

DOE–DOT CNG–H₂ Workshop Summary and Highlights

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*DOE Vehicular Tank Workshop
April 29, 2010 – Sandia National Laboratories, CA*

On December 10-11, 2009, experts from China, India, Brazil (by webinar), Canada and the United States met in Washington, D.C., to share lessons learned about deploying CNG and hydrogen-fueled vehicles in public transit fleets and the consumer sector.

Objectives of the Workshop:

1. Compare properties and behavior of CNG and hydrogen, including blends, and discuss R&D underway in each country for the safe use of these fuels
2. Discuss safety and testing of onboard and bulk storage tanks and identify research, regulations, codes and standards needed to ensure their safe use
3. Describe safety requirements and regulatory framework in each country and assess ways to harmonize domestic and international codes and standards
4. Collect data and information from demonstration activities and real-world applications in Brazil, China, India, and the United States
5. Conduct follow-up workshops, conduct collaborative R&D and testing, share hydrogen roadmaps and education/training plans and activities

Structure of Workshop

- Overview of United States Hydrogen & Fuel Cell Activities (Sunita Satyapal, DOE)
- Technical Keynote Address: CNG, H₂, CNG-H₂ Blends: Critical Fuel Properties and Behavior (Jay Keller, Sandia National Laboratories)
- Safety and Regulatory Structure for CNG, CNG-H₂ Vehicles and Fuels
 - India (Ambrish Mishra, Oil Industry Safety Directorate, Ministry of Petroleum and Natural Gas)
 - China (Jinyang Zheng, Zhejiang University)
 - United States (Barbara Hennessey, DOT/NHTSA)
- Successful Adoption of CNG and Emerging CNG-H₂ Program in India (Narendra Pal, Univ. Nevada, Reno, and Indian Oil Corporation)
- Lessons Learned from Practical Field Experience with High Pressure Gaseous Fuels (Doug Horne, Clean Vehicle Education Foundation)
- CNG and Hydrogen Tank Safety, R&D, and Testing (Joe Wong, Powertech)
- Overview of Indian Hydrogen Program and Key Safety Issues for Hydrogen Fuel (Dilip Chenoy, Society of Indian Automobile Manufacturers)
- Hydrogen Vehicles and Fueling Infrastructure in China (Jinyang Zheng)
- Hydrogen Vehicles and Fueling Infrastructure in India (Das, Indian Institute of Technology)
- The Hydrogen Laboratory and The Brazilian Reference Center for Hydrogen Energy (Newton Pimenta, University of Campinas)
- Controlled Hydrogen Fleet Infrastructure Demonstration and Validation Project (John Garbak, DOE)
- Discussion, Action Items

Hydrogen Behavior – Myth Busting



**Jay Keller,
Sandia National Laboratories**

**Topical Lecture
Progress in Hydrogen Safety: International Short
Course Series**

June 15-19, 2009



Hydrogen Myths

- ⇒ Hydrogen Molecular Diffusivity is 3.8 times that of CH₄
 - Therefore it diffuses rapidly and mitigates any hazard
- ⇒ Hydrogen is 14.4 times lighter than air
 - Therefore it rapidly moves upward and out of the way
- ⇒ We do not know the flammability limits for H₂
- ⇒ We just do not understand hydrogen combustion behavior
 - Hydrogen release is different than other fuels
 - Radiation is different than other fuels



Hydrogen Myths

- ⇒ Hydrogen hazards can be compared favorably to experiences with other hydrocarbon fuels
 - Less dangerous than gasoline, methane ...
- ⇒ Simply adding hydrogen to natural gas improves engine efficiency and lowers emissions.
- ⇒ ICE's are 33% less efficient than are Fuel Cells (@50% DOE / FreedomCar current goal)
- ⇒ Hydrogen always ignites
 - Joule-Thomson heating, Static electric discharge, Shock heating ...
- ⇒ Hydrogen is toxic and will cause environmental harm
 - "... We need to be indemnified against a hazardous toxic hydrogen spill ..." – Generic Insurance Company



Oil Industry Safety Directorate (OISD)

Provide a Professional Technical body for hydrocarbon sector to:

1. Elaborate safety standards & procedures
2. Check implementation of safety regulations and analysis of incidents
3. Interface with regulators of industry

OISD – Duties

1. Development of standards
2. Institutionalized safety audits
3. Incident investigations, collation & analysis
4. Capacity building (training)
5. Safety performance evaluation
6. Collaboration with international organizations
7. Dissemination of information

Codes & Standards for CNG H₂ & CNG

• Motor Vehicles Acts / Rules:

1. AIS 24: Safety & procedural requirement for type approval of CNG operated vehicles by ARAI
2. AIS 28: Code of practice for use of CNG in ICE by ARAI
3. ISO (BIS) specification for components

• Explosives Act:

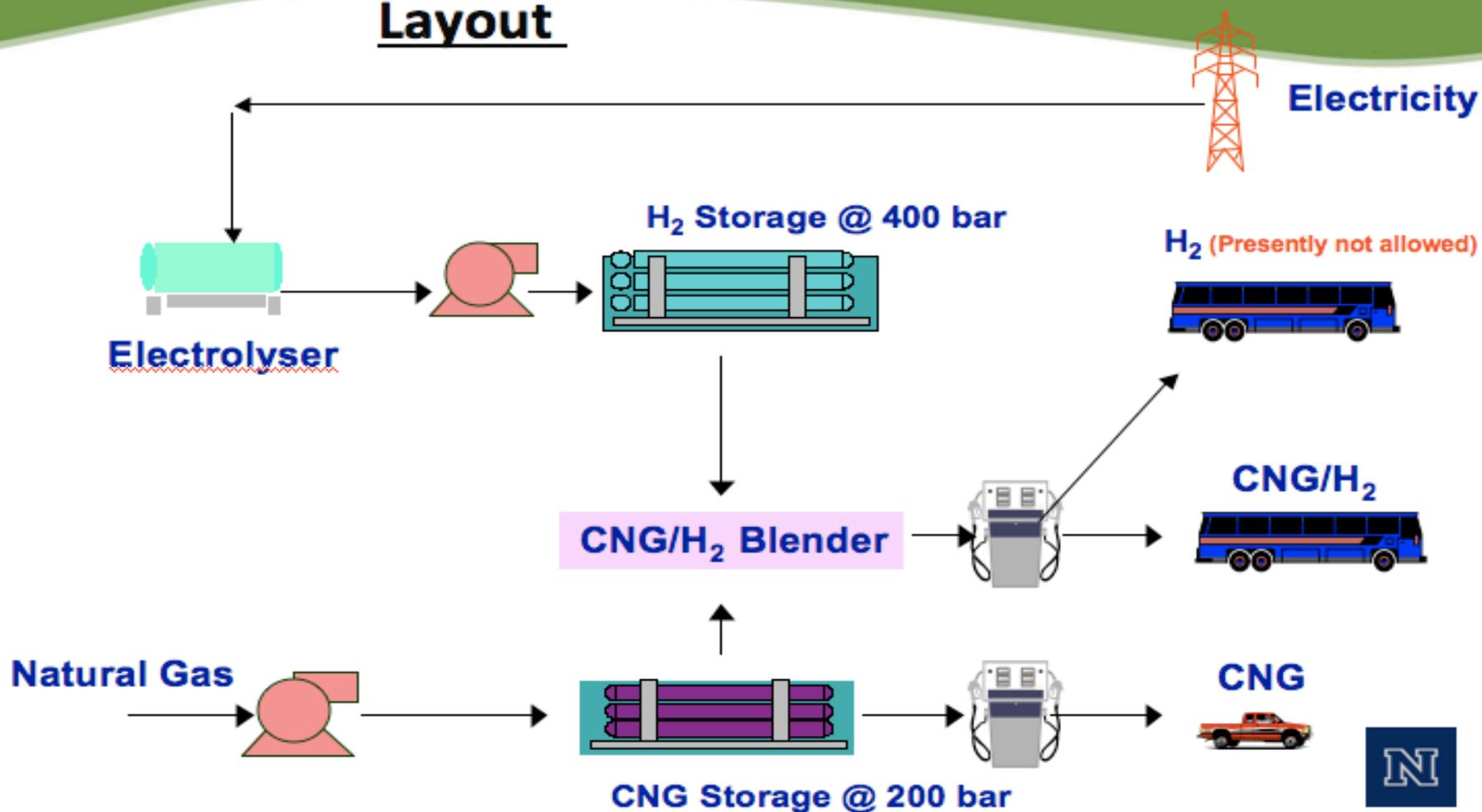
1. Gas cylinder rules
2. OISD STD-179: Safety requirements on compression storage, handling and refueling of natural gas in the automotive sector by OISD

H-CNG Dispensing Station Indian Oil Corporation Retail Outlet Dwarka, New Delhi



H-CNG Dispensing Station Indian Oil Corporation Retail Outlet Dwarka, New Delhi

Layout



Codes and Standards For H:CNG+

-No Change in Vehicles system up to 20% Mix

Explosives Act :

- Need certain Changes in

OISD STD-179 :Safety requirements on compression storage, handling, and refueling of natural gas for use in automotive sector as regards inter-distances and specific safety requirements

Areas of Concern

- Quality monitoring of Natural Gas
- Tamper-proof Filling Nozzle
- Proper Fitment and Maintenance of CNG Systems and Vehicles

Initiatives on Transportation & Power Generation:

1. Green Initiative for Future Transportation (GIFT)
 - Develop & demonstrate hydrogen powered IC engines & fuel cell vehicles – deploy one million hydrogen vehicles by 2020
2. Green Initiative for Power Generation (GIP)
 - Developing and demonstrating hydrogen powered IC engine/turbine & fuel cell – setup 1,000MW hydrogen based power generation capacity

R&D, Infrastructure & Deployment

1. Fuel mixture strength requirement
2. Engine backfire (continues to be a major engine issue)
3. Hydrogen utilization with diesel engines
4. Deployment of Three-wheelers with the hydrogen-powered ICE
5. Develop pipelines & fueling stations



National Standardization Bodies

1. SAC/TC 309 National Technical Committee 309 on Hydrogen Energy Standardization Administration of China (ISO/TC 197)
2. SAC/TC 262 National Technical Committee 262 on Boilers and Pressure Vessels of Standardization Administration of China (ISO/TC 11)
3. SAC/TC 31 National Technical Committee 31 on Gas Cylinders of Standardization Administration of China (ISO/TC 58)
4. SAC/TC 114 National Technical Committee 114 on Automotive Standardization (ISO/TC 22, 177)

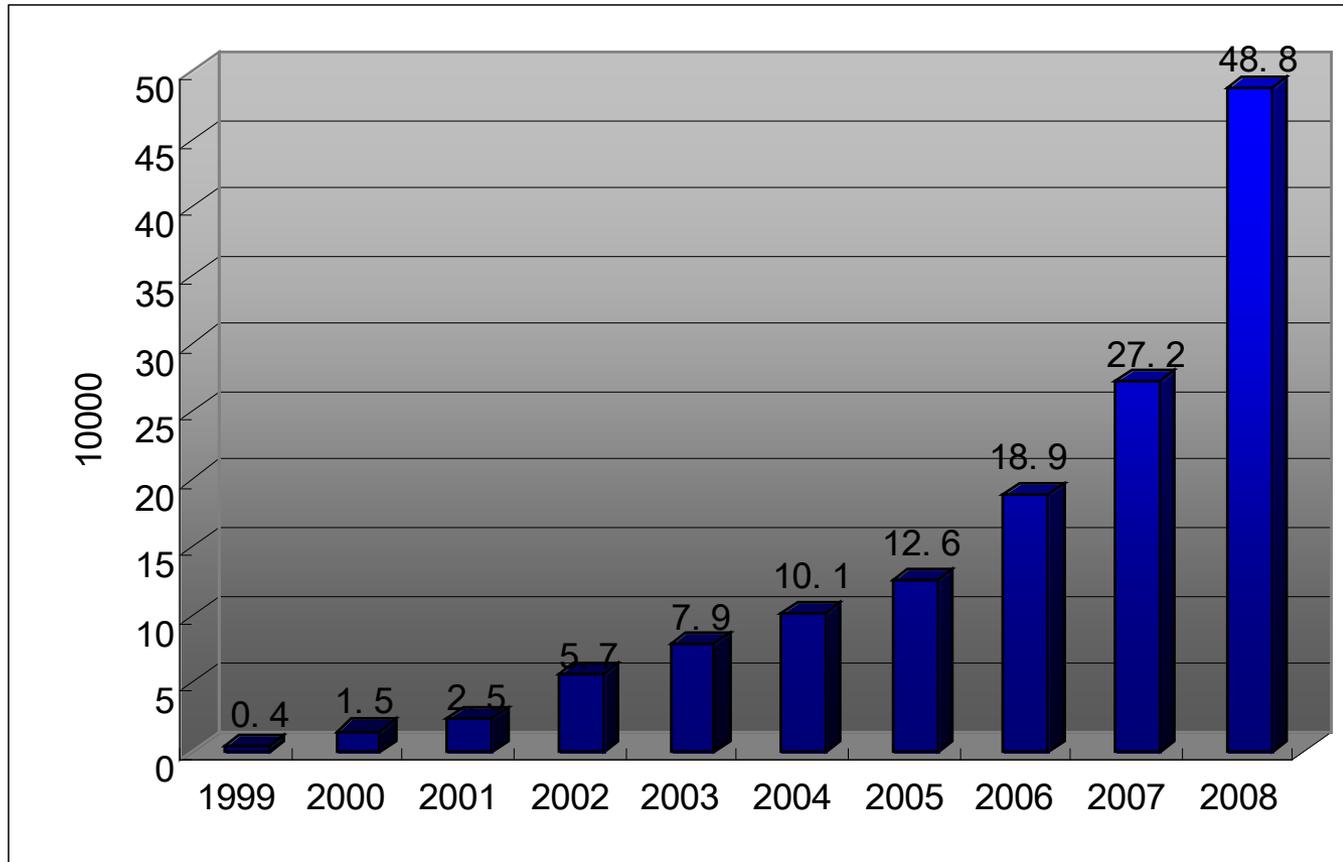
Major Issues, Needs:

1. Tank regulation: Types 1, 2 & 3 tanks are allowed, but Type 4 tanks are not allowed in China
2. Additional proposed cooperation with international regulatory bodies
3. Standards for the design of hydrogen fueling stations



Over the last five years, CNG vehicles have developed rapidly. The proportion of CNG taxis and buses in some key promotion cities has reached over 50%





CNG vehicle development in China during past ten years

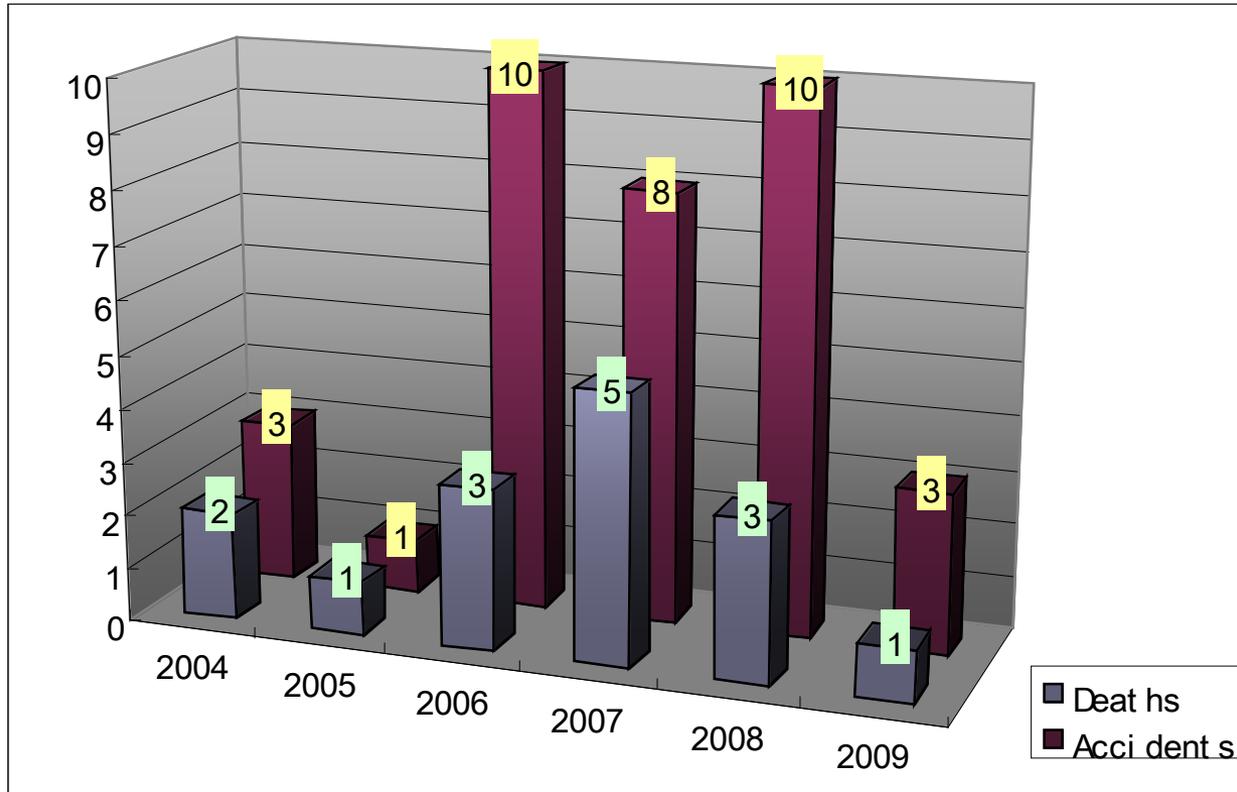
China: CNG Fueling Infrastructure

- 555 natural gas fueling stations in China
- 5 hydrogen fueling stations in China

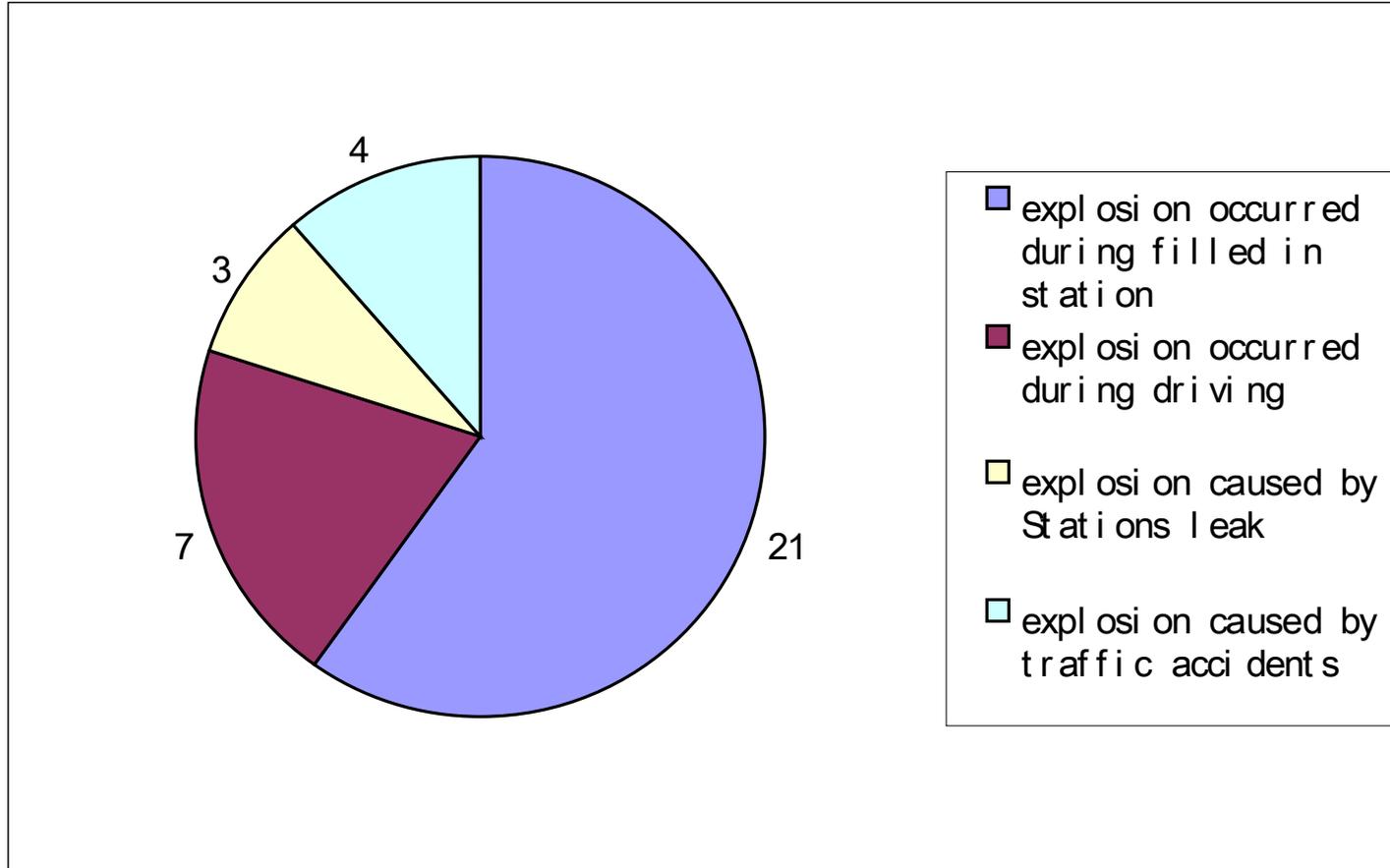


China: CNG Fueling Infrastructure





CNG vehicle accidents in the last six years



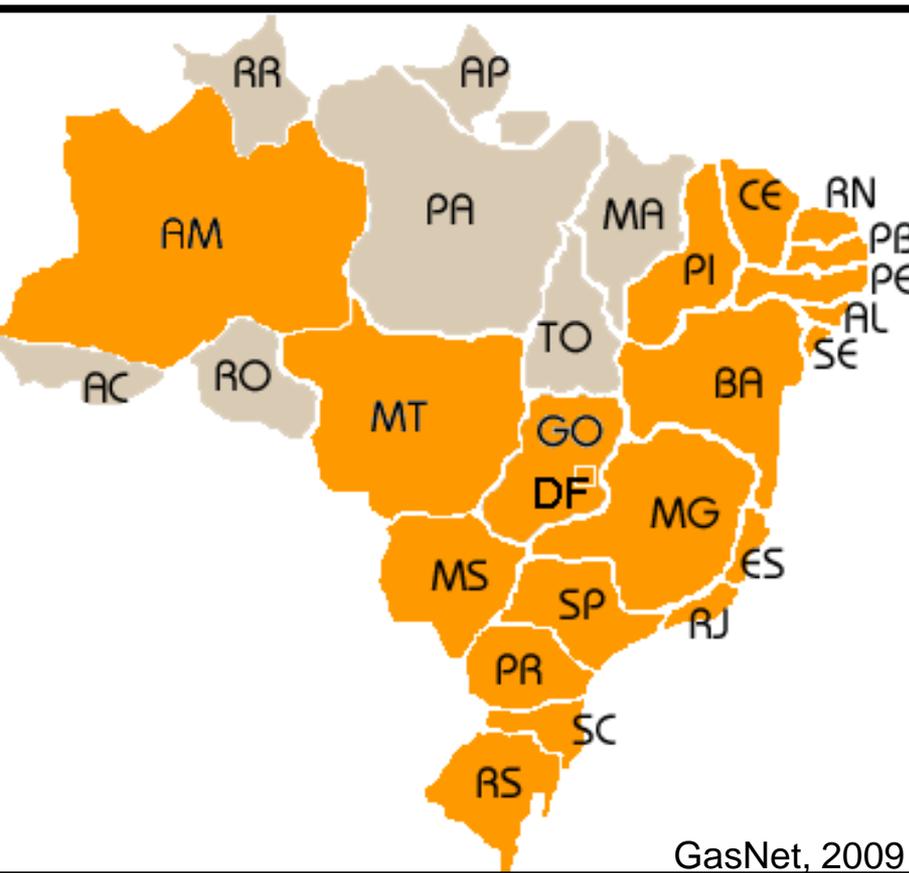
CNG vehicle accidents

- Published hydrogen standards and codes
 - Industrial Hydrogen (GB3634)
 - Pure hydrogen, High-Purity hydrogen and Ultrapure Hydrogen (GB/T7445)
 - Technical Code on Safe Use of Hydrogen Gas(GB4962)
 - Design Code on Hydrogen Gas Stations (GB50173)
 - Technical Requirements on Water Electrolysis System for Hydrogen Production (GB/T 19774)
 - Technical Requirements on Pressure Swing Adsorption System for Hydrogen Purification (GB/T 19773)

- Standards under development
 - Technical Code on Hydrogen Energy Automobile Refueling Stations (GB 50XX)
 - Hydrogen Energy Terminology (GB/T XXXX)
 - Fiber-reinforced high-pressure hydrogen cylinders with aluminum liner for land vehicle tanks
 - Stationary flat steel ribbon wound vessels for storage of high pressure hydrogen
 - Basic requirements for the safety of hydrogen systems

Collaborate under framework of energy cooperation between China and USA

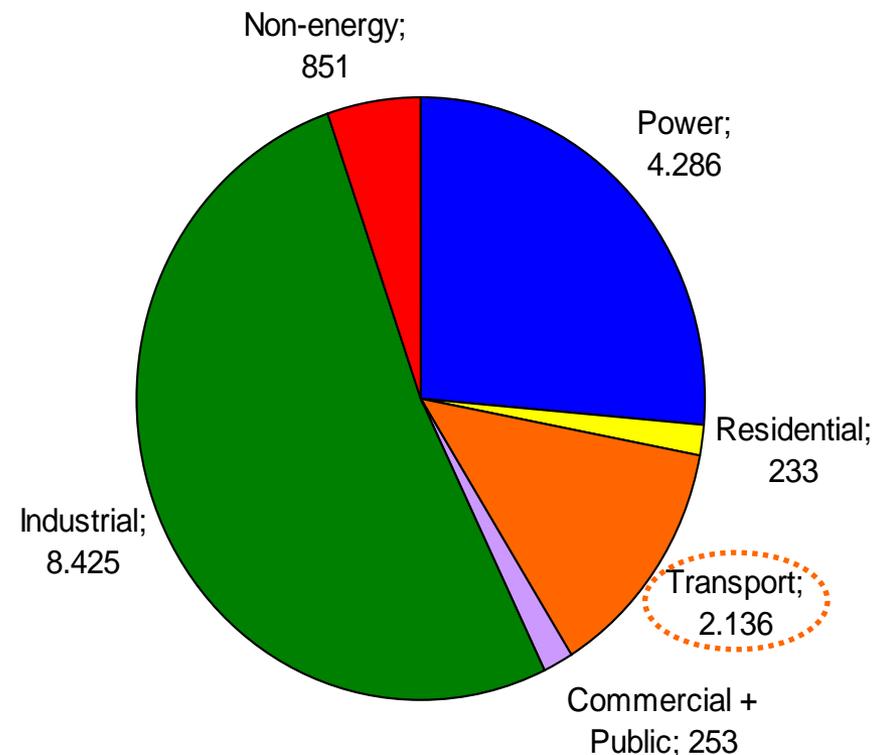
- Seek opportunities to jointly apply for research funding from DOE , DOT, MOST, etc.
- Study of related standards and safety requirements, especially in the field of hydrogen embrittlement, fast filling, safety distance, etc.
- Develop International Standards, such as Hydrogen/CNG Stations, High Pressure Hydrogen Containers, High Pressure Hydrogen Supply Systems
- China is ready to be the Convener to develop an international standard on HCNG station and Pressure Swing Adsorption and would appreciate support by the USA and India



Natural Gas Supply: 25.9×10^3 toe
 Natural Gas Consumption: 15.3×10^3 toe

- States with CNG stations
 - States without CNG stations
- Stations in Brazil: 1.750
 Vehicles on CNG: ~1,5 million

Natural Gas Consumption (10^3 toe)



The Brazilian Reference Center for Hydrogen Energy

- National effort to work on Hydrogen technology includes research institutions (State University of Campinas & the University of Sao Paulo) & government agencies (National Reference Center for Hydrogen Energy (CENEH))
- Hydrogen Lab at UNICAMP: Primary hydrogen research facility



LH2 Laboratory Projects:

1. Distributed Generation: Project Span from 2002 – 2008 which includes 5 kW of PEM fuel cells with hydrogen from natural gas
2. VEGA: UNICAMP fuel cell hybrid electric vehicle
3. LH2 & CENEH: Cooperative agreement with Itaipu (Brazilian / Paraguayan hydroelectric company) which includes supporting Itaipu hydrogen infrastructure, production & fuel cell application projects
4. LH2 & CENEH: Cooperative projects to foster CNG + H₂ development

Action-items: Info Sharing

	Brazil	China	India	US/Canada
R&D/testing		Embrittlement data archive		H-CNG?
		Component & cylinder testing		H ₂ embrittlement-Mat Data Handbook
		Type 4 test data		MH-thermal management
	Database for failure modes	Database for failure modes	Database for failure modes	QRA approach
		Multifunctional layered steel pressure vessels for stationary bulk hydrogen storage		Database for failure modes
				Cylinder testing
			2-3 wheeler safety data – CNG	
Codes/Standards	CNG, HCNG, H ₂	CNG, HCNG, H ₂	CNG, HCNG, H ₂	CNG, H ₂
			3 wheelers	
	Fuel specification data sheet	Fuel specification data sheet	Fuel specification data sheet	Fuel specification data sheet
Education and Training			Exchange of experience/training	EMR training C/S workshops
	Online resources available for all categories	Online resources available for all categories	Online resources available for all categories	Online resources available for all categories

Information Resources:

- Agenda, workshop overview & presentations available on the DOE link below:
- http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_cng_and_h2.html

Information Resources

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Programs and Offices

Publications	<h2>Compressed Natural Gas and Hydrogen Fuels Workshop</h2> <p>Fuel experts from China, India, and the United States shared lessons learned about deploying CNG- and hydrogen-fueled vehicles in public transit fleets and the consumer sector at the <i>Compressed Natural Gas and Hydrogen Fuels: Lessons Learned for the Safe Deployment of Vehicles</i> workshop. The U.S. Department of Energy (DOE) and the U.S. Department of Transportation (DOT) hosted the workshop on December 10-11, 2009. Here you'll find information about the workshop's focus, agenda and notes, and presentations.</p> <p>Some of the following documents are available as Adobe Acrobat PDFs. Download Adobe Reader.</p> <h3>Focus of the Workshop</h3> <p>The workshop aimed to:</p> <ul style="list-style-type: none">• Compare fuel properties—including blends—industries, and applications (e.g., product specifications, tanks, reliability, safety procedures, risk mitigation, and dispensing)• Identify research needed to ensure safe use of onboard and bulk storage tanks• Determine ways to standardize domestic and international codes and standards• Collect feedback from demonstration activities and real-world applications in the United States and internationally• Identify future workshops, briefings, classes, communication plans, and collaborations needed. <h3>Agenda and Notes</h3> <p>The following agenda and notes provide summary information about the workshop.</p>
Program Publications	
Technical Publications	
Educational Publications	
Conferences & Meetings	
Annual Merit Review Proceedings	
Workshop & Meeting Proceedings	
Data Records	
Databases	
Glossary	

Quick Links

- Hydrogen Production
- Hydrogen Delivery
- Hydrogen Storage
- Fuel Cells
- Technology Validation
- Codes & Standards
- Education
- Systems Analysis

Thank You