Fonds voor rechtvaardige transitie

JTF C-RECYCLE Mechanical recycling training

26-02-2026

avans hogeschool

UNIVERSITY OF APPLIED SCIENCES

Avans University of applied Science

- Breda – 's-Hertogenbosch – Tilburg - Roosendaal
- +/- 30.000 students
- +/- 54 degrees in 20 faculties
- +/- 3.300 employees
- Centres of Expertise:
  - Material and Energy Transition (MNEXT)
  - Art, Design & Technology
  - Brede Welvaart en Nieuw Ondernemerschap
  - Future-Proof Education
  - Perspectief in Gezondheid
  - Veiligheid & Veerkracht

AVANS, HZ & ECOSYSTEEM

curio

TU Delft

WAGENINGEN UNIVERSITY & RESEARCH

PORT OF MOERDIJK

REWIN

Impuls Zeeland

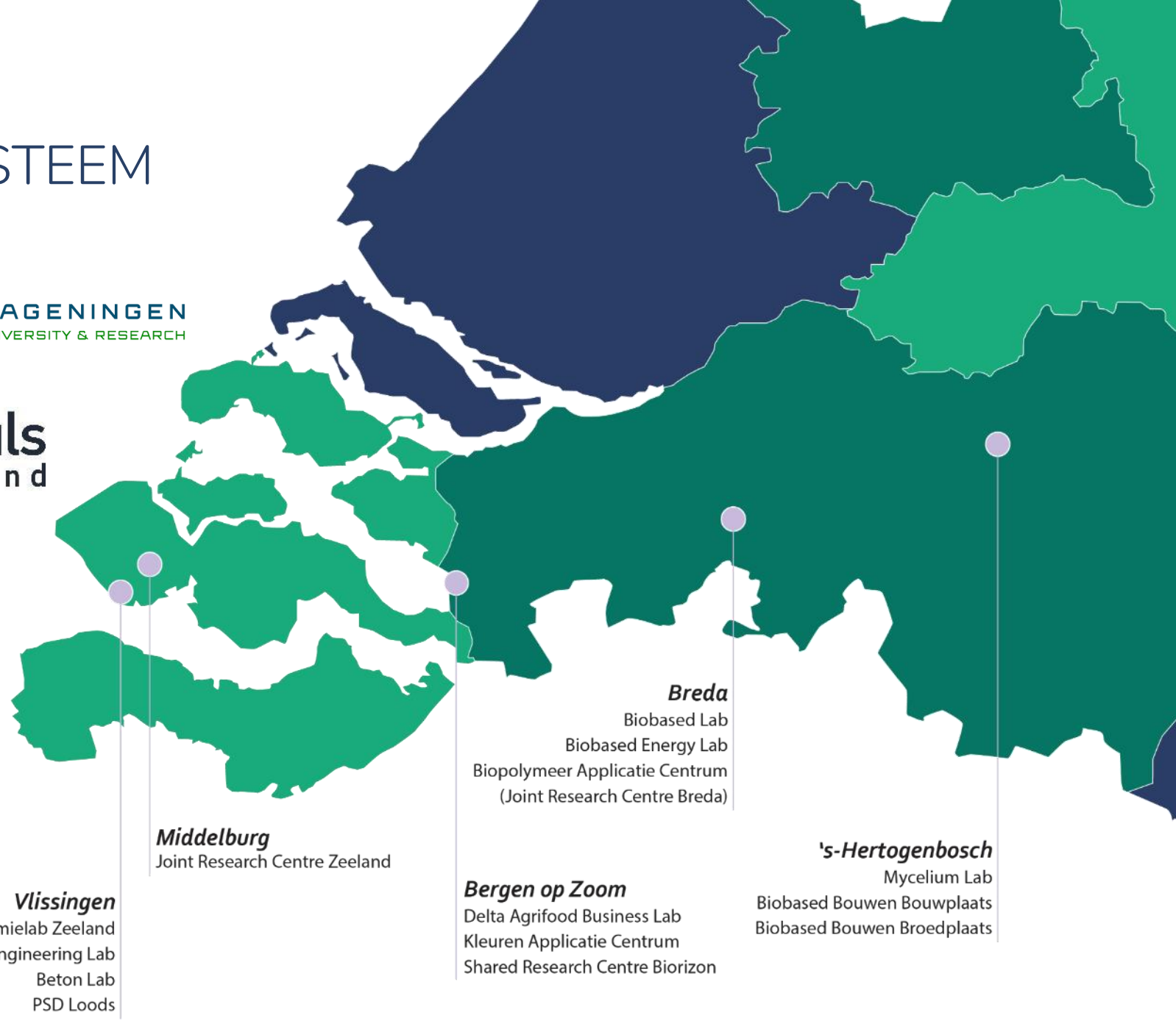
TOPSECTOR ENERGIE
Empowering the new economy

TKI•BBE

Provincie Zeeland

Provincie Noord-Brabant

+/+ 200

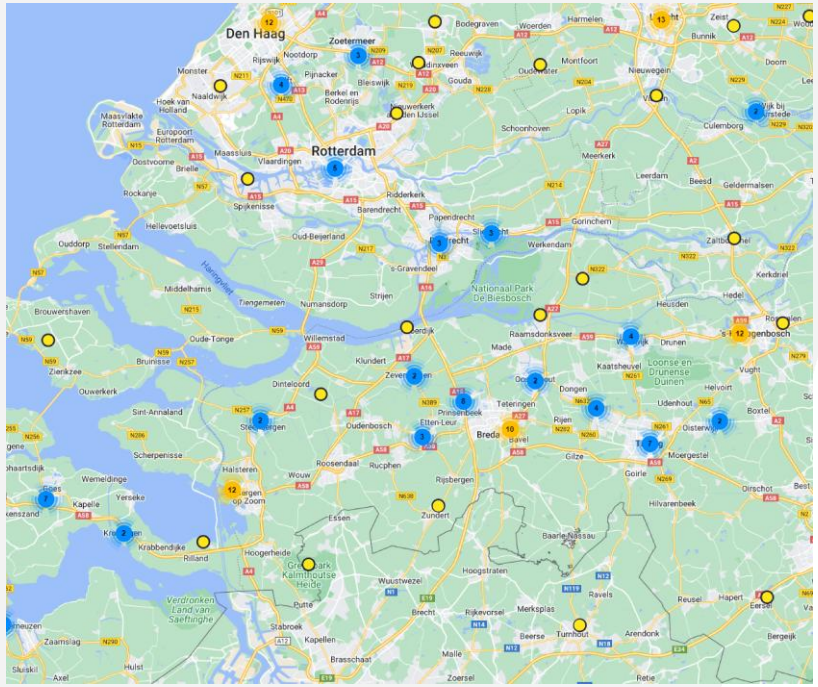


PART OF AN ECOSYSTEM (KNOWLEDGE, SME, EDUCATION)

- International activities & playing field
- Regional focus

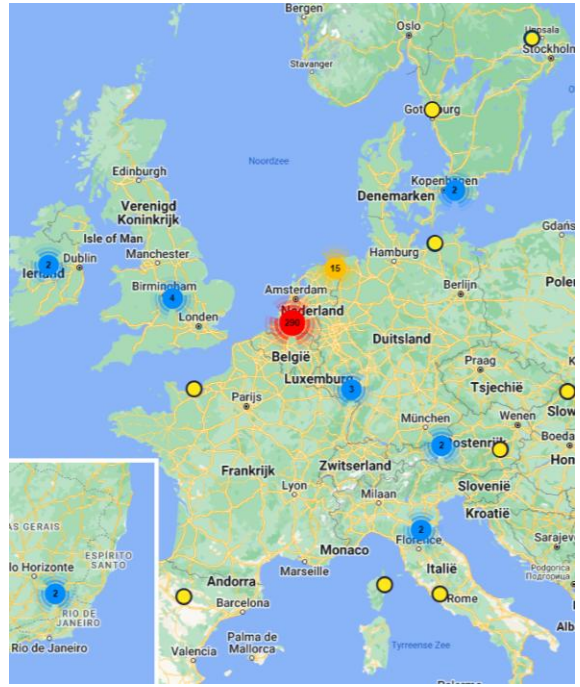
= partner
= 2+ partners
= 10+ partners
= 250+ partners

Regional



National

International



Companies & Network

Education & Research

Governmental & Funding

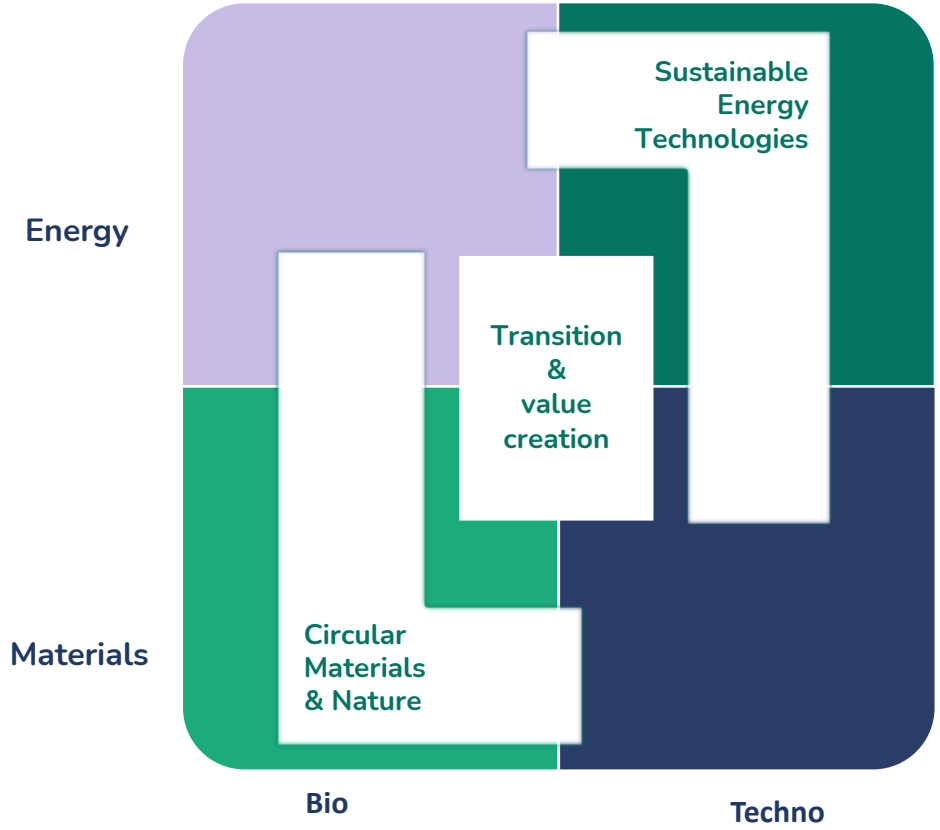
MNEXT – Material & Energy Transition

Applied research and education in collaboration with the professional field with the aim of realizing solutions for issues within the following **3 themes**:

1. SUSTAINABLE ENERGY TECHNOLOGIES
   Supply, storage, distribution and end use

2. CIRCULAR MATERIALS & NATURE
   Responsibility in design, production, use & recovery

3. TRANSITION & VALUE CREATION
   Scaling up of technology and business case, for the benefit of economy & society



FUTURE RETHINKERS

RESEARCH GROUPS MNEXT

ENERGY

MATERIALS

RENEWABLE ENERGY CARRIERS

SMART ENERGY

BIOBASED RESOURCES & ENERGY

BIOBASED TRANSITIONS

BIOBASED BUILDING BLOCKS & PRODUCTS

BIOBASED BUILDING

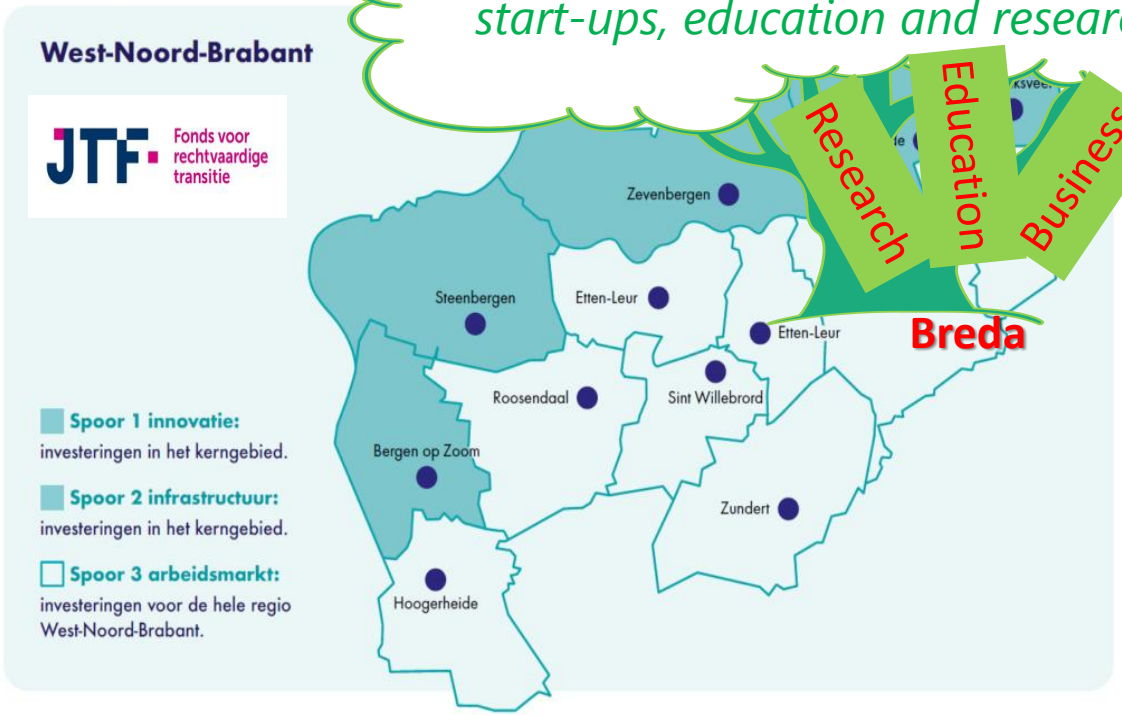
MARINE BIOBASED CHEMISTRY

avans hogeschool

UNIVERSITY OF APPLIED SCIENCES

Research Focus: Chemical recycling of solid residual streams using pyrolysis and solvolysis technology

Establish a chemical recycling hub for innovation and education (with industries, start-ups, education and research institutes)



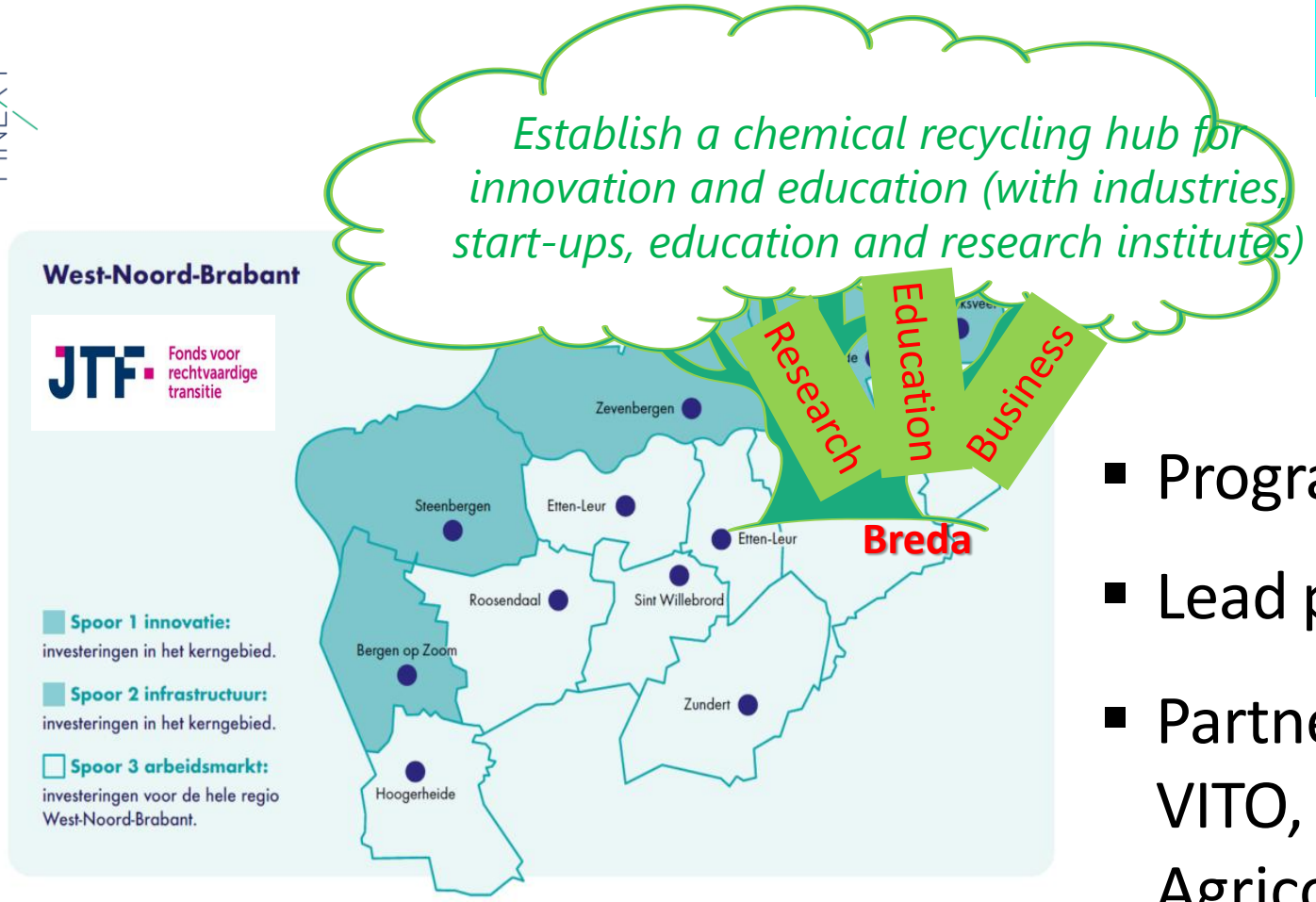
Research

Education

Business

- ***Chemical recycling Process development and optimization***
- ***Pyrolysis liquid upgrading and application.***
- ***Pyrolysis char modification and application.***
- ***Process simulation and Techno-economical analysis***

C-RECYCLE – an introduction



- Program: Just Transition Fund (JTF)
- Lead partner: Avans - MNEXT
- Partners: Corsair Europe, Tue, RUAS, VITO, GCC, Teqtix Phenolic Solutions, Agricon Nederland, NPSP
- Runtime: 1 June 2024 – 31 July 2026
- Budget total: € 3.494.290,85

Main Objective

- To support the training of the new and existing labor force that is needed for the transition of the linear chemical industry towards a circular chemical industry in West-Noord-Brabant
- With a focus on the chemical recycling of plastics for use in a wide range of high-value products.
- These products include not only energy derivatives such as fuels but also versatile building blocks for new polymer synthesis, advanced materials (like graphene), and hydrogen (H_2).

Sub-goals

- Facilitate innovation in chemical recycling
- Share knowledge and experiences
- Update and expand the curriculum on chemical recycling
- Provide On the Job Training

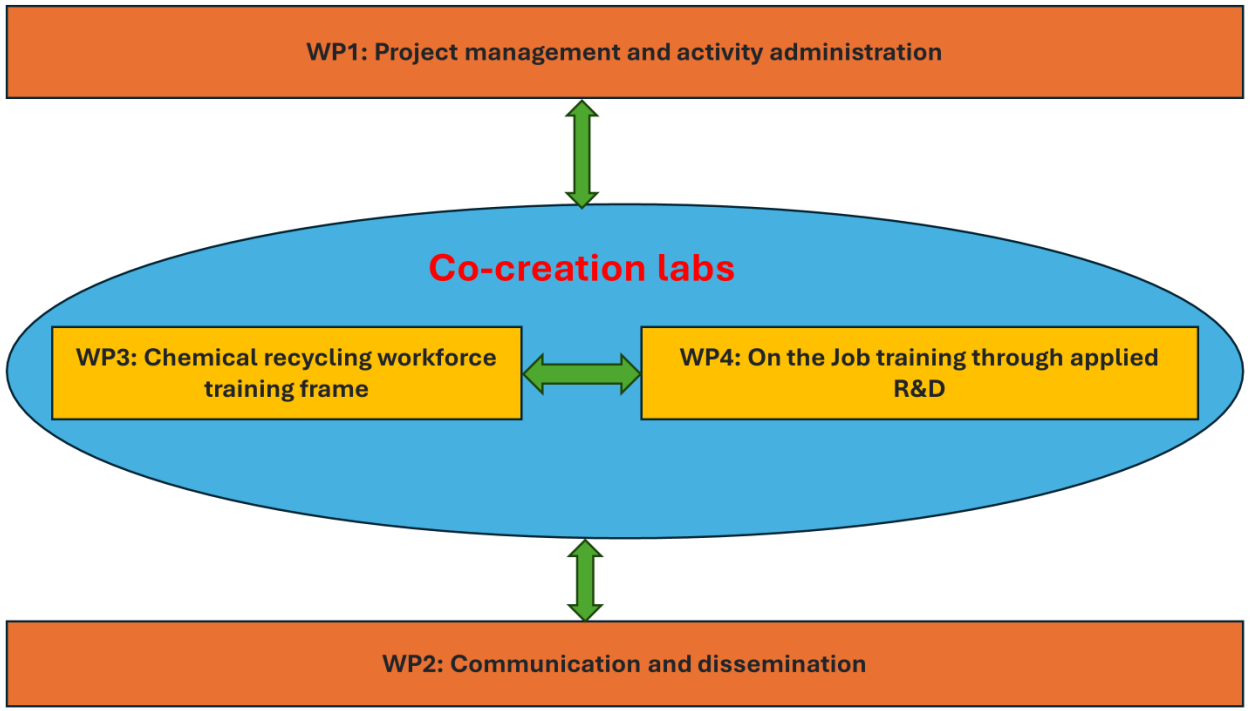
Project activities

WP1: Project management and activity administration

WP2: Communication and dissemination

WP3: Chemical recycling workforce training frame

WP4: On the Job training through applied R&D



Co-creation labs

- Avans: research & education on lab scale and business support
- GCC: pilot scale facilities for research, education & Lifelong learning

C-RECYCLE – Trainings

- **1. Mechanische recycling / Pretreatment (NPSP @willem bottger/@aditya.babu@npsp.nl en MNEXT @q.zhou1@avans.nl)**
- Locatie & datum: NPSP (Delft) | donderdagmiddag 26 februari 2026 | 14:00 tot 17:00 uur
- Tijdens deze middag ga je in op de voorbehandeling van materialen en de kernprincipes van mechanische recycling. Je leert welke stappen nodig zijn om materialen geschikt te maken voor hoogwaardige herverwerking, en welke technische en praktische keuzes hierbij een rol spelen.

- **2. Solvolyse (Vito @Sandra Corderí Gándara en MNEXT @Qian Zhou)**
- Locatie & datum: VITO (Mol) | donderdagmiddag 12 maart 2026 | 14:00 tot 17:00 uur
- Deze training behandelt solvolyse als techniek binnen chemische recycling: hoe werkt het proces, welke typen kunststofstromen zijn geschikt, en wat zijn voor- en nadelen ten opzichte van andere routes? Je krijgt inzicht in praktijkcases en onderzoeksresultaten.

- **3. Pyrolyse (GCC @Kathalijne Kollen | Green Chemistry Campus, TU/e @M.v.SintAnnaland@tue.nl/@Yang Liu, MNEXT @Chenyu Zhou, Agricon @eric@agriconnederland.nl en Corsair @onno@corsairnow.com)**
- Locatie & datum: GCC (Bergen op Zoom) | donderdagmiddag 26 maart 2026 | 14:00 tot 17:00 uur
- Je maakt kennis met pyrolyse als route om complexe kunststofstromen om te zetten naar olie- of gasachtige producten. We bespreken opstelling, procescondities, opbrengsten en toepassingen, aangevuld met een passend praktijkvoorbeeld.

- **4. LCA & Circular Business Models (BWNO @Marleen Janssen Groesbeek en MNEXT @Alexander Compeer)**
- Locatie & datum: MNEXT (Breda) | dinsdagmiddag 14 april 2026 | 14:00 tot 17:00 uur
- In deze training leggen we de koppeling tussen technologie en business. Je leert hoe je met ‘Life Cycle Assessment’ (LCA) milieu-impact in kaart brengt en hoe je circulaire businessmodellen ontwikkelt rond recyclinginstallaties en -diensten.

Agricon Nederland

C-Recycle

Plastic Waste Management in the Netherlands

Eric Petersen
Director | Cradle-to-Cradle & waste recycling expert

C-Recycle

Plastic Waste Management in the Netherlands

Medegefinancierd door de Europese Unie

Het project C-Recycle heeft een totaalbudget van €3,5 miljoen en wordt medegefinancierd door de Europese Unie, het ministerie van Economische Zaken en Klimaat, het ministerie van Sociale Zaken en Werkgelegenheid, uit het Just Transition Fund.

A

Circular Economy - Waste

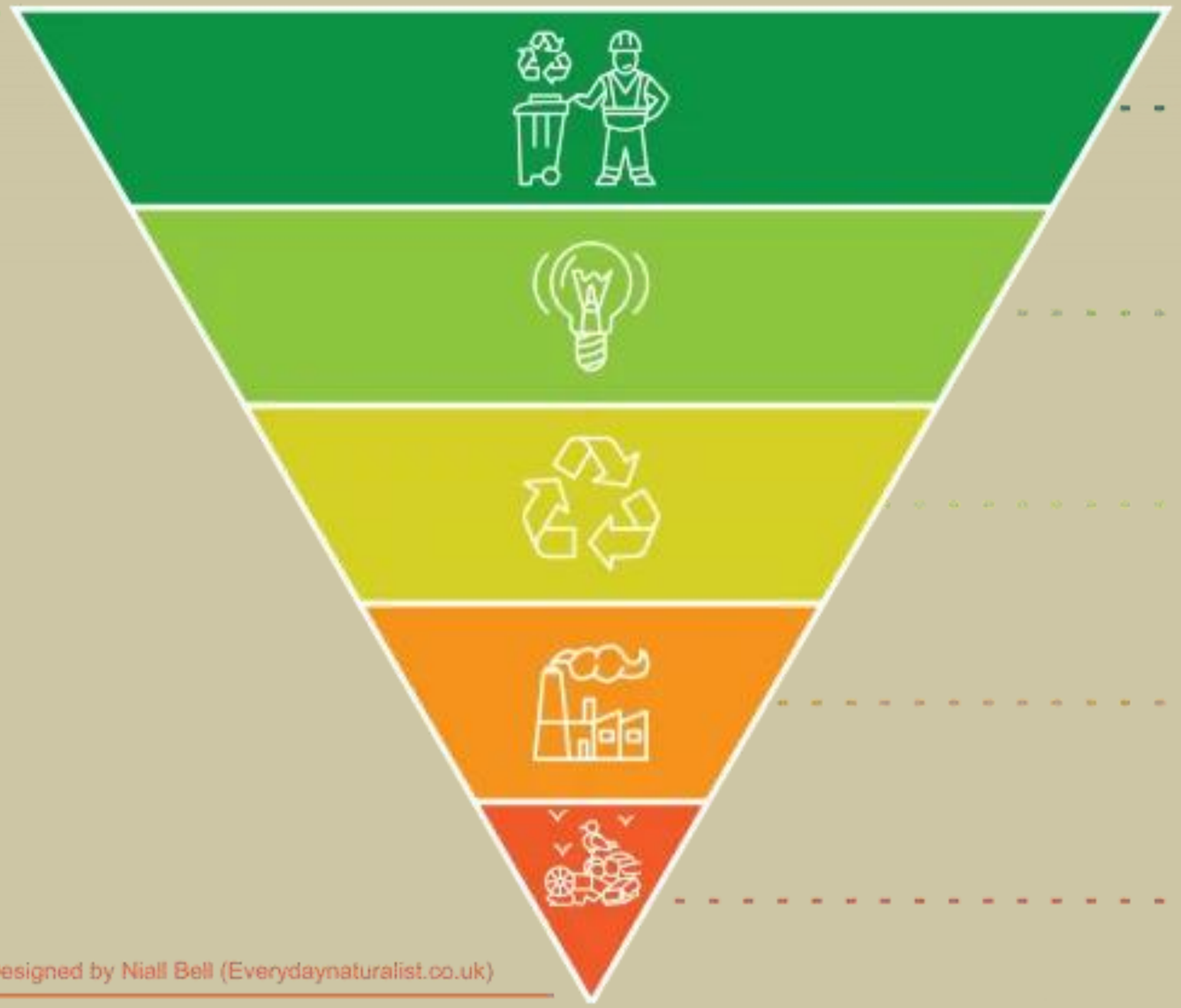
Waste management |
Today’s waste is tomorrow’s raw material

We help companies by offering services in the field of disposal and processing waste streams in the Netherlands and Belgium. We always try to maximize reusability and recycling of waste.

- Consultancy in waste management
- Inventory, analyze and optimize current waste streams
- Closed and Open loop solutions
- Intelligent Material Pooling - know where and when to pool materials.
- Material passports

Most Desirable

Least Desirable



Reduce

Using less material in design & manufacture. Keeping products for longer. Reducing consumerism.

Re-use

Checking, cleaning, repairing, refurbishing, repair, whole items or spare parts.

Recycle

Turning waste into a new substance or product including composting if it meets quality protocols.

Recover

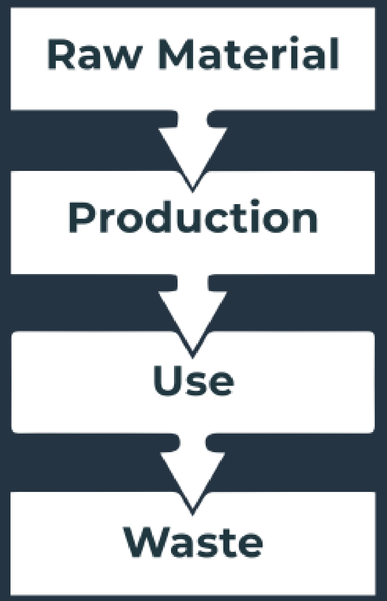
Including anaerobic digestion, incineration with energy recovery, gasification and pyrolysis.

Landfill

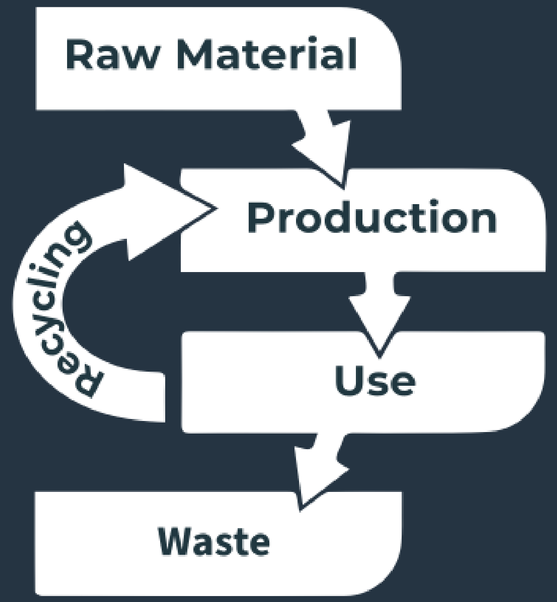
Disposal in landfill. Also incineration of waste without energy recovery.

Designed by Niall Bell (Everydaynaturalist.co.uk)

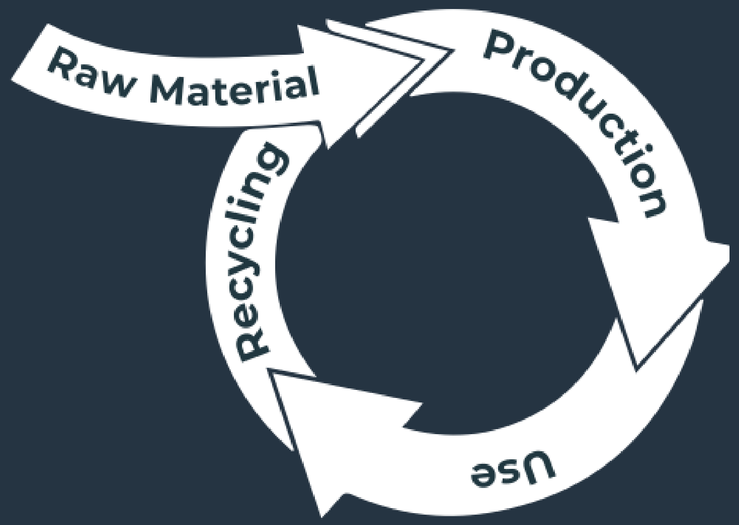
Linear economy



Reuse economy



Circular economy



We cannot do without plastics !

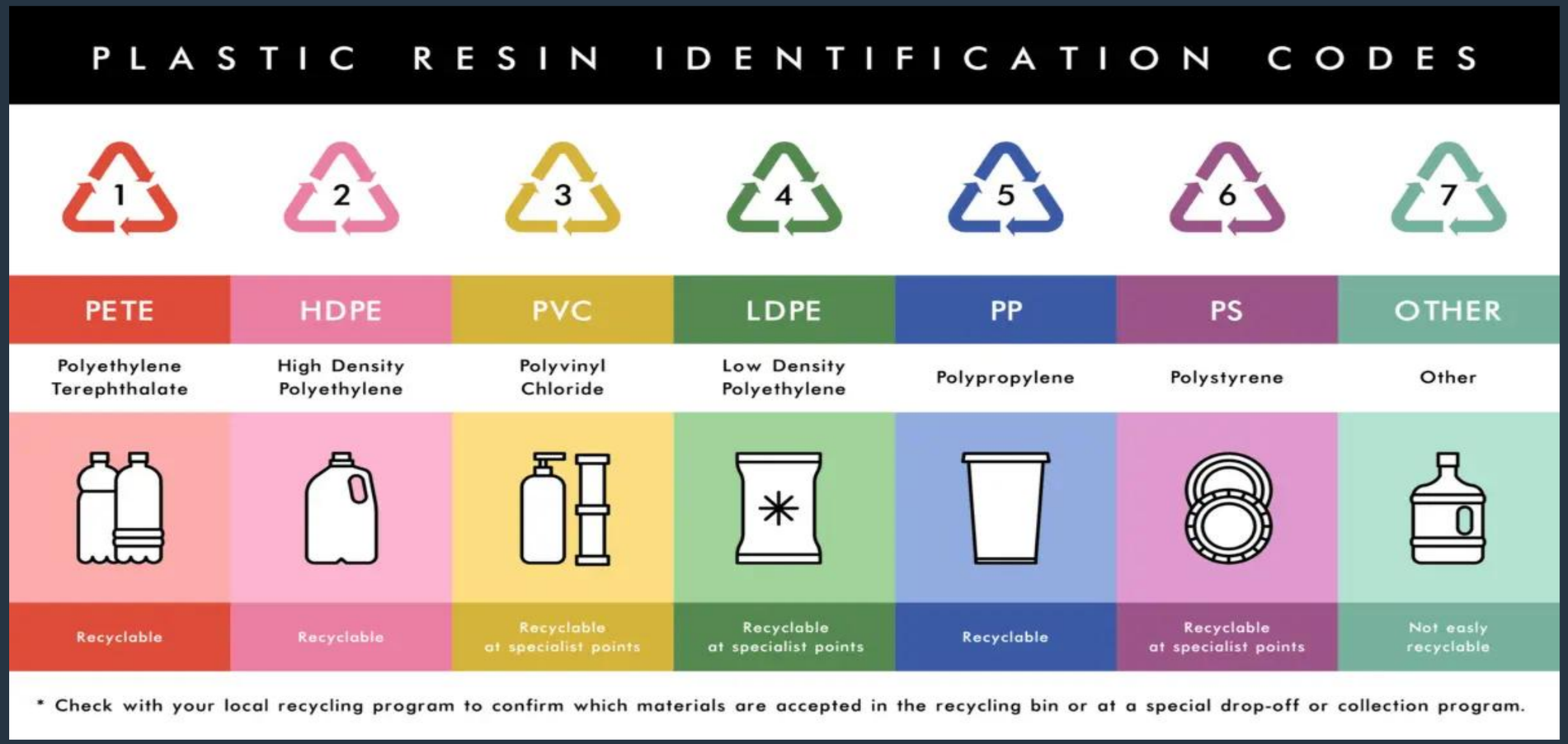
Production and use

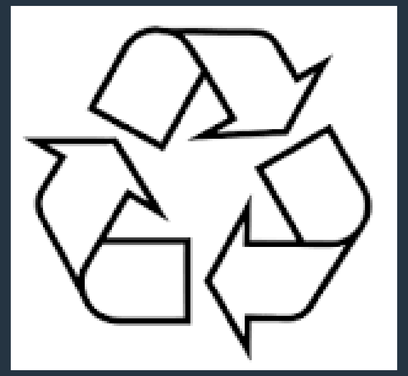
End off life collection

Household & Companys

Collection and sorting

Sorting Recycling technology





Recycling solutions

Mechanical
Chemical
Energy recovery
Landfill

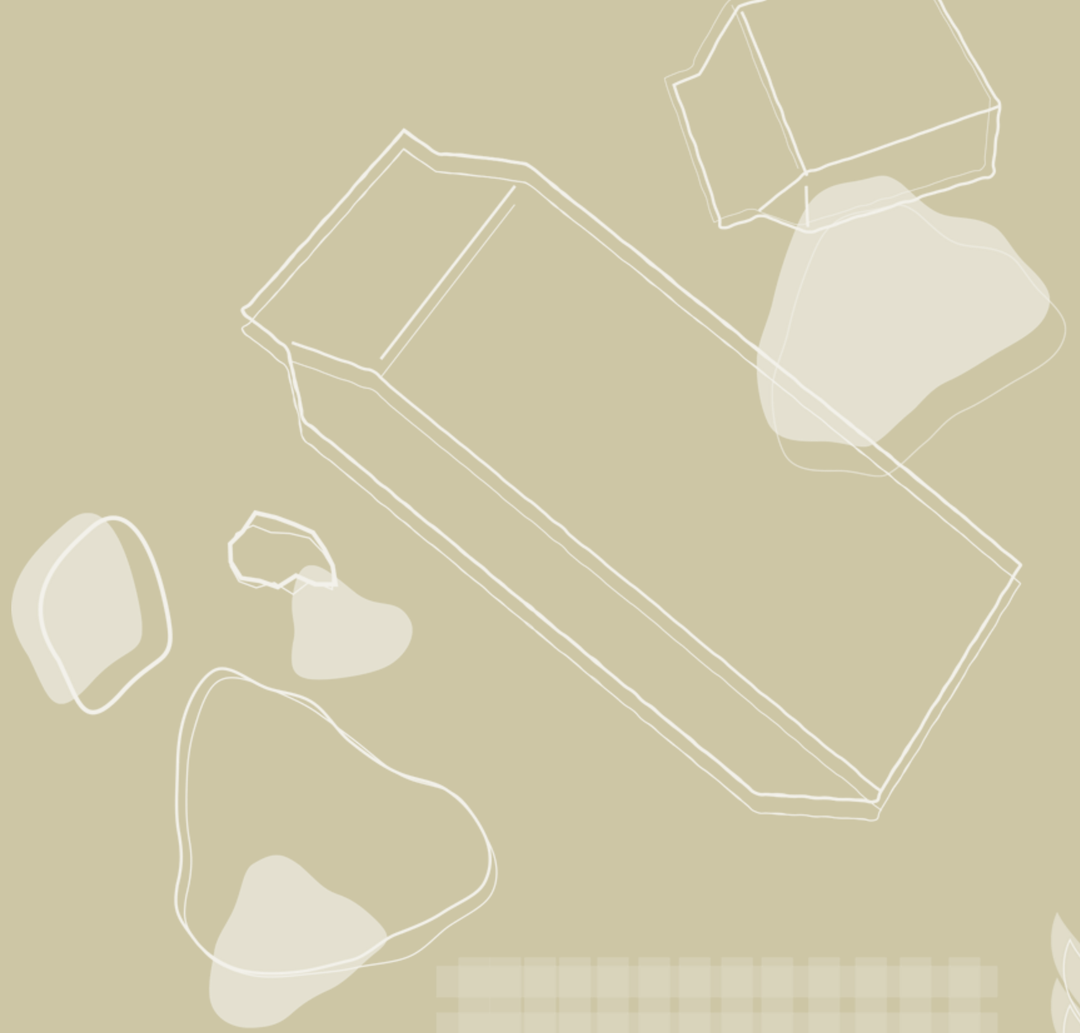
- Waste legislation and regulations
- European Waste Framework Directive (Kaderrichtlijn afvalstoffen)
- Waste Shipment Regulation (EVOA - Europese Verordening Overbrenging Afvalstoffen)
- Diwass may 2026
- CMP Circulaire materiaal Plan 30 dec 2025

Raw Materials

Raw material | The goal is to convert waste into new raw material streams for open and closed loop solutions.

In an open loop solution the waste is converted into a raw material and used for other purposes than the original product. And in a closed loop solution the waste is converted / recycled in to the original product.

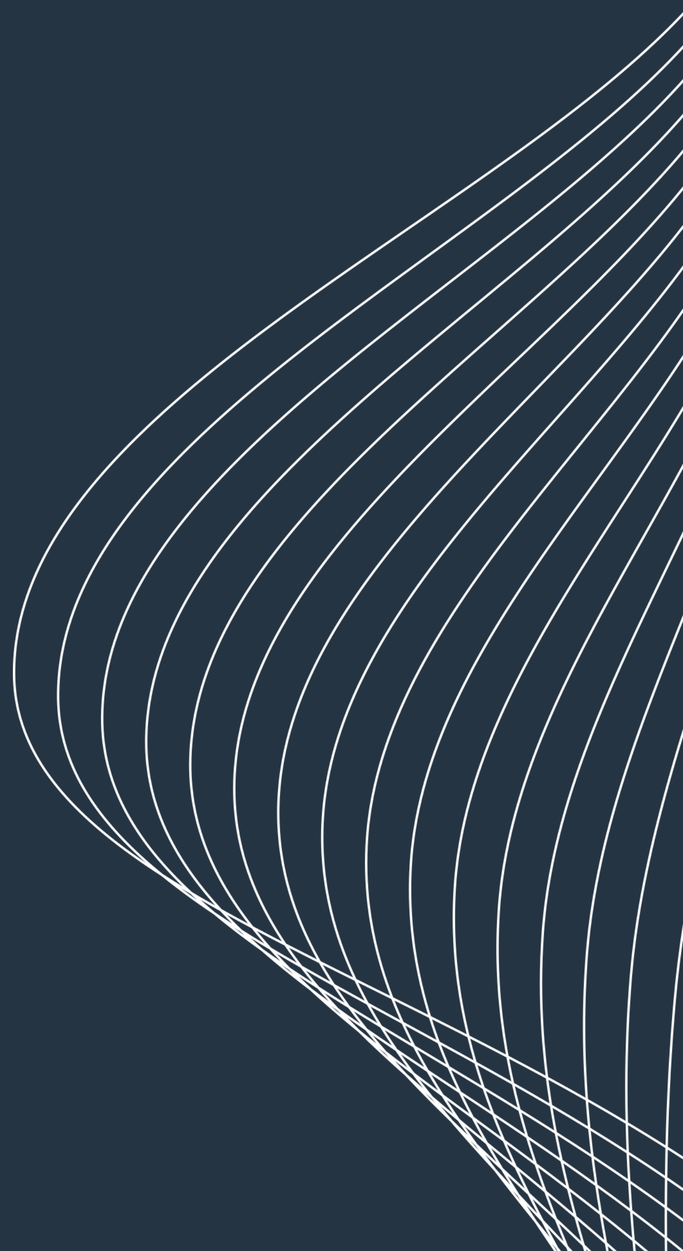
Example: From rope to rope.



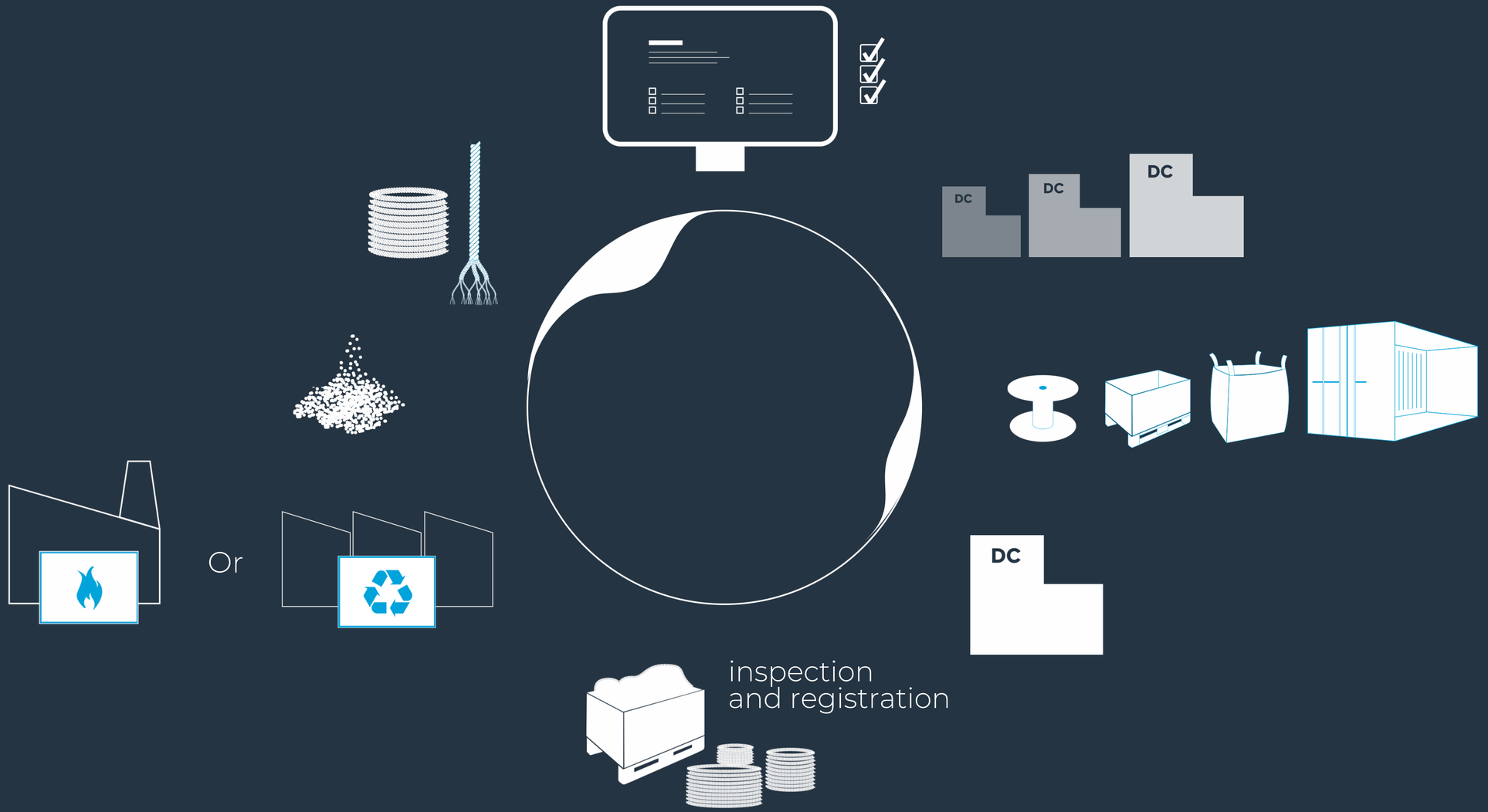
A to Z solution— Hendrik Veder Group

Hendrik Veder Group

The Force of Smart Connection

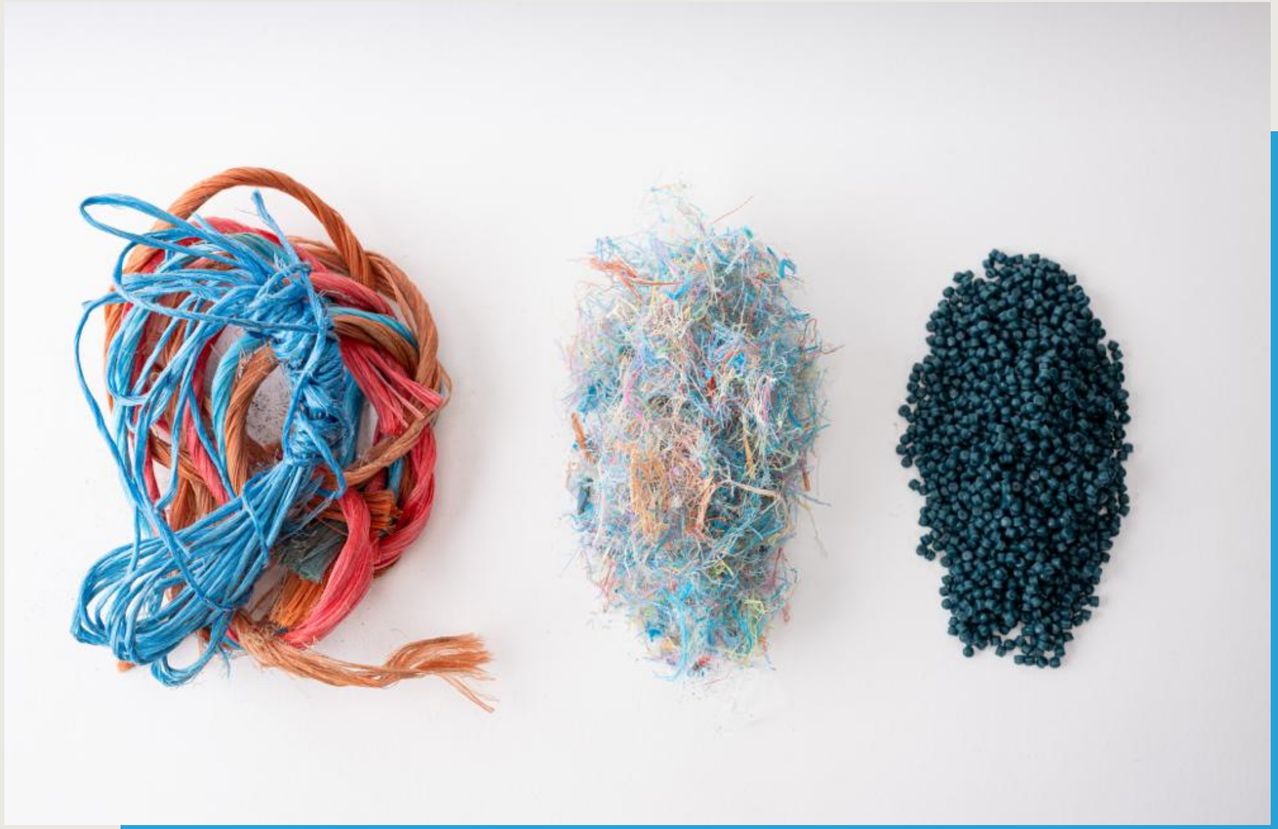


Take back system — Hendrik Veder Group



One rope, many lifelines — Hendrik Veder Group

Blue label Ropes



One rope, many lifelines

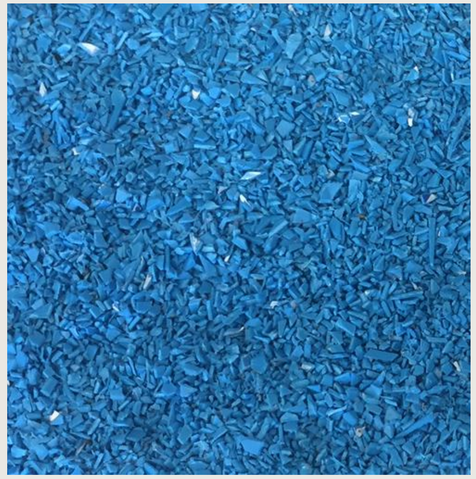
One rope, many lifelines — Hendrik Veder Group

Blue label Ropes

Design for recycling

Reuse - Recycling

Example recycling — supermarket baskets



Supermarket | re-sets 3 - 7- 10- years | disassembled | divided by type of material to create value | recycled | raw material |

Plastic recycling almost bankrupts ?

C-Recycle

Transformation of the chemical industry towards a circular future

Medegefinancierd door de Europese Unie

Het project C-Recycle heeft een totaalbudget van €3,5 miljoen en wordt medegefinancierd door de Europese Unie, het ministerie van Economische Zaken en Klimaat, het ministerie van Sociale Zaken en Werkgelegenheid, uit het Just Transition Fund.

Inteligent material pooling — banknotes

Medegefinancierd door de Europese Unie

Het project C-Recycle heeft een totaalbudget van €3,5 miljoen en wordt medegefinancierd door de Europese Unie, het ministerie van Economische Zaken en Klimaat, het ministerie van Sociale Zaken en Werkgelegenheid, uit het Just Transition Fund.

?

Waste or raw material - Agricon Nederland

Agricon Nederland

Is it waste? | | or raw material?

Nabasco®

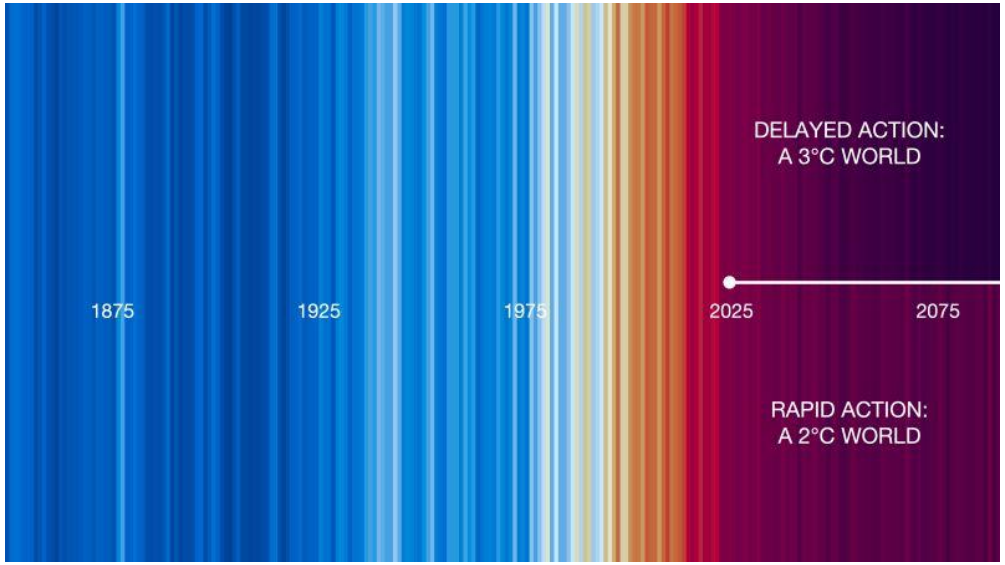
Architectural Biobased Facades

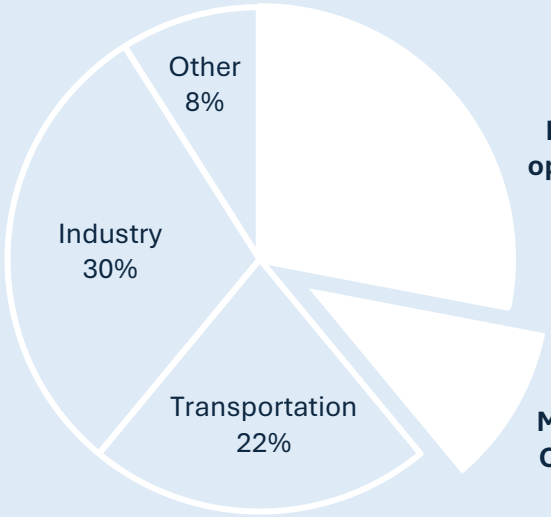
Proven. Sustainable. Beautiful.

npsp nabasco

PROBLEM: GLOBAL WARMING

3.2% of all CO_2 emissions worldwide caused by material in facades





Building operations 28%

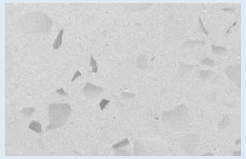
Building Materials and Construction 12%

40% of total CO_2 emissions are caused by the **built environment**[1]

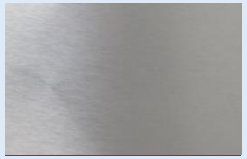
40% of this is due to the **materials used**[2]

20% of this is due to their use in **facades**[3]

Limestone 50mm
Albion EPD
15.5$kgCO_2e/m^2$



13mm GFRC
FibreC EPD
19$kgCO_2e/m^2$



1.5mm stainless
Seele EPD
22$kgCO_2e/m^2$

Brick with mortar
ICE
40.5$kgCO_2e/m^2$

3mm anodised alu
Hydro EPD
79$kgCO_2e/m^2$

150 mm precast
Techcrete EPD
86$kgCO_2e/m^2$

Ceramic tile
NKB EPD
90$kgCO_2e/m^2$

1] UN Environment and International Energy Agency (2017).
2] Life Cycle Assessment (LCA) of Building Refurbishment: A Literature Review. Energy and Buildings, 135 (2017), pp. 286–301.
3] LETI Embodied Carbon Primer. Supplementary Guidance to the Climate Emergency Design Guide; LETI: London, UK, 2020

PROBLEM: European and National legislation for built environment

Stick & Carrot

EU and National legislation is entering force steering towards low CO_2:

- Whole Life Carbon (2028) as part of EPBD
- CBAM - Carbon Border Adjustment Mechanism (2026)
- European Critical Raw Materials Act (2026)
- EU Bioeconomy Strategy (2025)
- Carbon Removal & Carbon Farming Framework

Specific demands already validated

- Products purchased by governments or semi-public companies (e.g. rail, municipalities, provinces) are **increasingly valued** at environmental impact / CO_2 (source: ProRail, Lightwell, Van Doorn Lighting)
- **Values CO_2 reduction:** Province Utrecht **875 euro/ton,** Amsterdam **418 euro/ton,** Enschede and Province of Noord-Holland **400 – 800 euro/ton**.

npsp nabasco

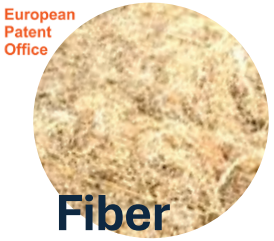
SOLUTION

Nabasco developes, manufactures and sells biobased facades that store CO_2 for a long period

INGREDIENTS

Filler

Waste drinking water
Natural pigments
Biochar



Fiber

Flax
Reed
Recycled toilet paper

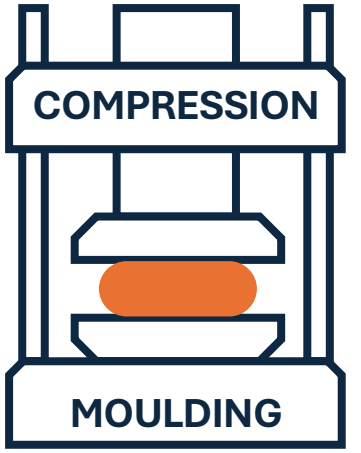
Resin

Biofuel waste
Bagasse
Bacteria sewer waste

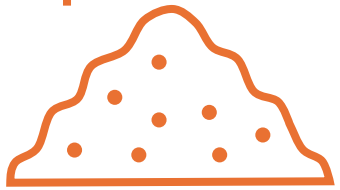
EU patented Nabasco

Mixing wastebased and biobased ingredients into dough and baking under pressure into Facade Panels

MIXING



SHREDDER



GRINDER

Recycling into fillers at EOL

PORTFOLIO: REALISED AND UNDER CONSTRUCTION SHOWING TRACTION AND GROWING IN SIZE

CLIENT
Waternet

SIZE
72 m^2

CLIENT
Business Centre Treeport

SIZE
177 m^2

CLIENT
Vink Bouw

SIZE
1270 m^2

CLIENT
Waternet

SIZE
550 m^2

CLIENT
Trudo / Hurks

SIZE
26 m^2

CLIENT
HDSR

SIZE
200 m^2

CLIENT
Prorail

SIZE
2700 m^2

CLIENT
Realdania

SIZE
273 m^2

SOLUTION

Nabasco biobased facades solve the climate change problem by storing CO_2 for a longer period and do not use critical raw materials

Facade material	CO_2 impact in kg CO_2/m^2	Presence of Critical Raw Materials
Precast Concrete	86	Can be
Aluminium sheet	79	Yes
Red brick	40,5	No
Stainless steel	22	Can be
Nabasco 8012	**13**	**No**
Nabasco 8040	**-14**	**No**

What do we do?

NPSP

MATERIALS R&D

- Universities
- Universities of Applied Science
- Research Institutes
- Raw Material Suppliers

PRODUCT DEVELOPMENT

- Design Agencies
- Production Companies

PILOTS & PROJECTS

- Launching Customers
- Project clients & architects

- Enable and drive the material transition to bio-composites
- Strive for maximum circularity in the composition and use of bio-composite materials and products
- Research on product properties like mechanics, fire, life-time, sustainability, price

Nabasco Products

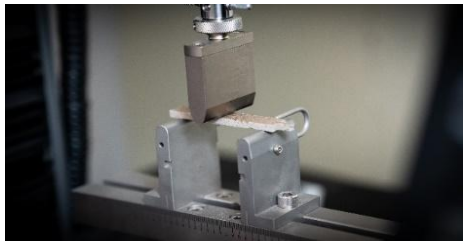
SERIAL PRODUCTS

- Distributors
- End-Clients

(various segments)

- Develop and manufacture serial products for B2B customers, including engineering, design and sustainability

NPSP Lab facilities



Testing

- Instron tensile tester
- Charpy impact tester
- Impact tester pendulum hammer according to EN 62262
- QUV accelerated weathering equipment
- Outdoor weathering test set up
- Moisture Analyzer
- Colorimeter
- Water immersion test
- Rheometer

Manufacturing

- Z-blade Kneaders: 2, 7, 100 and 150 liter
- Heated presses: 20, 100, 250, 300 tons
- Hot air ovens
- Ball mill + sieves
- Grinders and Milling equipment
- CNC equipment
- Autocad, Fusion

NPSP R&D Team

Mariam Abbas
Chemical Lab technician

Material production, testing

Sam Lonis MSc
Aerospace Engineer

FEM calculations
Coating, Electric Enclosures

Nikolo Pemaj
Junior Researcher

Material production, testing, research
Quality Control

Nina Rodenburg MSc
Industrial Designer

Facades specialist
Business Cases

Chinmayi Narasimha MSc
Industrial Designer

Fire
Biodegradation
Life Time Expectance

Aditya Babu MSc
Materials Scientist

Material Research,
Gray box modelling
End-of-Life

Willem Böttger MSc
Director Innovation

Building Physics

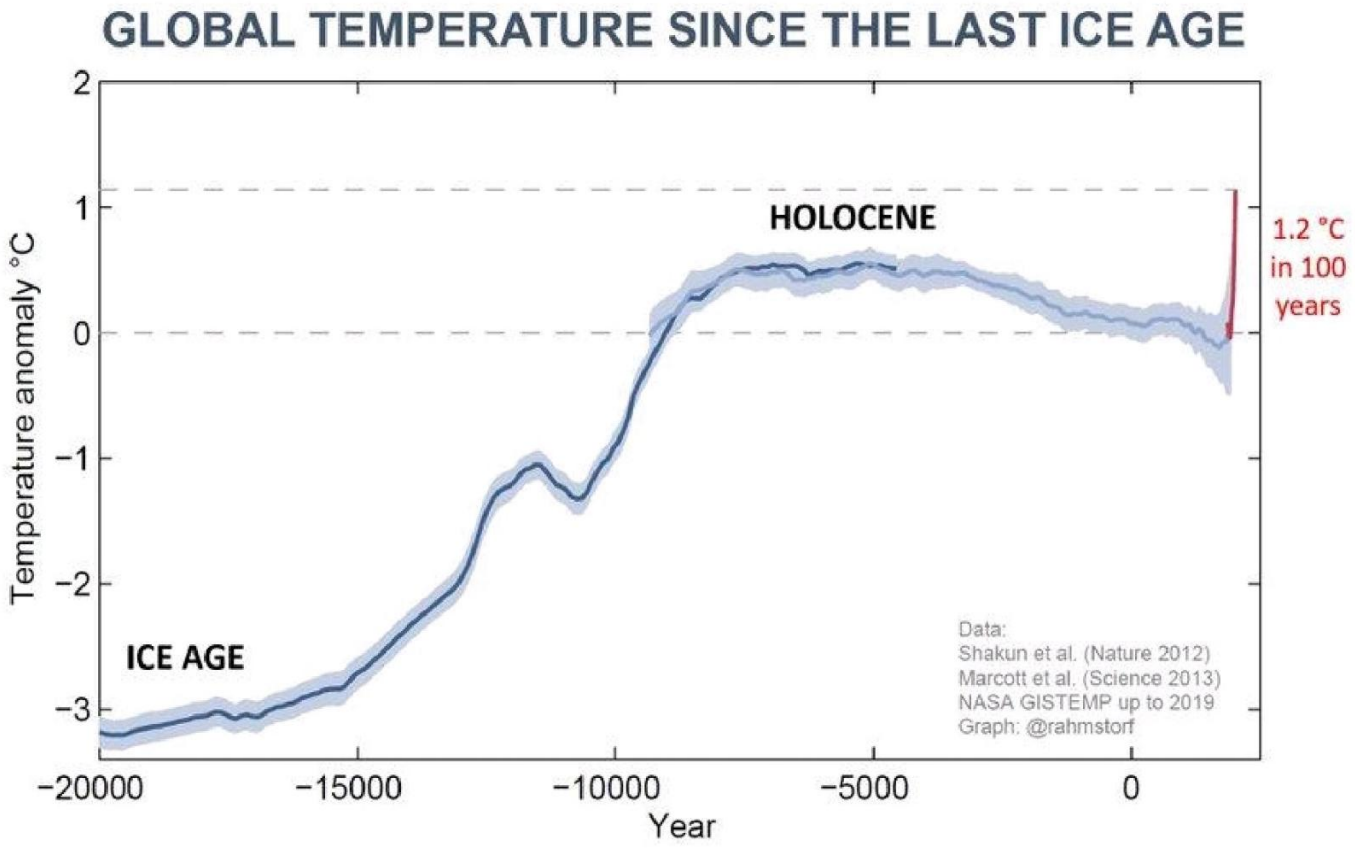
Mechanical Recycling of Thermosetting Composites

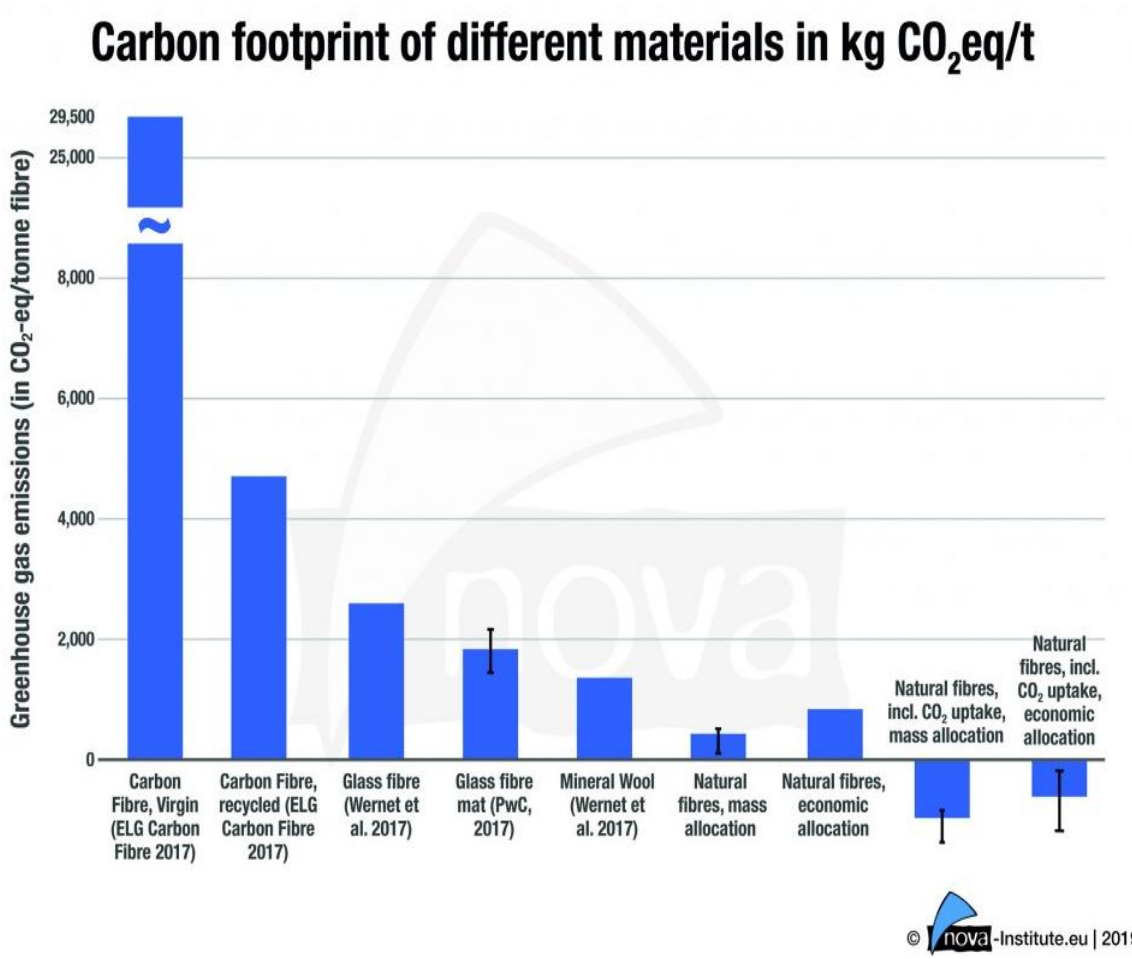
JTF Just Transition Fund

Medegefinancierd door de Europese Unie

npsp nabasco

DRIVER 1: Temperature rises due to CO2 and composites are part of this





DRIVER 2…more and more Raw Materials are getting Critical in EU

EU: 2011: 14 CRM's
2014: 21 CRM's
2017: 27 CRM's
2020: 31 CRM's

- Scarce earth materials in electronics, solar panels, energy supply, ànd built environment
- Ores from less scarce earth materials such as aluminum have an increasingly lower content -> need more energy to mine per kg

Antimony	Germanium	Phosphate rock
Bauxiet	Hafnium	Phosphorus
Baryte	Helium	Rare Earth
Berylium	Indium	Elements
Bismuth	Lithium	Scandium
Borate	Magnesium	Silicon metal
Cobalt	Natural graphite	Strontium
Coking coal	Natural rubber	Tantalum
Fluorspar	Niobium	Titaan
Gallium	PGMs	Tungsten
		Vanadium

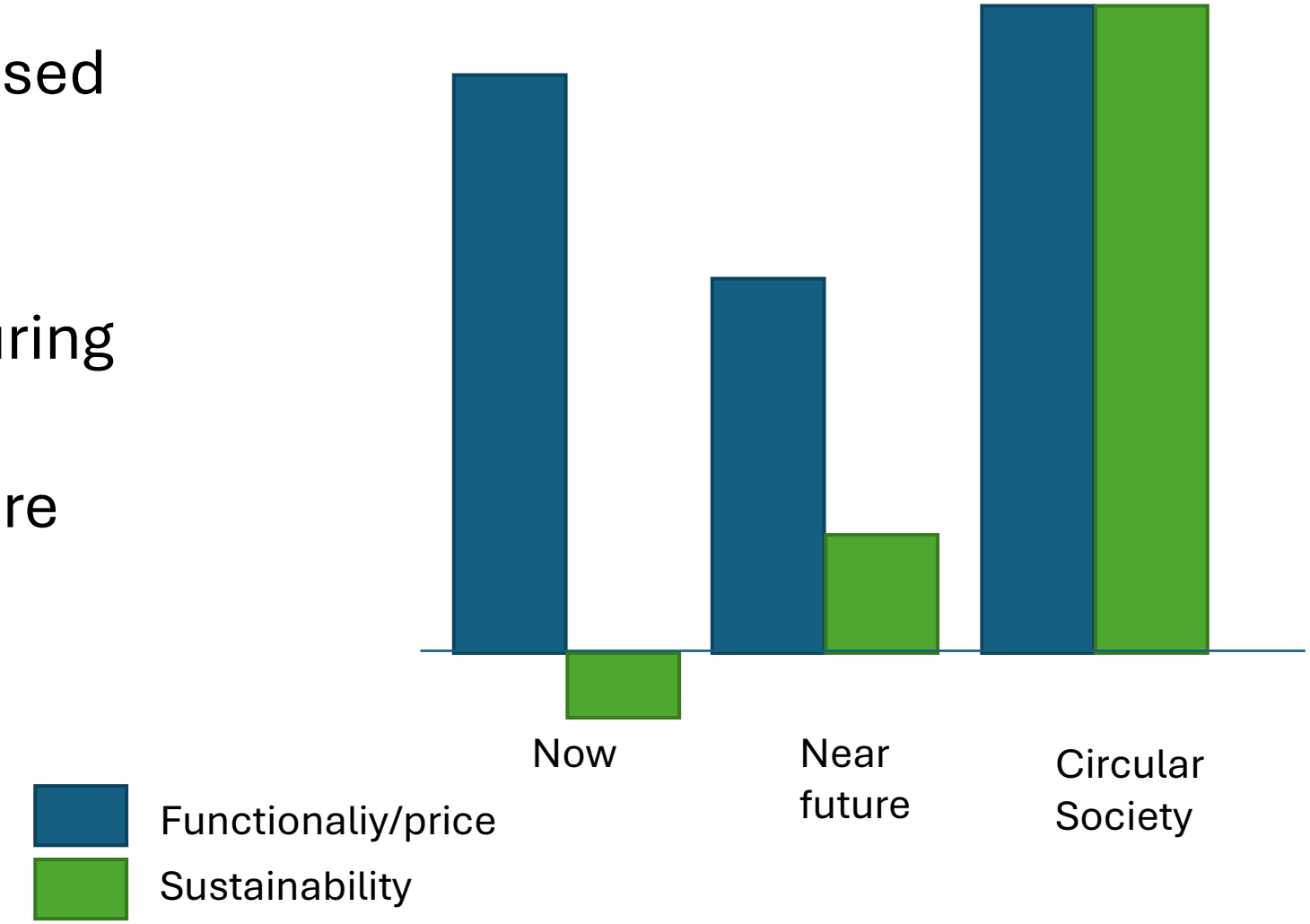
Bron: HCSS, TNO en CE Delft (2011)

… and the mixing in composites leave us with a challenge

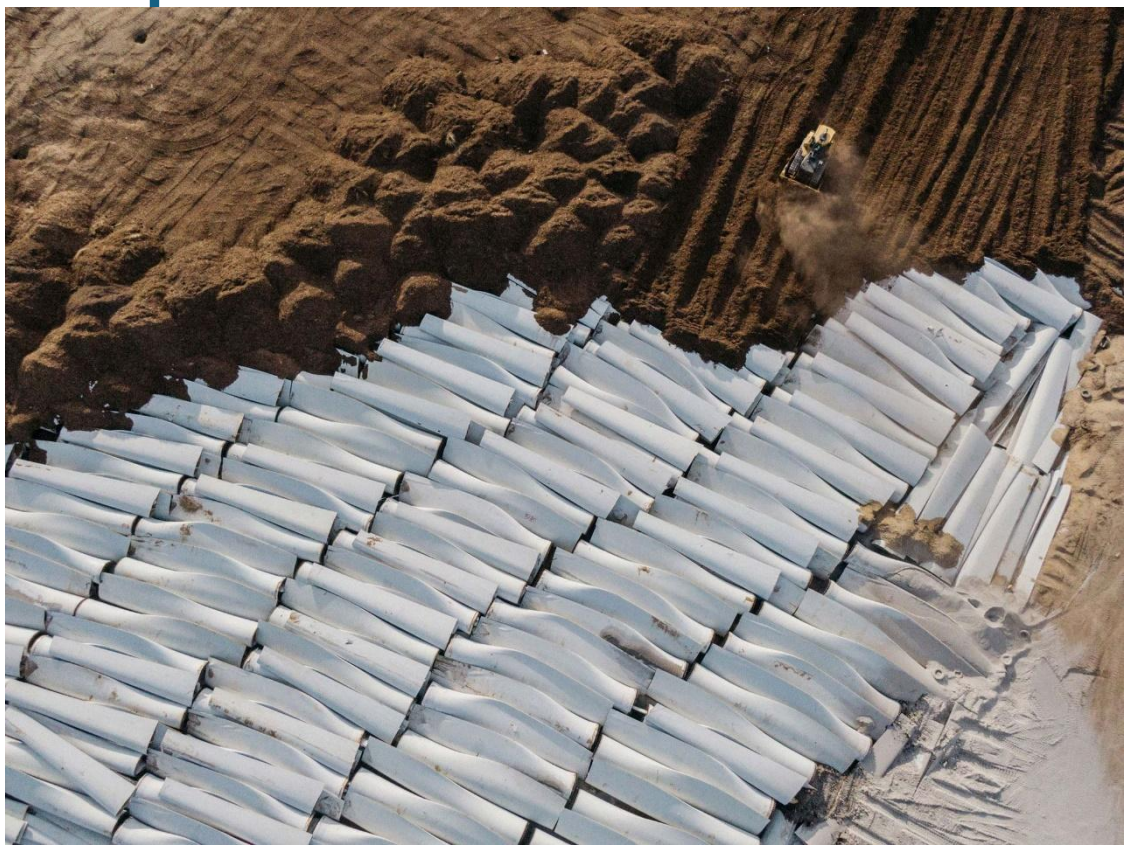
Functionality over price increased by mixing:

- Glass fiber with Borate
- Cobalt to accelerate resin curing
- Plastics with colorants, pthalates, UV blockers and fire retardants

… but can hardly be separated afterwards



DRIVER 3 And composite waste is a growing problem



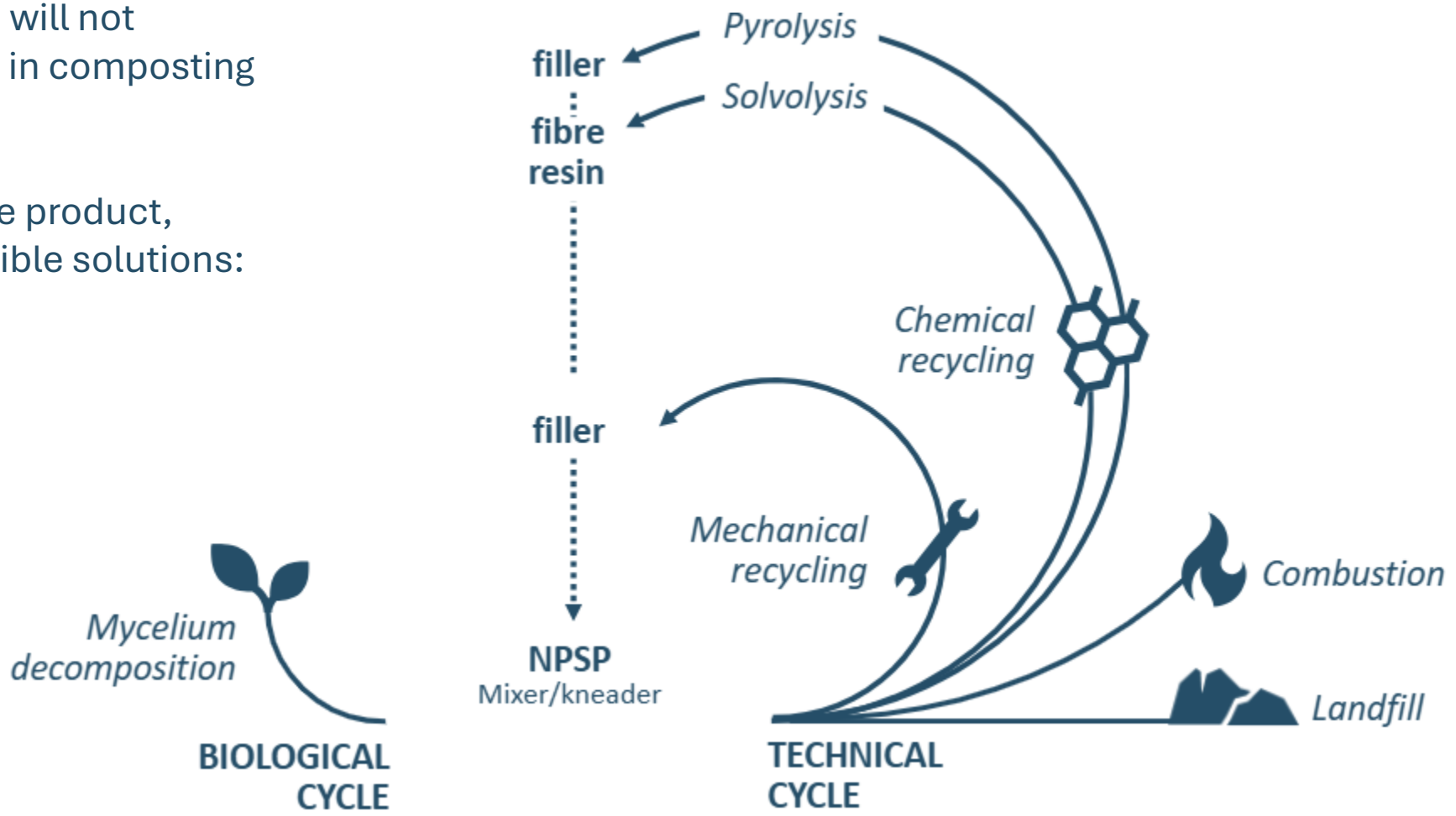
Fragments of wind turbine blades await burial at the Casper Regional Landfill in Wyoming.

“Repurposing is good, but can’t turn all turbine waste into playgrounds.”

Multiple End of Life solutions at NPSP

Durable biobased products will not degrade quick in nature nor in composting facilities.

After shredding a composite product, there are four realistic possible solutions:



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What is Mechanical Recycling?

Mechanical recycling is a physical process in which waste (composite) is reduced in size (without chemical or thermal degradation of the matrix) to produce reusable material.

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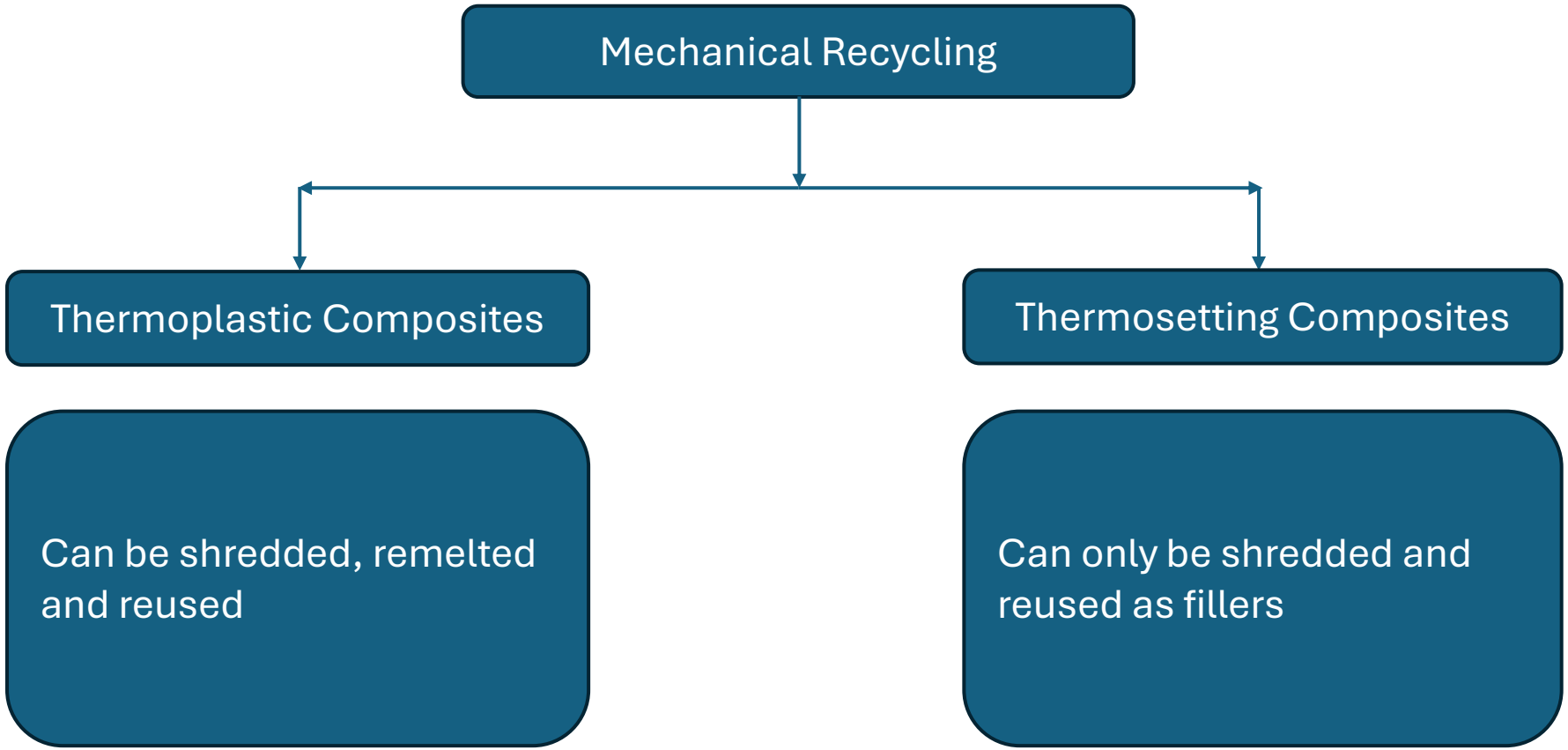
Mechanical Recycling-Thermosets vs Thermoplastics



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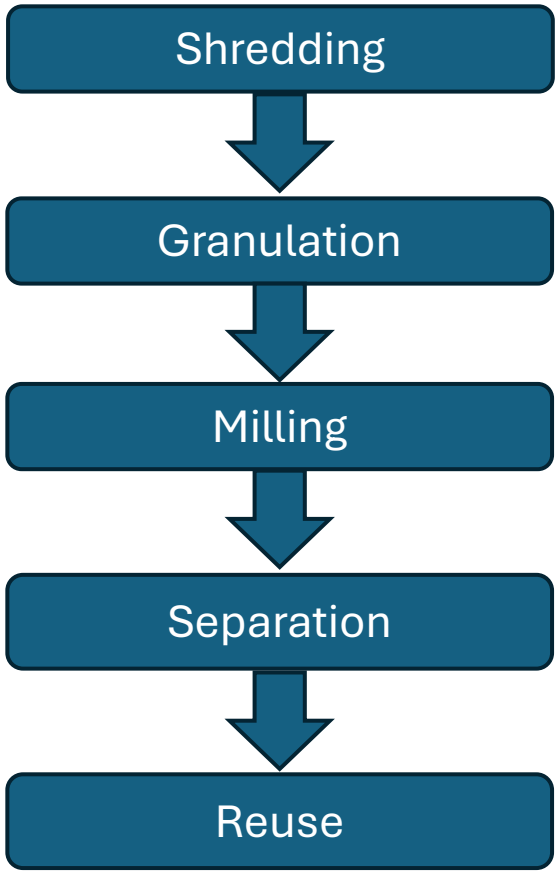
Mechanical Recycling Process



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Size Reduction of Materials

Size Reduction of Hard/Brittle Materials:

- Pressure: Jaw crushers, toggle crushers
- Impact: hammer mills, drum mills, jet impact mills
- Friction: hand mortars, disc mills

Size Reduction of Soft, Elastic, Fibrous Materials:

- Shearing: Rotary mills
- Cutting: Shredders, knife mills

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Shredding

Product

Fragments

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Granulation

Fragments

Granules (~2-4 mm)

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Milling

Granules (~2-4 mm)

Fine powder (<125 microns)

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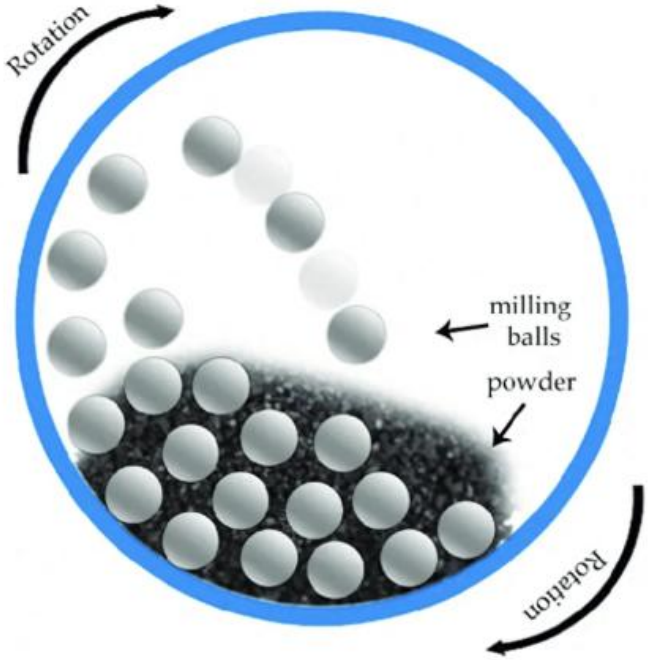
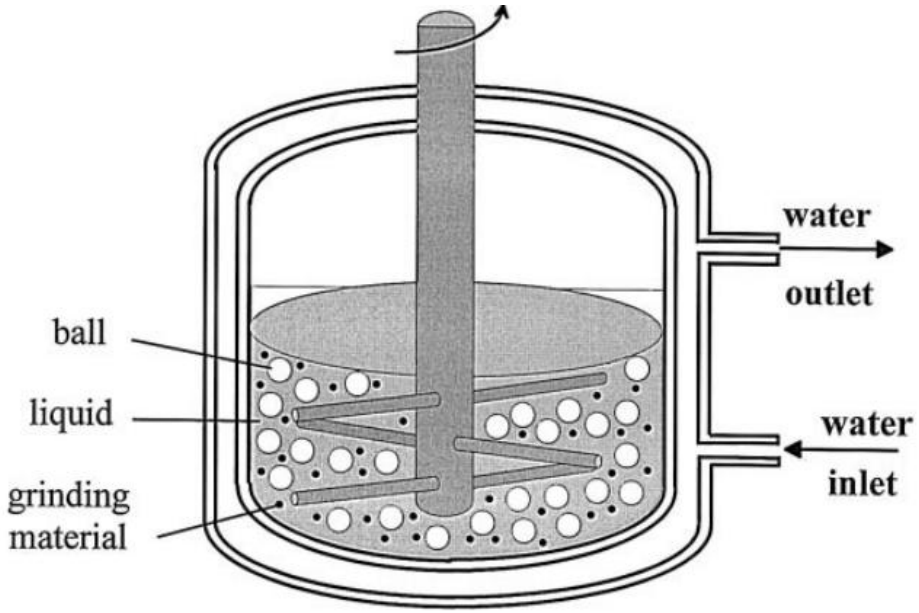
Milling Examples



Ball Milling

Rotor Milling



Attrition Milling

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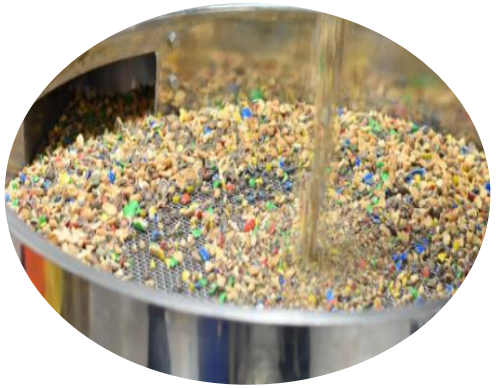
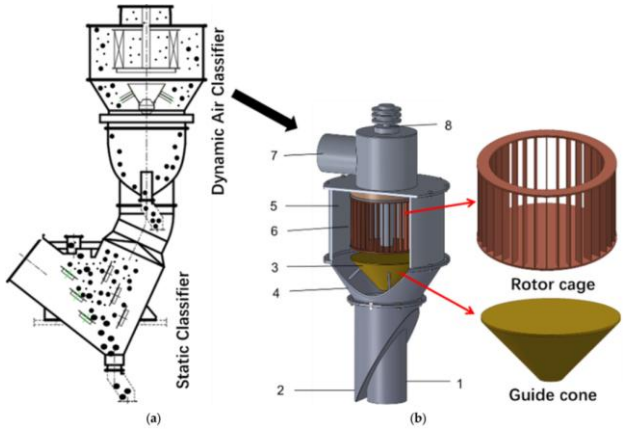
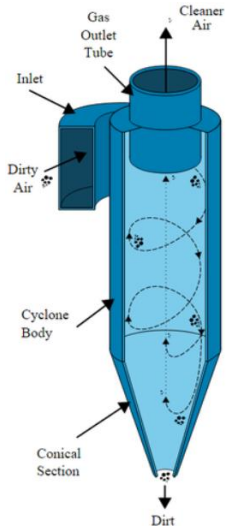
Separation



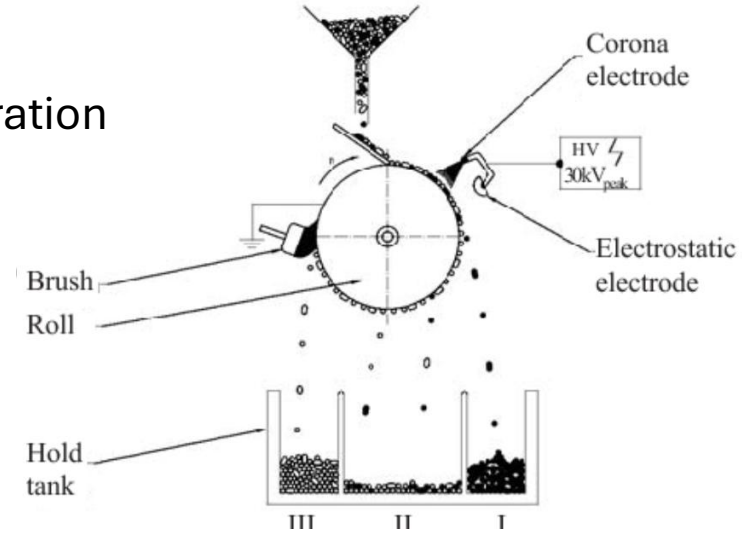
Sieving



Air Classifier



Cyclone separation



Electrostatic separation

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Challenges

- Fibre Damage and Loss of reinforcement
- Heterogenous Recycled Material
- Limited High Value Applications
- Difficult Separation of Components
- Dust and Health Concerns

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Opportunities with Mechanical Recycling

- Industrially feasible, scalable
- Less energy intensive compared to other forms of recycling
- Functional reuse instead of structural recovery
- Closed loop production scrap recycling

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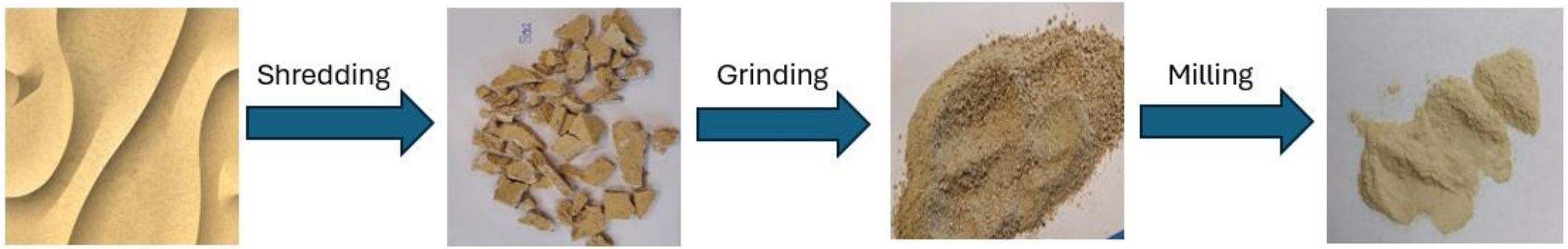
Mechanical Recycling Workflow at NPSP



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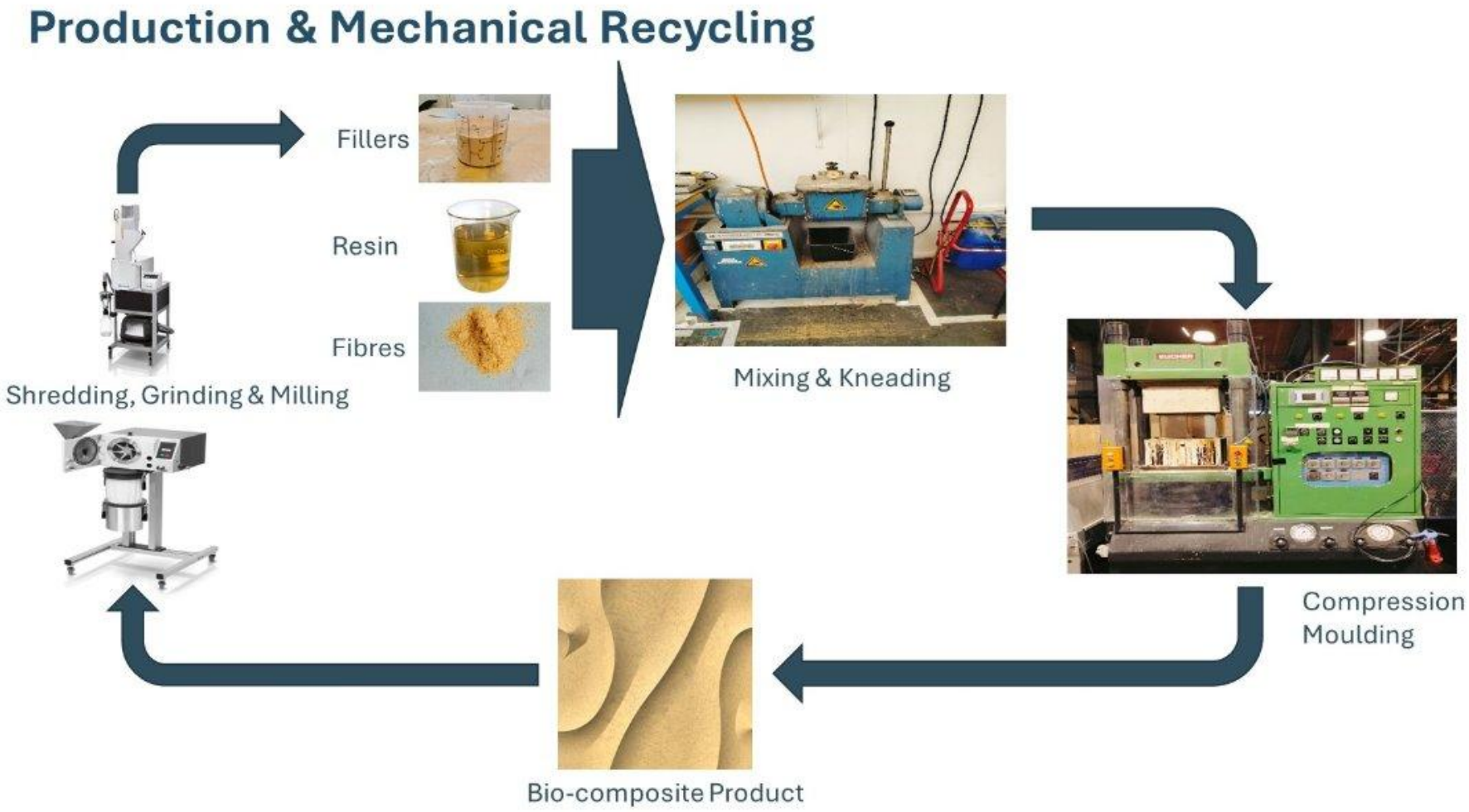
BMC Manufacturing Process with End of Life Solution



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Design of Experiments

Choice for the source of grinded fillers:

- B and C choice products (Post-industrial waste)
- Accelerated (QUV) weathered products
- Real-time/Outdoors weathered products

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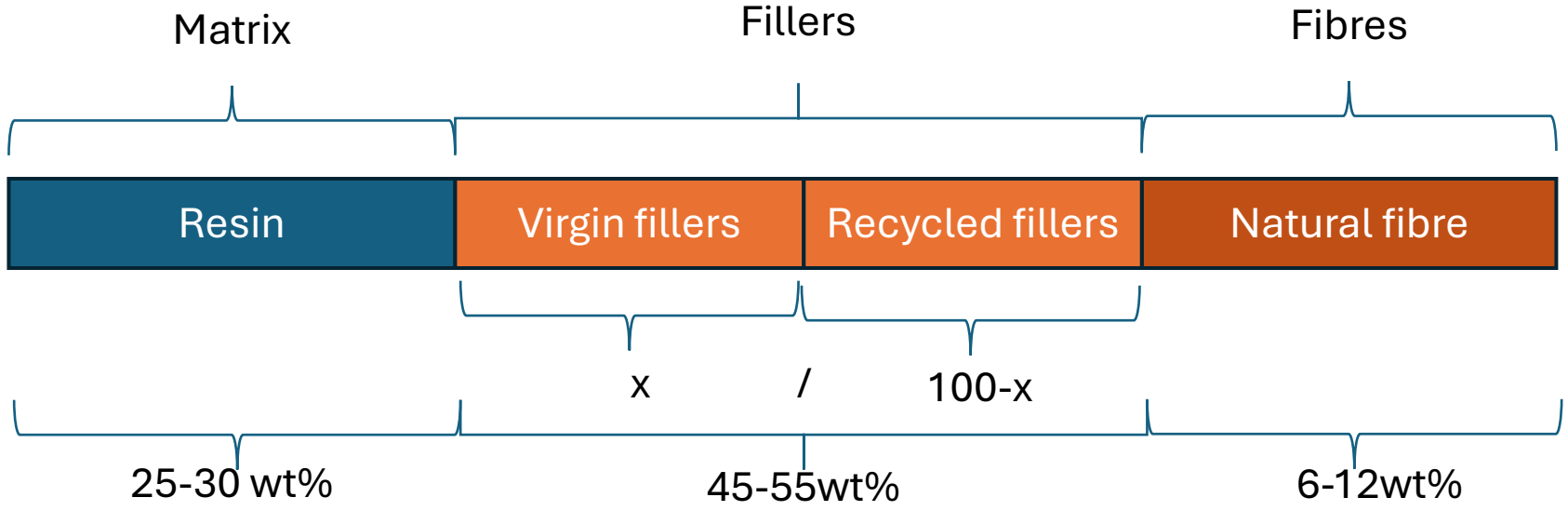
Design of Experiments



Doughs with different ratios of Virgin to recycled fillers are made and tested:

- Recycled fillers / Virgin fillers – (0/100) - Reference
- Recycled fillers / Virgin fillers – (25/75)
- Recycled fillers / Virgin fillers – (50/50)
- Recycled fillers / Virgin fillers – (75/25)
- Recycled fillers / Virgin fillers – (100/0)

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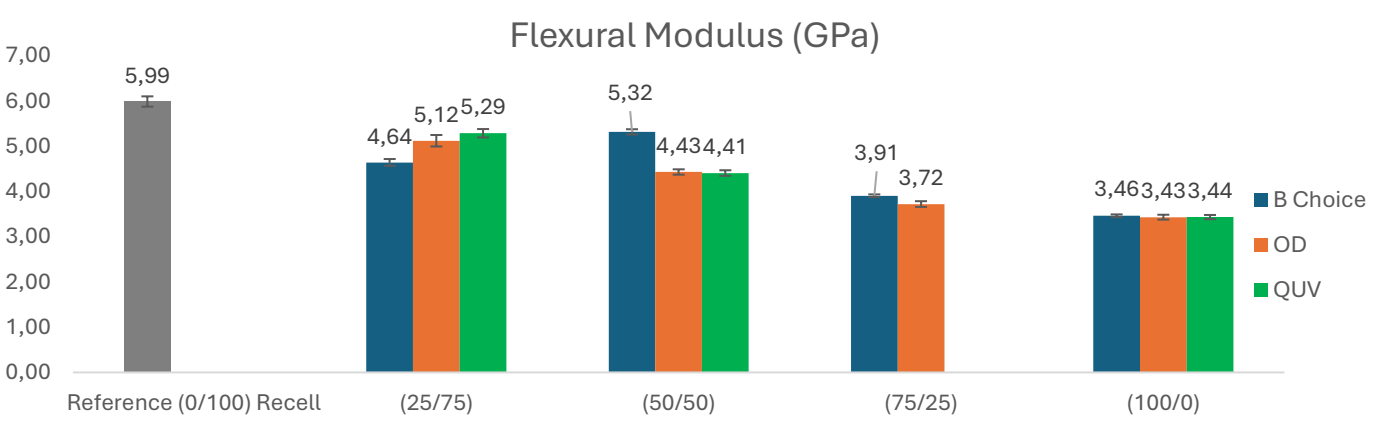
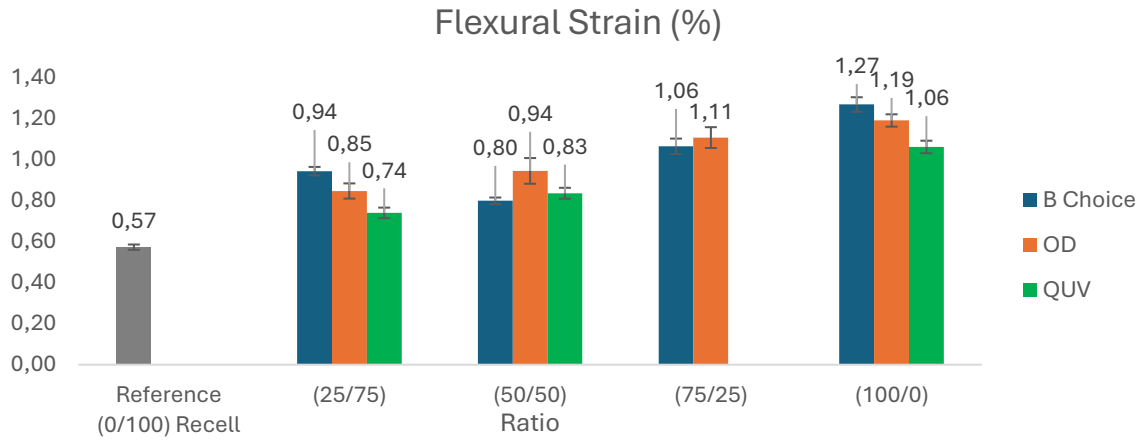
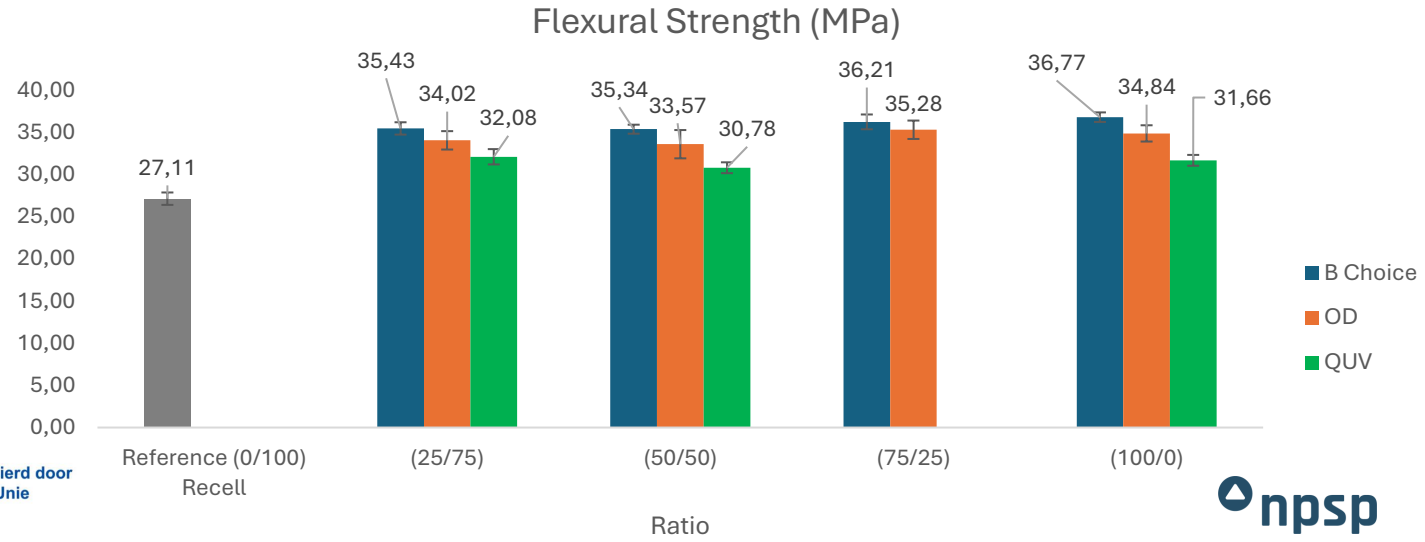
Mechanical Testing of Composites







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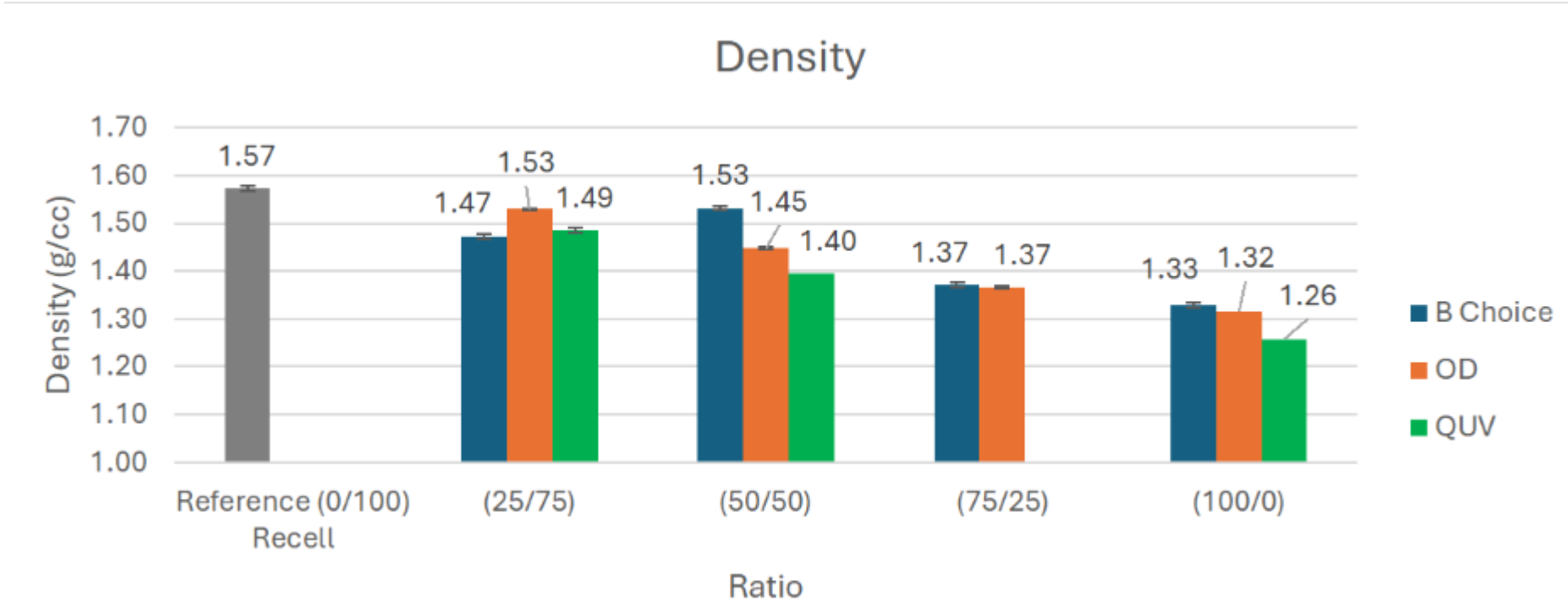
Mechanical Testing of Composites



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Conclusions

- Technically promising
- Economic environmental analysis has to be studied (transportation, value of recycled materials, energy consumption)

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THANK YOU!