Transform the European Process Industries

4th International Workshop on Innovation and Production Management in the Process Industries (IPM2022)

12th & 13th May 2022, Industrial Park Höchst, Frankfurt, Germany

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Welcome

Dear Participants of the 4th International Expert Workshop on Innovation and Production Management in the Process Industries!

We are looking forward to two days of vital dialogue how the process industries´ transformation to climate neutrality can be implemented and accelerated – a huge challenge with an even increased importance in the light of the war in Ukraine.
We are pleased to have registrations from international experts from business and academia providing expertise, experience as well as fresh perspectives in these turbulent times.

With this expert workshop, we want to bring industry and academia together to

- reflect about scenarios about the development of the process industries in Europe after the Russian war
- highlight the systemic nature of the challenges in the areas of energy and raw material transformation taking recent geopolitical developments into consideration
- discuss new business models and technologies
- exchange best practices
- strengthen the international network of professionals researching management issues in the process industries

The industrial park Höchst is a special place for discussing about the upcoming transition towards CO_2-neutrality. Founded in 1863, this site has a long history of transformation. But now the shift towards energy and raw materials from renewables is on the agenda will determine the future of this site. We consider this park to be an innovation campus and accelerator of the transition where new technologies can be upscaled in an industrial setting and concepts of industrial-urban symbiosis can become a reality!
The collaboration between industry and academia is of crucial importance for tackling the transformation challenge. We are glad that we have two academic journals as partners for this workshop and invite you to consider publishing your findings in these journals.
Now: Let's be curious and open! Let's explore how we can jointly make the transformation a success - for the industry, for new businesses, for the environment and for society – supported by impactful research.

Welcome to Frankfurt

Hannes Utikal Janine Heck Marcel Loewert Bernd Winters
All Center for Industry and Sustainability (ZIN)

Summary

Dear Participants,

we thank you for sharing facts, figures, findings, perspectives on the topics of the Transformation of the European Process Industries!
We value the opportunities of in-depth discussions during those two days of in presence meetings. We needed this setting for making sense of the complexity, variety and ambiguity of information on the transformation of the process industries in Europe – in times of turbulence and war.
Our goal was to shed light on the different dimensions and levels of the transformation challenge. Please find an overview over the presentations and topics for discussion below.

Multi-Level-Perspective

Systems level:
How do different countries and industries translate the EU Gree Deal to their national contexts?

Company level:
How can companies transform their activities to achieve CO_2-neutrality in 2045? (scenarios, pathways, business models, technologies)

Innovation and production management level:
What innovation methods are suitable to handle the challenge?
What are the latest technological developments in the fields of energy transformation and defossilisation of feedstock for the process industries (CCU, CCS, hydrogen)?

Systems level

- “The European Process Industries towards climate neutrality, circularity and competitiveness: Activities and Insights from the SPIRE network and Processes4Planet program”, Prof. Dr. Ludo Diels (SPIRE)
- “The role of hydrogen in the process industries – implications on energy infrastructure”, Dr. Florian Ausfelder (DECHEMA)
- „Hydrogen Cluster Belgium, the Netherlands, and North-West Germany“, Tobias Sprenger (EWI)
- "Transformation of the Process Industries in Germany and Europe“, Prof. Dr. Stefan Lechtenböhmer (Wuppertal Institut)
- „Circular Bioeconomy: Closing Carbon Cycles in Chemical Industries“, Dr. Manfred Kircher (KADIB)
- „The Next Big Thing: Biologisation“, Dr. Michael Brandkamp (ECBF)

Company level

- “Roles of industrial parks in the transformation: knowledge hub, innovation campus, business driver”, Prof. Dr. Thomas Bayer (Infraserv Höchst)
- „Covestro will be fully circular“, Dr. Hanno Brümmer (Covestro)
- „Sustainability at Mitsubishi Chemical: reaching carbon neutrality and the implementation of a circular economy“, Dr. Lisa Weigand (Mitsubishi Chemical)
- “Carbon neutrality as business driver”, Angélique Terrien (Procter & Gamble)
- „Sustainability tensions on the way to greenhouse gas neutrality in the chemical industry“, Janine Heck (ZIN/WWU Münster)
- „Managing sustainability-oriented alliances: Strategies, tactics and the road to better goal fulfilment“, Elizaveta Johansson (Luleå University of Technology)
- „Combined Heat and Power – An Insight into a current project at the Industriepark Höchst“, Dr.-Ing. Paul Michael Falk (Infraserv Höchst)
- „Analysis of renewable industrial energy sourcing – a holistic approach“, Florian Frieden (WWU Münster)

Innovation and production management level

- "The HYBRIT demonstration of a fossil-free iron- and steelmaking value chain“, Dr. Christer Ryman (HYBRIT)
- „Green hydrogen for the decarbonisation of industry: A developer & owner’s perspective“, Anton Hoffmann (Hynamics)
- „Decarbonisation of the Process Industries- Carbon Capture from Waste-to- Energy Plants by means of the Carbonate Looping Process“, Carina Hofmann (TU Darmstadt)

- „Energy transition pathways for process industry“, Dr. Stefan Diezinger (Siemens Energy)
- „Carbon capture and utilization for production of green methanol and upgrading of biogas“, Dr. Francisco Vidal Vázquez (KIT)
- „A new process for the production of renewable synthetic fuels: Power and Biogas to Liquid“, Dr. Andreas Waibel (CAPHENIA)
- „Recycling – a sucess story of over 40 years“, Dr. Nabila Rabanizada (REMONDIS Recycling)
- „Demonstrating the Industrial Scale Feasibility of Chemical Recycling in Germany“, Julian Odenthal (ARCUS Greencycling)
- „Green Future with HOSTAFORM® POM ECO-B“, Dr. Klaus Kurz (Celanese)
- „Lignin for high-value applications“, Dr. Wienke Reynolds (Lignopure)
- „Exploring sustainability integration and digitalization of the company innovation work process for non-assembled products“, Prof. Dr. Dr. Thomas Lager (Mälardalen University)
- „Power-to-X – From vision to industrial implementation“, Prof. Dr. Roland Dittmeyer (KIT)
- Daniel Murrenhoff (Siemens Energy)
- „Pharmaceuticals Production Needs Steam – how to Perform the Transition to Green Energy?“, Dr. Werner Sievers (Sanofi-Aventis)
- „The Smart Paint Factory Alliance – Digitalize the coatings industry, make it sustainable end-to-end, and keep it competitive“, Dr.-Ing. Wolfram Keller (Chem4Chem)
- „Intelligent Decabonisation - Can Artificial Intelligence and Cyber-Physical Systems Help Achieve Climate Mitigation Targets?“ Dr. Oliver Inderwildi (Cambridge University & CMPG Innovations)

Our workshop survey identified the following three topics as most important for the transformation of the process industries:

- The redesign of a company’s energy and raw material mix: defossilisation of energy and raw materials and the interdependencies between the two
- The development of sustainable business models, thus the integration of the triple bottom line (profit, planet, people) systematically in corporate strategy making
- Regulation as a driver for innovation in product and process innovation (e.g. EU taxonomy, green finance, sustainable supply chain regulation)

Organizational and Scientific Committee

Prof. Dr. Hannes Utikal *(Chair), Provadis Hochschule, Center for Industry and Sustainability (ZIN), Germany, Journal of Business Chemistry, hannes.utikal@provadis-hochschule.de*

Prof. Dr. Dr. Thomas Lager, *Mälardalen University, School of Innovation, Design and Engineering, Sweden, thomas.lager@mdh.se*

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Dr. Florian Ausfelder, *DECHEMA e.V., Germany, Department Energy and Climate, florian.ausfelder@dechema.de*

Dr.-Ing. Marcel Loewert, *Provadis Hochschule, Center for Industry and Sustainability (ZIN), Germany, Journal of Business Chemistry, marcel.loewert@provadis-hochschule.de*

Welcome from the president of Provadis Hochschule

Prof. Dr. Uschi Bicher-Otto, *President of Provadis Hochschule*

Dear participants of the international workshop IPM2022,

as President of Provadis Hochschule, I am delighted to present the brochure of our expert workshop on 12th and 13th May 2022 here at Industriepark Höchst to you. Interested and very committed participants have contributed to an extremely successful workshop. Many thanks to all of you!

Provadis Hochschule sees itself as an university focusing on industry. The curricula of the bachelor and master degree programs in our three faculties as well as the university's research projects are therefore focused on industry. With regard to the urgent problems in the area of digitalization and climate protection, for example, industry in Germany but also worldwide is facing enormous challenges. Extensive transformation processes in all areas of industry are imminent; they must be recognized, planned and accompanied. Our project "Process4Sustainability" supports companies in their sustainable development and is closely linked to our teaching and further research activities.

The aim of our international expert workshop IPM2022 was to bring together experts from different fields to exchange ideas, to promote networking and to identify common ideas for the future. This was achieved in an impressive way during the two days of the workshop, many thanks to all of you. My sincere thanks also go to all who have ensured the excellent success both in the run-up to and during the workshop.

Welcome from our sponsor Infraserv Höchst

Jürgen Vormann, *CEO Infraserv Höchst*

"The man-made contribution to climate change poses major challenges for the economy and for society and will have to lead to profound changes in the private, social and economic spheres. Climate policy has long been a central and important policy field in Germany and in Europe, with corresponding implications for all other fields of political action. Against the background of our current knowledge about the cause, extent and presumed course of climate change, it is all the more important to define and socially negotiate, by means of our collective mind, a balanced system of goals that takes into account all relevant fields of political action. An effective climate protection policy must increasingly develop into a global climate protection policy, and the goals to be pursued in terms of climate policy must be accepted and enforceable at the global level - at least in the countries that are relevant from a climate policy perspective (and thus also in Germany). An alarmist climate protection policy that disregards or ignores justified economic and social goals will not be sustainable and will thus fail in achieving the climate protection goals pursued itself.“

Some statements from our speakers and participants

Attendee list

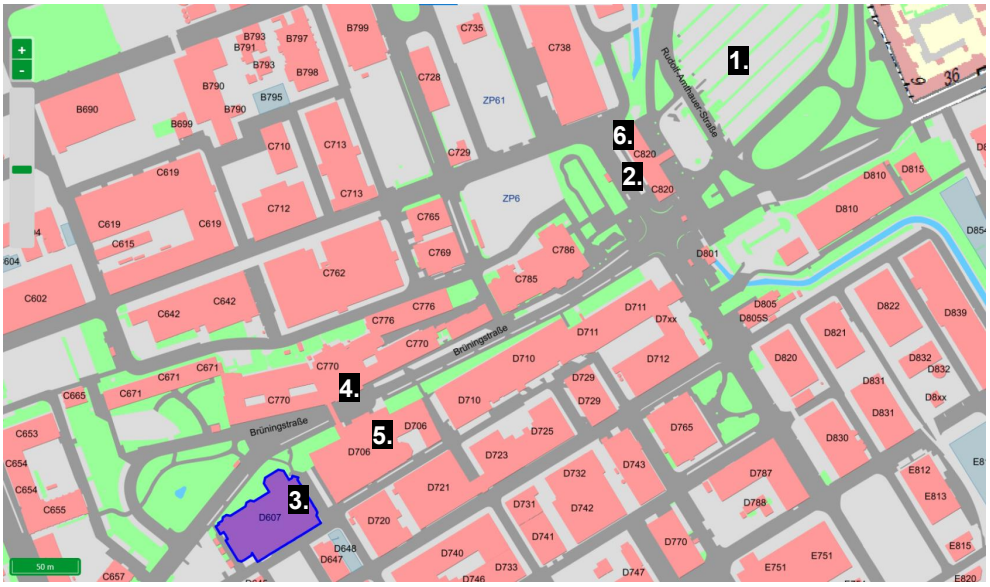
Participant name	Institution/University
Alex Lisiecki	Provadis Hochschule
Alexander May	Provadis Hochschule
Amin El Abbassi	Zentrum für Industrie und Nachhaltigkeit
Andrea Dorothea	DB Schenker
Andreas Waibel	CAPHENIA
Anke Reining	Infraserv Höchst
Anja Laqua	Kuraray
Anton Hoffmann	Hynamics
Bernd Winters	Zentrum für Industrie und Nachhaltigkeit
Björn Hekman	Provadis Hochschule
Carina Hofmann	TU Darmstadt
Christer Ryman	HYBRIT
Christian Bölling	EIT Manufacturing Central
Christoph Auch	Endure Consulting
Christoph Hofmann	Provadis Hochschule
Christopher Hilgert	Hessen Trade & Invest
Daniel Murrenhoff	Siemens Energy
Dieter Regnat	Clariant
Elizaveta Johansson	Luleå University of Technology
Erik Söder	DuDeChem
Florian Ausfelder	DECHEMA
Florian Frieden	WWU Münster
Francisco Vidal Vázquez	Karlsruhe Institute of Technology
Hannes Utikal	Zentrum für Industrie und Nachhaltigkeit
Hanno Brümmer	Covestro
Ida Dinges	DECHEMA
Janine Heck	Zentrum für Industrie und Nachhaltigkeit
Jens Leker	WWU Münster
Jörg Schappel	Kuraray
Julian Odenthal	ARCUS Greencycling

Participant name	Institution/University
Jürgen Vormann	Infraserv Höchst
Klaus Kurz	Celanese
Lisa Weigand	Mitsubishi Chemical Europe
Ludo Diels	A.SPIRE
Maja Borowska	Procter & Gamble
Manfred Kircher	KADIB
Marc Verelst	Procter & Gamble
Marcel Loewert	Zentrum für Industrie und Nachhaltigkeit
Maren Schmidt	COM Software GmbH
Maria Fulde	FLD Technologies
Markus Waltz	Mainova
Mathias Bösl	Spark e-Fuels
Maxime Lemee	Schenker
Michael Brandkamp	ECBF European Circular Bioeconomy Fund
Nabila Rabanizada	REMONDIS Recycling
Norman Hendrik Riedel	ITICON
Oliver Inderwildi	Cambridge University & CMPG Innovations
Paul Michael Falk	Infraserv Höchst
Peter Samuelsson	KTH
Peter Dziezok	Procter & Gamble
Ralf Kindervater	BIOPRO
Ralf Ehret	Provadis Hochschule
Roland Dittmeyer	Karlsruhe Institute of Technology
Sophie Drakopoulos	DB Schenker
Stefan Brand	Clariant
Stefan Diezinger	Siemens Energy
Stefan Lechtenböhmer	Wuppertal Institut
Steffen Gutensohn	Lufthansa Industry Solutions
Suman Sen	LG Chem
Sven Diedrich	Provadis Hochschule
Thomas Bayer	Infraserv Höchst
Thomas Beck	Infraserv Höchst

Participant name	Institution/University
Thomas Lager	Mälardalen University
Tobias Sprenger	Energiewirtschaftliches Institut an der Universität zu Köln
Ursula Bicher-Otto	Provadis Hochschule
Valentino Franco	Mainova
Vanessa Wirth	CAPHENIA
Voldřich Karel	ISFC
Werner Sievers	Sanofi-Aventis
Wienke Reynolds	LignoPure
Wolfram Keller	Chem4Chem

Directions

Geographical location
of the buildings for the **IPM2022**



MAP LEGEND

1. Parking Area Row 4
2. Industriepark Höchst Tor Ost: Receipt of the visitor passes
3. **Building D607** ‚Alte Färberei':
   - Plenary
4. **Building C770**:
   - Track Circular economy (Hörsaal, 2nd floor)
   - Table 2 Bioeconomy (Hörsaal, 2nd floor)
   - Table 6 Digitization & Sustainability (Brüning, 3rd floor)
5. **Building D706:**
   - Table 3 Sustainability Management (Room 203, 2nd floor)
6. **Building C820:**
   - Table 1 Recycling (1st floor)
   - Table 5 Energy transformation II (2nd floor)

On the **first day** (May 12th, 2022), signs will be placed directing the participants to the building D607 of the plenary session.
‚**Alte Färberei**' in Building D607 (marked in blue) will be the **main room** for the two-day workshop.

Direction
from the Parking Area Row 4 to the Industriepark Höchst Tor Ost

Address:
Parkplatz Höchst, 65929 Frankfurt am Main (direct use for Google Maps)

➡ ≙ The arrow marked in the map shows the sign C820 which is placed in front of Industriepark Höchst Tor Ost.
In the direction of the arrow is the parking area row 4.

DO NOT USE 

Program

12th May	Presentations and Tour Industriepark Höchst	
10:00 – 10:30	Registration and coffee	D607 Alte Färberei
10:30 – 11:00	Welcome and Workshop Introduction	D607 Alte Färberei
11:00 – 11:45	Plenary “The European Process Industries towards climate neutrality, circularity and competitiveness: Activities and Insights from the SPIRE network and Processes4Planet program”, Prof. Dr. Ludo Diels (SPIRE) Facilitator: Prof. Dr. Hannes Utikal	D607 Alte Färberei
11:45 – 12:30	Plenary "The HYBRIT demonstration of a fossil-free iron- and steelmaking value chain", Dr. Christer Ryman (HYBRIT) Facilitator: Prof. Dr. Dr. Thomas Lager	D607 Alte Färberei
12:30 – 13:30	Lunch	D607 Alte Färberei
13:30 – 14:15	Plenary “The role of hydrogen in the process industries – implications on energy infrastructure”, Dr. Florian Ausfelder (DECHEMA) Facilitator: Prof. Dr. Hannes Utikal	D607 Alte Färberei
14:15 – 15:00	Plenary “Roles of industrial parks in the transformation: knowledge hub, innovation campus, business driver”, Prof. Dr. Thomas Bayer (Infraserv Höchst) Facilitator: Prof. Dr. Hannes Utikal	D607 Alte Färberei

15:00 – 15:30	Coffee break			D607 Alte Färberei
15:30 – 17:00	Presentations in two thematic areas and discussion			
	Track Hydrogen Anton Hoffmann (Hynamics) Tobias Sprenger (EWI) Facilitator: Dr.-Ing. Marcel Loewert	D607 Alte Färberei	Track Circular economy Dr. Hanno Brümmer (Covestro) Dr. Lisa Weigand (Mitsubishi Chemical) Facilitator: Prof. Dr. Ralf Ehret	C770 2. OG Hörsaal
17:30 – 18:30	Tour Industriepark Höchst			
19:00 – 21:30	Evening program – joint dinner @Zum Bären			

13th May	Presentations and Roundtable Discussions	
08:00 – 08:30	Introduction	D607 Alte Färberei
08:30 – 09:15	Plenary "Transformation of the Process Industries in Germany and Europe" Prof. Dr. Stefan Lechtenböhmer (Wuppertal Institut) Facilitator: Prof. Dr. Hannes Utikal	D607 Alte Färberei
09:15 – 10:00	Plenary “Carbon neutrality as business driver”, Angélique Terrien (Procter & Gamble) Facilitator: Prof. Dr. Hannes Utikal	D607 Alte Färberei
10:00 – 10:30	Coffee break	D607 Alte Färberei

10:30 – 12:00	Presentations in two thematic areas and discussion			
	Track New Technologies and Carbon Capture Dr. Stefan Diezinger (Siemens Energy) Carina Hofmann (TU Darmstadt) Facilitator: Prof. Dr. Ralf Ehret	C770 2. OG Hörsaal	Track CCU Dr. Francisco Vidal Vázquez (KIT) Dr. Andreas Waibel (CAPHENIA) Facilitator: Dr.-Ing. Marcel Loewert	D607 Alte Färberei
12:00 – 13:00	Lunch			D607 Alte Färberei
13:00 – 13:30	Transform the European process industries: Survey on most important topic for academia and industry			D607 Alte Färberei
13:30 – 15:30	Roundtable discussions (parallel)			
Recycling	Dr. Nabila Rabanizada (REMONDIS Recycling), Julian Odenthal (ARCUS Greencycling), Dr. Klaus Kurz (Celanese) Facilitator: Bernd Winters			C820 1.OG
Bioeconomy	Dr. Wienke Reynolds (Lignopure), Dr. Manfred Kircher (KADIB), Dr. Michael Brandkamp (ECBF), Prof. Dr. Ralf Kindervater (BIOPRO) Facilitator: Prof. Dr. Thomas Bayer			C770 2. OG Hörsaal
Sustainability Management	Janine Heck (ZIN/WWU Münster), Elizaveta Johansson (Luleå University of Technology), Prof. Dr. Dr. Thomas Lager (Mälardalen University) Facilitator: Prof. Dr. Ralf Ehret			D706 Room 203

Energy transformation I	Dr.-Ing. Paul Michael Falk (Infraserv Höchst), Daniel Murrenhoff (Siemens Energy), Prof. Dr. Roland Dittmeyer (KIT) Facilitator: Dr.-Ing. Marcel Loewert	D607 Alte Färberei
Energy transformation II	Florian Frieden (WWU Münster), Dr. Werner Sievers (Sanofi-Aventis) Facilitator: Dr. Stefan Brand	C820 2.OG
Digitization	Dr.-Ing. Wolfram Keller (Chem4Chem), Dr. Oliver Inderwildi (Cambridge University & CMPG Innovations) Facilitator: Prof. Dr. Jens Leker	C770 3. OG Brüning
15:30 – 16:30	Summary from the Roundtable discussions and presentation of the survey results Facilitator: Prof. Dr. Hannes Utikal, Prof. Dr. Dr. Thomas Lager, Prof. Dr. Jens Leker, group facilitators	D607 Alte Färberei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Hochschule
Prof. Dr.
Hannes Utikal
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Hochschule
Janine Heck
WWU
Prof. Dr. Jens
Leker
Prof. Dr. Dr.
Thomas Lager
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Zentrum für Industrie
nd Nachhaltigkeit (ZIN)
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BUSINESS CHEMISTRY

Plenary Sessions set the scene:
30 min keynote, 10 min for questions

Prof. Dr. Ludo Diels, *SPIRE*

Title: The European Process Industries towards climate neutrality, circularity and competitiveness: Activities and Insights from the SPIRE network and Processes4Planet program

Ludo Diels, Dr. in chemistry & biotechnology, is professor emeritus at Antwerp University, former scientific advisor sustainable chemistry at VITO, the chair of the Advisory & Program Group of A. SPIRE. In that function he is chairing the preparation of research and development strategy and programs for the whole process industry in Europe towards climate neutrality, circularity and competitiveness (Processes4Planet). He is the chair of the advisory group of the shared research centre Biorizon on bio-based aromatics, and as such also strongly involved in the biobased economy in Europe.

The European Process Industries towards climate neutrality, circularity and competitiveness: Activities and Insights from the SPIRE network and Processes4Planet program

A.SPIRE is the European cross-sectorial Association committed to manage and implement the Processes4Planet co-programmed partnership in the context of the Cluster 4 (Digital, Industry and Space) of Horizon Europe funding programme.

The P4Planet Partnership, successor to the Horizon 2020 SPIRE Partnership, aims to transform the European process industries to achieve circularity and climate neutrality at the EU level by 2050 while enhancing their global competitiveness.
The three ambitions are covered by 4 leavers and 14 innovations areas:

- Process innovation (electrification, CCU, energy mix & heat recovery, process and resource efficiency)
- Industrial symbiosis and Hubs4Circularity (including circularity and upcycling)
- Digitalisation (including material tracking & tracing)
- Taking into account societal innovation.

The Strategic Research and Innovation Agenda (SRIA) 2050 document highlights the Partnership's collaborative and holistic approach to deliver the cross-sectorial innovation,

essential to achieve "An integrated and digital European Process Industry, fostering a "well-below 2 degrees scenario and a fully circular future for our planet and society."

A.SPIRE's vision is that the future of Europe lies in strongly enhanced cooperation across sectors and across borders, enabling a meaningful step change in competitiveness and sustainability performance that brings benefits for Europe and all its citizens.

Dr. Christer Ryman, *HYBRIT*

Title: The HYBRIT demonstration of a fossil-free iron- and steelmaking value chain

Christer Ryman is Regulatory Affairs Director at HYBRIT Development AB. He holds a M.Sc. degree in Process Metallurgy from the Royal Institute of Technology in Stockholm and a research degree (TechLic.) in Energy Engineering from Luleå Technical University. Christer Ryman has worked in various R&D positions in the mining and metal sectors in Scandinavia, to a large extent with a focus on resource efficiency, climate mitigation and sustainability. Since 2018 he has been actively involved in the development of the electro-hydrogen-based iron ore reduction technology to create a fossil-free value chain from iron ore to steel. This development has in a short time gone from a research stage (TRL3-4) to an experimental development (TRL6-7), with a path to industrial implementation (TRL8-9) within a few years.

The HYBRIT demonstration of a fossil-free iron- and steelmaking value chain

Currently, crude iron production in coal-fired blast furnaces, followed by steel manufacturing using oxygen converters, represents 95% of the global steel production from iron ore. This route is particularly suitable to produce high quality and high strength carbon steel, however even a state-of-the-art blast furnace process results in generation of about 1.6 tons of CO_2 per ton of crude steel (global average approximately 2.2 tons of CO_2 per ton crude steel). The HYBRIT technology for iron and steelmaking have the potential to make this traditional way of producing steel obsolete. To this end, the HYBRIT Demonstration project plans to realise the breakthrough of fossil-free steel production by developing a complete, new value chain based on fossil-free hydrogen, resulting in an annual production of 1.2 Mt crude steel. This entails a significant degree of innovation at both technological and logistical levels: with regards to plant design, operating approach, construction, quality, reliability, availability, and maintenance. The HYBRIT Demonstration project includes the construction of a greenfield, first-of-a kind, full-scale plant for the direct reduction of iron ore with 100% hydrogen.

This is a major innovation compared to the best available natural gas-based technologies, which can use hydrogen to only a limited extent. Moreover, the project includes fossil-free hydrogen production via a water electrolysis plant in Gällivare (500 MW), making use of the high shares of wind and hydropower in the electricity production of the region. This constitutes an unprecedented production capacity of fossil-free hydrogen, given that the global production capacity of electrolytic hydrogen amounted to less than 150 MW in 2018. Moreover, steel production with oxygen converters will also be phased out, as the sponge iron will be designed to be melted in an electric arc furnace. This is a technology that is already established for scrap-based melting but must now be adapted to high shares of hydrogen reduced sponge iron and the production of complex steel qualities.

Dr. Florian Ausfelder, *DECHEMA*

Title: The role of hydrogen in the process industries - implications on energy infrastructures

Dr. Florian Ausfelder studied chemistry at the Technical University in Karlsruhe (now KIT). He obtained his PhD in Physical Chemistry from the University of Edinburgh. He worked as a postdoc at Stanford University in California and with a Marie-Curie Fellowship to the Universidad Complutense de Madrid in Spain. He joined DECHEMA in 2007 as project scientist in national and international research projects. He currently heads DECHEMA's subdivision on energy and climate as well as DECHEMA's energy working groups.

His work is focused on industrial transformation and GHG reduction potentials in the chemical industry, including alternative energy supply, CO_2 utilization (CCU), PtX-Technologies. He is the coauthor of several current publications on the technology options for the European and German chemical industry, studies on flexibility in the primary industry sector, infrastructure requirements as well as Power-to-X processes and most recently, a detailed study on the future of European ammonia production.

The role of hydrogen in the process industries - implications on energy infrastructures

The German government has launched a series of publicly funded research and development projects to address the main challenges of a future hydrogen economy.

These so-called "Leitprojekte" investigate hydrogen and power-to-X technologies in an off-shore environment (H2Mare), production technologies for electrolyzers (H2Giga) and the transport of hydrogen (TransHyDE).

TransHyDe is dedicated to transport options for hydrogen. There are 9 sub-projects, each dealing with a specific challenge and environment. Of these, 4 sub-projects are at a large scale and meant to demonstrate the applicability and scalability of the technology.

(A) MUKRAN – New spherical H_2-storage vessel

(B) GET-H2 – Experimental H_2-pipeline

(C) CAMPFIRE – Ammonia as H_2 transport option

(D) HELGOLAND – Logistics and supply chain for LOHC (liquid organic hydrogen carrier)

The remaining 5 sub-projects are more fundamentally oriented based and aim to bring their respective technologies forward and lay the foundation for future development and implementation.

(1) System Analysis

(2) Safe and secure Infrastructure: Materials testing, sensors, safety and security

(3) H_2-Transport with ammonia

(4) Transport and use of liquid hydrogen

(5) Standardisation, technical norms and certification

The system analysis specifically will look into the interactions arising from introducing hydrogen as a new energy carrier into the energy system and how possible scenarios might develop.

Prof. Dr. Thomas Bayer, *Infraserv Höchst*

Title: The roles of industrial parks in the transformation: knowledge hub, innovation campus, business driver

Thomas Bayer is a trained technical chemist and acts as head of new technologies at Infraserv Höchst, responsible for R&D projects and the evaluation of new technical processes. He has 35 years of experience in chemical and pharmaceutical industry in development and production and longstanding experience in several national and EU funded projects.

The roles of industrial parks in the transformation: knowledge hub, innovation campus, business driver

Industriepark Höchst in Frankfurt am Main is one of Europe's largest and most successful industrial estates. Its success continues to grow as it attracts new tenants from the chemical, pharmaceutical and life science industries. Currently, around 90 companies have research, development and production facilities at the park. They all benefit from the central location in Europe's heartland, outstanding access to global markets and a deep, broad pool of skilled workers fed by an advanced educational system and an extremely attractive region.

The site's experienced operator and service provider, Infraserv Höchst, maintains two special location-specific advantages: a specialized, organically evolved utilities infrastructure, which Infraserv Höchst continuously improves through large investments, and a vast service portfolio covering virtually all secondary processes that allows tenants to focus on their core business.

Especially for Start-up’s and SMEs Industriepark Höchst is an ideal environment for the development of new methods and processes for sustainability. Infraserv Höchst supports these activites with its network on site, in the region and beyond.

Prof. Dr. Stefan Lechtenböhmer, *Wuppertal Institut*

Title: Transformation of the Process Industries in Germany and Europe

Prof. Dr. Stefan Lechtenböhmer is Director of the Division Future Energy and Industry Systems of the Wuppertal Institute for Climate, Environment and Energy, Wuppertal, Germany and holds an adjunct professorship in Environmental and Energy Systems with a special focus on Future Sustainable Energy Systems at Lund University, Sweden.

He acquired his PhD in energy and environmental management at the International Institute for Management, University of Flensburg, Germany. He conducts applied research in national and international energy and climate scenario analysis particularly on low carbon industries. He has lead intensive stakeholder processes on deep decarbonisation scenarios with energy intensive industries. His research topics include design and evaluation of combined energy system and industrial transformation and Energiewende, GHG emission inventories and projections, sustainable building and planning, and the coal and natural gas sectors.

Stefan Lechtenböhmer is member of the UNFCCC Roster of Experts for GHG-Inventories, Policies & Measures, and GHG-Projections as well as Member of the steering group of the G7 Low Carbon Society Research Network. He leads SCI4climate.NRW, the scientific part of the initative IN4climate.NRW, which has been initated by over 20 large industrial companies, associations, state government and science to achieve a climate neutral and competitive basic industry.

Transformation of the Process Industries in Germany and Europe

The new IPCC report once again makes clear how important the process industries are for the goal of climate neutrality. It shows that the focus must shift from incremental efficiency improvements to more transformative changes in terms of renewable energy and feedstock sources, material efficiency and greater circularity.

Angélique Terrien, *Procter & Gamble*

Title: Carbon neutrality as business driver

Angélique Terrien, Procter & Gamble Supply Chain Engineering Sustainability Vice President, Product Supply Innovation Leader Kronberg

Carbon neutrality as business driver

The climate crisis affects every home and family, everywhere in the world. Most consumers and customers globally now want brands they buy to help them live a more environmentally conscious lifestyle, and the latest science has made it clear that decisive action must be taken to avoid the most significant impacts of climate change. P&G Company aspires to be the best consumer good company. Net Zero manufacturing, operations and supply chain will directly be linked to the irresistible superiority of our products. P&G is committed to use innovation and ingenuity to unlock new solutions to address climate change P&G is tackling these challenges head-on by reducing our footprint and leveraging our scale to foster unprecedented collaboration across our value chain.

The best area to learn Sustainability is the German Market as consumers and customers are extremely demanding. The ecosystem is rich and at the edge of the industry both in Water and Energy technologies and Industry 4.0 Excellence. Thanks to CF Investment, Kronberg PSIC is in the centre of gravity of this ecosystem. Our commitment to deploy global modular solutions across our 200 sites and beyond with our Leading suppliers was very well perceived, and P&G was recognized as an Industry thought leader by the World Economic Forum. We will launch a Sustainability Catalyst event in April 2022 partnering with BU and selected partners on solving the grand challenges on water and GHG to 0. To deliver our Ambition 2040 across our 200+ sites, transportation and beyond, we listed all grand challenges to solve to create a menu of scalable, modular, and global solutions. We called them The Menus.

The PSIC innovation forum to accelerate P&G's road to Net Zero – by collaborating with partners from our local ecosystem on globally applicable sustainable supply chain solutions. The Product Supply Innovation Center (PSIC) in Kronberg, Germany, was set up in 2021 as one of three PSIC centers of P&G globally to create sustainable future supply chain solutions by intelligent operations. P&G's investment in facilities and talent from various European locations has produced an organization of 50+ specialists who leverage P&G innovations and insights from the collaboration with a network of suppliers, tech companies, R&D institutions and top universities.

PSIC expertise was a driving force behind the announcement in September 2021 of P&G's commitment to eliminate its GHG emissions by 2040. Solutions defined within the PSIC ecosystem will help steer P&G's global sustainable business transformation along its accelerated climate neutrality action roadmap towards Net Zero. We will run a 2nd annual PSIC Sustainability Summit is a crucial forum to drive tangible progress and to develop new perspectives with expertise from P&G and external partners. The Summit aims to produce modular, scalable and affordable solutions for GHG emissions and water consumption in P&G's plants. These ideas will be a major contribution to make the world's largest consumer goods manufacturer's global supply chain future-proof and resilient – touching billions of consumers daily – and to drive it to Net Zero by 2040.

Two focus tracks per day:

12th of May: Hydrogen and Circular Economy

13th of May: CCU and Track New technologies and Carbon Capture

Two insights on state-of the art developments (each 30min) and discussion

Anton Hofmann, *Hynamics*
Track Hydrogen

Anton Hoffmann is business developer and project manager at Hynamics Germany, a 100% affiliate of EDF group, the leading international utility. Hynamics develops, co-invests and operates green, industrial hydrogen based assets with a development pipeline > 2,5 GW in Germany, France and UK. Anton is driven by providing sustainable carbon free solutions, has a background in process engineering, the renewable energy sector and power-to-x technologies.

Green hydrogen for the decarbonisation of industry: A developer & owner's perspective

This presentation aims at providing an overview on the challenges and opportunities of green hydrogen projects from the perspective of developers and investors. Based on Hynamics' experience with industrial green hydrogen projects e.g. the Westküste100 project, a short view on the regulatory framework, the renewable electricity supply as well as commercial considerations that are required to reach bankability will be discussed.

Tobias Sprenger, *EWI*
Track Hydrogen

Tobias Sprenger is a Research Consultant at the Institute of Energy Economics at the University of Cologne (EWI). His research focuses on the decarbonization of industry and the development of a hydrogen economy.

Hydrogen Cluster Belgium, the Netherlands, and North-West Germany

In the study “Hydrogen cluster Belgium, the Netherlands, and North-Western Germany – A projection and analysis of demand and production until 2030”, EWI analyzes how potential local imbalances in the supply of low-carbon hydrogen of the potential hydrogen cluster Belgium, the Netherlands, and North-Western Germany might be addressed. Depending on how much demand in industry and transport will increase, there could be a supply gap of up to 11 TWh per year in this cluster in 2030 from today’s perspective.

The hydrogen production volumes in the study are calculated using an EWI database on existing, under construction and planned projects. The location of potential demand of low-carbon hydrogen are identified in a bottom-up analysis

Dr. Hanno Brümmer, *Covestro*
Track Circular Economy

Since July 2021 **Hanno Bruemmer** is Senior Vice President for Supply Chain & Logistics for Europe, Middle East, Africa and Latin America and member of the Leadership Team of Global Commercial Operations at Covestro.
Before that was Global Head of Production and Technology for the Business Unit Polyurethanes. Hanno Bruemmer is a PhD chemist and started at Bayer in 1996. In his career he has held positions of increasing responsibilities in Innovation followed by Production & Technology included assignments in several locations in Germany as well as in Baytown, Texas, USA.
He is a member of the Industrial Advisory Board of the European Institute of Industrial Leadership. Hanno Bruemmer is married and has three adult children.

Covestro will be fully circular

At Covestro, our goal is to embed circular economic principles into the fabric of our operations leading the plastics industry.
Becoming circular means avoiding waste, developing innovative recycling, exploring alternative sources of sustainable raw materials, and utilizing renewable energy.
The presentation will outline Covestro's sustainability roadmap with specific examples which includes aiming for climate neutrality for own emissions by 2035.

Dr. Lisa Weigand, *Mitsubishi Chemical Europe*

Track Circular Economy

- 2008 – 2011: B.Sc. Chemistry – RWTH Aachen University
- 2011 – 2014: M.Sc. Chemistry – RWTH Aachen University
- 2014 – 2018: PhD. Chemistry – Imperial College London
- 2018 – 2021: Laboratory Manager R&D – UPM Biochemicals
- Since 2022: Advisor Circular Economy – Mitsubishi Chemical Europe

Sustainability at Mitsubishi Chemical: reaching carbon neutrality and the implementation of a circular economy

At Mitsubishi Chemical we believe in the power of chemistry to solve social and environmental issues and create a more sustainable future for humans, our society and planet earth. The presentation discusses the steps already taken and future plans on our journey to become carbon neutral and implement a circular economy.

Dr. Stefan Diezinger, *Siemens Energy*
Track New Technologies and Carbon Capture

Stefan Diezinger is currently Vice President, Sustainable Energy Systems, Siemens Energy. In his current capacity, he works with companies to assess, develop, and implement decarbonization strategies. Prior to the spinoff of Siemens Energy, Mr. Diezinger held a number of executive sales positions with Siemens AG, including Vice President, Sales, Industrial Business. He has also worked in project management and engineering capacities. Mr. Diezinger holds a bachelor's degree in business administration from the University of California at Berkley, a master's in process engineering, and a Ph.D. in process engineering, both from FAU Erlangen-Nürnberg.

Energy transition pathways for process industry

The presentation will give an overview on different technologies for decarbonization of process industries like low carbon energy, heat integration, electrification, power to X, residuals. For selected examples use cases and references will be presented.

Carina Hofmann, *TU Darmstadt*
Track New Technologies and Carbon Capture

Carina Hofmann is working as a research scientists at the Institute for Energy systems and Technology at the Technical University Darmstadt since 2018. She studied Mechanical Engineering at the University of Applied sciences in Giessen. Before she started working in Darmstadt, she was working as thermal design engineer in the power plant sector at General Electrics for 5 years, focusing on reduction on emissions and plant optimization. Currently, her main research focus is on innovative technologies for the CO_2-capture, carbon capture and utilisation and the carbonate looping process. She is a doctoral candidate.

Decarbonisation of the Process Industries- Carbon Capture from Waste-to- Energy Plants by means of the Carbonate Looping Process

In Waste-to-Energy (WtE) plants, municipal solid waste (MSW) is combusted while power and/or heat are produced. This approach will largely remain as a promising option to handle the MSW capacities in the future. The generation of MSW is related to the growth rate of population and industrial activities, and it is expected to grow from nearly 1.3 billion tons per year at present to approximately 4.0 billion tons per year in 2025 [1]. Worldwide, approximately 750 WtE plants with a yearly MSW treatment capacity of almost 83 million tons are currently in operation [2]. WtE plants represents a stationary CO_2 emitter that is reasonable large for the implementation of efficient carbon capture and storage (CCS) processes. Thereby, the benefits of an efficient MSW treatment along with the supply of clean energy and are combined. While using MSW with a high biogenic content, even net negative CO_2 emissions can be achieved.

The Carbonate Looping (CaL) process represents one promising option to capture CO_2 from WtE plant exhaust gases. A limestone-based sorbent stream circulates between two interconnected circulating fluidized bed reactors.

The flue gas of the host plant is fed to the first reactor, the so-called carbonator, where CO_2 reacts exothermically with calcium oxide (CaO) forming calcium carbonate ($CaCO_3$) according to Eq. 1.

$$CO + CaO \leftrightarrow CaCO \pm 178.2 kJ/mol \text{ (1) } 2(g)\ s\ 3(s) \quad (1)$$

The partly carbonated sorbent is subsequently transported to the second reactor, the so-called calciner, where the temperature of the sorbent is raised to reach calcination conditions. Consequently, $CaCO_3$ decomposes to CaO and CO_2. The required heat for the calciner can be either supplied by means of oxy-fuel combustion of supplementary fuel, such as solid recovered fuels (SRF) or by indirectly heating with an additional combustor. Due to the relatively high operation temperatures of the CaL process, efficient excess heat recovery by means of a dedicated supercritical water-steam cycle is feasible [3].
The feasibility of the continuous CO_2 capture from a flue gas typical for WtE plants using an SRF-oxy-fired CaL process has been demonstrated in 1 MW_{th} scale, showing capture rates in the carbonator of 80% and a total capture rate of more than 90% [4].

In this presentation the 1 MW_{th} Carbonate Looping test facility at Technical University Darmstadt will be introduced and related projects results, performed at this facility, will be presented, and a full scale concept will be explained. Furthermore, an outlook on future projects of the group will be given.

[1] D. Hoornweg, P. Bhada-Tata, 2012. What a Waste, A Global Review of Solid Waste Management. Urban Development & Local Government Unit, World Bank, Washington, DC 20433 USA.

[2] D. C. Wilson, 2015. Global Waste Management Outlook. International Solid Waste Association General Secretariat, Vienna, Austria.

[3] Y. Lara, P. Lisbona, A. Martinez, L. M. Romeo, 2014. A Systematic approach for high temperature looping cycle integration. Fuel, 127:4-12.

[4] Haaf M, Peters J, Hilz J, Unger A, Ströhle J, Epple B. Combustion of solid recovered fuels within the calcium looping process – Experimental demonstration at 1 MWth scale. Experimental Thermal and Fluid Science 2020;113:110023.

Dr. Francisco Vidal Vázquez, *KIT*

Track CCU

I am post-doc working as project manager and researcher in the area of CCU and Power-to-X at the Institute of Micro Process Engineering (IMVT) at the KIT since the last 4 years. I studied chemical engineering at the UPV (Valencia, Spain) and I completed my PhD focused on CO_2 utilization in 2018 for the Aalto University (Helsinki, Finland). In Finland, I worked for VTT Technical Research Centre of Finland for almost 6 years in different EU and Finnish-funded research projects.

Carbon capture and utilization for production of green methanol and upgrading of biogas

Carbon capture and utilization (CCU) has the potential for replacing fuels and chemicals for applications which are very difficult or impossible to decarbonize. The content of this presentation focuses on the application of CCU for production of green methanol and upgrading of biogas to biomethane. Methanol is a liquid chemical with high energy density, which has many applications in the chemical industry. Recently, methanol has gained a lot of attention as alternative renewable fuel for the shipping industry. Biomethane is also a valuable product which can be used as a direct substitute of natural gas.
In the last few years, we have been developing our own Power-to-Methanol technology for decentralized applications. The core of this technology is based on a patent-pending process for capturing CO2 from point sources and converting it to methanol. We validated our process by experimental and simulation work. We used this information now for developing a fully-integrated Power-to-Methanol container-sized plant which we are building at the Energy Lab 2.0 at the Campus Nord of the Karlsruhe Institute of Technology. The work is a collaboration between several units at the KIT and funded mainly by the German ministry of education and research (BMBF). The units involved are the Institute for Micro Process Engineering (IMVT), the Project, Process and Quality Management (PPQ) service unit, the Institute for Automation and Applied Informatics (IAI) and the Institute for Astroparticle Physics (IAP).

The plant will be commissioned at the beginning of 2023. Finally, we also started preparing the transfer of this technology to industry through our planned start-up called ICODOS – Intelligent Carbon Dioxide Solutions, for which we are still in the pre-seed stage.

Dr. Andreas Waibel, *CAPHENIA*
Track CCU

Dr. Andreas Waibel is Chief Technology Officer (CTO) at CAPHENIA and holds a PhD in atmospheric science. He combined his passion for flying with research on the environmental impact of air traffic at an early age.
Waibel studied physics in Freiburg, Edinburgh and Heidelberg. In 1993, he graduated at the Max- Planck Institute for Nuclear Physics, in a research group on atmospheric physics. He then conducted research at the Max-Planck Institute for Chemistry in Mainz together with Nobel Prize winner Paul Crutzen on mechanisms of ozone depletion in the Northern Hemisphere. In 1997, he received a doctorate for his work.
After receiving his doctorate, Waibel began his career at Lufthansa in 1998, where he helped shape the company's environmental concepts as a consultant. In 2007, he began working intensively on alternative fuels and in 2012 came into contact with the CAPHENIA process for the first time, which immediately convinced him.
Waibel subsequently led the resulting research and development project within Lufthansa to implement the new process.
In 2019, after LH pulled out of the development, Waibel decided to continue on the path of alternative fuels and he joined CAPHENIA as Chief Technology Officer.

A new process for the production of renewable synthetic fuels: Power and Biogas to Liquid

Renewable synthetic fuels will play a central role in the necessary energy and transport turnaround. After all, the energy of the future must not only be renewable, but also storable and transportable. Renewable liquid fuels have decisive advantages overall, while alternative energy sources such as hydrogen or batteries are reaching their limits. However, the existing production routes of renewable synthetic fuels also encounter crucial obstacles. These include not only process-related challenges, but also the limitation of individual raw materials, the limitation of the availability of renewable electricity and the sometimes prohibitively high manufacturing costs.

The CAPHENIA process helps overcome these barriers. By combining BtL (Biomass-to-Liquid) and PtL (Power-to-Liquid) process elements, as well as a novel combination of process steps, the demand for renewable electricity (by a factor of 6), as well as the manufacturing costs can be significantly reduced. Furthermore, the process allows to use the entire material flow of a biogas plant (i.e. the methane as well as the CO_2). Thus, CO_2 emissions from biogas plants can be avoided in the future. Until now, these have been separated from the biogas material flow (when fed into the natural gas grid) and emitted into the atmosphere.

In essence, the CAPHENIA process represents a new route for the production of syngas (CO/H_2). This platform chemical can serve both for the production of fuels, but also as a feedstock for the production of other basic chemicals.

Roundtable discussions allow in-depth discussions in small groups:

Several 10-15 min presentations on individual aspects of the roundtable topic followed by a discussion in which all members of the small group participate.

Dr. Nabila Rabanizada, *REMONDIS Recycling*

Table: Recycling

Academic Degree:

- Diploma in Mechanical Engineering, University Kassel, Institute of Materials Engineering (Plastics and Recycling Technology)
- Doctorate at University BW Munich, Faculty for Aerospace Engineering, Institute of Mechanics (Prof. Alexander Lion)

Experience:

- Der Grüne Punkt, Duales System Deutschland GmbH, Product and Process Development Department
  - Head of application development PET
  - Planning, construction of sensor panel according to automotive standard (VDA 270)
  - Conformity development

- Berner Kunststofftechnik GmbH/Dannemann Global Extrusion GmbH
  - Quality management / Head of development
- REMONDIS Recycling GmbH & Co. KG
  - Head of Research and Development

Recycling – a sucess story of over 40 years

Plastics recycling was developed at REMONDIS as early as the 1970s, out of a desire to recycle waste as sustainably as possible and to generate secondary raw materials. In 1982, we pioneered the processing of waste plastics on an industrial scale and thus became the knowledge centre for plastics recycling. Techniques for processing such as magnetic and eddy current separators were developed and optimised here together with engineers. Further processes with shredding, washing and separation technology as well as the extruder were also further developed.

Our growing expertise in all areas from waste to raw material, i.e. the collection, sorting, separation and cleaning of various plastics, has enabled us to achieve a very high-quality product that today demonstrates actual circular economy in practice. Our recycling processes are adapted in detail to each material flow and are always designed according to the motto "minimum energy input for maximum product yield".

In theory, several processes are available for the processing of plastics. The mechanical processing of the waste is always the first step for each subsequent process. Thus, solvent-based separation, depolymerisation and pyrolysis or molecule recovery can only work with specific input that has already been mechanically processed. Each additional step means further energy input and efficiency losses. For this reason, REMONDIS focuses on sustainable and high-quality processes in mechanical recycling.

The role model process here is the PET bottle cycle where it is already possible to produce bottles for food applications made from 100% post consumer waste plastic. But other polymers such as HDPE, LDPE and PP, which are very often found in packaging, are also being recycled and used in high-quality applications without any necessity of adding virgin material. Thus, a film is recycled into a film and a cosmetic bottle becomes a new cosmetic bottle. The growing interest of the packaging industry and other product segments in using recyclates in their production creates the opportunity to further invest in processes and achieve higher purities. It is crucial that we do not lose sight of the original motivation: To recycle as much material as sustainably as possible.

REMONDIS - Working for the future

Julian Odenthal, *ARCUS Greencycling*

Table: Recycling

- Since Feb 2021: Head of Business Development @ ARCUS Greencycling Technologies
- 2014-Feb 2021: Engagement Manager in strategy consulting @ EY Parthenon and OC&C Strategy Consultants
- MSc in Business Administration and Management from WHU – Otto Beisheim School of Management
- BSc in Industrial Management from European University of Applied Sciences

Demonstrating the Industrial Scale Feasibility of Chemical Recycling in Germany

Chemical recycling can play a vital role in improving the circularity of plastics through improving overall recycling rates as well as delivering high quality and high value feedstocks for the chemical industry. However, to achieve this goal we need to bring the value chain together and implement chemical recycling processes as a robust and flexible “translating technology” between the waste management industry and the chemical industry.

Therefore, ARCUS has developed and leads the way in providing a chemical recycling solution for currently non-recyclable mixed plastics waste streams with as little as possible prior sorting or cleaning of mixed plastics waste. Our process successfully handles a wide range of polymers from PP, PE, and PS to difficult to process PVC, ABS, or PET.

ARCUS is currently building a fully authorized (BImSch approved, REACH registered, as well as (soon) ISCC, RedCert2, and EfbV certified) 4,000 t/a industrial-scale pilot plant in Frankfurt a.M going-live in Q3 2022. This plant will o- er customers a highly robust process at an industrial scale to either test the suitability of a wide variety of waste streams for chemical recycling and utilize the facility to produce commercially usable pyrolysis oil.

Dr. Klaus Kurz, *Celanese*

Table: Recycling

Klaus Kurz studied Chemistry (1980-1988) at TU Kaiserslautern, TU Clausthal-Zellerfeld, University Wien (1985 Diplom-Chemie, 1988 Ph.D. in Polymer Physical Chemistry). Research Chemist in the Research Laboratory of Polymer & Plastics Division of Hoechst AG, Frankfurt. From 1997 until 2009 in Ticona (subsidiary of Celanese) several R&D management positions for different Business Lines (POM, Polyester, LFT). Between 2009 and 2015 Innovation Technology & Open Innovation roles in Celanese; his current role is Sr. Principal Chemist POM. Author and co-author of many patents, publications as well as invited speaker and chairman of conferences; active member of subgroups at CEFIC and Plastics Europe. His areas of expertise include (Physical) Chemistry of polymers, Engineering Thermoplastics, Polymerization Technology, Compound development and additives, Biobased and Life Cycle Assessment, Innovation Management Processes.

Green Future with HOSTAFORM® POM ECO-B

To support a more environmentally sustainable future, a key element for success will be transitioning to more carbon neutral materials. With Hostaform® POM ECO-B, our customers in diverse industries (automotive, medical, consumer and many others) do meet both, regulatory/specification and sustainability targets at the same time. Based on a recent Life Cycle Assessment (cradle-to-gate; according to ISO 14040/44) at Celanese Frankfurt-Hoechst factory, main factors contributing to the carbon load of the POM production process arise from steam, electricity, and methanol used as a raw material for the POM manufacturing. By replacing methanol from natural gas to biogas as feedstock, the POM production process is overall not affecting physical and chemical properties of POM. Hostaform® POM ECO-B contains up to 97% bio-content using an ISCC+ certified mass-balance approach; the respective CO2 footprint per kilogram of polymer (GWP) is less than half of fossil based POM, and yet is considered an equivalent virgin material.

Dr. Wienke Reynolds, *Lingopure*

Table: *Bioeconomy*

- Studies of Bioprocess Engineering at the TU Hamburg (TUHH, 2007 – 2013)
- Doctorate in the field of biorefinery (process development and modelling) at the Institute of Thermal Process Engineering of the TUHH (2013 – 2019)
- Co-Founder and CTO of LignoPure GmbH (since 2018)

Lignin for high-value applications

Consumers' demands for their everyday consumer goods are growing, especially with regard to more sustainable and natural alternatives. This presents the industry with major challenges, not only n plastics and materials but especially e.g. in cosmetics and skin care. Ambitious goals are set to reduce dependence on oil and to use innovative raw materials. However, this transformation is not an easy task. The industrial processes and procedures are optimized for petro-based materials, and the bio-based industry has so far only insufficiently been able to provide actually functional raw materials that can be used directly in current processing technologies. Many current alternatives do not meet the performance or functionality required by the industry. For example, the number of UV filters taken off the market every year exceeds the number of new sustainable alternatives. In addition, plantations are being set up on a large scale, and land and food resources are being used to produce the bio-based materials, which of course is at the expense of the sustainability aspect.

Lignopure uses lignin, a by-product of bioethanol refineries and pulp processes, which is normally burned to produce energy. Using the company's patented technology, Lignopure makes the natural protective functionalities of lignin in the plant accessible to natural cosmetics in the form of a novel cosmetic ingredient. This is on the one hand made possible by matchmaking lignin-type and properties with the product and process requirements as well as tailored particle properties.

The core product is LignoBase^{TM}, lignin in the form of microparticles in various product variants, which can be used by formulation developers and cosmetics manufacturers as SPF booster, pigment, antioxidant and rheological aid in innovative skin care products.

In addition to the direct sale of lignin for cosmetic applications, Lignopure bundles its know-how in lignin downstream processing and application development in a service area (lignin application platform): Customers are supported in the development of their own innovative, sustainable products based on lignin and e.g feasibility studies and prototype developments in the material area for lignin manufacturers carried out.

Lignopure will be the first European supplier of lignin-based care ingredients, but also sees itself in a pioneer role to enable lignin valorization in demanding, high-value markets as well as a connection point for different emerging industries.

Dr. Manfred Kircher, *KADIB*

Table: Bioeconomy

Manfred Kircher is a freelance advisor for bioeconomy. His consulting work is based on more than 30 years of experience in the chemical industry and the development of an internationally active bioeconomy cluster with companies and research institutes.
His career milestones are biotechnological research and development (Degussa AG, Germany), production (delegated to Fermas s.r.o.; Slovakia), venture capital (delegated to Burrill & Company; USA) and biotechnology partnering and branding (Evonik Industries AG; Germany). Delegated by Evonik he chaired the Board of the Cluster Industrial Biotechnology (CLIB-Cluster e.V.; Germany) and developed this association of German and international industries, small and medium-sized enterprises (SME), academia and investors to an recognized organisation for unfolding bioeconomical value chains. In 2014 he founded KADIB, a consultancy for bioeconomy. Since 2020 he serves on the board of BioBall e.V., an association that promotes waste recycling technologies and the implementation of bio-based circular value chains.

Circular Bioeconomy: Closing Carbon Cycles in Chemical Industries

Chemical production today is mainly based on fossil raw materials such as crude oil, natural gas and, to a small extent, coal. The end-of-life treatment of the products manufactured in this way leads to the emission of CO_2, which accumulates in the atmosphere and thus contributes to climate change. Only a small part of chemical production uses biomass as a carbon source; this is about 13% in Germany and 10% throughout Europe. Only for the bio-based products produced in this way is the carbon cycle closed, because their end-of-life-treatment CO_2 emissions are, on balance, bound back into biomass by photosynthesis. By contrast, for 87% of today's chemical products, the carbon cycle is not closed; their value chains are linear, not circular.
In order to make the chemical industry more sustainable, it is obvious to call for a complete switch to biomass as a raw material. However, this is countered by the fact that twice as much carbon of fossil as biological origin is consumed globally today,

with the energy sector claiming the lion's share. A complete conversion to biomass is therefore already impossible in terms of quantity. Biomass is largely used for food and production capacities for industrial purposes are therefore limited.

The modern bioeconomy will therefore have to limit itself to those applications that are dependent on carbon. This is primarily the organic chemistry sector. The energy sector, on the other hand, can switch to carbon-free alternatives and should therefore rely less on bioenergies.

In fact, as mentioned earlier, the chemical sector uses biological carbon sources and does so primarily for fine and specialty chemicals. However, the most significant area of basic chemistry by volume is only in niche biobased production. This is due to the properties of biobased raw materials and biotechnological processes. These raw materials already bring functionalities with them and the high specificity of biological processes makes them particularly suitable for the production of functionalized products. On the other hand, the high oxygen content and low carbon density of biomass and the limited scalability of biotechnological processes are disadvantages for bulk chemicals. A second reason for the hesitant switch to biological raw materials lies in the European framework conditions. Namely, the EU Emissions Trading Scheme (EU-ETS) puts a burden on energy-related emissions SCOPE 1 and 2, thus promoting decarbonization of energies. The product-related emissions SCOPE 3, on the other hand, are not priced and thus the EU-ETS fails as an incentive system to defossilize chemical products.

Nevertheless, there is no way around chemical defossilization in the long term, so biomass availability must be assessed at an early stage. As a result, the limitation of biomass becomes clear, because already today's European chemical products would require about a quarter of the total European biomass capacity. One way out is to intensify waste recycling. To this end, Provadis School of International Management & Technology is conducting the R&D&I project BioBall (Bioeconomy in a Metropolitan Region) funded by the German Federal Ministry of Education and Research (BMBF) to develop processes for transforming bio-based waste from the Frankfurt/Rhine-Main metropolitan region into chemical products. Addressed are wastes ranging from wastewater to green waste, food waste, and CO_2, and products of different added value ranging from basic chemicals to functionalized materials up to food.

Such processes lay the foundation for completely closing the carbon cycles of organic chemistry and integrating the natural carbon cycle via photosynthesis with technical cycles of carbon capture and utilization (CCU), material recycling and the utilization of residual materials by cascading in the circular bioeconomy.

Dr. Michael Brandkamp, *ECBF*

Table: *Bioeconomy*

Dr. Michael Brandkamp is General Partner of the European Circular Bioeconomy Fund.
He has been one of the initiators and spokesperson for the management of High-Tech Gründerfonds from 09/2005 to 31.12.2019.
Before working for High-Tech Gründerfonds he worked as Departmental Director for Innovation Financing and Investment within the KfW Banking Group and as the Head of the Berlin office of tbg Technologie-Beteiligungs-Gesellschaft mbH.
Dr. Michael Brandkamp studied Economics at the Universities of Münster, Nairobi and Bonn. As a research associate he was awarded a doctorate at the Technical University of Freiberg (Saxony) on Technologies for Innovative Start-up Enterprises.

The Next Big Thing: „Biologisation"

The development of a sustainable bio-based economy will lead to disruptive economic changes. Venture capitalists focused on targets to drive digitization in the past are now moving their attention to the bioeconomy. Driven by innovation, changing consumer demand and public support, the transition from a fossil-linear to a bio-based circular economy will speed up. A redefinition of business models and many value chains, or more precisely value circles, are changing the entire economic landscape, step by step. We call it "Biologisation". Despite Biologisation being a must to survive on the planet, it comes with a high level of uncertainty, which requires flexibility and a willingness to take risks. A perfect situation for the proliferation of start-ups and the successful investment of venture capital, mainly since most of the bioeconomy markets are enormous.
According to the European Commission, "the bio-based economy or bioeconomy involves the production of renewable biological resources (terrestrial and aquatic) and converting these resources and waste streams into value-added products such as food, feed and bio-based products."
By 2030, Europe could expect €1.8tr in net benefits from the Circular Economy[1] ,

and sustainable-driven innovations leveraging biological cycling scenarios will contribute to this growth (i.e. recyclable, compostable, or biodegradable products). Today, the bioeconomy sector generates about €2 trillion in annual turnover in the EU and over 18 million jobs[2]. Investing now in circular business and conversion technologies will benefit a growing market segment and a cleaner future considering the industrial promises offered by the biotechnology revolution (including biochemistry, biomaterials, and biorefineries) and the desired bio-based carbon economy (biomass production). The value creation by bio-based products and technologies is growing in sectors such as consumer-packaged goods (CPG); food and nutrition; agro, farming, forestry and aquaculture; and cosmetics and personal care. The annual rise of bio-based chemicals +26% and bio-based plastics +13% are reliable indicators of an emerging industry with solid growth potential[3].

However, Bioeconomy investments are not an easy home run. Providing appropriate feedstock sources, production facilities, logistics, and sales in large, growing but uncertain high competitive markets makes scaling up companies challenging. In addition, the regulatory framework is changing for the better but is often uncertain. Therefore, you need excellent execution power, experience, and networks to scale your business and invest successfully in this sector. If you add innovation and a fantastic unique selling position in growing markets, you have a chance to meet unicorn potential. Alternative protein sources are coming up like Protix, the worldwide leader in producing black soldier fly, and Prolupin, a company selling vegan milk alternatives made out of the regional crop lupin. You find impressive examples like Oatly, valued at approximately 4 billion in the food industry. Innovation is creating huge markets. In the textile industry, Renewcell is building up a new recycling approach. The company is worth around 400 million euros.

More and more investors allocating their capital to venture capital funds learned that the trade-off between impact and IRR turned to synergy. They consider targets risky without affecting social development goals or aligning to environmental, social and good governance criteria. Therefore, they are open to investing in impact funds to participate in the exciting transformation opportunities to a sustainable biobased economy. So, after digitization, Biologisation might be the next big thing.

[1] Money makes the world go round (and will it help to make the economy circular as well?). FinanCE Working group. 2016.

[2] Food, bioeconomy, natural resources, agriculture and environment factsheet 2019. European Commission 2019.

[3] Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 EN. Ronzon et.al. (2017)

Prof. Ralf Kindervater, *BIOPRO*

Table: Bioeconomy

Prof. Dr. Ralf Kindervater is the CEO of BIOPRO Baden-Württemberg GmbH. BIOPRO is the innovation agency of the state of Baden-Württemberg for the topics bioeconomy and health industry (biotechnology, pharmaceutical industry, and medical technology). After completing his chemistry studies with a degree in biochemistry and biotechnology (TU Braunschweig), he completed his doctoral thesis in the field of enzyme technology at the “Gesellschaft für Biotechnologische Forschung (Helmholz facility)”. He established BIOPRO Baden-Württemberg GmbH on behalf of the state government in 2003 and has been managing it ever since. In November 2014, he was appointed as an honorary professor at the Karlsruhe Institute of Technology (KIT) in the Faculty of Chemical Engineering and Process Engineering. Prof. Dr. Kindervater is a member of the Baden-Württemberg Advisory Council "Sustainable Bioeconomy" and the German national Bioeconomy Council.

Janine Heck, *ZIN /WWU Münster*
Table: *Sustainability Management*

Janine Heck works at Center for Industry and Sustainability (ZIN) at Provadis School of International Management and Technology since 2020. Here, she mainly is in charge of the Journal of Business Chemistry (JoBC). In addition, she is a PhD candidate at the Institute for Business Management in the Department of Chemistry and Pharmacy in Münster.

Sustainability tensions on the way to greenhouse gas neutrality in the chemical industry

This study examines which sustainability tensions chemical companies perceive on their way to greenhouse gas (GHG) neutrality and how they deal with them. A qualitative content analysis of 27 interviews and 22 sustainability reports shows that tensions can be classified into seven categories. The tension “business success vs. greenhouse gas saving” is described by all investigated companies and thus occurs most frequently. Moreover, the tensions are interdependent and connected via the topic “energy”. The responses are classified into three categories based on Putnam et al. (2016). The study shows that chemical companies are aware of tensions between their business and GHG neutrality and accept those tensions which is the first step to manage them (Smith & Lewis, 2011). However, more specific responses to the tension “business success vs. greenhouse gas saving” are urgently needed as transformation is not economically self-sustaining (in the short term) and timely conversion of production is highly important.

Putnam, L. L., Fairhurst, G. T., & Banghart, S. (2016). Contradictions, Dialectics, and Paradoxes in Organizations: A Constitutive Approach. Academy of Management Annals, 10(1), 65–171. https://doi.org/10.1080/19416520.2016.1162421

Smith, W. K., & Lewis, M. W. (2011). Toward a Theory of Paradox: A Dynamic Equilibrium Model of Organizing. Academy of Management Review, 36(2), 381–403. https://doi.org/10.5465/amr.2011.59330958

Elizaveta Johansson, *Luleå University of Technology*

Table: *Sustainability Management*

Elizaveta Johansson is a PhD candidate at Luleå University of Technology in Sweden. Researches on organizational aspects of sustainability transition, more specifically on circular business model innovation and on managing alliances for developing sustainable technologies.

Managing sustainability-oriented alliances: Strategies, tactics and the road to better goal fulfilment

Elizaveta Johansson, Johan Frishammar, Anna Brattström

To address climate change, firms are increasingly forming strategic alliances for sustainability, i.e. cooperative arrangements aimed at creating more environmentally friendly technologies, products and services. Such alliances are more complex than regular R&D collaborations as they i) have dual objectives (simultaneously pursuing economic and environmental goals), ii) presuppose collaboration outside of traditional value chains and sectors and iii) operate under dense societal and political pressure. Based on a multiple case study of eight such alliances, we identify the three meta strategies, namely sustainability visioning, relational contracts and meta- stakeholder management, which firms deploy to enhance goal fulfilment. When these strategies are implemented over the different phases of an alliance (alliance formation, alliance design, and post-formation) they imply different tactics which vary by phase, i.e. specific activities and actions which resolve conflicts and problems, improve collaboration and boost alliance outcomes. The paper collates these approaches into a contingency framework which contextualize the three meta strategies and their associated tactics along the phases of a sustainability alliance life cycle and thereby help companies improve results of engaging in partnerships for sustainability. The framework provides new theoretical implications for the literature on strategic alliances and hands-on advice for management practice.

Prof. Dr. Dr. Thomas Lager, *Mälardalen University, School of Innovation, Design and Engineering,*
Table: *Sustainability Management*

Exploring sustainability integration and digitalization of the company innovation work process for non-assembled products

Koteshwar Chirumalla, Thomas Lager, Mikael Ankerfors

Since corporate sustainability predominantly is materialized through marketing and sales of sustainable products, integrating sustainability aspects in product innovation in general, and in the product innovation work process in particular, is critical. In an exploratory inquiry, involving informants in nineteen global manufacturing companies in six sectors of the process industries, sustainability integration and the digitalization of the innovation work process for non-assembled products has been explored. Preliminary findings indicate that the case-companies already have come far on the road in institutionalizing sustainability perspectives in raw material selection, process technology development and product design. However, the study further disclose a need for a more in-depth inquiry and understanding on HOW alternative operational best practices and tools in a more systematic approach can make sustainability an integral part of this work process. The empirical results further demonstrate that the case-companies not yet have come far on their journeys with respect to product innovation work process digitalization. However, the high case-company importance ratings of six potential expected outcomes from such digitalization and in particular the digitalization of customer and product information, should incentivize companies in the process industries to put this topical area higher on their digitalization agendas.

Dr.-Ing. Paul Michael Falk, *Infraserv Höchst*

Table: *Energy Transformation I*

- Since october 2019 lecturer at the Darmstadt Graduate School of Energy Science and Engineering at the TU Darmstadt
- Since May 2018 Project Manager at Infraserv GmbH & Co. Höchst KG
- April 2018 PhD in mechanical engineering at the TU Darmstadt
- PhD Topic: Evaluation of district heating systems based on exergy analysis

Combined Heat and Power – An Insight into a current project at the Industriepark Höchst

The presentation will give an insight into the various energy systems at the Industriepark Höchst. The focus will be on the heat supply systems needed to meet the customers demand. Currently, a new gas turbine power plant is being build and a practical experience report will be given.

Daniel Murrenhoff, *Siemens Energy*

Table: *Energy Transformation I*

Daniel Murrenhoff is currently working as a sales manager within industrial applications with the focus on early phase consulting of customers in process industries such as pulp & paper and chemical. Beforehand Mr. Murrenhoff has gained experience as a regional sales manager and project lead for the modernization of decentralized gas turbine power plants. Before entering the sales area he has been active as a project lead within Siemens Gas Turbine Engineering and R&D. Mr. Murrenhoff holds a Bachelors Degree in Mechanical Engineering from Ruhr-Universität Bochum and a Master of Science from WWU Münster / RWTH Aachen in Energy Economics.

Prof. Dr. Roland Dittmeyer, *KIT*

Table: *Energy Transformation I*

Prof. Dr.-Ing. habil. Roland Dittmeyer graduated in chemical engineering from the Friedrich-Alexander University of Erlangen-Nuremberg in 1989 and received his doctorate in chemical reaction engineering from the Technical Faculty there in 1994. In 2001, he also habilitated there in the field of technical chemistry and was appointed Privatdozent in 2002 and Extraordinary Professor in 2006. Since 2009, he has been professor and director of the Institute for Microprocess Engineering at the Karlsruhe Institute of Technology. Previously, he worked for 11 years at DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V. in Frankfurt am Main. He is the author of more than 170 peer-reviewed scientific publications and holds 13 patents.

Power-to-X – From vision to industrial implementation

It becomes clearer and clearer every day that mankind must quickly and deeply reduce its greenhouse gas emissions to limit global climate change. Net zero greenhouse gas emission targets have been set by many countries, and strategies how to achieve this have been worked out and are being implemented increasingly. The cost of power generation from renewable energy is continuing to fall, in particular from wind and solar, and CO_2 taxation is on the rise and can be expected to accelerate further. As a consequence, the so far unfamiliar concept of turning the combustion products CO_2 and H_2O back into chemical energy carriers with the help of electrical energy is receiving more and more attention. The presentation will briefly introduce the main concepts assembled under the general term “Power-to-X”. It will describe the motivation for Power-to-X and some of the key steps. It will analyse to what state the research and technology development has evolved. An overview of stakeholders and industrial projects will be given from the authors perspective. Technical, economic and ecologic aspects connected to the choice of location for Power-to-X plants will be discussed, and the research and development done in the field of Power-to-X at the Institute for Micro

Process Engineering will be put in this context. Special emphasis will be laid on modular technologies along the whole value chain from CO_2 capture to the upgrading of Power-to-X products to meet existing requirements and standards. This is considered important to enable a widespread decentralised production of sustainable chemical energy carriers based on renewables.

Florian Frieden, *WWU Münster*
Table: *Energy Transformation II*

Florian Frieden is doing his doctorate under Prof. Dr. Jens Leker at the Institute for Business Management in the Department of Chemistry and Pharmacy in Münster. There he is part of the battery team, which is primarily concerned with the economic and ecological analysis of batteries. His research focuses on the practical use of stationary batteries in an industrial environment. He works on holistic cost models that see batteries as a component in the overall context of decarbonizing the energy system. Thus, he aims to contribute to the sustainable transformation of the industry.
In addition to his doctorate, he works as a consultant at FutureCamp Climate GmbH and supports client companies in the sustainable transformation of their business model, among other things. Furthermore, he drafts decarbonization roadmaps for companies and industry associations in this context.

Analysis of renewable industrial energy sourcing – a holistic approach

Today the energy intensive industry is facing the challenge of decarbonizing its huge energy consumption to reach the goals of the Paris Agreement. As renewable energies (RE) are becoming economically viable in recent years, they make up larger parts of our energy mix. But RE are subject to fluctuations which can not be accepted by industrial plants. To make renewable energy sources usable for industrial plants, batteries must store energy to compensate for fluctuations.
This paper is aiming to analyze the cost-optimal configuration of renewable energies sourcing for industrial plants. To do that demand profiles of industrial plants are compared with the power generation of wind turbines and photovoltaic plants. The location of the study is defined as Germany, as the location of power generation through RE is important and has a significant impact on the results. The gap between power generation and demand is where stationary battery storage systems come into play. Therefore, multiple storage systems like lithium-ion batteries (with different cathode materials), redox flow batteries and lead-acid batteries are compared to find the

most cost-efficient option. Besides cost-efficiency, also power input and output are investigated to find technically fitting storage systems. To get a holistic picture of the energy demand of industrial plants, heat energy is also included. In the model carbon neutral heat is produced exclusively by electrode boilers and heat pumps. While the latter have a much higher energy efficiency, electrode boilers need to be used for higher temperature levels. This way a realistic model for a fully carbon neutral industrial plant is set up.

The system is then benchmarked against a combined heat and power (CHP) plant, which represents the currently most widely used technology to generate power in industrial facilities. In order to make the systems comparable, the modelled CHP plant will be equipped with a carbon capture and storage (CCS) unit. So, the plant will be locally carbon neutral like the RE system. On the other side the CCS unit will increase the price of the CHP plant.

Dr. Werner Sievers, *Sanofi-Aventis*

Table: *Energy Transformation II*

Werner Sievers is Head of Industry Park Operations of Sanofi-Aventis Deutschland in Frankfurt/Germany. He graduated in Chemical Engineering from Technical University Munich, started after his PhD in the Research&Development of former Hoechst AG in Frankfurt, and was then for many years in production. He was Plant Manager in a Large-Scale-Biotec-Plant and then as Site Head responsible for production of all chemicals produced in Frankfurt. Dr. Werner Sievers chairs the Interessengemeinschaft Regelwerke Technik e.V. und is lecturer in Biotechnology at the University of Applied Sciences Frankfurt.

Pharmaceuticals Production Needs Steam – how to Perform the Transition to Green Energy?

Production of active pharmaceutical ingredients are based on chemical and biotechnological processes. The chemical reaction and the bio fermentation have lots of steps around as up- and downstream operations and solvent recycle loops. Almost all of the technical assets like reactor, fermenter, distillation unit, crystallizer, dryer, filter etc need heating energy, which is today provided by steam. On top of that need all biotec operations huge amounts of steam for sanitization and sterilization. Today´s usual situation is a central steam generation in a plant or in a chem park, mostly based on fossil primary energy from oil or gas or coal, then providing steam to each user. On our ambition to climate neutrality, we have to find solutions and pathways, how to replace a central steam unit and / or to replace individually on each point of use the heating unit by renewable energy assets, under all well known restrictions of time pressure, financial budget and compliance. The presentation shows, on how many assets and operations steam is needed, how integrated and deeply involved steam based processes in pharmaceutical production are. Pharmaceuticals production needs steam – how can we perform the transition to renewable energies?!

Dr.-Ing. Wolfram Keller, *Chem4Chem*

Table: *Digitization*

Dr. Wolfram Keller, born in 1961, studied chemistry at Darmstadt Technical University. He graduated in biochemistry in 1989. Having joined Merck Group he kept various position in R&D, production and technical marketing, mainly in the electronic chemicals business in Germany and South East Asia. In 1997 Dr. Keller joined PRTM management consultants, now part of PWC, where he focused on innovation and operations management in the global pharmaceutical and chemical industry. In 2005 he became part of the Central European health care and chemicals management team of Arthur D. Little.

In 2008 he decided to operate his own management consultancy, Wolfram Keller Professional Services, which allowed him to keep a better balance between project assignments and other interests. Since then he conducted several surveys on topics such as digitalization, its impact on jobs in the chemical and pharmaceutical industry and its compatibility with sustainability, for example, and published their results.

In recent years Dr. Keller focused increasingly on industry and company value chains and the progress of digitalization in the chemical industry. He founded the competence network CHEM4CHEM®, joined the VCW board (Association of Chemistry and Economics) and became a founding partner of the Smart Paint Factory Alliance.

The Smart Paint Factory Alliance – Digitalize the coatings industry, make it sustainable end-to-end, and keep it competitive

Germany's coatings industry consists of approx. 250, mainly small and mid-sized companies. They develop and produce know-how intense, often custom-tailored paints and coatings for a broad variety of applications, e.g. cars, windmills, furniture, floors, toys and packaging.

Empiric, human expertise, often acquired over decades, is instrumental for product design and development, bulk production, tinting and applications. Knowledge is often considered as "head monopoly", securing recipes, formulations and last

not least the own job and a root cause for the silo mentality that is so typical for this conservative, yet successful industry segment.

Manufacturing process capability is traditionally low, though, due to the lack of systematic approaches and willingness to collect, share and use material, process and asset related data. While the level of automation is still lower than in other specialty chemicals segments, the hesitation to adopt digital technologies and concepts such as Artificial Intelligence or Modular Plants is higher here.

On the ecologic side, the raw material base is still largely fossil-based, and - not surprisingly - regularly subject to regulatory restrictions or even bans, as it was the case for solvents or TiO_2. Re-use of coatings after its intended strong and lasting protection of surfaces is not yet a realistic option. Recycling of end-of-life coatings is in its embryonic stage, at best. CO_2, resource and energy related reduction targets are lacking feasible approaches yet.

Individual small and mid-sized companies will not be able to link the so-called haptic world of materials, processes and assets with the complementing virtual world of data and digital applications on their own due to capability and resource reasons.

The Smart Paint Factory Alliance, being set up early in 2022, has developed the vision to connect the haptic world of materials with the virtual data world for the benefit of coatings industry, companies and society. The ultimate vision is a digitalized, end-to-end, sustainable and competitive coatings industry, ideally globally.

First step first, though: The roadmap to make the vision achievable is currently under development. It will combine cross-sectoral human and artificial intelligence of players from the front end through the back end of the coatings industry value chain and its periphery. The value chain needs to include mining and drilling operations, raw material manufacturing, paint formulation and production, coatings applications, industrial and private customers, retro logistics and recycling. The periphery includes sustainability, digitalization, and other experts as well as scientific, technical and commercial services, products and equipment from a whole variety of suppliers. The Smart Paint Factory Alliance will orchestrate them to ensure the synergy of scale required for what is a true transformation of an entire industry segment.

Smart Paint Factory Alliance founding members: Hochschule Niederrhein, Krefeld; Fraunhofer-IFAM, Bremen; ORONTEC, Wuppertal; European Centre for Dispersion Technologies (EZD), Selb; Wolfram Keller Professional Services, Darmstadt.

Dr. Oliver Inderwildi, *Cambridge CARES, Cambridge University & CMPG Innovations*

Table: *Digitization*

Dr. Oliver Inderwildi has more than 20 years of experience in sustainability research and consulting gained in academia, think tanks, the private sector as well as international organisations. Dr Inderwildi combines in-depth knowledge on computational methods for efficient resource use with hands-on experience in business and political processes driving decarbonisation. He has published more than 70 academic research articles, 10 White Papers and has created numerous sustainable business models for private sector clients.

Intelligent Decabonisation - Can Artificial Intelligence and Cyber-Physical Systems Help Achieve Climate Mitigation Targets?

The talk will provide an overview over Intelligent Decarbonisation which was just published by Springer Nature. The book comprehensively assesses the current and future impact of digital technologies and artificial intelligence (AI) on the decarbonisation of key economic sectors.

It is is divided into four parts – Technology, Impact, Implications and Incubation – moving clearly from the theoretical and technical to the real-world effects and areas for future development. It also presents insights into the economic and environmental transformation fostered by digital technologies.

Intelligent Decarbonisation brings together work from private and public sector professionals, academics and think tank experts, and provides truly comprehensive insights into the topic. It is an interesting and informative text for policymakers, researchers and industry professionals alike.

ABOUT US

The industrial park Höchst as an innovation campus

The industrial park is an experienced partner in handling large-scale innovation projects. We are happy to partner up to upscale new low-carbon technologies and to test and implement new concepts in the field of industrial symbiosis.

Current focus topics are:

- Green energy supply
- Green raw materials
- Circular economy and new business models
- CCU & CCS
- Sustainable Industrial Area Management & Industrial-urban symbiosis
- Sustainable Business models

Contact us:

Dr.-Ing. Marcel Loewert, Center for Industry and Sustainability, Provadis Hochschule

Prof. Dr. Thomas Bayer, Infraserv Höchst, New Technologies

Dr. Thomas Beck, Infraserv Höchst, New Business Development

Team Provadis Hochschule

Prof. Dr. Hannes Utikal, *Zentrum für Industrie und Nachhaltigkeit, Provadis Hochschule, Process4sustainability.eu, Journal of Business Chemistry*

Since 2016, Hannes leads the Center for Industry and Sustainability at Provadis Hochschule.

After his management studies and PhD in organization design at the university of Cologne, he worked several years at an international pricing and marketing consultancy before joining Provadis Hochschule.

His activities encompass applied research and professional education activities on the transformation of the process industries in Europe. Currently, he leads the cluster process4sustainability.eu and focusses especially on the development of sustainable business models and the collaboration between business and society.

Together with Prof. Leker (University of Münster), he is editor in chief of the journal of Business Chemistry (businesschemistry.org). He is member of the board of the German “Vereinigung für Chemie und Wirtschaft“ as part of the Gesellschaft Deutscher Chemiker (www.gdch.de/vcw)

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Janine Heck, *Workshop Program comittee, Zentrum für Industrie und Nachhaltigkeit, Provadis Hochschule, Journal of Business Chemistry*

Janine works at the Center for Industry and Sustainability at Provadis Hochschule and is executive editor of the Journal of Business Chemistry since 2020. She worked on the program for the workshop.

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Bernd Winters, *Zentrum für Industrie und Nachhaltigkeit, Provadis Hochschule, Process4Sustainability*

Senior project manager of the cluster “Process4Sustainabilty” - focus on internal and external stakeholders and the corresponding communication based on the approaches of the materiality analysis. Facilitator in different scientific projects and trainer for entrepreneurship and other related issues.

Access to and years of experience with the European start-up ecosystem based on our collaboration with the EIT.

Academic background: Economics; other fields of professional experiences as trainer: leadership and communication.

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Prof. Thomas Bayer, *FB NaWiT & VP Research & ISH New Technologies*

Thomas Bayer is a trained technical chemist and head of new technologies at Infraserv Höchst, responsible for R&D projects and the evaluation of new technical processes. At Provadis Hochschule he acts as dean of the department of natural science and technology and VP Research.
He has 35 years of experience in chemical and pharmaceutical industry in development and production and longstanding experience in several national and EU funded projects.

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Dr.-Ing. Marcel Loewert, *Zentrum für Industrie und Nachhaltigkeit, Provadis Hochschule, Business Development*

Since 2022, Marcel operates as Business Development and Project Manager at the Center for Industry and Sustainability.

For the past seven years, Marcel's work is dedicated to sustainability and renewable energy, from his Master's thesis over his PhD to his work as head of operations in a tech-startup from Karlsruhe.
With his KIT-doctorate in process engineering (with focus on energy processes), Marcel joined the team as the contact person for technological approaches on sustainability and energy transition. Within the cluster "Process4Sustainabilty" he paves the pathway for the industrial park Höchst, initiates

contacts and project ideas, connects challenge owners with solution providers and leads several projects on transformation.

He supports those claims with the development of “Provadis technology briefings” and his editor role in the Journal of Business Chemistry for a special issue on this event.

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Amin El Abbassi, *Zentrum für Industrie und Nachhaltigkeit Provadis Hochschule*

Project assistant of the cluster "Process4Sustainabilty" during his bachelor studies "Industrial Engineering" at the Darmstadt University of Applied Sciences

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Prof.Dr-Ing. Ralf Ehret, *Provadis Hochschule, FB NaWiT*

Ralf has been employed at Provadis University since 2013 and is currently Vice Dean of the Faculty of Science and Technology.

After studying chemistry and gaining his PHD at the Technical University in Darmstadt, he was employed in the chemical-pharmaceutical industry in management positions for 18 years.

Since joining Provadis University, he has been teaching in the field of physical chemistry, analytical and technical chemistry as well as life cycle analysis. In addition to teaching, he studies the environmental impacts of processes and participates in national and international research projects on LCA, such as currently in CO2Chem, Carbohydrate Waste to Chemicals and the synergistic development of biotechnological and chemical processes to add value to decentralised C1-material flows.

He is a member of GdCh.

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Sven Diedrich, *Provadis Hochschule, FB NaWiT, Process4Sustainability*

Since 2021, Sven is employed as a research assistent at Provadis Hochschule for “Process4Sustainability”. He has been working on “Technology Briefings” as part of the cluster’s work.
He is a Masters Degree student attending the Provadis Hochschule, presently in the 2nd semester of the studies in Chemical Engineering.

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