8th Conference on CO_2

Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

www.CO2-chemistry.eu

Online conference tickets available

CO_2 as chemical feedstock – a challenge for sustainable chemistry

24–25 March 2020 / Maternushaus, Cologne (Germany)

Conference Journal

- Policy & Innovation
- Renewable Carbon & Renewable Energy
- Carbon Capture & Electrolysis
- Six Innovation Award Presentations
- Special Dinner Presentation & Award Ceremony
- Hydrogen Production, Electrochemistry & Mineralisation
- CO_2 for Chemicals & Materials
- CO_2 for Chemicals & Fuels
- Parallel Session

Organiser	Innovation Award Sponsor	Premium-Partner	Gold Sponsor	Bronze Sponsor
nova Institute for Ecology and Innovation	covestro	EnergieAgentur.NRW	ENVIRO Ambient	TOTAL
www.nova-institute.eu	www.covestro.com	www.energieagentur.nrw	www.enviroambient.com	www.total.com

In Cooperation with

IASA International Association for Sustainable Aviation e.V.

www.iasaev.org

1st European Summit on CO_2-based Aviation Fuels

COLOGNE · GERMANY · 23 MARCH 2020

· Policy & Strategy · CCU Fuels & Power-to-Liquid Technologies · Sustainable Aviation · Panel Discussion with Speakers of the Day

www.co2-chemistry.eu/aviationfuels

8th Conference on CO_2

Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

8th Conference on CO_2

Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

Table of Contents

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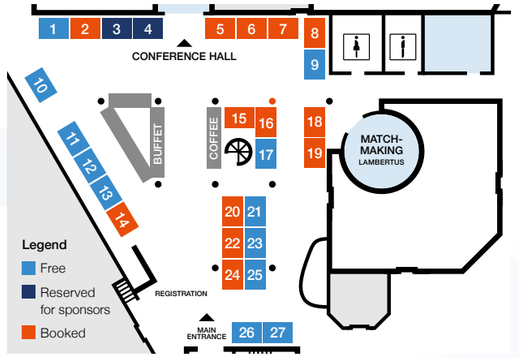
Matchmaking

We would like to draw your attention to our professional matchmaking tool Pitch and Match we are using for our conferences.

- Meet decision makers of the Industry – 1-on-1
- Find new networking and business opportunities
- Arrange meeting place and time with ease
- Manage all your meetings in one simple user-friendly environment
- Get email alerts for meeting requests

You are not yet registered?
To use our match making tool, please ask Ms. Svenja Geerken directly.

Exhibition Information



List of Exhibitors

Exhibition will take place from 23–25 March 2020.

Booth 02 | BT2i – Business & Technology Intelligence for Innovation
Booth 05 | EnergieAgentur.NRW
Booth 06 | nova-Institut
Booth 07 | Total
Booth 08 | Media Table
Booth 14 | Zeton
Booth 15 | Haldor Topsoe
Booth 18 | Matchmaking
Booth 19 | Poster Session
Booth 22 | Innovation Award "Best CO_2 Utilisation 2020"
Booth 24 | Innovation Award "Best CO_2 Utilisation 2020"

book your booth soon

Venue

Maternushaus
Kardinal-Frings-Straße 1–3
50668 Cologne
+49 (0)221 163 10
www.maternushaus.de

Exhibition
co2-chemistry.eu/exhibition-booking

Registration
co2-chemistry.eu/registration

Register now!

The "8th Conference on Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers" and the "1st European Summit on CO_2-based Aviation Fuels" will take place with 99% probability. Despite limitations in worldwide travel due to the Corona virus, 140 participants have already registered and we expect more than 150. So far, the Cologne area has very few cases of infection and there are no official restrictions for events.

In order to make participation possible despite travel limitations, we offer the entire conference as a paid webinar. The online participants can see the presentations, listen to the talks and ask questions using "Slido".

The best way to take advantage of all networking opportunities is in person on site. However, if this is not possible, you can register now for the webinar at half price. The entire conference will be live-streamed.

All registration options at
www.co2-chemistry.eu/registration

Dear participants,

Welcome to the "8th Conference on Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers" – and for the first time also of the "European Summit on CO_2-based Aviation Fuels". The use of CO_2 is becoming an increasingly urgent issue, especially since numerous technologies are now available to produce fuels and chemicals from CO_2 and renewable energy. The expansion of solar and wind energy as well as green hydrogen grids is providing a fresh tailwind. CCU technologies are becoming better understood and political circles are increasingly demanding support. Because this too has become clear: Although the use of CO_2 instead of fossil raw materials is climate-friendly and the future, CO_2-based products are still 2 to 3 times more expensive than those made from cheap fossil fuels. In order to gain momentum, it therefore needed supportive political framework conditions such as a fossil carbon tax or binding quotas for e.g. CO_2-based kerosene.

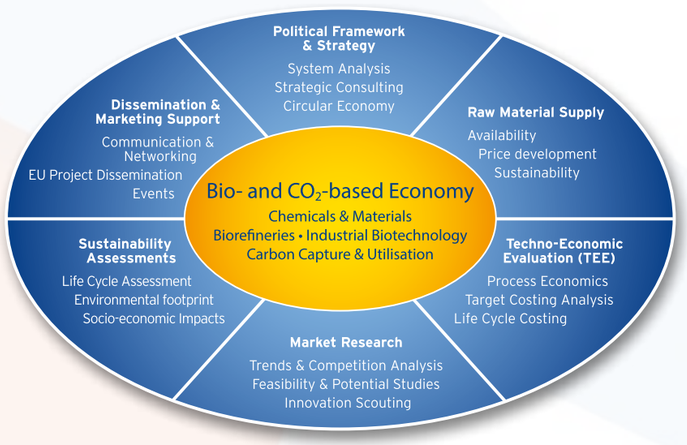
The three-day conference aims to bring all participants up to date with the latest technical and political developments and then to discuss future strategies in numerous panel discussions. And it is all about communication and networking!

We wish all participants new insights, ideas and inspiration. The future belongs to CO_2 use and we have the chance to shape the way together.

Your nova team

Michael Carus
Managing Director

Achim Raschka
Head of Technology and Markets



nova Institute for Ecology and Innovation

nova-Institute is a private and independent research institute, founded in 1994; nova offers research and consultancy with a focus on bio-based and CO_2-based economy in the fields of food and feedstock, techno-economic evaluation, markets, sustainability, dissemination, B2B communication and policy. Every year, nova organises several large conferences on these topics; nova-Institute has more than 35 employees and an annual turnover of 3 million €.

www.nova-institute.eu

8th Conference on CO2 Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

Message from the Minister

North Rhine-Westphalia as an industrial hub is integrated into worldwide value creation networks like few other regions. Industry is vital for the future development and growth of North Rhine-Westphalia.

By improving on processes, implementing new technologies, decoupling industrial growth from greenhouse gas emissions, strengthening the circular economy and developing innovative, climate-neutral products and services, industry in North Rhine-Westphalia plays a crucial role in addressing the issue of global warming. A continuously modernising, climate-friendly industry with an internationally competitive edge is needed to guarantee sustainability and prosperity for North Rhine-Westphalia.

The chemical industry in particular is a mainstay of North Rhine-Westphalia's industrial sector and a key factor in the overall economic success of our state. Like no other industry, chemistry business is an innovation driver for the entire economy – especially when it comes to the transition to climate neutrality.

Our shared responsibility for achieving international climate targets requires strengthening the chemical sector's innovative spirit and developing our state into a forward-looking centre of industry capable of competing with the best in the world.

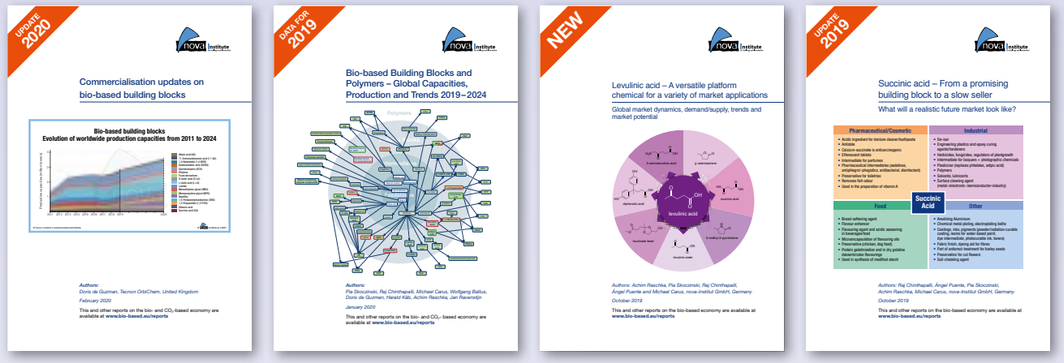
Furthermore, industry needs the right regulatory and structural framework along with clear development perspectives. On the way to carbon-neutral production, it is important to keep a proper balance between ecology and economy. It is mainly the large energy consumers in the chemical industry which are facing radical changes when it comes to wise and responsible use of resources during the move towards becoming climate-neutral. Numerous research institutes and private-sector companies from North Rhine-Westphalia are conducting research for shaping these changes. The state has a uniquely large concentration of know-how and expertise across a wide range of fields.

The industrial transformation therefore provides immense opportunity for innovation and making the chemical industry in North Rhine-Westphalia even more competitive.

Professor Dr. Andreas Pinkwart
Minister of Economic Affairs, Innovation, Digitalization and Energy of the State of North Rhine-Westphalia

Market and Trend Reports

nova Institute for Ecology and Innovation



THE BEST MARKET REPORTS AVAILABLE

Bio- and CO_2-based Polymers & Building Blocks

1st European Summit on CO_2-based Aviation Fuels

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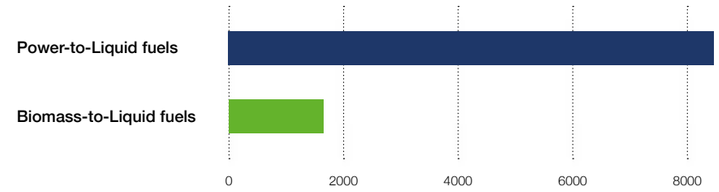
Sustainable Strategies & Solutions for Cleaner Air Transport

The vital question for the future of aviation is: how do we tackle greenhouse gas (GHG) emissions from aviation and their serious impact on the climate? There are not many options available. Electric-driven aviation is, for the next decades, only suitable for short distance flights.
The use of bio-based kerosene is confronted by NGOs as "putting un-acceptable pressures on natural resources, such as forests and land". It is also hampered by quality and standard issues for different biomass sources and conversion processes.

Advantage of PtL-based fuels

Achievable air mileage for an A320neo per ha of land (km/ha*yr)



Source: German Environmental Agency (UBA), Dessau 2016

A big hope are aviation fuels based on the utilisation of CO_2 and green hydrogen: CO_2 as a GHG is not only the problem, it can also be part of the solution. Essential is the capture and re-use of CO_2 – meeting the challenge of climate change in aviation requires a circular use of CO_2. And fortunately, a global market is waiting for those who are helping the airlines to meet the requirements of the Paris Climate Agreement.

Improving the efficiency of aircraft by an expected annual average of 1.5% is going to limit GHG-emissions, but will surely not be sufficient. In addition, such measures would have to consider and include existing aircraft as well. Therefore, the development of an economically viable production of CO_2-based aviation fuels, also called Power-to-Liquid (PtL) or E-Fuels, is the most promising pathway for cleaner air transport.

Organiser

IASA International Association for Sustainable Aviation e.V.
www.iasaev.org

nova Institute for Ecology and Innovation
www.nova-institute.eu

1st European Summit on CO_2-based Aviation Fuels

COLOGNE · GERMANY · 23 MARCH 2020

DAY OF SUMMIT / 23 MARCH 2020

Conference Opening

10:00 **Rudolf Dörpinghaus and Ralf Nolting**
IASA
Michael Carus
nova-Institut
Conference Opening

Policy & Innovation

Chairperson **Michael Carus, nova-Institut**

10:10 **Rudolf Dörpinghaus**
IASA
Options and Opportunities of Advanced Aviation Fuels – Towards a Sustainable Future of Flight

10:30 **Werner Diwald**
Deutschen Wasserstoff- und Brennstoffzellen-Verband (DWV)
eKerosene – Solution for the Aviation Industry

10:50 **Roland Dittmeyer**
KIT
Decentralized Conversion of CO_2 into Fuels and Chemicals

11:10 **Harry Lehmann**
German Environmental Agency
Power-to-Liquid: Opportunities for Environment and Climate Protection in the Aviation Sector

11:30 **Klaus-Peter Willsch**
Parlamentsgruppe Luft- und Raumfahrt, Deutscher Bundestag
The Role of Politics in Promoting Sustainable Aviation

11:50 **Discussion with all Speakers of the Session**

12:05 **Lunch Break**

1st European Summit on CO_2-based Aviation Fuels

COLOGNE · GERMANY · 23 MARCH 2020

DAY OF SUMMIT / 23 MARCH 2020

CCU Fuels & Power-to-Liquid Technologies

Chairpersons **Rudolf Dörpinghaus and Ralf Nolting, IASA**

13:30 **Michael Carus**
nova-Institut
CO_2-based aviation fuels – the best option available

13:50 **Gunnar Holen**
Nordic Blue Crude
Providing Liquid Electricity for the Aviation Industry

14:10 **Janne Hulkko**
VTT
Paraffinic Aviation e-Fuels by Fischer-Tropsch Route

14:30 **Samir Rachidi**
IRESEN
Changing Landscape in the Energy Sector: Power to L from Morocco

14:50 **Lukas Geissbühler**
Synhelion
Liquid Fuels from CO_2, Water and Concentrated Sunlight

15:10 **Discussion with all Speakers of the Session**

15:25 **Coffee Break**

Sustainable Aviation

Chairperson **Michael Carus, nova-Institut**

16:00 **Philippe Fonta**
SCRUM-Consult
Potential Contribution of CO_2-based Aviation Fuels in the Basket of Measures for Climate Mitigation

16:20 **Oskar Meijerink**
SkyNRG
How Can We Scale the Use of CO_2-based Aviation Fuels

16:40 **Alexandru Iordan**
SAF+ Consortium Inc.
1st Project on Converting Industrial Emissions to SAF in North America

17:00 **Seungwoo Kang**
IRENA
Hydrogen For e-Fuels: A Renewable Energy Perspective

17:20 **Discussion with all Speakers of the Session**

17:35 **Panel Discussion**

18:00 **Closing Conference**

20:00 **Get together**

Can the European Union‘s kerosene demand be met by the amount of biomass produced in the EU?

Regarding climate change and tackling its mitigation there is no question that the aviation industry has to reduce its greenhouse gas impact and has to shift to alternative fuels. If the European Union wants to achieve its ambitious climate goals, it needs to decouple it growing kerosene demand from fossil resources. In 2018, the consumption of aviation fuel and kerosene in the EU amounted to 62.8 million tonnes[1] which is equivalent to 2,895 million GJ[2]. How can this large quantity, 99.9% of which is currently produced from fossil sources, mainly crude oil, be shifted to alternative raw materials? Is it possible to produce this amount with biomass from the EU? Or is Power-to-Liquid (PtL) the only realistic alternative?

Michael Carus
CEO of
nova-Institute

The following table gives an overview of the aviation fuel / kerosene yields per hectare for different crops and calculates the required areas under cultivation.

Table 1: Different biomass sources and PtL production pathways of jet fuel and kerosene: Yields per hectare and area demand in the European Union

Production pathway	Jet fuel yield (GJ/ha*a)	Jet fuel / kerosene demand in the EU, 2018 (million GJ)	Area required for the entire coverage of the EU Jet fuel/kerosene demand (million ha)	Current area cultivated in the EU (million ha)	How much of the cur-rent area is needed to fulfil the jet fuel / kerosene demand in the EU
Maize (AtJ)	56	2,895	51.7	8.3	x6.2
Sugar beet (AtJ)	149	2,895	19.4	1.7	x11.2
Rapeseed oil (HEFA)	48	2,895	60.3	6.9	x8.7
Sunflower oil (HEFA)	31	2,895	93.4	4.0	x23.2
PtL PV	580 -1070	2,895	5 - 2.7	no data	no data
PtL Wind	470 - 1040	2,895	6.2 - 2.8	no data	no data

Notes to the table:
AtJ: Alcohol-to-Jet fuel (based on bioethanol)
HEFA: Hydroprocessed Esters and Fatty Acids
PtL: Power-to-Liquid
PV: Photovoltaic
Crop yields based on FAOSTAT 2016, yields biomass to jet fuel / kerosene based on UBA 2016: Power-to-Liquids – Potentials and Perspectives for the Future Supply of Renewable Aviation Fuel.

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COLOGNE · GERMANY · 23 MARCH 2020

The table clearly shows that it is impossible to cover the EU’s kerosene demand with domestic biomass when switching to first-generation bio-based alternatives, e.g. maize. The current area in the EU under this energy crop yielding high amounts of starch is currently 8.3 million ha. 51.7 million ha would be needed to cover the kerosene demand with maize, this is 6.2 times the current area under maize. The EU’s total agricultural area is 107 million ha (2017[3]) and is used primarily for food and feed production. This means finding an additional area of 51.7 million ha to meet the kerosene demand with maize is inconceivable. Of course, further agricultural land is available, but estimated to be at a few million ha only and less arable due to poor soil resulting in lower yields. Other agricultural crops show similar results. Even the inclusion of second-generation raw materials such as wood, short rotation coppice (SRC) or straw does not produce better results. For example, the yield of SRC per ha is in the same order of magnitude as for agricultural crops. To go the bio-based kerosene route, it will be necessary to import over 95% of the biomass.

For the Power-to-Liquid route, the situation is considerably more relaxed. With the help of solar or wind energy, only comparatively small areas of between 2.7 and 6.2 million ha are needed to fully cover alternative kerosene demand. These areas can be in the arid deserts and semi-deserts, on existing buildings in the case of photovoltaic (PV) or on off-shore plants in the case of wind energy. Even combinations of wind and agriculture are possible. This is a much more realistic option.

On the other hand, renewable electricity is needed for a variety of competing applications (household and industrial electricity demand, transport), so in reality the PtL option will also rely on imports from regions with high output yields of solar energy, e.g. the Sahara. Due to the high solar radiation, only 1.8 million ha of the Sahara surface are needed to meet the EU alternative kerosene demand via photovoltaics and CO_2. Based on the fact that the Sahara has a total area of 920 million ha, only 0.2% of the Sahara’s surface would be sufficient for this purpose.

Takeaway message

The high demand for aviation fuel / kerosene in the European Union can only be met to a very small extent by domestic biomass. If this path is taken, more than 95% of the bio-mass must be imported.

Covering the demand via Power-to-Liquid with the help of solar and wind energy and CO_2 is comparatively easy due to the considerably higher efficiency of the land use. It is expected that this will result in the use of a mix of domestic renewable energies and imports from North Africa. It should be noted that covering only 0.2% of the Sahara‘s surface area with photovoltaics would be sufficient to cover the EU’s entire aviation fuel / kerosene requirements.

[1] Fig. 7, https://www.fuelseurope.eu/dataroom/static-graphs/
[2] http://w.astro.berkeley.edu/~wright/fuel_energy.html
[3] https://ec.europa.eu/info/news/eu-agricultural-outlook-arable-land-area-continue-its-decline_en

1ST DAY OF CONFERENCE / 24 MARCH 2020

Conference Opening

10:00 **Michael Carus**
nova-Institut
Conference Opening

Policy & Innovation

Chairperson **Michael Carus, nova-Institut**

10:10 **Michael Theben**
Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen
The Role of CO_2 in the New Energy System from a Political Point of View

10:30 **Torsten Schwab**
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
Remote Airfields as an Entry Market Niche for Decentralized PtL Production

10:50 **Damien Dallemagne**
CO_2 Value Europe
Building the CCU Industry in Europe: Progress and Perspectives

11:10 **Frank Köster**
EnergieAgentur.NRW
Clean Fuels for Transport – NRW Projects and Perspectives

11:30 **Christoph Gürtler**
Covestro
Brighter Use of Resources – New CO_2-based Materials

11:50 **Discussion with all Speakers of the Session**

12:05 **Lunch Break & Poster Session**

8th Conference on CO_2 Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

1ST DAY OF CONFERENCE / 24 MARCH 2020

Renewable Carbon & Renewable Energy

Chairperson **Damien Dallemagne, CO_2 Value Europe**

13:30 **Dmitri Bogdanov**
LUT University
A 100% Renewable Energy System and the Necessary Inclusion of Power-to-X

13:50 **Arne Kätelhön**
RWTH Aachen
Climate Change Mitigation Potential of Carbon Capture and Utilization in the Chemical Industry

14:10 **Ouda Salem**
Fraunhofer ISE
Towards a Sustainable "Energiewende" – Power-to-X Technologies as a Matchmaker

15:25 **Coffee break & Poster Session**

14:30 **Jaap Vente**
TNO
CO_2 Emission Reduction: Feasible under Current Economic Conditions

14:50 **Michael Carus**
nova-Institut
Sustainable Chemical and Plastics Industry based Entirely on Renewable Carbon

15:10 **Discussion with all Speakers of the Session**

Carbon Capture & Electrolysis

Chairperson **Juha Lehtonen, VTT**

15:45 **Cyril Bajamundi**
Soletair Power
Soletair Power – Building as Carbon Sinks

16:05 **Paul E. King**
Enviro Ambient
Low-cost, Low-Footprint CO_2 and Blue Hydrogen for CO_2-Derived Products Production

14:30 **Kurt Wagemann**
DECHEMA
Electrolysis as the Key to Chemical and Fuel Production based on CO_2

14:50 **Discussion with all Speakers of the Session**

8th Conference on CO_2 Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

1ST DAY OF CONFERENCE / 24 MARCH 2020

Six Innovation Award Presentations

Chairpersons: Michael Carus and Asta Partanen, **nova-Institut**

17:00 **Michael Carus**
nova-Institut
Innovations Award Introduction

17:10 **Stefanie Kesting**
CO_2 Value Europe
Changing the World with CCU

17:20 **Stafford Sheehan**
Air Co.
Air Vodka from CO_2

17:30 **Matthias Slatner**
Austrian Centre of Industrial Biotechnology
PHAs from CO_2-Recycling

17:40 **Madison Savilow**
Carbon Upcycling Technologies
Watch with a Concrete Face from CO_2

17:50 **André Bechem**
Climeworks
First Commercial Direct Air Capture (DAC) Technology

18:00 **Doris Hafenbradl**
Electrochaea
Electrochaea Power-to-Gas Technology with Biological Methanation – a Grid-scale Energy Storage Solution

18:10 **Shannon Nangle**
Wyss Institute for Biologically Inspired Engineering at Harvard
PHAs and Sustainable Chemicals from CO_2

18:20 Cold Beer on Tap in the Exhibition Space

20:00 Dinner Buffet & Jazz Music

Special Dinner Presentation & Award Ceremony

Chairpersons: Michael Carus and Asta Partanen, **nova-Institut**

20:40 **Ellen Palm**
Lund University
Conflicting Expectations on Carbon Dioxide Utilisation

21:00 **Sucheta Govil**
Covestro
On Our Way to Circular Economy: How Start-ups Contribute to the Covestro Strategy

21:10 Innovation Award Ceremony

22:30 Traditional German Bowling

8th Conference on CO_2 Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

2ND DAY OF CONFERENCE / 25 MARCH 2020

Hydrogen Production, Electrochemistry & Mineralisation

Chairperson: Alexis Bazzanella, **DECHEMA**

09:00 **Frithjof Kublik**
Shell
The 10 MW electrolyser project REFHYNE fully integrated into the Shell Refinery in Cologne

09:20 **Reinier Grimbergen**
TNO VoltaChem
Strategies for Integrating CO_2 Capture with Utilisation

09:40 **Frank Kensy**
b.fab
CO_2 Utilisation via Formate Biorefinery

10:00 **Jan Skocek**
Heidelberg Cement
Demolished Concrete Mineralization as CCU Approach

10:20 Discussion with all Speakers of the Session

10:35 Coffee Break & Poster Session

CO_2 for Chemicals & Materials

Chairperson: Heleen de Wever, **VITO**

11:00 **Alexis Bazzanella**
DECHEMA
GHG Neutral Chemical Industry by 2050 – Fact or Fiction?

11:20 **Babette Pettersen**
LanzaTech
Recycled Carbon and the Circular Economy

11:40 **Juha Lehtonen**
VTT
Fossil-free Polycarbonate Polyols from Captured Carbon Dioxide and Renewable Hydrogen

12:00 **Pavan Kumar Manvi**
RWTH Aachen
Carbon Dioxide: A Raw Material for Textile Industry

12:20 Discussion with all Speakers of the Session

12:35 Lunch Break & Poster Session

2ND DAY OF CONFERENCE / 25 MARCH 2020

CO_2 for Chemicals & Fuels

Chairperson Haralabos Zorbas, **IBB Netzwerk**

14:00 Reza Ranjbar
Centre for Process Innovation
CO_2 to Food: Solve the Global Challenges of Greenhouse Gas Carbon Dioxide and Food Shortage by Converting CO_2 to Single Cell Proteins in Gas Fermentations

14:40 Frédéric Chandezon
SUN-ERGY project
SUN-ERGY: A Large Scale Initiative on Fossil-free Fuels & Chemicals for a Circular Economy

14:20 Christoph Gatzen
Frontier Economics
e-Fuels – The Missing Building Block for the Change to Future Mobility

15:00 Tore Sylvester Jeppesen
Haldor Topsøe
How to Utilise Carbon Dioxide to Enable Electrification of Fuels and Chemicals

15:20 Coffee Break & Poster Session

Chairperson Frank Köster, **EnergieAgentur.NRW**

15:50 Kai Hortmann
Total
Jens Baumgartner
Sunfire
The e-CO_2MET Project: From Renewable Electric Energy to Methanol

16:30 Martin Roeb
DLR
Solar Towers For Fuel Production from CO_2 and Water

16:10 Christian Schweitzer
bse engineering
Florent Baudu
McPhy France
Standard Modules 20 MW CO_2-to-Methanol Plant

16:50 Nicholas Flanders
Opus-12
CO_2 Electrochemical Conversion to Chemicals and Fuels

17:10 Discussion with all Speakers of the Session

Networking Reception

8th Conference on CO_2 Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

2ND DAY OF CONFERENCE / 25 MARCH 2020

Parallel Session: National and International Research Projects (Room: Adelheid)

14:00–15:20

Heleen de Wever
BioRECO$_2$VER
BioRECO$_2$VER: Biotechnological Approaches for Capture and Conversion of CO_2

Sarah Refai
CLIB
BioCOnversion: Developing new Process Routes – from CO to polymers

Sylvia Gildemyn
OWS
CAPRA: Turning Syngas into Added-value Chemicals using Anaerobic Fermentation Technology

Ana López Contreras
Wageningen University
BIOCON-CO_2 : Bioconversion of Industrial CO_2 Effluents into Commodities for Chemicals and Plastics.

Discussion with all Speakers of the Session

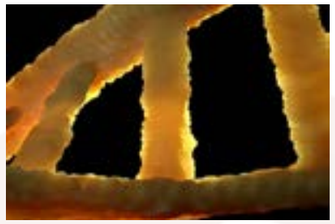
Poster Session at booth 19 (during breaks)

- Marcin Panowski, Czestochowa University of Technology (PL): Adsorption purification of CO_2 from refinery industry for CCS/CCU
- Julius von Sacken, DAH-Gruppe (DE): Die DAH-Welt
- Dalia Liuzzi, Institute of Catalysis and Petrochemistry (CSIC) (ES): Ru catalysts for the production of biofuels via Fischer-Tropsch synthesis: evolution to jet fuels
- Maria Elena Russo, Ist. Research on Combustion - Consiglio Nazionale delle Ricerche (IT): Biocatalysts for CO_2 capture and utilization by enzymatic reactive absorption
- Francesca Mazzega-Ciamp, Life Cycle Engineering Srl (IT): CO_2 utilisation focused on market relevant dimethyl ether production, via 3D printed reactor and solid oxide cell based technologies
- Io Antonopoulou, Luleå University of Technology (SE): Enzyme-aided CO_2 absorption using a novel hybrid ionic liquid: amine blend
- Muhammad Sohail, Qatar Environment & Energy Research Institute (QEERI), Hamad Bin Khalifa University (HBKU) (QA): Molecular Engineered CO_2 Reduction Catalysts Bearing Rylenediimide (RDI) Super-Reductants
- Michael Egermeier, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria (AT): CarboFeed: A biotech based platform technology for CO_2 utilization in yeast

Nominees for the Innovation Award

"Best CO_2 Utilisation 2020"

Air Co.
Air Vodka from CO_2

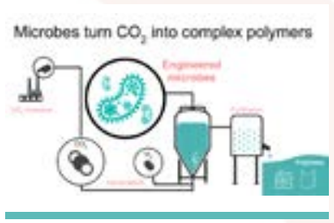


Austrian Centre of Industrial Biotechnology
PHAs from CO_2-Recycling

Carbon Upcycling Technologies
Watch with a concrete face from CO_2

Climeworks AG
First commercial direct air capture (DAC) technology

Electrochaea GmbH
Electrochaea Power-to-Gas Technology with Biological Methanation – a grid-scale energy storage solution



Wyss Institute for Biologically Inspired Engineering at Harvard
PHAs and sustainable chemicals from CO_2

Organiser nova Institute for Ecology and Innovation

Co-organiser CO_2 VALUE EUROPE

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Air Co.
Air Vodka from CO_2

Air Co., an organisation that created the world's first ever carbon negative spirits. Utilising ground-breaking, proprietary technology to transform carbon dioxide into the purest, highest quality, and most sustainable alcohol on the planet, Air Co. improves the air we breathe every day. With core inputs of only carbon dioxide, water and renewable electricity, Air Co.'s production method actively helps prevent climate change by removing the most abundant greenhouse gas from our planet (CO_2) and turning it into ultra-high purity alcohol. The first application is the world's first carbon negative spirit, Air Vodka.

www.aircompany.com

Austrian Centre of Industrial Biotechnology
PHAs from CO_2-Recycling

Austrian Centre of Industrial Biotechnology (acib) has developed two independent methods using the greenhouse gas CO_2 for production of biopolymers. This allows the environmentally friendly production of bio-based and biodegradable natural polymers. acib uses a highly sophisticated strain of cyanobacteria which is able to productively grow in a photobioreactor without sugars or oil using light and CO_2 to generate PHA (TRL 4). In addition, acib has further developed a technology using the bacterium Ralstronia eutropha (aka Cupriavidus necator). This technology can use both H_2 (e.g. from electrolysis of water using excess of electric energy) and CO_2 (TRL 3) to produce PHA (TRL4). Accordingly, the production of high quality PHA produced by valorisation of the greenhouse gas CO_2 is already possible with acib's technology. We now strive to conduct further optimisation and are looking for industrial partners.

www.acib.at

Carbon Upcycling Technologies

Watch with a concrete face from CO_2

Carbon Upcycling Technologies (“CUT”) was formed to use the pollution of today to build the materials of tomorrow by converting CO_2 gas into solid products. CUT sells advanced solid products derived from greenhouse gas emissions and cheaply available solids. With this material, CUT started a consumer product line. These products include a yoga mat, the “Negative Bracelet”, a bracelet made with captured atmospheric carbon, and even a watch with a concrete face. This material not only replaces carbon-intensive traditional materials, but these products give consumers a voice in climate change discussions. CUT’s vision is to show that collaboration is the key to a low carbon world – low impact materials can be used without changing supply chains drastically. Furthermore, each purchase changes the status quo because it’s the accumulation of small actions that really make a big difference.

www.carbonupcycling.com

Climeworks

First commercial direct air capture (DAC) technology

Climeworks captures CO_2 from air with the world’s first commercial direct air capture (DAC) technology. The Climeworks DAC plants capture CO_2 with a filter and are powered solely by either waste or renewable energy. They play an important role in the production of fuels from air-captured carbon dioxide and green power. A new facility on the premises of Karlsruhe Institute of Technology (KIT) combines all four steps required to produce synthetic fuels from air and green power in the project “Kopernikus”. Climeworks DAC technology secures the supply of CO_2 from air. Through electrolytic splitting, Fischer-Tropsch synthesis and hydrocracking, the production of synthetic fuel is proven. This way, fuels of high energy density can be used in a carbon-neutral way and green power can be stored.

www.climeworks.com

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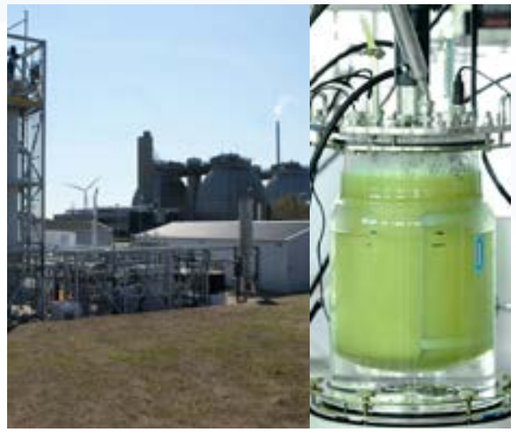
Electrochaea

Electrochaea Power-to-Gas Technology with Biological Methanation – a grid-scale energy storage solution

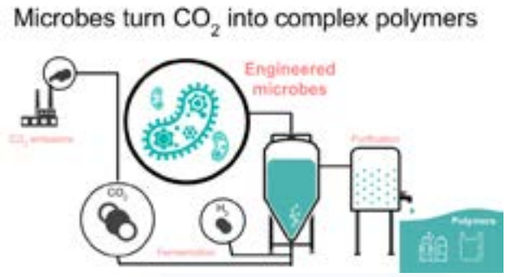


Electrochaea is commercialising a grid-scale energy storage solution. Our proprietary Power- to-Gas (P2G) process converts renewable energy and carbon dioxide into grid-quality renewable methane for storage and distribution. In Switzerland and Denmark plant operators are already injecting renewable methane into commercial gas grids. Electrochaea provides a technology based on biological methanation that makes it possible to store renewable energy and recycle CO_2 in a cost-effective way. This allows efficient energy and CO_2 storage as renewable methane. When renewable power is available but not immediately used, renewable methane can be stored in the gas grid, thereby enabling a growing market for renewable electric power and creating a growing source of renewable gas.

www.electrochaea.com

Wyss Institute for Biologically Inspired Engineering at Harvard

PHAs and sustainable chemicals from CO_2



The Wyss Institute for Biologically Inspired Engineering is building a versatile fermentation platform to convert CO_2 into sustainable chemicals. Widespread adoption of bioproduction is an essential part of a sustainable future. The main barrier for it is cost. We propose using genetically engineered microbes to produce desirable products from gaseous sources. CO_2 waste streams and locally generated H_2 will be fed to the engineered microbes on site. Using continuous gas fermentation technology, we make products, such as polyhydroxyalkanoate (PHAs) biopolymers and triglycerides (TAGs) milk lipids. We have demonstrated production of tailored PHAs from CO_2 on lab scale and are working to expand our product portfolio and scale. Gas fermentation is the next step for industrial bioproduction to lower costs and as a sustainable use of resources.

www.wyss.harvard.edu/news/shannon-nangle-on-microbes-and-mars

20 valuable comments on Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

Centre for Process Innovation,
Reza Ranjbar
“I will present cpi’s capability ,as an open access facility, for supporting research and development from laboratory to large scale in the field of conversion of carbon dioxide to food and will give a short case study about conversion of greenhouse gases to food/feed.“

CO_2 Value Europe,
Damien Dallemagne
“Learn how technology developers and project owners work together to bring the best CCU technologies to the market.”

Covestro,
Christoph Gürtler
“The use of CO_2 for polyols turns out to a platform technology that can be used for a series of applications in daily life.“

DECHEMA,
Alexis Bazzanella
“If we don’t find a societal consensus on a GHG neutral chemical industry, Europe is likely to lose its petrochemical production base.”

DECHEMA,
Kurt Wagemann
“The lecture will describe the potential bottlenecks for the large-scale production of renewable hydrogen as feedstock for CO_2-utilisation.“

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ),
Torsten Schwab
“Aviation apart from the big routes might just be one of the keys for PtX development.“

Fraunhofer Institute for Solar Energy Systems (ISE),
Ouda Salem
“In this presentation, an overview of Power-to-Liquid activities at the Fraunhofer ISE will be presented; highlighting the technical feasibility of selected PtL candidates and emphasizing the market and political frame for realizing such promising technologies.“

Frontier Economics,
Christoph Gatzen
“e-Fuels – The Missing Building Block for the Change to Future Mobility.“

Haldor Topsøe,
Tore Sylvetser Jeppesen
“Electrolysis of CO_2 enables electrification of the chemical industry based on CO feedstock.“

HeidelbergCement,
Jan Skocek
“As a pathway to substantial CO_2 reduction of cement industry, a project based on CO_2- mineralization of cement paste from old concrete and its utilization as a cementitious material is presented.“

Leitat,
Guiomar Sánchez
“Transforming industrial CO_2 waste into value-added chemicals and plastics: The BIOCON-CO_2 approach.“

Nordic Blue Crude,
Gunnar Holen
“Nordic Blue Crude: Providing renewable Liquid Electricity to the aviation industry in large quantities.“

OWS,
Sylvia Gildemyn
“CAPRA demonstrates the potential of microbial fermentation technology to diversify the product spectrum from syngas.“

RWTH Aachen,
Arne Kätelhön
“Carbon capture and utilization in the chemical industry has the technical to reduce annual GHG emissions by up to 3.5 Gt CO_2-eq in 2030.”

Soletair Power,
Cyril Bajamuni
„How buildings can be turned in to carbon sinks and improve people’s wellbeing“

Synhelion,
Lukas Geissbühler
“A high-temperature solar process enabling energy-efficient and cost-effective production of synthetic liquid fuels.”

TNO,
Jaap Vente
“Industrial symbiosis through CO_2 valorization can lead to cost efficiency and reduced CO_2 emissions.“

Total & Sunfire,
Kai Hortmann & Jens Baumgartner
“Total and Sunfire are proud to present a common project on the conversion of CO_2 and renewable electric energy into methanol.“

VTT,
Janne Hulkko
“VTT has enhanced CO_2 to jet fuels -process significantly by circulating light hydrocarbons and unreacted gases.“

VTT,
Juha Lehtonen
“By VTT process, polyols with carbon content over 90 % from carbon dioxide can be produced from biogenic CO_2 and renewable hydrogen.“

Premium Partner EnergieAgentur.NRW

The EnergyAgency.NRW works on behalf of the state government of North Rhine-Westphalia as an operative platform with broad expertise in the field of energy: from energy research, technical development, demonstration, market launch and energy consultancy to continuous vocational training. Many of its activities focus on energy efficiency and climate protection.
In times of high energy prices it is more important than ever to forge ahead with the development of innovative energy technologies in NRW and to highlight from an impartial point of view how companies, local authorities and private individuals can handle energy more economically or make appropriate use of renewables.

The EnergyAgency.NRW operates with around 140 employees mainly from its locations in Düsseldorf, Gelsenkirchen and Wuppertal. It receives funding from, among others, the European Union's ERDF (European Regional Development Fund).

EnergieAgentur.NRW

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Cluster and Network Management

Acting on behalf of the Ministry of Economic Affairs, Innovation, Digitalization and Energy of the State of North Rhine-Westphalia, the EnergyAgency.NRW manages the Clusters "EnergyRegion.NRW" and "CEF.NRW" and is responsible for high-powered networks for climate protection in a total of 27 individual assignments. These encompass, for example, the subjects of system transformation, energy infrastructure, energy market design, business and financing models, knowledge management, as well as the networks Foreign Trade, Biomass, Fuel Cells, Hydrogen and Electromobility, Energy Efficiency in Municipalities, Energy Efficiency in Companies, Geothermal Energy, CHP/Local and District Heating, Future Fuels and Drives, Photovoltaics, Heat/Buildings, Hydropower and Wind Energy.
The EnergyAgency.NRW also organises the networks "Energy Economy" and "Mining Economy". The network operations focus on highly competitive co-operative ventures to initiate innovative projects and products, to speed up their market readiness and to exhaust all economic potentials.

Fuels and Drives of the Future Network

The EnergyAgency.NRW launched its Fuels and Drives of the Future Network in 2005. The aim is to muster all the forces along the respective value chains in order to develop joint solutions for future forms of climate-friendly mobility and liquid or gaseous transport fuels (e.g. synthetic fuels, biofuels). This also encompasses the development of new technologies and the testing of new business models.

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Renewable Carbon –

Key to a Sustainable and Future-Oriented Chemical and Plastic Industry

Why do we need "Renewable Carbon"?

In order to fight climate change, we need to curb our consumption of fossil resources. This has been shown in many studies and several even quantify how much of the remaining fossil resources need to be left in the ground. In the energy sector this is possible through "decarbonisation". However, this strategy is not feasible for organic chemistry, which is defined by the use of carbon. So, for the important chemical and plastic industries, we need to find alternative carbon sources in order to shift towards sustainable and climate-friendly production and consumption. We call these alternative carbon sources "renewable carbon".

Staying with the widely-accepted concept of "decarbonisation" is not only nonsense for the chemical and plastics industry, it is also dangerous, since it shifts attention away from the unavoidableness of carbon use and therefore from the question of the "right" carbon sources. Furthermore, in light of growing scarcity of other finite resources – metals, minerals, rare earths – carbon will be an important backbone of humankind's product needs, since it is available in almost unlimited quantities in the atmosphere.

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

What is "Renewable Carbon"?

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 biosphere, atmosphere or technosphere – but not from the geosphere. Renewable carbon circulates between biosphere, atmosphere and technosphere, creating a carbon circular economy.

There are only three sources of renewable carbon:

Biosphere: **Renewable carbon gained from all types of biomass**

- Food crops;
- Non-food crops;
- Side streams, by-products and biogenic waste;
- Includes measurable bio-based carbon content as well as "biomass balance and free allocation" approach.

Technosphere and atmosphere: **Renewable carbon from direct CO_2 utilisation (Carbon Capture and Utilisation (CCU), also Power-to-X)**

- Fossil point sources (while they still exist);
- Biogenic point sources (permanently available);
- Direct air capture.

Technosphere: **Renewable carbon from recycling of already existing plastics and other organic chemical products**

- Mechanical: limited quantities and qualities, limited in handling of mixed fractions;
- Chemical: gasification, pyrolysis, chemolysis, solvolysis and more, early technology stage, first commercial plants expected in five years;
- Enzymatical: early stage technology;
- Incineration, but only with CO_2 capture and utilisation (CCU).

In order to provide the full benefits of these technologies, all of them should run on renewable energies in order to avoid additional fossil fuels consumption for the supply of material carbon. However, this is a long-term vision and the first steps should be taken as soon as possible to account for the urgency of the climate crisis. For CCU the use of renewable energy is indispensable.

How realistic is a shift towards "Renewable Carbon"?

Of course, shifting relevant amounts of chemical and plastics production towards the use of renewable carbon will require significant efforts by the industry, by policy and by society as a whole. For the different sources of renewable carbon, different factors will determine their success. For biomass, land availability is extremely important and it depends on a large variety of political decisions and climate change impacts.

The provision of affordable renewable energy from solar, wind and hydro power is vital for all three sources of renewable carbon to decarbonise the required energy, but it is especially indispensable for CCU technologies (mostly in the form of green hydrogen). Our own calculations show that a range of 15 to 20 PWh would be required to cover the 2018 global carbon demand of the chemical industry by CO_2 utilisation with renewable energy, depending on the efficiency of electrolysis and further processes. Based on a typical photovoltaics (PV) yield of about 250 GWh/km²/y in the Sahara we calculate: In order to produce 20 PWh from PV, an area of 80,000 km² is needed. This constitutes only 0.9% of the total area of the Sahara of 9,200,000 km².

Political support will also be extremely important to get this new concept and several very young technologies off the ground. A range of measures are conceivable, among them the idea of a probably very effective fossil carbon tax (applied to fossil carbon as a feedstock, not to CO_2 as an emission). Similar concepts are also being discussed in the framework of the Green Deal proposed by the European Commission, where it is called "carbon border adjustment". Most importantly, political measures should push for a general switch to renewable carbon and not discriminate between the different sources. They should be technology neutral and let the market forces, regional availabilities and other factors decide which source of renewable carbon is chosen in a given context.

Last but not least, a large number of industries and researchers have indicated their agreement with the proposed strategy of switching to renewable carbon. This strategy is doable, will have significant positive impact on the climate if done right and will keep innovation, investment and employment in Europe.

Download this paper, the long version including much more detailed information and further documents at:

www.bio-based.eu/nova-papers

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Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers
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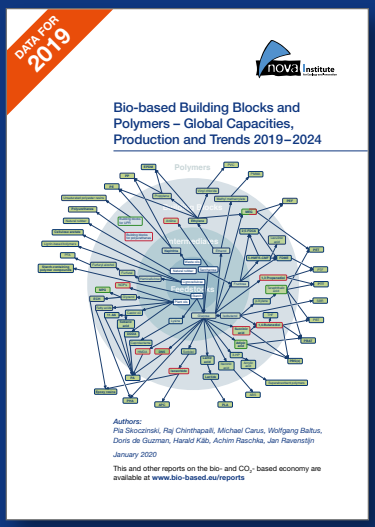

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