

KUWAIT INTERNATIONAL HYDROGEN TECHNOLOGY SYMPOSIUM

CO₂ Utilization and Storage Challenges and Solutions

Prof. Dr.-Ing. Matthias Franke

The Kuwait Hydrogen Outlook from Vision to Action
Hilton Kuwait Resort | State of Kuwait
5 & 6 March 2024



Fraunhofer-Gesellschaft

Leading organization for applied research and development



30 000

staff members



3,0 Bn. €

Turnover

thereof 2.6 Bn. € Contract research



76

Institutes

Funding mix

70% contracts

from private and public sector

30% base funding

by government and federal states



6200

customers from
private sector



Data based on 2022

Fraunhofer UMSICHT

Institute for Environmental, Safety, and Energy Technology



4500 m²
Technical Center



Oberhausen /
North-Rhine Westphalia



2100 m²
Technical Center



Sulzbach-Rosenberg /
Bavaria

- **7th largest** Fraunhofer Institute
- **600** Employees
- Operating budget 2023: **69,6 million €**

Fields of research

Sustainable restructuring of the economy and society: circular, climate-neutral, economical



Circular Economy

Materials and processes for a circular use of resources:
From lab-scale towards industrial scale



Carbon Management

Sustainable use of carbon from biomass, waste and carbon dioxide



Green Hydrogen

Materials and processes for elektrochemical generation, utilization and storage of green hydrogen



Local Energy Systems

Concepts and technologies for transformation of energy supply of districts and industries

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International projects and cooperations





Waste Generation and Management



Waste Recycling



Download:
s.fhg.de/kuwait-waste-atlas

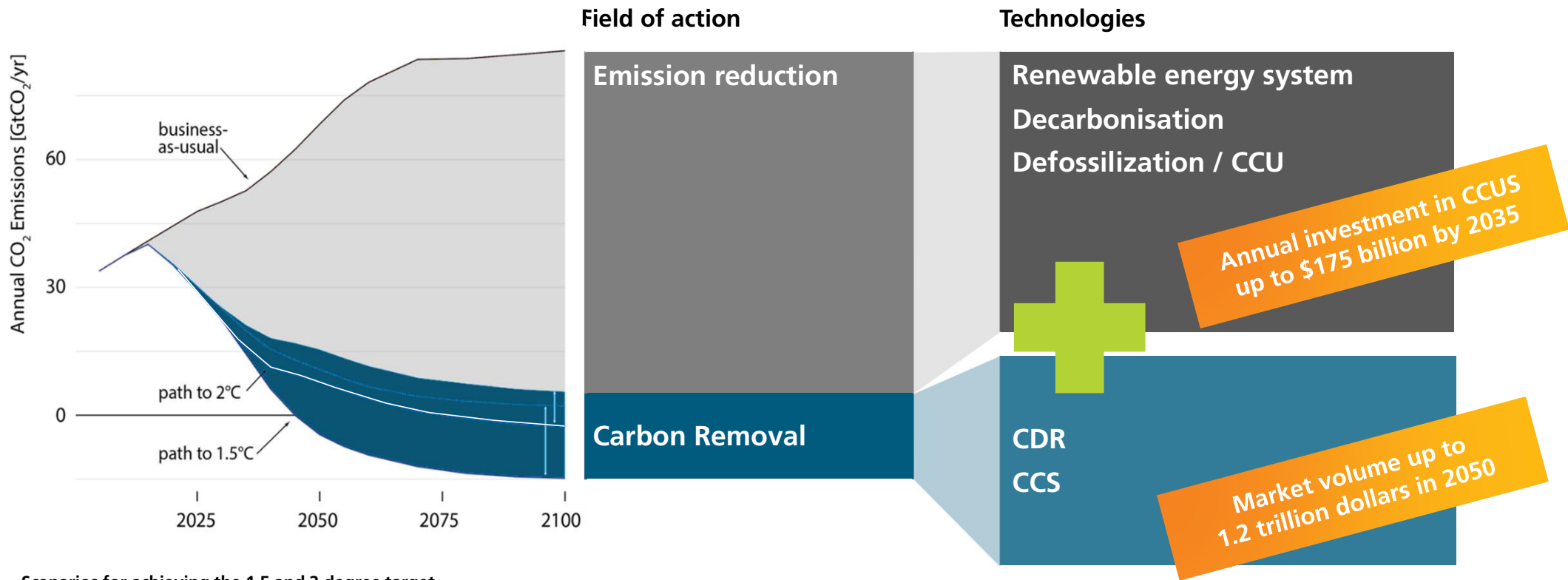
Kuwait - eMISK_{Waste}

National Waste Management Strategy until 2040



Climate change scenarios

IPCC: CDR ist required to limit global warming to 1.5° C



Scenarios for achieving the 1.5 and 2 degree target.

Mercator Research Institute on Global Commons and Climate Change (MCC) gGmbH | Berlin

Climate action in place

CCUS in the European Union and Germany



Paris agreement



European Green Deal

European Net-Zero Industry Act

European Emission Trading Directive

European Climate Law (net-zero by 2050)

Federal Climate Law

European CCS Directive



Carbon Management Strategy

Carbon dioxide storage law

Climate action in place

Decarbonization ambitions in the GCC

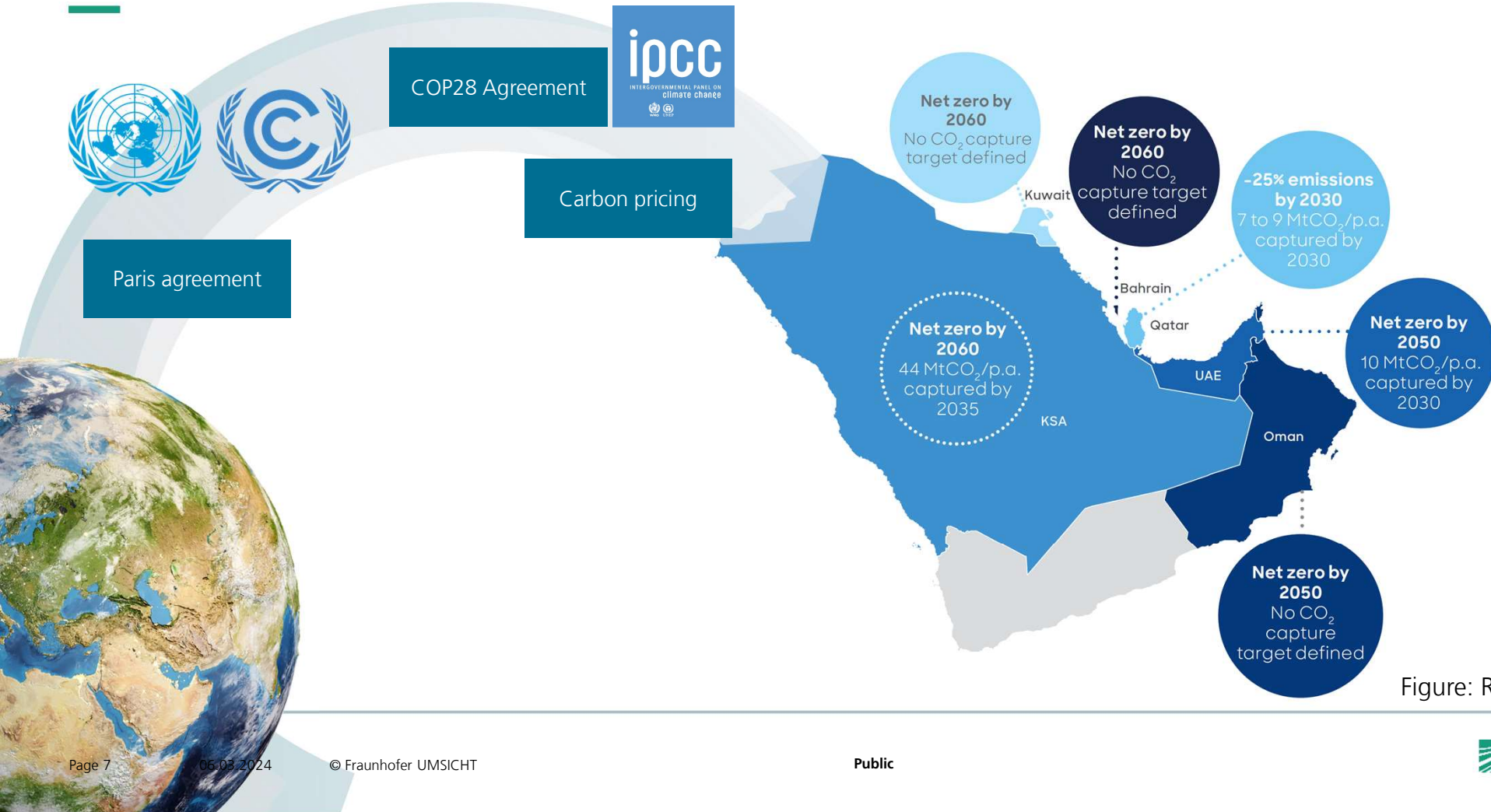


Figure: Roland Berger, 2023

Climate action in place

CCUS facilities in the GCC

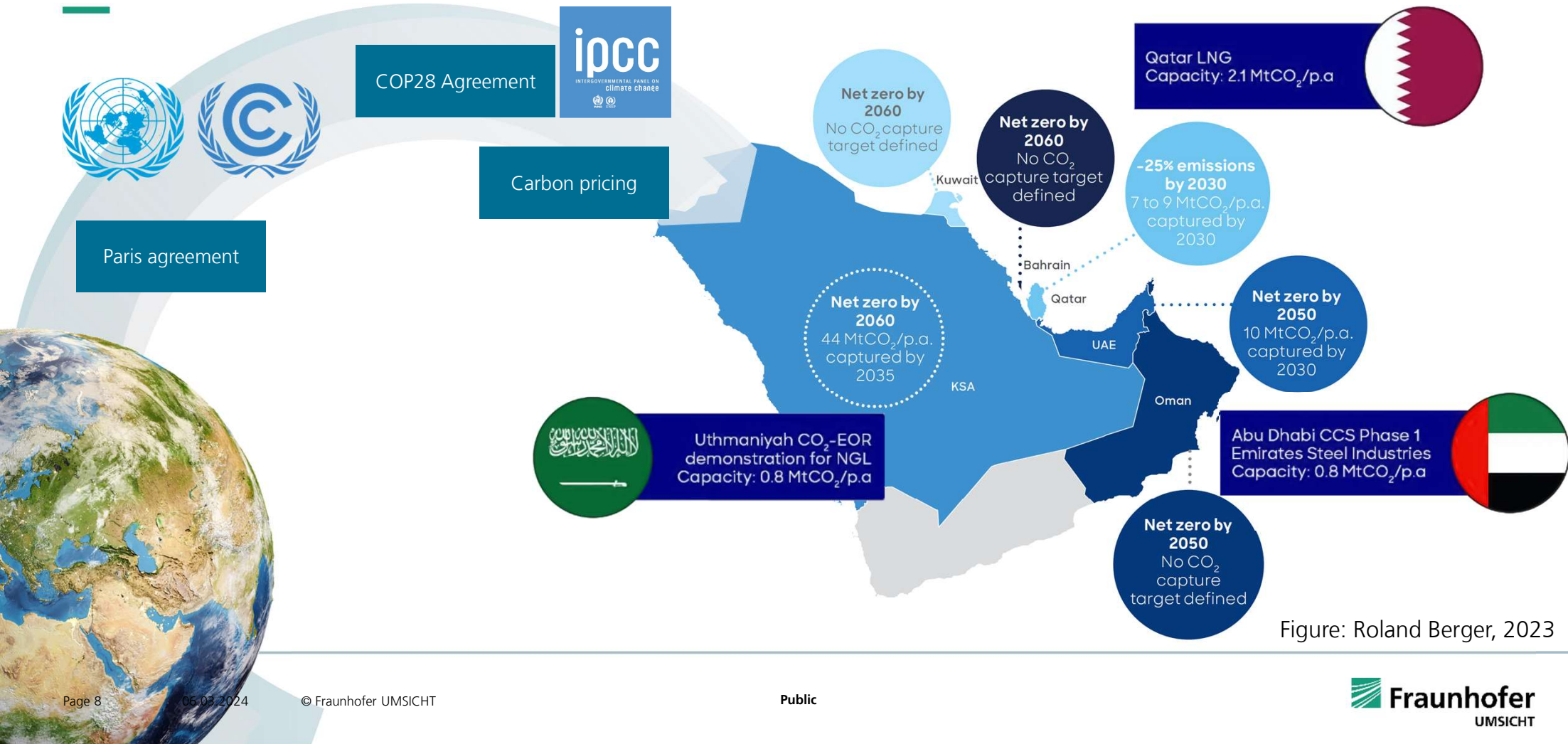
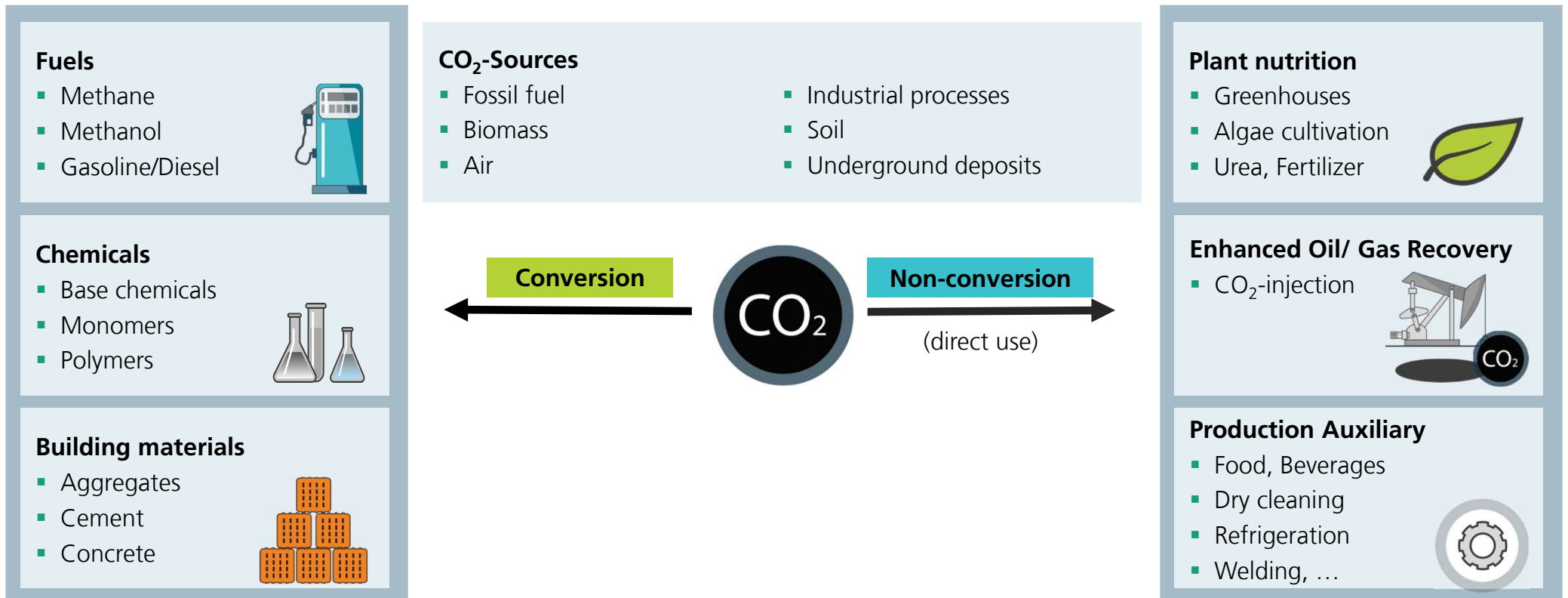


Figure: Roland Berger, 2023

Carbon capture, utilization and storage

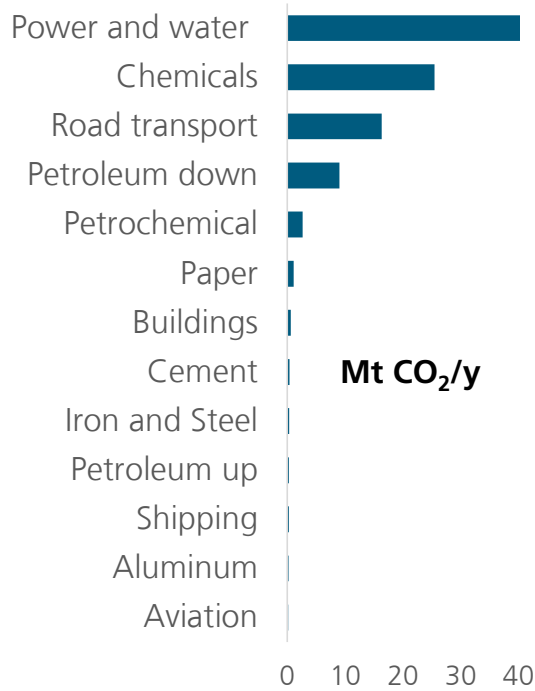
Sources and Pathways for CO₂ use



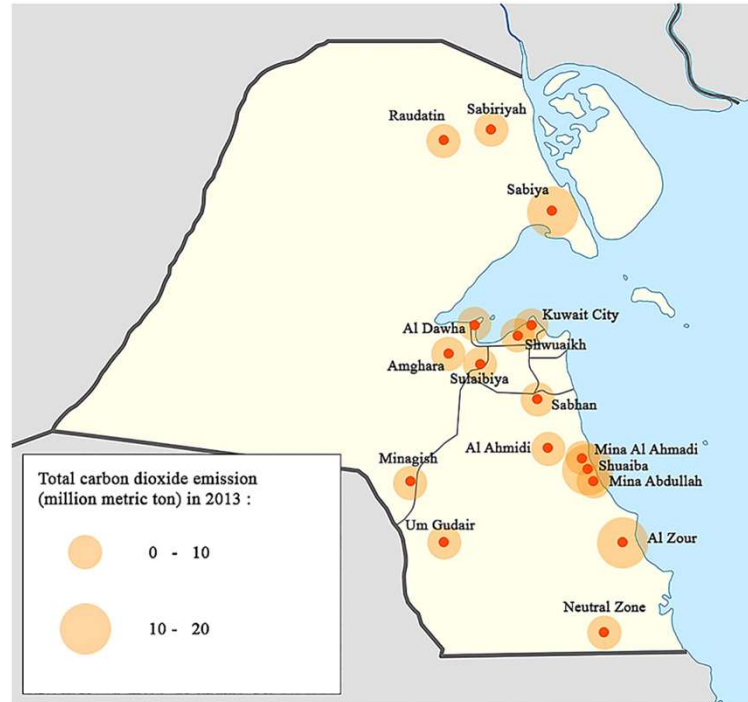
Source: Modified acc. to IEA 2021

CO₂-Emissions and location of oilfields in Kuwait

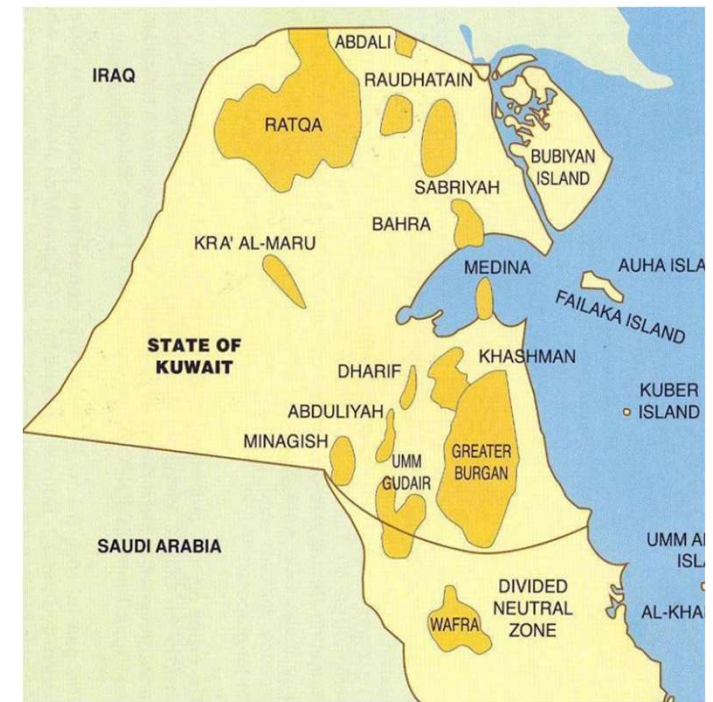
Carbon dioxide sources and natural sinks in close proximity



CO₂-emissions by sector (Al-Mutairi et al., 2017)



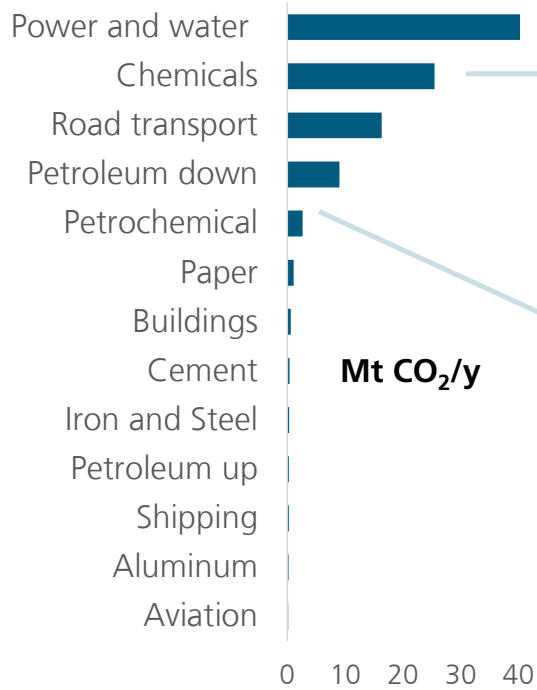
Geographical distribution of CO₂-emissions from stationary sources in Kuwait (Al-Mutairi et al., 2017)



Location of Kuwait oilfields (Al-Mutairi et al., 2017)

CO₂-Emissions in Kuwait and hydrocarbon-based products

Opportunities for carbon capture and utilization



CO₂-emissions by sector (AL-Mutairi et al., 2017)

Chemicals



- Asphalt
- Detergents
- Plastic products
- Fertilizers
- Paints
- Greases
- Industrial gases
- Sulfuric acid

Petrochemical products



- Urea
- Ammonia
- Ethylene
- Polyethylene
- Ethylene glycol
- Polypropylene
- Paraxylene
- Benzene
- Styrene monomer



Fuels

- Methane
- Methanol
- Gasoline/Diesel



Chemicals

- Base chemicals
- Monomers
- Polymers



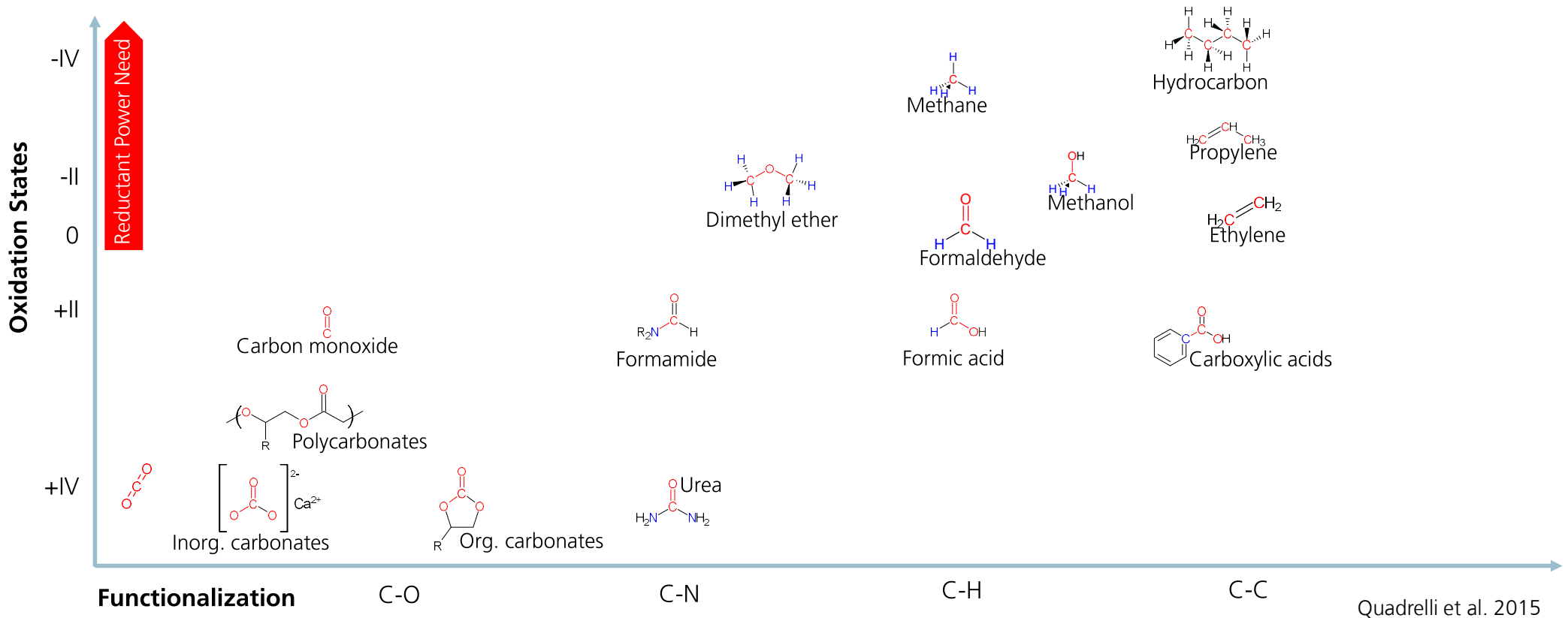
Building materials

- Aggregates
- Cement
- Concrete



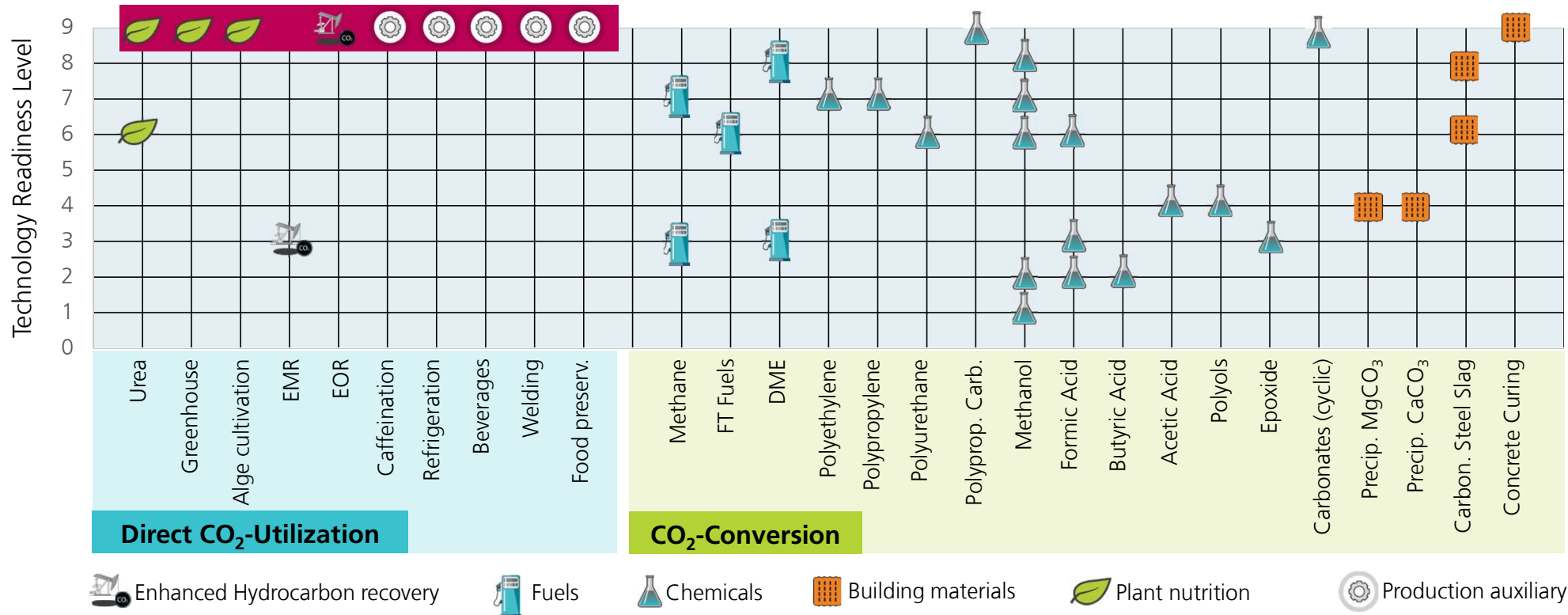
Carbon Capture and Utilization

Energy required for CO₂ conversion is equivalent to oxidation reduction



Selection criteria for CCUS-options

Technology Readiness








Sources: Chavez & Partenie 2020; Kleijne et al. 2022; own estimations

Selection criteria vor CCUS-options

Comparative Matrix (exemplarily)

* Market size in the EU

** Product value for EU

Pathway	Product	CO ₂ -binding capacity in kg / kg product	TRL	Retention time	Market size * in Mt / y	Product value ** in € / t
Fuels 	Gasoline/Diesel	3,14	6-8	< 6 months	530	1,100
Chemicals 	Polypropylene	3,14	8-9	Years decade	13.2	1,000
Building materials 	Aggregates & CO ₂ -cured concrete	0,35	9	Centuries	< 1,000	50
Plant nutrition 	Algae proteins	1,80	5-7	< 6 months	20	13,000
EOR 	CO ₂ -injection	n/A	9	centuries	65-80	n/A

Sources: Philbin 2020; Chavez & Parvenie 2020; European Commission 2019; Hepburn et al. 2019

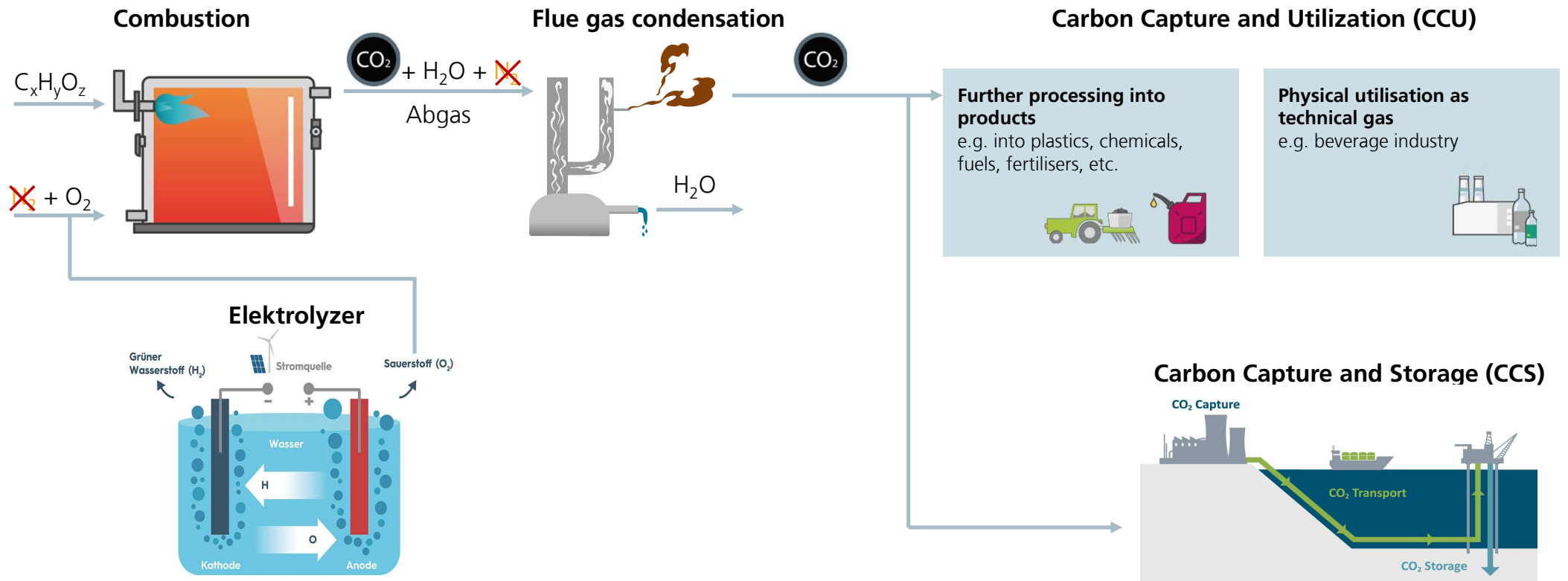


BO₂CCU – Oxyfuel combustion of
biomass and waste

Oxyfuel combustion of biogenic gases and separation of a
high-purity CO₂-stream in addition to heat generation.
2022 – 2024

Why OxyFuel-Combustion ...

... and why now?





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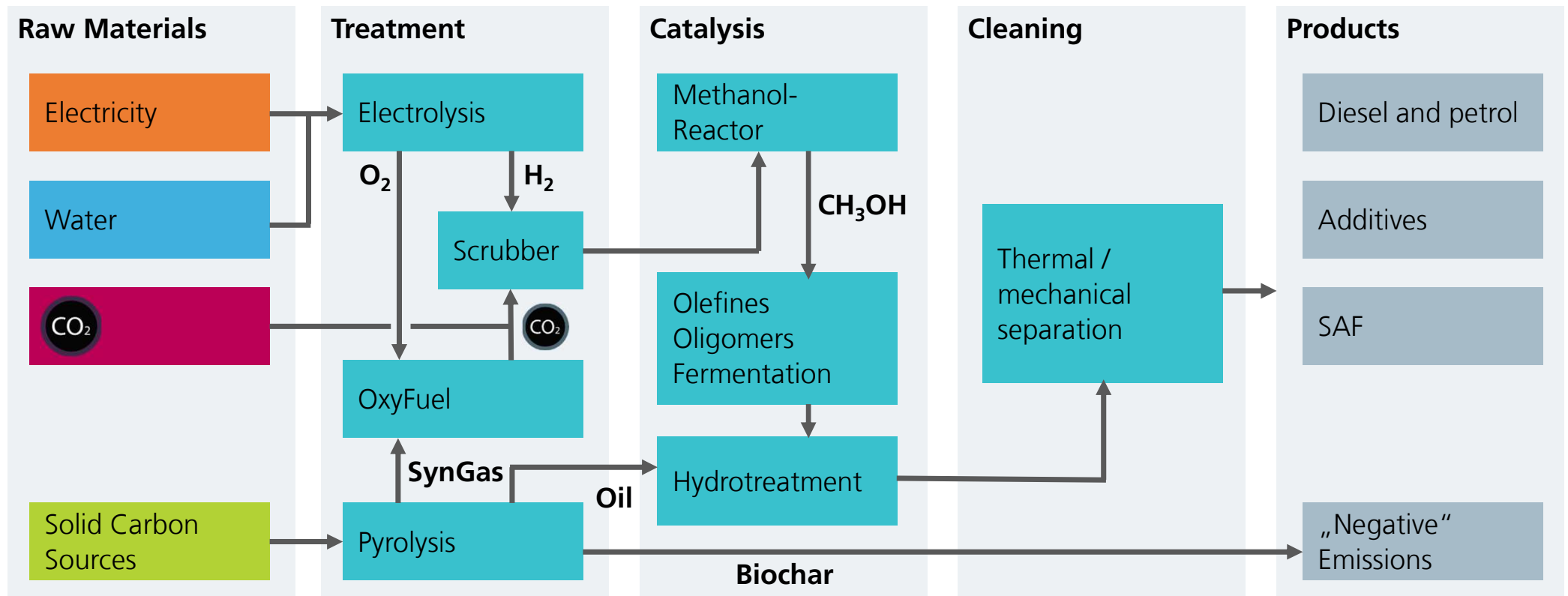
SynergyFuels - Sustainable fuels from Biomass, CO₂ and green electricity

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Integration of Power-to-X Technologies and Biomass-to-Liquid
Technologies

2023 – 2026 | 14 Mio. EUR

Sustainable fuels from Biomass, CO₂ and green electricity

Power-to-X Technologies and Biomass-to-Liquid Technologies in combination





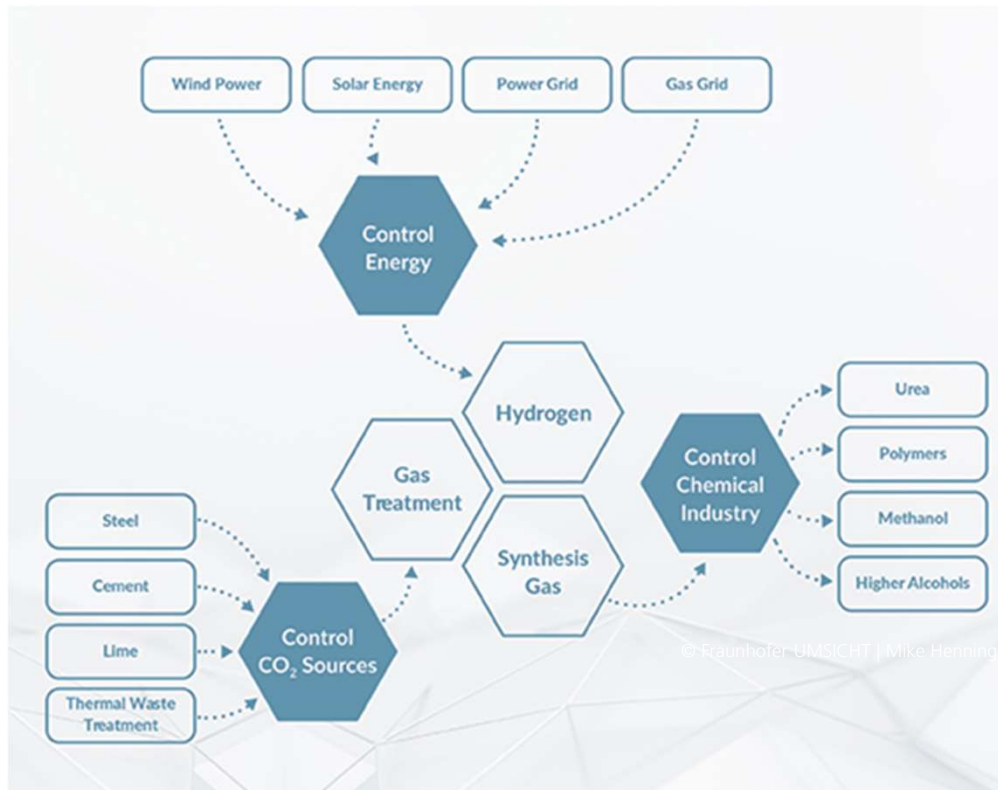
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Carbon2Chem – Transformation of Thyssenkrupp Steelworks

Utilization of smelter gases from steel production to create
primary products for fuels, plastics, or fertilizers
2016 – 2025 | 144 Mio. EUR | 20 Mt/p.a. CO₂-Utilization

Gascleaning and conditioning

Research and development at industrial scale



Amine scrubbing and desulphurization

Gas conditioning for synthesis

Pressure Swing adsorption (PSA)

H₂-supply



Outlook

Kuwait as a regional CCUS Hub

Storage of CO₂ in depleted oil fields → CCS

Investment in CCU R&D at demonstration scale

Capacity building in CCU

Expansion of renewable energy production

Adaptation of legal framework and policies

Business models for capture, transport, storage and utilization of CO₂

Carbon dioxide storage capacities

Low Carbon products and derivatives

Kuwait as a regional CCUS hub

Many thanks for
your attention



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