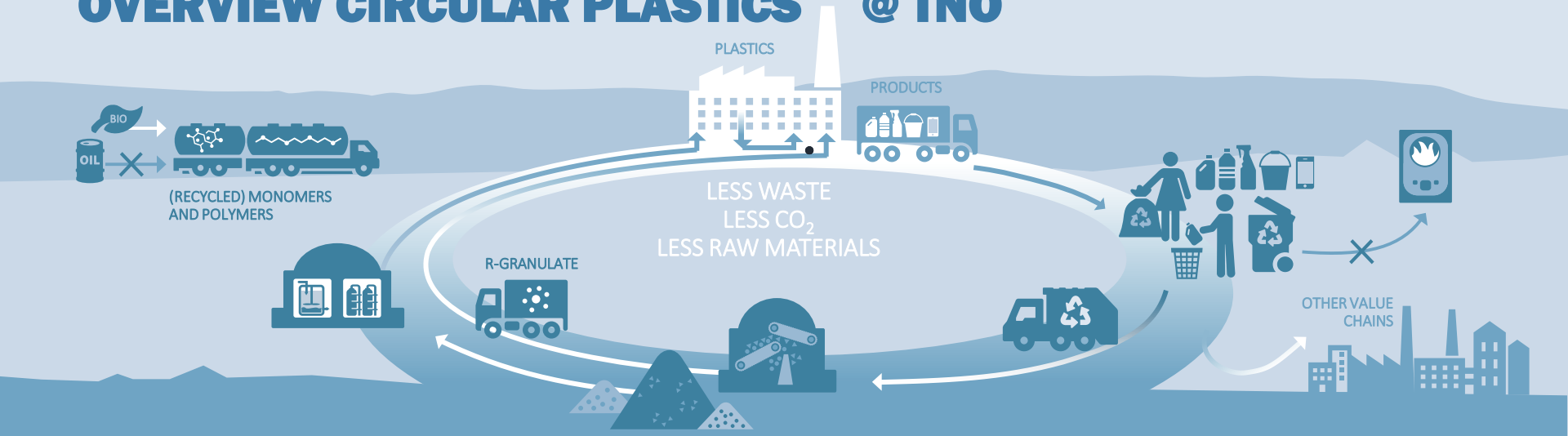
PLAST2bCLEANED

1 February 2022

Esther Zondervan-van den Beuken (TNO)

This Project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement N. 821087

OVERVIEW CIRCULAR PLASTICS @ TNO



1
SYSTEM INTEGRATION, VALUE CHAIN DESIGN AND LIFE CYCLE ASSESSMENT

2
DESIGN FOR CIRCULARITY

3
SORTING & WASHING

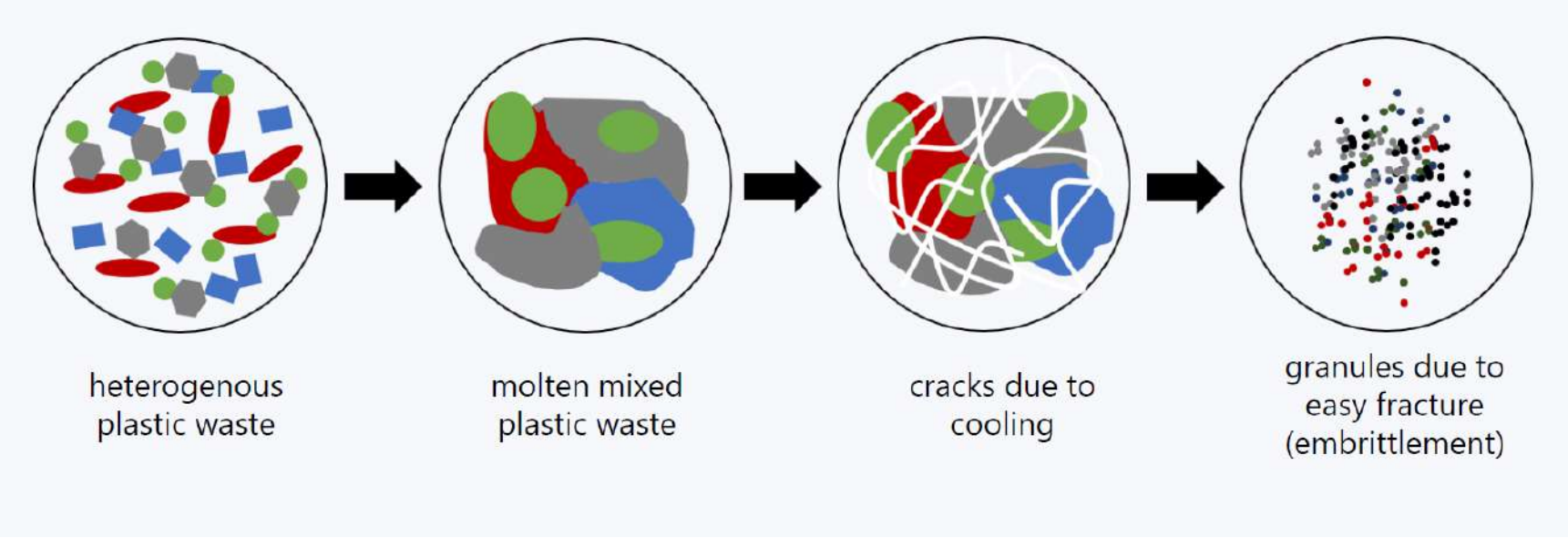
4
RECYCLING:
- THERMOCHEMICAL RECYCLING
- DEPOLYMERISATION
- DISSOLUTION

5
MICROPLASTICS

TNO innovation for life

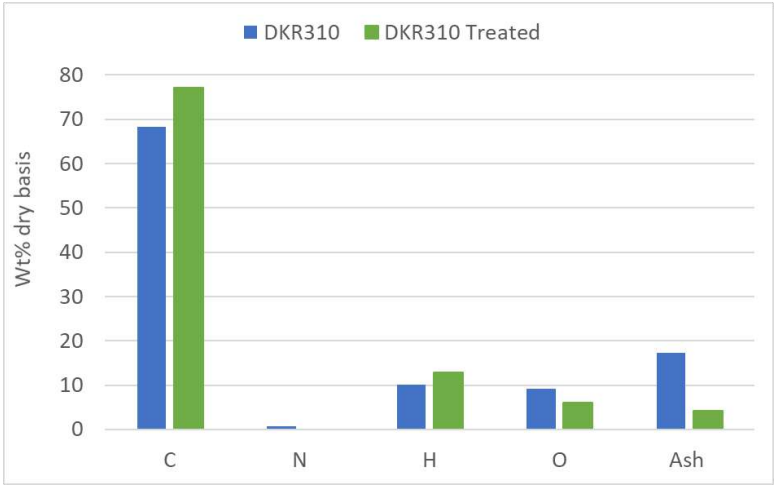
3. SORTING AND WASHING

TECHNOLOGY DEVELOPMENT: UPWASH – CONCEPT



3. SORTING AND WASHING

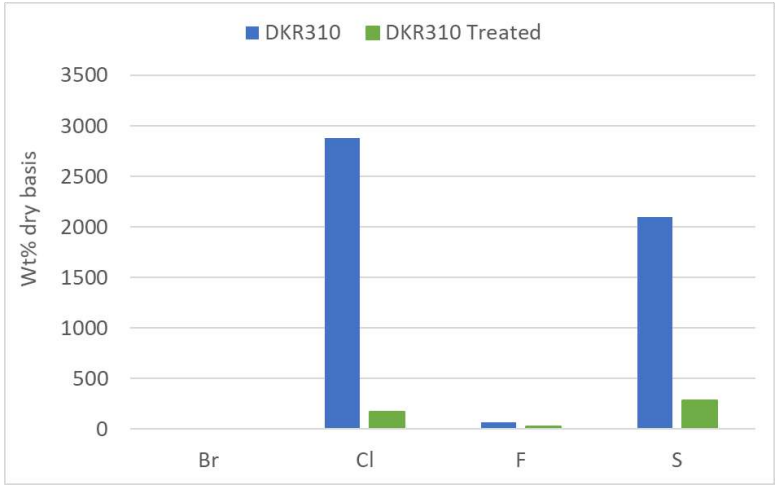
TECHNOLOGY DEVELOPMENT: UPWASH – TYPICAL RESULT



Strong reduction on ash composition upon treatment

Reduction of the organics fraction (O content)

Strong reduction of Cl and S upon treatment



4. RECYCLING TECHNOLOGY DEVELOPMENT

ANALYSIS & TECHNOLOGY DEVELOPMENT

TECHNO-ECONOMIC & STRATEGIC BUSINESS ANALYSIS

- Techno-economic Feasibility studies
- Market analysis and benchmarking
- Business analysis

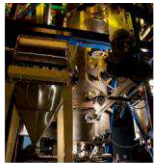
TECHNOLOGY DEVELOPMENT

- Waste pre-treatment
- Pyrolysis, gasification, dissolution and chemolysis
- Various polymers, plastic mix streams, biomass streams
- Experience with fixed bed, fluid bed and screw reactor technology for conversion of feedstock


Dissolution


Screw reactor


Bubbling fluidized bed


Indirect fluidized bed

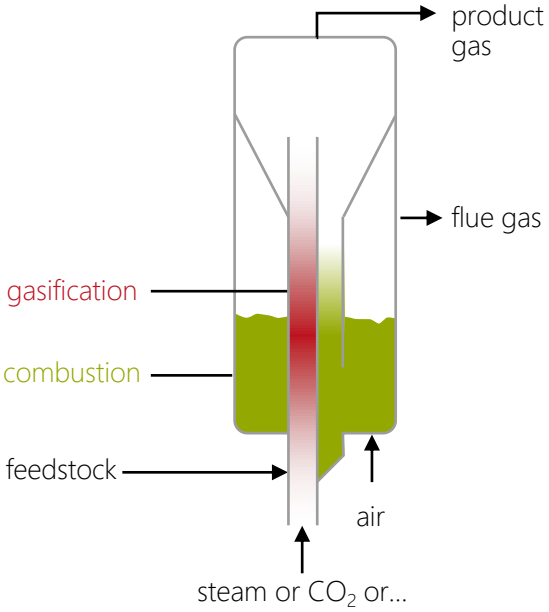

Polystyrene

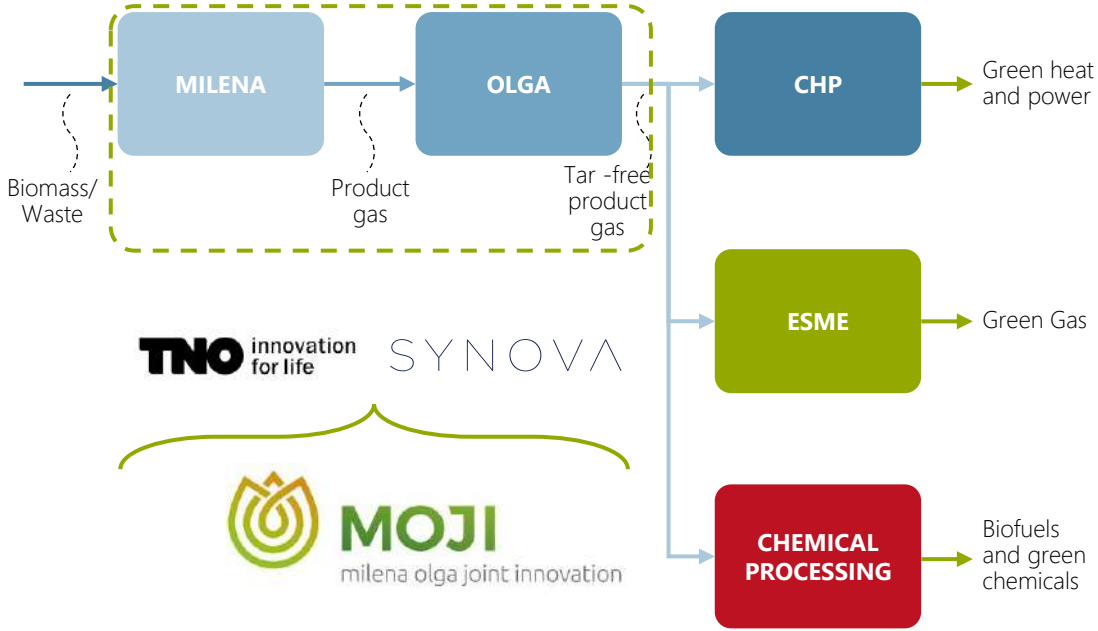

Refuse derived fuel (RDF)


Packaging foils

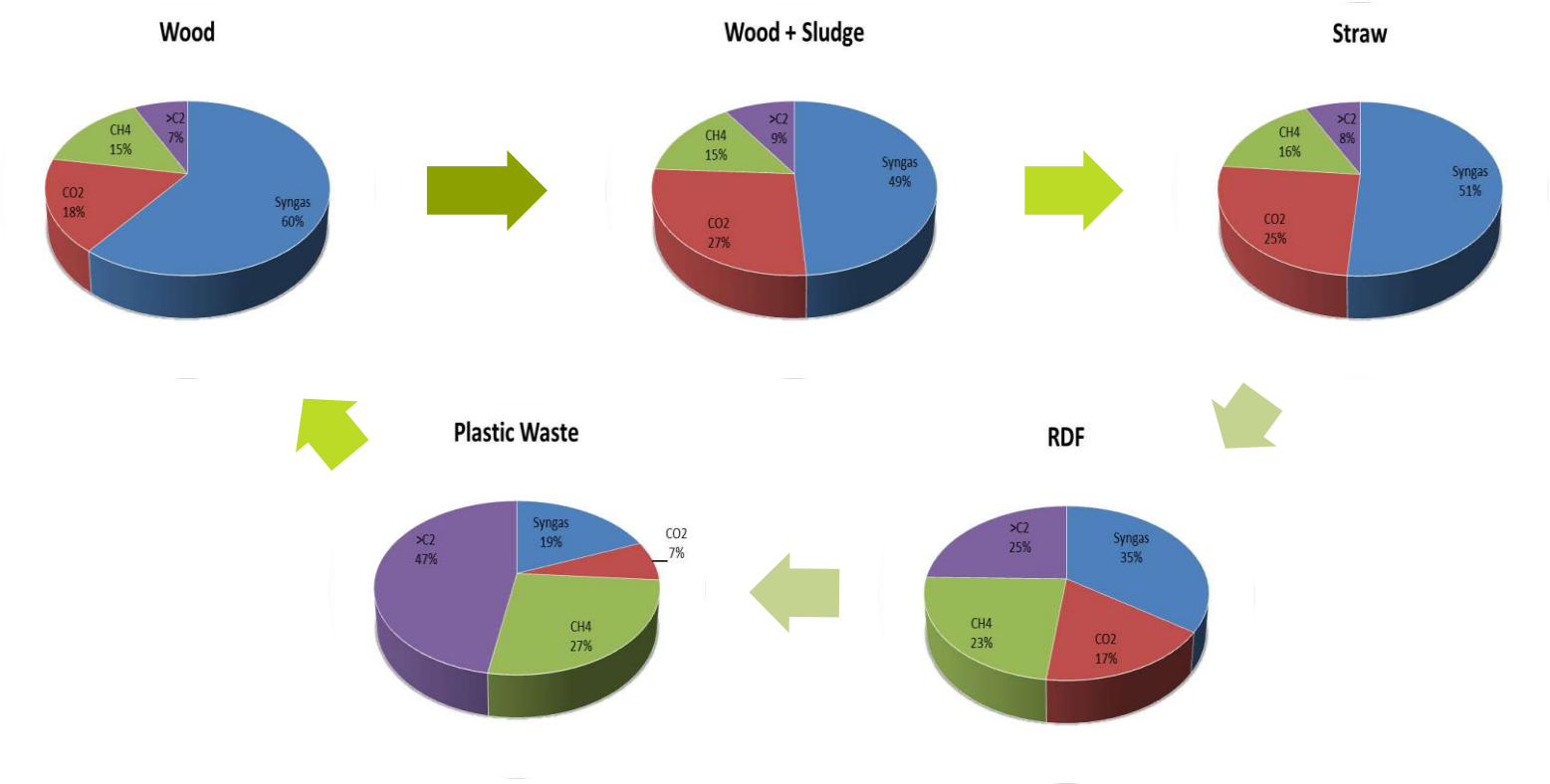
4. THERMAL CRACKING

A PLATFORM TECHNOLOGY FOR ENERGY AND CHEMICALS





4. OUTPUT THERMAL CRACKING VERSATILE, FEED DEPENDENT



All data in volume%, results obtained in lab and pilot scale indirect gasifier @ TNO

PLAST2bCLEANED

OVERVIEW OF THE PROJECT

The overall aim of PLAST2bCLEANED is to develop a human and environmentally safe recycling process for Waste Electrical and Electronic Equipment (WEEE) plastics in a technically feasible and economically viable manner.

Key technologies developed within the project are:

- Improved sorting of HIPS and ABS
- Dissolution of Waste Electrical and Electronic Equipment (WEEE) plastics in superheated solvents;
- Separation of additives to concentrate BFR and ATO fractions for recycling;
- Energy efficient recovery of solvent and of polymer.

32

kton CO2 emissions saved

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CONSORTIUM

PLAST2bCLEANED

Industry/SME

Recycling Company: Coolrec

Engineering company: JUCHHEIM

Polymer

Bromine fraction

Antimony fraction

Plastics producer: ELIX POLYMERS

Bromine recovery: ICL

Antimony recovery: Campine

End user: Electrolux

Chemical industry

Chemical industry

Dissemination and exploitation: Sustainable INNOVATIONS

Research Institutes

Coordinator: TNO

Fraunhofer ICT

GAIKER

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OBJECTIVES

The overall aim of PLAST2bCLEANED is to develop a human and environmentally safe recycling process for Waste Electrical and Electronic Equipment (WEEE) plastics in a technically feasible and economically viable manner.

1. **Development of a mechanical presorting technology**
2. **Closing 3 loops using dissolution under superheated conditions by separation of :**
   - **(1) the polymer**
   - **(2) the bromine**
   - **(3) the antimony trioxide**
3. **Process integration and scale-up**
4. **Performance testing of process and products**
5. **System optimizing for sustainability and economic viability**

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Main results obtained

1. **Pre-processing and sorting**:
   RAMAN equipment set-up and spectral library.
   Measuring conditions with Raman spectroscopy defined for WEEE streams.

2. **Dissolution under superheated conditions**: A process flow is set-up based on >300 experiments. Removal of ATO on specs, removal of Br almost on spec. ATO and BFR recovered to be further processing.

3. **Impact assessment**: better environmental performance and reduced costs by using 50% rABS and rHIPS compared to virgin material in first analysis

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WP1 PRE-PROCESS: SENSING AND SORTING

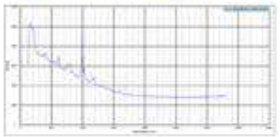
Aim of WP1: DESIGN A PRE-TREATMENT AND SORTING PROCESS to provide separate and clean polymers (ABS and HIPS) from WEEE streams

- To identify all coloured polymers (including blacks)
- To sort ABS & HIPS for upgrading in other WPs

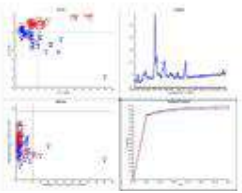
WEEE streams

Raman spectroscopy
(2 lasers)

1) Spectrum analysis



2) Spectral data analysis
(*Chemometrics*)



WEEE polymers classification

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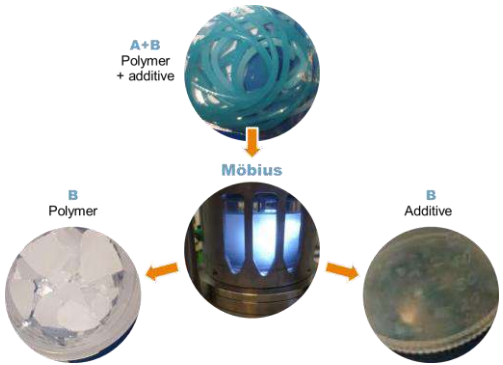
WP2: PROCESS DEVELOPMENT

- Dissolution of HIPS respectively ABS
- Separation of the bromine (Brominated Flame Retardants, BFRs) and antimony trioxide (ATO) additives
  - With high yield
  - Recovery of ATO with low levels of organic contaminants
  - Recovery of BFRs with low levels of inorganic contaminants
- Recovery of solvent and polymer samples
- Lab scale development as preparation for scaled-up demo TRL 5/6
- Möbius concept



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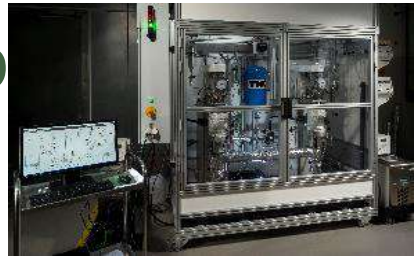
WP2: PROCESS DEVELOPMENT IN CLOSE COOPERATION BETWEEN TNO AND FHG

From basic testing in pressurized test tubes to a 100 g/day semi-batch process

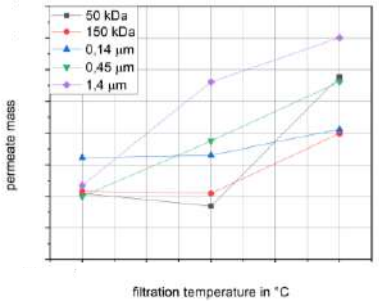
TNO



FHG

Main results

- Process developed
- Dissolution, filtration and sedimentation steps
- Removal of BFR and ATO from polymer on spec
- ATO and BFR recovered to be further processed at partners



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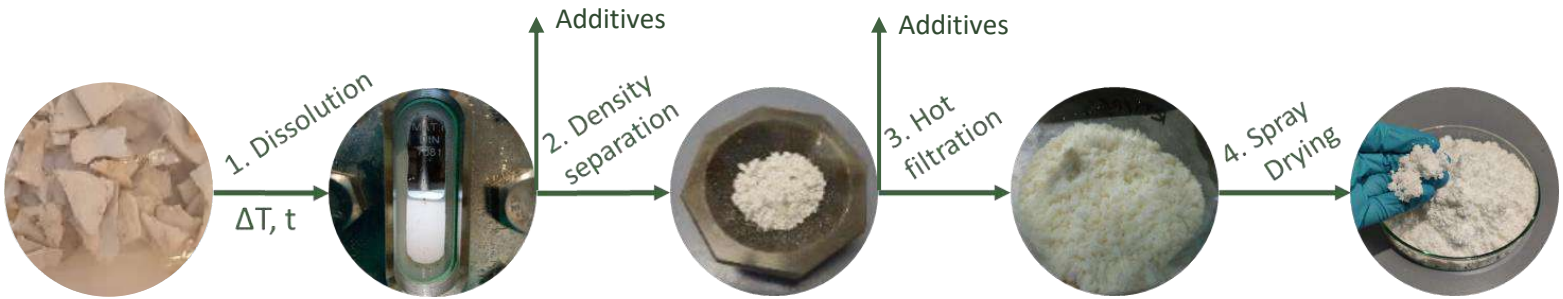
WP3: SCALE-UP DEMONSTRATOR AT FHG - ICT

Goal:
Scale-up the process developed in WP2 to TRL5, focused on one polymer in the WEEE stream



- Close cooperation between TNO – Delft and Fraunhofer – ICT.
- Demonstrator is intended to be an 'open access facility' for the recycling of polymer, bromine and antimony trioxide fractions from secondary plastics from WEEE products after Plast2bCleaned
- Intention of TNO is to scale-up their Möbius technology for other streams as well

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WP4: PERFORMANCE TESTING OF PROCESS AND PRODUCTS

Goal: to assess the effectiveness of the process, and the quality of its output fractions

- Removal efficiency assessment
- Purified polymer quality assessment
- Formulation for end-user application
- Output Bromine and Antimony containing fractions testing

Webinair PRE-1000-1 method by Patrick de Kort, Regulatory Affairs Manager for Plastics Recyclers Europe

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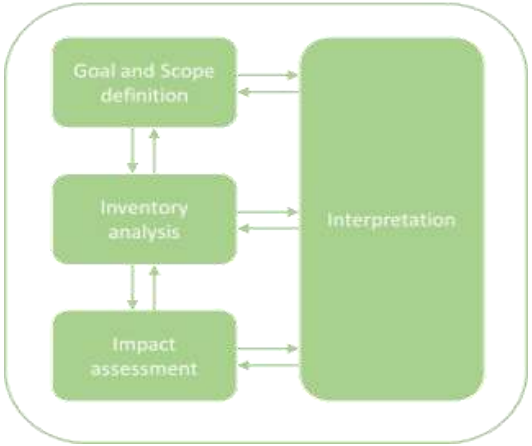
WP5: ECONOMIC AND ENVIRONMENTAL ASSESSMENT

Goal: Develop a recycling process that is environmentally sound and economically viable.

- Environmentally sound: LCA - Address the environmental impact of a full product system along the entire life cycle (ISO 14040).
- Economically viable: LCC - Address the economic viability by mapping all costs and profits along the life cycle (ISO 14045).



Waste perspective: to compare the P2bC recycling method to other recycling methods

"The End-of-Life treatment of 1 tonne of WEEE plastics in a defined average composition and particle size, coming from a WEEE treatment plant".

Product perspectives (ABS and HIPS): to compare the benefits of using recycled plastics (and flame retardant) instead of virgin materials

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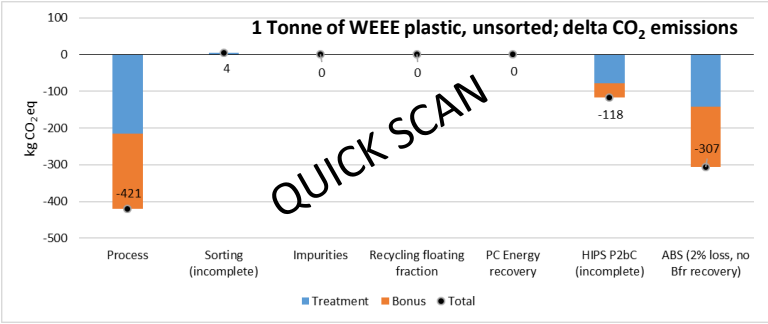
WP5: FUNCTIONAL UNIT

*1 external door frame (made out of 0.495 kg **ABS**) of a washing machine with overall running time of 220 washing cycles per year and an expected lifespan of 10 years (7,000 running hours)".*

*1 inner liner (made out of 5.7 kg **HIPS**) of a household refrigerator's cabinet with overall running hours of 78,840 hours and an expected lifespan of 9 years"*

Main results quick scan

- P2bC reaches a lower CO_2 impact compared to the reference.
- ABS is contributing more to the total impact savings compared to HIPS.
- Life Cycle Costing showed that the use of 50% rABS & 50% rHIPS allow to reduce the costs significantly compared to virgin ABS and HIPS



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PLAST2BCLEANED CORPORATE VIDEO (PUBLIC)

https://www.youtube.com/watch?v=nlNFrMGhaj4&feature=emb_imp_woyt

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Summary

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3 Process integration and scale-up

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Thank you!

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