

Current market situation: CO₂ as chemical feedstock for polymers

nova-Institute

Value from CO₂: The Power of
Biotechnology

23 November 2021



Pauline Ruiz, nova-Institute, pauline.ruiz@nova-institut.de



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- Customised Carbon Footprint Calculation Tools
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- Comprehensive Sustainability Assessments
- Sustainability Integrated Technology Development (SUITE)
- Critical Reviews



Communication

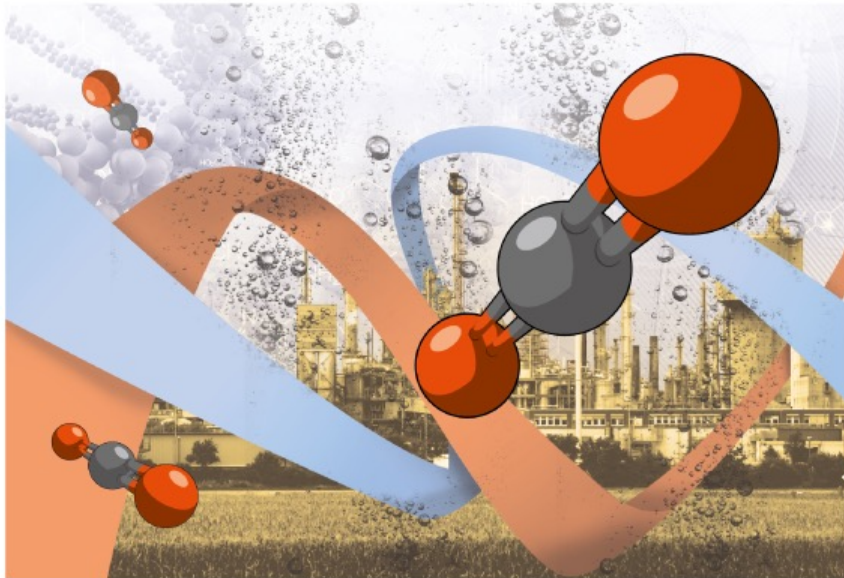
- Comprehensive Communication & Dissemination in Research Projects
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- Political Framework, Measures & Instruments
- Standards, Certification & Labelling

Carbon Dioxide (CO₂) as Chemical Feedstock for Polymers

Technologies, Polymers, Developers and Producers



*Authors: Pauline Ruiz, Achim Raschka, Pia Skoczinski,
Jan Ravenstijn and Michael Carus, nova-Institut GmbH, Germany*

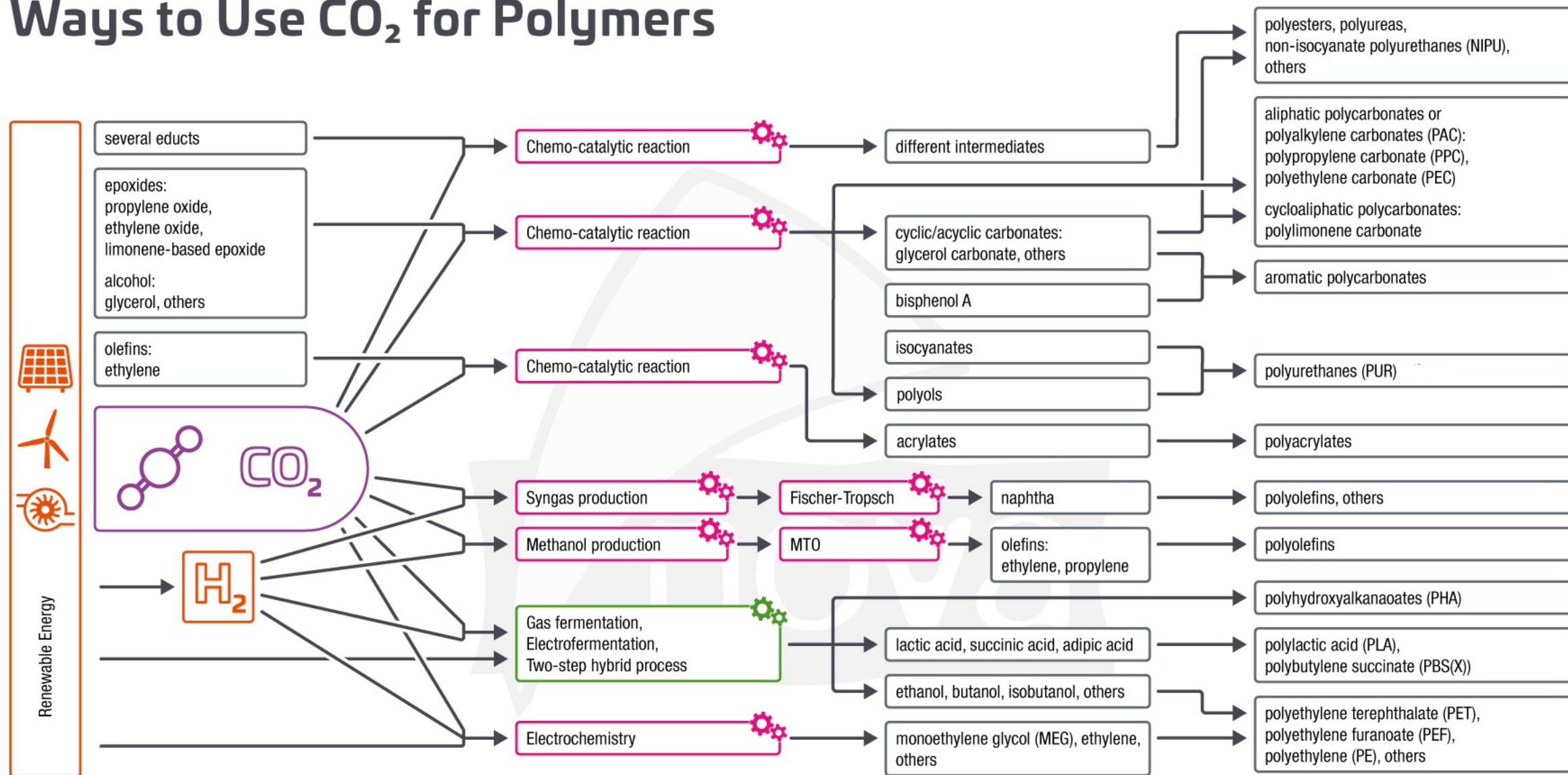
January 2021

This and other reports on renewable carbon are available at
www.renewable-carbon.eu/publications

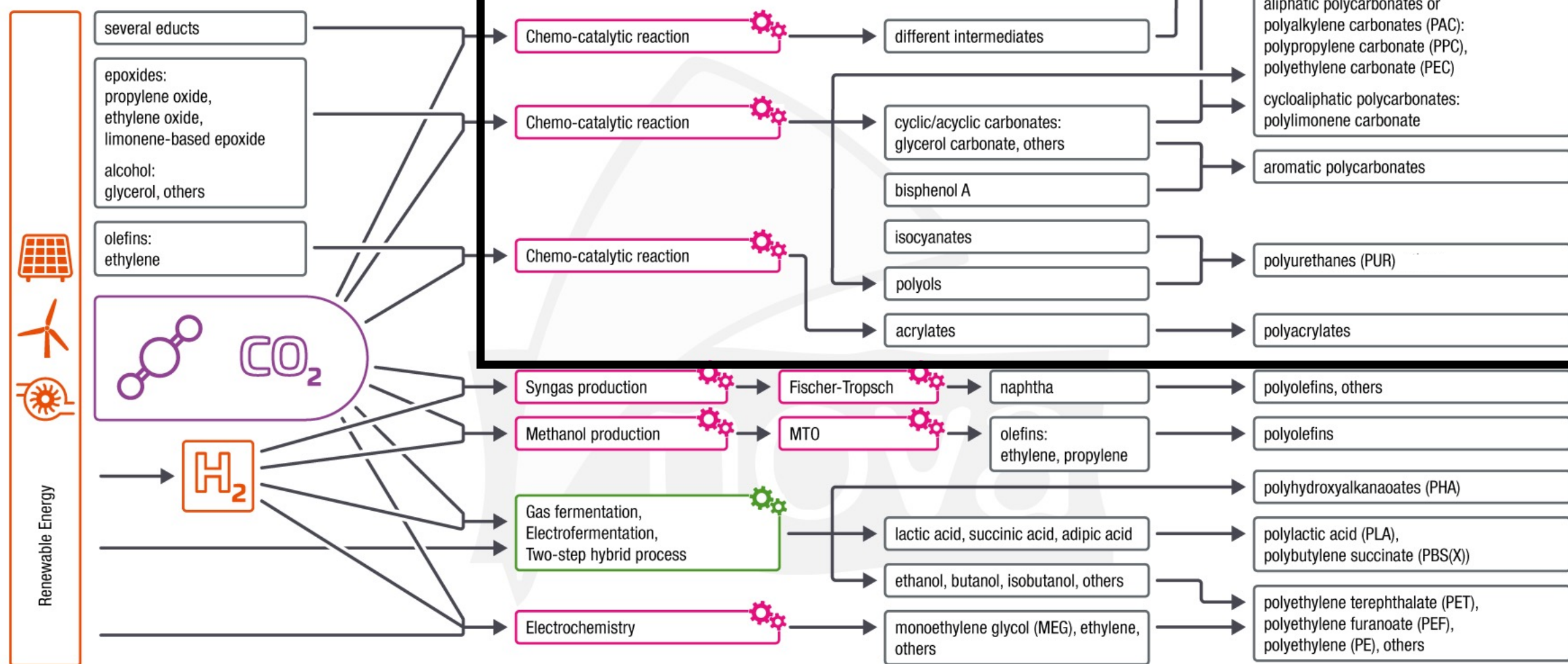
20 % allowance with
novaWinSpec22

- Published in January 2021
- 100 pages
- More than 40 companies and research projects presented
- € 1,000 – www.renewable-carbon.eu/publications

Ways to Use CO₂ for Polymers



Ways to Use CO₂ for Polymers



Production capacities for CO₂-based polycarbonates

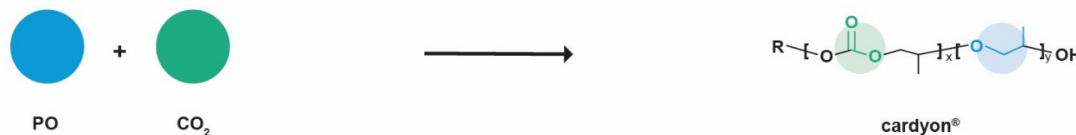
Company	Country	Capacity	Final products	CO ₂ share (%)	CO ₂ -based carbon content (%)
Polycarbonate synthesis and polyol synthesis for polyurethanes					
Asahi Kasei and various under their licenses	Various	750,000 t/a	Aromatic polycarbonates	17.3	4.7
Covestro	Germany	5,000 t/a	Polycarbonates polyols for	20	5.5
Empower Materials	USA	850,000 t/a	Polycarbonates	40	ca. 11
Jiangsu Zhongke Jinlong	China	30,000 t/a	PPC	40	11
Jilin Boda New Materials	China	30,000 t/a	PPC	40	ca. 11
Inner Mongolia Mengxi High-Tech Group	China	3,000 t/a	PPC, PEPC, PPCHC	ca. 40	ca. 11
Saudi Aramco (formerly Novomer)	United States	5,000 t/a	PPC, PEC	43	ca. 12
Taizhou BangFeng Plastic	China	30,000 t/a	PPC	ca. 40	ca. 11
Nanyang Zhongju Tianguan - Tianguan Group	China	5,000 t/a	PPC	ca. 40	ca. 11

- Ca. 850,000 t/a of CO₂-based polymers already produced
- Ca. 5.4 % of total weighted CO₂-based carbon content

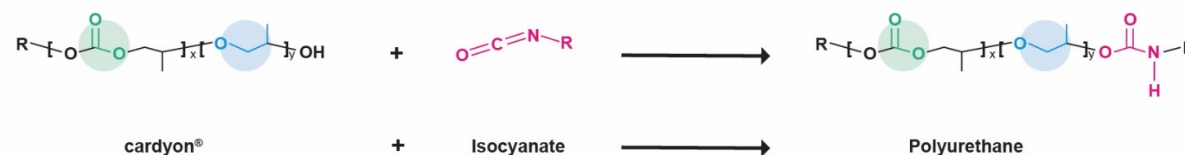
Chemical conversion of CO₂ to polycarbonate polyols



PRODUCTION OF CARDYON®



PRODUCTION OF PU WITH CARDYON®

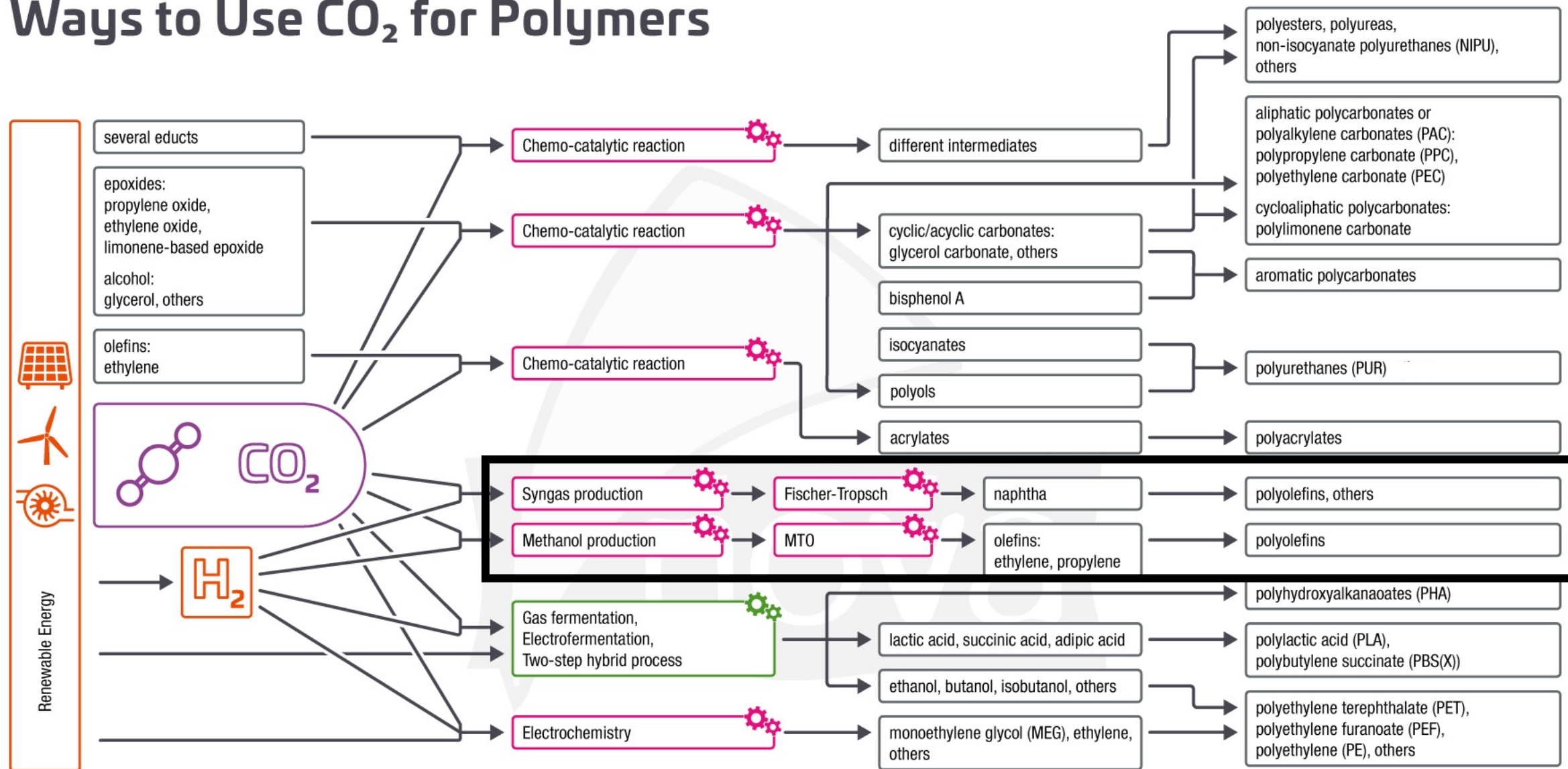


PO = Propylene oxide, PU = Polyurethane



- Cardyon® contains up to 20 % CO₂ by weight
- The produced polyurethane is used for foams, such as in mattresses, in textiles applications and in elastomer products

Ways to Use CO₂ for Polymers

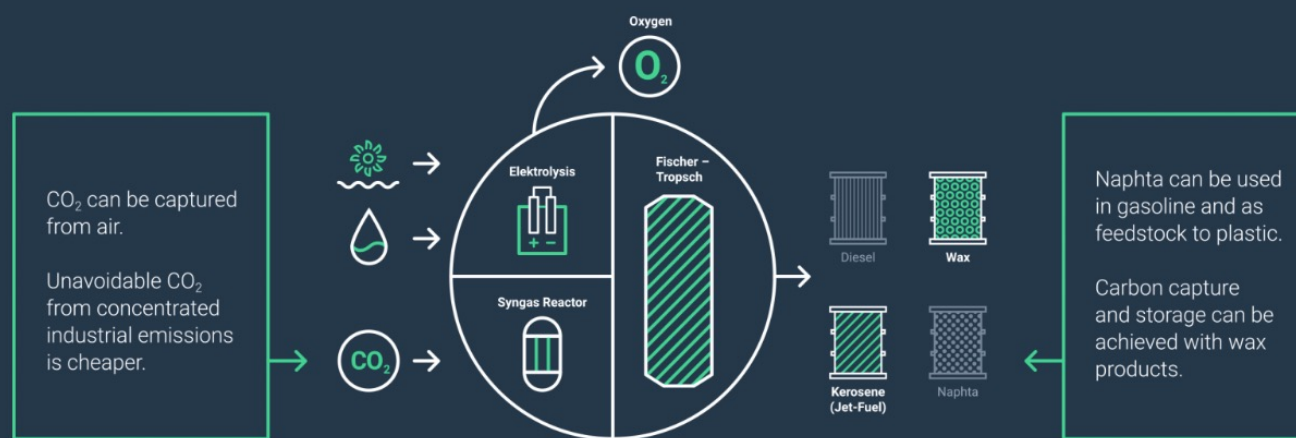


Chemical conversion of CO₂ to naphtha (building block) via Fischer-Tropsch reaction

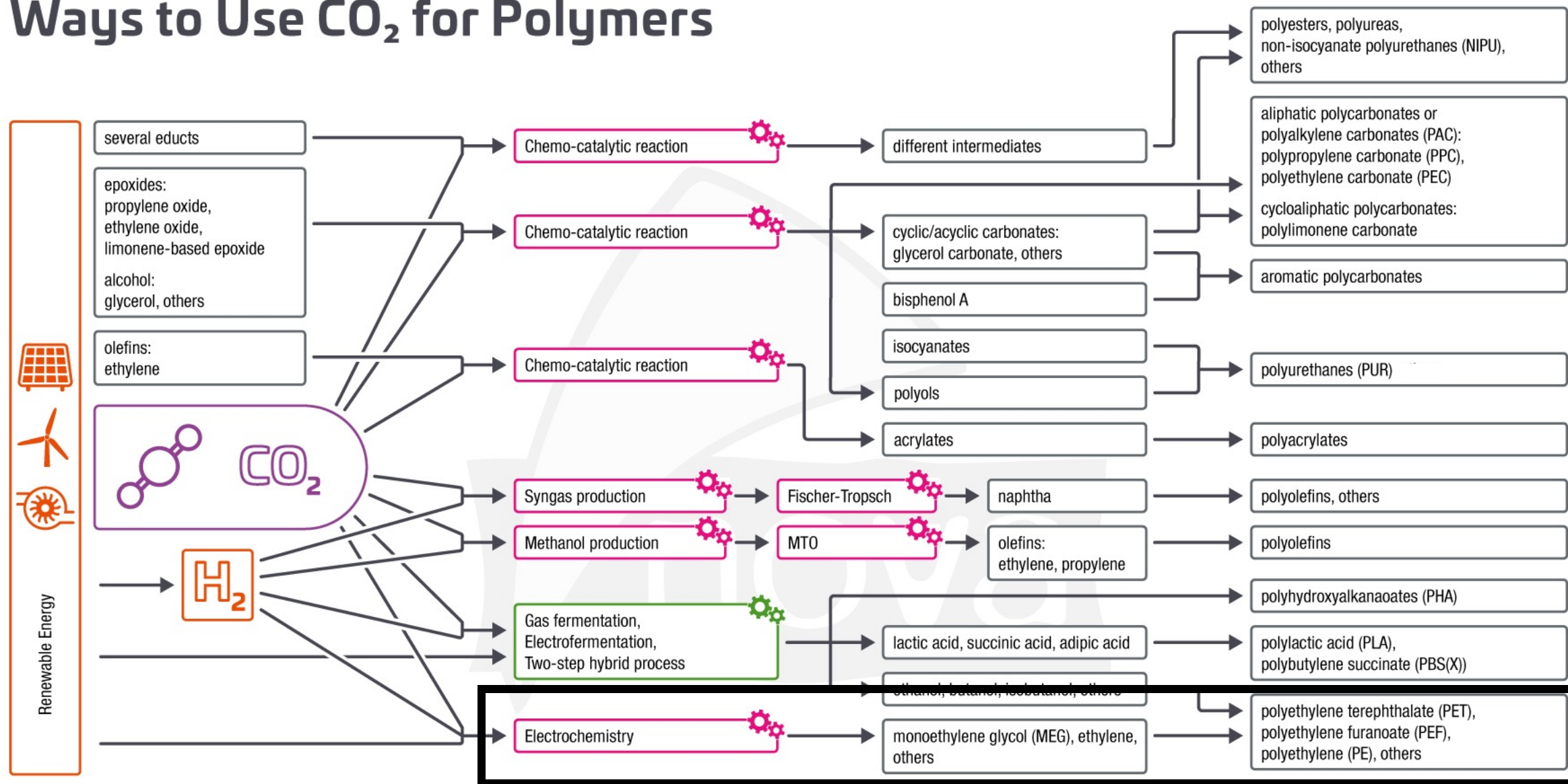


- 1** Renewable Energy is used to split water vapor (H₂O) to hydrogen (H₂) and oxygen
- 2** Hydrogen from electrolysis reacts with carbon dioxide (CO₂) and is reduced to carbon monoxide (CO)
- 3** Synthetic gas (H₂ and CO) is converted to Blue fuel products consisting of wax, enhanced premium diesel and naphtha through a catalytic process

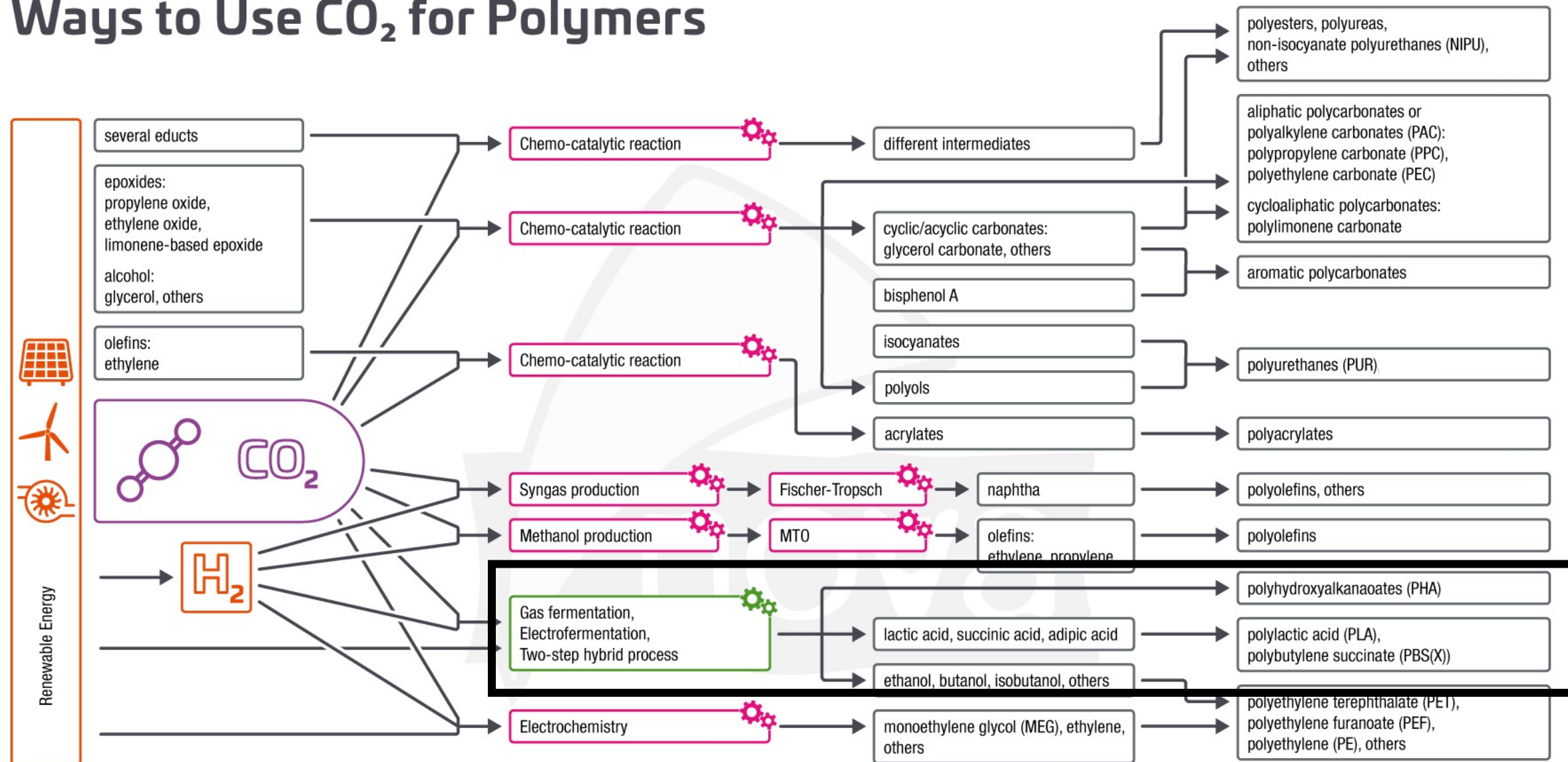
Production & Products



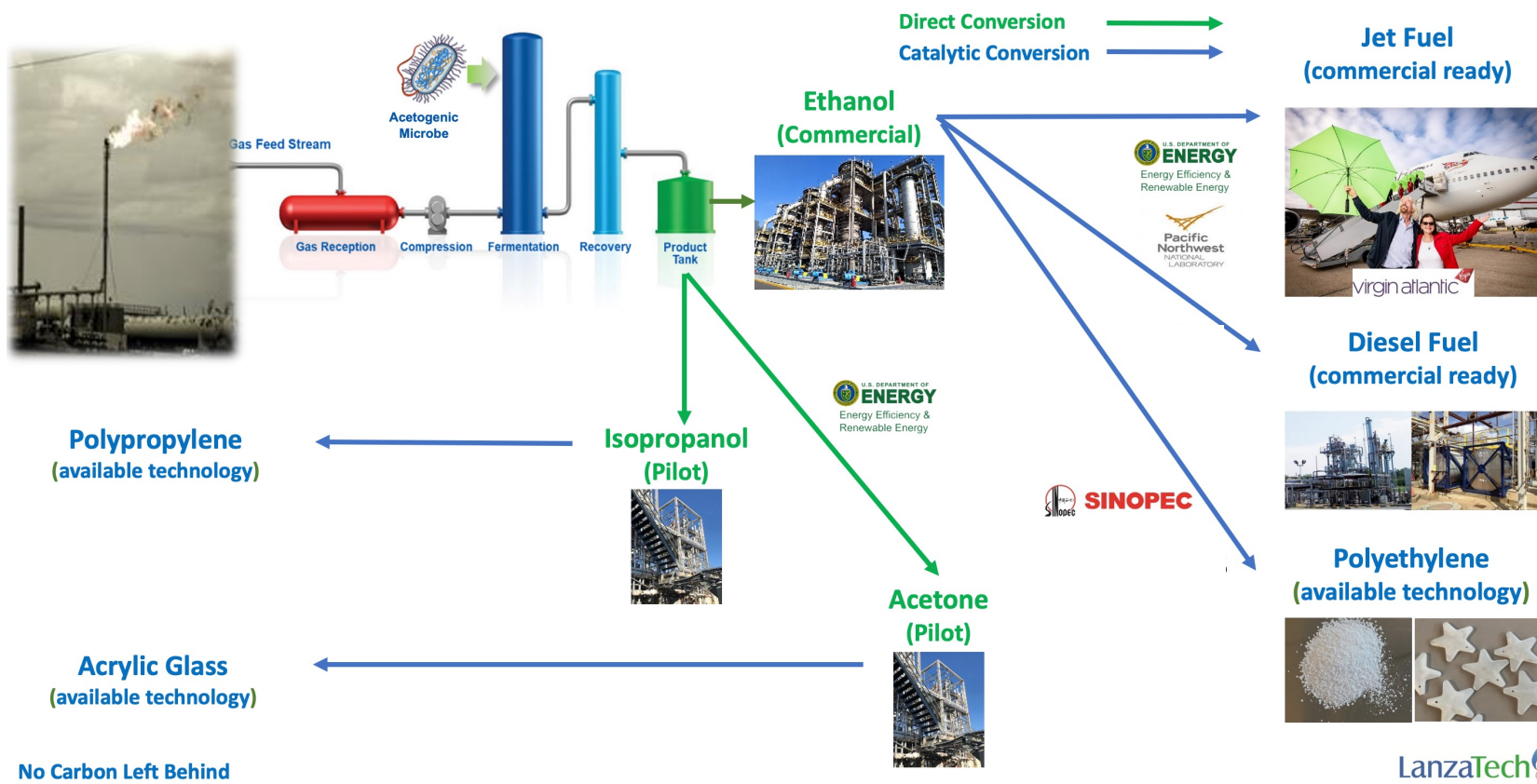
Ways to Use CO₂ for Polymers



Ways to Use CO₂ for Polymers



Biotechnological conversion of CO₂ to ethanol (building block)



Biotechnological conversion of CO₂ to ethanol (building block)

Further synthesis to polymers and surfactants



LANZATECH, TOTAL AND L'ORÉAL ANNOUNCE A WORLDWIDE PREMIERE: THE PRODUCTION OF THE FIRST COSMETIC PLASTIC BOTTLE MADE FROM INDUSTRIAL CARBON EMISSIONS

Clichy, 27th October 2020 – Through their innovative partnership, LanzaTech, Total and L'Oréal have premiered the world's first sustainable packaging made from captured and recycled carbon emissions. The successful conversion process takes place in three steps:

- **LanzaTech** captures industrial carbon emissions and converts them into ethanol using a unique biological process.
- **Total**, thanks to an innovative dehydration process jointly developed with IFP Axens, converts the ethanol into ethylene before polymerizing it into polyethylene that has the same technical characteristics as its fossil counterpart.
- **L'Oréal** uses this polyethylene to produce packaging with the same quality and properties as conventional polyethylene.



INDIA GLYCOLS LIMITED

World-first laundry capsule in market made from industrial carbon emissions

21/04/2021

London: Unilever has partnered with LanzaTech and India Glycols to produce a surfactant made from industrial carbon emissions instead of from fossil-fuels. The innovative shift in production utilises biotechnologies and a newly configured supply chain between the three partners, who are working together for the first time.

Typically derived from fossil fuels, surfactants are a critical ingredient for creating the foam and cleaning action of many household cleaning and laundry products, from dish soaps to fabric detergents. The new process now allows surfactants to be made using recycled carbon.

Recycled carbon is a key form of renewable carbon and is essential to eliminating the use of fossil fuels. A recent report published by the Nova Institute and Unilever in April 2021¹ estimates that demand for fossil-derived chemicals will more than double by 2050. Renewable carbon production will need to increase by a factor of 15 by 2050 to phase-out the use of fossil carbon in consumer products.



INDIA GLYCOLS LIMITED



13
JUL 2021

LanzaTech and lululemon partner to create the first fabric using recycled carbon emissions

Partnership includes India Glycols Limited and Far Eastern New Century

Biotechnology company LanzaTech today announced it has partnered with lululemon athletica inc. (NASDAQ:LULU), an athletic apparel company, to create the world's first yarn and fabric using recycled carbon emissions that would otherwise be emitted to the atmosphere as pollution. LanzaTech uses nature-based solutions to produce ethanol from waste carbon sources and is working with partners India Glycols Limited (IGL) and Far Eastern New Century (FENC, TWSE: 1402) to convert ethanol to polyester.

Recycling carbon is a fundamental element of the circular economy, which will keep fossil carbon in the ground, reducing pollution and fossil fuel usage when used to make polyester. With a lower carbon footprint, this innovation could transform lululemon's products and the apparel industry.

Biotechnological conversion of CO₂ to polyhydroxyalkanoates (PHAs)



- Newlight Technologies opened an assumed 7,000 – 8,000 t/a commercial gas fermentation plant for PHBV for cutlery and drinking straws and for eyewear, wallet and handbags.



International Conference on
CELLULOSE FIBRES
2–3 February **2022**
Hybrid Event



Conference on
CO₂-based Fuels
& Chemicals **2022**
23–24 March • Hybrid Event



10–12 May
Hybrid Event

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

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Thank you for your attention!



Sustainability

M. Sc. Pauline Ruiz

+49 (0) 2233 48 14-62

pauline.ruiz@nova-institut.de

Sustainability assessment / LCA

Chemicals, building blocks & polymers

Material Science

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