



2025+

The Fuel Science Center

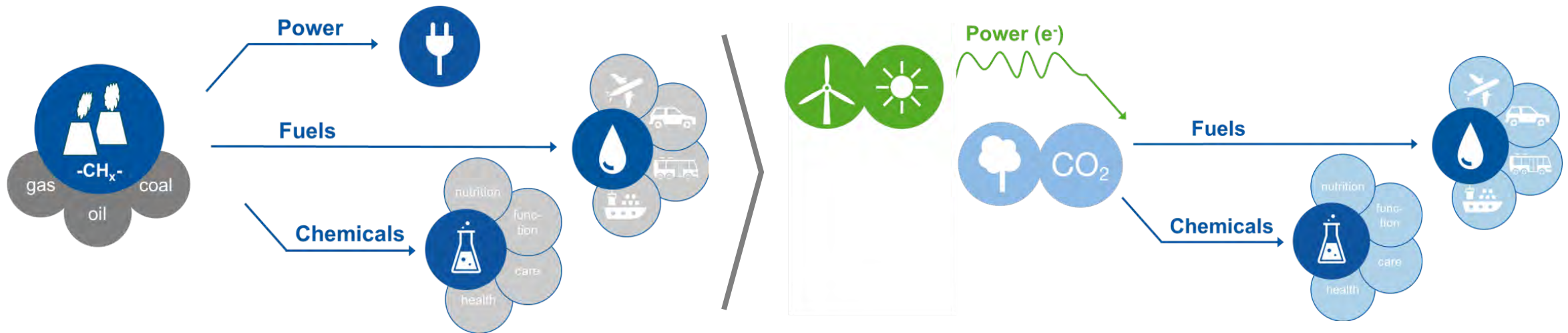
Adaptive Conversion Systems for Energy Carriers and Chemicals from Renewable Resources

CoE Review Workshop | Follow-Up Proposal 2025+

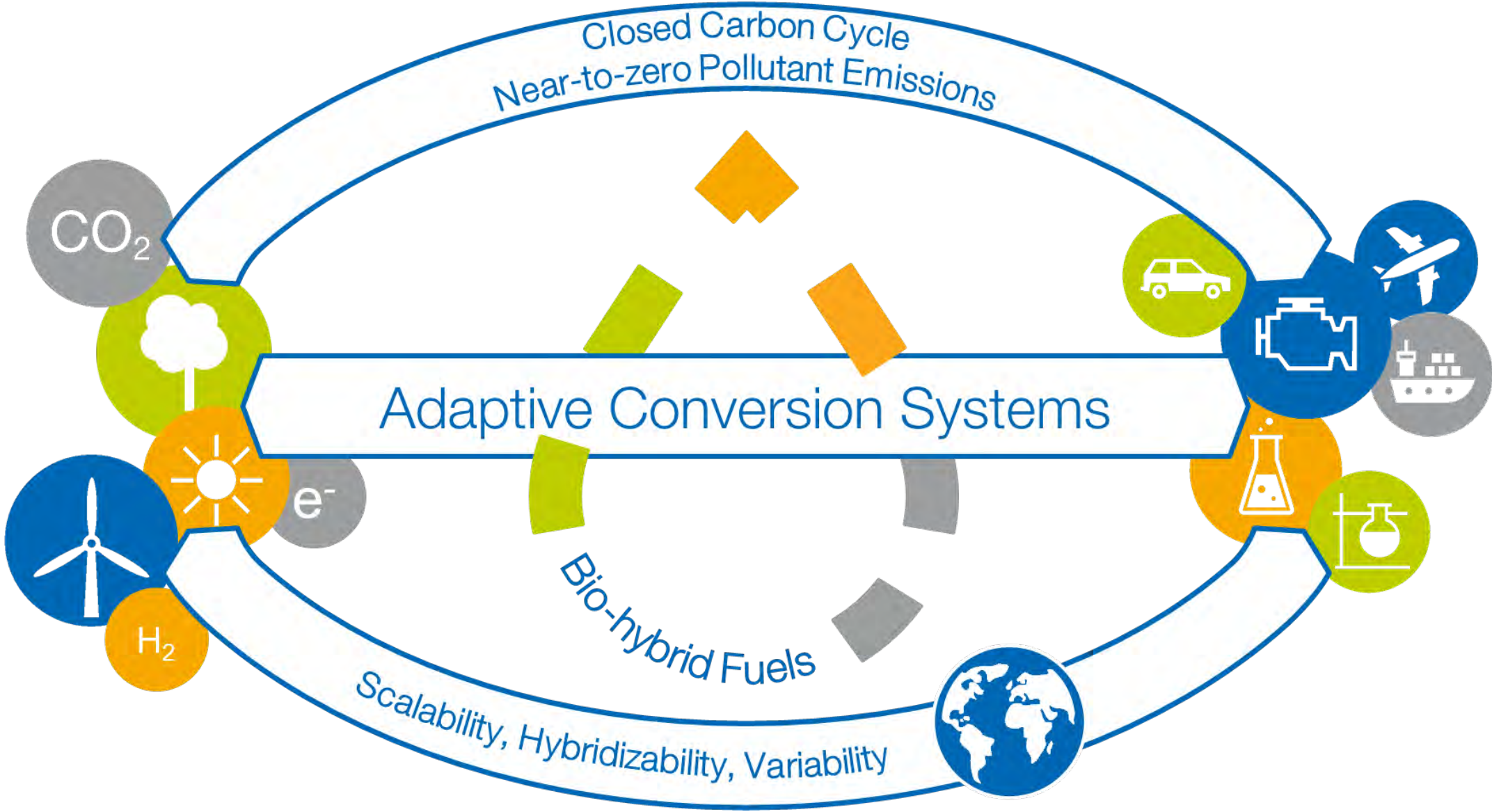
Aachen, 07.11.2022



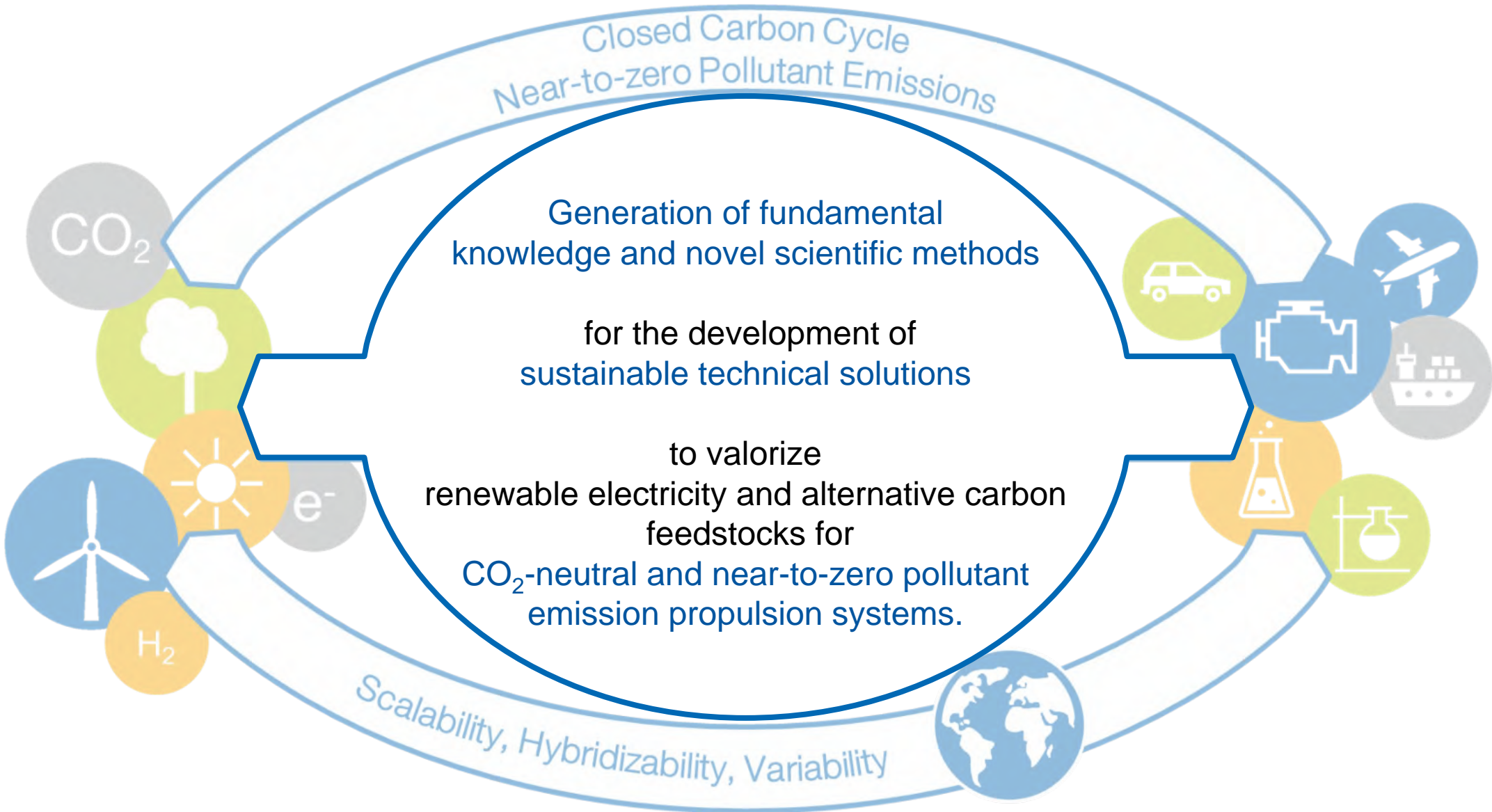
Motivation



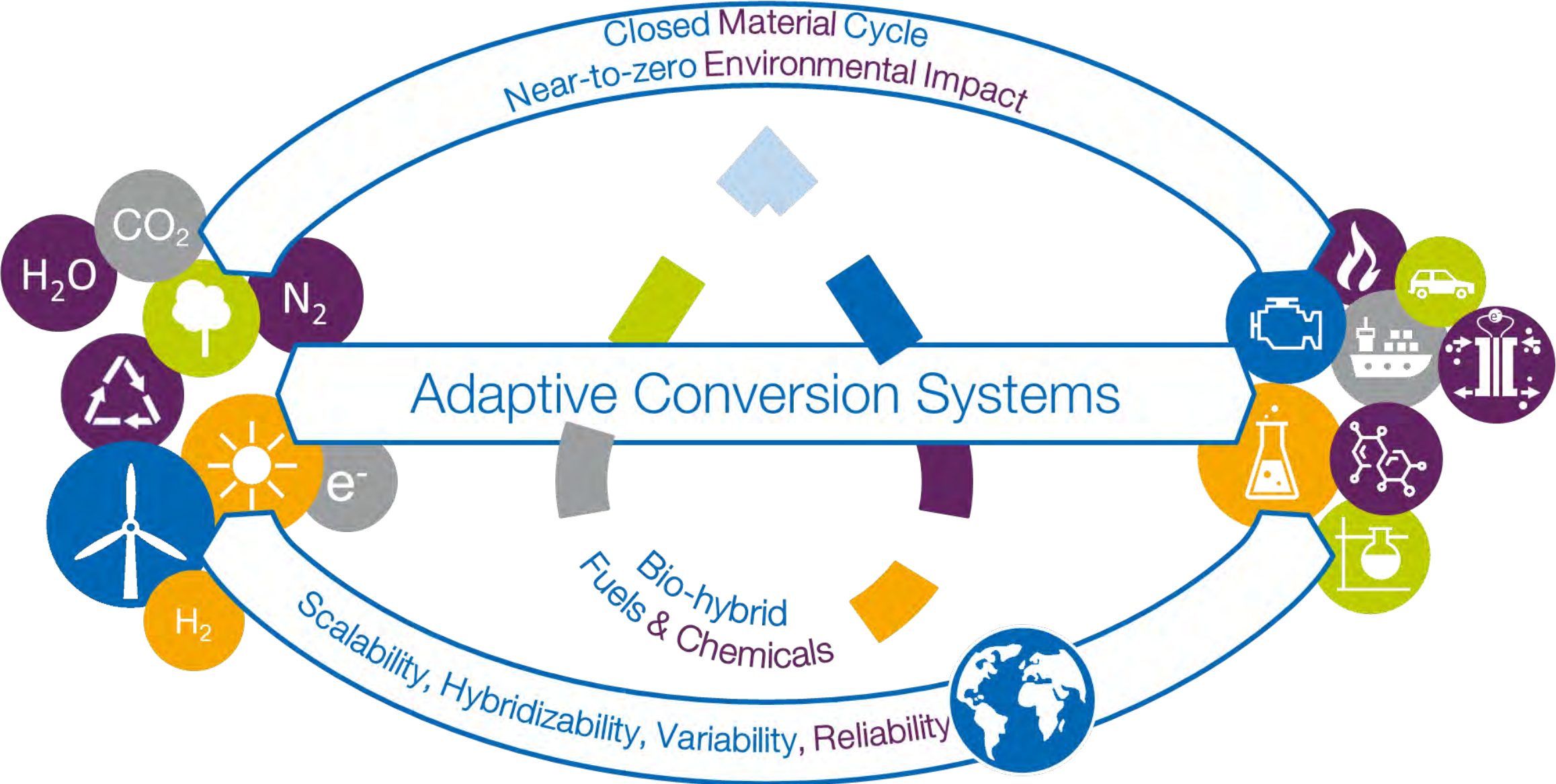
Vision - Today



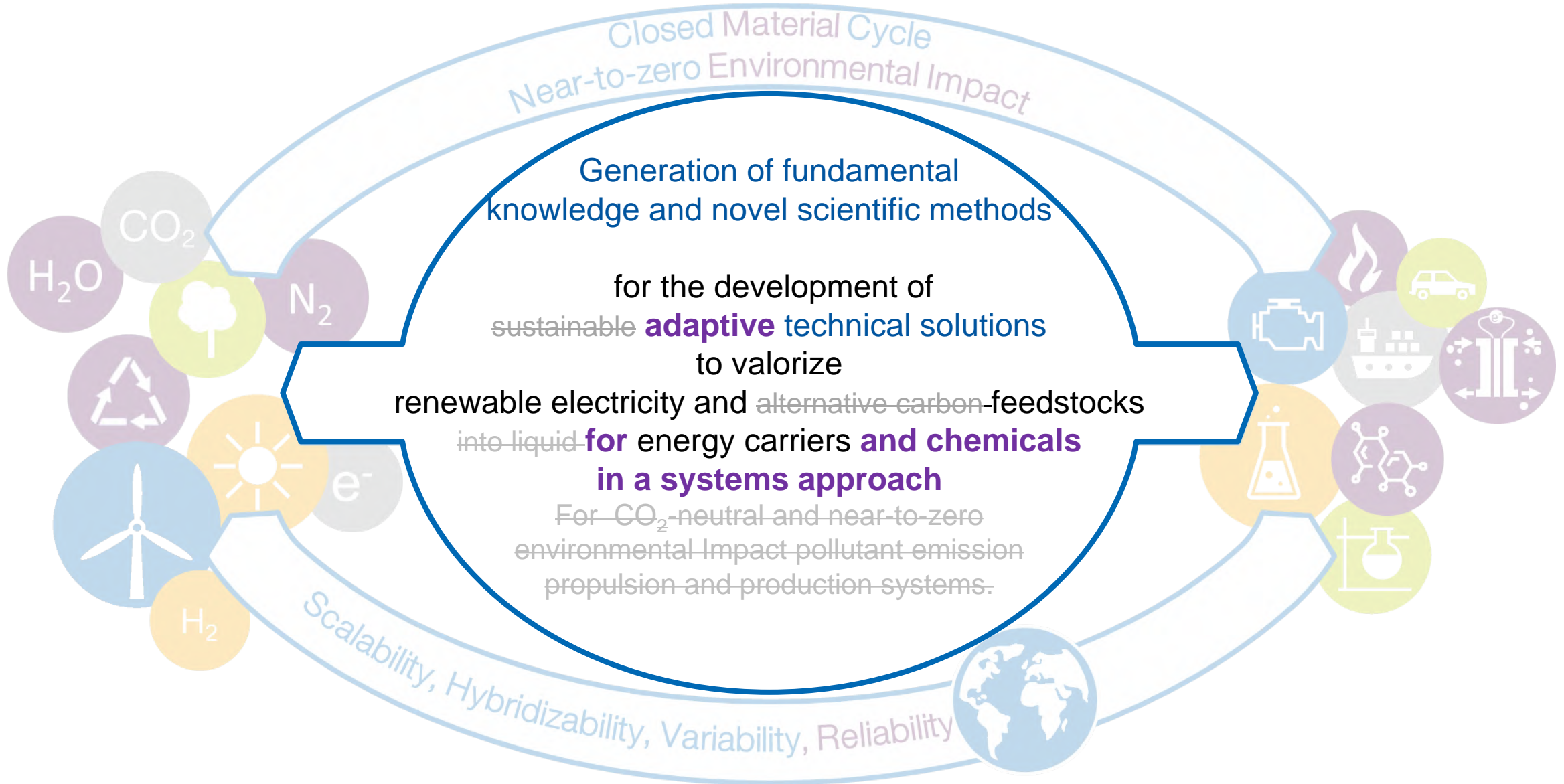
Vision - Today



Vision - 2025+



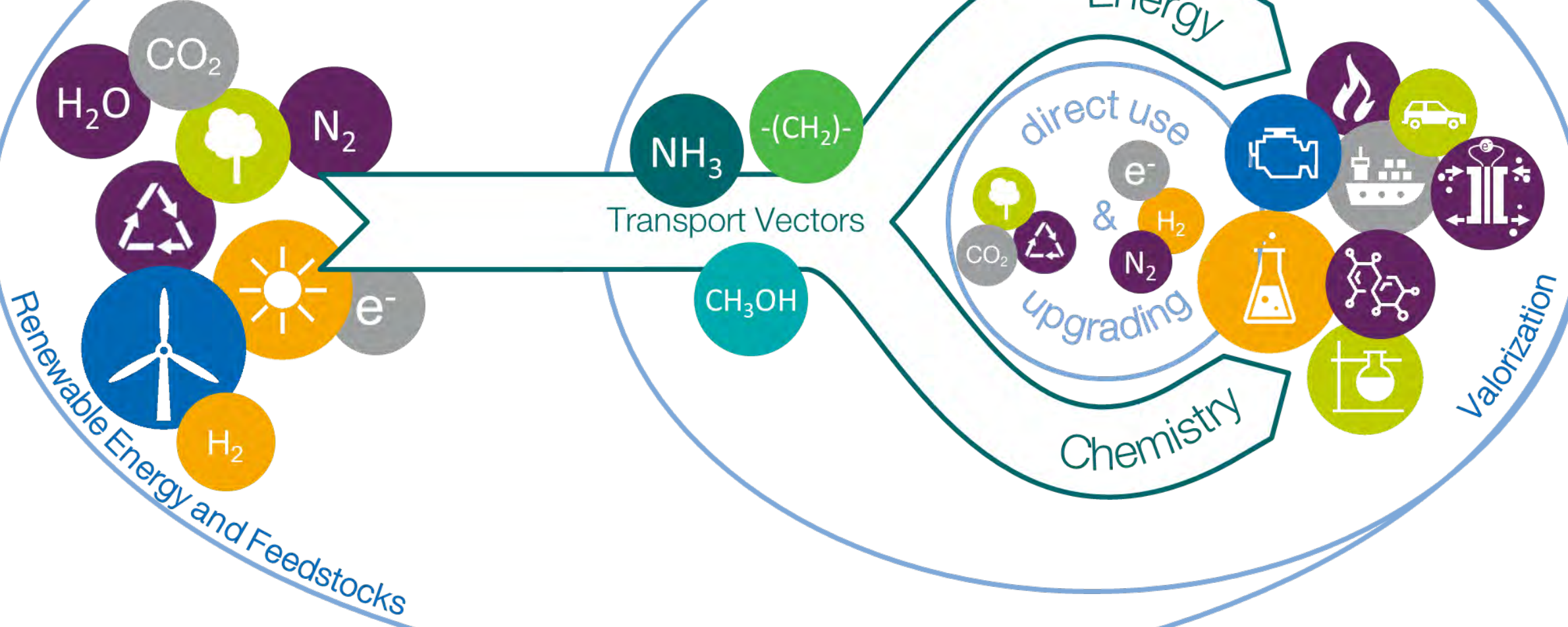
Vision - 2025+



Mission - 2025+

FSC Systems

FSC Technologies

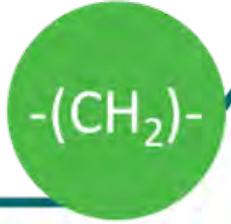


FSC Systems

FSC Technologies

Key Topics

Resilient & Adaptive Conversion Systems



Transport Vectors

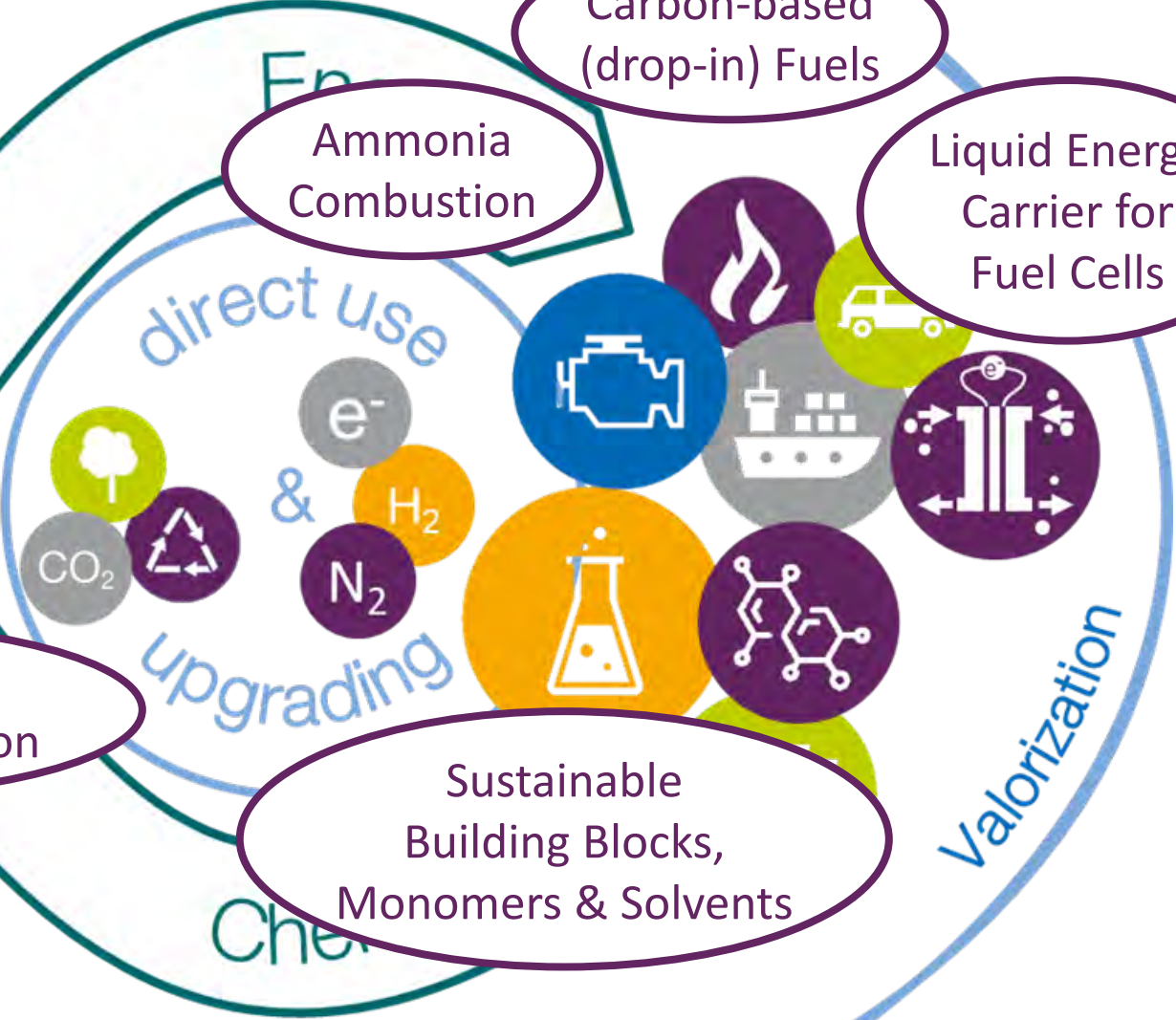


Integrated CO_2 Capture & Conversion

Ammonia Combustion

Carbon-based (drop-in) Fuels

Liquid Energy Carrier for Fuel Cells



direct use

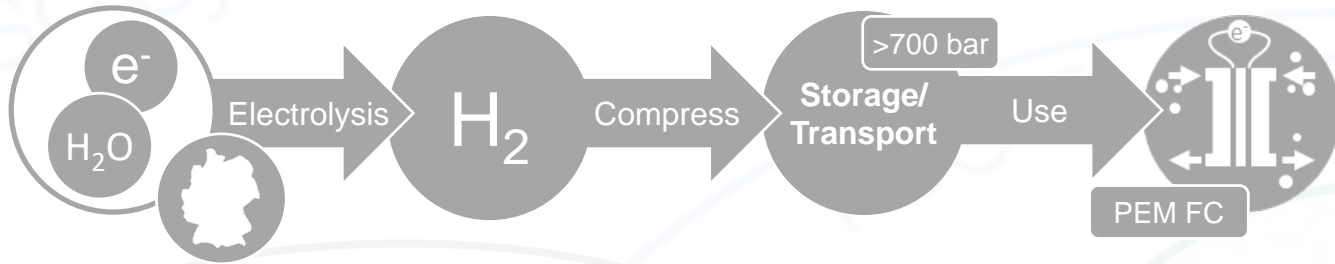
e^- & H_2

upgrading

Valorization

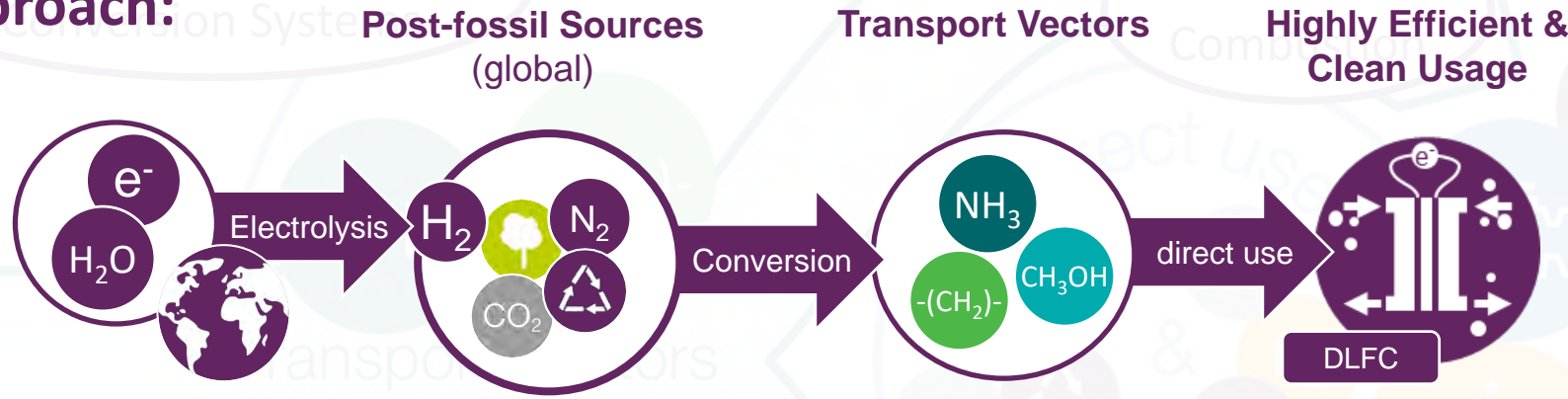
Sustainable Building Blocks, Monomers & Solvents

Direct Use in H₂ Fuel Cell – Traditional Approach



New Key Topic

FSC Approach:



Integrated CO₂ Capture & Conversion

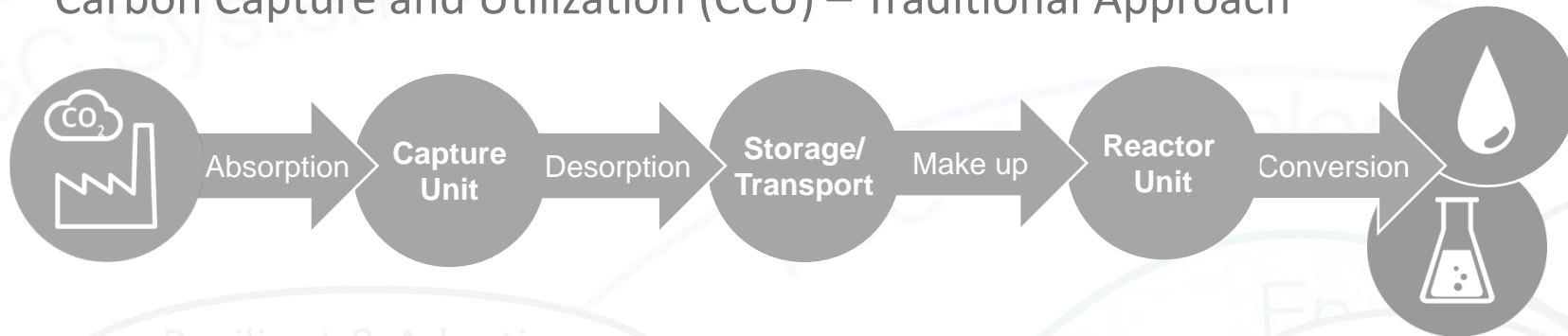
Sustainable Building Blocks, Monomers & Solvents

Carbon-based (drop-in) Fuels

Liquid Energy Carrier for Fuel Cells



Carbon Capture and Utilization (CCU) – Traditional Approach



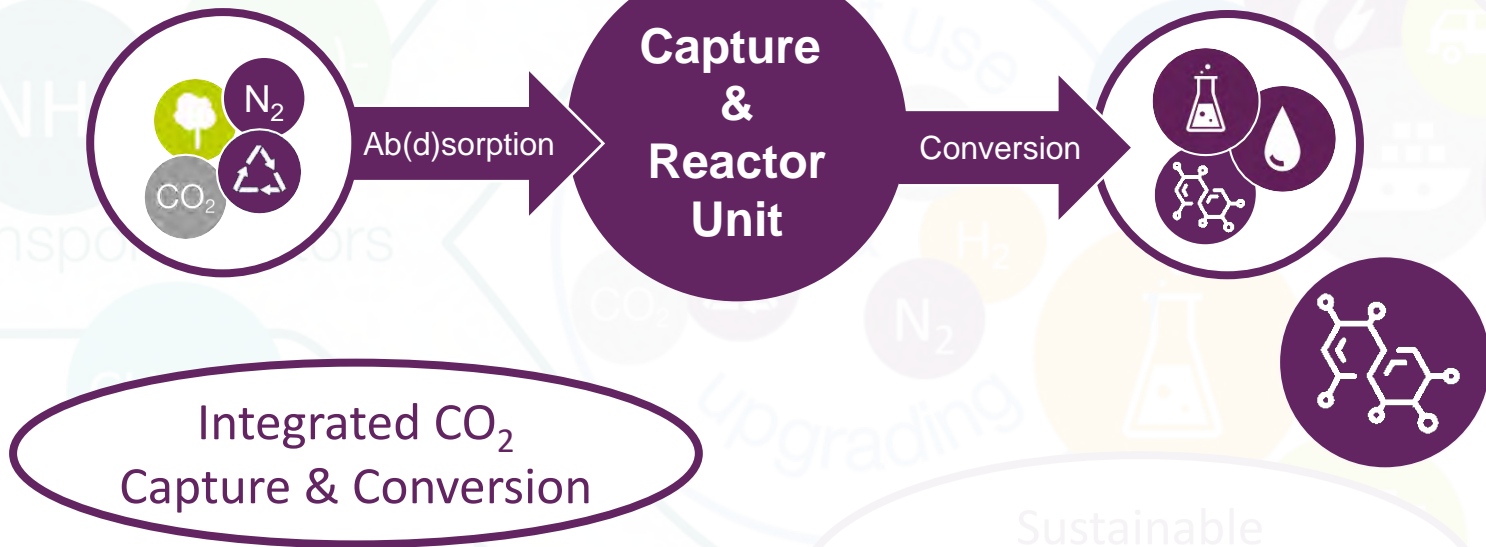
New Key Topic

FSC Approach:

Post-fossil Sources
(biogenic, air)

Integrated Process
(multifunctional, multi-dimensional, dynamic)

Improved Products
(function, emission, recyclability, etc)



Integrated CO₂ Capture & Conversion

Carbon-based (drop-in) Fuels

Liquid Energy Carrier for Fuel Cells

Sustainable Building Blocks, Monomers & Solvents

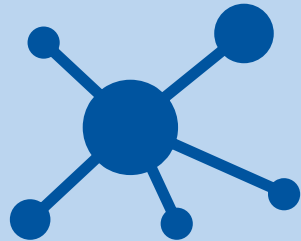
Valorization



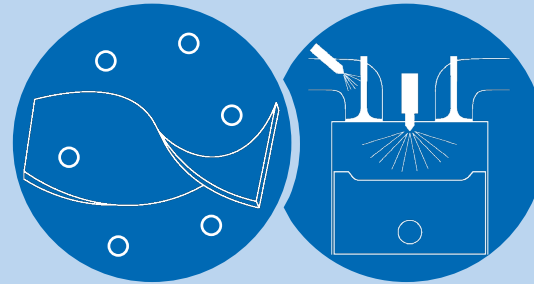
Structure of the Research Program: Key Topics Extend Across all Competence Areas

Competence Areas

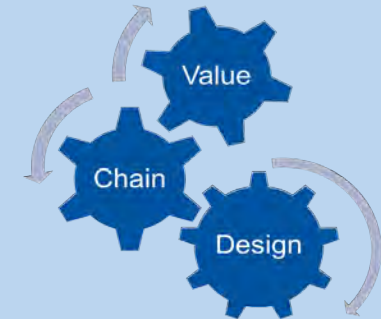
CA1:
Molecular Transformations
and Interactions



CA2:
Interfacial Phenomena
and Devices



CA3:
Fuel Design and Sustainable
Cross-sectorial Value Chains



Integrated CO₂ Capture & Conversion

Interdisciplinary
Key Topics

- 🔹 synthetic targets
- 🔹 catalyst & materials
- 🔹 multifunctional systems
- 🔹 dynamics / mechanisms

- 🔹 phase equilibria
- 🔹 mass transfer and kinetics
- 🔹 model-based reactor design
- 🔹 dynamic reactor modeling

- 🔹 conceptual process design
- 🔹 value chains
- 🔹 LCA & TEA
- 🔹 decentralized production

Systems Design Forum

Molecule

Device

System

High Indicated Efficiency with Low NOx and no Soot by Molecular Spark

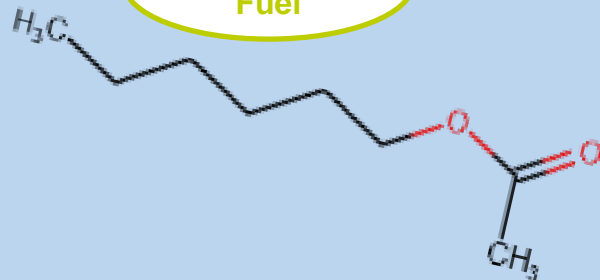
Variation of High Reactivity Fuel Composition

Competence Areas

CA1: Molecular Transformations and Interactions

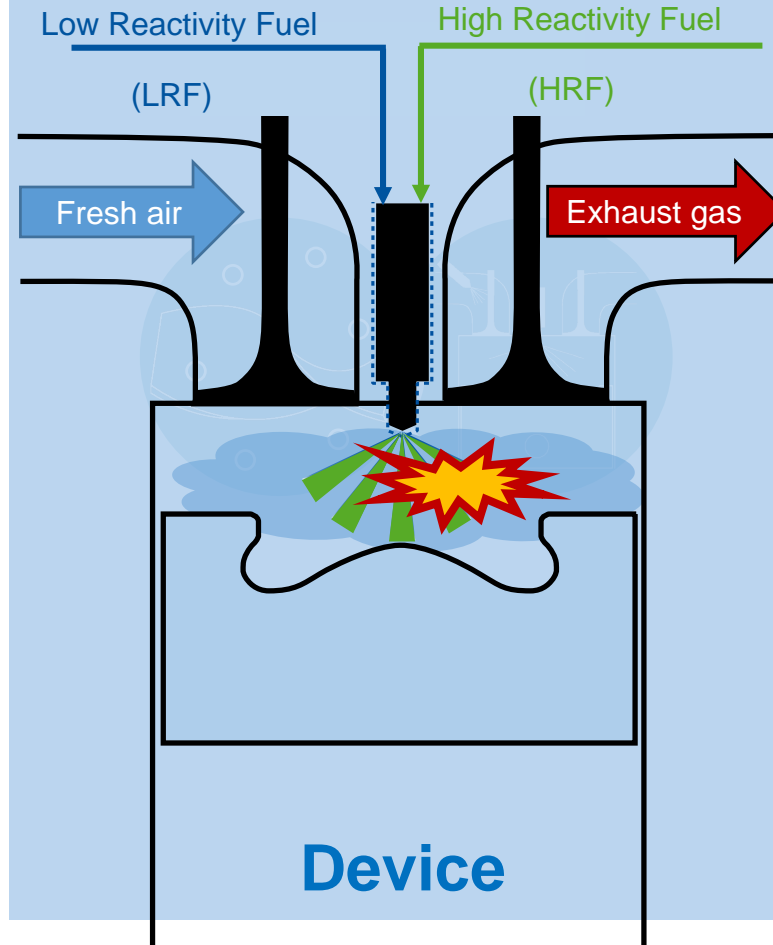
LRF	HRF	DCN
—■—	1-Octanol	34.8
—▲—	1-Octanol	30.5
—◆—	10 vol.-% Ethanol 90 vol.-% 1-Octanol	30.5
—▼—	30 vol.-% Ethanol 70 vol.-% 1-Octanol	17.5
—●—	Hexyl acetate	28

Bio-hybrid Fuel



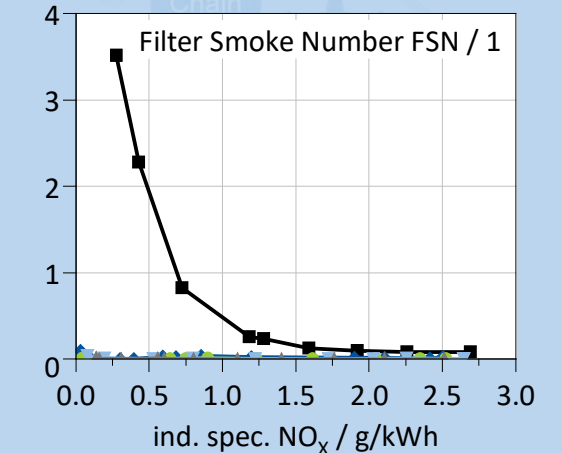
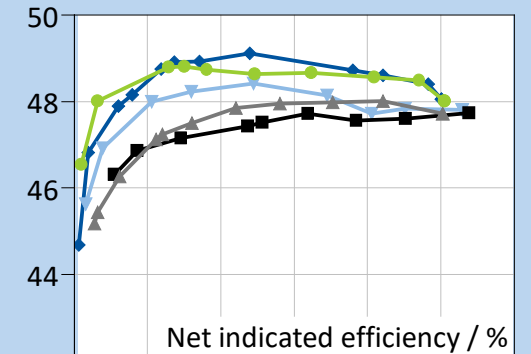
Molecule

CA2: Interfacial Phenomena and Devices



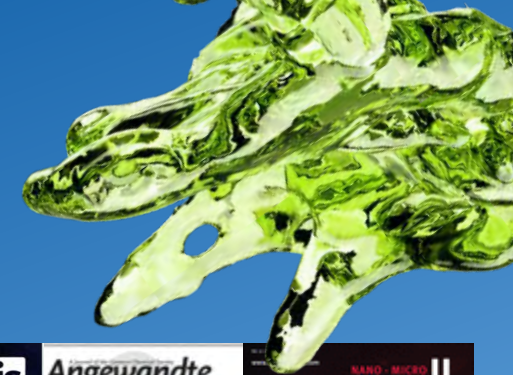
Device

CA3: Fuel Design and Sustainable Cross-sectorial Value Chains



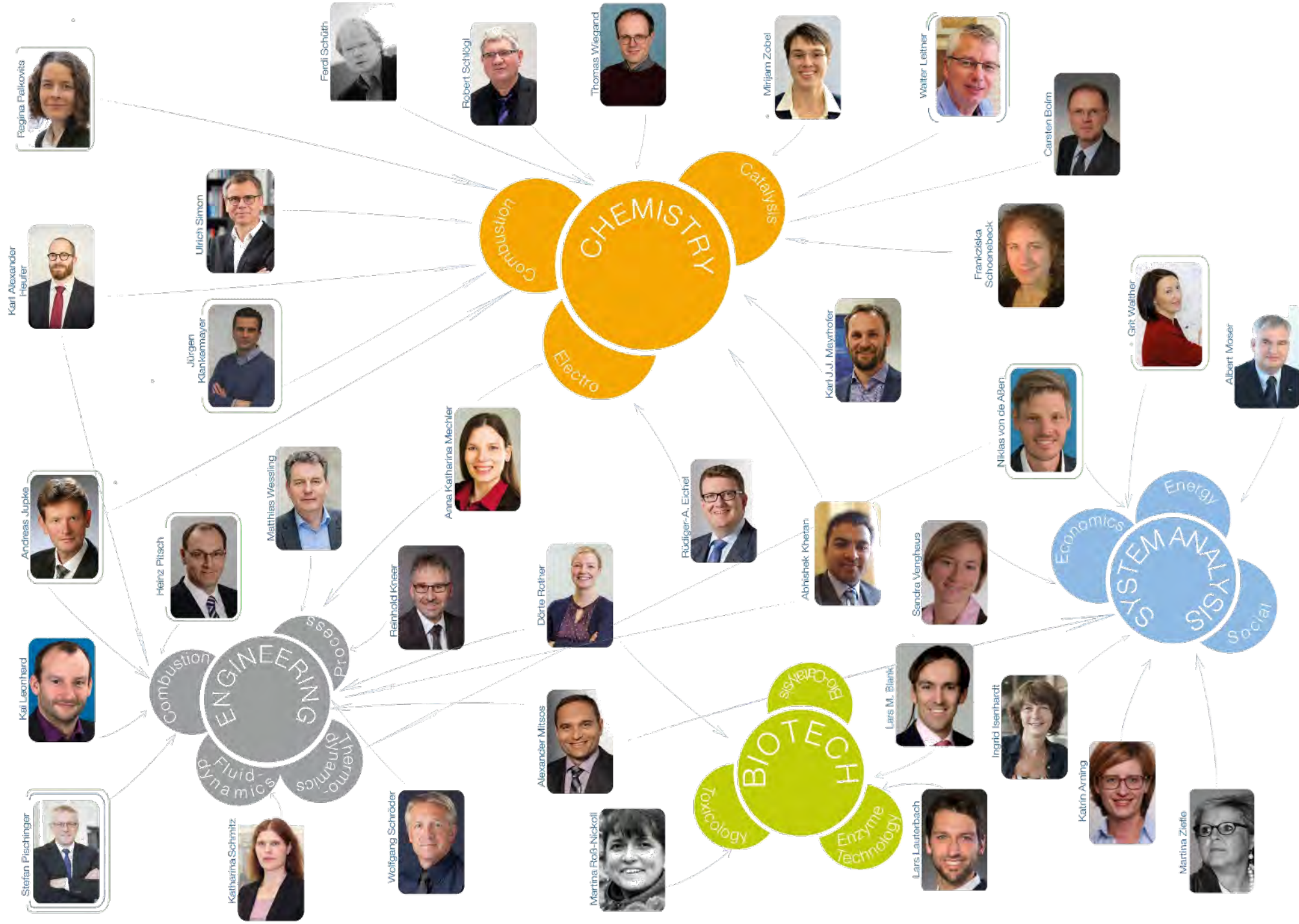
System

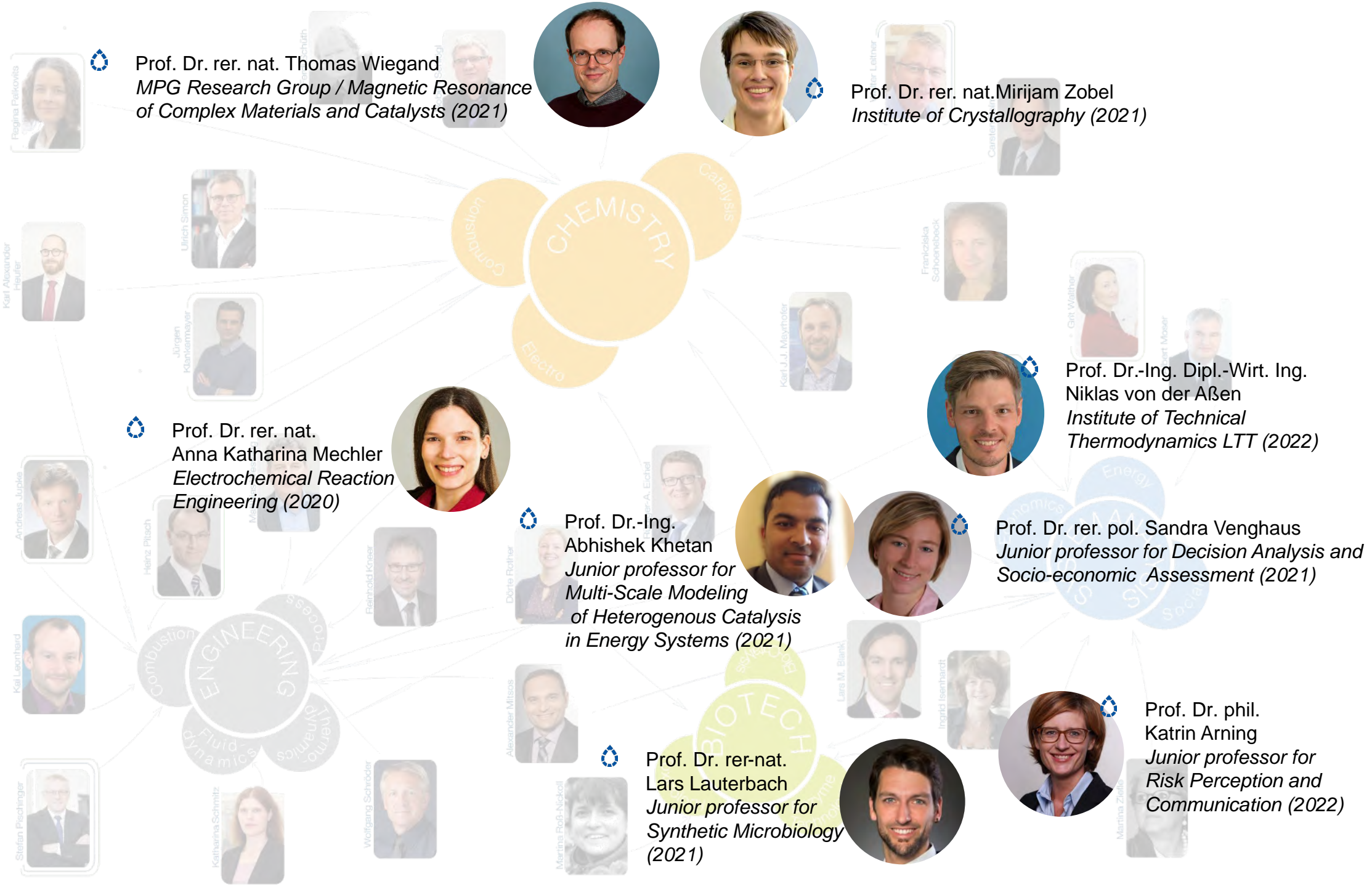
Shaping the Field of „Fuel Science“



The collage features the following elements:

- Journals:** *Chemie*, *JACS*, *microbial biotechnology*, *Science of the Total Environment*, *ACS Catalysis*, *Angewandte Chemie*, *small*, *AEM*, *ENERGY POLICY*, *CATALYSIS TODAY*, *CATALYSIS B: ENVIRONMENTAL*, *CHEMSUSCHEM*, *ACCOUNTS OF CHEMICAL RESEARCH*, *energy&fuels*, *ChemCatChem*, *JACS*, *FUEL*, *CHEMISTRY A European Journal*, *alton ransactions*, *Combustion and Flame*, *ENERGY AND CLIMATE CHANGE*, *Ammonia Formation Rate*, *THE JOURNAL OF PHYSICAL CHEMISTRY*, *Science*, and *METABOLIC ENGINEERING*.
- Diagrams:**
 - Procedurally-generated wood particle models:** Shows a 0.5 mm wood particle and reaction-diffusion simulations to extract intrinsic kinetics.
 - Determination of regimes for kinetic vs. mass transfer control:** A plot of Effectiveness Factor vs. Intraparticle Thiele Modulus showing kinetically-limited, intermediate, and diffusion-limited regimes.
 - Biomass Conversion Cycle:** A circular diagram showing the conversion of Lignocellulose to Lignin and Cellulose via Aqueous H₃PO₄ / 2-MTHF Pretreatment, followed by H₃PO₄ Swelling, H₃PO₄ Cycle, and Pentoses, leading to Furfural.
 - Electrochemical Cell:** A diagram of an electrochemical cell with an Anode and Cathode. At the anode, H₂O is oxidized to H⁺ and O₂. At the cathode, H⁺ is reduced to H₂. The cell is used for the conversion of HMF to FDCA.
 - AFM Image:** An Atomic Force Microscopy (AFM) image of a Ni-Mo catalyst on a Ti-Cu substrate.
 - Chemical Reaction:** A reaction scheme showing the conversion of a biomass-derived molecule to a furfural derivative.
- Charts and Graphs:**
 - Ammonia Formation Rate:** A bar chart comparing the ammonia formation rate of Ti₃C₂-MNSs and Ti₃C₂-MNRs. The rate for Ti₃C₂-MNRs is significantly higher (approx. 6.5 μg h⁻¹ mg⁻¹) compared to Ti₃C₂-MNSs (approx. 1.0 μg h⁻¹ mg⁻¹).
 - Equilibrium Graph:** A graph showing the equilibrium between CO₂ and MeOH.
 - Energy and Climate Change:** A graphic showing the relationship between energy and climate change.
- Other Elements:**
 - Products:** A diagram showing the conversion of biomass to products like pCA and FA.
 - Waste-water treatment:** A diagram showing the separation of products from waste-water.
 - Metabolic Engineering:** A diagram showing the metabolic engineering of a microorganism.





Prof. Dr. rer. nat. Thomas Wiegand
 MPG Research Group / Magnetic Resonance
 of Complex Materials and Catalysts (2021)

Prof. Dr. rer. nat. Mirijam Zobel
 Institute of Crystallography (2021)

Prof. Dr. rer. nat.
 Anna Katharina Mechler
 Electrochemical Reaction
 Engineering (2020)

Prof. Dr.-Ing.
 Abhishek Khetan
 Junior professor for
 Multi-Scale Modeling
 of Heterogenous Catalysis
 in Energy Systems (2021)

Prof. Dr. rer. pol. Sandra Venghaus
 Junior professor for Decision Analysis and
 Socio-economic Assessment (2021)

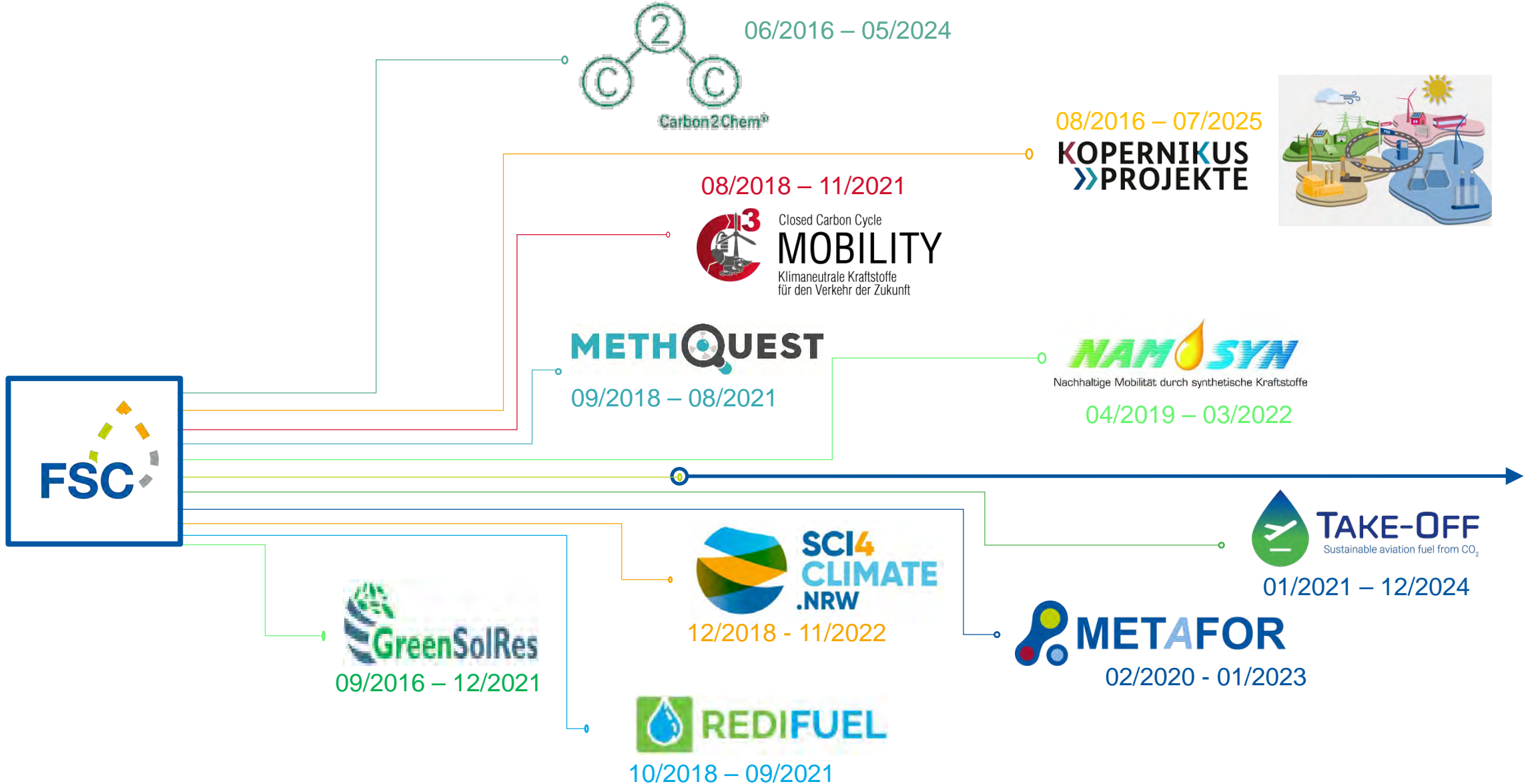
Prof. Dr. rer-nat.
 Lars Lauterbach
 Junior professor for
 Synthetic Microbiology
 (2021)

Prof. Dr. phil.
 Katrin Arning
 Junior professor for
 Risk Perception and
 Communication (2022)

Prof. Dr.-Ing. Dipl.-Wirt. Ing.
 Niklas von der Aßen
 Institute of Technical
 Thermodynamics LTT (2022)

From Fundamental Research to Application

Contributions of FSC PIs and Concepts in Translational Projects



FSC PIs, Co-Workers & Guests of our 10th International Conference on Fuel Science in Aachen

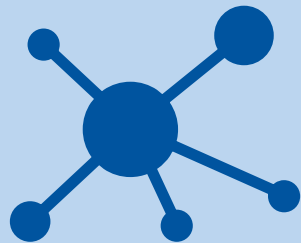




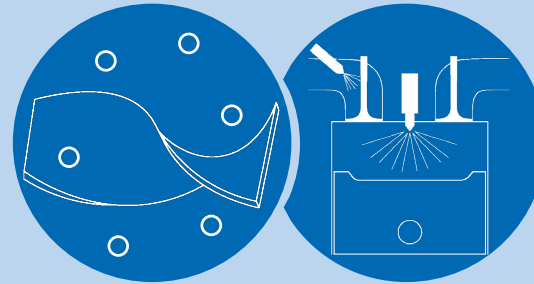
Structure of the Research Program: Key Topics Extend Across all Competence Areas

Competence Areas

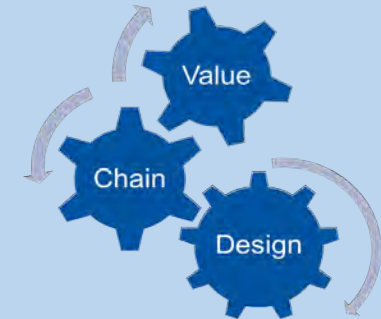
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Molecule

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System

Evolution of FSC 2.0: an Adaptive Scientific Platform



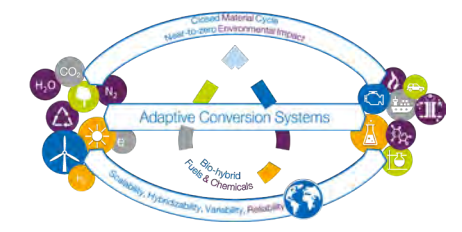
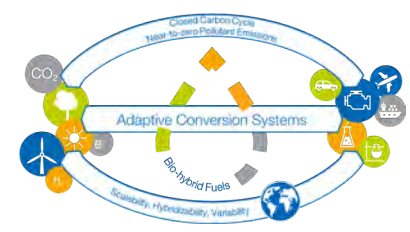
Global Challenges
(„pressure to act“)

„Food vs Fuel“

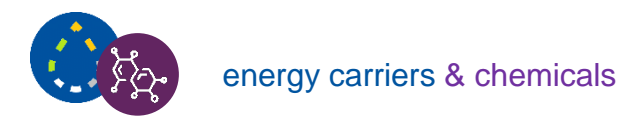
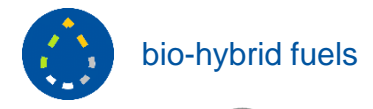
diversification of the energy and feedstock supply

building a resilient energy and chemistry nexus based on renewable energy

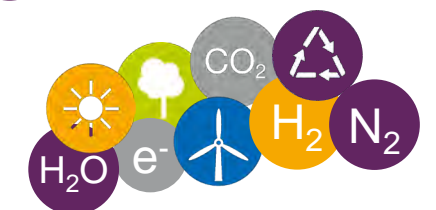
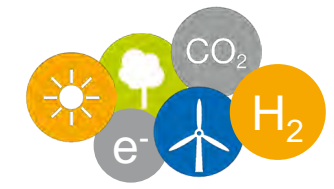
Vision & Mission



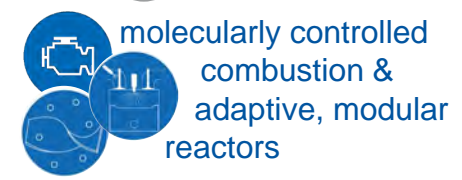
Target Molecules



Feedstocks



Devices



System

