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RECYCLED CONTENT OPTIONS PAPER FOR PACKAGING

Prepared By Australian Packaging Covenant Organisation

APCO

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Executive Summary

APCO has sought to understand the implications of future requirements for recycled content into packaging in support of its members and key stakeholders. The Federal Department of Climate Change, Energy, the Environment and Water (DCCEEW) has sought feedback from packaging industry stakeholders to inform the implementation pathways for recycled content mandates.

The purpose of this Recycled Content Option Paper is to synthesise comprehensive industry feedback, a global research and literature review and scenario modelling by presenting ambitious and achievable options for the adoption of recycled content into packaging.

At the heart of the research design was the completion of comprehensive stakeholder engagement, global literature review, development of a Recycled Content Material Analysis Tool to support the focus areas of reprocessing capacity, standards and certifications and traceability. Extensive industry consultation and engagement with subject matter experts was undertaken to support the development of this document, which is outlined in **Appendix J Stakeholder engagement summary**.

The resulting options paper is intended to assist government to explore how and when recycled content mandates might be implemented via its upcoming policy review and to inform its public consultation processes. The paper considers the key issues and opportunities raised by industry. It unpacks the evidence requirements and compliance process for validating recycled content claims.

It is important to acknowledge that Australia's packaging value chain operates within a global economy and supply chain. This has been recognised throughout the discussion areas including certifications, global data traceability standards and in considering scenarios for target setting that include both domestic and internationally procured recyclate-derived feedstock. Industry agrees that all used packaging in Australia, whether imported or domestically manufactured requires pathways to achieve material circularity.

Where there is consensus among the industry stakeholders this has been indicated. Where indications were differing in their approach, the paper outlines the options available to progress recycled content into packaging applications. Where there is insufficient information or it was out of scope for this paper but important to acknowledge, this has been included in a separate section titled *'Areas required further investigation'*. Finally key findings in relation to data traceability are also captured in this paper and any additional insights are summarised here.

There is consensus among industry for the following:

- 'Recycled Content First Principles' were established in consultation with the group, receiving broad industry support. The principles have been applied to the approach and outputs of this paper. Within these principles is industry support for a percentage of recycled content in packaging being domestically sourced.
- the definitions and their meaning of recycled content in the context of certifications have received industry consensus.
- that future recycled content targets should be considered at a material and application level.
- desire to maximise recycled content in packaging with consideration of technical and quality requirements.
- eco-modulated fees are a fairer way of distributing the costs required to deliver the 2025 National Packaging Targets, when compared with the current turnover based model.

- traceability standards and certifications are essential for making recycled content claims in a global supply chain. These are critical elements for ensuring a level playing field for claims from international companies and are of high importance to stakeholders.
- pre- and post- consumer content both have value in pursuing material circularity and should continue to be tracked and reported.
- support of the chain of custody approaches outlined in the National Framework and there is support for mixed approaches for flexibility in the market.
- when making claims on recycled content using the Mass Balance approach, industry is supportive of the requirements of the National Framework.
- that certification programs are independently audited. Certifications exist for all major packaging materials and are in use by large manufacturers (implying that they are not a new system cost) though their application is inconsistent, and information is not routinely made available to brand owners.
- certifications need to be interoperable, though it is noted that this is limited.
- credible and cost-effective verification options need to be available for small business.
- it is assumed that recycled content claims management could be available immediately, with sophistication increasing over time. However, it is important to give more time for full enforcement to allow members to work on their internal processes to ensure meaningful compliance at packaging product level, particularly for SME's.

Options were presented in the paper in the following areas:

- summary of recycled content target options drawn from the Recycled Content Material Analysis Tool. An analysis of each material type has been conducted and are presented in Appendix H Recycled content target visualisers.
- potential regulatory options related to eco-modulation.
- free allocation and associated on-pack claims.
- option for allowing mass balance across multiple sites.
- identification of a Trans-Tasman or Pacific approach in the context of mass balance.
- options further verification of recycled content.

Data definitions and standards are essential for consistency and accountability and data exchange between supply chains and management software. Key findings in relation to data traceability include:

- data quality, availability and consistency are a critical challenge and opportunity for the system and a known pain point for industry. Early action and strong oversight are essential for early success and confidence.
- key elements for recycled content traceability are not covered by the National Framework.
- an industry-led implementation guidance is recommended for the packaging industry to complement the National Framework
- to support recycled content traceability, data and technologies must be interoperable and align with global standards and protocols.

Areas identified as requiring further investigation or an opportunity for additional analysis are captured through the paper. These include:

- there are numerous format-specific use- cases likely to require target exemptions. These should be documented via a transparent process by a standing technical review committee.
- continued research and an established review process of technical maximums.
- enhancing the Recycled Content Target Analysis tool to provide more insight into competing offtake markets and add economic impact overlays.
- analyse impact of various eco-modulation scheme design settings as a complement to mandates
- whilst credible schemes are available and in place, there is a need for detailed comparison mapping, enhanced interoperability, and ongoing oversight to ensure industry confidence.
- trade legalities surrounding domestic recycled content, to meet the requirements of the World Trade Organisation.
- recognition of international supply chains and the relationship with export regulation.
- compliance in the context of material availability.
- compliance in the context of material accessibility.
- consideration of other non-packaging recycled content offtake requirements for brand owners
- comparative impact of product cost based on value.
- traceability for pre and post-consumer recycled content in glass
- technical considerations for recycled material in packaging applications.
- recycled material quality (plastic)over time.
- LCA studies on environmental and human health impacts.
- systems related to mechanical and advanced recycling. With free allocation of mass balance is essential to enable viably priced food-contact soft plastic manufacture. A mechanical-first incentive mechanism may be considered to ameliorate any perceived inequity in policy design.

When considering implementation of recycled content targets, understanding the current operating environment is critical. In this regard, annual reporting is already required of brand owners where compliance against recycled content claims is considered on a tonnage basis. A requirement for Certification evidence is currently optional in this process.

Industry survey results indicate that respondents would be able to achieve short term recycled content targets within four years which clearly highlights the opportunity for phased implementation of targets.

Purpose

APCO has sought to understand the implications of future requirements for recycled content into packaging in support of its members and key stakeholders. The Federal Department of Climate Change, Energy, the Environment and Water (DCCEEW) has sought feedback from packaging industry stakeholders to inform the implementation pathways for recycled content mandates.

The purpose of this Recycled Content Option Paper is to synthesise comprehensive industry feedback, a global research and literature review and scenario modelling by presenting ambitious and achievable options for the adoption of recycled content into packaging from the perspectives of:

- Material availability and domestic and international accessibility.
- Incentives and interventions to drive demand.
- Enablers including the role of standards and certifications.
- Traceability including the future data requirements to demonstrate compliance.

The paper also seeks to provide perspectives as to how long industry requires to be regulation ready.

Research design

The methodology applied for the development of the Options Paper is outlined below.

Initially, the project team identified core focus areas for the work and established the following workstreams:

Table 1 Project workstreams

Workstream	Focus Area
Reprocessing & End Markets	Availability and accessibility: What is the current availability of recyclate used in packaging and what are the barriers to accessing it domestically versus internationally? Incentives and interventions: What incentives or interventions are required to drive demand for and availability of recyclate and what might this look like for Australian recycled content?
Certifications	Enablers: What roles do standards, certification and traceability play and how should these be used?
Traceability	Timing and pathway: What is a realistic timeline to deliver an uplift in recycled content in packaging placed on the market in Australia?

A stakeholder engagement plan was developed, and wide consultation was conducted with industry stakeholders on focus areas including through the establishment of the Recycled Content Reference Group; conduct of one-to-one interviews; the capture additional data through surveys and a complete literature review on recycled content opportunities and barriers. An overview of the stakeholder engagement conducted for this paper is available at Appendix I.

'Recycled Content First Principles' were established in consultation with the group, receiving broad industry support. The principles have been applied to the approach and outputs of this paper.

A global literature review on recycled content by material type was conducted. This included a comprehensive analysis of academic literature, published reports and case studies; and identifying challenges and opportunities at a packaging material level.

An approach has been identified by APCO to assess a 'technical maximum' for recycled content into packaging at a material level. This process should be used to inform the achievable maximum of recycled content by material type over time, having regard for the packaging format. It is acknowledged that what is technically achievable and what is achievable in practice may differ and that technical maximums will likely increase over time with technological advances. This should be tracked, and long-term targets periodically updated. This approach is discussed further in Considerations of material technical maximum.

Summaries for each packaging material type were developed following the literature review, to provide the global and Australian context for application of recycled content into packaging. Separately, an analysis of the challenges and opportunities for the industry was also developed using the research and findings from one-to-one interviews. This overview is available at Appendices A-D.

A Recycled Content Target Analysis Tool was developed to inform availability and accessibility of recycled content in different scenarios which incorporates the following data inputs:

- 21-22 Baseline packaging placed on market, recycled content levels and country of origin.
- Packaging POM growth rates 2022-2027.
- Packaging reprocessing capacity and projected growth rates.
- Population growth 2027 to 2046.
- Recycled Content Target Setting inputs.

This 'phase 1' of tool development, focuses only on projected packaging placed on market, tonnage requirements for recycled content packaging mandates and domestic reprocessing capacity. While out of scope for this project, future phases of the tool will consider applications of packaging recyclate into other end market applications. The tool could also have commodity prices overlayed to understand the economic impact of possible recycled content requirement settings. More information on the development of the tool is available at Appendix F Recycled content target analysis tool explanatory notes.

The variables used to inform the scenarios generated by the tool were collected from the industry through a Recycled Content Targets Survey and through data analysis enabled by the Tool. This survey was circulated to all APCO stakeholders, including a large cohort of manufacturers, the Australian Council of Recycling (ACOR) and Australian Institute of Packaging (AIP), allowing them to provide input on short-term and long-term targets, the proportion of Australian feedstock, and the expected timeline for achieving the short-term targets.

A comprehensive review was undertaken of applicable audited third-party certifications by material type to understand current industry usage, and the benefits and alignment of certifications in the context of managing traceability and compliance. Certification requirements were then mapped to the National Framework for Recycled Content Traceability (NFRCT) to identify gaps and to understand their comprehensiveness and applicability across the packaging value chain.

An assessment of recycled content definitions across existing ISO and Australian Standards, certification programs, existing frameworks and guidelines and global literature on recycled content was completed. Definitions were considered by the Recycled Content Reference Group and consensus was achieved. The definitions have been adopted within this Options Paper.

Desk research was conducted on requirements for traceability-related data standards as well as traceability technology solutions. Findings from international working groups were also incorporated.

Options Paper Development

The Options Paper aims to provide information to DCCEEW by sharing industry's view on recycled content in packaging. Where there is consensus among the industry stakeholders this has been indicated. Where indications were differing in their approach, the paper outlines the options available to progress recycled content into packaging applications. Where there is insufficient information or it was out of scope for this paper but important to acknowledge, this has been included in a separate section titled '*Areas requiring further investigation*'. Finally key findings in relation to data traceability are also presented in this paper and any additional insights are summarised within the Executive Summary.

The findings of this work and the Recycled Content Target Analysis Tool will be used to progress resource development and prototype traceability and compliance data requirements. It will also support strategic projects including a review of the Sustainable Packaging Guidelines (SPGs) in the context of a mandated packaging design.

First Principles

The first principles by which the industry is addressing recycled content in packaging in this paper are:

1. Government intends to mandate for recycled content in packaging.
2. Ideally mandates for recycled content should increase over time towards a technical maximum.
3. Any increases are known, predicable, iterative to enable the market to comply or lead.
4. The system defaults to uplifting and action for material circularity on an if not, why not basis.
5. Organisations have confidence to invest in domestic reprocessing.
6. A percentage of recycled content should be sourced domestically.
7. Records must identify pre- and post-consumer recycled content.
8. Mandates apply at an organisational aggregate annual level and minimum recycled content mandates by format must be actioned in accordance with sustainable design standards.
9. Intervention is balanced to enable market confidence and the freedom to procure as needed.
10. International suppliers are held to the same certifications, standards, and accountability.
11. Existing certifications are recognised wherever possible.
12. System governance and decision making is open and transparent.

These principles were developed in consultation with the Recycled Content Reference Group and received feedback from Collective Action Group and Material Stewardship Committees. The principles have a broad consensus of support and were used to inform possible design approaches within this document.

Consensus 1: There is consensus among industry around first principles.

Definitions and meaning

Throughout the document reference is made to recycled content terms. The adopted meaning of these terms has been incorporated into the general definitions in this section. Additionally, this section outlines definitions and their meaning of recycled content in the context of certifications which have received industry consensus. Finally, data governance definitions and the meaning adopted through this document are provided.

General definitions

Contact [application] is a reference to input material or packaging that is suitable for direct product contact. This includes food-contact applications.

Industry is a reference to the participants of the stakeholder engagement and consultation activities completed in the development of this paper.

Non-contact [application] is a reference to input material or packaging that is *not* suitable for direct product contact including in food-contact applications.

Recycled material means pre and post-consumer material that is available as an input for inclusion in the manufacture of packaging.

Recyclate has the same meaning as 'recycled material'.

Recycled content means the proportion of packaging made from recycled material.

Technical maximum in the context of this document, is used to describe the highest potential of substitution of recycled material in place of virgin material in packaging by considering parameters such as (but not limited to) packaging primary function and performance, polymer type, material type, quality of recycling, mechanical properties, and processibility.

Recycled content definitions

All definitions of recycled content used across industry must be consistent with definitions for recycled material under AS/ISO 14021. These definitions have been considered through consultation and there is consensus on their adoption within this Options Paper.

Materials

- Pre-consumer material

  Materials diverted from the waste stream during a manufacturing process and have therefore never made it to the end-user. Excluded is reutilisation of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it without being modified in any way.

  The AS/ISO 14021 definition of pre-consumer material leaves some room for interpretation. Going beyond AS/ISO 14021 and the NFRCT, the following definitions of regrind, rework, and scrap as developed by UL (UL Knowledge Trust, 2020) are considered acceptable pre-consumer material:

  - Regrind*: Recovered material that has been used at least once in a manufacturing process and has gone through a size reduction process to be made into smaller pieces for reuse into a different product or component and/or go through another manufacturing process prior to use with the same/different product or component.

- Rework*: Materials or products that did not meet specifications upon exiting a process and require one or more tasks to be completed to correct the errors before entering the next processing step or finished goods inventory.
- Scrap: Rejected or discarded material generated by a manufacturing process that is useful only after it is reprocessed.

*Note: Regrind and rework alone do not count as pre-consumer recycled content if they are being used to produce the same product or component for the same product. They will count if they are used to produce a different product or component and/or go through another manufacturing process prior to use with the same/different product or component.

- Post-consumer material

  Material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain, for example, due to defects or end-user dissatisfaction.

Chain of custody

All definitions of chain of custody and chain of custody models must be consistent with definitions under ISO 22095:2020:

- Chain of custody

  Chain of custody describes the rules for managing recycled materials, to ensure their characteristics remain transparent through the supply chain and can be accounted for in the final recycled content goods.

- Identity preservation

  Identity preservation is a chain of custody model in which recycled materials from different sources are kept separate and never mixed with each other or with non-recycled materials as they move through the supply chain.

- Segregation

  Segregation is a chain of custody model in which recycled materials with identical characteristics from different sources are combined, but are never combined with non-recycled materials, as they move through the supply chain.

- Controlled blending

  Controlled blending is a chain of custody model in which recycled and non-recycled materials with different characteristics are mixed in specific ratios resulting in a known percentage of recycled materials in each output/product.

- Mass balance

  Mass balance is a chain of custody approach in which recycled materials and non-recycled materials are combined at any point in the supply chain over a defined period. The total amount of recycled materials incorporated into outputs must not exceed the total input amount after accounting for system losses. The percentage of recycled content in individual products or outputs is not known, but the average content for all the products or outputs produced during the defined period can be calculated.

- Book and claim

Book and claim is a chain of custody model in which the physical flow of recycled content in the supply chain is not connected to the administrative record flow. For each unit of recycled material placed on the market, credits are created, which can be bought and attributed to products which may not physically contain any recycled content.

Other definitions

In addition to these, the further definitions used in this document relating to recycled content are:

- Verification

  Verification involves examination, inspection, testing, and reviewing a product to establish whether it meets certain specifications. Verification is usually point-in-time specific.

- Certification

  Certification includes assessment against a known standard or specification that is nationally or internationally recognised. It requires ongoing surveillance and certification may be withdrawn if the process or specification changes.

Consensus 2: Definitions and their meaning of recycled content in the context of certifications which have received industry consensus.

Data governance definitions

Data Standard

Data standard is a key term used to define the framework for organising data, enabling seamless communication between systems, which allows the establishment of structured data management, documenting data sources and transformations. This framework enables stakeholders to trace data origins and changes. It is a requirement for traceability.

Interoperability

As defined by new European Interoperability Framework, the interoperability is the ability of organisations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organisations, through the business processes they support, by means of the exchange of data between their ICT systems.

Proposed recycled content targets for packaging

Voluntary targets for recycled content already exist at a material level within the 2025 National Packaging Targets. The aggregate target across all material types is 50% average recycled content included across packaging by 2025. The current reported aggregate recycled content across all material types is 40% (APCO, 2024).

However, there are significant variations in the level of recycled content achievement at a material level. This is particularly important when we consider packaging applications such as 'food-contact'. To address this, there is consensus among industry that future recycled content targets should be considered at a material and application level and this paper considers target options in that way.

Consensus 3: There is consensus among industry that future recycled content targets should be considered at a material and application level.

Considerations for reprocessing technologies used for packaging materials

Understanding the packaging reprocessing value chain in detail requires examination of the complex and diverse mix of reprocessing technologies available for different material types. This includes investigating:

- The suitability and capacity of reprocessing technologies to convert packaging into recycled material for use in packaging applications.
- The ability to provide recycled materials to manufacturers.
- The challenges and opportunities each technology faces.
- The benefits of implementing a range of technologies to achieve desired outcomes for both pre-consumer and post-consumer packaging.

To assist policymakers in understanding the packaging reprocessing process and the relative opportunities and challenges for different reprocessing technologies, material summaries have been prepared and are available at Appendices A-D. These material summaries cover each of the major packaging material groups (plastics, paper and paperboard, glass, and metals). Wood packaging is not in scope for the development of recycled content targets as it has low potential as a recycled content feedstock.

Each summary has been prepared with a focus on recycled content and includes the following key sections:

- The state of the packaging material group in Australia, including historical and projected data on packaging placed on market, recovery rates, reprocessing applications, and levels of recycled content.
- An assessment of the reprocessing technologies used for each major packaging material group including:
  - Manufacturing of virgin raw materials used in packaging.
  - The opportunities for recycled material to substitute for virgin material as inputs to this process; and
  - The necessary inputs and outputs for optimal process efficiencies.

- An overview of the opportunities and challenges in reprocessing pre- and post-consumer packaging for each material group, both at the level of specific reprocessing technologies (where applicable) and for the material group.

The material summaries provide additional context to the recycled content target scenarios presented in the paper and it **strongly recommended** they be considered together.

Understanding availability of packaging recyclate for packaging applications

The availability of recyclate for packaging applications is a complex and evolving space. For some material groups, recycled content is already a strong contributor to packaging placed on market (e.g. paper and paperboard, glass). Therefore, providing an estimate of the domestic reprocessing sector's ability to provide recycled material to meet recycled content targets can be done with a reasonable degree of confidence. For other material groups, the reprocessing landscape is still evolving, and complex dynamics are involved that make assessing the extent of domestic recycled content made available to packaging manufacturing difficult and subject to a high degree of variation.

Some of the factors influencing the availability of domestic recycled content include:

- **Development of additional reprocessing capacity:** While current operational reprocessing capacity is more readily determined, there are a range of prospective and planned increases to reprocessing capacities domestically which are at different stages of development. The delay, modification or cancellation of these projects would have significant impact on the availability of domestic recycled content.
- **Changing regulatory environment:** The development of additional reprocessing capacity is similarly impacted by the regulatory environment in which it operates. Without having certainty on the development of future policies regarding reprocessing and recycled content, the certainty of the continued viability of domestic reprocessing is decreased.
- **Competitive markets for feedstocks and outputs of reprocessing technologies:** The packaging-to-packaging recycled content value chain does not exist in a vacuum. Both the collection feedstocks and the outputs of the reprocessing sector are subject to competition from other offtake pathways that do not lead to recycled content being made available to packaging applications. This also impacts the accepted materials of reprocessors, who may preference alternative materials for reprocessing over packaging materials, further reducing the overall reprocessing throughput of collected packaging.
- **Quality and consistency of feedstocks and recycled material:** The quality of feedstocks to the reprocessing sector plays a large role in determining the quality and consistency of the outputs the sector produces. Pre-consumer, single stream and Container Deposit Scheme materials generally result in lower contamination levels and align best with the design of the reprocessing systems they feed into. Updates to design standards for packaging are also likely to improve the quality and consistency of feedstock. These considerations are not applicable for chemically recycled polymers, which produce materials considered equivalent to virgin inputs (however, feedstock inputs will still impact the efficiency of the outputs).

International availability of recycled content is similarly difficult to determine with a high degree of confidence without significant additional international research and stakeholder consultation. Feedback from the stakeholder engagement process highlighted that international recycled content is readily available and traceable. However, suppliers are operating at a varying degree of reliability and confidence, both in terms of the quality and consistency of material, as well as the traceability standards placed on the content provided. In addition, the market trading mechanisms for international recycled content remain relatively immature, and getting access to high quality, broad information on the real time availability of international recycled content is a challenge. This challenge is considered further under *Traceability Data Requirements* for an interoperable protocol.

In some instances, international recycled content providers are well prepared to immediately provide high quality, traceable recycled content as a feedstock to packaging placed on market in Australia, as in the case of chemically recycled plastics certified through ISCC+. In other instances, significant additional work is needed to ensure the recycled content is suitable for the Australian market.

In April 2024, the European Parliament adopted the Packaging and Packaging Waste Regulation (PPWR)[1] to harmonise the EU's internal market for packaging. Among the provisions is a requirement that packaging and packaged products imported into the EU from third countries must also comply with the minimum recycled content requirements. In addition, imports may enter the market only when originating from a country that has equivalent rules concerning the prevention and reduction of emissions into air, water and land associated with recycling operations.

Developing a deeper understanding of the availability of international recycled content for packaging placed on market in Australia has been highlighted as a point where additional work will be required by policymakers to further refine the target setting process.

Additional analysis opportunity 1: Ongoing tracking of reprocessing capacities and technologies is advised. More detailed analysis of international feedstocks quality and flows would assist target settings.

Considerations of material technical maximum

In line with the outlined first principles, the consensus is that the industry should aim to maximise the recycled content in packaging while considering the technical and quality requirements of the material at an end market and application level.

Consensus 4: Industry seeks to maximise recycled content in packaging with consideration of technical and quality requirements.

For the purposes of this analysis, stakeholders provided indicative technical maximums by material, based on current technologies. These are shown in the table below and used in the Recycled Content Target Analysis Tool. These figures will require detailed validation via the consultation process and ongoing tracking by an expert technical committee as feedstock quality improves and reprocessing technology advances.

[1] European Parliament legislative resolution of 24 April 2024 on the proposal for a regulation of the European Parliament and of the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC (COM(2022)0677 – C9-0400/2022 – 2022/0396(COD))

Table 2 Material type technical maximum ranges

Material type	Food grade suitability	High level assumption of technical maximum[2]	Additional commentary
Rigid PET	Food grade	90%-100%	Industry is already producing some PET rigid formats at 100% recycled content. Range provided to account for format level variability.
Rigid PET	Non-food grade	90%-100%	
Rigid HDPE	Food grade	40%-60%	Industry is already producing some food grade HDPE rigid formats at 50% recycled content and 100% recycled content for non-food grade HDPE packaging formats. Range provided to account for format level variability.
Rigid HDPE	Non-food grade	80%-100%	
Rigid PP	Food grade	30%-50%	High level of variability in food grade capability due to limited technology and approvals for mechanically reprocessed rigid PP. Technical maximum could be significantly higher under chemical reprocessing (up to 100% as is consistent with virgin material)
Rigid PP	Non-food grade	30%-50%	
Flexible PE	Food grade	80%-100%	Assumed chemical recycling for flexible food grade recycled content, capable of producing up to 100% recycled content as is consistent with virgin material. Chemical recycling is capable of producing up to 100% for non-food grade flexible PE also, but the assumption has been made that mechanical recycling would be preferenced for non-food grade applications and non-food grade indicative response from industry is between 10% and 40%.
Flexible PE	Non-food grade	10%-40%	
Flexible PP	Food grade	80%-100%	Assumed chemical recycling for flexible food grade recycled content, capable of producing up to 100% recycled content as is consistent with virgin material. Chemical recycling is capable of producing up to 100% for non-food grade flexible PP also, but the assumption has been made that mechanical recycling would be preferenced for non-food grade applications and non-food grade indicative response from industry is between 10% and 40%.
Flexible PP	Non-food grade	10%-40%	
Paper and paperboard	Food grade	80%-100%	Industry already producing some formats and material types using 100% recycled content. However, significant variations exist across applications, formats and materials and should be taken into consideration in target setting process. For simplicity, the technical maximums displayed for paper and paperboard are reflective of large tonnage packaging types (e.g. corrugated cardboard, boxboard/cartonboard), but industry feedback indicates that the technical maximum for other types (e.g. paper cups) is significantly lower (up to 30%). Total recycled content must also be maintained below 100% for most materials to account for fibre replacement.
Paper and paperboard	Non-food grade	80%-100%	
Aluminium	Food grade	70%-95%	Industry indicates high levels of recycled content potential in aluminium, approaching 95%, with some industry players already achieving 80%-90% recycled content in aluminium cans. Range provided to account for format and application variability.
Aluminium	Non-food grade	70%-95%	
Steel	Food grade	10%-30%	Industry feedback indicates a minimum of 10% is achievable currently, with supporting literature indicating 30% with current technology.
Steel	Non-food grade	10%-30%	
Glass	Food grade	70%-100%	Industry recycled content target levels are already targeting 70% recycled content in glass packaging. There are some examples of higher recycled content levels (up to 100%) for glass bottles, but range provided to account for format and application variability.

[2] Based on industry feedback, published industry targets and research. While these are possible rates for total recycled content in a given packaging item, industry feedback indicates a need for continued virgin inputs to maintain material quality through multiple reprocessing cycles.

Establishing technical maximums for recycled content in packaging materials requires a detailed understanding of recycling quality and consistency. This understanding is crucial for effectively using recycled materials in product.

That said, the current use of recycled content for most materials is currently well below technical maximum, which creates an opportunity for policy makers to set a progressive upward trajectory over time, and calling on technical committees to explore, document, publish and iteratively update technical maximum guidance over time as performance improves.

Additional analysis opportunity 2: Continue research and an established review process of technical maximums.

Process for determining technical maximums

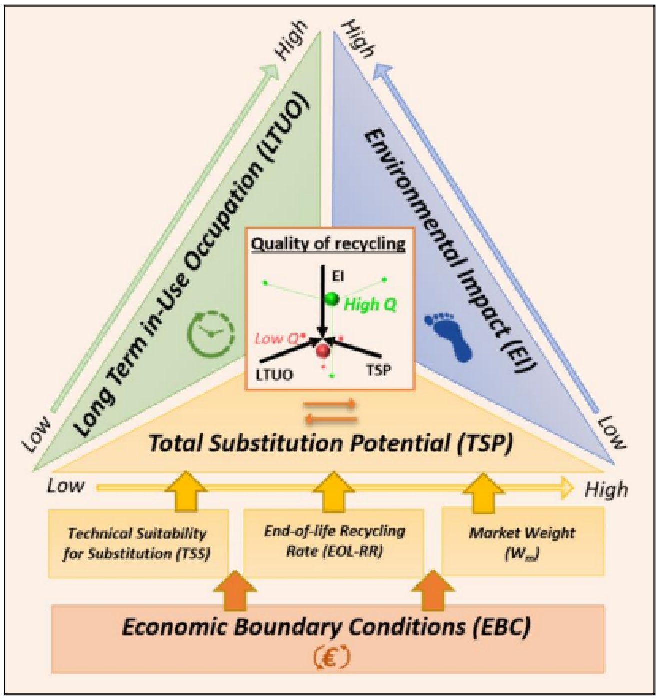
Determining if recycled materials are a good substitute for virgin materials involves understanding the technical requirements of the intended manufacturing process and final application. The complex relationship between the technical properties of recycled materials and their use as substitutes for virgin materials in packaging shows the need for a thorough assessment of recycling quality.

The European Union Waste Framework Directive provides a structured approach to transform waste into valuable resources through recovery operations, building on the work of Grant et al. (2020) and Caro et al. (2023). This framework for assessing the quality of recycling comprises three main dimensions:

- Total Substitution Potential (TSP),
    - TSP quantifies the ability of recycled materials to replace primary materials, considering factors such as Technical Suitability for Substitution (TSS), End-Of-Life Recycling Rate (EOL-RR), Market Weight (Wm), and Economic Boundary Conditions (EBC).
- Long-Term in-Use Occupation (LTUO), and
    - LTUO evaluates the longevity of materials in society, aligning with circular economy principles to minimise resource dissipation.
- Environmental Impact (EI).
    - EI assesses the environmental consequences of recycling, aiming to maximise material recovery while minimising environmental impacts.

Together, these dimensions offer a structured approach to evaluating recycling quality, essential for determining the optimal percentage of recycled materials suitable for packaging applications. See below.

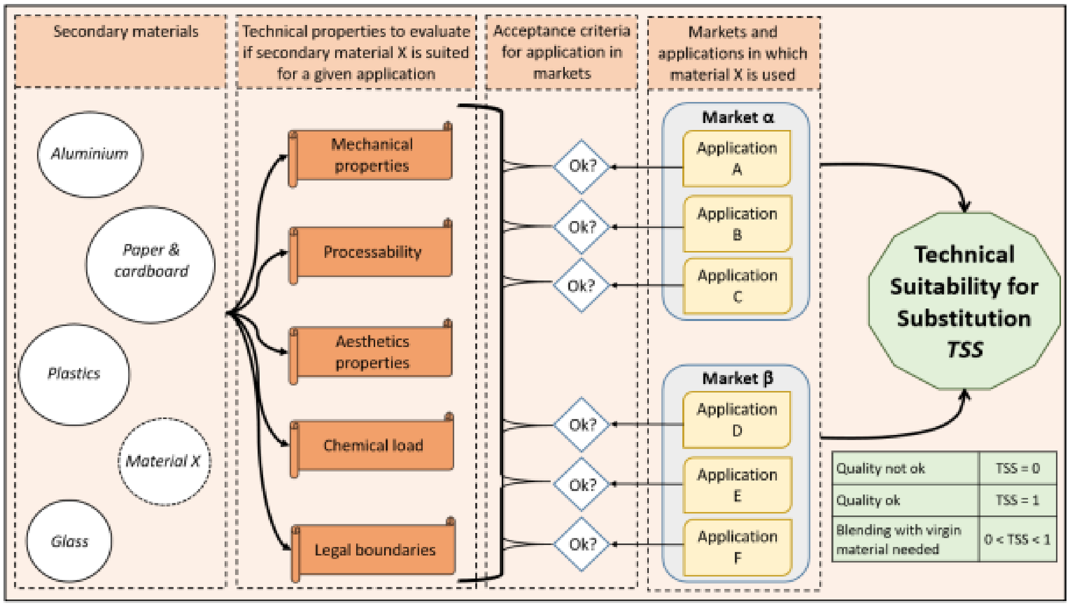
Figure 1 Schematic representation of the proposed quality framework for recycling. Based on the three dimensions, namely the Long Term in-Use Occupation (LTUO), Environmental Impact (EI), and Total Substitution Potential (TSP), the quality of recycling can quantitatively be evaluated (Caro et al., 2023)



The TSP dimension and TSS factor are the most applicable with regards to determining and understanding the technical maximums for recycled content percentages in packaging formats. Assessing the TSS at a detailed level is important to ensure accurate evaluation. This involves checking if the recycled material's technical properties are suitable for production, as reprocessors must ensure material quality fits production processes. Simply stating that a recycled material can be used in one market but not another overlooks crucial application-level factors. By analysing each application individually, we better understand the TSP and the quality of recycling.

Five key properties are proposed for assessing the technical quality of recycled material for substitution potential: mechanical strength, processability, aesthetics, chemical composition, and regulatory compliance (Figure 3), Technical strength and processability are crucial for determining the technical limits for packaging formats. However, aesthetics, chemical composition, and regulatory compliance are also essential when considering post-consumer recycled material in packaging. These factors ensure that recycled materials meet necessary standards, such as food contact requirements and chemical safety regulations. Table 3 provides and overview on technical properties to assess the suitability of secondary material by material type and a further delve into mechanical properties be found in Appendix E Overview of mechanical properties.

Figure 2 Theoretical framework for the determination of the technical suitability for the substitution (Caro et al., 2023).



The complexity of packaging materials and their widespread use present significant technical challenges for the incorporation of recycled material. Assessing recycled content's suitability involves understanding mechanical properties, processability, and the impact of additives.

The European Union Waste Framework Directive offers a structured approach to determine if recycled materials meet necessary requirements, highlighting the importance of a thorough assessment to optimise their use in packaging. Evaluating Total Substitution Potential (TSP) and Technical Suitability for Substitution (TSS) is fundamental, considering factors like mechanical properties, processability, aesthetics, and regulatory compliance.

The proposed European Union Waste Framework Directive presented in

provides a structured approach to assessing recycling quality, essential for realising the potential of recycled materials in packaging applications. Currently, the potential for recycled material in packaging applications is currently unknown or ill-defined. However, it is acknowledged the current use of recycled content for most materials is currently well below technical maximum.

A documented exemptions process for formats and use cases that do not align with the material level guidance is discussed under *Areas requiring further information.* There is intention to develop Best Practice Design Guidelines to support this and build industry knowledge and capability over time.

Table 3 Overview of technical properties to assess the suitability of secondary material by material type[3]

	Mechanical properties *Set of properties that a material exhibits upon the application of forces*	**Processability** *Behaviour of a material during the various processing stages*	**Aesthetical properties** *Material properties that are attributed by aesthetic judgment*	**Chemical load** *Content of chemical compounds present in a material*	**Legal boundaries** *Legislation & standards that are applicable on the use of secondary materials*
Plastics	• Predominant mechanical characteristics are Strength (e.g., tensile strength), stiffness (e.g., tensile modulus), and impact strength (e.g., Charpy impact strength) • The presence of foreign polymers changes certain mechanical properties due to potential compatibility issues between polymer blends.	• Determined by the flow behaviour e.g., via Melt Flow Index (MFI). The preferred MFI depends on the used polymer processing technique.	• Colour and odour are limiting factors for some product uses (e.g., packaging applications).	• Plastics contain IAS (additives, monomers, solvents, processing aids) and NIAS (impurities, oligomers, degradation products).	• Plastics production, use, and recycling are regulated by international standards like REACH, POPs, WEEE, FSANZ, FDA, EFSA, RoHS, and FCM .
Glass	• The mechanical quality of glass is strongly affected by the presence of glass types different from the main glass cullet type, depending on their chemical composition. E.g., production of flat glass is only possible from flat glass (or from raw materials).	• Contamination of non-glass materials should meet certain specifications to avoid defects in the walls and bottom of the glass furnaces and other equipment.	• Maximum accepted levels of false colours in a given coloured cullet differ according to the desired product quality by the manufacturer and glass grades.	• Heavy metals (e.g., Co, Cr, Ni, Sb) are a concern related to the glass recycling as they can cause processability issues and adversely affect the colour properties of the mix of cullet and raw materials.	• Glass is exempted from REACH obligations, unless: "they meet the criteria for classification as dangerous according to Directive 67/548/EEC & • Directive 1999/45/EC".
Paper and cardboard	• Recycling paper and carton board decreases fibre quality due to chemical and mechanical treatments, causing irreversible changes. • Hornification of cellulose fibres reduces bonding potential and strength with each recycling cycle.	• Contamination of non-paper materials (e.g., plastics, adhesives) are undesired for technical reasons. • Waste contaminants are difficult to remove as equipment is not prepared to receive it.	• Odor is an important aspect in the perceiving properties of paper and cardboard packaging and limits the application range.	• Paper and paper products contain various chemicals, mainly from conversion processes like printing and gluing. • Chemicals may also be unintentionally added through impurities, by-products, or contamination during use.	• The production, use and recycling of paper are regulated by REACH and by national regulations.

Aluminium	• Oxides lead to the formation of microcracks and voids. Hence, Al scrap cannot contain excessive oxide in any form.	• The EN 13920 standard for Al and Al alloy scrap limits foreign materials, allowing:
		  ○ 0.5% magnetic Fe
		  ○ 5% moisture and oil
		  ○ 3% fines (after drying)
				• In the case of Al, many problematic impurities can occur, including Si, Mg, Ni, Zn, Pb, Cr, Fe, Cu, V, and Mn.
				• Compared to many metals, Al presents a high degree of difficulty in the removal of tramp elements, due to thermodynamic barriers.
					• The production, use and recycling of Al are regulated by international regulations such as REACH and by the technical guide for metals and alloys by the Council of Europe

[3] Caro, D., Albizzati, P.F., Cristobal Garcia, J., Saputra Lase, I., Garcia-Gutierrez, P., Juchtmans, R., Garbarino, E., Blengini, G., Manfredi, S., De Meester, S. and Tonini, D., Towards a better definition and calculation of recycling, EUR 31409 EN, Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-76-98958-5, doi:10.2760/636900, JRC131531

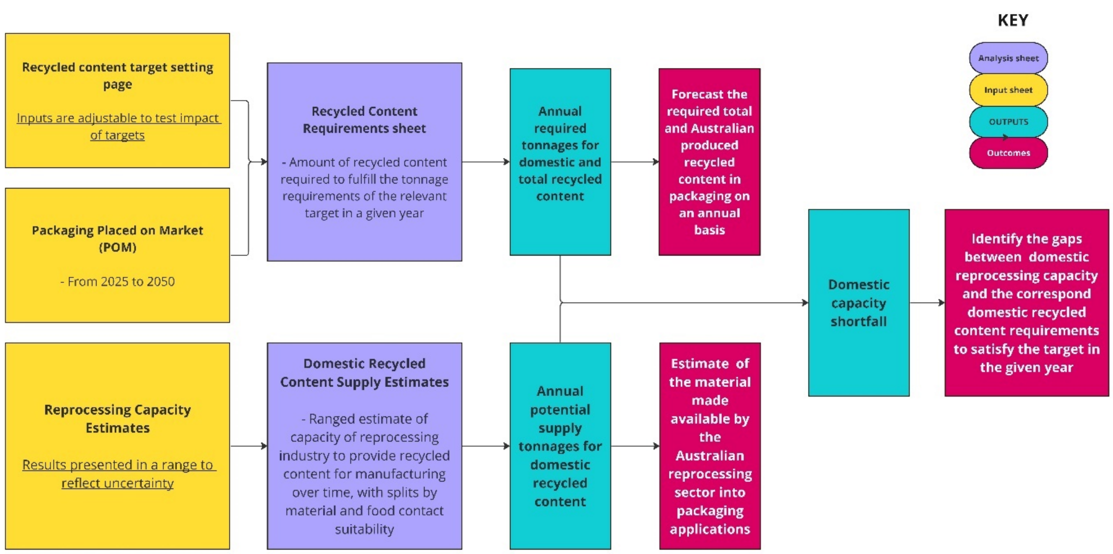
Modelling recycled content requirements for packaging

To understand the impact and feasibility of recycled content targets on packaging placed on market in Australia, a preliminary Recycled Content Target Analysis Tool was developed. The objectives of this tool are to:

- Produce a forecast of packaging placed on market across Australia between 2022 and 2040.
- Assess the current recycled content levels for different packaging materials, both from international and domestic sources.
- Estimate the recycled content tonnage requirements (total recycled content and Australian sourced recycled content) of tested scenarios based on stakeholder consultation and feedback.
- Estimate the 5-year upper limit of Australian reprocessing capacity for a given material and technology and the suitability of its output in different applications (e.g. contact sensitive applications).[4]

A high-level schematic of the Recycled Content Target Analysis Tool has been provided in **Error! Reference source not found.**.

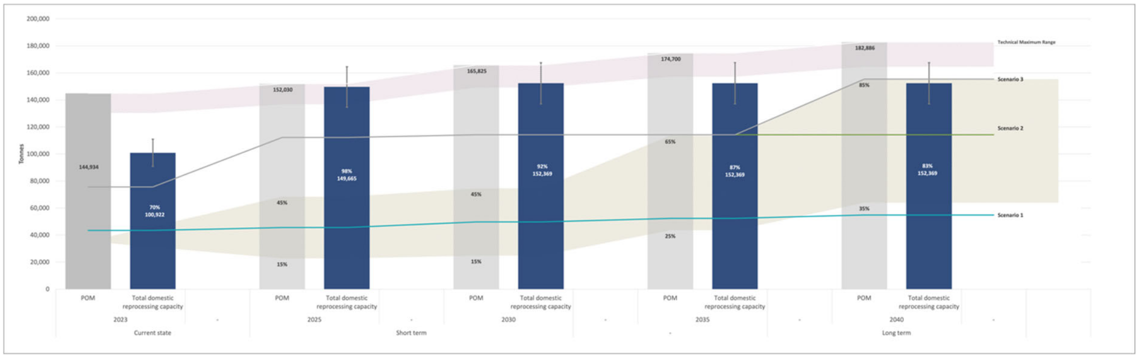
Figure 3 Schematic of APCO Recycled Content Target Analysis Tool



The results of the scenario analysis and outputs of the tool provide a mechanism to overlay industry target ambition on available domestic reprocessing capacity and to examine possible target setting under a range of scenarios. An example output has been provided in Figure 4, and material specific charts have been included in Appendix H Recycled content target visualisers. A summary of the limitations and assumptions included in the analysis process have been included in **Appendix F**.

[4] Estimates of reprocessing capacity were developed on a 5 year projected basis and applied and assumed flat beyond this point as reliability of data and capacity estimates were diminished beyond this point.

Figure 4 Example output of Recycled Content Target Analysis Tool



Additional analysis opportunity 3: Enhance Recycled Content Target Analysis tool to provide more insight into competing offtake markets and add economic impact overlays.

To provide recycled content target options for consideration a series of scenarios have been developed for assessment. These scenarios have been founded in the First Principles in particular principles 1, 2, 3, 4, 6 and 8 and have been applied using the same logic across all material types. The scenarios and their rationale are provided in Table 4 Proposed Scenarios for testing. below.

These scenarios have been designed as preliminary trajectories for each material type which have been tested through consultation. Additional analysis will be conducted to be sensitive to material level considerations.

Table 4 Proposed Scenarios for testing.

Scenario	Rationale
Mandate current 2025 National Packaging Target recycled content target	Existing voluntary target **Addresses Principles 1, 4 and 8**
Lower of: 75% of available domestic reprocessing capacity or low end of technical maximum range	Maximise use of domestic material, which is available today. Notional 75 % target is respectful of other domestic off-take market customers. **Addresses Principal 4**
Lower of: 75% of available domestic reprocessing capacity + gap to high ambition made up with international recycled material, or low end of technical maximum range	Maximises domestic material, and assumes the balance is secured from international sources. Respectful of other domestic off-take markets **Addresses Principal 4 and 6**
Technical maximum range	Indicative of best possible material circularity outcome **Addresses Principles 2, 3, 4, 8**

Summary of recycled content target analysis

Table 5 High and low end tested targets for recycled content

Material	Food grade Suitability	2025		2030		2035		2040	
		Low end	High end	Low end	High end	Low end	High end	Low end	High end
Aluminium	Food grade	1%	35%	0%	35%	0%	35%	0%	35%
Aluminium	Non-food grade	35%	70%	35%	70%	35%	70%	35%	70%
Steel	Food grade	10%	35%	7%	35%	7%	35%	7%	35%
Steel	Non-food grade	1%	35%	1%	35%	1%	35%	0%	35%
Paper and paperboard	Combined	32%	60%	30%	60%	29%	60%	27%	60%
Flexible HDPE	Food grade	2%	15%	5%	15%	5%	30%	5%	45%
Flexible HDPE	Non-food grade	10%	20%	10%	20%	10%	20%	10%	20%
Flexible LDPE	Food grade	0%	15%	1%	15%	1%	30%	1%	45%
Flexible LDPE	Non-food grade	10%	20%	10%	20%	10%	20%	10%	20%
Flexible PP	Food grade	3%	15%	6%	15%	5%	30%	5%	45%
Flexible PP	Non-food grade	10%	20%	10%	20%	10%	20%	10%	20%
Glass Amber	Food grade	50%	70%	50%	70%	50%	70%	50%	70%
Glass Flint	Food grade	44%	50%	50%	52%	49%	55%	47%	65%
Glass Green	Food grade	34%	55%	40%	55%	38%	65%	36%	70%
Rigid HDPE	Food grade	20%	30%	20%	30%	20%	40%	20%	55%
Rigid HDPE	Non-food grade	20%	80%	20%	80%	20%	80%	20%	80%
Rigid PET	Food grade	30%	74%	30%	69%	30%	65%	30%	85%
Rigid PET	Non-food grade	30%	55%	30%	59%	30%	70%	30%	85%
Rigid PP	Food grade	12%	25%	11%	25%	10%	30%	10%	30%
Rigid PP	Non-food grade	20%	30%	20%	30%	20%	30%	20%	30%

Increasing recycled content into packaging

There are barriers to post-consumer recycled material being produced and incorporated into packaging at sufficient scale, quality, and price to deliver a packaging-to-packaging circular economy.

Table 6 Barriers to post-consumer recycled content in packaging (APCO internal analysis, 2024)

Reprocessors	Packaging manufacturers	Packaging users
Producing recycled resin is uneconomical Quality / volume of feedstock	Cheaper / higher quality substitutes (virgin resin) Cost of incorporating recycled content Technical challenges Quality concerns (variability and/ or low quality)	Low awareness or confidence in recycled content (perceived quality and safety concerns) Unable to verify recycled content claims

Barriers exist across the packaging value chain, from the high reprocessing costs through to the impact on volumes and quality of reprocessing feedstock from incorrect disposal of packaging waste. These are referenced in Appendix G Stakeholder interview key insights but summarised below in the context of incentivising recycled content in packaging.

Reprocessors

Reprocessors are unable to produce recycled material at the price required to compete with close substitutes, such as virgin or even offshore recycled material. This is due to the cost of producing recycled material suitable for packaging applications in Australia, particularly in plastics and in high-grade applications, such as food contact packaging. This limits the incentives for reprocessors to invest in additional capacity and / or in new technologies or ways to improve efficiencies in their production.

Whilst Australia is a net importer of packaging, reprocessors face variable quality and quantity of feedstock which impacts the grade of recycled material they can produce. This is in part due to unenforced design standards, limited import regulations, and poor sorting at source with consumer and business users' incorrectly disposing of packaging. This impacts the quality and consistency of packaging waste flowing through recycling systems. The costs to recovery and sorting centres to address this contamination adds to the already high costs of producing recyclate.

Reprocessors are also often bound by Environmental Protection Legislation that create additional regulatory, licensing and cost barriers to the processing, storage and export of partially reprocessed materials.

Packaging manufacturers

Packaging manufacturers, without a regulatory mandate or the willingness of consumers to pay a premium for recycled content, are incentivised to use cheaper alternatives to Australian recycled feedstocks (mainly virgin resin), which have greater compatibility with existing machinery. Industry agrees that the price differential between recycled and virgin materials; and domestic versus international recycled materials remains the most critical barrier.

In addition, there are costs for packaging manufacturers associated with incorporating recycled content into their packaging, which they may be unwilling to incur without a regulatory mandate. For example, in many instances it requires an initial investment outlay to:

- Change the design of packaging. This could involve a costly process of sourcing, selecting and testing materials, designing and testing formats, testing the compatibility of materials with existing equipment, and implementing labelling changes. This can take several years and incur considerable cost.
- Update packaging equipment and machinery to ensure compatibility with new designs.

There are also technical challenges with incorporating recycled content into certain packaging formats. This is discussed in detail above under *Considerations for technical maximum.*

Packaging users

Concerns about greenwashing are widespread and currently there are limited ways for business and consumers packaging users to easily verify recycled content claims for packaging and/ or to gain reassurance on the safety and quality of recycled content. Although there are internationally recognised certification schemes, such as ISCC+, they are not consistently adopted or understood in Australia. Certificate holders tend to be larger manufacturers, with the application of these certification among packaging users is diverse. In some cases, packaging users do not apply or describe the certification correctly, or may not ask for any evidence of certification, relying instead on manufacturer claims. This undermines confidence in recycled content and consumers' willingness to pay a premium for it.

Packaging users often incorrectly dispose of packaging and/or contaminate recovery streams. There are multiple drivers of contamination from incorrect disposal, including:

- Under-investment in business and consumer education
- Complexity of packaging and inconsistency in kerbside systems, which increases the likelihood of disposal errors.
- Absence of a mandated national on-pack labelling scheme leads to incomparable, inaccurate, or lack of evidence for on-pack claims (greenwashing), that can create confusion on the correct disposal pathway for a packaging item.
- Lack of financial incentives for:
    - consumers to avoid, reuse and correctly dispose of packaging. For example, where financial incentives are offered (CDS), we see greater recovery rates (APCO, 2024).
    - B2B recycling, which results in substantial quantities of high-quality material such as corrugated cardboard and LDPE wrap being sent to landfill.
- Lack of confidence in the recycling system which can deter participation. Consumer confidence in recycling has been damaged due to crises arising from incomplete and fragile recycling systems, such as the suspension of the REDcycle Program.

Options for incentivising recycled content

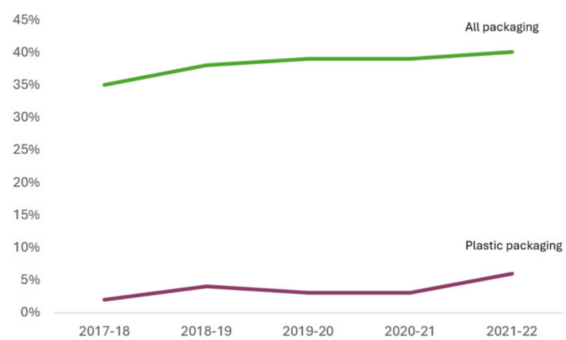
The barriers to scaling the production of Australian post-consumer recycled content are across the value chain and require a multi-faceted approach to designing interventions. Potential regulatory options are appraised in Table 7 below, and comprise:

- Mandate recycled content only
- Mandate recycled content and eco-modulation
- Mandate domestic recycled content
- Eco-modulation only

As noted in the First Principles section, industry is supportive of recycled content mandates, though analysis concludes that without a domestic mandate, procurement could be driven offshore. Eco-modulation provides a complementary tool to support mandates and is explained further below.

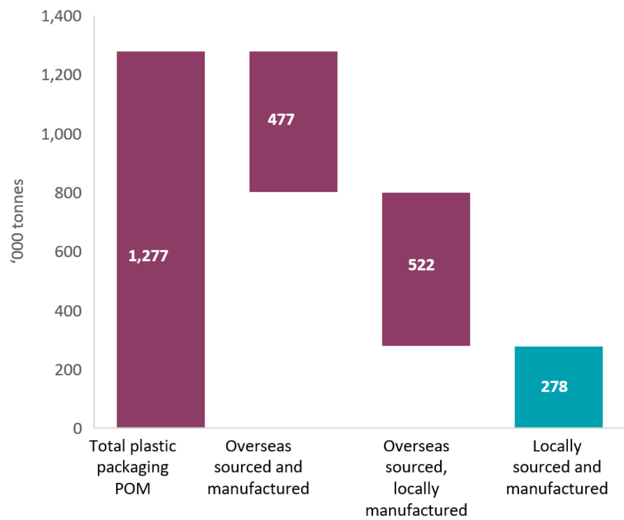
Data in Figure 5 shows the proportion of post-consumer recycled content in packaging. With Australia's packaging comprised of only 40% recycled materials and only 6% for plastic packaging, recycled content targets are an important driver of markets for recycled materials. However, other interventions are also required to address recovery gaps in collection, sorting and reprocessing and other barriers that impede the production recycled materials in Australia and their incorporation into packaging.

Figure 5 Post consumer recycled content (plastic) as a proportion of packaging placed on market (tonnes),(APCO, 2024)



A key concern for industry is that, in the absence of a specific requirement to use Australian recycled content, internationally sourced materials may be more competitive. This is particularly so for the 38% of Australia's packaging that is manufactured overseas and 17% that is manufactured in Australia from imported materials (APCO, 2024). As shown in Figure 6 only 278,000 tonnes, or 22% of plastic packaging placed on the market is manufactured in Australia from locally sourced materials.

Figure 6 Locally and overseas sourced and manufactured plastic packaging placed on the market in 2021-22 (APCO, 2024 and Evello, 2024)



In the context of plastics, polymer production is a global enterprise with significant scale economies and large benefits from integration in monomer production (e.g. Ethylene into Polyethylene). International players are investing in recycling infrastructure globally to produce recycled resin, making it challenging for Australian producers to compete, given limited scale and access to competitively priced local virgin feedstock (naphtha or natural gas).

Domestic mandates could address this concern, by incentivising packaging manufacturers to use a proportion of Australian recycled content, where it is available.

If recycled content targets for plastic packaging cannot include targets for Australian-sourced material, the most competitive source of recycled resin is likely to come from large scale players offshore because of the economies of scale available to these producers.

In developing a mandate for recycled content, it is necessary to consider the potential constraints and incentives faced by packaging manufacturers that may prevent them from meeting an Australian recycled content mandate and to consider what this means for regulatory design. Constraints and disincentives faced by packaging manufacturers may include:

- Supply side constraints, if economic gaps in collection, sorting and reprocessing are not addressed, or the cost of doing so are prohibitive.
- Quality and volume concerns, particularly contamination from packaging users' incorrectly correctly disposing of packaging.
- Limited repercussions from non-compliance
- Limits in recycled content that can incorporated into certain packaging without compromising its functionality.

The role of eco-modulation

The determination of fees based on the environmental impact of products, in this case packaging, is referred to as eco-modulation (i.e. ecological modulation). Eco-modulated fees for packaging are typically based on assessments of the downstream costs arising from the amount and type of packaging placed on the market. They are used for packaging schemes in countries including Belgium, the Netherlands and France.

Eco-modulated fees can be designed to:

- Incentivise packaging producers to design for sustainability – including reduction, reuse or recovery (including, incorporation of post-consumer recycled content in packaging).
- Provide a mechanism to monitor and incentivise compliance with a sustainable design standard and/or recycled content mandate.
- Raise funding to be delivered into the downstream system as service fees, to address economic gaps in collection, sorting and reprocessing, to support the infrastructure to deliver circular economy outcomes and fund education campaigns to support correct disposal of packaging.

For the purposes of this paper, eco-modulation will be used to refer to all three of these functions. The first two points of incentivising packaging design and incentivising compliance with recycled content are unlikely to distinguish between local and imported materials. The third function of raising funds to address economic gaps in the downstream system provides an important mechanism to support domestic recycled content outcomes that is distinct from the levying of fees. Funds raised through eco-modulated fees can be delivered into the downstream system as service fees, which support increased collection and recycling and delivery of recyclate into the market at a competitive price. It is important to note that the primary objective is environmental, that is to increase recycling and decrease waste to landfill rather than a trade measure that would favour local over imported materials.

Eco-modulation is a way to allocate costs that aligns to 'cost to packaging footprint' rather than to 'turnover'. Cost is allocated based on each participant's packaging footprint and the costs of managing their packaging in the downstream system, incentivising change. Participants that reduce their packaging footprint or design packaging to be more easily managed in the downstream system are rewarded for those actions. Recent consultation conducted by APCO in May 2024 through a process that engaged with more than 800 participants indicated widespread acknowledgement that eco-modulation is a fairer way to allocate costs than a fee model based on annual turnover.

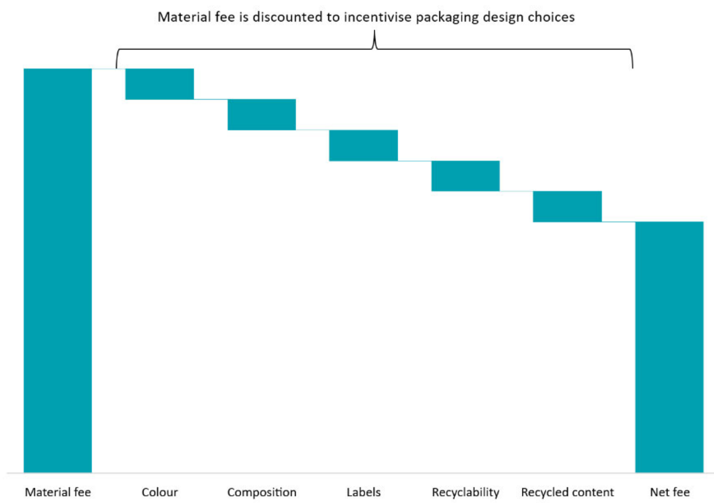
Consensus 5: Eco-modulated fees are a fairer way of distributing the costs required to deliver the 2025 National Packaging Targets, when compared with the current turnover based model.

There are existing packaging schemes that use eco-modulation of fees to incentivise the incorporation of recycled content in packaging (Evello, 2024) including:

- Germany offers a 0.10 euro discount for flexible packaging with more than 10% post-consumer recycled content in sensitive packaging; and 20% for non-contact sensitive
- France has a 10% fee reduction for greater than 50% recycled content in cardboard.
- Canada (Quebec) offers a 20% bonus for more than 50% recycled content in packaging

The Netherlands has implemented an eco-modulated model for its extended producer responsibility scheme. A fee is set for a particular material, such as PET. Different materials would carry different material fees depending on the downstream costs, such as collection and recovery. Discounts are then applied to the material fee based on the sustainable design characteristics of the packaging, such as whether it contains the required level of recycled content. The organisation pays the net fee.

Figure 7 Example of eco-modulation of fees based on packaging material and design features (Evello, 2024)



Additional analysis opportunity 4: Analyse impact of various eco-modulation scheme design settings as a complement to mandates

Options for consideration

Table 7 Options for incentivising recycled content in packaging

Option	A Mandate recycled content only	B Mandate recycled content and eco-modulation	C Mandate levels of domestic recycled content	D Eco-modulation only
Summary	If effectively enforced, this will increase the recycled content in packaging compared to under the voluntary 2025 NPTs. However, there is a risk that packaging manufacturers meet the mandated recycled content requirement from cheaper offshore providers, and as a result mandating recycled content alone is not sufficient for an Australian packaging-to-packaging circular economy to emerge In addition, the market for recycled content in packaging will be insufficient to create demand for large quantities of recycled materials not suitable or needed for packaging-to-packaging use.	If effectively enforced, a mandate will increase the recycled content in packaging compared to under the voluntary 2025 NPTs. This could be supported and extended through a model for eco-modulation that: • Incentivises and rewards uses of recycled content relative to virgin materials through the levying of eco-modulated fees. This would increase overall recycled content. • Delivers service fees into the downstream system to overcome economic barriers to collection and recycling, thereby supporting the delivery of Australian recyclate into the market at competitive prices. This would increase Australian recycled content in both packaging and non-packaging applications. Service fees provided into the downstream system will also incentivise private investment. • a soft enforcement tool, penalising non-compliance with the mandate.	Packaging manufacturers use domestic recycled content to meet the mandate to use Australian recycled content. There is a need to check whether this mandate is compatible with international trade law. (See Areas requiring further investigation.*)* To be effective, it is important that there are sufficient resources and a willingness to enforce and support compliance, and there may be a need for additional regulation to address economic gaps in collection, sorting and reprocessing where improved demand is insufficient to incentivise investment	This involves a model for eco-modulation that: • Incentivises and rewards uses of recycled content relative to virgin materials through the levying of eco-modulated fees. This would increase overall recycled content. • Delivers service fees into the downstream system to overcome economic barriers to collection and recycling, thereby supporting the delivery of Australian recyclate into the market at competitive prices. This would increase Australian recycled content in both packaging and non-packaging applications.

Option	A Mandate recycled content only	B Mandate recycled content and eco-modulation	C Mandate levels of domestic recycled content	D Eco-modulation only
Desired outcomes delivered	Packaging manufacturers invest in capabilities to incorporate recycled content	• Local and imported recycled content is supported through levying of eco-modulated fees. • The competitiveness of Australian recyclate is supported through service fees that overcome economic barriers to their manufacture. • Packaging manufacturers are incentivised to use Australian recycled content and invest in capabilities to incorporate into their packaging. • Stable demand for Australian recycled resin incentivises domestic production, and reprocessing capacity comes online	Packaging manufacturers are incentivised to use Australian recycled content and invest in capabilities to incorporate into their packaging.	• Packaging manufacturers are incentivised to use Australian and imported recycled content and invest in capabilities to incorporate into their packaging. • Stable demand for Australian recycled resin incentivises domestic production, and reprocessing capacity comes online. • Funding from eco-modulated fees is used to address outstanding economic gaps in collection, sorting and reprocessing, support packaging users to correctly disposal of packaging in recycling streams and generally improve the quality of recycled resin
Factors that might undermine desired outcome	• Cheaper offshore recycled resin is sourced which undermines delivery of Australian packaging to packaging circular economy, and means stable demand for high quality Australian post-consumer recycled resin might not emerge • Price of producing Australian recycled content resin remains too high • Technical barriers remain. • Insufficient coordination across the supply chain may mean economic gaps in collection, sorting and reprocessing remain and interventions to address packaging users' incorrect disposal of materials in recycling streams do not materialise • Traceability of recycled resin, and accurate data reporting. • Sufficient resources and a willingness to track and enforce non-compliance with the mandate.	• Technical challenges may remain. • Traceability of recycled resin, and accurate data reporting.	• Price of producing PCR resin remains too high • Technical barriers remain • Insufficient co-ordination across the supply chain may mean economic gaps in collection, sorting and reprocessing remain and interventions to address packaging users' incorrect disposal of materials in recycling streams do not materialise • Traceability of recycled resin, and accurate data reporting. • Sufficient resources and a willingness to track and enforce non-compliance with the mandate.	• Volatility of the price of virgin resin, may make it difficult to implement an eco-modulated mechanism to bring quality and price of Australian recycled resin in line with virgin. • Technical challenges may remain. • Traceability of recycled resin, and accurate data reporting is required.

Recycled content standards and certifications for packaging

Traceability standards for packaging

Traceability standards and certifications are essential when making claims about recycled content. They ensure both the validity of the recycled content claim, and support any health, environmental, and safety requirements for the use of recycled content in new products. They are particularly important in creating a level playing field for claims in a competitive global supply chain and high-quality auditing processes are agreed by industry to be essential. Traceability is generally demonstrated through chain of custody models.

Consensus 6: There is consensus among industry that traceability standards and certifications are essential for making recycled content claims in a global supply chain.

Pre- and post- consumer recycled material to accelerate material circularity

The 2025 National Packaging Targets specifically aim to increase the use of post-consumer recycled material in packaging. This is paramount to support the development of markets for recovered packaging material, and to address leakage of packaging waste into the environment.

However, industry also highlights the important role of pre-consumer recycled content in packaging and the opportunities to improve waste along the value chain by supporting this material as an input. Industry also acknowledges the technical challenges associated with the use of post-consumer recycled content in contact-sensitive packaging.

Therefore, Industry consensus is supportive of organisations using recycled content from both pre- and post-consumer sources as part of a transition towards post-consumer recycled content, provided any associated claims clearly differentiate what type of recycled content is used.

Consensus 7: Pre- and post- consumer content both have value in pursuing material circularity and should continue to be tracked and reported.

Importantly, for recycled content targets to drive the market towards circularity, all claims made on packaging need to be aligned with AS/ISO 14021. At a minimum, these claims need to be:

- clear in the scope of the claim
- truthful and accurate
- substantiated with evidence
- provide enough information to allow for reasonable comparison by the end user
- specific about the environmental aspects within the scope of the claim
- explicit with an explanatory statement
- consider the relevant life cycle stages and load shifting to other life stages

Organisations setting recycled content targets and making associated claims must provide a distinction between pre-consumer and post-consumer material. This is supported by AS/ISO14021 and the green claims guidance issued by the Australian Competition and Consumer Commission (ACCC). When making claims about recycled content in packaging, it is important that statements are compliant with regulations under Australian Consumer Law.

Claims can be self-declared, verified by an external party, or certified through an approved accreditation body for a particular scheme such as International Sustainability and Cabon Certification (ISCC+) or Forrest Stewardship Council (FSC).

Additionally, Industry indicated that verification options need to be available to small businesses that are credible and cost-effective, and that independent auditing is preferred, and essential for certification.
Appropriate certifications are explored in Appendix I Certifications mapping.

Chain of custody models and mass balance approaches

Chain of custody models must be consistent with the framework outlined by ISO22095:2020 and the National Framework for Recycled Content Traceability (National Framework). Traceability of recycled material must start at material processing and have separate recording for pre-consumer and post-consumer material.

Industry supports the position of the National Framework which allows the following chain of custody approaches:

- Identity preservation,
- Segregation,
- Controlled blending, and
- Mass balance.

Industry also acknowledges the need for mixed approaches to allow for flexibility within the market to drive uptake. In addition, the process for verifying and certifying the claims made through these processes is essential to market development and confidence along the value chain.

Consensus 8: There is consensus among industry in support of the chain of custody approaches outlined in the National Framework and there is support for mixed approaches for flexibility in the market.

Mass balance chain of custody approaches can be applied for recycled material derived from both mechanical and chemical recycling.

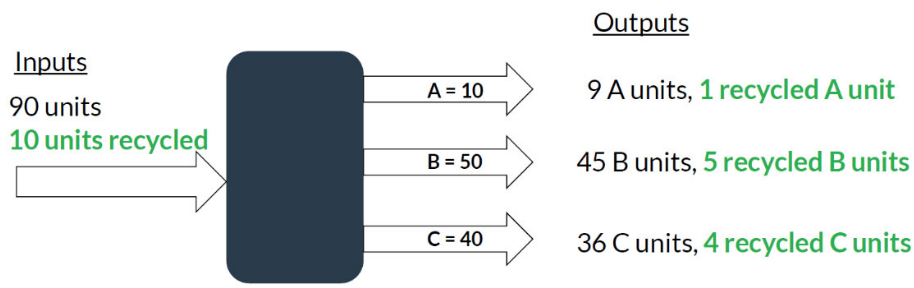
Four mass balance allocation methods may be used by industry to calculate and substantiate recycled content claims in packaging, as outlined in the National Framework.

Proportional Allocation

Using this method, recycled content claims are made in the same proportion as product outputs. For example, if 100 units of material are input into the reprocessing system, made up of 90 units from virgin sources and 10 from recycled sources, and three products are created, the recycled content units are allocated according to the proportion of the output accounted for by these three products. That is, if Product A is 10% of the total output, Product B is 50% of the total output, and Product C is 40% of the total output, the recycled content units allocated to each output are calculated as follows:

- Product A = 10% * 10 recycled input units = 1 Recycled Unit allocated to Product A
- Product B = 50% * 10 recycled input units = 5 Recycled Units allocated to Product B
- Product C = 40% * 10 recycled input units = 4 Recycled Units allocated to Product C

Figure 8 Proportional Allocation (GreenBlue, 2021)



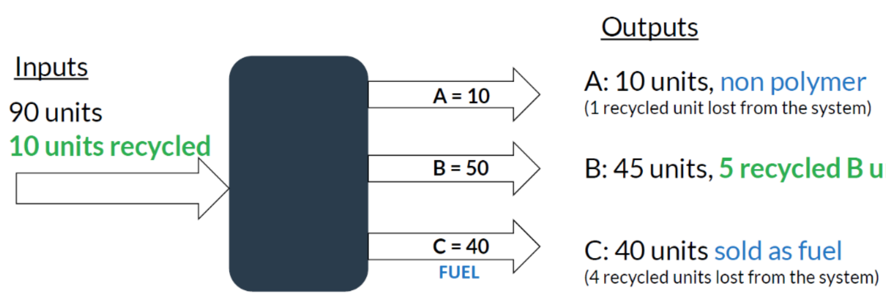
Polymer Only

Using this method, recycled content claims can only be made on products that are converted to polymers. For example, three products are produced by a facility, a non-polymer output (10%), fuel (40%), and a polymer (50%). 10% of the inputs are recycled material, the other 90% is virgin material. The only output that may carry a recycled content claim is the polymer, with the recycled content proportion calculated as:

- Product B: 50% * 10 recycled content input units = 5 Recycled Units allocated to Product B.

All other recycled content is lost from the system.

Figure 9 Polymer only. (GreenBlue, 2021)



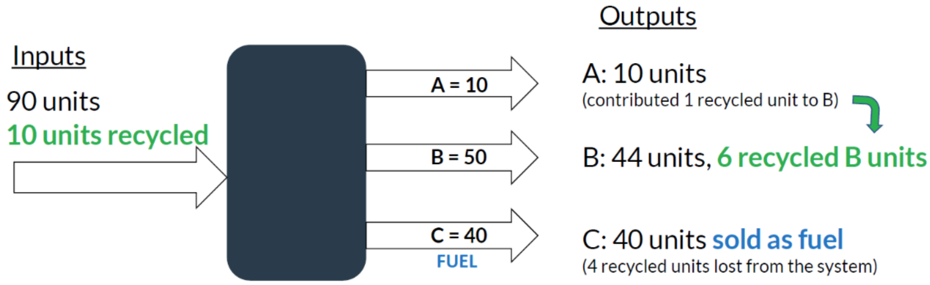
Fuel Exempt

Using this method, recycled content claims can apply to any co-product, excluding fuel. Any portion of recycled content that is sold or consumed as fuel cannot be allocated. For example, three products are produced by a facility, a non-polymer output (10%), fuel (40%), and a polymer (50%). 10% of the inputs are recycled material, the other 90% is virgin material. The reprocessor only wants to claim recycled content on the polymer output, Product B. This is calculated as follows:

- Product B: (50% * 10 recycled content input units) + (10% * 10 recycled content input units allocated from Product A) = 6 Recycled Units allocated to Product B.

The 4 Recycled Units that would otherwise be allocated to fuel are lost from the system and cannot be reallocated.

Figure 10 Fuel exempt. (GreenBlue, 2021)

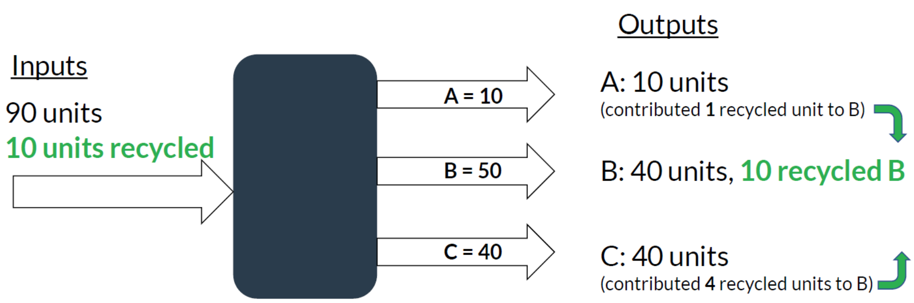


Free Allocation

Using this method, any output generated through the recycling process can be allocated recycled content. For example, three products are produced by a facility, a non-polymer output (10%), fuel (40%), and a polymer (50%). 10% of the inputs are recycled material, the other 90% is virgin material. The reprocessor only wants to claim recycled content on the polymer output, Product B. This is calculated as follows:

- Product B: (50% * 10 recycled content input units) + (10% * 10 recycled content input units allocated from Product A) + (40% * 10 recycled content input units allocated from Product C) = 10 Recycled Units allocated to Product B.

Figure 11 Free Allocation (GreenBlue, 2021)



As previously discussed, the Australian market is still in the early stages of developing reprocessing capacity, for chemical recycling, and there is a need to support investment in this industry to capture material that cannot be recycled economically or efficiently through mechanical recycling.

The chemical recycling industry prefers the ongoing applicability of mass balance using the free allocation method. Without it, they report an unbridgeable economic gap for chemically recycled polymers, which would effectively make food-contact recycled packaging unachievable in the foreseeable future.

However, free allocation for chemical recycling may be perceived to create an uneven playing field for the mechanical recycling sector which primarily uses methods such as segregation, identity preservation, and controlled blending, and does not produce fuels as an output of the recycling process.

There is a global movement away from free allocation towards fuel exempt. This is to support the circular economy and keep resources at their highest and best use within the economy for as long as possible. However, the infrastructure in these markets is different to the availability, scale and type of infrastructure in Australia. At the current time, it is necessary for these facilities to allow for many different forms of offtake to support a transition to a circular economy.

Consensus 9: When making claims on recycled content using the Mass Balance approach, industry is supportive of the requirements of the National Framework.

When making claims on recycled content using the Mass Balance approach, industry is supportive of the requirements of the National Framework including:

- Mass balance period is recommended to be 12 months or less.
- Mass balance accounting must be material specific and is not permitted between product groups
- Mass balance allocation can be proportional, polymer only, fuel exempt, or free.

In addition to these:

- Mass balance accounting must record pre-consumer and post-consumer input separately.
- Mass balance reporting must include information on allocation method used and recycling process (mechanical and/or chemical) involved.
- Claims made using mass balance accounting must state the recycled content percentage as “attributed”.

Analysis of available certifications and the National Framework

Verifiable recycled content is essential to the development of markets for recycled content in packaging. It is important that measures of recycled content included in progress towards the National Packaging Targets are verified and/or certified to avoid overstating the achievements made towards a circular economy for packaging. Industry considers audited certifications to be essential for ensuring a “level playing field” for evidence for domestic and internationally sourced material claims.

Barriers to verified or certified recycled content include:

- Long and global supply chains
- Lack of consistency between standards
- Length of time to achieve certification
- Confidence in certification documentation

Across the industry, there are varying degrees of engagement with verification and certification of recycled content. For organisations using certifications, these are generally obtained through independent third-party certification such as ISCC+. Some organisations may not have their own certifications but may request them of their suppliers. However, the application of these certifications differs, with some only using an organisational certificate and others requiring transaction certificates for every recycled content purchase or sale.

In evaluating certifications, independent third-party certifications should be prioritised, with the organisation providing the certification being an accredited certification body through the Joint Accreditation System of Australia and New Zealand (JASANZ) or another International Accreditation Forum (IAF) member. IAF members are responsible for auditing the auditors of certification schemes.

Consensus 10: There is consensus among industry that certification programs are independently audited.

Industry supports the position of the National Framework that interoperability of certifications is essential. This will ensure a competitive and flexible landscape, as well as one that is robust. It is noted, however, that further verification is often required to ensure the due diligence of the purchasing party has been done. This may include cross-checking the authenticity of documentation by reviewing the certification body's website or conducting site visits of suppliers as part of the supplier management process.

An analysis of available certifications, including their time and cost burden can be found at Appendix I Certifications mapping. Only RecyClass, ISCC+, and SCS Global have some level of interoperability and require pre- and post-consumer recycled content to be separated.

The current state of certification of recycled content is varied, with companies finding it difficult to rely on certification alone. There is anecdotal evidence that even within one certification scheme, recycled content proportions can be calculated differently. This is explored further under **Compliance**.

In addition, the interoperability of existing standards is limited, with most certifications requiring the entire value chain to be certified through their organisations. Some, such as RecyClass, refer also to recognised certifications indicating a level of interoperability is available. In addition to certifications which can be expensive and time-consuming, there are verification processes available, such as the GECA Claims Validation program to review recycled content claims in their alignment with the ISO14021:2016 standard and UL 2809-2 ECVP for Recycled Content Standard.[5]

Consensus 11: There is consensus among industry for interoperable certifications.

Consensus 12: There is consensus among industry for credible and cost-effective verification options to be available for small business.

Additional analysis opportunity 5: Whilst credible schemes are available and in place, there is a need for detailed comparison mapping, enhanced interoperability and ongoing oversight to ensure industry confidence.

Options for consideration

Free allocation and associated claims

Free allocation is important driving the circularity of flexible plastics for food contact packaging uses but could create a perception of inequity between chemical and mechanical production methods.

Allowing free allocation in chemical recycling to pool recycled content credits is consistently permitted across the industry, however, the potential unintended consequences of this are not fully explored. Whether free allocation is allowed in chemical recycling or both mechanical and chemical, differentiating claims between "contains recycled content" and "recycled content attributed" is imperative to ensure consumers and businesses understand how a recycled content claim has been made. All claims made by mass balance must be required to use "recycled content attributed".

[5] Note: the ISO14020 series of standards is currently under review and any verification programs and certifications aligned with this series will need to be reviewed as they are released.

Table 8 On pack claim regulation options

Option A	Option B
Do not regulate on-pack claims for recycled content	Regulate on-pack claims for recycled content to be used in the following context: • Mass balance methods required to use "Recycled Content Attributed". • Identity preservation, segregation, and controlled blending methods may use "Contains Recycled Content"

Mass balance – multiple sites

Industry proposes allowing mass balance across multiple sites within one country to support consistency for brands who purchase from one supplier with multiple manufacturing sites within one country.

There may also be validity in supporting a Trans-Tasman or Pacific approach to recycled content to support our regional neighbours who have limited reprocessing capacity, restricted available land and small local markets. This could also support the business case for investment in local reprocessing infrastructure.

All mass balance accounting outside of specific sites must demonstrate the appropriate controls are in place to validate the claims made.

Further verification of recycled content

There is an opportunity for government or an external party to provide further verification support to organisations regarding recycled content, including to clarify the different recycled content calculations within and between certifications. This is further explored in **Compliance**.

The core purpose of further verification may be to relieve the industry burden of reviewing the same suppliers or to support the interoperability of existing certifications. There may also be a role for supporting Reprocessors in the interim period where they are working through the certification process which can be lengthy and impact access to markets.

APCO is prepared to play a role in the verification process of recycled content in the packaging industry. Options for levels of verification are outlined in Table 9 below.

Table 9 Options for verification of recycled content

Option A	Option B	Option C	Option D
Develop a verification process with a desktop review and on-site visit. Likely to be conducted by an external third party.	Develop a verification process with a desktop review only.	Verification is limited to confirmation of existing certifications through desktop review. Conducted by APCO.	Recycled Content Traceability Standard finalised by APCO.
Organisations would submit evidence to substantiate their claim and would need to meet criteria set by APCO to have this accepted.	Could be conducted by APCO or an external third party. Organisations would submit evidence to substantiate their claim and would need to meet criteria set by APCO to have this accepted.		Audited by an external third party and a full traceability certification is offered.

Data governance for traceability and compliance – implementing the National Framework

Data governance ensures that recycled content claims are accurate and verifiable by establishing a robust traceability system supported by reliable data and appropriate technology solutions. Without a clear understanding of the data requirements and the deployment of effective traceability software, the implementation of recycled content targets and compliance certifications would be significantly compromised.

The role of data governance is essential in achieving the Federal Government's objectives for recycled content targets, applicable certifications, and traceability.

The Data Management Association (DAMA)[6] data governance principles provide guidance on the necessary data frameworks, standards, and interoperability data protocols to support the mentioned Federal Government's objectives, ensuring that all claims and targets are backed by credible, traceable data.

Data governance is vital for maintaining transparency, supporting regulatory compliance, and promoting sustainable practices within the packaging industry. By integrating data governance into the broader strategy for recycled content, we can monitor recycled content target performance, compliance is easily demonstrable, and the transition towards a circular economy is effectively supported.

Key finding 1: Data quality, availability and consistency are a critical challenge and opportunity for the system and a known pain point for industry. Early action and strong oversight are essential for early success and confidence.

Traceability data requirements

Key elements for traceability

Effective traceability requires four critical elements:

- **Interoperable Protocols based on global standards** (e.g. GS1): Adopting protocols based on GS1 standards to ensure consistent data communication across different systems and organisations.
- **Industry-Specific Frameworks**: Developing a packaging-specific traceability framework to identify and capture the essential data elements required across the supply chain.
- **Industry-Specific Data Standards:** Implementing uniform data standards within the packaging industry to enable consistent data management and reporting.
- **Technology Solutions:** Leveraging advanced technology to manage and analyse traceability data effectively.

These elements relate to Data Governance principles and ensure consistent, precise, and efficient data sharing and traceability across the entire supply chain and **are not covered** by the National Framework.

[6] *DMBOK - Data Management Body of Knowledge*. (n.d.). DAMA. https://www.dama.org/cpages/body-of-knowledge

Key finding 2: Key elements for recycled content traceability are not covered by the National Framework.

DCCEEW National Framework for Recycled Content Traceability (NFRCT)

There is a significant gap between the data required by certifications and the key data elements listed in the National Framework because the framework is material agnostic, therefore does not provide the granularity with respect to the data required from the packaging sector. Further implementation guidance is required, such as the GS1 Germany Circular Plastics framework. Noting that the Germany implementation guidance does not fully align with the National Framework and it was developed for Germany, which highlights the need for an industry-specific approach to packaging traceability in Australia, requiring more comprehensive data elements and stakeholder collaboration.

Additional analysis opportunity 5: There is a need to develop an industry-led implementation guidance for the packaging industry to complement the National Framework.

For the full details on the identified data gaps, please refer to the full paper on **Traceability Data Requirements**.

Global best (emerging) practices and legislation related to traceability

Global best practices and legislation, such as the United Nations Transparency Protocol (UNTP), the Packaging and Packaging Waste Regulation (PPWR) with Digital Product Passports (DPP), and the French Anti-Waste Law (Loi AGEC), emphasise the importance of standardised, interoperable protocols and data standards for effective traceability.

These initiatives aim to enhance sustainability, data accuracy, and compliance across the packaging industry and other sectors by ensuring consistent data sharing and traceability throughout the supply chain.

Where practical, Australian traceability data standards should align to international best practices. For the full details on the relationship between global best practice for traceability and the National Framework, please refer to the full paper on **Traceability Data Requirements**.

Traceability technology solutions

Technology solutions can support stakeholders to implement recycled content traceability, as they enable transparency and accuracy in tracking materials throughout the supply chain. This allows verification of recycled content claims, fostering consumer trust and regulatory compliance.

With an understanding of the Traceability Data Requirements, technical solutions to support stakeholders to implement recycled content traceability in line with the National Framework can be better understood by exploring how the required data can be collected and exchanged throughout the system.

Addressing challenges and barriers to effective data exchange

Challenges and barriers to effective packaging data exchange, include:

- Sharing data in a timely manner.
- Lack of alignment across international value chains.
- Dealing with country-specific data requirements.
- Exchanging accurate, complete, and consistent data.

Traceability technical solutions can solve these challenges when they:

- Allow unique identification.
- Capture and record data related to a product / packaging solution.
- Communicate and share data between supply chain actors.

Uptake of traceability technical solutions

The implementation of technical solutions is an added effort to business, and there are some key drivers for successful industry uptake of technical solutions, including:

- Compliance with regulations. In Australia, the proposed packaging mandate plays an integral role in adopting solutions.
- Financial benefits including automation and supply chain visibility – businesses need to demonstrate benefits (e.g. to consumers) from the new requests, or a financial incentive is desired to balance new associated costs with data requests, data storage, sharing and new technology tools.
- Growing political and social pressures around sustainability issues – greenwashing is now more than ever a common topic of discussion as it can affect consumer behaviour and allow free-riders.
- Favouring solutions that support additional business needs – with new requirements and investments, the new technical solutions should integrate with and allow improvements on other processes as part of BAU activities of business.

There are challenges to effective implementation of traceability technical solutions, including:

- Ensuring system data interoperability
- Identifying the right technologies
- Securing the required funding.

To support recycled content traceability, data and technologies must be interoperable and align with global standards and protocols.

Key finding 6: To support recycled content traceability, data and technologies must be interoperable and align with global standards and protocols.

For the full details on the relationship between global best practice for traceability and the National Framework, please refer to the full paper on **Traceability Technical Solutions Requirements**.

Traceability data requirements and traceability technology solutions

The options presented in Table 10 and Table 11 have been drawn from extensive research on global best practice for traceability data standards and technical solutions. They intend to support implementation of the National Framework in the content of packaging and are proposed in a staged way for minimal viable product (MVP) through to greater complexity. In this way, data quality and system capabilities will be enhanced over time and ensures readiness for traceability requirements.

Adoption of the options presented will result in the establishment of a comprehensive traceability system which will provide the following benefits:

- **Enhanced Compliance:** Ensures that recycled content claims are verifiable and compliant with new regulations.
- **Market Confidence**: Builds trust among consumers and stakeholders by providing transparent and reliable data on recycled content.

- **Sustainability Goals:** Supports Australia's environmental goals by promoting sustainable practices and circular economy principles.
- **Efficiency and Innovation:** Encourages technological innovation and improves operational efficiency within the packaging industry.

By implementing a robust traceability framework, Australia can lead in sustainable packaging practices, ensuring compliance, enhancing market transparency, and driving the transition towards a circular economy.

For the full details on the options provided, please refer to the full papers for **Traceability Data Requirements** and **Traceability Technical Solutions Requirements**. Each action is linked to a recommendation and/or opportunity as listed in these documents through the ID column.

Table 10 List of identified actions for NFRCT implementation based on traceability data requirements.

Timing	ID	Option	Action	Needs	Supporting resource / tool	Proposed Responsibility	Consequence if not addressed
Immediate	RD1	Use Global Standards for Better Efficiency	Organisations use global packaging-industry standards (eg GS1 and ISO).	Reduces complexity and ensures consistent production. Enhances interoperability and streamlines digital processes. Guarantees interoperability across Standards and systems.	Complement list of other relevant Standards for traceability (e.g. additional to GS1). Appendix C of the NFRCT lists relevant standards based on key data elements as part of the framework, but it does not include other standards to support the identified key data elements under Traceability Data Requirements. Examples are ISO/IEC DIS 18975 and RFC 9264.	Federal Government	Traceability and mandate compliance would be compromised
Immediate	RD3/RD4	Use Industry-Specific Data Standards / Development of a translation sheet	Organisations to utilise open packaging data standards aligned with GS1. Organisations to create a translation sheet for semantic interoperability.	Provides a consistent framework adaptable to national requirements. Enhances data accuracy and efficiency in the packaging industry. Allows members to use their own data taxonomy while meeting APCO requirements, or the requirements of any other administrator. Simplifies information exchange and improves data management.	Translation sheet	Organisations and Administrators	Data quality is compromised – organisations don't understand the ask
Immediate	OD1	Create *a* Traceability Framework for Packaging	Federal Government to develop a comprehensive traceability framework for the packaging industry, expanding from the key data requirements on the NFRCT.	Defines essential data points for supply chain transparency. Helps comply with new packaging mandates and improves recycled content tracking.	The development of an Australian equivalent of the GS1 Germany Circular Plastics Traceability guideline. Case study in the packaging industry using GS1 Standards for data sharing and defining mandatory/optional data fields outlined in this case study by Rumetshofer et al[7]. Confirmation of mandatory data to be shared with APCO in line with the packaging mandate.	Federal Government	Conflicts in sharing data with administrator

[7] Rumetshofer, T., Straka, K., & Fischer, J. (2024). How the Digital Product Passport Can Lead the Plastics Industry towards a Circular Economy—A Case Study from Bottle Caps to Frisbees. *Polymers*, *16*(10), 1420. https://doi.org/10.3390/polym16101420

Timing	ID	Option	Action	Needs	Supporting resource / tool	Proposed Responsibility	Consequence if not addressed
12-24 months	OD2	Develop Incentive Mechanisms for Data Sharing	The packaging System to establish incentives to encourage high-quality data sharing.	Supports small and medium enterprises (SMEs) with resources for data management. Demonstrates the business benefits of data sharing while protecting intellectual property. Reduces resistance and improves data quality.	Agreement on possible mechanisms and rules for implementation.	Federal Government & APCO	Data quality is compromised – suppliers see no value in sharing data
12-24 months	OD4	Align Regulations with Traceability Goals	Federal Government to integrate traceability requirements into existing regulations, including Data Governance-related policies.	Standardises digital policies and simplifies compliance. Enhances market surveillance and responds effectively to supply chain issues. Example: Collaborate with an overarching Data Strategy Australian Agency (Digital Council (ADC) or Data and Digital Federal Government Department) for digital transformation and data policies.	Traceability Framework for Packaging (OD1) can be incorporated into a packaging mandate. Example: Collaborate with the Australian Digital Council (ADC) or Data and Digital Federal Government Department for digital transformation and data policies.	Federal Government	Data quality is compromised – organisations see no value in sharing data or have conflicts in sharing data with administrator
36 + months	OD3	Promote a Voluntary Cross-Industry Data Standard	Federal Government to encourage the adoption of a common data standard across industries.	Reduces reporting burden and simplifies compliance. Ensures data consistency and suitability for multiple sectors. Reduces reporting burden and simplifies compliance to multiple administrators.	Lead by Federal Government, a working group for a cross-industry data standard development is created. The group is for streamlining data sharing cross-industries when same products are liable to multiple administrators.	Federal Government	Reporting burden

Timing	ID	Option	Action	Needs	Supporting resource / tool	Proposed Responsibility	Consequence if not addressed
36 + months	RD2	Investigate use cases within packaging industry for implementation of a global protocol with decentralized approach.	Proof of concepts - Organisations to investigate use cases and understand benefits and feasibilities in adoption of a global protocol with decentralised approach, in line with the recommendations from the United Nations Transparency Protocol (UNTP).	Addresses scalability and important data governance issues with existing traceability solutions. Facilitates cross-border and cross-industry data sharing. Supports digital product passports and conformity assessments. 80% of packaging is imported in Australia. This implementation allows data sharing at a global level (e.g. stakeholders based overseas) and across the full supply chain.	Implementation guideline (considerations, step-by-step)	Federal Government	Traceability at global level is compromised

Table 11 List of identified actions for NFRCT implementation based on traceability technical solutions.

Timing	ID	Option	Action	Needs	Supporting resource / tool	Proposed Responsibility	Consequence if not addressed
Immediate	RT2 / RT4 OT1	Enable uptake of suitable traceability technical solutions to support stakeholders implement NFRCT.	Federal Government to encourage development and adoption of various traceability technical solutions. The Packaging System to prioritise inclusivity in technical solution innovations. Federal Government to develop or delegate enabling factors that can support stakeholders to uptake suitable traceability technical solutions.	Meets the varying needs, capabilities, and readiness levels of different organisations. Supports effective uptake of suitable traceability technical solutions in line with the NFRCT. Ensures suitability of solutions for both large international entities and SMEs. Encourages accessibility of solutions to SMEs through additional funding and capacity-building. Provides certainty for stakeholders to invest in new technologies. Identifies challenges and opportunities for stakeholders using traceability technical solutions. Helps stakeholders use traceability technologies effectively for implementation of the NFRCT.	Guidance Documents – easy to use material to support engagement with industry (e.g. “first step” guides adapted to the language spoken by stakeholders). Stakeholder Surveys Training & Webinars Funding Mechanisms	Federal Government & Packaging System	Organisations are not capable of collecting, storing and/or sharing traceability-related data, compromising mandate compliance.

Timing	ID	Option	Action	Needs	Supporting resource / tool	Proposed Responsibility	Consequence if not addressed
12-24 months	RT1 OT2	Drive Data and Technical Standardisation	Organisations use relevant global and packaging industry-specific standards and follow global best practices. Federal Government to drive or delegate standardisation across recycled content traceability data and technical solutions	Ensures data can be stored and exchanged seamlessly across systems. Encourages compatibility between Australian and wider international developments. Ensures consistent data exchange and storage to different systems, across the fully supply-chain and at a global level. Encourages adoption of best practices from international initiatives.	Implementation of data and technical standards and protocols Lead by Federal Government, a data and technical standardisation group the development of standards for this area. It includes guidelines for implementation of relevant global standards; data and technology-related standards (e.g. cybersecurity).	Federal Government	Traceability and mandate compliance is compromised because of the lack of standardisation
36 + months	RT3 OT3	Develop Digital Product Passport compatible system for Australia that could enable recycled content traceability as one use case.	The Packaging System to develop an extendable and flexible DPP-compatible system for Australia that supports recycled content traceability as one use case. Federal Government to develop or delegate a DPP-compatible system for Australia that could support stakeholders implement the NFRCT	Supports multiple use cases and applications, including recycled content traceability. Aligns with global Digital Product Passport (DPP) developments to support cross-border solutions. Define a DPP-compatible system through regulation and standardisation. Implement a DPP-compatible system across the supply-chain that supports recycled content traceability.	Implementation of DPP compatible system for recycled content traceability in packaging sector. Lead by Federal Government, a DPP implementation working group. Understanding relevant findings from EU that could be applicable for AU context for traceability.	Federal Government & Packaging System	Missing opportunity to implement an existing technology and data sharing model. Reporting burden for AU companies selling into EU.

Implementation pathway proposal for consideration

Much of the required infrastructure for increased recycled content is already in place.

Manufacturers engaged through this options paper report a usage of relevant third-party certifications and a readiness to rapidly scale compliance and provide data to their customers, to help them uplift their own compliance.

Manufacturers report that they can access materials to service recycled content mandates. Where locally reprocessed recyclate feedstock is not available (e.g. food-contact LDPE and PP), industry indicates that they are already able to procure it from credible international providers (noting that an analysis of the economic implications of this were outside the scope of this paper).

As the primary liable parties under the Covenant, brand owners already have compliance reporting obligations in place and an ability to opt into SKU level data services under the ARL.

Under the Covenant, Australian brand owners and packaging manufacturers already provide recycled content usage metrics to demonstrate compliance (via APCO annual reporting). This is done on an annual retrospective basis, specifying the level of recycled content overall and per material stream by tonnage. Brand owners are also asked to provide suitable evidence for their claims.

With this information already available, basic compliance and claims management for recycled content by material type at an annual tonnage level is already enabled. APCO continues to support members to uplift the quality and accuracy of that data, and to emphasise the need for evidentiary support for claims and support for third party certification of those claims.

Under the ARL program, operated by APCO, over 500,000 products already report the recyclability of their packaging at a product composition or SKU level.

Some infrastructure and capability will need to be built for brand owners to be regulation ready.

Despite the NPTs having been in place since 2018, there remains a very variable level of packaging data management maturity across the sector (in comparison to other sustainability reporting indicators). Uplifting requirements would be cost and time imposition on brand owners, requiring them to work on material traceability in their supply chains to access data and perform their own pre-submission due diligence. Early investment in shared data standards and infrastructure would reduce the burden on individual reporting entities, increase the speed and quality of their participation, accelerate action, and enable higher quality insights.

Managing mandatory recycled content claims (and other sustainable design requirements) within the ARL and/or a brand owners individual in-house product-level management system is likely to require additional training and investment, which is estimated to take an additional 12-18 months. Exact time and cost for implementation is dependent on complexity of requirements and how quickly requirements are yet to be defined.

Audit and compliance regimes and brand owner support would likely need to be increased to assure data quality, especially in the early years as industry transitions and builds its data capability and competence.

Data captured through the Recycled Content Targets Survey, indicates that brand owners and manufacturers felt they would be able to establish their full organisational capacity to confidently demonstrate compliance across a product portfolio with short-term material targets within four years.

Table 12 Analysis of survey respondents of years to achieve short term recycled content targets.

Material	Contact Sensitivity	1 year	2 years	3 years	4 years	5 years	6 years
Aluminum	Contact						
Aluminum - Non-beverage	Non-contact						
Boxboard/Cartonboard	Non-contact						
Corrugated cardboard	Non-contact						
Flexible HDPE	Contact						
Flexible HDPE	Non-contact						
Flexible LDPE	Contact						
Flexible LDPE	Non-contact						
Flexible PP	Contact						
Flexible PP	Non-contact						
Glass Amber	Contact						
Glass Flint	Contact						
Glass Green	Contact						
High wet strength carrier board	Non-contact						
Kraft paper	Non-contact						
Moulded fibreboard	Non-contact						
Polymer coated paperboard/ pa	Non-contact						
Rigid HDPE	Contact						
Rigid HDPE	Non-contact						
Rigid LDPE	Contact						
Rigid LDPE	Non-contact						
Rigid PET	Contact						
Rigid PET	Non-contact						
Rigid PP	Contact						
Rigid PP	Non-contact						
Steel - Mild steel	Contact						
Steel - Mild steel	Non-contact						
Steel - Stainless steel	Contact						
Steel - Stainless steel	Non-contact						
Steel - Tin-plate steel	Contact						
Steel - Tin-plate steel	Non-contact						

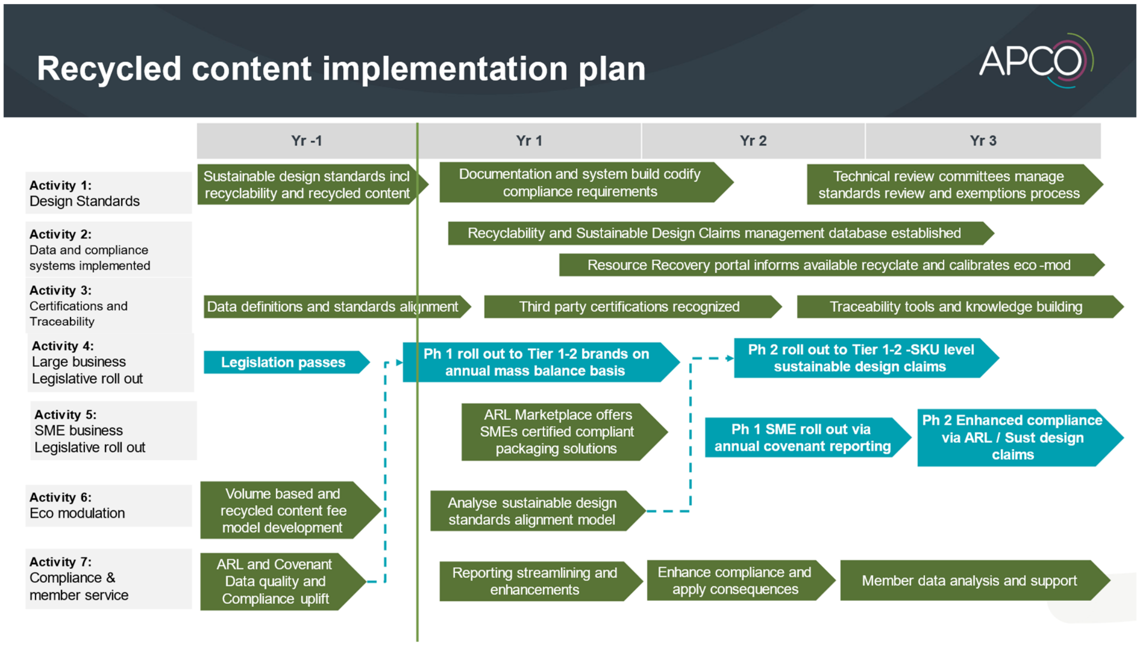
0-25th percentile	
25th-50th percentile	
50th-75th percentile	
75th-100th percentile	

Given the data capability uplift for industry would be needed to access supply chain data, it is assumed that small and medium sized enterprises (SMEs) may require additional time and support, and / or a simplified mechanism to comply. A delayed roll out would enable them to leverage the work of larger organisations in validating supply chain claims. Further opportunities to support SMEs in this context is discussed under Areas requiring further investigation.

Consensus 13: Considering existing requirements, recycled material availability, current data maturity, existing reporting frameworks and industry skill sets, it is assumed that recycled content claims management could be available immediately, with sophistication increasing over time. However, industry considers it important to give more time for full enforcement to allow members to work on their internal processes to ensure meaningful compliance at packaging product level.

Given the requirements stated above; to increase regulation-grade data and evidence availability; to move over time from annual corporate level tonnage-based claims to SKU level sustainable design packaging claims (as would be required by ACCC for any on-pack claims); to provide additional capability building and support to SMEs, a possible roll out implementation plan is suggested below.

Figure 12 Possible phased roll-out of compliance requirements.



Areas requiring further investigation

Trade legalities

This options paper has focused heavily on domestic reprocessing capability, whilst acknowledging that members operate in global supply chains. It is understood that there are complexities in requiring domestic content in a target.

Eco-modulation may have a role in supporting domestic recycled content. The options proposed in this paper do not attempt to distinguish between local and imported recycled content for the purposes of levying fees. Taking this model a step further by establishing a price signal favouring local over imported need to be carefully considered to ensure compliance with requirements of the World Trade Organisation. Concurrently, Industry notes exceptions to free trade regulations are possible where they relate to environmental impact management and anticipates that the use of service fees to support collection and recycling of waste would be recognised as an environmental measure rather than a trade measure.

Industry also notes the approach the EU[8] has taken to this is to limit the import of products that do not meet its specifications and design standards. Implementing similar requirements for all importers of recycled resin to meet the environmental and labour standards of Australia may support the local packaging and recycling industry to compete, while simplifying the legalities associated with free trade.

Recognition of international supply chains and the relationship with export regulation

Australia imports most of its finished packaging and some recycled packaging manufacturing feedstock (Primepac, 2020). Significant investment has been made in domestic reprocessing over the past few years by Federal and State governments, however reprocessor capacity projections over the coming 10

[8] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste

years indicate that growing markets for recycled packaging materials and balancing supply and demand will remain a key challenge.

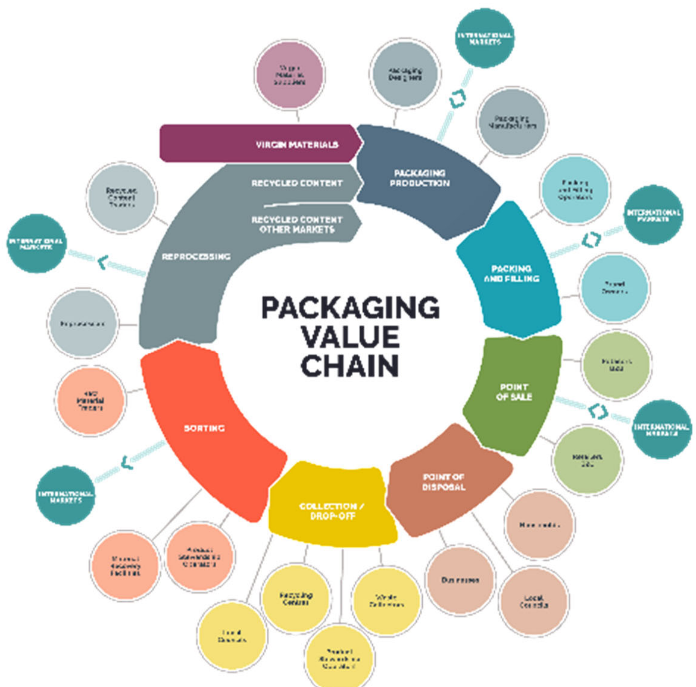
Any policy position should support Australian recyclers to secure markets for their products so that they can in turn grow domestic capacity and investment. To the best extent possible, this should promote the trade of recycled materials at highest and best value, including in international markets, in line with ACOR's 'Recyclers in Product Stewardship' (ACOR, 2024) issues paper'.

Recycled materials and partially processed goods are available from international markets, if traceability criteria can be applied and met, and will be required in the short term to meet the domestic ambition of maximising recycled content at least cost.

Even with best endeavours, supply and demand of recyclate is likely to be bumpy in the next decade with time-based surpluses and short falls to be managed for the economic benefit of all parties in the value chain.

Many brand owners are part of global companies with complex international supply chains to procure and produce their sustainable packaging and operate existing contracts in multiple countries offering scale.   This means that some materials may be partially reprocessed onshore and then move offshore before being reimported as recycled commodities or finished goods.

Figure 13 Packaging value chain depicting interactions with global supply chains for feedstock and finished goods.



This is already evident in the examples of imported oil for domestic film manufacture, paper bales exported to be re-made into bags and reimported or PET, exported as pellets and reimported as bottles and trays.

Widespread uptake of traceability frameworks and digital product passports will provide more confidence on this chain of custody and should enable a more fluid and nuanced approach to import and export management, that still meets the spirit of waste and recyclate definitions under the RAWR Act 2020.

The RAWR Act requires regulated 'waste' materials (at this stage, recyclable glass, tyres, plastic and paper) to meet requirements as outlined in specific rules, in order to be 'licensed' for export. For example, recovered plastic must be 'processed'; that is "sorted, washed, cleaned and transformed, for example, into hot washed flakes", in order to be exported. The lengthy and expensive licensing process, with fees exceeding $19,000 for initial applications and $13,000 for variations, coupled with a wait time that can stretch from eight weeks to six months, effectively hinders access to export markets for processed recycled commodities, and stymies investment in domestic capacity growth.

Plastic pellets have very recently been clarified as no longer being regarded as a "regulated waste material under the RAWR Act, but sorted, washed and flaked plastic remains a regulated material.

Policy design should consider how to maximise the flow of industrial feedstocks and minimise encumbrance of export regulation and licensing where product is of demonstratable quality and there is evidence of customer demand.

These asymmetries and encumbrances on the flow of recycled content feedstocks further reduced markets incentives to establish reprocessing in Australia and increase the price of procuring recyclate for brand owners.

They also have a direct impact on working with our Pacific Island nation partners who are unable to build scaled reprocessing on their own shores and need to work with Australia on regional solutions to manage this plastic packaging waste.

Compliance

Material availability

Where material is unavailable to meet the requirement for domestic recycled content, certification of recycled content and verification of suppliers becomes more important.

In addition, there is a need to determine what would constitute a lack of availability and whether this includes commercial considerations. For example, if domestic recycled content is more than 10x more expensive than virgin material, this could be considered as unavailable.

To appropriately enforce compliance on domestic recycled content, more information is required regularly from industry, including:

- Virgin commodity prices (local and international)
- Recycled content commodity prices (local and international)
- Reprocessing capacity
- MRF throughput and output
- Output markets split by local and international but not individual buyers.

Material accessibility

The proposed implementation approach assume that policy will roll out to larger market actors in the first wave and then be extended to smaller market actors because those with market power have already obtained certifications and verifications; and established supply/procurement agreements within the packaging supply chain.

A possible risk of this is that larger market actors secure a first mover advantage in sweeping up available recycled material via long term offtake agreements, leaving insufficient supply for smaller operators.

However, insights from stakeholders suggest that manufacturers with market scale who operate in the wholesale markets will secure long term offtakes themselves and that this material will be made available to smaller brand owners via finished goods.

This needs to be tested further in detailed policy design.

An opportunity may exist where finished wholesale packaging goods that have passed appropriate certifications and standards could be made available via the ARL Marketplace, providing a trusted source of packaging with high quality recycled content and design standard claims verification.

Material offtake

It has been assumed that the scope and context of this options paper is a consideration of possible mandated recycled content targets for packaging products. Should the policy scope be extended to consider material circularity for packaging-materials-derived recyclate consumed by the packaging sector, there may be scope to include requirements for non-packaging recyclate offtake by brand owners.

For example, much mechanically reprocessed post-consumer flexible plastics will struggle to meet the required standards to return to consumer packaging. However, brand owners may procure recycled PE content for other use cases including back of house systems, trolleys, asphalt, furniture etc. Industry believes that inclusion of a broader set of procurement requirements could support the mechanical processing sector and realise broader economy wide circularity benefits whilst enhancing a product stewardship mindset.

Different recycled content calculations

Some anecdotal information suggests that even with the same certification, recycled content calculations can differ, resulting in different claims on-pack. To provide adequate verification on recycled content claims, a greater understanding is needed of:

- the ways in which recycled content is calculated between and within certifications, and
- how these calculations apply or vary between suppliers and countries.

This would inform acceptable thresholds for variance in the verification process.

Comparative impact of product cost based on value

Economic analysis has not been undertaken as part of this options paper.

Pre- and post consumer recycled content in glass

While most recommendations and guidelines state pre- and post-consumer material should be measured and traced separately, local glass Reprocessors have raised that they are not able to separate these for the purposes of the National Packaging Targets or claims on packaging. This will require further investigation before permitting an exemption for glass, particularly as other manufacturers advertise post-consumer recycled content in glass and the European Container Glass Federation has published a position paper on calculating total recycled content and post-consumer recycled content[9].

[9] FEVE European Container Glass Federation (2020), https://feve.org/wp-content/uploads/2020/10/FEVE-paper-on-recycled-content-and-PCR-October-2020.pdf

Technical considerations

Recycled material in packaging applications

Currently, the potential for recycled material in packaging applications as discussed under Considerations of material technical maximum, is currently unknown or ill-defined. This presents an opportunity for policymakers and technical committees to explore, document, and publish guidance on the total substitution potential of recycled materials in packaging applications.

Systems and infrastructure - Mechanical and advanced recycling

If it is accepted that free allocation is given to chemical processing, to enable material circularity for contact use cases, then chemically reprocessed materials may obtain a market advantage over mechanical. Further research is required to test the likeliness of this possibility to eventuate. If it is determined that chemical is advantaged by claims made under free allocation, there may be a need for additional pricing interventions to encourage continued investment in mechanical reprocessing. If LCAs support a lower environmental impact of mechanical reprocessing, government could support a mechanical first approach with variable eco-modulation setting and tools. A project would need to be initiated to establish a checklist and/or decision tree.

This could be managed by business rules within an eco-modulation fee calculation engine, for example:

“**when** domestic reprocessing capacity = >x **and** standards exist for use case y (e.g. food contact mechanically processed milk bottle) **then** material with evidence to demonstrate it was mechanically reprocessed (via APCO reporting looking up a valid ISCC+ certificate) gets a better eco-modulation fee than the same product with chemically recycled polymer per ISCC+”

In addition, there may be the opportunity to specify the post-consumer material that can be processed through chemical recycling to further strengthen a mechanical first approach and ensure chemical recycling addresses problematic materials that would not otherwise be able to be recycled.

Material quality over time

This discussion focuses on plastic packaging because its complex material structure poses numerous technical challenges and is widely used across various industries. Similar challenges apply to other packaging materials, and the principles discussed here can be applied to them as well.

The functionality of plastic packaging relies on its mechanical properties and processability. Plastic packaging complexity stems from its extensive use of additives, fillers, pigments, and modifiers tailored for specific applications. Even within the same polymer type such as polyethylene, variations in molecular weight distribution are precisely adjusted for different uses.

The functionality of materials is based on its mechanical properties, which are used to describe the technical functions of materials such as stiffness, strength and hardness and its ability to be processed. The values and importance of these properties varies depending on the material application. For example, HDPE films would have low importance or value for stiffness whereas HDPE crate requires a high value.

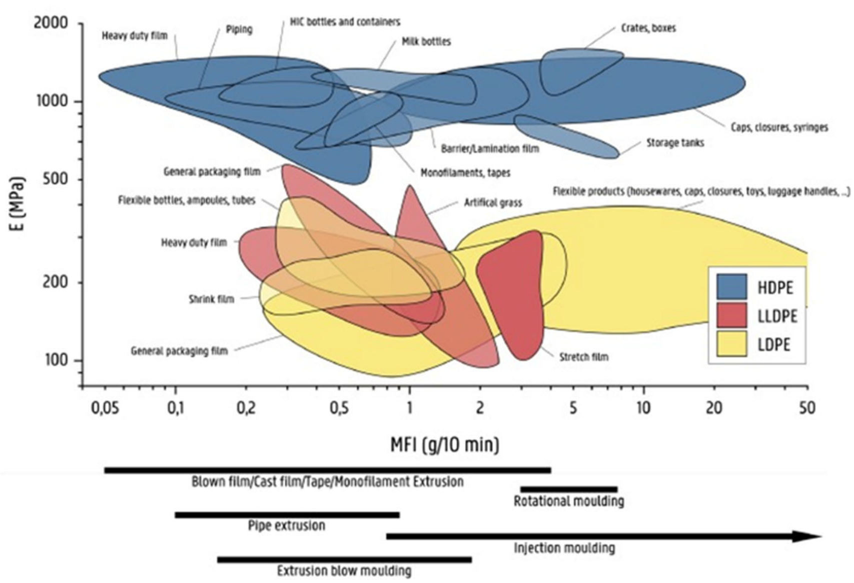
Polymers are often categorised on “grade” based on their Melt Flow Index (MFI) or Intrinsic Viscosity (IV), a measure of melted polymers ability to flow. Inversely related to molecular weight, different grades of polymers can vary depending on additives and fillers. The highly diverse specifications within packaging materials can be highlighted by Avient's (formerly PolyOne) product portfolio which comprising over 4,000 resin grades of specialty polymer formulations.

Academic research shows that mechanical recycling causes molecular changes and increased MFI in polyolefin materials due to chain scissions from repeated melt extrusions, leading to significant differences in the processing performance of recycled resins. Essentially, mechanical recycling alters polymer structure and properties, affecting their suitability as direct substitutes for virgin materials.

Furthermore, the transfer of compounds among various plastics during their lifespan adds complexity, altering the characteristics of recycled plastics. Academic studies emphasise the hurdles of mechanical recycling, investigating methods such as restabilisation and co-polymer usage to improve polymer resilience to contaminants. Nevertheless, the lack of comprehensive understanding regarding the technical standards of recycled plastics presents obstacles for polymer processors and end market opportunities, limiting their ability to replace virgin materials.

Additional research and product testing is needed to understand the multiplying effect of reprocessing recycled material. The finding of this will continue to inform our understanding of a technical maximum for recycled content.

Figure 14 Mapping of the elastic modulus and MFI for commercially available PE grades for a selection of typical applications (Demets et al., 2021).



Environmental and human health impact

Based on the literature review, comparisons between virgin and recycled materials have been widely studied, primarily focusing on emission reduction during the production of primary materials. However, comprehensive studies on individual recycling processes and their impacts on worker health, safety, and pollution leakage are often lacking. Detailed assessments of the recycling and reprocessing of each material type are essential to mitigate pollution.

A holistic approach is needed, integrating best practices for each material type's recycling process and identifying hotspots through Life-Cycle Assessment (LCA) to achieve a complete understanding of overall sustainability. Further insight of the recycling process can lead to better environmental and human health outcomes. For instance, Groh et al. (2019) identified hundreds of chemicals in plastic packaging, with about 147 being classified as hazardous, yet their full impact on the environment and human health remains to be fully assessed. This is the same for fibre-based packaging. For more information on this please refer to the Appendix A Material summary – plastic packaging in Australia and Appendix B Material summary – paper & paperboard packaging in Australia.

Additionally, evaluating worker health and safety during the collection and sorting of recyclable materials and assessing the environmental impact and toxicity of recycled materials throughout their life cycle are crucial steps in understanding the broader implications of recycling.

Traceability - ethical sourcing of input material

Recognising that Australia operates in a global supply chain means it is necessary for consider the ethical sourcing of secondary or recycled materials for plastic packaging including the socio-economic implications for waste pickers and their communities. Waste pickers play a crucial role in the recycling process and organisations should be considering, through their Modern Slavery Act obligations, the living and working conditions of these individuals. Research could examine how integrating waste pickers into formal recycling systems impacts their livelihoods, aiming to enhance social inclusion and economic empowerment. Understanding the socio-economic benefits of ethical sourcing, such as job creation and community development, can help in forming policies that support sustainable and fair practices. Emphasizing fair trade principles in the recycled materials market can support waste pickers to receive fair recompense and will contribute to a more equitable and sustainable recycling industry.

Appendices

Appendix A Material summary – plastic packaging in Australia

Material placed on market[10]

Plastic packaging POM in Australia in 2021–22 is estimated at 1.28 million tonnes (±17%), which was 18.3% of all packaging POM. Plastic packaging POM in Australia continues to grow, with total plastic packaging POM growing by 8% between 2020-21 and 2021-22.

Plastic packaging consumption is dominated by high-density polyethylene (HDPE) (26.0%), low-density polyethylene (LDPE) (25.7%), polypropylene (PP) (19.8%) and polyethylene terephthalate (PET) (14.0%). Around 77% of plastic packaging was used in the B2C sector, with another 23% used in the B2B sector (mainly LDPE films and HPDE or PP in rigid packaging applications).

A breakdown of the five year historical POM tonnages for plastic packaging has been provided in the table below.

Table 13 Plastic packaging POM from 2017-18 to 2021-22, by material type[11]

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
PET (1)	132,000	154,000	163,000	149,000	179,000
HDPE (2)	351,000	316,000	275,000	287,000	332,000
PVC (3)	20,000	15,000	17,000	15,000	11,000
LDPE (4)	254,000	233,000	276,000	331,000	328,000
PP (5)	164,000	155,000	218,000	215,000	253,000
PS (6)	11,000	11,000	17,000	17,000	17,000
EPS (6)	22,000	16,000	23,000	29,000	30,000
Bioplastic (7)	1,000	6,000	9,000	4,000	2,000
Other (7)	111,000	16,000	20,000	21,000	17,000
Unidentified	Not reported	78,000	107,000	111,000	109,000
Total	**1,067,000**	**1,000,000**	**1,124,000**	**1,179,000**	**1,277,000**

Of the 1.28 million tonnes of plastic packaging POM in 2021–22 an estimated 627,000 tonnes (49.1%) were identified as rigid plastic packaging, and 528,000 tonnes (41.4%) as flexible plastics. The format of the other 122,000 tonnes (9.5%) could not be identified in sufficient detail to classify this material as either rigid or flexible.

Most flexible ackaging was made from LDPE (58%), followed by HDPE (15%) and PP (13%).

Most rigid packaging was made from HDPE (35%), followed by PET (26%) and PP (23%).

[10] APCO, Australian Packaging Consumption and Recovery Data 2021-22
[11] Ibid

Table 14 Plastic packaging POM in 2021–22, by material type and rigid/flexible classification.

Material type	Rigid (tonnes)	Flexible (tonnes)	Unknown (tonnes)	Total (tonnes)
PET (1) – Natural	136,000	3,000	5,000	145,000
PET (1) – Transparent	26,000	0	0	26,000
PET (1) – Opaque	3,000	6,000	0	8,000
HDPE (2) – Natural	168,000	13,000	22,000	203,000
HDPE (2) – Coloured	52,000	64,000	12,000	129,000
PVC (3)	3,000	8,000	1,000	11,000
LDPE (4)	9,000	307,000	11,000	328,000
PP (5) – Natural	56,000	54,000	8,000	118,000
PP (5) – Coloured	89,000	14,000	32,000	135,000
PS (6)	16,000	0	1,000	17,000
EPS (6)	30,000	0	0	30,000
Bioplastic (7)	2,000	0	0	2,000
Other (7)	1,000	17,000	0	17,000
Unidentified	37,000	42,000	29,000	109,000
Total (tonnes)	**627,000**	**528,000**	**122,000**	**1,277,000**
Total (%)	**49.1%**	**41.4%**	**9.5%**	**100.0%**

Plastic packaging is projected to grow at a five-year compound annual growth rate (CAGR) of 2.5% per year. A breakdown of the projected POM tonnages for plastic packaging has been provided in the table below.

Table 15 Plastic packaging POM from 2021–22 to 2026–27, by material type[12]

Material Type	2021-22 Tonnes	2022-23 Tonnes	2023-24 Tonnes	2024-25 Tonnes	2025-26 Tonnes	2026-27 Tonnes	CAGR %
PET (1)	179,000	183,000	188,000	192,000	197,000	202,000	2.4%
HDPE (2)	332,000	338,000	345,000	351,000	358,000	365,000	1.9%
PVC (3)	11,000	9,000	8,000	7,000	6,000	5,000	-14.1%
LDPE (4)	328,000	341,000	354,000	368,000	383,000	398,000	3.9%
PP (5)	253,000	259,000	265,000	271,000	277,000	283,000	2.3%
PS (6)	17,000	16,000	16,000	15,000	15,000	14,000	-3.1%
EPS (6)	30,000	30,000	31,000	31,000	32,000	32,000	1.7%
Bioplastic (7)	2,000	2,000	3,000	3,000	3,000	4,000	14.5%
Other (7)	17,000	18,000	18,000	19,000	19,000	20,000	2.5%
Unidentified	109,000	111,000	114,000	117,000	120,000	123,000	2.5%
Total	**1,277,000**	**1,308,000**	**1,340,000**	**1,374,000**	**1,409,000**	**1,446,000**	**2.5%**

Recovery[13]

Post-consumer plastic packaging recovery in Australia in 2021–22 is estimated at 258,000 tonnes (±10%), or 6.6% of all post-consumer packaging recovery. Approximately 146,000 tonnes (56.7%) of plastic packaging were recovered through Municipal Solid Waste (MSW) collections, with another

[12] Ibid
[13] APCO, Australian Packaging Consumption and Recovery Data 2021-22

78,000 tonnes (30.0%) recovered through Commercial and Industrial (C&I) collections and 32,000 tonnes (12.4%) recovered through separate Container Deposit Scheme (CDS) related collections

Table 16 Plastic packaging recovery from 2017–18 to 2021–22, by material type.

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
PET (1)	57,000	55,000	55,000	58,000	90,000
HDPE (2)	66,000	73,000	60,000	66,000	71,000
PVC (3)	1,000	1,000	2,000	0	0
LDPE (4)	28,000	22,000	15,000	32,000	60,000
PP (5)	12,000	21,000	20,000	30,000	19,000
PS (6)	2,000	3,000	4,000	2,000	1,000
EPS (6)	4,000	4,000	4,000	9,000	5,000
Bioplastic (7)	0	0	0	0	0
Other (7)	1,000	0	1,000	0	4,000
Unidentified	Not reported	3,000	17,000	10,000	7,000
Total	**173,000**	**182,000**	**179,000**	**207,000**	**258,000**

Of the 258,000 tonnes of plastic packaging recovered in 2021–22 around 196,000 tonnes (76%) was rigid, and 62,000 tonnes (24%) was flexible. Recovery of flexible plastic packaging is predominantly LDPE film recovery from B2B applications.

Table 17 Plastic packaging recovery in 2021–22, by material type and rigid/flexible classification.

Material type	Rigid (tonnes)	Flexible (tonnes)	Total (tonnes)
PET (1) – Natural	83,000	0	83,000
PET (1) – Transparent	6,000	0	6,000
PET (1) – Opaque	0	0	1,000
HDPE (2) – Natural	47,000	0	47,000
HDPE (2) – Coloured	24,000	0	24,000
PVC (3)	0	0	0
LDPE (4)	1,000	59,000	60,000
PP (5) – Natural	8,000	0	8,000
PP (5) – Coloured	9,000	2,000	11,000
PS (6)	1,000	0	1,000
EPS (6)	5,000	0	5,000
Bioplastic (7)	0	0	0
Other (7)	4,000	0	4,000
Unidentified	7,000	0	7,000
Total (tonnes)	**196,000**	**62,000**	**258,000**
Total (%)	**75.9%**	**24.1%**	**100.0%**

Plastic packaging recovery in 2021–22 by material use destination are provided in Error! Reference source not found. and Error! Reference source not found.. The destination of recovered plastic packaging was split relatively evenly across local (46%) and overseas applications (54%).

Table 18 Plastic packaging recovery in 2021–22, by material type and destination of material.

Material type	Local	Overseas	Unknown destinations	Total
	(tonnes)	(tonnes)	(tonnes)	(tonnes)
PET (1) – Natural	38,000	46,000	0	83,000
PET (1) – Transparent	5,000	0	0	6,000
PET (1) – Opaque	1,000	0	0	1,000
HDPE (2) – Natural	21,000	26,000	0	47,000
HDPE (2) – Coloured	18,000	7,000	0	24,000
PVC (3)	0	0	0	0
LDPE (4)	13,000	47,000	0	60,000
PP (5) – Natural	5,000	3,000	0	8,000
PP (5) – Coloured	10,000	1,000	0	11,000
PS (6)	0	1,000	0	1,000
EPS (6)	1,000	4,000	0	5,000
Bioplastic (7)	0	0	0	0
Other (7)	4,000	0	0	4,000
Unidentified	4,000	4,000	0	7,000
Total (tonnes)	**119,000**	**139,000**	**0**	**258,000**
Total (%)	**46.1%**	**53.9%**	**0.0%**	**100.0%**

The use of recovered plastic packaging is dependent in large part on the packaging source application and polymer type. Many of the typical applications are summarised in Table 19.

Table 19 Typical uses of recycled plastics in Australia.

Polymer	Major uses of recycled polymer	Minor uses of recycled polymer
PET	Beverage bottles.	Timber substitutes, geo-textiles, other textiles, felted panels, pallets and fence posts.
HDPE	Milk bottles, films, pallets, wheelie bins, irrigation hose and pipes.	Cable covers, extruded sheet, moulded products, shopping and garbage bags, slip sheets, drip sheets for water, wood substitutes and mixed plastics products (e.g. fence posts, bollards, kerbing, marine structures and outdoor furniture), materials handling and roto-moulded water tanks.
PVC	Industrial and garden hose, profiles, pipes and conduit.	Gumboots, mats, resilient flooring, mudflaps and coving (decorative building mouldings).
LDPE / LLDPE	Film (including builders' and agricultural film, concrete lining, freight packaging, garbage bags, shopping bags), agricultural piping.	Binder additive to asphalt, trickle products, vineyard cover, pallets, shrink wrap, roto-moulding, slip sheets, irrigation tube, timber substitutes, cable covers, builders' film, garbage bags, carry bags, and other building industry applications.
PP	Crates, boxes and plant pots.	Electrical cable covers, building panels and concrete reinforcement stools (bar chairs and shims), furniture, irrigation fittings, agricultural and garden pipe, drainage products (such as drain gates) and tanks, builders' film, kerbing, bollards, concrete reinforcing and a wide variety of injection moulded products.
PS	Bar chairs and industrial spools.	Office accessories, coat hangers, glasses, building components, industrial packing trays, wire spools and a range of extrusion products.
EPS	Waffle pods for under slab construction of buildings.	Synthetic timber applications (including photo frames, decorative architraves, fence posts), XPS (extruded polystyrene) insulation sheeting, and lightweight concrete.

Manufacturing and reprocessing

Manufacturing process

The production of virgin polymers starts with the extraction of fossil feedstocks like coal, crude oil, and natural gas turning them into high purity polymers through a chemical process. Most plastics are fabricated through the treatment of petrochemicals into monomers - most popularly ethane gas or naphtha which are by-products of the petroleum industry (Hamilton et al., 2019). Plastics can also be made from cellulose, coal, natural gas, and most long chain hydrocarbons.

The process of manufacturing plastics from virgin materials involves several key steps, each of which plays a critical role in transforming raw materials into finished plastic products.

Virgin plastic manufacturing generally involves the following steps[14]:

1. Raw Material Extraction
    - **Feedstocks**: The primary raw materials for producing plastics are derived from petroleum and natural gas, which provide the hydrocarbons necessary for plastic production.
    - **Extraction**: These feedstocks are extracted from the earth through drilling and mining processes.
2. Crude Oil Refining and Natural Gas Processing

[14] https://www.plasticcollectors.com/blog/how-is-plastic-made/

- **Distillation**: Crude oil is refined in a distillation column to separate it into different fractions based on boiling points. Natural gas is processed to remove impurities.
- **Cracking**: The heavier fractions are subjected to a process called cracking, where large hydrocarbon molecules are broken down into smaller, more useful molecules like ethylene and propylene, which are the building blocks for many plastics.

3. Polymerisation

   - **Monomer Production**: Ethylene, propylene, and other small molecules (monomers) are produced through cracking and other chemical processes.
   - **Polymerisation**: Monomers are chemically bonded to form long chains called polymers. This can be achieved through various methods:
     - **Addition Polymerisation**: Monomers add together without the loss of any molecule.
     - **Condensation Polymerisation**: Monomers combine with the loss of a small molecule, usually water.

4. Compounding

   - **Blending**: Polymers are blended with additives to enhance their properties. Additives can include stabilisers, plasticisers, colorants, and fillers.
   - **Pelletising**: The compounded mixture is extruded into strands, cooled, and chopped into uniform pellets or granules, which are easier to handle and transport.

5. Moulding and Forming

   - **Injection moulding**: Plastic pellets are melted and injected into a mould to form specific shapes. This method is commonly used for producing complex and high-precision parts.
   - **Extrusion**: The melted plastic is forced through a die to create continuous shapes like pipes, sheets, and films.
   - **Blow moulding**: Used to create hollow objects like bottles by inflating a molten plastic tube (parison) inside a mould.
   - **Thermoforming**: Plastic sheets are heated to a pliable forming temperature and shaped using moulds.

6. Finishing and Assembly

   - **Trimming**: Excess material is trimmed away from moulded or formed parts.
   - **Surface Treatment**: Parts may undergo surface treatments like painting, printing, or coating to achieve the desired appearance and properties.
   - **Assembly**: Individual plastic components are assembled into final products, which may involve welding, fastening, or bonding parts together.

These steps collectively enable the transformation of raw hydrocarbons into a wide range of plastic products used in countless applications worldwide.

Recycling process

The recycling of plastics and the integration of recycled content in manufacturing depends largely on the type of recycling technology used. In broad terms, plastic recycling is categorised as either mechanical or chemical recycling, with various distinctions made between that describe the technologies employed in the recycling process.

The aim of **chemical** recycling is to turn plastic feedstock back into its original fossil state of aggregate to follow a similar process including a conversion of broken-down oil and gas into petrochemicals to be processed into monomers. This means chemical recycling changes the state of aggregation of plastic waste and breaks it down into its basic chemical's elements (hydrocarbons or monomers) which form the foundation to make new polymers.

On the other hand, in mechanical recycling, plastic waste is collected, sorted, cleaned, melted, and reformed into new products. This process typically involves melting down the plastic and reshaping it into pellets or flakes that can be used to manufacture new products. Mechanical recycling focuses on reusing plastics by melting and reshaping them, while chemical recycling involves breaking down plastics into their chemical components or converting them into other useful chemicals or fuels.

Table 19 shows an overview of prominent plastic reprocessing technologies, mechanical and chemical recycling. While both approaches aim to divert plastic waste from landfills and reduce the reliance on virgin materials, they differ significantly in their processes, capabilities, and outcomes. Both technologies are described in more detail in the following section.

Table 20 Plastic recycling technologies and Australian industry breakdown

Recycling type	Process	Technology	Commonly used synonyms	AUS Example
Mechanical (Physical) reprocessing	Mechanical recycling		Remelting of plastics, conventional recycling, thermos-mechanical recycling	
	Solvent-based recycling	Dissolution	Dissolution-based recycling, dissolution recycling, solvent-based purification, solvent purification	
Chemical reprocessing	Chemical depolymerisation	Enzymolysis, Chemolysis, Solvolysis	Monomer recycling, monomer recovery, chemolysis	
	Thermal depolymerisation	Pyrolysis, hydrocracking	Thermolysis, cracking	e.g. Brightmark, PlastOil modular pyrolysis, IQ Energy Australia, Licella and CAT-HTR™ technology.[15]
		Gasification, hydrothermal	No common synonym	

Mechanical recycling

Mechanical recycling, also known as back to plastics recycling, and involves five major steps aiming to retain the material's inherent properties to convert plastic waste into secondary raw materials for reuse:

[15] King, S., J., Hutchinson, S., Boxall, N., & CSIRO. (2021). *Advanced recycling technologies to address Australia's plastic waste*. CSIRO, Australia. https://library.sprep.org/sites/default/files/2021-08/advanced-recycling-australia-plastic-waste.pdf

Figure 15 Plastics recycling process (adapted from Technavio, 2016 & from CSIRO, 2017)

1. Collection and sorting:
    - **Collection**: Plastic is collected from a variety of sources, including MSW kerbside streams, business waste collection and via container deposit scheme redemption, and transferred to a material recovery facility for sorting.
    - **Sorting**: Collected material undergoes manual and automated sorting at material recovery facilities to remove major contaminants and sort it according to its shape, density, size, colour or chemical composition.
2. Chipping:
    - Sorted plastic is passed through a chipper which consists of cylinder of blades that cut plastic down to a predetermined grill size often called flakes.
3. Decontamination and drying:
    - Contaminants, such as dirt, adhesives, paper labels are removed with thorough washing. After washing, plastic flakes are dried to remove moisture. This can be done using centrifuges, air drying, or thermal drying systems.
4. Extrusion and Pelleting:
    - Cleaned and chipped plastic flakes can be put through an extruder which melts and shapes them into pellets, ready for conversion into new products or packaging (Ragaert et al. 2017).

Input

Mechanical recycling is most efficient when feedstock is pre-sorted by plastics type. If polymer types enter the mechanical recycling process as mixed feedstock process efficiency and product quality is reduced.

Throughput

In theory, many commonly used plastic items can be recycled via mechanical recycling. However, it takes cutting-edge technology to recycle plastics to plastics for the application in food and beverage packaging due to strict safety requirements. Therefore, mechanical recycling can be divided into primary and secondary recycling techniques which are generally both well established and widely applied[16]. The techniques differ in the context of inputs namely respective feedstock they process.

Primary mechanical recycling predominantly uses post-production thermoplastic scrap to produce materials that have properties close to those of virgin plastics and can usually be applied in similar high-value applications. For secondary mechanical recycling, post-consumer plastic waste is typically used as feedstock. Primary recycling involves extruding pre-consumer polymer or pure polymer streams from post-consumer feedstock such as clear bottle streams. Secondary recycling includes post-consumer plastic feedstock that usually requires sorting of polymer waste streams, reduction of polymer waste size, followed by extrusion. Contaminants in post-consumer feedstock such as other polymers or different waste residues often lead to decreased properties of the recycled polymer. This is also referred to as *downcycling or open loop* recycling if the recycled material is used for different applications.

Table 21 Primary and Secondary mechanical recycling

Recycling technique	Main suitable input	Output	Australian example
Primary mechanical recycling	Pre/Post-industrial and clean post-consumer plastic feedstock (PET, PE, PP)	Similar high-value applications (recycle)	Martogg CPA (Albury and Altona) Visy
Secondary mechanical recycling	Post-consumer plastic feedstock (PET, PE, PP)	Lower value applications (downcycle[17])	

Chemical recycling

Chemical recycling, also referred to as advanced, molecular or feedstock recycling, is an umbrella term describing a range of different technologies and processes particularly efficient in processing multilayer packaging and mixed plastic waste streams (Lahtela, Silwal and K¨arki, 2020).

Chemical recycling involves processes that transform the chemical structure of the polymers in plastic[18] waste back into their starting materials e.g. hydrocarbon molecules and monomers[13]. These materials can produce a range of different outputs including fuels, chemical products or feedstock for the chemical industry. These materials can be but are not always turned back into high-value polymers or low-value polymers (Rollinson & Oladejo, 2020). To produce such outputs chemical recycling processes require the mixing of virgin and recycled plastic[19].

Chemical recycling technologies have the potential to treat more heterogenous plastic waste streams with certain levels of contamination that cannot be managed by mechanical recycling processes (Dogu et al., 2021). Because of the nature of returning recovered polymers back to the chemical building blocks, chemically recycled plastics are therefore equivalent to virgin inputs and are suitable for contact sensitive applications.

[16] Faust, K., Denifl, P., & Hapke, M. (2023b). Recent advances in catalytic chemical recycling of polyolefins. *ChemCatChem*, *15*(13). https://doi.org/10.1002/cctc.202300310
[17] Downcycling is mitigated by stringent sorting processes at the front end to ensure coloured or poor-quality plastic waste is removed prior to processing.
[18] The term plastic is often used as a generic term for a chemical linkage of a series of building blocks, called monomers, to form larger molecules, called polymers e.g., polyethylene (PE) (Chamas et al., 2020). Polyethylene can then be divided into low-density Polyethylene (LDPE), medium-density Polyethylene (MDPE) and high-density Polyethylene (HDPE). Reusable bags, agricultural and food packaging film are typical applications of LDPE, while MDPE and HDPE are essential for producing toys, milk bottles, shampoo bottles, houseware, industrial packaging and pipes for water and gas distribution.
[19] Cater, L. (2024b, February 26). *Commission sparks greenwashing fears in row over '100 percent recycled' claims*. POLITICO. https://www.politico.eu/article/european-commission-spark-greenwashing-fears-row-over-100-percent-recycled-claim-plastic/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202024-02-26%20Packaging%20Dive%20%5Bissue:59480%5D&utm_term=Packaging%20Dive

The process for chemical recycling has been outlined below[20]:

1. Collection and Sorting:
   - **Collection**: Plastic is collected from a variety of sources, including MSW kerbside streams, business waste collection and via container deposit scheme redemption, and transferred to a material recovery facility for sorting.
   - **Sorting**: The collected plastics are sorted to separate different types of plastics. While chemical recycling can handle mixed plastic feedstocks, further sortation assists in removing unwanted plastic types (e.g. PVC) and improves the effectiveness of the chemical recycling process.
2. Pre-Treatment:
   - **Washing:** Contaminants, such as dirt, adhesives, paper labels are removed with thorough washing.
   - **Shredding**: Sorted plastic is passed through a chipper which consists of cylinder of blades that cut plastic down to a predetermined grill size often called flakes.
3. Chemical Recycling Processes:
   - Sorted plastics are broken down into their constituent monomers using a variety of different chemical recycling technologies, typically through a combination of heat and temperature treatment. A full description of common chemical recycling technologies has been provided below.
4. Purification:
   - The outputs of chemical recycling technologies are then purified to remove unwanted by-products.
5. Re-polymerisation:
   - The purified chemical feedstocks are polymerised to create new plastic resins. These resins can be tailored to specific applications by adjusting the polymerisation process and adding necessary additives.

The specific outcomes of chemical recycling rely heavily on the specific chemical recycling process applied. The following table outlines the three major technologies applied during chemical recycling, their inputs, outputs and Australian examples. A further discussion on these technologies has also been provided below.

[20] King, S., J., Hutchinson, S., & Boxall, N. (2021). *Advanced recycling technologies to address Australia's plastic waste*. CSIRO, Australia. https://library.sprep.org/sites/default/files/2021-08/advanced-recycling-australia-plastic-waste.pdf

Table 22 Chemical recycling technologies

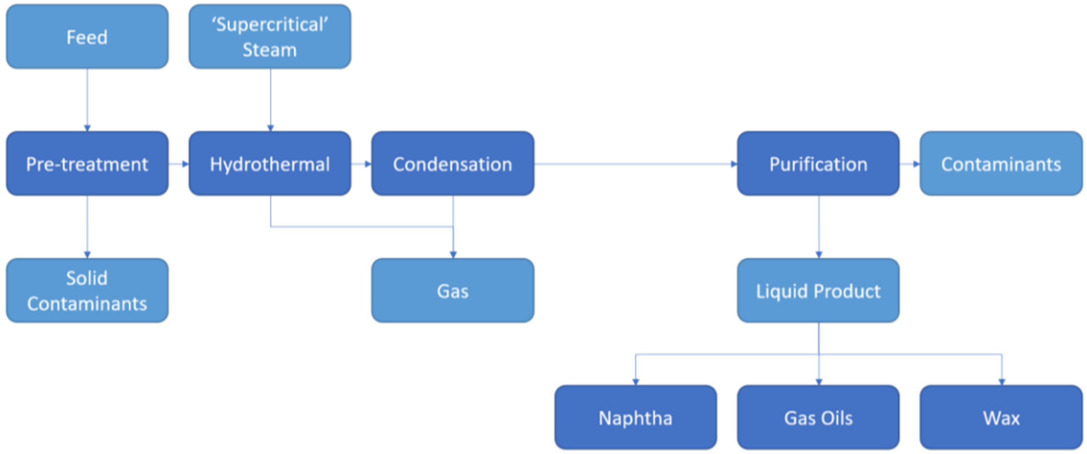
Technology[21]	Input and level of sensitivity to feedstock	Output	Australian example
Pyrolysis	Mixed polyolefins, 2,4,5,6 – HDPE, LDPE, PP, PS	Pyrolysis oil which can be converted into fuel, hydrocarbon molecules (chemical feedstock) or monomers (polymer feedstock)	Brightmark, PlastOil modular pyrolysis, IQ Energy Australia
Thermal depolymerisation	Mixed polyolefins, 2,4,5,6 – HDPE, LDPE, PP, PS PS and PET < 10% Avoid chlorinated plastics (e.g. PVC)	Heavy oil, naphtha (light oil), syngas (and/or other gases) and char which can be converted into fuel, hydrocarbon molecules (chemical feedstock) or monomers (polymer feedstock)	Licella and CAT-HTR™ technology
Gasification	Mixed polyolefins, 2,4,5,6 – HDPE, LDPE, PP, PS PS and PET okay Avoid chlorinated plastics (e.g. PVC)	Energy, ash and syngas which can be converted into fuel, hydrocarbon molecules (chemical feedstock) or monomers (polymer feedstock)	

Thermal depolymerisation

Chemical recycling of plastic waste is understood according to the definition given in recent scientific publications (Delva et al., 2019; Collias et al., 2021) as a process where the polymer chains are converted into its oligomers, monomers or other basic chemicals (such as carbon monoxide, carbon dioxide, methane, and hydrogen) via depolymerisation. This can be achieved through thermal or chemical depolymerisation. These different categories can treat different input streams, vary in their specific processes and result in different outputs. in the context of the Australian demand for recycled content a disadvantage of chemical depolymerisation compared to thermal is its requirement in processing relatively clean, mono-streams (i.e., uncontaminated by other polymers or non-polymers) to produce desired outcomes. Therefore, this section focuses on thermal depolymerisation which as the ability to reprocess multi-layer hard to recycle feedstock. Thermal depolymerisation during chemical recycling can be achieved through different technologies that can largely be subdivided into pyrolysis, hydrothermal recycling and gasification as summarised in Collias et al. (2021). All of them take place at elevated temperatures hence they are being labelled as thermochemical recycling.

[21] King, S., J., Hutchinson, S., & Boxall, N. (2021). *Advanced recycling technologies to address Australia's plastic waste*. CSIRO, Australia. https://library.sprep.org/sites/default/files/2021-08/advanced-recycling-australia-plastic-waste.pdf

Figure 16 Thermal depolymerisation process[22]

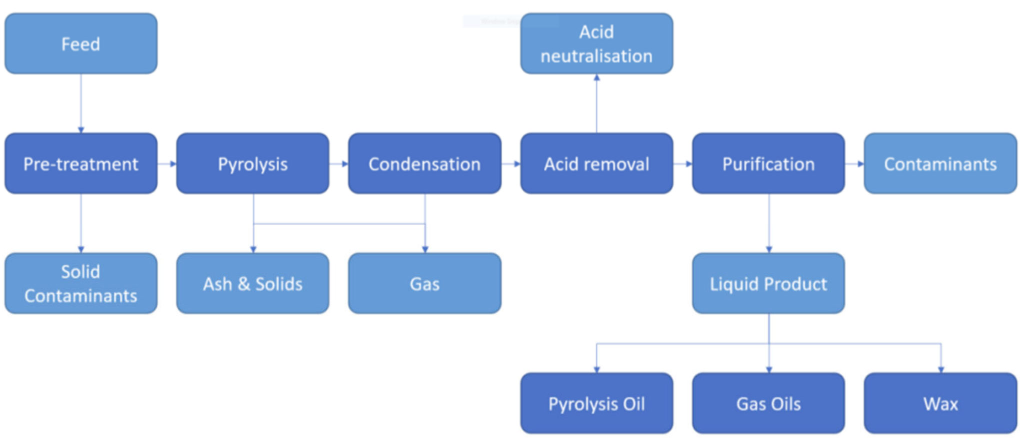


Pyrolysis

The process of pyrolysis uses heat (typically in the range of 300–650°C) in an oxygen-deprived environment to break down polymers and obtain simpler hydrocarbon molecules in the form of pyrolysis oil and non-condensable gases. The pyrolysis oil can be converted to monomers for plastics manufacturing or for other petrochemical products.

Pyrolysis can treat mixed polyolefin plastic waste (including multilayers and multi-materials) with higher contamination levels than it is possible via mechanical recycling (Li et al., 2022). However, it has its own limitations in terms of the quality of input feedstock (Kusenberg et al., 2022a). If fed with multilayer packaging and mixed plastic feedstock, pyrolysis oils generated from post-consumer plastic waste needs to undergo different pre-treatment and upgrading steps[25] as it is composed of a range of hydrocarbon molecules and requires further purification before it can be used as a feedstock for polymer production (Hann & Connock, 2020). An illustration of a typical pyrolysis process is shown in Figure x below:

Figure 17 Pyrolysis process[23]



[22] Herriott, A. (2023). *Plastic Recycling Reimagined: A High-Level Overview of Non-mechanical Recycling*. WRAP https://wrap.org.uk/sites/default/files/2023-10/Plastic%20Recycling%20Reimagined%20-%20Overview%20of%20Non-mechanical%20Recycling%20%28003%29.pdf
[23] Ibid

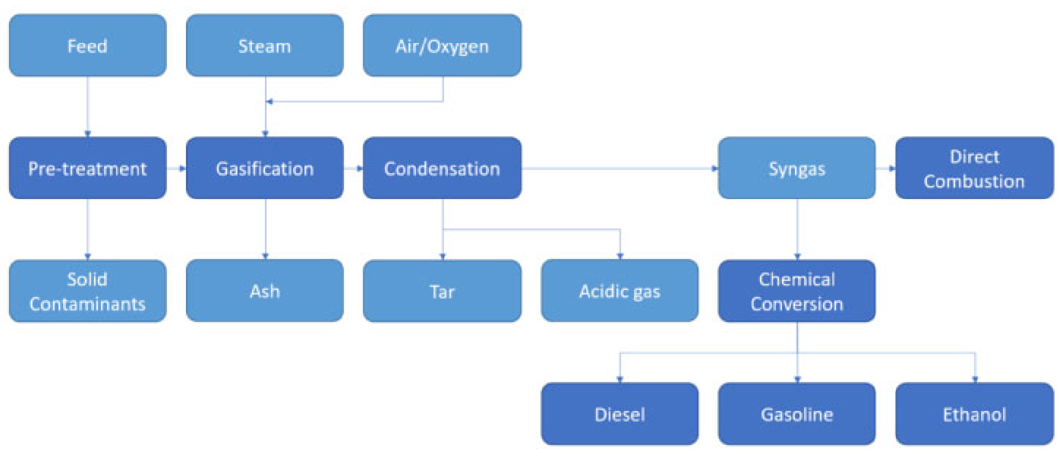
A challenge linked to the application of pyrolysis processes refers to the steady flow of consistent quality feedstock in large amounts needed to make the complex purification and separation processes economically viable (Qureshi et al., 2020; Ragaert et al., 2017). The treatment of by-products generated throughout the process can also be challenging and costly. Despite these challenges, there have recently been increasing examples of pyrolysis plants operating on pilot and commercial scale, aiming to produce chemical feedstocks for plastics manufacturing or other chemicals. In some cases, these plants combine their processes with fuel production to increase the economic viability of their operations (Hann & Connock, 2020).

Gasification

Gasification heats plastic waste (around 500–1300°C) under limited oxygen supply to generate "syngas". Syngas can be used as a feedstock to a range of chemical processes, including conversion into polymers. As a result of the high operating temperature, gasification technologies have a higher feedstock flexibility as it is less sensitive to the feedstock material than pyrolysis. In theory, any plastic can be used as a feedstock for gasification, However, the process does not cope well with feedstock containing PVC. In practice the process mostly targets mixed plastic streams.

Gasification technologies have mainly been commercially applied to fuel production instead of plastic-to-plastic recycling (Hann & Connock, 2020). Moreover, there are significant carbon losses that occur from the process of partial oxidation of plastic waste.

Figure 18 Gasification process[24]



Comparing mechanical and chemical recycling

The benefits and challenges for both mechanical and chemical recycling have been outlined below:

Benefits mechanical

- **Market maturity:** Mechanical recycling is well established in Australia, with a range of high tonnage recycling plants in operation across Australian East coast.
- **Cost effectiveness:** Mechanical recycling technology operates at a lower cost than chemical recycling alternatives.
- **Emissions:** Lower greenhouse gas emissions (GHG) compared to virgin production, chemical recycling technologies and incineration.

[24] Ibid

- **Suitability for single polymer feedstocks and non-packaging applications:** Some plastics have a high thermal stability, which allows it to undergo multiple melt-and-remould cycles in mechanical recycling processes. E.g., it has been found that LDPE can be extruded up to 100 times at 240°C[25] (Rahimi & Garciá 2017)

Challenges mechanical

- **Polymer degradation:** Polymers cannot be recycled infinitely without significant reduction of quality and properties thus mechanically recycling generally leads to downcycling over time. Polymer degradation also occurs during the recycling of thermoplastics due to the chemical and physical forces exerted during extrusion.
- **Feedstock restrictions:** Mechanical recycling requires clean and consistent, single polymer feedstocks to operate efficiently and produce high quality outputs. Mechanical recycling is generally not able to deal with the challenge of polymer contamination or contaminated feedstocks
- **Food contact suitability:** While mechanical recycling can meet food contact specifications for some rigid polymers, mechanical recycling has a lower ability to meet the requirements for food contact compliant applications, particularly with post-consumer flexible plastics.

Benefits chemical[26]

- **Diverse Feedstock:** Chemical recycling can handle a broader range of plastic types and is well-equipped to handle complex packaging formats and mixed plastic feedstocks.
- **Purity and Performance:** The outputs of chemical recycling technologies are suitable for producing high-performance plastics and other chemicals.
- **Food-Grade Materials:** Chemically recycled plastics can meet stringent purity standards required for food-grade applications, expanding their usability in sensitive applications.

Challenges chemical

- **Process Intensity:** Chemical recycling processes are complex and energy demanding technologies, making the energy intensity of chemical recycling comparatively high when compared with mechanical recycling.
- **High Costs:** The initial capital investment and operational costs of chemical recycling facilities are high compared to mechanical recycling.[27]
- **Mixed Plastics:** While chemical recycling can handle mixed polymer feedstocks better than mechanical recycling, the diversity of plastic types still poses challenges in optimising the process for consistent output quality. Some polymers, particularly PVC, also pose a significant challenge to chemical recycling due to its ability to damage equipment.
- **Yields:** Production losses and resulting varying yields (which are highly impacted by feedstock quality) which are generally lower than mechanical recycling.
- **Market development:** Chemical recycling is in early stages of development in Australia, with a limited ability to produce recycled content for packaging over the coming years.

[25] although performance is reduced after 40 extrusions, with significant changes in processability and mechanical properties observed
[26] King, S., J., Hutchinson, S., & Boxall, N. (2021). *Advanced recycling technologies to address Australia's plastic waste*. CSIRO, Australia. https://library.sprep.org/sites/default/files/2021-08/advanced-recycling-australia-plastic-waste.pdf
[27] Faust, K., Denifl, P., & Hapke, M. (2023c). Recent advances in catalytic chemical recycling of polyolefins. *ChemCatChem*, *15*(13). https://doi.org/10.1002/cctc.202300310

- **Supply chain complexity:** Chemical recycling requires long supply chains and is reliant on additional industry players (e.g. co-processing of naptha into PE and PP polymers) which face a variety of challenges in a domestic context.
- **Need for offshore co-processing:** Australia's only PE refinery, Qenos, has recently ceased operations in Australia, meaning international operators will be required to refine chemical recycling outputs into new (PE) polymers for packaging.

Ultimately, Australia needs multiple options to improve recovery and recycling of waste plastics to meet national recovery (80% average recovery by 2030) and packaging (50% average recycled content, and 70% plastic packaging recycled by 2025) targets, and a mix of mechanical and chemical recycling for flexible and rigid plastics will be required to meet any Australian sourced recycled content mandates in plastic packaging.

Mechanical recycling represents a cheaper, higher yield pathway for the recovery of clean, single polymer feedstocks for manufacturing into non-contact sensitive applications and a limited amount of contact sensitive applications (e.g. PET bottles). However, mechanical recycling has a limited set of applications when it comes to packaging-to-packaging flexible plastic recovery or when feedstocks contain mixed polymers or large amounts of contamination.

Chemical recycling is highly complementary to mechanical recycling as it provides a pathway for problematic wastes, such as mixed, flexible and contaminated plastic wastes that might otherwise go to landfill. However, chemical recycling, and the supporting infrastructure that enables packaging-to-packaging applications for recovered material, must continue to develop over the coming years to represent a viable solution to the feedstocks and applications not covered by mechanically recycled plastics.

Recycled content[28]

The PCR content of plastic packaging was 74,000 tonnes, or 6% of total plastic packaging POM, an increase from 3% in the previous year. The pre-consumer recycled content was 23,000 tonnes (2%), and virgin (primary) resin feedstock dominated supply at 1.18 million tonnes or 92% of source material.

[28] APCO, Australian Packaging Consumption and Recovery Data 2021-22.

Table 23 Plastic packaging POM in 2021–22, by material type and recycled content.

Material type	Post-consumer source		Pre-consumer source		Virgin source		Total
	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)	(tonnes)
PET (1) – Natural	27,000	19%	8,000	5%	110,000	76%	145,000
PET (1) – Transparent	6,000	22%	1,000	5%	19,000	73%	26,000
PET (1) – Opaque	1,000	6%	2,000	20%	6,000	74%	8,000
HDPE (2) – Natural	15,000	7%	3,000	1%	185,000	91%	203,000
HDPE (2) – Coloured	5,000	4%	1,000	1%	123,000	96%	129,000
PVC (3)	0	0%	0	0%	11,000	100%	11,000
LDPE (4)	6,000	2%	5,000	1%	317,000	97%	328,000
PP (5) – Natural	0	0%	1,000	1%	116,000	99%	118,000
PP (5) – Coloured	15,000	11%	3,000	2%	118,000	87%	135,000
PS (6)	0	1%	0	0%	17,000	99%	17,000
EPS (6)	0	0%	0	0%	30,000	100%	30,000
Bioplastic (7)	0	0%	0	0%	2,000	100%	2,000
Other (7)	0	0%	0	0%	17,000	100%	17,000
Unidentified	0	0%	0	0%	109,000	100%	109,000
Total	**74,000**	**6%**	**23,000**	**2%**	**1,179,000**	**92%**	**1,277,000**

Key challenges

Cost comparison with virgin inputs

Virgin plastics benefit from significant economies of scale compared to the production of recycled plastics. Virgin plastics are produced in well estabslihed and large-scale operations, resulting in lower costs per unit of material produced. The price of virgin plastics is closely tied to fluctuating oil prices, which can be low, making virgin plastics cheaper.

On the other hand, recycled plastics incur high fixed costs due to the extensive collection, sorting, cleaning, and processing requirements of producing recycled material. These added costs make recycled plastics more expensive and reduce their competitiveness in the market.

Closure of Qenos

The closure of the Qenos refinery has significant implications for the production of recycled polyethylene (PE) plastics in Australia. Qenos has been the largest player in the Australian polyethylene and polymer market and has also been involved in a variety of projects to recover post-consumer plastics and produce recycled resins for packaging manufacturing. The closure of Qenos's facilities undermines the local production capacity needed to meet recycled content mandates.

Logistical challenges

The high cost of transporting collected plastics to sorting and reprocessing facilities, especially over long distances, can significantly impact the overall cost-efficiency of the recycling process. With most plastics recycling infrastructure operating on the East coast of Australia, the cost and environmental implications of transporting recovered plastics across large distances from remote or regional areas mitigates the benefits from recycling.

Lack of harmonised policy and kerbside collection

Inconsistent policies and regulations across states and territories can further complicate supply chain coordination, making it difficult to implement uniform practices and standards nationwide.

Contamination

Post-consumer plastics are often contaminated with food residues, labels, and other materials (both unwanted plastics and other materials). Contamination complicates the sorting process and can reduce the quality and yield of recyclable materials.

PVC contamination

PVC packaging is not currently recycled in Australia though it has been in the past. PVC is a contaminant for the reprocessing of other plastics. For example, it becomes corrosive for equipment used in rPET manufacturing and acts as a contaminant in products derived from feedstock recycling of other plastic types. In the past, PVC was collected and diverted through a manual sorting process. It is possible to install additional technology to sort PVC within MRFs. The PVC industry in Australia is obviously sensitive to a ban on PVC single-use and packaging products, however, there are international examples where PVC, along with PS and EPS are being intentionally designed out of packaging and substituted with other materials (Ellen MacArthur Foundation, 2016).

Chemicals of concern

A comprehensive database (CPPdb) identified numerous hazardous chemicals in plastics packaging, yet substantial data gaps impede thorough risk assessments. Recent studies found per and polyfluoroalkyl substances (PFAS) found in plastics food storage bags and single-use packaging, with notable levels in plant-based products (Stroski, K. M., and Sapozhnikova, Y., 2023). PFAS exposure is linked to liver damage and metabolic disorder (Zhang, J. et al., 2023), while substitutes like polyfluoroalkyl phosphate esters (PAPs) pose endocrine and reproductive risk. (Ao, J. et al, 2023).

Key opportunities

Increased extended producer responsibility

Extended producer responsibility schemes are effective mechanisms for increasing the collection of post-consumer plastics by providing economic incentives to producers, improving waste management infrastructure, enhancing consumer participation, and ensuring regulatory support. These schemes not only boost the collection rates but also contribute to the overall efficiency and sustainability of the recycling ecosystem.

Policy confidence

Delivering a long-term, national scheme for mandated recycled content will deliver investment confidence to boost the market demand for recycled plastic packaging into new packaging products. Industry can already deliver recycled for rigid plastic polymers content beyond current demand levels, and policy that incentivises the development of additional infrastructure will drive further increases in capacity.

Appendix B Material summary – paper & paperboard packaging in Australia

Material placed on market[29]

Paper and paperboard packaging is the predominant material used in packaging placed on market in Australia, making up 52.3% of all packaging placed on market in 2021-22. Paper and paperboard packaging has been estimated at 3.65 million tonnes over this period (±7%), up 8% from the 2020-21 result.

Paper and paperboard packaging is dominated by corrugated cardboard (75.9%), carton board (8.8%) and kraft paper (7.9%), with a variety of other material types making up the remaining 7.4% of paper and paperboard packaging POM. Approximately 56% of paper and paperboard packaging was used in the B2B sector, and 42% was used in B2C applications. The sector of use of the other 2% could not be identified.

A breakdown of the 5 year historical POM tonnages for paper and paperboard packaging has been provided in the table below.

Table 24 Paper and paperboard packaging POM from 2017-18 to 2021-22, by material type[30]

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Boxboard/ Carton board	181,000	288,000	316,000	315,000	320,000
Corrugated cardboard	2,408,000	2,544,000	2,513,000	2,539,000	2,772,000
HWS[b] carrierboard	15,000	20,000	25,000	31,000	25,000
Kraft paper	63,000	195,000	180,000	246,000	290,000
Moulded fibreboard	50,000	51,000	56,000	63,000	65,000
PCPB[c] – Aseptic	38,000	38,000	40,000	49,000	51,000
PCPB – Gable top	12,000	12,000	12,000	15,000	16,000
PCPB – Cold cup	6,000	6,000	13,000	8,000	8,000
PCPB – Hot cup	12,000	12,000	23,000	18,000	20,000
PCPB – Other	4,000	4,000	4,000	4,000	6,000
Polymer coated paper	112,000	94,000	1,000	1,000	1,000
Other fibre packaging[d]	0	0	95,000	99,000	80,000
Total	**2,901,000**	**3,262,000**	**3,277,000**	**3,387,000**	**3,654,000**

Paper and paperboard packaging is projected to grow at a five-year compound annual growth rate (CAGR) of 4.0% per year. A breakdown of the projected POM tonnages for paper and paperboard packaging has been provided in the table below.

[29] APCO, Australian Packaging Consumption and Recovery Data 2021-22
[30] Ibid

Table 25 - Paper & paperboard packaging POM from 2021–22 to 2026–27, by material type[31]

Material Type	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	5 yr CAGR
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	%
Boxboard/Cartonboard	320,000	329,000	339,000	349,000	360,000	370,000	3.0%
Corrugated cardboard	2,772,000	2,858,000	2,947,000	3,038,000	3,133,000	3,230,000	3.1%
HWS[c] carrierboard	25,000	26,000	26,000	27,000	28,000	29,000	2.8%
Kraft paper	290,000	298,000	306,000	314,000	322,000	331,000	2.6%
Moulded fibreboard	65,000	67,000	69,000	72,000	74,000	76,000	3.3%
PCPB[d] – Aseptic	51,000	53,000	55,000	58,000	60,000	62,000	4.0%
PCPB – Gable top	16,000	17,000	17,000	18,000	19,000	20,000	4.0%
PCPB – Cold cup	8,000	8,000	8,000	8,000	8,000	8,000	0.3%
PCPB – Hot cup	20,000	20,000	21,000	22,000	23,000	24,000	4.0%
PCPB – Other	6,000	6,000	6,000	6,000	6,000	7,000	3.4%
Polymer coated paper	1,000	1,000	1,000	1,000	2,000	2,000	2.0%
Other fibre packaging[c]	80,000	83,000	85,000	88,000	91,000	94,000	3.2%
Total	**3,654,000**	**3,766,000**	**3,882,000**	**4,002,000**	**4,125,000**	**4,252,000**	**4.0%**

Recovery[32]

Post-consumer paper & paperboard packaging recovery in Australia in 2021–22 is estimated at 2.50 million tonnes (±11%). An estimated 2.15 million tonnes (86%) of recovered paper & paperboard packaging was corrugated cardboard. Of this corrugated cardboard around 1.23 million tonnes (55%) was from C&I collections, and 0.90 million tonnes (44%) from municipal solid waste collections (MSW).

Table 26 Paper and paperboard recovery

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Boxboard/ Cartonboard	98,000	131,000	107,000	108,000	114,000
Corrugated cardboard	1,663,000	1,849,000	1,988,000	2,114,000	2,150,000
Polymer coated paperboard	14,000	5,000	5,000	2,000	3,000
Other fibre packaging[b]	42,000	60,000	128,000	145,000	236,000
Total	**1,817,000**	**2,045,000**	**2,229,000**	**2,370,000**	**2,502,000**

Of the collected material, approximately 53% was used in local applications, while 47% was exported.

Recovered paper & paperboard are largely used in packaging applications. The application of much of the exported scrap paper & paperboard could not be determined with any certainty (accounting for the large ‘Unknown’ quantity), however, much of this would be used as an input into packaging manufacture overseas, and corrugated cartons in particular.

[31] Ibid
[32] Ibid

Table 27 Applications of recovered paper and paperboard

Material type	Packaging applications (tonnes)	Non-packaging applications (tonnes)	Unknown applications (tonnes)	Total (tonnes)
Boxboard/Cartonboard	41,000	0	73,000	114,000
Corrugated cardboard	1,407,000	11,000	731,000	2,150,000
HWS carrierboard	0	0	0	0
Kraft paper	0	0	0	0
Moulded fibreboard	0	0	0	0
PCPB – Aseptic	0	0	0	0
PCPB – Gable top	0	0	0	0
PCPB – Cold cup	0	0	0	0
PCPB – Hot cup	0	0	0	0
PCPB – Other	0	0	3,000	3,000
Polymer coated paper	0	0	0	0
Other fibre packaging	182,000	1,000	52,000	236,000
Total (tonnes)	**1,631,000**	**12,000**	**860,000**	**2,502,000**
Total (%)	**65.2%**	**0.5%**	**34.4%**	**100.0%**

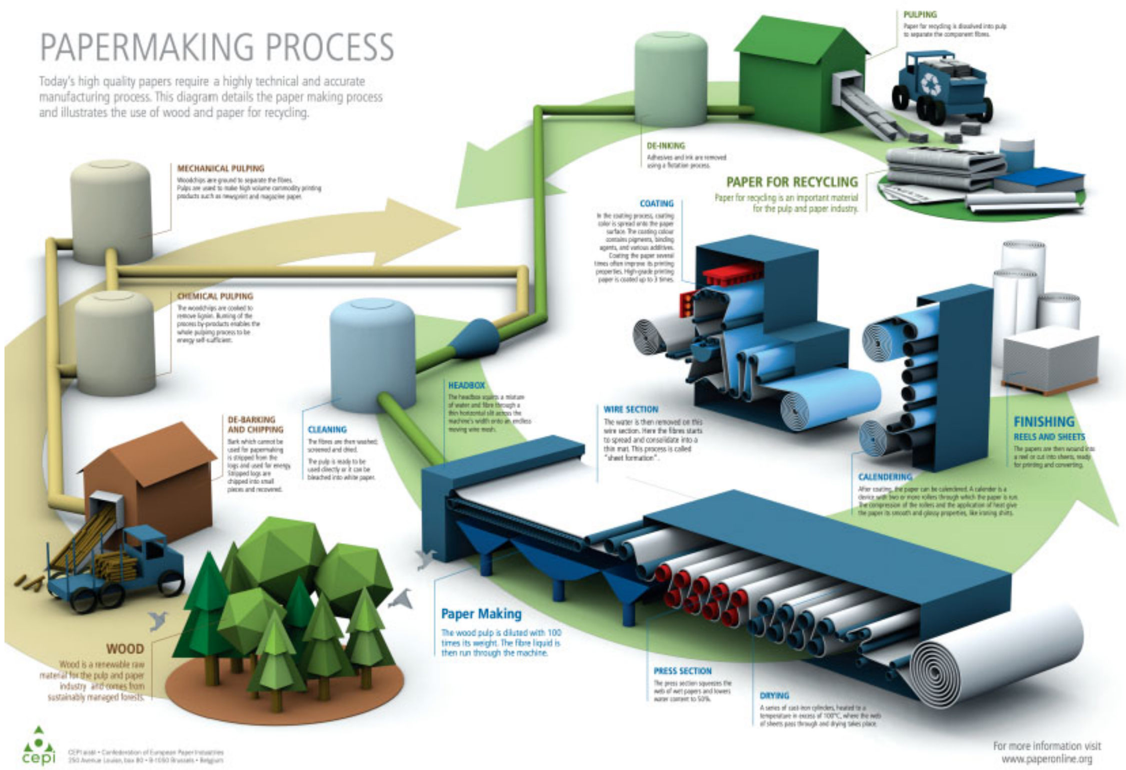
Manufacturing and reprocessing

Manufacturing process

The pulp and paper industry encompasses a diverse range of manufacturing operations, each producing various forms of paper and board tailored for different sector uses. Whether for packaging, printing, or specialty applications, all paper and board products originate from either virgin wood pulp, sourced domestically or through imports, or recycled fibre.

In the production process, water, along with chemicals and additives, is combined with the pulp to form a composite material. This composite is then processed and rolled out into sheets, ready for further conversion into the desired end products. Variations in processes and additives across the pulp and paper industry are dictated by the intended end uses of the material. Mills adjust their methods to meet specific requirements, such as strength or brightness, for different paper grades.

Figure 19 Pulp and paper manufacturing process[33]



Recycling process

In the paper recycling process, paper and paperboard materials undergo physical disintegration to break down into cellulose fibres within a paper mill. The recycling process for paper and paperboard involves steps similar to those used in making paper from virgin fibres. Depending on the required properties and quality of the paper grade, recycled fibres may be blended with virgin fibres to achieve the desired outcome.

Following initial sortation and grading at a material recovery facility, sorted paper is sent to a separate facility for pulping, cleaning, screening, and, in some cases, de-inking. Subsequently, the fibre is formed into a "wet lap." Depending on the facility's capabilities, it may be dried on-site or sold to another location for drying. After pressing and drying, the product becomes "dry lap," which can then be rolled and sold for manufacturing into new fibre products.

There are two primary methods of re-pulping: mechanical and chemical. Mechanical re-pulping involves the removal of large contaminants, refining by washing, sorting, milling, removal of finer contaminants, thickening, optional bleaching, and final drying. This method is typically used for producing paper of lower grades. Chemical re-pulping includes all these steps along with de-inking to brighten up the pulp for use in higher value paper grades like printing and copy paper. De-inking involves a chemical step to free the ink from the pulp and a mechanical step of flotation to physically separate the removed ink from the rest of the pulp.[34]

[33] *About Pulp & Paper | www.cepi.org*. (n.d.). https://www.cepi.org/about-cepi/history-of-pulp-paper/
[34] Caro, D., Albizzati, P., Cristóbal Garcia, J., et al. & European Commission, Joint Research Centre. (2023). *Towards a better definition and calculation of recycling – proposals for calculating recycling yields in multi-output processes and recycling of biodegradable waste, and a quality framework for recycling*. Publications Office of the European Union, 2023. https://data.europa.eu/doi/10.2760/636900

Table 28 Recycling process for paper and paperboard[35]

<table>
<tr><th>Step</th><th>Process</th><th>Pulp type</th><th>Description</th><th>Type of facility</th></tr>
<tr><td>1</td><td>Paper sorting</td><td>All</td><td>Paper is sorted and graded by quality in an MRF. Generally, the classifications are based on weight, colour, usage, and raw materials.</td><td>MRF</td></tr>
<tr><td>2</td><td>Pulp preparation</td><td rowspan="3">Mechanical</td><td>The recovered paper is combined with water in a pulper which separates fibres in paper sheets to produce pulp slurry.</td><td rowspan="7">Wet lap (paper pulping facility).</td></tr>
<tr><td>3</td><td>Cleaning</td><td>The pulp slurry is cleaned to remove contaminants lower to < 2% (such as clay, metals, and glue).</td></tr>
<tr><td>4</td><td>Screening</td><td>The pulp is then filtered through a screen.</td></tr>
<tr><td>5</td><td>De-inking</td><td>Mechanical (optional)</td><td>Inks are removed from the fibre either by washing or flotation.</td></tr>
<tr><td>6</td><td>Bleaching</td><td>Chemical</td><td>If the pulp is used to manufacture white paper, a bleaching process is required.</td></tr>
<tr><td>7</td><td>Forming</td><td rowspan="2">Mechanical</td><td>A large volume of water is added to the pulp slurry, and the mixture is distributed onto a fast-moving screen for drainage. The fibres begging to form a weak paper sheet (‘paper’).</td></tr>
<tr><td>8</td><td>Pressing</td><td>The ’paper’ is pressed between rollers to squeeze out remaining water, approximately 50% of the water content.</td></tr>
<tr><td>9</td><td>Drying</td><td></td><td>Heat or drying is applied in this process. It furthers reduces the water content to approximately 7-10%.</td><td>Dry lap (paper pulping facility)</td></tr>
<tr><td>10</td><td>Rolling</td><td></td><td>The finished paper is processed into large rolls which are ready to be manufactured into new products.</td><td>Paper manufacturer</td></tr>
<tr><td>11</td><td>Making</td><td></td><td>The paper undergoes cutting, printing, folding or moulding processes before being assembled into various types of packaging applications.</td><td>Packaging manufacturer</td></tr>
</table>

Recycled fibre is a significant raw material for the paper and board industry, driven by economic pricing, environmental regulations, and advancements in de-inking and fibre recovery technologies. However, its application is not universal and is constrained by performance needs, declining fibre quality with increased recycling, fluctuations in production versus consumption affecting availability, and technological challenges in specific applications.

Waste paper is sourced from two primary streams:

1. **Paper Mill Scraps**: These are remnants and trimmings generated during the paper manufacturing process. (Pre-consumer waste)
2. **Discarded Paper Waste**: This includes various paper products discarded after consumer use, such as magazines, corrugated cardboard, printer paper, packaging papers, newspapers, cardboard dairy and juice cartons, unsolicited direct mail, phone books, and more.

Recycled waste paper and board encompass a diverse range of grades that cannot be universally utilised in recycled fibre and paper production. Therefore, recycling companies categorise waste papers into different groups for trading purposes. The Australian Recovered Paper Specification (AuRPS) recognises seventeen waste paper grade, each representing distinct characteristics and suitability for specific recycling processes and end market uses.

[35] From ACOR. Final column added by Rawtec and final step added by APCO.

Table 29 Australian Recovered Paper Specification grades

Grade Name	Specification	Common End Uses
Soft Mixed	• Consist of a mixture of various qualities of paper that contains a high percentage of old new papers and coloured advertising inserts with no limit as to other fibre content.	• Corrugated cardboard boxes • Folding cartons
Hard Mixed	• Consist of a mixture of various qualities of paper and paperboard that contains a high percentage of corrugated and folding carton boards with no limit as to other fibre content.	• Corrugated cardboard boxes • Folding cartons
Kerbside Newspaper	• Consists of old newspaper, excluding sunburned. • Contains no more than the normal percentage of coloured advertising inserts, magazines, and domestic office and stationery papers as typically generated from kerbside collections and sorted by MRF.	• Plaster liner wallboard • Corrugated carboard boxes • Folding cartons • Export newsprint
Kerbside Newspaper #7	• Consists of old newspaper, excluding sunburned. • Contains no more than the normal percentage of coloured advertising inserts, magazines, and domestic office and stationery papers as typically generated from kerbside collections and sorted by MRF.	• Plaster liner wallboard • Corrugated carboard boxes • Folding cartons • Newsprint
News, De-inked Quality #8	• Consists of baled, sorted, fresh newspaper, excluding sunburned. • Should be free from paper other news and relatively free from magazines. • Contains no more than the normal percentage of coloured advertising inserts, and domestic office and stationery papers as typically generated by newspaper press rooms and/or from positive kerbside sorting processes.	• Newsprint • Tissue
Over Issue News #9	• Consists of unused overrun newspapers that was printed on newsprint, baled or securely tied in bundles. • Contains no more than the normal percentage of coloured advertising inserts.	• Newsprint • Tissue •
Magazines	• Consists of sorted baled coated magazines, catalogues, and similar printed materials. • May contain a small percentage of uncoated news- type paper as typically generated in this grade.	• Newsprint
Old Corrugated Containers	• Consists of used corrugated cardboard boxes having liners of either test liner, or kraft. • May include folding cartons, and similar boxboard products	• Corrugated carboard boxes • Folding cartons
Premium OCC	• Sorted single and/ or double lined kraft cardboard • Material has been specifically sorted to be free of boxboard, off- shore corrugated, plastic and wax.	• Corrugated carboard boxes • Folding cartons
Corrugated Clipping	• Consists of new corrugated sheets and trim generated in the manufacture of corrugated cartons containing liners of either text liner or kraft.	• Corrugated carboard boxes • Folding cartons

Grade Name	Specification	Common End Uses
Office Pack #1	• Consists of more than 95% uncoated papers, as typically generated by offices and printers. • Contains mainly white ground wood free ledger, bond, envelope, writing and other similar papers and <5% selected white- coated papers.	• White- lined corrugated cardboard boxes • Plaster liner wallboards • White pulp • Tissue
Office Pack #2	• Consists of more than 70% uncoated and less than 30% coated papers, as typically generated by offices and printers. • Contains mainly white and coloured ground wood free ledger, bond, envelope, writing and other similar papers.	• White- lined corrugated cardboard boxes • Plaster liner wallboards • White pulp • Tissue •
Sorted White Ledger	• Consists of uncoated printed or unprinted sheets, trim, guillotined books, and cuttings of white ground wood free ledger, bond, writing, and all other papers that have a similar fibre and filler content. • Must be free from treated padded, heavily printed stock, and adhesives.	• White- lined corrugated cardboard boxes • Plaster liner wallboards • White folding cartons • White pulp • Tissue
Unsorted Office Papers	• Consists of printed or unprinted paper typically generated in an office environment that may include a document destruction process. • May contain white, coloured, coated and uncoated papers, manila and pastel coloured file folders.	• White- lined corrugated cardboard boxes • Plaster liner wallboards • Tissue
Coated Book Stock	• Consists of coated ground wood- free paper, printed or unprinted in sheets, shavings, guillotined books and cuttings. • A reasonable percentage of paper containing fine ground wood may be included.	• White- lined corrugated cardboard boxes • Plaster liner wallboards • Tissue
Hard White Ledger	• Consists of sheets and trim of new (industry generated) printed or unprinted white ground wood free paper used in the manufacture of envelopes, forms, and stationery. • All stock must be free of non- impact printing while a small percentage of coating and carbonless paper is allowable.	• White- lined corrugated cardboard boxes • Plaster liner wallboards • Office and stationery papers • Tissue
Liquid Paperboard	• All liquid carton board as commonly found in used gable top milk cartons sorted from domestic kerbside collections at MRFs. • All cartons may have a maximum of 10% mechanical fiber and total fiber content of not less than 50% as typically contained in aseptic cartons.	• Office and stationery papers

Recycled content[36]

The post-consumer recycled (PCR) content of paper & paperboard packaging in 2021-22 was 1.99 million tonnes, or 54% of total paper & paperboard packaging POM, an increase from 53% in 2020-21. The pre-consumer recycled content was 0.49 million tonnes (13%), and 1.18 million tonnes (32%) was sourced from virgin (primary) feedstocks.

Table 29 -30 Paper & paperboard packaging POM in 2021–22, by material type and recycled content[37]

Material type	Post-consumer source		Pre-consumer source		Virgin source		Total
	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)	(tonnes)
Boxboard/Cartonboard	115,000	36%	76,000	24%	129,000	40%	320,000
Corrugated cardboard	1,789,000	65%	343,000	12%	639,000	23%	2,772,000
HWS carrierboard	0	0%	2,000	8%	23,000	92%	25,000
Kraft paper	16,000	5%	54,000	19%	221,000	76%	290,000
Moulded fibreboard	55,000	85%	3,000	5%	6,000	10%	65,000
PCPB – Aseptic	0	0%	0	0%	51,000	100%	51,000
PCPB – Gable top	0	0%	0	0%	16,000	100%	16,000
PCPB – Cold cup	0	0%	1,000	7%	8,000	93%	8,000
PCPB – Hot cup	0	0%	2,000	8%	18,000	92%	20,000
PCPB – Other	0	1%	0	1%	6,000	99%	6,000
Polymer coated paper	0	0%	0	0%	1,000	100%	1,000
Other fibre packaging	15,000	18%	6,000	8%	59,000	74%	80,000
Total	**1,990,000**	**54%**	**487,000**	**13%**	**1,177,000**	**32%**	**3,654,000**

Key challenges

The effectiveness of recovered-paper reprocessing and remanufacturing hinges on several factors, including the quality of the recovered paper, technical specifications of the remanufactured product, and sustainability and cost-effectiveness of end markets.

Contamination from Co-mingled Recycling

Paper contamination in the co-mingled recycling bin, caused by extrinsic sources like glass fines, food waste, organics, nappies, batteries, and clothing, significantly reduces the recyclability of recovered fibre. These contaminants pose challenges to the sorting process and compromise the quality and longevity of recovered paper fibre.

Sorting Challenges at MRFs

Inadequate sorting outcomes at Material Recovery Facilities (MRFs) across Australia result in an inability to meet contamination specifications. Insufficient sorting technology hampers MRFs' ability to separate mixed paper and contaminated recyclables from potentially recoverable materials, further diminishing the quality of recovered fibre.

[36] APCO, Australian Packaging Consumption and Recovery Data 2021-22.
[37] Ibid

Packaging Design Limitations

Packaging designs that do not support recyclability and the longevity of recovered fibre contribute to recycling challenges. Certain elements such as dyes, inks, polymer layers, and mixed materials used in packaging inherently limit the recoverability of paper fibre, making it more difficult to recycle and reintegrate into new products.[38]

Food contact suitability

Recycling cellulose fibre-based food contact materials, like papers and boards, poses unique food safety challenges. Unlike polymer recycling, paper and paperboard recycling involves complex physico-chemical properties and mechanical considerations, requiring careful evaluation for direct food contact safety. Contaminant transfer from recycled paper and paperboard materials remains a focus of scrutiny, demanding improved safety assessment protocols and practical solutions.

Manufacture of papers and boards from recycled fibres requires meticulous selection of paper grades and suitable cleaning methods to minimise potential migration of health-concern substances into foodstuffs. The German Federal Institute for Risk Assessment (BfR) recommends this approach, emphasising the importance of careful consideration in choosing the grade of recycled paper and employing appropriate cleaning methods. Furthermore, particular attention must be given to potential migration of substances like benzophenones, phthalates, and bisphenols from recycled paper into foodstuffs, with specified migration limits provided for these substances[39]; and per- and polyfluoroalkyl substance (PFAS) in food-contact materials (FCMs) have highlighted significant environmental and health concerns,[40]

Regulations on mineral oil hydrocarbons (MOH), particularly aromatic ones (MOAH), set migration limits to ensure food safety when using recycled fibre-based FCM.[41] US states policies and the European Parliament's regulation banning PFAS in food packaging underscore the urgent need for robust data, hazard assessments, and regulations to safeguard environmental and human health.

European legislation on FCM lacks specific regulations for virgin or recycled paper and paperboard food contact materials. However, guidelines like the BfR Recommendation XXXVI from the German Federal Institute for Risk Assessment (BfR) outline substances and conditions for P&B manufacture. Compliance with these guidelines, including additional requirements for ingredients like printing inks and adhesives, is essential for recycled fibre-based products.

Limited Domestic Demand

The end markets for recycled paper products are influenced by global trade dynamics, consumer preferences, and government procurement policies. Factors such as supply and demand fluctuations and currency exchange rates impact the value of Australian recycled paper exports. Additionally, barriers to entry for new manufacturers of recycled paper products constrain domestic demand.

[38] Schandl H, King S, Walton a, Kaksonen AH, Tapsuwan S and Baynes TM. (2020). *National circular economy roadmap for plastics, glass, paper and tyres*. CSIRO. https://www.csiro.au/en/research/natural-environment/Circular-Economy
[39] Franz, R., & Welle, F. (2022). *Recycling of Post-Consumer Packaging Materials into New Food Packaging Applications—Critical Review of the European Approach and Future Perspectives*. Sustainability, *14*(2), 824. https://doi.org/10.3390/su14020824
[40] APCO (2023). *Action Plan to Phase Out PFAS in Fibre-Based Food Contact Packaging version 3.* APCO. *https://documents.packagingcovenant.org.au/public-documents/Action%20Plan%20to%20Phase%20Out%20PFAS%20in%20Fibre-Based%20Food%20Contact%20Packaging*
[41] Franz, R., & Welle, F. (2022). *Recycling of Post-Consumer Packaging Materials into New Food Packaging Applications—Critical Review of the European Approach and Future Perspectives*. Sustainability, *14*(2), 824.

Export markets

China's National Sword Policy has had a profound impact on the global recycling landscape, leading Australia to seek alternative markets for its recovered fibre and adhere to stricter contamination standards. This policy shift has also prompted Australian paper mills to demand lower contamination levels.

Export restrictions

The Recycling and Waste Reduction (Export – Paper and Cardboard) Rules 2023, effective from July 1, 2024, regulate the export of waste paper and cardboard. Exporters must obtain a waste export license, aligning with contamination thresholds. These rules aim to balance industry needs with environmental preservation. However, the domestic market may lack the capacity to absorb all fibre sold by Material Recovery Facilities (MRFs). To accommodate all recovered fibre domestically, demand would need to increase by approximately 70%.[42]

Following the implementation of the paper ban rules in July 2024, it is estimated that there will be between 750,000 and 1.1 million tonnes of recovered paper seeking export markets.[43] However, whether such materials will meet Government rules for processing or sorting to specific requirements remains uncertain, prompting ongoing export considerations.

Small Profit Margins

Parts of the paper and paperboard supply chain operate under tight profit margins, making it challenging for businesses to remain financially viable. Larger vertically integrated companies are better equipped to manage operational costs, consolidating their position in the industry.

Capacity Constraints

The current infrastructure has limited capacity to handle increases in recovered mixed paper post-ban. Long approval processes, high capital investment requirements, and regulatory burdens hinder the expansion of reprocessing facilities, slowing down the development of the recycling infrastructure.

Recycling facility distribution

The paper production industry in Australia is consolidated, with eight facilities across four states (NSW, Victoria, Queensland, and Tasmania) dominated by key players such as Visy Industries, Australian Paper, Norske Skog, and Orora (Industry Edge, 2019). Entry barriers into the market are high due to substantial capital investment requirements, lengthy approval processes for new infrastructure, and extended contract durations needed to secure supply chains and end markets.[44]

Infrastructure Gaps

Some regions in Australia lack sufficient infrastructure for recycling and reprocessing paper products. Low volumes of recovered material and long transportation distances make traditional recycling solutions economically unviable in regional areas. Western Australia, in particular faces challenges in establishing reprocessing facilities for paper and paperboard.

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[42] Rawtec Pty Ltd. (2020). *SA recycling options for recovered paper and cardboard, public report*. Government of South Australia. P16 & 25 https://www.greenindustries.sa.gov.au/resources/sa-recycling-options-for-recovered-paper-and-cardboard
[43] Harford, N., & French, J. (2022b). Australian Recycling infrastructure, readiness and capacity. In Australian Council of Recycling, *Australian Council of Recycling*. https://acor.org.au/wp-content/uploads/2023/06/220623_acor_infrastructure_readiness_report_june_2022_-_updated.pdf
[44] Schandl H, King S, Walton a, Kaksonen AH, Tapsuwan S and Baynes TM. (2020). *National circular economy roadmap for plastics, glass, paper and tyres*. CSIRO, Australia. https://www.csiro.au/en/research/natural-environment/Circular-Economy

Data Limitations

The lack of accurate and comprehensive data, including life-cycle assessments of substitution products, hampers efforts to target improvements and justify investments in recycling infrastructure. Data gaps related to collection, sorting, and contamination of recyclables impede decision-making and hinder the development of sustainable solutions.

Key opportunities

Incorporating additional recycled content

As part of the 2021-22 consumption and recovery report questionnaire, large paper and paperboard manufacturers were requested to provide percentage estimates of the easily achievable post-consumer recycled content (without major redesign or manufacturing equipment upgrades) for each paper and paperboard material type. It was reported that paper and paperboard packaging could "Easily achieve" a 76% PCR rate, compared to 54% currently[45].

While post-consumer recycled content in paper and paperboard applications is strong across boxboard/cartonboard, corrugated cardboard and moulded fibreboard, manufacturers are confident that there is additional capacity to incorporate recycled content into the manufacturing process.

Table 30 - 31 Potential paper & paperboard packaging post-consumer recycled content, by material type and level of intervention.

Material type	Current (%)	Easily achievable (%)
Boxboard/Cartonboard	36%	65%
Corrugated cardboard	65%	77%
HWS carrierboard	0%	65%
Kraft paper	5%	81%
Moulded fibreboard	85%	89%
PCPB – Aseptic	0%	55%
PCPB – Gable top	0%	55%
PCPB – Cold cup	0%	55%
PCPB – Hot cup	0%	55%
PCPB – Other	1%	Insufficient data
Polymer coated paper	0%	Insufficient data
Other fibre packaging	18%	74%
Total	**54%**	**76%**

Build A Polishing Plant

Establishing a polishing plant can effectively reduce contamination in mixed paper/cardboard sourced from Material Recovery Facilities (MRFs) to meet the standards required for overseas markets. This facility can also separate Old Corrugated Containers (OCC)/board for sale to interstate or international markets with contamination levels below 1%. Utilising technologies such as trommels, ballistics, magnets, optical sorters, and labour can help minimise contamination. Integrating this facility with an MRF can streamline operations and reduce costs.

[45] Note that data is only reported where packaging manufacturers representing more than 20% of total packaging POM (by material type) responded to the related survey questions.

Build A Lap Product Plant

Another option is to construct a plant that produces a 'lap' product from recovered fibre. This facility would pulp the recovered fibre into lap or pulp sheets, which can be sold as wet lap or further processed into dry lap. Manufacturing companies in Australia or overseas can then utilise this product to create commercial products.

Kerbside Bin Models

Consider altering kerbside bin models to minimise contamination of recovered fibre. Introducing a separate fibre bin/crate at kerbside dedicated to recovered fibre can help reduce contamination. MRFs can accept this material at a distinct location within the facility, further ensuring it meets required specifications.

Further areas for improving circularity in the paper and cardboard material stream include:

- Sorting and strategic diversion of specific grades
- Enhancing sorting capabilities to comply with export regulations
- Ensuring paper/cardboard materials meet appropriate export specifications
- Introducing alternate packaging products to replace low-recovery-rate packaging
- Conducting targeted community education initiatives
- Enhancing recovery of high-quality cardboard from the commercial and industrial (C&I) sector
- Implementing local processing of the municipal solid waste (MSW) stream.

Appendix C Material summary – glass packaging in Australia

Material placed on market[46]

Glass packaging POM in Australia in 2021–22 is estimated at 1.14 million tonnes (±15%), or 16.4% of all packaging POM. Between 2020–21 and 2021–22 there was a decrease in glass packaging POM of 140,000 tonnes (-11%). Packaging POM was mostly locally sourced and locally manufactured (78%), with most of the remainder imported empty packaging (13%).

Table 32 31 - Glass packaging POM from 2017–18 to 2021–22, by material type.

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Amber glass	438,000	381,000	334,000	233,000	181,000
Flint glass	471,000	643,000	606,000	605,000	494,000
Green glass[b]	364,000	258,000	216,000	445,000	468,000
Total	**1,273,000**	**1,283,000**	**1,156,000**	**1,283,000**	**1,143,000**

Glass packaging consumption is determined for three main colours, which are amber, flint (clear) and green glass. Flint glass makes up 43.2% of glass POM, followed by green glass (41.0%) and amber glass (15.8%). Almost all glass packaging was used in consumer applications.

Glass packaging is projected to grow at a five-year compound annual growth rate (CAGR) of 2.5% per year. A breakdown of the projected POM tonnages for glass has been provided in the table below.

Table 32 - 33 Glass packaging POM from 2021–22 to 2026–27, by material type.

Material Type	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	CAGR
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	%
Amber glass	181,000	185,000	190,000	195,000	199,000	204,000	2.5%
Flint glass	494,000	506,000	518,000	531,000	544,000	557,000	2.5%
Green glass	468,000	480,000	492,000	504,000	516,000	529,000	2.5%
Total	**1,143,000**	**1,171,000**	**1,200,000**	**1,229,000**	**1,260,000**	**1,291,000**	**2.5%**

Recovery[47]

Post-consumer glass packaging recovery in Australia in 2021–22 is estimated at approximately 0.72 million tonnes (±12%). An estimated 458,000 tonnes (64%) of glass packaging was recovered through MSW collections, with another 260,000 tonnes (36%) recovered through separate CDS collections. Less than 1% was reported as recovered through C&I related collections.

[46] APCO, Australian Packaging Consumption and Recovery Data 2021-22
[47] Ibid

Table 34 33 - Glass packaging recovery from 2017–18 to 2021–22, by material type.

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Amber glass	189,000	174,000	202,000	202,000	174,000
Flint glass	212,000	283,000	366,000	374,000	315,000
Green glass	180,000	117,000	131,000	228,000	230,000
Total	**582,000**	**574,000**	**699,000**	**805,000**	**718,000**

Recovered glass packaging is mostly returned into packaging applications. For non-packaging applications, large quantities of packaging glass are crushed and used in civil construction. The major application of this crushed glass is as a substitute for virgin sand or aggregate in road construction – typically blended with virgin sand and aggregate and then mixed with cement to manufacture road-base products. Crushed glass sand and aggregate are also regularly used in non-structural concrete mixes. Almost all recovered glass was sent to local applications.

Table 34 - 35 Glass packaging recovery in 2021–22, by material type and material use application

Material type	Packaging applications	Non-packaging applications	Unknown applications	Total
	(tonnes)	(tonnes)	(tonnes)	(tonnes)
Amber glass	123,000	51,000	0	174,000
Flint glass	191,000	124,000	0	315,000
Green glass	138,000	91,000	0	230,000
Total (tonnes)	**452,000**	**266,000**	**0**	**718,000**
Total (%)	**63.0%**	**37.0%**	**0.0%**	**100.0%**

Table 35 - 36 Glass packaging recovery in 2021–22, by material type and destination of material

Material type	Local	Overseas	Unknown destinations	Total
	(tonnes)	(tonnes)	(tonnes)	(tonnes)
Amber glass	174,000	0	0	174,000
Flint glass	314,000	1,000	0	315,000
Green glass	229,000	1,000	0	230,000
Total (tonnes)	**717,000**	**1,000**	**0**	**718,000**
Total (%)	**99.8%**	**0.2%**	**0.0%**	**100.0%**

Manufacturing and reprocessing

Manufacturing process

Glass manufacturing involves blending silica sand, soda ash and limestone to Silica sand, feeding them into a furnace heated above 1,500°C, resulting in molten material that cools to form soda-lime glass, the most common and least expensive type, representing about 90% of all manufactured glass.[48]

[48]Jacoby, M. (2021b, July 30). *The sensors that make glass recycling possible*. Chemical & Engineering News. https://cen.acs.org/materials/inorganic-chemistry/light-based-sensors-glass-recycling/99/i28

The glass manufacturing industry is categorised into five sectors:

1. Container glass or packaging glass
2. Flat glass
3. Domestic glass (tableware)
4. Continuous filament glass fibre
5. Special glass – optic glass

Each type of glass within these sectors has its own melting point and physico-chemical composition, tailored to its specific application and properties required for that application.

Recycling process

The recycling of waste glass involves two primary methods: open-loop recycling and closed-loop recycling. Open-loop recycling involves using waste glass in alternative applications (construction, infrastructure, etc.) while closed-loop recycling uses recovered waste as a substitute for raw materials to produce new glass.

Glass recycling process[49]

1. Collection and sorting
    - **Collection**: Glass is collected from a variety of sources, including MSW kerbside streams, business waste collection and via container deposit scheme redemption, and transferred to a material recovery facility for sorting.
    - **Sorting**: Glass goes through a variety of manual and automated sorting processes to remove contaminants and sort by colour.
2. Cleaning and Preparation
    - **Washing**: Sorted glass is washed to remove labels, adhesives, and other residues.
    - **Crushing**: The cleaned glass is crushed into glass cullet. Cullet is easier to handle and improves the reprocessing efficiency.
    - **Additional Sorting**: The cullet may undergo further sorting to remove any remaining impurities.
3. Melting and production
    - The sorted and cleaned cullet is melted in a furnace at high temperatures until it becomes a molten product.
    - The molten glass is formed into new products depending in the desired application.

Pre-consumer waste is typically more homogeneous compared to post-consumer waste. While pre-consumer waste may not require any treatment at all, post-consumer waste often necessitates varying degrees of sorting, collection, and treatment due to its diverse and complex nature.[50]

[49] https://www.stoelzle.com/the-right-way-to-dispose-of-glass-packaging/
[50] Rodriguez Vieitez E, Eder P, Villanueva Krzyzaniak A, & Saveyn H. (2011). *End-of-Waste criteria for glass cullet: Technical proposals* (Issue ISBN 978-92-79-23101-8). EUR 25220 EN. Luxembourg (Luxembourg): Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC68281

Advantage of using glass cullet[51]

Glass remanufacturing plants can use glass cullet alongside conventional raw materials like limestone ($CaCO_3$), sand (SiO_2), and soda ash (Na_2CO_3) to lower the melting temperature, thereby reducing energy consumption in the production process. The glass waste undergoes pre-treatment as mentioned above. The pre-treated feedstock is crushed and fed into the furnace along with the primary materials to be melted, replacing conventional raw materials. The melted glass is moulded into new products such as bottles and jars. Importantly, glass does not degrade during recycling, allowing for infinite recycling cycles.[52]

Glass packaging is manufactured in three primary colours: amber (brown), green, and flint (clear). When producing new glass packaging from recycled cullet, there are limitations on colour blending. Amber packaging, commonly used for beer, can utilise flint and green cullet, while green packaging can use flint and green cullet. Flint glass packaging, on the other hand, requires clear cullet. Demand for different colours varies across regions, with the wine industry in South Australia exhibiting a higher demand for green glass, necessitating the transportation of cullet from other capitals to Adelaide at times. Virgin glass primarily consists of silica and soda ash, and cullet can be blended with these materials in significant proportions, with blends exceeding 60% being feasible with good quality cullet. However, the current cullet content in glass production is typically in the range of 41% (APCO, 2021-22), much lower than its potential capacity.

Recycled content[53]

As part of the 2021-22 Consumption and Recovery Study, packaging manufacturers were requested to provide percentage estimates of the easily achievable post-consumer recycled content (without major redesign or manufacturing equipment upgrades). It was reported that the easily achievable PCR content for glass packaging is 63%, compared to 41% currently.

[51] **Waste glass terminology: cullet**
*In general, the word **cullet** can be used to refer to either "broken glass" or to "waste glass". A distinction should be made regarding internal vs. external cullet: this distinction is important because internal cullet is not regarded as waste, while external cullet (which can be pre- or post-consumer) is classified as waste. When using the word "cullet" in the context of end-of-waste it will always refer to external cullet.*
***Internal cullet** is composed of defective products detected and rejected by a quality control process during the industrial process of glass manufacturing, transition phases of product changes (such as thickness and colour changes) and production offcuts. The basis of the definition of internal cullet is the fact that these materials are immediately absorbed by the respective industrial process as a raw material for a new melting operation, not leaving the glass manufacturing plant. Internal cullet cannot be considered as waste as it was never a product.*
***External cullet** is "waste glass that is collected and/or reprocessed with the purpose of recycling". External cullet can be of two types: (1) pre-consumer, also called post-industrial glass cullet, and (2) post-consumer glass cullet.*
*(1) **Pre-consumer cullet** is waste glass resulting from the manufacturing of products that contain glass as one of their components, and which leaves the specific facility where it was generated, becoming waste but not reaching the consumer market. An example of pre-consumer cullet is the glass cullet constituted by offcuts and pieces from defective manufacturing of e.g. the production of car windows from flat glass, which leave the car window manufacturing facility and are re-melted in the flat glass manufacturing facility.*
*(2) **Post-consumer cullet** is waste glass originated after the use of the glass products at the consumer market.*
(Reference from Elena Rodriguez Vieitez, et al., 2011, End-of Waste Criteria for Glass Cullet: Technical Proposals, Publications Office of the European Union)
[52] Caro, D., Albizzati, P., Cristóbal Garcia, J., et al. & European Commission, Joint Research Centre. (2023). *Towards a better definition and calculation of recycling – proposals for calculating recycling yields in multi-output processes and recycling of biodegradable waste, and a quality framework for recycling*. Publications Office of the European Union, 2023. p 11 https://data.europa.eu/doi/10.2760/636900
[53] APCO, Australian Packaging Consumption and Recovery Data 2021-22.

Table 36 - 37 Potential glass packaging post-consumer recycled content, by material type

Material type	**Current**	**Easily achievable**
	(%)	**(%)**
Amber glass	46%	68%
Flint glass	38%	54%
Green glass	42%	69%
Total	**41%**	**63%**

In 1 Jan 2021, waste export ban on glass, exporters will no longer be able to send unprocessed waste glass overseas. Companies operating in Australia will need a licence to export processed waste glass.

The European Commission has established end-of-waste criteria for glass cullet, aiming to clarify when it ceases to be waste. These criteria ensure environmental protection and support recycling. Glass cullet must meet technical requirements and comply with existing standards.[54],[55]

Waste Shipment Regulations and Consequences for Waste Glass

There is a series of international regulatory instruments, recommendations, compliance guides and guidelines to be considered regarding the monitoring and control of shipment of waste to other countries.

The following regulations are of particular importance in for waste glass:

- Basel Convention of 22 March 1989 on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (Basel Convention, 1989).
- OECD Council Decision C(2001)107/Final of the OECD Council concerning the revision of Decision C(92)39/Final on the Control of Transboundary Movement of Wastes Destined for Recovery Operations (OECD, 2001).
- Regulation (EC) No. 1013/2006 on shipments of waste (EC, 2006).
- Commission Regulation (EC) No. 1418/2007 concerning the export for recovery of certain waste listed in Annex III or IIIA to Regulation (EC) No. 1013/2006 of the European Parliament and of the Council to certain countries to which the OECD Decision on the control of transboundary movements of wastes does not apply (EC, 2007).

The most important international regulations are the Basel Convention and the OECD Council Decision. (Rodriguez Vieitez E. et al., EU, 2012)[56]

[54] *Commission Regulation (EU) No 1179/2012 of 10 December 2012 establishing criteria determining when glass cullet ceases to be waste under Directive 2008/98/EC of the European Parliament and of the Council.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012R1179.

[55] Rodriguez Vieitez E, Eder P, Villanueva Krzyzaniak A, & Saveyn H. (2011). *End-of-Waste criteria for glass cullet: Technical proposals* (Issue ISBN 978-92-79-23101-8). EUR 25220 EN. Luxembourg (Luxembourg): Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC68281

[56] Ibid

Table 37 - 38 Department of Agriculture, Water and the Environment, Waste Glass Industry Standards, Snapshot of MRA Consulting Group's Report, February 2021.

Furnace Ready Glass Standards			
Parameter	**Beneficiated Cullet Specifications**	**Scrap Specifications Circular 2020**	**Commission Regulation (EU) No 1179/2012**
Organisation	ACOR	ISRI	European Commission
Jurisdiction	Australia	United States of America	European Union
Sizing	• All pieces must be <50mm • <10% of pieces to be <8mm	• Ideally between 9.5mm and 19mm	• No size specified • As specified in customer/ industry specification.
Colour	• Flint: • Flint glass: min. 98% • Other colours: max. 2% (<0.3% may be dark green/blue) • Amber: • Amber glass: min. 90% • Other colours: max. 10% (<5% may be dark green, <5% may be dark blue • Green: • Green glass: min. 90% • Other colours: max. 10% (<1% may be dark blue)	• Flint: • Flint glass: min. 95% • Other colours: max. 5% (<5% amber, <1% green, <0.5% other) • Amber: • Amber glass: min. 90% • Other colours: max. 10% (<10% flint, <10% green, <5% other) • Green: • Green glass: min. 70% • Other colours: max. 30% (<15% flint, <15% amber, <10% others)	• As specified in customer/industry specification.
Contaminants	• Organic matter: <3kg per tonne of cullet • Ferrous material: <3g per tonne of cullet • Non-ferrous metals: <15g per tonne of cullet • Ceramics, refractory, glass-ceramic, etc: <15g per tonne of cullet • Prohibited Material: • Cullet should be free from non-glass containers, including aluminium cans, plastic bottles and containers, and steel containers • Cullet should be free from any Pyroceramic material	• Organic matter: limits to be set in buyer and seller agreement • Prohibited Material: • Ferrous materials • Non-ferrous metals • Ceramics • Other glass • Other material such as bricks, rocks, etc	• Ferrous materials: <50ppm • Non-ferrous metals: <60ppm • Non-metal non-glass inorganics (e.g. ceramics, stones, porcelain, pyroceramics): <100ppm for glass cullet size >1mm • Organic matter: <2000ppm • Prohibited Material: Hazardous material listed in Annex III to Directive 2008/98/EC. e.g. Aldrin, Endrin, DDT, Mirex.
Moisture Content	Less than 3 per cent	Not specified	Not specified

Furnace Ready Glass Standards			
Parameter	**Beneficiated Cullet Specifications**	**Scrap Specifications Circular 2020**	**Commission Regulation (EU) No 1179/2012**
Purchase Agreement	• The following should be specified in the Purchase Agreement: • Cullet grade: outline accordance with these specifications • Quantity: tonnes • Packaging: in boxes or in bulk • Price: agreed price ($AUD/tonne or relevant overseas currency and exchange rate payment terms) • Rejection terms	• The following should be agreed in writing: • Cullet grade: outline accordance with these specifications • Quantity: tonnes or car/truckloads • Packaging: in boxes or in bulk • Price: $USD/2,000 pounds or $USD/hundred weight • Terms: terms shall be "net cash 30 days after date of shipment" unless otherwise agreed upon	• The producer must provide a statement of conformity with end-of waste criteria: • Name and technical provisions of an industry specification or standard • Cullet grade: outline accordance with the specifications and criteria in this regulation • Quantity: kilograms • Management system verified by an accredited conformity assessment body or verifier
Testing and Sampling	Representative 100kg sample testing: • Ceramics and Metals • 100kg to be hand sorted and contaminants removed and weighed • Colour • 5kg to be passed over screen with square holes between 6 and 7mm in size • Flint: 1kg of cullet retained on screen to be removed and hand sorted to determine level of non-flint glass • Amber: 500g of cullet retained on screen to be removed and hand sorted to determine level of amber glass • Green: 500g of cullet retained on screen to be removed and hand sorted to determine level of green glass • Mixed: 500g of cullet retained on screen should be removed and hand sorted to determine the amounts of each glass	Not specified	Qualified staff shall carry out visual inspection of each consignment to verify compliance with the appropriate specification. Further sampling and testing shall be taken due to suspicion of possible hazardous properties. Appropriate frequencies of monitoring shall be established for: • Analysing representative samples of glass cullet gravimetrically to measure the total non-glass components

Key challenges

Glass used for household and commercial applications

Glass is utilised not only for packaging but also for household and commercial durable applications like drinking glasses, plates, cookware, and vases. The presence of different glass type in glass cullet can significantly impact the quality of glass products. These different forms of glass melts at different temperatures compared to packaging glass. For instance, when manufacturing container glass with soda-lime physico-chemical composition inadvertently deposited in Container Deposit Scheme (CDS). To address this issue, active education programs are implemented in commercial and household settings to ensure that packaging glass remains separate from other glass forms, thereby maintaining the quality and integrity of the recycling stream.[57]

Collection system that compact and contaminate glass flows

Co-mingled kerbside collection system poses challenges due to glass breakage and cross-contamination with other recyclables. This results in difficulty recovering small glass fragments, leading to significant amounts of glass ending up in landfills or incorrectly disposed of at the kerbside. Roughly 10% of waste glass is diverted to construction or industrial uses, with the majority exported or stockpiled. Over 280 kilotons of glass annually face landfill due to improper disposal before collection. [58]

Glass cullet contaminants

Contaminants found in glass cullet can be categorised into two groups: non-glass material components and glass material components that are detrimental for new glass manufacturing.

Non-glass material components include[59]:

- Metals (both ferro-magnetic and non-ferro-magnetic)
- Non-metal, non-glass inorganics such as ceramics, stones, and porcelain (often abbreviated as "CSP" or "KSP")
- Glass ceramics, also known as pyro-ceramics or vitro-ceramics, which are heat-resistant non-glass ceramic materials[60]
- Organics, including food remains, strapping, plastic, wood, and textiles
- Hazards, which encompass hazardous materials contained in bottles and jars, as well as medical or chemical refuse contained within needles and syringes.

[57] Allan, P. (2019). *Assessment of Australian recycling infrastructure-Glass packaging update*. Sustainable Resource Use Pty Ltd, Department of the Environment and Energy. P11 https://www.dcceew.gov.au/environment/protection/waste/publications/assessment-australian-recycling-infrastructure-glass-packaging

[58] Schandl H, King S, Walton a, Kaksonen AH, Tapsuwan S and Baynes TM. (2020). *National circular economy roadmap for plastics, glass, paper and tyres*. CSIRO. P41-42 https://www.csiro.au/en/research/natural-environment/Circular-Economy

[59] Rodriguez Vieitez E, Eder P, Villanueva Krzyzaniak A, & Saveyn H. (2011). *End-of-Waste criteria for glass cullet: Technical proposals* (Issue ISBN 978-92-79-23101-8). EUR 25220 EN. Luxembourg (Luxembourg): Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC68281

[60] Glass ceramics are also referred to as pyro-ceramics, and they are also known as vitro-ceramics; these are heat resisting inorganic materials. Amongst all types of inorganic contaminants, pyro-ceramics are considered by industry as one of the most difficult ones to detect and separate out because of their glass appearance. For their effective removal, specialized and innovative equipment is needed.

Colour

Container glass production typically uses four colours of cullet: clear or flint, green, brown or amber, and mixed cullet. These colour requirements are driven by commercial rather than environmental factors.

Manufacturers have varying maximum accepted levels of false colours in coloured cullet depending on the desired product quality. Strictest requirements apply to flint glass manufacturing, while mixed glass has the highest tolerance for other colours.

Typical maximum limits of colour contamination for container glass manufacturing are as follows[61]:

- Flint glass: < 4% to < 6% (according to FERVER, even lower at < 2%)
- Brown glass: < 5% to < 15%
- Green glass: < 5% to < 30%

Hindrances to new and existing local markets for recycled glass

Industry concerns raised in interviews primarily revolve around two key issues: the compliance of recycling operations with environmental standards for waste handling and the duplication of compliance requirements for recycled-glass products across various jurisdictions.

Transport costs and logistics

Transporting glass cullet to cullet users presents challenges due to its high density, low specific value, and the abundance of raw materials it substitutes. As glass is primarily produced and consumed locally, waste glass collection and utilisation also tend to be local. Limited sophisticated sorting technology, mainly owned by a few large companies, further complicates the process. Additionally, the distance to beneficiation plants or glass manufacturers adds extra costs for glass cullet transportation. However, for certain types of glass cullet, it may still be profitable to haul longer distances for collection or glass manufacturing purposes.[62]

Key opportunities

Investment in sorting and re-processing technology or alternative system

Glass cullet must undergo colour sorting into flint, green, and amber for recycling into glass containers. Additionally, sorting out of ceramics, porcelain, and other glass composition types and contaminants is crucial for various applications, necessitating significant capital investment.

However, in Australia, most glass recyclers lack efficient sorting and cleaning technology. Out of 193 facilities, only 18 utilise automated methods such as x-ray, camera, or laser technologies, while the majority still rely on manual sorting processes.[63]

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[61] Rodriguez Vieitez E, Eder P, Villanueva Krzyzaniak A, & Saveyn H. (2011). *End-of-Waste criteria for glass cullet: Technical proposals* (Issue ISBN 978-92-79-23101-8). EUR 25220 EN. Luxembourg (Luxembourg): Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC68281

[62] Elena Rodriguez Vieitez, Peter Eder, Alejandro Villanueva and Hans Saveyn, 2011, End-of Waste Criteria for Glass Cullet: Technical Proposals, Publications Office of the European Union, Luxembourg, 2011, ISBN 978-92-79-23101-8, doi:10.2791/7150, EUR 25220 EN, JRC 68281. P21.

[63] CSIRO. (August 2022.). *Improving Australia's glass recycling*. https://www.csiro.au/en/news/All/Articles/2022/August/glass-recycling

To improve glass recycling and minimise the need for large capital investments, it's essential to maintain the quality of glass flows throughout its lifecycle, utilise separation-at-source systems to reduce cross-contamination, invest in sorting and re-processing technologies, strengthen end markets through government procurement and incentives, engage with civil construction and regulatory bodies to increase uptake of recycled glass, encourage behavioural and cultural change through education and incentives, and implement tracking technologies and data collection for efficiency and effectiveness measurement.[64]

Glass manufacturing is dominated by a few large companies, like Orora, Visy and Owens Illionis (O-I). They are making significant investments in the glass reprocessing industry, aiming to enhance sustainability and recycling efforts.

Increased glass beneficiation capacity

Orora's Glass Beneficiation Plant, located in Gawler, South Australia, processes used glass through container deposit schemes, producing cullet transferred to the Orora Gawler glass plant for transformation into new glass containers. The facility, operational since October 2022 with a $25 million investment, can process up to 150,000 tonnes of glass annually, contributing to Orora's goal of achieving 60% recycled content for glass beverage containers by 2025. This initiative reduces glass waste in landfills and aligns with Orora's commitment to net zero greenhouse gas emissions by 2050.[65]

Visy has expanded its Laverton beneficiation facility in Victoria by an extra 100,000 tonnes per year. Visy plan to enhance and expand the capacity of glass packaging furnaces, notably at their Spotswood facility in Melbourne. Visy aims to increase the recycled content of their bottles to 60–70%, up from 30–35% in 2020, with their current recycled content rate at around 45%.[66]

ReGroup has launched a new glass beneficiation plant in Sydney, which now processes some glass packaging from New South Wales that used to go to Melbourne.[67]

Potential application for recycled content beyond glass packaging

Beyond recycling glass packaging waste back into packaging production, there are several secondary markets for glass cullet. It can be utilised as a filter media for water quality projects, although this specialised application does not yield a high market price per tonne. Similarly, glass can be used as an abrasive material in sandblasting, but competition with readily available sand limits its market potential. [68]

Another application is in road base and sub-base construction, where cullet can absorb large volumes of material and does not require the same quality standards as packaging production. This makes it a viable outlet for glass stockpiles with higher contaminant levels. Road material suppliers like Alex Fraser and Downer are involved in this market. [69]

[64] Schandl H, King S, Walton a, Kaksonen AH, Tapsuwan S and Baynes TM. (2020). *National circular economy roadmap for plastics, glass, paper and tyres.* CSIRO. P38-39 https://www.csiro.au/en/research/natural-environment/Circular-Economy
[65] Young, A. (2022, October 7). *Orora opens its >5m glass beneficiation plant*. The Shout. https://theshout.com.au/orora-opens-its-25m-glass-beneficiation-plant/
[66] Recycling Victoria. (2023). *Recycling Victoria Market Insights Reports*. The State of Victoria Department of Energy, Environment and Climate Action. https://www.vic.gov.au/market-summary
[67] Ibid
[68] Allan, P. (2019). *Assessment of Australian recycling infrastructure-Glass packaging update*. Sustainable Resource Use Pty Ltd, Department of the Environment and Energy. P11 https://www.dcceew.gov.au/environment/protection/waste/publications/assessment-australian-recycling-infrastructure-glass-packaging
[69] Ibid

Potters Industries operates recycling systems for window and windscreen glass, repurposing it into road marking paint and other applications in the medical and military sectors.[70] Other application listed:

- Use in ceramic sanitary ware production
- Use as a fluxing agent in brick manufacture
- Use in sports turf and related applications (for example, as top dressing, root zone material or golf bunker sand)
- Use as an abrasive

Improve kerbside collection system

Victoria has implemented a four-stream waste and recycling system, introducing a new purple bin for glass-only. By providing separate glass-only bins, Victoria anticipates an increase in the supply of uncontaminated glass to the recycling sector, facilitating higher-quality glass-to-glass remanufacturing processes.[71]

[70] Ibid

[71] Kolovos, B. (2022, September 29). *All Victorians to get four wheelie bins to enable recycling of soft plastics and pizza boxes.* The Guardian. https://www.theguardian.com/australia-news/2022/sep/29/all-victorians-to-get-four-wheelie-bins-to-enable-recycling-of-soft-plastics-and-pizza-boxes

Appendix D Material summary – metal packaging in Australia

Material placed on market[72]

Metal packaging POM in Australia in 2021–22 is estimated at 398,000 tonnes (±13%), or 4.3% of all packaging POM. Between 2020–21 and 2021–22 there was an increase in metal packaging POM of 44,000 tonnes (+17%). Metal packaging consumption is dominated by tin-plate steel can (54.1%) and aluminium beverage can (33.7%) consumption. Around 78% of metal packaging was used in the B2C sector, with the other 22% used in the B2B sector.

Of the 298,000 tonnes of metal packaging POM, about 74% was locally manufactured using materials from overseas, 7% was locally manufactured from local materials, 14% arrived as imported filled packaging and 5% was imported empty packaging.

Table 39 38 - Metal packaging POM from 2017–18 to 2021–22, by material type.

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Beverage aluminium	79,000	86,000	82,000	95,000	100,000
Non-beverage aluminium	13,000	14,000	7,000	7,000	11,000
Tin-plate steel	121,000	127,000	139,000	125,000	161,000
Mild steel	Not reported	19,000	19,000	26,000	24,000
Stainless steel	Not reported	0	1,000	0	1,000
Total	**213,000**	**246,000**	**248,000**	**254,000**	**298,000**

The estimated five-year CAGR for metal packaging POM from 2021–22 to 2026–27 is 1.9% per year.

Table 40 39 - Metal packaging POM from 2021–22 to 2026–27, by material type.

Material Type	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	CAGR
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	%
Beverage aluminium	100,000	101,000	102,000	103,000	104,000	105,000	1.0%
Non-beverage aluminium	11,000	11,000	12,000	12,000	12,000	13,000	2.5%
Tin-plate steel	161,000	165,000	169,000	173,000	177,000	181,000	2.4%
Mild steel	24,000	25,000	25,000	26,000	26,000	27,000	2.5%
Stainless steel	1,000	2,000	2,000	2,000	2,000	2,000	2.5%
Total	**298,000**	**304,000**	**310,000**	**316,000**	**322,000**	**328,000**	**1.9%**

Recovery[73]

Post-consumer metal packaging recovery in Australia in 2021–22 is estimated at around 151,000 tonnes (±20%), which was 3.9% of all post-consumer packaging recovery. Between 2020–21 and 2021–22 there was an increase in metal packaging recovery of 4,000 tonnes (+3%).

Around 97,000 tonnes (63.7%) of metal packaging were recovered through MSW collections, with another 36,000 tonnes (23.9%) recovered through separate CDS collections, and 18,000 tonnes (11.7%) through C&I collections. A small quantity of 1,000 tonnes (0.3%) was collected through C&D related collections.

[72] APCO, Australian Packaging Consumption and Recovery Data 2021-22
[73] Ibid.

Table 41 40 - Metal packaging recovery from 2017–18 to 2021–22, by material type.

Material Type	2017-18	2018-19	2019-20	2020-21	2021-22
	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Beverage aluminium	53,000	65,000	66,000	73,000	62,000
Non-beverage aluminium	4,000	3,000	3,000	3,000	3,000
Tin-plate steel	45,000	52,000	53,000	53,000	68,000
Mild steel	Not reported	17,000	17,000	18,000	18,000
Stainless steel	Not reported	0	1,000	0	0
Total	**102,000**	**137,000**	**139,000**	**147,000**	**151,000**

Most recovered metal went into unknown applications, as a consequence of the large international markets for aluminium and steel scrap, and the relatively small contribution of scrap metal packaging to these markets. Almost all recovered metal went overseas (99.3%), highlighting the strength of this material's export markets.

Table 41 - 42 Metal packaging recovery in 2021–22, by material type and material use application.

Material type	Packaging applications	Non-packaging applications	Unknown applications	Total
	(tonnes)	(tonnes)	(tonnes)	(tonnes)
Beverage aluminium	0	0	62,000	62,000
Non-beverage aluminium	0	0	3,000	3,000
Tin-plate steel	0	0	68,000	68,000
Mild steel	0	18,000	0	18,000
Stainless steel	0	0	0	0
Total (tonnes)	**0**	**19,000**	**133,000**	**151,000**
Total (%)	**0.0%**	**12.5%**	**87.5%**	**100.0%**

Table 42 - 43 Metal packaging recovery in 2021–22, by material type and destination of material.

Material type	Local	Overseas	Unknown destinations	Total
	(tonnes)	(tonnes)	(tonnes)	(tonnes)
Beverage aluminium	0	62,000	0	62,000
Non-beverage aluminium	0	3,000	0	3,000
Tin-plate steel	0	68,000	0	68,000
Mild steel	1,000	18,000	0	18,000
Stainless steel	0	0	0	0
Total (tonnes)	**1,000**	**150,000**	**0**	**151,000**
Total (%)	**0.7%**	**99.3%**	**0.0%**	**100.0%**

Manufacturing and reprocessing

Manufacturing process

Metal-based packaging materials are widely utilised in food packaging due to their excellent barrier properties and high recyclability. They come in various forms, including cans, barrels/drums and composite cans, and are often used as closures for glass bottles.

There are four main types of material used in packaging:

- Aluminium
- Tin-plate steel
- Mild steel
- Stainless steel

Aluminium[74]

1. Extraction and Refining
    - **Extraction and grinding**: Bauxite ore is extracted, rinsed of clay particles and passed through a grinder to produce a more consistent material.
    - **Crushing and digesting:** Ground mineral is pumped into pressure tanks with a caustic soda or sodium hydroxide solution and treated with heat to produce sodium aluminate slurry.
    - **Settling:** Slurry is passed through into lower pressure settling tanks to remove red mud and any further solids in the solution.
    - **Precipitation and calcination:** Solution is cooled and pumped into precipitators and blended with aluminium hydroxide seed crystals to form large aluminium crystals. These crystals are heated to remove impurities and create alumina.
2. Smelting
    - Alumina is reduced to aluminium through electrolysis.
3. Casting
    - Molten aluminium is cast into large ingots or slabs through processes such as direct chill casting. Ingots or slabs are re-melted and cast into smaller ingots, billets, or rolling slabs, depending on the final product requirements.
4. Rolling and finishing
    - **Rolling:** Aluminium slabs are hot rolled through rolling mills to produce thin sheets or plates. These sheets are then further cold rolled to obtain the required thickness and mechanical properties.
    - **Annealing and coating**: The rolled aluminium sheets may be annealed (heat-treated) or coated with finishes based on their intended use
    - **Forming**: The finished aluminium is converted into packaging products

Steel[75],[76]

1. Steel Making and Refining
    - **Iron conversion:** Iron is converted into steel by blowing oxygen through it using a basic oxygen furnace (BOF).

[74] https://www.basystems.co.uk/blog/aluminium-manufacturing-basics/
[75] https://www.thyssenkrupp-steel.com/en/products/packaging-steel/process-routes/
[76] https://www.steelmillsoftheworld.com/products/cs/tinplatecoils/Tinplate_manufacturing_route.pdf

- **Steel refining:** The steel undergoes additional refining to ensure a very clean and high-quality base metal.

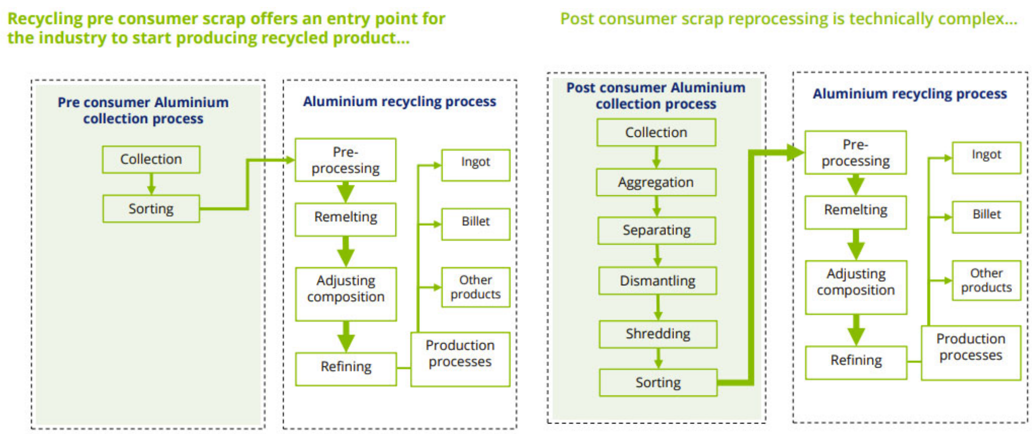
2. Rolling and Finishing

- **Rolling:** Steel slabs are hot rolled through rolling mills to produce thin sheets or plates. These sheets may then be further cold rolled to obtain the required thickness and mechanical properties.
- **Annealing:** Rolled sheets may undergo annealing (heat treatment) to relieve stresses and improve ductility.
- **(Tin plate steel) Electrolytic Tin Plating:** Coated with a thin layer of tin through an electrolytic process.

Recycling process

Comparing pre- and post-consumer reprocessing

Figure 20 Cast Anew: Opportunities to bring aluminium to life through manufacturing & recycling, Australian Aluminium Council, September 2022.



Pre-consumer scrap, generated during the production process of aluminium and its alloys, serves as a high-quality and cost-efficient feedstock for recycled billet production. This scrap offers simplicity and efficiency in recycling due to its quality and consistency.

Advantage of pre-consumer scrap

- Pre-consumer scrap stream directly feeds re-melters, enabling the production of recycled billets with enhanced efficiency.
- Originating directly from fabricators, pre-consumer scrap offers known quality and alloy composition, reducing preprocessing requirements.
- Efforts to optimise process efficiency often focus on minimising pre-consumer scrap generation.

Post-consumer scrap, collected from diverse sources such as construction sites, automobiles, solar frame and rails, and aluminium cans. It has more steps involving during collection process as shown on the diagram above.

Aluminium[77]

1. **Collection and sorting:** aluminium packaging materials are collected from a range of sources, including kerbside collection streams and container deposit scheme sources.
2. **Crushing and baling:** Sorted aluminium products are crushed by MRFs prior to baling for further reprocessing.
3. **Remelting and casting:** Uncoated scrap aluminium is re-melted to high temperatures and cast to produce aluminium ingots, ready to be used for new manufacturing. Coated aluminium scrap is passed through a rotary gas furnace prior to re-melting to remove any coatings.

Steel[78,79]

1. **Collection and sorting:** Steel packaging materials are collected from a range of sources, including kerbside collection streams and container deposit scheme sources. A series of technologies, including magnets, are used to provide effective means of separation.
2. **Crushing and baling:** Sorted steel products are crushed by MRFs prior to baling for further reprocessing.
3. **Shredding and melting:** The sorted steel packaging is shredded into smaller pieces to facilitate easier handling and more efficient melting. Shredded steel is fed into a furnace to produce steel ingots.
4. **Rolling and coiling:** Ingots are fed through sheet rollers and coiled to produce steel rolls.
5. **Manufacturing:** Steel sheets are cut and lacquered, and formed into a variety of steel packaging and non-packaging products.

Recycled content[80]

The PCR content of metal packaging was 40,000 tonnes, or 13% of total metal packaging POM, a small and probably insignificant decrease from 15% in the previous year.

The pre-consumer recycled content was 67,000 tonnes (22%), and 192,000 tonnes (64%) was sourced from virgin (primary) feedstocks.

The proportion of pre-consumer recycled content in aluminium based packaging is relatively high compared to other packaging material types due to the nature of aluminium goods manufacturing, which typically involves relatively large quantities of pre-consumer scrap generation.

[77] https://aluminium.org.au/about-aluminium/how-aluminium-is-made/recycling/
[78] Pooraka Bottle & Can. (2022, November 17). *Scrap Metal Recycling Process*. https://www.recyclingdepotadelaide.com.au/scrap-metal-recycling-process
[79] https://cms.ssc.nsw.gov.au/files/content/website/residents/waste-and-recycling/waste-education-posters-and-recycling-information/steelrecyclingprocessdiagram.pdf
[80] APCO, Australian Packaging Consumption and Recovery Data 2021-22

Table 44 43 - Metal packaging POM in 2021–22, by material type and recycled content.

Material type	Post-consumer source		Pre-consumer source		Virgin source		Total
	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)	(tonnes)
Beverage aluminium	24,000	24%	36,000	36%	40,000	40%	100,000
Non-beverage aluminium	1,000	6%	3,000	30%	7,000	65%	11,000
Tin-plate steel	12,000	7%	26,000	16%	124,000	77%	161,000
Mild steel	3,000	13%	2,000	6%	19,000	80%	24,000
Stainless steel	0	7%	0	14%	1,000	79%	1,000
Total	**40,000**	**13%**	**67,000**	**22%**	**192,000**	**64%**	**298,000**

As part of the 2021-22 Consumption and Recovery Study, packaging manufacturers were requested to provide percentage estimates of the easily achievable post-consumer recycled content (without major redesign or manufacturing equipment upgrades). It was reported that the easily achievable PCR content for metal packaging is 91%, compared to 13% currently.

Table 45 44 - Potential metal packaging post-consumer recycled content, by material type.

Material type	Current	Easily achievable
	(%)	(%)
Beverage aluminium	24%	95%
Non-beverage aluminium	6%	Insufficient data
Tin-plate steel	7%	85%
Mild steel	13%	Insufficient data
Stainless steel	7%	Insufficient data
Total	**13%**	**91%**

Key challenges[81]

Lack of sufficiently scaled demand

Establishing recycling partnerships with off-takers who have with clear emissions targets.

Lack of clear product specifications

Smelters leading the market by marketing products that are x% recycled with y% emissions.

Lack of recycling capacity reductions

Investing in modular, standalone recycling facilities rather than small-scale pilots using headroom in primary smelting facilities

Regulatory restrictions on reprocessing

Directly engaging with government [82] to develop standards for scrap quality & composition

[81] Australian Aluminium Council & Deloitte Touche Tohmatsu. (2022). *Opportunities to bring aluminium to life through manufacturing & recycling*. https://aluminium.org.au/wp-content/uploads/2022/11/Cast-Anew-Aluminium-Discussion-Paper_Public-FINAL.pdf
[82] Note: (1) such as the involvement the European Aluminium Association (EAA) and the Organisation of European Aluminium Refiners and Remelters (OEA) have had in shaping EU-25 scrap standards.

Availability and quality of scrap aluminium

Building dedicated scrap recycling facilities in central locations and close proximity to remelters.

Cost of scrap collection

Investing in supply partnerships & technology to drive economies of scale and margins
(Deloitte and Coreo, Australian Aluminium Council, 2022)

Australia's Current Aluminium Recycling Capability

Despite Australia's integrated primary aluminium sector, the closure of the car industry led to the shutdown of two aluminium rolling mills, resulting in the loss of manufacturing capabilities. As aluminium smelters cannot accept contaminated scrap, specialist recyclers handle both pre- and post-consumer scrap, exporting it for recycling due to logistical challenges and low recovery rates. Some domestic initiatives exist, such as Boyne Smelters Limited (BSL) and Capral Aluminium and Tomago Aluminium's partnership, aiming to increase recycled content and access low-carbon aluminium. However, most recyclers export their scrap to South Korea and Indonesia being major buyers, along with European countries and India.

Key opportunities

End markets and related specifications

Exported steel packaging undergoes rigorous sorting at Material Recovery Facilities (MRFs) to meet contamination and bale density standards. This ensures seamless integration into post-consumer metal pools for recycling. The recycled steel and aluminium are then utilised in diverse durable applications such as vehicles, construction materials, and other manufactured goods.

Australia's Potential Recycling Capability

In 2022, the Australian Aluminium Council collaborated with Deloitte and Coreo research[83] has identified significant opportunities for manufacturing and recycling through cross-value chain coordination, including with government agencies. Leveraging Australia's integrated aluminium industry presents opportunities for value-added manufacturing and redeveloping recycling capabilities as part of an integrated circular industry. This aligns with the need to transition regional economies and establish a new manufacturing base independent of mineral deposits.

Two projects have been proposed

1. **Increase recycling capacity** - Global demand for recycled aluminium is surging due to emerging minimum content regulations and corporate preferences for low-carbon goods. Implementing circular industry policies could reduce costs and risks associated with recycling domestic pre- and post-consumer scrap.
2. **A closed-loop mine-to-panel solar value chain** initiative aims to create a sustainable cycle from raw material mining to solar panel production. Aluminium, a key component, is already manufactured domestically for solar frames and rails. However, for true sustainability, solar panels and other renewables must be designed with recyclability in mind to minimise waste and promote a circular economy.

[83] *AAC, Deloitte and Coreo* (2024, March 20). *Cast Anew project - the Australian Aluminium Council*. The Australian Aluminium Council. https://aluminium.org.au/news/aac-deloitte-and-coreo-cast-anew-project/

International market demand

While Australia currently has limited post-consumer reprocessing of steel or aluminium packaging, international markets for these commodities remain robust. Two aluminium smelter operators in Tasmania and Queensland are reportedly exploring facility upgrades to accommodate used aluminium beverage cans, potentially enhancing local reprocessing capacity. This could provide some stability against fluctuations in international trading conditions.

- Prices for recovered tin-plate steel cans and aluminium beverage cans have shown significant recovery over the past three years since hitting lows in mid-2020. While they have tapered off from the peak prices observed in March 2022,[84] they remain at relatively high levels. Both tin-plate steel cans and aluminium beverage cans experienced a decline in prices from the exceptionally high levels seen in the first half of 2022 but have demonstrated resilience and steady growth through early 2023.
- The export trajectory of tin-plate steel cans and aluminium beverage cans witnessed a sharp decline from a peak in mid-2021 across the 2021–22 financial year, followed by a resurgence since mid-2022.[85] The elevated prices during the 2021–22 financial year likely led to the depletion of stockpiles accumulated by Material Recovery Facility (MRF) operators and scrap metal traders during the period of depressed prices in 2020. With the stockpile drawdown completed, exports have stabilised near the level of MRF sorting, with diminishing incentive to stockpile. Exports have exhibited an upward trend in 2023, correlating with increasing scrap metal prices.
- **Container costs have reverted to near pre-COVID-19 levels.** International freight expenses were exceptionally high from mid-2020 to early 2023, exerting downward pressure on exports.[86] The elevated freight costs likely contributed to the high metals' prices during this period, as exporters sought to recover the costs associated with container contracts. However, freight costs experienced a sharp decline throughout 2022, reaching levels comparable to pre-COVID conditions by early 2023.

[84] Recycling Victoria. (2023). *Recycling Victoria Market Insights Reports*. The State of Victoria Department of Energy, Environment and Climate Action. https://www.vic.gov.au/market-summary
[85] Ibid
[86] Ibid

Appendix E Overview of mechanical properties

Adapted from (Demets et al., 2021).

Technical characteristics of plastics, including their physical quantities, units and ISO standards.

Technical characteristic	Description	Property [unit]	Standards
Mechanical			
Strength	The material's ability to withstand an applied load without failure (tensile strength) or plastic deformation (yield stress).	Tensile strength σ_m [MPa]	ISO 527
		Flexural strength σ_f [MPa]	ISO 178
		Yield strength σ_y [MPa]	ISO 527
Stiffness	The material's resistance to elastic deformation.	Elastic modulus E [MPa]	
		Tensile modulus E_t [MPa]	ISO 527
		Flexural modulus E_f [MPa]	ISO 178
Toughness	The total energy a material can absorb/dissipate before failure.	Surface under tensile curve [J/m^3]	ISO 527
Ductility	The total plastic deformation a material can withstand under loading before failure.	Tensile strain at break ε_b [%]	ISO 527
Impact strength	The material's ability to withstand a sudden load at a high deformation rate without failure	Charpy (un) notched impact strength a_c [kJ/m^2]	ISO 179
		Izod un(notched) impact strength a_i [kJ/m^2]	ISO 180
		Dart drop impact m_f [g]	ISO 7765
Processability			
Ease of flow	A polymer's melt viscosity is defined as the measure of the rate at which polymer chains can move relative to each other, at a certain temperature and shear rate (Gilbert, 2017).	Melt viscosity η [Pa•s]	ISO 3219
	The polymer's mass extruded under a fixed load over a specified time through a die of specified length and diameter at a fixed temperature.	Melt -Flow Index MFI [g/10 min]	ISO 1133
	Polymer specific (i.e., PET). The intrinsic viscosity is a measure of duration of a dissolved polymer to dilute through a specified capillary, relative to the pure solvent.	Intrinsic Viscosity IV [dl/g]	ISO 1628

Appendix F Recycled content target analysis tool explanatory notes

Overview

To understand the impact and feasibility of recycled content targets on packaging placed on market in Australia, a preliminary Recycled Content Target Analysis Tool was developed.

The objectives of this tool are to:

- Produce a forecast of the packaging placed on market across Australia between 2022 and 2040.
- Assess the current recycled content levels for different packaging materials, both from international and domestic sources
- Estimate the recycled content tonnage requirements (total recycled content and Australian sourced recycled content) of tested scenarios based on stakeholder consultation and feedback
- Estimate the upper limit of Australian reprocessing capacity for a given material and technology and the suitability of its output in different applications (e.g. contact sensitive applications)

Limitations

The Recycled Content Target Analysis Tool is designed to capture the insights outlined above. However, at this stage the Tool does not include a range of considerations that will need to be explored via further consultation to develop a more comprehensive picture of collection, reprocessing and manufacturing under recycled content mandates. These include:

- **Upper limit recycled content capacity:** The Recycled Content Target Analysis Tool currently models the upper limit capacity of Australian reprocessors to provide recycled content feedstock for recycled content into packaging applications. It does not capture the actual outputs made available to packaging, nor does it capture the factors that may limit the actual output of the reprocessing sector, including alternative destinations for feedstocks, supply of collected material for reprocessing, or other operational challenges of reprocessors.
- **Suitability of recycled content into specific packaging applications:** The Recycled Content Target Analysis Tool includes estimates of reprocessing capacity and the applicability of reprocessing capacity to both food grade and non-food grade packaging applications. However, there are several reprocessors included in the dataset that can provide recycled material to packaging applications but where that recycled material cannot be used across all applicable packaging formats and applications.
- **No collection details:** The Recycled Content Target Analysis tool Analysis Tool does not capture the supply of collected material required for the reprocessing sector to operate at full capacity.
- **No commercial considerations:** The Recycled Content Target Analysis Tool does not capture the various commercial considerations that may impact the supply of or demand for recycled content from Australian sources. These may include cost differentials between virgin and recycled content (and associated incentives), competitive markets for recycled content, or existing contractual offtake arrangements made by reprocessors.

We recommend that further investigation of these areas be conducted during industry consultation.

Data sources and assumptions

The Recycled Content Target Analysis Tool contains data from a range of published and commissioned sources. The sources for each of the data inputs used in the Tool have been outlined i below.

Table 72 - 46 Data sources for Recycled Content Target Analysis Tool

Data Point	Data Source	Notes and assumptions applied
Packaging placed on market (POM)	APCO 2021-22 Consumption and Recovery Data Report. Analysis undertaken by Blue Environment.	The 2021-22 Consumption and Recovery Data Report contains detailed information on packaging placed on market at a material level. This data is gathered by the consultant, Blue Environment, via a series of detailed industry surveys conducted with major packaging manufacturers and contains information on recycled material levels, material provenance, contact sensitivity of packaging POM, and associated 5 year growth rates. Further analysis was conducted to derive further insights on contact sensitive and non-contact sensitive packaging placed on market, as well as further splits between rigid and flexible plastics. **Note**: In some cases, small discrepancies between the material level POM levels calculated in the Tool and the published results in the 2021-22 report and accompanying Material Fact Sheets may be present. These discrepancies are minor and do not materially impact the results of the tool.
Packaging growth rates	APCO 2021-22 Consumption and Recovery Data Report. Analysis undertaken by Blue Environment.	Packaging growth rates have been calculated using the 5 year component/format level growth rates for each packaging material, collected as part of the 2021-22 Consumption and Recovery Data Report manufacturer survey process. As reliable estimates of packaging growth are not available after this point, the same material intensities have been applied to population growth after this point to determine growth after 2027. The Recycled Content Target Setting Analysis Tool does not capture predicted changes from re-use or lightweighting of packaging over time beyond the estimates provided by survey respondents.
Domestic reprocessing capacity estimates	APCO 2021-22 Consumption and Recovery Data Report + additional analysis undertaken by Blue Environment and APCO.	The 2021-22 Consumption and Recovery Data Report contains a breakdown of domestic reprocessing capacity at a material group level (glass, paper and paperboard, metals, plastics). To determine a more granular breakdown of reprocessing capacity at the material level, further analysis was conducted by the consultant, Blue Environment, to determine a 5 year "in the gate" projection of planned and operational reprocessing capacity for each targeted material type. Further analysis was conducted by APCO to derive an "out the gate" projection for reprocessing to be reflective of tonnages potentially made available for packaging applications. The yields from reprocessing technologies were sourced from Blue Environment and from other published sources, and have been selected to be reflective of the packaging to packaging yield losses throughout the reprocessing value chain. **Note**: Reprocessing estimates have been provided by Blue Environment for the 5 years covering 2022 to 2027. After this point, reprocessing capacity is assumed to remain constant. Proposed facilities due to come online after 2027 have not been included in these projections as the reliability of these estimates is low.

Data Point	Data Source	Notes and assumptions applied
		Note: Estimates of reprocessing capacity were conducted at the facility and organisational level. In some instances, the stated capacity of these facilities includes recycled material estimates that can only partially be attributed to use in packaging applications or can only be used in certain packaging applications. As this is a commercial consideration of the business this capacity has been included in the estimate. More research will be needed to map particular outputs at the facility or organisational level to particular packaging formats and applications. **Note**: Domestic reprocessing estimates are representative of the key technology applied to collected pre and post consumer material and do not necessarily reflect the ability of the Australian market to produce packaging materials from the reprocessing technology entirely onshore. E.g. chemical recycling has been included in the model, but the additional refining technology to produce packaging recycled material has not been included. In some cases, this material is not able to be reprocessed into particular polymers using domestic reprocessing technology.
Survey upper and lower industry ambition estimates	APCO Recycled Content Target Setting Survey	Responses provided as part of the APCO Recycled Content Target Setting Survey were analysed by the APCO team to derive upper and lower industry ambition levels, based on the 75^{th} and 25^{th} percentile of responses, respectively. 2025 and 2030 ambition levels have been mapped to the “short term” targets of the survey. 2040 has been mapped to the “long term” target responses of the survey, and 2035 has been mapped to the midpoint of the short and long term responses from the survey.

Appendix G Stakeholder interview key insights

As part of the stakeholder engagement process for this project, APCO conducted a series of detailed stakeholder interviews with industry representatives. A total of 14 60-minute interviews were conducted, giving stakeholders the opportunity to provide additional context on their views on the challenges and opportunities involved in the development of recycled content mandates for packaging placed on market in Australia.

The interviews focussed on exploring the key political, economic, technological, and environmental dimensions involved in implementing mandates for recycled content in packaging. In addition, stakeholders were asked to provide additional context on their organisation, their current experience with recycled content and how they would be impacted by the implementation of recycled content mandates.

A full list of the stakeholders interviewed as part of the stakeholder interview process has been included in the stakeholder engagement summary in Appendix J Stakeholder .

Agreement amongst stakeholders

The following key insights were drawn from the stakeholder interview process, highlighting where broad agreement was obtained from the majority of stakeholders interviewed. These insights largely mirror the feedback received in the recycled content reference group discussions as well as the first principles designed for the project.

Formal mandates are the most important lever for delivering investment confidence and demand

In the absence of recycled content mandates, there is not a sufficient lever to drive the demand for recycled content in the Australian market. Providing industry with formal mandates for recycled content in packaging will help to deliver confidence to recyclers and reprocessors that total demand for the content they produce will be sufficient to provide a business case for additional facilities and technologies to increase their capacity to supply recycled content to the market.

Targets must be ambitious to drive investment and must lead ahead of current reprocessing capacities

Targets that are based on the current capacity of the reprocessing sector will bolster demand for those materials but will not encourage the development of additional capacity. Future targets must be designed in excess of the domestic reprocessing capacity for each material to encourage growth in the sector. At the same time, these targets must give industry the sufficient lead time to expand to meet projected market needs by the time targets come into effect.

Targets must include multi-year, incremental on ramp to forecast RC requirements

Discrete short term and long-term milestones are important but must by complemented by incremental increases to recycled content targets in the intervening years. Stepping recycled content mandates up progressively on an annual/biannual basis will provide help to ensure a steady build in recycled content offtake requirements over time.

The industry is motivated to support and provide recycled content, but needs demand uplift

While the market for some recycled content into packaging is strong, demand is often constrained by the price differential between virgin and recycled feedstocks. In the absence of a formal mandate for recycled content, there is not sufficient demand given the price differential, availability and technical constraints of recycled content.

Some targets should be set including international and domestic recycled content together, with an on ramp for increasing the Australian sourced content requirements over time. Others are well placed to deliver domestically.

The ability of the domestic reprocessing sector to deliver recycled content for packaging manufacturing varies greatly across material types. Targets should be sensitive to the availability of Australian recycled content over time to ensure that they are realistic and reflective of domestic capacity.

Large organisations are best placed to adapt to initial targets

Sourcing recycled content as well as ensuring traceability and compliance with a recycled content mandate will require significant investment by organisations in initial years. Larger organisations with dedicated packaging and procurement teams will be best placed to meet these requirements in the initial years of implementation.

Bi-partisan government support for eventual scheme will build confidence in longevity

Given the long investment time required to develop additional reprocessing infrastructure to increase the supply of recycled content in packaging applications, industry confidence would be increased by mandates achieving broad bi-partisan support that reduces the risk of policy change over time.

Key challenges

Material Availability and uptake

Competition for international recycled content is likely to rise

The international market for recycled content is likely to become more constrained as more jurisdictions introduce recycled content requirements.

Where high quality recycled content is available, demand is constrained by price

In the absence of a mandate, the price differential between recycled and virgin content is too great to drive broad uptake of recycled content (plastics).

International RC adds to supply chain complexity

The supply of recycled content into global production is likely to increase the complexity of supply chains.

Transfer of hazardous materials present in recycled content

For some packaging types, particularly paper and paperboard, hazardous chemicals may be transferred in the production of packaging from recycled sources. This is of particular concern in food contact fibre packaging.

Difficulty in uptake for smaller organisations

The introduction of mandated recycled content targets will favour larger organisations with established international supply chains who can establish long term agreements, conduct supply chain traceability and manage supply chain complexity. Smaller players cannot currently deal with these requirements.

Large brand owners & retailers have diverse supply chains

For retailers and some large brand owners, the suppliers who provide product and packaging have diverse levels of complexity in their ability to incorporate recycled content into their packaging.

Traceability and international influence

There is a lack of consistent traceability mechanisms employed across international suppliers

While some suppliers have verified traceability mechanisms (e.g. ISCC+), there is a general lack of clear traceability employed across international suppliers. Due diligence to determine provenance of recycled content is currently being conducted by larger organisations reviewing their supply chain rather than certification.

Australia has little power to influence international recycled content markets

Australia is a comparatively small market in the region and has little influence over international recycled content providers to improve traceability in their supply chains. European RC mandates may not drive this either as they are not key customers for these regional suppliers. The introduction of traceability requirements in Australia may lead to flight from Aus market, with international providers preferencing other jurisdictions with lower entry requirements.

Data maturity is diverse across industry

Establishing recycled content mandates requires comprehensive data management practices by all players across industry. The introduction of mandates will require sensitivity to the increased requirements on organisations reporting recycled content and scaling up to best practice over time.

Timing and investment cycles

There is a mismatch in offtake contract terms

Some brands are cautious with offtake and want to agree to shorter term offtake arrangements (2-3 years), while manufacturers need longer term agreements (5-7 years) to build investment case.

On pack visibility is important to demonstrate the brand efforts in incorporating recycled content

Brand owners need confidence in the long-term availability of high-quality feedstock to be able to be sure they can continue to make these on pack claims.

Australia is subject to international lag times for food contact clearance

Food contact suitability in Australia follows international guidelines (EU/ US FDA) and is subject to the lengthy approvals process of those jurisdictions.

Infrastructural upgrades require long lead times

Infrastructural upgrades to enable enhanced or additional reprocessing or manufacturing stages are subject to long lead times, and specialised equipment may become more scarce as other jurisdictions move toward recycled content mandates.

Other challenges

Renewable/Bio-based inputs need to be considered in mandates

Mandates should include special consideration of renewable and bio-based inputs in packaging applications as these continue to develop.

Change in profile of recovery sector

Collection and reprocessing is a network. In some cases, players in this sector will need to undergo a change in profile, from extractors of valuable materials to being an integrated member of circular markets.

Further research on material deterioration

While resin manufacturers are aware that materials need to be appropriate for multiple reprocessing cycles, further research is needed to understand how deterioration impacts material quality over time and the need for further additives to maintain performance.

Short term impacts of recyclability

Some substitute materials with higher recyclability potential (e.g. mono-material films) may require more material to be used to achieve same performance outcomes.

Key opportunities

Long term offtake agreements provide confidence for investment

Successes have been seen in the market where long-term offtake agreements have been established. Fostering these markets enable investment certainty by providing clear business case.

Policy certainty will provide investment case

A well-articulated pathway for recycled content mandates over time is seen as the critical lever for investment certainty across the market.

Ecosystem approach to circularity for first movers

Industry collaboration and partnerships across collection, reprocessing and recycled content generation are critical for establishing the system.

International providers can provide secondary processing of chemical recycling outputs

International markets have capacity for the refinement and polymerisation of food grade recycled content, creating an opportunity for international networks to derive recycled content.

Appendix H Recycled content target visualisers

Interpretation of results

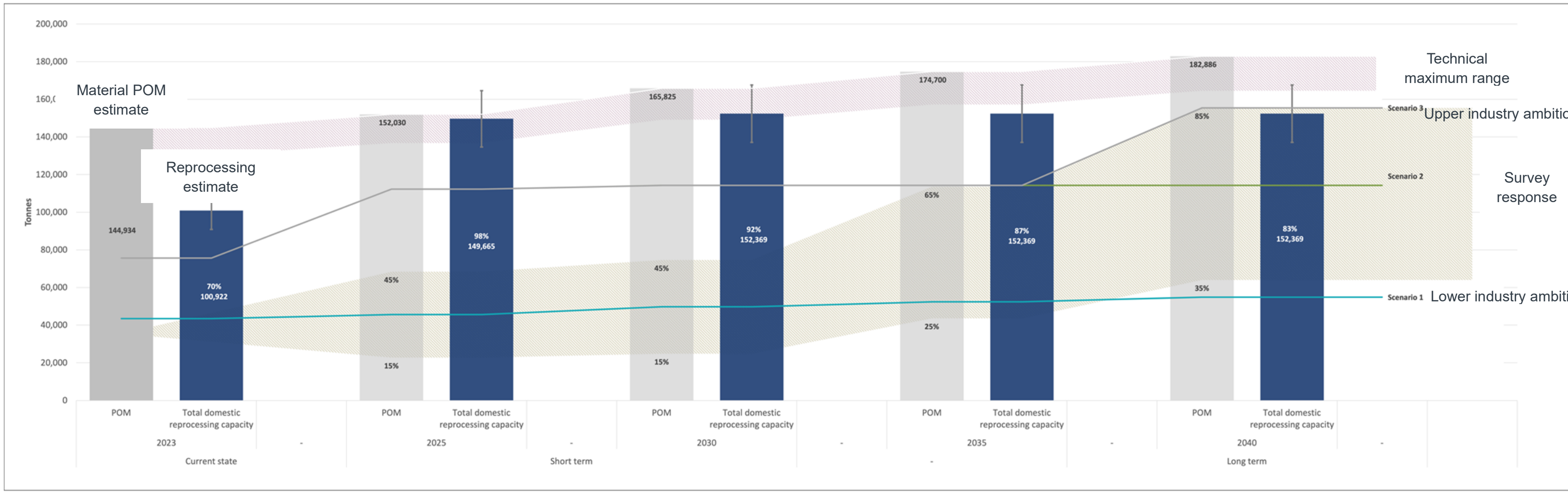
For each tested material type, APCO have prepared a summary chart and accompanying data table to illustrate:

- The material placed on market in 2023, 2025, 2030, 2035 and 2040, based on projected growth rates of each material.
- The total domestic reprocessing capacity in the given year[87] as well as the excess reprocessing capacity beyond the upper limit of industry ambition for the given year.
- The upper and lower industry ambition levels from the industry target setting survey, based on the 75th percentile and 25th percentile, respectively[88].
- The results of the tested scenarios against domestic recycled material needs and domestic reprocessing capacity.

An annotated example of the summary chart has been provided below.

[87] Note: reprocessing estimates have been calculated over the 5 years to 2027 and assumed constant after this point.
[88] Note: 2025 and 2030 ambition levels have been mapped to the "short term" targets of the survey. 2040 has been mapped to the "long term" target responses of the survey, and 2035 has been mapped to the midpoint of the short and long term responses from the survey.

Figure 21 Example output of recycled content target analysis tool



Rigid PET - Reprocessing, Recycled Content and Food Grade Suitability

Material context

- Industry has indicated that in some cases they are already using up to 100% recycled PET material in both food grade and non-food grade packaging formats. However, there is variability in the indicative technical maximum at a format and application level and this should be considered in the target setting process.
- Feedback from industry is that while facilities may be able to produce food grade recycled material, some proportion of the available reprocessing capacity to food grade applications will produce non-food grade recycled material only. Reprocessing surveys conducted as part of the analysis asked respondents to classify the output material splits by food grade and non-food grade suitability. However, where publicly available information was used in lieu of survey responses, primarily food grade facilities were allocated to food grade capacity. As such, the food grade capacity is likely to be lower than reported and the non-food grade capacity higher than reported.

Table 47 Rigid PET 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Sorting and shredding	Flake	44,190	44,190	44,190	47,037	47,037
Food grade	Sorting, shredding and pelletising	Pellets	35,066	35,066	66,375	66,375	66,375
Food grade	Sorting, shredding and product manufacture	Product manufacture	26,977	26,977	46,977	46,977	46,977
Food grade	**Total**		**106,234**	**106,234**	**157,542**	**160,389**	**160,389**
Non-food grade	Sorting and shredding	Flake	15,201	15,201	15,201	15,201	15,201
Non-food grade	Sorting, shredding and pelletising	Pellets	-	-	-	12,000	12,000
Non food grade	**Total**	Flake	**15,201**	**15,201**	**15,201**	**27,201**	**27,201**

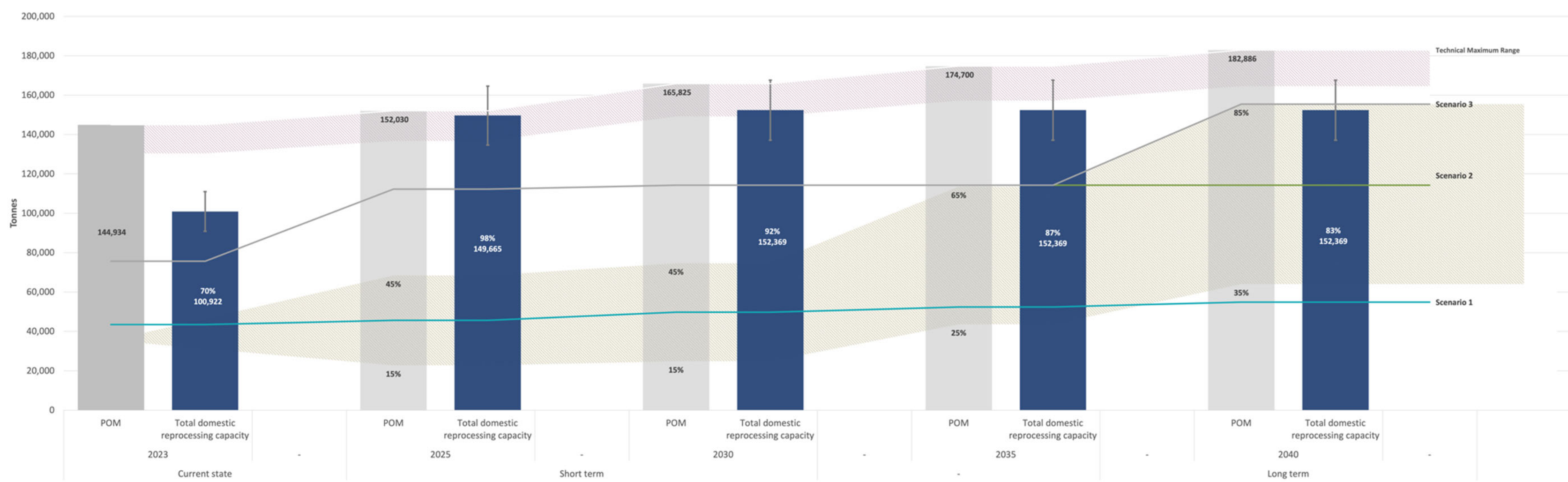
Table 48 Rigid PET 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Sorting and shredding	95%	Flake	41,981	41,981	41,981	44,685	44,685
Food grade	Sorting, shredding and pelletising	95%	Pellets	33,313	33,313	63,056	63,056	63,056
Food grade	Sorting, shredding and product manufacture	95%	Product manufacture	25,628	25,628	44,628	44,628	44,628
Food grade	**Total**			**100,922**	**100,922**	**149,665**	**152,369**	**152,369**
Non-food grade	Sorting and shredding	95%	Flake	14,441	14,441	14,441	14,441	14,441
Non-food grade	Sorting, shredding and pelletising	95%	Pellets	-	-	-	11,400	11,400
Non food grade	**Total**		Flake	**14,441**	**14,441**	**14,441**	**25,841**	**25,841**

Table 49 Rigid PET recycled content estimates and food grade splits by component

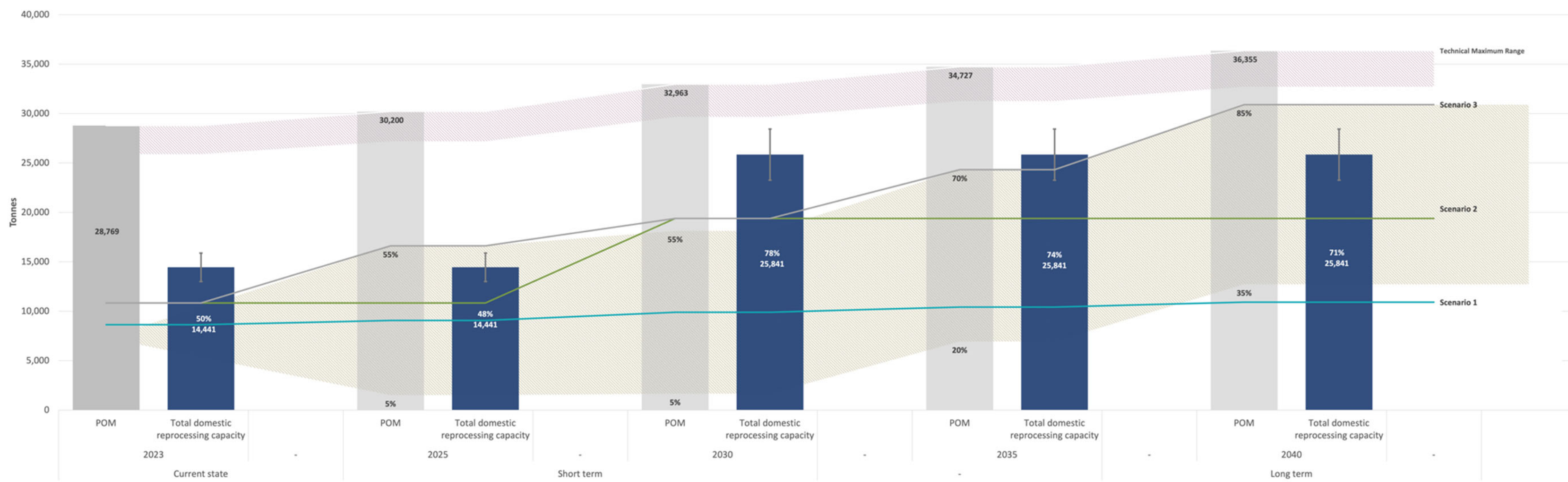
Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Bottle or jar	116,659	26,194	4,745	-	146	73	85,502	83%	17%
Closure or label	384	-	-	-	-	-	384	100%	0%
Tableware	6,413	10	-	-	-	-	6,403	98%	2%
Tub, tray or punnet	45,110	4,478	2,763	629	1,887	1,592	33,760	83%	17%
Other component group	186	-	-	-	-	44	142	6%	94%
Unknown	4,951	613	152	-	-	-	4,186	74%	26%
Total	**173,703**	**31,296**	**7,659**	**629**	**2,033**	**1,709**	**130,376**	**83%**	**17%**

Rigid PET – food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	144,934	152,030	165,825	174,700	182,886
	Reprocessing (tonnes)	100,922	149,665	152,369	152,369	152,369
Scenario 1	Total recycled content (%)	30%	30%	30%	30%	30%
	Australian recycled content (%)	30%	30%	30%	30%	30%
	Total tonnage requirements (tonnes)	43,480	45,609	49,747	52,410	54,866
	Australian tonnage requirements (tonnes)	43,480	45,609	49,747	52,410	54,866
	Domestic surplus (shortfall) – (tonnes)	57,442	104,056	102,622	99,959	97,504
Scenario 2	Total recycled content (%)	52%	74%	69%	65%	62%
	Australian recycled content (%)	52%	74%	69%	65%	62%
	Total tonnage requirements (tonnes)	75,692	112,249	114,277	114,277	114,277
	Australian tonnage requirements (tonnes)	75,692	112,249	114,277	114,277	114,277
	Domestic surplus (shortfall) – (tonnes)	25,231	37,416	38,092	38,092	38,092
Scenario 3	Total recycled content (%)	52%	74%	69%	65%	85%
	Australian recycled content (%)	52%	74%	69%	65%	62%
	Total tonnage requirements (tonnes)	75,692	112,249	114,277	114,277	155,453
	Australian tonnage requirements (tonnes)	75,692	112,249	114,277	114,277	114,277
	Domestic surplus (shortfall) – (tonnes)	25,231	37,416	38,092	38,092	38,092
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	90%	90%	90%	90%	90%
	Upper range tonnage requirements	144,934	152,030	165,825	174,700	182,886
	Lower range tonnage requirements	130,441	136,827	149,242	157,230	164,597
	Lower range domestic surplus (shortfall)	(29,519)	12,838	3,127	(4,861)	(12,228)

Rigid PET – Non-food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	28,769	30,200	32,963	34,727	36,355
	Reprocessing (tonnes)	14,441	14,441	25,841	25,841	25,841
Scenario 1	Total recycled content (%)	30%	30%	30%	30%	30%
	Australian recycled content (%)	30%	30%	30%	30%	30%
	Total tonnage requirements (tonnes)	8,631	9,060	9,889	10,418	10,906
	Australian tonnage requirements (tonnes)	8,631	9,060	9,889	10,418	10,906
	Domestic surplus (shortfall) – (tonnes)	5,811	5,381	15,952	15,423	14,935
Scenario 2	Total recycled content (%)	38%	36%	59%	56%	53%
	Australian recycled content (%)	38%	36%	59%	56%	53%
	Total tonnage requirements (tonnes)	10,831	10,831	19,381	19,381	19,381
	Australian tonnage requirements (tonnes)	10,831	10,831	19,381	19,381	19,381
	Domestic surplus (shortfall) – (tonnes)	3,610	3,610	6,460	6,460	6,460
Scenario 3	Total recycled content (%)	38%	55%	59%	70%	85%
	Australian recycled content (%)	38%	36%	59%	56%	53%
	Total tonnage requirements (tonnes)	10,831	16,610	19,381	24,309	30,902
	Australian tonnage requirements (tonnes)	10,831	10,831	19,381	19,381	19,381
	Domestic surplus (shortfall) – (tonnes)	3,610	3,610	6,460	6,460	6,460
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	90%	90%	90%	90%	90%
	Upper range tonnage requirements	28,769	30,200	32,963	34,727	36,355
	Lower range tonnage requirements	25,892	27,180	29,667	31,255	32,719
	Lower range domestic surplus (shortfall)	(11,450)	(12,739)	(3,826)	(5,413)	(6,878)

Rigid HDPE - Reprocessing, Recycled Content and Food Grade Suitability

Material context

- Industry has indicated that in some cases they are already using up to 50% recycled material in food grade and up to 100% recycled material in non-food grade packaging formats. However, there is variability in the indicative technical maximum at a format and application level and this should be considered in the target setting process.
- Feedback from industry is that while facilities may be able to produce food grade recycled material, some proportion of the available reprocessing capacity to food grade applications will produce non-food grade recycled material only. Reprocessing surveys conducted as part of the analysis asked respondents to classify the output material splits by food grade and non-food grade suitability. However, where publicly available information was used in lieu of survey responses, primarily food grade facilities were allocated to food grade capacity. As such, the food grade capacity is likely to be lower than reported and the non-food grade capacity higher than reported.

Table 50 Rigid HDPE 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Compaction, extrusion and product manufacturing	Product manufacture	237	237	237	237	237
Food grade	Sorting and shredding	Flake	70,540	70,540	70,540	77,802	77,802
Food grade	Sorting, shredding and pelletising	Pellets	3,886	3,886	21,732	21,732	21,732
Food grade	Sorting, shredding and product manufacture	Product manufacture	3,866	3,866	3,866	3,870	3,870
Food grade	Total		**78,530**	**78,530**	**96,376**	**103,641**	**103,641**
Non-food grade	Compaction, extrusion and product manufacturing	Product manufacture	126	126	126	126	126
Non-food grade	Sorting and shredding	Flake	43,886	43,886	43,886	43,886	46,286
Non-food grade	Sorting, shredding and pelletising	Pellets	10,300	10,300	10,300	17,230	17,320
Non-food grade	Sorting, shredding and product manufacture	Product manufacture	19,529	19,529	19,529	24,314	24,314
Non-food grade	Total		**73,841**	**73,841**	**73,841**	**85,557**	**88,047**

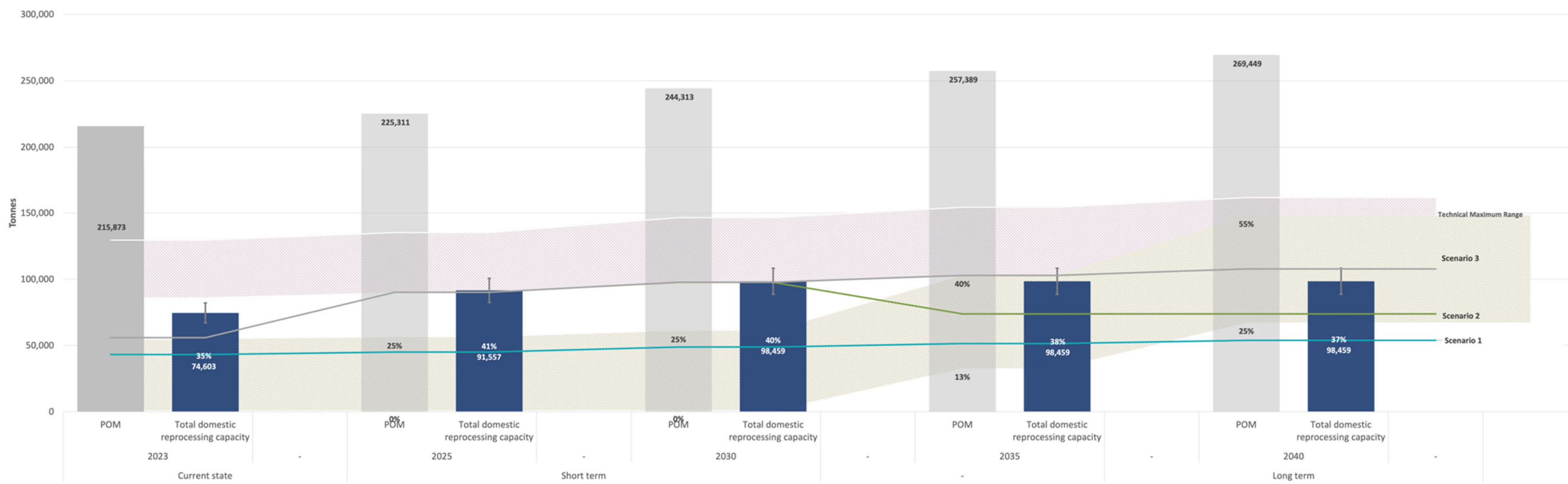
Table 51 Rigid HDPE 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Compaction, extrusion and product manufacturing	95%	Product manufacture	225	225	225	225	225
Food grade	Sorting and shredding	95%	Flake	67,013	67,013	67,013	73,912	73,912
Food grade	Sorting, shredding and pelletising	95%	Pellets	3,691	3,691	20,645	20,645	20,645
Food grade	Sorting, shredding and product manufacture	95%	Product manufacture	3,673	3,673	3,673	3,677	3,677
Food grade	Total			**74,603**	**74,603**	**91,557**	**98,459**	**98,459**
Non-food grade	Compaction, extrusion and product manufacturing	95%	Product manufacture	120	120	120	120	120
Non-food grade	Sorting and shredding	95%	Flake	41,692	41,692	41,692	41,692	43,972
Non-food grade	Sorting, shredding and pelletising	95%	Pellets	9,785	9,785	9,785	16,368	16,454
Non-food grade	Sorting, shredding and product manufacture	95%	Product manufacture	18,552	18,552	18,552	23,099	23,099
Non-food grade	Total			**70,149**	**70,149**	**70,149**	**81,279**	**83,645**

Table 52 Rigid HDPE recycled content estimates and food grade splits by component

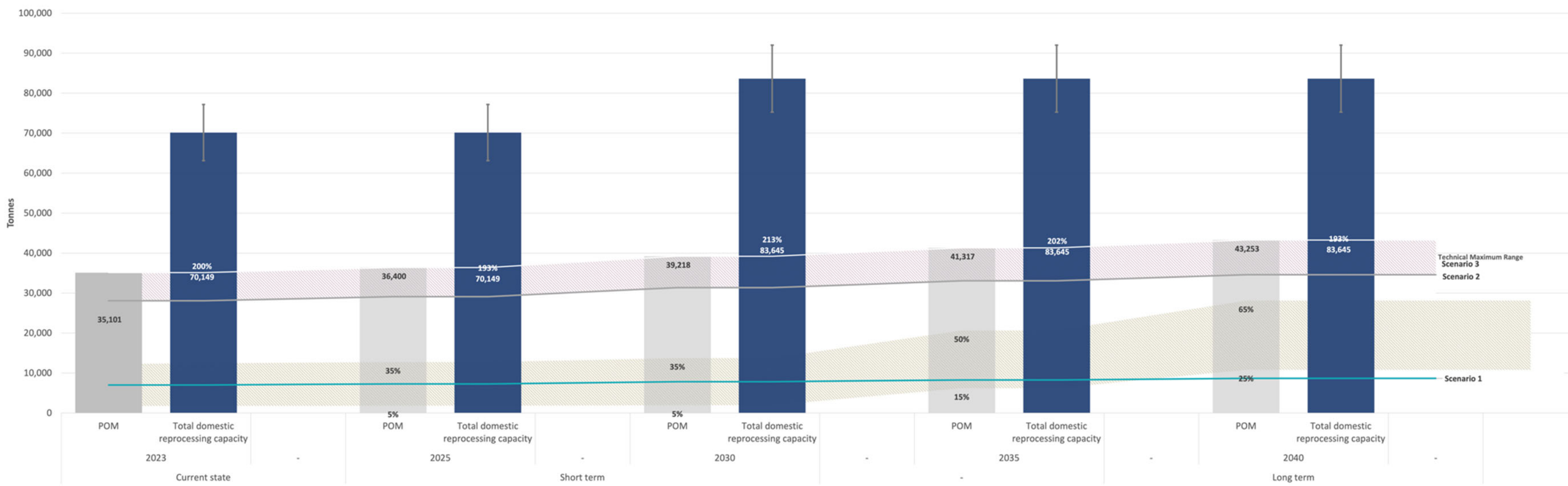
Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Barrel or drum	11,920	340	136	1,988	122	-	9,334	73%	27%
Bottle or jar	195,584	14,346	3,241	42,920	464	-	134,613	87%	13%
Closure or label	9,923	898	145	2,546	-	-	6,334	90%	10%
Pallet or bin	4,664	1,220	68	1,179	-	-	2,197	40%	60%
Returnable plastic crate	141	-	-	-	-	-	141	0%	100%
Tube or cartridge	2,554	128	51	746	-	-	1,630	55%	45%
Other component group	163	-	2	7	32	-	122	81%	19%
Unknown	26,025	1,330	78	2,736	-	-	21,882	93%	7%
Total	**250,974**	**18,263**	**3,721**	**52,122**	**618**	**-**	**176,251**	**86%**	**14%**

Rigid HDPE – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	215,873	225,311	244,313	257,389	269,449
	Reprocessing (tonnes)	74,603	91,557	98,459	98,459	98,459
Scenario 1	Total recycled content (%)	20%	20%	20%	20%	20%
	Australian recycled content (%)	20%	20%	20%	20%	20%
	Total tonnage requirements (tonnes)	43,175	45,062	48,863	51,478	53,890
	Australian tonnage requirements (tonnes)	43,175	45,062	48,863	51,478	53,890
	Domestic surplus (shortfall) – (tonnes)	31,428	46,495	49,597	46,981	44,569
Scenario 2	Total recycled content (%)	26%	40%	40%	29%	27%
	Australian recycled content (%)	26%	40%	40%	29%	27%
	Total tonnage requirements (tonnes)	55,952	90,124	97,725	73,844	73,844
	Australian tonnage requirements (tonnes)	55,952	90,124	97,725	73,844	73,844
	Domestic surplus (shortfall) – (tonnes)	18,651	1,433	734	24,615	24,615
Scenario 3	Total recycled content (%)	26%	40%	40%	40%	40%
	Australian recycled content (%)	26%	40%	40%	29%	27%
	Total tonnage requirements (tonnes)	55,952	90,124	97,725	102,956	107,780
	Australian tonnage requirements (tonnes)	55,952	90,124	97,725	73,844	73,844
	Domestic surplus (shortfall) – (tonnes)	18,651	1,433	734	24,615	24,615
Technical Maximum	Technical Max Upper Range	60%	60%	60%	60%	60%
	Technical max lower range	40%	40%	40%	40%	40%
	Upper range tonnage requirements	129,524	135,186	146,588	154,433	161,670
	Lower range tonnage requirements	86,349	90,124	97,725	102,956	107,780
	Lower range domestic surplus (shortfall)	(11,746)	1,433	734	(4,496)	(9,320)

Rigid HDPE – Non-food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	35,101	36,400	39,218	41,317	43,253
	Reprocessing (tonnes)	70,149	70,149	83,645	83,645	83,645
Scenario 1	Total recycled content (%)	20%	20%	20%	20%	20%
	Australian recycled content (%)	20%	20%	20%	20%	20%
	Total tonnage requirements (tonnes)	7,020	7,280	7,844	8,263	8,651
	Australian tonnage requirements (tonnes)	7,020	7,280	7,844	8,263	8,651
	Domestic surplus (shortfall) – (tonnes)	63,129	62,869	75,801	75,381	74,994
Scenario 2	Total recycled content (%)	80%	80%	80%	80%	80%
	Australian recycled content (%)	80%	80%	80%	80%	80%
	Total tonnage requirements (tonnes)	28,081	29,120	31,374	33,054	34,602
	Australian tonnage requirements (tonnes)	28,081	29,120	31,374	33,054	34,602
	Domestic surplus (shortfall) – (tonnes)	42,069	41,030	52,270	50,591	49,042
Scenario 3	Total recycled content (%)	80%	80%	80%	80%	80%
	Australian recycled content (%)	80%	80%	80%	80%	80%
	Total tonnage requirements (tonnes)	28,081	29,120	31,374	33,054	34,602
	Australian tonnage requirements (tonnes)	28,081	29,120	31,374	33,054	34,602
	Domestic surplus (shortfall) – (tonnes)	42,069	41,030	52,270	50,591	49,042
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	80%	80%	80%	80%	80%
	Upper range tonnage requirements	35,101	36,400	39,218	41,317	43,253
	Lower range tonnage requirements	28,081	29,120	31,374	33,054	34,602
	Lower range domestic surplus (shortfall)	42,069	41,030	52,270	50,591	49,042

Rigid PP - Reprocessing, Recycled Content and Food Grade Suitability

Material context

- Results from the reprocessing capacity analysis indicate that there is some domestic capacity to deliver food grade rigid PP to packaging applications. This is not inclusive of the allocation of chemical recycling capacity due to come online over the 5 year reprocessing projection period. Chemical recycling capacity has been allocated to flexible PE and PP packaging.
- Industry feedback is that there is not currently a method available for mechanical recycling of rigids PP to get US F&DA food contact without limitations. As such, chemical recycling may be the only viable pathway for food grade PP applications until a mechanical recycling pathway into food grade applications is available in Australia. As chemical recycling is yet to operate at a commercial scale in Australia, predicting the material specific capacities for chemical recycling technologies is uncertain at this time and should be considered in the target setting and consultation process.

Table 53 Rigid PP 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Compaction, extrusion and product manufacturing	Product manufacture	1,376	1,376	1,376	1,376	1,376
Food grade	Sorting and shredding	Flake	11,793	11,793	11,793	11,793	11,793
Food grade	Sorting, shredding and pelletising	Pellets	-	-	12,615	12,615	12,615
Food grade	Total	**Total**	**13,169**	**13,169**	**25,785**	**25,785**	**25,785**
Non-food grade	Sorting and shredding	Flake	10,211	10,211	10,211	10,211	10,211
Non-food grade	Sorting, shredding and pelletising	Pellets	2,841	2,841	2,841	15,091	15,091
Non-food grade	Sorting, shredding and product manufacture	Product manufacture	8,188	8,188	8,188	12,588	12,588
Non-food grade	Total	**Total**	**21,240**	**21,240**	**21,240**	**37,889**	**37,889**

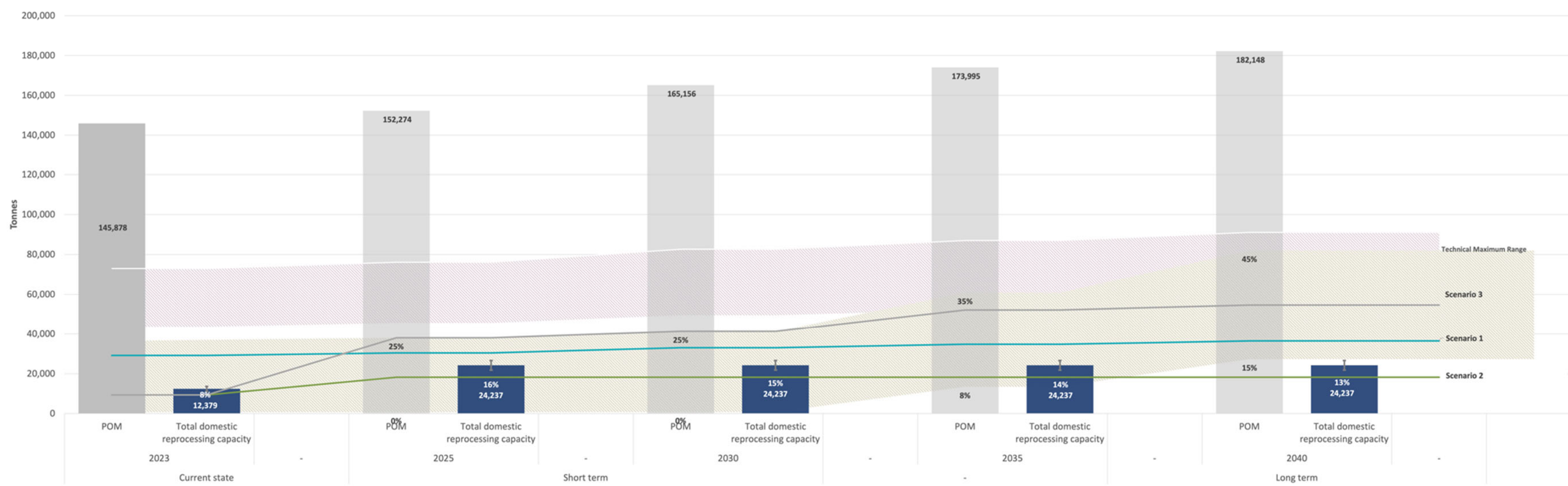
Table 54 Rigid PP 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Compaction, extrusion and product manufacturing	94%	Product manufacture	1,293	1,293	1,293	1,293	1,293
Food grade	Sorting and shredding	94%	Flake	11,086	11,086	11,086	11,086	11,086
Food grade	Sorting, shredding and pelletising	94%	Pellets	-	-	11,858	11,858	11,858
Food grade	Total		**Total**	**12,379**	**12,379**	**24,237**	**24,237**	**24,237**
Non-food grade	Sorting and shredding	94%	Flake	9,598	9,598	9,598	9,598	9,598
Non-food grade	Sorting, shredding and pelletising	94%	Pellets	2,670	2,670	2,670	14,185	14,185
Non-food grade	Sorting, shredding and product manufacture	94%	Product manufacture	7,697	7,697	7,697	11,833	11,833
Non-food grade	Total		**Total**	**19,965**	**19,965**	**19,965**	**35,616**	**35,616**

Table 55 Rigid PP recycled content estimates and food grade splits by component

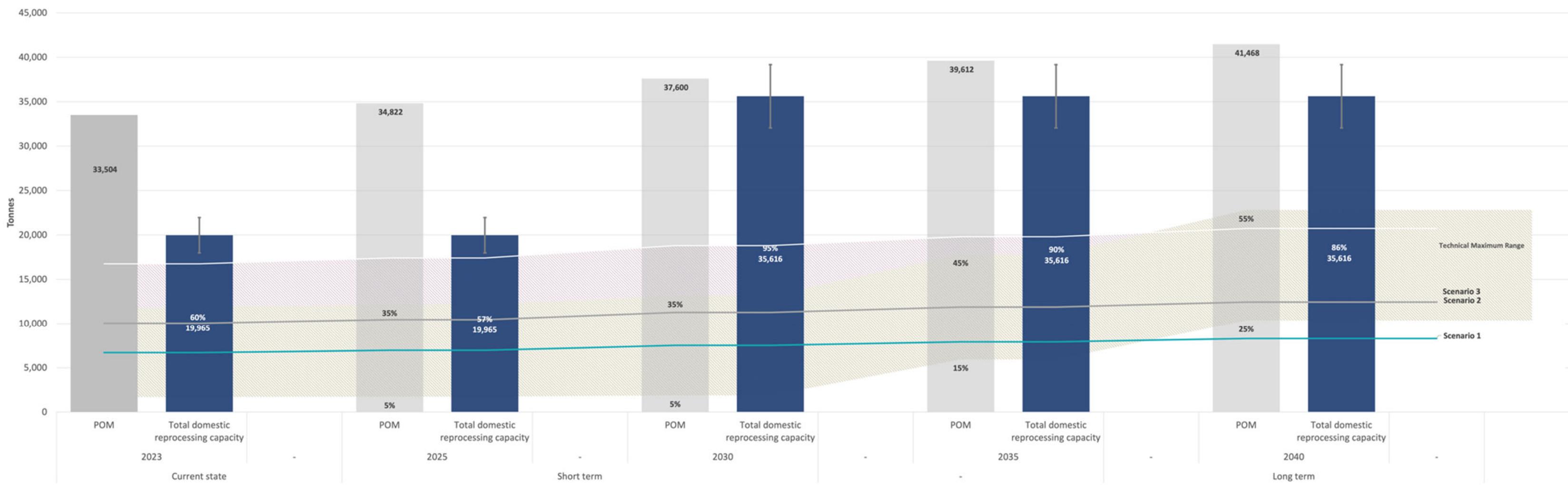
Format	**Material Placed on Market**	**Packaging Material Sourced Locally**			**Packaging material sourced from overseas**			**Food grade suitability**	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Barrel or drum	17,762	-	4	-	-	-	17,758	100%	0%
Bottle or jar	16,005	732	489	3,985	-	-	10,798	79%	21%
Carton or box	3,401	-	8	3,393	-	-	-	0%	100%
Closure or label	20,390	367	259	5,319	2	-	14,443	92%	8%
Pallet or bin	1,000	-	-	-	950	-	50	0%	100%
Returnable plastic crate (RPC)	107	-	-	107	-	-	-	93%	7%
Tableware	2,019	-	-	74	-	-	1,945	100%	0%
Tub, tray or punnet	83,002	12,540	2,055	25,958	-	691	41,758	76%	24%
Other component group	3,751	-	8	3,382	-	87	274	9%	91%
Unknown	31,947	473	355	1,117	-	-	30,002	97%	3%
Total	**179,382**	**14,112**	**3,177**	**43,335**	**952**	**778**	**117,028**	**81%**	**19%**

Rigid PP – Food contact



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	145,878	152,274	165,156	173,995	182,148
	Reprocessing (tonnes)	12,379	24,237	24,237	24,237	24,237
Scenario 1	Total recycled content (%)	20%	20%	20%	20%	20%
	Australian recycled content (%)	20%	20%	20%	20%	20%
	Total tonnage requirements (tonnes)	29,176	30,455	33,031	34,799	36,430
	Australian tonnage requirements (tonnes)	29,176	30,455	33,031	34,799	36,430
	Domestic surplus (shortfall) – (tonnes)	(16,797)	(6,217)	(8,794)	(10,562)	(12,192)
Scenario 2	Total recycled content (%)	6%	12%	11%	10%	10%
	Australian recycled content (%)	6%	12%	11%	10%	10%
	Total tonnage requirements (tonnes)	9,284	18,178	18,178	18,178	18,178
	Australian tonnage requirements (tonnes)	9,284	18,178	18,178	18,178	18,178
	Domestic surplus (shortfall) – (tonnes)	3,095	6,059	6,059	6,059	6,059
Scenario 3	Total recycled content (%)	8%	25%	25%	30%	30%
	Australian recycled content (%)	6%	12%	11%	10%	10%
	Total tonnage requirements (tonnes)	12,379	38,069	41,289	52,199	54,644
	Australian tonnage requirements (tonnes)	9,284	18,178	18,178	18,178	18,178
	Domestic surplus (shortfall) – (tonnes)	3,095	6,059	6,059	6,059	6,059
Technical Maximum	Technical Max Upper Range	50%	50%	50%	50%	50%
	Technical max lower range	30%	30%	30%	30%	30%
	Upper range tonnage requirements	72,939	76,137	82,578	86,998	91,074
	Lower range tonnage requirements	43,763	45,682	49,547	52,199	54,644
	Lower range domestic surplus (shortfall)	(31,384)	(21,445)	(25,309)	(27,961)	(30,407)

Rigid PP – Non-food contact



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	33,504	34,822	37,600	39,612	41,468
	Reprocessing (tonnes)	19,965	19,965	35,616	35,616	35,616
Scenario 1	Total recycled content (%)	20%	20%	20%	20%	20%
	Australian recycled content (%)	20%	20%	20%	20%	20%
	Total tonnage requirements (tonnes)	6,701	6,964	7,520	7,922	8,294
	Australian tonnage requirements (tonnes)	6,701	6,964	7,520	7,922	8,294
	Domestic surplus (shortfall) – (tonnes)	13,264	13,001	28,096	27,694	27,322
Scenario 2	Total recycled content (%)	30%	30%	30%	30%	30%
	Australian recycled content (%)	30%	30%	30%	30%	30%
	Total tonnage requirements (tonnes)	10,051	10,447	11,280	11,884	12,440
	Australian tonnage requirements (tonnes)	10,051	10,447	11,280	11,884	12,440
	Domestic surplus (shortfall) – (tonnes)	9,914	9,519	24,336	23,732	23,176
Scenario 3	Total recycled content (%)	30%	30%	30%	30%	30%
	Australian recycled content (%)	30%	30%	30%	30%	30%
	Total tonnage requirements (tonnes)	10,051	10,447	11,280	11,884	12,440
	Australian tonnage requirements (tonnes)	10,051	10,447	11,280	11,884	12,440
	Domestic surplus (shortfall) – (tonnes)	9,914	9,519	24,336	23,732	23,176
Technical Maximum	Technical Max Upper Range	50%	50%	50%	50%	50%
	Technical max lower range	30%	30%	30%	30%	30%
	Upper range tonnage requirements	16,752	17,411	18,800	19,806	20,734
	Lower range tonnage requirements	10,051	10,447	11,280	11,884	12,440
	Lower range domestic surplus (shortfall)	9,914	9,519	24,336	23,732	23,176

Flexible HDPE -Reprocessing, Recycled Content and Food Grade Suitability

Material context

- For food grade packaging, the current reprocessing capacity for flexible plastics remains low. Projected increases in chemical recycling capacity over the five year projected capacity analysis will increase this capacity, but it will remain low within the examined period. Future expansion of chemical recycling facilities to increase capacity have not been included in the analysis at this time as either the timeframe indicated or the level of certainty of the planned capacity increase did not meet the specifications of the analysis.
- As chemical recycling is yet to operate at a commercial scale in Australia, predicting the material specific capacities for chemical recycling technologies is uncertain at this time and should be considered in the target setting and consultation process. The indicative capacity splits used for chemical recycling capacity are 40% flexible HDPE, 20% flexible LDPE and 40% flexible PP.
- Where possible, non-food grade capacity has been included only where the capacity could potentially deliver recycled material into packaging. However, due to due to the complexity in splitting reprocessing capacity for organisations that have both packaging and non-packaging offtake pathways, this capacity is likely above that made available to packaging applications. Non-food grade packaging material may also not be suitable for all packaging applications.
- The closure of Qenos as a manufacturer of flexible PE limits the ability of the Australian domestic reprocessing sector to produce food grade PE without the need for further refinement offshore. The scope of the reprocessing capacity outlined below extends only to the chemical recycling process. Industry feedback indicates there are regional markets capable of refinement of PE using Australian chemically recycled material.

Table 56 Flexible HDPE 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Chemical recycling	Liquid hydrocarbons	6	6	5,839	13,839	13,839
Food grade	Sorting and shredding	Flake	26	26	26	26	26
Food grade	**Total**		**32**	**32**	**5,866**	**13,866**	**13,866**
Non-food grade	Compaction, extrusion and product manufacturing	Product manufacture	45	45	45	45	45
Non-food grade	Sorting, shredding and product manufacture	Product manufacture	1,769	1,769	1,799	30,499	30,499
Non-food grade	**Total**		**1,814**	**1,814**	**1,844**	**30,544**	**30,544**

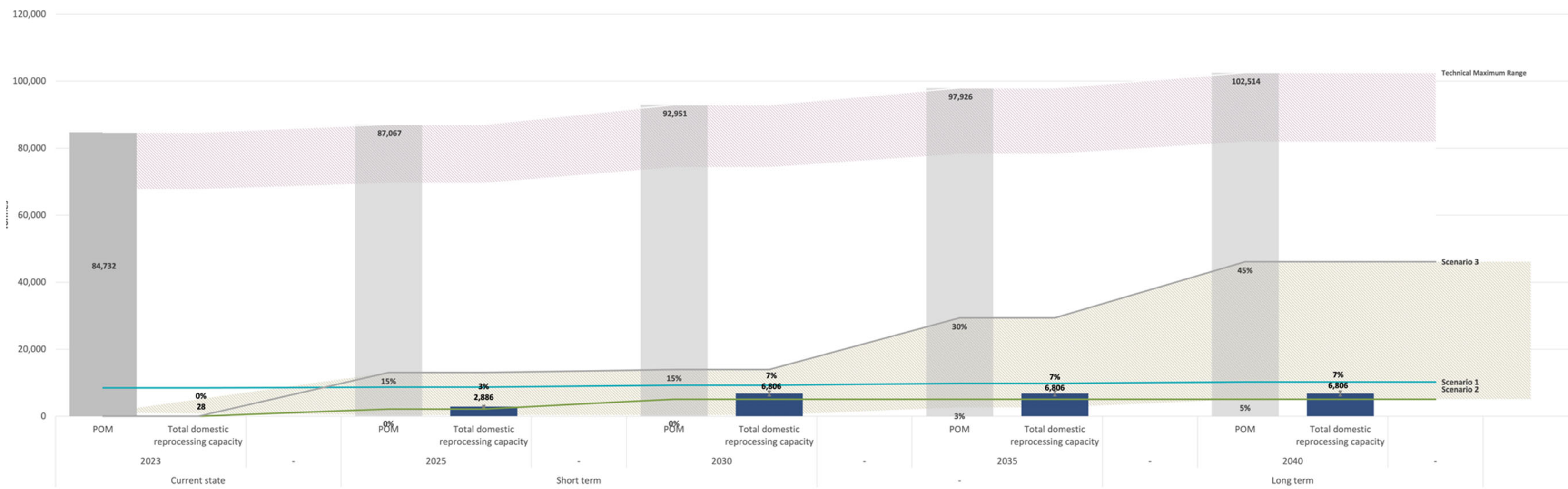
Table 57 Flexible HDPE 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Chemical recycling	49%	Liquid hydrocarbons	3	3	2,861	6,781	6,781
Food grade	Sorting and shredding	95%	Flake	25	25	25	25	25
Food grade	**Total**			**28**	**28**	**2,886**	**6,806**	**6,806**
Non-food grade	Compaction, extrusion and product manufacturing	95%	Product manufacture	43	43	43	43	43
Non-food grade	Sorting, shredding and product manufacture	95%	Product manufacture	1,680	1,680	1,709	28,974	28,974
Non-food grade	**Total**			**1,723**	**1,723**	**1,751**	**29,016**	**29,016**

Table 58 Flexible HDPE recycled content estimates and food grade splits by component

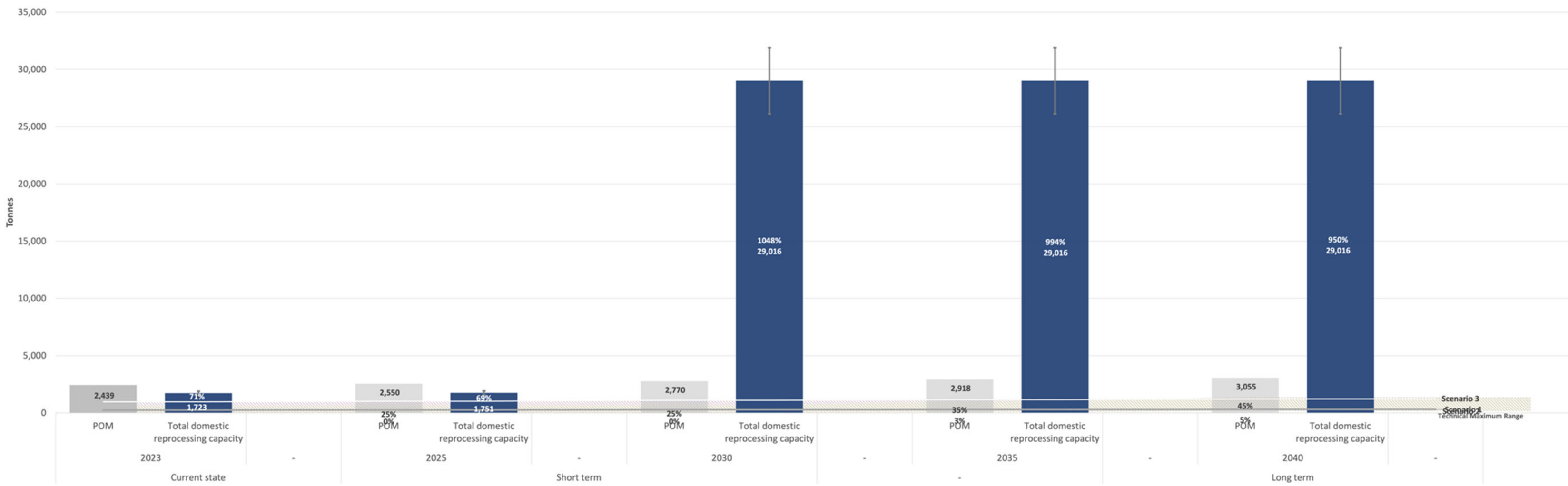
Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Bag or pouch	66,204	437	26	1,000	5	-	64,736	98%	2%
Closure or label	2,481	225	36	637	-	-	1,583	90%	10%
Shopping bag	6,525	-	-	-	-	-	6,525	100%	0%
Tube or cartridge	851	43	17	249	-	-	543	55%	45%
Wrap	2,316	1	-	1,613	1	-	701	98%	2%
Unknown	8,794	450	26	924	-	-	7,394	93%	7%
Total	**87,171**	**1,155**	**105**	**4,423**	**6**	**-**	**81,482**	**94%**	**6%**

Flexible HDPE – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	84,732	87,067	92,951	97,926	102,514
	Reprocessing (tonnes)	28	2,886	6,806	6,806	6,806
Scenario 1	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	8,473	8,707	9,295	9,793	10,251
	Australian tonnage requirements (tonnes)	8,473	8,707	9,295	9,793	10,251
	Domestic surplus (shortfall) – (tonnes)	(8,445)	(5,820)	(2,489)	(2,986)	(3,445)
Scenario 2	Total recycled content (%)	0%	2%	5%	5%	5%
	Australian recycled content (%)	0%	2%	5%	5%	5%
	Total tonnage requirements (tonnes)	21	2,165	5,105	5,105	5,105
	Australian tonnage requirements (tonnes)	21	2,165	5,105	5,105	5,105
	Domestic surplus (shortfall) – (tonnes)	7	722	1,702	1,702	1,702
Scenario 3	Total recycled content (%)	0%	15%	15%	30%	45%
	Australian recycled content (%)	0%	2%	5%	5%	5%
	Total tonnage requirements (tonnes)	21	13,060	13,943	29,378	46,132
	Australian tonnage requirements (tonnes)	21	2,165	5,105	5,105	5,105
	Domestic surplus (shortfall) – (tonnes)	7	722	1,702	1,702	1,702
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	80%	80%	80%	80%	80%
	Upper range tonnage requirements	84,732	87,067	92,951	97,926	102,514
	Lower range tonnage requirements	67,786	69,654	74,361	78,341	82,012
	Lower range domestic surplus (shortfall)	(67,758)	(66,768)	(67,555)	(71,534)	(75,205)

Flexible HDPE – Non-food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	2,439	2,550	2,770	2,918	3,055
	Reprocessing (tonnes)	1,723	1,751	29,016	29,016	29,016
Scenario 1	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	244	255	277	292	305
	Australian tonnage requirements (tonnes)	244	255	277	292	305
	Domestic surplus (shortfall) – (tonnes)	1,479	1,496	28,739	28,725	28,711
Scenario 2	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	244	255	277	292	305
	Australian tonnage requirements (tonnes)	244	255	277	292	305
	Domestic surplus (shortfall) – (tonnes)	1,479	1,496	28,739	28,725	28,711
Scenario 3	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	244	255	277	292	305
	Australian tonnage requirements (tonnes)	244	255	277	292	305
	Domestic surplus (shortfall) – (tonnes)	1,479	1,496	28,739	28,725	28,711
Technical Maximum	Technical Max Upper Range	40%	40%	40%	40%	40%
	Technical max lower range	10%	10%	10%	10%	10%
	Upper range tonnage requirements	975	1,020	1,108	1,167	1,222
	Lower range tonnage requirements	244	255	277	292	305
	Lower range domestic surplus (shortfall)	1,479	1,496	28,739	28,725	28,711

Flexible LDPE – Reprocessing, Recycled Content and Food Grade Suitability

Material context

- For food grade packaging, the current reprocessing capacity for flexible plastics remains low. Projected increases in chemical recycling capacity over the five year projected capacity analysis will increase this capacity, but it will remain low within the examined period. Future expansion of chemical recycling facilities to increase capacity have not been included in the analysis at this time as either the timeframe indicated or the level of certainty of the planned capacity increase did not meet the specifications of the analysis.
- As chemical recycling is yet to operate at a commercial scale in Australia, predicting the material specific capacities for chemical recycling technologies is uncertain at this time and should be considered in the target setting and consultation process. The indicative capacity splits used for chemical recycling capacity are 40% flexible HDPE, 20% flexible LDPE and 40% flexible PP.
- Where possible, non-food grade capacity has been included only where the capacity could potentially deliver recycled material into packaging. However, due to due to the complexity in splitting reprocessing capacity for organisations that have both packaging and non-packaging offtake pathways, some of this capacity is likely above that made available to packaging applications. Non-food grade packaging material may also not be suitable for all packaging applications.
- The closure of Qenos as a manufacturer of flexible PE limits the ability of the Australian domestic reprocessing sector to produce food grade PE without the need for further refinement offshore. The scope of the reprocessing capacity outlined below extends only to the chemical recycling process. Industry feedback indicates there are regional markets capable of refinement of PE using Australian chemically recycled material.

Table 59 Flexible LDPE in the gate 5-year reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Chemical recycling	Liquid hydrocarbons	6	6	2,923	6,923	6,923
Food grade	Sorting and shredding	Flake	647	647	647	647	647
Food grade	**Total**	**Total**	**653**	**653**	**3,569**	**7,569**	**7,569**
Non-food grade	Compaction, extrusion and product manufacturing	Product manufacture	7,894	7,894	7,894	7,894	7,894
Non-food grade	Sorting, shredding and pelletising	Pellets	1,775	1,775	1,775	3,775	3,825
Non-food grade	Sorting, shredding and product manufacture	Product manufacture	20,241	20,241	21,081	43,290	43,290
Non-food grade	**Total**	**Total**	**29,910**	**29,910**	**30,750**	**54,958**	**55,008**

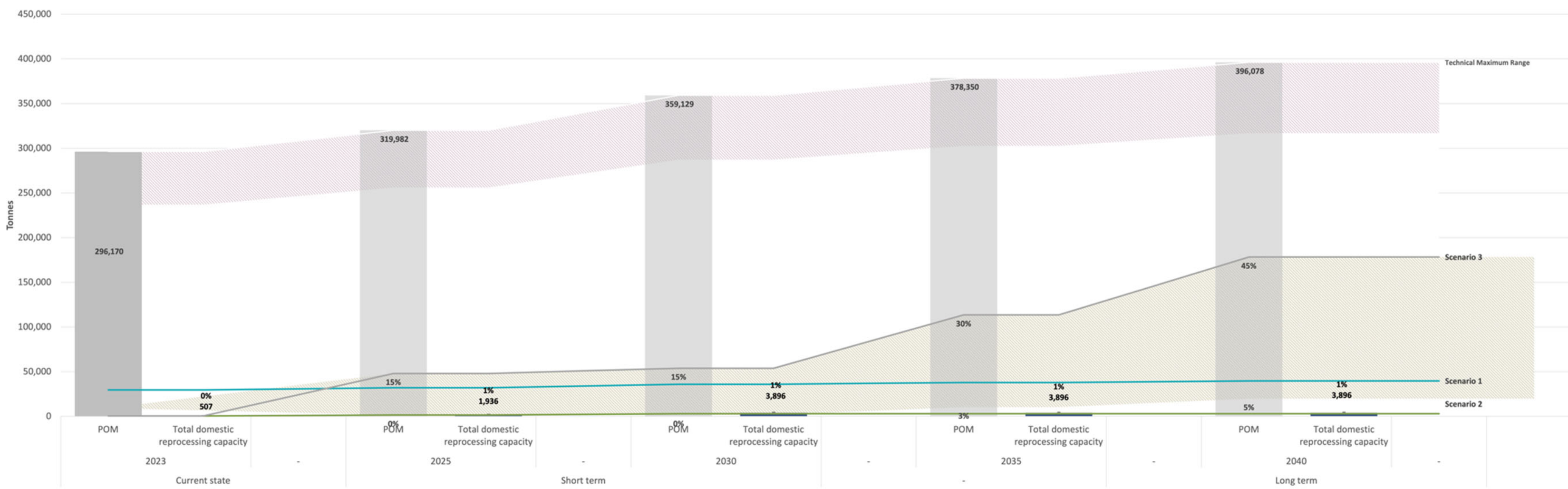
Table 60 Flexible LDPE 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Chemical recycling	49%	Liquid hydrocarbons	3	3	1,432	3,392	3,392
Food grade	Sorting and shredding	78%	Flake	504	504	504	504	504
Food grade	**Total**		**Total**	**507**	**507**	**1,936**	**3,896**	**3,896**
Non-food grade	Compaction, extrusion and product manufacturing	78%	Product manufacture	6,157	6,157	6,157	6,157	6,157
Non-food grade	Sorting, shredding and pelletising	78%	Pellets	1,384	1,384	1,384	2,944	2,983
Non-food grade	Sorting, shredding and product manufacture	78%	Product manufacture	15,788	15,788	16,443	33,766	33,766
Non-food grade	**Total**		**Total**	**23,330**	**23,330**	**23,985**	**42,867**	**42,906**

Table 61 Flexible LDPE recycled content estimates and food grade splits by component

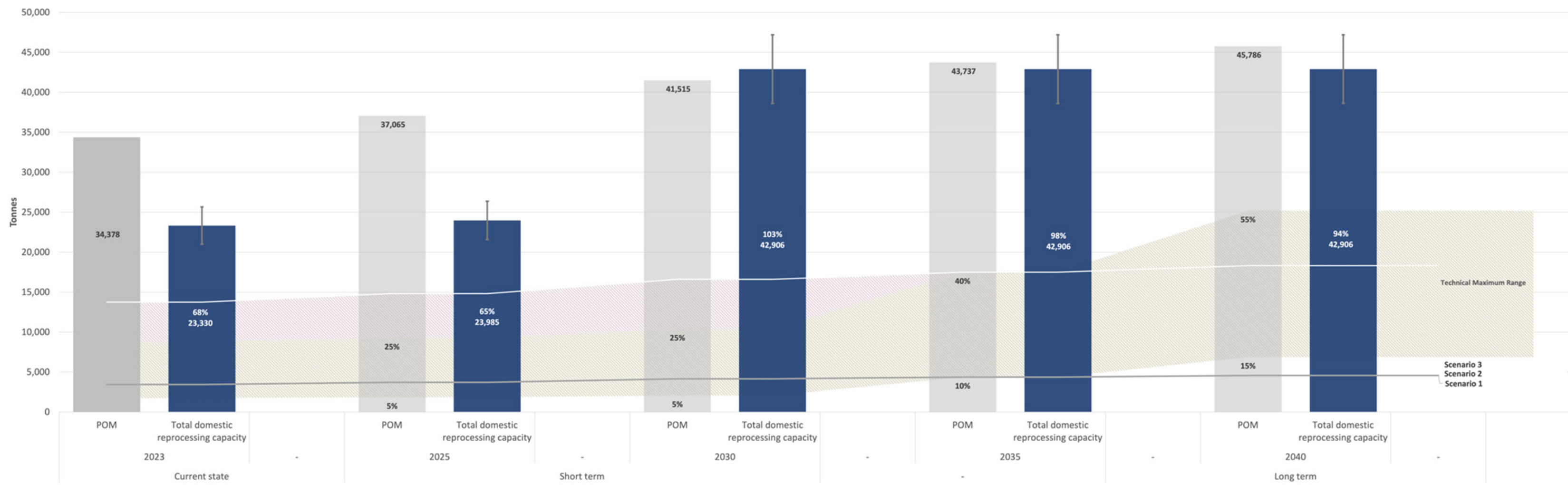
Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Bag or pouch	185,934	2,504	2,397	34,823	173	-	146,037	92%	8%
Closure or label	667	-	18	449	-	-	199	100%	0%
Shopping bag	15,063	-	-	-	-	-	15,063	100%	0%
Wrap	117,807	2,772	2,286	37,134	92	-	75,522	84%	16%
Unknown	11,078	142	121	283	-	-	10,532	99%	1%
Total	**330,547**	**5,418**	**4,822**	**72,689**	**265**	**-**	**247,353**	**90%**	**10%**

Flexible LDPE – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	296,170	319,982	359,129	378,350	396,078
	Reprocessing (tonnes)	507	1,936	3,896	3,896	3,896
Scenario 1	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	29,617	31,998	35,913	37,835	39,608
	Australian tonnage requirements (tonnes)	29,617	31,998	35,913	37,835	39,608
	Domestic surplus (shortfall) – (tonnes)	(29,110)	(30,062)	(32,016)	(33,938)	(35,711)
Scenario 2	Total recycled content (%)	0%	0%	1%	1%	1%
	Australian recycled content (%)	0%	0%	1%	1%	1%
	Total tonnage requirements (tonnes)	380	1,452	2,922	2,922	2,922
	Australian tonnage requirements (tonnes)	380	1,452	2,922	2,922	2,922
	Domestic surplus (shortfall) – (tonnes)	127	484	974	974	974
Scenario 3	Total recycled content (%)	0%	15%	15%	30%	45%
	Australian recycled content (%)	0%	0%	1%	1%	1%
	Total tonnage requirements (tonnes)	380	47,997	53,869	113,505	178,235
	Australian tonnage requirements (tonnes)	380	1,452	2,922	2,922	2,922
	Domestic surplus (shortfall) – (tonnes)	127	484	974	974	974
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	80%	80%	80%	80%	80%
	Upper range tonnage requirements	296,170	319,982	359,129	378,350	396,078
	Lower range tonnage requirements	236,936	255,986	287,303	302,680	316,862
	Lower range domestic surplus (shortfall)	(236,428)	(254,049)	(283,407)	(298,783)	(312,966)

Flexible LDPE – Non-food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	34,378	37,065	41,515	43,737	45,786
	Reprocessing (tonnes)	23,330	23,985	42,906	42,906	42,906
Scenario 1	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	3,438	3,707	4,151	4,374	4,579
	Australian tonnage requirements (tonnes)	3,438	3,707	4,151	4,374	4,579
	Domestic surplus (shortfall) – (tonnes)	19,892	20,278	38,755	38,533	38,328
Scenario 2	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	3,438	3,707	4,151	4,374	4,579
	Australian tonnage requirements (tonnes)	3,438	3,707	4,151	4,374	4,579
	Domestic surplus (shortfall) – (tonnes)	19,892	20,278	38,755	38,533	38,328
Scenario 3	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	3,438	3,707	4,151	4,374	4,579
	Australian tonnage requirements (tonnes)	3,438	3,707	4,151	4,374	4,579
	Domestic surplus (shortfall) – (tonnes)	19,892	20,278	38,755	38,533	38,328
Technical Maximum	Technical Max Upper Range	40%	40%	40%	40%	40%
	Technical max lower range	10%	10%	10%	10%	10%
	Upper range tonnage requirements	13,751	14,826	16,606	17,495	18,314
	Lower range tonnage requirements	3,438	3,707	4,151	4,374	4,579
	Lower range domestic surplus (shortfall)	19,892	20,278	38,755	38,533	38,328

Flexible PP – Reprocessing, Recycled Content and Food Grade Suitability

Material context

- For food grade packaging, the current reprocessing capacity for flexible plastics remains low. Projected increases in chemical recycling capacity over the five year projected capacity analysis will increase this capacity, but it will remain low within the examined period. Future expansion of chemical recycling facilities to increase capacity have not been included in the analysis at this time as either the timeframe indicated or the level of certainty of the planned capacity increase did not meet the specifications of the analysis.
- As chemical recycling is yet to operate at a commercial scale in Australia, predicting the material specific capacities for chemical recycling technologies is uncertain at this time and should be considered in the target setting and consultation process. The indicative capacity splits used for chemical recycling capacity are 40% flexible HDPE, 20% flexible LDPE and 40% flexible PP.
- Where possible, non-food grade capacity has been included only where the capacity could potentially deliver recycled material into packaging. However, due to due to the complexity in splitting reprocessing capacity for organisations that have both packaging and non-packaging offtake pathways, some of this capacity is likely above that made available to packaging applications.

Table 62 Flexible PP 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Chemical recycling	Liquid hydrocarbons	6	6	5,839	13,839	13,839
Food grade	**Total**	**Total**	**6**	**6**	**5,839**	**13,839**	**13,839**
Non-food grade	Compaction, extrusion and product manufacturing	Product manufacture	848	848	848	848	848
Non-food grade	Sorting, shredding and pelletising	Pellets	600	600	600	1,475	1,475
Non-food grade	Sorting, shredding and product manufacture	Product manufacture	6,637	6,637	6,637	35,923	35,923
Non-food grade	**Total**	**Total**	**8,085**	**8,085**	**8,085**	**38,247**	**38,247**

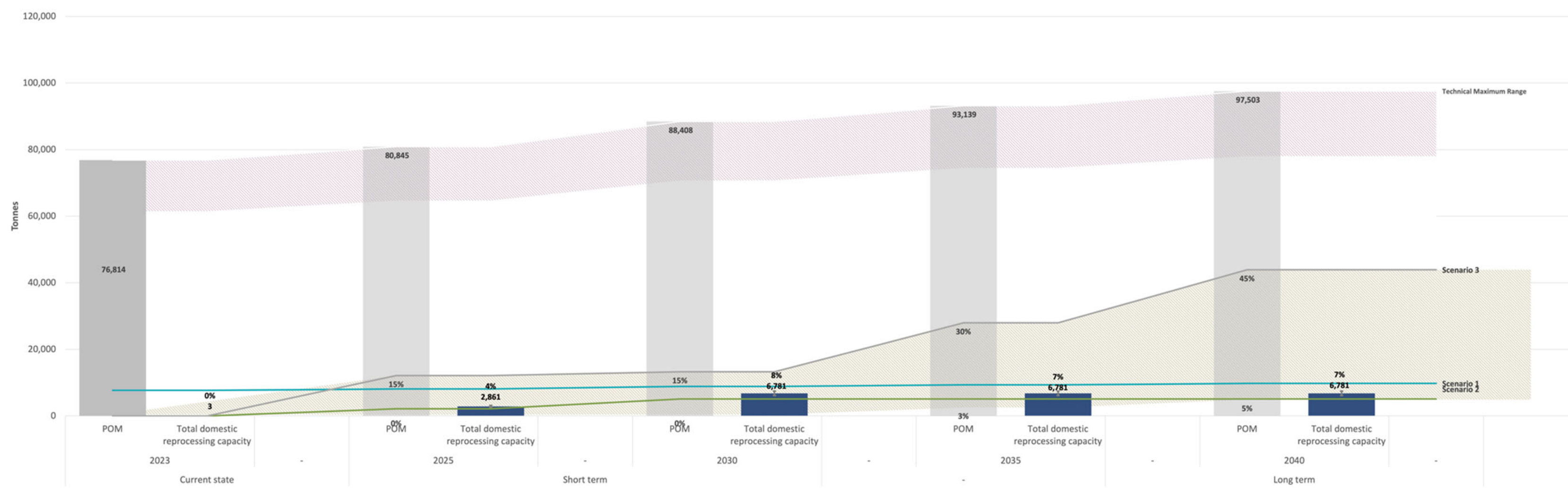
Table 63 Flexible PP 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Chemical recycling	49%	Liquid hydrocarbons	3	3	2,861	6,781	6,781
Food grade	**Total**		**Total**	**3**	**3**	**2,861**	**6,781**	**6,781**
Non-food grade	Compaction, extrusion and product manufacturing	94%	Product manufacture	797	797	797	797	797
Non-food grade	Sorting, shredding and pelletising	94%	Pellets	564	564	564	1,387	1,387
Non-food grade	Sorting, shredding and product manufacture	94%	Product manufacture	6,238	6,238	6,238	33,768	33,768
Non-food grade	**Total**		**Total**	**7,600**	**7,600**	**7,600**	**35,952**	**35,952**

Table 64 Flexible PP recycled content estimates and food grade splits by component

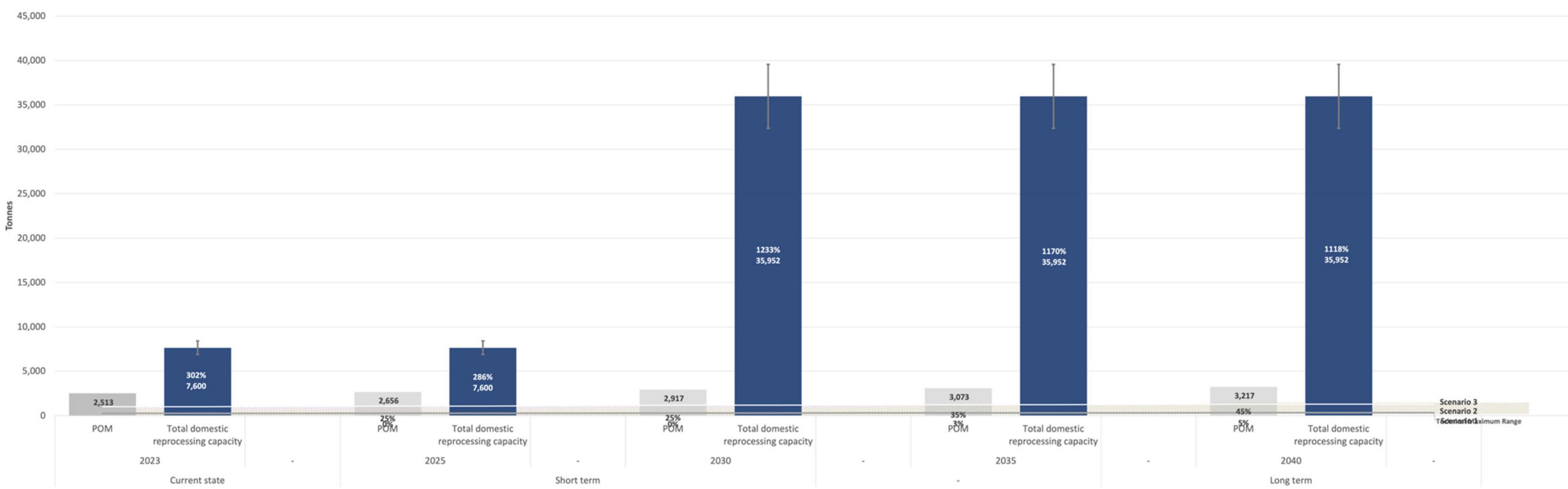
Format	**Material Placed on Market**	**Packaging Material Sourced Locally**			**Packaging material sourced from overseas**			**Food grade suitability**	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Bag or pouch	11,025	-	-	321	-	-	10,705	100%	0%
Closure or label	5,097	92	65	1,330	1	-	3,611	92%	8%
Wrap	53,698	-	-	9,270	23	-	44,405	97%	3%
Unknown	9,507	141	106	332	-	-	8,928	97%	3%
Total	**79,327**	**232**	**170**	**11,253**	**24**	**-**	**67,648**	**97%**	**3%**

Flexible PP – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	76,814	80,845	88,408	93,139	97,503
	Reprocessing (tonnes)	3	2,861	6,781	6,781	6,781
Scenario 1	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	7,681	8,085	8,841	9,314	9,750
	Australian tonnage requirements (tonnes)	7,681	8,085	8,841	9,314	9,750
	Domestic surplus (shortfall) – (tonnes)	(7,678)	(5,223)	(2,059)	(2,533)	(2,969)
Scenario 2	Total recycled content (%)	0%	3%	6%	5%	5%
	Australian recycled content (%)	0%	3%	6%	5%	5%
	Total tonnage requirements (tonnes)	2	2,146	5,086	5,086	5,086
	Australian tonnage requirements (tonnes)	2	2,146	5,086	5,086	5,086
	Domestic surplus (shortfall) – (tonnes)	1	715	1,695	1,695	1,695
Scenario 3	Total recycled content (%)	0%	15%	15%	30%	45%
	Australian recycled content (%)	0%	3%	6%	5%	5%
	Total tonnage requirements (tonnes)	2	12,127	13,261	27,942	43,877
	Australian tonnage requirements (tonnes)	2	2,146	5,086	5,086	5,086
	Domestic surplus (shortfall) – (tonnes)	1	715	1,695	1,695	1,695
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	80%	80%	80%	80%	80%
	Upper range tonnage requirements	76,814	80,845	88,408	93,139	97,503
	Lower range tonnage requirements	61,451	64,676	70,726	74,511	78,003
	Lower range domestic surplus (shortfall)	(61,448)	(61,815)	(63,945)	(67,730)	(71,221)

Flexible PP – Non-food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	2,513	2,656	2,917	3,073	3,217
	Reprocessing (tonnes)	7,600	7,600	35,952	35,952	35,952
Scenario 1	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	251	266	292	307	322
	Australian tonnage requirements (tonnes)	251	266	292	307	322
	Domestic surplus (shortfall) – (tonnes)	7,348	7,334	35,660	35,645	35,630
Scenario 2	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	251	266	292	307	322
	Australian tonnage requirements (tonnes)	251	266	292	307	322
	Domestic surplus (shortfall) – (tonnes)	7,348	7,334	35,660	35,645	35,630
Scenario 3	Total recycled content (%)	10%	10%	10%	10%	10%
	Australian recycled content (%)	10%	10%	10%	10%	10%
	Total tonnage requirements (tonnes)	251	266	292	307	322
	Australian tonnage requirements (tonnes)	251	266	292	307	322
	Domestic surplus (shortfall) – (tonnes)	7,348	7,334	35,660	35,645	35,630
Technical Maximum	Technical Max Upper Range	40%	40%	40%	40%	40%
	Technical max lower range	10%	10%	10%	10%	10%
	Upper range tonnage requirements	1,005	1,062	1,167	1,229	1,287
	Lower range tonnage requirements	251	266	292	307	322
	Lower range domestic surplus (shortfall)	7,348	7,334	35,660	35,645	35,630

Flint glass – Reprocessing, Recycled Content and Food Grade Suitability

Table 65 Flint glass 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Beneficiation	Beneficiated glass	234,196	234,196	281,696	300,696	374,704
Food grade	Beneficiation and packaging production	Glass packaging	-	59,375	59,375	59,375	59,375
Food grade	Total	**Total**	**234,196**	**293,571**	**341,071**	**360,071**	**434,079**
Non-food grade	Sorting and crushing	Crushed glass	143,119	143,119	157,369	157,369	202,732
Non-food grade	Total	**Total**	**143,119**	**143,119**	**157,369**	**157,369**	**202,732**

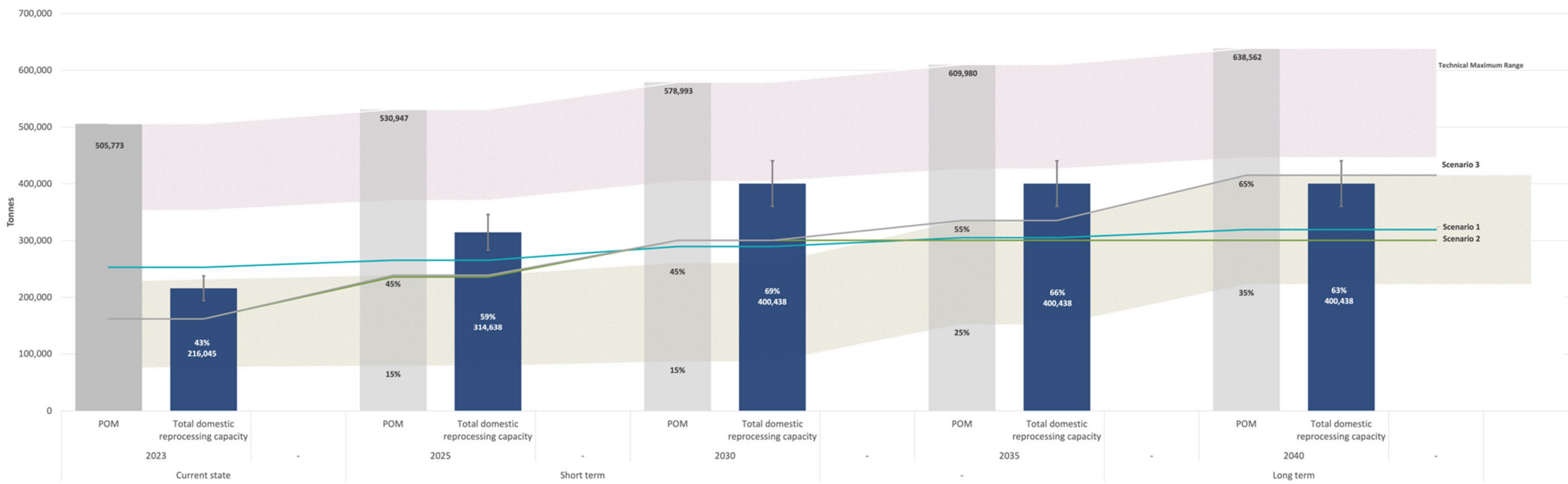
Table 66 Flint glass 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Beneficiation	92%	Beneficiated glass	216,736	216,736	260,555	278,083	346,355
Food grade	Beneficiation and packaging production	92%	Glass packaging	-	54,773	54,773	54,773	54,773
Food grade	Total		**Total**	**216,736**	**271,510**	**315,328**	**332,856**	**401,129**
Non-food grade	Sorting and crushing	92%	Crushed glass	132,027	132,027	145,173	145,173	187,020
Non-food grade	Total		**Total**	**132,027**	**132,027**	**145,173**	**145,173**	**187,020**

Table 67 Flint glass recycled content estimates and food grade splits by component

Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Bottle or jar	505,773	138,119	13,637	199,994	53,049	24,910	76,063	100%	0%
Total	**505,773**	**138,119**	**13,637**	**199,994**	**53,049**	**24,910**	**76,063**	**100%**	**0%**

Flint glass – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	505,773	530,947	578,993	609,980	638,562
	Reprocessing (tonnes)	216,045	314,638	400,438	400,438	400,438
Scenario 1	Total recycled content (%)	50%	50%	50%	50%	50%
	Australian recycled content (%)	50%	50%	50%	50%	50%
	Total tonnage requirements (tonnes)	252,886	265,473	289,496	304,990	319,281
	Australian tonnage requirements (tonnes)	252,886	265,473	289,496	304,990	319,281
	Domestic surplus (shortfall) – (tonnes)	(36,841)	49,164	110,941	95,448	81,157
Scenario 2	Total recycled content (%)	32%	44%	52%	49%	47%
	Australian recycled content (%)	32%	44%	52%	49%	47%
	Total tonnage requirements (tonnes)	162,034	235,978	300,328	300,328	300,328
	Australian tonnage requirements (tonnes)	162,034	235,978	300,328	300,328	300,328
	Domestic surplus (shortfall) – (tonnes)	54,011	78,659	100,109	100,109	100,109
Scenario 3	Total recycled content (%)	43%	45%	52%	55%	65%
	Australian recycled content (%)	32%	44%	52%	49%	47%
	Total tonnage requirements (tonnes)	216,045	238,926	300,328	335,489	415,065
	Australian tonnage requirements (tonnes)	162,034	235,978	300,328	300,328	300,328
	Domestic surplus (shortfall) – (tonnes)	54,011	78,659	100,109	100,109	100,109
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	70%	70%	70%	70%	70%
	Upper range tonnage requirements	505,773	530,947	578,993	609,980	638,562
	Lower range tonnage requirements	354,041	371,663	405,295	426,986	446,993
	Lower range domestic surplus (shortfall)	(137,996)	(57,025)	(4,857)	(26,548)	(46,555)

Green glass – Reprocessing, Recycled Content and Food Grade Suitability

Table 68 Green glass 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Beneficiation	Beneficiated glass	169,772	169,772	204,672	218,632	273,866
Food grade	Beneficiation and packaging production	Glass packaging	-	43,625	43,625	43,625	43,625
Food grade	**Total**	**Total**	**169,772**	**213,397**	**248,297**	**262,257**	**317,491**
Non-food grade	Sorting and crushing	Crushed glass	105,155	105,155	115,625	115,625	148,954
Non-food grade	**Total**	**Total**	**105,155**	**105,155**	**115,625**	**115,625**	**148,954**

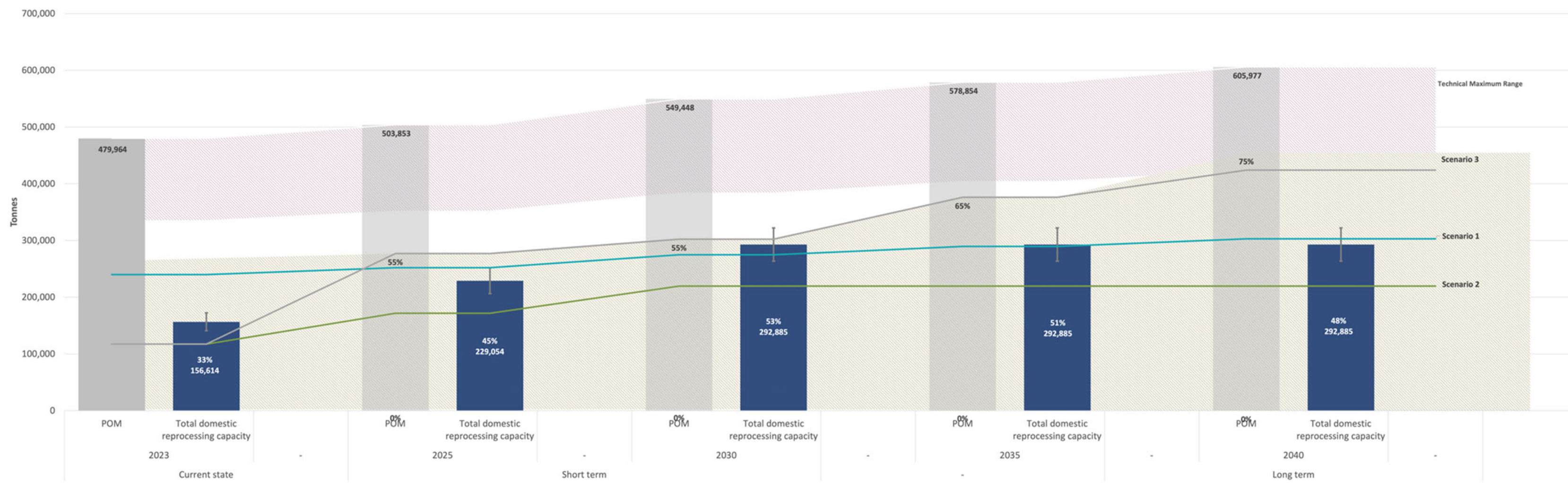
Table 69 Green glass 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Beneficiation	92%	Beneficiated glass	157,122	157,122	189,317	202,195	253,149
Food grade	Beneficiation and packaging production	92%	Glass packaging	-	40,244	40,244	40,244	40,244
Food grade	**Total**		**Total**	**157,122**	**197,366**	**229,561**	**242,439**	**293,393**
Non-food grade	Sorting and crushing	92%	Crushed glass	97,005	97,005	106,664	106,664	137,410
Non-food grade	**Total**		**Total**	**97,005**	**97,005**	**106,664**	**106,664**	**137,410**

Table 70 Green glass recycled content estimates and food grade splits by component

Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Bottle or jar	479,964	177,409	15,944	209,420	26,543	12,464	38,185	100%	0%
Total	**479,964**	**177,409**	**15,944**	**209,420**	**26,543**	**12,464**	**38,185**	**100%**	**0%**

Green glass – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	479,964	503,853	549,448	578,854	605,977
	Reprocessing (tonnes)	156,614	229,054	292,885	292,885	292,885
Scenario 1	Total recycled content (%)	50%	50%	50%	50%	50%
	Australian recycled content (%)	50%	50%	50%	50%	50%
	Total tonnage requirements (tonnes)	239,982	251,927	274,724	289,427	302,989
	Australian tonnage requirements (tonnes)	239,982	251,927	274,724	289,427	302,989
	Domestic surplus (shortfall) – (tonnes)	(83,368)	(22,873)	18,161	3,458	(10,103)
Scenario 2	Total recycled content (%)	24%	34%	40%	38%	36%
	Australian recycled content (%)	24%	34%	40%	38%	36%
	Total tonnage requirements (tonnes)	117,461	171,790	219,664	219,664	219,664
	Australian tonnage requirements (tonnes)	117,461	171,790	219,664	219,664	219,664
	Domestic surplus (shortfall) – (tonnes)	39,154	57,263	73,221	73,221	73,221
Scenario 3	Total recycled content (%)	33%	55%	55%	65%	70%
	Australian recycled content (%)	24%	34%	40%	38%	36%
	Total tonnage requirements (tonnes)	156,614	277,119	302,196	376,255	424,184
	Australian tonnage requirements (tonnes)	117,461	171,790	219,664	219,664	219,664
	Domestic surplus (shortfall) – (tonnes)	39,154	57,263	73,221	73,221	73,221
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	70%	70%	70%	70%	70%
	Upper range tonnage requirements	479,964	503,853	549,448	578,854	605,977
	Lower range tonnage requirements	335,975	352,697	384,614	405,198	424,184
	Lower range domestic surplus (shortfall)	(179,361)	(123,644)	(91,728)	(112,312)	(131,299)

Amber glass – Reprocessing, Recycled Content and Food Grade Suitability

Table 71 Amber glass 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Beneficiation	Beneficiated glass	150,980	150,980	168,580	175,620	205,077
Food grade	Beneficiation and packaging production	Glass packaging	-	22,000	22,000	22,000	22,000
Food grade	**Total**	**Total**	**150,980**	**172,980**	**190,580**	**197,620**	**227,077**
Non-food grade	Sorting and crushing	Crushed glass	53,029	53,029	58,309	58,309	75,117
Non-food grade	**Total**	**Total**	**53,029**	**53,029**	**58,309**	**58,309**	**75,117**

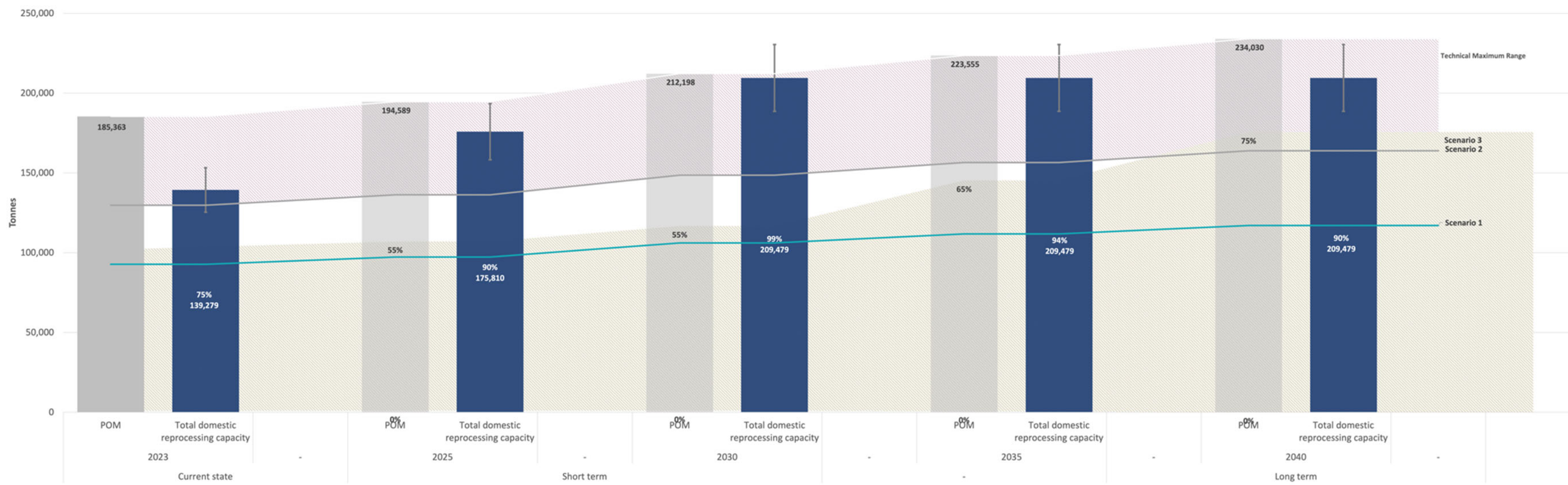
Table 72 Amber glass 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Beneficiation	92%	Beneficiated glass	139,535	139,535	155,771	162,265	189,440
Food grade	Beneficiation and packaging production	92%	Glass packaging	-	20,295	20,295	20,295	20,295
Food grade	**Total**		**Total**	**139,535**	**159,830**	**176,066**	**182,560**	**209,735**
Non-food grade	Sorting and crushing	92%	Crushed glass	48,920	48,920	53,790	53,790	69,296
Non-food grade	**Total**		**Total**	**48,920**	**48,920**	**53,790**	**53,790**	**69,296**

Table 73 Amber glass recycled content estimates and food grade splits by component

Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
	Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Bottle or jar	185,363	76,098	6,555	76,437	8,976	4,215	13,083	100%	0%
Total	**185,363**	**76,098**	**6,555**	**76,437**	**8,976**	**4,215**	**13,083**	**100%**	**0%**

Amber glass – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	185,363	194,589	212,198	223,555	234,030
	Reprocessing (tonnes)	139,279	175,810	209,479	209,479	209,479
Scenario 1	Total recycled content (%)	50%	50%	50%	50%	50%
	Australian recycled content (%)	50%	50%	50%	50%	50%
	Total tonnage requirements (tonnes)	92,682	97,295	106,099	111,777	117,015
	Australian tonnage requirements (tonnes)	92,682	97,295	106,099	111,777	117,015
	Domestic surplus (shortfall) – (tonnes)	46,597	78,515	103,380	97,701	92,464
Scenario 2	Total recycled content (%)	70%	70%	70%	70%	70%
	Australian recycled content (%)	70%	70%	70%	70%	70%
	Total tonnage requirements (tonnes)	129,754	136,212	148,539	156,488	163,821
	Australian tonnage requirements (tonnes)	129,754	136,212	148,539	156,488	163,821
	Domestic surplus (shortfall) – (tonnes)	9,525	39,597	60,940	52,990	45,658
Scenario 3	Total recycled content (%)	70%	70%	70%	70%	70%
	Australian recycled content (%)	70%	70%	70%	70%	70%
	Total tonnage requirements (tonnes)	129,754	136,212	148,539	156,488	163,821
	Australian tonnage requirements (tonnes)	129,754	136,212	148,539	156,488	163,821
	Domestic surplus (shortfall) – (tonnes)	9,525	39,597	60,940	52,990	45,658
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	70%	70%	70%	70%	70%
	Upper range tonnage requirements	185,363	194,589	212,198	223,555	234,030
	Lower range tonnage requirements	129,754	136,212	148,539	156,488	163,821
	Lower range domestic surplus (shortfall)	9,525	39,597	60,940	52,990	45,658

Paper & paperboard

Material context

- Paper and paperboard have an established history of incorporating recycled content into packaging materials.
- During the paper and paperboard recycling process, paper and paperboard materials are combined to form a variety of secondary applications. The application of recycled material into new applications is both a technical and commercial decision, making the reprocessing capacity for specific paper and paperboard materials highly variable. As such, the reprocessing capacity for paper and paperboard materials has been displayed at the group level.
- Recycled content technical maximums levels for paper and paperboard packaging products vary greatly based on format and application. For simplicity, the technical maximums displayed for paper and paperboard are reflective of large tonnage packaging types (e.g. corrugated cardboard, boxboard/cartonboard), but industry feedback indicates that the technical maximum for other types (e.g. paper cups) is significantly lower (up to 30%).
- Additional splits on recycled content target setting survey, material recycled content estimates and food grade suitability have been provided in the tables below at the material type level.

Table 74 Paper and paperboard 5-year in the gate capacity estimates

Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Other	Other	12,408	12,408	12,408	12,408	16,408
Sorting and pulping	Pulp	-	-	138,738	138,738	138,738
Sorting, pulping and paper production	Paper	1,728,050	1,728,050	1,728,050	1,813,866	1,813,866
Total	**Total**	**1,740,458**	**1,740,458**	**1,879,196**	**1,965,012**	**1,969,012**

Table 75 Paper and paperboard 5-year out the gate capacity estimates and yields

Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Other	90%	Other	11,167	11,167	11,167	11,167	14,767
Sorting and pulping	90%	Pulp	-	-	124,864	124,864	124,864
Sorting, pulping and paper production	90%	Paper	1,559,101	1,559,101	1,559,101	1,636,412	1,636,412
Grand Total		**Total**	**1,570,268**	**1,570,268**	**1,695,132**	**1,772,443**	**1,776,043**

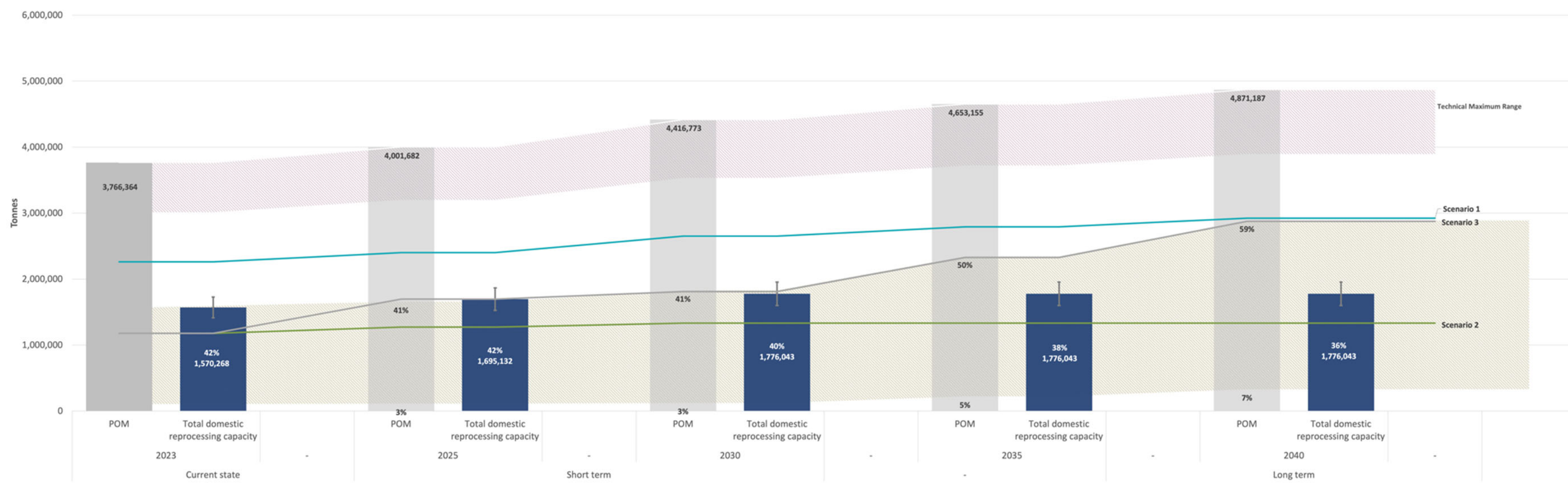
Table 76 paper and paperboard recycled content estimates and food grade splits by component

Material type	Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
		Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Corrugated cardboard	Carton or box	2,857,997	883,562	217,411	384,416	961,233	136,730	274,645	26%	74%
Boxboard/cartonboard	Carton or box	314,259	-	-	-	113,992	76,557	123,710	34%	66%
Boxboard/cartonboard	Tableware	7,961	-	-	-	3,981	1,990	1,990	25%	75%
Boxboard/cartonboard	Tub, tray or punnet	7,144	-	-	-	-	-	7,144	100%	0%
HWS carrierboard	Bag or pouch	792	-	495	-	-	111	186	0%	100%
HWS carrierboard	Carton or box	20,768	-	-	-	-	1,297	19,470	19%	81%
HWS carrierboard	Tub, tray or punnet	4,025	-	-	-	-	144	3,881	25%	75%
Kraft paper	Bag or pouch	129,793	-	2,526	40,630	397	17,626	68,614	26%	74%
Kraft paper	Can	56,450	9,622	9,622	19,244	5,987	5,987	5,987	100%	0%
Kraft paper	Wrap	65,995	-	83	663	20	11,656	53,573	34%	66%
Kraft paper	Other component group	45,668	-	-	-	115	7,926	37,628	33%	67%
Moulded fibreboard	Tableware	1,628	-	-	-	-	-	1,628	100%	0%
Moulded fibreboard	Tub, tray or punnet	65,590	18,595	-	-	38,688	3,461	4,846	56%	44%
Polymer coated paper	Bag or pouch	721	-	-	50	-	-	671	100%	0%
Polymer coated paper	Wrap	707	-	-	49	-	-	658	100%	0%
PCPB - aseptic	Carton or box	53,166	-	-	-	-	-	53,166	100%	0%
PCPB – cold cup	Tableware	8,327	-	-	-	-	552	7,775	100%	0%
PCPB – gable top	Carton or box	16,686	-	-	-	-	-	16,686	100%	0%
PCPB – hot cup	Tableware	20,280	-	-	-	-	1,664	18,616	100%	0%
PCPB – other	Bag or pouch	1,509	-	-	1,509	-	-	-	75%	25%
PCPB – other	Carton or box	168	-	-	4	-	-	164	100%	0%
PCPB – other	Tableware	1,985	-	-	1	-	-	1,984	100%	0%
PCPB – other	Tub, tray or punnet	1,511	-	-	-	-	-	1,511	100%	0%
PCPB – other	Other component group	663	-	-	-	33	33	597	100%	0%

Table 77 paper and paperboard recycled content survey responses and projected material placed on market

Material type	Food grade suitability	Material placed on market					Short term target		Long term target	
		2023	2025	2030	2035	2040	Low ambition	High ambition	Low ambition	High ambition
Corrugated cardboard	Food grade	735,986	782,426	864,060	910,304	952,958	0%	65%	15%	85%
Corrugated cardboard	Non-food grade	2,122,011	2,255,907	2,491,277	2,624,608	2,747,589	0%	65%	15%	85%
Boxboard/cartonboard	Food grade	115,610	122,511	134,861	142,079	148,736	0%	65%	15%	85%
Boxboard/cartonboard	Non-food grade	213,754	226,694	249,746	263,112	275,441	15%	75%	45%	85%
HWS carrierboard	Food grade	4,947	5,234	5,752	6,059	6,343	0%	25%	0%	45%
HWS carrierboard	Non-food grade	20,637	21,779	23,881	25,159	26,338	0%	45%	5%	65%
Moulded fibreboard	Food grade	38,194	40,733	45,126	47,541	49,769	0%	85%	0%	85%
Moulded fibreboard	Non-food grade	29,024	30,974	34,338	36,176	37,871	5%	85%	15%	85%

Paper and paperboard – combined capacity and material placed on market



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	3,766,364	4,001,682	4,416,773	4,653,155	4,871,187
	Reprocessing (tonnes)	1,570,268	1,695,132	1,776,043	1,776,043	1,776,043
Scenario 1	Total recycled content (%)	60%	60%	60%	60%	60%
	Australian recycled content (%)	60%	60%	60%	60%	60%
	Total tonnage requirements (tonnes)	2,259,818	2,401,009	2,650,064	2,791,893	2,922,712
	Australian tonnage requirements (tonnes)	2,259,818	2,401,009	2,650,064	2,791,893	2,922,712
	Domestic surplus (shortfall) – (tonnes)	(689,550)	(705,877)	(874,021)	(1,015,850)	(1,146,669)
Scenario 2	Total recycled content (%)	31%	32%	30%	29%	27%
	Australian recycled content (%)	31%	32%	30%	29%	27%
	Total tonnage requirements (tonnes)	1,177,701	1,271,349	1,332,032	1,332,032	1,332,032
	Australian tonnage requirements (tonnes)	1,177,701	1,271,349	1,332,032	1,332,032	1,332,032
	Domestic surplus (shortfall) – (tonnes)	392,567	423,783	444,011	444,011	444,011
Scenario 3	Total recycled content (%)	41%	42%	41%	50%	59%
	Australian recycled content (%)	31%	32%	30%	29%	27%
	Total tonnage requirements (tonnes)	1,560,351	1,695,132	1,810,877	2,326,578	2,874,000
	Australian tonnage requirements (tonnes)	1,177,701	1,271,349	1,332,032	1,332,032	1,332,032
	Domestic surplus (shortfall) – (tonnes)	392,567	423,783	444,011	444,011	444,011
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	80%	80%	80%	80%	80%
	Upper range tonnage requirements	3,766,364	4,001,682	4,416,773	4,653,155	4,871,187
	Lower range tonnage requirements	3,013,091	3,201,346	3,533,418	3,722,524	3,896,949
	Lower range domestic surplus (shortfall)	(1,442,823)	(1,506,214)	(1,757,376)	(1,946,482)	(2,120,907)

Aluminium

Material context

- Australia has low domestic reprocessing capacity for aluminium, with no projected expansion in domestic reprocessing capacity
- International recycled content is prevalent in both beverage and non-beverage aluminium can production, with a current recycled content rate of 58% in these formats (and a 23% post-consumer recycled content rate).
- With strong export markets across all metal packaging scrap and low domestic reprocessing, international recycled content is the likely future source of recycled content in aluminium packaging.

Table 78 Aluminium 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Smelting	Smelted metal	800	800	800	800	800
Food grade	**Total**	**Total**	**800**	**800**	**800**	**800**	**800**
Non-food grade	Smelting	Smelted metal	320	320	320	320	320
Non-food grade	**Total**	**Total**	**320**	**320**	**320**	**320**	**320**

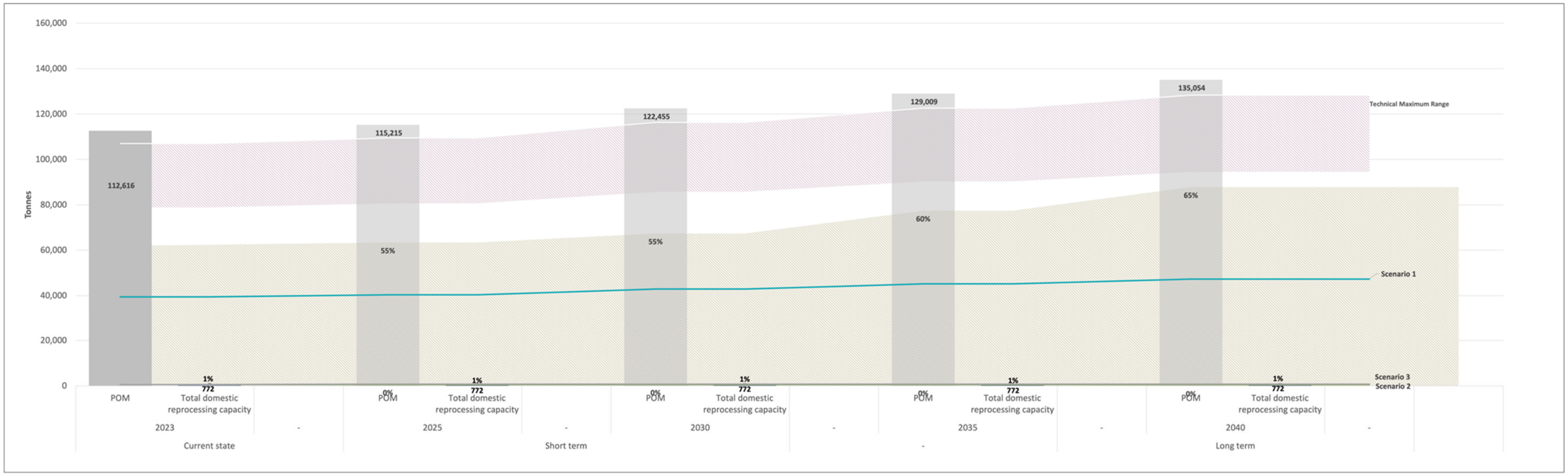
Table 79 Aluminium glass 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Smelting	97%	Smelted metal	772	772	772	772	772
Food grade	**Total**		**Total**	**772**	**772**	**772**	**772**	**772**
Non-food grade	Smelting	97%	Smelted metal	309	309	309	309	309
Non-food grade	**Total**		**Total**	**309**	**309**	**309**	**309**	**309**

Table 80 Aluminium recycled content estimates and food grade splits by component

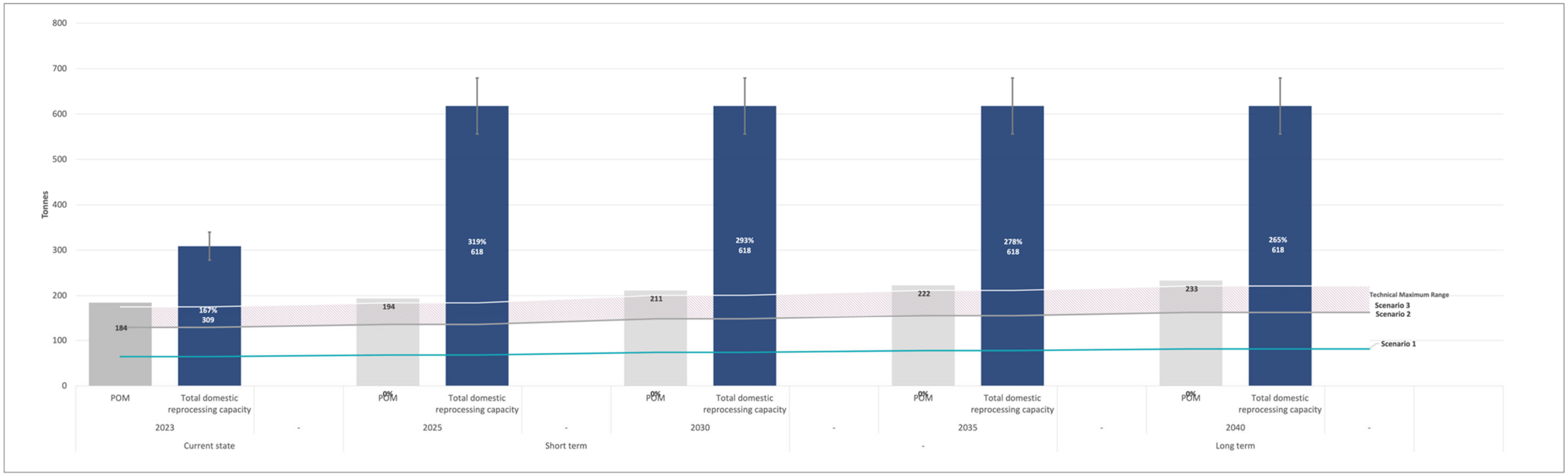
Material type	Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
		Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Beverage aluminium	Can	101,315	-	-	-	24,265	36,217	40,834	100%	0%
Non-beverage aluminium	Can	6,944	-	-	-	616	2,074	4,254	97%	3%
Non-beverage aluminium	Closure or label	673	-	-	-	1	4	667	100%	0%
Non-beverage aluminium	Tub, tray or punnet	3,604	-	-	-	-	1,190	2,415	100%	0%
Non-beverage aluminium	Tube or cartridge	264	-	-	-	40	132	92	100%	0%

Aluminium – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	112,616	115,215	122,455	129,009	135,054
	Reprocessing (tonnes)	772	772	772	772	772
Scenario 1	Total recycled content (%)	35%	35%	35%	35%	35%
	Australian recycled content (%)	35%	35%	35%	35%	35%
	Total tonnage requirements (tonnes)	39,416	40,325	42,859	45,153	47,269
	Australian tonnage requirements (tonnes)	39,416	40,325	42,859	45,153	47,269
	Domestic surplus (shortfall) – (tonnes)	(38,644)	(39,553)	(42,087)	(44,381)	(46,497)
Scenario 2	Total recycled content (%)	1%	1%	0%	0%	0%
	Australian recycled content (%)	1%	1%	0%	0%	0%
	Total tonnage requirements (tonnes)	579	579	579	579	579
	Australian tonnage requirements (tonnes)	579	579	579	579	579
	Domestic surplus (shortfall) – (tonnes)	193	193	193	193	193
Scenario 3	Total recycled content (%)	1%	55%	55%	60%	65%
	Australian recycled content (%)	1%	1%	0%	0%	0%
	Total tonnage requirements (tonnes)	579	63,368	67,350	77,405	87,785
	Australian tonnage requirements (tonnes)	579	579	579	579	579
	Domestic surplus (shortfall) – (tonnes)	193	193	193	193	193
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	70%	70%	70%	70%	70%
	Upper range tonnage requirements	106,985	109,454	116,332	122,558	128,301
	Lower range tonnage requirements	78,831	80,650	85,719	90,306	94,538
	Lower range domestic surplus (shortfall)	(78,059)	(79,878)	(84,947)	(89,534)	(93,766)

Aluminium – Non-food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	184	194	211	222	233
	Reprocessing (tonnes)	309	618	618	618	618
Scenario 1	Total recycled content (%)	35%	35%	35%	35%	35%
	Australian recycled content (%)	35%	35%	35%	35%	35%
	Total tonnage requirements (tonnes)	65	68	74	78	81
	Australian tonnage requirements (tonnes)	65	68	74	78	81
	Domestic surplus (shortfall) – (tonnes)	244	550	544	540	536
Scenario 2	Total recycled content (%)	70%	70%	70%	70%	70%
	Australian recycled content (%)	70%	70%	70%	70%	70%
	Total tonnage requirements (tonnes)	129	136	148	156	163
	Australian tonnage requirements (tonnes)	129	136	148	156	163
	Domestic surplus (shortfall) – (tonnes)	180	482	470	462	455
Scenario 3	Total recycled content (%)	70%	70%	70%	70%	70%
	Australian recycled content (%)	70%	70%	70%	70%	70%
	Total tonnage requirements (tonnes)	129	136	148	156	163
	Australian tonnage requirements (tonnes)	129	136	148	156	163
	Domestic surplus (shortfall) – (tonnes)	180	482	470	462	455
Technical Maximum	Technical Max Upper Range	100%	100%	100%	100%	100%
	Technical max lower range	70%	70%	70%	70%	70%
	Upper range tonnage requirements	175	184	201	211	221
	Lower range tonnage requirements	129	136	148	156	163
	Lower range domestic surplus (shortfall)	180	482	470	462	455

Steel

Material context

- Steel placed on market in Australia is dominated by tin-plate steel cans and mild steel barrels and drums. While mild steel drums have some domestic post-consumer recycled content, tin plate cans are primarily sourced with overseas material, with a current recycled content rate of approximately 24% (8% from post-consumer recycled content rate).
- Steel, like aluminium, has strong export and alternative offtake markets for recycled material.
- While steel can be easily recycled, steel packaging requires a high purity level for rolling for food cans. Feedback from industry places an indicative maximum recycled content for steel cans at between 10% and 30%.
- While some steel reprocessing capacity can be attributed to packaging pathways, reprocessors typically produce a range of both packaging and non-packaging products, meaning the total tonnage capacity and applicable format level capacity are likely lower than stated.

Table 81 Steel 5-year in the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Out the gate product	2023	2024	2025	2026	2027
Food grade	Smelting	Smelted metal	17,500	17,500	17,500	17,500	17,500
Food grade	**Total**	**Total**	**17,500**	**17,500**	**17,500**	**17,500**	**17,500**
Non-food grade	Smelting	Smelted metal	303	303	303	303	303
Non-food grade	**Total**	**Total**	**303**	**303**	**303**	**303**	**303**

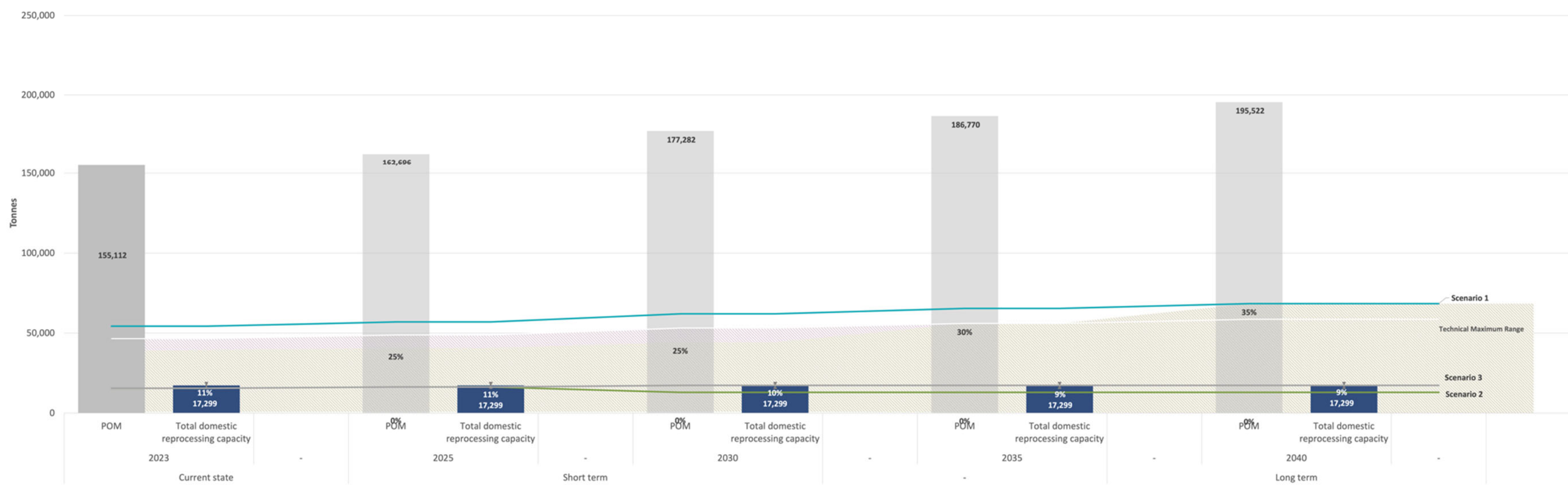
Table 82 Steel glass 5-year out the gate reprocessing capacity estimates

Food Grade Suitability	Type of reprocessing capacity	Estimated yield	Out the gate product	2023	2024	2025	2026	2027
Food grade	Smelting	99%	Smelted metal	17,299	17,299	17,299	17,299	17,299
Food grade	**Total**		**Total**	**17,299**	**17,299**	**17,299**	**17,299**	**17,299**
Non-food grade	Smelting	99%	Smelted metal	300	300	300	300	300
Non-food grade	**Total**		**Total**	**300**	**300**	**300**	**300**	**300**

Table 83 Steel recycled content estimates and food grade splits by component

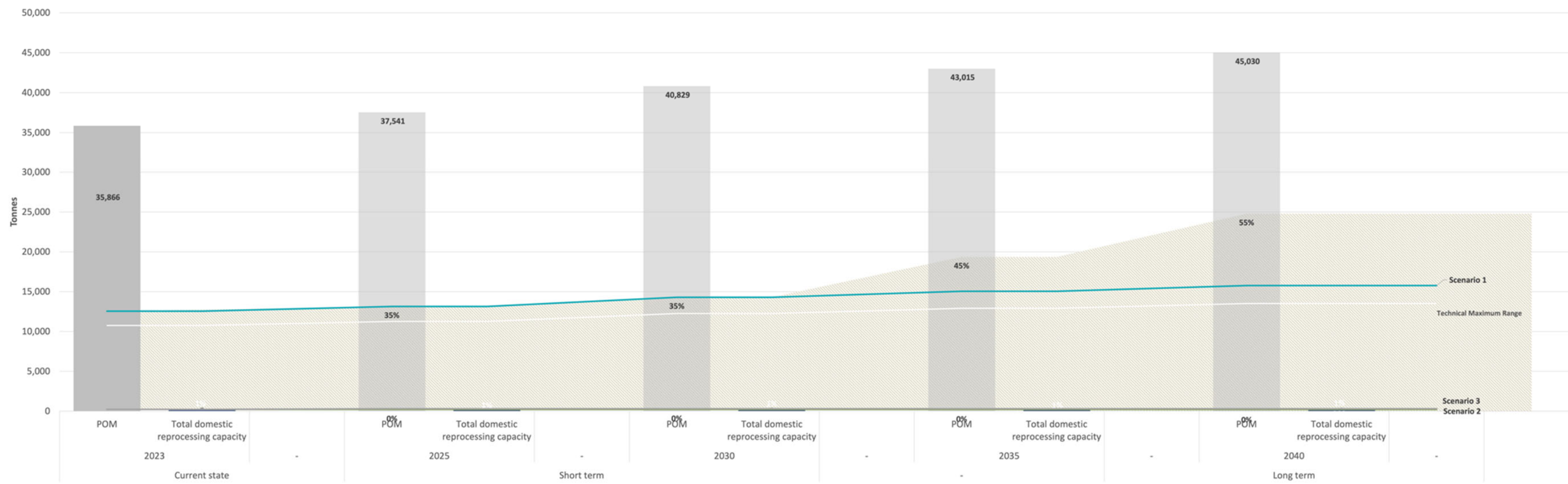
Material type	Format	Material Placed on Market	Packaging Material Sourced Locally			Packaging material sourced from overseas			Food grade suitability	
		Total POM	Post-consumer source	Pre-consumer source	Virgin source	Post-consumer source	Pre-consumer source	Virgin source	Suitable for food grade applications	Not suitable for food grade applications
Mild Steel	Barrel or drum	24,520	2,818	564	16,331	481	1,009	3,318	36%	64%
Stainless steel	Barrel or drum	1,506	-	-	-	99	209	1,198	71%	29%
Stainless steel	Tableware	14	-	-	-	5	-	9	100%	0%
Tin-plate steel	Barrel or drum	2,752	-	-	-	72	-	2,680	56%	44%
Tin-plate steel	Can	155,525	-	-	129	11,682	25,639	118,075	91%	9%
Tin-plate steel	Closure or label	6,573	-	-	55	150	924	5,444	27%	73%
Tin-plate steel	Unknown	86	-	-	-	9	18	60	100%	0%

Steel – Food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	155,112	162,696	177,282	186,770	195,522
	Reprocessing (tonnes)	17,299	17,299	17,299	17,299	17,299
Scenario 1	Total recycled content (%)	35%	35%	35%	35%	35%
	Australian recycled content (%)	35%	35%	35%	35%	35%
	Total tonnage requirements (tonnes)	54,289	56,943	62,049	65,370	68,433
	Australian tonnage requirements (tonnes)	54,289	56,943	62,049	65,370	68,433
	Domestic surplus (shortfall) – (tonnes)	(36,990)	(39,645)	(44,750)	(48,071)	(51,134)
Scenario 2	Total recycled content (%)	8%	8%	7%	7%	7%
	Australian recycled content (%)	8%	8%	7%	7%	7%
	Total tonnage requirements (tonnes)	12,974	12,974	12,974	12,974	12,974
	Australian tonnage requirements (tonnes)	12,974	12,974	12,974	12,974	12,974
	Domestic surplus (shortfall) – (tonnes)	4,325	4,325	4,325	4,325	4,325
Scenario 3	Total recycled content (%)	8%	25%	25%	30%	35%
	Australian recycled content (%)	8%	8%	7%	7%	7%
	Total tonnage requirements (tonnes)	12,974	40,674	44,321	56,031	68,433
	Australian tonnage requirements (tonnes)	12,974	12,974	12,974	12,974	12,974
	Domestic surplus (shortfall) – (tonnes)	4,325	4,325	4,325	4,325	4,325
Technical Maximum	Technical Max Upper Range	30%	30%	30%	30%	30%
	Technical max lower range	10%	10%	10%	10%	10%
	Upper range tonnage requirements	46,534	48,809	53,185	56,031	58,656
	Lower range tonnage requirements	15,511	16,270	17,728	18,677	19,552
	Lower range domestic surplus (shortfall)	1,788	1,029	(429)	(1,378)	(2,253)

Steel – Non-food grade



Scenario	Description	2023	2025	2030	2035	2040
	POM (tonnes)	35,866	37,541	40,829	43,015	45,030
	Reprocessing (tonnes)	300	300	300	300	300
Scenario 1	Total recycled content (%)	35%	35%	35%	35%	35%
	Australian recycled content (%)	35%	35%	35%	35%	35%
	Total tonnage requirements (tonnes)	12,553	13,139	14,290	15,055	15,761
	Australian tonnage requirements (tonnes)	12,553	13,139	14,290	15,055	15,761
	Domestic surplus (shortfall) – (tonnes)	(12,253)	(12,840)	(13,990)	(14,755)	(15,461)
Scenario 2	Total recycled content (%)	1%	1%	1%	1%	0%
	Australian recycled content (%)	1%	1%	1%	1%	0%
	Total tonnage requirements (tonnes)	225	225	225	225	225
	Australian tonnage requirements (tonnes)	225	225	225	225	225
	Domestic surplus (shortfall) – (tonnes)	75	75	75	75	75
Scenario 3	Total recycled content (%)	15%	35%	35%	45%	55%
	Australian recycled content (%)	1%	1%	1%	1%	0%
	Total tonnage requirements (tonnes)	5,359	13,139	14,290	19,357	24,767
	Australian tonnage requirements (tonnes)	225	225	225	225	225
	Domestic surplus (shortfall) – (tonnes)	75	75	75	75	75
Technical Maximum	Technical Max Upper Range	30%	30%	30%	30%	30%
	Technical max lower range	10%	10%	10%	10%	10%
	Upper range tonnage requirements	10,760	11,262	12,249	12,904	13,509
	Lower range tonnage requirements	3,587	3,754	4,083	4,301	4,503
	Lower range domestic surplus (shortfall)	(3,287)	(3,454)	(3,783)	(4,002)	(4,203)

Appendix I Certifications mapping[89]

Table 84 Material traceability certifications mapped for alignment to NFRCT

Aligns with National	Partially aligns with National Framework	Does not align with National Framework

Certification	Material Types	Allocation Method	Chain of Custody	Pre/Post	Certification Scope	Inpdnt Audit	Interoperability	Time Estimate	Cost Estimate	Comment
ISCC+	All	Segregation Controlled Blending Mass Balance (Free - moving to Fuel Exempt)	✓	Both - Separated	Company and site specific	Third Party	In the absence of certification along full supply chain, point of origin provides self-declaration, other stakeholders across supply chain must provide sustainability declaration.	18 Weeks	USD 5500 + CB	Chemical and mechanical recycling, licence fees 1,200 Euros to 28,000 Euros
Global Recycling Standard (GRS)	All (Min. 20% RC)	Mass balance	×	Both - Separated	Recycler Only - production of GRS products only, not the facility.	Third Party	GRS Only	12 Weeks	USD 9000	The Global Recycled Standard (GRS) is an input level standard which covers the recycler. All subsequent sites are certified to the Content Claim Standard (CCS), which is the chain of custody system of all Textile Exchange standards. After a successful audit by a third-party Certification Body (CB), a brand or supplier would be issued a scope certificate (SC) to the CCS with the GRS listed as a scope.
Content Claim Standard (CCS)	All	Segregation	✓	Both - Separated	CoC after GRS Recycler	Third Party	CCS + GRS Only	12 Weeks	USD 5000	

[89] ^EuCertPlast audit scheme is based on CEN EU standard EN 15343, Plastics — Recycled Plastics — Plastics recycling traceability and assessment of conformity and recycled content, EN 15344, Plastics — Recycled Plastics — Characterisation of Polyethylene (PE) recyclates, EN 15345, Plastics — Recycled Plastics — Plastics recyclate characterisation of (PP) recyclates, EN 15346, Plastics — Recycled plastics — Characterisation of poly (vinyl chloride) (PVC) recyclates, EN 15347, Plastics — Recycled Plastics — Characterisation of plastics wastes, EN 15348, Plastics — Recycled plastics — Characterization of poly (ethylene terephthalate) (PET) recyclates, CEN/TR 15353, Plastics — Recycled plastics — Guidelines for the development of standards for recycled plastics.

Certification	Material Types	Allocation Method	Chain of Custody	Pre/Post	Certification Scope	Inpdnt Audit	Interoperability	Time Estimate	Cost Estimate	Comment
RecyClass Recycling Process Certification	Plastic	Controlled Blending	✓ with transition option	Both - Separated	Any player in the value chain may apply for a certificate	Third Party	Recognised Certifications are available	16 Weeks		RecyClass & EUCertPlast^ audit schemes joined forces and combined under this certification. The audit schemes are based on the principles of the EN 15343 standard and focus on the traceability of the origin of waste in plastics recycling processes. Annual Renewal.
FSC	Fibre	Any	✓	Both - Mixed	CoC from point of origin	Second Party	FSC Only	24 Weeks		Annual surveillance audit. Recycled content only one part of certification
PEFC	Fibre	Variable	✓	Pre	Supply-chain and brand owner	Third Party	PEFC, EUDR data TF (linking to both SFM and Coc WG)			Calculate the content of recycled material based on ISO 14021 Align with EU Regulation of Deforestation-free Product (EUDR) and EUTR
ASI Chain of Custody	Aluminium	Mass Balance - Proportional	✓	Both - Separated	Bauxite to Aluminium production	Third Party	No	26-52 Weeks	USD 9000	3 year validity - price estimate based on median on-site audit days
SCS Global – Recycled Content Standard, V7.0 (July 2014)	All (Minimum 5% RC)	Segregation, Optional: Mass Balance	× ✓ with mass balance option only	Both - Separated	Product manufacturer and its supply chain	Second Party	Recognition of ISCC, FSC, Textile Exchange	12-month	USD 4000 - 6000	SCS Environmental Claims Certification Program – ISO 14021:1999, ISO 14024:1999 & ISO 14020:2000
RSB Standard for Advanced Products Certification	Plastic & Fibre	Mass Balance	✓	Both – unclear whether separated	Product manufacturers, and its supply chain	Third Party		3 months		RSB is an ISEAL Code Compliant Member
Intertek SAI Global	Plastic, Fibre	Mass Balance			Its own facility and supply-chain	Second Party				ISO 14021: 2016

Certification	Material Types	Allocation Method	Chain of Custody	Pre/Post	Certification Scope	Inpdnt Audit	Interoperability	Time Estimate	Cost Estimate	Comment
APR PCR	All	Mass Balance	✓ via APR	Post-consumer	Recycling facility	Third Party	APR certificate trading system – North America			Annually
Recycled Material Standard (RMS)	All – plastics, glass, metals and fibre	Segregation, Controlled Blending, **Book and Claim**, Mass Balance	✓	Both – Option for separated	Entities who generate, reprocess, or purchase recycled material	Third Party	No		USD 1000 – 2500 + annually maintenance fee	Annual audit
Circularise (Digital Product Passport)	Metals, Plastics	Mass Balance	✓	Both - Separated	Company and site specific	Third Party	Block-Chain	18 Weeks	USD 5500 + CB	ISCC Plus - requirements

Appendix J Stakeholder engagement summary

Purpose

A stakeholder engagement plan was implemented to inform the development of the Options Paper.

One purpose of the Options Paper is to present the areas of industry consensus in relation to the implications of future requirements for recycled content; and to share the different options available to progress recycled content mandates having regard to wider industry material availability and organisational capacity.

Methodology

The project utilised the following engagement methods to inform the outputs:

1. Peak body engagement
2. Member Surveys on certifications and target setting.
3. Utilisation of the APCO Monthly Newsletter and dedicated emails
4. Establishment of a Recycled Content Reference Group
5. Series of four (4) RC Reference Group Meetings
6. Presentation to Collective Action Group and Material Stewardship Committee's
7. 1:1 Value Packaging Chain Interviews
8. Engagement with certification bodies
9. Options Paper Consultation

The engagement activities occurred between **mid-February** and **end-May**.

Implementation

Member Surveys

Members were surveyed for qualitative and quantitative data on certification programs and recycled content target setting. The survey will be conducted via Survey Monkey and data was reviewed by the Project Team.

Sharing the surveys widely with the APCO network provided all sized businesses an opportunity to represent their views on certifications and achievable targets.

The **Certifications Survey** sought to capture the details of certifications relevant to recycled content in packaging across all material streams to support certification mapping exercise.

The **Recycled Content Targets Survey** sought quantitative and qualitative indicators on achievable recycled content targets by material type including:

- short and long-term indicators
- time (years) for an organisation to achieve a short-term goal (including business capacity [resources] and capability [systems])
- indictor on % of Australian feedstock.

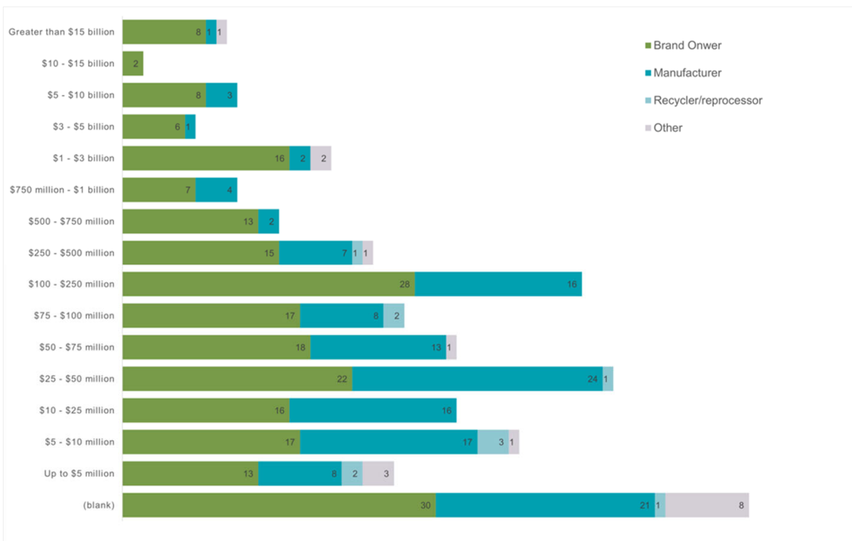
The results of the recycled content targets survey were used to inform the Recycled Content Target Analysis Tool developed to outline options for target setting. Figure 22 and Figure 23 provide an overview of survey responses by material, turnover and sector.

Figure 22 Recycled content survey responses by material type.

Material Type*	Min count
Aluminum Beverage/Non-Beverage	21
Boxboard/Cartonboard	59
Corrugated cardboard	56
Flexible HDPE	60
Flexible LDPE	75
Flexible PET	64
Flexible PP	64
Glass Amber	13
Glass Flint	13
Glass Green	12

Material Type*	Min count
High wet strength carrier board	46
Kraft paper	48
Moulded fibreboard	45
Polymer coated paperboard/ paper	48
Rigid HDPE	52
Rigid LDPE	39
Rigid PET	55
Rigid PP	50
Steel – Mild steel	18
Steel – Stainless steel	16
Steel - Tin-plate steel	24

Figure 23 Recycled content survey responses by sector and turnover.



APCO Monthly Newsletter, EDM and Social Media

The newsletter, EDMs and social media were utilised for specific requests for information. Readers were encouraged to provide their responses to the @marketinsights inbox managed by the Systems Transformation Team; or through completion of a survey.

Campaign 1 Certifications Survey	Request to share insights/research on recycled content. Launched Certifications Survey (Survey Monkey)

February 2024 - ***COMPLETE***
- Call out to readers to share insights/research on identified gaps in information for WS1
- Launch of Certifications Survey (Survey Monkey) WS2


Recycled Content Certification Survey

We are investigating recycled content certifications to inform our understanding of the role for standards and certifications as an enabler for recycled content traceability. To minimise additional requirements on members, we are seeking input on the type and application of certifications already adopted by stakeholders. Take the survey here.

Research Request: Packaging reprocessing and end markets

We are seeking your input on any relevant studies/resources to further inform the reprocessing of packaging and end markets for post-consumer packaging recyclate. If you are interested, email marketinsights@apco.org.au with your details and an overview of the available information.

March 2024 - ***COMPLETE***
- Reminder of the Certifications Survey

APCO NEWS

Recycled Content Certification Survey
We are investigating recycled content certifications to inform our understanding of the role for standards as an enabler for recycled content traceability. Take the survey here.

Results – Launch + reminder
Circulation: ~7000 x2
Clicks: ~75
Survey completed: >20

Campaign 2 RC Targets Survey	Launched Recycled Content Targets Survey (Survey Monkey)

10 May 2024 - ***COMPLETE***

Friday 10 May 2024 Unable to view this email? View in Browser

APCO **Recycled Content Survey**

Dear {{{Recipient.FirstName}}},

As a valued stakeholder in the packaging and recovery sector, we're reaching out to gain your input on an important survey on potential recycled content mandates for packaging.

The data collected will play a critical role in informing upcoming government consultation and will represent industry's views on the ambition and progression of recycled content target setting.

Your participation in this survey will:

- **Inform policy:** By sharing your insights, you'll help shape the recycled content targets for the industry. This is a chance to inform ambitious but achievable target setting.
- **Contribute to thought leadership:** APCO will use this information to draft an Options paper, which will be submitted to the government mid-year.

Please complete the survey here by **24 May 2024.**

If you have any questions, you can contact the APCO team via: apco@apco.org.au

Kind regards,
The APCO team.

You are receiving this email because you have opted in to recieve updates about the Australian Packaging Covenant Organisation (APCO) events and webinars or your company holds a Membership with APCO.

Manage your email preferences

21 May 2024 - ***COMPLETE***

Tuesday 21 May 2024 Unable to view this email? View in Browser

APCO **Recycled Content Survey**

Dear {{{Recipient.FirstName}}},

As a valued stakeholder in the packaging and recovery sector, we're reaching out to remind you about an important survey on potential recycled content mandates for packaging.

The data collected will play a critical role in informing upcoming government consultation and will represent industry's views on the ambition and progression of recycled content target setting.

Your participation in this survey will:

- **Inform policy:** By sharing your insights, you'll help shape the recycled content targets for the industry. This is a chance to inform ambitious but achievable target setting.
- **Contribute to thought leadership:** APCO will use this information to draft an Options paper, which will be submitted to the government mid-year.

Please complete the survey here by **24 May 2024.**

If you have any questions, you can contact the APCO team via: apco@apco.org.au

Kind regards,
The APCO team.

Results - Launch + reminder
Circulation: ~4000
Clicks: ~990
Survey commencement: 391
Survey completed: >150

Establishment of the Recycled Content Reference Group.

Representation was sought by invitation from the APCO Working Groups of CAG, DAS TAC and MSCs. Table 1 below details the participating organisations and their area of representation.

Table 85 Recycled Content Reference Group Participants

Company	Representation
AMCOR	Packaging Manufacturer
APR	Recycler and Reprocessor
Australian Institute of Packaging	Industry Body
Chemistry Australia	Industry Body
Close the Loop	Recycler and Reprocessor
Coles	Brand Owner (local)
Huhtamaki	Packaging Manufacturer
Licella	Chemical Reprocessor
Martogg	Recycler Reprocessor
Nestle	Brand Owner (global)
Nextek	Industry Expert
Pact Group	Manufacturer/Recycler
ReGroup	Recycler
Result Group	Manufacturer & Technology supplier
Sealed Air	Packaging Manufacturer
TMS Packaging	Packaging Manufacturer
Tomra Cleanaway NSW	Collector
Visy	Manufacturer/Recycler
Viva Energy	Advanced Reprocessor

Recycled Content Reference Group Meetings were held:

- Tuesday 5 March 2024
- Thursday 21 March 2024
- Tuesday 16 April 2024
- Friday 14 June 2024 (Joint meeting with Collective Action Group)

Participants were invited to participate under APCO's standard committee terms of reference (modified to relevance) and each meeting commenced with a Conflict of Interest and Competition caution.

Collective Action Group (CAG) & Material Stewardship Committees (MSCs)

The Project progress and feedback opportunities were also shared with the broader Collective Action Group and each Material Stewardship Committee on the basis below.

Table 86 Expert reference committee engagement

<table>
<tr><th>Date</th><th>Working Group</th><th>Content</th></tr>
<tr><td>13 March 2024</td><td>CAG</td><td rowspan="5">• Project summary by Project Lead.
• Summary of Reference Group discussion
• Feedback requests pending WS requirements.
• Testing technical maximum %ages
• Invitation for 1:1 stakeholder meetings.</td></tr>
<tr><td>26 March 2024</td><td>MSC Flexibles</td></tr>
<tr><td>27 March 2024</td><td>MSC Rigid</td></tr>
<tr><td>28 March 2024</td><td>MSC Fibre</td></tr>
<tr><td>9 April 2024</td><td>MSC Labels</td></tr>
<tr><td>7 May 2024</td><td>MSC Flexibles</td><td rowspan="4">• Project Update
• Summary of Reference Group discussion
• Sharing of the Recycled Content Target Setting survey</td></tr>
<tr><td>8 May 2024</td><td>MSC Rigids</td></tr>
<tr><td>9 May 2024</td><td>MSC Fibre</td></tr>
<tr><td>16 May 2024</td><td>CAG</td></tr>
<tr><td>18 June 2024</td><td>MSC Flexibles</td><td rowspan="3">• Project Update
• Testing technical maximums
• Testing target setting scenarios</td></tr>
<tr><td>19 June 2024</td><td>MSC Rigids</td></tr>
<tr><td>20 June 2024</td><td>MSC Fibre</td></tr>
</table>

Feedback received from APCO Working Groups was incorporated into a Feedback Summary Report.

Packaging value chain interviews

The purpose of the Packaging Value Chain (PVC) interviews was to fill any information gaps in desk research with targeted questions. These interviews provided the participants to engage more freely with APCO and supported the development of a summary challenges and opportunities for industry in adopting recycled content using the PESTLE Framework.

Participants in the Reference Group, CAC and MSC's were invited to contact APCO to arrange a one-to-one meeting with APCO's Head of System Transformation, Transformation Manager – Markets, Recycled Content Project Team Member.

Data gathered through the interview process in incorporated into the Material Summary Sheets at Appendices A-D and have been incorporated into the Key Insights represented at Appendix G Stakeholder interview key insights

A list of all participants in stakeholder interviews is provided in the table below.

Table 87 Stakeholder Interview Participants

Company	Interview Date
AMCOR	Packaging Manufacturer
Chemistry Australia	Industry Body
Close the Loop	Recycler and Reprocessor
Huhtamaki	Packaging Manufacturer
Licella	Chemical Reprocessor
Martogg	Recycler Reprocessor
Nestle	Brand Owner (global)
Result Group	Manufacturer & Technology supplier
Return & Earn - Tomra Cleanaway	Collector
Visy	Manufacturer/Recycler
Viva Energy	Advanced Reprocessor
COPAR	Packaging Manufacturer
PackTech	Automation/Fulfilment
Qenos	Advanced Reprocessor

1:1 Interviews – Member Certification
Meetings will be scheduled with technology solution providers and end market innovators including Close the Loop, Circularise, Rosella Street and Licella to understand primary challenges relating to obtaining certification.

Findings from this research have been used to guide additional interviews with certification bodies including ISCC+ and GRS to understand comprehensively the data requirements for each certification.

Peak body engagement

Ensuring the Options Paper was developed in consultation industry peak bodies, feedback was sought from the Australian Council of Recycling (ACOR), Australian Institute of Packaging (AIP) and Chemistry Australia. An overview of engagement is provided below.

Table 88 Peak body engagement

Peak body	Engagement summary
Australian Council of Recycling (ACOR)	• Regular meetings between APCO Head of Systems Transformation and ACOR's CEO. • Presentation to ACOR Industry Leadership Group • Recycled Content Reference Group representation • Document consultation
Australian Institute of Packaging (AIP)	• Recycled Content Reference Group representation • Document consultation
Chemistry Australia	• Recycled Content Reference Group representation • Document consultation. • 1:1 interview

Conclusion

The project has successfully engaged with:

- 22 individual organisations
- 9 industry sectors
- 5 APCO Working Groups.
- >7000 stakeholder contacts were invited to complete 2 industry surveys.
- >400 respondents.

This has resulted in a paper demonstrating areas of industry consensus and ability to provide stakeholders with a range of options for progressing recycled content in packaging.

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