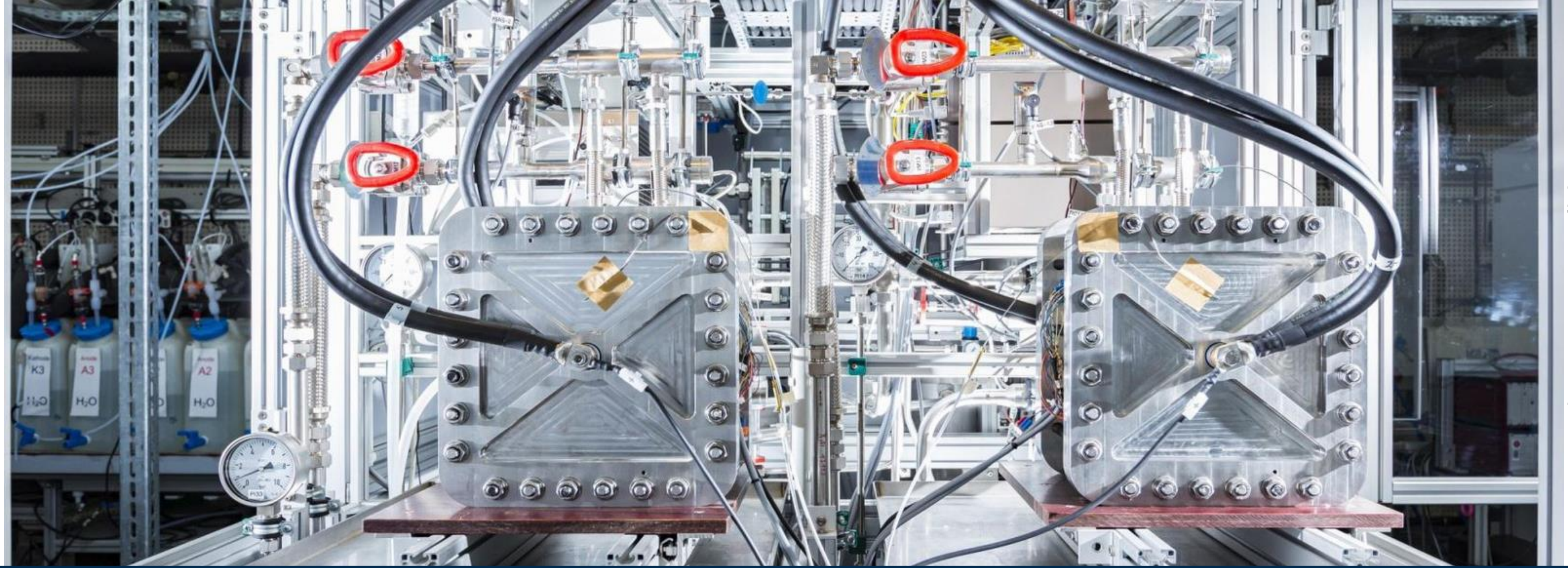


Environmental impacts of using hydrogen for defossilizing industrial specialty glass production

Christina Wulf, Petra Zapp, 21st September 2022, IRES Düsseldorf

JÜLICH Forschungszentrum

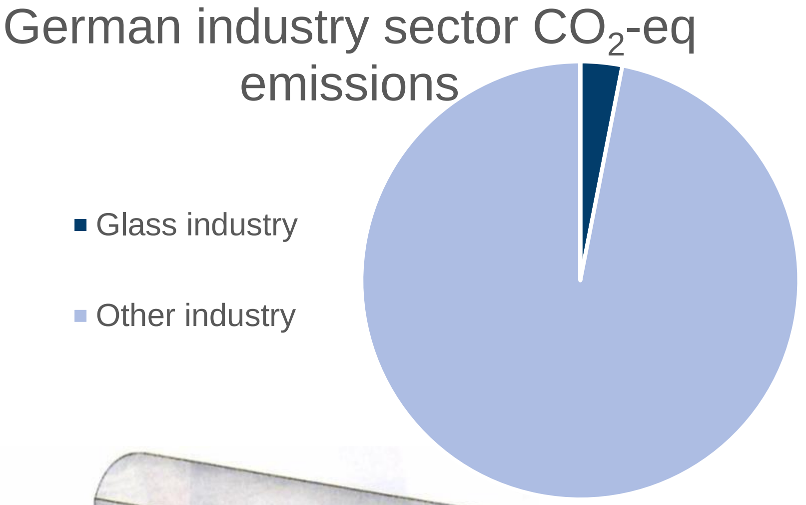
Glass industry in a transforming energy system

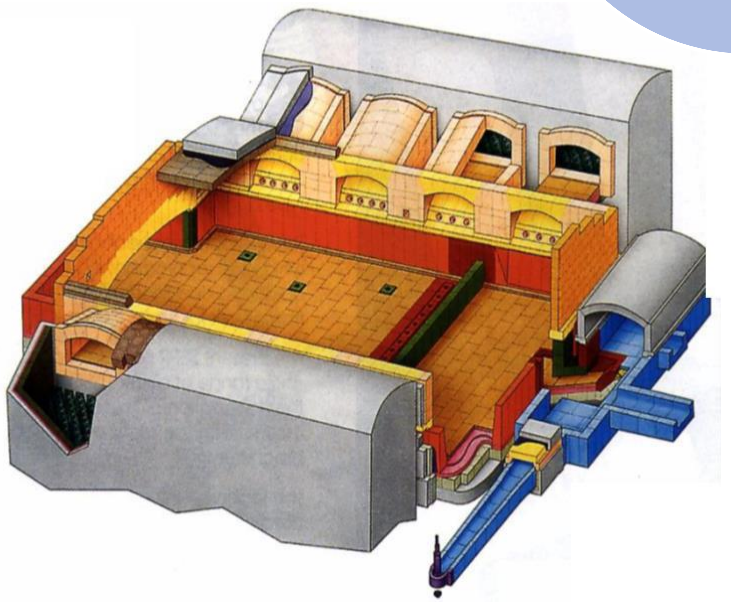
- 3.5 t CO_2-eq in 2020 by the German glass industry
- Process step with highest energy demand: heating of the glass trough
- More than 75% of the industries' energy demand is covered with natural gas

  → High carbon dioxide emissions

  → New challenges regarding security of supply
- Direct electrification not always possible

→ Using hydrogen for heating the glass trough

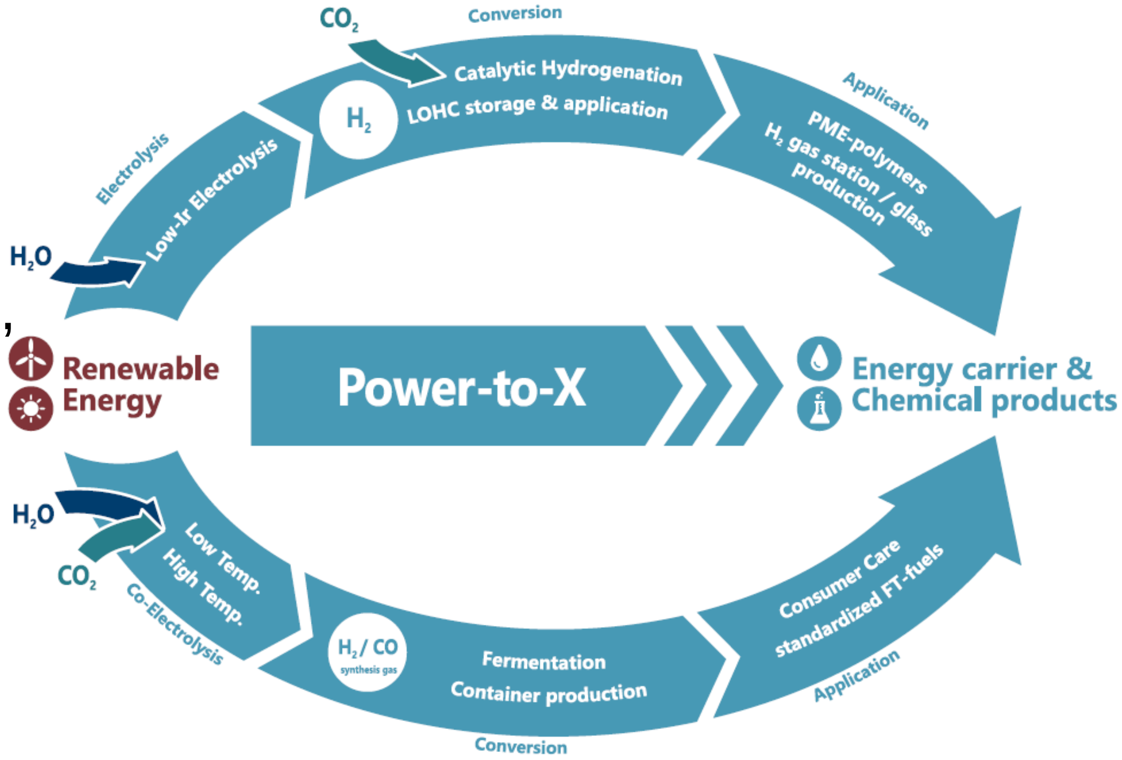




Source: Schott

Project KOPERNIKUS – Power-to-X II

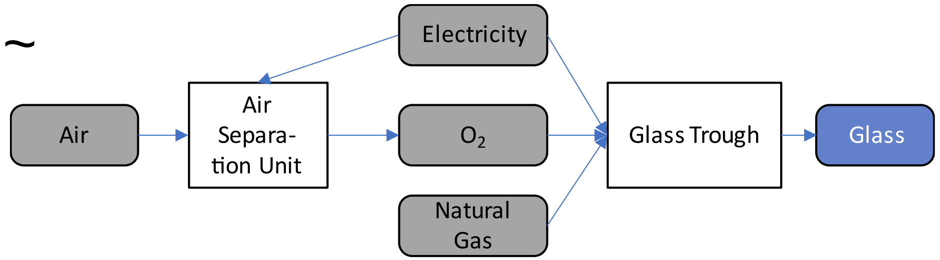
- Integration of renewable energies in different sectors:
  - Transport
  - Energy
  - Industry
- Development of chemical energy storage systems, energy carriers and chemical products
- Comprehensive assessment
  - Techno-economic
  - Societal acceptance
  - LCA
- Cooperation between academia and industry (Schott, Hydrogenious LOHC Technologies)



Ausfelder F, Dura H, editors. 3. Roadmap des Kopernikus-Projektes „Power-to-X“: Optionen für ein nachhaltiges Energiesystem mit Power-to-X-Technologien. Frankfurt: DECHEMA; 2021.

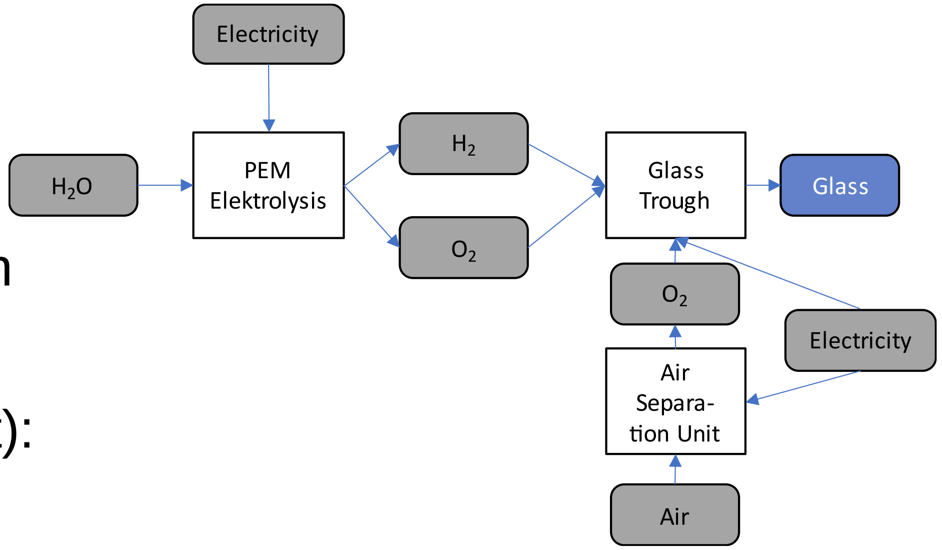
Glass production with hydrogen

- Melting in glass production needs high temperatures ~ 1200 °C
- Furnace fired by natural gas and oxygen



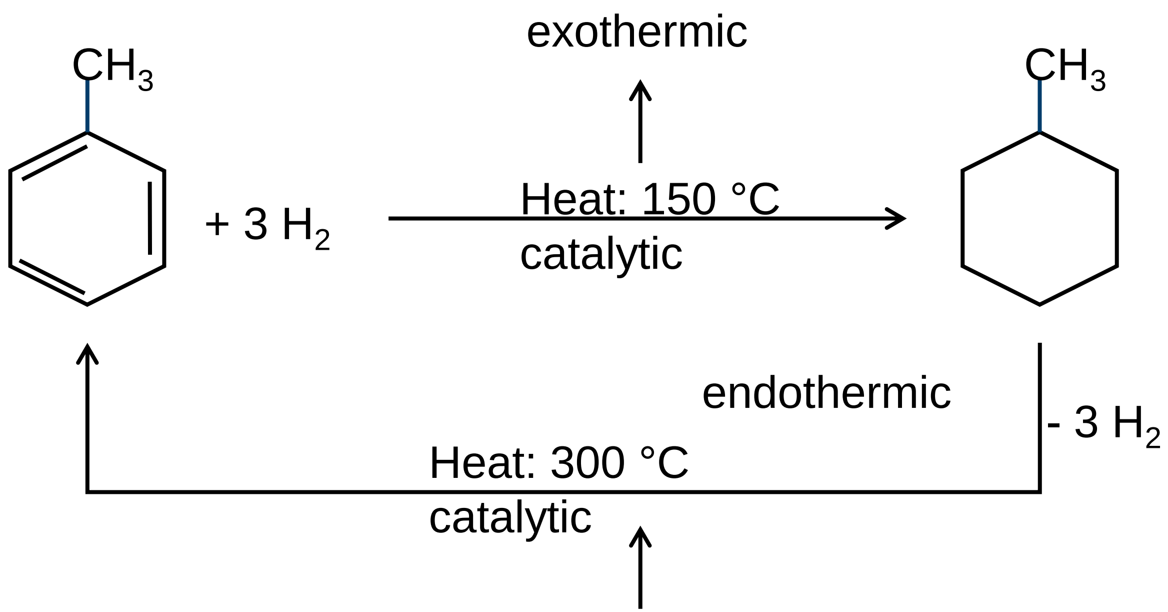
Glass production with hydrogen

- Melting in glass production needs high temperatures ~ 1200 °C
- Furnace fired by natural gas and oxygen
- Firing the furnace with hydrogen:
  - Hydrogen production on-site with electrolysis using oxygen as well
  - Off-site centralized hydrogen production (200 km transport):
    - Liquid hydrogen transport
    - Hydrogen transport by pipeline (100 bar)
    - Hydrogen transport with LOHC using the waste heat from furnace (100-400 °C) for LOHC dehydrogenation



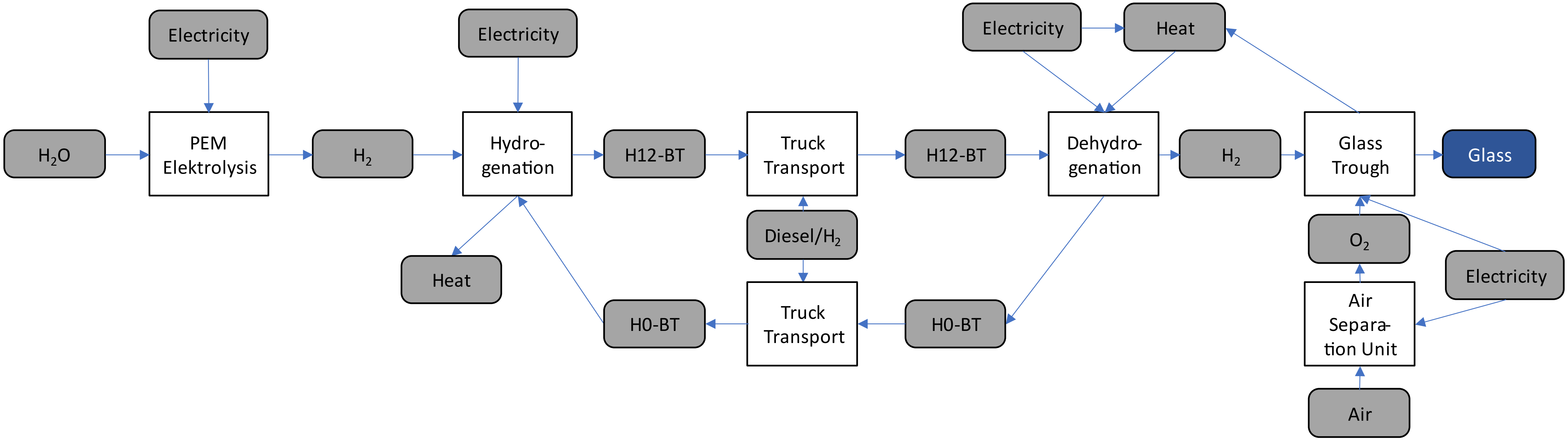
Excursus Liquid Organic Hydrogen Carrier

- Chemical compounds that bind hydrogen
- Up to 6.2 wt% stored hydrogen in LOHC possible
- Liquid can be handled like mineral oil products
- Possible compounds: e.g. benzyltoluene or toluene/ methylcyclohexane



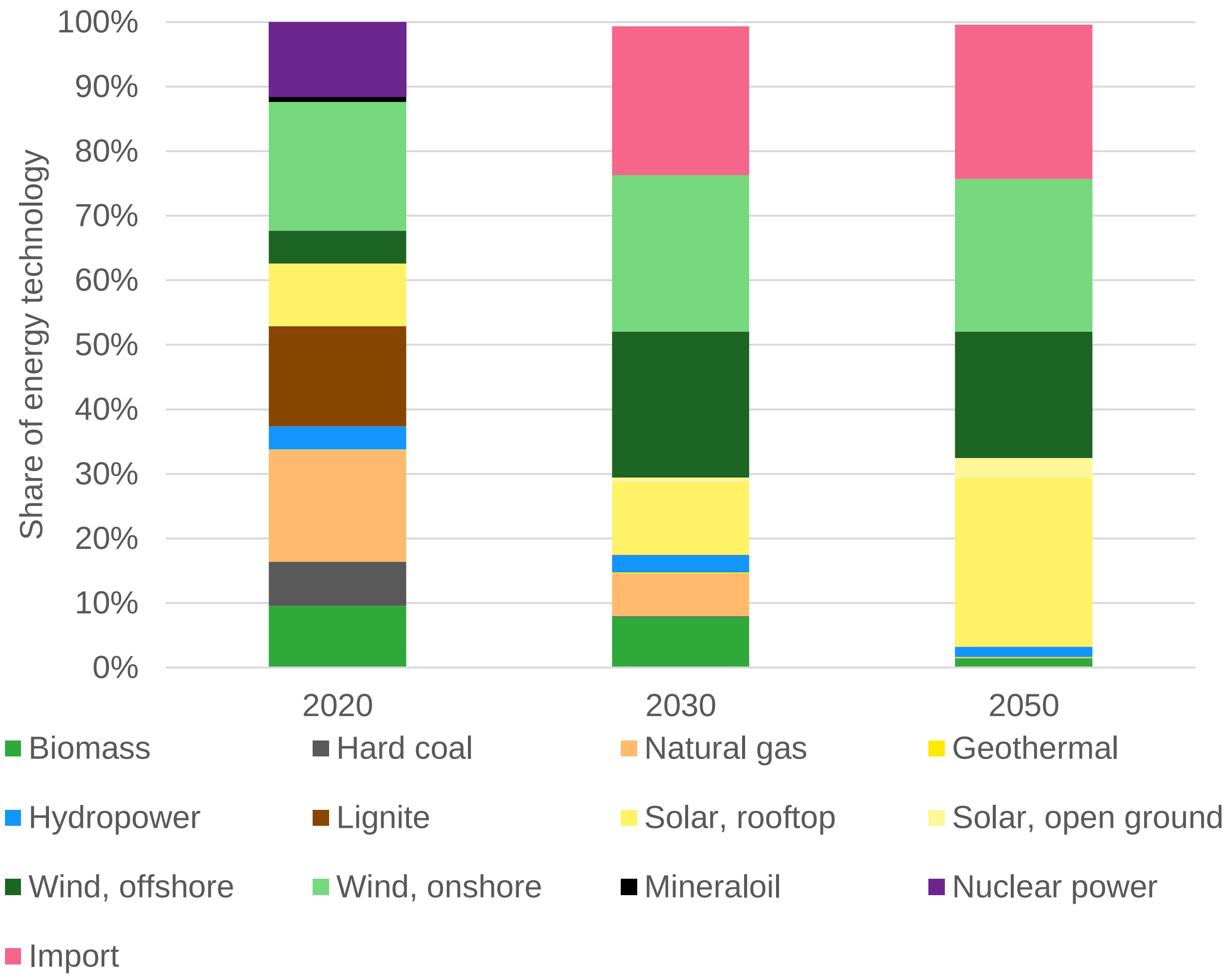
Glass production with heat integration for dehydrogenation

- Firing the furnace with transported hydrogen and using the waste heat (100-400 °C) for LOHC dehydrogenation
- Waste heat from melting end sufficient for 35% of heat for dehydrogenation, rest heat for dehydrogenation by electric heating



Modelling details

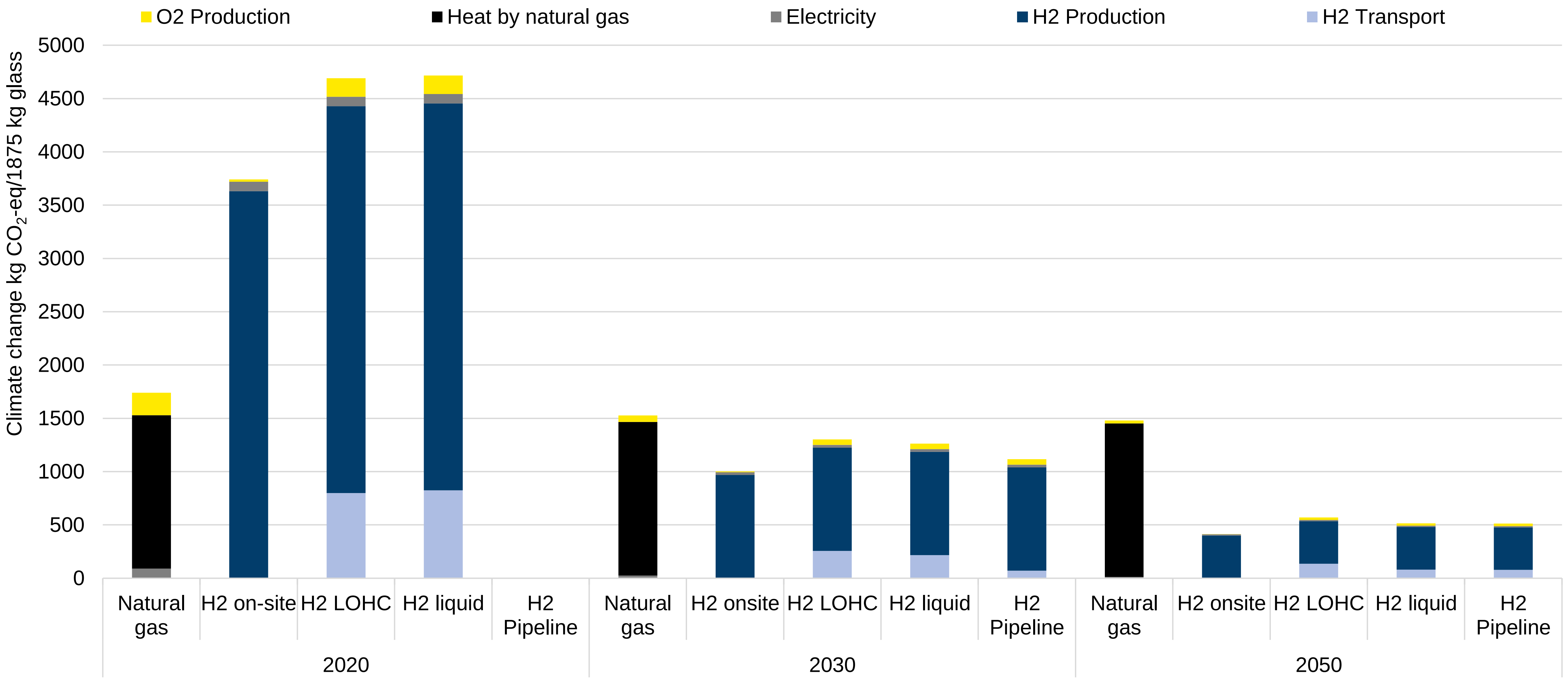
- Time frame: 2020, 2030, 2050 (pipeline option only 2030 and 2050)
- Geographical scope: Germany
- Functional unit : 1875 kg of specialty glass production (1 h of production)
- Feedstock for glass production not considered
- ReCiPe used for assessment
- Electricity mix: Based on Kopernikus P2X Energy Scenario



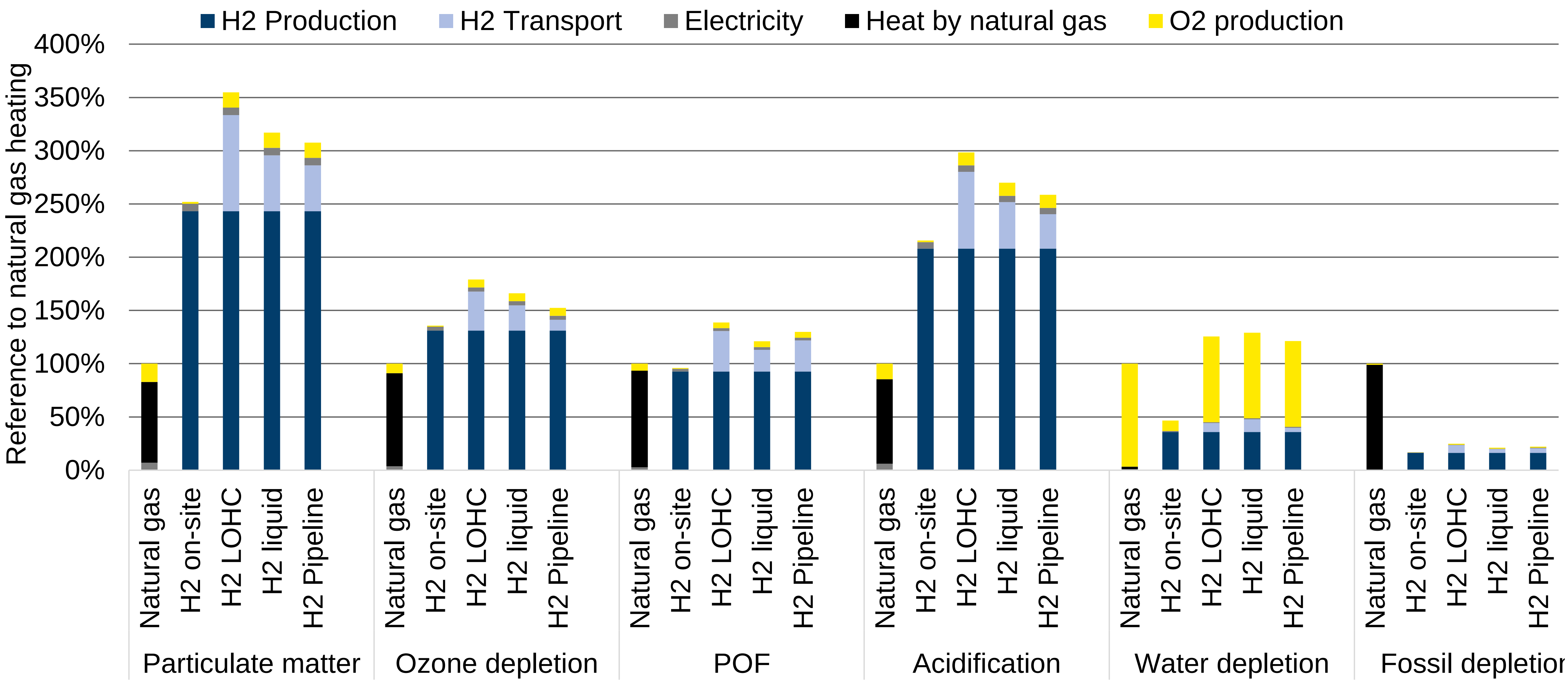
Technical details hydrogen transport

- Transport distance: 200 km
- Hydrogen transport capacity per truck ride
  - LOHC: 1530-1710 kg hydrogen (2020-2050)
  - LH2: 3500-4300 kg hydrogen (2020-2050)
- Dehydrogenation conversion rate (release factor): 85-95% (2020-2050)

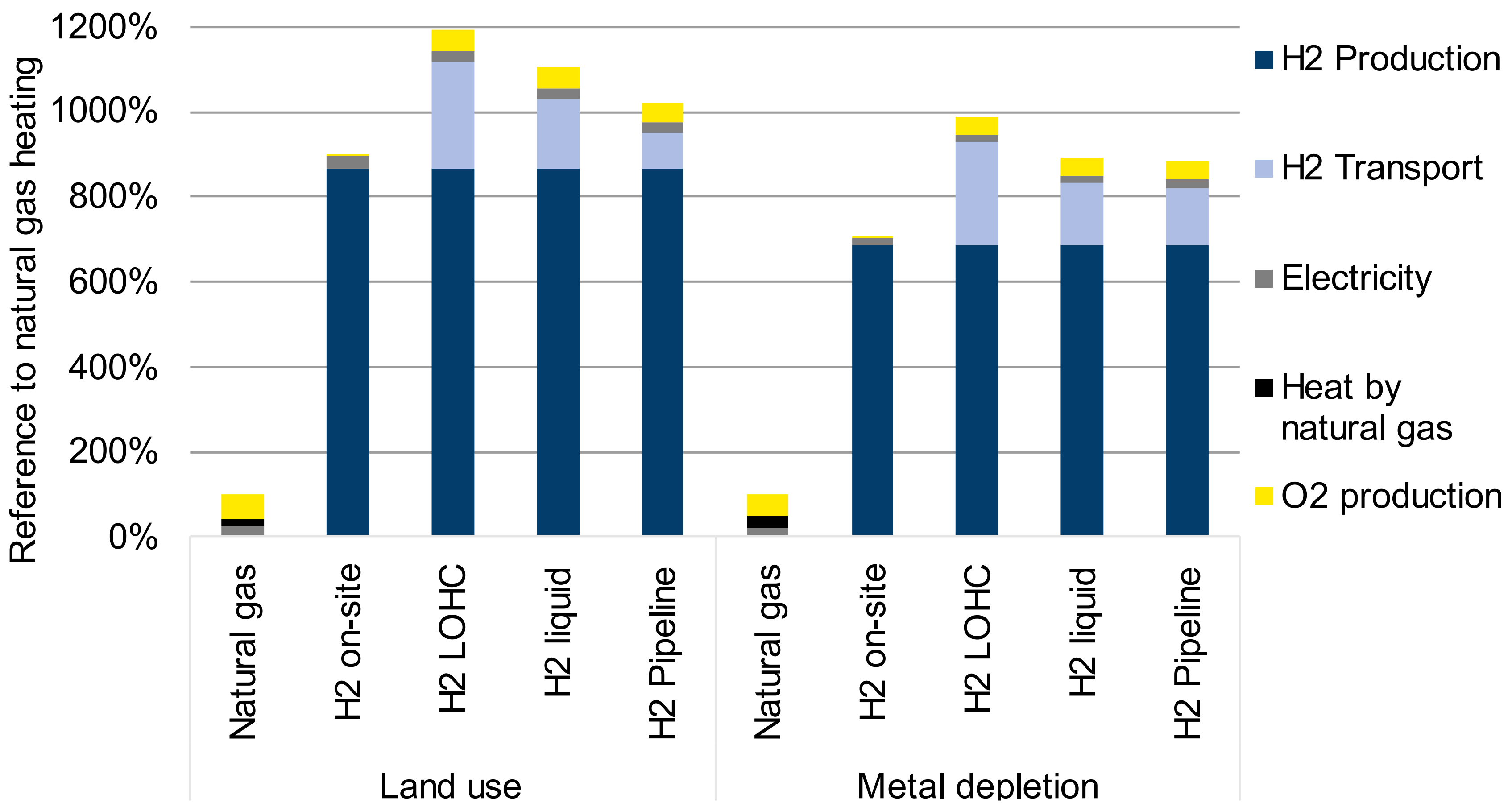
Impact on Climate change



Trade offs with other environmental impacts, 2050 I

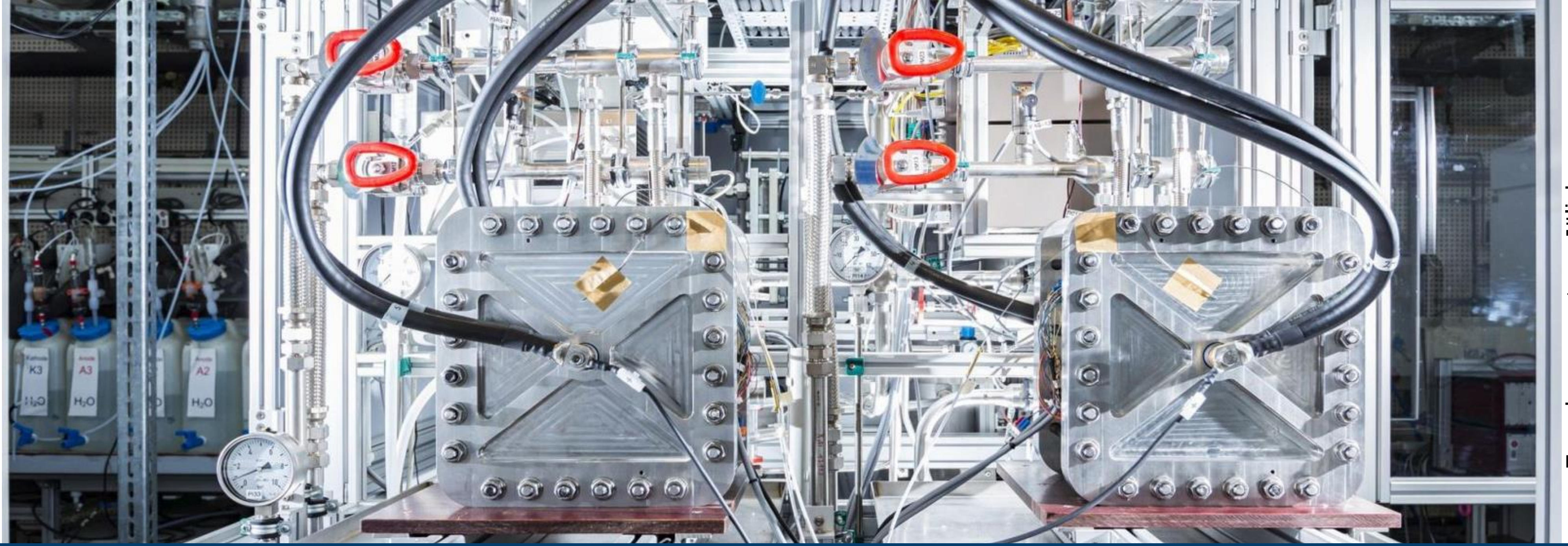


Trade offs with other environmental impacts, 2050 II



Conclusions

- In 2030 electrolytic hydrogen with German electricity mix is more climate friendly than natural gas for the heat supply of specialty glass production → quick adaption to alternative heating systems is advised
- On-site hydrogen production is most preferable due to the direct use of the oxygen
- Off-site hydrogen supply chains show similar results for Climate change and preference might depend on precise parameters, transport distance, gas grid connection …
- All hydrogen options need a fast and reliable transformation of the electricity system towards high shares of renewable energy sources, but that has side effects
  - Higher demand for land and metal resources
  - Increased environmental effects: Particulate matter, Acidification, and Ozone depletion



Source: Forschungszentrum Jülich

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