BioFibreLoop project (NTT elaboration)

The first part of the work in Task 4.1 consisted of researching legislation, regulations and scientific literature on ecodesign and its relevance to the textile sector. As mentioned above, ecodesign is a very hot topic at the moment and the European Union is focusing on it as a strategic tool to achieve the objectives of carbon neutrality and reduction of environmental impacts related to EU industrial activities. Therefore, although this was the first step in the definition of these guidelines, it will be continued until the end of the task period (M12) to keep up to date with EU decisions.

In parallel with the state-of-the-art (SOTA) research on ecodesign, the activity focused on deepening the knowledge of the products to be developed by the project and the production lines and processes to be implemented. In order to facilitate the work of the whole partnership and to avoid overlapping requests to the technical partners, NTT decided to start data collection by participating in the meetings carried out by DITF under Tasks 4.2, 4.3 and 4.5 for the definition of common product flowcharts, which will be detailed in the coming months. Figure 6 shows a screenshot of a flowchart that DITF is developing with the support of the other project partners on the Miro platform (with a zoom-in of the flowchart to show the level of detail of the data that the partnership is collecting), as an example of the progress in data collection and processing.

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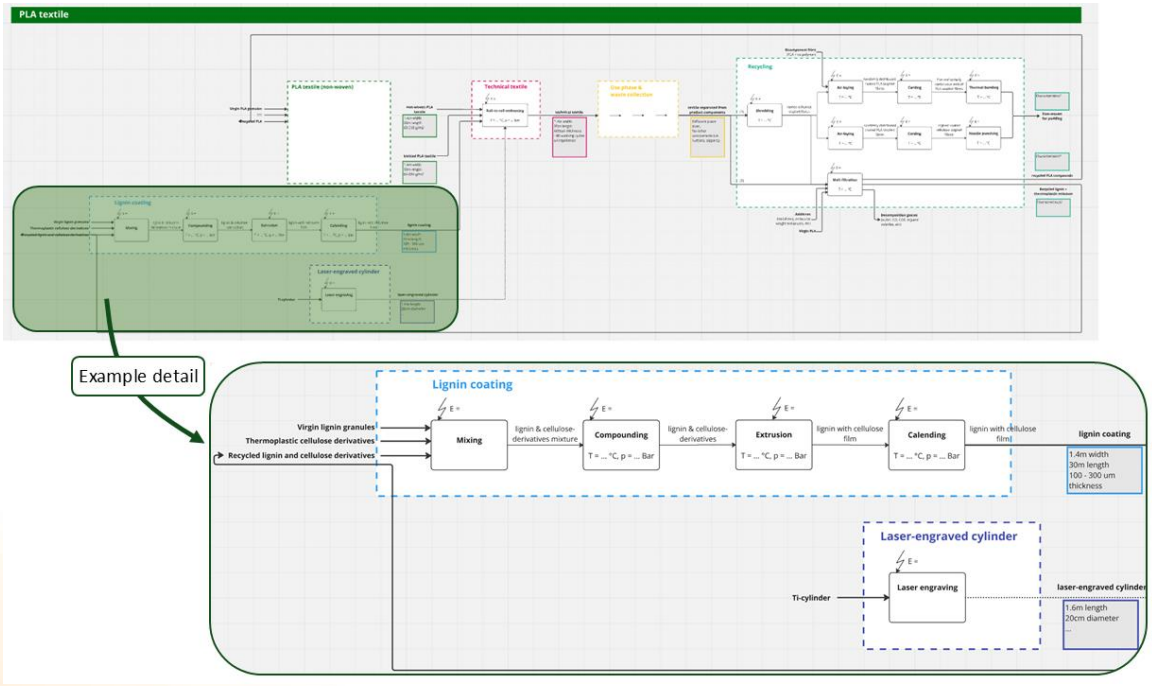

Figure 6 - Flowchart for PLA Textile and zoom on Lignin coating as detail example (DITF & NTT elaboration)

The construction of a flowchart, as detailed as possible, is an essential preliminary step for understanding by non-experts in the field under study. It allows for a global vision of the system and an understanding of the inputs, outputs, relationships and processes of the system being analysed. Ecodesign is one of the methodologies based on a Life Cycle Thinking framework (even if there is still no standardised methodology for carrying out an ecodesign study) and, in fact, ecodesign perfectly embodies the objectives for which Life Cycle Assessment was born, namely the optimisation and rationalisation of industrial systems.

In-line with the EC's "Stainable product policy & ecodesign", the project ecodesign strategy should follow these steps:

1. Analyse all components of a product/material, aimed at assessing the recyclability/reusability of the components comparing the product;
2. Identify the chemical composition of the non-replaceable key components and verify if they are recyclable or reusable;
3. Analyse secondary components (if key components are recyclable) and understand if they can be replaced to be made of the same (or compatible) materials, as those of the key components;
4. Investigate how many secondary components can be made with recyclable materials, without compromising the product performance according to KPIs;
5. Assess the technologies available for the recycling or end-of-life treatment of the key components;
6. Based on previous steps, design the simplest possible disassembly process.

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3.2. Next six months activity

After the preparatory activities of these months, the coming months will see the implementation of more operational activities and close collaboration between the partners involved in Task 4.1. The regulatory update will continue, accompanied by a more in-depth study of the state of research in the field of ecodesign (focusing, where possible, on bio-based products, even though the literature on this subject is not very extensive), looking for virtuous examples among companies in the sector, scientific literature and other European projects.

In parallel, the study of the project processes will continue with a detailed study of the flowcharts produced by WP4 in order to identify aspects, materials, inputs or processes that could represent hotspots for the product under analysis. This will make it possible to provide ideas and suggestions, inspired by existing virtuous examples and based on trends currently under development.

During this phase, operational meetings will also be held with the technical partners of WP1 and WP3 in order to confirm any doubts that may have arisen from the study of the flowcharts and to verify any updates in the design and process choices made by the technical partners.

For this purpose, an Excel file template was prepared to collect the data currently considered most relevant for the definition of an ecodesign guideline (to be modified, if necessary, as a result of the work and in-depth technical and legislative studies in the coming months), in order to have a more rational view of the data collected and to allow easier identification of hotspots; an example of the Excel file is shown in Figure 7.

biofibreloop

WP	4 - Safety and Sustainability Assessment
Task	4.1 - Guiding design principles
Deliverable	4.1 - Guiding design principles
Task Leader	NTT
Involved Partners	DITF, NFA, VTT, NIL, FreyZein, BEES, Knopf, BAT, A-Nov, IDENER

In italics, examples of compilation

N.	Product Name	Partner Involved	Product Description	Main Components	Components Detail (material)	Percentage of the total	Chemical composition	Recyclability of Components (estimates are also fine)	Reusability of Components (estimates are also fine)
1	*Lorem ipsum dolor*		*Lorem ipsum dolor sit amet, consectetur adipisci elit, sed do eiusmod tempor incidunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrum exercitationem ullamco laboriosam, nisi ut aliquid ex ea commodi consequatur.*	*Component 1*	*Material x*	*57%*		*non-recyclable*	*the component can be used, after shredding, as soundproofing material*
					Material y	*43%*		*70%*	
				Component 2	*Material z*	*100%*		*30%*	
					Material w	*50%*		*non-recyclable*	
				Component 3	*Material a*	*30%*		*not recyclable to date*	
					Material b	*20%*		*100%*	
2									
3									
4									

Figure 7 - Ecodesign - Excel File for Data Collection (NTT elaboration)

The information for the development of D4.1 will therefore come from two macro areas: information on the technical-legislative context and information on the project; the effort of collecting, processing

and aggregating this information will continue in the coming months in order to define the most appropriate guidelines for the project products. At the end of the work of the team involved in T4.1, all these information will be rationalized in the definition and writing of specific ecodesign guidelines for BioFibreLoop products. An activity plan for months 7-12 is shown in Figure 8.

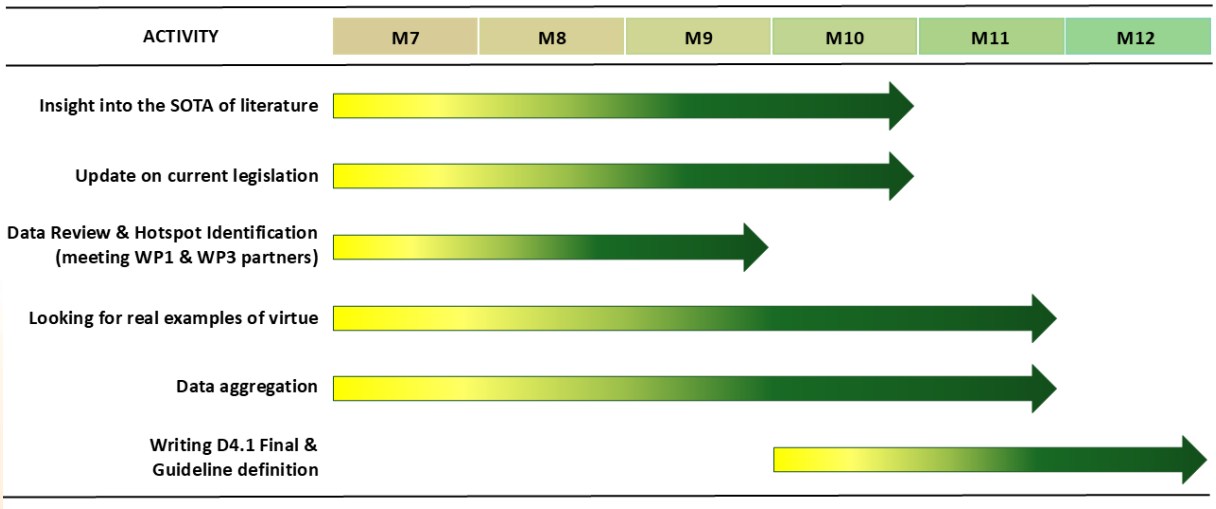

Figure 8 - Activity plan for M7-M12 (NTT elaboration)

3.3. Guideline structure

The BioFibreLoop Guidelines will serve as a practical and comprehensive resource to support the development of safe, sustainable and circular bio-based textiles. They will provide clear and actionable recommendations to help project partners integrate ecodesign principles at every stage of the product development process.

The document will include practical suggestions tailored to the specific needs of the project, offering best practices and concrete strategies to address key challenges such as material efficiency, recyclability and reduction of hazardous substances. These recommendations will ensure that the guidelines are not only in line with European regulations, but also feasible to implement in real-world scenarios.

Particular attention will be paid to critical hotspots, focusing on key materials and processes with significant environmental impacts. By identifying and addressing these hotspots, the guidelines will help project partners to prioritise interventions that maximise sustainability outcomes.

While some visual aids, such as diagrams and flowcharts, will be included to clarify complex concepts, the emphasis will be on providing detailed, practical information to ensure that the guidelines are both accessible and effective in driving sustainable innovation.

4. Final Remarks

The BioFibreLoop Deliverable 4.1 has established a solid foundation to guide the design of safe, sustainable and circular bio-based textiles. By integrating cutting-edge research, regulatory insights

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and the collaborative efforts of the project partners, this document lays the groundwork for achieving the ambitious goals of the project, while aligning with key European Union initiatives such as the Ecodesign for Sustainable Products Regulation (ESPR) and the Safe and Sustainable by Design (SSbD) framework.

The guiding principles defined here not only aim to improve material efficiency, reduce environmental impact and promote circularity, but also serve as a tool for innovation in bio-based textiles. The project's emphasis on pioneering sustainable functionalisation techniques, such as laser-based surface treatments, highlights the transformative potential of combining technological advances with eco-conscious design.

While this deliverable will primarily serve as a reference for the BioFibreLoop consortium, it aims for wider applicability by providing an example for other research and industrial initiatives. However, as the project progresses, it will be crucial to dynamically adapt these guidelines to ensure their relevance to the evolving needs of material development, product design and regulatory frameworks.

Ultimately, Deliverable 4.1 reflects BioFibreLoop's commitment to addressing the environmental challenges of the textile industry and contributing to a future where bio-based technical textiles are not only sustainable, but also competitive in terms of performance and innovation.

4.1. Main challenge of Task 4.1

As the project is still in its early stages, many critical design decisions—such as those concerning materials, machinery configurations, and process optimizations—are yet to be finalized. This presents a significant challenge in ensuring that the ecodesign guidelines can be fully tailored to the products that will eventually be developed. The lack of finalized specifications makes it difficult to predict with certainty how the guidelines will align with the technical and functional requirements of the end products.

Furthermore, the iterative nature of research and development means that unexpected obstacles may arise, requiring adjustments to the original design principles. For example, certain materials or technologies initially deemed suitable may prove less efficient or sustainable when tested at scale, necessitating revisions to both the guidelines and the processes. This dynamic environment underscores the importance of flexibility in the application of the guidelines, as well as the need for ongoing collaboration among project partners to align evolving technical decisions with the broader objectives of sustainability and circularity.

Despite these challenges, this early stage also offers a unique opportunity to influence the development process from the ground up. By embedding ecodesign principles at the inception of product development, the project can proactively address potential environmental impacts and ensure that the final outcomes are not only innovative but also aligned with the regulatory and ethical standards set by the European Union. This forward-looking approach will be instrumental in creating a strong foundation for the project’s success and its broader contribution to sustainable textile solutions.

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