

Hydrogen: Over The Road Delivery

Hydrogen Liquefaction

February 26, 2014



Attributes

- Product Density (4,500 Kgs/delivery)
- Purity – four 9's+
- Four North American Producers
- Large Transportation Fleet
- Easy Set-up, Reliable Supply
- Distribution Range
- Pump vs. Compression energy

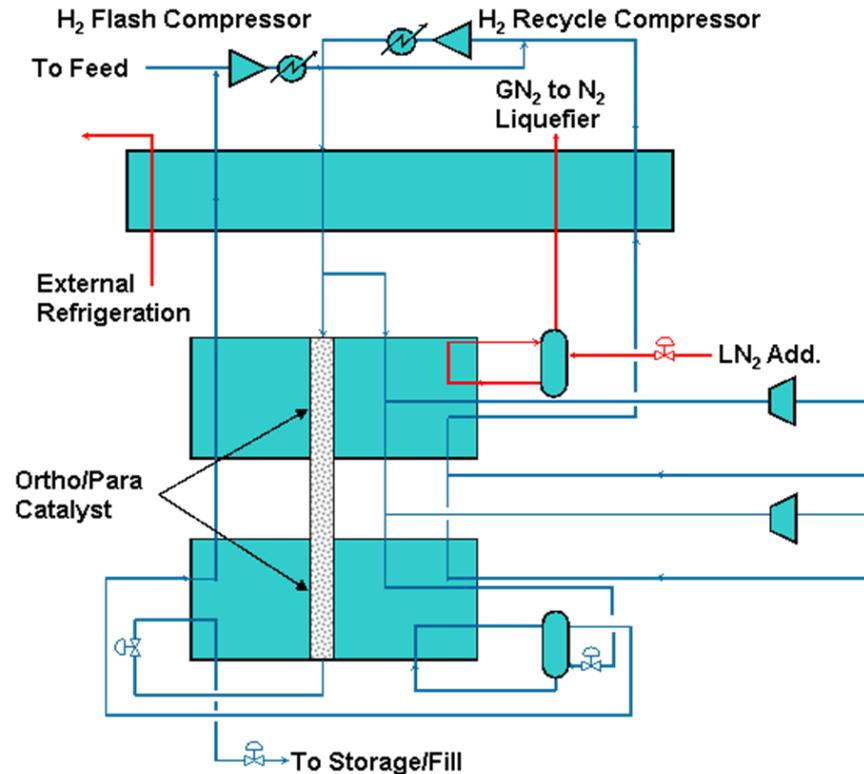
Challenges

- Safety
- Molecule conditioning (purity)
- Liquefaction Energy (13 kWh/kg)
- Capex / Opex
- Source Dependency



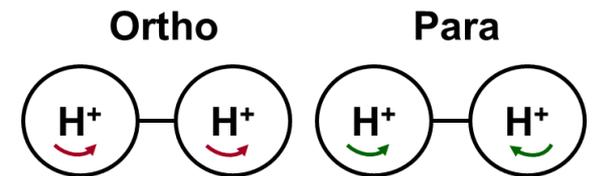
Purification Steps

- SMR-PSA
- De-Oxo
- Carbon Beds
- Gel Traps
- Drier Beds
- Condensing Units



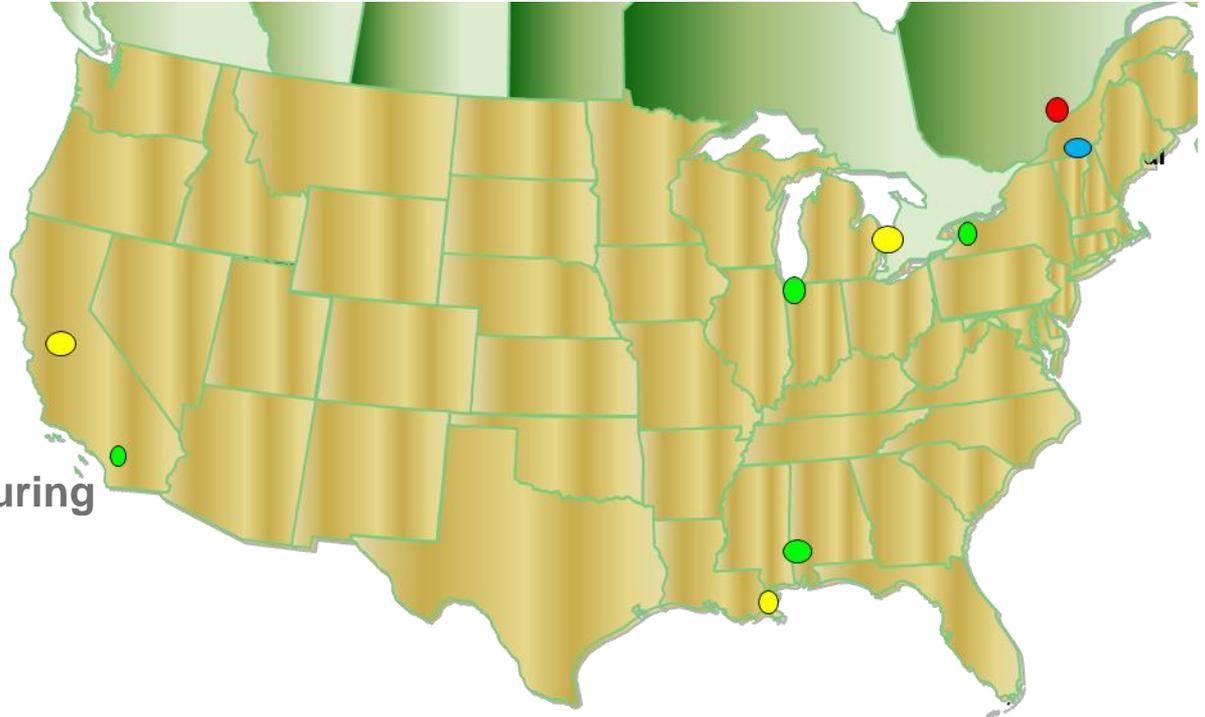
Difference is due to proton spin

- Normal Hydrogen is 75% Ortho, 25% Para
- Equilibrium Liquid Hydrogen is 0.2% Ortho, 99.8% Para



North America

- **250+ TPD Capacity**
- **Diverse Feedstocks**
 - Chlor-Alkali
 - SMR
 - Petro-chem
- **Market Positions**
 - Metro markets
 - High density manufacturing
 - Space Programs



Internationally

- **4-7 European Installations**
- **4-6 Japanese Installations**
- **India Program**
- **ESA French Guiana (South America)**

- Satisfies ASME J-2719 (hydrogen fuel quality)
- Immediate Solution (supply, infrastructure, logistics)
- Forecourt: attributes & challenges (NFPA-55)
- Energy & Capital: LH2 will ultimately be a back-up solution

Liquid hydrogen will not be the primary mode for the “Hydrogen Economy”, but it will play a significant support role