Welcome address

Serenella Sala, Head of Unit JRC.D.3 - Land Resources and Supply Chain Assessments

Rosalinda Scalia, Deputy Head of Unit DG RTD B.2 - Bioeconomy & Food Systems

European Commission

EU-funded research on bio-based plastics

Martin Policar, DG RTD B.1 – Green Transitions

Scope

Bio-based

made from biomass/biological resources, i.e., animals, plants, micro-organisms and derived biomass, including bio-waste

Polymers

"A polymer is a substance consisting of molecules characterised by the sequence of one or more types of monomer unit.….natural polymers that have not been chemically modified"…" Polymers that occur in nature that have not been chemically modified (other than by hydrolysis)"

Plastics

"'a material consisting of a polymer as defined in (REACH), to which additives or other substances may have been added, and which can function as a main structural component of final products, with the exception of natural polymers that have not been chemically modified…"

R&I framework programme

Horizon Europe Pillar II
Global Challenges and European Industrial Competitiveness

Cluster 6 - Food, Bioeconomy, Natural Resources, Agriculture and Environment

..circular bio-based systems from sustainably sourced biological resources…

Circular Bio-based Europe Joint Undertaking
https://www.cbe.europa.eu/

EUR 2 billion European **partnership** between the European Union and the Bio-based Industries Consortium (BIC)

Cluster 4 - Digital, Industry and Space

breakthrough technologies… dynamic industrial innovation

Made in Europe

Process for Planet P4P

CL&CL6, CBE JU: bio-based polymers/plastic/packaging, biodegradability

bio-based polymers/plastics/packaging, biodegradability

approx (70+103.5) M€

Examples of topics, ToA, budget and number of funded projects:

HORIZON-CL4-2024-RESILIENCE-01-35: **Biodegradable polymers** for sustainable packaging materials. (IA, 31 M€, 4p).

HORIZON-CL6-2022-CIRCBIO-02-03-two-stage: Sustainable **biodegradable novel bio-based plastics**: innovation for sustainability and end-of-life options of plastics. (IA, 12 M€, 2p).

……………….

HORIZON-JU-CBE-2023-IA-04 Recycling **bio-based plastics** increasing sorting and recycled content (upcycling) (IA, 15 M€, 2p)

HORIZON-JU-CBE-2024-IA-01 **Bio-based** materials and products for **biodegradable** in-soil applications 15 M€

HORIZON-JU-CBE-2025-IAFlag-03 Circular-by-design **fibre-based packaging** with improved properties- 18 M€

CL&CL6, CBE JU: bio-based polymers/plastic/packaging, biodegradability

- FIBER-BASED packaging: any sector
- FOOD PACKAGING with enahnced properties
- COMPOSITEs: any sectors (packaging, construction, automotive)
- PLASTICS with advanced performances (e.g., fire-resistance, isolation, etc.): any sectors
- BIODEGRADABLE polymers for AGRICULTURE/HORTICULTURE applications
- BIODEGRADABLE plastics for HUMANITARIAN context

CL&CL6, CBE JU enabling technologies; social innovation

enabling bio-based technologies approx 100 M€

HORIZON-CL4-2021-TWIN-TRANSITION-01-05: Manufacturing technologies for bio-based materials (Made in Europe Partnership) (RIA, 20 M€, 5p)

HORIZON-CL6-2025-01-ZEROPOLLUTION-01-two-stage: Substances of concern and emerging pollutants from bio-based industries and products: mapping and replacement (IA, 10 M€, 2p)

HORIZON-CL6-2025-01-CIRCBIO-11: Demonstration of reduced energy use and optimised flexible energy supply for industrial bio-based systems (IA, 11M€, 2p)

social innovation approx 220 M€

HORIZON-CL6-2023-ZEROPOLLUTION-01-7: Strategies to prevent and reduce plastic packaging pollution from the food system (RIA, 8M€)

HORIZON-CL6-2023-CircBio-02-1-two-stage: Circular Cities and Regions Initiative (CCRI)'s circular systemic solutions (IA, 58M€)

HORIZON-CL6-2024-ZEROPOLLUTION-01-3: Environmental impacts of food systems (RIA, 7M€)

EUROPEAN UNION

EU MISSIONS

RESTORE OUR OCEAN & WATERS

Concrete solutions for our greatest challenges

#EUmissions #HorizonEU #MissionOcean

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Mission objectives and targets

Restore our Ocean and Waters by 2030

PROTECT AND RESTORE MARINE AND FRESHWATERS ECOSYSTEMS AND BIODIVERSITY	• Protect at least 30% and strictly protect 10% EU's sea areas • Restore 25.000 km free flowing rivers • Marine nature restoration targets (incl. degraded seabeds, coastal ecosystems)
PREVENT AND ELIMINATE POLLUTION OF OUR OCEANS, SEAS AND WATERS	• **Reduce by at least 50% plastic litter** • **Reduce by at least 30% microplastics** • Reduce by at least 50% nutrient losses, chemical pesticides
MAKE THE BLUE ECONOMY CARBON- NEUTRAL AND CIRCULAR	• Net zero maritime emissions • Zero carbon aquaculture, • Low carbon multipurpose use of marine space

ENABLERS

- Digital Ocean and Waters Knowledge system
- Public mobilization and engagement

Bio-based materials enabling the transition

replacement of fossil intensive resources by sustainable and renewable biomass, including bio-waste

substantially contribute to climate neutrality and biodiversity and environmental protection

enabled by the power of biotechnology combined with advances in information technology - including AI

enabling the equal distribution of benefits and revenues along the value chain, from primary producers, to the industrial operators to end users, including local governments and citizens

increasing the level and appeal of jobs in agriculture, forestry and, potentially, fishery sectors, also due to the rapid deployment of digital tools for the primary production

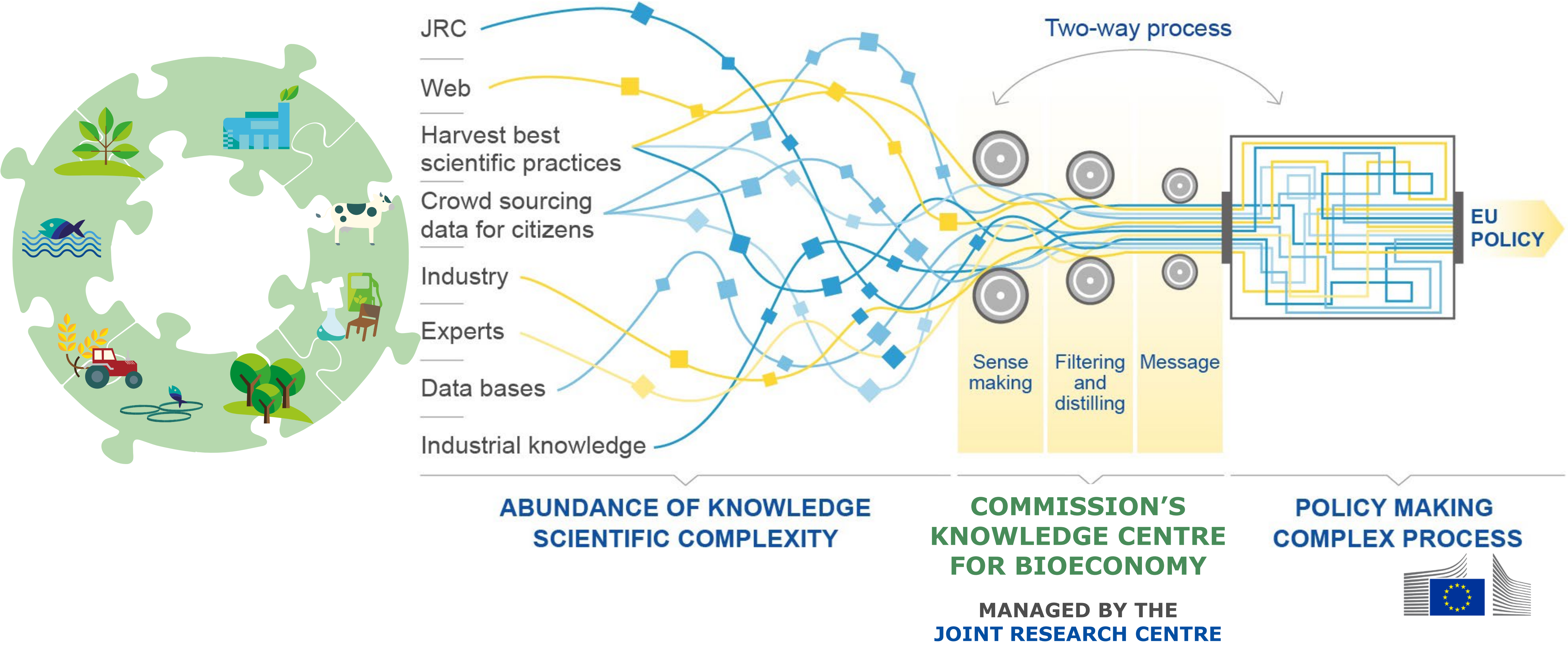
sustainability resilience inclusion

Introduction to the KCB deep dive on bio-based plastics

Maria Teresa Borzacchiello
EC Knowledge Centre for Bioeconomy

JRC.D.3 - Land Resources and Supply Chain Assessments

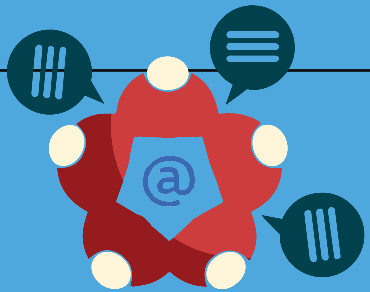
The Knowledge Centre for Bioeconomy



Knowledge Centre for Bioeconomy

Identifying and **filtering** relevant information and making it accessible.

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



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

Enhancing the **knowledge** base for policymaking.

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

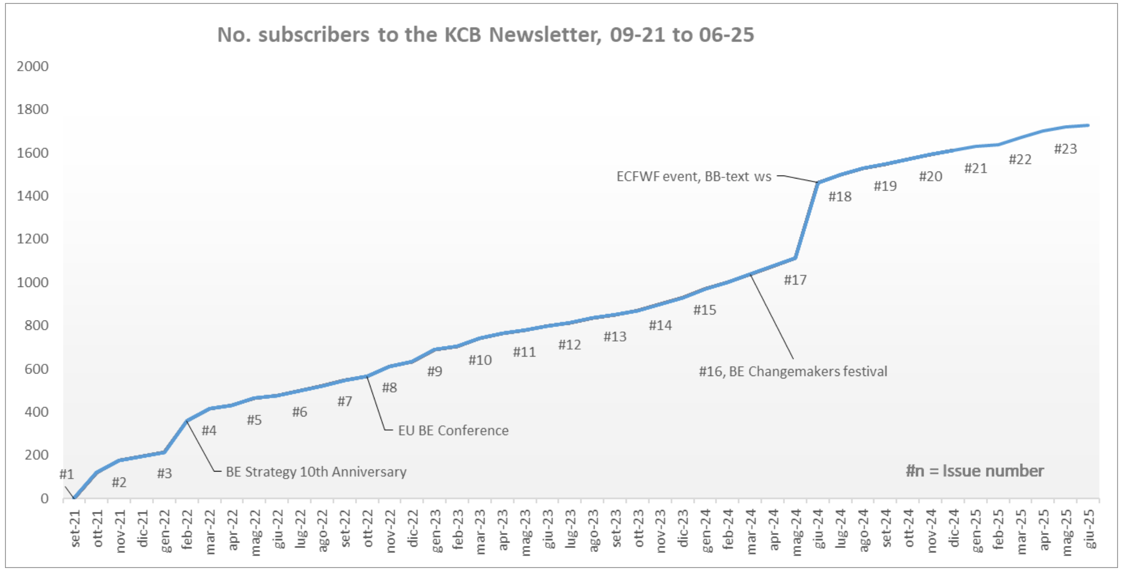
Knowledge Centre for Bioeconomy

The online knowledge base & the newsletter

Identifying and **filtering** relevant information and making it accessible:

>300 sources monitored weekly

Knowledge library with
>6.5k resources (publications, datasets, data visualizations, news, events, briefs, online tools, videos, definitions …)



>1700 subscribers to the Newsletter in Q2/25

Newsletter subscription at: https://ec.europa.eu/newsroom/know4pol/user-subscriptions/2358/create

Bringing together researchers, policymakers and other experts:

Community of Practice

The Community of Practice – focus on 2024 events

Participants from various DGs and practitioners, Bio-based textile workshop, June 2024, Brussels

European Consumer Food Waste **Forum**

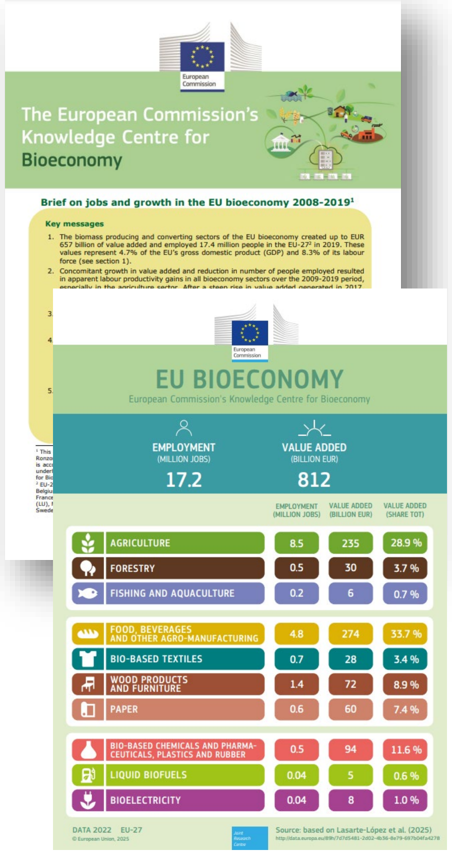
ECFWF public event, KCB tutorials stand and organising team (JRC & SANTE), June 2024, Brussels

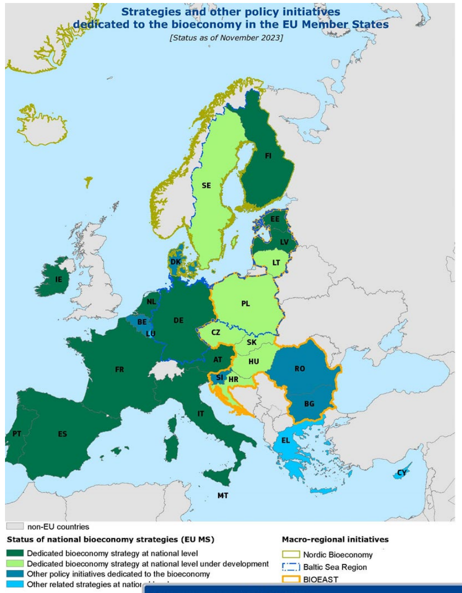
To join the CoP bioeconomy: https://ec.europa.eu/eusurvey/runner/CoP_bioeconomy

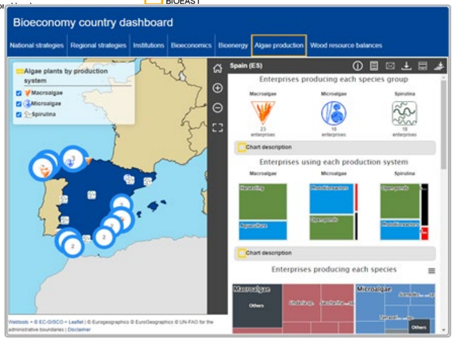
Knowledge Centre for Bioeconomy

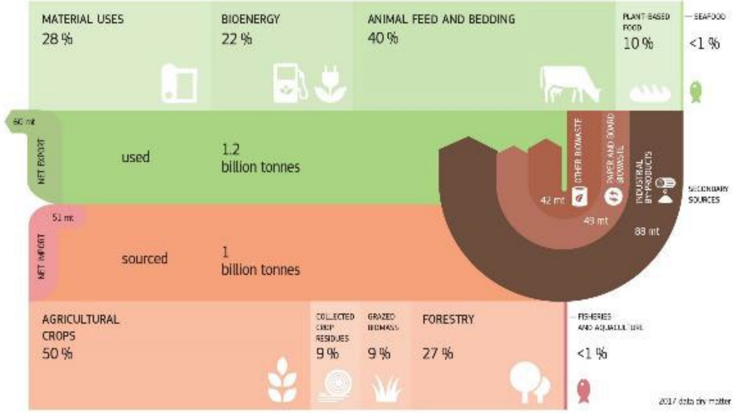
Analysing, synthesising and **communicating** available evidence.

Briefs, dashboards, videos & infographics





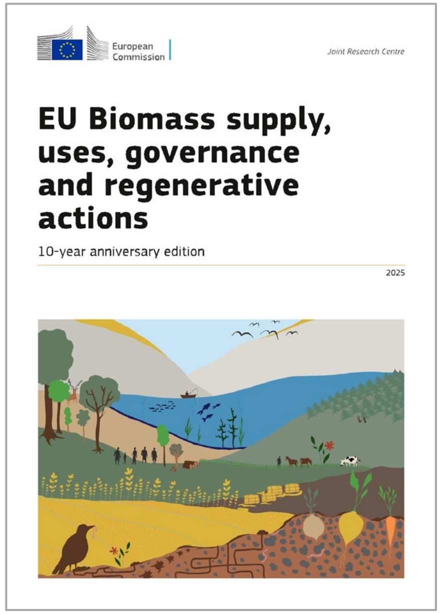




Knowledge Centre for Bioeconomy

Enhancing
the **knowledge** base
for policymaking.

EU Bioeconomy Monitoring System dashboard & evidence reports



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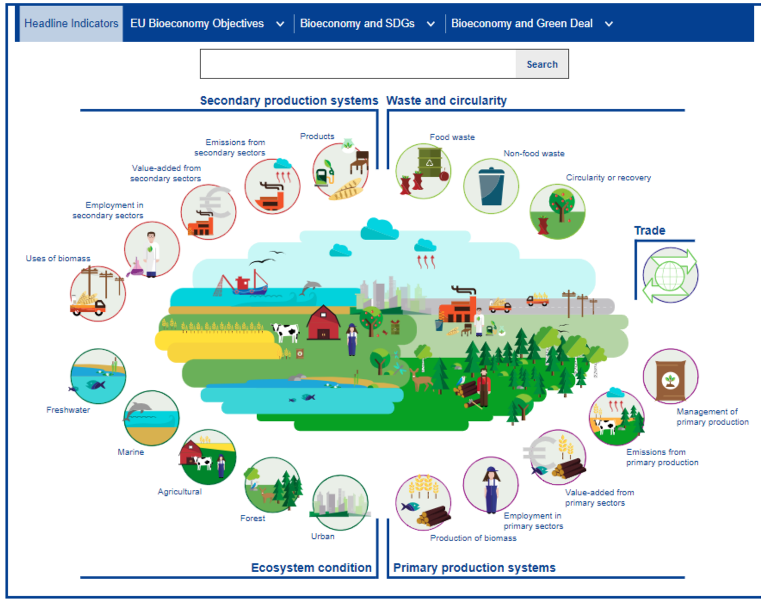

https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring

https://publications.jrc.ec.europa.eu/repository/handle/JRC140285

KCB deep dive on bio-based plastics

Collecting, synthesising and presenting the best available evidence on the bio-based plastics topic, to:

- discuss the main issues at stake to inform policymaking
- represent the sector in a clear and multifaceted way
- assess its potential role in the European bioeconomy context
- identify the knowledge gaps and opportunities for research and innovation in this field

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4 main topics for discussion today

Land use and resource competition

Material performance, costs and economic viability

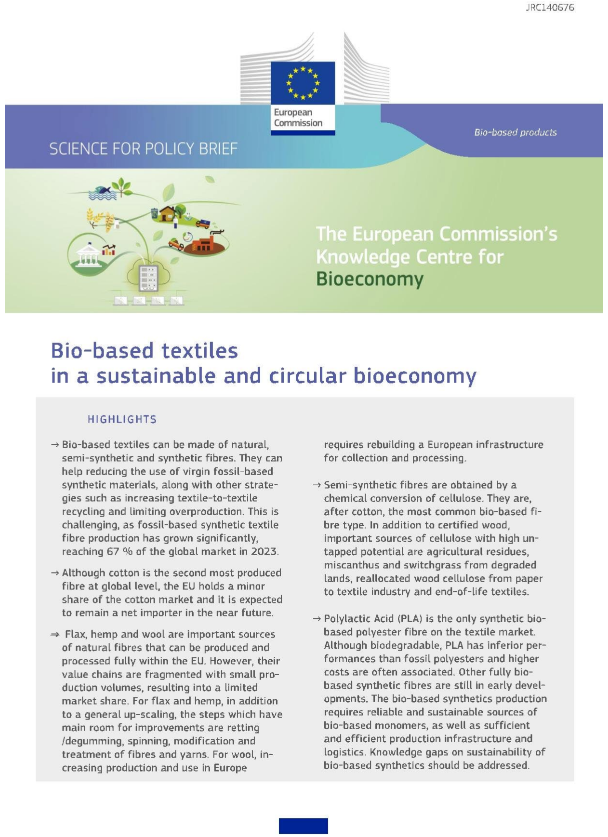
Environmental impacts

End of life management

Expected outputs

A **new topic page on bio-based plastics**, including:

- A '**knowledge for policy brief**', that synthesises currently available knowledge, facts and figures **(support from external expert)**
- An '**Explore further**' section including latest data, visualisations, projects and additional selected resources
- A '**Latest resources**' section with the latest news and publications in KCB's knowledge base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European Commission

SCIENCE FOR POLICY BRIEF

Bio-based products

The European Commission's Knowledge Centre for Bioeconomy

Bio-based textiles in a sustainable and circular bioeconomy

HIGHLIGHTS

→ Bio-based textiles can be made of natural, semi-synthetic and synthetic fibres. They can help reducing the use of virgin fossil-based synthetic materials, along with other strategies such as increasing textile-to-textile recycling and limiting overproduction. This is challenging, as fossil-based synthetic textile fibre production has grown significantly, reaching 67 % of the global market in 2023.

→ Although cotton is the second most produced fibre at global level, the EU holds a minor share of the cotton market and it is expected to remain a net importer in the near future.

→ Flax, hemp and wool are important sources of natural fibres that can be produced and processed fully within the EU. However, their value chains are fragmented with small production volumes, resulting into a limited market share. For flax and hemp, in addition to a general up-scaling, the steps which have main room for improvements are retting /degumming, spinning, modification and treatment of fibres and yarns. For wool, increasing production and use in Europe requires rebuilding a European infrastructure for collection and processing.

→ Semi-synthetic fibres are obtained by a chemical conversion of cellulose. They are, after cotton, the most common bio-based fibre type. In addition to certified wood, important sources of cellulose with high untapped potential are agricultural residues, miscanthus and switchgrass from degraded lands, reallocated wood cellulose from paper to textile industry and end-of-life textiles.

→ Polylactic Acid (PLA) is the only synthetic bio-based polyester fibre on the textile market. Although biodegradable, PLA has inferior performances than fossil polyesters and higher costs are often associated. Other fully bio-based synthetic fibres are still in early developments. The bio-based synthetics production requires reliable and sustainable sources of bio-based monomers, as well as sufficient and efficient production infrastructure and logistics. Knowledge gaps on sustainability of bio-based synthetics should be addressed.

Example – Topic page on bio-based textiles
https://knowledge4policy.ec.europa.eu/bio-based-textiles_en

Example – Science for Policy brief on bio-based textiles
https://publications.jrc.ec.europa.eu/repository/handle/JRC118214

Deep dive on bio-based plastics – next steps

May 2025

Start collaboration with bio-based plastics expert

Workshop on bio-based plastics

26/06/2025

- **Objectives**:
- to offer an overview of the policy framew ork
- to present preliminary results of the analysis performed by the expert
- to gather inputs from the participants on the current state of the art and knowledge gaps of the bio-based plastics sector

September 2025

draft **Knowledge for policy brief** for DG consultation

Bio –based plastics webpage

Autumn 2025

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

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

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

Overview of policy developments on bio-based plastics in EU

Werner Bosmans, DG ENV B.1 - Circular Economy, Sustainable Production & Consumption

European Commission

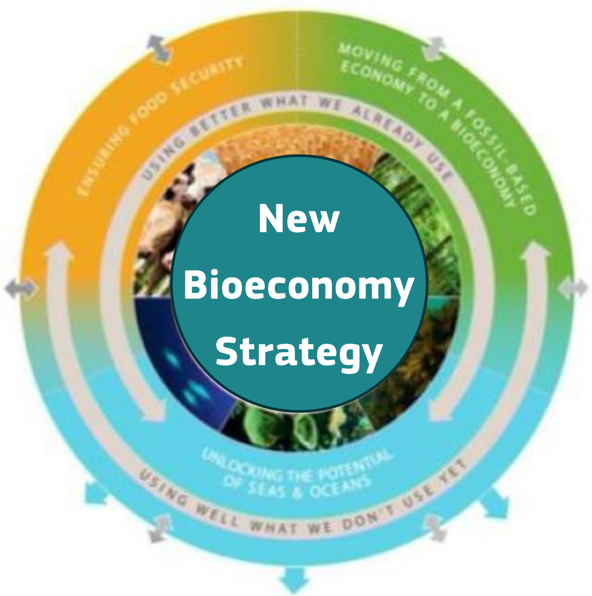
EU policies and the future of Biobased plastics

Werner Bosmans
Teamleader 'Plastics'
DG Environment

With the help of Jiannis Kougoulis
Bioeconomy team
DG Grow

A climate-neutral, resource-efficient and competitive economy

Maintaining the value of products, materials and resources in the economy for as long as possible



Scaling up biobased sectors, within ecological boundaries

Improving the economics and quality of recycling & curbing plastic waste & littering

European Commission

New Bioeconomy Strategy – a driver for green growth

- Position the EU in the **rapidly expanding bioeconomy market**
- Significant **growth** potential
- **Reduce our reliance on fossil fuels** & foster **our rural areas**

Competitiveness Compass, January 2025

- **Improve resource efficiency**
- **Reduce dependencies** on imported raw materials.
- **Prioritise manufacturing and using biomaterials**
- **Retain** them as long as possible in the economy

Clean Industrial Deal, February 2025

- **Diversification** of value streams
- Valorisation of farm **residues**
- Strengthening the role of **primary producers** and generating new jobs

Vision for Agriculture and Food, February 2025

European Commission

Interplay with policy areas in the *new* Commission

Biotech Act

Circular Economy Act

Start up and Scale up Strategy

Bioeconomy Strategy

Ocean Pact

Life Science Strategy

Sustainability criteria vs cascading use of biomass

Sustainability **supply** for the bioeconomy

- Ensure resilience of supply
- Assure that biomass is sourced sustainably
- Sustainable land management practices

Cascading principle - Prioritizing material **demand**

- Maximise resource efficiency & circularity
- Prioritise use of residues & byproducts to extend biomass availability
- Orient biomass from bioenergy towards higher value applications (i.e. material)

EU Bioeconomy strategy 2025: objective

- Enhance **long-term competitiveness** of the EU economy & strategic resilience
- Ensure **industrial leadership** in addressing climate change, biodiversity loss & pollution
- Lead in the emerging **biobased economy (*investments*)** & drive biotechnology innovation
- Secure **sustainably supplied biomass** & sustainable production of biological resources for food, materials, energy & services
- Create **green jobs**

European Commission

EU Bioeconomy strategy 2025: scope

Pillar I - Increasing resource-efficient & circular use of biological resources

Pillar II - From Lab to Fab, priorities for scaling up

Pillar III - Securing the competitive & sustainable supply of biomass, both domestically & from outside the EU

Pillar IV - Positioning the EU in the rapidly expanding international market

European Commission

Biobased plastics

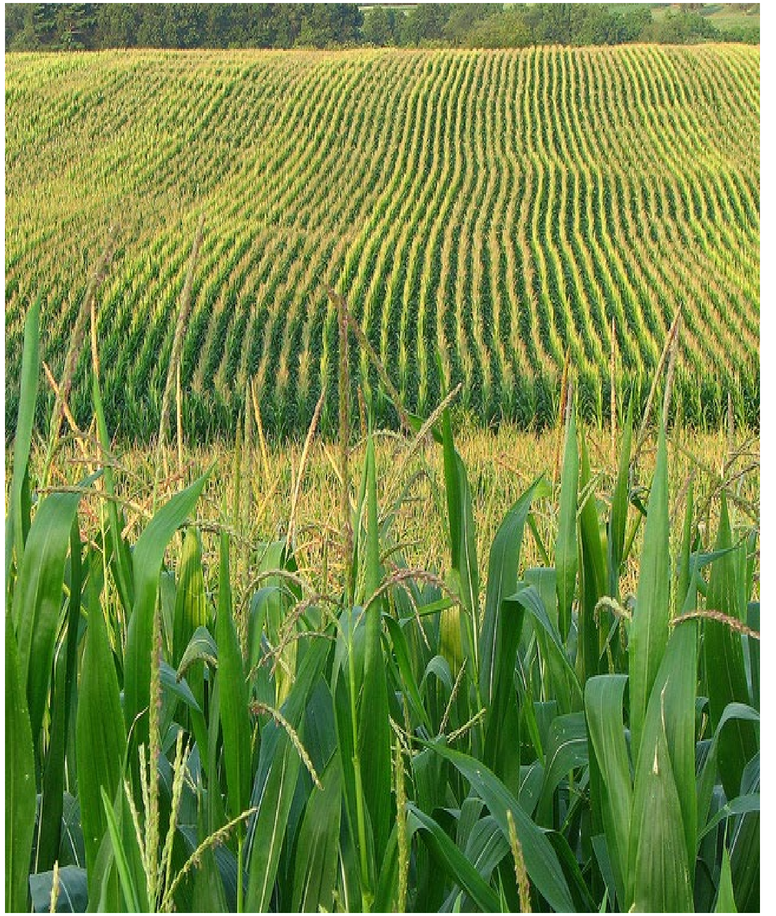
Communication 2022

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

Challenges:

- No perpetuating single use models
- 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

- ***Biodegradable*** plastics only for **specific applications** where full removal is not possible – No licence to litter



European Commission

Biobased plastics in **Taxonomy**

- **Climate Delegated Act (2021)**
  - Focus on plastic in its primary form
  - IF substantial contribution to climate change mitigation
  - A valid option **if biomass is compliant with bioenergy sustainability criteria** and **life-cycle GHG emissions are lower than fossil-based equivalent**

- **Environmental Delegated Act (2023)**
  - Focus on plastic packaging
  - IF substantial contribution to transition to a CE
  - A valid option **when biowaste feedstock is used**

PPWR: Biobased feedstock (art 8)

Entered into force in Feb 25

By 12 Feb 2028, EC to review state of play (and possible proposal) of biobased plastic packaging:

- Sustainability requirements
- Feedstock targets
- Interplay of recycled content and biobased targets
- Definition of biobased plastic

European Commission

Upcoming EC studies on biobased content targets in products

Study	Timeplan	Lead DGs	Feedback and consultation
Study on feasibility & impacts of bio-based & other non-fossil content requirements for products	Q3 2025 to Q4 2026	GROW	Targeted consultation activities from Q4/2025 to Q1/2026
Circular economy act impact assessment study (part on biobased content targets on 1-3 product groups)	Q3 2025 to Q4 2025	ENV/ GROW	Public consultation of CEA + targeted consultation Q4/2025
Packaging and packaging waste regulation art 8 implementation	Q3 2026 (tbc)	ENV / JRC	Sector consultation in Q1/2026

European Commission

Upcoming EC studies on biobased content targets in products

Communication: Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU → **Study on feasibility and impacts on setting bio-based and other non-fossil content requirements for products**

'Look on policy options to stimulate the market uptake of biobased products'

IA of Circular Economy Act → *'To move away from fossil materials, it is vital to mandate the use of new raw material sources like recycled and bio-based materials to substitute, for example, virgin fossil materials in plastics (Clean Industrial Deal)'*

Implement art 8 of PPWR → *'Review state of play (and possible proposal) of biobased plastic packaging'* refuse

share

reuse

return
&
collect

sort

recycle

Learn more about:

[Bioeconomy Strategy - European Commission] & [Plastics (europa.eu)]

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European Commission

Bio-based plastics sector and key issues at stake

Karin Molenveld, Programme Manager Renewable Plastics, Wageningen University Research

European Commission

Outline

General introduction
Why biobased plastics?
Possible production routes
Feedstocks for biobased plastics
Markets, performance, applications
End of life
Environmental impacts

Introduction plastics

Plastics are organic polymers that can be moulded into shape during manufacture

- Lightweight, versatile (in shapes and properties), durable, cost-effective, chemical resistance, hygiene, flexibility, transparency, strength, abundancy

First plastics were of renewable origin (eg, cellulose derivatives)

- Replacing scares natural materials like ivory

During and after WW II production of fossil-based plastics boosted

- Nylon (polyamides) for parachutes, ropes, body armor
- Plexiglas (polymethylmethacrylate) for aircraft windows

Raw material choice predominantly based on costs

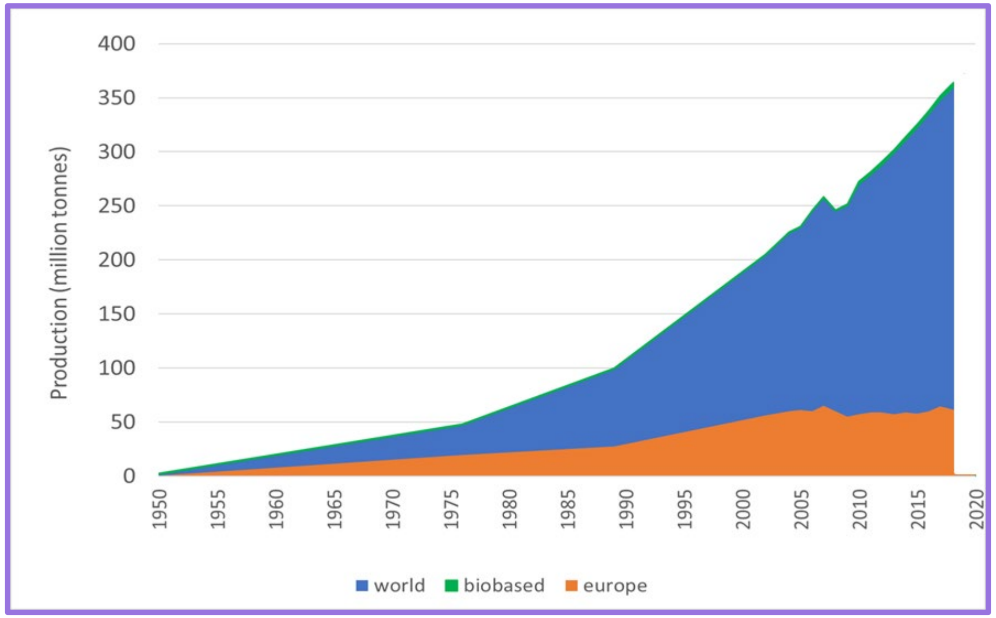
- **Nylon 11 is biobased (castor oil derived)**
- **Nylon 12 is fossil-based**

Cellulose Acetate bricks

Introduction plastics

Plastics Production Development

- Global market has grown > 400 million tonnes/annum
- Further extensive growth expected
- Strongest growth outside Europe
- Minor share of biobased plastics



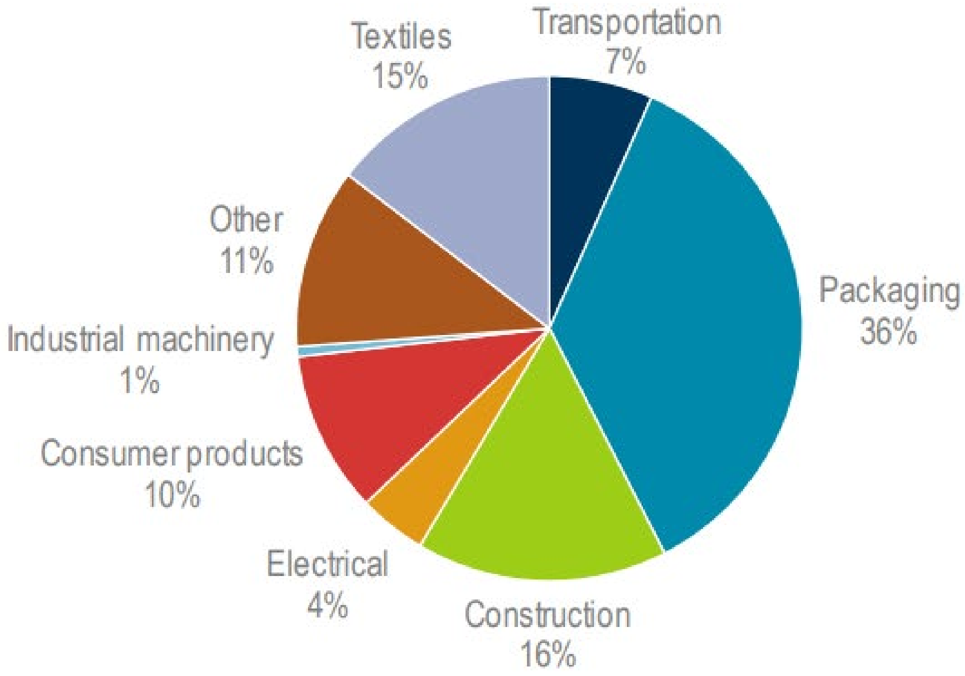
Development of global plastic production

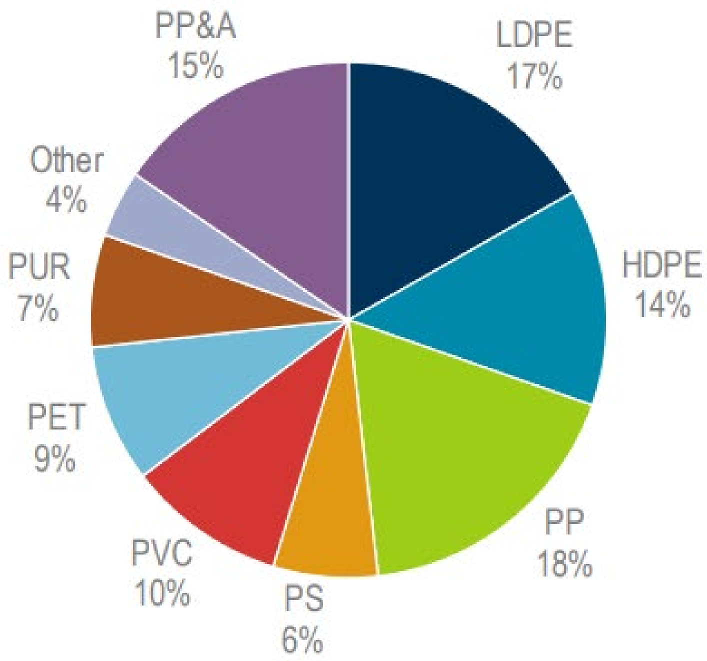
Introduction plastics

Plastic usage by end-use sector and resin type (source IEA, 2018),

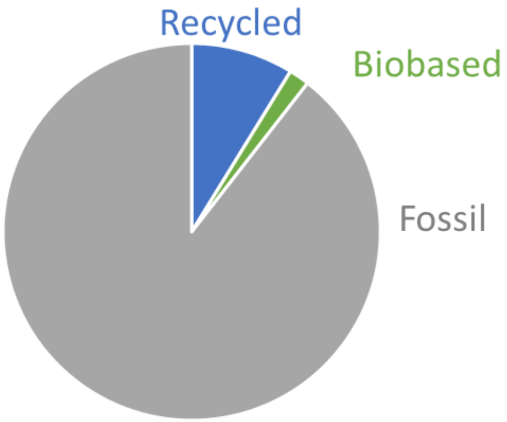
Main market is packaging

Polyethylene (PE) and polypropylene (PP) together have a market share of ~50%.





Introduction plastics



Since ~ 1980 concerns

Waste & pollution issues

Climate change related to fossil feedstock usage

Microplastics & safety concerns

Mitigation actions

Development of biodegradable plastics

Development of biobased plastics

Plastic recycling

Circularity models

Waste hierarchy

Plastic bans

Current status

Most plastics are still virgin fossil based

Biobased and recycled plastics are more expensive

Cheap imports slow down plastic transition

Special report 17/2023: Circular economy – Slow transition by member states despite EU action

Why biobased plastics?

Fossil fuel consumption for plastics and chemicals

~ 10% of fossil carbon is used as feedstock for chemicals and plastics

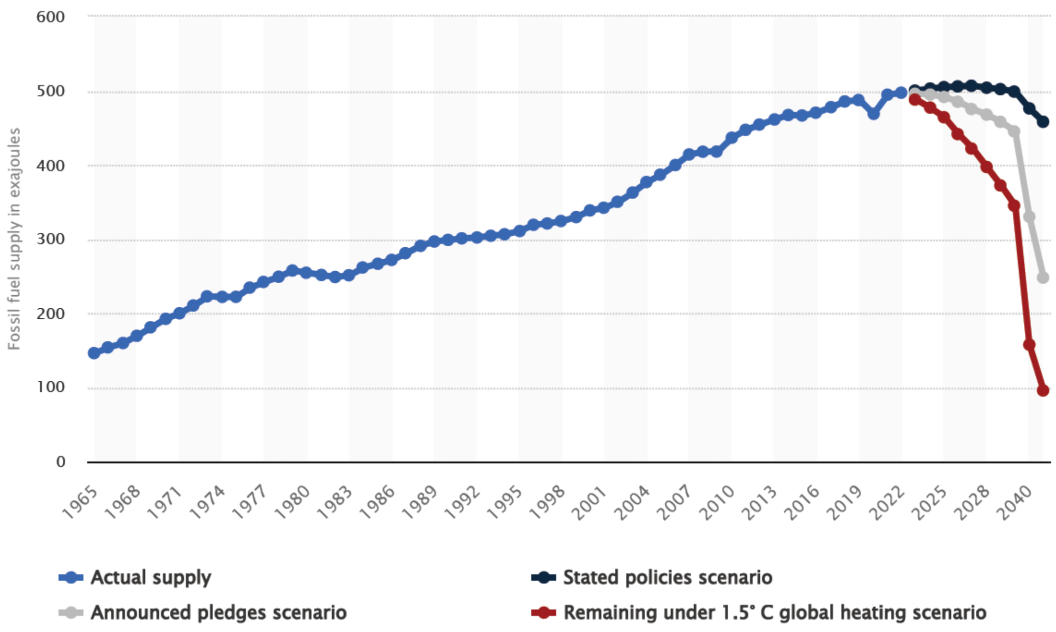
~ 7% is used as energy during production

Main use in bulk polymers like polyolefins and polystyrene and smaller part for engineering plastics adding up to a 90% share.

Due to the energy transition the relative share of petrochemicals will increase, the cost will increase and the relative contribution to (GHG) emissions will increase.

Global fossil fuel demand

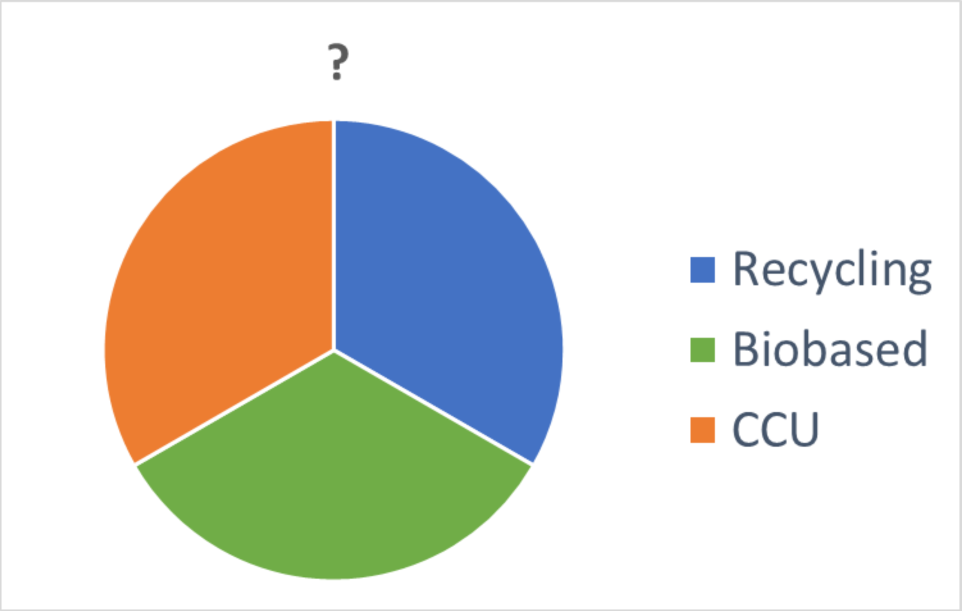
(Source:Statistica)



Why biobased plastics?

Alternative Carbon Sources
Three main options

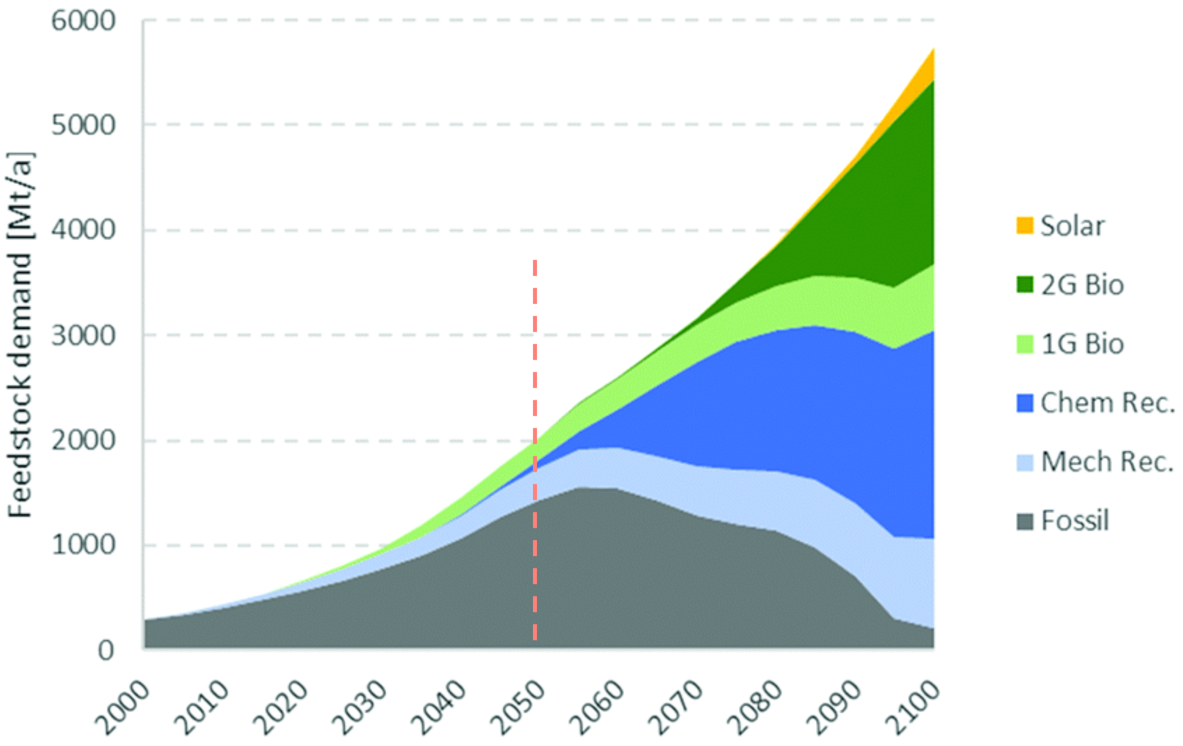
1. **Plastic recycling**
    - Mechanical
    - (Thermo) chemical
2. **Biobased feedstocks**
    - First generation
    - Second generation
3. **CCU**
    - Using Renewable energy

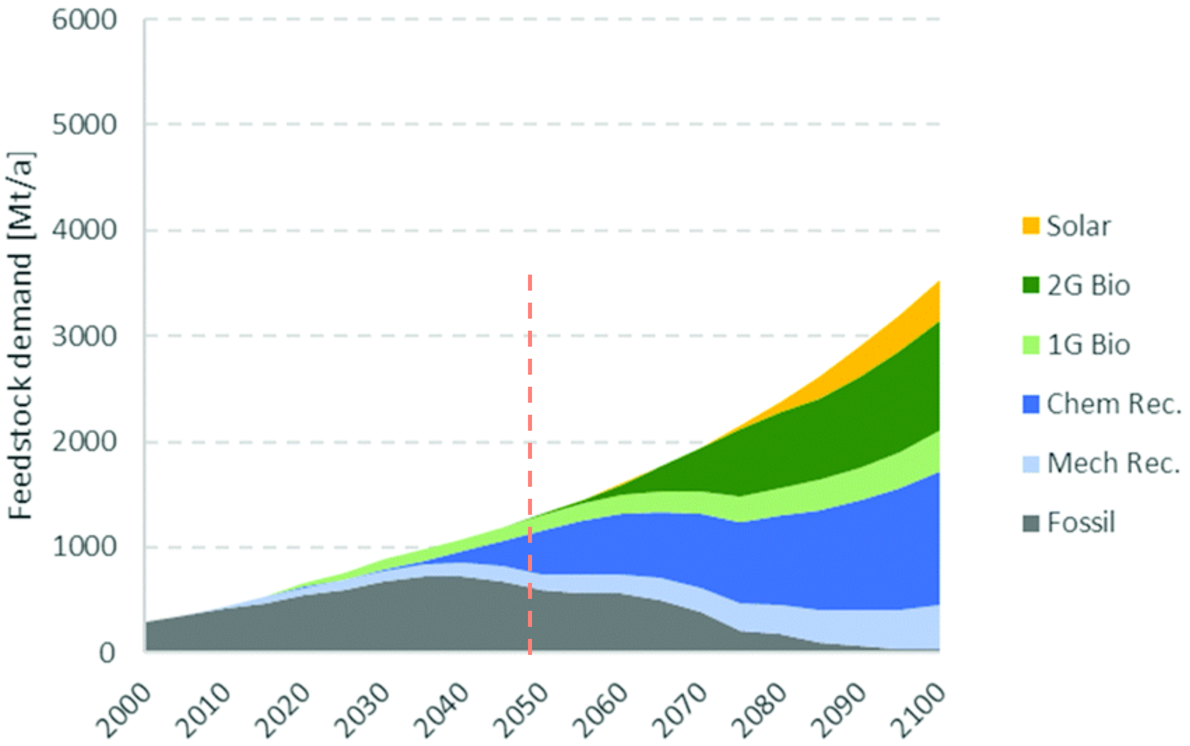


Alternative carbon sources (Biobased, CCU) are needed to allow growth of the chemical industry and to compensate for inevitable losses during recycling.

Why biobased plastics

Feedstock scenario's; left market driven, right regulated (J.-P. Lange Energy Environ. Sci., 14, 2021)





Why biobased plastics

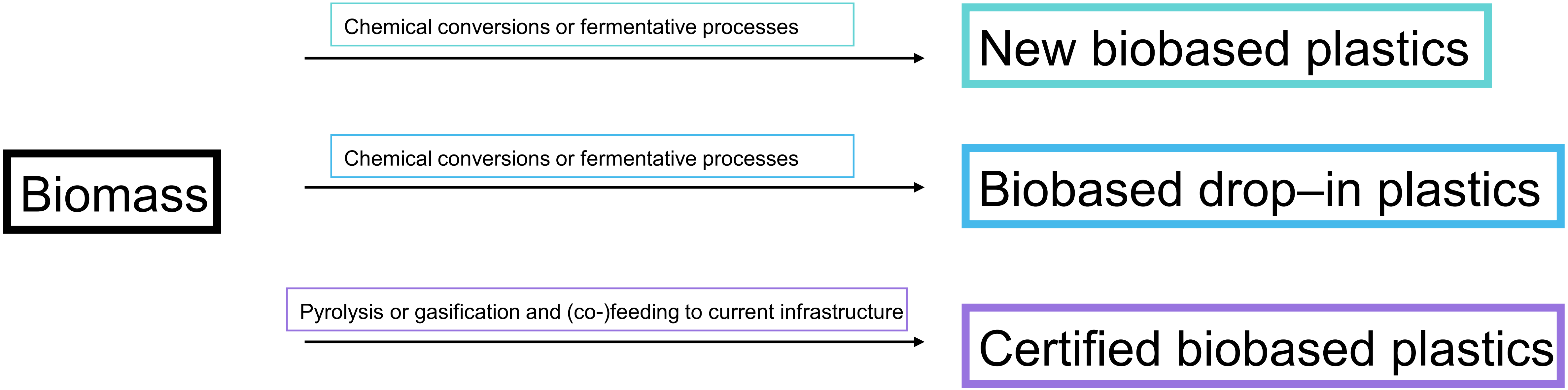
General conclusions regarding the feedstock transition

- Reducing the growth of feedstock consumption is essential
- Regulation is required
- CCS required to reach climate goals
- Efficient feedstock use, and processes with low energy demand are essential
- Products will become more expensive

- Losses during recycling are estimated to add up to 50%.
- Use of biomass as feedstock is essential, initially 1G and move to lignocelluloses
- To allow efficient feedstock use, shift in type of products required (from polyolefins to polyesters)
- CCU very expensive (high energy consumption), would also require product shift.
- New polymers require 20 years to break through and another 20 years to mature

Production routes for biobased plastics

Wide range of options



All routes require investment in additional installations and require a managed supply chain of biomass
Requirements for biomass pretreatment add to the cost.

Production routes for biobased plastics

New Biobased Plastic

Potential advantages

Efficient use of biomass

- More cost effective
- Lower environmental footprint

Processes with lower energy demand

- Low temperature processes

Decoupling from fuel and energy production

New functionalities

- Specific performance
- Improved recyclability
- Biodegradable or not persistent

Potential disadvantages

New production facilities

Long process of development and market introduction

New product design and development

Functional differences or disadvantages

Volumes initially too low for economic recycling

Production routes for biobased plastics

Drop-in Biobased Plastic

Potential advantages

Faster market introduction due to known properties

Can be recycled with fossil based plastics

Lower environmental footprint (GHG emission) as compared to fossil equivalent

Processes with lower energy demand

- Low temperature processes

Decoupling from fuel en energy production

Potential disadvantages

More expensive than fossil based equivalent

New production facilities required

No functional advantages

Inefficient use of biomass

Production routes for biobased plastics

Certified Bio-based Plastics

Potential advantages

Feedstock replacement allows versatile production of different plastic types and grades

Faster market introduction due to known properties

Can be recycled with fossil-based plastics

Lower environmental footprint (GHG emission) as compared to fossil equivalent, but depending on biobased content (% biomass added)

In operation for example using biodiesel produced from vegetable oils

Potential disadvantages

More expensive than fossil based equivalent

No functional advantages

Inefficient use of biomass

Pretreatment of biomass required (new facilities need to be developed)

Post treatment of pyrolysis oil may be required (new facilities)

Risk of only limited fossil feedstock replacement

Required scales can contribute to logistic challenges

Changes in current installation required on the long term (electrification)

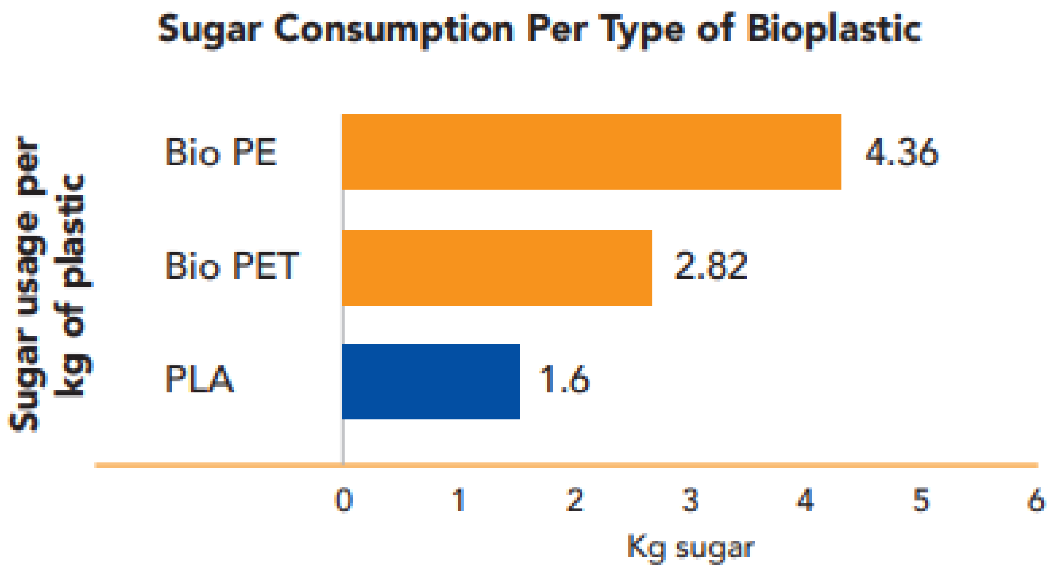
Production routes for biobased plastics

Important considerations

- Biobased resources are not abundantly available
- We need efficient conversion processes
- Biomass is oxygen rich, more logic to produce oxygen containing molecules
- Use of biomass leads to price increases

Efficient biomass use

(source Total Energies Corbion)



Feedstocks for biobased plastics

Biomass production and use

Most biomass is used for feed

- Additionally, EU imports ~ 70 Mt/y biomass for feed

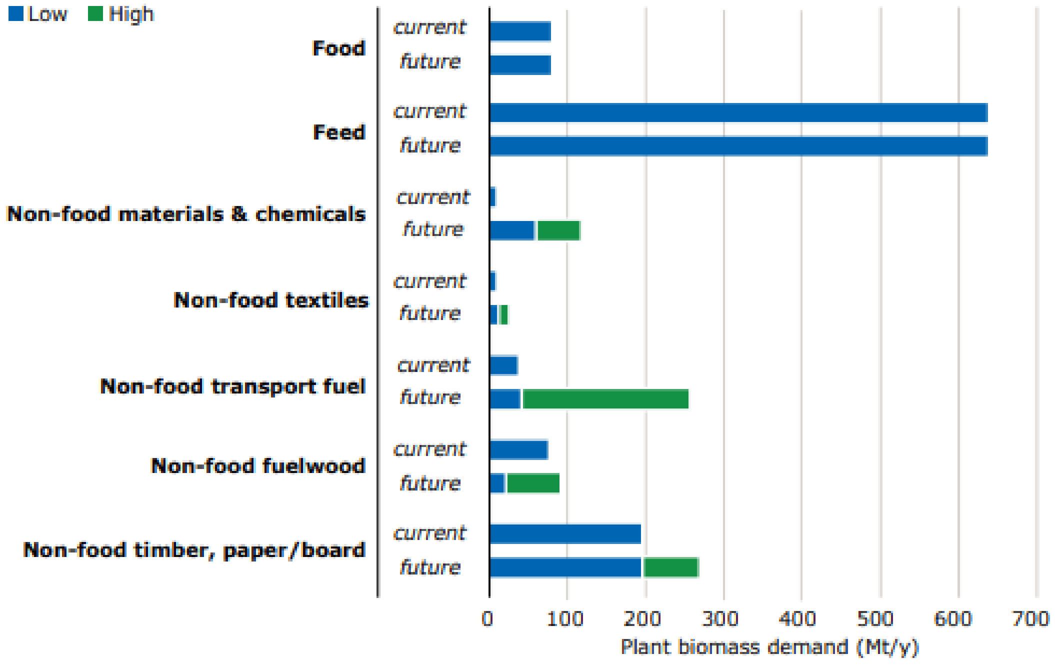
Biomass use for timber, paper/board is considerable and could grow

Current use for plastics and chemicals is low but expected to grow

Biomass use for electricity, heat and transport applications not desired/realistic

EU Plant Biomass demand

(Souce: Berkhout et al. Wageningen University, 2024)



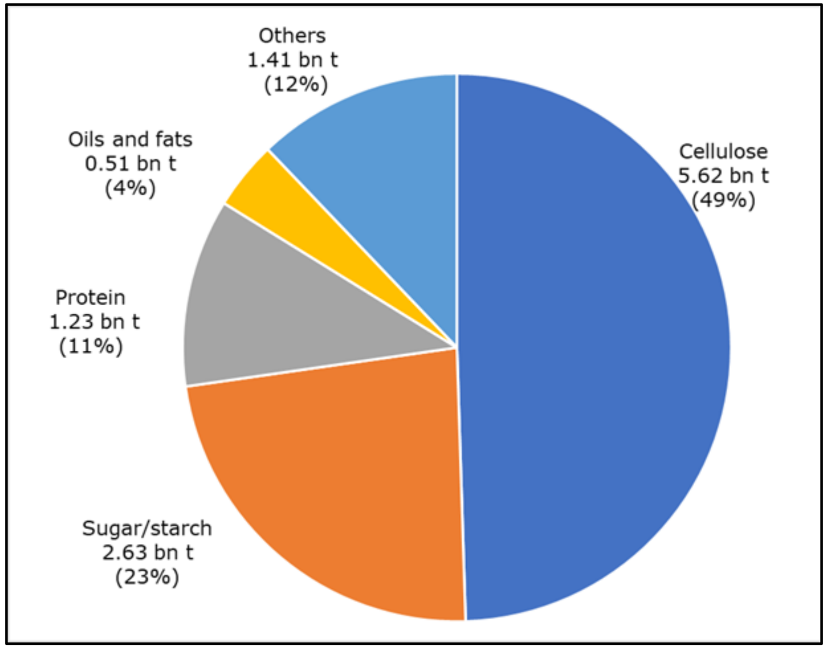
Feedstocks for biobased plastics

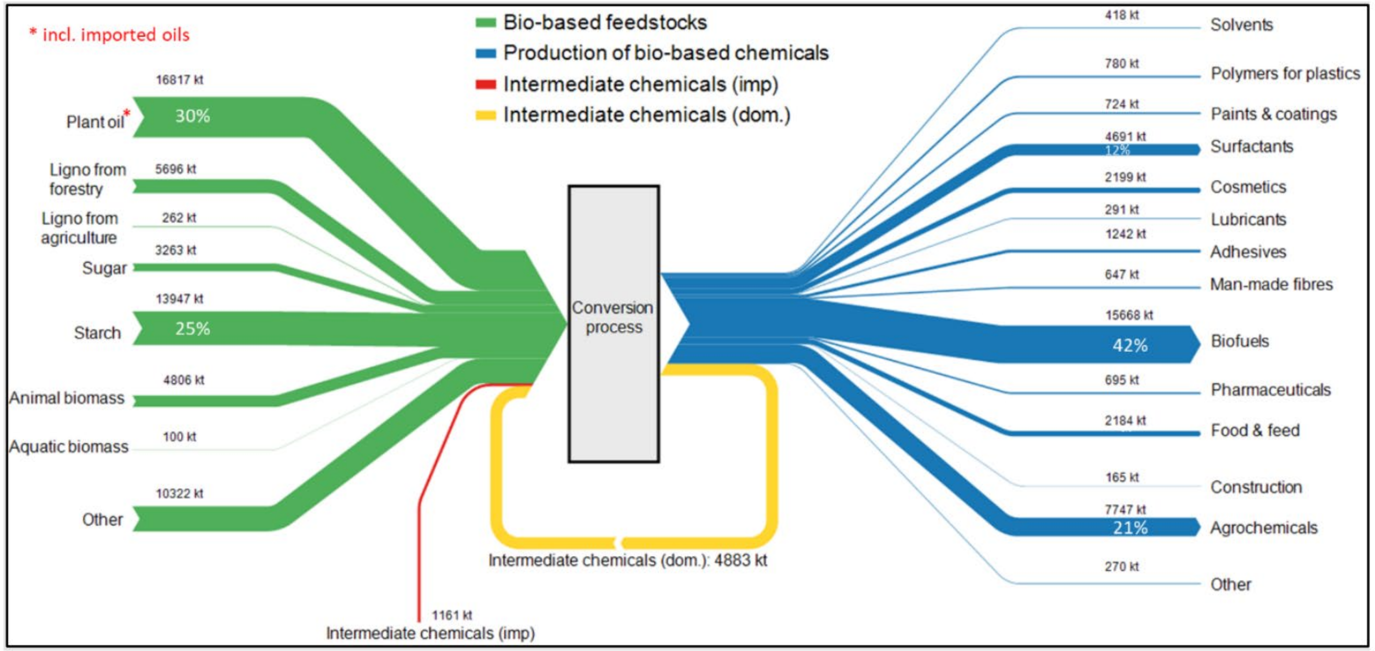
Type of biomass use should be considered

Abundant sources are (ligno)cellulose, sugar and starch; (sugar yield (beet and cane) ~ 10-15 ton/ha)

Oils and fats are scarcer; (yield palmoil ~3.3 ton/ha, rapeseed oil ~ 0.7 ton/ha)

This is not reflected in the uses in 2023





Source: Piotrowski, S. et al. 2015, Sturm et al. 2023

Feedstocks for biobased plastics

Current status

- Most used are sugars and starches in fermentation processes (50%)
- PHAs can be produced from sugars, vegetable oils or waste.
- Waste vegetable oils mainly used for biodiesel production

Main feedstocks for the production of biobased plastics.

Raw material	Feedstock	Biobased plastic
Starch	Corn, wheat, potato, tapioca	PLA, PTT, starch blends
Sugar	Sugar cane	PE, PLA, PHA
Castor oil	Ricinus	PA
Cellulose	Wood, cotton	CA
Edible oil	Palm, soy, rapeseed, sunflower	PHA
Waste vegetable oils	Used cooking oil, tall oil	Bioattributed plastics

Feedstocks for biobased plastics

General remarks

- Lignocellulosic agricultural side streams as such not well suited for chemicals and plastics production
- Need for technologies to make lignocellulosic side streams available for the production of chemicals at scale
- Non-food crops for fiber and wood are stand alone crops (not side streams), avoid energy usage

- Food and non-food products require the same crops and are interrelated
- Protein rich fibrous co-products are used as feed for livestock

Example Cereal:

- Plant based proteins for food
- Carbohydrates for chemicals and plastics
- Fibrous co-products for feed

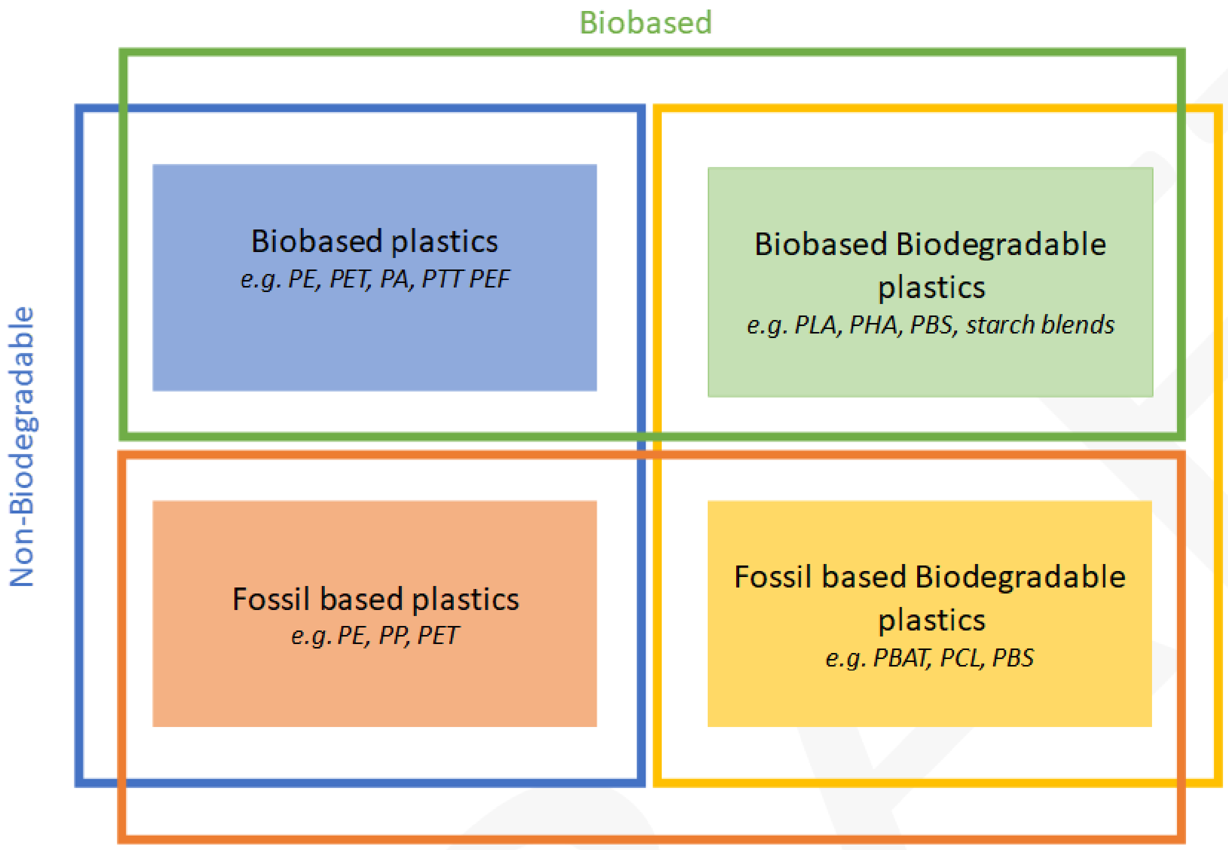
Bioplastics market

Classification

Biobased ≠ Biodegradable

Biobased plastics

- "New" biobased plastics
- Drop-in biobased plastics
- Bioattributed or certified biobased plastics



Bioplastics market

Current market shares

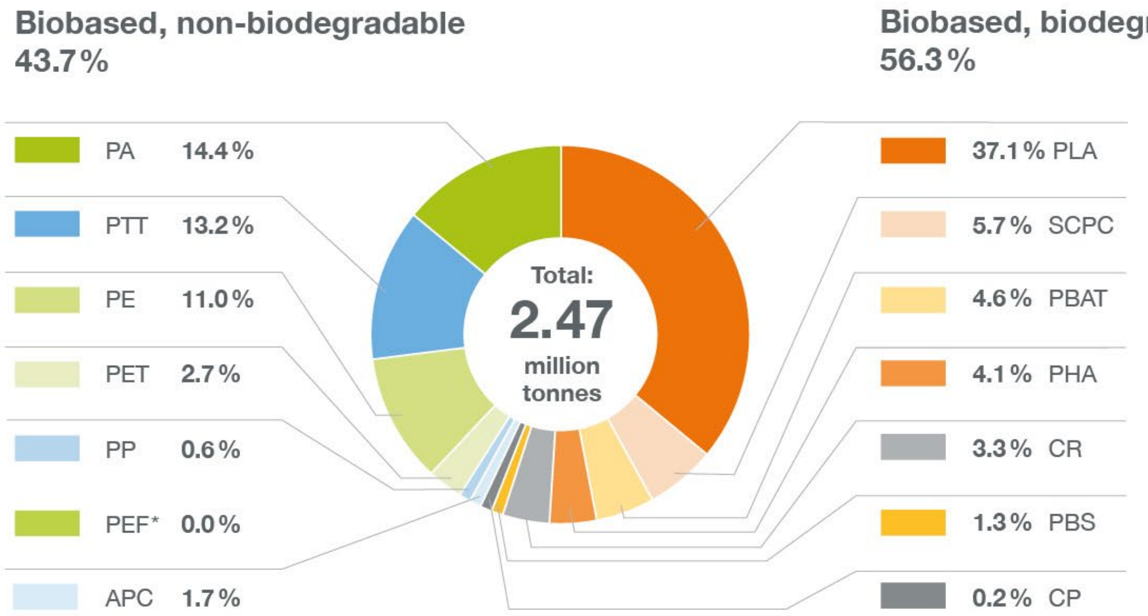
Production expected to double in the next 5 years

Main growth expected for:

- PLA
- PHA
- PE
- PP

Note: global bioethanol production for biofuel is about 135 million metric ton/a

Global production capacities of bioplastics 2024



Source: European Bioplastics, Nova institute (2024)

Bioplastics market

Current applications

Main application in packaging

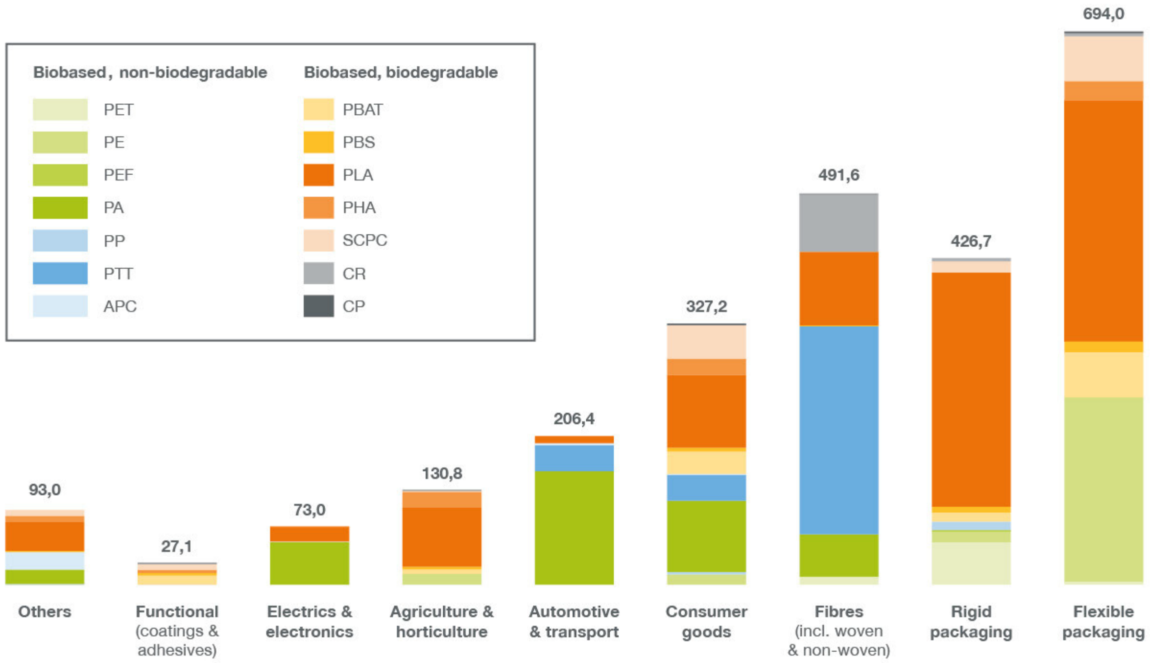
Substantial application in fibres (functionality driven)

In agriculture typically biodegradable plastics

Large share of PA in automotive

Global production capacities of bioplastics 2024 (market segments by polymers)

in 1,000 tonnes



Source: European Bioplastics, Nova institute (2024)

Bioplastics market

Growth limited by

- Economics; competitive disadvantage and lack of incentives
- This explains the relative success of biodegradable biobased plastics as there is no cheap fossil- based alternative

- Development time; 20 years to break through and additionally 20 years to mature

- Use biobased plastics because of specific advantages
- Not one to one replacement but specifically designed products uses the functionality

- Properties?

Bioplastics market

Remarks on properties

There is a wide range of fossil plastics with very different properties; does good or bad exist?

But:

- Mainly polyesters that are more susceptible for hydrolytic degradation
- As compared to polyolefins density of biobased polyesters is higher (can add to costs)
- Different processing characteristics of polyesters (low melt strength, high melt viscosity (IM), low crystalisation rate)

Examples of replacement options

Product type	Traditional	Biobased (not drop-in)
Blown flexible film	LDPE	PBAT, starch blends
Thermoformed rigids	PS, PET	PLA
Injection moulded articles	HDPE, PP	PLA, bioPBS
ISBM bottles	PET	PEF
Fibres for non-wovens (teabags)	PP	PLA

End-of-life options

End of life of plastics

Two main challenges:

- Recyclability (complex mixtures, contaminated products and aged plastics)
- Persistency in the environment, including microplastics and safety issues

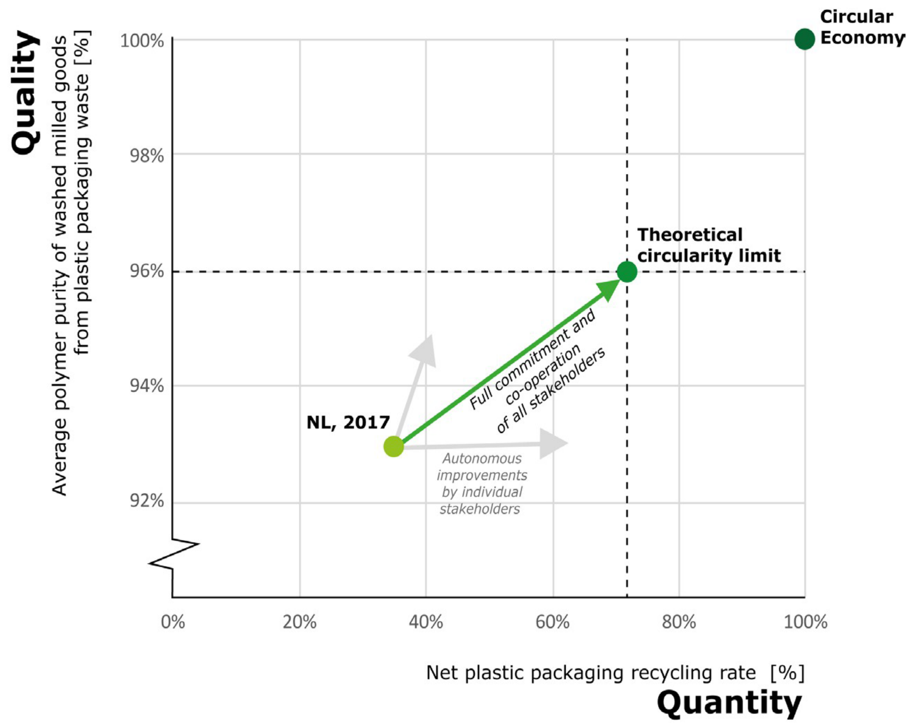
Plastic waste collection and treatment does not completely solve issues regarding fossil feedstock use and leakage to the environment

We need:

- Improved collection
- Improved sorting
- Improved recycling techniques

- Plastics with improved recyclability
- Plastics that not persistent

Recycling of plastic packaging in NL in 2017



Source: Brouwer et al. 2020, doi:10.3390/su122310021

End-of-life options

End of life of plastics

Recyclability is a system property

- Measured at a product level (circular by design)
- Fit in the waste management system
- Focus on feedstock (carbon) recovery and not on waste treatment

	Recycled to product *		Consumption *	Implied usage amount (%)
HDPE	749		7085	10%
PP	488		10464	5%
PET	1348		4300	31%

* Estimates in kt, figures of 2018. Data retrieved from reports of Plastic Recyclers Europe

Best practice is rPET bottles (circular, food contact)

- Separate collection, refund system
- Agreements on design, sufficient volume
- Decontamination methods
- Repair methods
- (alternative chemical recycling via solvolysis)

End-of-life options

End of life of plastics

Polyesters have benefits over commonly used polyolefins

Most biobased plastics are polyesters

Can be sorted and can be recycled

Sufficient volumes are required

Recycling Route	Collection efficiency (%)	Sorting efficiency (%)	Recycling efficiency (%)	Total efficiency (%)
Mechanical	70	80	90	~50
Chemical (solvolysis PET)	70	80	95	~55
Pyrolysis (mixed PE, PP)	70	80	50	~30
Gasification (mixed plastic)	70	90	50	~32

End-of-life options

Example PLA; very versatile at end-of-life and at present largest production volume

Post-industrial waste is used in house (trimmings) and for example in plant pots

PLA producers have set-up closed loop recycling (solvolysis, back to lactic acid)

Can be sorted out provided volumes are sufficient

Potential products, flow packs for cut vegetables (replacing BOPP), trays for meat or vegetables, flower pots

• In PMD,	sorted and subsequently recycled
• In residual waste	incinerated, release of biogenic carbon
• In GFT	composted with the content, no microplastics
• Littered	not persistent (meta study Hydra)

End-of-life options

Circularity example coffee capsule

Small product, hard to recover and recycle

Contains organic waste

Biobased compostable, vs aluminium, vs conventional plastic

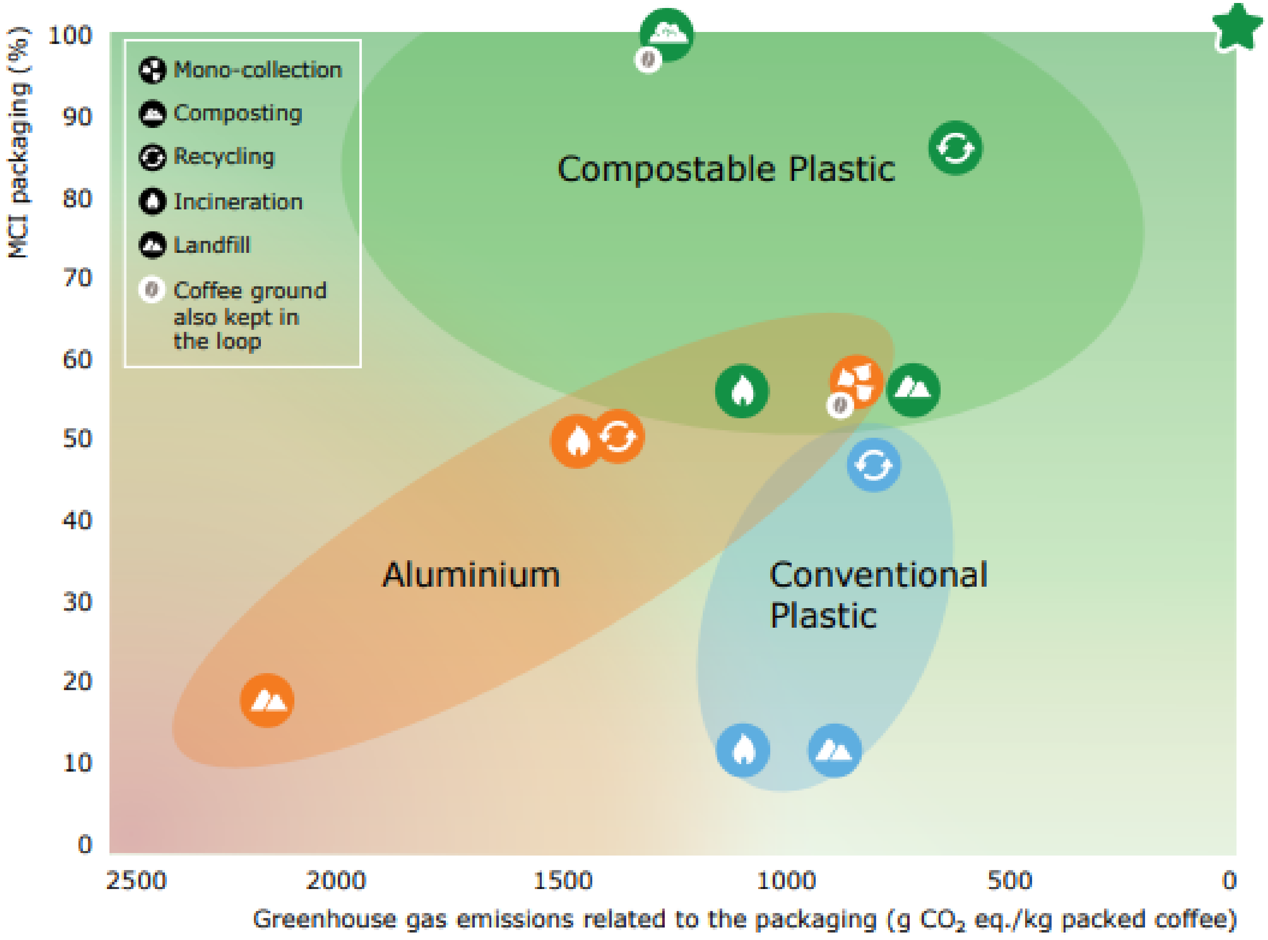
Different end of life scenarios

Composting coffee grounds only in mono-collection or when collected with GFT

Closed loop recycling of aluminium (thin walled) only possible in mono-collection

Conventional plastic can contaminate GFT

Impacts excluding content (coffee)



Environmental impacts

General remarks biobased vs fossil

Commonly lower GHG emission

Commonly higher impacts related to agriculture

- Depending on biomass type
- Depending on efficiency of production
- Waste streams often preferred

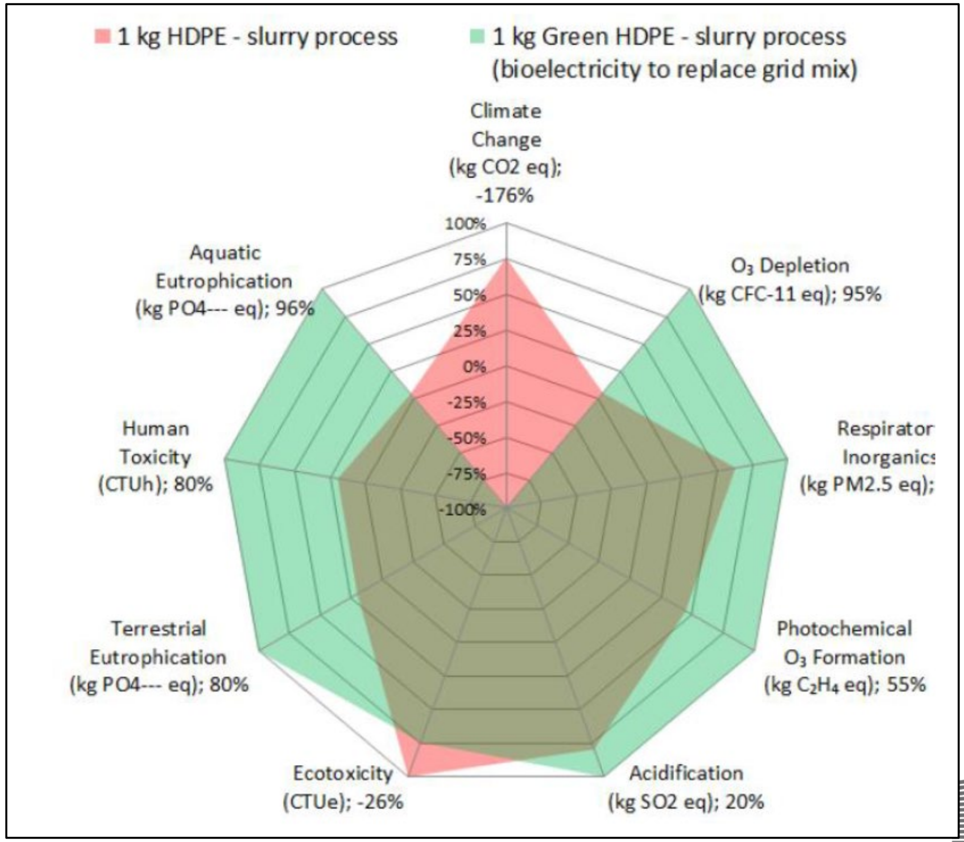
In LCA various aspects are not included

- Plastic pollution /microplastics
- Long term effects of climate change
- Biodiversity impacts
- Waste management

Impact of fossil plastic increases (relative share of impacts of oil drilling, shale gas processes)

LCA summary bioPE from sugar cane

Source: Braskem



Environmental impacts

Comparing with bioenergy production

Topic	Advantages for biomass use in biobased plastics as compared to bioenergy
GHG reduction	Biobased plastics often show higher reductions and additionally can offer carbon storage
Circular economy	Biobased plastics offer various recycling options and can -at end of life- be used for energy
Employment	Up to 10 times more employment due to longer and more complex value chains
Resource efficiency	Often higher land-use efficiency and resource efficiency
Added functionality	Various opportunities including biodegradability and reduced toxicity
Renewable alternatives	For plastics (carbon-based materials) the only alternative is direct use of CO_2

Source: Vural Gursel et al. Variable demand as a means to more sustainable biofuels and biobased materials, 2021

Environmental impacts

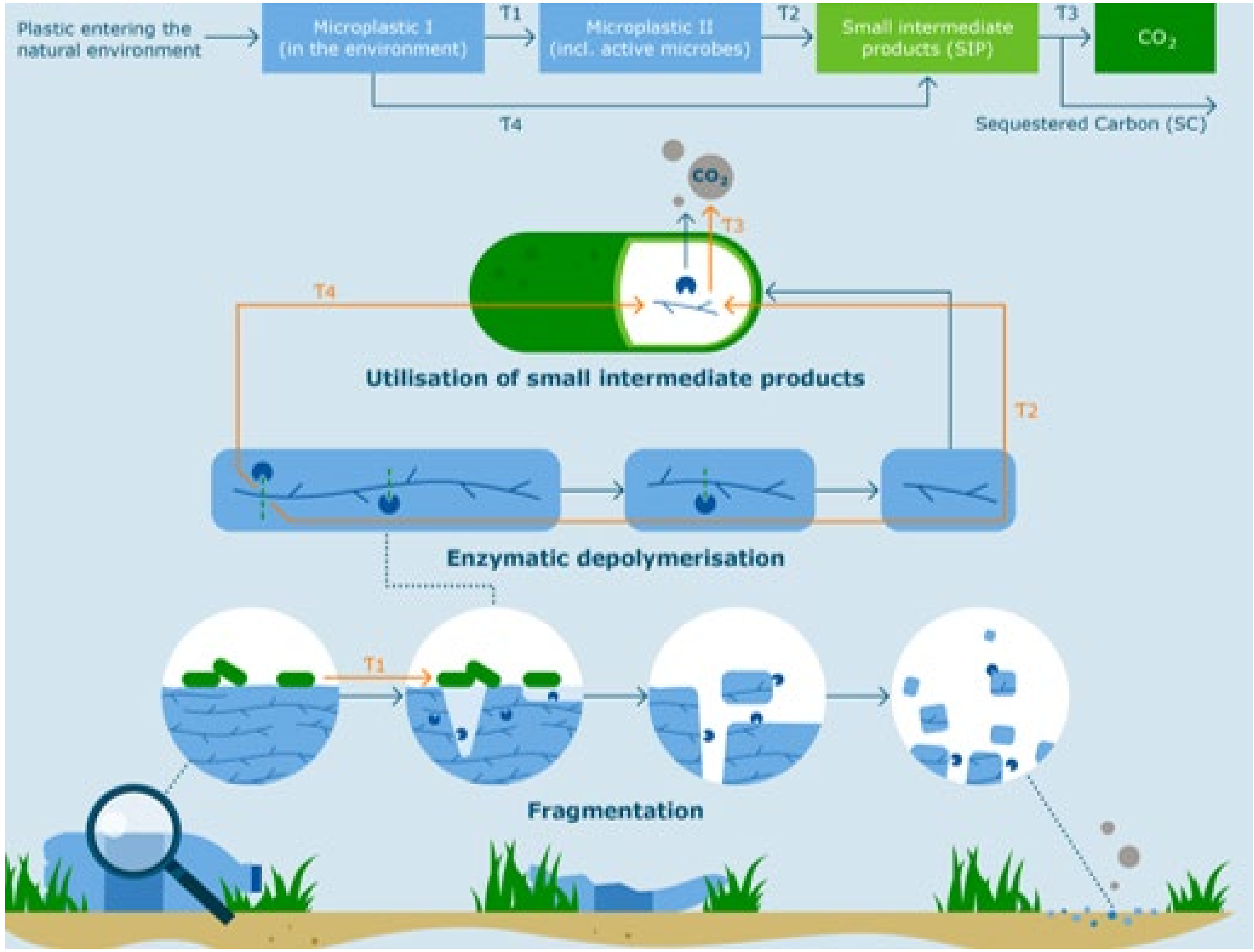
Microplastics

Important souces are:

- Synthetic fibres (textile)
- Car tyre abrasion
- Agricultural films
- Littered plastics
- Compost from GFT

Biodegradable plastics

- Microplastic formation is a part of the biodegradation process
- What is the effect of these microplastics?



Environmental impacts

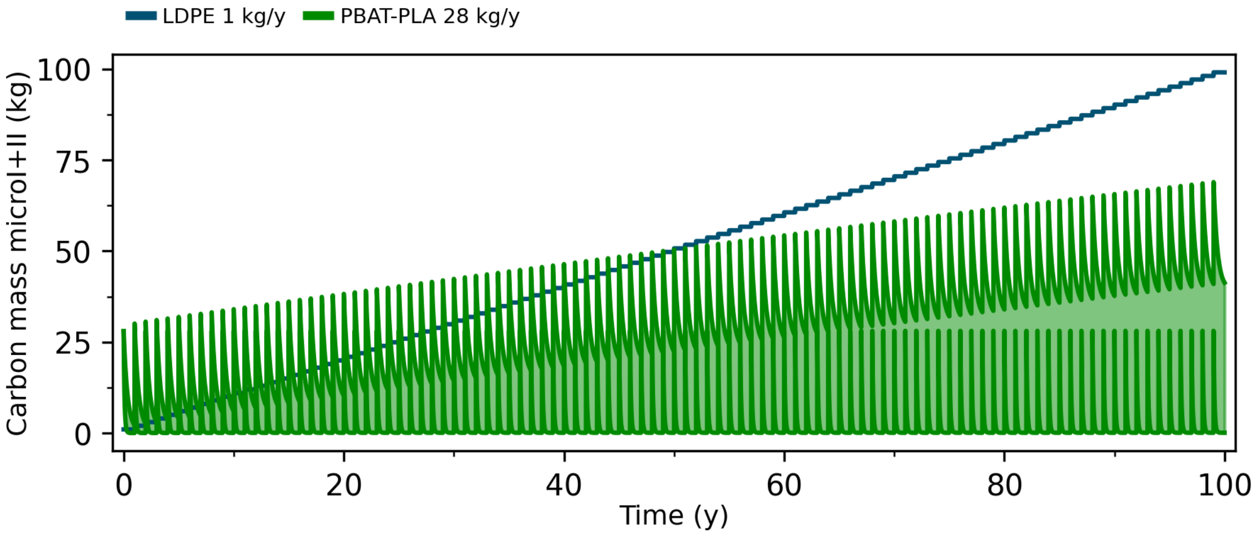
Persistency and microplastic accumulation; case study Mulch film

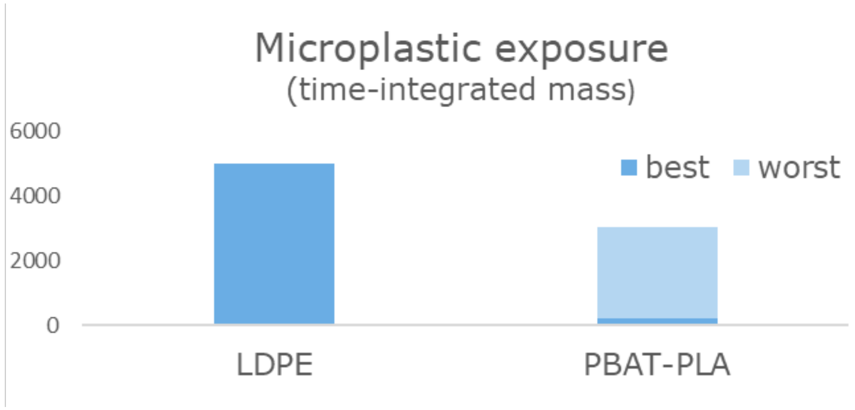
Recovery rates:

LDPE: 95%

PBAT-PLA: 0%

Even if biodegradable mulch films are left on the land microplastic accumulation is lower





Source: https://doi.org/10.1016/j.scitotenv.2024.177503

General remarks

Biobased plastics are needed in a future circular society

Efficient production routes with low energy demand required

Product shift required, oxygen containing plastics

Polyesters offer advantages during recycling

Move to plastics that are less persistent

Thank you

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