Providing CO_2 as Valuable Feedstock for Fuels, Chemicals and Plastics

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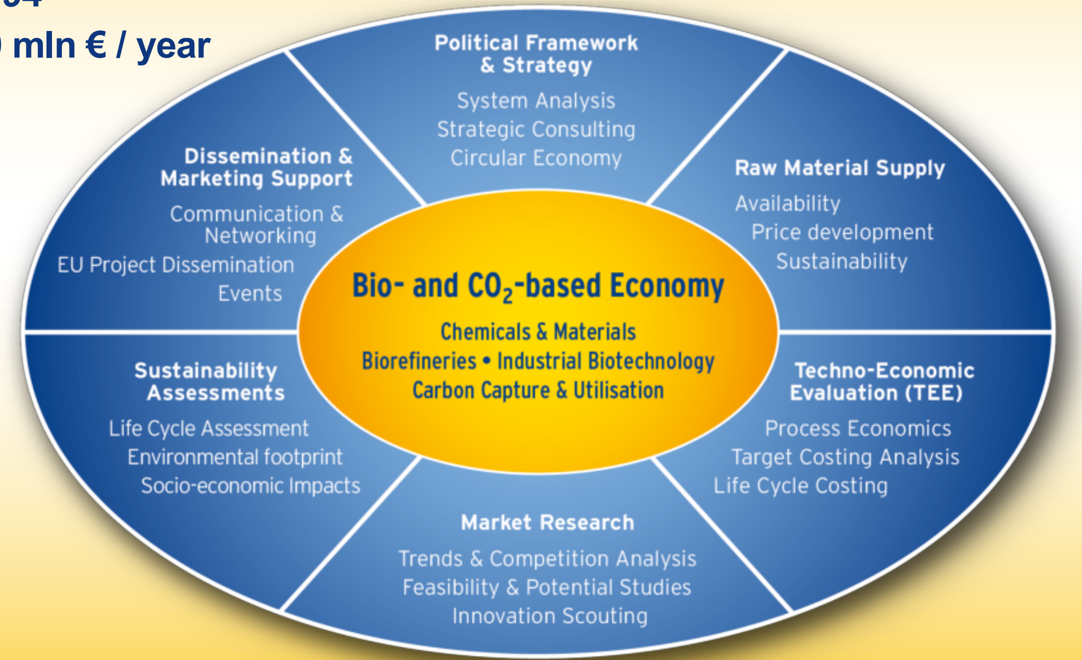
- **Turnover > 3.0 mln € / year**
- **35 employees**



Selected Customers from all Industrial Sectors

BIG BioInnovation Growth mega-Cluster | BMW | BASF We create chemistry | IKEA | BCG | BIO-BASED INDUSTRIES Public-Private Partnership

cefic | faurecia inspiring mobility | Corbion purac | LEIFHEIT AKTIENGESELLSCHAFT | Deloitte. |

CLIB 2021 | Ford | covestro | LEGO | ECORYS | FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

european bioplastics | | DUPONT | Nestlé | EY Building a better working world | FACHAGENTUR NACHWACHSENDE ROHSTOFFE e.V.

CO_2 VALUE EUROPE | PORSCHE | FKuR plastics - made by nature!® | playmobil | KPMG | giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

WWF | | NESTE | VELUX | meo CONSULTING TEAM | NIA สำนักงานนวัตกรรมแห่งชาติ

Selected Customers from Chemical Industry

- Anellotech
- cefic
- EVONIK – KRAFT FÜR NEUES
- Honeywell
- TEIJIN
- Arizona Chemical
- Corbion purac
- ExxonMobil – Energy lives here
- KRATON
- TOTAL
- avantium
- covestro
- Ferrostaal
- mondi
- storaenso
- BASF – We create chemistry
- DSM
- FKuR – plastics - made by nature!®
- NESTE
- SÜDZUCKER
- Borregaard
- DUPONT
- GOLDEN COMPOUND
- PCC SE
- SUIKER UNIE – A ROYAL COSUN COMPANY
- B·R·A·I·N
- Elastopoli Oy
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8th Conference on CO_2

Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

Award Sponsor

covestro

REGISTER NOW!

24.-25. March 2020

Maternushaus | Cologne | Germany

Sponsor

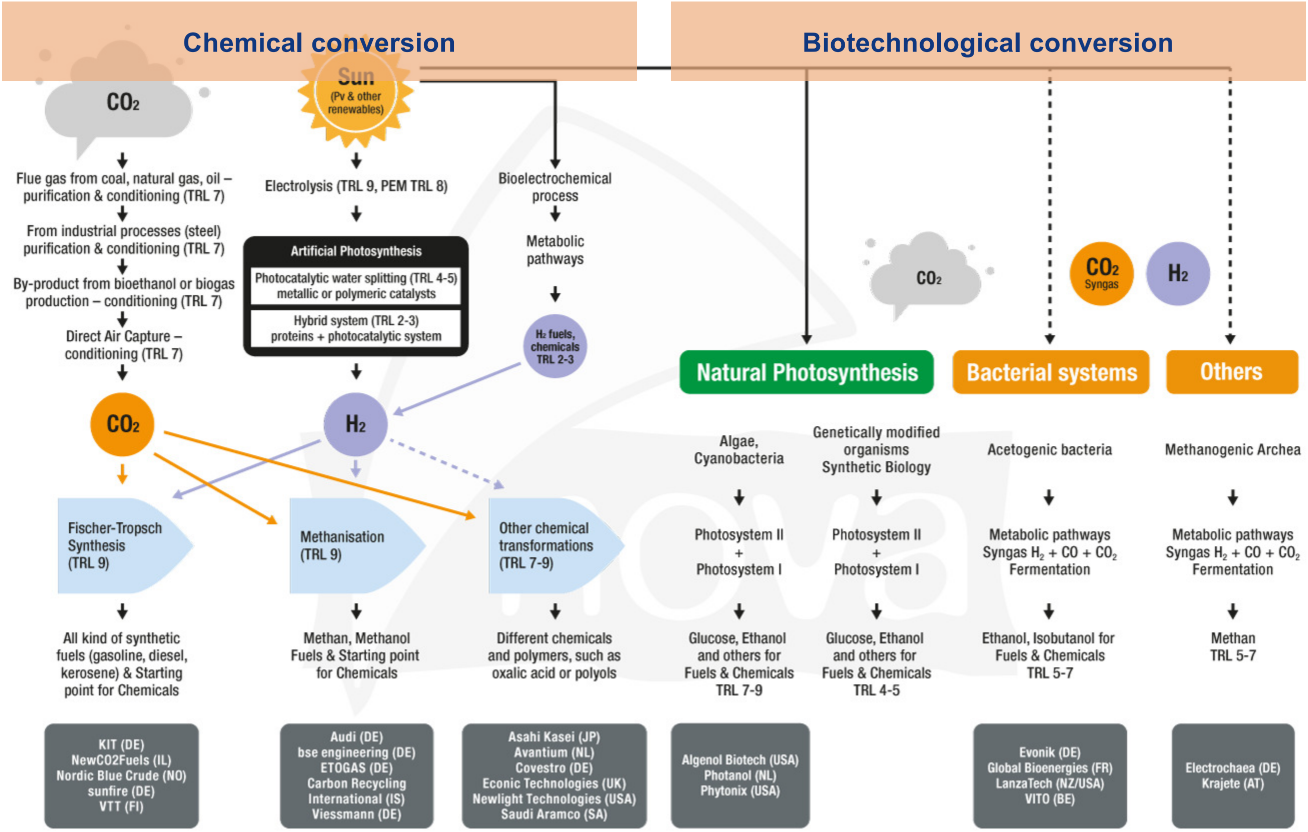
TOTAL

CO_2 Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

CO_2-based economy

Carbon Capture and Utilisation (CCU)

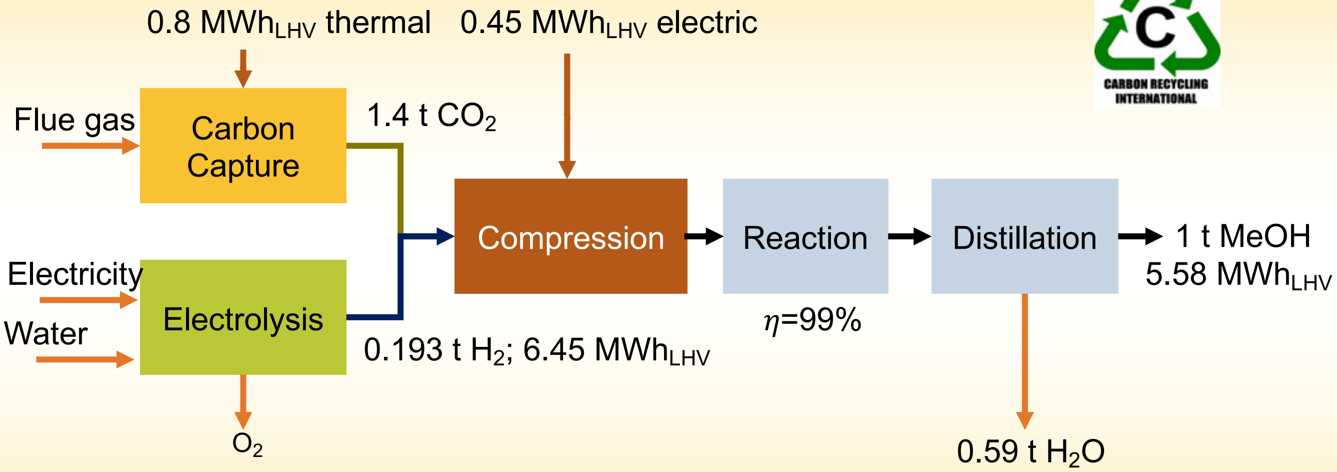
Carbon Dioxide Utilisation and renewable energy



All figures available at **www.bio-based.eu/markets**

www.bio-based.eu

Methanol Synthesis – Production of advanced fuels

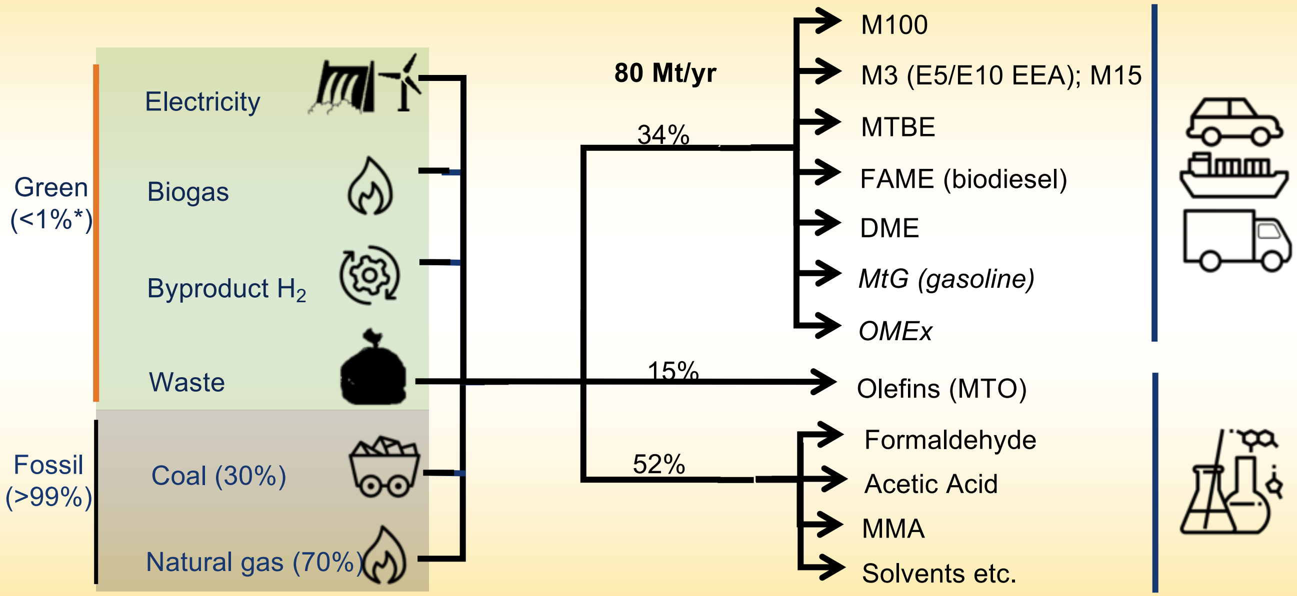


CARBON RECYCLING INTERNATIONAL

Overall efficiency larger than 60%

*Not including PSA

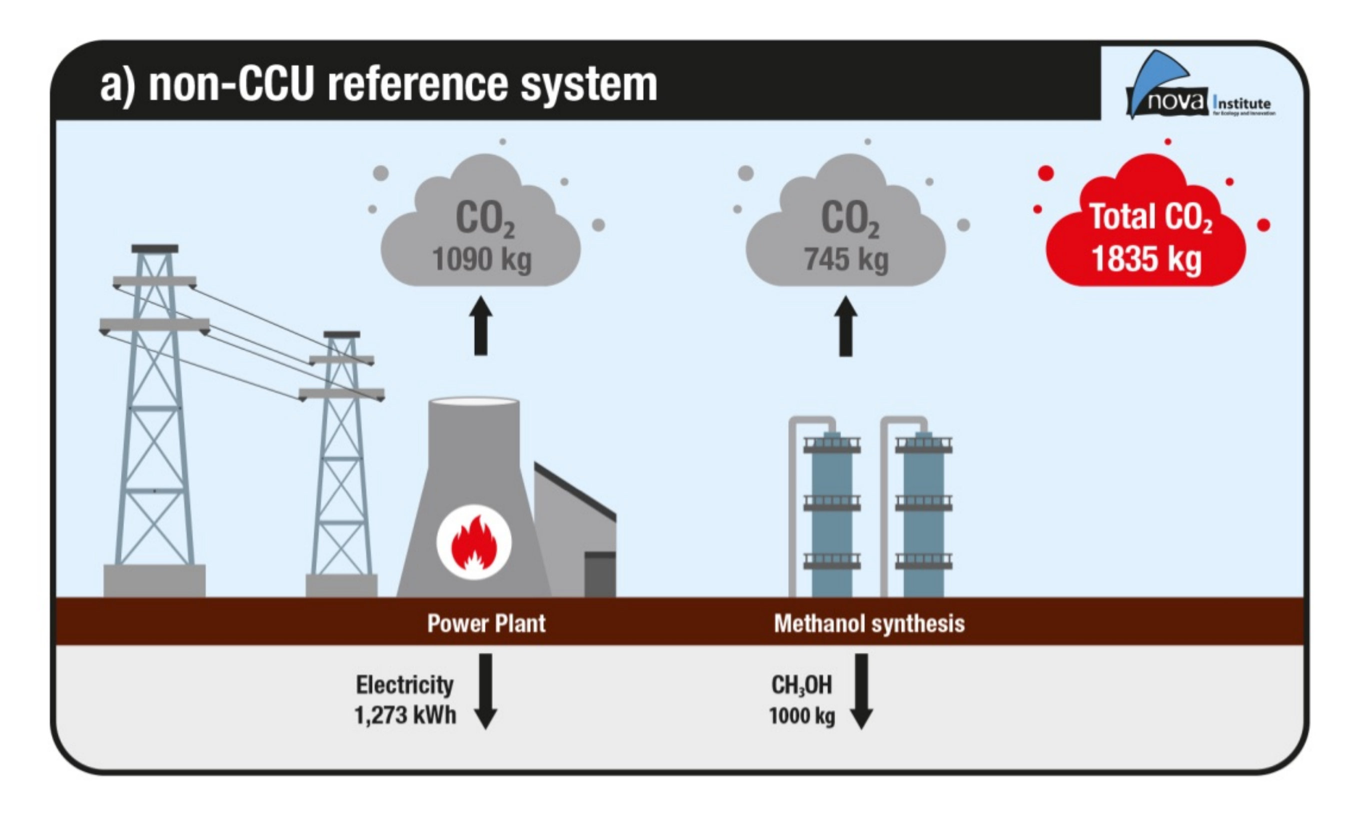
Methanol: the most versatile hydrocarbon



*Currently

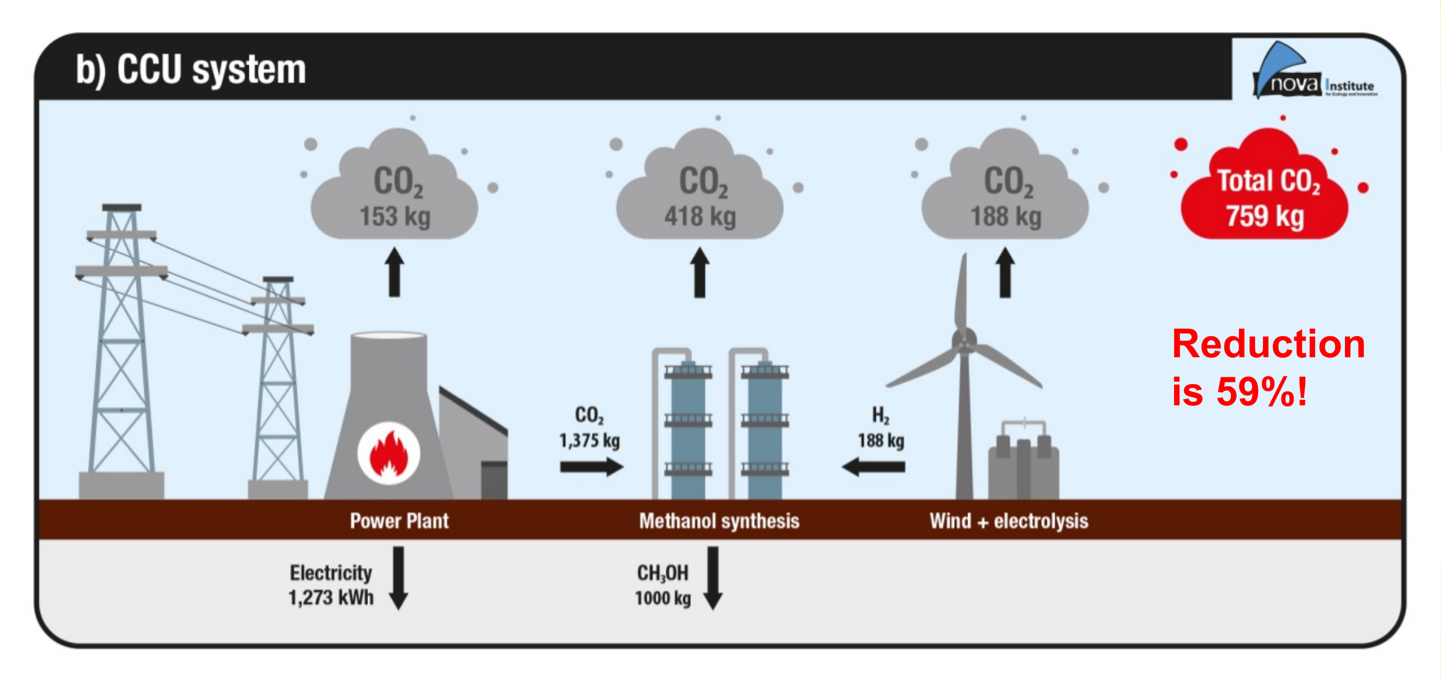
Source: CRI

Separate production of electricity and methanol (real data)



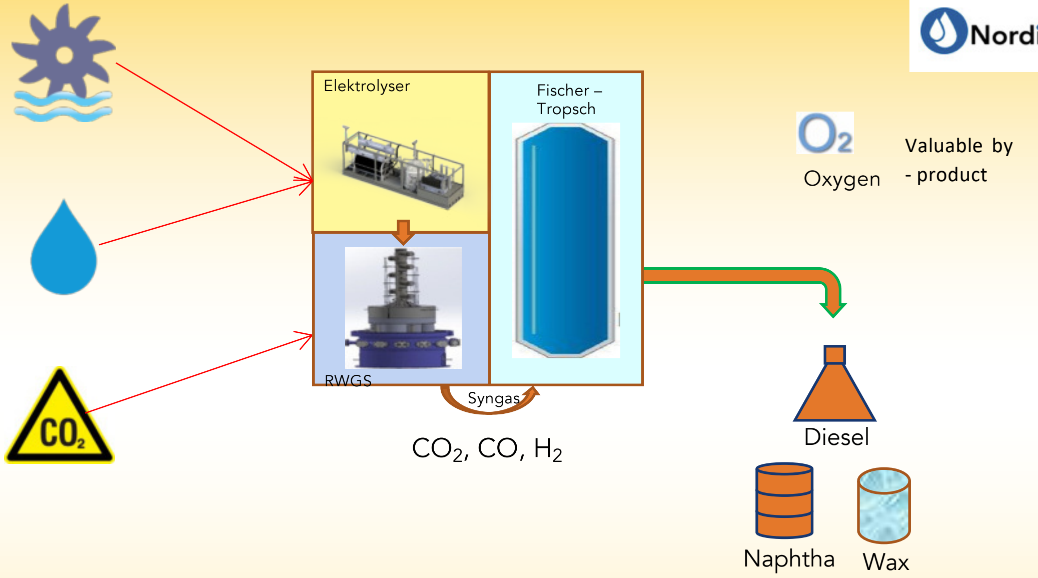
Source: Von der Assen, N., Voll, P., Peters, M. and André Bardow, A.: Life cycle assessment of CO2 capture and utilization: a tutorial review. Chem. Soc. Rev. 2014-01-20.

Joint production of electricity and methanol via CCU & wind energy (real data)



Source: Von der Assen, N., Voll, P., Peters, M. and André Bardow, A.: Life cycle assessment of CO2 capture and utilization: a tutorial review. Chem. Soc. Rev. 2014-01-20.

E Fuels – Production & Products (PtL)

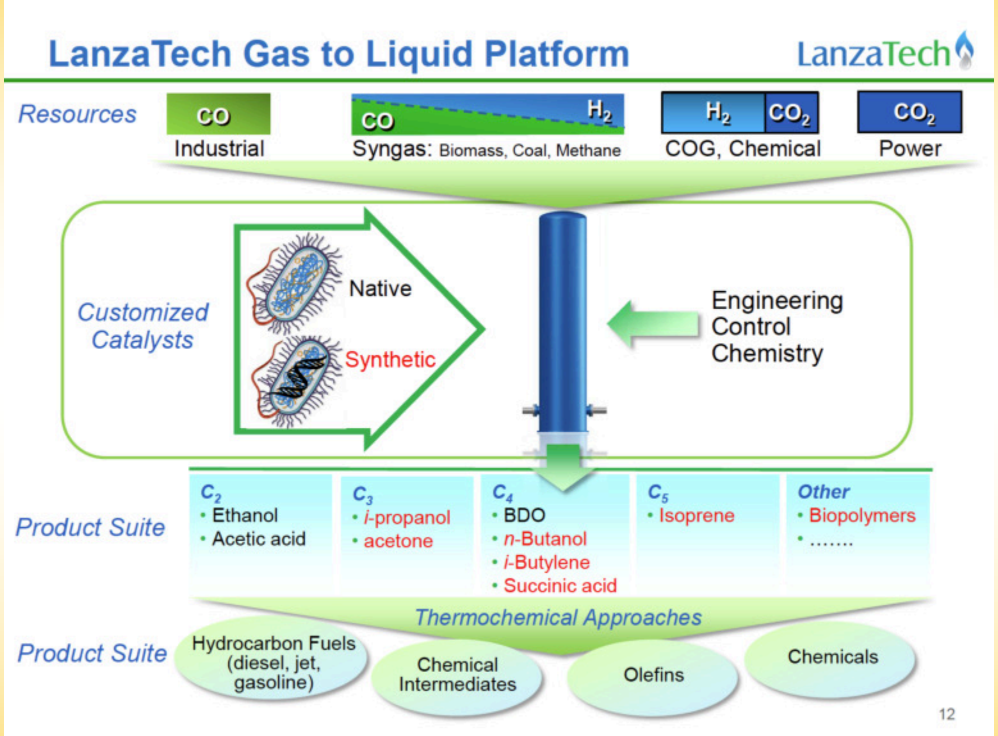


Renewable Energy is used to split water vapor (H_2O) to hydrogen (H_2) and oxygen

Hydrogen from electrolysis reacts with carbon dioxide (CO_2), and reduced to carbon monoxide (CO).

This synthetic gas (H_2 and CO) is converted to E-Products consisting of wax and enhanced premium diesel, Kerosene and naphtha through a synthesis process.

Biotechnology routes for CO_2 utilization



Microorganism can produce a wide range of molecules from CO_2

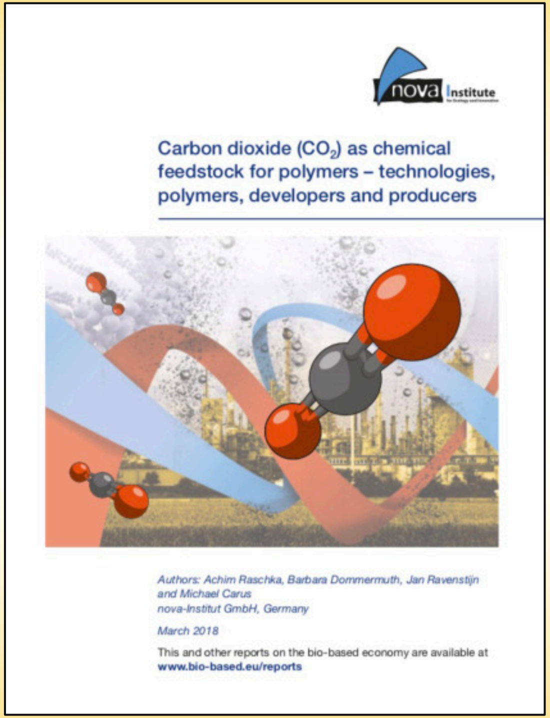
Source: Lanzatech 2018

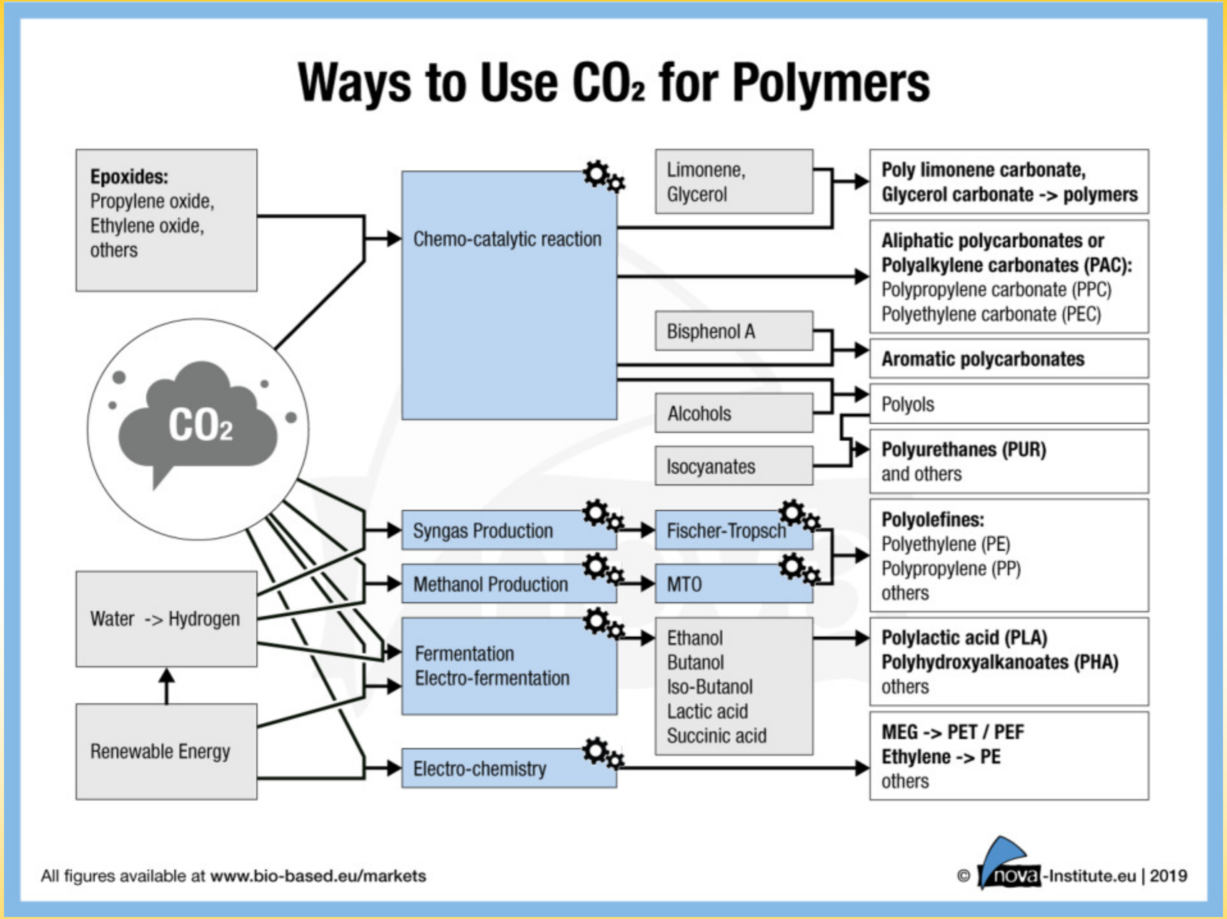
CO_2 utilisation – Alcohols and fuels

company	headquarter	scale	production site				start date	endproduct
			city	country	status	capacity / output power		
Biotechnological CO_2 conversion processes								
LanzaTech Inc.,	United States	commercial	Ghent	Belgium	construction	62,000 t/a	2019	ethanol and e.g. n-butanol
			Shougang	China	in operation	48,000 t/a	2018	
			Gurgaon	India	construction	34,000 t/a	2019	
			Nelspruit	South Africa	construction	52,000 t/a	2019	
			Modesto	United States	construction	35,000 t/a	2019	
				United Kingdom	planning	950,000 t/a		kerosene
Phytonix Corp.	United States	commercial		United States	planning	> 500,000 t/a	2019/2020	n-butanol
				Europe	planning			

CO_2 utilisation – Alcohols and fuels

company	headquarter	scale	production site				start date	endproduct
			city	country	status	capacity / output power		
Chemical CO_2 conversion processes								
Carbon Recycling International	Iceland	commercial	Grindavik	Iceland	in operation	4,000 t/a	2011	methanol
				Norway	planning	100,000 t/a	2021	
Nordic Blue Crude AS	Norway	commercial	Herøya	Norway	construction	8,000 t/a	2020	diesel, kerosene naphtha, wax
Rotterdam The Hague airport	The Netherlands	demonstration	Rotterdam	The Netherlands	planning	290,000 t/a		
Sunfire GmbH	Germany	demonstration	Dresden	Germany	in operation	> 3 t/a	2014	


nova Institute
Carbon dioxide (CO_2) as chemical feedstock for polymers – technologies, polymers, developers and producers
Authors: Achim Raschka, Barbara Dommermuth, Jan Ravenstijn and Michael Carus
nova-Institut GmbH, Germany
March 2018
This and other reports on the bio-based economy are available at
www.bio-based.eu/reports


Ways to Use CO_2 for Polymers
Epoxides: Propylene oxide, Ethylene oxide, others
CO_2
Water -> Hydrogen
Renewable Energy
Chemo-catalytic reaction
Syngas Production
Methanol Production
Fermentation Electro-fermentation
Electro-chemistry
Limonene, Glycerol
Bisphenol A
Alcohols
Isocyanates
Fischer-Tropsch
MTO
Ethanol Butanol Iso-Butanol Lactic acid Succinic acid
Poly limonene carbonate, Glycerol carbonate -> polymers
Aliphatic polycarbonates or Polyalkylene carbonates (PAC): Polypropylene carbonate (PPC) Polyethylene carbonate (PEC)
Aromatic polycarbonates
Polyols
Polyurethanes (PUR) and others
Polyolefines: Polyethylene (PE) Polypropylene (PP) others
Polylactic acid (PLA) Polyhydroxyalkanoates (PHA) others
MEG -> PET / PEF Ethylene -> PE others
All figures available at www.bio-based.eu/markets
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Strategy 2020

Renewable Carbon is the Key to a Sustainable and Future-Oriented Chemical and Plastic Industry

Major threats and challenges to our planet are

- Climate change and
- Biodiversity loss

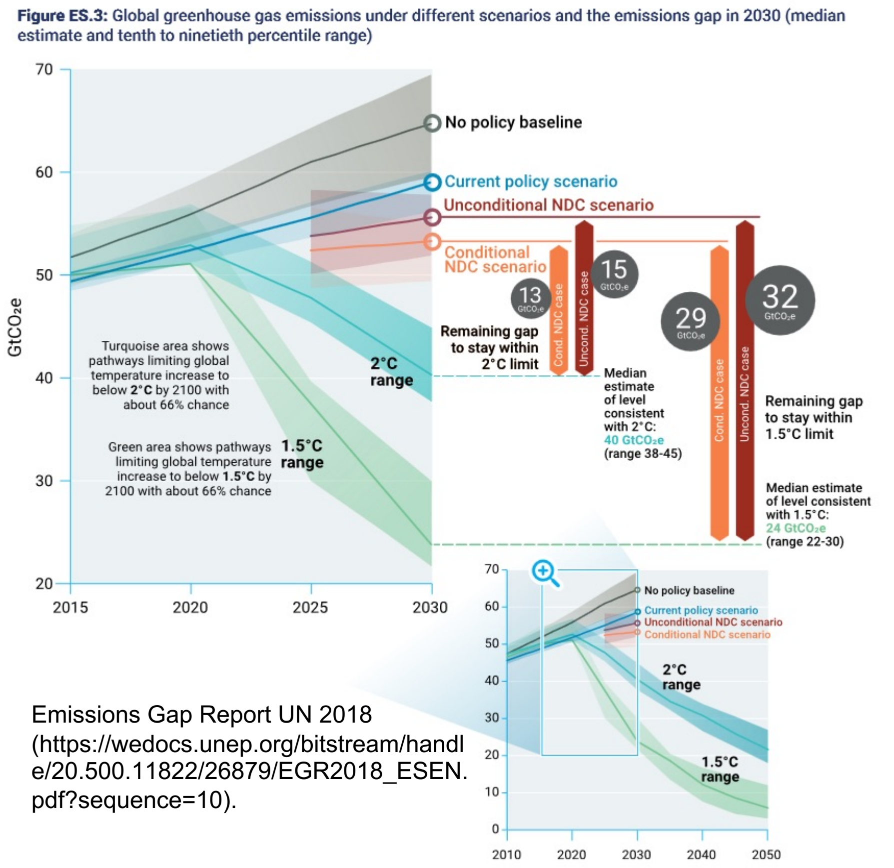
The main reason for climate change

- 75%: CO_2 emissions
- Mainly fossil CO_2 emissions from utilised crude oil, natural gas and coal

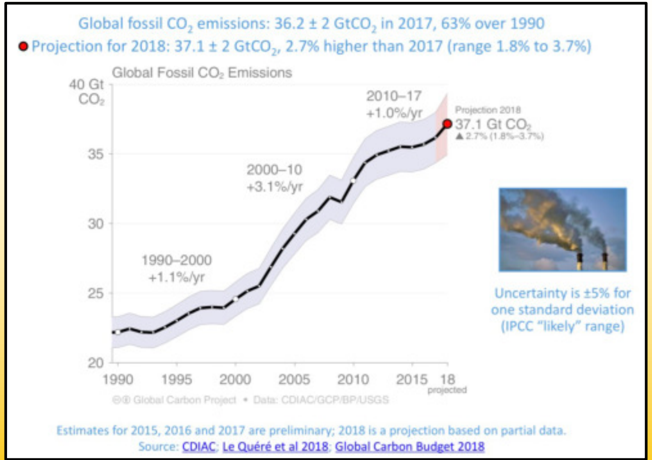
The main reasons for the biodiversity loss

- **Climate change**, alongside factors like land degradation and habitat loss, is emerging as a top threat to wildlife around the globe. https://www.scientificamerican.com/article/climate-change-is-becoming-a-top-threat-to-biodiversity/
- According to the Millennium Ecosystem Assessment, **climate change is likely to become one of the most significant drivers of biodiversity loss by the end of the century**. Climate change is already forcing biodiversity to adapt either through shifting habitat, changing life cycles, or the development of new physical traits. https://www.cbd.int/climate/intro.shtml
- By the end of the century, **climate change** and its impacts may be the **dominant direct driver of biodiversity loss** and changes in ecosystem services globally. https://www.greenfacts.org/en/biodiversity/l-3/4-causes-desertification.htm

- All time record: 37 Gt fossil CO_2 emissions in 2018 (below)
- More than 50 Gt CO_2e in 2018 (left)
- In 2030 (1.5 Grad C range): about 24 Gt CO_2e are allowed (left)



Emissions Gap Report UN 2018 (https://wedocs.unep.org/bitstream/handle/20.500.11822/26879/EGR2018_ESEN.pdf?sequence=10).



STOP Fossil Carbon Use

Globally, a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2°C.

McGlade & Ekins 2015: The geographical distribution of fossil fuels unused when limiting global warming to 2°C. Nature 2015; 517:187–190.

- Only a **full phase-out of fossil carbon** will help prevent a further increase in CO_2 concentrations.
- All of the **fossil carbon extracted from the ground** will sooner or later be **released into the atmosphere** where the CO_2 concentration will go up as a consequence.

"Renewable Energy"
Decarbonisation of the Energy Sector

There is a clear and more or less consistent Energy Policy to a 100% renewable energy system based on **solar, wind, hydro** and other renewable energies.

Apart from bioenergy, bio- and CO_2-based fuels, all of these deserve the term **"decarbonisation"**.

Green electricity and **green hydrogen** for the **energy** and **fuel sector**.

"Renewable Carbon" for a Sustainable Chemical and Plastic Industry

There is no corresponding policy or strategy for the material sector, especially for the chemical and plastic industry.

The term **decarbonisation** is **sheer nonsense** for organic chemistry, which is based on carbon. It is used out of lack of knowledge and as a direct analogue to the energy field. We should NEVER use it in this context!

But the term is not only nonsense, it is even risky because it avoids the **question of the "right" carbon sources.**

And this is exactly what we have to provide. We need a future oriented renewable carbon strategy. And there are only three sources of renewable carbon.

RENEWABLE CARBON

CO_2

Renewable Carbon is the Key

Definition

Renewable Carbon means all carbon sources that **avoid or substitute any additional fossil carbon from the geosphere**. Renewable Carbon can come from the atmosphere, biosphere or technosphere – but not from the geosphere. Renewable carbon circulates between atmosphere, biosphere and technosphere.

There are only three sources of renewable carbon

- Renewable carbon from **recycling** of already existing plastics and other organic chemistry products, from the *Technosphere*
- Renewable carbon gained from all types of **biomass**, from the *Biosphere*
- Renewable carbon from **direct CO_2 utilisation**, from the *Technosphere* and *Atmosphere*

The equivalent to decarbonisation in the energy sector is a transition to renewable carbon in the chemical and plastics industries.

RENEWABLE

CARBON

CO_2

www.renewable-carbon.eu