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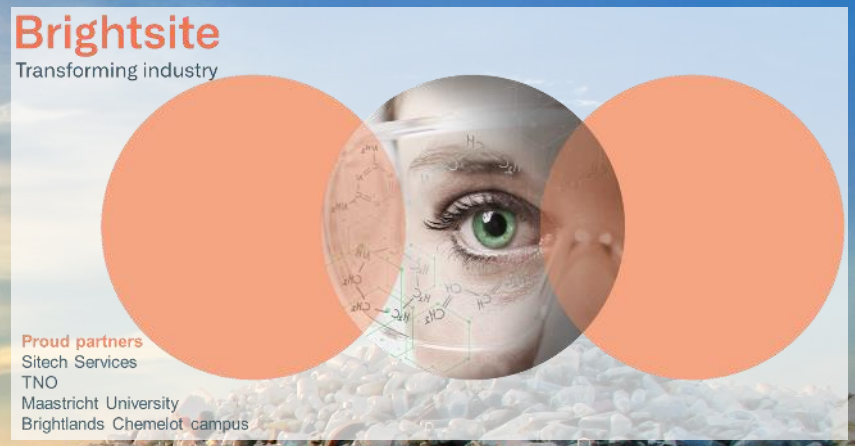

UPWASH, A DECONTAMINATION TECHNOLOGY FOR MIXED PLASTIC WASTES

3RD CIRCULAR CHEMISTRY CONFERENCE MARCH 29, 2023

RINKE ALTINK AND PEDRO ABELHA

Brightsite

Transforming industry

Maastricht University

TNO innovation for life

sitech services

Invention	Concept validation	Laboratory prototyping & incubation	Pilot production & demonstration	Initial market introduction	Market expansion

Public Investments

Private Enterprise

provincie limburg

Brightsite: Upscaling initiative

LINEAR TO CIRCULAR

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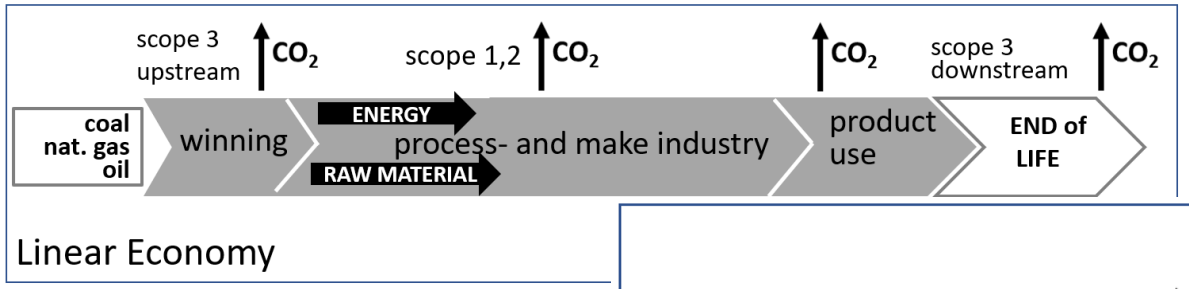
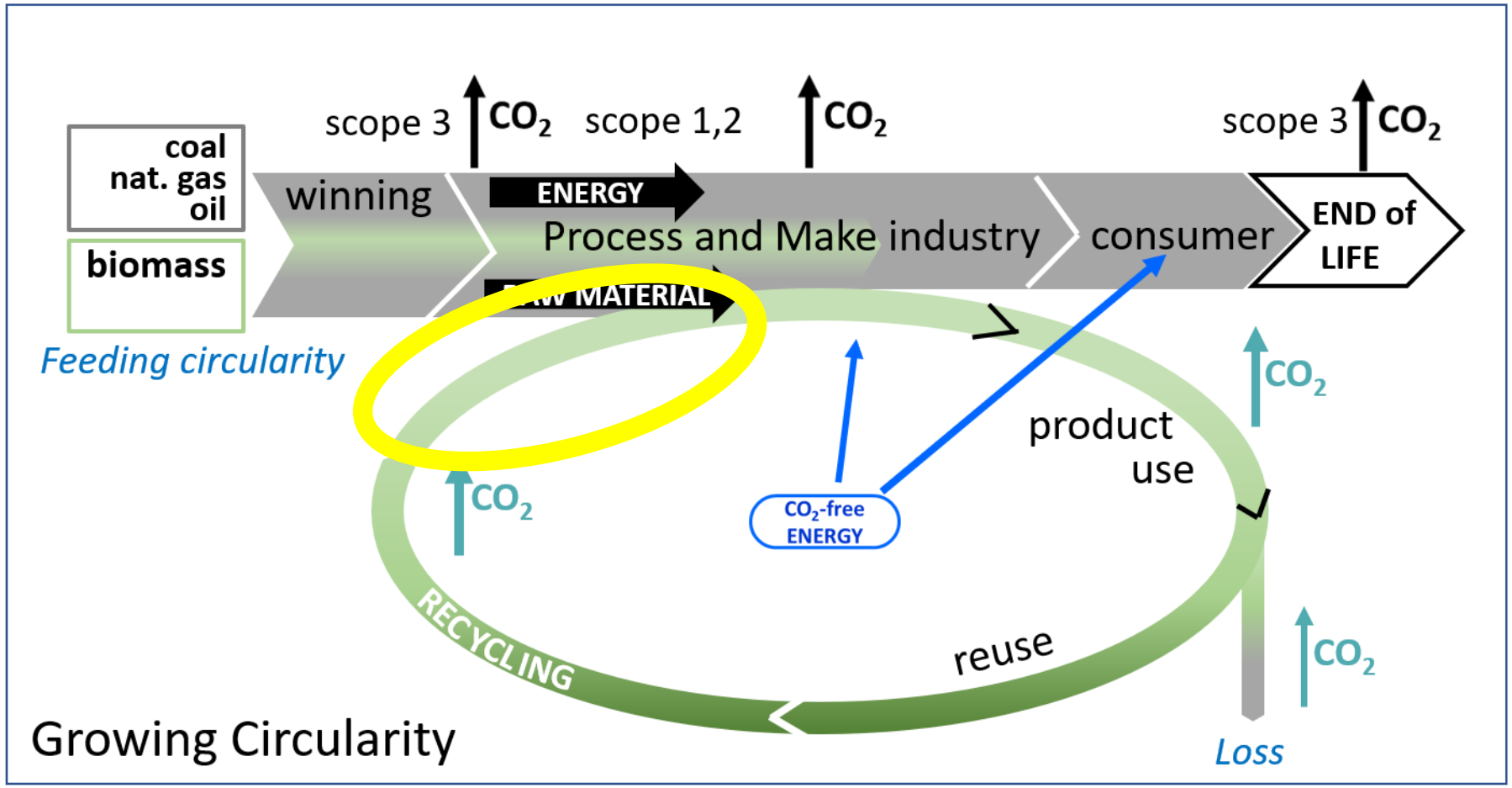


Linear Economy



Growing Circularity

THE CIRCULAR FEEDSTOCK GAP

- Mechanical Recycling

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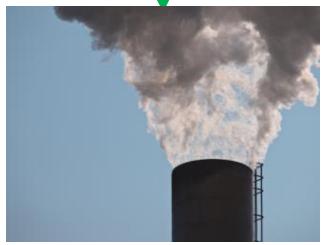
- Mono materials

- Glues
- Dyes/Inks
- Labels
- Etc.

Clean e.g. DKR 310

Rests e.g. DKR 350



Amount

Quality

Quality

- Thermo Chemical Recycling

€

- Mono types

- Oxygen
- Nitrogen
- Chloride
- Sulfur
- Etc.

GAP

Amount and quality

UPWASH PROCESS

- The Upwash Process is a hydrothermal concept process.
- Treatment of mixed plastic waste particles (shredded MPW fractions) with heated water under pressure at prolonged residence times (ca 30min).
- Derived from Torwash® developed by TNO (ECN) as a biomass waste upgrade technology.
- Upwash is targeting **mixed plastic wastes** to further separate plastic types and improve quality of process product streams to better suit mechanical and thermochemical recycling and plastics circularity.
- No other additional chemicals are involved in this pre-treatment process.

PLASTIC WASTE FEEDSTOCK (E.G. DKR310)

Product Specification 08/2014
Fraction-No. 310-1

Sorting fraction:	PLASTIC FILMS

A Specification/Description

Used, residue-drained, system-compatible items made of plastic film, surface > DIN A4, e.g. bags, carrier bags and shrink-wrapping film, incl. secondary components such as labels etc.

The supplement is part of this specification!

B Purity

At least 92 % by mass according to specification/description.

At least 42 % colourless, transparent films > DIN A 3

C Impurities

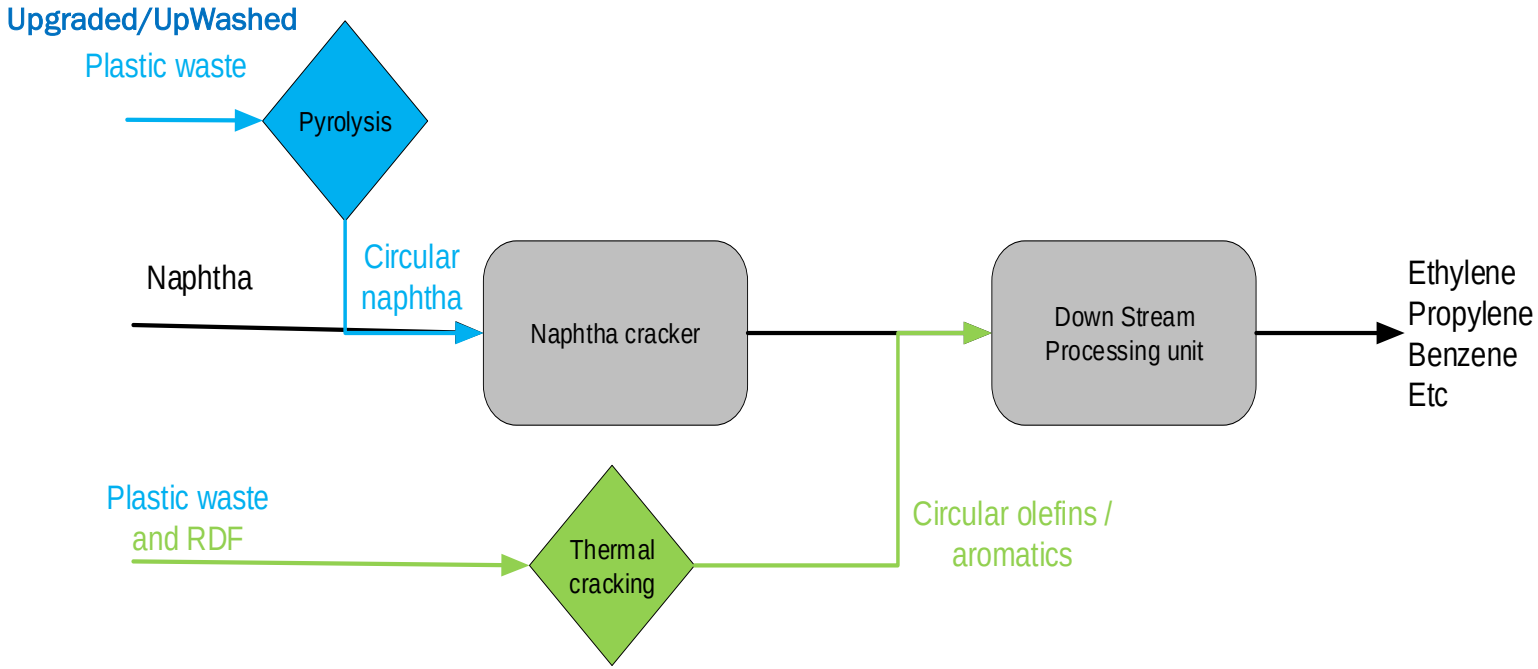
Max. total amount of impurities	8 % by mass
Metallic and mineral impurities with a unit weight of > 100 g are not permitted!	
Other metal items	< 0.5 % by mass
Other plastic items	< 4 % by mass
Paper, cardboard, carton	< 1 % by mass
Other residues	< 4 % by mass

Examples of impurities:
- Glass
- Composite paper/cardboard materials (e.g. liquid packaging boards)
- Aluminised plastics
- Other materials (e.g. rubber, stones, wood, textiles, nappies)
- Compostable waste (e.g. food, garden waste)

Pre-processing <u>needed</u> even at industrial scale !!!

CRACKING OF PLASTIC WASTES

- Circular naphtha being produced from “clean” plastic waste streams via pyrolysis
  - Solution? => Upgrading de plastic waste (UpWash)!
- Circular olefins/aromatics produced from plastic waste streams via thermal cracking
- Biobased olefins/aromatics produced from RDF streams via MILENA/thermal cracking



MILENA Technology
=> More flexible regarding feedstock quality !

- Both routes need to be further developed, improved and implemented
- Both routes will face a large challenge in matching the naphtha demand

MPW DECONTAMINATION - UPWASH

UPWASH general concept:
Hydrothermal treatment/upgrading for mixed plastic wastes (MPW)

e.g., DKR-310

Water + temp + pressure

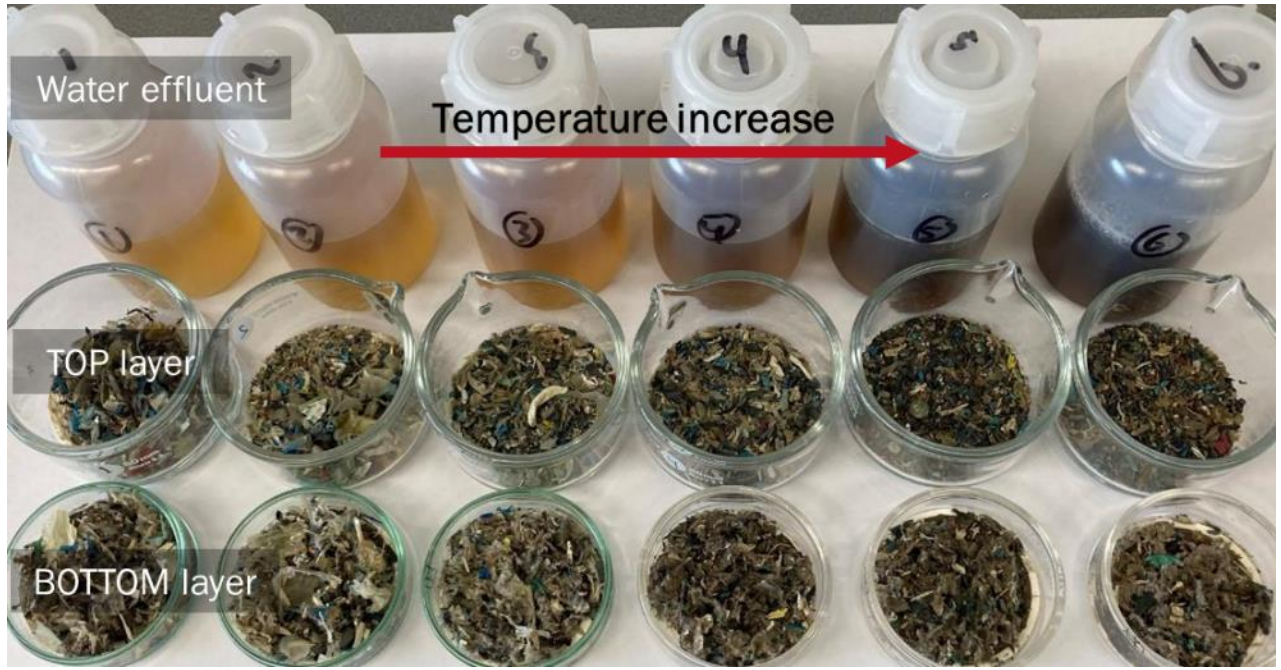
Optimum separation:

- Low density plastics (PE+PP) floats
  Clean from biogenic organics
- Water
  With biogenic organics + salts
  (dissolved/suspended)
- PET+PVC, etc (intermedium density) sinks
  - PVC, Possibly free of Cl
- Minerals+metals (higher density) sinks

MPW DECONTAMINATION - UPWASH

Lab-scale screening experiments

Multi-mini-autoclaves (100 ml)



INPUT: mixed plastic waste + H20

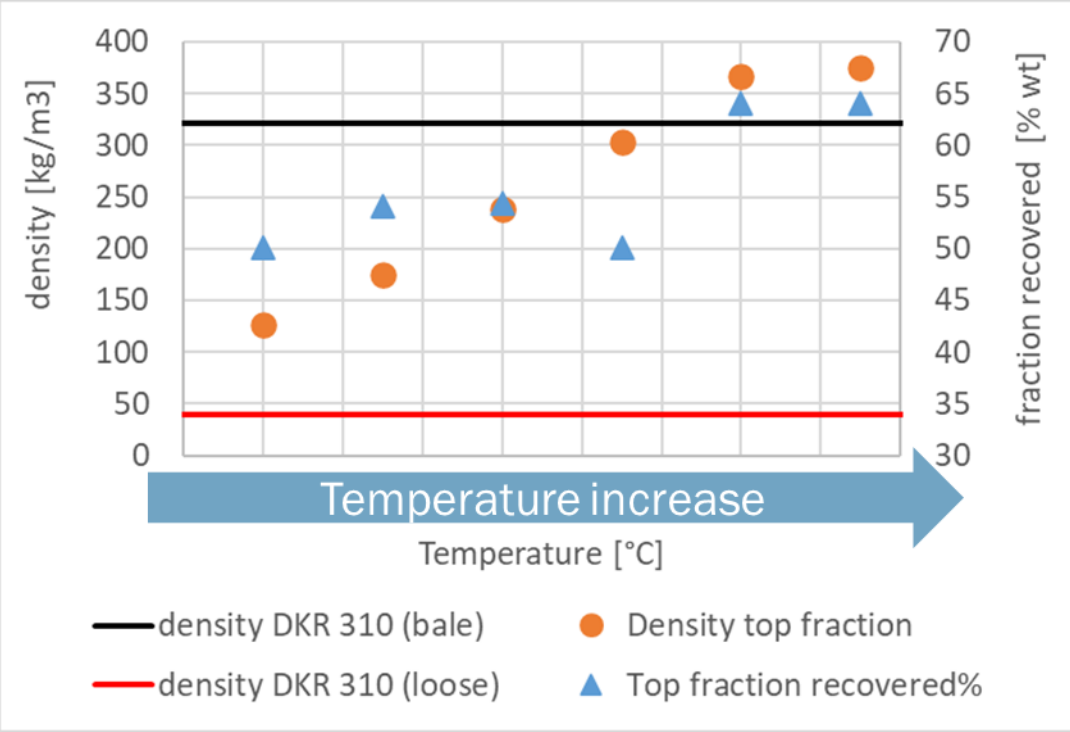
Time, T, P

Final OUTPUT products:

- Water + biogenic organics
- Top fraction (e.g. PE+PP)
- Bottom fraction (e.g. PET+PS+PVC, inerts)

MPW DECONTAMINATION - UPWASH

Lab-scale screening experiments



Fluffy input plastics

Densified output plastics

Temperature increase:

- More top fraction recovered 60-65% (PE+PP)
- density top fraction increases 350-400 kg/m^3

Note: density is given for loose bulk material – relevant for post-process feeding/handling

MPW DECONTAMINATION - UPWASH

Bench-scale production experiments INPUT

DKR-310 (milled < 20 mm)

DKR-310 (shredded < 100 mm)

MPW DECONTAMINATION - UPWASH

Bench-scale OUTPUT

e.g. DKR-310

TOP FRACTION

BOTTOM FRACTION

LIQUID FRACTION

MPW DECONTAMINATION - UPWASH

Bench-scale OUTPUT

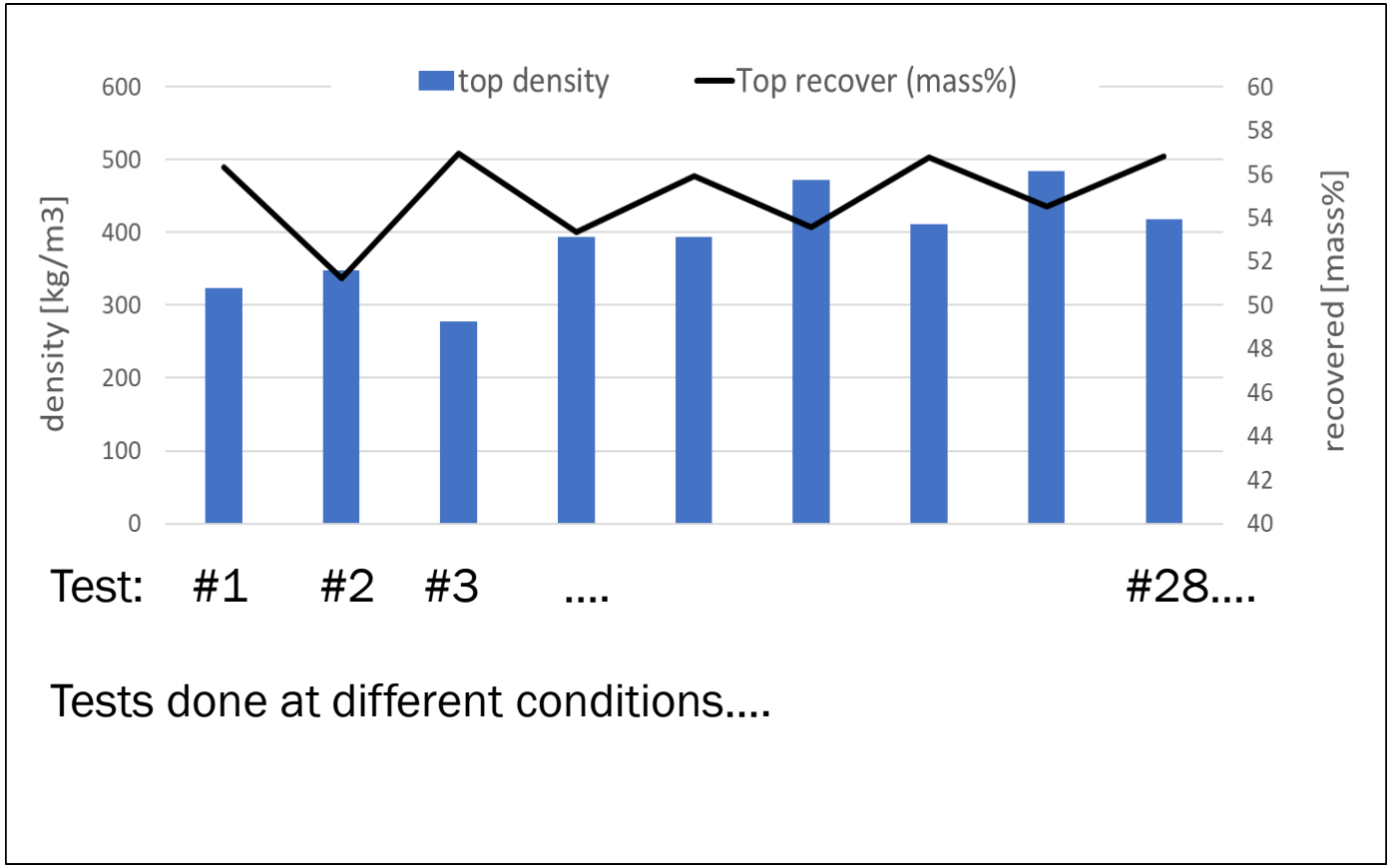
e.g., DKR-310

TOP FRACTION OUTPUT GRANULES (PE+PP)

Output size can be changed depending on the applied conditions

MPW DECONTAMINATION - UPWASH

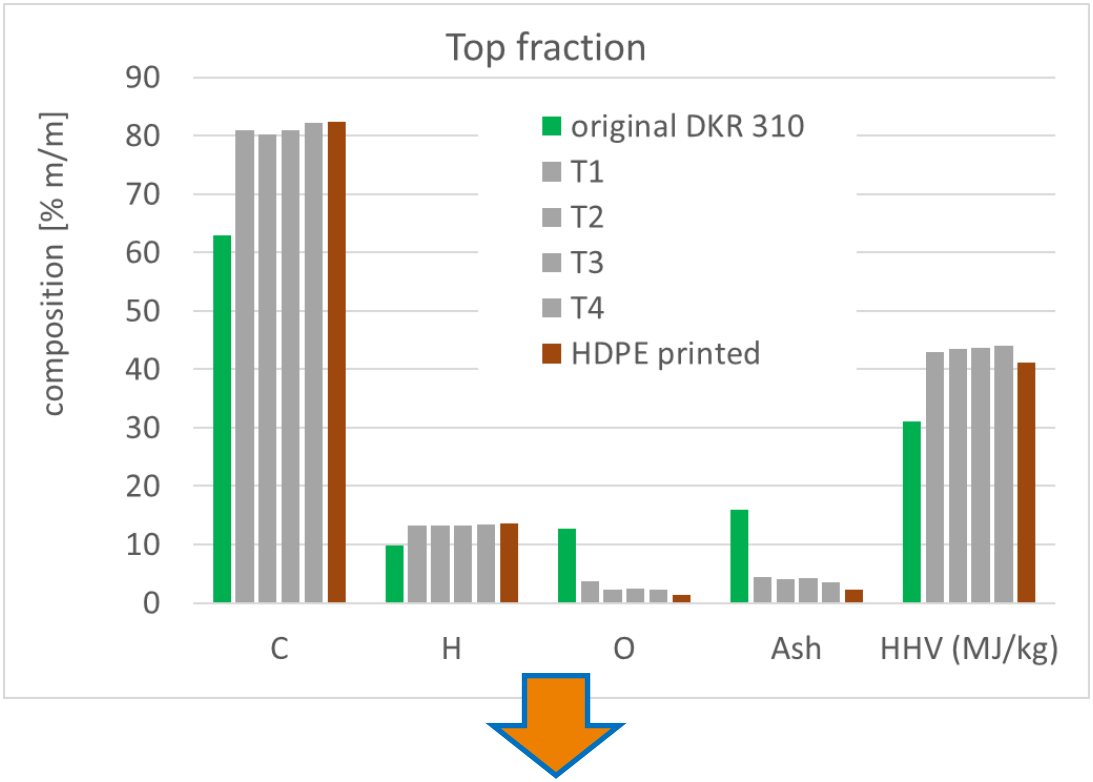
Bench-scale OUTPUT analysis results

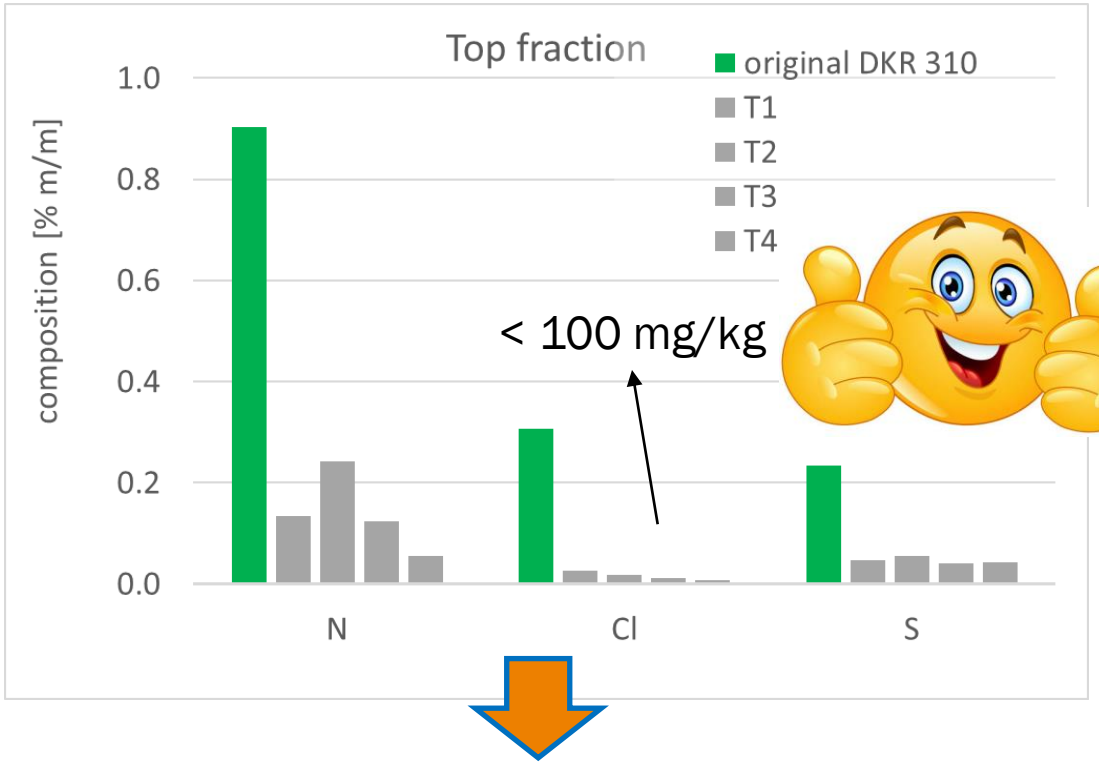


It is possible to recover about 50%mass of DKR-310 as polyolefins (PE+PP) – (top recover);
It is possible to separate the bottom plastics fraction from the inerts and suspended/dissolved biogenics

MPW DECONTAMINATION - UPWASH

Bench-scale OUTPUT analysis results





Treated DKR-310 top fractions:

- C, H, HHV - increases to contents similar to PE/PP
- O, ash - decreases to contents similar to PE/PP

Treated DKR-310 top fraction:

- N, Cl and S - decreases significantly (by a factor of 10)

MPW DECONTAMINATION - UPWASH

Bench-scale mixed plastic waste INPUT: DKR-350

DKR-350

DKR-350 (shredded < 100 mm)

DKR-350 (milled < 20 mm)

MPW DECONTAMINATION - UPWASH

Bench-scale mixed plastic waste [DKR-350] OUTPUT: separated plastics and biogenics

TOP Layer granules

BOTTOM Layer free of biogenics

Bottom Layer - biogenics

After treatment:

– Glass and stones easier to separate

After treatment:

– Metals easier to separate

MPW DECONTAMINATION - UPWASH

Bench-scale OUTPUT analysis results

WATER EFFLUENT DIGESTION TESTS

DKR-310	COD_{tot} (mg/l)	pH (-)	Conductivity (mS/cm)	biogas (nm3/ton)	CH_4 (% vol)	CH_4/COD_{tot} eff. (%wt)	$1\text{-}COD_{final}/COD_{tot}$ eff. (%wt)
Test#1	5335	6.13	2.24	1.6	59.0	51.2	59.5
Test#2	6011	6.25	2.47	1.7	60.8	49.5	55.9
Test#3	6931	6.25	2.56	1.7	64.1	45.9	53.9
DKR-350 Test#1	11268	4.61	2.52	3.7	54.8	51.7	58.1
DKR-310 Effluent re-use 3x concentrated	23900	6.1	8.2	5.5	79.4	50.6	54.2
DKR-310 Effluent re-use 8x concentrated	40100	6.1	17.1	9.8	74.1	52.9	56.7

- Not toxic for anaerobic digestion bacteria
- Can be used to produce biogas (1.6-9.8 m^3/ton with 55-79% CH_4)
- About 60-55% COD conversion

MPW DECONTAMINATION - UPWASH

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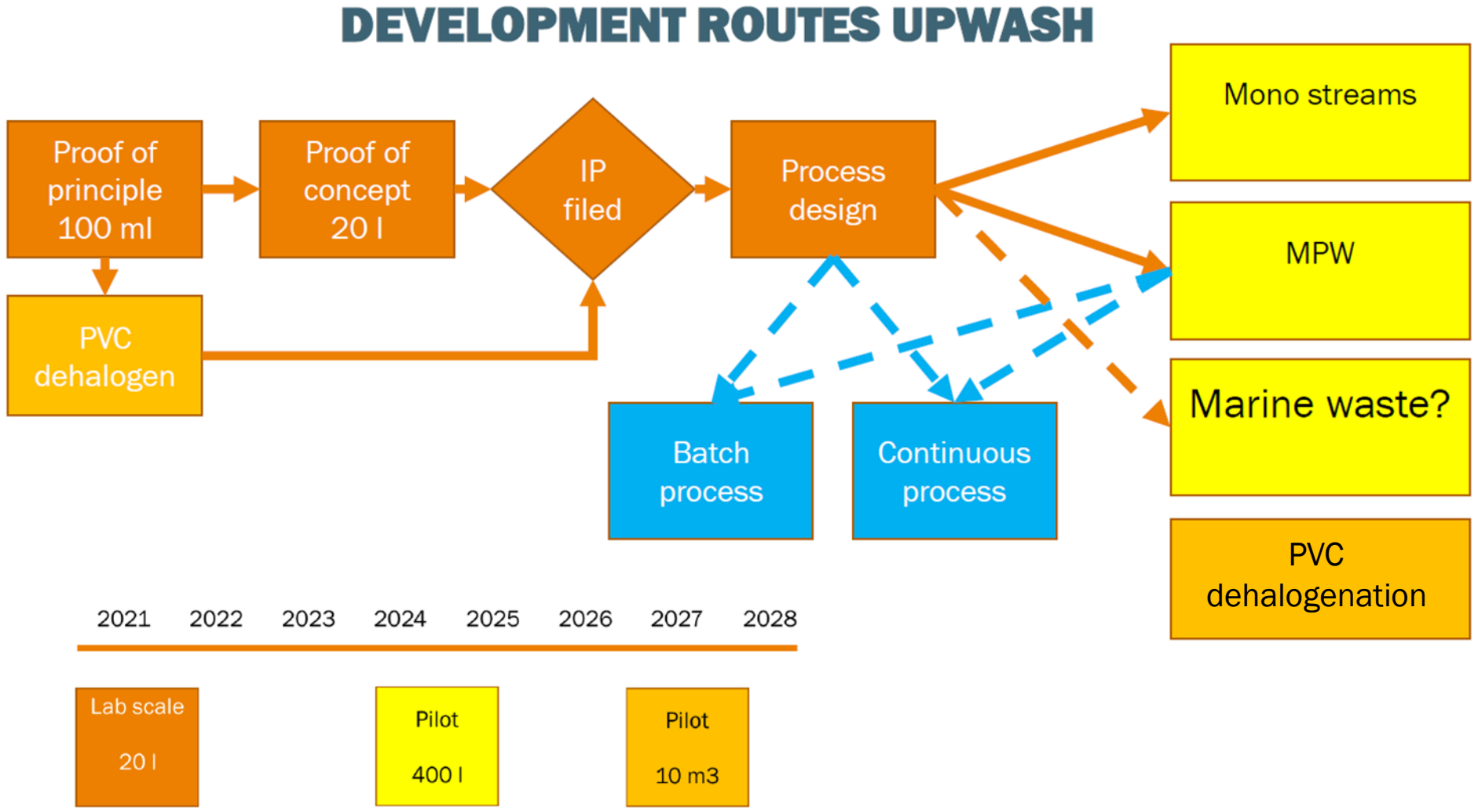
SCALING-UP…



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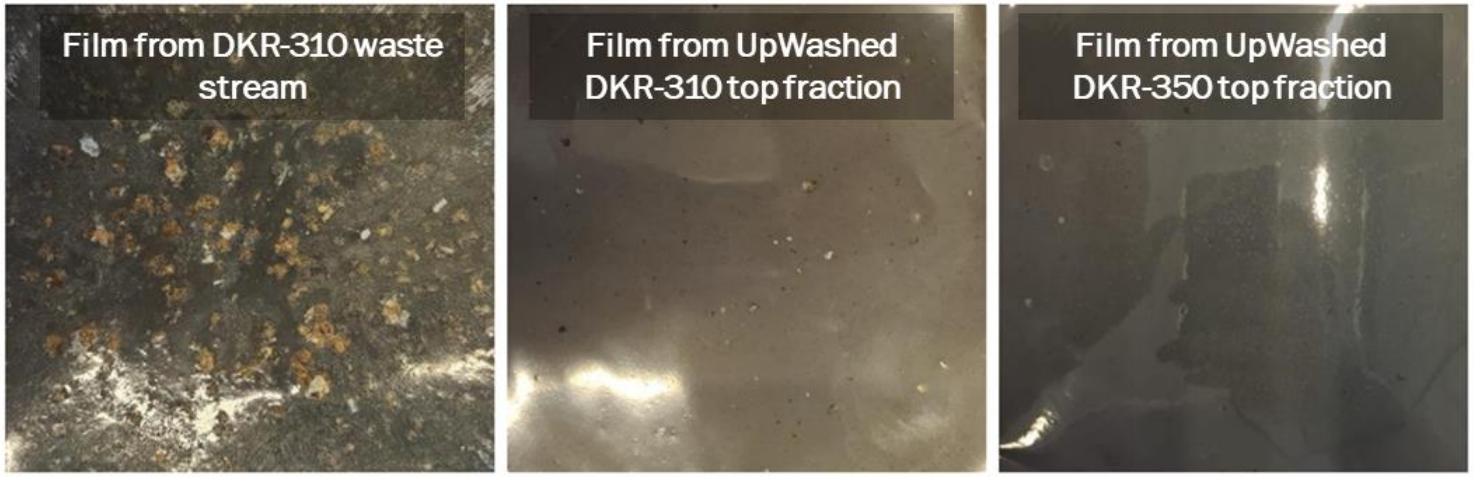
CONCLUSIONS

- UPWASH tests with **mixed plastic wastes**:
  - Top fraction composition similar to PE/PP (> 99% purity, polymer based)
    - increased density => better handling properties;
    - cleaned plastic granulates, **suitable for application to naphtha crackers** (low Cl and S contents!)
    - cleaned plastic granulates, **suitable for mechanical recycling (under research, see photos below)**



  - **Easy removal** of contaminants such as metal, glass, stones, sand, etc.

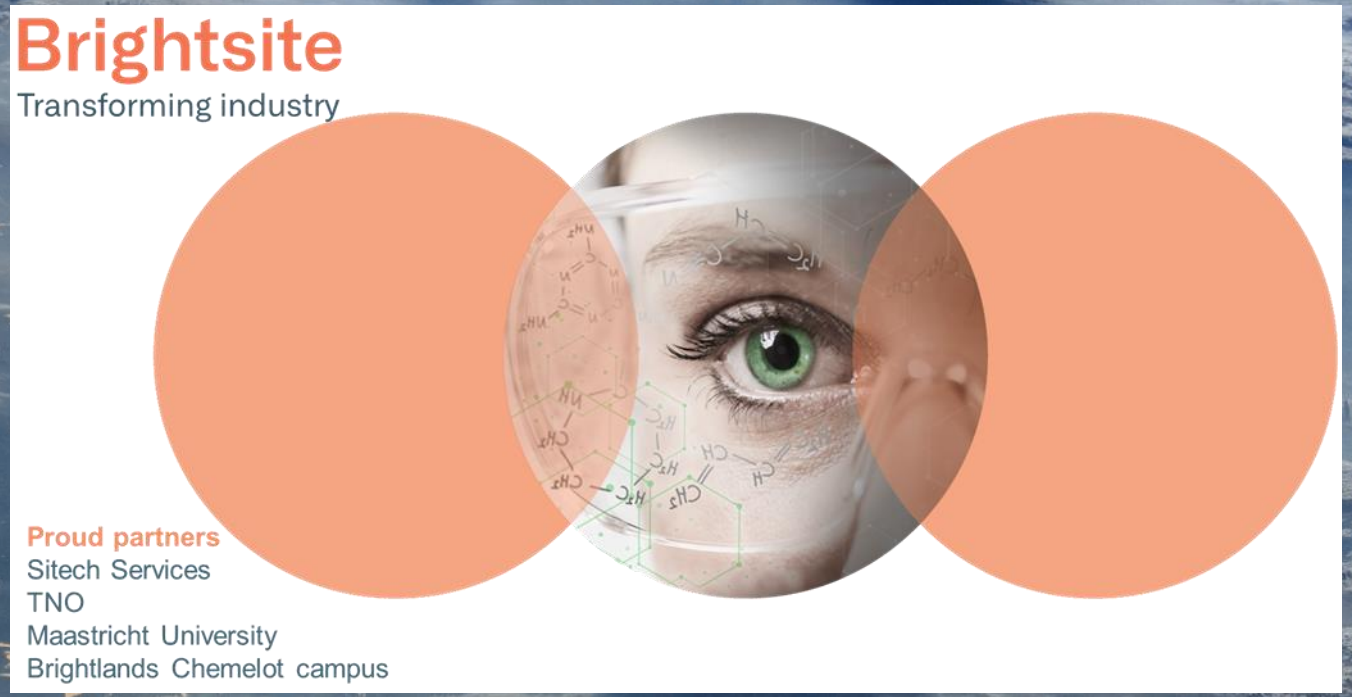
CONCLUSIONS

- Bench-scale tests with **mixed plastic wastes**:
  - **Bottom fraction increased density** => better handling properties;
  - **Plastics bottom fraction** is **suitable for gasification**; low Cl (< 0.02%) and S (< 0.1%) contents!!!)
  - **Suspended fraction biogenics** => possible to separate the biogenic solids from high density plastics; also **suitable for gasification**
  - **Water effluent** easy to treat by digestion => 60-55% COD conversion to biogas (1.6-9.8 m^3/ton with 55-65% CH_4)

Research still focused on [e.g. Brightsite, SyschemiQ and INREP]:

- Pigments and glues separation/recover still needs further research
- Other types of plastic wastes
- Scaling-up

THANK YOU FOR YOUR TIME



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