Hydrogen Energy

Building a sustainable, low-carbon society
Hydrogen: a CO₂ neutralizer

Industry

23% of CO₂ EMISSIONS

Transport

23% of CO₂ EMISSIONS

46% of CO₂ global emissions could be concerned by the hydrogen revolution

Source: IEA, 2021

$2,500 bn potential market for hydrogen in 2050

Zoom on hydrogen

Hydrogen in our energy mix

0% 2022
We need a combination of solutions to decarbonize different needs

<table>
<thead>
<tr>
<th>Use case</th>
<th>Ground (light, low intensity)</th>
<th>Ground (heavy, high intensity)</th>
<th>Rail</th>
<th>Waterborne</th>
<th>Aviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery electric</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>✓ Long distances, isolated areas, large vehicles</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Overhead wire</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-fuels</td>
<td></td>
<td></td>
<td>✓</td>
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<td>✓</td>
</tr>
</tbody>
</table>

Hydrogen can address all mobility segments

- Best suited solution
- In certain situations
Significant international momentum

- **110+** Giga-scale production (renewable and low-carbon projects)
- **550+** Large-scale Industrial usage (refinery, ammonia, methanol, steel and industry feedstock)
- **190+** Transport (trains, ships, trucks, cars and other mobility applications)
- **90+** Integrated hydrogen economy (cross-industry, projects with different types of end-uses)
- **90+** Infrastructure (hydrogen distribution, transportation, conversion and storage)

**~1,000** projects announced with **investments** of **$320 bn** (and a target of **$610 bn by 2030**)

**53%** industry
**18%** transport
+ large infrastructure projects emerging (exports, pipelines)

Updated in June 2023
**Primary Production**

- **Clean Power Generation**
- **Natural Gas**
  - Steam Methane Reformer + Carbon Capture
  - \( \text{CH}_4 + 2 \text{H}_2\text{O} \rightarrow 4 \text{H}_2 + \text{CO}_2 \)
- **Biomethane Production**

**Liquid Supply Chain**

- Large Electrolyser
- Liquefaction Plant
- Liquid Trailers & Tanks

**Gas Supply Chain**

- CO2 Capture
- CO2 Storage
- Filling Center
- Pipeline
- Gas Transport

**Liquid Fueling for Mobility**

- Heavy Duty
- Maritime (Bunkering)
- Aviation
- Train

**Industrial Applications**

- Gaseous Fueling for Mobility
  - From liquid hydrogen
  - From gaseous hydrogen
  - Light-duty Station (Cars)
  - Heavy-duty Station (Trucks, Trains)

**Hydrogen Value Chain**

- HEATING & POWER
  - INDUSTRY FEEDSTOCK
  - INDUSTRY ENERGY
- **Clean Power Generation**
- **Generation**
- **NATURAL GAS**
  - Large Electrolyser
- **BIOLOGICAL ENERGY**
  - Biological Energy
- **CO2 Capture**
  - CO2 Storage

**Energy Sourcing**

- Energy Sourcing
- Production
- Distribution
- End-Use
Building upon our strengths to move fast

- An approach focused on basins
- Leveraging Air Liquide’s long-standing operational excellence
- Relying on our best-in-class technologies and our capacity to innovate
- Partnerships as a key driver
Recognized operational excellence

Operational excellence

- Optimized energy procurement
- Extensive expertise with large industries
  300+ hydrogen plants
- Best-in-class safety, technical know-how and reliability,
  based on long-standing experience and existing operations
- Strong supply chain know-how and organization to develop
  efficient bulk logistics
  1,500+ hydrogen trailers
Focus on
15 key targeted basins
Electrolysis available technologies

**Alkaline (atmospheric pressure)**
- Mature
- Scalable
- Cost effective
- Lifetime

**Alkaline (pressurized)**
- Mature
- Scalable
- Cost effective
- High pressure
- (< 30bar)

**PEM (Proton Exchange Membrane)**
- Compact
- No KOH
- Fast Reactivity
- High pressure
Scaling up our electrolysis capacity

Leading position in large scale electrolysis to reach 3 GW capacity by 2030

<table>
<thead>
<tr>
<th>Project</th>
<th>Capacity</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybalance</td>
<td>1.2 MW</td>
<td>2018</td>
</tr>
<tr>
<td>Bécancour</td>
<td>20 MW</td>
<td>2021</td>
</tr>
<tr>
<td>Trailblazer</td>
<td>30 MW</td>
<td>2023</td>
</tr>
<tr>
<td>Air Liquide Normand’Hy</td>
<td>200 MW</td>
<td>2025</td>
</tr>
</tbody>
</table>
Bécancour (Canada): 20 MW - 8.2 tonnes of H₂ per day

Using local hydropower capacity

Emission reduction: 27,000 tonnes of CO₂ per year

Integrated in an existing H₂ production site since 2021
Building synergies at scale in key basins

Normandy Basin (FR)

The world’s first low-carbon hydrogen network and carbon capture as a service

- Innovative technologies
- Renewable energy sourcing
- Refineries’ needs for renewable and low-carbon products
- CO₂ capture on customers assets
- Large scale carbon management with shipping and storage in Europe
Joint-venture with Siemens Energy

The state-of-the-art gigawatt factory will ramp-up to an annual production capacity of three gigawatts by 2025. Located in Berlin, the new manufacturing site spans over 2,000 square meters. It leverages automation and robotics for the series production of Proton Exchange Membrane (PEM) electrolyzer modules.
Collaboration with TotalEnergies on retail network

Ambition

- A 50/50 joint venture to accelerate the development of an extended hydrogen station network, primarily for trucks, in 5 countries in Europe (France, Germany, Benelux), and take leading position in the H2 market.

Approach

- Building a consistent network of well positioned H2 stations in logistics hubs and along the main European traffic corridors, thus becoming a reference player.

- An alliance that will provide visibility to OEMs, transport fleets to accelerate vehicles deployment at scale, and to public bodies to accelerate financing supports.

- An accelerator to decarbonize heavy duty road transport as it will activate the H2 road mobility market in Europe.

- The JV will invest, build, own and operate the stations, source the hydrogen and the HRS technology on the market and distribute H2 to vehicles and transporters.
Thank you!