Hydrogen and breakthrough technologies in the chemical industry

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Innovation Programme

cefic

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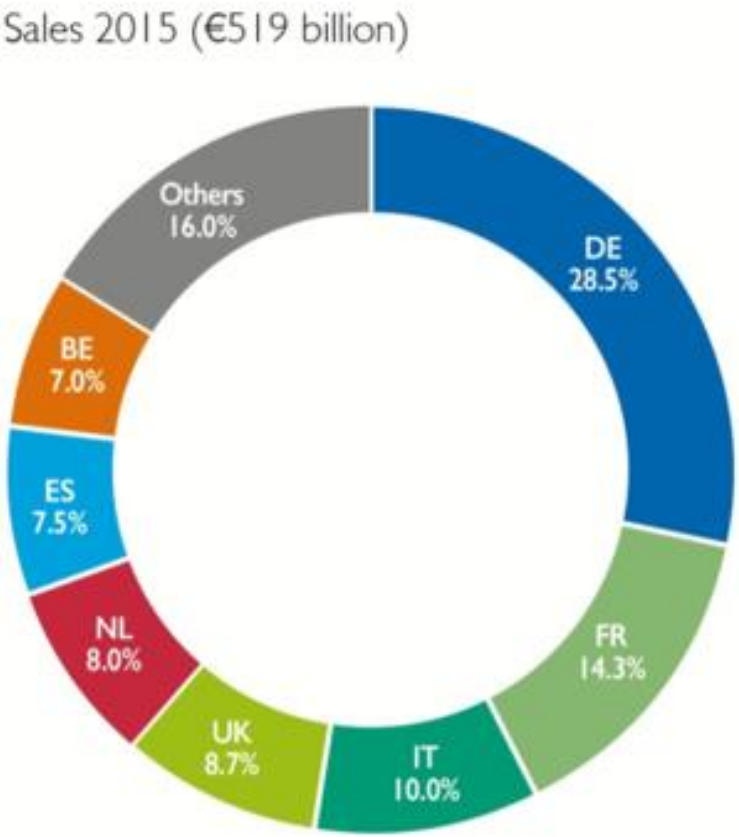
The question: What we offer to EU and what we need to remain competitive?

- ✓1.16 million of jobs
- ✓29 000 companies, 96% SMEs
- ✓€519 billion of revenues
- ✓State of the art **innovative solutions** helping EU to meet its societal challenges

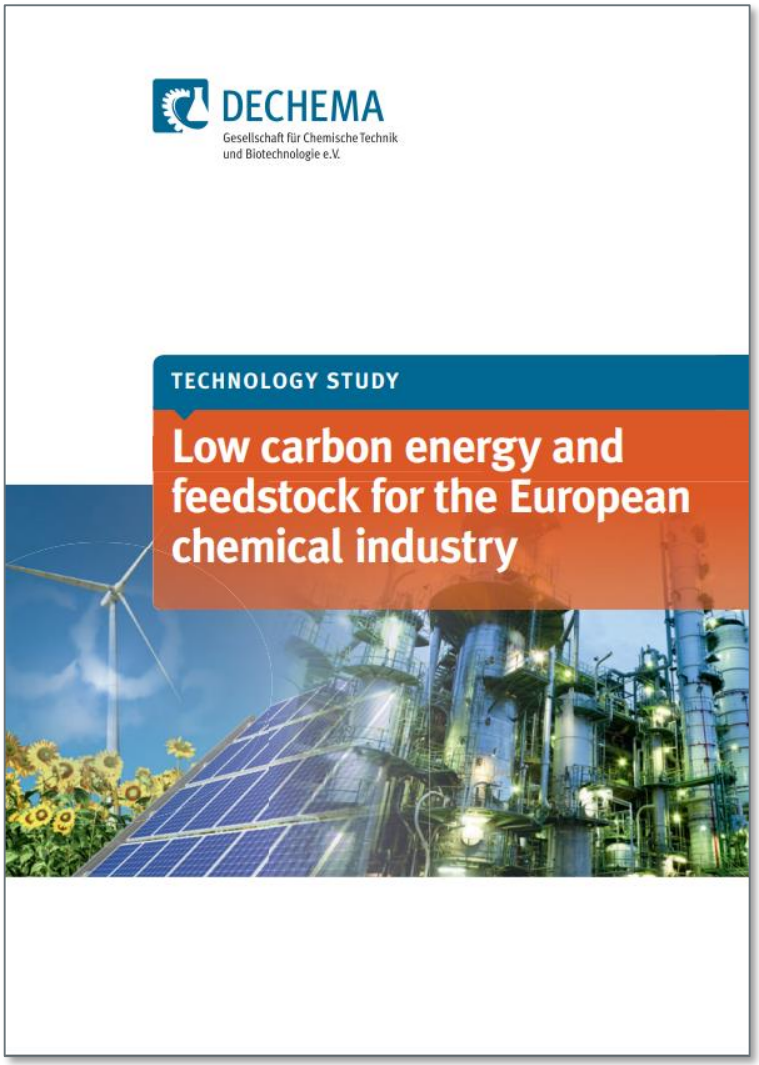


= key EU economic sector

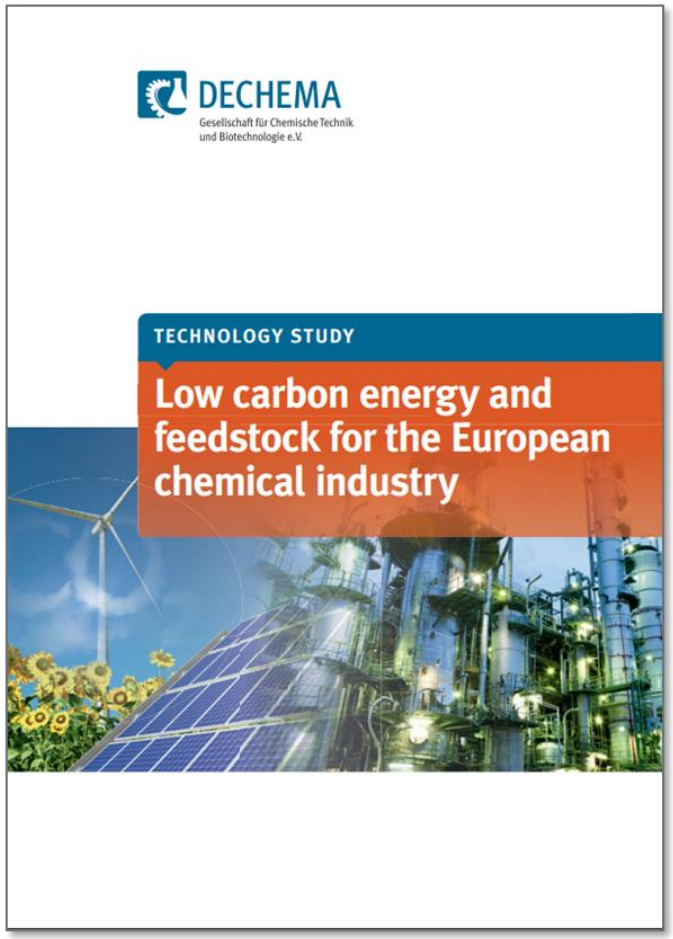
Source: Cefic Chemdata International - data for 2015

The world is changing fast

Dechema study 2016-2017



Dechema – The purpose of the study



- To provide quantitative data as input to the discussion on the future of the European chemical industry and the transition towards a carbon neutral society.
  - Promising low carbon technologies
  - Potential impact on CO_2 emissions reduction
  - Technological and financial limitations and barriers

Study scope

Low-carbon chemical production

- Methanol
- Ethylene
- Propylene
- BTX
- Ammonia (urea)
- Chlorine

accounting for ⅔ of the sector's GHG emissions

+ Low-carbon fuels production and use

Methanol, bioethanol, synfuels

Not included: Impact of chemical products on GHG savings in other sectors

Technological options

Low carbon power supply

Alternative carbon feedstock CO_2 (CO)

Biomass

Industrial symbiosis

Recycling

Power to heat

Energy efficiency

Overview of alternative production routes

Hydrogen/CO_2-based production routes

- Methanol via hydrogen and CO_2 (TRL 7)
- Ethylene and propylene via hydrogen-based methanol (TRL 8-9)
- BTX via hydrogen-based methanol (TRL 7)
- Synthetic diesel and kerosene via H_2 -based syngas and FT (TRL 5-7)
- Ammonia and urea via hydrogen and CO_2 (TRL 7)

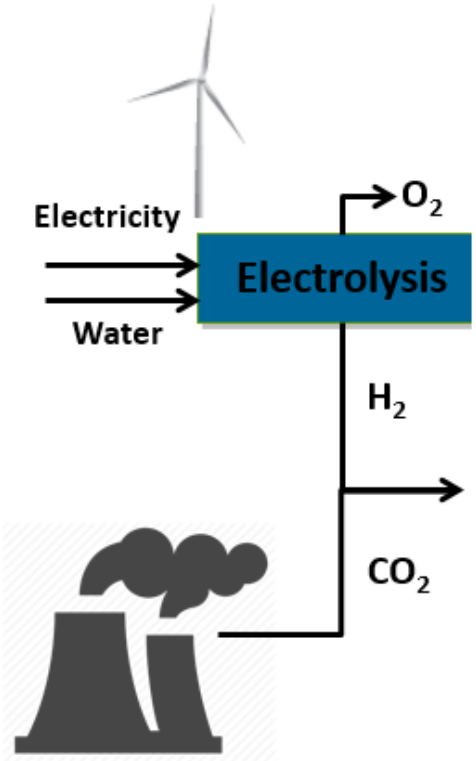
Biomass based routes

- Methanol from biomass (TRL 7)
- Ethanol from biomass (TRL 7-9)
- Ethylene from biomass (TRL 7-9)
- BTX from biomass (TRL 5-6)

Electricity based processes

- Chlorine production (TRL 9)
- Power to Heat

CO_2 valorization with H_2



$3\ H_2 + CO_2$ → Methanol synthesis → CH_3OH

- CH_3OH → MTO reaction → Ethylene & propylene: C_2H_4 und C_3H_6
- CH_3OH → condensation → DME: $CH_3\text{-}O\text{-}CH_3$
- CH_3OH → MTG reaction → gasoline/fuels: $CH_3\text{-}(CH_2)_n\text{-}CH_3 + n\ H_2O$

$n\ H_2 + CO_2$ → Fischer-Tropsch synthesis → hydrocarbons/fuels: $CH_3\text{-}(CH_2)_n\text{-}CH_3 + nH_2O$

$3\ H_2 + N_2$ → Ammonia synthesis → Ammonia to further products: $NH_3 + CO_2$ → urea: H_2NCONH_2

Scenarios

Business as Usual; low limit scenario assuming required extension of existing capacities, but no implementation of new technology options and no further advancement of efficiency measures

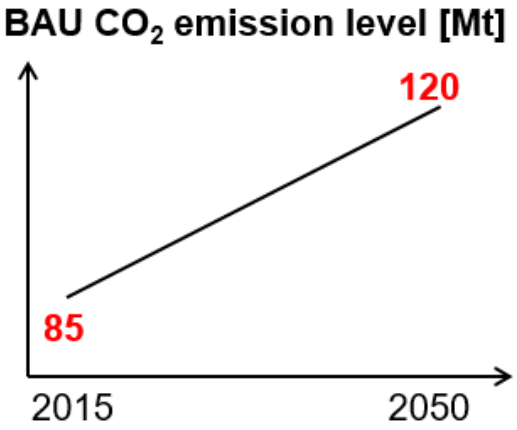
Intermediate; continuous efficiency improvements of 1% annually and slow starting, but steadily increasing deployment of breakthrough technologies; assumptions: policy measures to support emission reduction and pathways become sufficiently competitive, no early replacement of old plants

Ambitious; consequent implementation of technology options, fuel sector fully supports transition to carbon-neutral fuels; assumptions: minimum time for R&D, pilot or demonstration activities, commercial deployment without delays; full policy support and no economic constraints as hurdle; old plants are replaced early, decommissioning of depreciated plants.

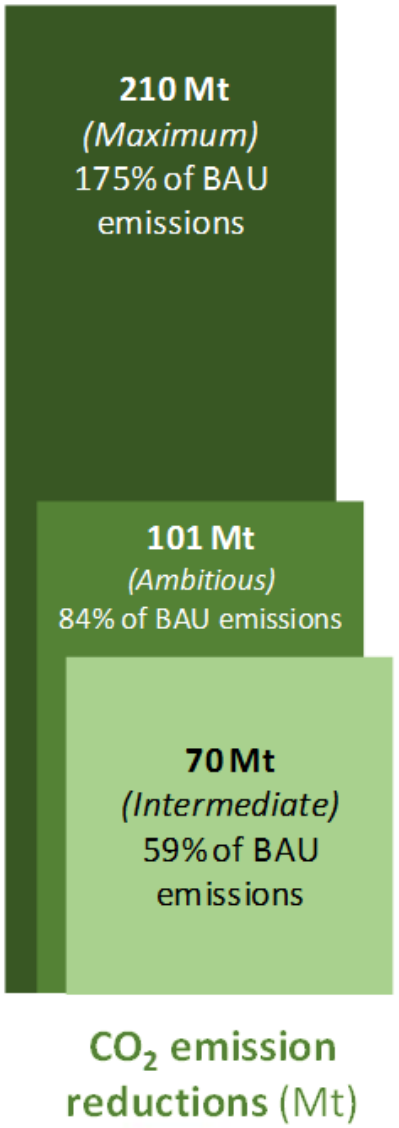
Maximum scenario; full carbon neutrality of the chemical industry and fuel sector by 2050 via a mix of the described technologies

Dechema report - Main conclusions (1)

CO_2 emission reductions

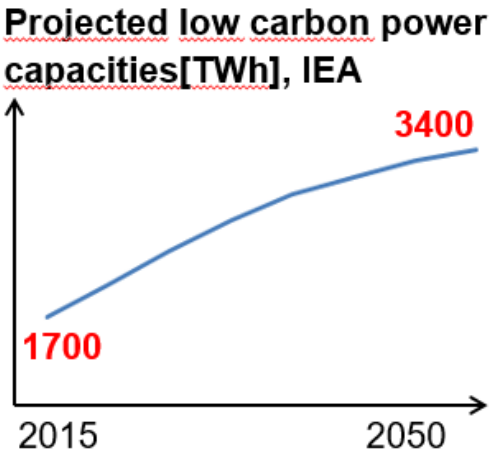


- High level of ambition as prerequisite for reaching GHG neutrality
- If fuels are included higher impact is leveraged

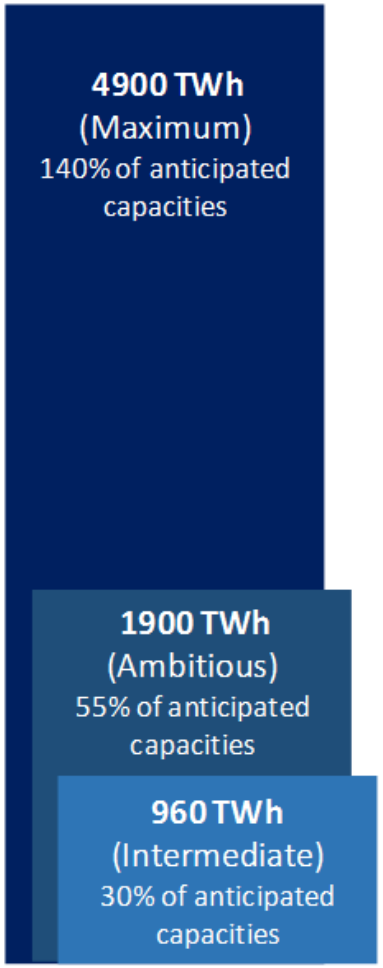


Dechema report - Main conclusions (2)

Low-carbon power demand for electricity-based processes



- Much more ambitious extension of low-carbon power capacities required, at least a factor 2 of the level currently anticipated by the IEA
- Critical factor outside the control of the chemical industry

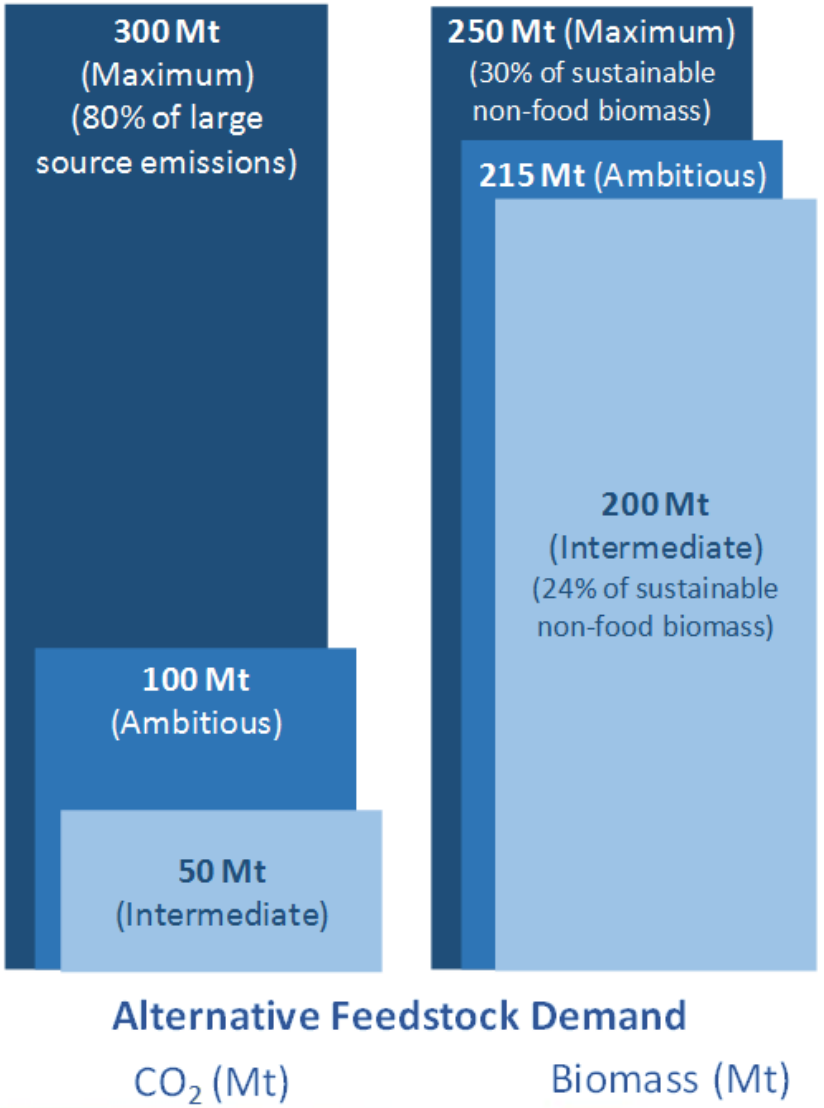


Low-carbon power Demand (TWh)

Dechema report - Main conclusions (3)

Feedstock demand

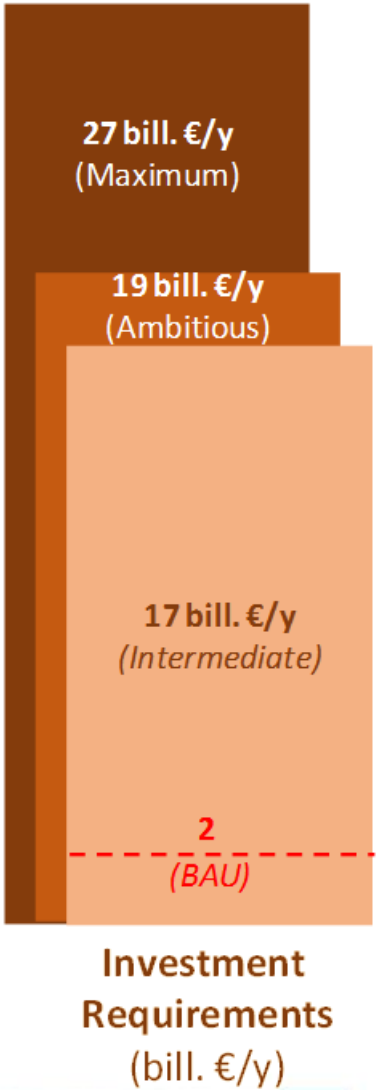
- CO_2 availability from industrial sources, to produce high volume chemicals is not a limiting factor in the investigated timeframe
- Non-food biomass availability for production of high volume chemicals is an issue, efficient biomass utilization is mandatory



Dechema report - Main conclusions (4)

Economic challenges

- Very high investment required
- Production cost levels from 2 (e.g. methanol) to 5 (e.g. BTX) times higher than fossil-based products; driven by electricity and feedstock cost
- Economic gap can only partly be reduced by research and innovation



Research, development and innovation requirements

Area	RD&I topic
Power to heat	Heat pump technology
Power to hydrogen	Hydrolysis technology (PEM, AEM, SOE, …)
Alternative H_2 production	Pyrolysis, photolysis, thermochemical process & CSP
Power to chemicals	Electrolysis improvement Electrochemical and –catalytic process improvement Plasma technology
Biomass	Lignocellulosic technologies
Alternative chemical production	New synthesis routes for Ammonia and Olefins (e.g. direct electrocatalytic conversion)
Circular economy and industrial symbiosis	Valorisation of waste streams and residues

Key messages

Challenges

Access to cheap and abundant low carbon energy as prerequisite

Biomass availability (*focus the use of biomass feedstock on highly functionalised chemical components with high biomass utilisation efficiencies)*

Large investments

Production cost not competitive

Priorties

Initiate ambitious R&I programmes, priority topics are e.g. efficient hydrogen generation and better valorization of biomass

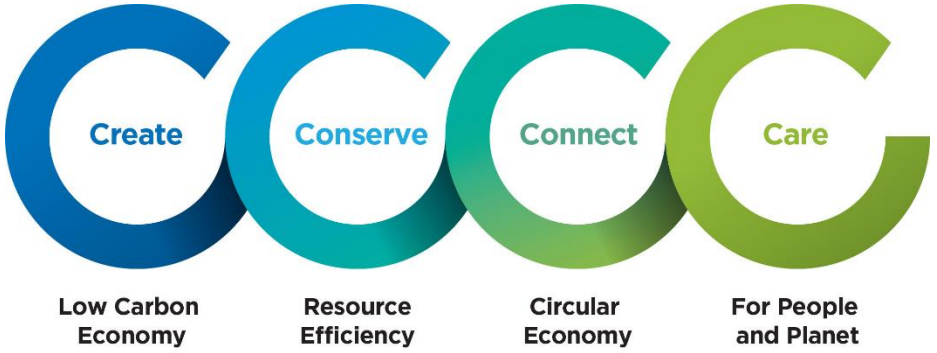
Engage in public-private partnerships to enable deployment and risk sharing

Intensify the dialogue between public and private stakeholders, facilitate more (cross-sectorial) collaboration models and strong policy support

The Cefic Sustainability Charter

https://chemistrycan.com/

- **Enabling role of the European chemical industry for a sustainable society**
- **Supporting role for Cefic**
- **Roadmap to progress in Sustainable Development:**



Thank you

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