NEW ENERGY FOR INDUSTRY

Industrial energy demand and GHG emission scenarios 2050 under changing technologies

- an Austrian case study

IEWT,
Vienna 2023

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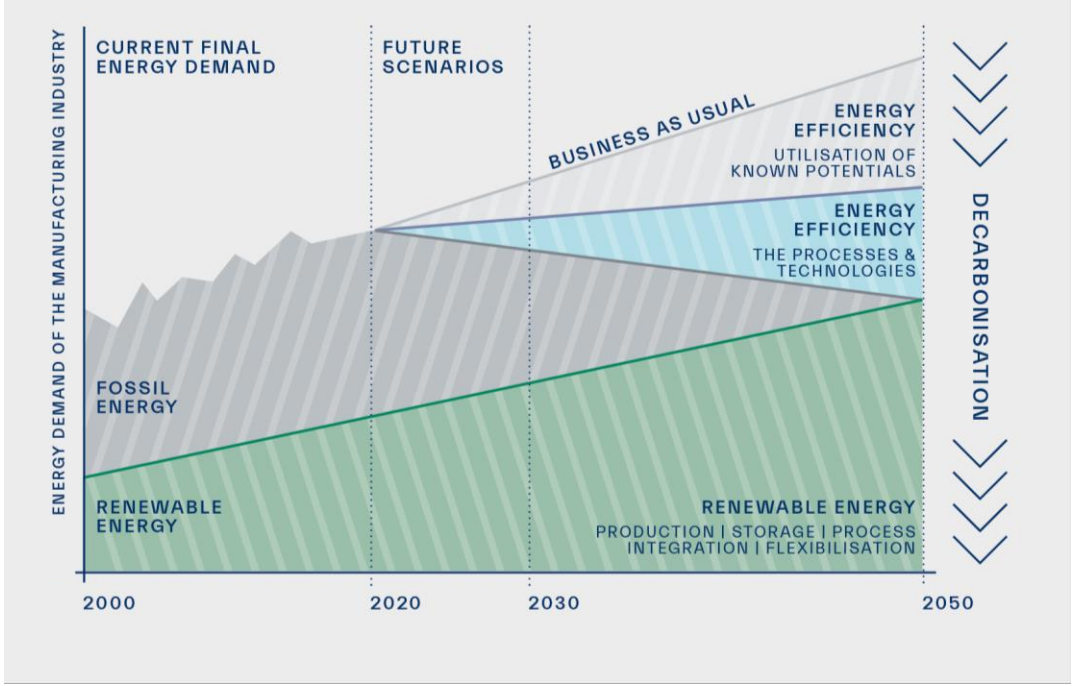
Austrian Institute of Technology

NEFI is an Energy Model Region funded by the Austrian Climate and Energy Fund.

VISION & GOALS

NEFI key technologies “Made in Austria” enable the decarbonisation of industrial energy systems and help to secure Austria’s position as an industrial location.



Decarbonisation of industrial energy systems

100 % renewable energy supply at selected locations

Added value “Made in Austria”

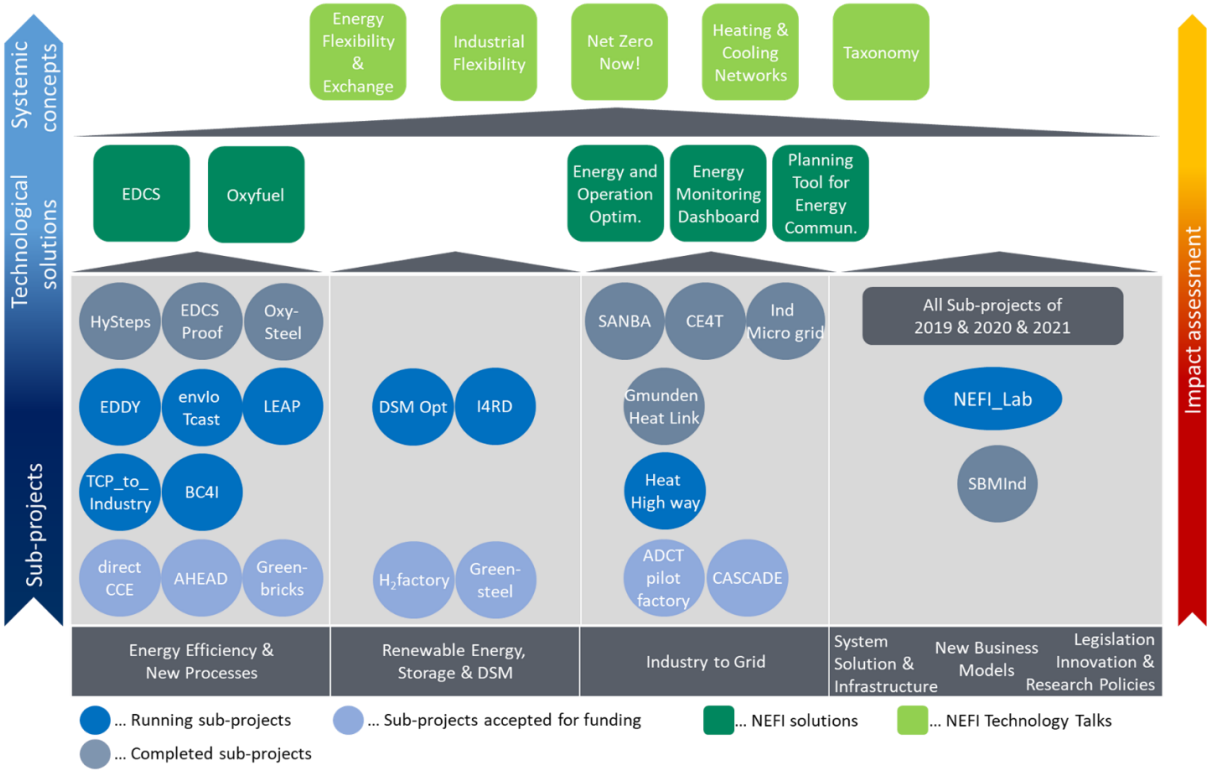
through export and technology development

Securing the industry location

contribution to the economic location Austria by user involvement

NEFI INNOVATION NETWORK

INNOVATION FIELDS – PROJECT LANDSCAPE – TECHNOLOGY SOLUTIONS



- 8 completed projects
- 9 running projects
- 7 starting projects

- Up to 100 Mio € total project volume (depending on KPC funding decision)
- 30 Mio € funding volume (KLIEN)
- KPC funding (decision pending)

- 125 partners from industry, RTOs and public institutions

DECARBONISATION SCENARIOS

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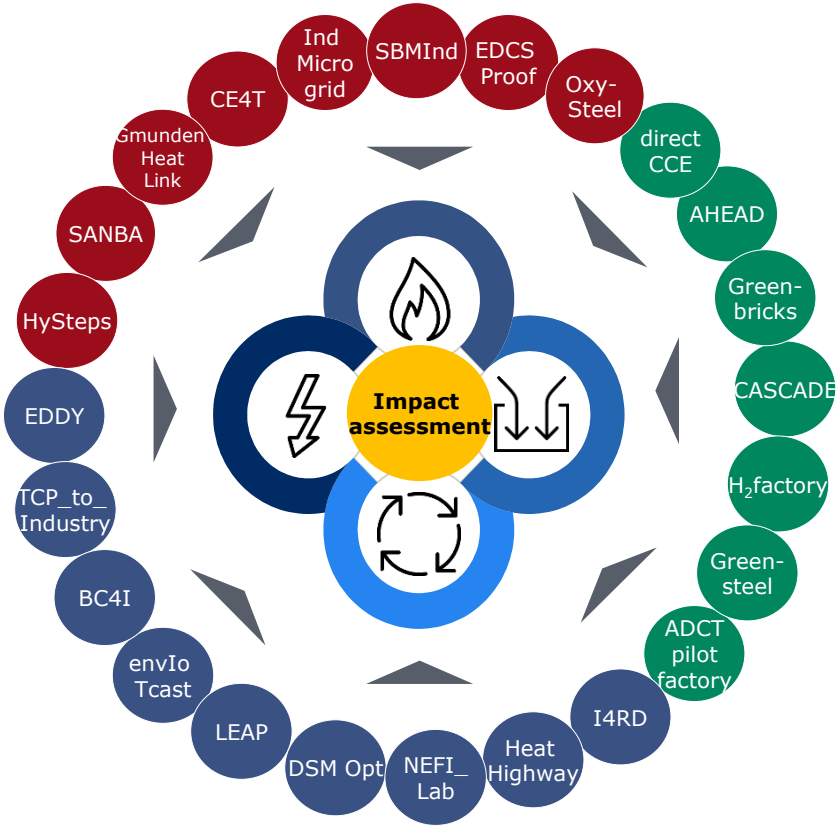
LEVERS OF ACTION

1. CO_2-neutral gases and biomass
- Hydrogen
- Bio-CH4
- Synthetic CH4
- Solid biomass

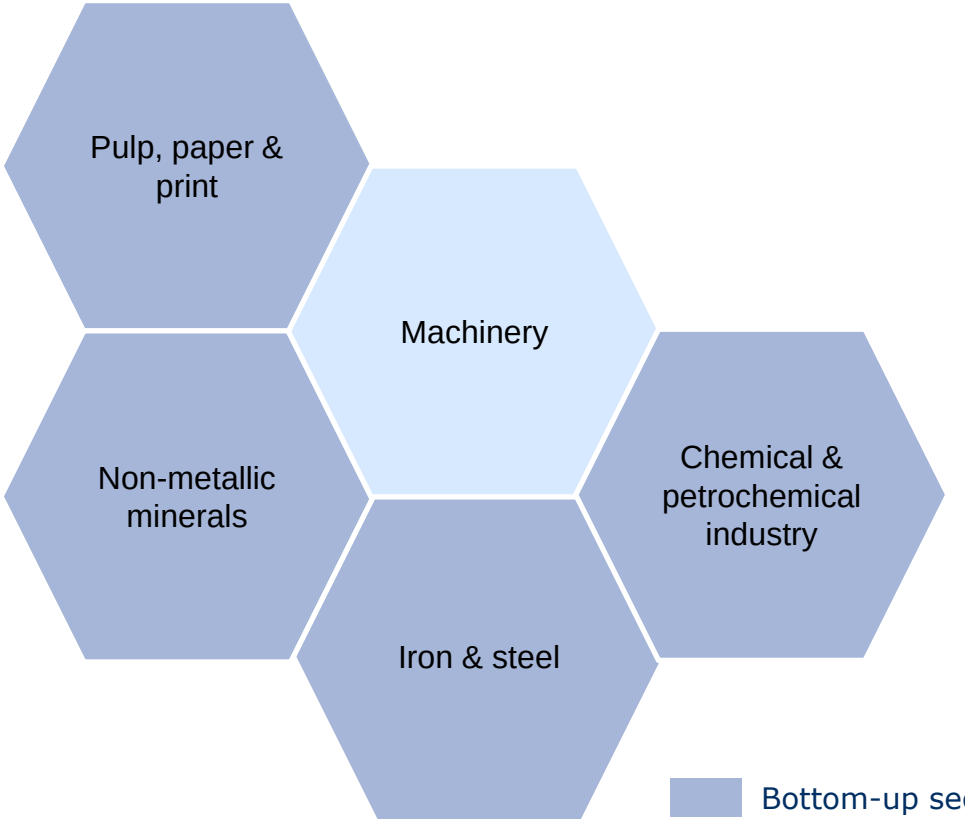
2. Electrification and energy efficiency
- Process efficiency improvements
- Heat pumps
- Stationary engines

3. Carbon capture
- Sequestration of geogenous emissions

4. Circular economy
- Increased use of end-of-life materials
- CO2-Usage for material production



TECHNOLOGY-BASED PROJECTIONS OF SECTOR PATHWAYS



We show…

- highlights of NEFI projects developing key technologies
- selected results in scenarios
  - Pathway-of-industry
  - Zero-emission

Bottom-up sector investigation in scenarios

SCENARIOS SHOW POSSIBLE TRANSFORMATION PATHWAYS

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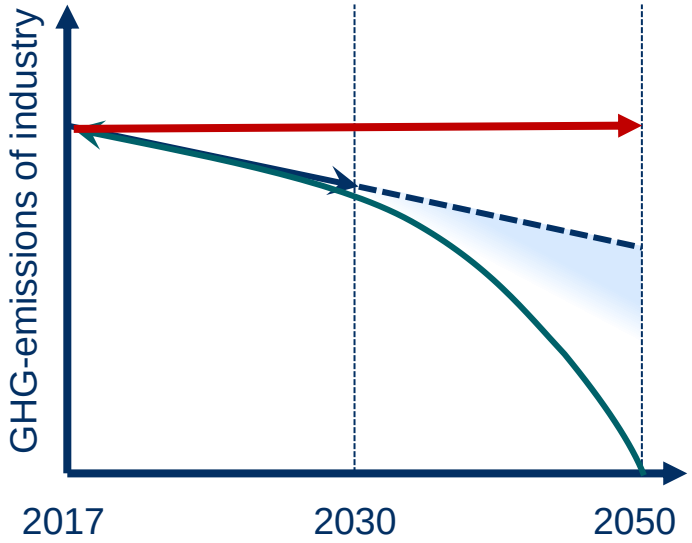
STAKEHOLDER ASSESSMENT OF SECTORSPECIFIC DEVELOPMENTS UNTIL 2030 AND BEYOND ARE CHALLENGED WITH NET-ZERO PATHWAY FROM SCIENTIFC BACKCASTING



Extrapolation of current trends
(Business-as-usual – BAU)

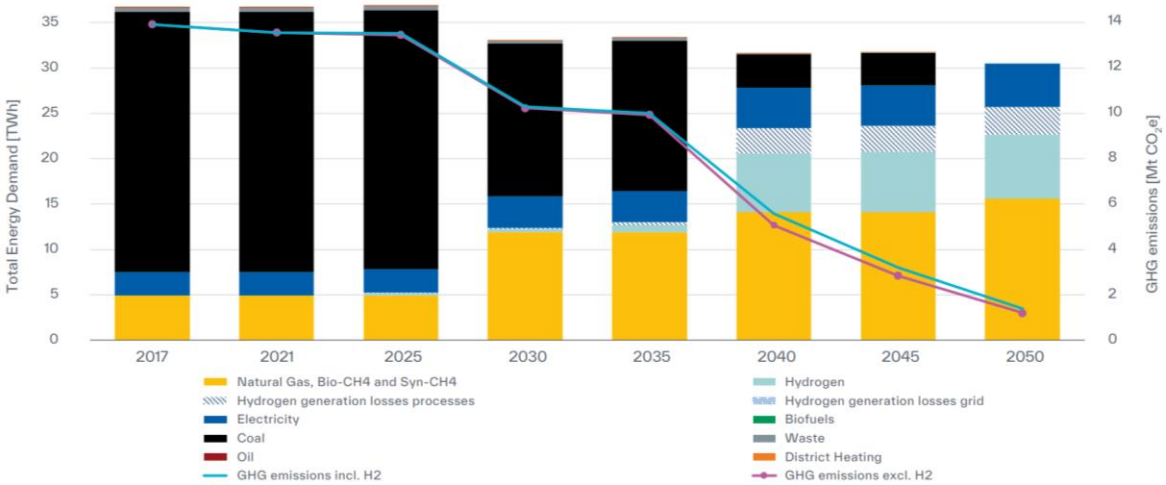
Assessment of sector development by industrial stakeholders until 2030 and beyond
(Pathway-of-industry – PoI)

Pathway for net-zero emissions 2050 according to backcasting methodology
(Zero-emission – ZEM)

IRON & STEEL - POI

CH_4-BASED DIRECT REDUCTION AND EAF

- Increasing usage of CH_4-DR/EAF incl. 30% H_2 per unit
- Substitution of 29 TWh coal/coke with 22 TWh of green gases
- Electricity demand for electrolysis can sit in- or outside the industrial balance border

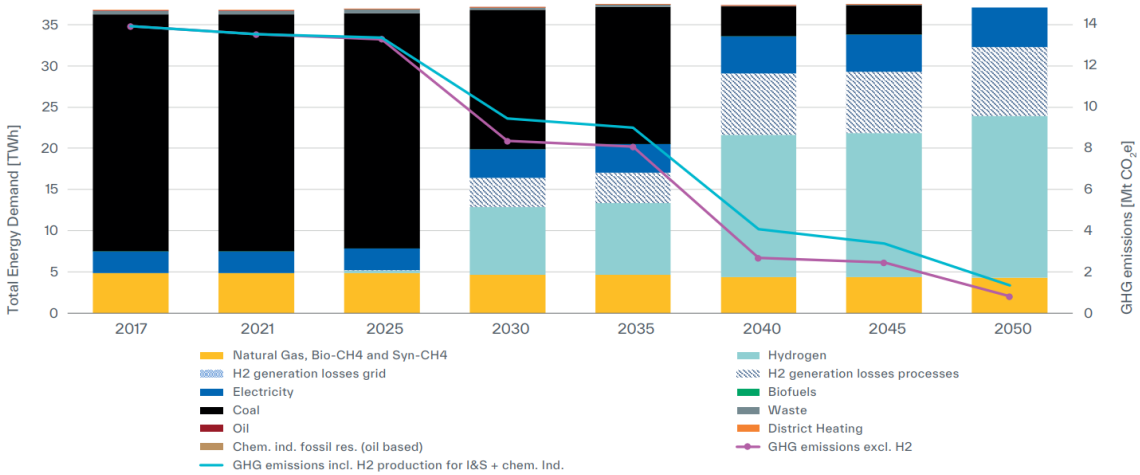


DR: Direct reduction, EAF: Electric arc furnace.

IRON & STEEL - ZEM

PRIMARY STEELMAKING IS THE MAIN DRIVER

- Usage of H_2-DR/EAF
- Increased electricity demand for electrolysis
  - Depending on the location: can sit in- or outside the industrial balance border
  - Residual emissions: 1 Mt CO_2

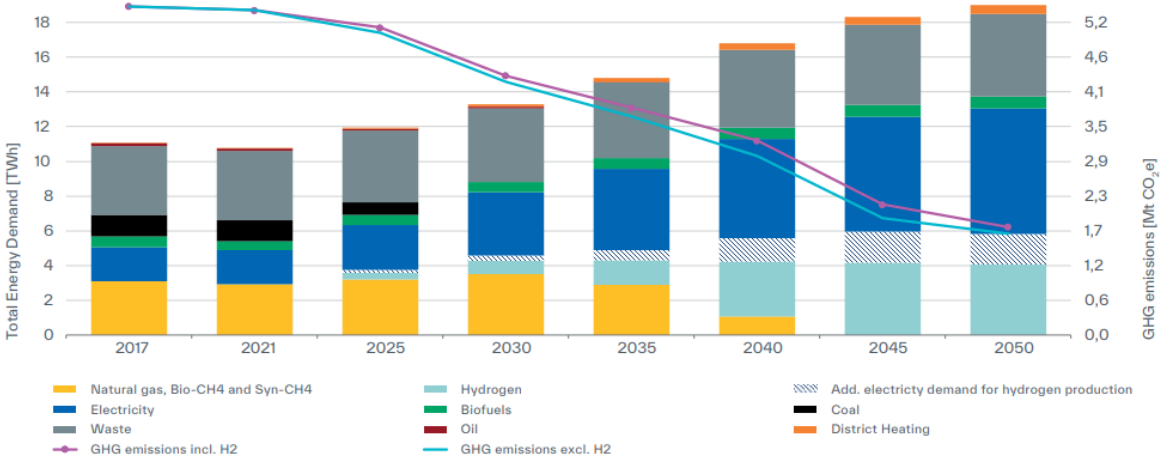


DR: Direct reduction, EAF: Electric arc furnace.

NON-METALLIC MINERALS - POI

AMINE SCRUBBER REQUIRES ADDITIONAL ENERGY

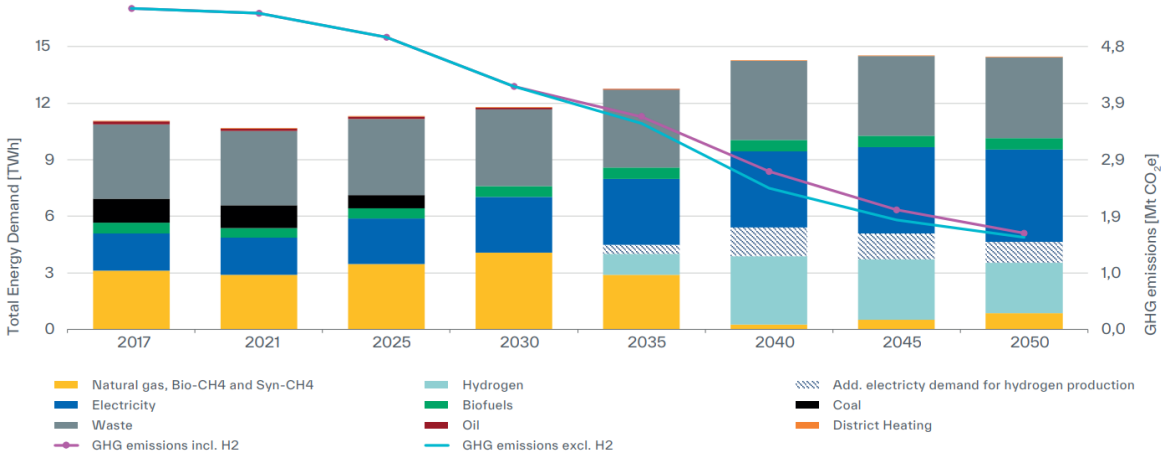
- Carbon Capture by amine scrubbing
  - Readily available technology
- No investigation of further usage/storage after sequestration
- Required energy provided through heat pumps (@130°C)



NON-METALLIC MINERALS - ZEM

INCREASED ELECTRIFICATION (DIRECT+INDIRECT)

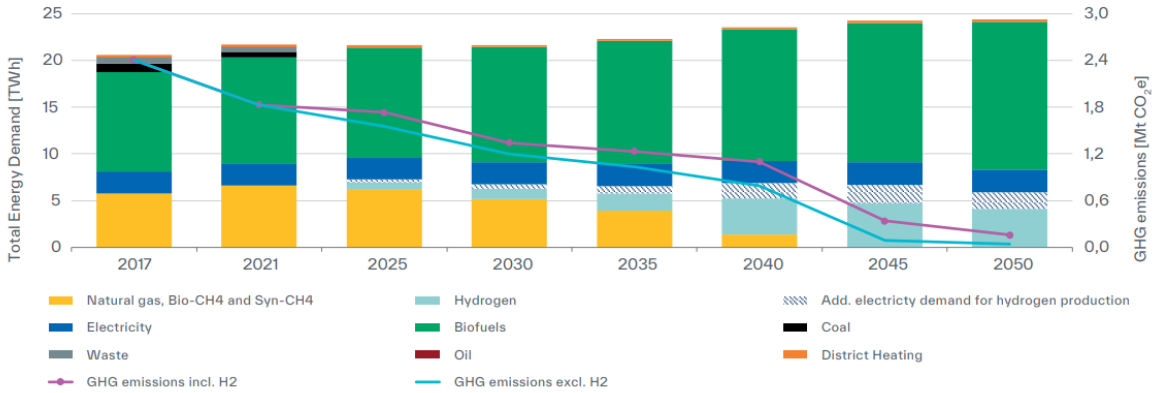
- Carbon capture with Oxyfuel
- No investigation of further usage/storage after sequestration
- Electrification
  - e.g. melting glass



PULP, PAPER & PRINT - POI

INTENSIFIED BIOMASS COMBUSTION

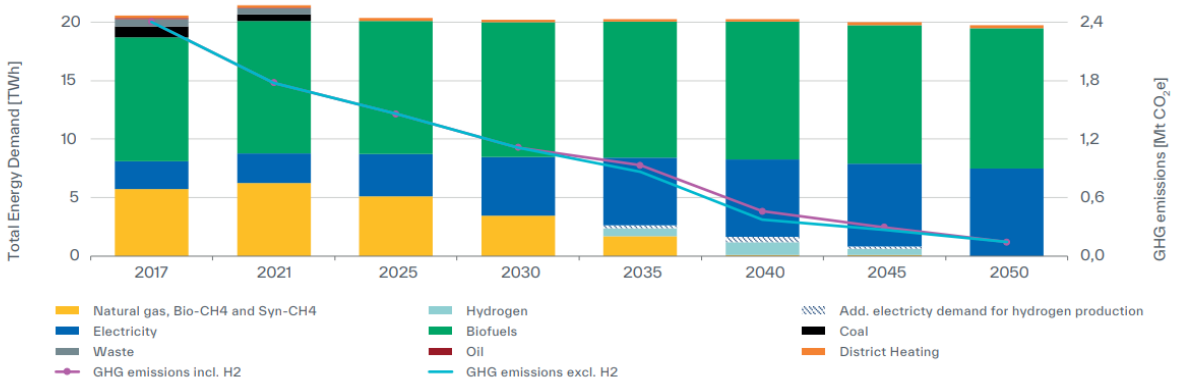
- Extension of current supply routes for biomass for combustion
- Retention of current plant structure
  - e.g. CHP-plants



PULP, PAPER & PRINT - ZEM

USE OF HEAT PUMPS UP TO 150°C

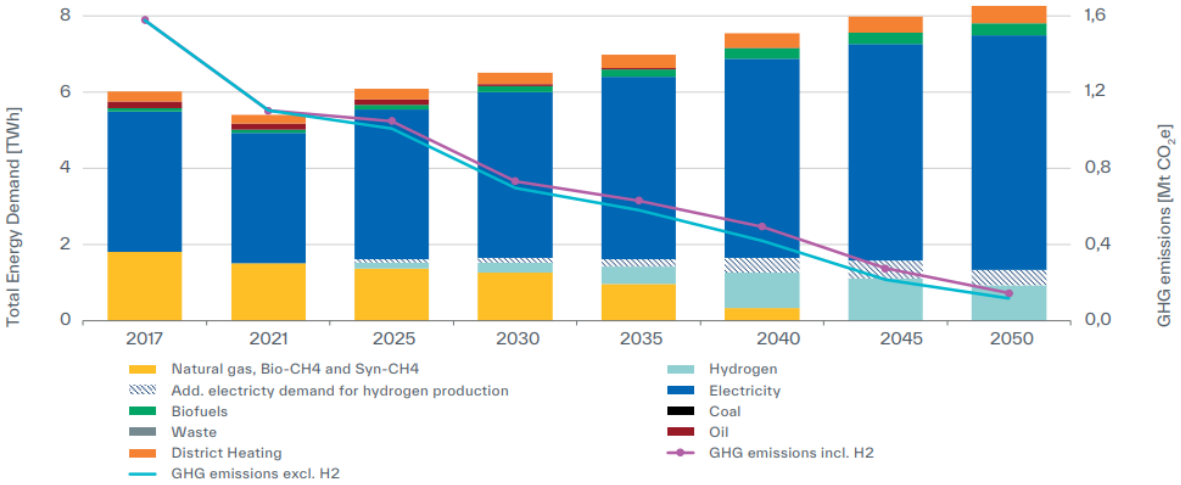
- Increased electrification
  - CHP operated exclusively with biogenic residues
  - Increased amounts of electricity purchased from outside
  - Production growth counterbalances increased efficiency



MACHINERY - POI

EXTENSIVE ELECTRIFICATION OF PROCESS HEAT

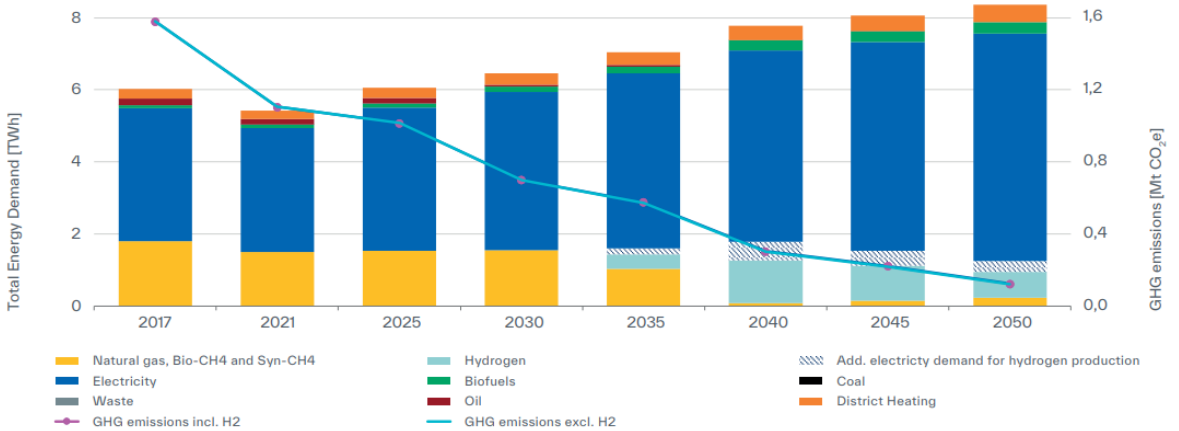
- Lower temperature levels provided by heat pumps
- Higher temperature levels (>150°C) provided by dir. heat
- Energy efficiency cannot compensate fully for production increase (approx. 50%)



MACHINERY - ZEM

EMISSION REDUCTIONS ARE GRID-DRIVEN

- Machinery sector is representative of other less energy intensive sectors
- Production growth outweighs energy efficiency gains
- Main drivers are heat recovery and use with heat pumps
- Hydrogen is only used in high temperature applications



CHEMICAL INDUSTRY - POI

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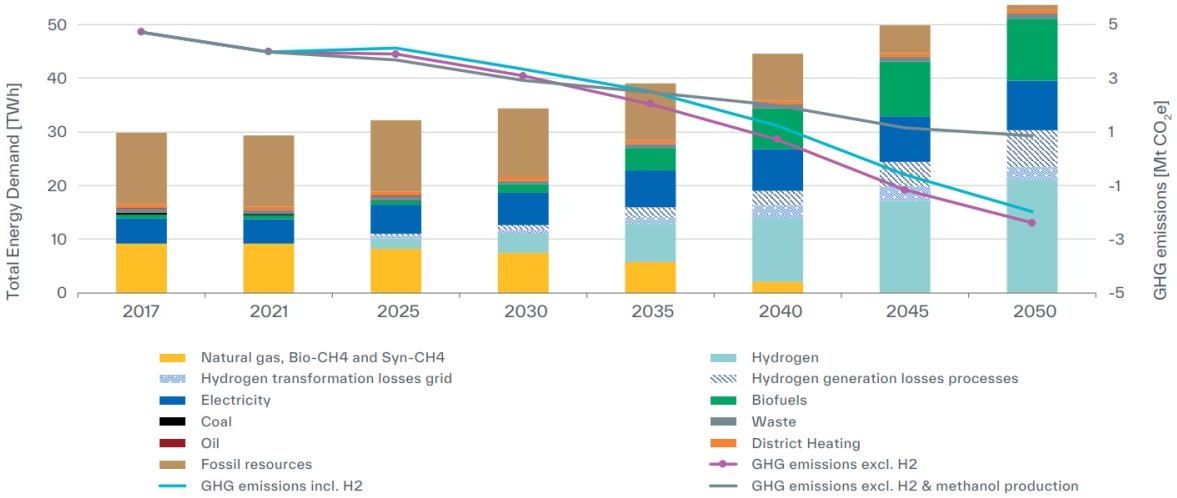
FEEDSTOCK SWITCH TO METHANOL PROVIDES A CARBON SINK

- H_2 replaces Methane, bio fuels replace nat. gas in methanol- and melamine synthesis
- Multiplying methanol demand for melamine synthesis increases energy intensity and provides a carbon sink
- Ammonia produced via CO_2 - reduction by H_2.
- Nitrate production via compressors with heat recovery
- Urea production via electric heaters

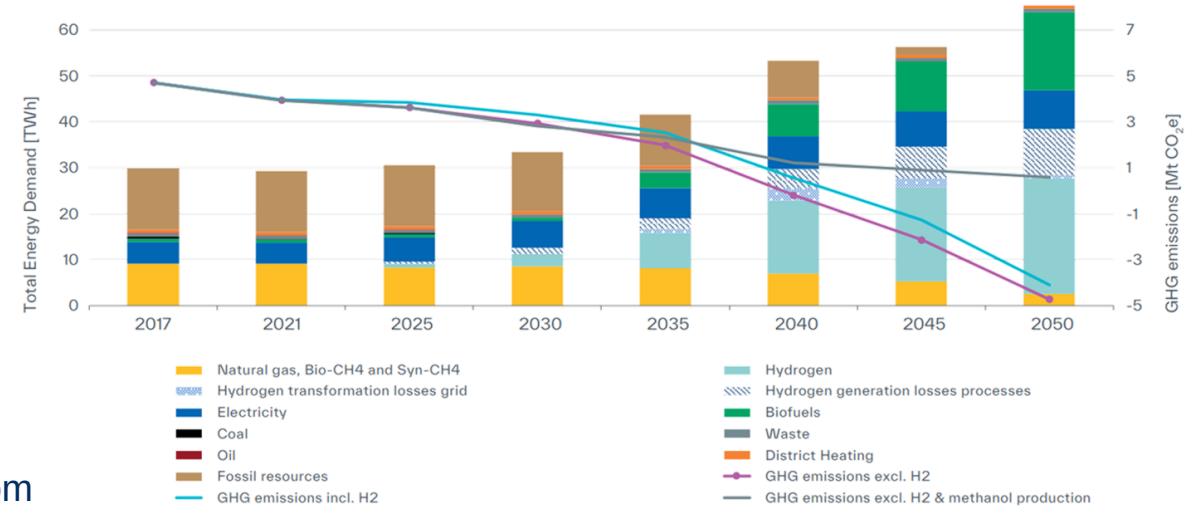


Negative emissions from 2040 only in the balance border of the industry. Currently these 4Mt are released in the end of life use in incinerators.

CHEMICAL INDUSTRY - ZEM

NATURAL GAS IS REPLACED BY HYDROGEN AND BIO-CH_4

- Olefin production from naphtha will be phased out by 2050.
- Methanol synthesis from 2040 only from biomass and hydrogen + CO_2
- Complete electrification of the saltpeter, urea and fertilizer production
- Electricity requirement increases from 5 TWh to 8 TWh, or including hydrogen production to 44 TWh!



Negative emissions from 2040 only in the balance border of the industry. Currently these 4Mt are released in the end of life use in incinerators.

NEFI'S LEVERS OF ACTION FOR CLIMATE NEUTRALITY - POI

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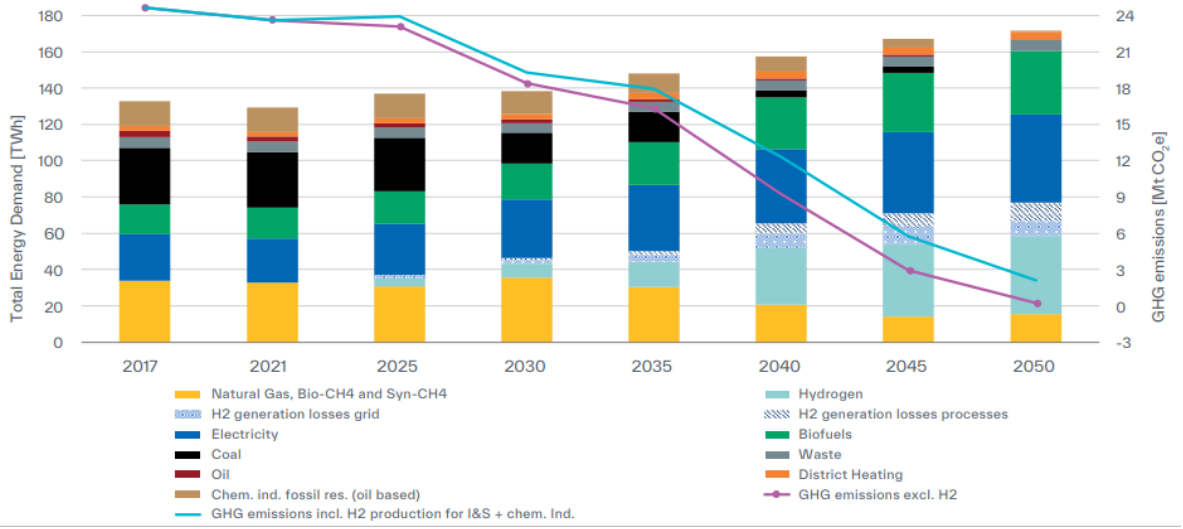
COMPARISON OF SCENARIO RESULTS – IDENTIFICATION OF NO-REGRET MEASURES

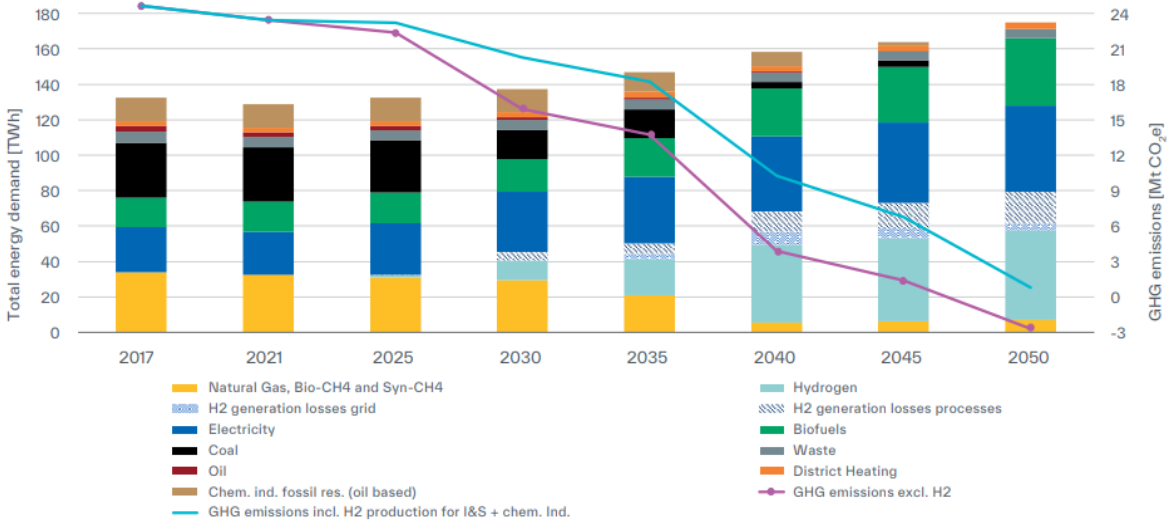
- Few differences between POI and ZEM indicate robust results
- There is no silver bullet – decarbonisation is driven by a combination of technology levers
  - CO_2-neutral gases for high temperature applications and feedstock
  - CCUS especially for mitigation of geogenous emissions
  - Electrification through heat pumps for low temperature applications
  - Circular economy can reduce energy demand additionally



NEFI'S LEVERS OF ACTION FOR CLIMATE NEUTRALITY - ZEM

COMPARISON OF SCENARIO RESULTS – IDENTIFICATION OF NO-REGRET MEASURES

- Few differences between POI and ZEM indicate robust results
- This transformation needs:
  - Further pilot plants
  - Scale-up of existing prototypes to industrial solutions
  - Accompanying development of necessary infrastrucutre
  - Further research (especially regarding integration of future industrial systems into the overall energy system)



LEARNINGS

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KEY TAKE-AWAYS

- The one central enabler of industry decarbonisation is the availability of abundant CO_2-neutral electricity. Imports of renewables (H_2-based) must be organized NOW.
- Electrification provides large efficiency gains AND better process control, possibly enabling product quality increases.
- Individual implementation concepts are necessary for processes. Therefore, additional R&D is necessary.

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