DECHEMA

Prof. Kurt Wagemann

Sectorcoupling with Power-to-X

Materials for the European Green Deal, 22 April 2021

The Power-to-X concept

- Power-to-Heat

- Power-to-Gas
  (Hydrogen, Methane)

- Power-to-Fuels
  (Terms: E-Fuels, Power Fuels, Synfuels)

- Power-to-Chemicals
  (Methanol, Ethene, …)

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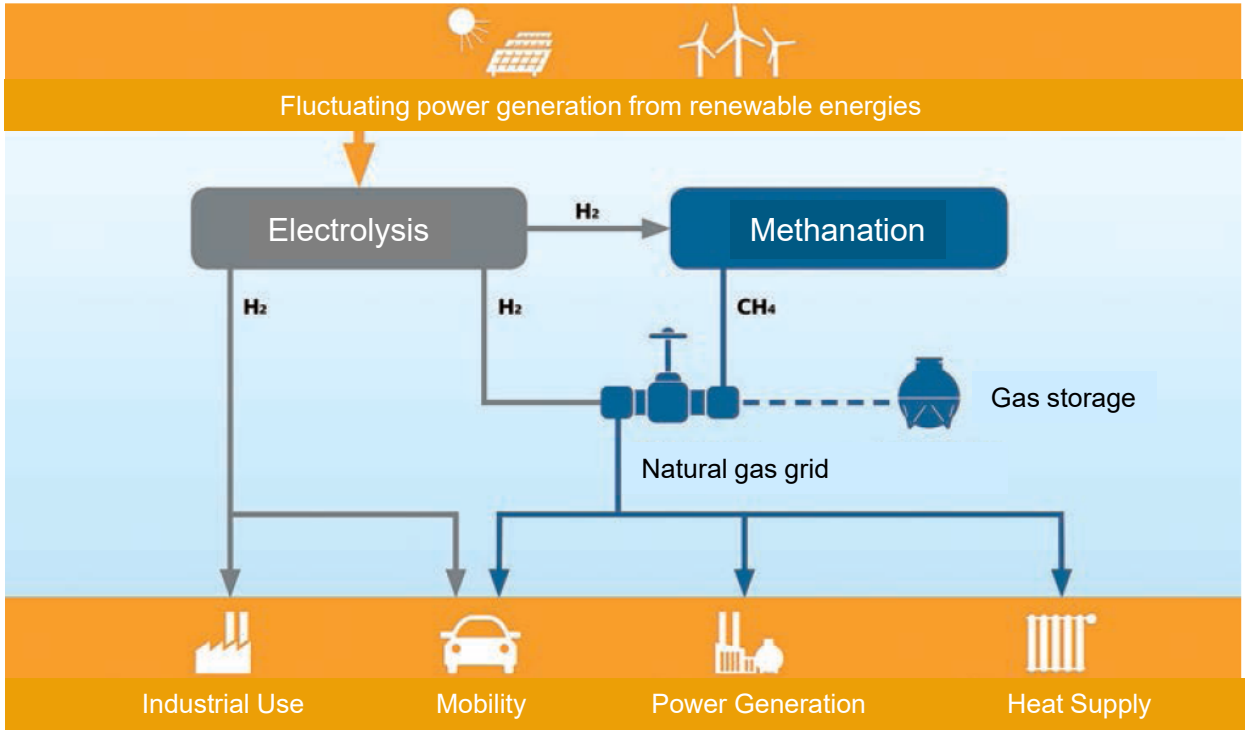
The Power-to-X concept

- Originally developed as „Power-to-Gas“ (M. Sterner, M. Specht 2009)

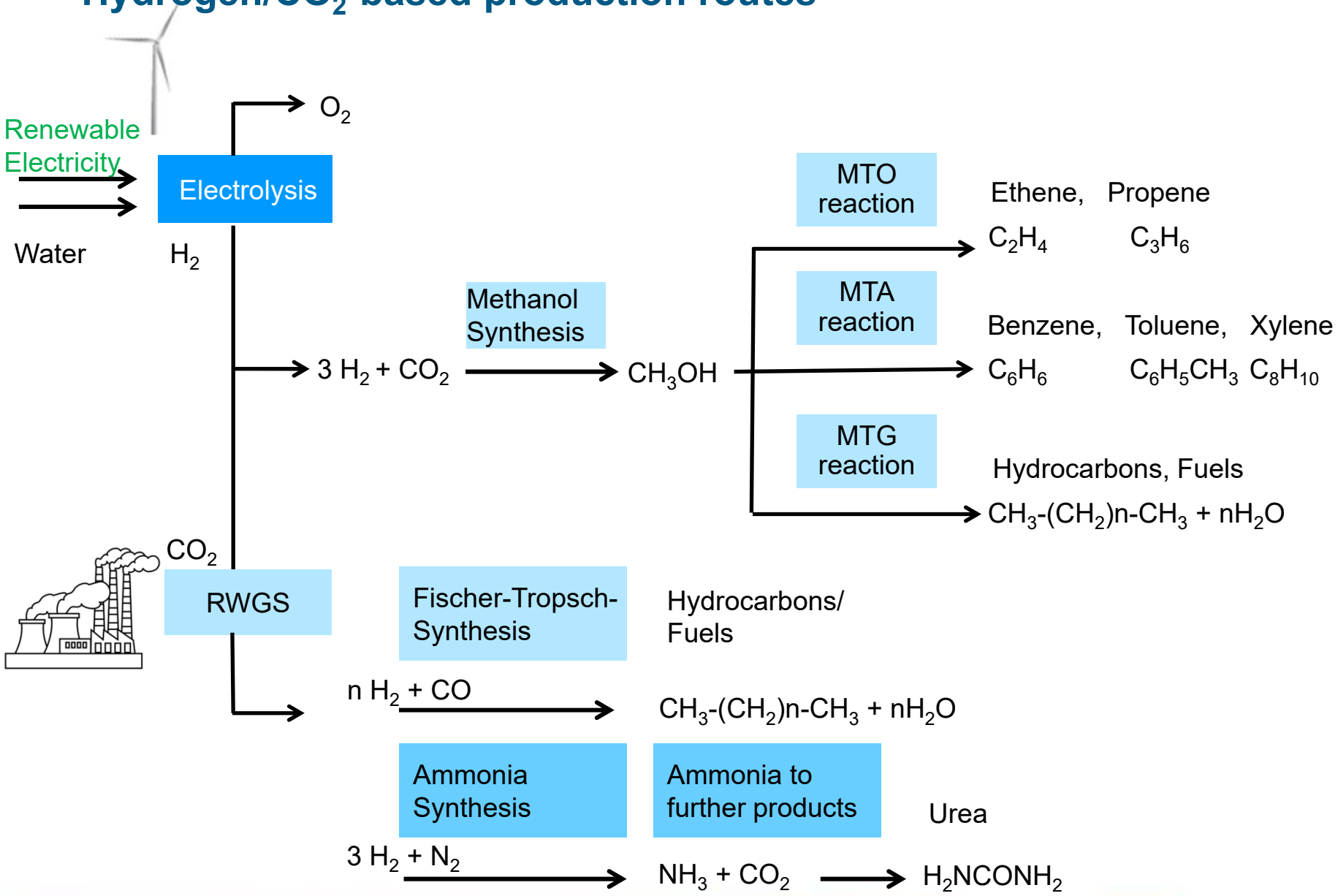


Water-Electrolysis:
$H_2O \rightarrow H_2 + 1/2O_2$

Methanation:
$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

Source: Energy 2.0 / Edition 6+7.2013

Hydrogen/CO_2-based production routes



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The Hydrogen-Initiave of the German Government – Flagship Projects / Platforms

Wasserstoff Leitprojekte
Grün. Groß. Global.

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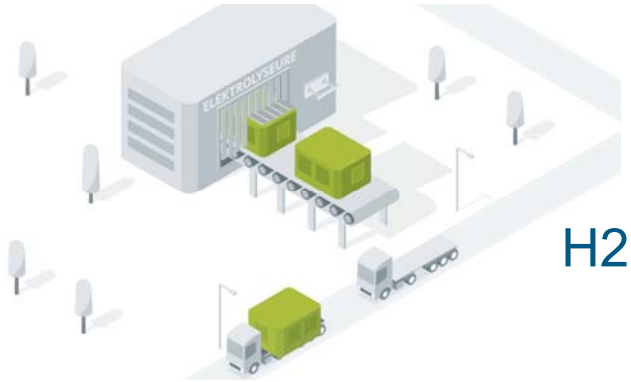

H2Giga: Ramp-up production

H2Mare: Offshore

TransHyDE: Transport solutions for green hydrogen

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Kopernikus-Project: P2X

Research, validation and implementation of "Power-to-X" concepts

Prof. W. Leitner
(RWTH Aachen und MPI für Chemische Energiekonversion Mülheim)

Prof. R.-A. Eichel
(FZ Jülich GmbH)

Prof. K. Wagemann
(DECHEMA e.V.)

GEFÖRDERT VOM

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KOPERNIKUS PROJEKTE
P2X
Die Zukunft unserer Energie

The Kopernikus-Projects

P2X
Power-to-X

Alternative use and storage of renewable energy

ENSURE
Use Cases

New network structures adapted to fluctuating energy supply

SynErgie
Demand Side Management

Adaption and flexibility of industrial processes to a new energy supply

Ariadne
Political Options

Acting as a guide for science and society through the energy transition

Partner-Projects

- **Rheticus**
- **WissKomm Energiewende**

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Die Zukunft unserer Energie

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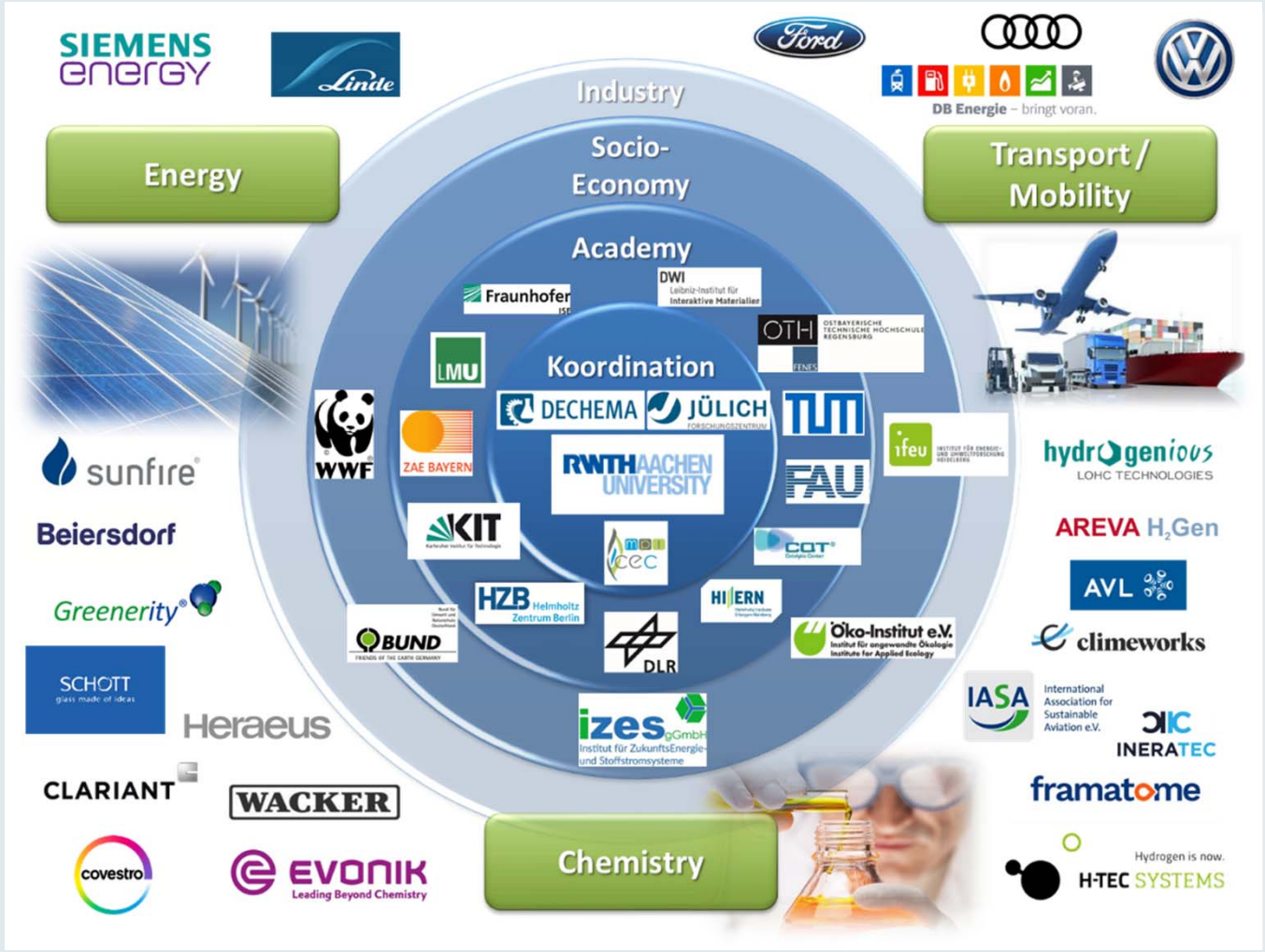
P2X - Phase II: Facts and figures



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Die Zukunft unserer Energie

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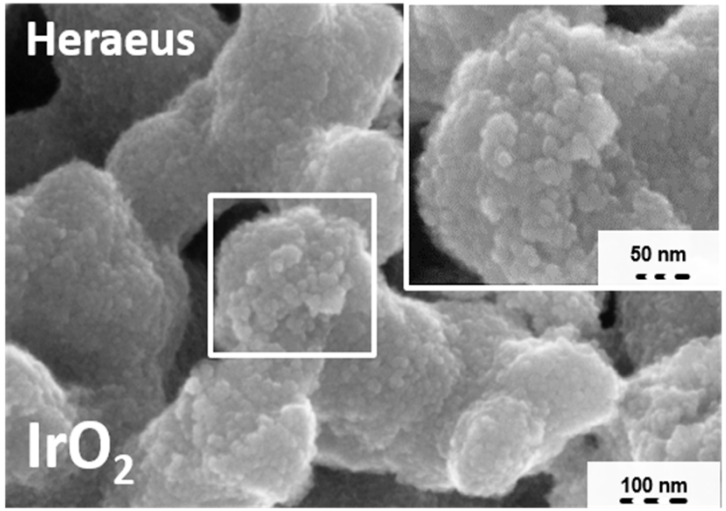
- **10 years (3, 3 and 4 years)**
- **43,3 Mio. € (Phase II, 30% industry)**
- **16 research institutes, 24 enterprises, 2 NGO‘s**

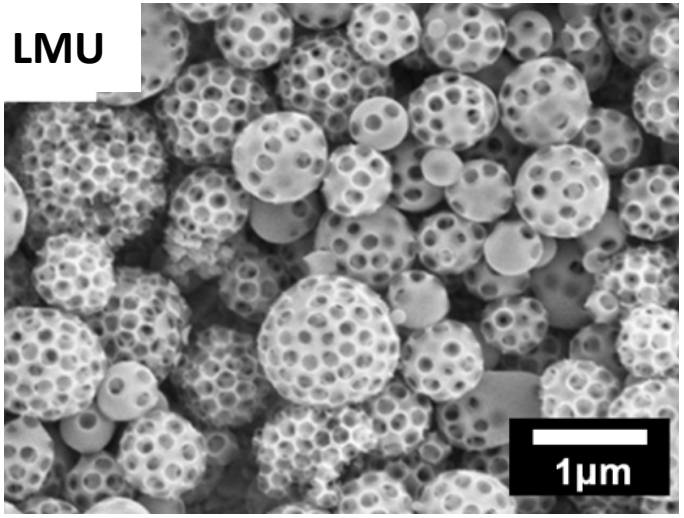
P2X: FC-A1 Water-Electrolysis

Development of highly structured catalysts



New nano-IrO_2 reference catalyst with large surface area

- Higher activity of the new nano-IrO_2 (≈ 160 m^2/g) P2X-reference-catalyst over the IrO_2-based benchmark catalyst



FC-A1 Gen 1 catalyst:
Sb:SnO_2 microstructures coated with IrO_2

- IrO_2 activity is sufficient, but requires highly structured catalyst with low packing density ($g_{Iridium}/cm^3_{electrode}$)

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FC-A2: Low-Temperature Co-Electrolysis: ***process integration***

- Optimization and further developement of gas diffusion electrode for CO_2 reduction
- High current densities up to 300 mA/cm² with high CO selectivity (FE_{CO} >80%)
- Operation at increased pressure without loss of performance
- Up-scaling (in combination with fermenter FC-B2) in smallest industrial scale in the scope of the associated project ***Rheticus***

First test operation of the 300 cm² electrolysis cell at Siemens AG

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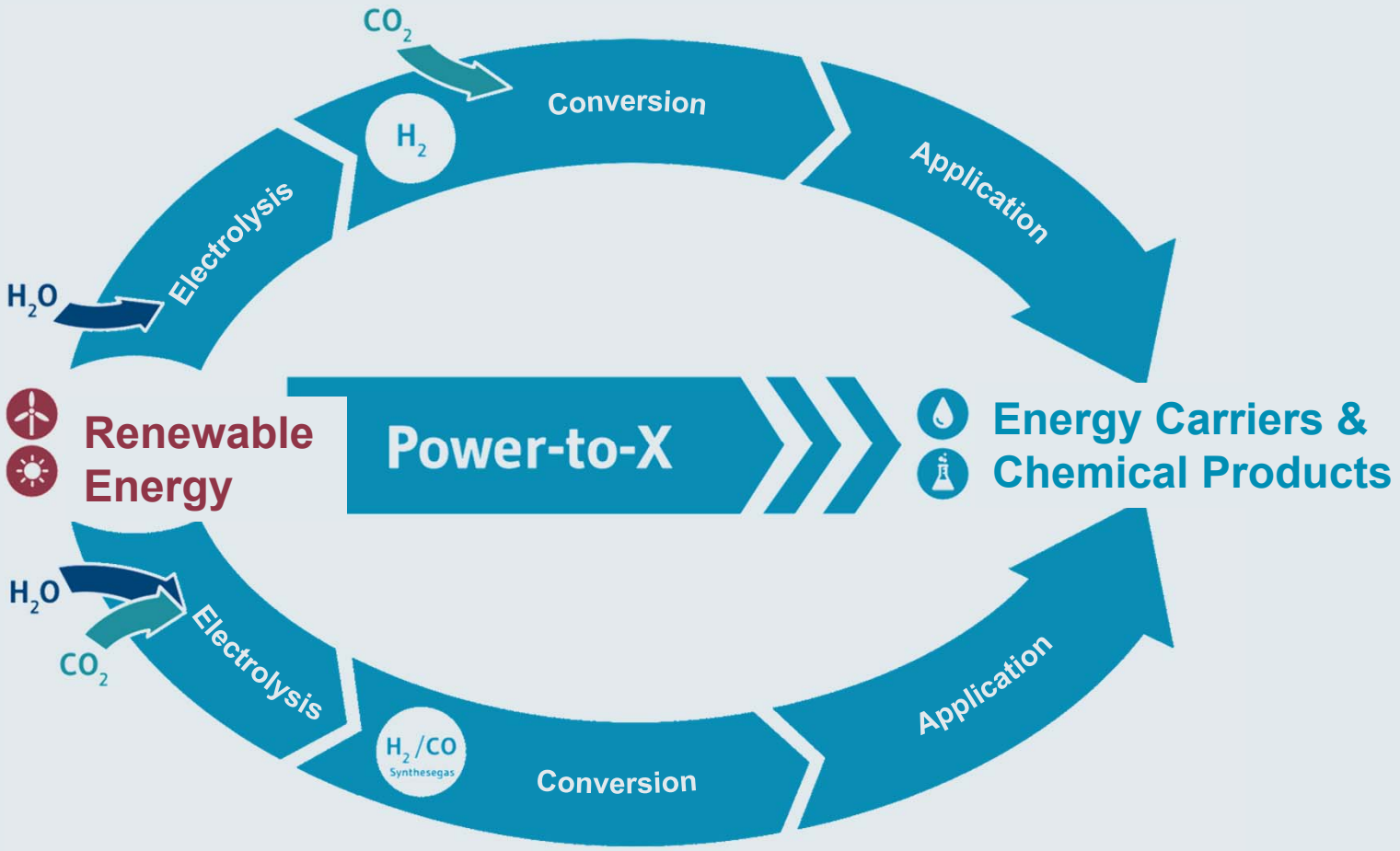
P2X - Phase II: Technology Pathways



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VALUE CHAIN HYDROGEN FOR SPECIFIC APPLICATIONS

ENERGY

Application as heating gas in the glass industry

www.bega.com

MOBILITY

Application as fuel at a H_2 filling station

www.h2.live

CHEMISTRY

Production of Polymethyleneether(PME)-Polymers

Photo source: Lecture Covestro, AP1.3a - Neuartige C1-Polyole für Polymeranwendungen
Lecture P. Wasserscheid AP1.2a,1.3b+c - H_2-Speicherung mittels LOHC-Technologien

KOPERNIKUS PROJEKTE P2X Die Zukunft unserer Energie

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VALUE CHAIN SYNTHESIS GAS FOR SPECIFIC APPLICATIONS

› Synthesis gas (CO and H_2) from the co-electrolysis of CO_2 and H_2O is converted into products for two sectors:

MOBILITY

Decentralized production of standardized CO_2-neutral fuels

Photo: Andreas Drollinger, KIT

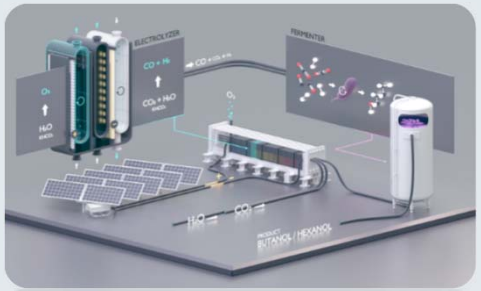
Fischer-Tropsch-Synthesis Hydrocracking Module (INERATEC / KIT)

Electrolysis SOEC Module (sunfire)

Direct Air Capture Module (Climeworks)

CHEMISTRY

Production of aliphatic alcohols



www.ohmymag.de

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Power-to-X: Which are the „Bottlenecks“?

- Availability of renewable energies
  (including social acceptance of wind parks)
- Efficient (direct) chemical conversion processes
- Large scale electrolysers
- High demand for precious and rare earth metals
  (wind turbines, PV, electrolysers)
  Low carbon technologies = high metal dependency*

* Source: James Clark, Department of Green Chemistry, Centre of Excellence - University of York/UK