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From CO_2 to Sustainable Energy Carriers - Challenges and Progress

Univ. Prof. Dr. Christoph Rameshan

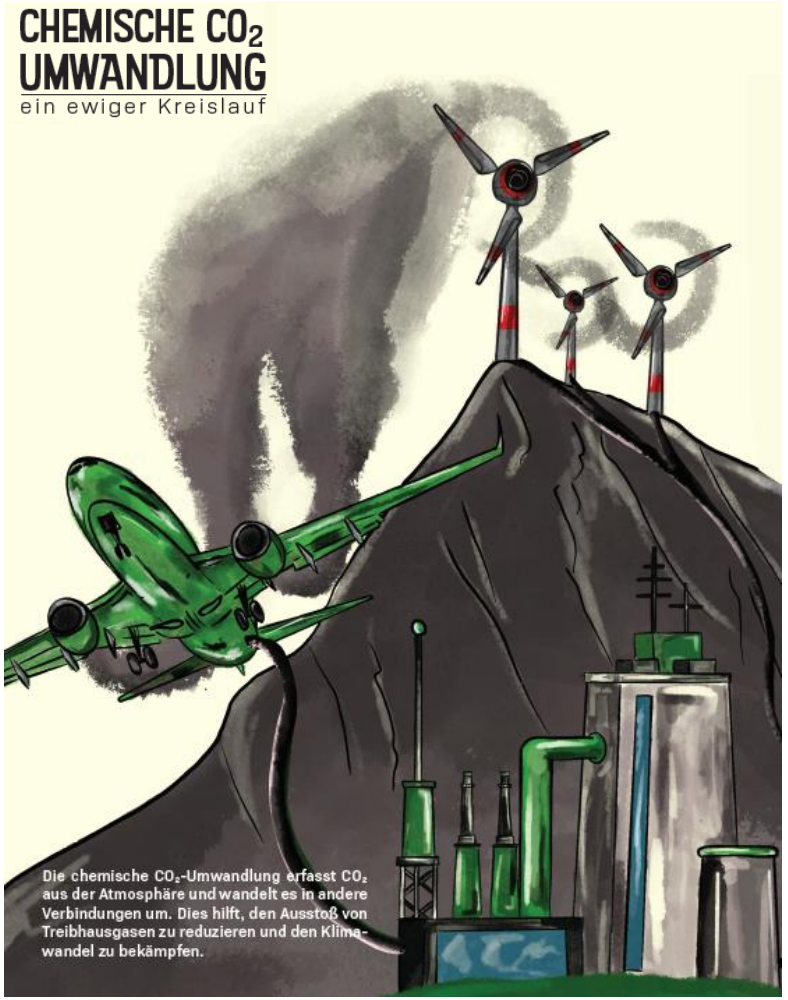
Chair of Physical Chemistry

THRIFTED CO_2

Eco-Mobility 2024, Vienna

Outline

- **Introduction**
  - Thermodynamic Background
  - CO_2 Activation
  - Energy Requirements
- **Example for CO_2 Utilization**
  - Perovskite as Ideal Catalysts
  - Reverse Water Gas Shift
- **Future Development**
  - Catalyst Scale-Up



© Sparkling Science Projekt: CO2 Umwandlung; https://co2-umwandlung.at/

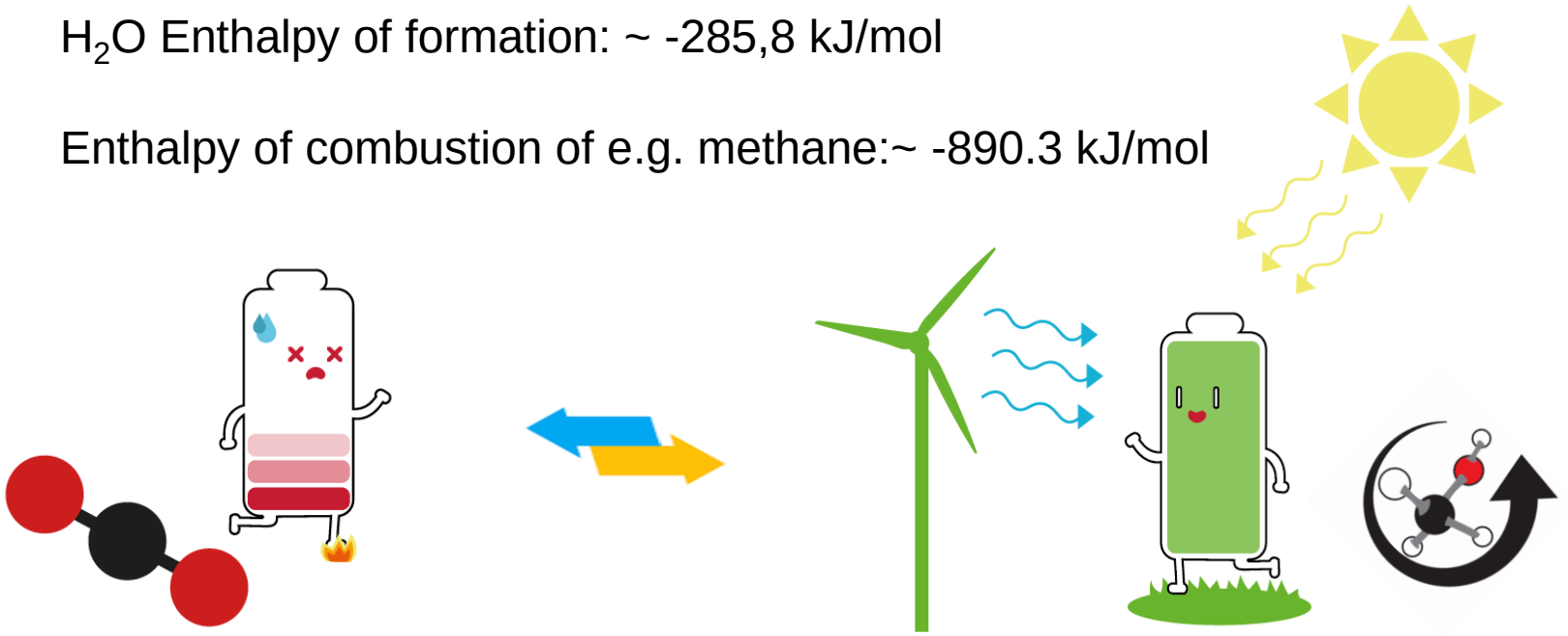
Challenge of CO_2 Activation

Thermodynamics:

CO_2 Enthalpy of formation: ~ -393,5 kJ/mol

H_2O Enthalpy of formation: ~ -285,8 kJ/mol

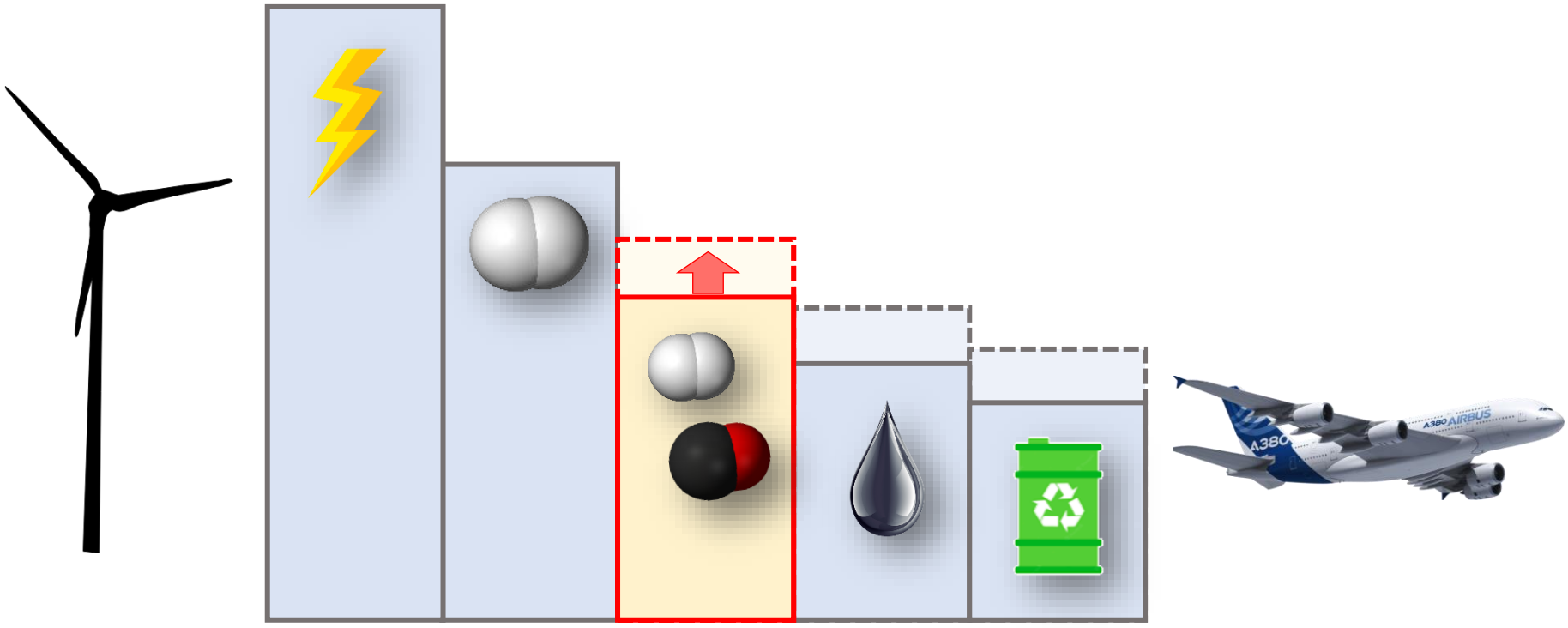
Enthalpy of combustion of e.g. methane:~ -890.3 kJ/mol



CO_2 is a chemical waste with almost no energy

CO_2 conversion with renewable energy and hydrogen

Chemical Energy Conversion



Valorisation of CO_2 is an energy intensive tasks. It is crucial to maximize the efficiency of every process step:

→ Hydrogen → CO_2 Conversion → FT Synthesis → Refinery

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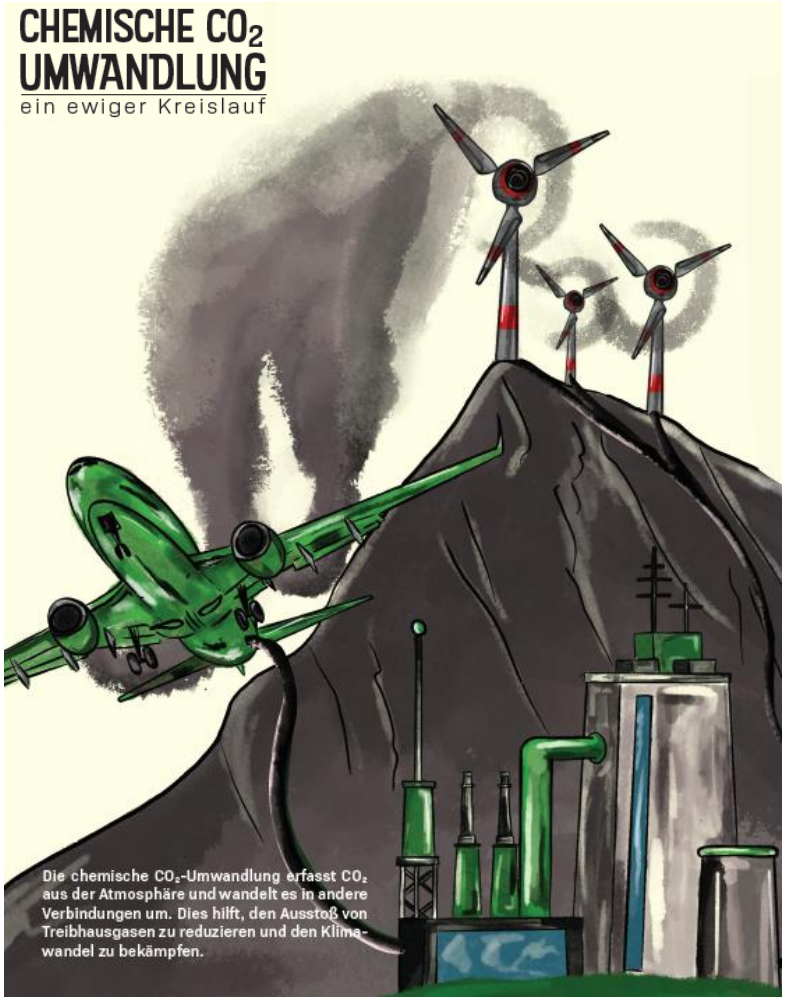
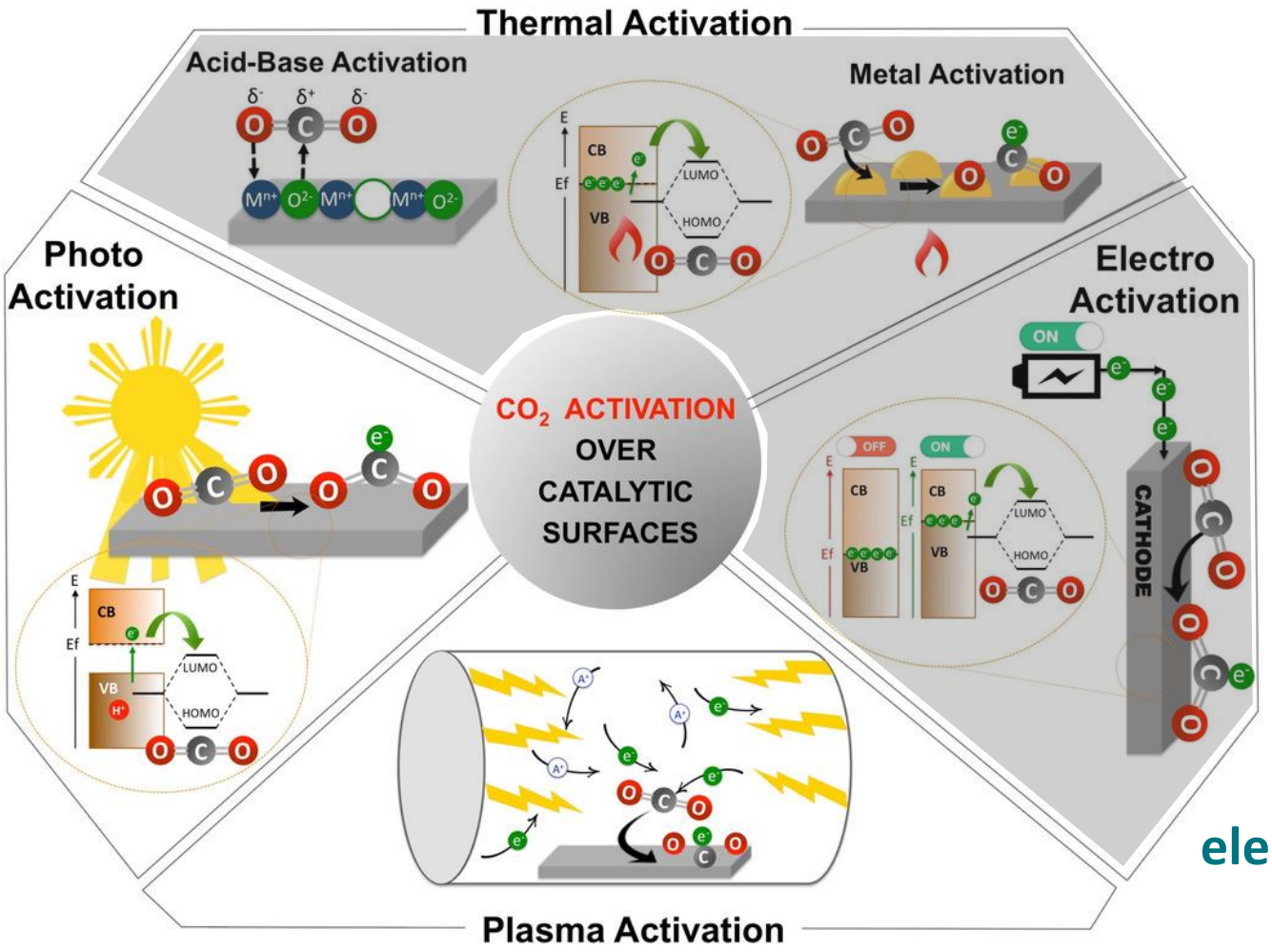


CO_2 Activation

Activation required: bending, inducing partial charges or electron transfer

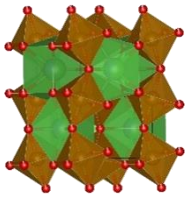


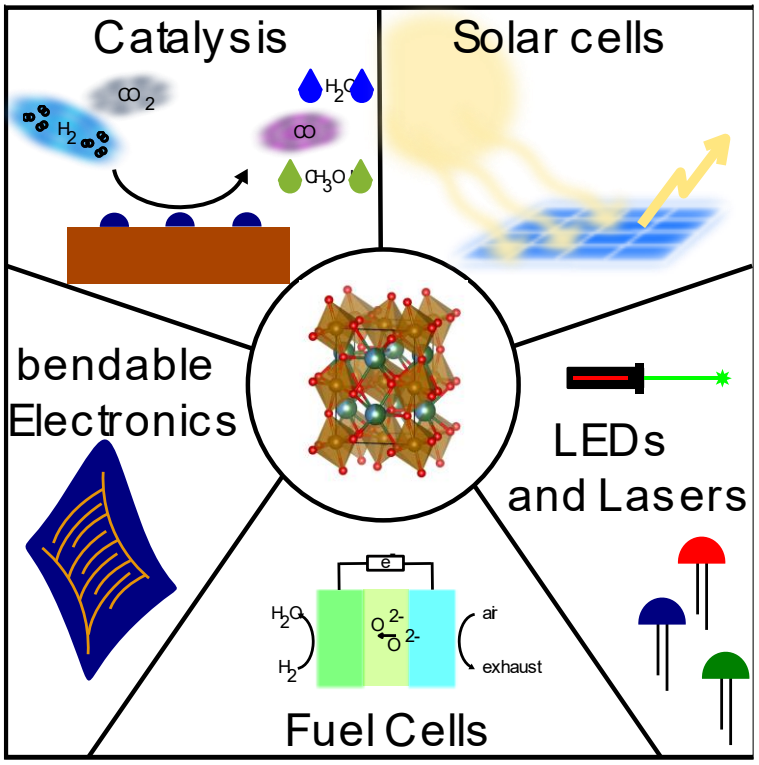
Combining catalysis and electrochemistry

A. Alverez et al. ChemPhysChem 18 (2017) 3135 DOI: 10.1002/cphc.201700782

Eierlegende Wollmilchsau

- **Material → Perovskite Oxides**





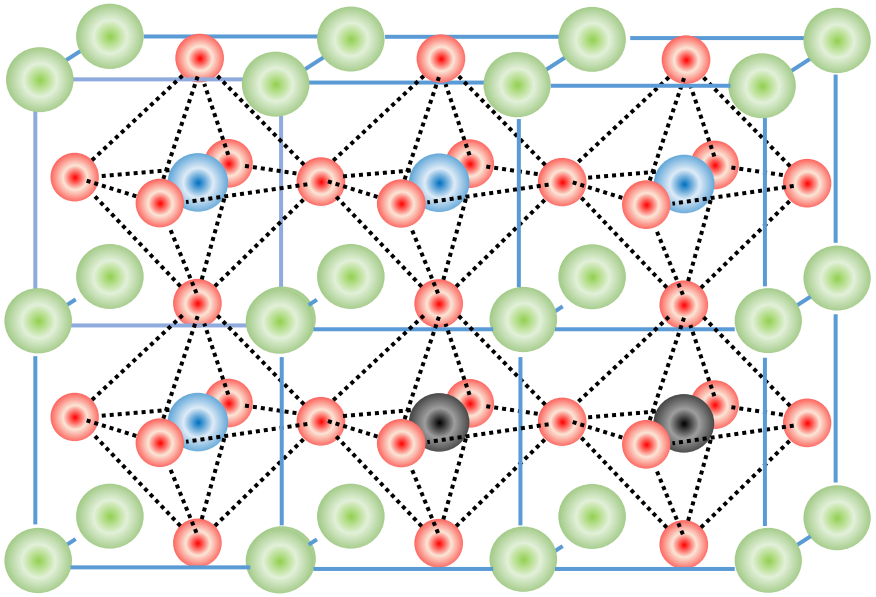
Applications:

Solid Oxide Electrolyser Cell
Solid Oxide Fuel Cell
Heterogeneous Catalysis
Electrocatalysis

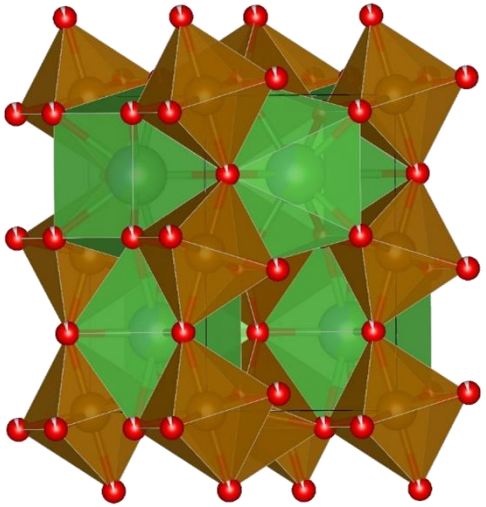
Chem. Commun. 59 (2023) 3948 – 3956 https://doi.org/10.1039/d3cc00456b

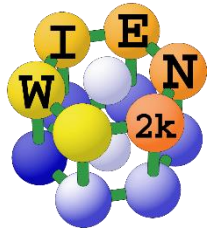
Doped Perovskites: ABO_3

A Site B Site Oxygen Dopant



B Site can be doped with catalytically active elements

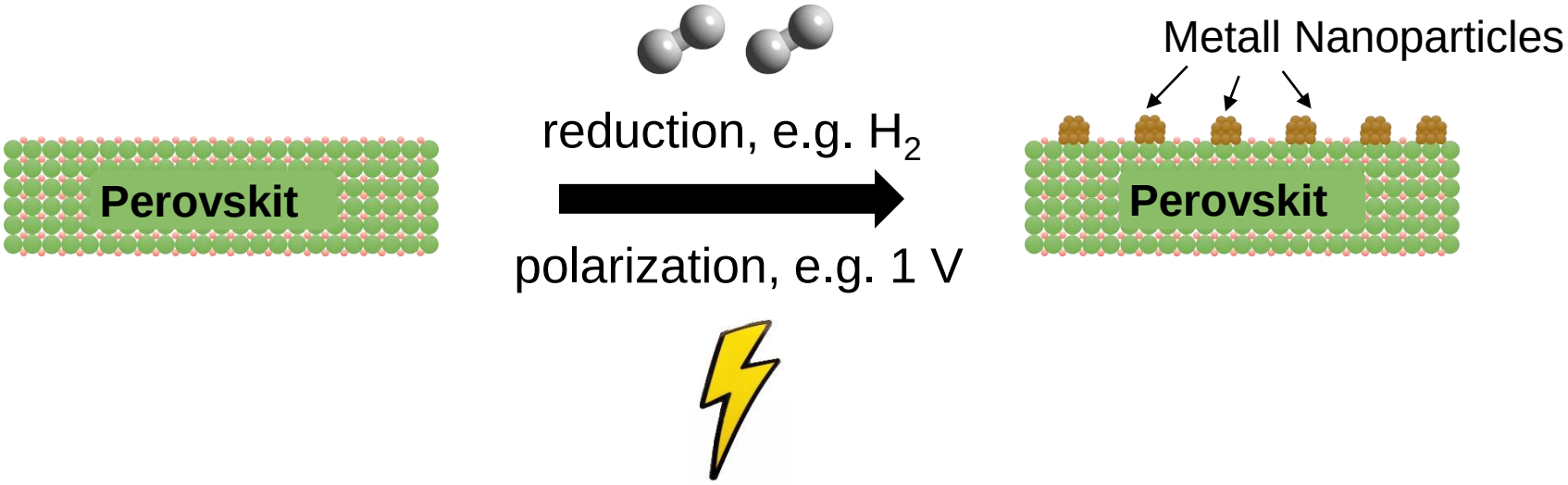




Tailored for high temperature CO_2 conversion: → rWGS
→ DRM

Special Property

Exsolution:

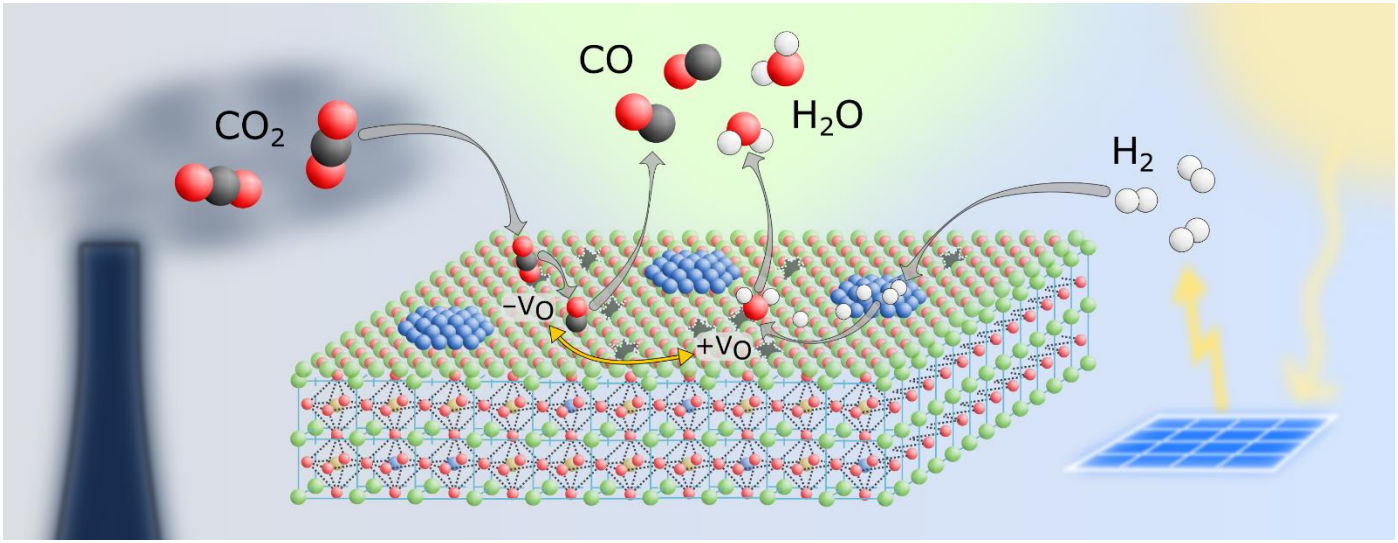


Migration of dopants to the surface → Nanoparticles

CO_2 Activation

Reverse Water-Gas Shift Reaction

$$CO_2 + H_2 \rightleftharpoons CO + H_2O \qquad 500 – 600°C$$



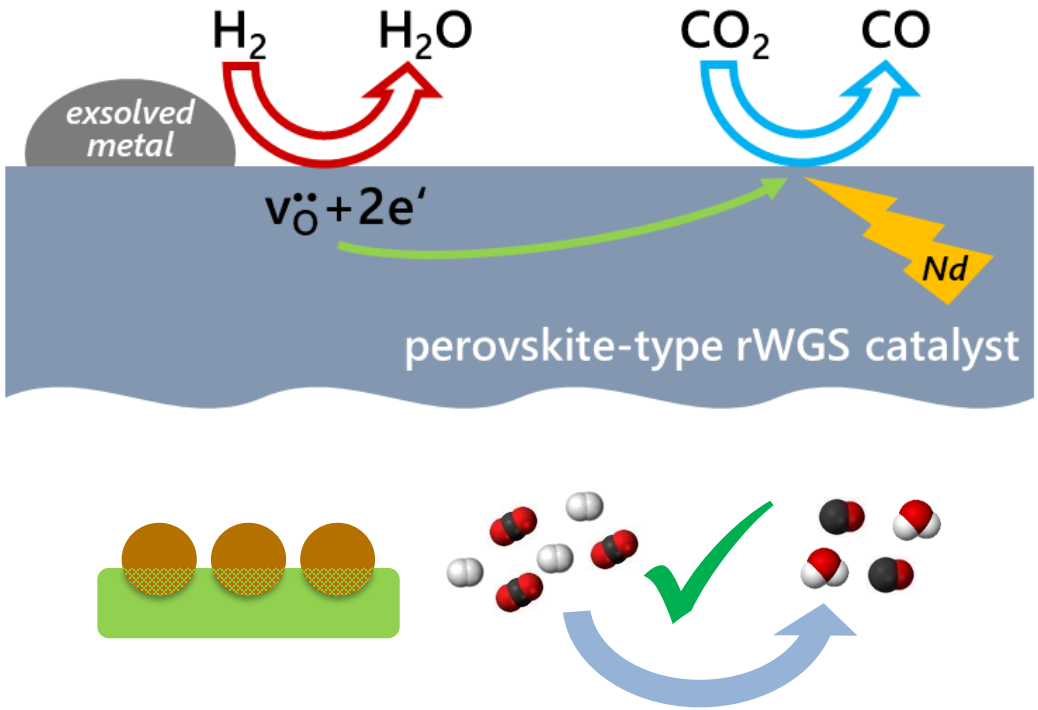
L. Lindenthal et al. Appl. Cat. B 292 (2021) 120183

CO_2 Activation

Job sharing between exsolved nanoparticles and perovskite lattice

→ H_2 splitting on nanoparticles, spill over to create oxygen vacancies

→ CO_2 activation at oxygen vacancies



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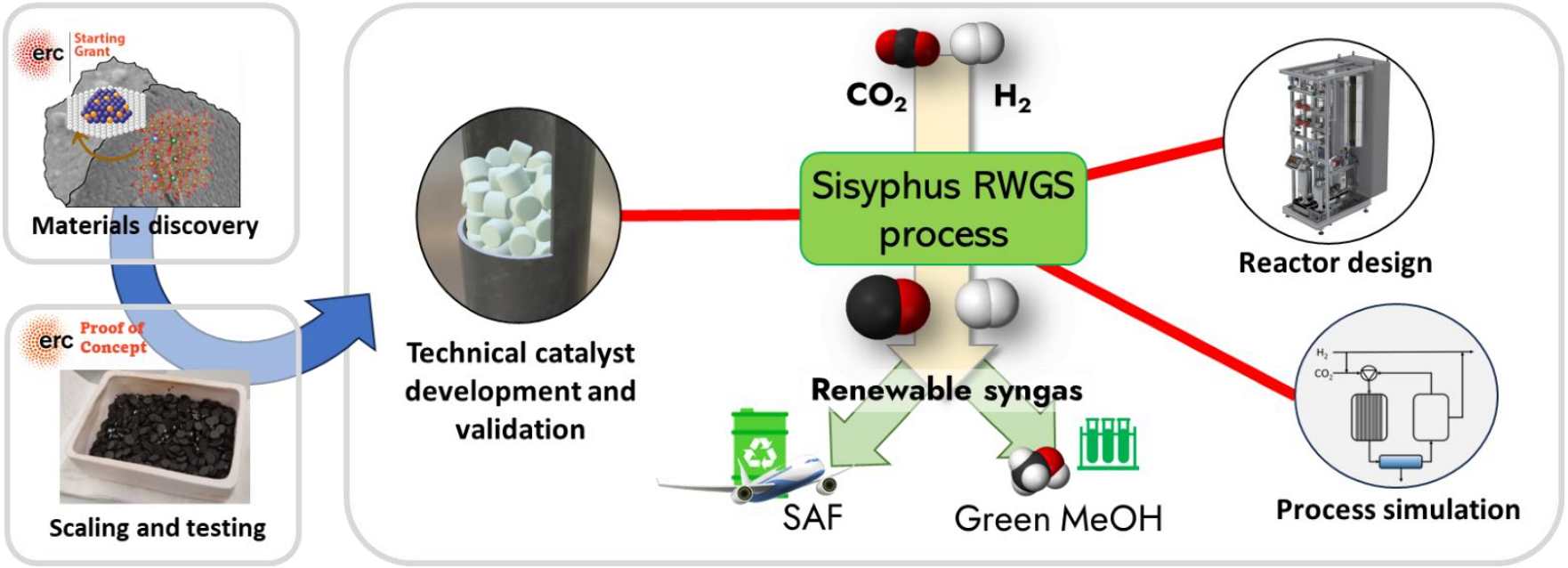
University Spin Off

SISYPHUS

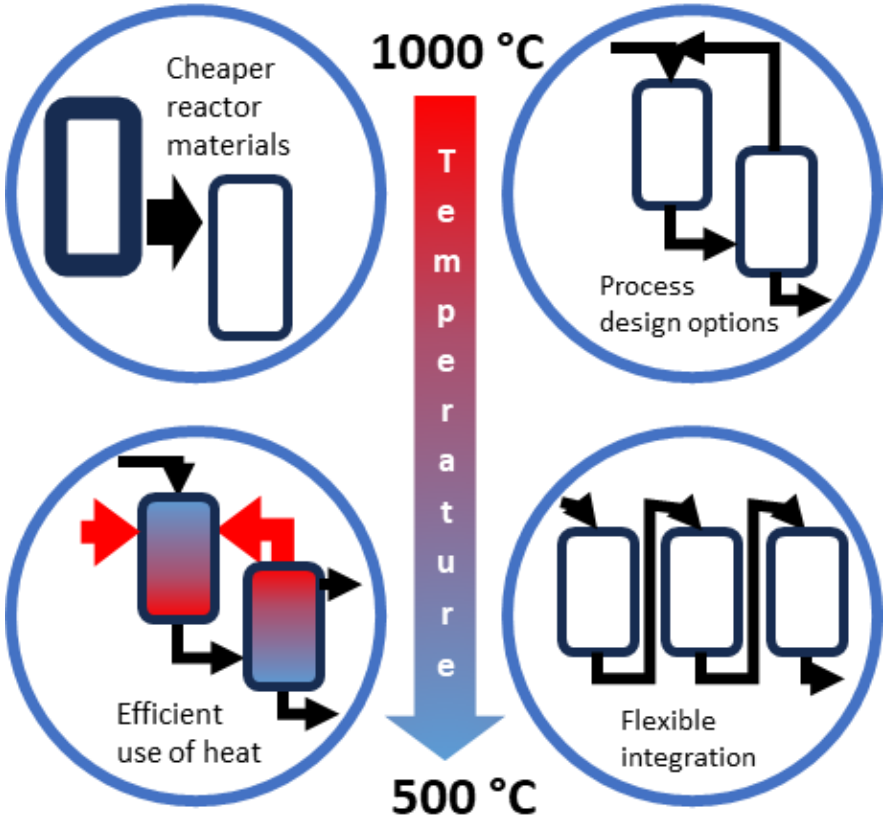
Recycling Carbon Forever

Dr. Tom Cotter

Dipl. Ing. Lorenz Lindenthal



University Spin Off



→ Biomass upgrade to renewable syngas

→ Sustainable syngas for green methanol and e-fuels (SAF)

ZAT Leoben GRÜNDERZENTRUM

TU WIEN INNOVATION INCUBATION CENTER

FFG Promoting Innovation.

FFG – Spin Off Fellowship

wirtschaftsagentur wien Gründungsstipendium

Unique catalyst technology allows for lower working temperature with confirmed superiority over state-of-the-art catalysts with respect to byproduct formation and activity.

Acknowledgement

Hedda Drexler
Raffael Rameshan
Lorenz Lindenthal
Schrenk Florian
Tom Cotter
Tobi Berger
Alexander Opitz
Andreas Nenning
Stefan Löffler
Thomas Ruh
Peter Blaha
Werner Artner

Physikalische Chemie
Montanuniversität Leoben

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