Renewable Carbon Concept and Initiative

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RENEWABLE CARBON

Bio-based CO_2-based Recycling

Circular Economy

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Selected Customers from Chemical Industry

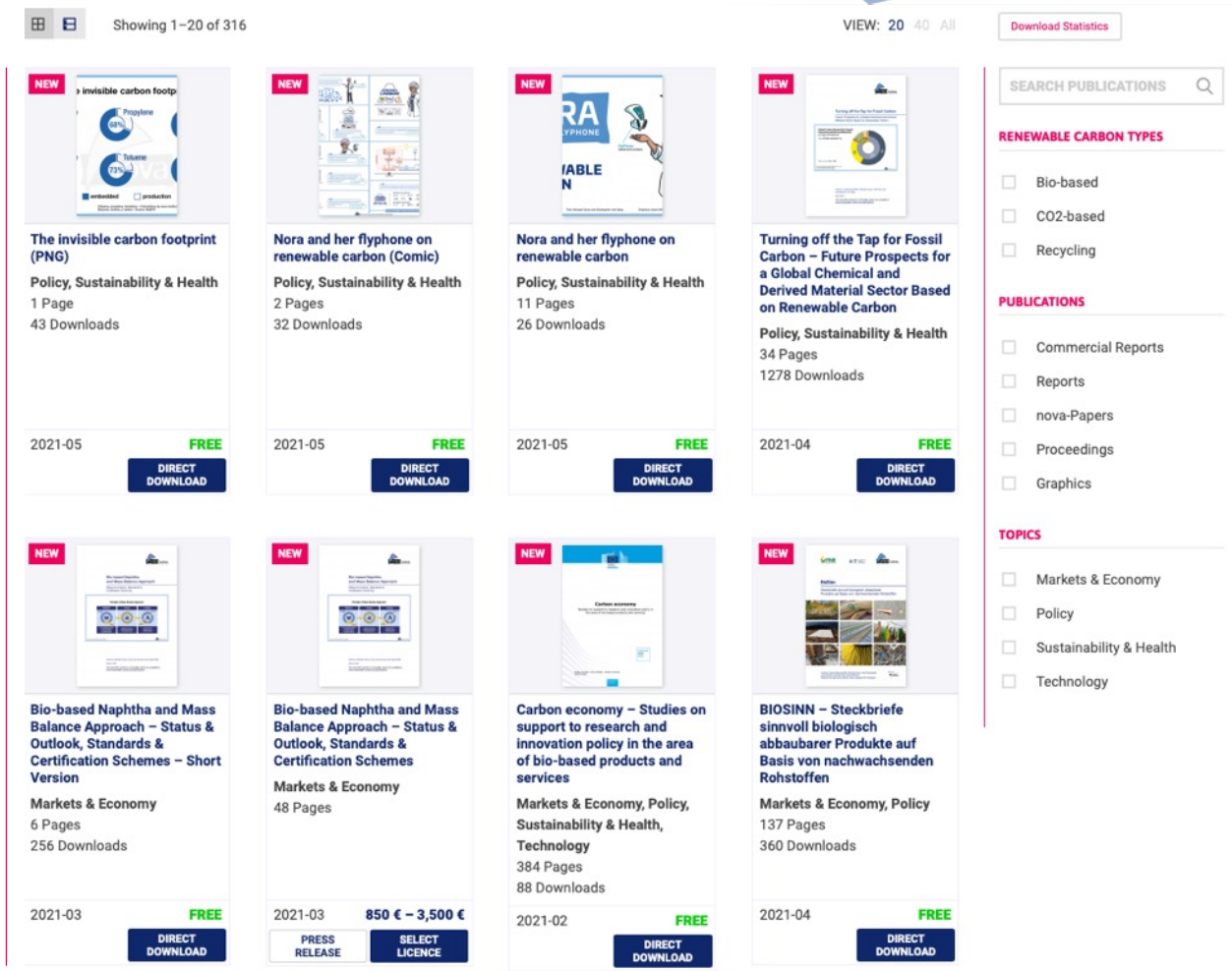
nova provides studies on all renewable carbon relevant topics such as bio-based & CO_2-based polymers as well as chemical recycling

Renewable Carbon Publications

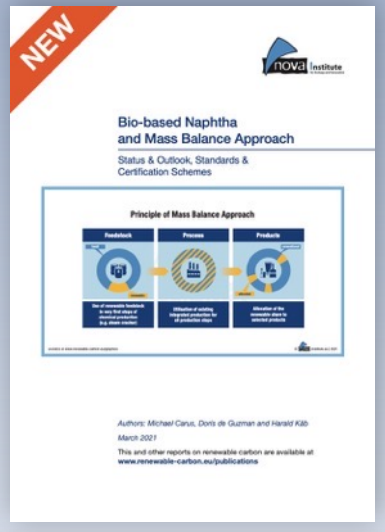
Over 300 publications on bio-based, CO_2-based and recycling by nova-institute

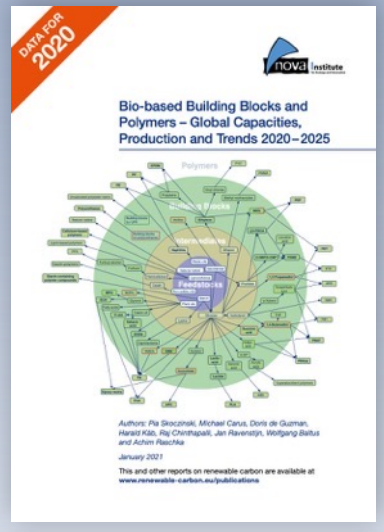
www.renewable-carbon.eu/publications

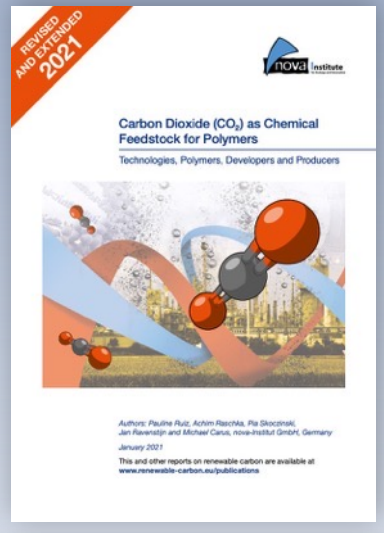
RENEWABLE CARBON PUBLICATIONS

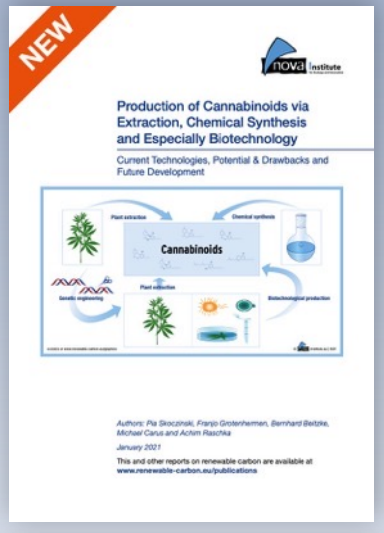


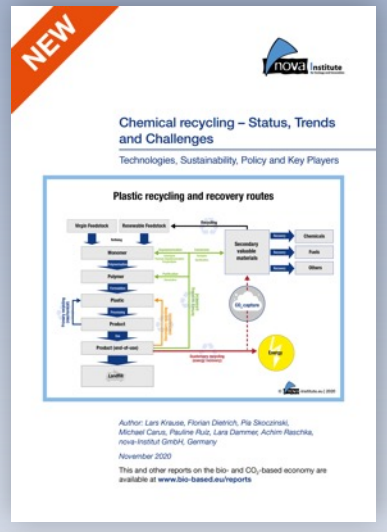
Bio-based Polymers & Building Blocks – the best market reports available

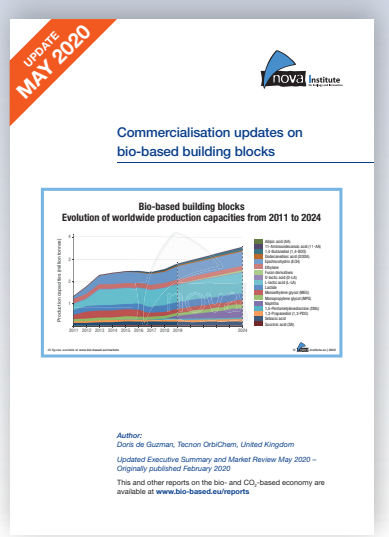


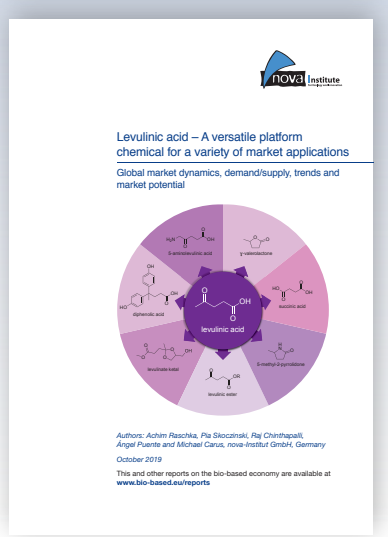


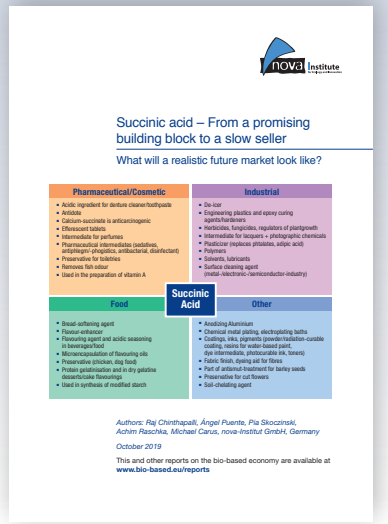












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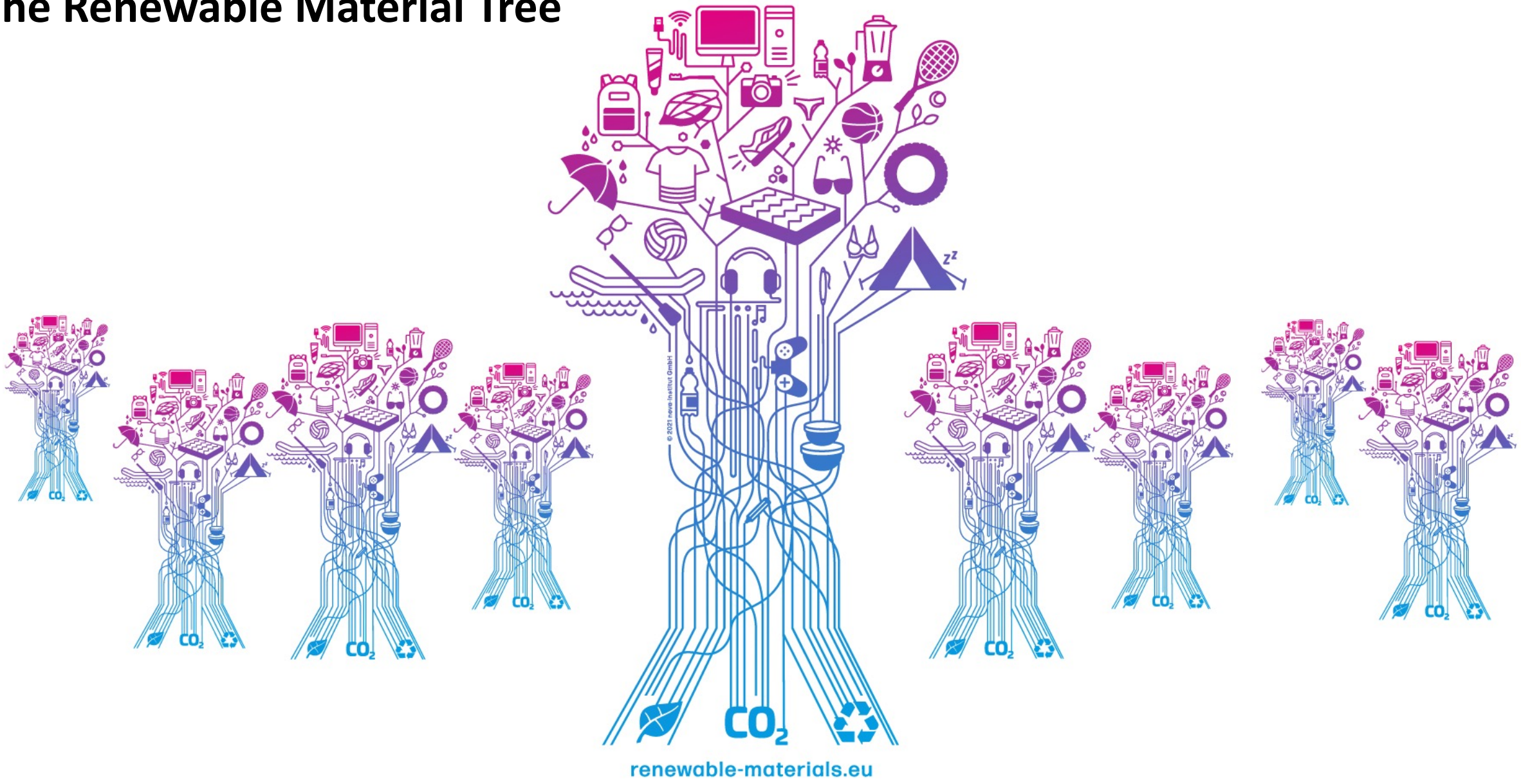
The Renewable Material Tree



The dilemma of fossil carbon

Major threats and challenges to our planet are

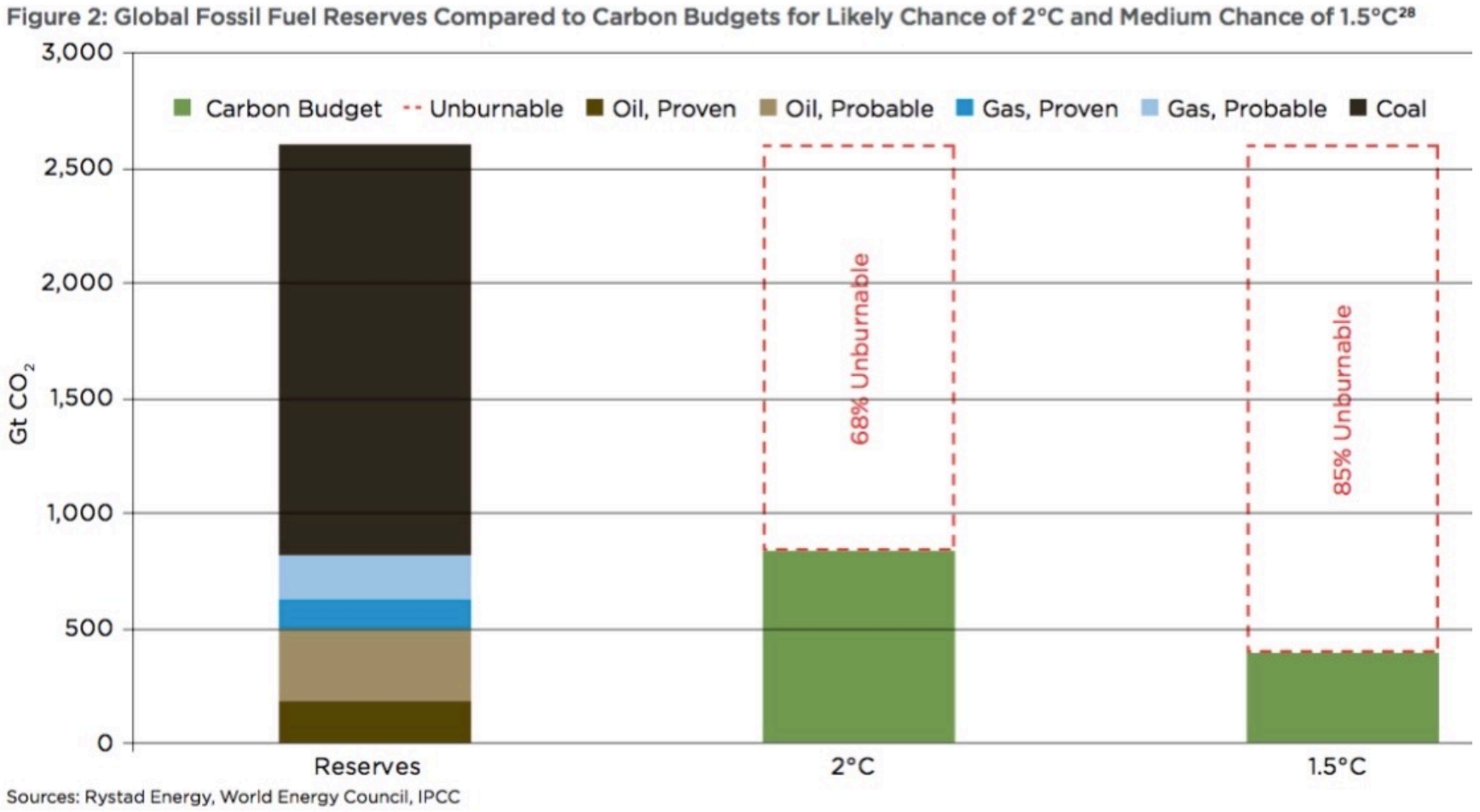
- Climate change and
- Biodiversity loss

STOP Fossil Carbon Use

„It is not CO_2 that is at the core of the climate problem, but the additional fossil carbon that we take out of the ground and which gets released in the atmosphere as CO_2 or other emissions. If the inflow is prevented, the CO_2 content of the atmosphere will no longer increase.“

Michael Carus, May 2020

STOP Fossil Carbon Use



- Globally, **a third of oil**, **half of gas** and **over 80 per cent of coal reserves** should remain unused in order to meet the target of 2°C.
  (McGlade & Ekins 2015)

- All of the **fossil carbon extracted from the ground** will sooner or later be **released into the atmosphere**

- Only a **full phase-out of fossil carbon** will help prevent a further increase in CO_2 concentrations.

Source: Oil Change International, 16-09

www.mcc-berlin.net/fileadmin/data/clock/carbon_clock.htm

Key points of the renewable carbon concept

- **72% from the GHG** emissions are directly related to **additional fossil carbon from the ground**.
- **Climate change** is likely to become one of the **most significant drivers of biodiversity loss**.
- **Decarbonisation** with renewable energies is a **good strategy for the energy sector**, but no issue for chemicals and materials, because most of them are based on carbon (just like humans ☺).
- There is a **lasting need for carbon** for chemicals and materials. All fossil carbon use has to end, as the carbon contained in the molecules of chemicals and plastics is prone to end up in the atmosphere sooner or later. **Only a full phase-out of fossil carbon will help to prevent a further increase in CO_2 concentrations**.
- The key challenge is to **replace demand** for fossil carbon by alternative carbon sources.
- The **equivalent to decarbonisation** in the energy sector is a transition to **renewable carbon** in the chemical and material industries.
- Those alternative carbon sources are **biomass**, **CO_2** and **recycling** of carbon containing waste streams (bio and plastic waste) – we need them all together to replace fossil carbon.
- We call them “**renewable carbon**”.

The Renewable Carbon Concept

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

RENEWABLE CARBON

entails all carbon sources that avoid or substitute the use of 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 biosphere, atmosphere or technosphere, creating a carbon circular economy.

Fossil carbon shall be completely substituted by renewable carbon, which is carbon from alternative sources: biomass, CO_2 and recycling. This is the only way for chemicals and plastics to become sustainable, climate-friendly and part of the circular economy – part of the future!

#renewablecarbon

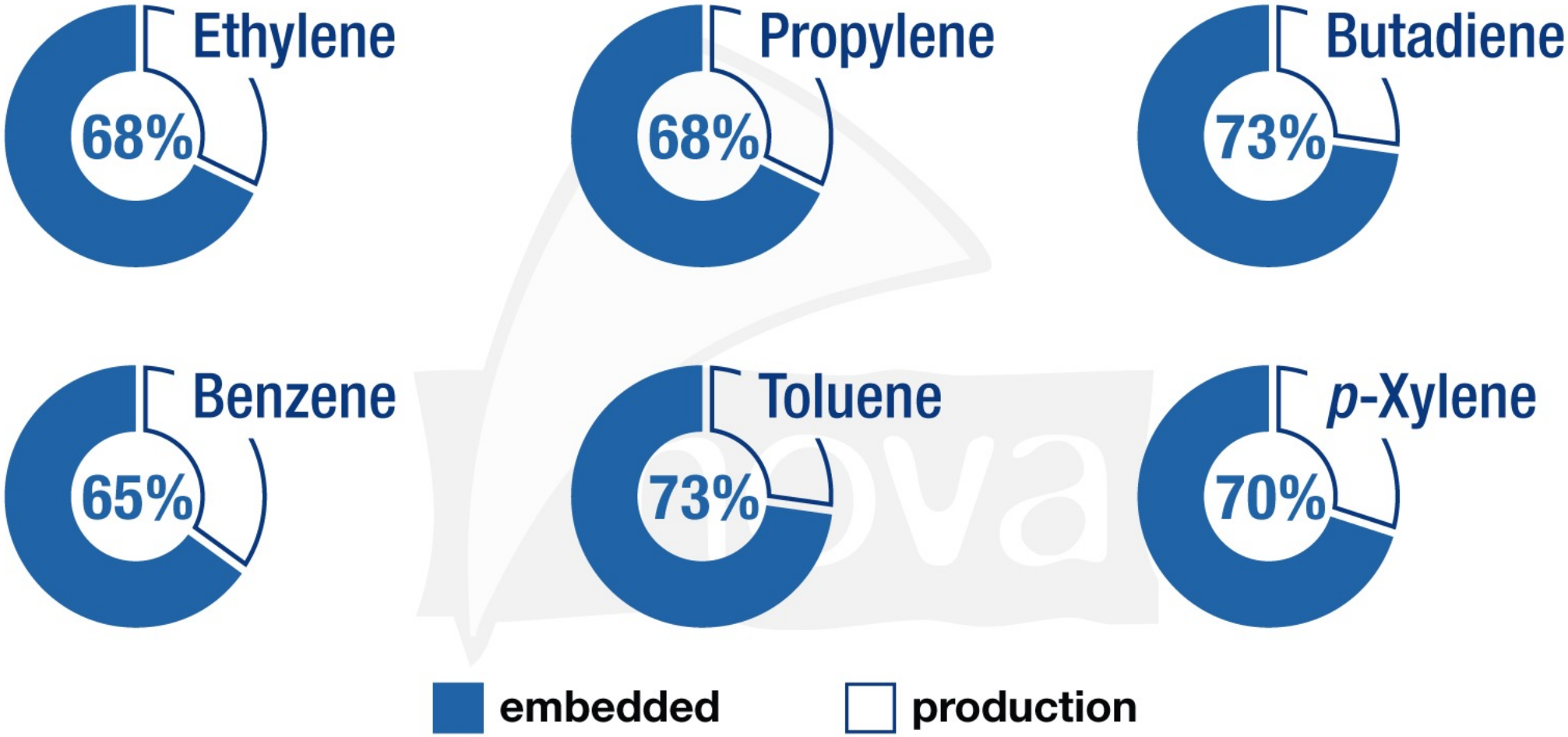
Renewable Carbon is the Key

For the first time since the industrial revolution, technology allows us to decouple the chemical, plastics, fibre and other material industries from the use of fossil carbon.

Demand for **Carbon Management**

Background nova-paper #12:
“Renewable Carbon – Key to a Sustainable and Future-Oriented Chemical and Plastic Industry”
Free download: www.renewable-carbon.eu/publications

The invisible carbon footprint



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

Ethylene, propylene, butadiene – Calculations by nova-Institute
Benzene, toluene, *p*-xylene – Source: BioBTX

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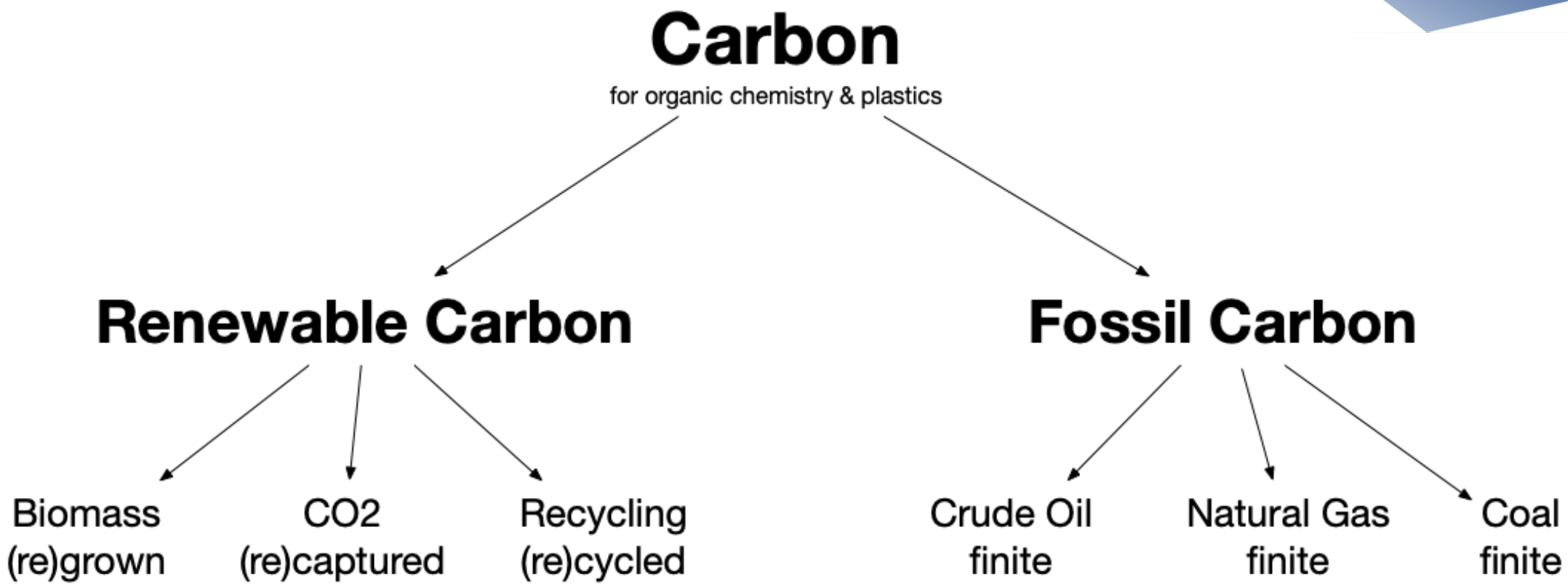
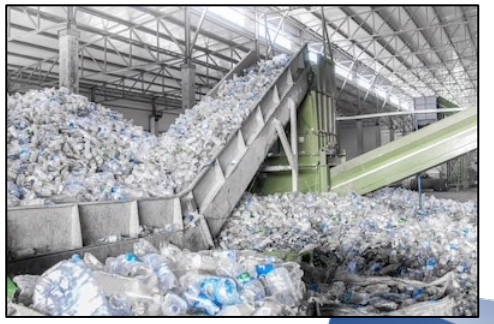

Carbon
for organic chemistry & plastics
Renewable Carbon
Fossil Carbon
Biomass
(re)grown
CO2
(re)captured
Recycling
(re)cycled
Crude Oil
finite
Natural Gas
finite
Coal
finite

The Renewable Carbon Family
the three sources of renewable carbon

- Renewable carbon gained from all types of **biomass** (first and second generation, side stream, biowaste), from the *Biosphere*

- Renewable carbon from **direct CO_2 utilisation**, from the *Technosphere* and *Atmosphere*

- Renewable carbon from mechanical and chemical **recycling** of already existing plastics and other organic chemistry products, from the *Technosphere*



Strategy in detail

- All three carbon sources are essential for a complete transition to renewable carbon, and
- all of them should be similarly used by the industry and supported by politics.
- **Don't fight a brother war!** There'd only be one winner: Fossil carbon.
- **Share to win!**
- To replace all the additional fossil carbon, we need the smartest mix of all three.
- We need a future materials policy – a policy on renewable carbon: **Carbon Management**
- **Renewable carbon as a guiding principle** to ensure sufficient space for investment: there is an urgent demand for **fast and large-scale transformation**

Carbon Management

Which of the renewable carbon options comes into play in a specific case is the topic of future carbon management.

- Policy should provide a general market pull for renewable carbon, without regulating the individual renewable carbon streams which could also lead to undesirable side effects with a high risk.
- Which of the renewable carbon options comes into play should be decided by feedstock availability, technology and market conditions as well as specific environmental issues. This depends on regional factors and concrete applications and production pathways.
- There is no one-size-fits-all answer ... except that it has to be renewable carbon. Renewable carbon is globally necessary for the chemistry of the future, but locally insufficient – here additional sustainable criteria play an important role.
- Example Biofuels: The demand for biofuels will decline drastically over the next decades in parallel with the success of the electric vehicle and the hydrogen fuel cell. It would be the task of politics to support the transformation of bioethanol and biodiesel producers into producers of raw materials for the chemical industry. In this way, the considerable investments and technological developments would not be lost and no additional arable land would be needed to supply the chemical industry with renewable carbon.

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Carbon economy – Studies on support to research and innovation policy in the area of bio-based products and services

FREE

Nova-Institute, together with COWI and Utrecht University published a report on the role of carbon in the global, European and regional economy for the Directorate-General for Research and Innovation (European Commission).

The report herein contains five Work Packages (WPs) that embody the requirements set out in the European Commission's "Studies on support to R&I policy in the area of bio-based products and services – Carbon Economy (Lot 1)." The main aim of the project was to map out the current pathways available for the transition towards a low carbon economy as well as the barriers that hinder this transition. Based on the conclusions and key findings from the WPs, the authors set the scene for the future of the bio-based sector with a particular focus on ten case studies of regions and cities across the EU (WP4), an evaluation of promising innovations and novel technologies for the realisation of such an economy and a sweeping regulatory analysis containing Q1 2020 updates (WP3) on EU directives and regulations that pertain to the low carbon economy. This attention to the local level as well as the broader policy sphere is supported by a scientific understanding of the low carbon economy (WP1), potential future scenarios towards 2050 (WP2) as well as clear dissemination of the findings across the entire study (WP5). In the frame of the study an animated educational video was produced. The final study report contains an executive summary followed by each Work Package in its entirety, which can also be treated as stand-alone reports in their own right.

Further information at: https://op.europa.eu/en/publication-detail/-/publication/8c4de15d-a17d-11eb-b85c-01aa75ed71a1

AUTHORS	COWI, Directorate-General for Research and Innovation (European Commission), nova-Institute, Utrecht University
DATE OF PUBLICATION	Feb 2021
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FILE TYPE	PDF
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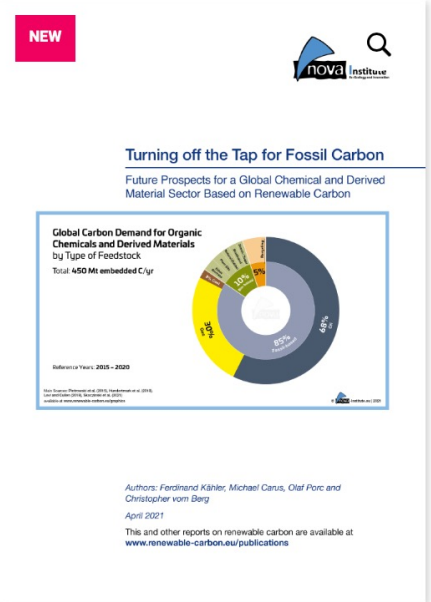
TURNING OFF THE TAP FOR FOSSIL CARBON – FUTURE PROSPECTS FOR A GLOBAL CHEMICAL AND DERIVED MATERIAL SECTOR BASED ON RENEWABLE CARBON



Turning off the Tap for Fossil Carbon – Future Prospects for a Global Chemical and Derived Material Sector Based on Renewable Carbon

FREE

New study on the feedstock for global chemical and derived material sector and future prospects for the transition from fossil to renewable carbon sources

In a new study, total carbon embedded in products from the chemical and derived material sector is examined on a global scale. This includes product groups like plastics, rubbers, textile fibres, detergents and personal care solutions. For the first time ever, total global amount of embedded carbon is calculated, visualized and connected to the different feedstocks. Furthermore, end-user applications are investigated and depicted. A 2050 scenario is introduced, which outlines future prospects to transition from fossil to renewable carbon sources. Solutions for the highly interconnected chemical industry are illustrated together with supporting policy measures. This report aims to raise awareness of the need for, and the technical, industrial and political feasibility of, the biggest transformation of the chemical and derived material sector since the industrial revolution.

AUTHORS	Ferdinand Kähler, Michael Carus, Olaf Porc and Christopher vom Berg
DATE OF PUBLICATION	Apr 2021
PAGES	34
LANGUAGE	
FILE TYPE	PDF
DOWNLOADS	96

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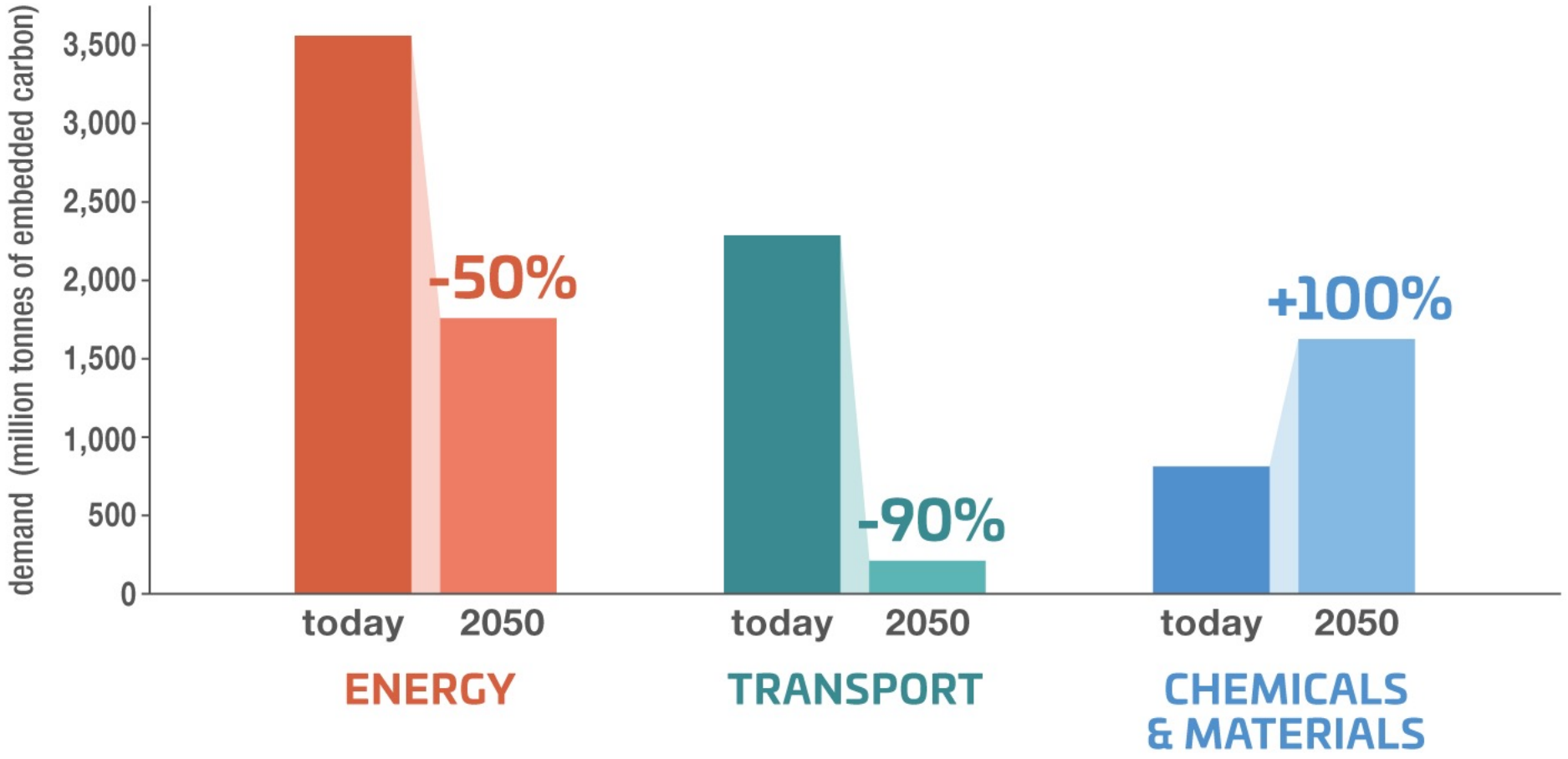
This study has been carried out on behalf of Unilever plc.

Embedded Carbon Demand for Main Sector

Today (2015–2020) and Scenario for 2050 (in million tonnes of embedded carbon)



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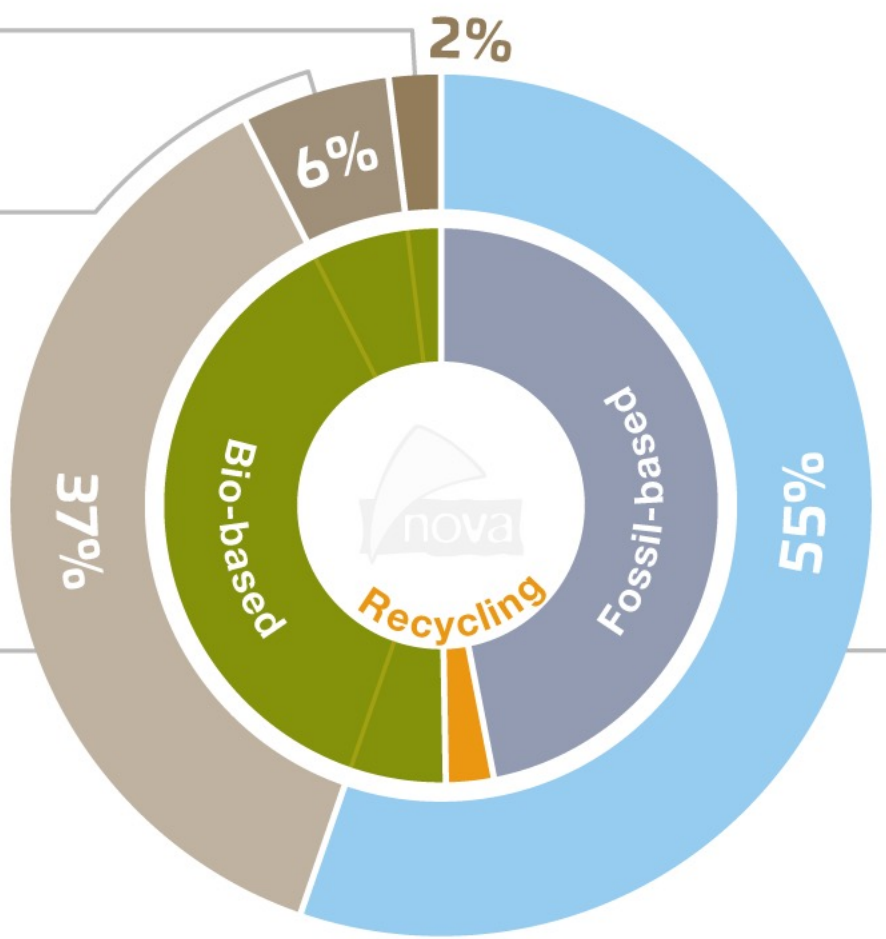
Global Carbon Demand for Chemicals and Materials by Sectors

Total: **814 Mt embedded C/yr** – Reference Years: **2015 – 2020**



Textiles (natural)
14 Mt embedded C/y

Pulp & Paper
46 Mt embedded C/y

Wood Construction & Furniture
304 Mt embedded C/y

Chemicals & Derived Materials
450 Mt embedded C/y

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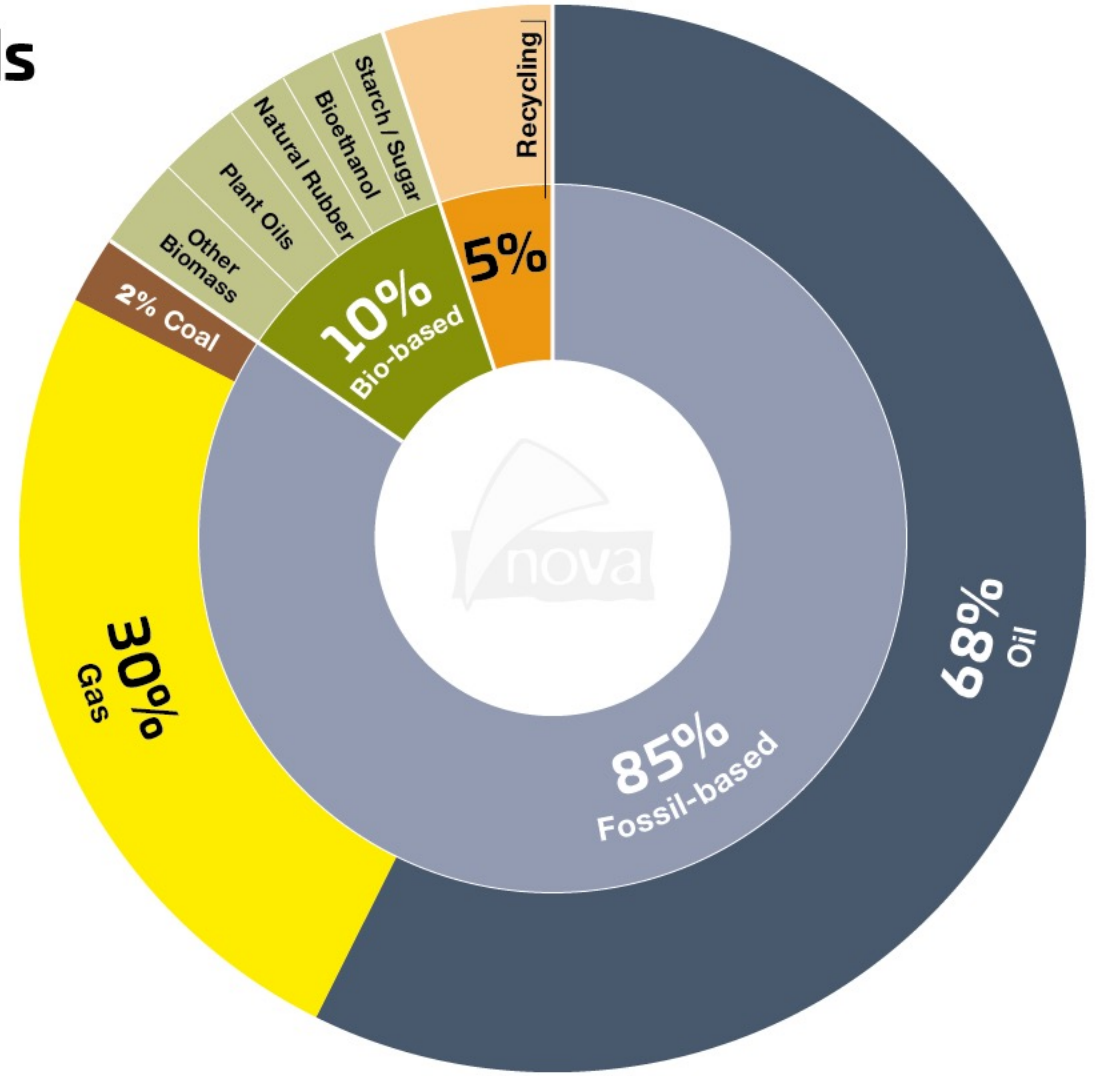
Global Carbon Demand for Organic Chemicals and Derived Materials

by Type of Feedstock

Total: **450 Mt embedded C/yr**



Reference Years: **2015 – 2020**

Main Sources: **Piotrowski et al. (2015), Hundertmark et al. (2018), Levi and Cullen (2018), Skoczinski et al. (2021)**
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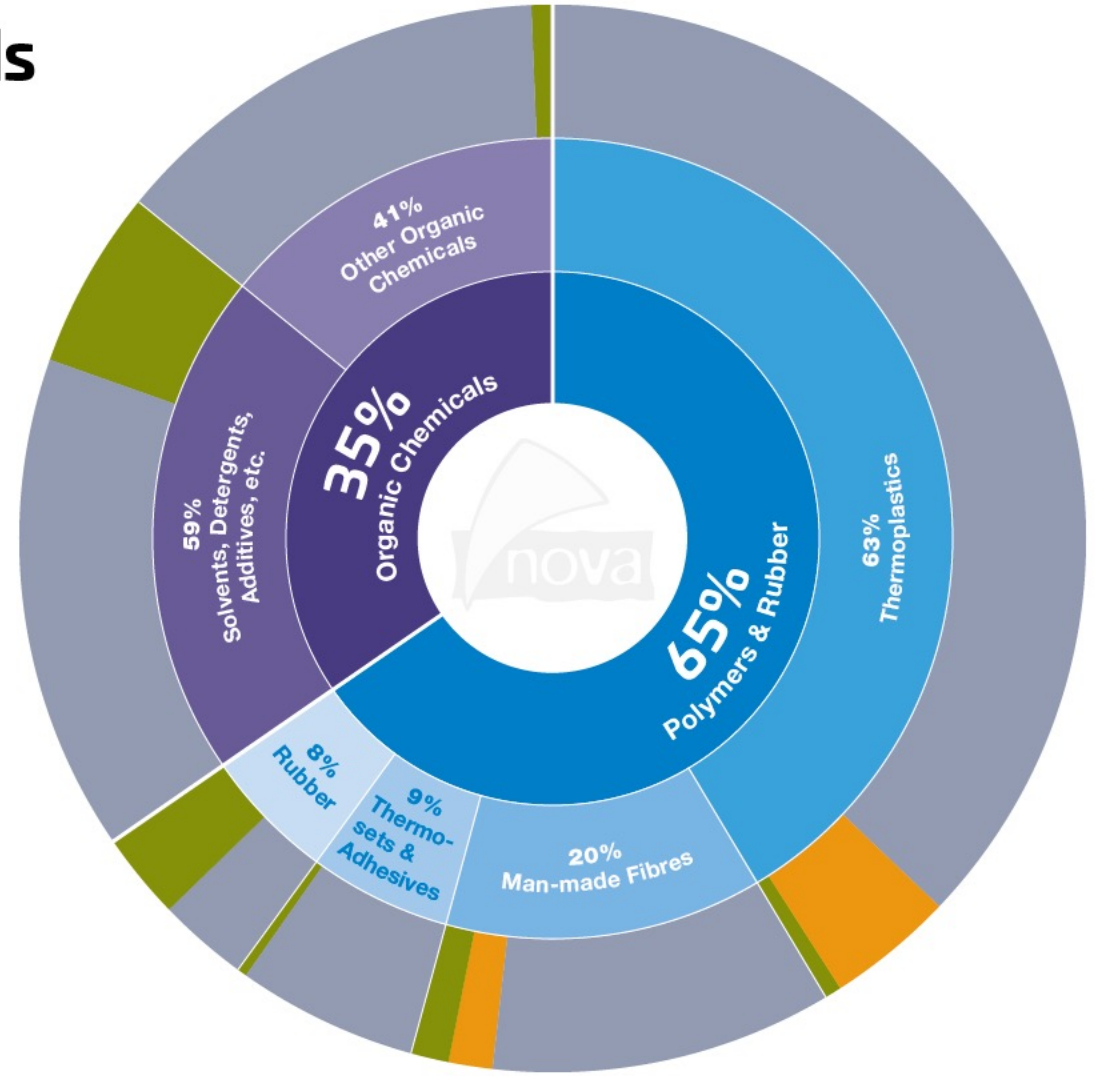
Global Carbon Demand for Organic Chemicals and Derived Materials
by Product Group

Total: **450 Mt embedded C/yr**

- Fossil-based
- Bio-based
- Recycling



Reference Years: **2015 – 2020**

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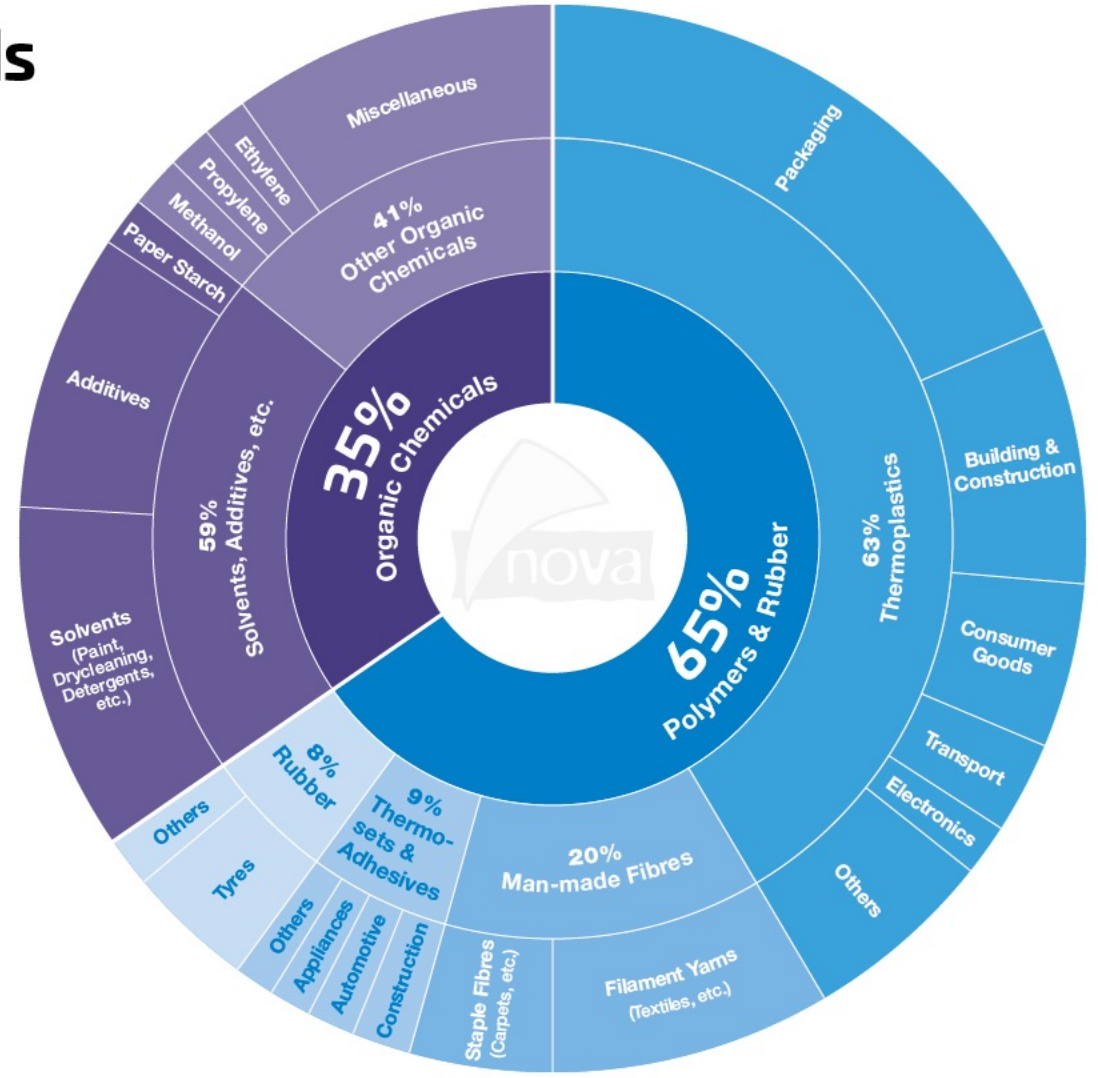
Global Carbon Demand for Organic Chemicals and Derived Materials

by End-user Application

Total: **450 Mt embedded C/yr**



Reference Years: **2015 – 2020**

Main Sources: **Geyer et al. (2017), Levi and Cullen (2018), Mordor Intelligence (2019), The Fiber Year Consulting (2020), Skoczinski et al. (2021)**

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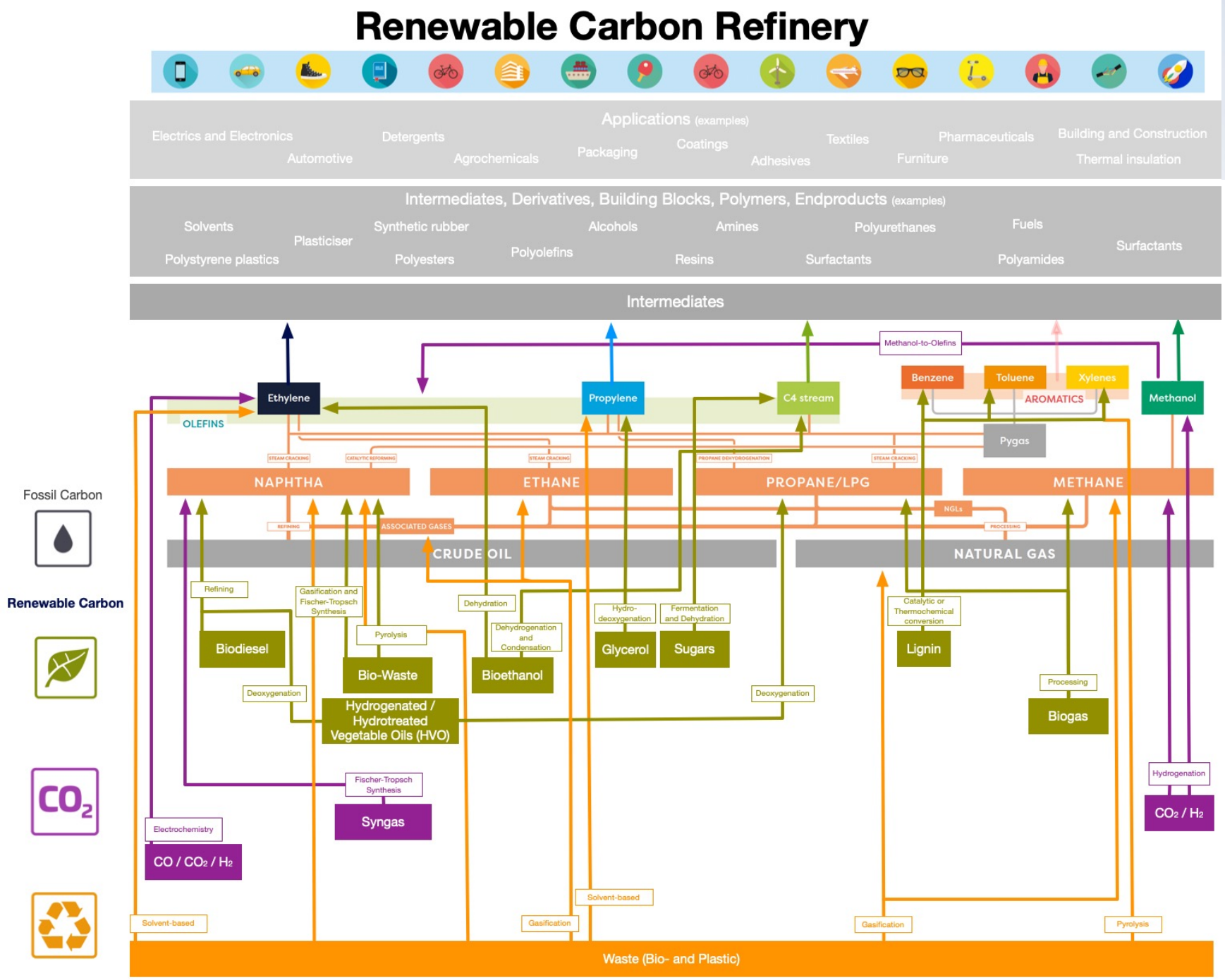
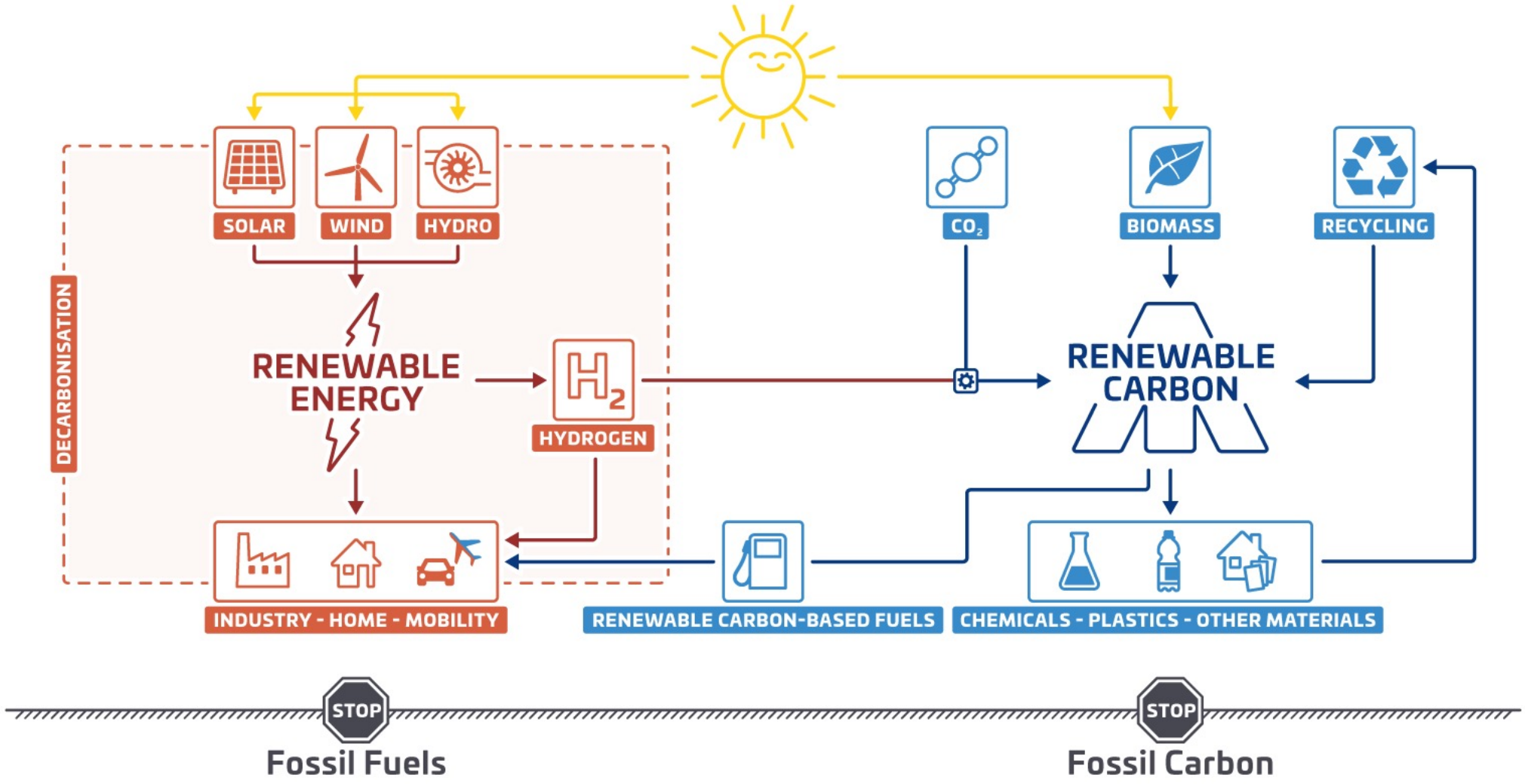


Renewable Carbon: Integration in existing Chemical Structures

Source: nova-Institut GmbH, Petrochemicals Europe

Renewable Energy and Renewable Carbon for a Sustainable Future



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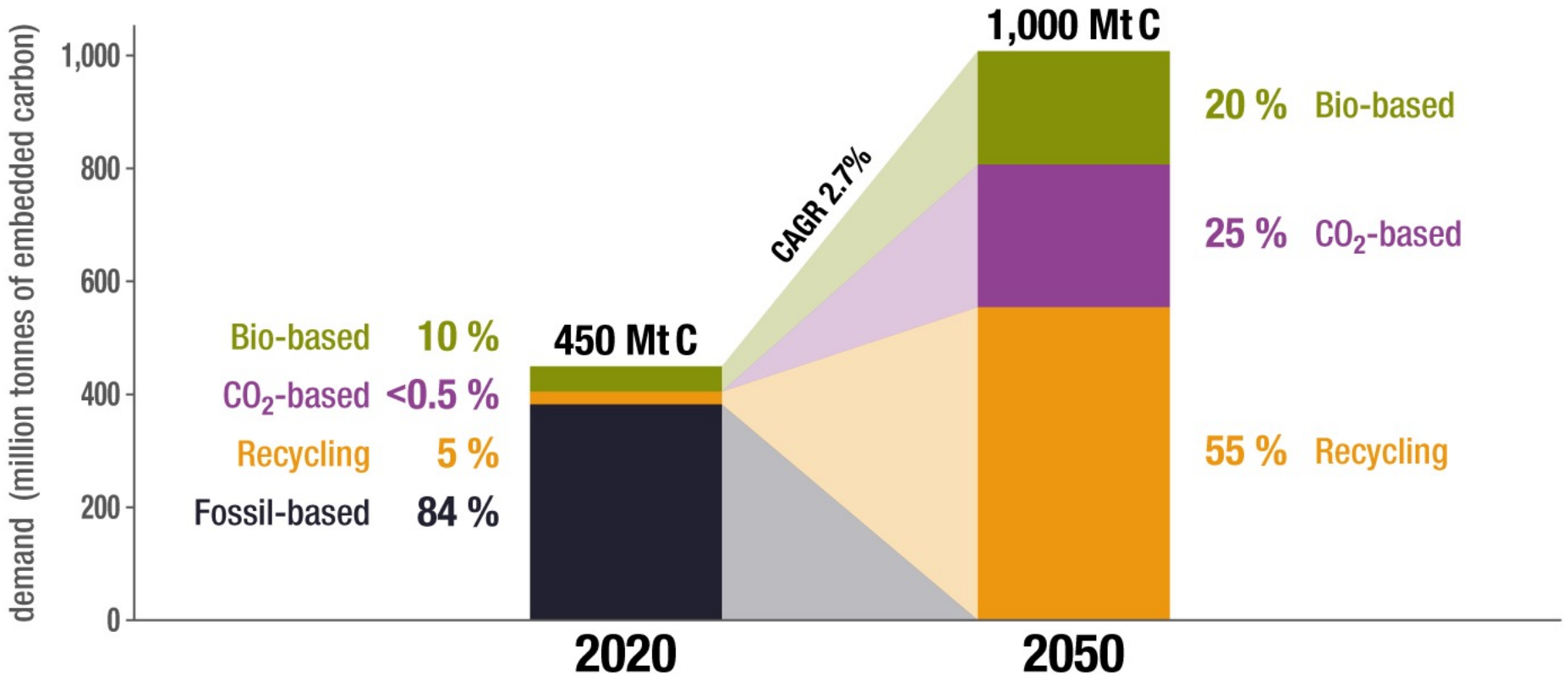
Global Carbon Demand for Chemicals and Derived Materials

in 2020 and Scenario for 2050 (in million tonnes of embedded carbon)



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Renewable Carbon is the key

The **chemical and plastics industry** may only develop into a sustainable sector once it bids farewell to fossil raw materials such as crude oil, natural gas and coal for good and **uses nothing but renewable carbon as a raw material in organic chemistry**.

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

For the first time since the industrial revolution, technology allows us to **decouple the chemical, plastics, fibre and other material industries from the use of fossil carbon**.

Renewable Carbon from Biomass

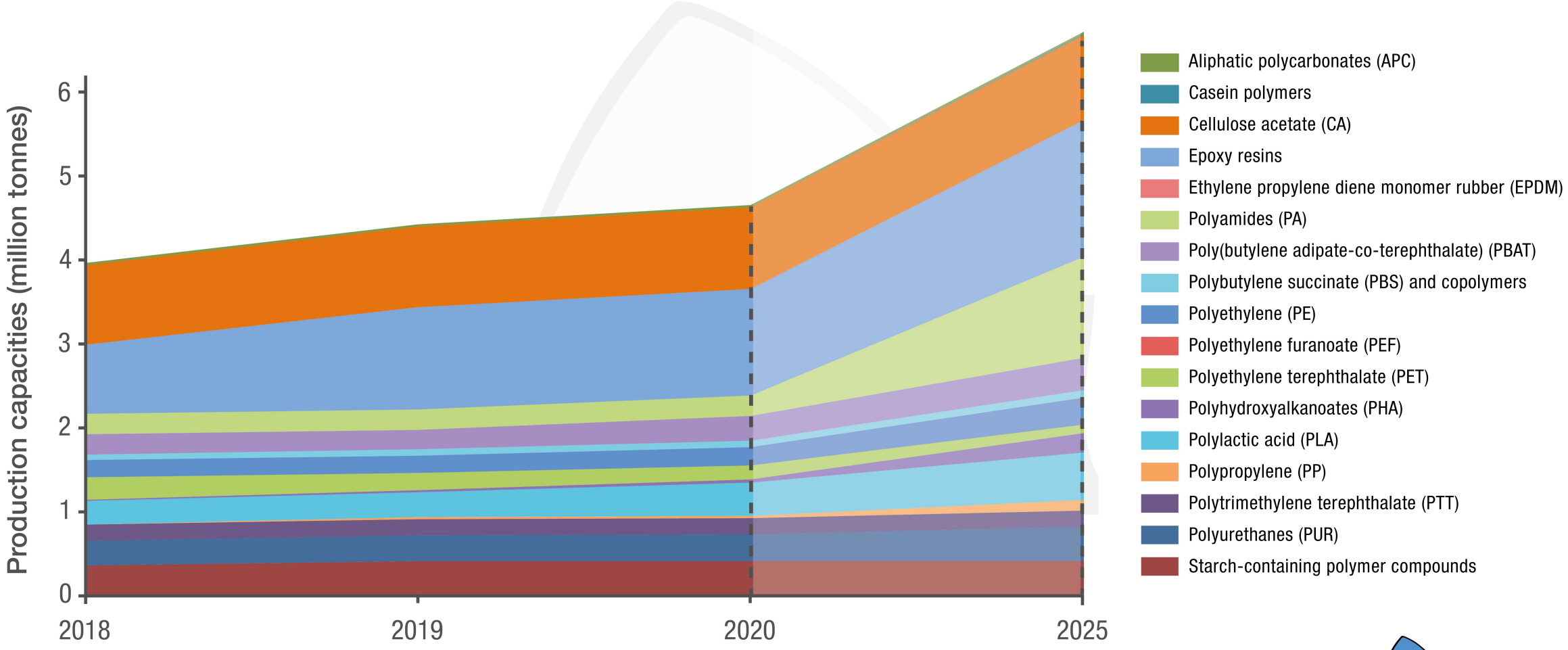
Pros in a nutshell

- Food crops:
  - Commodities, established in high volume, good logistics
  - Food crops: Protein-rich by-products
- Wide range of non-food feedstocks – no direct food competition, positive image
  - wood and lignocellulosic by-products and side streams
  - biogenic waste from industry and households
- Low GHG footprint compared with fossil resources
- New green chemical pathways
- Biotechnology as sustainable process technology

Cons in a nutshell

- Limited total volume
- Low land-efficiency
- Potential pressure on land and biodiversity
- Potential competition with food crops and a possible threat to food security

Bio-based polymers
Evolution of worldwide production capacities from 2018 to 2025



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High growth areas

- Fine Chemicals CAGR 5-10 %: body care, detergents, cosmetics, pharma
- Bio-based building blocks CAGR 11 %
- Bio-based polymers CAGR 8 % (far above fossil-based with 3–4 %)
- Bio-based Naphtha, high demand
- ... also there is no political support (except R&D), but barriers (SUPD)
- but demand from the brands! (see Renewable Carbon Initiative)

Renewable Carbon from CO_2

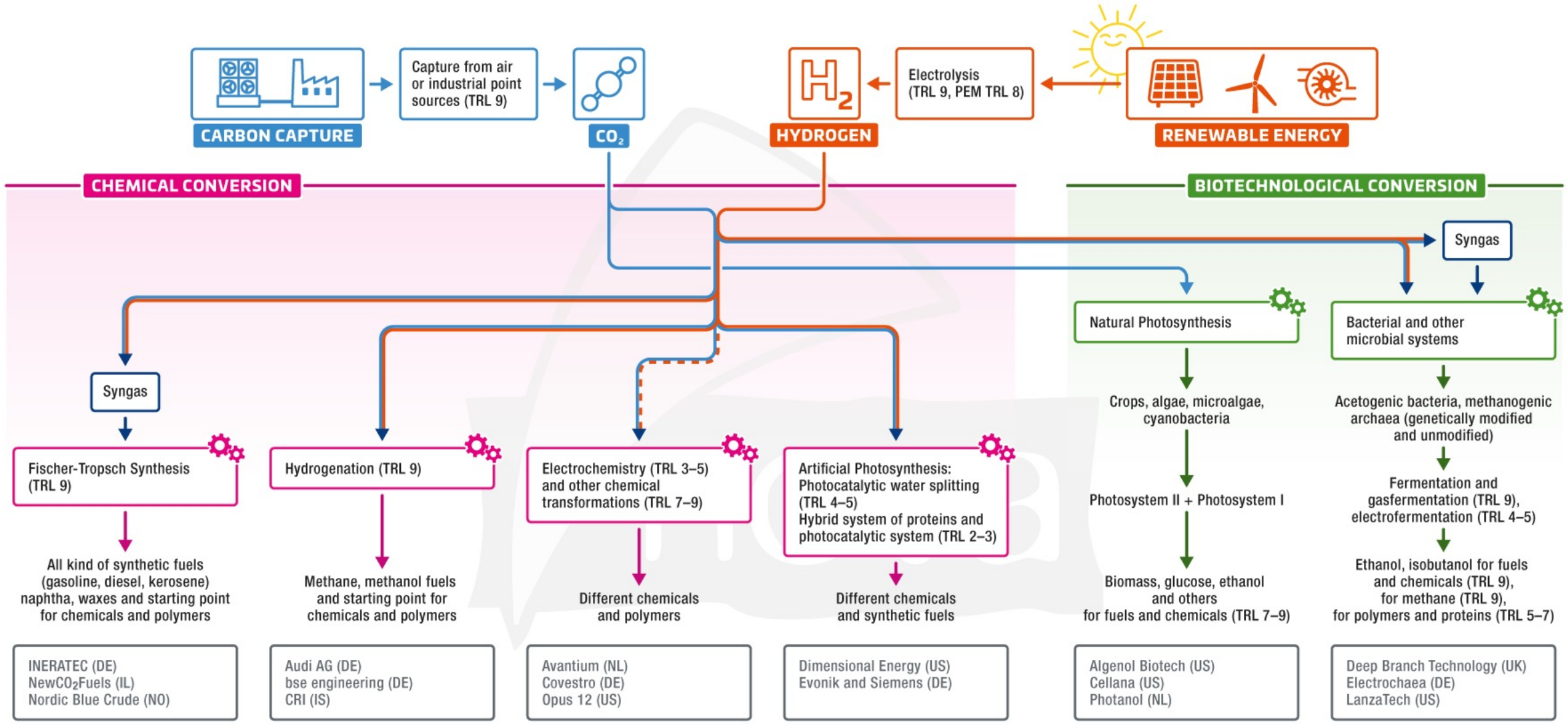
Pros in a nutshell

- Very high potential in volume (almost unlimited)
- Low demand for land and water, low carbon footprint
- High TRL technologies available
- Almost all chemicals and plastics can be produced from CO_2
- High employment potential
- Inexhaustible source of carbon for the next millennia
- Even “black” CO_2 carbon utilisation lead to relevant GHG reduction

Cons in a nutshell

- Potential lock in effects using fossil point sources
- Competition on limited renewable electricity
- High investment necessary

Carbon Dioxide Utilisation and Renewable Energy



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Non-energetic demand from the Chemical Industry

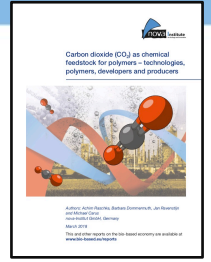
Different calculation show that a range of 15 to 20 PWh would be required to cover the entire carbon demand of the chemical industry today by CO_2 utilisation with renewable energy, depending on the efficiency of electrolysis and further processes. **For the production of 20 PWh solar power, only 0.9% of the Sahara region is needed for PV**.

The PV yield in the Sahara is typically about 250 GWh/km²/y (Breyer 2019, LUT University). That means: To produce 20 PWh from PV an area of 80,000 km² is needed. Compared to the total area of the Sahara of 9,200,000 km² this is only 0.9% of the Sahara region.

The energy won from this area could cover the global non-energetic carbon demand of the chemical and plastics industry as it was in 2018 when applying it to carbon capture and utilisation (CCU) processes.

The total area of deserts is even 30,000,000 km².

Ways to Use CO_2 for Polymers



Renewable Energy

several educts

epoxides:
propylene oxide,
ethylene oxide,
limonene-based epoxide

alcohol:
glycerol, others

olefins:
ethylene

CO_2

H_2

Chemo-catalytic reaction

Chemo-catalytic reaction

Chemo-catalytic reaction

Syngas production

Methanol production

Gas fermentation,
Electrofermentation,
Two-step hybrid process

Electrochemistry

different intermediates

cyclic/acyclic carbonates:
glycerol carbonate, others

bisphenol A

isocyanates

polyols

acrylates

Fischer-Tropsch

MTO

naphtha

olefins:
ethylene, propylene

lactic acid, succinic acid, adipic acid

ethanol, butanol, isobutanol, others

monoethylene glycol (MEG), ethylene, others

polyesters, polyureas,
non-isocyanate polyurethanes (NIPU),
others

aliphatic polycarbonates or
polyalkylene carbonates (PAC):
polypropylene carbonate (PPC),
polyethylene carbonate (PEC)

cycloaliphatic polycarbonates:
polylimonene carbonate

aromatic polycarbonates

polyurethanes (PUR), others

polyacrylates

polyolefins, others

polyolefins

polyhydroxyalkanoates (PHA)

polylactic acid (PLA),
polybutylene succinate (PBS(X))

polyethylene terephthalate (PET),
polyethylene furanoate (PEF),
polyethylene (PE), others

available at **www.renewable-carbon.eu/graphics**

Chemical conversion

Biotechnological conversion

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Renewable Carbon from Recycling

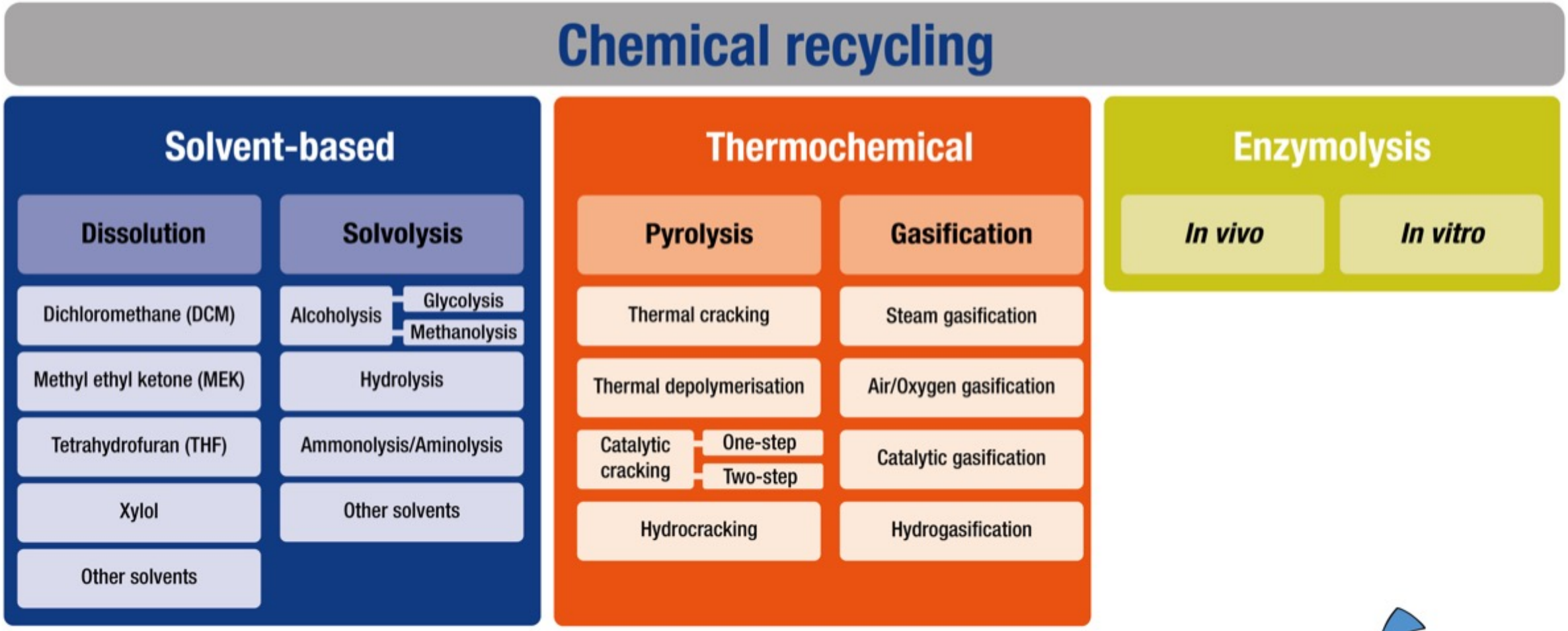
Pros in a nutshell

- Most important end-of-life option for plastics in the future circular economy
- Strong recycling targets in the European Union will guarantee access to renewable carbon from recycling
- Chemical recycling (different technologies): Basically no loss of quality compared to virgin feedstock

Cons in a nutshell

- Mechanical recycling: Limitation in quality, not allowed in many food applications
- Energy intensive processes
- Chemical recycling: early stage, first assessments on economic and environmental impacts available; investments waiting for clear political framework

Overview about the different methods for chemical recycling of plastic waste



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Political Measures to Support a Quick Transition to Renewable Carbon (see nova paper #12)

- **CO_2 emission tax (heavily discussed in public – e.g. carbon border adjustment EU)**
- **Taxation of fossil carbon** used in chemicals and plastics
  - A raw materials tax is much easier to handle than an emissions tax.
  - We are not allowed to use any more additional fossil carbon – and that is exactly what makes the tax effective and important.
  - The tax only has to be charged in a few points (extraction and import).
  - Automatically captures all sectors and applications that use fossil carbon – without exceptions
  - Recycling, biomass and CO_2 are automatically exempt from the tax.
- **Discontinuation of any funding** programmes in the **fossil** domain (estimate 20 billion US$ in the US alone
- **Higher costs for fossil CO_2 emissions** in the emissions trading system (ETS).
- Development of **certificates and labels** which indicate the **share of renewable carbon.**
- Establishing **quotas of renewable carbon** for “drop in” chemicals and plastics and a **quota for CO_2-based kerosene**.
- **Report about the percentage of renewable carbon** used in the production processes of the chemical and plastic industry (**Ranking**)

The Renewable Carbon Initiative

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

THE RENEWABLE CARBON INITIATIVE

lead by nova-Institute is launched in September 2020.

The aim of the initiative is to support and speed up the transition from fossil carbon to renewable carbon for all organic chemicals and materials.

The Renewable Carbon Initiative addresses the core problem of climate change, which is extracting and using additional fossil carbon from the ground that will eventually end up in the atmosphere. Companies are encouraged to focus on phasing out fossil resources and to use renewable carbon instead.

The initiative wants to drive this message, initiating further actions by bringing stakeholders together, providing information and shaping policy to strive for a climate-neutral circular economy.

PERSONAL SUPPORTERS

RENEWABLE CARBON INITIATIVE

Bio-based CO_2-based Recycling

... and almost 200 personal supporters

MEMBERS OF THE INITIATIVE

Beiersdorf
BioBTX
clariter
Cosun Beet COMPANY
covestro
Firmenich for good, naturally
Givaudan
Henkel
IBB Netzwerk GmbH
iff
LanzaTech
Lenzing Innovative by nature
NESTE
nova
SHV ENERGY
sorona
stahl
TC
TripleW
Unilever
uniper
UPM BIOFORE BEYOND FOSSILS

PARTNERS OF THE INITIATIVE

CO_2 VALUE EUROPE
ECBF European Circular Bioeconomy Fund
GLOBAL CO_2 INITIATIVE UNIVERSITY OF MICHIGAN
GO!PHA Global Organization for PHA
TextileExchange Creating Material Change
WWF

www.renewable-carbon-initiative.com

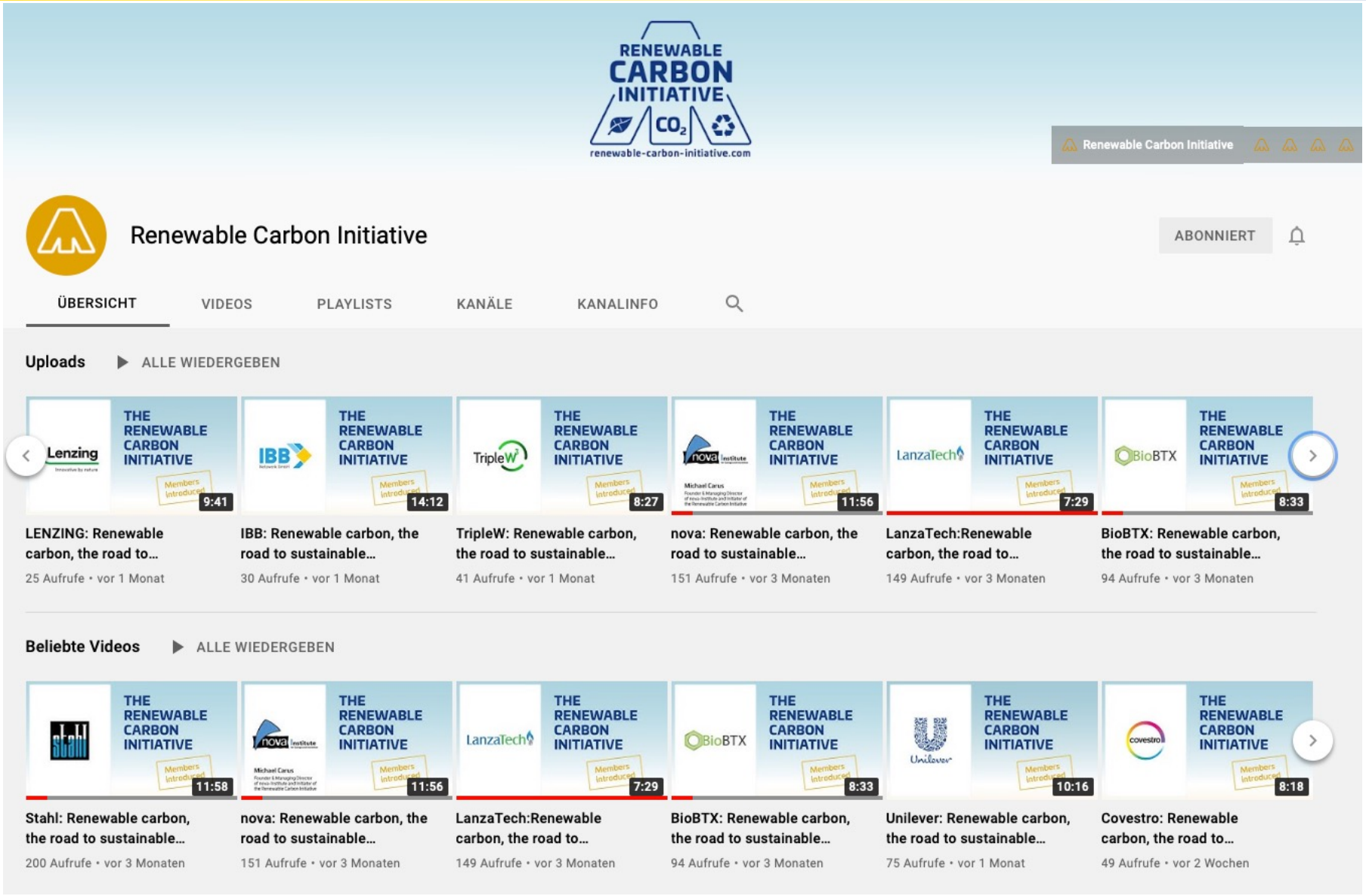
Company	Board membe	Country (Headquart	LE	SME/Clus	Start-u	Research Institut	Sector	Bio-Based	CO2-Based	Recyclin
Beiersdorf	x	DE	x				Consumer Goods	x		x
BioBTX		NL			x		Chemicals	(x)		x
Cosun Beet Company	x	NL	x				Sugar Beet Chemistry	x		
Covestro	x	DE	x				Polymers	x	x	x
DuPont Biomaterials		US	x				Polymers	x		
Firmenich		FR	x				Fine chemicals	x		
Givaudan		CH	x				Fine chemicals	x		
Henkel	x	DE	x				Consumer Goods	x	(x)	x
IBB		DE		x			Industrial Biotechnology	x	x	
IFF		US	x				Fine chemicals	x		
Lanzatech	x	US		x			Fuels & Chemicals		x	
Lenzing	x	AT	x				Fibres	x		x
Neste	x	DE/FI	x				Fuels & Chemicals	x	x	x
nova-Institut		DE		x			Renewable Carbon	x	x	x
SHV Energy	x	NL	x				Fuels & Chemicals	x		
Stahl	x	NL	x				Chemicals	x		
Technical Control		HK		x			Polymers	x		
TripleW		IL			x		biochemicals and bioplastics	x	x	x
Unilever	x	UK	x				Consumer Goods	x	x	x
Uniper		DE	x				Energy		x	
UPM	x	DE/FI	x				Biochemicals	x		

Ongoing and planned activities of the RCI
www.renewable-carbon-initiative.com

- **Media:** Press releases and library (presentations, graphics)
- **Background information**: Reports and glossary on RC related terms
- **Advocating** the renewable carbon concept to policy-makers **at the EU level**
- Develop **argumentation in favour of** renewable carbon as **a guiding principle** in future assessments
- Analyse the **GHG reduction potential of CCU** (and potentially other RC sources as well)
- Provide simple examples (a comic) and good examples (case studies) to **increase accessibility**
- Create a **RC community** for networking, project development and building supply chains
- **Three Working Groups for members have started**
  - **RC certificate & label** for the RC share in chemicals, materials and products
  - **Communication**, press releases, LinkedIn, Twitter
  - **Policy**, ongoing policy framework analysis: What is in the pipeline and when is the ideal time to influence it?
  - More will come …

Which activities would you like to see?

Renewable Carbon on YouTube



Membership in the Renewable Carbon Initiative

WHO CAN JOIN?

- **Companies** of all sizes, **start-ups** and **research institutes** can become members of the RCI.
  - Membership fees depend on size and type of the applicant.
  - Annual Fees (moderate fees aiming to many members):
    - Large Enterprises: 10,000 €
    - SMEs: 5,000 €
    - Start-Ups: 2,000 €
    - Research Institutes:1,000 €
    - https://renewable-carbon-initiative.com/membership/application/

- **Associations** interested in a partnership are welcome to contact Dominik Vogt (Dominik.vogt@nova-institut.de) for further information.

Thank you for your participation!

Visit us at:
https://renewable-carbon-initiative.com/

Or directly contact us:
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Christopher.vomberg@nova-institut.de