

Closing the loop for multilayer flexible packaging - barrier analysis

Final Report

ETH Zurich SusTec/sus.lab | December 31st, 2018



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Overview: Project report for the ClimateKic Project “Closing the loop for multi-layer flexible packaging – barrier analysis”

The challenge

- The EU uses 4 million (and growing) tons of flexible food packaging, where 80% are potentially “technically ready for recycling” with existing plastic streams according to the CEFLEX consortium
- Today, flexible packaging is generally less recycled than other packaging

Goal of the project

- **Help the CEFLEX Consortium** on their 2025 goal of closing the loop for post-consumer flexible packaging across Europe
- Understand **barriers for recycling** to a level of detail where they can be resolved – based on interviews with recyclers and other relevant stakeholder across Europe
- Ultimately create a **success case for transformation of an entire value chain** and derive best practices as a much-needed blueprint for action, as plastics is one of the first industries with a value chain approach to de-carbonize and close material loops

Who we are

Project delivered by

ETH zürich
sus.lab@SusTec

In cooperation with



Funded by



Executive summary – The challenge and our approach

▪ *The challenge*

- The majority of plastics waste goes currently to landfills and incineration, almost 75% of plastics are landfilled or incinerated and less than 15% of plastics currently make their way into new products
- Public pressure is leading to policy action and ambitious industry commitments to improve the circularity of plastic packaging, e.g.,
 - o The EU recently decided on a ban on some single use items and 25% reduction for others – effective by 2025
 - o Industry has started committing to ambitious goals – e.g. 100% of packaging to be reusable, recyclable or compostable by 2025
 - o Consortia are forming to search for solutions across value chains – like CEFLEX, with a mission to further enhance the performance of flexible packaging in the circular economy by designing and advancing better system solutions identified through the collaboration of companies representing the entire value chain
- In 2018, the EU set a target of 55% recycling by 2025 – meaning a dramatically increased share of recycled content also for packaging, this would require significantly increased use of recycled content, estimated at almost 50% for PET and ~30% for PE, PP
- To reach the 55% target, sorting capacity will need to increase by a factor of 2.6, recycling by almost a factor of five
- EU recycling targets are very ambitious for some member states less so for others
- Especially for flexible packaging, in many countries recycling is not yet taking place – Germany and Netherlands appear to be furthest on the journey

▪ *The goal of our project*

- Help the CEFLEX Consortium on their mission to further enhance the performance of flexible packaging in the circular economy by designing and advancing better system solutions identified through the collaboration of companies representing the entire value chain.
- Understand barriers for recycling to a level of detail where they can be resolved – based on interviews with recyclers and other relevant stakeholders across Europe
- Ultimately create a success case for transformation of an entire value chain and derive best practices as a much-needed blueprint for action, as plastics is one of the first industries with a value chain approach to de-carbonize and close material loops

▪ *Our approach*

- We interviewed ~30 stakeholders along the value chain, both from within the CEFLEX consortium and external experts
- To crystallize the most relevant barriers and derive first recommendations, we combined observations on the value chain, barriers and contested issues

Executive summary – General observations and observed barriers

■ *General observations on the dynamics in the value chain*

- Circular Economy is a fast emerging topic that will come with substantial changes for the entire value chain
- The speed of change, mostly driven by public debate and (planned) policy interventions, has not been foreseen by all players alike
- The change needed to address the current obstacles to Circular Economy will only be achieved by collaboration along the value chain
- Food packaging is an important application for packaging but no clear solution for the current linear system does exist as of now
- Regulation has to play an important role to set up markets and to spur innovation

■ *Observed barriers*

- Main barriers to scale up of recycling infrastructure are economic and technical, with „uncertainty on the path forward“ as an important „Meta-Barrier“
- One important „Meta-Barrier“ is the uncertainty about the future of the value chain – meaning uncertainty beyond normal business risk. This is preventing actors from moving decisively on strategy and investments. Change has to come to the entire value chain; incremental and unconnected change on separate value chain steps will not be sufficient to reach the overarching goals. In addition, the required change is very fast – technology will need to be developed and deployed in an uncertain policy environment. This uncertainty can (and needs to be) broken down into concrete issues – see “contested issues”
- Economics face temporary hurdles, as well as structural disadvantages
 - o Competition with virgin is structurally skewed: virgin plastics benefit from mature technology and marginal cost, and externalities that are not priced in - recycling technology is still immature, and investments are a barrier
 - o Industry structure in key steps of the value chain is fragmented and not well placed to take risks and move quickly
- Key technology is not yet ready – especially food packaging is an unsolved issue.
 - o Recyclate quality is still lower than virgin materials (e.g., material mixes, contamination with additives, multi-layer mixed materials)
 - o The market for low quality materials is small, esp. food grade packaging requires virgin material except for PET bottles
 - o Alternatives are not ready yet (e.g., chemical recycling is still at early stage, alternatives to plastics like paper may have a higher environmental impact and biodegradable materials lack scale)

Executive summary – Contested issues, the role of regulation and first view on the solution space

▪ *Contested issues and underlying assumptions*

- As discussed, “uncertainty” about the future of the value chain is one of the main barriers for moving forward
- Specifically, we identified 6 contested issues – arising from different assumptions about trends and drivers (e.g., how quickly technology will become available)
- Making these different assumptions explicit in a workshop allowed to understand where more factual information would be required, and provides the basis for alignment within the consortium
- The discussion confirmed the need for new technology, especially chemical recycling, the need for strong policy to create the market, the very limited role of bio-degradable plastics, and the need for brand owners in unlocking the market to create demand

▪ *Sketch of solution space*

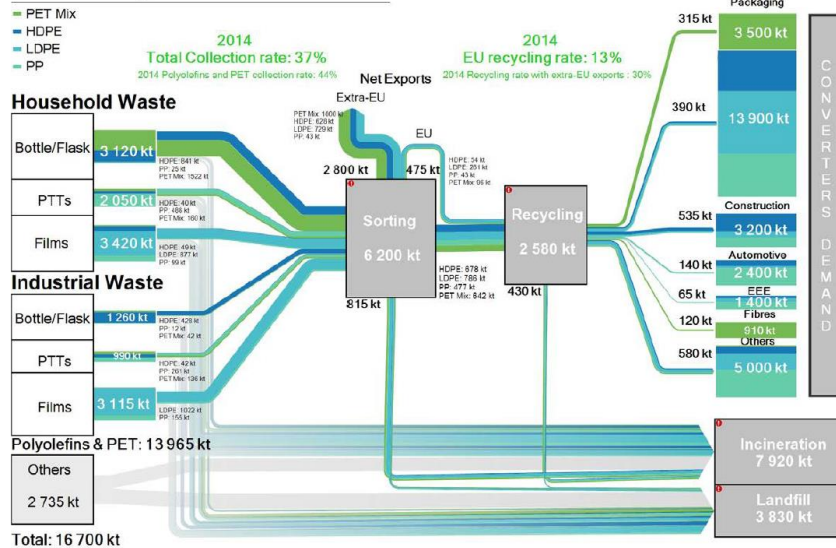
- At a system level, barriers are related to uncertainty as well as economic, technical, regulatory and social issues – a first view on recommendations for each of these barriers are provided
- Consistent and coherent policies will be key to overcome a multitude of barriers
 - Regulation has set ambitious targets that have been accepted by industry although not all of them being truly circular
 - Building functioning markets that can fulfil those targets in an economically efficient way will be a challenging task
 - Inconsistent and geographically fragmented policies could become a key barrier – increasing system cost and putting the targets at risk
 - There are also some societal/consumer challenges that policy and public education can address to reduce system cost, e.g., around willingness to sort, but also convenience of separating waste

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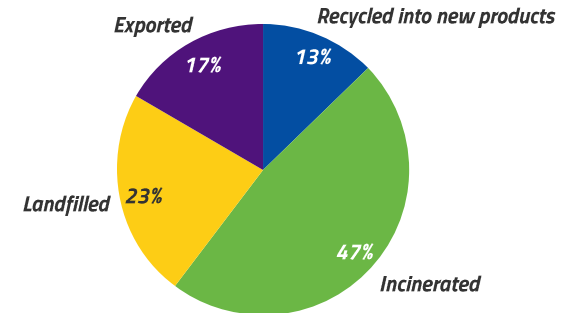
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The majority of plastics waste goes currently to landfills and incineration

2014 Europe Plastics Streams



- Almost 75% of plastics are landfilled or incinerated
- Less than 15% of plastics currently make their way into new products



Public pressure is leading to policy action and ambitious industry commitments to improve the circularity of plastic packaging

The EU recently decided on a **ban of some single use items** and a **25% reduction** for others – effective by 2025



Industry has started committing to ambitious goals – e.g. **100%** of packaging to be **reusable, recyclable or compostable by 2025**



Consortia are forming to search for solutions across value chains – like CEFLEX

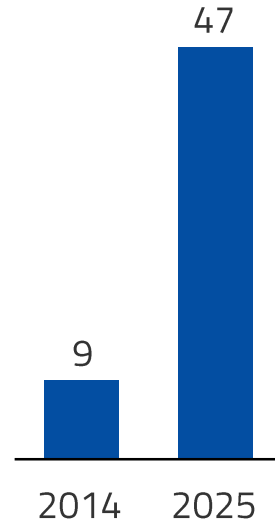


Mission is to further enhance the performance of flexible packaging in the circular economy by designing and advancing better system solutions identified through the collaboration of companies representing the entire value chain

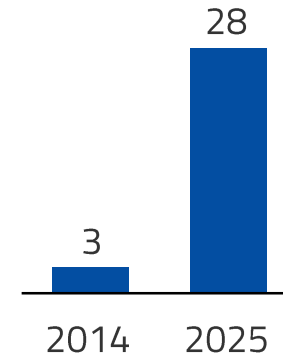
In 2018, the EU set a target of 55% recycling by 2025 - meaning a drastically increased share of recycled content also for packaging

- *Until 2025, the EU wants to increase the recycling target to 55%*
- *This would require significantly increased used of recycled content, estimated at almost 50% for PET and ~30% for PE, PP*

Recycled content of PET packaging
Percent



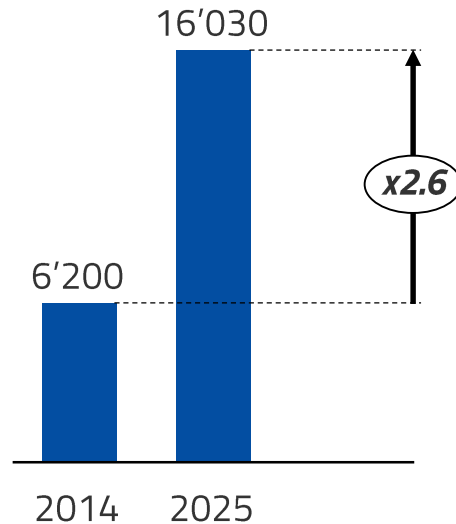
Recycling content of PP, PE packaging, Percent



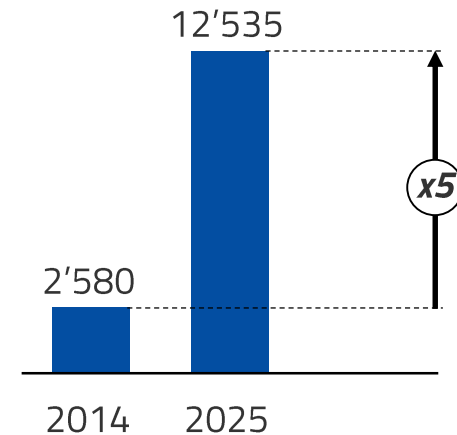
To reach the 55% target by 2025, sorting capacity will need to increase by a factor of 2.6, recycling by almost a factor of five

- *Until 2025, the EU wants to increase the recycling target to 55%*
- *Based on this, required increases in sorting capacity by a factor of 2.6 and recycling by almost a factor 5 were estimated*

Sorting capacity Europe¹
ktons



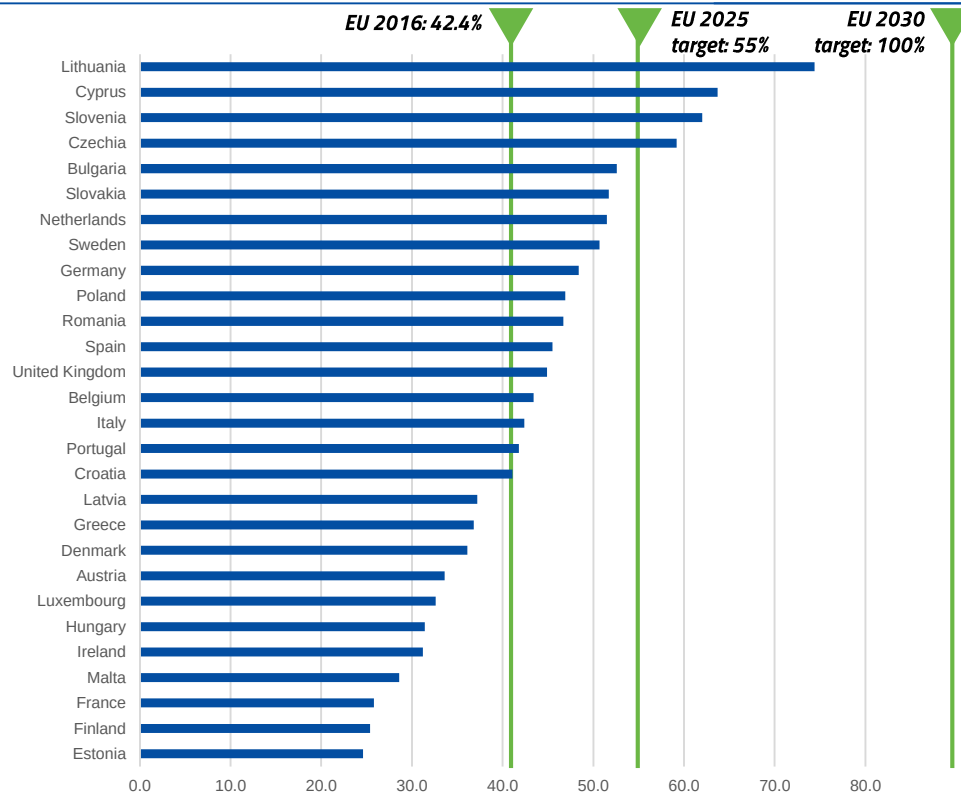
Recycling capacity Europe¹
ktons



¹ Without exports

EU recycling targets are very ambitious for some member states less so for others

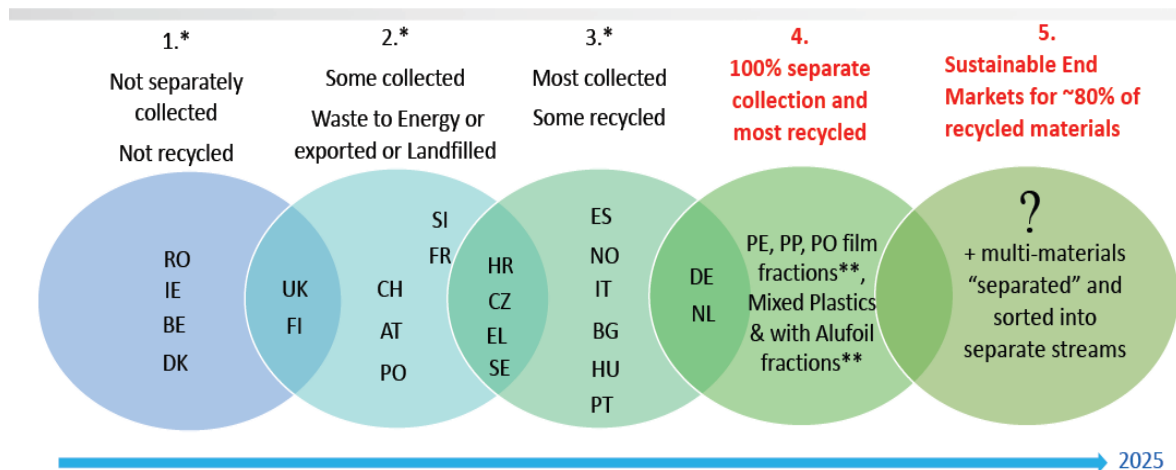
Plastic packaging collection rates in the EU (%) 2016



- The EU target is based on the new harmonized definition (2015), and only including waste that is sent into a final recycling process
- Although the numbers shown should reflect output sorting, the numbers reflect at least collection rates at this point
- Experts expect that if it was possible to measure municipal waste recycling rates in the way suggested– solely by reference to the weight of material entering the final recycling process – then some Member States' reported recycling rates would be up to 20% lower than they are now

Especially for flexible packaging, in many countries recycling is not yet taking place – Germany and Netherlands appear to be furthest on the journey

EU FP EOL Landscape & CEFLEX Ambition



* Need to further validate country practices with EXPRA ** Actual fractions still to be confirmed in W3

8 Source: FPE member survey (2015 based on 2014 practice – partially updated 2016)

www.CEFLEX.eu

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We interviewed ~30 stakeholders along the value chain, both from within the CEFLEX consortium and external experts

Company type		CEFLEX experts	External experts
Flexible packaging value chain	Raw material suppliers	   	
	Converters	   	
	Brand Owners	  	 
	Collectors & Sorters		
	Recyclers	    	
Stakeholder	Industry organizations	  	
	NGOs	n/a	  
	Policy	n/a	 
	Academia	n/a	 

To crystallize the most relevant barriers and derive first recommendations, we combined observations on the value chain, barriers and contested issues

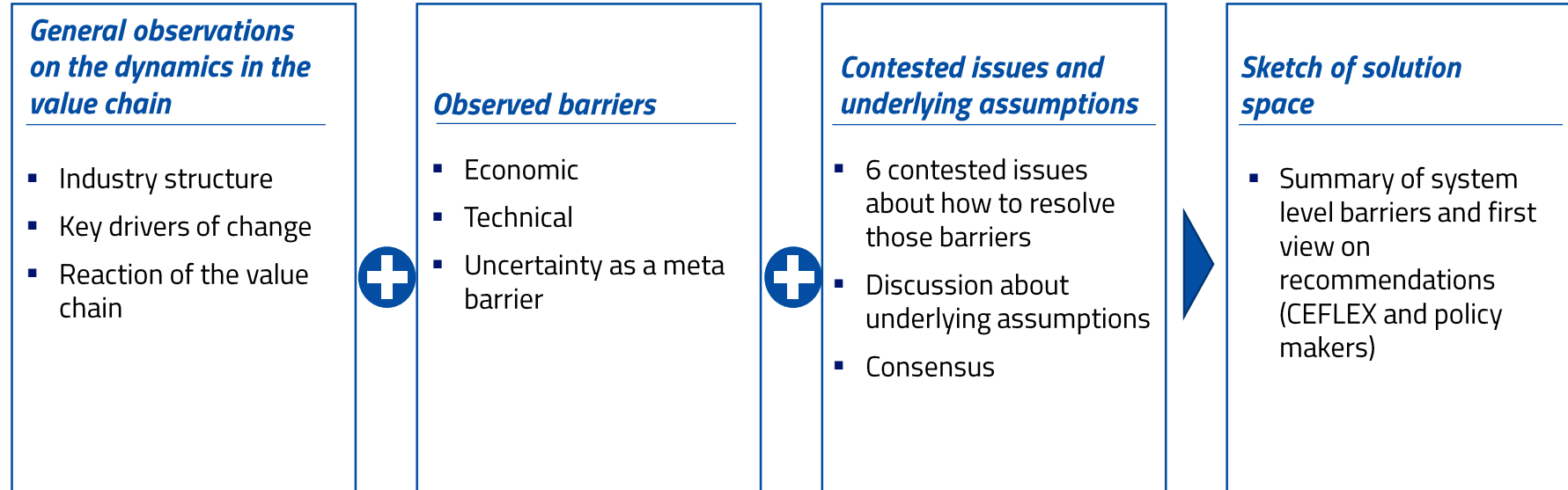


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Observations¹ on the dynamics of the value chain – 1/2

- ***New regulation as envisioned by the EU will require massive scale up of capacity on a number of value chain steps of the packaging industry within a short timeframe***
- Most players have been surprised by the speed of change that did not seem likely for many only two years ago
- As a result, the topic of Circular Economy has become attention from top management as a strategic issue
- ***Food packaging was identified as crucial to solve for a step change in recycling rates***
 - Recycling food contaminated plastics does not seem to be economically viable with existing infrastructure and technique
 - How to widely use recyclate in food packaging is unclear (except for PET and HDPE) given strict food safety legislation which is ranked highest priority by all interview partners
 - Not much scope is seen for replacement materials, especially multilayer, flexible packaging, as optimizing shelf life is seldomly up for discussion
 - Positive environmental impact of alternative materials or mono-materials is questioned
- ***No immediate solutions for food packaging are on the horizon, but the issue has started to drive innovation***
 - Many innovations have been available for > 10 years and are under testing now
 - More innovations are expected to become viable in the near future
 - There will be a market for bio-based materials
 - Big push for further technical advancements across the value chain is needed and players seem willing to engage in respective collaborations

Observations on the dynamics of the value chain – 2/2

Detailed in the following

- ***The need for finding solutions along the entire value chain sparked cross value chain collaboration***
 - Partnerships are being formed, especially with the involvement of recyclers (e.g., APK and MOL Group)
 - Acquisitions are taking place (e.g., Borealis acquiring mtm and Ecoplast; Remondis acquiring DSD), a development which is closely followed by the whole value chain
 - Consortia are forming, proactively addressing public and regulatory demands and trying to work on technical solutions which go beyond incremental innovation on a single value chain step (e.g., CEFLEX)
- ***The value chain is already starting to change: It will be increasingly important to secure access to existing material in use***
 - Specifically the role of recyclers is changing from end-of life to input; they are repositioned as raw material producers
 - Various other players are picking up recycler's activities (retailers, e.g. Schwarz Group, potentially chemical industry, e.g., Borealis)
 - There is a power shift from brand owners towards retailers as the latter have a) easier access to post-consumer waste (through return schemes) and b) direct exposure to customer pressure requiring them to act in order to protect their own brands
 - Most exposed to risk of bans of individual polymers are converters
- ***Role of regulator is contested in details of policy design but it is common understanding that closing the loop for flexible packaging will not happen without intervention on the institutional level***

Brand owners currently hold most of the market power but recycling businesses are likely to gain power in circular systems

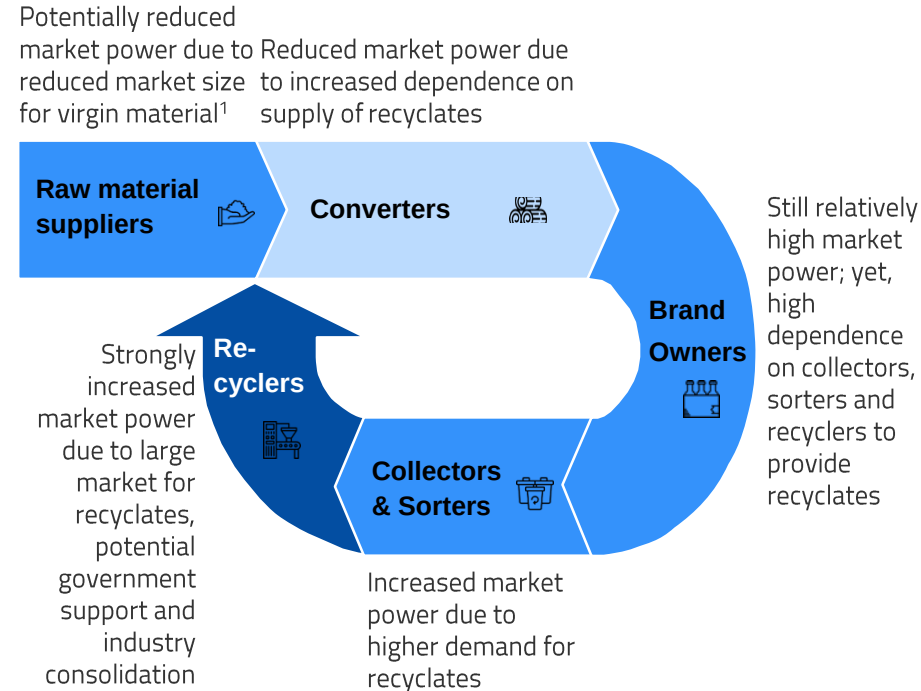
Market power:

Low power High power

Distribution of market power in a LINEAR value chain



Distribution of market power in a CIRCULAR value chain



The expected shift of market power is reflected in trends towards a vertical integration and horizontal consolidation of recycling businesses

Vertical integration

In the last 2-3 years, brand-owners and companies outside the industry are investing in capacity expansion within the disposal and recycling chain

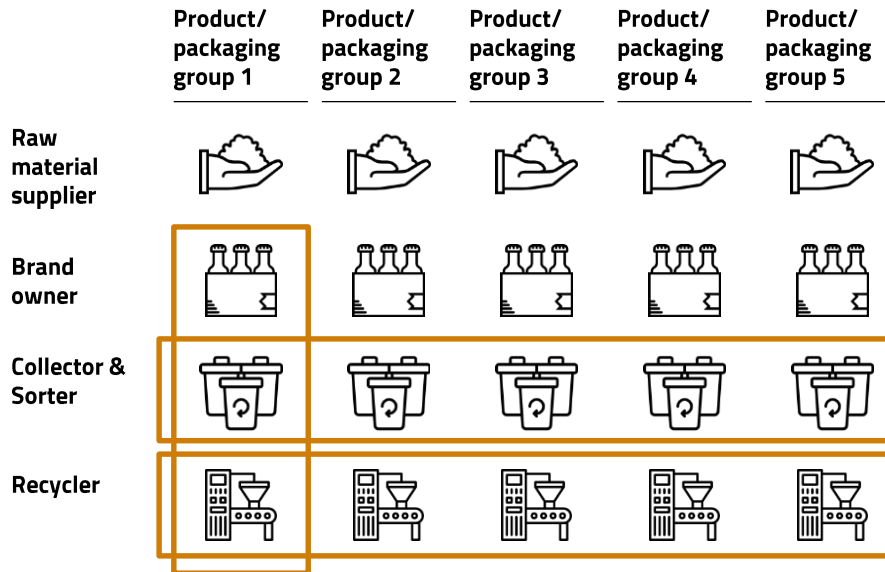
LIDL MOTHER IS NOW ALSO IN WASTE ECONOMICS

Business, germany

Facebook Twitter Google+ LinkedIn Pinterest



Movement in the waste market: the parent company of the discount chain Lidl and the supermarket chain Kaufland was the first trading company to set up its own dual system.



Horizontal consolidation

The collection and recycling industry experiences a consolidation of market actors in recent years

The deal is done: Remondis purchases Germany's "Green Dot" system

27.09.2018 – Shortly before 2:30 on Thursday morning, Remondis and the owners of Der Grüne Punkt (the Green Dot) took the plunge. After months of speculation and protracted negotiations, a contract was signed covering the sale of 100 per cent of Duales System Deutschland Holding GmbH & Co. KG (DSD) to Germany's largest waste management company. Remondis confirmed the contract signing to EUWID.



Remondis acquires D.

In addition, collaboration platforms are being established (e.g., CEFLEX) to increase collaboration across the value chain

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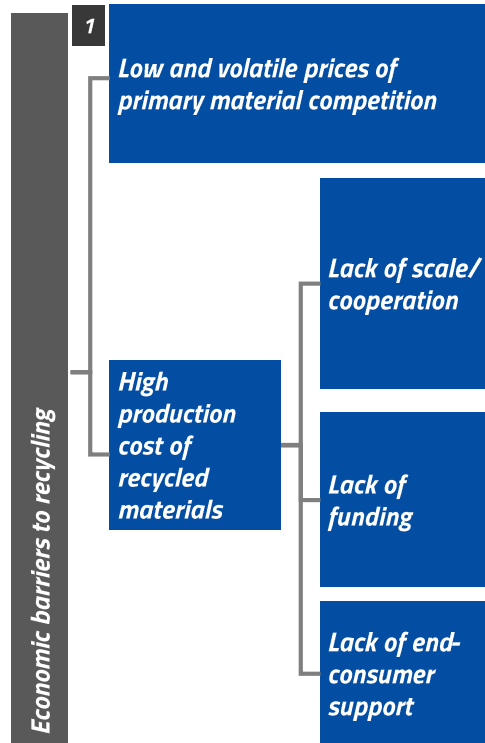
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Summary: Main barriers are economic and technical, with “uncertainty on the path forward” as an important “Meta-Barrier”

- We initially looked at barriers across 4 categories – policy, economic, technical and social
- In the following, we will **focus on economic and technical barriers**, as they are both the basis for policy and social interventions as well as influenced by policy
- One important **„Meta-Barrier“ is the uncertainty about the future of the value chain** – meaning uncertainty beyond normal business risk – preventing actors from moving decisively on strategy and investments:
 - **Scope:** change has to come to the entire value chain; incremental and unconnected change on separate value chain steps will not be sufficient to reach the overarching goals
 - **Time:** The required change is very fast – technology will need to be developed and deployed in an uncertain policy environment
- **Uncertainty can be crystallized to “contested issues”- see next chapter**
- **Finding a common view** – as a first step within the consortium – will therefore, be a key step to unleash suitable strategies and investment
- **Regulation plays a decisive role and can reduce the uncertainty** by providing clear goals and help in the set-up of new markets

Economic barriers are mainly related to low and volatile prices for primary material competition and high costs for recyclates

Identified barriers



Description

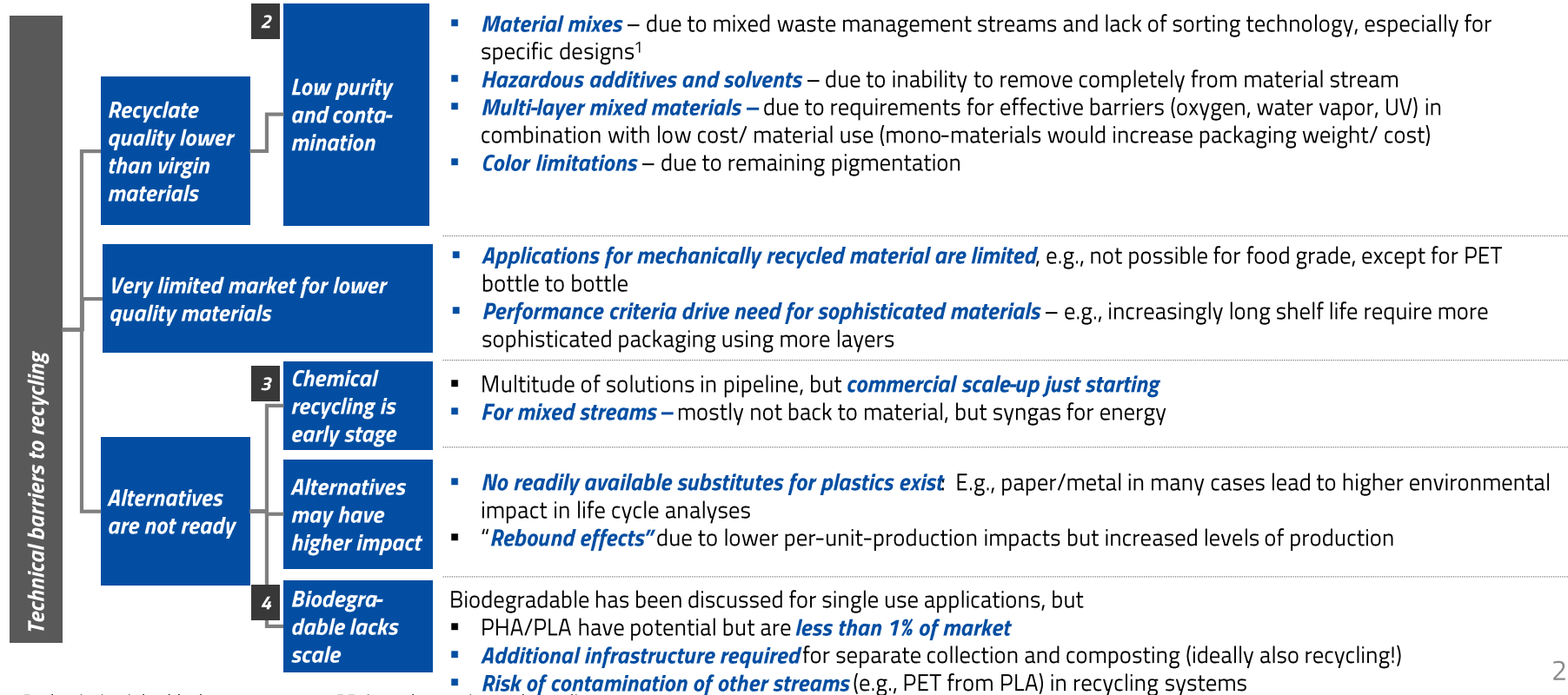
- **Low operating costs for primary plastics production** – due to economies of scale, low raw material prices, mature/ written off technology
 - **Market price of recyclate coupled to virgin price volatilities**
-
- **Lack of economies of scale** – due to trade offs between logistics costs of concentrating waste along with market fragmentation of sorters and recyclers vs efficiency of larger recycling plants and high investment requirements for e.g., chemical recycling processes
 - **Lack of waste stream access/ skills** at polymer producers
 - **Lack of cooperation across actors** – due to fear of losing competitive knowledge advantage: Lack of protectable IP leads to a partly “secretive” environment
-
- **Unwillingness to invest in new technologies** – due to lock-ins from previous infrastructure investments
 - **Lack of financial R&D support** – due lack of awareness of existing subsidies, cumbersome application processes and/ or exclusion of sorters¹
-
- **Lack of consumer cooperation** – inaccurate pre-sorting due to lack of information/rising complexity
 - **Fear of potential competitive disadvantage from higher price for recycled packaging** – due high price sensitivity especially in food retailing

¹ Due to classification as service providers

Technical barriers lead to low quality of recyclate with a limited market and a lack of alternatives to virgin materials

Identified barriers

Description

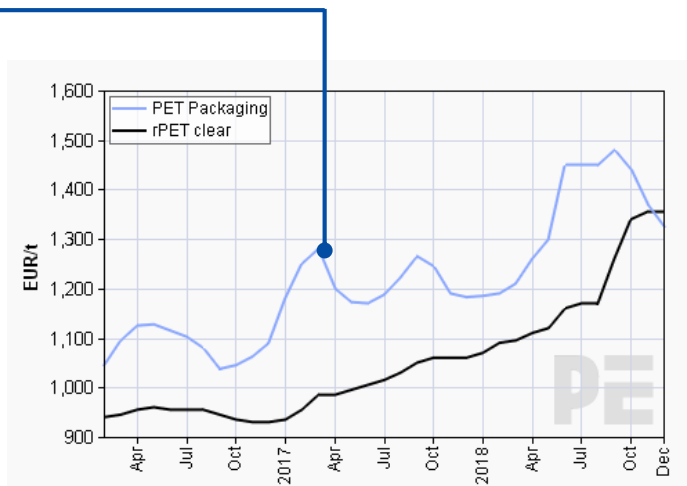


¹ Dark printing inks, black post-consumer PP impedes sorting and recycling

1 Secondary plastics are more expensive to apply than virgin materials

Prices for recycled materials can be below virgin, but recycled materials are not suitable for many applications and require virgin materials to meet purity standards

Price of virgin PET overall higher than price of clear rPET



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However, *de facto virgin material is often cheaper* - recyclate can only be reused for lower grade products and often requires adding virgin material

Lack of economies of scale as currently only small quantities of certain types of plastic (per polymer type) available for recycling

Lack of cooperation across value chain including industry, plastics converters, public and private waste management companies

Lack of funding for new technologies to reduce losses and inefficiencies in the recycling process

Lack of end-customer support to ensure quality inputs to the recycling industry via separate collection of plastic waste

Lower virgin prices driven by plummeting raw material prices and increased competition

Category	Sorting technology examples	Key barriers	Avg. purity
<i>Manual sorting</i>	Positive / negative (removing non-target material) sorting	Time and cost inefficient	>95%
<i>Shredding/sieving</i>	Drum screen separation (smaller items fall through)	First process step only	>95%
<i>Air / liquid density separation</i>	Sink-float separation (often in water)	First process step only	>95%
<i>Magnetic separation¹</i>	Eddy current (using counter-rotating magnetic field)	Not effective for all metal types	85-90%
<i>Spectrophotometric sorting</i>	- Near-infra red (NIR) - X-ray - Hyper-spectral imaging (HIS)	NIR cannot identify black polymers, research ongoing	80-90%

- While the purity can be higher than 95% for some plastics, **overall purity remains below what is often required**
- Sorting plants often **apply several of these technologies** for optimum cost-effective output
- Today's pre-treatment and sorting operations can **process more than 100,000 t/yr of plastics waste**

¹ To sort out magnetic iron and non-ferrous metals

- *Current penetration rate of recyclates in flexible packaging between 2-10%*
- *Chemical recycling needed to increase the use of recyclates*

Chemical recycling potential

- ***Environmental impact***: worse than mechanical recycling, expected to be significantly better than incineration*
- ***Applicability***: Applicable to heterogenous/ mixed plastics streams with pre-treatment
- ***High quality outcome***: Potential to increase supply of food grade plastics on the market

What is required to make it work

- ***Technological advances***: Need for scalable technological solutions that reduce operational cost and allow for appropriate recyclate quality
- ***New collaborations*** between the likely technology providers and investors (chemical industry) and waste stream owners
- ***Long term economic incentives to allow for successful competition with virgin***, e.g., carbon emission prices, e.g., recycling targets
- ***Further push for “clean waste streams”*** – economics still strongly driven by purity of streams

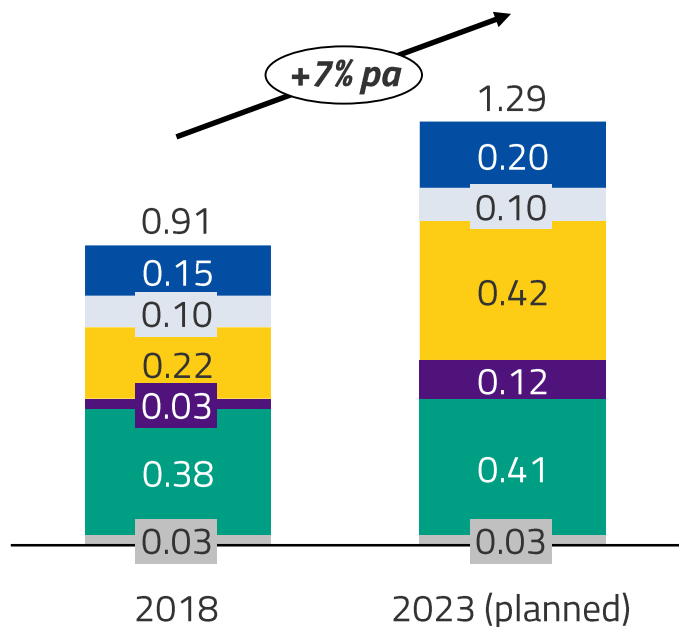
*Mechanical recycling saves 2.3 tons CO₂ per ton of waste, incineration emits 1.6 tons of CO₂ per ton of waste, pyrolysis ranges from -0.2 to -0.8 tons of savings

Source: Verkenning chemische recycling Hoe groot zijn - en worden - de kansen voor klimaatbeleid? – TU Delft

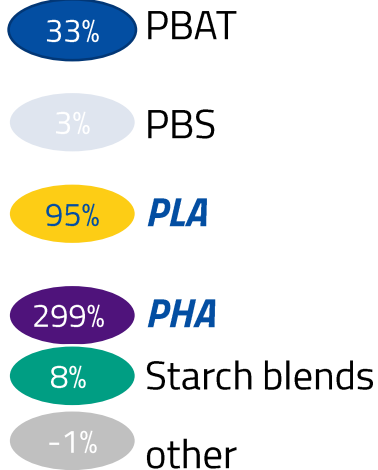
Bio-degradable* capacity is growing with a rate of 7% p.a., driven by PLA and PHA; however, the market is still small at ~0.2% of polymers

Global production capacity bio-degradable polymers, current and planned

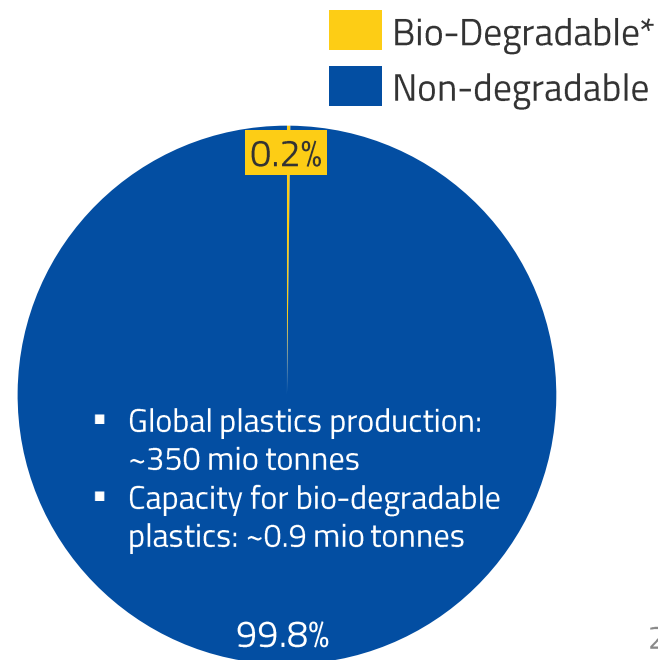
2018 vs 2023, Mtons



Growth until 2025



Share in global plastics market, 2018



4 There are several applications where bio-degradable/compostable* materials are discussed as a solution



- **Where separation of organic waste is difficult** – e.g., single use coffee capsules, food containers



Waitrose trial of paper based containers

- **Enabling use and recycling of paper in single use food containers** – e.g., as liners for single use coffee cups or food trays



- **Where entry into environment is very likely** – e.g., mulching film, small scale items and packaging in agricultural applications

Especially for food packaging – including flexible – the market appears to be evolving into the direction of **paper plus liner**, for either composting or recycling in the paper chain

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Contested issues form part of the “uncertainty” barrier – we identified 6 issues and played back for alignment in the consortium

- As discussed, *“uncertainty” about the future of the value chain is one of the main barriers* for moving forward
- We synthesized **6 contested issues** from interviews with CEFLEX stakeholders as well as based on other research and additional conversations outside CEFLEX
- Contested *issues typically arise from different assumptions about trends and drivers* (e.g., how quickly technology will become available)
- These issues were played back to *selected stakeholders in a workshop*, with the goal to
 - make these different assumptions explicit
 - discuss the assumptions and understand where more factual information would be required
 - align on a set of assumptions so that solutions can be designed

The discussion of contested issues confirmed a new trend to vertical integration and the need for chemical recycling

Contested issues

1

The value chain integration: Is vertical or horizontal integration most effective in fostering innovation?

2

The future of chemical recycling: Chemical recycling is discussed as a technology to allow for a significant increase in recycling. Will chemical recycling (CR) be a game changer to recycling of flexible packaging?

3

The bio-plastic confusion: “Bio-degradable” plastics have emerged in recent years as an alternative. Is bio-degradable plastic a solution or a distraction for the circular economy in Europe?

*Synthesis of discussion in first workshops**

Horizontal consolidation has always been common place in the industry – recently it seems that vertical integration is starting

Confirmed that chemical recycling will be needed, but economics are challenging, partly due to scale

Bio-degradable materials will remain niche, even though there is a strong pull in some markets

* Results reflect the discussion with workshop participants, a broader discussion in the CEFLEX Consortium will be key

Strong policies will be needed to create the market, and brand owners are key in unlocking demand

Contested issues

4 **The “push” and “pull” policy approach:** Tech-push instruments support R&D while demand-pull instruments create markets and accelerate deployment. Which policy mix is appropriate for the circular transformation?

5 **The ambitions of EU targets:** The EU sets ambitions targets to push circularity in the packaging industry, but are the EU targets too ambitious or can circular economy be effectively scaled on an EU level?

6 **The role of brand owners:** Brand owners hold most of the market power, but do they have the will to drive the circular economy in plastic packaging?

Synthesis of discussion in workshops*

Strong policy intervention and regulation needed. Purely voluntary instruments won't be sufficient – Information will be key as well

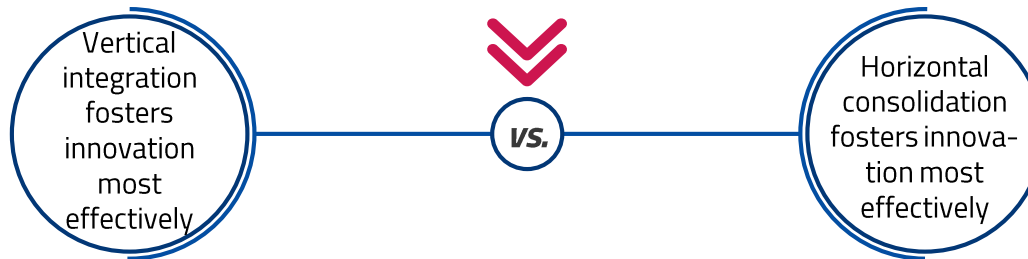
It is crucial to have ambitious targets; coordination at EU level is necessary

Brand owners are however key in unlocking demand and therefore allow for innovation across the chain

* Results reflect the discussion with workshop participants, a broader discussion in the CEFLEX Consortium will be key

Is vertical integration or horizontal consolidation of activities along the value chain most effective in fostering innovation?

Contested issue



What you need to assume

- Allows for a **strategic coordination of innovation** across the entire value chain (e.g., from packaging design to recycle production)
- **Fosters innovation through competition** as opposed to horizontal consolidation of value chain steps, which slow down innovative drive
- Allows for **specialization and economies of scale/agglomeration** (e.g., more innovation in process optimization)
- **Reduces the costs of innovation at system level** as vertical integration might result in “cherry picking” of individual players and hence, sub-optimal solutions (e.g., multiple parallel collection systems may result in a lack of critical mass)

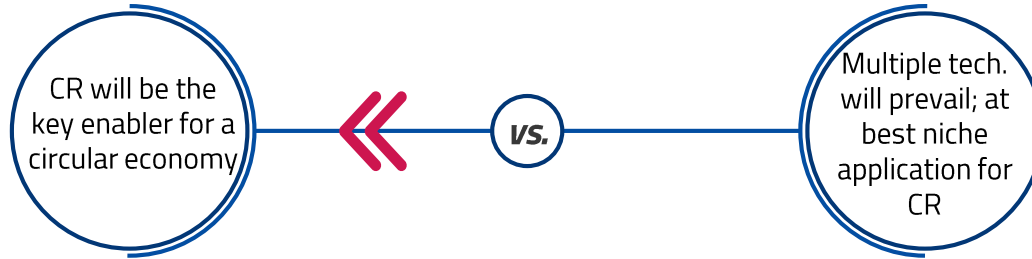
Result of the workshop

3 trends are emerging:

- **Horizontal consolidation** is common practice in the recycling industry. Integration between raw material/ polymer producers and recyclers (as for paper, aluminum) still lacking for plastics
- **Vertical integration**: High interest in the case of external players integrating vertically in the waste management value chain. The relevant question is whether other actors will follow this mode
- **Collaboration**: New model exemplified by CEFLEX - Companies tend towards cooperative approaches, beyond traditional vertical and horizontal models

Will chemical recycling (CR) be a game changer to recycling of flexible packaging?

Contested issue



What you need to assume

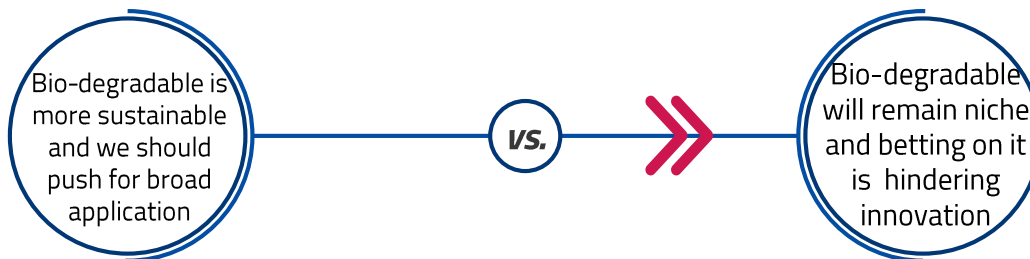
- Potential for **significant CO2 reduction** per ton of plastic produced
- Potential to **transform heterogeneous and contaminated/ mixed materials into high-quality** end product
- **Economics of the process will improve** significantly as the technology advances
- The future to eco-friendly flexible packaging will lie in a **diversified tech portfolio** (e.g., bio-degradable plastics, advanced mechanical recycling)
- The **potential of scalable CR still unclear**
- It is **unlikely that the economics of CR will significantly improve** over time

Result of the workshop

- Workshop participants agreed that chemical recycling has a big potential beyond the traditional complementary role
- Challenge of economics, especially economics of scale
- EPR and similar tools could be implemented and extended to manage the investment risk

Is bio-degradable* plastic a solution or a distraction for the circular economy in Europe?

Contested issue



What you need to assume

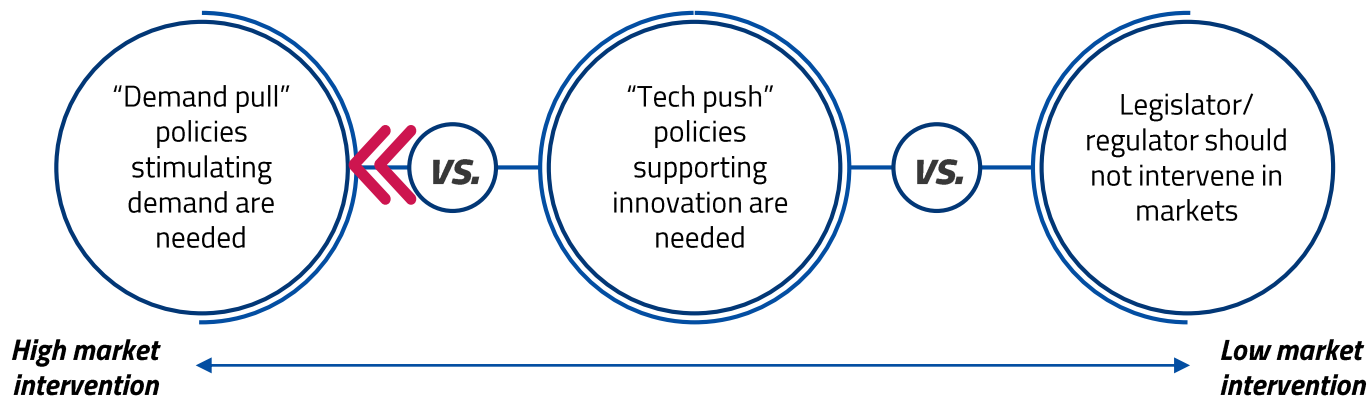
- ***We will never capture all waste***, even in Europe, so real bio-degradability is important
- With more R&D we will have ***materials that safely degrade in soil and marine environment and are widely applicable***
- Bio-degradable is ***no contradiction to recycling*** – PLA and PHA might be well recyclable - in sum this makes it the better option
- ***Bio-degradables can be enablers*** like organic waste collection and replacement of plastics with paper
- ***Materials suitable for mainstream packaging do not solve leakage into the environment***, as they do not degrade in soil or marine environment*
- Large scale recycling of traditional plastics is technically feasible and lower life cycle impact than bio-degradation
- ***Bio-degradables streams will remain too small for collection/recycling investment*** for at least the next decade
- ***Materials confuse customers***, creating contamination in organic streams

Result of the workshop

- Rise of bio-degradability pushed by high marketing appeal, strongly supported by the “outside world”
- However, workshop participants tend to agree that bio-degradable applications will remain niche applications

Which policy design/ degree of market intervention is appropriate for the circular transformation?

Contested issue



What you need to assume

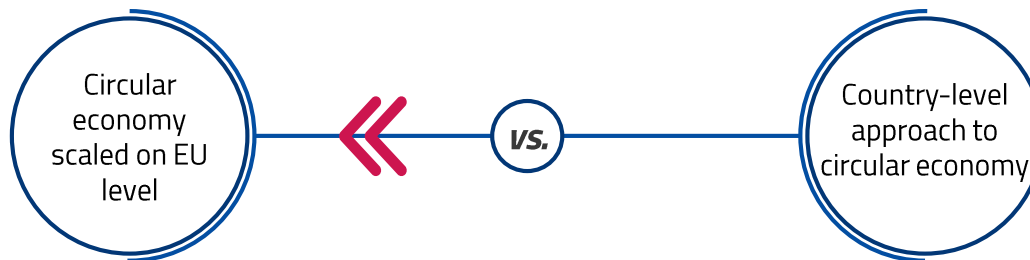
- **Quality cannot be easily brought to virgin levels**, hence market needs to be forced to adapt
- **Recylate is financially not competitive**, hence financial support is needed for deployment
- **Innovation of materials and recycling processes are the main barrier** to a circular plastic packaging value chain
- Drive supply of material, **increase economies of scale**
- Policy intervention is often based on **incomplete data and misleading assumptions**
- Wrong incentives or restraints bear the **risk of lock-in into mature technologies**

Result of the workshop

- Strong policy intervention and regulation needed. Purely voluntary instruments won't be sufficient.
- However, the common goal to be achieved must be well set, understood and agreed on by all stakeholders which currently is not the case

5 Are the EU targets too ambitious or can circular economy be effectively scaled on an EU level?

Contested issue



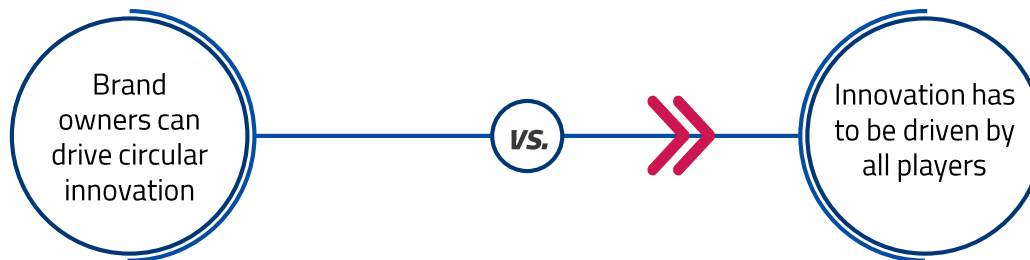
What you need to assume

- **Market needs to be scaled-up** to reach critical mass
- **Create equal competition** between countries and companies by implementing consistent standards
- **EU-wide approach is asking too much too soon** as it involves an economic cost that companies cannot afford
- **Difficult measurement** of progress as assessment measures for recycling not synchronized

Result of the workshop

- It is crucial to have ambitious targets; coordination at EU level is necessary

Contested issue



What you need to assume

- Brand owners have most of the **market power**
- Brand owner are the key decision makers and **"dictate" the specs of packaging materials**
- **Innovation should be driven by brand owners**
- **Regulation and customer's willingness to pay are key** barriers to recycling innovation
- **Brand owners depend on other players** (except for product design)
- **Burden of innovation should be distributed** across the value chain

Result of the workshop

- Brand owners or consumers alone will not bear the costs. They must be transparently integrated across the value chain
- Brand owners are however key in unlocking demand and therefore allow for innovation across the chain

Table of contents

- Overview and executive summary (p. 3)
- The challenge (p. 8)
- Our approach (p. 15)
- General observations on the dynamics in the value chain (p. 18)
- Observed barriers (p. 23)
- Contested issues and underlying assumptions (p. 32)
- ***Sketch of the solution space (p. 42)***

Summary of system level barriers and first view on recommendations (CEFLEX and policy makers) – 1/2

Barrier

» First view on recommendations

Uncertainty

- Uncertainty is a major barrier to decisive action required by the ambitious timescale

- Stakeholder alignment around issues will be key through: Identifying issues, clarifying the underlying assumptions, creating a fact base and aligning on a common view. CEFLEX might play a key role in this process
- Clear regulation will also be key

Economic

- Temporary hurdles: Competition with virgin is structurally skewed: virgin plastics benefit from mature technology and marginal cost
- Structural disadvantages: Externalities that are not priced in - recycling technology is still immature, and investments are a barrier
- Industry structure in key steps of the value chain is fragmented and not well placed to take risks and move quickly

- Policy support will be needed to allow overcoming the initial innovation investment barrier
- Policy might also be needed to ensure the long term viability of the market vs. virgin materials
- Brand owners will be key in unlocking demand
- Alignment in value chain is crucial together with a strong frame from policy to reduce uncertainty

Summary of system level barriers and first view on recommendations (CEFLEX and policy makers) – 2/2

Barrier

» First view on recommendations

Technical

- Technology is not yet ready – especially food packaging is an unsolved issue
- Future technologies will solve food packaging issue but might come with higher cost and life cycle impact than mechanical recycling

- To keep systems cost and environmental impact as low as possible, as much as possible material needs to be channeled towards mechanical recycling
- Increasing purity of incoming streams and improving sorting is very important
- Chemical recycling needs to be developed in parallel

Regulatory

- Inconsistent and geographically fragmented policies could become a key barrier – increasing system cost and putting the targets at risk

- Further research is required to analyse the extend of policy misalignment and the systemic inefficiencies created

Societal

- Consumers partly lack information or willingness to separate waste properly, but also e.g., accept less packaging and therefore convenience

- Inform and incentivize consumers – variation between countries indicates significant scope to share best practices
- Product bans might also be an option in some cases

Consistent and coherent policies will be key to overcome barriers

-  No major barriers identified
-  Potential for improvement
-  Is/ could become a significant barrier

- 
- Regulation has set ambitious targets that have been accepted by industry
 - Building functioning markets** that can fulfil those targets in an economically efficient way will be a challenging task
 - Inconsistent and geographically fragmented policies could become a key barrier** – increasing system cost and putting the targets at risk

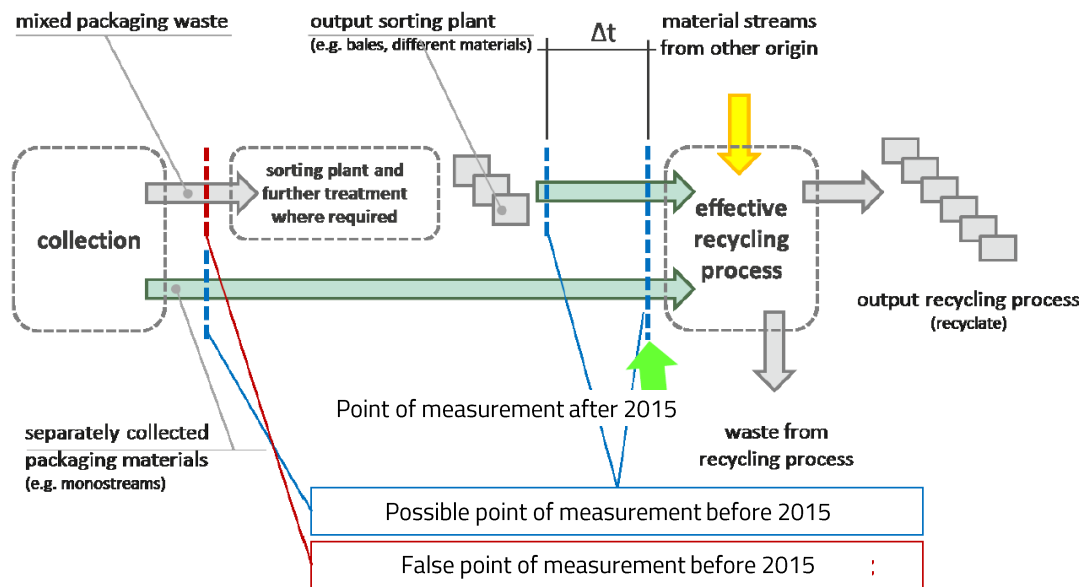
Role of the policy maker

Identified barriers

Set ambitious but realistic targets 	Targets appear ambitious (e.g., mismatch between requirements for food packaging and purity of recyclate) but stakeholders are confident they are reachable
Ensure clarity and coherence of definitions and terminology 	1 - Calculation methods for recycling rates differed by country in the past, the EU is now making an effort to harmonize - Ambiguous terminology of legislation, e.g., “Food containers” in EU Single-use plastics – unclear if it only concerns catering/ take-away, or also e.g., frozen food
Find balance between localization and fragmentation 	2 - Misalignment of national policy making and EU-level policy one of key barriers (see slide) - Fragmentation of EPR Schemes increases barrier to intra EU operations
Ensure side-effects and inter-dependencies are monitored and actively steered 	- Product bans (e.g., single use plastics) can result in higher impacts substitutes (paper bags, metal straws) - Revision of REACH legislation (2019) might increase number of restricted materials, which might lead to legacy material becoming waste in transition phase
Help overcome initial market development barriers 	Companies of the disposal industry (especially sorters) lack access to R&D funding (as they are classified as service providers and not as production industry)
Ensure long term economic feasibility and functioning markets 	TBD –too early

Calculation methods differed by country in the past, the EU is now making an effort to harmonize

Simplified waste management flow chart illustrating past possible points of measurement and **new harmonized measurement at entry of recycling process**



- **The EU passed the Revised Waste Framework Directive in Dec. 2015** (Part of the CE Package), to be transposed into country legislation
- **Goal was harmonization of measurement points.** „The revised legislative proposals on waste sets simplified and improved definitions and harmonised calculation methods for recycling rates throughout the EU”
- **The measurement point is now after sorting and includes all material that is sent towards a recycling process:** „The weight of the output of any sorting operation may be reported as the weight of the municipal waste recycled provided that such input waste is sent into a final recycling process”.

Misalignment of national and EU-level policy is a key barrier to promote the use of recyclates or bio-based plastics

Policy measures to increase the use of recyclate in flexible packaging are mostly designed on a national level...

Example: Ban of single use plastics vs. use of bio-based content



EU-wide ban of 10 single-use plastic products



Bio-based organic content requirement of >50% in compostable bags



Bio-based organic content requirement of >60% by 2021



Bio-based organic content requirement of >50% by 2020 and >60% by 2025



No ban on single-use plastics, but positive attitude towards compostable bags „if there are viable alternatives“



No specific regulation on single-use plastics in place or planned



... resulting in multiple system-level inefficiencies

- Confusion of all players along the value chain leading to inability of strategic planning
- Difficulties to collaborate across borders and across the value chain
- Lack of targeted infrastructure investments (e.g., recycling systems)
- Etc.

Further research is required to make appropriate recommendations for policy makers

- Further research is required to analyse the extend of policy misalignment and the systemic inefficiencies created
- SusTec at ETH Zurich will launch a project to analyze the existing policy landscape and draw conclusions this year (results will be shared with the CEFLEX consortium)

Policy makers can also have a role in increasing awareness and willingness of consumers to contribute in order to reduce system cost

Expectations on product shelf lives

- Requirements concerning **product shelf lives** in some cases are disproportionate from an ecological point of view (*Shelf life* is the recommended maximum time for which products can be stored. A more sophisticated packaging, using more layers, allows for longer shelf lives. Expectations on shelf life extension, e.g. by consumers, and sustainability aspects constitute a trade-off.)

Lack of awareness and willingness

- **Lack of awareness and willingness** to sort (e.g., due to habits or convenience)
 - Environmental awareness and habits differ considerably across different countries, regions, and socio-economic classes
 - Waste separation in particular is inconsistent between countries, and even municipalities which hampers the development of a correct and uniform waste separation behavior of consumers

Confusion of consumers

- **Confusion of consumers** due to inappropriate information on packaging (e.g., "bio-plastics")
 - Consumers are confused by inconsistent information on products concerning separation
 - For example, the label "bio-plastics" does not automatically imply fit for bio-degradability and composting

Appendix

About the authors



Dr. Catharina Bening – Member of the Steering committee and affiliated researcher

Catharina is a postdoc in the Group for Sustainability and Technology working on sustainable innovations and the role of firms and institutions. Her current research focuses on the sustainable circular economy and she is co-leading the NFP 73 project “TACLE”.



Dr. Petrissa Eckle – Executive director of sus.lab

Petrissa's deep passion for building a more sustainable future led her from a PhD in Physics to a PostDoc in Sustainability to 5 years in management consulting at McKinsey&Company, where she helped clients navigate the energy transition, embrace big data/analytics and build innovation centers. As leader of sus.lab, she is excited to use her experience to work with an equally passionate team to accelerate progress towards a sustainable future.



Jakob Prüss – Research Associate/PhD Candidate

Jakob investigates how policy framework conditions such as regulations, incentives or voluntary contributions affect innovative activities of firms towards a sustainable circular economy with a focus on the plastic packaging (reverse) value chain. Prior to his PhD studies, he worked as a Junior Economist/Policy Analyst at the OECD in Paris.



Dr. Nicola Blum – Member of the Steering committee and affiliated researcher

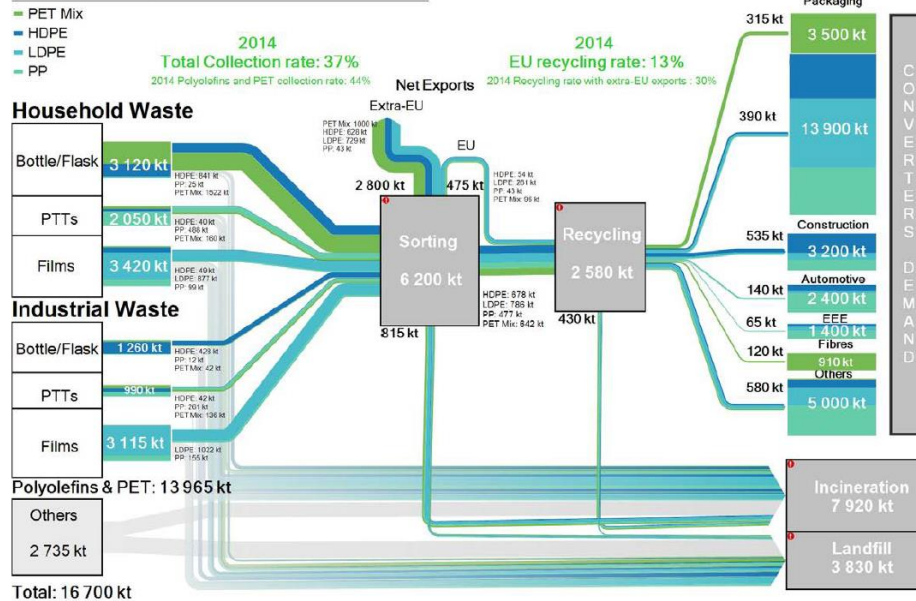
Nicola is a senior researcher at the Group for Sustainability and Technology and coach at STRIDE, an unschool for entrepreneurial leadership. She is and has been on the board and in the management of several ventures such as Impact Hub Zurich. Her current research focuses on the sustainable circular economy and she is co-leading the NFP 73 project “TACLE”.

GLOSSARY

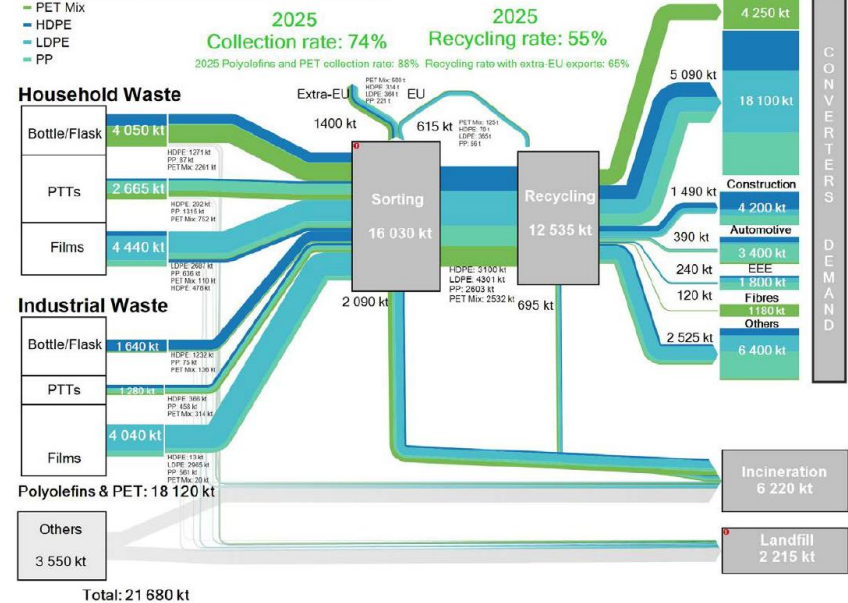
CR	Chemical recycling
EPR	Extended producer responsibility
EPS	Expanded polystyrene foam
LDPE	Low density polyethylene
NGO	Non-governmental organization
PET	Polyethylene terephthalate
PVC	Polyvinyl chloride
ROI	Return on investment
SME	Small and medium-sized enterprises
SUP	Single-use plastics
UV	Ultraviolet radiation
VC	Value chain

2014 flows EU and 2025 model for 55% target

2014 Europe Plastics Streams



2025 Europe Plastics Streams



Chemical Recycling – Technology overview

Depolymerization/ monomer recycling

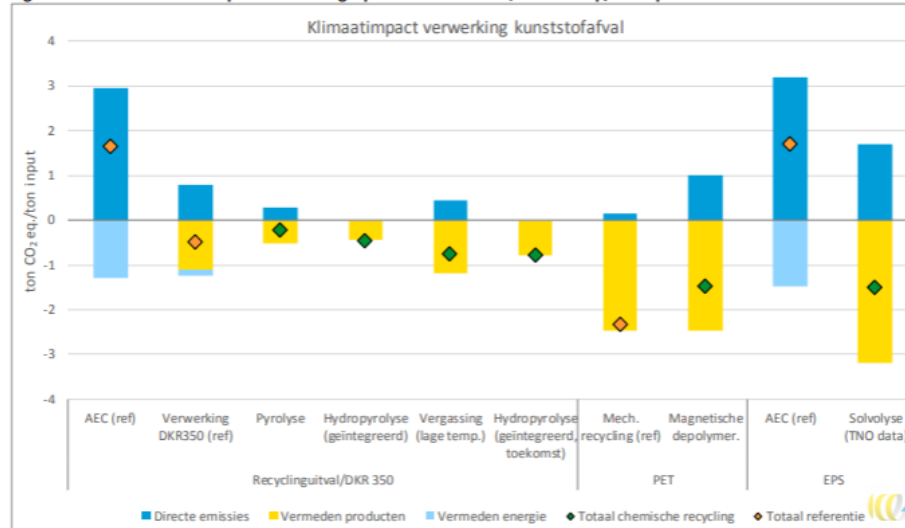
- Depolymerisation/ monomer recycling - puts used plastics through a chemical process that breaks them back down to their monomers.
- **Mainly for PET and Polyamide (works only for condensation-type polymers)** that can be re-monomerized
- Considerable scope for process improvements

Feedstock recycling (to naphta with C5-9) or Syngas C1

- **Breaking polymer chains down to hydrocarbon fractions** (i.e., similar to refinery process) through catalytic or thermal processing
- **Pyrolysis may offer the biggest potential**, because it should be able to process a wide range of low-quality mixed-plastics-waste streams.
- **This could be particularly useful for processing flexible packaging**, a major portion of the waste stream, which today's mechanical recycling processes cannot handle well

Chemical recycling – Environmental impact (CO₂)

Figuur 7 - Indicatie klimaatimpact verwerkingsopties kunststofafval, ton CO₂-eq./ton input



- Incineration in an AEC generates approx. +1.6 tons of CO₂eq./ton input
- Mechanical recycling saves approx. -2.3 tons of CO₂eq./ton input
- Pyrolysis and gasification estimated at approx. -0.2 to -0.8 tons of CO₂eq./ton input – clearly better than incineration
- Even better (but with much narrower applicability): Depolymerisation and solvolysis at ~-1.5 tons CO₂eq./ton input

More here:

<https://www.cedelft.eu/en/publications/2173/exploratory-study-on-chemical-recycling>

Source: Verkenning chemische recycling Hoe groot zijn - en worden - de kansen voor klimaatbeleid?

There are trade-offs between durability and degradability, but materials are getting better

PLA today is the most versatile bio-degradable material for packaging

- Today largely derived from sugar, but broader range possible. Input ca , 1.6-2kg material per kg
- Flexible and rigid applications, cold and hot
- Material is recyclable (but infrastructure does not exist yet)
- Degrades as per norm under high temperature industrial composting
- Current price ~2.5 EUR

PHA has potential to be “the next generation”

- Broad class of material generated by microbes (today mostly fed with sugar, but broad range of biomass possible), input ca 3kg material per kg
- Tunable characteristics open broad range of applications, including in multilayer flexible packaging
- Bio-degradable as per norm, home compostable, environment tbd*
- Current price ~4 EUR/kg

danimer
scientific
A Biotechnology Company

Multilayer PHA bag – in testing **PEPSICO**



*For home composting certificates exist, no standard measurement methodologies exist yet for degradation in the environment

Bio-degradation is only one criterion for compostability - EN 13432 gives criteria making a packaging material “compostable”

- **Disintegration** – the packaging sample is mixed with organic waste and maintained under test scale composting conditions for 12 weeks after which time no more than 10 % of material fragments are allowed be larger than 2 mm.
- **Biodegradability** - a measure of the actual metabolic, microbial conversion, under composting conditions, of the packaging sample into water, carbon dioxide and new cell biomass. Within a maximum of 6 months, biodegradation of the test sample must generate an amount of carbon dioxide that is at least 90 % as much as the carbon dioxide given off from the control / reference material.
- **Absence of any negative effect on the composting process.**
- **Low levels of heavy metals** (Potentially Toxic Elements) and no adverse effect of the quality of compost produced. Upper limits, in mg/kg of dry sample, are: zinc 150, copper 50, nickel 25, cadmium 0.5, lead 50, mercury 0.5, chromium 50, molybdenum 1, selenium 0.75, arsenic 5 and fluoride 100.
- The composted packaging material must **not have adverse effect on** the bulk density, pH, salinity (electrical conductivity), volatile solids, total nitrogen, total phosphorus, total magnesium, total potassium and ammonium nitrogen **characteristics of the compost.**

- 
- The EU wide norm EN13432 was introduced in 2000 and describes the tests for compostability
 - These criteria must be combined with a specific reference environment to allow judgement of a material (e.g., industrial composting, home composting, soil,...

Our interviews revealed different perceptions about the role of brand owners

Innovation is driven or hindered by decisions of the brand owner.

– **Raw material supplier**

Most flagship projects of brand owners are PR only and do not really trigger innovation across the value chain.

– **Converter**

Brand owners hold most of the market power in the industry and have highest margins. They should drive recycling innovation.

– **Recycler**

The regulator requires us to adhere to a lot of guidelines making it difficult to use recyclable materials esp. for food applications.

– **Brand owner**

Most GHG-emissions do not come from packaging but from ingredients of the products.

– **Brand owner**

The costs of EPR fees should be distributed across all players in the industry.

– **Brand owner**

Costs are key and customers are not willing to carry the costs of recyclable packaging –behavioral change is needed.

– **Brand owner**

Further regulatory challenges

Standardization

- Standardization of feedstock helpful to facilitate recycling.

Measurement

- Insufficient measurement and standards.

REACH

- Revision of REACH legislation (2019) might increase the number of restricted materials, which will be an additional challenge for the recycling industry.

Packaging legislation

- Excessively stringent interpretation of feed packaging legislation (inspired by food packaging legislation) may result in lower use of re-granulates.

Public procurement

- Public sector procurement policies could stimulate further demand.

Further economic challenges

Coupled markets

- Demand for recycled plastics largely results from unsatisfied demand for virgin material. Pricing of secondary plastics is highly disconnected from the costs that are incurred in producing them. Markets are not yet decoupled

Cost lock-ins

- Packaging has been cost-optimized over the past 30 years. More sustainable packaging, representing an added value, is more expensive as costs for collecting, sorting and processing are high.

High quality recycle

- Amount of existing high-end recycle is not available on the market to reach the industry objective of using 20% in 2025. Currently under 10% of recycle is kept in the loop.

Inertia

- Large companies are less reactive to disruptive technologies and developing niches, which could be scaled up as market demand grows. Recycling market is dominated by SMEs which have an advantage

Market shocks

- Low ability of the recycling sector to absorb market shocks.

Lack of data

- Lack of data on structure and performance of the flexible packaging industry.

Further technical challenges

Main barriers	a) No total separation and sorting of mixed plastic packaging streams possible b) Contamination by mixed post-consumer waste streams c) Contamination by additives and solvents
Variety of polymers	▪ Widely distributed and diverse nature of sources of plastic packaging waste relative to other recycling processes (e.g., paper, glass, aluminum).
Quality of recyclate	▪ Current plastic recyclate is of minor quality but has further potential.
Performance	▪ Requirements of brand owners towards technical aspects (e.g., shelf life) of packaging are disproportionate.
Low-value applications	▪ Mechanical recycling oftentimes entails low-value applications (e.g. asphalt substitute, railroad ties), excluding PET. PP and polyester polymer chains decrease in length after every cycle. Therefore, virgin feedstock will have to be added even in circular scenarios.
Biodegradables	▪ No established recycling streams for biodegradable plastics (i.e., PLA, PHA, TPS, PBS, PBAT, PBAS). These fractions are currently not separately collected and, instead, contaminate existing waste streams.
New materials	▪ From a recycling point of view, new materials (e.g., carbon fibers) pose a higher risk than common materials. This might remain a minor issue for packaging.

Further societal/systemic challenges

Mental barriers

- Most important barriers are mental, rather than physical.

Transparency

- Waste management and recycling systems tend to be non-transparent. Data on EPR fee flows is rare or non-existent.

Lack of substitution

- Lack of high-end applications: Many virgin applications are theoretically substitutable by recycled material (e.g., 'film-to-film' applications such as stretch around pallets or even 'film-to-rigid').

Misleading dissemination

- Risk of supporting and disseminating non-priority messages and false facts through media and interest groups (e.g., 'bio-degradability', 'marine littering').

Recommendations to foster circularity in flexible packaging

