GET TO ZERO

WITH MONO PET FLEXIBLE PACKAGING

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Meeting Race to Zero goals goals with mono PET flexibles

PROBLEM STATEMENT

HOUSEHOLD FLEXIBLE PACKAGING

The flexibles industry has a problem

Flexible packaging market EU

+ ~ 5 mil tons of flexible packaging; 70% food packaging
+ Biggest growing market: CAGR of 3.01% (2021-2026)
+ Trends: mono materials, virgin/carbon tax, EPR flexibles fees, carbon labelling, separate flexibles recycling target, Packaging and Packaging Waste Regulation proposal: 10% PCR by 2030, 50% by 2040 (food applications)
  Industry pledges: reducing CO^2 emissions by 2030

Previously, for flexibles, the winning ticket was the lower cost. But today the carbon footprint & circularity are where the focus lies

- Average rates for high quality recycling of B2C flexibles: ~0% (*Source: EMF)*
- Global Commitment report '22: recyclability targets not on track (*Source: EMF)*
- Significant limitations of chemical recycling of PE and PP flexibles: maximally optimised system needs at least ~45% virgin input and related carbon consumption (*Source: EMF)*

Problem statement

HOW TO GET 50% PCR INTO FLEXIBLE FOOD APPLICATIONS **AND** MEET 50% CARBON REDUCTON TARGETS?

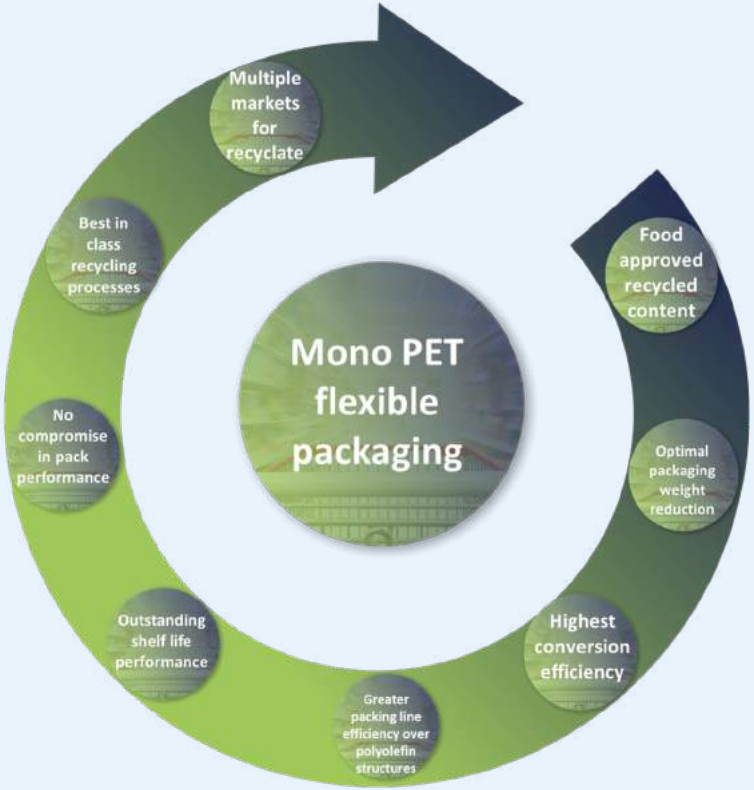
MONO PET FLEXIBLES

CIRCULAR PROPERTIES

Could Mono PET films be part of the answer?

For (~50-80%) of the household packaging portfolio

- Represents the optimum in terms of material usage and offers lower cost, **lower carbon** end of life outcomes
- Can help meet recycling targets and avoid Plastic Packaging tax
- Provides the only currently available and EFFICIENT way to get high levels of recycled content into food approved flexible packaging



Comparative analysis mono-materials

Production and use

Material benefits of BOPET

- Very high mechanical strength
- High temperature stability
- Available supply of food contact approved recycled content through mechanical and monomer recycling
- Excellent barrier to odour
- Ideal substrate for barrier coatings
- Perfect substrate for high speed printing
- Broadest temperature range from cryogenics to dual ovenable packaging

Impact of move to PO alternative

- Higher packaging unit weight or lower stiffness
- More packing lines needed for same output
- Not able to hit EU targets for use of recycled material
- Shorter shelf life products, or increased reliance on rigid packaging
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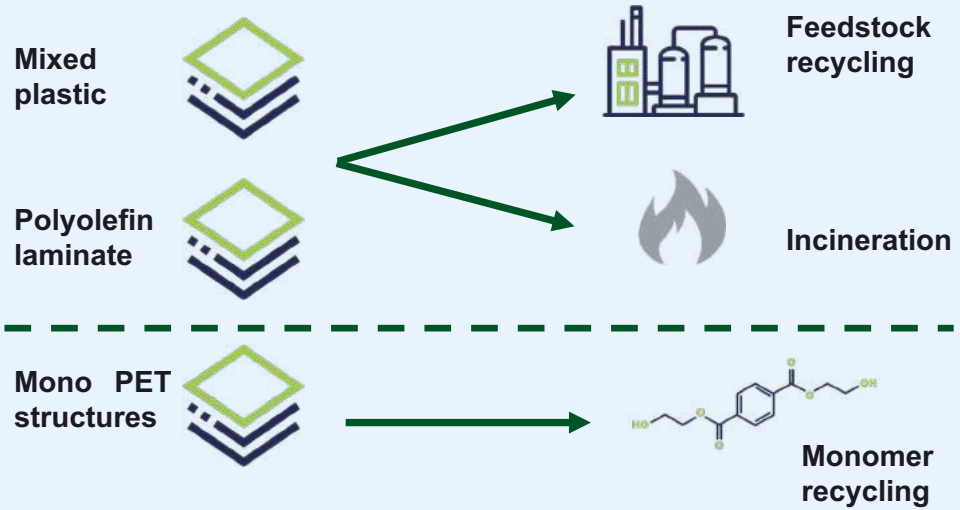
- Less ability to promote the final product
- Loss of consumer choice

Comparative analysis EoL pathways

Select EoL route based on lowest environmental impact

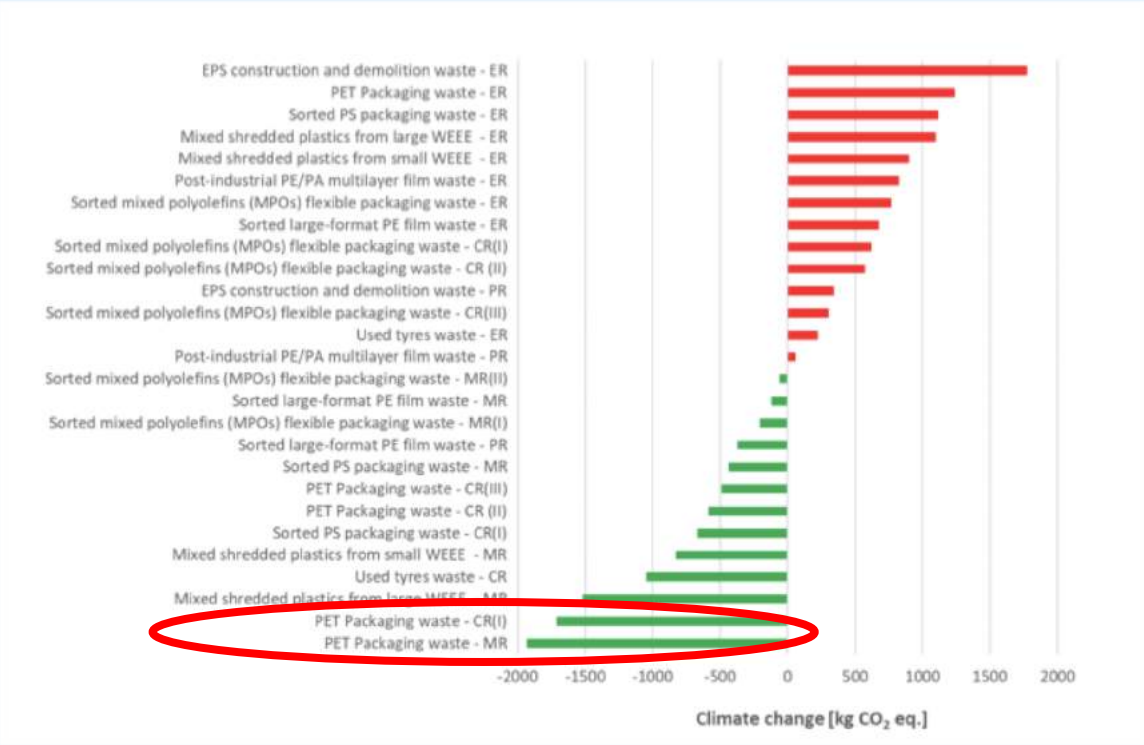


Feedstock recycling (pyrolysis) is a viable EoL option for household flexible packaging but has very **limited polymer to polymer yields, and is as such de-prioritised in various EU national Waste Directives** (*Source: CE Delft*)

Monomer recycling is a viable EoL option for household flexible packaging with **high polymer to polymer yields (**76-99%, *Source: Eunomia*), and lowest environmemtal impact (*Source: BFE, LCA*)

Comparative analysis EoL pathways – contd.

Select EoL route based on lowest environmental impact



Summary overview of climate change associated with the management of 1t of various plastic wastes.

green bars = net GHG savings
red bars = net GHG burdens
CR = chemical recycling
ER = energy recovery
MR mechanical recycling
PR = physical recycling

Source: Environmental and Economic assessment of plastic waste - European Commission - JRC, 2023, p.73

MONO PET FLEXIBLES

DELIVERING ON THE RESET GOALS WITH FLEXIBLE MONO PET PACKAGING

Meeting Race to Zero goals

With mono PET flexibles for household packaging

Race to Zero goal: halving emissions by 2030	
 100% to be maximum recyclable	Mono PET structures and monomer recycling offer the maximum in terms of plastic to plastic yields (76-99% vs max 55% - pyrolysis based recycling for mono PE and PP)
 20% less plastic used	Mono PET structures offer the option to reduce the amount of plastic in many applications. Replicating 12/60 PET/PE laminate would save 20% plastic with mono PET-structures
 50% use of recyclate	PET is the only current option for food contact approved recycled material, and the combination of mono PET and monomer recycling is the better environmental choice compared to its i.e PET/LDPE and mono PE alternative. • Mono PET has 27% lower GWP compared to PET/LDPE as a result of thinner film, with 50% recycled content. • The mono PE alternative has a 36% higher GWP compared to PET/LDPE. *(Source: LCA, TNO)*

VITA NOVA AMBITIONS

R&D on Mono PET packs for a circular economy

Vita Nova is a pre-competitive initiative by BOPET Films Europe and Searious Business

Focus areas

- Material Design: demonstration of material redesign options
- End-of-life: research on efficient sorting and recycling pathways, business case modelling, analysis on scalability, market readiness, and LCA
- Collaboration: foster open collaboration across the value chain, including producers, converters, recyclers, FMCGs, retailers to promote recycling with the lowest environmental impact, and get recyclate in at scale

VITA NOVA STATUS UPDATE

What have we achieved? What's next?

- Helped establish a PET flexiles working group under Petcore
- Demonstrated:
  - **Easy switch** is possible for a wide selection of applications ~50-80% – 🔎 Annex 1
  - **Weight reduction** potential: 20% – 🔎 Annex 2
  - **Environmental benefits** of mono PET vs mono PE and PET/LDPE

    LCA conducted by TNO - 🔎 Annex 2
    - Mono PET has 27% lower GWP vs PET/LDPE equivalent. Why: thinner film and 50% PCR
    - Mono PE alternative has a 36% higher GWP compared to PET/LDPE
    - NB: None of the above have designated monostream recycling pathways in Europe
  - **Positive sorting** results – lab-scale sorting test with HTP Cyclos and Pellenc:

    98% purity based on sorting with 2 NIRs – 🔎 Annex 3
  - **Virgin-like recycling** results – lab-scale monomer recycling trials with Poeidon plastics 🔎 Annex 4
- Developed a campaign to invite brand owners to join the **Lighthouse project** and prove the principle in practice

Proposition

Proving the principle in practice – creating an impact together

Vita Nova is inviting Race to Zero accelerators to join the pre-competitive Lighthouse Project and **prove the principle at semi-industrial scale that mono PET (r) PET packs:**

- Can significantly reduce the amount of plastic and increase the amount of PCR in a selection of existing structures, without negative impact on pack performance or packaging line efficiencies
- Can efficiently be recycled– chemically: pack to pack
- Offer carbon and economic benefits over existing packaging solutions

ANNEXES

Annex 1 - Target applications mono PET

Annex 2 - Environmental benefits: 2a) weight reductions; 2b) CO2 eq. reductions (LCA results)

Annex 3 - Positive sorting results based on NIR-detection

Annex 4 - Virgin-like recycling results

Annex 1 – Target applications

Easy switch for FMCGs and private label

Reset
A large proportion of household flexible packaging structures can easily be changed to mono PET without a loss in pack performance, and with lower cost, lower carbon impact

Target applications include
- convenience food
- snack foods
- fresh fruit and vegetables

Proven commercial case studies covering the majority of common packing methods including pre-made bags, horizontal flow wrap, VFFS and stand up pouches

Barrier options available for extended shelf life

ANNEX 2a – Environmental benefits

Weight reduction potential

Laminates of equivalent section stiffness

Combo	Thickness / µm	Total thickness /µm	Unit wt /gsm
PET/LLDPE	12/60	72	72
PET/PET	12/31	43	60
BOPE/LLDPE	20/65	86	79

The only way to significantly reduce pack weight from current mixed plastic laminates is to produce a mono PET laminate

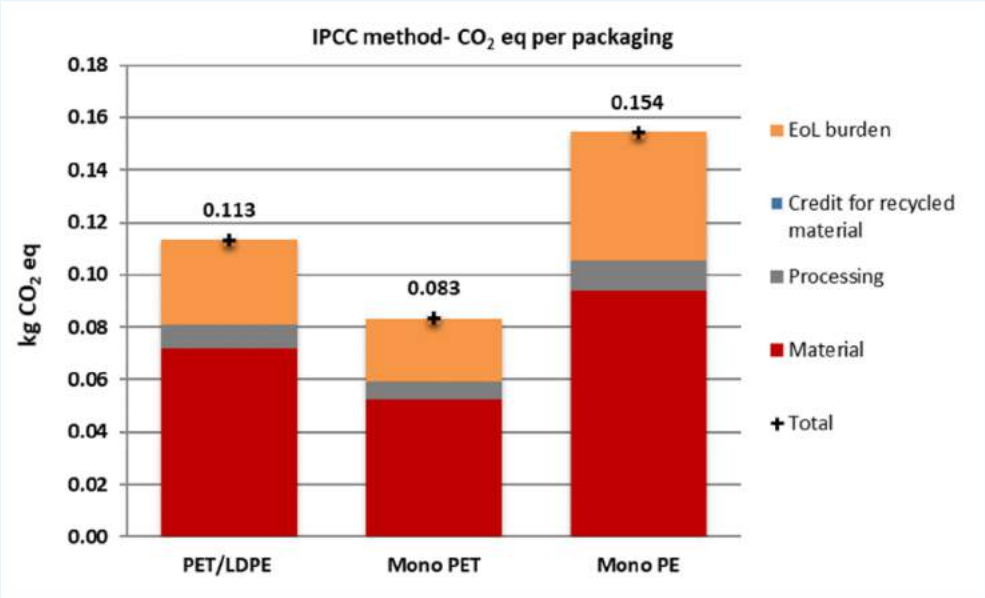
Replicating 12/60 PET/PE laminate with mono PET-structures

- Would save 20% plastic
- Unlocks the option to incorporae food compliant PCR
- Can enhance machine efficiency - 20%

ANNEX 2b – Environmental benefits (1/2)

CO2 eq. reductions based on mono PET (+50% PCR) vs mono PE, vs PET/LDPE

Current state of play – incineration

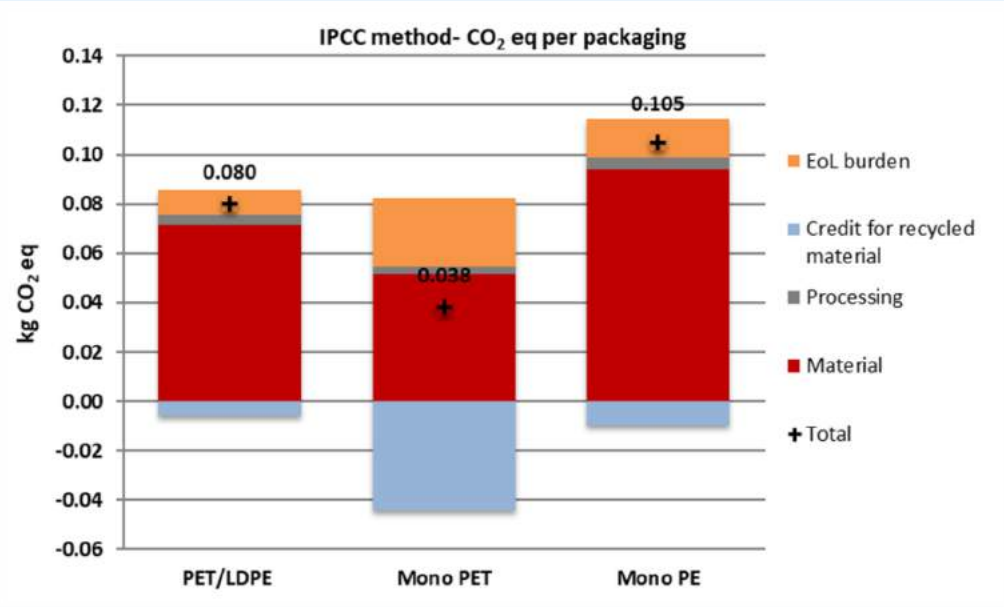


- Mono PET has 27% lower GWP compared to PET/LDPE as a result of thinner film and 50% recycled content
- The mono PE alternative has a 36% higher GWP compared to PET/LDPE
- Functional unit in LCA = 1 piece of packaging film for food (muesli) packaging application with the surface area of 500 cm2

ANNEX 2b – Environmental benefits (2/2)

CO2 eq. reductions based on mono PET (+50% PCR) vs mono PE, vs PET/LDPE

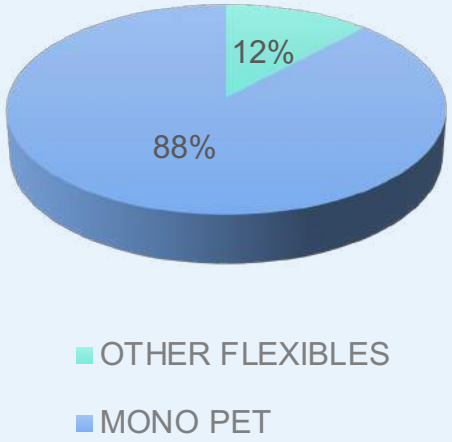
Future scenario – pyrolysis and monomer recycling



- Chemical recycling of films results in reduced GWP impacts by:
  - 24% for PET/LDPE films
  - 27% for mono PE compared
  - 51% for mono PET films
- For mono PET the chemical recycling is glycolysis and it is pyrolysis for the other two packaging alternatives
- The avoided CO2-eq. impact for the PET/LDPE film is 48% lower than mono PE film

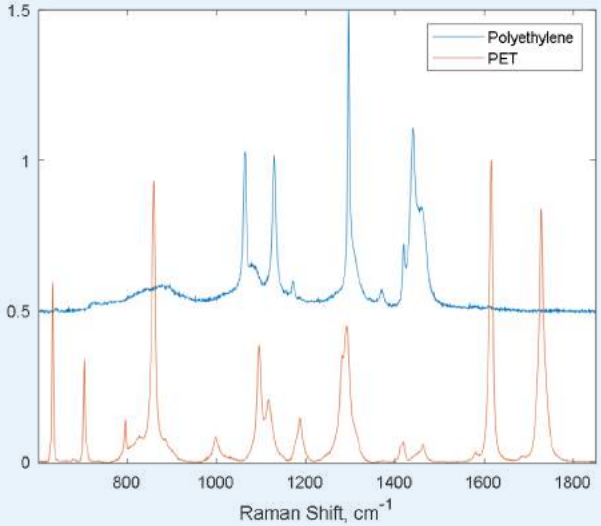
ANNEX 3 – Effective Sorting

Sorting trial results (HTP Cyclos and Pellenc)



Material differentiation = easy:

- 88% sorting efficiency - one pass process
- Can easily be improved to 98% - two pass process



Clear difference in infrared response between PE (blue) & PET (red)

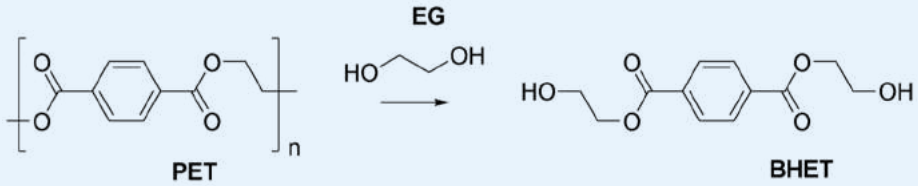
ANNEX 4 – Virgin like recycling results (1/4)

Monomer recycling trial results (Poseidon)

Recycling trial:
Subjecting different heat sealable printed PET films to a monomer recycling process

ANNEX 4 – Virgin like recycling results (2/4)

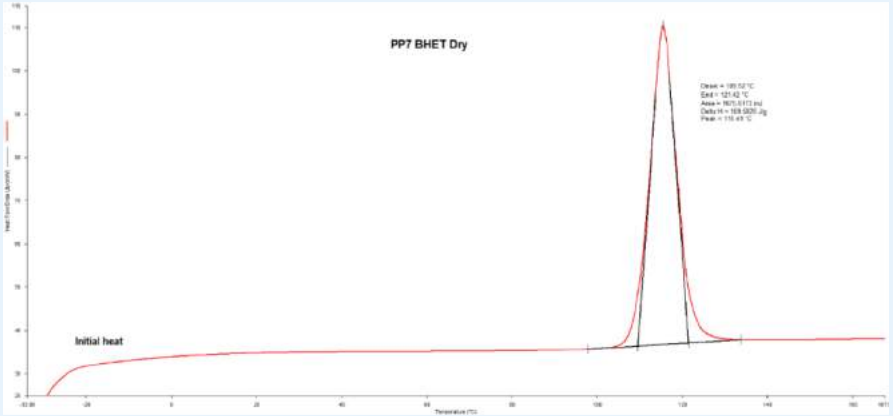
Monomer recycling trial results (Poseidon)



- Printed PET-film went through a glycolysis process
- Following the initial glycolysis reaction the crude product was subjected to a series of purification stages, which yielded high purity BHET monomer
- Subsequent analysis of the purified BHET material reveals it is of a quality indistinguishable from virgin polymer and suitable for film production

ANNEX 4 – Virgin like recycling results (3/4)

Monomer recycling trial results (Poseidon)



DSC analysis- single melt peak: confirming purity and suitability for re-polymerisation into high IV base polymer

Element	PET Input / ppm	BHET / ppm
Na	74	11
Mg	79	<1
Al	180	<1
P	100	22
K	29	<1
Ca	110	<1
Ti	4500	<1
Ni	1.3	<1
Cu	22	<1
Zn	5.1	<1
Ge	4.2	<1
Sr	3.9	<1
Zr	11	<1
Nb	8.6	<1
Sb	140	<1

Chemical analysis of the input material compared with the purified monomer (BHET) shows removal of common trace metal contaminants which is of critical importance for food contact applications

ANNEX 4 – Virgin like recycling results (4/4)

Monomer recycling trial results (Poseidon)

- Resulting PET sample was successfully extruded on a pilot line and a finished film sample was produced
- Properties set for the final film are equivalent to standard PET films used extensively by the packaging industry

Let’s win the Race to Zero together!

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#MonoPETpacks

BOPET FILMS Europe Searious BUSINESS

Vita Nova –An initiative from BOPET Films Europe and Searious Business.