Aspen Global Change Institute : Technologies and Policies to Decarbonize the Industry Sector

Opportunities in Chemical Manufacturing

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BASF

We create chemistry

BASF – We create chemistry

- Our chemistry is used in almost all industries
- We combine economic success, social responsibility and environmental protection
- Sales 2017: €64,457 million
- EBIT 2017: €8,522 million
- Employees (as of December 31, 2017): 115,490
- 6 Verbund sites and 347 other production sites

BASF Ludwigshafen

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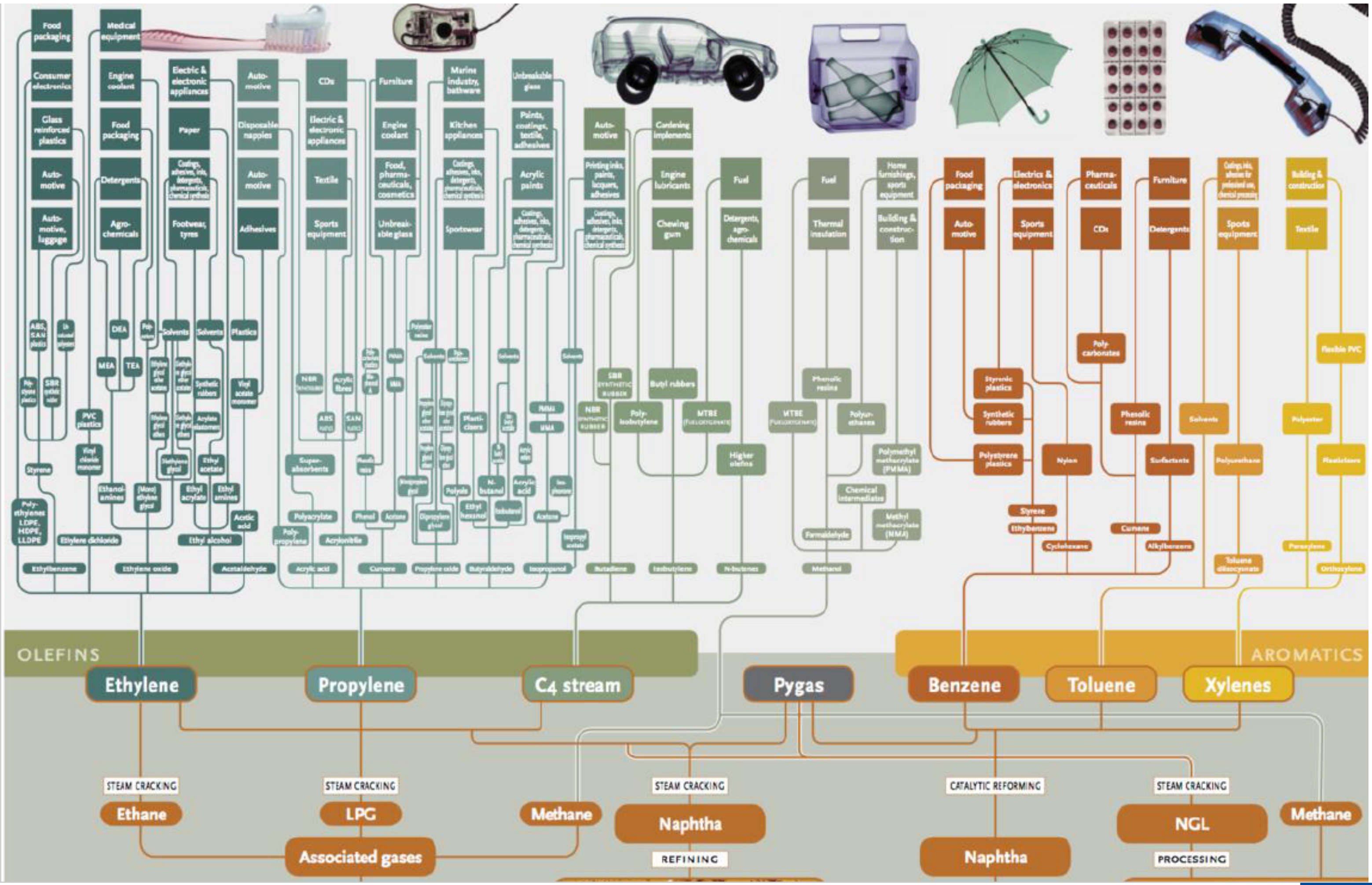
Chemical products contain carbon
„Decarbonization“ is not a usefull term

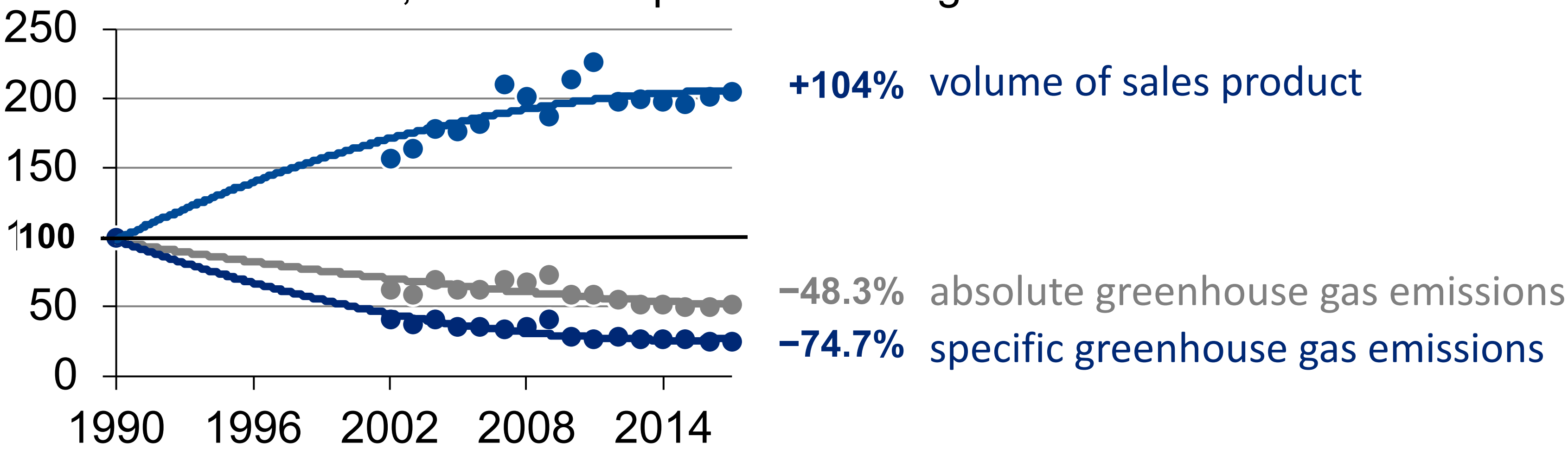


Petrochemical Value Chain

Reduction of greenhouse gas emissions with increased production

Development since 1990

Index 1990 = 100%, BASF Group excl. oil and gas business



Elements of Energy Management at BASF

Energy Verbund

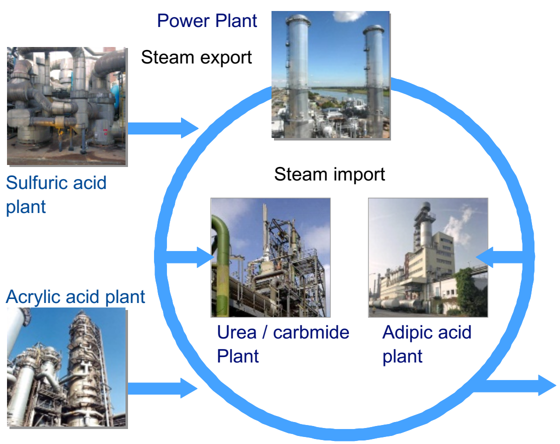
Linkage of energy flows between production plants

Energy Production

High efficient combined heat and power plants (CHP) with combined cycle gas turbines (CCGT)

Energy Efficiency

Process optimization e.g. new catalysts in the acrylic acid plant, heat integration, ...



Annual savings*
Primary energy 18 mill. MWh
CO_2 emissions 3.9 mill. t CO_2

Annual savings*
Primary energy 13 mill. MWh
CO_2 emissions 2.6 mill. t CO_2

Several hundred measures per year

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* BASF Group 2017

DECHEMA Technology Study: Low carbon energy and feedstock for the European chemical industry

- **Scope: European chemical industry**
  Methanol, ethylene/propylene, benzene/toluene/xylene, ammonia/urea, chlorine
  > 50% of energy consumption and GHG-emissions of European Chemical Industry

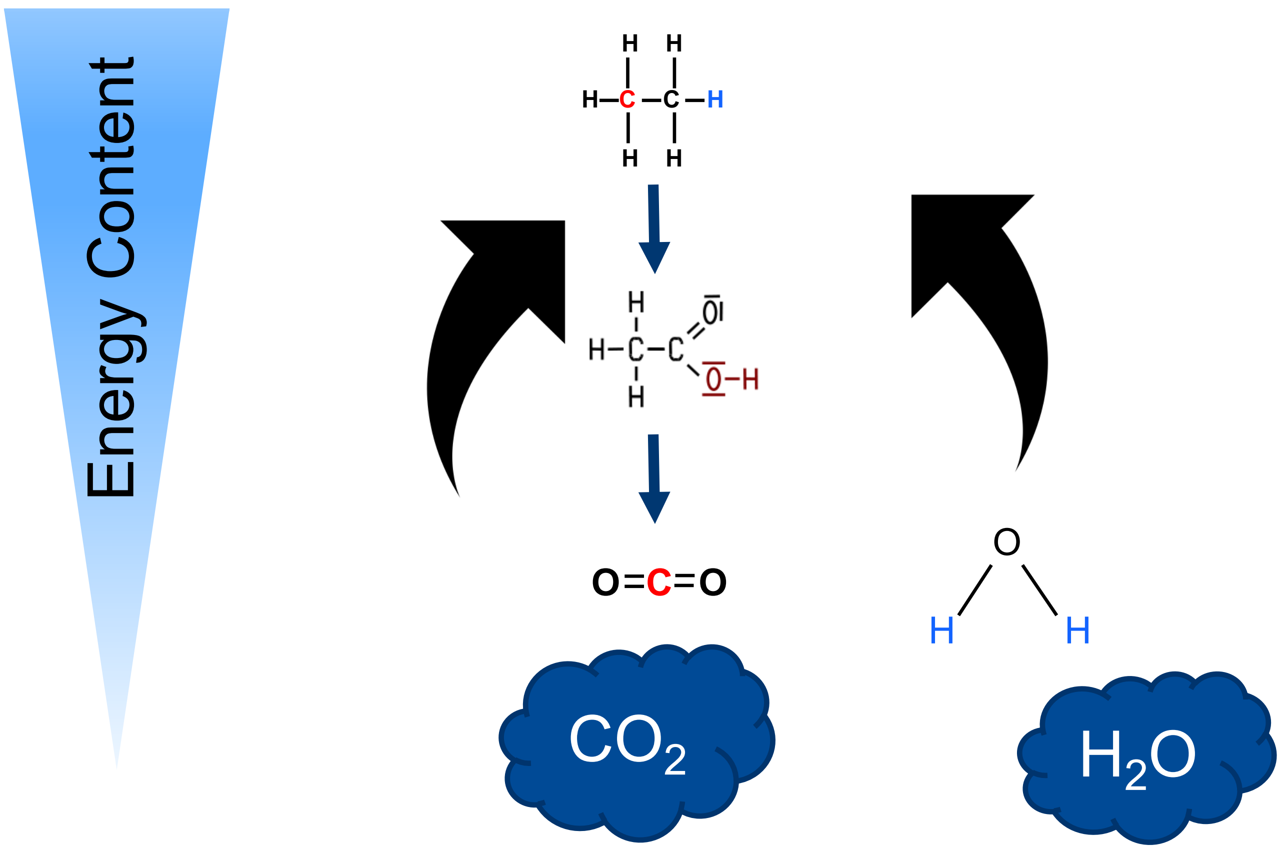
- **Technology measures**
  Energy efficiency, biomass and waste, H_2+CO_2-based processes, H_2 only from water electrolysis

- **Four Scenario calculations** based on selected percentages of technology implementation

- **No carbon leakage**

- Additional impact of CO_2-based methanol and ethanol as fuel component

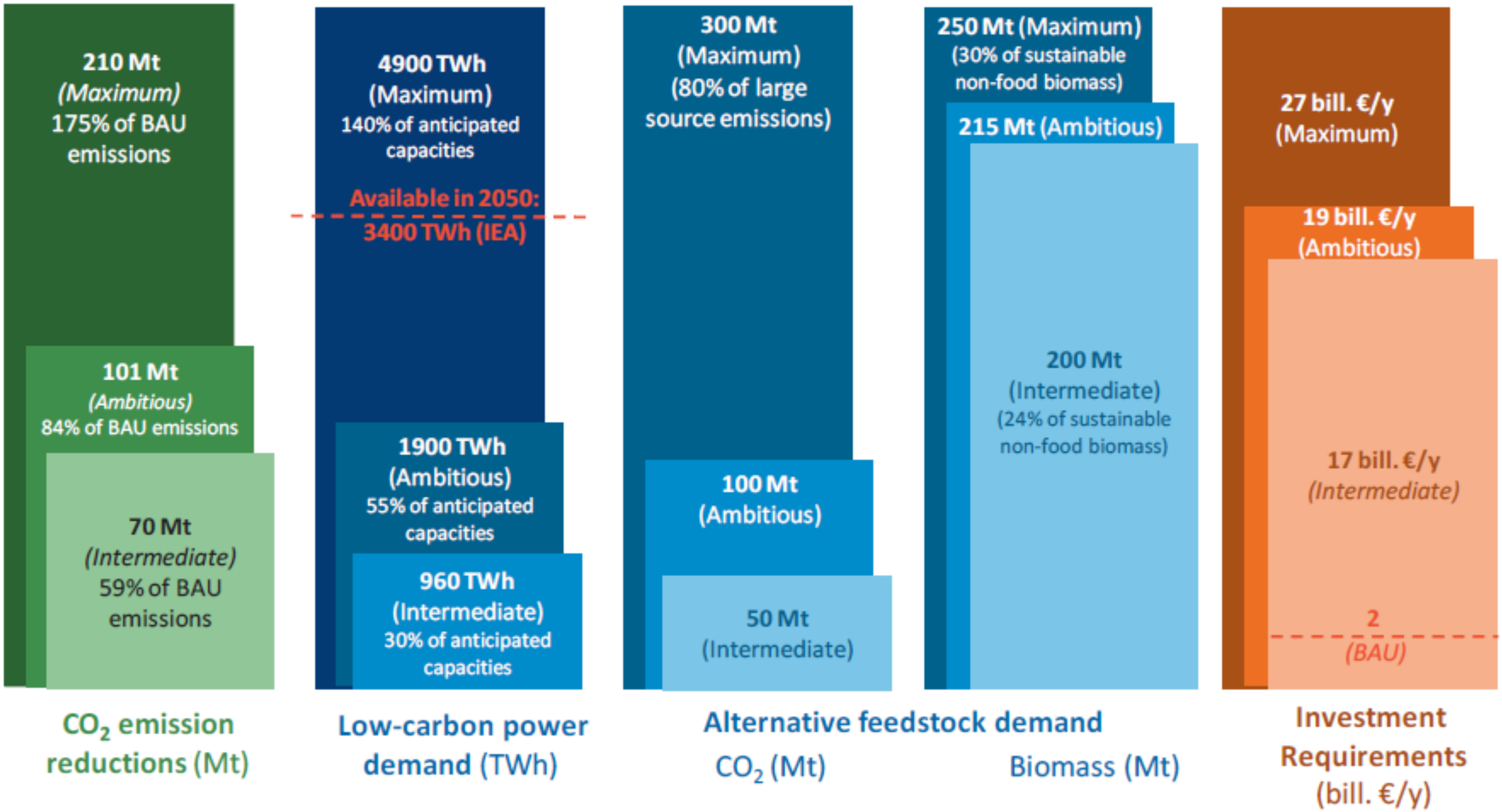
CCU: Using CO_2 as feedstock



Hydrocarbons
Benzene
Ethylen
Polyethylen
Polypropylen
…

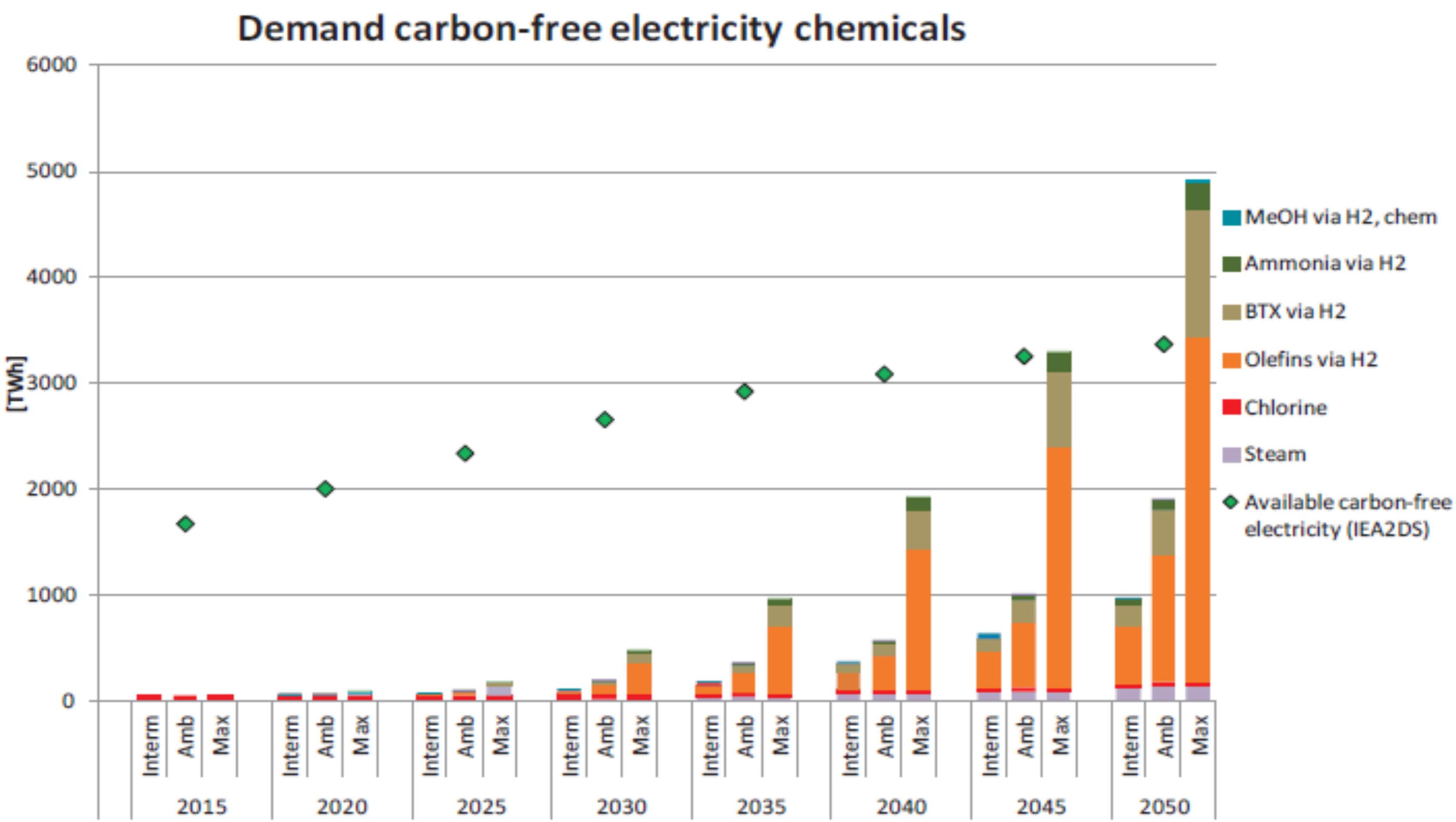
Oxygene rich Chemicals
Formaldehyde
Ethanol
Acrylic acid
Formic acid
…

DECHEMA Technology Study: Results of scenario calculations (w/o fuels production)



BAU: business-as-usual

DECHEMA Technology Study: Energy Demand



Emissions in the Chemical Value Chain

~ 20 Basic Chemicals

To produce

~20.000

Chemicals
in the value chain

80 %
GHG
Emissions

20 %
GHG Emissions

R & D
focus on big emitters needed

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Methane pyrolysis – a new source of H_2
Project outlook and financing aspects

Reference/demonstration unit on commercial scale
~€100 million investment
Start-up ≥2024,

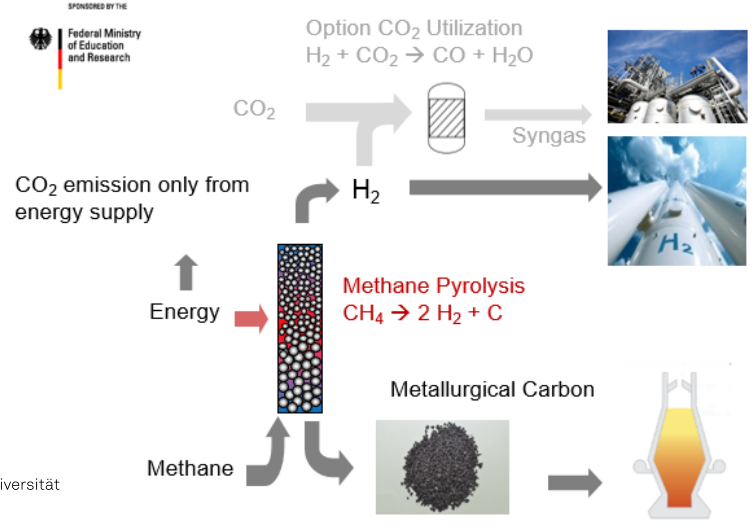
Pilot Unit
~€20-40 million investment
Start-up ≥2020,

R&D-Project
funded by the German Ministry of Education and Research

Risks

- breakthrough process development
- carbon utilization in metallurgy
- industrial scale reference required
- CAPEX and OPEX support needed

SPONSORED BY THE Federal Ministry of Education and Research



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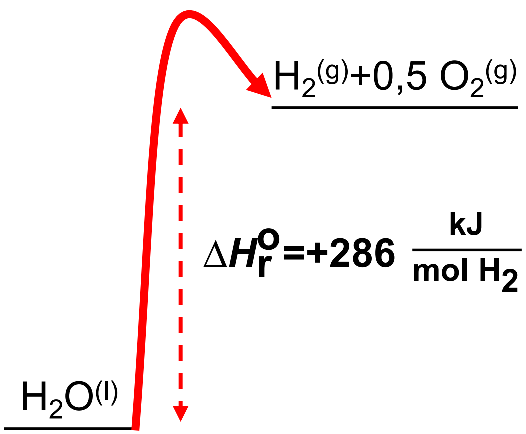
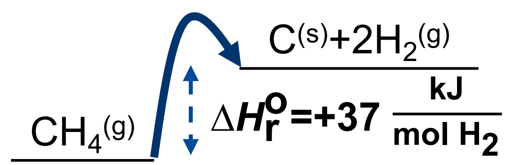
More Hydrogen from the same amount of renewable Energy by Methane Pyrolysis

H_2 by **Water Electrolysis**



H_2 by **Methane Pyrolysis**



87% less energy
But: fossile feedstock
Alternative: Bio-Methane if available

Our contribution to fulfill the Paris agreement – Avoidance with highest contribution

Energy Efficiency

High efforts to tackle remaining opportunities

Sustainable Biomass as feedstock

BASF Biomass Balance and dedicated Bio-based products

Waste as feedstock

Use waste in a reasonable way while limiting effects on climate

CO_2

CCU

Focus on products with high oxygen content and thus less energy needs

CO_2

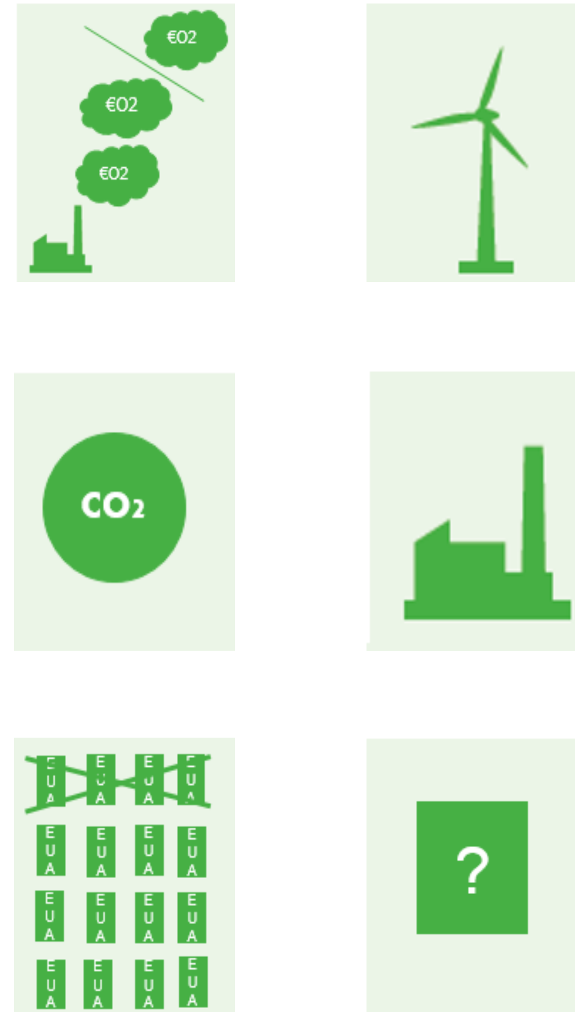
Avoidance by new production technologies

Research and Development of low CO2 processes for chemicals with highest emissions

Use of limited resources like biomass and renewable energy based on best value to society limit availability for chemistry

Learnings

- Large-scale CO2-reductions can only be achieved through a significant electrification of industrial processes, leading to a huge increase of low-carbon electricity demand.
- Radically lowering the price of renewable electricity, including Government driven surcharges and levies, presents an indispensable prerequisite for a successful industrial transformation.
- R&D funding programs contribute to accelerate the development of new technologies.
- To turn these R&D activities into actual investments, we need a global (at least G20) CO2 price to allow for a business case. The economic constraints around zero-carbon transformation needs to be acknowledged.



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