

# H2@Scale Workshop

NREL – Golden, CO

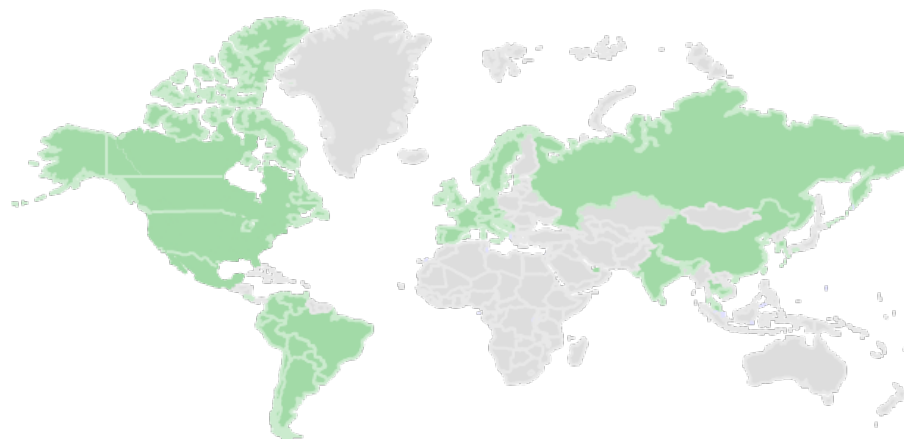
Albert Burgunder

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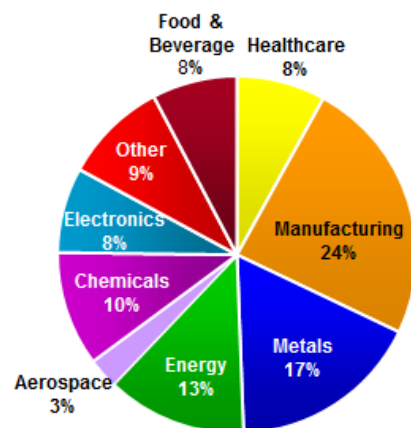


# Praxair at a Glance

- **A Fortune 250 company**
  - 2015 sales of \$12 billion
- **Global Industrial Gas Supplier**
  - Largest in North and South America
- **Operating in more than 50 countries**
- **27,000 employees**
- **One million customers worldwide**



## End Markets



- A component of the Dow Jones Sustainability Index – 11 years
- 100 Best Corporate Citizens for 2013 by Corporate Responsibility Magazine
- Regularly rated among the most shareholder-friendly chemical companies (*Institutional Investor*)
- Named among the “World’s Most Innovative Companies” by *Forbes*



MEMBER OF  
**Dow Jones Sustainability Indices**  
In Collaboration with RobecoSAM

# H2 Molecule Sources

Hydrogen Molecule Sources	Hydro-Carbon				Electrolysis			
	Natural CH4	Bio CH4	Others (ROG)	Natural Gas Liquids	Fossil Electricity	Renewable Electricity	Water	Salts
<u>Purpose Production</u>								
Hydro-Carbon Reforming (SMR)	✓	✓	✓				✓	
Electrolysis					✓	✓	✓	
<u>By-Product Production</u>								
Ethane Crackers				✓				
Chlor-Alkali Production					✓	✓	✓	✓

Reforming	$\text{CH}_4 + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2 + 4\text{H}_2$	Cracker	$\text{C}_2\text{H}_6 \rightleftharpoons \text{C}_2\text{H}_4 + \text{H}_2$
Electrolysis	$2\text{H}_2\text{O} \rightleftharpoons \text{O}_2 + 2\text{H}_2$	Chlor-Alkali	$\text{NaCl} + \text{H}_2\text{O} \rightleftharpoons 2 \text{Cl}_2 + 4 \text{NaOH} + 2\text{H}_2$

## Discussion Points

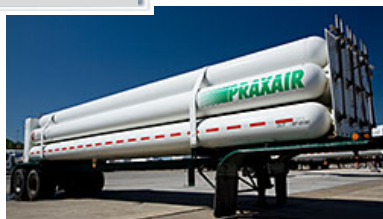
- Renewable H2 production & use of by-product H2 sources
- Capital requirement will influence development pathways
- Feedstock variable cost stability is an important factor

# Commercial Delivery Modes



Luxfer-GTM Technologies

## Compressed Gas



## Liquid Hydrogen



## High Pressure Pipeline Supply





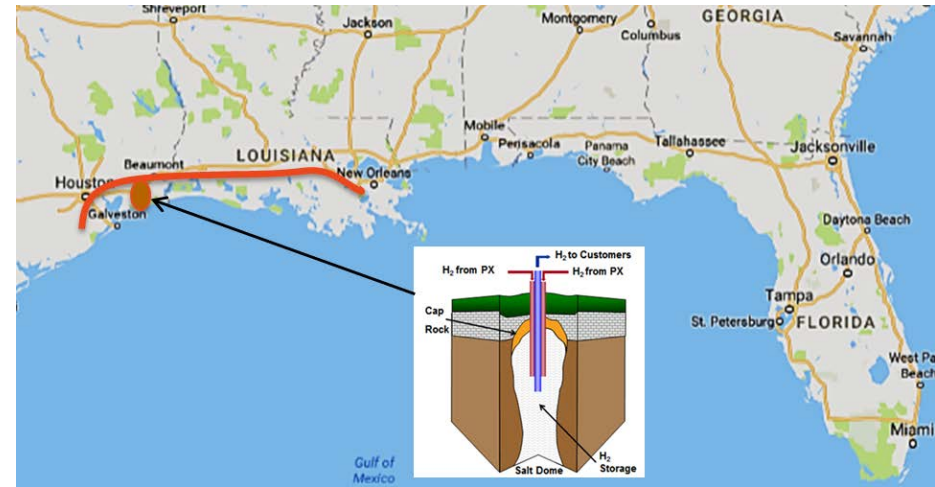
## Compressed

- 2K – 10K psi
- Unlimited capacity
- High capital intensity
- Thermal Management for filling
- Codes & Standards compliance
- Can be filled off pipeline delivery



## Liquid Storage

- High density storage
- Cryogenically efficient
- Codes and standards compliance
- “Over the road” transport, only.
- Refrigerant value (heat of compression)
- Capital intensive



## Pipeline

- Unlimited: Inputs & Supply Points
- 500 – 2K psi range
- Ability to “pack” for added storage
- Cavern Storage (geology critical)
- Capital intensity
- Federal & State regulations



# Thank You