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Netherlands



## Chemical Recycling in circular perspective

From vision to action: How Chemical Recycling steers the transition towards a circular and carbon neutral chemical industry

### Challenges & Opportunities



STAKEHOLDEREVENT  
Grenzeloos Circulair Event 2023

Dinsdag 14 november | 11.00 - 18.30 | Eemsdeltahal Delfzijl

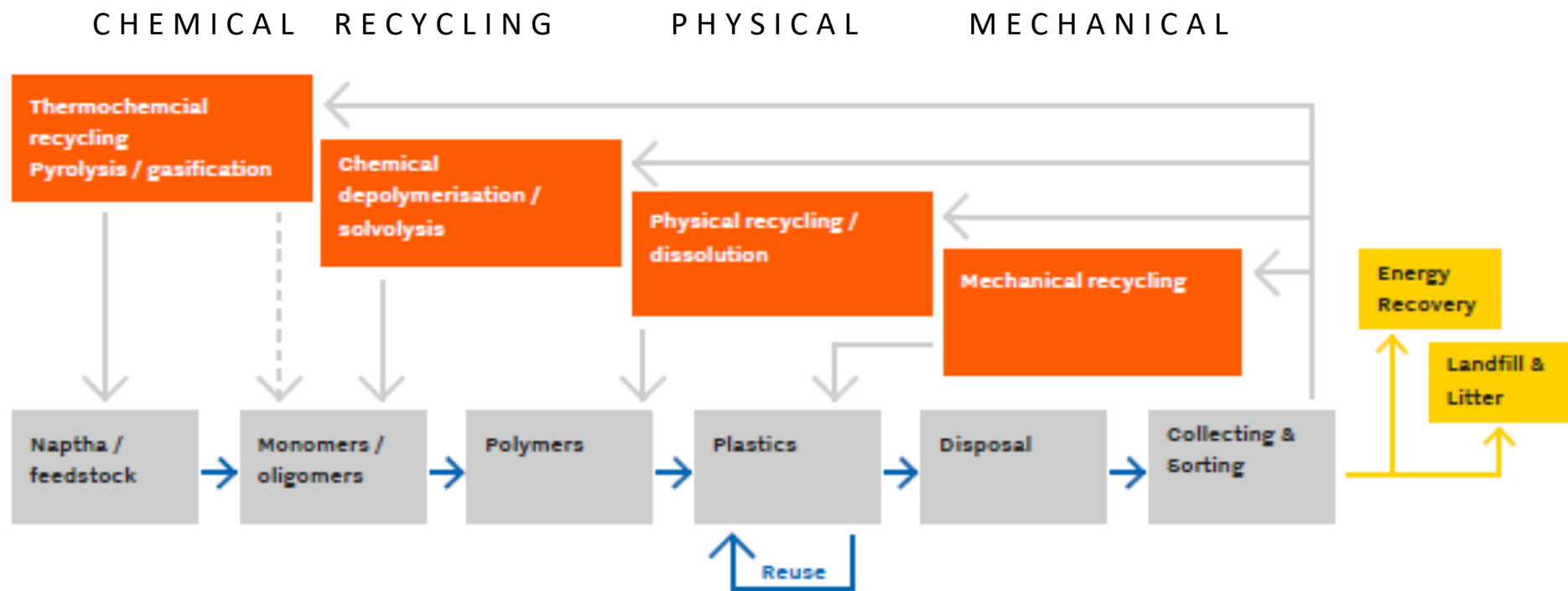


Rijksdienst voor Ondernemend Nederland



Willem Sederel, Chair Circular Biobased Delta

# Chemical Recycling – what is it and why?



Source: Esther van den Beuken, JRC Technical Report - Environmental and economic assessment of plastic waste recycling (2023)<sup>10</sup>

# Chemical Recycling – what is it and why?



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## › **LIMITS OF MECHANICAL RECYCLING :**

- **difficulties to handle multilayers products**
- **deinking / discoloration of plastics**
- **food contact for most polymers (PP, PE, PS)**
- **desodorisation of recycled plastics**
- **removal of forbidden substances (REACH, POP, RoHS)**
- **severe limitations for mixed plastics**
- **gradual degradation of properties at each cycle**

# Chemical Recycling Options



Circular Solutions	Chemical recycling	Options	Examples
 <p><b>A circular economy for plastics</b> Lets turn challenges into opportunities</p>	 <p><b>by Chemical or Thermal Route</b> Catalytic or Non-Catalytic</p>	<p>Solvolysis</p> <p>Depolymerisation</p> <p>Pyrolysis</p> <p>Gasification</p> <p><b>Top to bottom</b> More Energy Less CO2 saving</p>	<p>PET, PU, Nylon</p> <p>PS, PMMA</p> <p>HDPE, LDPE, PP</p> <p>RDF, SRF (waste)</p> <p><b>Top to Bottom</b> Lower Feedstock Quality needed</p>

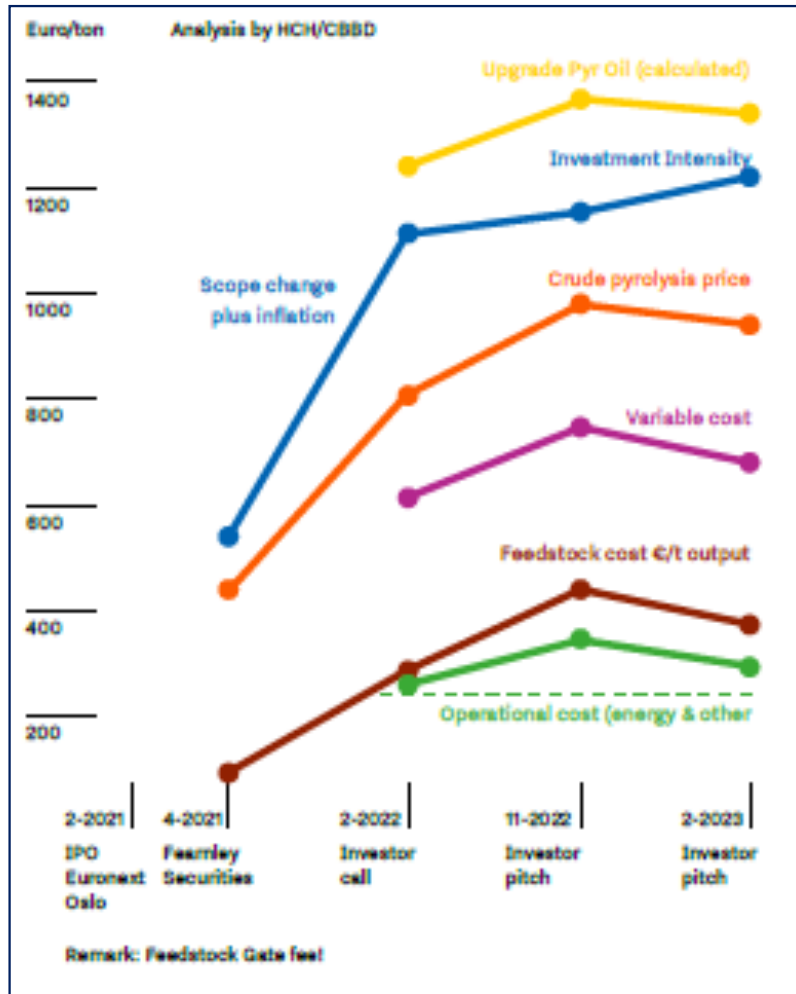
Chemical Recycling partnerships for upscaling in the Dutch ecosystem.

Technology provider Innovative SME	Chemical Corporate partner	CR (*)	Location CR-Plant (**)	Timing	Scale (Kt waste)
Plastic Energy (UK)	SABIC	P	Geleen	Q1 2024	20
Blue Alp	Shell	P	Moerdijk	2024	35
Pryme	Shell	P	Rotterdam	2023	40
Mura (UK)	Dow NL	H-P	Teesside	2023	20
Mura	Dow NL	H-P	Böhlen (D)	2024 (FID)	120
Fuenix Ecology	Dow NL	P	Weert	2023	15
Clariter	Teijin	P	Delfzijl	2024	60
Alterra	Neste	P	Vlissingen	2025	55
Ioniqa	Indorama	S	Geleen	2020	10
Ioniqa	Koch TS	S	Several	>2024	Roll out
Cure Tech	Niaga Covestro	S	Emmen	2023	25
BioBTX/Agilyx	Teijin	C	Delfzijl	2027	50
Synova	SABIC	C	tbd	2025 (FID)	50
Synova	Trinseo	D	Tessenderlo (B)	2024	15
Gidara	BP	G	Amsterdam	2024	175
Gidara	PoR	G	Rotterdam	2025/2026	180
Enerkem	Shell	G	Rotterdam	2023/2024	360

Source: Analysis by expert team Circular Biobased Delta

The Dutch  
Eco-system  
and best  
practices for  
Chemical  
Recycling





# Pryme Business Case: Industrial validation of scale, commissioning Q2-23



Source: Analysis by expert team Circular Biobased Delta

- Feedstock cost moved between 300-400€/t
- Energy and other operational cost moved between 310-375€/t
- Total Opex was between 600-800€/t for crude pyrolysis oil
- Sales price of crude pyrolysis oil was 800-1000€/t, leaving a 200€/t margin
- Upgrading of the pyrolysis oil via hydrotreating is estimated at 400€/t
- Sales price of upgraded pyrolysis oil (naphtha quality) was 1200-1400€/t
- Price moves up and down with energy and naphtha cost
- Capex has the tendency to go up over the project timeline.

# The Circular Biobased Delta eight pack How to de-risk Chemical Recycling

The Business Case	The Feedstock	The Technology	The Market
			

The Supply Chain	The Impact	The Location	The Policy
			

12: Rating the CBBB eight-pack categories

The Business Case	The Feedstock	The Technology	The Market
Capex Opex Margin ROI Sensitivities	Volume Quality Availability Sustainability Multiple sources	Due diligence Safety Scalability Continuous Process TRL/IP/FTO	Off take agreements Volumes & prices Competitive trends Green premium Time2market

The Supply Chain	The Impact	The Location	The Policy
Reliable supply Cost of transport Transparency Long term contracts Safety storage	Energy intensity LCA (CO2+7other) Which Benchmark Max Integration Avoid Lock-Ins	Location cost factors Close2feedstock/ market Ecosystem/ cluster Ease of permitting Skilled Labour	LT Vision and Strategy Incentives for 1st of kind Government as partner R&D support Active Policy Development

## Risk 1: business case

Is there a sufficiently profitable Business case at scale (longer term) with realistic Investment and Operational costs (including costs for feedstock, energy, etc.)?

## Risk 2: feedstock

Can we use sustainable Feedstock at the right quality for our CR-process at scale from multiple sources? (no single sources)

## Risk 3: technology

Is the Technology safe, scalable (to 100,000 t/yr), continuous, robust with stable operation, is there a realistic chance to become a low-cost producer? Is the plastic-to-plastic yield high enough?

## Risk 4: market

Is there demand for the CR product at current cost and price in the Market with a green premium and acceptable time to market?

## Risk 5: supply chain

Is there a transparent, sustainable Supply Chain with low CO<sub>2</sub> emissions and low health effects for workers, neighbours and other stakeholders?

## Risk 6: environmental impact

Is there a sufficient positive Environmental Impact from the CR-process in terms of CO<sub>2</sub> and other emission reductions versus virgin fossil (not incineration)?

## Risk 7: location

Is the Location attractive in terms of cost, logistics, eco-system, labour market, permitting and proximity to feedstock and market?

## Risk 8: policy

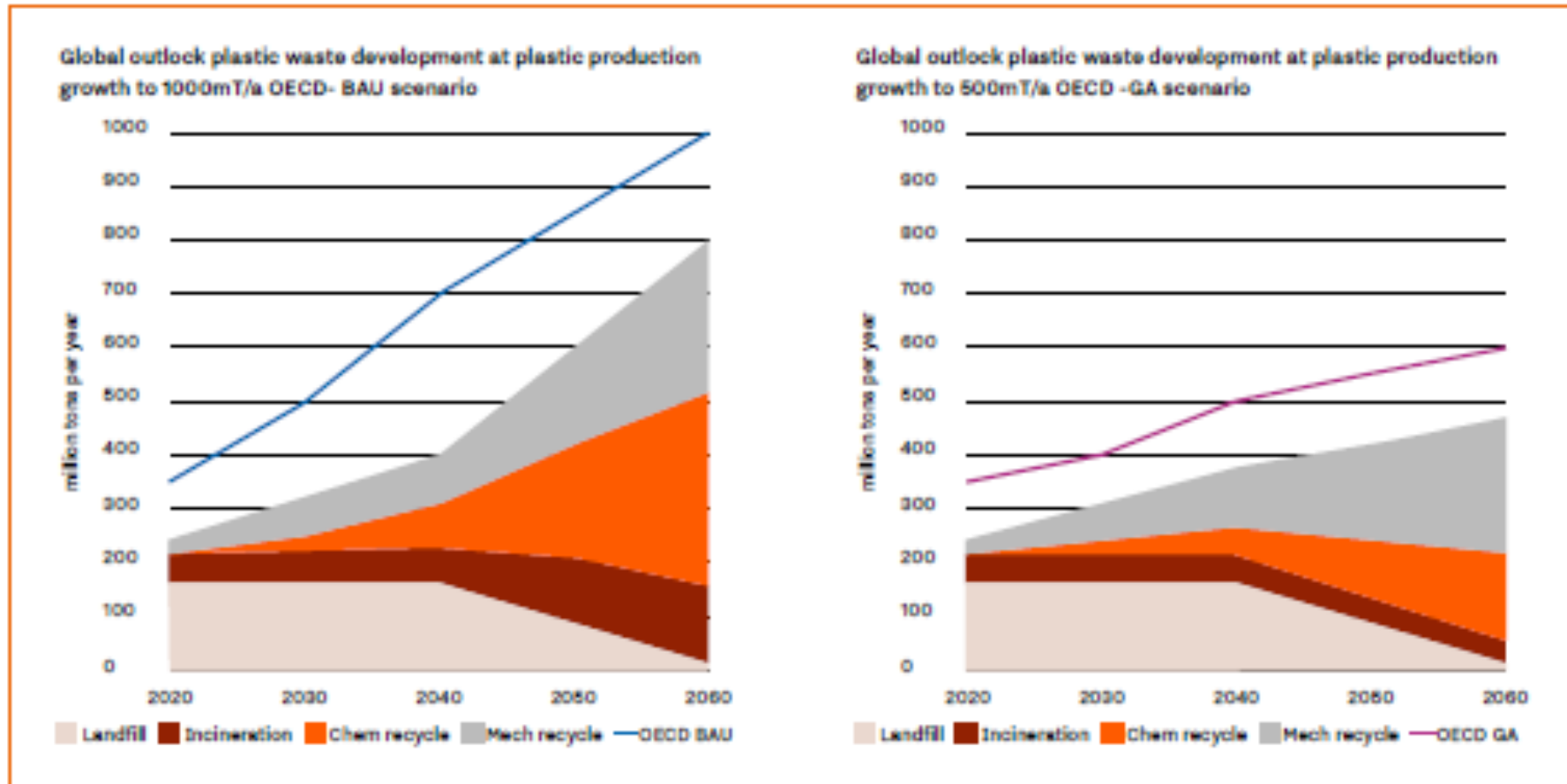
Is there an active and supportive Policy Development to support R&D and 1st of a kind plants with effective instruments? End of waste



## Corporate Commitments waste based and renewable raws -Global view

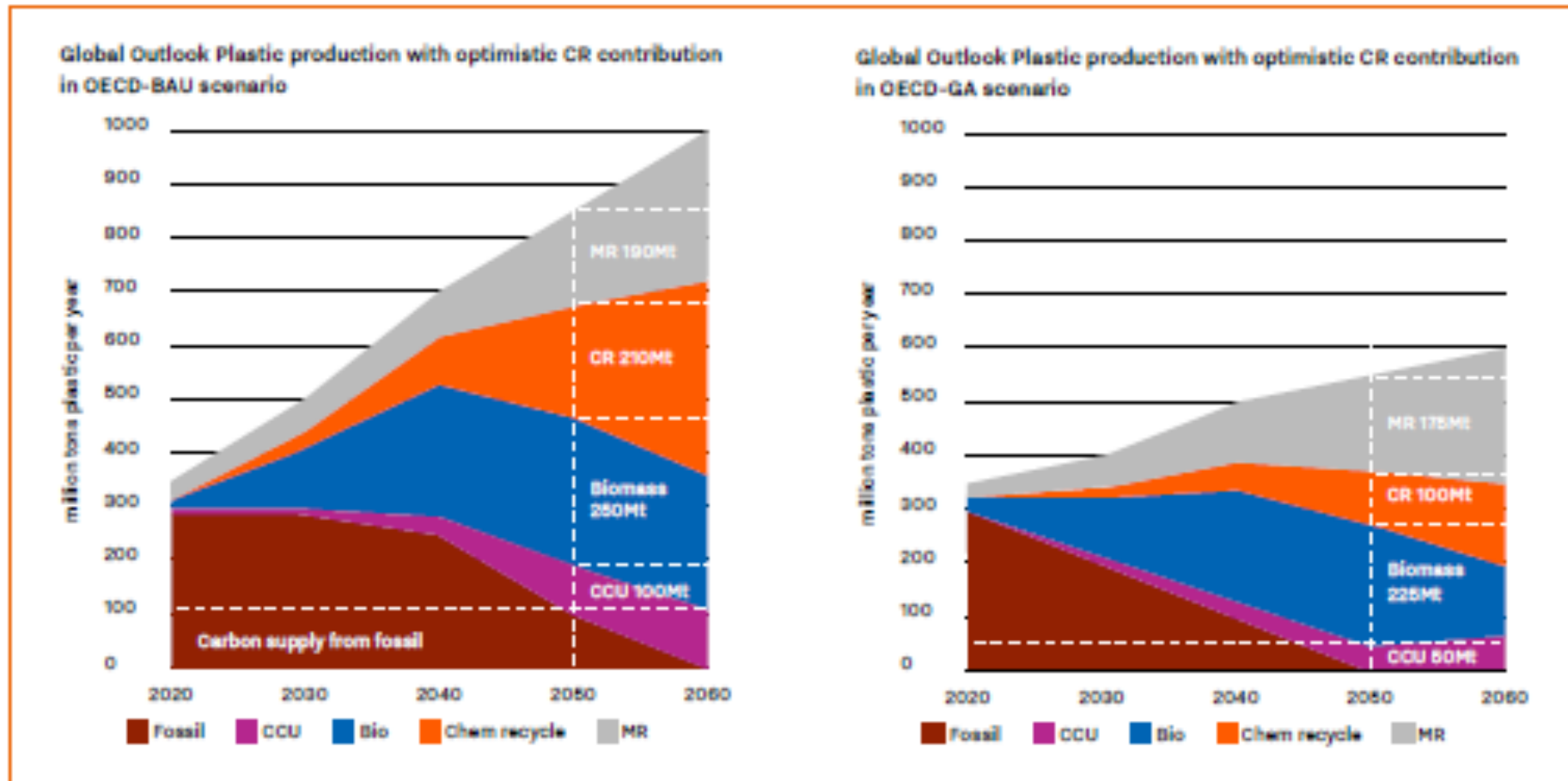
Company	Volume Commitment (t)	Timing	Scope of Commitment
BASF	250,000	2025	mixed plastic waste
Borealis	350,000	2025	mixed plastic waste
DOW	600,000	2030	PRS capacity (waste)
ExxonMobil	500,000	2026	mixed plastic waste
Indorama	400,000	2022	PET-recycle
Indorama	700,000	2025	PET-recycle
Indorama	25% feedstock	2030	PET-recycle
Lyondell Basell	2.000,000	2030	Recover, Revive, Renew
Neste	1.000,000	2030	mixed waste (upgraded)
SABIC	200,000	2025	Trucircle
SABIC	1,000,000	2030	Trucircle (mech, circular, bio)
Shell	1.000,000	2025	mixed waste
Unilever		2025	50% virgin plastic reduction

## Global plastic waste development and growth of MR & CR (2020 - 2060)



Source: Analysis by expert team Circular Biobased Delta

# Renewable and circular carbon development for plastics production



Source: Analysis by expert team Circular Biobased Delta

## Concluding Remarks



### Chemical Recycling in circular perspective

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### Valuable and unique points

- Dimensions as upscaling & innovation, financing, environmental aspects and policies needed
- More than 20 best practices from the Netherlands, showing the real life and transformative application of CR
- Toolboxes and strategic approaches that serve as blue prints to implement effective and sustainable initiatives for CR

Link: <https://hollandcircularhotspot.nl/publications/>



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# Heleen van Wijk

Business manager Circulaire Economie Groningen Seaports

Voorzitter Circulair Groningen



GRONINGEN SEAPORTS





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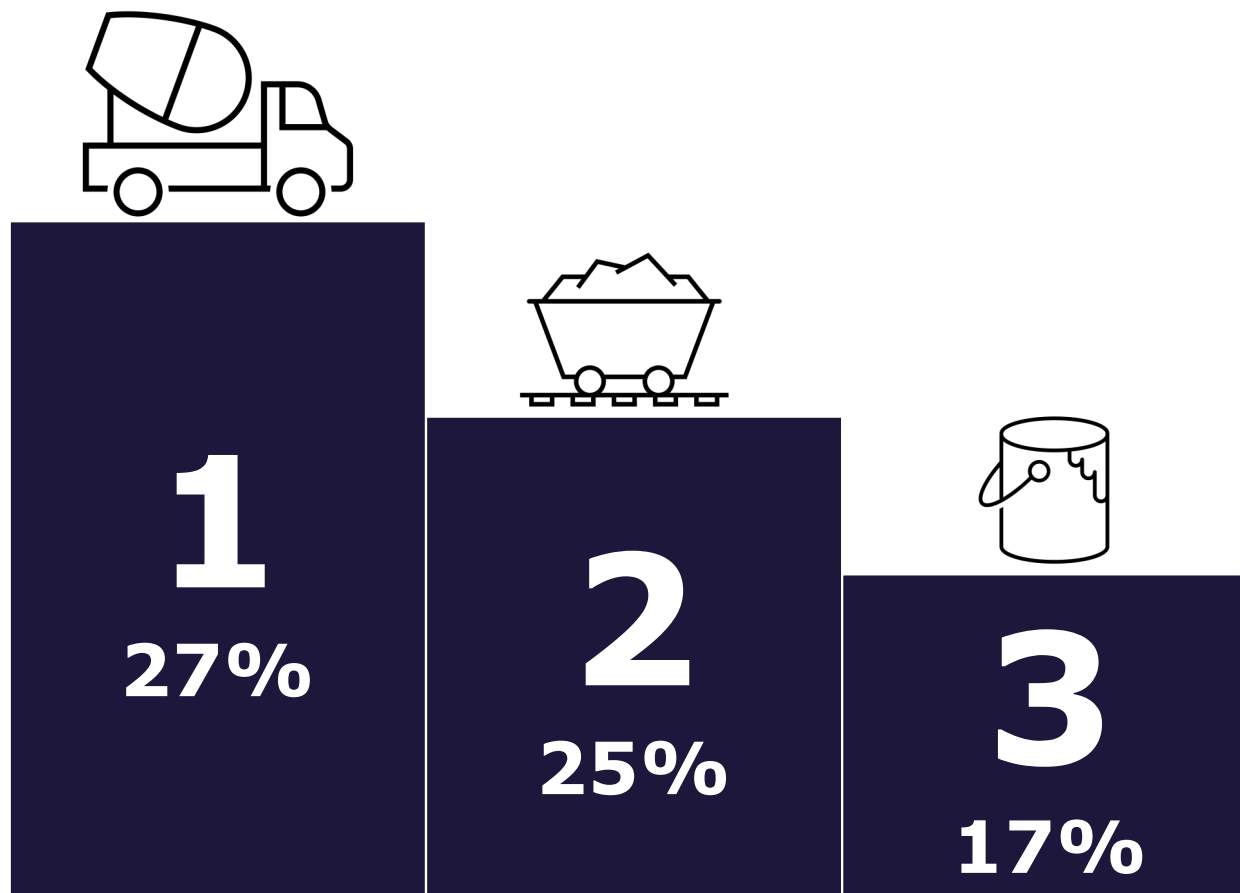
Grenzeloos Circulair  
**High-purity chemicals from plastic waste**

**Jasper Munier**  
**Business Development Director Northwest Europe**

November 14<sup>th</sup>



# Chemical industry: EU's third largest emitter of CO<sub>2</sub>

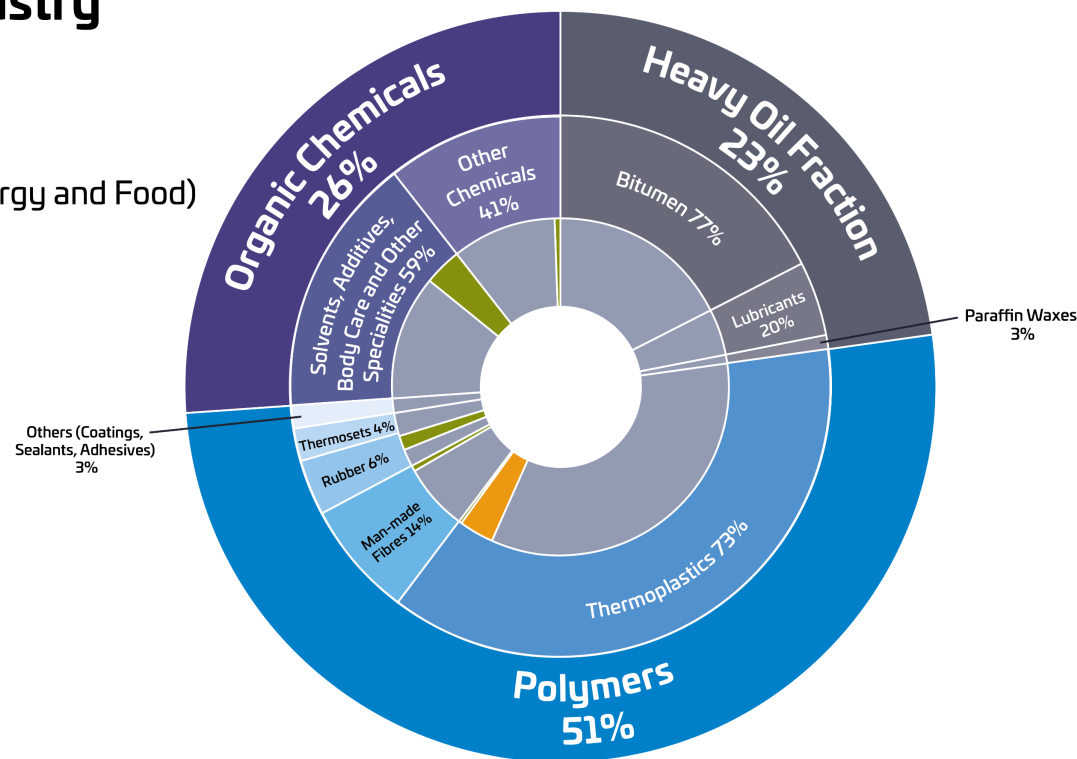


# The elephant in the room: feedstock

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 Reference Years: **2015–2022**

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# Of all the plastic waste, only 15% is used as raw material in the EU

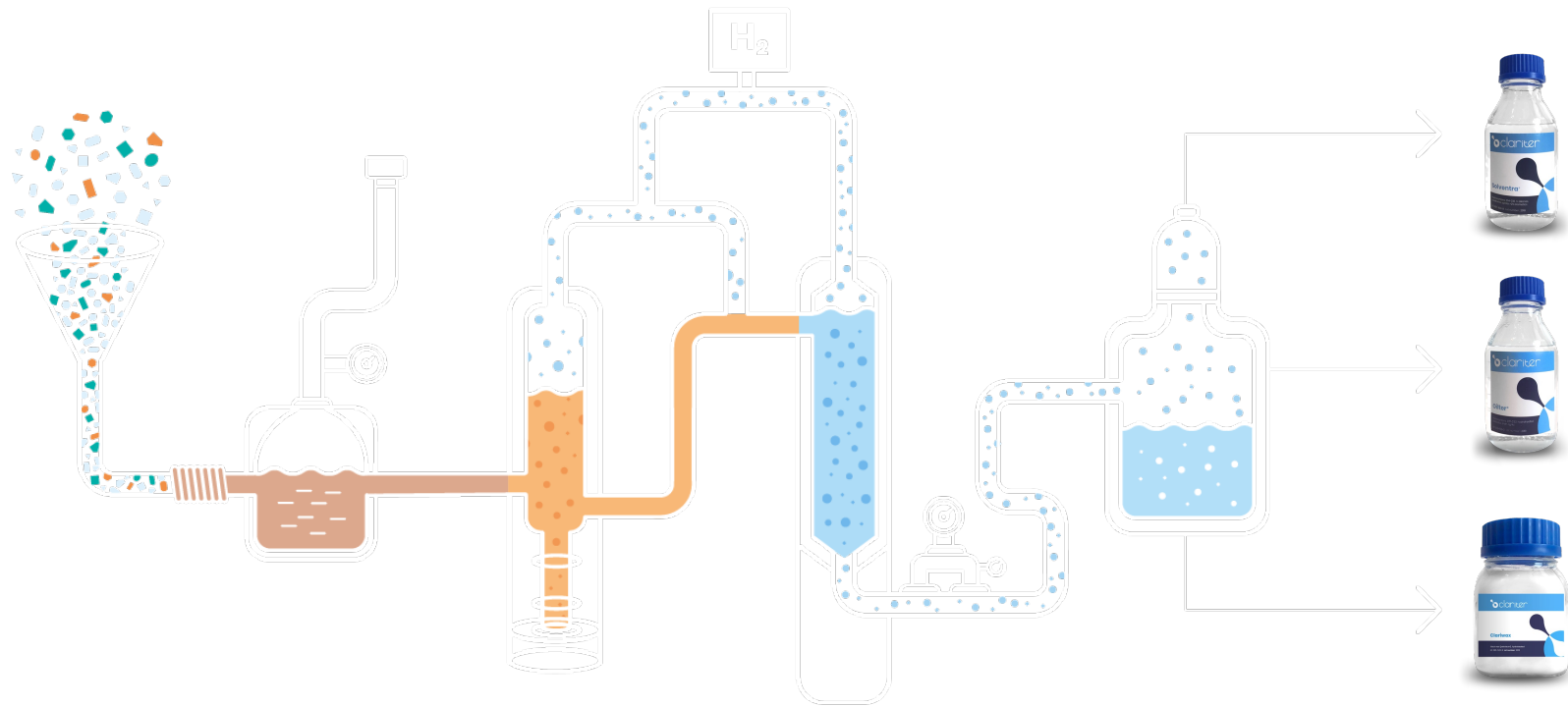
*The rest is being landfilled or burned as fuel*



Source: Plastics Europe Market Research Group (PEMRG) / Conversio Market & Strategy GmbH.  
Estimated data

Image: Ahmed Areef / Alamy Stock





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based petrochemicals

### **Solventra®**

\$3.4B market  
4.5% CAGR

- Paint and ink
- Pesticides
- Polishing products

### **Oilter®**

\$5B market  
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- Lubricants
- Cosmetics
- Personal care products

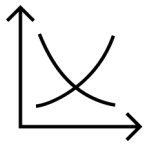
### **Clariwax®**

\$5.4B market  
3.9% CAGR

- Candles
- Fabric softeners
- Coating for food packaging



# Ensuring Pure Feedstock for Chemical Recycling



## Market demand

Implement strict policies on recycled content for chemical products (ESPR)



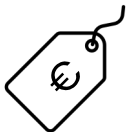
## Collection

Standardize collection processes to minimize contamination throughout Europe



## Sorting

Invest in advanced sorting technologies for effective separation



## ETS

Use ETS to incentivize recycled feedstock prioritization



[Let's connect!](mailto:Jasper.Munier@clariter.com)  
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MARKING CIRCULAR CHEMISTRY POSSIBLE

# Passion for Circular Chemistry

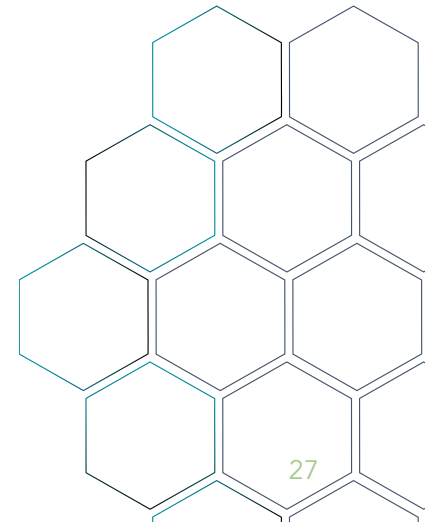
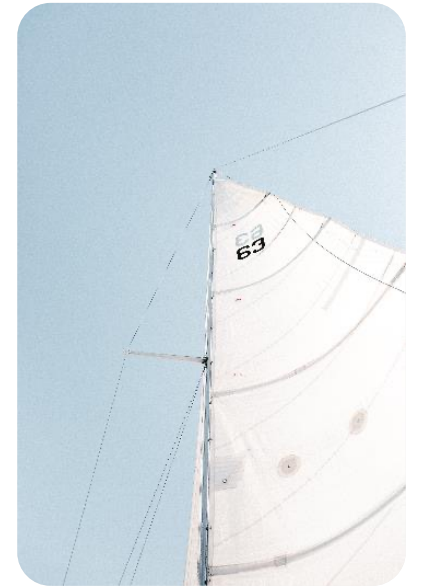
Tijmen Vries

BioBTX

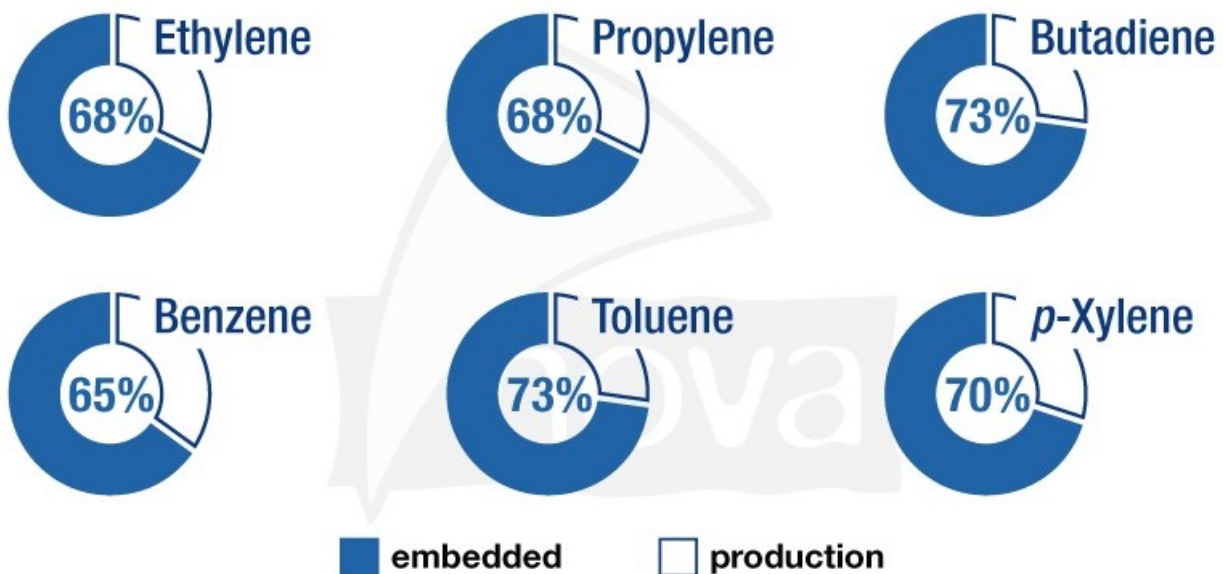
November 2023

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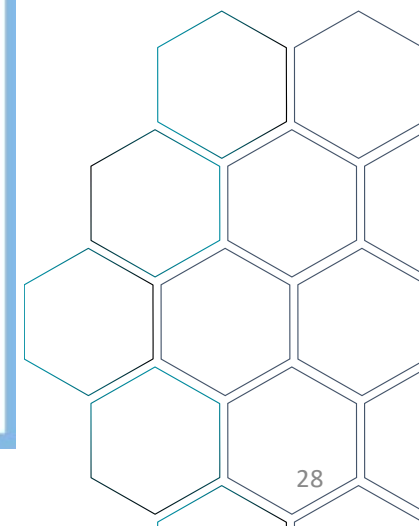
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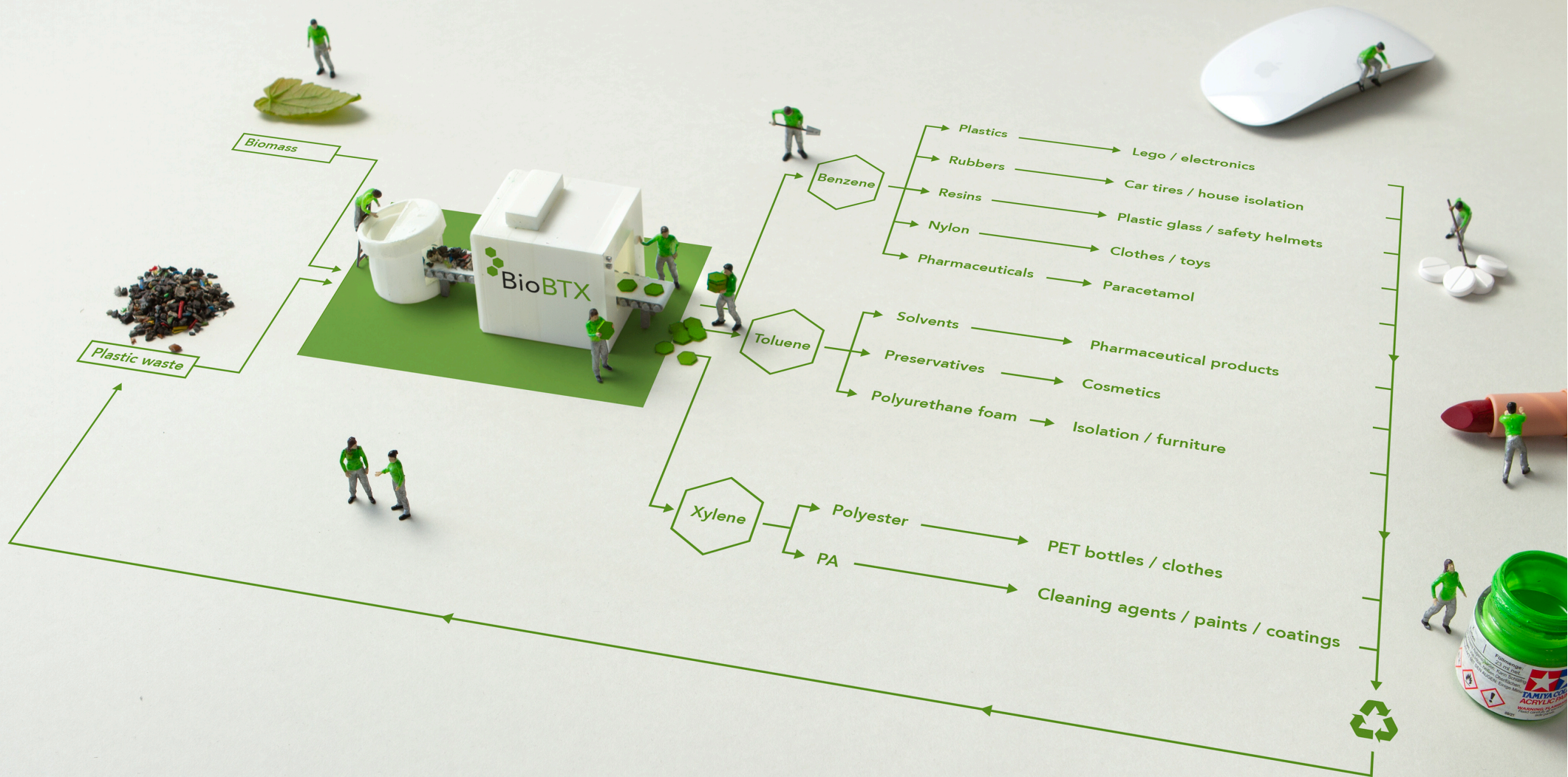


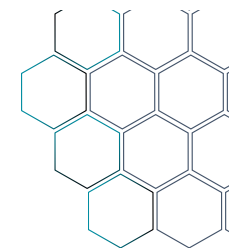
All figures available at [www.renewable-carbon.eu/graphics](http://www.renewable-carbon.eu/graphics)

Ethylene, propylene, butadiene – Calculations by nova-Institute  
Benzene, toluene, p-xylene – Source: BioBTX

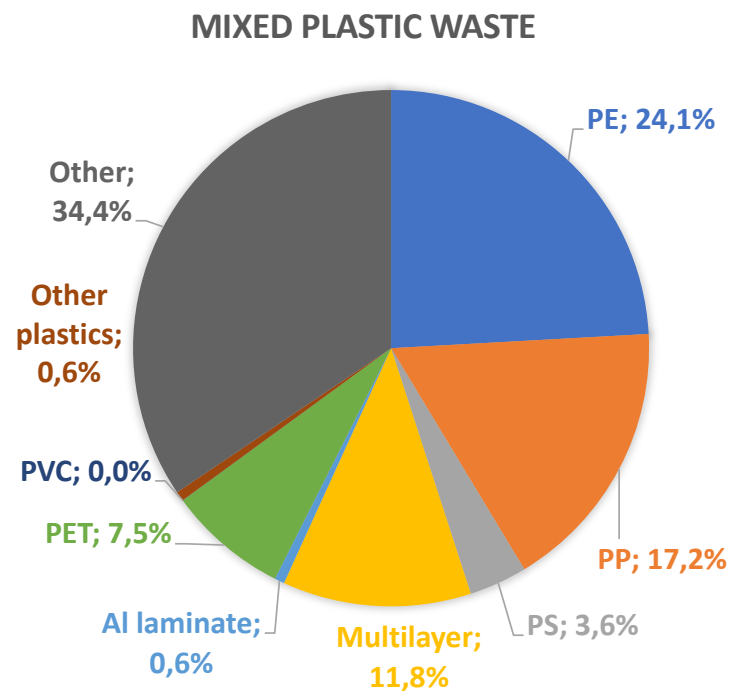
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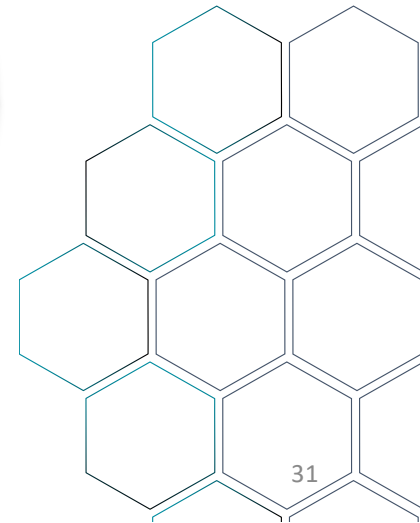
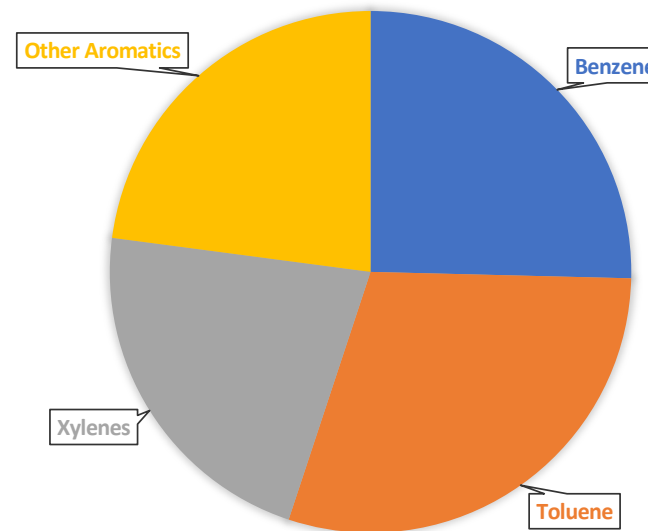
# From Mixed Plastic Waste....



# To Direct Drop-in Chemicals



BIOBTX PRODUCT COMPOSITION



16/11/2023



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MAKING CIRCULAR CHEMISTRY  
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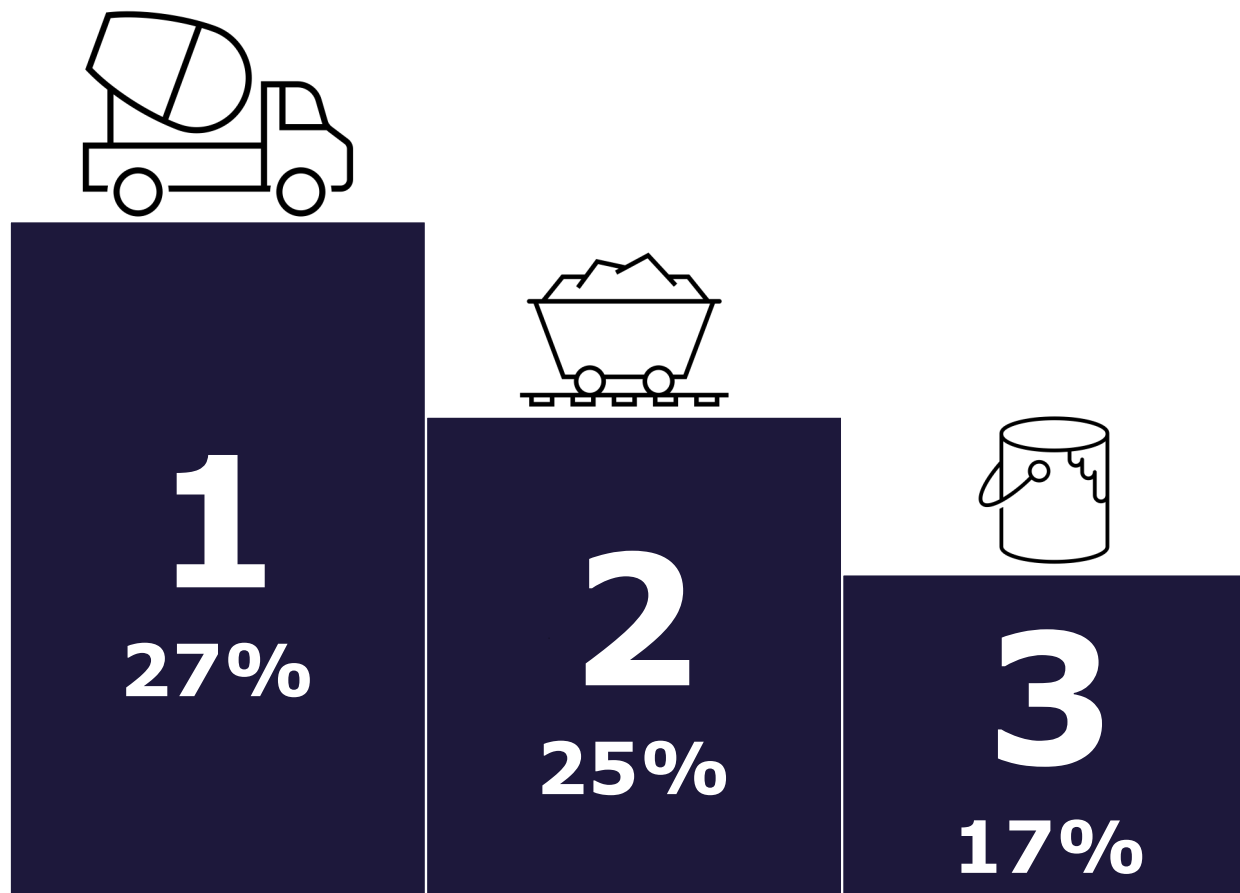


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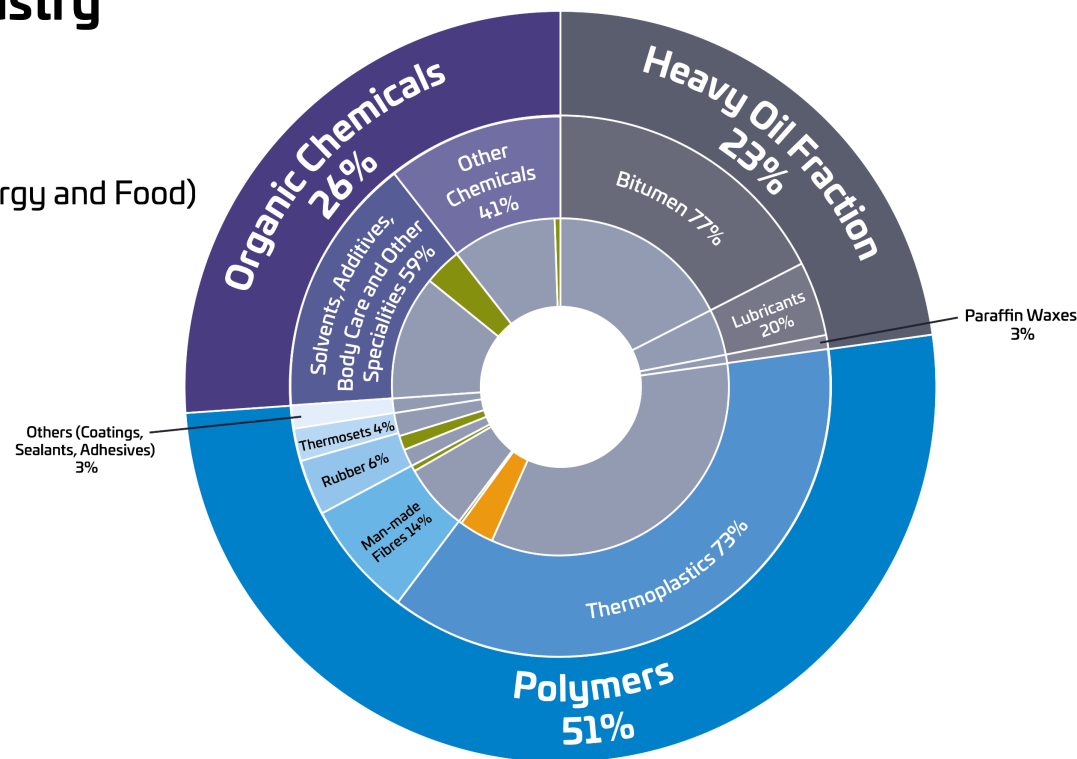


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**29.500.000 ton**

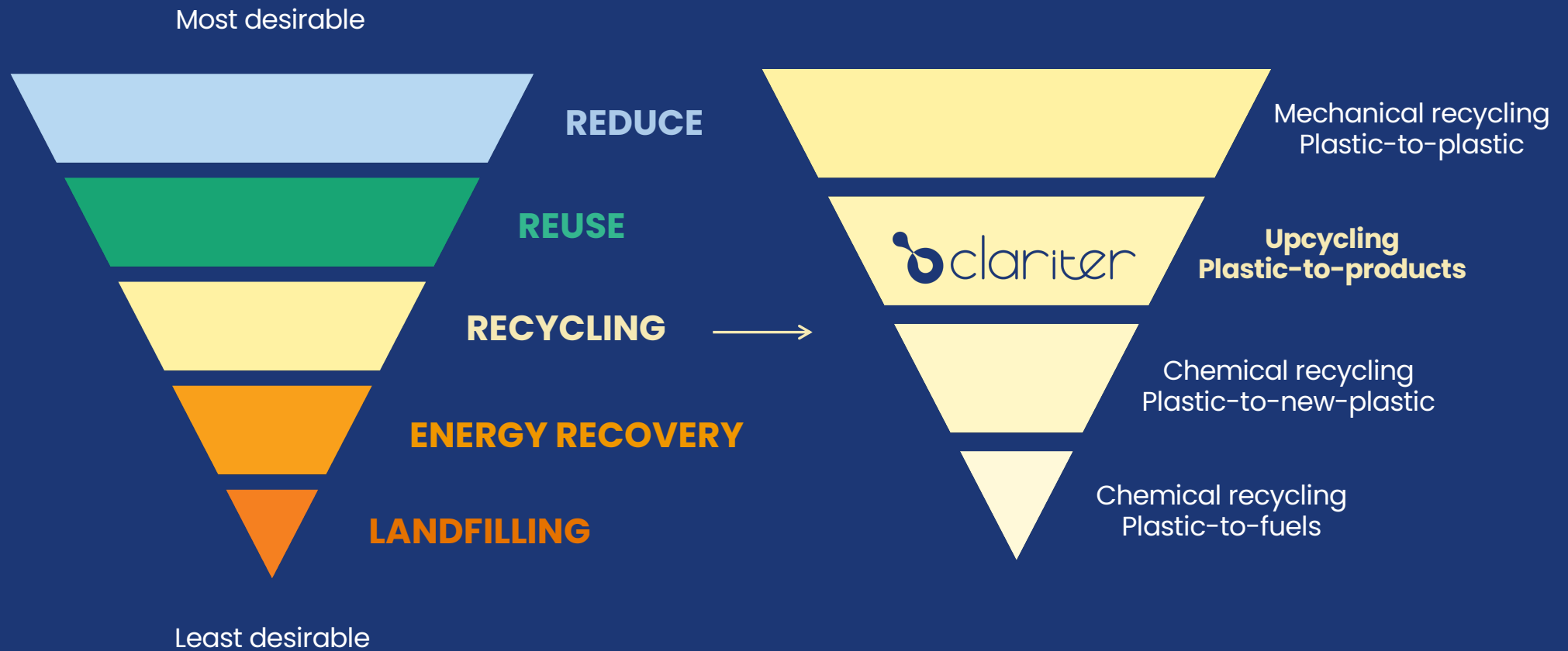


**24.900.000 ton**

Source: Plastics Europe Market Research Group (PEMRG) / Conversio Market & Strategy GmbH.  
Estimated data

Image: Ahmed Areef / Alamy Stock

# Resource efficiency



# Proprietary high-yield chemical upcycling

A patented process that takes a wide range of plastic types and converts low-value plastic waste into high-value products, with ~85% yield.

Feedstock



HDPE



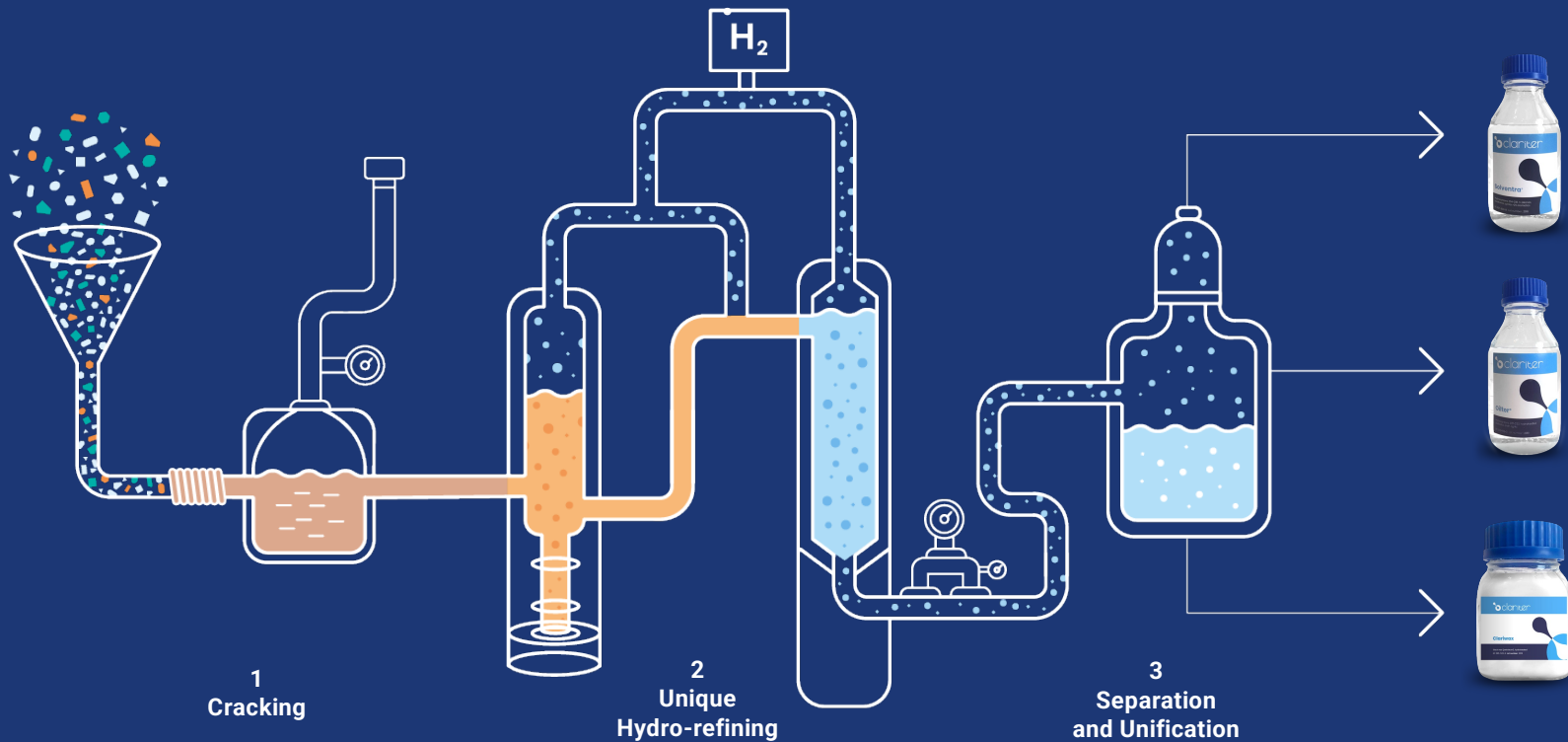
LDPE



PP



PS



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**Solventra®**

\$3.4B market  
4.5% CAGR

- Paint and ink
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**Oilter®**

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- Personal care products

**Clariwax®**

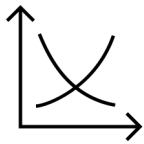
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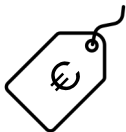
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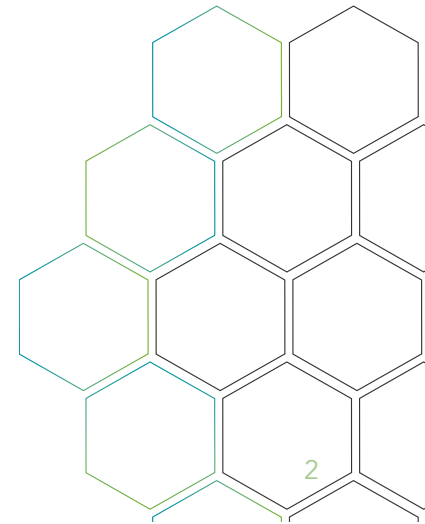
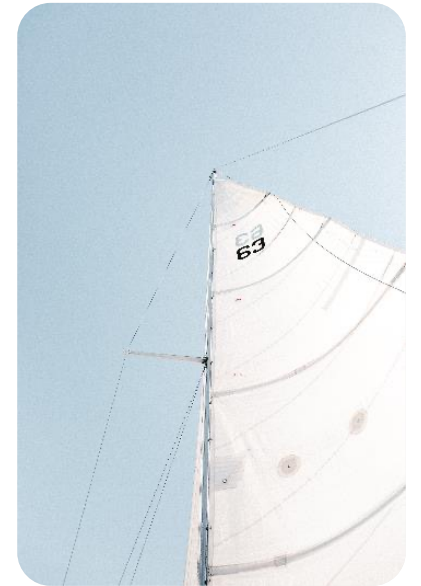
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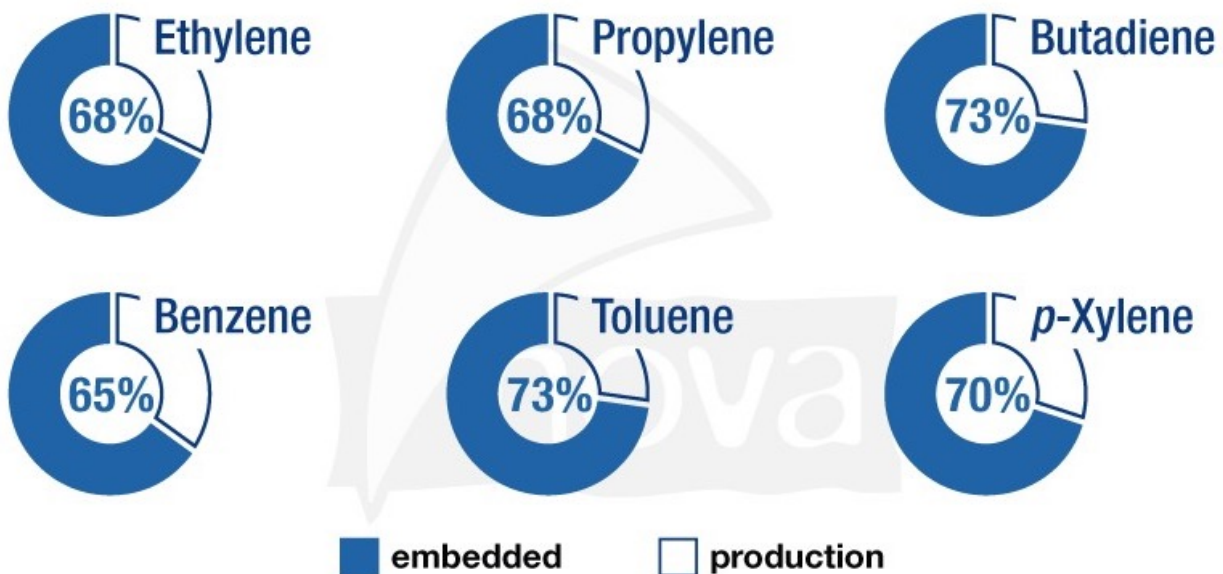
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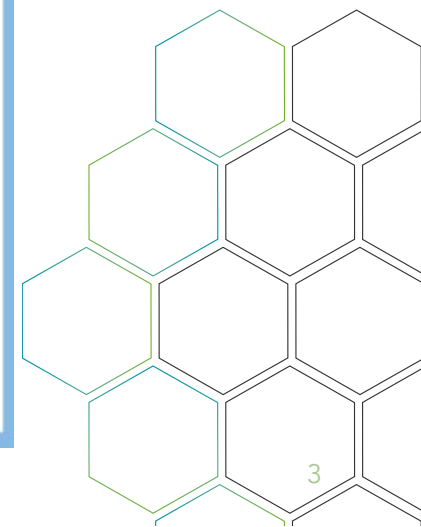
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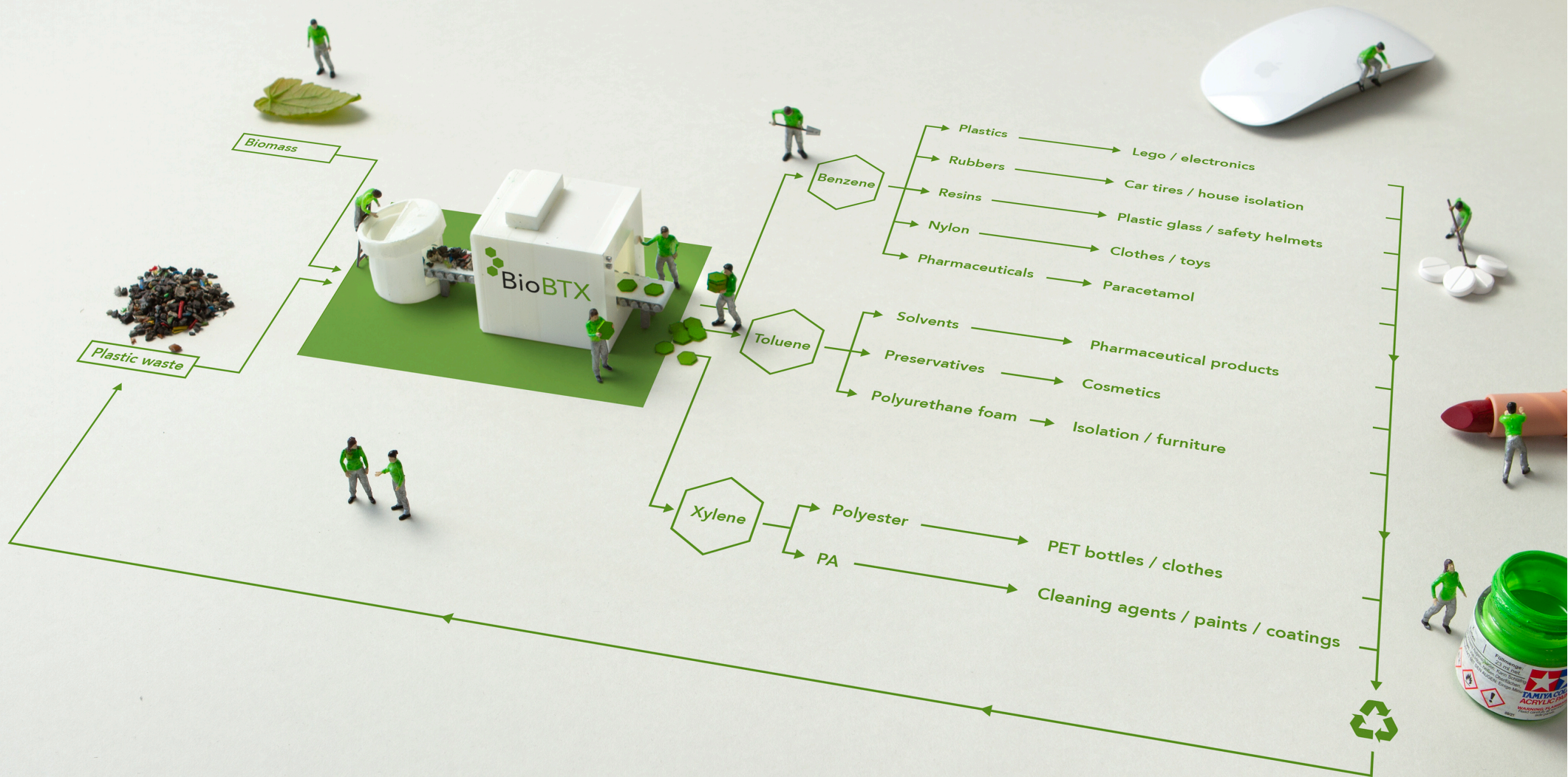


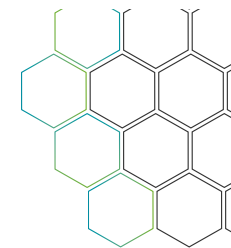
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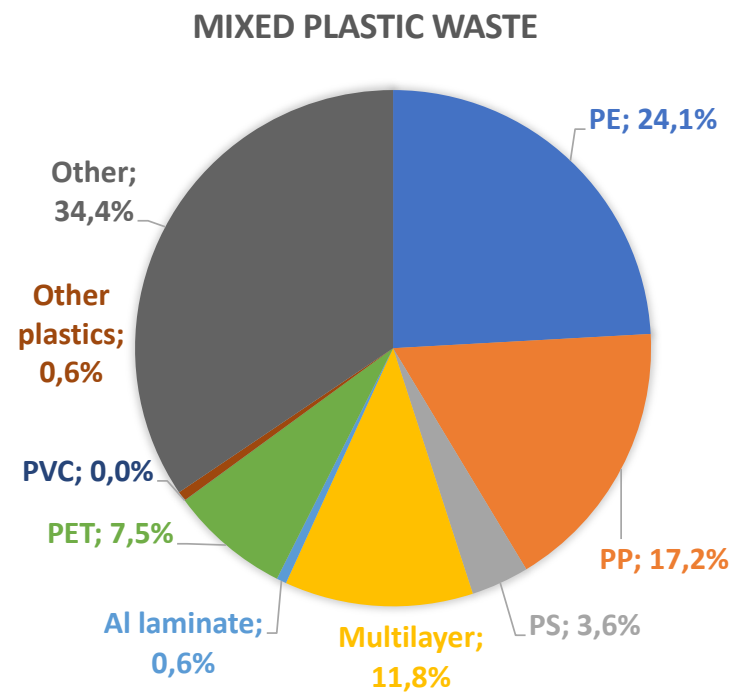
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# From Mixed Plastic Waste....

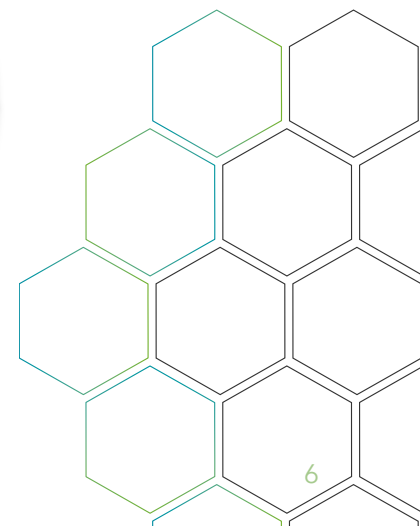
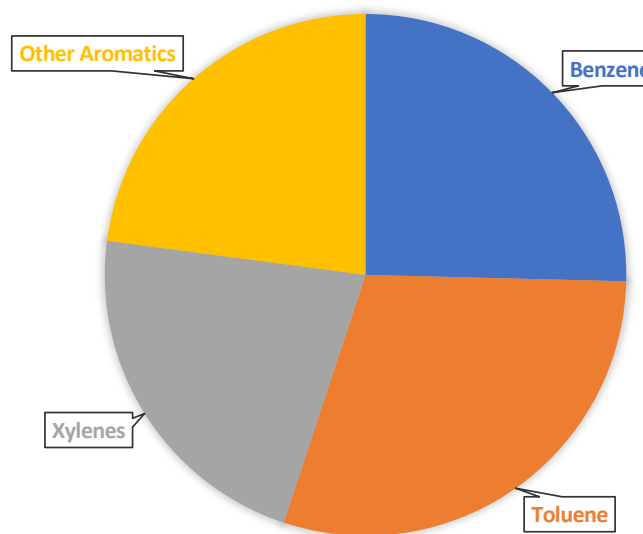




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**Challenges & Opportunities**



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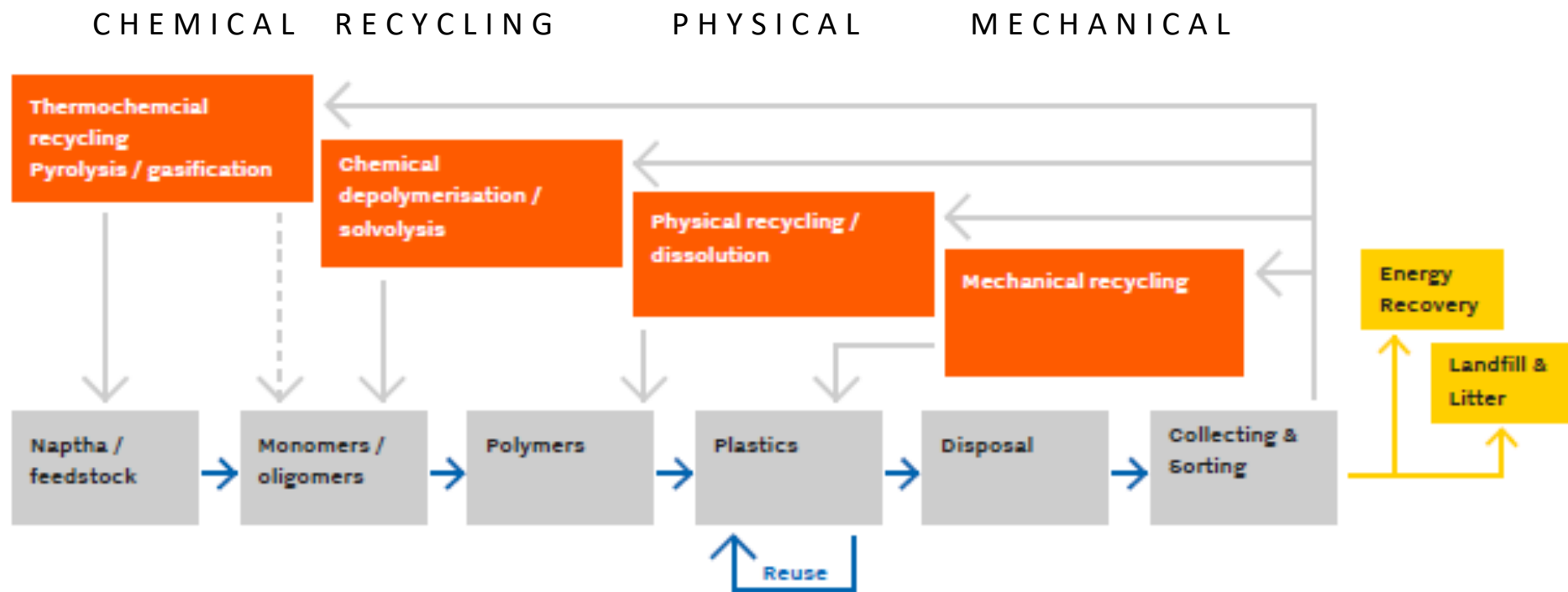


Rijksoverheid  
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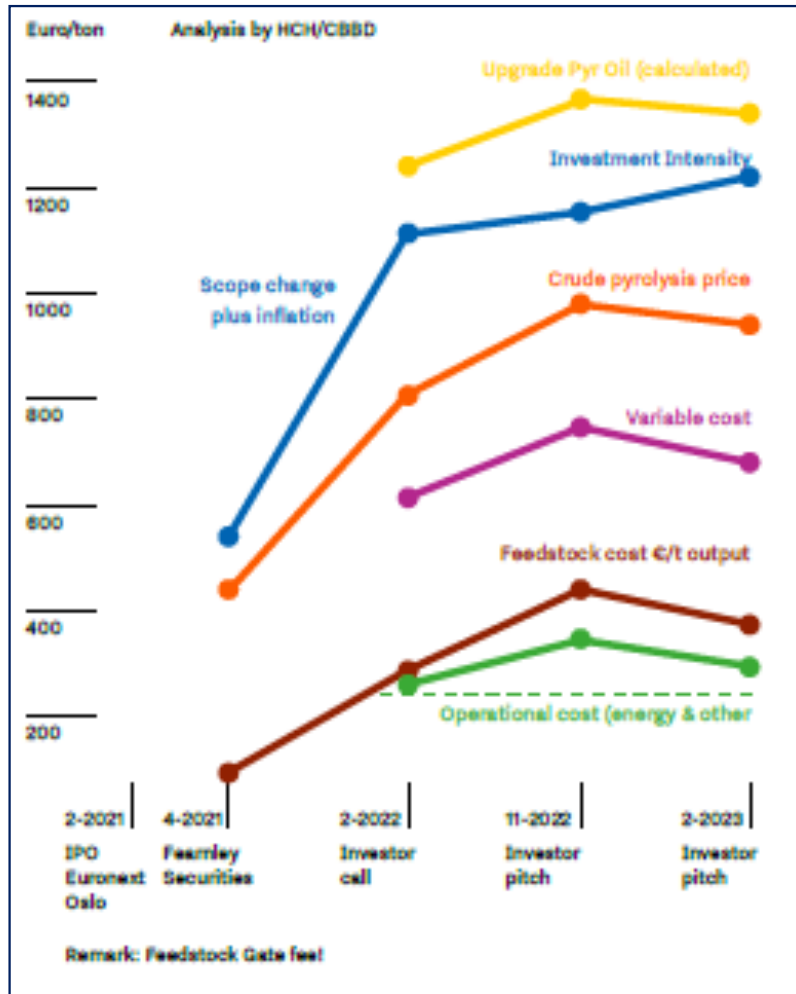
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Alterra	Neste	P	Vlissingen	2025	55
Ioniqa	Indorama	S	Geleen	2020	10
Ioniqa	Koch TS	S	Several	>2024	Roll out
Cure Tech	Niaga Covestro	S	Emmen	2023	25
BioBTX/Agilyx	Teijin	C	Delfzijl	2027	50
Synova	SABIC	C	tbd	2025 (FID)	50
Synova	Trinseo	D	Tessenderlo (B)	2024	15
Gidara	BP	G	Amsterdam	2024	175
Gidara	PoR	G	Rotterdam	2025/2026	180
Enerkem	Shell	G	Rotterdam	2023/2024	360

Source: Analysis by expert team Circular Biobased Delta

The Dutch  
Eco-system  
and best  
practices for  
Chemical  
Recycling





# Pryme Business Case: Industrial validation of scale, commissioning Q2-23



Source: Analysis by expert team Circular Biobased Delta

- Feedstock cost moved between 300-400€/t
- Energy and other operational cost moved between 310-375€/t
- Total Opex was between 600-800€/t for crude pyrolysis oil
- Sales price of crude pyrolysis oil was 800-1000€/t, leaving a 200€/t margin
- Upgrading of the pyrolysis oil via hydrotreating is estimated at 400€/t
- Sales price of upgraded pyrolysis oil (naphtha quality) was 1200-1400€/t
- Price moves up and down with energy and naphtha cost
- Capex has the tendency to go up over the project timeline.

# The Circular Biobased Delta eight pack How to de-risk Chemical Recycling

The Business Case	The Feedstock	The Technology	The Market
			

The Supply Chain	The Impact	The Location	The Policy
			

12: Rating the CBBB eight-pack categories

The Business Case	The Feedstock	The Technology	The Market
Capex Opex Margin ROI Sensitivities	Volume Quality Availability Sustainability Multiple sources	Due diligence Safety Scalability Continuous Process TRL/IP/FTO	Off take agreements Volumes & prices Competitive trends Green premium Time2market

The Supply Chain	The Impact	The Location	The Policy
Reliable supply Cost of transport Transparency Long term contracts Safety storage	Energy intensity LCA (CO2+7other) Which Benchmark Max Integration Avoid Lock-Ins	Location cost factors Close2feedstock/ market Ecosystem/ cluster Ease of permitting Skilled Labour	LT Vision and Strategy Incentives for 1st of kind Government as partner R&D support Active Policy Development

## Risk 1: business case

Is there a sufficiently profitable Business case at scale (longer term) with realistic Investment and Operational costs (including costs for feedstock, energy, etc.)?

## Risk 2: feedstock

Can we use sustainable Feedstock at the right quality for our CR-process at scale from multiple sources? (no single sources)

## Risk 3: technology

Is the Technology safe, scalable (to 100,000 t/yr), continuous, robust with stable operation, is there a realistic chance to become a low-cost producer? Is the plastic-to-plastic yield high enough?

## Risk 4: market

Is there demand for the CR product at current cost and price in the Market with a green premium and acceptable time to market?

## Risk 5: supply chain

Is there a transparent, sustainable Supply Chain with low CO<sub>2</sub> emissions and low health effects for workers, neighbours and other stakeholders?

## Risk 6: environmental impact

Is there a sufficient positive Environmental Impact from the CR-process in terms of CO<sub>2</sub> and other emission reductions versus virgin fossil (not incineration)?

## Risk 7: location

Is the Location attractive in terms of cost, logistics, eco-system, labour market, permitting and proximity to feedstock and market?

## Risk 8: policy

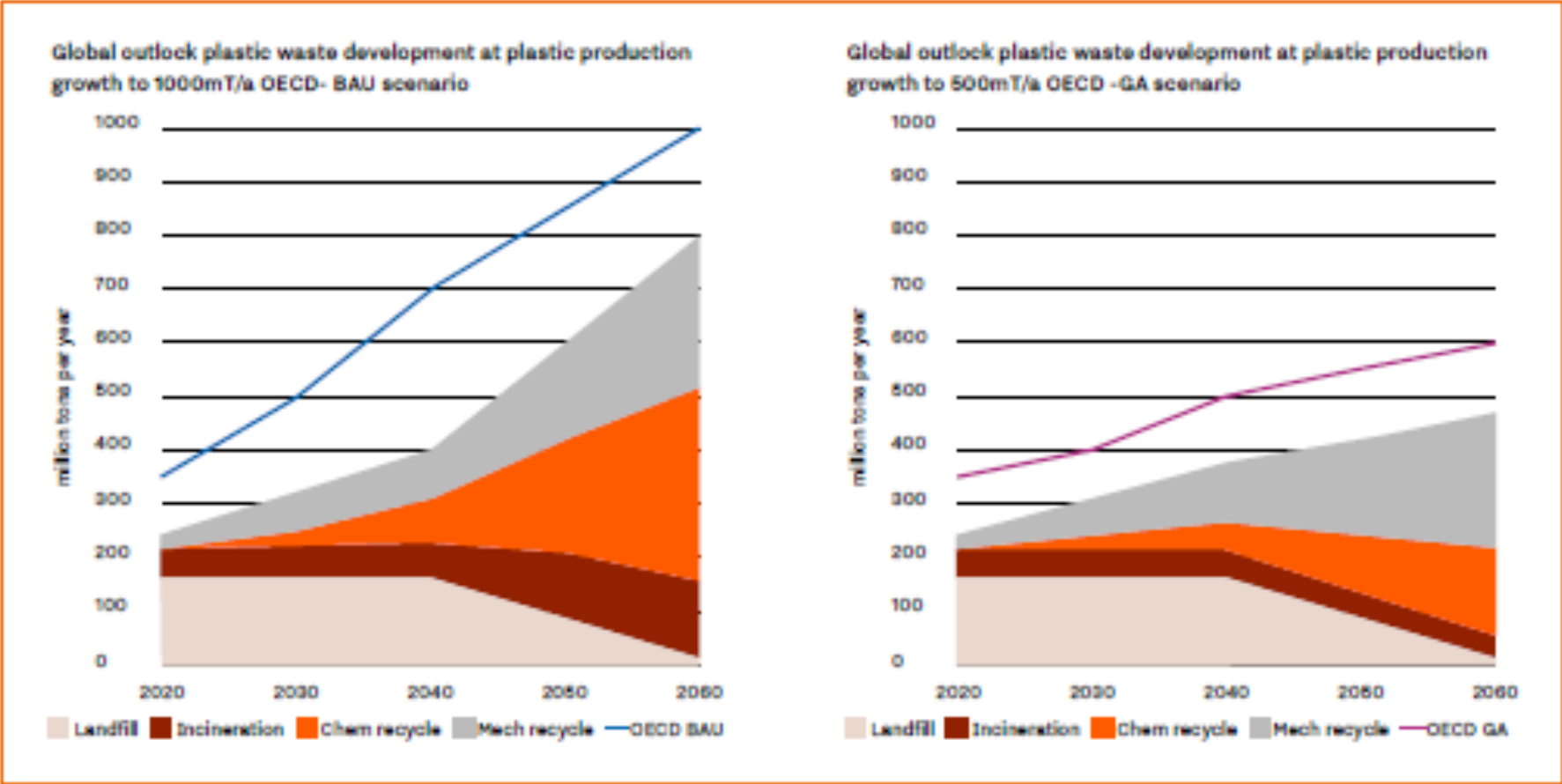
Is there an active and supportive Policy Development to support R&D and 1st of a kind plants with effective instruments? End of waste



## Corporate Commitments waste based and renewable raws -Global view

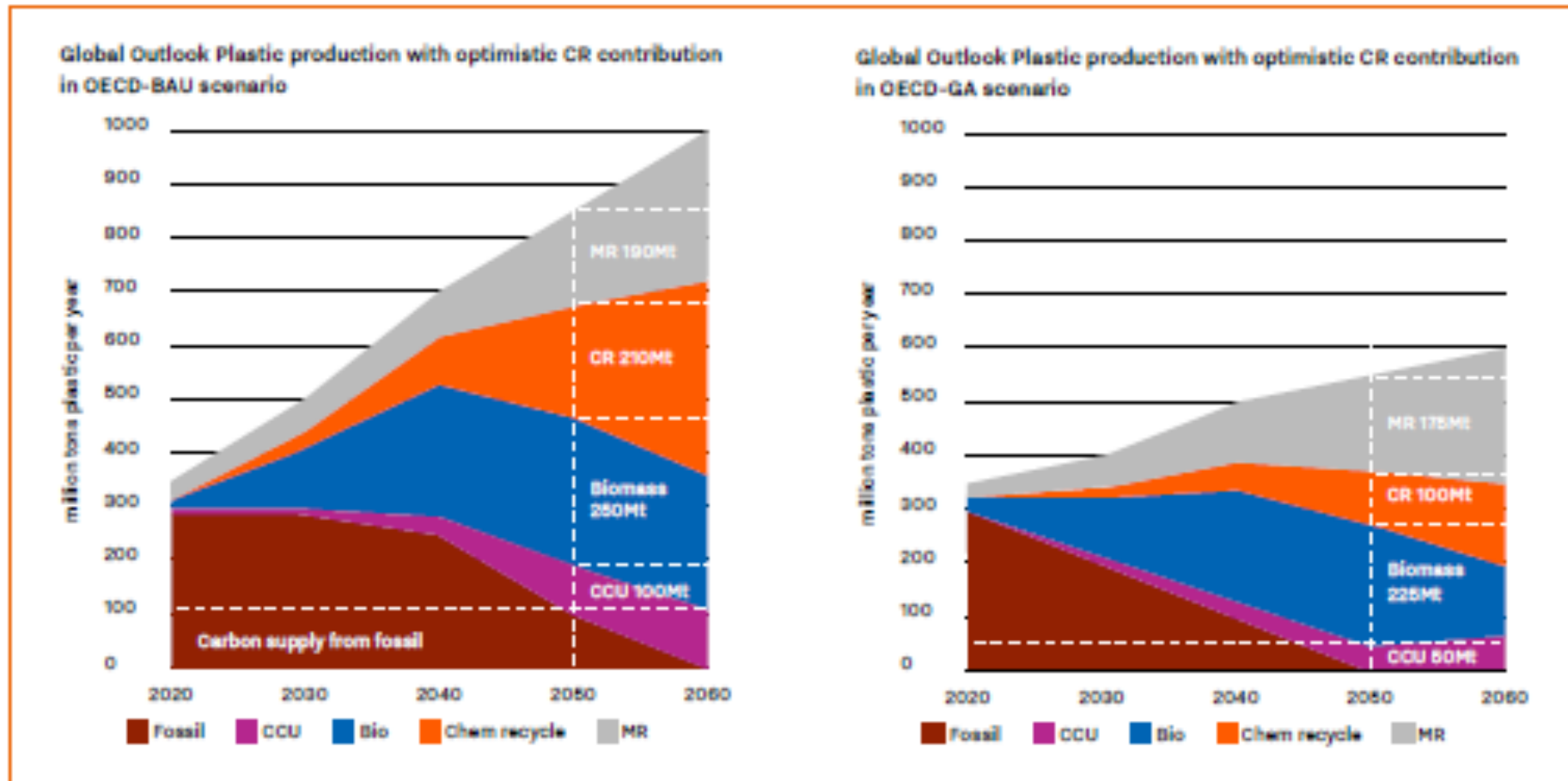
Company	Volume Commitment (t)	Timing	Scope of Commitment
BASF	250,000	2025	mixed plastic waste
Borealis	350,000	2025	mixed plastic waste
DOW	600,000	2030	PRS capacity (waste)
ExxonMobil	500,000	2026	mixed plastic waste
Indorama	400,000	2022	PET-recycle
Indorama	700,000	2025	PET-recycle
Indorama	25% feedstock	2030	PET-recycle
Lyondell Basell	2.000,000	2030	Recover, Revive, Renew
Neste	1.000,000	2030	mixed waste (upgraded)
SABIC	200,000	2025	Trucircle
SABIC	1,000,000	2030	Trucircle (mech, circular, bio)
Shell	1.000,000	2025	mixed waste
Unilever		2025	50% virgin plastic reduction

# Global plastic waste development and growth of MR & CR (2020 - 2060)



Source: Analysis by expert team Circular Biobased Delta

# Renewable and circular carbon development for plastics production



Source: Analysis by expert team Circular Biobased Delta

## Concluding Remarks



### Chemical Recycling in circular perspective

From vision to action: How Chemical Recycling steers the transition towards a circular and carbon neutral chemical industry

### Valuable and unique points

- Dimensions as upscaling & innovation, financing, environmental aspects and policies needed
- More than 20 best practices from the Netherlands, showing the real life and transformative application of CR
- Toolboxes and strategic approaches that serve as blue prints to implement effective and sustainable initiatives for CR

Link: <https://hollandcircularhotspot.nl/publications/>