DESIGN GUIDE

REUSE AND RECYCLING of plastic packaging for private consumers

NETWORK FOR CIRCULAR PLASTIC PACKAGING

The Design Guide is the updated and revised 3rd edition of 'Design Guide for Reuse and Recycling of Plastic Packaging for Private Consumers'. Previous editions were published in 2015 and 2019.

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1 Introduction to the Design Guide

Packaging for private consumption has two primary functions: It protects a product during transport from the manufacturer to the consumer, and it provides important product information to the consumer. Once a consumer is finished using the product in the packaging, the packaging has no value for the consumer and is thrown away.

Plastic packaging should not end up in household trash cans as worthless waste. Instead, to a greater extent, packaging should be designed in a way so it remains a valuable resource, where either the packaging or the material's properties and value are kept in a circular cycle.

The purpose of this design guide is to present an overview of the considerations that can help lead the way to optimized circularity for plastic packaging that ends up in private households.

Along with the changes in packaging design, it is essential that efforts are made at every level to ensure an improved infrastructure for collecting, sorting and treating plastic waste in Denmark - both for reuse and recycling solutions. Only by optimizing every link in the chain will it be possible to achieve a circular economy for plastic packaging in Denmark.

More recommendations for handling plastics in household waste in the future can be read at Plast.dk.

Broad collaboration

The Design Guide is the result of a broad collaboration between many links in the value chain – from packaging manufacturer, producer and waste collector to recycling companies, retail chains and other stakeholders.

The working group who did the groundwork and made the Design Guide a reality was set up by the Network for Circular Plastic Packaging under the direction of the Danish Plastics Federation. The working group is made up of representatives from the partner companies and organizations listed on the back of the Design Guide.

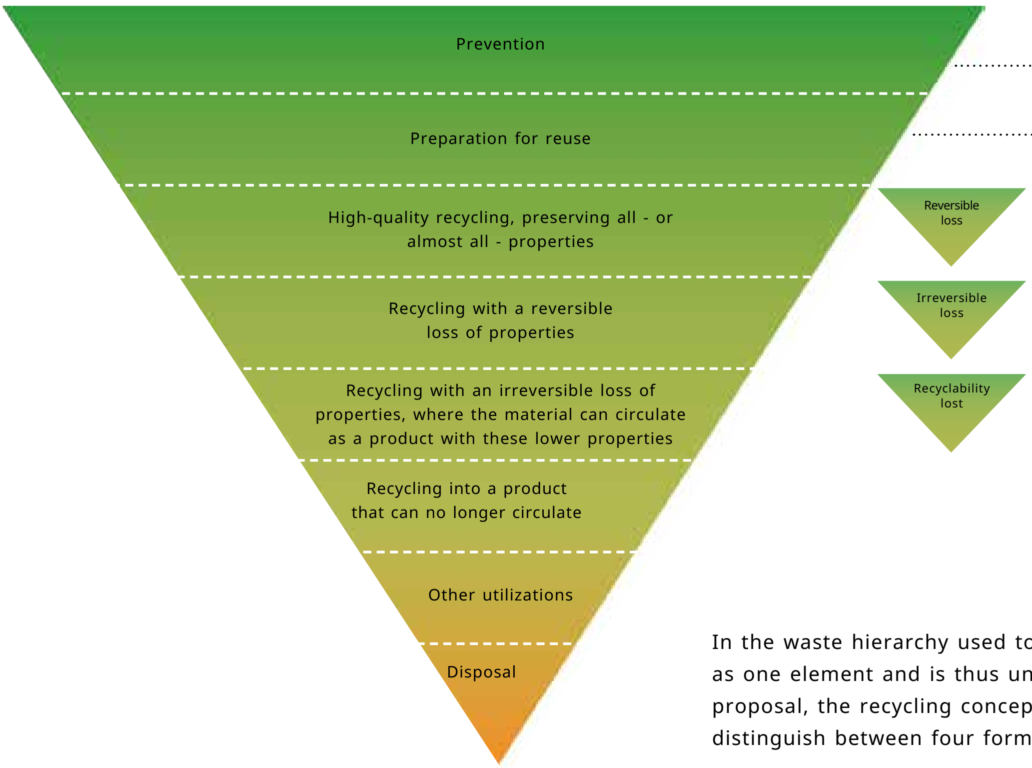
1.1 Design Guide vision

The vision behind the Design Guide is to strengthen the market for reusable and recycled plastic packaging, and to make Denmark a global frontrunner in the circular reuse and recycling of plastic packaging.

Plastic waste must be recognized and treated as a valuable resource rather than useless waste. The goal is to keep plastic out of our natural environment and out of waste incineration plants. 40% of virgin plastic raw materials in the EU are used for packaging. It is therefore of primary importance that we look at the possibilities for packaging reuse. After this it is essential to find ways to design plastic packaging so it can be recycled at the highest possible level. Design-level innovations are central to achieving these goals, and this guide therefore presents the business models, considerations and recommendations for designing reuse solutions and for designing plastic packaging for recycling.

Waste Hierarchy: IDA and the Ellen MacArhur Foundation

Recycled plastics used for new packaging must have a high quality, comparable to virgin plastic, if it will come into contact with food or personal care products. This is consistent with the priority order in the waste hierarchy developed by the Danish Society of Engineers (IDA) to promote quality in recycling. The waste hierarchy has been enlarged to include Ellen MacArthur's four business models for reuse: Refill on the go, refill at home, return on the go and return from home.



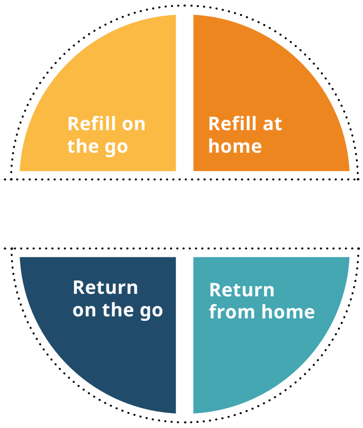


Figure: Ellen MacArthur Foundation

In the waste hierarchy used today, recycling is treated as one element and is thus undifferentiated. In IDA's proposal, the recycling concept is expanded to distinguish between four forms of recycling.

Source: IDA, Circular recycling, November 2021.

At the moment there is a high demand and limited supply of recycled plastic in a quality high enough to be used again for new packaging - especially for food and near-food packaging.

To make high-quality plastic out of plastic waste from households requires an effort at every link of the circular value chain. Collaboration is essential to reach this common goal, as a single link in the chain - such as the sorting link - can hinder opportunities for the next link in the chain.

If we are to succeed, we must be ambitious and think in terms of long-term solutions. This is a major transition, one which will take place in stages and take many years. To stay on target, the Design Guide recommends using the dogmas below as a guide:

1.1.1 Design Guide dogmas

- The Design Guide shall open up possibilities for innovation – not limit them.
- Reuse solutions shall be strengthened.
- Design Guide shall enable users to make decisions about business model and packaging on an informed basis, and to understand the impact of their choices on the packaging's potential for reuse and recycling, and thus also on economics.
- Packaging design shall facilitate the sorting of packaging into food, near-food and non-food fractions, for example, by means of markings that can be read by sorting technology.
- Collection and sorting shall also be strengthened so plastic can be sorted into clear, black and mixed colors at sorting facilities, and so food, near-food and non-food packaging can be distinguished from each other.
- The properties of plastics shall be preserved during recycling in order to preserve their circular potential, market value and possibilities for use.
- The quality of packaging streams for food, near-food and non-food shall be strengthened and made uniform, so that the recycled raw material is in focus during design, sorting and recycling.

1.1.2 Enormous circular potential

The vision for circular plastic packaging has been defined in Denmark, and it points to an enormous circular potential and many ways to take action in relation to business models, design and technology development. Realizing this potential will require close cooperation and political action targeted at creating favorable frameworks for the reuse, sorting and treatment of plastic packaging waste in Denmark.

In this guide, we have chosen to present design requirements from the perspective that packaging reuse comes first and/or later the material can be recycled into a quality that enables circularity in the entire value chain.

It is important that an ambitious effort is made at all links of the value chain. Therefore in the section on design for recycling, the guiding principle is based on the following, "Would I take my own packaging back again as recycled raw material?"

It is still essential that packaging can fulfill its intended function. If, for example, special barrier properties are needed to increase shelf life, the focus must be on this.

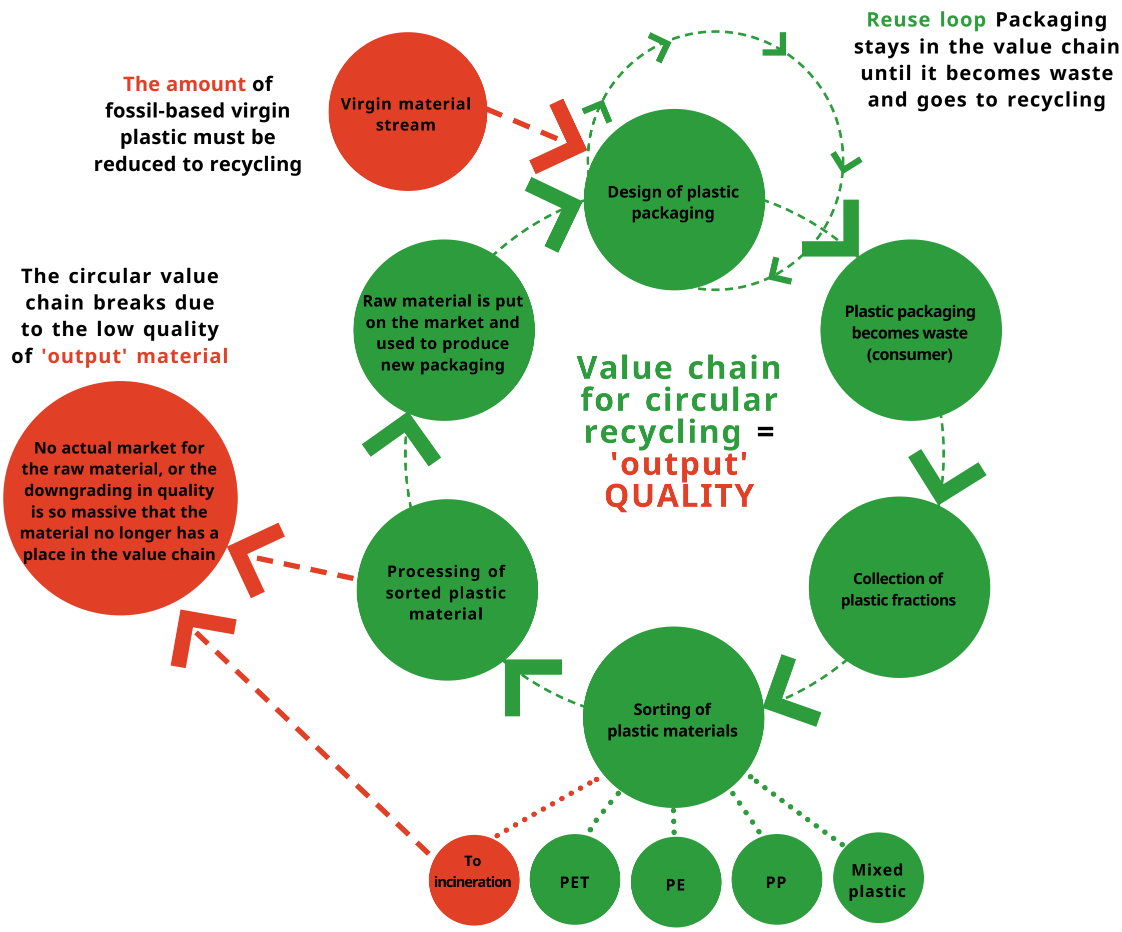
In this design guide, packaging is "designed for recycling" when it meets the recommendations found in the green and yellow columns of the green-yellow-red tables in the Design Guide. There are separate tables for PP (page 44), PE (page 48), PET (page 54) and flexible films (page 57).

The figure on this page illustrates the value chain for circular packaging: It begins with the packaging being designed for reuse or recycling, to it being either reused or recycled and to the plastic packaging being sorted and reprocessed, after which it re-enters the market again to be sold as "new" recycled plastic raw material.

Before we can speak of 'true circular recycling' of packaging, it must be possible to sell the recycled material on the market to be used again in new production. Circularity thus depends on there being a market for the raw material. This places a demand on the quality of the recycled material. And very high quality standards exist for recycled plastic that will be used for food, near-food and non-food packaging.

In many cases, virgin material or raw materials need to be added to fulfill technical or purity requirements for plastic processing or use. Virgin material is added to compensate for material loss in the value chain. An effort must be made to use as little virgin material as possible.

The figure thus also illustrates how important it is to think packaging design simultaneously with quality of recycled materials if the circular loop is to be realized.



1.2 How to use the Design Guide

Packaging design involves many different stakeholders, such as designer, packaging manufacturer, advertising agency and the manufacturer of the product inside the packaging. The influence each of these stakeholders has and the decisions they are involved in during the design process varies.

For this reason the Design Guide is organized in levels, each representing the different choices in the design process. No matter where you are located in the design process and which decisions you are involved in making, you can use the Design Guide to:

- gain a better understanding of the considerationsbehind the choices made by others in the design process you are part of.
- make your decisions in the design process on an informed basis.

This guide does not recommend any one solution, but it can help decision makers make informed decisions, where both small and large steps are steps in the right direction.

Frame of reference
Design Guide's frame of reference – limitations and packaging purpose and possibilities.

Choice of business model
Review of the decisions that must be made before choosing packaging. Here the focus is especially on reuse and recycling.

Choice of material
Insight into the properties of different plastic types and possibilities for reuse or recycling.

Choice of design
Schematic overview and concrete examples of packaging design and opportunities for circular reuse or recycling.

1.2.1 Abbreviations

B2B: Sales transaction between two businesses

B2C: Sales transaction between a business and a consumer

CMR chemicals: (C: Carcinogen, M: Mutagen, and R: Reprotoxic) These chemicals are considered extremely hazardous to human health, as some of them can have long-term effects on health and can be fatal or cause permanent damage

EPS: Expanded polystyrene

FCM: Food contact material

Hydrolysis: A process in which a molecule reacts with water and is converted into smaller molecules

IML: In-mold labeling/marking

IPA: Isophthalic Acid (affects crystallization rate and thus clarity)

IV: Intrinsic Viscosity (expression for the molecular chain lengths in plastics)

MIR: Mid-infrared spectroscopy

NIAS: Non-intentionally added substances. These substances can come from various sources, such as gasoline from a plastic gas can, adhesives from packaging labels, printing inks or reactive products that derive from plastic manufacturing itself

NIR: Near-infrared spectroscopy

OM: Overall Migration – overall migration of substances that migrate from plastic to a food. cf. EU No 10/2011

OM2: Test conditions (10d/40°C) for overall migration during long-term storage at room temperature. cf. EU No 10/2011

OM7: Test conditions (2h/175°C) for overall migration at high temperatures with fatty foods cf. EU No 10/2011

PE: Polyethylene

PET: Polyethylene terephthalate

PP: Polypropylene

rPP, rPE and rPET: Recycled PP, PE and PET

SML: Specific Migration Limit – maximum permissible amount of a specific substance migrating from plastic to food

Tie Layer: A material that bonds two incompatible layers together, e.g., PE and EVOH in a process like coextrusion

1.2.2 Definitions and concepts

Circular economy: Circular economy is either the recycling of materials or - better yet - the prevention of waste through products that can be repaired or upgraded. It is also about innovative business models where consumers can return the product for repairs or upgrades, or where instead of selling products, they can be leased to get the most out of the products and their resource consumption.
Source: The Danish Environmental Protection Agency

Reuse: A system where packaging can be refilled or used for its intended purpose - with or without auxiliary products that are found on the market and enable the packaging to be refilled (like a SodaStream system for water rather than single-use PET bottles). Reusable packaging is packaging or packaging components that are designed to carry out, or prove their ability to carry out, a minimum number of cycles (filling to emptying) in a reuse system.
Source: ISO 18603:2013.

Recycling: Any recovery operation where waste materials are reprocessed into products, materials or substances, whether these are used for their original purpose for other purposes. This includes the processing of organic matter, but not for energy use and processing into materials that are used for fuel or for backfilling operations. This is about using materials in waste again.
Source: Danish Environmental Protection Agency, Waste Act §3 no. 22

Circular Recycling - the Design Guide definition: Circular recycling is when packaging can be recycled into raw material that will be used for the same type of packaging, like a meat tray that is recycled into new food packaging, or a shampoo bottle that is recycled into a new shampoo bottle. The circular recycling principle is presented on *page 32*.

Spiral recycling - the Design Guide definition: Spiral recycling is when packaging can be recycled into packaging in another quality, like a meat tray recycled into near-food packaging. When packaging cannot be recycled for its original purpose, traceability disappears and leaves the circular cycle, after which the material can be recycled according to the spiral recycling principle. The spiral recycling principle is presented on *page 33*.

Packaging: Packaging is the general term for products that are used to pack, protect, handle or distribute goods from manufacturers to consumers, and for the presentation of goods, whether these are raw ingredients or processed goods.

Primary packaging is the packaging that is in direct contact with the product. Also referred to as sales packaging.

Secondary packaging functions to gather a number of units into a larger unit. This can both be to sell several units at a time or to facilitate the handling of goods. It can be removed from the product without changing the properties of the product. Also referred to as multipack packaging.

Tertiary packaging is packaging designed to facilitate the handling and transport of multiple sales units or multipack packaging, and to protect goods from damage caused from physical handling or transport. Also referred to as transport packaging. Definition from*Danish packaging act no. 766 of May 30, 2020.*

Transport packaging: Great quantities of different transport packaging are used. Both when products are sent between companies and to consumers. For example, when shipments are packed in boxes or using plastic film. The Danish Chamber of Commerce Design Guide addresses three types of transport packaging that have the potential for reuse and recycling: pallets, film and shipping crates. Read more in The Retail Sector Design Guide for Plastic Packaging, *Dansk Erhverv, 2022*. The new plastic packaging design guide for the retail sector.

Quality is defined based on expectations to the material/product and the recyclability of the product. A product that can stay in the circular cycle and can be recycled into a material with a high value and high use potential can be considered a high quality material. Potential has to do with the chemical and physical requirements the recycled material can meet.

Food quality (food contact material or FCM) is defined as a quality that meets the legislative requirements for input material (traceability), substance content and migration of these. Depending on the specific use of the material the finished packaging is tested for migration to the relevant product (fatty, acidic, etc.), which helps ensure that the material is suitable as a food contact material. Prevailing requirements for materials, processing technologies and facilities can be found in regulations: *(EU) No 10/2011 (plastics for FCM), (EU) No 2022/1616 (recycled plastics for FCM), (EC) No 2023/2006 (GMP) and (EC) No 1935/2004 (all materials for FCM)*.

Near-food quality is defined as a quality that is close to food contact material quality (food grade), used for products such as personal care, cosmetics, hygiene and cleaning.

The quality requirements for near-food and FCM are similar with regard to technical quality and migration. In contrast to FCM, there are no traceability requirements for input.

Non-food quality Non-food is plastic that may be produced with chemicals and colorants that are not suitable for direct food contact or near-food. It can also be packaging that is produced in food grade quality, but is used as packaging for non-food and near-food products. Even if the material is processed using approved decontamination technology, the material is not permitted for use

De facto standards: In order to preserve an existing material's properties and thereby the value of the material, the Design Guide makes use of the concept "de facto standards". This refers to a kind of standardization of a plastic type, so the plastic recycling stream becomes stronger and more uniform in these properties. It differs from plastic type to plastic type whether a de facto standard can be established. The de facto standard for rPET *(p. 40)* can be purchased as a raw material and has existed for several years, e.g., PET bottles. For rPE and rPP the Design Guide defines instead some frameworks for the properties in a mix of recycled PP and PE - *see page 49*.

Mono-material: A mono-material is a material that consists of a single type of material. For instance, it can be a type of PP or a combination of PP and OPP (oriented).

Multi-layered materials - also called multilayer - is plastic material that consists of several layers of various material types that are often not compatible in recycling.

1.3 Included and not included in the Design Guide

The Design Guide focus is on packaging that ends up with consumers and is either reused or collected for recycling after being sorted by households in Denmark.

The section on **Packaging Reuse** focuses primarily on package design for reuse and to a lesser extent on reuse infrastructure. More information on reuse schemes and reuse infrastructure can be found in other relevant guides dealing with this topic. Among these are Resolve PR3 and WEF Consumers Beyond Waste.

The section on **Packaging Recycling**is based on how the system for collection, sorting and treatment of waste from households functions in today's Denmark. There could easily be other optimal design and material choices for packaging for reuse and recycling that ends up in cycles other than household waste.

Because the best pay-off in terms of quality and economy comes from optimizing existing plastic streams, this section focuses on the three biggest streams of plastic packaging in Danish household waste.

The Design Guide focuses on the plastic types PP, PET and PE, as they make up over 90% of the plastics in household waste. Other plastic types like PS and EPS can easily be recycled, and there are good examples of this in Denmark.

The Design Guide has been updated as technological developments and innovation have transformed the possibilities for design, material selection, infrastructure, sorting and recycling.

1.3.1 Bio-based and biodegradable plastics

Because the focus of the Design Guide is on reuse and recycling in general, the only information provided about bio-based and biodegradable plastics is found in this section of the Design Guide.

Bio-based plastics: Many types of plastic can be made from biomass. Bio-based plastics are typically made from renewable resources such as sugar beets, sugar cane, corn and/or cellulose. Bio-based plastics can also be produced from residual products such as forestry products. There are both advantages and disadvantages to bio-based plastics.

Current parameters are agricultural land use, deforestation, CO_2footprint, pesticides and water consumption. The environmental and climate impact depends on the calculation method and where the biomass comes from. Various certifications take this into account - for example ISCC and RSB.

Bio-based plastics in PP, PET and PE can be recycled without problems together with fossil-based plastics in PP, PET and PE and can therefore be mechanically recycled.

Biodegradable plastics can be made from biomass, oil/gas or a mixture of these and cannot be recycled together with other plastics. Biodegradable plastics can be broken down by microorganisms (bacteria or fungi) and become water, biomass, CO_2 and/or methane.

Biodegradable plastics only very rarely break down in practice in nature, and therefore should NOT end up there.

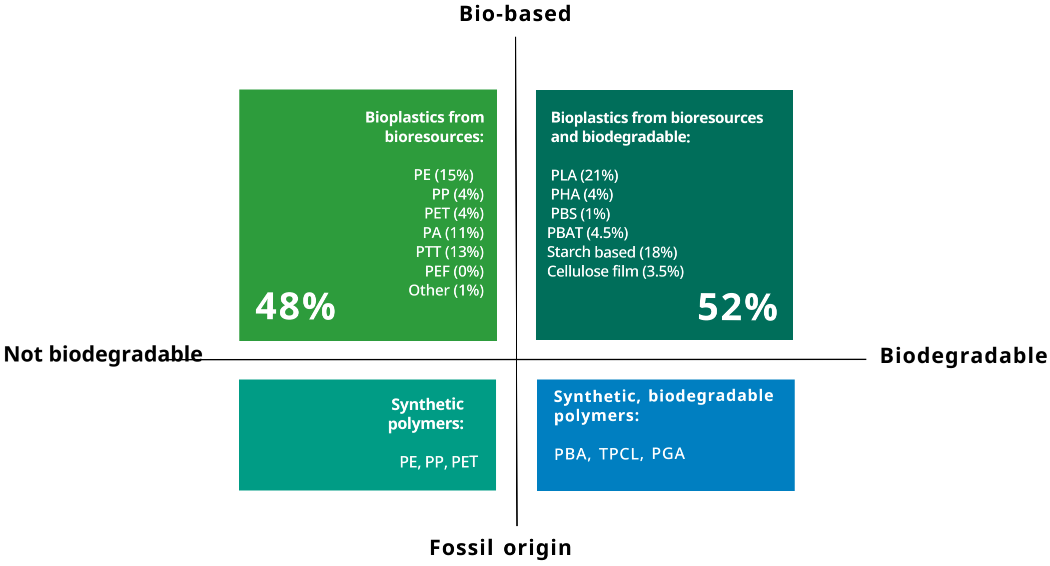
Biodegradable plastics must be collected and broken down in industrial facilities intended for this purpose. There is, however, a difference as to which type of facility municipal food waste is sent to in Denmark. Not all biodegradable plastics sent to a biogasification facility are suited for biological decomposition. Much of it is therefore sorted out for incineration.

In cases where biodegradable plastic is collected together with 'ordinary' plastic for recycling, it will not be sorted out for recycling. Instead, it will be sorted out as a residual product in the sorting process and then incinerated. Because biodegradable plastics cannot be used in new plastic products, biodegradable plastics cannot be recycled together with other recyclable plastics.

In Denmark, biodegradable plastic may only be used in packaging IF it is 100% certain that it will end up in an industrial composting facility or biogas facility where it can be decomposed rather than sorted out. Biodegradable bags for handling bio-waste can be used if the bio-waste is sent to a facility that can handle it.

In the European Commission's proposal for legislation on packaging and packaging waste, there are examples such as stickers for fruit and vegetables where biodegradable plastic packaging is an advantage. You can find the EU proposal of 30 May 2018 amending the Waste Directive 2008/98/EC here: *https://faolex.fao.org/docs/pdf/eur178599.pdf*

Figure: Bio-based and biodegradable plastic. According to European Bioplastics and the Nova-Insitute, 2.2 million tons of bio-based and biodegradable plastics were produced globally in 2022. In comparison, 390 million tons of plastics were produced in 2021. Read more at *www.european-bioplastics.org*.



(Source: European Bioplastics) http://docs.european-bioplastics.org/publications/market_data/2022/Report_Bioplastics_Market_Data_2022_short-version.pdf

2 Choosing a packaging strategy

This section presents a number of issues you need to consider before you embark on the actual design process for your packaging. The section reviews the concepts from the waste hierarchy: Avoid, reuse and recycle. The purpose is to clarify whether it is possible to reduce material consumption in the packaging.

Before choosing your packaging, you should consider the following: Which business model is right for your product seen from a holistic point of view?

The purpose of the packaging: What is the function of the packaging, and is the packaging necessary?

- To protect the product, to protect its contents (migration-proof), for consumer health and safety/shelf life/product safety.

Where will the packaging end up after end use?

- Reuse scheme, collected separately for reuse or recycling, deposit or take-back systems for reuse or recycling, or household plastic collected for recycling.

2.1 Refuse, reduce, reuse and recycle

Once you have answered the above questions, consider these concepts: Refuse, reuse and recycle. For all three concepts, you should assess the possibility of reducing material consumption.

Refuse
The product is delivered to the consumer without packaging.

Reuse
Packaging is reused in its original form. A deposit system is implemented or an existing system expanded so that packaging is returned to the relevant supplier after use.

Recycle
Recycle packaging as raw material for new products, if possible as new packaging with the same purpose.

Reduce
Reduce the material consumption of the individual packaging component. Consider whether your sales packaging can also be used for, e.g., transport packaging.

Optimize product volume and design to make packaging consumption and transport more efficient.

Reducing material consumption should not hinder reuse, recycling or increase product waste.

Use as much recycled material as possible.

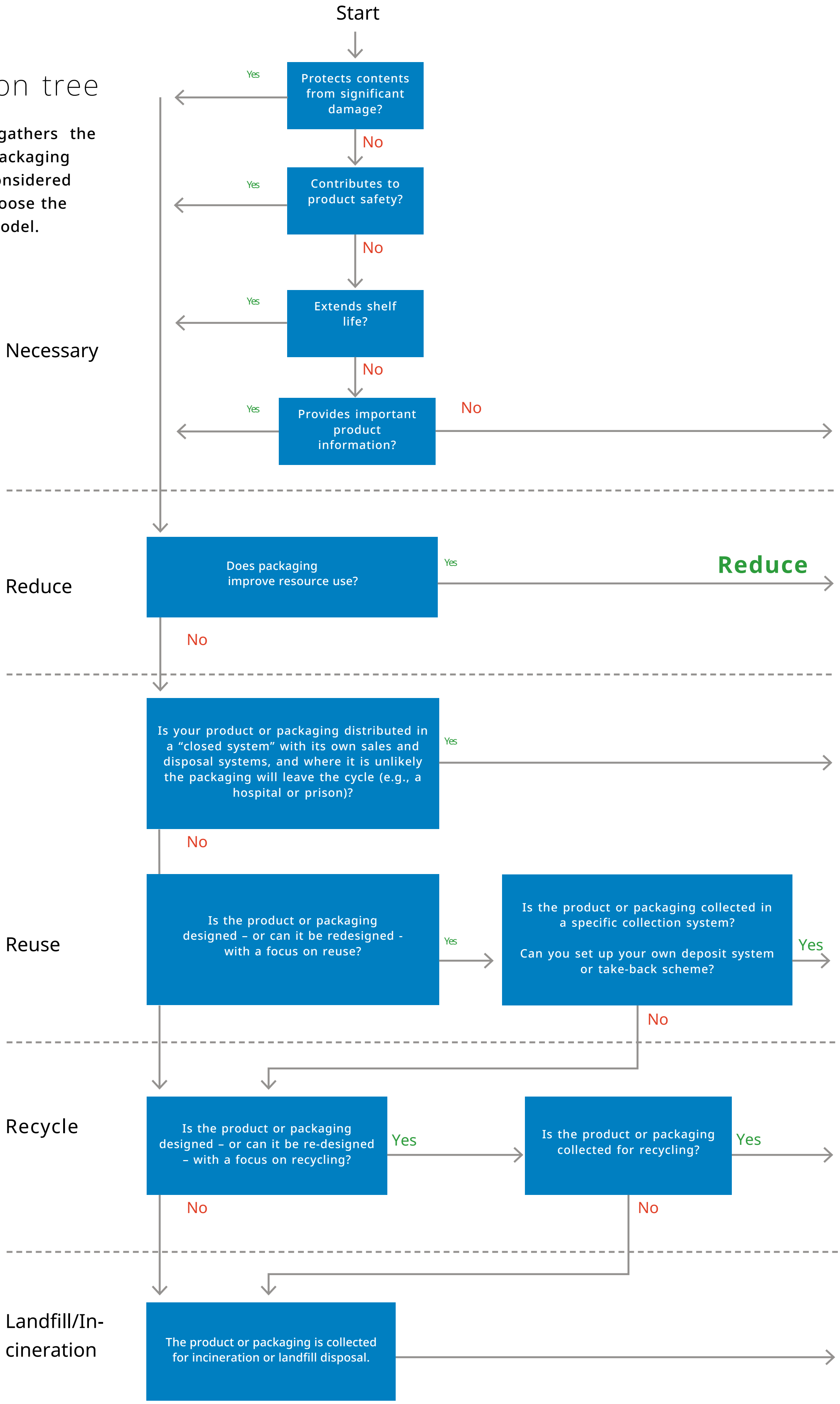
Emptying packaging content to reduce product waste

The packaging design itself should make it easy for the consumer to empty the packaging of its contents completely after normal use, so that product waste - and its environmental impact - is limited. This part of the design is important, as a significant amount of all product and food waste comes from residential households.

The emptying properties of the packaging can influence how a consumer disposes of used packaging. When the packaging is easy to empty, it reduces water consumption and other resources used for cleaning before the packaging is sorted for reuse or recycling. Consumers are more likely to sort packaging for reuse or recycling if it is easy to clean and is not perceived as waste.

2.2 Decision tree

The decision tree gathers the questions about packaging that need to be considered before you can choose the right packaging model.



Remove product/packaging

Remove unnecessary packaging or modify the packaging where possible, as this can lead to the greatest reduction of emissions. It is important that this does not compromise contents and product safety.

Considerations

The product/packaging is NOT problematic/ unnecessary - but further investigation may be needed

The product/packaging is NOT problematic/ unnecessary, but further investigation may be needed

The product/packaging is NOT problematic/ unnecessary, but further investigation may be needed

Considerations

- REDUCE material consumption at the individual packaging level where possible.
- Use materials that can be recycled into the same product categories to achieve CIRCULARITY as a first priority (food packaging to food packaging).
- If this is not possible, use materials that are recognized as recyclable. See the design guidelines in sections 7, 8 and 9.
- OPTIMIZE product volume and design to optimize packaging consumption and transport.
- Use RECYCLED materials as much as possible.
- COMMUNICATE clearly to the consumer about how to sort the packaging.

When designing for REUSE, you must ensure:

- There is a collection system for reuse, or you can establish a take-back scheme on your own or together with the relevant partners.
- There is knowledge about the number of times the packaging can be expected to be reused (LCA analysis).
- The packaging can be recycled in the end (as per the Design Guide). The total environmental and climate emissions for reuse does not exceed the environmental and climate emissions of, e.g., recyclable packaging. This can happen when water and soaps are used to clean the packaging before reuse, or when CO_2 emissions in connection with transport are too high.

The product/packaging is NOT problematic/unnecessary - but further investigation may be needed

The product/packaging is necessary but CANNOT be reused or recycled today and is therefore considered problematic

- EVALUATE the packaging. The product/packaging can only be assessed in a meaningful way when all packaging components (primary, secondary and tertiary) are assessed and evaluated based on a "cradle to grave" LCA.
- REDUCE material consumption at individual packaging level where possible. Packaging designed to reduce material consumption must not prevent reuse/recycling or compromise product safety.
- OPTIMIZE product volume and design so that packaging consumption and transport are optimized.
- Use RECYCLED materials as much as possible.
- INVEST in recycling.

CONSIDER using alternative materials and be mindful of the following:

- Origin of the material
- Use of the recycled material
- Reusability and recyclability
- Water consumption, transport, CO_2 emissions, land use
- Biodiversity

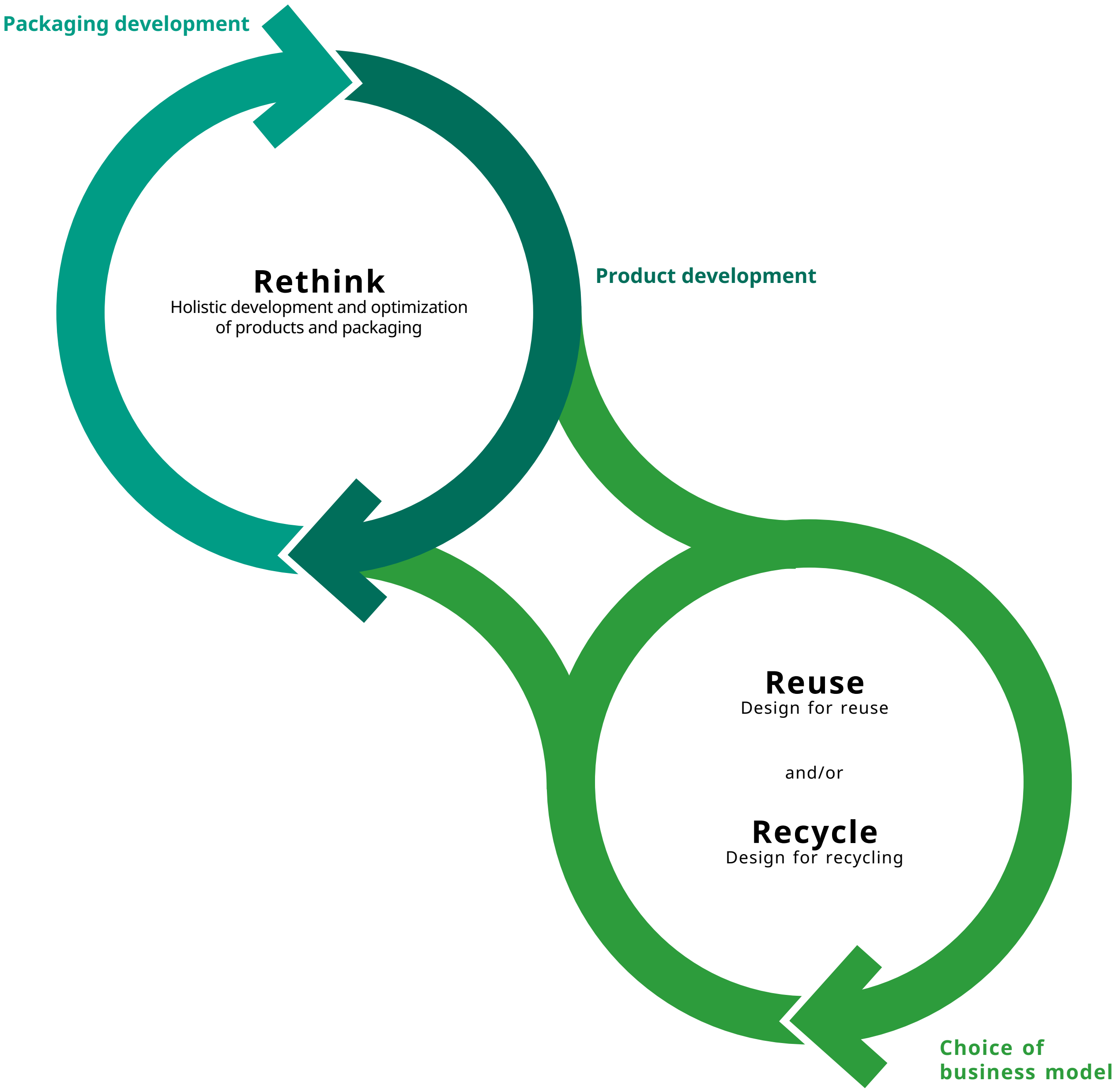
2.2.1 Packaging development process

The concepts avoid, reuse and recycle have now been considered, and the decision has been made to give the product packaging.

Deciding on a packaging strategy is rarely a simple A to B process. Collaborating with internal partners and external actors can open up a treasure trove of design possibilities where a product and its packaging can be looked at in its totality to be developed and refined.

Both product and packaging can be adapted to optimize resource consumption and to avoid unnecessary waste such as overpackaging.

The packaging development process is illustrated here:



3 Packaging reuse

The purpose of this section is to present various business models for reusable packaging, and the considerations that need to be made for each to ensure the best possible outcome for the environment. This enables making a decision about design for reuse on an informed basis.

Reuse of packaging means that the packaging does not change its shape or structure, but is simply used again as is - usually after some form of cleaning.

When it comes to choice of packaging, designing packaging for reuse provides the greatest benefits for the environment.

Effectively scaled, reuse systems have the potential to ensure that reusable packaging in its lifetime has a lower climate impact per use, lower resource consumption per gram packaging and is less likely to end up in the natural environment compared to single-use packaging. *Source: Many happy returns, 2021 (whiterose.ac.uk).*

Reusable packaging is part of a circular reuse system where packaging is used, collected, cleaned and refilled over and over again. The reusable packaging discussed in this design guide refers to packaging designed to be used for the same purpose multiple times, and in this way contributes to reduction of packaging consumption.

3.1 Business models for reuse

Different packaging reuse schemes are found on the B2C market. Each business model for reuse requires careful consideration with regard to product safety, packaging design and the infrastructure for reusable packaging.

The aim of all four models is to reduce packaging consumption, but the concepts are very different.

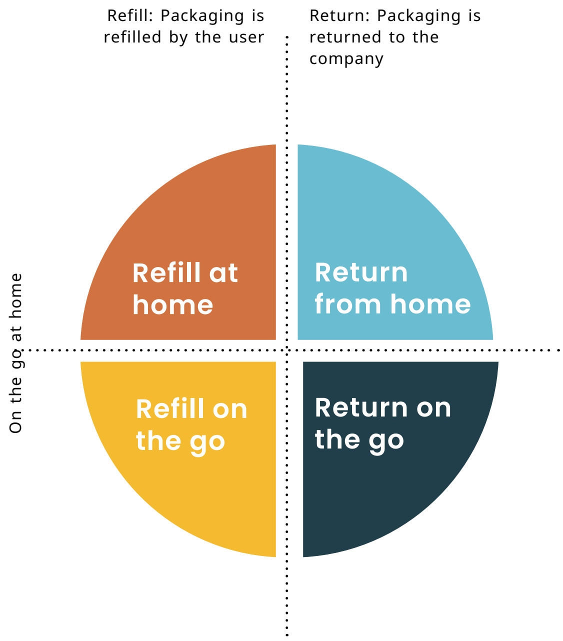
Refill at home is a model where the consumption of material used for sales packaging is reduced and users refill a container at home. This could be through subscription schemes where users receive a concentrate or tablet and they mix the product in a reusable container themselves, or when soap is purchased in a refill bag and filled into a pump container at home.

Refill on the go is a model where consumers bring their own packaging to the point of sale and fill it at a dispenser station. Among the benefits here are that the sales packaging is completely absent, and consumers can purchase a quantity that exactly fits their needs.

Return from home is when used packaging is picked up at the consumer's home, or the consumer returns the used packaging in a pre-paid shipment. Packaging is part of an organized circular cycle. For example, when boxes from a food delivery service are returned for reuse.

Return on the go is a reuse model where operators cooperate in a logistics system like the deposit system for bottles. The objective is two-fold: to reduce packaging and just as importantly, to reduce the amount of wastage lost out of the system.

You can read more about the various models in the Ellen McArthur Foundation publication "Reuse".



Source: Ellen MacArthur Foundation

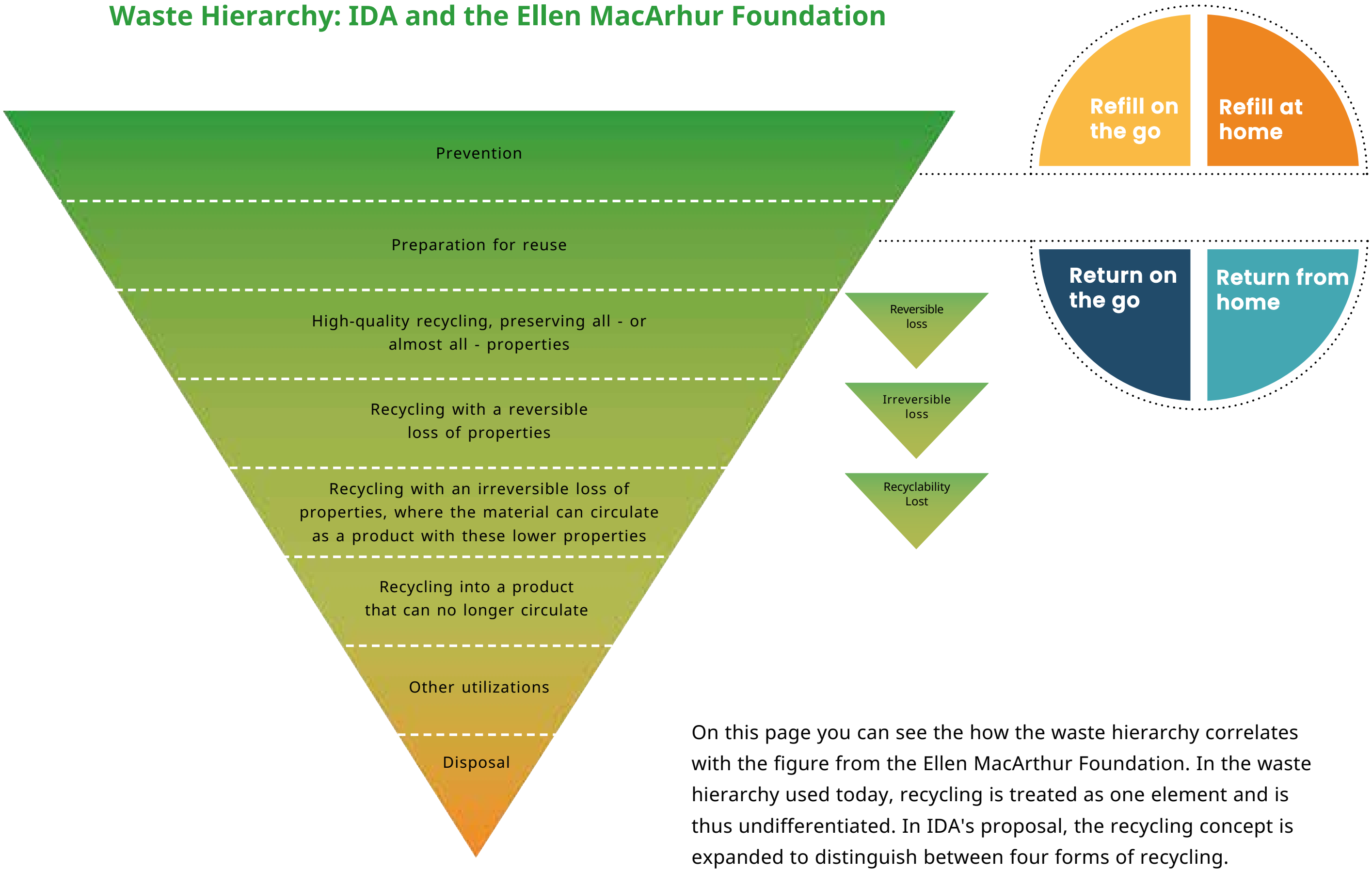
The models "Return from home" and "Return on the go" comply with the official EU definition of a reuse model (see the new packaging directive) *Source: https://ec.europa.eu/transparency/documents-register/detail?ref =-COM(2022)677&lang=en*

Reuse of food packaging in private households

Packaging, which is used and reused by consumers at home to store food or other products in (for example, using a plastic tub to store leftovers), is not included in any of the four reuse models. Private reuse solves a storage task, as in the example of leftovers, but it has a negligible effect in reducing single-use plastic consumption.

3.1.1 Waste hierarchy

Waste Hierarchy: IDA and the Ellen MacArhur Foundation



On this page you can see the how the waste hierarchy correlates with the figure from the Ellen MacArthur Foundation. In the waste hierarchy used today, recycling is treated as one element and is thus undifferentiated. In IDA's proposal, the recycling concept is expanded to distinguish between four forms of recycling.

Source: IDA, Circular Recycling, November 2021

3.2 Reuse cases

Here are some examples of the different business models for reuse and how they can be employed in practice.

Prevent/Reduce

Refill at home

Case: Refillable bottles for cleaning products from Coop Änglamark

Coop Änglamark offers refillable solutions for spray cleaning products. Users buy a reusable spray bottle that can be filled up at home with a mixture of concentrate and water and then shaken. Consumers can reuse spray components right after purchase, unnecessary transport of water and diluted detergent can be avoided, and plastic consumption from packaging is reduced by 80%.

Prevent/Reduce

Refill on the go Case: Refill your coffee cup at 7/11

At 7/11 customers can get coffee to go in a coffee cup they bring from home. This eliminates the need for new packaging and makes packaging the responsibility of the coffee cup owner. 7/11 offers a financial incentive to customers who use this solution, and they save DKK 3 each time they buy a cup of coffee using their own cup.

Prepare for reuse

Return from home

Case: Cirqle – an online platform for reusable packaging

Cirqle has made reusable packaging digital by connecting packaging to an online platform where the reuse process can be managed. All reusable packaging can be connected to the reuse service using RFID tags. Cirqle calculates the concrete savings on the platform. Read more at www.cirqle.org.

Prepare for reuse

Return from home

Case: ReZip – reusable transport packaging for e-commerce

The Danish company ReZip makes reusable transport packaging for e-commerce. Customers can choose a reusable packaging solution on the webshop and can find drop-off points on the ReZip app. The packaging can be returned in a red mailbox or at a PostNord or DAO service point. When customers scan and return the packaging, they are rewarded with a voucher. Read more at www.re-zip.com.

Prepare for reuse

Return on the go Case: New Loop – deposit system for takeaway packaging

The Danish consortium New Loop is working to establish an integrated deposit system for takeaway packaging. They make cups and food containers and supply packaging to companies and to large events. They partner with major takeaway chains and food suppliers. Read more at www.thenewloop.dk.

new loop

Prepare for reuse

kleen hub®

Return on the go Case: Kleen Hub - a lender of take-away packaging

KleenHub is a Danish company that lends reusable packaging to takeaway businesses. The customer borrows the packaging from KleenHub and has ten days to return it to a service point or takeaway provider in the network. If the packaging is not returned, the customer is pays a price that corresponds to the packaging's purchase price. Read more at www.kleenhub.com/da.

Prepare for reuse

Return on the go Case: ReCIRCLE – subscription scheme for food packaging

re CIRCLE

The Swiss company ReCircle is on its way into the Danish market and produces meal containers, pizza boxes, and cups for food and drinks. Partners – restaurants, schools, businesses or local event organizers – buy a subscription from ReCircle and order the amount of product they need. Customers pay a deposit to borrow the packaging, which can be used for as long as the customer wishes and returned afterwards to any partner in the network. Read more at www.recircle.eu/dk/om.

Find many more examples under the 'Upstream Innovation' tab on the Ellen MacArthur Foundation website *www.ellenmacarthurfoundation.org*/or at *www.planetreuse.eu*.

3.3 Considerations for a reuse solution

- As much as possible, reusable packaging should be designed simultaneously with product/business concept development.
- Reusable packaging must ensure product quality and durability.
- Reusable packaging must be as easy as possible for consumers to return, and should be supported by a take-back system.
- Reusable packaging - in its construction, complexity and durability - must be easy to clean and prepare for reuse. Be sure to engage in a dialogue with the owner of the washing facility before designing your packaging.
- The construction and material consumption of reusable packaging must be optimized in relation to packaging life span and environmental impact.
- The take-back system logistics must be optimized on an ongoing basis as it is rolled out and expanded.
- Reusable packaging must be recyclable according to the circular recycling principle when it can no longer be reused.

3.4 Design of packaging for reuse– general criteria and recommendations

It is recommended that you think about design for reuse simultaneously with product and business model development. Choose a material that can ensure maximum reusability, that is resistant to mechanical impacts while in circulation (see section on durability below), and that can ensure packaging recyclability when it can no longer be reused.

Packaging must not contain materials or layers that limit or hinder recycling.

Packaging should be designed to contain the maximum amount of recycled material (where feasible) and to meet food and product safety standards. Doing this will help maximize the environmental and climate impact of the reuse scheme.

In addition to "design for recycling", the following design criteria for reusable packaging should be taken into account:

- **Durability.** Containers should be designed to optimize durability. In other words, to increase durability to the point where maximum environmental and social benefits are achieved. Containers should be designed to withstand scratching and denting enough to achieve a minimum average number of use cycles. Containers must be resistant to tainting from flavors, fragrances and colors that leach from products. Note: Tainting results in fewer use cycles and can reduce consumer confidence and acceptance.

- **Design for refilling.** Containers must be designed to withstand multiple filling processes. This means, for example, that it must be possible to use the designed closures multiple times on the same container.

- **Safety.** Containers filled at locations other than the point of sale (e.g., spice jars filled at production facilities), can have single-use closures. However, these must have the same or a higher level of safety as existing closure systems and maintain the same or a higher level of consumer confidence. For containers that are filled at the point of sale (e.g. coffee cups), safety is ensured by employees at the point of sale or by customers, and therefore the closures should be reusable.

- **Design for collection and logistics.** Whenever possible, packaging should be designed to be stackable to reduce transport and logistics costs.

- **Weight.** The weight of the packaging should be optimized according to the chosen material and to meet durability requirements. Weight affects a container in several ways. A higher weight can increase durability to a certain extent, but it also increases CO_2emissions connected with transport.

- **Design for cleaning, washing and drying.** Packaging must have an internal bottom angle of 90°or more to facilitate drying, washing and disinfection. Containers should be designed with smooth interior surfaces for more efficient emptying and cleaning. Small holes and unevenness that can trap liquid and promote microbial growth should be avoided. A container should be formed to facilitate air flow during drying.

- **Branding labels and artwork** (in a closed or common system). If the packaging is to be part of a joint system, distinctive branding often hampers reusability. For instance, if an event and year are printed on the packaging, it cannot be used for other events. The souvenir effect should also be considered to minimize packaging lost out of the system.

- **Labels.** If labels are needed to declare contents and product information, they must be able to be removed prior to new use.

- **Marking solutions for reuse.** The packaging directive will contain marking requirements for reuse solutions, for example, digital markings or QR codes.

For more details on design considerations further information can be found in guides published by Resolve PR3 *PR3 Standard Part 2 Container Design (resolve.ngo)* and WEF - Consumer Beyond Waste *WEF_Consumers Beyond Waste_Community Paper_Design Guildelines Sep 2021.pdf*

3.5 Infrastructure and logistics for reusable packaging

Investigate whether the new reusable packaging can be part of a new or existing scalable take-back or infrastructure system. Also investigate whether the new packaging can be part of a harmonized packaging design, which will enable you to take advantage of the logistics benefits this can provide. See case examples on pages 21-23.

If the packaging cannot be part of a harmonized packaging design, consider collaborating with other industry stakeholders to optimize take-back system logistics and other business costs. Experience shows that placing some form of deposit value on packaging in a reuse system is the best way to ensure a high return rate. Dialogue, collaboration and ongoing development between all links in the value chain are essential for achieving an optimal reuse system.

For more details on take-back programs and logistics, PR3 has produced a more in-depth guide, 'Reusable Packaging System Design Standards', which can be found at *www.resolve.ngo*.

More information is also available in the guide from the World Economic Forum: Consumer Beyond Waste.

3.6 What is an environmental assessment?

Reuse systems may have higher start-up costs and periodically have a greater environmental impact than single-use alternatives. When you get the right system up and running, it is almost always better in the long run to choose a reuse system rather than a single-use solution. Both with regard to environmental impact and economics.

If you choose the reuse route, you have to work to bring down the overall environmental impact. To ensure this, it is important to design reusable packaging that can be part of a reuse and logistics system that is both scalable and can be optimized further in relation to environmental impact.

Environmental impact is defined in general terms and is weighted differently in different situations and organizations and depends on who is making the calculations and which methods are used. Still, it has been shown that environmental impact and economic costs decrease the more times a given packaging unit can be reused.

Environmental impact is determined by different parameters that need to be considered in the design phase:

- Material choice
- Container/packaging design (shape, weight, size, etc.)
- Cleaning/washing process
- Take-back logistics – technology and number of cycles
- Collection system
- Transport
- Possibility for recycling at end-of-life

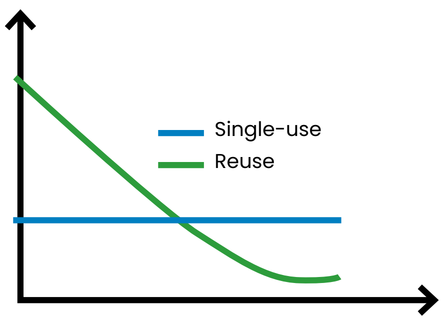
Key factors in a successful reuse solution

Economic factors

1. How many times is the packaging reused?
2. How much does the packaging cost?
3. What is the cost of washing the packaging?
4. How many products will be transported in total?

Environmental impact

Environmental impact



Number of times packaging is used

A reusable solution can negatively impact the environmental footprint if there is a high loss rate and a low rate of return. Therefore, reusable packaging design should pay as much attention to developing or joining an existing reuse system as to packaging design.

The illustration above outlines the economic factors that must be considered with a reuse solution and the affect the number of reuses has on environmental impact.

3.6.1 Rules for labeling packaging for food safety and reusability

Packaging that will be reused for food in a reuse system must comply with food safety and hygiene requirements.

It is the responsibility of the packaging manufacturer to ensure that the packaging is tested for migration so it complies with the rules for repeated use of food packaging.

Packaging labels must also declare the conditions for packaging reuse. Food business operators that refill the packaging must ensure the packaging can be cleaned sufficiently, as per Hygiene Directive 852/2004, Annex II, Chapter V.

The cod roe container is an example of packaging that is marked with instructions for reuse in private households based on approved testing.

It is therefore legal to claim that the cod roe packaging can be reused - but reuse in private households is not part of a defined reuse solution.

4 Packaging recycling

This section presents facts and knowledge about the recycling process, sorting technologies and types of plastic found in household waste, all of which are essential to have in mind when making a decision about business model for the design of packaging and prerequisites for designing for recycling.

If you determine that the packaging is not fit for reuse and will have to be recycled after end use instead, it is important the packaging is designed so it can retain its properties and quality in a circular recycling process. It is also important to know which recycling methods and sorting your packaging will go through in the country of sale. Based on this you can determine an appropriate ambition level.

When consumers are finished with the packaging, they throw it away as household waste. In many cities in Denmark plastic can be discarded in a separate household waste container. It is then taken to at least one facility for sorting, where the plastic is often sorted multiple times. After this, the plastic is sent on to be recycled.

Mechanical recycling is the most widespread recycling method - read more on page 29. In the final stage of the recycling process, the material is used to produce new packaging or other products.

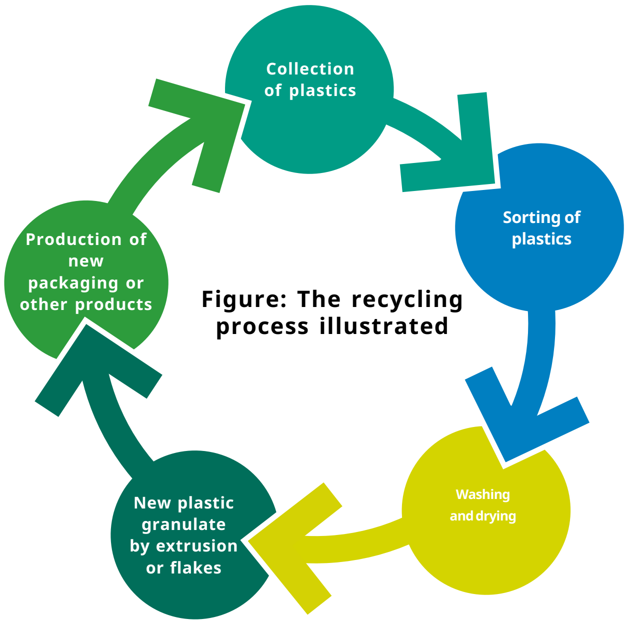


Figure: The recycling process illustrated

Example of the plastic sorting process

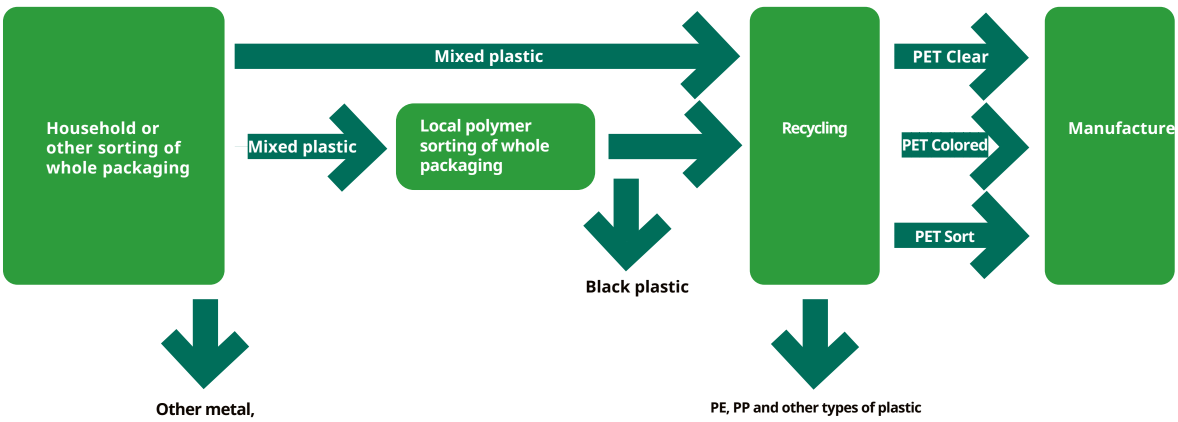
When plastic is discarded as household waste, it first goes through a rough sorting where whole packaging containers are sorted out as plastic waste. Either the packaging is sorted at household level or in a rough sorting after collection that removes metal, glass, food and beverage cartons and other waste.

After this the plastic can be sorted by polymer type - either as whole packaging or in smaller pieces after the packaging has been broken down. This could be into material types such as PP, PE and PET.

To sort whole packaging containers by polymer, all of its components must be identifiable by an NIR scanner. This means that packaging containing carbon black pigment is rejected, as a NIR scanner cannot detect carbon black. However, certain local facilities for rough sorting have developed solutions for sorting packaging with carbon black pigment.

As shown in the PET example below, the individual polymer types are sorted by color and sent on for recycling, where they are broken down and flake sorted. Unknown polymers from subcomponents are removed and colored flakes are sorted. Flakes are washed and made ready for remelting, filtering and decontamination.

This example shows the plastic sorting process for PET, but it is the same for PE, PP or other types of plastic.



4.1 Three technologies for recycling plastics

There are three main technologies used for recycling plastic waste, which are listed below. This design guide focuses on design for recycling using mechanical recycling, as this is the primary recycling method in the EU today, and one in which plastic is recycled into plastic with the least possible loss.

- **Mechanical recycling** The most widespread form of plastic recycling. Plastic waste is sorted mechanically using scanners (e.g., NIR or MIR), sink-float tank and other equipment like ballistic separators, foil filters and electronic separation. After this it is washed and remelted.

  Challenge: Loss of quality

- **Biological degradation** A developing market Plastic is broken down with the help of bacteria, enzymes or other basic chemical elements that can subsequently re-enter the biological cycle again. It is therefore important the input does not contain substances that are harmful to the biological cycle.

  Challenge: Lack of cohesion between biodegradable plastics (the individual plastic type) and the treatment facilities. Biodegradation does not contribute to the circular use of plastics.

- **Chemical recycling** A developing market The plastic is broken down with the help of thermochemical processes, solvents, etc., into basic chemical building blocks that create the basis for new products such as new plastic, oil or transport fuel. Chemical recycling should be thought of as complementary to mechanical recycling - not as a substitute.

  Challenge: High energy consumption

4.1.1 Sorting concepts

Below is a list of plastic sorting technologies for mechanical and chemical recycling:

NIR sorting: Sorting into polymer types using near-infrared light. Plastics with a high content of carbon black do not reflect enough light and therefore cannot usually be recognized by NIR. Some specialized NIR scanners can sort dark fractions - including carbon black - into a combined dark stream.

MIR sorting: Sorts plastics colored with carbon black, but requires the plastic to be washed and shredded into flakes.

Electrostatic separation: Sorts into polymer types using electrostatic charge.

AI and machine learning: Software that uses cameras and image recognition technology to recognize types of similar looking products in a mixed plastic waste stream (e.g., bottles, trays and tubs). The technology is combined with robotic arms and is widely used to purify homogeneous streams such as PET bottle streams and remove products that do not belong in the stream.

Sink-float sorting: Sorts plastics based on their different densities in water. The technology is not very good at separating plastic types with nearly identical density (e.g., PP and PE). It can be used to sort heavier PET from the polyolefins PP and PE.

Magnetic density sorting: Separates mixed material streams in a one-step process using density separation with magnets and magnetic liquids.

Gravimetric sorting: Analysis by weight - a range of analysis methods that sort material on the basis of mass.

Digital watermarks: Sorting with the help of markings that are printed on the packaging during the production phase.

4.2 Types of plastics in household waste

If the quality of plastic waste from households is to be improved, we need to strengthen the plastic streams that are the largest right now. Good recycling possibilities require large and uniform quantities of plastic waste that are high in quality.

Studies carried out by the City of Copenhagen show that 91% of its sorted plastic consists of three polymer types: PP, PE and PET. So optimizing the quantities of packaging in these types of plastics gives the greatest possibility for uniform quality and economy. This is why design for recycling in the Design Guide focuses on these three plastic types (see the figure showing the distribution of plastics collected in households).

Other types of plastic can also be recycled, but Danish household waste contains only small quantities of these.

Another type of packaging that often ends up in households is Expanded Polystyrene Foam (EPS). After private citizens sort EPS, it can be delivered to a recycling station, where it is compressed and recycled into new products. Work is being done to expand this solution. You can see which municipalities collect EPS for recycling at www.eps-airpop.dk.

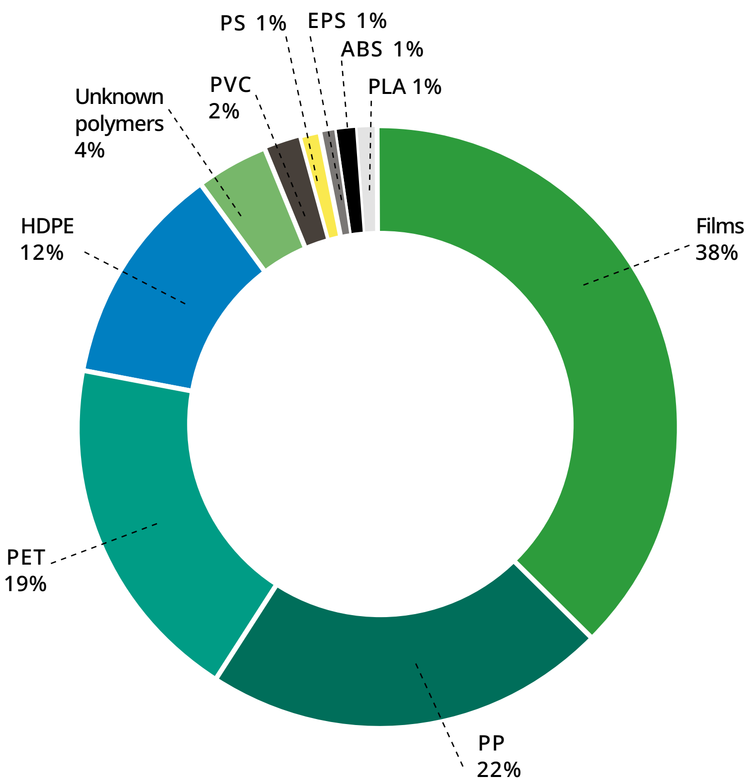
The same study analyzed the composition of the packaging by product type as well as the actual products found in household plastic waste bins. The analysis indicates that as much as 76% of the plastic comes from packaging, while the rest - 24% comes from products like toys, baskets, etc. These calculations are based on 4 random samples totaling 2,712 kg (see figure on page 31 which shows the composition of packaging in plastic waste from households).

It is estimated that 100% of the foil fraction comes from packaging - 50% from food and 50% from non-food. The residual fraction "other products" covers the unrecognizable small pieces that were left after all products had been separated out on the table according to polymer type. It is estimated that "other products" are divided 50/50 between product and packaging. The packaging share is estimated to contain a general distribution of hard plastics (food 61%, near-food 35%, non-food 4%).

In the Design Guide work has been done to ensure that the packaging share of household waste can be recycled into a quality that can be used again for new packaging - food, near-food or non-food packaging.

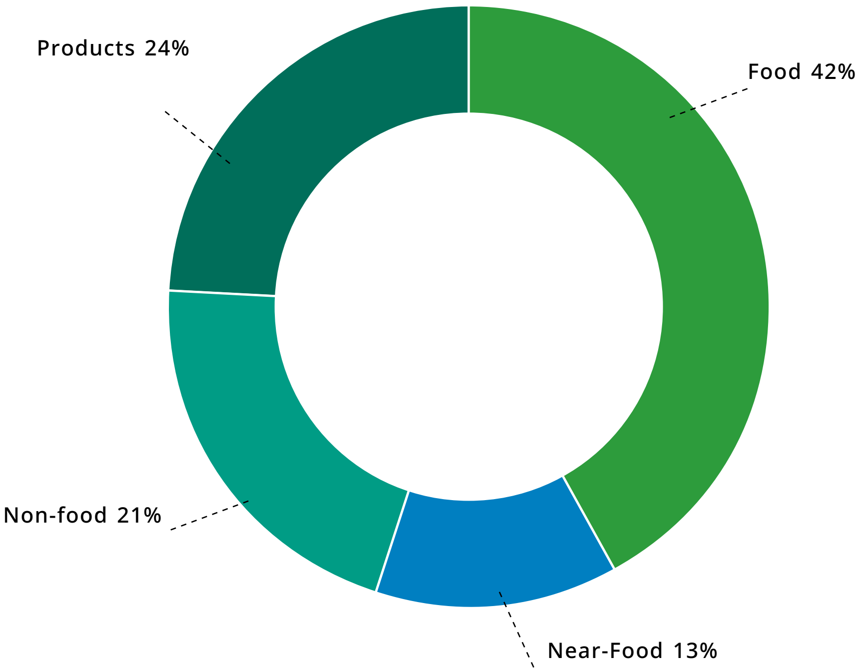
4.2.1 Polymer distribution in household plastic waste

The diagram shows the polymer distribution of all plastics from samples of household-collected plastic waste in the City of Copenhagen in 2019.



4.2.2 The composition of packaging in household plastic waste

The diagram shows the composition of packaging (food, near-food, non-food) and products from samples of household-collected plastic waste in the City of Copenhagen in 2019.



4.2.3 Sorting plastic packaging using pictograms

National waste pictograms can help citizens and businesses sort their waste correctly. For this reason, the Design Guide recommends that packaging as a general rule should be marked with pictograms for plastic sorting, so as much plastic as possible is sorted for recycling. This will also be one of the requirements in the new packaging directive. After this, it is developments in technology and innovation that will determine how much is actually sorted and recycled into new raw materials at sorting and recycling facilities.

Example: Bags for snacks are in most cases made of mono-PP with a very thin layer of metallization (less than 1%). Recycling experiments with these bags have shown that they can be recycled into a quality for use as new raw materials that can be sold on the market. Flexible film packaging like coffee bags and snack bags can therefore be labeled as plastic and sorted as plastic waste by citizens.

There are some exceptions to this, which are explained in the instructions for sorting waste in Denmark published by the Danish Environmental Protection Agency. One example is plastic containers with leftover paint. These must be delivered to a recycling station as hazardous waste.

Read more in the Guidelines on the sorting criteria for household waste' at *www.retsinformation.dk*

4.3 Two approaches to recycling

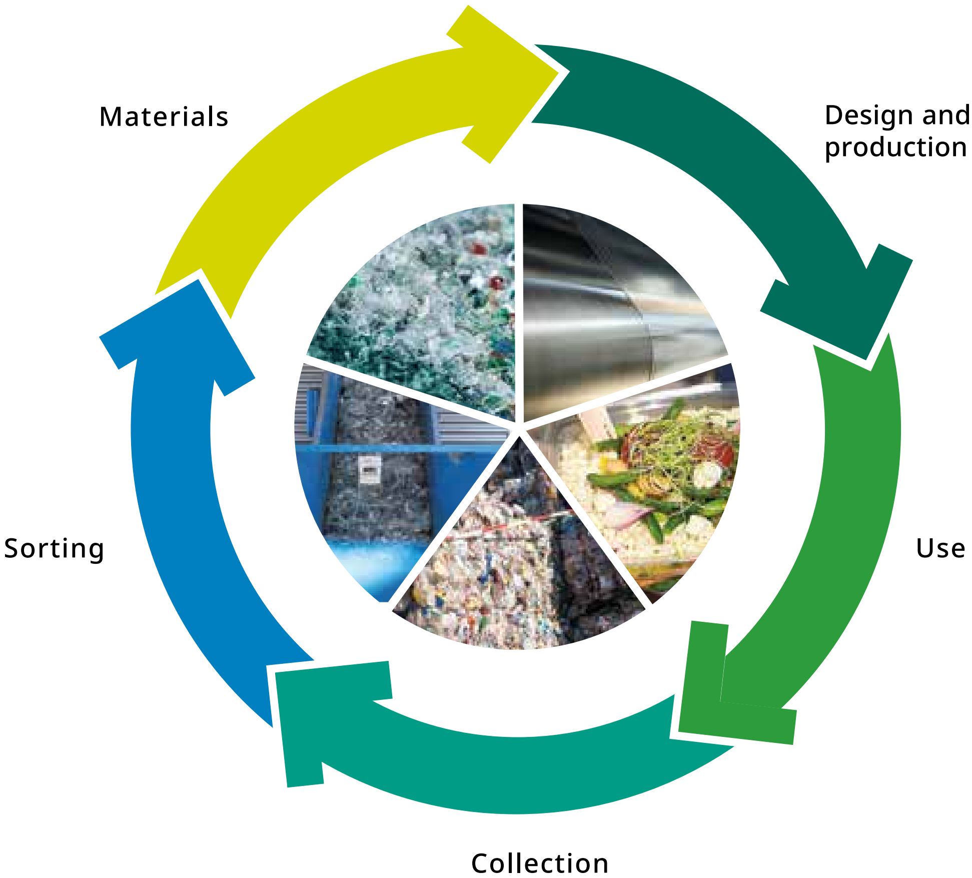
Before you begin to design your packaging for recycling, you need to determine the following: Which type of plastic best suits your product, and how high of a recycling ambition do you have for the packaging you are going to design? Many types of packaging must comply with different packaging laws and regulations. This means that your business model depends on plastic type and functional requirements that apply for the packaging.

There are two different approaches to recycling:

1. You design packaging so it can be recycled into raw material for the same type of packaging. This is referred to as circular recycling. **Example**: Food packaging (meat tray) becomes food packaging, near-food packaging (shampoo bottle) becomes near-food packaging.

2. You design packaging that can be recycled for use as another type of packaging with other properties. This is referred to as spiral recycling. **Example:** Food packaging (salad tub) becomes non-food packaging (paint bucket).

4.3.1 The circular recycling principle



The following applies to the circular recycling principle:

- Recycled materials can be used in the packaging, and the material can be used as recycled material in the same type of packaging.
- It must be possible to sort the packaging correctly.
- When it is recycled, the packaging must not contaminate the quality of other recycled materials with non-intended added substances (NIAS).

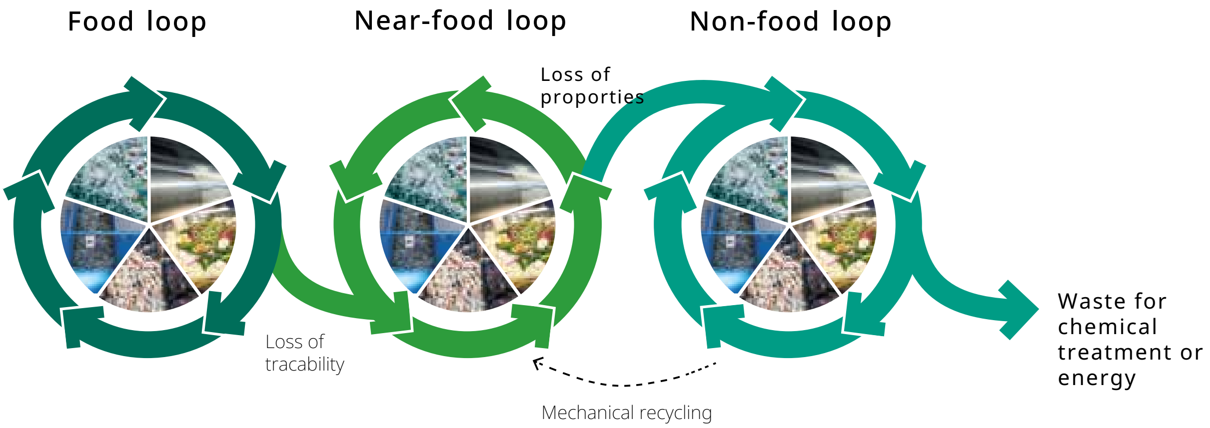
4.3.2 The spiral recycling principle

When the material cannot be recycled into raw material for the same type of packaging, its specific properties are downgraded and it leaves the circular cycle. After this, the material can be recycled according to the spiral recycling principle. With this loss of quality, specific qualities degenerate to more general properties that can be used in other types of products.

In certain cases, non-food packaging can be recycled for near-food packaging use if there is documentation that it has the correct technical and health quality. For example, plastic from household waste can become packaging for cosmetics (near-food), even though some of the waste comes from non-food packaging.

Packaging used for food must comply with prevailing regulations for chemical food safety and hygiene requirements. It is therefore very difficult to use recycled plastic that has been used in other applications besides food packaging to make new food packaging

Certain types of packaging not intended for food use, such as cosmetics and personal care, also have strict requirements with regard to plastic quality and migration properties.



4.3.3 Principles to follow when designing packaging for recyclability

When designing packaging for recyclability, you must think these 5 principles into the design process:

- **Clean up your own mess.** It must be possible to recycle and utilize 100% of the packaging as raw material for similar packaging.
- **Think holistic design.** The packaging solution in its entirety (including lids, printing and labels) must never compromise product safety in the recycling process.
- **Think of others.** The design must take into account the recycling streams of others. The design must be mindful of the risk of misdetection, which could contaminate the recycling streams of others.
- **Freedom to innovate.** The Design Guide promotes the view that anything goes as long as the design does not compromise product safety or functional properties when the material is recycled.
- **Think recycling in a holistic perspective.** Be mindful of all links in the value chain for design and recycling so nothing is proposed that can ruin the recycling opportunities elsewhere in the value chain.

5 Decision ladder – Design for recycling

The decision ladder on the next page goes through the various decision steps that must be considered in the process of designing recyclable plastic packaging.

The decision ladder gathers the questions and considerations involved when designing plastic packaging for recycling.

The starting point for the decision tree is your chosen business model and packaging type, and from here the tree guides you through the material options that are available when designing for packaging recycling.

To ensure as much packaging as possible is recycled for all purposes, and to meet existing regulations for products like food and cosmetics, there is a need for mechanical sorting technologies capable of sorting food, near-food and non-food packaging separately.

According to regulations for food contact materials, the only technology capable of this at the moment is the mechanical recycling process for PET. However, the stipulation is that maximum 5% of the input material comes from non-food contact PET. This is to ensure that contamination from undesirable substances is kept to a minimum.

Looking forward, it is desired that recycling facilities will able to sort PET packaging from household waste separately into food packaging (food) and other packaging (near-food and non-food). This will make it possible to convert trays, tubs, cups and lids in PET into new packaging and to keep it within the circular recycling economy.

Other technologies for recycling food contact materials besides mechanical recycling of PET must file applications and be assessed as new technology in compliance with the regulations for recycled plastic packaging in contact with food (Novel Technology). This applies to the recycling of other polymers such as PP and PE.

Decision ladder

1 Determine the purpose of the packaging in relation to the packaged product.

- Are there any particular rules and regulations that apply to the product? For example, will the packaging come into food contact or have to meet environmental labeling requirements?
- Are there any requirements that relate to the packaging's properties, for example, to preserve a product's shelf life, barrier properties or something else?

2 Assess the options for recycling in relation to the packaging's function

- Design for a separate collection system for recycling
- Design for circular recycling that ends up in household waste
- Design for spiral recycling that ends up in household waste

See the circular and spiral recycling principles on pages 32 and 33.

3 Consider how to uphold the 5 principles for recyclability in your design process

- Clean up your own mess
- Think holistic design
- Think of others
- Freedom to innovate
- Think recycling in a holistic perspective

See the 5 principles for designing for recyclability on page 33.

4 Assessment of materials based on current regulations and the Danish household waste collection and sorting system in 2022

PP and PE can:

- be recycled in a completely closed system from food to food, if it has not been with consumers
- be circularly recycled from near-food to near-food or non-food to non-food from household waste, or from food to food if novel technology is used (more details on page 39)
- be recycled from non-food to near-food
- be spirally recycled from food, non-food to near-food or non-food from household waste

PET can:

- be circularly recycled from food to food from household plastic waste (see details on page 49)
- be circularly recycled from food to food
- be circularly recycled from non-food to non-food
- be recycled from non-food to near-food
- be circularly recycled from non-food to non-food in a separate non-food stream, if it staysin a separate waste stream that is prioritized in household waste going forward

EPS can:

- Be circularly recycled from non-food to non-food, if collected and deposited separately, e.g., at recycling stations with EPS collection.
- be spirally recycled from food to non-food, if it is collected and deposited separately, e.g., at recycling stations with EPS collection.

6 Choice of material

This section presents the criteria and requirements for recycling plastic for food packaging, assessing food safety and assessing packaging for cosmetic products and personal care. It also reviews the design principles for packaging in PP, PE, PET and flexible films.

You can find design principles and packaging examples in PP, PE and PET, as these three plastic types account for 80-90% of the total amount of household plastic waste collected in Denmark.

Besides these three types of plastic, EPS is often used as a protective packaging material, as its properties are different from PET, PP and PE due to the material's large air content. After sorting EPS, it can be delivered to a recycling station, where it is compressed and recycled into new products.

When choosing a material for your packaging design, it is important that you first read "2 - Choosing a packaging strategy"*on page 15*. You can make a qualified material choice based on choice of packaging strategy and based on your identified context and ambition level.

6.1 Documentation for recycled plastics

Requirements for documenting the contents of recycled plastics used in packaging and other products are growing. National legislation on producer responsibility, the EU single-use plastics directive and EU packaging regulations will all require methods for calculating environmental impact for plastics. There will also be requirements for documenting traceability in the value chain.

The design guide recommends using procedures and standards that are transparent, verifiable and auditable so users are ensured reliability, traceability and data integrity. The design guide does not make recommendations about specific existing procedures or standards that can satisfy traceability requirements.

Ask your supplier if you need documentation on amount of additives, product origin, proportion of recycled plastic, etc. For recycled FCM, this must be stated in the declaration of conformity cf. 1616/2022 Annex III.

There are standards and rules, like those in the Commission document on rPET in bottles from SUP (Directive (EU) 2019/904),[1] that define the rules for calculating rPP, rPE and rPET content in recycled plastic packaging. As an example, the percentage of virgin additives can be deducted from the total percentage of recycled plastic contained in the packaging.

[1] COMMISSION'S IMPLEMENTING DECISION: Laying down rules for the application of Directive (EU) 2019/904 of the European Parliament and of the Council regarding the calculation, verification and reporting of data on recycled plastic content in single-use plastic beverage bottles

6.1.1 Assessment of food safety for recycled packaging

Plastic is a material with many good properties and that comes in many types. When recycling plastic for food packaging, it is important to make sure that no unwanted substances migrate from plastic to the food. If there is print, glue or paper on the recycled packaging, it can contaminate the plastic with unwanted substances (NIAS) that can migrate to the food. Also, the food packaging may have been used by the consumer to store something other than food and thus be contaminated with unwanted chemical substances.

It is the responsibility of the producer to ensure the food safety of the packaging. This means the packaging manufacturer by labeling or by providing documentation must declare the conditions under which a given packaging can be used, such as food type(s), use temperature and use period. This also applies to packaging made from recycled plastics.

Manufacturers of food packaging made from recycled plastic must address the following:

1. Is the recycled plastic made from plastic waste that was originally food contact material, thus complying with the requirements of EU Regulation 10/2011 and the associated plastic positive list?
2. Is the recycled plastic still suitable for the same applications (food type, use temperature and use period) as the original packaging, and do the plastic and the finished materials and components comply with the rules for migration?
3. Is the recycled plastic manufactured in an EU-approved recycling process, and has it been demonstrated by appropriate testing that the material does not contain unwanted substances that may pose a health risk when used in food packaging?
4. Does the recycled plastic comply with the requirements in EU Regulation 2022/1616, and is the plastic accompanied by a declaration of conformity as required in the regulation's Annex III?

At present, EU Regulation 2022/1616 includes two types of suitable recycling technologies:

- Mechanical recycling of PET after the consumer stage.
- Recycling from product cycles within a closed and controlled chain without collection at consumer level.

In addition, it is possible to manufacture and use recycled plastic under development as a new technology or "Novel technology". This requires publication of the company's risk assessment, notification to the EU Commission and ongoing publication of the company's monitoring results.

Packaging with a functional plastic barrier, including ABA packaging, is now included under regulation 2022/1616.

ABA packaging consists of an A layer of virgin plastic (suitable for food contact) on the outer and inner sides, and a B layer, which is recycled plastic. The B layer must meet the same requirements as recycled plastic for direct food contact. This rules out using, for instance, a more impure rPET behind the functional barrier.

6.1.2 Assessment of near-food use for recycled packaging

Near-food covers a wide range of products that are contact sensitive. These include disposable diapers, cosmetics, shampoo, cleaning products and pet food. The requirements for the individual product categories have a bearing on the choice of packaging quality.

In practice this means that food-contact packaging, which is regarded as a form of quality standard, is often in demand, as today it is the plastic type typically available on the market for recycled plastic with a quality higher than non-food. However, there are other ways to comply with regulations for near-food packaging. This could be in the form of supplier declarations and tests. An example of this is migration testing, which is described in the guidelines for using recycled plastic in packaging published by Cosmetics Europe, the European trade association for cosmetics:

https://www2.mst.dk/Udgiv/publikationer/2021/07/978-87-7038-331-8.pdf

Packaging for cosmetics and personal care products must comply with existing legislation for these two product types. Cosmetics legislation in Regulation (EC) No. 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products) specifies:

- **Article 3 - Safety:** "A cosmetic product made available on the market shall be safe for human health when used under normal or reasonably foreseeable conditions of use…"
- **Article 17 - Traces of Prohibited Substances:** "The non-intentional presence of a small quantity of a prohibited substance stemming from impurities of natural or synthetic ingredients, the manufacturing process, storage, **migration from packaging**, which is technically unavoidable in good manufacturing practice, shall be permitted provided that such presence is in conformity with Article 3."

For washing and cleaning products, the detergent regulation (European Parliament and Council Regulation (EC) No. 648/2004 of 31 March 2004 on detergents) similarly requires that products placed on the market are safe for consumers to use.

In practice, the implication in these regulations is that either a toxicological assessment can be made evaluating the safety of particular packaging, or that plastic intended for food contact can be used.

Due to different safety level requirements and threshold values for individual substances, a decision should be made about both product and method. For inspiration, consider the methods in the Danish Environmental Protection Agency publication, Initial safety assessment of recycled plastic for packaging of cosmetic products".

A safety assessment could also contain conclusions related to the following: REACH, NIAS screening, overall migration, allergens, PAH analysis and sensory tests.

For many product types, packaging may be subject to rules defined by special labeling programs like the Allergy Label or the Nordic Swan Ecolabel. It is recommended to check up on these requirements as they apply to single-use packaging.

7 Design of packaging in PP and PE

Material properties of PP and PE

The polyolefins PP and PE can be used for a multitude of products and packaging, as the properties of these plastic types can be adapted relatively easily to both manufacturing processes and product requirements. For this reason, PP and PE are some of the most widely used plastic materials today and are found in a wide range of products, both food, near-food and non-food.

When designing packaging in PP and PE, you must decide on a strategy and principles for recycling in the design phase. This means you must consider which quality the packaging will be recycled into when it can no longer used as packaging. Read about the principles for designing for recycling on *page 33*.

Material properties and recycling

PP and PE from packaging can be recycled into many new products if the plastic is sufficiently sorted and cleaned. For packaging there are requirements for the material’s technical and/or chemical properties, depending on what kind of product the material will be used for.

PP and PE are used for a multitude of products, such as packaging for hygiene products, chemicals and food. It is precisely for this reason that PP and PE in household plastic waste is found in many qualities, where one quality may be contaminated by substances from another quality. This presents challenges when it comes to recycling PP and PE for use in more critical products, such as near-food and food packaging.

rPP and rPE for food quality

It is not yet possible to recycle PP and PE from food packaging to food packaging again. Exceptions apply if the process is approved under Novel Technology (cf. EU 2022/1616), or if the specific products are collected in a closed return system where the packaging has not been used by private consumers.

For PP and PE to be recycled into food contact materials requires control and traceability of input materials.[2] In addition, the content of undesirable substances (NIAS) must be below the stipulated threshold values.

Unlike PET, PP and PE have a very open structure,which makes it easier for substances from previous uses to migrate into the plastic and contaminate it. This could contribute to the recycled material no longer being able to be used as food contact material.

It is therefore recommended to design PP and PE products for food and near-food in uncolored or white coloring to provide the possibility for circular use. It remains to be seen which type of adhesives and labels are best in relation to recycling in emerging Novel Technologies.

rPP and rPE for near-food quality

rPP and rPE can be used as near-food quality. Near-food comprises a wide range of products that are contact-sensitive, such as disposable diapers, cosmetics, shampoo, soap and pet food. For many near-food applications, there are no direct requirements on input materials. But in the case of cosmetics and hygiene products, recycled materials must be safety assessed for substances that may be contained in the packaging. These could be CMR substances with reference to the particular use of the packaging (fatty/water-based products and leave-on/rinse-off products).

rPP and rPE for non-food quality

rPP and rPE have numerous application areas within a broad range of products, where requirements often exist for the material's technical properties but where no major regulations exist for chemical properties. This is true for non-food packaging such as paint buckets and furniture.

[2] This means that the plastic must be FCM and must be collected without having had contact with residual waste. Plastic can be collected together with other fractions, such as metal, but it is not permitted to sort out plastic from residual waste and use it for food contact (EU) 2022/1616).

From NIR-sorted plastic household waste

The diversity in scope and application of PE and PP leads to a great variation of properties in the PP and PE from household plastic waste. The result is that output materials will be of mixed quality. The properties of the input virgin plastic depend on which process the material was originally made for. Thermoforming, blow molding, foil blowing and injection molding each use their own type of PP or PE.

In recycling, sorting is based on the overall material type and not on the process the material is made for. The result is an output material with properties determined by the mixed input materials.
This is what we define as the de facto properties of the recycled output material. And it is this form of standard you ought to maintain.

We can expect that as quantities increase, methods will be developed to sort plastic into qualities targeted at the different manufacturing processes. With this in mind, the Design Guide offers a very broad definition of a de facto standard. On the basis of data from collected and recycled household PP and PE at existing facilities, de facto standards are defined as follows:

7.1 De facto standards for PP and PE

PE-HD Post-consumer regenerate from household plastic

Properties	Worth/ Value	Norm
Density	0.95 g/cm3	EN ISO 1183-1A
MFR 190/2,16	0.4 g/10 min.	EN ISO 1133
MFR 190/5	1.6 g/10 min.	EN ISO 1133
Tensile Stress, Yield	24 MPa	EN ISO 527
Elongation, Yield	12%	EN ISO 527
Tensile Stress, Break	17 MPa	EN ISO 527
Elongation, Break	50-100%	EN ISO 527
E-mod, 23 °C	650 MPa	EN ISO 527
Flexural Modulus	890 MPa	EN ISO 527
Charpy Impact, 23 C	NB	EN ISO 179
Charpy Impact, Notched, 23 C	23 kJ/m^2	EN ISO 179
Charpy Impact, Notched, -20 C	5.4 kJ/m^2	EN ISO 179

PP Post-consumer regenerate from household plastic

Properties	Worth/ Value	Norm
Density	0.92 g/cm3	EN ISO 5990
MFR: 230/2.16	20±5 g/10 min.	EN ISO 1133
Tensile Stress, Yield	27 MPa	EN ISO 527
Elongation, Yield 1	0%	EN ISO 527
Tensile Stress, Break	24 MPa	EN ISO 527
Elongation, Break	13%	EN ISO 527
E-mod, 23 °C	1100 MPa	EN ISO 527
Flexural Modulus	1100 MPa	EN ISO 527
Charpy Impact, 23 C	85 kJ/ m^2	EN ISO 179
Charpy Impact, Notched, 23 C	7 kJ/m^2	EN ISO 179
Charpy Impact, Notched, -20 C	2.2 kJ/m^2	EN ISO 179

Source: Aage Vestergaard Larsen Inc. The above figures are nominal values only. Particularly suitable for injection molding. It is always necessary to carry out testing for the application in question.

7.2 Design considerations for recyclable PP packaging

When designing PP packaging for recycling, a number of factors have an influence on the final design recommendation. This section looks at the facts, considerations and challenges that should be taken into account when designing the subcomponents of the packaging.

PP	Facts	Considerations
Materials (main components)	For efficient sorting, PP must be recognized by the sorting system, which can be based on NIR technology, gravimetric sorting or a combination of the two. › NIR technology: Requires the plastic to be optically visible. › Gravimetric sorting: This method sorts out both PP and PE. Therefore, subsequent electrostatic or NIR sorting of PP and PE is required. Gravimetric sorting is a highly effective method for sorting collected PP plastic waste, as it can sort out all packaging materials. The quality of rPP depends on how effectively it can be cleansed of other materials. Including the amount of PE is mixed in with rPP. Recycled PP typically has lower mechanical properties than a new raw material. For various food applications, you need to upgrade the PP packaging with an oxygen barrier. EVOH, SiOx and AlOx are used as barrier layers, depending on whether it is flexible film packaging or thermoformed packaging. For EVOH in thermoformed packaging, the rPP quality depends on the amount of EVOH and what is used to bind the PP and EVOH together. It is not possible to separate the individual layers in a plastic laminate using mechanical recycling.	The density should be below 0.97 g/cm^3. This means that no chalk or other mineral fillers may be added that increase the density above this level. No additives are allowed that lower the application potential of the recycled material. A small amount of PE content is accepted in rPP, but it is not desired. The fluidity of the melt can be adjusted during reprocessing in relation to the desired fabrication process. In thermoformed packaging, EVOH is used as a barrier material. But it can be problematic and only works in rPP, because a "dilution" occurs with pure PP packaging in the collected plastic waste. EVOH contaminates rPE/rPP depending on which tie layer is used. With a PP based (PP-g-MEH grafted) tie layer, less than 6% is accepted in the "green/high value" category, and more than 6% in the "yellow/low value" category. With other types of tie layers, up to 1% is accepted in "yellow" Over 1% EVOH with other types of tie layers is not considered recyclable.

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PP	Facts	Considerations
Color	rPP in natural or light colors has the highest value, as there are more possible applications for clear plastic in the next cycle. However, all colors that can be sorted using NIR are currently recycled. Without color sorting, rPP has a gray color and can mainly be turned into products in darker colors. NIR sorting is a widely used technology for sorting plastics that utilizes the different reflective qualities of the different types of plastics. The problem is, however, that many current NIR techniques cannot recognize plastics that contain large amounts of carbon-black pigment.	In order to get a light-colored fraction for recycling, PP flakes must be sorted using camera technology into dark colors and light colors. Whenever possible, clear plastics should be chosen so that rPP can retain the highest use potential and the highest value as long as possible. If coloring is required, NIR detectable colors should be chosen so that the plastic can be sorted for recycling. Avoid adding dark color pigments as much as possible. If it is necessary for the sake of recycling content or marketing, use at least one of the colors that NIR can detect.
Closures (lids, top film, sealing film, caps)	In rPP, a certain amount of contamination with PE is accepted without destroying the material's properties. Combinations with other materials should be avoided. Membrane sealing with PP and PE films are preferred. If an aluminum or PET membrane is used that cannot be removed completely before disposal, this component will negatively affect the recyclability of the packaging.	Packaging should be designed so that sub-components are made of PP and PE. If sub-components are made of materials other than PP and PE, they must be naturally or easily separable from the container before disposal. Subcomponents with a density above 1 g/cm^3 are accepted if they are separated by coarse mechanical shredding (grinder). Aluminum and PET laminate membranes must be of a quality that lets them be removed in one piece, without leaving membrane residue on the PP packaging.

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PP	Facts	Considerations
Direct printing on main components	When recycling with a "Novel Technology", removal of printing inks can be part of the process. Direct printing or IML has no significance for recycling here. With other recycling processes where printing ink is not removed, the recycled material has a lower value. With the sorting and washing methods currently available, PP can only be recycled for use as non-food packaging and materials. Direct printing affects the color and value of the recycled PP, but it does not affect the possibility for recycling.	For rPP used in non-food applications, residues from printing inks are accepted. Direct printing, PP In-Mold-Label film. self-adhesive PP labels and PE labels with decoration are allowed in thermally stable colors.
Labels, sleeves and wrappers (decoration)	A label consists of adhesive, main material and printing ink. Labels are essential for communicating the contents of the packaging with the end user. With the sorting and washing methods currently available, PP can only be recycled for use as non-food packaging and materials. Printed labels made of PP can therefore be included in recycling. Sleeves, wrap-arounds and wrappers are decorations that are shrink-wrapped or wrapped around the packaging. Large printed sleeves and cardboard wrappers can lead to missorting. Plastic sleeves and wrappers must not hinder NIR scanning. Labels made of materials other than PP and PE must be able to be washed off in water and sorted out. Most recycling processes wash using 40°C cold water. With "Novel Technology" warm water (>70 °C) is used.	Labels should be made of PP or PE. Sleeves, wrap-arounds and wrappers must be able to be sorted out in the recycling process and must not hinder correct NIR scanning of the packaging. Packaging decoration in materials other than PP and PE should be tested for NIR missorting before being put on the market. Adhesive-free decoration of materials other than PP should be easy to remove by the end user without leaving any residue. Alternatively, the decoration should be automatically separated by compression during collection. Information on the packaging should encourage consumers to remove decoration completely before recycling. Adhesive and label must leave the container, and any residues should wash off. PVC labels must not be used, as sorted out residual materials are complicated to dispose of.

Example of packaging designed in PP for recycling
The Buko packaging from Arla is an example of a PP box with a lid decorated with PP IML. The product is sealed with thin aluminum foil.

7.3 Design recommendations for PP packaging for recycling

		Recycling High Value	Recycling Low Value	Cannot Be Recycled
Clarity		White or light coloring, but preferably without added color	Dark coloring that can be sorted using NIR	Coloring that cannot be sorted using NIR
Main component (container, tub, tray, bottle, film)	**Materials**	>95% PP	Max 30% PE	Fillers that give a density above 0.97 g/cm³
	Barriers	AlOx, SiOx coating and maximum 6% EVOH with PP based tie layer	EVOH >6% with PP based tie layer and max 1% EVOH with other tie layers	EVOH more than 1% with other binders. PA, PVDC or aluminum foil
	Additives (scavengers, anti-fog, anti-slip and similar)	Only additives necessary for processing or protection against sunlight		Flame retardants, plasticizers, oxo/ bio/ photo degradation additives
Subcomponent	**Closures** (top film, lids, seals)	Plastic laminates in PE and PP or other closures that are removed completely after opening	Materials > 1g/cm³ density that are separated by coarse shredding/grinder	Closures in other materials which cannot be separated from the packaging after opening
	Caps and lids	PP or PE mono-plastic without mineral filler	Materials > 1g/cm³ density that are separated by coarse shredding/grinder	All other materials that are not separated from the packaging by coarse shredding/grinder
Direct printing on the main components		Direct printing and In-Mold-Label in PP with thermally stable colors	Thermally unstable colors, paper IML where fibers can be washed off in cold water	IML in materials other than PP that cannot be washed off in cold water
Labels (adhesive, main material and printing inks)		Self-adhesive labels in PP and PE that do not hinder NIR detection. Labels in other materials that do not hinder NIR detection and can be washed off in cold water		Labels in PET, paper and cardboard that cannot be washed off in cold water. Labels that interfere with NIR sorting. PVC labels
Adhesive-free decoration materials (stretch sleeves, shrink sleeves, stretch labels and cardboard wrapping)		PE and PP sleeves that do not hinder NIR detection Decoration that is removed by the end user Decoration which is automatically removed by compression during collection	Full surface coverings in materials other than PP and PE that do not hinder NIR detection	PVC and all full surface coverings that interfere with NIR detection
Emptying		The packaging is naturally empty after use or residual contents can be washed out in cold water	The remaining contents can only be washed out in warm water	Cannot be emptied or washed, and the residual content damages the quality of the recycled plastic, e.g., sealant
Combination of materials in the packaging solution		PE components Materials with a density > 1g/cm³ that can only be separated by coarse shredding/grinding	Materials with a density < 1g/cm³ that can only be separated by coarse shredding/grinder	All other materials that are not separated from the packaging by coarse shredding/grinder
Other (inserts, pads, etc.)		Loose items that can be easily separated or removed	Materials that can only be separated by coarse shredding/grinder	All other materials that are not separated from the packaging by coarse shredding/grinder

7.4 Design considerations for recyclable PE packaging

When designing PE packaging for recycling, there are a number of factors that influence the final design recommendation. The following sections takes a closer look at the facts, considerations and issues that should be taken into account when designing the various elements of the packaging.

PE	Facts	Considerations
Materials (main components)	To ensure effective sorting, PE must be recognized by the sorting system, which is based on NIR technology, gravimetric sorting or a combination of both. Gravimetric sorting: This method sorts out both PP and PE. Therefore, subsequent electrostatic or NIR sorting of PP and PE is required. Gravity sorting has high a utilization of the collected PE plastic waste, as all packaging is sorted out. PE will degrade to a certain extent after repeat reprocessing where heat and oxygen are present. This can lead to altered mechanical properties when compared to the virgin raw material. The quality of rPE depends on how effectively it is rinsed of other materials. Including how much PP is mixed in with rPE. For various food applications, PE packaging needs to be upgraded with an oxygen barrier. EVOH, SiOx and AlOx barrier layers are used in films and thermoformed packaging. EVOH in thermoformed packaging contaminates rPE but is accepted depending on the binding layer used.	It is possible to define a kind of de facto standard for rPE with characteristics that should be aimed for in any production of rPE in order to deliver a well-defined raw material with the highest possible value. The content of PP should be < 1%. The density must be below 0.97 g/cm^3. This means that no chalk or other mineral filler may be added that increases the density above this level. In thermoformed packaging, EVOH is used as a barrier material. But this can be problematic and only works in rPE, because a "dilution" occurs with pure PE packaging in the collected plastic waste. EVOH contaminates rPE depending on which binding layer is used. With a PE-based (PE-g-MEH grafted) binding layer, less than 6% is accepted in the "green/ high value" category and more than 6% in the "yellow/low value" category With other types of tie layers, up to 1% is accepted in "yellow" Over 1% EVOH with other types of tie layers is not considered recyclable.

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PE	Facts	Considerations
Color	rPE in transparent or light colors has the highest value as there are more possible applications for light-colored (white) plastic in the next cycle. However, all colors are currently recycled. NIR sorting is a widely used technology for sorting plastics that utilizes the different reflective qualities of the different types of plastics. The problem is, however, that many current NIR techniques cannot recognize plastics that contain large amounts of carbon-black pigment.	Whenever possible, uncolored or light colors should be chosen so that rPE can retain the highest use potential and the highest value for as long as possible. If coloring is required, NIR detectable colors should be chosen so that the plastic can be sorted for recycling. Avoid adding dark color pigments as much as possible. If it is necessary for the sake of recycling content or marketing, use at least one of the colors that NIR can detect.
Closures (lids, top film, sealing film, caps)	Closures are a necessary part of the total packaging solution and are important for ensuring consumer safety, protecting the product and preserving the durability of the packaged item. In order to achieve the best barrier and sealing properties, closures often consist of a multi-layer multi-material solution. Closures can have printing on them.	Packaging should be optimally designed so that closures/subcomponents are made of PE. Sealing with PE film does not require the film to be completely removed before recycling. If materials other than PE are used, closures/sub-components must be easy to separate from the container without leaving residues before disposing and recycling the container. Aluminum and PET membranes/closures must be of a quality that can be removed in one piece and that leave no membrane residues on the PE packaging. In cases where closures with multi-layer materials cannot be removed by the end user, the closures must be made in a way that does not cause misdetection in the packaging recycling stream.

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PE	Facts	Considerations
Direct printing on main components	When recycling with "Novel Technology", the removal of printing inks is part of the process. Here, direct printing or IML has no impact on recycling. With other recycling processes where printing ink is not removed, the recycled material has a lower value. With rPE (from mechanical recycling) recycled for non-food packaging, residues of printing inks from direct printing on the packaging are accepted. If the printing inks are not dissolved during the washing process, the value of the recycled PE goes down.	With rPE used for non-food applications, printing ink residues are accepted. Direct printing, PE In-Mold-Label film and self-adhesive PE labels with decoration are allowed with thermally stable colors.
Labels, sleeves and wrappers (decoration)	A label consists of adhesive, main material and printing ink. Labels are essential for communicating the contents of the packaging with consumers. The label materials may pose a contamination risk to the PE recycling stream. Labels made of materials other than PE must be able to be washed off in water. Most recycling processes wash using 40°C cold water, whereas Novel Technologies developed today use hot water (>70°C). Sleeves, wrap-arounds and wrappers are decorations that are shrink-wrapped or wrapped around the packaging.	PE In-Mold-Label film and self-adhesive PE labels with decoration are permitted and can be included in the PE return stream together with the packaging. Sleeves, wrap-arounds and wrappers must be able to be sorted out in the recycling process and must not hinder correct NIR scanning of the packaging. Packaging decoration in materials other than PE should be tested for NIR missorting before it is put on the market. Adhesive-free decoration in materials other than PE should be easy to remove by the end user without leaving any residue. Alternatively, automatically separated by compression during collection. Packaging information should encourage consumers to remove decoration completely before recycling. Decoration that cannot be removed from the packaging reduces the quality of rPE. This applies especially for decoration made of PET, paper and cardboard, which are incompatible with PE and compromise the quality of rPE. Decorations such as these must therefore be able to be removed from the packaging, e.g. by washing in water. The glue and label must be completely removed from the container, so that glue residue can be washed off.

7.5 Design recommendations for PE packaging for recycling

		Recycling High Value	Recycling Low Value	Cannot Be Recycled
Clarity		White or light coloring, but preferably without added color	Dark coloring that can be NIR sorted	Coloring that cannot be sorted using NIR
Main component (container, tub, tray, bottle, film)	**Materials**	>99% PE	<5% PP	Fillers that give a density above 0.97 g/cm^3
	Barriers	AlOx, SiOx coating and maximum 6% EVOH with PE based binder	EVOH >6% with PE based binder and max 1% EVOH with other binders	EVOH more than 1% with other binders. PA, PVDC or aluminum foil
	Additives (scavengers, anti-fog, anti-slip and similar)	Only additives necessary for processing or protection against sunlight		Flame retardants, plasticizers, oxo/ bio/ photo degradation additives
Subcomponent	**Closures** (top film, lids, seals)	Plastic laminates of PE or other closures that are removed completely after opening	Materials > 1g/cm^3 density that are separated by coarse shredding/grinding	Closures in other materials which cannot be separated from the packaging after opening
	Caps and lids	PE monoplastic without mineral filling or PP lids that can be easily separated.	Materials > 1g/cm^3 density that are separated by coarse shredding/grinding	All other materials that are not separated from the packaging by coarse shredding/grinder
Direct printing on main components		Direct printing and In-Mold-Label in PE, with thermally stable colors	Thermally unstable colors, paper IML, where fibers can be washed off in cold water and which do not hinder NIR detection	IML in other than PE that does not wash off in cold water
Labels (adhesive, main material and printing inks)		Self-adhesive labels in PE that do not hinder NIR detection Labels in other materials which do not hinder NIR detection and can be washed off in cold water		Labels in PET, paper and cardboard that cannot be washed off in cold water. Labels that interfere with NIR sorting. PVC labels
Adhesive-free decoration materials (stretch sleeves, shrink sleeves, stretch labels and cardboard sleeves)		Sleeves that do not hinder NIR detection Decoration that is removed by the end user Decoration which is automatically removed by compression during collection		Full surface coverings that hinder NIR detection
Emptying		The packaging is naturally empty after use and can be washed in cold water	Residual contents can only be washed out in warm water	Cannot be emptied or washed, and the residual content damages the quality of the recycled plastic, e.g. sealant.
Combination of materials in the packaging solution		PE components Materials >1 g/cm^3 that are separated by coarse shredding/grinder	Materials <1 g/cm^3 that are separated by coarse shredding/grinder	All other materials that are not separated from the packaging by coarse shredding/grinder
Other (inserts, pads, etc.)		Loose items that can be easily separated or removed		All other materials that are not separated from the packaging by coarse shredding/grinder

8 Design of packaging in PET

Material properties of PET

PET is a polymer with excellent properties in its pure form. It is not necessary to add additives, and only a few auxiliary substances need to be added in the manufacturing process. PET has a strength and rigidity that enables it to withstand high pressure and resist impacts. PET has good gas barrier properties and can be thermally stabilized.

Material properties of PET in recycling

In the melt-down stage, all types of plastic break down. In contrast to PP and PE, which have high thermal degradation rates at normal processing temperature, the degradation of PET is predominantly done by hydrolysis. A very small proportion is due to thermal degradation at process temperature. Due to hydrolysis, the degradation process is reversible, which makes PET a particularly suitable choice of material for recycling. If it is kept pure, PET can be recycled more times than PP and PE, as PET can be regenerated in the recycling process.

PET's application areas can be divided into 4 main groups:

- Injection and blow molding (bottles and other containers)
- Film manufacturing/ Thermoforming (trays and film)
- Strapping
- Textiles

8.1 The de facto standard for PET

Bottles made of PET represent the largest amount of PET collected for recycling. It makes good sense to define the "de facto standard" for PET based on the quality of collected bottles.

- Copolymer PET with an IPA content of 1.7%. (IPA = Iso Phthalic Acid)
- IV value ranging from 0.67-0.75
- Total migration compliance equivalent to OM2 for all types of food
- Specific migration compliance (SML) at 10d/40°C for all types of food

8.2 Design considerations for recyclable PET packaging

When designing PET packaging for recycling, there are a number of factors that influence the final design recommendation. The following section reviews the facts, considerations and issues that should be considered when designing the different subcomponents of the packaging.

PET	Facts	Considerations
Materials (main components)	PET is a very well-defined material, but its natural stickiness requires some form of surface treatment. Well-known solutions are silicone coating or antiblock additives. The sealing properties of PET are often improved by laminating PET with PE, but the result is a multilayer material that is difficult to recycle. The sealing properties can also be improved in the A layer of an ABA structure, for example PETG-APET-APET or an A layer with a higher IPA content. Crystallized PET (CPET) can also be used in applications that require high temperatures (oven applications). For this application, PET is crystallized to a degree and is often modified to improve impact strength. Keep the main component of the packaging as 'pure' as possible. Avoid printing, labels, sleeves, etc., as much as possible and print consumer information and decoration on lids or sealing films instead. Currently, there is not enough rPET on the market to meet demand 100%. It will be necessary to add new virgin raw material to the circular PET cycle.	PET is a relatively flexible material, and a blend of "modified" PET does not pose a problem for recycling. Materials such as PETG, (PET with higher IPA content) and CPET can be included in the recycling process, but they must not compromise quality and clarity in the clear stream. It is important to consider which stream the packaging will end up in when it is recycled. It is important to consider its impact on clarity in the clear stream, and the risk of error and non-detection when it is recycled. Purification processes for recycled PET are effective and well documented. Under the terms of EU Regulation 2022/1616 all recycled PET for food contact must undergo decontamination, which is why it is no longer necessary to use a functional barrier as an outer layer. Using mono materials is a necessity in clear fractions and is preferable in opaque/colored streams. Example: Clear PET/PE contaminates the clear stream, while an opaque/colored PET/PE does not contaminate the colored stream. In all cases, error detection should be considered. Multimaterials should generally be avoided.

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PET	Facts	Considerations
Color	Clear plastics offer the widest range of applications in the next cycle, and at the same time place the greatest demands on the recycling process. NIR is a widespread technology for sorting plastics that distinguishes different plastic types by the different ways they reflect light waves. The drawback with NIR technology is it cannot recognize dark colored plastics with a high content of carbon black, as this absorbs the light from NIR. This results in non-identified plastic fractions. Many opaque applicationscontain various amounts of carbon black, making them undetectable using NIR technology. For recycling, all the colored materials are mixed in a so-called jazz fraction. It is not possible to a color jazz fraction using a lighter color, as light colors have a poor coverage effect. In recycling, non-bottle plastics are expected to end up in two fractions: - A semi-clear fraction - A mixed colored faction (jazz faction) Using carbon-black pigment is the most effective way to color a jazz fraction, but this still makes sorting by NIR impossible.	When choosing clear materials for packaging, you should address the requirements and considerations for recycling and for a circular economy. If coloring is necessary, consider the following: - Choose NIR detectable colors - Be aware that recycled PET can be used under different time/ temperature conditions than original PET. - You should therefore always choose a color masterbatch that meets the strictest requirements - or migration test conditions OM7 (applications up to 2 hours at 175° C). - Always consider NIAS in the next cycle when you choose color masterbatches. - Black is the most flexible color when it comes to the recycled material's application, as carbon black has the highest coverage effect.

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PET	Facts	Considerations
Closures (lids, top film, sealing film, caps)	Closures are a necessary component of the total packaging solution. Packaging closures and barrier seals are important for shelf life. Sealing films can also contain printing. In order to achieve the best barrier and sealing properties, closures often consist of a multilayer multi-material solution. Multi-materials are difficult to separate and can lead to misdetection during sorting. This will cause problems during processing and affect the quality of the finished product. NIAS from multi-material and possibly printing pose the biggest problems for the packaging recycling stream. Caps and lids are generally removed in flake sorting after the packaging has been shredded. Flake sorting is usually done using NIR sortation.	Closures should be easy to remove by the end user without leaving any residue. Information on the packaging should encourage consumers to remove closures completely before recycling. When closures cannot be removed by the end user, it must be manufactured in a way that does not lead to misdetection in the packaging recycling stream: › The best solution is to not use printing.If printing is desired, ensure that the printing inks do not cause NIAS but stay on the closure. For easier sorting and better quality in recycling, sealing film should be made of a different material than PET › Design closures so that they can be removed as early as possible - preferably by the consumer. › Design caps so they can be detected by NIR sortation and have a density under 1 g/cm^3, so they can be float sorted.
Direct printing on main components	Printing inks are undesirable in the packaging recycling stream under all circumstances. Inks that are dissolved during the washing process can potentially contaminate the recycling stream via the water. Inks not dissolved during the washing process can pose a hazard as a source of NIAS in the next cycle. If the inks are not dissolved during the washing process, they compromise clarity in the clear stream.	Direct printing on main components is not recommended.

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PET	Facts	Considerations
Labels, sleeves and wrappers (decoration)	A label consists of adhesive, main material and printing ink. Labels play an essential role in communicating the contents of the packaging to consumers. Printing inks can affect the clarity of a clear recycling stream and pose a potential NIAS hazard in the next cycle. Adhesives can affect the clarity of a clear recycling stream and pose a potential NIAS risk in the next cycle. The label's material may pose a risk of contamination to the recycling stream. Sleeves and wrappers are decorations that are shrink-wrapped or wrapped around the packaging. Large paper labels can lead to misdetection if there is no visible PET edge. When in doubt, get it tested.	Decoration should be easy to remove by the end user without leaving any residue. Design the packaging so that complete separation of components is part of the opening routine. Packaging information should encourage consumers to remove decoration completely before recycling. Printing inks should be designed so that they stay on the label and do not dissolve in water during prewash and wash. Adhesive should be designed so that it stays attached to the label and does not dissolve in the water during unheated prewash. Since labels are not wanted in the recycling stream, they should be designed to be removed from the actual packaging as early as possible in the recycling process. This can be done in the following ways: › The label is attached to the foil lid and is removed along with the foil lid by the end user › Labels are removed during pre-wash (fresh water) › Labels should be removable during the washing process (concentration of caustic soda at approx. 65-85° C) › Attach decoration without adhesives, e.g., using wrappers and shrink sleeves › Decoration can be made out of any material that does not block NIR sortation. However, decoration should never be made from PET, as it complicates flake sorting and can lead to printing inks and NIAS in recycling › Decorated packaging must be tested for missorting before it is put on the market
Other	"Other" refers to anything else that can be added to the packaging and that is not mentioned in this design guide (absorbing pads, inserts, etc.). Whatever this may be, you should keep principles of this design guide in mind.	Every kind of "other" should be designed so it will not contaminate the packaging recycling stream. The best way to ensure this is for the "other" to be removed as early as possible in the recycling process. "Other" should not lead to misdetection.

8.3 Design recommendations for PET packaging for recycling

		Recycling High Value	Recycling Low Value	Cannot Be Recycled
Clarity and color		Transparent PET or semi-transparent PET	Colored PET in thermally stabile colors rPET that is slightly colored from previous cycles Colors that comply with the strictest safety conditions, preferably the migration conditions listed in OM7.	Colored PET containing a high level of carbon black, which makes sorting difficult
Main component (container, tub, tray, bottle, film)	**Materials**	Mono-materials	Multimaterials that do not affect product safety or the physical properties of the de facto standard in the next cycle (i.e. PETG-APET-APET)	Biodegradable mono-materials. Multimaterials that are missorted or directly affect either food safety or physical properties of the de facto standard in the next cycle (i.e. PET/PE)
	Barriers	SiOx or AlOx		PA (Nylon), EVOH
	Additives (scavengers, anti-fog, anti-slip and similar)	No additives	The solution must not affect de facto standards and must not create NIAS	Additives that make PET biodegradable. Solutions at risk of NIAS and misdetection
Subcomponent	**Closure with and without print** (top film, lid, seals)	All components that are completely removed by the user after opening	Materials other than PET with density <1 g/cm³. Materials that can only be sorted after shredding	Other materials with density >1 g/cm³ and materials that are not detectable using NIR sortation
	Closures with caps and lids	Closures with density <1 g/cm³ and can be separated using NIR after shredding		Closures that consist of materials with a density >1 g/cm³ or that cannot be NIR sorted

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	Recycling High Value	Recycling Low Value	Cannot Be Recycled
Direct printing on main components	No printing or laser engraving only	Color printing that is completely washed off in a hot wash at approx. 65-85˚C, including jet date marking	Color printing on the packaging that is not washed in a hot wash at approx. at 65-85˚C
Labels (adhesive, main material and printing inks)	No or smallest possible label with an adhesive that washes of at minimum 65˚C	Labels that are removed by hot wash at approx. 65-85˚ C	Labels and adhesives that cannot be removed by hot wash at approx. 65-85˚ C PET labels
Adhesive-free decoration materials (stretch sleeves, shrink sleeves, stretch labels and cardboard sleeves)	Decoration that is completely removed by the end user after opening Decoration which is removed at collection Surfaces that do not hinder NIR sortation before shredding		Materials that hinder NIR sortation before shredding Materials that are not removed during sortation (NIR, Density <1 g/cm^3, ballistic separator)
Emptying	Packaging is naturally empty after use	Can be emptied with some difficulty Contents are washed out in an unheated prewash	Contents that cannot be washed out in a pre-wash
Combination of materials in the packaging solution	The same transparent material is used to design the entire packaging solution	The packaging solution consists of materials that can easily be sorted using NIR after shredding and have a density <1 g/cm^3	Packaging solution consists of materials that cannot be separated after shredding
Other (inserts, pads, etc.)	Must be completely removable without leaving traces of material or adhesive		"Other" that cannot be removed without leaving traces of material or adhesive

9 Design of flexible film packaging

Material properties of flexible films
Flexible films, laminates, multilayer materials and soft plastics are all names for the same type of packaging and can be used for food, near-food and non-food. The packaging can consist of multiple layers of the same or different materials. The composition provides the properties necessary for a particular product. The packaging properties are adapted to the product application and the packing process.

Flexible packaging is manufactured from a variety of materials, such as PP, PE, PET, PA, paper and aluminum. These can also have different coatings/additives which can provide different barrier, strength and shelf life properties.

The primary task of packaging is to protect the product and give it the longest possible shelf life. Part of this is making sure that the packaging has a tight seal. This can be challenging in a packing environment where moisture, water or dust can cause production difficulties. Secondly, the film must run as efficiently as possible on the packing line, which means paying attention to potential problems in the production environment.

Advantages
One advantage of flexible packaging is that it has a much lower material consumption compared to other types of packaging. By using different materials and thicknesses, flexible packaging can be adapted to the needs of the individual foodstuff. This makes it possible to achieve maximum shelf life, which helps minimizes food waste. The specific composition of flexible packaging can also be optimized to benefit the food's development and maturation process.

Disadvantages
Flexible packaging is found in many combinations and compositions, which makes sorting complicated. Compared to hard plastic, flexible films have a high surface area in relation to volume, which can result in a large amount of product residue, making washing and reprocessing difficult. This is also the case with printing inks, which account for a larger proportion of weight in flexible films.

When you design flexible packaging in flexible films, you must consider business model and principles for plastic recycling in the design phase.

Material properties of flexible films in relation to sorting and recycling
In relation to plastic waste from households flexible film packaging is the first to be sorted out. Films designed in mono-materials are easier to recycle than multilayer films, which mostly end up being incinerated. A precondition for recycling is that the film packaging is collected and sorted correctly. Since mono-material films consist of only one plastic type, they offer greater potential in terms of application and marketing, whereas multilayer films, generally consisting of non-compatible plastic types like PET and PE, will often not be compatible with recycling processes, nor will they comply with the technical requirements for production methods and products.

Flexible films currently make up around 38% of the plastic waste collected from households. The majority of this waste consists of PE films, whereas a smaller share are PP films and laminated multilayer films *(Source: The City of Copenhagen, page 30).*

Recycling value
If flexible films - whether monolayer or multilayer - contain printing ink, they cannot be recycled for the use as new food contact packaging. This is due to the fact that in a mechanical recycling process, the printing ink will mix with the material to be used as new raw material, and in that way the the printing ink come in direct contact with the food. Direct contact between printing ink and food can lead to undesirable substances migrating to the food itself. For this reason, flexible films designed for recycling must be recycled into products in near-food or non-food quality.

Sorting
To achieve a high recycling rate for flexible packaging requires the packaging to be sorted again after being separated from hard plastics.

The fractions with the highest value are mono-PP and mono-PE (density <1 g/cm$_3$). The remaining parts will be a blend of all types of plastic (density >1 g/cm$_3$) and will be sorted out.

Flexible films must be able to be sorted by gravimetric and NIR sorting. A precondition for this is that the density of the materials is not altered by adding chalk or other substances affecting the density. It is also a precondition that NIR scanning is not affected by pressure, coloring and metallization.

Barrier materials
Different types of packaging may require specific barrier properties for oxygen, water, light, aroma, etc. This can be achieved using barrier layers or coatings such as EVOH, PVOH, SiOx, AlOx, PVdC, acrylic or metallization.

EVOH is widely accepted in combination with a compatible tie layer. For example, a PE-g-MAH tie-layer for PE films. Experiments have shown that more than 5% EVOH in the plastic input reduces the quality of the recycled plastic. In the total amount of PE waste, a dilution is likely to occur, which means the effects of EVOH will be minimized to an acceptable level.

SiOx, AlOx, Acryl, EVOH and PVOH and metallization should be applied in a thickness which does not affect the detection/sorting and recycling process. Metallized film does not pose a challenge for the recycling process itself, but it can pose a challenge for NIR sorting.

PVdC is undesirable due to the release of chlorine when heated.

Adhesives and printing inks

Flexible packaging often contains both printing inks and adhesives. Printing inks on flexible packaging will mix with the recycled material. The amount of printing inks and adhesive can affect the functional properties of the recycled material and result in an undesirable migration of chemical substances if the recycled material is used for packaging/products regulated for NIAS content and migration.

Therefore, it is recommended to use as little adhesive and pigments as possible. Avoid thermally unstable pigments such as nitrocellulose (NC), which breaks down during extrusion and lowers the functional quality of recycled plastic.

Mono-material films are films consisting of one or more layers of the same type of material. Mono-materials often consist of the same type of plastic but with different properties, such as sealing properties and rigidity.

Films with multiple layers - also called multilayer films - consist of several layers of different types of materials, which are often not compatible in recycling.

9.1 Design recommendations for flexible film packaging for recycling

	Recycling High Value	Recycling Low Value	Cannot Be Recycled
Materials	Mono-materials in PP or PE. PE, PP > 90% of the total material Density < 1g/cm³	Mix of PP/PE < 90% of the total material Density < 1g/cm³	Multilayer materials with PET, PA, aluminum, paper Density > 1g/cm³
Barriers	EVOH, PVOH, SiOx, AlOx, Acrylic, metallization < 5% of total weight		PVdC EVOH > 5% of total weight
Adhesive/glue	< 5% of total weight	< 10% of total weight	> 10% of total weight
Printing/decoration	Thermally stable inks	Thermally unstable inks	Inks that block NIR scanning
Dyeing	None	Light colors	Carbon black
Closures (zippers, spouts, caps, seals)	Closure made of the same material as the film packaging		Closure not made of the same material as the film packaging
Labels	Labels made of the same material as the foil packaging		Labels not made of the same material as the foil packaging
Emptying	The packaging is naturally empty after use	The packaging is difficult to empty	

9.2 Redesign of flexible packaging - examples

The primary task of packaging is to protect the product and give it the longest possible shelf life. Part of this is making sure that the packaging has a tight seal. This can be challenging in a packing environment where moisture, water or dust can cause production difficulties. Secondly, the film must run as efficiently as possible on the packing line, which means paying attention to potential problems in the production environment.

Case: Redesign of rice packaging

The original rice packaging consisted of PETP/PE which was chosen for the product and machinery to ensure good protection, a long shelf life and optimal production flow on the machinery.

In 2020-2021 there was a desire to move away from PET, because the material is incompatible with PE in the recycling process. Of the materials available at the time, the most optimal solution was packaging in OPP/PE. Even though it is not a mono-construction, it is a solution that is designed for recycling.

At the beginning of 2022, the first tests were sucessfully carried out on a PE/PE packaging solution. Therefore, the decision was made to convert to a PE/PE packaging, and all purchases and reorders were for PE/PE.

To ensure the shelf life and food quality is not compromised, it is important to retain the original properties of the packaging. Documenting this as well as making changes and adjustments to the packing machinery require a good deal of testing and patience. But it can be done.

The packaging is designed for recycling and, provided it is collected as plastic waste, it will be sorted as PE.

Case: Re-design of cheese packaging

Castello packaging has traditionally consisted of:

1) a thick laminate bottom layer made from nylon (PA) and polyethylene (PE).

2) a thin, decorated laminate top layer also made from PA and PE.

The PA gives the film rigidity, impact strength, heat protection and a gas barrier to keep out oxygen and prevent mold. The PE component provides bonding properties and a moisture barrier to keep the cheese from drying out.

The new packaging is also built up with a top and a bottom layer.

1) A mono bottom layer that is coextruded PP with a core EVOH barrier.

2) A mono top layer made up of two layers of PP.

The overwrap is oriented polypropylene (OPP). OPP is a PP film which is stretched after extrusion. It gives the film the rigidity it needs to withstand the mechanical processes involved in the production. Orientation raises the melting point of the PP, which protects the film surface from the heat of the welding trays that seal the packaging.

The inner layer is cast polypropylene (CPP). The CPP in the inner layer has a lower melting point than the overwrap, so the welding heat can transmit from the overwrap and fuse the inner layer securely to the bottom layer. The inner layer also has a core of EVOH, which provides a gas barrier.

Purity: The packaging achieves a PP purity of around 95% and is therefore recyclable if it is collected and sorted correctly.

Case: Redesign of coffee packaging

Coffee demands a lot from its packaging. To obtain an optimal preservation of the coffees taste and quality, the packaging must be airtight and robust. In collaboration with the flexible packaging manufacturer Polyprint, BKI has further developed the coffee's OPP/PE packaging so today the coffee is packed in a pure monofraction, namely a pure PE film.

10 Overview of relevant legislation

Extended producer responsibility for packaging

On December 31, 2024, Extended Producer Responsibility for packaging and packaging waste (EPR) will take effect in all EU countries. The purpose of producer responsibility is to promote a circular economy, whether the actions taken involve solutions for reuse or recycling.

The key points of producer responsibility in Denmark:

- Producer responsibility lies with the actor with the greatest influence on the design of packaging as declared in “the polluter-pays-principle". This means the entity that fills merchandise into the packaging and puts the goods on the market is responsible for collecting, sorting and recycling the packaging.

- The Government sets packaging criteria and fees for the different packaging types. The purpose of fees is to create an incentive to use packaging that can be reused or designed for high-quality recycling, and to advance the use of recycled plastics in new plastic packaging.

- Collective schemes are to be established for managing the planning, administration and legal tasks on behalf of the producers.

- All packaging types are covered by the legislation, regardless of industry and application. This includes primary, secondary and tertiary packaging.

- As something new, targets for packaging reuse are being introduced before extended producer responsibility goes into effect.

You can read the political agreement for extended producer responsibility for packaging here: *https://mim.dk/media/231679/aftale-om-udvidet-producentansvar-for-emballage-og-engangsprodukter.pdf*

The Waste Directive

This directive sets the framework for handling waste, including establishing a waste hierarchy that defines the priorities for waste prevention efforts and actions that can lead to the reduction of packaging waste:

- Prevention (measures to reduce packaging)

- Preparing for reuse (increased use of reusable packaging)

- Recycling (designing packaging for recyclability)

- Other recovery (incineration)

- Disposal (landfills)

You can read the waste framework directive from 2008 (2008/98/EC) in its entirety here: *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0098*

Ecodesign for Sustainable Products Regulation (ESPR)

Sustainability is to be the new normal for products in the EU, and one of the proposals that aims at improving sustainability in products is the New Ecodesign Directive for Sustainable Products. Because it is a framework directive that can be enacted without amending existing regulation, the rules proposed may impact the requirements for reuse, recyclability and the design of plastic packaging.

You can read more in the Proposal for Ecodesign for Sustainable Products Regulation *https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en*

Single-use Plastics Directive (SUP)

On 31 July 2021, legislation took effect on single-use plastics that include measures on producer responsibility and the ban of certain products. The following types of plastic packaging are affected: Food containers, cups for beverages, beverage containers, lightweight plastic carrier bags, wrappers and films.

You can read more about the European Parliament and Council Directive (EU) 2019/904 of 5 June 2019 on the reduction of the impact of certain plastic products on the environment here: *https://eur-lex.europa.eu/legal-content/DA/TXT/ PDF/?uri=CELEX:32019L0904&from=EN*

Packaging Directive **Regulations are currently being revised for adoption as a directive.**

The directive aims at doing something about the increasing quantities of packaging waste in the EU, addresses and removes the barriers to circularity, promotes packaging reuse and reuse schemes, and adopts measures that will boost the use of recycled plastics in plastic packaging and create a better framework for high-quality recycling. The Commission’s goal is for all packaging to be either reusable or recyclable by 2030. The amended packaging directive is expected to be implemented in 2024 at the latest.

You can read more about the European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste or find the proposal here: *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31994L0062*

Recycled plastics for Food Contact Materials (FCM):

On October 10, 2022, regulation 1616/2022 on using recycled plastics in FCM went into effect. The regulations set requirements for collecting plastic waste for recycled FCM, assessment and approval of technologies and processes, and documentation for recycled plastics and materials fabricated from recycled plastics.

You can read about the regulation here. *https://eur-lex.europa.eu/eli/reg/2022/1616/oj*

11 Timeline of EU directives related to plastics and packaging

2020

EU member states adopted laws to comply with rules laid out in Packaging and Packaging Waste Directive 2018/852.

The Commission introduced several guidelines to the single-use plastics directive, including labels requirements for specifying plastic content and proper waste disposal methods for the following:

- Sanitary napkins and tampons
- Wet wipes
- Tobacco products with filters
- Beverage cups **(SUP)**

2021

Labeling rules took effect on July 3, 2021 (proper waste disposal + content and impact of certain plastics) for:

- Sanitary pads and tampons
- Wet wipes
- Tobacco products with filters
- Beverage cups **(SUP)**

Member states adopted measures to comply with the single-use plastics directive. **(SUP)**

Member states prepared reports on how they will achieve ambitious reductions in the consumption of disposable cups and food containers and beverage containers made from plastics (2022 to 2026). **(SUP)**

On July 21, the following packaging made from single-use plastic was banned:

- Food and beverage containers made from EPS
- Beverage cups made from EPS
- Lightweight carrier bags
- Wrappers
- Films **(SUP)**

2022

The start of ambitious reductions in the consumption of single-use cups and food and beverage containers made of plastic (2022 to 2026). **(SUP)**

In March, a law was proposed introducing new regulations for sustainable products. These regulations may impact the requirements for reuse/recyclability and the design of plastic packaging. **(ESPR)**

2023

Extended producer responsibility on tobacco products with filters took effect. **(SUP) (EPR)**

2024

By December 31 at the latest, all member states must put measures in place that enable compliance with extended producer responsibility for all packaging. **(PPWR) (EPR)**

By December 31 at the latest, extended producer liability schemes must be introduced for:

- Food containers
- Packages and packaging
- Containers for beverage up to 3 liters
- Beverage cups
- Lightweight carrier bags **(SUP) (EPR)**

2025

Target that 10 million tons of recycled plastic will be used to produce new products in the EU market. **(PLS)**

Target that a minimum of 65% of all packaging waste will be recycled. **(PPWR)**

Target that a minimum of 50% of all plastic will be recycled. **(PPWR)**

Target that PET beverage bottles will contain at least 25% recycled plastic. **(SUP)**

Target that 77% of all beverage bottles up to 3 liters on the EU market will be separately collected for recycling (in weight per year). **(SUP)**

2026

Ambitious goals to reduce the consumption of single-use cups and food and beverage containers made of plastic will be achieved (2022 to 2026). **(SUP)**

2027

By July 3 at the latest, the Commission will evaluate the single-use plastics directive. They will make a report to the Council, the Parliament and the EECS, together with a proposal for legislation where relevant. **(SUP)**

2029

Target that 90% of all beverage bottles up to 3 liters on the EU market will be separately collected for recycling (in weight per year). **(SUP)**

2030

Target that beverage bottles will contain at least 30% recycled plastic. **(SUP)**

Target that all plastic packaging on the EU market will be able to be recycled or reused. **(PLS) (SUP)**

Target that over 50% of all plastic waste in Europe will be recycled. **(PLS)**

Target that EU's sorting and recycling capacity will be quadrupled compared to 2015. **(PLS)**

Minimum target that 55% of all plastic is recycled. **(PPWR)**

Target that a minimum of 70% of all plastic packaging will be recycled. **(PPWR)**

SUP = Single-Use Plastics Directive. (June 2019)

EPR = Extended Producer Responsibility. (January 2023 and January 2025)

PPWR = Packaging and Packaging Waste Regulation, amending Directive 2018/852 and Directive 94/62/EC (May 2018)

PLS = European Strategy for Plastics (January 2018)

ESPR = Ecodesign for Sustainable Products Regulation (proposed in March 2022)

The Design Guide was developed by a working group set up by the Network for Circular Plastic Packaging, under the direction of the Danish Plastics Federation. The working group was made up of representatives from:

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