Hydrogen – Market state & trends

Fireside chat – Hertie School

3 March 2022
# The role of hydrogen in a net-zero energy system

<table>
<thead>
<tr>
<th>Role of H₂</th>
<th>Industry</th>
<th>Transport</th>
<th>Power Sector</th>
<th>Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;No-regret“</td>
<td>• Reaction agents (DRI steel) • Feedstock (ammonia, chemicals)</td>
<td>• Long-haul aviation • Maritime shipping</td>
<td>• Renewable energy back-up depending on wind and solar share and seasonal demand structure</td>
<td>• Heating grids (residual heat load)</td>
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<tr>
<td>Potential, dependent on economics</td>
<td>• High-temperature heat</td>
<td>• Trucks and buses • Short-haul aviation and shipping • Trains</td>
<td>• Absolute size of need given other flexibility and storage options</td>
<td></td>
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<tr>
<td>Electrification preferred</td>
<td>• Low-temperature heat</td>
<td>• Cars • Light-duty vehicles</td>
<td></td>
<td>• Building-level heating</td>
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</tbody>
</table>

Source: Agora Energiewende, 12 Insights on Hydrogen (2021)
• **50 GW of green hydrogen projects** have been announced to be in operation by 2030
  o Netherlands (11 GW), Spain (6.4 GW), Denmark (5.6 GW) and Germany (5.4 GW) top the list

• Already **25% more than EU’s 40 GW** installed capacity target
  o In Spain, Germany and the Netherlands project pipeline exceeds national 2030 targets

• More projects still expected to be announced
  o E.g. **HyDeal ambition** aims for 67 GW by 2030 in Spain
Electrolyser manufacturing to industrial scale - 20 GW/y of gigafactories by 2025

Announced electrolyser manufacturing capacity by 2025 and expansions by 2030 (GW/year), as of October 2021

88% of 20 GW/y gigafactories by 2025 are in Europe, expansions to 30 GW/y announced by 2030

All technologies move to industrial scale by 2025, even the younger and innovative SOEL and AEMEL technologies
Green hydrogen costs reduction with deployment and technological developments

- Learning curve effect with **accelerated deployment** of green hydrogen
  - 45% CAPEX reduction by 2025
  - More **market certainty** driving down cost of capital
  - Lower BoP and EPC costs
- Electrolyser technology trends further reduce costs to **below 2.5 €/kg**
  - Increasing **operating pressures**
  - Increasing **integration** with the renewable energy source
  - Upcoming technologies: **AEMEL** and **SOEL**
## Infrastructure options for hydrogen

### Pipeline
- Repurposing of existing natural gas pipelines
- Construction of new hydrogen pipelines

### Ship
- Liquid Hydrogen
- Liquid Organic Hydrogen Carrier (LOHC)
- Ammonia

### Electricity
- Transmission lines

### Truck
- Compressed gas containers, LOHC

### Overground storage
- Compressed, liquified, solid, derivatives

Not ideal for mass storage due to inefficiencies, large space requirements, boil off. Costs exceed €1/kg H2 (€30/MWh). Exceptions are derivatives.

### Underground (geologic) storage
- Salt caverns
- Aquifers
- Depleted gas fields

Gas is stored in large geologic structures underground at enormous volumes and for timescales as short as hours or as long as months.
Projects in hydrogen transport infrastructure, storage in all geologies

- Hydrogen transport infrastructure and storage projects along IPCEIs

- Underground hydrogen storage trials
  - In all geologies (salt caverns, lined rock cavern, aquifers, depleted fields)
  - **Cost competitive** at seasonal time scale with \(~0.6\, \text{€/kg}\) H2 storage costs

- Large-scale hydrogen **compression**
  - To become available in coming years, scale advantages in **costs and efficiency**
  - Switch to **centrifugal** compression
  - Developments in **efficient electrochemical compression**
Increasing hydrogen demand in industry and for e-fuels

- 50% green hydrogen quota for industry proposed in FF55 package by 2030

- Primary steelmaking rapidly switching to hydrogen DR plants
  - 35% of current primary steel capacity in the EU ~80 TWh/y H2 demand by 2030

- E-fuels adoption in shipping and aviation
  - 2.6% RNFBO target FF55 transport sector leading to ~ 90 TWh/y H2 demand by 2030
  - Industry pledges 10% SAF in aviation, 2% e-kerosene target in Germany by 2030
  - Fuel switch to e-methanol in shipping - led by Maersk
National hydrogen strategies

- Hydrogen strategies are often combined with electrolysis targets by 2030
  - National electrolysis targets add up to **38 GW by 2030**
- Already close to **EU’s 40 GW** installed capacity target by 2030
  - Countries like the Netherlands, Germany, Spain already have **more announced projects than their target**
- Several **strategies are still under development** expected to be published soon
  - In Sweden, Denmark, Finland and Eastern Europe - many expected to be published soon
Gallery walk

Hydrogen IPCEI projects
Lacq Hydrogen
Full green hydrogen value chain

• Part of larger HyDeal Ambition, and to become part of the European Hydrogen Backbone

• 4.5 GW electrolysis capacity, 6 GW Solar PV using excellent conditions in Spain.
  o 1.3 Mt/y emissions savings by 2035

• Storage in aquifer and transport using repurposed gas pipelines

• Next to industrial use, hydrogen reconversion in dispatchable power plant in Lacq industrial
GETH2
Complete green hydrogen value chain

- Green hydrogen transport storage and industrial use will lead to 16 Mt/year CO2 emissions savings by 2030

- **300 MWel electrolysis capacity** by 2026, use in steelmaking and refining

- Dedicated hydrogen infrastructure using repurposed pipelines and salt cavern storage

- By 2025 connections to Dutch backbone and by 2026 to Duisburg-Hamborn (ThyssenKrupp steel)

- Latest by 2030 - network extension to Salzgitter steel region
Green Octopus MD
Green hydrogen infrastructure

- ~200 km of pipeline network, newly built and retrofitted
- Salt cavern with 50 Mio. Nm³ storage capacity volume for levelling variable green hydrogen production
- Integration of the regulatory sandbox „Energiepark Bad Lauchstädt“
- The pipeline network is linked to other infrastructures and expandable to NL, DK, PL and CZ
- Integration with EHB, connected to other IPCEI projects
Your Guide

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