A designer strategy

HANDBOOK

towards

PPWR

compliancy

SPD Master Thesis
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Introduction

Dear Reader,

In December 2024, the European Council adopted the Packaging and Packaging Waste Regulations (PPWR), set to take effect in 2030. These regulations mandate that all packaging designs comply with recyclability standards to advance the transition to a circular economy. **Packaging that fails to meet these standards will not be allowed on the market.**

This handbook is part of my master's thesis, which examines a segment of an FMCG's product portfolio to assess its recyclability under the anticipated PPWR guidelines. It provides a strategic framework for packaging design changes, offering insights into my approach, findings, and practical design recommendations. The handbook focuses on three specific packaging categories: rigid plastics with in-mould labels, composite cans, and plastic-paper packaging.

The knowledge presented here is based on extensive desk research, utilising tools such as RecyClass and 4evergreen, as well as expert input from the recycling industry and internal discussions with various stakeholders at an FMCG company. While the final regulations are expected by 2028, this handbook contains certain assumptions to address potential compliance challenges. As such, it serves as an initial foundation, meant to evolve and improve over time. Think of it as a stepping stone towards achieving compliance with the PPWR. If you have any questions or new insights to share, please do not hesitate to reach out.

Enjoy reading and exploring!
Tessa Bronsky

Table of content

How to read

This page provides an overview of the various colors, icons, and abbreviations used throughout this handbook, explaining their meanings and how to navigate the content effectively.

COLOURS

Red	Orange	Yellow	Green
! or ---	*-- or -*	*Sorting evaluation needed*	*0*

ICONS

! *Knock-out* --- *Large impact* - *Impact*

ABBREVIATIONS

PPWR - Packaging and Packaging Waste Regulations
PCR - Post Consumer Recycled Content
NIR - Near Infra Red
IML - In-Mould Label
PP - Polypropylene

About PPWR

The PPWR is built on multiple pillars that shape packaging regulations and requirements. While this handbook primarily focuses on recyclability, it is important to consider the broader regulatory landscape. This section provides an overview of the other key pillars.

Recyclability

Packaging should be made from materials that can be easily recycled. This involves choosing the right materials, simplifying the design, and avoiding multi-material packaging that complicates the recycling process. Clear guidelines help ensure packaging can be processed efficiently.

Minimum recycled content

To promote circularity, the PPWR requires a minimum percentage of recycled content in packaging. This pushes manufacturers to use more recycled materials, reducing reliance on virgin resources and supporting the recycling industry.

Packaging minimisation

Packaging should be as efficient as possible, using the least amount of material while still protecting the product. Reducing the weight and volume of packaging also helps reduce waste and transportation costs.

Harmonised labelling

Consistent and clear labelling across the EU helps consumers properly sort their packaging for recycling. Harmonised labels provide straightforward instructions to guide users on disposal or recycling practices, reducing contamination in recycling streams.

Extended producer responsibility

Under EPR, producers are accountable for the end-of-life treatment of their packaging. This includes ensuring packaging is collected, recycled, or reused, thus encouraging producers to design packaging with its entire lifecycle in mind.

Other

Waste Prevention: Focus on reducing packaging waste from the outset.
Reuse and Refill Systems: Encourages packaging systems designed for reuse and refill.
Biodegradable and Compostable Packaging: Sets requirements for packaging that is biodegradable or compostable.
Optimised Sorting and Recycling: Improved processes for sorting and recycling packaging waste.

2028

Criteria for D4R guidelines
Recyclability performance grades
EPR framework

2030

Weight recyclable > 70%
Minimum 10% PCR
Material minimisation requirements
Harmonised (digital) labelling
Packaging waste reduction by 5%

2035

Recyclability at scale > 55%
Packaging waste reduction by 10%

2038

Weight recyclable > 80%
Minimum 25% PCR

About recycling

To understand why certain requirements are made, it is good to have an understanding of recycling itself. The visual below illustrates the recycling journey and highlights key requirements that arise from each stage.

1.

Disposal by consumers

Proper labelling is essential to guide correct disposal, while avoiding mixed materials and confusing recycling streams.

2.

Collection & transportation

This is the first stage of packaging compaction. Design multi-material components to be easily separable at this stage.

3.

Sorting at facility

Design for detectability by avoiding dark colours and ensuring NIR compatibility, while ensuring separability with easily removable components compatible with the primary material.

4.

Compaction to bales & transportation

Packaging parts are baled and sent to the adherent recycling facility

5.

Grinding into flakes in recycling plant

During grinding into flakes at the recycling plant, ensure labels (with inks/adhesives) are easily separable.

6.

Washing

Ensure that inks do not bleed and fibre loss is minimised to avoid contamination and losing strength.

7.

Float sink separation

During float-sink separation, ensure materials have appropriate densities for effective separation.

8.

Drying & additional processing

In drying and additional processing, materials are dried to remove moisture and may undergo further treatments to enhance recyclability.

PCR

THE FRAMEWORKS

The strategic frameworks developed here provide guidance for achieving PPWR-compliant packaging design. They address key challenges such as recyclability, sortability, and contamination, while aligning with regulatory requirements. Built upon insights from interviews, industry tools, and case studies, they offer a structured approach to assessing current packaging, identifying opportunities for improvement, and implementing effective design changes.

0

For plastic*

*This framework is based on learnings from rigid plastic with in-mould labels and plastic-paper food packaging; plastic tubs with a carton sleeve. This framework therefore does not necessarily apply to all plastic packaging.

SORTABILITY

Compactability

- Shape/form
  The packaging should not bounce or roll of the conveyor belt
- Rigidness
  The packaging should be compactible with mechanical pressure

Detectability

- \- Label
  The label or sleeve should not hinder the detectability of the colour and material of the main packaging body
- \- Materials
  The different material type components (e.g. sleeve, cap) should not hinder the detection of the main packaging body. The main packaging body should be plastic. Avoid non-plastics.
- \- Colours
  The inks should not contain carbon black as this limits detection by NIR. The colour of the main packaging body should be detectable (transparent/white/colour).

Materials, separability

- ! Closure: liners, seal, valve
  Avoid using different materials for the closure. If needed, ensure separability is easy. Avoid metals.
- Components/composition
  Should be easily separable under mechanical pressure or mono.
- \- Sleeves
  Should be easily separable under mechanical pressure or mono.

CONTAMINATION

Labels

- --- IML
  Should be removable/separable in the recycling process and should be the same material as the base material.
- \- Inks
  Should be non-bleeding, EuPia compliant, not containing carbon black and not effect the colour of the base material & PCR.
- \- Adhesives
  Should not affect the quality of the PCR, should be removable or water soluble.

Multi-materials -
Should not affect the quality of the PCR or give impurities (e.g. carton should not contain fibre loss).

PPWR

Other PPWR pillars
To ensure compliancy, the other PPWR pillars besides recyclability should be taken into account: e.g. minimum PCR, packaging minimization, harmonized labelling.

The factors should be prioritised based on their respective impact by the following symbols:
! *Knock-out* --- *Large impact* - *Impact*

For paper*

*This framework is based on learnings from specific composite can food packaging and carton sleeves. This framework therefore does not necessarily apply to all carton/composite packaging.

SORTABILITY

Detectability

- Label
  The label should not hinder the detectability of the material of the main packaging body or be separated before sorting.
- Materials
  The different material type components (e.g. sleeve, cap) should not hinder the detection of the main packaging body. The main packaging body should have a minimum of 80% of paper.*

Materials, separability

- Closure: liners, seal, valve
  Avoid using different materials for the closure. If needed, ensure separability is easy. The liner should be reduced to a minimum to ensure it does not withhold too many fibers.
- Components/composition
  Should be easily separable under mechanical pressure (collection & friction test) or mono.

CONTAMINATION

Multi-material

- ! Yield
  Yield must be at least 80% after recycling. Other materials should be removable or not affect the quality of PCR.*
- ! Lamination
  Paper should not be double sided laminated, there should be an "open" surface so the recycling process can take out the fibers.

Sheet adhesion

- Adhesives
  Should not affect the quality of the PCR, should be removable or water soluble. Should not lead to sheet adhesion. Avoid hot melt.

Visual impurities

- Decorations
  Should be removable/separable in the recycling process.
- Inks
  Should be non-bleeding, EuPia compliant and preferably not of a dark or bright colour.

PPWR

Other PPWR pillars

To ensure compliancy, the other PPWR pillars besides recyclability should be taken into account: e.g. minimum PCR, packaging minimization, harmonized labelling.

**Requirement for a standard mill. Requirements for recyclability can differ per country.*

The factors should be prioritised based on their respective impact by the following symbols:

! *Knock-out* **---** *Large impact* **-** *Impact*

RIGID PLASTIC WITH IML

One category that was researched is the rigid plastics with in-mould labels. The in-mould label is integrated into the plastic during moulding, providing a clean, high-quality finish.

1

Design guidelines

Based on the anticipated PPWR guidelines, online tools, and the framework, specific design guidelines have been established for rigid plastics with in-mould labels. Plastic should be the predominant material by weight and cover the largest part of the packaging surface. The criteria below serve as the foundation for redesign efforts. Throughout this book, the framework can be referred to as a valuable tool and reminder during the design process.

1. White or Transparent Packaging: In-mould labels are **not** recommended for these materials to reduce contamination in recyclability. (---)
2. Coloured Packaging: In-mould labels should be the same material as the base, with the printed ink weight comprising less than 1% of the total packaging weight. Dark colours should be avoided. (-)
3. Ink Bleeding: Ensure that inks used on the labels do not bleed during washing processes to prevent contamination. (!)
4. Ink Compliance: All inks must comply with EuPIA guidelines to ensure safety and recyclability. (!)
5. Sorting Compatibility: Avoid non-detectable carbon black inks, as these hinder sorting efficiency during recycling. (sorting)
6. Coating Weight: The combined weight of inks and lacquers should not exceed 5 grams per square metre (gsm). (contamination)
7. Label Coverage: For natural PP packaging, label coverage should be limited to less than 50% for containers under 500 mL and less than 70% for containers over 500 mL to facilitate effective sorting. (sorting)
8. Lids and Seals: Use the same material as the base or ensure that components can be easily separated under pressure. Avoid metallic components. (!)
9. Adhesives: Avoid adhesives, as they can contaminate the post-consumer recyclate (PCR). (contamination) (---)
10. Add-ons: Use the same material type as the base. Ensure tamper evidence is integrated into the packaging rather than applied as a separate sticker.
11. Rigidity & Shape: Design packaging to be compactable under pressure, facilitating efficient transportation and recycling. Ensure that round shapes do not interfere with the sorting process by rolling unpredictably in different directions. (sorting)

In summary, packaging should be designed to ensure easy detectability, separation, and sorting. Maximise the use of recycled content wherever possible and aim to produce high-quality post-consumer recyclate (PCR) through thoughtful design.

Design requirements

Following the research, a set of specific design requirements can be made for rigid plastic with in-mould labels.

Materials:

- Ensure mono material compatibility for all add-on components. If this is not feasible, ensure the components can be separated under for example mechanical pressure
- Avoid use of metals and aluminium with plastics
- Try to integrate add-ons like tamper evidence into the base packaging instead of as separate elements

In-mould labels:

- Ensure IML labels are removable during the recycling process for example in mechanical separation or shredding
- Ensure IML labels are made of the same material as the base packaging
- Ensure white or transparent base packaging can be sorted into the white or transparent recycling stream. If the IML label is coloured, the packaging may end-up in the coloured stream, resulting in a downgrade in quality.

Inks:

- Suppliers should exclude carbon black pigments or if inks are removable, use as little carbon black as possible
- Minimize ink usage as much as possible and use lighter ink colours where feasible
- Use water-soluble inks, provided they do not contaminate the PCR

01 **Strive for mono-materials**

02 **Separable components under mechanical pressure**

Recommendations

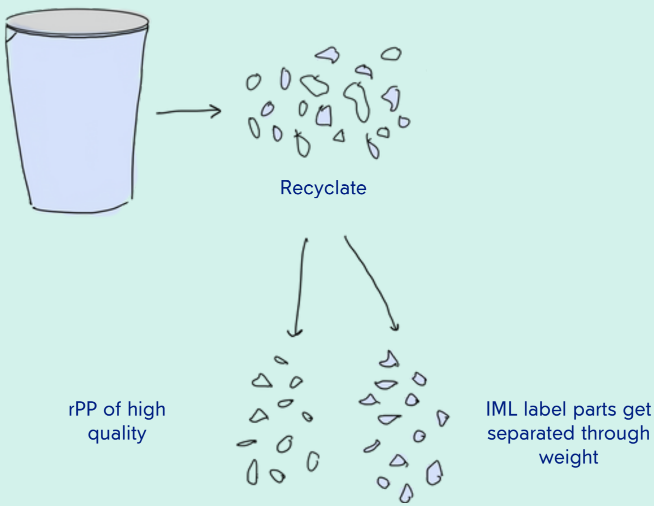
This section consolidates key recommendations and highlights design changes needed to address pressing issues in packaging sustainability. By building on existing solutions and exploring forward-thinking innovations, the goal is to inspire and provide practical starting points for the industry.

General design recommendations

An integrated tamper-evidence design is essential to ensure security while reducing waste from additional components. Packaging should avoid the use of carbon black pigments, as these hinder detectability in sorting processes. Similarly, inks should be minimised to reduce contamination risks. The effect of rigid and round packaging on sortability should be further explored by mimicking the recycling process.

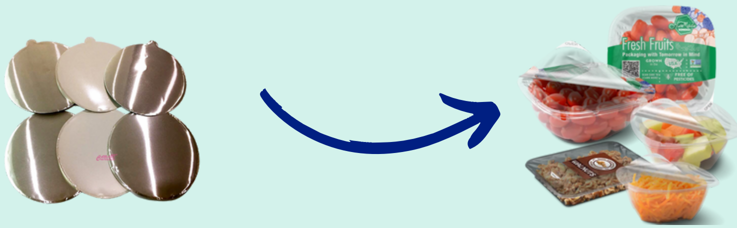
IML solutions

For in-mould label (IML), the inks used can significantly contaminate recycled plastic material (PCR) and the underlying base colour can not be identified. Long-term solutions should focus on developing IMLs that detach from the base material during mechanical pressure or shredding. This ensures that inks from the labels do not contaminate the recycled material.



Recommendations

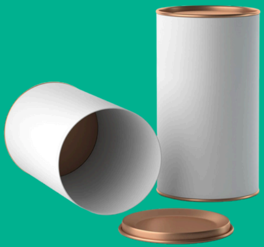
Aluminium seal
An aluminium can often be replaced with a polypropylene (PP) seal. This substitution eliminates the sorting issues caused by aluminium and ensures compatibility with plastic recycling streams.



Other solutions to explore
Additional solutions worth exploring include the use of shrinkable, removable, or washable sleeves that can be easily separated during recycling to reduce contamination. Designing for reusability is another promising avenue, as it extends the lifecycle of packaging and reduces waste. Developing innovative methods for mechanical separation within recycling processes could also address some of the current challenges. For specific cases, alternative materials like metal tins or glass jars could be viable options for a more sustainable future.

COMPOSITE CANS

Another category that was researched are the composite cans. Composite cans are predominantly made of paper, but have a metal liner inside the packaging, to ensure barrier properties are met.



2

Design guidelines

Based on the anticipated PPWR guidelines, online tools and the framework, specific design guidelines have been established for paper recycling, under which we scale the composite cans. Paper should be the predominant material by 80% of the packaging. The criteria below serve as the foundation for redesign efforts. Throughout this book, the framework can be referred to as a valuable tool and reminder during the design process.

1. Yield: Ensure a fibre yield threshold of at least 80% during the recycling process to maximise material recovery and minimise waste. Prioritise the use of high-quality fibres that can withstand multiple recycling cycles.
2. Visual impurities: Minimise visual impurities, such as ink residues, adhesives, metallics or other contaminants, to ensure that the recycled material maintains a clean and uniform appearance.
3. Sheet adhesion: Layers of the packaging should separate easily during recycling. Avoid adhesives or bonding methods that prevent fibres from breaking down in water-based recycling systems.
4. Multi-material usage: Limit the use of multi-material combinations to avoid complications in recyclability. If unavoidable, ensure materials can be easily separated or are compatible with fibre-based recycling streams. The paper material should also be recognizable to the consumer, so the packaging gets disposed in the right stream.

In summary, packaging should be designed to include as much mono-material as possible to ensure high-quality post-consumer recyclate (PCR). If this is not possible, the packaging should be designed to be easily separable under mechanical pressure.

Design requirements

Following the research, a set of specific design requirements can be made for the design of better recyclable composite cans.

Materials:

- Ensure mono material compatibility for all add-on components: bottom, cap and sprinkler (or seals). If this is not feasible, ensure the components can be separated under for example mechanical pressure
- Ensure the used paper is of high-quality fiber to address the minimum yield
- Keep the percentage of liner within the base can as low as possible compared to the paper percentage
- Ensure the paper is not double side laminated. We need a surface where the recycling water can “attack” the paper and take out fibers

Inks:

- Minimize ink usage as much as possible
- Try to use lighter inks instead of darker ones
- Do not use water-soluble inks they contaminate the PCR

01 **Strive for mono-materials**

02 **Separable components under mechanical pressure**

Recommendations

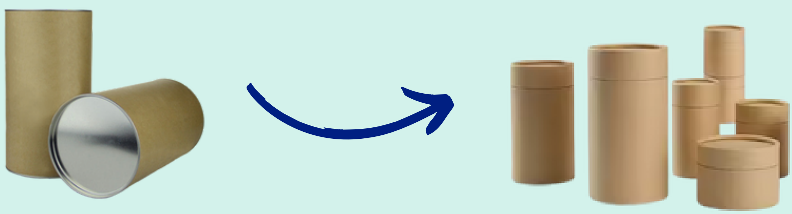
This section highlights general recommendations and actionable design changes for composite cans, informed by current best practices and innovative possibilities. By addressing key issues and exploring alternative materials and designs, these recommendations aim to inspire recyclable transformations in packaging.

General design recommendations

Composite cans present unique challenges due to their multi-material construction. Moving towards mono-material solutions is a fundamental step in improving recyclability. Simplifying the material composition enhances the efficiency of sorting and recycling processes. Where different materials are used, ensuring mechanical separability under pressure is critical. Collection and friction tests should validate this functionality. Additionally, minimising ink usage across all components reduces contamination and improves the quality of recycled material. The reduction of aluminium liners, where feasible, is also important for compliance with recyclability goals.

Main issues to work on

Two significant issues require immediate attention: the metal bottom and plastic tops with sprinklers. Replacing the metal bottom with a paper-based alternative can significantly enhance the recyclability of the can. Similarly, substituting the plastic top with a paper-based solution aligns with the move towards mono-materials and improves the product's end-of-life processing. However, as the top can be seen as a “loose” component, ensuring mechanical separability is also a good first step.



Recommendations

Other solutions to explore

Moving entirely to a single material type offers a streamlined solution to recycling challenges. For instance, Van Gilse's powdered sugar packaging demonstrates the feasibility of switching entirely to plastic for certain applications. Completely paper-based cans, which companies like Papacks are supporting, offer another recyclable option. For applications requiring greater durability, metal cans, like those used by Euroma, or glass jars, such as those used by Verstegen, provide alternative pathways.

Refilling sachets represent a significant opportunity for reducing waste and extending the lifecycle of packaging. Implementing reusable cans could be particularly impactful in categories with frequent repeat purchases, such as spices or powdered products.

PLASTIC + CARTON SLEEVES

A final category examined is plastic packaging with a glued paper sleeve. The combination of paper and plastic optimises the strengths of both materials. Both frameworks can be applied to assess the recyclability of this packaging type.

3

Design guidelines

Given that the packaging types studied here include both paper and plastic, it is essential to ensure that these materials are recycled separately. The same design guidelines apply to both individual cases as those used for previously researched packaging: follow paper guidelines for the sleeve and plastic guidelines for the tub. The criteria below form the essential foundation for redesign efforts and serve as valuable tools and reminders during the design process.

1. For design for plastic recycling, refer to section 1
2. For design for paper recycling, refer to section 2
3. Adhesives: avoid adhesives as they can contaminate the PCR for both plastic and paper. Opt for solutions that are easily separable under mechanical pressure. (contamination)
4. Label coverage: As the base plastic packaging is covered by the paper sleeve, ensure the plastic part can reach the correct recycling stream. (sorting)
5. Use minimum inks and where possible lighter inks. Not dark or bright colours.
6. Paper recycling: ensure paper is not double side laminated as the recycling water should be able to reach the paper surface.
7. Lids and Seals: Use the same material as the base or ensure that components can be easily separated under pressure. Avoid metallic components. (!)

In summary, packaging should be designed to ensure easy detectability, separation, and sorting. In the case for plastic-paper packaging, it should be designed in a way that the different materials can easily separate from each other, for example due to mechanical pressure (during bailing). Maximise the use of recycled content wherever possible and aim to produce high-quality post-consumer recyclate (PCR) through thoughtful design.

Design requirements

Following the research, a set of specific design requirements can be made for plastic packaging with paper sleeves.

Materials:

- Ensure mono material compatibility for all add-on components. If this is not feasible, ensure the components can be separated under for example mechanical pressure. The carton should be separated from the plastic before sorting detection.
- Avoid use of metals and aluminium with plastics
- Ensure the used paper is of high-quality fiber to address the minimum yield

Adhesive usage:

- Where possible, design without adhesives. This ensures better separation and also less chances of sheet adhesion and contamination.

Inks:

- Minimize ink usage as much as possible, avoid dark or bright colours.
- Do not use water-soluble or mineral inks, provided they contaminate the PCR

01 Strive for mono-materials

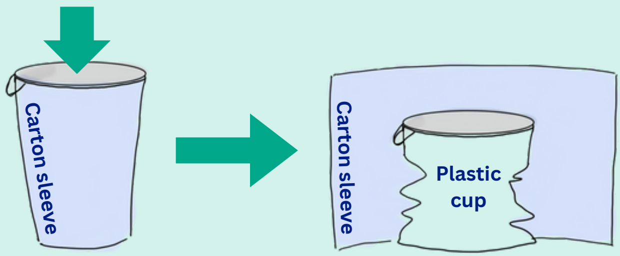
02 Separable components under mechanical pressure

Recommendations

This section provides general recommendations and specific design changes to enhance the sustainability of plastic tubs with paper sleeves. By focusing on mechanical separation, material optimisation, and reduction of contaminants, these suggestions aim to align packaging design with future regulations and sustainability goals.

General design recommendations

To improve recyclability, the design should prioritise mechanical separation of the paper sleeve from the plastic tub. Ensuring that the sleeve can be efficiently removed during the recycling process is critical for maintaining the purity of the recycled plastic. This could involve using innovative sleeve attachment methods or designing the sleeve to detach under pressure. Using perforated edges or click-systems could help this. Ink usage on the paper should also be minimised to prevent visual impurities in the recycled material. When inks are necessary, lighter or water-based inks are preferable to reduce contamination risks. Exploring mono-material solutions, where the entire packaging is made from a single material, could eliminate separation challenges altogether. Additionally, minimising or eliminating glue dots reduces contamination risks and simplifies the recycling process. An example can be seen below.



Other solutions to explore

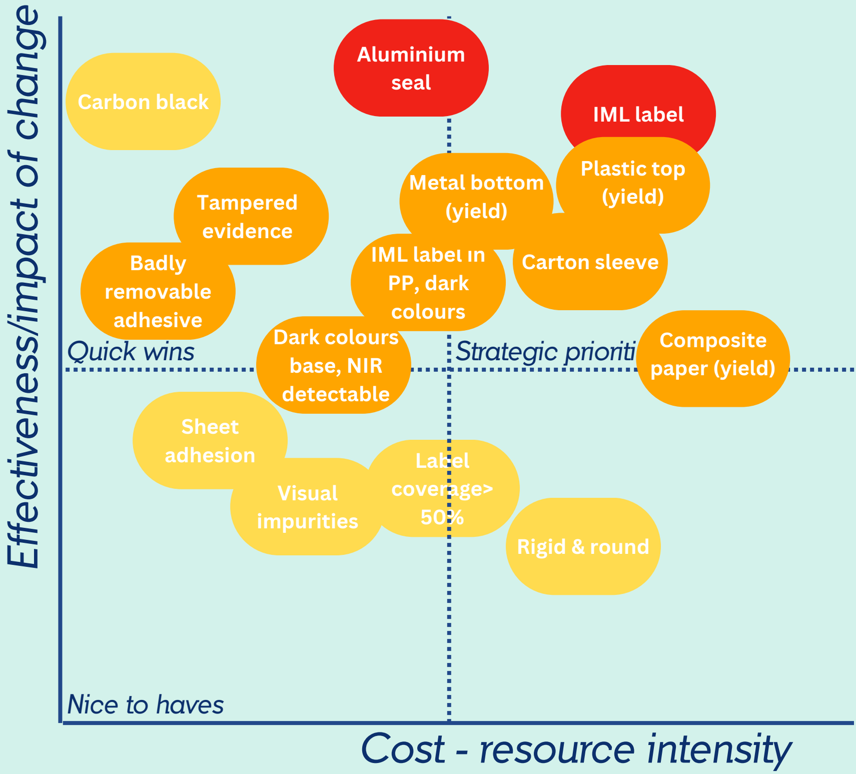
As mentioned previously, moving entirely to one material, for example plastic, could also be an interesting direction, provided it meets recycling standards. Research and testing in the rigid plastics with IML's could then be extrapolated to the plastic-paper packaging.

COMPLEXITY DRIVERS

4

Impact & complexity

By examining the various factors that need to be adjusted in packaging to ensure compliance, we can create a "recyclability impact" versus "cost/resource intensity" matrix. This matrix provides an overview of the impact and resources associated with design changes. The matrix below offers a generalised perspective, developed in collaboration with internal stakeholders. It serves as a guide to understanding the complexity of implementing design changes, highlighting the need to prioritise finding feasible solutions.



In the top right section, the strategic priorities are highlighted as key areas of research that will have a significant impact on recyclability but require investment in cost or resources. Replacing aluminium with plastic seals is relatively straightforward, whereas changing in-mould labels (IML) is more challenging due to the lack of comparable solutions. Modifying the product's form and shape also requires considerable cost and resources. While the exact impact of rigid and round shapes on sortability remains uncertain, it is not an immediate priority but should be considered in future redesigns. Other design changes, such as removing carbon black or integrating tamper evidence into the same material type, are easier to implement.

For high-quality paper recycling, the input stream should contain as much paper as possible, with yield strength being the most important factor. However, maintaining barrier properties in packaging adds complexity. Changing the bottom of the packaging is relatively straightforward, whereas altering the cap and composite base is more challenging due to the lack of existing solutions. Other design changes, such as reducing ink usage, are easier to implement.

Changes to carton sleeves present additional challenges due to the lack of comparable alternatives. One option could be to transition entirely to either all paper or all plastic. If the carton sleeve can be easily separated from the plastic before entering the sorting stream, it could remain a viable packaging type. Removing adhesives could be a first step, also improving sheet adhesion. Other design changes, such as reducing ink usage, are easier to implement.

A general overview of complexity drivers and decision points can be found on the next pages.

Complexity drivers

Redesigning packaging to align with recyclability and PPWR compliance introduces several layers of complexity. These complexities can be broadly categorised into four areas: time, cost, consumer perceptions, and technical feasibility. Understanding the drivers and integrating them into the design process early can help accelerate decision-making and improve collaboration across stakeholders. This section outlines some complexity drivers and provides decision points to guide designers through the challenges.

Existing solutions

The availability of pre-existing solutions significantly affects complexity.
If a solution already exists, such as a PP seal replacing an aluminium seal, implementation is far easier. Conversely, if the required solution is novel or untested, the process becomes highly complex and resource-intensive.

Decision point: investigate whether suppliers or competitors offer proven solutions that can be adapted to your design. Collaborate with suppliers to leverage their existing innovations.

Supplier capabilities

The ease of implementation is often related to supplier readiness. If the supplier already has the capability to produce the desired change, complexity is reduced. Engaging suppliers without the required technology or expertise increases lead times and costs.

Decision point: assess supplier readiness and engage with those who can deliver proven, scalable solutions.

Equipment updating

The adaptability of existing manufacturing lines plays a critical role in complexity. If a line already requires upgrades, incorporating design changes becomes less disruptive. However, introducing materials that are incompatible with current machines gives challenges.

Decision point: evaluate whether the machine or line needs updating in the near future to reduce cost to test your innovations.

In-house vs. outsourced production
The location of production impacts complexity. Changes are often easier and less costly to implement in in-house facilities. Outsourced production, especially involving multiple suppliers, adds layers of coordination, cost and variability.

Decision point: prioritise testing and scaling innovations in in-house facilities before rolling them out to outsourced suppliers.

Scale of implementation
Packaging redesigns for larger volumes present unique challenges compared to smaller runs. Smaller volumes can often adopt the designs of larger players or learn from early adopters. For larger volumes, implementing changes across multiple suppliers and plants introduces logistical complexity.

Decision point: see if it is feasible to pilot the design change at a single facility and at a lower scale. Assess the difficulty of implementing this in the other plants with other lines.

Impact on look and feel
Significant visual or tactile changes to packaging can complicate the redesign process. Large changes may require some transitional packaging formats or a great marketing story to preserve brand trust with consumers.

Decision point: consider introducing intermediate design formats and develop a compelling narrative to explain the changes to consumers.

Shelf life
Design changes that affect the shelf life of a product are particularly complex, as they impact product quality and supply chain processes. Materials that compromise barrier properties may require extensive testing and development.

Decision point: often a change in shelf life is not feasible. Therefore test in an early phase whether the packaging design change will have an impact on this.

Note: every case remains unique, therefore it is difficult to give an indication of cost and time before trialling. This might still change.

Transition score

To prioritise design changes, you can develop complexity to transition scoring. This score is based on internal discussions and would need further research and refinement. However, for now it can be a good help when having to make complex decisions whilst comparing packaging design changes.

Cost impact (**C**): includes production cost changes, supplier investments, and potential cost savings.
Scale: 1 (low cost impact) to 10 (high cost impact).

Time to implement (**T**): accounts for design lead time, supply chain adaptation, and validation cycles.
Scale: 1 (short time frame) to 10 (long time frame).

Consumer perception change (**P**): evaluates how significant the change is from the consumer's perspective, such as usability or visual appeal.
Scale: 1 (minor change, easily accepted) to 10 (major change, potential resistance).

Technical feasibility (**F**): measures how easily the change can be achieved within existing technical constraints, including machine adaptability and material compatibility.
Scale: 1 (technically simple) to 10 (technically challenging).

Complexity Drivers (**CD**): the secondary drivers mentioned in the previous section can be assigned additional scoring

$$\textit{Transition score} = wC \cdot C + wT \cdot T + wP \cdot P + wF \cdot F + wCD \cdot CD$$

Where (wC,T,P,F,CD) are weights assigned to the importance of each factor summing to 1 to your liking. CD can also be left out of the calculation.

If a design change has a high transition score but is mandatory (e.g., for regulatory compliance), it should be flagged as a strategic priority for immediate focus.

This scoring system can provide a structured approach to evaluating and prioritising packaging design changes, helping to streamline the decision-making process and highlight areas requiring additional attention.

CLOSING TIPS & ADVICE

5

Recommendations

Main design recommendations
Throughout this handbook, I have consistently emphasised two overarching goals for designing packaging for recyclability:

1. Prioritise **mono-material** designs to simplify recycling processes and reduce contamination.
2. Ensure that components made of different materials are **mechanically separable**, particularly under mechanical pressure.

Additionally, I strongly advise testing and certifying the worst-case scenarios of your packaging types to anticipate potential issues and enhance resilience in diverse recycling systems.

Key learnings and advice
As I reflect on the past thesis work, one significant realisation is that the PPWR (and sustainability) transition is a dynamic process. Guidelines, tools like RecyClass, and our collective knowledge evolve continuously. Designing with a focus on the bigger picture and long-term goals is essential to navigate this uncertainty effectively.

One of the most valuable aspects of this process has been **engaging with practitioners,** particularly recycling experts. Their hands-on knowledge of real-world recycling challenges and opportunities can provide invaluable guidance and insights. I encourage designers to collaborate with these experts to ground their decisions in practical realities.

Understand the recycling industry
A deep understanding of the recycling industry is important for designing recyclable packaging. Knowing why certain materials or designs are non-recyclable and recognising the limitations of existing systems form the foundation of effective design decisions.

Navigating complexity
One of the difficulties I encountered was managing the complexities involved in making decisions, especially within a large organisation. With so many interdependent factors; technical feasibility, cost, consumer perceptions and more, it can be difficult to determine the best path forward. My work aims to begin unravelling this complexity and provide a framework that others can build upon.

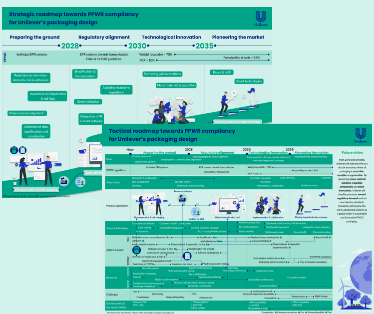
The next phase...

The first phase focused on building a framework and foundation for PPWR-compliant design. In the next phase, this can be expanded to place greater emphasis on defining complexities. By integrating an overview of company capabilities, goals, current packaging specifications, and PPWR requirements, a software tool could be developed to optimise forward-looking packaging decisions.

This tool would provide tailored recommendations for redesigning existing packaging to meet PPWR standards, enabling data-driven decision-making while ensuring feasibility and recyclability. This could for example be another interesting student thesis topic.

In addition to this practical handbook, I created an A3 process template designed to guide you through the process, serving as a visual summary of the key insights presented here. To complement this, I also developed a roadmap to help consider future perspectives, ensuring designs remain relevant and forward-thinking. Together, I hope these tools inspire action, foster innovation, and support on the journey towards more sustainable packaging solutions.

ROADMAPS



PROCESS TEMPLATE