

U.S. Industrial Hydrogen Infrastructure







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Future Hydrogen Demand will Dwarf Current Industrial Markets

In 2015, with the Worldwide Fuel Cell market still in its infancy:

-  **Transit Buses***
 - 130,000-150,000 buses in service
-  **Light Duty Vehicles***
 - 17- 80 million vehicles in service
-  **Hydrogen Usage**
 - 20 – 90 million tons per year
-  **Current Worldwide Merchant Capacity**
 - 2.5 million tons per year

*Sources: UBS Warburg Global Equity Research, Ballard June 2000

D. Hart – Imperial College, UK, Hydrogen Supply for SPFC Vehicles, 2000

U.S. Hydrogen Production

- ✍ **Total U.S. Production about 9 Million Tons/Year***
 - Captive -- 7.5 Million Tons/Year
 - Ammonia, Methanol, Chemicals & Refineries
 - Merchant -- 1.5 Million Tons/Year
 - Over 80 plants
 - Major Producers - Air Liquide, Air Products, Praxair, BOC

- ✍ **Major sources**

- Natural gas reforming (95%)
- Purification of Chemical By-Product (5%)

- ✍ **Major hydrogen markets -- Refining, Chemicals, Metals, Electronics**

Hydrogen Distribution Options

High-Pressure Gas Delivery (2,600 lbs per sq. in.)

- Regional distribution - 100 mile radius
- Cylinders
- Tube Trailer

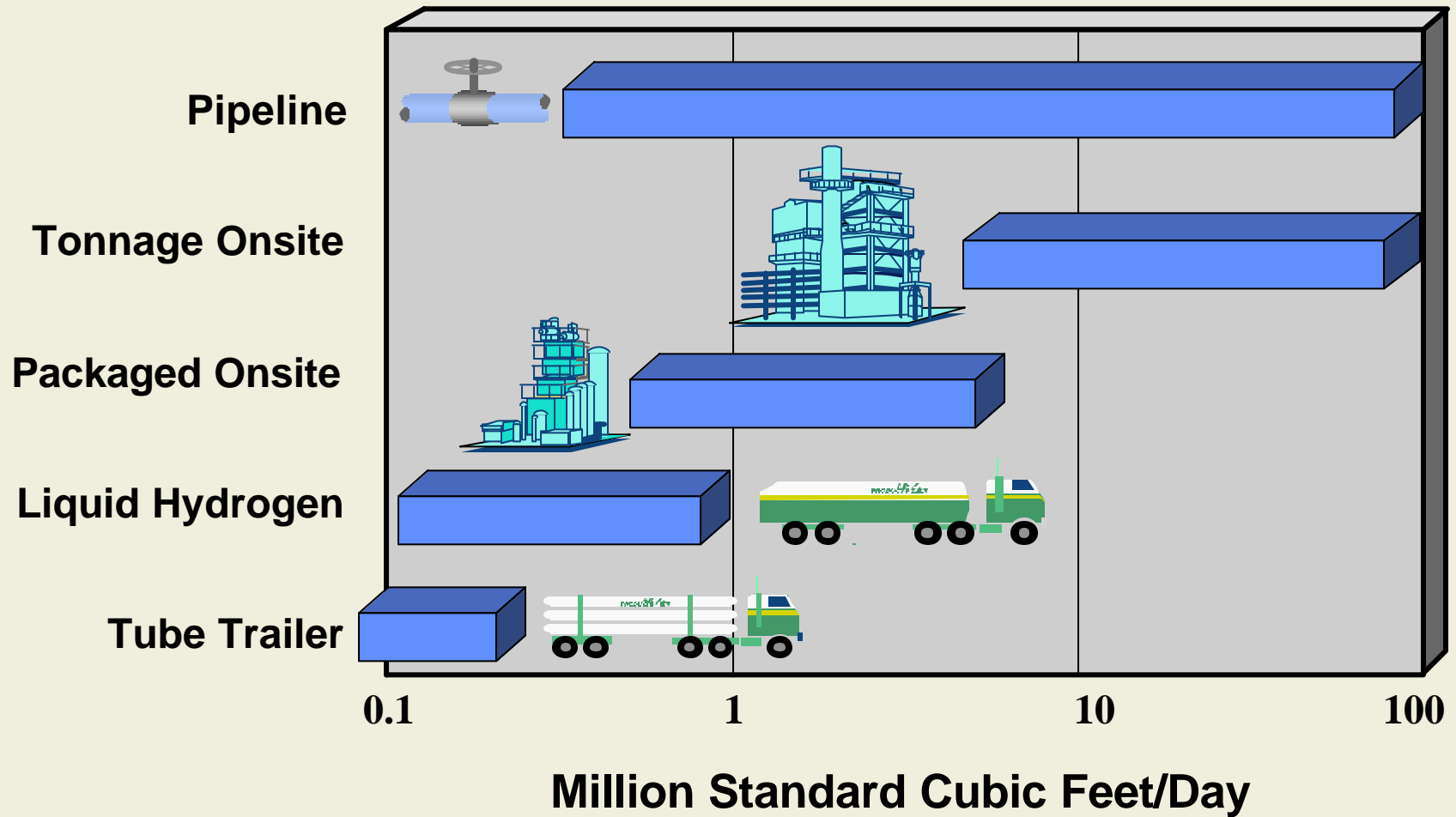
Liquid Delivery (- 423 °F)

- Long distance distribution - up to 1000 mile
- Liquid Storage and re-vaporization
- Liquid Compression and Vaporization

On-Site Production of Gas

Pipeline Delivery of Gas


Hydrogen Supply Options



Air Products Liquid and Bulk Hydrogen Plants and Distribution Terminals



North American Liquid Hydrogen Production and Distribution

 **11 Plants - 283 Tons/day***

 **Distributed via**

- Over-the-Road Trucks (10,000 - 15,000 gallons)
- Railcars (28,000- 34,000 gallons)
- Barge (250,000 gallons)

 **Over 3,000 Deliveries/Month – One Every 15 Minutes**

 **About 1000 Customer Locations**

* Source: 2001 Chemical Economics Handbook - SRI International

H₂ Pipeline Networks

H₂ Pipelines operated by Air Liquide, Air Products, Praxair

- About 500 miles
- Texas, Louisiana, California, Indiana

Air Products Pipelines

- Houston, Louisiana, Los Angeles
- Over 300 miles
- 22 plants
- 760 Million Std. Cubic Feet/day (1,900 tons/day)

North American Liquid Hydrogen Plants

