European Commission

The European Commission's Knowledge Centre for Bioeconomy

Community of Practice Workshop

Bio-based textiles

Expert workshop on latest research findings, market trends and policy needs

26 June 2024
9.30 -16.30 CET

Venue: European Commission - DG Research & Innovation - Orban building, room 03/78
Sq. Frère-Orban 8, 1000 Bruxelles, Belgium

Online: Teams connection

Summary report

This is an internal report of a workshop organised by the European Commission's Knowledge Centre for Bioeconomy. The workshop took place physically on 26 June 2024 in Brussels. The workshop was a closed event with in-person attendance to guarantee a safe space for discussion. Participants were active in their personal capacity rather than in their institutional roles.

The points presented in this report summarise the views expressed by the participants and do not necessarily reflect the position or opinion of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication.

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Background

In 2020, textile consumption in Europe had on average the fourth highest negative impact on the environment and climate change after food, housing and mobility from an overall life cycle perspective[1]. It was the consumption area with the third highest impact on water and land use, and the fifth highest in terms of raw material use and greenhouse gas emissions European consumers spend on average €282 billion every year on clothing, while 5 million tonnes of clothing and footwear are discarded and 80% of postconsumer textiles goes to incineration or landfill. Moreover, about 8 % of European microplastics released to oceans are from synthetic textiles. Globally, between 200,000 and 500,000 tonnes of microplastics from textiles enter the global marine environment annually, i.e. 16-35% of all microplastics released to oceans[2].
The European consumers' demand for textiles is growing together with their attention to sustainability aspects. Making use of alternative fibres, based on renewable (bio-based) resources, is one of the strategies the textile sector may adopt to sustainably satisfy this demand.
According to a study published in 2024 by AFRY[3], in a high material substitution scenario, cellulosic textiles would allow to save annually 3 Mt CO2 eq compared to synthetic textiles by 2050. In general, bio-based textiles offer great potential to defossilise the textile industry, but their bio-based origin still entails trade-offs, such as the impacts related to land use, processing and end-of life disposal.

The Knowledge Centre for Bioeconomy (KCB) is a European Commission initiative on improved knowledge management for bioeconomy-related policymaking. It aims at developing a common and robust knowledge base for a sustainable and circular bioeconomy.
The increasing importance of the bio-based textiles and the opportunity for innovation they bring in the European industrial landscape supported the KCB's decision to enrich its knowledge base with a new deep dive on this subject. In the framework of the task A5 "Knowledge analysis, synthesis and dissemination" of the Administrative Arrangement "KCB Support 3" between DG RTD and the JRC, a new KCB topic page on bio-based textiles will be set up by January 2025. Following the 'linked knowledge pyramid' concept , the webpage will include: a video introducing the main messages related to the bio-based textile topic, a 'knowledge for policy brief' synthesising currently available knowledge, facts and figures on bio-based textiles, an "Explore further" section that will include latest data, visualisations, projects and additional selected resources available and a "Latest resources" section with the latest news and publications in the KCB knowledge base, related to bio-based textiles.
In this context, in May 2024 the KCB started cooperating with two recognised scientists in the bio-based textile field, Dr. Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery at Wagening University and Research, and Dr. Mikael Skrifvars, Professor of Polymer technology at University of Borås. The experts are collaborating with the KCB to draft a state of the art, a knowledge gap analysis and an industrial outlook for the bio-based textile sector, to synthesise such contents and to identify key messages to be included into the above-mentioned knowledge for policy brief.

[1] Textiles and the environment: the role of design in Europe's circular economy — European Environment Agency (europa.eu)
[2] Microplastics from textiles: towards a circular economy for textiles in Europe — European Environment Agency (europa.eu)
[3] fam_executive_booklet_eng.pdf (afry.com)

Expert Workshop Organisation

To ensure the policy brief could provide policymakers at EU and national level a multifaceted and up to date representation of the bio-based textile sector, the KCB organised the Expert workshop on bio-based textiles, which took place in Brussels on 26 June 2024 in hybrid modality. Such workshop aimed to gather inputs and views on several aspects related to the bio-based textiles sector: available feedstock, process, current and future market trends, environmental impacts, trade-offs, knowledge gaps and policy needs. With this aim, it targeted around 30 attendees among policy makers, practitioners and researchers working in the bio-based textile filed. Accordingly 29 participants attended the workshop in person (of which 12 European Commission staff members and 17 external experts from 8 different Member States) (Figure 1) and 19 attended online (of which 3 external experts and 12 European Commission staff members), ensuring a sufficient variety of expertise and view angles.

Figure 1: Workshop participants

Source: Original photo by the authors

The morning session of the workshop (see agenda in Annex I) provided participants with an overview of the European policy landscape with relation to bio-based textiles, some examples of industrial innovation projects and the preliminary results of the analysis carried out by the contracted experts. Such elements represented a suitable background to start an open discussion on the latest research findings, market trends and policy needs. In the afternoon, the in-person participants split in two groups, attending two parallel sessions, respectively on knowledge gaps and opportunities for R&D in the bio-based textile sector, facilitated by Mr. Skrifvars and on the potential role of the bio-based textile sector within the EU, facilitated by Ms. Harmsen.

The event

This section reports the main contents presented and discussed during the workshop. The interventions and the working table discussions are synthesised and organised into subsections to facilitate reading, the slides presented are in Annex II.

1. Welcome address

Peter Wehrheim, Head of Unit - DG RTD B.2 - Bioeconomy & Food Systems

Innovative, sustainable bio-based textiles can reduce the environmental and negative climate impact of the textile industry and therefore are a societal opportunity. This workshop aims to investigate the opportunities for the development of the bio-based sector, within the European bioeconomy.

Bio-based textiles as a sub-sector of the bioeconomy

The EC understanding of the bioeconomy includes all sectors, services and investments that produce, process, distribute, or consume biological resources from animals, plants, microorganisms, including organic waste and ecosystem services. According to the 2018 EU Bioeconomy Strategy, the bioeconomy includes the primary sectors (agriculture, fisheries, forestry, and aquaculture) and all the sectors utilising the biomass from these different areas. Hence, it is an intersectoral, holistic, circular and sustainable concept. The bioeconomy addresses all dimensions of sustainability and the Strategy targets five objectives: 1) Ensuring food and nutrition security 2) Managing natural resources sustainably 3) Reducing dependence on non-renewable resources 4) Mitigating and adapting to climate change 5) Strengthening European competitiveness and creating jobs.

In 2021, the bioeconomy provided 5% of the EU's GDP and 8.2% of the EU's workforce. In terms of employment, innovative bio-based business offers new job opportunities, which partially counterbalance the structural downward trends affecting the primary sectors.

Looking into the latest available data from the JRC Bioeconomy Monitoring System, in 2021, in the EU27 almost 700,000 people were employed in the bio-based textiles sector. The value added by this sector was 25 billion EUR representing 3.5% of the total value added of biomass producing and converting sectors. Despite the multiple possible benefits it can bring, this sector did not follow the same increasing trend that other bio-based industries followed from 2012 on.

The benefits of the bio-based materials

Shifting to bio-based materials could bring three main kinds of benefits. Firstly, they are renewable and derived from natural resources, reducing the reliance on fossil fuels and other non-renewable resources. This helps mitigate environmental damage and reduce carbon emissions, leading to a more sustainable and environmentally friendly sector. Secondly, bio-based materials are often biodegradable or compostable, reducing waste accumulation and pollution. Moreover, diversifying raw material sources by using bio-based materials fosters economic resilience. It reduces vulnerability to price fluctuations in resource markets and creates new opportunities for farmers and rural communities by providing crop diversification options.

Bioeconomy Policy evolution

The EU adopted its first Bioeconomy strategy in 2012 and updated it in 2018. The bioeconomy is contributing to all dimensions of the European Green Deal. In April 2023, EU Member States adopted the "Conclusions on the opportunities of the bioeconomy in the light of current challenges with special emphasis on rural areas". In March 2024, the Commission launched the Communication on Building the future with nature, committing to update the Bioeconomy strategy by the end of next year.

The 2025 EU Bioeconomy Strategy and the actions the Commission will propose must be underpinned by robust scientific evidence. The experts attending this workshop can contribute to strengthening the evidence base around bio-based textiles, to identify current and future challenges and opportunities as well as possible policy needs to bring bio-based textiles from niche to norm.

2. Introduction to the KCB deep dive on bio-based textiles

Valeria Magnolfi, Knowledge Management Officer - JRC.D.1 - Forests and Bioeconomy

The Knowledge Centre for Bioeconomy

The Knowledge Centre for Bioeconomy (KCB) is a European Commission initiative, launched in 2017. The 2018 Bioeconomy strategy recognises a specific role for the KCB in supporting the knowledge base for policymaking and for tracking the progress towards a sustainable bioeconomy. The KCB collects and consolidates knowledge from different sources, identify and filter relevant information, making it accessible through its website (https://knowledge4policy.ec.europa.eu/bioeconomy_en). This one-stop-shop for bioeconomy related information, displays a knowledge library including news, publications, events, datasets and audio-visual contents for more than 5600 curated resources. In addition, the KCB manages a Community of Practice: a network of people who work on a common area, exchange knowledge and views and work together on specific topics. In January 2024 the Community of Practice on Bioeconomy opened up to researchers, practitioners and policymakers from all over Europe and beyond, and it now gathers 162 participants.

The deep dive on bio-based textiles

The KCB is committed to analyse and synthesise knowledge within the bioeconomy domain, to provide high-quality information for better policymaking at European level. In line with this mission, the KCB is collecting and processing data and up to date evidence on bio-based textiles to present and disseminate them through a dedicated webpage, including a short video and a knowledge for policy brief, targeting policy makers at EU and national level.
To realise the policy brief on bio-based textiles, in May 2024 the KCB started collaborating with two recognised scientists in the field: Dr. Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery at Wagening University and Research, and Dr. Mikael Skrifvars, Professor of Polymer technology at University of Borås. They presented the preliminary results of the state of the art, knowledge gap analysis and sector outlook they performed. Their presentations paved the way to the afternoon working table discussions, aimed to collect the contributions of the experts attending this workshop, to be integrated into the knowledge for policy brief. The ambition of this document, is to provide an effective and multifaceted representation of the bio-based textile sector, highlighting challenges and opportunities, especially in the research and innovation field. The review process will involve the policy DGs from September 2024. The policy brief will be ready for publication by the end of the year and the topic page on bio-based textiles will be online by January 2025. Representatives of the European Commission participating illustrate the policy framework surrounding the bio-based textiles and the specific needs, in terms of knowledge, of the current or future policy development.

3. The bio-based textiles within the EU industrial policy

Cornelia Mohor, Policy Assistant - DG GROW G.1 - Tourism, Textiles

The policy and regulatory landscape for the textile industry is evolving quite fast thanks to a package of new policies and regulations redefining how the textile products are made, marketed, consumed and disposed off in the EU.

EU strategy for sustainable and circular textiles and related measures

The EU strategy for sustainable and circular textiles, published in 2022, aims to create a greener, more competitive sector that is more resistant to global shocks on the 2030 horizon. To do so, the

Strategy lays out a forward-looking set of actions. One of these actions is the creation of a framework to set ecodesign requirements for products, including textiles, through the Ecodesign for Sustainable Products Regulation (ESPR). The ESPR sets binding performance requirements (durability, reusability, repairability; fibre-to-fibre recyclability and recycled fibre content; minimise the presence of substances of concern; ban on the destruction of unsold clothing and footwear) and a delegated act for textiles is under preparation.

Today, compulsory elements on the label of a textile product do not go much beyond the fibre content. In 2023 the Commission launched a plan to update and revise the **Textile Labelling Regulation,** to introduce further mandatory disclosure of information, as well as codes/symbols to identify fibres, leather/fur authenticity, origin, care, uniform size, allergenic substances etc. The Commission is currently analysing the results of both the targeted and the open consultation for the revision of the EU Textile Labelling. It is preparing the textiles expert group meeting, an informal expert group including national delegates from Member States, and the validation workshop with stakeholders. The Commission could adopt the proposed regulation by the first quarter of 2025.

Transition Pathway for the Textiles Ecosystem

The 2021 European industrial strategy identifies textiles as a key product value chain. The **Transition Pathway for the Textiles Ecosystem** was co-created with stakeholders and published on 6 June 2023. It points out the production and uptake of new bio-based, recycled and renewable fibres as one of the areas where investments are most needed. In addition, it identifies 50 specific actions to help make the EU textiles ecosystem greener, more digital, resilient and competitive. Public and private stakeholders are invited to share their concrete actions to help implement the Transition Pathway via the online call for pledges. On 1 March 2024, the Commission published the first set of pledges from stakeholders. Examples of stakeholders' commitments to support the Strategy, include sustainable textile fibre innovations, new solutions for bio-colorant production and application for the textile industry, development of fibres with a percentage of recycled materials. A new report will be published in about one year.

Horizon Europe

The Commission, through the EU's key funding programme for research and innovation Horizon Europe, addresses two main research and innovation gaps in the bio-based textiles field. The first one concerns the development and boosting of the production of innovative bio-based textile fibres and may enable the identification of new textile fibre names to be added to Annex I of the EU Regulation on textile names and related labelling. In fact, there is a lot of innovation in relation to man-made cellulosic fibres as well as plant fibres and the idea is to support the sector in terms of investments. The second focuses on innovative bio-based solutions to replace hazardous conventional chemicals in textile production.

Boosting Biotechnology and Biomanufacturing in the EU

In March 2024, the Commission launched the **Communication on Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU**, that summarises the current challenges and barriers for biotechnology and biomanufacturing and proposes actions to address these challenges in a timely manner, in line with the Communication on the Long-term competitiveness of the EU. It also explores ways to foster engagement and collaboration, including through international dialogue and cooperation. There are various actions put forward by this communication and the first one, "**Simplified regulatory framework and faster access to market**", aims to stimulate the market demand by streamlining regulatory pathways. As a follow up to this

communication and its first action, two studies are in the pipeline. The first one, to be published during Q4/2025, will investigate possible pathways for the development and deployment of the bio-based industries in the EU. It will also identify the most relevant raw materials, both organic and inorganic, and intermediates, including bio-based intermediates (e.g., chemicals, polymers, natural polymers and compounds), that are currently imported into the EU and that could be replaced by sustainable bio-based resources/products of EU origin. Finally, it will focus on the impact of legislation on biomass. The second study will investigate how the legislation that applies to biotech and biomanufacturing could be further streamlined across EU policies. Its objective will be to explore targeted simplifications to the regulatory framework by mid 2025.

4. The bio-based textiles within the EU environmental policy

Paola Migliorini, Deputy Head of Unit - DG ENV B.1 - Circular Economy, Sustainable Production & Consumption

This intervention has been summarized in this report together with the following one to streamline the exposition.

5. Ecodesign Sustainable Product Regulation (ESPR)

Carsten Wentink, Policy Officer - DG ENV.B.4 - Sustainable Products

The bio-based textiles are part of a larger sector, which is at the centre of the EU strategy for sustainable and circular textiles and its related measures. In this context of legislation, the Commission aims to fully understand the potential of the bio-based textiles with respect to the objectives laid out by the strategy.

EU sustainable and circular textile strategy

The **EU sustainable and circular textile strategy** addresses the production and consumption of textiles, whilst recognising the importance of the textiles sector. It enables a sustainable and circular development, limiting the environmental impacts the textile sector can produce, inside and outside the EU. The Strategy answers also to a very important call from the industrial stakeholders, who claimed for a clear, consistent and comprehensive policy framework.

The strategy implements the commitments of the European Green Deal and the Circular Economy Action Plan, supporting coherent objectives. The upcoming Bioeconomy Strategy will certainly boost their achievement, and other measures will contribute too. In the vision laid out by the Strategy, by 2030, all textiles placed on the EU market should be durable, repairable and recyclable, to a great extent made of recycled fibres, free of hazardous substances, produced respecting social rights and the environment. With the statement "fast fashion is out of fashion", the Strategy aims to make profitable re-use and repair services widely available. On the 2030 horizon, producers take responsibility for their products along the value chain and circular rather than throw-away clothes have become the norm, with sufficient capacities for recycling and minimal incineration and landfilling.

To enable this vision, the Commission proposed several measures and rules that address ecodesign requirements, product information, greenwashing, voluntary claims, extended producer responsibility, waste management and shipment, with the overall aim to ensure that circular and sustainable textiles become the norm. Such measures will act on the design, use and disposal practices.

DESIGN

On the design side, a good implementation of the **Ecodesign for Sustainable Products Regulation (ESPR)** with regards to textiles is quite essential for achieving the ambitions of the textile strategy. The overall environmental impact of the products that we produce and consume every day is directly linked to a highly inefficient use of resources, showing an urgent need to align production and consumption with planetary boundaries. The ESPR represents the main tool to significantly improve the circularity, energy performance and other environmental sustainability aspects of products placed on the EU market. The ESPR replaces the Ecodesign Directive 2009/125/EC enlarging its scope to non-energy related products and emphasising more and more on other types of requirements such as life durability, CO2 footprint and recycled content of products. It establishes a framework legislation, entered into force on 18 July 2024. Regularly updated multiannual working plans set out priorities for developing secondary legislation, namely delegated acts, setting specific requirements for specific products, based on detailed impact assessments. This procedure ensures the requirements are appropriate for the product groups that are in the scope of a certain delegated act.

Ecodesign requirements are essentially performance and information conditions, aimed to:

- Improve product durability, reusability, upgradability and reparability
- Make products more energy and resource-efficient
- Address the presence of substances that inhibit circularity
- Increase recycled content
- Make products easier to remanufacture and recycle
- Set rules on carbon and environmental footprints
- Improve the availability of information on product sustainability

Performance requirements remove from the market the worst performing products on certain products aspect. For instance, if a product is required to have a certain minimum share of recycled or renewable components, then products that do not comply with that requirement are not placed on the market anymore. Information requirements could go beyond performance requirements, for instance by means of classes of performance.

Delegated acts can set requirements on a series of sustainability aspects (figure 2).

Figure 2: Key Ecodesign aspects under ESPR

Source: Presentation 5. Ecodesign Sustainable Product Regulation (ESPR) (see Annex 2)

This does not mean that every delegated act must regulate all of them. Product-specific measures can select those product sustainability aspects that are deemed relevant. Such requirements could be set for almost all categories of physical goods (with some exceptions, such as food and feed, as

defined in Regulation 178/2002). For groups of products that share enough common characteristics, the framework allows horizontal rules to be set, going beyond the product-by-product approach. For instance, multiple types of products present sustainability concerns over the use of polyester and it would be possible to set cross-cutting requirements for all those materials.

Ecodesign requirements apply to any product that is placed on the market, including imported ones, making it necessary to create a level playing field and a number of instruments and tools to boost market surveillance. One of these is the **Digital Product Passport (DPP)**, a digital identity card which will make electronically accessible (e.g. through a QR code) to consumers, manufacturers, and authorities a set of information on sustainability, circularity and regulatory compliance of products. Information to be included in the DPP will be identified by the Commission, in close consultation with all relevant stakeholders, and will depend on the specific product in question. This information can include:

- Product's technical performance
- Materials and their origins
- Repair activities
- Recycling capabilities
- Lifecycle environmental impacts

Such information could not only help consumers to make more aware consumption choices, but they could also be useful for market surveillance authorities or recyclers.

The ESPR enables mandatory **Green Public Procurement** criteria to be set for EU authorities who purchase the products that it will regulate. A delegated act on ecodesign requirements is a basis to set even more ambitious green public procurement criteria. This has the potential to significantly boost demand for sustainable products, in turn, further incentivising companies to invest in this area.

Recently, a report estimated that between 4 and 9% of unsold textiles never reach the consumers at all. Many unsold products in the EU are simply destroyed, a practice that wastes valuable resources. For the first time in the EU, the ESPR introduces measures to address this practice, by introducing a **ban on the destruction of unsold textiles and footwear** and opening the way for similar bans in other sectors, if evidence shows they are needed. It will require large and eventually medium-sized companies across all product sectors to disclose annual information on their website, such as the number and weight of products they discard, as well as their reasons for doing so.

As setting product specific requirements is a time and labour-intensive process, the EC needs to prioritise those products that have the highest impact and improvement potential with regards to ecodesign requirements. The regulation includes a list of product groups, introduced by the Co-legislators. Textiles - notably garments, but also footwear, which is part of the broader textile industrial ecosystem - are included in this provisional list. Furniture and mattresses are also there. Products prioritisation is based on their impacts and the extent to which we can address those impacts with ecodesign requirements, the market size and the volume of sales and trade.

The working plan specifying the product groups to be regulated must be adopted within nine months after ESPR entering into force, meaning around March 2025. Before that moment, the Commission will consult the Ecodesign Forum - a consultation body including MS national experts, representatives of the industry, SMEs, civil society groups, environmental groups - on the working plan. There will be a call for applications to be a member of this forum soon after the summer.

An extensive **preparatory study** led by the JRC will put the basis for the introduction of Ecodesign requirements, green public procurement criteria and revised EU Ecolabel criteria for textile products. These instruments will be considered in parallel to ensure maximum synergy and complementarity. The JRC will carry out research in line with the ESPR, following the structure prescribed by the Methodology for Ecodesign of Energy-related Products (MEErP). The MEErP consists of seven tasks: task 1 on scope, task 2 on markets, task 3 on user behaviour, task 4 on technologies, task 5 on environment and economics, task 6 on design options, and task 7 on policy scenarios. The used methodology will be adapted to the specific features of the textile product group and the requirements set by the ESPR. The project will also analyse information in accordance with the EU Ecolabel Regulation 66/2010. The preparatory study, which is the pivotal basis for the impact assessment, focuses on apparel, making it likely the delegated act will also focus on apparel. Apparel, the largest textile product group with the largest incremental impact, is very heterogeneous in terms of its product composition. Nevertheless, the product requirements may fit in one delegated act. The study aims to identify eco-design requirements by carrying out a market and user behaviour analysis, analysing best available technologies in relation to product sustainability aspects, and performing an environmental assessment, based on life cycle assessment, of the products in scope. The outcomes of the first three tasks of this preparatory study have already been published, a very extensive stakeholder consultation took place in spring 2024 and the JRC is now analysing its results and revising the text. At the same time, the JRC is working on the next deliverable, on the technologies and environmental assessments. Another stakeholder meeting will take place later in the year. The JRC will invite registered stakeholders to express their views and to provide comments on draft deliverables of the preparatory study in writing and during three technical working groups. Interested stakeholders can register by leaving their contact information via this link.
Once the preliminary study will be finalised, it will be impact assessed further to make it possible to have requirements on textile by 2026. The value chain has then to adapt and redesign cycles. In fact, the ESPR legal text sets a transition period of at least 18 months.
Making the requirements on textiles operational requires a big standardization effort and all the technical details of the requirements should be clarified. For instance, requirements on durability may relate to color fastness, fabric resistance to pilling and abrasion, or dimensional change due to washing. Requirements on reparability may refer to ease of separation of materials. A recycled content requirement could be further declined into fiber to fiber or chain of custody systems related aspects. Requirement on environmental impacts will be linked to Product Environmental Footprint (PEF) indicators. In addition, trade-offs should be carefully considered: ambitions on durability could have a negative effect on recyclability and high thresholds on recycled shares should be compatible with comfort needs.

USE

To make the textile use more sustainable and circular, the Commission proposed some **measures to empower consumers**. In particular, the review of the EU Ecolabel criteria for textiles (harmonised with the Ecodesign requirements) awarding environmental excellence, the revision of the Textile Labelling Regulation, the information requirements and the Digital Product Passport will ease informed purchasing choices, while encouraging truly sustainable business practices and products. In parallel, the Empowering Consumers in the Green Transition Directive and Green Claims Directive, respectively in force since February 2024 and proposed in March 2023, aim to tackle greenwashing. The first, bans generic environmental claims and ensures a more visible guarantee information. The second ensures voluntary environmental claims and labels are

substantiated, verified and well communicated and introduces rules on public and private labelling schemes. It could be finalised in early 2025.

END OF LIFE

In 2023 the Commission proposed a revision to the Waste Framework Directive to introduce mandatory and harmonised Extended Producer Responsibility (EPR) schemes for textiles in all EU Member States. Producers will **cover the costs of management of textile waste,** which will also give them **incentives to reduce waste and increase the circularity of textile products** – designing better products from the start. How much producers will pay to the EPR scheme will be adjusted based on the environmental performance of textiles, a principle known as '**eco-modulation**'. Common EU EPR rules will also make it easier for Member States to implement the requirement to **collect textiles separately from 2025**, in line with current legislation. The producers' contributions will finance investments into **separate collection, sorting, re-use and recycling capacities**, creating business opportunities for social enterprises active in the collection and treatment of textiles. The proposal will also **promote research and development into innovative technologies** for the circularity of the textiles sector, such as fibre-to-fibre recycling. Finally, the proposal also addresses the issue of **illegal exports of textile waste to countries ill-equipped to manage it.** The new law would clarify what constitutes waste and what is considered reusable textiles, to stop the practice of exports of waste disguised as being done for reuse. This will complement measures under the updated Regulation on waste shipments that will ensure that shipments of textile waste only take place when there are guarantees that the waste is managed in an environmentally sound manner.

A relevant term of reference: the policy framework for bio-based, biodegradable and compostable plastics

In November 2022, the Commission adopted the Communication (not legally binding) on a policy framework for biobased, biodegradable and compostable plastics, bringing clarifications on bio-based, biodegradable and compostable plastics and setting out the conditions to ensure that the overall environmental impact of their production and consumption is positive. Bio-based plastics and bio-based textiles share common opportunities: they can help to defossilise industry, reducing our dependency on fossil resources and meeting our climate neutrality targets, while creating new job opportunities. Nevertheless, they both face challenges such as the use of secondary rather than primary biomass, the cascading principle, the application of the sustainability criteria for land use, biodiversity and GHG. Research and innovation efforts should thus tackle these aspects.

6. Q&A

Mikko Makkaela, research professor at the Technical Research Centre of Finland (VTT), remarked bio-based textiles still represent a minority share in the global production of textile fibres, while synthetic fibres, mainly polyester, dominate the market.
Which measure is there or will be put in place to address this unbalance?

Paola Migliorini answered that ESPR and all the other relevant regulations horizontally apply to all textile products, addressing every kind of textile fibre, independently of its origin.

Peter Wehrheim affirmed the bioeconomy offers an approach to tackle this issue and to drive the transition to a circular, climate neutral economy by 2050.

Hafiz Kaleem, R&D Project Manager - Polymer Business Unit at the European Centre for Innovative Textiles (CETI) asked if the ecodesign requirements will be able to address sustainable sourcing of raw materials.

Carsten Wentink highlighted how challenging will be setting effective eco-design requirements. Every type of product has peculiar environmental impacts, during all its life cycle: from the sourcing of the raw materials, which may affect land use change or ecosystem biodiversity, to the use, which may determine release of microplastics in the environment, to the end of life. All these impacts should be considered.

Luz Walter, Secretary General at the European Textile Technology Platform (Textile ETP) remarked how the lack of data representing the textile sector undermines a good understanding of its dynamics. According to available data, today about 2/3 of all the textile fibres produced in the world are synthetic while the mass flow analysis on textile waste by JRC[4], shows more than 60% of the textile waste is bio-based textile materials from clothing. This gap sheds lights on how few information we have on where the produced fibres end up: we know that the clothing industry requires more bio-based fibres while technical textiles are mainly synthetic, but quantitative data on the final destination of the produced fibres in terms of product category are missing.

Valeria Magnolfi and Paola Migliorini agreed on this point and invited participants to point out available data sources and to share them in the Bioeconomy community of practice to help filling these knowledge gaps.

7. Industrial innovation in the bio-based textile field

Simone Maccaferri, Project Officer - CBE-JU

The **Circular Bio-based Europe Joint Undertaking (CBE-JU)** is a two billion euros public-private initiative by the European Commission and by the Bio-based Industry Consortium (BIC). It contributes to the European Green Deal objectives by accelerating the transition from fossil-based to bio-based industrial solutions.

The **CBE-JU project portfolio on bio-based textiles** includes 9 projects dealing with:

- the suitability, availability and sustainability of alternative fibre sources and feedstock
- innovation in the biorefining of side streams, secondary biomass or crops restoring contaminated or degraded soils, as well as cellulose extraction and processing of postconsumer bio-waste
- the development of additives, finishing and coatings
- end of life management of bio-based textiles

Below, some examples of CBE JU projects are illustrated.

EFFECTIVE - Advanced Eco-designed Fibres and Films for large consumer products from biobased polyamides and polyesters in a circular EConomy perspecTIVE (IA) was coordinated by AquafilSLO, from 2018 to 2022. The project focussed on the production of sustainable sugars and the sourcing of sustainable vegetable oils from discards of the food industry. Such raw materials were converted into bio-based polymers, especially polyamides and bio-based and biodegradable polyesters, and validated into large consumers products (i.e. garments, carpets, films for food and non-food packaging applications). The entire objective was to close the loop of the material cycle

[4] Techno-scientific assessment of the management options for used and waste textiles in the European Union

by getting compostable films from biomaterials or ensuring the recyclability of the bio-based polyamide or specialty polyamide that were produced by the project. The project founded a pre-industrial scale demo plant in Lubjiana, SI. CBE-JU organised an exhibition in different Commission's buildings to showcase specialty textiles, T-shirts, swimsuit and carpets produced by the project.

Glaukos, coordinated by Bio Base Europe Pilot Plant, has just ended. The project aimed to develop innovative textile fibres and textile coatings with increased bio-based content of textile products, preventing the release of microplastics in the environment. The objective was: i) to produce itaconic acid through fermentation of industrial side streams (molasses and waste from the sugar industry) as a building block ii) to produce new polymers that had a right balance between strength and biodegradability for the targeted applications; iii) to use such polymers to produce bio-based yarns with balanced spinnability, durability and biodegradability. The concept of bio-recyclability was at the centre of the Glaukos project. The project studied a new plastic degrading "nylonase" enzyme and engineered microbes that can use plastic as feedstock. Starting from the polymers produced through the polymerization of the itaconic acid, the project demonstrated at laboratory scale the possibility of degrading them into monomers through a depolymerisation process. It also showcased the possibility of upcycling such monomers towards PHA, to be further used in the textile application and bio-based polymer application. Glaukos produced prototypes of fishing gears and technical garments.

Bio-LUSH and FIBSUN are ongoing sister projects, responding to a call on the use of novel natural fibres. Bio-LUSH started in May 2023, coordinated by the University of Stockholm, and it aims to unlock the hidden potential of European plant resources. The project deals with the conversion of biomass into sustainable and high quality fibre materials that can be used for a wealth of bio-based applications. A textile application, based the extraction of cellulose and nanocellulose from poplar and nettle, is included. In this case, cellulose and nanocellulose are processed to acquire antimicrobial properties, mainly by using nanocellulose or antimicrobial agents that are characteristic of this feedstock. The fibres deriving by this process could substitute viscose and lyocell and could be used for specialty garments and clothes where antimicrobial properties are important (e.g. in some industrial or clinical settings).

FIBSUN started in June 2023, coordinated by Luke. The project deals with novel fibre value chains and ecosystem services from sustainable feedstock. It explores the use of different feedstock for different industrial applications. Among these, the cardoon value chain for the textile production can improve soil health and carbon storage in the soil. In fact, the cardoon cultivation can provide ecosystem services in term of restoration of degraded soil. In parallel, cardoon fibres have good characteristics in terms of strength, flexibility, lightweight, biodegradability and availability. A joint venture between a textile company and a local cluster of SMEs launched a dedicated case study in the north of Portugal aimed to test the cardoon cultivation, harvesting, processing and production of clothing with cardoon fibres.

UNLOCK started in 2021 and it is coordinated by CIDETEC. It aims to valorise the keratin part of the waste feathers generated by the poultry industry to produce innovative functional geotextile materials for agricultural applications. The advantages derived from the use of feather keratin includes: i) tailor-made biodegradation, ii) input on organic nitrogen to soil, iii) zero waste generation at their end of life and iv) cost competitive materials.

The major future outlooks for the bio-based textile portfolio in the CBE-JU will be:

- Upscaling of the technology level of novel fibre biorefineries,
- Enhancing or adapting functionalities, processes, and pilot manufacturing of existing bio-based fibers, including those of synthetic origin

- Upscaling and broadening the scope of innovative bio-based chemicals and processes to substitute hazardous chemical/coatings/additives

8. Bio-based textile sector: state of the art and potential role in the EU bioeconomy

Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery – WUR

Fibre types and characteristics

The bio-based textile sector includes three value chains producing three fibre types:

1. **Natural fibres** are bio-based fibres produced by biological organisms, such as plants, animals and microorganisms. Examples include cotton flecks, hemp and wool. Production starts with farmers who harvest crops or breed animals for their hairs (labour intensive activities). Production has environmental impacts (requires land, water and pesticides), but the final product is biodegradable. For cotton, the main challenge relates to sustainable production. A sustainable development of the European bast fibres production would rather require the establishment of a European supply chain, including production and processing facilities, and the improvement of the retting process. New promising alternative natural fibres that can grow in Europe should also be identified. From the consumer point of view, natural fibres and cotton in particular are widely accepted. Bast fibres (linen, hemp) are less used while wool and other animal hairs are not attractive for vegetarians and vegan people.
2. **Semi-synthetic fibres** are man-made fibres made of bio-based polymers, often cellulose from wood or other fast growing crops like bamboo, but also proteins. They are also called regenerated cellulose fibres or man-made cellulosic fibres (MMCFs), requiring chemical processes for treating cellulose pulp and spinning to fibres. Examples include viscose, lyocell or cupro, commonly accepted by consumers. Such final products are biodegradable but the production, starting with forest owners or farmers, has environmental impacts (requires land, water and pesticides) which could be limited. Further challenges to be tackled in order to increase the European semi-synthetic fibres production, include the development of new Europe-based processing facilities. Finally, the potential of proteins (e.g. milk protein) for semi-synthetic fibres production might be further investigated.
3. **Synthetic fibres** are fully man-made fibres. The chemical industry produces synthetic fibres starting from the monomers to build up the polymers, mostly outside Europe. These fibres can be both fossil-based (produced from fossil oil) and bio-based, but they are mostly fossil-based. Fossil-based examples include polyester, polyamides and elastane but the market is dominated by one type of polyester (PET). Fully bio-based polyesters (PLA, PEF, PHAs) and partly bio-based polyesters (PET, PTT, PBT) are available or in development. Bio-based polyesters/polyamides volumes are currently low due to price, availability (land use) and questions about sustainability. Applications of new polyesters in textiles are in development. Synthetic fibres are attractive for consumers due to price, availability and performance. Regarding consumer acceptance, drop-ins are not an issue, as materials are similar, while fully bio-based alternatives (PLA, PEF, PHAs) have different properties and raise some concern. Synthetic fibres are often not biodegradable, and they accumulate in nature (microplastics). Drop-ins are also not biodegradable, while fully bio-based ones are being investigated.

These three fibre types correspond to three different value chains, that at a certain point come together in the creation of textiles and then yarns and fabric, which have to be finished and dyed. In this way, different types of materials are combined into one product.

Global fibre production

Textile Exchange published global fibre production data for 2022, showing the volumes of plant fibres (27%), animal fibres (2%), man-made cellulosics (6%) and synthetic fibres (65%), but also of bio-based PET (0.01%) and bio-based polyamide (0.4%). These data refer to the global fibre production, for apparel, technical textiles, footwear, etc. and it does not represent the fibres' final application, which is an issue. Today, about 2/3 of the global fibre production is made from fossil oil and 1/3 is made from bio-based materials, revealing how challenging it might be to phase out fossil oil for the textile sector.

Sources of renewable carbon

Textiles are made of carbon, making it necessary to find solutions for a transition from fossil carbon to renewable carbon and in particular for a sustainable and circular sourcing, production and use of carbon-based feedstock. In the framework of the Transformative Bioeconomies project, Wageningen University and Research investigated the "renewable carbon for a fossil free society" theme. The project identified three options to provide renewable carbon for chemicals, plastics, materials, food and feeds and also the heavy transport: i) carbon recycling, ii) biomass and iii) carbon dioxide (figure 3). Such solutions, and biomass in particular, can contribute to increase the overall sustainability and circularity of the textile sector, by reducing the use of (virgin) resources, phasing out fossil resources, preventing the release of harmful microfibres to the atmosphere.

Figure 3: Today and tomorrow potential transition to renewable carbon for natural, semi-synthetic and synthetic fibres

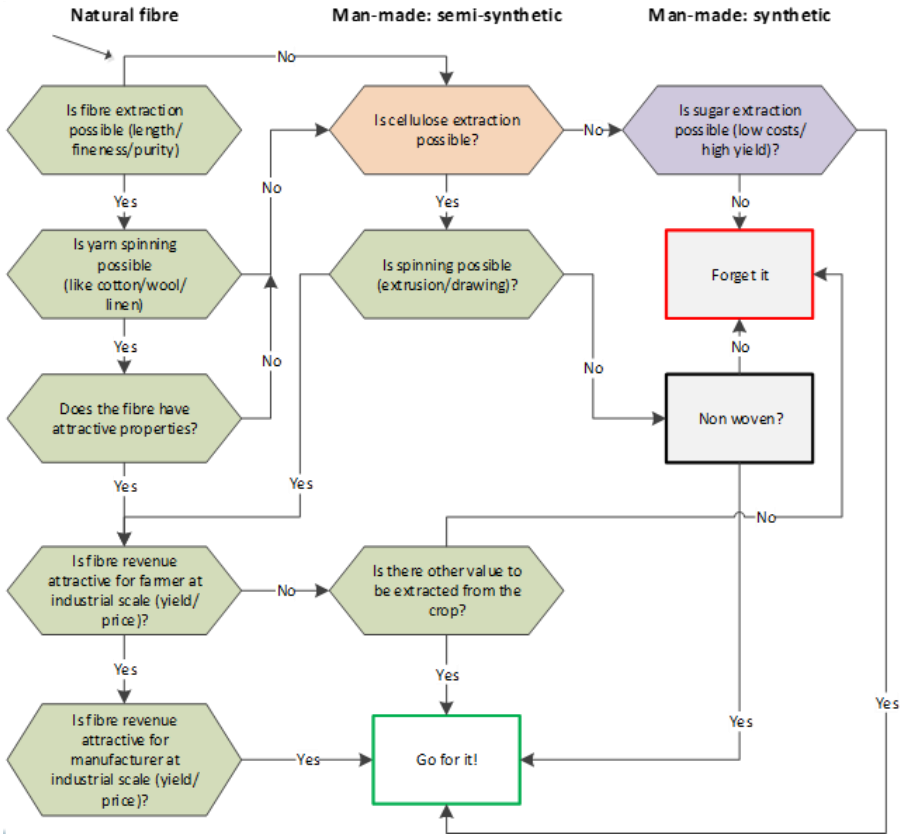
Today	Fossil	Biomass	Recycled	CO_2
Natural fibre	Not possible	Mature	In development	Not possible
Semi-synthetic fibre	Not possible	Mature	In development	Not possible
Synthetic fibre	Mature	In development	In development	In development

Tomorrow?	Fossil	Biomass	Recycled	CO_2
Natural fibre	Not possible	Mature	In development	Not possible
Semi-synthetic fibre	Not possible	Mature	In development	Not possible
Synthetic fibre	Mature	In development	In development	In development

Source: Presentation 8. Bio-based textile sector: state of the art and potential role in the EU bioeconomy (see Annex 2)

Dr. Paulien Harmsen together Dr. Michiel Scheffer developed a decision tree, showing possible biomass conversion options, among the three types of fibres (figure 4).

Figure 4: Decision tree for biomass conversion into different kind of fibres



Source: Presentation 8. Bio-based textile sector: state of the art and potential role in the EU bioeconomy (see Annex 2)

Overarching challenges and possible solutions

The bio-based textile sector development faces many challenges and opportunities, which are common to the different kind of fibres.

The phase out of fossil resources represents a big challenge for the textile sector, which heavily relies on fossil feedstock. Such feedstock should be replaced with sustainable one, e.g. bio-based feedstock. Nevertheless, biomass and land availability are limited, and the textile sector may compete for them with other sectors (e.g. fibres production vs food production, textile production vs building material production). Such competition requires to identify optimal biomass streams, fibre crops and fibre types to make a sustainable development of the bio-based textile sector in Europe possible. Gaps in the processing and infrastructure need also to be addressed, together with challenges related to circularity, R-ladder and end of life options.

Price, availability and properties of final products will keep on playing a major role in determining consumer behaviours. To succeed on the market, it will be crucial for the bio-based textile sector to address consumer behaviour and to create a level playing field.

9. Knowledge gaps and opportunities for R&D in the bio-based textile sector

Mikael Skrifvars, Professor of Polymer technology - University of Borås

Approaching the bio-based textile topic, with the aim of analysing the challenges and opportunities it is facing, requires a good understanding of the available feedstock, processed resources and the different value chains.

Bio-based textile fibre alternatives (excluding cotton, wool)

- **Annual cellulose bast fibres** (e.g. flax, hemp, jute), subject to complex and labour intensive mechanical processing, which have a long historical use

- **MMCFs**, mainly produced from wood but also bamboo, through chemical processing
    - Viscose (chemical process involving dissolving and regeneration, in use since 1893), Lyocell (cellulose dissolving by solvent and fibre precipitation)
    - Cellulose carbamate, cold alkali, ionic liquid
    - Microfibrillated cellulose

- **Recycled end-of-life cotton and viscose fibres**, which are a good source for new fibres, as they are quite easy to reprocess utilising different type of chemical processes. Economic viability, compliance with market requirements and available technologies still represent challenging aspects.

- **Bio-based synthetic polymer fibres**, made from various biomass sources, through large scale polymer processing and fibre melt extrusion (same process to produce conventional fossil polyesters)
    - Polylactic acid (PLA)
    - Partly biobased polyesters: PPT, PBT
    - Furandicarboxylic acid (FDCA) polyesters

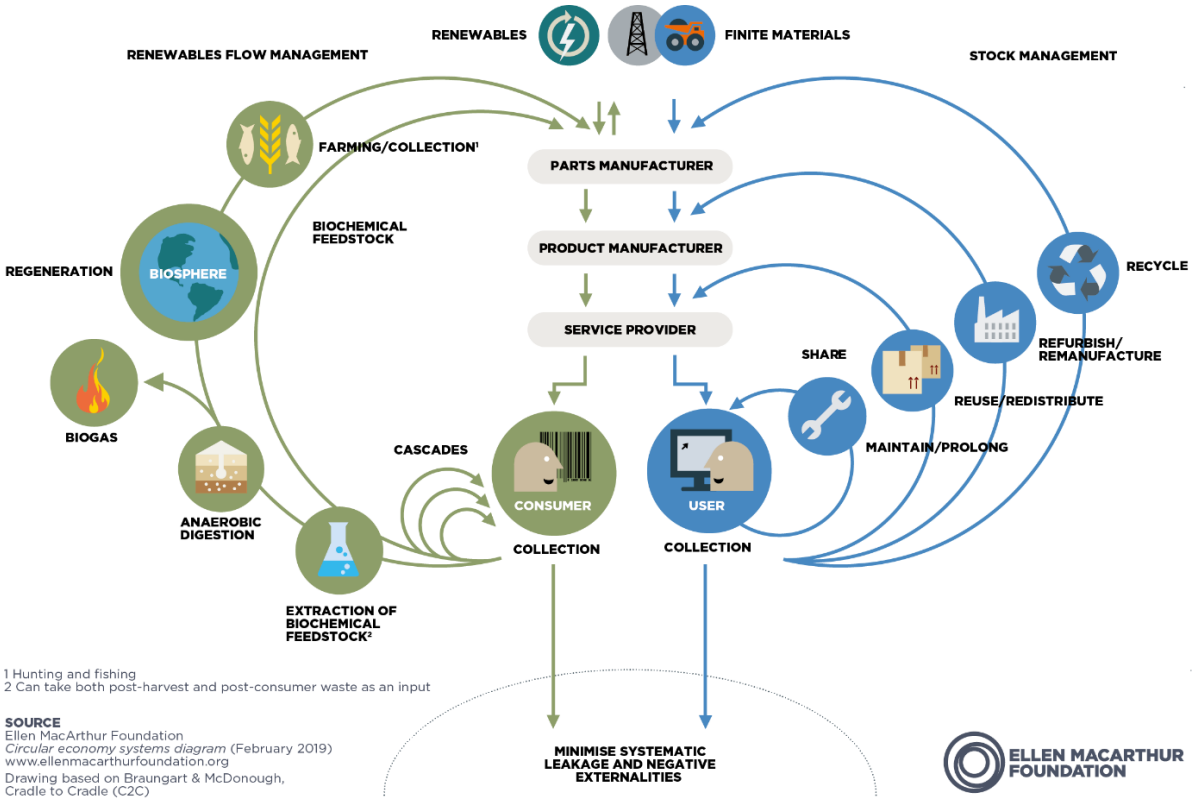
- **New fibres under development**:
    - Polyhydroxyalcanoates (produced by microorganisms)
    - Protein based: casein, silk
    - CO_2 based polyesters

The bio-based fibres within the circular economy

Ellen McCarthy Foundation's butterfly model represents the relations between bioeconomy and circular economy (figure 5).

It shows that bioeconomy and circular economy are very closely integrating and actually overlapping. In addition, it illustrates the bioeconomy and the circular economy will be of equal size. In fact, whereas bioeconomy is still much smaller, its dimension will increase quite a lot when the fossil economy will be phased out. Finally, the model includes end of life materials from both the bioeconomy and the circular economy. This material dissipation phenomenon is due to degradation and should be limited. The release of microplastics in the environment is a good example of material dissipation in the textile field.

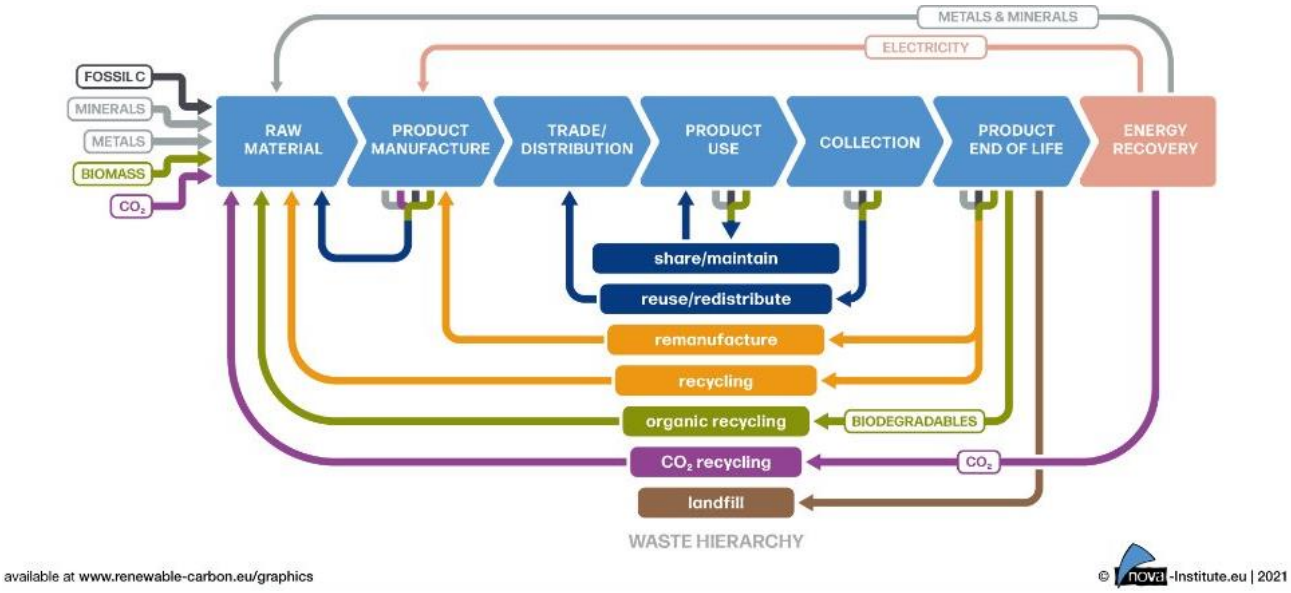
Figure 5: Circular economy butterfly diagram



Source: Ellen MacArthur Foundation

Nova Institute produced also a very good model for the circular economy (figure 6), which looks like a traditional linear model but it actually represents as circular all the steps of the value chain.

Figure 6: Comprehensive concept of circular economy



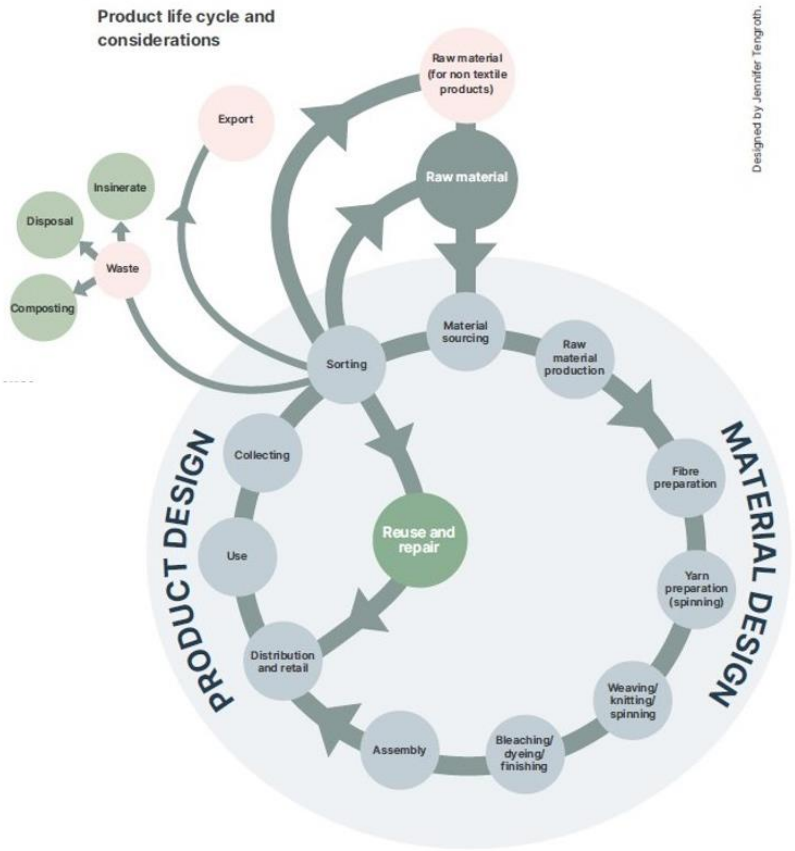
Source: Nova Institute

In addition, this model's inputs include fossil carbon, minerals, metals, biomass and also carbon dioxide. The carbon dioxide, collected through carbon capture and utilisation technologies, is the last step of the energy recovery process. A few years ago, carbon dioxide recovery and reuse was

considered as something very far away and unrealistic, while nowadays the plastic industry sees it as the only alternative to fossil raw materials.

Another model which is particularly focussed on textiles was elaborated by the Foundation for Swedish textile research - TEKO in the context of the Sustainable Fibre Toolkit 3 (figure 7). It represents the product life cycle for textiles, showing the textile processing, and in particular, the conversion of fibres into the final textile products is quite complex, much more complex than the conversion of polymers into plastic products. The greatest part of the textile waste will not be back into this circle, which is a major issue to address.

Figure 7: Product life cycle for textiles



Source: Sustainable Fibre Toolkit 3 – The Foundation for Swedish textile research – TEKO

Value chains – Bio-based fibres

The bio-based textiles can be produced through very different processes and value chains, but the common starting point are fibre forming polymers. To get biopolymers to produce bio-based fibres, there are four options:

- Extract polymers from biomass (carbohydrates, proteins, PHA polyesters, lignin), like in the case of viscose
- Extract chemicals from biomass and convert them into polymers (lactic acid, plant oils, dicarboxylic acids), like in the Glaukos project. This kind of process is becoming popular and there is an increasing attention to the extraction of biomolecules, in particular bio-monomers, from biomass and biomass waste streams
- Polymers produced by microorganisms (Polyhydroxyalcanoate Polymers or PHA)
- Use carbon dioxide as a carbon source for polymers, which is in the starting phase but will develop

There is a variety of feedstock and process which can be used. Every process has its own history, labour intensity, can be applied at small or large scale, requires different investments and has its own environmental impact. Such variety is both a challenge and opportunity for the development of the sector.

New material technologies and concepts

There are many examples of companies and start-ups which launched new business based on textile material recovery and reuse. End of life textiles can be recycled into new textiles by regenerating cellulose textile fibres (viscose, lyocell) from 100% textile waste, such as worn-out jeans and production scraps, without using wood. In addition, textile waste can be seen as a raw material source, to manufacture yarns, fabrics and garment made from 100 % recycled materials. Other companies focussed on CO_2 recycling, launching new technologies to incorporate CO_2 into new materials to produce elastic textile.

Bio-based fibres and special natural fibres are also attracting a huge interest, with more and more applications in the technical textile field, especially in composites reinforcement. Flax, hemp and other natural fibres are currently utilised to make structural composites. In addition, 3D printing and additive manufacturing application to bio-based product and components are getting more and more popular.

Biomimetics are also developing quite fast, making available renewable bio-based alternatives, performing as well as the traditional or fossil-based technical textiles.

10. Parallel session: Knowledge gaps and opportunities for R&D in the bio-based textile sector

Chaired by Mikael Skrifvars, Professor of Polymer technology - University of Borås

Figure 8: Working group 1

Source: Original photo by the authors

Resources and raw materials for bio-based textiles

Biomass availability represents a limiting factor for the growth of the bio-based fibre production. In particular, the scarce availability of sustainable wood resources to produce cellulosic fibres is referred to as “cellulose gap”. Answers to this gap could be:

- Recycling textile waste, both through mechanical degradation of fibres, and chemical regeneration into virgin fibres. EPR, giving responsibilities to producers, promotes the recycling of fibres.

- Cultivation of fibres like hemp or cardoon on degraded land. Information on available land for cultivation, consumer acceptance and market trends might help to fully understand their potential.

The EU Deforestation-free products Regulation makes it compulsory for cellulosic fibres to comply with traceability requirements, resulting in significant administrative burdens. An extension of traceability requirements application to all fibres could support a level playing field for European sustainable fibres producers, making them more competitive with respect to the Asian producers of fossil-based fibres.

Technologies for conversion from raw material to textile

Innovative mechanical processes are already available at the industrial scale. Alternative feedstock like mycelium may also be processed. Scalability at the European level represents an important challenge, together with keeping the production process sustainable. New technologies are advancing quite fast, the production of spray dress is an impressive example[5].

Production infrastructure and value chain from raw material to end-product

Whereas annual bast fibres like flax and hemp have a high potential in terms of sustainability, the European value chain for processing such fibres lacks important steps, such as the spinning one. The European market conditions are not attractive for this business. In parallel, apparel brands started moving to Asia due to better conditions. In Europe, a small scale and high value production of sustainable fibres could flourish, targeting a niche of environmental conscious consumers. Keep such production competitive will remain challenging but a supporting policy framework may help.

Fibre properties according to customer demands and market specifications

Sustainability starts from the design of a textile product. Nevertheless, the design of a textile product, and thus the properties of the fibres it is made of, are highly influenced by the market demand. ESPR requirements should find a compromise between promoting sustainability standards (e.g. a certain share of bio-based or recycled fibres into textile products) and allowing producers to satisfy customers demands in terms of comfort but also from an aesthetic point of view. Labelling could be automatised, displaying textile composition.

Existing or developing market demand with end-use customers

Mandatory Green Public Procurement criteria for EU authorities are the main way the European policy can promote the purchase of bio-based textiles. On average, consumers choose the products they like, or they find comfortable. Nevertheless, the business level could support the change, orienting consumer choices on sustainable products. A carbon tax on textiles could also play a role.

End-of-life handling methods and strategies

A detailed representation of the value chain can help identifying the most polluting steps of the textile production process. Micro plastics pollution is a major issue, and cellulose particles may represent a problem too. Knowledge gaps on how dangerous microplastics or microparticles from textiles should be addressed. End-to-end environmental assessments should carefully consider the

[5] See spray paintable liquid fabric

impact of coatings and finishing. According to recent studies, the finishing affects the release of microplastics. Perfectly biodegradable finishing processes are already available. Bio-based coatings are also available but not common due to the cost barriers.
The impact of a circular textile economy, based on textile waste sorting and recycling, is still unknown. The blending of different fibres hinders the textiles waste recycling. On the other hand, mono-material is more expensive. With the current technologies, probably the cellulosic recycling process will not scale up. Many traditional professions related to repairing and refurbishing textile products are disappearing, which make them important from a social point of view.

Position in the circular economy system
Bio-based fibres can significantly contribute to make the textile sector more circular, but it is difficult to prove this at the industrial scale, due to the waste composition. Fibre to fibre recycling brings true environmental benefits. Recycling synthetic fibres is also important, even if apparently polyester recycling is more energy intensive than polyester production from raw materials.

Market value and feasibility, end-use product costs
Conventional cotton can cost 2 Eur/kg while polyester's price is up to 9 EUR/kg. Recycled viscose is more expensive than the conventional one. The market for innovative synthetic bio-based polymers such as PLA is still very limited.

Other factors of importance
Terminology should be clear: semisynthetic fibres is not appropriate as no synthesis happens in the production process; "man-made cellulosic fibres" is more correct. It is also important to define what is bio-based, considering the difference between bio-based and biodegradable.

11. Parallel session: Potential role of the bio-based textile sector within the EU bioeconomy

Chaired by Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery – WUR

What is bio-based textile for you?

Figure 9: Word cloud created through Mentimeter

Source: Screenshot from the polling platform Mentimiter

Cotton production in EU

Cotton is cultivated in Europe, mainly in Spain and Greece, for a total of 320000 hectares. The cultivation may be further expanded in Southern Spain, which is investing in a regional supply chain, Greece and Italy (Sicily). Nevertheless, soil and water availability represent major constrains. Economic viability is also a concern and climate change may make the cotton cultivation in EU even more challenging. In addition, the European cotton production could not satisfy the European demand, which largely rely on the Asian production, more competitive also due to low labour costs.

The European cotton value chain suffers not only of low feedstock availability, but also of limited spinning, weaving and finishing capacity. Such intermediate steps are missing as, in the current market conditions, they are not viable. The recycling capacity is also very limited and should increase.

Structural investments and EPR schemes could help to tackle these issues.

Bast fibres production in EU

Despite climate change is making their cultivation more challenging, flax and hemp are currently produced in Europe. Hemp is a versatile plant, easy to grow – even on contaminated soils - and harvest on big surfaces, used in both textiles and other applications. Industrial hemp has a high impact profile and a variety of uses. Further high potential bast fibres are ramie, hop, kenaf, sisal, cardoon, cattail stem fibre, nettle, banana fibres, sunnhemp, Japanese knotweed, sunflower stem fibre. Bast fibres cultivation could be further introduced in crop rotation systems.

The European flax/linen industry rely on a premium niche. Besides, the traditional flax production basin could be affected by climate change, and diversification is not optional anymore. Expertise and knowledge transfer from flax cultivation to other bast fibres cultivation should be promoted.

In general, specific agricultural and processing know-how, capacities and technologies have space

for improvement. Nevertheless, many high TRL solutions for both sourcing bast fibres and use them in the textile and composites production are already available.
The European bast fibre value chain deals with limited feedstock availability and lack of production facilities, in particular processing infrastructures for extraction and refining, but also harvesting tools, scotching/decortication facilities, wet spinning and weavers' equipment as well as efficient, low impact and scalable cottonisation technologies. Retting technologies should be further developed, as less weather dependent retting process could ensure consistency of fibre quality. Low investments, competition of the building materials and composites industries and limited consumer acceptance are also hindering a wider use of bast fibre in textiles at European level. Many solutions could allow to overcome these obstacles, ranging from certification schemes for cultivation and traceability of flax and hemp, to coordinated initiatives to establish local supply chains or facilitate the industrial scale up. In fact, the bast fibres production should find synergies with final manufacturers and apparel brands, to get more in touch with consumers. Big industrial players can also play a role, driving the demand for large volumes.

Wool production in EU
Despite sheep farming and pastoralism are historically well known and still present in Europe, most wool available in the EU is not suitable for garment applications. For this reason, Europe largely rely on wool imports (e.g. from New Zeeland). European wool, rather than incinerated, could be used to produce technical textiles.

Bio-based MMCFs production in EU
Bio-based MMCFs production can take advantage of a variety of feedstock - not only wood from forests but also from eucalyptus, willow, poplar, wood residues and other residue streams. Further potential feedstock includes barley, sugarcane, rice straw, wheat straw, pineapple, banana, waste from pulp and paper industry, food and feed residues or invasive plants like Japanese knotweed.
Europe has a good industrial capacity for MMCFs production, with large-scale production facilities. Consumer acceptance is not an issue for viscose, lyocell and tencel. Nevertheless, the market volume of bio-based MMCFs is still very small. Recycling shows a high potential for further development.

Bio-based synthetics production in EU
The bio-based synthetic fibres are an alternative to fossil-based ones, which can reduce CO_2 emissions. Their impact on microplastics pollution should be further investigated. PLA, PHA, PBT, bPET, bPTT, bPE and bPU can be produced from sustainable feedstock such as lignine and secondary biomass. There is a large space for development, as the available technologies are currently at TRL 4 or 5. Production capacity and expertise in efficient conversion of biomass into bio-based synthetics is still limited.

Alternative approaches for polyester (PET)
Once phased out fossil resources, alternatives for polyester (PET) use in textile could include other polyesters (bPET, PEF, PBT), MMCFs, bast fibres and fibre to fibre recycling.

Microfibre/microplastics
Microplastics pollution is a serious issue. A new generation of textiles, including MMCFs, could answer to the need of limiting microplastics pollution. Banning fibres releasing microplastics unless for specific applications may be a drastic solution. Tackling this problem could anyhow create some market space for alternative crops cultivation and opportunities for farmers. Nano-

fibres and nano-plastics from production and use should also be considered. Solid calculation methods shall be put in place.

Land use

Textiles fibres cultivation will compete for land availability with other sectors. Policy makers will decide on priority land use based on sustainability and economic viability. Sustainability criteria should apply not only to biomass for energy use, but also to other applications, such as textiles. Smart farming could offer an alternative. The textile sector should focus on the valorisation of agricultural and forestry residues as well as on algae biomass.

Further inputs

The European policy, in particular the Green Claims Directive and the EU Circular and Sustainable Textile Strategy, do not sufficiently recognise and promote the role bio-based textiles.
The EU Circular and Sustainable Textile Strategy focuses on recycled content (fibre-to-fibre, i.e. pre or post-consumer waste), leaving secondary biomass behind.
The Product Environmental Footprint (PEF) methodology does not consider important positive aspects (e.g. biodegradability, reduction of microplastics) and advantages for farmers, soil health and biodiversity that bio-based solution can bring. The Product Environmental Footprint Category Rules (PECR) could be reconsidered, improving comparability of synthetic and natural fibres, to ensure consumers are provided with correct information. LCA is a very important tool, but it also does not consider socio-economic aspects.

12. Conclusions and next steps

Valeria Magnolfi, Knowledge Management Officer - JRC.D.1 - Forests and Bioeconomy

The workshop enabled a fruitful discussion between European Commissions policy makers and external experts. The policy framework described by European Commission staff as well as the inputs on available feedstock process, current and future market trends, environmental impacts, trade-offs, knowledge gaps and policy needs, provided by the experts, will be elaborated in a dedicated technical report and summarised in the knowledge for policy brief on bio-based textiles (figure 10).

Figure 10: KCB deep dive on bio-based textiles timeline

Source: Presentation 2. Introduction to the KCB deep dive on bio-based textiles (see Annex 2)

Such information material will integrate the outcomes of this workshop, which contributed to a better understanding of a complex sector such as the bio-based textile sector.
To extend the possibility to provide inputs to experts who did not attend the workshop in person, the KCB created and launched a survey, including the questions discussed during the parallel sessions.

List of Annexes

Annex 1: Agenda
Annex 2: Presentations

Annex 1: Agenda

9.30-10.00	**0. Registration**
PART 1	Chaired by Valeria Magnolfi, Knowledge Management Officer – JRC.D.1 - Forests and Bioeconomy
10.00-10.10	**1. Welcome address**
	Peter Wehrheim, Head of Unit - DG RTD B.2 - Bioeconomy & Food Systems
10:10-10:20	**2. Introduction to the KCB deep dive on bio-based textiles**
	Valeria Magnolfi, Knowledge Management Officer - JRC.D.1 - Forests and Bioeconomy
10:20-10:35	**3. The bio-based textiles within the EU industrial policy**
	Cornelia Mohor, Policy Assistant - DG GROW G.1 - Tourism, Textiles
10:35-10:50	**4. The bio-based textiles within the EU environmental policy**
	Paola Migliorini, Deputy Head of Unit - DG ENV B.1 - Circular Economy, Sustainable Production & Consumption
10:50-11:05	**5. Ecodesign Sustainable Product Regulation (ESPR)**
	Carsten Wentink, Policy Officer - DG ENV.B.4 - Sustainable Products
11:05-11:20	**6. Break**
11:20-11:35	**7. Industrial innovation in the bio-based textile field**
	Simone Maccaferri, Project Officer - CBE-JU
11:35-11:55	**8. Bio-based textile sector: state of the art and potential role in the EU bioeconomy**
	Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery - WUR
11:55-12:15	**9. Knowledge gaps and opportunities for R&D in the bio-based textile sector**
	Mikael Skrifvars, Professor of Polymer technology - University of Borås
12:15-13:15	**10. Networking lunch**
PART 2	
13:15-15:45	**11. Parallel sessions**
	Working table on the potential role of the bio-based textile sector within the EU bioeconomy, chaired by Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery, WUR Working table on knowledge gaps and opportunities for R&D in the bio-based textile sector, chaired by Mikael Skrifvars, Professor of Polymer technology, University of Borås
15.45-16.15	**12. Wrap-up**
	Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery - WUR Mikael Skrifvars, Professor of Polymer technology - University of Borås
16.15-16.30	**13. Conclusions and next steps**
	Valeria Magnolfi, Knowledge Management Officer - JRC.D.1 - Forests and Bioeconomy

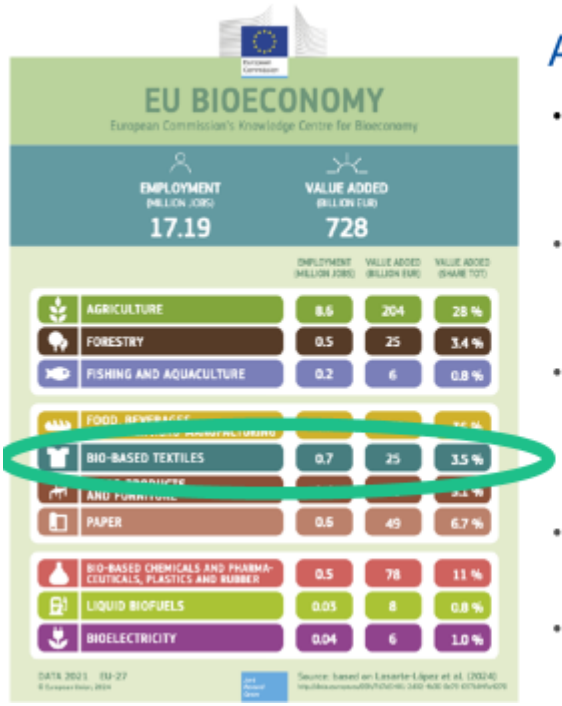
Annex 2: Presentations

What is the bioeconomy?

All sectors and associated services and investments that **produce, use, process, distribute or consume** biological resources (animals, plants, micro-organisms, including organic waste), including ecosystem services.

Three dimensions of sustainability

Five objectives



A key sector of the EU's economy

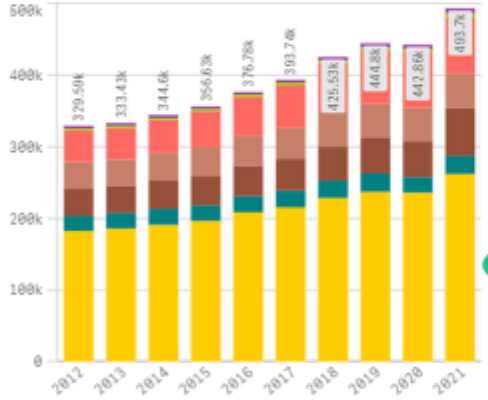
- Based on this definition the **bioeconomy is an important sector in the EU**: **8.2%** of the EU's workforce and **5.0%** of GDP
- The **bioeconomy's share in GDP is much higher** (10.4% for EU-28 in 2020), when including **bioeconomy services** (Ronzon WUR 2023)
- **High innovation potential** for sustainable / new biobased products through **biomanufacturing** (e.g. bio-based textiles, packaging, cosmetics, building material and services e.g. carbon farming)
- **Biobased textiles: 3.5% of the bioeconomy, 0.7 Mn jobs**
- **High job creation potential**, in rural and coastal areas

Growing importance of bio-based industries in the EU Bioeconomy

BB industries in EU*
- 7.9 million workers
- €494 billion of value added

*Construction and waste treatment are not accounted for

Development of value added in the bio-based industries between 2012 and 2021 in EU27 (mio €)



Bio-based chemicals (12.1 bn €)
Pharmaceuticals (62.0 bn €)
Plastics and rubber (3.8 bn €)
+ 4.9% compared to 2019

Paper (48.7 bn €)

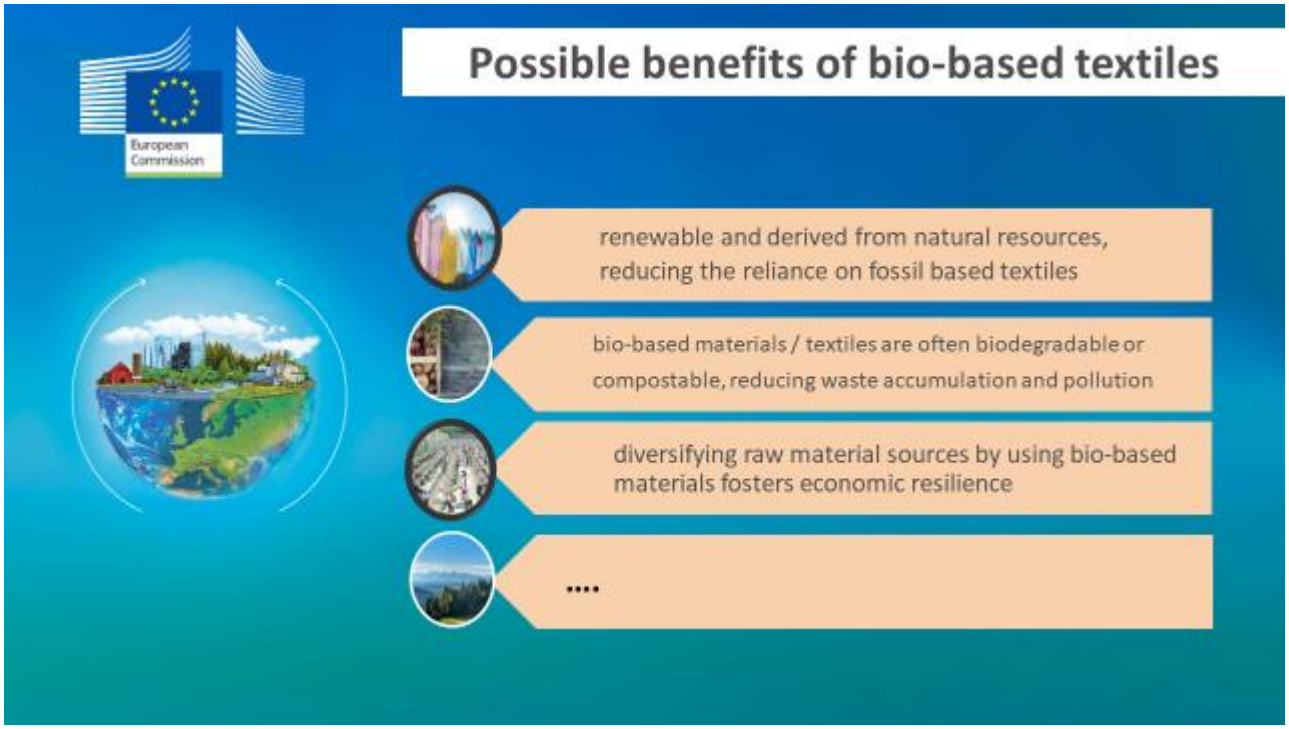
Wood products and furniture (66.3 bn €)

Bio-based textile (25.4 bn €)

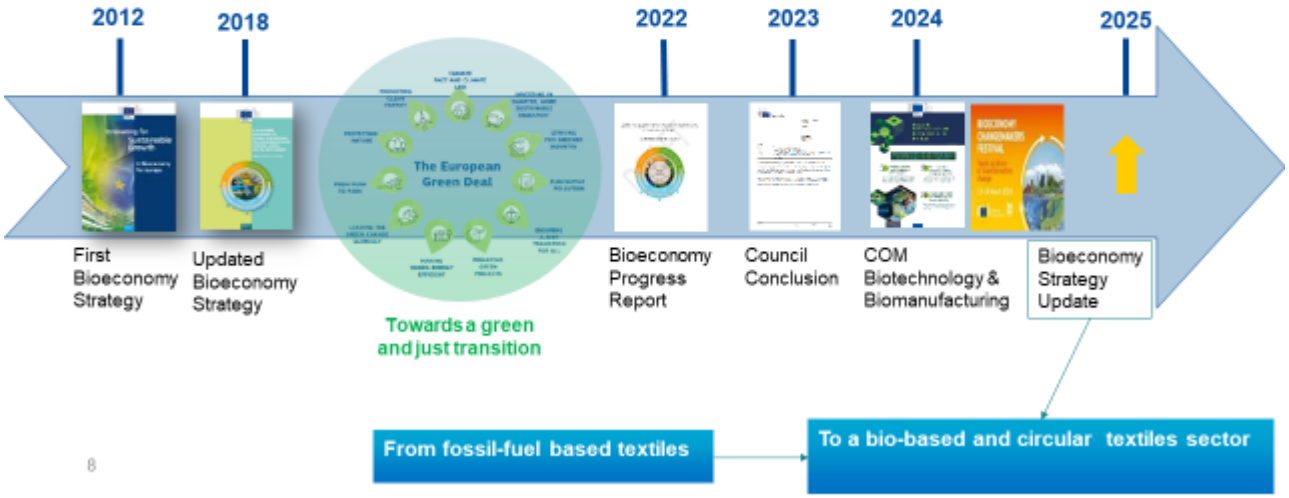
Food, beverage and tobacco (262.2 bn €)
+ 10.4% compared to 2019

Source: https://knowledge4policy.ec.europa.eu/bioeconomy/topic/economy_en

European Commission



Good timing for this workshop: Up-date of the EU Bioeconomy Strategy in 2025



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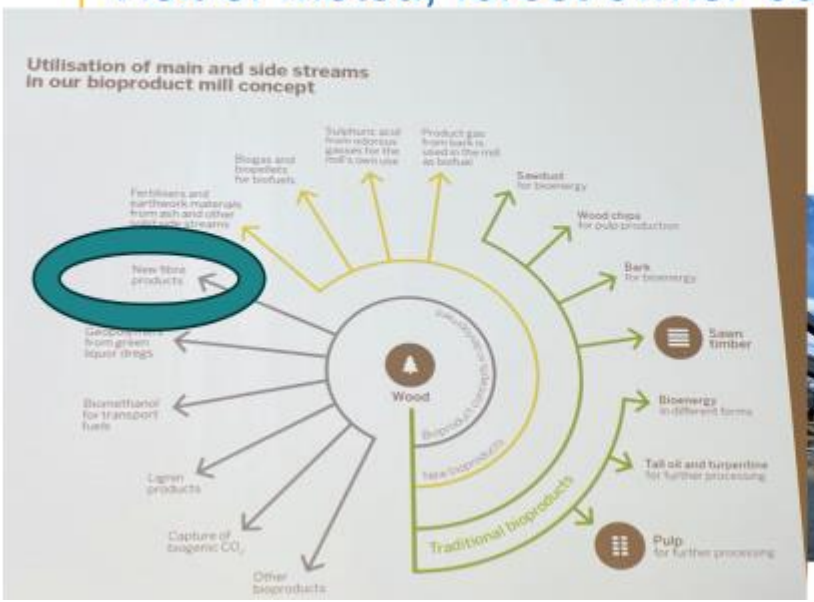
Visit of Metsä, forest owner cooperative



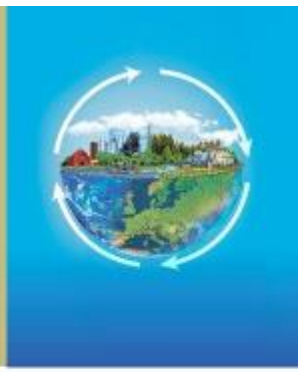
Wood-based textile fibre e.g.

- Kuura fibre from pine and spruce
- Tencel fibre from ecucalyptus

Thank you

More infor on EU bioeconomy:
https://knowledge4policy.ec.europa.eu/bioeconomy_en

Updates on events and policies via my LinkedIn account



European Commission

Introduction to the KCB deep dive on bio-based textiles

Valeria Magnolfi, Knowledge Management Officer - JRC.D.1 - Forests and Bio-Economy

Bio-based textiles - Expert workshop on latest research findings,market trends and policy needs

Brussels, June 26, 2024

Knowledge Centre for Bioeconomy

https://knowledge4policy.ec.europa.eu/bioeconomy_en

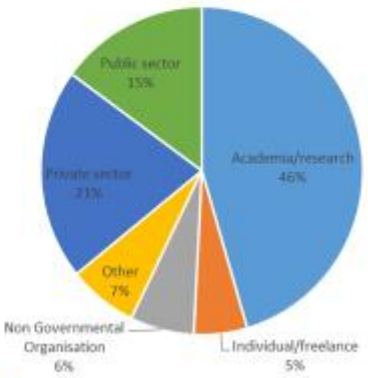
Knowledge Centre for Bioeconomy

Bringing together researchers, policymakers and **other experts** in the field.

The Community of Practice – Communication & Outreach

Period Sep. 2018 – Dec. 2023

Total no. subscribers: 162



To join the CoP bioeconomy: https://ec.europa.eu/knowledge4policy/cop_bioeconomy_en

Knowledge Centre for Bioeconomy

Analysing, synthesising and **communicating** available evidence.

Briefs, dashboards, videos

https://knowledge4policy.ec.europa.eu/visualisation/interactive-sankey-diagrams-woody-biomass-flows-eu-member-states_en

https://audiovisual.ec.europa.eu/en/video/I-224445?&lg=EN

https://knowledge4policy.ec.europa.eu/bioeconomy/topic/ecoanamy_en

https://knowledge4policy.ec.europa.eu/visualisation/bioeconomy-different-countries_en#algae_prod_plants

Deep dive on bio-based textiles

overall aim

- To analyse, synthesise data and up-to-date evidence on bio-based textiles
- To present and disseminate them through specific outputs (videos, briefs, data visualisations etc.), structure them in a user-friendly web-based format

expected final output

Bio-based textiles

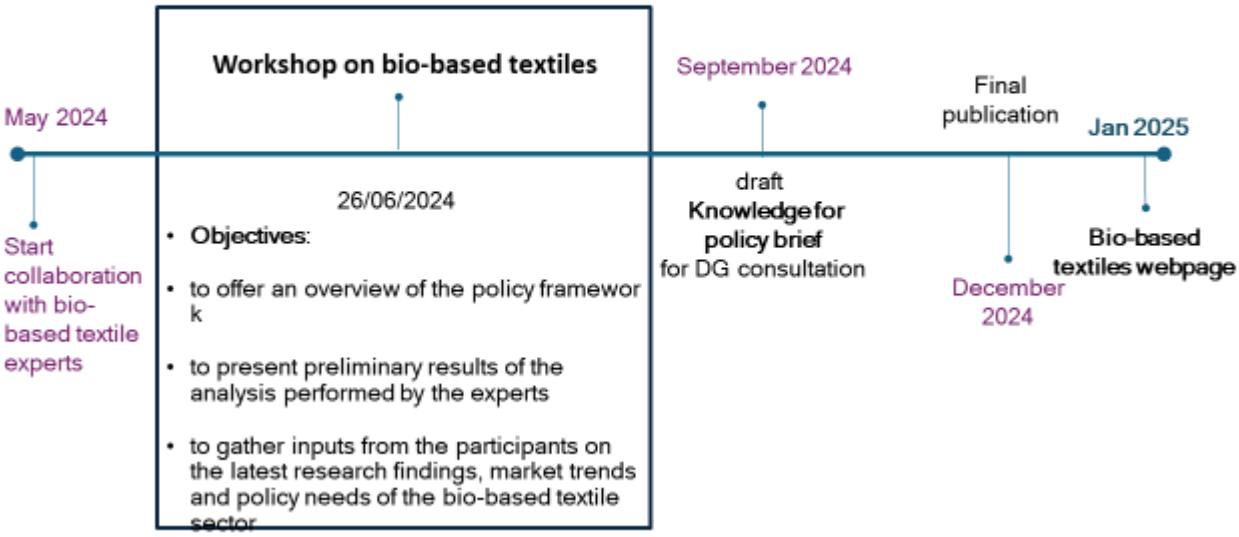
Access knowledge resources on bio-based textiles

Bio-based textiles are…

We can use them for…

The bio-based textiles production in the EU…

Deep dive on bio-based textiles



Thank you and enjoy the workshop!

EC Knowledge Centre for Bioeconomy website: https://knowledge4policy.ec.europa.eu/bioeconomy_en

Subscribe to the KCB Newsletter: https://ec.europa.eu/newsroom/know4pol/user-subscriptions/2358/create

Join the Community of Practice on bioeconomy: https://ec.europa.eu/eusurvey/runner/CoP_bioeconomy

Contact us at: EC-Bioeconomy-KC@ec.europa.eu

EU Science Hub
joint-research-centre.ec.europa.eu

Sustainable and Circular Textiles

- The policy and regulatory landscape for the industry has been fundamentally changing
- Package of policies and upcoming regulations are redefining how textile products are made, sold and consumed in the EU

Road to 2030: the vision of the EU Strategy for Sustainable and Circular Textiles

By 2030, all textile products placed on the EU market are:

- durable, repairable and recyclable
- to a great extent made of recycled fibres
- free of hazardous substances
- produced respecting social rights

Ecodesign Regulation

Binding performance Ecodesign requirements:

- Durability, reusability, repairability
- Fibre-to-fibre recyclability and recycled fibre content
- Minimise the presence of substances of concern
- Ban on the destruction of unsold clothing and footwear

Delegated Act for Textiles under preparation

Review of the EU Textile Labelling Regulation

- Aims to introduce mandatory disclosure of information
- Codes/symbols to identify fibres, leather/fur authenticity, origin, care, uniform size, allergenic substances and others

2021 updated Industrial Strategy

- Identifying textiles as a key product value chain
- The 'Transition Pathway for the Textiles Ecosystem' → production and uptake of new bio-based, recycled and renewable fibres is one of the areas where investments are most needed

Examples of commitments:

- sustainable textile fibre innovations
- new solutions for bio-colorant production and application for the textile industry
- develop fibres with a percentage of recycled materials

Research and Innovation gaps (Horizon Europe)

- Innovation of bio-based fibres in the textile sector to boost inter alia the development of novel types of textile fibres → applications for new textile fibre names under the EU Textile Labelling Regulation
- Innovative bio-based solutions to replace hazardous conventional chemicals in textile production

Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU

- The Communication summarises the current challenges and barriers for biotechnology and biomanufacturing and proposes actions to address these challenges in a timely manner, in line with the Communication on the Long-term competitiveness of the EU
- It also explores ways to foster engagement and collaboration, including through international dialogue and cooperation

Action 1: Simplified regulatory framework and faster access to market

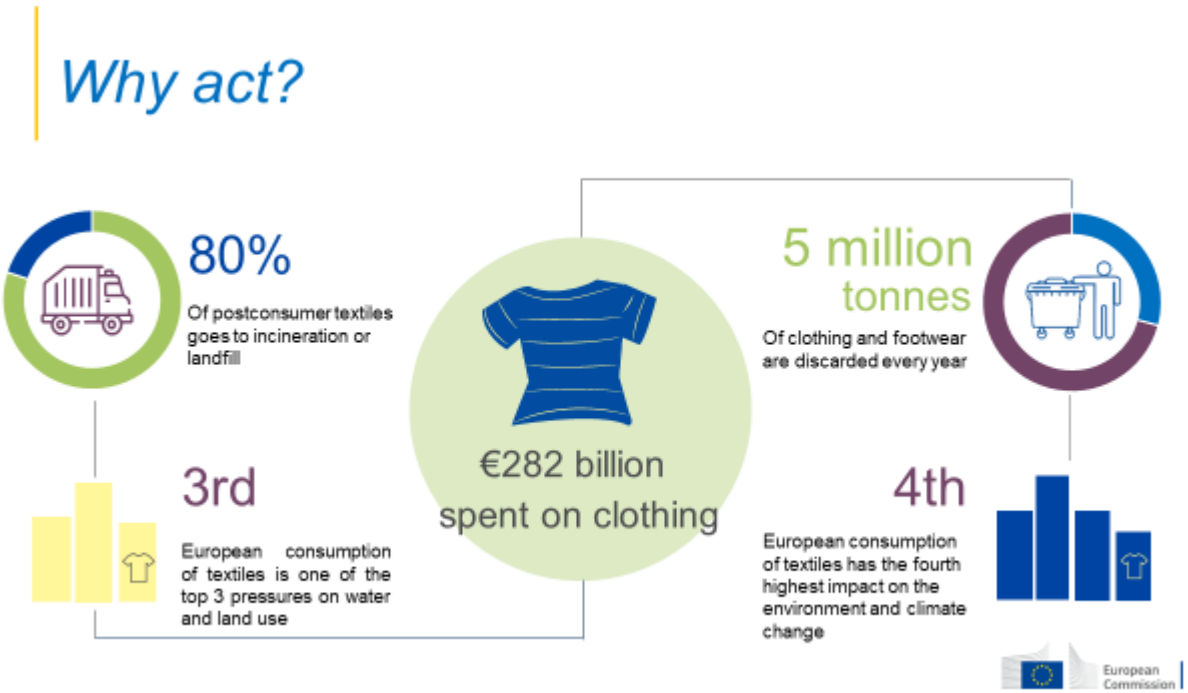
Streamlining regulatory pathways

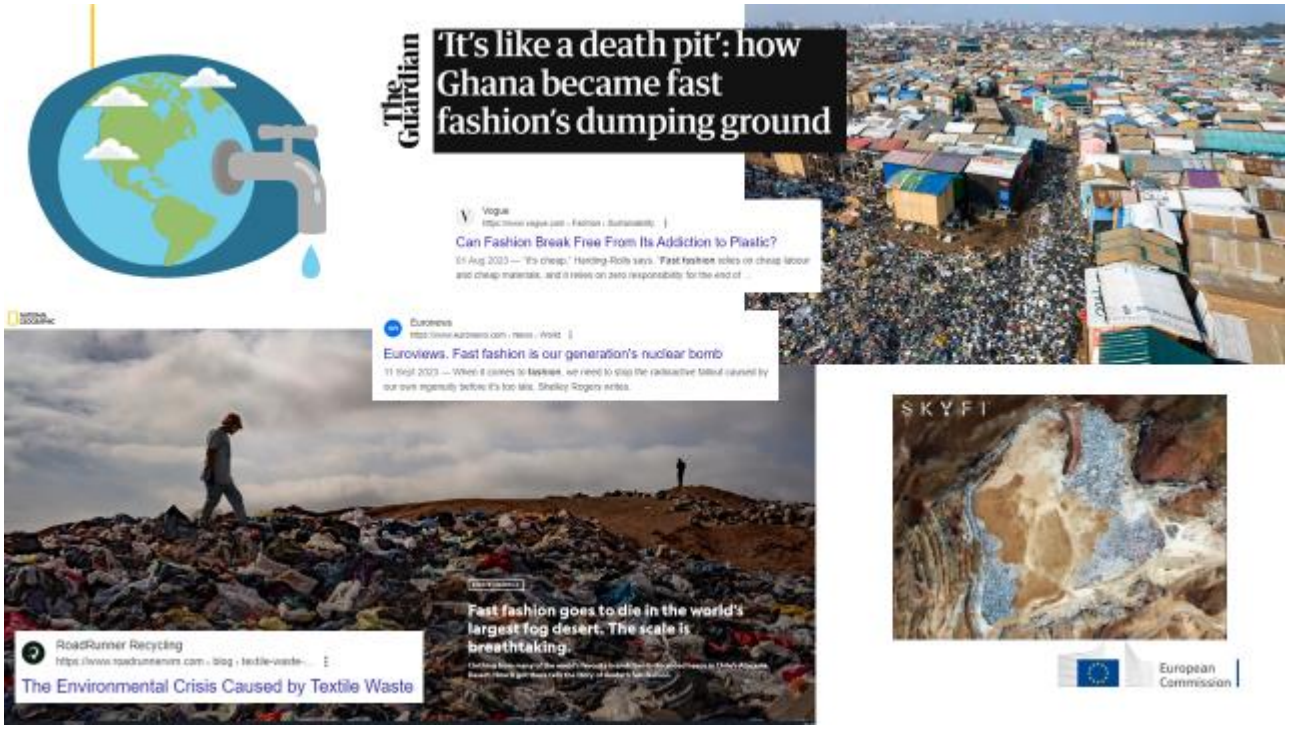
- Launch a **study** that will map key current industrial **bio-based value chains → textiles**
  - **Objectives** (amongst others)
    - Development and deployment of the bio-based industries in the EU and their challenges and opportunities
    - Identify the most relevant raw materials, both organic and inorganic, and intermediates, including bio-based intermediates (e.g., chemicals, polymers, natural polymers and compounds, etc.), that are currently imported into the EU and that could be replaced by sustainable bio-based resources/products of EU origin
    - Impact of legislation on biomass
  - **Timeline:** To be published during Q4/2025.

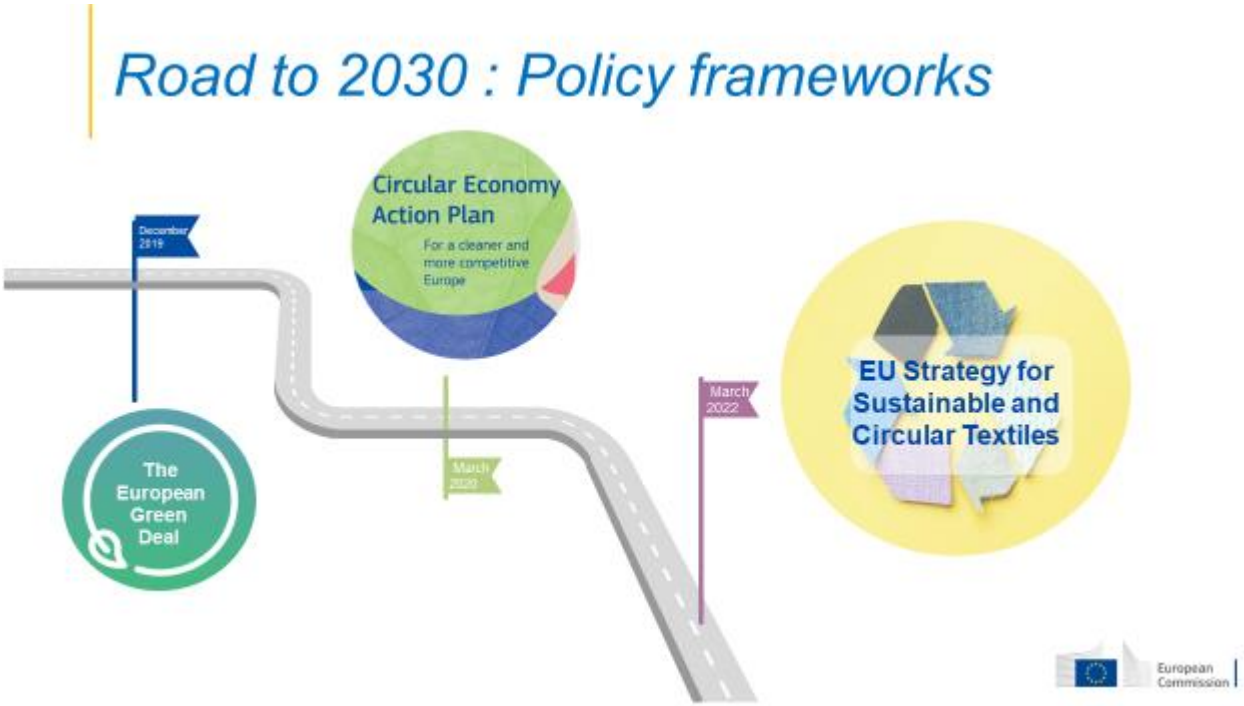
Streamlining regulatory pathways

- Launch a **study** analyzing how the **legislation that applies to biotech and biomanufacturing** could be further **streamlined across EU policies**
  - **Objective:** Exploring **targeted simplifications** to the regulatory framework
  - **Timeline:** Mid-2025


European Commission
Sustainable and Circular Textiles
Paola Migliorini
Deputy Head of Unit
Circular Economy, Sustainable Consumption and Production
DG Environment
European Commission


Why act?
80%
Of postconsumer textiles goes to incineration or landfill
3rd
European consumption of textiles is one of the top 3 pressures on water and land use
€282 billion spent on clothing
5 million tonnes
Of clothing and footwear are discarded every year
4th
European consumption of textiles has the fourth highest impact on the environment and climate change
European Commission


The Guardian
'It's like a death pit': how Ghana became fast fashion's dumping ground
Vogue
Can Fashion Break Free From Its Addiction to Plastic?
Euronews
Euroviews. Fast fashion is our generation's nuclear bomb
Fast fashion goes to die in the world's largest fog desert. The scale is breathtaking.
RoadRunner Recycling
The Environmental Crisis Caused by Textile Waste
SKYFI
European Commission


Road to 2030 : Policy frameworks
December 2019
Circular Economy Action Plan
For a cleaner and more competitive Europe
The European Green Deal
March 2020
March 2022
EU Strategy for Sustainable and Circular Textiles
European Commission

Road to 2030: the vision of the Strategy

By 2030, all textiles placed on the EU market should be:

- durable, repairable and recyclable
- to a great extent made of recycled fibers
- free of hazardous substances
- produced respecting social rights and the environment

"Fast fashion is out of fashion"

Profitable **re-use and repair services** are widely available

Producers take responsibility for their products along the value chain

Circular rather than throw-away clothes **have become the norm,** with sufficient capacities for **recycling** and minimal incineration and landfilling

European Commission

New measures, new rules

European Commission

New rules: design

DESIGN → USE → END OF LIFE

Ecodesign for Sustainable Products Regulation

Binding performance requirements:

- Durability, reusability, reparability
- Fibre-to-fibre recyclability and mandatory recycled fibre content
- Minimising and track the presence of substances of concern
- Microplastics release → Commission brochure on main sources of unintentional release of microplastics in the environment, including textiles

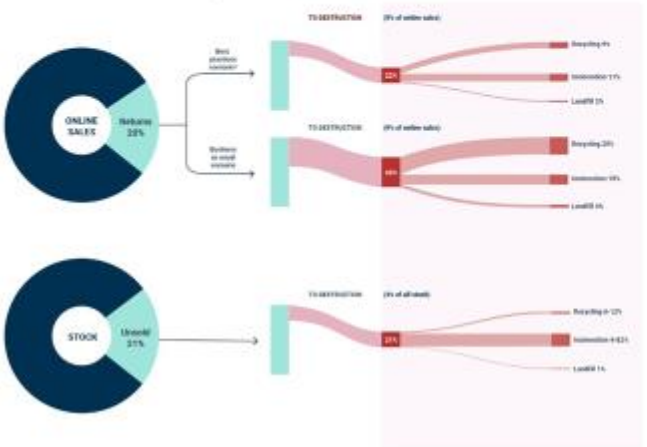
N.B. For all products on EU market (imported or not)

European Commission

New rules: design

DESIGN → USE → END OF LIFE

4-9% of clothing on the EU market are destroyed before use



Ecodesign for Sustainable Products Regulation

Prevention of destruction of unsold consumer goods

Transparency requirements for those discarding unsold goods, and possibility to ban their destruction for relevant product groups.

Ban on destruction of **apparel** and **footwear** after 2 years

European Commission

New rules: design

Process for adoption of new Ecodesign measures

- Working programme
- Start working on products
- Preparatory study & Impact Assessment
- Ecodesign Forum
- Adoption of ecodesign measures (18m)
- Measure applies

European Commission

New rules: use

Empower consumers to make informed purchasing choices and encourage truly sustainable business practices and products

- Information requirements + Digital Product Passport

EU Ecolabel www.ecolabel.eu

- Review of **EU Ecolabel** criteria for textiles – awarding excellence (from 2024)

- Revision of Textile Labelling Regulation

European Commission

New rules: use

DESIGN → USE → END OF LIFE

Empower consumers and tackle greenwashing

- Ban of generic environmental claims
- More visible guarantee information

Empowering Consumers in the Green Transition, in force since February 2024

- Ensuring voluntary environmental claims and labels are substantiated, verified and well communicated
- Introducing rules on public and private labelling schemes

Green Claims Directive, proposed March 2023

European Commission

New rules: end of life

DESIGN → USE → END OF LIFE

→ Upcoming obligation to establish separate collection of textile waste by 2025

WFD Targeted Revision

- Textile waste from households and similar waste is **prepared for reuse**
- Mandatory and EU-harmonised national **Extended Producer Responsibility** (EPR) schemes with eco-modulation of fees
- Promote research and development into innovative technologies for circularity
- Definition of textile waste VS re-usable textiles

Waste Shipment Regulation, 2021

European Commission

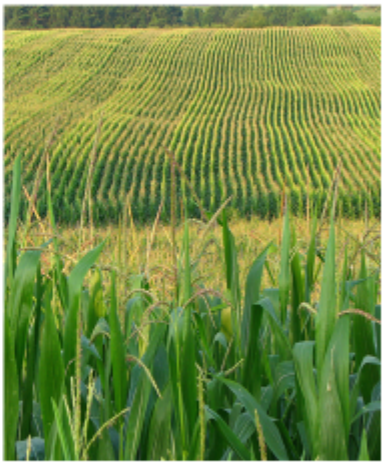
Biobased materials: an alternative?

Policy framework for biobased, biodegradable and compostable plastics – November 2022

- To **defossilise** industry, reducing our **dependency on fossil resources** & meeting our **climate neutrality targets**
- To **create jobs**

Challenges for textiles too!

- **Secondary** vs primary **biomass**
- Integrate the **cascading principle**
- **Sustainability criteria** to comply with:
  - RED III – for land use and biodiversity
  - For GHG – more research needed



European Commission

Thank you

European Commission

European Commission

Ecodesign for Sustainable Products

Bio-based textiles workshop

Carsten Wentink, DG Environment

Why Ecodesign?

Inefficient resource use & supply shortages/ dependencies

(Re)Align production & consumption with **planetary boundaries**

Create **new business models** & opportunities

European Commission

Why ecodesign for textiles? Vision of the Textile Strategy

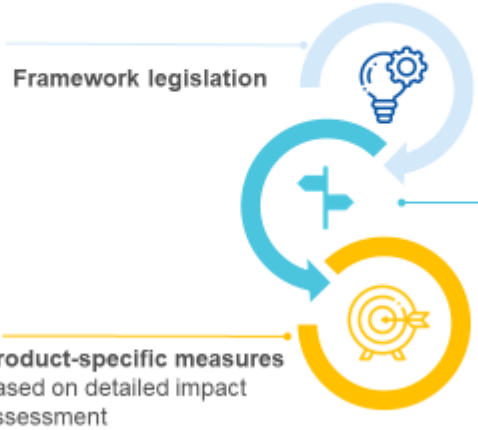
- By 2030, all textile products placed on the EU market are:
  - **durable, repairable and recyclable**
  - to a great extent **made of recycled fibres**
  - free of hazardous substances
  - produced respecting social rights **and the environment**
- "**Fast fashion is out of fashion**" - consumers benefit longer from high quality textiles
- Profitable **re-use and repair services** are widely available
- In a competitive, resilient and innovative textile sector producers take responsibility for their products along the value chain
- **Circular** rather than throw-away clothes have become the norm, with sufficient capacities for recycling and minimal incineration and landfilling

European Commission

How will ESPR work?
1. Establishing a **Framework legislation**

ESPR = framework legislation

i.e. does not set specific measures. Rather, it enables their later adoption



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How will ESPR work?

2. Novel Sustainability & Ecodesign approach

Broad Scope

Moving beyond energy-related products to a wide product scope

New sustainability & ecodesign aspects

e.g. Durability, CO_2 footprint, Recycled content, etc.

Horizontal measures

Common ecodesign requirements for products with similarities

Strong focus on product information

Digital Product Passport & Labels

European Commission

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Key Ecodesign aspects under ESPR

European Commission

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How will ESPR work?

3. By **adding new tools**

Mandatory Green Public Procurement

ESPR will enable mandatory GPP criteria to be set for contracting authorities or contracting entities

Prevention of destruction of unsold consumer goods

Transparency requirements for those choosing to discard unsold goods, and ban on destruction of unsold textile products.

Market surveillance and customs controls

Strong focus on controls of regulated products, including planned market surveillance activities, support to common projects and investments.

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Two types of ecodesign requirements

Article 5

General framework for adoption of ecodesign requirements (including product-specific and horizontal measures)

Article 6

Performance Requirements

Article 7

Information Requirements

Article 8

Digital Product Passport

European Commission

Products listed in ESPR legal text for prioritization in the first working plan

INTERMEDIATES

- Iron & Steel
- (Prep Study started)

- Chemicals

- Aluminum

FINAL PRODUCTS

- Textiles, notably garments and Footwear

- Furniture & Mattresses

- Energy related products, including reviews

- Paints

- Information and communication technologies

- Detergents

- Tyres

- Lubricants

European Commission

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Next steps – first **working plan**

Art. 18 – Product prioritisation criteria

- Volume of EU sales & trade
- Need to review, adapt to changed technologies & market
- Internal Market & Economic resilience
- Value Chain Distribution of Impacts
- Contribution to EU climate, environmental and energy objectives
- Improvement potential without dis-proportionate costs

European Commission

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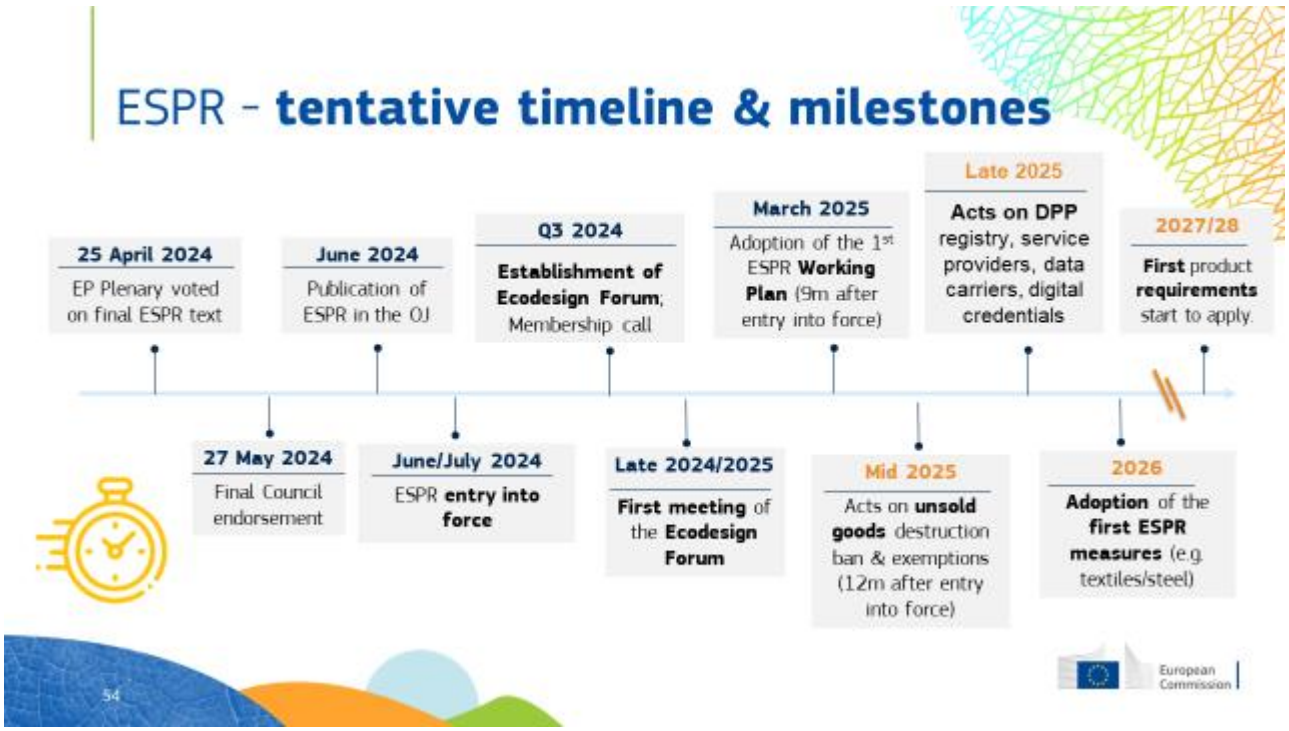
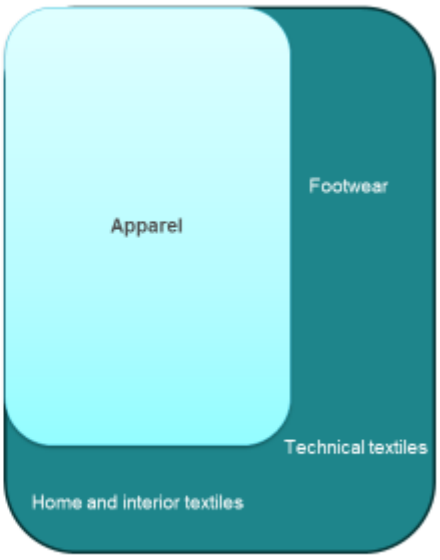

ESPR – tentative timeline & milestones
25 April 2024
EP Plenary voted on final ESPR text
27 May 2024
Final Council endorsement
June 2024
Publication of ESPR in the OJ
June/July 2024
ESPR entry into force
Q3 2024
Establishment of Ecodesign Forum, Membership call
Late 2024/2025
First meeting of the Ecodesign Forum
March 2025
Adoption of the 1st ESPR Working Plan (9m after entry into force)
Mid 2025
Acts on unsold goods destruction ban & exemptions (12m after entry into force)
Late 2025
Acts on DPP registry, service providers, data carriers, digital credentials
2026
Adoption of the first ESPR measures (e.g. textiles/steel)
2027/28
First product requirements start to apply.
54
European Commission


ESPR - next steps and process
Start working on product
Preparatory Study & Impact Assessment
1.5-2 years
Consultation of Ecodesign Forum
Adoption of Measure
18 months
Measure applies
Stakeholder input collected throughout
55
European Commission

Textiles under ESPR

- Textile products to be covered by ecodesign requirements will be determined by the **ESPR working plan**
- A preparatory study has already been launched in anticipation of the working plan and based on commitments in the textile strategy.
- The preparatory study focuses on **apparel (including clothing accessories)**
- **Other textile and footwear products** will still be considered for inclusion in the ESPR working plan.



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A preparatory study as basis for impact assessment

Tasks based on MEErP	Content
Task 1 – Scope	- Overview of regulations, **standards**, voluntary schemes - **Scope** and definitions proposal
Task 2 – Market	- Description of market of products in scope
Task 3 – Users	- Consumer behaviour in relation products in scope
Task 4 – Technology	- Technical description of products in scope - Description of technical aspects with influence on environmental performance → **product aspects** - Proposal of base cases and best available technologies
Task 5 – Environment and economics	- Environmental and economic assessment of base cases (environmental impact assessment, lifecycle costing)
Task 6 – Design options	- Proposal of design options based on best available technologies - Environmental and economic assessment of best available technologies
Task 7 – Scenarios	- Evaluation of potential policy options for textiles - Scenario analysis and recommendations

Possible ecodesign requirements for textiles

How to operationalize? – Standardization needs?

- Durability → Color fastness? Fabric resistance to pilling and abrasion? Dimensional change due to washing?
- Reparability → Ease of separation of materials?
- Recycled content → fiber to fiber? Chain of custody systems
- Environmental impacts → PEFCR?
- Etc

Performance and/or information requirements

Trade-offs

- *Durability vs recyclability, recycled content vs comfort, etc*

Scope

- *Apparel as likely focus of first DA*

To be determined through preparatory study and impact assessment

European Commission

Thank you

European Commission

Circular Bio-based Europe
Joint Undertaking

Industrial innovation in the bio-based textile field

Simone Maccaferri
Project Officer
Brussels, 26 June 2024

Circular Bio-based Europe
A competitive bioeconomy for a sustainable future

Circular Bio-based Europe Joint Undertaking

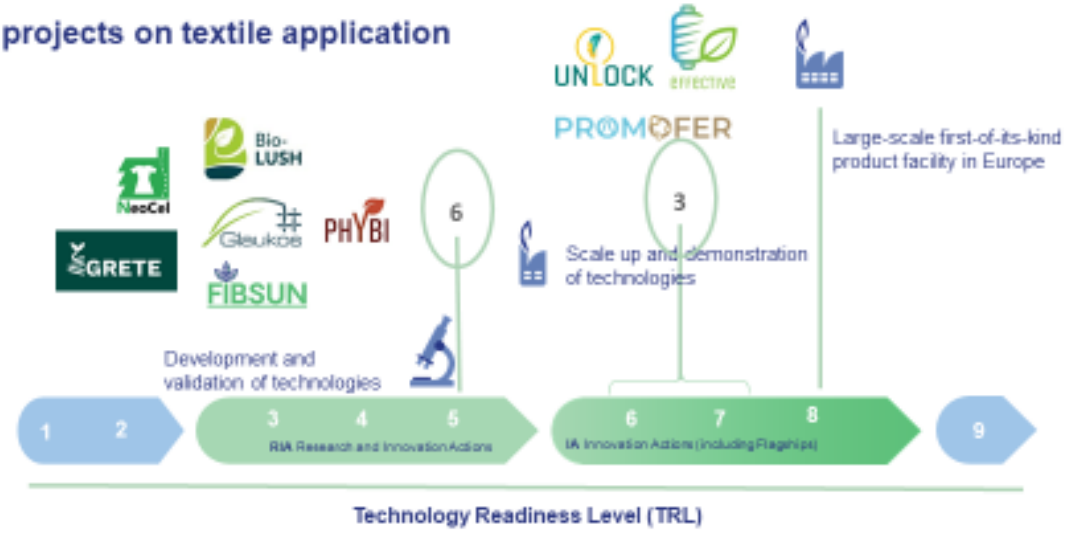
€2 billion public-private initiative

CBE JU is funding projects that deliver bio-based solutions – materials and products made from waste and biomass – in an innovative, sustainable and circular way

- Contributing to the European Green Deal
- Part of Horizon Europe, the EU R&I funding programme
- Building on the success of its predecessor BBI JU
- Launched in 2021, operates until 2031

02

CBE projects on textile application



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What is CBE JU textile portfolio about?

1. **Alternative fibres source and feedstock suitability, availability and sustainability**
2. **Biorefinery innovation** (i.e., exploitation of side streams, processing of post-consumer biowaste, cellulose extraction, etc.)
3. **Additives, finishings & coatings**
4. **End-of-life (EoL) management of bio-based textile**

Some examples of CBE JU projects

1. **EFFECTIVE**
2. Glaukos
3. Bio-LUSH
4. FIBSUN
5. UNLOCK

EFFECTIVE - Advanced Eco-designed Fibres and Films for large consumer products from biobased polyamides and polyesters in a circular EConomy perspecTIVE (IA)

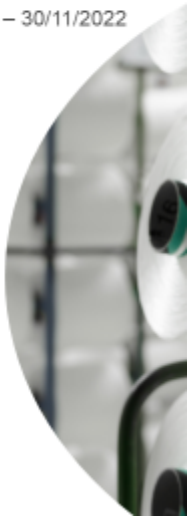
Project lead: AquafilSLO (Slovenia)
https://effective-project.eu

CBE JU contribution: € 7,2 M

Duration: 01/06/2018 – 30/11/2022

Main challenge:

Demonstrating the production of innovative bio-based polyamides and polyesters from sustainable feedstock and their validation into large consumers products (i.e. garments, carpets, films for food and non-food packaging applications).



1. Production of **sustainable sugar** and sourcing of **sustainable vegetable oils.**

2-3-4. **Biorefineries**: **conversion of sustainable feedstock into biobased polymers** (biobased polyamides and biobased & biodegradable polyesters) at pilot and demo/pre-industrial scale.

5. Transformation of biobased polymers into:
- **Textile yarns, fabrics, and garments and textile flooring prototypes** (biobased polyamide);
- **Films for packaging applications** (biobased polyamide and bio-polyesters).

6. **Closing the loop** in the material cycle through composting (compostable films from bio-materials), chemical recycling (bio-based Polyamide 6) and mechanical recycling (bio-based specialty Polyamide).

Some examples of CBE JU projects

1. EFFECTIVE
2. **Glaukos**
3. Bio-LUSH
4. FIBSUN
5. UNLOCK

Circular solution for the textile industry (RIA)

Project lead: Bio Base Europe Pilot Plant, Belgium
http://www.glaukos-project.eu/

BBI JU contribution: € 4,1 M
Duration: 01/06/2020 – 31/05/2024

Main challenge:

Develop innovative **textile fibres and textile coatings** with increased biobased content of textile products that reconcile an excellent environmental performance with adequate technical characteristics focusing on microplastic pollution prevention.

Objectives:

i) To produce *itaconic acid* as building block through fermentation of industrial side-streams

ii) To design and produce new polymers by finding the right balance between strength and biodegradability for the targeted applications

iii) To create bio-based yarns with balanced spinnability, durability, biodegradability

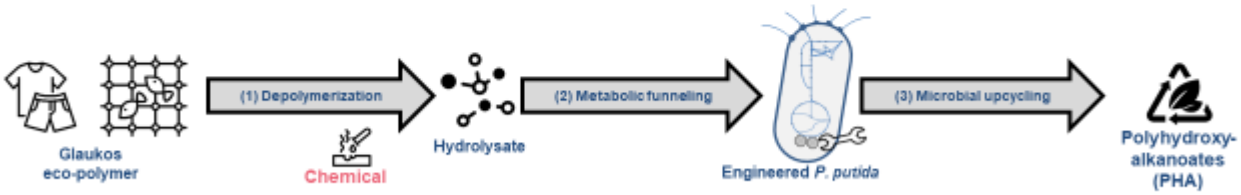
End-of-Life option: Bio-recycling

Challenge:

- Environmental degradation is a "last resort" option, ideally, materials are kept in the circular economy

Glaukos solution and outcomes:

- New plastic-degrading "nylonase" enzymes
- Engineered microbes that can use plastic as feedstock
- Demonstrated degradation of polymers back to monomers, and microbial upcycling of nylon



Glaukos clothing and gear prototype






Some examples of CBE JU projects

1. EFFECTIVE
2. Glaukos
3. **Bio-LUSH**
4. FIBSUN
5. UNLOCK

Biomass valorization for sustainable and high-quality fiber materials (RIA)

Project lead: University of Stockholm, Sweden
https://biolush.eu/

CBE JU contribution: € 4,5 M

Duration: 01/05/2023 – 30/04/2027

Main challenge:

By revitalizing marginalized areas and promoting circular biomass valorisation, Bio-LUSH unlocks the **hidden potential of European plant resources**, such as forest residues, marine plants, and weeds, extracting high-quality fibers from them.

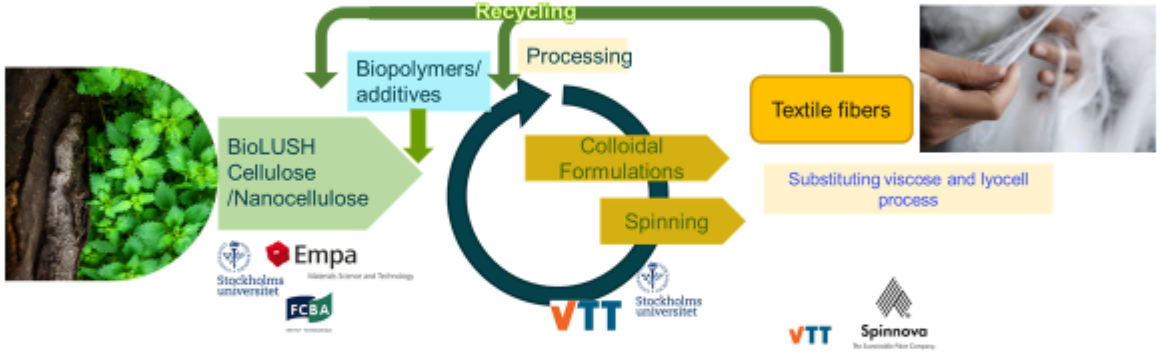
Objectives:

i) Develop a **flexible, "green/clean" process for converting high-value biomass** from secondary sources and underexplored plant resources, reducing environmental impact.

ii) Demonstrate market entry potential for high-quality fibers in **textile, food packaging and composites**, promoting sustainable bio-based products.

iii) Measure the impact of biobased fibers on reducing reliance on fossil resources in European manufacturing,

BioLUSH Textile Fiber Road Map



- Poplar and nettle as feedstock
- Antimicrobial fibers with dry and wet strength
- Recyclable textile fibers

Strategies to introduce antimicrobial property into fibers

1. Utilizing lignin nanocellulose
2. Using antimicrobial agents from eg. nettle to the spinning dope
3. Post surface treatment of fibers after spinning

Some examples of CBE JU projects

1. EFFECTIVE
2. Glaukos
3. Bio-LUSH
4. **FIBSUN**
5. UNLOCK

Novel fibre value chains and ecosystem services from sustainable feedstocks (RIA)

FIBSUN

Project lead: LUKE, Finland

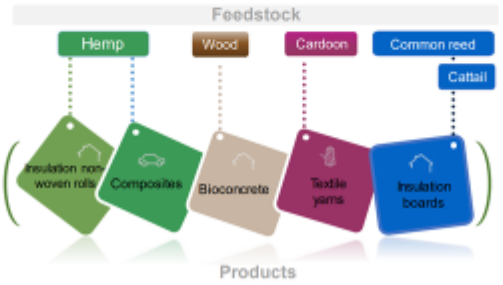
https://www.fibsun.eu

CBE JU contribution: € 4,5 M

Duration: 01/06/2023 – 31/05/2027

Main challenge:

FIBSUN aims to support the development of resilient and competitive production systems and enhanced provision of **ecosystem services from degraded soils** through five sustainable fibre value chains for construction, automotive and textile sectors.



Value chain for cardoon/processing of cardoon

Cardoon production
- Farming
- Cardoon harvest
- Separation part plants

Processing of plants
- Drying
- Mechanical decortication
- Re-wetting
- Drying
- Fibers characterisation

Development of textile yarns
- Fiber processing
- Yarn processing

FIBSUN aims to **promote soil improvement** by using novel crop plants.

Cardoon has important characteristics, while providing ecosystem service:

Strength
Flexibility
Lightweight
Biodegradability
Availability

food for sustainability

Tearfil Textile Yarns

Some examples of CBE JU projects

1. EFFECTIVE
2. Glaukos
3. Bio-LUSH
4. FIBSUN
5. **UNLOCK**

Unlocking a new feather bioeconomy for keratin-based agricultural products (IA)

Project lead: CIDETEC, Spain

BBI JU contribution: € 5,1 M

https://unlock-project.eu/

Duration: 01/05/2021 – 30/04/2025

Main challenge:

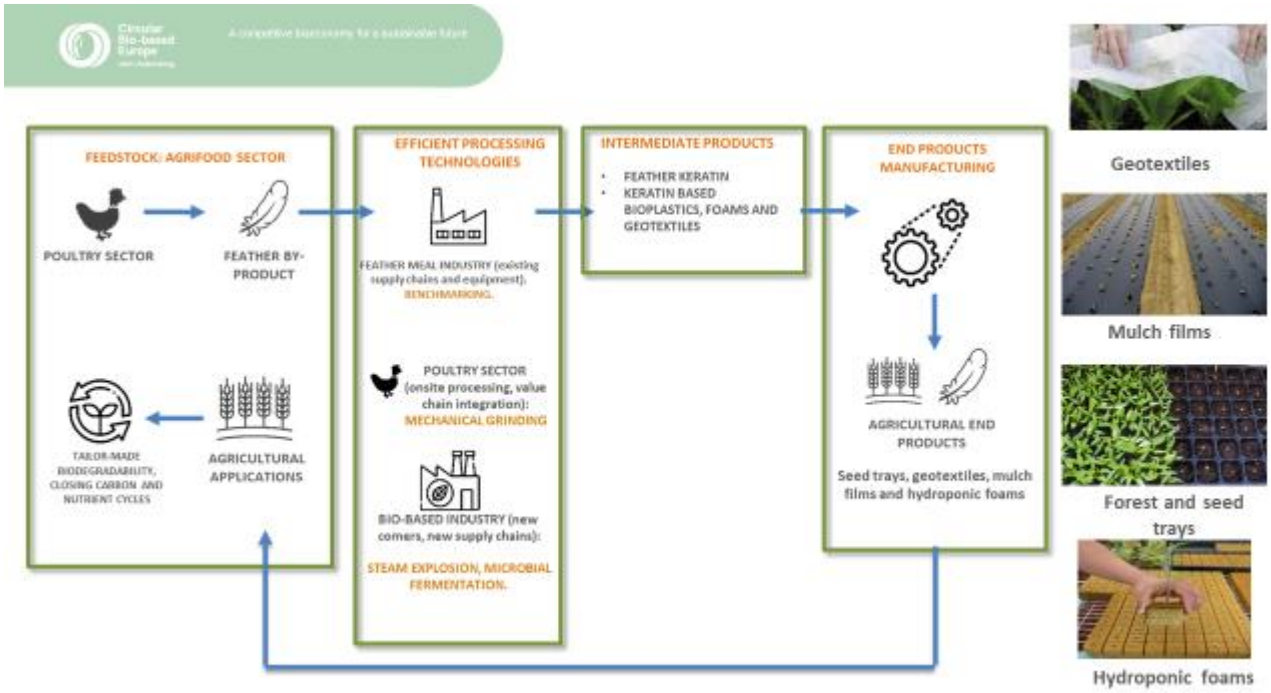
Design and demonstrate an economically and environmentally sustainable supply-chain for a feather-based bioeconomy which will generate innovative functional materials for agricultural applications

Objectives:

i) Optimise **feather conversion technologies**

ii) **To generate innovative bio-based functional materials** for agricultural applications with significant advantages derived from the use of feather keratin: i) tailor-made biodegradation, ii) input on organic nitrogen to soil, iii) zero waste generation at their end of life and iv) cost competitive materials.

iii) **To manufacture feather-based end-products for agricultural sector**

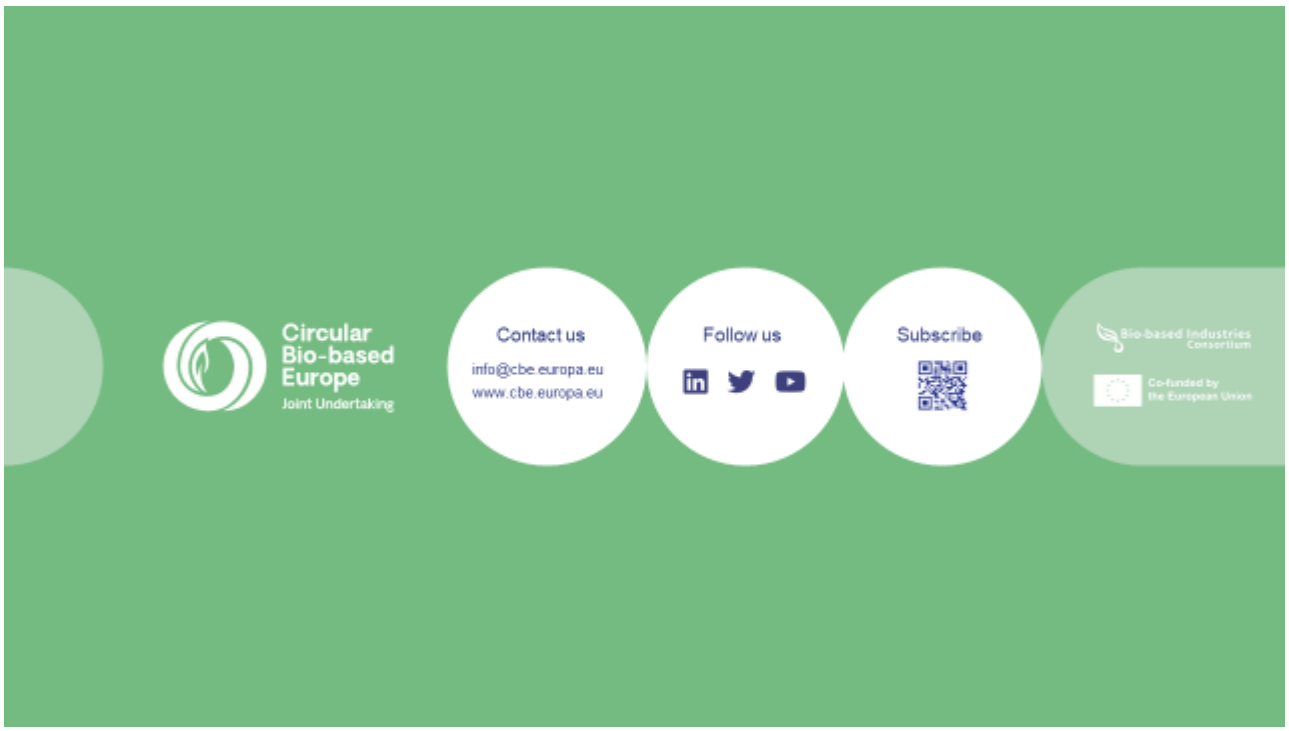


Future outlooks for the textile portfolio

1. **Upscaling the TRL of novel fibres biorefineries**

2. **Enhancing or adapting functionalities, processes, and pilot manufacturing of existing bio-based fibers, including those of synthetic origin**

3. **Upscaling and broadening the scope of innovative bio-based chemicals and processes to substitute hazardous chemical/coatings/additives**

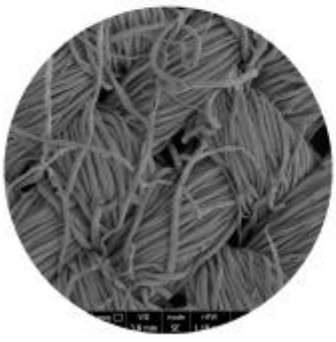


Biobased textile sector

State-of-the-art and potential role in the EU bioeconomy

26-06-2024, Brussels

Paulien Harmsen, Senior Scientist Sustainable Textiles & Biorefinery - WUR



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What is biobased textile?

Textile industry: 3 value chains to produce 3 fibre types

1 Natural fibres	2 Semi-synthetic fibres	3 Synthetic fibres
Biobased **fibres** of biological origin formed by plants, animals	Man-made fibres of biobased **polymers** (cellulose), often called regenerated cellulose fibres or MMCFs	Man-made fibres made by polymers build up from **monomers** (fossil or biobased)
Resources: Produced by farmers that produce fibre crops or breed animals for their hairs	Resources: Produced by forests owners that produce wood	Resources: Mainly fossil oil, but also biobased options
Fibres: Cotton, flax, hemp, wool etc	Fibres: Viscose, lyocell, cupro etc.	Fibres: Polyester(s), polyamide(s), elastane etc.

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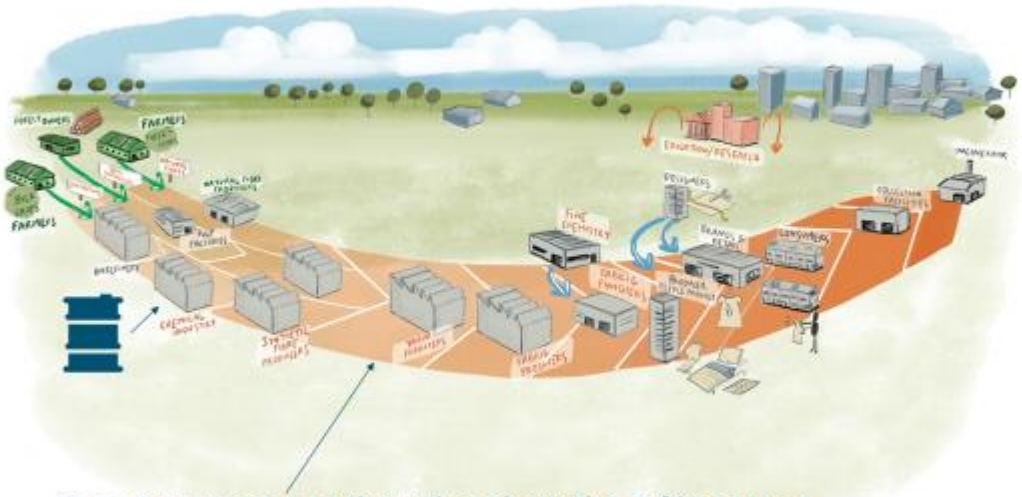
3 Value chains – 3 Fibre types



At a certain point in the value chain the 3 fibre types come together in the creation of textiles

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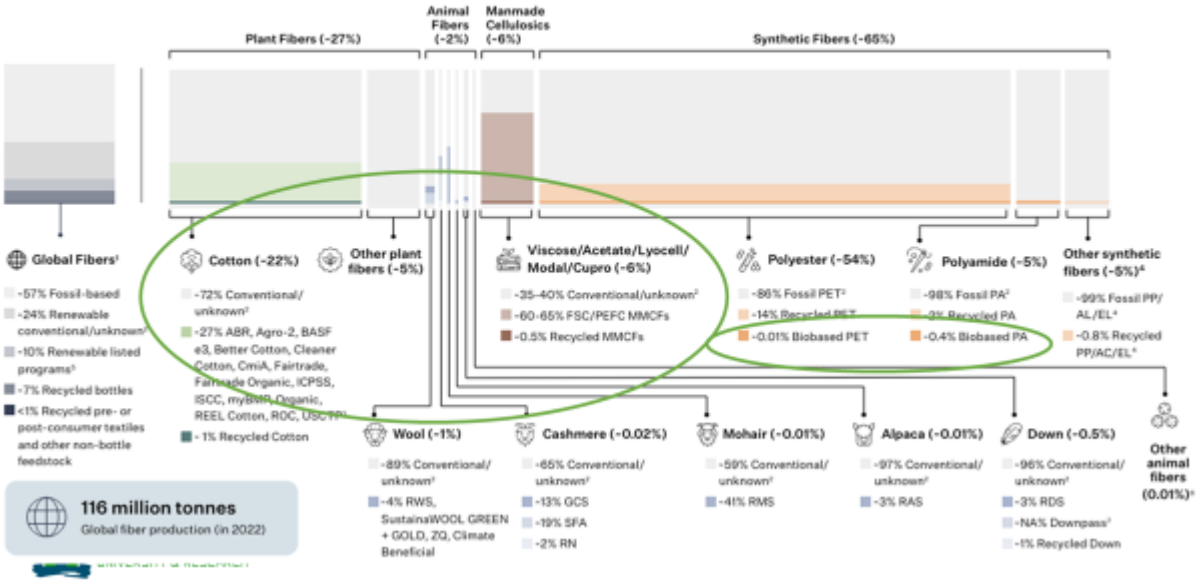
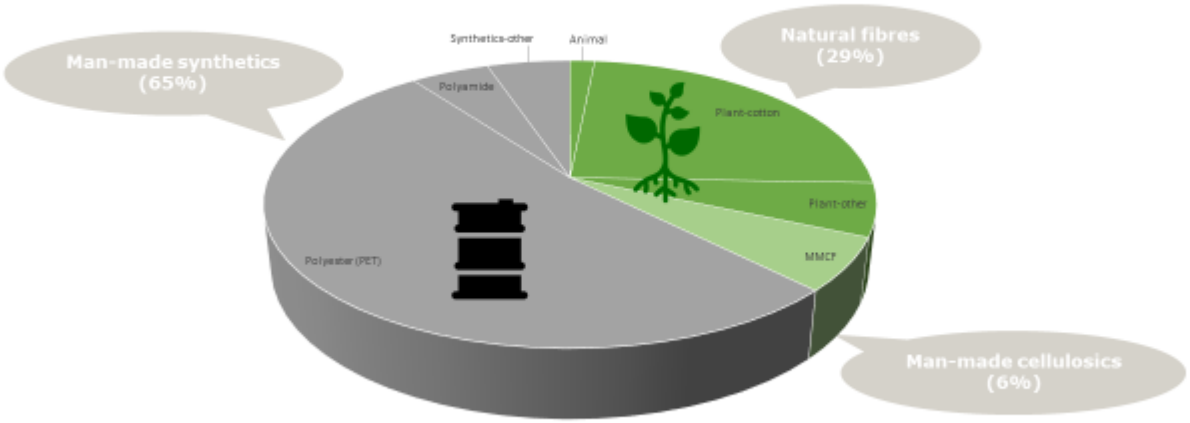
The global fiber market 2022: Program overview[2]



Resources for textile fibres

Worldwide fibres 116 Mtons/y (2022)



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Textiles are made of carbon

- From fossil carbon to renewable carbon:
  - How and where do we source the carbon-based feedstock?
- What needs to change in production and use of textiles to make them circular?

Harmsen, P., W. Post and H. L. Bos (2022). *Textile for circular fashion. Part 2: From renewable carbon to fibres.* Wageningen, Wageningen University & Research.

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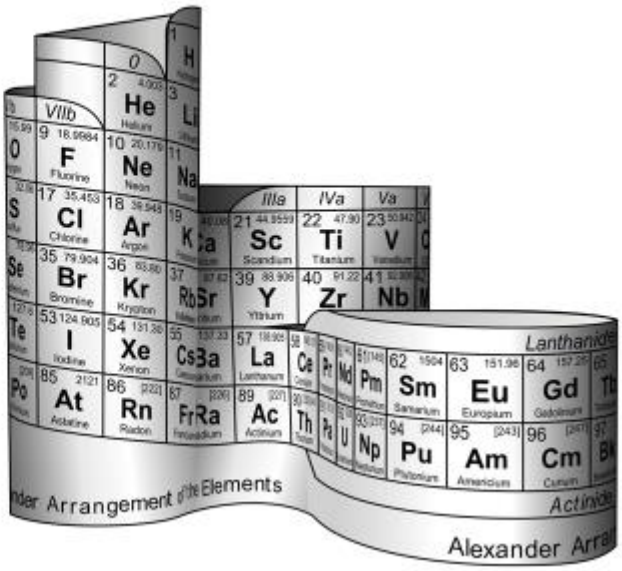
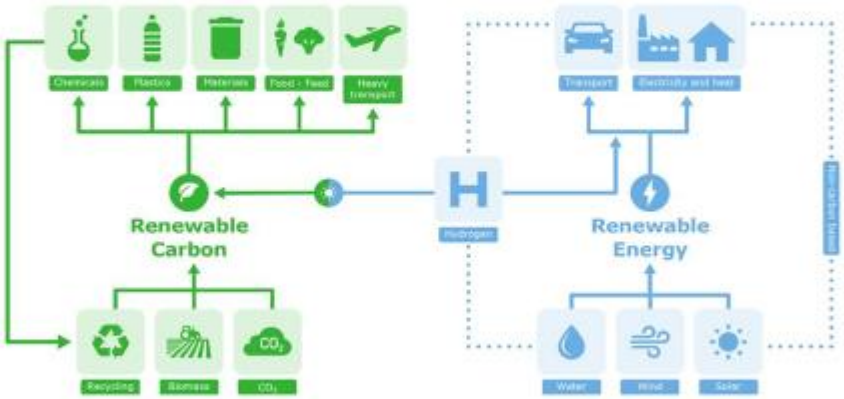


Sources of renewable carbon

TRANSFORMATIVE Bioeconomies

Towards a materials transition that phases out fossil feedstock

Renewable Carbon for a Fossil Free society



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Carbon sources for future circular textile fibres

- For circular textiles we aim to
  - Reduce the use of (virgin) resources
  - Phase out fossil resources
  - Prevent the release of harmful microfibres to the atmosphere
- As renewable carbon source we have three options
  - Biomass
  - Recycled content
  - CO_2

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Today & Tomorrow

Today	Fossil	Biomass	Recycled	CO_2
Natural fibre	Not possible	Mature	In development	Not possible
Semi-synthetic fibre	Not possible	Mature	In development	Not possible
Synthetic fibre	Mature	In development	In development	In development

Tomorrow?	Fossil	Biomass	Recycled	CO_2
Natural fibre	Not possible	Mature	In development	Not possible
Semi-synthetic fibre	Not possible	Mature	In development	Not possible
Synthetic fibre	Mature	In development	In development	In development

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1 Natural fibres; common characteristics

- Production
  - Production start with farmers
  - Requires land, water, pesticides
  - Harvest is labour intensive
- Consumers
  - Cotton is accepted, bast fibres (linen, hemp) less attractive
  - Wool and other animal hairs less attractive for vegetarians/vegans
- Environment
  - Fibres are biodegradable

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Overview natural fibres

fibre name/Material	Explanation	fibre type	polymer class	specific polymer	sources
Abaca	A hard fiber from the leaf stems that form the trunk of the abaca plant, Musa textilis. Of the	Natural fibre	Polysaccharide	Cellulose	Biobased
Agave	A genus of plants native to the western hemisphere that has been distributed worldwide are	Natural fibre	Polysaccharide	Cellulose	Biobased
Alpaca	A domesticated cousin of the llama and a member of the camel family, native to the high An	Natural fibre	Polyamide	keratin	Biobased
Angora goat	A small, hardy animal that can find nourishment in rough brushland where other animals are	Natural fibre	Polyamide	keratin	Biobased
Angora rabbit	A breed of rabbit originally raised in North Africa and France and now raised in Great Britain,	Natural fibre	Polyamide	keratin	Biobased
Bamboo fibre	Fiber that can be produced from the bamboo plant grown in China, India, and Indonesia as w	Natural fibre	Polysaccharide	Cellulose	Biobased
Banana fibre	Fibers, which are obtained from plants of the banana family. Abaca, obtained from Musa text	Natural fibre	Polysaccharide	Cellulose	Biobased
Bast fibre		Natural fibre	Polysaccharide	Cellulose	Biobased
Camel	A large ruminant mammal used in the deserts of Asia and Africa as a pack animal and for ridir	Natural fibre	Polyamide	Keratin	Biobased
Cashmere	1. A fine, soft, downy wool undergrowth produced by the cashmere goat, which is raised in t	Natural fibre	Polyamide	Keratin	Biobased
Cotton	A vegetable seed fiber consisting of unicellular hairs attached to the seed of several species	Natural fibre	Polysaccharide	Cellulose	Biobased
Feather	Feathers are epidermal growths that form a distinctive outer covering, or plumage, on both a	Natural fibre	Polyamide	Keratin	Biobased
Flax	A slender annual plant, Linum usitatissimum, the bast fiber of which also is called linen. The	Natural fibre	Polysaccharide	Cellulose	Biobased
Hair	Used interchangeably with fiber in reference to vegetable and animal fibers. It is difficult to	Natural fibre	Polyamide	Keratin	Biobased
Hemp	A coarse, strong, lustrous bast fiber obtained from the inner bark of the hemp plant, Cannabi	Natural fibre	Polysaccharide	Cellulose	Biobased
Henequen	A hard leaf fiber obtained from the henequen plant, Agave fourcroydes, of the Amaryllidace	Natural fibre	Polysaccharide	Cellulose	Biobased
Hop fibre	A bast fiber obtained from the stems or vines of the hop plant, Humulus lupulus. It is woven	Natural fibre	Polysaccharide	Cellulose	Biobased
Jute	A bast fiber obtained from the round pod jute, Corchorus capsularis, or the long pod jute, Co	Natural fibre	Polysaccharide	Cellulose	Biobased
Kemp	A short, coarse wool or hair fiber with a large (>60% of fiber diameter), unevenly developed	Natural fibre	Polyamide	Keratin	Biobased
Kenaf	A soft bast fiber similar to jute, obtained from the inner bark of the kenaf plant, Hibiscus can	Natural fibre	Polysaccharide	Cellulose	Biobased
Linen	Linen is one of the oldest known textile fibers. Archeologists in the country of Georgia in 20	Natural fibre	Polysaccharide	Cellulose	Biobased
Llama	1. Lama glama, a ruminant animal native to the high Andean regions of southern Ecuador, Pe	Natural fibre	Polyamide	Keratin	Biobased
Milkweed	Milkweed plants, Asclepias incarnata and A. syriaca, yielding a floss and a bast fiber. The floss,	Natural fibre	Polysaccharide	Cellulose	Biobased
Mink	Fur or fiber from animals in the genus Mustela.	Natural fibre	Polyamide	Keratin	Biobased
Mohair	1. A long, white, lustrous hair obtained from the angora goat. It ranges from 4 to 12 in. (10 to	Natural fibre	Polyamide	Keratin	Biobased
Muskrat	Animal fiber from the muskrat, genus Ondrata, usable in textiles	Natural fibre	Polyamide	Keratin	Biobased
Nettle fibre	A fine, soft bast fiber obtained from two species of the stinging nettle, Urtica dioica and Urti	Natural fibre	Polysaccharide	Cellulose	Biobased
Palm fibre	Any fibers obtained from plants or trees of the palm family. See palmetto, palmyra, piassava	Natural fibre	Polysaccharide	Cellulose	Biobased
Pineapple fibre	A fine, strong, white, lustrous leaf fiber obtained from the pineapple plant, Ananas comosus.	Natural fibre	Polysaccharide	Cellulose	Biobased
Raffia	1. A leaf stalk fiber obtained from the raphia palm, Raphia ruffia, in the Democratic Republic	Natural fibre	Polysaccharide	Cellulose	Biobased
Rattan	A lightweight, very tough fiber obtained in strips from the woody stems of plants of the genu	Natural fibre	Polysaccharide	Cellulose	Biobased
Rubber, natural	A raw material (polyisoprene) obtained from the sap (latex) of the rubber tree (Hevea sp.). T	Natural fibre	Rubbers	Polyisoprene	Biobased
Sheep hairs	Ruminant quadruped mammal of the genus Ovis whose likely ancestry has been traced to th	Natural fibre	Polyamide	Keratin	Biobased
Silk	Continuous protein filament (fibroin) produced by the larvae of various insects, especially m	Natural fibre	Polyamide	Fibroin	Biobased
Sisal	A hard leaf fiber obtained from the sisal plant, Agave sisalana, of the Amaryllidaceae family.	Natural fibre	Polysaccharide	Cellulose	Biobased
Vicuña	The smallest species of South American camel family, the vicuña, Vuchenia vicugna, is native	Natural fibre	Polyamide	Keratin	Biobased
Wool	Traditionally, fibers covering the skin of sheep, Ovis sp. However, as defined in the Wool Pro	Natural fibre	Polyamide	Keratin	Biobased

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1 Natural fibres; challenges/gaps

- Cotton
  - Sustainable production
- Bast fibres
  - European crops, is growth possible?
  - Improve isolation of bast fibres (retting processes)
  - Invest in European processing facilities
- New alternatives
  - What are promising new crops that can grow in Europe?

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2 Semi-synthetic fibres; common characteristics

- Production
  - Production starts with forest owners or farmers
  - Requires land, water, pesticides?
  - Based on cellulose; mainly wood, but also other (fast growing) crops like bamboo can be used
  - Processing to cellulose pulp and spinning to fibres are chemical processes
- Consumers
  - No big issues, accepted by customers
- Environment
  - Fibres are based on cellulose and thus biodegradable

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Overview semi-synthetic fibres

Fibre name/Material	Explanation	fibre type	polymer class	specific polymer	sources
Cellulose, acetate		Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Cellulose, carbamate		Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Cellulose, cold alkaline		Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Cellulose, ionic liquid		Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Cellulose, microfibrillated		Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Lyocell	Generic classification for solvent-spun cellulosic fiber approved for use in the U.S. by the FTC	Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Milk fiber	Milk fibers are regenerated protein fibers made from a chemical substance and casein, whic	Semi-synthetic fibre	Polyamide		Biobased
Modal	British generic fiber category for manufactured fibers of cellulose having a high breaking stre	Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Rayon	A generic fiber category defined by the Federal Trade Commission as "a manufactured fiber	Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Rayon, Cuprammonium rayon (Cupro)	Rayon yarn or staple made by the cuprammonium process. It is a regenerated cellulose. In th	Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Viscose, wood	One of the three types of rayon and that which is produced in the greatest quantity and clive	Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased
Viscose, bamboo	Regenerated cellulosic fiber produced from bamboo.	Semi-synthetic fibre	Polysaccharide	Cellulose	Biobased

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2 Semi-synthetic fibres; challenges/gaps

- Use of land, water, pesticides
- Growth is possible, based on European crops
  - Invest in European processing facilities?
- Not only cellulose but also proteins can be processed into semi-synthetic fibres (e.g. based on milk protein)
  - Is there potential?

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3 Synthetic fibres; common characteristics

- Production
  - Mostly outside Europe
  - Starts with the fossil industry
  - Monomers and polymers are produced by the chemical industry
  - Dominated by one type of polyester (PET)
- Consumers
  - Attractive for consumers due to price, availability and performance
- Environment
  - Fibres are often not biodegradable, accumulate in nature (microplastics)

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Overview synthetic fibres

fibre name/material	explanation	fibre type	polymer class	specific polymer	sources
acrylic		synthetic fibre	Polyacrylic	Polyacrylic acid	Fossil (oil)
Aramide		Synthetic fibre	Polyamide	Aramid	Fossil (oil)
Elastane		Synthetic fibre	Polyurethane	Elastane	Fossil (oil)
Elastodiene	(British usage) A generic name for fibers of natural or synthetic rubber	Synthetic fibre			Fossil (oil)
Elastoester	A generic name for fiber defined by the FTC as at least 85% by weight aliphatic polyether and	synthetic fibre			Fossil (oil)
Elastomer	A synthetic rubbery material, which has the excellent stretchability and recovery of natural r	Synthetic fibre			Fossil (oil)
Fluoropolymer	Generic name for fiber defined by the Federal Trade Commission as "a manufactured fiber c	Synthetic fibre			Fossil (oil)
Micropolyester	more absorbent, breathable, and more comfortable.	Synthetic fibre	Polyester	polyethylene terephthalat	Fossil (oil)
Neoprene	A generic name for a type of synthetic rubber made from the monomer chloroprene. Can be	Synthetic fibre	Rubbers		Fossil (oil)
Nylon 11		Synthetic fibre	Polyamide	Nylon 11	Fossil (oil)
Nylon 4		Synthetic fibre	Polyamide	Nylon 4	Fossil (oil)
Nylon 6		Synthetic fibre	Polyamide	Nylon 6	Fossil (oil)
Nylon 6,12		Synthetic fibre	Polyamide	Nylon 6,12	Fossil (oil)
Nylon 6,6		Synthetic fibre	Polyamide	Nylon 6,6	Fossil (oil)
Nylon fibre	A generic fiber category defined by the federal trade commission as "a manufactured fiber i	Synthetic fibre	Polyamide		Fossil (oil)
Polyacrylate	Any addition polymer based on one or more esters of acrylic acid, CH2 =CH−COOR. Various po	synthetic fibre	Polyacrylate	Polyacrylic acid	Fossil (oil)
Polyacrylic acid	Addition polymer based on acrylic acid, CH2 =CH−COOH. Used as a water-soluble sizing mate	Synthetic fibre	Polyolefin	Polyacrylic acid	Fossil (oil)
Polyacrylonitrile (PAN)		synthetic fibre	Polyacrylic	Polyacrylonitrile	Fossil (oil)
Polybutadiene		Synthetic fibre	rubbers	Polybutadiene	Fossil (oil)
Polybutylene furanedicarboxylate (PBF)		Synthetic fibre	Polyester	butylene furanedicarboxy	Biobased
Polybutylene succinate (PBS)		Synthetic fibre	Polyester	Polybutylene succinate	Biobased
Polybutylene terephthalate (PBT)		synthetic fibre	Polyester	polybutylene terephthalat	Fossil (oil)
Polyester fibre	Generic name for "a manufactured fiber in which the fiber-forming substance is any long-ch	Synthetic fibre	Polyester	polyethylene terephthalat	Fossil (oil)
Polyester Recycled fibre	Recycled polyester (rPET) is a synthetic textile fiber and is obtained by melting the plastic an	Synthetic fibre	Polyester	polyethylene terephthalat	Recycled
Polyether fibre	Manufactured fiber from a polymer containing ether [R–O–R] groups. Various experimental f	Synthetic fibre			Fossil (oil)
polyethylene (PE) fiber	olefin fiber made by extruding polyethylene. For many years, the features of a low melting p	synthetic fibre	Polyolefin	Polyethylene	Fossil (oil)
Polyethylene furanedicarboxylate (PEF)		Synthetic fibre	Polyester	yethylene furanecarboxyl	Biobased
Polyethylene terephthalate (PET)		Synthetic fibre	Polyester	olyethylene terephthalat	Fossil (oil)
Polyimide fibre (PI or PEI)	Manufactured fiber that is used in high temperature, flame-retardant applications. The polyi	Synthetic fibre			
Polyisobutene		synthetic fibre	rubbers	Polyisobutene	Fossil (oil)
Polyisoprene		Synthetic fibre	Rubbers	Polyisoprene	Fossil (oil)
Polylactic acid (PLA)	A manufactured fiber in which the fiber forming substance is composed of at least 85% by we	Synthetic fibre	Polyester	Polylactic acid	Biobased
Polyolefin	Any long-chain synthetic polymer composed of at least 85% by weight of ethylene, propylen	synthetic fibre	Polyolefin		Fossil (oil)
Polypropylene (PP)	olefin fiber manufactured from the addition polymer of propylene, CH3 −CH=CH2, obtained	Synthetic fibre	Polyolefin	Polypropylene	Fossil (oil)
Polystyrene (PS)	A manufactured fiber made of melt- or dry-spun polystyrene. The fiber has low to medium s	Synthetic fibre	Polyolefin	Polystyrene	Fossil (oil)
Polytetrafluoroethylene (PTFE)		Synthetic fibre		Polytetrafluoroethylene	Fossil (oil)
Polytrimethylene terephthalate (PTT)		Synthetic fibre	Polyester	ytrimethylene terephtha	Fossil (oil)
Polyurethane (PU) fibre	A synthetic fiber that was produced in Germany during the Second World War and later the s	Synthetic fibre	Polyurethane		Fossil (oil)
Polyvinyl alcohol (PVAl)		Synthetic fibre	Polyolefin	Polyvinyl alcohol	Fossil (oil)
Polyvinyl chloride (PVC)		Synthetic fibre	Polyolefin	Polyvinyl chloride	Fossil (oil)
Rubber, synthetic	A manufactured elastomeric polymer, includes synthetic polyisoprene, polybutadiene, certa	synthetic fibre	rubbers		Fossil (oil)
Spandex	A generic fiber category that has been defined by the Federal Trade Commission as "a manuf	Synthetic fibre	Polyurethane	Elastane	Fossil (oil)

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3 Synthetic fibres; challenges/gaps

- Production
  - Fully biobased polyesters (PLA, PEF, PHAs) and partly biobased polyesters (PET, PTT, PBT) available/in development
  - Application of new polyesters in textiles in development
  - Biobased polyesters/polyamides volumes low due to price, availability (land use) and questions about sustainability
- Consumers
  - Drop-ins are no issue, as materials are similar
  - Fully biobased alternatives (PLA, PEF, PHAs)?
- Environment
  - Drop-ins not biodegradable, fully biobased ones are being investigated

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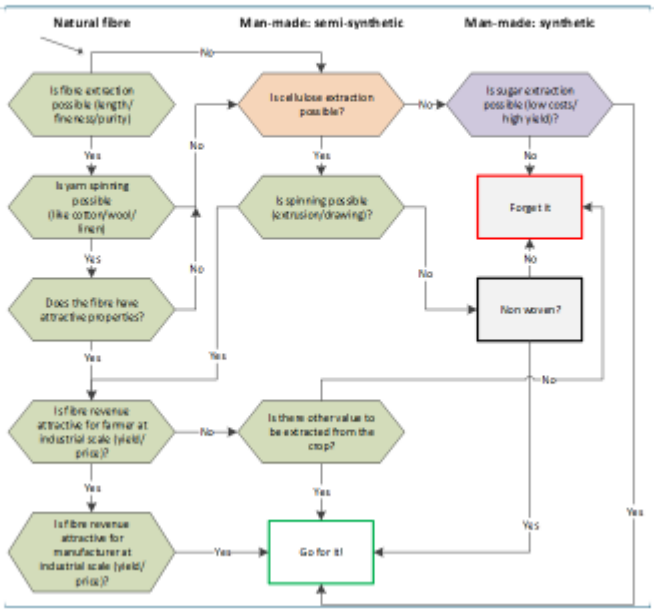
Biomass decision tree



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Overarching challenges

- Biomass discussions for food, energy and biobased products (e.g. textiles)
  - What if fossil resources are phased out? 2/3 is of fibres is now fossil-based
  - Food vs fibre discussions; Building vs textile discussions
- Consumer behaviour
  - Price, availability, properties
  - Not level playing field (import China)
- Circularity
  - R-ladder
  - End-of-life options

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Outlook (in my view)

- Growth of biobased fibres for textile in Europe is possible
  - Land use is a big puzzle; competing uses
    - #Ha?
    - Which biomass streams/fibre crops?
    - Which fibre types in particular?
  - Gaps in processing infra-structure need to be solved
  - Consumer behaviour/acceptance needs to be addressed
- All is dependent on the availability of fossil resources in the future

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Thank you

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Wageningen Food & Biobased Research

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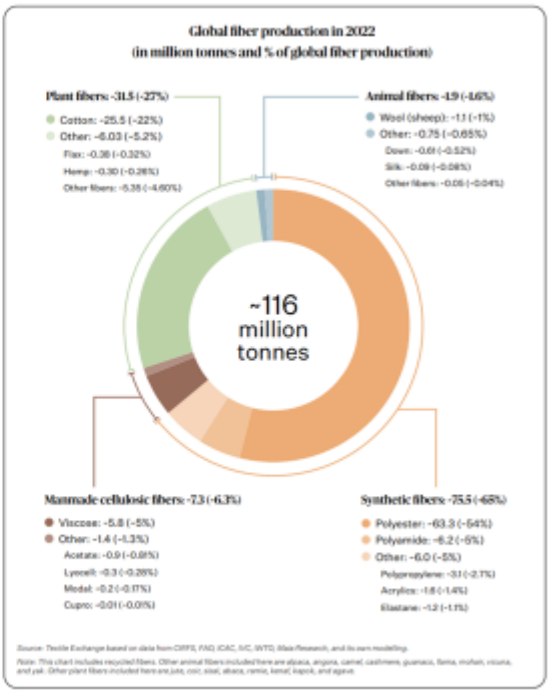
Global fibre production*

*Apparel, home, footwear, others

- Natural fibres 29 wt%
  - Plant 31,5 M tonnes
  - Animal 1,9 M tonnes
- Semi-synthetics 6 wt%
  - MMCFs 7,3 M tonnes
- Synthetics 65 wt%
  - Polyester (PET) 63,3 M tonnes
  - Polyamide 6,2 M tonnes
  - <1 wt% is biobased

App. 1/3 of the global fibre production is biobased



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Knowledge gaps and opportunities for R&D in the bio-based textile sector

Mikael Skrifvars

Professor Polymer Technology
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Bio-based textiles Expert Workshop on latest research findings, market trends and policy needs

June 26, 2024

Venue: European Commission - DG Research & Innovation
Orban building, room 03/78, Sq. Frère-Orban 8, 1000 Bruxelles, Belgium

MSK 20240€

Bio-based textile fibre alternatives (excluding cotton, wool)

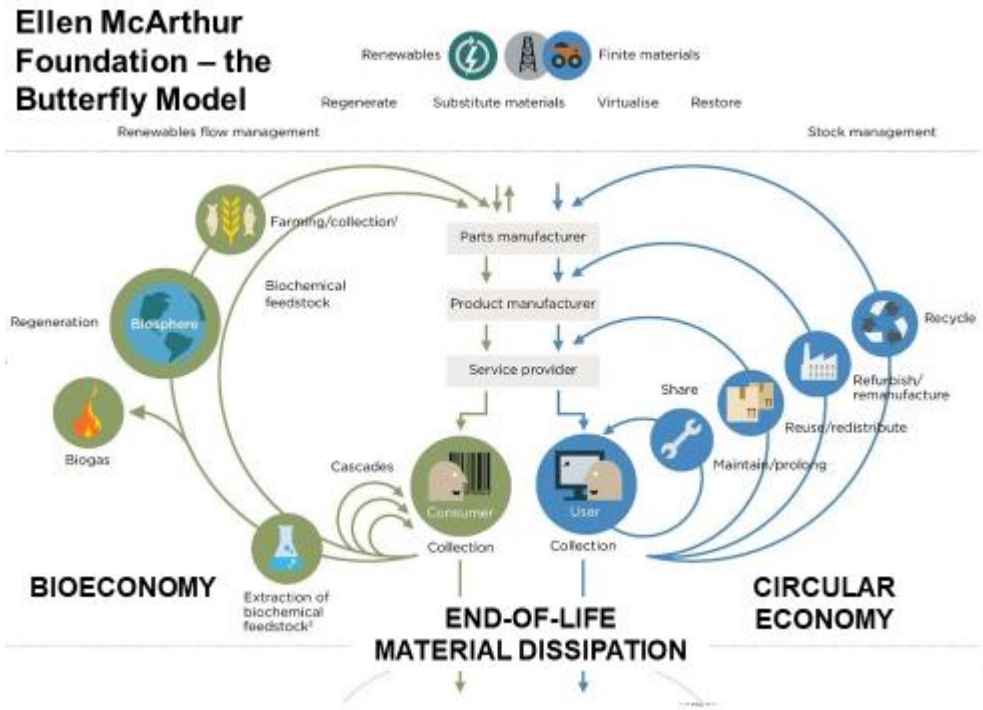
- Annual cellulose bast fibres:
  - Flax, hemp, jute,…
- Man-made cellulose fibres:
  - Viscose, Lyocell
  - Cellulose carbamate, cold alkali, ionic liquid
  - Microfibrillated cellulose
- Recycled end-of-life cotton and viscose fibres
- Bio-based synthetic polymer fibres:
  - Polylactic acid (PLA)
  - Partly biobased polyesters: PPT, PBT
  - Furandicarboxylic acid (FDCA) polyesters
- New fibres under development:
  - Polyhydroxyalcanoates (produced by microorganisms)
  - Protein based: casein, silk
  - CO_2 based polyesters

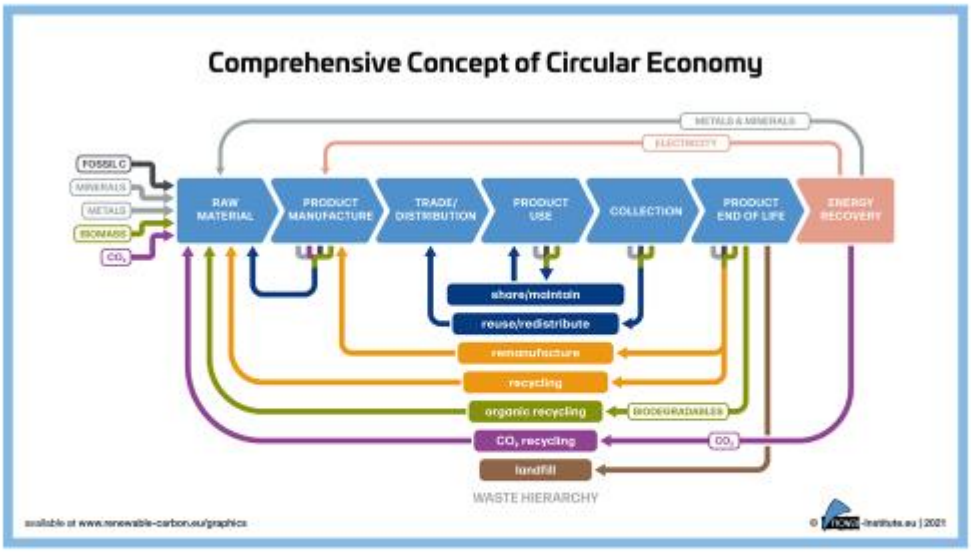
BIOPOLYMERS

MSK 202406

Renewable bio-based fibres in the circular economy

MSK 20240609





Source: Nova-Institute, http://nova-institute.eu/

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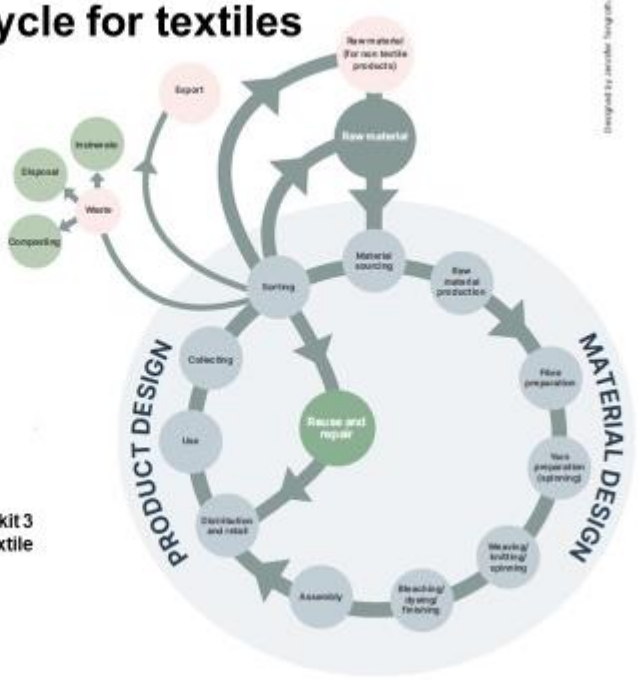
Product life cycle for textiles



Source: Sustainable Fibre Toolkit 3 The Foundation for Swedish textile research - TEKO

Bio-based textiles value chain - overview

Natural fibres
- Annual plant bast fibres

Mechanical processing

Man-made cellulose fibres
- Viscose
- Lyocell
- Cellulose carbamate
- Cold alkaline
- Ionic liquid

Chemical processing

Bio-based synthetic polymer fibres
- Polylactic acid (PLA)
- Partly biobased polyesters: PPT, PBT
- Furan dicarboxylic acid (FDCA) polyesters

Large scale polymer processing and fibre melt extrusion

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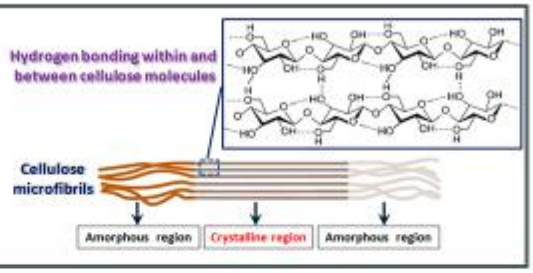
Biopolymers – the alternatives

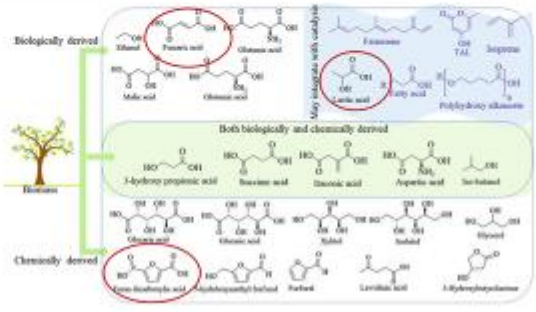
Extract polymers from biomass

carbohydrates, proteins, PHA polyesters, lignin



Extract chemicals from biomass and convert to polymers

lactic acid, plant oils, dicarboxylic acids



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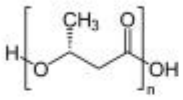
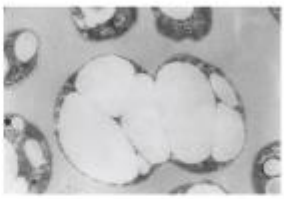
Biopolymers – the alternatives

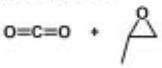
Polymers produced by microorganisms



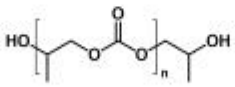
Polyhydroxyalcanoate polymers, (PHA)



Use CO_2 as carbon source for polymers



Carbon dioxide



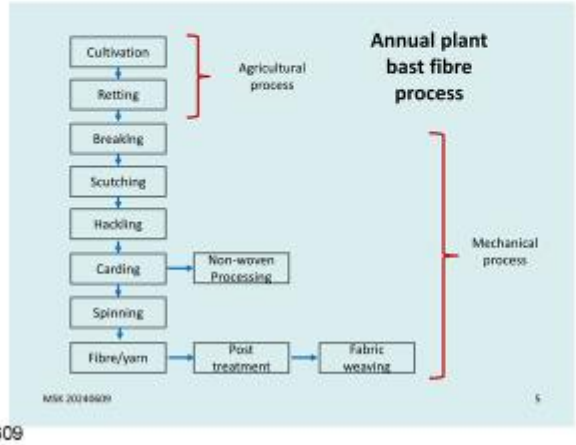
Carbonate polymer

Requires carbon capture and utilisation (CCU)

Annual cellulose bast fibres

Flax, hemp, jute,…

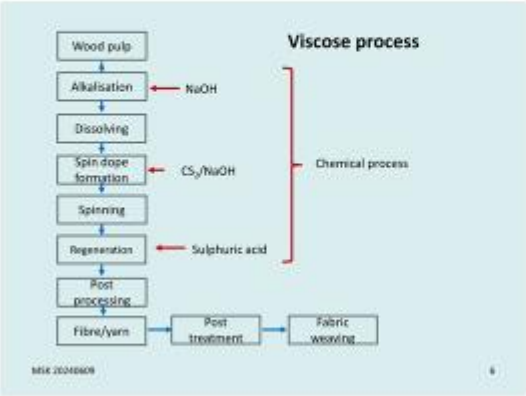
A mechanical process involving many steps, labour intensive, long historical use



Man-made cellulose fibres

Viscose

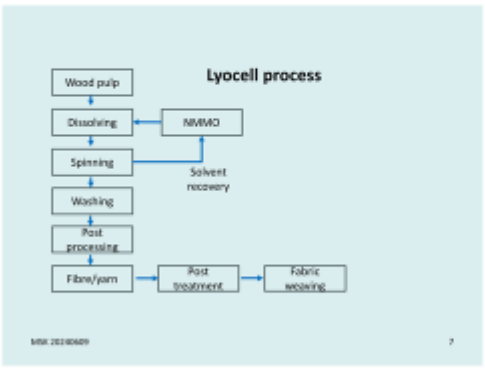
A chemical process involving dissolving and regeneration, in use scince 1893

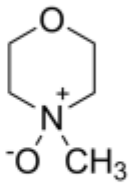


Man-made cellulose fibres

Lyocell

Cellulose dissolving by solvent and fibre precipitation





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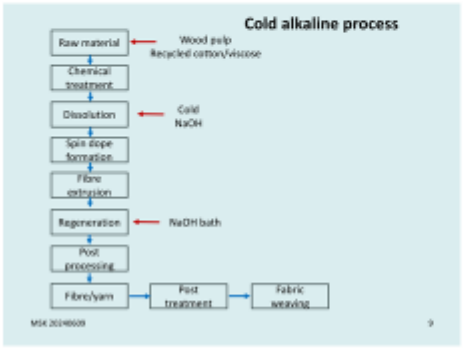
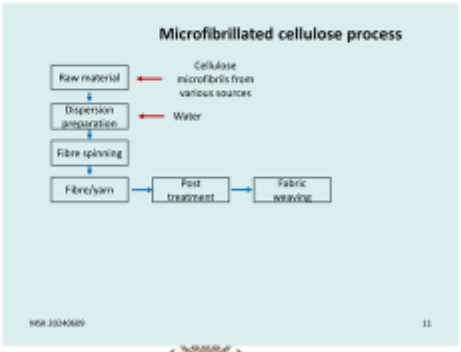
Man-made cellulose fibres – new developments

Cold-alkaline process, cellulose carbamate process, ionic liquid process, microfibrillated cellulose process

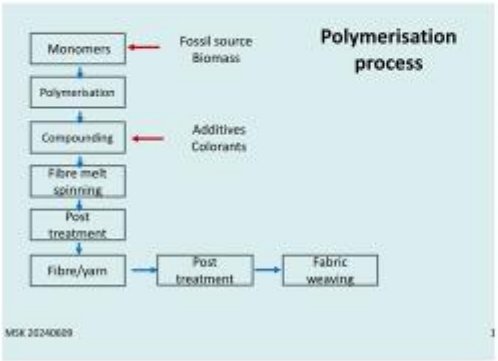
Chemical and mechanical processes, recent commercial introduction
Recycling of end-of-life textiles one driving force for development

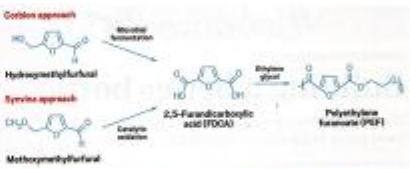




Synthetic biopolymer fibres

Polylactic acid (PLA), FDCA polyesters, PBT/PPT polyester,
Polymerisation of biomonomers, can be partly of biobased origin
Melt spinning extrusion into filaments
Biomass waste streams can be used for monomers





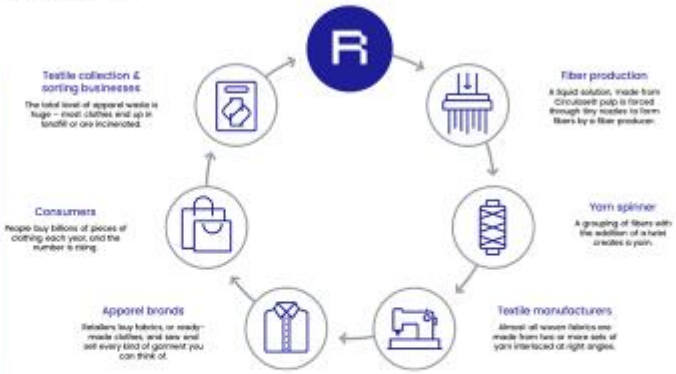
Value chains – Bio-based fibres

Characteristics to consider:

- Very different process steps depending on fibre type
- Huge variation in time of industrial introduction – from historical times to very recent times
- Large variations in production scale and production rates
- Production investment costs varies for different bio-fibres
- Environmental impact is different, and can be related to different stages in the value chain
- Can be very manual labour intensive, or highly automatized
- Process technology level can vary from rather simple to very advanced
- Can be integrated in other industrial production or can be on its own

New material technologies and concepts

Renewcell – Circulose dissolving pulp made from 100 % recycled textiles



Allows alternative production of regenerated cellulose textile fibres (Viscose, Lyocell) without using wood

End of life textiles can be recycled to new textiles

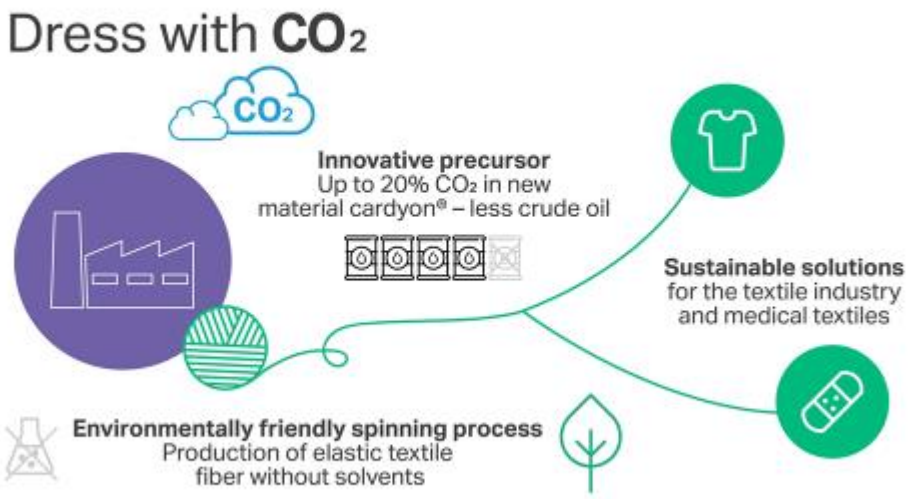
www.renewcell.com www.circulo.se

Waste and end of life products is seen as a material source – Pure Waste

Pure Waste – manufacturer of yarns, fabrics and garment made from 100 % recycled materials

www.purewaste.com

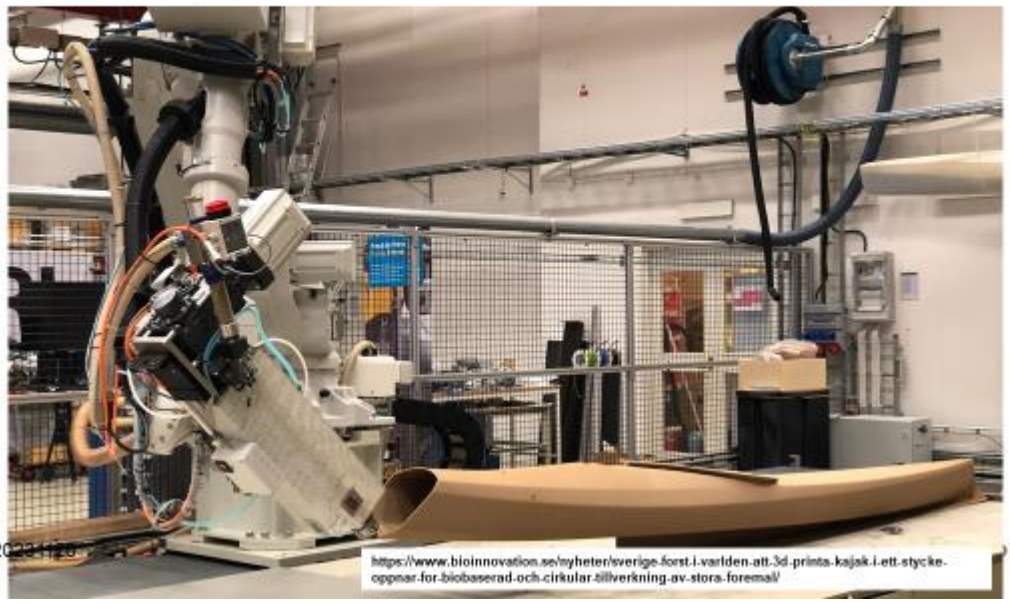
Covestro: Yarns from carbon dioxide – Cardyon®



https://interplasinsights.com/covestro-develops-elastic-textile-fibres-made-from-carbon-di/

Emerging technologies – Additive manufacturing

3D printed kayak - Recycled plastic reinforced with wood fibre by Biofiber Tech, Melker of Sweden and RI.SE



https://www.bioinnovation.se/nyheter/sverige-forst-i-varlden-att-3d-printa-kajak-i-ett-stycke-oppnar-for-biobaserad-och-cirkular-tillverkning-av-stora-foremal/

Biomimetics – traditional and modern technical material solutions

http://www.educapoles.org/multimedia/picture_gallery_detail/arctic_people/1

https://www.npmarathon.com/polar-clothing

Challenges for bio-based textiles – to be discussed:

1. Resources and raw materials for bio-based textiles
2. Technology for conversion from raw material to textile
3. Production infrastructure and value chain from raw material to end-product
4. Fibre properties according to customer demands and market specifications
5. Existing or developing market demand with end-use customers
6. End-of-life handling methods and strategies
7. Position in the circular economy system
8. Market value and feasibility, end-use product costs

Thank you for the attention!