



# **Bio-based and CO<sub>2</sub>-based polymers**

## **Markets, frameworks, hurdles and opportunities**

**Green Chemistry - White Biotechnology**  
**Cherleroi, 08 May 2019**

**Achim Raschka**  
**(Head of Markets & Technology)**  
**nova-Institut GmbH, Hürth (Cologne), Germany**



# Bio-based & CO<sub>2</sub>-based Economy

## Departments

- Sustainability
- Economy & Policy
- Technology & Markets
- Communication

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# nova-Institut GmbH – SME

private and independent research institute  
interdisciplinary, international team



- **Founded in 1994**
- **Turnover 3.0 mln € / year**
- **30 employees**





# Selected customers from industry, associations and public as well as political institutions



## Associations/Clusters/NGOs

AVK (DE), APAG (EU), BIC (EU), BioEconomy Cluster (DE), Birdlife (EU), CEFIC (EU), CLIB2021 (DE), CO<sub>2</sub> Value Europe (EU), EIHA (EU), EPF (EU), European Bioplastics (EU), IAR (FR), IBB (DE), VHI (DE), WWF (US/DE)

## Automotive Industry

Brose (DE), BMW (DE), Mercedes/Daimler (DE), Dräxlmaier (DE), Faurecia (DE), Ford (DE), Johnson Controls (DE), Porsche (DE), Quadrant (DE), VW (DE)

## Chemistry, Plastics & Other Materials

Anellotech (US), BASF (DE/CA), Borregaard (NO), BRAIN (DE), Corbion (NL), Covestro (DE), CropEnergies (DE), DuPont (US/DE), Elastopoli (FI), EnobraQ (FR), Eridania Sadam (IT), Evonik (DE), ExxonMobil Chemical (BE/US), FKUR (DE), Gidotec (FI), Global Green Chemicals (THA), Golden Compound (DE), Honeywell (US), Hyne Timber (AU), InfraServ (DE), Kraton (US), Mondi (AT), Neste (FI), PCC SE (DE), Peter Greven (DE), SABIC (NL/SA), Stora Enso (SE), Südzucker (DE), Suiker Unie (NL), Synvina (NL), Teijin (JP), Total (FR), UPM (FI)

## End Applications

Colruyt (BE), ESE Expert (DE), geobra Brandstätter Stiftung/PLAYMOBIL® (DE), IKEA (SE), Kosche (DE),

Lego (DK), Leifheit (DE), Logocos (DE), Nestlé (CH), Neudorff (DE), REWE (DE), Velux (DK), WhiffAway (UK)

## Consulting & Financing

AFC Consulting (DE), Blezat Consulting (FR), Boston Consulting Group (DE), Clever Consult (BE), ClouPartners (DE), Deloitte (NL), E4Tech (UK), Ecorys (FR), Ernst & Young (FR/DE), Inter-American Development Bank (US), KPMG (MY), meó Consulting (DE)

## Engineering

Coperion (DE), Ferrostaal (DE), Reifenhäuser (DE), Uhde-Inventa Fischer (DE)

## Ministries & Institutions

BBI (EU), BBI-JU (EU), BfN (DE), BMBF (DE), BMELV (DE), DBU (DE), DECC (UK), DEFRA (UK), European Commission (EU), FAO (IT), FNR (DE), GIZ (DE), KfW (DE), Ministry of Economic Affairs (NL), Netherlands Enterprise Agency (NL), NIA (TH), UBA (DE)

## Research Institutes

Fraunhofer UMSICHT (DE), HS Bremen (DE), IFEU (DE), INNVENTIA (SE), INRA (FR), Joint Research Centre (EU/SP), London Imperial College (UK), Öko-Institut (DE), RAPRA (UK), VTT (FI), Wageningen UR (NL), Wuppertal Institut (DE)



# Current Projects



## European research projects

**AFTERLIFE** – Advanced Filtration Technologies for the Recovery and Later conversion of relevant Fractions from wastewater. (09/2017 – 08/2021)

**BioForever** – BIO-based products from FORestry via Economically Viable European Routes. (09/2016 – 08/2019)

**BioMonitor** – Towards a method for the collection of statistical data on bio-based industries and bio-based products. (06/2018-05/2022)

**BioRECO<sub>2</sub>VER** – Microbial platforms for CO<sub>2</sub>-reuse processes in the low-carbon economy. (01/2018 – 12/2021)

**CHASSY** – Model-Based Construction and Optimisation of Versatile Chassis Yeast Strains For Production Of Valuable Lipid and Aromatic Compounds. (12/2016 – 12/2020)

**COSMOS** – Camelina & crambe Oil crops as Sources for Medium-chain Oils for Specialty oleochemicals. (03/2015 – 08/2019)

**MAGIC** – Marginal lands for Growing Industrial Crops: Tuning a burden into an opportunity. (06/2017 – 05/2021)

**MARISURF** – Novel marine derived biomolecules and industrial biomaterials. (09/2015 – 08/2020)

**PEference** – From bio-based feedstocks via di-acids to multiple advanced bio-based material with a preference for polyethylene furanoate. (09/2017 – 04/2022)

**PULP2VALUE** – Processing Underutilised Low value sugarbeet Pulp into VALUE added products. (07/2015 – 06/2019)

**ReSolve** – REnewable SOLVEnts with high performance in application and improved toxicity profile. (06/2017 – 05/2020)

**STAR4BBI** – Standards and Regulations for the Bio-based Industry. (09/2016 – 08/2019)

**WoodCircus** – Underpinning the vital role of the forest-based sector in the Circular Bio-Economy. (11/2018-10/2021)

**Zelcor** – Zero Waste Ligno-Cellulosic Biorefineries by Integrated Lignin Valorisation. (09/2016 – 08/2020)

## National projects

**BEPASO** – Bioökonomie 2050: Potentiale, Zielkonflikte, Lösungsstrategien. (12/2016 – 01/2020)

**BioCONversion** – Bioconversion of CO/syngas into a plastic precursor. (04/2018– 04/2021)

**WeRümA** – Werkstoffentwicklung auf Basis von Rübenschnitzeln für marktrelevante Anwendungen. (01/2017 – 12/2020)

**ZeroCarb FP II** – Nachhaltigkeitsanalysen für die Teilprogramme Bioplastics, 2Acid+, Green Mining and Additives 1. (02/2017 – 09/2019)

# Bio-based Polymers & Building Blocks – the best market reports available



**Data for 2018**

**NOVA Institute**

## Bio-based Building Blocks and Polymers – Global Capacities Production and Trends 2018-2023

Authors: Raj Chinthapalli, Pia Skoczinski, Michael Carus, Wolfgang Bahus, Doris de Guzman, Harald Kab, Achim Raschka, Jan Ravenstijn, 2019

This and other reports on the bio-based economy are available at [www.bio-based.eu/reports](http://www.bio-based.eu/reports)

**UPDATE 2019**

**NOVA Institute**

## Carbon dioxide (CO<sub>2</sub>) as chemical feedstock for polymers – technologies, polymers, developers and producers

Authors: Achim Raschka, Dr. Pia Skoczinski, Jan Ravenstijn and Michael Carus  
nova-Institut GmbH, Germany  
February 2019

This and other reports on the bio-based economy are available at [www.bio-based.eu/reports](http://www.bio-based.eu/reports)

**UPDATE 2019**

**NOVA Institute**

## Succinic acid: New bio-based building block with a huge market and environmental potential?

Pharmaceutical/Cosmetic	Industrial
<ul style="list-style-type: none"> <li>Acids ingredient for deodorant deodorant/soaps</li> <li>Antibiotic</li> <li>Calcium succinate is antiosteogenic</li> <li>Cholesterol labels</li> <li>Intermediate for perfumes</li> <li>Pharmaceutical intermediates (antibiotics, antipsychotics, antiepileptics, antidiabetic)</li> <li>Preservative for hairdies</li> <li>Resin for nail color</li> <li>Used in the preparation of vitamins</li> </ul>	<ul style="list-style-type: none"> <li>De-icer</li> <li>Engineering plastics and epoxy resin</li> <li>Agriplastic/hardener</li> <li>Antibiotics, fungicides, regulators of plant growth</li> <li>Intermediate for lacquers + photographic chemicals</li> <li>Plasticizer (polyurethanes, adipic acid)</li> <li>Polymers</li> <li>Solvents, lubricants</li> <li>Surface cleaning agent (metal-electronics-semiconductor industry)</li> </ul>
Food	Other
<ul style="list-style-type: none"> <li>Bread softening agent</li> <li>Flavor enhancer</li> <li>Flavoring agent and sweetener according to International Food Additive Codex</li> <li>Microencapsulation of flavoring oils</li> <li>Preservative (chicken, dog food)</li> <li>Protein gelatinisation and in dry product (macaroni, soups)</li> <li>Used in synthesis of modified starch</li> </ul>	<ul style="list-style-type: none"> <li>Amidating Aluminium</li> <li>Chemical metal plating, electroplating baths</li> <li>Coating, ink, pigments (polymerization-variable coating, resin for water-based paint, dielectric, photoconductor, ink, binder)</li> <li>Flavor (bread, opening aid for films)</li> <li>Part of additive treatment for safety nets</li> <li>Prepolymer for soil fixings</li> <li>Soil stabilizing agent</li> </ul>

Authors: Raj Chinthapalli, Dr. Pia Skoczinski, Achim Raschka, Michael Carus, nova-Institut GmbH, Germany  
Update March 2019

This and other reports on the bio-based economy are available at [www.bio-based.eu/reports](http://www.bio-based.eu/reports)

**NOVA Institute**

## Commercialisation updates on bio-based building blocks

Author: Doris de Guzman, Tecnon DGB/Chem, United Kingdom  
June 2017

This and other reports on the bio-based economy are available at [www.bio-based.eu/reports](http://www.bio-based.eu/reports)

**NOVA Institute**

## Standards and labels for bio-based products

Authors: Lara Dammer, Michael Carus and Dr. Asta Partanen  
nova-Institut GmbH, Germany  
May 2017

**NOVA Institute**

## Bio-based polymers, a revolutionary change

Comprehensive trend report on PHA, PLA, PUR/TPU, PA and polymers based on FDCA and SA: Latest developments, producers, drivers and lessons learnt

Picture: Gebr. Kunststoffwerk

Jan Ravenstijn  
March 2017

E-mail: [j.ravenstijn@gnmail.nl](mailto:j.ravenstijn@gnmail.nl)  
Mobile: +31.6.2247.8593

Author: Jan Ravenstijn, Jan Ravenstijn Consulting, the Netherlands  
April 2017

This and other reports on the bio-based economy are available at [www.bio-based.eu/reports](http://www.bio-based.eu/reports)

**NOVA Institute**

## Policies impacting bio-based plastics market development and plastic bags legislation in Europe

Authors: Dirk Carrez, Clever Consult, Belgium  
Jim Pirat, DECC, France  
Dr. Harald Kab, narocoin Innovation Consulting, Germany  
Lara Dammer & Michael Carus, nova-institute, Germany  
March 2017

This and other reports on the bio-based economy are available at [www.bio-based.eu/reports](http://www.bio-based.eu/reports)

**NOVA Institute**

**narocoin**  
INNOVATION CONSULTING GMBH

## Market study on the consumption of biodegradable and compostable plastic products in Europe 2015 and 2020

A comprehensive market research report including consumption figures by polymer and application types as well as by geography, plus analyses of key players, relevant policies and legislation and a special feature on biodegradation and composting standards and labels

**Bestsellers**

Disposable tableware, Biowaste bags, Carrier bags, Rigid packaging, Flexible packaging

Authors: Harald Kab, narocoin, Inc., Florence Aeschelmann, Lara Dammer, Michael Carus (nova-institute)  
April 2016

The full market study (more than 300 slides, 3,500€) is available at [bio-based.eu/top-downloads](http://bio-based.eu/top-downloads).





# 12<sup>th</sup> International Conference on Bio-based Materials

15–16 May 2019, Maternushaus, Cologne, Germany

[www.bio-based-conference.com](http://www.bio-based-conference.com)

15 – 16 May 2019  
Maternushaus | Cologne | Germany

[www.bio-based-conference.com](http://www.bio-based-conference.com)

About 200 participants already registered

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# Save the Date: nova-Sessions in 2019



## **Bio-based Building Blocks and Polymers – Markets, Trends and Innovations**

30 April 2019, 10:00 - 16:30 h  
Terminal 1, Airport Cologne/Bonn, Germany

## **nova Session on Technology of the Future: Carbon Capture and Utilization (CCU)**

24 September 2019, 10:00 - 16:30 h  
Airport Cologne/Bonn, Germany

## **EU Circular Economy and Plastic Policy**

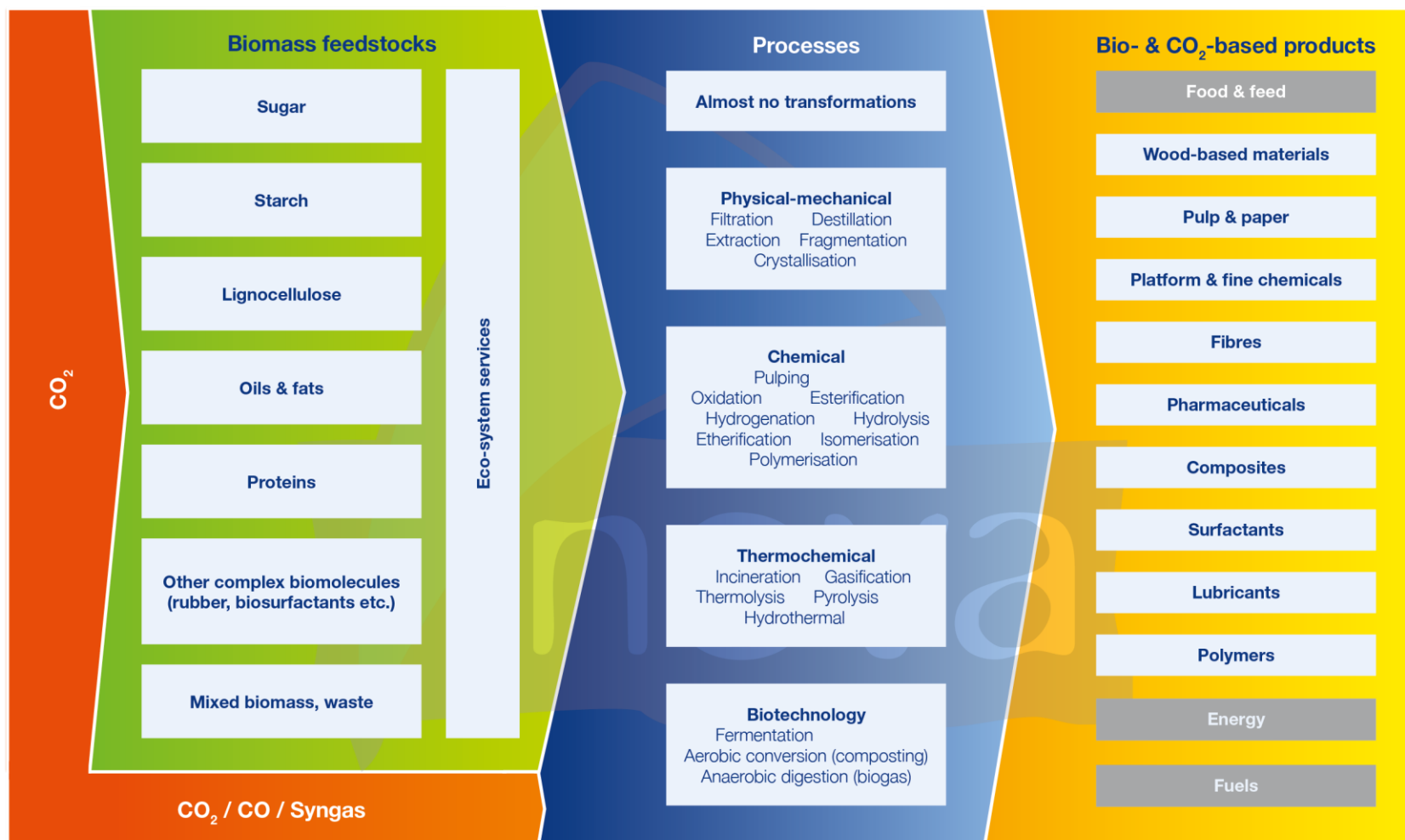
21 May 2019  
Wölhaff Conference Center, Terminal 1,  
Airport Cologne/Bonn, Germany



Contact: Mr. Dominik Vogt, +49 (0) 2233 48 14 49, [Dominik.vogt@nova-institut.de](mailto:Dominik.vogt@nova-institut.de)

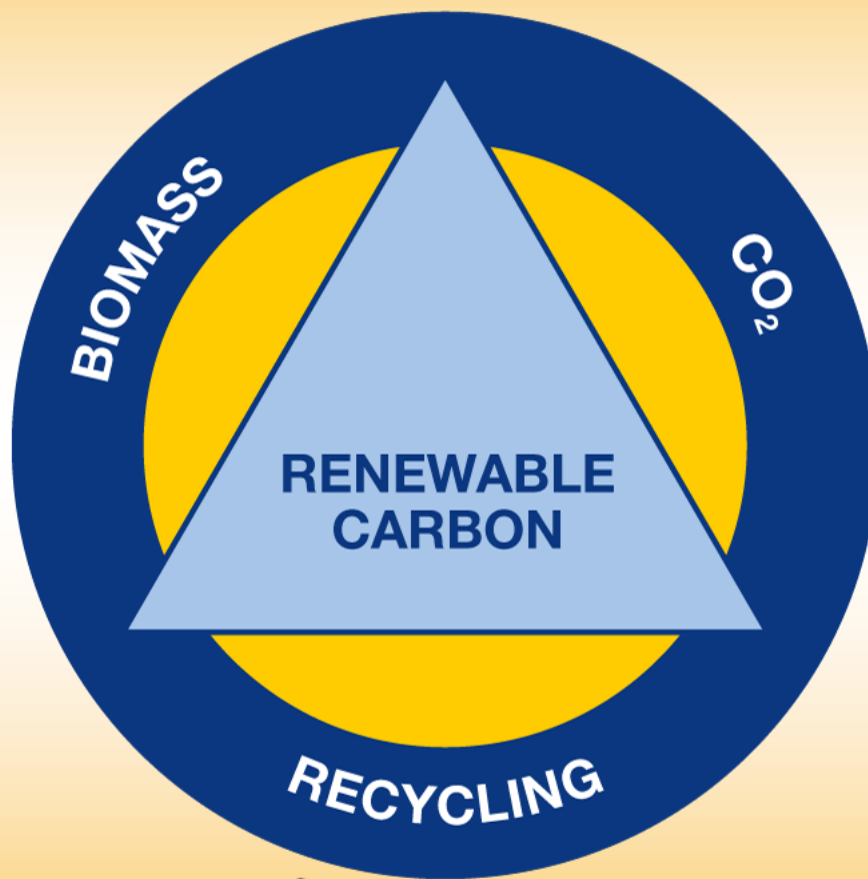
**All conferences at [www.bio-based.eu](http://www.bio-based.eu)**

# Bio- and CO<sub>2</sub>-based Economy: feedstocks, processes and products



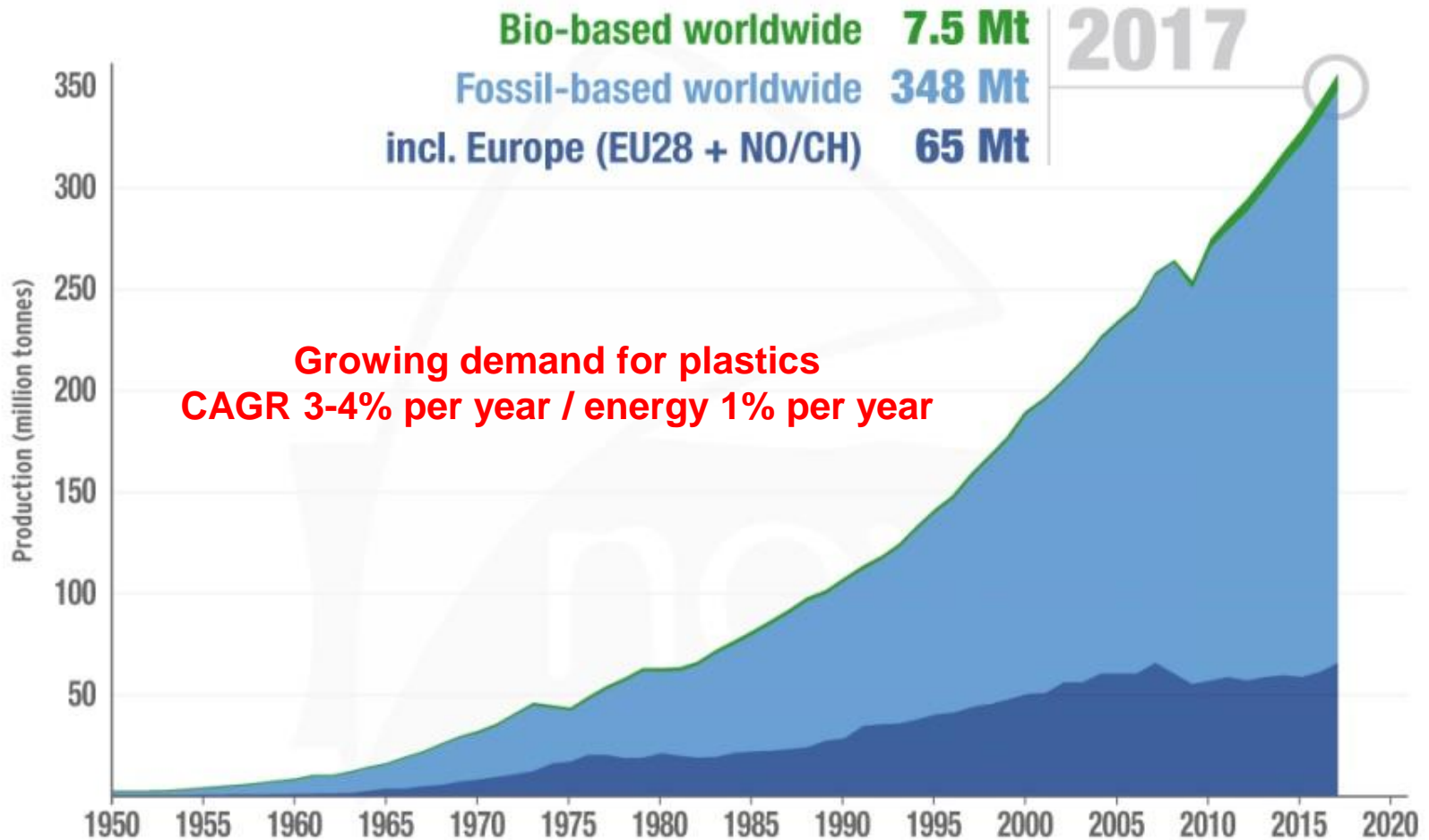


# Renewable Carbon Strategy



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# Plastics production from 1950 to 2017

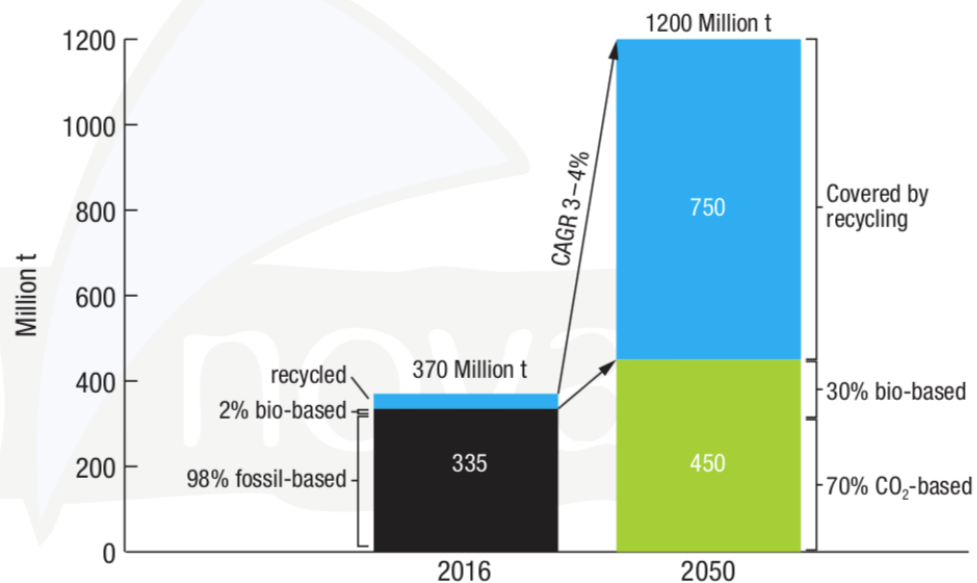


Includes thermoplastics, polyurethanes, thermosets, elastomers, adhesives, coatings and sealants and PP-fibres. Not included PET-, PA-, and polyacryl-fibres.

Data source:  
PlasticsEurope, Consultic and nova-Institute



## World Plastic Production and Carbon Feedstock in 2016 and Forecast for 2050 (in Million tonnes)

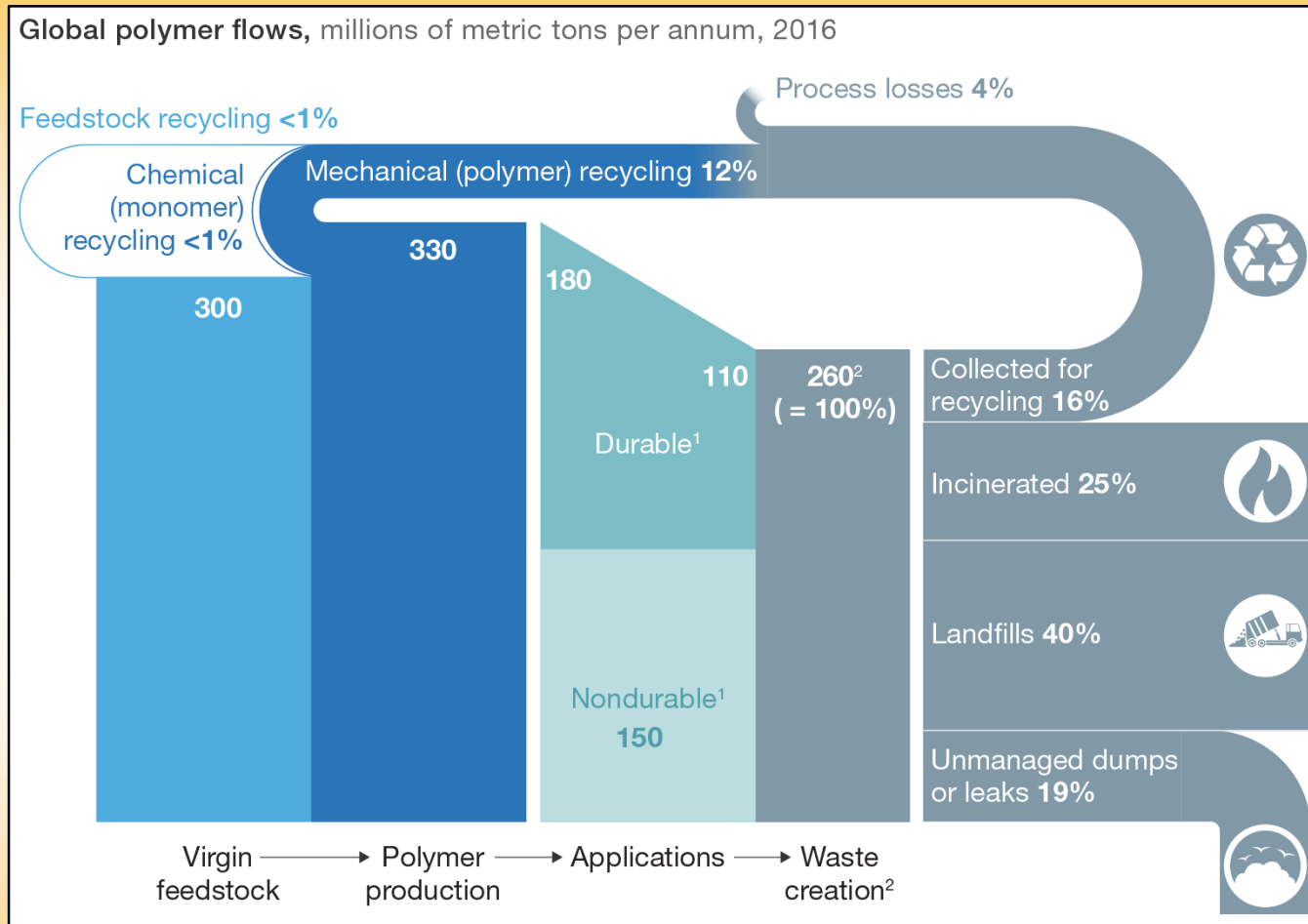


The virgin plastic production of 335 Million t in 2016 will increase to 450 Million t in 2050, completely based on renewable carbon. The total demand for plastics of 1,200 Million t in 2050 will be mainly covered by recycling.

Strong recycling efforts could keep the steadily growing demand for new plastics between 400 and 500 million tonnes by 2050. This demand could then be met, for example, by 30 percent biomass and 70 percent direct CO<sub>2</sub> use. The biomass required for this would amount to around 1% of the biomass currently used worldwide in all areas of application (13 - 14 billion tonnes, 60 percent of which is feed for the production of milk and meat alone).



# The majority of global plastics waste currently goes to landfill & incineration



Policy decisions needed to bring to reality the switch of the plastic-waste flow from landfill and incineration to recycling.

Developed economies face high costs due to small scale and lack of efficient collection and sorting processes with so far limited application of automation.

<sup>1</sup> Durable applications with an average lifetime >1 year will end up as waste only in later years; non-durable applications go straight to waste

<sup>2</sup> 150 million metric tons of mixed plastic waste from nondurable applications that end-up as waste in same year, plus 110 million metric tons of mixed plastic waste from production in previous years

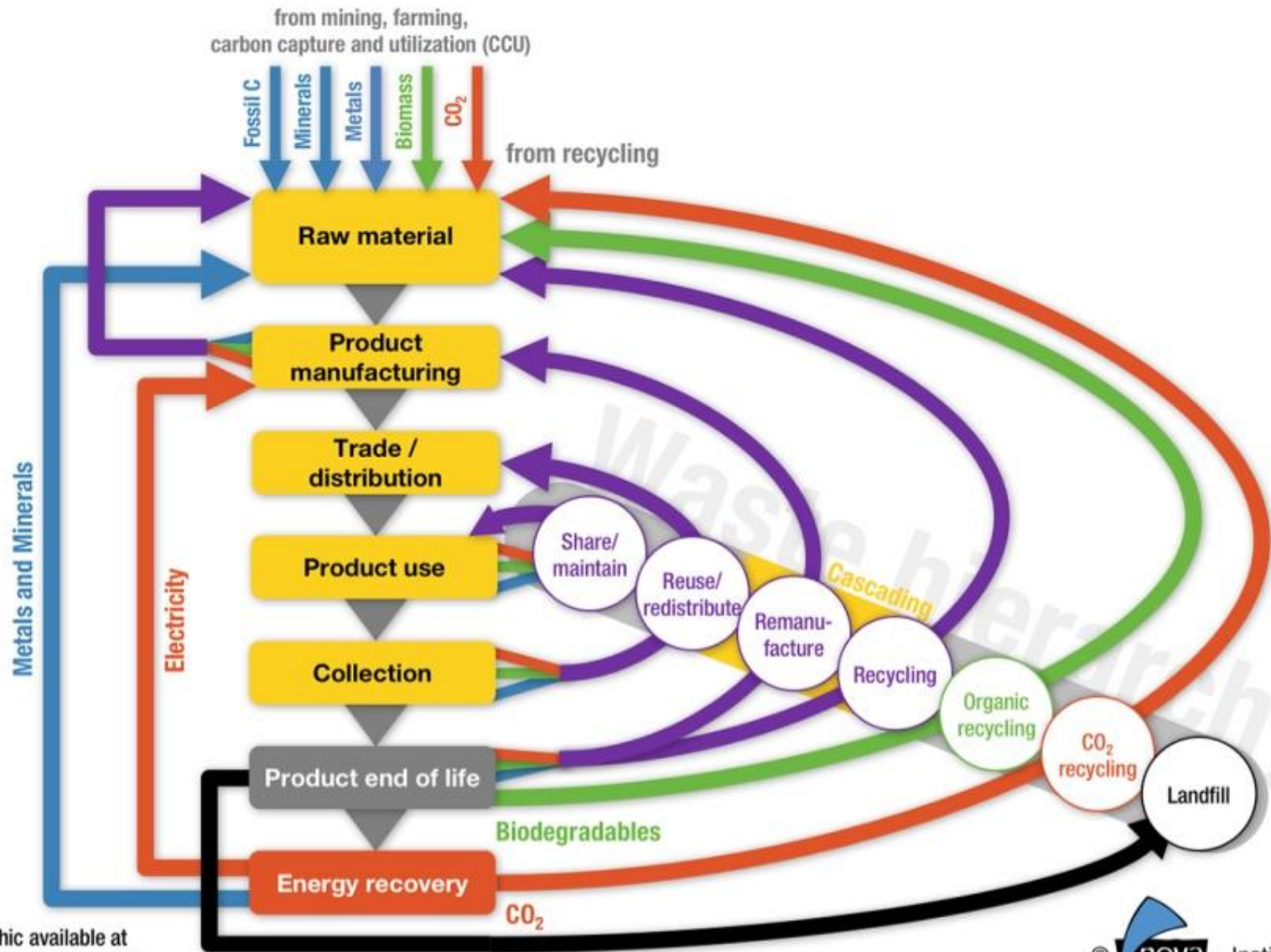


# Plastic Waste



Source: The Japan Times

# Comprehensive Concept of Circular Economy







# Recycling



**Currently politicians mainly count on recycling schemes to preserve fossil resources.** In a circular economy the recycling of existing plastic materials and other organic chemistry products is, **without any doubt, an important source for renewable carbon which could** and should be exploited more comprehensively.

However, you should not succumb **to the illusion that recycling will be able to provide the lion's share of renewable carbon in a sustainable manner.** Recycling must not be turned into an incontrovertibly true principle that is applied without any **sustainability assessments.**

Chemical (and biochemical) recycling have to expanded in future – including the recycling of CO<sub>2</sub> and other C<sub>1</sub>-sources from offgases and wastes.



# Latest Market Data on Bio-Based Polymers



# What is new?



**Data for 2018**

**nova Institute**  
For Ecology and Innovation

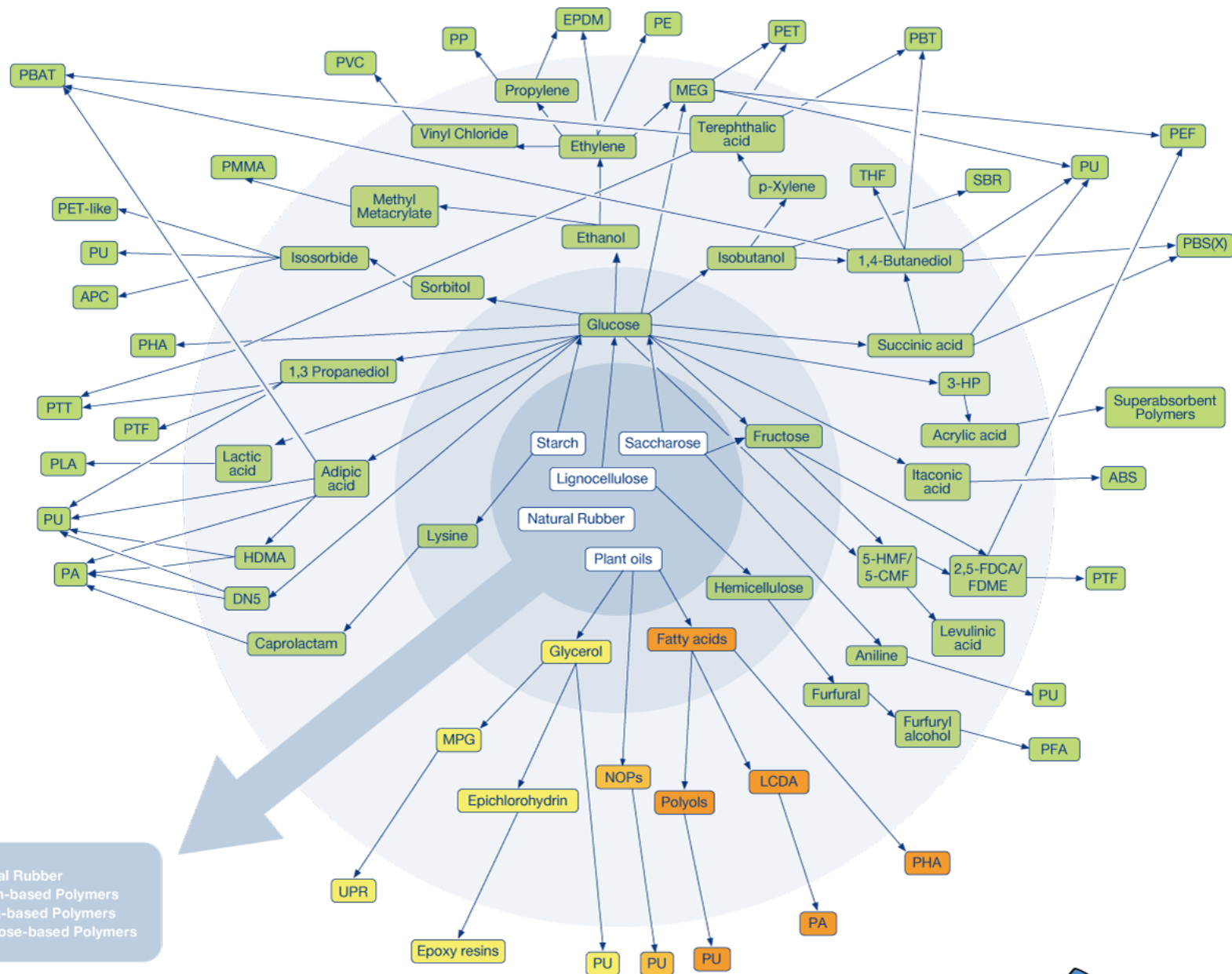
## Bio-based Building Blocks and Polymers – Global Capacities, Production and Trends 2018–2023

**Authors:**  
Raj Chinthapalli, Pia Skoczinski, Michael Carus, Wolfgang Baltus, Doris de Guzman, Harald Káb, Achim Raschka, Jan Ravenstijn  
February 2019

This and other reports on the bio- and CO<sub>2</sub>- based economy are available at [www.bio-based.eu/reports](http://www.bio-based.eu/reports)

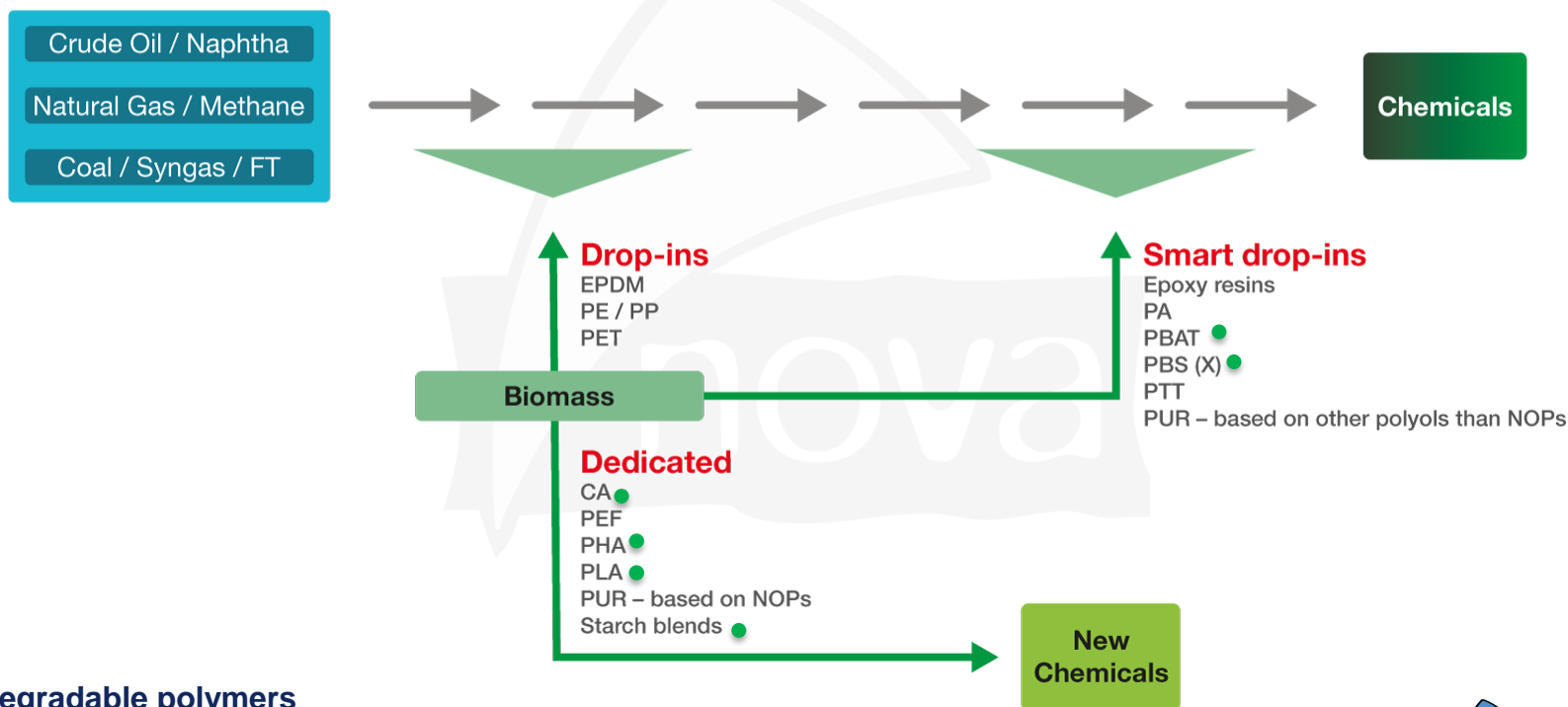
**Short and full version available:**  
[www.bio-based.eu/reports](http://www.bio-based.eu/reports)

- Comprehensive information on capacity development from 2018 to 2023, per bio-based building block and polymer
- **For the first time production data for the year 2018, per bio-based polymer**
- Detailed functional and production-related information on a total of 17 bio-based building blocks and 16 polymers
- Analyses of market developments and producers per building block and polymer
- **Detailed research, calculation and explanation of the market development of cellulose acetate (CA), bio-based epoxy resins and bio-based polyurethanes**
- Comprehensively updated **171 detailed company profiles** – from start-ups to multinational corporations





# Schematic differentiation of pathways of drop-in, smart drop-in and dedicated bio-based chemicals

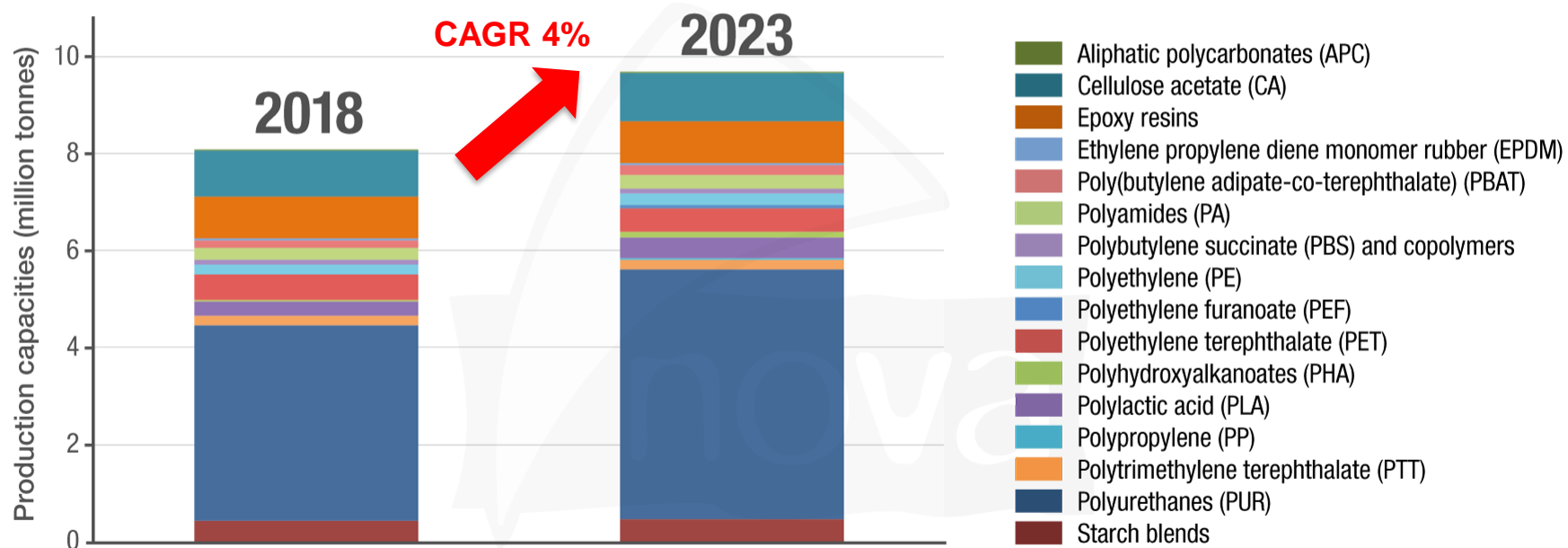


● biodegradable polymers

All figures available at [www.bio-based.eu/markets](http://www.bio-based.eu/markets)



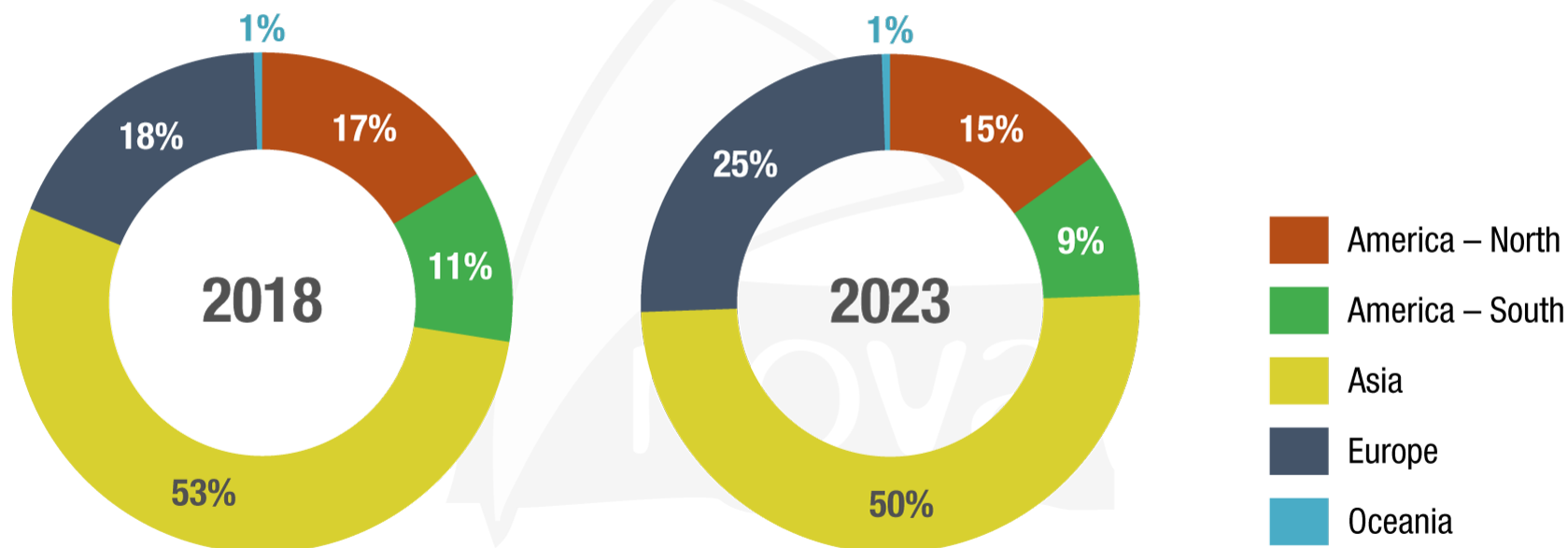
# Bio-based polymers production capacities in 2018 and 2023



All figures available at [www.bio-based.eu/markets](http://www.bio-based.eu/markets)



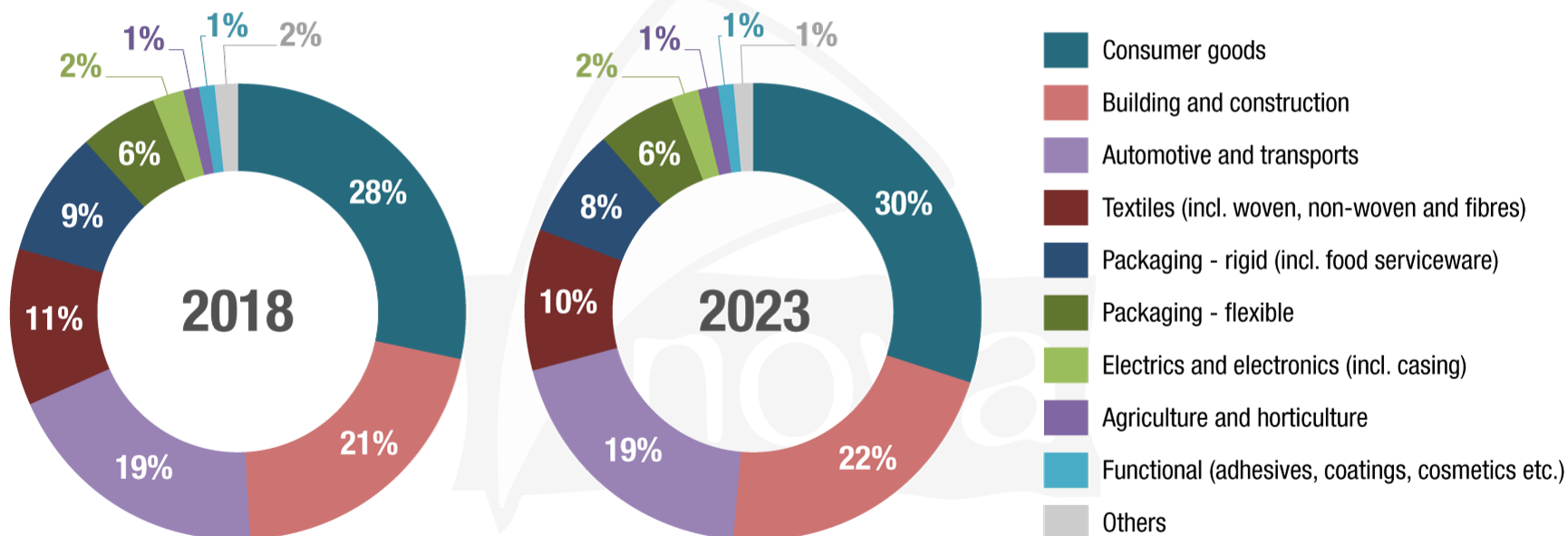
## Global production capacities of bio-based polymers by region in 2018 and 2023 (excluding polyurethanes, epoxy resins and cellulose acetate)



All figures available at [www.bio-based.eu/markets](http://www.bio-based.eu/markets)



## Shares of the produced bio-based polymers in different market segments in 2018 and 2023



All figures available at [www.bio-based.eu/markets](http://www.bio-based.eu/markets)

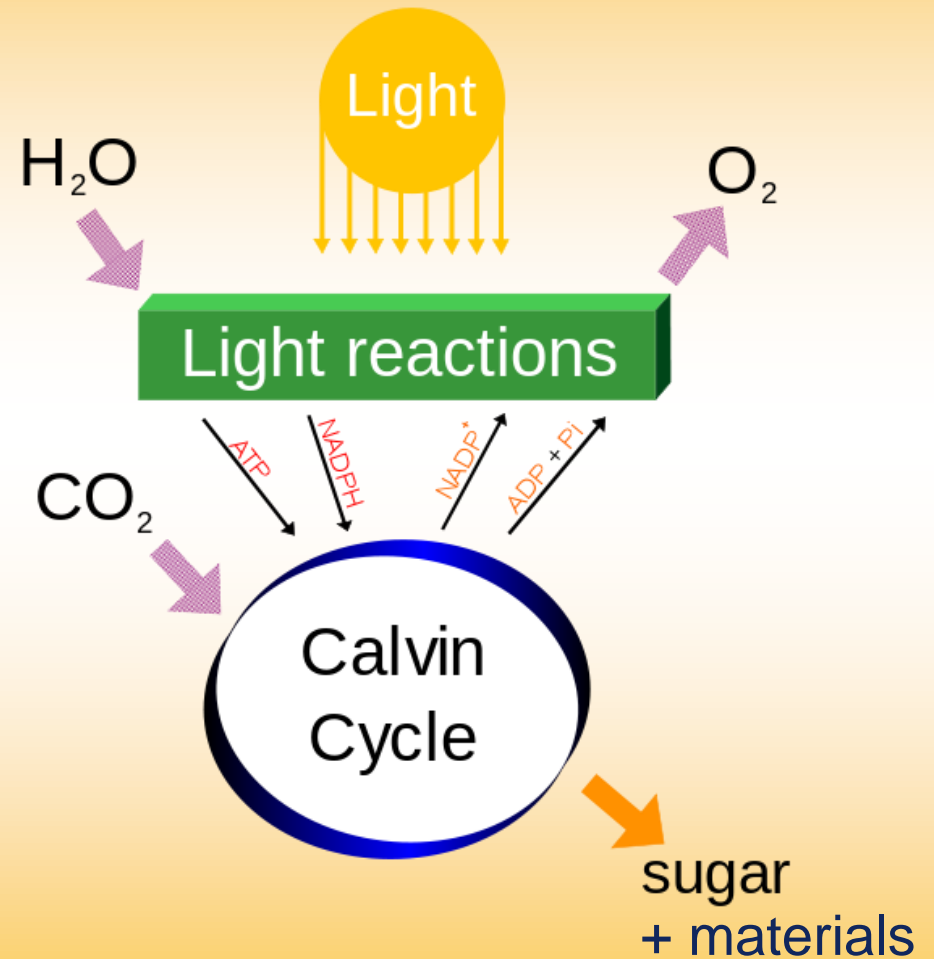
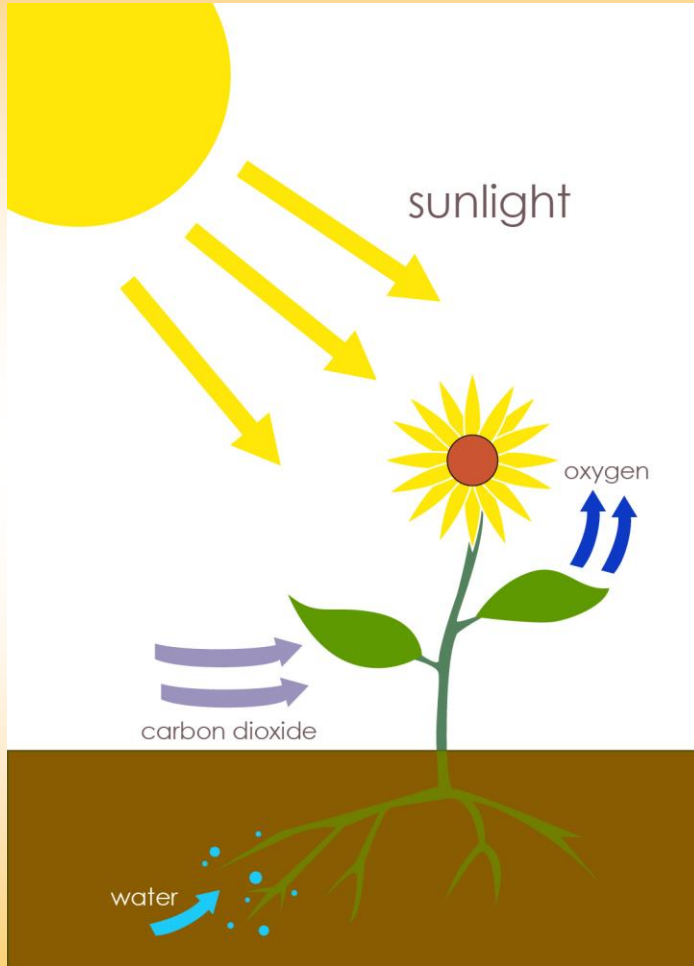




**Polymers based on CO<sub>2</sub>**  
**An overview on possible technologies**

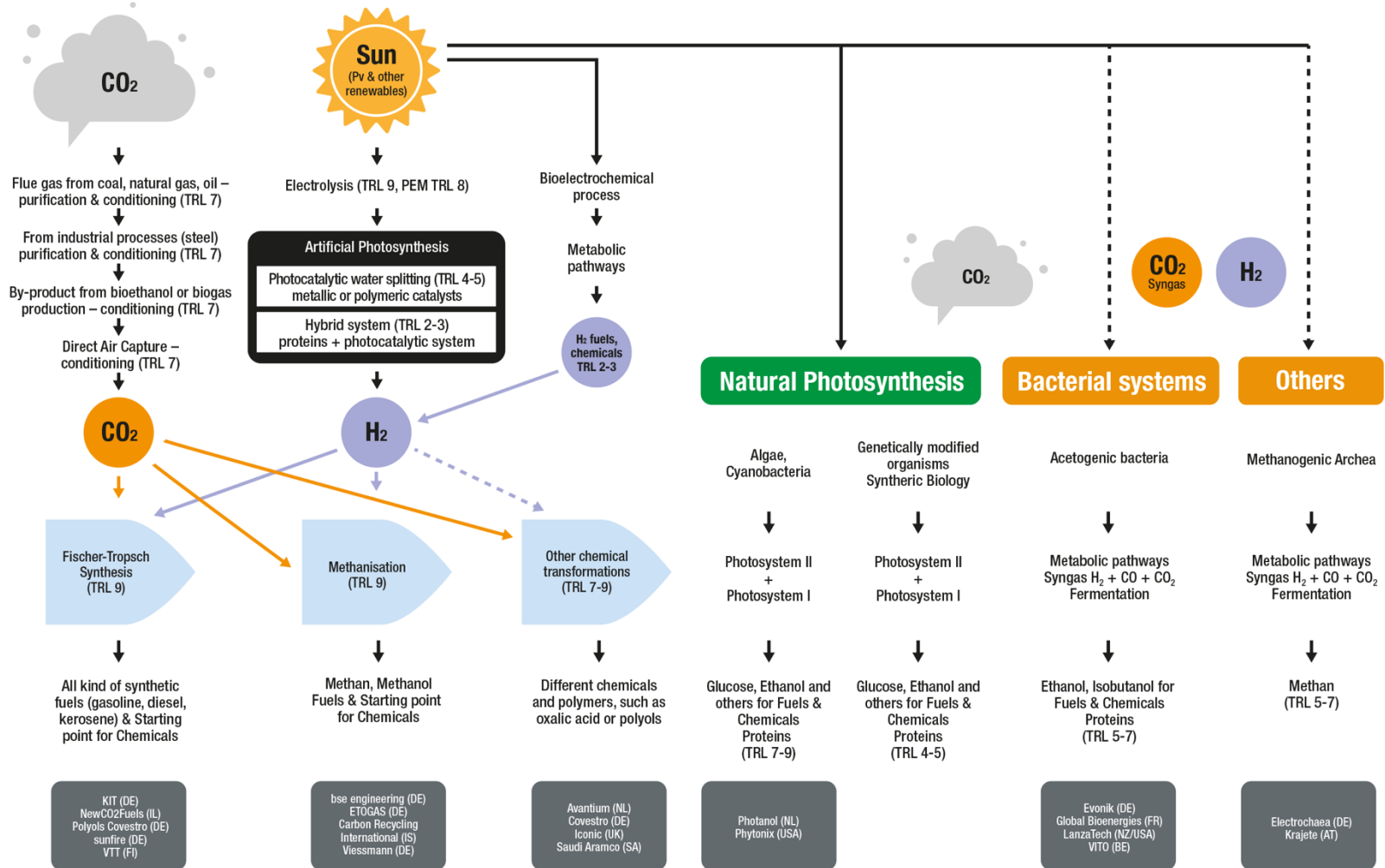


# Carbon Dioxide Utilization in natural photosynthesis



Source: Wikipedia (Daniel Mayer, At09kg; CC-by-sa 3.0)

# Carbon Dioxide Utilization and renewable energy





# CCU Implementations



Nova started a list to get an overview on already existing CCU installations:

## CO<sub>2</sub> capture

- Currently 28 projects / companies listed for CO<sub>2</sub> capture from various sources: ambient air, pre combustion, oxyfuel combustion and post combustion
- Ranging from pilot, demonstration, pre-commercial to commercial scale

## CO<sub>2</sub> utilisation

- Currently 70 projects / companies listed using or planning to use CO<sub>2</sub> for the production of fuels, polymers, proteins, gases, concrete / cement and chemicals
  - Ranging from lab, pilot, demonstration, pre-commercial to commercial scale
- **closer look on 13 companies with plants in demonstration and commercial scale**

## Carbon utilisation

- Chemical recycling as a further approach of recycling not only CO<sub>2</sub> but carbon containing waste in general



# CO<sub>2</sub> utilisation - fuels



company	headquarter	scale	production site			capacity	start date	endproduct
			city	country	status			
<b>Biotechnological CO<sub>2</sub> conversion processes</b>								
LanzaTech Inc.,	United States	commercial	Ghent	Belgium	construction	62,000 t/a	2019	ethanol and e.g. n-butanol and kerosene
		commercial	Shougang	China	in operation	48,000 t/a	2018	
		commercial	Gurgaon	India	construction	34,000 t/a	2019	
		commercial	Nelspruit	South Africa	construction	52,000 t/a	2019	
		commercial	Modesto	United States	construction	35,000 t/a	2019	
Phytonix Corp.	United States	commercial		United States	planning	> 500,000 t/a	2019 / 2020	n-butanol
		commercial		Europe	planning			
<b>Chemical CO<sub>2</sub> conversion processes</b>								
Carbon Recycling International	Iceland	commercial	Grindavik	Iceland	in operation	4,000 t/a	2011	methanol
Nordic Blue Crude AS	Norway	commercial	Herøya	Norway	construction	8,000 t/a	2020	diesel, kerosene naphtha, wax
Sunfire GmbH	Germany	demonstration	Dresden	Germany	in operation	> 3 t/a	2014	



# CO<sub>2</sub> utilisation

## Gases, proteins, polyols and others



company	headquarter	scale	production site			capacity / output power	start date	endproduct
			city	country	status			
<b>Biotechnological CO<sub>2</sub> conversion processes</b>								
Algenol Biotech	United States	commercial	Fort Myers	United States	in operation		2014	spirulina, colorants, proteins
Electrochaea GmbH	Germany	commercial (demonstration)	Avedøre	Denmark	in operation	50 Nm <sup>3</sup> /h / 0.5 MW	2016	methane
		commercial (demonstration)	Solothurn	Switzerland	in operation	35 Nm <sup>3</sup> /h / 0.35 MW	2018	
		commercial (demonstration)		Hungary	planning	500 Nm <sup>3</sup> /h / 5 MW		
Photanol B.V.	Netherlands	demonstration	Delfzijl	The Netherlands	planning	20 t/a	2020	organic acids
<b>Chemical CO<sub>2</sub> conversion processes</b>								
Asahi Kasei Corp.	Japan	commercial		Taiwan	In operation	150,000 t/a	2007	polycarbonates
Audi AG		commercial (demonstration)	Werlte	Germany	in operation	300 Nm <sup>3</sup> /h / 3 MW	2013	methane
Covestro AG	Germany	commercial	Dormagen	Germany	in operation	5,000 t/a	2016	polyols, polyurethanes
Econic Technologies Ltd.	United Kingdom	commercial (demonstration)	Runcorn	United Kingdom	in operation		2018	polyols
Newlight Technologies, Inc.	United States	commercial		United States	in operation	23,000 t/a	2014	polyhydroxyalkanoates



# Carbon utilisation

## Chemical recycling of plastic waste

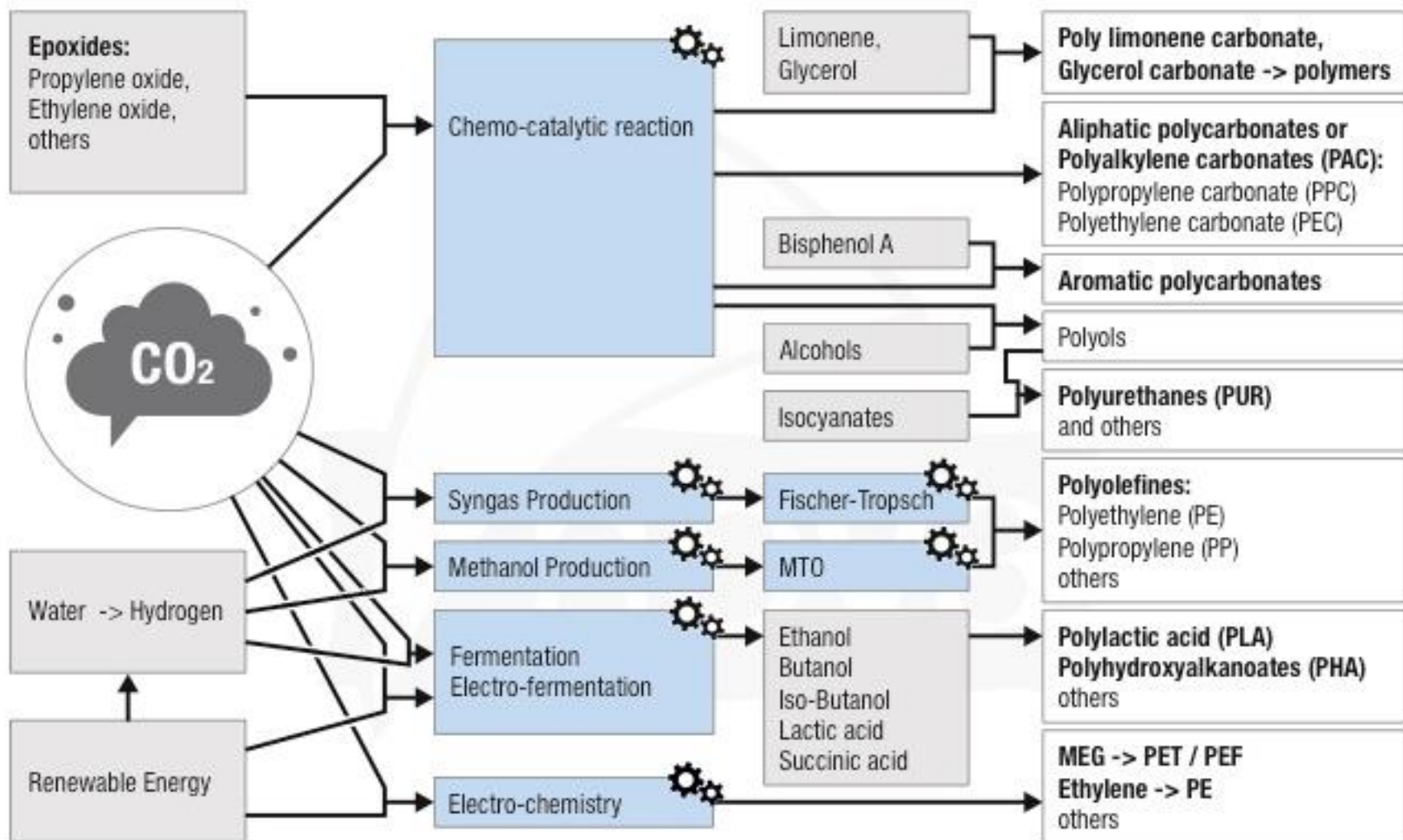
company	headquarter	scale	production site			start date	endproduct	
			city / region	country	status			capacity
<b>Chemical CO<sub>2</sub> conversion processes</b>								
Arbeitsgemeinschaft Kohlenstoffkreislaufwirtschaft NRW (Arge K2 NRW)	Germany	commercial	NRW	Germany	planning		chemicals	
BASF SE	Germany	commercial (demonstration)	Ludwigshafen	Germany	in operation	2018	plastics	
Enerkem	Canada	commercial	Edmonton	Canada	in operation	31,000 t/a	2015, 2017	methanol, ethanol
		commercial	Rotterdam	The Netherlands	planning	219,000 t/a		methanol
		commercial	various	China	planning			methanol
ReNewELP	United Kingdom	commercial	Teesside	United Kingdom	construction		2019	liquid hydrocarbons, chemicals, new plastics
Showa Denko K.K.	Japan	commercial	Kawasaki	Japan	in operation		2003	CO <sub>2</sub> for beverages



# Polymers from Carbon Dioxide



# Ways to Use CO<sub>2</sub> for Polymers





# Polycarbonates



When we talk about Polycarbonates in the field of CCU we address mainly:

## **Aliphatic Polycarbonates** like

- **Polyethylencarbonate** (PEC)
- **Polypropylencarbonate** (PPC)
- Copolymers of both (PEPC)

## **Cycloaliphatic Polycarbonates**, e.g.

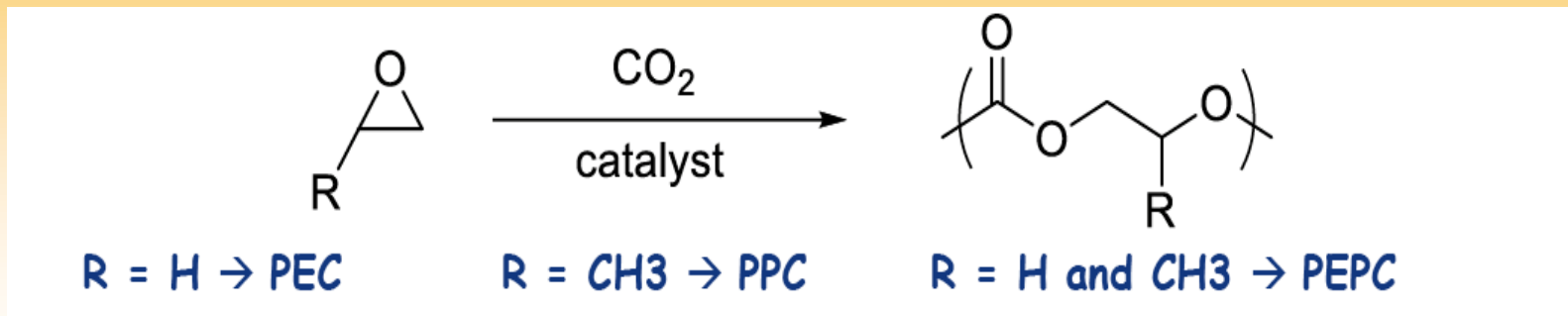
- polycyclohexene carbonate (PCHC)

## **Poly-Limonenecarbonate** (PLimC)

## Aromatic **Polycarbonate** (PC)



# Alliphatic Polycarbonates



Epoxide

Polycarbonate

-> More in the presentation of Richard French / Eonic

**Several players for PEC/PPC:**

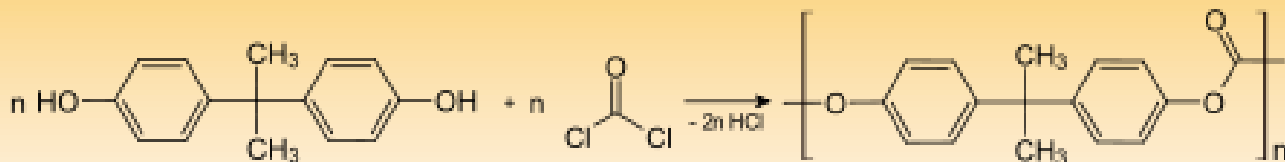
Novomer (Saudi Aramco), Empower Materials, Eonic, SK Innovation, ...



# Aromatic Polycarbonate



## Standard Process:

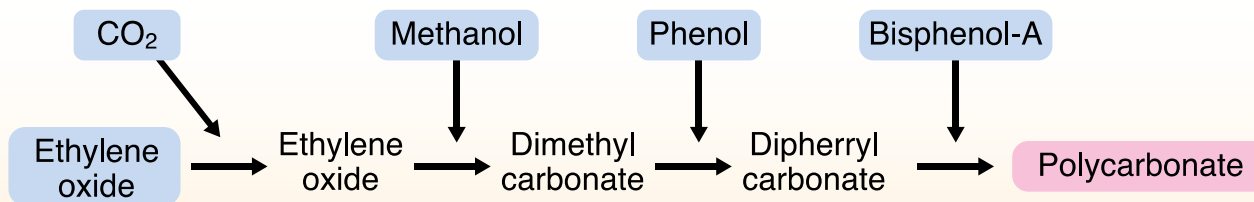


**Phosgene**  
(toxic)

for Carbonyl group

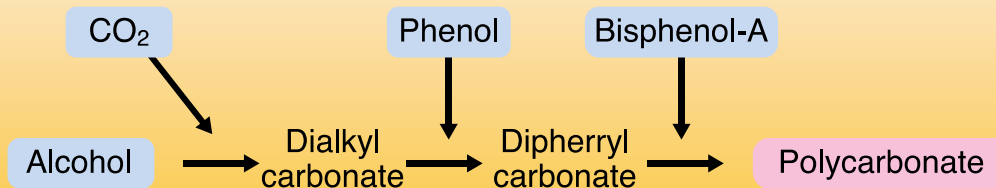
## Asahi Kasei Chemicals:

*Flowchart of previously developed non-phosgene PC process*



**Phosgene**  
free

*Flowchart of non-phosgene PC process with the DRC for DPC*



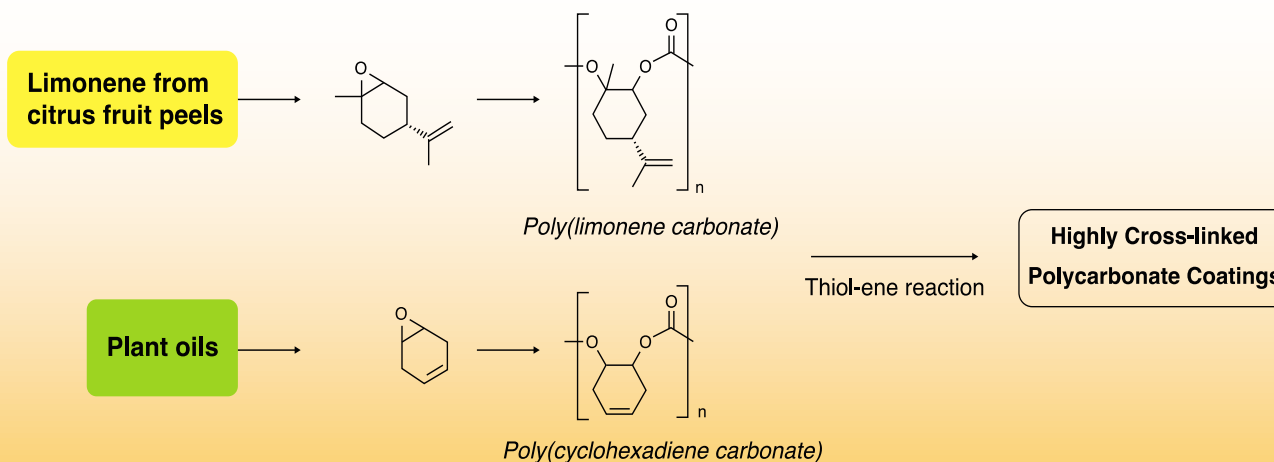
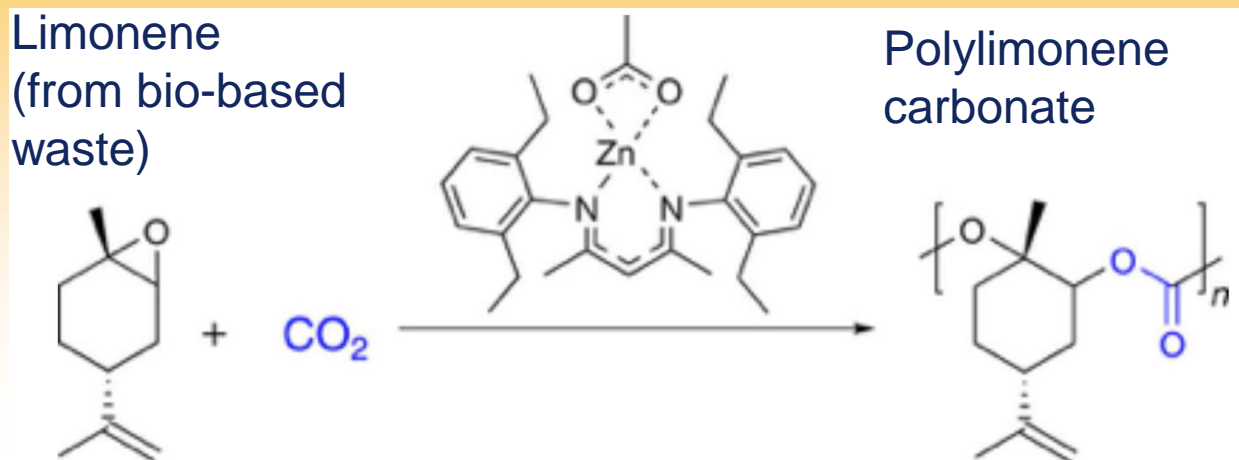
**150 kt/a in Taiwan**  
**since 2007**

**Awarded from the**

**American Association of Chemistry**



# Polylimonene carbonate

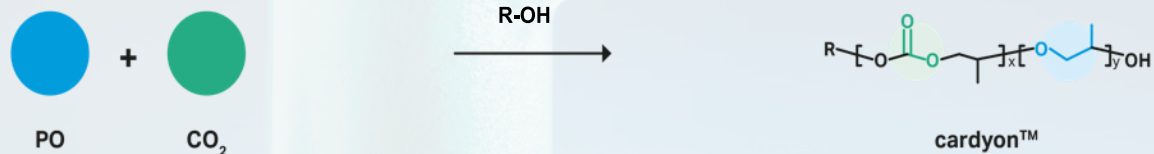


Source: Hauenstein et al. 2016,  
Williams et al. 2015

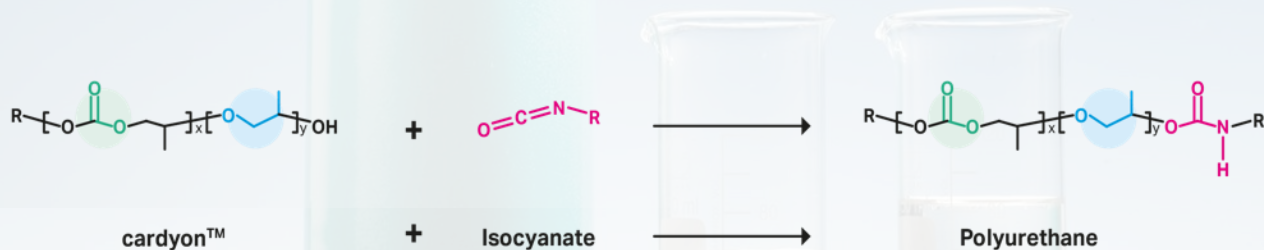




## PRODUCTION OF CARDYON™



## PRODUCTION OF PU WITH CARDYON™

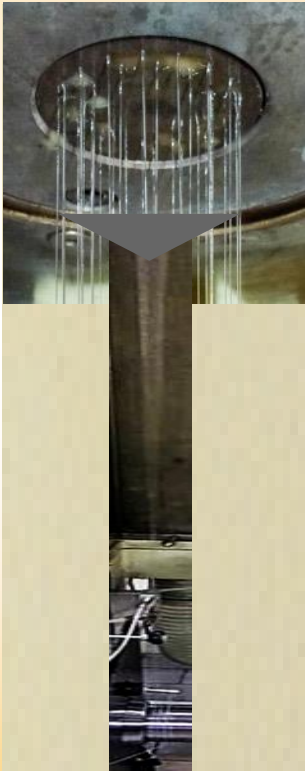




# Melt spun CO<sub>2</sub>-TPU fibre filament processing: Direct knitting of TPU yarn and fabrics



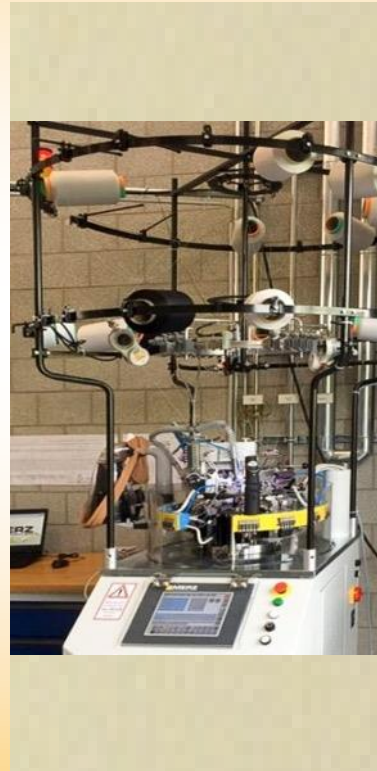
Filament  
processing



Bobbin with CO<sub>2</sub>  
based TPU yarn



Knitting machine for  
TPU yarn processing



Knitted fabric from CO<sub>2</sub>  
based TPU yarn



-> more from Covestro

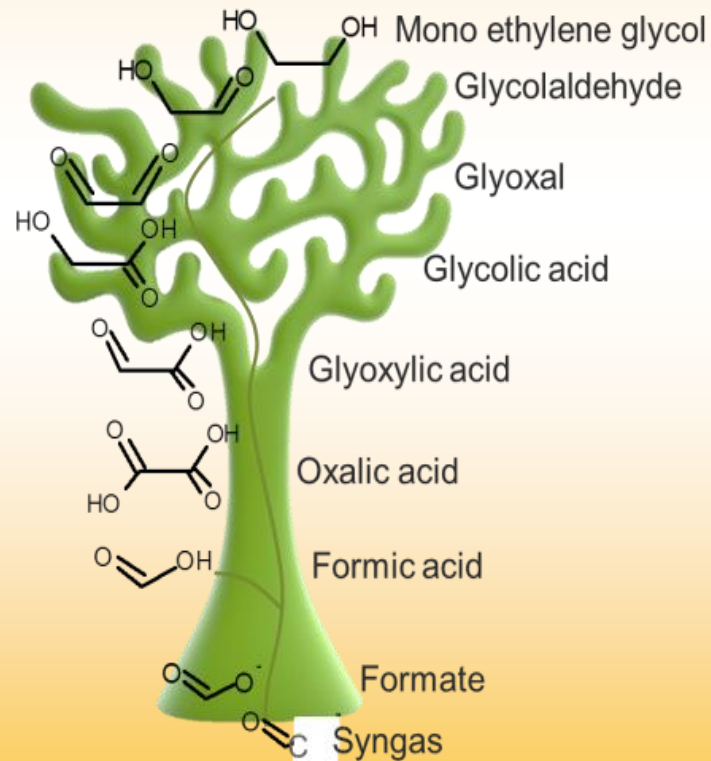




# Electrocatalysis by Avantium



Acquisition of assets of Liquid Light puts Avantium in the leadership position in electrocatalysis technologies and carbon dioxide reduction1



Several options for high value products

-> more from Avantium

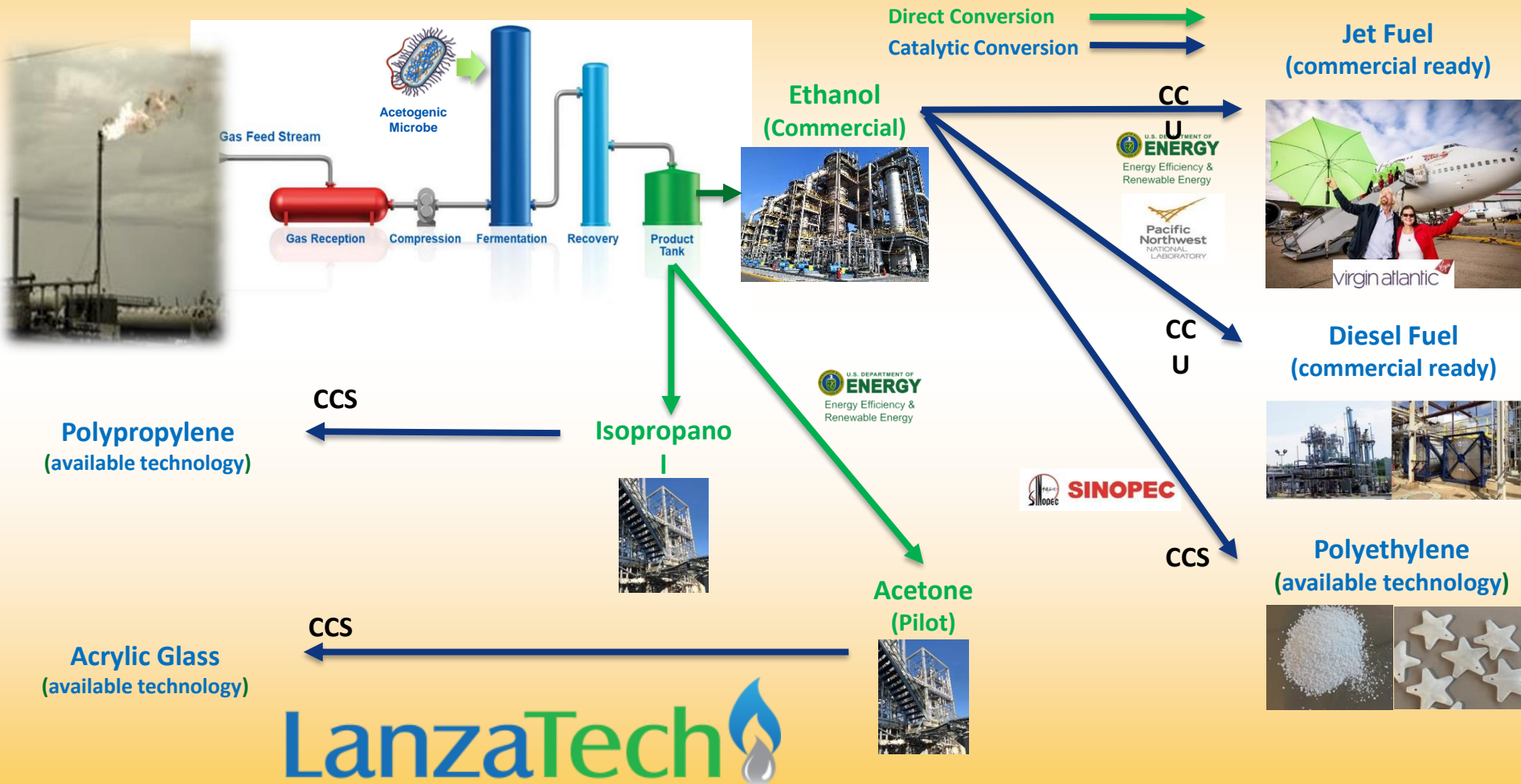
CO<sub>2</sub>



# Biotech: LanzaTech

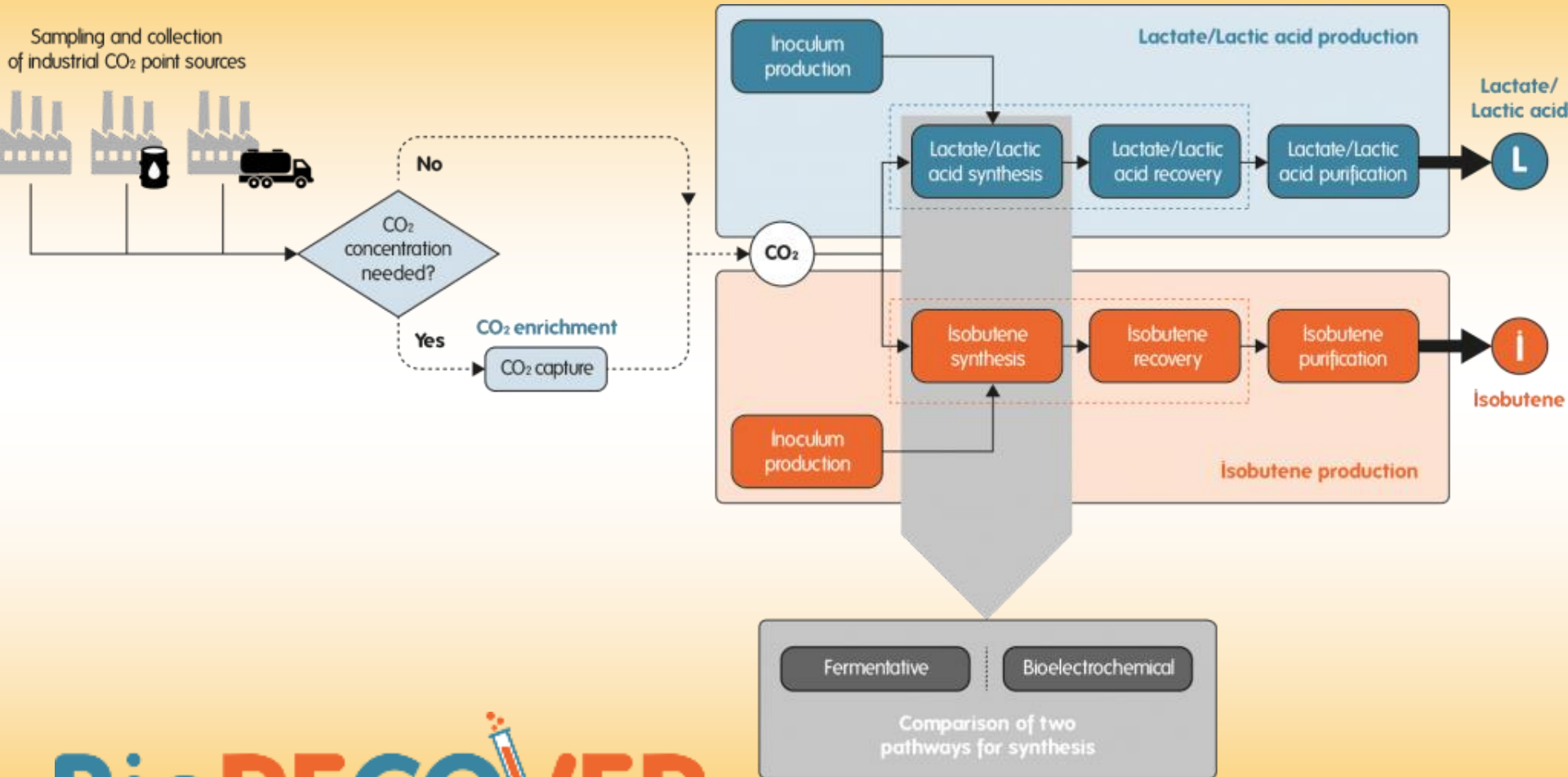


## LanzaTech's Commercial, Pilot Stage and Immediate Target Products





# Biotech: BioRECO2VER



# BioRECO<sub>2</sub>VER





New project *BioCONversion*:

## From emissions to a valuable feedstock for plastic precursors

The new project *BioCONversion* unites multidisciplinary expertise from academia and industry in a cross-border consortium to make CO-containing process gases available for the production of added-value chemicals. The German Federal Ministry of Education and Research (BMBF) funded € 1.5 million to develop an innovative bioprocess to convert syngas into a defined plastic precursor by evaluating different technology approaches. The three years project coordinated by the open innovation cluster CLIB<sup>2021</sup> has been kicked-off end of May 2018 and is element of CLIB's internationalisation strategy within the cross-border BIG-Cluster initiative of the regions of the German state of North Rhine-Westphalia, the Netherlands and the Belgian region of Flanders.

ask Sarah Refai

nova-Institute

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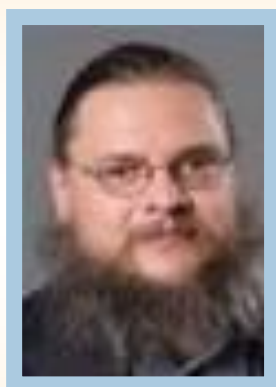


Federal Ministry  
of Education  
and Research

BioCONversion



# Thank you for your attention!



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Bio- and CO<sub>2</sub>-based economy  
Technology & Markets  
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# Applied research for your needs

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Sustainability



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**Daniel Steeg**

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