



May 23 - 2019

Parco Tecnologico Comune di Capannori - Segromigno in Monte - Lucca



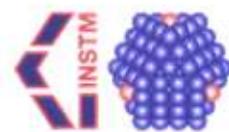
PLASTIC AGE & CIRCULAR ECONOMY By Emo Chiellini



Former Full Professor



Former Chairman



Co-Founder & Former S. C. Member



Chairman

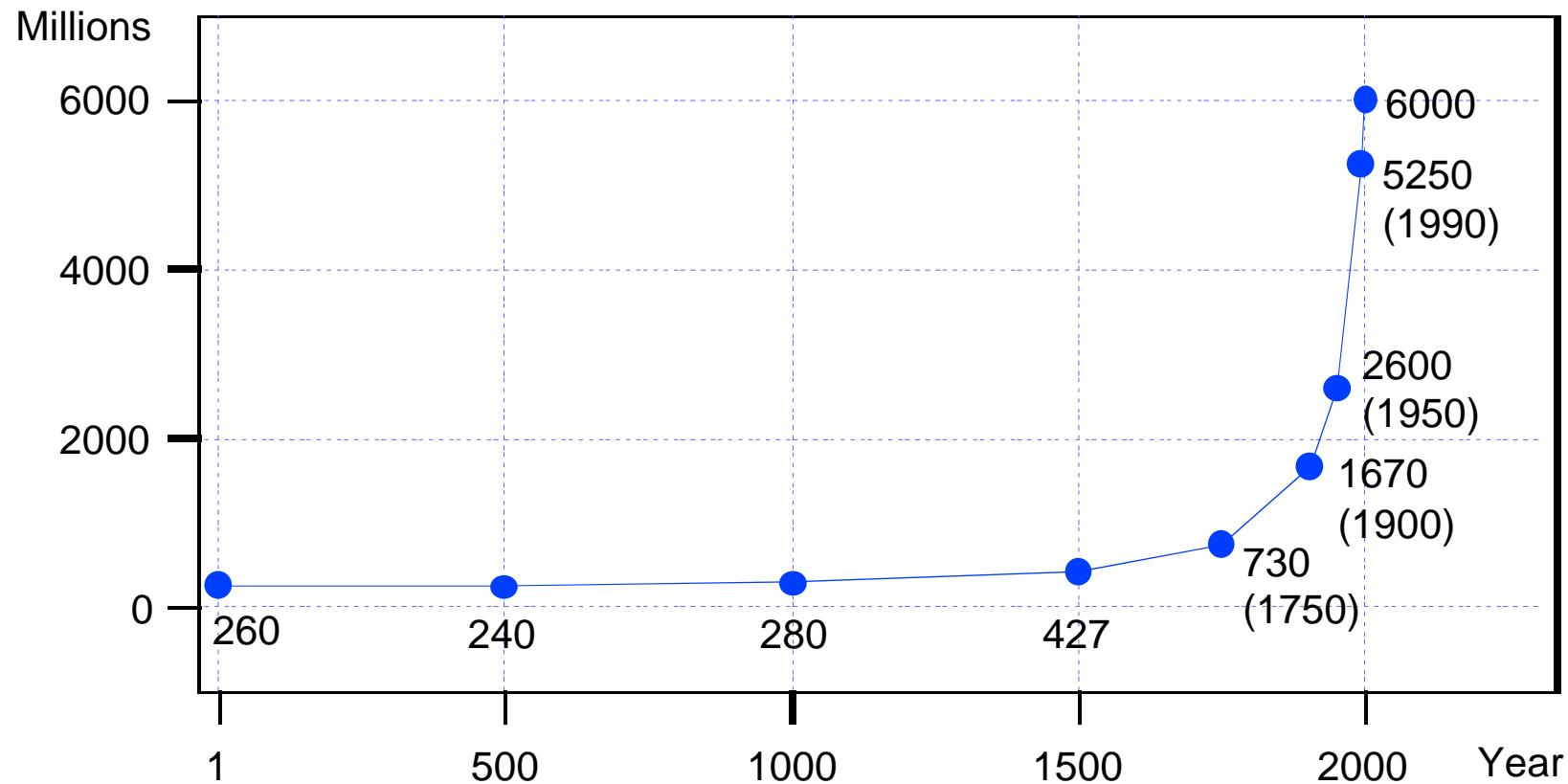


Assignee Giulio Natta
Chemistry Award 2018



Growth of World Population

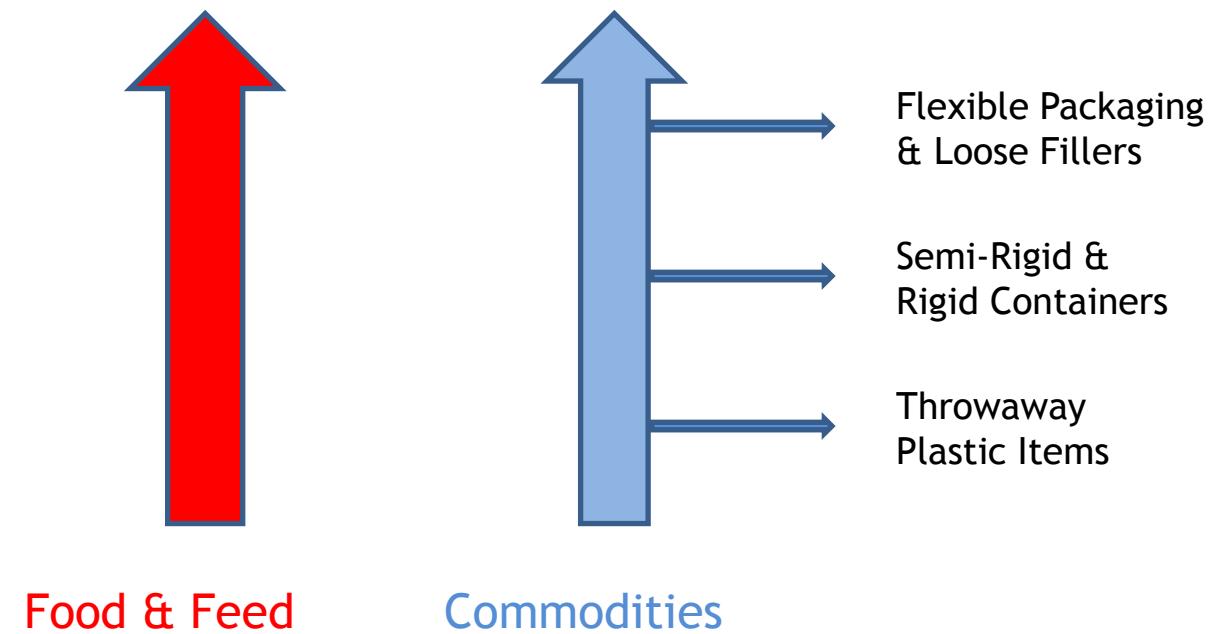
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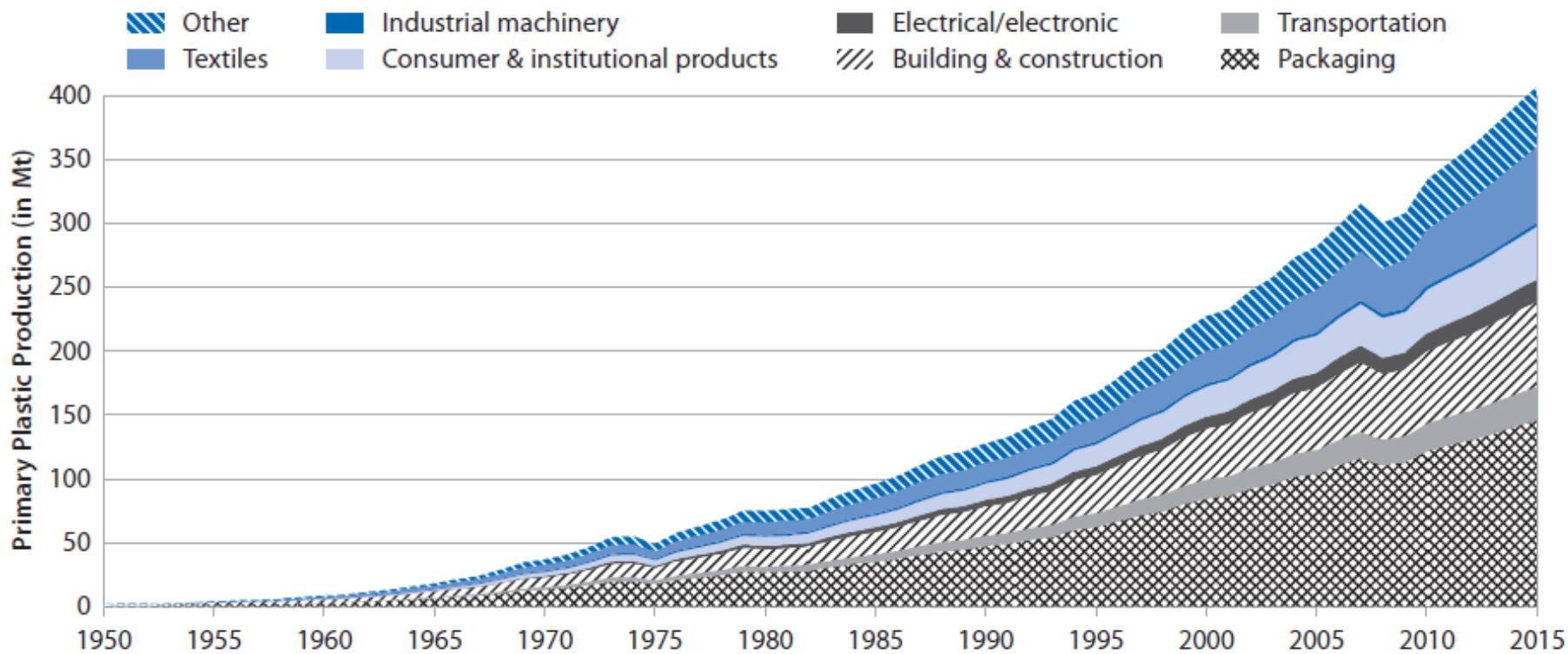
Growing of Needs vs Growing of Population





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Global Primary Plastics Production by Sector, 1950 to 2015 (million tonnes)

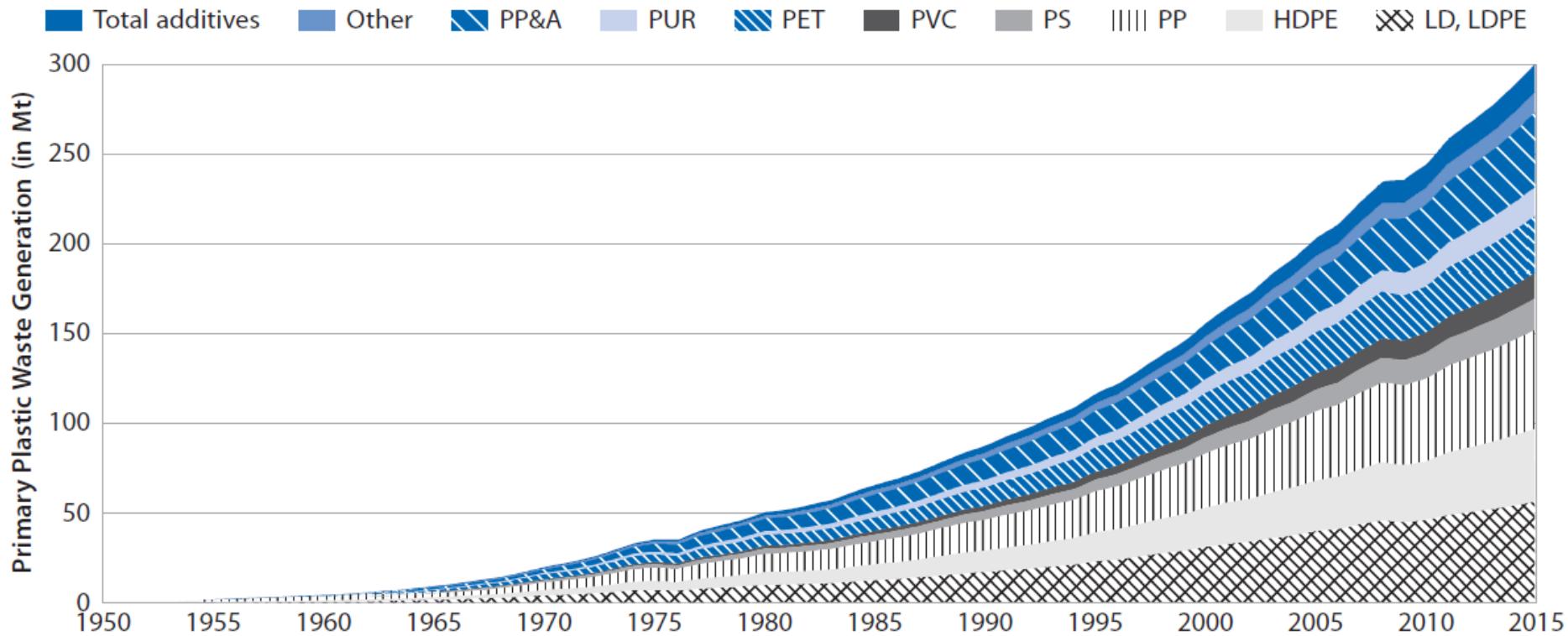


Geyer, Jambeck and Law (2017[1]), Production, use, and fate of all plastics ever made, <http://bit.ly/2uBs8AT>.



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Global Plastics Waste Generation by Polymer (million tonnes), 1950 to 2015



Geyer et al. (2017), *Production, use, and fate of all plastics ever made*, <http://bit.ly/2uBs8AT>.



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Improving Markets for Recycled Plastics Trends, Prospects and Policy Responses

**Improving Markets
for Recycled Plastics**
TRENDS, PROSPECTS AND POLICY RESPONSES



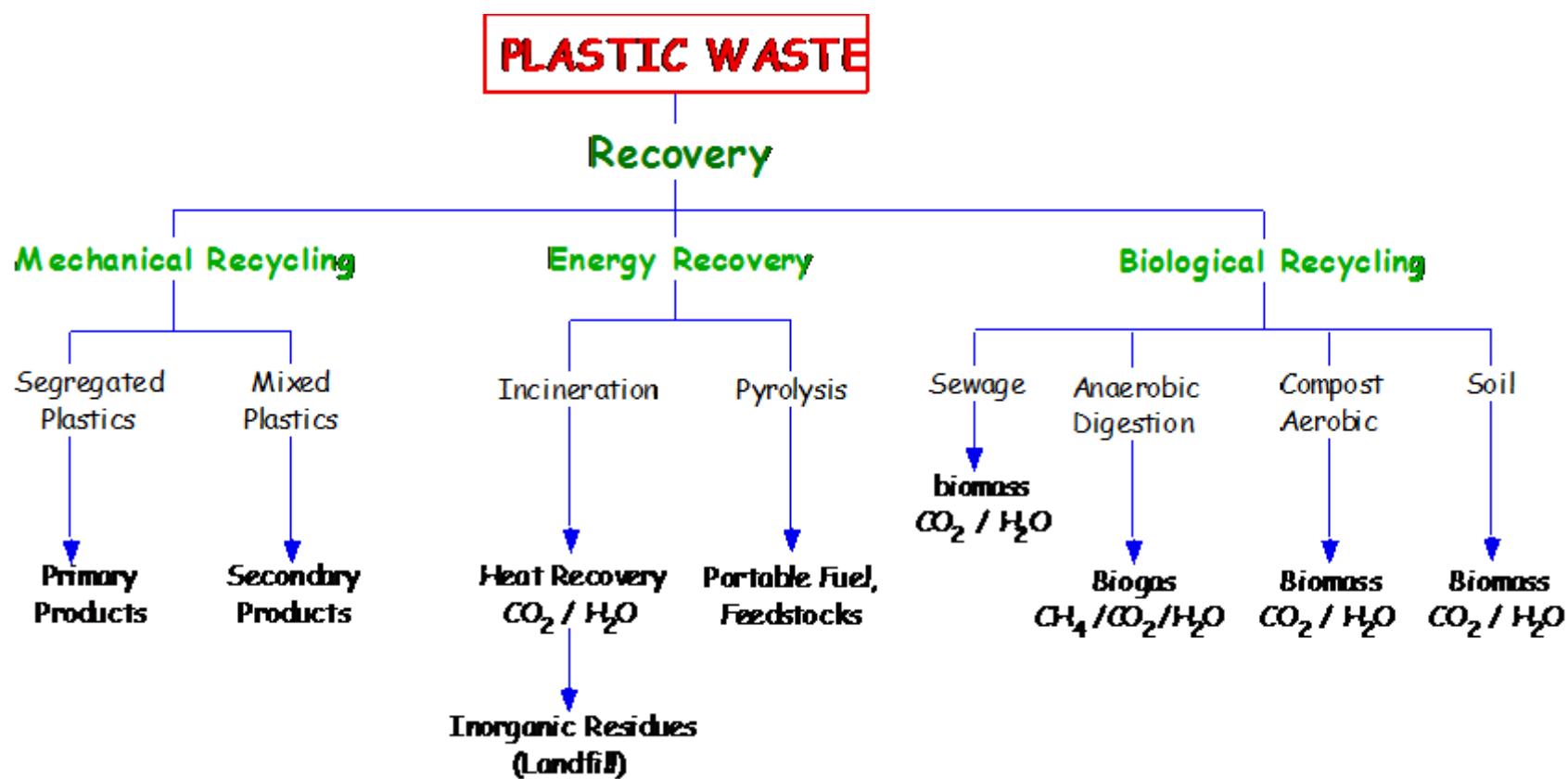
The image shows a large, dense pile of crushed plastic bottles against a blue background. A green line graph with an upward-pointing arrow is overlaid on the pile, symbolizing growth and improvement in the market for recycled plastics.

OECD



Plastic Waste Management Options

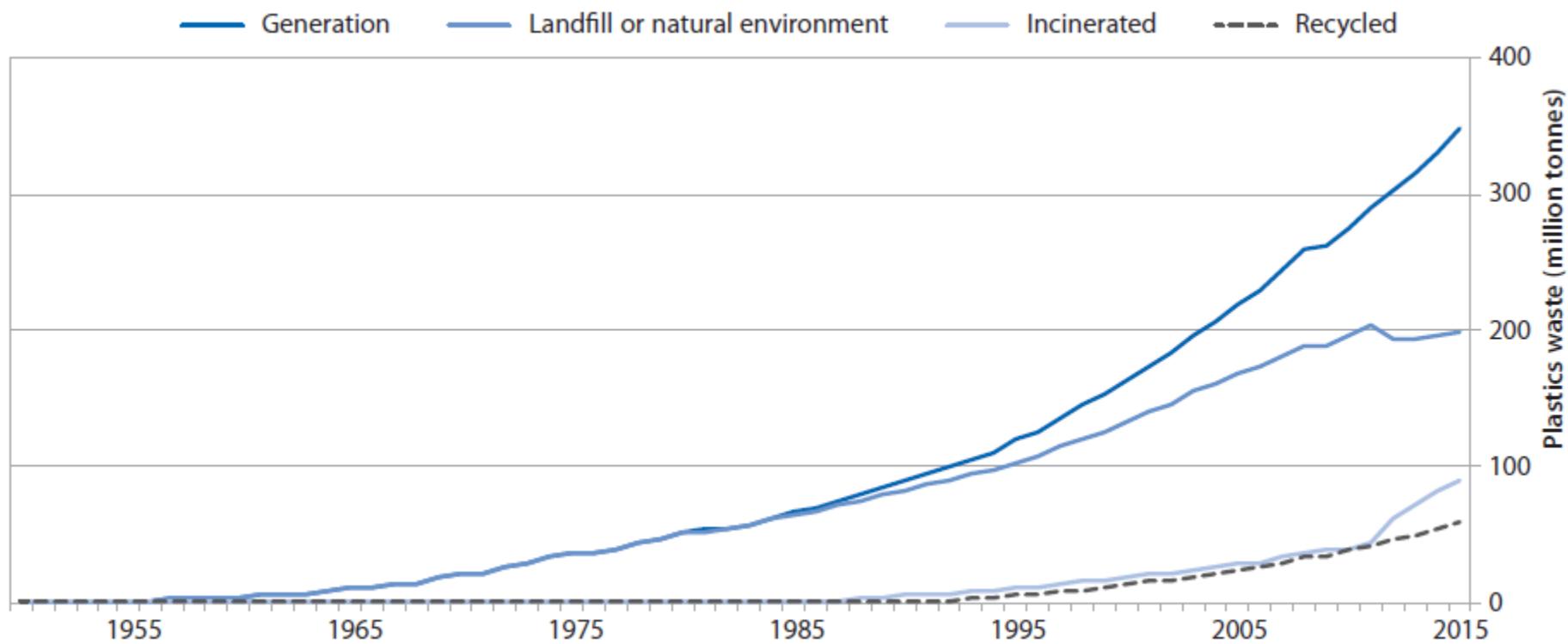
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Global Plastics Waste Generation, Recycling, Incineration, and Disposal: 1950 to 2015

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OECD, based on data from Geyer, Jambeck and Law (2017[1]), Production, use, and fate of all plastics ever made, <http://bit.ly/2uBs8AT>.



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Biopolymers, Facts and Statistics



IfBB
Institute for Bioplastics
and Biocomposites



Biopolymers

facts and statistics

2016

H

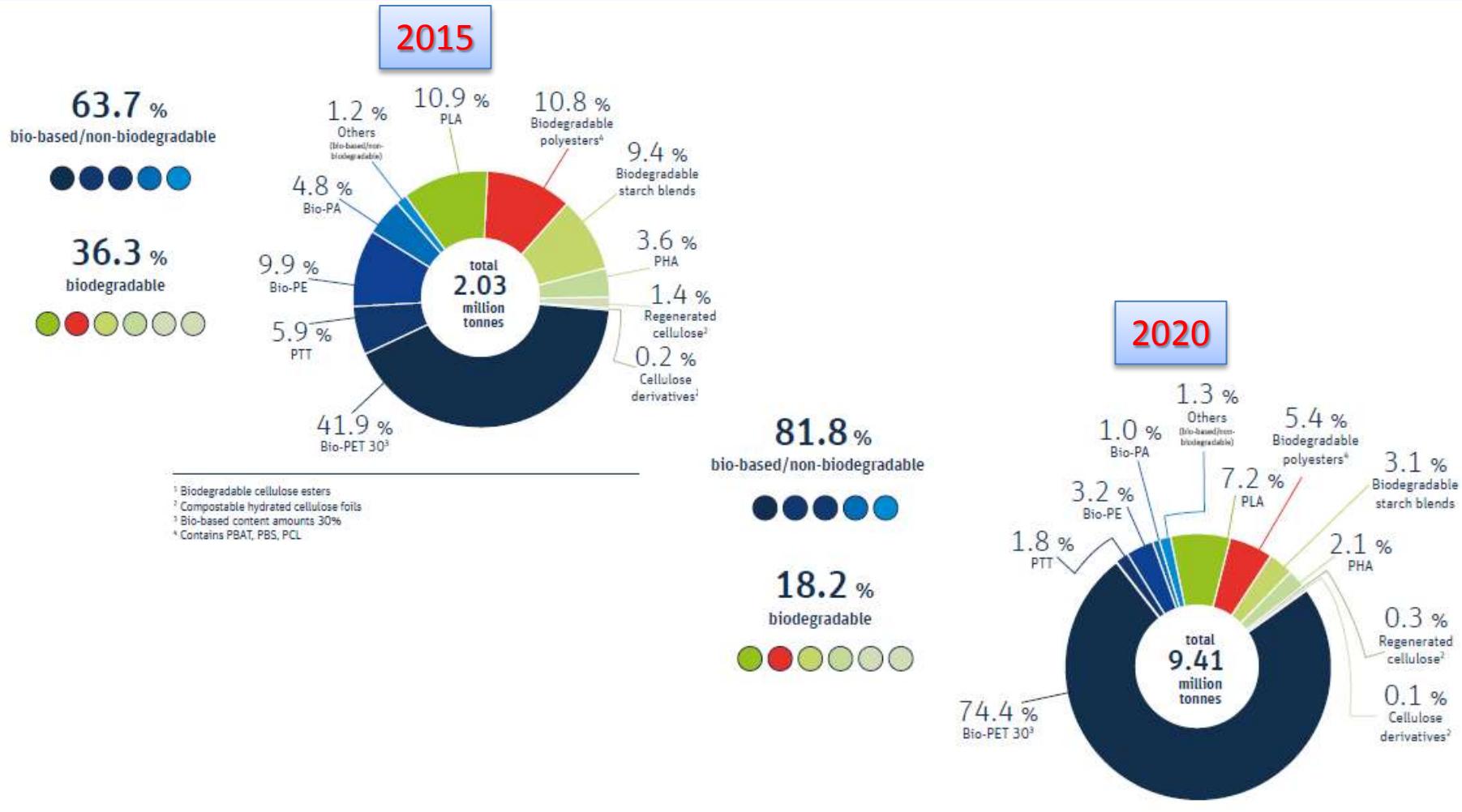
HOCHSCHULE
HANNOVER
UNIVERSITY OF
APPLIED SCIENCES
AND ARTS

Fakultät II
Maschinenbau und
Bioverfahrenstechnik



New Economy “Bioplastics” Production Capacities by Material Type 2015-2020

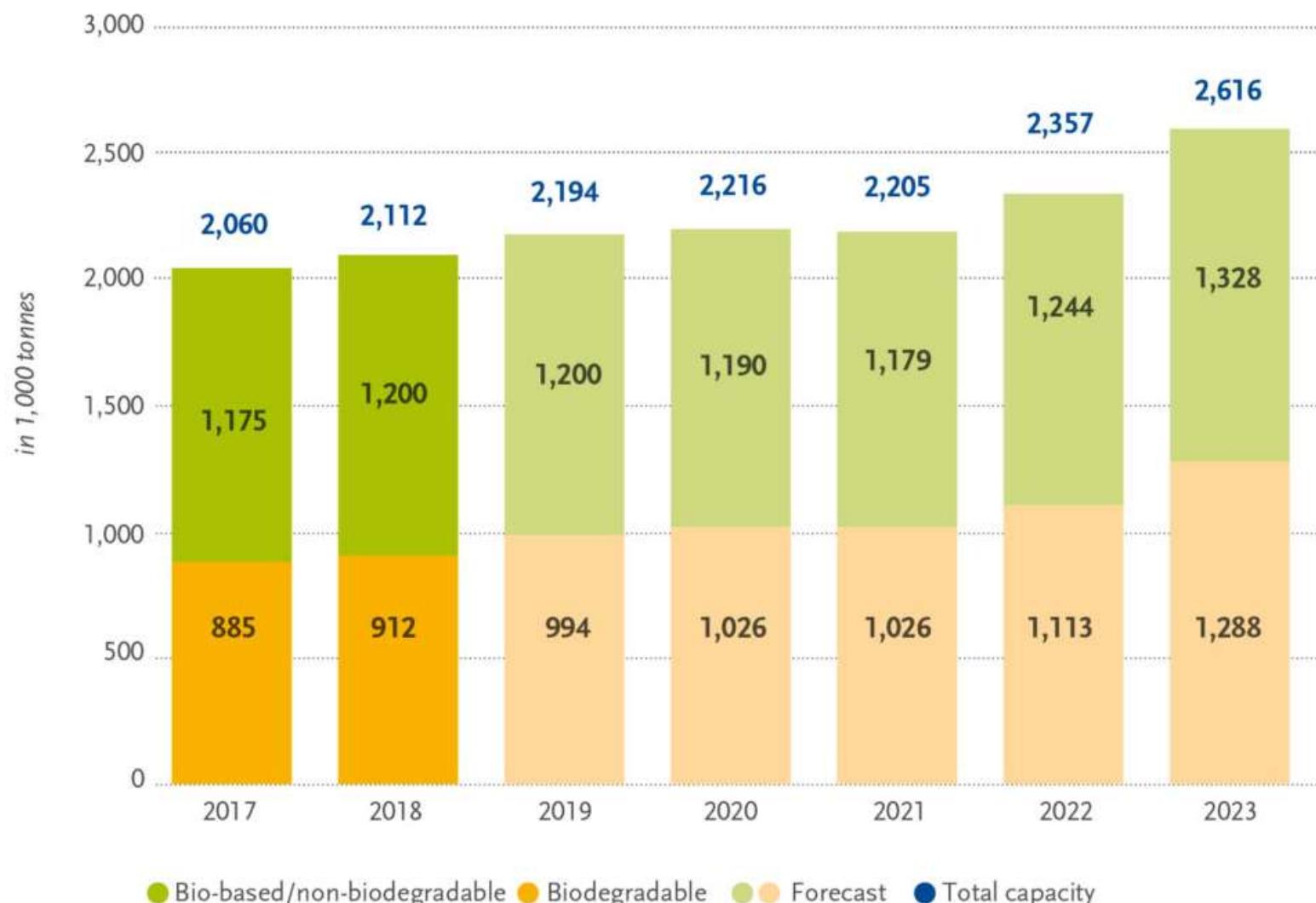
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Global Production Capacities of Bioplastics

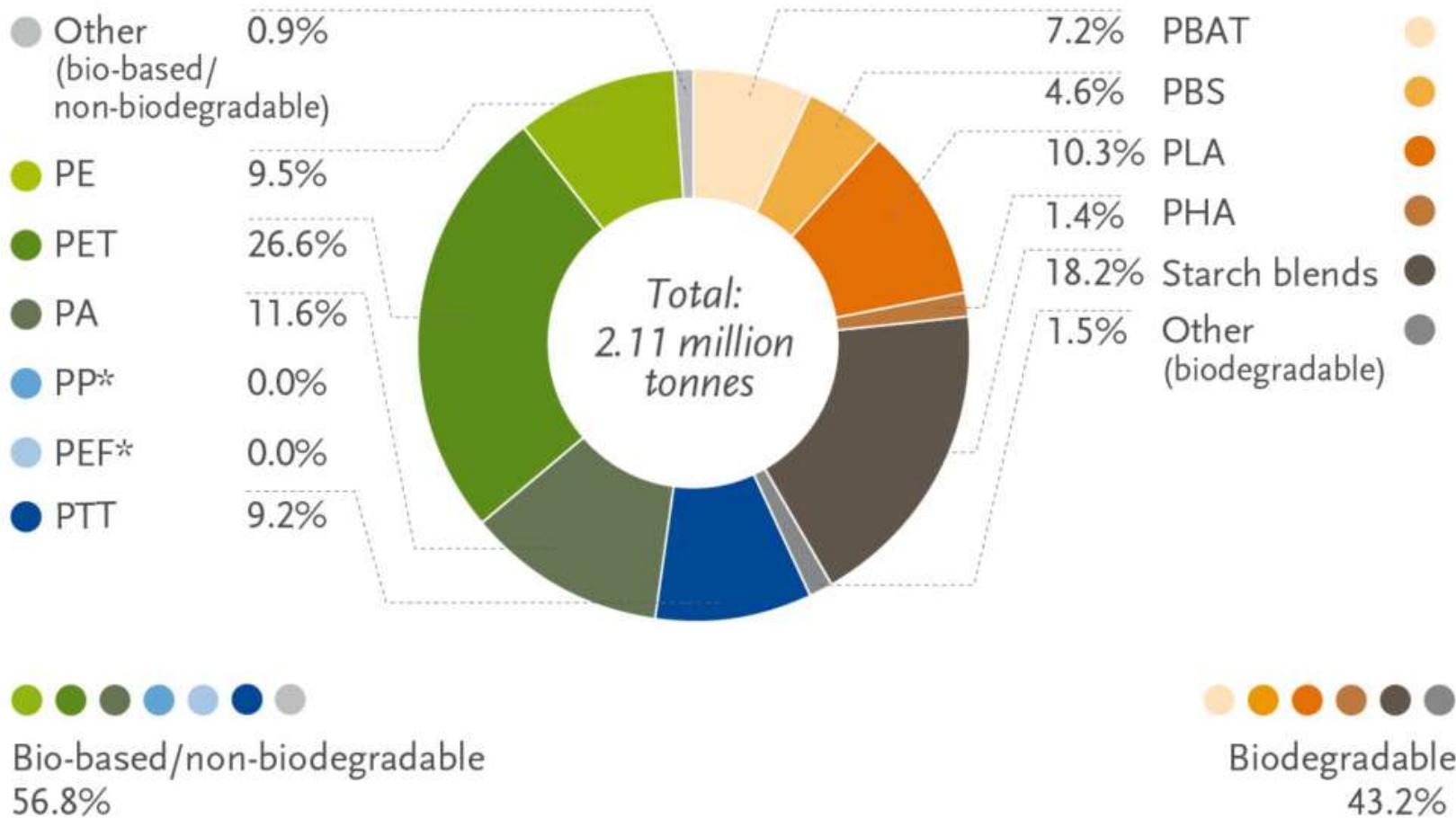
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Global Production Capacities of Bioplastics 2018 (by material type)



*Bio-based PP and PEF are currently in development and predicted to be available at commercial scale in 2023



Global Production Capacities of Bioplastics 2018 (by Region)

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Total:
2.11 million tonnes

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

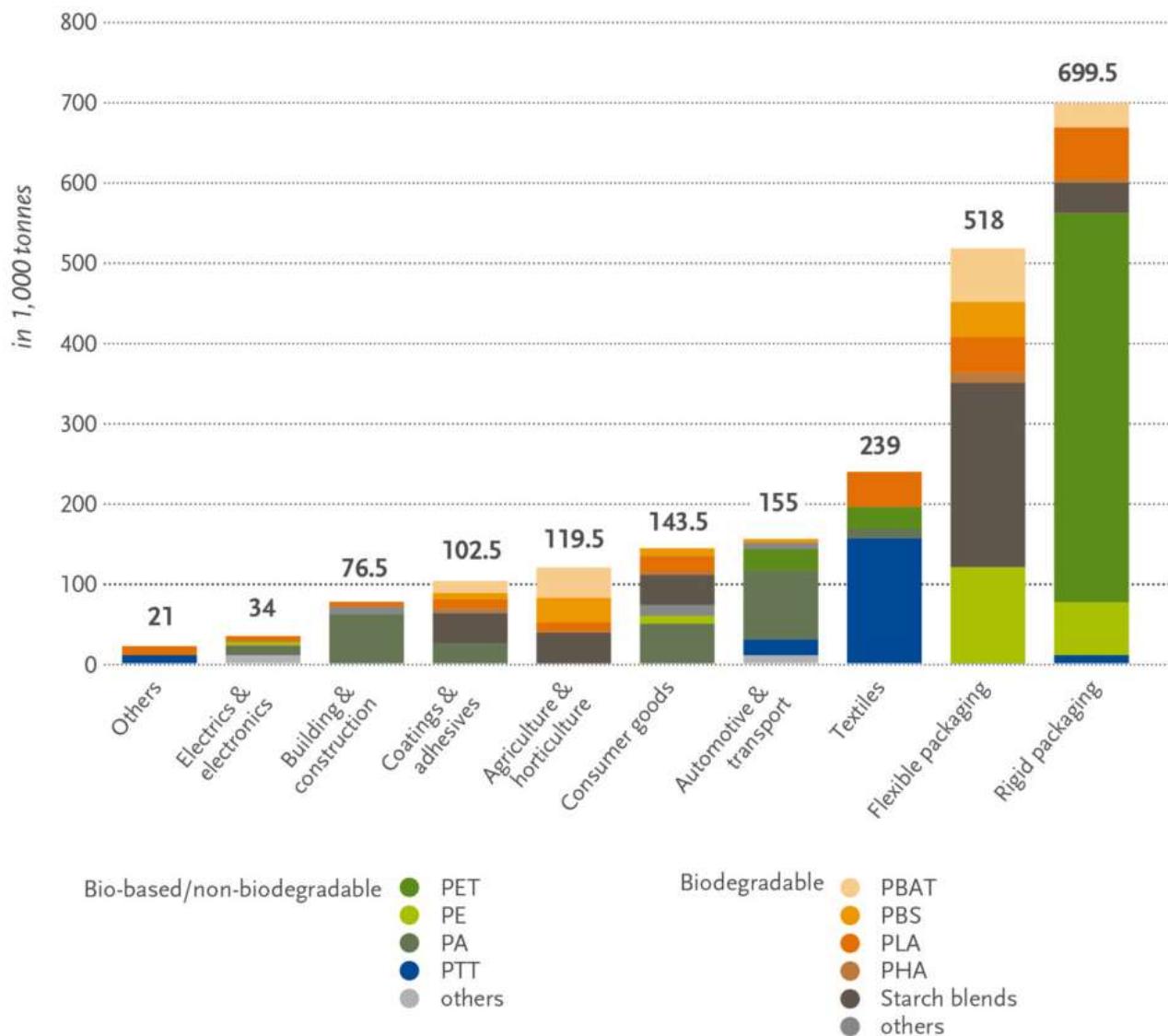


European Bioplastic, nova-Institute 2018, www.european-bioplastics.org/market



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Global Production Capacities of Bioplastics 2018 (by Market Segment)





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Bio-based Polymeric Materials

Mass Balance for 1 ton. Production

Polymer Type	Flow Materials		
	Type	Amount (Ton)	Reaction Steps (Nr)
PE	Potato	27.5	7
	Corn	7.0	7
	Wheat	10.9	7
PLA	Potato	9.3	5
	Corn	2.4	5
	Wheat	3.5	5
	Sugar Beet	9.2	4
PET-100	Sugar Cane	11.3	4
	Potato	17.9	9
	Corn	4.6	9
	Wheat	7.0	9
	Sugar Beet	17.6	8
	Sugar Cane	21.7	8

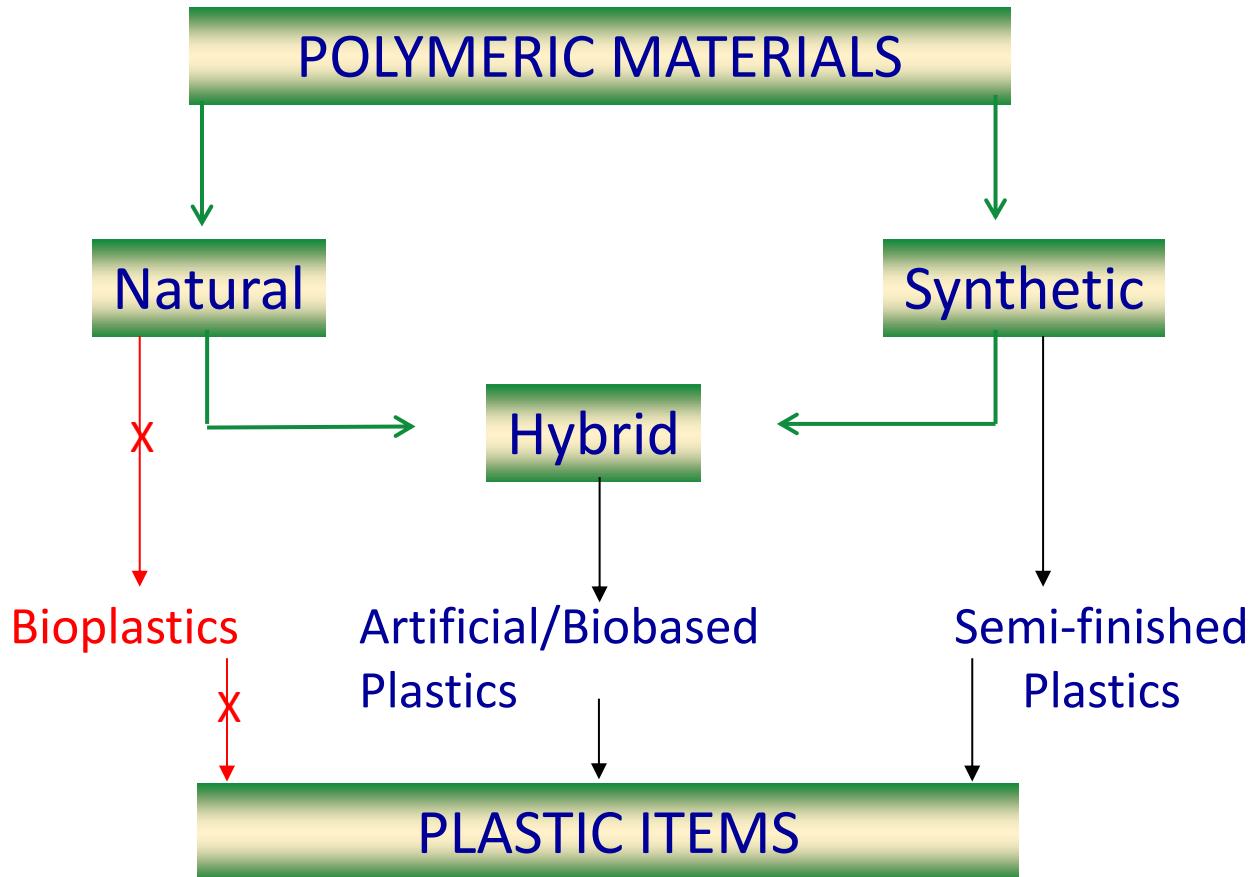
*PET-30
Raw Material ca. 25%



Biodegradable Polymeric Materials & Plastics Nomenclature

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HYDRO-BIODEGRADABLE

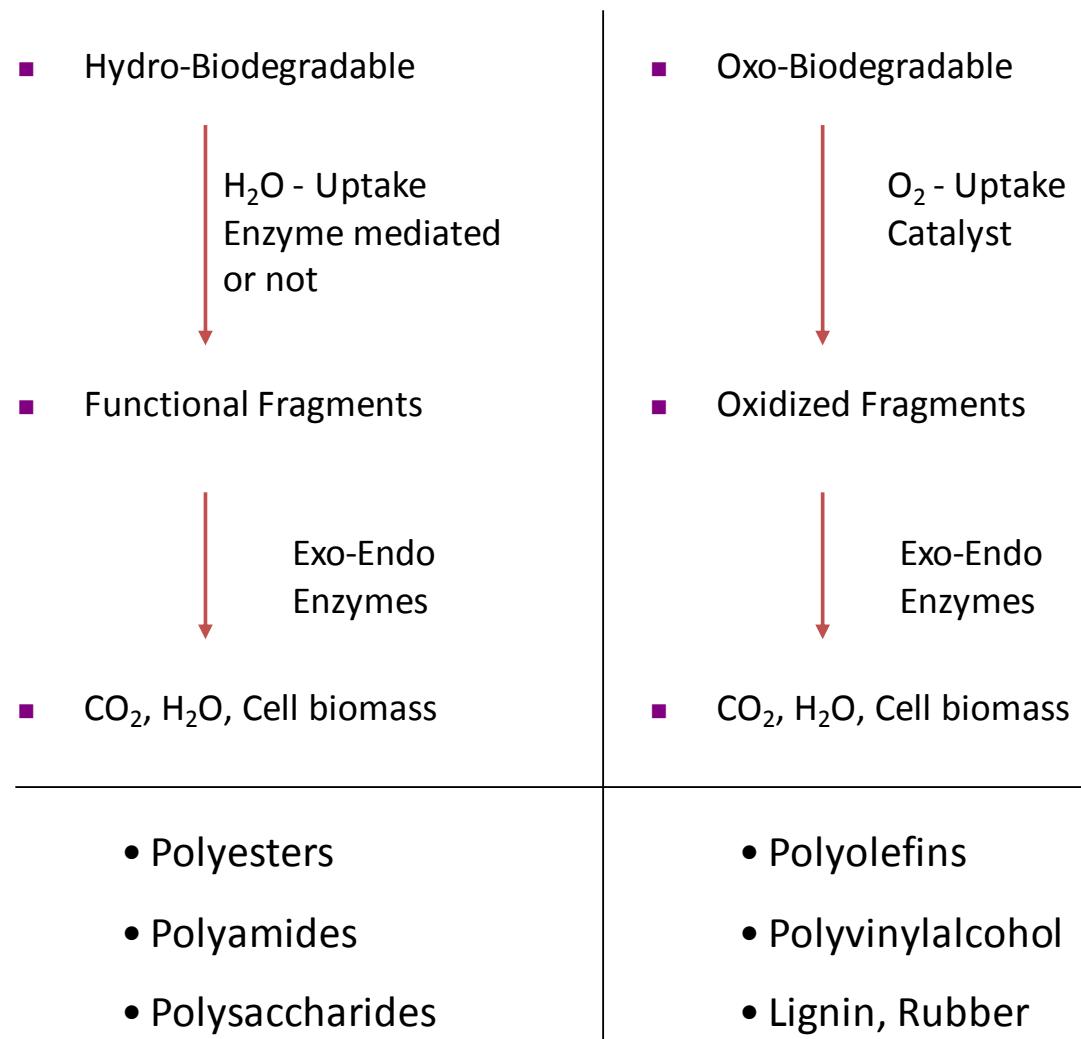


OXO-BIODEGRADABLE



Environmentally Degradable Polymers & Plastics

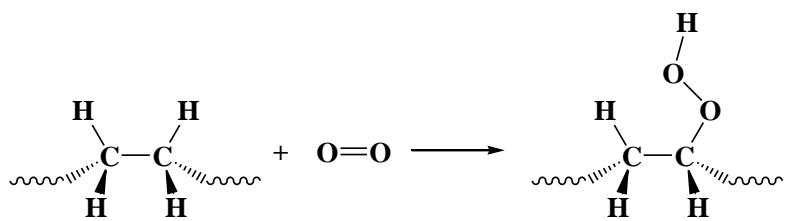
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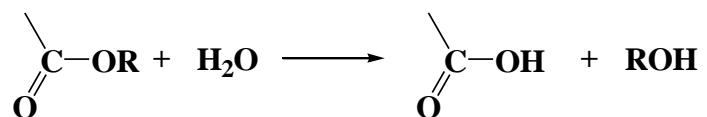
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Energetics Profiles in Oxo- & Hydro-Biodegradables Primary Steps



$$E_{att} = (E_{O-H} + E_{O-O} + E_{C-O}) - (E_{C-H} + E_{O=O})$$

$$E_{att} = +50.6 \text{ Kcal/mole}$$



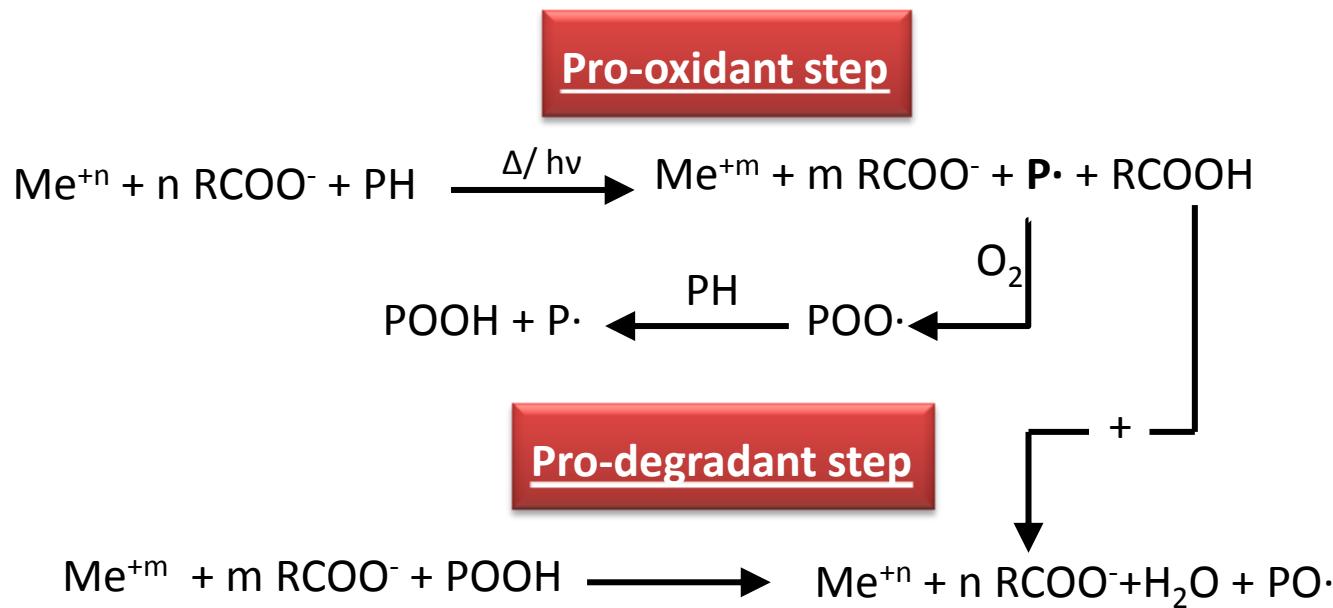
$$E_{att} = (E_{C-OH} + E_{O-H}) - (E_{C-OR} + E_{O-H})$$

$$E_{att} = + 3.3 \text{ Kcal/mole}$$



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Tandem Role of Pro-oxidant/Pro-degradant Additives



Me: Fe, Mn, Co

PH = PE or PP

Me

		E° (Volt)
Fe^{+3}	$+ \text{e}^- \longrightarrow \text{Fe}^{+2}$	+0.77
Mn^{+3}	$+ \text{e}^- \longrightarrow \text{Mn}^{+2}$	+1.54
Co^{+3}	$+ \text{e}^- \longrightarrow \text{Co}^{+2}$	+1.83



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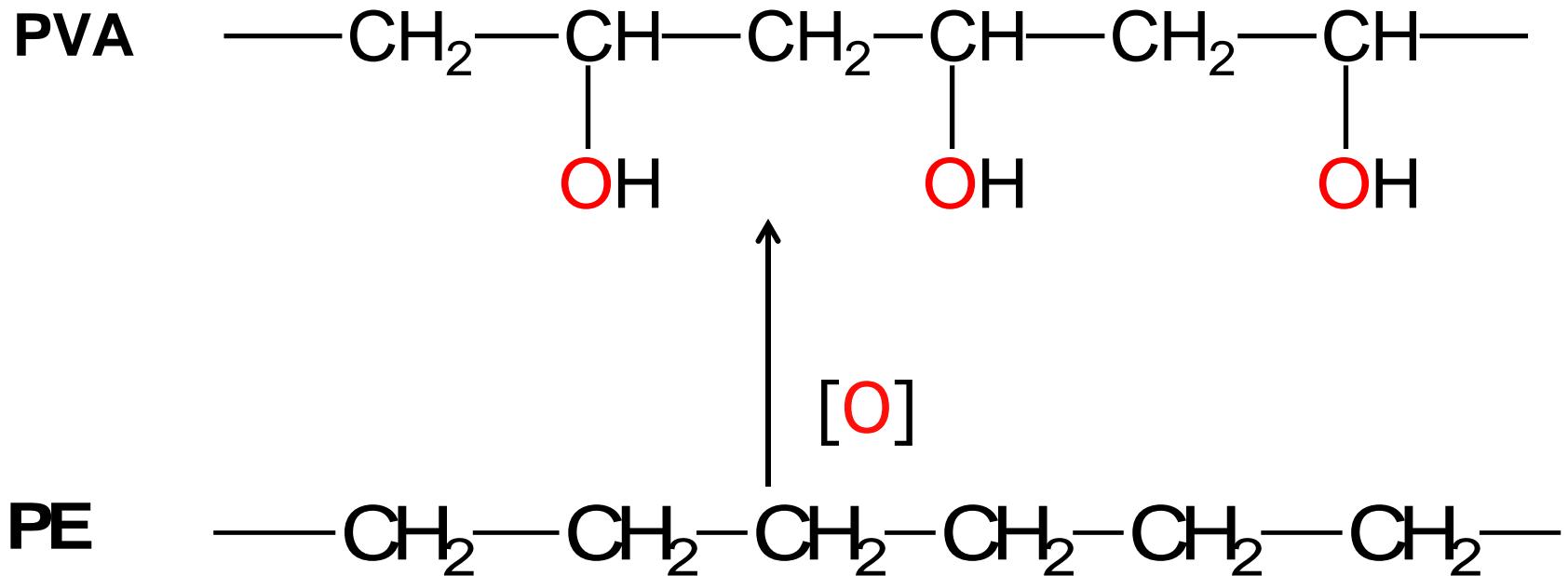
Full Carbon Backbone Synthetic Polymers

- Polyethylene - TDPA
- Polypropylene - TDPA
- Polystyrene - TDPA
- Poly(vinylalcohol) PVA
- Polyisobutene
- Polybutadiene
- Polyisoprene
- Poly(vinyl chloride)
- Poly(cyanoacrylates)
- Poly(alkyl acrylates)
- Poly(alkyl metacrylates)
- Poly(acrylonitrile)
- Poly(acrylamide)
- Poly(vinyl amine)



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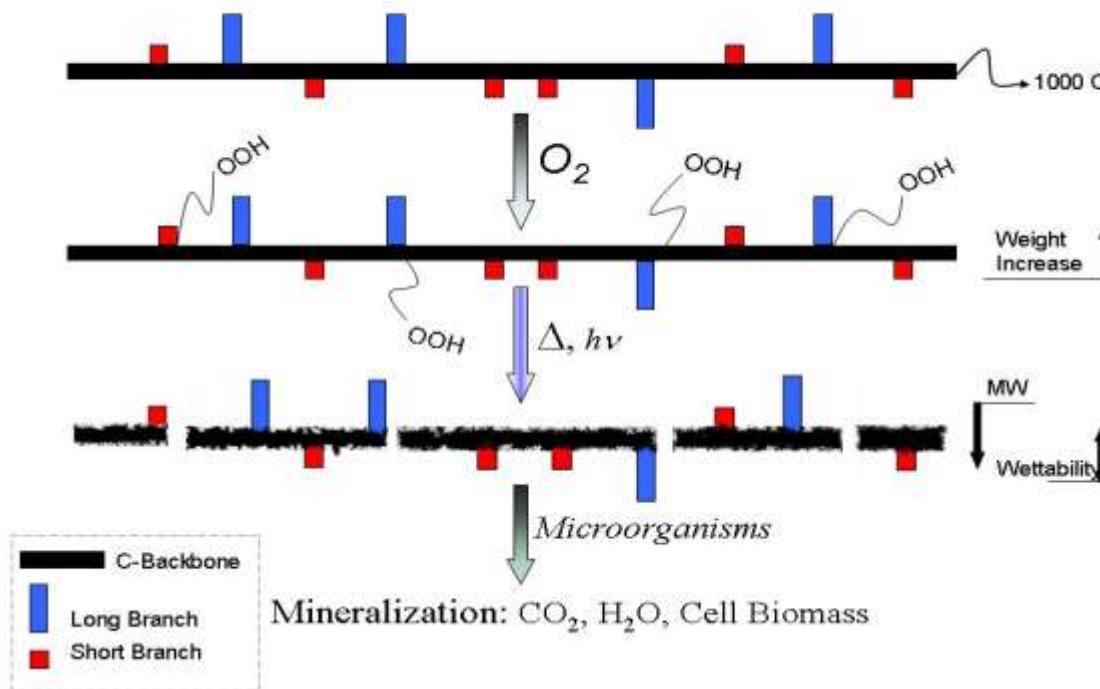
Oxo-Biodegradable Full Carbon Backbone Polymers





Schematic Representation of PE* Oxo-Degradation

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- Parameters to be monitored:
- 1. Weight increase; 2. Carbonyl index; 3. Wettability;
- 4. Molecular weight; 5. Solvent extraction



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Biotech Production PHAs from Fragmented Poly(hydrocarbon)s

- "Oxidized Polyethylene Wax as a Potential Carbon Source for PHA Production."
I. Radecka , V. Irorere, G. Jiang, D. Hill, C. Williams, G. Adamus, M. Kwiecień, A. A. Marek, J. Zawadiak, B. Johnston, M . Kowalcuk.
Materials, 9(5), 367 (2016)
- "The Molecular Level Characterization of Biodegradable Polymers Originated from Polyethylene Using Non-Oxygenated Polyethylene Wax as a Carbon Source for Polyhydroxyalkanoate Production."
B. Johnston,G. Jiang, D. Hill, G. Adamus,I. Kwiecień,M. Zięba, W. Sikorska, M. Green, M. Kowalcuk, I. Radecka
Bioengineering , 4(3), 73 (2017)
- "The Microbial Production of Polyhydroxyalkanoates from Waste Polystyrene Fragments Attained Using Oxidative Degradation"
B. Johnston, I. Radecka, D. Hill, E. Chiellini, V. I. Ilieva,W. Sikorska, M. Musioł, M. Zięba, A. A. Marek, D. Keddie, B. Mendrek, S. Darbar, G. Adamus and M. Kowalcuk
Polymers, 10, 957 (2018)



Microorganism Capable of Hydrocarbons Oxidation

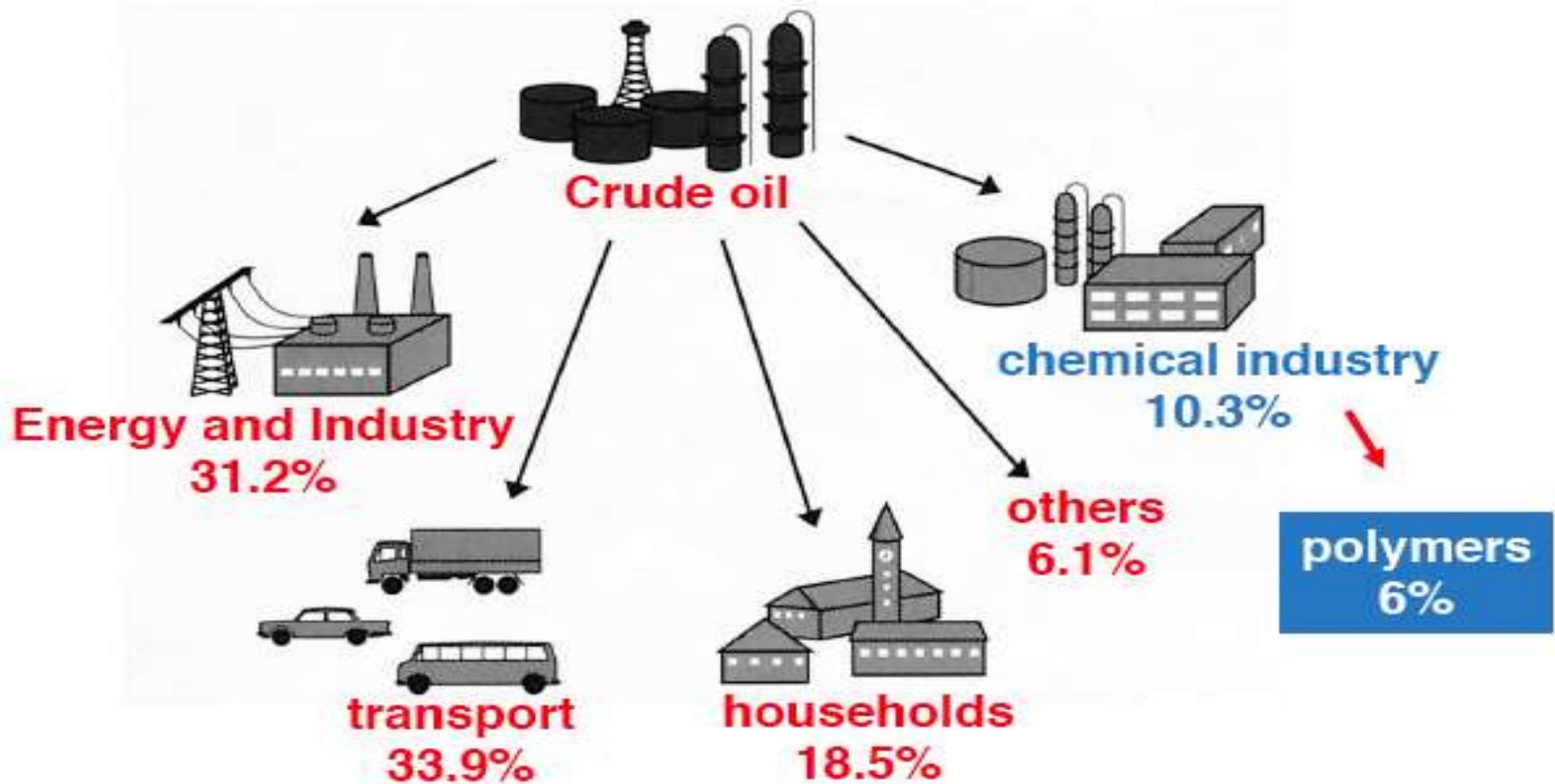
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Bacteria		Yeast - Algae- Fungi
<i>Achromobacter</i>	<i>Pseudomonas</i>	<i>Candida</i>
<i>Acinetobacter</i>	<i>Spirillum</i>	<i>Cryptococcus</i>
<i>Actinomyces</i>	<i>Stenotrophomonas</i>	<i>Debaryomyces</i>
<i>Aeromonas</i>	<i>Rhodococcus</i>	<i>Endomyces</i>
<i>Alcaligenes</i>	<i>Vibro</i>	<i>Hansenula</i>
<i>Arthrobacter</i>		<i>Mycotorula</i>
<i>Bacillus</i>		<i>Pichia</i>
<i>Beneckeia</i>		<i>Rhodotorula</i>
<i>Brevibacterium</i>		<i>Saccharomyces</i>
<i>Corynebacterium</i>		<i>Selenotila</i>
<i>Flavobacterium</i>		<i>Sporidiobolus</i>
<i>Micromonospora</i>		<i>Sporobolomyces</i>
<i>Mycobacterium</i>		<i>Torulopsis</i>
<i>Nocardia</i>		<i>Trichosporon</i>
<i>Phormidium</i>		<i>Zalerian</i>



From Feedstocks to Polymers Consumption of Mineral Oil (Typical Pattern of Developed Countries)

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Energy Resources Alternative to Crude Oil

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- Solar [600 sq. Km of solar panels in the Sahara desert]
- Biomass & 2nd Generation Biofuel
- Hydroelectric
- Aeolian
- Hydrogen
- Nuclear



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Bio-based and Fossil Fuel-based Plastics Coexistence Year 2012

The book cover features a green background with diagonal light-green stripes. At the top, the title 'PLASTICS AND SUSTAINABILITY' is written in large, bold, black capital letters. Below the title is a subtitle in a smaller, italicized font: 'Towards a Peaceful Coexistence between Bio-based and Fossil Fuel-based Plastics'. In the center is a photograph showing a man with glasses looking out from a window at a landscape of green fields and trees. The author's name, 'MICHAEL TOLINSKI', is printed below the photo. At the bottom left is the Wiley logo, and at the bottom right is the Scrivener logo, which consists of a stylized 'S' and 'P' intertwined.

PLASTICS AND
SUSTAINABILITY

*Towards a Peaceful Coexistence between
Bio-based and Fossil Fuel-based Plastics*

MICHAEL TOLINSKI

WILEY

Scrivener



Greetings from my Hunting German Pointers

May 23 - 2019

