NEW RECYCLING TECHNOLOGIES

Advancing Circularity in Flexible Packaging

PERSPECTIVES

CEFLEX

May 2025

TABLE OF CONTENTS

"Evolving and new technologies are essential additions to the existing recycling toolbox. Not replacements for improving packaging design, mechanical or chemical recycling, but nevertheless important complements and combinations we need to develop and deploy at a commercial scale in the next five years.

Our mission at CEFLEX is to ensure all flexible packaging is collected, sorted, and recycled into materials with the right quality that can displace virgin plastic in that end market application and support a circular economy. To deliver on this - and the ambitious targets of the Packaging and Packaging Waste Regulation (PPWR) - we must continue to innovate to develop recycling technologies so that recycled materials from flexible packaging can be used in the full range of flexible packaging applications and in increasing levels of incorporation.

The new recycling technologies identified here offer an important pathway to upgrade material quality, enable more demanding end market applications, and even help increase recycling rates by addressing complex waste streams that conventional approaches cannot yet process effectively."

Graham Houlder, Project Coordinator

"CEFLEX has actively scouted, supported, and assessed a diverse set of solutions to help increase the quality of flexible packaging recycling to meet demand of all end applications - including the most demanding. This wave of technology assessment highlights the contribution of wet friction washing, delamination, deinking, extraction, and dissolution as five classes to monitor, engage and support.

These technologies have the potential to complement chemical recycling which is expected to deliver virgin like quality including food contact material. They can deliver Post Consumer Recyclates (PCR) from household collected waste which can match demanding application requirements not met by mechanical recycling today.

Through collaboration with stakeholders and academic partners, we've developed a detailed recycling technologies roadmap. It shows how each solution fits into the bigger picture - where it can add the most value, specific feedstock requirements, and how it complements both mechanical and chemical pathways. A pre-requisite for these technologies, is having constant access to the bale grades, i.e., feedstock, which do not exist as such today. We are currently working on a sorting strategy recommendation which will enable, once implemented in Europe, to make available the necessary bale grades at the required specification for each technology.

To continue accelerating circularity, we need continue innovating and scale smart, targeted technologies that build on the strengths of what exists today. This isn't about choosing one path over another, it's about achieving the perfect blend of solutions for a more sustainable packaging future."

Dana Mosora, Senior Consultant

BOOSTING CIRCULAR MATERIALS

The Circular Economy for Flexible Packaging (CEFLEX) initiative is a collaboration of over 180 European companies, associations and organisations representing the entire value chain of flexible packaging. Together, we work to make all flexible packaging in Europe circular.

Our 'Mission Circular' aims to ensure all flexible packaging materials are collected, sorted and recycled – ready to be returned to the economy in sustainable end markets substituting virgin materials.

Scouting, engaging with and supporting promising recycling technologies with potential to advance the quality and quantity of recyclates available on the market is a role CEFLEX actively plays to achieve this vision.

Together with stakeholders from across the value chain and academic researchers, CEFLEX has examined a range of solutions, including avanced decontamination in mechanical recycling technologies and physical recycling, that can complement existing mechanical and chemical recycling approaches. The goal: high-quality recycled polyolefins, essential for meeting demanding end market applications and achieving higher recycling rates.

A pre-requisite to the implementation of these technologies is the evolution of sorting towards more granular and precise definition of the final bale grades, to meet the requirements of each new technology. CEFLEX's Sorting Strategy Recommendation, due for release late 2025, will support this.

Deployed and scaled in a targeted manner, these technologies can make a critical difference to implementing the Packaging and Packaging Waste Regulation (PPWR) for achieving challenging recycled content and even more challenging recycling rate targets.

This publication aims to add to the toolkit of recycling solutions available to help drive a circular economy for flexible packaging materials, helping to identify promising emerging technologies, understanding their potential impact, and contributing to create the necessary enablers for them to be commercially viable and scalable.

Key Challenges for Flexible Packaging and The Role of New Recycling Technologies to Address Them

Targeted new sorting and recycling solutions can be key to overcoming technical and economic barriers that have limited flexible packaging recycling and circularity to date.

Improving the quality of recycled materials – A sizable proportion of flexible packaging structures – approximately 3.2 million tonnes a year (38%) -contain multiple layers and materials that are difficult to separate and decontaminate using conventional mechanical recycling. Scaling promising technologies in delamination, ink removal, contaminant extraction and dissolution can help produce higher quality recycled plastics.

Increasing recycling rates – Current recycling rates for flexible packaging are still a challenge in all but the most advanced recycling nations. Implementing these new emerging technologies will help increase overall rates and enable more flexible packaging materials to incorporate fit for purpose recycled polymers.

Enabling high(er)-value applications – Many of the new technologies identified are focused on increasing the value and range of recycled polyolefins so they can meet the stringent requirements for higher value end market and potentially even contact sensitive applications, expanding their value in the circular economy.

This latest round of CEFLEX new technologies work looked at emerging recycling technologies that will help increase recycling rates and boost recycled content quality and availability.

Five classes of technologies under consideration emerged:

Advanced Wet Friction Washing

Delamination

Deinking

Extraction

Dissolution

TARGETED ANALYSIS FROM ACROSS THE VALUE CHAIN

The CEFLEX team and research partners at the University of Ghent (BE) were supported by a task force of stakeholders from across the value chain. Together, they established key criteria for the evaluation of technologies with the objective of **boosting quality and recyclate value in a mechanical or physical recycling process.**

Across each of the five technology classes, the group assessed:

- Type of packaging structure/design able to be recycled
- Potential contribution to reaching recycling rate and recycled content targets
- Enablers needed to maximize the impact of each technology on PPWR target implementation

Scope of work focused on advanced decontamination in mechanical recycling or physical recycling with the potential to advance recyclate quality beyond the identified state of the art technologies available today. Principally, classes of **technologies delivering advanced decontamination via deinking, delamination extraction or dissolution** – with the ability to remove contaminants before or during extrusion, deinking or delamination.

After initial scouting and desk research by technology class, **over 20 projects or technology developments were identified - with 12 technology providers selected for in-depth research and interview**. A mixture of desk research, data assessment, interviews, analysis and validation with task force advisors lead the research process.

Given the need for action and adoption of new technologies to enable reaching both recycling rate and recycled content targets, identified technology providers relied on examining their potential for reaching relevant thresholds:

- An operationally effective system ready for full commercial deploy ment within 5 years (Technology Readiness Level 8-10)
- Value creation assessment – and consequent investability
- Capacity to achieve processing of a minimum of 10-15 thousand tonnes (KTPA) of material a year at commercial scale launch.

New recycling technologies matrix - segmentation

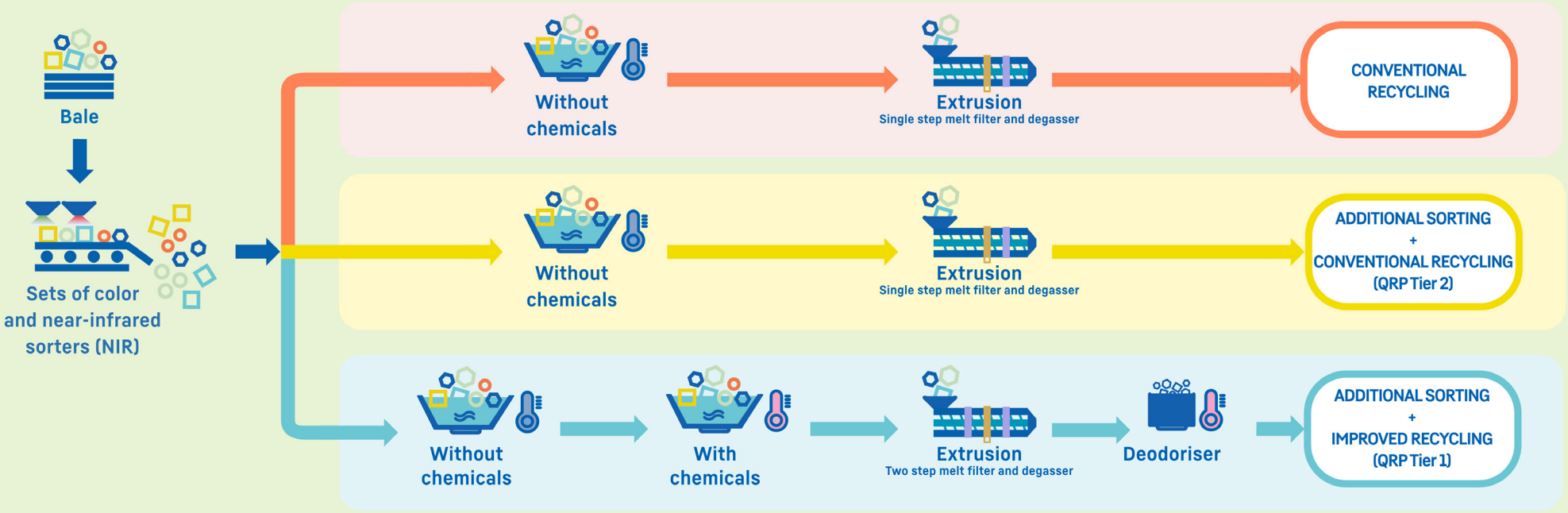
	Type of Technology	Contaminant Removal before Extrusion	Additive and Contaminant Removal during Extrusion	Deinking	Delabeling	Delamination
Advanced Decontamination	FRICTION WASHING -DRY	pla.to			pla.to	
	FRICTION WASHING -WET	HydroDyn		HydroDyn	HydroDyn	HydroDyn
	WATERBASED FLAKES TREATMENT WITH CAUSTIC AND DETERGENT	HydroDyn (HydroClean)		**HydroDyn (HydroClean)** **BASF Chemicals / Fych** SOREMA / **KEYCYCLE®**	HydroDyn (HydroClean)	HydroDyn (HydroClean) Fych
	AQUEOUS FLAKES TREATMENT WITH ADDED SOLVENT, NON ATEX			**SMART COLORING**		**saperatec**
	NON-AQUEOUS SOLVENT/ACID/BASE FLAKES TREATMENT, ATEX			**BluePlastics** Flexloop (P&G)		
Extraction	SCO2 STRIPPING		CIMPA (Aimplast, CTT, IPC) COtooCLEAN **SUPErPE (IPC)**			
Dissolution	POLYMER DISSOLUTION WITH ANTI-SOLVENT PRECIPITATION					**Dissolution (Fraunhofer) APK**
	POLYMER DISSOLUTION WITH PRECIPITATION BY COOLING AND EVAPORATION		TNO Möbius (CIMPA)	PureCycle® (PP) DOW + P&G (PE) OBBOTEC TNO Möbius (CIMPA)	**PureCycle® (PP)** DOW + P&G (PE) **OBBOTEC** TNO Möbius (CIMPA)	PureCycle® (PP) DOW + P&G (PE) OBBOTEC TNO Möbius (CIMPA) ReVentas
	DISSOLUTION IN EXTRUDER		NEXTEC (NextLoop) (TBC) Krauss Maffei			

The technology scouting process was structured around three key technology classes: Decontamination, Extraction and Dissolution.

Over 20 technology projects or companies were identified and classified.

From these, 12 technology providers (in dark orange) were selected for in-depth interviews and further analysis.

State of the Art Mechanical Recycling and New Technologies



Current state of the art in Mechanical Recycling (MR) encompasses all commercially available technology processes, which can be categorised into two main approaches:

Conventional Mechanical Recycling

- Basic processing without secondary sorting, hot washing, or chemical washing
- Ends with simple extrusion, producing recyclates with minimal purification

Advanced Mechanical Recycling

- Hot washing with chemicals to remove fiber and organic contamination
- Extrusion with double filtration to eliminate non-target polymers and metal residues
- Deodorization process for near-complete removal of volatile organic compounds (VOCs), improving odour quality

Advanced approaches significantly enhance recyclate quality, making it more suitable for higher-value applications.

AN ESSENTIAL REQUIREMENT FOR DELIVERING LEGISLATIVE TARGETS AND THE CIRCULAR ECONOMY

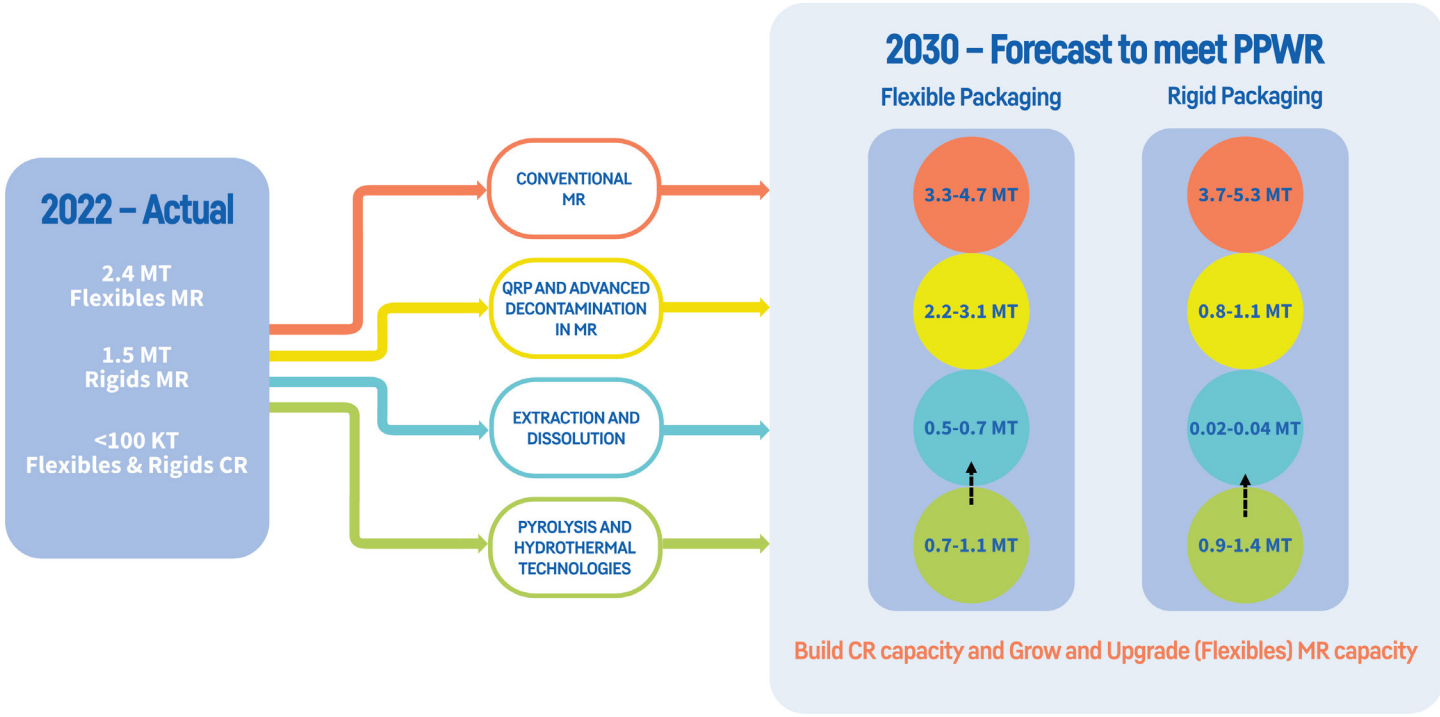
In depth modelling from CEFLEX's Möbius platform has quantified and brought new understanding to the significant jump in mechanical, physical and chemical recycling capacities needed by 2030 and 2035 to meet PPWR targets.

The headline might be overall European recycling capacities will have to triple within the next ten years. However, the most essential detail to increase material circularity and for industry to meet format-specific recycling rates and recycled content targets is the shift from quantity to quality recycling. Post-consumer recyclate (PCR) has to be aligned to end market demand and produced at the quality demanded by each end market application.

To achieve this, new emerging technologies - such as advanced decontamination in the recycling process or with solvents via either extraction of contaminants or dissolution of polymers– will need to be available and commercialised at scale, demonstrating the business case for investment and recycled polymers of required quality to serve their respective targeted end markets.

2030 Recycling Rate Targets
Recycling Capacities Required by Technology Segment - C&I and HH packaging

Projected required capacities for flexible and rigid packaging – commercial, industrial and household – by recycling pathways and technology segment to meet PPWR targets in recycling rates and recycled content. Aligned to end market recyclate quality demand in new and existing applications in a low market growth scenario (1% CAGR) using CEFLEX Möbius modeling platform.



How does CEFLEX generate modelling and forecasts of recycling capacities and technologies required?

CEFLEX's Möbius platform maps material flows and infrastructure required to develop the circular economy for flexible plastics using over 80 inputs and assumptions to build a probability model. It draws on different growth scenarios, market intelligence, academic analysis and expert judgement from across the value chain to give a range of recycling capacity required rather than a fixed point.

By combining this with an in-depth assessment of end market demand for recycled content – in both quantity and quality - the model is able to segment and attribute capacity by recycling pathways: conventional, advanced decontamination, physical and chemical. Together, this information has shaped the scouting and assessment of new technologies to ensure it is relevant and required.

Legislative targets in the Packaging and Packaging Waste Regulation

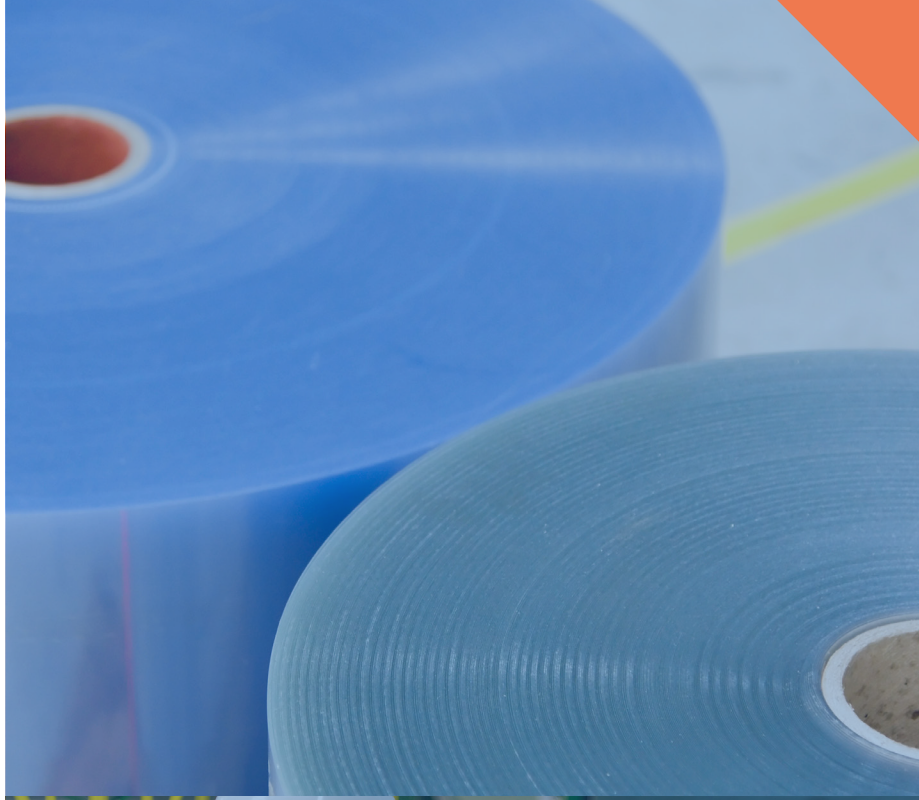
The Packaging and Packaging Waste Regulation (PPWR) places a welcome focus and urgency on higher recycling rates, recycled content and increased quality – critical pillars of CEFLEX's Mission Circular vision. But significant challenges lie ahead, notably ensuring a 55% recycling rate for flexible plastic packaging by 2035.

Recycled content requirements

PACKAGING TYPE	RECYCLED CONTENT TARGET (2030)
Contact-sensitive flexible plastics	**10%** PCR content
Non-contact-sensitive flexible plastics	**35%** PCR content

Recycled rate requirements

2030	2035
55% recycling rate for plastic packaging	**55%** recycling rate for plastic flexible packaging



KEY TAKEAWAYS FOR NEW RECYCLING TECHNOLOGIES

Innovative **deinking, delamination, extraction and dissolution** technologies are an essential part of the puzzle to improve recyclability and recycled content quality.

1. **Design for recyclability** is a prerequisite to any new recycling technology – boosting its technical feasibility and business case. Accelerating adoption of the most ambitious approaches – like 'Designing for a Circular Economy' guidelines – to reduce multi-material, multi-layer structures (including Mixed Polyolefins) is a key enabler for the output and economics.

2. **Targeted scale up and commercialisation** of identified solutions needs to happen to help achieve legislative targets and the circular economy. They are essential tools for the recycling industry to shift from 'quantity' to 'appropriate quality' recycled polymers aligned to end market demand. One pre-requisite for scale up is the effective demonstration of the business case for investment by each technology provider with demo scale pilots. Another is access to the specific bale grades which contain the appropriate packaging structures for which the technology delivers on quality and yield necessary to make it commercially viable. A Sorting Strategy Recommendation from CEFLEX will be made available and address this requirement.

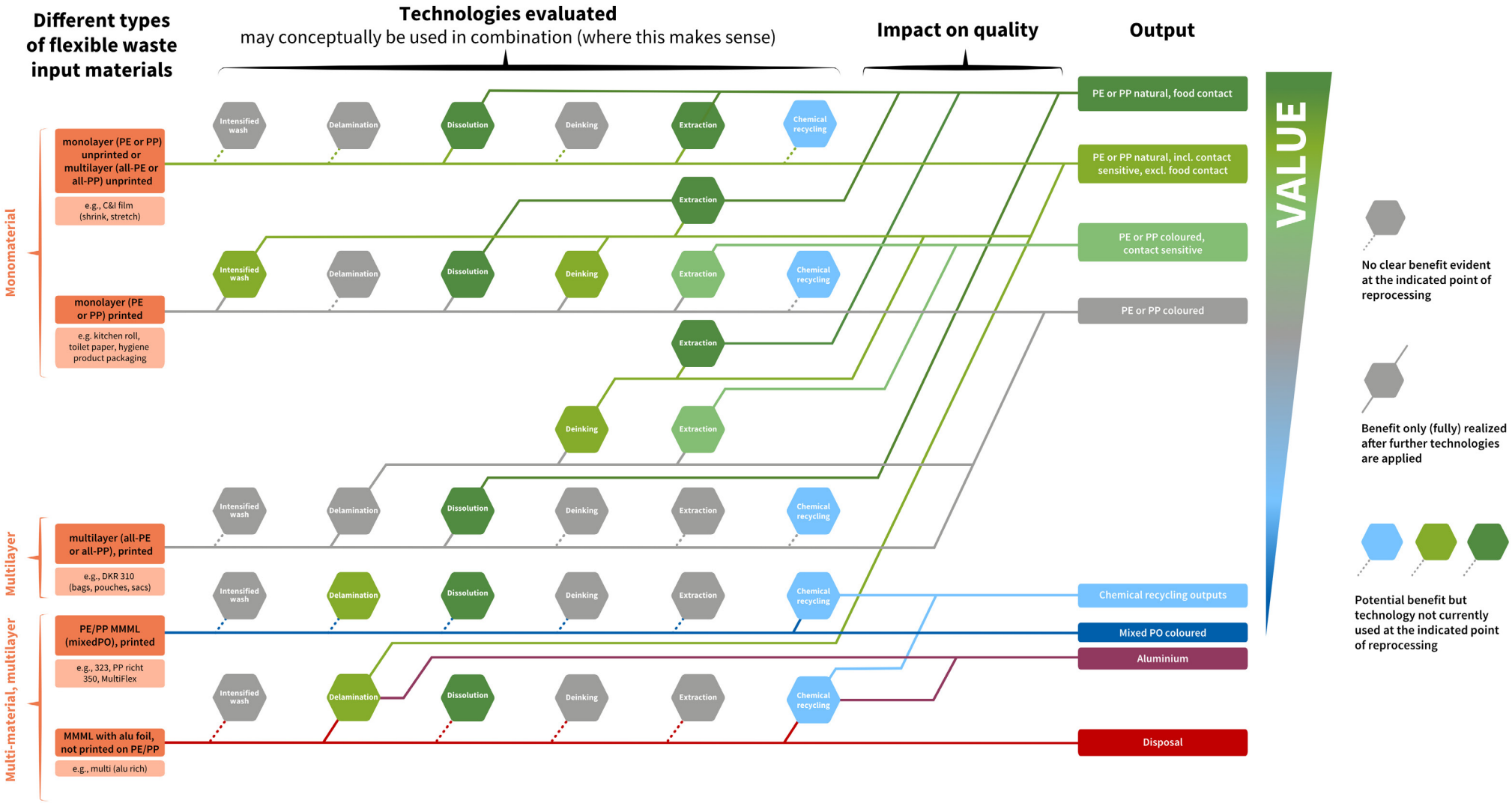
3. **An ability to deliver non-coloured and/or contact sensitive quality material will be a substantial advantage.** Supplying recyclate to cosmetic or food industries will unlock major benefits for these technologies business case and the circular economy.

4. **Smarter sorting improves efficiency and business case while polyolefin separation technologies have potential to lift recycling rates.** Most analysed technologies - except delamination – do not significantly enhance recycling rates because they currently focus only on mono-material feedstock. Broader adoption of technologies tackling mixed plastics feedstock and deployment of smart sorting will contribute to increasing flexible packaging recycling rates.
In the meantime, efficient PE and PP flake separation technologies do unlock this potential and an important component for increasing recycling rates.

5. **Mixed Polyolefin (PO) the current go-to feedstock for chemical recycling.** Based on the current state of development of these analysed technologies to show technical feasibility on Mixed PO, this feedstock remains the target for Chemical Recycling. It means a new bale grade which contains PE, PP and PE/PP packaging structures not included in other monomaterial based bale grades or resulting from rejects of the sorting for monomaterial bale grades. Such bale grade will still have a controlled composition to correspond to requirements from Chemical Recycling.

Implementing New Recycling Technologies – a roadmap for application

Achieving the perfect blend: In addition to understanding the distinct role each recycling technology plays in enabling a more efficient and circular packaging system, **CEFLEX's New Recycling Technology Implementation Roadmap shows how they can be implemented in concert together** – and on which feedstocks – to achieve best results.



Enhancing the Value of Recyclates with an Appropriate Blend of Technologies

New recycling technologies can significantly increase the value of recyclates and, in some cases, improve recycling rates. However, their effectiveness depends on the type of packaging waste. Not all technologies lead to better quality or higher recycling rates for every waste stream. The implementation roadmap chart (see graphic) provides an overview of where different technologies add value and how specific input streams can be converted into higher-value recyclates.

For instance: Deinking benefits printed film waste but does not improve mass-coloured film waste. Laminated reverse-printed packaging requires delamination before deinking becomes effective.

Example: Printed Multilayer Packaging Waste

Intensified washing, deinking, and extraction have limited impact because **inks and adhesives are trapped between layers.**

Delamination first enables these processes, making them effective for multilayer films, just as they are for monolayer films.

Example: Monolayer PE or PP Films

A waste bale of printed **monolayer PE or PP films** is typically recycled into **colored rPE or rPP.**

Applying **intensified washing** can remove surface ink, producing a **natural-color recyclate.**

If ink adhesion is strong, **deinking** may be necessary.

Dissolution-based processes can refine recyclates, making them suitable for **contact-sensitive applications.**

Extraction processes can remove contaminants for contact-sensitive uses but usually do not remove pigments.

Chemical recycling is unlikely, as **mechanical recycling is cost-competitive** for this waste type.

Delamination is unnecessary for monolayer packaging, as it has no effect.

KEY FINDINGS

Advanced wet friction washing

A ready to go technology delivering better quality feedstock for extrusion or chemical recycling with a relatively low capital investment

Benefits:	Removes contaminants before extrusion for efficient extrusion
Challenges:	Market penetration at scale
Opportunity:	Add-on technology to increase efficiency of mechanical recycling
Key Enabler:	Adoption by sorting and recycling facilities

HydroDyn

Innovative Cleaning Solutions for Flexible Plastics
Operating in Germany since 2014, the company has grown to a 45-person team, offering plug-and-play containerised systems for sorting, cleaning, and drying.

A key innovation is HydroCleaner, a patented single-stage mechanical cleaning technology that uses friction and hydrodynamic effects to achieve high-level decontamination an a >70% yield.
This system is particularly effective for surface-printed flexible plastic packaging, ensuring thorough cleaning and preparation for high-quality recycling.

Installed Capacity Q4 2024
Over 100KT/year
for various polymers

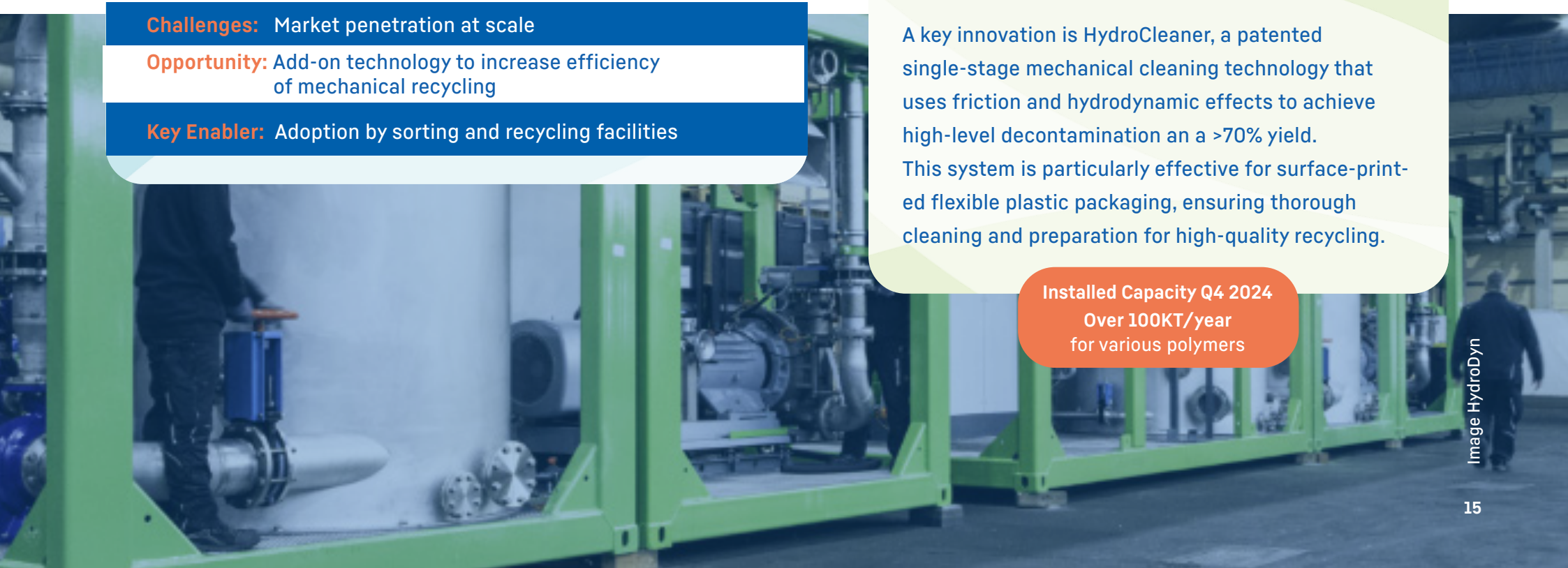


Image HydroDyn

Delamination

Proven technology with medium-low capital investment improving recyclate quality and properties - such as colour and odour - with potential to lift recycling rates

Benefits: Quality recycling of multi-material-multilayer flexible packaging

Challenges: Economic feasibility for household waste to be confirmed

Opportunity: Deliver CosPaTox quality for the products

Key Enabler: Smart sorting for dedicated bales specification

Delamination is a proven recycling technology with an expected European capacity of 50,000T–100,000T by 2030, supported by a medium-to-low CAPEX investment.

With commercial plants already operational or under construction in 2024, delamination can enhance recyclate quality and support PPWR implementation by improving mechanical properties, colour and odor, plus contribute to rising recycling rates (RR) for flexible packaging. Combining it with smart sorting for dedicated feedstock, separation of polyolefin flakes resulting from the process and deinking, delamination becomes a valuable and scalable solution for multilayer flexible plastics.

Saperatec: Advancing Water-Based Delamination

Saperatec, founded in 2010, launched its first commercial-scale plant (32,000T/year) in Dessau-Rosslau, Germany, in 2024. The company has grown to a 50+ person team across its plant, laboratory, and R&D department.

Its water-based delamination process, enhanced by a customised chemical mix, is principally designed to separate polyethylene-aluminum (PolyAl) feedstock from beverage cartons. The process is also ready to handle aluminum-containing flexible plastic packaging, depending on the availability of sorted bales. Deinking is not part of the process.

The recycled polyethylene (rPE) produced meets proven quality standards for use in home care and personal care products and is targeted to achieve CosPaTox guideline quality.

Installed Commercial Capacity
Q4 2024
32,000 tonnes / year

Image Saperatec

Delamination

Fych: Tailored Recycling Solutions for Flexible Plastics

A Spanish startup founded in 2019; it specialises in designing customised recycling solutions for its clients. The company operates with a team of 11 people and provides licensed installations that include maintenance and monitoring services.

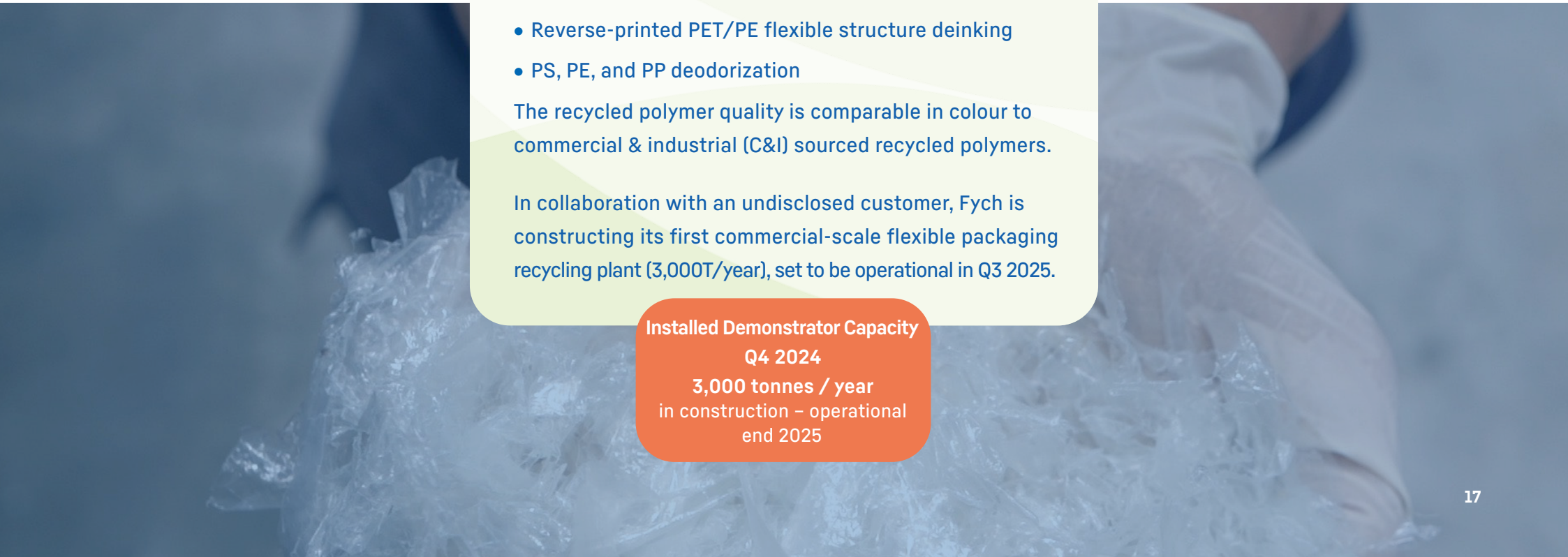
Its water-based delamination process is combined with steam-based decontamination (deodorization) and concurrent deinking and has been successfully proven for:

- PET/PE tray delamination
- Reverse-printed PET/PE flexible structure deinking
- PS, PE, and PP deodorization

The recycled polymer quality is comparable in colour to commercial & industrial (C&I) sourced recycled polymers.

In collaboration with an undisclosed customer, Fych is constructing its first commercial-scale flexible packaging recycling plant (3,000T/year), set to be operational in Q3 2025.

Installed Demonstrator Capacity
Q4 2024
3,000 tonnes / year
in construction – operational end 2025



Deinking

A key technology supporting higher quality recyclates and improved material recovery with a medium-to-low capital expenditure (CAPEX) investment.

Benefits: Improves mechanical properties, colour, and odour

Challenges: Needs investment in commercial-scale plants

Opportunity: Contact sensitive recycled materials could be possible, pending EFSA approval

Key Enabler: Sorting and pre-treatment for maximum yield

" Deinking can play a key role in advancing the circular economy for flexible packaging in Europe and Packaging and Packaging Waste Regulation (PPWR) goals. The business case for these innovations will also become increasingly attractive as specific sorting specifications are introduced, maximizing process efficiency. This is particularly relevant for achieving CosPaTox-quality recyclates, potentially ensuring safety and high performance for contact sensitive applications".

Dana Mosora

A European deinking capacity potential of 50-100KTPA by 2030 is currently assessed; but far more will be needed to meet demand. Plants by both Fych – who also provide deinking alongside their delamination processes - and KEYCYCLE® are currently central to this growth.

KEYCYCLE®: Turnkey Deinking Solutions for Flexible and Rigid Plastics

KEYCYCLE®, the owner of Cadel Deinking® technology since 2020, provides turnkey deinking solutions, including equipment and cleaning chemicals for water-based ink removal. Their process, they state, achieves 95% removal of external printing from flexible packaging and HDPE and PP rigid plastics

Installed Commercial Capacity
Q4 2024
6,000 tonnes / year
7 lines of 500 kg/h

Image KEYCYCLE

Deinking

Smart Coloring: Innovating Solvent-Based Deinking for Recyclability

Smart Coloring, a German company founded in 2019, became part of CAMM Solutions GmbH in 2024. With 14 patents, the company aims to license its technology to recyclers once integrated into their processes.

Their core technology and applications include emulsion-based washing (water-solvent mixture of about 95 : 5) on flake level for effective decontamination and deinking – a focus solution improving recyclability by extraction/removal of organic contaminates (also non-VOCs) out of the plastics. It works with PE- and PP-rich bales to produce high-quality recyclates, principally in the personal care and cosmetics sectors , where applications require stringent material purity.

With a focus on enhancing recyclability and material purity, Smart Coloring's technology has the potential to support higher-quality recycled plastics for premium applications.

Installed Technology Testing Capacity Q4 2024
500-liter pilot installation available for trial runs on specific feedstocks

Extraction

High-potential technology for mono-material plastic streams, capable of achieving food-contact quality for demanding applications and raising recycling quality on target polymers

Benefits: Enables contact-sensitive recycled polyolefins

Challenges: Successful demonstration followed by scale-up investment

Opportunity: Can potentially serve high-value application in food-contact packaging, pending EFSA approval

Key Enabler: Regulatory approval for contact-sensitive recyclates

If successful, this innovative decontamination method could set a new benchmark for food-grade recycled plastics, expanding sustainable solutions for packaging.

Installed Capacity Q4 2024
Demonstrator of 2 x 100 litre batch units in 2025

Supercritical CO_2 Purification: Advancing Food Grade Recycling

The French Industrial Technical Centre for Plastics and Composites (IPC), with funding from the European Commission (ERDF), launched a Supercritical CO_2 decontamination project to achieve virgin-like polymer purity for high-value applications.

The process swells the polymer matrix, allowing contaminants to diffuse into the CO_2. The result is a high-purity polymer, free from almost all organic substances. Some pigments or masterbatch components may remain, and ink removal has not yet been tested.

An ideal feedstock is deinked or unprinted mono-material flexible plastics, with the potential to lift the quality to food contact material (FCM) standards (pending EFSA dossier approval).

A demonstrator with two 100L batch units has been operational since February 2025 - aiming to prove both technical and economic feasibility, paving the way for commercial-scale investments, beginning with pilot plans for a 1000 tonne a year demonstrator by 2027.

Image IPC

Dissolution

A physical recycling process where polymers are selectively dissolved in specific solvents and treated to extract the polymer in its purest state.

Benefits: Produces ultra-pure recycle for high-end applications

Challenges: Demonstrate the business case for mix PO

Opportunity: Can potentially serve high-value applications in food-contact packaging, pending EFSA approval

Key Enabler: Regulatory approval for contact-sensitive recyclates

With pending business case demonstration and investment commitments, dissolution technology has the largest projected capacity among the five recycling technologies analysed. By 2030, its potential capacity is estimated at 250,000T/year, requiring a medium-level CAPEX investment.

The process has a proven impact on recyclate quality - enhancing purity and mechanical properties – and potential to increase recycling rates by recovering high-value polymers from mix polyolefins waste.

As a young technology, it requires further process engineering improvement to address performance in continuous process. Smart sorting can enable more targeted and better quality input feedstock further unlocking the full benefits of dissolution in advancing the circular economy.

PureCycle: Ultra-Pure Recycled Polypropylene

Polypropylene (PP) recycler PureCycle, operates as a standalone producer with technology based on intellectual property from Procter & Gamble (P&G).

The company has a 150-person team worldwide, with a 49KTPA commercial plant in Ohio, USA and a 59KTPA second generation facility currently in financing phase in Antwerp, Belgium.

Their processes take in PP-rich feedstock to produce ultra-pure recycled polypropylene - and PureCycle has already received FDA non-objection letters for their recycled PP, demonstrating an ability to meet stringent food contact requirements.

Installed Commercial Capacity Q4 2024
49KTPA commercial plant and 59KTPA plan in financing

Image PureCycle

Dissolution

IVV Fraunhofer: Advancing Dissolution Technology for High-Purity Recycling

IVV Fraunhofer has a 40-person team dedicated to developing dissolution technology in partnership with GAW Technologies GmbH, a German engineering firm. The technology is being commercialised under license for various clients with the aim of achieving a scalable, high-purity recycling solution.

The technology is developed under confidential agreements for Mixed Plastics and Mix PO feedstock - with a current recyclate quality targeting use in home and personal care products; future plans target achieving Food Contact Material (FCM) quality.

No commercial-scale plants are under construction yet; but two pilot plants support testing and on-going R&D. One in Indonesia in collaboration with Unilever (1,000T/year capacity) and a 400T/year site in Germany.

Installed Pilot scale Capacity
Q4 2024
2 pilot plants in Germany and Indonesia

OBBOTEC: Dissolution Technology for High-Purity Recycled Plastics

This family-owned company based in the Netherlands since 2018, specialises in producing virgin-like recycled plastics and eventually licensing its technology.

The company has grown to a 17-person team leveraging a pilot plant, processing 150–200kg batches - and is currently developing a commercial-scale demonstration plant (20,000T/year) dedicated to post-industrial PE-rich film.

Future plans include extending the process mix plastics feedstock from household collection.

Installed Demonstrator Capacity
Q4 2024
Pilot batches of 150-200kg

ImagePureCycle

New Technologies and the CEFLEX Recycling Strategy*

Contribution to achieving recycling capacities and recyclate qualities to deliver on Packaging and Packaging Waste Regulation targets

TECHNOLOGY CLASS	FEEDSTOCK	CAPACITY POTENTIAL BY 2030	POTENTIAL IMPACT	CONTRIBUTION TO RECYCLING STARTEGY	ENABLERS
ADVANCED WET FRICTION WASHING	PIR, C&I 310 type	Market penetration	Better quality feedstock	Add-on technology to MR	Demonstration of value creation
DELAMINATION	PIR, C&I ***HH: Mix Plastics***	50-100 KT	Better quality Higher recycling rate	Deliver on better quality Increase recycling rate	Sorting specifications CosPaTox target
DEINKING	PIR, C&I, 310 type ***HH: Mix Plastics***	50-100 KT	Better quality	Better mechanical properties, color, odor	Sorting specifications CosPaTox target
EXTRACTION	310 type ***HH: Mix Plastics***	20-100 KT	Better quality	Most demanding applications quality Contact-sensitive quality	Financing commercial plant
DISSOLUTION	PIR, C&I, 310 type ***HH: Mix Plastics***	250 KT	Better quality Higher recycling rate	Most demanding applications quality Contact-sensitive quality	Further process engineering improvement

Feedstock in bold italics means only plans to start work on it.

**Based on self declaration of each technology provider, put in context for The Recycling Strategy Recommendation by CEFLEX*

CONCLUSIONS AND RECOMMENDATIONS FOR THE VALUE CHAIN

Unlocking Circularity: Scaling Recycling Technologies for a Sustainable Packaging Future

The packaging value chain is at a pivotal moment. With the Packaging and Packaging Waste Regulation (PPWR) setting ambitious recycling and recycled content targets for 2030 and beyond, the industry must embrace and enable targeted recycling solutions with high potential for achieving commercial scale within 2030-2035. Emerging technologies offer a specific opportunity to tackle flexible packaging challenges, but realising their full potential requires urgent action to overcome key challenges challenges for maximised impact and demonstrate their business case for investment in action.

A New Generation of Recycling Technologies

Advanced decontamination with mechanical and physical recycling technologies have the potential to increase recycling rate, enhance recyclate material quality, and shift the industry's focus from volume-based recycling to high-quality circular materials.

Many providers are gearing up to scale their capacities, with projections ranging from 50,000 to 200,000 tonnes per technology by 2030—with Dissolution alone expected to reach 250,000 tonnes. Once their respective business case demonstration phase completed, if fully deployed, these innovations could play a decisive role in meeting the PPWR's recycling rate and recycled content targets.

However, scaling these technologies in time to meet 2030 goals will not be easy. Access to suitable feedstock, investment in commercial-scale facilities, regulatory clarity and suitable approval speeds for processes compliant with food-contact quality, and seamless integration with existing recycling infrastructure remain major roadblocks. Without strategic interventions across the value chain, the industry risks falling short of its commitments.

From Promise to Reality: Enabling Large-Scale Deployment

To unlock the full potential of these technologies, the packaging industry must take bold steps to fully assess their respective business cases and subsequently to accelerate their adoption. A key priority is the **widespread implementation of design-for-recycling guidelines**, particularly for complex multi-material and multi-layer flexible packaging. Packaging designed for recycling will **improve sorting efficiency, increase recyclability rates, and optimise feedstock** for emerging recycling processes - supporting harmonised feedstock in volumes required for plant viability.

At the same time, further technology developments and subsequent investments in smart sorting and polymer separation technologies must be accelerated for scale up. **Advanced sorting systems**, along with **polyolefin (PE/PP) separation innovations**, will be essential in creating the adequate input streams for advanced decontamination via mechanical and physical recycling.

Policy and financial mechanisms also need to evolve to support emerging technologies. Targeted incentives, public-private partnerships, and more transparent and fluid approval process for food-contact applications can provide the necessary momentum to bring these solutions to market. In such enabling context aligning with PPWR, Waste Framework Directive and the emerging EU Circular Economy Action Plan, ambitions will provide **a stable and attractive investment environment** for this.

A Call to Action: Aligning the Value Chain for Impact

While new recycling technologies hold the key to recycled content replacing virgin materials across a range of new and existing applications, their success depends on collaborative action across the value chain. Brand owners, retailers, recyclers, policymakers, and investors must work together to:

- **Adopt design-for-recycling principles across the board** to improve recyclability
- **Scale investment in recycling infrastructure** to accelerate demonstration followed by commercial deployment
- **Clarify and streamline regulatory approvals**, particularly for contact-sensitive applications
- **Advance sorting and separation technologies** to ensure a steady supply of high-quality feedstock

By embracing innovation, collaboration, and strategic investment, the packaging industry can transition from a quantity-based recycling to a quality model accelerating the circular economy.

This shift is not just necessary for compliance—it is a competitive opportunity to lead the way in sustainable packaging solutions that are both economically viable and environmentally responsible. **The time to act is now**.

Contact:

Dana Mosora

Senior Consultant, CEFLEX

dana@ceflex.eu

With thanks to our new recycling technology task force and partners:

Attero
CITEO
Capri Sun
DOW
Gualapack
MURA Technology
Orlen
PepsiCo
Saperatec
Siegwerk
Suez
University of Gent

CEFLEX