Plastics in the Circular Economy

Jan Jager

NHL STENDEN hogeschool

NHL Stenden University of Applied Sciences

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Professorship Sustainable Plastics
Emmen (0,6 fte)

Professorship Circular Plastics
Leeuwarden (0,2 fte)

CIV DC Tech (Drenthe College)
Secondary Vocational Education
Sustainable Chemical Technology
Emmen (0,2 fte)

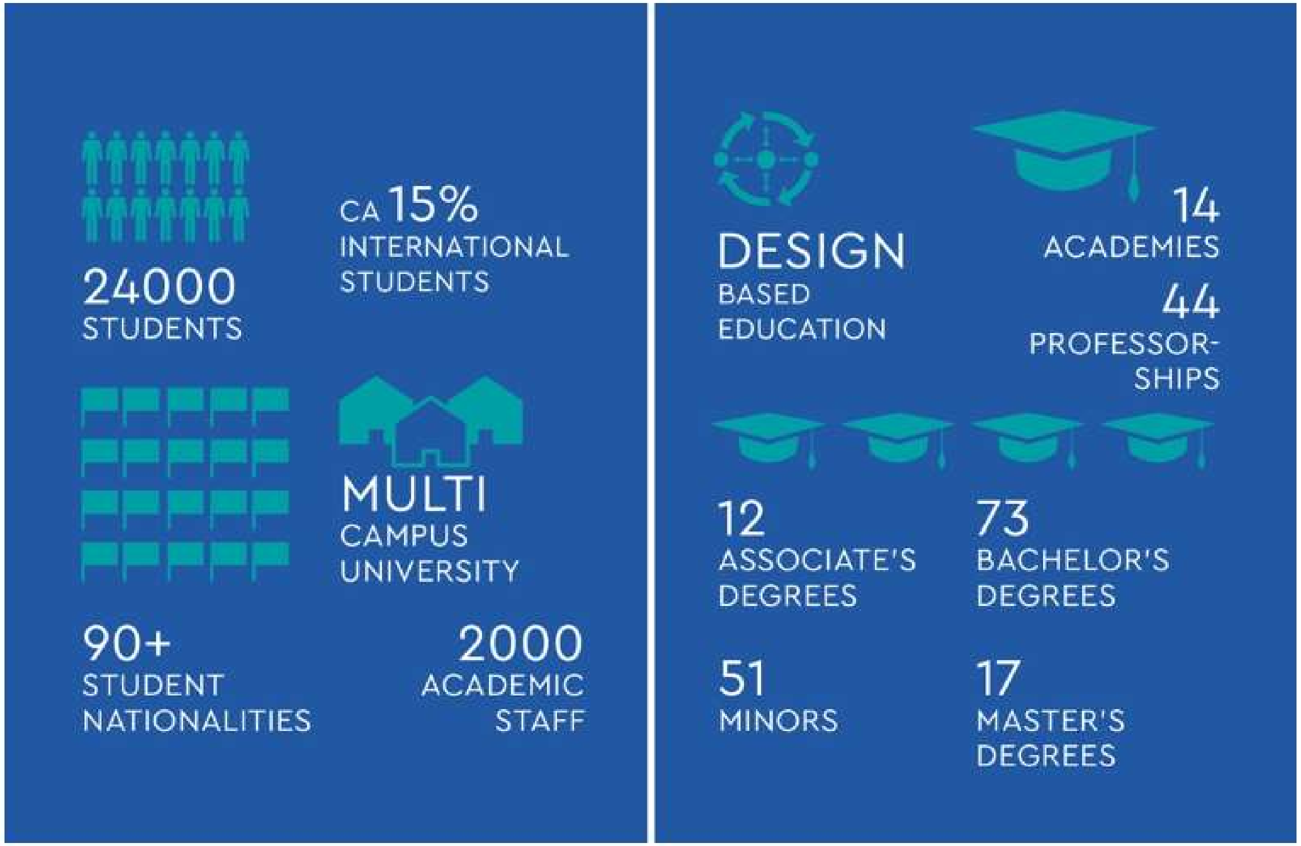
NHL Stenden University of Applied Sciences: history

- Formerly Hogeschool Drenthe (with locations in Emmen, Meppel, and Assen).
- Merger (01-01-2008) with CHN, Christelijke Hogeschool Nederland (Leeuwarden).
- Formation of Stenden University of Applied Sciences.
- Merger (01-01-2018) with NHL, Noordelijke Hogeschool Leeuwarden (Leeuwarden).
- Formation NHL Stenden University of Applied Sciences.

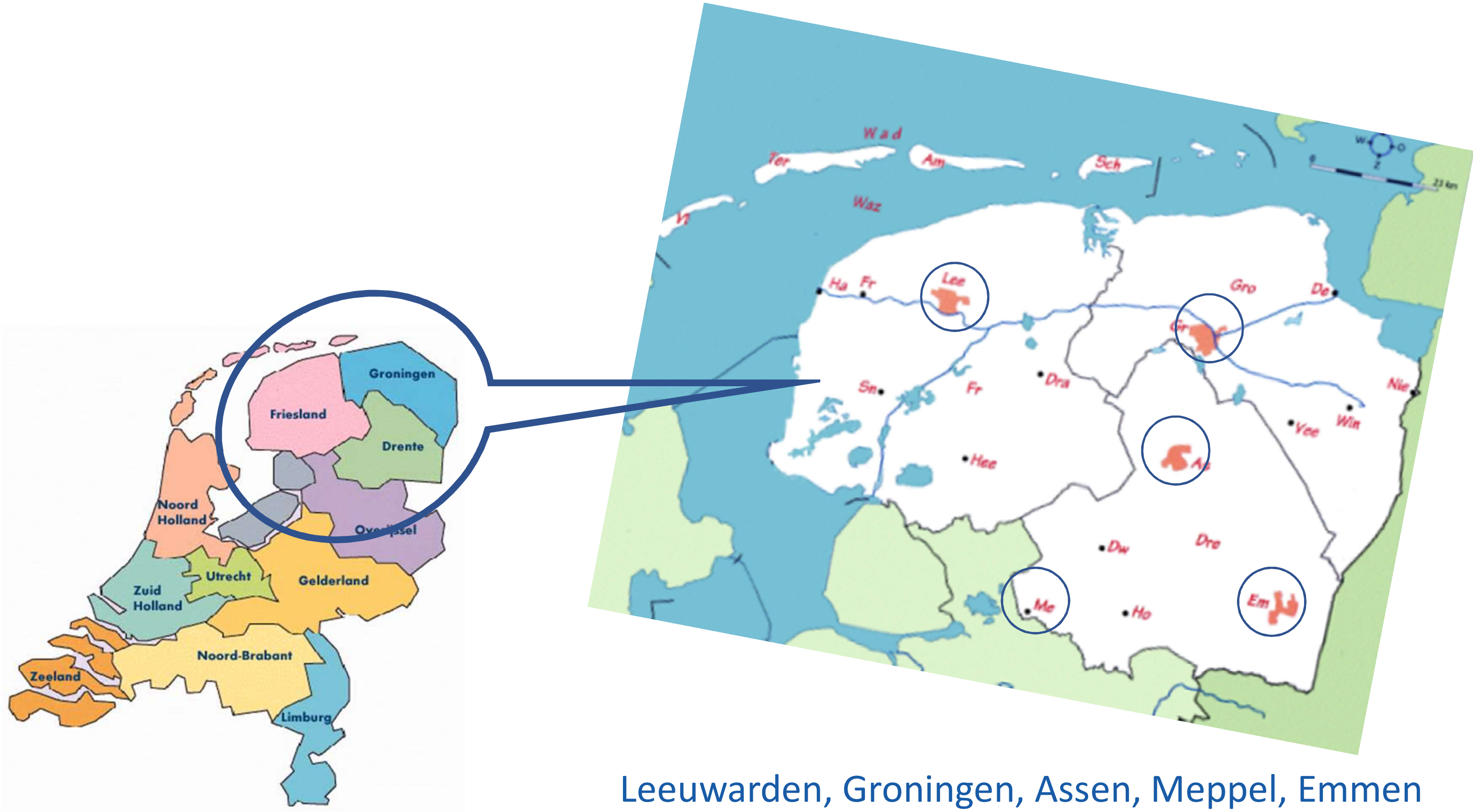
NHL hogeschool:

Stenden hogeschool:

NHL Stenden: some key data



NHL Stenden University of Applied Sciences: locations



Leeuwarden, Groningen, Assen, Meppel, Emmen

NHL Stenden: locations abroad

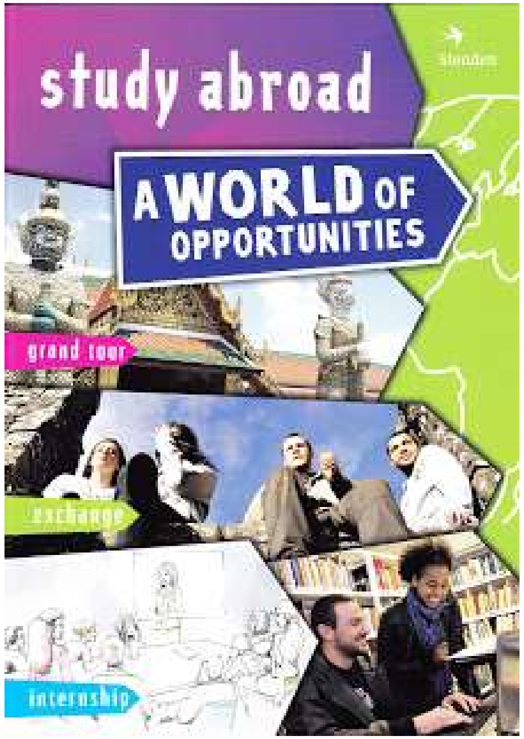
NHL Stenden has branche campuses abroad (International Hospitality Management, International Business Administration, Tourism Management, and Disaster Management).

Bali:

Bangkok:

Quatar:

Zuid-Afrika:



Green PAC: Center of Expertise (CoE)

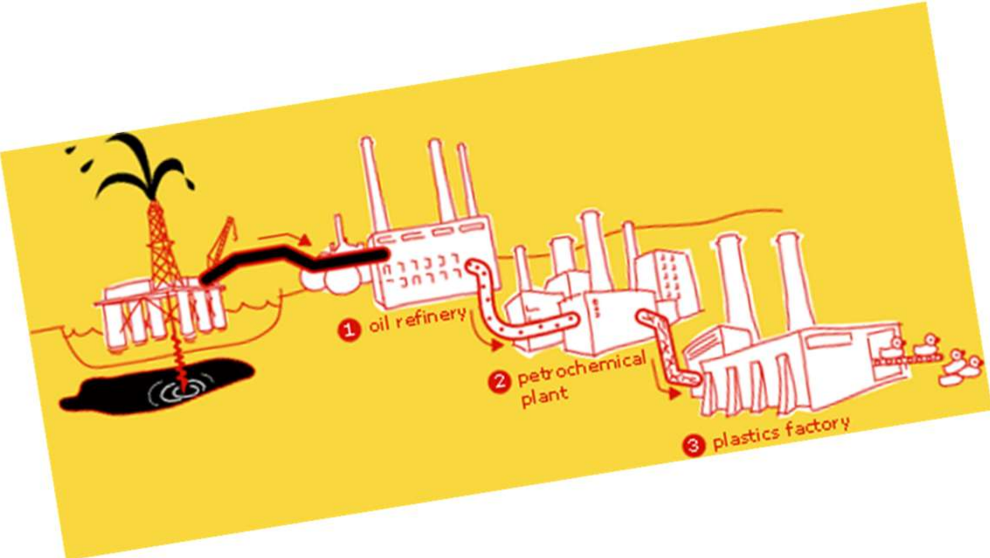
- Cooperation with Hogeschool Windesheim (Zwolle): **Green PAC** (CoE).
- Applied and practice-oriented research .
- Topics:
    - **Composites and biocomposites.**
    - **3D printing (FDM en SLA).**
    - **Bioplastics (biobased and /or biodegradable).**
    - **Fibers and yarns.**
    - **Recycling (mechanical- or chemical recycling of plastics).**

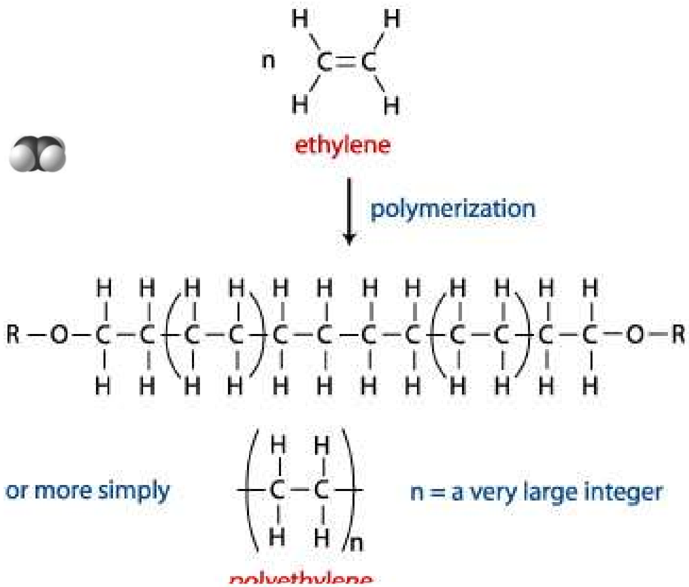
Green PAC
Polymer Application Centre
Een initiatief van Stenden en Windesheim

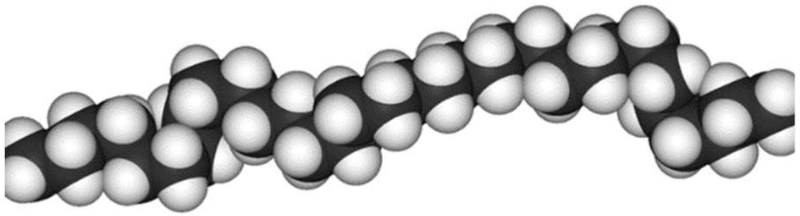
- iLAB, Innovation Laboratory in Zwolle (located on the Polymer Science Park) and in Emmen (located on the Emmtec Industry & Business Park).
- COCI, Centre of Open Chemical Innovation in Emmen (located on the Emmtec Industry & Business Park).

Origin of plastics

Plastics and polymers

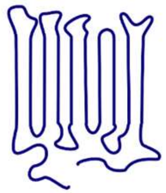




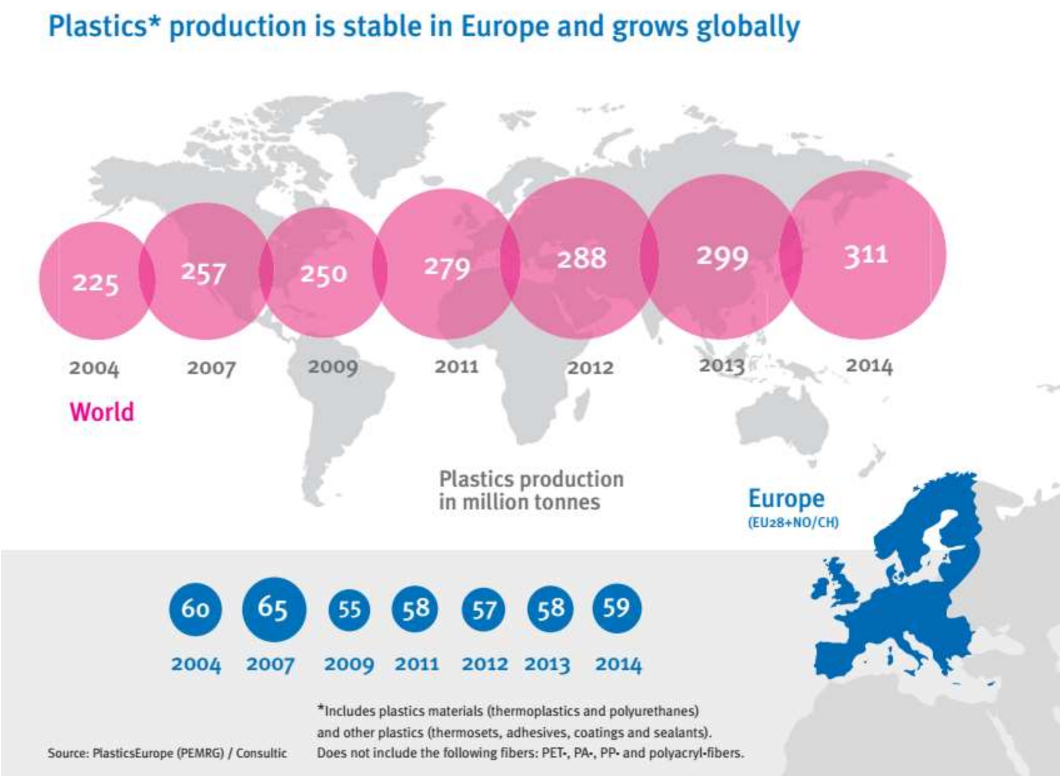


Amorphous vs. crystalline

- Polymers
  - Thermoplast
    - Amorphous
    - (Semi)-crystalline
  - Elastomer (rubber)
  - Thermoset



Plastics*Europe* – plastics: global production

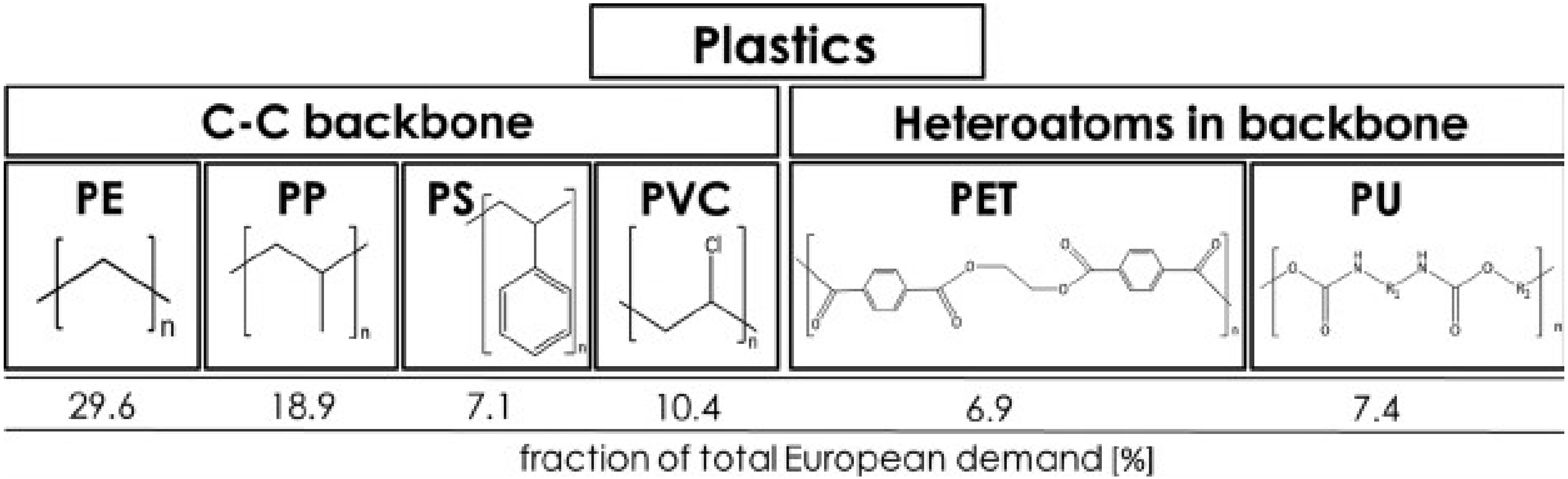


Weight Titanic:
52,310 ton

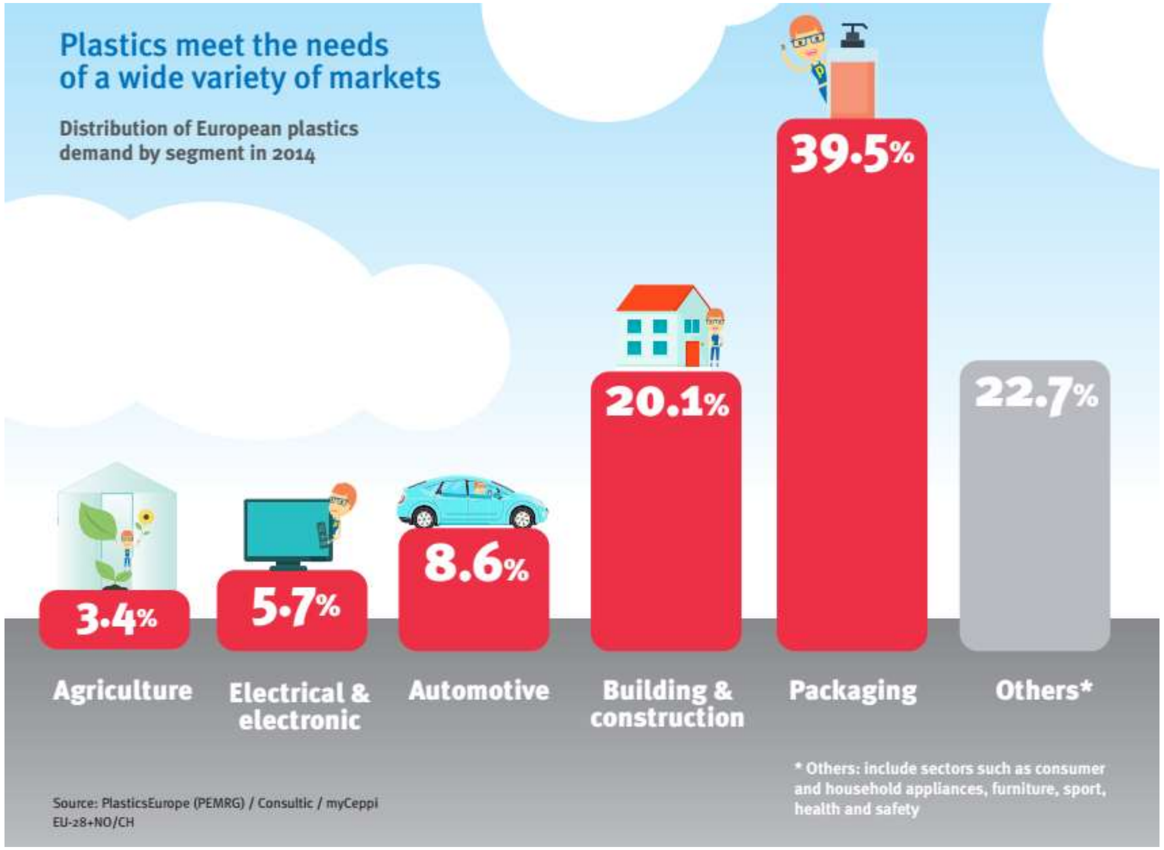
5945 Titanics!!!

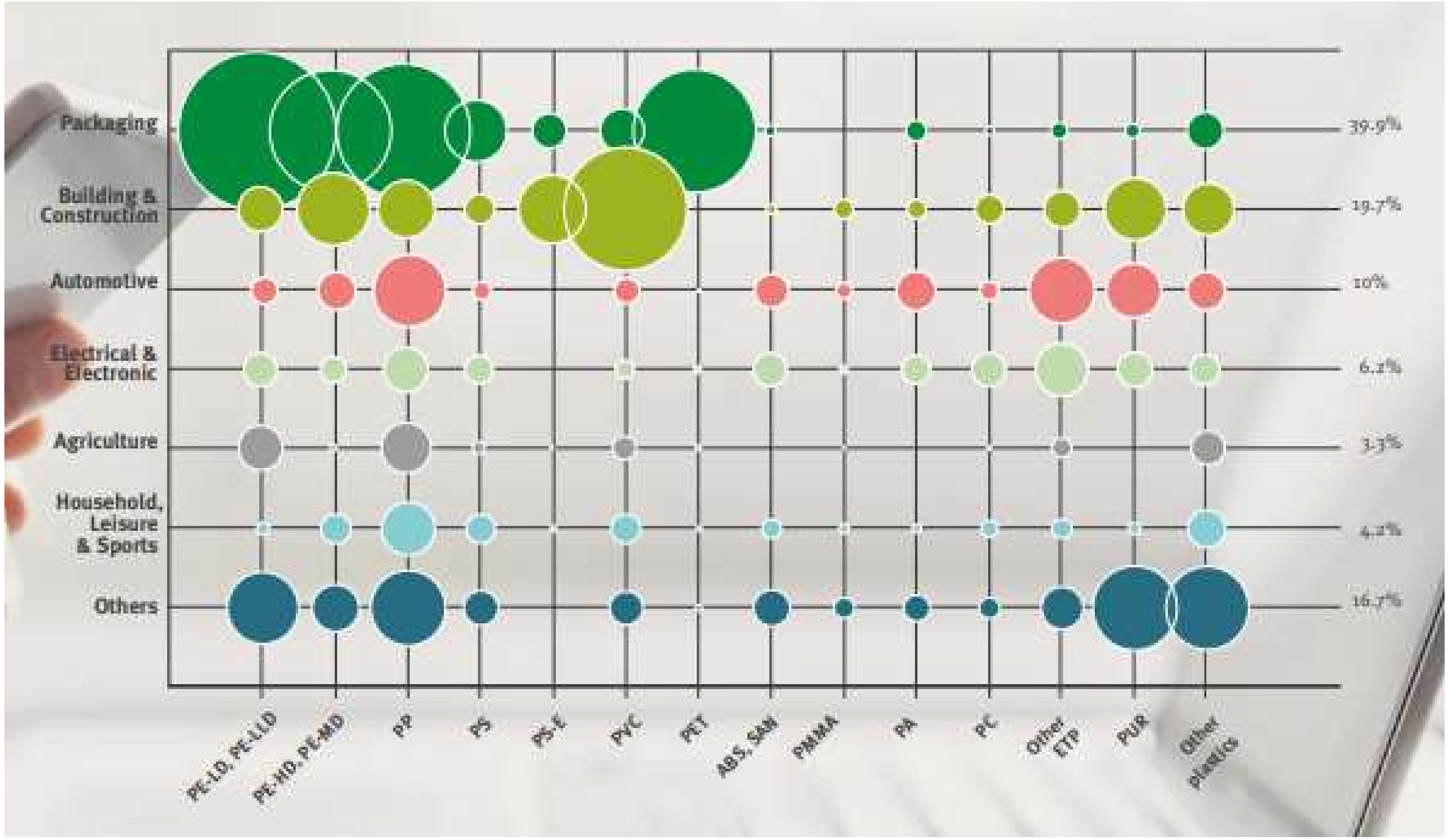
Structure of polymers

All carbon backbone vs. heteroatom backbone



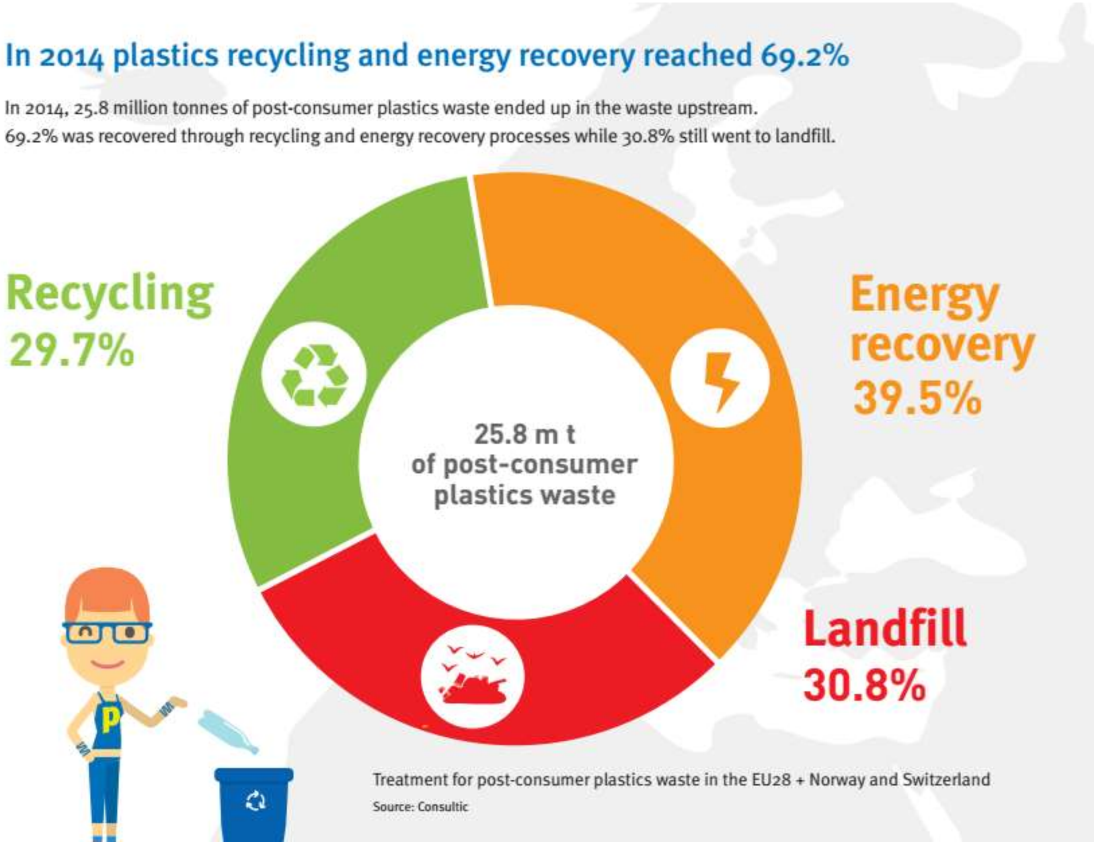
PlasticsEurope – plastics: applications



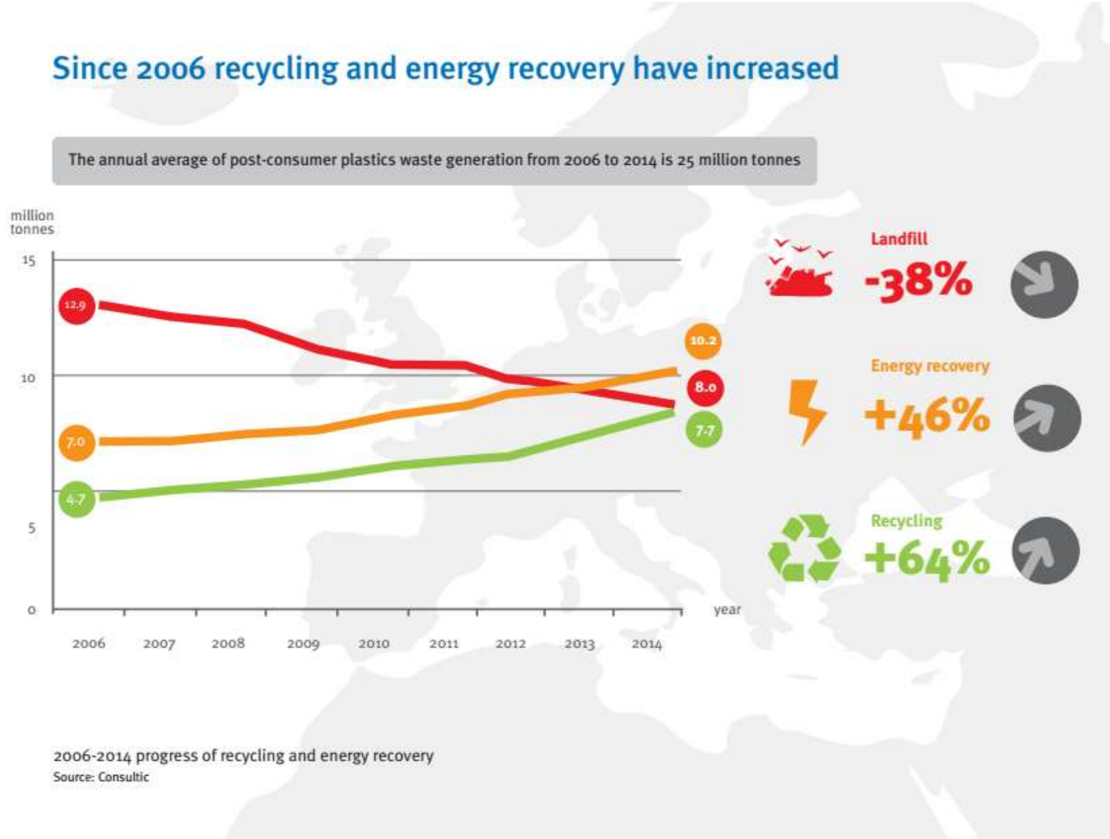


European plastics converter demand by segments and polymer types in 2016
Data for EU28+NO/CH.

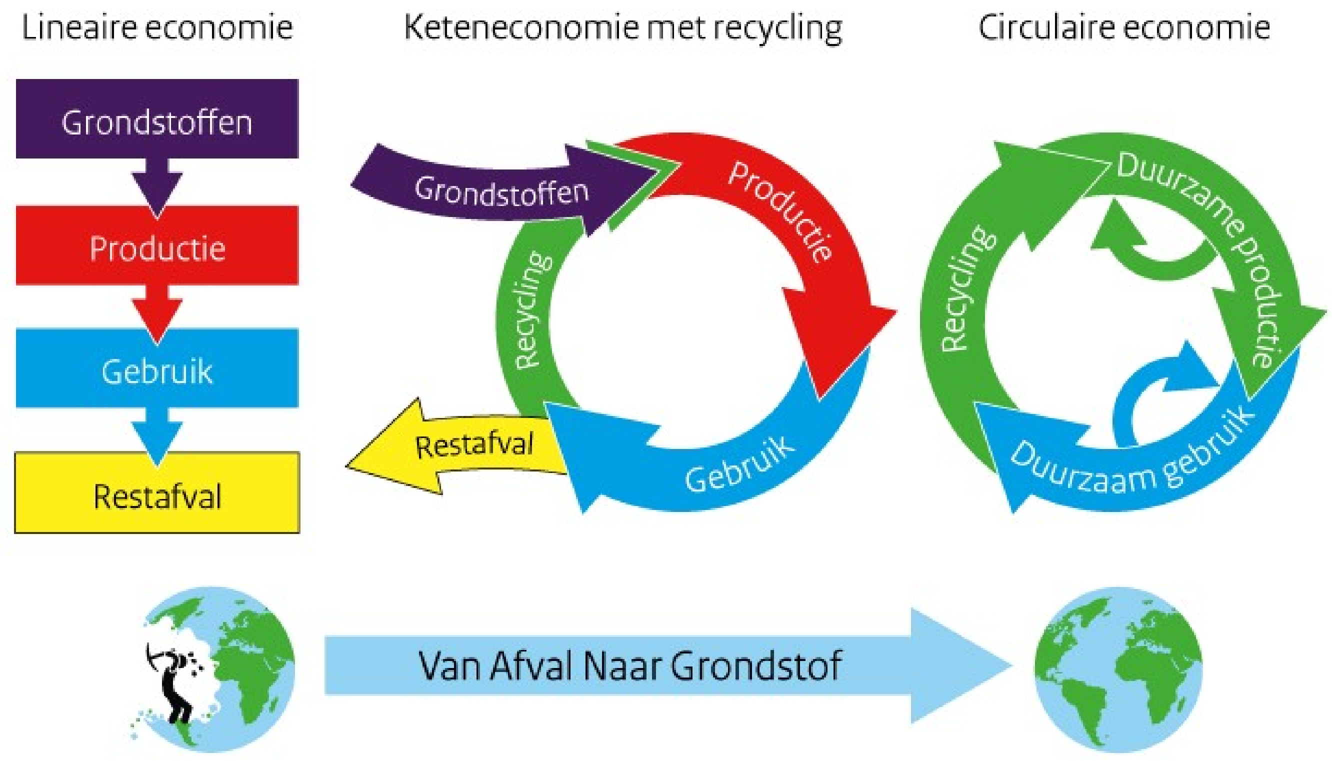
PlasticsEurope – plastics: recycling



Plastics*Europe* – plastics recycling trends



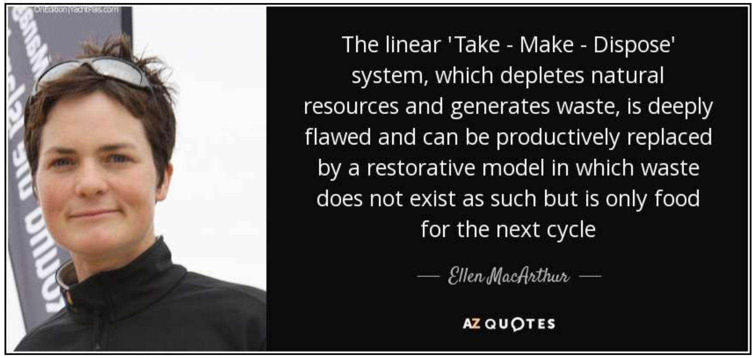
Linear economy vs. circular economy

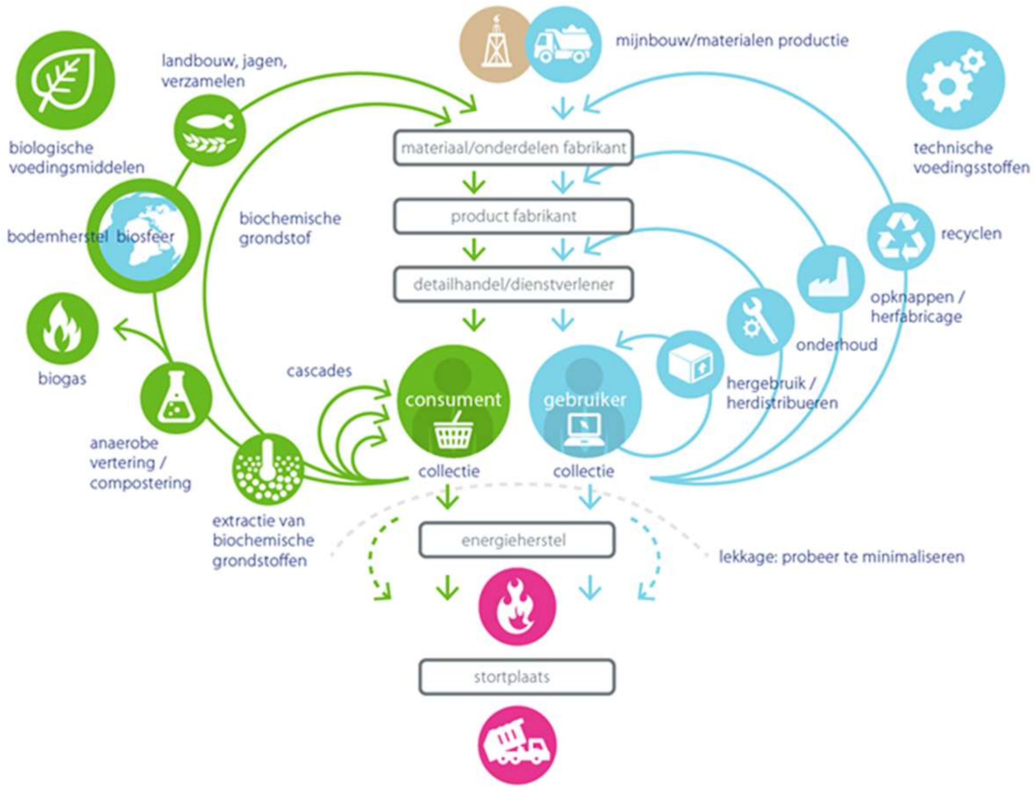


[Invulling programma Van Afval Naar Grondstof]() (Mansveld, 28 januari 2014)

Ellen MacArthur Foundation

ELLEN MACARTHUR FOUNDATION
Rethink the future

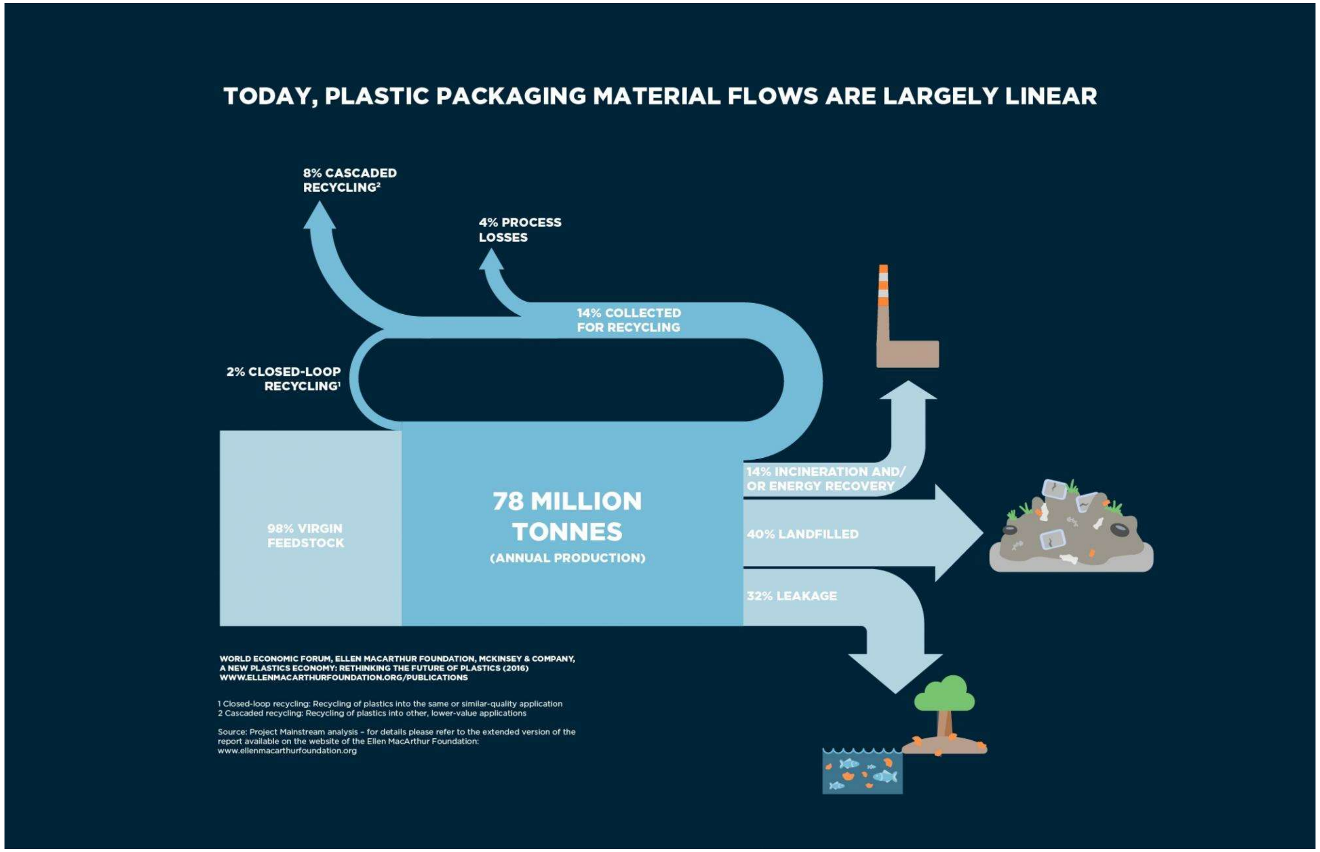




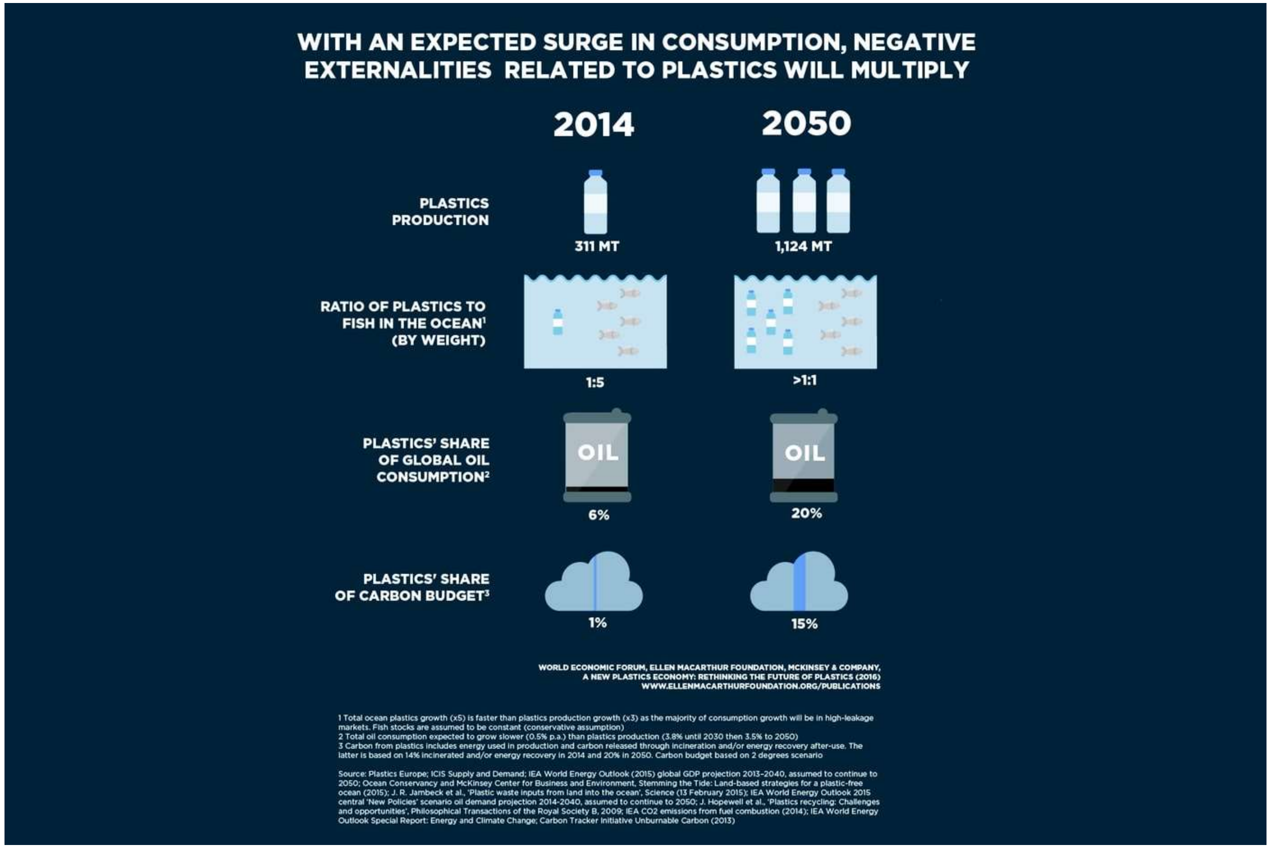
The New Plastics Economy

Ellen MacArthur Foundation
World Economic Forum
McKinsey & Company

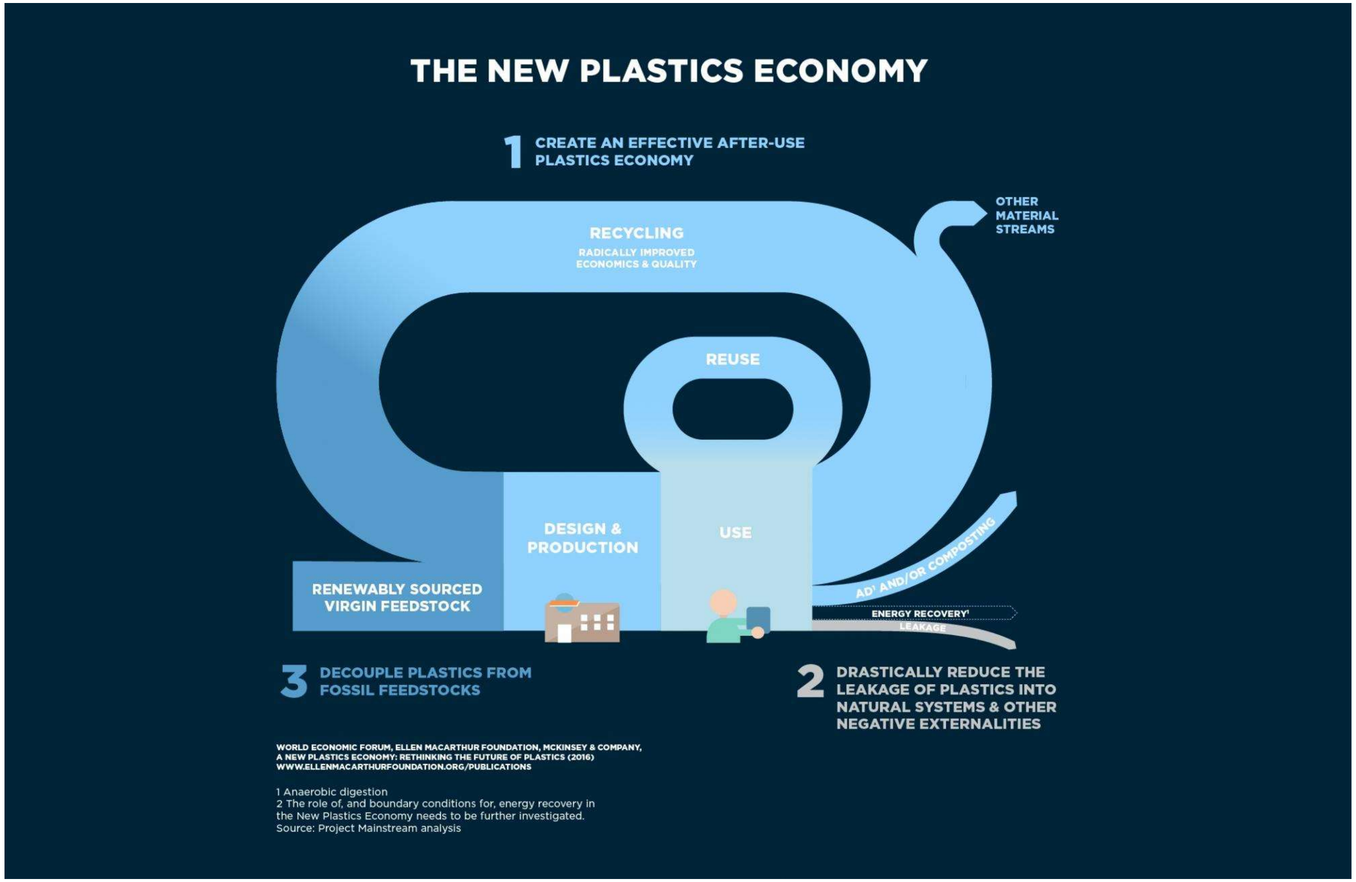
The New Plastics Economy: huidige situatie



The New Plastics Economy: situatie 2050



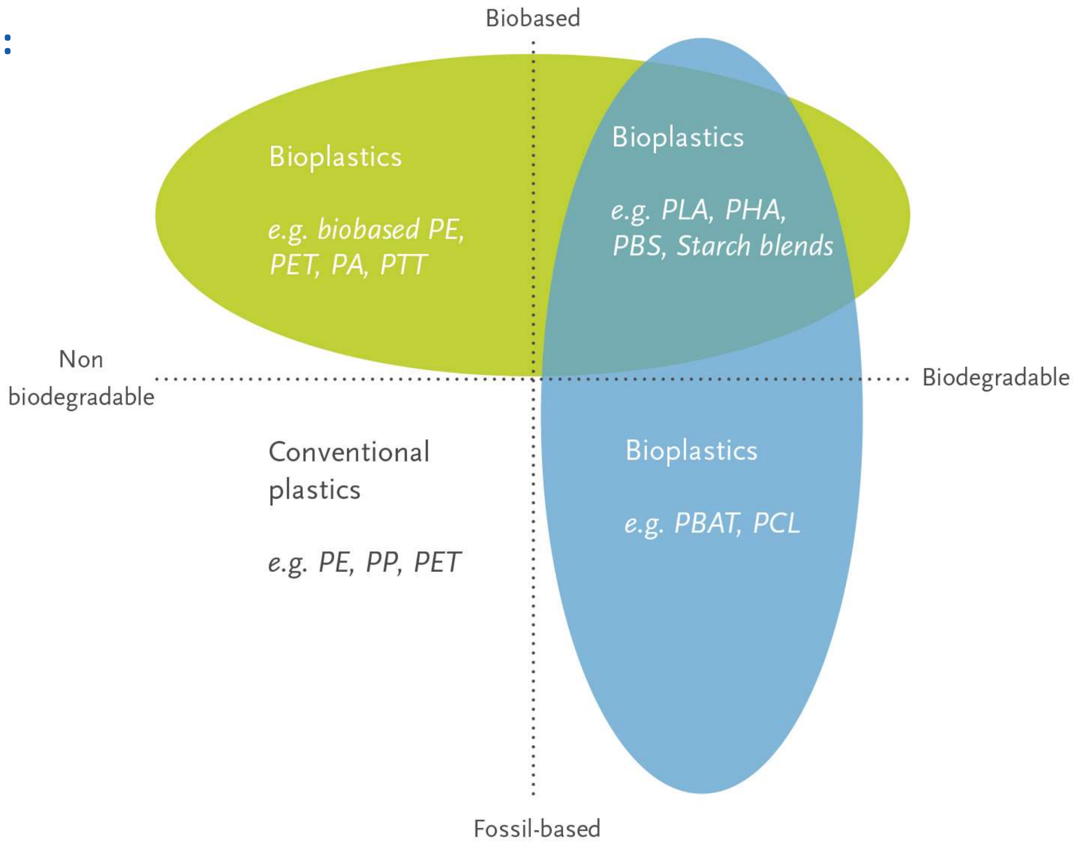
The New Plastics Economy: situatie 2050 (2)



Out of the plastic trap: saving the Mediterranean from plastic pollution

WWF Publication 2018

Bioplastics:

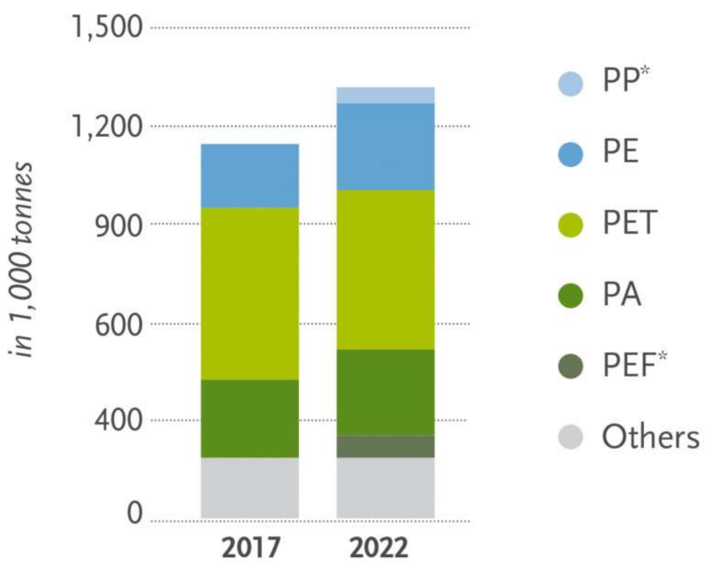


Biobased plastics

Biobased or partially biobased durable plastics, such as biobased or partially biobased PE, PET or PVC, possess properties, which are identical to their conventional versions. These bioplastics are technically equivalent to their fossil counterparts; yet, they help to reduce a product's carbon footprint. Moreover, they can be mechanically recycled in existing recycling streams.

European Bioplastics

Bio-based & durable bioplastics 2017 vs. 2022



Bio-based PP and PEF are currently in development and predicted to be available in commercial scale in 2020.

Source: European Bioplastics, nova-Institute (2017).
More information: ***www.bio-based.eu/markets*** *and* ***www.european-bioplastics.org/market***

Biobased content

Companies with biobased bioplastics can either indicate the 'biobased carbon content' or the 'biobased mass content' of their products. As these units of measurement differ, the typical numeric percentage value will differ, too, and must be taken into account, especially when drawing comparisons.

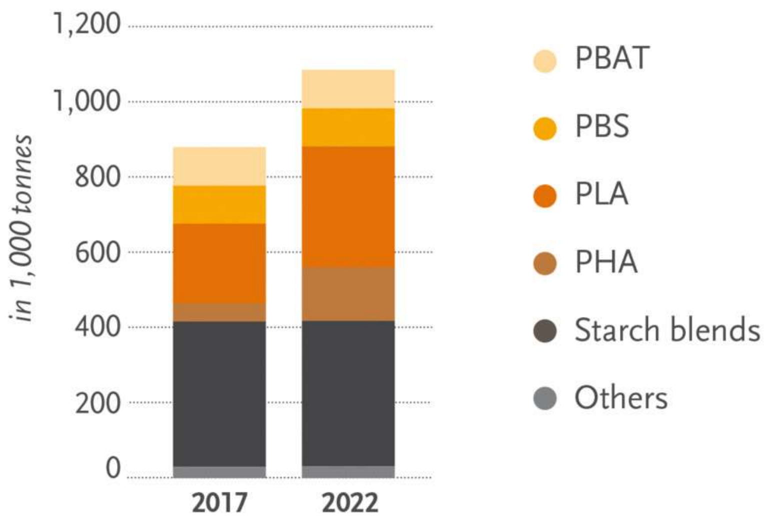
A well-established methodology to measure the biobased carbon content in materials or products is the 14C-method (EU standard: CEN/TS 16137, corresponding US-standard: ASTM 6866). Certification schemes and derived product labels based on the European and the U.S. standard are available – for example by the Belgian certifier Vinçotte or German certifier DIN CERTCO.

Biodegradable plastics

The property of biodegradation does not depend on the resource basis of a material. This feature is directly linked to the chemical structure of the polymer and can benefit particular applications, in particular packaging. Biodegradable plastic types offer new ways of recovery and recycling (organic recycling). If certified compostable according to international standards such as the EN 13432 (preferably by an independent third party), these plastics can be composted in industrial composting plants.

European Bioplastics

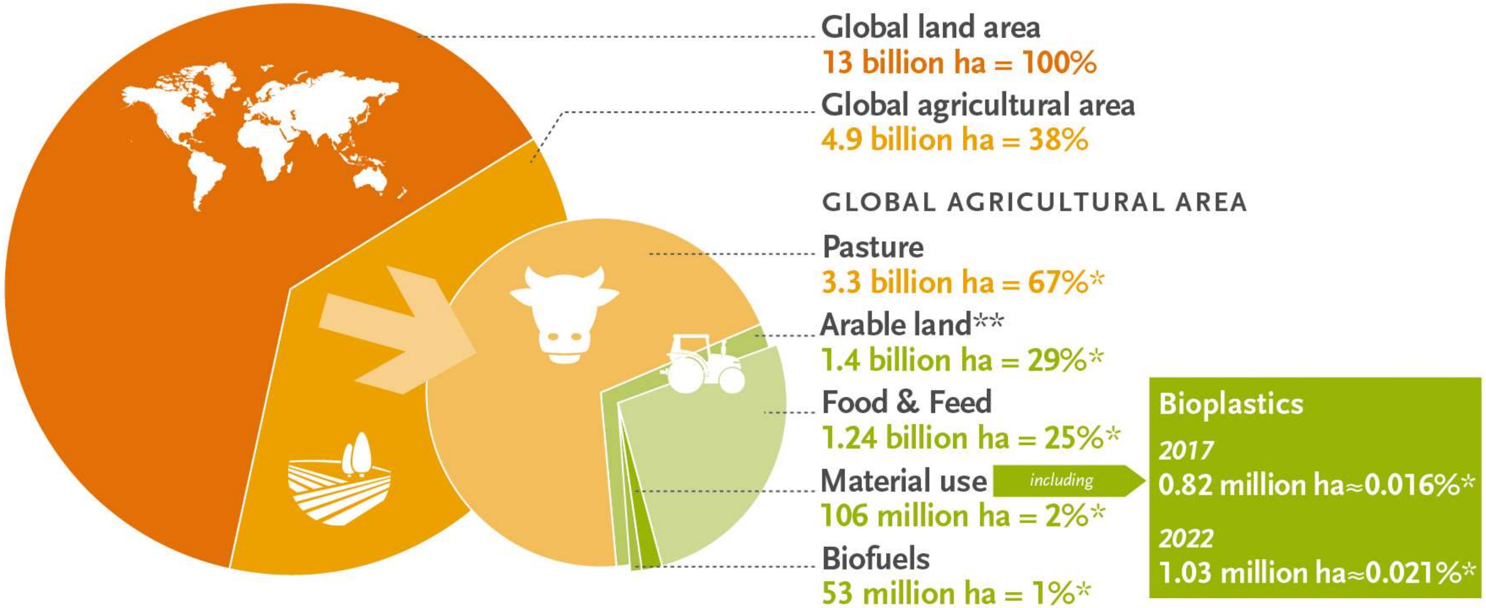
Biodegradable bioplastics 2017 vs. 2022



Source: European Bioplastics, nova-Institute (2017).
More information: ***www.bio-based.eu/markets*** *and* ***www.european-bioplastics.org/market***

European Bioplastics

Land use estimation for bioplastics 2017 and 2022

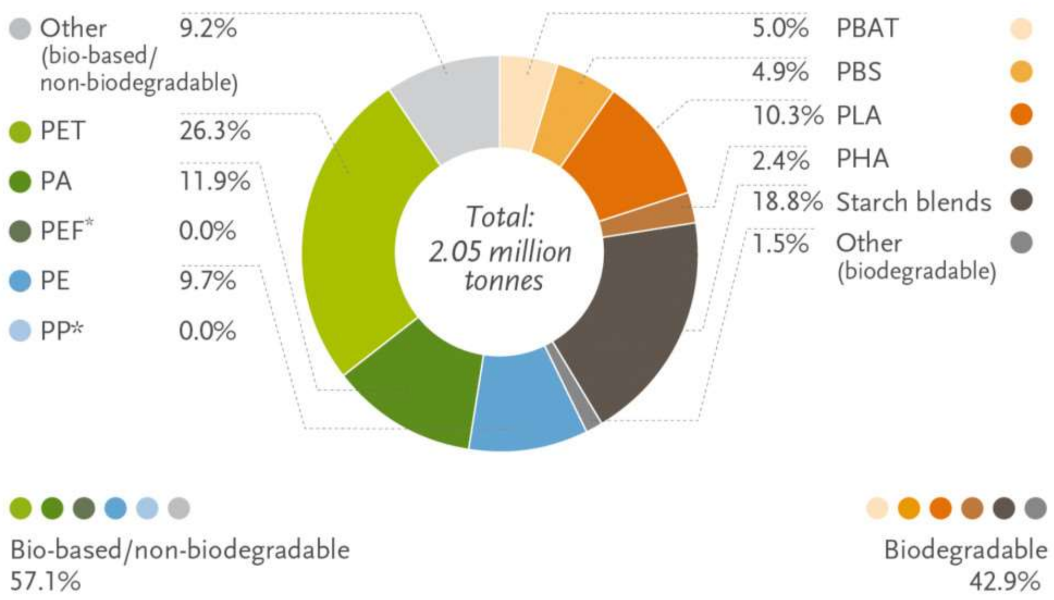


Source: European Bioplastics (2017), FAO Stats (2014), nova-Institute (2017), and Institute for Bioplastics and Biocomposites (2016). More information: ***www.european-bioplastics.org***

** In relation to global agricultural area*
*** Including approx. 1% fallow land*

European Bioplastics

Global production capacities of bioplastics 2017 (by material type)

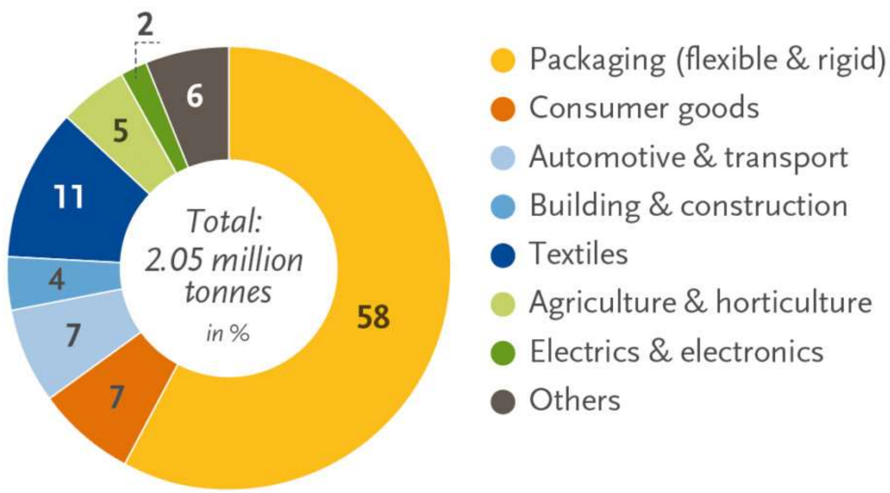


**Bio-based PP and PEF are currently in development and predicted to be available in commercial scale in 2020.*

Source: European Bioplastics, nova-Institute (2017).
More information: ***www.bio-based.eu/markets*** *and* ***www.european-bioplastics.org/market***

European Bioplastics

Global production capacities of bioplastics in 2017 (by market segment)



Source: European Bioplastics, nova-Institute (2017). More information: ***www.bio-based.eu/markets*** *and* ***www.european-bioplastics.org/market***

European Bioplastics

Global production capacities of bioplastics in 2017 (by region)

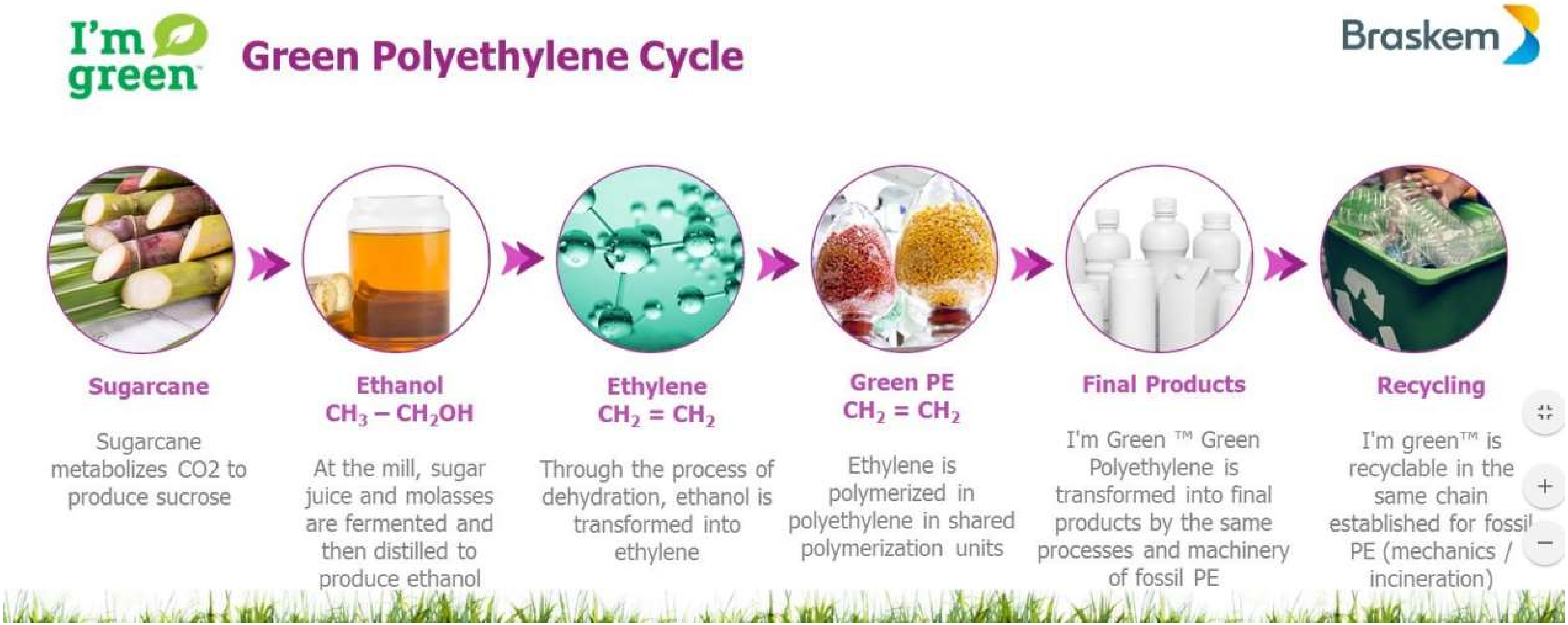
Total:
2.05 million tonnes

- Asia
- South America
- North America
- Europe
- Australia/Oceania

** Production in Australia/Oceania is a small proportion relativ to the global production capacity.*

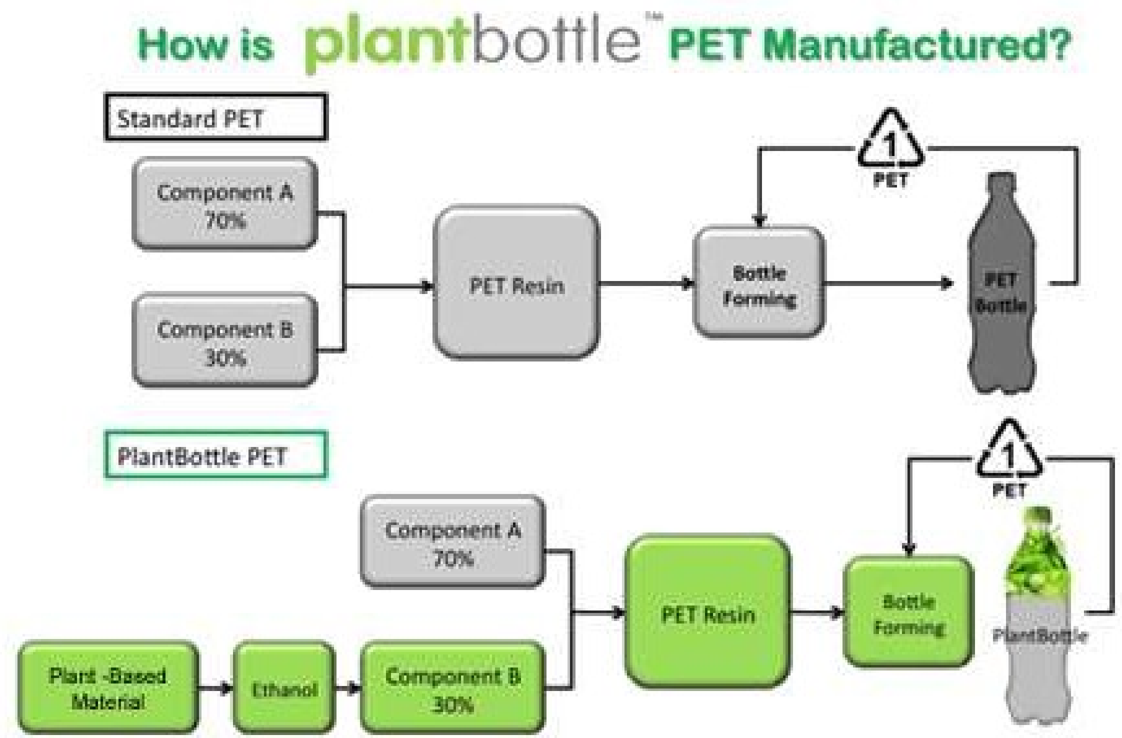
Source: European Bioplastics, nova-Institute (2017).
More information: ***www.bio-based.eu/markets*** *and* ***www.european-bioplastics.org/market***

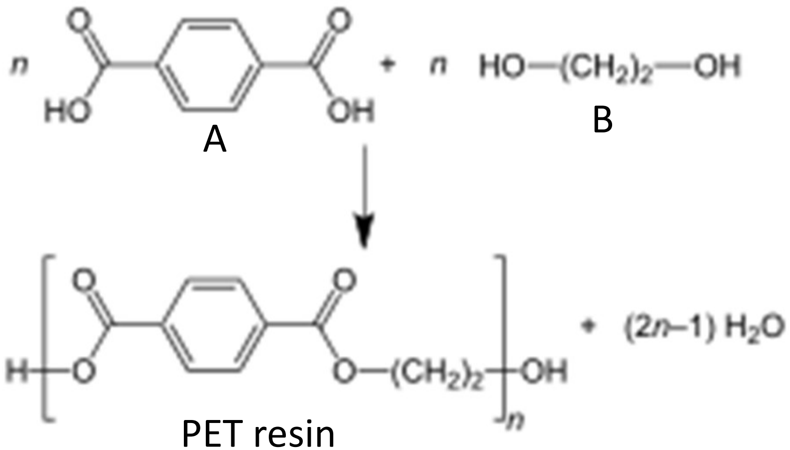
Bioplastics: biobased PE



Bioplastics: biobased PE

Bioplastics: biobased PE



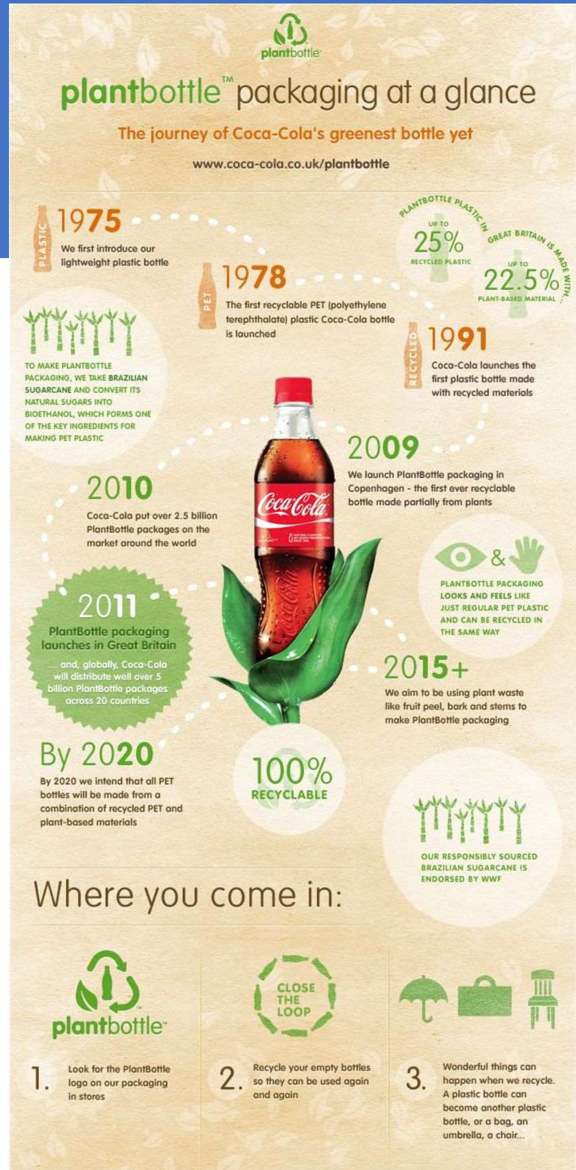


PET resin

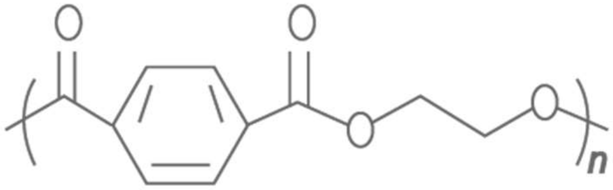
A: not commercial
B: commercial

Bioplastics: biobased PET

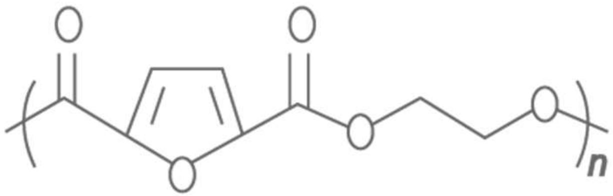
Bioplastics: biobased PET



Bioplastics: biobased PEF

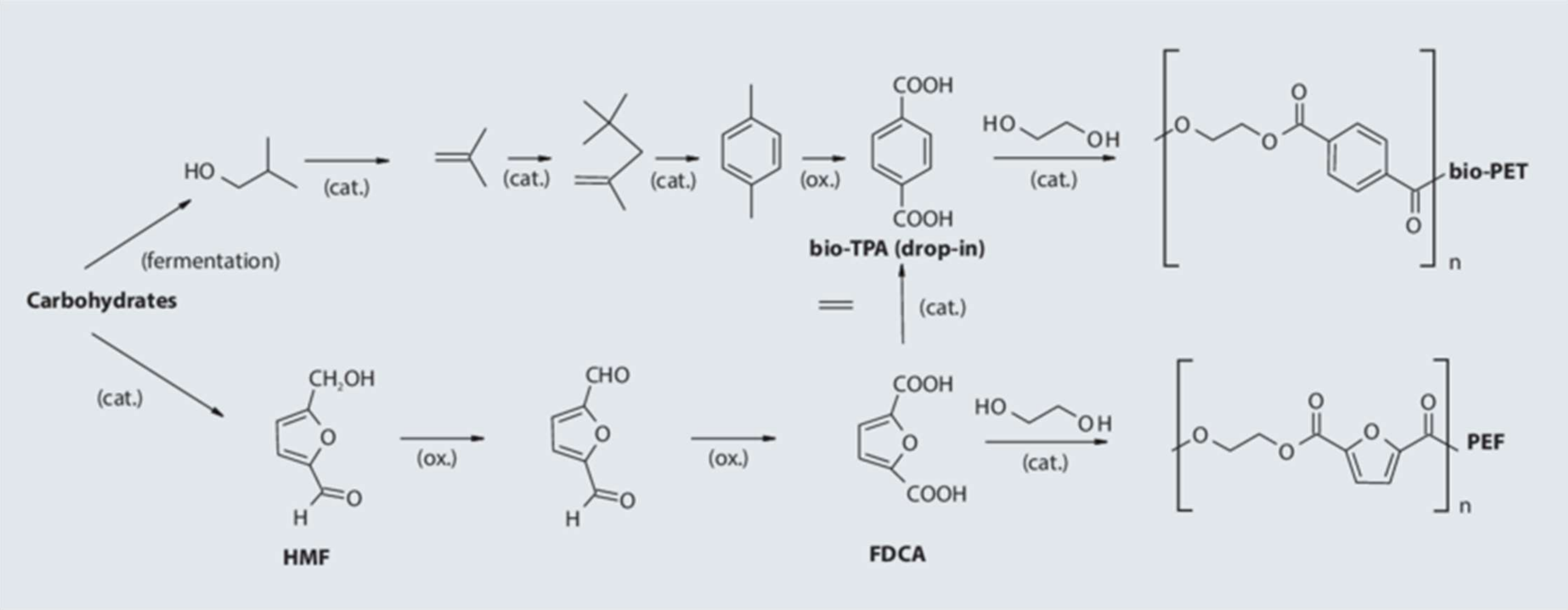


Polyethylene terephthalate (**PET**)

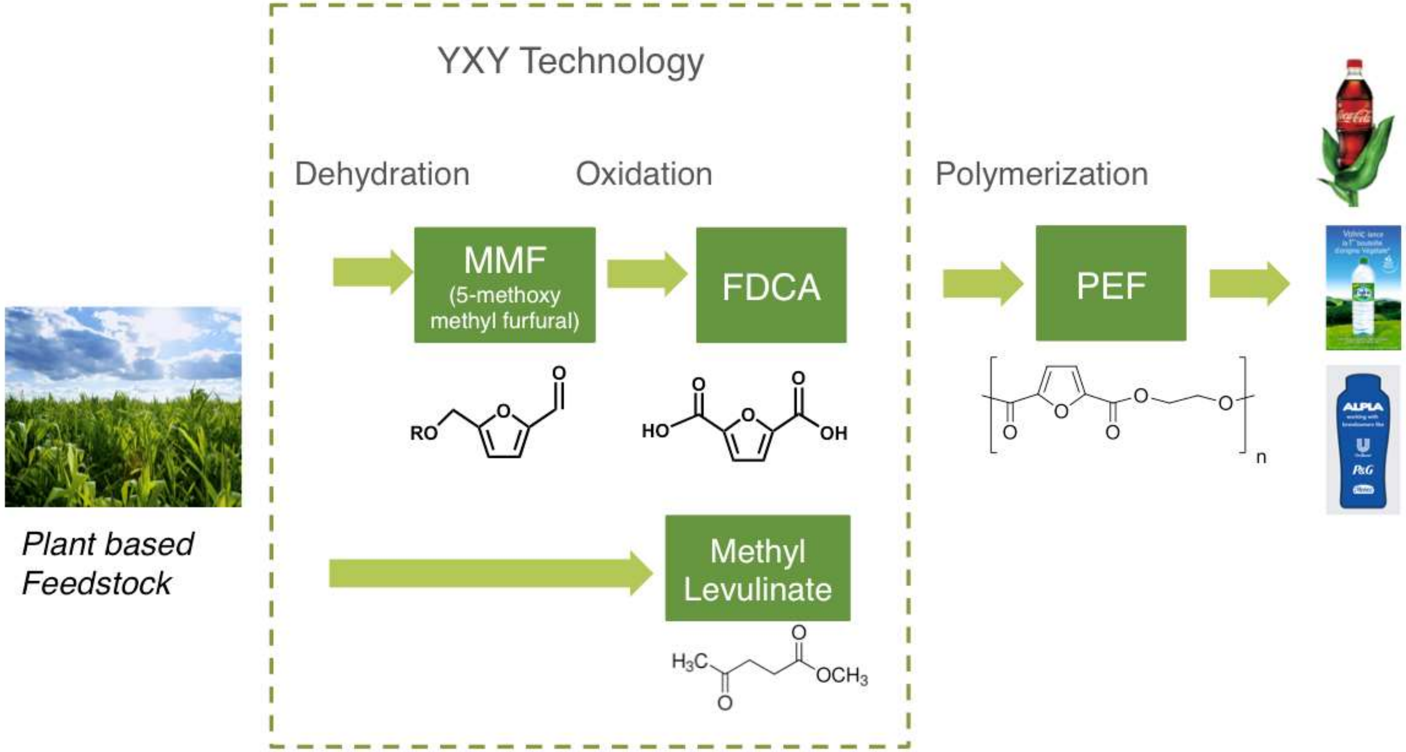


Polyethylene Furanoate (**PEF**)

Bioplastics: biobased PET and PEF



Bioplastics: biobased PEF

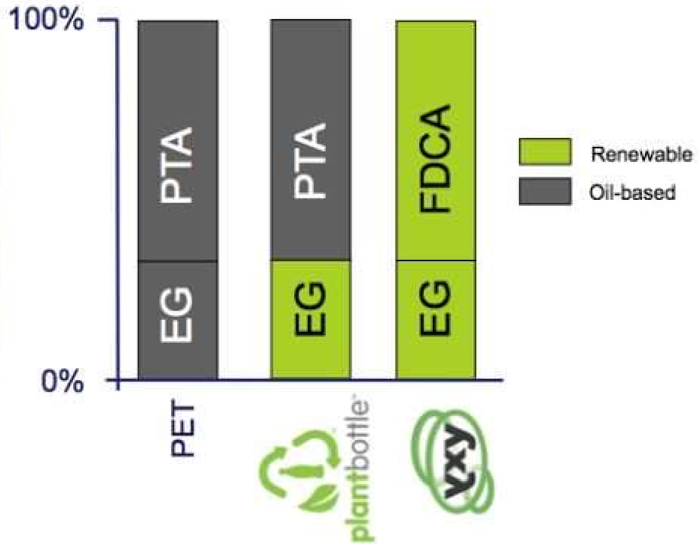


Bioplastics: biobased PEF

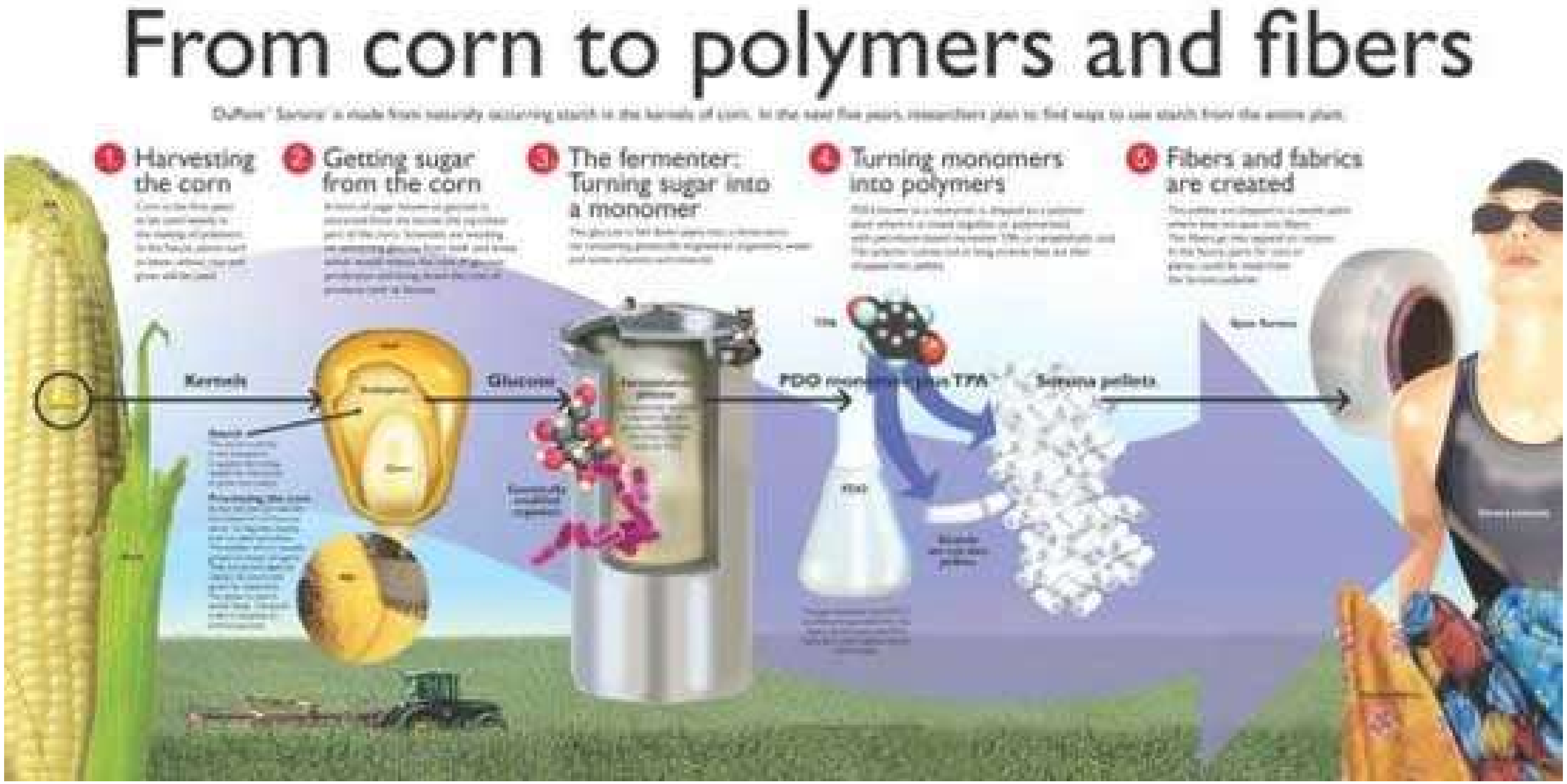
Moving to 100% green

AVANTIUM

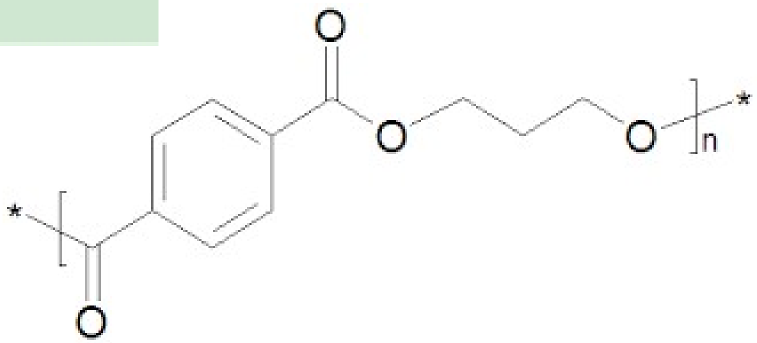
- PET is the most widely used polyester made of PTA and EG
- Plantbottle launched in 2010 - PET with biobased EG and oil-based PTA
- PEF by Avantium: biobased FDCA + biobased EG = 100% green



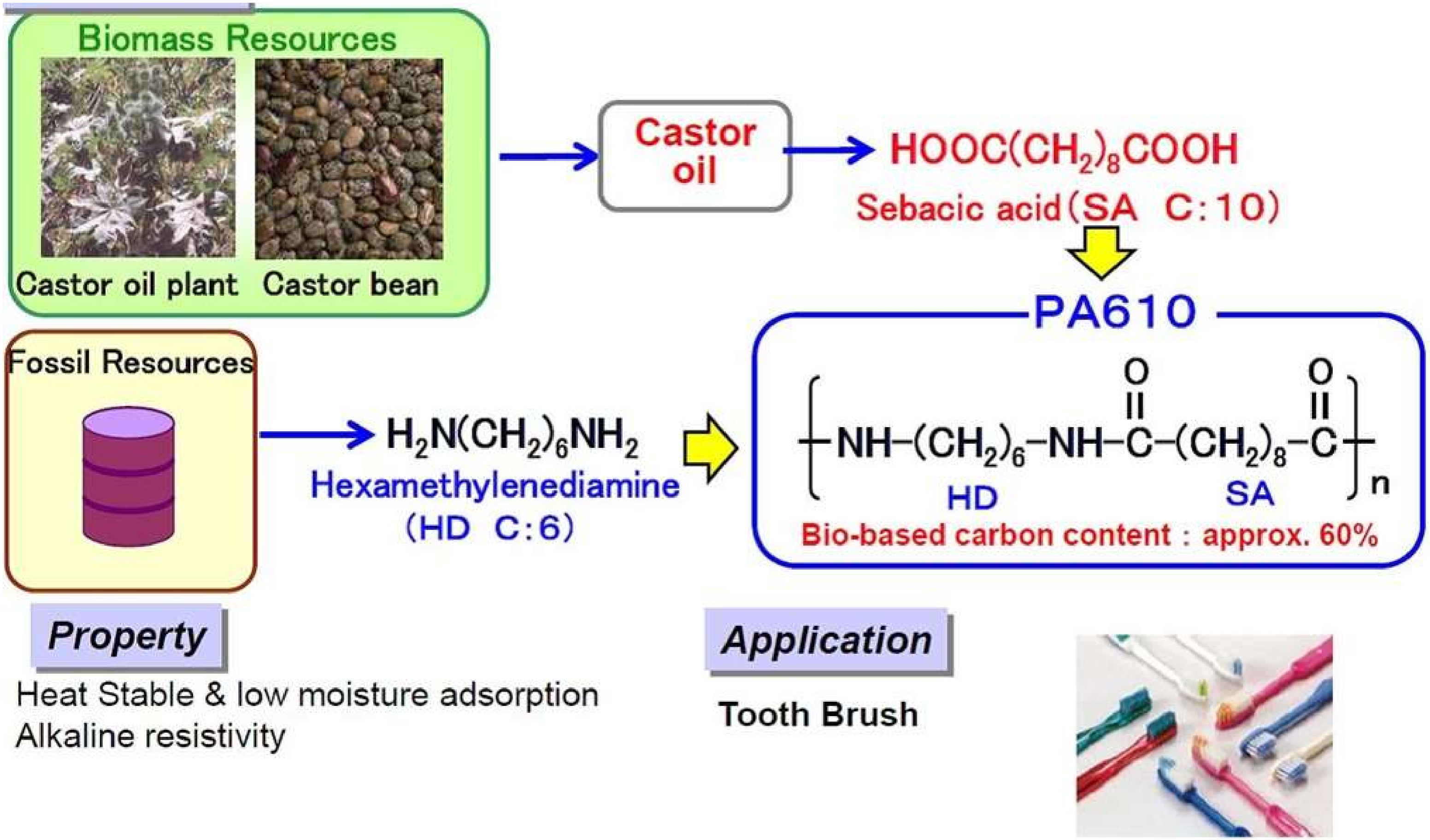
Bioplastics: biobased PTT 30



Bioplastics: biobased PTT



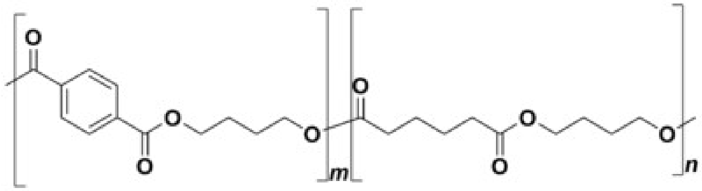
Bioplastics: biobased PA6,10



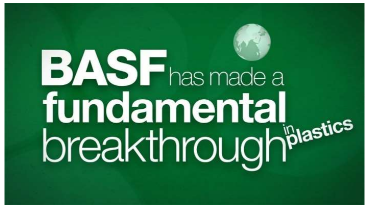
Bioplastics: biobased PAs

Mit den fischer greenline Produkten ist fischer weltweit der erste Hersteller, der ein Sortiment an biobasierten Befestigungssystemen anbietet. Damit richten wir uns an Kunden, die während dem Bauen, Renovieren und Dekorieren auch beim Thema Befestigen großen Wert auf Nachhaltigkeit legen.

Bioplastics: compostable PBAT



Bioplastics: compostable PBAT



Bioplastics: compostable PBAT

European standard EN 13432,
Australian standard AS 4736

European standard
EN 13432

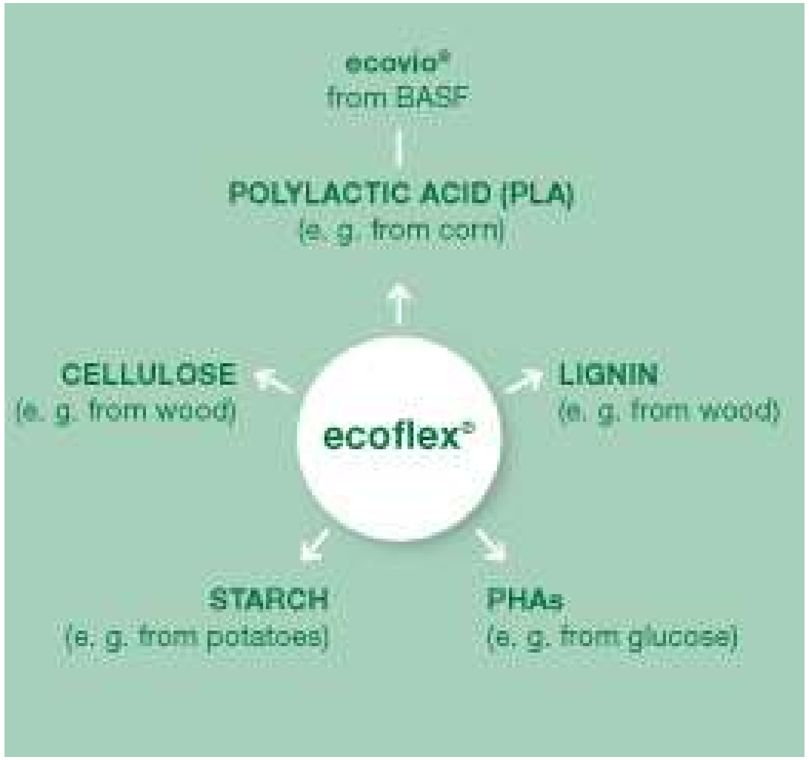
American standard
ASTM 6400

Japanese standard
GreenPla

Home composting

Chinese standard
GB/T

Bioplastics: compostable PBAT



Bioplastics: compostable PBAT

ecoflex® and ecovio®

- **ecoflex®**
  - Based on fossil carbon
    * partially renewable grades
  - Compostable
  - Compound Enabler for renewable materials

- **ecovio®**
  - ecoflex® and PLA Compound
  - Compostable
  - 10-75% Renewable Content
  - Large range of properties and applications.

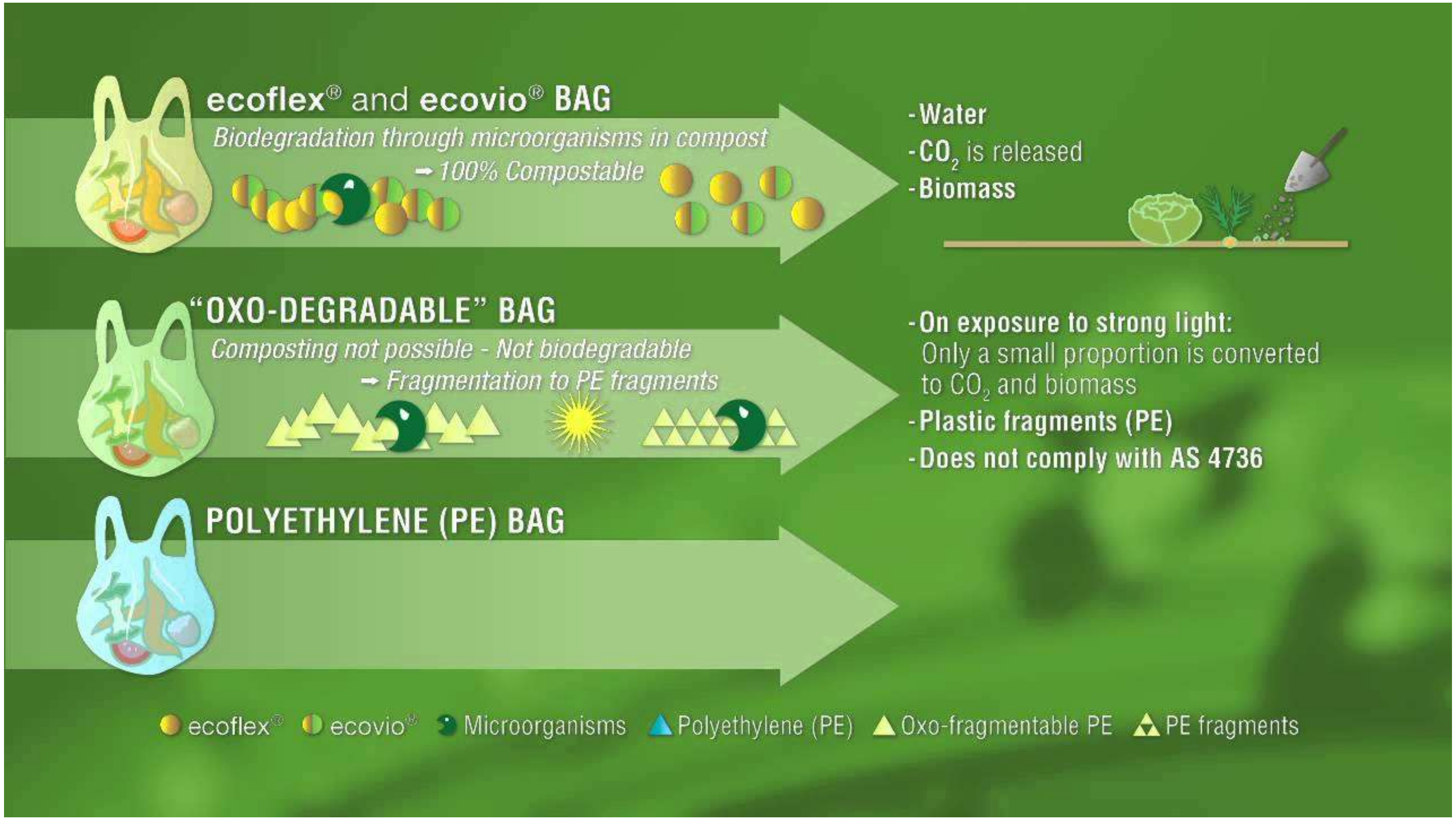
Original

2 weeks composting

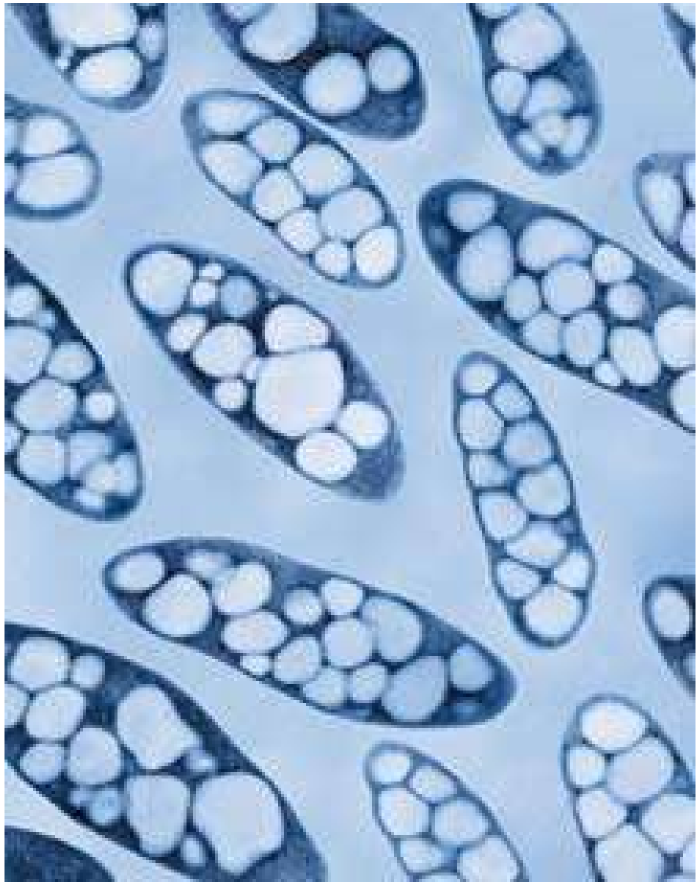
4 weeks Composting

BASF
We create chemistry

Bioplastics: compostable PBAT

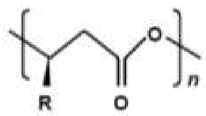


Bioplastics: biodegradable PHA



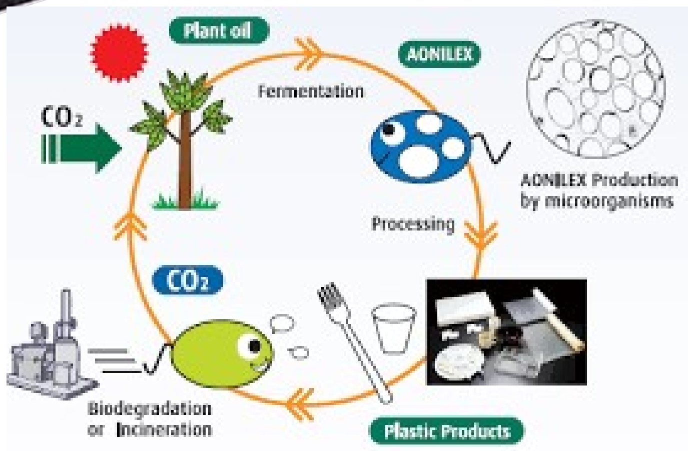
PHA

- Bioplastic from the family of polyesters (e.g. PET)
- Good moisture and gas barrier
- Excellent film forming and coating properties
- Good biodegradability

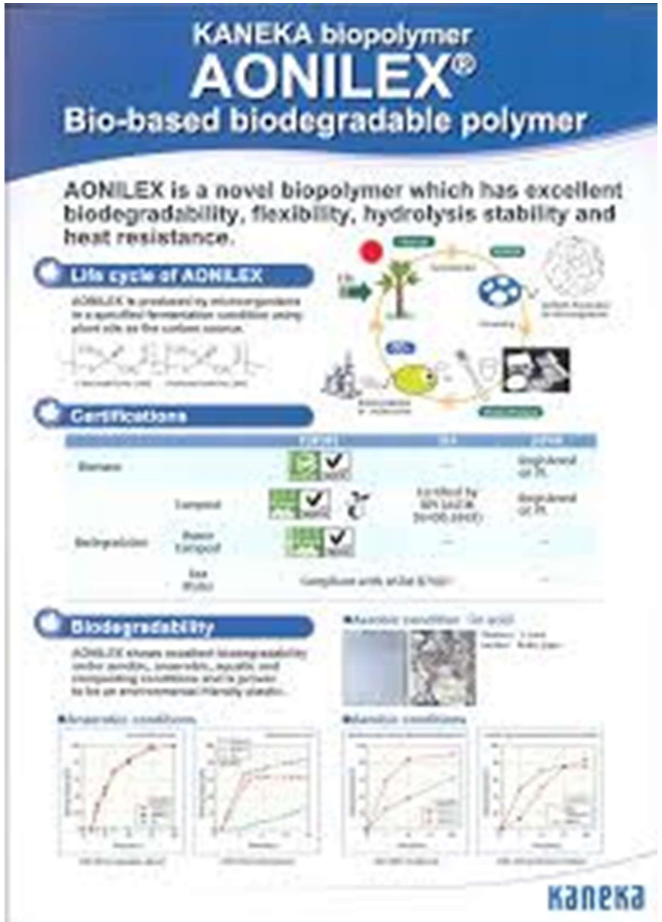


PHA	R group
PHB	$-CH_3$
PHV	$-CH_2CH_3$
PHBV	$-CH_3$, $-CH_2CH_3$
PHBHx	$-CH_3$, $-CH_2CH_2CH_3$
PHBO	$-CH_3$, $-(CH_2)_4CH_3$
PHBD	$-CH_3$, $-(CH_2)_6CH_3$
etc.	

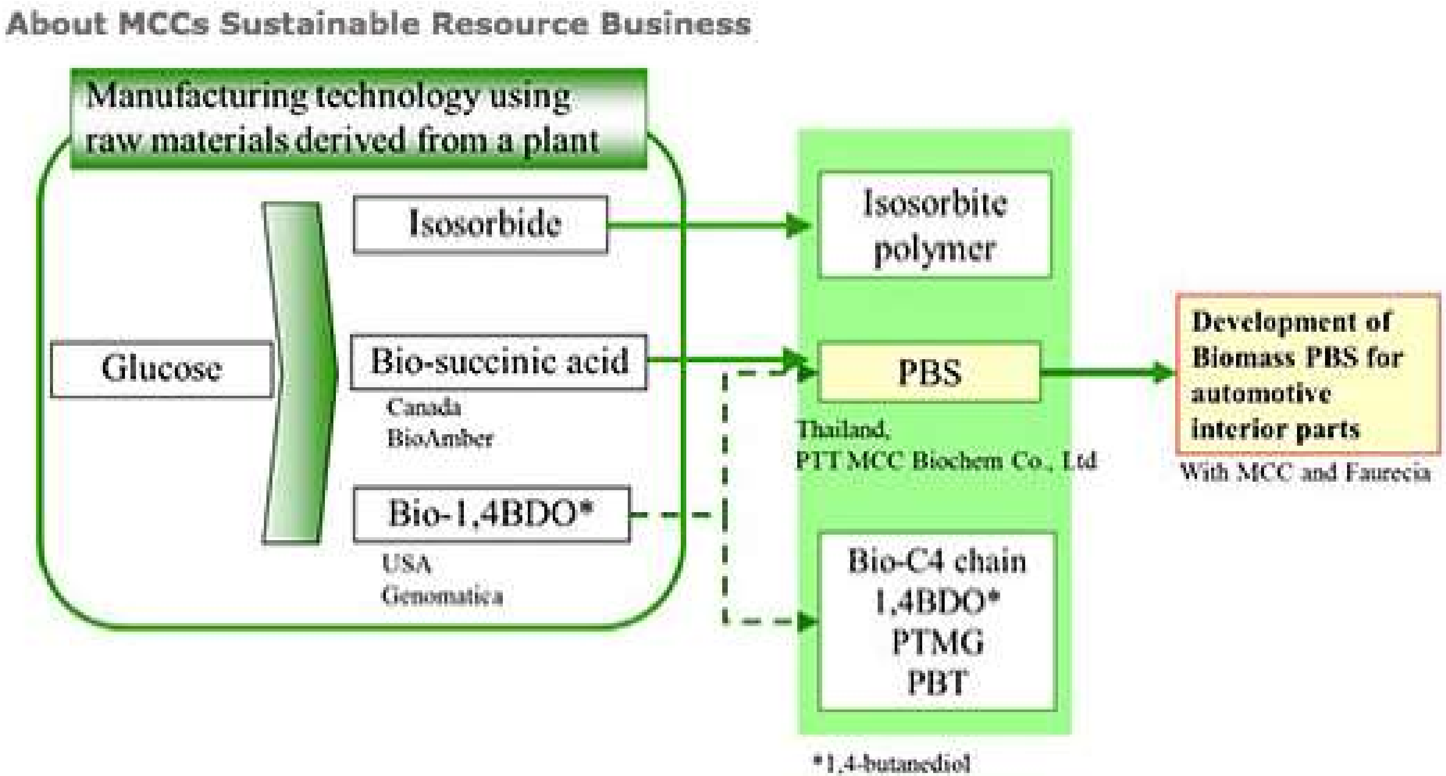
Bioplastics: biodegradable PHA



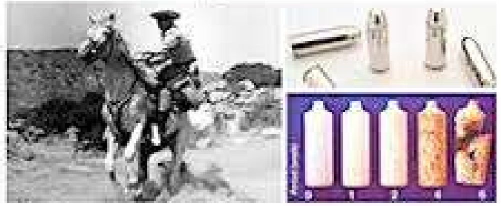
Bioplastics: biodegradable PHA



Bioplastics: biodegradable PBS



PBS: The Lone Ranger of thermoplastics

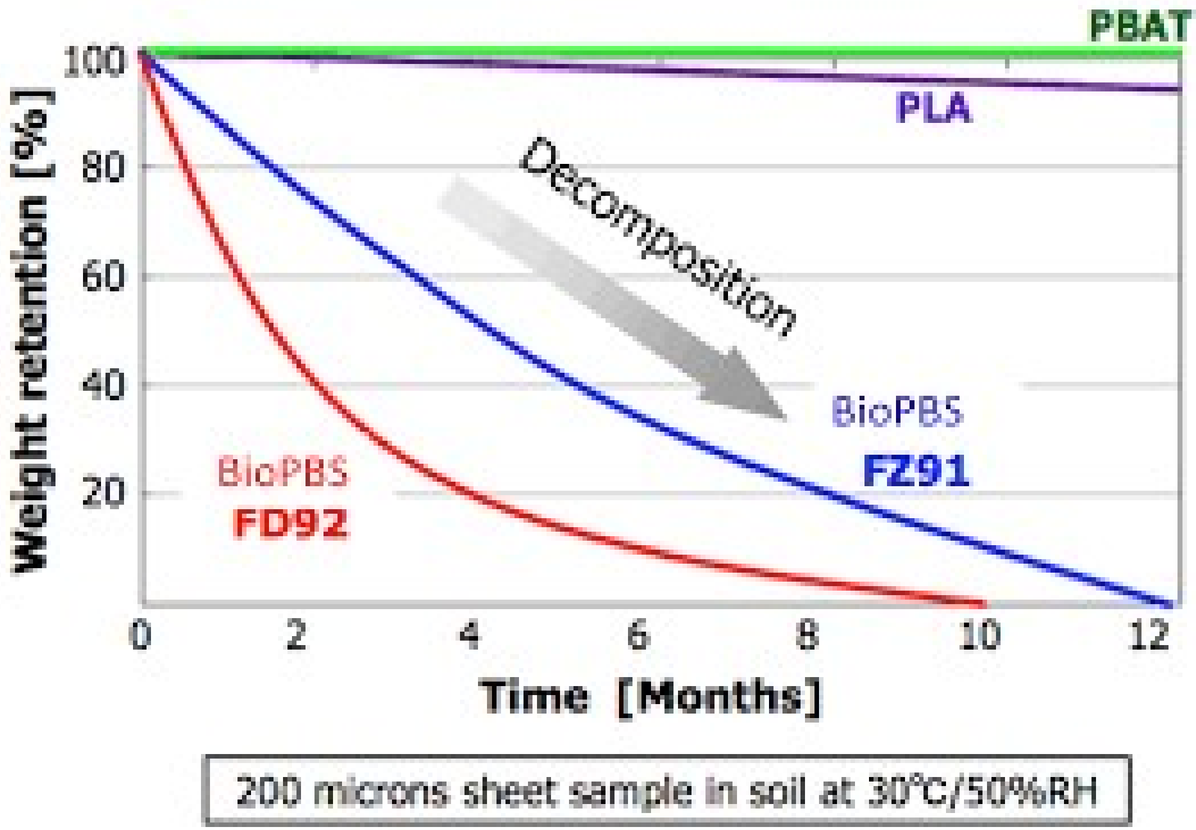


It's tough. It performs. But it's biodegrable too. It leaves town when the job's done. A real bio-based silver bullet, kemosabe.

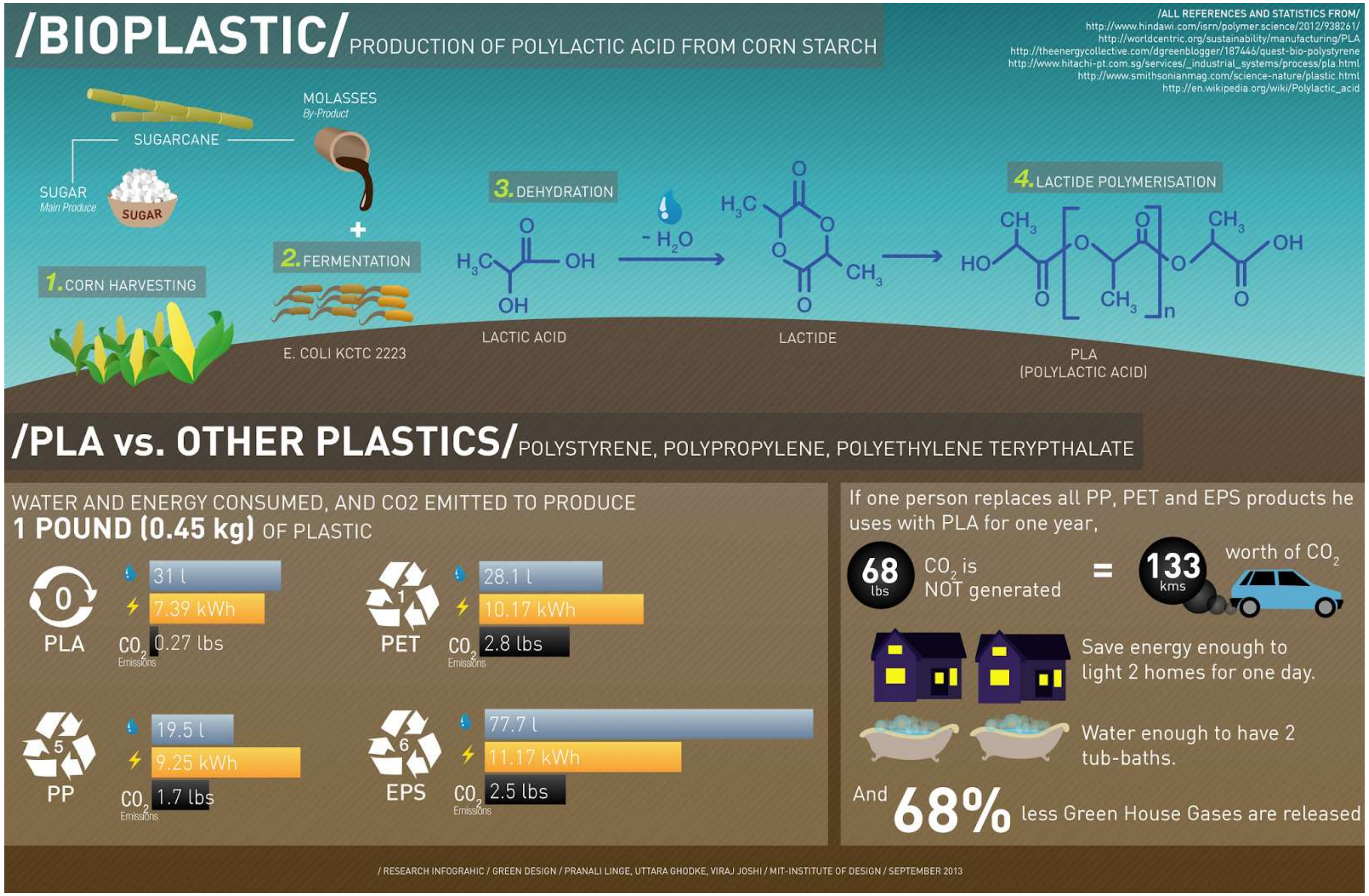
Reverdia, Wageningen UR Food & Biobased Research in hook-up to advance on biobased PBS.

Bioplastics: biodegradable PBS

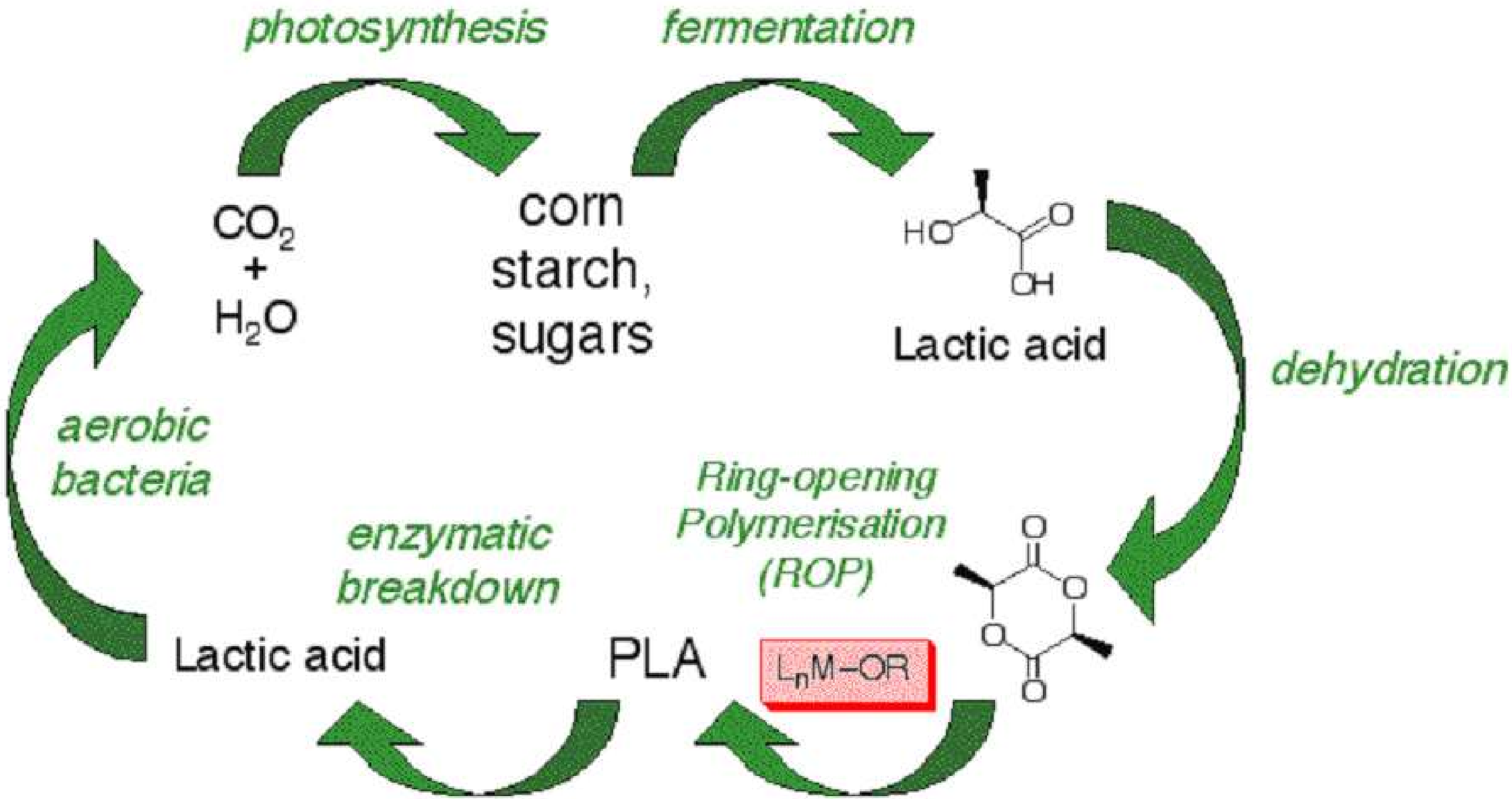
Bioplastics: biodegradable PBS



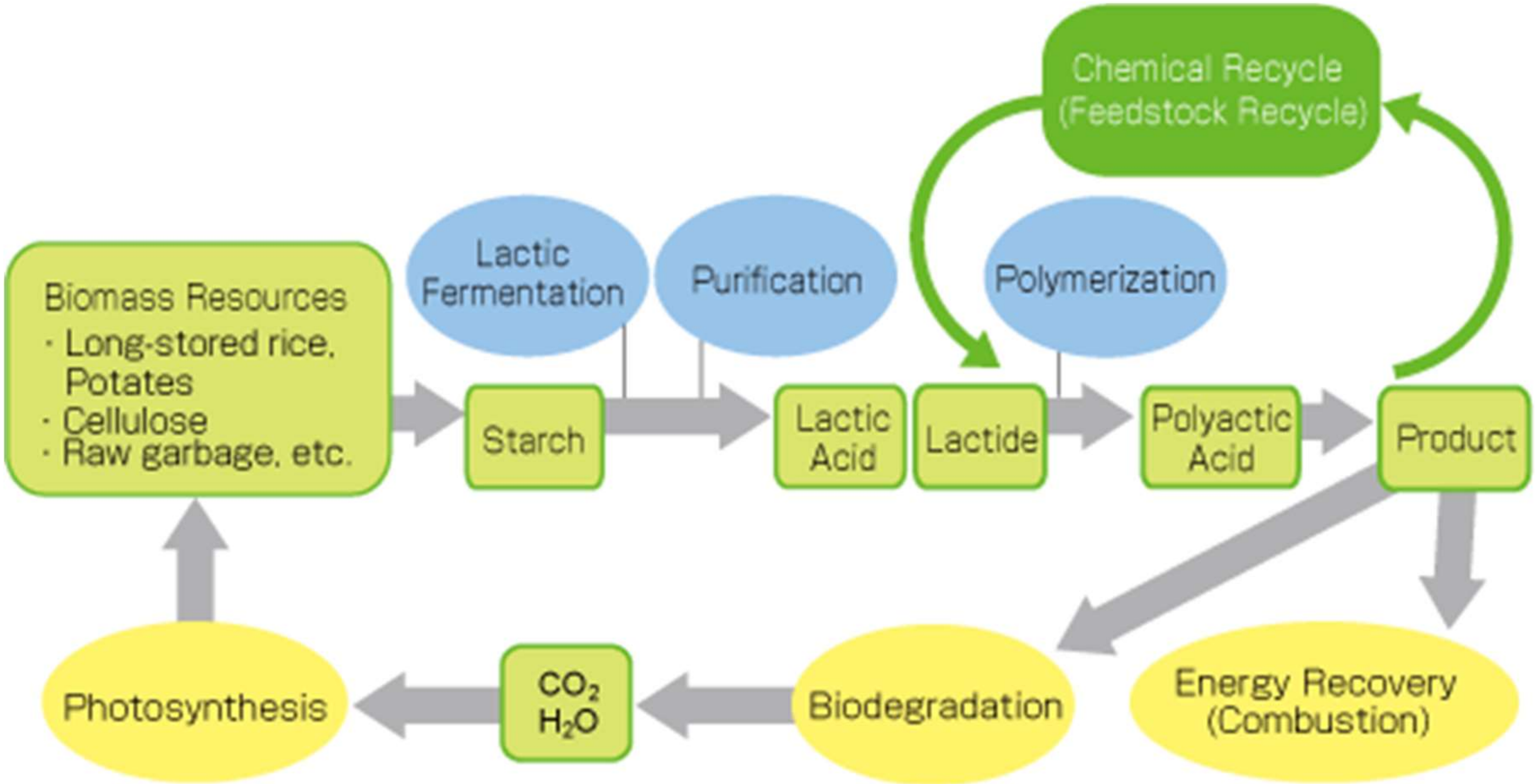
Bioplastics: compostable PLA



Bioplastics: compostable PLA



Bioplastics: compostable PLA



Bioplastics: compostable PLA

Bioplastics: compostable PLA