Market-Pull Measures for Bio-based Plastics in EU Product Legislation

The Problem Definition, Baseline and Policy Option Overview

August 2026

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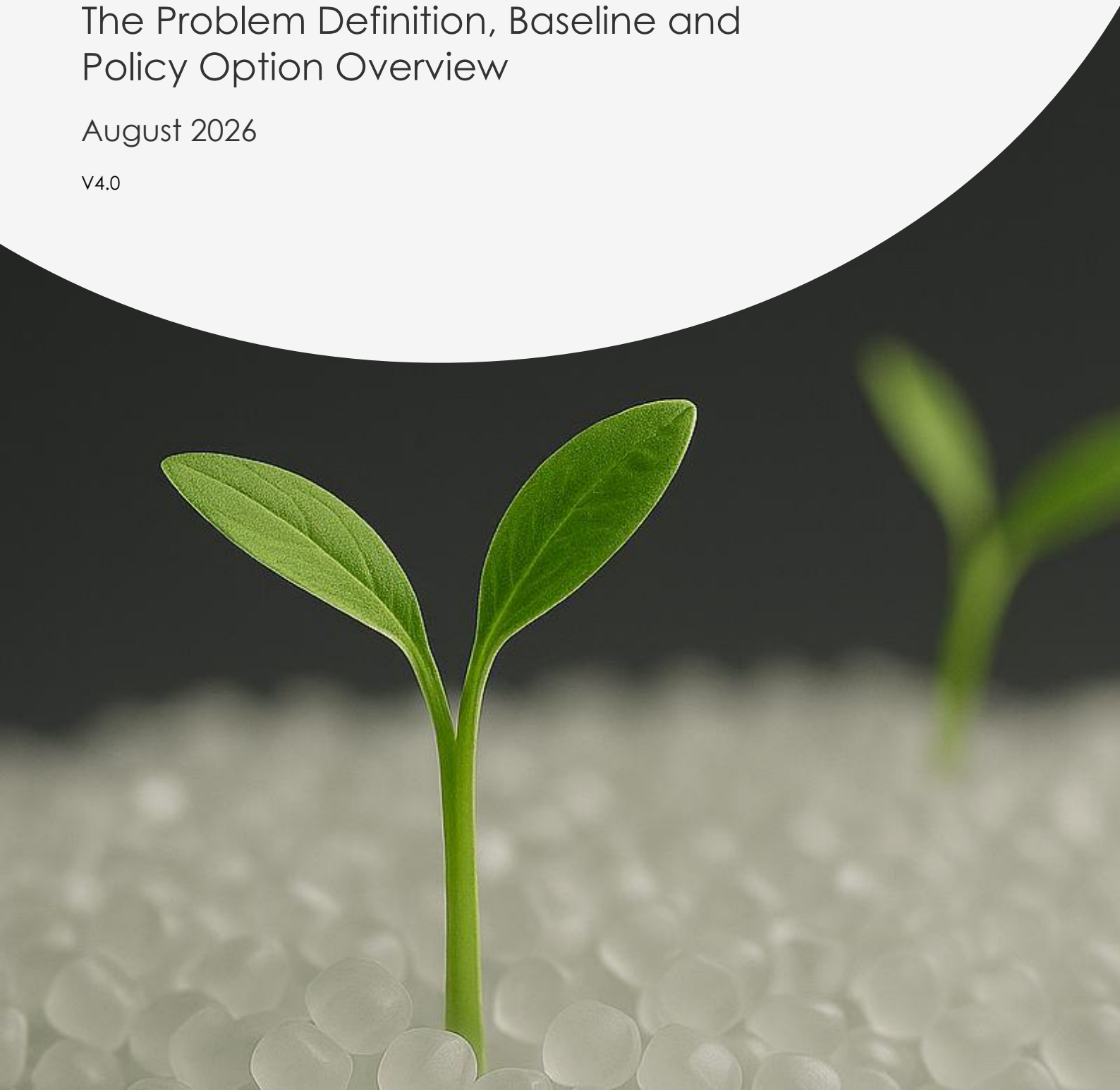

Report For

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About this Study

Bio-based plastics are plastics derived wholly or in part from biological rather than fossil feedstocks. They include drop-in bio-based polymers that are chemically identical to their fossil counterparts, such as bio-PE and bio-PET, dedicated bio-based polymers with no direct fossil equivalent, such as PEF (the JRC uses the term dedicated to distinguish these from drop-ins), mature inherently bio-based polymers with a long commercial history and no viable fossil equivalent, and a broad range of bio-based chemical intermediates used across the plastics value chain. The term refers only to the material's origin. Some bio-based plastics also possess functional properties such as biodegradability or compostability, but these are separate characteristics and are not inherent to bio-based content.

The case for scaling bio-based plastics in the EU rests on four intersecting objectives:

1. **Climate,** because substituting fossil carbon with biogenic renewable carbon reduces lifecycle greenhouse gas emissions in most applications.
2. **Strategic autonomy,** because bio-based plastics reduce dependence on imported crude oil and petrochemical intermediates.
3. **Industrial competitiveness,** because the EU holds comparative advantages in bio-manufacturing pathways, including biochemical, catalytic, fermentation-based and hybrid production routes, and in the white biotechnology patents that bio-based production can draw on.
4. **Renewable feedstock substitution,** because bio-based plastics replace a finite fossil feedstock with a renewable biological one. This objective is analytically distinct from the climate case: it is a resource-system transition, not only an emissions reduction.

Despite these advantages, bio-based plastics have represented only around one percent of global plastic production for over a decade. **This is not simply a market condition: it sits uneasily alongside the EU's own stated commitments, including climate neutrality by 2050, the ambition set out in the EU Bioeconomy Strategy to bring forward bio-based content requirements under PPWR, and the strategic autonomy case reflected in the EU's continued dependency on imported crude oil and petrochemical feedstocks.** The problem definition set out in this report explains why voluntary action and incremental incentives have not closed this gap, and why targeted demand-side instruments are needed.

This study examines why the gap has persisted and what EU product legislation can do to close it**. It was commissioned by a seven-member industry consortium—Arkema, Avantium, Borealis (Borouge International), Braskem, Neste, UPM and Vioneo—together representing the upstream bio-based plastics and chemicals supply chain. Eunomia Research and Consulting has conducted the study independently, drawing on public evidence, academic literature, and structured consultation with all seven consortium members as well as other industry and policy stakeholders.** The aim is to assess demand-side measures across the full range of EU product policy, including but not limited to packaging.

The work is structured in two phases:

- **Phase 1, set out in this report,** establishes the analytical foundation: a problem definition grounded in the specific market failures preventing scale-up, a mapping of the EU legislative landscape and the operative bio-based plastics hooks within it, findings from industry consultation, a framework for the policy option architecture, and a prioritisation of the end-use sectors where demand-side instruments are most actionable**.**

- **Phase 2 will operationalise the Phase 1** architecture to delegated-act-ready specification, including full quantitative impact assessment and mass balance and chain-of-custody rules at implementation level.

Executive Summary

A decade of limited market growth suggests that technical feasibility alone is insufficient to scale bio-based plastics, raising the question of whether stronger demand-side measures are needed.

Bio-based plastics have been commercially available for more than a decade, yet they have not achieved significant market penetration. In the EU, bio-based plastics have remained below 1% of total plastic production for much of the past decade, while globally their share has generally remained between 0.5% and 1%. Capacity forecasts have repeatedly overestimated market growth: industry bodies projected around 7.2 million tonnes of global capacity by 2019, roughly double what was realised. This suggests that the challenge is not technical feasibility but the ability of existing market incentives to support sustained investment.

This matters because a plastics sector that remains overwhelmingly fossil-based sits uneasily alongside the EU's climate-neutrality objectives, the Bioeconomy Strategy, and wider ambitions for strategic autonomy. Europe continues to account for a substantial share of global bio-based plastics production, indicating that industrial capability exists. The central question is why deployment has remained limited despite that capability.

Recent growth in global bio-based polymer production, reaching approximately 4.5 million tonnes in 2025, suggests that the market may be beginning to expand. However, much of this growth is occurring outside Europe, raising questions about the EU's future position in the emerging renewable-carbon economy.

This study focuses on four priority sectors; *packaging, textiles, construction and automotive.*

These were prioritised based on four criteria: ***Fossil demand scale.*** *The sector must account for a substantial share of total fossil plastic consumption;* ***Bio-based substitution potential.*** Commercially available bio-based polymers must exist for at least the dominant material types in the sector***; Active or near-term legislative hook.*** A delegated act, review clause or implementing measure must be active or in formal preparation within the study horizon (approximately 2025 to 2032); *and,* ***Manageable structural barriers.*** No dominant polymer should lack a commercially viable bio-based equivalent, and no overriding regulatory constraint should systematically exclude bio-based materials from the sector's primary applications.

Why Has Growth Remained Limited Despite Technical Maturity?

> *The evidence points to a persistent demand-side market failure: bio-based plastics are commercially proven, but investment remains constrained by an enduring cost premium that voluntary demand has not overcome.*

Bio-based polymers typically remain more expensive than fossil-based alternatives. In most cases, bio-based resins cost approximately 1.5 to 2 times as much as their fossil counterparts. This difference reflects structural factors, including mature fossil supply chains, decades of process optimisation, and the continuing under-pricing of environmental externalities.

Voluntary demand has not been sufficient to overcome this cost differential. Demand tends to increase when fossil prices are high and weaken when they fall, creating uncertainty for investors considering long-term production capacity. As a result, capacity growth has consistently lagged expectations despite repeated forecasts of expansion.

Bio-based plastics also compete for feedstocks with the transport sector, where biofuel and sustainable aviation fuel mandates create a growing and legally backed source of demand. RED III establishes a principle of prioritising material uses over energy uses, but it does not attach a comparable demand-side mechanism to materials. As a result, bio-based materials compete for many of the same feedstocks without an equivalent policy-driven source of demand. The introduction of a bio-based materials target would alter that balance by creating a dedicated demand signal for material uses. The principal barrier

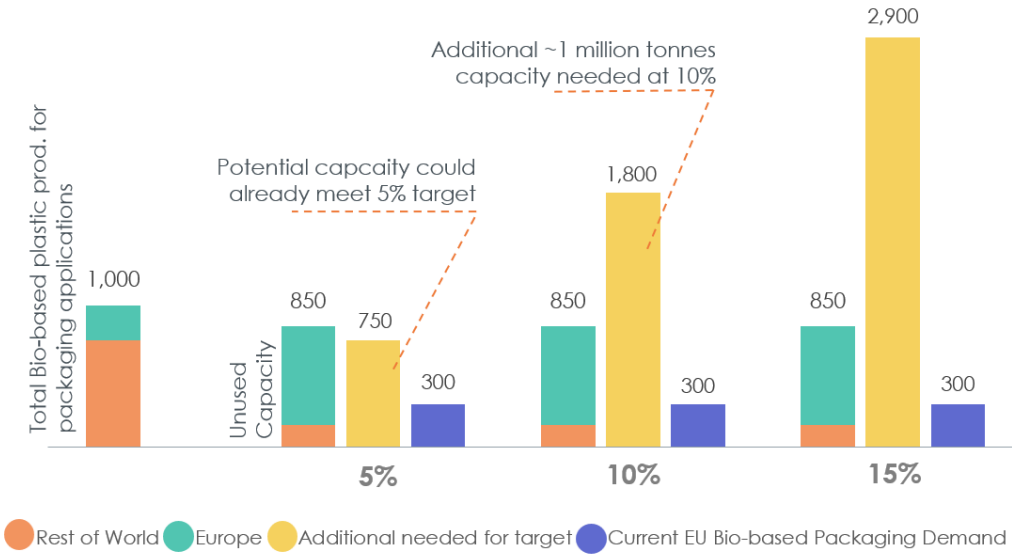
to scale-up is therefore not technological readiness, but the absence of a durable demand signal capable of supporting investment over the lifetime of industrial assets.

What would a packaging target achieve?

> *The evidence suggests that a 10% bio-based feedstock target for packaging would create a meaningful demand signal while imposing only limited costs on consumers, making packaging a credible starting point for market development.*

The modelling suggests that a 10% bio-based feedstock-use target would increase EU demand for bio-based packaging feedstock by approximately 1,800 kt above current levels, of which around 1,300 kt would represent genuinely new demand. A 5% target would likely have only a limited effect on investment, while a 15% target risks outpacing currently foreseeable supply. On the evidence reviewed, a 10% target appears to represent a meaningful and achievable starting point (Figure E 1).

Figure E 1: Bio-based packaging demand required by target level, with increment above current demand (ktonnes)



The most notable finding is that consumer impacts are small. Although bio-based resins remain significantly more expensive than fossil alternatives, packaging represents only a small share of most retail product costs. Across the packaging formats assessed, the estimated retail price effect remains below 1% even at the highest target levels modelled, and falls as low as 0.05% in some 10% target scenarios (Table E 1). A modest feedstock-use target therefore creates a meaningful demand signal while imposing only limited costs on consumers.

Table E 1: Packaging Costs and End Product Price Increases

Product	Target	Added cost per pack	Packaging cost increase	Product price increase
HDPE orange juice bottle 34g, product price €2.96	5%	€0.0020	3.9%	0.07%
	10%	€0.0039	7.7%	0.13%
	15%	€0.0059	11.6%	0.20%
PET water bottle 24g, product price €0.70	5%	€0.0015	4.2%	0.21%
	10%	€0.0029	8.3%	0.41%
	15%	€0.0044	12.5%	0.62%
Flexible PE bread bag 5g, product price €1.50	5%	€0.0003	3.2%	0.02%
	10%	€0.0005	6.5%	0.04%
	15%	€0.0008	9.7%	0.05%

The assessment finds that a target should be set on the use of bio-based feedstock rather than on the bio-based content of the finished product. A content target measures what the finished plastic is made of, whereas a feedstock-use target measures the renewable feedstock used to produce it. Feedstock use is the more robust basis because bio-based content can be measured in different ways, and a content-based approach can produce different results for different polymer chemistries.

Verification is critical to the credibility of any feedstock-use target. Because much of the near-term supply is co-processed with fossil feedstock, the bio-based share cannot be determined from the finished product and must instead be tracked through the supply chain using mass balance.

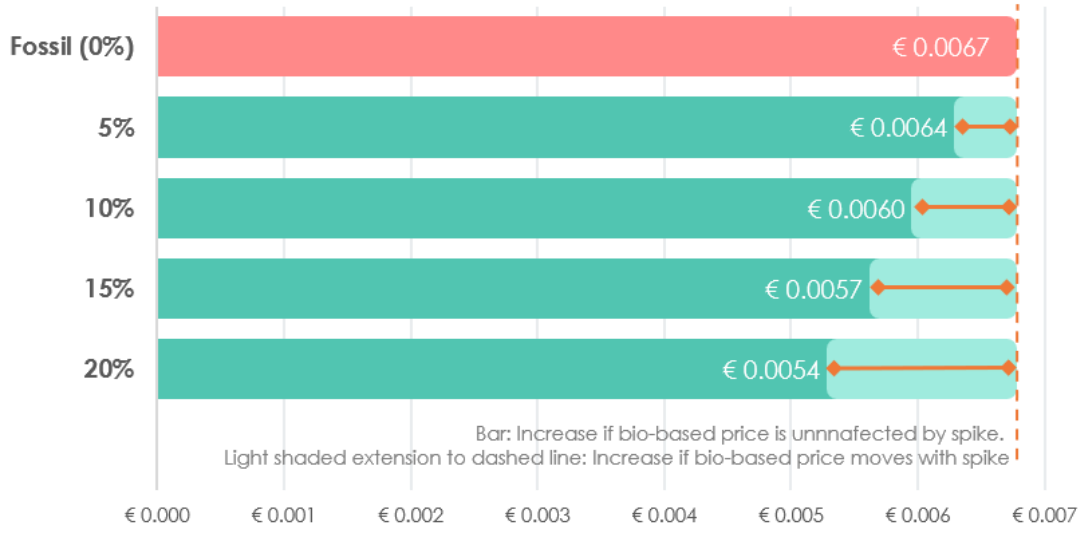
The assessment supports a narrow form of mass balance that keeps claims tied to physical material flows. Under the proposed chemical-connectivity safeguard, the quantity of bio-based credit assigned to a product can never exceed the quantity of bio-based feedstock entering the process.

How does this compare with existing market volatility?

> The estimated cost of a bio-based feedstock target is small relative to the price volatility that downstream markets already experience from fossil feedstocks.

The results indicate that the packaging-cost impact of a target in the 5% to 15% range is smaller than the routine volatility already experienced in fossil-polymer markets. The cost effect of a bio-based target is fixed and predictable, whereas fossil-resin price movements remain uncertain and potentially much larger (Figure E 2). The proportionality of a packaging target should therefore be considered in the context of the volatility that downstream markets already absorb.

Figure E 2: HDPE orange juice bottle: pack cost increase under a €200/tonne fossil price shock, by target



What are the environmental implications?

> The environmental evidence does not identify a barrier to a 10% packaging target: there are greenhouse-gas benefits, and land requirements remain modest at the scale assessed.

The assessment identifies two principal environmental findings.

First, the greenhouse-gas benefit is substantial and consistent.

Across all polymer mixes and end-of-life scenarios assessed, replacing fossil feedstocks with bio-based feedstocks reduced emissions. Estimated savings range from approximately 8.2 to 8.6 million tonnes of CO2e per year under a 10% packaging target, with less than 5% variation across scenarios. The climate benefit does not depend strongly on either recycling outcomes or the specific polymer mix used for compliance.

Second, land availability does not constrain a target at this scale.

Land-use requirements vary according to polymer chemistry and feedstock crop. Polyolefins require roughly two and a half times the land of polyesters per tonne, and crop choice has an even larger influence. However, a 10% packaging target would require only around 0.5% to 3.5% of EU agricultural land, or at most about a third of a percent of global cropland. Current production capacity becomes a constraint well before land availability does.

The analysis therefore finds no evidence that land availability would prevent implementation of a packaging target at the levels considered. While differences in land use exist between polymer pathways, a wider set of environmental considerations should be considered in future land use criteria assessments.

What has Phase 1 concluded?

> Phase 1 finds that the central questions are no longer whether intervention is justified, but how it should be designed and calibrated. The market failure is evident, the policy architecture is identifiable, and a packaging target appears both proportionate and deliverable.

Taken together, the evidence supports the adoption of a coordinated demand-side policy package, implemented across multiple legislative instruments rather than relying on any single regulatory measure – see Figure E 3. At its core should be a feedstock-use target for plastic packaging, anchored to the only legal basis currently established in enacted legislation.

Packaging emerges as the appropriate lead sector because PPWR Article 8 provides an immediately available legislative hook. By contrast, the textile, construction, and automotive sectors are considered at the level of policy architecture and future option development, with sector-specific measures to be established as their respective legislative frameworks and regulatory hooks come into force.

Phase 1 has established the overall policy architecture. Phase 2 will focus on resolving a limited number of design questions that determine how the instrument is implemented in practice

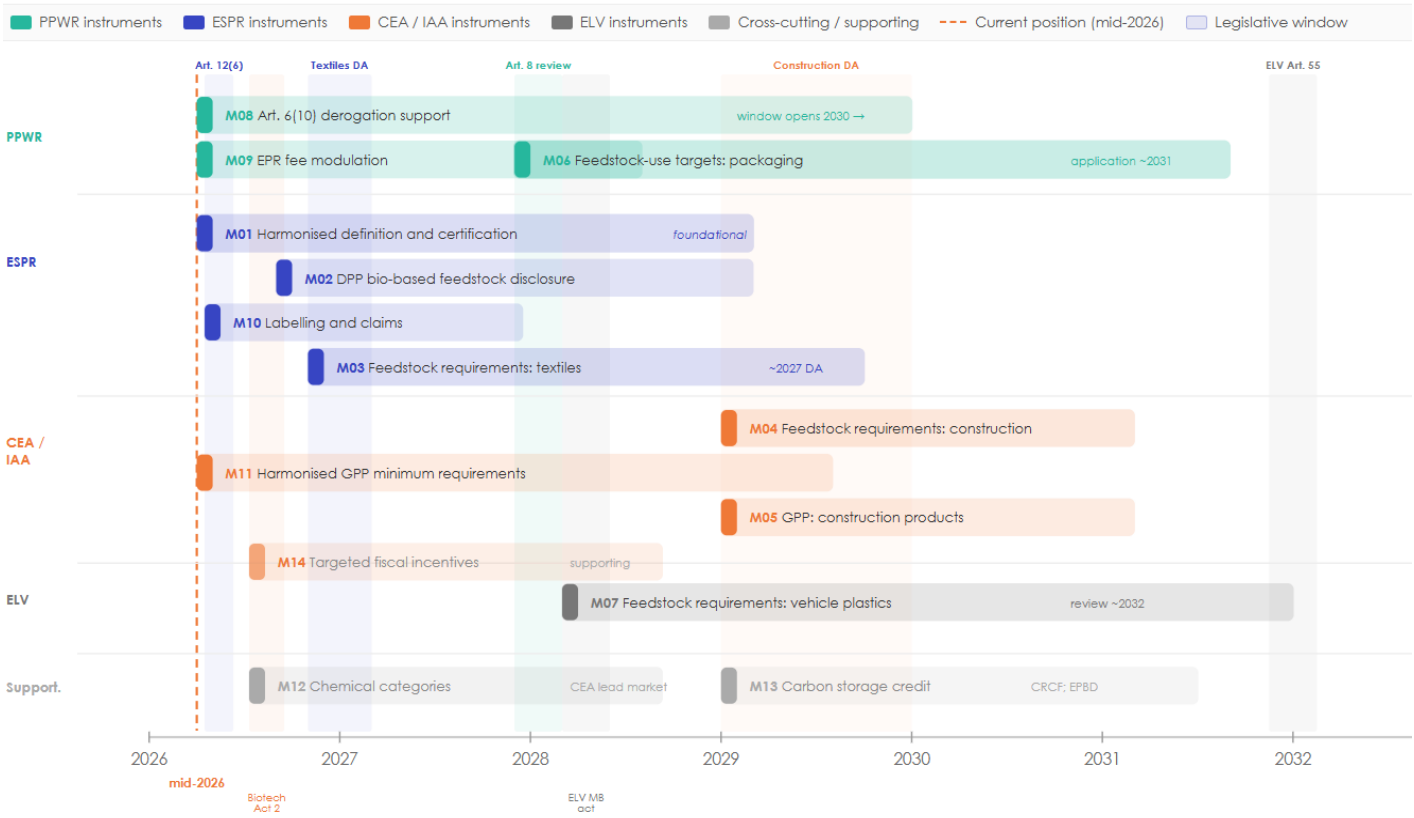
The evidence indicates that:

- the principal barrier to growth is a persistent demand-side market failure;
- bio-based feedstock use is the most appropriate target metric;
- mass balance with chemical connectivity is the appropriate verification framework;
- a 10% packaging target represents a credible and deliverable starting point;
- consumer-price impacts are likely to be limited;

- greenhouse-gas benefits are substantial; and
- land availability does not constrain deployment at this scale.

Packaging emerges as the most appropriate lead sector because a legislative pathway already exists through PPWR Article 8. The textile, construction and automotive sectors require further development as their respective policy frameworks evolve.

Figure E 3: Illustrative Timing Windows for Measures



Bar length indicates the approximate action window from mid-2026 onward. Swim lanes group instruments by primary legislative vehicle. Shaded vertical bands mark key legislative deadlines or windows. Complementary instruments (M15) and Option B (M16) are omitted from the timeline; M15 instruments operate across the full period and M16 (Option B) requires a new standalone regulation with no confirmed timeline.

What remains for Phase 2?

> Phase 2 focuses on implementation: determining target levels, managing competition for feedstocks, and designing the sustainability and compliance systems needed to support market deployment

Phase 1 establishes the policy architecture. Phase 2 will focus on calibration and implementation. The principal questions that remain open are:

- the appropriate level of ambition across different sectors;
- interactions between sectors competing for shared feedstock supplies;
- the role of industrial-policy measures supporting EU processing capacity;
- the adaptation of RED III sustainability criteria for materials applications;
- detailed compliance and certification arrangements; and
- the future role of greenhouse-gas performance thresholds.

Table of Acronyms

Acronym	Meaning
CBAM	Carbon Border Adjustment Mechanism
CCU	Carbon Capture and Utilisation
CEA	Circular Economy Act
c-PCR	Complementary Product Category Rules
CPR	Construction Products Regulation
DG ENV	Directorate-General for Environment
DG GROW	Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
DPP	Digital Product Passport
ELV	End-of-Life Vehicles
ELVR	End-of-Life Vehicles Regulation
EPBD	Energy Performance of Buildings Directive
EPR	Extended Producer Responsibility
ESPR	Ecodesign for Sustainable Products Regulation
ETS	EU Emissions Trading System
ISCC	International Sustainability and Carbon Certification
FOAK	First-of-a-Kind
GHG	Greenhouse Gas
GPP	Green Public Procurement
HEFA	Hydroprocessed Esters and Fatty Acids
HVO	Hydrogenated Vegetable Oil
IAA	Industrial Accelerator Act
ISO	International Standards Organisation
JRC	Joint Research Centre
LCA	Life Cycle Assessment
MEErP	Methodology for Ecodesign of Energy-related Products
PCR	Post-Consumer Recycled
PPWR	Packaging and Packaging Waste Regulation
RC	Recycled content
RED III	Renewable Energy Directive III
RFNBO	Renewable Fuels of Non-Biological Origin
RSB	Roundtable on Sustainable Biomaterials
SAF	Sustainable Aviation Fuel
SUPD	Single-Use Plastics Directive
TRL	Technology Readiness Level

Contents

1.0 Introduction and Scope **11**
1.1 Bio-based Plastic Definition and Pathways 12
1.2 Priority End-Use Sectors for Bio-based Plastics Market-Pull Measures 13
2.0 The Current Policy Setting for Bio-based Plastics **16**
2.1 Framework Instruments 18
2.2 Product Legislation Instruments 21
2.3 Flanking Instruments 24
2.4 Overview of Policies against Measures 25
3.0 Problem Definition: Market Failure and the Case for Intervention **27**
3.1 Overview of Current Market Position 27
3.2 Seven Structural Drivers of Market Failure 29
3.3 Likelihood the Problem will Persist 36
4.0 Baseline Scenario: Where the Market Stands Without Further Intervention **38**
4.1 Current Policy Conditions: An Incomplete Framework 39
4.2 The European Investment Climate: Structural Constraints on Bio-based Plastics Growth 45
4.3 The Fossil-Bio Cost Differential: Current Position and Baseline Trajectory 48
4.4 Bio-based Capacity, Utilisation and the Baseline Production Trajectory 60
4.5 Environmental Performance of Bio-based Plastics 67
5.0 Developing a Policy Option **75**
5.1 Objectives: What the Option Must Achieve 75
5.2 Designing a Target: Feedstock Use, Not Bio-based Content 76
5.3 Instrument Stack and Tiers 79
5.4 Policy Option Architecture 83
5.5 Instrument Specifications 83
6.0 Analytical Demonstrator: Bio-based feedstock-use targets for plastic packaging under PPWR (M06) **89**
7.0 Phase 2 Scope – Other Priority Sectors and Open Design Questions **103**
7.1 Why Each Sector Needs a Different Entry Point 103
7.2 The Design Questions Phase 2 Must Resolve 104
8.0 Conclusions and Handover to Phase 2 ..... **107**
A.1.0 Priority Screening Assessment **110**
A.2.0 Policy Landscape Matrix: Rationales **112**
A.3.0 Baseline Growth Trajectory **117**
A.3.1 Current Production and Capacities 117
A.3.2 EU Bio-based Capacity Pipeline 118
A.4.0 Derivation of the Bio-Naphtha Range **119**
A.5.0 Cradle-to-gate GHG footprints of bio-based polymers **122**
A.6.0 Packaging Place on Market Estimates **124**

1.0 Introduction and Scope

Bio-based plastics represent only around 1% of EU plastic production and have done so for a decade. Capacity growth has repeatedly failed to meet forecasts while capacity utilisation is around 74%. This is not simply a market condition, it is a market failure, and is incompatible with the EU's stated political commitments, including climate neutrality by 2050, the EU Bioeconomy Strategy ambition to bring forward bio-based content requirements under PPWR, and the strategic autonomy case reflected in the EU's continued dependency on imported crude oil and petrochemical feedstocks. The case for scaling bio-based plastics in the EU rests on four objectives:

1. **Climate change**, because substituting fossil carbon with biogenic renewable carbon reduces lifecycle greenhouse gas emissions in most applications;

2. **Strategic autonomy**, because bio-based plastics reduce dependence on imported crude oil and petrochemical intermediates;

3. **Industrial competitiveness**, because the EU holds comparative advantages in bio-manufacturing pathways, including biochemical, catalytic, fermentation-based, and hybrid production routes, and white biotechnology patents that bio-based production can leverage; and

4. **Renewable feedstock substitution**, because bio-based plastics replace a finite fossil feedstock with a renewable biological one. The ideal end state is materials that are both bio-based and recycled. This objective is analytically distinct from the climate case: resource system transition, not only emissions reduction, which is the basis for the report's argument that bio-based and recycled routes are treated as complementary rather than pooled.

This study examines why this market failure exists, what EU product legislation can do to overcome it and why targeted demand-side instruments are needed.

Purpose of this Study

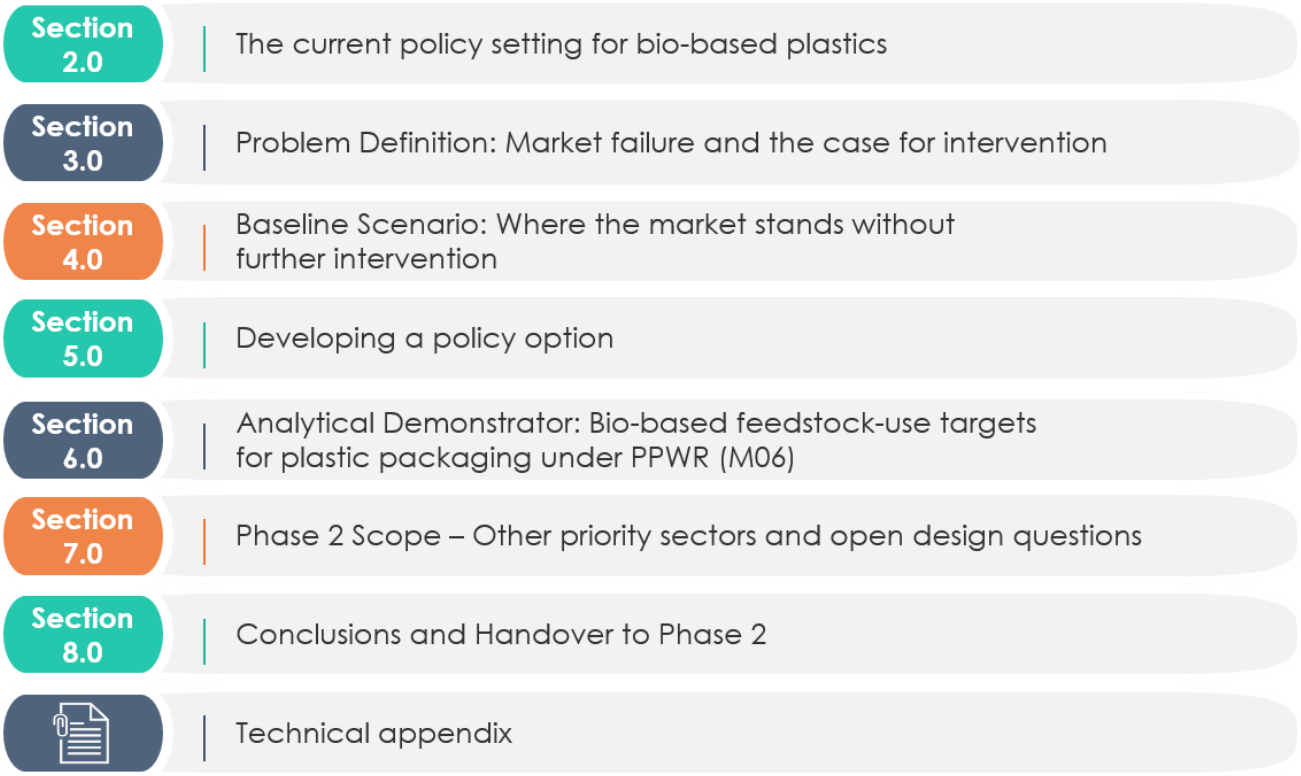
This independent study was commissioned by a seven-member industry consortium—comprising Arkema, Avantium, Borealis (Borouge International), Braskem, Neste, UPM, and Vioneo—representing the upstream bio-based plastics and chemicals supply chain. Drawing on academic literature, public evidence, and extensive consultations with consortium members alongside external industry and policy stakeholders, this research examines why the market share for bio-based plastics remains limited and explores how EU product legislation can effectively address this market failure.

To ensure a rigorous approach, the study's framework follows the European Commission's Better Regulation Guidelines and loosely aligns with the structure of a formal Impact Assessment. This alignment ensures that the evaluation of existing policy, underlying systemic problems, and the justification for EU intervention is grounded in the best available evidence, ensuring proposed measures deliver tangible benefits to European society, the economy and the environment. Ultimately, these findings aim to provide EU policymakers with actionable insights to design effective demand-side measures for bio-based materials.

The project is structured in two phases. This report presents **Phase 1** of the study, establishing the analytical foundation of the research including the problem definition and the baseline scenario. It proposes a potential policy option with the impact of a feedstock target for packaging acting as a demonstrator.

Phase 2 (forthcoming) will detail the specific policy measures and assess their practical implementation and interactions. This recognises that target setting is as much about the implementation framework as the magnitude of the target itself when it comes to ambition setting.

This Phase 1 report is structured as follows:



1.1 Bio-based Plastic Definition and Pathways

Bio-based plastics are derived wholly or in part from biological rather than fossil feedstocks. Following the European Commission's Joint Research Centre (JRC) classification, this study distinguishes bio-based polymers by the stage of production at which fossil feedstock is replaced by biomass, resulting in three broad pathways:

- **Drop-in bio-based polymers**, materials chemically identical to their fossil-based counterparts, such as bio-PE and bio-PET;
- **Dedicated bio-based polymers** with no direct fossil equivalent, such as PEF, PLA and PHA. The JRC uses the term 'dedicated' to distinguish these from drop-ins;[1] and
- **Mature inherently bio-based polymers** that are chemically distinct, with no viable fossil equivalent and a long commercial history, such as PA11 and natural rubber. These sit within the JRC's dedicated category but are treated separately in this study, as their maturity removes the recyclability and system-integration barriers that affect some dedicated polymers.

This study does not treat attributed (or certified) bio-based plastics, produced by mass balance co-feeding of biomass-derived intermediates at the refinery stage, as a separate polymer classification. Attribution is a feedstock provenance and chain-of-custody question, not a distinction in the polymer's chemistry or downstream use, and is addressed separately within the study's mass balance and chain-of-custody discussion (see Section 5.2).

The term bio-based refers only to material origin. Some bio-based plastics may also possess functional properties such as biodegradability or compostability, though these are separate characteristics and not inherent to bio-based content.

1.2 Priority End-Use Sectors for Bio-based Plastics Market-Pull Measures

Identifying priority end-use sectors is a prerequisite for both demand-side and supply-side instrument design. Bio-based substitution potential, legislative vehicles and structural barriers all vary by polymer type and application, making sector-level analysis necessary to ground instrument specifications in realistic supply and demand conditions, regardless of which policy architecture is ultimately preferred.

Both options assessed in this study require a sector-grounded evidence base: Option A requires sector-specific instrument design; Option B requires an aggregate obligation level calibrated against a realistic, sector-disaggregated supply and demand trajectory. Cross-sector cannibalisation of shared polymer streams (particularly bio-PE, bio-PP and epoxy resins) is also a live risk: a demand signal in one sector can redistribute existing supply rather than pulling new capacity, and understanding where that risk concentrates requires sector-level analysis.

This study applies four criteria to identify priority sectors for Phase 1 and Phase 2 analysis. Sectors meeting all four are included in the priority set. Sectors failing on the legislative hook criterion are flagged for a future study phase rather than analytically dismissed.

Prioritisation Criteria

Fossil demand scale. The sector must account for a substantial share of total fossil plastic consumption. Scale determines the size of the demand signal a target would generate and the credibility of the investment case it would support.

Bio-based substitution potential. Commercially available bio-based polymers must exist for at least the dominant material types in the sector. The criterion does not require full polymer coverage: the addressable sub-set must be large enough to give instrument design meaningful scope.

Active or near-term legislative hook. A delegated act, review clause or implementing measure with a bio-based feedstock-use or content parameter must be active or in formal preparation within the study horizon (approximately 2025 to 2032). This is the binding filter for inclusion in the current phase.

Manageable structural barriers. No dominant polymer should lack a commercially viable bio-based equivalent, and no overriding regulatory constraint should systematically exclude bio-based materials from the sector's primary applications. Partial barriers are accommodated through explicit scope delimitation.

Fossil Plastic Demand by Sector

Packaging accounts for over 40% of global fossil plastic demand at approximately 177 Mt per year. Building and construction is the second largest sector at approximately 73 Mt per year, where PVC dominates through its use in pipes, profiles and flooring.

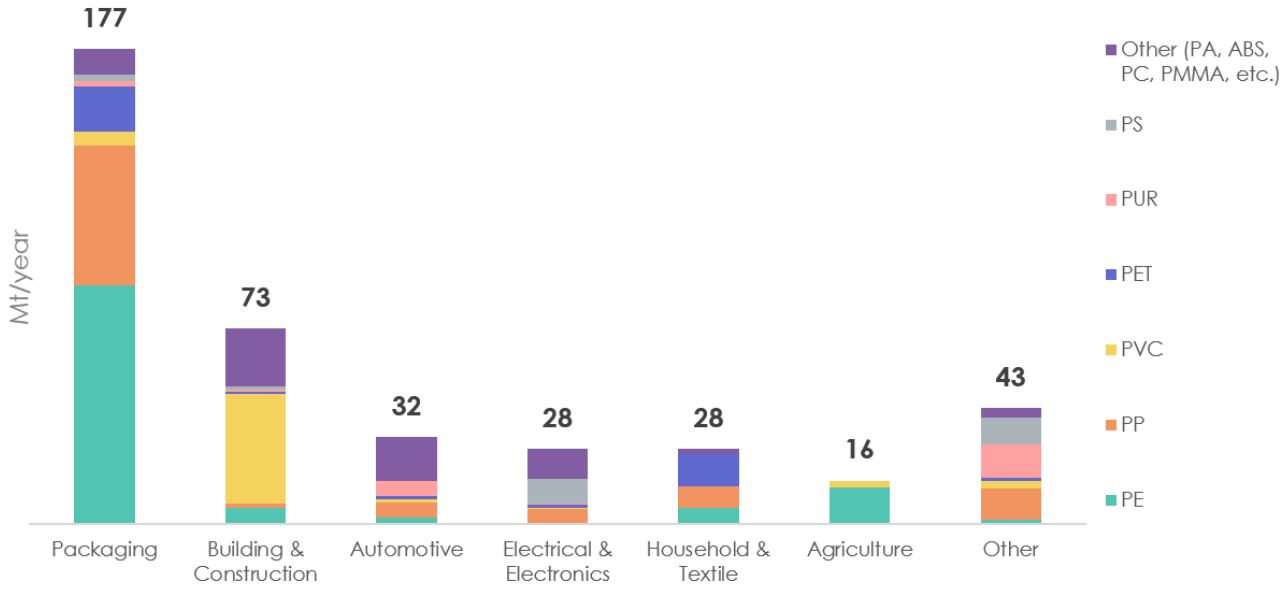
Figure 1-1 shows the distribution of global fossil plastic consumption across end-use sectors and polymer types, drawn from Houssini et al. (2025).[1]

Packaging is dominated by PE and PP. In building and construction, PVC is the single most important polymer, with PE and PUR also significant. Automotive (approximately 32 Mt), electrical and electronics (approximately 28 Mt) and household and textile (approximately 28 Mt) form a mid-tier. Agriculture is the smallest sector at approximately 16 Mt per year.

[1] Houssini, A. et al. (2025) Global Plastics Accounting Dataset. SI Dataset 2, Tab2-3.

Figure 1-1: Global fossil plastic consumption by sector and polymer type 2022 (Mt/year).

Source: Houssini et al. (2025), SI Dataset 2, Tab2-3. PE = polyethylene; PP = polypropylene; PVC = polyvinyl chloride; PET = polyethylene terephthalate; PUR = polyurethane; PS = polystyrene.



Bio-based Polymer Market: Current Sector Distribution

Bio-based polymers account for approximately 1% of EU plastic production. Their distribution across sectors diverges sharply from the fossil baseline: fibres and packaging together represent nearly half of global bio-based production, while construction and electronics have very low penetration despite technically viable bio-based alternatives being commercially available.

According to nova-Institut data for 2025, fibres (mainly CA and PTT) account for 28% of global bio-based polymer production and packaging (mainly bio-PE, bio-PET and PLA) for a further 21%. Building and construction accounts for only 6% of bio-based production (mainly epoxy resins and PUR) and electrical and electronics for 5% (mainly epoxy resins and PA).[2]

Low penetration in construction and electronics reflects the absence of market-pull instruments, not technical infeasibility: bio-PUR insulation and bio-epoxy adhesives are commercially available today. The position in these sectors is analogous to that of bio-based packaging before regulatory attention created the current supply base. Low penetration is, therefore, an argument for intervention rather than against it.[3]

Priority Sector Assessments

The following detail the priority sector assessments. **Given the criteria above, packaging, textiles, building & construction, and automotive are the sectors that are the focus of the rest of this report**. Narrative on the other sectors and the full screening assessment can be found in Appendix 1.0.

[2]Carus, M., Skoczinski, P., Dammer, L. and Raschka, A. (April 2026) Bio-based Building Blocks and Polymers: Global Capacities, Production and Trends 2025-2030. nova-Institut GmbH, Hürth. Figure 10, p.20.

[3]Carus, M. et al. (April 2026), op. cit., p.21.

Packaging

Packaging meets all four criteria and is the near-term priority and Phase 1 quantitative demonstrator. The legislative hook is direct: PPWR Article 8 is titled 'Biobased feedstock in plastic packaging' and commits the Commission to a review with powers to set binding targets by 12 February 2028.

Bio-based PE, PET (partial and full), PP, PLA, PHA and PEF are all commercially available and recycling-compatible in drop-in applications. Article 6(7) enables EPR fee modulation, Article 6(10) provides a recyclability derogation pathway for dedicated polymers, and Article 12 establishes a labelling framework. There are no overriding structural barriers for the drop-in route.

Textiles

Textiles meet all four criteria and share near-term priority status. The ESPR Annex I(i) textiles delegated act (~2027) is the nearest actionable legislative window outside PPWR in which a bio-based content parameter can be specified in a binding instrument.

Bio-nylon, bio-PET, bio-PTT, cellulose acetate, PEF and PLA-based fibres are all commercially available. Fibres are already the largest single market segment for bio-based polymers globally (28% of bio-based production). There is no functioning synthetic textile-to-textile recycling loop at scale, so there is no recycled content conflict of the kind that complicates packaging design.

Building and Construction

Construction is a near-to-medium term priority. Its large fossil plastic demand and active policy hooks are strong, but the dominance of PVC in the most common applications limits the addressable market to a specific polymer sub-set for which bio-based alternatives exist today.

At approximately 73 Mt per year, construction is the second largest fossil plastics sector. CPR standardisation work was committed in 2026, an ESPR delegated act for construction products is anticipated around 2029 to 2030, and IAA Article 11 procurement requirements are estimated to generate between 1.1 and 1.7 Mt per year of additional demand for sustainable construction materials.[4]

The constraint concerns PVC. PVC dominates construction plastics through pipes, window profiles and flooring, and there is currently no commercially available bio-based equivalent: bio-based VCM has not reached commercial scale. This reduces the effective addressable market within construction significantly relative to its headline figure.

The study's construction scope is therefore limited to polymer applications where bio-based substitution is viable today: PUR (insulation and sealants), epoxy resins (adhesives, coatings and composites), PA (technical components), and drop-in bio-PE and bio-PP where the specification permits. PVC-dominated applications are out of scope for the near-to-medium term. Long product lifetimes make this the sector where the biogenic carbon storage argument is strongest, and public procurement can create near-term demand for bio-PUR and bio-epoxy applications without waiting for the ESPR delegated act window.

Automotive

Automotive meets all four criteria on a medium-term horizon. PA11 from castor oil is the most commercially established option, and the ELV mass balance implementing act (~2028) is the nearest cross-instrument coherence point requiring attention in the current phase.

Fossil plastic consumption is approximately 32 Mt per year globally, with PA, PUR and polyolefins dominating. Bio-PA6/66 and bio-PUR are also commercially available. Safety and durability requirements restrict bio-based substitution in structural and safety-critical components, but non-structural applications (interior trim, insulation, coatings) present substantially lower barriers. The mass balance framework for ELV recycled content and any bio-based feedstock target must operate on compatible accounting principles to avoid conflicting obligations at vehicle component level. The ELV Article 55 review (~2032) is the primary legislative hook.

[4]European Commission (2026) Proposal establishing measures for industrial capacity and decarbonisation in strategic sectors (Industrial Accelerator Act). COM(2026)100. Impact Assessment, procurement demand estimates by sector.

2.0 The Current Policy Setting for Bio-based Plastics

The Commission has published and are planning successive instruments that directly or indirectly relate to bio-based plastics, shown in Figure 2-1.

In 2020, the Circular Economy Action Plan was adopted, which states that, for plastics, the Commission will develop a policy framework on "*sourcing, labelling and use of bio-based plastics, based on assessing where the use of bio-based feedstock results in genuine environmental benefits, going beyond reduction in using fossil resources*".[5]

In 2021, a Communication on Sustainable Carbon Cycles (COM(2021) 800 final) **proposed the aspirational objective of a minimum of 20% of plastic products being from sustainable non-fossil sources by 2030**.[6] However, the COM only commits to engaging with stakeholders to work together to achieve this objective; there are no related planned measures and "sustainable non-fossil sources" are not mentioned elsewhere in the COM.

In 2022, a Communication on bio-based, biodegradable and compostable plastics was exploratory, emphasising that reducing, reusing, and recycling plastics must remain the top priorities. It noted concerns around greenwashing and approaches for accounting bio-based content. Specifically, the Communication highlights concerns on using chain of custody and attributing a share of bio-based feedstock to end-products through mass balance accounting, declaring it an unsuitable method to confirm the actual share of bio-based content.[7]

Subsequent instruments have moved materially. Caution on chain of custody and mass balance no longer reflect current Commission legislative practice, demonstrated by RED III (2023)[8] and the SUPD[9] implementing act (February 2026), which both legislate mass balance as a compliance mechanism. RED III also sets out sustainability criteria. Although not applicable to bio-based plastics, the criteria provide a legislative model for sustainability governance of biomass feedstocks.

PPWR goes further by creating an explicit review mechanism and legal empowerment for future bio-based feedstock requirements, sustainability criteria and labelling rules. The Commission's April 2026 commissioned study (Carus et al., nova-Institut) advances the available evidence, relating to packaging. It reports on technology readiness at TRL 9 for established drop-in polymers, presents a GHG reduction range of 30-40% relative to fossil alternatives for those polymers under defined system boundary assumptions, and sets out an illustrative target methodology at packaging-category level. The study concludes that bio-based feedstock and recycled content are complementary rather than substitutable, supporting the parallel-not-competing design principle.

Moving forward, the EU legislative framework for bio-based plastics is organised here across three tiers: overarching **framework instruments (CEA, Bioeconomy Strategy, Biotech Act 2, IAA)** that set the political mandate; **product legislation instruments (PPWR, ESPR, ELVR, CPR**) that contain operative bio-based feedstock and content hooks; and **flanking instruments (RED III, ETS/CBAM, SUPD**) that shape cost

[5] European Commission (2020) A new circular economy action plan: For a cleaner and more competitive Europe (COM(2020) 98 final). European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0098

[6] The objective was to be in full consideration of the EU's biodiversity and circular economy objectives and of the policy framework for bio-based, biodegradable and compostable plastics. Source: European Commission (2021) Susainable Carbon Cycles (COM(2021) 800 final). European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021DC0800

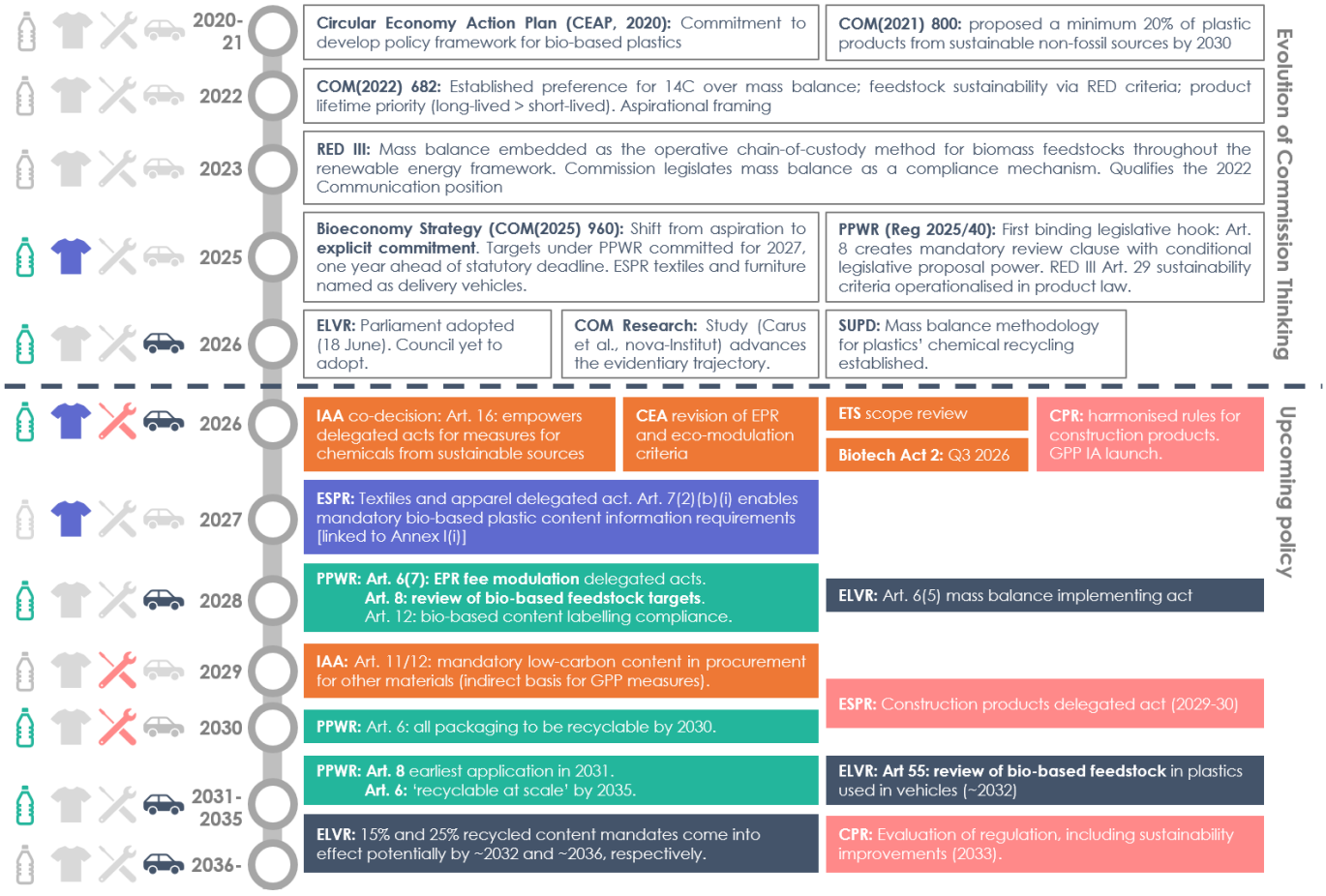
[7] European Commission (2022) EU policy framework on biobased, biodegradable and compostable plastics (COM(2022) 682 final) European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52022DC0682

[8] European Parliament & Council of the European Union (2023) Directive (EU) 2023/2413 of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. Official Journal of the European Union. https://eur-lex.europa.eu/eli/dir/2023/2413/oj/eng

[9] European Parliament & Council of the European Union (2019) Directive (EU) 2019/904 of 4 June 2019 on the reduction of the impact of certain plastic products on the environment. Official Journal of the European Union, L 155, 1-19. https://eur-lex.europa.eu/eli/dir/2019/904/oj

signals, measurement frameworks, and sustainability criteria. Figure 2-1 shows how key elements of the EU legislative framework fit together chronologically. Each instrument is described below.

Figure 2-1: Timeline of policy relating to bio-based plastics



White boxes are historic. Teal boxes relate to upcoming packaging policies, blue to textiles, pink to construction, and dark grey to automotive.

2.1 Framework Instruments

Across the European policy landscape, there are three instruments that, together, will form the framework for bio-based plastics. Building on existing plans, strategies and commitments, these framework instruments can provide mechanisms to sustainably support the wider bio-based plastics' market. These instruments set the direction of travel and provide provisions for delegated acts.

Bioeconomy Strategy (COM(2025) 960)

The Bioeconomy Strategy (COM(2025) 960, November 2025) is a Commission communication rather than binding legislation. It is a **primary source of the political commitments** that give operational force to several other instruments, such as the commitment to adopt PPWR bio-based targets in 2027 (one year ahead of the statutory deadline), and the Bio-based Europe Alliance procurement commitment (EUR 10 billion by 2030).

The Bioeconomy Strategy also commits to apply feedstock sustainability criteria to bio-based plastics. It establishes the framing that bio-based plastics must meet sustainability standards consistent with the broader bioeconomy framework. It supports green public procurement (GPP), stating that the upcoming revision of the Public Procurement Directives will, among others, seek to further promote and facilitate the public procurement of biobased solutions.

The Strategy concludes its aim to reinforce Europe's resource security "*by reducing strategic dependencies on fossil-based and imported raw materials, and by diversifying supply chains built on renewable and circular resources*".[10]

Bioeconomy Strategy (2026-2028)

The Annex of COM (2025) 960 states actions (2026-2028) relating to instruments described here:

- Adopt **Biotech Acts**
- **RED III:** (A) Publish a report, in line with Article 3(3) (establishing the legal framework for the cascading use of biomass), on the impact of Member States' support schemes for biomass, including on biodiversity, climate and the environment, and on possible market distortions. (B) The Energy Union package for the decade ahead will account for the experience gained by the implementation of RED**,** including its sustainability criteria**.**
- **PPWR:** Adoption of criteria and targets for bio-based plastics under PPWR
- **ESPR:** Delegated acts on eco-design requirements for textiles and furniture
- **CPR:** Adopt standardisation requests for various products under the CPR

Additionally, the COM states that sustainable biomanufacturing and other bio-based economic activities will be recognised in the revisions of the EU Taxonomy Delegated Acts.

Biotech Act 2

As outlined in the Bioeconomy Strategy, the Biotech Act 2 aims to boost competitiveness and sustainability through **industrial biotechnology** and **biomanufacturing**, via streamlined permitting and regulatory sandboxes. This Act is part of the Commission Work Programme 2026 and is intended to broaden the scope of the Biotech Act I (which focused on health).

In Biotech Act 2, bio-based materials are a priority lead market, including bio-based plastics and polymers. The Act is intended to make these bio-based solutions more affordable, competitive, and

[10] European Commission (2025) A strategic framework for a competitive and sustainable EU bioeconomy (COM(2025) 960 final) European Commission. https://environment.ec.europa.eu/document/download/dbf8d2ba-9332-4f7a-b336-f356fa4b7236_en?filename=COM_2025_960_1_EN_ACT_part1_v10_0.pdf

deployable at an industrial scale by 2040 – thus reducing the EU's dependence on virgin fossil feedstocks.

The Commission initiated a call for evidence May to June 2026, and the legislative instrument is planned for Q3 2026.

Biotech Act 2: Current Proposed Scope of Impact Assessment[11]

To support industry and address the two scale-up gaps (between demonstration and commercial production, and the move from initial market entry to industrial scale), the Act aims to streamline regulation and create market enablers for lead markets including bio-based plastics. The proposed scope of enablers within the call for evidence for the impact assessment include:

- **Lead Market Demand Measures:** Introduce market pull measures to create demand, such as setting mandatory minimum content requirements for carbon from bio-based feedstock.
- **Lead Market Supply Measures:** Examine supply-side measures, such as a possible 'made in Europe' requirement and regulatory sandboxes (which provide controlled environments to test new ideas and gather evidence under supportive oversight).
- **Predictability for Investors**: Measures to improve predictability, such as: (A) clarifying classifications for novel bio-based products that do not fit into existing categories, and (B) transparent timelines for market pull measures (e.g., establishing and gradually increasing minimum content requirements).
- **Sustainability Criteria**: Ensuring alignment with established sustainability frameworks (including RED III), focusing on directing biomass towards higher-value applications.
- **Simplified Permitting and Fast-Track Authorisations**: Streamlining administrative processes and tackling bottlenecks to reduce entry delays, whilst implementing accelerated procedures for specific solutions and specific support for SMEs and start-ups.
- **Market Harmonisation Tools and Non-legislative Support Measures**: Seeking to eliminate market fragmentation by enhancing networks, harmonising regulatory and certification requirements, fostering the use of sustainable biobased and/or recycled carbon-based feedstocks, and facilitating access to funding.

Circular Economy Act (CEA)

Circular Economy Act (CEA) will establish an overarching framework for lead markets and demand-side instruments, though, at time of writing, there is no published text (as of July 2026, expected Q4 2026). The CEA will build on the second Circular Economy Action Plan. Three potential mechanisms are directly relevant to bio-based plastics:

- recycled content provisions for product categories beyond packaging, with **bio-based feedstock substitution provisions** where suitable recycling technologies are unavailable at scale, mirroring PPWR Art. 8(2)(c) with wider product scope (see later);

- harmonised EPR minimum requirements explicitly including bio-based feedstock-use targets for plastics as a permitted fee modulation criterion across all sectors with EPR coverage; and

- **binding green public procurement ('GPP') minimum requirements** modelled on IAA Articles 11/12 (see later in section), with bio-based feedstock criteria alongside lifecycle GWP requirements.

The **CEA may establish overarching definitions (such as 'bio-based plastics') and sustainability criteria** for its lead market instruments. However, it is not the primary vehicle – it will cross-reference other existing frameworks.

[11] European Commission (2026) Call for Evidence for Impact Assessment. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/17394-Biotech-Act-II_en

Industrial Accelerator Act (IAA)

Industrial Accelerator Act (IAA, COM(2026)100)[12] is a legislative proposal (introduced March 2026), which aims to strengthen the manufacturing sector, bolster economic security, and accelerate industrial decarbonisation by mandating "Made in EU" and low-carbon requirements across strategic markets. The strategic markets include Energy-Intensive Industries (EIIs) – including chemicals, chemical products, and plastics manufacturing – as well as the automotive value chain. The IAA is relevant for two key measures:

- it establishes precedent for GPP, and
- it empowers demand-side measures for chemicals from 'sustainable carbon sources'.

Articles 11 and 12 create binding mandatory procurement criteria for low-carbon steel (25%), cement (5%), and aluminium (25%). Although not a bio-based plastics mandate, the provision is a **direct architectural precedent for bio-based content GPP requirements**. It empowers Article 16 delegated acts to replicate this requirement for bio-based chemicals.

A GPP requirement in the draft text is eligibility for benefits based on whether products and components are "Made in EU". The draft distinguishes between "Union origin" and "content equivalent to Union origin" (Articles 7, 8, and 9). Equivalency is granted to countries with which the EU has free trade agreements or those part of the Agreement on Government Procurement. Further country exclusions are possible (either partially or wholly) in the future, via delegated acts. As it is currently drafted, China would be excluded from many lead-market benefits – as would India and the United States for certain benefits.

IAA's operative term of "sustainable carbon sources" is not equivalent to "bio-based" and is defined as "*biomass that complies with the sustainability criteria laid down in Article 29 of Directive (EU) 2018/2001 [RED II], waste and carbon from capturing carbon dioxide emissions*". Therefore, bio-based plastics' intermediates qualify under that definition.

Article 16 empowers delegated acts for demand-side measures for chemicals from sustainable carbon sources. As this is broader definition, it is not a primary bio-based plastics pull-lever. Although Article 16 includes criteria with a sustainability dimension via climate neutrality, the sustainability requirements for bio-based feedstocks are not its primary purpose. IAA also does not create mass balance or chain-of-custody frameworks for bio-based plastics, but Article 16 delegated acts will need to define the relevant methodologies for implementation.

The IAA is in active co-decision. Parliament and Council amendments can still shape Article 16 scope and ambition. The procurement directives revision (Q4 2026) will set the procedural framework within which IAA Article 16 delegated acts operate. Both are active 2026 windows.

[12] European Commission (2026) COM(2026) 100 final 2026/0068 (COD). https://single-market-economy.ec.europa.eu/document/download/9bc8eb85-4d43-4025-be7b-c86b9f3648ec_en

2.2 Product Legislation Instruments

Each of the following instruments relate to one or more of this study's in-scope product groups: packaging (PPWR), automotive (ELVR), textile (ESPR) and construction (ESPR, CPR). They are distinct instruments, yet they build upon the framework instruments and the flanking instruments, and – at times – reference each other. Each regulation or act establishes pathways for different provisions and measures specific to their product group, including bio-based feedstock targets, definitions and standards, green public procurement mandates, and more. There are future delegated acts and reviews that will determine how and when these regulations will be implemented, as well as the level of harmonisation between them.

Packaging and Packaging Waste Regulation (PPWR)

The **Packaging and Packaging Waste Regulation ('PPWR')** comes into effect in August 2026. It aims to efficiently manage the entire lifecycle of packaging, while reducing the environmental footprint, through harmonised rules. It **defines bio-based plastics** (Article 3, point 53) as: "'*biobased plastics' means plastics made from biological resources, such as biomass feedstock, organic waste or by-products, and irrespective of whether the plastics are biodegradable or non-biodegradable*".

Under Annex II, Table 1, biodegradable plastics are distinguished from other plastic categories. A footnote clarifies that bio-based polymers that are not readily biodegradable are covered under the standard plastic categories (such as PET, PP and PE). In this study, biodegradability is not a focal point.

PPWR includes mandates on bio-based plastics – notably one for their review and one around bio-based plastic content labelling.

Under Article 8, by 12 February 2028, PPWR mandates the Commission to review the state of bio-based feedstock in plastic packaging. **The Commission is empowered to introduce specific mandates for bio-based feedstock** following the review – such as sustainability requirements, bio-based feedstock-use targets, and introduce the possibility of using bio-based feedstock to achieve the minimum recycled content targets (set in Article 7). The earliest application of bio-based targets via Article 8 would be in 2031. The review also allows for the definition of bio-based plastics to be amended, if necessary.

Under Article 12(4), from 12 August 2028, any bio-based plastic content label on packaging must comply with harmonised specifications established by the Commission. However, Recital 68 clarifies that this is not mandatory.

PPWR contains multiple mandates relating to recycling and recycled content. Article 7(7) mandates the recycled content methodology implementing act (December 2026), which includes mass balance and chain-of-custody design. PPWR allows Member States to modulate EPR fees based on recycled content (Article 6(7)). Under Article 8(2)(c), the Commission may propose a legislative amendment to allow bio-based feedstock to be used to meet the minimum recycled content targets (set in Article 7). Alongside recycled content targets, **PPWR has mandates for all packaging to be recyclable by 2030 and recycled at scale by 2035**. These apply to all packaging – which, as it stands per the definitions and Annex II Table 1, includes packaging made with bio-based plastics. The designed routes for derogation from this are Article 6(10) on innovative packaging derogation and Article 8(2)(c) on food-contact substitution.

End-of-Life Vehicles Regulation (ELVR)

The **End-of-Life Vehicles Regulation** ('**ELVR**') aims to minimise waste by enforcing strict standards for the recycling, reuse, and recovery of vehicle components. It provides provisions for future review.

The ELVR cross-references the PPWR definition of bio-based plastics. **Article 55 requires a comprehensive review of bio-based plastics in the sector by 72 months after entry into force (~2032).** This review will assess the state of technology, environmental performance, economic performance, availability of supply, and sustainability criteria.[13] The Commission is empowered to introduce specific mandates for

[13] Directive (EU) 2018/2001 is cross-referenced in relation to sustainability criteria, which is RED II. This is now superseded by RED III, whose sustainability criteria are discussed here, as one of the flanking instruments.

bio-based plastics following the review – such as setting mandatory standards for bio-based feedstocks and establishing targets for the use of bio-based feedstock in plastics used in vehicles. These targets may, or may not, be integrated with recycled content targets – depending on the review's findings.

Article 6(5) mandates the mass balance implementing act (by ~2028), which will establish the recycled plastic content calculation methodology (including mass balance). This is set to be published after the PPWR's recycled content calculation methodology (via Article 7), making coherence across these two acts and any bio-based feedstock-use content framework an active cross-instrument design priority.

The European Parliament formally adopted ELVR (voted on 18 June 2026). The Council's adoption remains before the regulation enters into force and, in principle, will become applicable 24 months later (~2028).

Ecodesign for Sustainable Products Regulation (ESPR)

Ecodesign for Sustainable Products Regulation (ESPR, Reg 2024/1781) entered into force 18 July 2024. Delegated acts will operationalise product-level requirements – with proposed dates of **2027 for textiles and apparel, and 2029-2030 for construction products**. A Methodology for Ecodesign of Energy-related Products (MEErP) is currently active for the textiles and apparel delegated act[14]. **ESPR establishes the legal basis for bio-based plastic content from renewable sources within these specific product groups.**

Under Annex I(i), the "use or content of sustainable renewable materials" is a named product parameter for all delegated acts, and Recital 24 establishes bio-based product performance requirements. Linked to Annex I(i), **Art. 7(2)(b)(i) enables mandatory bio-based content information requirements** in each delegated act. The bio-based plastic content information can be communicated through the Digital Product Passport (DPP) – the primary mechanism under the ESPR for communicating a product's environmental performance. This DPP data point requirement is further confirmed by the JRC DPP Methodology (JRC145830, 2026), which establishes the tiered access framework (from public claim at Tier 1 to chain-of-custody documentation at Tier 4). The DPP will come into force through the delegated acts, with the central registry planned to be operational by mid-2026.15

Annex I(i) defines the named product parameter and Recital 24 explicitly identifies "materials with bio-based content" as a subset of renewable resources. However, **ESPR does not have a formal, standalone definition for bio-based plastics or content,** to ensure that the 2027 textiles act definition of bio-based content is consistent with the definitions in the construction (2029-30) and chemicals/polymers (future working plan) acts.

According to the 2025-2030 Working Plan16, ESPR will complement the CEA and "*will be central for making our economies more circular […] by incorporating criteria promoting reparability, recyclability and recycled content*". Similar to PPWR, this presents an upcoming policy design question on the potential complementarity of bio-based and recycled content. Unlike PPWR, there is no explicit mention of closed-loop (i.e., textile-to-textile) recycling at scale requirement. However, the preparatory study for textile apparel does propose a DPP data point of "Origin of the recycled content" – to distinguish between material from textiles versus other sources, from the EU or non-EU.[17]

Marketing Construction Products (Construction Products Regulation, CPR)

Regulation (EU) 2024/3110, adopted on 27 November 2024, is a legislative framework designed to standardise the marketing of construction products across Member States – including the alignment of construction standards with green transition goals. It establishes the requirement to report a product's

[14] Joint Research Centre (n.d.) Project plan – Textile products. Product Bureau. https://susproc.jrc.ec.europa.eu/product-bureau/product-groups/467/project-plan
[15] Joint Research Centre (2026) Methodology for defining data requirements for the Digital Product Passport under the EPR framework. https://publications.jrc.ec.europa.eu/repository/handle/JRC145830
[16] European Commission (2025) Ecodesign for Sustainable Products and Energy Labelling Working Plan 2025-2030. (COM(2025) 187 final) European Commission. https://environment.ec.europa.eu/document/download/5f7ff5e2-ebe9-4bd4-a139-db881bd6398f_en?filename=FAQ-UPDATE-4th-Iteration_clean.pdf
[17] Gonzalez-Torres, M. and Arcipowska, A. (2026) Study on DPP content for textile apparel products under ESPR. JRC science for policy report. JRC recommendations to support DPP requirements in the framework of the ESPR Regulation. European Commission. https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2026-05/Textiles_DPP_20260513.pdf

environmental sustainability performance[18] against harmonised technical specifications, which are set by the Commission (Article 15(3)(a) and Annex II). It also mandates that DPPs will be mandatory for every product regulated by harmonised technical specifications. Under Annex III, the harmonised technical specifications can include product requirements for specific families, including (but not limited to):

- minimising life-cycle greenhouse gas emissions,
- maximising reused, recycled and by-product content,
- recyclability and the capability to be remanufactured,
- the capability of different materials or substances to be separated and recovered during dismantling or recycling procedures, and
- sustainable sourcing.

Harmonised technical specifications are to differentiate classes of performance per (and potentially across) product families (via future delegated acts and standardisation processes). Article 82 states that any financial incentives must only target the highest two classes of performance (per Articles 5(5) and 22(9)). Therefore, this CPR framework establishes the pathway to support products with better environmental performance, however, the metrics used to measure this performance are not finalised and may (or may not) directly support the use of bio-based plastics.

Supporting the CPR, the Commission's Working Plan 2026-2029 (COM/2025/772 final)[19] was published in December 2025. The plan states that it aligns with the Bioeconomy Strategy and ESPR. It establishes that DPPs are to include relevant information on a product's labelling, carbon footprint and bio-based content. The Working Plan also confirms that the Commission is supporting the drafting of complementary product category rules (c-PCR).[20] C-PCR aim to accelerate the development of technical content needed to implement the CPR environmental sustainability provisions – which may include the assessment of bio-based plastics against fossil-based alternatives within construction products.

Green public procurement is supported under Article 83, which mandates mandatory minimum environmental sustainability requirements for construction products used in public contracts. The Commission must launch the first impact assessment for setting these requirements by 31 December 2026. It also states that the EU Ecolabel and other officially recognised national or regional EN ISO 14024 type I ecolabelling schemes may be used to demonstrate compliance with the minimum environmental sustainability requirements.

By 9 January 2033, the Commission will conduct an evaluation of the CPR, including on sustainability improvements of products and the built environment (Article 93).

[18] This includes the following characteristics related to the life cycle assessment of a product: "climate change effects – fossil fuels", "climate change effects – biogenic", and "climate change effects – land use and land use change" (Annex II, points b-d, as of 8 January 2026). From 9 January 2030, other characteristics – such as "land use related impacts" (Annex II, point s) must also be declared. Annex II also requires harmonised technical specifications to cover, as much as possible, the product's capability to temporarily bind carbon and of other carbon removals.

[19] European Commission (2025) (First) CPR Working Plan for 2026-2029. (COM(2025) 772 final). European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0772

[20] European Innovation Council and SMEs Executive Agency (EISMEA) (2025) Support to Standardisation activities performed by CEN, CENELEC and ETSI. European Commission. https://eismea.ec.europa.eu/funding-opportunities/calls-proposals/support-standardisation-activities-performed-cen-cenelec-and-etsi-3_en : "Topic 24 SMP-STAND-2025-ESOS-01-IBA Construction complementary Product Category Rules (c-PCR) development and coordination related with Action 71 of 2025 AUWP on Construction products"

2.3 Flanking Instruments

Flanking instruments shape the underlying policy landscape that influence bio-based polymer producers and the wider bio-based plastics market. They are included here because: RED III sets the standard for sustainability criteria across EU policy and impacts biofuels (a competing use of bio-based feedstocks); the ETS scope review is an active 2026 process with direct relevance to bio-based plastics economics; and SUPD defines a mass balance methodology for chemical recycling of plastics for recycled content measurement, which may influence the mass balance methodology for bio-based feedstock-use content.

Renewable Energy Directive III (RED III)

RED III sets a binding target of at least 42.5% renewable energy in the EU's energy mix by 2030. A key sector target is the 29% renewable share in transport. It caps food/feed-based biofuels at 7%. Advanced biofuels (such as forestry residues or algae) and 'renewable fuels of non-biological origin' ('RFNBO', such as green hydrogen, e-methane, e-methanol, and e-ammonia), have transport targets of at least 1% in 2025 and at least 5.5% by 2030 (of which 1 percentage point must be from RFNBOs).

Article 29 sustainability criteria are the primary technical sustainability framework for bio-based feedstocks in EU legislation. They are cross-referenced[21] directly in PPWR Article 8 and ELV Article 55.

RED III embeds mass balance as the operative chain-of-custody method throughout the renewable energy framework for biomass feedstocks. It is the most developed and legally established mass balance framework for biomass in EU law. Its methodology and certification scheme recognition (ISCC, REDcert, RSB) are directly relevant to how bio-based plastics mass balance should be designed. The nova-Institut DG Environment study (Carus et al., April 2026) explicitly includes mass balance via ISCC/RSB/REDcert as eligible for PPWR bio-based content targets.

RED III **does not define harmonised definitions** for bio-based content, its measurement, or for product labelling purposes – nor does it establish a carbon cost signal for bio-based plastics production specifically.

Emissions Trading System (ETS) and Carbon Border Adjustment Mechanism (CBAM)

ETS and CBAM require polluters to pay for their greenhouse gas (GHG) emissions by placing a cap on the total emissions allowed from in-scope installations and operators. ETS covers EIIs such as power generation, manufacturing (e.g. steel, cement, oil refining), aviation within certain regions (e.g. EEA), and, more recently, maritime transport. Starting in 2026, the CBAM covers six product groups: cement, iron & steel, aluminium, fertilisers, electricity, hydrogen. **Plastics, polymers and chemicals are not in scope but are indirectly affected through the in-scope materials** (e.g., fertilisers for bio-based feedstocks).

Under EU ETS monitoring and reporting rules, eligible biomass fuels may be assigned an emission factor of zero when sustainability criteria are met. For bio-based polymer production, biogenic carbon is embedded in the product rather than combusted, so this factor does not directly apply. In fossil-based polymer production, petrochemical producers also do not pay for the CO_2 embedded in the naphtha or gas they consume as feedstock.

The ETS scope review is underway in summer 2026 and is examining whether the zero-emissions factor treatment for biogenic carbon should be extended or adjusted. CBAM scope review (expected 2030) may extend to plastics.

[21] The cross-references in PPWR/ELV are technically to RED II criteria, as RED III was not yet published at time of the regulation drafting. RED II is superseded by RED III.

Single-use Plastic Directive (SUPD)

The SUPD implementing act was adopted in February 2026 and, of most relevance, it defines a mass balance methodology for chemical recycling of plastics for recycled content measurement. This methodology is specific to recycled content under WFD Article 3(17) and does not transfer to bio-based content accounting. However, it is the first time mass balance has been legislated as a compliance mechanism for plastics product legislation. Its significance is as a precedent and analogy, not as a directly applicable framework.

Additionally, the SUPD framework has end-of-life and recyclability sustainability dimensions that are indirectly relevant to how dedicated bio-based plastics interact with recycling targets. However, the SUPD does not include bio-based sustainability requirements.

2.4 Overview of Policies against Measures

Table 2-1 summarises the instruments within the EU policy landscape against the types of measures that have been discussed. It also highlights which instruments have an active window – such as a consultation period and upcoming delegated acts. For each measure, different instruments have different levels of influence. Measures on targets, sustainability criteria, lead markets / GPP criteria, and mass balance/chain-of-custody frameworks have the greatest breadth of coverage.

Bio-based targets have primary levers at the framework level (via CEA and the Bioeconomy Strategy) and at the product-specific level (ESPR Recital 24 includes bio-based content performance). ELVR Article 55 and PPWR Article 8 mandate the review of bio-based plastics, which may result in bio-based feedstock targets. Thus, ESPR, ELVR and PPWR all require additional reviews and delegated acts to implement any actual targets.

RED Article 29 is cross-referenced within most of the planned sustainability criteria (in CEA, Bioeconomy Strategy, PPWR and ELVR). Overall, sustainability criteria are unilaterally confirmed as high priority for feedstocks of bio-based plastics.

Some of the assessed instruments define certain key terms (such as PPWR Article 3 defining "bio-based plastic packaging"); many of the assessed instruments call for harmonised definitions and standards. However, **the primary standardisation vehicle is ESPR and the CEN/CENELEC/JTC 24 process**. These definitions and standards will then, in turn, influence the scope and implementation of the regulations' delegated acts.

Bio-based plastics is framed as a lead market priority within the Bioeconomy Strategy – with the CEA, CPR, and IAA establishing routes to mandate for GPP for sustainable and/or bio-based materials.

Overall, Table 2-1 shows that the policy landscape has the means to implement many types of measures across many instruments. These have the potential to be harmonised and complementary, however, as some design windows are currently active, the implementation and effectiveness of measures are yet to be determined.

Table 2-1 - Policy Landscape Matrix.

P = primary lever; R = review clause; S = secondary relevance; Y = active design window; refers to processes where study outputs can directly inform instrument design in 2026. ***Justification for scoring can be found in the Appendix***

Measure type	Bioeconomy Strategy / Biotech Act 2	CEA	PPWR	ESPR	ELVR	CPR	IAA	ETS / CBAM	SUPD	RED III
Bio-based feedstock content targets	P	P	R	P	R	S	S			
Sustainability requirements	P	S	P	P	R	P	S			P
Harmonised definitions / standards	S	S	S	P		S				
Lead markets / GPP criteria	P	P		S		P	P			
Carbon cost signals for bio-based						S	S	P		
Mass balance / chain-of-custody framework	S	P	P	S	S				S	P
Active Window	Y	Y	Y	Y	Y	Y	Y			

3.0 Problem Definition: Market Failure and the Case for Intervention

A problem definition is a foundational element of the European Commission's Better Regulation methodology and a prerequisite for any well-structured policy assessment. Its purpose is to establish, clearly and with supporting evidence, what policy problem exists, why it persists, and why intervention is warranted. In the logic of this study, **the problem definition (Section 3)** sits between the **policy context (Section 2)** and the **baseline evidence synthesis (Section 4).** It provides the analytical bridge between the two, translating the broad policy landscape into a precise articulation of the market and regulatory failures that the **study's proposed instruments (Section 5)** are designed to correct. Without a well-specified problem definition, there is a risk that policy options are designed against implicit or poorly defined assumptions about what needs to change, rather than against a structured and evidenced account of why current conditions are failing to deliver stated objectives.

3.1 Overview of Current Market Position

The bio-based plastics sector has not materialised at scale despite a decade of policy attention, incremental regulatory measures and voluntary industry commitments. Only 1.1% of European plastic production in 2024 was bio-based or bio-attributed. The low market share of bio-based plastics exists in a landscape of wider structural decline in European plastics manufacturing, presenting a challenge to decarbonisation and industrial resilience in the region. Global capacity utilisation at ~79%, falling well below projected levels, reflects demand-side constraint rather than supply-side limitation. This is a market failure that policy is specifically designed to correct.

Despite growing policy ambition for scaling bio-based plastics, market uptake remains negligible. The global market share of bio-based plastics has remained almost static for a decade, fluctuating between 0.5-1% of total plastic production. In 2024, only 0.6% of the 430.9Mt global plastics production was bio-based or bio-attributed, and in Europe, only 1.1% (~0.5Mt) of 54.5Mt plastics produced were bio-based or bio-attributed.[22]

Growth in the sector has repeatedly fallen short of industry forecasts, though the pattern is more nuanced than a simple story of stagnation. Between 2019 and 2024, global production held broadly flat at around 3.8 Mt, against a forecast compound annual growth rate of approximately 3% that implied closer to 4.4 Mt by 2024.[23] A genuine step-change followed in 2025, when global production reached 4.5 Mt, driven by roughly 550 kt of new epoxy resin and PLA capacity coming online in Asia.[24] A separate issue needs to be kept distinct from this forecasting record: nova-Institut has itself revised its reported 2018 production figure downward, from 7.2 Mt to 3.5 Mt across successive editions of its market report, after identifying an error in how bio-based polyurethane volumes were calculated.[25] Some of the apparent decline visible between older and more recent editions therefore reflects this correction rather than a genuine contraction in the market, and the two effects should not be conflated. On this record, nova's own more recent projection of an 11% CAGR to 2030 warrants caution, since compound annual growth rates have consistently understated the lumpy, capacity-driven nature of growth in this sector.

The low market share of bio-based plastics presents a strategic problem and an untapped opportunity for Europe. There is continued and rapid structural decline in the competitiveness of European plastics manufacturing as production shifts to other regions, including China, the US, Thailand and Brazil. Between 2006–2024 the EU global plastics market share declined from 22% to 12%.[26] Addressing this decline through increasing market uptake of bio-based plastics contributes to Europe's industrial

[22] Plastics Europe (2025) Plastics the Fast Facts 2025. https://plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2025/
[23] Carus, M. (2020) *Global Markets and Trends of Bio-based Building Blocks and Polymers 2019–2024*. nova-Institut GmbH, Hürth, Germany.
[24] Skoczinski, P., Carus, M., Tweddle, G. et al. (2026) *Bio-based Building Blocks and Polymers – Global Capacities, Production and Trends 2025–2030*. nova-Institut GmbH, Hürth, Germany. Available at: https://doi.org/10.52548/PILO4285.
[25] Carus, M. (2020) *Global Markets and Trends of Bio-based Building Blocks and Polymers 2019–2024*. nova-Institut GmbH, Hürth, Germany, p.3.
[26] Plastics Europe (2025) Plastics the Fast Facts 2025. https://plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2025/

security/resilience by reducing dependency on imported fossil fuels. Environmentally, transitioning away from virgin fossil-based feedstock is essential for aligning the plastics system with the Paris Climate Agreement, which cannot be achieved through reduction and recycling alone.[27]

A range of stakeholders are impacted by this problem. At the core are industry and value chain actors, including bio-based feedstock suppliers (i.e., agriculture and forestry), biopolymer producers, converters and brands placing products on the market. Closely linked are competing users of biomass, including the bioenergy sector and food and feed systems, who would be affected by any policy that increases demand for biomass. Waste management stakeholders (e.g., collectors, sorters and recyclers) also play a decisive role in determining the real-world environmental performance of bio-based plastics, while national and local authorities are central to the implementation, enforcement and provision of waste management systems. Citizens present another key group, as their purchasing decisions and disposal behaviours directly influence outcomes for bio-based plastics. Ultimately, if reliance on fossil fuels continues, all EU citizens will be impacted in the long term by the negative consequences of climate change in the region.

Moreover, moving the bio-based plastic sector beyond its current niche could contribute to job creation and economic growth in the EU. Europe contributes nearly a quarter (23.5%) of global bio-based and bio-attributed plastics production and in the decade between 2014-2023, the European rubber and bio-based plastic sector provided on average €3.2 billion added value every year, offering around 57,000 jobs on a yearly basis, 25-30 % of which are estimated to be related to manufacturing and production of bio-based plastics.[28] Harnessing the potential of this sector could not only bring environmental benefits, but also socio-economic advantages.

Table 3-1: Overview of Current Market

Evidence	What this means
~1% of EU plastic production *is bio-based or bio-attributed (2024)*	The sector is commercially negligible despite a decade of policy attention and voluntary commitments.
~74% capacity utilisation *EU bio-based plastics producers, 2025*	Underutilisation raises unit costs and suppresses investment returns, reinforcing the market failure cycle.
22% → 12% *EU global plastics market share, 2006–2024*	The broader industrial base that bio-based plastics depend upon is in structural decline.
6× increase *in EU chemical sector closure announcements, 2022–2025*	At 17.2 Mt/yr by 2025, closures now affect ~9% of EU chemical production capacity — including steam crackers critical for drop-in bio-based polymers.
97.6% *EU crude oil import dependency (2022 — record high)*	Bio-based plastics offer a route to reducing dependence on imported fossil feedstocks and diversifying EU chemical supply chains.
~57,000 jobs *in EU bio-based chemicals sector; EUR 3.2bn value added/year*	There is an existing industrial base to build on — but without market-pull it faces continued erosion.

Source: Plastics Europe (2025); European Bioplastics / Nova Institut (2025); Cefic Closure Radar (2025); Eurostat (2023); JRC Policy Brief JRC145443 (2026); industry consultation, April 2026.

[27] Systemiq (2023) Towards Ending Plastic Pollution by 2040. Available at https://norden.diva-portal.org/smash/get/diva2:1798266/FULLTEXT01.pdf

[28] JRC (2026) Bio-based plastics in a sustainable and circular bioeconomy, Policy Brief, JRC145443, 3 March 2026.

Global demand for plastic continues to grow. Although there is credible supply potential, viable conversion technologies and pioneering biopolymer research, the European bio-based plastics sector faces a series of economic, regulatory and infrastructure barriers which are limiting uptake. As fossil-based plastics remain dominant and Europe risks further competitive decline, addressing the challenges for bio-based plastics uptake in Europe is important for both climate and industrial security in the region.

3.2 Seven Structural Drivers of Market Failure

The stagnation of the bio-based plastics market reflects seven interlinked structural drivers that together form a reinforcing dynamic the market cannot resolve without targeted policy intervention. Two of these drivers are system critical in the sense that they determine the form of intervention required, not merely its urgency:

The first is the fossil feedstock advantage and bioenergy competition: fossil plastics carry no carbon charge on their embedded feedstock carbon, establishing a structural price floor that bio-based materials cannot undercut, while binding biofuel mandates create policy-manufactured competition for sustainable biomass that bio-based chemicals cannot match. Together these two distortions compound rather than substitute for each other, and they cannot be corrected by generic non-fossil instruments: bio-based-specific demand signals are analytically necessary.

The second system-critical driver is the definitional and verification gap, which functions as a prerequisite constraint: no content target, EPR modulation criterion, or related policy instrument can be credibly designed, monitored, or enforced until a harmonised definition and chain-of-custody standard are in place. The remaining five drivers reinforce the case for intervention but shape its urgency and scope rather than its fundamental form.

This section examines seven key market and regulatory failures which are contributing to the negligible market share of bio-based plastics. These factors are complex and interlinked across both the European and global industrial landscape and have been limited to those drivers that are within the EU remit to influence, as well as those that have an overbearing influence on the problem in question. Each driver is summarised in the table below and detailed in the following sections.

Table 3-2 Seven structural drivers of bio-based plastics market failure

	Driver	Summary and evidence
1	**Structural cost differential**	Bio-based polymers cost 1.5 to 2x their fossil equivalents (JRC, 2026), a gap that will not close through market forces without binding demand signals to drive scale-up.
2	**Fossil feedstock advantage and bioenergy competition**	Two compounding distortions: fossil feedstock carbon is unpriced everywhere, and binding biofuel mandates (RED III, ReFuelEU Aviation, FuelEU Maritime) promote sustainable biomass to energy use. Generic non-fossil instruments cannot correct either; bio-based-specific measures are required.
3	**European chemicals in structural decline**	EU plastics market share fell from 22% (2006) to 12% (2024); chemical sector closures rose six-fold between 2022 and 2025, and nine steam cracker closures cut EU capacity by 16%, directly affecting drop-in bio-based polymers.
4	**Investment uncertainty**	Without durable demand-side market pull, capital-intensive bio-based projects are delayed, downsized or relocated (Vioneo Antwerp cancelled, January 2026), trapping the sector in a low-utilisation, high-cost cycle.
5	**Policy fragmentation**	PPWR, ESPR, the CEA and the Bioeconomy Strategy reference bio-based materials without harmonised definitions, methodologies or aligned objectives, raising compliance uncertainty and investment risk, particularly for SMEs.
6	**Definitional and verification gaps**	No harmonised EU definition, chain-of-custody standard or consistent mass balance methodology exists for bio-based content. This is a prerequisite constraint: no demand-side instrument can be designed, monitored or enforced without it.

	Driver	Summary and evidence
7	**Interaction risks with recycling objectives**	PPWR recycled content targets risk crowding out bio-based investment, while Article 6 recyclability requirements create a market access barrier for dedicated polymers (PEF, PLA) that cannot yet recycle at scale.

Driver 1. Structural Cost Differential

Bio-based plastics face a structural cost disadvantage relative to their fossil-based counterparts, with production costs for functionally equivalent polymers estimated at 1.5 to 2 times higher.[29] This differential arises from a combination of interrelated factors:

- **Feedstock costs for bio-based materials in Europe are generally higher**, reflecting their dependence on agricultural inputs, land use considerations and competition with other biomass applications.[30]
- **Processing costs are elevated**, particularly where conversion technologies remain less mature or have not yet benefited from large-scale optimisation. Some bio-based polymer pathways are still at relatively low technology readiness levels, which limits process efficiency and increases risk.[31]
- **Production volumes remain comparatively small**, preventing converters and brands from achieving economies of scale that would otherwise reduce unit costs.[32,33]
- **Fossil-based plastics benefit from decades of technological refinement**, extensive global supply chains and deeply entrenched industrial ecosystems.[34] These advantages translate into highly optimised production processes, mature feedstock supply chains and comparatively low costs compared to bio-based plastics.
- **The price of fossil-based plastics fails to internalise the environmental externalities** associated with fossil carbon extraction and use, including greenhouse gas emissions and resource depletion. As a result, the market price of fossil-based plastics does not reflect their full societal cost.

As bio-based plastics are not supported by regulatory mechanisms that create guaranteed markets or reward bio-based content, this cost gap persists. Consequently, purchasing decisions across value chains are predominantly driven by short-term cost considerations, with buyers typically prioritising the lowest upfront price. This dynamic structurally favours fossil-based plastics, even in applications where bio-based alternatives are technically feasible and environmentally advantageous. In the absence of robust demand-pull measures, the sector is unlikely to achieve the scale necessary to drive down costs. As a result, convergence in production costs between bio-based and fossil-based plastics is unlikely to occur through market forces alone, underscoring the need for coordinated policy intervention.

Driver 2. Fossil Feedstock Advantage and Bioenergy Competition

The use of second-generation biomass for chemicals—particularly lignocellulosic feedstocks like straw and wood—is in direct competition with biofuels for the energy sector, especially transport. While there is strong policy support for the energy sector, no comparable regulatory framework exists for the

[29] JRC (2026) Bio-based plastics in a sustainable and circular bioeconomy, Policy Brief, JRC145443, 3 March 2026.
[30] Döhler, N., et. Al. (2022) Market dynamics of biodegradable bio-based plastics: Projections and linkages to European policies. Available at: Link
[31] JRC (2026) Bio-based plastics in a sustainable and circular bioeconomy, Policy Brief, JRC145443, 3 March 2026.
[32] Döhler, N., et. Al. (2022) Market dynamics of biodegradable bio-based plastics: Projections and linkages to European policies. Available at: Link
[33] European Bioplastics (2025) European Bioplastics presents the Results of the 2025 Market Data Report. Available at: Link
[34] Innovation News Network (2024) The Innovation Platform Issue 20. Available at: Link

chemical sector. This creates an un-level playing field between feedstocks for energy and material use, putting bio-based materials at a disadvantage.

Under the Green Deal the EU is driving a transition to carbon neutrality in the transport sector and in recent years has increased the ambition and scope of three key policies:

1. **Renewable Energy Directive (RED):** The updated RED III has more than doubled specific renewable energy targets for the transport sector, from 14% to 29%, and expanded to include aviation and shipping as well as road and rail.
2. **ReFuelEU Aviation regulation:** sets a 70% target for the minimum volume share of sustainable aviation fuel (SAF) and synthetic aviation fuels for the aviation sector by 2050
3. **FuelEU Maritime regulation:** sets increasing emission reduction targets for shipping (which can be achieved using bio-based fuels).

Importantly, these policies either cap or exclude food and feed crops as feedstocks, meaning growing demand in these sectors will have to be met with second and third-generation biomass. Analysis by nova-Institut predicts a significant increase in demand for non-fossil carbon-fuels in Europe, potentially almost doubling between 2020-2050, with demand in the short term met largely by non-food/feed crop biomass feedstocks.[35] Accordingly, the aviation industry and SAF producers will be willing to pay much higher prices for biomass feedstock to meet quotas and avoid fines.[36] Without comparable targets and financial incentives from Member States (e.g., tax exemptions/subsidies for biofuels), the chemicals sector will not be able to bridge the cost gap. [37]

Although restrictions on the use of food and feed crops do not currently exist for chemicals, the food security concerns that drove RED's caps on crop-based biofuels represent a live policy risk: precedent suggests that if bio-based chemicals demand scales toward first-generation feedstocks, comparable restrictions could follow.

The two-level failure and bio-naphtha

A further dimension of this driver is that the two distortions are compounding rather than alternative explanations. Bio-naphtha co-produced from HEFA refining is increasingly available as a chemical industry feedstock, and in principle represents a near-term supply route for drop-in bio-based polymers. In practice, it attracts no meaningful chemical industry demand because the fossil price gap suppresses demand independently of biofuel competition: even where bio-naphtha is available, producers have no regulatory or financial incentive to pay the premium over fossil naphtha. This illustrates why correcting the bioenergy mandate asymmetry alone is insufficient: a direct demand-side signal for bio-based materials use is required alongside any feedstock rebalancing measure. It is also why bio-based-specific instruments are analytically necessary rather than generic non-fossil targets, which would not correct either distortion.

Driver 3. European Chemicals in Structural Decline

The European chemicals sector, which represents 5 to 7% of total industry sales, over 1.2 million direct jobs and one of the EU's top five export sectors, has seen its competitiveness decline rapidly over the past 15 years.[38] Between 2006 and 2024, Europe's share of global plastics production fell from 22% to 12%, even as global plastics production grew 16.3% since 2018 and 4.1% in 2024 alone. Over the past decade, EU chemical sector turnover and production value fell by 0.9% and 1.7% respectively, while enterprise numbers and employment rose by only 5% and 2%. Between 2022 and 2025, announced

[35] Harrandt, J., Carus, M., vom Berg, C., Hark, N. 2025: EU and global: Biomass Demand for Transport Fuels, Aviation and Shipping up to 2050 and Implications for Biomass Supply to the Chemical Sector
[36] ibid
[37] Carus, M., Porc, O., vom Berg, C., Kempen, M., Schier, F. and Tandetzki, J.: Is there enough biomass to defossilise the chemicals and derived materials sector by 2050. novaInstitut GmbH (Ed.), Hürth, Germany, 2025-02.
[38] Cefic and Advancy (2025) The competitiveness of the European Chemical Industry. Available at https://cefic.org/resources/the-competitiveness-of-the-european-chemical-industry-a-cefic-advancy-report/

closures in the sector rose from 2.9 Mt to 17.2 Mt per year, a six-fold increase, representing around 9% of European chemical production capacity.[39]

This decline reflects several price and non-price competitiveness factors:

- **European energy costs remain structurally higher**: natural gas is projected to stay two to three times more expensive than in the USA and electricity 1.5 to 2 times higher, a gap widened by the shift away from Russian gas since 2022, from which China and India continue to benefit through discounted supply.[40]
- **Raw material costs for bio-based inputs such as bioethanol, sugar and starch run close to double those in the USA, Brazil and Canada**, reflecting both feedstock access and local subsidies, while duty-free sugar imports further advantage Chinese producers.[41]
- **Labour costs are around twice those in China and the Middle East, and five times those in the rest of Asia,** according to Cefic.[42] Regulatory compliance adds a further, structural burden: a 2016 Commission-commissioned assessment found EU chemical enterprises incurred around €10 billion a year in compliance costs between 2004 and 2014, split across industrial emissions mandates, chemical-specific regulation and workplace safety requirements.[43]
- Finally, **R&D investment has lost ground:** no new steam cracker has been built in Europe in three decades bar INEOS's Belgian project, whose furnaces were shipped in from Thailand, and the average European cracker is now 45 years old.[44] Europe's share of global chemicals R&D spending fell from around 28% in 2009 to 18% in 2024, and its share of patent applications has also declined,[45][46] while China's R&D spending rose from 12% to 31% over the same period.[47]

This matters for bio-based plastics because some production depends on existing petrochemical infrastructure. The closure of nine steam crackers between 2022 and 2025, a 16% reduction in European cracking capacity, directly affects drop-in polymers such as bio-PE and bio-PP, which are typically produced by co-feeding biomass into existing fossil processes.[48]

Driver 4. Investment Uncertainty

Complex and un-harmonised sustainability regulation, together with the absence of credible demand-side frameworks, **creates additional costs for companies and adds uncertainty, slowing investment in bio-based plastic production in Europe or diverting it elsewhere.** Scaling up bio-based plastics is capital-intensive, not only at the polymerisation stage but also in upstream feedstock processing and downstream manufacturing adaptation. These investments typically carry first-of-a-kind or early commercial risk, volatile input costs, and payback periods extending over a decade or more.[49] Predictable offtake agreements or policy-backed market guarantees are critical to unlocking private capital: without confidence in stable, sufficient demand, firms cannot build robust business cases or

[39] Cefic (2025) European chemical closures and investments radar 2022-2025. Available at https://cefic.org/resources/european-chemical-closures-investments-radar-2022-2025/
[40] ibid
[41] ibid
[42] ibid
[43] European Commission. (2016). *Cumulative cost assessment for the EU chemical industry*. Final Report. Prepared by Technopolis Group, Centre for European Policy Studies (CEPS), and VVA Consulting. Luxembourg: Publications Office of the European Union. doi:10.2873/392331
[44] Chemsec (2026) Examined: Is European chemical industry in crisis? (Part 1). Available at: https://chemsec.org/examined-is-european-chemical-industry-in-crisis-part-1/
[45] Cefic (2025) Facts & Figures of the European Chemical Industry. Available at https://cefic.org/facts-and-figures-of-the-european-chemical-industry/capital-ri-spending/ [Date accessed 21/04/2026]
[46] European Commission, Joint Research Centre, Grassano, N., Napolitano, L., M'barek, R., Rodriguez Cerezo, E. and Lasarte Lopez, J., Exploring the global landscape of biotech innovation: preliminary insights from patent analysis, Publications Office of the European Union, Luxembourg, 2024, https://data.europa.eu/doi/10.2760/567451 , JRC137266.
[47] Cefic (2025) Facts & Figures of the European Chemical Industry. Available at https://cefic.org/facts-and-figures-of-the-european-chemical-industry/capital-ri-spending/ [Date accessed 21/04/2026]
[48] Cefic (2025) European chemical closures and investments radar 2022-2025. Available at https://cefic.org/resources/european-chemical-closures-investments-radar-2022-2025/
[49] Döhler, N. et al. (2022) Market dynamics of biodegradable bio-based plastics: projections and linkages to European policies. Available at: https://www.sciencedirect.com/science/article/pii/S2667041022000064.

secure financing on acceptable terms. Despite EU efforts to de-risk innovation and investment in bio-based technologies, funding remains insufficient for start-ups and scale-ups in the bioeconomy.[50]

Investment uncertainty means firms struggle to reach final investment decisions, and projects are consequently delayed, downsized or cancelled.[51,52,53] **In January 2026, for example, Vioneo scrapped plans for a €1.5 billion fossil-free plastics factory in Antwerp in favour of China, citing faster construction and cheaper access to green methanol.**[54] Elsewhere, cost pressures, weak demand and feedstock shortages have pushed back production start dates for planned European bio-attributed chemical capacity: Futerro's planned PLA plant in France, for instance, is now scheduled to start production by the end of 2029, having originally targeted 2027, following the 2024 opening of its first PLA plant in China[5556].

Underutilisation further deters investment. In 2025, average bio-based plastics production capacity utilisation was around 74% in Europe and 79% globally, with some polymer segments considerably lower. Suboptimal utilisation raises unit production costs by spreading fixed costs over lower output, eroding competitiveness against fossil-based alternatives and weakening the cash flow needed to service debt and fund expansion. Financiers respond with a higher cost of capital or reluctance to fund further projects, reinforcing a self-sustaining cycle: insufficient demand limits utilisation, low utilisation sustains high costs, and high costs suppress demand, deterring further investment. Bond and loan market pricing already reflects these pressures, including weaker earnings, falling share prices and ratings downgrades for companies in the sector[57].

Driver 5. Policy Fragmentation

Several EU legislative and strategic instruments acknowledge the role of bio-based materials, but they do so without harmonised definitions, consistent methodologies or aligned policy objectives. This lack of coherence limits their collective effectiveness, creates uncertainty for market actors and increases the cost of doing business across the EU, especially for SMEs.[58]

The contribution of bio-based plastics to compliance remains unclear, particularly where trade-offs with recyclability arise. Notably:

- **Under the Packaging and Packaging Waste Regulation (PPWR)** the focus on recyclability, reuse and waste reduction does not translate into clear incentives or requirements for bio-based content, nor does it establish standardised approaches for its measurement or verification (Article 8).
- **The Ecodesign for Sustainable Products Regulation (ESPR)** provides a broader framework for product sustainability, but its reliance on future delegated acts and the absence of a cross-cutting methodology for bio-based content create uncertainty around its future treatment within ecodesign requirements.
- **The Circular Economy Act** is expected to introduce demand-side measures, yet without a harmonised framework, there is a risk of inconsistent treatment relative to recycled or other low-

[50]European Commission (2025) A strategic framework for a competitive and sustainable EU bioeconomy. Available at: https://environment.ec.europa.eu/document/download/dbf8d2ba-9332-4f7a-b336-f356fa4b7236_en?filename=COM_2025_960_1_EN_ACT_part1_v10_0.pdf.
[51]Packaging Insights (2026) Avantium delays operational start of FDCA plant, costs rise by millions. Available at: https://www.packaginginsights.com/news/avantium-fdca-plant-delay.html.
[52]Plastics News (2023) Corbion calls off French PLA bioplastics plant. Available at: https://www.plasticsnews.com/news/corbion-calls-french-pla-bioplastics-plant/.
[53]Ethanol Producer Magazine (2024) ADM, LG Chem cancel plans to develop lactic acid, PLA projects in Illinois. Available at: https://ethanolproducer.com/articles/adm-lg-chem-cancel-plans-to-develop-lactic-acid-pla-projects-in-illinois.
[54]Belga News Agency (2026) Vioneo drops Antwerp factory plans and opts for China. Available at: https://www.belganewsagency.eu/vioneo-drops-antwerp-factory-plans-and-opts-for-china.
[55]Argus Media (2026) European biochemicals projects stall. Available at: https://www.argusmedia.com/en/news-and-insights/latest-market-news/2792384-european-biochemicals-projects-stall.
[56]Futerro (n.d.) Futerro aims to set up a new fully integrated PLA biorefinery in Normandy, France. Available at: https://www.futerro.com/futerro-aims-to-set-up-a-new-fully-integrated-pla-biorefinery-in-normandy-france/.
[57]OPEC (2014) Executive summary report: petrochemicals outlook, challenges and opportunities. Available at: https://energy.ec.europa.eu/system/files/2016-12/opec_petrochemical_outlook_-_nexant_executive_report_0.pdf.
[58] European Commission (2025) A Strategic Framework for a Competitive and Sustainable EU Bioeconomy. Available at https://environment.ec.europa.eu/document/download/dbf8d2ba-9332-4f7a-b336-f356fa4b7236_en?filename=COM_2025_960_1_EN_ACT_part1_v10_0.pdf

carbon materials. The EU Bioeconomy Strategy sets out high-level objectives for the use of renewable resources but lacks binding measures or implementation tools specific to bio-based plastics, leaving its impact dependent on downstream legislation.

Collectively, these gaps result in a fragmented policy landscape characterised by regulatory uncertainty, increased compliance complexity and weak investment signals. Without alignment on definitions, accounting methodologies and policy objectives, the EU risks limiting the effectiveness of its policy framework and constraining the scale-up of bio-based plastics.

Driver 6. Definitional and Verification Challenges

There is currently no fully harmonised approach across EU legislation for defining bio-based content, applying chain-of-custody systems or recognising mass balance accounting. As a result, bioeconomy market entry is often delayed because of uncertainty about how to classify novel bio-based products that do not clearly fit within existing legally recognised categories.[59] This fragmentation creates legal uncertainty for producers, complicates enforcement for national authorities and limits the comparability of sustainability claims for consumers, thereby constraining the market for bio-based plastics in Europe.

It is important to distinguish the existence of a categorical definition from the absence of an operational one. PPWR Recital 53 defines bio-based plastics as plastics made from biomass, which provides a legal category but establishes no measurement methodology, chain-of-custody framework, or verification standard. These operational elements, which determine what counts as bio-based for compliance purposes, how bio-based content is measured and attributed through complex supply chains, and what evidence producers must provide, remain entirely unharmonised across Member States and legislative contexts. The JRC DPP Methodology (JRC145830, 2026) independently corroborates this: it identifies the absence of a standardised definition for "*content of sustainable renewable materials*" as a primary barrier to implementing bio-based disclosure requirements under the ESPR Digital Product Passport framework. This is not a gap that the Bioeconomy Strategy or the Biotech Act process can resolve on their own; it requires a dedicated harmonisation measure as a prerequisite for every other demand-side instrument to function.

The technical tools required for robust verification are already well established yet their application to bio-based plastics remains inconsistent. Chain-of-custody systems, including mass balance approaches, are widely used in sectors such as biofuels, agriculture and parts of the chemical industry. Certification schemes developed by organisations such as ISCC and frameworks promoted by Cefic demonstrate that these methods can provide credible and auditable tracking of renewable inputs. [60] [61] However, in the absence of clear and harmonised EU-level recognition there are divergent interpretations across Member States and policy contexts. Industry stakeholders report that this increases the cost of compliance (especially for SMEs) and can create reputational risks, particularly where sustainability claims may be challenged or perceived as misleading.[62]

Ultimately, harmonised definitions and credible verification frameworks are essential for scaling bio-based markets, as they provide legal certainty, enable effective policy design and build trust among market participants. Without such a framework, it remains difficult to implement robust demand-side measures, such as content requirements or procurement criteria, or to ensure their consistent enforcement, thereby limiting the effectiveness of policy efforts to increase the uptake of bio-based plastics.

Driver 7. Interaction Risks with Recycling Objectives

Poorly designed bio-based content measures could conflict with PPWR recycled content targets and recyclability requirements, creating perverse incentives that favour fossil-based recycled plastic over

[59] European Chemicals Agency (ECHA), Bio-Based Chemicals in REACH, 2023
[60] ISCC (n.d.) Certification: ISCC EU Certification. Available at: Link
[61] Cefic (n.d.) Guidance and management frameworks. Available at: Link
[62] European Bioplastics (2025) Bioplastics – Industry Standards, Certifications & Labels. Available at: Link

bio-based.[63] The PPWR sets ambitious and increasing minimum recycled content targets for any plastic part of packaging which is >5% of the total packaging unit. Targets must be met using recycled content generated from post-consumer plastic waste. This could divert investment from brands away from bio-based alternatives as they prioritise (fossil-based) post-consumer recycled content to meet legal thresholds.

Recyclability at scale requirements (i.e. the extent to which packaging achieves a certain level of recycling in real-world conditions), pose an additional challenge. All packaging placed on the EU market must be recyclable from 2030 onwards and from 2035 any packaging material must be recycled at a minimum rate of 55% across the EU to remain on the market.

This presents a significant barrier for novel biopolymers such as PLA or PEF because these materials currently occupy a negligible market share (<1%) and they lack the widescale collection and sorting volumes needed to hit the 55% threshold. The result is a conflict—bio-based materials cannot scale without being on the market, but they may be banned under PPWR because they have not yet scaled. While this does not impact drop-in bio-based plastics, it could hamper development of novel and dedicated bio-based plastics which do not rely on the fossil-based plastic value chain.

Extended producer responsibility (EPR) fees could also deter brands from using bio-based plastics. Under the PPWR, EPR fees will be modulated based on recyclability performance grades. As some bio-based plastics require specialised sorting that is not yet widespread in European facilities, they may receive lower recyclability grades, resulting in higher EPR fees. Thus, there is a risk of financially penalising producers for choosing dedicated bio-based plastics over fossil-based PET or PE for instance.

Ultimately, regulation which does not sufficiently consider the interactions with recycling objectives and the role which bio-based plastics could play in reducing GHG emission and fossil-fuel reliance, could dis-incentivise the use of bio-based content packaging.

[63] European Parliament & Council of the European Union (2025) Regulation (EU) 2025/40 of 19 December 2024 on packaging and packaging waste (PPWR), adopted December 2024. Official Journal of the European Union. https://eur-lex.europa.eu/eli/reg/2025/40/oj

3.3 Likelihood the Problem will Persist

Bio-based plastics have remained below 1% of EU plastic production for a decade, despite credible supply potential, viable conversion technologies, and clear strategic rationale for their use. Growth predictions have consistently failed to materialise. This persistence of low uptake in the face of available solutions is the defining feature of the problem: the constraint is not technical but structural, rooted in a set of reinforcing market failures that business-as-usual will not resolve.

The most immediate structural failure is a cost disadvantage that the market does not correct. Production costs for bio-based polymers are estimated at 1.5 to 2 times those of functionally equivalent fossil-based alternatives. This gap reflects a combination of unpriced environmental externalities in fossil plastics, higher bio-based feedstock costs, elevated energy and processing costs in European production, and the inability to achieve economies of scale at current volumes. None of these factors is self-correcting: the fossil cost advantage is structurally entrenched, not temporary.

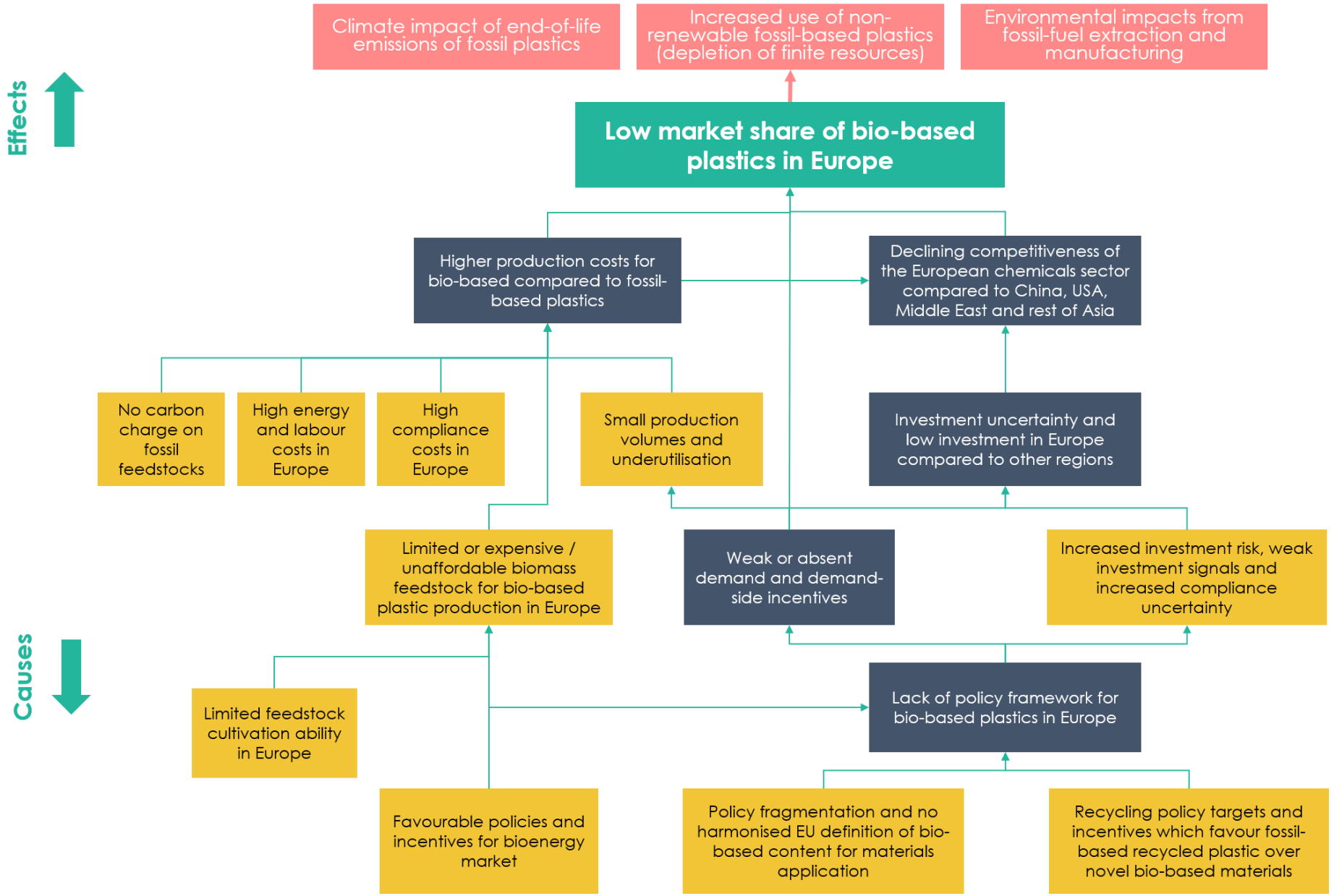
A second, compounding failure is the absence of a demand-side policy signal, combined with an active policy asymmetry that disadvantages bio-based materials relative to bioenergy. The Renewable Energy Directive (RED III) creates mandatory blending obligations for biofuels, with certified compliance pathways, subsidy eligibility, and a decade of supporting infrastructure. No equivalent instrument exists for bio-based plastics. The biomass hierarchy principle in RED III nominally prioritises material use over energy use, but is not given operational effect through any mandatory instrument that re-directs feedstock toward the materials sector. Bio-based plastics therefore compete for feedstock against a subsidised and mandated energy demand they cannot match. The absence of bio-based-specific content targets, combined with fragmented definitions and verification frameworks, compounds this by increasing regulatory uncertainty and compliance costs, particularly for smaller producers.

The result is a sustained failure of investment, at precisely the moment when the window for EU industrial leadership is narrowing. Bio-based production processes are less mature than fossil incumbents and require sustained capital investment to reach competitive scale. Without a credible long-term demand signal, investors cannot build a business case: Neste deprioritised renewable chemicals in February 2025 citing insufficient regulatory market-pull, and Vioneo cancelled its Antwerp plant in January 2026 for the same underlying reasons, redirecting investment to China. If the EU investment environment does not improve materially, European producers will continue to lose ground to competitors operating in lower-cost environments with stronger domestic demand signals. The market will not self-correct; the failures identified here are structural, and they interact in ways that make each individually harder to overcome.

Problem Tree

The diagram below sets out the core problem to be addressed by policy, the underlying factors driving the problem and the resulting impacts/consequences of the problem. The likely evolution ('baseline scenario') of the seven problem drivers identified is presented in more detail in the following section.

Figure 3-1: Problem tree for low market share of bio-based plastics in Europe



4.0 Baseline Scenario: Where the Market Stands Without Further Intervention

The baseline scenario outlines assumptions about how the bio-based plastics market is expected to evolve from 2025 to 2035 or 2040. These projections are based on the breadth of policy activity underway, described in Section 2, as well as the existing and forecast market barriers, highlighted in Section 3. Over the past decade, policy has been insufficient to create market change. Without new market-pull measures beyond those already in place or planned, the baseline scenario remains largely static. It considers macro, sectoral and external factors. The baseline serves as the foundation for assessing the proposed policy options, highlighting current policy limitations and identifying opportunities to create new drivers and address existing or anticipated barriers.

This baseline focuses on the evolution of five core elements:

1. **Current EU policy conditions;**
2. **The European investment climate ;**
3. **The fossil-bio cost differential;**
4. **Capacity and utilisation; and**
5. **Environmental performance of bio-based plastics.**

The baseline starts in **2025 and projects to 2035 or 2040 depending on data reliability**, using historical trends (past 10+ years), planned policies and academic literature. While the geographic scope is confined to the European Union +3, certain data points extend to neighbouring countries, such as the United Kingdom. These instances are explicitly identified and clearly delineated. The baseline scenarios are quantified as far as possible, and where not possible (e.g., due to lack of data), qualitative assessments are made.

4.1 Current Policy Conditions: An Incomplete Framework

The EU policy landscape for bio-based plastics offers little near-term market pull. **PPWR Article 8 mandates a review of bio-based packaging feedstocks by 2028, but binding utilisation targets are unlikely before around 2031, leaving a near-term gap in price support and investor risk reduction. Baseline policies on fossil-based recycled content, design-for-recycling criteria and EPR risk creating cost and market-access barriers for dedicated bio-based plastics, which lack mature, at-scale recycling infrastructure, an effect compounded by strong biofuel mandates.** The absence of harmonised definitions, mass-balance verification standards and Green Public Procurement criteria adds regulatory risk for brands and fails to recognise or reward the long-term carbon storage benefits of bio-based materials. **ESPR and CPR may improve visibility of bio-based content through Digital Product Passport requirements, but disclosure alone is unlikely to materially shift demand. The Bioeconomy Strategy's commitments are not binding, and the 20% sustainable non-fossil feedstock target proposed in COM (2021) 800 final lacks any measures to achieve it, so neither counts as a pull-measure in the baseline. As of mid-2026, the Biotech Act 2 and CEA have no quantified or published pull-measures, and while the IAA and ELVR set a precedent for such measures, they carries no confirmed bio-based plastics mandate.** As a result, the market share of bio-based plastics is projected to remain roughly static at niche status rather than achieve meaningful growth.

Summary of Qualitative and Quantitative Assumptions on Baseline Policy Trajectory

	Downward / disadvantaged trajectory for bio-based plastics
	Neutral / unchanging trajectory bio-based plastics
	Upward / advantaged trajectory bio-based plastics

Factor/ Metric	*Path-way*	2025	2030	2040	Basis
Content/feed stock requirements Market Failure: 2	***Drop-in***	No impact	No impact	No impact	No mandated pull-measure for bio-based feedstock use. Biofuel mandates not considered sufficient to disadvantage drop-in polymers.
	Dedi-cated	Limited impact	Disincentive	Barrier to market	Recycled content mandates to promote fossil-based/incumbent plastics and limit dedicated bio-based plastics. (Not applicable to construction sector.)
Recycling at scale / closed-loop mandate Market Failure: 7	***Drop-in***	No impact	No impact	No impact	No mandate to specifically benefit drop-in polymers' recycling.
	Dedi-cated	Limited impact	Barrier to market	Barrier to market	Acts as potential barrier for dedicated bio-based plastics in packaging, and a disincentive for automotives. (No applicable to textiles and construction.)
EPR Fee modulation Market Failure: 7	***All***	No impact	Cost disincentive	Cost disincentive	Eco-modulation for bio-based feedstock content could be introduced under CEA but unconfirmed. Recycled content modulation is planned for packaging and textiles, which may exacerbate cost differential between bio- and fossil-based. Not applicable to automotive or construction sectors.
Definitions, and verification Market Failures: 5, 6	***All***	Limited impact	Market uncertainty and delays	Reduced investment; limited growth	No confirmed equivalent directive to RED III, to provide clarity and safeguards to industry and investors. Limits investment/growth.

The Confirmed Legislative Hook: PPWR Article 8

PPWR Article 8 is the only enacted EU provision that directly addresses bio-based feedstock in plastics, but it does not constitute market-pull in the baseline. Article 8(1) of Regulation (EU) 2025/40 requires the Commission to review the technological development and environmental performance of bio-based plastic packaging by 12 February 2028, taking into account the sustainability criteria in Article 29 of the Renewable Energy Directive (RED III). Article 8(2) then empowers the Commission, where appropriate, to present a legislative proposal to lay down sustainability requirements for bio-based feedstock, set targets to increase its use, introduce a conditional substitution route within the Article 7 recycled content obligation, and amend the statutory definition of bio-based plastic. The route is review, then a legislative proposal subject to ordinary codecision: the earliest realistic application of any resulting targets is approximately 2031. The baseline is therefore not a policy vacuum; it contains a confirmed legal clock and a Commission mandate to act. What it does not contain is any current instrument creating demand, signalling price support, or reducing investor risk.

Likely Legislative Hook: ESPR Annex I(i) for Textiles and Apparel, and for Construction

By 2027 for textiles and by 2029-30 for construction products, the ESPR delegated acts could serve as primary regulatory levers for introducing bio-based feedstock use requirements in products, alongside other sustainability requirements and harmonised information requirements. Annex I provides the legal basis for product sustainability requirements to be established through delegated acts, while Recital 24 supports the broad consideration of sustainability aspects. This legal basis is already available under the ESPR and can be operationalised through delegated acts without amendment of the primary legislation.

According to Article 4(4) of the ESPR, the date of application for a delegated act generally cannot be earlier than 18 months from its entry into force. Therefore, potential bio-based content targets are likely to be enforceable by late 2028 or during 2029 for textiles, and, for construction, sometime from late 2030 to during 2032 – depending on when the delegated act is published.

Potential Legislative Hooks: ELVR Article 55 and CPR Articles 83 & 93

The Commission is mandated to conduct evaluations of the ELVR and CPR, under Articles 55 and 93 respectively.

For ELVR, in ~2032, a specific review by must assess the technological state and performance of bio-based plastic (and elastomers from reprocessed tyres), which could lead to bio-based feedstock-use targets. Despite the review being a confirmed active window in the future, there are no confirmed targets or other pull-measures currently. Thus, the review and its outcomes are not drivers within the baseline.

For CPR, by early 2033, the Commission is required to carry out the regulation's first major evaluation. The scope includes sustainability improvements of products and the built environment. The review should also **assess CPR's correlation to ESPR and the potential of EPR.** As the ESPR delegated act for construction will be published by this point, there could be implications for bio-based content stemming from this evaluation. However, the lack of confirmed mandates means that this is not a driver within the baseline.

CPR Article 83 mandates minimum environmental sustainability requirements for construction products used in public contracts.

Content Requirements and Targets

Demand for recycled content, particularly within packaging and vehicles, is promoted through recycled content targets, shown in Table 4-1. As producers are required to meet these, the targets promote use of incumbent polymer types (such as PET and PE). Whilst this does not negatively impact drop-in bio-based polymers, **the baseline scenario assumes that it will create a barrier for novel or mature dedicated bio-based polymers**, as these plastics will not have recycling infrastructure necessary to meet recycled content targets.

Table 4-1: Recycled Content Targets

Recycled Content	*Relevant Policy*	2025	2030	2040
Packaging	*PPWR*	Limited*	~10–35% PCR	~25–65% PCR
		Application dependent		
Textiles	*ESPR*	No mandate	Likely mandate	Likely increased mandate
		Planned, but no fixed targets yet.		
Vehicles	*ELVR*	No mandate	Preparations for upcoming mandates	Min. 15% RC, 6 years after ELVR** Min. 25% RC, 10 years after ELVR**
Construction	*ESPR (CPR)*	No mandate	Low likelihood mandate***	Likely mandate***

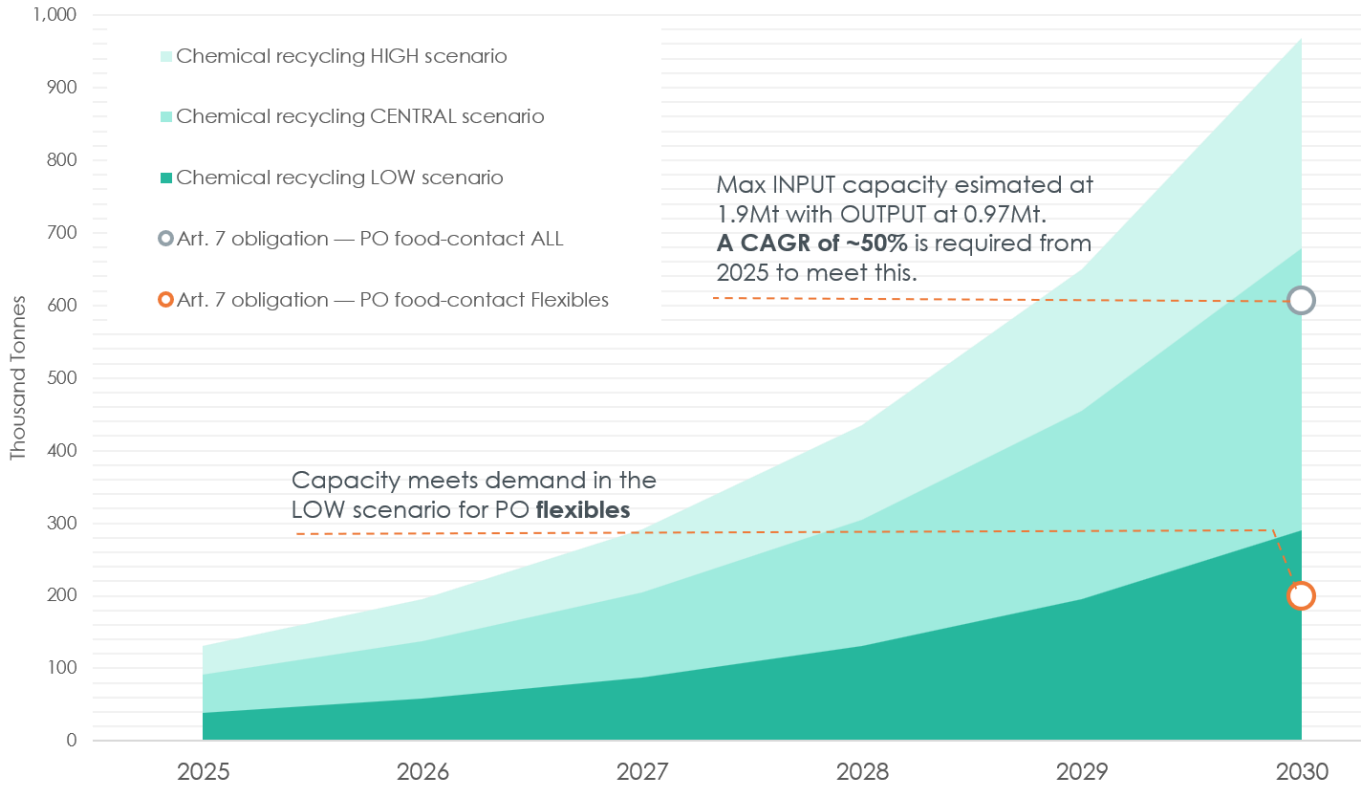
**Limited*: Minimum of 25% recycled content for PET beverage bottles under SUPD.*
***ELVR timings*: The earliest the 15% and 25% mandates could come into effect is by ~2032 and ~2036, respectively.*
*** ESPR delegated act unlikely to be enforceable by 2030; will be by 2040. CPR dependent on harmonised technical specifications' requirements, the implication on the classes of performance, and the c-PCRs. Generally, dependent on harmonisation between different legislative instruments.*

Availability of Food-Contact Recycled Content

Recent industry projections illustrate the uncertainty surrounding future supply of food-contact-compliant recycled polyolefins. While announced chemical recycling projects suggest substantial future capacity growth, a significant proportion of this capacity remains contingent on projects that have not yet reached operation.

Figure 4-1 compares projected PPWR Article 7 demand for food-contact polyolefin packaging with estimated output from pyrolysis-based chemical recycling scenarios. The scenarios are derived from Fraunhofer input-capacity projections and converted to estimated output capacity using assumed process yields. The high scenario represents the maximum feasible upper bound implied by announced projects, while the central and low scenarios reflect more conservative assumptions regarding project delivery.

Figure 4-1: Art.7 Obligations versus Projected Pyrolysis-Based Chemical Recycling Capacity. Fraunhofer estimates that INPUT capacity was 0.26Mt in 2025 and will rise to 1.9Mt by 2030 which includes 719kt of cancelled projects, therefore this figure represents that maximum feasible upper bound (HIGH scenario) for the EU.



Biofuel Targets

The current and planned policy on biofuels affects the feedstock used for both transport fuel and plastics – such as sugar crops (sugarcane, sugar beets, etc.), starch crops (e.g., corn/maize), and vegetable oils. As the transport sector strives to reach its increasing biofuel targets (29% by 2030), this may decrease feedstock availability and increase costs for bio-based plastics – due to increased competition. This contradicts RED III Article 3(3) that states material use is higher priority use of biomass than fuel/energy usage.

As bio-based plastics do currently not have counterpart targets, quotas, or fines, **the baseline scenario assumes that the demand driver for biofuels will not simultaneously promote the use of biomass in bio-based plastics.**

Promotion of Recycling

Additional to recycled content requirements, the EU policy landscape (particularly PPWR) supports and promotes recycling. Certain planned measures create barriers for dedicated bio-based plastics, and do not explicitly promote drop-in bio-based plastics. These measures are outlined below.

Design-for-recycling, Recycling at Scale and Closed-loop Recycling

In the baseline scenario, the requirements around recycling are assumed to become a barrier to market for dedicated plastics within packaging, and a disincentive for their use in vehicles.

PPWR requires all packaging be 'designed for recycling' by 2030, practicably 'recyclable at scale' by 2035, and, by 2038, only packaging with high 'recyclability grades' can be placed on the market. The

ELVR mandates that at least 20% of recycled content targets are sourced from ELVs (i.e., closed-loop recycling requirement). These objectives promote the use of plastics that can be recycled at scale and produce meaningful quantities of recycled materials to be used in production.

Currently, there are no comparable recycling requirements confirmed for textiles or construction.

For dedicated bio-based polymers with differentiated functional performance (such as enhanced barrier properties), there is an absence of recycling pathways recognised as "at scale" within existing EPR and other regulatory frameworks. Even where materials are technically recyclable, limited collection, sorting, and reprocessing infrastructure can function as a de facto market access barrier.

EPR Fee Modulation

The baseline trajectory assumes that as recycled content requirements increase, demand for cheaper fossil-based recycled materials will increase. This creates a cost disincentive for use of bio-based plastics in packaging.

EPR eco-modulation creates a financial demand signal for the incumbent polymer types that are currently recycled at scale (PE, PET, etc.). Thus, drop-in bio-based plastics are not disadvantaged; however, this measure does not incentivise their use over fossil-based alternatives.

Dedicated (novel) bio-based plastics are directly disadvantaged, as packaging producers and brands will be tied to incumbent polymers and their recyclates, to reduce their EPR fees through increasing their recycled content. In the baseline scenario, this is a cost disincentive at a minimum. After 2030, with increasing recycled content mandates, the cost differential may become a barrier to market.

EPR fee modulation does not apply to vehicles or construction sector. As such, this measure is less likely to impact mature, dedicated bio-based polymers (e.g. PA11) to the same degree, where applications and performance characteristics are well established and within the automotive (and construction) sectors. However, mature, dedicated bio-based polymers are still at a cost disadvantage.

Harmonised Definitions, Verification, and Criteria

Definitions, Mass Balance and Chain-of-custody

Within the baseline, there is not a definitional and verification framework. A harmonised bio-based content definition feeding into CEN/CENELEC/JTC 24[64] vocabulary is a prerequisite for cross-sector coherence across PPWR, ESPR delegated acts, and ELVR. Therefore, it will remain difficult to implement robust demand-side measures or to ensure their consistent enforcement. This limits the effectiveness of policy efforts to increase the uptake and limits investment appetite in bio-based plastics. For example, a lack of confirmed interpretation of chain-of-custody system for bio-based plastics may increase the cost of compliance, can create reputational risks, and results in market uncertainty.[65] This uncertainty promotes stagnation of growth in demand and capacity (more on capacity growth in Section 4.4).

Labelling and Claims

The absence of a harmonised definition also undermines the voluntary labelling framework that already exists in enacted law. PPWR Article 12(4) provides for voluntary bio-based content labelling, operative from August 2028 or 24 months after the relevant implementing act is adopted. CPR and ESPR establish a framework for ecolabelling and DPP claims that may include provisions on bio-based content. Directive 2024/825/EU sets the unfair commercial practice boundary for sustainability claims, prohibiting voluntary sustainability labels that do not meet specified requirements. Together, these provisions create a nascent legal framework for bio-based claims, but one that cannot function effectively in the baseline: without a consistent EU definition of bio-based feedstock and a mandatory mass balance standard, voluntary

[64] CEN/CLC/JTC 24 is a joint technical committee established by CEN-CENELEC dedicated to the DPP framework and system architecture

[65] European Bioplastics (2025) Bioplastics – Industry Standards, Certifications & Labels. Available at: Link

claims lack a common verification basis, exposing brands to reputational and legal risk and suppressing the commercial premium that might otherwise help close the cost differential with fossil-based alternatives.

Sustainability Criteria

The baseline does not forecast the adoption of sustainability criteria. Sustainability criteria are mandated to support the implementation of bio-based feedstock-use targets – i.e., to ensure that biomass is produced, sourced, managed, and processed to an acceptable and enforceable standard. The baseline does not include any bio-based plastic targets, as these targets are not yet mandated, so there is no respective sustainability criteria, either. RED III sustainability criteria do not create a direct market-pull signal for bio-based plastics. In the baseline they may influence feedstock sourcing standards but do not create market demand.

End-of-life Management

The packaging end-of-life impacts within the baseline have already been discussed – within the EPR and recycling requirements, under PPWR.

In the baseline, there is not a policy mandate to unlock the potential benefits of capturing embedded bio-based carbon, except for the construction sector's CPR mandates. Whilst packaging lifetimes are less than a year, textiles can average 1-5years and automotive 10-20 years. Products with longer lifetimes can perform better as their embedded emissions are spread over more years. This benefit is not clearly valorised in the current policy trajectory.

Green Public Procurement

The baseline assumes that green public procurement ('GPP') criteria for bio-based plastics will not be established throughout the assessed timeframe. As such, GPP is not a driver for demand within the baseline.

The IAA's procurement-based lead market creation provides a direct precedent to implement "Made in EU" and low-carbon preferences in public procurement and public support scheme. However, it does not establish concrete GPP criteria targeting bio-based plastics.

The 2022 Communication on a policy framework for bio-based, biodegradable and compostable plastics also does not establish procurement rules or targets for bio-based plastics, nor does it translate into operational GPP criteria. Its role is, therefore, preparatory rather than regulatory.

For construction products used in public contracts, GPP is supported under CPR (Article 83). The first impact assessment is to be initiated by the end of 2026, after which delegated acts can follow to mandate minimum environmental sustainability requirements. This mandate is not specific to bio-based plastics; the environmental performance required may not include or prioritise bio-based content.

The absence of bio-based plastic content requirements in GPP criteria reflects a set of unresolved methodological and scientific challenges, identified in JRC analysis.

4.2 The European Investment Climate: Structural Constraints on Bio-based Plastics Growth

The European petrochemical sector is experiencing a period of **structural contraction** which has implications for the capital and infrastructure needed to scale the bio-based plastics industry. Driven by **prohibitive energy costs** and **weak demand**, European **chemical plant closures have surged** since 2022 while **confirmed new capacity investments have slowed**. This contrasts sharply with capacity expansions in highly competitive regions like China, the US, India and the Middle East, eroding Europe's global competitiveness. For the bio-based plastics segment, this systemic decline in the broader chemicals landscape threatens the shared infrastructure and investment security required for upscaling. Without demand-side policy measures and de-risked investment, the baseline conditions point towards market stagnation or limited growth to 2040.

Summary of Qualitative and Quantitative Assumptions for Baseline Competitiveness Trajectory

Factor/Metric	2025	2030	2040	Basis
Bio-based plastics market share in Europe	1%	Stagnant	Stagnant	Cost competitiveness pressures and demand saturation are resulting in slowed and declined investment levels – with no evidence to support change or uplift in near to medium term.

Capacity Closures

Cost competitiveness pressures and demand saturation present an ongoing challenge to capacity and investment in the European petrochemical industry, indicating a future trend of survival/stagnation rather than a platform for significant widespread growth in the sector. Chemical plant closures in Europe have surged sixfold since 2022, reaching a cumulative 37 Mt of capacity— around 9% of European production capacity. Nearly half of these capacity closure announcements have been made within upstream petrochemicals, directly impacting steam cracking capacity and having a knock-on effect on upstream and downstream segments. According to Cefic, energy costs were cited in 49% of cases, followed by low demand (19%) and overcapacity (9%). Geographically, the largest shares of closures were in Germany and the Netherlands, together accounting for around 45% of announced capacity closures. Across Europe, around 20,000 direct jobs and 89,000 indirect jobs are estimated to be at risk.

Investment Slow-down

At the same time, confirmed investments have slowed and declined in recent years, with closures not fully offset by announced investment. Between 2022 and 2025, confirmed investments in chemical capacity in Europe decreased from 2.7 Mt to 0.3 Mt (-90%), although as of December 2025, 5 Mt of announced investments were yet unconfirmed. Petrochemicals and speciality chemicals[66], particularly investment in the battery value chain, account for 83% of confirmed investments. At 59% of confirmed investments 2022-2025, petrochemicals is the largest segment, but the 3.8 Mt capacity investments are lower than the 17.8 Mt announced for closure. Polymers and basic inorganics accounted for only 17% of confirmed chemical capacity investments in Europe 2022-2025. Belgium (36%), Germany (12%) and France (6%) were the top three countries in terms of confirmed capacity investments. In addition, the total confirmed investment CAPEX decreased between 2022-2025 by 81%, from €7.6 bn to €1.5 bn.

[66] Speciality chemicals use various feedstocks including refined petrochemical products and natural substances. They are used in high-value applications such as additives, adhesives, dyes and coatings, primarily for sectors like healthcare, agriculture and electronics.

The result over the past four years, has been a widening gap between investment and closures across Europe, with Belgium standing out as the exception with a number of large investments. This is in contrast to capacity expansions in China, ROAPAC (particularly India), the Middle East and USA. Indeed, rapid economic growth, urbanisation and increasing demand for consumer products as population purchasing power rises in economies like China, India and other Asian countries has caused a surge in demand for petrochemical products, including plastics.[67] While forecasts suggest that Europe will see overall growth for the petrochemical market to 2030 (e.g., CAGR 6.5%)[68], this is attributed to ongoing recovery after the COVID pandemic coupled with additions to oil and gas capacity in the region. In comparison, a CAGR of 7.4% is expected in the Asia Pacific petrochemicals market from 2023-2030.[69]

Employment Outlook

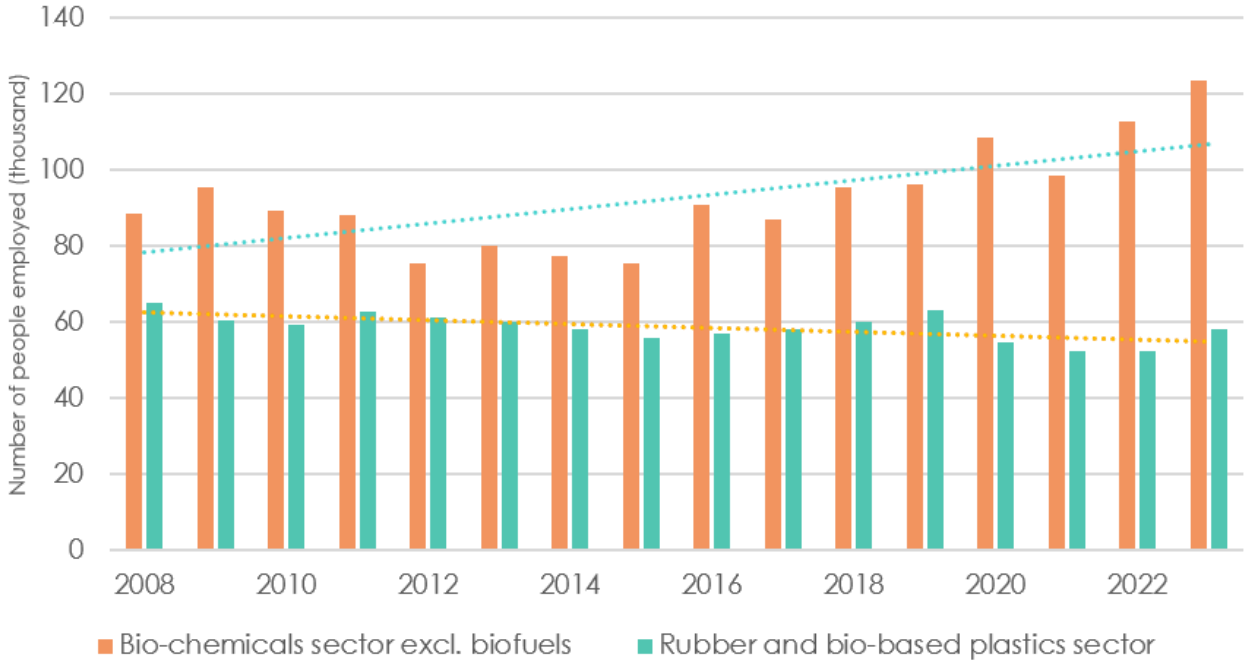
Historic employment data further builds a picture of limited/slow growth in the baseline trajectory for the market share of bio-based plastics. Jobs in the chemical sector in Europe have been relatively stable between 2015-2022 at around 1.2 million direct jobs and 19 million indirect jobs across EU supply chains. The number of people employed in the biomass producing and converting sectors (the bioeconomy) has also decreased slightly, from 18.5 million in 2012 to 17.2 million in 2021 (-7%). Although this hides sectoral differences— the agricultural sector led the decline— and while employment in bio-based chemicals, pharmaceuticals, plastics and rubber increased over the same period (see Figure 4-2), figures for this sector are still relatively low and do not indicate a past or imminent trend of rapid or significant employment growth. Of the ~57,000 jobs in the rubber and bio-based plastics sector (NACE rev. 2), 25-30% (approx. 14,250 to 17,100 jobs) are directly tied to the manufacturing and production of bio-based plastics.[70]

The EU Bioeconomy Strategy, which commits to boosting demand for bio-based content in products, the proposed Industrial Accelerator Act, and industry predictions anticipate future job creation in the sector in the order of hundreds of thousands in Europe.[71] But this trend depends on the level and scope of bio-based content targets and relies on the overall investment environment in Europe and would need to drive beyond relocating jobs from the fossil fuel sector and increased mechanisation of agricultural production (which has a net negative impact on low-skilled jobs), as well as overcoming the present labour shortage in the European plastics sector.[72]

Ultimately, the outlook for bio-based plastics market share in Europe is stagnant or limited growth to 2040 rather than a major uplift, with structural barriers to investment including higher feedstock and energy costs, market saturation and excess low-cost supply from other markets. While high-level EU policy goals point toward growth, the immediate economic reality reveals a broader chemicals sector in a state of contraction and restructuring which has implications for the capital and infrastructure needed for the bio-based sector to scale. Without strong incentives for greater investment coupled with policies which drive demand, the self-reinforcing cycle between demand, economies of scale and de-risked investment will not exist, and Europe will continue to lose ground to more competitive regions.

[67] Epcm Holdings (n.d.) Petrochemicals: Current status, future perspective and possible alternatives. Available at: https://epcmholdings.com/petrochemicals-current-status-future-perspective-and-possible-alternatives/
[68] Grandview Research (2024) Petrochemical Market (2025-2030). Available at: https://www.grandviewresearch.com/industry-analysis/petrochemical-market
[69] Grandview Research (2025) Asia Pacific Petrochemicals Market Size & Outlook, 2022-2030. Available at: https://www.grandviewresearch.com/horizon/outlook/petrochemicals-market/asia-pacific
[70] European Commission (2026) Knowledge Centre for Bioeconomy. Available at: https://knowledge4policy.ec.europa.eu/bioeconomy-knowledge-centre/topic/bio-based-plastics_en
[71] European Bioplastics (2016) How many jobs could be created in the bioplastics industry in Europe until 2030? Available at:https://www.european-bioplastics.org/faq-items/how-many-jobs-could-be-created-in-the-bioplastics-industry-until-2025/
[72] Gerlach (2024) Critical skill shortage in plastics processing industries intensifies. Plastics Information Europe. Available at: https://pieweb.plasteurope.com/Default.aspx?pageid=19990&docid=254890

Figure 4-2: Employment in the bio-chemicals sector and rubber and bio-based plastics sector 2008-2023 EU-27



Source: Jobs and Wealth in the European Union Bioeconomy (Biomass producing and converting sectors): Results from a collaboration between the JRC and the nova-Institute[73]

[73] JRC (2025) Jobs and wealth in the EU bioeconomy / JRC – Bioeconomics. European Commission, Joint Research Centre (JRC). Available at: https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

4.3 The Fossil-Bio Cost Differential: Current Position and Baseline Trajectory

Under the baseline scenario, **cost premiums persist** as a key constraint on bio-based plastics market share. Bio-based alternatives remain, on-balance, more expensive than fossil equivalents and premiums exceed the level that many stakeholders are willing to pay voluntarily. Process optimisation and technology improvements **may reduce costs incrementally**, but there is no evidence that they will deliver rapid cost convergence by 2035, especially given the **uncertain investment environment** in Europe and **declining industrial competitiveness**. With a lack of additional market-pull measures or significant carbon pricing escalation, the baseline position for bio-based plastics is constrained growth and continued economic disadvantage against fossil-based incumbents rather than market transformation over the next 10 to 15 years.

Summary of Assumptions for Baseline Cost Differential Trajectory

Factor /Metric	2025	2030	2040	Basis
Cost differential	equivalent polymers around 1.5-2x higher[74]			No evidence for rapid cost convergence by 2035, due to: • Failure to internalise the environmental externalities, though cost of carbon is likely to increase • The relative shares, absolute costs, processing yields and volatility drivers of feedstocks are distinct, leading to cost divergence • Technology readiness is not a barrier for all polymers, but challenges for optimisation and scaling will persist • Affordable and sustainable feedstock may not be (readily) available

Current Position: Feedstock Supply Constraints

Feedstock costs account for a significant proportion of material manufacturing costs for bio-based plastics. For the many routes of bio-based polymer production, understanding the different constraints and demand levels is important to understand the reasoning behind the cost differential.

Two separate factors determine how much bio-based feedstock ultimately reaches polymer production and how much it will cost. Distinguishing between them is important because they have different causes and require different policy responses.

- The first is **biomass availability**: how much material exists in crops[75], forests and waste streams, and how much of the first, second and third-generation feedstocks can realistically be collected, processed and brought to market.

- The second is **conversion capacity**: how much of that biomass can be transformed into feedstocks that polymer producers can use. For all conversion routes, first, second and third

[74] JRC (2026) Bio-based plastics in a sustainable and circular bioeconomy, Policy Brief, JRC145443, 3 March 2026.
[75] Unlike for biofuels, crops are an eligible feedstock for bio-based polymer production under the EU Taxonomy.

generation feedstocks exist. As such, biomass may be abundant, but they may remain inaccessible to the chemical sector if suitable conversion facilities do not exist, or if existing facilities are configured to produce other products. Different conversion routes sit at different stages of deployment. The existing European biorefineries and co-processing facilities are thus strategic assets to deliver bio-based materials at scale.

These constraints arise in different parts of the system. For waste and residue oils and fats, the primary constraint is biomass availability: feedstock supply is limited, and additional conversion capacity would not materially increase output. As waste and residue oils and fats are primary feedstocks for HVO/HEFA production (under RED III and ReFuelEU feedstock eligibility requirements), the co-produced bio-naphtha is similarly constrained by limited feedstock availability. Although this is not the only pathway for bio-naphtha production, co-produced bio-naphtha is also constrained by conversion choices, as the HVO/HEFA biorefineries do not necessarily separate and market naphtha to chemical customers. Conversely, wood residues present the opposite situation: the resource is relatively abundant, but Europe currently has limited capacity to convert it into feedstocks suitable for polymer production.

Treating feedstock availability as a single issue obscures the source of the constraint in each case. Understanding whether the limiting factor is biomass supply or conversion capacity is important because the policy measures needed to address them are fundamentally different – making first, second and/or third-generation feedstock eligibility a policy decision, rather than a technical given.

The next section describes feedstock availability of crude tall oil, waste residues, cellulosic sugars and first-generation ethanol – highlighting key constraints and demand drivers that are likely to persistent within the baseline and influence the cost differential. Following this, the conversion capabilities for HVO/HEFA, ethanol dehydration and methanol-to-olefins are assessed, based on factors such as technology readiness levels, feedstock availability, competition levels, and recent investment decisions. These assessments do not cover every feedstock nor every conversion route for every bio-based polymer; they are intended to give deeper insights across a broad range of options, to highlight the nuances and variability of impacts affecting biomass availability and conversion routes. This work feeds into the feedstock cost trajectory within the baseline.

Feedstock Availability

Physical feedstock availability is not generally the binding constraint on scale-up; cost and competition for the same biomass are often more important. This is most clearly the case for large, diffuse resource streams such as agricultural and forestry residues, where the available resource base is substantial relative to plausible demand from the plastics sector. The picture is different for concentrated by-product streams such as crude tall oil and used cooking oil. Their supply is tied to the output of other industries and cannot be expanded independently. In these cases, cost and competing demand determine how a largely fixed resource is allocated, rather than stimulating additional supply.

Biomass Availability at the EU Scale

The EU has substantial biomass resources available for non-fossil carbon production. The EU produces approximately 295 Mt of agricultural residues each year, of which around 146 Mt could be collected without depleting soil organic carbon.[76] Independent analysis suggests that around one-fifth of the chemical sector's carbon demand could be supplied from biomass by 2050 without displacing food or feed production.[77]

[76] European Commission, Joint Research Centre (2023) Biomass production, supply, uses and flows in the European Union: an integrated assessment. Publications Office of the European Union. Agricultural residue production is estimated at approximately 295 Mt dry matter per year. See also Monforti, F. et al. (2015) 'Optimal energy use of agricultural crop residues preserving soil organic carbon stocks in Europe', Renewable and Sustainable Energy Reviews, 44, pp. 519–529.
[77] Carus, M. et al. (2025) Is there enough biomass to defossilise the chemicals and derived materials sector by 2050? Renewable Carbon Initiative / nova-Institut.

Crude Tall Oil: A Case Study in Feedstock Competition

Waste-derived feedstocks illustrate how demand, rather than physical scarcity, can become the limiting factor. Crude tall oil (CTO), a by-product of the kraft pulping process, provides a useful example. European production was approximately 650 kt in 2019.[78] Because CTO production is linked directly to softwood pulp output, supply can only grow in line with the pulp industry and cannot be expanded independently.

Demand, however, is increasing more rapidly. CTO is listed as an advanced feedstock under Annex IX-A of the Renewable Energy Directive, allowing it to be used in advanced biofuels that benefit from favourable regulatory treatment. Demand from aviation fuels has been particularly strong.

Recent market evidence reflects these pressures. Weaker European softwood pulp production reduced CTO supply through 2025 and 2026, while Nordic refiners increased imports of US crude tall oil by more than 80% between 2023 and 2025 to compensate. [79]

The relevant issue is therefore not a lack of physical resource, but increasing competition for a limited regional supply. The frequently cited projection of 2.3 Mt of crude tall oil by 2030 refers to global availability rather than European production. The study from which the figure originates anticipated European supply constraints emerging after 2022 and a widening European demand-supply gap after 2025, a pattern now visible in the market. [80]

Because crude-tall-oil-derived products are already included within the bio-naphtha and HEFA supply estimates used elsewhere in this report, they should not be treated as additional feedstock.

Other Waste and Residue Feedstocks

Other advanced feedstocks recognised under the Renewable Energy Directive (RED) include used cooking oil, animal fats, the biomass fraction of municipal solid waste, and a range of agricultural and food-processing residues, including bagasse, olive pomace and brewers' spent grain.[81]

Used cooking oil and waste fats are particularly relevant to plastics production because they already contribute to renewable naphtha supply. One European assessment estimated total EU biofuel-eligible waste and residue availability at around 220 Mt per year, comprising approximately 139 Mt of crop residues, 44 Mt of municipal solid waste, 44 Mt of forest residues and around 1 Mt of used cooking oil.[82]

As with crude tall oil, the main constraint is not physical availability but market competition. Existing bioenergy mandates and associated incentives often make these materials more valuable as fuel feedstocks than as feedstocks for materials. Expanding their use in plastics therefore depends primarily on economic and policy conditions rather than resource availability.

Cellulosic Sugars

Second-generation cellulosic sugars remain commercially constrained. Production costs are substantially higher than for first-generation sugars, commercial-scale facilities remain limited, and policy support for advanced biofuels increases competition for the same molecules.

As a result, greater use of cellulosic sugars in plastics is likely to depend on changes in the relative incentives facing energy and material applications.

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[78] Aryan, V. and Kraft, A. (2021) 'The crude tall oil value chain: global availability and the influence of regional energy policies', *Journal of Cleaner Production*, 280, 124616.

[79] Argus Media (2026) 'Less EU CTO supply meets soft rosin markets', 6 March.

[80] Aryan and Kraft (2021), The approximately 2.3 Mt 2030 figure widely cited elsewhere is this paper's global availability estimate (2.26 Mt), not a European trajectory. European crude tall oil output tracks softwood kraft pulp production, forecast to grow at around 1 to 1.8% a year to 2024 and around 1% a year to 2030; the paper's own analysis anticipates European supply becoming constrained after 2022 and European demand for crude-tall-oil-based biofuels exceeding total European availability after 2025.

[81] European Commission (2021) *EU Biorefinery Outlook to 2030*. Independent Expert Report by E4tech, WUR, BTG, FNR and ICONS.

[82] European Commission, Directorate-General for Environment (2022) *Biobased plastic: sustainable sourcing and content: final report*. Publications Office of the European Union.

First-Generation Ethanol

First-generation ethanol faces a different set of conditions. Unlike many advanced feedstocks, it is already available at commercial scale and is not subject to the same level of mandate-driven competition for supply.

The EU currently produces approximately 6.3–6.5 Mt of renewable ethanol annually, most of which is used for fuel blending. Ethanol dehydration to ethylene is a commercially proven technology and is discussed further in the ethanol-to-ethylene and methanol-to-olefins section.

Implications for this Assessment

The evidence reviewed suggests that feedstock availability is generally constrained more by economics and competing demand than by absolute biomass supply. Agricultural residues, waste streams and renewable ethanol all exist at commercially relevant scale. The key question is not whether biomass is physically available, but whether policy and market conditions direct that biomass towards materials rather than energy applications.

Feedstock Conversion Capability

Technology readiness is not the principal barrier for all polymers, but challenges for optimisation and scaling will persist as a constraint for bio-based plastics in general. Most polymers are described as mature and commercially available, with many at high TRL, including TRL 9. Expected development pathways include optimisation and scaling of existing production routes, biological and technological improvements such as more efficient enzymes, engineered microorganisms and improved fermentation processes and feedstock diversification beyond first-generation sugars towards lignocellulose, waste products and C1 gases from industrial emissions. [83]

Although alternative feedstocks for bio-based plastics are not new, such as agricultural by-products or waste, established production methods for first generation biomass still dominate from an economic perspective. More than 50% of bio-based plastics are produced from high-productivity crops such as sugar cane, wheat and corn (1st generation biomass), with virgin feedstock remaining the most common input.[84] Second and third generation bio-based material production faces high R&D costs.

Only after reaching higher TRL can optimisation and scaling commence to reduce costs – which, due to limited legislative and fiscal support mechanisms, are not likely to be achieved for novel bio-based plastics over the next 10 to 15 years. Lower TRL polymers (i.e., novel bio-based) will continue to face higher costs to 2030 (and likely 2040) in the baseline scenario. To achieve the economies of scale needed for process optimisation, to overcome biological bottlenecks in the conversion process and to scale bio-based plastics, a demand-side boost is needed. The required investment in production technologies will not follow unless producers can rely on growth in demand for bio-based plastic products.

HVO and HEFA

Regarding the potential supply of bio-based feedstock to existing petrochemical infrastructure through the drop-in route, specifically bio-naphtha and other renewable hydrocarbons produced as co-products of HVO and HEFA biorefineries. The HVO/HEFA biorefineries must, under RED III and ReFuelEU requirements, source feedstocks sustainably and limit the volumes from food/feed crop biomass. Waste oils, fats and related waste feedstocks are primarily used and face constraints.

Feedstock Supply Is the Primary Constraint

[83] Nova (2026), Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40.
[84] Joint Research Centre (2026), Bio-based plastics in a sustainable and circular bioeconomy.

Available European supplies of oils, fats and related waste feedstocks are insufficient to meet projected demand across all sectors. The Commission estimates that the vegetable oils, waste oils and animal fats that could realistically be mobilised within the EU amount to around 2.1 million tonnes of oil equivalent (Mtoe) per year by 2030, rising to 4.7 Mtoe under a high-mobilisation scenario. Projected demand for advanced biofuels from these feedstocks over the same period is 10.7 Mtoe, leaving a shortfall of between 6.0 and 8.6 Mtoe that the Commission expects to be met through imports.[85] This assessment is for a defined set of feedstock, so a wider eligibility scope would increase the resulting volumes.

The EU is increasingly dependent on imported waste oils, and several exporting countries are introducing or considering export restrictions to retain feedstocks for domestic refining.[86]

Co-Produced Bio-Naphtha Faces the same Feedstock Constraint

The waste oils and fats feedstock supply gap is not specific to aviation. The Commission's assessment covers demand across road transport, aviation and shipping, as well as the principal conversion routes that use these feedstocks. HVO/HEFA biorefineries' co-produced bio-naphtha for the chemical sector draws on the same underlying resource base: **the limiting factor is the total quantity of waste oils and fats that can be sustainably collected, rather than demand from any individual sector.**[87]

This distinction is important when considering a bio-based feedstock target. Expanding production capacity alone cannot increase the availability of European waste oil and fat feedstocks, as their supply remains limited. Therefore, to expand co-production of bio-naphtha supplied to European chemical producers, additional feedstocks will need to be imported or come from resources that might otherwise have been used elsewhere in the bioeconomy.

The Constraint Operates at Both Feedstock and Product Level

This feedstock competition reinforces the two-level market failure framing established earlier in this report. Biorefinery capacity exists and is growing, and a fraction of its output is suitable for plastics production. But in the absence of a structured demand signal from the plastics sector, these molecules flow entirely to fuel applications where mandated demand already exists. The bioenergy mandate competition described in Section 4.1 operates at the feedstock level as well as at the product level: not only do biofuel mandates compete for the same biomass inputs, they also absorb the petrochemical-grade co-products that could otherwise enter plastics supply chains.

Production Capacity Exists, but Market Incentives Favour Fuels

The technology to produce substantially larger volumes of bio-naphtha is already commercially available. In 2022, Honeywell announced that its Ecofining process, previously used primarily to produce renewable diesel and aviation fuel with naphtha as a co-product, could also be configured to maximise renewable naphtha production.[88] **The main constraint is therefore economic rather than technical.** Existing technology can support large-scale production of bio-naphtha for chemical applications. However, current policy incentives and market conditions generally make the production of transport fuels more attractive than the production of chemical feedstocks.

Only a portion of the naphtha produced by a biorefinery is available for use as chemical feedstock. Some is consumed on site to support the refining process. Hydrotreating requires significant volumes of

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[85]European Commission, Directorate-General for Research and Innovation, Exergia, E3Modelling, Wageningen University & Research, BEST, BTG and Politecnico di Torino (2024) Development of Outlook for the Necessary Means to Build Industrial Capacity for Drop-in Advanced Biofuels: Final Report. Luxembourg: Publications Office of the European Union. Table 4-7, p.47. DOI: 10.2777/679307. Available at: https://op.europa.eu/en/publication-detail/-/publication/b1c97235-c4c3-11ee-95d9-01aa75ed71a1/language-en (Accessed: 17 July 2026).

[86] SkyNRG and ICF (2026) Sustainable Aviation Fuel Market Outlook Report – 2026. Available at: SkyNRG SAF Market Outlook 2026 Insights and Trends

[87]European Commission et al. (2024), Section 4.3.3 and Table 4-7, p.46 to p.47. The four-step method determines feedstock suitability for each conversion technology, subtracts biomass already used for biofuels, power and heat, converts the remainder to a fuel production potential, and compares that potential with projected demand.

[88]Honeywell (2022) 'Honeywell Introduces New Technology to Produce Key Feedstock for Plastics'. Press release, 9 February 2022, Des Plaines, IL. Available at: https://www.honeywell.com/us/en/press/2022/02/honeywell-introduces-new-technology-to-produce-key-feedstock-for-plastics (Accessed: 17 July 2026).

hydrogen, and one published plant model found that steam reforming one-third of the naphtha output, together with two-thirds of the fuel gas produced, was sufficient to meet the facility's entire hydrogen demand. The remaining naphtha is typically blended into fuel streams and sold as fuel. Declining diesel demand as vehicle electrification progresses is expected to reduce bio-naphtha demand for fuel blending, potentially making additional volumes available for chemical applications. Supplying the chemical sector instead requires operators to keep the naphtha separate and have access to a market willing to purchase it as feedstock.[89]

Implications for this Assessment

Bio-naphtha already exists in significant volumes as a co-product of biorefineries built to meet aviation-fuel demand. No additional biomass resources, and no new production investment, are required for it to be produced. What limits its use in plastics is not production itself but market demand. In the absence of a demand signal from the plastics sector comparable to that provided by fuel mandates, bio-naphtha is more likely to be directed into fuel markets than sold as chemical feedstock.

The fossil-bio cost differential described in this section is therefore not solely a matter of production economics. It is also shaped by competition between end uses for a feedstock stream that already exists. Where fuel markets provide stronger incentives, bio-naphtha is more likely to flow into fuel applications than into plastics production.

Ethanol dehydration and methanol-to-olefins

Two further routes reach commodity polymers from non-fossil feedstock without going through a steam cracker at all: dehydration of ethanol to ethylene, and conversion of methanol to light olefins. **Neither yet operates at commercial scale in the EU, but both are technically mature**, and each exposes a different form of the supply-side constraint described above.

Ethanol to Ethylene

Technology Readiness

Ethanol dehydration is a mature, commercial technology. The process converts ethanol to ethylene in a single step and has operated at commercial scale for more than a decade outside of the EU. Braskem has produced bio-based ethylene from ethanol at its Triunfo facility in Brazil since 2010, and Croda operates the same route in the United States.[90]

The process requires approximately **1.8 tonnes of ethanol per tonne of ethylene produced**.[91]

Feedstock Availability

Feedstock supply is less constrained for this route than for most other bio-based pathways into commodity polymers. Ethanol is already produced at substantial scale within the EU. Audited industry data indicate that EU and UK producers supplied approximately 5.4 million tonnes of renewable ethanol in 2024, representing around 85% of installed capacity. This implies total production of approximately 6.3–6.5 million tonnes.[92] This volume is predominantly first-generation, with European second- and third-generation (advanced) ethanol capacity being around 200 kilo tonnes in 2023. [93]

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[89]Zech, K.M., Dietrich, S., Reichmuth, M., Weindorf, W. and Müller-Langer, F. (2018) 'Techno-economic assessment of a renewable bio-jet-fuel production using power-to-gas', Applied Energy, 231, pp. 997 to 1006, Table 6 and Section 2.2.3, p.1001. The scenario models a 500 kt/yr plant processing jatropha oil, with hydrogen supplied by steam reforming of the plant's own co-product streams.

[90]European Commission (2021) EU Biorefinery Outlook to 2030. Study by E4tech, Wageningen University and Research, BTG, FNR and ICONS for DG Research and Innovation. Luxembourg: Publications Office of the European Union. doi:10.2777/103465.

[91]ePURE (2025) European renewable ethanol: key figures 2024. Brussels: European Renewable Ethanol Association. Audited data released 9 September 2025; ePURE members and other reporting producers account for approximately 85% of EU installed capacity.

[92] ePURE (2025) European renewable ethanol: key figures 2024. Brussels: European Renewable Ethanol Association. Audited data released 9 September 2025; ePURE members and other reporting producers account for approximately 85% of EU installed capacity.

[93] JRC (2025) Advanced Biofuels in the European Union Status Report on Technology Development, Trends, Value Chains and Market; JRC144512; doi:10.2760/1570541; p.21, Table 3.

Most of this volume is used in transport fuels. According to the same audit, around 86.5% of ethanol production is directed to fuel blending, compared with 6.9% for industrial uses and 6.6% for food and beverage applications. Expanding ethanol use for chemicals would therefore compete directly with existing transport-fuel demand.

Factors that may Ease Competition for Feedstock

Two developments could reduce this competition over time:

First, declining petrol demand as vehicle electrification progresses is expected to reduce ethanol demand for fuel blending, potentially making additional volumes available for chemical applications.

Second, EU sustainable-finance rules do not restrict the use of crop-derived ethanol for chemical production. While the EU Taxonomy excludes food and feed crops from certain transport-fuel applications, it permits their use in the manufacture of basic organic chemicals and plastics.[94] Crop-derived ethanol therefore remains an eligible feedstock for bio-based polymer production even where it cannot count towards transport-fuel objectives.

Potential Contribution to Ethylene Supply

The European Commission's *EU Biorefinery Outlook* assessed ethanol dehydration as a source of bio-based ethylene. Against an EU steam-cracker ethylene capacity of approximately 23 million tonnes, the study modelled a high-case scenario in which ethanol dehydration supplied 50% of incremental ethylene production by 2030, and a low-case scenario in which it supplied 10%.

These scenarios were developed in 2021 and assume continued growth in European ethylene demand. Subsequent cracker closures have increased uncertainty around that assumption. The figures are therefore best interpreted as indicators of the route's potential contribution rather than as current forecasts. **Currently**, **ethanol dehydration is yet to operate at commercial scale in the EU.**

Methanol to Olefins

Technology Readiness

Methanol-to-olefins (MTO) is also a commercially proven technology. Unlike ethanol dehydration, MTO produces both ethylene and propylene, and the ratio between the two products can be adjusted to reflect market demand. The technology has operated commercially at large scale since 2013, primarily in China.

MTO is more feedstock-intensive than ethanol dehydration, requiring approximately **2.8–3.0 tonnes of methanol per tonne of ethylene and propylene produced**.[95]

Feedstock Availability

The main constraint in Europe is feedstock supply rather than technology. Announced European renewable-methanol projects imply potential capacity of around 10 million tonnes per year by 2030, but realised capacity remains substantially lower. Much of the anticipated supply is already associated with maritime and aviation fuel markets.[96]

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[94]Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021 establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or adaptation. OJ L 442, 9.12.2021.

[95]Tian, P., Wei, Y., Ye, M. and Liu, Z. (2015) 'Methanol to olefins (MTO): from fundamentals to commercialization', ACS Catalysis, 5(3), pp. 1922 to 1938. doi:10.1021/acscatal.5b00007. The Shenhua Baotou performance test recorded 2.96 tonnes of methanol per tonne of combined ethylene and propylene.

[96]GENA Solutions and Methanol Institute (2025) Project Navigator Methanol, December 2025 release. Announced global renewable and low-carbon methanol capacity to 2030 exceeded 45 Mt/year against a realistic build-out estimated at 6 to 13 Mt/year; Europe accounts for roughly a third of the e-methanol and a tenth of the biomethanol pipeline.

As with ethanol, chemical applications compete with transport-energy uses for the same molecules. Demand is reinforced by policy measures including FuelEU Maritime, ReFuelEU Aviation and renewable-fuels targets under the recast Renewable Energy Directive.[97]

Evidence from Recent Investment Decisions

The importance of feedstock availability is illustrated by Vioneo's decision in January 2026 to relocate its first commercial MTO project from Antwerp to China.

The proposed facility would have used Honeywell UOP technology to produce approximately 300,000 tonnes per year of polyethylene and polypropylene from around 800,000 tonnes of green methanol. It would have been Europe's first commercial-scale MTO polymer plant.[98]

According to company statements, the relocation reflected concerns over the availability and cost of renewable methanol in Europe, together with permitting and financing conditions. Secured access to renewable methanol was identified as a prerequisite for future European investment.

Because the technology remained unchanged, the decision highlights feedstock availability and feedstock cost—not technological readiness—as the principal constraint on deployment in Europe.

Implications for this Assessment

The two routes face different constraints. Ethanol dehydration benefits from an established European feedstock base but competes with transport-fuel demand for supply. Methanol-to-olefins relies on a commercially proven conversion technology but is constrained by limited availability of renewable methanol, much of which is already committed to other sectors.

In both cases, feedstocks are subject to competing demands from energy-sector policies. This reinforces the distinction made elsewhere in this assessment: directing non-fossil carbon towards material applications may require policy measures aimed specifically at plastics and chemicals, rather than technology-neutral instruments operating across the wider bioeconomy.

For all polymer pathways above, the selected examples are intended to provide a range of nuances and showcase the variability of impacts affecting biomass availability and conversion routes. They are not an exhaustive list of all pathways. Phase 1 assesses a wider range of polymer pathways.

Current Position: Cost Differential

At present, bio-based plastics face a structural cost disadvantage relative to their fossil-based counterparts, with production costs for functionally equivalent polymers around 1.5 to 2 times higher.[99] **Error! Reference source not found.** illustrates this cost differential for a selection of polymer types, based on 2024 prices per kilogramme.[100] A 2022 study found that less than 25% of stakeholders surveyed would accept a price premium above 20%.[101]

There are several factors driving this differential. Most notably, as the incumbent, the fossil fuel industry has benefitted from over a hundred years of optimisation and government support, resulting in economies of scale, streamlined chemical processes, efficient supply chains, cheap raw materials and

[97]Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 (recast Renewable Energy Directive, RED III). OJ L, 2023/2413, 31.10.2023. The 42% renewable-fuels-of-non-biological-origin target applies to hydrogen used in industry by 2030, rising to 60% by 2035.

[98]Reported in the chemical trade press in January 2026 (for example Chemical and Engineering News and Argus Media) and in Vioneo company statements. Vioneo is an A.P. Moller Holding company; the planned Antwerp plant would have used Honeywell UOP methanol-to-olefins technology.

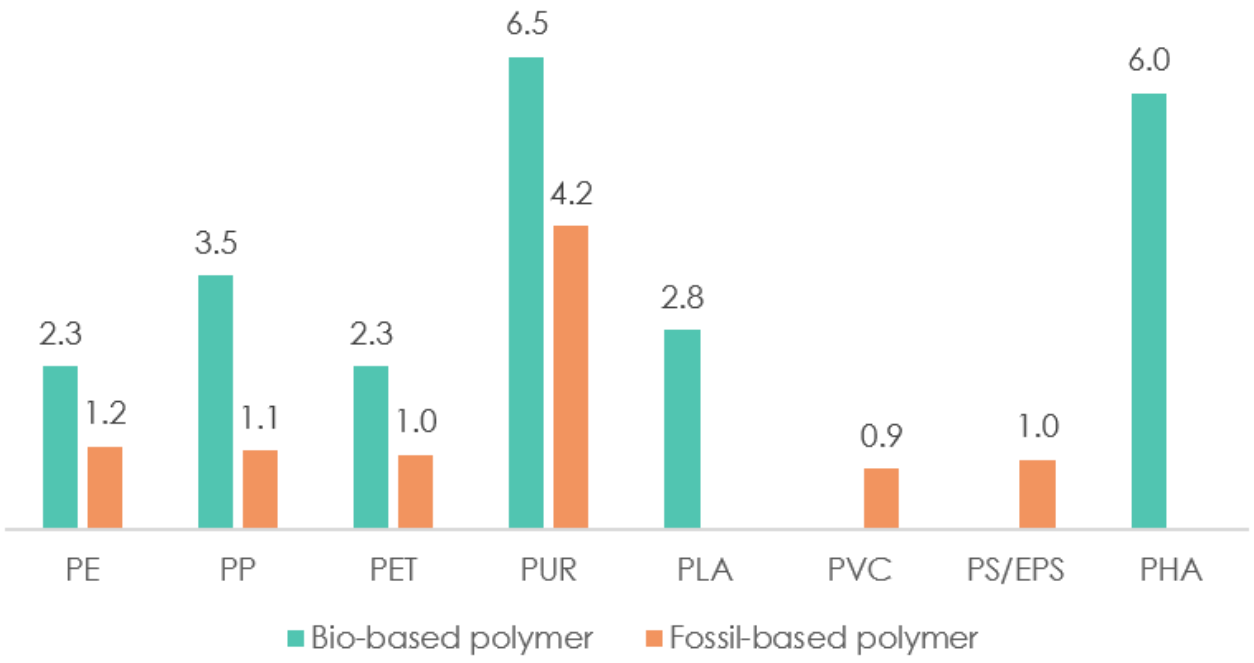
[99]JRC (2026) Bio-based plastics in a sustainable and circular bioeconomy, Policy Brief, JRC145443, 3 March 2026.

[100] Nova (2026), Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40; Nova (2026), Bio-based Building Blocks and Polymers – Global Capacities, Production and Trends 2025–2030.

[101] Wood E&IS GmbH / Trinomics (2022), Biobased plastic sustainable sourcing and content.

very high conversion yields, all of which act to maintain low fossil-based material prices. Predicting the exact trajectory for all these factors and their impact on cost parity is complex and constrained by limited data. The projected evolution of these drivers will change the cost-differential to varying degrees and in different ways, ultimately dependent on demand, investment and the implementation/impact of key policies in the pipeline.

Figure 4-3: Fossil-based vs Bio-based Polymer Prices (2024, €/kg)



Sources: UNComtrade, nova-institute [102]

Baseline Trajectory

The future trajectory of the cost-differential between fossil- and bio-based plastics relies on the evolution of multiple and interlinked economic, political and technological drivers. The cost differential is forecast to be influenced in the baseline by a reduction in advantages for fossil-based plastics, as well as the persistence of certain costs associated with feedstock availability and conversion.

Erosion of Fossil-based Advantages

First, policy at both EU and global levels is seeking to increase the cost of carbon. This could begin to escalate the price of fossil-based polymers and improve cost-parity for bio-based polymers, but progress looks slow and failure to internalise the environmental externalities in the price of fossil-based plastics is likely to continue within the baseline timeframe. There are two key planned EU policies which could influence the cost of carbon in products, but neither look set to reduce the cost-differential between fossil- and bio-based plastics by 2040:

- **CBAM** currently excludes plastics, polymers and chemicals. The Article 30 review, originally due by end of 2025, has not yet resulted in scope extension for these sectors. The Commission has since indicated a further report is expected around 2027, with full alignment with EU ETS sectors targeted by 2030. This makes the direction of travel clear (inclusion is plausible before 2030) without asserting a firm commitment that hasn't actually materialised yet. This timeframe is too

[102] Fossil-based: UNComtrade EU market prices, https://comtradeplus.un.org/ Accessed: May 2026. Bio-based: Nova (2026), Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40; Nova (2026), Bio-based Building Blocks and Polymers – Global Capacities, Production and Trends 2025–2030.

late to impact the cost differential in 2030. By 2040, the baseline scenario assumes no inclusion as there is yet to be official confirmation of this change in scope.

- There is **ETS** asymmetry for polymer production as petrochemical producers pay no carbon charge on the CO_2 embedded in the naphtha or gas they consume as feedstock. This asymmetry means rising ETS carbon prices do not close the fossil/bio-based cost gap at the feedstock level. The Commission has committed to review the ETS scope in July 2026, examining the zero-emissions factor treatment for biogenic carbon. A favourable outcome would reduce the fossil/bio-based cost differential. However, updates would define the legislative framework post-2030 and without the results of the review, the baseline cannot take any potential changes from the review into consideration meaning the trajectory of the cost differential is not impacted in this scenario.

Moreover, political intention to phase out fossil fuel subsidies are unlikely to significantly erode fossil-based cost advantages by 2035. International and EU commitments e.g. COP26 Glasgow Climate Pact and the EU's 8th Environment Action Programme, call for the phase out subsidies for fossil fuels without delay. In 2024, global explicit subsidies for fossil fuels were $0.73 trillion (0.6% of global GDP), with implicit subsidies $6.7 trillion (5.8% of global GDP). In Europe, subsidies have been stable between 2015-2021, but more than doubled in 2022 due to COVID and Russia's invasion of Ukraine, and in 2023, subsidies stood at €111 billion.[103] Subsidies did decline in nine Member States between 2015-2023, and in 20 member States between 2022-2023 but these still remain above 2021 levels in most countries.[104] Most Member States lack plans to phase out subsidies and 48% (€53.1bn) of subsidies do not have a planned end-date before 2025. Moreover, global explicit subsidies are predicted to decline only slightly in the medium-term, with implicit subsidies increasing as fuel consumption in emerging markets continues to rise.[105]

Ultimately, while global and EU policy does exist to drive the price of fossil-based carbon up, eroding the price advantages of fossil-based plastics, the implementation and impact look neither fast nor big enough to achieve significant price-parity and level the playing field within the next 10-15 years.

Feedstock Cost Trajectory and Constraints

Feedstock costs account for a significant proportion of material manufacturing costs for both fossil- and bio-based plastics, yet the relative shares, absolute costs, supply chain economics, processing yields and volatility drivers of the two systems are distinct, leading to cost divergence. A 2021 JRC technical report comparing bio-based and fossil-based value chains found that bio-based PET and PUR (bio-based plastics with the largest market shares) had a cost share for feedstock of 86%, much higher than the 45% for their fossil-based counterparts.[106]. Not only is the absolute material cost baseline typically 1.5-2 times more expensive than fossil-based, transport and storage costs are often higher as bio-based feedstocks tend to be bulkier and more perishable than petrochemical feedstocks and sourced from widely dispersed and small-scale suppliers not co-located with bio-refineries.[107]

The baseline scenario does not consider the physical availability of feedstock to be a limiting factor, however, this does not mean affordable and sustainable feedstock will automatically be available to EU bio-based plastic producers.[108] The Nova/BIC/RCI study finds that covering 20% of the chemical industry's carbon demand with biomass by 2050 is realistic without compromising food and feed supply, while global agricultural production is projected to increase by 31% by 2050 under business-as-usual conditions. There are non-EU feedstocks currently in use that can provide scalable, sustainable, land-

[103] EEA (2025) Fossil fuel subsidies in Europe. Available at: https://www.eea.europa.eu/en/analysis/indicators/fossil-fuel-subsidies
[104] ibid
[105] IMF (2026) Fossil fuel subsidies. Available at: https://www.imf.org/en/topics/climate-change/energy-subsidies
[106] Spekreijse, J., Vikla, K., Vis, M., Boysen-Urban, K., Philippidis, G. and M'barek, R., Bio-based value chains for chemicals, plastics and pharmaceuticals, EUR 30653 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-7632459-1, doi:10.2760/712499, JRC124141. Available at https://pq-ue.ani.pt/brochuras/h-europa/alimentacao--bioeconomia--recursos-naturais--agricultura-e-ambiente/jrc_technicalreport_biobased_valuechains.pdf
[107] Ali Omidkar, Razieh Es'haghian, Hua Song, Predicting biomass transportation costs: A machine learning approach for enhanced biofuel competitiveness, Cleaner Logistics and Supply Chain, Volume 16, 2025, 100252, ISSN 2772-3909, https://doi.org/10.1016/j.clscn.2025.100252
[108] Carus, M. et al. (2025), Is there Enough Biomass to Defossilise the Chemicals and Derived Materials Sector by 2050? nova-Institut/BIC/RCI.

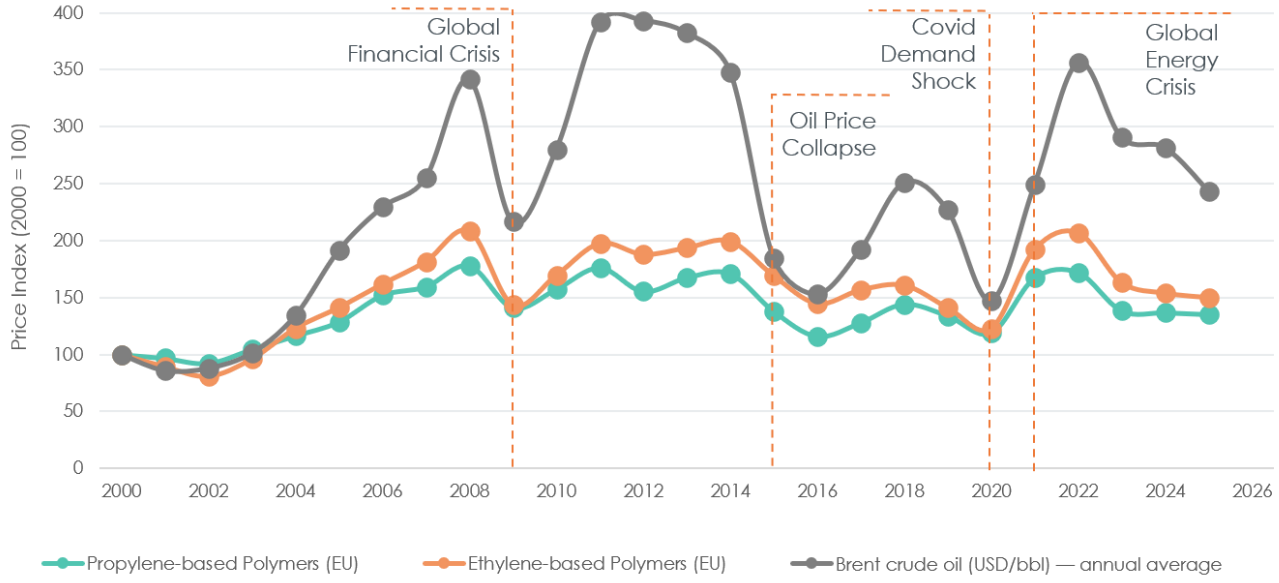
efficient supply into the future. The origin of feedstock is not a confirmed criterion within EU policy. There is no evidence to suggest producers will shift away from the currently embedded global supply chains.

Cost Volatility is Difficult to Predict

It is difficult to predict whether future cost volatility will narrow or widen the gap between fossil- and bio-based plastics. The costs of fossil-based plastics are closely linked to oil prices, which can fluctuate significantly over time. As shown in Figure 4-4, polymer prices have historically moved in line with changes in Brent crude prices. Because oil markets are shaped by global supply and demand, including decisions made by major oil-producing countries outside Europe, European manufacturers have limited influence over these price movements. [109]

The primary drivers of bio-based plastic costs are different. These include weather conditions, crop yields, fertiliser and other agricultural input costs, and land-use policies. As a result, fossil- and bio-based plastics are exposed to different sources of market risk and price volatility.

Figure 4-4: Fossil-based polymer prices vs. brent crude prices



Source: UNComtrade (2026), Statistica (2026) [110] [111]

Bio-based Plastics face a Structural Cost Disadvantage

Current evidence suggests that bio-based plastics are likely to remain more expensive than fossil-based alternatives under the baseline scenario. This cost gap reflects several factors, including the long-term optimisation of fossil-based production processes, high conversion efficiencies, established infrastructure, and continuing policy support for fossil-based supply chains.

In contrast, biomass resources are geographically dispersed and generally require more complex supply chains, increasing production and logistics costs. Competition for biomass from sectors supported by dedicated policy mandates, particularly biofuels, also increases pressure on feedstock availability and price.

[109] Organization of the Petroleum Exporting Countries ('OPEC') Member Countries (12): Algeria, Republic of the Congo, Equatorial Guinea, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Saudi Arabia, and Venezuela. Non-OPEC Partners (10; allied nations): Azerbaijan, Bahrain, Brunei, Kazakhstan, Malaysia, Mexico, Oman, Russia, South Sudan, and Sudan.
[110] Statista (2026) Average annual brent crude oil price from 1976 to 2025 Brent crude oil price annually 1976-2025 | Statista
[111] UN Comtrade (2026) Database: Custom extract https://comtradeplus.un.org/TradeFlow?Frequency=A&Flows=all&CommodityCodes=3901&Partners=0&Reporters=all&period=2025&AggregateBy=none&BreakdownMode=plus

The baseline does not close the cost gap.

Under current policy assumptions, the cost differential is not expected to narrow enough to move bio-based plastics beyond niche market applications. While technological improvements may reduce production costs over time, the baseline does not include strong demand-side measures capable of reducing investment risk or driving the scale economies needed for wider market adoption.
As a result, bio-based plastics are expected to remain at a competitive disadvantage relative to fossil-based plastics throughout the assessment period.

4.4 Bio-based Capacity, Utilisation and the Baseline Production Trajectory

The bio-based plastics sector remains fundamentally constrained by a **lack of market demand rather than limited manufacturing capacit**y, leading to significant **underutilisation** of existing facilities. Historical growth forecasts have been **systematically overstated** because they rely on optimistic supply-side announcements without accounting for real-world demand barriers. While near-term growth could technically be achieved by **leveraging these idle assets or utilising secondary hydrocarbon byproducts** from renewable fuel refineries, these raw materials will continue to flow towards **heavily mandated energy sectors** instead of plastics due to stronger financial incentives. Consequently, Europe's competitive position within the global market is weakening, and bio-based polymers are projected to remain a marginal alternative

The medium (probability-weighted) scenario is adopted as the baseline trajectory for this study at both the EU and global levels. The medium scenario is the appropriate counterfactual for assessing the proportionality and additionality of the policy instruments. A demand-constrained baseline is what makes those instruments necessary. The gap between the industry's aspirations and the observed reality is what makes them proportionate.

Under this trajectory, bio-based polymers remain a marginal fraction of total EU plastics consumption through to 2035. Growth comes primarily from the partial delivery of an identified but uncertain facility pipeline. The low and high scenarios are retained as sensitivity bounds. They illustrate the range of outcomes depending on whether announced projects deliver and whether utilisation recovers, but neither the observed trajectory (in which the market remains essentially flat) nor the full pipeline scenario (in which every announced project reaches production on schedule) is the most probable outcome

Summary Baseline Capacity, Utilisation and Production Trajectory

Factor/ Metric	2025	2030	2035	Basis
Global				
Production (kt)	2,000	2,550	3,250	Total of polymers from priority sectors derived from Nova (2026) and assuming a 5% CAGR.
Utilisation	~79%			Nova reports production at 100% capacity (CA, epoxy, EPDM, PE, PET, PP, PUR). 58% for all other polymer blended operating rate (Carus 2026 p.51).
Capacity (kt)	2,520	3,220	4,100	Based on production/capacity
Europe (EU 27+3)				
Production (kt)	230	390	550	Derived from Nova (2026) from global data and future capacity based on announced plants
Utilisation	~74%			See global
Capacity (kt)	300	520	740	See global

Note: capacity does not include potential bio-naphtha increase as this is contingent on demand created for that as a polymer feedstock which is not a certainty under baseline conditions.

Scope of Analysis

The starting point for the baseline is a market that has been unable to meaningfully increase its share of total plastics production despite aggressive growth projections for many years. **Global bio-based polymer production was estimated to be 3.8 Mt in 2019[112] and at 3.8 Mt again in 2024.[113] Over the same period, total global plastics production grew from approximately 368 Mt to 431 Mt.[114] Bio-based market share has slightly decreased, with a share at or marginally below 1%.**

The most recent data suggests this may be turning. Nova-Institut reports global bio-based polymer production reaching 4.5 Mt in 2025 (installed capacity 5.1 Mt), a real capacity-driven increase of around 700,000 tonnes in a single year, concentrated in epoxy resin and PLA expansion in Asia. Whether this marks a durable break from the prior five years of stagnation, or a one-off step change, is not yet clear from a single year of data.[115]

The nova headline covers all 17 commercially available bio-based polymers, including several categories that are not relevant to all of the study's priority sectors of packaging, textiles, automotive and construction. Epoxy resins, polyurethanes and cellulose acetate (CA) accounts for approximately 65% of bio-based production, but only 40% of the demand in priority sectors. But even this is asymmetric as they account for only 14% of packaging. CA, in particular has a distorting effect due to around 80% destined for cigarette filters with only the fibre portion relevant to textiles (approximately 88 kt) and the film portion relevant to packaging (approximately 121 kt) are included.[116]The baseline total production for 2024 is therefore reduced to 3.6 Mt by removing cigarette filters. The nova-Institut also published polymer shares per end use group which allows a derivation of 2 Mt of demand for the priority groups. A further derivation is possible taking EU shares of each polymer to arrive at 230 kt of EU production.

A full list of in-scope polymers and their 2024 production volumes is provided in Appendix A.3.1.

Industry Projections Versus Observed Trajectory

The nova-Institut annual market reports are the primary source of capacity and production data for bio-based polymers globally and are used by both European Bioplastics and Plastics Europe. The data itself is valuable and the best available. However, the growth projections attached to that data have a track record worth scrutinising.

Nova-Institut's own market tracking illustrates the pattern. Its 2016 edition forecast a 4% CAGR to 2021 already a marked slowdown from the 10% growth seen between 2012 and 2014.[117] Its 2020 edition, following a substantial downward restatement of prior production figures, forecast a more modest 3% CAGR to 2024, implying production of approximately 4.4 Mt. [118] Confirmed 2024 production was 3.8 Mt, the same as in 2019: growth flattened again. Even nova's own progressively more cautious projections have consistently overshot the market's actual performance.

The explanation is possibly methodological. The Carus et al. study describes the approach using capacity projections based principally on forecasts from companies that are already producing bio-

[112] Wood E&IS GmbH (2022) Biobased plastic: sustainable sourcing and content. for European Commission, DG Environment.

[113] Carus, M. et al., (2026) *Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40*. Study for the European Commission, DG Environment., citing Skoczinski et al. 2025.

[114] Plastics Europe, "Plastics: the Facts 2024".

[115] Skoczinski, P. et al., "Bio-based Building Blocks and Polymers: Global Capacities, Production and Trends 2025–2030", nova-Institut, February 2026, p.11 and p.18.

[116](2026) *Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40*. Study for the European Commission, DG Environment, Table 5. CA fibre and film portions estimated from total CA production of approximately 1,100 kt, with approximately 80% allocated to cigarette filter tow.

[117] Aeschelmann, F. and Carus, M. (2017) *Bio-based Building Blocks and Polymers: Global Capacities and Trends 2016-2021*. Hürth: nova-Institut GmbH.

[118] Skoczinski, P., Chinthapalli, R., Carus, M., Baltus, W., de Guzman, D., Käb, H., Raschka, A. and Ravenstijn, J. (2020) *Bio-based Building Blocks and Polymers: Global Capacities, Production and Trends 2019-2024*. Hürth: nova-Institut GmbH.

based polymers or have announced actions in the period to 2030.[119] This is a supply-side aggregation of company announcements, without demand-side modelling, without weighting by investment decision status, and without applying any historical discount for non-delivery.

The 2025 data illustrates the practical consequence. Global production reached 4.5 Mt in 2025, up from 3.8 Mt in 2024, an increase of around 700 kt (18%) in a single year, driven by an estimated 550 kt of genuine new capacity concentrated in epoxy resin and PLA expansion in Asia. Rather than smooth annual growth, the real pattern is long flat periods followed by step-changes tied to specific capacity coming online. **A blended CAGR figure obscures this lumpiness and conveys a steadiness the underlying data does not support. The current nova projection of 11% CAGR to 8.5 Mt by 2030 should be treated with caution.[120]** This study's own baseline scenario adopts a 5% CAGR, less than half nova's projection, precisely to correct for the systematic overstatement documented above.

The Demand-Side Barrier

The bio-based plastic subset with genuine discretionary capacity (excluding CA, epoxy resins and PUR, whose production figures are calculated backwards from building block trade data and therefore show capacity equal to production by construction) had actual output of approximately 1.44 Mt in 2024 against 2.47 Mt of installed capacity: a utilisation rate of 58%.[121,122] Industrial norms for capital-efficient polymer production are typically 85–90%. The gap between installed capacity and actual production demonstrates that the primary barrier to growth is insufficient demand, not insufficient supply. Building additional capacity without addressing this demand deficit will not change the trajectory.

European Baseline Trajectory

Facility Pipeline

The EU baseline is constructed from the identified facility pipeline rather than from applied CAGR projections, because individual European projects can be traced and their delivery probability assessed. Six facilities have been publicly identified as adding bio-based polymer or intermediary capacity in Europe (See Appendix A.3.2). The total announced polymer capacity is 630 kt. The probability-weighted polymer capacity, accounting for project status and delivery confidence, is 324 kt.

The facility pipeline in Appendix A.3.2 covers plants making dedicated bio-based polymers. Biorefinery capacity is not listed there. Bio-naphtha supply is modelled separately, from the SkyNRG and ICF projection of total European renewable fuel capacity, which is an industry-wide figure rather than a plant-by-plant list. Announced biorefinery expansions are therefore captured through that projection rather than through the pipeline table.

Plastic Packaging Demand Growth

Although packaging waste generation, including plastic packaging, has historically increased in both absolute and per capita terms across the EU[123], driven in part by the growth of single-use formats linked to on-the-go consumption and e-commerce, this trend is expected to flatten over the period to 2030. **This expectation reflects regulatory compliance rather than organic market saturation. The PPWR**

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[119] Carus, M. et al., (2026) *Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40*. Study for the European Commission, DG Environment.,, p.20.

[120] Skoczinski, P. et al., "Bio-based Building Blocks and Polymers: Global Capacities, Production and Trends 2025–2030", nova-Institut, February 2026, p.18.

[121] Carus, M. et al., (2026) *Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40*. Study for the European Commission, DG Environment., p.51.

[122] Carus, M. et al., (2026) *Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40*. Study for the European Commission, DG Environment., p.21. Production numbers for bio-PE and bio-PP are reported as production rather than capacity, since these drop-in polymers are produced in existing fossil crackers using bio-attributed feedstock.

[123]Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on packaging and packaging waste, recital 114.

introduces binding per capita packaging waste reduction targets of 5% by 2030, 10% by 2035 and 15% by 2040 (relative to a 2018 baseline), which Member States must meet through prevention measures such as reuse and refill systems, economic instruments and extended producer responsibility schemes.[124] This is consistent with evidence of a broader deceleration in EU virgin plastic production between 2018 and 2022, attributed to a combination of oil price volatility, global production overcapacity, import competition, environmental regulation and shifting consumer behaviour.[125] For the purposes of this study, plastic packaging demand to 2030 is therefore assumed to be broadly flat: this reflects the combined effect of these regulatory drivers, rather than a straightforward extrapolation of the historical growth trend still evident in the most recent packaging placed on the market data.[126]

Biorefinery Co-product Supply

Growth in biorefinery capacity is expected to slow in the early 2030s, primarily because feedstock availability becomes increasingly constrained. The SkyNRG and ICF outlook identifies a point around 2030 at which demand for feedstocks eligible under ReFuelEU Aviation exceeds supply. However, this feedstock category is narrower than the full range of oils and fats that biorefineries can process and does not, by itself, determine the volume of bio-naphtha that can be produced alongside fuels.

The dedicated production figures above already include some output derived from bio-naphtha. Bio-PE and bio-PP produced via the drop-in route (where bio-naphtha is fed into conventional steam crackers alongside fossil naphtha) are reported by nova-Institut as production rather than capacity, and these volumes are therefore embedded in the baseline starting point. **What is not captured in those figures is the incremental bio-naphtha supply expected from new and expanding biorefinery capacity, principally driven by the scale-up of sustainable aviation fuel (SAF) production.**

HVO and HEFA biorefineries are designed to produce renewable diesel and sustainable aviation fuel from lipid-based feedstocks. The hydroprocessing of oils and fats yields a range of renewable hydrocarbons, including a light fraction (broadly in the C5 to C12 range) that is chemically equivalent to fossil naphtha and can serve as feedstock for conventional steam crackers. This bio-naphtha fraction is a structural co-product of the refining process. **In this report, bio-naphtha means renewable naphtha that meets the quality and composition requirements of its fossil-based counterpart (typically the C5 to C10 fraction), allowing it to be used as a drop-in feedstock.**

EU HEFA biorefinery output reached approximately 4.2 Mt in 2025, comprising 3.9 Mt of HVO and 0.3 Mt of SAF.[127] European SAF and renewable fuel capacity is projected to reach 4.7 Mt by 2030, with 3.0 Mt already operational or under construction as of 2026.[128]

A substantial volume of bio-naphtha is embedded within the aviation-fuel capacity already being built in Europe.

European aviation-fuel capacity is projected to increase from 1.4 million tonnes in 2025 to 4.7 million tonnes by 2030. This matters because aviation-fuel biorefineries typically produce significant quantities of naphtha as a co-product. Renewable diesel facilities generally produce only 4–10% naphtha because they do not require extensive hydrocracking. By contrast, aviation-fuel production relies on hydrocracking and typically generates around 28–32% naphtha and light gases as part of the process.[129]

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[124] Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on packaging and packaging waste, Article 43.

[125] Amadei, A., Venturelli, S. and Manfredi, S. (2025) Plastics materials flows in the EU-27 and their environmental impacts: unveiling the European plastic value chain. Luxembourg: Publications Office of the European Union. Available at: https://data.europa.eu/doi/10.2760/6579757 (Accessed: 7 July 2026).

[126] De Laurentiis, V., Orza, V. and Listorti, G. (2026) Estimating packaging placed on the market at national level: packaging model updates version 2.0. Luxembourg: Publications Office of the European Union. Available at: https://data.europa.eu/doi/10.2760/4178900 (Accessed: 7 July 2026).

[127] EBB, "Statistical Report 2025/2026", European Biodiesel Board, 2026.

[128] SkyNRG and ICF (2026) *SAF Market Outlook 2026*.

[129] UOP LLC (2023) Honeywell UOP Ecofining Process: UOP's Solution for Renewable Feedstock Processing. Datasheet ref. UOP-Ecofining-Process-Datasheet-20230817, version 5.1, August 2023. Des Plaines, IL: UOP LLC, A Honeywell Company. Figures are volume percentages of oil feed. Available at: https://ess.honeywell.com/content/dam/ess/en/documents/document-lists/uop/events/india-energy-week-2025/hon-ess-uop-ecofining-process-datasheet.pdf (Accessed: 17 July 2026).

With a 65% naphtha to polymer conversion rate, at the lower end, if operators produce only the aviation fuel required for compliance and use remaining capacity to produce renewable diesel, polymer-equivalent output is estimated at approximately 0.59 million tonnes. At the upper end, if aviation-fuel capacity operates largely as designed, output could reach approximately 0.98 million tonnes. **This assessment uses 0.59million tonnes by 2030 as a conservative estimate of *potential* for the baseline**. The full calculation is provided in Appendix A.4.0.[130]

> This estimated range does not represent the volume *expected* to be sold into the plastics market. Under current market conditions, producers have limited incentive to separate and market bio-naphtha because established fuel mandates already provide a ready outlet for these streams. Instead, the range is intended to estimate the volume of bio-naphtha that *could* be made available from Europe's planned aviation-fuel build-out if a demand signal emerged from the plastics sector. As already discussed in Section 4.2, the technology needed to recover and utilise these streams at commercial scale is already available.

Three Scenarios

Three scenarios are modelled from the current EU production base of approximately 227 kt of in-scope polymers:

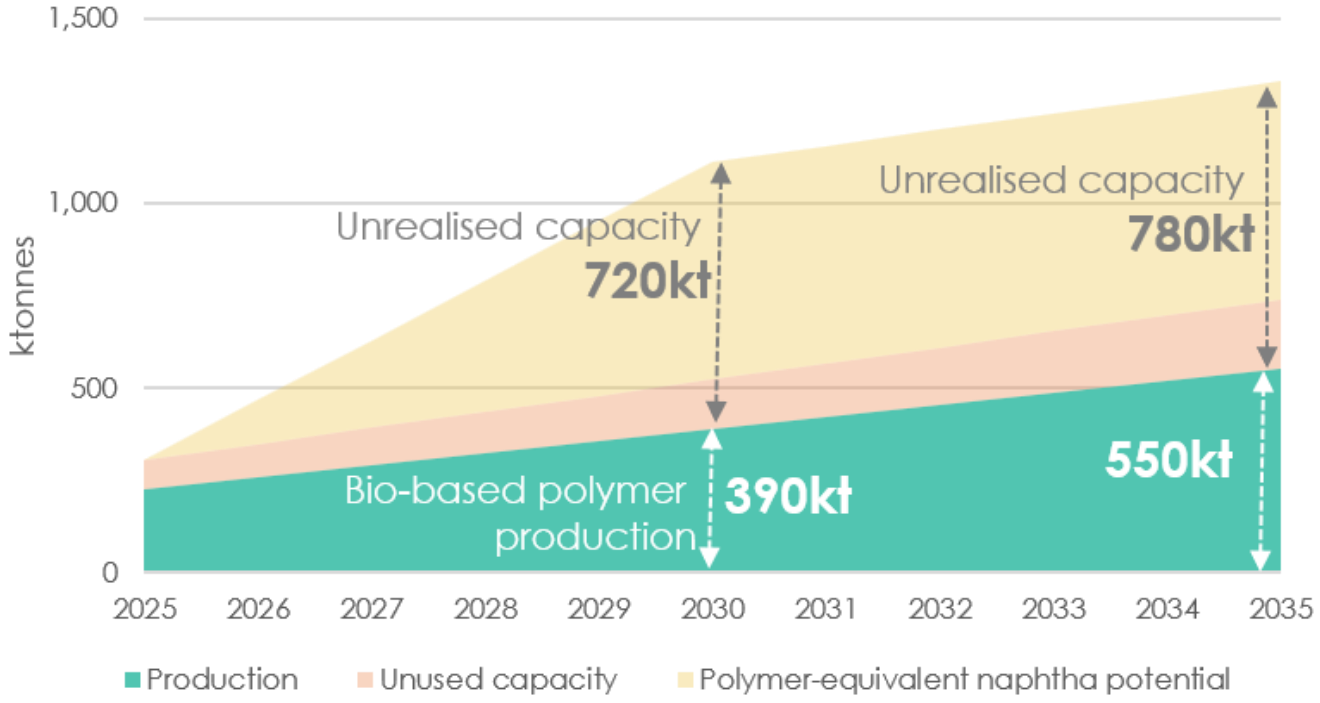
- Under the **low (observed trajectory)** scenario, no new facility reaches production and utilisation stays the same. A small amount of potential capacity may be available from biofuel coproduction.
- Under the **high (full pipeline)** scenario, all 630 kt of announced EU capacity reaches production and full utilisation with production reaching approximately 940 kt by 2035.
- The **medium (probability-weighted)** scenario is adopted as the baseline for this study. It applies probability weights to the facility pipeline based on project status: high-confidence projects (under construction or partly operational) at 100%, medium-confidence (announced, delayed) at 50%, and low-confidence (planning stage, concept engineering) at 25%. Under this scenario, EU production of in-scope bio-based polymers reaches approximately 390 kt by 2030 and 550 kt by 2035. Biofuel coproduction potential reaches 300 kt by 2035.

[130]Zech, K.M., Dietrich, S., Reichmuth, M., Weindorf, W. and Müller-Langer, F. (2018) 'Techno-economic assessment of a renewable bio-jet-fuel production using power-to-gas', Applied Energy, 231, pp. 997 to 1006. Table 6, p.1003. DOI: 10.1016/j.apenergy.2018.09.169.

Figure 4-5 shows the **medium (probability-weighted)** scenario. The bio-naphtha supply figures cited above represent incremental supply from new biorefinery capacity, shown as a separate layer.

Figure 4-5: EU 27+3 Bio-based Plastics Production and Capacity – Baseline Scenario

In the baseline scenario, EU bio-based polymer production is projected to reach approximately 390 kt by 2030, up from around 230 kt in 2024. A further 720 kt of potential supply exists through underutilised facility capacity and bio-naphtha co-production, but without a demand signal this potential is unlikely to be realised.



Global Baseline Trajectory

At the global level, individual facilities cannot be traced with the same precision. Global scenarios therefore use applied growth rates, presented alongside the track record evidence that the highest of these has not previously materialised. The global starting position for in-scope polymers is approximately 1,800 kt of production.

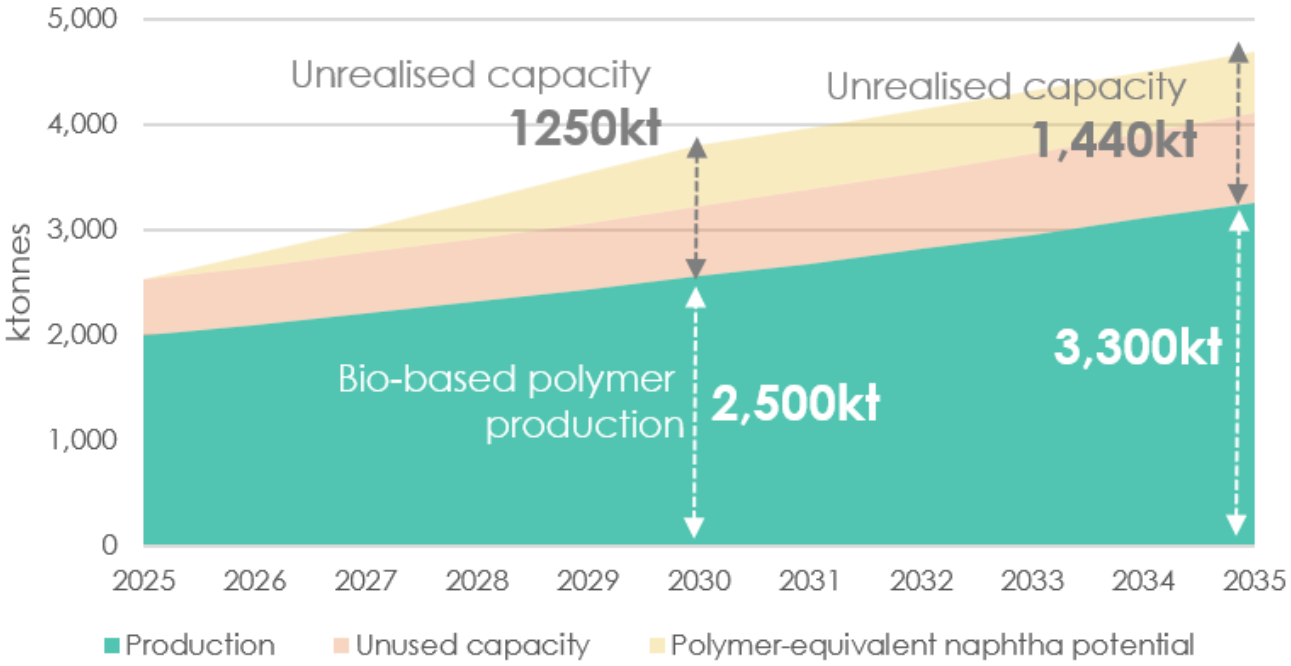
Three scenarios are modelled.

- The **low (observed trajectory)** scenario reflects the empirical record of near-zero net market share growth between 2019 and 2024 and the JRC's own assessment that bio-based plastics will remain below 1% of global capacity by 2030.[131] Production stays approximately flat at 2,000 kt through to 2035.
- The **high (industry aspiration)** scenario applies the nova headline capacity growth rate of 11% CAGR to the in-scope base, reaching approximately 5,700 kt by 2035.
- The **medium (5% CAGR)** scenario is adopted as the global baseline. It uses the lower end of the Wood study's own 2020–2025 projected capacity growth range. Under this scenario, global in-scope production reaches approximately 2,500 kt by 2030 and 3,300 kt by 2035 (Figure 4-6).

Figure 4-6: Global Bio-based Plastics Production and Capacity – Baseline Scenario

Globally, bio-based polymer production is projected to reach approximately 2,500 kt by 2030 and 3,300 kt by 2035. A further 1,250 kt of potential supply exists in 2030, rising to 1,440 kt by 2035, through underutilised capacity and EU bio-naphtha co-production. As with the EU trajectory, this potential is unlikely to be realised without a demand signal.

[131] JRC (2026) "Support for bio-based feedstock in plastic packaging", Policy Brief, March 2026.



Interpreting the Baseline

The gap between the industry's projections and the observed trajectory is itself the central finding of the baseline. **The bio-based plastics sector has consistently projected growth that has not materialised because the projections aggregate supply-side intentions without accounting for the demand-side barriers that prevent those intentions from translating into actual production.**

Near-term growth, where it occurs, is more likely to come from filling existing idle capacity than from new capital investment. The 58% utilisation rate for discretionary-capacity polymers represents a large stock of built but underused assets. Closing the utilisation gap from 58% to 85% would increase production substantially from the existing base without requiring any new facility investment. This is the cheapest and fastest form of growth available, and it is entirely demand-constrained.

Europe's position within the global picture is weakening under business-as-usual conditions. Europe holds approximately 14% of global in-scope capacity,[132] but the highest-growth polymers (PHA, PLA, PP) are concentrated in Asia and North America, where feedstock is cheaper, supply chains are more established, and binding fuel mandates create co-product economics that improve the business case. Without demand-side intervention, Europe's share of global bio-based polymer capacity is likely to decline.

4.5 Environmental Performance of Bio-based Plastics

Bio-based plastics offer a potential greenhouse gas reduction compared with fossil alternatives, but the performances of both are highly variable and depend on multiple factors. The magnitude of variability for each is comparable. Substitution alone does not achieve net-zero emissions. The potential benefit of bio-based plastics comes with a potential trade-off: it shifts environmental burdens rather than removing them, mainly by increasing the potential for acidification and eutrophication from fertiliser use in feedstock cultivation. (Though, the non-GHG burdens of the fossil-based plastics are not discussed here, they also exist as part of the trade-off.)

Current figures are a performance floor, not a ceiling: industrial scaling, better plant utilisation and cleaner production energy could improve them significantly. But under the current no-policy baseline, stagnant demand means these gains are unlikely to be realised.

This section establishes the environmental baseline: what is known, as of mid-2026, about how bio-based plastics perform relative to the fossil-based materials they would displace, and what that performance means for the counterfactual against which the policy options are assessed. It draws on the independent peer-reviewed literature in preference to industry-curated summaries. The evidence is reviewed and converted into the baseline position and the parameters carried into the Phase 2 impact assessment.

This analysis addresses the impacts of **production and feedstock**. It treats **bio-based (a property of feedstock origin) as distinct from biodegradable or compostable (properties of end-of-life behaviour):** the two are independent, and degradability sits on a separate policy axis (bio-waste and the Single-Use Plastics Directive) outside this study's frame.

The baseline summary below provides a snapshot of the full range of results available demonstrating that there are several options for GHG reduction. Specific and relevant figures are taken forward for the more detailed impact assessment.

Summary Baseline Environmental Performance – GHG differences per mass unit

Factor/ Metric	2025	2030	2035	Basis
Bio-PE vs fossil	-142% to -43%			No indication of any changes to production or scale that would show further GHG changes for bio-based (other than generalised effects of decarbonisation). Scale is missing to help provide further efficiencies. Range is best performing bio (incl. biogenic uptake) versus worst performing fossil (non-EU) and best performing fossil (EU) versus worst performing bio (excl. biogenic uptake). Both bio- and fossil-based polymers demonstrate comparable magnitudes of variability. The non-GHG burdens of the fossil comparator sit outside the categories compared here.
Bio-PP vs fossil	-125% to -73%			
Bio-PET vs fossil	+190% to +3%			
PEF vs Fossil PET	-447% to -43%			
PLA vs Fossil PET	-302% to -46%			

Climate Performance

Bio-based plastics generally reduce greenhouse gas (GHG) emissions relative to their fossil-based counterparts, but the scale of potential benefit is variable. The variability stems from a range of factors, such as agricultural yields, fertiliser use, energy sources, and more. The most comprehensive independent synthesis, a meta-analysis of 98 emerging bio-based materials across 130 prospective LCA studies harmonised to cradle-to-grave, found a mean GHG footprint 45% lower than fossil counterparts. The spread between products was wide: although 80 of the 98 improved on their fossil comparator, none reached net-zero emissions.[133]

A second review is more cautious. Screening 25 studies against the EU Product Environmental Footprint (PEF) method, it found variation between studies of the same polymer running to 200–400%, so no polymer type could be declared consistently best.[134] It also traced some reported net-negative results to how the carbon absorbed during biomass growth is credited, a question of accounting, addressed next, rather than a flaw in the underlying science.

For packaging in particular, end-of-life management is a notable factor in overall performance. The analytical demonstrator, described within Section 6 '*Climate Benefits of Switch from Fossil to Bio-based*', provides further insight into the potential climate benefits of switching to bio-based plastic packaging for different polymer types, based on the end-of-life management.

Biogenic Carbon Accounting

The accounting treatment of biogenic carbon is the basis most life-cycle standards use, and the underlying physical process it describes is not in dispute. Carbon dioxide absorbed as biomass grows is recorded as an uptake, and carbon released back to the atmosphere is recorded as an emission, each counted at the point it happens.[135]

Figure 4-7: −1/+1 vs 0/0 accounting logic, showing the running carbon balance at growth, gate and end of life



PAS 2050, ISO 14067 and the GHG Protocol Product Standard all recognise biogenic carbon uptake and subsequent release as physical life-cycle flows, a −1/+1 accounting logic, but they are not equally permissive on storage. PAS 2050 goes furthest: carbon still stored beyond its 100-year assessment window

[133] Zuiderveen, E.A.R., Kuipers, K.J.J., Caldeira, C., Hanssen, S.V., van der Hulst, M.K., de Jonge, M.M.J., Vlysidis, A., van Zelm, R., Sala, S. and Huijbregts, M.A.J. (2023) 'The potential of emerging bio-based products to reduce environmental impacts', Nature Communications, 14, 8521, pp. 1–4. doi:10.1038/s41467-023-43797-9.

[134] Walker, S. and Rothman, R. (2020) 'Life cycle assessment of bio-based and fossil-based plastic: a review', Journal of Cleaner Production, 261, 121158. doi:10.1016/j.jclepro.2020.121158.

[135] European Commission (2022) Biobased plastic: sustainable sourcing and content. Final report (Wood Environment & Infrastructure Solutions / Trinomics), TEC6513EU, p. 37. doi:10.2779/668096.

is treated as if it were never released. ISO 14067 and the GHG Protocol take a more cautious line, requiring storage to be disclosed rather than credited into the headline result.[136]

This distinction matters mainly for long-life applications, principally construction and to a lesser extent automotive, where products plausibly hold carbon for decades; it has little bearing on the packaging-dominated scope of this baseline, where end of life typically arrives within a few years.

What unites the −1/+1 standards is not disagreement about the underlying principle, but concern about how it can be implemented in practice. Tracking biogenic carbon through the system is conceptually straightforward, and each standard attempts to do so in some form. The difficulty is that greenhouse-gas accounting does not track physical reality directly. Instead, it relies on inventories, emissions factors and background datasets that simplify reality into a form that can be compiled and audited. Transparency in data tracking and reporting methods is therefore important.

The challenge lies in the available data rather than the underlying science. Fossil carbon can usually be represented with generic emissions factors because its origin makes little difference to the accounting outcome. Biogenic carbon is different. Determining the climate impact of an activity such as incineration requires information about how much of the material being burned is biogenic, and most background datasets do not record that information at the level of detail a strict −1/+1 approach would require.

The resulting asymmetry is therefore a data problem, not a physics problem. It is this limitation, rather than disagreement over whether biogenic carbon uptake should be recognised, that has led standards to favour disclosure and transparency over fully netting biogenic uptake and release.[137]

The JRC Plastics LCA method reaches a similar conclusion. It requires biogenic carbon flows to be tracked throughout the system and the biogenic carbon content of a polymer to be reported at the factory gate, but it keeps that information separate from the scored climate result for the same data-quality reasons described above.[138]

This remains an active area of methodological development. As recently as June 2025, the Commission's Technical Advisory Board was discussing a hybrid "-1/+1 with carbon transfer" approach for a future Environmental Footprint update. This would move closer to the EN 15804 approach than a strict 0/0 treatment. However, member views remained divided and important questions, including the treatment of storage credits and landfill emissions, had not been resolved.[139] The discussion is therefore best understood as an indication of where thinking may be moving rather than as a statement of current methodology.

For most of the packaging and other short life applications covered by this assessment, the choice between accounting conventions has little effect on overall results. EN 16760 finds that where biogenic carbon is fully released at end of life, both approaches produce the same whole-life-cycle outcome; the main difference is how emissions and credits are distributed across life-cycle stages.[140] The distinction becomes more important for durable products and for material retained within recycling systems, where the Commission's own sourcing study concludes that zero-rated approaches can understate the benefits of bio-based materials.[141]

Importantly, this methodological debate does not need to be resolved before a feedstock-use target can be implemented. The JRC method already treats carbon accounting and feedstock verification as

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136 ibid

137 Nessi, S., Sinkko, T., Bulgheroni, C., Garcia-Gutierrez, P., Giuntoli, J., Konti, A., Sanye-Mengual, E., Tonini, D., Pant, R., Marelli, L. and Ardente, F. (2021) Life Cycle Assessment (LCA) of alternative feedstocks for plastics production. Part 1: the Plastics LCA method. EUR 30725 EN. Luxembourg: Publications Office of the European Union,

138 ibid

139 European Commission, Joint Research Centre (2025) Biogenic Carbon Accounting in EF Methods, EF Technical Advisory Board meeting, 25 June 2025. Directional only: reflects TAB discussion at the time and had not been adopted as of that meeting.

140 European Commission (2022) Biobased plastic: sustainable sourcing and content. Final report (Wood Environment & Infrastructure Solutions / Trinomics), TEC6513EU, p. 37. doi:10.2779/668096.

141 ibid

separate questions. Biogenic carbon content at the factory gate is reported as a disclosure requirement regardless of how climate impacts are subsequently characterised.[142]

A PPWR Article 8 target would follow the same logic. Compliance could be based on a verified measure of bio-based feedstock entering the value chain, expressed as a mass or carbon share at the factory gate, rather than on a product-specific greenhouse-gas result. This is broadly analogous to the approach used under RED III, where compliance is demonstrated against defined methodologies and sustainability criteria rather than through product-specific end-of-life assessments.

The Wider Impact Profile and the Central Trade-off

Climate is not the whole picture. The same meta-analysis finds non-renewable energy use 39% lower for bio-based products, but the eutrophication potential is 369% higher. There is no statistically significant difference on acidification, ozone depletion or photochemical ozone formation.[143] The dominant driver of the potential eutrophication penalty is synthetic fertiliser use in feedstock cultivation, which means the potential effect is feedstock-specific rather than a fixed cost of switching to bio-based: it scales with how fertiliser-intensive the feedstock is. Studies using waste or residue streams, instead of purpose-grown crops, report substantially lower impacts in this category.[144]

A second, PEF-screened review reaches the same qualitative conclusion. Bio-based polymers are generally worse on ecotoxicity, acidification and eutrophication, with bio-PET the worst performer overall.[145] The Commission's sourcing study agrees, while adding a mitigating finding: the biomass-production phase is typically under 10% of the cradle-to-grave impact (bio-PET excepted).[146]

The baseline implication is burden-shifting: a feedstock switch trades one set of impacts for another. A target framed solely on climate or fossil substitution risks moving burdens into the water and nutrient categories, unless feedstock sustainability is addressed alongside it.

Land Use and Feedstock

At today's volumes, bio-based feedstock takes a very small share of farmland: around 0.02% of global agricultural land, and under 0.04% of global biomass demand.[147] These are present-scale figures. They do not answer the question a target raises, which is how much additional land a scale-up would need.

How much feedstock a polymer needs is set by its chemistry. Making a polyolefin discards the oxygen in the biomass and loses carbon as carbon dioxide, so around 4 kg of sugar is needed per kg of bio-PE against about 1.6 kg per kg of PLA.[148] Polyesters are therefore more feedstock-efficient per kilogram than polyolefins. This is a property of the molecule, and it holds whichever polymer is used and whether they are designated drop-in or dedicated.

Land-use change is consistently identified as the single largest uncertainty in bio-based GHG footprints. Only 13% of the studies in the meta-analysis included land-use-change emissions, and the absence of a

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[142] Nessi, S., Sinkko, T., Bulgheroni, C., Garcia-Gutierrez, P., Giuntoli, J., Konti, A., Sanye-Mengual, E., Tonini, D., Pant, R., Marelli, L. and Ardente, F. (2021) Life Cycle Assessment (LCA) of alternative feedstocks for plastics production. Part 1: the Plastics LCA method. EUR 30725 EN. Luxembourg: Publications Office of the European Union, p. 130.

[143] Zuiderveen, E.A.R., Kuipers, K.J.J., Caldeira, C., Hanssen, S.V., van der Hulst, M.K., de Jonge, M.M.J., Vlysidis, A., van Zelm, R., Sala, S. and Huijbregts, M.A.J. (2023) 'The potential of emerging bio-based products to reduce environmental impacts', Nature Communications, 14, 8521, pp. 1–4. doi:10.1038/s41467-023-43797-9.

[144] European Commission (2022) Biobased plastic: sustainable sourcing and content. Final report (Wood Environment & Infrastructure Solutions / Trinomics), TEC6513EU, p. 16. doi:10.2779/668096.

[145] Walker, S. and Rothman, R. (2020) 'Life cycle assessment of bio-based and fossil-based plastic: a review', Journal of Cleaner Production, 261, 121158. doi:10.1016/j.jclepro.2020.121158.

[146] European Commission (2022) Biobased plastic: sustainable sourcing and content. Final report (Wood Environment & Infrastructure Solutions / Trinomics), TEC6513EU, p. 16. doi:10.2779/668096.

[147] European Commission (2022) *Biobased plastic: sustainable sourcing and content. Final report* (Wood Environment & Infrastructure Solutions / Trinomics), TEC6513EU, p. 16. doi:10.2779/668096.

[148] Institut für Biokunststoffe und Bioverbundwerkstoffe (IfBB) (2025) *Biopolymers: Facts and Statistics 2025*. Hannover: Hochschule Hannover.

harmonised method makes the effect hard to isolate.[149] Sugar cane and sugar beet are the lowest-risk feedstocks on both GHG and ILUC grounds; edible-oil routes carry higher ILUC risk.[150]

Although policy does not currently address this uncertainty or provide a harmonised measurement method, there are existing safeguards – such as RED III and EU Regulation on Deforestation-free Products[151] – which create constraints on a subset of first-generation feedstocks. These instruments aim to promote emissions reduction, whilst setting sustainability criteria and protections against deforestation.

Measurement and Comparability

The main limitation of the current evidence base is not a lack of studies, but a lack of methodological comparability between them. No published study fully implements the EU Product Environmental Footprint (PEF) method. Reported results for the same polymer and study scope can differ by 200–400%, and in some cases by more than an order of magnitude.[152] A review of 44 studies found that the average assessment covered only eight environmental impact categories, that only one study applied the full PEF framework, and that additives were included in just seven studies.[153] The JRC Plastics LCA method was developed to address these shortcomings, but its application is still evolving.[154]

The greatest source of inconsistency is how studies define the comparison itself. Many assessments use a simple per-kilogram functional unit, which can disadvantage dedicated polymers with no direct fossil equivalent. For example, PEF can achieve the same packaging function as PET using less material, meaning that a kilogram-for-kilogram comparison does not fully capture differences in product performance.[155] This makes pure material-level comparisons for anything other than drop-ins fraught with uncertainty.

The fossil benchmark is also changing as underlying datasets are updated. Revisions to successive ecoinvent releases have increased the reported greenhouse-gas footprint of several fossil feedstocks, with naphtha showing one of the largest changes following updates to methane-emissions data.[156] As a result, more recent assessments tend to show a larger gap between fossil and bio-based materials than older studies.

These comparisons should be interpreted with some caution. Many bio-based assessments still rely on earlier database versions, while fossil comparators increasingly use more recent datasets. Comparing results derived from different database generations can therefore overstate the apparent advantage of bio-based materials. Consistent application of the same background data remains an important condition for robust comparison.

The Environmental Baseline: What Is Carried Forward

Converting the review into a baseline position: bio-based plastics on the EU market today deliver a real but partial and variable GHG benefit, with no defined path to net-zero on a substitution basis, a potential

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[149] Zuiderveen, E.A.R., Kuipers, K.J.J., Caldeira, C., Hanssen, S.V., van der Hulst, M.K., de Jonge, M.M.J., Vlysidis, A., van Zelm, R., Sala, S. and Huijbregts, M.A.J. (2023) 'The potential of emerging bio-based products to reduce environmental impacts', Nature Communications, 14, 8521, pp. 1–4. doi:10.1038/s41467-023-43797-9.

[150] European Commission (2022) Biobased plastic: sustainable sourcing and content. Final report (Wood Environment & Infrastructure Solutions / Trinomics), TEC6513EU, p. 16. doi:10.2779/668096.

[151] European Commission (2023) Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation.

[152] Walker, S. and Rothman, R. (2020) 'Life cycle assessment of bio-based and fossil-based plastic: a review', Journal of Cleaner Production, 261, 121158. doi:10.1016/j.jclepro.2020.121158.

[153] Bishop, G., Styles, D. and Lens, P.N.L. (2021) 'Environmental performance comparison of bioplastics and petrochemical plastics: a review of life cycle assessment (LCA) methodological decisions', Resources, Conservation & Recycling, 168, 105451. doi:10.1016/j.resconrec.2021.105451.

[154] Nessi, S., Sinkko, T., Bulgheroni, C., Garcia-Gutierrez, P., Giuntoli, J., Konti, A., Sanye-Mengual, E., Tonini, D., Pant, R., Marelli, L. and Ardente, F. (2021) Life Cycle Assessment (LCA) of alternative feedstocks for plastics production. Part 1: the Plastics LCA method. EUR 30725 EN. Luxembourg: Publications Office of the European Union.

[155] Carus, M. et al. (2026) Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/4. Hürth: nova-Institute,

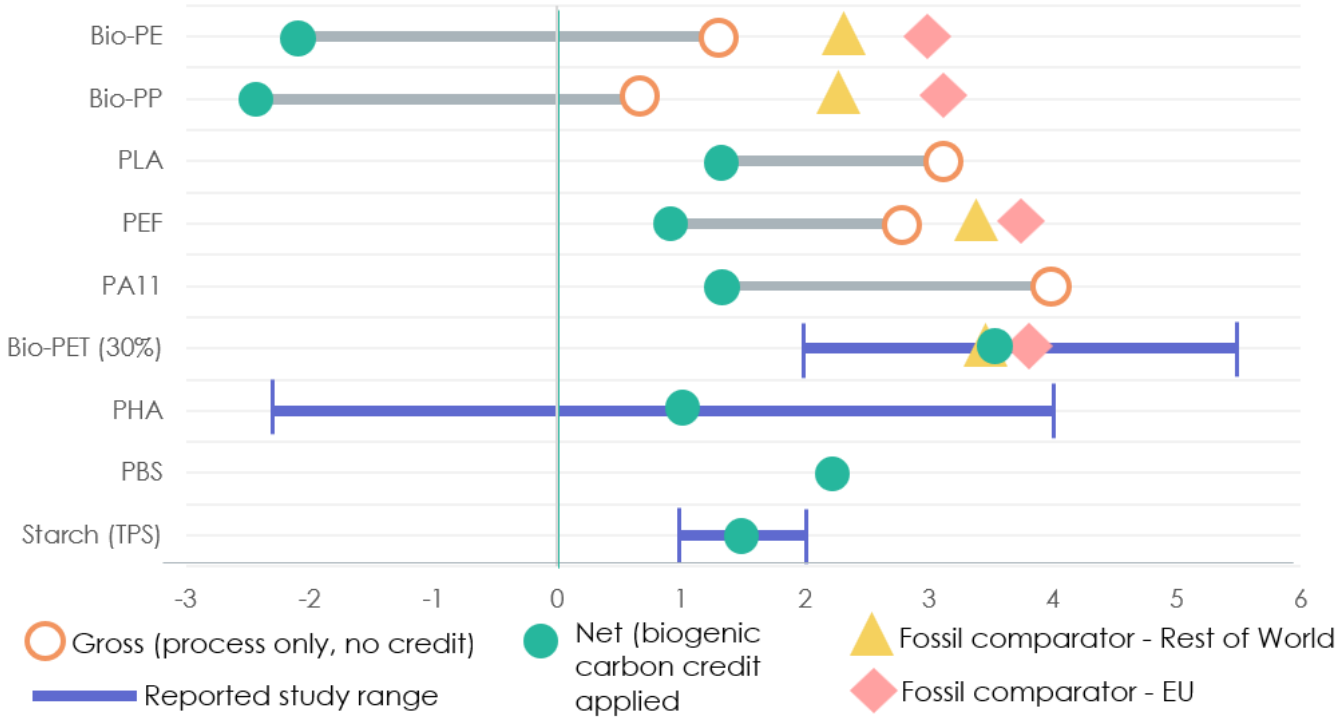
[156] ibid

eutrophication trade-off, and marginal land-impact at current scale. The impact assessment in Section 4 measures improvement against this counterfactual, using the per-polymer GHG assumptions set out below.

The clearest single statement we can make about the climate performance of bio-based plastics is a relative one. On a harmonised cradle-to-grave basis, the available meta-analysis places their greenhouse gas emissions roughly 45% below the fossil materials they replace,[157] a reduction that is real but partial and does not reach net zero on a substitution basis. The per-polymer cradle-to-gate figures behind that headline are shown in Figure 4-8. They should be read as indicative rather than a strict ranking, since they come from studies using different methods and boundaries and are not directly comparable line to line.[158] Full data sources are in the Appendix.

Figure 4-8: Cradle to gate GHG of Bio-based Plastics (kg CO2e per kg polymer)

Cradle-to-gate greenhouse gas intensity of bio-based plastics, on both accounting conventions. Filled markers show the net figure with the biogenic carbon credit applied; hollow markers show the gross process emissions without the credit; blue lines show the reported range across studies. Eight polymers (APC, casein, cellulose acetate, epoxy resins, EPDM, PBAT, PTT, PUR) are omitted because no land use advantage data could be identified.



What happens at end of life determines how much of this benefit is actually realised, and it plays out differently for the two materials. A bio-based polymer draws carbon dioxide out of the atmosphere as the feedstock plant grows, and gives some of it back when the material eventually breaks down or is burned. A fossil-based polymer works differently: making it releases carbon that had been locked underground for millions of years, carbon that was not part of the atmosphere's normal cycle until it was extracted.

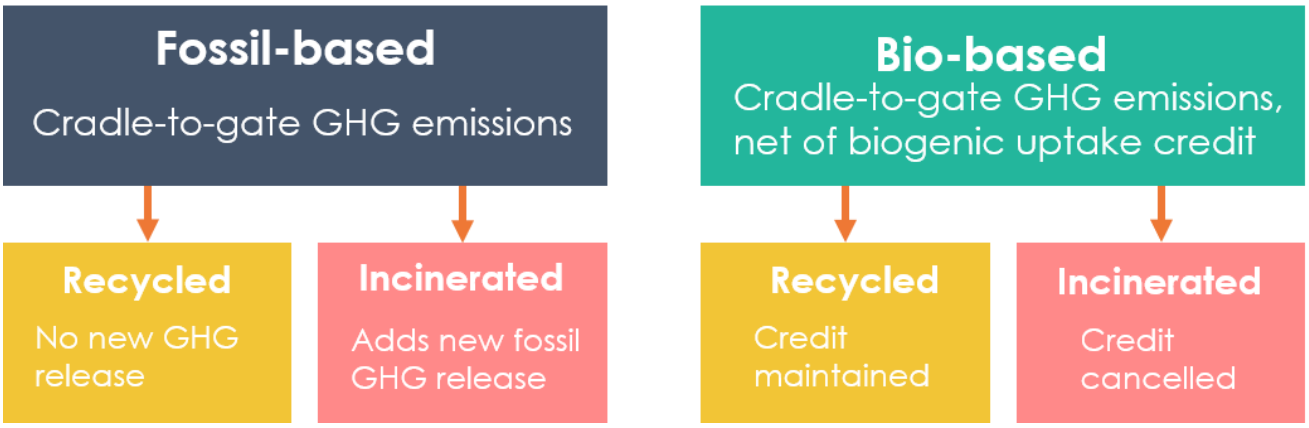
If both materials are recycled, neither release has happened yet, and a straightforward factory-gate comparison is a fair one. If both are incinerated instead, the fossil route adds genuinely new carbon to

[157] Zuiderveen, E.A.R. et al. (2023) 'The potential of emerging bio-based products to reduce environmental impacts', Nature Communications, 14, 8521.

[158] The per-polymer figures combine values from Carus, M. et al. (2026) Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/4. nova-Institute, April 2026, Table 6, p.35, with Walker, S. and Rothman, R. (2020) 'Life cycle assessment of bio-based and fossil-based plastic: a review', Journal of Cleaner Production, 261, 121158, which reports variation of 200 to 400% between studies of the same polymer.

the atmosphere, while the bio-based route only returns carbon that was drawn down a few years earlier. Because a drop-in polymer is chemically identical to its fossil counterpart from the gate onward, this asymmetry works entirely in bio-based's favour: the factory-gate comparison understates the advantage by the polymer's full biogenic carbon content, regardless of lifetime, and the gap widens further on a full cradle-to-grave basis.

Figure 4-9: The basics of carbon flows for fossil and bio-based plastics, recycled vs incinerated end-of-life routes



At the level of the whole market, these intensities translate into modest absolute quantities, and the two components behave differently. The priority-sector bio-based market is around 2 Mt globally as of mid-2026.[159] Because biogenic uptake can be calculated from first principles for every polymer, the carbon embedded in that market can be stated precisely, at approximately 2.8 $MtCO_2$.[160] Gross process emissions cannot be stated as precisely, because the underlying studies cover only part of the market: robust data covers roughly 80% of packaging-relevant volume but only around 40% of volume across all applications, and process emissions for that group are in the order of 2 million tonnes of CO_2e.[161] Both figures are small against a global plastics market of roughly 400 Mt, which produces around 1 billion tonnes of CO_2e annually up to the polymer granulate stage. That modest scale is itself a feature of the baseline: it reflects how early and sub-scale the bio-based market still is.

The Trajectory of Current Performance

The GHG figures above describe bio-based plastics as they are produced today, and that production base is small and early in its commercial life. A cradle-to-gate footprint has two parts that behave very differently. Process emissions come from converting feedstock into polymer; biogenic carbon comes from the atmosphere and is embedded in the material. Biogenic uptake can be calculated from first principles for every polymer, since it is fixed by the polymer's carbon content and the share of that carbon which is biological in origin[162] (measured by mass, or by carbon content for partly bio-based polymers such as bio-PET). Process emissions cannot be calculated this way: they exist only where individual life-cycle studies have measured them, and many polymers simply have not been studied.

That gap in coverage matters. Robust process-emission data exists for roughly 80% of packaging-relevant production, so the evidence is strongest for packaging, where this study's quantitative analysis is concentrated. It is weakest for the high-tonnage polymers dominating the other priority sectors: epoxy resins and polyurethanes in construction and automotive, and cellulose acetate and PTT in textiles. No

[159] Based on Eunomia analysis of Table 5 global production for 2024 (Carus et al. 2026, p.25), thermoplastic polymers only, with cellulose acetate reduced to its non-tow fraction (approximately 209 kt).

[160] Eunomia calculation. Embedded biogenic carbon is the in-scope production volume multiplied by the biogenic uptake derived from first principles for each polymer.

[161] Eunomia analysis, weighted by production volume.

[162] The biogenic uptake is derived as the carbon mass fraction of the polymer repeat unit multiplied by the biogenic carbon fraction and by 44.01/12.011, and validated against the published values in Carus, M. et al. (2026).

robust cradle-to-gate data exists for these polymers in the available literature. That absence is itself informative: it shows how little these polymers have been assessed relative to packaging polymers.

Current environmental performance should not necessarily be treated as representative of long-term outcomes. The bio-based polymer industry remains relatively young and operates at a fraction of the scale of the petrochemical industry with which it competes. The literature consistently suggests that future improvements are more likely to come from scale, learning and incremental optimisation than from technological breakthroughs. Most major bio-based polymers are already technically mature; the remaining challenge is large-scale commercial deployment rather than further scientific development.[163]

Academic reviews reach a similar conclusion, identifying a maturity gap between the long-established fossil plastics industry and the younger bio-based sector.[164] Meta-analyses that model commercial-scale production rather than current production volumes also tend to report larger environmental benefits, consistent with performance improving as industries scale and mature.[165]

Two distinct mechanisms drive this improvement, and only one depends directly on growth in bio-based plastics demand. ***The first is scale***. As production volumes increase, fermentation yields, conversion efficiency and plant utilisation tend to improve. These gains depend on higher production volumes and the investment that accompanies them. Capacity utilisation for many dedicated bio-based polymers remains relatively low, at around 58% in mid-2026, meaning existing facilities are operating well below their installed capacity.[166] Increasing utilisation of existing plants would improve environmental performance per kilogram of output before any new production infrastructure is required.

The second mechanism is the decarbonisation of energy systems. Bio-based polymer production still relies on fossil energy for process heat and power in many cases. As electricity systems and industrial energy supplies decarbonise, the greenhouse-gas footprint of production can fall further, regardless of whether bio-based polymer demand increases. The environmental performance of bio-based plastics therefore depends both on the development of the industry itself and on wider progress in energy-system decarbonisation.

Any improvement trajectory should be understood primarily as a climate result, not as a uniform improvement across all environmental indicators. As discussed above, some impacts associated with biomass production, such as eutrophication potential, may increase as feedstock cultivation expands—many of these are also localised and have potential for mitigation. An improvement in greenhouse-gas performance therefore needs to be considered alongside possible trade-offs elsewhere in the environmental profile.

This distinction matters for the baseline scenario. The improvements associated with scale are unlikely to be realised automatically. The same conditions that have constrained investment and limited market growth also constrain the gains in efficiency and utilisation that scaling would bring. Recent project deferrals and relocations illustrate this dynamic.

The no-policy counterfactual is therefore not simply today's industry continuing unchanged; it is an industry that remains below the scale at which many of its anticipated efficiency gains would occur. The performance reported in this assessment reflects what the current industry can achieve at its present level of deployment. Further improvements remain possible, but depend on the market conditions and investment needed to support growth.

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[163] Carus, M. et al. (2026) Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/4. Hürth: nova-Institute, p. 31.

[164] Walker, S. and Rothman, R. (2020) 'Life cycle assessment of bio-based and fossil-based plastic: a review', Journal of Cleaner Production, 261, 121158. doi:10.1016/j.jclepro.2020.121158.

[165] Zuiderveen, E.A.R. et al. (2023) 'The potential of emerging bio-based products to reduce environmental impacts', Nature Communications, 14, 8521. The meta-analysis is built on prospective life-cycle studies, which model production at commercial scale.

[166] Carus, M. et al. (2026) Support for bio-based feedstock in plastic packaging analysis under the Packaging and Packaging Waste Regulation (EU) 2025/4. Hürth: nova-Institute, p. 51, reporting 1.44 Mt actual production against 2.47 Mt installed capacity for dedicated bio-based polymers.

5.0 Developing a Policy Option

This section sets out the policy option that the study proposes in response to the problem defined in Section 3 and the baseline trajectory established in Section 4. It is organised in two parts. Section 5.1 states the objectives the option is designed to achieve, mapped against the seven structural drivers of market failure and Section 5.2 presents the policy option architecture.

5.1 Objectives: What the Option Must Achieve

The policy option pursues a single overarching aim: to correct the structural market failure that has held bio-based plastics at approximately 1% of EU plastic production for a decade, and to do so through demand-side instruments that create a predictable, investable market signal. This aim rests on the four intersecting objectives set out in Section 1:

- climate (substituting fossil carbon with biogenic renewable carbon),
- strategic autonomy (reducing dependence on imported fossil feedstocks),
- industrial competitiveness (leveraging the EU's comparative advantage in biomanufacturing), and
- renewable feedstock substitution (transitioning the resource base of the materials system, a goal analytically distinct from emissions reduction and the basis for parallel rather than pooled targets).

Translated into operational terms, the option is designed to deliver the specific outcomes set out below, each of which addresses one or more of the structural drivers identified in Section 3.0.

Table 5-1: Operational objectives mapped to structural drivers

	Operational objective	How the option delivers it	Drivers addressed
A	**Create mandatory, investable demand for bio-based feedstock**	Binding feedstock-use targets and procurement requirements that override the structural fossil cost advantage and give investors a demand signal to write into a business case	1, 2, 4
B	**Resolve the definitional and verification gap**	A harmonised EU definition of sustainably sourced bio-based feedstock and a single mass balance chain-of-custody standard, as a prerequisite for every other instrument	5, 6
C	**Provide market access for dedicated polymers**	Support package around the PPWR Article 6(10) derogation, EPR recognition and feedstock-use credit	4, 7
D	**Keep bio-based and recycled routes complementary**	Separate, non-interchangeable targets and a coordinated certification approach system, so bio-based demand is not crowded out by recycled content compliance	7
E	**Avoid penalising bio-based for the bioenergy distortion**	Bio-based-specific instruments (not generic non-fossil targets) that the bioenergy mandate asymmetry uniquely requires	2
F	**Sustain and grow EU-based processing capacity for bio-based plastics**	Demand-pull instruments create an investable market for bio-based polymers processed in the EU, sustaining the cracker and polymerisation infrastructure that underpins both drop-in and dedicated production.	3,4

5.2 Designing a Target: Feedstock Use, Not Bio-based Content

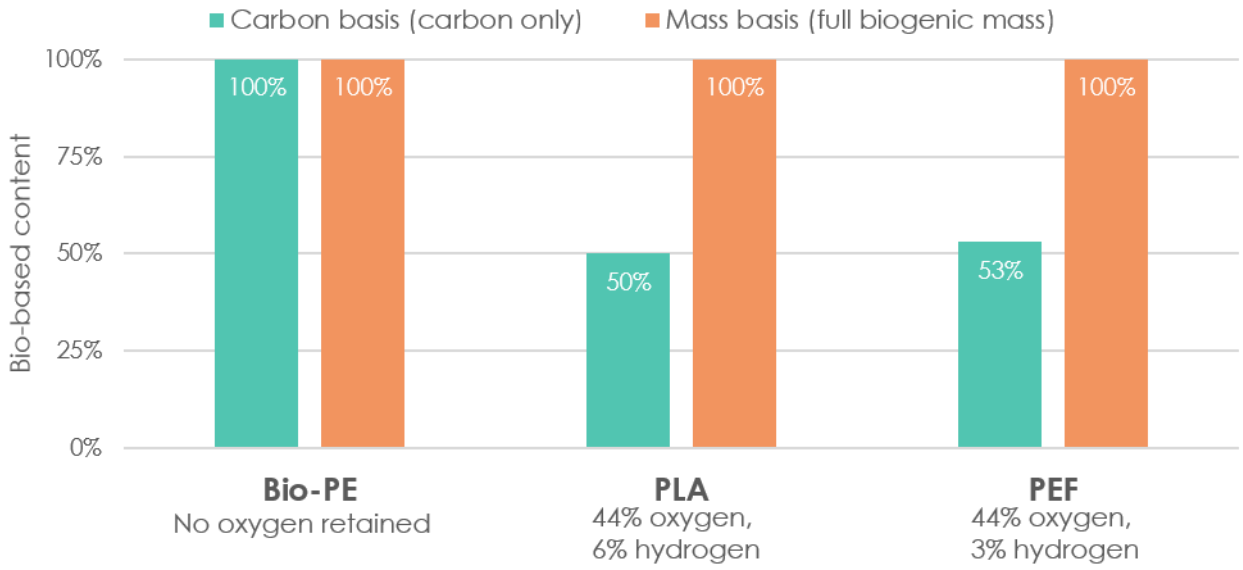
The instruments set out below share a common design choice that shapes how each is measured and enforced: they target the use of **bio-based feedstock rather than the bio-based content** of the finished product. The distinction is analytical rather than presentational, and it has direct consequences for which polymers a target rewards, how compliance is verified, and where in the value chain the obligation should sit.

Why Feedstock Use, Not Bio-based Content

Bio-based content can be expressed on two different bases that give materially different figures for the same material. A carbon basis measures the share of the carbon in the polymer that is of recent biological origin, determined by radiocarbon analysis under EN 16640 or ASTM D6866.[167] A total-content basis measures the share of the whole material that is bio-based, combining radiocarbon and elemental analysis under EN 16785-1.[168] For pure hydrocarbon polymers, such as polyethylene and polypropylene, the two bases converge, because the material is almost entirely carbon. For oxygen-rich polymers such as PET and PEF they diverge, because the oxygen retained from the feedstock is counted on a mass basis but not on a carbon basis (see Figure 5-1).

A content target defined without specifying its basis would therefore embed an ambiguity, and a content target defined on a carbon basis would systematically understate the bio-based contribution of exactly the oxygen-retaining dedicated polymers, PEF and PLA, that the policy is also intended to encourage. **A feedstock-use target avoids this: expressed as the quantity of bio-based carbon entering the value chain, it is neutral between polymer chemistries, and it maps directly onto the operative language of PPWR Article 8(2)(b), which empowers the Commission to set targets to increase the use of bio-based feedstock rather than the bio-based content of packaging.** The defined language for packaging targets can later be used as a basis for measures across the automotive, construction, and textiles sectors.

Figure 5-1: Example Carbon Content of Bio-based Polymers



[167] European Committee for Standardization (2017) EN 16640:2017 Bio-based products: bio-based carbon content. Determination of the bio-based carbon content using the radiocarbon method. Brussels: CEN; ASTM International (2022) ASTM D6866-22 Standard test methods for determining the biobased content of solid, liquid, and gaseous samples using radiocarbon analysis. West Conshohocken, PA: ASTM International.

[168] European Committee for Standardization (2015) EN 16785-1:2015 Bio-based products: bio-based content. Part 1: Determination of the bio-based content using the radiocarbon analysis and elemental analysis. Brussels: CEN.

Verifying a Feedstock-use Target: Mass Balance and Chain-of-custody

A feedstock-use target is only as credible as the chain-of-custody model that verifies it. Because a drop-in bio-based molecule is chemically identical to its fossil equivalent, the two cannot be distinguished in a mixed process stream, and physical segregation from feedstock to product is rarely practical at commercial scale. Mass balance is the pragmatic alternative: bio-based input is tracked through the production system, and an equivalent quantity of output is attributed as bio-based, under a certified bookkeeping scheme.

This dependence on mass balance is at its sharpest for the route that carries much of the near-term drop-in supply. A significant share of the incremental bio-based feedstock identified in the supply analysis is bio-naphtha and other renewable hydrocarbons, produced as co-products of HVO and HEFA biorefineries. These renewable hydrocarbons enter shared steam crackers as a small fraction commingled with fossil naphtha and are then diluted across the entire cracker output. Physical segregation through the cracker is not possible, so the route only becomes usable if that diluted bio-based input can be attributed to defined product volumes rather than spread indistinguishably across all products. **A recognised mass-balance method is therefore a prerequisite for the biorefinery route rather than an optional refinement: without an agreed way to allocate the bio-naphtha co-product stream to specific outputs, that feedstock cannot translate into creditable bio-based polymer, and a material part of the realistic near-term supply would fall outside any feedstock-use target.**

Not every mass-balance convention is acceptable for a materials target. **The study's position is that mass balance with a chemical-connectivity guardrail is the only approach likely to command agreement across the value chain. Bio-based attribution must not exceed the bio-based carbon that physically enters it. The free-attribution conventions used in some fuel accounting, which allow a bio-based credit to be assigned to outputs with no physical connection to the bio-based input, are not appropriate here, as the policy goal is bio-based material rather than energy.** Verification then operates in two layers. Radiocarbon analysis provides a physical check on finished products that contain bio-based carbon, while certified mass-balance bookkeeping under a recognised scheme provides chain-of-custody assurance across the steps where physical measurement is not possible. Harmonised recognition of those schemes, and of the underlying bio-based feedstock definition, is a prerequisite for the whole instrument stack and is carried as a foundational measure (M01).

Eligibility: Processing Location, Not Feedstock Origin

An analytical distinction cuts across all three polymer pathways: geographic origin operates at three distinct levels in bio-based plastics supply chains, each of which has different policy design implications and requires separate treatment.

Level	What it means
Biomass origin	Where feedstocks are grown or sourced
Chemical processing origin	Where intermediates and polymers are manufactured
Product manufacturing origin	Where downstream products are converted or assembled

This distinction matters because the term 'made in EU' is politically significant but analytically ambiguous in complex industrial value chains. The IAA draft text defines EU-origin and its equivalency, as it relates to GPP. However, this does not limit eligibility for polymers counting towards content targets. A bio-based plastic product can be 'made in EU' at the conversion stage while the polymer was manufactured outside the EU from feedstock grown on another continent. Each configuration has a different profile of EU industrial value-added, job creation, and strategic autonomy benefit, and an instrument that applies a location criterion without specifying which level it operates at risks producing unintended effects.

A related design question is where the obligation should attach. **The study's working position is that chemical processing location, rather than feedstock origin, is the more workable eligibility criterion: attaching eligibility to processing within EU jurisdiction keeps the instrument enforceable and consistent with existing market-access logic, without discriminating against verified sustainable feedstock produced outside the EU, such as certified sugarcane bio-based polyethylene**. This is presented as an open design question for Phase 2 rather than a settled conclusion, and the treatment of verified sustainable non-EU supply is one of the points the Phase 2 instrument design will need to resolve.

These principles, a feedstock-use metric, mass-balance verification with a chemical-connectivity guardrail, and processing-location eligibility, underpin the instrument stack described in the following section. Their operational specification, including scheme recognition, allocation rules and any differentiated thresholds, is a Phase 2 deliverable.

Bio-based Polymer Pathways and Policy Relevance

Distinguishing between bio-based polymer pathways has material implications for policy design;

Drop-in bio-based polymers are chemically identical to their fossil-based counterparts (e.g. PE, PP) and therefore compatible with existing processing and recycling infrastructure; for these materials, recyclability and mass-balance chain-of-custody systems are the primary design considerations.

Dedicated (novel) bio-based polymers (e.g. PEF, PLA, PHA) which often have differentiated functional performance, can face additional structural barriers: integration into established recycling systems, recognition within extended producer responsibility (EPR) compliance frameworks, and alignment with design-for-recycling rules that were developed around material volumes these polymers have not yet reached. This can be the case despite significant offtake interest. In policy discourse, such materials are sometimes referred to as 'novel' polymers, a term used here to denote their distinct differences relative to incumbent fossil-based polymers rather than their maturity or time on the market.

Mature, dedicated bio-based polymers (e.g. PA11, natural rubber) occupy a distinct position. Their chemistry is fixed, their applications and performance characteristics are well established, and they do not face the same recyclability or system-integration uncertainties. Their principal constraint is economic: fossil-based alternatives benefit from structurally lower feedstock costs, reflecting the same price asymmetry that disadvantages bio-based materials more broadly.

> A core design challenge across EU product legislation is that bio-based plastics are not a single category. Drop-in bio-based polymers, mature dedicated polymers, and novel polymers raise materially different questions for sustainability criteria, chain-of-custody rules, recyclability assessment, and EPR integration. Phase 1 establishes where instruments must be differentiated; Phase 2 will consider how to keep measures equitable / harmonised despite the differences in implementation.

5.3 Instrument Stack and Tiers

Table 5-2 sets out all candidate instruments, grouped by tier and numbered sequentially.

The tier classification operationalises three tests from the Better Regulation Toolbox: the necessity test (whether the objective is met without the measure), the proportionality test (whether the content and form of the measure is limited to what is necessary) and administrative burden minimisation (delivering the objective in the simplest and least costly way).

- **Foundational (M01, M02).** Prerequisites for the verification or enforcement of other measures. Neither generates market pull itself, but the option cannot function or be policed without them.

- **Core (M03, M04, M05, M06, M07).** The demand-pull mechanism itself: a binding feedstock-use requirement that satisfies the necessity test directly. M05 is included here because, for construction categories not yet covered by a binding feedstock-use target, procurement is the only demand mechanism currently available. This classification is reassessed if a binding construction target is added in Phase 2.

- **Enabling (M08).** A proportionality response to a Core measure's design, not an independent necessity. M08 exists because M06's technology-neutral framing would otherwise exclude dedicated polymers from market access.

- **Reinforcing (M09, M10, M11).** Not required for a Core measure to bind, but each improves its cost-effectiveness, uptake or the trust environment around it through a different lever: price (M09), information (M10) or procurement (M11).

- **Supporting (M12 to M15).** Extend the same demand-pull logic to further categories or provide complementary instruments for carbon accounting and fiscal bridging. None is required for the Core measures to function.

The Administrative burden column in Table 5-2 records whether each measure reuses an existing legislative mechanism or requires new administrative machinery, since minimising new machinery is itself part of the proportionality case for the option.

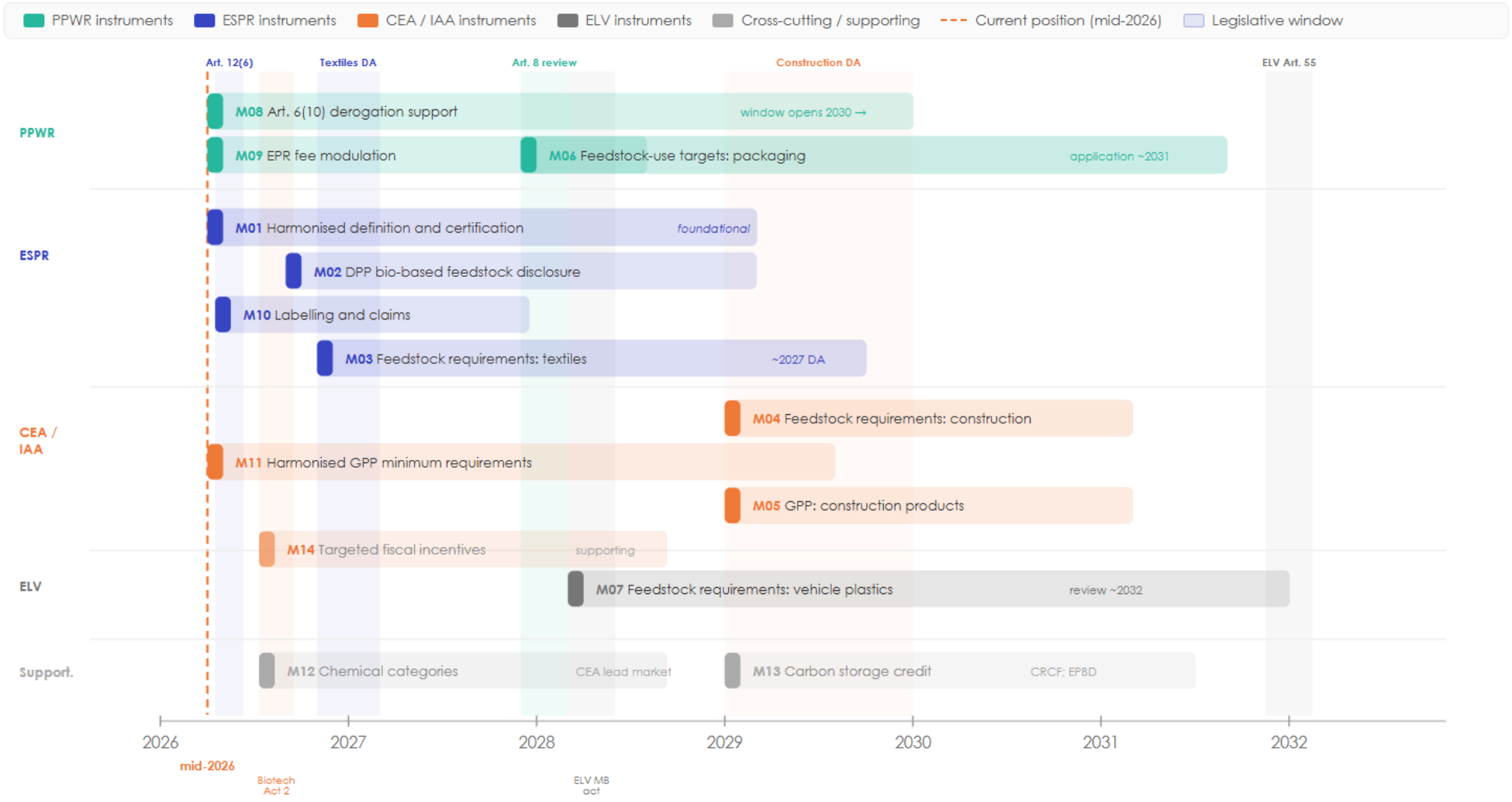
Figure 5-2 shows the illustrative timings for the measures with the policy windows for different legislative instruments. **There are significant windows opening and closing within the next two years.**

Figure 5-3 shows the same instrument stack mapped to the priority sectors.

Table 5-2: Instrument stack, tiers and legislative hooks

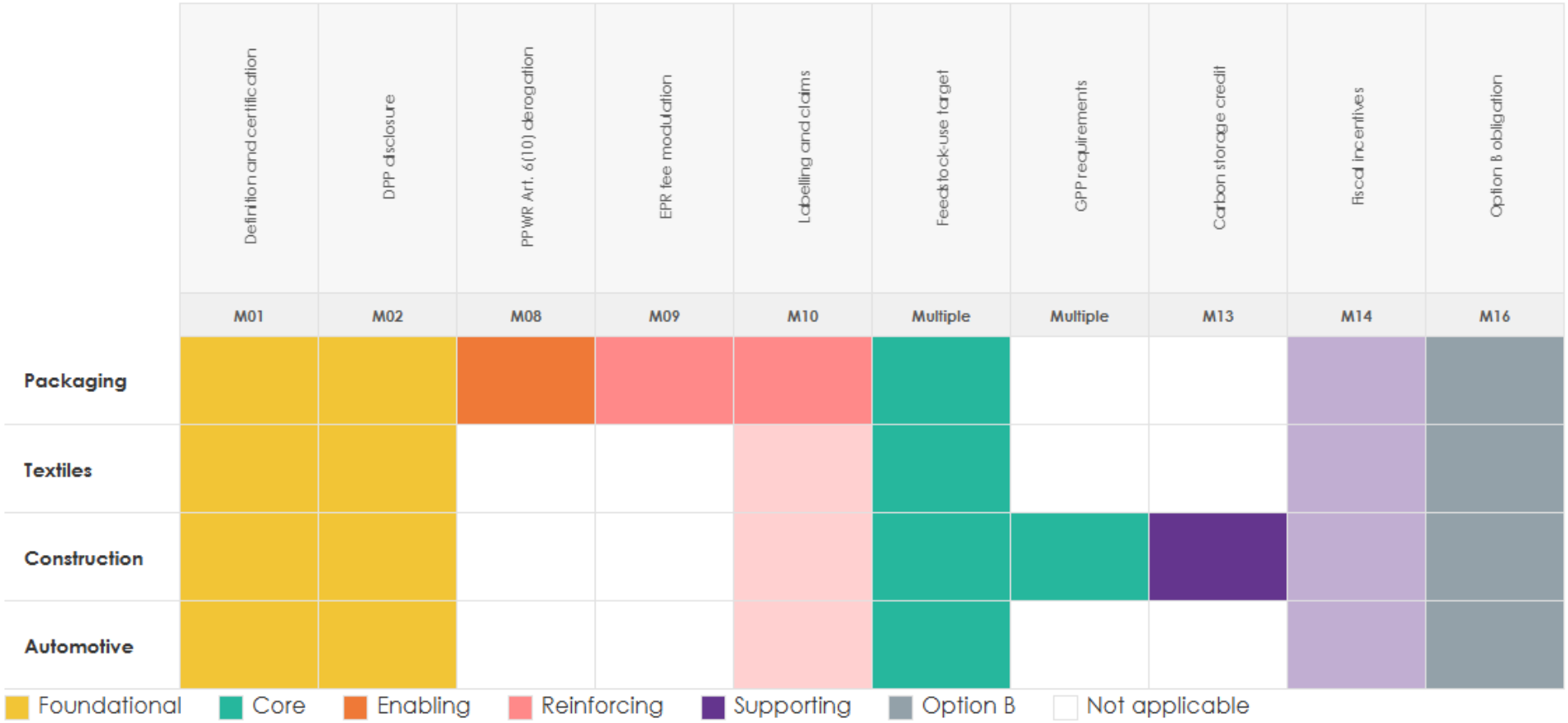
Ref.	Measure	Obj.	Legislative hook	Administrative burden
Foundational				
M01	Harmonised bio-based feedstock definition and certification	B	CEA; ESPR Annex I(i); CEN/TC 411	**High** - new definition and certification framework, built once and reused by every other measure
M02	DPP bio-based feedstock disclosure	B	ESPR Art. 7(2)(b)(i); CPR Art. 22(7)	**Low** - reuses ESPR Digital Product Passport infrastructure
Core				
M03	Bio-based feedstock requirements: synthetic textile fibres	A, D, E	ESPR textiles DA	**Medium** - new compliance and verification obligation under an ESPR delegated act
M04	Bio-based feedstock requirements: construction plastics	A, D, E	ESPR DA; CPR standards	**Medium** - new compliance and verification obligation under an ESPR delegated act
M05	GPP for bio-based construction products	A	IAA Art. 11; CEA Mech. D; CPR Art. 83	**Low** - uses the existing GPP criteria-setting process under IAA Art. 11. **Medium** - new mandatory minimum environmental sustainability requirements, under CPR Art. 83
M06	Bio-based feedstock-use targets for plastic packaging	A, D, E	PPWR Art. 8(2)(b)	**Medium** - new compliance and verification obligation under PPWR Art. 8(2)(b)
M07	Bio-based feedstock requirements: vehicle plastics	A, D, E	ELVR Art. 55; ESPR vehicles DA	**Medium** - new compliance and verification obligation under an ESPR vehicles delegated act
Enabling				
M08	Art. 6(10) derogation support package (dedicated polymers)	C	PPWR Art. 6(10), 7(7), 8(2)(b)	**Low** - uses the existing PPWR Art. 6(10) derogation provision
Reinforcing				
M09	EPR fee modulation for bio-based packaging	C	PPWR Art. 6(7); CEA Mech. C	**Low** - modulates an existing EPR fee-setting mechanism
M10	Bio-based labelling and claims framework	B	Dir. 2024/825/EU; ESPR DPP	**Low** - reuses the PPWR Art. 12(6) labelling framework
M11	Harmonised GPP minimum requirements (bio-based)	A	IAA Art. 16; CEA Mech. D	**Low** - uses the existing GPP criteria-setting process under IAA Art. 16 **Medium** – new mandatory minimum environmental sustainability requirements, under CPR Art. 83
Supporting				
M12	Lead market designation for bio-based chemical categories	A, F	CEA lead market (Biotech Act 2 lead market)	**Low** - uses the existing CEA lead market mechanism (unknown burden related to the proposed Biotech Act 2 lead markets)
M13	Carbon storage credit for long-lived bio-based products	N/A	CRCF; EPBD	**Medium** - requires a new accounting convention within the CRCF
M14	Targeted fiscal incentives	A	CEA enabling; CPR Art. 82; InvestEU	**Medium** - new eligibility criteria within existing InvestEU and CEA enabling channels, and within CPR classes of performance (via new harmonised technical specifications)
M15	Technology-neutral defossilisation instruments	N/A	Various; ETS scope review	**Not assessed** - sits outside the Option A architecture
Option B				
M16	Tradeable fossil plastic obligation	A	New standalone regulation	**High** - new standalone regulation, certificate registry and price-floor mechanism

Figure 5-2: Illustrative Timing Windows for Measures



Bar length indicates the approximate action window from mid-2026 onward. Swim lanes group instruments by primary legislative vehicle. Shaded vertical bands mark key legislative deadlines or windows. Complementary instruments (M15) and Option B (M16) are omitted from the timeline; M15 instruments operate across the full period and M16 (Option B) requires a new standalone regulation with no confirmed timeline.

Figure 5-3: Measures mapped to Priority Sectors



Lighter tint of a tier colour indicates an applicable but secondary role for that sector (no icon shown).

Packaging carries the fully worked demonstrator. Textiles, construction and automotive are quantified at target level using the same method, with detailed design parameters set out sector by sector. The foundational instruments (M01, M02) span every sector by design. The Feedstock-use target and GPP requirements columns each bundle more than one measure; the specific measure varies by sector. Option B operates across all sectors placing virgin fossil plastic on the EU market.

5.4 Policy Option Architecture

The study delivers two structurally distinct options for comparative assessment;

- **Option A is a pragmatic package of demand-side instruments** operating across existing and proposed instruments including PPWR, ESPR, the Circular Economy Act (CEA), the Industrial Accelerator Act (IAA) and the End-of-Life Vehicles (ELV) Regulation, creating market pull through feedstock-use targets, EPR modulation, public procurement requirements and a labelling framework.

- **Option B is a supply-side tradeable fossil plastic obligation scheme**, under which producers and importers placing virgin fossil plastic on the EU market must demonstrate a minimum share of bio-based production, either physically or by purchasing certificates from bio-based producers.

The two options are genuinely distinct in their point of intervention, administrative architecture and distributional effects, but they are designed to be compatible: Option B can operate as a compliance flexibility mechanism within Option A rather than only as a standalone alternative.

5.5 Instrument Specifications

This sub-section specifies the foundational, core and enabling instruments individually. For each, it states the mechanism, the key design parameters, the principal design risk, the near-term action required, and the current status. Operative instruments anchored in enacted law (PPWR, ESPR, ELV, IAA) are specified at design-parameter level; legislative-horizon instruments (CEA, Biotech Act 2) are specified as provisions to seek, pending published text.

M01 Harmonised bio-based feedstock definition and certification *(Foundational)*	
Mechanism	A single EU definition of bio-based feedstock plus a certification framework setting how bio-based feedstock is measured and how chain of custody is verified, referenced by every downstream instrument so that each product-group delegated act does not define the term differently.
Key design parameters	Two parallel compliance routes: physical verification via 14C for segregated supply chains, and mass balance with chemical-connectivity guardrails for mixed streams. Chemical connectivity is the only mass balance principle accepted across the consortium. Sustainability criteria built on the substantive basis of RED III through a purpose-built implementing act rather than direct cross-reference. Anchored in CEN/TC 411 standardisation and aligned to the Biotech Act 2 minimum bio-based content provisions.
Principal design risk	Measurement-standard inconsistency. EN 16785-1 (mass-converted) and ASTM D6866 / EN 16640 (carbon-based) produce materially different bio-based figures for oxygen-rich polymers such as PET; without harmonisation, delegated acts cross-referencing voluntary labels inherit that inconsistency. A CEN standardisation mandate is the resolution path.
Near-term action	Secure the harmonised-definition mandate in the CEA and Biotech Act 2 text; align with ESPR Annex I(i) and CEN/TC 411.
Status	Foundational prerequisite for all other measures. Mass balance allocation methodology deferred to Phase 2 pending methodology finalisation.

M02 DPP bio-based feedstock disclosure *(Foundational)*	
Mechanism	Uses the ESPR Digital Product Passport to carry a mandatory bio-based feedstock data field, so feedstock origin and share travel with the product and are available to enforcement, procurement and EPR systems.
Key design parameters	Disclosure of feedstock share and chain-of-custody route (physical or mass balance), aligned to the JRC DPP data-requirements methodology; data granularity and access rights set within the ESPR DPP framework. A disclosure obligation, not a threshold.
Principal design risk	Disclosure without conversion. Disclosure instruments without an explicit legislative review clause tend not to convert into binding requirements over time; the delegated act should carry a dated review clause.
Near-term action	Ensure the bio-based feedstock parameter is included when the horizontal DPP data requirements are set under ESPR Art. 7(2)(b)(i).
Status	Foundational; depends on the M01 definition.

M03 Bio-based feedstock requirements: synthetic textile fibres *(Core)*	
Mechanism	Sets a bio-based feedstock parameter in the ESPR textiles delegated act for synthetic fibres, with bio-PET and bio-nylon as examples of drop-in candidates.
Key design parameters	Uses the ESPR Annex I(i) bio-based parameter. Textiles is the first category where this parameter can be specified, and there is no recycled-content conflict because there is no synthetic textile-to-textile loop at scale.
Principal design risk	Import dependence: bio-PET arrives entirely as imports and is invisible in EU production data, so verification must work for imported fibre.
Near-term action	Position the bio-based parameter for the textiles DA (approximately 2027).
Status	Core; full demonstrator in Phase 2.

M04 Bio-based feedstock requirements: construction plastics *(Core)*	
Mechanism	Bio-based feedstock requirements for construction plastics, via an ESPR delegated act and CPR standards.
Key design parameters	No Article 6 recyclability barrier applies, making construction a strong sector for dedicated and mature polymers; long product lifetimes strengthen the biogenic carbon storage case; the CPR standardisation route carries the requirement.
Principal design risk	Long delegated-act timeline (approximately 2029 to 2030) and standards-development lead time delay the demand signal.
Near-term action	Scope the parameter against CPR standards and the EPBD.
Status	Core; demonstrator in Phase 2.

M05 GPP for bio-based construction products *(Core)*	
Mechanism	Green public procurement requirements specific to bio-based construction products, pairing with M04 on the construction sector.
Key design parameters	IAA Art. 11 is the hook, supported by CEA Mechanism D; construction-specific criteria sit beneath the horizontal GPP floor in M11.
Principal design risk	Overlap with M11: the construction-specific criteria must stay coherent with the horizontal GPP floor.
Near-term action	Align with the construction parameter (M04) and IAA Art. 11.
Status	Core.

M06 Bio-based feedstock-use targets for plastic packaging (Core)	
Mechanism	A binding minimum bio-based feedstock-use target for plastic packaging under PPWR Art. 8(2)(b): the central demand-pull instrument of the option.
Key design parameters	Framed as feedstock-use and applied above product level through mass balance, so PLA and PEF fit. Target level is the key variable (a 5% target creates approximately 745 Kt of new demand, linear with level). The supply analysis indicates a level above 5% is needed to trigger genuinely new investment, because approximately 0.6 to 0.8 Mt is available against approximately 1.07 Mt required at 5%. The review route is Art. 8(1) by 12 February 2028, with earliest application of targets around 2031.
Principal design risk	A 5% target may be largely covered by existing and announced capacity and so may not stimulate investment; the level must be set to pull capacity growth without creating an unmeetable shortfall. Proportionality must be demonstrable against the cost-gap evidence.
Near-term action	Build the Art. 8(2)(b) case for the 12 February 2028 review.
Status	Core; earliest application around 2031. The full impact demonstrator is Section 6.0

M07 Bio-based feedstock requirements: vehicle plastics (Core)	
Mechanism	Bio-based feedstock requirements for vehicle plastics, via the ELV Art. 55 review and the ESPR vehicles delegated act.
Key design parameters	A large-volume end market in which castor-based PA11 drop-ins already dominate regardless of policy design; the near-term priority is mass balance coherence between ELV, PPWR and ESPR (ELV mass balance act around 2028).
Principal design risk	Mass balance incoherence across the three instruments; the ELV Art. 55 review timing (around 2032) is later than packaging.
Near-term action	Secure mass balance coherence in the ELV mass balance act (around 2028).
Status	Core; demonstrator in Phase 2.

M08 Art. 6(10) derogation support package (dedicated polymers) (Enabling)	
Mechanism	A support package built around the PPWR Article 6(10) innovative-packaging derogation, giving dedicated polymers (PLA, PHA, PEF) a near-term route to market while the volumes needed to pass the Article 6 recyclability tests do not yet exist.
Key design parameters	Guidance on innovative-packaging criteria; EPR fee relief during the five-year derogation window from 2030; a feedstock-use credit. Addresses the gap that guidance C(2026) 2151 final does not cover packaging already commercially available.
Principal design risk	The derogation is a market-access provision, not a market-pull mechanism; on its own it creates no demand, so it must be paired with M06 and M09. Legal uncertainty persists for existing producers until the guidance gap is closed.
Near-term action	Commission guidance clarifying the innovative-packaging criteria and the position of already-marketed dedicated-polymer packaging.
Status	Enabling; relies on enacted PPWR Art. 6(10), 7(7) and 8(2)(b).

M09 EPR fee modulation for bio-based packaging (Reinforcing)	
Mechanism	Modulates extended producer responsibility fees under PPWR so that packaging using bio-based feedstock attracts lower fees, creating a price signal at the point where producers are already obligated.
Key design parameters	The obligated party is producers (the PPWR Art. 45 term), not manufacturers. Modulation criteria are based on verified bio-based feedstock share through M01 certification, and dovetail with CEA Mechanism C.
Principal design risk	Modulation must not double-count with recycled-content modulation or create a perverse incentive against recyclability; bio-based and recycled criteria are kept non-interchangeable.
Near-term action	Include bio-based feedstock among the eco-modulation criteria in the PPWR Art. 6(7) implementing work.
Status	Reinforcing; operative hook in enacted PPWR.

M10 Bio-based labelling and claims framework (Reinforcing)	
Mechanism	A harmonised framework for voluntary bio-based content labels, so claims are consistent, verifiable and not misleading, linking the PPWR Art. 12(6) label format to the Directive 2024/825/EU substantiation rules.
Key design parameters	PPWR Art. 12(6) creates the harmonised format for voluntary labels (implementing act deadline 12 August 2026); this is a labelling framework, not a mandatory disclosure. Substantiation runs through Directive 2024/825/EU, which replaced the withdrawn Green Claims Directive. Measurement consistency depends on M01 to avoid the EN 16785-1 versus EN 16640 divergence.
Principal design risk	Without M01 harmonisation the label inherits inconsistent bio-based content figures, exposing it to a greenwashing challenge if substantiation is weak.
Near-term action	Feed bio-based plastics into the Art. 12(6) implementing act (due August 2026) and align with the Directive 2024/825/EU substantiation regime.
Status	Reinforcing.

M11 Harmonised GPP minimum requirements (bio-based) (Reinforcing)	
Mechanism	Harmonised green public procurement minimum requirements that include bio-based feedstock criteria, using public demand as a pull instrument.
Key design parameters	IAA Art. 16 is the procurement hook, supported by CEA Mechanism D. Minimum requirements are harmonised across member states to avoid fragmentation.
Principal design risk	Procurement criteria are only as strong as their mandatory floor; voluntary criteria under-deliver.
Near-term action	Secure bio-based criteria in the IAA Art. 16 GPP framework.
Status	Reinforcing.

Table 5-3: Supporting instruments (summary)

Ref.	Measure	Role in the option
M12	Bio-based feedstock requirements: chemical categories	Designates selected bio-based chemical categories as CEA lead markets. This prioritises the category for streamlined permitting, blended finance and coordinated procurement attention, rather than imposing a feedstock-use requirement. It builds investment conditions in categories not yet ready for a binding target under M03, M04, M06 or M07.
M13	Carbon storage credit for long-lived bio-based products	Recognises the biogenic carbon stored in long-lived bio-based products, principally construction materials, through the Carbon Removals and Carbon Farming Regulation (CRCF) and the Energy Performance of Buildings Directive (EPBD). The accounting convention for short-lived products, including packaging, is not yet settled and is not relied on in this option.
M14	Targeted fiscal incentives	Time-limited fiscal support, for example capital allowances or reduced-rate financing via InvestEU, for bio-based production capacity where the green cost premium is bridgeable and demand is price-inelastic. Operates through existing CEA enabling provisions rather than a new fiscal instrument.
M15	Technology-neutral defossilisation instruments	Cross-cutting instruments that reduce fossil carbon intensity without specifying bio-based content, for example a free-allowance or contract-for-difference mechanism under the EU ETS Directive or the Clean Industrial Deal. These sit outside the CEA, PPWR and ESPR architecture and are noted here for coherence rather than specified as part of this option.

Option B in brief

Option B (M16) places an obligation on importers and EU producers of virgin fossil plastic to surrender bio-based certificates per tonne placed on the market, with certificates issued to verified bio-based producers and traded in a capped market with a price floor and a buy-out option. Its strongest structural argument is that it is the plastics-sector equivalent of what the EU ETS does for process emissions: the ETS prices carbon in energy and industrial processes; Option B prices fossil carbon in plastic feedstock. Both correct the same underlying failure, that fossil feedstock carbon is unpriced. The recommended near-term configuration is an importer-and-EU-producer obligation, a capped certificate market, priority-polymer scope, and operation as a compliance flexibility route within Option A, transitioning to a full upstream-plus-downstream architecture as bio-based supply scales.

Design Variants – Approaches to Implementation of Measures

Within the single pragmatic option, a small number of design variants remain on genuinely contested questions where alternative approaches are defensible. Each is noted here as an architecture choice and developed in full, with the study's working position and the Phase 2 task, in Section 7.0(Live policy design questions for Phase 2).

Supporting EU chemical processing capacity – tensions that need resolving

Objective F, supporting EU chemical processing capacity against structural sector decline (Driver 3), is only partly served by a dedicated instrument. M12 extends CEA lead market designation to selected chemical categories, prioritising them for streamlined permitting and blended finance. This is deliberately an encouragement route rather than a compliance mandate, a mandatory EU-processing requirement would put the option in direct conflict with verified non-EU supply chains and raises WTO exposure the study is not positioned to resolve at this stage.

The larger share of Objective F is instead carried by how the feedstock-use targets (M03, M04, M06, M07) are operationalised, specifically whether the EU-origin criterion is applied as an evaluation preference or a compliance condition. That question is currently unresolved and reserved for Phase 2, and it mirrors the live, contested debate over the equivalent geographic provisions in PPWR's recycled-content rules, where the same mandate-versus-preference tension has not been settled either.

Table 5-4 - Design variants within the 'pragmatic' option

Design variant	Working position and Phase 2 task
Geographic criterion: EU origin as mandate or preference	EU-based chemical processing (not feedstock origin) is the right criterion; the study leans towards an evaluation preference rather than a compliance mandate, and it must stay defensible for verified sustainable non-EU supply.
Target scope: bio-based-specific vs broader non-fossil	Leans bio-based-specific, justified by the bioenergy mandate asymmetry that generic non-fossil targets cannot correct; genuinely contested (Biotech Act 2 workshop split approximately 51/49).
Mass balance allocation methodology	Mass balance with chemical-connectivity guardrails; attribution not exceeding the bio-based carbon entering the value chain at each stage.

6.0 Analytical Demonstrator: Bio-based feedstock-use targets for plastic packaging under PPWR (M06)

This section works the PPWR Article 8 packaging case through in quantitative detail to assess the impact of measure **M06 - Bio-based feedstock-use targets for plastic packaging**. It is presented as a demonstrator of the analytical method the study will apply across all priority sectors in Phase 2, not as a complete impact assessment of a single instrument. Packaging is chosen because it is the only instrument with a confirmed legislative hook in enacted law (the Article 8 review due by 12 February 2028), an engaged Commission counterpart, and sufficient data to model now. The findings carry forward the confirmed Phase 1 modelling.

Packaging is the initial entry point. Phase 2 will also assess the other measures presented in this report, as they relate to the textiles, construction and automotive sectors.

The Article 8 Pathway and Instrument Logic

Article 8(1) of the PPWR requires the Commission to review the technological development and environmental performance of bio-based plastic packaging by 12 February 2028, taking account of the sustainability criteria in Article 29 of the Renewable Energy Directive. Article 8(2) then empowers the Commission, where appropriate, to bring forward a legislative proposal to: (a) set sustainability requirements for bio-based feedstock; (b) set targets to increase the use of bio-based feedstock; (c) allow bio-based feedstock to count toward the Article 7 recycled-content targets where 2022/1616-compliant recycling for food-contact packaging is unavailable; and (d) amend the definition of bio-based plastic. **The sequence is review, then legislative proposal, then codecision, so the earliest realistic application of any target is around 2031.** This is the instrument the demonstrator works through, and its timing is the reason the study treats the design questions as live now rather than settled.

Article 8(2)(b) and Article 8(2)(c) are structurally distinct instruments that can operate at the same time; they are not alternatives, and neither makes the other redundant. Article 8(2)(b) creates a standalone mandatory feedstock-use target that applies because the feedstock is bio-based, independent of any recycling obligation. Article 8(2)(c) is a conditional substitution mechanism: where 2022/1616-compliant recycling for food-contact packaging is unavailable, bio-based feedstock may count toward the Article 7 recycled-content obligation. The defensible policy case is therefore Article 8(2)(b) alone, or Article 8(2)(b) and 8(2)(c) together. It is never Article 8(2)(c) alone, because a substitution mechanism cannot create demand on its own.

For dedicated polymers (PEF, PHA, PLA), Article 8(2)(b) is the prerequisite instrument. Without a mandatory demand signal, new dedicated-polymer capacity struggles to close its investment case: the cost gap to fossil polymers is structural rather than cyclical, and voluntary green-premium markets collapse when fossil prices fall. A mandatory target converts uncertain premium revenue into contracted compliance demand, which is what makes long-payback investment rational. Article 8(2)(c) cannot do this for dedicated polymers, because it depends on conditions those materials may not yet satisfy at scale: an applicable recycled-content obligation, market access under Article 6, and a demonstrated recyclability position.

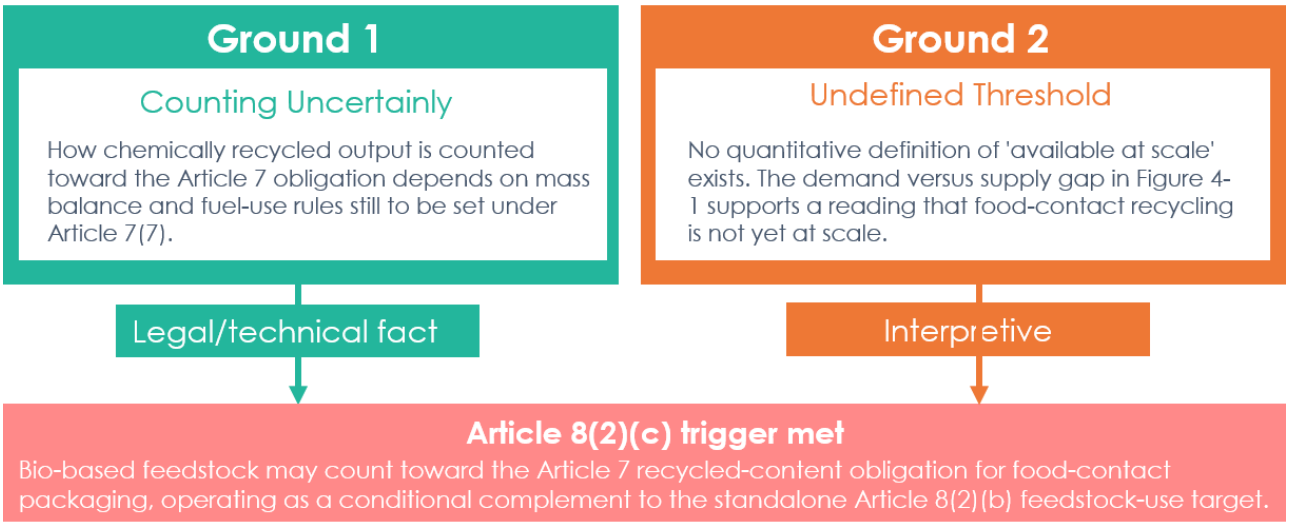
Article 8(2)(c) is best understood as a complementary flexibility, and its value is greatest for drop-in polymers rather than dedicated ones. Its natural application is bio-PE and bio-PP in food-contact uses, where compliance with the Article 7 recycled-content obligation may be constrained by the limited supply of food-contact-compliant recycled polyolefins. Even under optimistic chemical-recycling deployment, the scale, timing and regulatory status of food-contact-suitable output remain uncertain, so a substitution route has real potential value there. This does not change the study's central conclusion: Article 8(2)(b) provides the direct market-pull signal, and Article 8(2)(c) is a conditional complement to it. The comparison of the two instruments is set out in Table 6-1.

Table 6-1: Article 8(2)(b) and 8(2)(c) compared

Dimension	Art. 8(2)(b): feedstock-use target	Art. 8(2)(c): recycled content substitution
Instrument type	Mandatory feedstock-use requirement	Conditional compliance pathway
Trigger	Unconditional: all plastic packaging in scope	Conditional: only where 2022/1616 recycling unavailable
What it requires	Minimum bio-based feedstock share, regardless of recycling availability	Bio-based feedstock may count toward Art. 7 obligation
Compliance basis	14C or mass balance chain-of-custody	Empirical finding that compliant recycling is unavailable
Sector scope	All plastic packaging in scope	Food-contact packaging only
Relation to Art. 7	Independent: operates alongside, does not substitute	Substitutes for part of the obligation where recycling absent
Simultaneous?	Yes: both can apply to the same producer	Yes: additive, not alternatives

Two independent lines of evidence indicate that this substitution route is already available at commercial scale rather than being contingent on a future market scenario. The first is counting uncertainty: how chemically recycled output is attributed toward the Article 7 obligation depends on the mass balance and fuel-use allocation rules still to be fixed under the Article 7(7) methodology, so the volume that can actually be counted as food-contact recycled content is lower and less certain than headline capacity implies. The second is the undefined threshold: neither Article 8 nor the recyclability framework defines the quantitative point at which compliant food-contact recycling counts as available at scale, so the availability finding is a matter of interpretation, and the demand-versus-supply gap shown in Figure 4-1 supports a reading that it is not yet at scale.

Figure 6-1: Two independent grounds that the Article 8(2)(c) substitution route is available now



PPWR Article 6 Interaction and Market Access for Dedicated Polymers

Before the demand and cost findings, the interaction with the Article 6 recyclability framework has to be set out, because it determines which polymers a feedstock-use target can actually reach. Article 6 creates two successive barriers for dedicated polymers. From 2030, a design-for-recycling assessment grades packaging A to C, and anything below the C threshold is treated as technically non-recyclable; this is a recyclability test, not a recycling rate. From 2035, a recycled-at-scale threshold is added, so the material must be demonstrably recycled in sufficient quantities in practice. From 2038, the C grade becomes a hard market bar. Dedicated polymers cannot currently demonstrate sortability and recyclability at existing volumes, because dedicated sorting and recycling lines only become economic

at volumes that do not yet exist. A minimum feedstock target is what creates the volume that makes both criteria achievable, which is the link between the Article 8 instrument and the Article 6 barrier.

The Article 6(10) innovative-packaging derogation is the only near-term route to market for dedicated polymers, and it is a market-access provision, not a market-pull mechanism. It provides a five-year window from 2030 for packaging with demonstrable environmental benefits, subject to prior notification to the competent authority and a timeline for reaching recyclability. Because it opens the door but does not create demand, the study pairs it with a dedicated support package (measure M08): guidance on the innovative-packaging criteria, EPR fee relief during the derogation, and a feedstock-use credit. One point remains unresolved: the guidance document C(2026) 2151 final does not address packaging already commercially available, which leaves existing producers of dedicated-polymer packaging in legal uncertainty. This is flagged here and carried into the instrument-design work in Phase 2.

What the demonstrator models. The findings that follow quantify the impact of a single overarching feedstock-use target under Article 8(2)(b), applied across plastic packaging as a whole. The study proposes that Article 8(2)(b) and 8(2)(c) could coexist, with 8(2)(b) as the primary demand signal and 8(2)(c) as a complementary substitution route for drop-in polyolefins in food-contact applications.

In the first instance, however, the demonstrator models the overarching 8(2)(b) target alone. Article 8(2)(c) is not separately quantified here, because its effect is conditional on the recycling landscape and specific to certain applications. Modelling the overarching target keeps every figure in the demand, cost, land and GHG findings attributable to one clearly defined instrument, which is what the next four subsections set out.

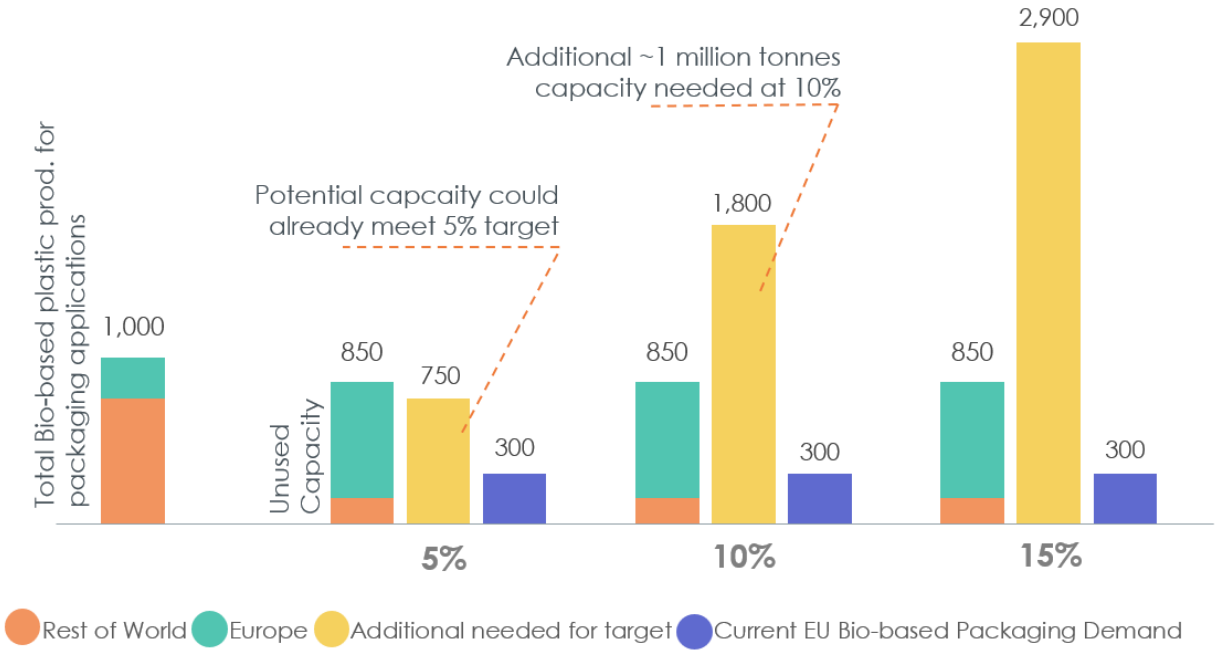
Impact 1: Demand for Bio-based Feedstock

A feedstock-use target under Article 8(2)(b) creates a step change in demand for bio-based packaging. At a 5% target, EU bio-based packaging demand rises to approximately 1,050 Kt, roughly 3.5 times the current EU bio-based packaging demand of approximately 300 Kt, an increment of approximately 750 Kt of new demand above the current level (see Appendix A.6.0 for background consumption estimates – 2030 demand for plastic packaging is not expected to increase as discussed in Section 4.4). The relationship is linear with target level.

Table 6-2: Bio-based feedstock demand by target level (EU packaging)

Target level	Total demand required	Incremental new demand
5%	~1,050 Kt	+750 Kt
10%	~2,100 Kt	+1,800 Kt
15%	~3,150 Kt	+2,900 Kt

Figure 6-2: Bio-based packaging demand required by target level, with increment above current demand (ktonnes) Note: all numbers rounded to the nearest 50



The important finding here is that at a 5% target, the unused capacity is close to the extra demand which is unlikely to stimulate growth. Given the unrealised capacity is comprised of an estimated 590kt of naphtha potential, this target could signal demand that would realise that potential.

A 10% target solidifies the need for significant growth, with an additional 1 million tonnes likely to spark investment not already in the system. **A 15% target massively outstrips projected supply which, depending on the implementation timeline, may be difficult to achieve and could create a shortage for businesses trying to source the material.** It is possible that a sliding scale, similar to the PPWR recycled content targets, could be deployed here. The SAF mandate offers a useful precedent: targets starting at 6% in 2030 and rising to 70% by 2050, combined with flexibility mechanisms to manage short-term over or undersupply rather than fixed five-yearly step increases, which the SAF experience shows can create matching difficulties of their own.

It is also important to recognise the interplay between other possible targets in different sector, their implementation timeline, and the polymers each is likely to affect, in order to fully assess the combined demand-versus-capacity implications rather than treating each target in isolation. Phase 2 will look at this interplay as other sector targets (e.g. for automotive) and their sequencing affect the conclusions around target magnitude and necessary capacity.

A further point worth recognising: the lead time for new capacity (typically several years from investment decision to operation) means achievability depends as much on how far in advance a target is signalled as on the target level itself. A target set with insufficient lead time could create a shortage even at a level that would otherwise be reachable in the long run.

Impact 2: Consumer Cost and Volatility Context

Three reference packaging formats were modelled to test how a PPWR bio-based feedstock target translates into cost at the pack and product level: a rigid HDPE orange juice bottle, a rigid PET water bottle, and a flexible PE bread bag. These formats were selected to span the packaging mix which together account for the large majority of EU packaging polymer demand, and one flexible format, which sits under a distinct PPWR recyclability category and carries a materially lower pack mass. Each demonstrator applies the same resin price assumptions (bio-based resin at €2,250 per tonne, fossil resin between €1,040 and €1,180), and the same 60% resin share of final production cost. Pack mass and retail price for each format are drawn from a single representative SKU, as an illustrative basis intended to test the order of magnitude of the cost effect, not a market-representative average.

Table 6-3 sets out the added cost per pack, the resulting packaging cost increase, and the pass-through to final product price, for each format at 5%, 10% and 15% bio-based feedstock targets.

Table 6-3: Packaging Costs and End Product Price Increases

Product	Target	Added cost per pack	Packaging cost increase	Product price increase
HDPE orange juice bottle 34g Product price €2.96	5%	€0.0020	3.9%	0.07%
	10%	€0.0039	7.7%	0.13%
	15%	€0.0059	11.6%	0.20%
PET water bottle 24g Product Price €0.70	5%	€0.0015	4.2%	0.21%
	10%	€0.0029	8.3%	0.41%
	15%	€0.0044	12.5%	0.62%
Flexible PE bread bag 5g Product Price €1.50	5%	€0.0003	3.2%	0.02%
	10%	€0.0005	6.5%	0.04%
	15%	€0.0008	9.7%	0.05%

Across all three formats, the retail price effect of a bio-based feedstock target remains small even at the upper end of the range tested, but the three formats are not equally exposed to it. The PET water bottle shows the largest proportional pass-through of the three, reaching 0.62% at a 15% target, more than three times the HDPE bottle's 0.20% and over ten times the bread bag's 0.05%. This is not because PET carries a larger absolute cost increase (its added cost per pack is in fact the smallest of the three rigid and semi-rigid comparisons), but because packaging represents a comparatively larger share of a low-value product: at €0.70 retail, the water bottle has far less headroom to absorb any cost change than the €2.96 orange juice bottle.

The flexible PE bread bag is the least cost-sensitive format on every measure, by a wide margin. Its added cost per pack at 15% (€0.0008) is around an order of magnitude below the rigid formats, driven by its very low pack mass of 5g against 24g for the PET bottle and 34g for the HDPE bottle. Because the

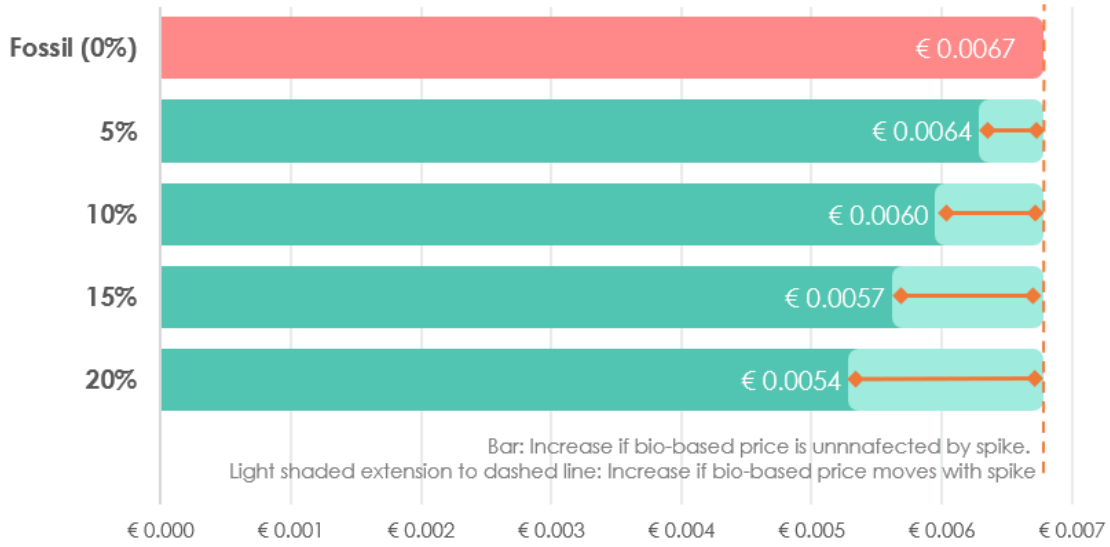
bread bag is a mass-per-pack effect rather than a resin-price effect (all three formats use the same bio-based and fossil resin price assumptions), this result is a structural feature of the flexible film format itself, not an artefact of the specific SKU chosen.

Bio-based Content Reduces Exposure to Fossil-price Volatility

A bio-based feedstock target does not increase a pack's exposure to fossil price volatility; it reduces it. Figure 6-3 illustrates this effect using a €200 per tonne change in fossil resin prices as the reference shock. An all-fossil HDPE bottle absorbs the full increase, equivalent to approximately €0.0067 per pack. As the share of bio-based content increases, the portion of the pack exposed to fossil-price movements falls. The corresponding increase declines to approximately €0.0064 per pack at a 5% target and €0.0054 per pack at a 20% target.

The figure presents a range of possible outcomes. The lower bound assumes the bio-based resin price is unaffected by the fossil-price shock. The upper bound assumes the bio-based price increases euro-for-euro with the fossil price change, representing the maximum possible pass-through. **Under neither assumption does the pack become more exposed to fossil-price volatility than an equivalent all-fossil pack.**

Figure 6-3: HDPE orange juice bottle: pack cost increase under a €200/tonne fossil price shock, by target



The same relationship is observed for the PET water bottle and the flexible PE bread bag. PET shows the smallest reduction in exposure, with the 20% target scenario remaining close to the all-fossil reference case. The flexible film format shows the largest reduction. Across all three packaging formats and all target levels assessed, increasing bio-based content reduces or maintains exposure to fossil-price volatility; it never increases it.

The 2020–2022 fossil price cycle illustrates the relative scale of the cost impacts involved. Between the COVID-19 demand collapse and the energy price shock following Russia's invasion of Ukraine, HDPE prices moved by approximately €600 per tonne. For the example bottle used in this assessment, this equates to a cost change of around €0.028 per unit, roughly 14 times larger than the estimated impact of a 5% bio-based feedstock requirement.

While this period was unusually volatile, it illustrates a broader point. **Over a typical investment or business-planning horizon, uncertainty arising from fossil feedstock prices is likely to be substantially greater than the predictable cost of a modest bio-based feedstock target.** A compliance-driven bio-based requirement introduces a known cost premium. Exposure to fossil feedstock markets creates a variable and potentially much larger source of cost uncertainty.

Initial Conclusions

The cost case for PPWR bio-based feedstock targets in the 5 to 15% range is strong across all three packaging formats tested. Retail price effects stay under one percent even at the upper end of the range, and the underlying packaging cost increase does not exceed the level of cost volatility the market already absorbs from fossil price movements, even when the target range is extended to 20%. This strengthens the proportionality case set out elsewhere in this section: a target in this range represents a smaller cost shock than fossil resin markets already deliver on a routine basis. The premium is therefore large at the resin level but negligible at the point of sale, and that gap is itself part of the case for intervention: voluntary demand cannot bridge a resin-level premium of this size, yet the consumer cost of closing it through a mandatory target is trivial. This matters because the survey evidence shows fewer than a quarter of buyers will accept a resin premium above 20% voluntarily, yet the same premium reaches the shopper as under 1% of retail price, so a mandate closes a gap voluntary demand cannot.

The three formats are not equally placed to absorb a target, however, and this has a bearing on how ambition might reasonably be differentiated by format. PET packaging, represented here by the water bottle, combines a comparatively high proportional price pass-through with the narrowest margin against the fossil price volatility reference of the three formats. Flexible PE film, represented here by the bread bag, sits at the opposite end on every measure: lowest absolute cost, lowest proportional pass-through, and the widest margin against normal market volatility.

This asymmetry is worth carrying into Phase 2 as a design question, not a conclusion in itself. A flexible film format that can absorb a materially higher bio-based feedstock target at negligible cost, and that also faces more constrained recycled content pathways under PPWR Article 6 (packaging categories 9, 11, 13 and 18), would be a natural candidate for differentiated, more ambitious targets, since bio-based feedstock would represent an available lever where recycled content is a more constrained one. That second premise, on recycled content pathways for flexible formats, is not yet established in this study and needs to be tested against the evidence before it can support a differentiated target design; the cost analysis here establishes only that cost is not the constraint standing in the way of it for flexible formats specifically.

Impact 3: Greenhouse Gas Framework and Land use Outcomes

A feedstock-use target does not specify which polymers are used to meet it, and that choice has measurable environmental consequences. This finding models what a 10% bio-based feedstock target for EU plastic packaging could mean for two of those consequences, the agricultural land it would require and the greenhouse gas it would avoid, and sets out why the answer depends on assumptions the study cannot yet fully settle.

As modelled here, a bare 10% target leaves the choice of polymer to the market, but that is a modelling choice for this illustration, not a claim about what the policy has to do. The instrument itself could include design features, thresholds, differentiated targets or incentives, that steer allocation toward particular polymers. And, whether it should, is one of the open questions this finding sets up for Phase 2. What follows holds polyethylene and polypropylene on their drop-in bio-based equivalents throughout, because no polyester substitutes for them in the applications they serve, and varies only which polymers serve the polyester slot.

The modelling is built from four polymers because together they make up around 90% of EU plastic packaging. LDPE, HDPE, PP and PET dominate the market a feedstock-use target would apply to, so for this illustration the demonstrator simplifies to a full switch within that group rather than modelling a more realistic but far more complex mix of many polymers each switching at a different rate. That simplification is what makes the scenario tractable, and it should be read as illustrative of the scale involved, not as a forecast of how compliance would actually be distributed.

What Decides how much Land a Target Needs

Each polymer becomes bio-based within its own chemical family. Bio-based polyethylene serves polyethylene demand. Bio-based polypropylene serves polypropylene demand. The polyester slot, which today is PET, is served by bio-based PET, PEF or PLA.

Polymers are assumed not to swap across families to meet a target. What the packaging has to do, whether it is a film, a bottle or a rigid tray, decides which polymer can do the job, and a feedstock target does not change that.

Why Chemistry Drives Feedstock Demand

Polyethylene and polypropylene are hydrocarbons. When they are produced from plant sugars, the oxygen contained in the sugar is removed and some carbon is lost as carbon dioxide during processing. Polyesters such as PLA and PEF retain that oxygen within the final material.

On a consistent basis, **the land use ratio of producing a tonne of polyolefin compared to producing a tonne of polyester runs from about 1.9 at published operating yields to about 2.9 on raw IfBB figures**. Accordingly, polyolefins on average require around two and a half times more sugar and their production therefore uses around two and a half times more agricultural land. Typical feedstock requirements are approximately 4 kg of sugar per kg of bio-based polyethylene, compared with around 1.6 kg per kg of PLA.[169]

This relationship holds across all crops evaluated. However, the ratio describes the carbohydrate route. Since a triglyceride is roughly 12% oxygen against 53% for glucose, the oxygen-loss penalty does not transfer to lipid routes.[170] Therefore, the land use ratio is driven by polymer chemistry rather than crop yield, geography, or whether a polymer is classified as a drop-in or dedicated alternative. Bio-based PET illustrates this point. Although it is generally treated as a drop-in polymer because it is chemically equivalent to conventional PET, it is a polyester, and its land requirements per tonne are comparable to those of other polyesters rather than polyolefins.

The Crop Matters More than the Polymer Mix

Meeting a 10% bio-based feedstock target for packaging needs roughly 0.9 million hectares if the crop is sugar beet or sugarcane. As an upper bound sensitivity, wheat would need about 5.4 million hectares. Figure 6-4 shows the range of agricultural land demand, per feedstock.[171] In practice, a 10% target would be achieved through a diversified portfolio of feedstocks and technologies – different implementation pathways would result in different land-use implications. For comparison, in 2020, biofuels (without allocation of co-products[172]) was estimated to require 9.64 million hectares of land to meet consumption demand.[173]

The difference between these estimates reflects crop yields, not the polymers themselves. Different crops produce very different amounts of biomass per hectare, with yields varying severalfold. By contrast, the feedstock required to produce each polymer is determined by its chemistry and remains

[169] Institut für Biokunststoffe und Bioverbundwerkstoffe (IfBB) (2025) *Biopolymers: Facts and Statistics 2025*. Hannover: Hochschule Hannover. Polyolefins require of the order of 4 kg of sugar per kg of polymer, against about 1.6 kg per kg of PLA. The assumed conversion is conservative for a modern plant; however, the ratio is insensitive to it because the polyester side also moves in the same direction.

[170] This does not imply lipid routes are land-efficient; oil crop yields per hectare are lower.

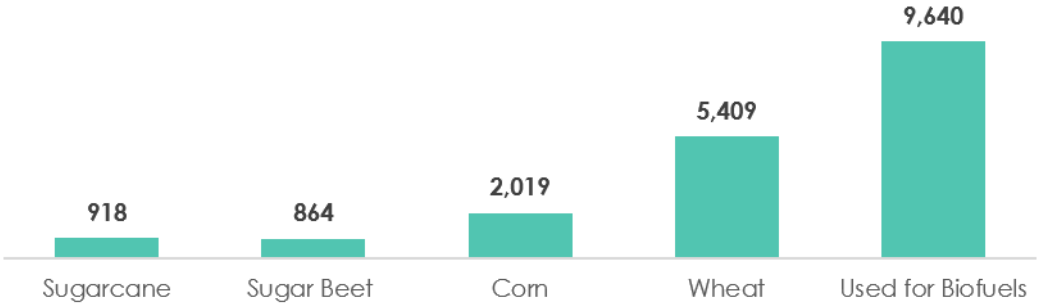
[171] Institut für Biokunststoffe und Bioverbundwerkstoffe (IfBB) (2025) Biopolymers: Facts and Statistics 2025. Hannover: Hochschule Hannover. Land-use factors per tonne of finished polymer, applied to the packaging polymer composition in Figure 8-1 and to a 10% feedstock target on the 21,300 kt packaging baseline.

[172] Land use was not allocated to co-products to maintain methodological scope across the factors used here and in Figure 6-4. However, it should be noted that RED III requires land-use change emissions to be allocated between the main fuel and its co-products. The IFEU (2023) report (cited below) estimates biofuel land use – when accounting for co-products and still including imports – drops from 9.64 to 5.27 million hectares.

[173] Institut für Energie- und Umweltforschung Heidelberg (ifeu) (2023) *The Carbon and Food Opportunity Costs of Biofuels in the EU27 plus the UK:* Based on the volumes of crop-based biofuels consumed in Europe in 2020, the total sum of occupied land is 9.64 million hectares - without allocation of co-products, including imports.

constant. Sugar beet and sugarcane have very similar land requirements, which is an important finding. An efficient European sugar beet crop requires roughly the same amount of land as imported sugarcane feedstock, suggesting that sourcing feedstock within Europe does not necessarily increase land demand. However, land use should not be considered on a standalone basis for policy differentiation between polymer pathways at the target levels assessed.

Figure 6-4: Agricultural Land demand by feedstock, 10% target (Khectare)



Note: The wheat case is an upper bound sensitivity rather than a scenario. The land demand required to meet the consumed volume of biofuel in Europe in 2020 is shown for comparison.

Land Does Not Limit a 10% Target

The EU has approximately 156 million hectares of farmland. A 10% bio-based packaging target would require between 0.55% and 3.45% of that area, depending on the feedstock crop used.[174]

This comparison assumes that all feedstock is sourced from EU farmland, making it a deliberately conservative estimate. In practice, bio-based feedstocks are traded on global markets and are not sourced exclusively from Europe. Globally, there are approximately 1,600 million hectares of cropland.[175] Relative to this total, the same target would require between 0.05% and 0.34% of cropland. Even under the highest (and somewhat unrealistic in practice) land-use scenario assessed (wheat), the requirement is around one-third of one percent of global cropland.

Table 6-4: Land required for a 10% bio-based feedstock target, as a share of EU farmland and of world cropland.

Feedstock crop	Land needed (kha)	Share of EU farmland	Share of world cropland
Sugar beet	864	0.55%	0.05%
Sugarcane	918	0.58%	0.06%
Corn	2,019	1.29%	0.13%
Wheat	5,409	3.45%	0.34%

Supply Runs Out Before Land Does

This report reaches a similar conclusion from a different line of evidence. The EU produces approximately 295 million tonnes of crop residues each year, of which an estimated 146 million tonnes

[174]Eurostat (2023) *Farms and farmland in the European Union: statistics*. Luxembourg: Statistical Office of the European Union. EU-27 utilised agricultural area is approximately 156 million hectares.

[175]Food and Agriculture Organization of the United Nations (2025) *Land statistics 2001 to 2023: global, regional and country trends*. FAOSTAT Analytical Brief 107. Rome: FAO. doi:10.4060/cd5765en. World total agricultural land in 2023 was approximately 4,800 million hectares, of which cropland accounted for approximately 1,600 million hectares and permanent meadows and pastures for approximately 3,200 million hectares. Cropland is used as the comparator here because feedstock crops are grown on cropland, not pasture.

could be collected without depleting soil carbon.[176] Separate analysis suggests that, by 2050, around one-fifth of the chemical sector's carbon demand could be met from biomass without displacing food or feed production. [177]

The more immediate constraint is therefore production capacity, not land availability. Current EU bio-based polymer capacity falls well short of what would be required to meet a 5% packaging target, let alone a 10% target. On the evidence reviewed, production capacity (see Section 4.4) would be exhausted before land availability became a limiting factor. Land therefore does not appear to constrain a packaging target at the scale considered here.

Where Land Constraints Become Important

Land availability can constrain the use of bio-based feedstocks, but the constraint emerges at much larger scales than those considered for packaging targets.

The Scale at which it Bites

Peer-reviewed research estimates that meeting global chemical-sector demand entirely from biomass in 2050 would require approximately 463 million hectares of land.[178] This is comparable to current estimates of unused productive land worldwide. At that scale, land availability becomes a significant constraint on further expansion.

This is why net-zero transition scenarios do not rely on biomass alone. Across 24 scenarios drawn from 15 studies, biomass supplies around one-fifth of chemical-sector feedstock demand in 2050, with recycling and carbon capture providing the remainder. [179]

Converting all EU plastic packaging to bio-based feedstocks would require approximately 9.2 million hectares of land, equivalent to around 0.6% of global cropland.[180]

A tonne of bio-based polyolefin needs about two and a half times the land of a tonne of bio-based polyester. At a 10% target that gap is too small to matter: both sit well under 1% of world cropland. It starts to matter only if bio-based feedstock grows to cover most of the packaging market, and at that point it is the polymer mix, not the target, that decides how much land is involved.

This is not a ranking of polymers and it is not an argument for one over another. It sets out how far bio-based plastics can grow before land becomes a real conversation.

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[176]European Commission, Joint Research Centre (2023) *Biomass production, supply, uses and flows in the European Union: an integrated assessment*. Luxembourg: Publications Office of the European Union. Agricultural residue production is estimated at approximately 295 Mt dry matter per year. See also Monforti, F. et al. (2015) 'Optimal energy use of agricultural crop residues preserving soil organic carbon stocks in Europe', *Renewable and Sustainable Energy Reviews*, 44, pp. 519 to 529.

[177]Carus, M. et al. (2025) *Is there enough biomass to defossilise the chemicals and derived materials sector by 2050?* Renewable Carbon Initiative / nova-Institut.

[178]Gabrielli, P., Rosa, L., Gazzani, M., Meys, R., Bardow, A., Mazzotti, M. and Sansavini, G. (2023) 'Net-zero emissions chemical industry in a world of limited resources', *One Earth*, 6(6), pp. 682 to 704. doi:10.1016/j.oneear.2023.05.006. Table 1 reports the land requirement for the biomass route in 2050 as 4,628 thousand square kilometres across ammonia, methanol and plastics combined. Available land is the difference between the highest estimate of unused productive land (56,500 thousand square kilometres) and land already used by human activity (52,000 thousand square kilometres).

[179]Harrandt, S. et al. (2024) *Evaluation of Recent Reports on the Future of a Net-Zero Chemical Industry in 2050*, as cited in Carus, M. et al. (2026) *Support for bio-based feedstock in plastic packaging: analysis under the Packaging and Packaging Waste Regulation (EU) 2025/40*. Hürth: nova-Institute. The assessment covers 24 scenarios drawn from 15 studies.

[180]Land intensities as footnote 2, scaled to higher substitution levels on the same packaging baseline.

The Climate Benefits of Switch from Fossil to Bio-based

The demonstrator estimates avoided greenhouse gas emissions under three end-of-life scenarios for three polymer mixes, which range from approximately 8.2 to 8.6 million tonnes of CO_2e. The results are remarkably consistent across all scenarios. Across the nine combinations of polymer mix and end-of-life assumption, the variation is less than 5%.[181]

The end-of-life scenarios are:

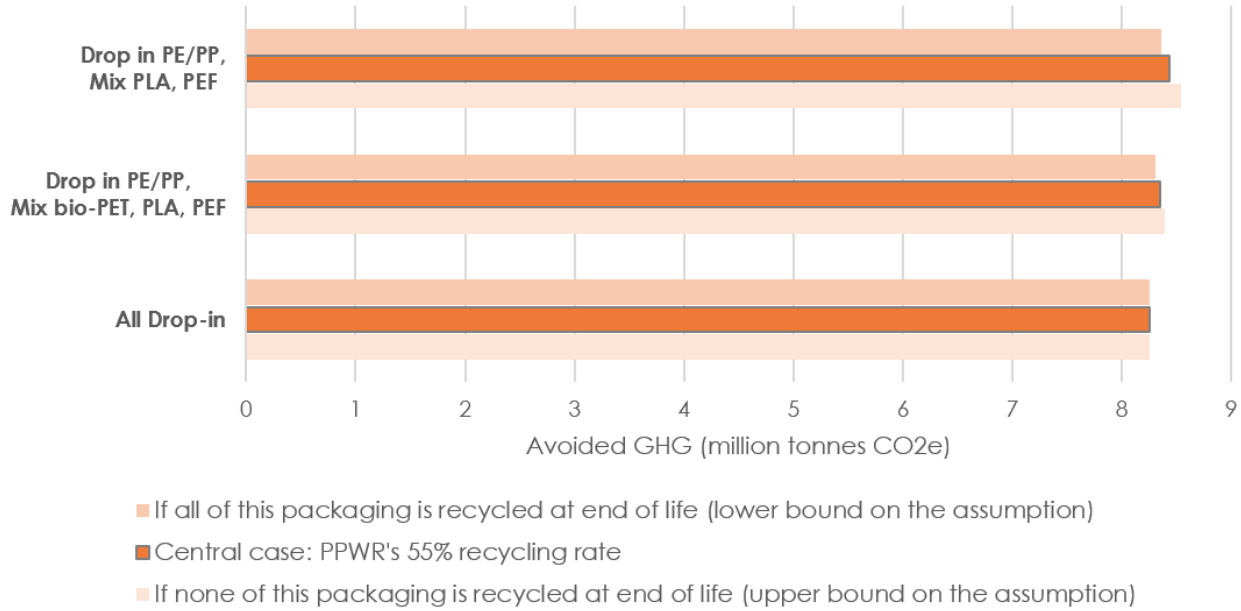
- 100% recycling;
- 100% incineration; and
- a central case based on a 55% recycling rate.

The central case used in this assessment reflects the EU's existing recycling target. Under the PPWR, Member States must recycle at least 55% of plastic packaging waste by weight by 31 December 2030. While this target applies to plastic packaging generally rather than bio-based packaging specifically, it provides a reasonable basis for the analysis.

The polymer mixes differ only in the polyester component. In all cases, polyethylene and polypropylene are supplied by bio-based PE and PP. The variation lies in the PET share, which is represented by: (1) bio-PET alone, (2) a combination of bio-PET, PLA and PEF, or (3) PLA and PEF only.

The climate benefits of switching to bio-based plastics depend more on what happens to the packaging at end of life, than on the material itself. As discussed in Section 4.5, this issue is important because the relative climate performance of fossil and bio-based plastics depends on whether the carbon contained in the packaging is released. If both materials are recycled, neither has yet released its carbon to the atmosphere, making a factory-gate comparison appropriate. If both are incinerated, the fossil route releases carbon that was previously stored underground, whereas the bio-based route returns carbon that was absorbed from the atmosphere during biomass growth.

Figure 6-5: Avoided greenhouse gas by polymer mix and end-of-life assumption, 10% target



[181] Per-polymer avoided greenhouse gas is calculated as fossil cradle-to-gate plus fossil end-of-life, minus bio-based cradle-to-grave, weighted by the packaging polymer composition and applied to a 10% feedstock target on the 21,300 kt packaging baseline. Fossil comparators are per-polymer and location-specific (ecoinvent 3.11, EF 3.1). Bio-based figures sit predominantly on ecoinvent 3.9 and 3.9.1; comparing across versions can overstate the bio-based advantage, and that caveat applies here.

Two factors explain why the results vary so little across scenarios:

- **First, the drop-in polymers are chemically identical to the fossil polymers they replace.** As a result, they displace the same end-of-life emissions as their fossil counterparts. Changes to the end-of-life assumption therefore have little effect on the comparison. This is why the all-drop-in scenario produces the same result whether the packaging is assumed to be recycled or incinerated.

- **Second, the polyester component accounts for only around one-fifth of the packaging covered by the target.** Even where climate impacts differ between polyester options, the effect on the overall result is limited.

The practical implication is that the climate benefits of a 10% feedstock target are relatively insensitive to these assumptions. The overall result does not depend strongly on the recycling rate assumed, nor on the choice of polyester used to meet the target.

Some scenarios containing PLA and PEF show slightly greater greenhouse-gas savings under the incineration assumption than under the recycling assumption. This result may appear counterintuitive, but the effect is primarily driven by the fate of the fossil comparator, rather than by the recyclability or recycling performance of the bio-based polymers.

As the scenarios do not model polymer-specific end-of-life routes and do apply a uniform recycling rate, **the difference does not imply that incineration performs better than recycling.** When packaging is incinerated, fossil polymers release carbon that was previously stored underground. Avoiding those emissions contributes to the apparent benefit of the bio-based alternative. Because polyolefins contain a high proportion of carbon, this effect is relatively large.

Under the recycling assumption, those end-of-life emissions do not occur for either material. The comparison therefore depends primarily on the emissions associated with producing each polymer. In this case, PLA and PEF contain less embedded carbon than PET, resulting in slightly smaller calculated savings. As noted above, the drop-in polymers show no such variation because they are chemically identical to the fossil polymers they replace.

Issues, Complications and Oversimplifications

The first-generation feedstock figures used for land are a deliberate upper bound, not a sourcing forecast. In practice, a diversified portfolio of feedstocks and technologies would be expected to be used, rather than a single feedstock pathway. Sugar beet, corn and wheat all sit under the sustainability criteria and crop limits of the recast Renewable Energy Directive,[182] which steer the European trajectory toward second-generation and waste feedstocks that fall outside this crop table and carry a different, generally lower, land signature. Those routes are a Phase 2 refinement.

The 55% recycling rate is a national aggregate across all plastic packaging, not a rate specific to bio-based polymers, and applying it uniformly here is a simplification worth flagging. In practice, PLA and PEF face a harder path to that rate than the drop-in polyolefins do. PLA is a known contaminant in PET recycling streams today, and dedicated collection for PLA or PEF does not exist at scale. Figure 6-5 shows this matters little for the climate result, because the recycled and incinerated bounds sit within a few percent of each other. It matters more for the circularity objectives the PPWR pursues alongside its feedstock provisions, and it belongs there rather than here.

Recycling defers when carbon is released rather than eliminating the release altogether, and the demonstrator's recycling bound should not be read as claiming permanent storage. Recognised carbon accounting conventions (e.g. ILCD, PAS 2050, GHG Protocol) typically apply a ~100-year assessment horizon and treat carbon storage as time-dependent, with finite-duration storage generally considered temporary and not equivalent to permanent removals. The recycling bound is therefore best read as one end of a genuine range, not as a claim that recycling removes the emissions question entirely.

[182] Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (recast), as amended by Directive (EU) 2023/2413, Article 29 and the associated limits on food and feed crop feedstocks.

Eutrophication is an environmental impact category in which bio-based plastics have the potential to perform less favourably. It is driven primarily by fertiliser use during feedstock cultivation. As a result, eutrophication may increase with feedstock demand, meaning the same polymer characteristics that increase land requirements also have the potential to increase nutrient-related impacts.

Taken together, the land-use and greenhouse-gas results do not identify a constraint on a target at this scale. The climate benefits are substantial and vary little across the polymer mixes assessed. Land requirements remain small under all feedstock scenarios and relative to the land available.

The connection between the two becomes more important at higher levels of bio-based feedstock use. Polymers that require more biomass per tonne of output tend to have higher land-use and nutrient-related impacts, and therefore influence the scale at which land availability becomes a meaningful constraint. **That consideration is more relevant to the long-term expansion of bio-based feedstocks than to the initial target assessed here.**

What This Needs to Settle in Phase 2

An open policy question is whether compliance should be steered toward more land-efficient polymers through differentiated targets or incentives, or whether producers should be allowed to meet a common target using the least-cost options available. At a 10% target, the choice has little effect on either greenhouse-gas emissions or land use. Climate benefits are similar across all polymer mixes assessed, and all remain well within the land available.

The choice becomes more significant at higher levels of bio-based feedstock use. Polymers that require less biomass per tonne of output allow a given quantity of feedstock to support more production. **The argument for a technology-neutral approach is therefore primarily about near-term deployment and supply availability rather than environmental performance.** As feedstock use expands, the environmental implications of polymer choice are likely to become more important.

The finding that a factory-gate greenhouse-gas comparison is effectively equivalent to a full life-cycle assessment for drop-in polymers—provided bio-based and fossil packaging receive the same end-of-life treatment—is important for future standard design. **Because drop-in bio-based polymers are chemically identical to their fossil counterparts, the bio-based route displaces exactly the carbon the fossil route would otherwise release.** Renewable energy policy already applies a similar logic, assessing biofuels at the point of production rather than tracking emissions after combustion. A comparable factory-gate approach could therefore be justified for drop-in packaging polymers, provided it is coupled with feedstock sustainability requirements similar to those in RED III Article 29.

The case is less straightforward for dedicated polymers, as their overall performance depends more heavily on end-of-life outcomes. **Nevertheless, the evidence points in the same direction: across all scenarios tested, bio-based dedicated polymers deliver GHG savings relative to fossil alternatives**. While a factory-gate assessment does not capture the full picture, it provides a reliable indication of climate benefit and may offer a proportionate evidential standard at this stage, avoiding a significantly greater reporting burden for dedicated polymers than for drop-in materials. Whether more granular performance thresholds become appropriate as the evidence base matures is a question for Phase 2.

Two-stage instrument design; Proposal for Phase 2

The study proposes a two-stage GHG framework. Stage 1, implementable now, is a mandatory harmonised cradle-to-gate LCA disclosure as a condition of compliance credit: every producer claiming bio-based feedstock publishes a verified LCA following a Commission-specified methodology, without needing to meet a threshold. This builds the evidence base without requiring methodological consensus that does not yet exist. Stage 2, once the JRC methodology and CEN standardisation are settled, introduces a binding GHG threshold calibrated against the Stage 1 data – which considers the incorporation of relevant RED III rules, such as cascading use hierarchy and co-product allocations. The critical design requirement is that the delegated act include an explicit review clause with a defined date, methodology condition and data condition, so that Stage 1 is transitional rather than permanent.

Parallel to this, feedstock sustainability criteria are used to ensure land use and other upstream impacts are minimised, similarly to RED III implementation.

7.0 Phase 2 Scope – Other Priority Sectors and Open Design Questions

The packaging demonstrator establishes the method: define the instrument and its legal architecture, quantify the demand signal, test the consumer cost impact against tolerated volatility, estimate the land footprint with sustainability caveats, and frame the GHG case in two stages.

Phase 2 applies this method to the remaining priority sectors, each of which has a different legislative hook and a different polymer profile, so the demonstrator design differs by sector even though the analytical steps are the same. No quantification is attempted at Phase 1 stage; this section confirms, for each sector, the hook, the polymer profile, the data sources already offered by consortium members, and the model that carries the sector.

Table 7-1: Priority Sectors in Phase 2

Sector	Primary hook and window	What the Phase 2 demonstrator covers
Textiles	ESPR Annex I(i) textiles DA (~2027)	No recycled-content conflict (no synthetic textile-to-textile loop at scale); bio-nylon and bio-PET as examples of drop-in candidates; the first product category where the Annex I(i) bio-based parameter can be specified.
Construction	ESPR DA (~2029-30); CPR standards; EPBD	No Article 6 recyclability barrier, so a strong sector for dedicated and mature polymers; long lifetimes strengthen the biogenic carbon storage case; procurement-led demand.
Automotive	ELV Art. 55 review (~2032); ELV mass balance act (~2028)	Large-volume end market; castor-based PA11 drop-ins dominate regardless of policy design; near-term priority is mass balance coherence between ELV, PPWR and ESPR.

7.1 Why Each Sector Needs a Different Entry Point

Textiles is the cleanest first demonstrator because bio-based feedstock and recycled content do not compete for the same tonnes: there is no synthetic textile-to-textile recycling loop operating at scale, so a bio-based feedstock-use parameter does not cut across a recycling obligation. **The ESPR Annex I(i) textiles delegated act, expected around 2027, is the first product category in which a bio-based feedstock-use parameter can be specified directly, which makes textiles the natural place to prove the parameter design.** Examples of drop-in candidate polymers for textiles include drop-in bio-PET and bio-based polyamide (bio-nylon), both chemically identical to their fossil comparators and therefore less influenced by end-of-life assumptions (see the drop-in point in Section 4.5). Phase 2 will settle the scope of polymers to be run primarily through Model 3 for textiles (demand by sector and target level) to size the signal, with Model 1 (green cost premium and bridgeability) testing affordability at garment level. As of mid-2026 the polymer split and consumption baseline still depend on sector data not yet held by the project team, with Plastics Europe sector consumption data the key outstanding input.

Construction suits dedicated and mature bio-based polymers because it does not carry a PPWR Article 6 style recyclability barrier, so materials not designed for closed-loop recycling are not disadvantaged at the design stage. **Long product lifetimes give construction the strongest biogenic carbon storage case of the three sectors, which links the feedstock-use target (M04) to the carbon storage credit instrument (M13) and the EPBD lifecycle framework.** In line with the Phase 1 scope decision, the construction demonstrator is limited to polyurethane (PUR), epoxy, polyamide (PA) and drop-in PE and PP, rather than the full construction polymer set. Demand here is procurement-led, so the sector is carried by Model 3 alongside the GPP for bio-based construction products instrument (M05), with UPM

polymer cost data offered as an input. The primary hooks (the ESPR delegated act expected around 2029 to 2030, CPR standards and the EPBD) open a later window than textiles.

Automotive is a large-volume end market in which castor-based polyamide drop-ins already dominate the bio-based share, largely independent of policy design, which shifts the near-term Phase 2 question away from demand stimulation. **The immediate priority in automotive is mass balance coherence: ensuring the accounting rules under the ELV Regulation, PPWR and ESPR treat the same bio-based tonnes consistently, so a producer is not asked to certify the same material three different ways.** The relevant windows are the ELV mass balance implementing act (expected around 2028) and the ELV Article 55 review (expected around 2032), the latest of the three sector windows. Phase 2 runs automotive through Model 2 (supply availability) and Model 3 (demand), with the coherence work handled through the legal analysis rather than the quantitative models, and Borealis automotive market data offered as an input.

7.2 The Design Questions Phase 2 Must Resolve

The instrument architecture in Section 5.4 rests on a single pragmatic option, but several design choices within it are not yet settled. On some the study already leans in a clear direction and Phase 2 operationalises it; on others there is no settled position yet, and Phase 2 consultation and modelling are needed to reach one. This section flags both kinds honestly, because the questions without a current lean are often where the cross-sector modelling will do the most work.

A consistent principle runs through several of the positions below: where a design choice depends on methodology or standards that are not yet finalised, the study favours phased design, disclosure and adaptation first rather than hard-coding a figure or threshold that later has to be unpicked.

The questions below are the ones material enough to warrant attention; further operational questions will surface as instrument specification moves to delegated-act level.

Should the targets be bio-based specific, or defined around any non-fossil feedstock?

Whether demand-side instruments should be bio-based specific or defined around a broader category of non-fossil or renewable feedstocks is the most consequential unresolved design question. The two-level market failure argument supports a differentiated answer: the fossil cost advantage justifies intervention for all non-fossil pathways, while the bioenergy mandate asymmetry (biomass, unlike chemical recycling or CCU, faces competing demand from subsidised energy uses) justifies bio-based specificity for the instruments that correct that distortion.

Working position: feedstock-use targets and EPR fee modulation (M09) should be designed around a harmonised bio-based feedstock definition, because a generic non-fossil target cannot reach the bioenergy distortion; green public procurement criteria and lifecycle GWP based instruments (ESPR, EPBD, and IAA Article 16, which uses "sustainable carbon sources" rather than "bio-based" as its operative term) may operate on a broader renewable or low-carbon basis, which is more appropriate to their objective.

What should the targets be, and how should they interlock across sectors?

Target ambition is not yet settled, and because the study is cross-sector it is not only a question of what number each sector can bear but of how the targets interact through shared supply and staggered legislative timing. The biorefinery and allocation data now support ambition above 5% for packaging (see Section 6.0), but no specific level, glide path or review schedule is fixed.

Three dimensions need Phase 2 resolution:

- whether to set a common ambition level across sectors or calibrate each to its own cost sensitivity and supply position, since flexible film and construction polyurethane are not the same problem;
- how targets interact through overlapping bio-PET and drop-in supply, so that aggregate ambition across packaging, textiles, construction and automotive is constrained by total

availability in a way no single-sector target reveals, which is a question that only exists because the study looks across sectors;

- and how to sequence targets across the different legislative windows so they build a coherent demand trajectory rather than spiking then slumping the supply signal.

There is no settled position yet on any of the three; resolving the cross-sector interlinkage is one of the study's distinctive potential strengths.

Should EU chemical processing be a condition of market access, or an evaluation preference?

Chemical processing origin is analytically distinct from biomass origin and requires separate treatment. **Introducing an EU location preference during the demand-building phase risks channelling investment toward EU facilities rather than maximising the global capacity needed to meet EU demand, while deferring it to a post-scale trigger risks losing the industrial benefit entirely if capacity is built elsewhere first.** The IAA is instructive: for steel, concrete, aluminium and vehicles it sets Union origin requirements in procurement using the Union Customs Code last-substantial-transformation rule, which in chemical value chains typically falls at downstream conversion rather than polymer manufacture, so that rule would capture conversion but not the higher-value chemical processing stage that EU industrial policy is primarily seeking to support.

Working position: EU-based chemical processing (not feedstock origin) is the right geographic criterion, and the study leans towards an evaluation preference rather than a compliance mandate; a mandatory requirement would put the option in direct conflict with verified non-EU supply chains, including certified sugarcane bio-PE, and raises WTO exposure the study is not positioned to resolve at this stage. Four dimensions require Phase 2 resolution:

- timing (demand-building phase versus post-scale trigger);
- FTA partner treatment, consistent with the IAA's WTO GPA approach;
- the cost of an open global market versus a preference regime;
- and whether the Customs Code approach or a purpose-built origin definition is appropriate.

How should compliance be verified when physical segregation is not commercially viable?

Two compliance routes are appropriate, mirroring recycled content under the SUPD and PPWR. **Where feedstocks are physically segregated, bio-based content can be confirmed by radiocarbon (14C) analysis; where they enter mixed processing streams, physical segregation is not commercially viable at scale and mass balance chain-of-custody accounting is the appropriate methodology, with chemical connectivity as the boundary condition (bio-based carbon attributed only to products that chemically incorporate it).** 14C is an audit and enforcement tool rather than a practical primary mechanism: it is expensive, takes days, and gives misleading results for mass balance producers where bio-based carbon has been allocated to co-products.

Working position: For both routes the primary compliance evidence is third-party certification scheme documentation and audit trails.

Can materials-before-energy cascading survive contact with integrated biorefineries?

The materials-before-energy cascading principle has broad support as a directional objective, but its application is more complex where the same biorefinery stream serves both aviation fuel and chemical markets, as it does for several consortium members.

Working position: cascading is supported as a directional principle where feedstock can genuinely be directed to either use, but it is not appropriate as a categorical rule in integrated biorefinery contexts where chemical and fuel co-production is inherent to the process design. Phase 2 sustainability guardrail design develops the boundary conditions.

Should sustainability criteria be borrowed from RED III directly, or adapted for materials?

RED III Article 29 provides the most developed substantive framework for biomass sustainability in EU law, and its schemes (ISCC, REDcert, RSB) are already widely used in the bio-based supply chain. Direct cross-reference raises two problems: RED III's GHG thresholds are calibrated against fossil fuel energy comparators rather than materials feedstock comparators, and cross-reference would inherit future RED revisions without a specific decision about bio-based plastics.

Working position: RED III Article 29 criteria are the appropriate substantive basis, delivered through a purpose-built implementing act that adapts them for materials applications, rather than by direct cross-reference. Phase 2 develops this architecture and specifies scheme recognition criteria for both compliance routes.

Should a GHG performance threshold sit alongside the feedstock-use target, and when?

A feedstock-use target drives volume but does not by itself guarantee climate benefit, since a bio-based route with a weak lifecycle profile could satisfy the target while delivering little or no GHG emissions saving. **The study's position is that a GHG performance safeguard is warranted in principle, but a binding numerical threshold cannot responsibly be set until the underlying methodology and standards are in place, so the safeguard should be phased rather than imposed at once.**

The proposed architecture is disclosure first, moving to a relative threshold once the evidence base supports it: producers report the lifecycle GHG performance of the material against a defined comparator, which builds the dataset and the reporting discipline, and a binding threshold follows only when the JRC Plastics LCA methodology is settled and the CEN standardisation work is in place. Setting a binding threshold before those are ready would either lock in a comparator that is later revised, or penalise pathways on the basis of figures that are not yet methodologically robust.

What is not yet settled is the level at which any eventual threshold should bite, whether it should be absolute or relative to a fossil comparator, and which comparator basis to use, all of which depend on methodology decisions outside the study's control.

8.0 Conclusions and Handover to Phase 2

Phase 1 set out to establish whether the case for demand-side intervention holds, and what a workable instrument would look like. **The case does hold, and the broad shape of the instrument is now clear, even where some parameters remain to be determined.** The market failure is real and self-reinforcing: capacity has remained flat despite projected demand growth, the barrier sits primarily on the demand side, and voluntary demand has been unable to bridge the resin-level price premium observed. Left unaddressed, the gap is likely to persist.

Four conclusions form the core of the policy option:

1. **Feedstock use, rather than bio-based content, is the appropriate basis for a target**, consistent with the operative text of PPWR Article 8.

2. **Mass balance with chemical connectivity is the appropriate verification framework**, supported by two compliance routes: radiocarbon analysis where feedstocks are physically segregated, and mass-balance chain-of-custody accounting where they are not.

3. **EU chemical processing and conversion, rather than feedstock origin, is the most appropriate geographic criterion**, with a preference for evaluation incentives rather than a binding compliance requirement.

4. **A phased greenhouse gas safeguard is the preferred approach**: lifecycle performance is disclosed initially, with any binding threshold introduced only once the JRC methodology and CEN standards are established.

The packaging demonstrator serves three purposes and supports each of them.

1. It demonstrates a methodology that can be transferred to other priority sectors: define the instrument and legal basis, size the demand signal, test affordability, estimate land requirements, and assess greenhouse gas impacts.

2. **It shows that a 10% bio-based feedstock target for packaging is both meaningful and achievable.** The resin-level premium is substantial, but translates into a retail cost increase of as little as 0.05%, well within the volatility already absorbed from fossil price movements. A mandate can therefore close a gap that voluntary demand has not been able to bridge, at negligible cost to consumers. On that basis, 10% represents a credible starting point. The appropriate level for other sectors, interactions between sectors, and implementation details remain Phase 2 questions.

3. **Land use does not constrain a target at this scale.** Land demand is determined primarily by polymer chemistry and crop choice, not by whether a polymer is classified as drop-in or dedicated. Polyolefins derived from plant sugars require around two and a half times more land than polyesters, while crop selection has an even larger effect. Even so, a 10% packaging target would require approximately 0.5% to 3.5% of EU farmland, or as little as 0.05% of global cropland. Production capacity becomes a constraint well before land availability.

4. **The greenhouse gas case is strong and consistent across all scenarios tested.** Switching to bio-based feedstocks reduces GHG emissions across every polymer mix and end-of-life pathway assessed. At a 10% target, estimated savings remain stable at approximately 8.2–8.6 million tonnes of CO_2e per year, with less than 5% variation across all nine combinations modelled. The climate benefit therefore does not depend on recycling rates or on which polymers producers choose for compliance. What varies is confidence rather than magnitude: estimates for drop-in polymers are the most robust because they are chemically identical to the fossil materials they replace, while estimates for dedicated polyesters rely on a less mature evidence base.

Taken together, the land and climate findings point in the same direction. The drop-in polyolefins provide the most robustly evidenced climate benefit, but are also the most land-intensive. At a 10%

target this distinction has little practical significance. The climate benefit is realised regardless of polymer choice, and land requirements remain modest across all options. The difference becomes more important only at much higher levels of bio-based feedstock use, where finite biomass resources must be allocated more efficiently.

Whether policy should steer compliance towards more land-efficient polymers, or leave that choice to the market, is a legitimate design question. However, it is more relevant to large-scale market expansion than to the initial packaging target considered here.

Phase 1 also identifies the questions that remain open. Target levels beyond packaging, interactions between sectors competing for the same feedstocks, and the appropriate level for any future greenhouse gas threshold have not yet been determined. These are the issues that Phase 2 modelling and stakeholder consultation are intended to resolve.

Phase 1 establishes the problem, the policy architecture, and the analytical method. It shows that packaging can move now. Phase 2 will translate that architecture into calibrated policy specifications across packaging, textiles, construction and automotive applications.

Appendix

A.1.0 Priority Screening Assessment

Sectors Outside the Priority Set

Electrical and Electronics

Electronics is excluded on legislative hook grounds, not analytical grounds. Bio-based epoxy and PA are commercially available for this sector's dominant polymer types, but no ESPR delegated act with a bio-based parameter is currently active or in preparation for electronics products.

The ESPR working plan 2025 to 2030 covers electronics products but focuses on energy performance and hazardous substances, intersecting with WEEE and RoHS rather than with a bio-based feedstock-use parameter. The Annex I(i) bio-based content provision has not been activated for any electronics product group. The sector is flagged as a candidate for inclusion in a future study phase if ESPR scope expands.

Agriculture

Agriculture is excluded from study scope. The primary policy parameter for agricultural bio-based films (PBAT and PHA mulch films) is soil biodegradability, not feedstock origin, placing this sector outside the feedstock-use framework the study addresses.

Household Goods and Other Sectors

No near-term legislative hook equivalent to the four priority sectors has been identified for household goods and other residual applications. The mixed polymer profile also makes instrument architecture more complex than for sectors with a clearer dominant polymer set. These sectors are background context for the study.

The four priority sectors are characterised in further detail in Table 8-1 which sets out their market context, primary legislative vehicle and key features relevant to instrument design.

Table 8-1: Screening assessment for priority sector selection

Sector	Fossil demand (Mt/yr)	Bio-based substitution options	Active legislative hook (2025-2032)	Structural barriers	Study priority
Packaging	~177	Bio-PE, bio-PET (partial and full), bio-PP, PLA, PHA, PEF: commercially available; recycling-compatible in drop-in applications	PPWR Art. 8 (2028 review); Art. 6(7) EPR modulation; Art. 6(10) dedicated polymer derogation; Art. 12 labelling	None for drop-in route. Dedicated polymers require Art. 6(10) recyclability derogation.	**Near-term priority**
Textiles / Fibres	~28 (H&T combined)	Bio-nylon, bio-PET, bio-PTT, CA, PEF, PLA fibres: commercially available at varying scales. Fibres are the largest single bio-based market segment globally (28% of bio-based production)	ESPR Annex I(i) textiles DA (~2027); named in Bioeconomy Strategy; preparatory MEErP study active	No synthetic textile-to-textile recycling loop at scale; no recycled content conflict	**Near-term priority**
Building and construction	~73	Bio-PUR, bio-epoxy, bio-PA, bio-PE/PP: commercially available. Bio-PVC: not commercially available	CPR standardisation (2026); ESPR construction products DA (~2029-30); EPBD lifecycle GWP; IAA Art. 11 GPP	PVC structural gap (pipes, profiles, flooring): no commercial bio-based equivalent. Scope limited to PUR, epoxy, PA and drop-in PE/PP	**Near-to-medium term priority**

Sector	Fossil demand (Mt/yr)	Bio-based substitution options	Active legislative hook (2025-2032)	Structural barriers	Study priority
Automotive	~32	PA11, bio-PA6/66, bio-PUR, bio-PP, bio-PE: commercially established for interior and under-bonnet applications	ELV Art. 55 bio-based review (~2032); ELV mass balance implementing act (~2028)	Safety and durability constraints in structural/safety-critical components; non-structural applications present lower barriers	**Medium-term priority**
Electrical and electronics	~28	Bio-epoxy, bio-PA: commercially available for dominant polymer types. Technical potential not activated by policy	No active ESPR DA with bio-based parameter. Working plan 2025-2030 focused on energy performance and hazardous substances (WEEE/RoHS)	No overriding technical barrier; WEEE/RoHS substance restrictions add design complexity	**Not included: no current hook**
Agriculture	~16	PBAT, PHA mulch films: available. Biodegradability in soil is the operative performance requirement	No near-term hook with feedstock-use parameter; end-of-life performance is the policy parameter	Different regulatory logic; excluded from study scope from the outset	**Excluded from scope**
Household and other	~43 (other)	Mixed polymer profile; bio-based options exist for specific applications but no dominant polymer type	No near-term dedicated hook; potential future ESPR coverage	No overriding structural barrier	**Not included: no near-term hook**

Note: fossil demand figures are global totals from Houssini et al. (2025), SI Dataset 2, Tab2-3. Bio-based production segment shares from Carus et al. (April 2026), Figure 10, p.20.

A.2.0 Policy Landscape Matrix: Rationales

Key: P = primary lever or direct hook | R = review clause or conditional proposal power | S = secondary or indirect relevance | Y = active design window in 2026 | blank = not relevant

Bio-based Feedstock Content Targets

Instrument	Score	Rationale
CEA	P	The CEA is the overarching framework instrument for lead markets. Its design is still open but it is expected to set binding demand-side instruments including bio-based content requirements for product categories beyond packaging. Multiple Member State position papers submitted to the consultation explicitly called for minimum bio-based content targets under the CEA architecture. Primary lever because it is the top of the instrument hierarchy for this measure type.
Bioeconomy Strategy / Biotech act 2	P	The Bioeconomy Strategy (COM(2025) 960) explicitly commits to adopting criteria and targets for bio-based plastics under PPWR in 2027, one year ahead of the Article 8 statutory deadline, and names ESPR textiles and furniture delegated acts as delivery vehicles. The Strategy does not itself legislate targets, but it is the primary political mandate that makes those targets politically unavoidable. The Biotech Act 2 can legislate targets, and the call for evidence gives mandatory minimum content requirements as an example pull measure that can be introduced. P rather than S because it is the source of the binding commitment, not merely relevant to it.
PPWR	R	PPWR Article 8(2) creates a conditional legislative proposal power: if the review finds bio-based plastics technically ready and environmentally beneficial, the Commission shall present a proposal for sustainability requirements and targets. This is a review clause (R), not a target itself. The targets do not yet exist in the PPWR text and will require a new legislative proposal and full co-decision to introduce. R is accurate.
ESPR	P	ESPR Annex I(i) explicitly names "use or content of sustainable renewable materials" as a product parameter for delegated acts. Recital 24 confirms bio-based content performance requirements are within scope. This is a confirmed legal basis that is directly operable through delegated acts without primary legislation amendment. P is correct.
ELVR	R	ELV Article 55 mirrors PPWR Article 8 in structure: the Commission must review bio-based plastic content in vehicles within 72 months of entry into force and present a conditional legislative proposal. Same structure as PPWR: review clause, not a target. R is correct.
CPR	S	CPR Article 15(3)(a) and Annex II sets out the requirement to measure environmental performance per the harmonised technical specifications, set by the Commission. Under Annex III, the harmonised technical specifications can include product requirements including sustainable sourcing and minimising life-cycle greenhouse gas emissions. Bio-based feedstock may be used as a route to achieve this. S is correct.
IAA	S	IAA Article 16 empowers delegated acts for demand-side measures for chemicals from sustainable carbon sources. This is broader than bio-based-specific content targets and the operative term is "sustainable carbon sources" not "bio-based." It is relevant because bio-based plastics intermediates qualify under that definition, but it is not a primary bio-based content target lever in the same sense as PPWR Art. 8 or ESPR Annex I(i). S is defensible. Could argue R given the conditional delegated act power, but S seems more accurate given the breadth of the definition.
ETS/CBAM		The ETS creates a cost signal (zero emissions factor for biogenic carbon) but does not set bio-based content targets for products. CBAM may affect the fossil/bio-based cost differential if it is extended to plastics, but this is speculative and not yet in scope. Blank is correct.
SUPD		The SUPD implementing act is specific to recycled content targets for single-use plastic products. It has no bio-based content target provisions. Blank is correct.
RED III		RED III does not set bio-based content targets for plastic products. It sets renewable energy and fuel targets. Its Article 29 sustainability criteria are cross-referenced in PPWR

		Art. 8 and ELV Art. 55 but as sustainability guardrails, not as content targets. Blank is correct.

Sustainability Requirements

Instrument	Score	Rationale
CEA	S	The CEA is expected to set overarching sustainability criteria for lead market instruments, but it is primarily an architecture instrument rather than a sustainability criteria instrument. Its sustainability requirements will cross-reference existing frameworks (RED III, ESPR LCA). S rather than P because the primary sustainability criteria for bio-based plastics are established in RED III and cross-referenced in PPWR/ELV, not originated in the CEA.
Bioeconomy Strategy / Biotech Act 2	P	The Bioeconomy Strategy is the primary source of the political commitment to apply feedstock sustainability criteria to bio-based plastics. It establishes the framing that bio-based plastics must meet sustainability standards consistent with the broader bioeconomy framework. It cross-references RED III Article 29 throughout. Biotech Act 2 call for evidence notes that the impact assessment will explore sustainability criteria for biomass, similar to the criteria set out for bioenergy use. P because it sets the political mandate for sustainability requirements even though RED III provides the technical criteria.
PPWR	P	PPWR Article 8(1) explicitly requires the Commission review to assess bio-based feedstock sustainability, and Article 8(2) requires any legislative proposal to include sustainability requirements. RED Article 29 criteria are cited directly in the Article 8 text.
ESPR	P	ESPR requires lifecycle assessment (LCA) and PEF methodology for delegated acts that include performance requirements. Any ESPR delegated act specifying bio-based content parameters will need to demonstrate whole-lifecycle sustainability.
ELVR	R	ELV Article 55 requires a Commission review of bio-based plastic content and cross-references RED Article 29 sustainability criteria explicitly. Like PPWR, the sustainability requirements would only apply if a legislative proposal follows from the review. R (conditional on legislative proposal) rather than P.
CPR	P	CPR establishes the requirement to report sustainability performance against harmonised technical specifications (Article 15(3)(a) and Annex II). Article 82 states that financial incentives must only target the highest two classes of (environmental) performance. P because CPR prioritises sustainability requirements and performance – via reporting and fiscal incentives – within primary legislation.
IAA	S	IAA Article 16 criteria include contribution to climate neutrality, which is a sustainability dimension. But sustainability requirements for bio-based feedstocks are not the primary purpose of IAA Art. 16.
SUPD		The SUPD implementing act for recycled content does not include bio-based sustainability requirements. However, the SUPD framework more broadly has end-of-life and recyclability sustainability dimensions that are indirectly relevant to how dedicated bio-based plastics interact with recycling targets.
RED III	P	RED III Article 29 sustainability criteria are the primary technical sustainability framework for bio-based feedstocks in EU legislation. They are cross-referenced directly in PPWR Article 8 and ELV Article 55. P is correct and arguably the most important P in this row.

Harmonised Definitions / Standards

Instrument	Score	Rationale
CEA	S	The CEA may establish overarching definitions for its lead market instruments, which could include a bio-based content definition. But it is not the primary standardisation vehicle — that is ESPR and the CEN/CENELEC/JTC 24 process.

Bioeconomy Strategy / Biotech Act 2	S	The Bioeconomy Strategy calls for harmonised definitions and measurement frameworks but does not itself create them. It points to ESPR and CEA as the delivery vehicles. There is no clear evidence that the Biotech Act 2 will set out harmonised definitions/standards, even if the call for evidence notes the impact assessment is to assess market harmonisation tools.
PPWR	S	PPWR Article 3 defines "bio-based plastic packaging" but the definition is minimal and does not resolve the measurement and chain-of-custody questions. The Article 8 review may lead to a more operational definition in a legislative proposal, but it does not currently create one.
ESPR	P	ESPR is the primary vehicle for harmonised bio-based content definitions through two mechanisms: (1) each delegated act must specify how the Annex I(i) "sustainable renewable materials" parameter is measured, which forces definition; and (2) ESPR Digital Product Passport requirements mandate data standards that require defined bio-based content measurement. The JRC DPP Methodology (2026) explicitly identifies the absence of a harmonised definition as a primary barrier.
ELVR		The ELV Regulation does not create bio-based content definitions. Its mass balance implementing act (Art. 6(5)) is relevant to measurement methodology but is in the mass balance row, not this one.
CPR	S	The Commission's Working Plan 2026-2029 (COM/2025/772 final) states that CPR's implementation will align with the Bioeconomy Strategy and ESPR. S is correct as the Plan aims for DPP reporting to be harmonised with the primary lever set out under ESPR.
IAA		The IAA uses "sustainable carbon sources" as its operative term but does not harmonise the definition of bio-based content for product labelling or target purposes.
ETS/CBAM		No bio-based content definition role..
SUPD		The SUPD implementing act defines a mass balance methodology for recycled content, not bio-based content. Not relevant to this row..
RED III		RED III defines sustainability criteria for biomass feedstocks but not bio-based content measurement for product labelling purposes. Its criteria are relevant to sustainability guardrails but not to the harmonised definition of what counts as bio-based content in a product.

Lead Markets / GPP Criteria

Instrument	Score	Rationale
CEA	P	The CEA is the primary instrument for EU lead market architecture. It is expected to set binding GPP minimum requirements and lead market instruments across product categories. This is its core purpose.
Bioeconomy Strategy / Biotech Act 2	P	The Bioeconomy Strategy establishes the Bio-based Europe Alliance with a EUR 10 billion bio-based materials procurement commitment by 2030. It explicitly frames bio-based plastics as a lead market priority. The Biotech Act 2 call for evidence notes that the impact assessment is to assess the creation of lead markets to stimulate market uptake, and notes plastics and polymers as potential lead markets.
PPWR		PPWR does not have GPP or lead market provisions. Article 47(4) has a public procurement reference for sustainable packaging but it is narrow.
ESPR	S	ESPR performance requirements in delegated acts effectively create lead market demand by requiring products to meet bio-based content standards, which indirectly stimulates procurement of bio-based materials. But ESPR is not itself a GPP instrument
ELVR		No GPP provisions in the ELV Regulation relevant to bio-based content.
CPR	P	CPR Article 83 mandates minimum environmental sustainability requirements for construction products used in public contracts.

IAA	P	IAA Articles 11 and 12 create binding mandatory procurement criteria for low-carbon steel, cement, and aluminium — the direct architectural precedent for bio-based content GPP requirements. Article 16 delegated acts can replicate this for bio-based chemicals.
ETS/CBAM		No GPP role.
SUPD		No GPP role.
RED III		No GPP role for bio-based plastics.

Carbon Cost Signals for Bio-based

Instrument	Score	Rationale
CEA		The CEA does not directly create carbon cost signals.
Bioeconomy Strategy / Biotech Act 2		The Bioeconomy Strategy does not create carbon cost signals — it creates demand commitments and political mandates. The Biotech Act 2 evidence indicates alignment with the Strategy – demand pull measures but no carbon cost signals.
PPWR		PPWR does not create carbon cost signals.
ESPR		ESPR performance requirements can include GHG performance criteria but this is through lifecycle assessment rather than a direct carbon cost signal.
ELVR		No carbon cost signal provisions.
CPR	S	Under Annex III, the harmonised technical specifications can include minimising life-cycle greenhouse gas emissions. Harmonised technical specifications differentiate classes of performance per (and potentially across) product families. Article 82 states that financial incentives must only target the highest two classes of performance (per Articles 5(5) and 22(9)). Therefore, the CPR framework establishes a financial pathway to support products with better environmental performance, however, the metrics used to measure this performance are not finalised. S because carbon performance is not a confirmed consistent metric across product families, nor is it a standalone measure of overall performance.
IAA	S	The IAA creates demand for low-carbon materials in procurement, which creates an indirect carbon cost advantage for bio-based materials that qualify. This is S rather than P because the signal operates through procurement criteria, not through a direct carbon pricing mechanism.
ETS/CBAM	P	The ETS assigns a zero emissions factor to biogenic carbon from sustainably sourced biomass, creating a structural cost advantage for bio-based over fossil production at the energy use stage of manufacturing. CBAM, if extended to plastics in the 2030 scope review, would significantly alter the fossil/bio-based cost differential. P is correct as the primary carbon pricing mechanism relevant to bio-based production economics.
SUPD		No carbon cost signal role.
RED III		RED III creates demand signals for bioenergy and biofuels but not a carbon cost signal for bio-based plastics production specifically. Its effect on the cost of biomass feedstock (by creating competing demand from the energy sector) is actually a negative cost signal for bio-based materials.

Mass Balance / Chain-of-custody Framework

Instrument	Score	Rationale
CEA	S	The CEA will create lead market instruments including bio-based content requirements. Any such instrument will need a chain-of-custody and mass balance methodology to be enforceable. The CEA is likely to cross-reference whichever methodology ESPR or PPWR establishes first, rather than creating its own. S rather than P because it is a follower, not a first-mover, in methodology design. Not blank: the CEA design process is an opportunity to specify cross-referencing architecture explicitly rather than leaving it to later interpretation.
Bioeconomy Strategy / Biotech Act 2		The Bioeconomy Strategy calls for harmonised measurement frameworks but does not specify mass balance methodology. The Biotech Act 2 evidence does not specify mass balance methodology, either.
PPWR	P	Two grounds for P. First, PPWR Article 7(7) (due December 2026) is establishing the mass balance methodology for recycled plastic content — the direct institutional precedent for how PPWR handles the mass balance design problem. The choices made here (certification scheme recognition, audit requirements, chain-of-custody record-keeping, fuel-use exclusion handling, allocation of compliance obligations) will constrain what the bio-based equivalent under Article 8 can look like. Second, when the Article 8 legislative proposal is brought forward, it will require a comparable implementing act for bio-based content mass balance. PPWR is therefore both the immediate precedent context and the eventual host instrument for bio-based content mass balance rules.
ESPR	P	The ESPR textiles delegated act (2027) will likely be the first instrument in EU product legislation to require an operational bio-based content chain-of-custody methodology — ahead of the PPWR Article 8 legislative proposal, which requires a full review and co-decision process before targets apply. To specify a bio-based fibre content performance requirement under Annex I(i), the delegated act must either establish or cross-reference a verified measurement methodology. This makes ESPR the first-mover in bio-based content methodology design, not a follower. The ESPR DPP Tier 4 chain-of-custody documentation architecture reinforces this: it creates the infrastructure within which the methodology will operate.
ELVR	S	ELV Article 6(5) requires a mass balance implementing act for recycled plastic content calculation approximately 2028. Methodological coherence between the ELV recycled content mass balance and any bio-based content framework is an active cross-instrument design priority.
IAA	S	The IAA does not create mass balance or chain-of-custody frameworks for bio-based plastics but Art. 16 delegated acts will need methodology; will likely cross-reference ESPR/PPWR first-mover
ETS/CBAM		No mass balance role for bio-based plastics specifically.
SUPD		The SUPD implementing act (February 2026) establishes a regulatory mass balance methodology for chemical recycling of plastics — the first time mass balance has been legislated as a compliance mechanism for plastics product legislation. The SUPD methodology is specific to recycled content under WFD Article 3(17) and does not transfer to bio-based content accounting. Its significance for this study is as a precedent and analogy, not as a directly applicable framework.
RED III	S	RED III embeds mass balance as the operative chain-of-custody method throughout the renewable energy framework for biomass feedstocks. It is the most developed and legally established mass balance framework for biomass in EU law. Its methodology and certification scheme recognition (ISCC, REDcert, RSB) are directly relevant to how bio-based plastics mass balance should be designed. The nova-Institut DG Environment study (Carus et al., April 2026) explicitly includes mass balance via ISCC/RSB/REDcert as eligible for PPWR bio-based content targets. P is chosen because RED III provides the primary existing framework, but the study is explicit that adaptation is needed, not wholesale adoption.

A.3.0 Baseline Growth Trajectory

A.3.1 Current Production and Capacities

Table 8-2: Global Production and Capacities 2024

Polymer	Production 2024 (t)	Capacity basis	Util. rate	Capacity (t)	Spare cap (t)
Aliphatic polycarbonates (APC)	38,000	*Operating-rate estimate*	58%	65,517	27,517
Casein polymers (CP)	3,600	*Operating-rate estimate*	58%	6,207	2,607
Cellulose acetate (CA)	222,200	*Reported (prod = cap)*	100%	222,200	-
Epoxy resins	1,350,000	*Reported (prod = cap)*	100%	1,350,000	-
EPDM rubber	1,000	*Reported (prod = cap)*	100%	1,000	-
Polyamides (PA)	349,000	*Operating-rate estimate*	58%	601,724	252,724
PBAT	79,000	*Operating-rate estimate*	58%	136,207	57,207
PBS and copolymers	13,000	*Operating-rate estimate*	58%	22,414	9,414
Polyethylene (PE)	219,000	*Reported (prod = cap)*	100%	219,000	-
Polyethylene furanoate (PEF)	2,000	*Operating-rate estimate*	58%	3,448	1,448
Polyethylene terephthalate (PET)	70,000	*Reported (prod = cap)*	100%	70,000	-
Polyhydroxyalkanoates (PHA)	76,000	*Operating-rate estimate*	58%	131,034	55,034
Polylactic acid (PLA)	385,000	*Operating-rate estimate*	58%	663,793	278,793
Polypropylene (PP)	23,000	*Reported (prod = cap)*	100%	23,000	-
Polytrimethylene terephthalate (PTT)	270,000	*Operating-rate estimate*	58%	465,517	195,517
Polyurethanes (PUR)	411,000	*Reported (prod = cap)*	100%	411,000	-
Starch-containing compounds (SCPC)	76,000	*Operating-rate estimate*	58%	131,034	55,034
TOTAL (all polymers)	**3,587,800**			**4,523,097**	**935,297**
			avg	79%	

Table 8-3: EU Production and Capacities 2024

Polymer	Global Production 2024 (t)	Produced in EU?	EU rate	EU production (t)	Util. rate	Capacity (t)
Aliphatic polycarbonates (APC)	38,000	*No*	0%	**-**	58%	-
Casein polymers (CP)	3,600	*Yes (niche)*	25%	**900**	58%	1,552
Cellulose acetate (CA)	222,200	*Yes*	11%	**24,442**	100%	24,442
Epoxy resins	1,350,000	*Yes*	3%	**44,550**	100%	44,550
EPDM rubber	1,000	*No:*	0%	**-**	100%	-
Polyamides (PA)	349,000	*Yes*	21%	**73,290**	58%	126,362
PBAT	79,000	*Yes*	89%	**70,310**	58%	121,224
PBS and copolymers	13,000	*No*	0%	**-**	58%	-
Polyethylene (PE)	219,000	*Limited*	5%	**10,950**	100%	10,950
Polyethylene furanoate (PEF)	2,000	*Yes*	100%	**2,000**	58%	3,448
Polyethylene terephthalate (PET)	70,000	*No*	0%	**-**	100%	-
Polyhydroxyalkanoates (PHA)	76,000	*Yes (small)*	13%	**9,880**	58%	17,034
Polylactic acid (PLA)	385,000	*No: Futerro FR from 2030*	0%	**-**	58%	-
Polypropylene (PP)	23,000	*Yes (small)*	65%	**14,950**	100%	14,950
Polytrimethylene terephthalate (PTT)	270,000	*No*	0%	**-**	58%	-
Polyurethanes (PUR)	411,000	*Yes*	27%	**110,970**	100%	110,970
Starch-containing compounds (SCPC)	76,000	*Yes*	39%	**29,640**	58%	51,103
TOTAL (all polymers)	**3,587,800**			**391,882**		**526,586**
					avg	74%

Source: Production = nova Table 5 (Carus et al. 2026). Segment shares read from nova Fig.8 per-polymer chart (Carus 2026, p.30). EU capture rate = EU27+3 production as a share of global production for this polymer. Seeded from Fig.5 composition x 0.5 Mt, divided by global Table 5 production.

A.3.2 EU Bio-based Capacity Pipeline

Table 8-4: EU Bio-based Capacity Pipeline

Project / producer	Location	Feedstock / product	Additional EU Capacity	Probability weighting	Baseline relevance
Syclus	Geleen, Netherlands	Bio-ethanol to bio-PE	100 kt/year	50%	Capacity addition delayed from 2026 to 2030
Avantium	Chemie Park Delfzijl in the Netherlands	PEF	5Kt/year	100%	Capacity confirmed, scaling up
Futerro	Port Jerome, France	Plant starches to bio-PLA	75 kt/year	25%	Planning submitted; potential late-decade capacity
Blue Circle Olefins	Rotterdam, Netherlands	Methanol to bio-PP and bio-PE	200 kt/year	25%	Funding secured; concept engineering and permitting underway
UPM Leuna	Leuna, Germany	Wood to bio-MEG, bio-MPG, fillers and industrial sugars	150 kt/year	100%	Partly operational; contributes to intermediary supply
Vioneo	China *(was Belgium until late 2025)*	Methanol to bio-PP and bio-PE	None	0%	Relocation indicates competitiveness and feedstock-location risk
Total Additional Planned Volume in Europe			**630 kt/year**	**324 kt**	**Unlikely for all to be fully realised.**

A.4.0 Derivation of the Bio-Naphtha Range

Capacity Assumptions

European SAF and renewable fuel capacity is projected to reach 4.7 million tonnes by 2030, up from 1.4 million tonnes in 2025. This figure is taken directly from the SkyNRG and ICF outlook and is used throughout this assessment.

SkyNRG and ICF define this figure as **nameplate capacity**: the maximum output a facility could achieve if operated at full capacity. It does not represent expected annual production. In practice, some facilities will operate below full utilisation and some may produce renewable diesel rather than aviation fuel, as diesel-mode operation is estimated to be around 30% less expensive than aviation-fuel-mode operation.

Naphtha Yield Assumptions

The quantity of naphtha produced depends on how a biorefinery is configured. Different operating modes produce substantially different co-product yields.

Diesel-mode operation

Naphtha typically accounts for between 4% and 10% of total output in renewable diesel production. Two independent sources report similar results: Honeywell UOP's Ecofining process datasheet and an independent techno-economic assessment of a comparable facility. The latter reports naphtha production of approximately 4% of feedstock input alongside diesel production of approximately 68%.

Aviation-fuel-mode operation

Naphtha yields are significantly higher when facilities are configured to produce aviation fuel. Aviation-fuel production requires a hydrocracking step that converts longer hydrocarbon chains into jet-fuel-range molecules. Naphtha and light gases are produced as unavoidable co-products of this process.

The source model reports naphtha yields of 31.5% for jatropha oil, 29.9% for used cooking oil and 28.5% for rapeseed oil. Palm oil produces a substantially lower yield (9.1%) because its shorter molecular structure requires less hydrocracking. As this reflects a feedstock-specific effect rather than a plant-configuration effect, palm oil is excluded from the representative range.

This assessment therefore applies an aviation-fuel-mode naphtha yield of **28–32%**.

These figures are reported on a C5-C8 carbon-range basis. Elsewhere, this report adopts a broader C5-C10 definition of naphtha. Converting the source results to the broader definition would increase both diesel-mode and aviation-fuel-mode yields. The values used here should therefore be regarded as conservative estimates.

Operating Scenarios

The most uncertain assumption in the calculation concerns how much of the projected 4.7 million tonnes of capacity operates in aviation-fuel mode and how much operates in diesel mode.

Lower-bound scenario: compliance operation

ReFuelEU Aviation requires that sustainable aviation fuel accounts for at least 6% of aviation fuel supplied at EU airports from 2030. [183]

[183] European Union (2023) Regulation (EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023 on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation). Official Journal of the European Union, L 2023/2405, 31 October 2023, Article 4. The minimum SAF share of aviation fuel supplied at Union airports is set at 2% from 2025 and 6% from 2030.

EU aviation fuel demand is projected at approximately 46 million tonnes per year. While this figure is published for 2040 and 2050 rather than 2030, it is applied here as an approximate proxy in the absence of a more specific EU-wide 2030 projection. [184]

Six percent of 46 million tonnes corresponds to approximately 2.5 million tonnes of aviation fuel output. This is substantially below the projected 4.7 million tonnes of nameplate capacity and is consistent with SkyNRG and ICF's observation that planned capacity exceeds near-term mandated demand.

Under this scenario:

- approximately 2.5 million tonnes of capacity operates in aviation-fuel mode;
- approximately 2.2 million tonnes operates in diesel mode.

Applying the yield assumptions above and the 65%* cracker-to-plastics conversion factor used elsewhere in this report produces an estimated polymer-equivalent naphtha potential of approximately **0.59 million tonnes**.

Upper-bound scenario: full aviation-fuel operation

The upper-bound scenario assumes that the full 4.7 million tonnes of projected capacity operates in aviation-fuel mode. Applying the 28–32% naphtha yield range and a 65%* cracker-to-plastics conversion factor produces a polymer-equivalent naphtha potential of approximately **0.86–0.98 million tonnes**.

*__Bio-naphtha is well suited to steam cracking and may offer yield advantages relative to conventional fossil naphtha__. Following hydrotreatment, bio-naphtha consists predominantly of saturated straight-chain and branched paraffins, with very low sulphur content and few aromatic compounds. Conventional fossil naphtha contains a broader mixture of hydrocarbons, including naphthenes and aromatics. The reference naphtha used in Ullmann's cracker yield data contains approximately 21% naphthenes and 6% aromatics.[185]

Because paraffins generally produce higher ethylene yields during steam cracking, the 65% cracker-to-polymer yield used in this assessment is likely to be conservative. The value is based on conventional fossil naphtha rather than bio-naphtha, and future work should test it against actual bio-naphtha composition data.[186]

Resulting Bio-naphtha Range

This assessment uses a range of **0.59–0.98 million tonnes of bio-naphtha by 2030**.

The lower bound reflects a scenario in which facilities produce only the volume of aviation fuel required to meet regulatory obligations and allocate remaining capacity to renewable diesel production. The upper bound reflects a scenario in which projected aviation-fuel capacity operates largely as designed.

Neither value should be interpreted as a forecast. Together they provide a plausible range based on alternative assumptions regarding future capacity utilisation.

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[184]European Commission, European Alternative Fuels Observatory (2026) 'Sustainable Aviation Fuels (SAF) and other Alternative Fuels Used for Aviation'. Available at: https://alternative-fuels-observatory.ec.europa.eu/transport-mode/aviation/general-information-and-context (Accessed: 17 July 2026). Projected EU aviation fuel demand is given as approximately 46 million tonnes a year for 2040 and 2050; this study applies that figure as an approximate proxy for 2030 demand in the absence of a more precise EU-official 2030 figure, and flags this as an approximation in Appendix A.

[185]Zimmermann, H. and Walzl, R. (2007) 'Ethylene', in Ullmann's Encyclopedia of Industrial Chemistry. Weinheim: Wiley-VCH Verlag GmbH & Co. KGaA. DOI: 10.1002/14356007.a10_045.pub2. Reference full-range naphtha feedstock: 21.06 wt% naphthenes, 5.98 wt% aromatics, boiling range 26 to 183 degrees Celsius.

[186]Pominville-Racette, M., Overend, R., Achouri, I.E. and Abatzoglou, N. (2025) 'Hydroprocessed ester and fatty acids to jet: are we heading in the right direction for sustainable aviation fuel production?', Energies, 18(15), 4156. DOI: 10.3390/en18154156.

Limitations and Uncertainties

This calculation does not capture several potentially important factors.

Feedstock availability

The calculation assumes that sufficient feedstock is available to operate the projected capacity. As discussed in Locations 2 and 3, Europe does not currently have sufficient domestic supplies of oils and fats to support its planned biorefinery build-out. Realising this capacity therefore depends on continued feedstock imports.

Carbon-range adjustment

The calculation applies the original C5-C8 naphtha yields reported in the source literature. Converting these figures to the broader C5-C10 definition used elsewhere in the report would increase the estimated range.

Post-2030 capacity development

No separate estimate is produced for 2035. Available evidence suggests that capacity growth is likely to slow after 2030 as feedstock constraints become more significant. Simply scaling the 2030 range forward would therefore risk overstating future availability.

Pending further analysis, the 2035 value is held at the same 0.59–0.98 million tonne range as a placeholder rather than an independent estimate.

Commercial availability

The calculation estimates the volume of bio-naphtha that could be physically produced. It does not estimate how much of that volume would be separated, marketed and sold to chemical customers.

This is a distinct question from production potential. Evidence suggests that commercial sales are already occurring: Neste supplies bio-based naphtha to chemical-sector customers including Mitsui and SK Geo Centric. However, no consistent source was identified that would support a robust estimate of future sales volumes.

For this reason, the range presented here should be interpreted as **potential availability** rather than forecast supply.

A.5.0 Cradle-to-gate GHG footprints of bio-based polymers

This table sets out cradle-to-gate greenhouse gas footprints (kg CO2/kg polymer) for the 17 priority polymers covered in this study, alongside the biogenic carbon uptake that feeds into each figure. The cradle-to-gate footprint captures process emissions from feedstock through to the factory gate; biogenic uptake is the CO2 sequestered during biomass growth and embedded in the polymer, which is credited against process emissions under the -1/+1 accounting convention used in ISO 14067, EN 16760 and related standards.

Robust cradle-to-gate GHG data exists for only seven of the 17 polymers, covering roughly 80% of packaging-relevant volume but only around 40% of volume across all applications. For the remaining ten polymers (aliphatic polycarbonates, casein, cellulose acetate, epoxy resins, EPDM, PBAT, PTT and PUR, plus the two Rothman-sourced polymers noted below), no defensible cradle-to-gate value exists in the current literature. Where the low/mid/upper columns are blank and marked "Gap," only a first-principles biogenic uptake estimate is available; there is no corresponding cradle-to-gate process emissions figure to combine it with.

The biogenic uptake basis column explains how each source has treated the sequestered carbon within its cradle-to-gate figure, and this varies considerably between polymers:

- **Included**: the source's cradle-to-gate figure already nets the biogenic credit against process emissions (PA11, PP).
- **Excluded**: the source reports biogenic uptake separately, so it must be combined with process emissions to reach a net cradle-to-gate figure (PE, PEF, PLA).
- **Gate (Rothman)**: figures are drawn from Walker & Rothman's dataset, where the accounting basis for biogenic carbon within the cradle-to-gate value is not clearly isolated.
- **Mixed basis**: the underlying sources apply inconsistent conventions to biogenic carbon within the same figure, which materially widens the reported range (bio-PET, PHA).
- **No defensible cradle-to-gate value in current sources**: no cradle-to-gate process emissions figure exists at all; only the first-principles biogenic uptake calculation is shown

The confidence and notes column flags where a figure should not be generalised. The PA11 cradle-to-gate value, for example, is solid but applies only to castor-derived PA11; it cannot be extended to PA6 or PA6,6. Several other values (PBS, bio-PET, PHA, SCPC) rest on a single Rothman observation or a mixed accounting basis and should be treated as indicative rather than definitive.

Table 8-5: Cradle-to-gate GHG footprints of bio-based polymers

Polymer	Biogenic uptake basis	Cradle-to-Gate GHG Footprints of Bio-based Polymers			Biogenic uptake (kg CO2/kg)	Source (report, page)	Confidence and notes
		Low	Mid	Upper			
Aliphatic polycarbonates	No defensible cradle-to-gate value in current sources				1.54		Gap
Casein polymers	No defensible cradle-to-gate value in current sources				1.94		Gap
Cellulose acetate (CA), ~50% bio	No defensible cradle-to-gate value in current sources				1.00		Gap

Polymer	Biogenic uptake basis	Cradle-to-Gate GHG Footprints of Bio-based Polymers			Biogenic uptake (kg CO2/kg)	Source (report, page)	Confidence and notes
		Low	Mid	Upper			
Epoxy resins, ~45% bio	No defensible cradle-to-gate value in current sources				0.79		Gap
EPDM rubber	No defensible cradle-to-gate value in current sources				1.57		Gap
Polyamides (PA), PA11 only	Included		**1.30**		2.64	nova Table 7, p.37; Arkema Rilsan PA11 (castor)	Solid for PA11 only.; not generalisable to PA6 or PA6,6
PBAT	No defensible cradle-to-gate value in current sources				0.92		Gap
Polybutylene succinate (PBS) and copolymers	Gate (Rothman; basis not isolated)		**2.30**		2.04	Walker & Rothman 2020 Fig 9	Very low. One observation only
Polyethylene (PE)	Excluded	-2.20	**-2.12**	-0.50	3.14	nova (Apr 2026) Table 6, p.35; Braskem ACV Brasil 2023	Higher
Polyethylene furanoate (PEF)	Excluded		**2.78**		1.93	Puente et al (Nova and Avantium)[187]	Higher
Polyethylene terephthalate (PET), ~30% bio (bio-MEG)	Mixed basis (Rothman, conventions mixed)	2.00	**3.50**	5.50	0.46	Walker & Rothman 2020 Fig 9; Wood 2022 p.16 (reductions 1.8 to 2.2 vs fossil PET)	Low. Not a true bio-PET value; depends on bio share
Polyhydroxyalkanoates (PHA), incl. PHB	Mixed basis (Rothman; negatives are credited)	-2.30	**1.00**	4.00	2.04	Walker & Rothman 2020 Fig 9; Wood 2022 p.16	Low. Very wide range
Polylactic acid (PLA)	Excluded	0.10	**1.26**	3.10	1.83	nova Table 6, p.35 (ecoinvent 3.11; Vink & Davies 2015)	Higher
Polypropylene (PP)	Included		**0.60**		3.14	nova Table 6, p.35	Higher
Polytrimethylene terephthalate (PTT), ~31% bio	No defensible cradle-to-gate value in current sources				0.63		Gap
Polyurethanes (PUR), ~30% bio	No defensible cradle-to-gate value in current sources				0.52		Gap
Starch-containing compounds (SCPC), TPS	Gate (Rothman)		**1.50**	**-0.13**	1.63	Walker & Rothman 2020 Fig 9; Wood 2022 p.16 (0 to >50% reduction)	Low

[187] Puente, Á., de Jong, E., Goumans, I., Braña, P., Molina-Maturano, J. and Stratmann, M. (2026) 'Life Cycle Assessment of an Emerging, Innovative Biopolymer: Poly(Ethylene Furanoate)', *Sustainability*, 18(11), p. 5367. Available at: https://doi.org/10.3390/su18115367.

A.6.0 Packaging Place on Market Estimates

The JRC recently (July 2026) published estimates for packaging placed on the market in 19 Member States. It should be noted that the scope is considerably narrower than the plastic packaging quantities discussed in this study. Their model covers only PET, PP, HDPE and PS/EPS polymers, excludes tertiary and industrial packaging, is limited to household retail (and, for a subset of products, food-service) consumption, and covers 19 Member States and a defined set of consumer product categories rather than the full EU27 market.[188] The authors' own comparison against a full-scope plastics material flow analysis shows their four polymers represent only around 45% of the equivalent quantities in that broader model, and that broader model itself excludes several packaging-relevant polymers such as LDPE/LLDPE film and PVC.1 Figures from this source should therefore not be read as a ceiling on total EU plastic packaging quantities.

Figure 8-1 is based on the JRC's earlier work with a larger scope.[189] The report gives the packaging sector's 2022 consumption as 33.9% of total EU plastic consumption (62.8 Mt), which comes out to 21.3 Mt.

Figure 8-1: Estimated Packaging Place on Market in EU in 2022 (ktonnes)

Polymer	Packaging (2022)	Proportion (2022)
LDPE	6,262	29%
HDPE	3,834	18%
PP	4,984	23%
PS	639	3%
EPS	298	1%
PVC	405	2%
PET	4,132	19%
PUR	0	0%
ABS	0	0%
PMMA	64	0.3%
PA	0	0%
PC	298	1.4%
Other fossil	64	0.3%
bio-PP	64	0.3%
bio-PUR	64	0.3%
CA	43	0.2%
Other bio	149	1%
bio-PE	*42*	
PLA	*18*	
PHA	*12*	
PBAT	*34*	
Bio-PET 30%	*7*	
PBS	*4*	
PEF	*1*	
Other	*30*	
Total	**21,300**	
Total Bio-based	320	
Proportion Bio-based	1.5%	

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