

H2 fuel for the maritime sector: Vision from a H2 supplier

H2PORTS - 2nd Stakeholders group
meeting

Erwan Bruneau

Product Manager Europe – Hydrogen for Mobility & Energy Transition

Air Products Public



**CARBUROS
METALICOS**
Grupo Air Products



Hydrogen Leadership

Air Products has more than **60 years of hydrogen experience** and is at the forefront of hydrogen energy technology development.

Global Hydrogen Capabilities and Experience

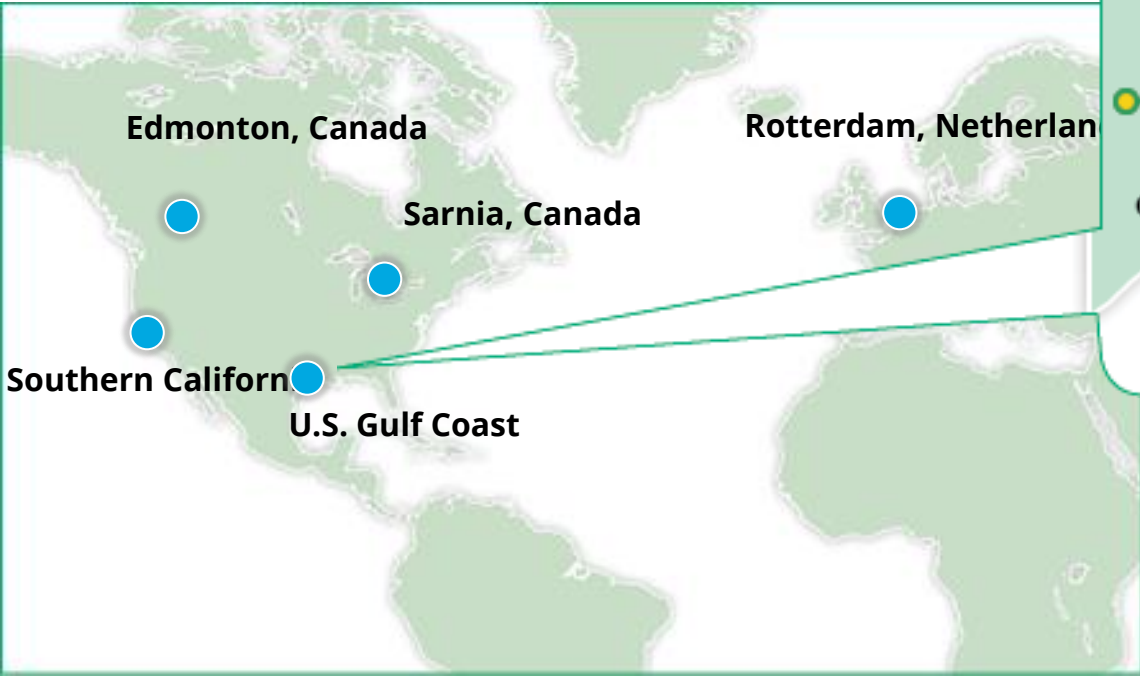
- Worldwide leadership position in outsourced Hydrogen production and recovery
 - Hydrogen supplier since 1975 (first liquefier to NASA)
- Own and operate over **80 large hydrogen plants** around the world with established reputation for high reliability operation
 - Over **1400 operating years** for Hydrogen plants using SMR, gasification and electrolysis technology
- Initial focus on the refining and chemical industries
- **Since 1993, > 250 H₂ station projects** in 20+ countries
 - > 1,500,000 fueling/year / > 10,00,000 total fueling
- Member of the **Hydrogen Council**, a global CEO-led initiative with a united and long-term vision to develop the hydrogen economy



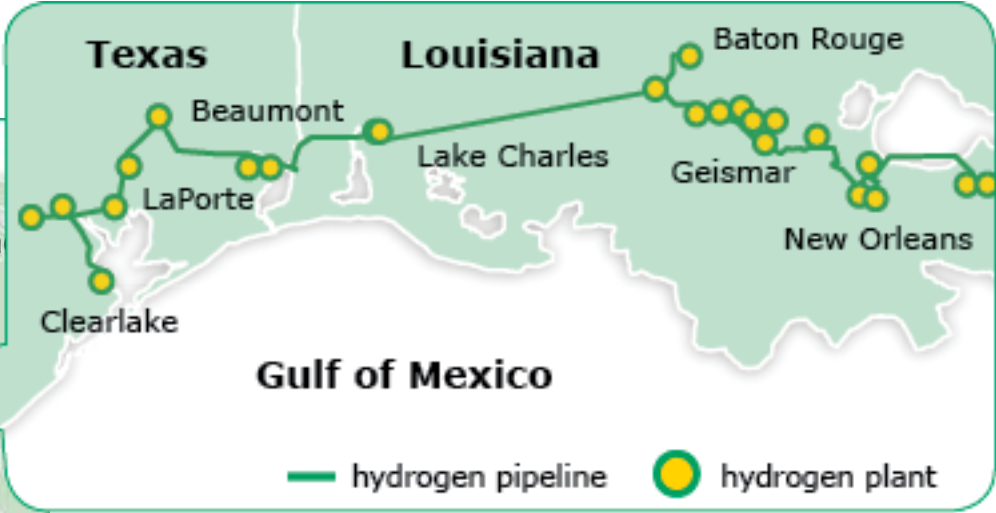
Hydrogen pipelines

A new standard for reliability

Major hydrogen pipelines



World's largest H₂ pipeline system



U.S. Gulf Coast*

- 1,126 km of pipeline
- >40 Millions NM³/day total capacity from 24 hydrogen production facilities

*includes Gulf Coast Ammonia investment announced in Jan 2020

Liquid hydrogen leadership

World-class liquid hydrogen supplier

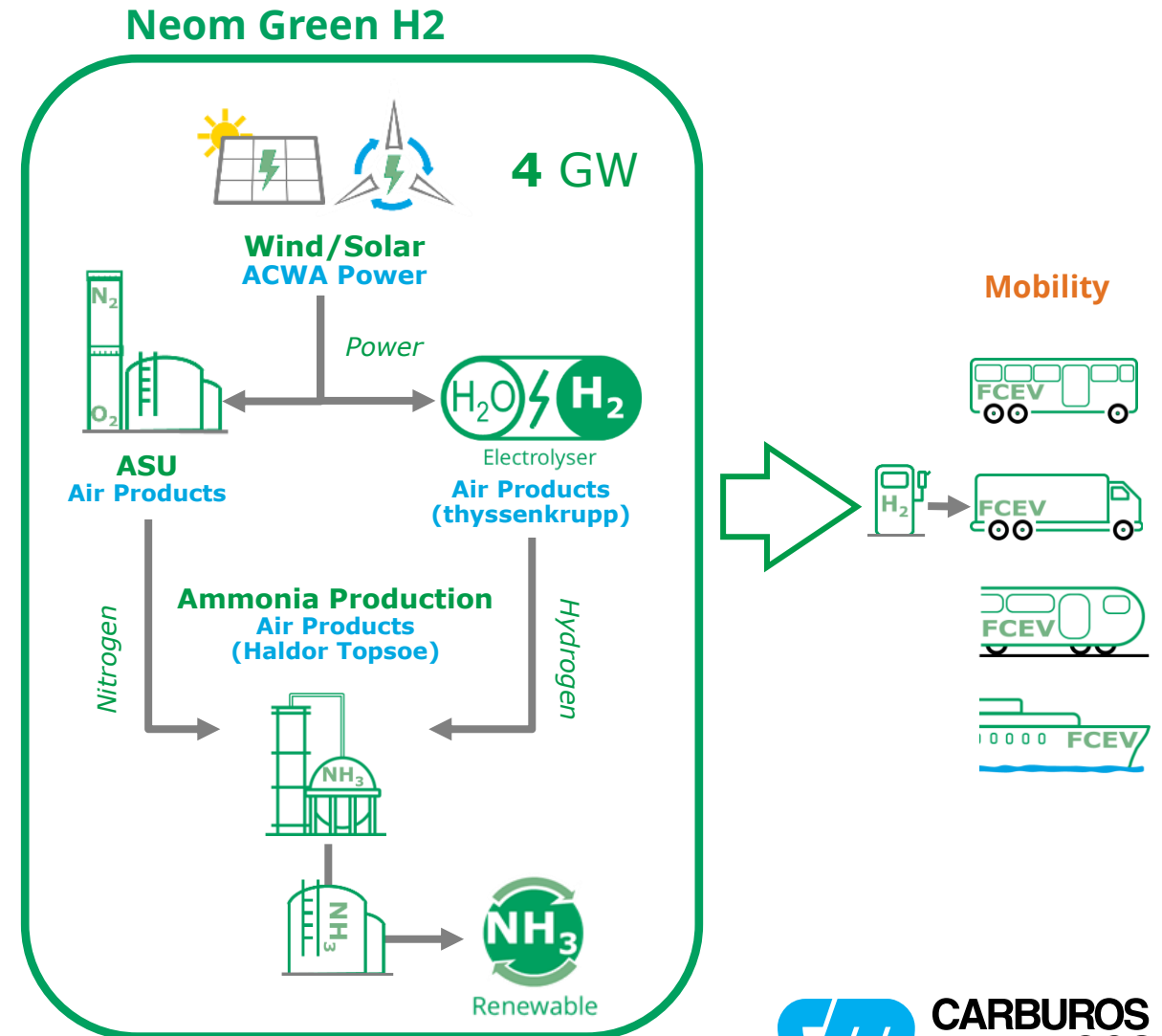
Air Products' major liquid hydrogen production facilities today



- New liquid hydrogen plant announced in LaPorte, Texas (30 TPD, 2021)
- New liquid hydrogen plant recently announced in California (2021)
- Air Products operates own fleet of hydrogen trailers and uses own drivers

Lead the way to mass produced clean Hydrogen

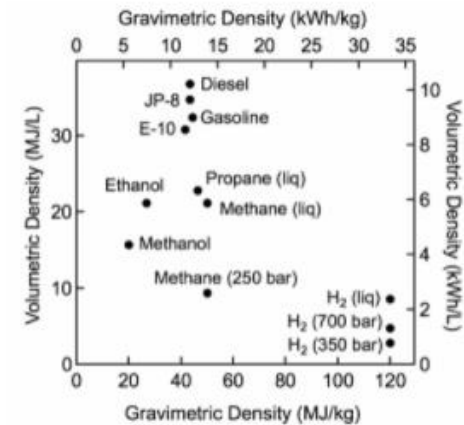
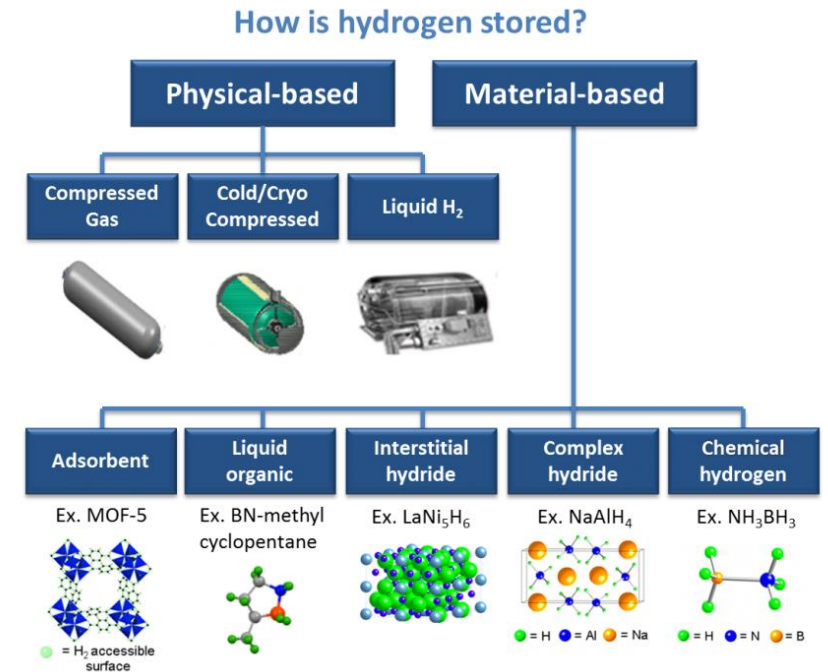
- AP announced a \$5billion project with ACWA power and city of Neom for the production of **green Hydrogen** for export
- Over 4GW of Renewable power to produce **650Mt/day of H2 from 2025**
- Partnering with technology providers to deliver largest green H2 project
- Ammonia used as **hydrogen carrier** for export around the world
- Hydrogen transported from Neom and dispensed by Air Products at point of use
- Hydrogen to meet European requirements on renewable fuels according to RED II



Air Products Public

Options for hydrogen storage

- Hydrogen identified as a game changer energy carrier for transport decarbonisation
- Hydrogen can be stored:
 - « physically » under pressure as a gas, liquefied or even as solid
 - Within other materials with chemical bonds or as an alternative carrier
- Hydrogen mobility is developed primarily through the use of PEM fuel cells, requiring high purity H₂
- Storage of pure hydrogen has benefits:
 - Long experience of gaseous and liquid storage systems
 - Management of hydrogen quality
 - Benefit of composite vessels development for pressurised systems



DOE technical Targets for Onboard Hydrogen Storage for Light-Duty Vehicles

Proven hydrogen storage solutions

- Challenges vs existing fossil based fuels:
 - H₂ systems have volumes of **x8 to x20** depending on storage method
 - Cylindrical storages more challenging to integrate
 - Suitable storage method depending on application
- Challenge to design an onboard storage system for the various maritime usages taking into account:
 - Volume taken by the fuel & storage equipment
 - Weight of fuel & storage equipment
 - Form factor of pressurised or liquefied fuel storage vessels
- Proven technologies considered in heavy duty applications:
 - Gaseous hydrogen at various pressures
 - Liquid hydrogen
- Ammonia longer term solution due to higher energy density



Fuel supply solutions for Maritime applications

- Comparison of two hydrogen fuel routes
 - Gaseous hydrogen can be stored at different pressures to meet specific requirements
 - Liquid hydrogen systems are more complex to minimise boil off/losses and reduce risks

Fuel Type	Pressure/temperature	Hydrogen capacity (kg)	Energy content (40ft cont equivalent)	Gravimetric efficiency (% mass)	Ship sizes
Gaseous Hydrogen	500bar/Ambiant	1,000	18MWe	3,5 - 5	+
Liquid hydrogen	5bar/-253°C	3,500	63MWe	10-20	++

- Refuelling methods:
 - Integrated storage system in ship:
 - + *Ideal, optimised onboard integration*
 - + *Simplified refuelling operation*
 - Storage module swap:
 - + *Minimal port infrastructure and utilities*
 - + *Flexibility of supply to all locations*
 - + *Hydrogen filling under supplier management*



Conclusion

- Clean hydrogen sources at scale available soon !
- Expertise exists to develop maritime use of hydrogen for certain applications
- Development of storage systems need to take into account the hydrogen specifics for fuel supply to location and to ship
- Ammonia to offer potential for larger vessels

Thank You
tell me more

Air Products Public



**CARBUROS
METALICOS**
Grupo Air Products