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Fit for recycling – How inks enable a Circular Economy

German Paint and Printing Ink Associations
Represented by Ewald Rempel (Sun Chemical) & Alina Marm (Siegwerk)

What we want….

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Recycling of plastic waste with the least loss of material value → high quality recyclates

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Foto credits: Siegwerk, https://www.awg-info.de/privatkunden/gelber-sack

What we get…

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Recyclates that are not fit for broad use

Sorted input stream PCW

PCR

1) Washing
2) Extrusion > 200°C

Quality impairment of PCR[1]

Caused by contaminants like food residues, adhesives, barrier materials, inks, etc.

- Odor
- Gel particles, black spots
- Mechanical properties
- Discoloration
- Color fluctuations
- Optical uniformity
- Haze

1. Qualitative assessment, depending on the target application
Source: Recycling of flexible packaging - heat stable inks and deinking I Dec 2022

Circular Economy and Recycling – a fast moving topic

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Today's recycling techniques and packaging materials are not fit for the ambitious recycling goals on global, EU and national level Scientific background is often lacking (but improving)

How to get there?

Understand behaviour of today's packaging structure on today's recycling practices and improve it (Design for recycling – D4R)

Innovate recycling techniques to improve recyclate quality. (Collecting/ Sorting/Deinking)

Innovate inks and other packaging materials to support today's recycling techniques

EU Plastic packaging recycling rates/targets			
2016	2021	2025	2030
42%	40%	50%	55%

By 2030 all plastic packaging should be recyclable!

Huber – cl
source

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Let us explore how inks can contribute to the CE and recycling ambitions

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- The Life Circle Assessment perspective of inks in packaging
- Supporting the move to monomaterials
- Quo Vadis Nitrocellulose?
- De-inking for high quality recyclate
- Driving forces of a circular economy

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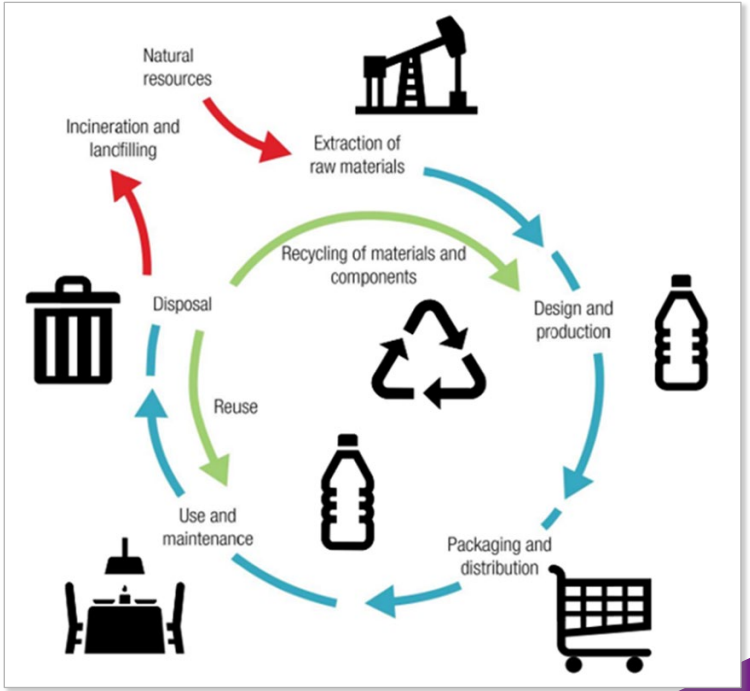
Circular Economy

Life Cycle Assessment

What is Life Cycle Assessment?

- Life Cycle Assessment (LCA) is a systematic method for evaluating the environmental impacts of a product, process, or activity throughout its entire life cycle
- LCA considers various environmental aspects, such as resource depletion, energy consumption, greenhouse gas emissions, and other pollutants
- LCA helps identify areas where improvements can be made to minimize environmental harm and optimize sustainability - but is often lacking (but improving)



Life Cycle Assessment (LCA) vs. Product specific assessment

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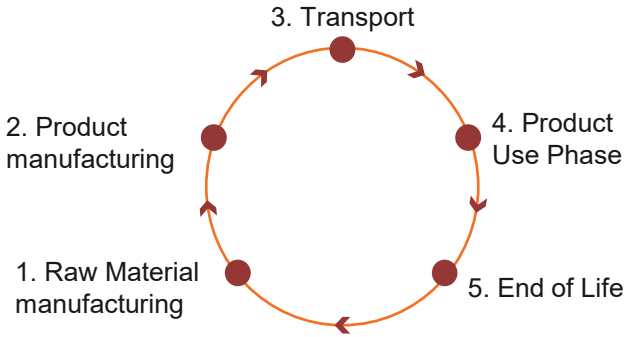
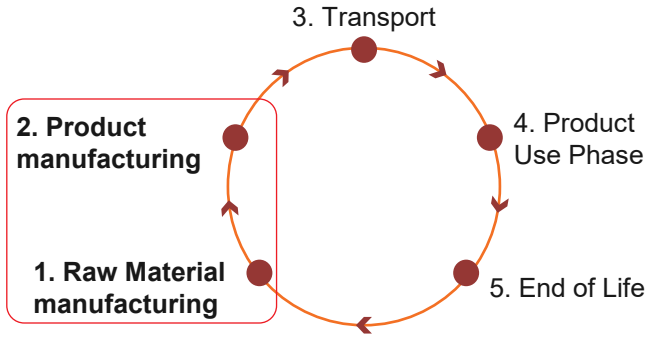
Two different options to determine the environmental impact of a product

Life Cycle Assessment (LCA)



- Must cover the full life cycle of a product
- Printing inks are not manufactured for direct use by end customer
- Product use phase & end of life are mainly unknown for printing ink manufacturer

Product specific assessment



- Focussing only on the steps in the life cycle related to the ink manufacturing (direct impact)
- Enable customers to calculate their own product related environmental impact
- “Cradle-to-gate” approach

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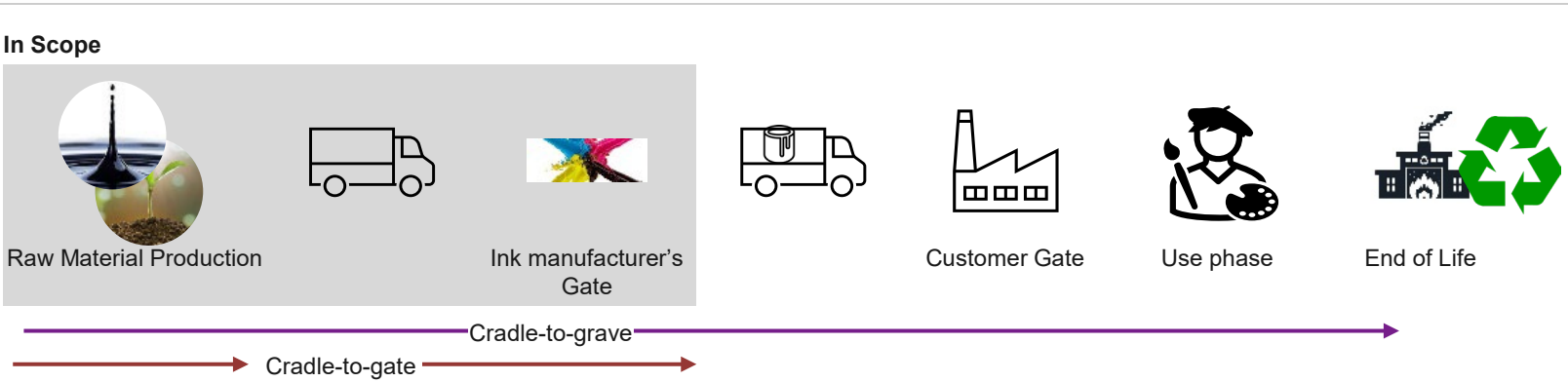
Cradle-to-gate approach

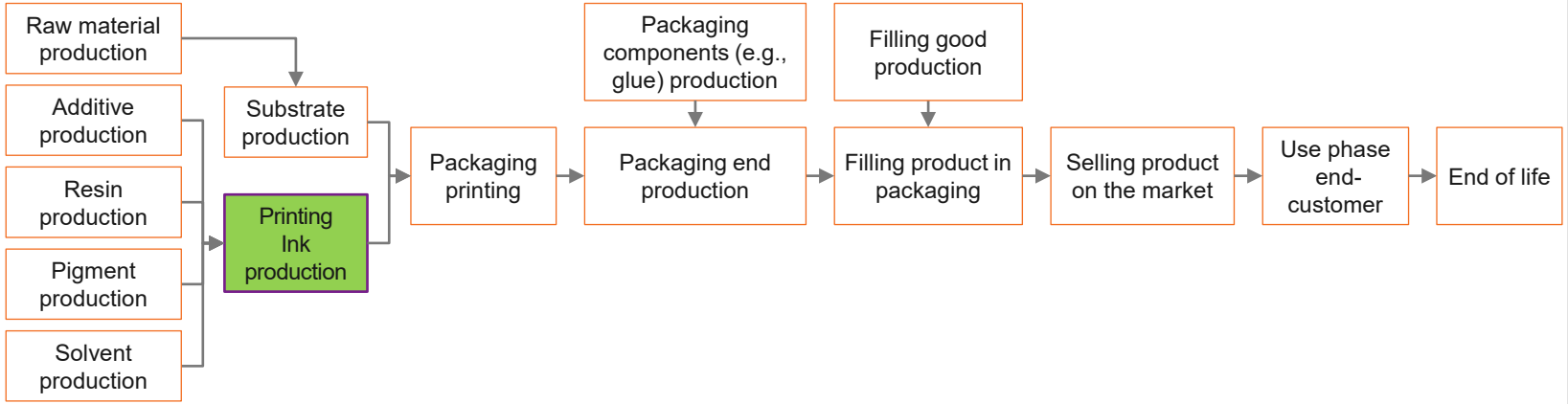


- Enables the printing ink manufacturer to control the environmental impact of stages in its own hand
  - Raw material supply (supplier firsthand data retrieval possible)
  - Own manufacturing process
- Enables customer to calculate their own environmental impact
- No double counting along the value chain
- Reflecting the ink manufacturing impact in the best possible way

Printing Ink manufactures in the value chain

The position of a printing ink manufacturer in the value chain is directly impacting the contribution of an ink to the footprint of the final product

Example: Value chain for packaging of filled goods



- Printing ink producers are only a small piece of the long value chain
- Only ~2% of the finished product carbon footprint is the ink contribution
- Position: Middle of first half of the value chain

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Circular Economy

Supporting the move to mono-materials

Why use Flexible Packaging structures?

- Price competitiveness
- Eye-Catcher - presentation of the product - advertisement
- Less weight and waste volume compared to glass or metal containers
- Barrier functions protecting the product
  light, moisture, oxygen, microbial activity, taste & smell, evaporation, physical containment

Complexity of packaging structures versus recycling

- Multimaterial packaging has lately become under pressure due to the combination of various materials with different properties like polymers, aluminum and inorganic barrier coatings
- Multimaterial packaging is therefore difficult to recycle in existing waste management infrastructures without a de-lamination step before de-inking and granulation
- A reduction of material complexity would most likely cause a shorter shelf-life, especially of food products
- The trend points towards monomaterial structures based on Polyolefin substrates in combination with suitable barrier coatings like SiOx and AlOx which are fully compatible in the recycling stream

Typical Flexible Packaging Components

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Monomaterials

- Polyolefins (PE & PP)
- Polyester (PET)
- Polyamide (PA)

Organic coating

- Acrylics
- EVOH
- PVdC

Ceramic coating

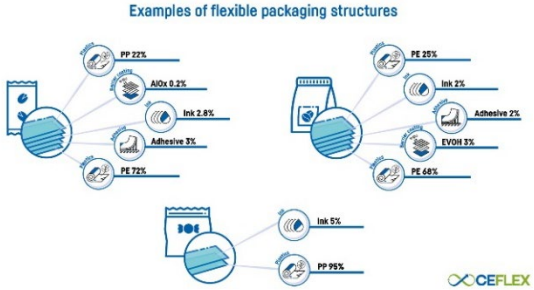
- Silicon Oxide (SiOx)
- Aluminium Oxide (AlOx)

Metallization

- Thin layer coating of metallic aluminum

Multilayers

- Combination of various monomaterials and barrier coatings



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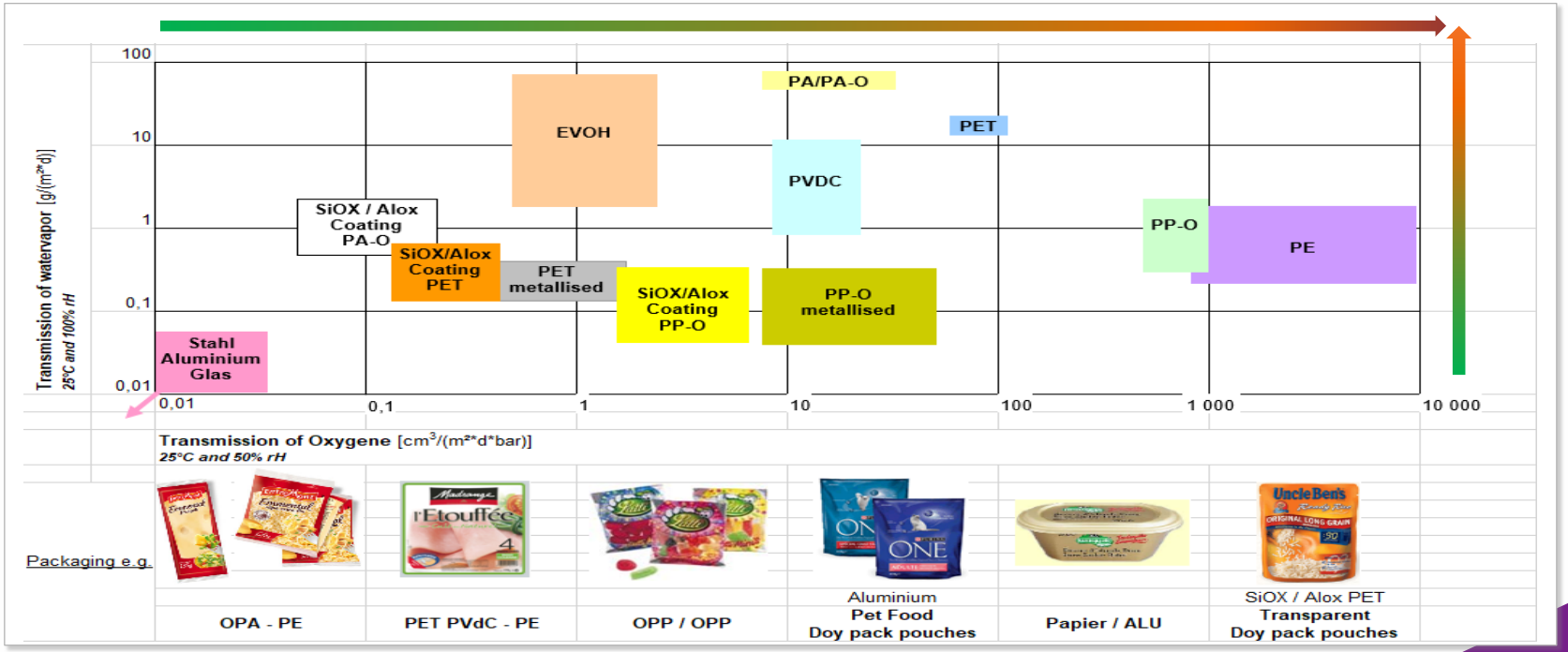
Barrier Properties of Packaging structures



Monomaterials

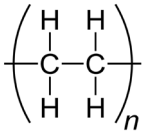
Typical substrates: PE, PP, PET and PA

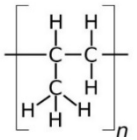
Advantages

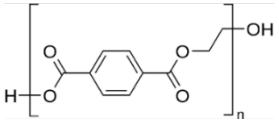
- Easy to recycle (after de-inking)
- No need for de-lamination
- Good moisture barrier
- Flexible

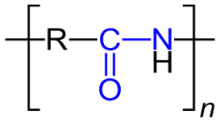
Disadvantages

- Poor gas barrier though properties are increasing with polymer density PE → PA
- PET and PA not compatible with Polyolefin recycling stream









Coated Polyolefins

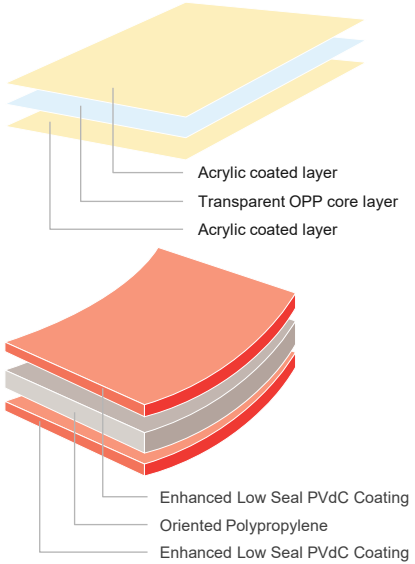
Typical substrates: BoPP coated with Acrylic, EVOH or PVdC

Advantages

- Very high moisture barrier
- Very high O2 barrier
- Good aroma barrier
- Crack resistant

Disadvantages

- Problematic for recycling – reduces quality of the recyclate (yellowing)
- PVdC may release carcinogenic dioxines when heated during extrusion of recyclate



Ceramic coating

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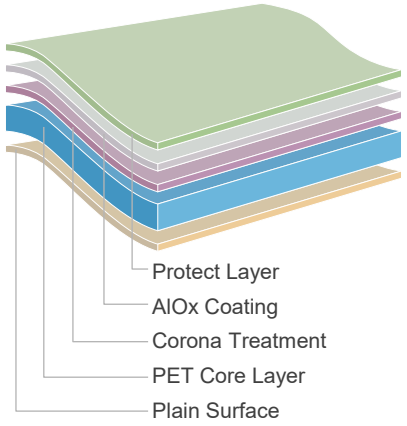
Typical substrates: PET, BoPP, PA

Advantages

- Generally, very high all-round barrier properties
- Fully compatible in recycling stream
- Not detected by metal detectors
- Suitable for microwave

Disadvantages

- Not crack resistant (glass like) – potential loss of barrier properties
- AlOx can be challenging to overprint
- SiOx can be difficult to laminate
- Cost



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Metallization

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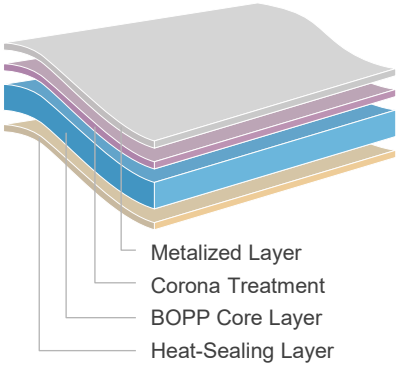
Typical substrates: PET, BoPP

Advantages

- Generally, very high all-round barrier properties
- Light barrier
- Improved optical aspects

Disadvantages

- Not separable during recycling causing discolouration of recyclate
- Detected by metal detectors
- Not suitable for microwave



Multilayers

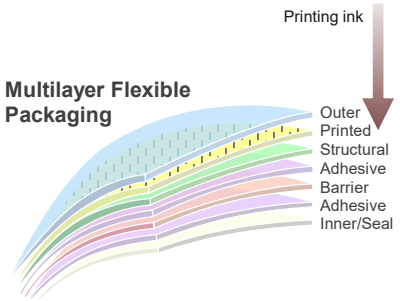
Typical substrates: Combination of different materials and barrier coatings

Advantages

- Generally, very high all-round barrier properties
- Tailored design for very specific needs
- Protection of barrier coatings

Disadvantages

- Not fully recyclable without prior de-lamination into monomaterials
- Need for de-lamination primer



Quo Vadis Nitrocellulose?

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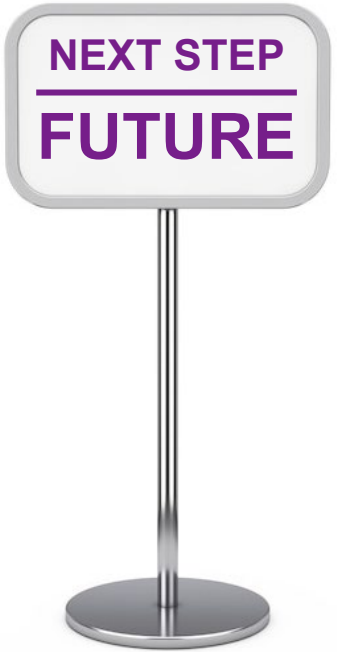
Practical solutions in a changing market environment



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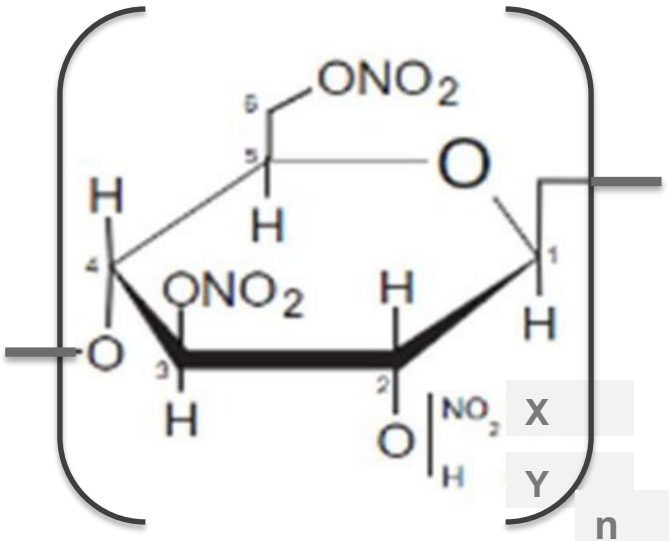
What is nitrocellulose?

- **Nitrocellulose** (NC) is a common binder system used in solvent-based printing inks and varnishes for Flexible Packaging to a very large extend
- In flexo and gravure printing this technology covers approximately more than 80% of the entire market for solvent-based inks in Europe



Printing inks for Flexible Packaging

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Typical binder systems and their properties – pros and cons

Binder	NC, NC/PU	PVB	PVC	PU
Gravure printability	☺	☺	☺	☺
Flexo printability	☺	😐	☹	☺
Pasteurisation	😐	☺	☺	☺
Sterilisation	☹	☺	☺	☺
Range of substrates (adhesion)	universal	universal	universal	very universal
Printing speed	very high	high	very high	very high
Surface printing	☺	☹	☹	☹
Lamination High Perfromance	☹	☺	☺	☺
Lamination Medium perfromence	☺	☺	☺	☺
Lamination Standard Performance	☺	☺	☺	☺
Mechanical recycling	☹	☺	☹	☺

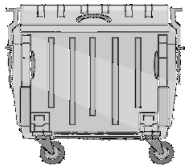
Binders account for around 10-20% of a solvent-based ink

NC is a very versatile binder system with many pros but also a very strong con ...

NC = nitrocellulose PU = polyurethane PVC = polyvinlyl chloride PVB = polyvinyl butyral

The future of NC inks

Physical Recycling



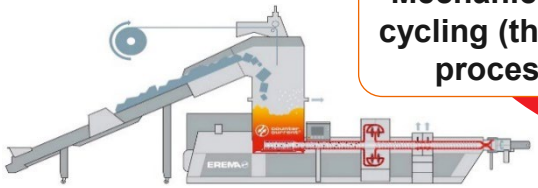
Printed Film Polymers

Volatiles, filter residue

Physical Recycling

Sorting and Cold washing

Mechanical re-cycling (thermal process)



Regranulation 240 – 250°C

Physical recycling is a thermal process that leads to thermal decomposition of **temperature sensitive nitrocellulose**

The future of NC inks

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Current ink binders flexible packaging

Flexo printing:

- **90% Nitrocellulose (NC)**

Gravure printing:

- **75% NC**
  25% PVB, PVC and **PU** for high temperature (sterilization 120–130°C) applications

VS

Upcoming / new regulations

- **German “Minimum Standard”**
  Large format PE laminates printed with NC are not compatible with German recycling system;
  but: no legal or financial consequences
- **Packaging & Packaging Waste Regulation (EU)**
  By 2030 all packaging must be recyclable – non-recyclable packaging will be banned
  Criteria will be defined (“delegated acts”)
- **Design for recycling (D4R) criteria by European Standard (CEN Institute)**
  Anticipated for 2027
- **Ceflex and RecyClass**
  D4R guideline amendment expected for Q4
  Q1 2024 based on ongoing scientific evalu

Check and rephrase

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The future of NC inks

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Conclusion

- We will get some kind of specific D4R criteria for inks (‘Mindeststandard’, RecyClass, Ceflex, CEN, PPWR) in the future
- Criteria and details to need to be defined

Good news: There are potential alternatives available

- Alternative binders (PU, PVB)
- Modified mechanical recycling process: Deinking instead of “only” cold-washing

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De-inking for creating high quality recyclates

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PU-ink systems are better suited for mechanical recycling, but it is not a silver bullet

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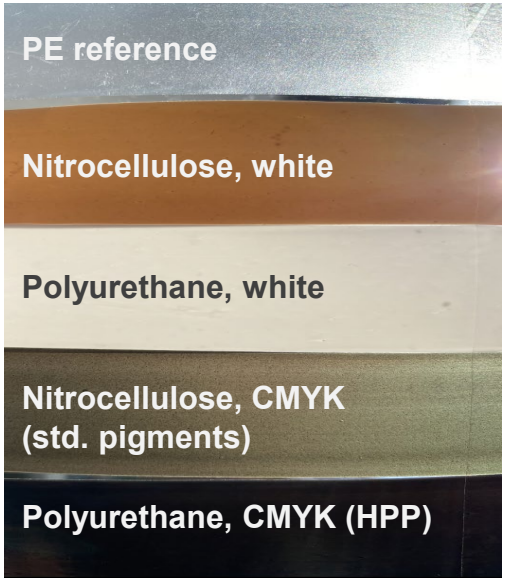
Optical appearance of extruded film based on printed material



Qualitative overview impact binder

Property	General purpose NC-ink	Heat-stable PU-ink
Gassing during extrusion	Not ok	Ok
Odor recyclate	Not ok	Ok
Gel particles, mechanical properties	Not ok	Not ok – Ok
Discoloration recyclate	Not ok	Not ok
Suitable for food contact (FCM)	No	No

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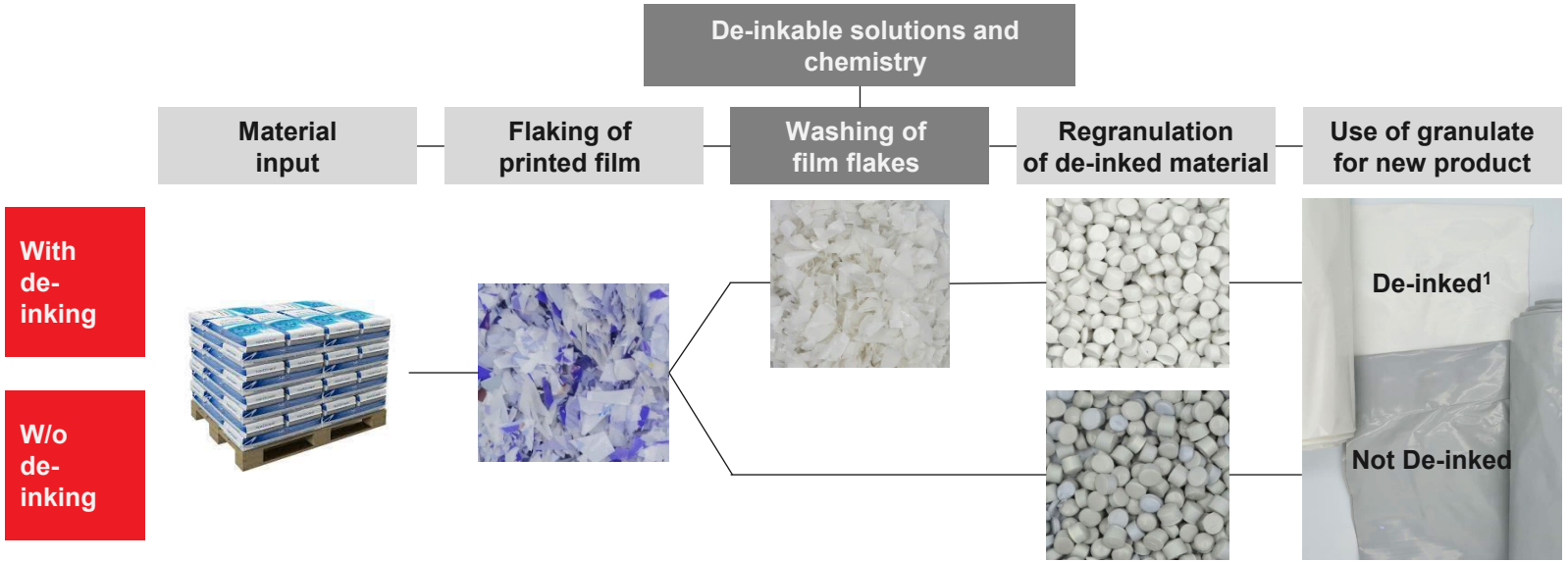
Source: Recycling of flexible packaging - heat stable inks and deinking I Jul 2023

De-inkable solutions allow production of colorless recyclates from printed Post Consumer Waste (PCW)

Basic steps de-inking

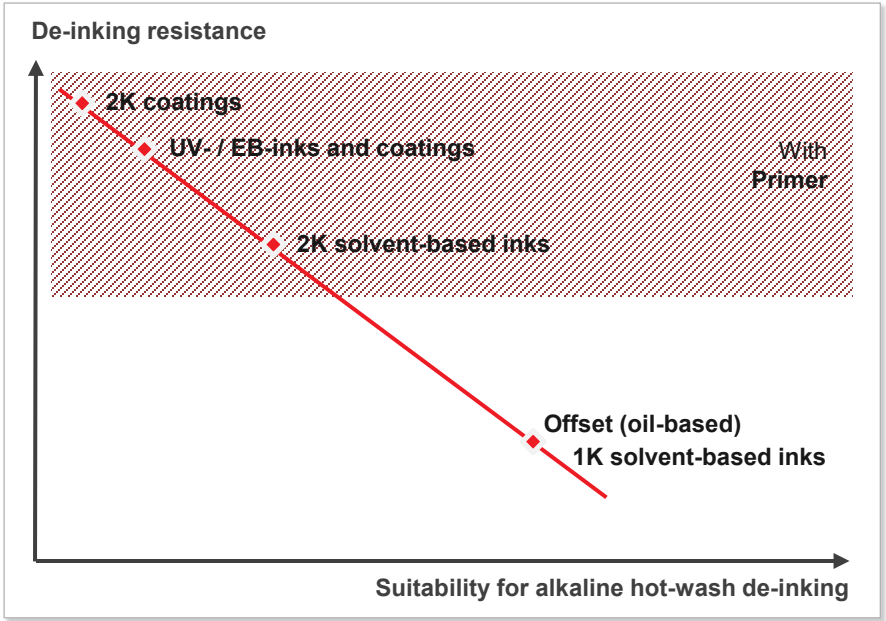


1. No additives / masterbatch, 100% recyclate content in films

Source: Recycling of flexible packaging - heat stable inks and deinking I Jul 2023

Making packaging de-inkable

Systematic de-inking studies of all relevant print structures on-going



- De-inking of any structure possible, but can require **too harsh conditions** for cost-efficient industrial application (time, temperature, chemicals)
- **1K SB inks** proven to be **optimal for de-inking**
- De-inking **primers** allow for de-inking of most inks
- De-inking primers can **delaminate**, extending the range of de-inking possibilities

Source: Recycling of flexible packaging - heat stable inks and deinking I Jul 202

Delamination/de-inking primers ensure smooth de-inking of reverse-printed structures

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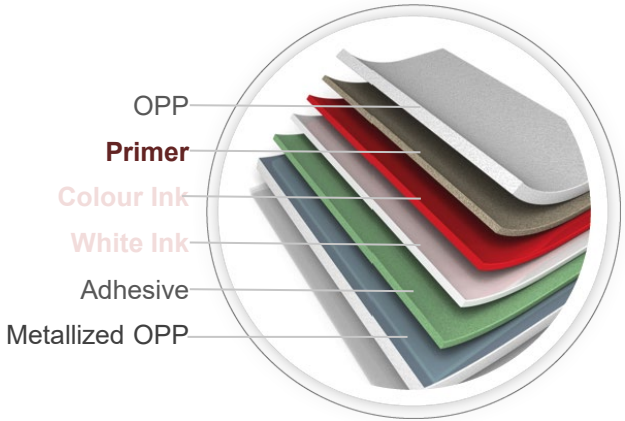
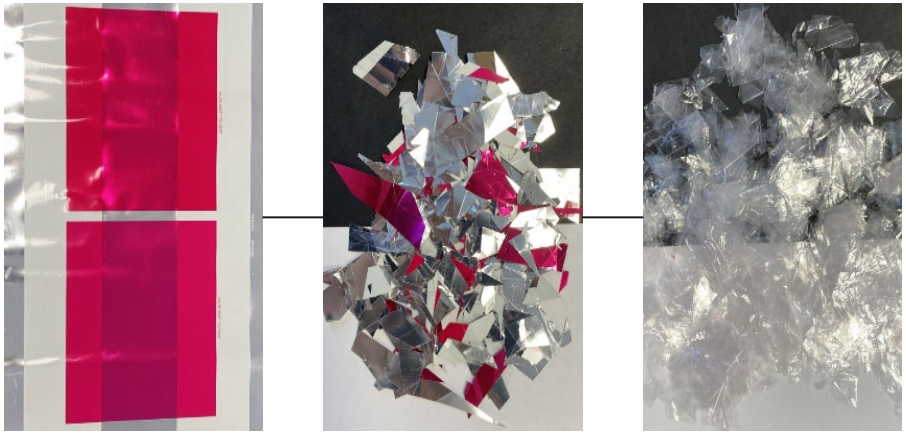
Option 2

De-inkable structure with Primer



Delamination/de-inking of OPP/met-OPP structure



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Source: Recycling of flexible packaging - heat stable inks and de-inking I Jul 2023

De-inking/de-laminatio can be combined with printed coatings for barrier

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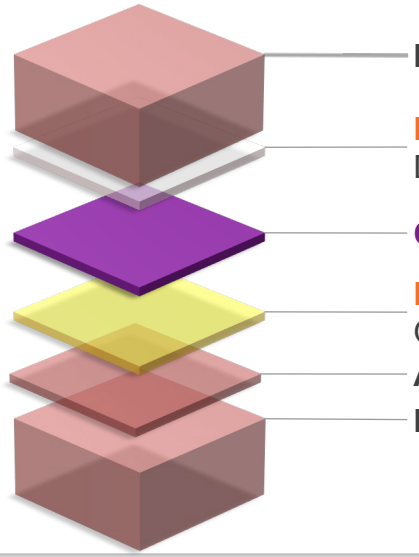
Enabled by functional coatings



MDO-PE

Primer
Delamination / de-inking primer

Color / White

Printed oxygen barrier
Oxygen barrier coating

Adhesive

PE

Stand-up pouch with high barrier

Flakes after de-inking

De-inking is emerging in the market, but needs application at scale

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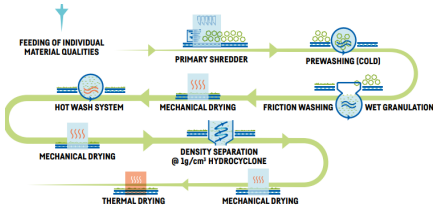
Industry initiatives

CEFLEX Quality Recycling Process (QRP)[1]



Packaging converters

Coveris – UK (PE films)

ReCover recycling facility[2]

Huthamaki – Turkey[3]

De-inkable on market / ready for market[4]

1: Link to CEFELX: CEFLEX ‘Quality Recycling Process’ - CEFLEX2: Link to Coveris PR: Coveris opens new ReCover recycling facility with pioneering technology | Coveris; 3: Huthamaki Annual Report, 2022, p. 165; 4: Siegwerk

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Driving forces of a circular economy

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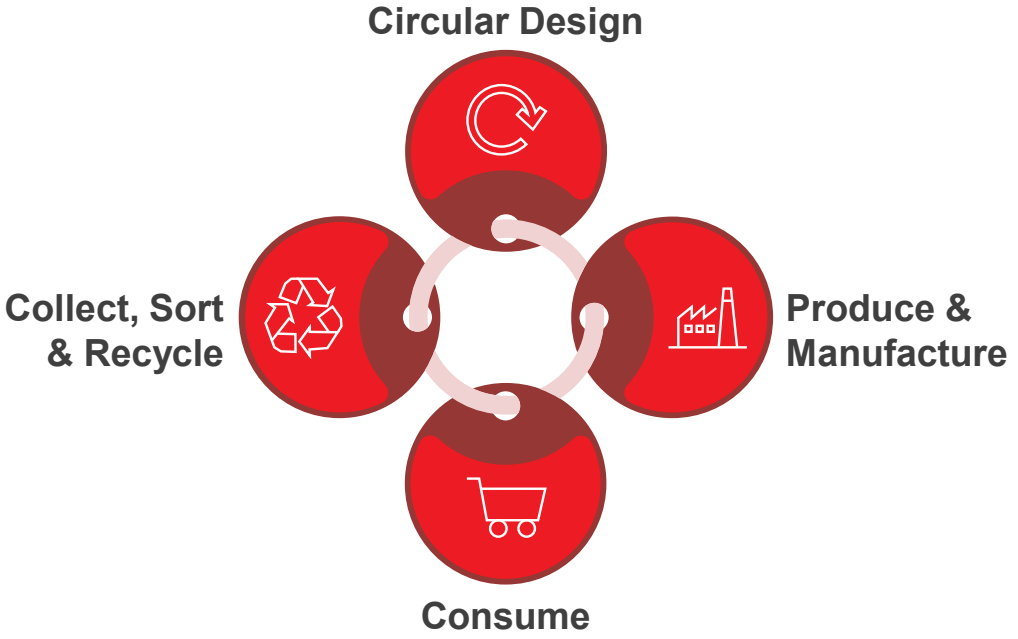
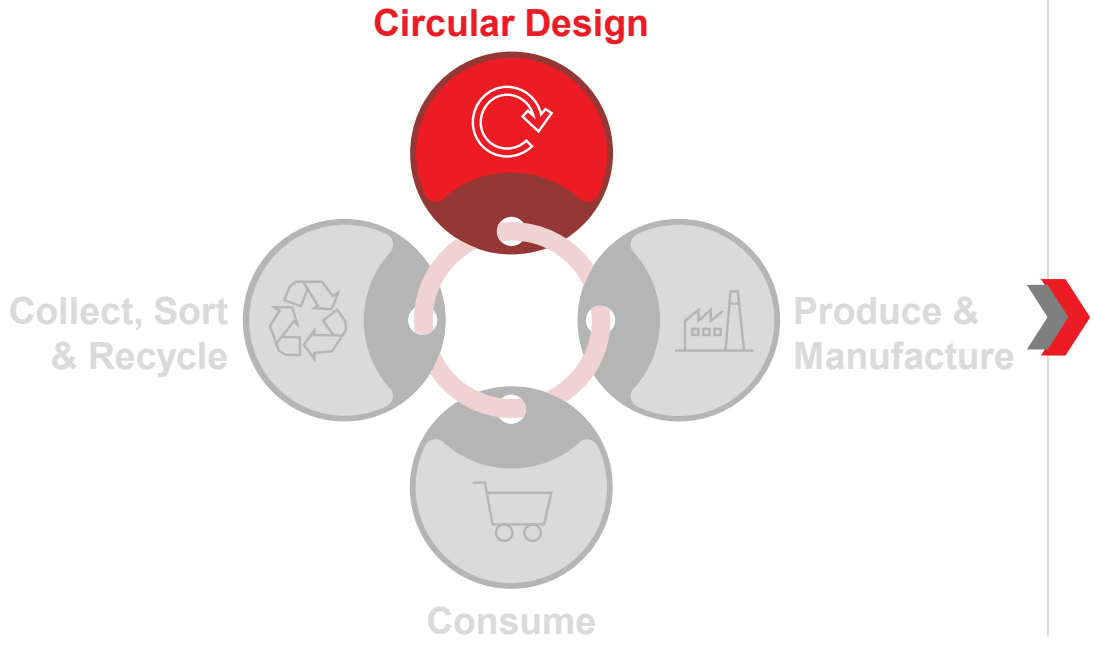
Key Success Factors



Circular Design



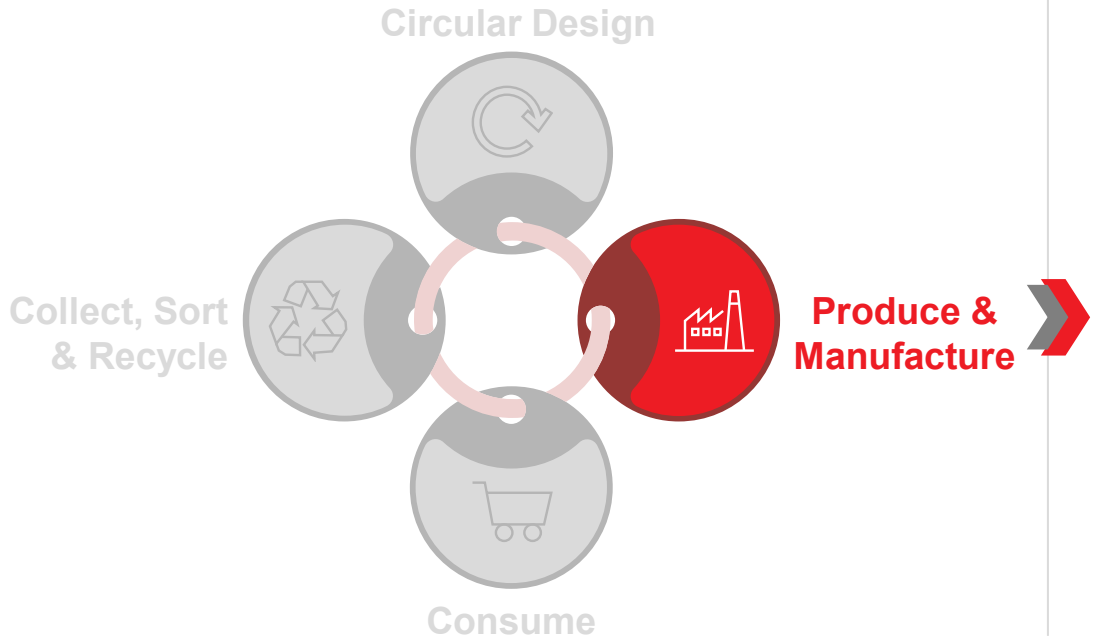
Increasing (harmonized) design for recycling guidelines

From multi-material to mono-material

Reduce unnecessary packaging

Inks, primers and OPVs have a key role in Circular Design: barrier, heat-stable inks, de-inking etc.

Produce & Manufacture



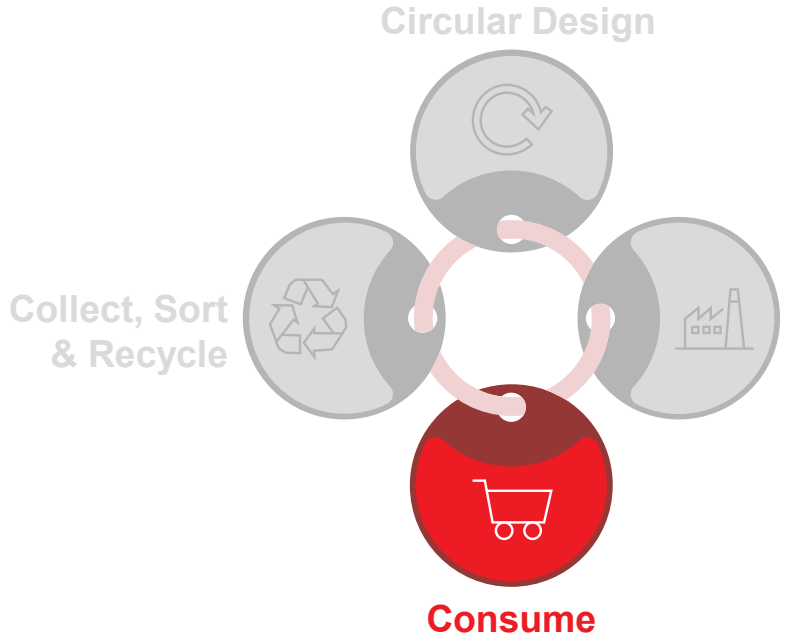
Increase the use of recycled material (food contact suitable)

Replacing fossil raw material with bio-renewable alternatives

Optimize production: reduction of waste

Investment in transition to monomaterial packaging structures

Consume

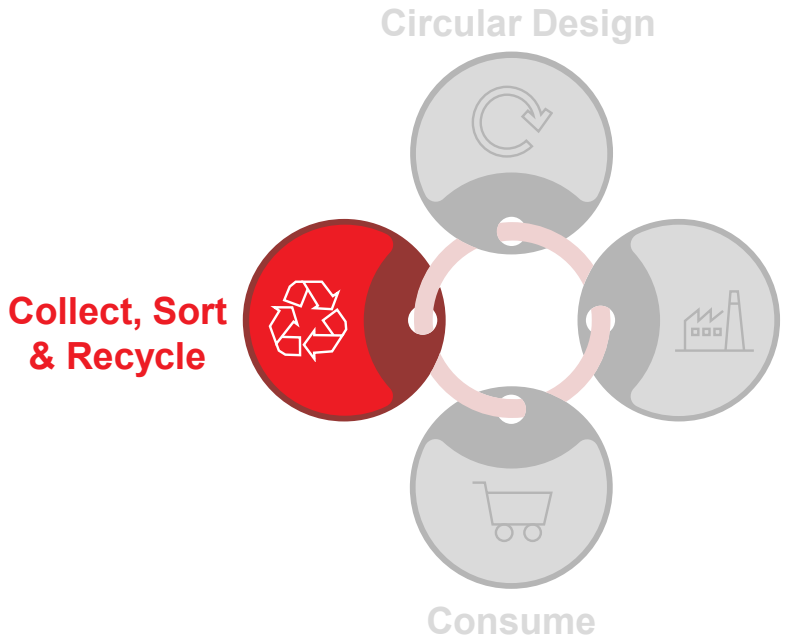


Consumers are paying more attention to the problem of plastic waste

Do not forget about reusable options

Goal: Consumer acceptance of recycled packaging

Collect, Sort & Recycle



Recycling conserves dwindling resources

Extended Producer Responsibility Laws

Recycling needs investments (e.g. de-inking, sorting technologies)

Support: Waste separation at household level

Circular Economy and Recycling – a fast moving topic

Activities on regulatory level

- Packaging and Packaging Waste Regulation
- CEN Working group - Design for recycling for plastic packaging products
- Global regulatory trends

Activities on Industry level

- CEFLEX
- RecyClass
- APR

Market movement

Thank you!

Q&A

Feedback welcome

www.WirSindFarbe.de