Clean Hydrogen session

Session co-chairs:

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Introduction: Hydrogen usages

Usage in 2020

“Industrial” $\text{H}_2$
- World $\approx 90$ Mt/yr
- Chemistry (ammonia)
- Refining
- Iron & steel

Usages in 2030 and beyond

“Industrial” and “energy” $\text{H}_2$

Achieving deep decarbonization of $>80\%$ of CO$_2$ emissions requires hydrogen

- Ultra-low-carbon $\text{H}_2$ as feedstock, e.g., ammonia
- High-grade heat for industry & in steel
- $\text{H}_2$ to decarbonize the gas grid
- Fuel cells/synfuels for heavy transport and long distances

Source: FCH-JU

H$_2$ Needs x6 until 2050

Source: Global Hydrogen Review 2021, IEA

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Introduction: Clean hydrogen needs

2020: Fossil H₂
≈ 11 kg of CO₂ per kg of H₂

Challenge for 2030 and beyond

- Low carbon H₂ production route ➔ Electrolysis
  Carbon footprint: Depends on the electricity origin
  • below 2.5 kgCO₂/kgH₂ if renewable or nuclear
  • As high as 13 kgCO₂/kgH₂ if based on gas turbine (combined cycles)

- Electrolysis status
  • 2022: ~ 700 MW installed worldwide
  • Forecasts: 2 GW by end 2023; based on announced projects, ~200 GW by 2030, and ~ 420 GW including early-stage projects.

➔ need for an acceleration of electrolysers manufacturing: gigafactories
  • In 2020: production capacity for electrolysers just 2 GW globally
  • 14 different manufacturers now have plans for an electrolyser Gigafactory, across 12 different countries, for different electrolysis technologies
  • Production capacity expected to reach 155 GW/year by 2030 (strong increase since last forecast)

Source: Global Hydrogen Review 2021, IEA

Source: Global Hydrogen Review 2023, IEA
Introduction: H₂ production by electrolysis

- Several technologies with different levels of maturity

Introduction: H₂ value chain and R&D challenges

• H₂ value chain

Production  Storage & distribution  Conversion

Electrolysis
Other production routes

Fuel cell

Internal combustion engines

Source: NEL

Source: SYMBIO

Source: Toyota

• H₂ R&D challenges

Still some work to meet the key performance indicators
• Performance / efficiency
• Durability
• Cost

Requiring work from materials to systems
• New materials: catalysts, electrodes and membranes
• New designs + associated processes
• Balance of Plant components
• Advanced control including diagnostics
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Program & speakers

• Membranes for Low-temperature Water Electrolysis and Fuel Cells: Past, Present, and Future
  Dr. Christopher Arges,
  Associate Professor, Pennsylvania State University, PA

• Hydrogen Production Using Low-temperature PEM Electrolysis
  Dr. Iryna Zenyuk,
  Associate Professor, University of California, Irvine, CA

• The Technology Solution We Need for Industrial-scale H2 Production and Storage to Achieve Net Zero
  Dr. Enass Abo-Hamed,
  CEO H2GO Power, UK

• Monitoring and Diagnostics Tools for Fuel Cell Systems
  Dr. Vanja Subotic,
  Associate Professor, Graz University of Technology, Austria

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