H₂ Energy
At the heart of the energy transition
40 years of development in Hydrogen for our customers

Production & Supply chain

Distribution Networks

Markets Segments

Key Figures

Production

Supply-chain

US Gulf Coast

Northern EU

Singapore

Hydrogen
Oxygen
Nitrogen
Synthetic gas

Hydrogen and syngas facility
Oxygen and nitrogen facility
Cogeneration facility
Synthetic gas facility

Process industries
Oil & Gas
Steel, Glass
Electronics
Transportation
Space

> 14 bn m³/yr
> 1,850 km H₂ pipeline
> 46 large H₂/CO plants
> 40 electrolysers in operation
> 2 bn € sales
Air Liquide investments in Hydrogen Mobility

- **Mobility for Professionals**
  - US+EUROPE
  - 9 HRS

- **Mobility for Consumers**
  - US North-East
  - 12 HRS
  - + Supply chain

- **Mobility for Consumers**
  - California
  - 4 HRS

- **Mobility for Consumers**
  - Japan
  - 6 HRS

- **Mobility for Consumers**
  - Dubai
  - 1 HRS

- **Mobility for Consumers**
  - Korea
  - 1 HRS

- **Power to Gas**
  - Denmark
  - 5 HRS
  - + 1 Electrolyzer

- **Mobility for Consumers**
  - Germany
  - 11 HRS

- **Mobility for Consumers**
  - Paris, Brussels and Rotterdam
  - 5 HRS

- **>100 Hydrogen recharging stations (HRS) installed by Air Liquide in the world**

- **>40 directly invested and operated by Air Liquide**

- **> Member of 2 consortia developing HRS networks, each time with 25% of 80-100 HRS**

- **> H2 Supply chain in the US and Denmark**

- **> Investment via ALIAD in 5 Start ups**
AL HRS examples in the EU

In-door

Dual-pressure

On hydrogen pipeline

Stand alone

Integrated urban stations
Regulation effect on permitting process - Forklifts HRS - FR

Drafting & adoption of forklifts HRS FR regulation

* Arrêté du 26 novembre 2015 relatif aux prescriptions générales applicables aux installations mettant en œuvre l’hydrogène gazeux dans une installation classée pour la protection de l’environnement pour alimenter des chariots à hydrogène gazeux lorsque la quantité d’hydrogène présente au sein de l’établissement relève du régime de la déclaration pour la rubrique n° 4715
## Regulations effect on HRS cost - *comparison between Jp/EU/US*

<table>
<thead>
<tr>
<th>Japan</th>
<th>Europe / US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trained operator having HPGSL licenses present when station is opened</td>
<td>Self service, remote monitoring</td>
</tr>
<tr>
<td>Office building for operator</td>
<td>No office</td>
</tr>
<tr>
<td>Reinforced concrete walls (or large safety distance) around high pressure H2 equipment</td>
<td>Simple walls around technical area. Refrigeration unit just out of ATEX zone.</td>
</tr>
<tr>
<td>Fire wall at boundary limit (for urban HRS using GHPGSR(^1) Art.7-3-2)</td>
<td>Not needed</td>
</tr>
<tr>
<td>Water tank, pump &amp; water spraying system on H2 buffers</td>
<td>Not needed</td>
</tr>
<tr>
<td>Piping design safety factor = 4</td>
<td>Piping design safety factor = 2.4 or 3.5</td>
</tr>
<tr>
<td>Stainless steel specific nickel content</td>
<td>Stainless steel 316L</td>
</tr>
<tr>
<td>Specific codes, standards and inspection requirements ⇒ very few suppliers outside Japan can comply &amp; cost is higher</td>
<td>Europe / US codes and standards are mastered by many suppliers and notified bodies.</td>
</tr>
</tbody>
</table>
HRS CAPEX comparison - *Base 100*
Japan way forward: HRS New regulation Task Force

<table>
<thead>
<tr>
<th>Theme</th>
<th>Results</th>
</tr>
</thead>
</table>
| Mitigation the distance between dispenser and public road | Mitigated from 8m to 5m  
METI released on April 2018 |
| Abolition sprinkling water for buffer tank | System mitigated  
- From: Cistern + pump driven by gasoline engine  
- To: Directly piping from city water |
| Mitigation the distance between compressor / buffer cabinet and battery limit | Mitigated from 8m to 5m  
- METI released on April 2018  
- Only for distance of battery limit  
- Distance from ignition/flame is still 8m |
| Etc… | |
Regulatory environment in EU

**EU Directives**
- PED, TPED
- AFID
- ATEX, EMC, MD, MID...

**Requirements and obligations**
- applicable through EU

**Standards**
- European CEN CENELEC
- International ISO IEC

**Member States Laws**
- Transposition

**Checking Compliance**
- Governments administrations
- Notified Bodies
- Self Certification

**Permits and Certification**
**ISO - EU Main HRS standards**

**Automotive**
- Vehicle Equipment:
  - ISO 19881: Gaseous H2 Land vehicle Fuel Tank
  - ISO 19882: Gaseous H2 Land Vehicle TPRD

**Refueling Guidelines**
- ISO 19880-1

**Interface Standards**
- ISO 17268 - Fueling Connectors
- ISO 14687 - Quality
- ISO 19880-8 Quality Assurance
- ISO 21087 Analytic Methods
- EN 17127: Hydrogen Refueling station including refueling protocols
- EN 17124 H2 QUality and Quality Assurance

**Station: ISO 19880-1**
- Dispenser Component Standards
  - ISO 19880-2 - Dispenser
  - ISO 19880-3 Valves
  - ISO 29880-4 Compressors
  - ISO 19880-5 - Hose
  - ISO 19880-6 - Fittings

**Storage, NFPA 2**
- ISO 19884 Storage (stationary)

**Generator /Electrolyzer**
- ISO 22734
- ISO 16110-1,2
Lessons learned

To unlock HRS rollout safely and at affordable cost

> A proper regulatory framework is needed
  ➔ Find a balance between over-regulation and no regulation
  ➔ To be built on the basis of existing projects and with the industry (third party experts are not always a solution)

> Harmonisation of the regulations among EU countries
  ➔ Share of best practices among countries taking advantage of EU countries having paved the way (D, F, NL…), e.g.
    ○ Safety distances and other risk mitigation measures
    ○ Storage threshold before requiring additional impact studies or authorization (D > 3t)
  ➔ Ensure similar implementation of EU directives requirement among EU countries
    ○ Ex. AFID: quality requirements, IED application to onsite production

> International standards help lowering costs and accelerating deployments
Next regulations to come when scale up

> Large scale HRS in urban environment
  ➔ Safety distances for large H2 amounts stored
  ➔ Liquid H2 storage, transportation…
  ➔ Autonomous footprint

> On-site production
  ➔ Small scale SMR, integration of large electrolysers with HRS …
  ➔ Distinct regulations between production/distribution  -> German example

> Multi-fuels refuelling stations
  ➔ Avoid stacking of mitigation measures

> Special features for autonomous vehicles…. 