HYDROGEN PRODUCTION, STORAGE AND TRANSPORT FOR E-FUEL PRODUCTION

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Vice-chair HTCP
Building blocks for e-fuel production Workshop Event
In a nuthsell

**Members**
- 23 Member Countries
- 9 Sponsors
  - European Commission + UNIDO

**Tasks**
- 5 Ongoing
- 39 Finished
  - ≥ 8 in definition

**Experts involved**
In collaborative research on hydrogen and hydrogen technologies
Main pathways for producing Hydrogen and hydrogen-based products

Source: The Future of Hydrogen, IEA 2019
Today’s hydrogen production

Hydrogen production mix, 2020 and 2021

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Note: CCUS = carbon capture, utilisation and storage.
Potential renewable hydrogen pathways

Task on the topic: TiD Renewable Hydrogen Production
Various types of electrolysis

- Alkaline electrolysis (AEL)
- Proton exchange membrane (PEMEL)
- Solid oxide electrolysis (SOE)
- Anion exchange membrane electrolysis (AEMEL)

<table>
<thead>
<tr>
<th></th>
<th>Alkaline electrolyser</th>
<th>PEM electrolyser</th>
<th>SOE electrolyser</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Today</td>
<td>2030</td>
<td>Long-term</td>
</tr>
<tr>
<td>Electrical efficiency (%, LHV)</td>
<td>63-70</td>
<td>65-71</td>
<td>70-80</td>
</tr>
<tr>
<td>Operating pressure (bar)</td>
<td>1–30</td>
<td>30–80</td>
<td>1</td>
</tr>
<tr>
<td>Operating temperature (°C)</td>
<td>60–80</td>
<td>50–80</td>
<td>650</td>
</tr>
<tr>
<td>Stack lifetime (operating hours)</td>
<td>60 000</td>
<td>90 000</td>
<td>100 000</td>
</tr>
<tr>
<td>CAPEX (USD/kWₑ)</td>
<td>500</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>1 400</td>
<td>850</td>
<td>700</td>
</tr>
</tbody>
</table>

Source: The Future of Hydrogen, IEA 2019
Potential growth global electrolyser capacity by 2030, based on current project pipeline

Notes: RoW = rest of world; ALK = alkaline electrolyser; PEM = proton exchange membrane electrolyser; SOEC = solid oxide electrolyser. Only projects with a disclosed start year for operation are included. Projects at very early stages of development, such as those in which only a co-operation agreement among stakeholders has been announced, are not included.

Source: IEA Hydrogen Projects Database (2022)
Potential growth low-carbon hydrogen production by 2030, based on current project pipeline

- Note: current hydrogen production about 90 Mt/a

Notes: RoW = rest of world; APS = Announced Pledges Scenario. In the left figure, the blue columns for 2020 and 2030 refer to projects at advanced planning stages. The right figure includes both projects at advanced planning and early planning stages. Only projects with a disclosed start year for operation are included.

Indication cost (reductions) hydrogen

Levelised cost of hydrogen production by technology in 2021 and in the Net Zero Emissions by 2050 Scenario, 2030 and 2050

Notes: Ranges of production cost estimates reflect regional variations in costs and renewable resource conditions. The dashed areas reflect the CO₂ price impact, based on CO₂ prices ranging from USD 15/tonne CO₂ to USD 140/tonne CO₂ between regions in 2030 and USD 55/tonne CO₂ to USD 250/tonne CO₂ in 2050.

Production cost hybrid solar-PV and wind

Source: Global Hydrogen Review, IEA, 2022
Modes and cost of hydrogen transport/delivery

Source: Global Hydrogen Review, IEA, 2022
European hydrogen backbone development

- EU H2 backbone network proposed by gas infrastructure companies (EHB/news)
- Currently, 31 European gas infrastructure companies in the partnership
Hydrogen infrastructure development: the case of the Netherlands

- Conversion of natural gas infra to hydrogen, including large-scale storage (e.g. salt caverns): HyWay27
  
  Phase 1: ready 2025 – 2026: large industrial clusters on the coast + the connection to storage  
  Phase 2: ready 2027 - 2028  
  Phase 3: ready no later than 2030, other routes
Hydrogen storage

Compressed gaseous

Liquid hydrogen

Underground hydrogen storage (UHS)
Underground geological storage of hydrogen

<table>
<thead>
<tr>
<th></th>
<th>Salt cavern</th>
<th>Depleted gas field</th>
<th>Saline aquifer</th>
<th>Lined hard-rock cavern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific investment</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Levelised cost of storage</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Cushion gas*</td>
<td>25-35%</td>
<td>45-60%</td>
<td>50-70%</td>
<td>10-20%</td>
</tr>
<tr>
<td>Capacity</td>
<td>Medium</td>
<td>Large</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>Annual cycles</td>
<td>Multiple</td>
<td>Few</td>
<td>Few</td>
<td>Multiple</td>
</tr>
<tr>
<td>Geographic availability</td>
<td>Limited</td>
<td>Variable</td>
<td>Variable</td>
<td>Abundant</td>
</tr>
</tbody>
</table>

* The volume of gas required as permanent inventory in a storage facility to maintain sufficient pressure to meet withdrawal demands at a high rate, even at low storage levels.

Source: Energy Technology Perspectives 2023, IEA 2023
Hydrogen technology TRL assessment

Source: Global Hydrogen Review, IEA 2022
Thank You!