Hydrogen Safety in Florida (and Elsewhere)

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Distributed Energy Road Show

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Hydrogen Fundamentals

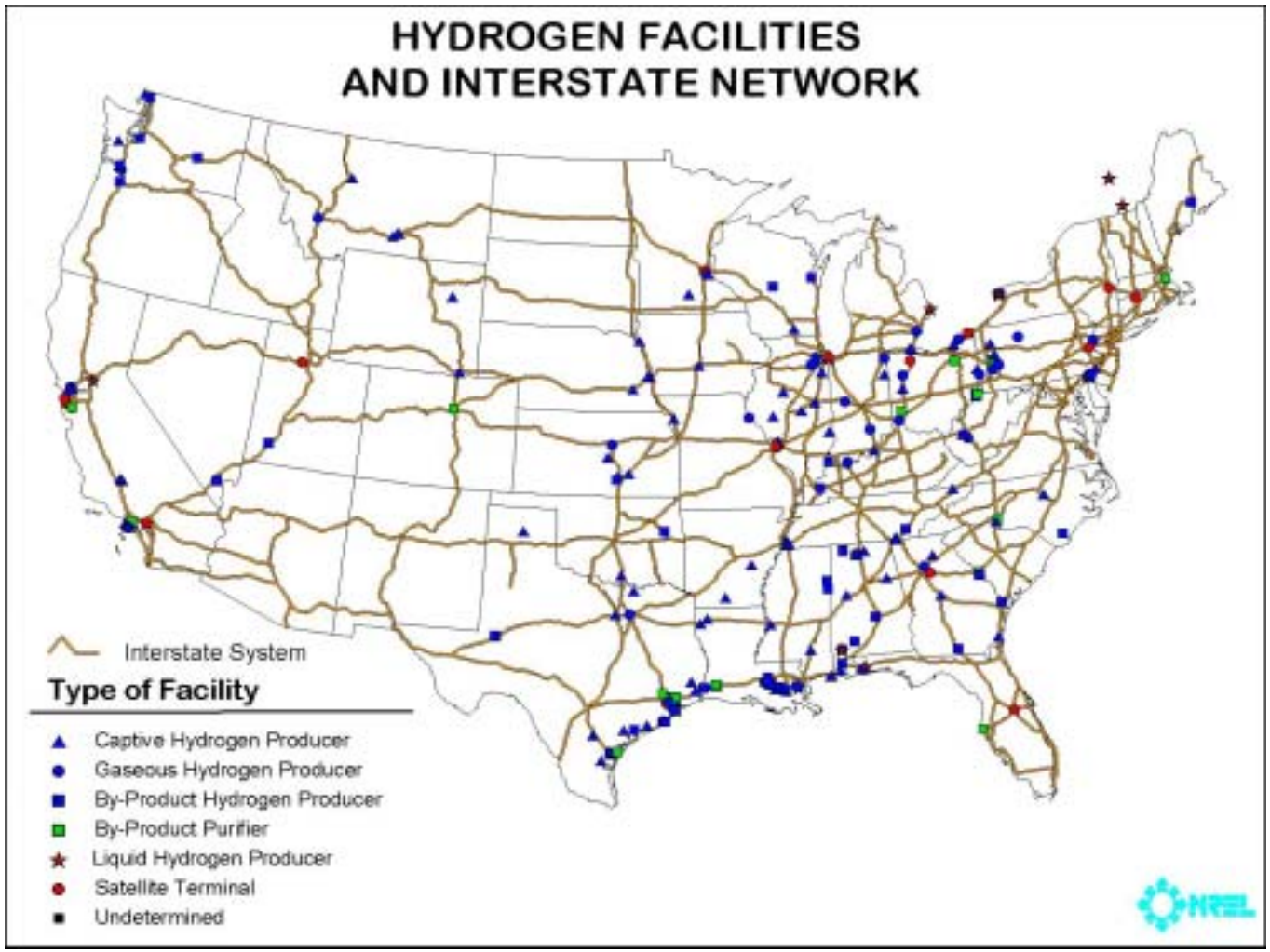
- Energy Content: 60,958 Btu/lb – highest energy content of all fuels on a **weight** basis
  - This is why NASA uses hydrogen – they care a lot more about weight than volume)
  - Energy content is about three times higher than gasoline, natural gas, and propane on a **weight** basis
  - Energy content is only about one third that of natural gas and about an eighth that of propane on a **volume** basis
- Flammability limits (in air): 4.1 v% - 74 v%
- Explosion limits (in air): 18.3 v% - 59 v%

Hydrogen Today

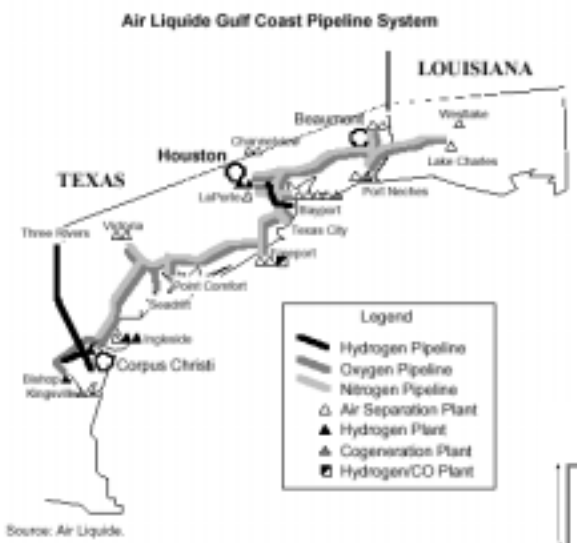
- Production (9 million tons per year)
  - Steam methane reforming
  - Electrolysis
  - Byproduct
- Uses – largely in industrial settings
  - Petroleum upgrading
  - Food processing (hydrogenation)
  - Semiconductor processing
  - NASA (only large-scale fuel use)
- Transporting/Delivery
  - Pipeline
  - Liquid tanker
  - Tube trailer (compressed gas)

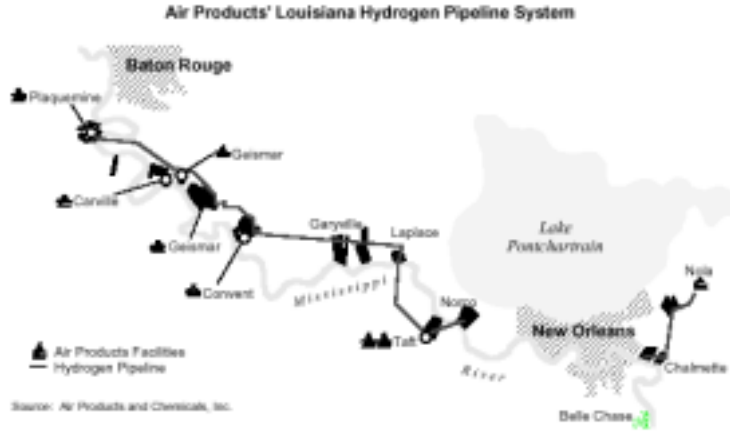
NASA-KSC's 850,000 gal Storage Sphere

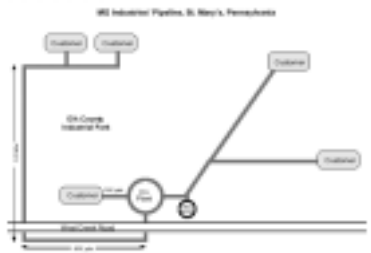
Hydrogen Facilities in the US

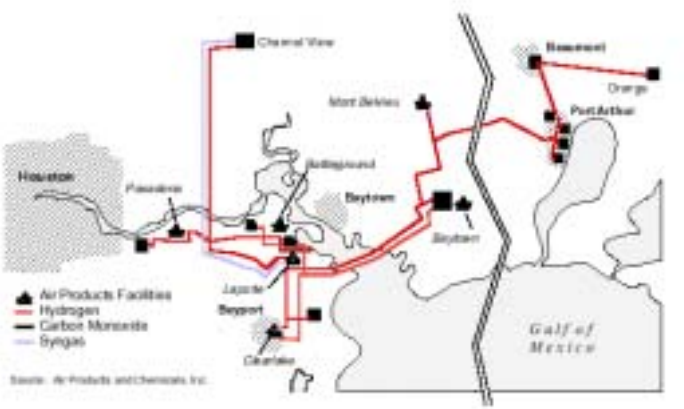


Hydrogen Pipelines





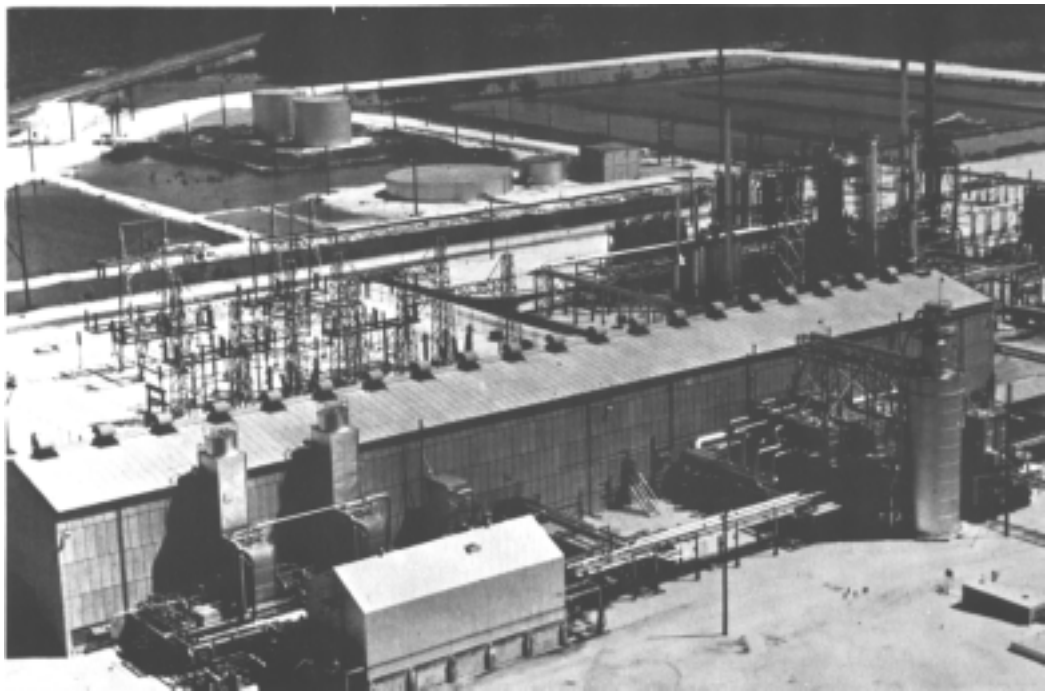




Codes and Standards

- Code-making bodies in the US
  - About 20 major developers (excluding federal agencies such as EPA and DOT)
  - Nearly all is done using a consensus process
- Must be adopted by each jurisdiction to be "legal" and binding
  - Approximately 44,000 jurisdictions in the US
  - Federal, state, county, city or town

LH_2 was once made in Florida



USAF's "Pappa Bear" - West Palm Beach

Code Developers

- International Code Council, Inc. (ICC)
  - Building Officials and Code Administrators International (BOCA)
  - International Conference of Building Officials (ICBO)
  - Southern Building Code Congress International, Inc. (SBCC)
- Underwriters Laboratories (UL)
- National Fire Protection Association (NFPA)
- CSA International
- Society of Automotive Engineers (SAE)
- Institute of Electrical and Electronic Engineers (IEEE)
- American Society of Mechanical Engineers (ASME)
- International Electrotechnical Commission (IEC)
- International Organization for Standards (ISO)
- Compressed Gas Association (CGA)
- Natural Gas Institute (NGI)
- US Department of Transportation
- Occupational Health and Safety Administration (OHSA)

Issues

- Codes & standards are being developed in advance of, or in parallel with, hydrogen-fueled systems
  - Codes & standards development must be coordinated with technology development
  - Efforts should be devoted to R&D efforts to validate proposed standards (i.e., need data to support or validate proposed requirements)
- Coordination is vital
  - All applications involve production, transportation, storage, dispensing, and use of hydrogen
  - A large number of organizations are involved in generating codes & standards

Key Codes

Component Technology	Codes	Status
Production	NFPA 70/ NEC/CEC ASME Boiler-Pressure Vessel Sec. VIII	mature mature
Transportation:	DOT 49 CFR	mature mature
Pipeline	NEC/CEC ANSI/ASME B31.1, B31.8	mature mature
Storage	NFPA 50 A: Gaseous Hydrogen NFPA 50 B: Liquid Hydrogen ASME Boiler-Pressure Vessel Sec. VIII	mature (1994) mature (1994) mature
Vehicle Refueling Stations	HV-3: Hydrogen Vehicle Fuel NFPA 52: CNG Vehicle Fuel HV-1: Hydrogen Vehicle Connector NGV1: NGV connectors	being developed base for HV-3 being developed base for HV-1
Hydrogen Vehicles	HV-3: Hydrogen Vehicle Fuel NFPA 52: CNG Vehicle Fuel HV-2: Gaseous Hydrogen Tanks NGV2: CNG Storage Tanks	being developed base for HV-3 being developed base for HV-2

ISO-TC197

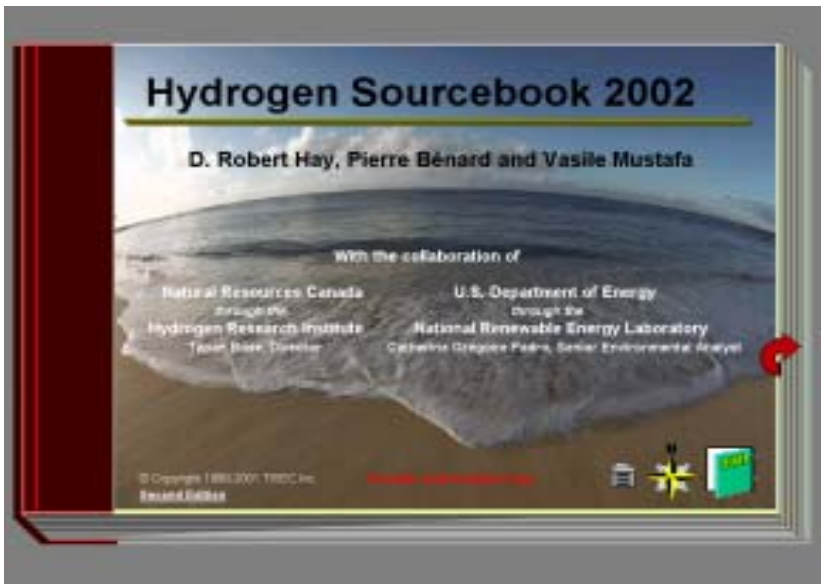
Identification Number	Title	Working Group	Convener (Country)
DIS 13984	Liquid H_2 - Land Vehicle Fueling System Interface	WG 1	SCC (Canada)
DIS 14687	H_2 Fuel-Product Specification	WG 3	ANSI (USA)
NP 15594	Airport H_2 Fueling Facility	WG 4	DIN (Germany)
NP 15866	Gaseous H_2 and H_2 Blends--Vehicular Fuel Systems	WG 5	ANSI (USA)
NP 15869	Gaseous H_2 - Vehicle fuel tanks	WG 6	ANSI (USA)
NP 15916	Basic requirements for safety of H_2 systems	WG 7	DIN (Germany)
WD 13985	Liquid H_2 - Land vehicle fuel tank		SCC (Canada)
WD 13986	Tank containers for multimodal transport of liquid H_2		SCC (Canada)

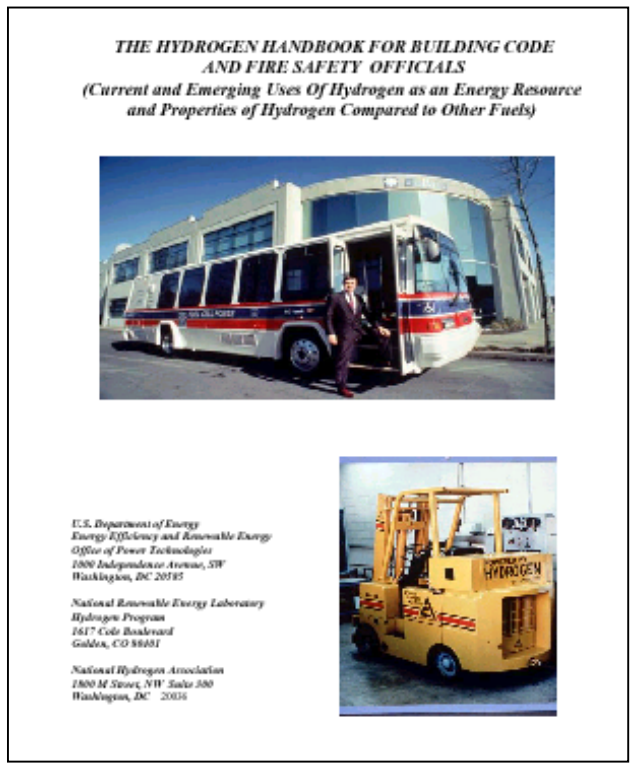
Hydrogen Uses - Tomorrow

- Mobile Applications
  - Fuel cell vehicles (buses, trucks, passenger)
  - Modified ICEs
- Stationary Applications
  - Uninterruptible power supplies
  - Backup/premium power
  - CHP
- Portable Applications

Guidelines for Hydrogen Systems

- The Hydrogen Handbook for Building Code and Fire Safety Officials
- The Hydrogen Sourcebook



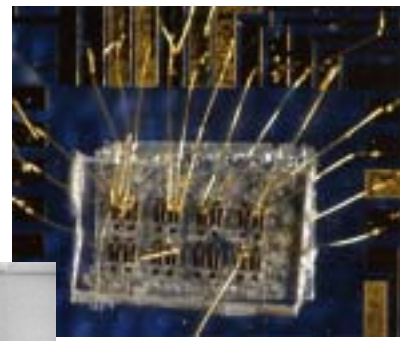


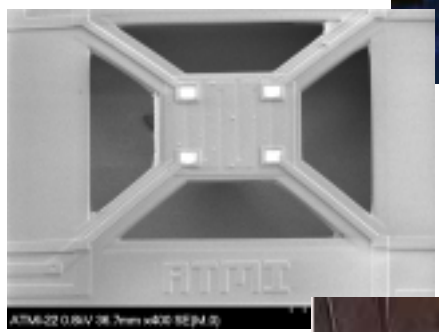
Typical Hydrogen Site Plan Review

- Confinement
- Review Potential for Ignition
- Minimizing Consequences
- Review the Need for Detectors
- Safety Analysis
- Review Site-Specific Factors
- Personal Investigation

Detection

- Sensors
  - Safe, reliable, cheap sensors being developed
  - Placement is important
- Odorants
  - Diffusion/dispersion matching is difficult
  - Poison to fuel cell?





Safe Hydrogen Systems

- Safety issues can be handled through testing, certification, and codes & standards, just like with any other fuel
- Sustained, collaborative government-industry RD&D needed
  - Fuel cell and vehicle systems development are critical
  - Infrastructure and codes & standards development require significant government participation (on all levels)
  - Coordination is key

For more information:

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