

# State of the art of LH<sub>2</sub> installations and facilities



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Pre-normative REsearch for Safe use of Liquid HYdrogen

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1966



# Outline



- Motivation
- Liquid hydrogen delivery infrastructure
  - Production
  - Liquefaction plants
- Stationary LH<sub>2</sub> large storages
- Liquid hydrogen trailers
- LH<sub>2</sub> based fueling station
- Conclusions

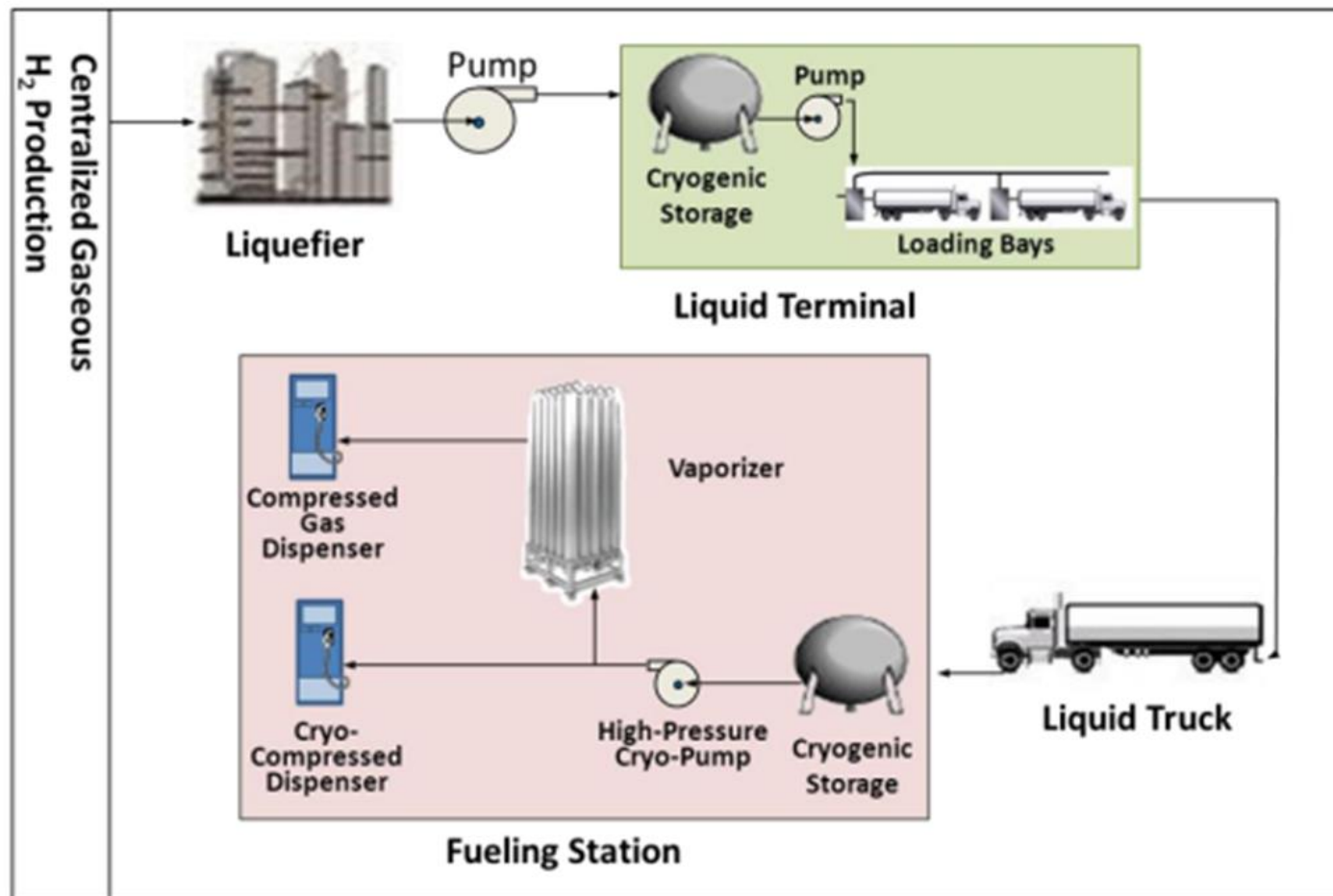
# Motivation



- Scale-up of existing and new applications: increasing H<sub>2</sub> demand.
- Liquid hydrogen (LH<sub>2</sub>) provides **higher densities** => **improved logistic** and **higher throughput** compared to compressed gaseous transport and storage



# Liquid hydrogen delivery infrastructure



# Hydrogen Production

Biomethane reforming



Electrolysis  
*Low carbon electricity*

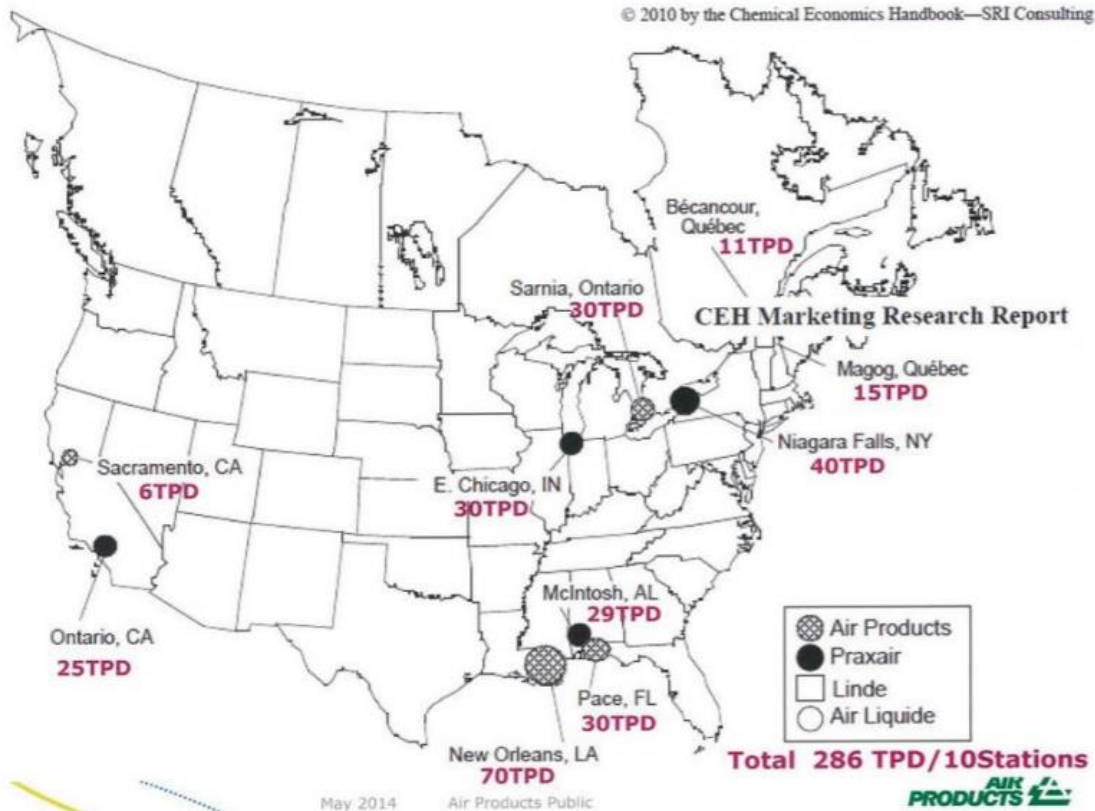


Natural Gas Reforming  
+ Carbon Capture and  
Storage (CCS)



**Low Carbon  
Hydrogen**

# « Large scale » liquefiers in operation



Europe:

Air Products 5 tpd – Rozenburg NL

Linde 4 tpd – Ingolstadt GE

6 tpd – Leuna GE

Air Liquide 10 tpd – Waziers FR

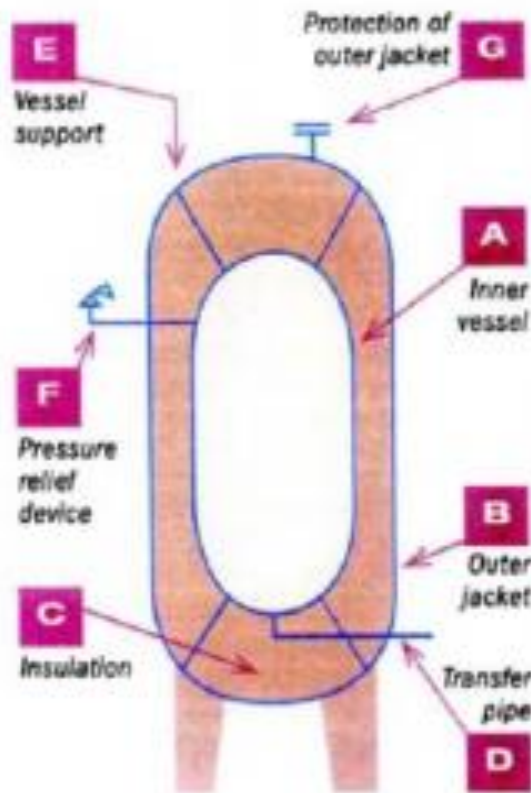
2 tpd – Kourou - Guyana

Since 2018, multiple announcements for large scale liquefiers from 10 to 30 tpd across North America and Europe.

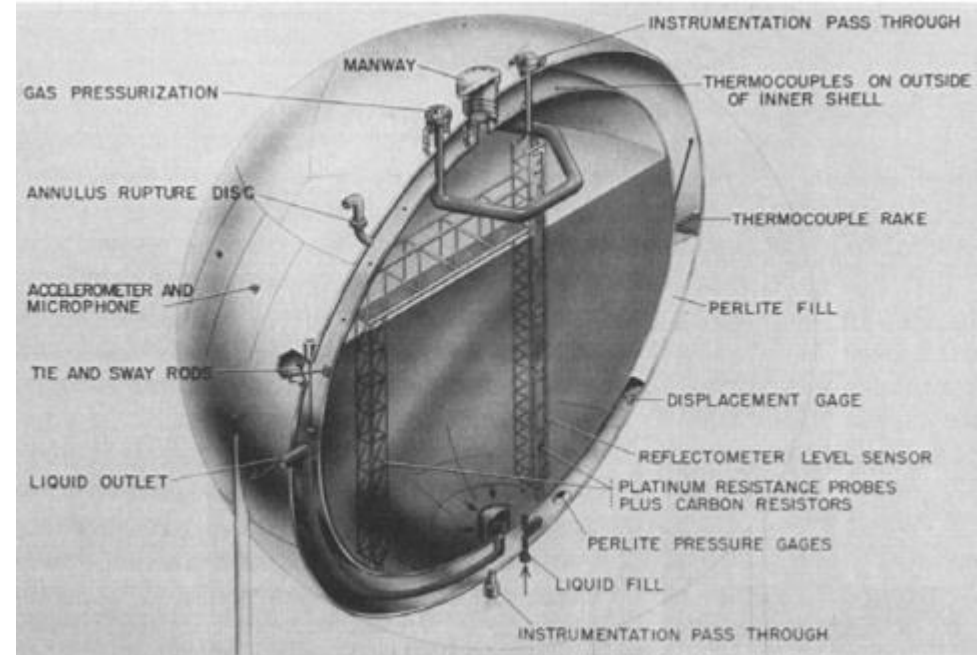
# Stationary LH<sub>2</sub> storage

$T(\text{LH}_2) = -253^\circ\text{C}$

- Vacuum insulated vessels
- Inner pressure vessel for pressure
- External protective jacket to retain perlite



# World largest LH<sub>2</sub> storage: NASA Kennedy space center



$V = 3800 \text{ m}^3$  / double wall vacuum perlite (1.3 m of thickness) /  $D_{int/ext} = 18.75 / 21.34 \text{ m}$   
Operating pressure = 6.2 bar / boil off = 0.025%/day



# Waziers in France



- 4 horizontal tanks of 250 m<sup>3</sup> each

- Internal/external diameter = 4.02 / 5.1 m

- Perlite thickness = 500 mm

- Liquefaction unit = 10 t/d

# Liquid hydrogen trailers



- Insulated using a vacuum super insulation.
- The Vacuum Super Insulation is a system of thermal insulation which includes:
  - A double shell insulation space (interspace) where static high vacuum is limiting heat transfer by conduction and convection.
  - A blanket of alternate layers of highly reflecting shields and insulating spacers to prevent heat transfer by radiation as well as conduction between shields.
  - An adsorbent (molecular sieve) placed in the vacuum space in order to achieve an adequate level of vacuum at low temperature by adsorption of residual gases and moisture.



# LH<sub>2</sub> transfer

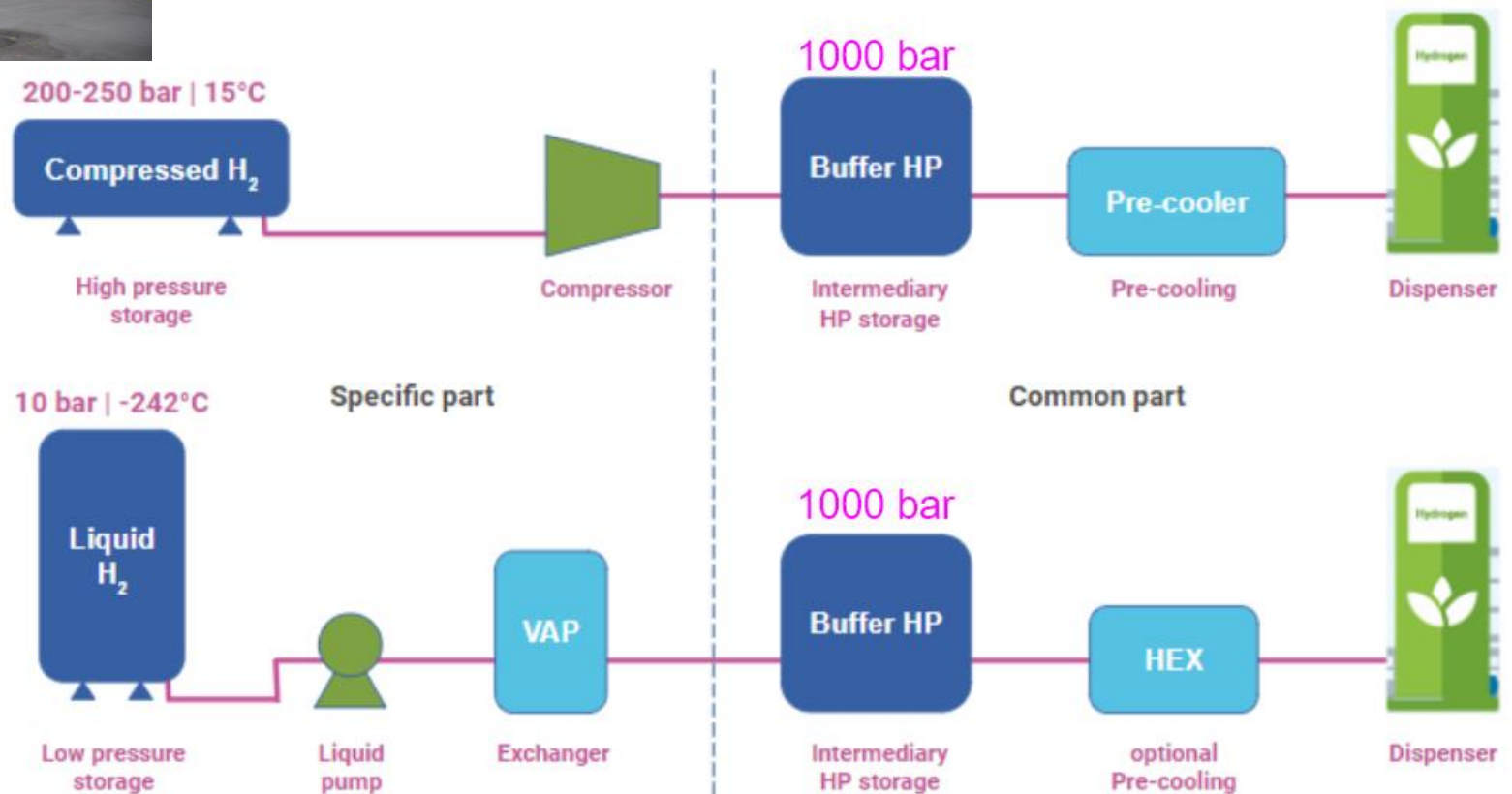


**To transfer LH<sub>2</sub> from a storage to another :**

1 - by pressure build-up (natural pressure build up or voluntary vaporization of LH<sub>2</sub> via a external heat exchanger). Hence, the pressure in the “mother storage” becomes higher than pressure in the “daughter storage” and LH<sub>2</sub> transfer is easy.

2 - pumping in the “mother storage” using an appropriate piston cryogenic pump.

# LH<sub>2</sub>-based fuelling station



# Conclusions

- Short description of the whole logistic chain of LH<sub>2</sub> and the associated technology from the liquefaction to the use in a fuelling station.
- Difference between a GH<sub>2</sub> and LH<sub>2</sub> refuelling station.
- One of the main challenge of the LH<sub>2</sub> infrastructure is risk and safety. PRESLHY goal was to improve the knowledge on LH<sub>2</sub> accidental behaviour.

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**FUEL CELLS AND HYDROGEN**  
JOINT UNDERTAKING



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