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Closing the loop for multilayer flexible packaging - barrier analysis

Final Report

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

Climate-KIC

Climate-KIC is supported by the
EIT, a body of the European Union

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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

CEFLEX

Funded by

Climate-KIC
ETH zürich

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.,
    - The EU recently decided on a ban on some single use items and 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, with a mission 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 dramatically increased share of recycled content also for packaging, this would require significantly increased used 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 ambitions 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 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
- **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

For references/ sources please see main document

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
    - 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
    - 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.
    - Recyclate quality is still lower than virgin materials (e.g., material mixes, contamination with additives, multi-layer mixed materials)
    - The market for low quality materials is small, esp. food grade packaging requires virgin material except for PET bottles
    - 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)

For references/ sources please see main document

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

For references/ sources please see main document

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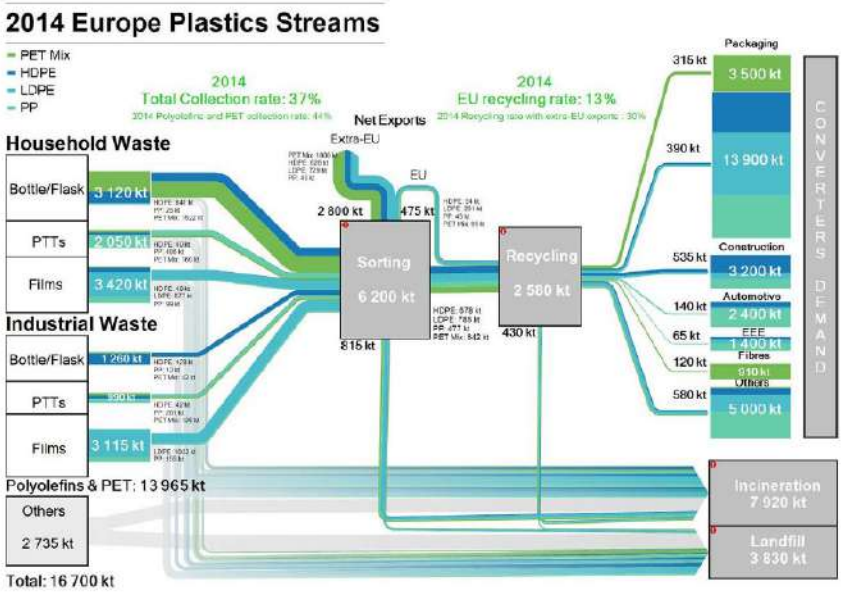
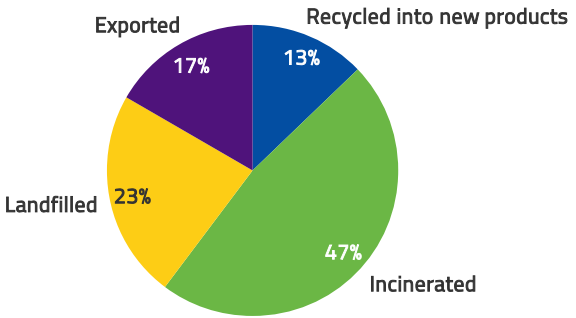
The majority of plastics waste goes currently to landfills and incineration



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



Source: Blueprint for plastics packaging waste: Quality sorting & recycling, Deloitte for Plastics Recyclers Europe (both charts)

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**

suez · VEOLIA · amcor · PEPSICO · Coca-Cola · WWF · H&M · DANONE · Walmart · L'ORÉAL · Unilever · Nestlé · Ahold Delhaize

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

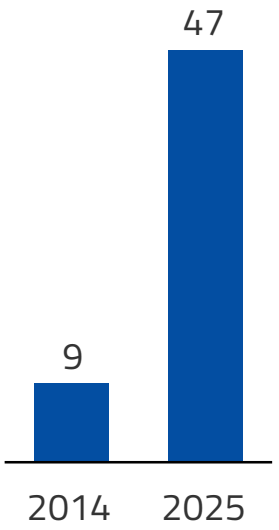
Mission is to further enhance the performance of flexible packaging in the circular economy by designing and advancing better system solutions identified through the collaboration of companies representing the entire value chain

Source: EU Circular Economy Package –approved in EU parliament 1.11.2018, target: law by 2021; Ellen MacArthur Foundation: Global Commitment, published 29.10.2018, https://ceflex.eu/what-we-do/

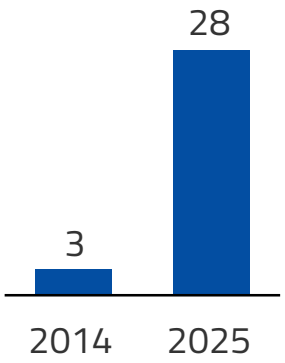
In 2018, the EU set a target of 55% recycling by 2025 - meaning a drastically increased share of recycled content also for packaging

- 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

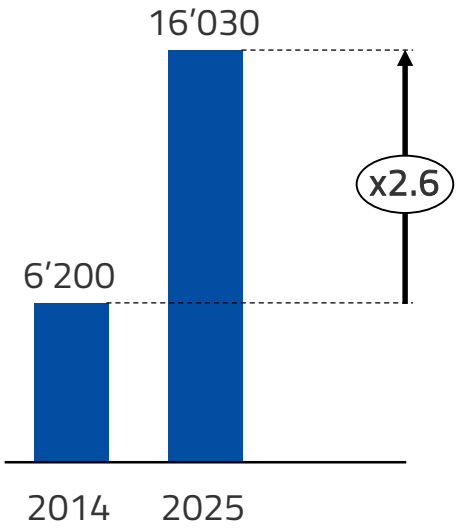


Source: Blueprint for plastics packaging waste: Quality sorting & recycling, Deloitte for Plastics Recyclers Europe

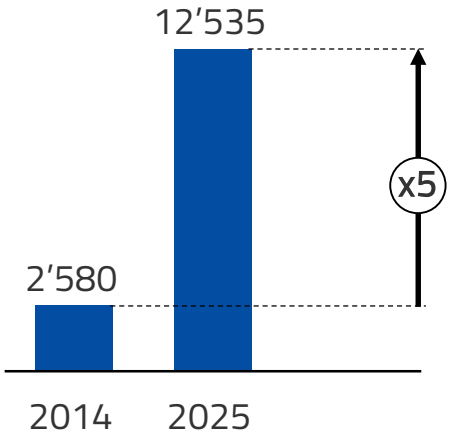
To reach the 55% target by 2025, sorting capacity will need to increase by a factor of 2.6, recycling by almost a factor of five

- 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 Europe[1]
ktons



Recycling capacity Europe[1]
ktons

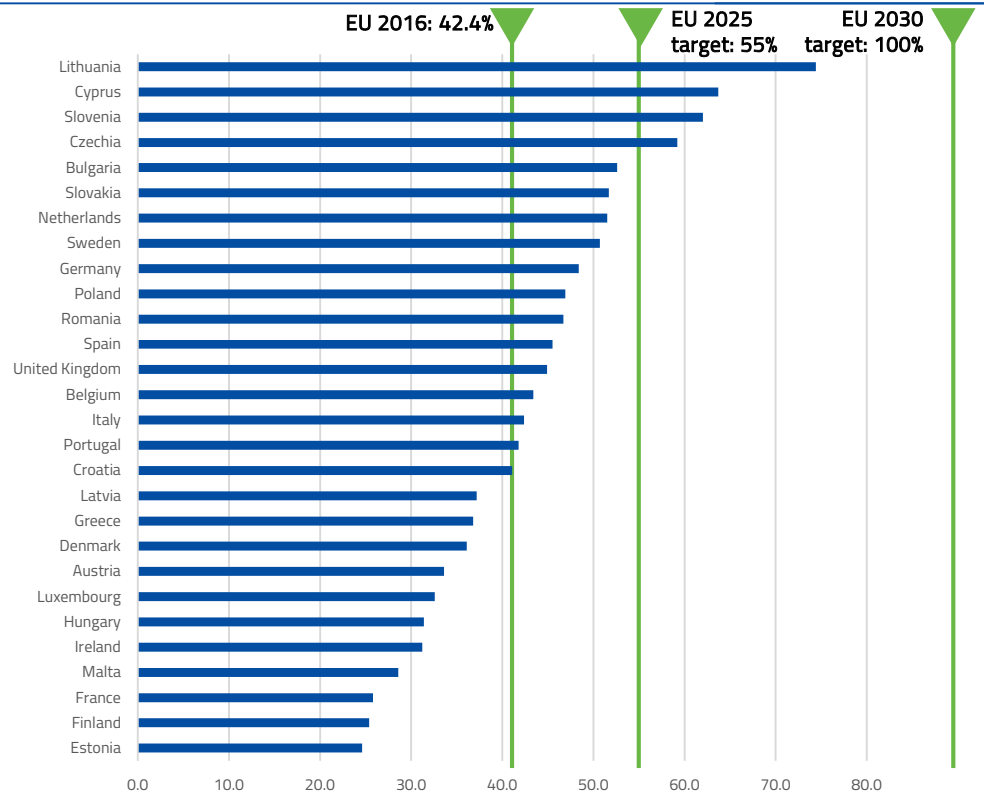


1 Without exports

Source: Blueprint for plastics packaging waste: Quality sorting & recycling, Deloitte for Plastics Recyclers Europe

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

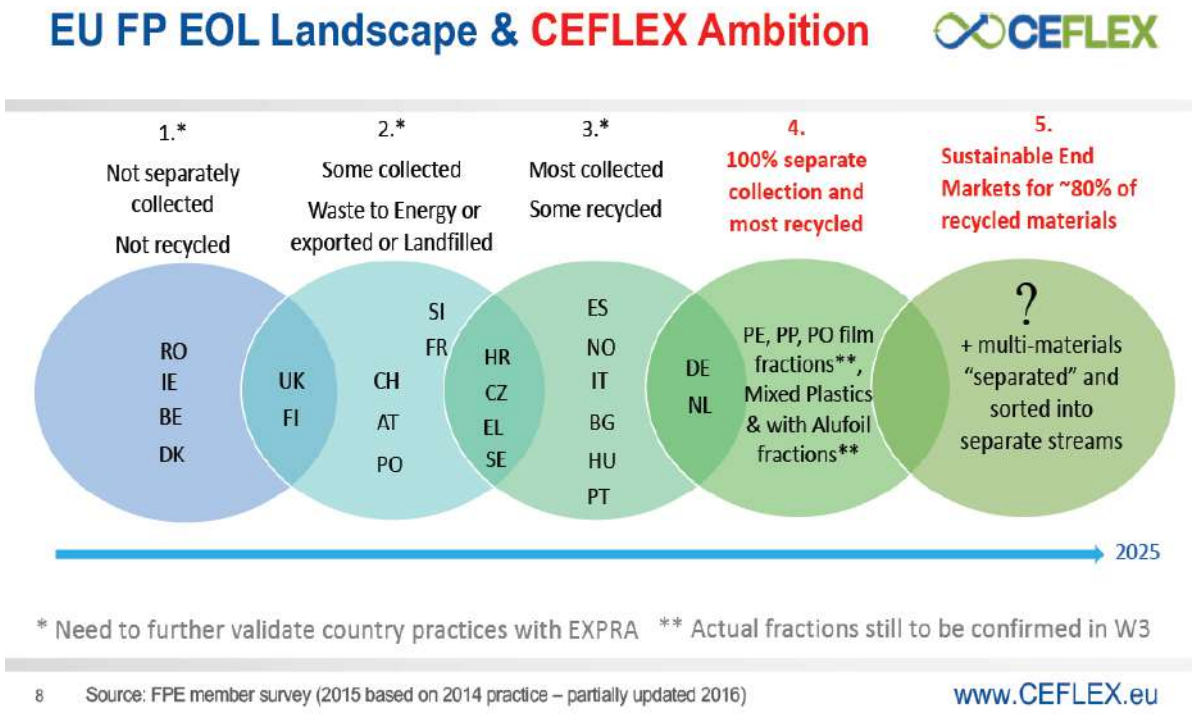
Plastic packaging collection rates in the EU (%), 2016



- To our understanding, all numbers reflect collection rates at this point
- The EU target will be based on the new harmonized definition, measuring after collection, and only including waste that goes into a recycling process
- 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

Source: CEPS (2018), Eurostat Plastics, all data based in national reporting

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



Source: CEFLEX Homepage

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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	BOREALIS, DOW, DUPONT, BASF	covestro
	Converters	mondi, rkw, Constantia, amcor	
	Brand Owners	MARS, DANONE, Nestlé	coop, LEGO
	Collectors & Sorters	suez	
	Recyclers	htp, mtm plastics, SAICA, PYRAL, APK	Getränkekarton-Recycling
Stakeholder	Industry organizations	e-PRO, Expra, CORE PLA	PET
	NGOs	n/a	Food Packaging Forum, ocean care, WWF
	Policy	n/a	GRÜNE
	Academia	n/a	ETH zürich, Wuppertal Institut

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

General observations on the dynamics in the value chain

- Industry structure
- Key drivers of change
- Reaction of the value chain

Observed barriers

- Economic
- Technical
- Uncertainty as a meta barrier

Contested issues and underlying assumptions

- 6 contested issues about how to resolve those barriers
- Discussion about underlying assumptions
- Consensus

Sketch of solution space

- Summary of system level barriers and first view on recommendations (CEFLEX and policy makers)

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Observations[1] 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

1 Observations stem from the interview data and where labeled "observations" as interviewees mentioning these agreed unanimous on these issues

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

Indicative

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

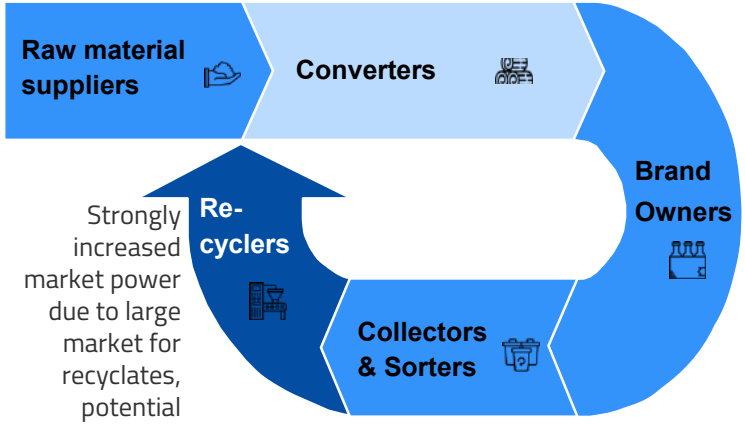
Distribution of market power in a LINEAR value chain

- **Raw material suppliers** — Large corporates with relatively high market power depending on raw material supplied
- **Converters** — Corporates of all sizes with some market power stemming from collaborations with raw material suppliers
- **Brand Owners** — Large corporates with high market power due to proximity to the customer and generally good to high profitability
- **Collectors & Sorters** — Mostly small players with relatively low profit margins (profiting on governmental support); in some countries structured as state-owned monopoly/ oligopoly
- **Recyclers** — Highly fragmented landscape of small players, which currently profit from government subsidies and high demand for materials

Distribution of market power in a CIRCULAR value chain

Potentially reduced market power due to reduced market size for virgin material[1]

Reduced market power due to increased dependence on supply of recyclates



Still relatively high market power; yet, high dependence on collectors, sorters and recyclers to provide recyclates

Strongly increased market power due to large market for recyclates, potential government support and industry consolidation

Increased market power due to higher demand for recyclates

Source: Created by the authors based on interviews and discussions

1 Depends if raw material suppliers become also suppliers of recyclate

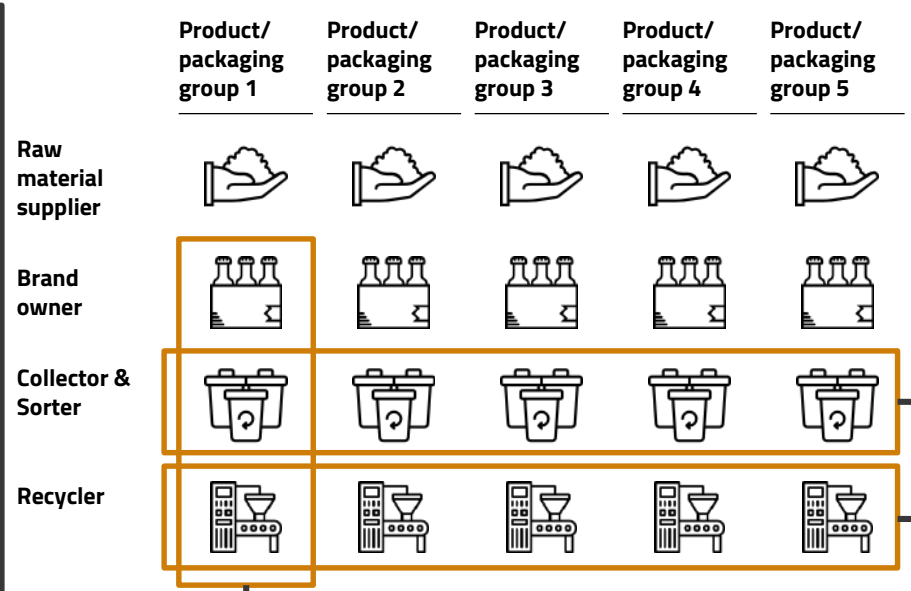
The expected shift of market power is reflected in trends towards a vertical integration and horizonal consolidation of recycling businesses

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

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

Sources: Left: Original from Badische Zeitung, 30.09.2018, Right: EuWid, 27.09.2018, Middle: Own chart

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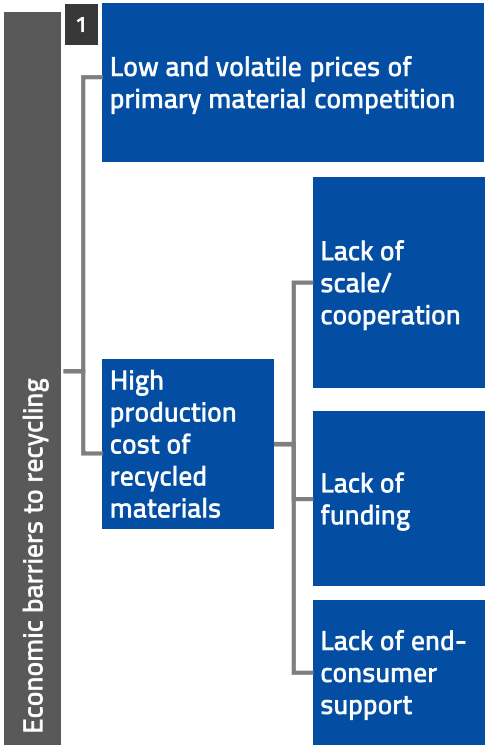
Summary: Main barriers are economic and technical, with "uncertainty on the path forward" as an important "Meta-Barrier"

- 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

x Additional details in the following



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

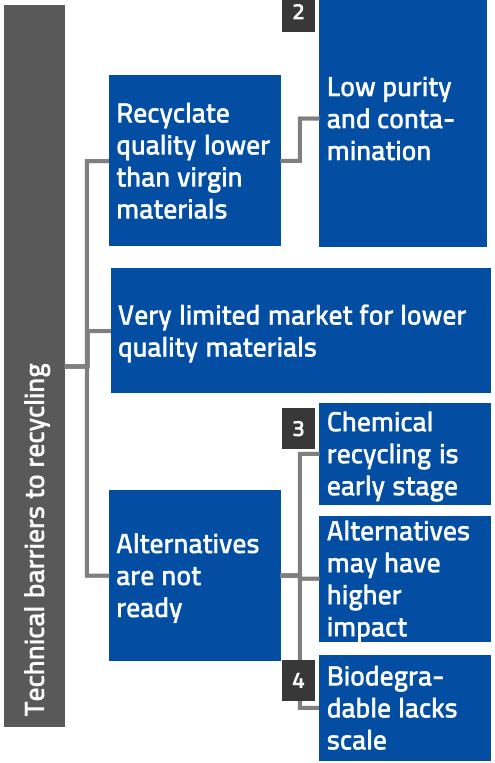
- **Unwillingness to invest in new technologies** – due to lock-ins from previous infrastructure investments
- **Lack of financial R&D support** – due lack of awareness of existing subsidies, cumbersome application processes and/ or exclusion of sorters[1]

- **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

x Additional details in the following



Identified barriers	Description
Recyclate quality lower than virgin materials → Low purity and conta-mination	▪ **Material mixes** – due to mixed waste management streams and lack of sorting technology, especially for specific designs[1] ▪ **Hazardous additives and solvents** – due to inability to remove completely from material stream ▪ **Multi-layer mixed materials –** due to requirements for effective barriers (oxygen, water vapor, UV) in combination with low cost/ material use (mono-materials would increase packaging weight/ cost) ▪ **Color limitations** – due to remaining pigmentation
Very limited market for lower quality materials	▪ **Applications for mechanically recycled material are limited**, e.g., not possible for food grade, except for PET bottle to bottle ▪ **Performance criteria drive need for sophisticated materials** – e.g., increasingly long shelf life require more sophisticated packaging using more layers
Alternatives are not ready → 3 Chemical recycling is early stage	▪ Multitude of solutions in pipeline, but **commercial scale-up just starting** ▪ **For mixed streams –** mostly not back to material, but syngas for energy
Alternatives are not ready → Alternatives may have higher impact	▪ **No readily available substitutes for plastics exist**: E.g., paper/metal in many cases lead to higher environmental impact in life cycle analyses ▪ **"Rebound effects"** due to lower per-unit-production impacts but increased levels of production
Alternatives are not ready → 4 Biodegra-dable lacks scale	Biodegradable has been discussed for single use applications, but ▪ PHA/PLA have potential but are **less than 1% of market** ▪ **Additional infrastructure required** for separate collection and composting (ideally also recycling!) ▪ **Risk of contamination of other streams** (e.g., PET from PLA) in recycling systems

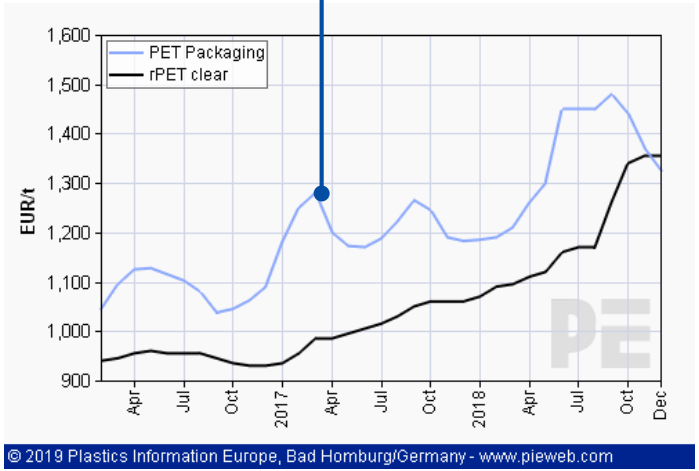
1 Dark printing inks, black post-consumer PP impedes sorting and recycling

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

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

Price of virgin PET overall higher than price of clear rPET



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

Source: Plastics Information Europe (2018), Recycling today (2017), European Strategy for Plastics in Circular Economy

2 Sorting technologies are not yet capable of creating sufficient purity

Category	Sorting technology examples	Key barriers	Avg. purity
Manual sorting	• Positive / negative (removing non-target material) sorting	• Time and cost inefficient	>95%
Shredding/sieving	• Drum screen separation (smaller items fall through)	• First process step only	>95%
Air / liquid density separation	• Sink-float separation (often in water)	• First process step only	>95%
Magnetic separation[1]	• Eddy current (using counter-rotating magnetic field)	• Not effective for all metal types	85-90%
Spectrophotometric sorting	• Near-infra red (NIR) • X-ray • Hyper-spectral imagining (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

Source: Plastics Europe (2018), OECD, Improving Markets for Recycled Plastics (2018), Singh et al (2016) , Plastic zero (2013)

3 More innovation is required to scale up chemical recycling

- 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

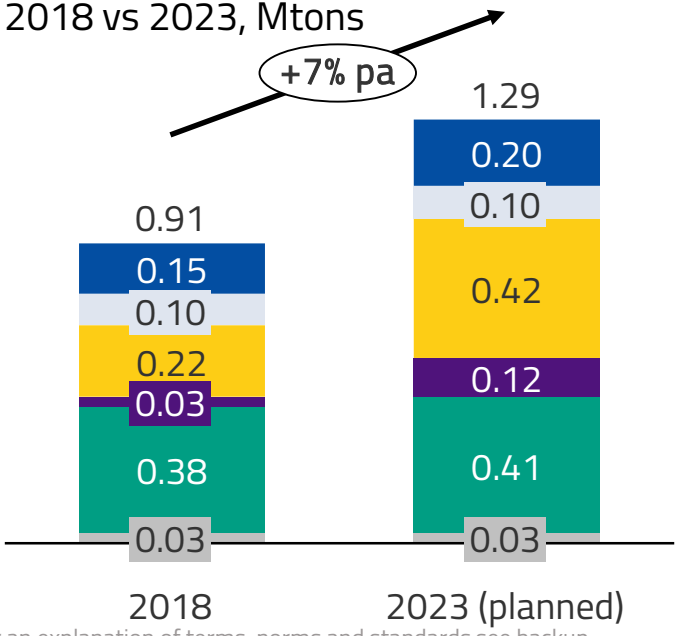
*Mechanical recycling saves 2.3 tons CO2 per ton of waste, incineration emits 1.6 tons of CO2 per ton of waste, pyrolysis ranges from -02 to -0.8 tons of savings

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

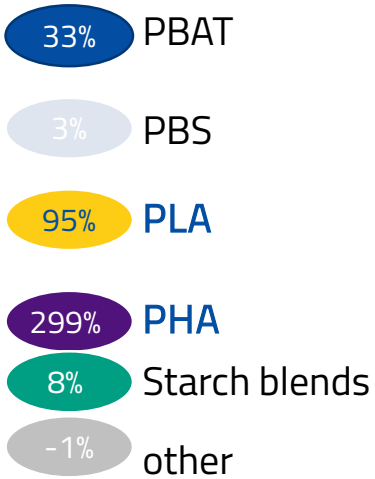
4 Bio-degradable* capacity is growing with a rate of 7% p.a., driven by PLA and PHA; however, the market is still small at ~0.2% of polymers

Global production capacity bio-degradable polymers, current and planned

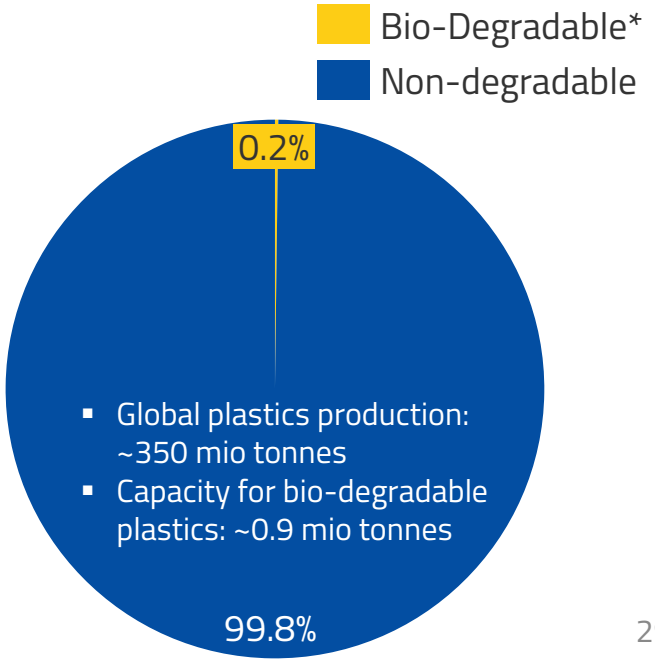
2018 vs 2023, Mtons



Growth until 2025



Share in global plastics market, 2018



* For an explanation of terms, norms and standards see backup

Source: European Bioplastics Market Forecast 2018, nova-Institute (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

* For an explanation of terms, norms and standards see backup

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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	Synthesis of discussion in first workshops*
1 **The value chain integration**: Is vertical or horizonal integration most effective in fostering innovation?	Horizontal consolidation has always been common place in the industry – recently it seems that vertical integration is starting
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?	Confirmed that chemical recycling will be needed, but economics are challenging, partly due to scale
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?	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	Synthesis of discussion in workshops*
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?	Strong policy intervention and regulation needed. Purely voluntary instruments won't be sufficient – Information will be key as well
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?	It is crucial to have ambitious targets; coordination at EU level is necessary
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?	Brand owners are however key in unlocking demand and therefore allow for innovation across the chain

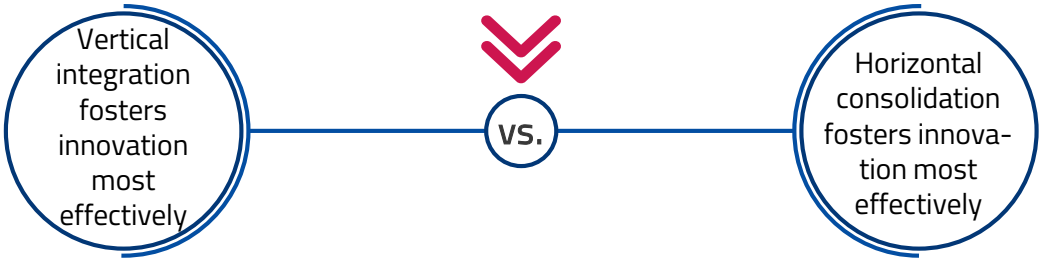
* Results reflect the discussion with workshop participants, a broader discussion in the CEFLEX Consortium will be key

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

Climate-KIC

Result of discussion in workshop

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 recyclate 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:

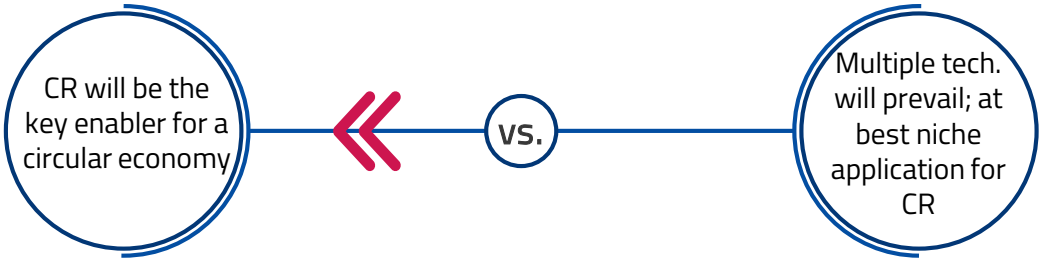
- **Horizontal consolidation** is common practice in the recycling industry. Integration between raw material/ polymer producers and recyclers (as for paper, aluminum) still lacking for plastics
- **Vertical integration**: High interest in the case of external players integrating vertically in the waste 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

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

Climate-KIC

Result of discussion in workshop

Contested issue



What you need to assume

- Potential for **significant CO2 reduction** per ton of plastic produced
- Potential to **transform heterogenous 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

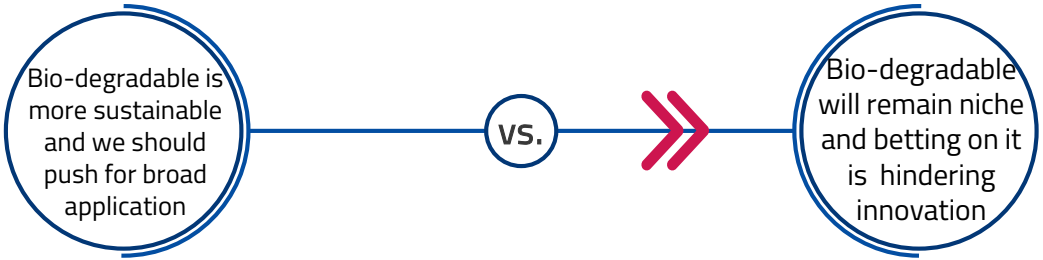
- Workshop participants agreed that chemical recycling has a big potential beyond the traditional complementary role
- Challenge of economics, especially economics of scale
- EPR and similar tools could be implemented and extended to manage the investment risk

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

Climate-KIC

Result of discussion in workshop

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**
- **Materials suitable for mainstream packaging do not solve leakage into the environment**, as they do not degrade in soil or marine environment*

- Bio-degradable is **no contradiction to recycling** – PLA and PHA might be well recyclable - in sum this makes it the better option
- 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

- **Bio-degradables can be enablers** like organic waste collection and replacement of plastics with paper
- **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

* For an explanation of terms, norms and standards see backup

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

Climate-KIC

Result of discussion in workshop

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 misguiding assumptions**
- Wrong incentives or restraints bear the **risk of lock-in into mature technologies**

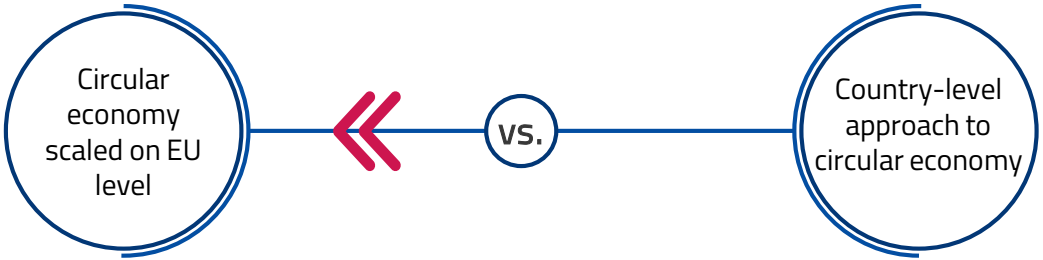
Result of the workshop

- 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?

Result of discussion in workshop

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

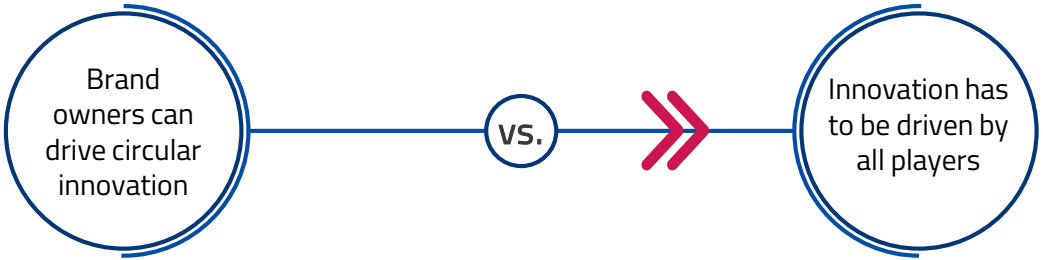
Result of the workshop

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

6 Do brand owners have the will to drive the circular economy?

Result of discussion in workshop

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

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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

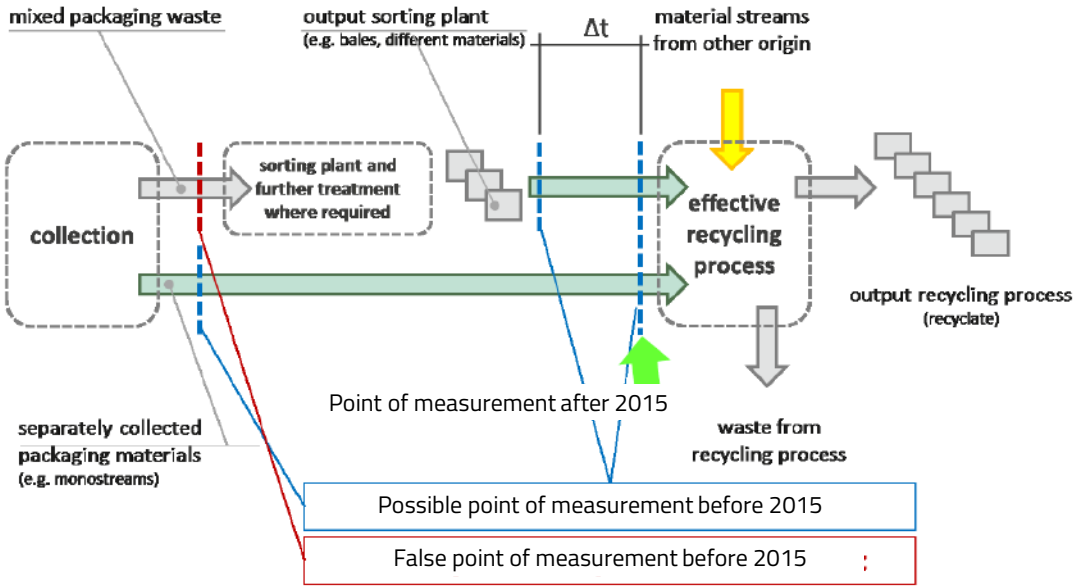
No major barriers identified
Potential for improvement
Is/ could become a significant barrier

- 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

1 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".

2 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

Expecta-tions 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