Verification of Recycled and Bio-based Plastics

Suggesting control elements to ensure credible claims

Erika Ekman, Johanna Wachtmeister, Oscar Norberg
Trossa AB, 2026

SWEDISH ENVIRONMENTAL
PROTECTION AGENCY

Contents

Summary

The shift toward a circular and bio-based economy has increased the need for reliable claims about recycled and bio-based plastics. New EU and national regulations, such as the Packaging and Packaging Waste Regulation, the Single-Use Plastics Directive, and national plastics taxes, now require verified recycled content and more substantiated environmental claims. As the value of certified materials rises, so do risks of fraud, highlighted by falsified certificates and misreported post-consumer content outside the EU. This creates a strong demand for verification systems that can credibly demonstrate origin, content, and traceability.

This report reviews existing verification and certification systems and assesses how well they provide credible assurance across the plastics value chain. The analysis draws on desktop research, stakeholder interviews, and a systematic review of certification schemes and chain-of-custody models. It identifies the control elements needed for credibility, such as auditor competence, audit frequency, documentation practices, supplier due-diligence, and transparent communication, and evaluates how consistently current systems apply them.

The report concludes that current verification and certification systems for recycled and bio-based plastics are essential but not yet robust enough to meet rapidly evolving regulatory and market demands. While certification is the primary mechanism for demonstrating credible claims, the landscape is fragmented. Certification schemes differ widely in transparency, audit quality, and the stringency with which standards are applied. Physical chain-of-custody models such as identity preserved, segregated, and controlled blending, provide the strongest assurance of material origin, whereas many mass-balance variants and book-and-claim systems do not ensure a physical or chemical link between input and output, limiting their credibility.

Inconsistencies in documentation requirements, limited supplier risk assessment, and variable clarity in communication and claims further reduce trust. International standards provide a foundation, but their broad formulation leads to inconsistent interpretation, reducing comparability across schemes. Overall, a more harmonized, transparent, and rigorous verification framework is needed to prevent fraud, support compliant actors, and ensure that claims align with regulatory expectations.

Building on these conclusions, the report outlines several priorities for next steps. First, the proposed control elements should be validated through broader stakeholder engagement to ensure practical applicability and alignment with regulatory objectives. This includes refining terminology, clarifying requirements, and identifying inconsistencies between existing certification schemes. Second, the establishment of national or EU-level minimum requirements for verification systems is recommended to harmonize expectations, reduce administrative burden, and strengthen confidence in recycled and bio-based content claims. This includes clearly defining which chain-of-custody models satisfy the intended outcome. Third, regulators could enhance supervision through risk-based inspections, targeted audits, and sample testing to verify compliance. Fourth, further

development of analytical methods for recycled content, as well as systematic integration of laboratory testing for bio-based materials, should be encouraged, given current limitations. Finally, digital traceability solutions such as blockchain and digital product passports represent promising long-term tools for improving transparency and reducing fraud risk. Together, these steps would support the emergence of a more reliable and coherent verification environment that better serves policy goals and industry needs.

1. Introduction

The transition toward a circular and bio-based economy has placed increasing focus on the use of alternative plastic raw materials, particularly recycled and bio-based plastics. These materials are seen as important to reducing environmental impact, enhancing efficient use of resources, promoting a circular-economy and meeting climate and sustainability goals. As a result, regulatory frameworks as well as market actors are placing growing demands on the use of such materials in plastic products.

Recent and upcoming legislation at both the EU and national levels includes specific requirements for the content of recycled material in various plastic applications. Currently, such requirements are confirmed for packaging[1] and vehicles[2], with discussions ongoing regarding electronics and other sectors. In many cases, the legislation not only mandates a certain percentage of recycled content but also specifies that the recycled material must originate from post-consumer sources, meaning waste generated by end users, rather than industrial scrap or production residues.

Furthermore, the EU Packaging and Packaging Waste Regulation (PPWR) stipulates that if recycled material (or products containing it) is imported, the recycling process must meet the same standards as those applied within the EU. These legal requirements are expected to increase the value of verified recycled raw materials. However, this also creates undesirable incentives for fraud or misrepresentation, where materials may be falsely declared as recycled or from post-consumer source to meet regulatory or market demands.

While the current regulatory focus primarily concerns recycled content, bio-based plastics are also gaining attention. There are already several certification systems in place for bio-based materials, but a closer examination is needed to assess their applicability and effectiveness in the context of evolving legal and market requirements.

Against this backdrop, there is a need to investigate a systematic approach to control the authenticity of claims regarding content of recycled (post-consumer) and bio-based plastic materials. The objective of such a “verification system” would be to ensure that claims regarding sustainable materials (post-consumer recycled and bio-based plastic) are credible and support the development of circular material flows. Credibility builds on transparency, accuracy and robustness of the system.

[1] Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on Packaging and Packaging Waste, Amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and Repealing Directive 94/62/EC (Text with EEA Relevance).

[2] European Council, ‘Circular Economy’.

Framework conditions in this report is that for the system to be considered credible, it shall ensure a physical and chemical connection between the input (recycled/biobased content) and output (the provided plastic product). It shall also accurately take actual conversion factors and process losses into account.

Verification system objectives

A verification system shall:

1) Credibly ensure a physical and chemical connection between the input (the recycled/biobased content) and output (the resulting plastic product).
2) Contribute to market incentives for recycled or bio-based materials.
3) Accurately take actual conversion factors and process losses into account.

Various elements and versions of this already exist, including certification schemes, traceability standards and to some extent also laboratory material analysis technologies. However, methodologies differ within schemes and between producers.

This report provides an overview of commonly used existing verification systems, highlighting similarities and inconsistencies. Based on interview studies, it also highlights uncertainties and loopholes in existing systems. Finally, the report suggests key control elements that could meet the defined verification system objectives.

This assignment was carried out by Trossa AB, commissioned by the Swedish Environmental Protection Agency and finalized in January 2026.

1.1 Purpose and scope

The purpose of this report is twofold:

1. **Research of verification systems of material claim**
   To explore and describe in-practice methods for verifying that plastic raw materials sold as “recycled” or “bio-based” are genuinely what they claim to be. This includes identification of certifications, traceability mechanisms, documentation requirements, and analytical techniques that can be used to substantiate such claims throughout the value chain.

2. **Assessment of minimum verification requirements and certifications**
   To investigate existing verification systems of recycled and bio-based plastic materials and identify control elements for verification. This involves:
   - Exploring existing verification systems (certifications and standards) currently in use within the plastics industries.
   - Extracting and analyzing commonly used control elements in these verification systems

- Building on and adding to the above, suggest control elements of trustworthy and credible verification systems for recycled and biobased plastics.
- Evaluate current certification systems according to the control elements control and identify suggestions for improvements to certifications, standards and methodologies used.

The findings from this assignment will support efforts to increase transparency, trust, and sustainability in the use of recycled and bio-based plastic materials, and may inform future policy development, procurement criteria, or industry guidelines.

This background sets the stage for a deeper exploration of verification methods and the potential for certification systems to support a trustworthy and transparent market for sustainable plastic materials.

1.2 Background and context

The certification of plastic recycling capacity is gaining momentum across Europe. More than 60% of Europe's recycled plastics output is now third-party certified under the RecyClass scheme (formerly EUCertPlast), reflecting a significant increase in certified recycling capacity.[3]

Increased demand for recycled and biobased plastics, due to sustainability and regulatory drivers, creates distorted incentive for committing fraud and increases especially related to non-EU countries. Reports from China reveal documented cases where virgin PET was falsely marketed as recycled PET, resulting in companies being fined. These incidents underscore the strong economic incentives driving such fraudulent practices. [4]

Another example is from India where the national plastic recycling scheme was exploited through the creation of over 700,000 fake recycling certificates allowing companies to falsely claim compliance and avoid penalties, resulting in fines for systemic non-compliance.[5]

Certificates suffer from a lack of transparency and differing requirements, which can lead to inconsistent standards, low-quality audits, and misleading claims. Industry reports confirm that current certification schemes are fragmented, complex, and lack harmonization, creating inconsistencies and opportunities for misleading claims.[6]

[3] RecyClass, 'RecyClass Certifies over Half of Europe's Plastic Recycling Capacity'.

[4] ChinaReplas, 'Still Cheating despite Heavy Penalties? Identification Criteria for Virgin and Recycled PET - The 8th China International Recycling Plastics Exhibition.'

[5] *CPCB Uncovers Massive Fraud*.

[6] Weick and Ray, 'Certifications Can Drive Plastics Circularity'.

1.2.1 Trends driving the need for verification and certification of plastic materials

EU recycled content targets

The EU has introduced mandatory recycled content targets for certain products. For example, the Single-Use Plastics Directive requires beverage bottles to contain 25% recycled plastic by 2025 and 30% by 2030.[7] The Packaging and Packaging Waste Regulation (PPWR) further extends such targets to all plastic packaging (graduating up to 35% for many packaging types and to 2040 up to 65%).[8] Critically, to count toward these targets, the recycled content will need to be verified. PPWR Article 7 explicitly calls for record-keeping and traceability of recycled content and for the Commission to define methodologies for compliance. This effectively means that in a few years, any packaging on the EU market claiming recycled content to meet legal targets will require third-party verification in the future EU harmonized system.

National plastics taxes

Some EU countries have fiscal measures that require verification of recycled plastics which indirectly force certification. One example is Spain's Plastic Packaging Tax, Spanish Law 7/2022 in force since 2023.[9] The tax charges €0,45 per kilogram on non-recycled plastic used in packaging. Recycled content is exempt for the tax provided it is proven with an accredited certificate according to ISO 17065 (or similar) and meets standards equivalent to EN 15343 for this purpose. In practice, Spanish packaging producers have had to obtain certification to avoid the tax on their recycled portion.[10]

Also, the UK Plastic Packaging Tax has been in force since April 2022 and applies to plastic packaging that contains less than 30% recycled content.[11] It requires manufacturers and importers of plastic packaging to register, keep records, and pay a tax rate set annually. The government provides detailed guidance on obligations, registration, exemptions, due-diligence checks, and legislation.

Italy has a similar tax under consideration which require standards equivalent to EN 15343 to verify recycled content.[12] These taxes create a direct monetary incentive for companies to get their recycled plastic certified.

Potential fraud and mislabeling

Incorrect or fraudulent recycled content claims especially for imported packaging pose a significant risk. British Plastics Federation mentions an emergence of false

[7] European Commission, 'Single-Use Plastics - Environment - European Commission'.

[8] EU 2025/40, Packaging and Packaging Waste Regulation (PPWR).

[9] Spanish Law on Recycled Plastics 7/2022, BOE-A-2022-5809.

[10] RecyClass, 'How to Ensure Compliance with the Spanish Plastic Tax?'

[11] UK Government, 'Plastic Packaging Tax'.

[12] DataBeyond, 'How Recycling Companies Should Respond to Italy's 2026 Plastic Tax - Databeyond.Com'.

certificates, regarding recycled plastics which makes it important to have strong systems to stop fraud and check that recycled content claims are real.[13] The trade organization believes a verification or certification system is necessary to prevent fraud. Clear national and international standards would ensure fairness for compliant companies and increase recycled plastic use.

Anti-greenwashing regulation

The EU's Empowering Consumer Directive (EU) 2024/825 on empowering consumers for the green transition together with the upcoming Green Claims Directive are regulations linked to consumer law will prohibit generic claims like "eco-friendly" or "contains recycled material" unless they are substantiated by recognized methodologies.[14] Claims of recycled or bio-based content will almost certainly need certification to be considered substantiated. Retailers and brand owners might be wary of legal and reputational risks and will indicate increasingly insisting on certified proof for any recycled content claims on products.

[13] British Plastics Federation, 'BPF Calls for Companies to Report Fraudulent Recycled Material Claims'.

[14] Empowering Consumers Directive, EU 2024/825.

1.2.2 Value-chain for recycled and bio-based plastics

The following description and image provide a generalized and simplified overview of the recycled plastic respectively bio-based value chain, illustrating relevant key stages. It also highlights the roles of various actors, certification bodies, and regulatory authorities.

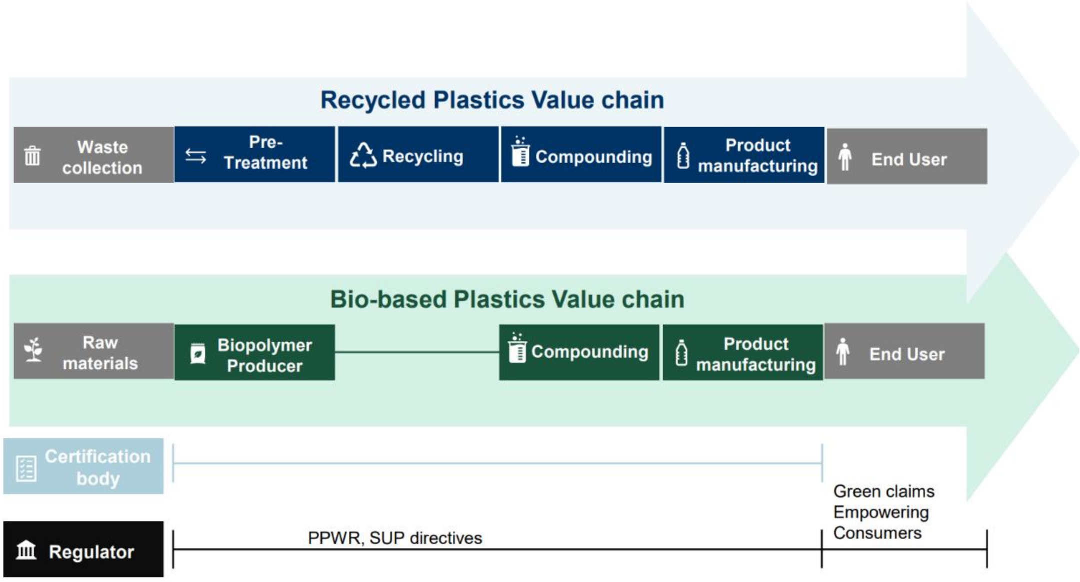

Figure 1: Value chains for recycled and bio-based plastics, including key actors and regulatory context (author's own work). Illustration: Trossa AB

Step	Recycled/ Biobased	Description
Waste collection	Recycled	Municipal waste management services or private collection companies responsible for gathering plastic waste from households, businesses, or industrial sources.
Pre-Treatment	Recycled	Separates plastic waste by polymer type, colour, and contamination level to prepare for recycling. Pre-treatment includes cleaning and preparing plastic by removing contaminants such as labels, dirt, and residues.
Recycling	Recycled	Converts plastic waste into reusable material via mechanical methods (such as grinding, melting, and pelletizing) or chemical recycling (cracking, pyrolysis, gasification, and depolymerization).
Bio-based Raw materials	Biobased	Provides bio-based feedstock such as corn, sugarcane, or cellulose for biopolymer production.
Biopolymer Producer	Biobased	Converts biomass into biopolymers through fermentation or chemical synthesis.
Compounding	Both	Produces plastic pellets or granules for use in manufacturing. Takes polymers (virgin or recycled) and modifies them by adding additives, fillers, colorants, stabilizers, or blending with other polymers to meet specific requirements.
Product manufacturing	Both	Uses plastic materials to create new products such as packaging or components.
End User	Both	Consumers use the final product and contribute to recycling through disposal behaviour.
Certification body	Both	Independent organizations that verify whether recycled plastic materials and processes meet specific standards.
Regulator	Both	Government authorities that set and enforce legal requirements for recycled plastics in packaging and products.

1.3 Delimitations

To ensure clarity and maintain a focused scope, this report defines specific delimitations. These boundaries are necessary to concentrate on the core objective, verifying claims about recycled and bio-based plastic raw materials, while excluding areas beyond the intended purpose.

This report is limited to the verification of recycled and bio-based plastic materials. Broader requirements such as environmental criteria for recycling processes, product safety regulations e.g., EU chemical legislation such as REACH, POPs, RoHS, and corporate social responsibility aspects are excluded from the scope.

The analysis seeks to identify verification systems that can ensure physical presence of the claimed content. In this report, this is operationalized as the presence of a specific post-consumer recycled (PCR) plastic or bio-based plastic. For example, if purchasing a polyethylene (PE) material or product that claims to be made of "30% PCR plastic", is it possible to verify that there actually is physical presence of 30% recycled PE in that specific material or product?

Furthermore, the analysis focuses primarily on relevant certification schemes within the European market and does not provide a comprehensive global mapping. While the EU and national regulations are referenced for context, detailed implementation and enforcement mechanisms are outside the scope. Stakeholder engagement was restricted due to time constraints, and findings should be interpreted accordingly.

Finally, the report does not cover functional properties of end products, such as mechanical performance or durability, but concentrates solely on verifying the origin and content of raw materials.

1.4 Definitions

In this report, the following definitions are used:

Audit - process for obtaining relevant information about an object of conformity assessment and evaluating it objectively to determine the extent to which specified requirements are fulfilled

Certification - third-party attestation related to an object of conformity assessment, with the exception of accreditation.

Chain of custody - process by which inputs and outputs and associated information are transferred, monitored and controlled as they move through each step in the relevant supply chain.[15]

Chain-of-custody system - set of measures designed to implement a chain of custody, including documentation of these measures.

---

[15] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

The purpose of a chain-of-custody system is to provide credibility that the given material or product has a set of specified characteristics. The information linked to materials or products is transferred, monitored and controlled throughout the entire supply chain or parts of it.[16]

Chain-of-custody model - approach taken to control inputs and outputs and associated information in a particular chain-of-custody system. A chain-of-custody model is typically designed to preserve a set of specified characteristics.[17]

Claim - declared information regarding the specified characteristics of a material or product.

Conformity assessment - demonstration that specified requirements are fulfilled. Conformity assessment can be performed as first-party activity, second-party activity.

Inspection - examination of an object of conformity assessment and determination of its conformity with detailed requirements or, based on professional judgement, with general requirements

Process - set of interrelated or interacting activities that use inputs to deliver an intended output.[18]

Site - location with geographical boundaries at which defined activities under the control of an organization are carried out. Sites may be in one geographical area but need not be contiguous. For example, a road can separate two geographical areas that are operated as a single site. Activities can include material extraction, production, manufacturing, recycling, storage, trade and/or transportation.

Traceability - ability to trace the history, application, location or source(s) of a material or product throughout the supply chain.

Traceability system - manual or electronic system that provides the ability to access any or all information relating to the material or product under consideration throughout their life cycle, by means of accessing documented information.

Verification - confirmation of truthfulness, through the provision of objective evidence that specified requirements have been fulfilled. The objective evidence needed for a verification can be the result of an inspection, audit or other forms of determination such as performing alternative calculations or reviewing documents. The activities carried out for verification are sometimes called a "qualification process" and can result in certification. The word “verified” is used to designate the corresponding status.

---

[16] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

[17] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

[18] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

2. Methodology

The methodology chapter outlines the approach undertaken to collect, analyze, and interpret data relevant to certification schemes within the recycled and biobased plastics sector. The methodology used combined both desktop research and targeted stakeholder interviews, this with actors representing different parts of the plastic value chain. This chapter details the processes and methods applied to generate a thorough understanding of the current certification landscape.

2.1 Review of verification methods

To build a comprehensive understanding of the current landscape, the project reviewed:

- Key actors and experts across the plastics value chain
- Standards and certification schemes related to verification of recycled and bio-based plastics
- Other verification methods that could be relevant like chain-of-custody documentation, laboratory testing, digital tools etc.

This review was carried out through a combination of desktop research and interviews with identified key stakeholders and experts representing various segments of the plastics value chain. The following stakeholders were involved Emballator, IKEA, Innovation and Chemical Industries in Sweden (IKEM), Plastic Recyclers Europe, Rondoplast, Sekab, Stena Recycling, Swedish Standards Institute (SIS), and Trioworld.

The research aimed to capture both formal documentation and practical insights into how verification systems work and what is important to maintain credibility and transparency. The desktop review focused on reports, certification schemes, standards, and audit schemes and guidelines, while the interviews provided perspectives from actors across the plastics value chain. This approach ensured a comprehensive understanding of current practices and challenges without limiting the analysis to publicly available documents alone.

The data analyzed comprised of relevant certification schemes, chain-of-custody models, standards, audit methods and laboratory testing.

2.2 Control elements for verification systems

Based on the review of documents, inputs from interviews and expert feedback as well as the authors' own experience, control elements needed to ensure reliability of claims were identified. These were designed to be clear, specific and applicable across different recycled and biobased verification schemes. The criteria address aspects such as requirements on certification bodies and auditors, how audits are conducted, chain-of-custody models standards and communication.

Control elements that are similar, but insufficient, are also listed to clarify with precision which practices meet verification credibility criteria, and which practices that do not.

To provide clarity, the evaluation scale applied to each identified relevant verification method was categorized using the following evaluation scale:

- **Meets criteria** – Features that meet specified criteria critical for a verification system to be considered robust and credible.
- **Nice to have** – Features that enhance the verification system's functionality or transparency but are not strictly mandatory.
- **Not enough** – Features that do not meet specified criteria critical for a verification system to be considered robust and credible.
- **Not relevant** – Features that do not apply to the specific context or scope of the verification system under review, e.g. features relevant specifically to recycled materials are not relevant for bio-based materials and vice versa.

This categorization enabled a consistent and transparent framework for comparing systems in the subsequent analysis phase, while also supporting stakeholder discussions around prioritization and applicability.

Stakeholder consultation

The proposed control elements and criteria were validated through consultations with relevant stakeholders and key experts. This process ensured prioritization of the most critical criteria according to Swedish Environmental Protection Agency. Feedback was incorporated to refine the requirements and ensure alignment with stakeholders. Due to the limited timeframe of the project, the number of participants was restricted although efforts were made to ensure diversity in the selection.

2.3 Mapping of control elements to existing certification schemes

This phase of the project concentrated on assessing the extent to which existing certification and verification systems correspond with the control elements established earlier in the study.

Approach

- Comparing set control elements described in Appendix – Control elements for verifying recycled and bio-based plastics covering certification body competence, audit practices, chain-of-custody models, documentation, and communication standards.
- Existing certification schemes were assessed against these control elements on a high level with an indication of compliance based on public information and interviews.
- To the summary described in 4.2 Overview of existing certification schemes according to control elements four levels were used:
    - **All** – All reviewed schemes meet the criteria.
    - **Most** – Most reviewed schemes (more than appr. 70%) meet the criteria.
    - **Some** – Around half of the reviewed schemes meet the criteria.
    - **Few** – Few reviewed schemes (less than appr. 30%) meet the criteria.
    - **None** – None of the schemes meet the criteria.
    - **Not assessed** – The control element was not evaluated due to either lack of information or complexity in comparability between certification schemes.

The reviewed certification schemes differ significantly in the amount of information they provide. Some schemes are considered to have low credibility due to their limited detail. Even for those with thorough documentation, evaluating their requirements and rules can be challenging. This difficulty persists even when the documentation is easily accessible since the presentation of the information is organized in completely different manners.

In general, gaining a complete understanding and managing a certification scheme requires substantial time and effort. To achieve a comprehensive mapping of certification schemes, a more detailed analysis is necessary. This should include direct engagement with each scheme to address specific questions and obtain detailed information.

3. Verification methods

This chapter presents the results of the review of verification methods for recycled and bio-based plastics. It outlines the main approaches used today, such as certification schemes, standards, chain-of-custody models, audits, and laboratory testing and summarizes that provide the key elements to credibly verify plastic materials.

3.1 Overview of verification methods

There are several verification solutions, which are all designed to give confidence to purchasers of plastic packaging that the level of recycled or bio-based content as stated can be relied on.

Method	Usage	Description
Certification schemes	Used today	Several different certification schemes currently exist that verify plastic content. These systems facilitate traceability of material sources, thereby offering a reliable method to substantiate claims regarding recycled or bio-based content. Certain schemes operate internationally, while others function on a regional level, such as within Europe. Additionally, some programs are only active in a limited number of countries. Other verification systems (such as chain-of-custody models, third-party audits, and document review) are often part of the certifications schemes.
Chain-of-Custody models	Used today	Chain-of-custody models are used to track materials through each step of the supply chain to verify their origin and amount. They were originally developed in industries like forestry and agriculture and later adopted by the plastics industry when sustainable raw materials became common. These models define how certified materials must be separated, mixed, or accounted for during production. The different chain-of-custody models (identity preservation, segregation, mass balance and book & claim) have different ways of ensuring transparency. Documentation is specified to make sure content matches what enters and leaves the system although different ways of calculating can be used depending on the model used.
Third party Audits	Used today	This process involves checking documentation, reviewing material flows, and verifying compliance with standards. It can help establish credibility and may be carried out by a company's compliance organization, a national supervisory authority or as part of a certification program.
Document review	Used today	Allocation of recycled/biobased content via accounting. Maintaining clear records showing how certified material flows between processes. This includes input/output quantities, allocation decisions, and timing.
Laboratory testing	Limited use	A laboratory-based scientific testing methodology can be utilized to quantify the recycled or bio-based content present in plastic materials. E.g to use chemical or thermal analysis to detect recycled content or radiocarbon analysis (C14) for biobased materials.
Digital Traceability Systems	Limited use	Tracks material origin, certification, and transformation. Currently limited in use but could expand with blockchain or centralized platforms with future technologies.

3.2 Certification schemes

Findings revealed significant variability in the extent and quality of publicly available information regarding certification schemes. Some certification schemes offered limited transparency, and even well-established programs presented challenges in understanding how verification is practically conducted. This underscores the complexity and time-consuming nature of comparing certification requirements and highlights the need for clearer, harmonized frameworks.

Below are the certification schemes, which are most relevant in terms of usage in Europe and robustness, described more in detail. For the full list of certification schemes see also Appendix. The following data has been compiled.

- **Scope -** Defines what can be certified such as product application, plastic types, processes, or material characteristics.
- **Description -** Provides a short explanation of the certification's purpose and key features, including whether it focuses on traceability, content verification, or sustainability criteria.
- **Geography -** Indicates the regions or countries where the certification scheme is primarily applied or recognized.
- **Referenced standards -** Lists the certification scheme documents, international or national standards that the certification scheme aligns with or uses as a basis.
- **Methodologies described -** Describes the verification approach used, such as audits, laboratory testing (e.g., C14 analysis), chain-of-custody models (identity preserved, controlled blending, mass balance), or digital traceability tools.
- **Recycled -** Whether the certification can be used for recycled plastic content.
- **Biobased -** Whether the certification can be used for bio-based plastic content.

Table 1: List of Certification Schemes

Certification	Scope	Description	Geography	Referenced standards	Methodologies described	Re-cycled	Bio-based
AENOR	Certification of either the traceability process or the share of recycled content in materials of PE, PP, PVC, PS or PET.	Certification schemes only available in Spanish. Certification of traceability process or mechanically recycled content according to EN 15343.	Spain (main hub), Brazil, Central America, Chile, Colombia, Dominican Republic, Ecuador, Italy, Mexico, Morocco, Peru, Poland, Portugal.	RP E17.01 (Traceability) RP E17.02 (Recycled Content) **EN 15343** in combination with standard for relevant polymer ISO 9001	Audits by AENOR Chain of custody (E17.01) Mass balance (E17.02) but only mechanical recycling so actually controlled blending.	X	
APR PCR	Certification of reclaimers, converters, manufacturers regarding traceability from waste to resin (pellets). Mechanical recycling of plastic resins: PET, PP, PE.	Certification of post-consumer mechanically recycled content in plastic pellets according to EN 15343. Certification is written in coordination with RecyClass audit scheme for traceability and RecyClass can be used as verification.	North America (mainly). Some certified companies are located in Indonesia, Taiwan and Brasil.	APR PCR Standard: APR-PCR-101 ISO 22095 ISO 17065 ISO 14021 **EN 15343**	Third-party audits Chain of custody Physical segregation Controlled blending	X	
DIN-Geprüft Biobased	Certification of biobased content in products and packaging.	Certification of biobased content share based on testing. Biobased share must be specified on labels.	Germany (main hub), France, Italy, NL, Spain, Belgium, US, Canada, Australia, NX, China, Japan, South Korea, Taiwan	DIN Geprüft Biobased certification scheme: ASTM D6866 and/or ISO 16620-2	Third-party audits C14 testing Elemental analysis		X
DIN-Geprüft Recycled	Certification of recycled content in products and packaging. The quality or functionality of the material is not assessed.	Certification of recycled content according to EN 15343 with focus on the system for traceability. RecyClass can be used as verification.	Germany (main hub), Austria, Switzerland, EU-countries, UK, Norway	DIN Geprüft Recycled certification scheme: **EN 15343** ISO 14021 ISO 9001	Third-party audits Traceability (un-specified)	X	

Certification	**Scope**	**Description**	**Geography**	**Referenced standards**	**Methodologies described**	**Re-cycled**	**Bio-based**
ISCC PLUS	Certification of businesses and products for alternative feedstocks (origins) for the production of plastics, metals, biofuels, textiles. Includes sustainability requirments and calculation of GHG-values.	Certification for circular and bio-based materials of various kinds. The whole value-chain must be certified. Uses primarily mass balance as chain-of-custody model for traceability. Type of model, type of origin and material are featured in the logo. Can comply with EN 15343 as a volontary add-on. Can be based on materials with other certifications: ex FSC	Globally used	ISCC PLUS Version 3.4.2 ISCC PLUS 102 governance ISCC 208 Logos and claims ISO 22095 **EN 15343** and identification according to the relevant polymers can be included. EN 16785-1 ISO 9001 ISO 14001	Internal audits Third-party audits Chain of custody Physical segregation Controlled blending Mass balance Attribution based on mass or energy Trace the atom C14-testing "Book and claim" or "Multiple accounting" are not OK	X	X
NEN Bio-based	Certification of biobased content based on analysis in two types of products: Group I-products can be described by a molecular formula (ex a substance or a polymer). Group II-products are mixtures (ex plastic material).	Certification of Biobased Carbon Content and/or Biobased Content, based on analysis, and complemented by calculations. Share must be specified on label.	NL (primarily) and in Europe	NEN Bio-based certification scheme EN 16785-1 ISO 17065 ISO 17025 ISO 9001 EN 16575	Third-party audits Elemental analysis for carbon content C14-testing for biobased carbons		X

Certification	Scope	Description	Geography	Referenced standards	Methodologies described	Re-cycled	Bio-based
OK Bio-based	Certification of biobased carbon content in products or materials. Other environmental aspects are not assessed.	Certification of Biobased Carbon Content = BCC levels based on testing = Bio C / Total C. Classification from 1 to 4 stars can be featured in the logo: 1: ≥20% - < 40% BCC 2: ≥40% - < 60% BCC 3: ≥60% - < 80% BCC 4: ≥80% - < 100% BCC	Many European countries (Germany, Austria, Italy, Spain, Poland, Romania, Greece, Belgium, Czech, Slovenia, Portugal, Switzerland, Albania; and globally in India, China, Singapore, Saudi arabia, UAE and Egypt.	OK Bio-based certification scheme EN 16640 ISO 14021 EN 16575 ISO 17025 TÜV AUSTRIA document TS-OK20 ASTM D6866	Third-party audits Elemental analysis for carbon content C14-testing for biobased carbons		X
OK Renewable	Certification of products made of materials with renewable carbon (fuels are excluded). Based on other material certifications: NEN-Biobased, DIN Geprüft, Flustix recycled, ISCC+, OK biobased & OK recycled, RecyClass, RedCert2, RSB	Certification of Renewable Carbon Share = RCS = Sum of (bio+bioCO2+CCU+recycled) / Total C Classification from 1-5 is featured in the logo (acc to annex 2.1). 1: ≥20% - < 40% RCS 2: ≥40% - < 60% RCS 3: ≥60% - < 80% RCS 4: ≥80% - < 100% RCS 5: RCS = 100%	New certification (from 2025), targeting the European markets as well as global companies	OK Renewable certification scheme EN 16640 EN 16785-1 & 2 ISO 14021 ISO 16620-1 & 2 ISO 17025 ASTM 6866	Third-party audits if needed but remote is OK. Traceability (un-specified) Underlying certifications (with third-party audits required) according to list. Massbalance Attribution (fuel exempt)	X	X
OK Recycled	Certification of products of various materials: Plastic, Aluminum, Paper, Textiles	Recycled Content = RC = Sum of recycled plastics material / Total mass of plastics in product	Mainly used in Austria, Belgium, Spain, India, Egypt, UAE.	**EN 15343** ISO 14021 Certification scheme not found	Traceability (un-specified) Mass balance	X	

Certification	Scope	Description	Geography	Referenced standards	Methodologies described	Re-cycled	Bio-based
Ocean Bound Plastic	Certification of all stages in the cycle: Collection, recycling, brand, neutrality (credits).	Since different parts in the product-chain can be certified, the criteria look very different. In order to certify products, the organization and the suppliers need to be certified. Share must be specified on product labels. For Neutrality certification, credits are sold and bought.	Mainly used in Asia, but globally in countries with significant coastal plastic pollution.	OBP Certification Programs: -Collection -Recycling -Brand -Neutrality (provider and user) No refs to other standards	Third-party audits Chain of custody (un-specified)	X	
RecyClass + EUCertPlast	Certification of plastic recyclers for traceability of pre- and post-consumer plastics.	Certification of recycling process for traceability of two variants: Segregation- or Controlled blending methods. RecyClass Recycling Process certification is equivalent to EuCertPlast.	Mainly used in Europe, but spreading globally, primarily in Asia and Latin America.	RecyClass Audit Scheme: -RECYCLING PROCESS -CERTIFIATION BODIES & AUDITORS REQUIREMENTS **EN 15343** ISO 22095 ISO 14021 ISO 17065 ISO 9001	Third-party audits Chain of custody Segregation Controlled blending	X	
RecyClass	Certification of recycled plastic and recycling processes at a site. Processes: compounding, converting, storage, trading or other activities with the plastics value chain.	Certification of recycled plastics and recycling processes based on traceability and quality. Requires certification of recycling process. Focuses on EU plastics.	Mainly used in Europe, but spreading globally, primarily in Asia and latin America.	RecyClass Audit Scheme: -RECYCLED PLASTICS TRACEABILITY -CERTIFIATION BODIES & AUDITORS REQUIREMENTS -Claims guide EN 15343 ISO 22095 ISO 14021 ISO 17065 ISO 9001	Third-party audits Chain of custody Controlled blending	X	

Certification	Scope	Description	Geography	Referenced standards	Methodologies described	Re-cycled	Bio-based
Global Recycled Standard	Certification of Recycled material in plastic based textiles (polyester, nylon). Non-plastic based textiles (wool, cotton) can probably also be certified.	Certification for recycled content in textile materials and products based on trceability. Certification also includes environmental/social criteria.	Globally used but focus on the textile sector.	GRS GRS Implementation manual CCS ISO 14021	Third-party audits Chain of custody Mass balance	X	
Recycled Claim Standard	Certification of Recycled materials in materials and products of any type.	Certification with criteria for recycled materials claims based on traceability. Companion to GRS but without social/environmental add-ons.	Globally used but focus on the textile sector.	RCS RCS Implementation manual CCS ISO 14021	Third-party audits Chain of custody Mass balance		X
Biobased Content Certification	Certification of biobased content in fuels, polymers and products from all types of biomass.	Certification of biobased content based on traceability. Other certifications (according to list) can be used as verification.	Globally used, but focus in the US, Europé and Australia/NewZealand.	SCS-114 SCS Standards Certification and Approval Requirements ISO 17065	Third-party audits (farm-level) Chain of custody Physical segregation Mass balance	X	(X)
Recycled Content Certification	Certification of recycled content mateials and products of all kinds. I.e. building materials, electronics, packaging, plastics, resins, textiles, wood/paper; mechanical/-chemical recycling.	Certification of products of plastics or other materials with minimum 5% recycled content based on third-party audits and selected chain-of-custody-models.	Globally used, but focus in the US.	SCS-103 SCS Standards Certification and Approval Requirements **EN 15343** ISO 17065 ISO 22095 ISO 14021 ISO 9001	Third-party audits (onsite based on risk-based approach from auditor) Chain of custody Physical segregation Controlled blending Mass balance	X	

Certification	Scope	Description	Geography	Referenced standards	Methodologies described	Re-cycled	Bio-based
QA-CER	Certification of sorters, converters, manufacturers of plastics, textiles and composites.	Certification of recycled content according to EN 15343.	European focus, mainly Belgium, Spain, Germany, France, Poland. Also in Latin America and China.	QA-CER recycled content scheme **EN 15343** ISO 17021-1 ISO 22095 ISO 14021 ISO 9001	Third-party audits Chain of custody Controlled blending	X	
Recycled Material Standard	Certification of: Product groups, activities (sorting, converting etc.), facility and chain-of - ustody systems. Scope will be listed on certificate and in RMS database.	Certification of recycled materials (primarily plastics and not fuels), based on chain-of-custody model. Type of model is featured in the logo: Average content (% specified) Mass balance Attributes of Recycled Content (ARC)	North America focus, mainly the US, Canada and Mexico	RMS Framework RMS Plastics Module RMS Plastics Material Classification RMS Label Trademark Guidelines ISO 14021	Third-party audits Chain of custody Physical segregation Controlled blending Mass balance (all types)	X	
REDcert-2 (Material flow)	Certification of products made from biobased, biomass-balanced and recycled products in the chemical industry. Aligns with EU RED; no deforestation.	Certification of sustainable material flows and the substitution of fossil raw materials with, for example, sustainable biomass and recyclates in the chemical and processing industry as well as products made thereof. Can be based on materials with other certifications: REDcert-EU, FSC, PEFC, ISCC+, RSB, RSPO, RecyClass, EU-certplast.	European focus	RED Renewable Energy Directive EU 2018-2001 REDcert-2-Scheme principles: - Sustainable material flows in the chem industry -Logo and claims REDcert-EU-Scheme principles for neutral inspections ISO 17065 ISO 14021 ISO 22095	Third-party audits Chain of custody Mass balance: - Process-specific - Process-non-specific: Free attribution and Fuels excluded models	X	X

Certification	Scope	Description	Geography	Referenced standards	Methodologies described	Re-cycled	Bio-based
REDcert-EU (Mobility)	Certification of operators: Producers of biomass (agricultural), waste-producers, gathering operations, conversion operations etc. as well as renewable fuels, recycled carbon fuels, biofuels and bioliquids. Calculation of GHG is included.	Certifies sustainable biomass, renewable fuels of non-biological origin (RFNBO) and recycled carbon fuels (RCF). Can be based on other certifications: SURE-EU	European focus	RED Renewable Energy Directive EU 2018-2001 REDcert-EU- Scheme principles: -Scope and basics v08 -Neutral inspections -Mass balance -Definitions ISO 17065	Third-party audits Chain of custody Mass balance: - Process-specific - Process-non-specific: Free attribution and Fuels excluded models	X	X
UL Validated	Certification of recycled content in several product categories: Plastics, textiles, packaging, paper, building materials, furniture etc.	Various kinds of sources for recycled material can be certified based on mass balance method and traceability of credits (which can move freely within for ex a production site) that are valid for one year.	North America focus but also used in Europe and Asia.	UL 2809 (can be bought) **EN 15343**	Audits by UL Chain of custody Mass balance Attribution of credits	X	

3.3 Overview of relevant standards

Ensuring credibility in recycled and biobased plastics requires adherence to recognized international standards. These standards provide the technical foundation for traceability, chain-of-custody systems, and verification of material content. However, some standards are limited in scope or practical application. Gaps include insufficient detail for complex supply chains and lack of harmonization across different material types, which can create challenges for consistent implementation and certification.

3.3.1 ISO 22095:2020 Chain of custody – General terminology and models

This standard defines five different chain-of-custody models for chain-of-custody systems. Each model has specific requirements that allow different claims to be made about materials or products and/or production processes that are delivered using that chain-of-custody model. See section 3.4 for a further description of these models. The standard also highlights that as these models have different rules as they cater to different expectations. Two common types of expectations are highlighted:

- Item-based expectations, where there are expectations that the material output bears the identified characteristics
- Market-based expectations, where the expectations are that the model will contribute and incentivise sustainable (e.g. recycled or bio-based) materials to be produced.

The standard highlights that certification schemes may have its own chain-of-custody requirements, which an organisation needs to follow if it is certified.

The standard includes several of the control elements listed in this report (e.g. competence, communication, regular evaluation) but does not define precise qualitative requirements for these elements (such as third-party audit or audit frequency).

It is important to note that where the certification schemes refer to the ISO 22095:2020 standard, this keeps many options for implementation open. Examples of this include choice of chain-of-custody model, type of inspection or audit frequency. Thus, a reference to the standard does not in itself substantiate claims about an organisation or its produced goods. The standard does not specify requirements for the models (e.g. the mass balance model) in detail.

3.3.2 SS-EN 15343 Plastics - Recycled Plastics: Plastics recycling traceability and assessment of conformity and recycled content,

This standard describes procedures for ensuring traceability in mechanical recycling. It is relevant for producers of recycled plastics that need proof of traceability.

The standard lists requirements such as control of input materials, e.g. by record-keeping (section 4.1) and batch identification procedures (section 4.2). The characteristics of the recyclate shall also be described in accordance with relevant standards (section 4.3). These steps shall be "appropriately documented and recorded" and the recycler shall be able to provide this data.

The standard further describes that "the purchaser shall ensure that the level of traceability is suitable for the intended application". Thus, the standard does not in itself require a specific quality level for the traceability information but leaves it up to the purchaser to assess if the provided data has satisfactory detail. The standard similarly also notes that the "preferred method of identification and administration will depend on the size of the recycling operation and the origin of the material and consequently is not specified in this standard" (note to chapter 4).

The standard covers *both pre-consumer and post-consumer* as recycled content but excludes recovered material from the same manufacturing process that generated the material. Information about if the product/material consists of post-consumer material can be documented as per information requirements (table 1 of the standard) about origins, which include indicating ”type of waste, e.g. pre-user, post user, demolition waste". As noted above, the standard does not specifically require this information about origin but indicates that it shall be "recorded as appropriate to the end use application", i.e. the purchaser's needs.

Chapter six of the standard further notes that "At present there are no reliable technologies for an analytical determination of the recycled content in a material or product. Consequently, the traceability information from both the recycled and the virgin materials will be needed to calculate the recycled content" (chapter 6, note 1). To this regard, the standard requires the recycler to provide documented evidence of the recycled content or previous history of the material, if requested to do so (chapter 5).

This standard is intended for both pre- and post-consumer recycled materials. Information about this aspect *can* be provided to purchasers, but there is no guarantee that this is done without a request from the purchaser. The standard does indicate that the recycler shall provide such information upon request and that the recycler shall maintain and document its control of incoming materials to provide such information.

To determine if recycled plastic is of post-consumer origin, it is necessary to ask for information. The standard caters for that this shall be provided upon request (if not already done at the recycler's initiative).

This standard is focused on the input side of production and record-keeping. It does not define requirements for a chain-of-custody model and as such does not in itself provide any certainty regarding actual physical presence of recycled content in the product.

3.3.3 SS-EN 15347-1:2024 Plastics – Sorted plastics wastes – Part 1: General Characterisation

The purpose of this standard is to provide a method for characterizing waste. This enables transparency in transactions. The characterization provides information about maximum or minimum thresholds for presence of contaminants of the main polymer. This is important as it can be used to determine suitability for a recycling process, end applications and value of the batch.

The standard differentiates between optional and required data. Examples of required data include pre- or post-consumer, main polymer and other polymers present.

It then indicates details about how to take, measure and document samples to determine the content of the batch.

3.3.4 EN 16640 Bio-based products - Bio-based carbon content - Determination of the bio-based carbon content using the radiocarbon method

EN 16640 provides a standardized method for determining the bio-based carbon content of products through radiocarbon (C14) analysis. This technique measures the proportion of biogenic carbon relative to total carbon in a material, offering a scientifically robust way to verify bio-based content claims. The standard is widely referenced in certification schemes and environmental labeling for products containing bio-based components.

This standard is fundamental for ensuring credibility in bio-based content claims because it relies on direct physical evidence rather than documentation alone. By using radiocarbon analysis, EN 16640 enhances transparency and reduces the risk of misleading claims. However, its scope is limited to carbon-based materials and does not address other sustainability attributes such as recyclability or environmental performance. Broader adoption and integration into certification frameworks would strengthen market trust.

EN 16640 is considered one of the most reliable methods for verifying bio-based content because it uses radiocarbon dating principles to distinguish between fossil and biogenic carbon. It is often applied alongside EN 16785-1, which combines laboratory testing with calculation for total bio-based content. While EN 16640 provides strong scientific credibility, it requires specialized laboratory equipment and expertise, which can increase costs and limit accessibility for smaller producers. Its methodology cannot be applied to recycled content verification, highlighting a gap that must be addressed through complementary traceability and certification systems.

3.3.5 EN 16785 Bio-based products - Bio-based content - Part 1

EN 16785-1 specifies a method for determining the bio-based content of products using a combination of laboratory analysis and calculation. The standard applies to solid, liquid, and gaseous products and is widely used in certification schemes and environmental labeling. It ensures that claims about bio-based content are based on verifiable, standardized procedures, typically involving radiocarbon (C14) analysis and elemental composition testing.

This standard is essential for creating transparency and trust in the market for bio-based products. By providing a harmonized approach, it reduces the risk of misleading claims. However, its application is limited to bio-based content and does not address other sustainability aspects such as recyclability or environmental impact.

EN 16785-1 offers a robust methodology by combining physical testing with calculation, making it more credible than documentation-only approaches. Its reliance on C14 testing provides strong scientific evidence of biogenic carbon presence. The standard is referenced in multiple certification schemes and could be used more often as a way of physically verifying the bio-based content.

3.3.6 ISO 14021:2016 Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling)

ISO 14021 is an international standard that sets requirements for self-declared environmental claims, such as “contains recycled material” or “recyclable.” Its purpose is to ensure that these claims are accurate, verifiable, and not misleading. For recycled and bio-based plastics, the standard requires that any statement about content or recyclability be supported by documented evidence and calculated using recognized methods. Claims must specify the percentage of recycled or bio-based material and avoid vague or broad environmental assertions. Transparency is essential, and supporting information should be available to regulators and stakeholders upon request. Implementing ISO 14021 helps prevent greenwashing and strengthens trust in environmental labeling.

ISO 14021 provides a framework for improving the credibility of environmental claims. By requiring evidence and transparency, it addresses a key challenge of misleading or unsubstantiated claims. This approach supports consumer confidence and regulatory compliance. The standard is widely referred to in certification schemes. However, applying the standard in practice can be challenging because it leaves room for interpretation, especially when dealing with complex materials like recycled and bio-based plastics.

While ISO 14021 establishes fundamental principles for claim integrity, its current version has limitations. The standard does not provide detailed definitions or descriptions, which can lead to inconsistent interpretation across industries. For recycled plastics, additional guidance is often needed, and for bio-based plastics, complementary standards such as EN 16848 and EN 16935 provide more specific requirements. Therefore, ISO 14021 should be used as a guiding framework but combined with other standards and robust traceability systems to ensure credibility and harmonization. This integrated approach minimizes risks of greenwashing and enhances trust in environmental labeling.

3.4 Analysis of traceability in chain-of-custody models

Traceability can be defined as "the ability to trace the history, application or location of a product". Traceability records can be used to identify supply chain actors that take the legal ownership throughout the supply chain.[19]

Similarly, but not identical, a chain of custody means a "chain of responsibility for the custodianship of materials or products as they move through a supply chain". The purpose of a chain of custody is to "ensure that the specified *characteristics that are claimed* for a particular material or product (or for the market as a whole) *are indeed the ones that are actually delivered in the output*" (italics added).[20]

A chain-of-custody model indicates specific "*requirements that allow different claims to be made* about materials or products and/or production processes that are delivered using *that chain-of-custody model*" (italics added).[21] There are several different chain-of-custody models, which are described in standards (see above section 3.3.1).

These different chain-of-custody models have a varying level of flexibility regarding both the physical and chemical connection between the input and output, and how conversion factors and process losses are calculated.

This section provides an analysis of how different chain-of-custody models fulfil the verification system objectives (see also introduction).

Verification system objectives

A verification system shall:

1) Credibly ensure a physical and chemical connection between the input (the recycled/biobased content) and output (the resulting plastic product).
2) Contribute to market incentives for recycled or bio-based materials.
3) Accurately take actual conversion factors and process losses into account.

The analysis has concluded two *verification system requirements for chain-of-custody models* that need to be fulfilled in order to meet these objectives. These are:

[19] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

[20] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

[21] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

Correct monomer requirement

A “correct” recycled or bio-based monomer refers to the monomer(s) that need to be used (chemically) to produce the intended material (polymer). This means that both chemical and physical traceability shall be in place.

The correct monomer requirement answers to verification system objectives one and two. These objectives seek to ensure that the methods used do not distort market competition in favour of actors that:

- allocate credits (relevant to mass balance method) from a monomer or other molecule that cannot possibly be a part of the produced material
- allocate credits (relevant to mass balance method) from energy / residue energy to the product

Steering away from such practices is important as they:

- do not support the market for different recycled or bio-based plastics,
- disadvantage the producers that pay a (often higher) price for the correct monomers (the price may be higher because the supply is lower).
- can lead to lack of trust in the traceability system from buyers and consumers

By using the correct monomer in the production, the market *demand* for that type of plastic is increased. This is in turn anticipated to lead to increased *supply* of specific types of (recycled and bio-based) monomers, thus improving market availability for these materials.

Production location requirements

The requirements indicate that a single production site and single production process shall be the allowed system boundary for making calculations. This is needed for calculations to depict actual conversion factors and actual losses.

A *process* is a number of interrelated or interacting activities that use inputs to deliver an intended output. The production process of LDPE plastic pellets can be used as an example. It is possible to use both LDPE bottles and canisters as input products. After they have been shredded to LDPE flakes, they can be recycled (e.g. melted) in the same recycling process. The recycling process consists of mixing, melting, blow moulding, cooling and quality check. It is possible to use both virgin and recycled material in the same process.

A *site* is a geographically defined location where activities are carried out. A site does not necessarily need to be contiguous, but site facilities need to be in near proximity of each other. A site has geographical boundaries and cannot for example include facilities in multiple cities.

Again, using the example of a LDPE recycling site, a road may for example separate two geographical areas that are part of the same site. On one side of the road, the shredding takes place. On the other side of the road, the compounding into new LDPE plastic takes place.

The production location requirement thus answers to verification system objective one and three. These objectives seek to ensure that the methods used do not distort market competition in favour of actors that (non-exhaustive examples):

- define conversion factors and actual losses at overall organisation level rather than for each site and process, thus not depicting figures for the actual process
- ”cherry-pick” the best performing conversion factor within an organisation.

Steering away from such practices is important as they:

- can lead to lack of trust in the traceability system from buyers and consumers
- disadvantage producers that make calculations based on actual conditions.

The following sections describe commonly used chain-of-custody models and indicate whether they fulfil the *verification system requirements for chain-of-custody models* (the correct monomer requirement and production location requirement).

3.4.1 Identity preserved model

In the identity preserved model, input materials originate from a *single source*, and both relevant input materials and related product are kept *physically separated* from other materials throughout the supply chain. As a result, the output product can be traced back and directly linked to the exact input material from which it originates. ISO 22095 defines the identity preserved model as a "chain-of-custody model in which the materials or products originate from a single source and their specified characteristics are maintained throughout the supply chain".

The identity preserved model meets the correct monomer requirement, as material from a single source and of a specific type is maintained throughout the value chain. The production location requirement is also fulfilled, as the production process, (Process A in figure 2) is carried out within a single site and process.

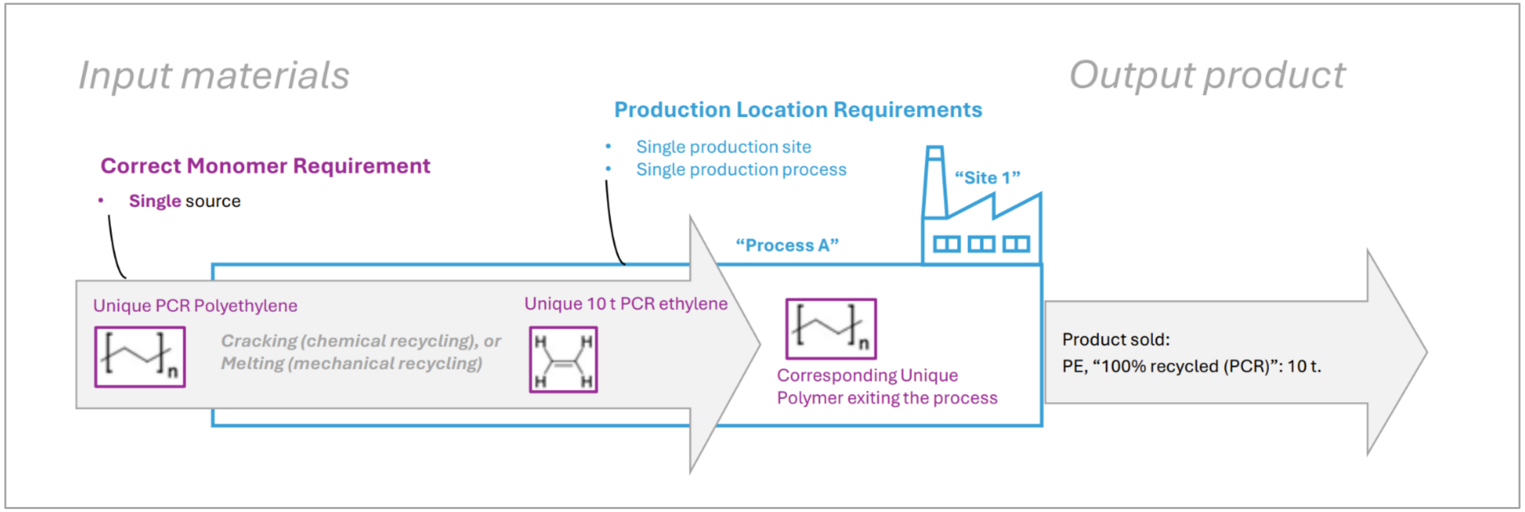

Figure 2. Chain of Custody, Identity preserved model vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that this chain-of-custody model also can be applied to bio-based plastics. Illustration: Trossa AB

3.4.2 Segregated model

In the segregated model, inputs may originate from different sources but shall have identical characteristics (e.g. PCR PE). This means that the identity of a specific source may not be preserved, but the output product will maintain the specific properties (e.g. be made completely of PCR PE) and the organization can make claims thereafter (e.g. 100% PCR PE).

ISO 22095 defines the segregated model as a "chain-of-custody model in which specified characteristics of a material or product are maintained from the initial input to the final output". In addition, "addition of material with different characteristics and/or grade to the input is not allowed. Commonly, material from more than one source contributes to a chain of custody under the segregated model."

The segregated model meets the correct monomer requirement, as material from a specific type is maintained throughout the value chain. The production location requirement is also fulfilled, as the production process (Process A in figure 3) is carried out within a single site and process.

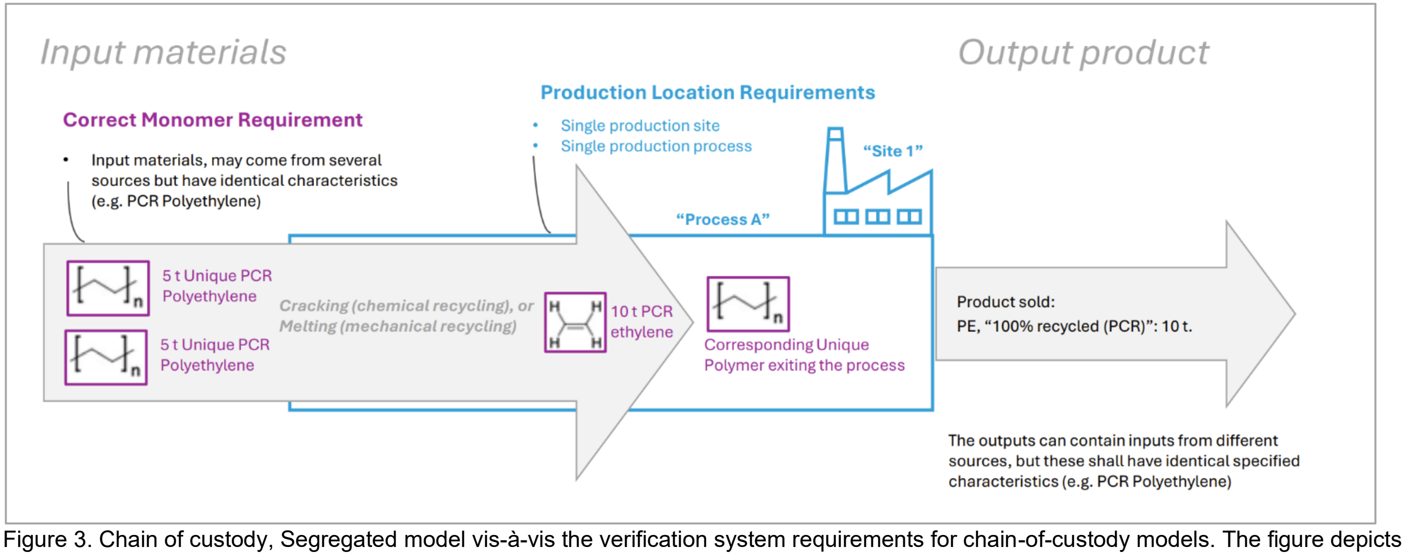

Figure 3. Chain of custody, Segregated model vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that the model also can be applied to bio-based plastics. Illustration: Trossa AB.

3.4.3 Controlled blending model

In the controlled blending model, materials or products with certain specified characteristics (e.g. PCR PE) can be mixed, in accordance with certain criteria, with materials or products without that set of characteristics (e.g. fossil PE).

This produces a product with a known proportion of the specified characteristics (e.g. 25% PCR PE). As this ratio is always known throughout the value chain, the output percentage can always be ensured.

ISO 22095 defines the controlled blending model as a “chain-of-custody model in which materials or products with a set of specified characteristics are mixed according to certain criteria with materials or products without that set of characteristics resulting in a known proportion of the specified characteristics in the final output” (this chain-of-custody model is also referred to as the "single percentage method").

The controlled blending model meets the correct monomer requirement, as a defined and carefully documented *share of material from a specific type* is maintained throughout the value chain. The production location requirement is also fulfilled, as the production process (Process A in figure 4) is carried out within a single site and process.

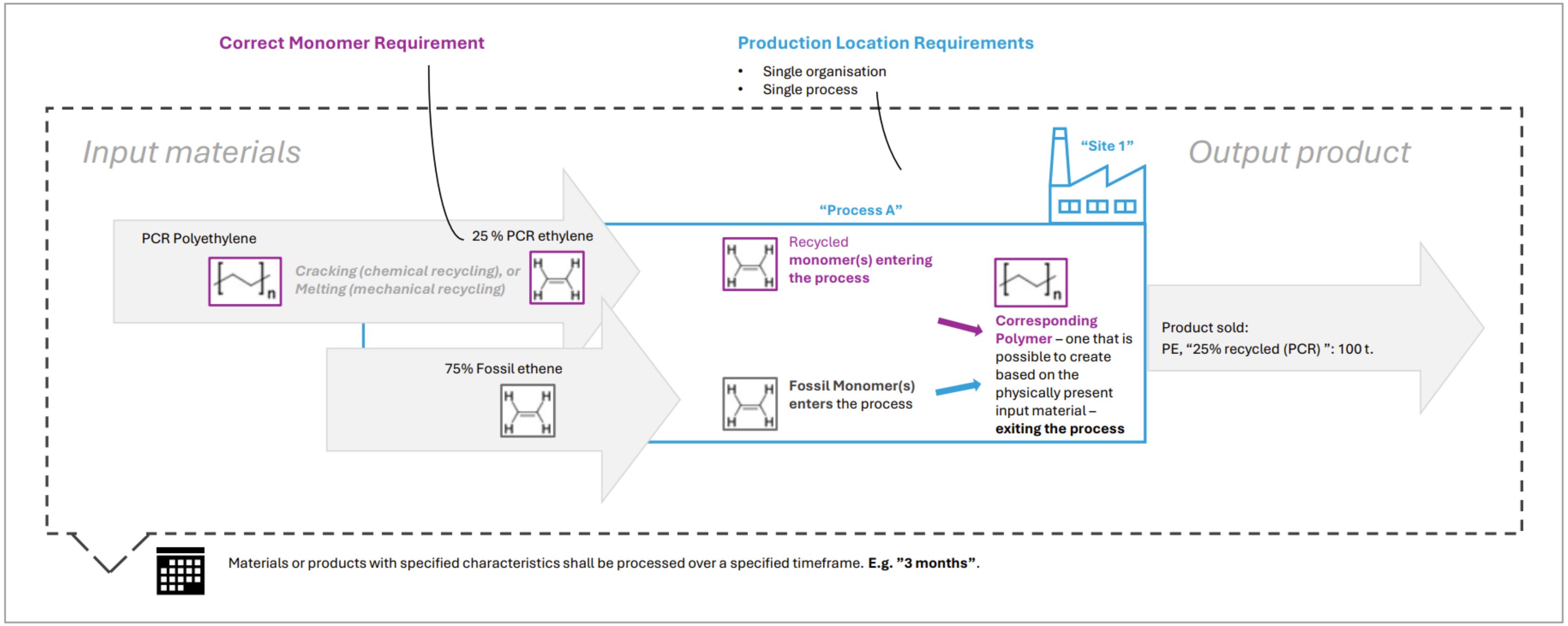

Figure 4. Chain of custody, Controlled blending model vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that the model also can be applied to bio-based plastics. Illustration: Trossa AB.

3.4.4 Mass balance models

ISO 22095 defines the mass balance model as a "chain-of-custody model in which materials or products with a set of specified characteristics are mixed according to defined criteria with materials or products without that set of characteristics". Further, "the proportion of the input with specified characteristics might only match the initial proportions on average and will typically vary across different outputs".

Attribution in a mass-balance context refers to the rules and methods used to assign a portion of sustainable or recycled feedstock to specific outputs, while allocation is the process of accounting for and distributing these inputs to the outputs in a complex production system. Attribution defines the rules for where the credit for the sustainable input can go (e.g., proportionally to all products or re-allocated to a subset), whereas

Allocation is the actual bookkeeping and distribution of that sustainable content to specific finished goods (the distribution of credits).

There is an on-going development of standards to further detail how a mass balance model should be applied.[22] It is important to note that when these documents are published, they may provide important updates to this section. The three methods detailed related to the mass balance credit method build on experience of actual practices, provided by interview with experts and practitioners.

3.4.4.1 Mass balance model – Rolling average method

The rolling average method can be used in cases where there is a fluctuating proportion of input materials meeting the defined characteristics (here, post-consumer recycled or bio-based plastics) entering the organization over a defined period. In these cases, using the rolling average method, a "claim period" is defined (e.g. three months), which allows the organization to claim an average allocated percentage of PCR or bio-based share over the claim period.[23]

Using this method, materials or products with a set of specified characteristics are mixed according to certain criteria with materials or products without that set of characteristics resulting in a known proportion of the specified characteristics in the final output.

The rolling average percentage method is similar to the credit method, the same system boundaries and other requirements can be used for both methods. However, using the rolling average percentage method, all products produced during the time period share a certain percentage of the attributed sustainable material (i.e. the "rolling average"), corresponding to the share of sustainable material in the inputs. For example, if 30% of the inputs during the time period are sustainable/recycled, all products produced get assigned a 30% share claim.

According to experts interviewed, this method is not currently widely used in plastics recycling. The reason for this is stated to be that this method would typically result in a low share of recycled / bio-based material, often too low to provide a sales advantage (e.g. a 3% share).

---

[22] International Organization for Standardization (ISO), *ISO 22095-2 Chain of Custody Part 2: Requirements and Guidelines for Mass Balance*; International Organization for Standardization (ISO), *ISO/DIS 13662 (EN) Chain of Custody - Mass Balance - Requirements and Guidelines*.

[23] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

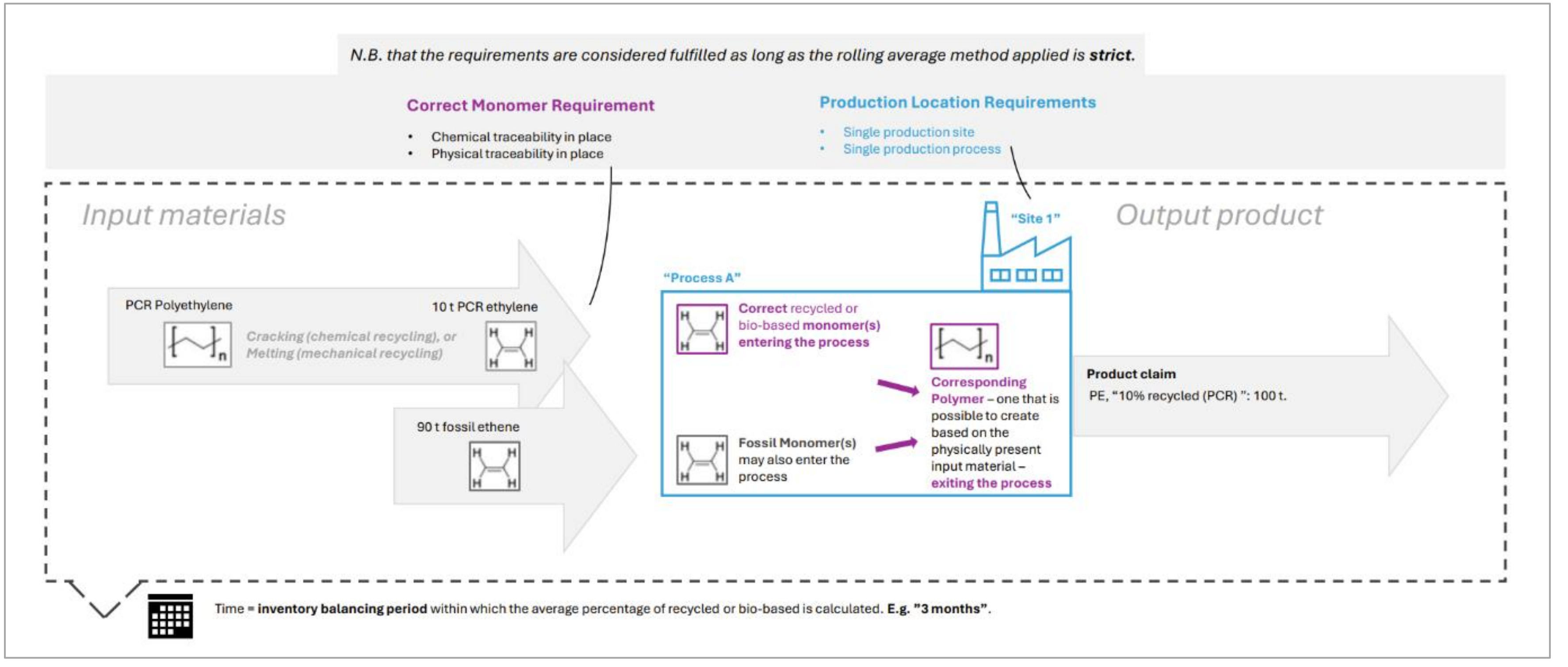

Figure 5. Chain of custody, Mass balance model – Rolling average method, vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that the model also can be applied to bio-based plastics. Illustration: Trossa AB.

The rolling average model meets the correct monomer requirement, as there is physical and chemical traceability. The production location requirement is also fulfilled, as the compounding ("Process A" in figure 1) is carried out within a single site and process in this model. However, the requirements are only considered fulfilled if the rolling average method applied is ***strict***.

In practice, it is also possible to apply the rolling average method without complying to the correct monomer requirement (e.g. if not applied strict, credits can be moved from “similar products”, that may be made of other materials) or the production location requirements (e.g. if the system boundaries are drawn around an entire global organization, credits can be transferred from a site in Asia to a site in Europe). These cases are not illustrated but exist in practice.

3.4.4.2 Mass balance model - Credit method

The credit method is widely referenced in certification schemes and described in the ISO 22095 standard: “The credit method can be used when two or more types of input are used in a material or product. The recorded output amount of each type shall be equivalent to the physical input, considering conversion factors.

The conversion factor shall be defined within each material or product at each site, and it shall be applied to define the amount of credit to enter the credit account, when using the output as the basis for calculation, or to withdraw the credit when using the input as the basis for calculation.

The credit account balance shall be calculated for each period according to the formulae given in Annex C of the standard. For each material or product, the organization shall set up and maintain a credit account for each type of input used as an output declaration. The organization shall ensure that the credit account is not overdrawn within the balancing period.”[24]

However, according to interviews with experts, there is a large variation in how the model is applied in practice. Based on these interviews, this report details three examples of commonly used methods to apply the credit model, indicating to which extent they are considered to meet the verification system objectives.

3.4.4.3 Mass balance model - Credit method 1: “Global credit transfer”

In the global credit transfer method, the organization can make claims of sustainable or recycled material based on a very liberal allocation of credits linked to different input materials. The allocation can also take place within all parts of a global organization.

[24] International Organization for Standardization (ISO), *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*.

As a practical example, this could mean that an organization that purchases various “sustainable inputs” (e.g. different recycled plastics, both post-industrial and post-consumer, or bioenergy) and “non-sustainable inputs” (fossil materials) would be able to allocate credits from “sustainable materials” to any given output material.

- Credits can be transferred between different processes; they are not tied to individual processes and do not need to be based on actual conversion factors and material losses. System boundaries can in practice include an entire global organization with sites in different countries or continents. Because of this, chemical and physical traceability cannot be ensured.
- Calculations can be based on material mass, economic value or energy content.
- Overcompensation can be permitted; credit allocation to an output/product does not necessarily follow actual chemical reactions and stoichiometric principles.
- Overcompensation can be permitted; All credits can be allocated to one product although it might not be possible to produce that product from the input. With overcompensation allocation takes place even though a share cannot chemically derive from the input. When overcompensation is done, credits can for example, be allocated from a raw material to give an output 100% attributed content although that output does not chemically origin 100% from that input. Chemical reactions and stoichiometric principles are not followed.
- Credits derived from energy recovery processes can be attributed to the material content of certified products.
- Credits can be attributed across products that are “similar in nature”. The definition of “similar in nature” is very wide, which may open possibilities to transfer credits between e.g. plastic and carton.[25]
- Non-proportional attribution is allowed between the outputs/products of one process without following chemical traceability and permitting overcompensation, as long as the credit account is balanced.
- Claims and communications shall accurately represent the applied system and its limitations. As the system may include several sites in several countries (as long as they belong to the same organization) and calculations can be based on mass, economic value or energy content, and credits can be transferred between different processes, the possibility to make claims of “sustainable content” is relatively wide.

[25] International Organization for Standardization (ISO), *ISO/DIS 13662 (EN) Chain of Custody - Mass Balance - Requirements and Guidelines*.

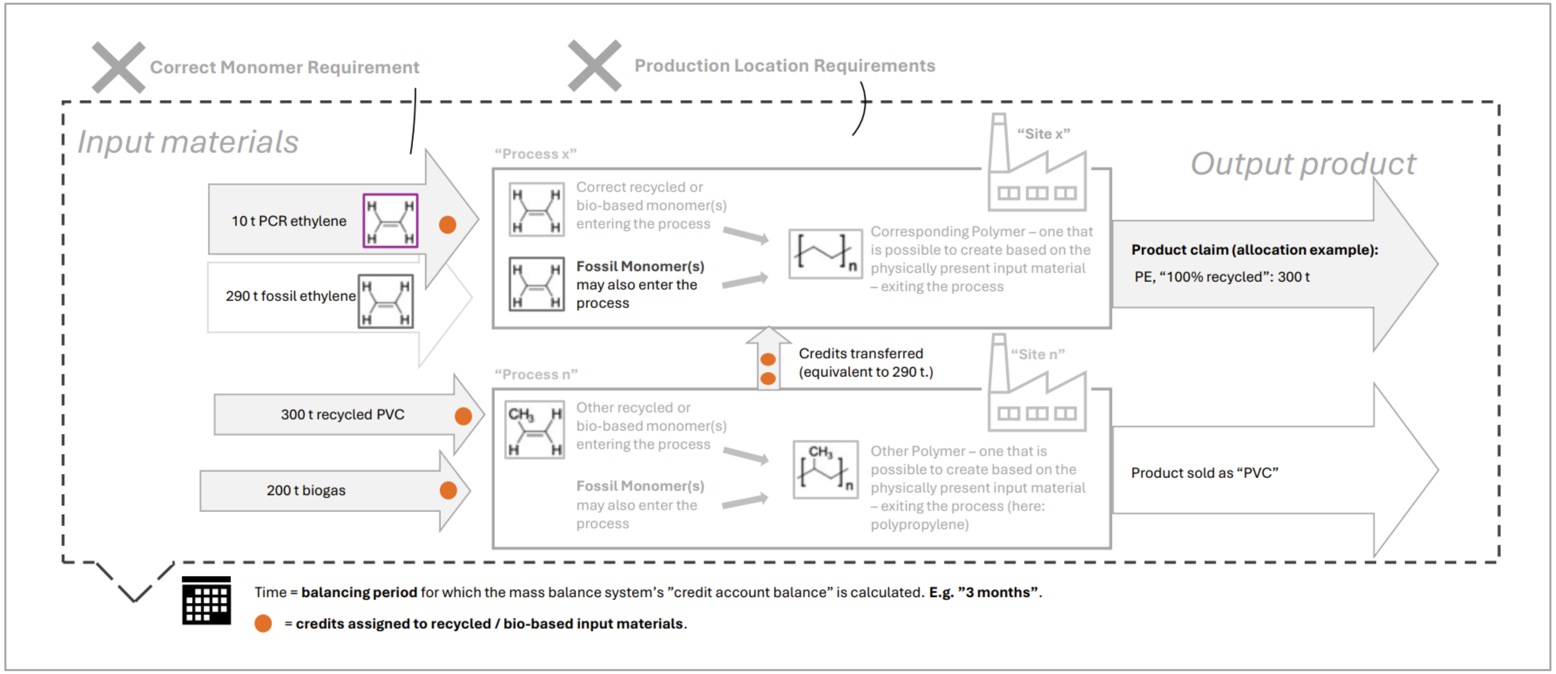

Figure 6. Chain of custody, Mass balance model - Credit method 1: "Global credit transfer", vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that the model also can be applied to bio-based plastics. Illustration: Trossa AB.

The global credit transfer model does not meet the correct monomer requirement, as it does not ensure physical and chemical traceability; credits may in practice be allocated from one material to another. Nor is the production location requirement fulfilled, as in this model, credits may be allocated between production sites as the organization sees fit.

3.4.4.4 Mass balance model - Credit method 2: “Intra-site credit transfer”

The intra-site credit transfer model has the same characteristics as the global credit transfer model but is limited to one site.

The intra-site credit transfer model does *not* meet the correct monomer requirement, as there are no physical and chemical traceability and credits may in practice be allocated from one material to another. Nor is the production location requirement fulfilled, as credits may be allocated between production processes as the organization sees fit in this model.

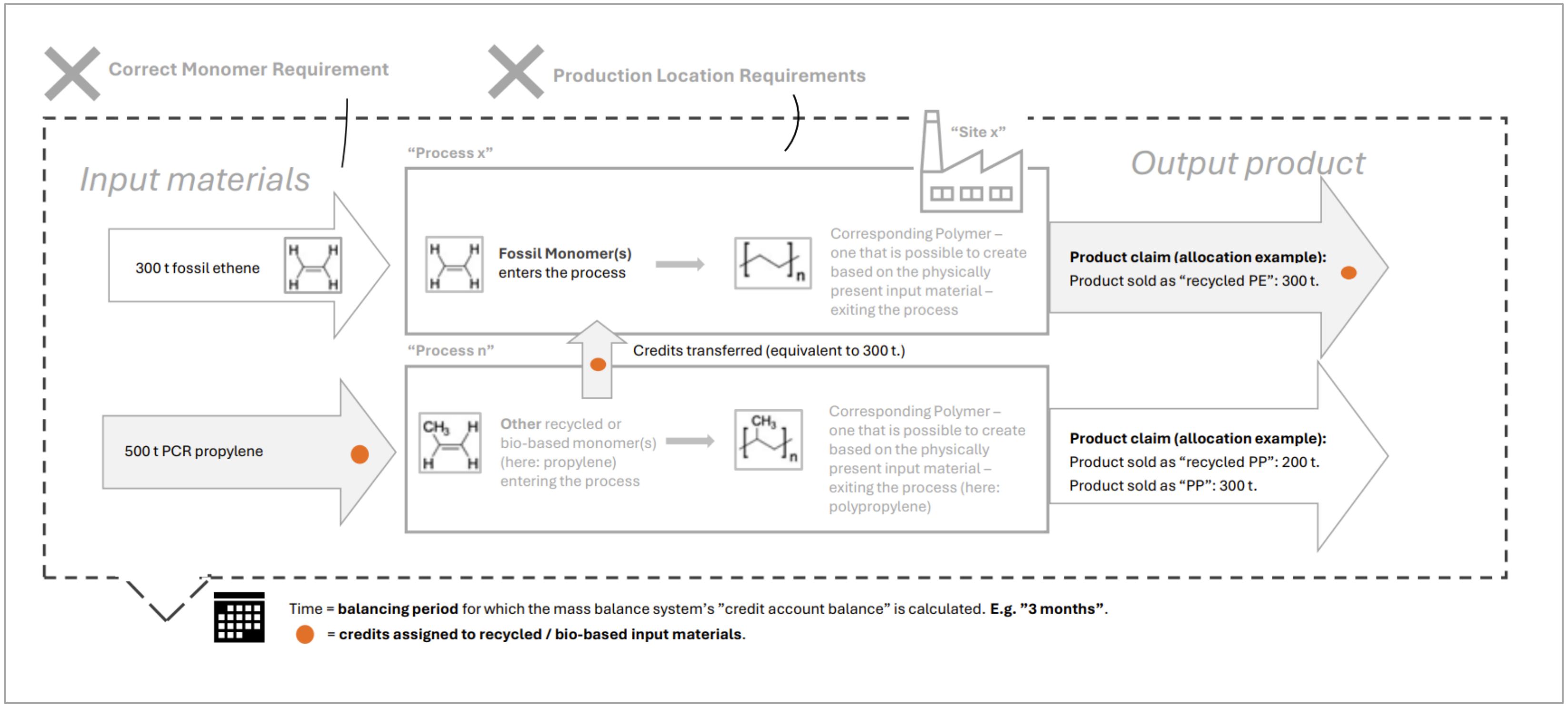

Figure 7. Chain of custody, Mass balance model - Credit method 2: "Intra-site credit transfer", vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that the model also can be applied to bio-based plastics. Illustration: Trossa AB.

3.4.4.5 Mass balance model - Credit method 3: “Strict approach”

In the strict approach:

- Credits are not allowed to be transferred between different processes; they are strictly tied to individual processes and shall be based on actual conversion factors and material losses.
- Both chemical and physical traceability shall be ensured for the process in use, with calculations based on material mass rather than economic value or energy content.
- Overcompensation is not permitted; credit allocation to an output (product – here meaning the produced plastic material) shall follow actual chemical reactions and stoichiometric principles.
- Non-proportional attribution is allowed, as long as chemical traceability is ensured.
- All claims and communications shall accurately and transparently represent the applied system and its limitations.
- Credits derived from energy recovery processes are not allowed to be attributed to the material content of certified products.
- When the above criteria are fulfilled, non-proportional attribution is allowed between the outputs/products of one process.

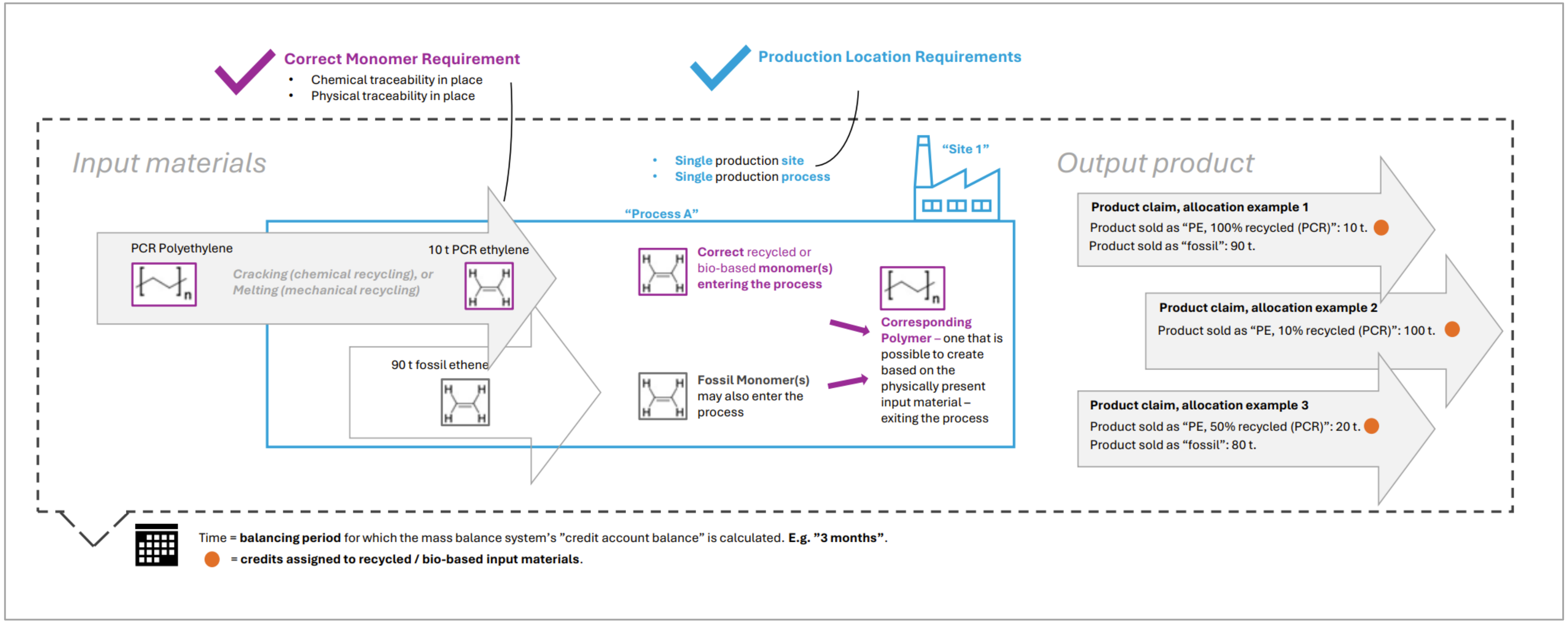

Figure 8. Chain of custody, Mass balance model - Credit method 3: "Strict method", vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that the model also can be applied to bio-based plastics. Illustration: Trossa AB.

The strict mass balance model meets the correct monomer requirement, as a defined and carefully documented *share of material from a specific type* is allocated to product. The production location requirement is also fulfilled, as the compounding (Process A in figure 1) is carried out within a single site and process in this model.

3.4.5 Book and claim model

ISO 22095 defines the book and claim model as a model that aims “to ensure that for each purchase for which a claim is made, materials or products with the same specified characteristics have been produced.” It is “an alternative chain-of-custody model in which the administrative record flow is not connected to the physical flow of materials or products throughout the supply chain.

After production the information on specified characteristics within the supply chain is decoupled from any material or product. Credits are issued when materials or products enter the market. The credits may be traded and sold independently of the physical delivery of materials or products” (ISO 22095).

The model can also be referred to as "certificate trading model" or "credit trading". It is often used “where the certified/specified material cannot, or only with difficulty, be kept separate from the non-certified/specified material, such as green credits in electricity supply” (ISO 22095).

The book and claim model does not meet the correct monomer requirement, as there is no physical and chemical traceability. Nor is the production location requirement fulfilled as materials can be traded on a global level (within a controlled system).

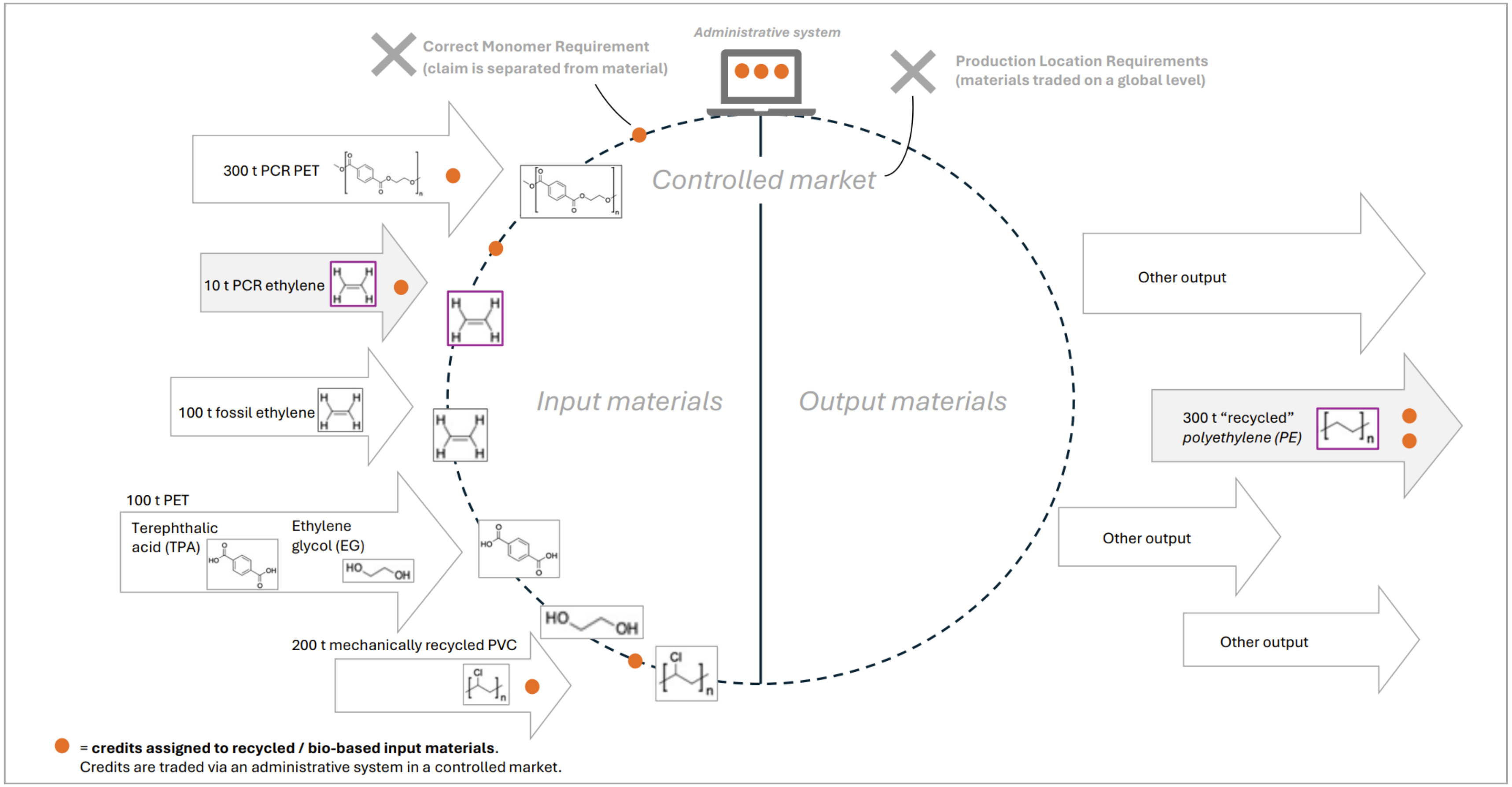

Figure 9. Chain of custody, Book and claim model, vis-à-vis the verification system requirements for chain-of-custody models. The figure depicts recycled material, using the production of polyethylene (PE) as an example. N.B. that the model also can be applied to bio-based plastics. Illustration: Trossa AB

3.5 Laboratory tests

Laboratory-based testing methods aim to physically verify recycled or bio-based content in plastics, offering a scientific complement to documentation and audits.

Existing laboratory testing methods for bio-based content include elemental analysis and C14 analysis. These approaches provide clear results regarding the proportion of fossil versus renewable carbon.

The analysis of recycled content is not as straightforward and these methods are not widely used today since they are in early development, but they could play an important part in the future. Specifically, these approaches could be promising for spot checks, particularly for imported plastic packaging where traceability is weak. However, they are related with high costs, scalability issues, and uncertain accuracy and applicability depending on material types at this stage.

A report by British Plastics Federation (BPF) from 2022 mentions several initiatives exploring laboratory test methods to physically determine the recycled content in plastic packaging.[26] For example, technology based on fluorescent tagging where molecular markers are added during recycling that can later be detected to quantify recycled content, or another method that uses inorganic luminescent taggants detectable via infrared scanners for instant verification of recycled material ratios.

These technologies, combined with financial and record audits, could provide evidence for verifying claims for recycled plastics.

While promising for spot checks, especially for imported packaging where documentation may be unreliable, current limitations include high costs, scalability challenges, and unknown accuracy. One further concern could be to make the test method proof of potential fraud. Testing every batch would be impractical, so selective sampling is the most feasible option. At present, these methods are in early development and applicable mainly to mechanically recycled plastics, with potential restrictions on material types and precision. There are also published work using traditional analytical methods like untargeted GC-MS analysis, FTIR and NIR indicating that these methods could distinguish recycled materials from virgin[27,28,29].

---

26 Morgan and Jordan, *Verification Solutions to Support Delivery of Recycled Content in Plastic Packaging*.

27 Chen et al., 'Identification of Recycled Polyethylene and Virgin Polyethylene Based on Untargeted Migrants'.

28 Beigbeder et al., 'Study of the Physico-Chemical Properties of Recycled Polymers from Waste Electrical and Electronic Equipment (WEEE) Sorted by High Resolution near Infrared Devices'.

29 Ajorloo et al., 'Incorporation of Recycled Polypropylene and Fly Ash in Polypropylene-Based Composites for Automotive Applications'.

4. Analysis of existing verification systems

The first chapter 4.1 Criteria for verification systems outlines the criteria including control elements of a credible verification system. The nest chapter 4.2 Overview of existing certification schemes according to control elements shows an analysis of how the current market situation looks today.

4.1 Criteria for verification systems

To ensure credible claims about recycled and bio-based material, verification systems must be supported by robust control elements that guarantee transparency, consistency, and trust throughout the supply chain. Based on the findings in the previous chapters concerning traceability and chain-of-custody models, a set of control elements are suggested. The control elements define the minimum criteria and best practices for certification bodies, auditors, and associated processes, forming the foundation for reliable verification.

Objective of control elements
The specified criteria shall ensure a production of bio-based or recycled material that: credibly can claim a share of recycled or bio-based material that has been used in the production at hand (defined as a production process during a specific and defined time period to which the claim is linked).

Suggested control elements

The control elements are described and argued for in this chapter. The full list of suggested control elements can be found in Appendix.

4.1.1 Certification, certification body and auditor requirements

To maintain credibility, transparency, and consistency in verifying recycled and bio-based plastics, certification of recycled and bio-based materials is a widely adopted practice.

Meets criteria

Certification bodies and auditors must apply clear, reliable, and consistent certification practices. It is essential that certification schemes are based on well-defined criteria, while auditors and audit schemes should promote openness and transparency by establishing and following transparent certification criteria and procedures throughout the entire process. Certifications must be issued by an accredited body under ISO 17065 or similar standard and remain free from conflicts of interest to guarantee impartiality and credibility. Furthermore, auditors must have documented expertise in plastic recycling and traceability systems to be able to carry out the audit.

To enable stakeholders to clearly understand the certification coverage, the scope of certification must be explicitly defined, specifying whether it covers the product, process, or organization. Both the certification requirements and audit procedures must be publicly available to enable transparency and comparability.

Also, the certificates shall be easily verifiable through public platforms and include a clearly defined validity period to ensure ongoing compliance.

Nice to have

Criteria listed as “Nice to have” cover:

Independence from national standard organization and quality control can further enhance certifications credibility. If the certification body itself owns the standard, it is no longer fully independent since it has a direct interest in both the rules and the certification. This can conflict with ISO 17065 requirements for impartiality.

To improve impartiality and risk for conflicts of interests, certification bodies should be independent from national standards organizations and free from conflicts of interest with the companies they certify.

4.1.2 Audit

To ensure that claims about recycled or bio-based material in a defined production process are credible, the audit process shall meet certain principles that safeguard transparency, impartiality, and reliability.

Meets criteria

A clearly defined audit scope is essential because it specifies what is being assessed, such as processes, documentation, and manufacturing facilities, ensuring that the verification covers all critical aspects of production. Furthermore, on-site audits are fundamental since they allow auditors to visually inspect operations and confirm that practices align with certification requirements. Audits shall be carried out by accredited third-party bodies to ensure impartiality and credibility, and recurring audits at least every three years help maintain ongoing compliance and trust in the system.

Procedures for managing non-conformities, including suspension or withdrawal of certificates, are equally important to uphold integrity when issues arise. Finally, a comprehensive audit report that includes findings and a clear statement of conformity provides transparency and accountability.

Nice to have

Surveillance audits could help maintain compliance and identify issues between certification cycles, reducing fraud risk and enhancing trust. However, making them compulsory would increase costs and administrative burden. For this reason, they are recommended as best practice rather than a strict requirement.

Another way could be to use unannounced inspections to provide ongoing assurance of compliance.

Not enough

By contrast, relying solely on desktop audits, internal audits, or second-party audits is not sufficient. These approaches lack the independence and depth needed to verify compliance effectively and therefore cannot guarantee credibility on their own.

4.1.3 Chain-of-custody (traceability)

Traceability through a robust chain-of-custody system is essential for credible claims about recycled or biobased material and is the basis for certification schemes today.

Meets criteria

First, certifications shall clearly declare which chain-of-custody model is applied. Models like identity preserved and segregated provide the highest level of assurance because certified material is either kept completely separate or only combined with other certified sources, ensuring physical integrity throughout the supply chain. Controlled blending allows mixing of certified and non-certified material under strict documentation and batch-level controls, which is particularly relevant for mechanical recycling and biobased fuels.

Mass balance approaches introduce complexity. While they enable flexibility in chemical recycling and biobased raw material systems, they shall be applied with strict rules to maintain credibility. The strict credit method is considered robust because it ties credits to specific processes, reflects actual conversion factors, and prevents overcompensation or allocation from unrelated sources.

Not enough

Less stringent versions, such as intra-site or global credit methods, pose risks of market distortion and weaken traceability, making them insufficient for credible claims. Similarly, rolling average percentage methods and book-and-claim systems lack the necessary physical or process-specific link between input and output, which undermines transparency and trust.

In short, strong chain-of-custody models are the backbone of reliable certification. They ensure that claims reflect real material flows and prevent practices that could mislead customers or regulators

4.1.4 Other verification methods

While chain-of-custody documentation continues to serve as the principal approach for verifying recycled and biobased content, supplementary verification methods may enhance or reinforce credibility. At present, these additional methods are not extensively utilized.

Meets criteria

For biobased plastics, laboratory methods such as elemental analysis combined with radiocarbon (C14) testing provide a scientific way to determine biobased content. Standards like EN 16640, and EN 16785-1 prescribe these methods, offering an alternative or supplementary approach to chain-of-custody verification. If physical testing is applied, it is essential that laboratories are ISO 17025 accredited to ensure accuracy and reliability of results.

Nice to have

Physical testing of recycled plastics through laboratory analysis can help identify additives or hazardous substances, reducing the risk of recycling materials that pose environmental or health hazards. Although not widely used today, such testing could support stricter compliance and environmental certifications.

Manual inspection of materials during processing remains a practical measure to verify characteristics and prevent contamination. Additionally, digital traceability tools, such as blockchain-based systems, can enhance transparency and provide tamper-proof records of material origin. While these technologies are not yet standard, they represent promising innovations for improving trust and transparency in supply chains going forward.

Not enough

Visual checks can provide initial indications of whether a material appears virgin or recycled, prompting further investigation if needed. However, visual inspection alone is not sufficient evidence to verify material claims and should only be used as a supplementary measure alongside more robust verification methods.

4.1.5 Standard references

Certification shall align with recognized international standards to ensure consistency, credibility, and comparability across markets. Clear definitions of key terms within the certification scope are essential to avoid ambiguity and misinterpretation of claims.

Meets criteria

Standards such as EN 15343 provide the foundation for traceability and accurate calculation when it comes to recycled content, which is critical for verifying material flows and supporting credible claims for recycled plastics.

ISO 22095 provides clear terminology and models for chain of custody, ensuring that all parties understand and apply the same principles when tracking material through complex supply chains. However, this standard cannot support claims about an organization's materials or products. ISO 22095 includes guidance to address this issue, but additional verification steps are required for credible claims.

For recycled plastics, the EN 15342–15348 series define characterization methods for different polymer types, supporting accurate identification and conformity assessment.

For bio-based materials, standards such as EN 16575, EN 16640, EN 16785-1, and EN 17228 specify how to determine bio-based carbon content and overall bio-based material share using robust scientific methods like radiocarbon analysis, elemental analysis, and material balance. These standards also define clear terminology and characterization methods, ensuring that bio-based claims are based on verifiable data rather than assumptions.

Communication standards, provide guidance on how recycled and bio-based content should be communicated transparently and accurately. ISO 14021 addresses environmental labels and self-declared claims while EN 16848 and EN 16935 set requirements for business-to-business and business-to-consumer communication focusing on bio-based materials. Together, these standards reduce the risk of misleading statements and greenwashing, ensuring claims are clear, verifiable, and aligned with internationally accepted principles.

By referencing these standards, certification schemes can deliver harmonized, credible, and scientifically sound verification processes that meet regulatory and market expectations.

4.1.6 Documentation

To credibly verify recycled or bio-based material claims, robust documentation and process control is essential. Documentation does not contain proof but can verify together with sample checks and procedures show credibility.

Meets criteria

A documented quality management system is essential for all process industries and provides the foundation for consistent operations and compliance. Documented demonstrating that a quality management system is in place is needed. Certification against recognized standards such as ISO 9001 demonstrates that procedures are in place to manage quality and reduce risks of errors or inconsistencies.

Accurate classification of waste in the recycling process is critical for traceability of recycled plastics. Recording the category, origin, and official waste codes ensures transparency and alignment with EU requirements, while distinguishing between post-consumer and pre-consumer sources supports credible claims.

Supplier information, including name and address, is necessary to establish accountability and enable verification of material origins. Similarly, detailed purchase and incoming material records, covering material type, recycled or biobased share, batch numbers, and delivery dates, are vital for tracking inputs and confirming compliance with certification standards.

Proper handling of incoming material strengthens integrity throughout the process. Recording batch information, implementing batch-handling systems, conducting manual inspections, and maintaining separate storage prevent contamination and ensure that recycled or biobased content is preserved. Regular stock inventories add another layer of control.

Clear process documentation, such as flow charts and batch protocols, provides transparency on how materials move through production. Including calibration procedures and quality control measures ensures that deviations are identified and addressed, maintaining reliability in output claims. In addition, documenting the reaction mechanism and stoichiometry of the process, as well as the sustainable share calculations for each output product, strengthens traceability and supports credible verification.

Finally, output information should be comprehensive. Descriptions of the product, recycled or biobased share, batch identification, and customer details enable full traceability from input to final delivery. This level of documentation is essential for substantiating claims and meeting regulatory and market expectations.

4.1.7 Supplier risk assessment and due diligence

Managing supplier risk and conducting due diligence are critical steps to prevent fraud and ensure transparency in the supply chain. These measures help identify high-risk suppliers, evaluate compliance, and reduce exposure to unethical practices that could undermine certification credibility especially when importing from suppliers from outside the EU.

Nice to have

Today supplier risk assessment and due diligence is not a widely used criteria in current certification schemes and is therefore assessed as a “nice to have” criteria. However, it could be argued that it should be a “meets criteria” for suppliers outside the EU.

Having a clear policy on relevant sustainability topics, such as environmental protection, human rights, labor rights, and anti-corruption, strengthens trust and accountability. An internal anti-corruption policy, for example, addresses bribery and fraud risks, which are particularly relevant in complex global supply chains.

Supplier due diligence goes further by requiring organizations to identify and assess sustainability related risks across their operations and supply chains. Proportionate risk measures help ensure sustainability claims are both accurate and ethical. While these practices are not yet standard in certification schemes, they represent an important step toward trustworthy and responsible verification.

4.1.8 Communication

Clear and accurate communication of claims and labels is essential to maintain trust and prevent misleading practices in the market for recycled and bio-based plastics.

Meets criteria

Claims shall at least follow recognized standards, such as ISO 14021 for self-declared environmental claims, to ensure consistency and credibility. This provides a common framework that businesses and consumers can rely on. However, these standards lack sufficient detail to solely define or substantiate claims for recycled plastics. For bio-based plastics also references to EN 16848 and EN 16935 are needed.

Matching claims to the certified product, component, or process is critical. Any claim shall correspond exactly to what is covered in the certificate and audit report to avoid misrepresentation. Similarly, claims shall align with the certified chain-of-custody model (e.g. whether mass balance, segregation, or controlled blending is used) so that the method used for allocating recycled or bio-based content is transparent and verifiable. If mass balance is applied, the claim shall specify the exact method, such as strict attribution or “trace-the-atom” to prevent ambiguity.

Minimum content thresholds are another important safeguard. Claims and labels can only be used when the recycled or bio-based content meets or exceeds defined minimum specifications, ensuring that marketing statements reflect meaningful environmental benefits. For consumer-facing claims, additional rules apply: the certified component shall represent a significant share of the product’s total plastic weight to avoid misleading impressions.

Disclosure of origin adds further transparency. Indicating whether the material is post-consumer, pre-consumer, or biobased helps stakeholders understand the environmental impact and supports informed choices. On-product labels, when used, should clearly state the basis of the claim, including the chain-of-custody model and, where relevant, the mass balance method. Providing information on the percentage of recycled or biobased content strengthens credibility and enables consumers and businesses to make decisions based on verified data.

Nice to have

Internal policies to prevent greenwashing are highly recommended to help organizations avoid exaggerated or misleading claims, ensuring that communication remains honest and aligned with certification standards. While not always mandatory, such measures significantly enhance trust and reduce reputational risk.

4.2 Overview of existing certification schemes according to control elements

This chapter evaluates current certification and verification systems in relation to previously established control elements described in section 4.1 aiming to assess their strength and reliability. The mapping and analysis (shown in Appendix) are not claimed to be comprehensive but rather offers an indication of what is covered by each of the certifications included. The summary evaluation of each control element is described as one of six categories. The meanings of these are as follows:

- **All** – All reviewed schemes meet the criteria.
- **Most** – Most reviewed schemes (more than appr. 70%) meet the criteria.
- **Some** – Around half of the reviewed schemes meet the criteria.
- **Few** – Few reviewed schemes (less than appr. 30%) meet the criteria.
- **None** – None of the schemes meet the criteria.
- **Not assessed** – The control element was not evaluated due to either lack of information or complexity in comparability between certification schemes.

In total, documents from 21 certification schemes were analyzed and mapped to which degree they meet the criteria described for each of the 68 control elements divided into 8 areas. In the appendix each evaluation both have a color (green = meets criteria, yellow = unclear, partly or not specified, red = does not meet mandatory criteria) and one or a few words describing how well the criteria is fulfilled.

The analyzed certification schemes differ widely in many ways. For example, on extensiveness, structure and described content, leading to large variations in ease of finding the searched information. Also, variations regarding the ease of finding the certification schemes on public websites were significant. Some certifications have multiple documents which focus on separate matters which also complicates information finding.

4.2.1 Certification, certification body and auditor requirements

The national requirements on certification bodies vary and the most rigid requirements are found in Spanish law. Requirements for ISO 17065 accreditation were searched for in the assessed certification schemes and were found in some, however interestingly not in the Spanish certification AENOR. For all reviewed certifications, certification scope is clearly defined, but transparency is inconsistent, most schemes publish audit procedures and criteria, but a few keep them internal. All certifications are independent with regards to the certifying companies, and most are also independent from national standards organizations and the certifications themselves. Most certifications have a clearly defined validity period for the certificate.

Based on the assessed documentation, the certifications demonstrating the highest level of criteria fulfilment in this area are: APR PCR, NEN Biobased, RecyClass and RED cert.

4.2.2 Audit

Third-party verifications are required according to all certifications. In most cases, on-site audits are also mandatory and only in a few cases, based on risk assessment, desktop audits can be used as only audit method. Desktop audits are also accepted for certifications of biobased material where the content is verified by C14-analysis.

For most certifications audit frequencies are specified and vary between one to six years. There are 11 certifications that require annual on-site recertification audits. For all certifications with intervals longer than one year, surveillance audits are required. These are in several cases performed as desktop audits, which could be a weakness.

Unannounced audits are rarely used since they are costly and might disrupt companies more necessary even though they would strengthen credibility.

Based on the assessed documentation, the certifications demonstrating the highest level of criteria fulfilment in this area are: AENOR, APR PCR, ISCC+, RecyClass, GRS, RCS, Recycled Content Certification, QA-CER, RMS and RED cert.

4.2.3 Chain-of-custody (traceability)

Most certifications declare a chain-of-custody model, but the stringency varies. Some of the certifications for bio-based material rely fully on C14-analysis and chain-of-custody methods are not mentioned. Identity preserved methodology is only described in a few certification schemes. For mechanical recycling segregation and controlled blending are the most used methods.

For chemical recycling the mass-balance approach is the most common although it is most often not clear which type of mass balance is used. The mass-balance method is also used for some of the certifications for biobased plastics. Unfortunately, many schemes apply vague requirements or permit global credit transfers, which weaken traceability and create opportunities for misleading claims. In some cases, credits can be shifted across sites or regions without clear physical or temporal links to production, undermining consumer trust.

Strict credit-based mass-balance approaches, where credits are tied to specific production processes and timeframes, are less common but represent best practice.

Some of the certifications are very specific in which chain-of-custody models to use while others describe several to choose between depending on what suits the circumstances best. As noted above, there are also large variations in the requirements for certifications referring to the mass-balance approach. A few of the certifications do not seem to specify at all which mass-balance method to use, while others describe one or several variants, all calling it mass balance. This makes it hard to pinpoint to which degree they fulfil the control element requirements.

Certifications only relying on the physical traceability approach's identity preserved, segregation and/or controlled blending are the following: AENOR, APR PCR, DIN-Geprüft Recycled, RecyClass and QA-CER. That means that they do not approve of mass-balance methodology at all.

Certifications referring to both methods for physical traceability and mass balance are the following: GRS, RCS, Biobased Content certification, Recycled Content certification, RMS and RED cert. One certification refers only to the strict mass-balance approach: ISCC+.

4.2.4 Other verification methods

Physical C14 testing is or can be used for some of the certifications for biobased materials: DIN-Geprüft Biobased, ISCC+, NEN Biobased, OK Biobased and RED cert.

For recycled plastics certifications based on the EN 15343 standard there are included some testing that are mainly focused on identification of plastic polymer and quality of the recyclate. Otherwise, testing is not specified in the schemes. Digital traceability tools described in section 3.5 are not integrated as standard methods in existing certification schemes.

4.2.5 Standard references

All certifications refer to some standards but how these standards are referenced often lack comprehensive detail, and their implementation may be inconsistent, resulting in ambiguity regarding definitions and methodologies.

Although the importance of defining chain-of-custody methods only a few certifications reference ISO 22095: APR PCR, ISCC+, RecyClass, Recycled Content Certification, QA-CER and RED cert-2.

For mechanically recycled plastics, standards like EN 15343 and EN 15342–15348 are considered critical, yet only some schemes fully incorporate them: AENOR, APR PCR, DIN-Geprüft Recycled, ISCC+, OK Recycled, RecyClass, Recycled Content Certification and QA-CER.

For bio-based plastics, standards such as EN 16575, EN 16640 and EN 16785-1 and EN 17228 are essential for credible claims and in some of the certifications for bio-based plastics at least one of these are included in the schemes: DIN-Geprüft Biobased, ISCC+, NEN Biobased, OK Biobased and OK Renewable.

Communication standards like ISO 14021 (and for bio-based EN 16848 and EN 16935) are important for transparency and preventing misleading claims. None of the certifications refer to EN 16848 and EN 16848 but most refer to ISO 14021: APR PCR, DIN-Geprüft Recycled, ISCC+, OK Biobased, OK Renewable, OK Recycled, RecyClass, GRS, RCS, Recycled Content Cert, QA-CER, RMS and RED cert-2.

4.2.6 Documentation

Documentation requirements vary significantly between certification schemes, leading to inconsistencies that create challenges for stakeholders and end users when evaluating the credibility of different certifications. Some systems require detailed records and precise batch tracking to substantiate claims, whereas others provide only limited guidance. This makes it hard to generalize and is the reason why it several control elements are labeled as “Not assessed”. These disparities underscore the necessity for greater harmonization and more explicit protocols to ensure that all certification schemes deliver a comparable standard of assurance concerning material origins and their movement throughout the supply chain.

Critical for fulfilling the various requirements for certification of recycled or biobased plastics is however a systematic workflow for documentation, which for example can be verified by a quality management system like ISO 9001.

The following certifications refer to ISO 9001: AENOR, APR PCR, DIN-Geprüft Recycled, ISCC+, NEN Biobased, Ocean Bound Plastics, RecyClass, Recycled Content Cert, QA-CER and RED cert.

4.2.7 Supplier risk assessment

These control elements were not fully assessed but only a few certifications were found to describe sustainability due to diligence risk checks or anti-corruption measures at all. This is particularly concerning for suppliers outside the EU.

4.2.8 Communication

Internal anti-greenwashing policies are generally not mandatory and basic claim alignment with certificates is generally required. This information was not consistently found, and these two control elements were not fully assessed. Detailed rules for origin disclosure, minimum content thresholds, and labeling vary a lot and are often not clearly specified or missing. Based on the assessed documentation, the certifications that came out with most criteria fulfilments in this area are the following: APR PCR, DIN-Geprüft Biobased, OK Biobased, RecyClass and RMS.

The following certifications were slightly below: AENOR, ISCC+ and NEN-biobased.

4.3 Summary of insights

In summary, the evaluation of all 68 control elements shows that some certification schemes meet substantially more requirements than others. For recycled plastics the following certification schemes apply: APR-PCR and RecyClass, followed by QA-CER.

For biobased plastics the following certification schemes apply: ISCC+ and OK Biobased, followed by DIN-Geprüft Biobased and NEN Biobased.

5. Conclusions

This chapter summarizes the main findings from the analysis of verification systems for recycled and bio-based plastics. It identifies key gaps such as inconsistent application of standards, lack of harmonization, and insufficient audit rigor, which undermine credibility and comparability. Based on these findings and suggested control elements described in chapter four, recommendations are provided to strengthen current and future verification frameworks, improve transparency, and ensure that claims about recycled and biobased content are reliable and aligned with regulatory and market expectations.

5.1 Insights regarding verification systems

Understanding the origin of materials is becoming increasingly critical, particularly as legislation mandates that a growing share of plastic products and packaging must be made from sustainable sources, such as post-consumer recycled, or bio-based plastics.

This report has sought to answer the fundamental question: is it possible to verify that post-consumer recycled or bio-based materials de facto are present in a product when such a claim is made? If so, what methods enable this verification, and with what degree of certainty?

In the case of bio-based plastics, it is possible to carry out carbon analyses to test that the actual content is bio-based. However, verifying post-consumer recycled material is not possible via laboratory analyses. Instead, verification relies on robust traceability practices that build on chain-of-custody models that are sufficient to achieve this condition. To ensure this level of physical presence of the claimed content (post-consumer /recycled plastic), this report has concluded that the identity preserved, segregated, controlled blending or strict versions of mass balance are able to verify this condition.

Below, some key insights and reflections regarding verifications based on the study are listed.

Challenges prioritizing verification despite its importance

Although verification methods (e.g. certifications, laboratory tests, digital traceability tools) can play an important role in providing credibility to plastic materials, they are not always prioritized by companies, as implementing them introduces additional costs for certification, audits, and administrative work. Interviews with stakeholders indicate that smaller companies or industries with limited resources may delay or avoid adopting robust traceability systems.[30]

[30] It should however be noted that stakeholder interviews indicate that if verification methods were required by legislation, smaller companies would adapt.

The variation in information provided about bio-based or post-consumer recycled content (based on choice of chain of custody as required by certification schemes) may as a result lead to inconsistent sustainability claims, making it harder for customers and regulators to trust recycled or biobased content declarations. This may in turn weaken overall confidence in circular plastic solutions and slow down the transition toward more sustainable material use.

Certification is essential for credibility and compliance

Today's certification landscape lacks harmonization and transparency. Differences in scope, terminology, and audit rigor create inconsistencies and reduce comparability between schemes. In addition, public access to certification criteria and audit procedures is often restricted, which further risks undermining trust and accountability.

Despite this, robust certification systems have the potential to be a key element in verifying recycled and bio-based content, ensuring compliance with EU regulations, and preventing fraud in the marketplace. However, their current effectiveness is limited, with improvements needed, in clear and transparent criteria, streamlined requirements, audit processes, and the application of claims and labels to make certification schemes truly credible. For example, clear definitions of "recycled content" (post-consumer vs. pre-consumer) or specification of mass-balance models used and how communication and claims can be used in relation. In relation to claims and labelling, the report highlights that certification labels can only support credible communication when they are applied with strict consistency and clear parameters. Labels must accurately reflect what has been certified, including the exact share of recycled or bio-based content, the chain-of-custody model used, and whether the material originates from post-consumer or pre-consumer sources. To avoid misleading claims, labels should never be used in isolation or without accompanying information that clarifies their scope, limitations, and the conditions under which the claim is valid.

Standards used lack detail and are applied inconsistently

While international standards provide an essential overarching framework for traceability and chain-of-custody systems, they are referenced and applied in markedly different ways across existing certification schemes. Some schemes only cite a standard at a high level, without specifying how its requirements are operationalized, whereas others claim to be fully "based on" a particular standard, even when their implementation deviates from its intent. This inconsistent use of terminology creates ambiguity around definitions, scope, and methodological boundaries, particularly regarding chain-of-custody models and the conditions under which each model may be applied. The flexibility granted by some of the standards makes it difficult to ensure uniform implementation and comparability between certification systems.

This further underlines the importance of regulation in this field to provide clear guidance on terminology such as the suggested control elements.

Chain-of-custody methods vary greatly

For materials with recycled and bio-based properties, certifications and chain-of custody systems are important elements for ensuring orderly handling of these materials and providing proof of the claimed properties. Chain-of-custody systems enable information associated with a material to be shared between actors in the supply chain.

The choice of chain-of-custody model has a direct impact on the level of traceability achieved and thus the ability to verify plastic material. It also determines what claims can legitimately be made. For example, the different applications of mass-balance models may result in a large variation concerning the connection between the claim made and actual content, which would create significant market disparities. This is currently not sufficiently communicated to consumers.

This report has highlighted the importance of understanding differences between chain-of-custody models regarding the level of physical presence (recycled or bio-based) of the claimed property that they provide.

Other chain-of-custody models may be needed to enable circular plastics at scale

The framework condition for the analysis was to investigate which verification systems would provide ensure physical presence in a product of its claimed content (e.g. 30% recycled PE in a product labelled "30% PCR").

However, consultations with stakeholders also highlight that this level of physical presence is not practical for large-scale chemical recycling facilities, where the scale of the process requires that many different plastics, for practical and economic reasons, are co-recycled. Where a cracking technology (used in chemical recycling) has broken down mixed materials to small molecules, it is not possible to track the origin of specific atoms. This means that the correct monomer requirement would in practice not be able to satisfy.

Meanwhile, these technologies would make significant contributions to the circular economy of plastics. For example, chemical recycling enables more flexible quality requirements for the input materials, while being well disposed for removing hazardous substances from the input materials – enlarging the possibilities to recycle a greater share of plastic waste.

For chemical recycling technologies to be developed at scale, mass-balance models that do not satisfy the correct monomer requirement need to be possible. This should be kept in mind when developing regulatory requirements for chain-of-custody models for the recycling industry.

Auditing practices are uneven

Current certification schemes show significant variation in how audits are conducted. While third-party, on-site audits are widely recognized as essential for ensuring impartiality and depth, their application differs depending on competence requirements, documentation scope, and audit frequency. In some cases, reliance on desktop or internal audits compromises the robustness of verification and increases the risk of non-compliance or fraud.

Harmonizing minimum audit requirements, such as mandatory annual on-site inspections for all certified sites, would strengthen credibility, improve consistency across schemes, and reduce opportunities for manipulation. It is possible to design requirements or schemes, so the annual audits focus primarily on the most relevant topics, such as maintaining the required chain-of-custody system. Establishing clear competence criteria for auditors and standardized documentation protocols would further enhance transparency and trust in certification systems.

Supplier risk management is underdeveloped

Current certification schemes rarely include structured supplier risk management, sustainability due diligence, or anti-fraud measures. This leaves significant gaps in global supply chains, particularly outside the EU where regulatory oversight is weaker.

Without systematic risk assessment, companies in the plastic value chain may fail to identify high-risk suppliers or regions vulnerable to non-compliance, fraud, or unethical practices.

To strengthen credibility, verification systems could integrate mandatory supplier risk evaluation, including checks on origin, compliance history, and sustainability performance. Incorporating anti-fraud protocols, such as transaction-level traceability, would reduce vulnerabilities and improve trust across complex, multi-tier supply chains

Limited use of alternative verification methods

For bio-based materials, it is indeed possible to verify the content through carbon analysis, specifically radiocarbon (C14) testing in combination with elemental analysis. Such an analysis measures the ratio of biogenic carbon to fossil carbon in the material, providing an accurate and credible method for determining bio-based content. This approach is implemented in most certification schemes for bio-based plastics and recognized in standards such as EN 16640 and EN 16785-1.

For recycled plastics, today's testing practices focus primarily on characterizing the incoming waste and the recycled materials. These methods rely mainly on visual inspection and/or physical analyses, such as assessing density, pellet size, color, or contamination levels, and are designed to evaluate material quality rather than to verify claims about recycled content.

Unlike for bio-based plastics, there are currently no laboratory tests that can provide reliable differentiation between recycled and virgin plastics. This limitation arises because both materials share the same polymeric structure; their molecular composition is identical, meaning that conventional chemical, thermal, or elemental analysis cannot distinguish between them. As a result, laboratory testing cannot be used to substantiate claims of recycled content with the level of credibility achieved through radiocarbon analysis for bio-based materials.

Some alternative laboratory-based test methods exist, such as fluorescent tagging as described in section 3.5, although these tests would also be relatively easy to manipulate and therefore lack robustness. Regardless they are not widely adopted or systematically integrated into current certification frameworks.

Another alternative verification method mentioned in this study is digital technologies. These technologies, such as blockchain-based traceability systems, could potentially also significantly enhance transparency, strengthen credibility, and reduce opportunities for fraud in the future, but are not implemented in certification schemes today. Most systems depend heavily on documentation and chain-of-custody models, while physical testing and advanced digital traceability tools remain underutilized.

These gaps indicate that certification frameworks could improve their robustness by incorporating complementary verification methods that provide direct, physical evidence of material characteristics. The most promising alternative methods for verifying recycled material through chemical analyses (LC-MS, FTIR, NIR) are a long way from being commercially used in this purpose. However, more research and technological development is needed to find the appropriate digital and testing solutions for verification systems.

5.2 Recommendations and next steps

The central contribution of this study is the identification of a set of control elements, described in chapter four, that can serve as a foundation for strengthening the credibility of recycled and bio-based plastic claims. By integrating or referencing such control elements into future legislative frameworks, regulators can create clearer and more consistent expectations for verification and traceability of plastics across the value chain. Such clarity would, in turn, guide certification schemes to align their methodologies with regulatory requirements, ensuring that their systems remain robust, transparent, and fit for purpose.

Building on this core contribution, the report suggests a few recommendations and next steps:

1. **Validation of control elements**

To strengthen the proposed list of control elements, it is essential to validate and align them within a broader group of stakeholders. This will ensure that the elements are practical, credible, and suitable as a foundation for future regulation.

Given the limited time available in this study to conduct a full stakeholder dialogue involving certification scheme actors and regulators, the process should focus on targeted alignment efforts, including:

- Aligning terminology, structure and requirements of the control elements and further compare across existing certification schemes to identify any inconsistencies.
- Engaging key stakeholders across the plastics value chain, including certification bodies, industry representatives, and regulatory authorities, to confirm relevance and feasibility.

Such validation will provide a clear basis for reviewing the proposed control elements and support the development of harmonized standards or vocabulary for legislation. Achieving this will require structured collaboration with organizations managing these certification schemes.

2. **Mandate national or international minimum requirements**

An international (EU-level) framework that mandates minimum requirements for verification systems and certification schemes could be one way to ensure credibility and consistency. Such a system would benefit stakeholders involved in using or regulating recycled content by reducing administrative burdens and streamlining compliance. Key elements would include consistent audit reporting, alignment with globally recognized standards for multinational operations, annual on-site audits, and scientifically monitored laboratory testing based on the control elements. Furthermore, restrictions on how communication of claims is carried out including requirements on implementing measures to prevent misleading claims. The British Plastics Federation (BPF) framework, could for example provide inspiration for how a verification framework for recycled and bio-based plastics could be designed.[31]

3. National controls and supervision

National regulatory authorities could explore the possibilities for regulatory oversight practices, such as conducting sample testing and inspections to ensure compliance with certification requirements and traceability standards. This could include on-site audits, verification of documentation, or laboratory-based testing of material properties. The purpose is to confirm that certified organizations follow the defined chain-of-custody model, maintain accurate records, and meet the minimum criteria for recycled or bio-based content. Regular and risk-based audits and inspections strengthen credibility, prevent misuse of claims, and provide transparency for stakeholders.

4. Explore alternative tools for verification

For bio-based plastics, established analytical methods are already used within certification schemes to determine bio-based content. The key question is how these methods should be integrated into a verification or certification system, particularly regarding sample testing procedures, audit frequency, and the documentation required to demonstrate compliance. These aspects could be incorporated as control elements in future minimum requirements for bio-based products.

For recycled plastics, analytical methods capable of determining the percentage of recycled content or verifying the origin of the recycled material are still limited and mainly focused on quality and characterization of waste. The report therefore recommends further exploration of analytical approaches, including assessing the reliability and robustness of available methods. Additional research is needed on emerging technologies highlighted earlier in the report, such as fluorescent tagging, luminescent taggants detectable through infrared scanning, LC-MS, FTIR and NIR, to evaluate whether they are sufficiently reliable for use in verification systems.

Verification of recycled or bio-based content will continue to rely on a combination of chain-of-custody documentation and analytical methods. Today, established standards form the basis for third-party certification and audits, which remain the primary means of assurance. In the future, digital tools, such as digital product passports and blockchain-based ledgers, may strengthen data reliability and improve access to verifiable information, making it easier to trust and validate material claims in alternative ways.

[31] Morgan and Jordan, *Verification Solutions to Support Delivery of Recycled Content in Plastic Packaging*.

6. References

Ajorloo, Mojtaba, Maryam Ghodrat, and Won-Hee Kang. 'Incorporation of Recycled Polypropylene and Fly Ash in Polypropylene-Based Composites for Automotive Applications'. *Journal of Polymers and the Environment* 29 (April 2021): 1–12. https://doi.org/10.1007/s10924-020-01961-y.

Beigbeder, Joana, Didier Perrin, Jean-François Mascaro, and José-Marie Lopez-Cuesta. 'Study of the Physico-Chemical Properties of Recycled Polymers from Waste Electrical and Electronic Equipment (WEEE) Sorted by High Resolution near Infrared Devices'. *Resources, Conservation and Recycling* 78 (September 2013): 105–14. https://doi.org/10.1016/j.resconrec.2013.07.006.

British Plastics Federation. 'BPF Calls for Companies to Report Fraudulent Recycled Material Claims'. British Plastics Federation. Accessed 9 December 2025. https://www.bpf.co.uk/article/bpf-calls-for-companies-to-report-fraudulent-recycled-material-c-3799.aspx.

Chen, Zhi-Feng, Qin-Bao Lin, Qi-Zhi Su, Huai-Ning Zhong, and Cristina Nerin. 'Identification of Recycled Polyethylene and Virgin Polyethylene Based on Untargeted Migrants'. *Food Packaging and Shelf Life* 30 (December 2021): 100762. https://doi.org/10.1016/j.fpsl.2021.100762.

ChinaReplas. 'Still Cheating despite Heavy Penalties? Identification Criteria for Virgin and Recycled PET - The 8th China International Recycling Plastics Exhibition.' 23 April 2025. https://www.replas.org.cn/en/507.html.

CPCB Uncovers Massive Fraud: Over 600,000 Fake Pollution-Trading Certificates Found in Plastic Recycling Audit – Climate Samurai. 15 July 2024. https://climatesamurai.com/2024/07/15/cpcb-uncovers-massive-fraud-over-600000-fake-pollution-trading-certificates-found-in-plastic-recycling-audit/.

DataBeyond. 'How Recycling Companies Should Respond to Italy's 2026 Plastic Tax - Databeyond.Com'. Accessed 21 January 2026. https://www.databeyond.com/blog/how-recycling-companies-should-respond-to-italys-2026-plastic-tax.

Directive (EU) 2024/825 of the European Parliament and of the Council of 28 February 2024 Amending Directives 2005/29/EC and 2011/83/EU as Regards Empowering Consumers for the Green Transition through Better Protection against Unfair Practices and through Better Information.

European Commission. 'Single-Use Plastics - Environment - European Commission'. Single-Use Plastics, 6 November 2025. https://environment.ec.europa.eu/topics/plastics/single-use-plastics_en.

European Council. 'Circular Economy: Council and Parliament Strike Deal on Rules for Vehicle Circularity and Management of End-of-Life Vehicles'.

Accessed 15 January 2026. https://www.consilium.europa.eu/en/press/press-releases/2025/12/12/circular-economy-council-and-parliament-strike-deal-on-rules-for-vehicle-circularity-and-management-of-end-of-life-vehicles/.

International Organization for Standardization (ISO). *ISO 22095-2 Chain of Custody Part 2: Requirements and Guidelines for Mass Balance*. under publication. https://www.iso.org/standard/84427.html.

International Organization for Standardization (ISO). *ISO/DIS 13662 (EN) Chain of Custody - Mass Balance - Requirements and Guidelines*. under publication. https://www.iso.org/obp/ui/fr/#iso:std:iso:13662:dis:ed-1:v1:en.

International Organization for Standardization (ISO). *SS-ISO 22095:2020 Chain of Custody – General Terminology and Models*. Version 1. Svenska Institutet för Standarder (SIS), 3 November 2020. https://www.sis.se/produkter/foretagsorganisation/foretagsorganisation-och-foretagsledning-ledningssystem/foretagsorganisation/ss-iso-220952020/.

Morgan, Steve, and Helen Jordan. *Verification Solutions to Support Delivery of Recycled Content in Plastic Packaging*. 2022.

RecyClass. 'How to Ensure Compliance with the Spanish Plastic Tax?' How to Ensure Compliance with the Spanish Plastic Tax?, 27 November 2024. https://recyclass.eu/news/how-to-ensure-compliance-with-the-spanish-plastics-tax/.

RecyClass. 'RecyClass Certifies over Half of Europe's Plastic Recycling Capacity'. Recyclass.Eu, 16 September 2025. https://recyclass.eu/news/recyclass-certifies-over-half-of-europes-plastic-recycling-capacity/.

REGULATION (EU) 2025/40 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 December 2024 on Packaging and Packaging Waste, Amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and Repealing Directive 94/62/EC. Accessed 9 December 2025. https://eur-lex.europa.eu/eli/reg/2025/40/oj/eng.

Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on Packaging and Packaging Waste, Amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and Repealing Directive 94/62/EC (Text with EEA Relevance) (2024). http://data.europa.eu/eli/reg/2025/40/oj.

Spanish Law - Ley 7/2022, de 8 de Abril, de Residuos y Suelos Contaminados Para Una Economía Circular, Pub. L. No. Ley 7/2022, BOE-A-2022-5809 48578 (2022). https://www.boe.es/eli/es/l/2022/04/08/7.

UK Government. 'Plastic Packaging Tax'. GOV.UK, 1 April 2025. https://www.gov.uk/government/collections/plastic-packaging-tax.

Weick, Mark, and Nicole Ray. 'Certifications Can Drive Plastics Circularity'. How Improving Recycled Plastics Certifications Can Support Circularity, 5 June 2023. https://www.ey.com/en_us/insights/climate-change-sustainability-services/certifications-can-drive-plastics-circularity.

Appendix – Control elements for verifying recycled and bio-based plastics

Including mapping against existing certification schemes

#	Area	Control element - Detailed Description	Recycled	Bio-based	Covered by	AENOR	APR PCR	DIN-Geprüft Biobased	DIN-Geprüft Recycled	ISCC PLUS	NEN Biobased	OK Biobased	OK Renewable	OK Recycled	Ocean Bound Plastics	RecyClass (+ EUcert) Process	RecyClass Plastics	Global Recycled Standard	Recycled Claim Standard	Biobased Content Cert	Recycled Content Cert	QA-CER	Recycled Material Standard	RED cert-2	RED cert-EU	UL Validated
1.	**Certification, Certification Body and Auditor requirements**																									
1.1	Accreditation	Certification shall be issued by an accredited certification body under ISO 17065 to ensure credibility and impartiality.	Meets criteria	Meets criteria	Some	Not specified	Yes	Not specified	Not specified	Not specified	Yes	Not specified	Not specified	Not specified	Not specified	Yes	Yes	Not specified	Not specified	Yes	Yes	Not specified	Not specified	Yes	Yes	Not specified
1.2	Clear certification scope	Certification scope regarding what the certification covers (Product, process, site or organisation (multi-site) level) as well as chain-of-custody and mass-balance models shall be clearly specified.	Meets criteria	Meets criteria	All	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1.3	Transparent requirements	Transparent information about certification process and requirements shall be publicly available.	Meets criteria	Meets criteria	Most	Yes, but only in spanish	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Not clearly specified	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
1.4	Transparent audit process	The audit process shall be described transparently and made publicly available.	Meets criteria	Meets criteria	Most	Yes, but only in spanish	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Not clearly specified	Yes	Yes	Yes	Yes	Yes, apart from validity	Yes	Yes	Yes	Yes	Yes	No
1.5	Competence and experience	The certification body and its auditors shall have documented relevant knowledge and experience in for the certification scope. Auditors shall undergo training and meet technical knowledge requirements (e.g. knowledge of EN 15343 and ISO 22095).	Meets criteria	Meets criteria	Few	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Yes	Yes	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Yes	Yes	Not specified
1.6	Independence	The certification body is independent from any national standards organization and independent from both the organization being certified and the owner of the standard. If the certification body itself owns the standard, it is no longer fully independent since it has a direct interest in both the rules and the certification.	Nice to have	Nice to have	Most	No	Yes	Partly	Partly	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
1.7	Independence	The certification body and its auditors shall have no conflicts of interest with the company being certified.	Meets criteria	Meets criteria	All	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

#	Area	Control element - Detailed Description	Recycled	Bio-based	Covered by	AENOR	APR PCR	DIN-Geprüft Biobased	DIN-Geprüft Recycled	ISCC PLUS	NEN Biobased	OK Biobased	OK Renewable	OK Recycled	Ocean Bound Plastics	RecyClass (+ EUCert) Process	RecyClass Plastics	Global Recycled Standard	Recycled Claim Standard	Biobased Content Cert	Recycled Content Cert	QA-CER	Recycled Material Standard	RED cert-2	RED cert-EU	UL Validated
1.8	Quality Control of Auditor Performance	Control mechanisms in place to continuously review auditors' credibility to enhance coherence and consistency between auditors.	Meets criteria	Meets criteria	Not assessed																					
1.9	Certificate verification	Publicly available possibility to verify certificate validity (e.g on certification scheme's website).	Meets criteria	Meets criteria	Not assessed																					
1.10	Certificate validity period	Clearly defined validity period of certificate.	Meets criteria	Meets criteria	Most	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
2	**Audit**																									
2.1	Audit scope	Clearly defined audit scope in line with Certification Scope. Audit shall at least cover manufacturing facility of recycled/biobased material and relevant procedures. Clearly communicated in scheme or similar.	Meets criteria	Meets criteria	Most	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Info not found	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Info not found
2.2	Desktop audit	Third-party audit solely conducted through desktop audits remotely by reviewing documentation without on-site visits to verify compliance.	Not enough	Not enough	Few	Yes, but in comb with on-site	Yes, but in comb with on-site	Yes, but in comb with testing	Yes, but in comb with on-site	Yes, but in comb with on-site	Yes, but in comb with testing	Yes, but in comb with testing	Yes, but in comb with online	Info not found	Yes, but only at specific situations	Not used	Not used	Yes, but in comb with on-site	Yes, but in comb with on-site	Yes, but in comb with online	Yes	Not used	Yes, but in comb with on-site	Yes, but in comb with on-site	Yes, but in comb with on-site	Info not found
2.3	On-site audit	On-site audits are required. If a certificate covers multiple sites, the audit shall include visits to all sites to make a visual inspection in the production.	Meets criteria	Meets criteria	Most	Yes	Yes	No	Yes	Yes	No	No	Can be replaced with online camera	Info not found	Yes	Yes	Yes	Yes	Yes	Yes, based on risk-assessment	Yes, based on risk-assessment	Yes	Yes	Yes	Yes	Info not found
2.4	Third-party audit	Audits shall be conducted by accredited external auditors or certification bodies to assess compliance with the certification standards.	Meets criteria	Meets criteria	All	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.5	Certification- and Re-certification audit Third-party audit frequency	Audits are conducted on a re-occuring basis: - at least every third year. - by a third party - on-site	Meets criteria	Meets criteria	Most	Yes, cert valid for 3 years	Yes, cert valid for 3 years	No, cert is valid for 6 years	No, cert is valid for 5 years	Yes, cert valid for 1 year	No, cert is valid for 5 years	Yes, cert valid for 1 year	Yes, cert valid for 1 year	Yes, cert valid for 1 year	Not specified	Yes, cert valid for 1 year	Yes, cert valid for 1 year	Yes, cert valid for 1 year	Yes, cert valid for 1 year	Not specified	Yes, cert valid for 1 year	Yes, cert valid for 3 years	Yes, cert valid for 3 years	Yes, cert valid for 1 year	Yes, cert valid for 1 year	Info not found
2.6	Surveillance audit	Audits conducted between certification- and re-certification audits. The scope of the audit is based on the certificate held. Surveillance audits can, forexample,e be done annually. Surveillance audits can be conducted in the form of on-site audit, desktop audit, first- or third-party audit.	Nice to have	Nice to have	Some	Yes	Yes	Yes	Yes	Not relevant	Yes	Not relevant	Not relevant	Not relevant	Not specified, but annual summaries are	Not relevant	Not relevant	Not relevant	Not relevant	Not specified	Not relevant	Yes	Not specified	Yes	Yes	Info not found
2.7	Unannounced audits	Third-party auditors conduct surprise audits without prior notice to verify ongoing compliance.	Nice to have	Nice to have	Few	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Can be used	Can be used	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found	Info not found

#	Area	Control element - Detailed Description	Recycled	Bio-based	Covered by	AENOR	APR PCR	DIN-Geprüft Biobased	DIN-Geprüft Recycled	ISCC PLUS	NEN Biobased	OK Biobased	OK Renewable	OK Recycled	Ocean Bound Plastics	RecyClass (+ EUcert) Process	RecyClass Plastics	Global Recycled Standard	Recycled Claim Standard	Biobased Content Cert	Recycled Content Cert	QA-CER	Recycled Material Standard	RED cert-2	RED cert-EU	UL Validated
2.8	Non-conformity management	Clear procedures are defined for handling non-conformities, including rules for suspending or withdrawing the certificate.	Meets criteria	Meets criteria	Not assessed																					
2.9	Audit report	Audit Report that includes the final statement of conformity and details of the audit findings.	Meets criteria	Meets criteria	Not assessed																					
3	**Chain of Custody (Traceability)**	At least one of the below "Meets criteria"-Chain of Custody models must be used.																								
3.1	Declaration of Chain of Custody Model Type	The certificate holder shall declare which chain-of-custody model is used for the recycled material (e.g. Segregation, Controlled Blending, Mass Balance, or Book & Claim)	Meets criteria	Meets criteria	Most	Yes	Yes	No, cert is based on test	Yes	Yes	No, cert is based on test	No, cert is based on test	No	Info not found	Not described	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Info not found
3.2	Identity Preserved	Materials or products originate from a single source and their specified characteristics are maintained throughout the supply chain.	Meets criteria	Meets criteria	Few	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Info not found	Not described	Not described	Not described	Yes, based on descr.	Yes, based on descr.	Not described	Not described	Not described	Not described	Not described	Yes	Info not found
3.3	Segregated	In the segregated model, inputs may originate from different sources but shall have identical characteristics. This means that the identity of a specific source may not be preserved, but the output product will maintain the specific properties and the organisation can make claims thereafter.	Meets criteria	Meets criteria	Some	Not described	Yes	Not relevant	Not described	Not described	Not relevant	Not relevant	Not described	Info not found	Not described	Yes	Not described	Yes	Yes	Yes	Yes	Not described	Yes	Yes	Yes	Info not found
3.4	Controlled Blending	Certified and non-certified materials are blended in controlled ratios, with proper documentation. There is no mass-balancing period to spread out the incoming material over. Currently mainly relevant for mechanical recycling and biobased fuels, which can be used in plastics.	Meets criteria	Meets criteria	Some	Yes, based on descr.	Yes	Not relevant	Yes, based on descr.	Not described	Not relevant	Not relevant	Not described	Info not found	Seems to be an alternative	Yes	Yes	Yes	Yes	Not described	Yes	Yes	Yes	Yes	Not described	Info not found
3.5	Mass Balance - Unspecified model	Chain of custody model in which materials or products with a set of specified characteristics are mixed according to defined criteria with materials or products without that set of characteristics. Relevant for chemical recycling and biobased raw-materials.	Not enough	Not enough	Few	Not described	Not described	Not relevant	Not relevant	Not described	Not relevant	Not relevant	OK to use	Info not found	Seems to be an alternative	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Info not found
3.5.1	Mass balance model - Credit method	The credit method is applicable when two or more types of input are used in a material or product. The recorded output amount of each type shall be equivalent to the physical input, taking into account the conversion factor. The conversion factor shall be defined within each material or product at each site and it shall be applied to define the amount of credit to enter the credit account, when using the output as the basis for calculation, or to withdraw the credit when using the input as the basis for calculation. (ISO 22095)	Not enough	Not enough	Few	Not described	Not described	Not relevant	Not relevant	Not described	Not relevant	Not relevant	OK to use	Info not found	Seems to be an alternative	Not described	Not described	Yes, based on descr.	Yes, based on descr.	Yes, based on descr.	Yes, based on descr.	Not described	Yes	Yes	Yes	Info not found
3.5.1.2	Mass balance model - Strict credit method	Credits are not allowed to be transferred between processes: • Credits are not allowed to be transferred between different processes; they are strictly tied to individual processes and shall be based on actual conversion factors and material losses. • Both chemical and physical traceability shall be ensured for the process in use, with calculations based on material mass rather than economic value or energy content. - Meets the "production location requirement" - Meets the "correct monomer requirement" Currently mainly relevant for chemical recycling. Example: ISCC+ - "Trace-the-atom"	Meets criteria	Meets criteria	Few	Not described	Not described	Not relevant	Not relevant	Yes	Not relevant	Not relevant	Not described	Info not found	Not described	Not described	Not described	Yes, based on descr.	Yes, based on descr.	Yes, based on descr.	Yes, based on descr.	Not described	Yes	Yes	Yes	Info not found

#	Area	Control element - Detailed Description	Recycled	Bio-based	Covered by	AENOR	APR PCR	DIN-Geprüft Biobased	DIN-Geprüft Recycled	ISCC PLUS	NEN Biobased	OK Biobased	OK Renewable	OK Recycled	Ocean Bound Plastics	RecyClass (+ EUCert) Process	RecyClass Plastics	Global Recycled Standard	Recycled Claim Standard	Biobased Content Cert	Recycled Content Cert	QA-CER	Recycled Material Standard	RED cert-2	RED cert-EU	UL Validated
3.5.1.3	Mass balance model - Credit method - **Intra-site** and **process-specific** allocation	Allows transferring credits between multiple products within the same process at a single production site. Compared to strict credit method: - Meets the "production location requirement" - Unclear if this meets the "correct monomer requirement" Example: RedCert-EU	Not enough	Not enough	Few	Not described	Not described	Not relevant	Not relevant	Not described	Not relevant	Not relevant	OK to use	Info not found	Seems to be an alternative	Not described	Not described	Yes, based on descr.	Yes, based on descr.	Yes, based on descr.	Yes, based on descr.	Not described	Yes	Yes	Yes	Info not found
3.5.1.4	Mass balance model - Credit method - **Intra-site** and **process non-specific** allocation	Allows transferring credits between multiple processes within the same production site. Compared to strict credit method: - Does not meet the "production location requirement" - Does not meet the "correct monomer requirement" Example: RedCert-2	Not enough	Not enough	Few	Not described	Not described	Not relevant	Not relevant	Not described	Not relevant	Not relevant	OK to use	Info not found	Not described	Not described	Not described	Yes, based on descr.	Yes, based on descr.	Not described	Yes, based on descr.	Not described	Yes	Yes	Yes	Info not found
3.5.1.5	Mass balance model - Global credit method (Includes "process non-specific")	Allows transferring of credits between different sites, companies, or even across countries. Compared to strict credit method: - Does not meet the "production location requirement" - Does not meet the "correct monomer requirement"	Not enough	Not enough	Few	Not described	Not described	Not relevant	Not relevant	Not described	Not relevant	Not relevant	OK to use	Info not found	Seems to be an alternative	Not described	Not described	Not allowed	Not allowed	Not described	Not described	Not described	Yes	Yes	Yes	Info not found
3.5.2	Rolling average percentage method	The rolling average percentage method is based on the use of a fluctuating proportion of input bearing specified characteristics entering the organization over a defined claim period, allowing a claim of an average percentage to be made for the output over the claim period. Currently considered not widely used in practice regarding plastics.	Not enough	Not enough	Few	Not described	Not described	Not relevant	Not relevant	Not described	Not relevant	Not relevant	Not described	Info not found	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Yes	Not described	Not described	Info not found
3.6	Book & Claim	Certificates are traded separately from physical material; no physical link between claim and product.	Not enough	Not enough	Few	Not described	Not described	Not relevant	Not relevant	Not described	Not relevant	Not relevant	Not described	Info not found	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Not described	Yes	Yes	Info not found
4.	**Other verification methods**	Below verification methods could replace and/or complement other means of verification (e.g chain of custody documentation)																								
4.1	Physical testing - Recycled plastics	Laboratory tests to verify actual material content of additives etc.	Nice to have	Not relevant	None	Not specifie	Not specifie	Not relevant	Not specifie	Not specifie	Not relevant	Not relevant	No	Info not found	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not relevant	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Info not found
4.2	Physical testing - Recycled plastics - Characterization	Inspection and tests according to EN 15347 or relevant of EN 15342, EN 15344, EN 15345, EN 15346 or EN 15348. Only relevant for mechanical recycling.	Meets criteria	Nice to have	Some	Yes	Yes	Not relevant	Yes	Yes	Not relevant	Not relevant	Not specifie	Yes, based	No	Yes, based	Yes, based	Not specifie	Not specifie	Not relevant	Yes, based	Yes	Not specifie	Not specifie	Not specifie	Info not found
4.3	Physical testing - Bio-based plastics	Laboratory methods like elemental analysis coupled with C14 (radiocarbon) analysis can serve as an alternative verification method (outside of chain-of-custody models). For example, standards such as EN 16640 and EN 16785-1, including analytical methods to determine biobased content	Not relevant	Meets criteria	Few	Not relevant	Not relevant	Yes	Not relevant	Yes	Yes	Yes	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	No	Not relevant	Not relevant	Not relevant	Yes	Yes	Not relevant
4.4	Physical testing - Laboratory accreditation	If lab tests are used as verification method the test shall be done by a accredited laboratory. Any lab performing the tests must be ISO 17025 accredited. Only relevant if physical testing is used.	Nice to have	Meets criteria	Few	Not specifie	Not specifie	Yes	Yes	Not specifie	Yes	Yes	Yes	Info not found	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Info not found
4.5	Physical inspection of material	Manual inspection of materials to verify characteristics (visual auditing)	Not enough	Not enough	Some	Yes, in comb with testing	Yes, in comb with testing	Not relevant	Yes, in comb with testing	Yes, in comb with testing	Not relevant	Not relevant	Not specified	Yes, based on EN 15343	Not specified	Yes, based on EN 15343	Yes, based on EN 15343	Not specified	Not specified	Not specified	Yes, based on EN 15343	Yes, based on EN 15344	Not specified	Not specified	Not specified	Info not found
4.6	Digital Traceability	Digital tools and systems for tracking origin for enhanced transparency and traceability.	Nice to have	Nice to have	None	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Info not found	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Not specifie	Info not found

#	Area	Control element - Detailed Description	Recycled	Bio-based	Covered by	AENOR	APR PCR	DIN-Geprüft Biobased	DIN-Geprüft Recycled	ISCC PLUS	NEN Biobased	OK Biobased	OK Renewable	OK Recycled	Ocean Bound Plastics	RecyClass (+ EUcert) Process	RecyClass Plastics	Global Recycled Standard	Recycled Claim Standard	Biobased Content Cert	Recycled Content Cert	QA-CER	Recycled Material Standard	RED cert-2	RED cert-EU	UL Validated
5.	**Standard References**	Certification must align with recognized international standards. All key terms must be clearly defined in the certification scope to avoid ambiguity.																								
5.1	**ISO 22095:2020** "Chain of custody - General terminology and models"	Chain of Custody terminology according to the standard or equivalent.	Meets criteria	Meets criteria	Few	Not specifie	Yes	Not specifie	Not specifie	Yes	Not specifie	Not specifie	Not specifie	Info not found	Not specifie	Yes	Yes	Not specifie	Not specifie	Not specifie	Yes	Yes	Not specifie	Yes	Not specifie	Info not found
5.2	**EN 15343:2007** "Plastics - Recycled Plastics - Plastics recycling traceability and assessment of conformity and recycled content"	Traceability and calculation of recycled content according to the standard or equivalent. Is a must have for recycled plastics.	Meets criteria	Not relevant	Some	Yes	Yes	Not relevant	Yes	Yes	Not relevant	Not relevant	Not specified	Yes	Not specified	Yes	Yes	Not specified	Not specified	Not relevant	Yes	Yes	Not specified	Not specified	Not specified	Info not found
5.3	**Standard series EN 15342–15348** "Plastics - Recycled plastics - Characterization of PS / PE / PP / PVC / PET"	Characterization of various polymer recycling fractions according to the standards or equivalent. Referred to in EN 15343.	Meets criteria	Not relevant	Some	Yes	Yes	Not relevant	Yes	Yes	Not relevant	Not relevant	Not specified	Yes, based on EN 15343	Not specified	Yes, based on EN 15343	Yes, based on EN 15343	Not specified	Not specified	Not relevant	Yes, based on EN 15343	Yes	Not specified	Not specified	Not specified	Info not found
5.4	**EN 15347-1** "Plastics - Sorted plastics wastes - Part 1: General characterization"	Scheme for the characterization of sorted plastics wastes, laying out those properties for which the supplying party of the waste makes information available to the receiving party. Referred to in EN 15343.	Meets criteria	Not relevant	Some	Yes	Yes	Not relevant	Yes	Yes	Not relevant	Not relevant	Not specifie	Yes, based	Not specifie	Yes, based	Yes, based	Not specifie	Not specifie	Not relevant	Yes, based	Yes	Not specifie	Not specifie	Not specifie	Info not found
5.5	**EN 16575** - Bio-based products – Vocabulary	Terminology related to bio-based products in line with standard	Not relevant	Meets criteria	Few	Not relevant	Not relevant	Not specifie	Not relevant	Not specifie	Yes	Yes	Yes	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not specifie	Not relevant	Not relevant	Not relevant	Not specifie	Not specifie	Not relevant
5.6	**EN 16640** "Bio-based products - Bio-based carbon content - Determination of the bio-based carbon content using the radiocarbon method"	Determination of the bio-based carbon content according to the standard or equivalent.	Not relevant	Meets criteria	Few	Not relevant	Not relevant	Yes	Not relevant	Not specified	Not specified	Yes	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not specified	Not relevant	Not relevant	Not relevant	Not specified	Not specified	Not relevant
5.7	**EN 16785-1** "Bio-based products - Bio-based content - part 1	Determination of the bio-based content (radiocarbon + elemental analysis or material balance method) according to the standards or equivalent.	Not relevant	Meets criteria	Few	Not relevant	Not relevant	Not specifie	Not relevant	Yes	Yes	Not specifie	Yes	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not specifie	Not relevant	Not relevant	Not relevant	Not specifie	Not specifie	Not relevant
5.8	**EN 17228** "Plastics - Bio-based polymers, plastics, and plastic products - Terminology, characteristics and communication"	Specify the vocabulary, methods for characterization, and templates for reporting about bio-based polymers, plastics, and plastics products.	Not relevant	Meets criteria	None	Not relevant	Not relevant	Not specified	Not relevant	Not specified	Not specified	Not specified	Not specified	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not specified	Not relevant	Not relevant	Not relevant	Not specified	Not specified	Not relevant
5.9	**ISO 14021:2016** "Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling)"	Claims and communication of recycled / biobased content according to the standard or equivalent.	Meets criteria	Meets criteria	Most	Not specified	Yes	Not specified	Yes	Yes	Not specified	Yes	Yes	Yes	Not specified	Yes	Yes	Yes	Yes	Not specified	Yes	Yes	Yes	Yes	Not specified	Info not found
5.10	**EN 16848** "Bio-based products - Requirements for Business-to-Business communication of characteristics using a Data Sheet"	Requirements for transparent and non-misleading business to business communication of characteristics of bio-based products by means of a specific Data Sheet.	Not relevant	Nice to have	None	Not relevant	Not relevant	Not specified	Not relevant	Not specified	Not specified	Not specified	Not specified	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not specified	Not relevant	Not relevant	Not relevant	Not specified	Not specified	Not relevant
5.11	**EN 16935** "Bio-based products - Requirements for Business-to-Consumer communication and claims"	Requirements for transparent and non-misleading business-to consumer communication of characteristics of bio-based products by means of labelling and claims.	Not relevant	Nice to have	None	Not relevant	Not relevant	Not specified	Not relevant	Not specified	Not specified	Not specified	Not specified	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not specified	Not relevant	Not relevant	Not relevant	Not specified	Not specified	Not relevant
6.	**Documentation**																									

#	Area	Control element - Detailed Description	Recycled	Bio-based	Covered by	AENOR	APR PCR	DIN-Geprüft Biobased	DIN-Geprüft Recycled	ISCC PLUS	NEN Biobased	OK Biobased	OK Renewable	OK Recycled	Ocean Bound Plastics	RecyClass (+ EUcert) Process	RecyClass Plastics	Global Recycled Standard	Recycled Claim Standard	Biobased Content Cert	Recycled Content Cert	QA-CER	Recycled Material Standard	RED cert-2	RED cert-EU	UL Validated
6.1	Quality Management System	The Quality Management System shall include all relevant processes and documentation covering the certification scope. Documented evidence shall exist demonstrating that a quality management system is in place. Could be verified by a ISO 9001 or similar.	Meets criteria	Meets criteria	Some	Yes	Yes	Not specifie	Yes	Yes	Yes	Not specifie	Not specifie	Not specifie	Yes	Yes	Yes	Not specifie	Not specifie	Not specifie	Yes	Yes	Not specifie	Yes	Yes	Info not found
6.2	Classification of Waste - recycling process	The recycler shall document the category and origin of the waste. (E.g by reference to EN 15347-1) The waste shall be registered with the relevant six-digit waste code (according to the EU List of Waste) and indicate whether it is post-consumer or pre-consumer.	Meets criteria	Not relevant	Some	Yes	Yes	Not relevant	Yes	Yes	Not relevant	Not relevant	Not specifie	Yes, based	Not specifie	Yes, based	Yes, based	Yes, but not	Yes, but not	Not relevant	Yes	Yes	Yes, but not	Yes, but not	Yes, but not	Info not found
6.3	Supplier information	• Name and address of Supplier	Meets criteria	Meets criteria	Not assessed																					
6.4	Purchase and incoming material information	• Description of the material input (origin, PCR/PIR, biobased, chem rec, etc.) • Recycled/biobased share (certificate) • Polymer type • Product identification number (per batch) • Volume/weight • Batch-labels • Delivery date	Meets criteria	Meets criteria	Not assessed																					
6.5	Handling of incoming material	• Recording of batch information (procedure) • Batch-handling system (for input and output) • Manual inspection of materials to verify characteristics (visual auditing • Separate storage • Yearly stock inventory	Meets criteria	Meets criteria	Not assessed																					
6.6	Process information	• The reaction mechanism, stoichiometry, of the process • The sustainable share calculations of each output product • Flow-charts for internal processes, describing handling of input batches • Procedure for using batch-handling system (must include: recycled/biobased/virgin input, additives, output, byproducts, rejections) • Batch-protocols • Calibration of equipment (included in GMP) • Quality control (i.e. deviations are explained etc.)	Meets criteria	Meets criteria	Not assessed																					
6.7	Output information	• Description of product (polymer, color, other content, weight etc.) • Share of recycled/biobased material • Batch identification number • Procedure for using batch-handling system (shall include output verification) • Customer information (name, address, date, batch number, quantity etc.)	Meets criteria	Meets criteria	Not assessed																					
7.	**Supplier Risk Assessment and due diligence**																									
7.1	Policy for relevant ESG topics including (environment, human rights, labour rights and anti-corruption)	An internal anti-corruption policy is in place (to address bribery or fraud risks in the supply chain.	Nice to have	Nice to have	Not assessed																					
7.2	Supplier due diligence - ESG risks	The organization shall identify and assess ESG related risks associated with its operations, supply chain, and certification activities, and implement proportionate measures to mitigate those risks.	Nice to have	Nice to have	Not assessed																					
8.	**Communication**	How communication is conducted regarding claims and labels to businesses and end-consumers.																								
8.1	Anti-Greenwashing	Internal policies to prevent misleading claims and greenwashing practices.	Nice to have	Nice to have	Not assessed																					
8.2	Claims - Match with certificate	Claims shall match the certified product, component, or process listed in the certificate and audit report.	Meets criteria	Meets criteria	Not assessed																					

#	Area	Control element - Detailed Description	Recycled	Bio-based	Covered by	AENOR	APR PCR	DIN-Geprüft Biobased	DIN-Geprüft Recycled	ISCC PLUS	NEN Biobased	OK Biobased	OK Renewable	OK Recycled	Ocean Bound Plastics	RecyClass (+ EUcert) Process	RecyClass Plastics	Global Recycled Standard	Recycled Claim Standard	Biobased Content Cert	Recycled Content Cert	QA-CER	Recycled Material Standard	RED cert-2	RED cert-EU	UL Validated
8.3	Claims - Content Origin	Claims shall specify the origin of the certified content. e.g. "post-consumer" or "pre-consumer") or biobased content.	Meets criteria	Meets criteria	Most	Yes	Yes	Yes	Not require	Yes	Yes	Yes	Not require	Not require	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not require	Not require	Info not found
8.4	Claims - Chain of Custody Model	Claims shall be consistent with the certified chain-of-custody model. e.g. mass balance, segregation, controlled blending, "book and claim".	Meets criteria	Meets criteria	Some	Yes	Yes	Not relevant	Info not found	Yes	Not relevant	Not relevant	Not require	Not require	Info not found	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Info not found
8.5	Claims - Mass Balance Method	If mass balance has been used, claims shall specify the applied mass balance method. e.g. strict method,"trace-the-atom", attribution/allocation of credits.	Meets criteria	Meets criteria	Few	Not relevant	Not relevant	Not relevant	Not relevant	Unclear	Not relevant	Not relevant	Not require	Not require	Info not found	Not relevant	Not relevant	Info not found	Info not found	Not require	Not require	Not relevant	Yes	Unclear	Unclear	Info not found
8.6	Claims - Content Minimum Specification	Claims and labels can only be used if the content meets or exceeds the specified minimum threshold.	Meets criteria	Meets criteria	Some	Info not found	Yes	Yes	Info not found	Yes	Info not found	Yes	Yes	Info not found	No	Yes	Yes	Yes	Yes	Yes	Yes	No, but amount has to be specified	Yes	Info not found	Info not found	Info not found
8.7	Claims - Content Minimum Threshold	Claims and labels can only be used if the recycled/biobased content is at least 10%.	Nice to have	Nice to have	Some	Info not found	Yes	Yes	Info not found	Yes	Info not found	Yes	Yes	Info not found	No	Yes	Yes	Yes	No	Yes	No	Info not found	Yes	Info not found	Info not found	Info not found
8.8	Labels - Content Origin	Labels shall specify the origin of the certified content. e.g. "post-consumer" or "pre-consumer") or biobased content.	Meets criteria	Meets criteria	Most	Yes	Yes	Yes	Not required	Not required	Yes	Yes	Not required	Not required	Yes	Not relevant, only operators	Yes	Not required	Not required	Not required	Not required	Not required	Yes	Not required	Not relevant, only operators	Info not found
8.9	Labels - Claim Basis	Labels shall clearly indicate which chain-of-custody model has been used. e.g. mass balance, segregation, controlled blending, "book and claim".	Meets criteria	Meets criteria	Few	Not required	Not relevant, only pellets	Not relevant, due to C14-	Not required	Yes	Not relevant, due to C14-	Not relevant, due to C14-	Not required	Info not found	Not required	Not relevant, only operators	Not required	Not required	Not required	Not required	Not required	Not required	Not required	Not required	Not relevant, only operators	Info not found
8.10	Labels - Mass Balance Method	If mass balance has been used, labels shall specify the applied mass balance method. e.g. "trace-the-atom", attribution/allocation of credits.	Meets criteria	Meets criteria	None	Not relevant	Not relevant	Not relevant	Not relevant	Not required	Not relevant	Not relevant	Not required	Not required	Not required	Not relevant	Not relevant	Not required	Not required	Not required	Not required	Not relevant	Yes, by specific formulations	Info not found	Not relevant	Info not found
8.11	Labels - Content Percentage	Information is provided about percentage of recycled/biobased plastic content.	Meets criteria	Meets criteria	Some	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No	Info not found	Info not found	Info not found	Yes	Yes	Not relevant	Info not found