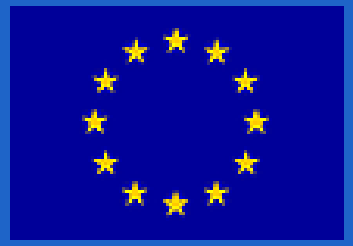
This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No. 859885.



Determination of Processability and Performance of Mechanically Recycled Flexible Plastics

Amir Bashirgonbadi, Laurens Delva, Kim Ragaert, Kevin van Geem

July 4, 2023

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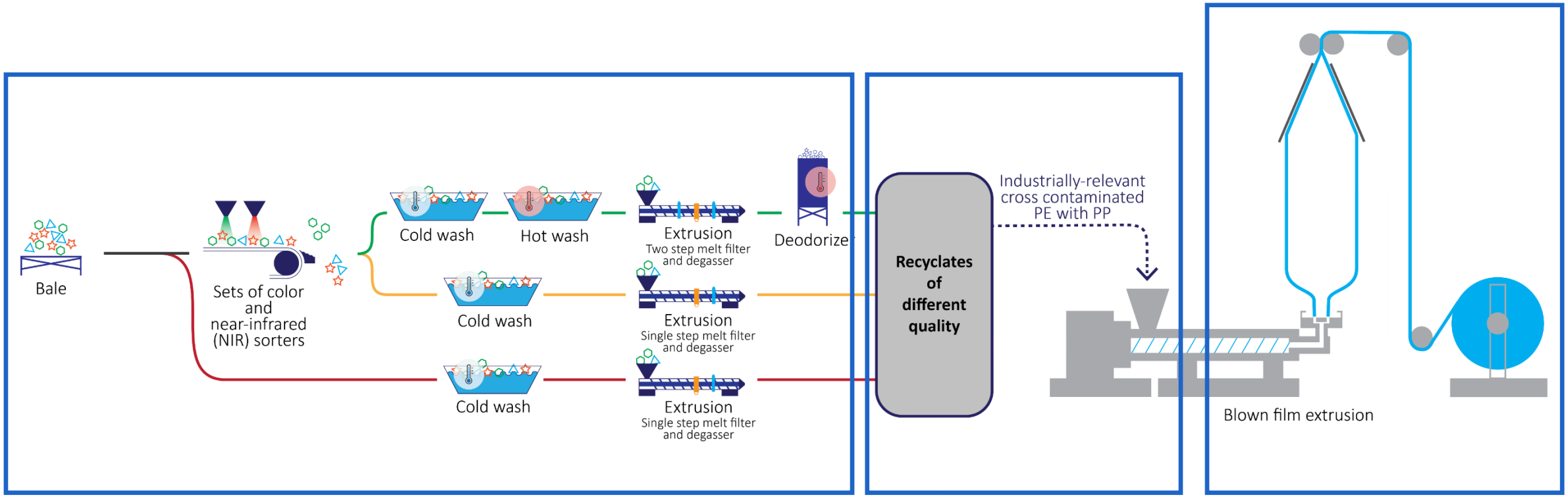
C-PlaNeT
CIRCULAR PLASTICS NETWORK FOR TRAINING

SCHEME OF AMIR'S PHD



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RECYCLING PATH FOR FLEXIBLES

Issues:

- Low quality/Limited applications
- Highly dependent on EPR

Source separation → Collection → Sorting at MRF → Recycling → Conversion

fostplus.be

ivago.be

indaver.com

ecoo.eu

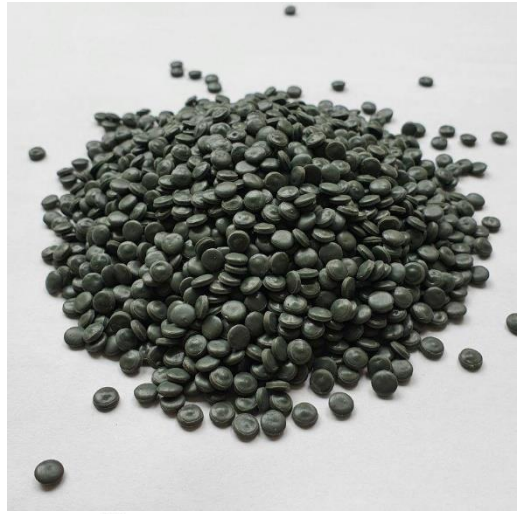
RECYCLING PROCESS

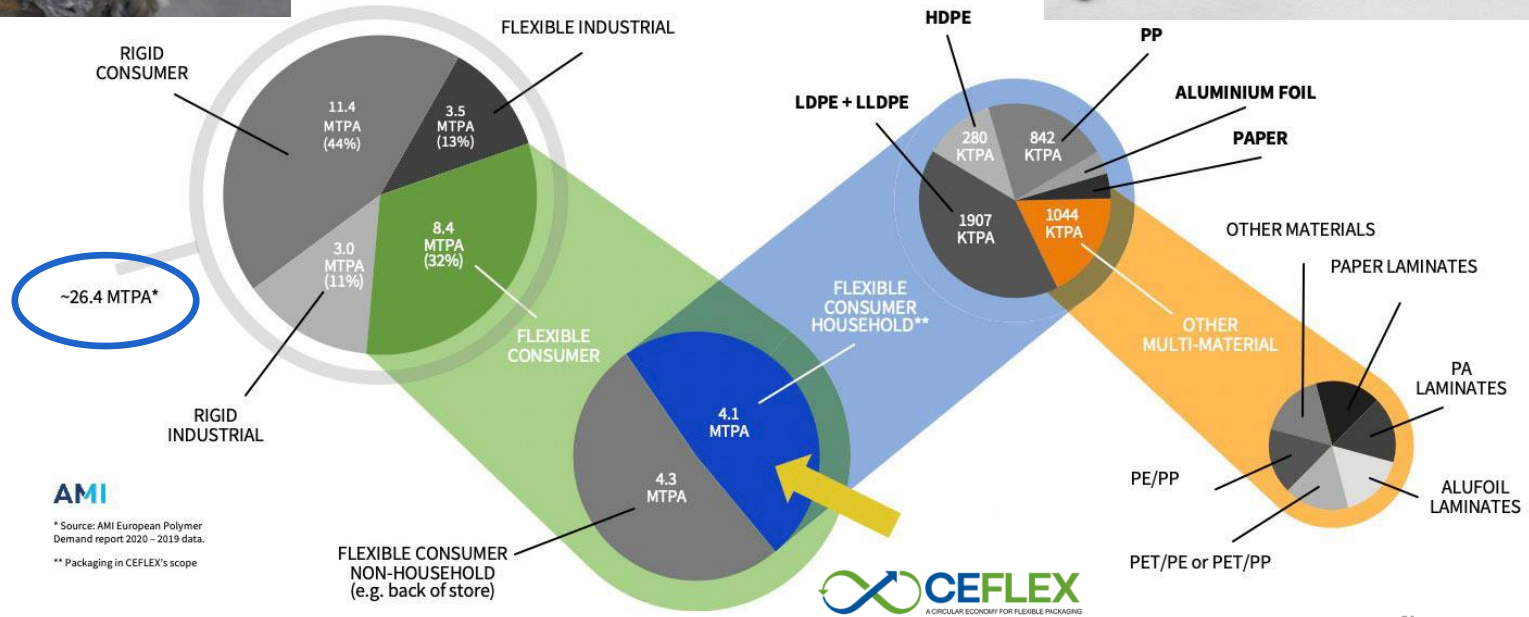
Sorted bales

Courtesy of Sorema

Recycling

Regranulate





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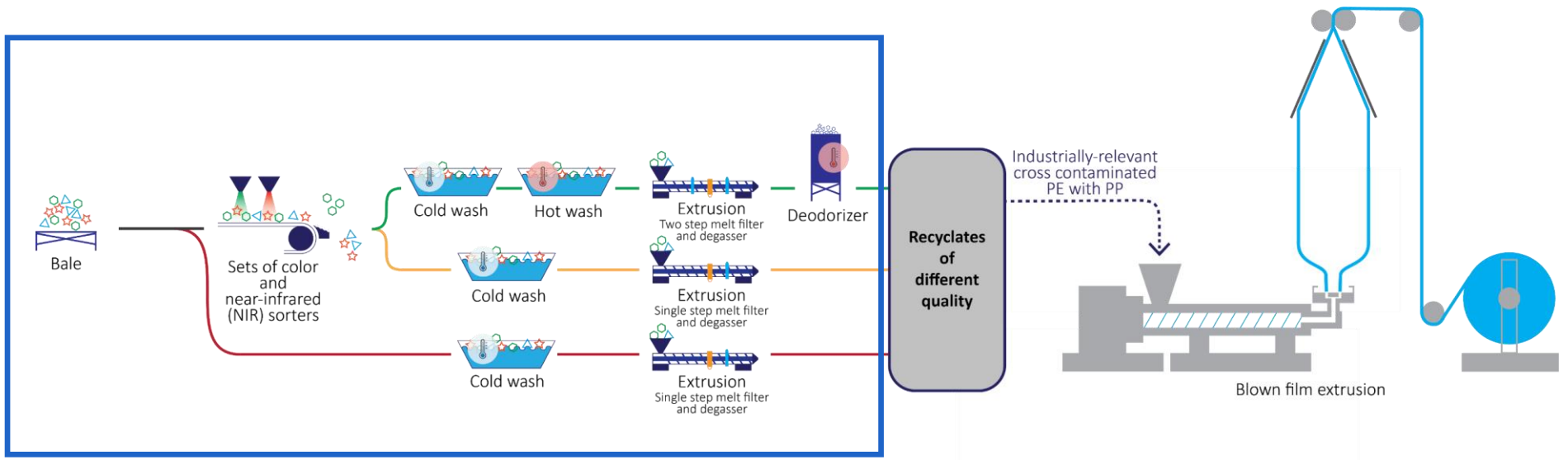


QUALITY RECYCLING PROCESS

QUALITY RECYCLING PROCESS

Waste Management 153 (2022) 41–51

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

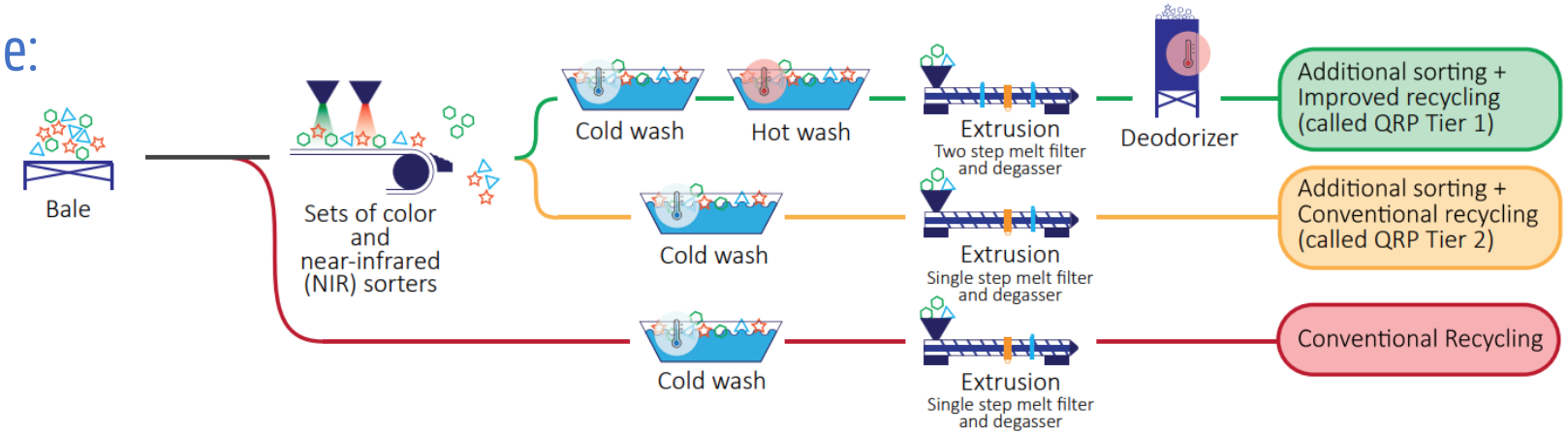
Quality evaluation and economic assessment of an improved mechanical recycling process for post-consumer flexible plastics

Amir Bashirgonbadi [a,c], Irdanto Saputra Lase [b], Laurens Delva [a], Kevin M. Van Geem [a], Steven De Meester [b,c], Kim Ragaert [c,*]

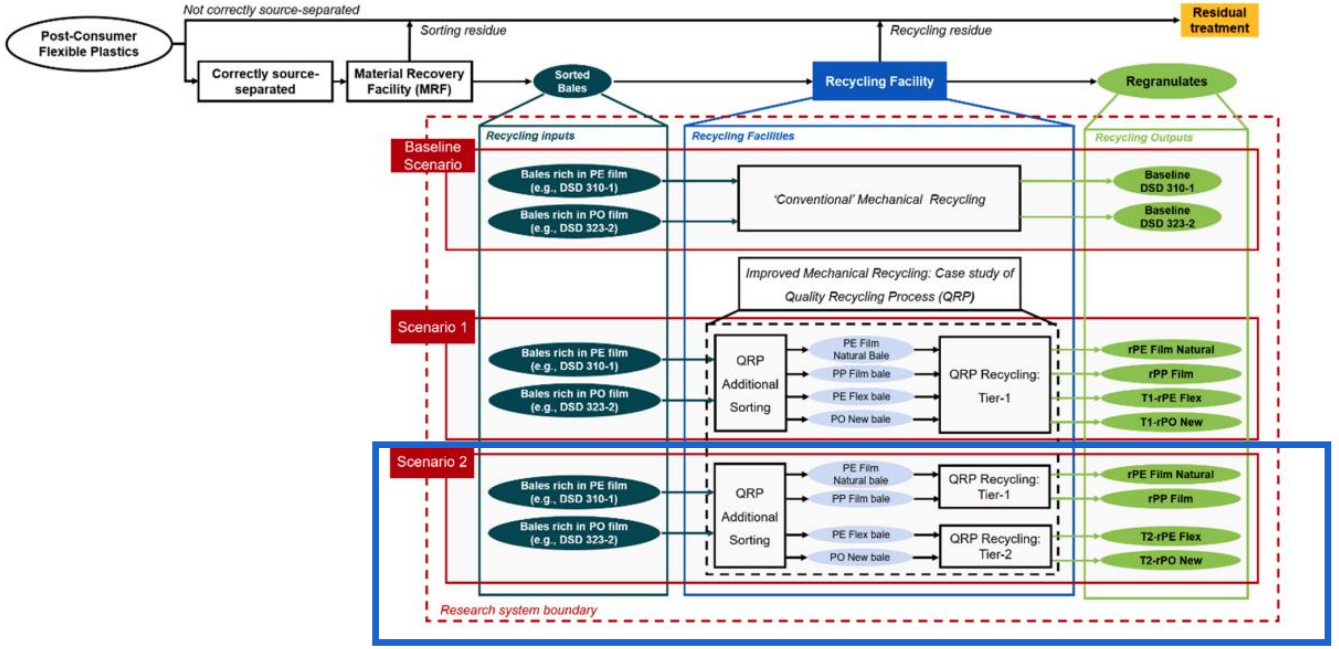
Process scheme:

Bales:

- DSD 310
- DSD 323



Scenarios:



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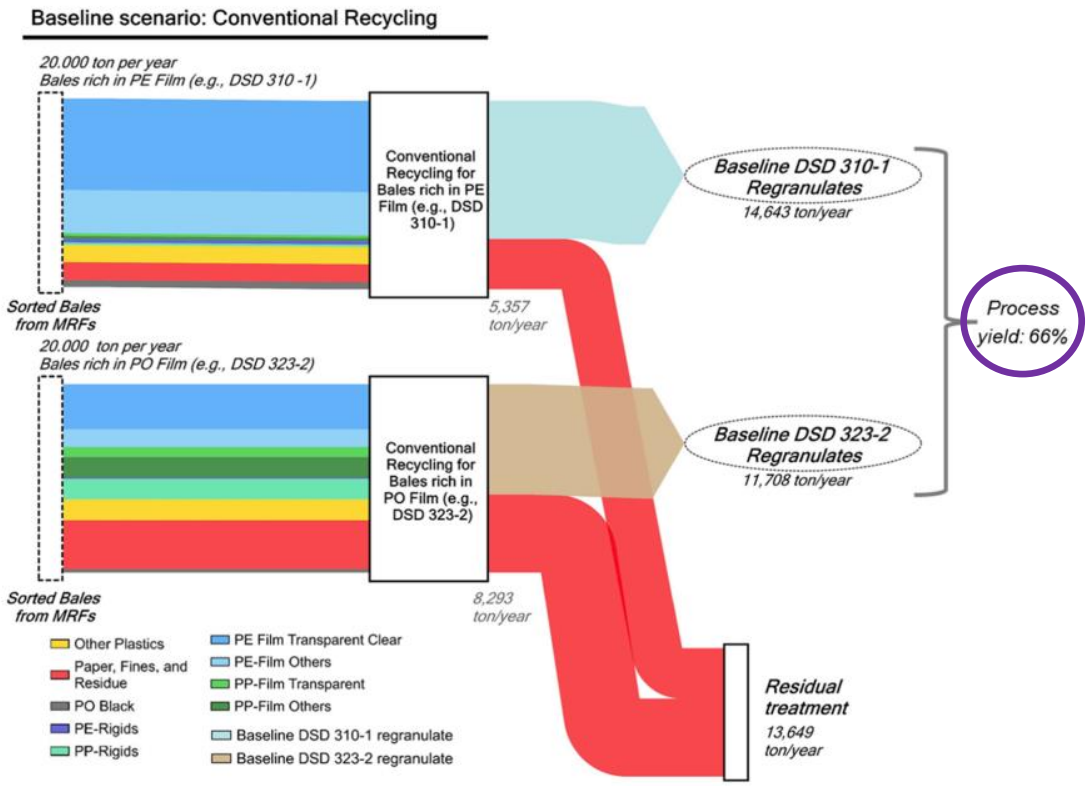
PROCESS YIELD

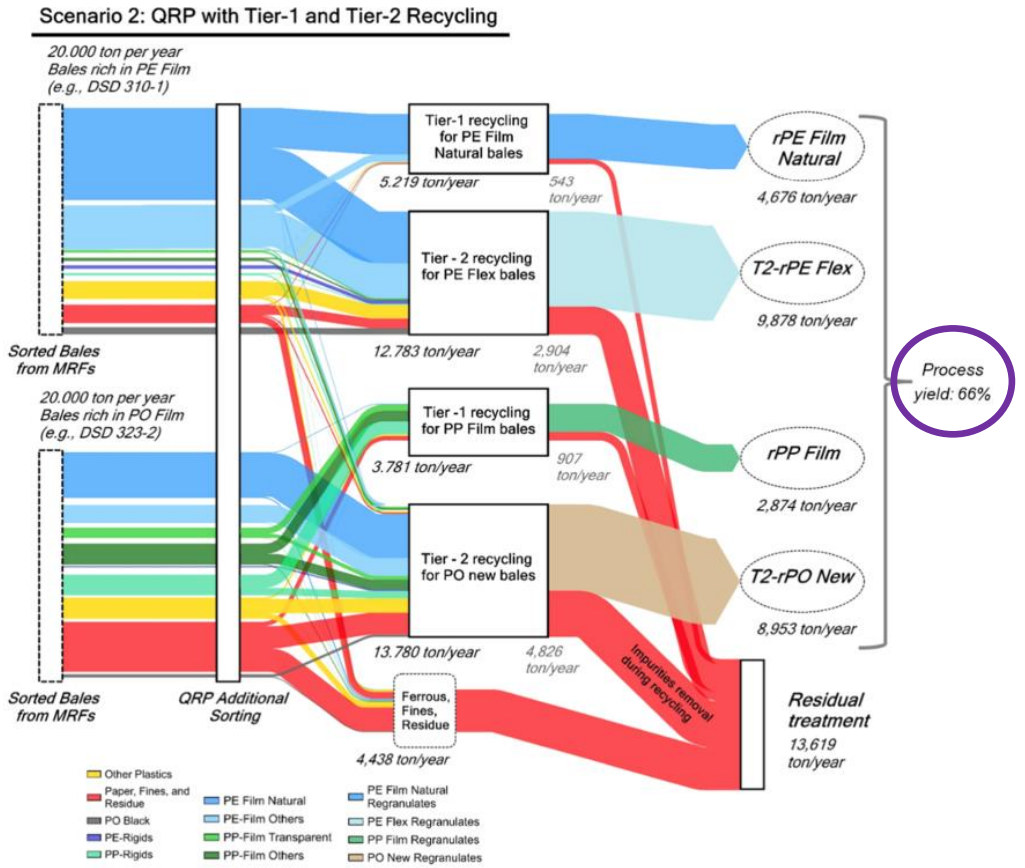
Contents lists available at ScienceDirect
Waste Management
journal homepage: www.elsevier.com/locate/wasman

Material flow analysis and recycling performance of an improved mechanical recycling process for post-consumer flexible plastics

Irdanto Saputra Lase [a], Amir Bashirgonbadi [b,d], Freek van Rhijn [e], Jo Dewulf [c], Kim Ragaert [d], Laurens Delva [b], Martijn Roosen [a], Martine Brandsma [e], Michael Langen [f], Steven De Meester [a,*]

- Scenario2 delivers a comparable yield to the baseline





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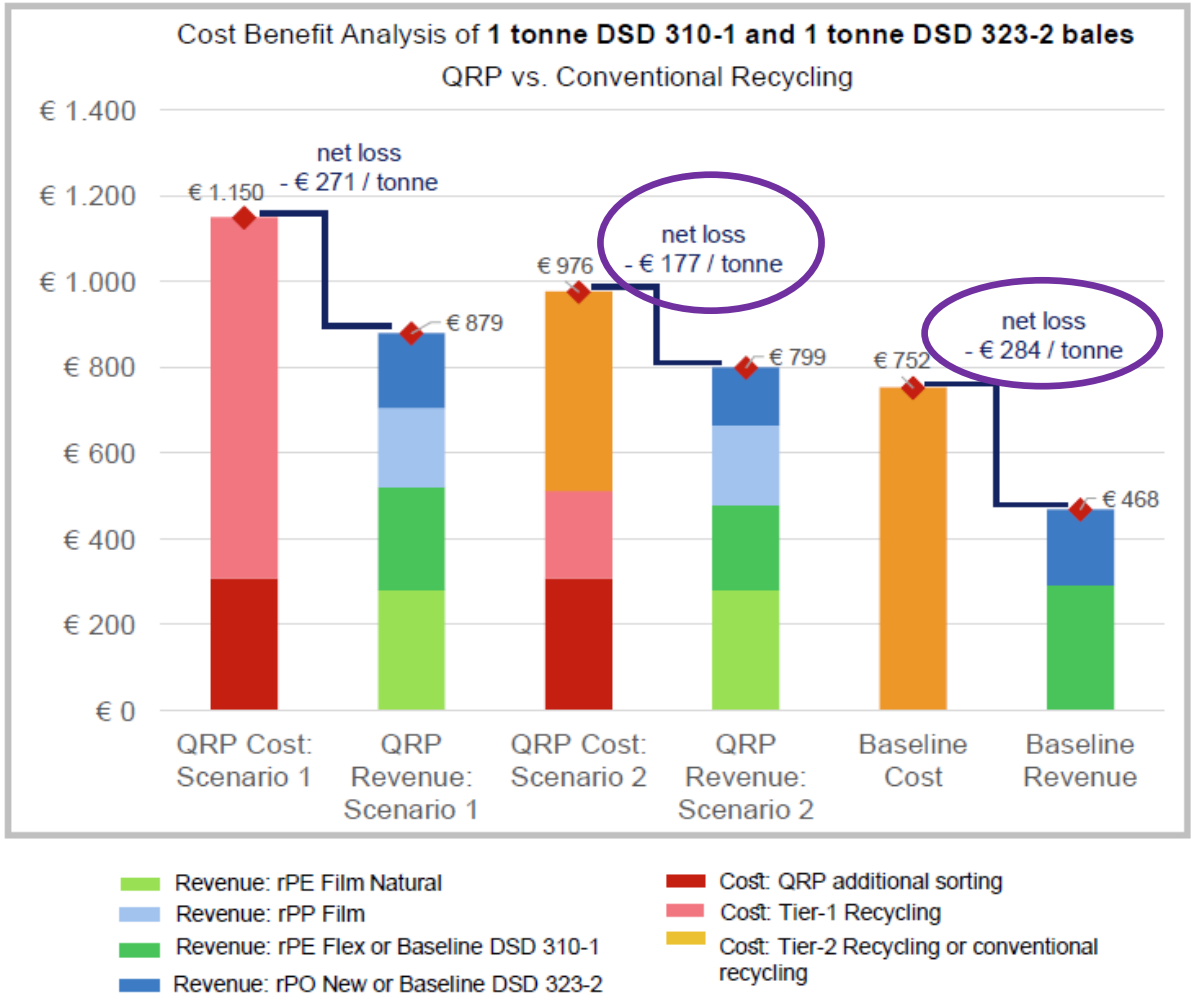
COST BALANCE OF THE PROCESS

- QRP scenario 2 is more self sustaining compared to the other scenarios.
- It provides regranulates of higher quality.
- And unlocks varied applications for the flexible regranulates



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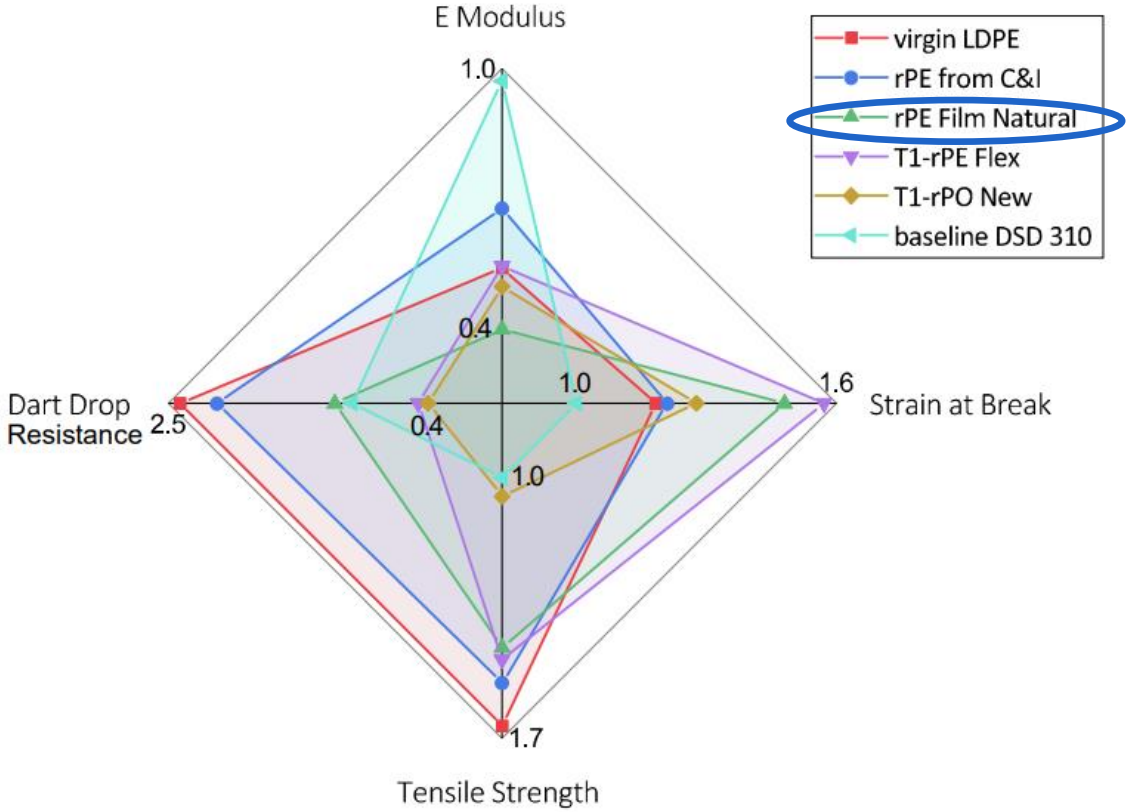
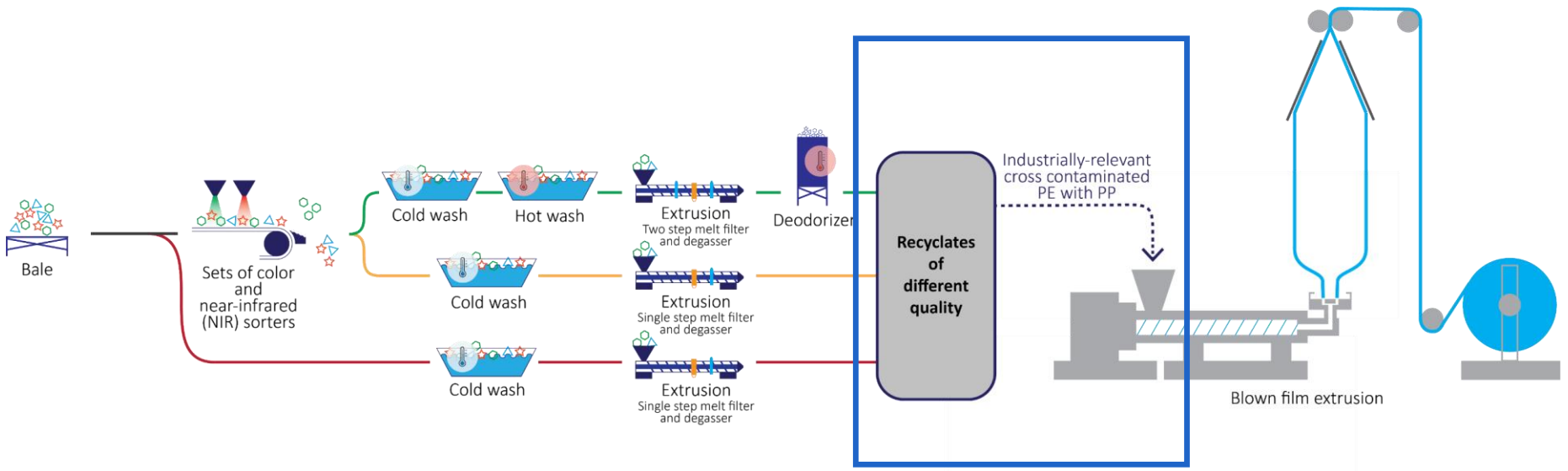
PERFORMANCE OF THE REGRANULATES

— Properties of the PE-rich regranulate and its application demonstration



Courtesy of PepsiCo



DETERMINATION OF COMPOSITION

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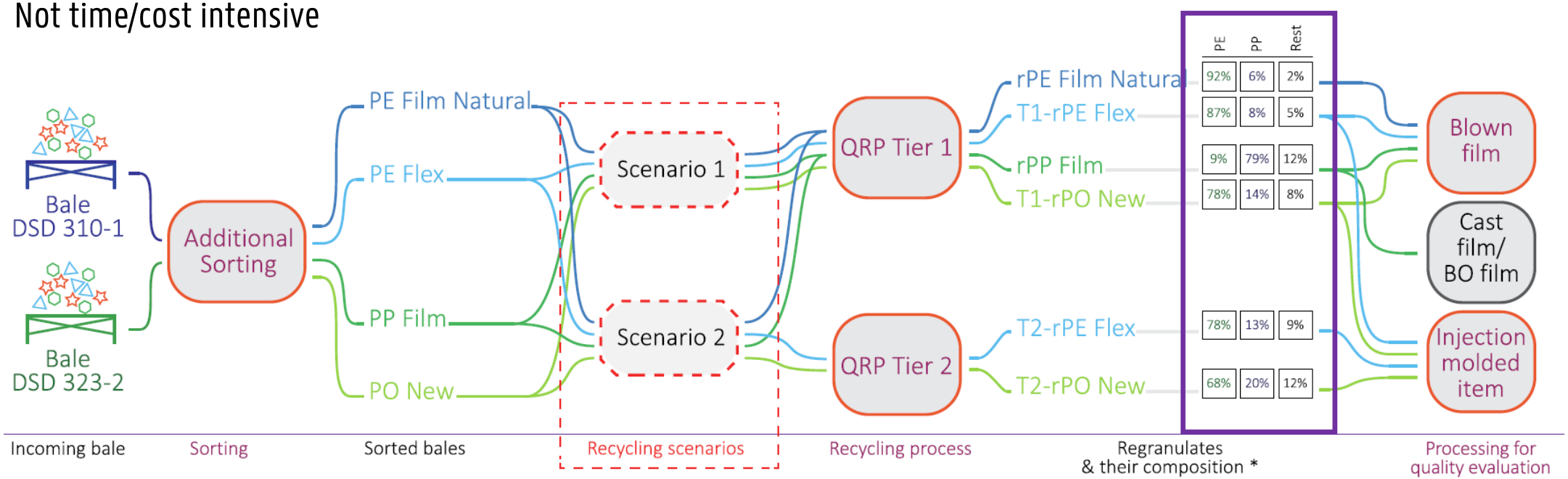
Will be submitted to the Polymer Testing journal (Summer 2023)

COMPOSITION OF RECYCLED FLEXIBLES

Cross contamination of PE and PP

A proper technique:

- Accurate
- Accessible
- Not time/cost intensive



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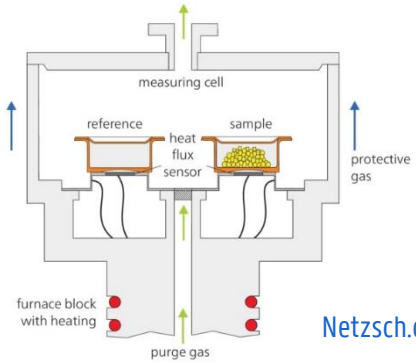
DETERMINATION OF CRYSTALLINITY/COMPOSITION

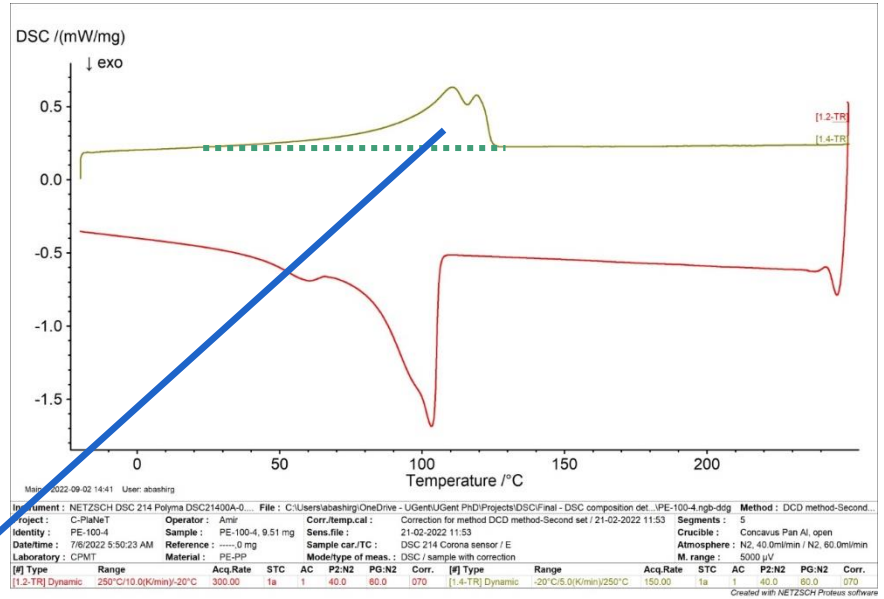
In a blend with a known composition:

$$\varphi_i = \frac{\Delta H_{m,i}}{\Delta H^0_{m,i} \times \%Xc,i} \times 100$$

- If we want to determine the composition in a blend, we should have a known (or a relatively accurate estimation of) crystallinity for each constituent.
- Remark: Crystallinity of each constituent changes with its content in the blend

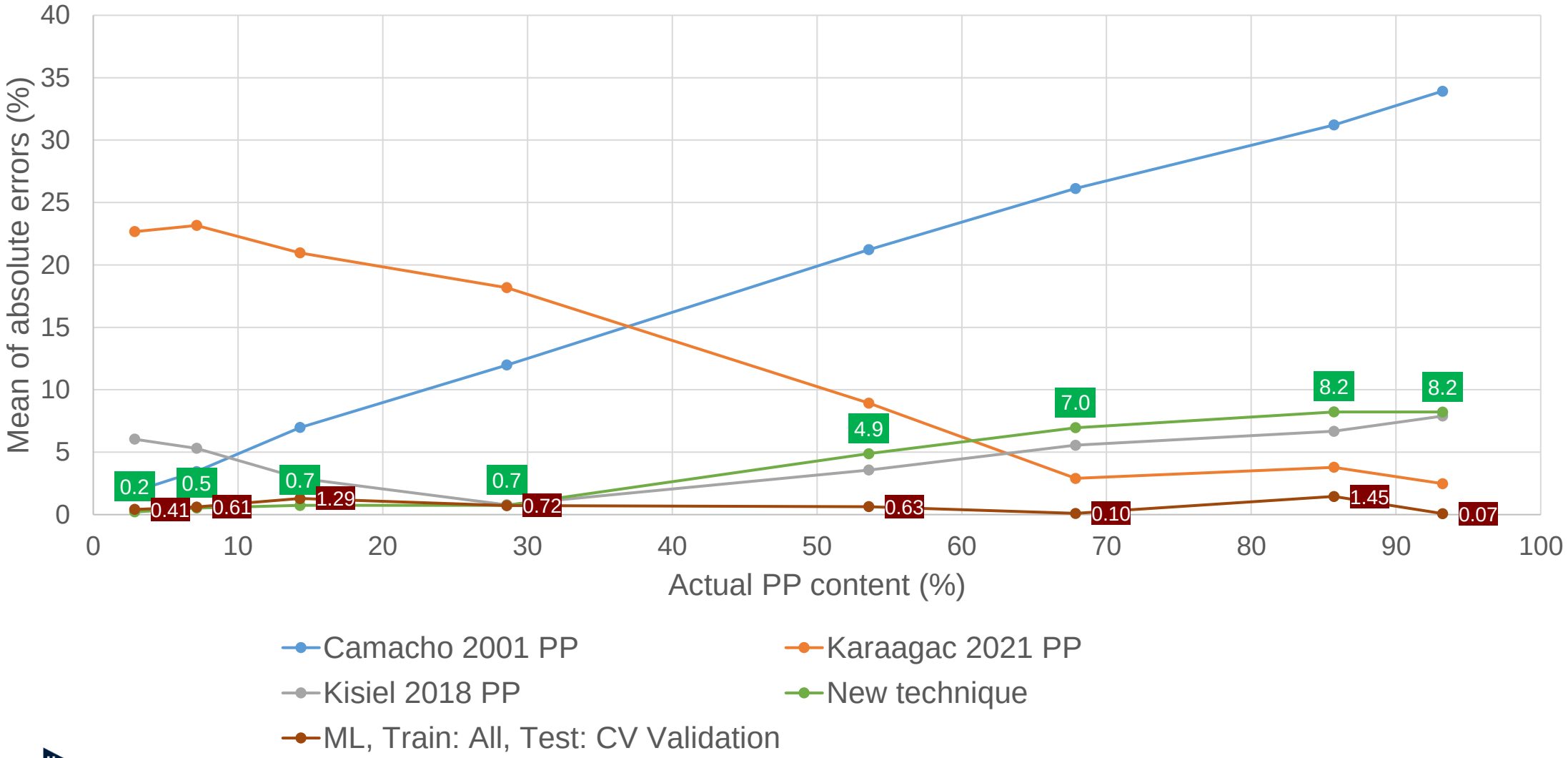


Netzsch.com



The enthalpy of fusion of a substance is a measure of the energy input, typically heat, which is necessary to convert a substance's crystals from solid to liquid state.

DIFFERENT TECHNIQUES BASED ON DSC



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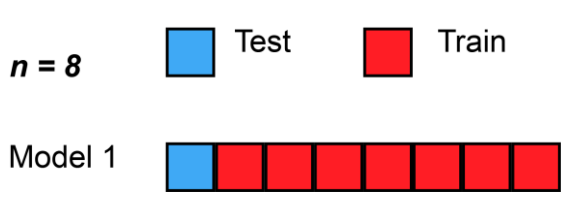
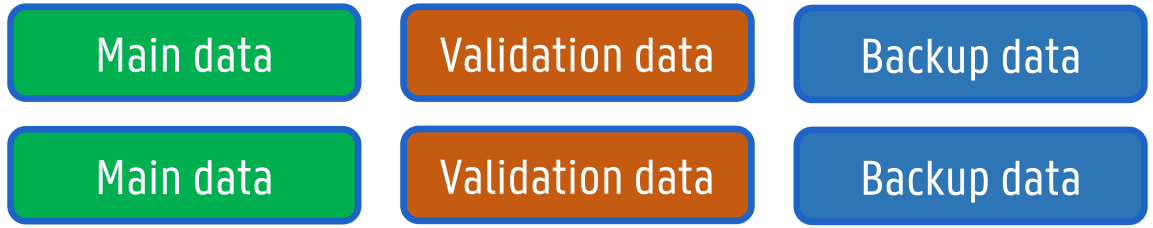
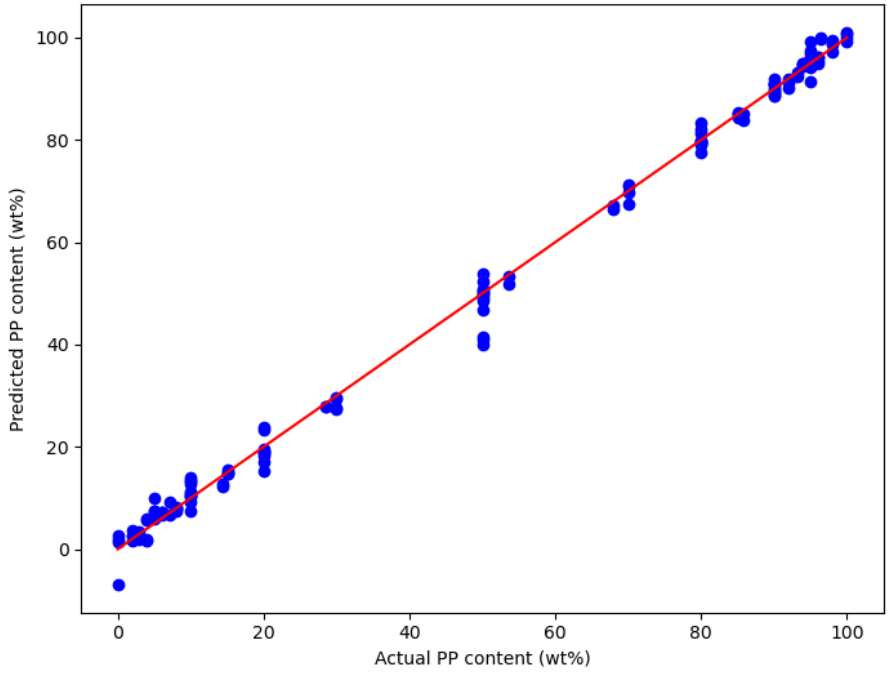
ARTIFICIAL INTELLIGENCE TECHNIQUE





Material	RMSE (%)	MAE (%)
LLDPE	1.47	1.05
LDPE	1.62	1.06
HDPE	1.58	0.91
PP	2.07	1.41



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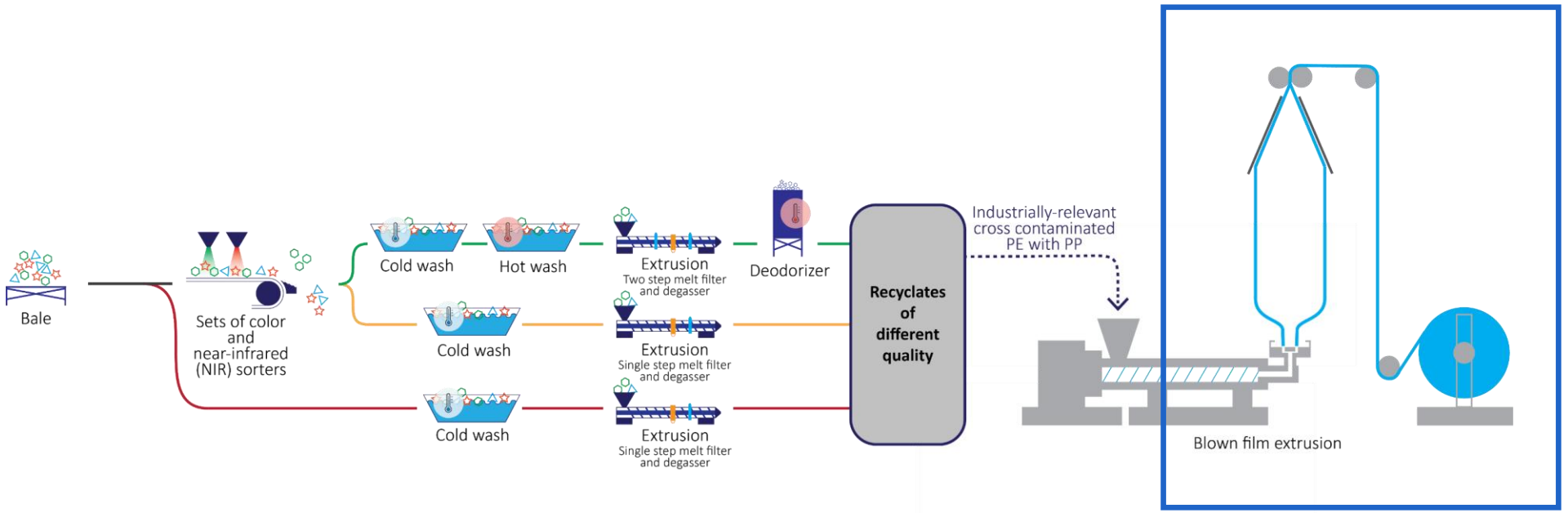


DETERMINATION OF PROCESSABILITY AND PERFORMANCE

Will be submitted to the Polymer Testing journal (Summer 2023)

RESEARCH QUESTION

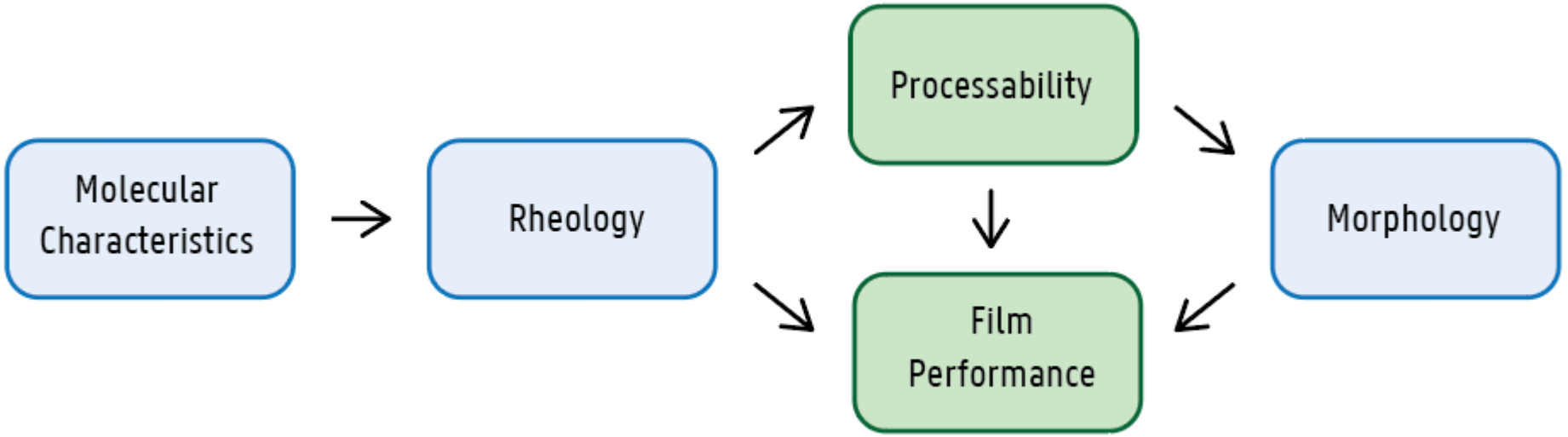
How can we quantify (and enhance) the Recycling Quality of the contaminated polyethylenes in film blowing applications?

- Contaminations? Polypropylene

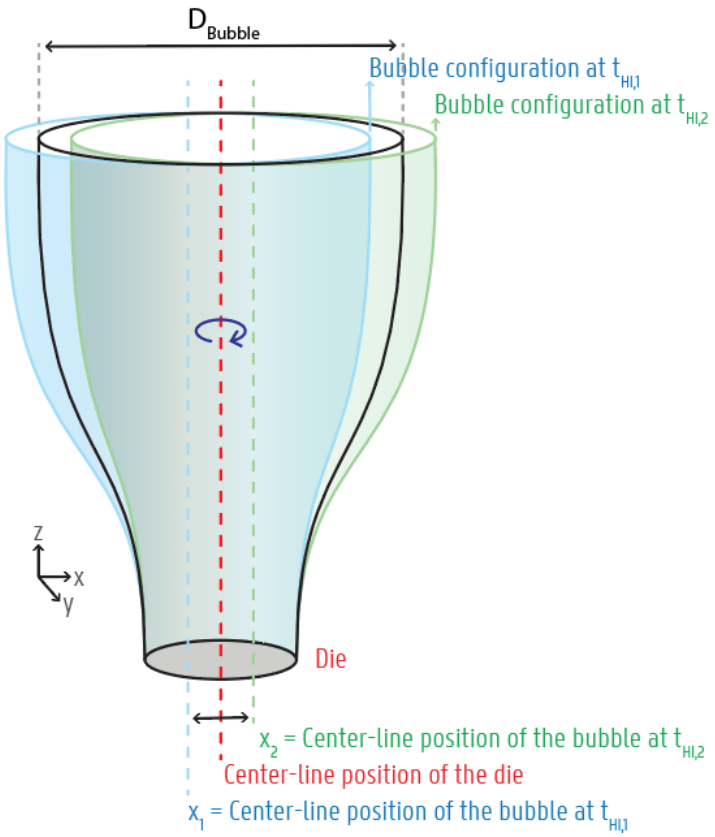
$$\mathbf{RQ} = \frac{\text{Recycled Quality}}{\text{Virgin Quality}} = \varphi_1 \times \text{Properties} + \varphi_2 \times \text{Processability}$$

1. A technique to define and measure blowability needs to be developed
2. ϕ_1 and ϕ_2 coefficients should be assigned
3. RQ should be predictable for certain (distribution of) molecules/blends

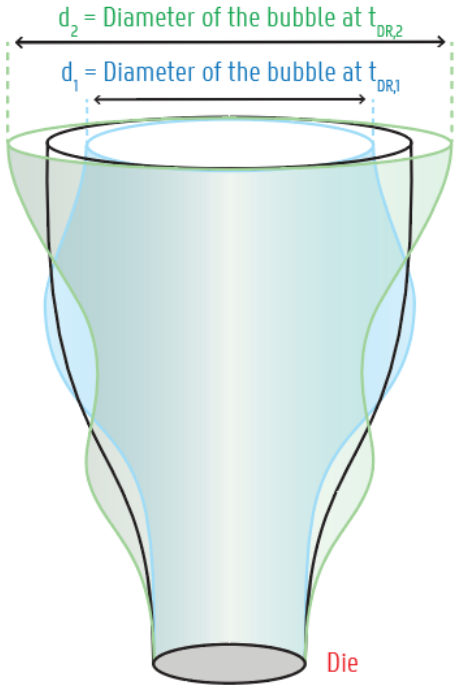
CORRELATION IN FILM BLOWING



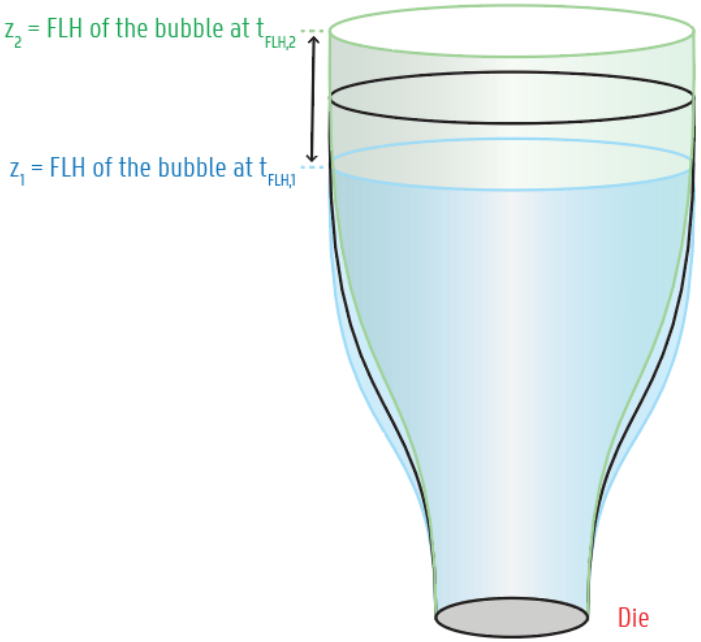
PROCESS INSTABILITIES



Helical Instability



Draw Resonance Instability



FLH Instability

FILM BLOWING INSTABILITIES

Draw resonance Instability

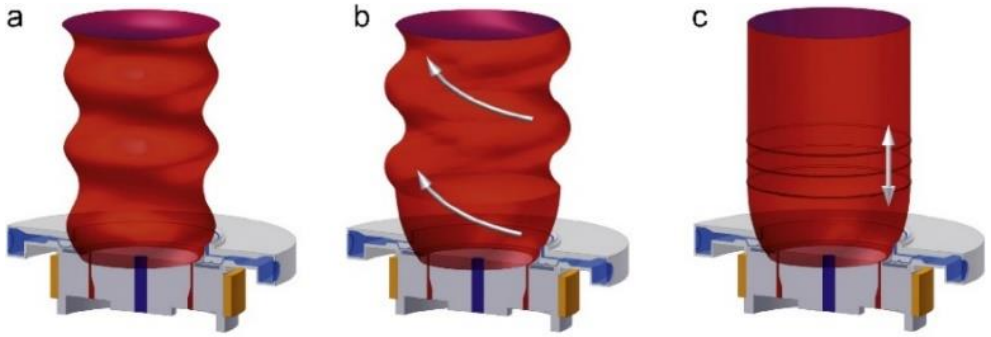
LDPE14 B4 T12

Helical instability

LDPE21 B4,5 T15

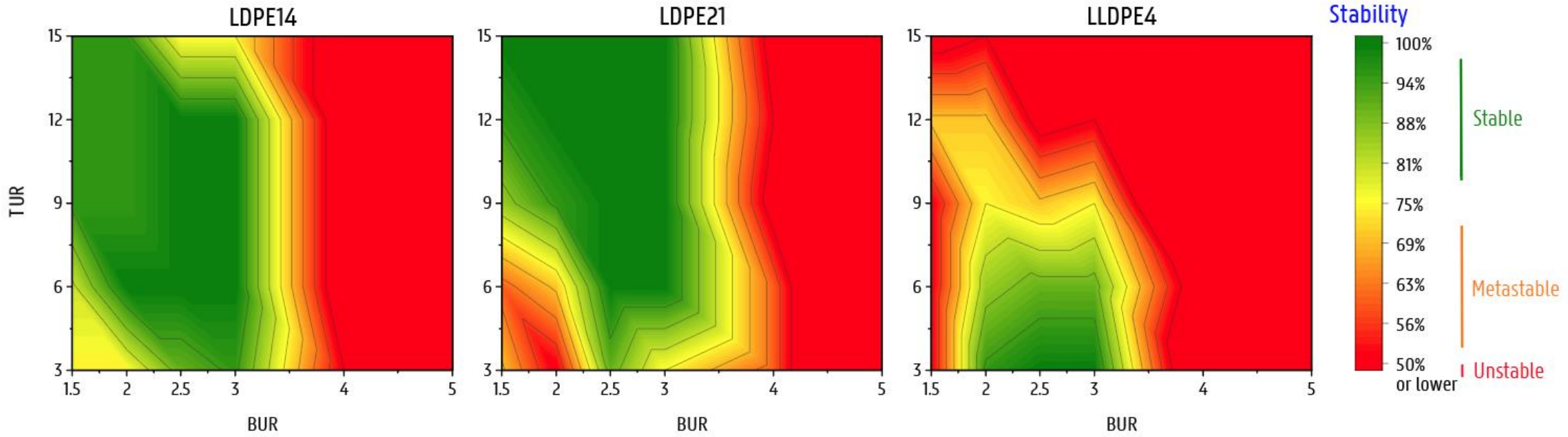
FLH instability

LLDPE4 B4 T12



Kolarik et al., International Journal of Heat and Mass Transfer 56 (2013) 694–708, https://doi.org/10.1016/j.ijheatmasstransfer.2012.09.025

QUANTIFICATION OF PROCESSABILITY



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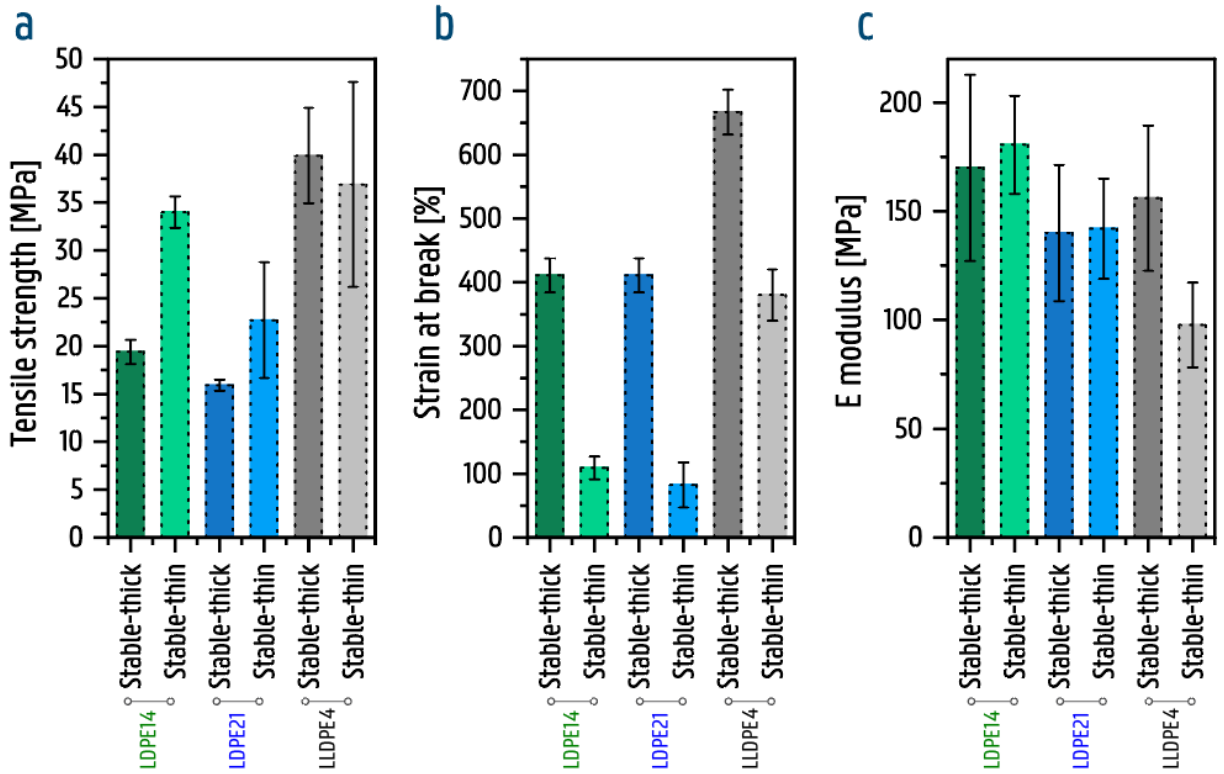
PERFORMANCE OF THE FILMS

— Mechanical performance of the films is correlated to their morphology and the choice of processing conditions.



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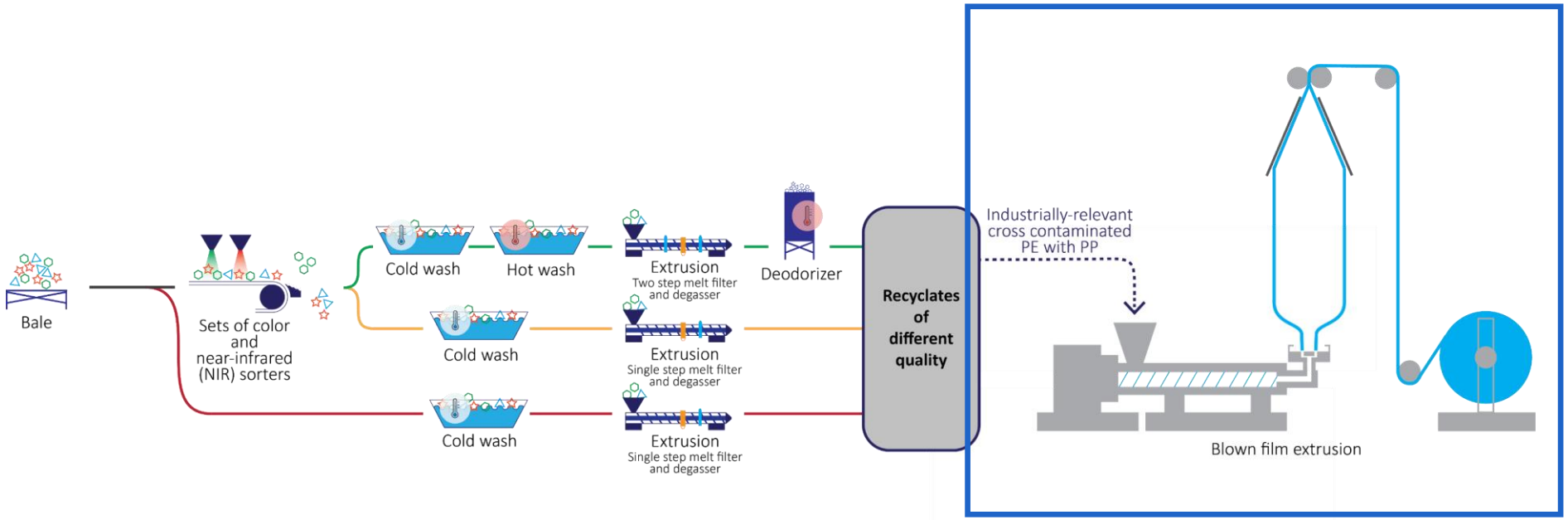

DETERMINATION OF RECYCLING QUALITY FOR PP CONTAMINATED PE STREAMS

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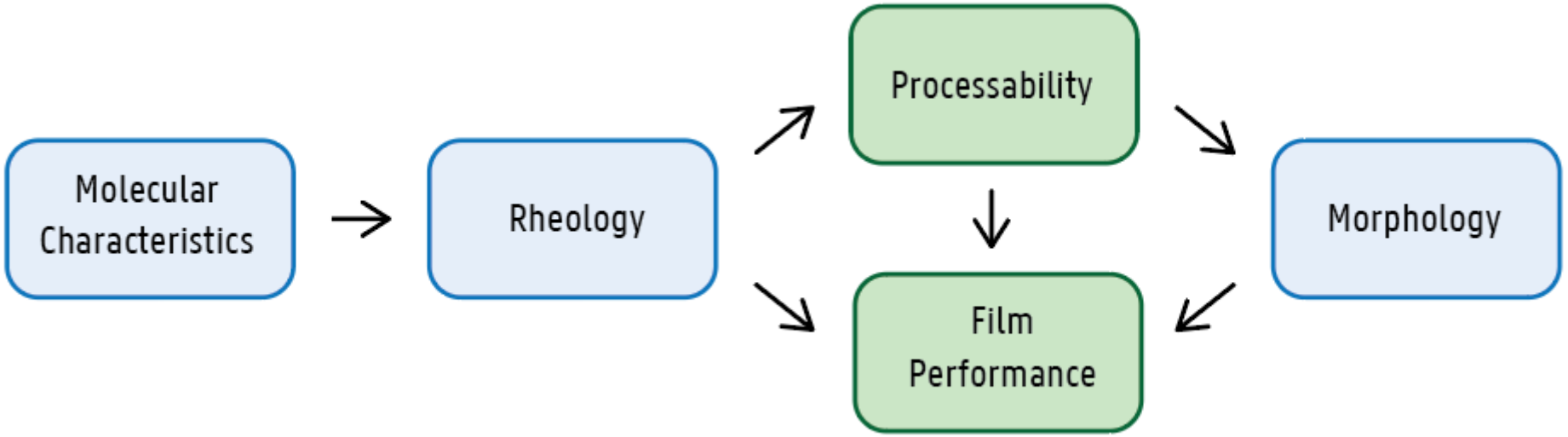
Will be submitted to the Polymer Testing journal (Fall 2023)

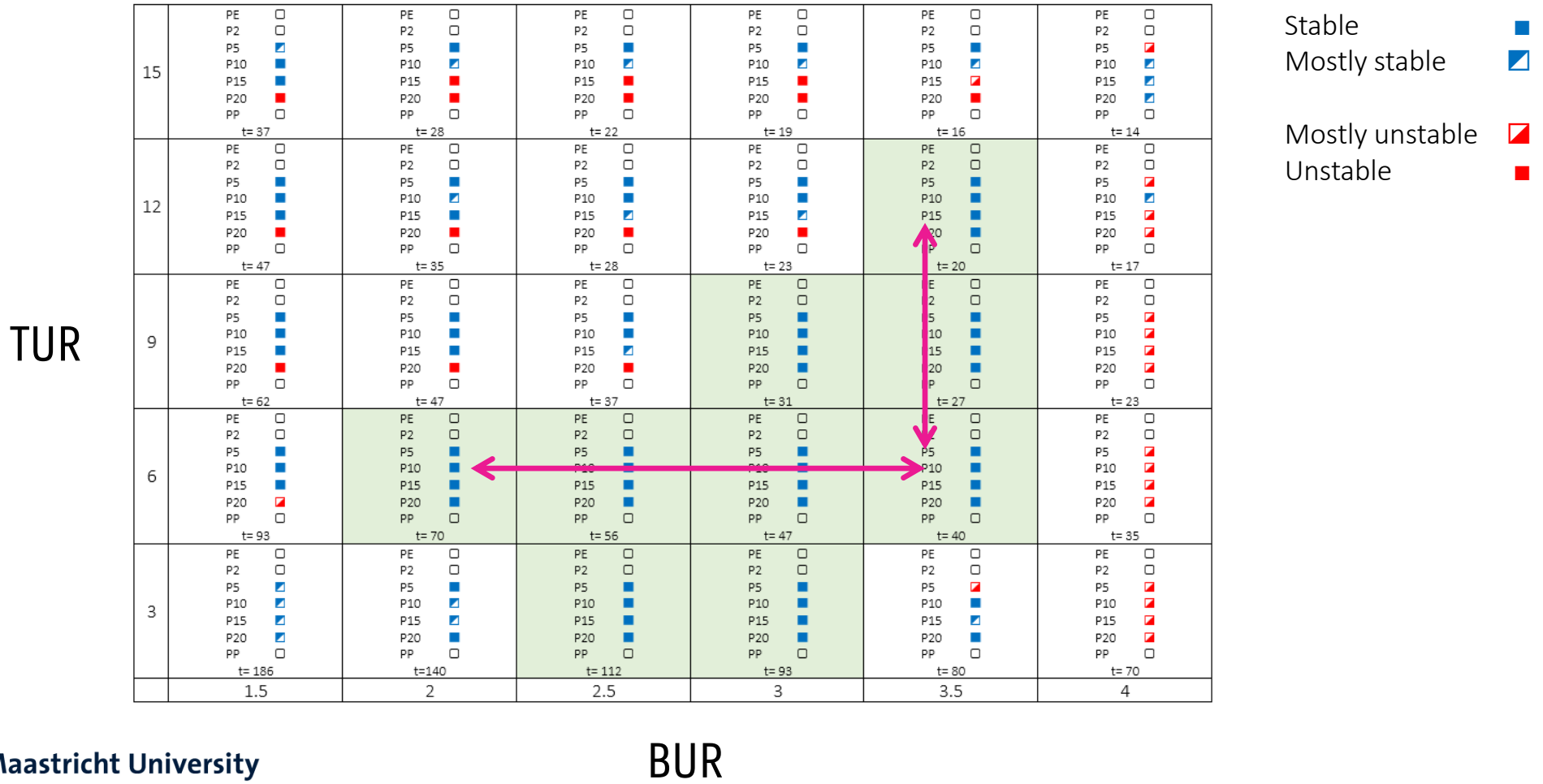
INFLUENCES OF THE CROSS CONTAMINATION



- PE fraction: engineered blend of 8 different PEs
- PP fraction: engineered blend of 5 different PPs

PROGRESS

- Materials: EB-PE and EB-PP (0%, 2%, 5%, 10%, 15%, 20%, 100%)



CONCLUSIONS

- Improvements in mechanical recycling processes can deliver high quality regranulates at a better cost balance
- Artificial intelligence assisted DSC can determine the composition of recycled blends accurately.
- We can quantify the processability of plastics for the production of films.
- We can determine the recycling quality of flexible regranulates by knowing their history and determining their composition.

THANKS!

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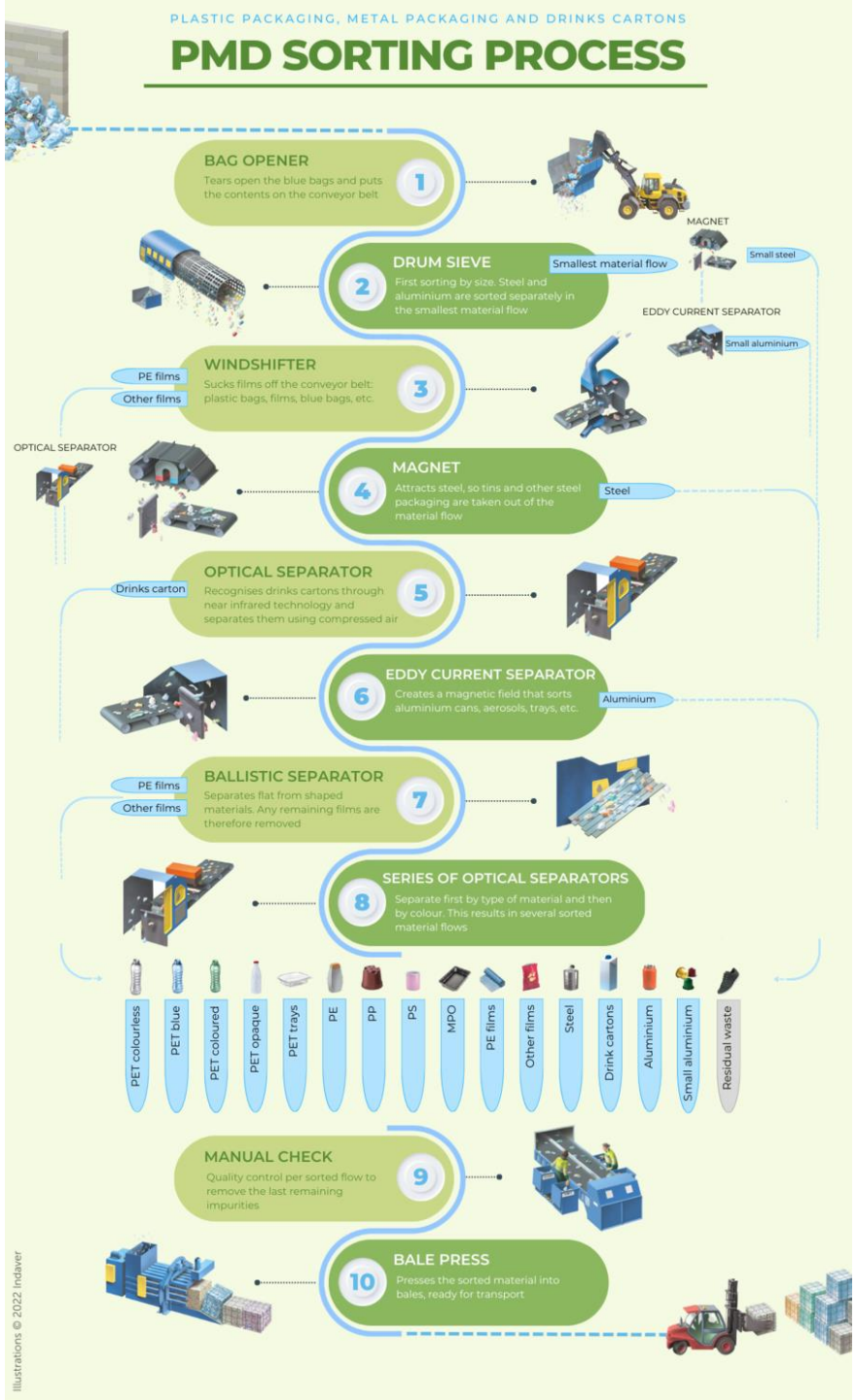
LCT
DRIVING CHEMICAL TECHNOLOGY

Circular Plastics
Making it happen

C-PlaNeT
CIRCULAR PLASTICS NETWORK FOR TRAINING

MATERIAL RECOVERY FACILITY

— Indaver's plant in Willebroek , BE



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