Green PAC

Polymer Application Centre

Circular Plastics Research & Education

M2i CONFERENCE 11 DEC 2018 NOORWIJKERHOUT

NHL STENDEN hogeschool

GreenPAC

Polymer Application Centre

NHL Stenden
University of Applied Sciences

Professorship Circular Plastics
Professorship Sustainable Polymers
Centre of Expertise GreenPAC

RUDY FOLKERSMA

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GreenPAC = CoE Smart Polymeric Materials (SPM)

An initiative of NHL Stenden Hogeschool (Emmen) and Hogeschool Windesheim (Zwolle)

Topics:

Sustainable polymers (biodegradable, compostable, biobased, recyling)
Biocomposites
Sustainable fibers (biobased (bioPET30) and compostable (PLA) fibers)
3D printing

Details:

www.greenpac.eu

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Bachelor courses:

- Information Technology
- Life Science
- Mechanical Engineering

Master course:

- Polymer Engineering

Laboratories:

- NHL Stenden
- Emmtec Services
- Senbis

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Stenden Laboratories
=engineering plastics=

Injection moulding machines (4)
Extrusion line for monofilament and profile
Twin-screw extrusion compounder
Certified testing facilities
Composites (thermoplastic and thermoset)

Senbis Laboratories
=applied polymer research=
Fiber spinning machines (small & large)
Rheological measurements (extrusion rheometer)
Thermal measurements (DSC, TGA, DTA etc.)

Emmtec Services Laboratories
=analytical services=

Wet analysis

MyConcept
=fabrication laboratory=

Education

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Master Polymer Engineering (together with RUG, Wageningen UR, and UT)

New Business Development (since November 2013)

Centre of Open Chemical Innovation at the Emmtec Industry & Business Park (Emmen)
iLAB at Polymer Science Park (Zwolle)

On site:
DSM EP
Teijin Aramid
Morssinkhof Plastics
Cumapol
Sunoil
Bonar
Inverko Plastics
API

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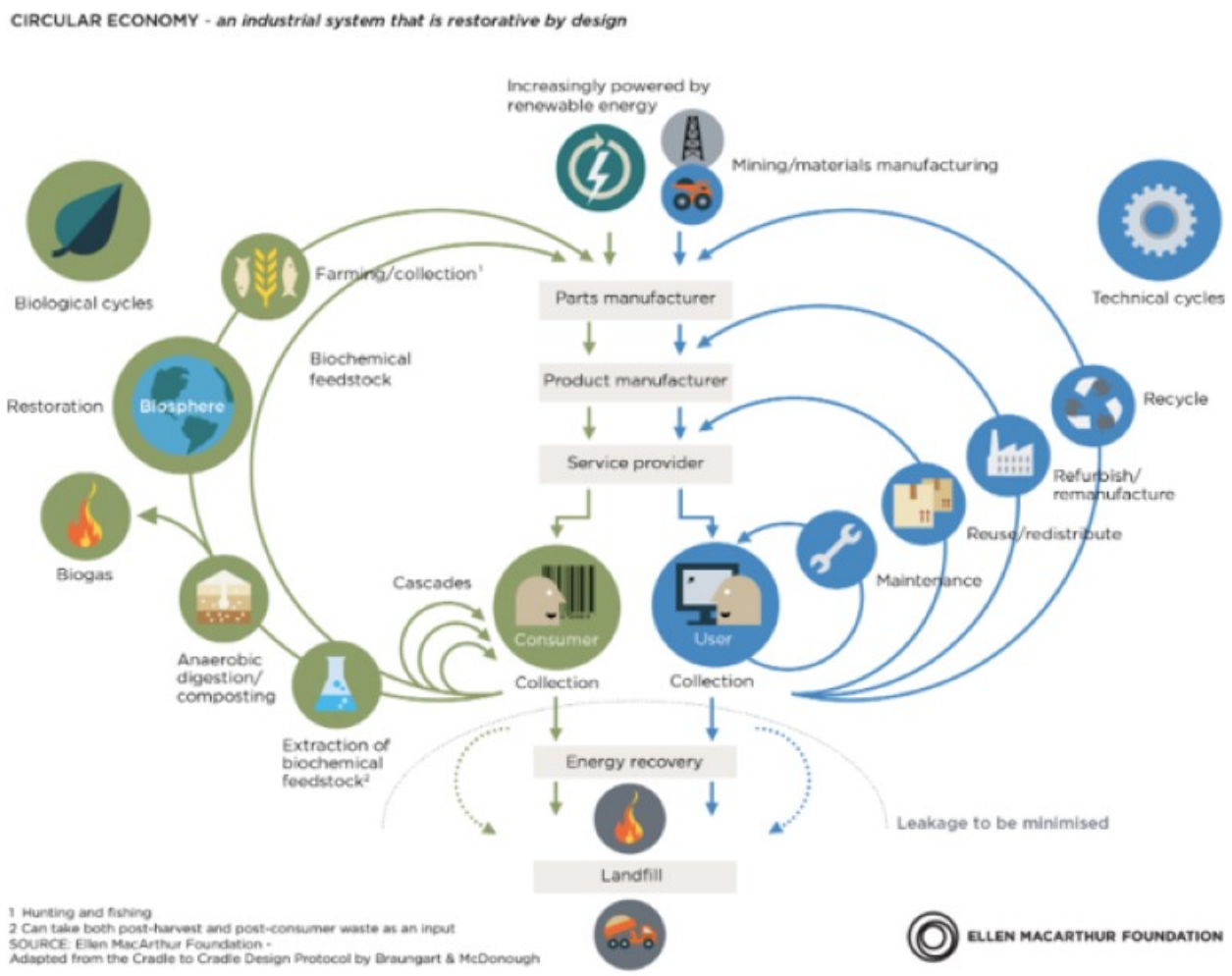
Professorship Sustainable Polymers / GreenPAC

- 3D printing (FDM en SLA)
- Biopolymers, biobased and/or biodegradable
- Yarns and fibers
- Biocomposites

Professorship Circular Plastics

- Mechanical recycling
- Chemical recycling
- Product design

Professorship Green Logistics
Professorship Computer Vision
Professorship Water Technology



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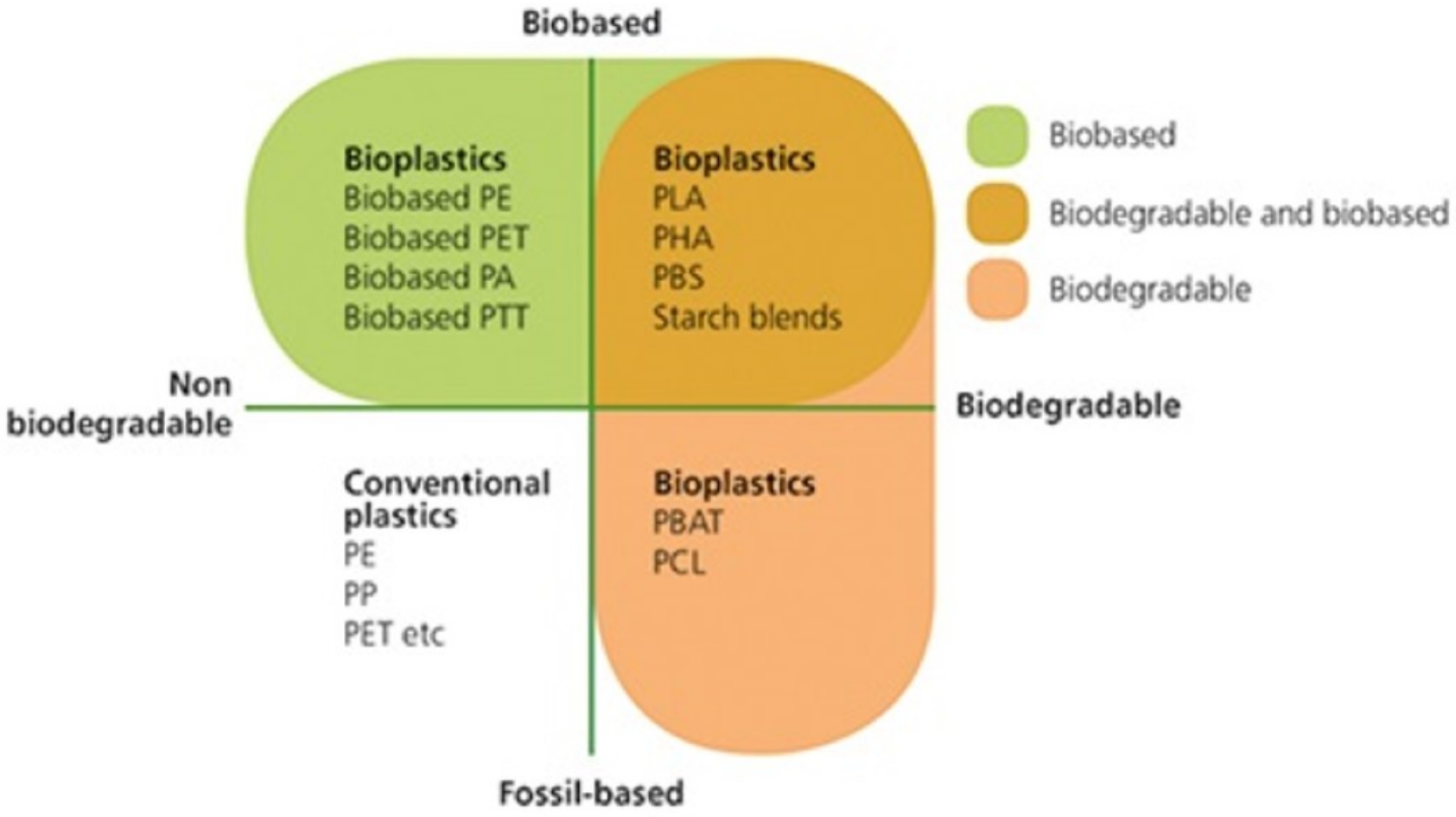
Classification of Plastics



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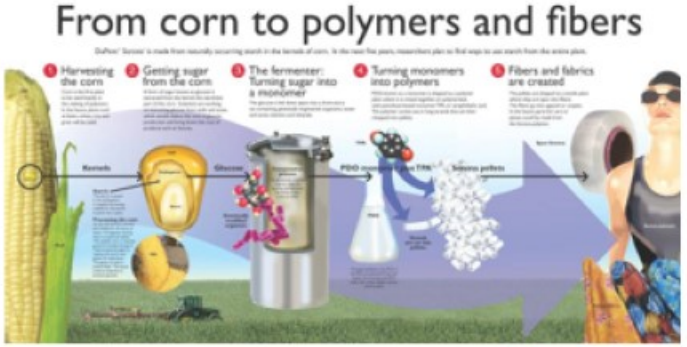
Biopolymers: biobased and non-biodegradable

biobased PET

biobased PE



biobased PTT

MOHAWK
SmartStrand
with DuPont™ Sorona® renewably sourced polymer*

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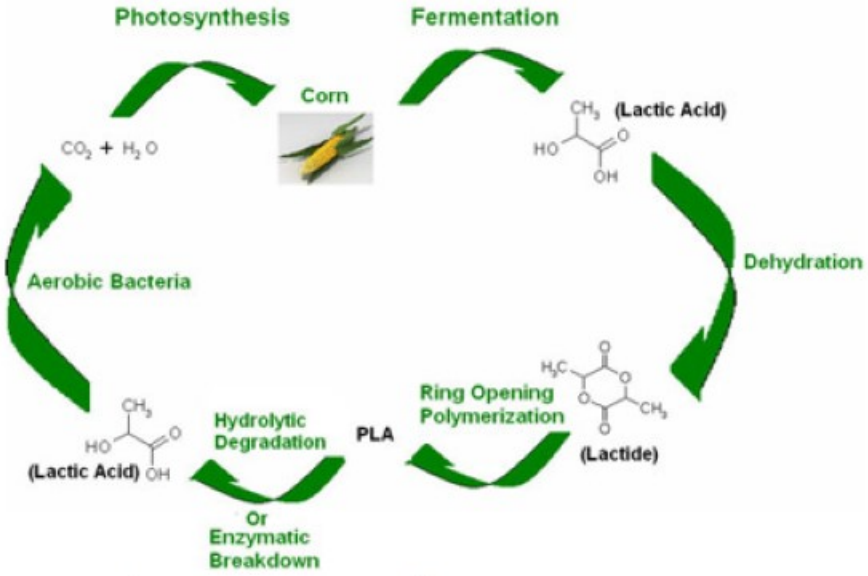
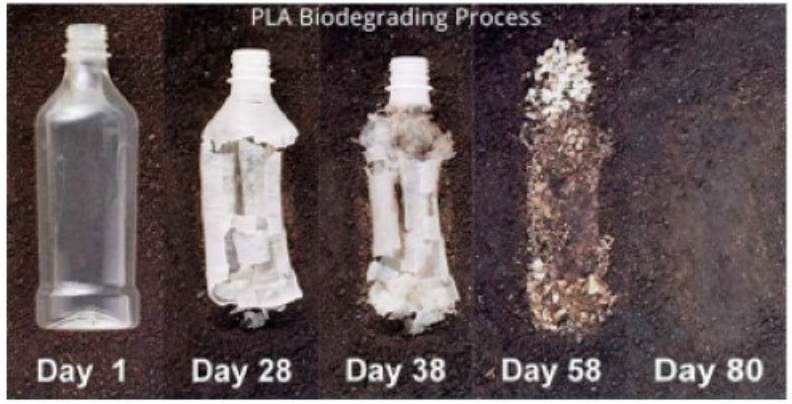
Biopolymers: biobased and biodegradable



PLA (polylactic acid)



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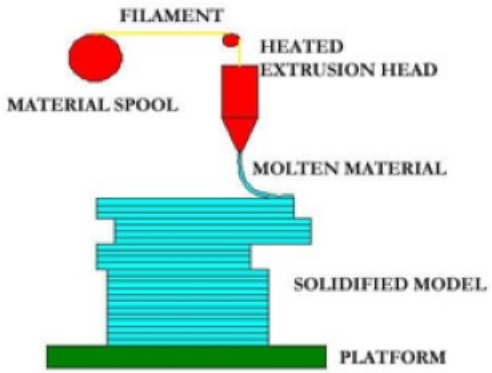
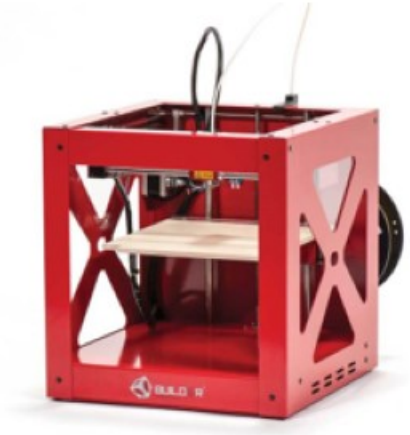
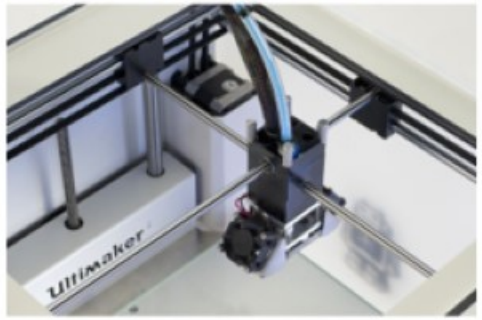
R&D topics GreenPAC:

New materials and applications for FDM 3D printing techniques







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R&D topics GreenPAC:

- New generation carpets from recycled PET bottles (mechanical recycling)
- Improvement of quality of recycled plastics (mechanical recycling)
- Chemical recycling of PET

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R&D topics EDR:

New generation biodegradable fibers (e.g. PBS or PLA)
New generation compostable carpets from corn (PLA-based)

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R&D topics EDR:

- Biocomposite bridge for Wildlands Adventure Zoo
- Biocomposite Solar Boat
- “Plantpaal” for bank protection
- Bioresin characterisation

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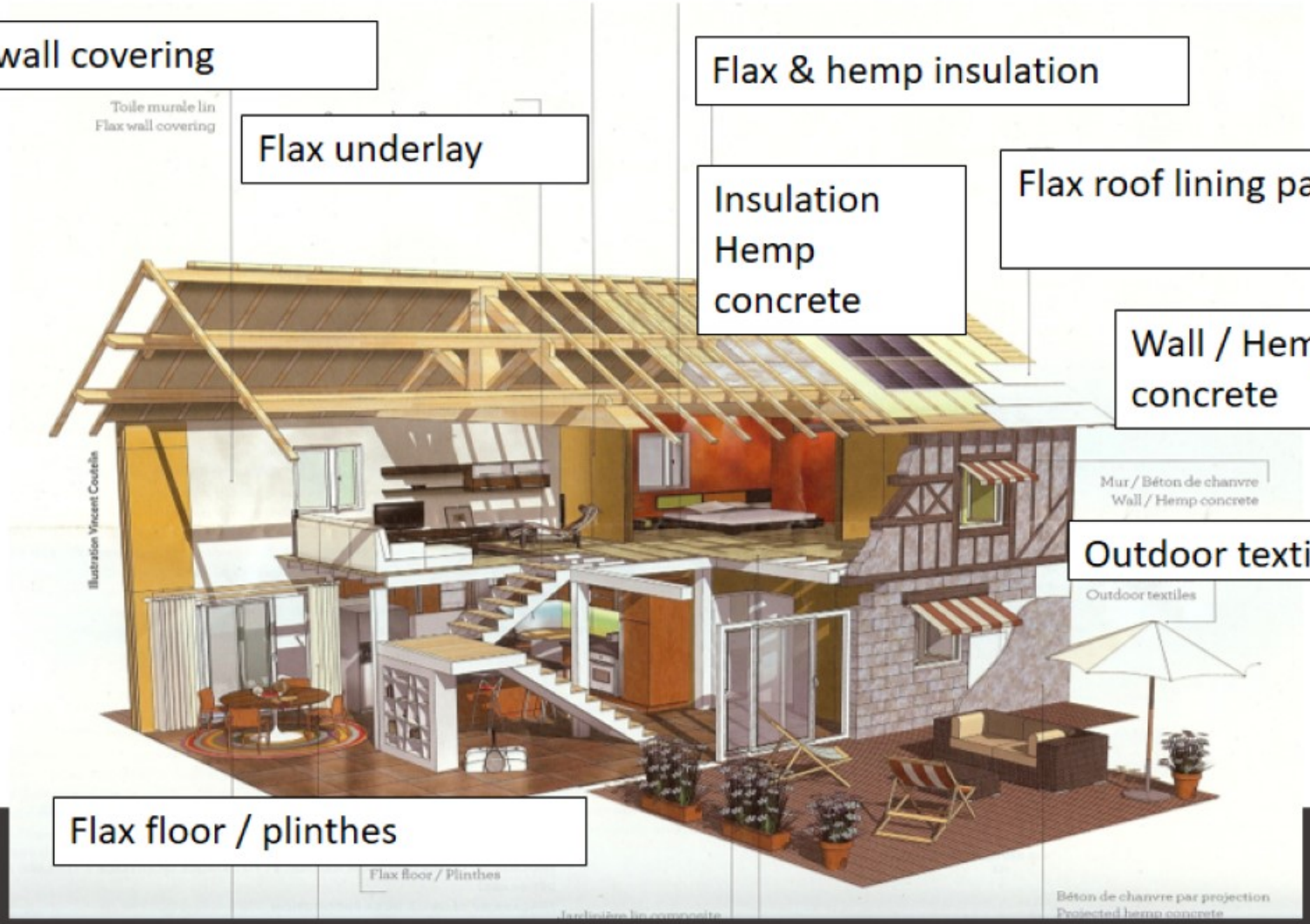

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R&D topics EDR:

- Fermentation technologie (investment in laboratory bio-reactors)
- Scale-up of fermentation technology with Drenthe College CIV

- Fermentation of glycerol to functional monomers
- Fermentation of biomass

Sunoil Biodiesel

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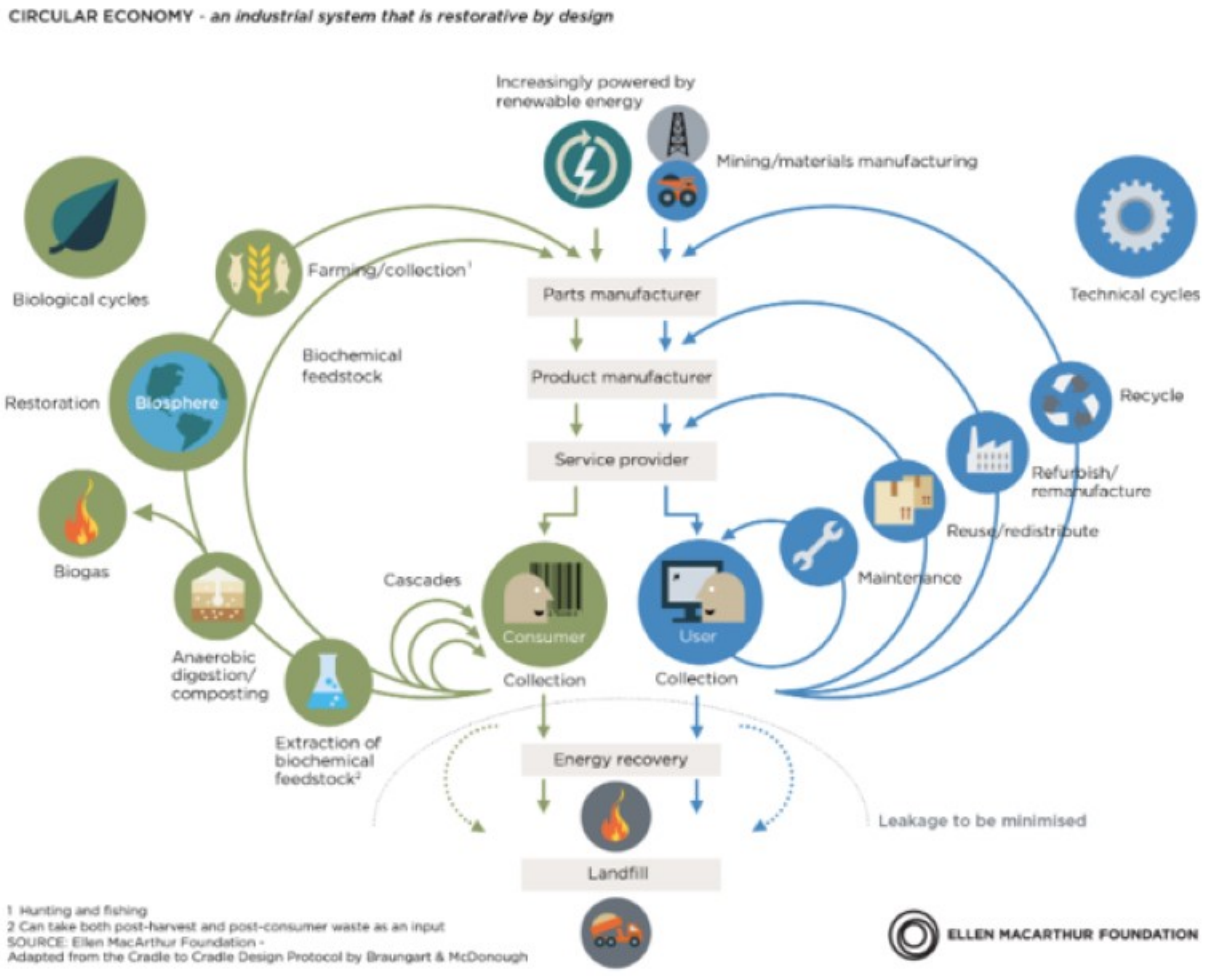
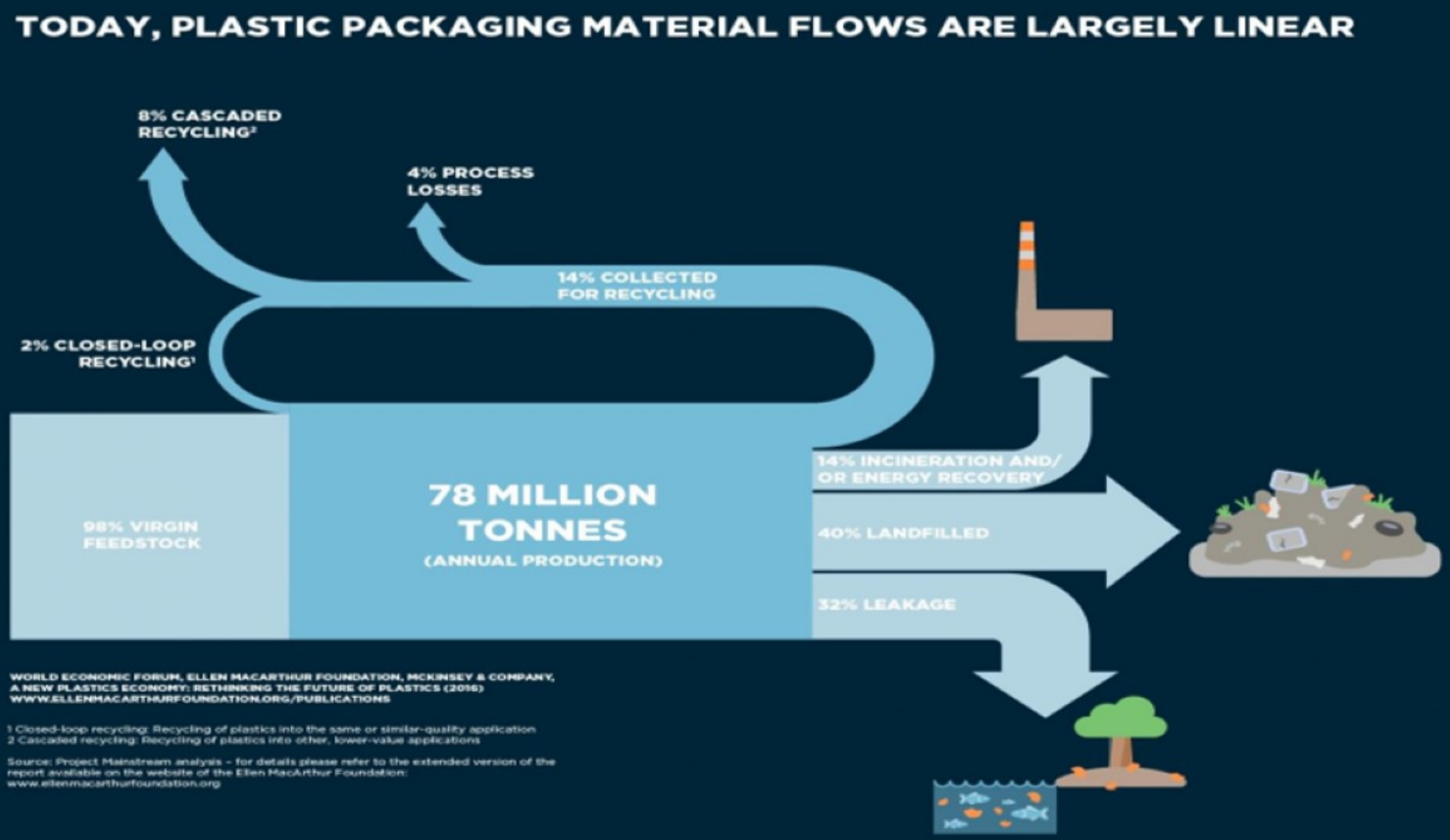
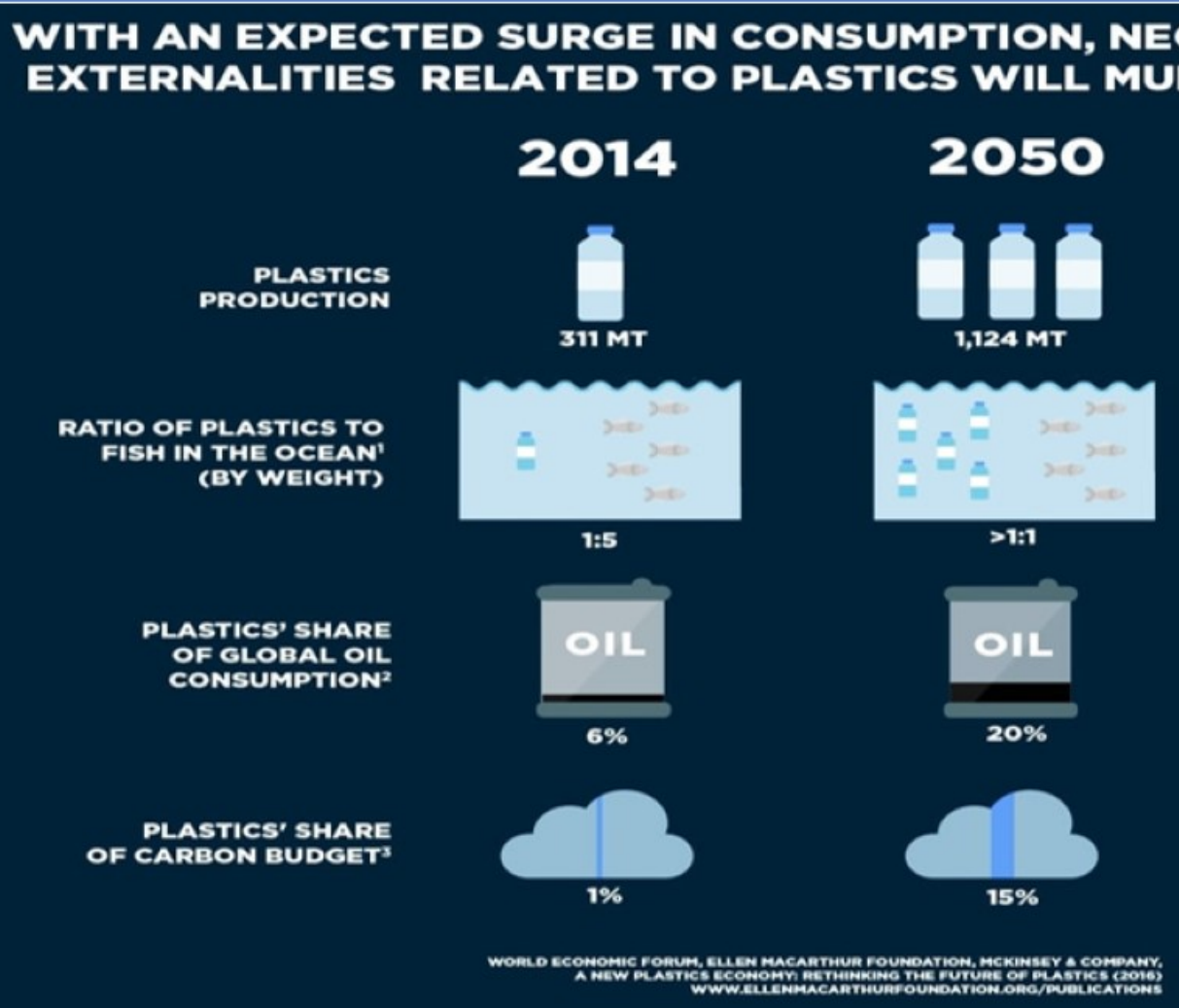


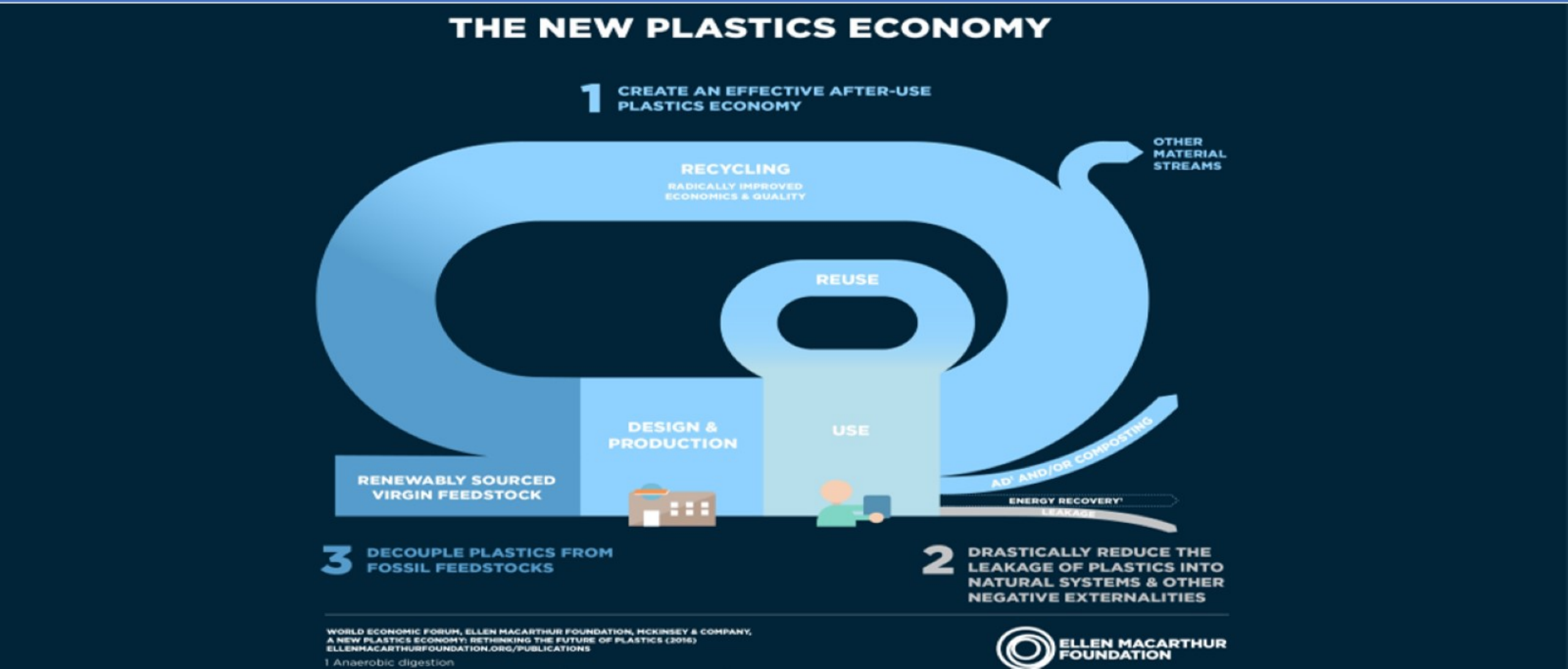
Current state of affairs



If we do nothing…(in 2050)



What we strive for…(in 2050)

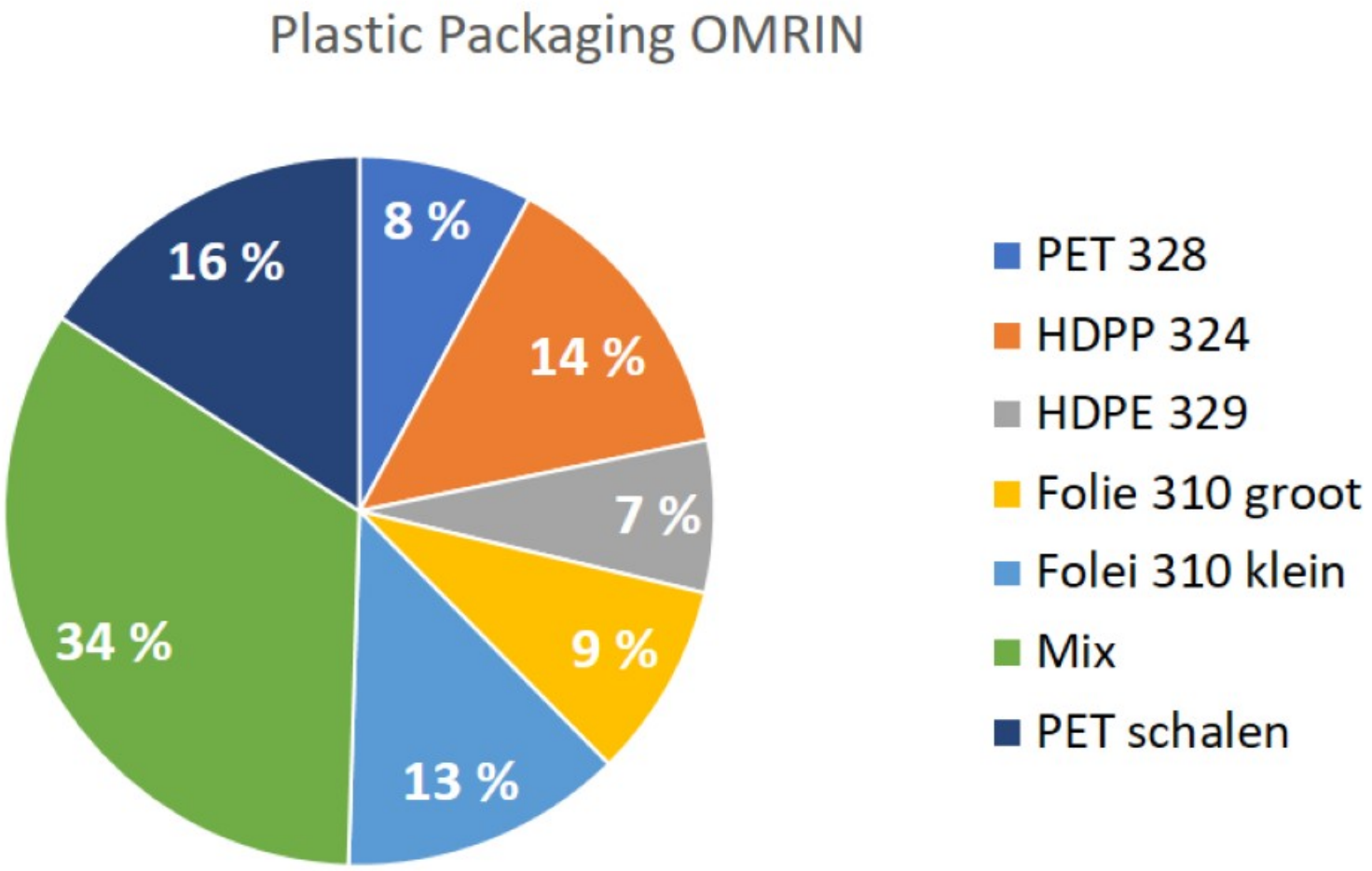


Projects Mechanical Recycling

Professorship Circular Plastics

- Waste odor PP after long period (Philips)
- Waste odor from foils (Omrin)
- **Closing the Loops**
- **Grease removal of PET trays (Cumapol)**
- Water, energy and chemicals recovery out of washing procedure (Wafilin Systems and Westra RVS)
- Recycling PLA (LIMM)
- **Detection of plastics in cooperation with Professorship Computer Vision and SME companies.**
- Application of recycled plastics of Omrin in products of Lankhorst and New Marble, and projects within plastic processing companies.
- Introduction circular plastics for products in the construction sector.

Closing the Loops



Closing the Loops

CLOSING THE LOOPS

Omrin, Philips, Cumapol, Lankhorst, (Inverko), Morssinkhof NHL STENDEN

PE / PP

PET

Optimize Mechanical Recycling

Washing procedure

Separating

Shreddering

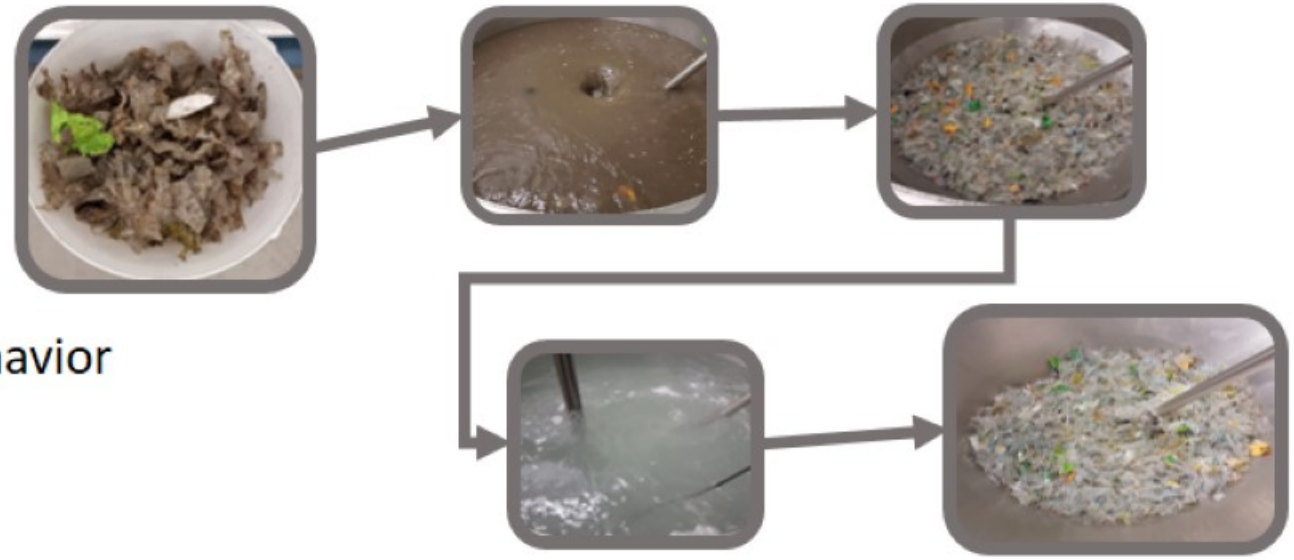
Closing the Loops

Materiaalspecificaties Philips aan het eind van de keten

Plastic	Molding	IR	Aesthetics	Particles	Gloss	Smell	Impact IEC	BP IEC	Technical feasibility
PET	OK	Semi-crystalline	OK	OK	Semi-gloss	OK	OK	NOK	NOK
PP	OK	Copolymer PP	Improve	NOK	Improve	NOK	OK	OK	NOK
PE	NOK	HDPE	NOK	OK	NOK	NOK	OK	OK	NOK

Grease removal of PET trays (Cumapol)

- Wasprocedure on a small scale
  - Washing with NaOH and Tubiwash
  - Rinsing with water
  - Drying
- Wasprocedure on a large scale
  - Shreddering of PET-trays
  - Rinse
  - Washing with NaOH and Tubiwash
  - Rinsing with water
  - Drying



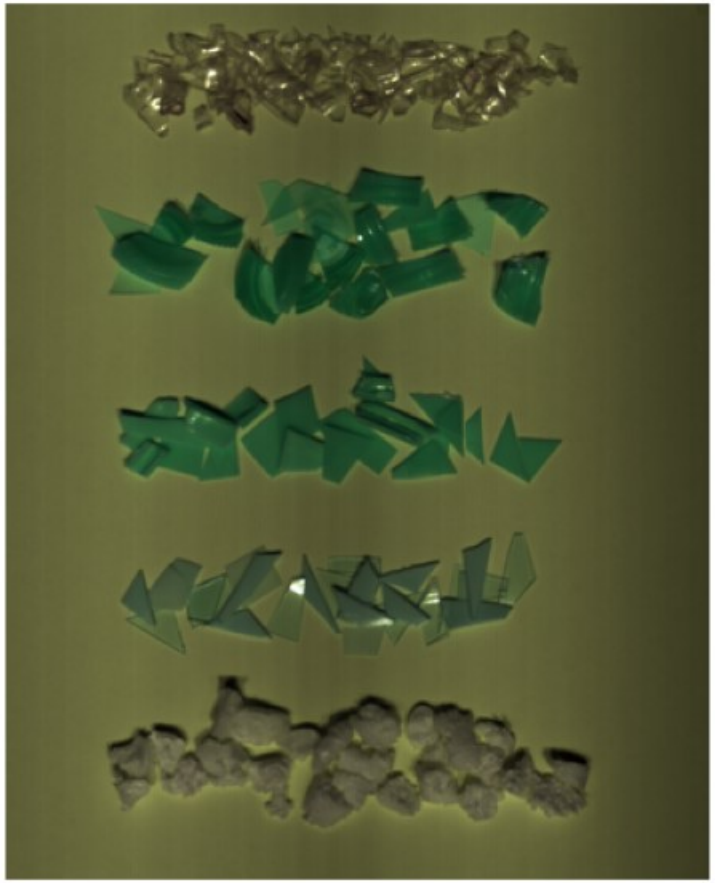
- Infrared spectroscopy (IR)
  - Determing functional groups
- Differential Scanning Calorimetrie (DSC)
  - Determing melting and congealing behavior

Detection of Plastics with FX-17 camera

- Differentiating between different kind of plastics
  - Shape, colour, content, additives

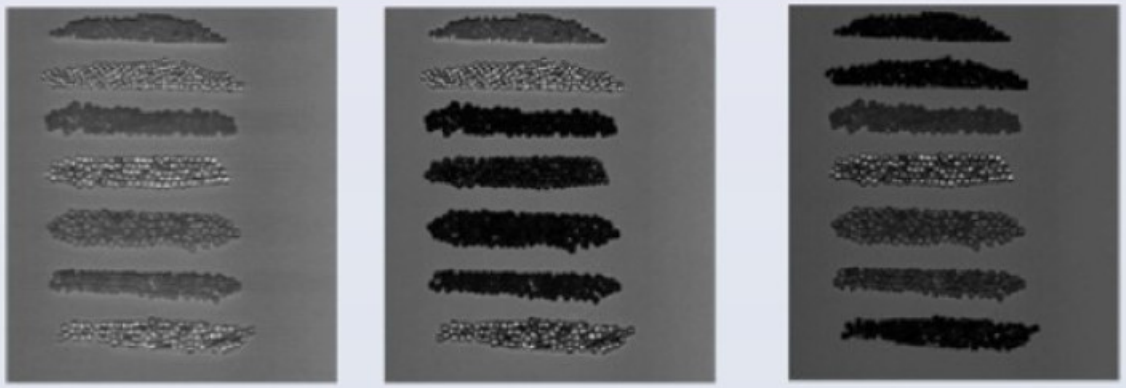
- FX-17

- Research: Hyperspectral Image a solution in combination with neural network?

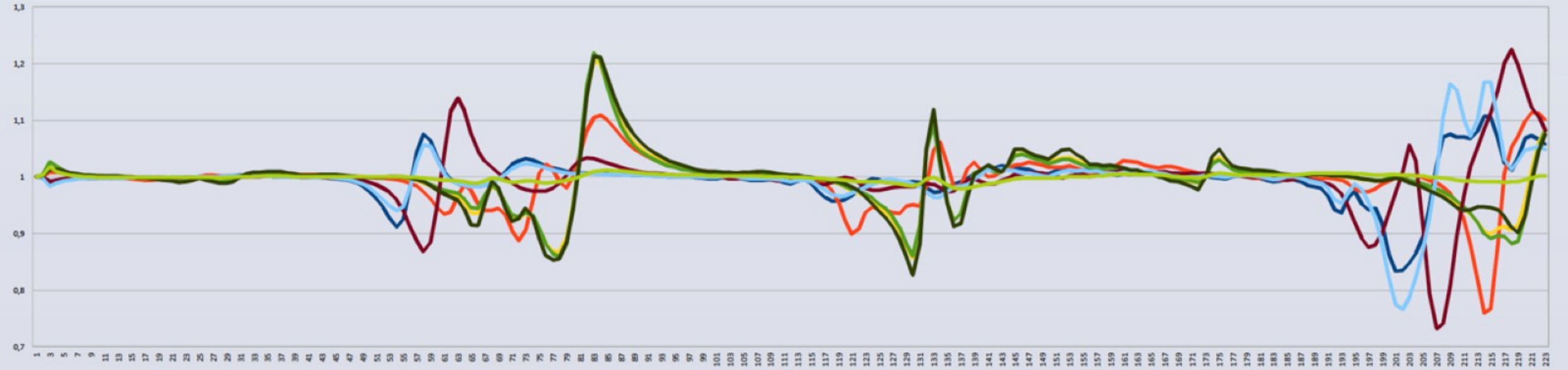


Plastics - Spectra

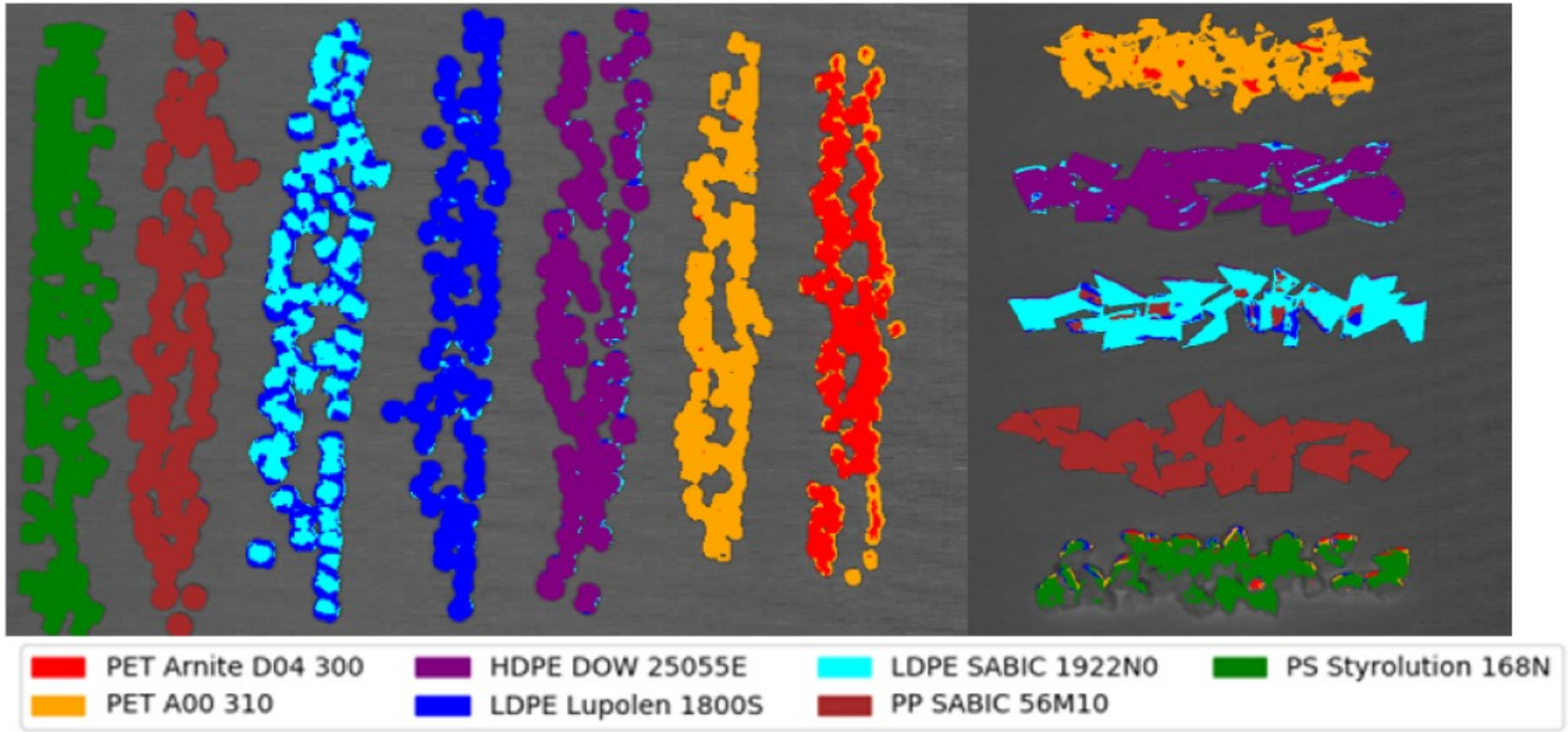
- 900-1700nm, divided over 224 bands



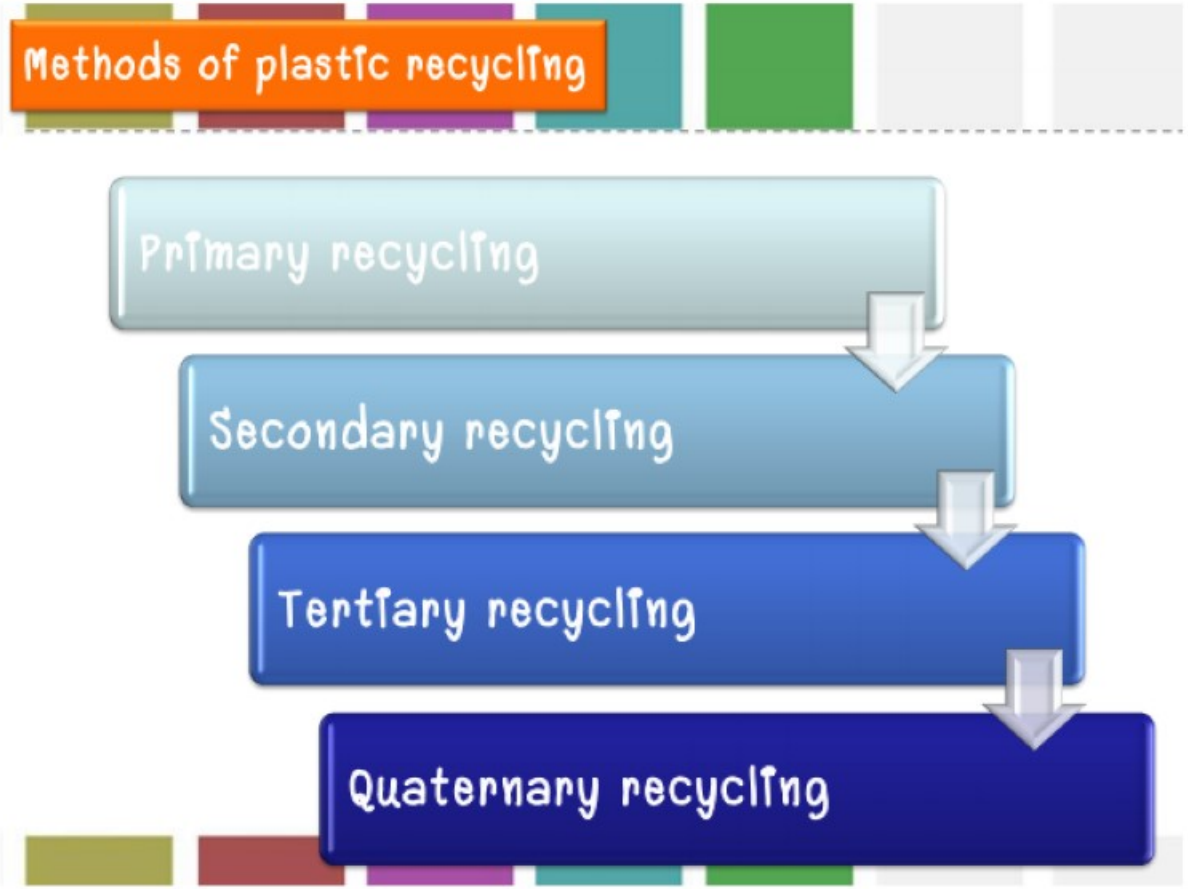
Band 1 Band 80 Band 208



Detection of Plastics with FX-17 camera



Plastics Recycling Methods



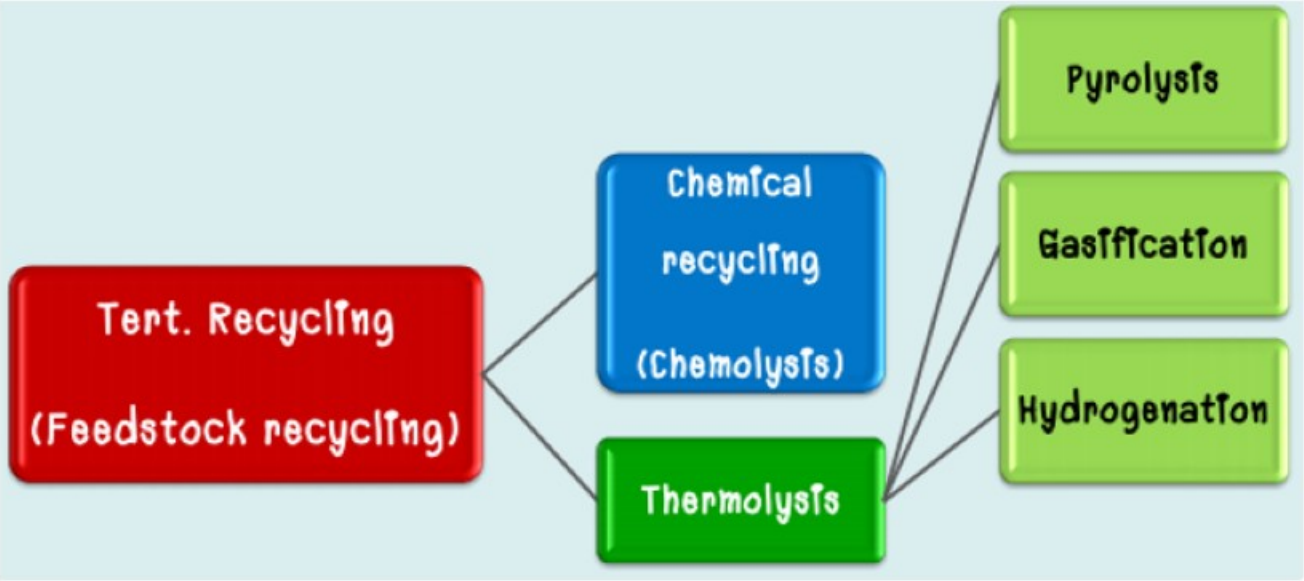
Using uniform and uncontaminated plastic waste to manufacture plastic products (reprocessing) can be used alone or added to virgin resin at various ratios.

Mechanical Recycling: using recycled plastic waste to manufacture new plastic products.

Converts discarded plastic products into high-value petrochemical or fuel feedstocks.

Energy Recovery: the useful retrieval of the energy content of plastic wastes by its use as an energy source to produce products such as steam and/or electricity.

Tertiary Recycling of Plastics (Chemical Recycling)



(work in progress: biocomposites)

- Chemical recycling (chemical depolymerization of chemolysis) only possible with condensation type polymers: polyesters (e.g. PET or PLA) or polyamides (e.g. PA6 or PA6,6)
- Thermolysis is possible with all polymers, including (bio)composite materials.

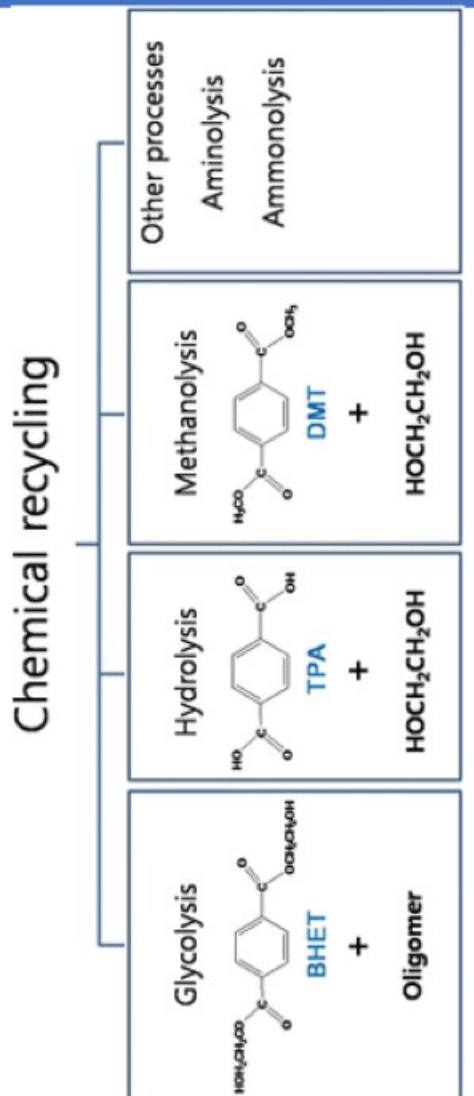
Chemical recycling of PET

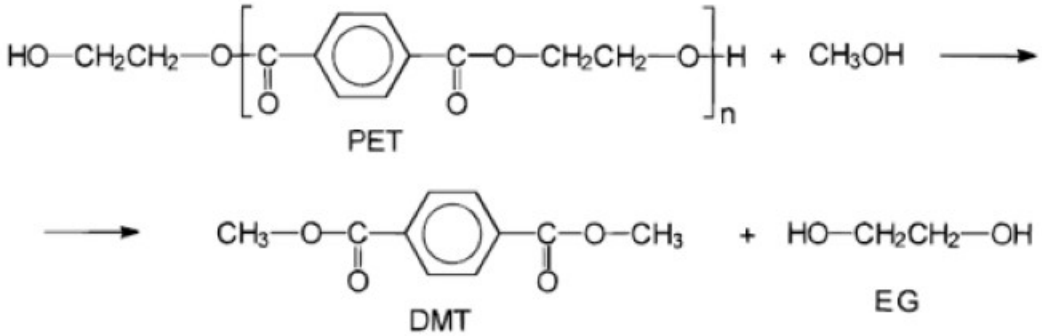
Products not suitable for mechanical recycling (secondary recycling)

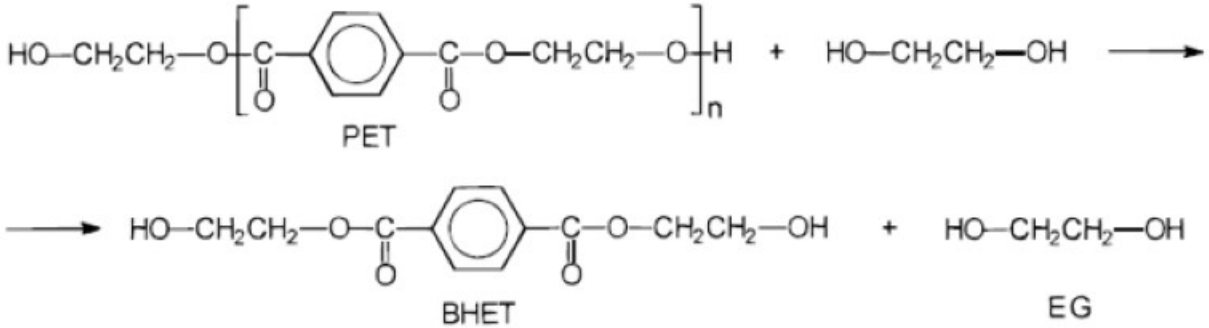
Our focus:

- All-polyester carpets
- Multi-layer PET films
- Textile products (including sports shirts)

Chemical recycling of PET

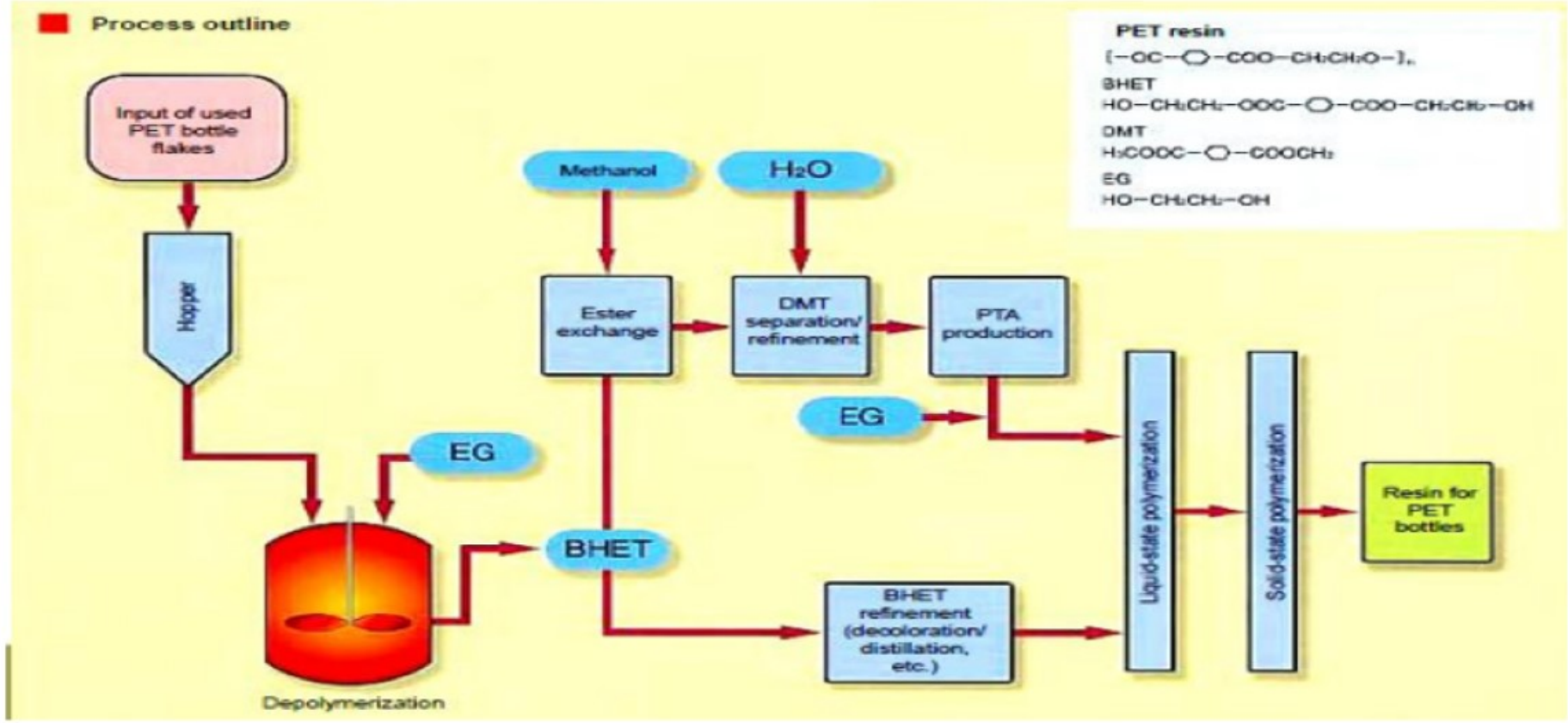






Three Process Steps

- Depolymerization of PET with ethylene glycol to BHET
- Purification of BHET (removal of dye stuffs and particles)
- Repolymerisatie of BHET to PET

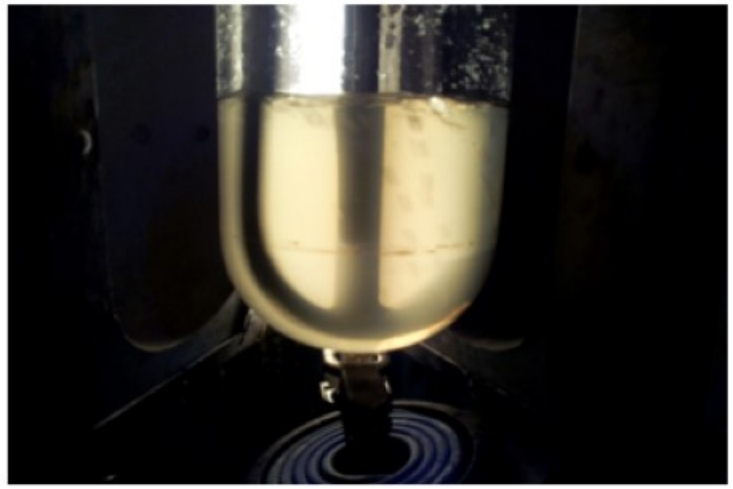


Depolymerization of PET

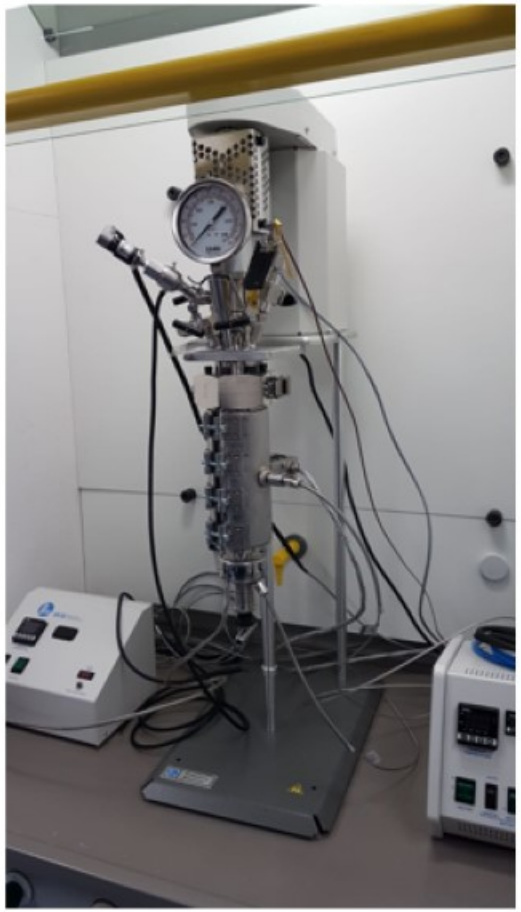
Process optimization in a 3L glass reactor:

- Catalyst (zinc acetate)
- Ethylene glycol (excess?)
- Process parameters (e.g. temperature profile)

at start



final situation



- Composition (BHET, dimer, trimer etc.) of resulting product, by means of HPLC

Product Development

- Circular Plastics LivingLabs
- Blokhuispoort (FDF)
- Concepting & Prototyping Lab
- Starting in 9-2018

Product Development

Focus op LDPE, PET – Shortlist:

- Draka/Prysmian

Design pressure cooker –> product development

- Probo Sign

Workshop Probo Circulair; circulair shopping

- DVC

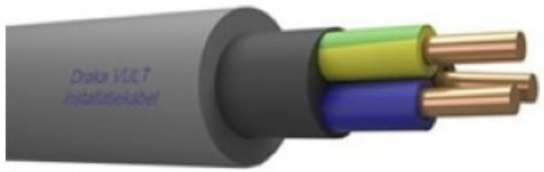
PET recycling; development sustainable chains

- Sphere

Quality of recyclate, blending recyclate

- New Marble

PET trays for Marble tiles



Product Development

Methods circular product development

- Erasmus + project
- Online database (open source)
- Circular product development manual
- Student projects Ireland, Catalonia
- September 3rd students in Leeuwarden
- Selection new projects June

CIRCULAR DESIGN
Learning for Innovative Design for Sustainability

Education

- Minor Circular Plastics
- Minor Sustainable Polymers
- Minor Composite Design Solutions
- Minor Bionics

- Minor Polymer Product Engineering
- Minor Composites

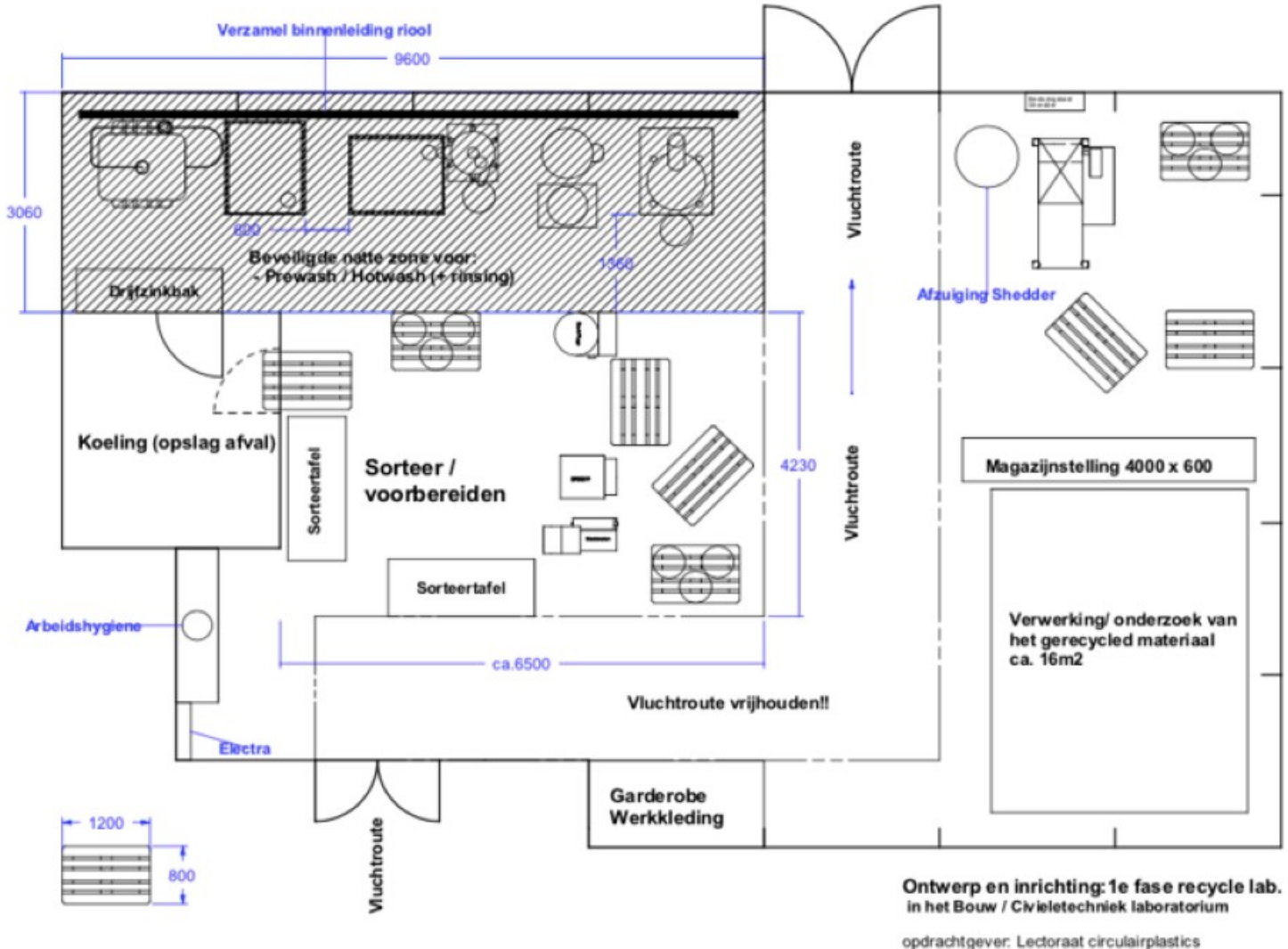
- Master Polymer Engineering

Minor Circular Plastics 30 EC

- **Circular Economy**
  Ellen MacArthur, People Planet Profit, Business Models, Green Logistics and Product Life Cycle
- **Packaging Technoloy**
  Methods of packaging, packaging policy, design methods, legislation and standards
- **Mechanical and Chemical Recycling**
  process technology, washing procedures, shreddering, sorting
- **Polymer Chemistry / Polymer Technology**
- **Research and Literature**
  Research methods and literature review
- **Practice and excursions**

- **Research Project Circular Plastics**
  Research within NHL Stenden or external partners; Omrin, Philips, Morssinkhof, Lankhorst, Huhtamaki or Circular Friesland

Recycle laboratory NHL Stenden



Test Centre Recycling of Plastics