

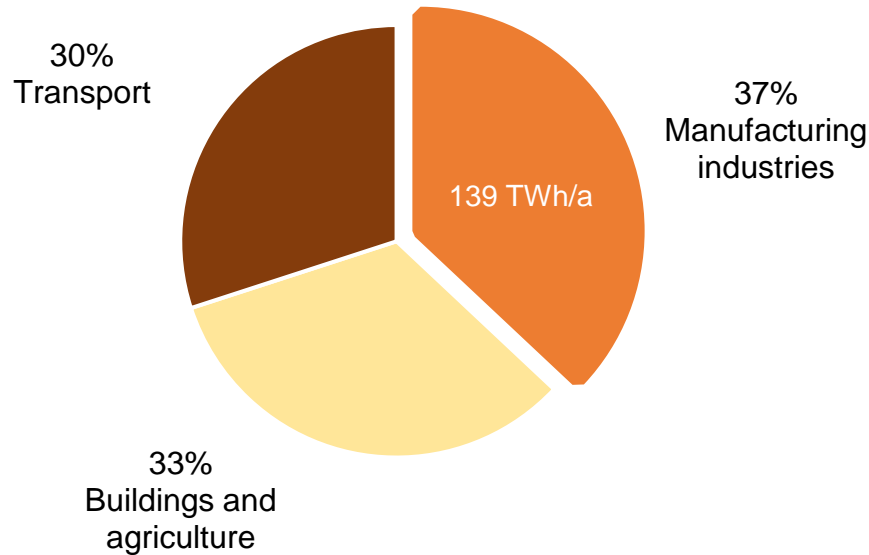


# NEW ENERGY FOR INDUSTRY

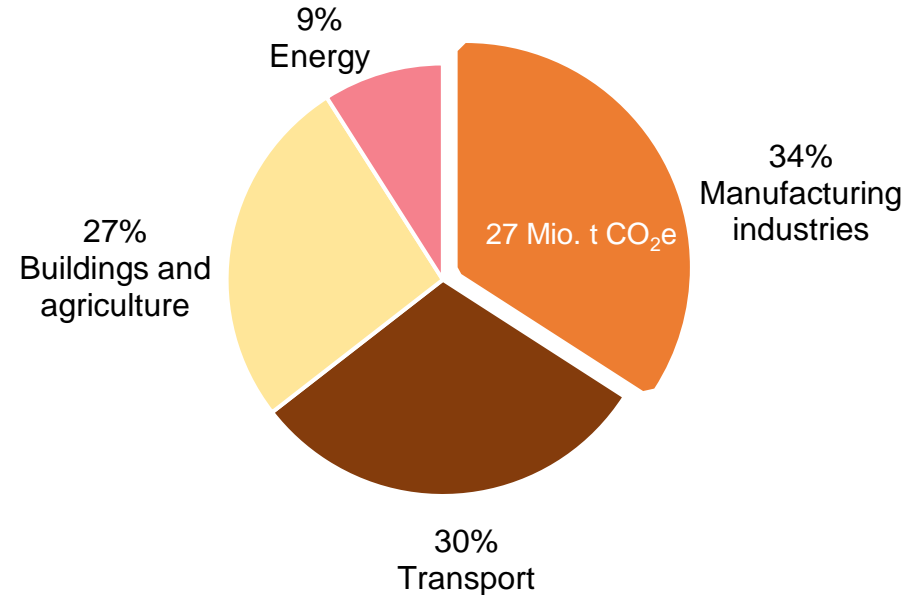
The NEFI innovation network  
of science, technology providers  
and companies demonstrates a  
pathway towards the decarbonisation  
of industry

# 1/3 OF GHG EMISSIONS IN AUT FROM MANUFACTURING INDUSTRIES

Primary energy demand by sector<sup>[1]</sup>



GHG-emissions by sector<sup>[2]</sup>



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.

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

### Previous energy scenarios:

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

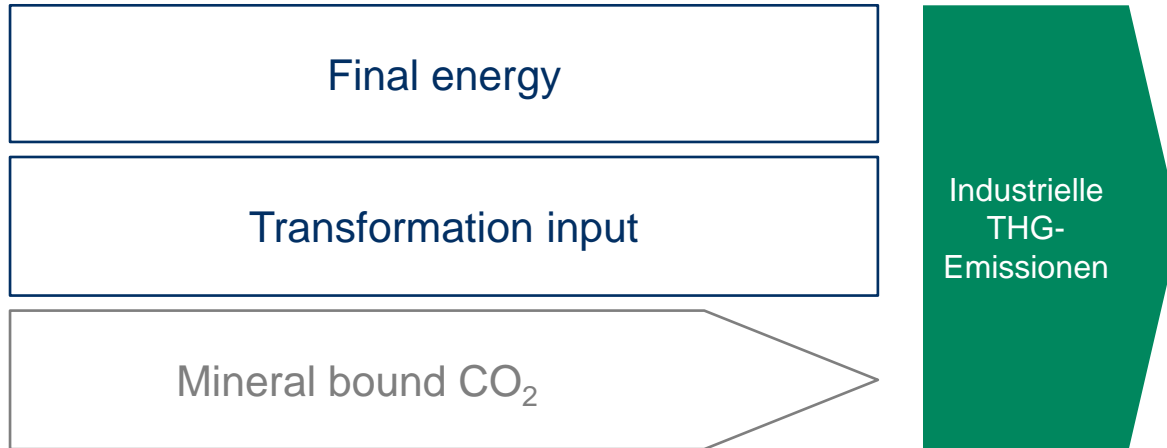
# THE NEFI SCENARIOS

## 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

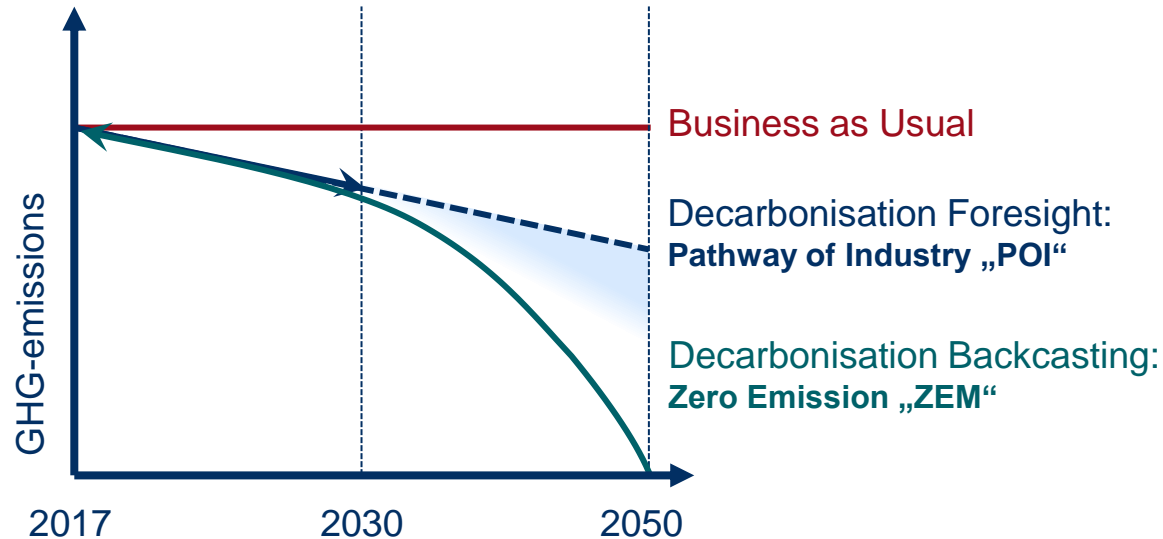
# ENERGY AND EMISSIONS BALANCE OF INDUSTRY

## 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 CO<sub>2</sub>-neutral gases and biomass combustion

- Hydrogen
- Bio-CH<sub>4</sub> and synthetic CH<sub>4</sub>
- 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 CO<sub>2</sub>-neutral gases and biomass combustion

- Hydrogen
- Bio-CH<sub>4</sub> and synthetic CH<sub>4</sub>
- Solid biomass



## Scenario Zero Emissions

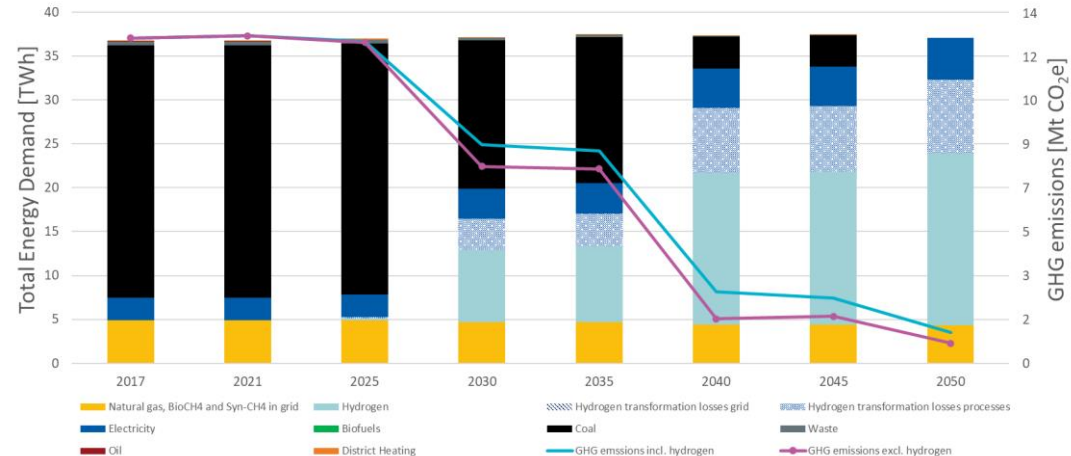
Exemplary results

# IRON & STEEL

## PRIMARY STEELMAKING IS THE MAIN DRIVER

- Usage of H<sub>2</sub>-DR/EAF <sup>3)</sup>
- Increased electricity demand for electrolysis
- Depending on the location: can sit in- or outside the industrial balance border
- Residual emissions: 1 Mt CO<sub>2</sub>

Total energy demand and GHG emissions of Iron and Steel - ZEM



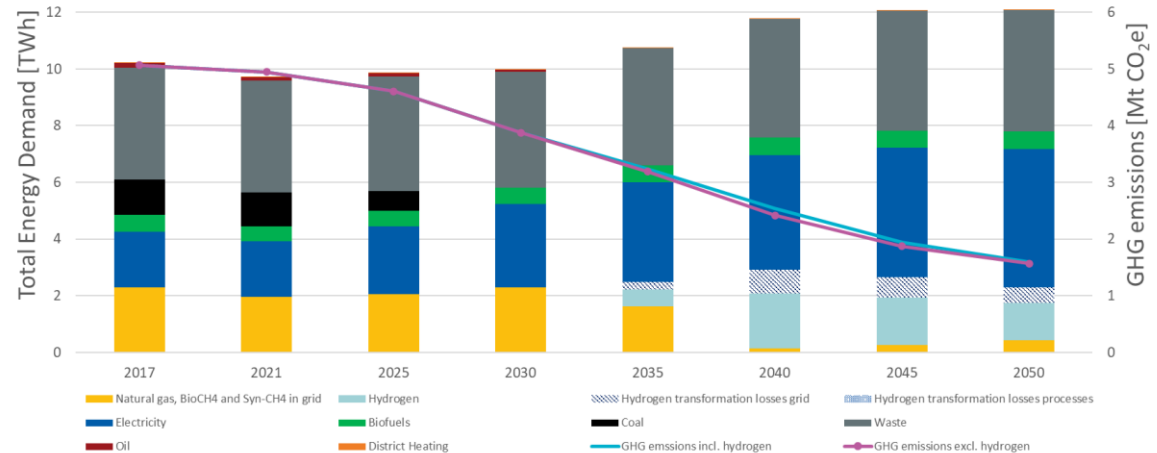
3) DR/EAF: Direct Reduction / Electric Arc Furnace

# NON-METALLIC MINERALS

## INCREASED ELECTRIFICATION (DIRECT+INDIRECT)

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

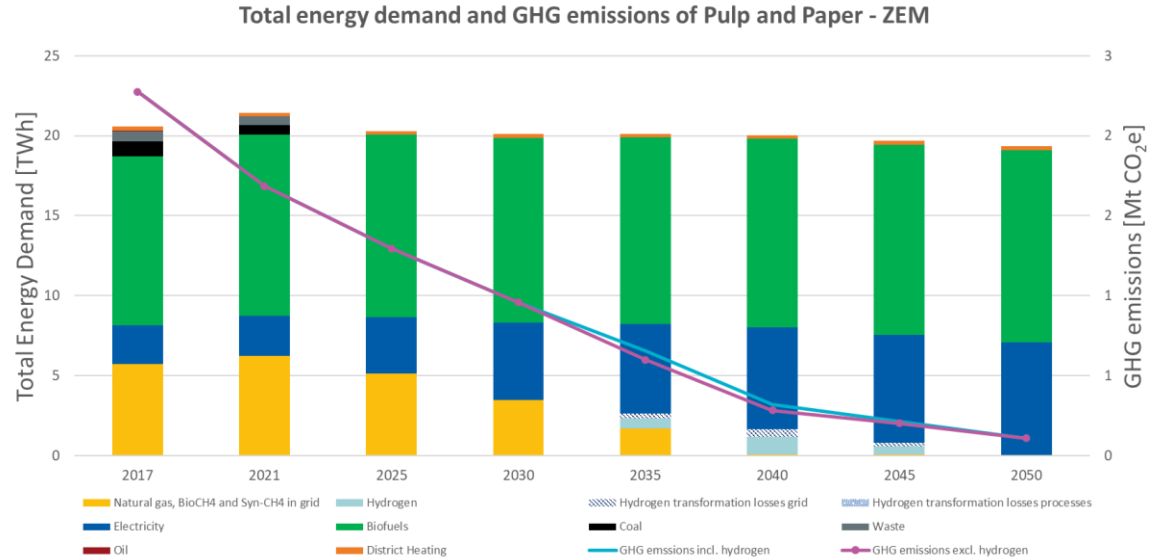
Total energy demand and GHG emissions of Non-metallic minerals - ZEM



# PULP, PAPER & PRINT

## USE OF HEAT PUMPS UP TO 150°C

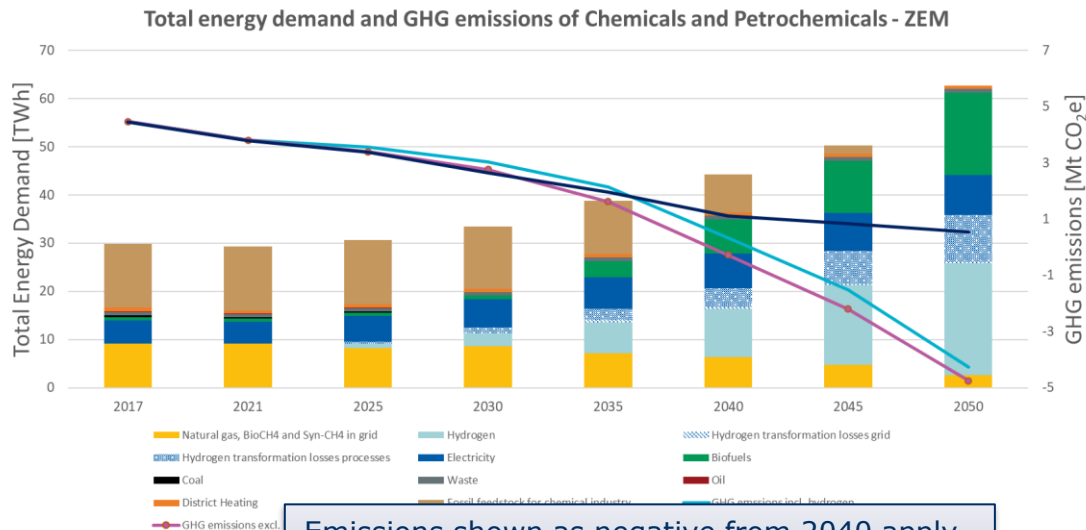
- Increased electrification
  - CHP operated exclusively with biogenic residues
  - Increased amounts of electricity purchased from outside
  - Production growth counterbalances increased efficiency



# CHEMICAL AND PETROCHEMICAL INDUSTRY

## NATURAL GAS IS REPLACED BY HYDROGEN AND BIO-CH<sub>4</sub>

- Olefin production from naphtha will be phased out by 2050.
- Methanol synthesis from 2040 only from biomass and hydrogen + CO<sub>2</sub>
- 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!



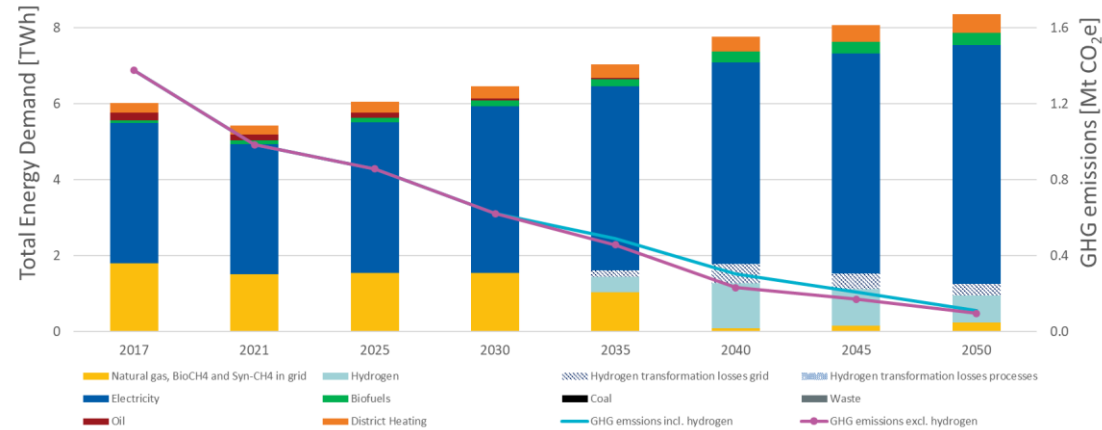
Emissions shown as negative from 2040 apply in the balance limit of the chem. Industry. However, 4 Mt of absorbed CO<sub>2</sub> is released again with current end-of-life recycling.

# MACHINERY

## 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

Total energy demand and GHG emissions of Machinery - ZEM



# „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:**

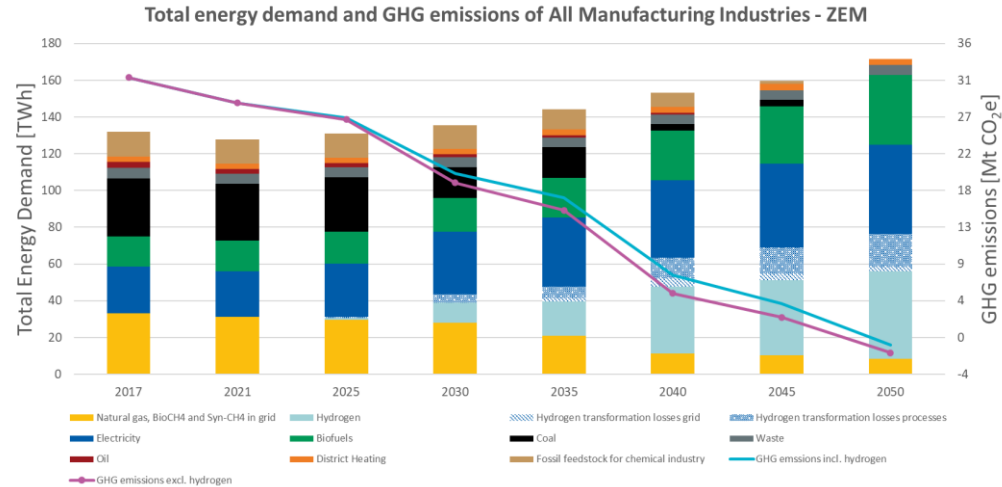
49 TWh power: +91% compared to 2017

48 TWh hydrogen, +68 TWh power

38 TWh biomass: +130% compared to 2017

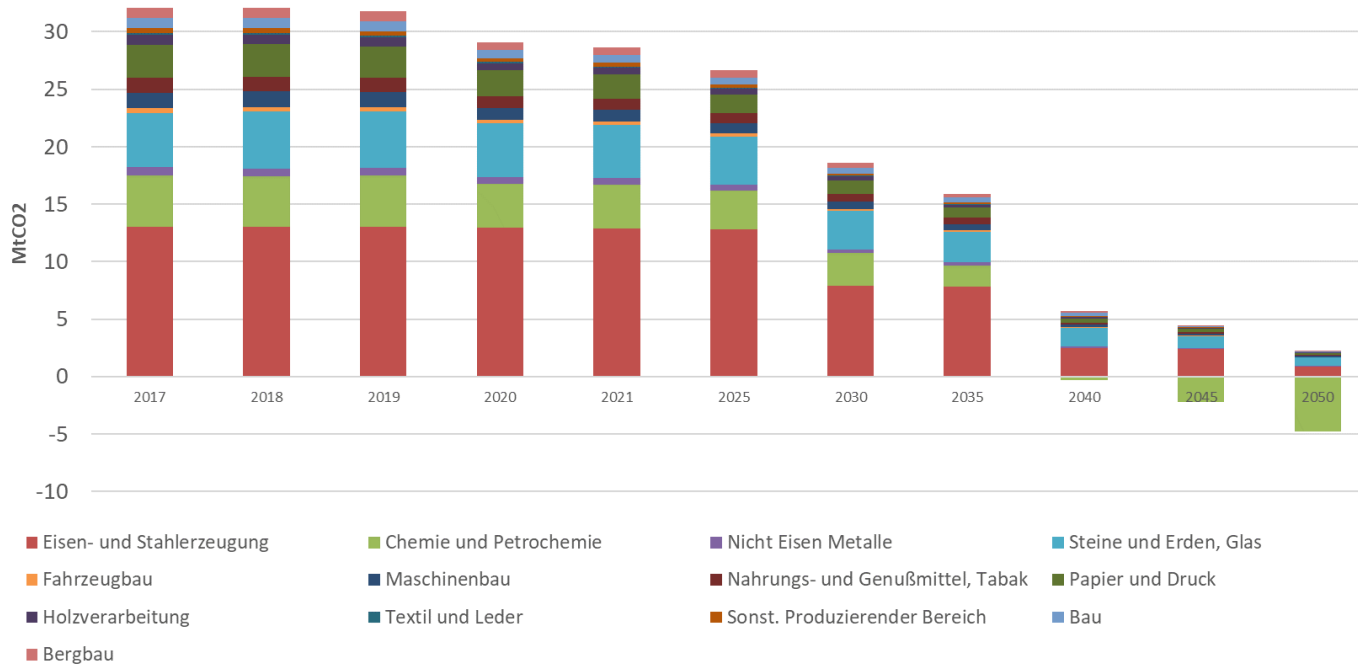
8.4 TWh CH<sub>4</sub>:

-75% compared to natural gas 2017



# „ZERO EMISSION“ SUMMARY

GHG emissions by sector of industry, ZEM





## Scenario Pathway of Industry

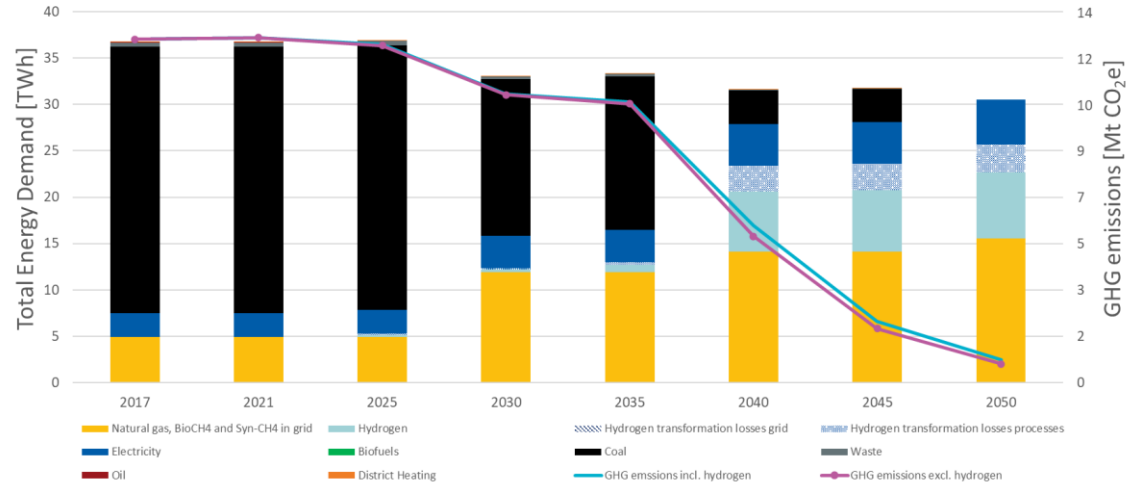
Exemplary results

# IRON & STEEL

## CH<sub>4</sub>-BASED DIRECT REDUCTION AND EAF

- Increasing usage of CH<sub>4</sub>-DR/EAF incl. 30% H<sub>2</sub> 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

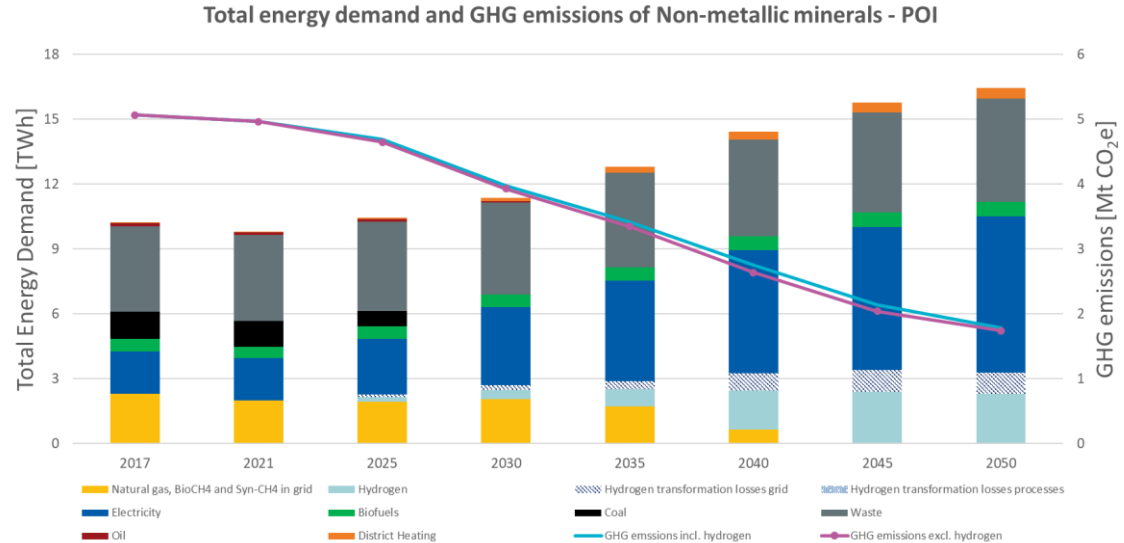
Total energy demand and GHG emissions of Iron and Steel - POI



# NON-METALLIC MINERALS

## AMINE SCRUBBER REQUIRES ADDITIONAL ENERGY

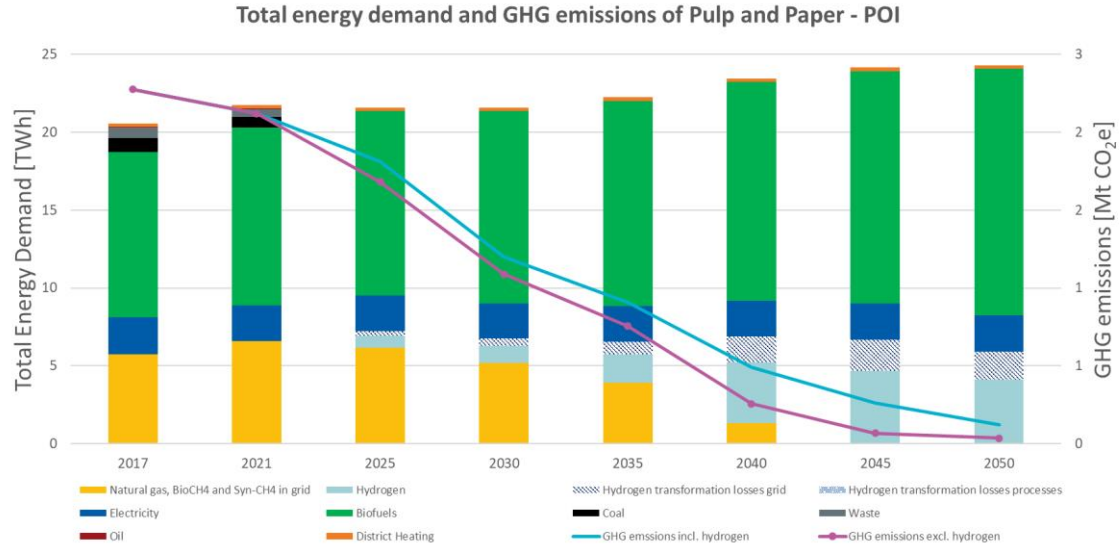
- Carbon Capture by amine scrubbing
  - Readily available technology
- No investigation of further usage/storage after sequestration
- Required energy provided through heat pumps (@130°C)



# PULP, PAPER & PRINT

## INTENSIFIED BIOMASS COMBUSTION

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

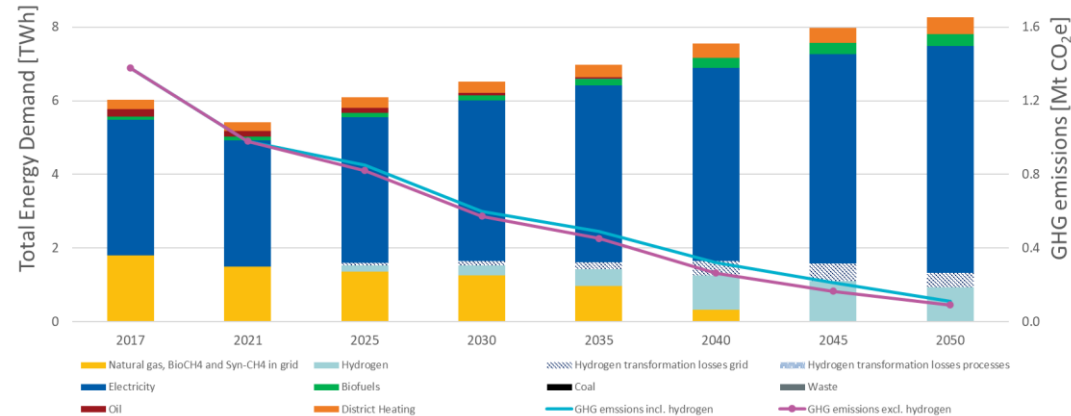


# MACHINERY

## EXTENSIVE ELECTRIFICATION OF PROCESS HEAT

- Lower temperature levels provided by heat pumps
- Higher temperature levels ( $>150^{\circ}\text{C}$ ) provided by direct heat
- Energy efficiency cannot compensate fully for production increase (approx. 50%)

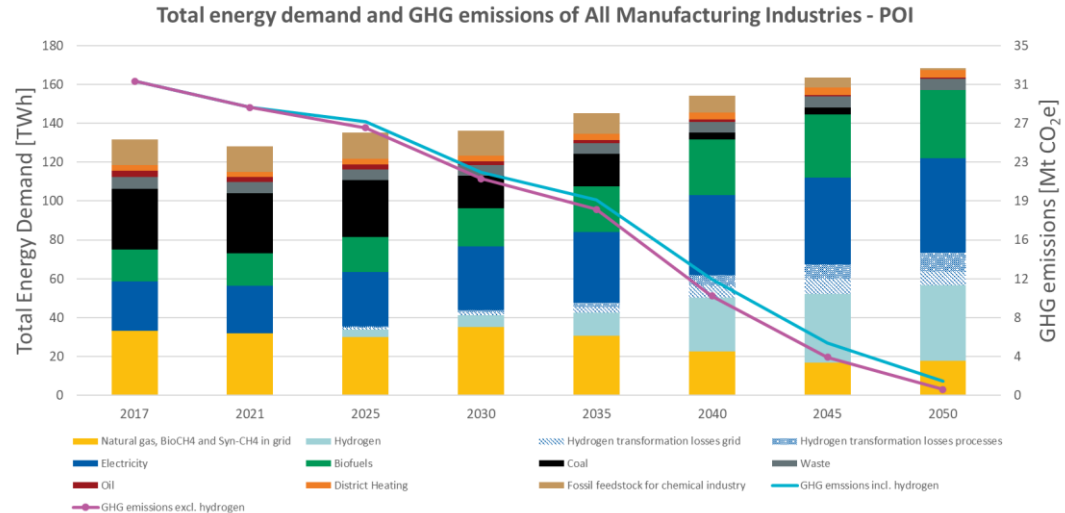
Total energy demand and GHG emissions of Machinery - POI



# „PATHWAY OF INDUSTRY“ SUMMARY

## CO<sub>2</sub>-NEUTRAL ENERGY SUPPLY IS KEY

- Two fuel-based decarbonisation solutions are visible
  - CO<sub>2</sub>-neutral gases and biomass
  - Electrification
- **GHG-emission reduction of 95%** is possible (comp. to 2017)
- **GHG-neutral supply of electricity and CO<sub>2</sub>-neutral gases is key!**
  - 49 TWh electricity: +90%
  - 58 TWh CO<sub>2</sub>-neutral gases (>61 TWh of electricity, if provided by H<sub>2</sub>)
  - 35 TWh solid biomass: +113%





NEW ENERGY  
FOR INDUSTRY

THANK YOU!