




12th World Renewable Energy Technology Congress & Expo-2021

Renewable Energy, Innovations, Technology & Energy Efficiency for a Sustainable Green Economy

Unlocking the Hydrogen Economy

thyssenkrupp Industrial Solutions AG, Germany

Karsten Radtke, BU Uhde

engineering. tomorrow. together.

thyssenkrupp

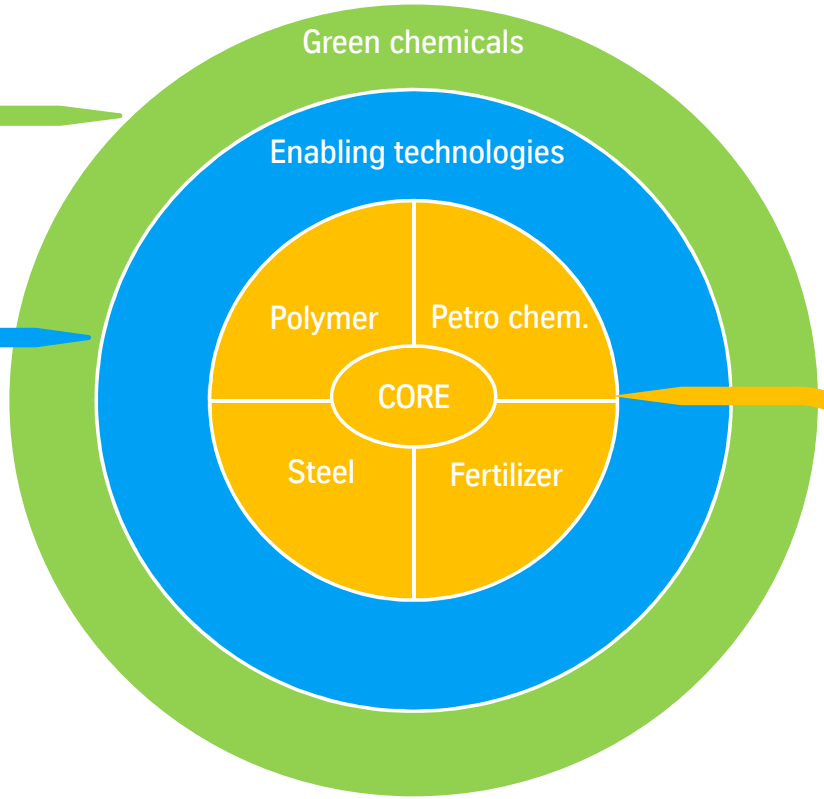
thyssenkrupp Uhde | We create a livable planet

Green Chemicals

- Green ammonia
- Green methanol & DME[1]
- Green synthetic natural gas
- CO_2 capture
- Green fuels (e.g. PtL[2], GtL[3])
- Green fertilizer

Enabling Technologies

- Green revamps (refineries)
- Blue hydrogen
- EnviNOx
- Polymer recycling
- Oleochemicals
- Biobased Polymers (e.g. PLA[4])
- Energy recovery
- Water desalination



CORE Technologies

- Fertilizers & Methanol
- Coke Plants (black & white side)
- Gas Cleaning Plants
- Refineries, Petrochemicals & Polymers
- High Pressure Technologies

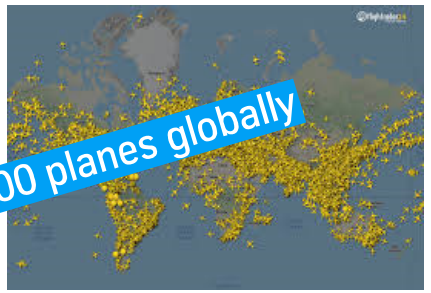
1) Dimethylether 2) Power-to-liquid 3) Gas-to-liquid 4) Polylactid acid

talking about Hydrogen…

Hydrocarbons are H_2 + C_n

… requires talking about Carbon!

Rationale for Synfuels



Simple thought:
instead of (in addition to) investing billions into new hydrogen/fuel cell or electric/battery operated cars, the world keeps driving the existing Otto and Diesel engines, and the aviation industry keeps flying the existing fleet of planes **– worldwide, without any modifications…**

…while using no fossil fuels

millions of combustion engine operated machinery

Can such target be achieved?
- Simple thought, simple answer: yes!

Rationale:
- Otto, Diesel and Jetfuel consist of hydrocarbons – H_2 and C
- In order to make green synfuel, sources of green H_2 and of green C required

German Minister of Transportation
Andreas Scheuer, **14 March 2021:**

"end of fossil fuel engines by 2035"

⇨ **Defossilization**
not Decarbonization!

+ Green Carbon = Climate Neutral Routes for Green Synfuel

CO_2 Offgas

or

Biomass

Water Electrolysis

or

Biomass

C

H_2

Methanol Route

MTG

MTO

Gasoline

(Diesel/Jetfuel)

Fischer-Tropsch Route

Diesel

Jetfuel

Naphtha

Hydrogen at scale – large alkaline water electrolysis plants

Advanced Water Electrolysis

- Zero-gap technology
- Innovative electrode coatings by DeNora
- High efficiency atmospheric operation
- Fast response to fluctuating power input
- Post-compression optional
- Full turnkey EPC plants
- Large capacity supply chain
- Global service

Experience cannot be copied.

#1 49% market share
supplier for electrolytic hydrogen production

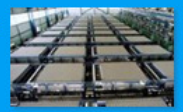
600
electrochemical plants realized worldwide

over **10 GW**
of power installed

Hydrochloric acid diaphragm electrolysis

Hydrochloric acid ODC[1] membrane electrolysis

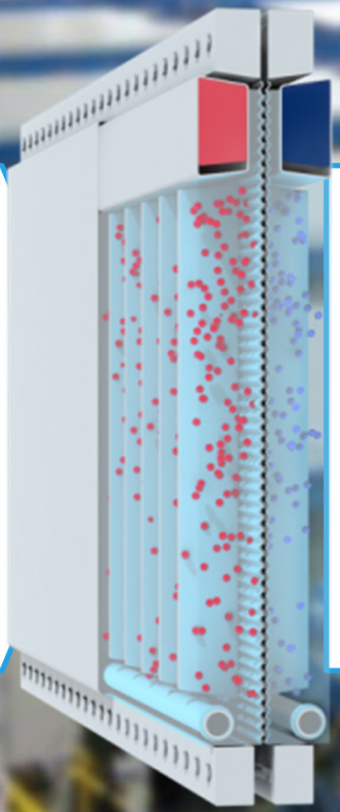
Chlor-alkali membrane electrolysis



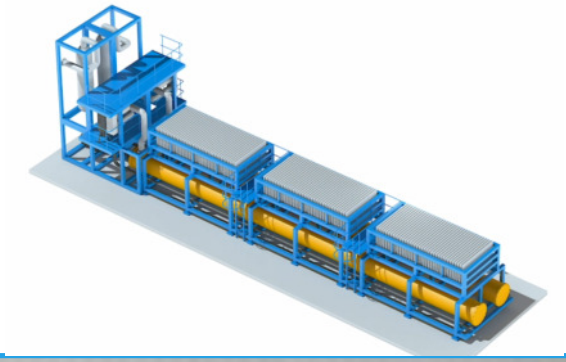
[1] ODC: Oxygen Depolarized Cathodes

Water electrolysis is the key technology for renewable hydrogen

Being market and technology leader in world-scale electrochemical plants for chlorine and caustic



…we developed a lean and cost effective solution for large scale alkaline water electrolysis for H_2 production



Background picture: 100 MW Chlorine plant Tessenderlo, Belgium

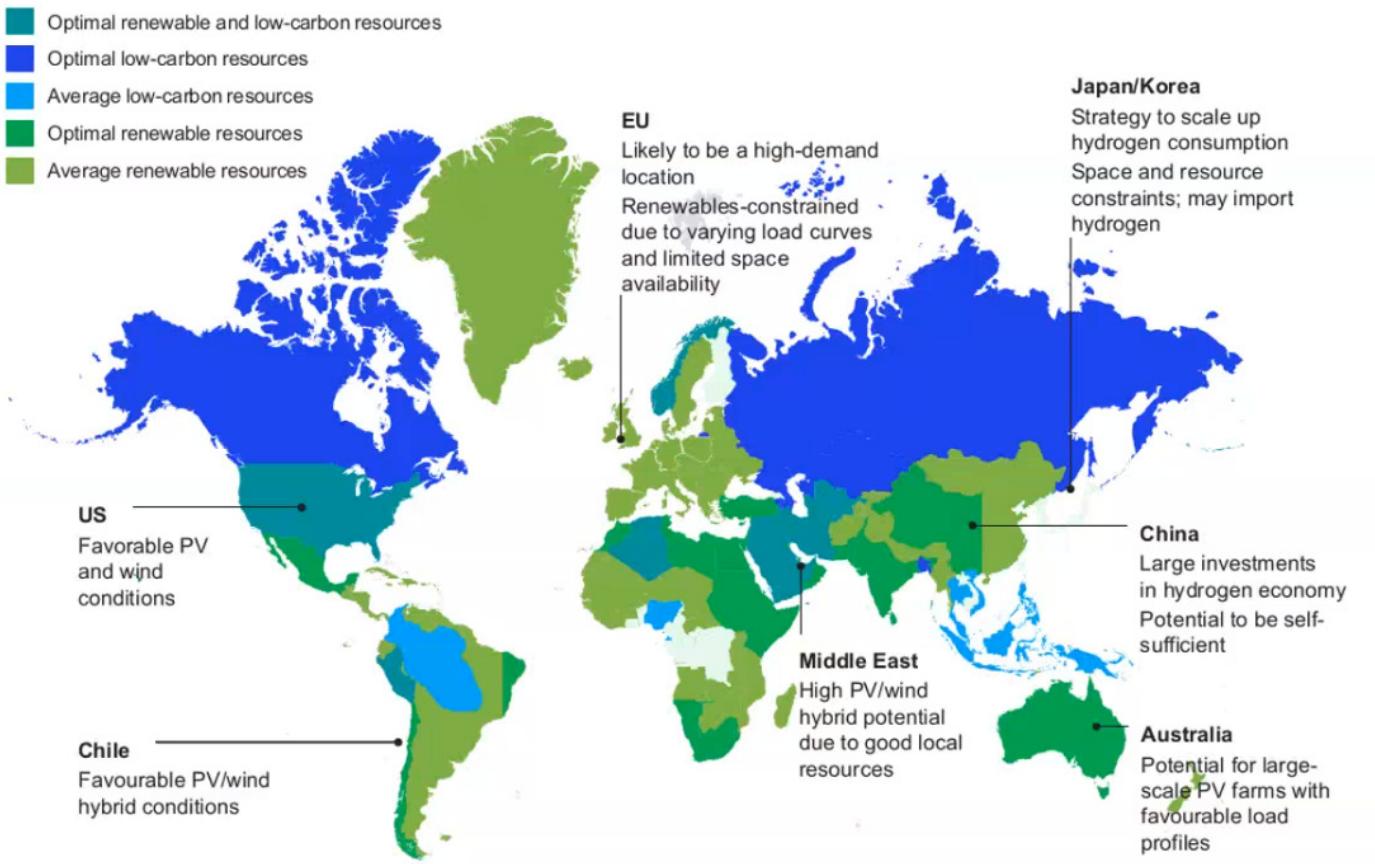
Regions with high potential for Renewables and Low-Carbon Resources

Key drivers…

- High availability of renewables
- Low E-power cost
- CO2 taxes
- Transportation restrictions
- CCS availability

resulting in potential for…

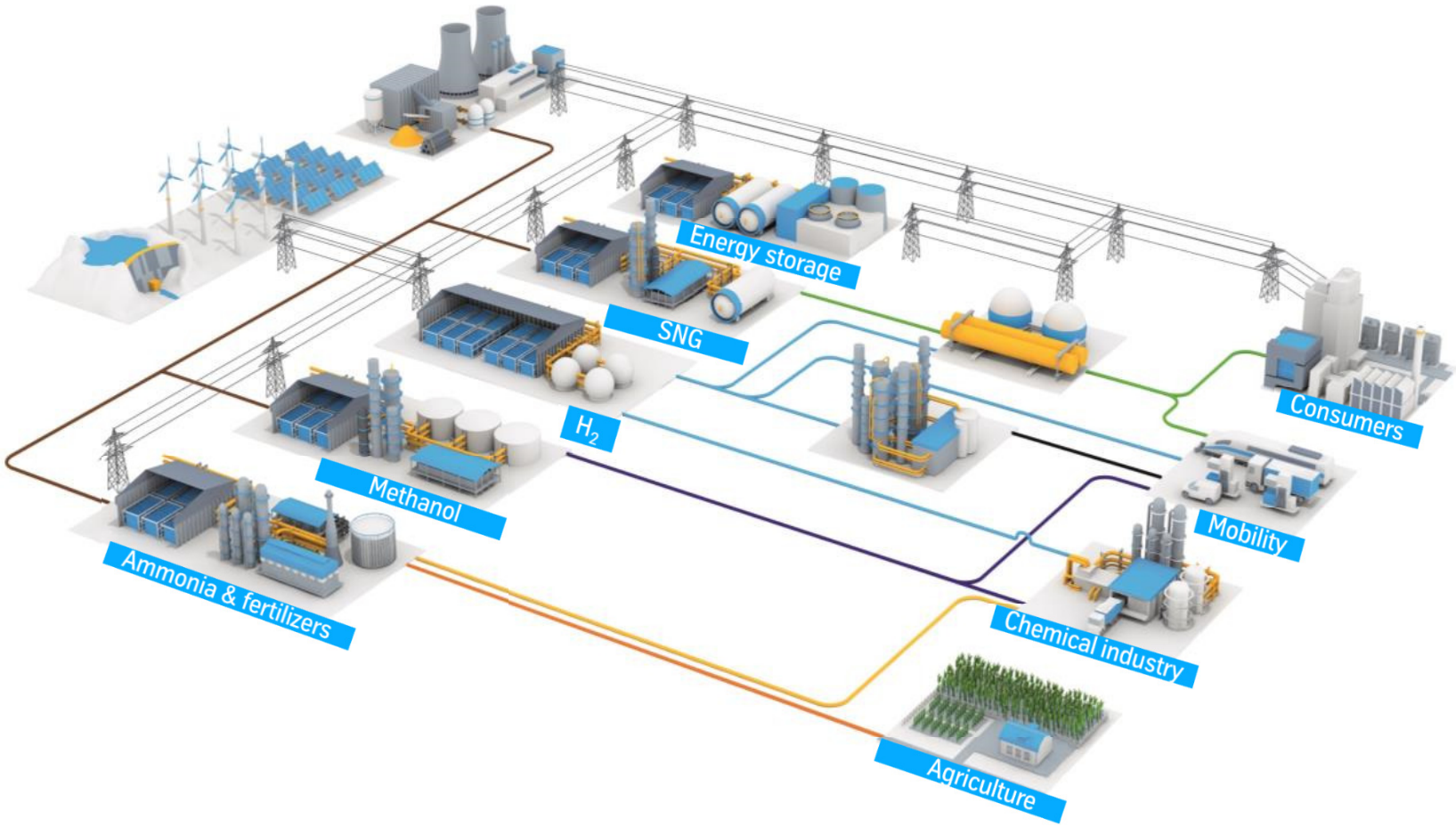
- New business in new regions
- New business in established regions
- Independence of gas prices
- Decentralized production
- Lowering transportation cost



SOURCE: IEA; McKinsey

Several regions have huge potential for PtX business either for CCS solutions or renewable resource solutions

Green Technologies @ Uhde: new value chains & markets unfolding



Applications

Synthetic Fuels & Energy Carriers

- green H2 and green biomass based
- Fischer-Tropsch or Methanol derived
- Carbon-neutral fuels in mobility and heat applications
- NH_3 / SNG as energy carriers for hydrogen

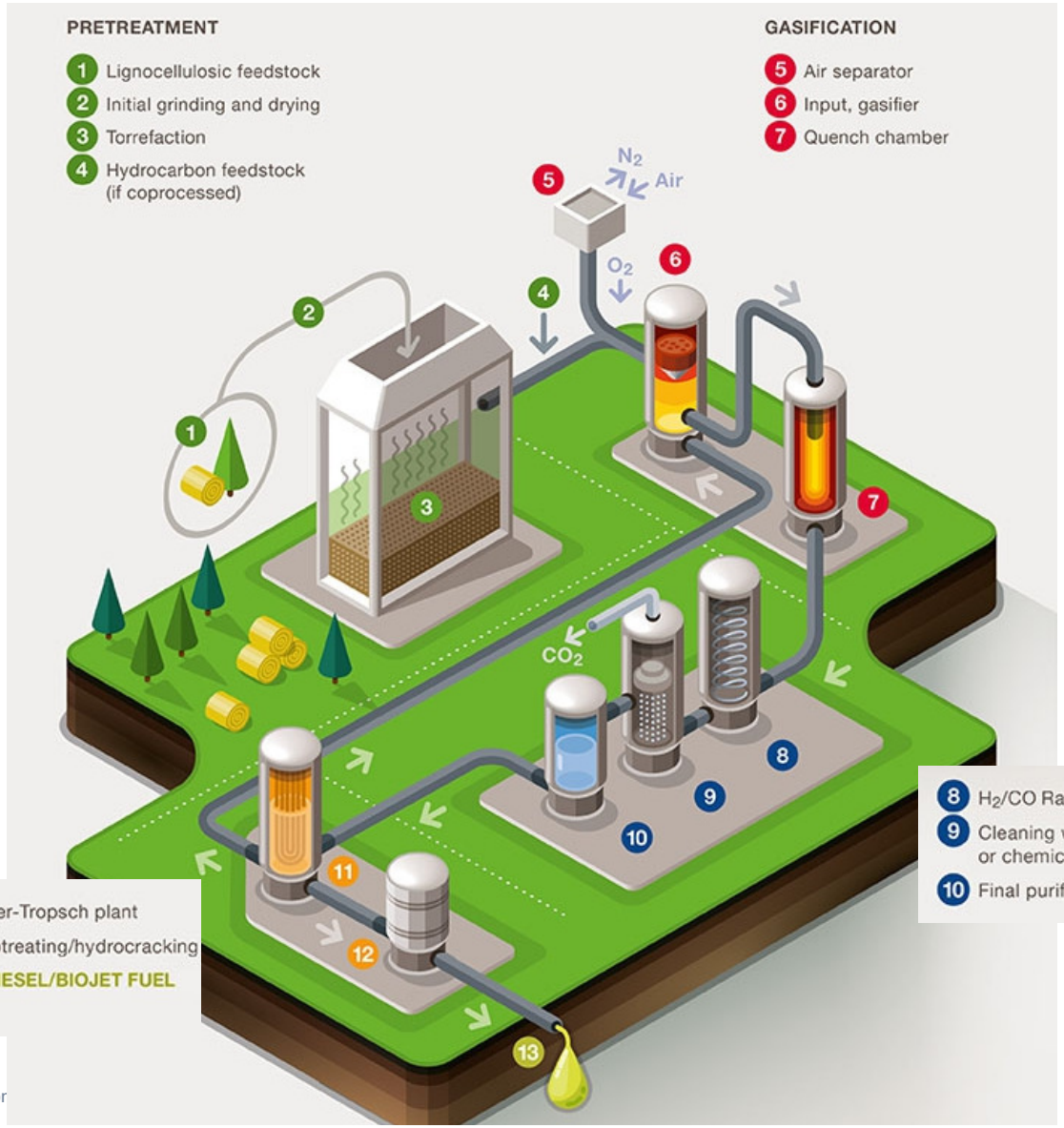
Power-to-hydrogen

- Chemical feedstock (e.g. power to steel)
- Re-electrification (long-term storage)
- Direct use in mobility applications (fuel cells)

Power-to-ammonia

- Chemical feedstock
- Fertilizer
- Energy carrier for hydrogen or direct use for energy
- Re-electrification (long-term storage)

BioTfueL: 2nd Generation bio-diesel and bio-jetfuel process chain



Technology for Bio-Diesel & Bio-Jetfuel

Biomass to green hydrogen to synthetic fuels at Dunkirk, France

Features

Client
Bionext

Technology
PRENFLO

Feedstock
Biomass, petcoke, coal, and meaningful combinations

Product output
FT products

Milestones

2014:	EPC contract
2017:	Mechanical Completion
2019:	Commissioning/start-up
2020:	100% Biomass successfully operated

Koppers-Totzek gasification
Modderfontein, South Africa
coal-to-ammonia/fertilisers

HTW coal gasification
Berrenrath, Germany
coal-to-methanol

Texaco (GE) coal gasification
Oberhausen, Germany
coal-to-hydrogen & oxochemicals

Over **100 Gasifiers** designed, built and put into successful operation by Uhde

PRENFLO coal gasification
Fürstenhausen, Germany
coal-to-syngas

HTW MSW gasification
Niihama, Japan
waste-to-energy

PRENFLO IGCC
Puertollano, Spain
petcoke/coal-to-energy/hydrogen

Our Gasification Experience

Carbon2Chem® Technical Center
From idea to commercial implementation

Pilot plant space:	3 700 m²
Laboratory space:	520 m²
Number of laboratories:	6
Number of offices:	12

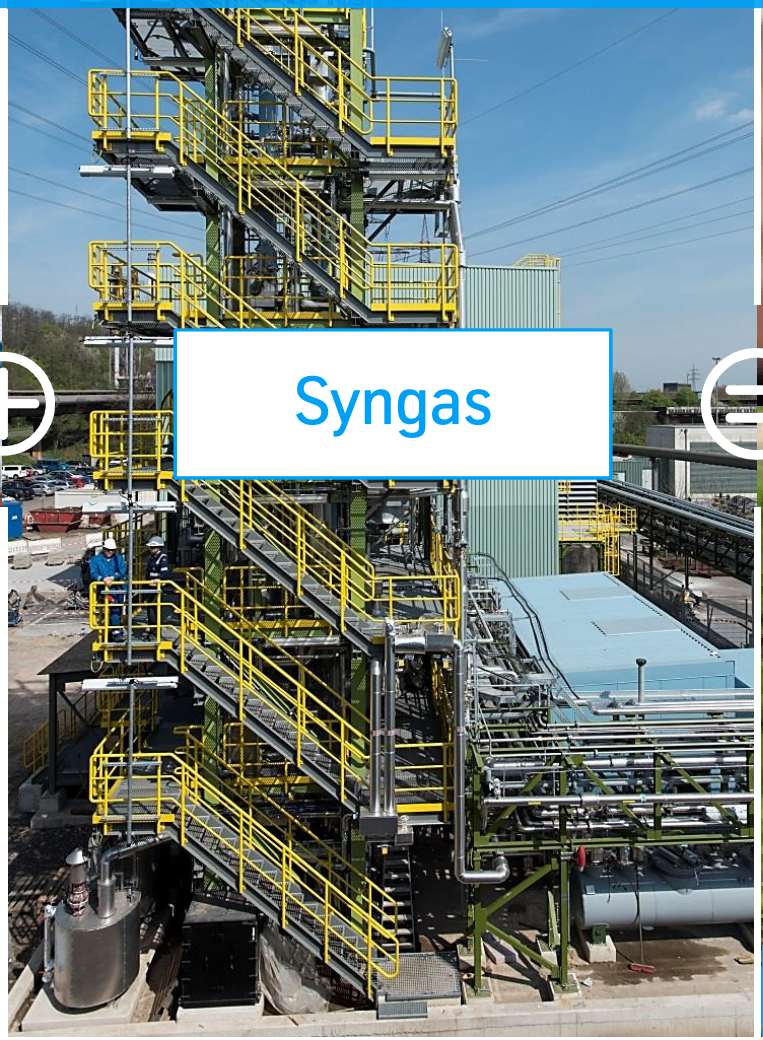
thyssenkrupp

Carbon2Chem®, Duisburg/Germany

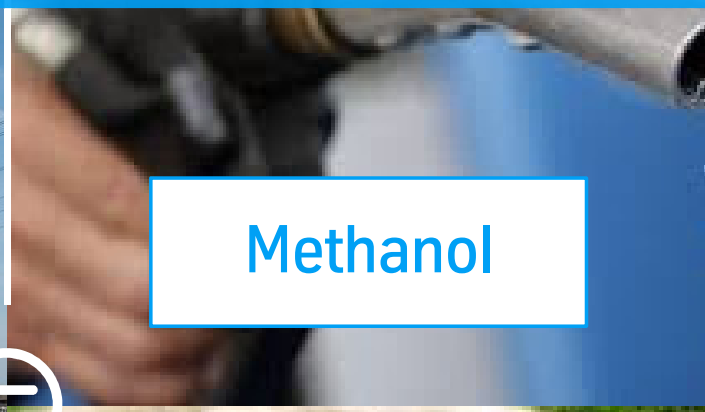
From idea to commercial implementation

Carbon2Chem® supported by
Federal Ministry of Education and Research
BMBF funding numbers 03EK3037 to 03EK3043

H_2



Syngas



Methanol

Ammonia

1st production: 2018

Summary & Conclusions Synfuels

- **Green Synfuels** can play a key role in **defossilization** of the industry and are the only option to sustain the existing assets in the **conventional mobility sector** worldwide (cars, trucks, planes, trains, machinery)

- **Green Synfuels:** all technologies are commercially available – based on **decades of experience** with large-scale applications:
  - **Methanol** Synthesis
  - Biomass **Gasification** (BioTfueL)
  - **MTG** (ExxonMobil) + **MTK** under development
  - **Fischer-Tropsch** Synthesis (Axens)

- **Green Carbon** can be generated via
  - biomass gasification **(BioTfueL)**
  - via CO_2 recycling **(Carbon2Chem)**

- **Green Hydrogen** can be generated via
  - water electrolysis **(UCE)**
  - biomass gasification **(BioTfueL)**

Porsche synthetic E-Fuel gas is just as clean as an EV, exec says

Seriously, synthetic fuel could be a game changer if Porsche's early projections pan out.

Sean Szymkowski Feb. 22, 2021 10:37 a.m. PT

LISTEN - 02:19

If Porsche has its way, your classic 911 may be sucking down sustainably produced synthetic gas before you know it.

Porsche

Thank You for Your Attention.

engineering. tomorrow. together.

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