Enabling frameworks for green hydrogen

Emanuele Taibi

*Power Sector Transformation Strategies*

*World Bank – CMI Joint Webinar Series*

Knowledge Exchange on Green Hydrogen for the Mediterranean Region

18 March 2021
The context: net-zero by 2050
World Energy Transitions Outlook 2021

Net annual CO₂ emissions (GtCO₂/yr)

- 2050 Baseline Energy Scenario
  - 46.5 GtCO₂

- 2050 Planned Energy Scenario
  - 36.5 GtCO₂

- 1.5°C Scenario
  - -0.4 GtCO₂

Reductions in sectors in 2050 from PES to 1.5-S

- Power and heat plants: -13.0 GtCO₂
- Buildings: -2.2 GtCO₂
- Buildings Other: -2.3 GtCO₂
- Transport: -8.4 GtCO₂
- Industry: -11.0 GtCO₂
- Other: -0.4 GtCO₂
- Removals: 0 GtCO₂
Why the renewed interest in hydrogen?

A net-zero emissions system requires solutions for hard-to-decarbonise sectors

- Hydrogen can be a clean energy carrier
- Hydrogen is a compromise solution for the renewables industry and the gas industry
- It opens an interesting transition pathway for today’s oil and gas exporting countries
- Falling renewable electricity cost make green hydrogen a feasible solution
The challenge: cost reduction for green hydrogen
Key assumptions electrolyser: Electricity price USD 20/MWh. Efficiency at nominal capacity: 65% in 2020 and 76% in 2050, Electrolyser investment cost (2020): USD 650-1000/kW (USD 130-307/kW as a result of 1-5 TW of capacity deployed by 2050).

Strategies for cost reduction
- Innovation
- Scaling up manufacturing
- Scaling up modules
- Learning-by-doing

Electrolyzers can become 40% cheaper in the short-term and up to 80% in the longer term

Source: IRENA (2020)
Why focusing on the electrolyzer cost?

Low electricity cost is not enough to achieve cost competitiveness. A low electrolyser also needed.
Global analysis of hydrogen potential and trade
LCOH Global Map

Time series of solar PV and wind per raster cell (%)

Solar and Wind CAPEX (USD/kW)
Electrolysers CAPEX (USD/kW)
Electrolysers replacement (USD/kW)
WACC (%)

Land eligibility constraints

• Distance to roads, railways, pipelines, water bodies
• Elevation
• Terrain slope
• Parks, monuments, reserves
• Protected landscapes

Regional supply cost curves

Optimization problem that minimizes LCOH based on a fixed hydrogen annual demand. The problem also calculates:

• Solar PV installed capacity
• Wind installed capacity
• Electrolysers installed capacity
LCOH analysis

LCOH optimization

![Graph showing LCOH, LCOE, and Electrolyzer OPEX + CAPEX costs as functions of RES to electrolyzer capacity ratio S. The optimum point is marked.](image)
Global Hydrogen Infrastructure and Trade analysis

### Supply
- Hourly profiles for wind/solar
- High-spatial resolution (0.1x0.1°)
- Optimized VRE-electrolyzer capacities
- Supply curves (amount vs. cost) by modeling country and region

### Infrastructure
- Hydrogen conversion (ammonia, methanol, liquids)
- Trading infrastructure (terminals, ships)
- H2 storage (underground and tanks)
- Trade costs as a function of distance

### Demand
- Energy and material demand by region and sector
- Technology mix by application
- Hydrogen demand based on conversion pathway (e.g. liquids)
- Total demand by modeling region

1. **Static modeling:** Supply + transport cost for representative trading routes (e.g. Chile to Japan)
2. **Optimized modeling:** Optimal domestic production vs. import + optimal carrier

- Steps
- Final product targeted
Multilateral collaboration to accelerate green H2
IRENA’s Collaborative Framework on Green Hydrogen

- **Green Hydrogen Ministerial Roundtable** at IRENA’s 10th Assembly mandated IRENA to establish a **Collaborative Framework on Green Hydrogen**, to foster dialogue between governments and private sector.

- **Established in June 2020**

- **Two plenary virtual meetings and one WG meeting in 2020**

- **Next plenary virtual meeting on 28 April 2021 (TBC)**

- **Participation to date:** 65 countries, Hydrogen Council and IPHE

- **Currently co-facilitated by the European Commission and Morocco**
Collaborative Framework on Green H2 – work areas

<table>
<thead>
<tr>
<th>Work Area</th>
<th>Scope identified by Members at the first meeting of the Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Establish a global knowledge database for green hydrogen</td>
</tr>
<tr>
<td>2</td>
<td>Strengthen collaboration with existing hydrogen initiatives and other relevant stakeholders</td>
</tr>
<tr>
<td>3</td>
<td>Evaluate the nexus between hydrogen and renewables as well as the flexibility from coupling power and hydrogen</td>
</tr>
<tr>
<td>4</td>
<td>Disseminate knowledge on transport and distribution of hydrogen</td>
</tr>
<tr>
<td>5</td>
<td>Disseminate and coordinate standards and regulatory frameworks</td>
</tr>
<tr>
<td>6</td>
<td>Sharing of best practices on financial mechanisms</td>
</tr>
<tr>
<td>7</td>
<td>Stimulating demand for and supporting the early uptake of green hydrogen in end-use sectors</td>
</tr>
<tr>
<td>8</td>
<td>Environmental, safety aspects and social acceptance</td>
</tr>
<tr>
<td>9</td>
<td>Applicability and relevance of hydrogen in small markets (such as SIDS)</td>
</tr>
</tbody>
</table>
Facilitating the WG on enabling frameworks of the WEF Accelerating Hydrogen initiative

- **Break-out session**
- **Draft summary of recommendations**
  - Incorporate feedback from different sources
  - Present results at WEF annual meeting
- **Outreach**
  - Engage with the key stakeholders in the climate negotiations
  - Contribute to the preparations for COP26
  - Communiqué at COP26

- **22 October 2020**
  - Agree on areas to focus
- **14 April 2021**
  - Workshop
- **May 2021**
  - Outline of next steps
- **World Economic Forum**
  - August 2021
- **COP 26**
  - November 2021

Collaborative Framework on Green Hydrogen
Emanuele Taibi
Power Sector Transformation Strategies
Etaibi@irena.org

https://www.irena.org/energytransition/Power-Sector-Transformation/Hydrogen-from-Renewable-Power

www.irena.org
www.twitter.com/irena
www.facebook.com/irena.org

www.instagram.com/irenaimages
www.flickr.com/photos/irenaimages
www.youtube.com/user/irenaorg
There is a high uncertainty in total cost and breakdown due to limited number of projects, confidentiality of the data and tailored design.
What is the impact on competitiveness?

Reduction in electrolyzer cost and lower electricity price represents the bulk of total cost reduction to reach the 2 USD/kg mark.
Hydrogen in the energy transition

Decarbonising the gas grid
- Provide seasonal storage for solar and wind
- Provide grid services from electrolysers
- Distributed stationary fuel-cell for heat and power generation

Decarbonising Transport
- FCEVs: performances of conventional vehicles
- FCEVs are complementary to BEVs in decarbonising road transport
- FC/E-fuels for rail, aviation, maritime sector (deep decarbonization)

Decarbonising Industry
- Replace fossil-fuel produced hydrogen
- Replace fossil-fuel based feedstocks
- New commodities e.g. iron pellets (DRI)

Source: IRENA (2018)