Thermoforming WG - Intro

PETCORE EUROPE Thermoforming Working Group

PETCORE EUROPE Thermoforms Event, Dijon, May 2025

May 27th, 2025

Goals

Advocate to trigger an increase in PET thermoforms recycling

Activities aligned with the requirements of collection, sorting and recycling as set for in the PPWR (towards 2028)

Work on the standardization activities that will stablish conditions of DfR and recyclability protocols of PET trays

Collect and increase communication on tray-to-tray development

Addressing the challenges

Recycling Infrastructure Improvements	Investment in sorting, separation, and collection systems	Advanced Cleaning Technologies:	Innovative decontamination methods and closed-loop systems
Regulatory Compliance Alignment:	Harmonizing EU and international standards	Economic Viability:	Integrating cost-effective solutions with sustainability goals

Thermoforming Working Group: Our heritage

ANA FERNANDEZ

Who has been decisive in the creation of the Thermoforming working group

Thermoforming Working Group: Chairs and Task Force Leaders

Chair

Samuel Pardo (Klöckner Pentaplast)

Co Chairs

Sebastien Richard (Guillin Emballages)

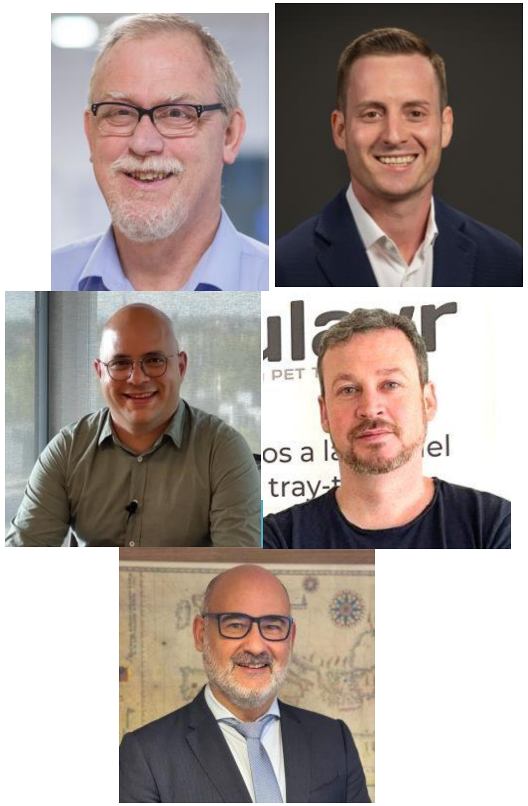
Liliana Orban (Starlinger)

PETCORE-EUROPE

Raphael Jaumot (Petcore)

Jose Antonio Alarcon (Secretary)

Argiris (TCEP)



Taskforces leaders

Antoine Boulery (Pellenc)

Michael Kerner (Starlinger)

Samuel Pardo (KP)

Sergio Collado (Sulayr)

José Queipo (Ecosense)

Taskforces structure

- **What has been done since the last TC?**
  - ✓TF1.- Collection and Sorting Lead by Antoine Bourely (Pellenc).-
    - ✓Sharing information about EPRs and tray collection in major countries. Currently FR is covered and detailed. BE and IT are ongoing. Others need action.
    - ✓Working to conduct external State of Play focused on PET thermoforms recycling across main EU countries & UK.
  - ✓TF2.-Recycling technologies Lead by Michael Kerner (Starlinger)
    - ✓Collaborative discussions on actual state-of-the-art technologies, developments, technical challenges.
  - ✓TF3.- Food contact Lead by Samuel Pardo (KP), Rui Silva (Evertis) and Swan Cecatto (AMB)
    - ✓Standard Operation Procedure and Methodology developed to evaluate food contact vs. non-food contact in PET thermoforms bales. German case study finished. Need to replicate across other countries feedstocks and market differ.
  - ✓TF4.- Standardization lead by Sergio Collado (Sulayr)
    - ✓Focus on TCEP activities regarding D4R guidelines for multilayers.
    - ✓Kicked-off delamination protocol development.
  - ✓Tf5.- Communication lead by Jose Queipo (Ecosense)
    - ✓Communication plan developed. Next step is implementation. Covering internal and external communications and feedback collection.

Actual landscape: PPWR driving circularity beyond purely recycled content
Further roll out requires retailer and packers' commitment.

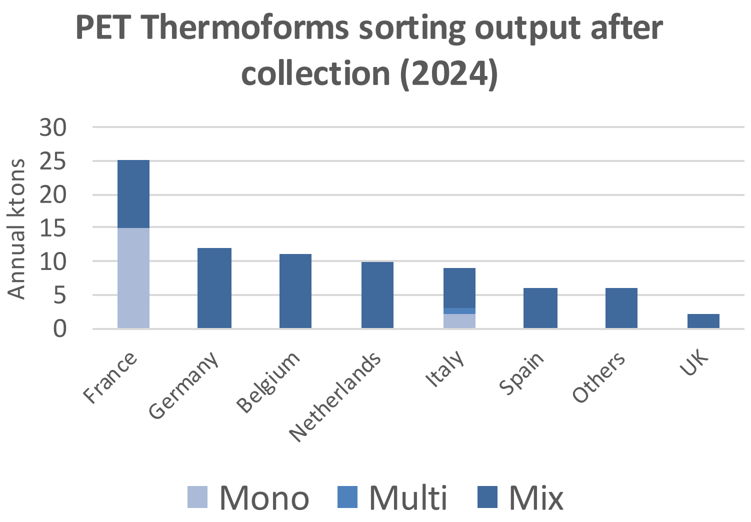
- Many early-stage projects but only regular supply from few projects as collection and sorting must increase

Projections by 2025 expected - 305kton

Country	2022	2025
Belgium		10,500
France	10,000	21,900
Italy		31,100
The Netherlands	25,000	65,000
Romania		10,000
Spain	22,000	167,000
Total	57,000	305,500

Table 1: Installed recycling (input) capacity for tray recycling (in tonnes per year) operating in 2022 and expected operating in 2025, in the EU27+3 region.
Source: ICIS analysis

Dedicated PET Thermoforms sorting – 70kton



Recycling projects with active capacity on the market – 130kton

Communication Taskforce

PETCORE EUROPE Thermoforming Working Group

PETCORE EUROPE Thermoforms Event, Dijon

May 27th, 2025

INTERNAL COMMUNICATION

In **modern collaborative projects**, ensuring timely and accurate communication of planned actions is critical — both **within the team and to external stakeholders**

THE OBJECTIVE

To outline the **INTERNAL and EXTERNAL communication channels** established to share upcoming activities of our workgroups, ensuring alignment, feedback, and stakeholder engagement.

INTERNAL COMMUNICATION

SUGGESTION BOX (Anonymous or Identified): Provide a channel for partners to share ideas and suggestions confidentially if they wish to do so.

Invite partners to contribute articles for the **INTERNAL BLOG,** success stories from their companies, or to participate in interviews.

ONLINE DISCUSSION FORUMS: Integrate forums into the intranet to facilitate the **exchange of ideas**, resolution of doubts and debate on relevant topics.
They allow for asynchronous communication and participation of all: **real-time channels** are essential for fast decision-making in critical phases

Conduct **REGULAR SURVEYS** to find out partners' opinions on different issues and the effectiveness of internal communication.

Communicate honestly and openly about the challenges and achievements of ThWG: Send periodically an email with the **NEWSLETTER** to show project progress, new additions, upcoming events, collaboration opportunities, member achievements, etc.

FACE TO FACE DISCUSSION FORUMS: This is the best example

INTERNAL COMMUNICATION

Collection And Sorting	*Recycling (Technology and Operation)*	*Food Compliance (FB, Atil 6, 5% Non Food)*	*Standarization-TCEP*
State of the Art Strategies and Technologies for Tray collection	State of the Art Technologies for Tray Recycling to all the stakeholders	Demonstrate food contact compliance of rPET from trays in both direct contact and functional barrier technologies.	Reference body for the Recyclability evaluation of Thermoformed packaging.
Promote and deploy the best technologies available for effective selection of Quality Tray Bales			

Pioneering PET circularity since 1993 PETCORE EUROPE

END WASTE RECYCLE THE 1

Collection and sorting

What is not sorted is not recycled

PETCORE EUROPE Thermoforming Working Group

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PELLENC ST

PET Thermoform Sorting: State of the Art

THERMOFORMS CONFERENCE 2025

ANTOINE BOURELY, CHIEF SCIENTIFIC OFFICER, DIJON, MAY 2025

PELLENC ST IN A NUTSHELL

- **Manufacturer of optical sorters**
- **Leader in France, Japan, Australia,…**
- **International** reach
- **Independent** company
- Main customers:
  - Material Recovery Facilities
  - Plastic recyclers
  - Textile sorters / recyclers

- **A mid-cap company!**

2001
YEAR FOUNDED

270
EMPLOYEES

3000
Machines in operation worldwide

15%
AVERAGE ANNUAL GROWTH FOR 6 YEARS

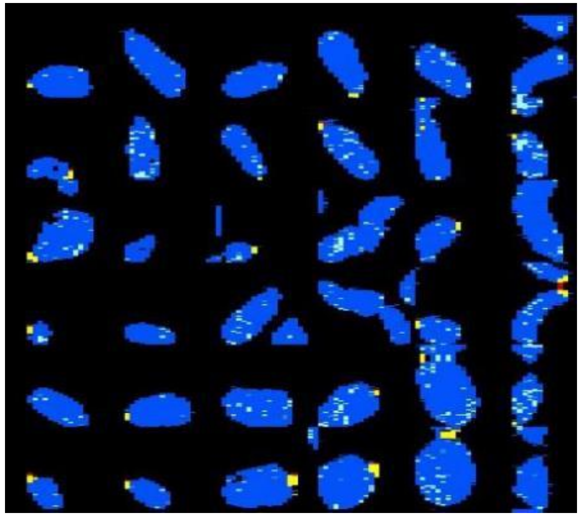
81
MILLION EUROS 2024 TURNOVER

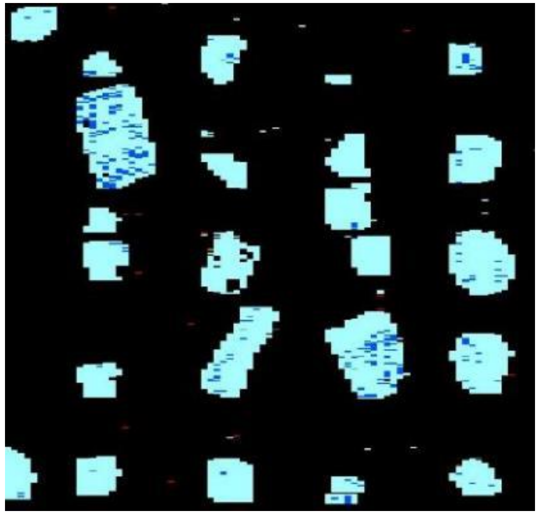
Specific sorting tasks for PET thermoforms

1. Separate trays from bottles
2. Separate monolayer trays from mutlilayers
3. Separate colored or opaque trays from transparent trays
4. Separate food from non-food trays with watermarks
5. Separate food from non-food trays with AI (shape and aspect)?

Differentiating Bottles from Trays With NIR

NIR lab images



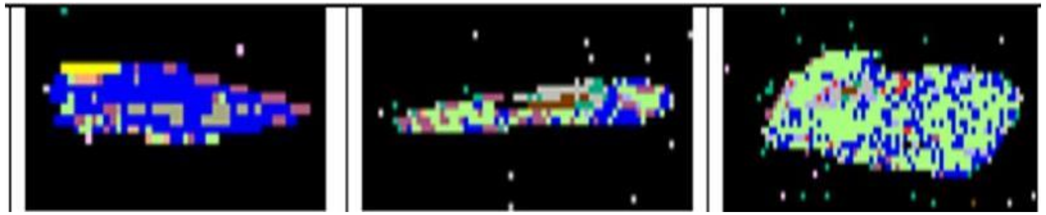


Clear bottles

Clear monolayer trays

Sorting images

Raw data



Processed data

Clear bottle Oil bottle Clear tray

Efficiency when ejecting bottles	Bottles ejected	Trays ejected
One sorting step	92 - 94%	< 5%

When sorting trays, bottles are still the priority

Scenario: ejection of trays
Settings optimized:

- to maximize bottle purity: > 98%
- to minimize bottle losses: 1%

- Resulting tray purity is acceptable

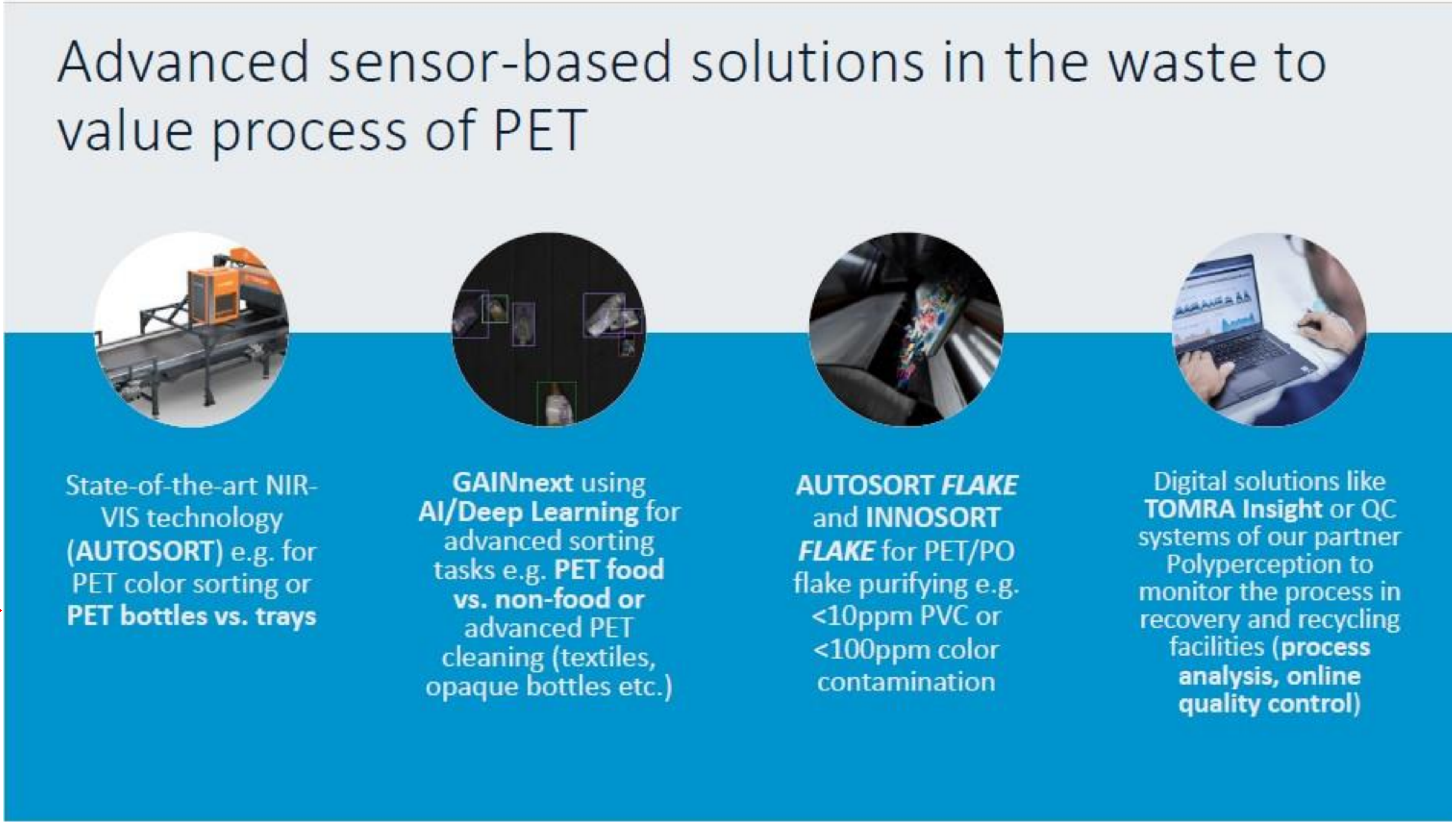
PELLENC ST	Bottles	Trays	Total	Purity
Box 2 Positive (kg)	0,84	5,6	6,44	87,5%
Box 1 Negative (kg)	73,76	1,08	74,84	98,6%
Total	74,6	6,68	81,28	
Efficiency	1,1%	83,8%		

Positive Fraction

Negative Fraction

Other players: TOMRA

NIR/VIS sufficient for bottles vs trays



Separating Multilayer vs Monolayer Trays

This separation is key to enable tray to tray recycling

Sorting task : eject monolayer trays from PET/PE multilayers

Much easier application, because clear chemical difference

Results (with NIR only):

PELLENC ST	PET monolayer	PET multilayer	Contaminants	Total	Purity
Box 2 Positive (kg)	34,4	0,22	1,74	36,36	94,6%
Box 1 Negative (kg)	0,84	19,2	4,92	24,96	
Total	35,24	19,42	6,66	61,32	
Efficiency	97,6%				

Proved at Wellman France for the first time in 2021

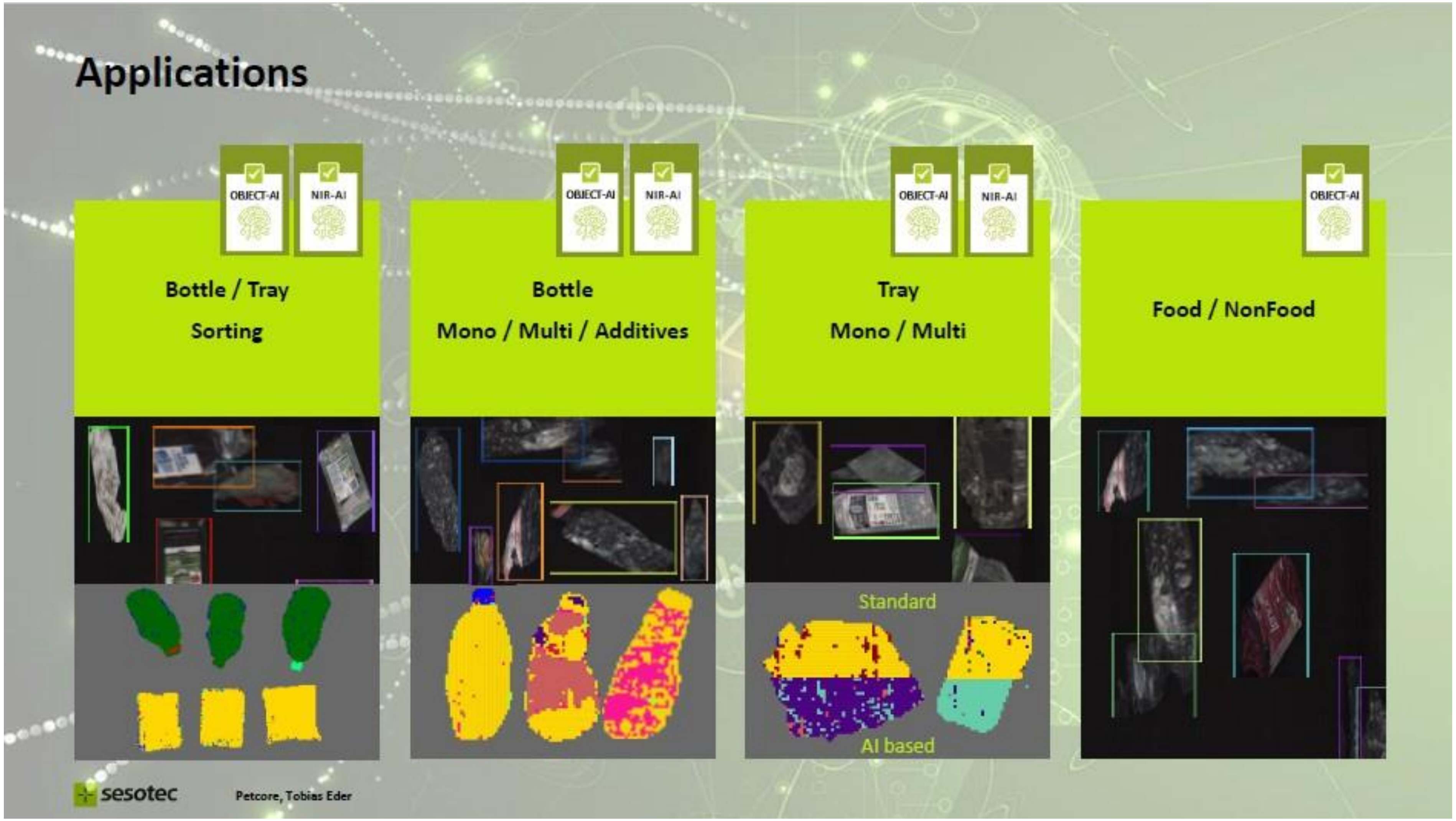
Multilayer stream

Monolayer stream

Other players: SESOTEC

Two types of AI:
- On objects
- On spectra (NIR)

Both are used for:
- Bottles vs trays
- Mono vs multi trays



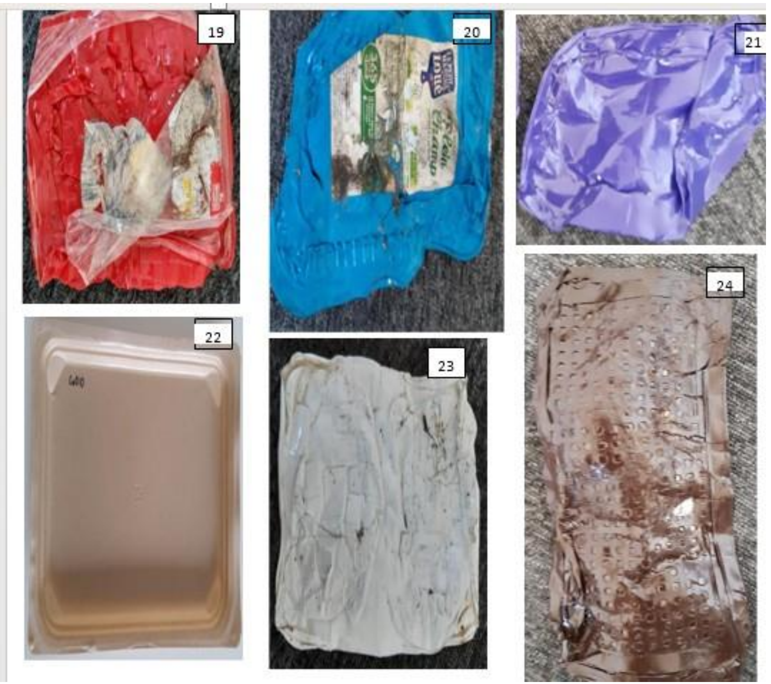
Separating Colored and Opaque from Transparent Trays

<u>Pellenc ST test on 12 opaque or colored trays :</u>

NIR signal is reflected by the dye => the second layer is not always detected in a multilayer

2 options:

* To sort them with the multilayer trays
* To sort them with colored bottles



Food vs non-food PET trays

Digital Watermarks
and
Artificial Intelligence

Separating food from non-food with Digital Watermarks (DW)

The marker is a high-resolution pattern (150 dpi) that can be:

- **Printed** (2D) or **Moulded** (3D)all around packaging
- Wide encoding capability (like a QR code)
- For trays, the moulded version is used
- The watermark must be read from either side

Excellent sorting capability: > 95% proven on PET trays

Main challenges:

- Data management and standardisation needed

Printed version (2D)

Looks Like This Performs Like This

Moulded Version (3D)

Separating food from non-food with AI?

Not offered yet (to our knowledge)

Key question: do we have enough aspect differences to play with ?

- The methodology of food contact task force could be use
- Many challenges ahead…

Examples : **Food** marker

Hook: shows **non-food** use

Recycling Technologies TF update

TASK FORCE GOALS:

Report State of the Art Technologies for Tray Recycling to all the stakeholders

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Key points

Challenges

Washing and Mono- / multilayer recycling

Overview of Washing and Delamination Technologies

Decontamination

Overview of Decontamination Technologies

Challenges material stream

- Material quality varies
  - Country, collection system & recycler
- Purity of the material stream
  - Higher organic contamination
  - Many colours
  - iV is generally lower
  - Other polymers (bags, films, blister,…)

Challenges for washing

- Food / non-food (95%) challenges sorting
- Modified and more robust washing lines
- More fines occur (tray flakes are more brittle)
- Water treatment
- (Delamination integrated in washing)

Mono- / mulilayer recycling

“PET is the material we want to recycle”

Monolayer:

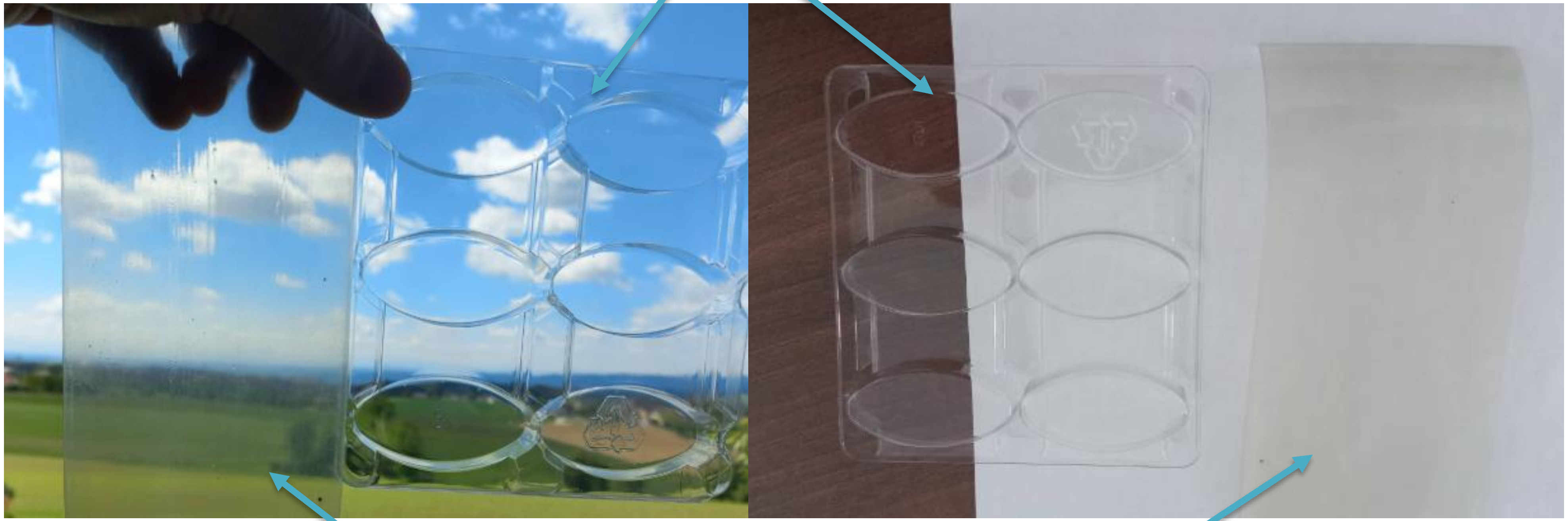
From the point of view of processability and final results:

- PET monolayer is clearly superior to multilayer!
- Top results with a wide range of technologies
- Highly transparent end products achievable

Mono- / mulilayer recycling

“To create a sense of difference in transparency”

rPET tray made from excellent PCR monoPET trays



rPET film made from PCR trays with remaining multilayer content

Multilayer recycling

- Multi-layer films are used for a wide range of packaging materials, particularly in the food industry
- Multilayer trays represent a particular challenge for recyclers as they consist of various materials. Separation of those materials is the key for high quality recycling.

- Typical 2 different process approaches
  - ➢ Thermo lamination
  - ➢ Co-extrusion

- Structure of multilayer PET trays:
  - ➢ PET as the primary structural material
  - ➢ Adhesive layer to bond different materials together (usually called tie layer)
  - ➢ PE sealing layer (with or without barrier properties)
    - ➢ EVOH (in case of barrier film)

Multilayer recycling

“Various non-PET materials make mechanical recycling more challenging and they have a negative impact on material quality“

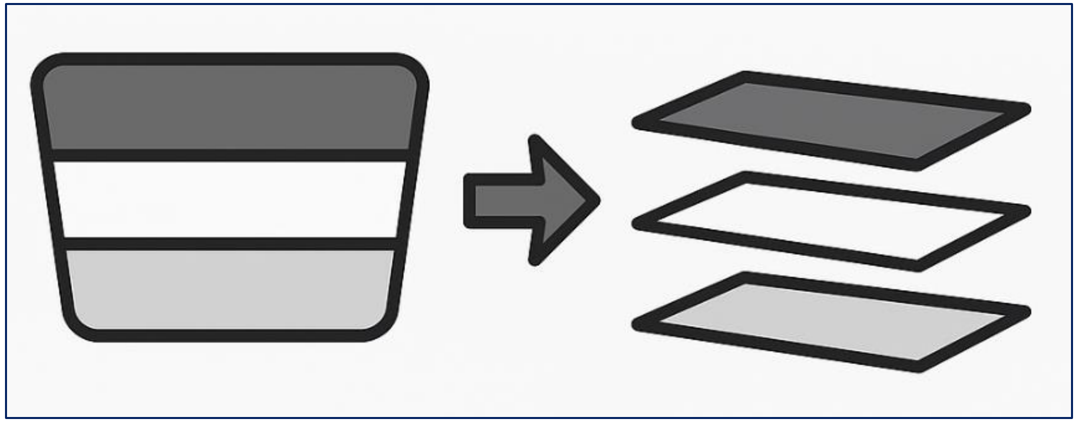
As an example:

- *PE & EVOH lead to cloudiness, haze*
- *Adhesive to ‘gel spots’ & discolouration*

- **Delamination therefore plays a key role in multilayer tray recycling!**

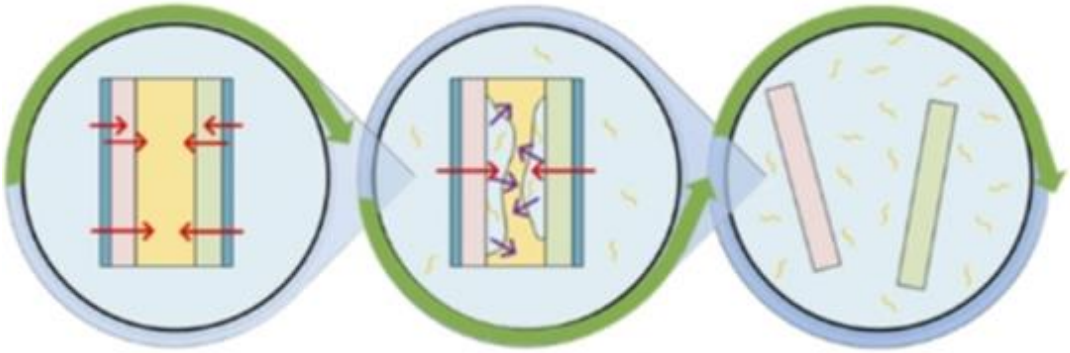
Delamination

Process of separating the different plastic layers from a multilayer tray so that each type of polymer can be recycled individually



Delamination

- Not all lamination techniques available on the market can be dissolved
- Impact factors on delamination process:
  - Adhesive type has a significant impact on the delamination process
  - Acrylic, water-based adhesives are the most suitable type
    - Fast delamination under caustic conditions
  - Thermo lamination adhesives based on EVA are less suited, but feasible
  - 2 component polyurethane adhesives have <u>lowest</u> compatibility or are not solvable

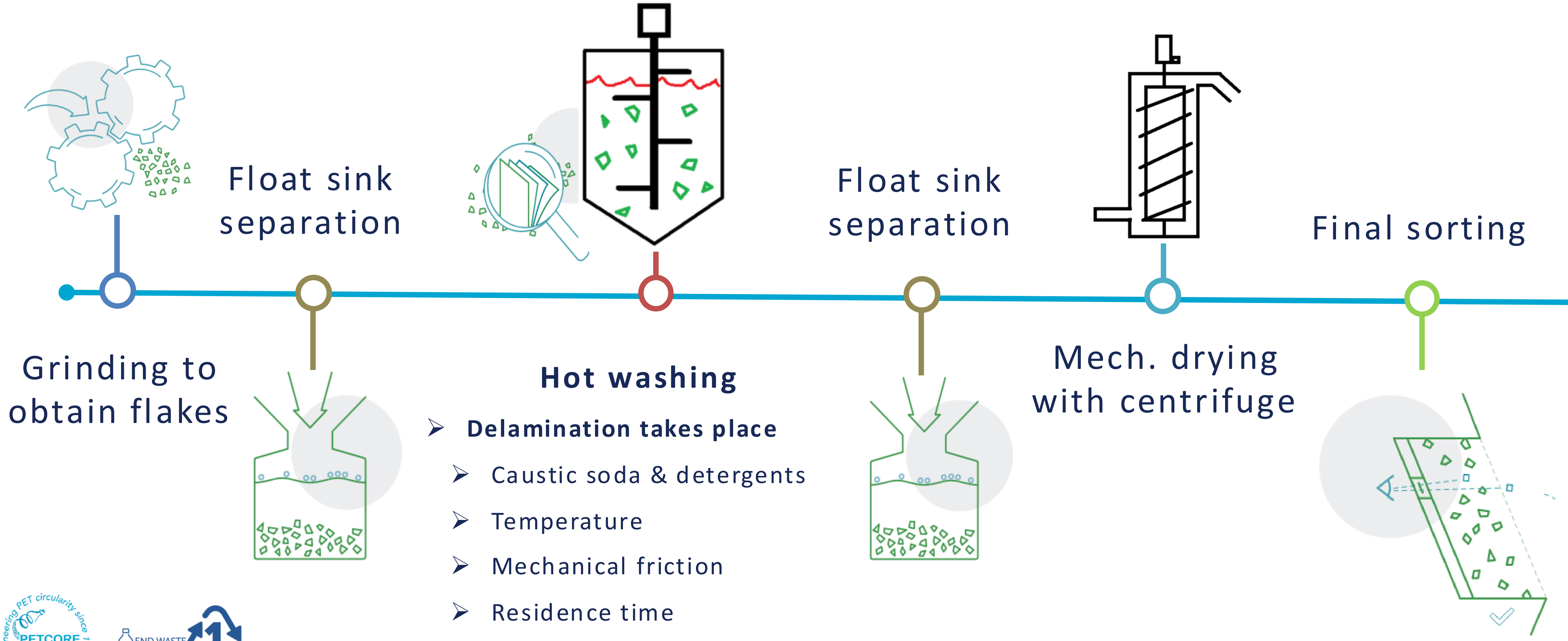


Delamination

- Mechanical approach:
  - Step 1: PE layer is separated from PET "Agglomerator/centrifuge" technology.
  - Step 2: PE is separated by windshifting.
  - Disadvantage: only works for some special tray types
- Combination of hot washing and mechanical approach:
  - Common practice
  - Most of the multilayer packaging can be dissolved
  - Process is usually patented

Delamination

- Combination of hot washing and mechanical approach:



Hot washing

- **Delamination takes place**
  - Caustic soda & detergents
  - Temperature
  - Mechanical friction
  - Residence time

Overview of technologies

Washing and delamination

Taskforce recycling

Close the loop for Trays

with Krones Recycling GmbH

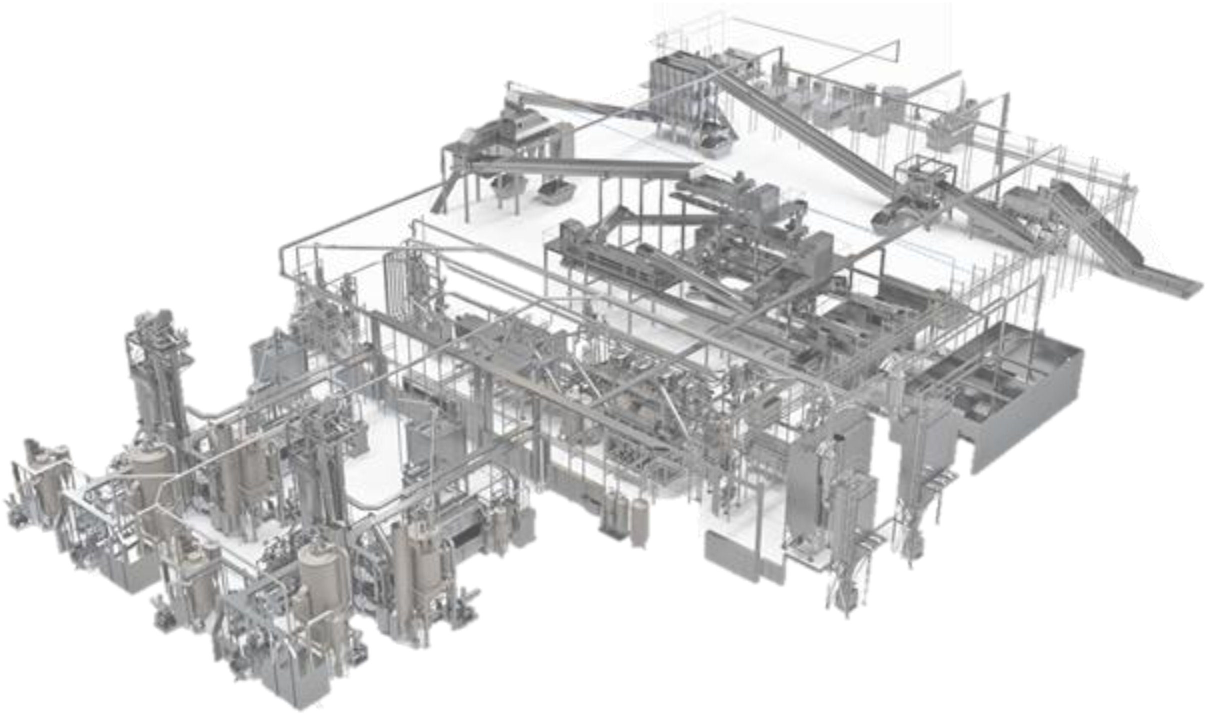
Nikolas Wolf / May 2025

What Krones Recycling offers

Whether PET, PE, PP or PS: At Krones Recycling, you will find **recycling systems for almost every type of plastic.** Here is our portfolio:

- **Turnkey recycling plants** for all common packaging plastics
- **Individual modules** for washing, grinding, sorting and decontamination
- **Single machines and retrofits** for upgrading existing plants
- **Waste water management**
- **Recycling Technology Center** for carrying out tests for and with our customers
- **Lifecycle Services**

Our goal: Saving energy and resources, while maximising the yield and quality of the recycled plastic.



Krones Recycling: From Waste to Resource

PET Bottle vs. PET Tray

Characteristic	Bottle	Tray
Shape	Curved	Flat
Mechanical Load Capacity	Brittle	Very Brittle Low IV Value
Composition	monolayer	Partially multilayer
Residual Load	low	High Content of Organic Residues
Bulk Density	250 – 280 kg/m³	120 – 150 kg/m³

PET Trays are more challenging, sensitive, and lighter than PET Bottles! Our Recycling Technology can be adapted to meet these needs.

Example: Input PCR PET-Trays

Example: Output PCR PET-Trays (without flake sorting)

The Innovation: Our concept for PET-Tray Recycling

Krones Recycling x Pac2Pac

- **Challenges**: Trays are brittle and lighter than PET-Bottles.
- **Solution:** Reduction of friction in the recycling process while ensuring high-quality washing results
- **Versatile Processing**: Handles PET trays, LDPE films, PP yogurt cups, HDPE cleaner bottles, and HIPS/XPS/EPS
- **Project PAC2PAC**: Collaborating with partners, Krones provided expertise in plastics and washing technology to recycle PET packaging into new packaging, promoting a circular economy.

Our innovative tray recycling concepts minimizes fines, enhancing efficiency and reducing waste, while consistently delivering high-quality output.

Read more

Success Story: PAC2PAC – Innovative Recycling of PET Packaging

Our Partners:

Bachmann Group, PET-MAN GmbH, Sesotec, Starlinger viscotec

The Goal: To create a perfect cycle for PET packaging

The Result:

"PAC2PAC" shows an innovative way in which
PET packaging from Swiss collection bags can
be recycled into new packaging, ensuring a circular economy

Our part in the project:

To support the project with our
expertise in plastics recycling and
especially with our high-quality washing technology.

From Waste to Resource:
High-quality Trays.

Krones Recycling x BASF: Closed loop for Multilayer-Trays

Partners:

- Südpack: Leading producer of PET/PE materials.
- Tomra: Market leader in sensor-based sorting solutions for waste management.
- **Krones:** Innovator in PET washing modules, including pretreatment, caustic cleaning, and hot post-washing.

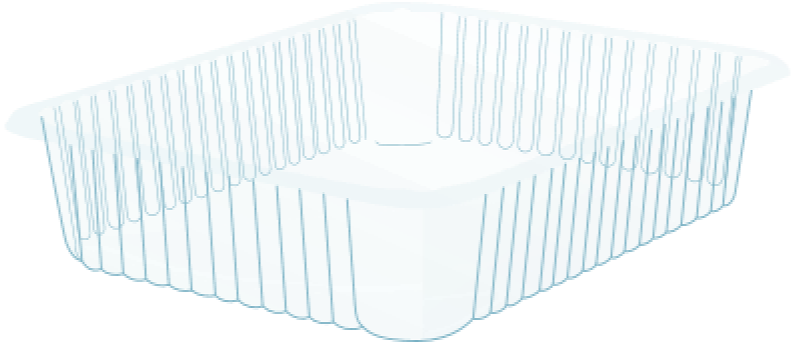
Collaborative Achievements:

- Advanced Sorting: Evaluated the capability to distinguish various multi-layer materials using Tomra's sorting technology.
- Innovative Recycling: Achieved successful debonding of PET/PE laminates at Krones Recycling Technology Center.

Proof of Concept: Demonstrated the technical and practical feasibility of recycling multi-layer materials using existing recycling infrastructure.

Multilayer Tray Recycling: Challenging, but achievable.

„At our facility, we proved that the delamination of multi-layer films works. However, the separation of the films can still be improved by optimizing individual process parameters as well as, for example, the particle size of the flakes."



Thore Lucks
Head of Engineering & Order Processing
Krones Recycling GmbH

Cleaning and Purifying of PET Trays

Valuable Polymers from Waste

Petcore Conference Thermoformed Trays
In Dijon from 27th to 28th of May, 2025

Hamburg, 16.05.2025

Autor: Michael Hofmann

AI-supported Sorting improves

1. **Shape Recognition makes PET Sorting efficient**

   NIR Sorting solely is not enough. Precision of sorting PET Trays and Bottles in pure fractions is mandatory, because of the difference of PET: IV, crystallization, degree of contamination.

2. **The HydroCleaner does not need hot-wash for a perfect cleaning.**

   Removing glue and paper labels completely in a HydroClean cold-wash.

3. **The HydroCleaner compensates LDPE detection defects from NIR sorting by delamination.**

   Below 60°C UltraPure hot-wash detaches residual LDPE laminates without PET crystalization.

The Challenge of Cleaning PET Trays from PCR

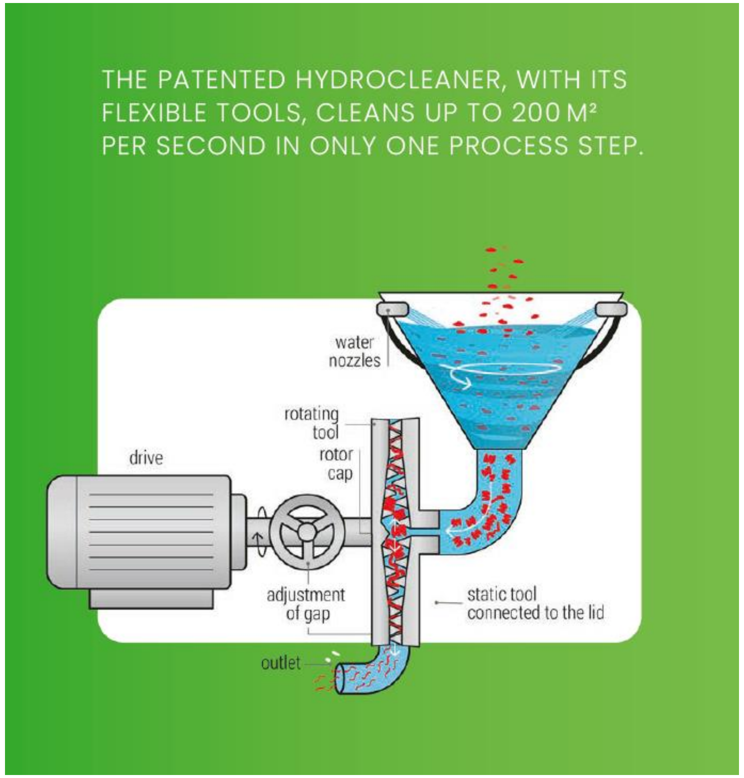
1. **Challenge #1: Lots of full size, printed paper labels with moisture-resistant adhesives.**

   Much more glue than with PET bottles. Print inks causing recontamination.
2. **Challenge #2: PE-laminates for sealing with lids-film**

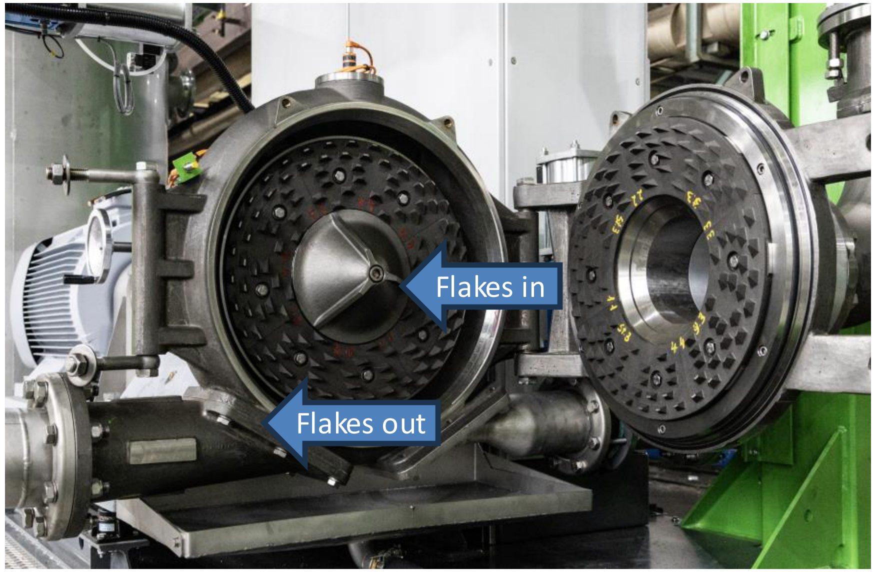
   HydroDyn has developed high performance tools for the removal of the LDPE laminates.
3. **Start of crystallization at lower temperatures beginning from 60°C**

   Makes flakes brittle. Mechanical dryers will cause fines.

The HydroCleaner – How it works



How it works



HydroCleaner with opened Stator-Rotor

1. **HydroCleaner**

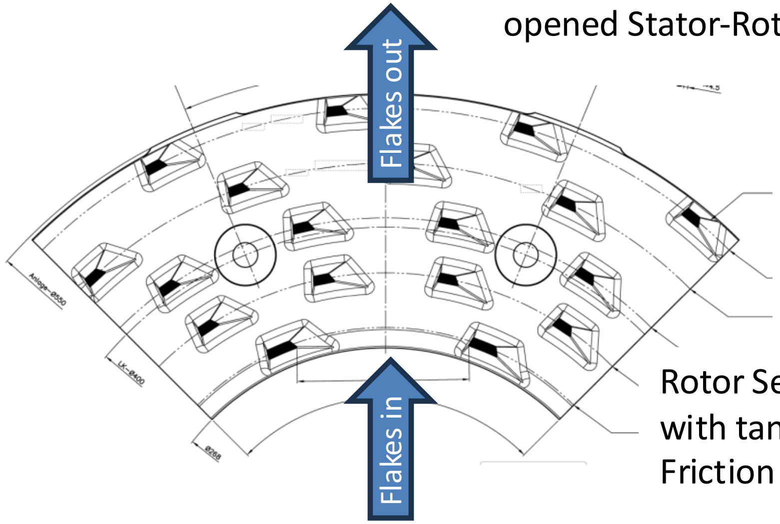
   Complementary Rotor and Stator applying surface friction and water turbulences

2. **HydroClean Cold-Wash**

   Takes of any extrinsic contamination from the PET flakes surfaces.

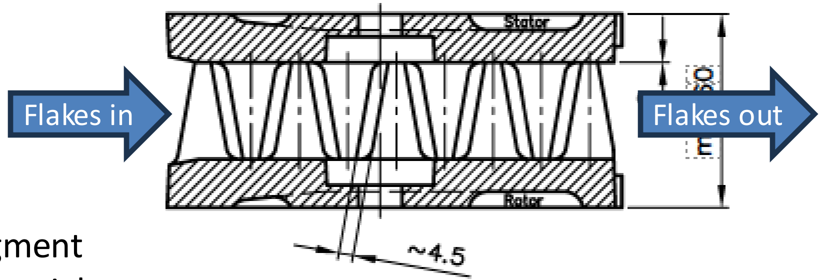
3. **Ultrapure Hot-Wash**

   Detaches LDPE Laminates from the PET flakes surfaces at temperatures < 60°C.



Rotor Segment with tangential Friction Zones

Stator-Rotor with Friction Zones as a Cut



Friction applies in the cleaning gap

Results

Purified Flakes from PCR PET Trays

1. **Purified Flakes with less than 100 ppm residual contamination**

   Hot-melt glue is transformed to colloids.

2. **Process Water Treatment**

   Splitted water circuits support rinsing with low water consumption.

3. **Reduced Fines**

   Working with temperatures not causing crystallization during the wash-process, but detaching LDPE-Laminates.

Contact:

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Chalenges

Decontamination

Taskforce recycling

Challenges for extrusion & decontamination

- PE, adhesive remains favour lump formation
- Contaminations have a negative effect on final quality
- In many cases a larger filter surface is often necessary
- IV build-up may be slowed down during polycondensation

Decontamination

- Restore food grade suitability
- Flake- , melt- or pellet-based
- Twin screw extruder & high vacuum degassing

Decontamination

Flake based

- Different process approaches
  - IR drying with downstream dehumidified air drying
  - Under vacuum & temperature
- Location
  - Before extrusion
  - Ideally combined in front of sheet extrusion

- Requirements:
  - Lower tolerance for foreign polymers / adhesive content
  - Limits at 1-2% PE content
    - Lower values are required for transparent material
- Advantages:
  - Good retrofitting option for sheet extruder
  - No AA build-up
  - Depending on the process, iV build-up is possible

Decontamination

- **Melt Based Process**:
  - ➢ Decontamination of plastic melt under vacuum
- Location:
  - ➢ Directly downstream of extrusion
- Advantages:
  - ➢ Fast iV build-up
  - ➢ Works with a higher multilayer / foreign polymer content (note ↑ multilayer - transparency ↓)
  - ➢ Good input quality leads to good colour results

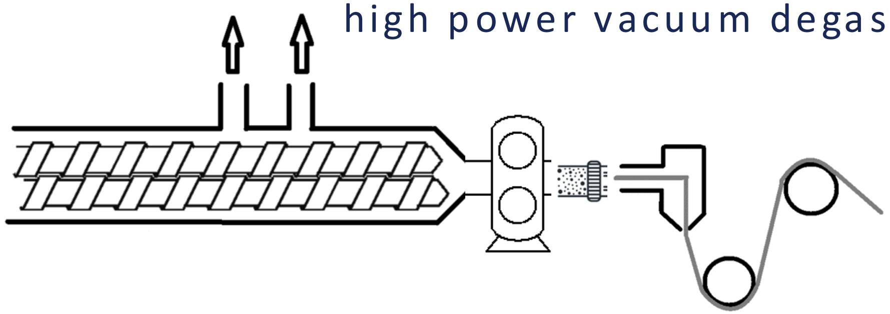
- **Pellet Based Process**:
  - ➢ Pellets are processed in a reactor vessel:
    - ➢ Residence time + defined temperature
    - ➢ Protective atmosphere (e.g.: N) or under vacuum
- Location:
  - ➢ Extra unit, downstream pelletiser
- Advantages:
  - ➢ Controlled iV build-up
  - ➢ Decontamination after recycling extruder (AA, benzene, limonene, etc.)
  - ➢ Ideal for transparent materials
  - ➢ Established technology from PCR BtB recycling

Decontamination

Twin screw extruder & high vacuum venting

- Process:
  - ➢ Combination of twin screw extruder & high power vacuum degassing
- Location:
  - ➢ Directly into the extruder process with downstream sheet extrusion
- Advantages:
  - ➢ Energy efficient as no pre-treatment is needed
  - ➢ Quick recipe changes feasible
  - ➢ Robust against foreign polymer in the process
    (note: foreign polymer transparency … *applies to <u>all</u> technologies)*
- Consider:
  - ➢ No iV bulid-up possible
  - ➢ Limited possibilities to get rid of AA, benzene and co.

high power vacuum degassing



Overview of technologies

Taskforce recycling

Overview of technologies

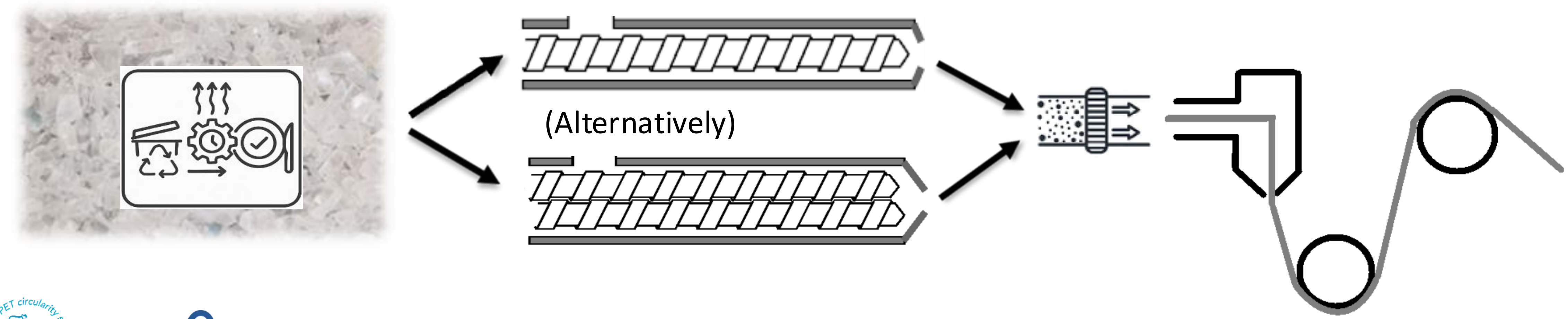
- Flake based decontamination followed by sheet extrusion

➢ Very energy efficient

  ➢ As decontamination always is linked to drying

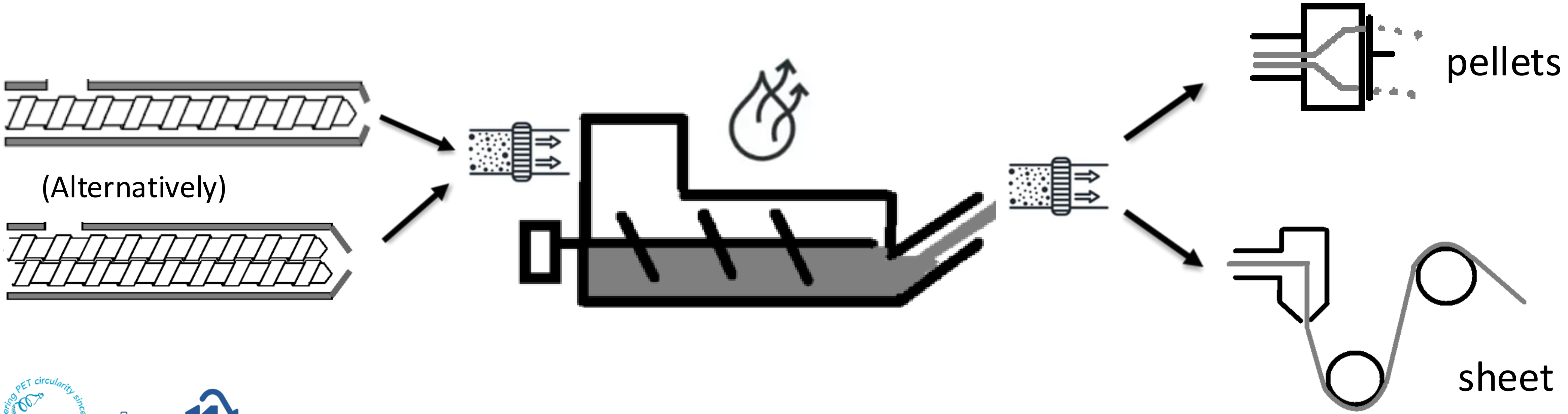
➢ iV build-up is possible

➢ Common practice / often also retrofitted



Overview of technologies

- Melt based decontamination combined either with pelletising or directly implemented in film extrusion
  - ➢ Very energy efficient (if directly implemented)
  - ➢ iV build-up



Overview of technologies

Melt based decontamination directly implemented in film extrusion

Multilayer flakes
iV: ~ 0,62 dl/g

Multilayer PET / PE Flakes
(~ 5-7% Polyolefin/EVOH content)

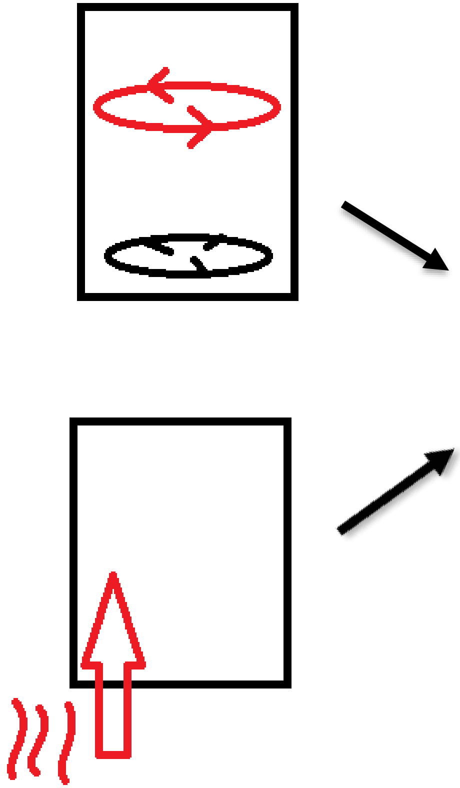
PE – Sheet flake direct to sheet

Sheet
iV: ~ 0,70 dl/g

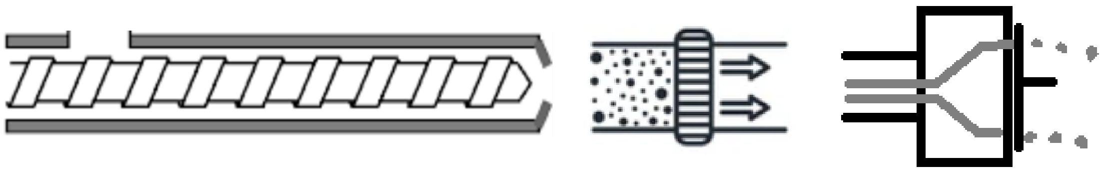
Inline produced sheet with melt based decontamination

Overview of technologies

Pre-treatment - extrusion - pellets - SSP



+ Higher multilayer content possible
+ Good colour values with multilayer remains
+ Higher process stability
+ Wider range of input streams



+ For high quality monoPET
+ Proven technology from BtB
+ Low iV build up

Thanks!

For further information please contact or join us!

Documents on specific tray recycling technologies of participating companies are at your disposal!

All technologies are available for trial runs! Get in touch with us!

- From laboratory scale
- To industrial scale

Taskforce

Food Contact Compliance in PET Tray Recycling

PETCORE EUROPE Thermoforming Working Group

PETCORE EUROPE Thermoforms Event, Dijon

May 27th, 2025

Strategy overview

- THE GROWING RELEVANCE OF RECYCLING IN CIRCULAR ECONOMY GOALS
- TO ACHIEVE CIRCULARITY ENSURING CONTACT COMPLIANCE IS A MUST
- **DEMONSTRATE FOOD CONTACT COMPLIANCE OF RPET FROM TRAYS**

Key challenges in PET recycling

Contamination and Purity of Materials: Food residues, adhesives, inks, other physical contaminants

Safety Regulations: EU (EFSA) food contact safety requirements

Standardization and Traceability

Lack of consistent recycling protocols and material origin traceability

Our focus

95% Food Contact Guarantee of Origin	• Ensure traceability and compliance with food safety standards and regulations (e.g., EU 10/2011, EU 2022/1616, FDA). • Develop certification or verification protocols for feedstock origin.
Bales Characterization	• Standardize how bales (e.g., plastic, paper, organic) are assessed for quality, contamination, and composition. • Use spectroscopy, visual inspection, or AI-based sorting tools.
Methodology & Guidelines Development	• Create a harmonized framework for sampling and testing material classification • Pilot across multiple countries to ensure adaptability to local feedstocks and regulations.
Testing & Validation	• Conduct cross-countries trials with industry partners. • Validate methods with real-world data and feedback loops.
Feedstock Library Creation	• Build a digital database of characterized feedstocks. • Include metadata: origin, composition, contamination levels, recyclability, etc.

Initial findings: mono and multi material clear

Type of material	Origin	Total weight reported (kg)	Percentage (%)	< 5% of non FGM
Mono clear (FD3)	France	305kg	95,7%	YES
Multi clear (FD9)	France	160kg	97,5%	YES
Mono and multi clear (FD12)	France	167kg	98,9%	YES
Mono and multi clear	Germany	33kg	95,4%	YES
Mono clear	Germany	23kg	86,0%	NO
Multi clear	Germany	35kg	99,8%	YES
Mono and multi clear	Portugal	5kg	99,6%	YES
Mono and multi clear	Portugal	5kg	97,4%	YES
Mono and multi clear	Portugal	5kg	99,0%	YES
Mono and multi clear	Portugal	5kg	99,6%	YES

Next steps

Market Share of PET Thermoforms food vs non-food

Clear mapping collection/sorting of PET thermoform

Coordinate procedures with Recycling technologies Taskforce

Digital product/watermarking or other technologies such as vision & IA to help proving food vs non-food

Pioneering PET circularity since 1993
PETCORE EUROPE

interzero®
zero waste solutions

Methodology and criteria for characterizing the non-food packaging percentage in post-consumer PET thermoform bales

PETCORE 27.5.25

Dr. Manica Ulcnik-Krump; Fabian Storz

Background / Regulatory framework

Background

PET packaging (bottles and trays) in Europe is recycled through established systems- deposit return, separate collection, or comingled collection.

To be used in food-contact applications, recycled PET must meet Regulation (EU) 2022/1616, Article 6 and Annex I.

Although PET in the EU is generally food-grade, contamination from non-food packaging is possible.

It must be shown that no more than 5% of the input comes from non-food uses.

Scope

This methodology developed by PETCORE members defines the standardized approach for evaluating post-consumer PET tray waste to ensure compliance with EFSA criteria, specifically Article 6 and Annex I.

The procedure helps categorize PET waste as food or non-food packaging, ensuring the proper use of PET from post-consumer bales.

Operating procedure of analysis

Bale Quality Check

Bale >5% non FCM — NO → **OK** for further **FCM** processing

YES ↓

Output >5% non FCM — NO → **OK** for further **FCM** processing

YES ↓

Blending to reduce the non FCM <5% — NO → **OK** for further **non FCM** processing

YES ↓

OK for further **FCM** processing

Bale Selection: Define a process for random bale selection with recorded sample size, frequency, and full traceability. Follow standard methods; justify any deviations.

Measurement: Cut the marked bale, take a sample, sort by category, weigh fractions, and record results.

Type of collection	Minimum Sample size (kg)	Frequency (sample/t treated)
Comingling	50	100 t
Separate collection	25	200 t
Deposit	10	400 t

Material sorting and classification guidelines- Principles of decision tree analysis

Inclusion

Materials excluded
Non-plastic materials such as: Metal; Cellulosic materials (e.g., paper, cardboard, wood)
Discard the following items: Materials larger than A4 size; Polymers other than PET, films/flexible packaging, and textiles

Materials included
The sorting into food and non-food categories, for the purpose of determining material share, is limited to PET trays and bottles.

Special cases
Stacked material that is cut and smashed during the sorting process is classified as lumps, as it becomes unidentifiable and cannot be properly sorted.

Classification

Calculation
Path dependency implemented to allow differentiation between recycling processes that handle either colored or only transparent trays and bottles.

$$\%FCM = \frac{Share\ PET\ food\ items}{All\ PET\ packaging\ items}$$

Databank of criteria's
9 Food and 6 Non-Food Criteria with 10 sample photos per category support operator decisions. The photo database is continuously expanded with examples from other countries.

Food grade criteria

Criteria: Label

Labels or images show food was stored inside.

Include names, ingredients, or expiration dates.

Clearly indicate food packaging.

Criteria: Soaker pad

Soaker pads absorb moisture to prevent leaks.

Preserve freshness in food like meat or berries.

Indicate food-grade packaging.

Food grade criteria

Criteria: Bottom of tray

Drainage channels prevent moisture and maintain food quality.

Designed for food packaging, not needed for non-food items.

Clearly indicates food application.

Criteria: Ventilation

Ventilation holes preserve freshness and extend shelf life.

Common in perishable food packaging, like berries.

Strong indicator of food use.

Non food grade criteria

Criteria: Label

Labels or images show non food was stored inside.

Include names, ingredients, or pictures

Clearly indicates non ood packaging.

Criteria: Paper on boarder

Paper borders protect and stabilize non-food products.

Used for items like toothbrushes or batteries.

Typical for non-food, not food packaging.

Non food grade criteria

Criteria: Hanger

Hangers enable shelf display for non-food items.

Common in electronics, tools, personal care.

Signal non-food packaging use

Criteria: Folded + sealed

Folded/sealed packaging protects non-food items.

Used for electronics, cosmetics, household goods.

Suggests non-food application.

Non food grade criteria

Criteria: Shape, based on functionality

Packaging shape fits specific non-food items.

Designed for products like toothbrushes or batteries.

Clearly indicates non-food use.

Criteria: Medical

Aluminum blister packs signal pharmaceutical use.

Common for pills, not food.

Clear non-food packaging indicator.

Reporting structure

General information for traceability according to EN 15347-1: 2024: Origin (household, commercial), pre or post consumer; type of collection; supplier information: batch size, load reference and sample size)

Type of material	Total weight reported (kg)	Percentage (%)	< 5% of non FGM
PET food + non-food material	Indicate the weight of PET food + non-food material.	100%	
PET from food consumer applications	Indicate the weight of PET from food consumer applications.	Indicate the % of PET from food consumer applications.	**YES / NO**
PET from non-food consumer applications	Indicate the weight of PET from non- food consumer applications.	Indicate the % of PET from non-food consumer applications.	

Interzeros's competence centre for plastics recycling

Material analysis in our accredited laboratory in Slovenia.

Internationally accredited for analyses of mechanical, physical, thermal, rheological and optical material properties of recyclate
(SIST EN ISO/IEC 17025)

Involved and trained for the material analyses according to the developed methods

Contact: manica.ulcnik-krump@interzero.de
& fabian.storz@interzero.de

FUNCTIONAL BARRIER

PETCORE EUROPE Thermoforming Working Group

PETCORE EUROPE Thermoforms Event, Dijon

May 27th, 2025

4th Monitoring plan

The intention of this monitoring period plan was :

- **Continue with the regular NIAS monitoring analysis as per regulation requirements**
- **Target migration extended to all members. As we have delayed the sample, we will ask for the analysis of all the lines between October 2024 and February 2025**
- **Analysis to be performed:**
  - **NIAS Screening to determine concentration of contaminants and decontamination efficiency**
    - **NIAS Screening In (Flake)**
    - **NIAS Screening out (Sheet)**
  - **Targeted migration 3 substances**
    - **Benzene**
    - **Limonene**
    - **BPA**
  - **Migration conditions**
    - **10d20ºC.- 25% of the lines (Group A to be shared)**
    - **10d40ºC.- 50% of the lines (Group B and C to be shared)**
    - **10d60ºC.- 25% of the lines (Group D to be shared)**
- **LAB Platform will be ready to accommodate the sampling orders.**

4th Monitoring plan

Petcore Functional Barrier mandatory testing, 2nd Campaign

156

Number - FB mandatory, 2nd campaign, non-draft, non-declined

FB mandatory requests, 2nd campaign

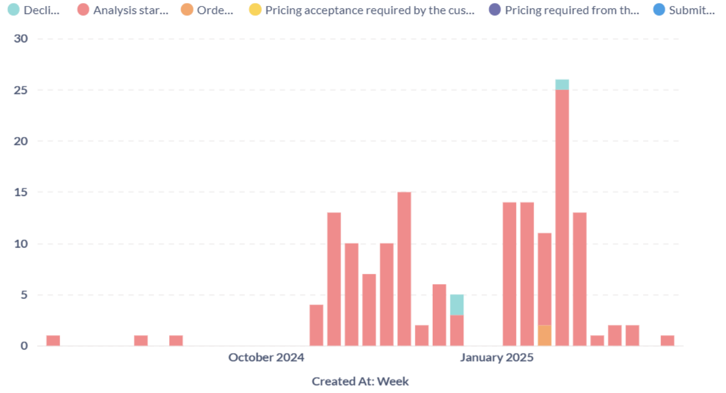
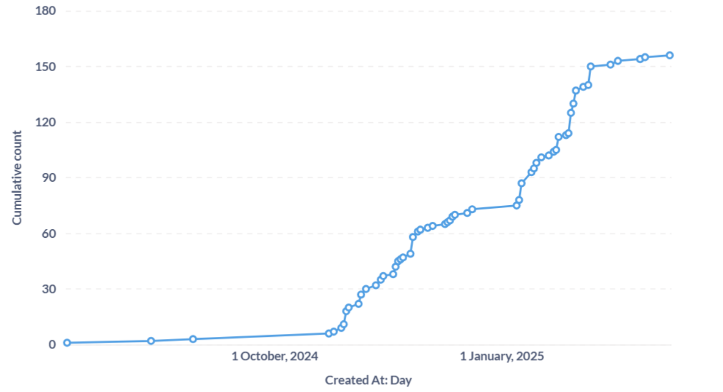


Chart of FB mandatory requests, 2nd campaign



FB mandatory 2nd campaign, orders per laboratory

Issued For ID: 8 bins	Companies → Name	Count
7535	Pack-Co S.r.l.	58
5136	J.S. Hamilton Poland Sp. z o.o.	43
7552	Sepack-Lab S.r.l.	34
7567	Ecol Studio S.p.A.	10
7550	AIMPLAS	7
7512	CHELAB SRL (Mérieux NutriSciences Italia)	2

FB mandatory, 2nd campaign, Petcore Group distribution

Count	Petcore Group
47	A
56	B
34	C
18	D
1	-

FB mandatory, 2nd campaign, all requests by status

Count	Case Status
2	Ordered
154	Analysis started
3	Declined

20 more frequent (incidental) substances

Substance	CAS	INPUT		OUTPUT	
		Frequency	Average* (µg/kg PET)	Frequency	Average* (µg/kg PE
limonene	138-86-3	88.79%	1187.88	67.29%	152.06
benzene	71-43-2	71.03%	428.70	98.13%	1292.65
toluene	108-88-3	47.66%	1562.81	44.86%	94.51
adipic acid, bis(2-ethylhexyl) ester	103-23-1	43.93%	12303.13	38.32%	4883.18
2,2-bis(4-hydroxyphenyl)propane	80-05-7	31.78%	5026.84	47.66%	3217.49
benzoic acid	65-85-0	30.84%	2505.69	26.17%	3286.57
p-cymene	99-87-6	25.23%	140.07	0%	ND (<17 - <1
γ-terpinene	99-85-4	23.36%	227.39	0%	ND (<10 - <1
phosphorous acid, tris(2,4-di-tert-butylphenyl)ester	31570-04-4	23.36%	12439.85	13.08%	7109.18
ethylbenzene	100-41-4	21.5%	388.82	3.74%	42.41
2-nonanone	821-55-6	19.63%	250.28	0%	ND (<10 - <1
2-heptanone	110-43-0	19.63%	311.00	0.93%	50.00
1-butanol	71-36-3	19.63%	588.60	0.93%	174.00
akr-30 pentaerythritol triacrylate (petia)	3524-68-3	19.63%	1116.40	19.63%	1390.71
styrene	100-42-5	18.69%	523.97	29.91%	132.12
eucalyptol	470-82-6	17.76%	309.93	0.93%	52.67
cyclohexane	110-82-7	16.82%	205.81	8.41%	148.60
pentanal	110-62-3	16.82%	292.29	1.87%	131.36
p-xylene	106-42-3	16.82%	256.48	13.08%	64.36

Worse case migration calculations

Substance	MW (g/mol)	CAS	OUTPUT		TOTAL MIGRATIC CALCULATION** Average* (µg/k food)
			Frequency	Average* (µg/kg PET)	
limonene	136.23	138-86-3	67.29%	152.06	5.50
benzene	78.11	71-43-2	98.13%	1292.65	46.77
toluene	92.14	108-88-3	44.86%	94.51	3.42
adipic acid, bis(2-ethylhexyl) ester	370.6	103-23-1	38.32%	4883.18	176.67
2,2-bis(4-hydroxyphenyl)propane	228.29	80-05-7	47.66%	3217.49	116.41
benzoic acid	112.12	65-85-0	26.17%	3286.57	118.91
p-cymene	134.22	99-87-6	0%	ND (<17 - <150)	<0.62 - <5.43
γ-terpinene	136.23	99-85-4	0%	ND (<10 - <150)	<0.36 - <5.43
phosphorous acid, tris(2,4-di-tert-butylphenyl)ester	646.94	31570-04-4	13.08%	7109.18	257.21
ethylbenzene	106.16	100-41-4	3.74%	42.41	1.53
2-nonanone	142.24	821-55-6	0%	ND (<10 - <150)	<0.36 - <5.43
2-heptanone	114.19	110-43-0	0.93%	50.00	1.81
1-butanol	74.12	71-36-3	0.93%	174.00	6.30
akr-30 pentaerythritol triacrylate (petia)	336.06	3524-68-3	19.63%	1390.71	50.32
styrene	104.15	100-42-5	29.91%	132.12	4.78
eucalyptol	154.25	470-82-6	0.93%	52.67	1.91
cyclohexane	84.16	110-82-7	8.41%	148.60	5.38
pentanal	86.13	110-62-3	1.87%	131.36	4.75
p-xylene	106.16	106-42-3	13.08%	64.36	2.33

Migration analysis results

Substance	MW (g/mol)	CAS	Migration testing			
			Test condition	Frequency of detection	Average of detected* (µg/kg food)	Average of al (µg/kg food
limonene	136.23	138-86-3	10d @ 20°C	0%	/	/
			10d @ 40°C	2.41%	8.07	0.19
			10d @ 60°C	0%	/	/
benzene	78.11	71-43-2	10d @ 20°C	35.71%	0.12	0.043
			10d @ 40°C	46.99%	2.25	1.058
			10d @ 60°C	60%	6.00	3.599
2,2-bis(4-hydroxyphenyl)propane	228.29	80-05-7	10d @ 20°C	14.29%	12.00	1.71
			10d @ 40°C	43.37%	15.48	6.71
			10d @ 60°C	10%	6.00	0.60

Preliminary Conclusions

- The numerous analyses carried out for this report give it **greater statistical significance**, although questions remain as to the accuracy of the results when carrying out measurements in the polymer itself.
  - The validity and practical significance of the results at the ppb level may **necessitate further scrutiny**.
- The concentrations of contaminants measured in the input and output remain relatively **comparable** to those measured in **previous reports**.
- The **migration measurements** obtained are **consistent with those reported previously** and with the results of the **migration simulations** presented in the preceding report within the limitations of the analytical methods.
- The findings also demonstrate considerable **variability in the outcomes**, along with substantial **disparities in LOD and LOQ** across different laboratories.
  - This underscores the necessity **for optimal standardisation of analytical methodologies and conditions,** including those for sampling and sample preparation.
  - It is imperative **to adhere to guidelines when calculating frequencies and mean values**, in order to ensure consistency in the approach and the validity of conclusions drawn.
- It´s still **premature to draw firm conclusions** about certain specific trends, particularly the influence of the equipment configuration and the correlation between migration results and certain migration simulations conducted previously under very specific conditions.
- It is however, essential to emphasise that:
  - the migration results indicate that the **actual migration is significantly lower** than that calculated based on the concentration in the sheet and considering total migration.
  - Consequently, this total migration **calculation method can be regarded as a worst-case scenario** for evaluating exposure and ensuring the safety of the material.
  - Only limonene in one of the samples tested gave a migration result of 0.45 µg/kg food while the worst case calculation was 0.42 µg/kg food.

KÖR Creating Industrial Intelligence

Thermoforms Conference 2025

How can the collection & sorting of PET Thermoforms be improved?

Dijon and Beaune, France
27 – 28 May 2025

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SERVICES VIA VALIDATED LABORATORY NETWORK:
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CORE EXPERTISE:

Development of easy-to-use online platform LABS.

Dedicated for PET.

The strategic partnership with PETCORE EUROPE

The strategic partnership

Launching a harmonized testing platform

Data collection

Standardized reporting & compliance

Accredited laboratory network

The importance of data to our business

KÖR

Let's talk about ~~FACTS~~ PRACTICE

Regulation (EU) 2022/1616

in the PET supply chain

KÖR

Why is testing data needed?

- ✓ To prove that you are production is safe
- ✓ To comply with the regulations
- ✓ To monitor your processes and obtain EFSA approval
- ✓ To identify trends in your production
- ✓ For Failure analyses
- ✓ For Traceability

What is important for your testing data?

- Useable data
- Comparable data
- Repeatable data
- Reliable data

KÖR

How do you order your testing demands?

Search for suitable laboratories on the market yourself...

OR

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KÖR

Coming soon

Simple download of all your data

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We will add data, like SML

Continuously expanding test portfolio

Our platform

Labs
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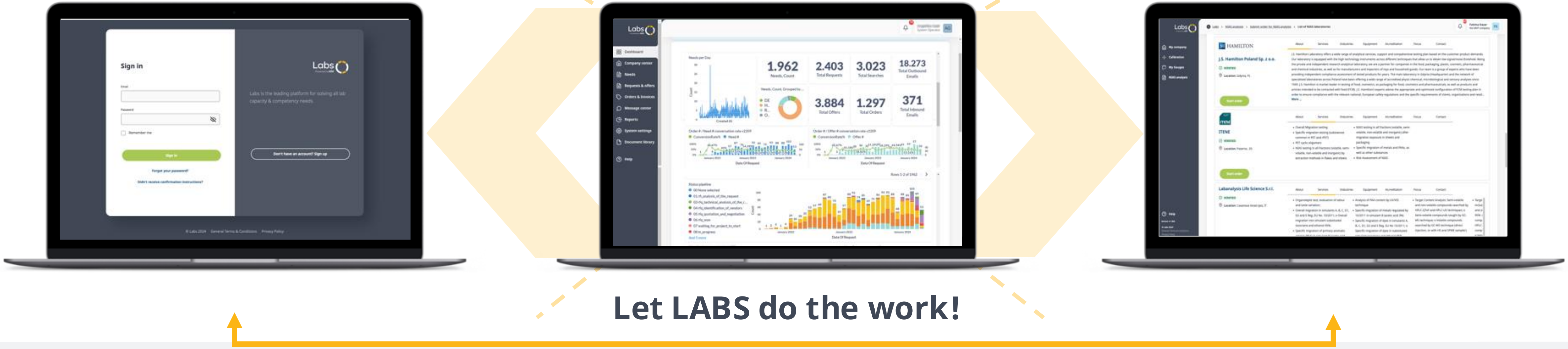
INDUSTRIAL MANUFACTURERS
CLIENTS

INDEPENDENT
LABORATORIES



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