

**TAPPI  
FlexPack  
PLACE**

**14-17 April 2024**



**Value Chain Collaboration To Deliver  
Circular Economy Initiatives  
In Flexible Packaging**

## Topics explored today

Collaboration, design, recycling strategy, regulatory drivers

1

CEFLEX and the case for value chain collaboration

2

Key deliverables in design accelerating progress

3

Key deliverables accelerating progress: Recycling strategy – 1<sup>st</sup> iteration:

- EU Legislation
- EU Virgin and Recycled Polymers Markets
- EU Recycling Capacities Projection
- Recycling Strategy Recommendation & Enablers

# Collaborating and innovating together



>180 stakeholders  
A critical mass  
across the entire  
value chain



**Material Producers**



**Film Producers and Converters**



**Brand Owners and Retailers**



**Waste Collectors, Sorters and Recyclers**



**Flexible packaging ecosystem**

# Our Vision and ‘Mission Circular’



Collection of **all** flexible packaging

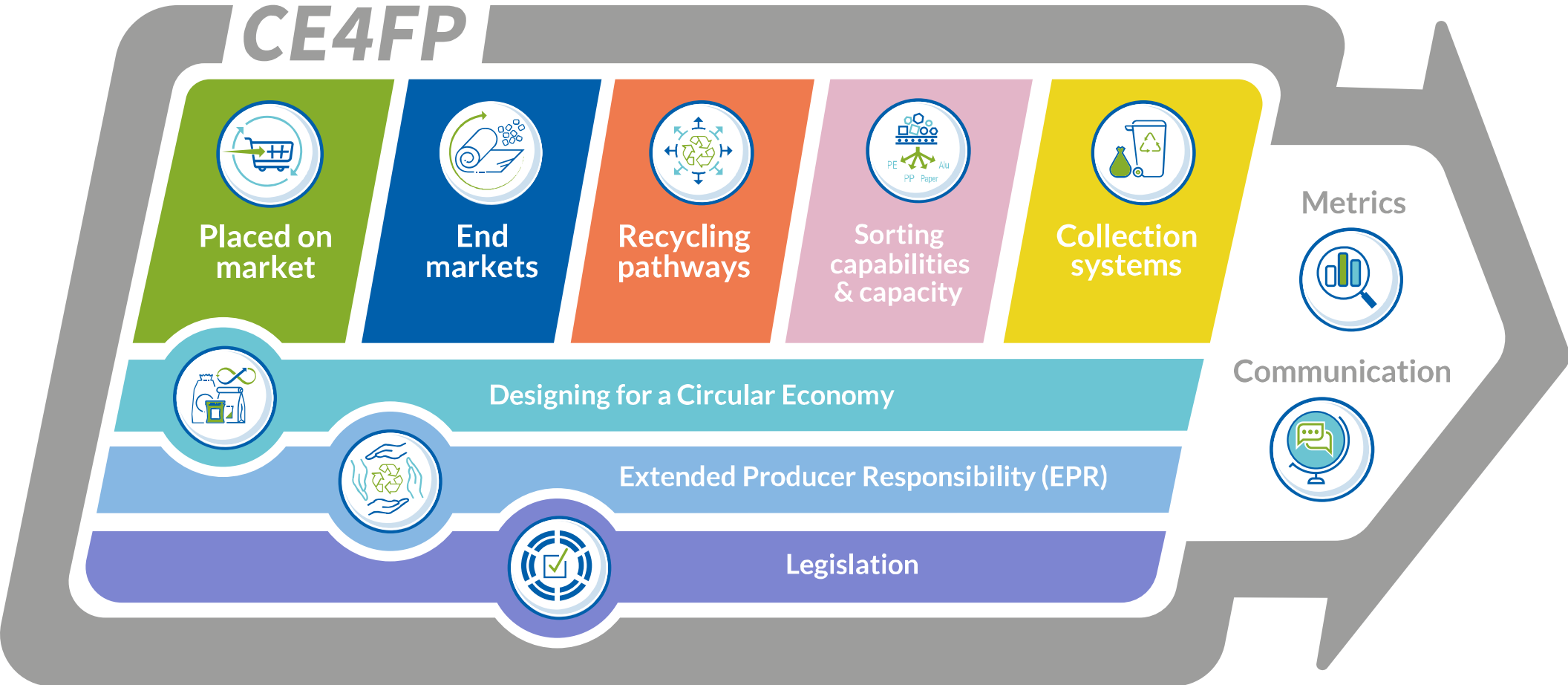
With over **80% of materials entering a recycling process** to be returned to the economy

And used by **sustainable end markets** to substitute virgin materials

# Creating the circular transition

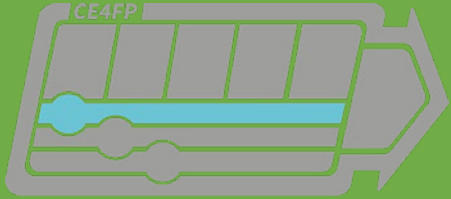


Demand, understanding, alignment, information, guidance, tools...



The CEFLEX demand driven circular economy model

# DESIGN



DESIGNING FOR A  
**CIRCULAR ECONOMY**  
IN ACTION

# Designing for a Circular Economy (D4ACE)

## Guidelines



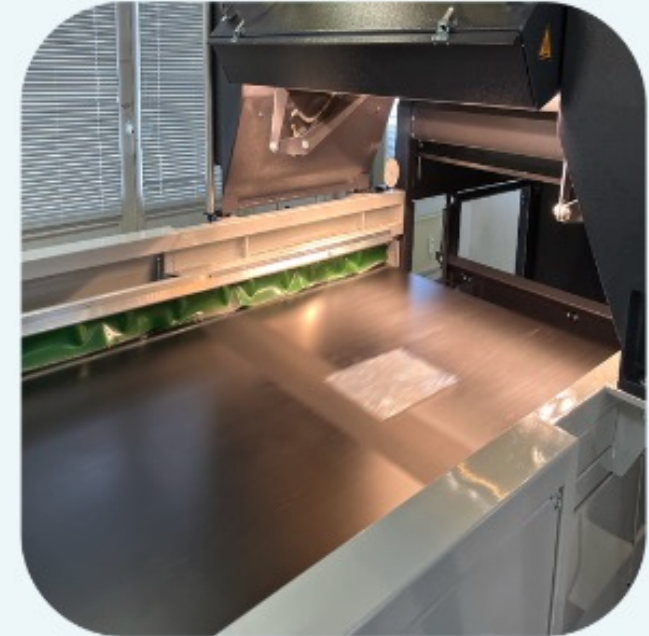
[guidelines.ceflex.eu](https://guidelines.ceflex.eu)

## Tools



[design-check.ceflex.eu](https://design-check.ceflex.eu)

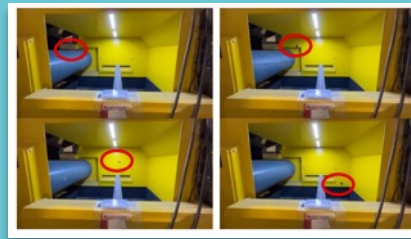
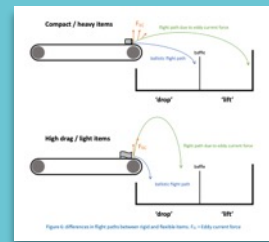
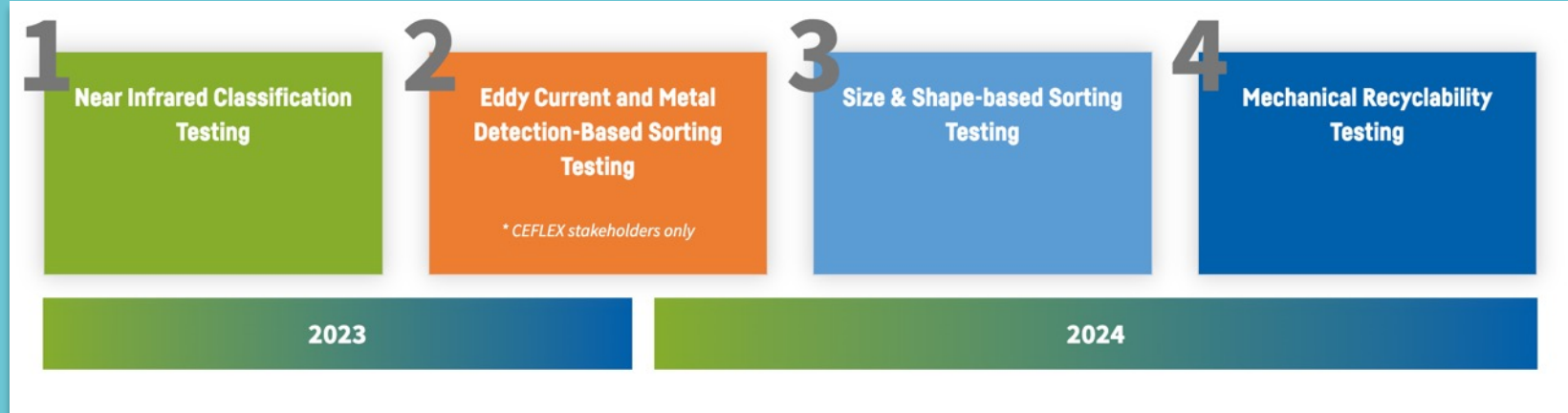
## Testing



Phase 2 programme

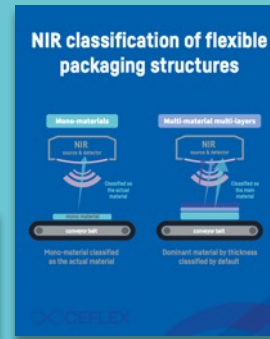
Clear and effective guidance from the flexible packaging value chain to transform how packaging is designed and accelerate progress

# Phase 2 testing – data-driven and transparent results



CEFLEX DANCE Phase 2 test results  
Metallized PE films mechanical recycling

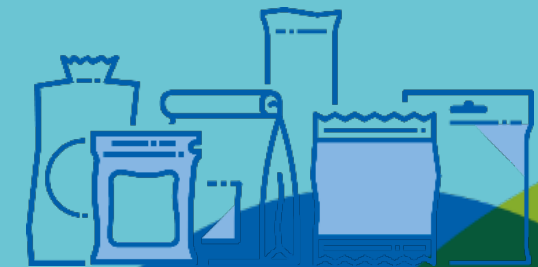
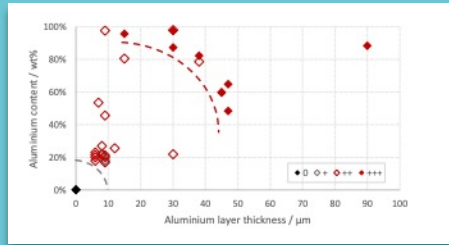
CE 2 test results  
Chemical recycling



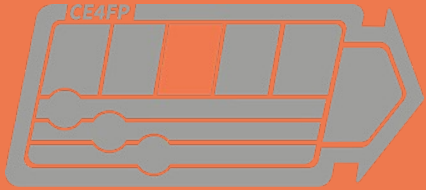
CEFLEX set out to examine and test what flexible packaging structures can and cannot be detected and correctly classified using existing NIR sorting technology

Stakeholders from across the value chain collaborated to provide a unique and detailed set of samples for testing

More than 100 flexible packaging structures and +240 samples  
Including PE, PP, PET, PA, EVOH, PVC, metallization, aluminum foil, inks, coatings, pigments, films, composites...



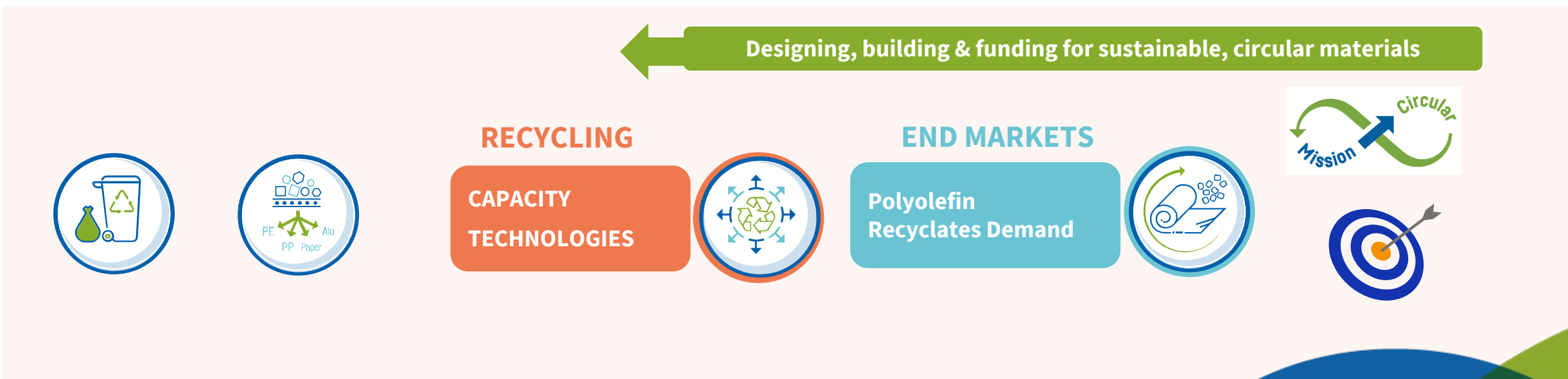
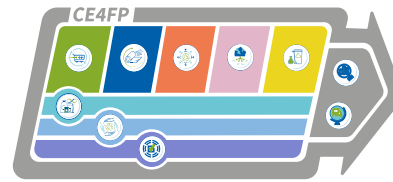
[guidelines.ceflex.eu](https://guidelines.ceflex.eu)



**A recycling strategy for flexible packaging**  
clarifying the capacities, technologies and actions  
required to achieve circularity



# Building a recycling strategy anchored in 'demand driven'



# Pathway to CEFLEX Recommendation



## Recycling Strategy – First iteration

### Flexible Packaging Placed On Market

#### End Markets for Polyolefin Recyclates Analysis

Rigid and flexibles  
Packaging and non-packaging

#### Flexible Packaging Recycling Capacity

MOBIUS model incorporating analysis of  
PPWR technologies and volumes

#### Chemical Recycling Project

Data to show the real-world impact and  
required capacity of chemical recycling

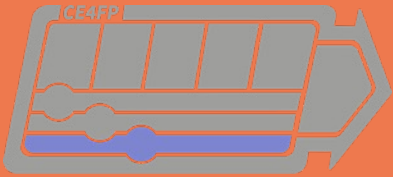
### Key questions to answer / Rationale

- Size of existing and potential end markets for recycled materials from flexible packaging?
- PCR penetration into these markets?
- Specification of this PCR?
- How robust is the data?

- Recycling capacity required to meet proposed PPWR contact and non-contact sensitive recycled content targets in 2030?
- Will there be enough recyclate to meet both targets?
- Can flexible plastics reach the same 55% recycling target ?

- What is the actual yield of a typical CR plant with today's technology?
- Indicative yields and how these relate to mechanical recycling
- The ideal feedstock which CR requires to deliver optimal economics

# Legislation



Implications for CEFLEX  
circular economy vision

## European legislative drivers: Recycled content minimum targets 55% recycling rate ‘recycled at scale’ by 2035



RECYCLED CONTENT TARGETS	2030	2040
Contact sensitive PET, excluding single-use beverage bottles	30%	50%
Contact sensitive, plastic materials other than PET, excluding single-use beverage bottles ( <b>includes contact-sensitive PO flexibles</b> )	<b>10%</b>	<b>25%</b>
Single-use plastic beverage bottles	30%	65%
Other plastic packaging (includes <b>non-contact sensitive flexibles</b> )	<b>35%</b>	<b>65%</b>

# Restrictions and reuse requirements (PPWR)

## Restriction

Use of single-use plastic grouped packaging such as **shrink wrap and collation film** to group bottles, cans, tins, pots, tubs and packets to enable or encourage consumers to buy more than one product.

From 1 January 2030

## Mandatory reuse

Transport packaging **including flexible formats** for deliveries between economic operators' own sites and those of linked or partner enterprises and within the same Member State.

From 1 January 2030

## Reuse target

40% reusable transport packaging, to be met collectively by pallets, foldable plastic boxes, boxes, trays, plastic crates, intermediate bulk containers, pails, drums and canisters, **including flexible formats or pallet wrappings** or straps for stabilisation and protection of products put on pallets during transport. By 2030.

# Rules for calculating recycled content

Applicable to single-use plastic beverage bottles only but sets the precedent for rules applying to all plastic parts of packaging, coming later

## Mechanical recycling



- Weight of recycled plastic divided by weight of plastic placed on the market
- Adopted in Commission Implementing Decision (EU) 2023/2683

## Chemical recycling



- Credit-based mass balance system with fuel-use exempt allocation method
- Draft proposal currently due to be voted in April, therefore method still subject to change

The proportion of recycled plastic content in bottles placed on the market as referred to in Article 2 shall be calculated by applying the following formula:

1.  $RC = R/W \times 100 \%$

Where:

- RC means proportion of recycled plastic content in bottles placed on the market as referred to in Article 2  
R means weight of recycled plastic used in bottles placed on the market as referred to in Article 4  
W means weight of plastic used in bottles placed on the market as referred to in Article 3

COMMISSION IMPLEMENTING DECISION

of 2023

laying down rules for the application of Directive (EU) 2019/904 of the European Parliament and of the Council as regards the calculation, verification and reporting of data on recycled plastic content in single-use plastic beverage bottles, repealing Commission Implementing Decision (EU) 2023/2683

**DRAFT**

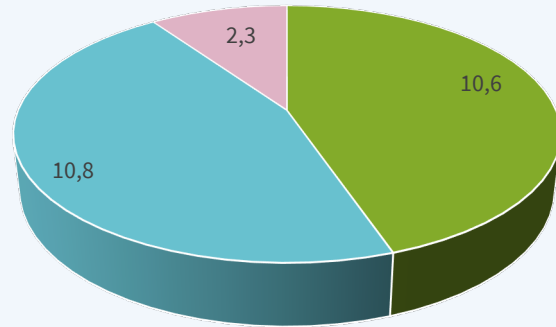
**Virgin  
polymer  
placed on  
market  
&  
End Market  
Demand**

# Virgin PE and PP POM data (2022)



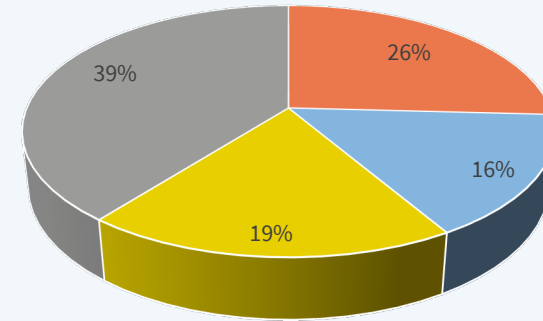
Based on raw AMI data

Total Virgin PE and PP Demand (Mt)



■ Flexible ■ Rigid ■ Semi-Flexible

Polymer Split - All Products - 2022

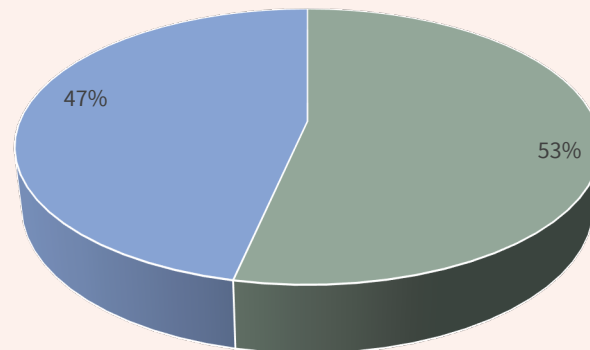


■ HDPE ■ LDPE ■ LLDPE ■ PP

Total in all 4 charts = 23.7 Mt

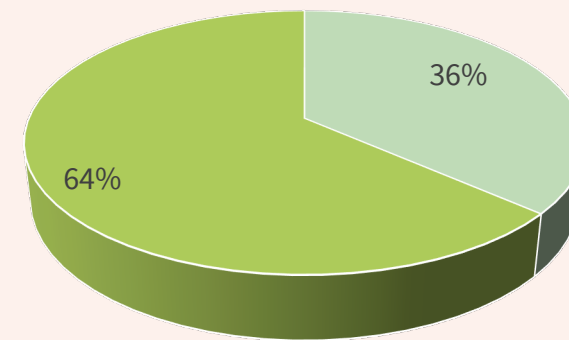
CEFLEX assumptions applied

Packaging Ratio - All Products



■ Packaging ■ Non-packaging

Contact Sensitive Ratio - All Products - 2022



■ Contact sensitive ■ Non-contact sensitive



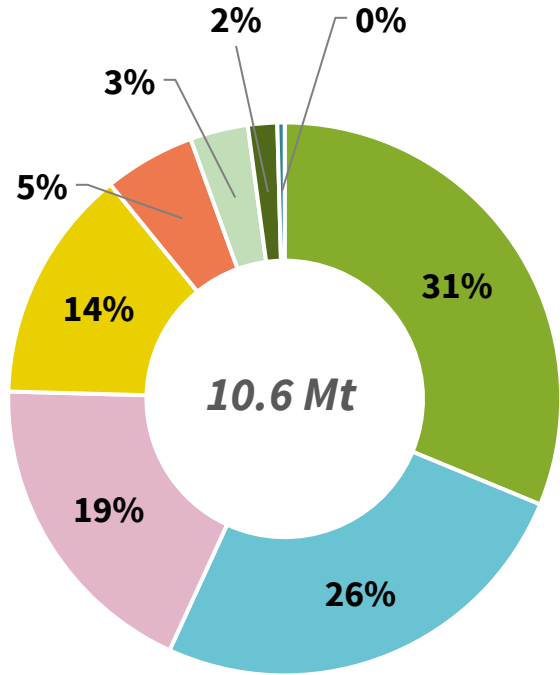
# Sector splits by category (2022)

Virgin PE and PP only



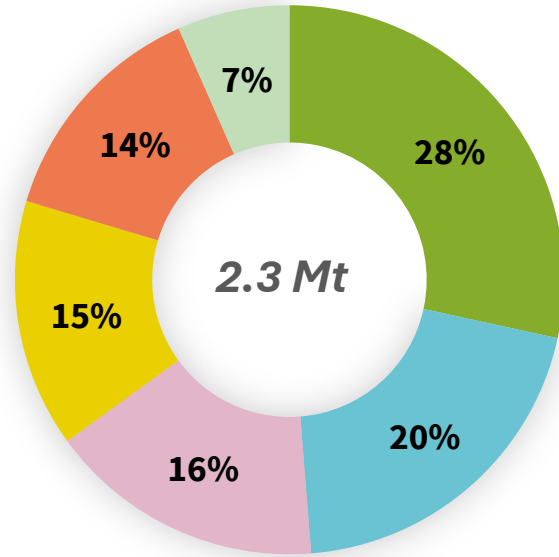
Data derived from AMI virgin PE and PP demand at converter  
 CEFLEX categorisation into flexible, rigid or semi-flexible products

End market demand - flexible plastics



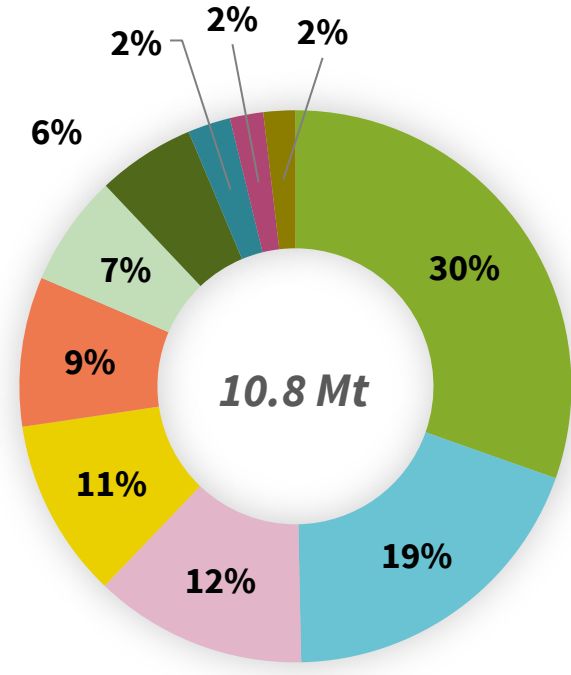
- Food Packaging
- C&I
- Bags & Sacks
- Other
- Agriculture
- Medical/hygiene
- Building & Construction
- Consumables

End market demand - semi-flexible plastics



- Medical/hygiene
- Electrical & Electronic
- Agriculture
- Textiles/apparel
- Other
- Mixed Packaging

End market demand - rigid plastics



- Food Packaging
- Building & Construction
- Automotive
- Consumables
- Industrial Packaging
- Other
- C&I
- Electrical & Electronic
- Medical/hygiene
- Agriculture

# Mechanical PCR demand

Based on 2022 AMI virgin POM data and CEFLEX assumptions



Summary of initial findings from the end market work - **provides detail on estimated:**

- Total virgin polymer demand (AMI) per category
- Non-contact sensitive fraction, as estimated from value chain interviews
- Mechanical PCR demand into this non-contact sensitive fraction
  - rPE + rPP + rPO

Assumes that there is the right quality of PCR available, and at the right price

Separate rPE and rPP data is available, as is the product demand split within the categories

Does not include any contact sensitive applications

	Virgin POM 2022 *	Non-contact sensitive requirement (est. %)	Average Mechanical Recycled Content (est.)
	Mt	%	Mt
Flexible packaging	7.6	44%	1.4
Flexible non-packaging	3.0	80%	0.9
Rigid packaging	4.8	41%	0.6
Rigid non-packaging	6.0	96%	1.6
Semi-flexible packaging	0.2	75%	0.0
Semi-flexible non-packaging	2.2	70%	0.1
<b>Totals / Averages</b>	<b>23.8</b>	<b>63%</b>	<b>4.6</b>

\*AMI data

Note: average recycled content based on interviews with recyclers and converters

# Virgin POM – split by category & polymer - 2022

Product Type & Packaging Status	AMI - Total Virgin POM 2022			Mechanical Recyclate* Potential 2022 (Kt)
	Virgin POM 2022 (Kt)	Contact Sensitive 2022 (%)	Non-Contact Sensitive 2022 (%)	
<b>Flexible</b>	<b>10,600</b>	<b>46%</b>	<b>54%</b>	<b>2,248</b>
Non-Packaging	2,963	20%	80%	862
Packaging	7,636	56%	44%	1,386
<b>Rigid</b>	<b>10,752</b>	<b>29%</b>	<b>71%</b>	<b>2,122</b>
Non-Packaging	5,925	4%	96%	1,558
Packaging	4,828	59%	41%	564
<b>Semi-Flexible</b>	<b>2,321</b>	<b>30%</b>	<b>70%</b>	<b>152</b>
Non-Packaging	2,167	30%	70%	118
Packaging	153	25%	75%	35
<b>Grand Total</b>	<b>23,673</b>	<b>37%</b>	<b>63%</b>	<b>4,523</b>

**\*As much rPolymer needed for flexibles as for rigids**

- More for Flexible packaging than non-packaging
- More for Rigids packaging than non-packaging

Polymer Type & Packaging Status	AMI - Total Virgin POM 2022 (Kt)	Contact Sensitive 2022 (%)	Non-Contact Sensitive 2022 (%)	Mechanical** Recyclate Potential 2022 (Kt)
<b>LDPE</b>	<b>3,672</b>	<b>33%</b>	<b>67%</b>	<b>976</b>
<b>LLDPE</b>	<b>4,544</b>	<b>36%</b>	<b>64%</b>	<b>932</b>
<b>PP</b>	<b>9,290</b>	<b>42%</b>	<b>58%</b>	<b>1,036</b>
<b>Flexible</b>	<b>2,386</b>	<b>81%</b>	<b>19%</b>	<b>120</b>
Non-Packaging	205	0%	100%	44
Packaging	2,181	88%	12%	76
<b>Rigid</b>	<b>5,204</b>	<b>24%</b>	<b>76%</b>	<b>880</b>
Non-Packaging	3,376	6%	94%	655
Packaging	1,828	59%	41%	225
<b>Semi-Flexible</b>	<b>1,700</b>	<b>41%</b>	<b>59%</b>	<b>36</b>
Non-Packaging	1,547	43%	57%	1
Packaging	153	25%	75%	35
<b>Grand Total</b>	<b>23,673</b>	<b>37%</b>	<b>63%</b>	<b>4,523</b>

**\*\*Less rPE rigid than rPE flexible needed**

- \*\*Significant higher demand for rigid rPP than flexible rPP**
- More non-packaging Rigid

# Mechanical PCR pathways

## Comparison of potential rPE and rPP addressable end markets



Recycled polymer type	Source material for PCR	Flexible			Rigids			Semi-flexible	
		Packaging		Non-packaging	Packaging		Non-packaging	Packaging	Non-packaging
		CS	nCS	nCS	CS	nCS	nCS	nCS	nCS
rPE	Flexible plastics	+	++	++	+	+	+		?
	Rigid plastics	+			+	++	++		
	Semi-flexible plastics	+			+	?	?		+
rPP	Flexible plastics	+	+	+	+	++	++	?	+
	Rigid plastics	+			+	++	++		
	Semi-flexible plastics	+			+	+	+	+	++

### rPE

primary opportunity for mechanical PCR is back into flexible applications, with some potential use in rigid and semi-flexible products

### rPP

some opportunity for mechanical PCR into flexible applications (limited to labels and textile packaging, predominantly), but greater opportunities into rigid and semi-flexible products

CS = contact sensitive applications

nCS = non-contact sensitive applications

+ = demand for mechanical PCR limited by market size, technical quality    ++ = larger market opportunity for mechanical PCR

+ = chemical PCR required to service this market

? = more investigation of PCR demand, quality and pathway required

# State of Play of Chemical Recycling in Europe

&

## CEFLEX yields / feedstock analysis

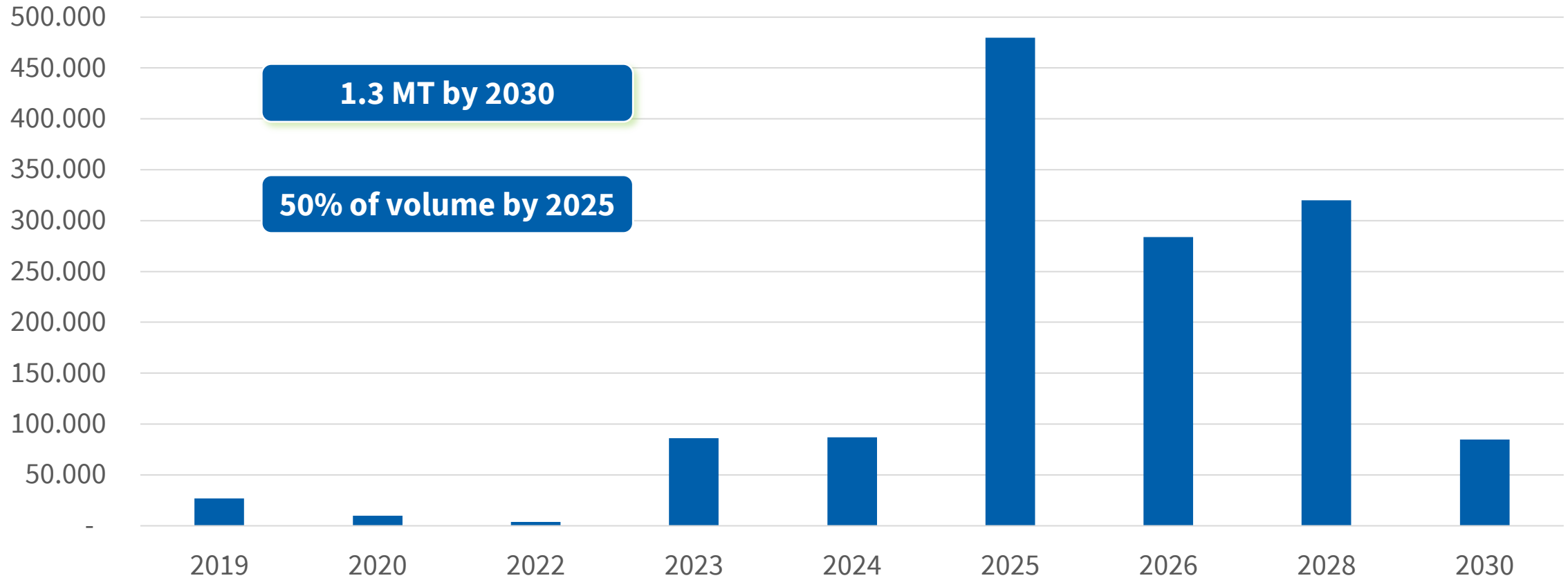


# Existing and planned capacities

## Pyrolysis and other thermal CR - by year



Chemical Recycling Europe - Volume growth







# Building a chemical recycling project



## 1. Why - lack of credible and unified data on chemical recycling

- Distil and present the facts on chemical recycling (CR) of polyolefins today on which to build understanding, consensus and transparency for industry, legislators and NGO's, spur further progress

## 2. What - CEFLEX multi-stakeholder CR project to:

- **Credible, shared data to show the real-world impact and required capacity of chemical recycling and provide a comparative benchmark with MR**
- **Provide a comparative benchmark with mechanical recycling**

## 3. The work done – Approach, data and analysis

- Build a simple model with which to communicate industry representative information/facts
- Populate model with information & real data made available to CEFLEX team
- Get feedback from CR providers on the model and fine tune it
- Quantify level of alignment

# CEFLEX'S Chemical Recycling 1<sup>st</sup> Project



## Key insights

1

**CR mass yield is between 66%-75% of MR mass yield**

2

**Like in MR, each CR technology needs specific feedstock composition to ensure economic viability**

- Pre-processing PO Content 65-85% (bale from MRF)
- Pyrolysis PO content 85-95% (material into pyrolysis reactor)

3

**Economics of CR are yield-based and yield-sensitive, as they are for MR**

### **In addition:**

- CR has its own specific requirements (at elemental composition level) which MR does not require, and for this pre-treatment prior to pyrolysis reactor is important and specific to each technology provider



## CEFLEX'S Chemical Recycling Project



### Key conclusions

1. **CE4FP can be realized if both MR and CR outputs are in alignment with the end markets demand, therefore complement each other**
2. **D4ACE implementation is the pre-requisite to economic viability of both MR and CR**
3. **EPR schemes have a key role in the repartition of the feedstock between MR and CR and, in alignment with the D4ACE and end markets demand**



# Recycling Capacities Projections



# We ask: required capacities to meet PPWR targets?



From what we know



To how we forecast

## The projected capacities for growth\*

- CR, MT: 1 (Reduction), 1.1 (Low Growth), 5.4 (Full Circularity); (0.6-1.5)
- MR, MT: 1.9 (Reduction), 2.3 (Low Growth), 6.4 (Full Circularity); (1.4-8.6)

## The estimated 2022 PCR content\*\*

- It is available for all end markets (packaging and non-packaging, flexible and rigid)
- It is estimated at 4.6 MT

## The methodology

- Segment MR by type of available or developing recycling technologies (TRL>5-6)
- Define technology match with end market specific requirements
- Align addressable end market volumes with required capacities to reach PPWR target

\* Based on CEFLEX's Möbius FP Recycling Capacities Model output

\*\*Source : CEFLEX Polyolefins End Markets Recyclates Analysis - March 2024

# The answer: needed capacities by technology



## 'Status Quo' Model

## Needed Recycling Capacity

Recycling Technologies Type	Quality Demanded	End Market Addressable Volume, KT 2022	2030 Capacities rPolymer, KT End Markets Reduction	2030 Capacities rPolymer, KT End Markets CE4FP(MR)
Chemical and Other Thermal Recycling	Virgin like (sometimes referred to as food grade)	6,233	1,000	1,300
Mechanical and Physical Recycling	"Prime" quality required "Potentially" Food Grade (The Holy Grail for Advanced MR)	1,054	200	200
	Non Food Grade & technical characteristics allow max % recycle in high value end application	8,948	1,700	6,200
	Non Food Grade & quality for robust applications (established, sometimes limited market demand)			

Addressable market as % of total polymers

69%

### Key data

- 2022 MR FP: 3.25 MT
- 2022 MR rigids: 3.5 MT
- 2030 MR: 1.9-6.4MT

### Question:

- What use for 4.5 MT of extra collected and sorted FP , after recycling?
- How much rPE and how much rPP?

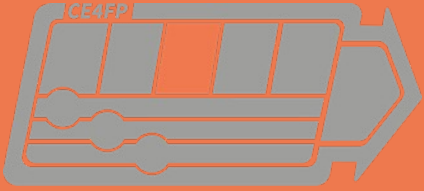
**Over 60% High Quality Recycling**

## The answer:

### Needed capacities by technology

- **Implementation of D4ACE** in household collected FP remains key enabler to growth in offtake of rPolymers (PE and PP) in all end market segments
- **Minimum 1.2 MT capacity input to CR** is needed as soon as possible to achieve 10% recycled polymer in food contact applications
- The currently installed flexibles MR capacity of 3.25 MT **can support reaching PPWR non-contact sensitive targets** if the technology diversifies to deliver high(er) quality recycling for both PE and PP
- **Increased flexibles MR capacity will increase circularity of FP** when the recycled polymer content increases above PPWR targets for both PE and PP

**Future flexible mechanical recycling will have to deliver the type of high(er) quality required by non-packaging applications to realise full use of new capacity**



# Recycling Strategy Recommendations & Enablers



# Recommended capacities\*

<b>Build</b>	1.0-1.5 MT CR capacities; viable feedstock via D4ACE and EPR
<b>Develop</b>	Minimum 250 KT Advanced MR to commercialisation, enabled by new and novel technologies
<b>Grow</b>	From between 1.5MT to approximately 6MT MR capacities with Quality Recycling Technologies (QRP) for PE and PP

\*Capacity of recycling plant, i.e. input material as output from sorting plants

# Recommended technologies

<b>Chemical</b>	<ul style="list-style-type: none"><li>• Pyrolysis</li><li>• Viable feedstock via D4ACE and EPR</li></ul>
<b>Advanced Mechanical</b>	<ul style="list-style-type: none"><li>• Dissolution</li><li>• Advanced decontamination: de-inking, de-lamination, extraction</li><li>• Novel technologies</li></ul>
<b>Mechanical</b>	<ul style="list-style-type: none"><li>• Diversification of Conventional MR into High(er) Quality Recycling of PE and PP</li></ul>

# Recommended action

<p><b>Chemical</b></p>	<ul style="list-style-type: none"> <li>• Legislative clarity on Mass Balance Calculation Method <b>NOW</b></li> <li>• Legislative clarification on CR as Recycling <b>NOW</b></li> </ul>
<p><b>Advanced Mechanical</b></p>	<ul style="list-style-type: none"> <li>• Implementation of D4ACE with mono-material PE and PP</li> <li>• Acceleration of developments towards TRL &gt;7</li> <li>• Novel technologies development</li> </ul>
<p><b>Mechanical</b></p>	<ul style="list-style-type: none"> <li>• Implementation of D4ACE with mono-material PE and PP</li> <li>• Enable/facilitate QRP type processes deployment: facilitate investment</li> </ul>



# Questions and Feedback



Thank you for your interest  
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