



H₂ Energy

At the heart
of the energy transition

40 years of development in Hydrogen for our customers

Production & Supply chain

Production

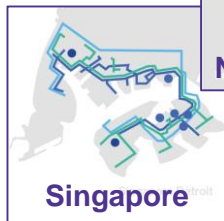


Supply-chain



Distribution Networks

US Gulf Coast



- Hydrogen
- Oxygen
- Nitrogen
- Synthetic gas
- Hydrogen and/or carbon monoxide facility and hydrogen source
- Oxygen and nitrogen facility
- Cogeneration facility
- Synthetic gas facility

Markets Segments

Process industries

Oil & Gas



Steel, Glass



Electronics



Transportation Space



Key Figures

- > 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



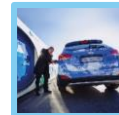
Mobility for Consumers
Korea
1 HRS



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



On hydrogen pipeline



Dual-pressure



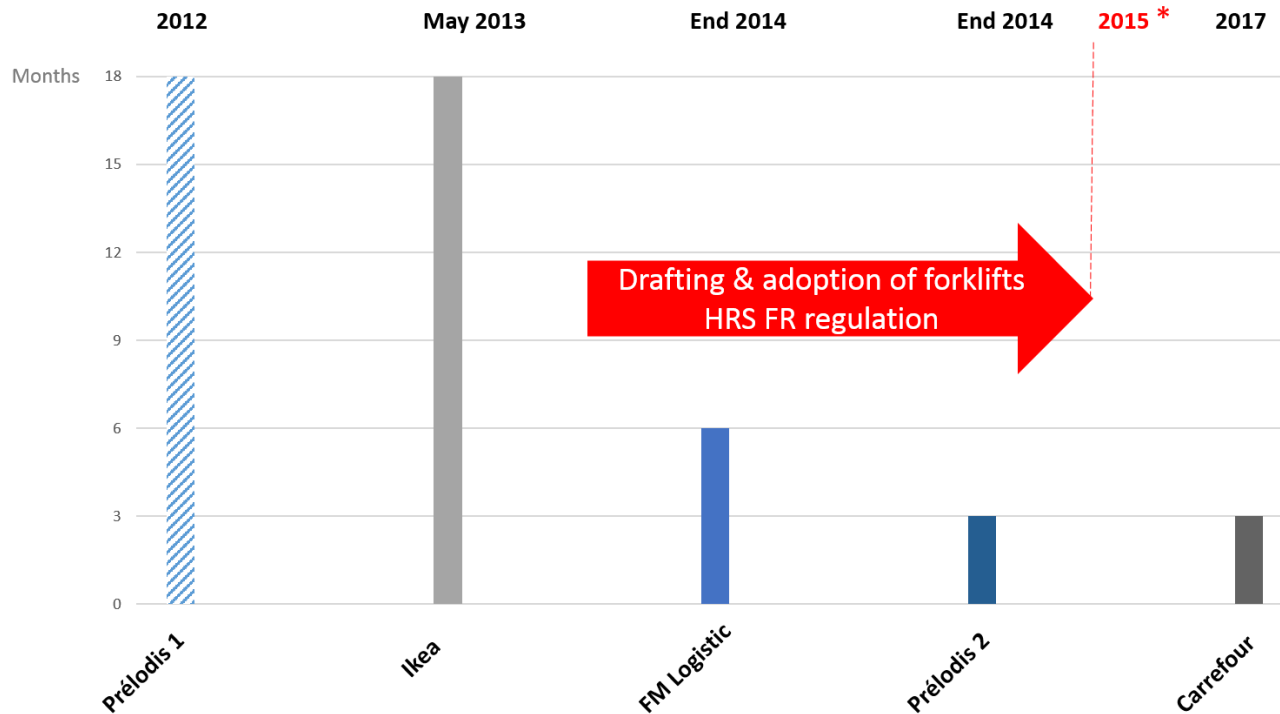
Stand alone



Integrated urban stations



Regulation effect on permitting process - Forklifts HRS - FR

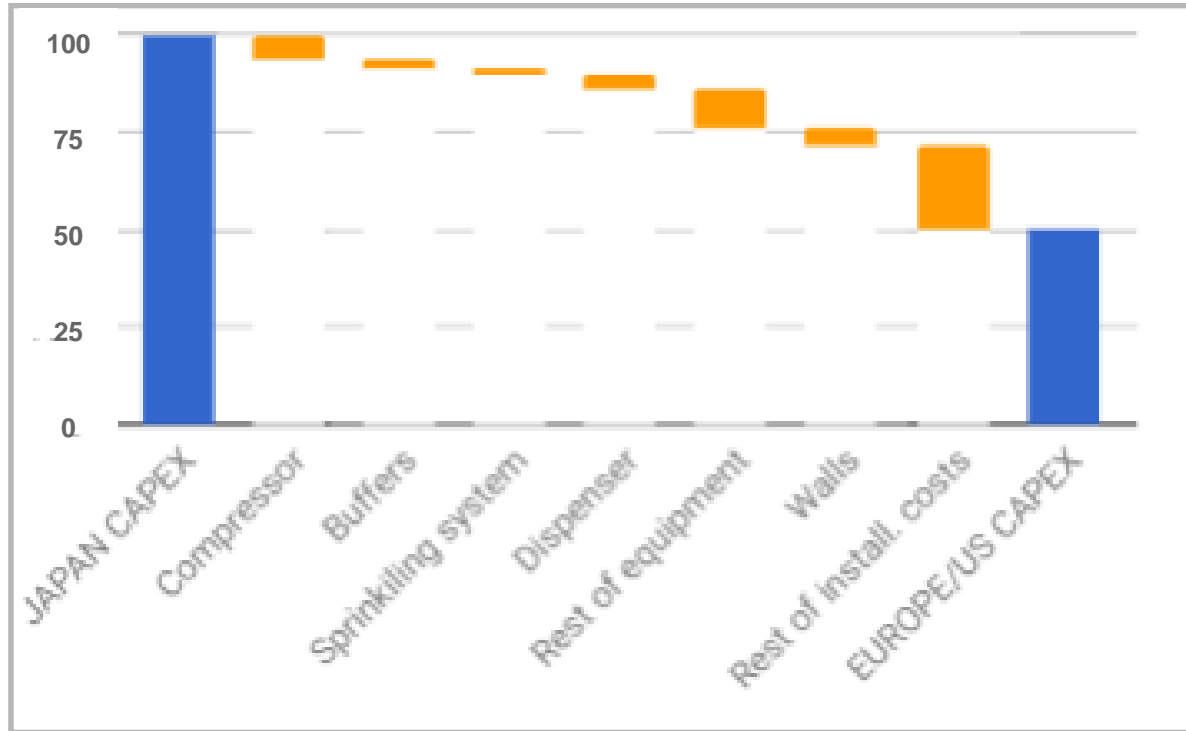


* Arrêté du 26 novembre 2015 relatif aux prescriptions générales applicables aux installations mettant en œuvre l'hydrogène gazeux dans une installation classée pour la protection de l'environnement pour alimenter des chariots à hydrogène gazeux lorsque la quantité d'hydrogène présente au sein de l'établissement relève du régime de la déclaration pour la rubrique n° 4715

Regulations effect on HRS cost - comparison between Jp/EU/US

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

HRS CAPEX comparison - Base 100



Japan way forward: HRS New regulation Task Force

State of items for regulation reform by CAO @June 2018

FY	2013	2014	2015	2016	2017	2018	Remark
Round	1st	2nd	3rd	4th	5th		
CAO items for HRS	1st (第一期)	12 items Released		All items Legislated			
	3rd (第三期)		18 items Released		5 items Legislated		*2 items added by TF
	5th (第五期)				20 items Released	All items Not Legislated	



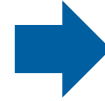
Theme	Results
Mitigation the distance between dispenser and public road	Mitigated from 8m to 5m - METI released on April 2018
Abolition sprinkling water for buffer tank	System mitigated - From : Cistern + pump driven by gasoline engine - To : Directly piping from city water
Mitigation the distance between 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...



Member States Laws
Transposition



Checking Compliance

Governments administrations
Notified Bodies
Self Certification



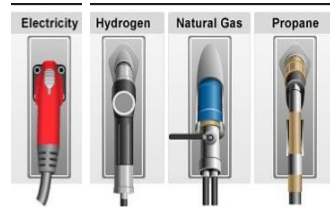
**Permits
Certification**

Requirements and obligations
applicable through EU



Standards

European



International



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

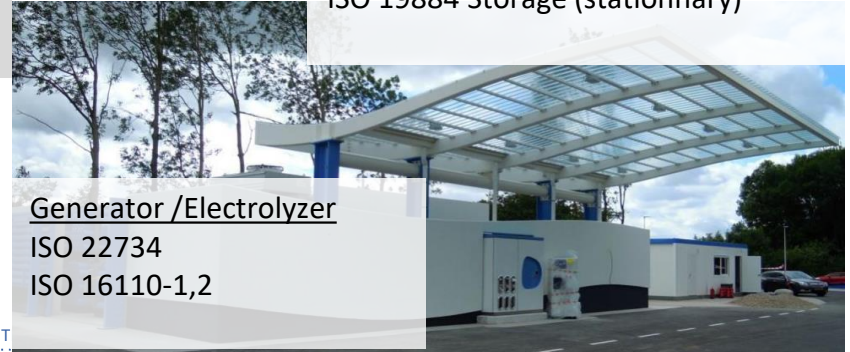
Dispenser Component Standards

- 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....