

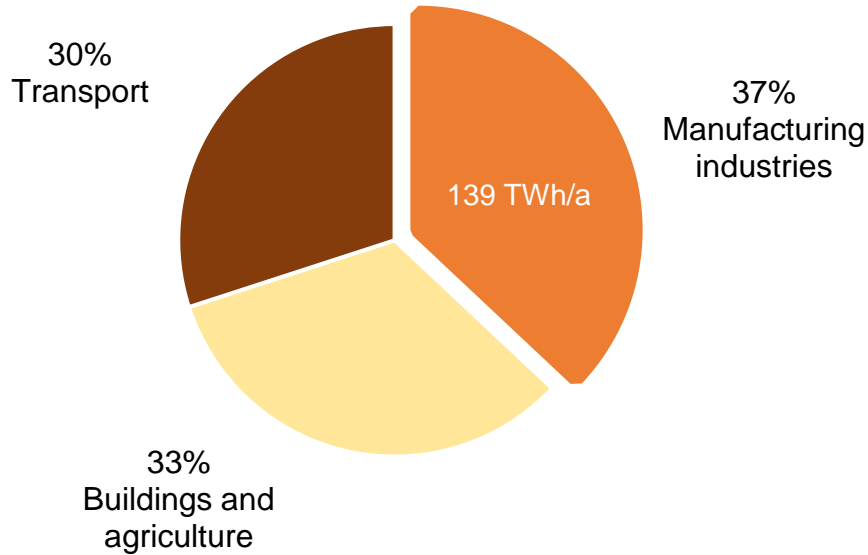


NEW ENERGY FOR INDUSTRY

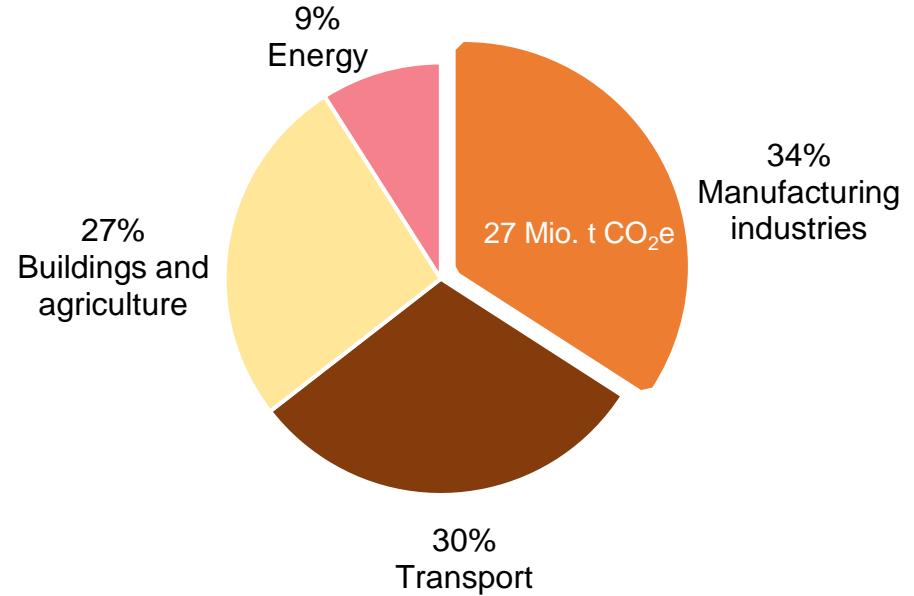
The NEFI innovation network of science, technology providers and companies demonstrates a pathway towards the decarbonisation of industry

1/3 OF GHG EMISSIONS IN AUT FROM MANUFACTURING INDUSTRIES

Primary energy demand by sector^[1]



GHG-emissions by sector^[2]



1) Sejkora et al., „Exergy as Criteria for Efficient Energy Systems – A Spatially Resolved Comparison of the Current Exergy Consumption, the Current Useful Exergy Demand and Renewable Exergy Potential“, *Energies*, 2020

2) Austrian Federal Environment Agency, „National Inventory Report 2021“

MOTIVATION FOR SCENARIO DEVELOPMENT

ENERGY SCENARIOS CAN BE A VALUABLE TOOL FOR ATTAINING CLIMATE GOALS

Strong drivers:

- Industrial climate neutrality goals
- European Green Deal / Austrian government goals / etc.

Previous energy scenarios:

- End-energy resolution of industrial demands
- Industrial aggregate; no industrial subsector focus

*Clear target.
Yet, the road is very much unclear!*

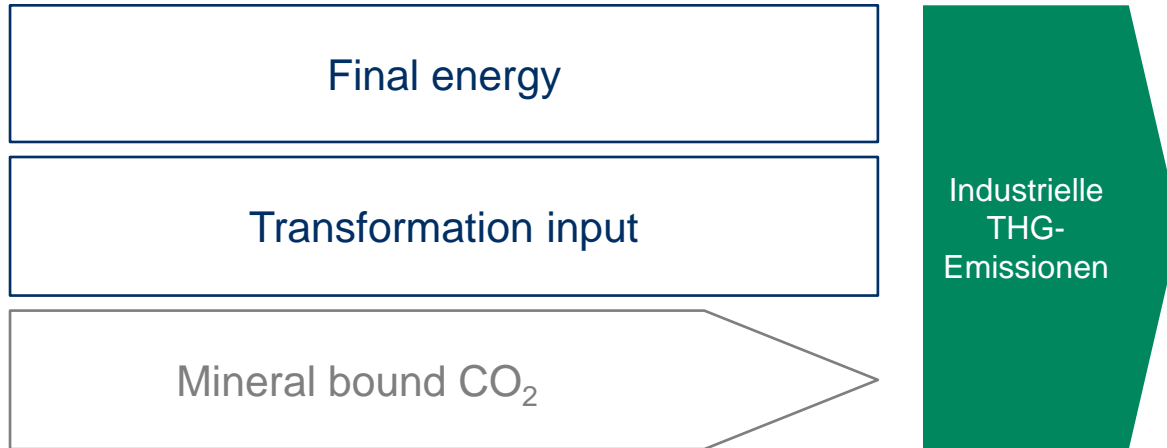
THE NEFI SCENARIOS

WHAT'S ON THE PLATE TODAY

- What balance border in industry is necessary for these scenarios?
- What scenario narratives were chosen?
- What technology groups constitute the road to climate neutrality?
- Core results

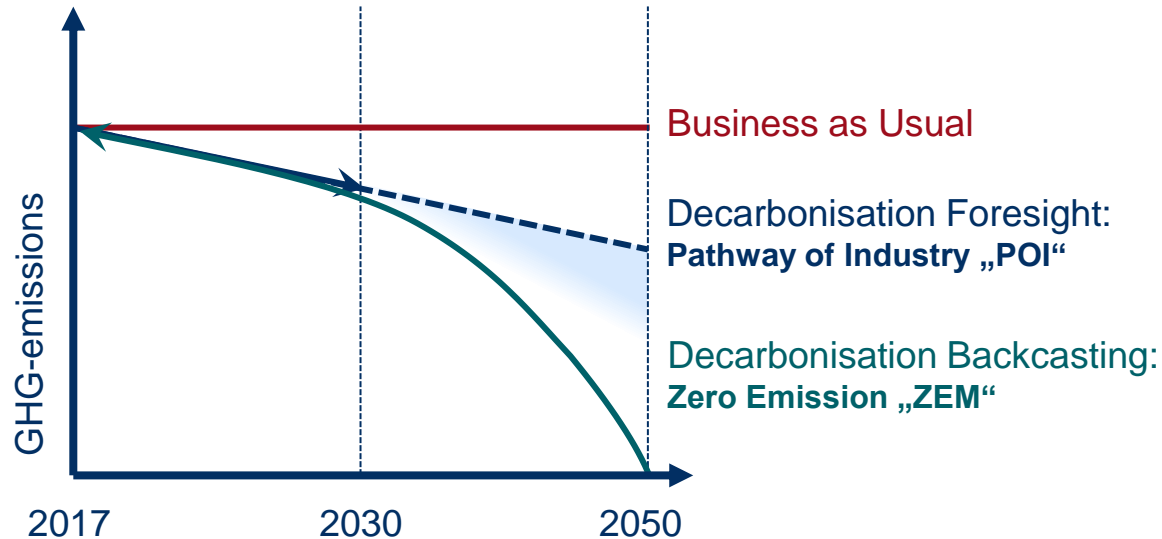
ENERGY AND EMISSIONS BALANCE OF INDUSTRY

THREE GHG-SOURCES EXIST



THE NEFI SCENARIOS

THREE SCENARIOS OPEN UP A BANDWIDTH OF DEVELOPMENT POSSIBILITIES



CLASSIFICATION OF DECARBONISATION STRATEGIES

FOUR TECHNOLOGY FAMILIES CAN BE DISTINGUISHED

Electrification

- Heat pumps
- Stationary engines

Use of CO₂-neutral gases and biomass combustion

- Hydrogen
- Bio-CH₄ and synthetic CH₄
- Solid biomass

Carbon Capture

- Especially for the sequestration of geogenic emissions
- Requires additional energy

Circular Economy

- Increased use of end-of-life products
- Substitution of primary resources

CLASSIFICATION OF DECARBONISATION STRATEGIES

INITIAL FOCUS LIES ON THREE OPTIONS:

Electrification

- Heat pumps
- Stationary engines

Carbon Capture

- Especially for the sequestration of geogenic emissions
- Requires additional energy

Use of CO₂-neutral gases and biomass combustion

- Hydrogen
- Bio-CH₄ and synthetic CH₄
- Solid biomass

Scenario Zero Emissions

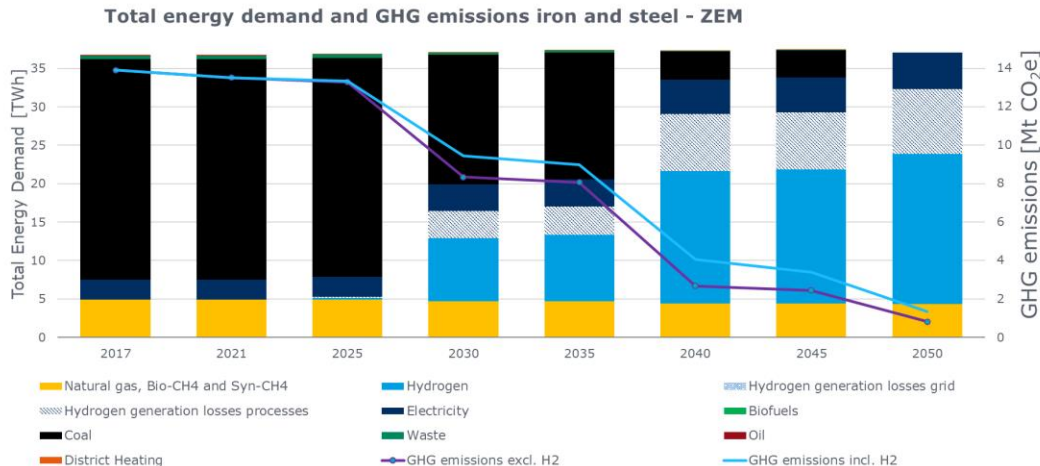
Exemplary results

IRON & STEEL

PRIMARY STEELMAKING IS THE MAIN DRIVER

preliminary

- Usage of H₂-DR/EAF ³⁾
- Increased electricity demand for electrolysis
- Depending on the location: can sit in- or outside the industrial balance border
- Residual emissions: 1 Mt CO₂

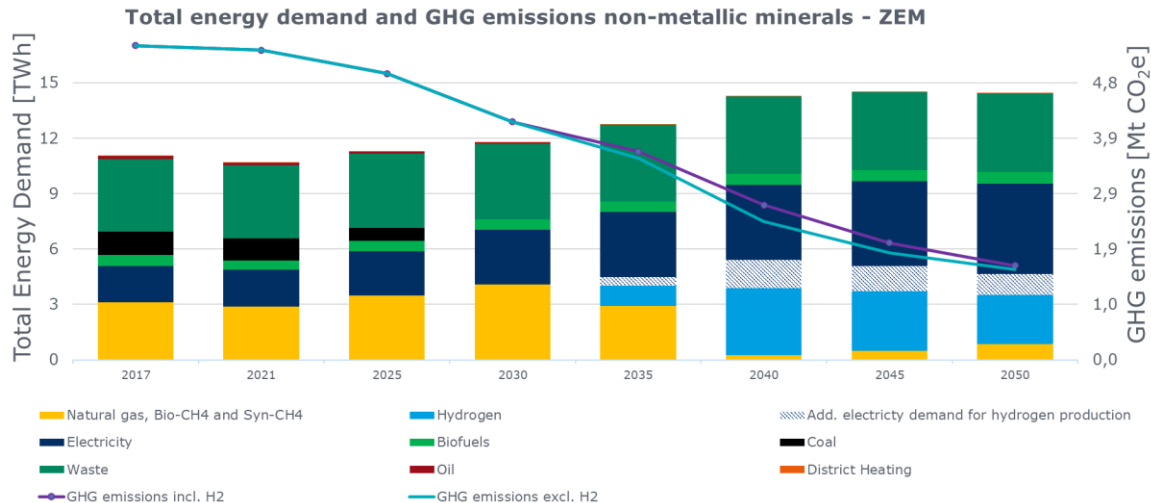


NON-METALLIC MINERALS

INCREASED ELECTRIFICATION (DIRECT+INDIRECT)

preliminary

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

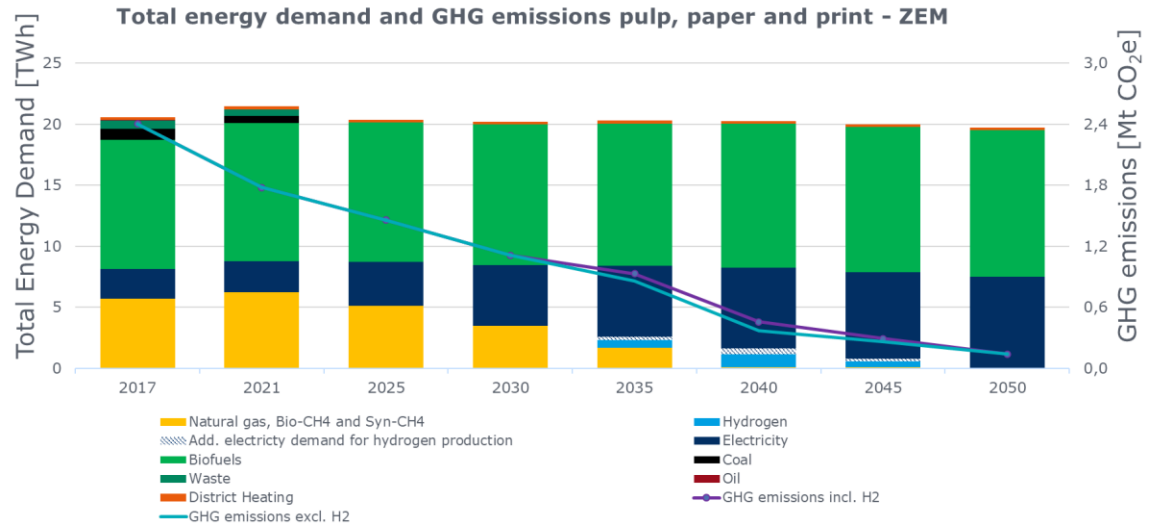


PULP, PAPER & PRINT

USE OF HEAT PUMPS UP TO 150°C

preliminary

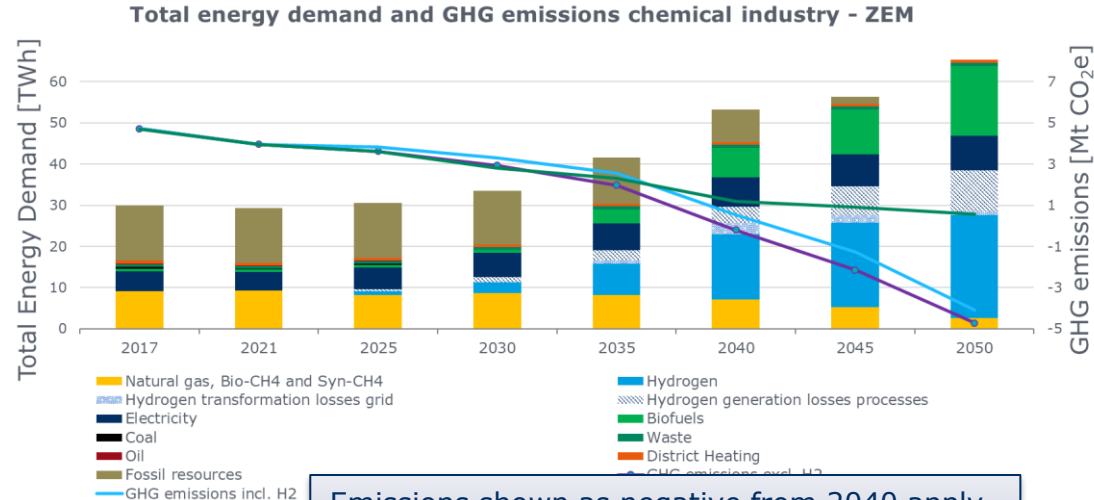
- Increased electrification
 - CHP operated exclusively with biogenic residues
 - Increased amounts of electricity purchased from outside
 - Production growth counterbalances increased efficiency



CHEMICAL AND PETROCHEMICAL INDUSTRY

NATURAL GAS IS REPLACED BY HYDROGEN AND BIO-CH₄

- Olefin production from naphtha will be phased out by 2050.
- Methanol synthesis from 2040 only from biomass and hydrogen + CO₂
- Complete electrification of the saltpetre, urea and fertilizer production
- Electricity requirement increases from 5 TWh to 8 TWh, or including hydrogen production to 44 TWh!



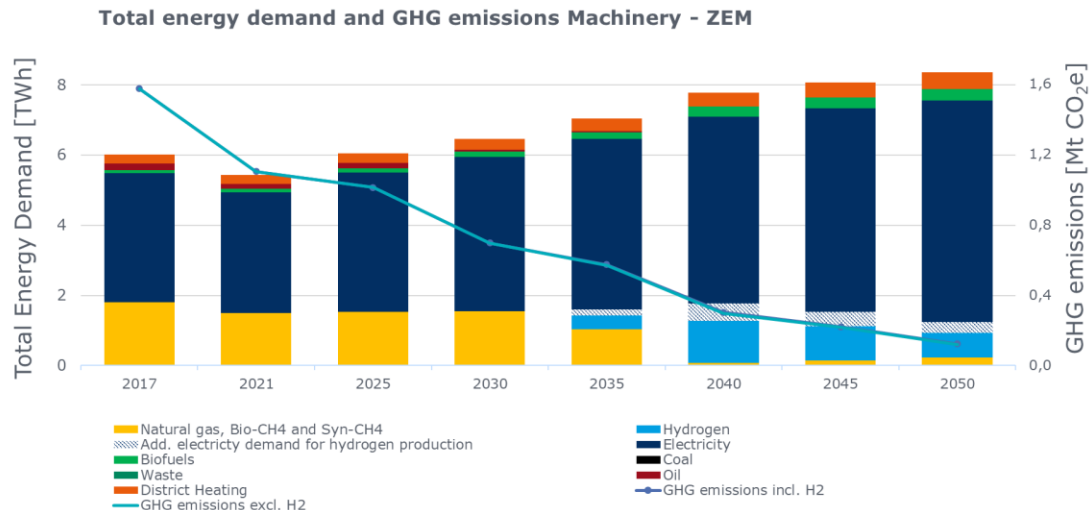
Emissions shown as negative from 2040 apply in the balance limit of the chem. industry. However, 4 Mt of absorbed CO₂ is released again with current end-of-life recycling.

MACHINERY

EMISSION REDUCTIONS ARE GRID-DRIVEN

preliminary

- 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



„ZERO EMISSION“ SUMMARY

AVAILABILITY OF RENEWABLE ENERGY SOURCES IS CRUCIAL

- Technology change allows phase-out of fossil fuels by 2035
- Emission reductions from then on through an increasing share of renewable electricity and gas
- **GHG-neutral supply is required:**

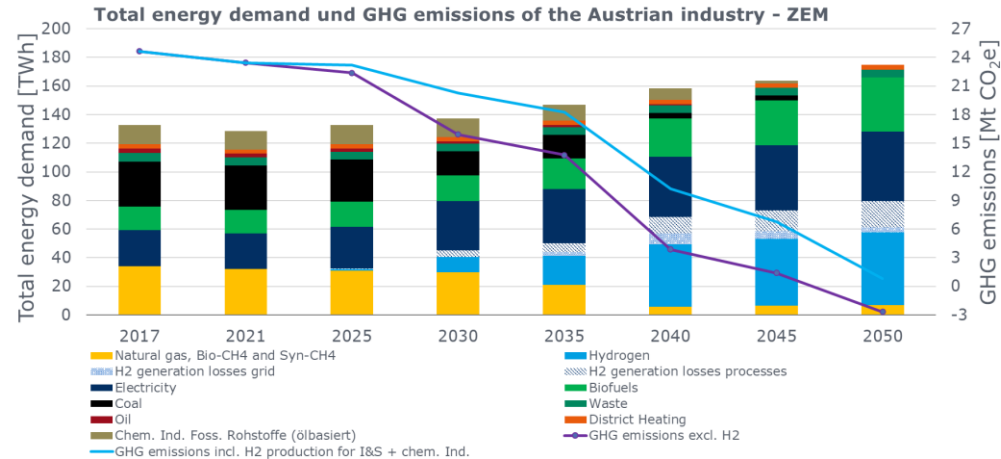
49 TWh power: +91% compared to 2017

51 TWh hydrogen, +73 TWh power

38 TWh biomass: +130% compared to 2017

6.9 TWh CH₄:

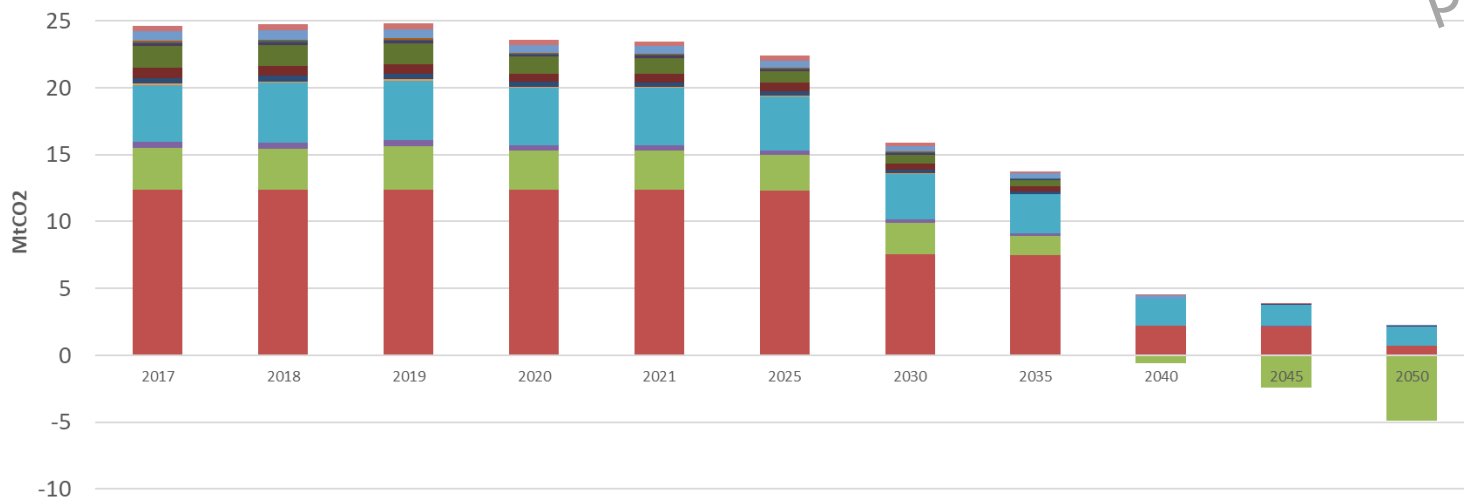
-80% compared to natural gas 2017



„ZERO EMISSION“ SUMMARY

preliminary

CO2 emissions by sector of industry, ZEM



- Iron and steel
- Chemical and petrochemical industry
- Non ferrous metals
- Transport equipment
- Machinery
- Food, tobacco and beverages
- Wood and wood products
- Textiles and leather
- Non specified industry
- Mining and quarrying
- Paper, pulp and print
- Construction

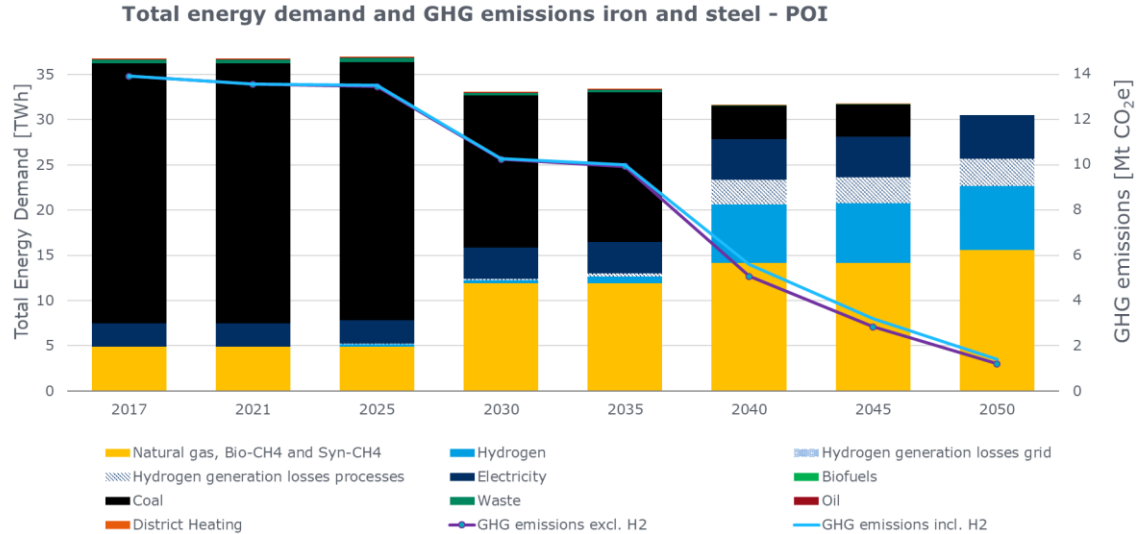
Scenario Pathway of Industry

Exemplary results

IRON & STEEL

CH₄-BASED DIRECT REDUCTION AND EAF

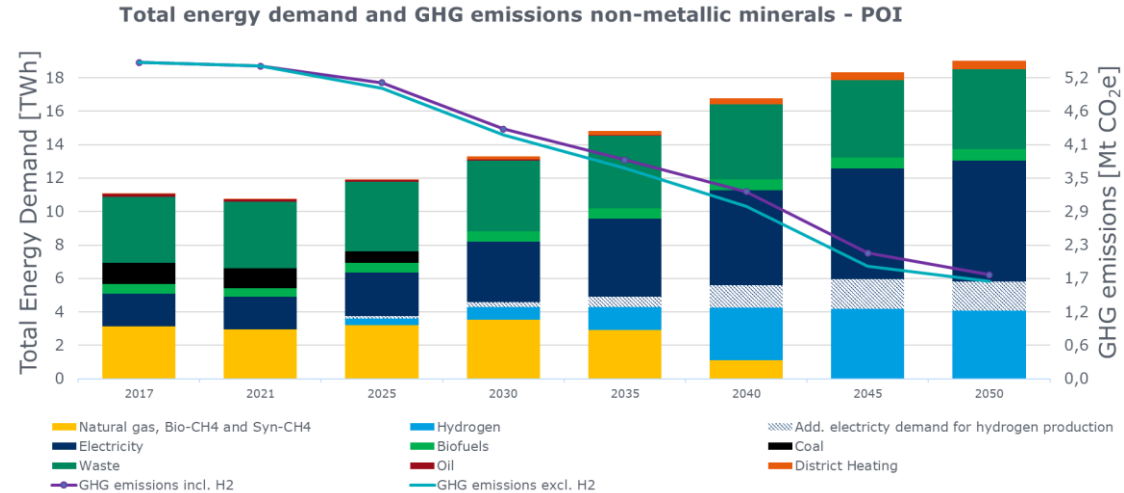
- Increasing usage of CH₄-DR/EAF incl. 30% H₂ per unit
- Substitution of 29 TWh coal/coke with 22 TWh of green gases
- Electricity demand for electrolysis can sit in- or outside the industrial balance border



NON-METALLIC MINERALS

AMINE SCRUBBER REQUIRES ADDITIONAL ENERGY

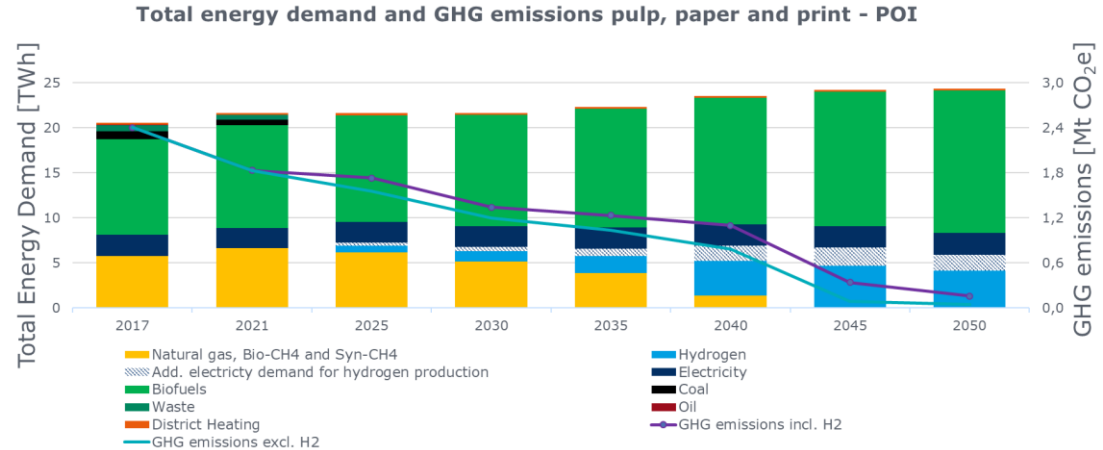
- Carbon Capture by amine scrubbing
 - Readily available technology
- No investigation of further usage/storage after sequestration
- Required energy provided through heat pumps (@130°C)



PULP, PAPER & PRINT

INTENSIFIED BIOMASS COMBUSTION

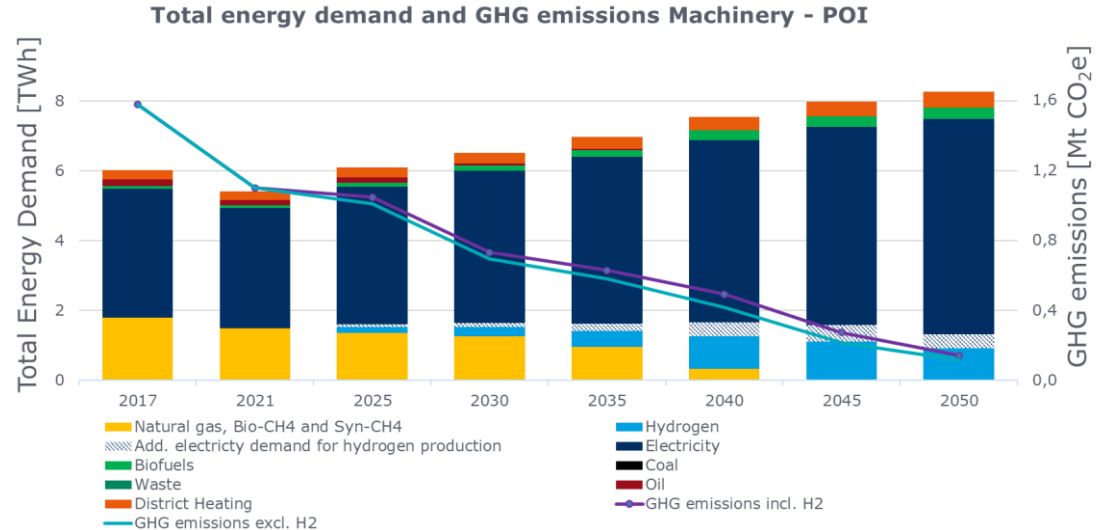
- Extension of current supply routes for biomass for combustion
- Retention of current plant structure
 - e.g. CHP-plants



MACHINERY

EXTENSIVE ELECTRIFICATION OF PROCESS HEAT

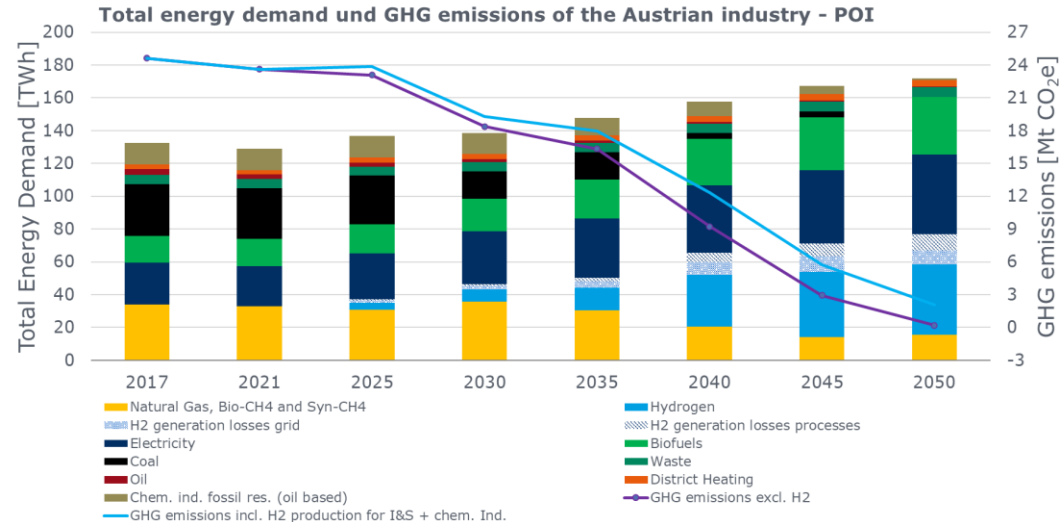
- Lower temperature levels provided by heat pumps
- Higher temperature levels (>150°C) provided by direct heat
- Energy efficiency cannot compensate fully for production increase (approx. 50%)



„PATHWAY OF INDUSTRY“ SUMMARY

CO₂-NEUTRAL ENERGY SUPPLY IS KEY

- Two fuel-based decarbonisation solutions are visible
 - CO₂-neutral gases and biomass
 - Electrification
- **GHG-emission reduction of 86%** is possible (comp. to 2017)
- **GHG-neutral supply of electricity and CO₂-neutral gases is key!**
 - 49 TWh electricity: +90%
 - 58 TWh CO₂-neutral gases (>61 TWh of electricity, if provided by H₂)
 - 35 TWh solid biomass: +113%





NEW ENERGY
FOR INDUSTRY

THANK YOU!