2006 DOE Hydrogen Program Annual Merit Review

Hydrogen Codes and Standards

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This presentation does not contain any proprietary or confidential information

Presented at the 2006 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Annual Merit Review held in Washington, D.C,.May 16-19, 2006.

Overview

Timeline	Barriers
• Project start date: 10-1-05 • Project end date: 9-30-06 • Percent complete: 50	• Codes and Standards Barriers addressed – Consensus national agenda on codes and standards (J,A,B,D,L) – Limited DOE role in development of ISO standards and inadequate representation by government and industry at international forums (F,G,H,I,K) – Current large footprint requirement for hydrogen fueling stations (P,N,M)
Budget	**Partners**
• Total project funding – DOE share: $1.26M – Contractor share: $22K • Funding received in FY05: $2.0M • Funding for FY06: $1.28M	• National H2/Fuel Cells Codes and Standards Coordinating Committee • FreedomCAR-Fuel Partnership C&S Technical Team • North American H2 Fuel Quality Team

Objectives

- Strengthen and implement consensus national agenda on domestic and international codes and standards for hydrogen systems in commercial, residential, and transportation applications

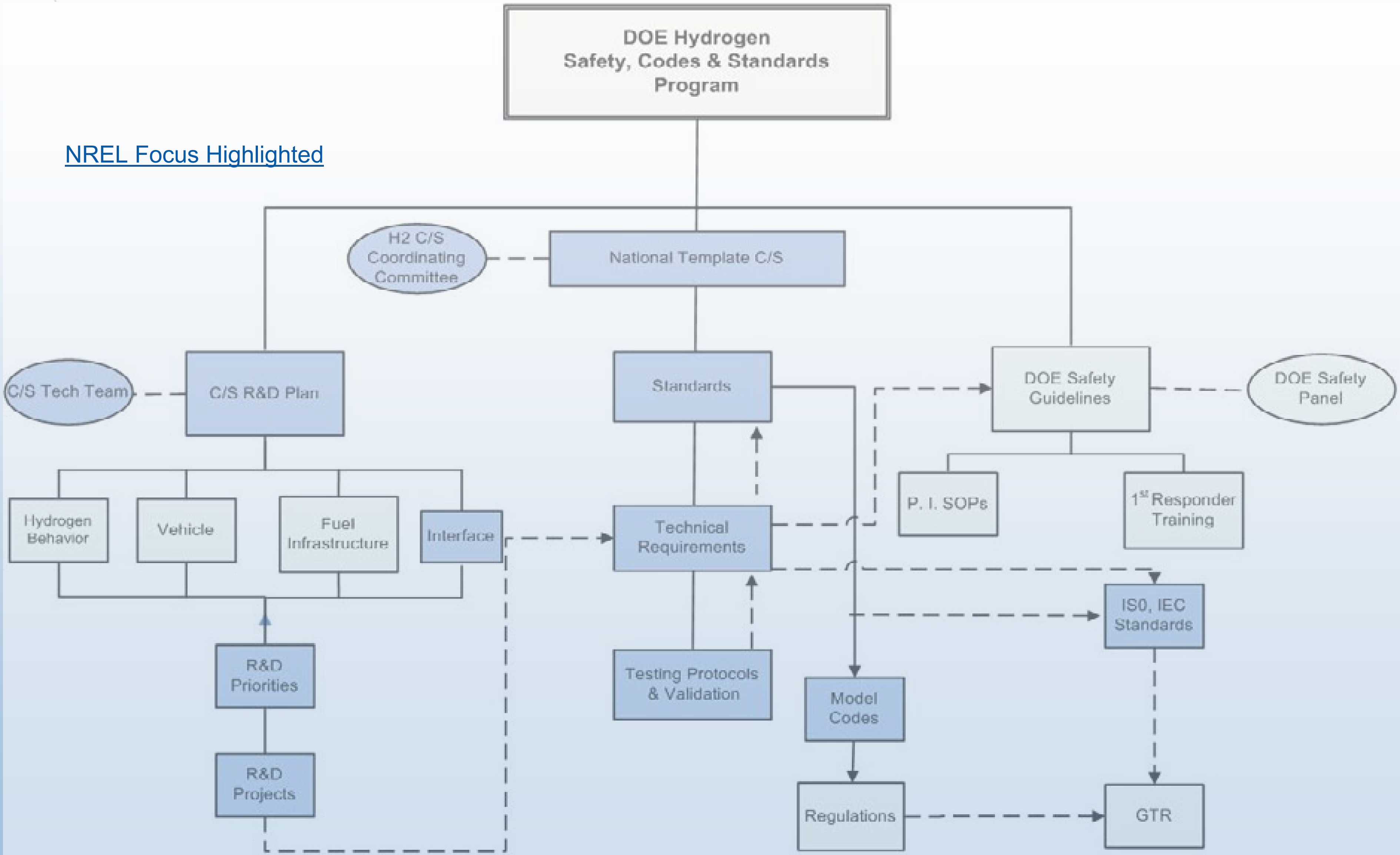
- Facilitate harmonization of requirements for hydrogen applications based on consensus R&D

- Enhance DOE's role in development of ISO and other international standards and strengthen representation by government and industry at international forums

- Integrate codes and standards activities from R&D to pre-commercialization

Approach: Program Structure

NREL Focus Highlighted



Approach

- Strengthen and implement unified national agenda for codes and standards
  - National templates adopted by consensus of SDO/CDOs
    - accelerate development of priority standards
    - designate and support lead SDO/CDOs
    - facilitate access to standards/model codes through ANSI website
  - Coordinate national/international codes and standards activities
    - National H_2/Fuel Cells Codes and Standards Coordinating Committee

- Coordinate and conduct R&D through Codes and Standards Tech Team R&D Roadmap
  - Fuel-Vehicle Interface
    - hydrogen fuel quality specifications
    - performance-based component testing and validation

- Harmonize requirements in domestic and international standards
  - Work with and coordinate key participants, e.g., ICC-NFPA, ISO TC197-SAE, IEC TC105-CSA, CGA-CSA/US TAGs

Technical Accomplishments/Progress

- Unified national agenda for codes and standards
  - Strengthened national consensus through National H2-FC C&S Coordinating Committee created in FY05 by DOE, NHA, USFCC that includes all key SDOs, CDOs, state/federal agencies, other stakeholders
  - Negotiated contracts with all key SDO/CDO to develop essential standards and model codes under significant budget constraints
- R&D to develop defensible standards for hydrogen systems
  - Codes and Standards Tech Team R&D Roadmap implementation
    - completed international guidelines for hydrogen fuel quality (ISO DTS14687-2)
    - prepared R&D/test plan for hydrogen fuel quality
    - facilitate development of better risk-informed codes and standards (with SNL)
- Harmonize requirements in domestic and international standards
  - member of ISO/TC197 WG 12 to prepare hydrogen fuel quality specification
  - member U.S. Technical Advisory Group, ISO/TC197, Hydrogen Technologies
  - work with CGA and CSA to coordinate ISO/TC197 and IEC/TC105
  - conduct semi-annual ISO-IEC “TAG-Team” meetings with NHA, USFCC

Technical Accomplishments/Progress: Unified National Agenda for Codes and Standards

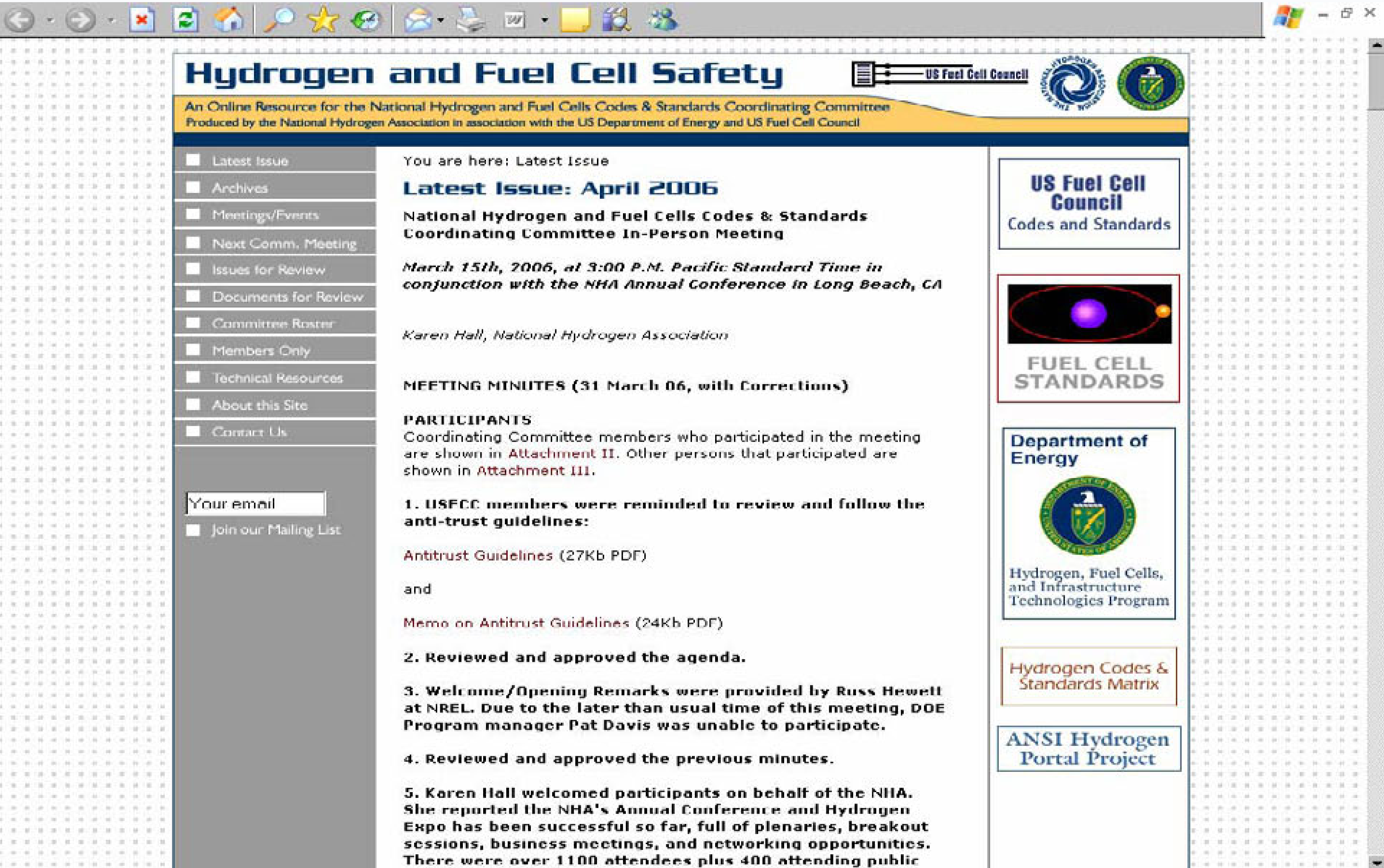
- Integrated ANSI Hydrogen (and Fuel Cells) Codes & Standards Portal (http://hcsp.ansi.org), DOE Hydrogen and Fuel Cells Codes and Standards Matrix and Database (www.fuelcellstandards.com), and Hydrogen and Fuel Cell Safety Report (www.hydrogensafety.info)
  - provides comprehensive information regarding published codes and standards documents, national and international codes and standards under development, and information for members of the NHFC4 and other stakeholders

- ASME completed *Design Margin Guidelines for High-Pressure Hydrogen Tanks* and *Properties for Composite Materials in Hydrogen Service* and will develop standards for high-pressure hydrogen tanks for stationary applications and use of non-steel metals and composite materials for high-pressure hydrogen storage tanks

Technical Accomplishments/Progress: Unified National Agenda for Codes and Standards

- Compressed Gas Association (CGA), Administrator for U.S. Technical Advisory Group (TAG) for ISO TC197 (Hydrogen Technologies) developed website to facilitate consensus positions on proposed international standards, balloting on specific TAG issues
- CSA-America developing performance-based requirements for gaseous hydrogen dispenser systems standards in collaboration with SAE
- Industry Panel on Hydrogen Codes (HIPOC) established
  - neutral forum to develop and submit hydrogen-related code provisions to ICC and NFPA and harmonize provisions in ICC and NFPA codes and standards
- Transition SDO/CDO contracts to DOE-GO competitive solicitation

Technical Accomplishments/Progress: Unified National Agenda for Codes and Standards



Hydrogen and Fuel Cell Safety

US Fuel Cell Council

An Online Resource for the National Hydrogen and Fuel Cells Codes & Standards Coordinating Committee

Produced by the National Hydrogen Association in association with the US Department of Energy and US Fuel Cell Council

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Latest Issue: April 2006

National Hydrogen and Fuel Cells Codes & Standards Coordinating Committee In-Person Meeting

March 15th, 2006, at 3:00 P.M. Pacific Standard Time in conjunction with the NHA Annual Conference in Long Beach, CA

Karen Hall, National Hydrogen Association

MEETING MINUTES (31 March 06, with Corrections)

PARTICIPANTS

Coordinating Committee members who participated in the meeting are shown in Attachment II. Other persons that participated are shown in Attachment III.

1. USFCC members were reminded to review and follow the anti-trust guidelines:

Antitrust Guidelines (27Kb PDF)

and

Memo on Antitrust Guidelines (24Kb PDF)

2. Reviewed and approved the agenda.

3. Welcome/Opening Remarks were provided by Russ Hewett at NREL. Due to the later than usual time of this meeting, DOE Program manager Pat Davis was unable to participate.

4. Reviewed and approved the previous minutes.

5. Karen Hall welcomed participants on behalf of the NHA. She reported the NHA's Annual Conference and Hydrogen Expo has been successful so far, full of plenaries, breakout sessions, business meetings, and networking opportunities. There were over 1100 attendees plus 400 attending public

US Fuel Cell Council Codes and Standards

FUEL CELL STANDARDS

Department of Energy

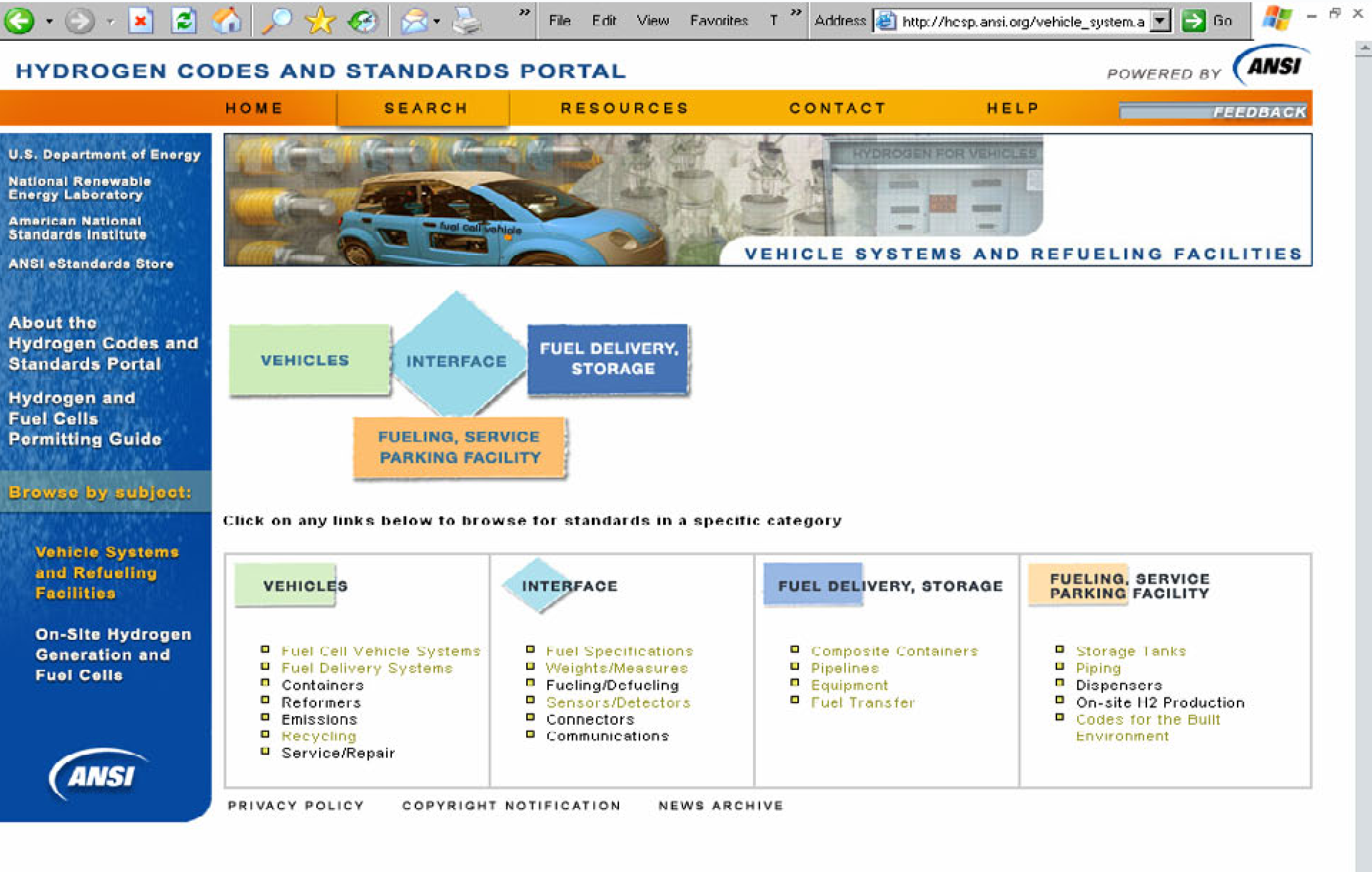
Hydrogen, Fuel Cells, and Infrastructure Technologies Program

Hydrogen Codes & Standards Matrix

ANSI Hydrogen Portal Project

Technical Accomplishments/Progress: Unified National Agenda for Codes and Standards

Technical Accomplishments/Progress: Unified National Agenda for Codes and Standards



Technical Accomplishments/Progress: Codes and Standards R&D Roadmap Implementation

Fueling Station-Vehicle Interface

- **Hydrogen Quality: Nozzle to Fuel Cell**
- Feedback Strategies
- Dispenser Protocol and Testing (70 Mpa)
- Fueling Components
- Station Grounding
- *Integrated Systems Design*

Technical Accomplishments/Progress: Fuel Quality – ISO TS14687-2 Table of Characteristics

Table 1 — Directory of limiting characteristics

Characteristics (assay)	**Type I** **Grade D**	**Type II** **Grade D**	**Laboratory Test Methods to Consider**
Hydrogen fuel index (minimum, %) [a, b]	99,99	99,99	
Para-hydrogen (minimum, %)	NS	95,0	
Non-hydrogen constituents (maximum content)			Dimensions in micromoles per mole unless otherwise stated
Total gases **Error! Reference source not found.**	100	100	
Water (H_2O)	5	5	ASTM D6348, D5454, (D1946 & D5466)[g]JIS K0225
Total hydrocarbons [c] (C_1 basis)	2	2	EPA T012, T015, ASTM (D1946 & D5466) [g], D6968, JIS K0114
Oxygen (O_2)	5	5	ASTM (D1946 & D5466) [g], JIS K0225
Helium (He), Nitrogen (N_2), Argon (Ar)	100	100	ASTM (D1946 & D5466) [g], JIS K0114
Carbon dioxide (CO_2)	2	2	ASTM (D1946 & D5466)[g], JIS K 0114, K 0123
Carbon monoxide (CO)	0,2	0,2	EPA 25C, ASTM (D1946 & D5466)[g], JIS K 0114, K 0123
Total sulfur compounds [d]	0,004 [f]	0,004 [f]	ASTM (D1946 & D5466) [g], D5504, JIS K 0127
Formaldehyde (HCHO)	0,01	0,01	EPA Method 11, NIOSH 2541, EPA T015, ASTM (D1946 & D5466) [g], JIS K 0114, K 0124, K 0123
Formic acid (HCOOH)	0,2 [f]	0,2 [f]	ASTM (D1946 & D5466) [g], JIS K 0123, K 0127
Ammonia (NH_3)	0,1 [f]	0,1 [f]	ASTM (D1946 & D5466) [g], EPA T015, JIS K 0127
Total halogenated Compounds	0,05	0,05	EPA 200.7, JIS K101
Max Particulates Size [e]	10 µm	10 µm	SCAQMD Method 301-91
Max Particulates Concentration [e]	1 µg/L @ NTP	1 µg/L @ NTP	Gravimetric (EPA IO 3.1)

Technical Accomplishments/Progress: Fuel Quality – R&D/Testing Approach Defined

Collect, evaluate, and report assemblage of data and information
Recommend H_2 fuel quality specifications

Fuel cell vehicle performance characteristics as a function of H_2 fuel contaminants

- Assessment of H_2 fuel quality
- BOP issues
- Correlation of model with vehicle
- Vehicle fuel cell pre and post test

Fuel cell performance characteristics as a function of H_2 fuel contaminants

- Single contaminant/level
- Contaminant/level combinations
- Test conditions
  - operational
  - physical
- Long duration tests
- Transient tests
- Alternate catalysts and materials

H_2 fuel quality dependence on suppliers' processing technology

- Source of H_2 fuel production
- Method of cleanup
- Alternative processes, methods for cleanup
- Technical, economic fuel-quality drivers

H_2 storage media characteristics as a function of H_2 fuel contaminants

- Single contaminant/level
- Contaminant/level combinations
- Choices of materials
- Long duration tests
- Cyclic and transient tests
- Operating conditions

Analytical instrumentation to monitor H_2 fuel quality

- Determine analytical parameters and constraints for key contaminants
- Identify/analyze alternative methods
- Conduct field tests

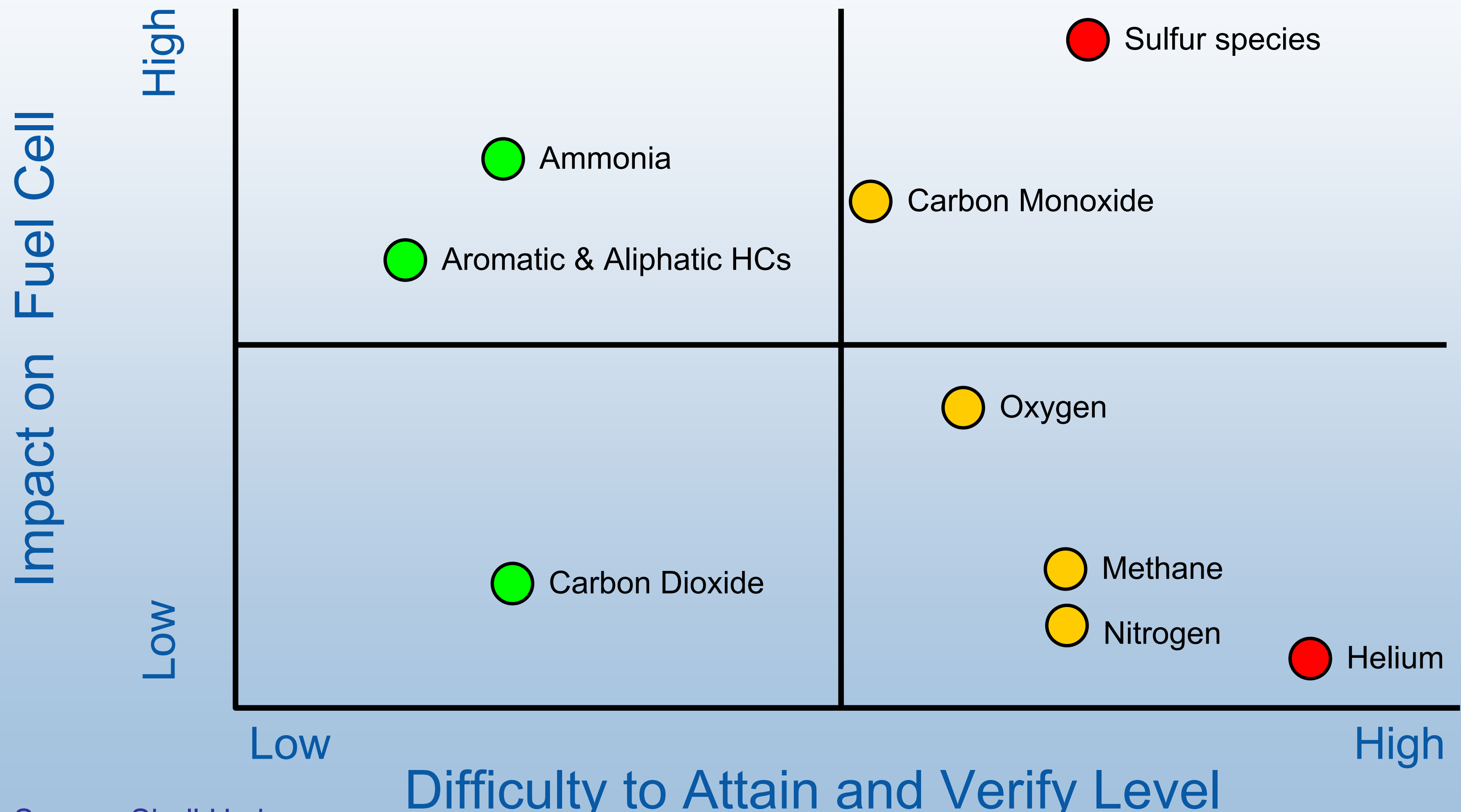
Modeling to support understanding of failure mechanisms, production/supply, material development, vehicle systems

Technical Accomplishments/Progress: Fuel Quality – Effects of Non-hydrogen Constituents on PEM Fuel Cells and Vehicle Systems Defined

Species	FC Stack	BOP	Storage
Inert gasses (Helium, Argon, Nitrogen)	H_2 dilution effect, affects system efficiency	Will affect purging rate and blowers	Believed to affect cycle life of reactive storage media
Hydrocarbons	Aromatics, acids, aldehydes, etc., degrade performance	Unknown	May affect cycle life of reactive storage media
Oxygen	Tolerant to > 500 ppm	May form ice	Believed to affect cycle life of reactive storage media
Carbon Monoxide	Reacts, degrades performance (reversible)	No effect	Believed to affect cycle life of reactive storage media
Carbon Dioxide	Tolerant at 100 ppm – limited CO back shifting	No effect	Believed to affect cycle life of reactive storage media

Source: SAE

Technical Accomplishments/Progress: Fuel Quality – Specification Tradeoffs Defined



Source: Shell Hydrogen

Technical Accomplishments/Progress: Hydrogen Purification Drivers (PSA)

Species	Adsorption Force	ISO TC 197 WG 12 (14687) Draft Spec	ATR Mol %	Purification Ratio for ATR	SMR Mol %	Purification Ratio for SMR	OVERALL EFFECT
Helium (He)	Zero	100 ppm (total inert)	500 ppm	5	500 ppm	5	NOT POSSIBLE
Hydrogen (H2)	Weak	99.99%	40-45%		75-80%		Impacts PSA recovery & Capital Cost
Oxygen (O2)		5 ppm	50 ppm	10	-	-	Impacts PSA recovery & Capital Cost
Argon (Ar)		100 ppm (total inert)	500 ppm	5	500 ppm	5	Impacts PSA recovery & Capital Cost
Nitrogen (N2)		100 ppm (total inert)	34-38%	3800	1000 ppm	10	Impacts PSA recovery & Capital Cost
Carbon Monoxide (CO)		0.2 ppm	0.1 -1 %	50000	0.1-4%	200000	Impacts PSA recovery & Capital Cost
Methane (CH4)		2 ppm (incl THC)	0.5 – 2%	10000	0.5 – 3%	15000	Impacts PSA recovery & Capital Cost
Carbon Dioxide (CO2)		2 ppm	15-17%	85000	15 -18%	90000	Relatively easier to remove
Total HC's		2 ppm (incl CH4)	0.1 %	500	0.5%	2500	Relatively easier to remove
Ammonia	Strong	0.1 ppm	Low ppm		Low ppm		Relatively easier to remove
Total Sulfur	Strong	0.004 ppm					Relatively easier to remove
Halogenates	Strong	0.05 ppm					Relatively easier to remove
Water (H2O)	Strong	5 ppm	Dew Point		Dew Point		Relatively easier to remove

Source: Chevron

Technical Accomplishments/Progress: Fuel Quality – Critical Constituents Defined

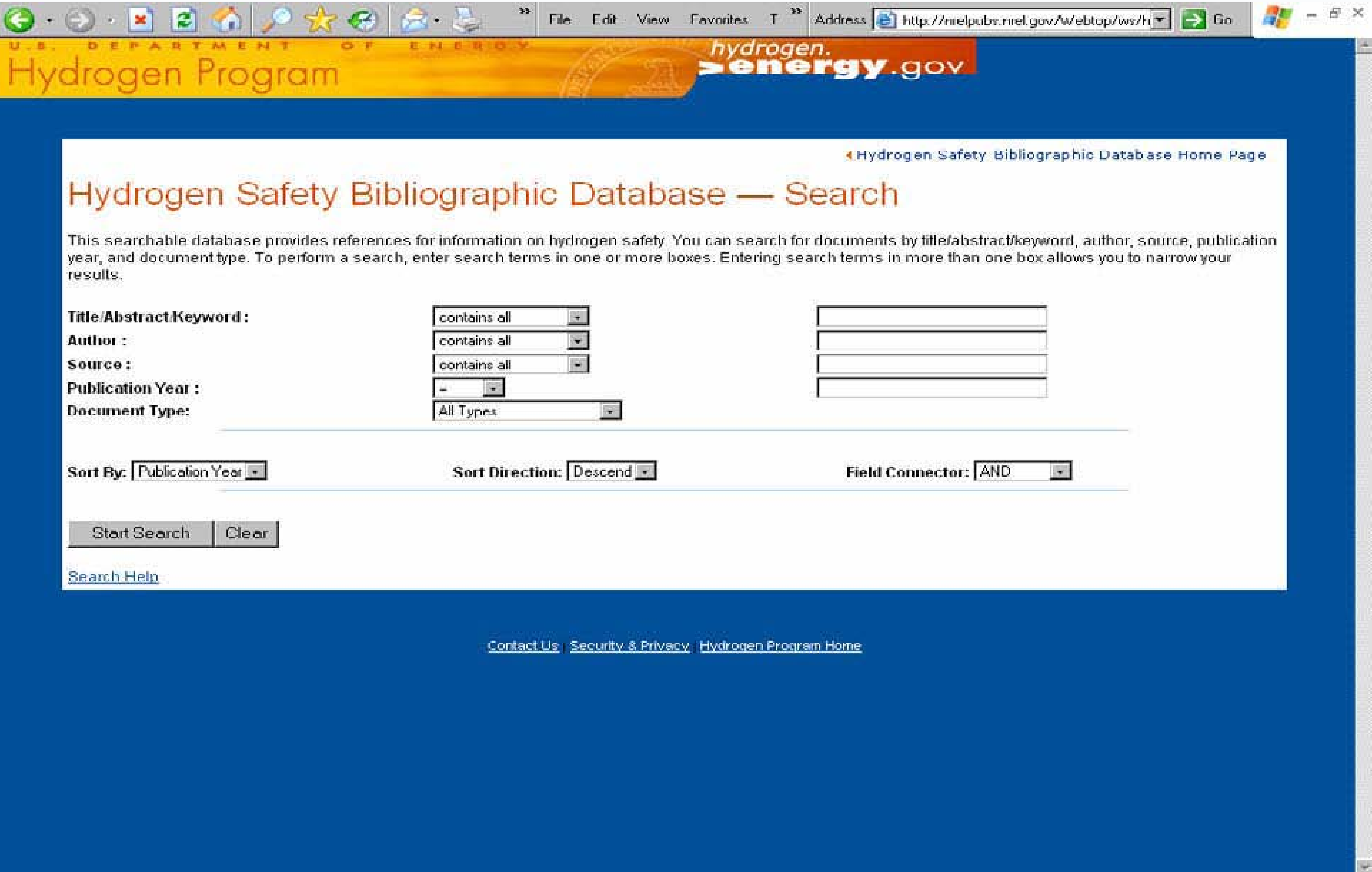
- To date, the North American team has identified the following as critical constituents around which near-term R&D and testing should be focused:
  - CO
  - S compounds
  - He
  - CH_4 and inerts
  - NH_3
  - Particulate Matter (<10µ diameter)

This list may change and other critical constituents may be identified as R&D and testing proceed

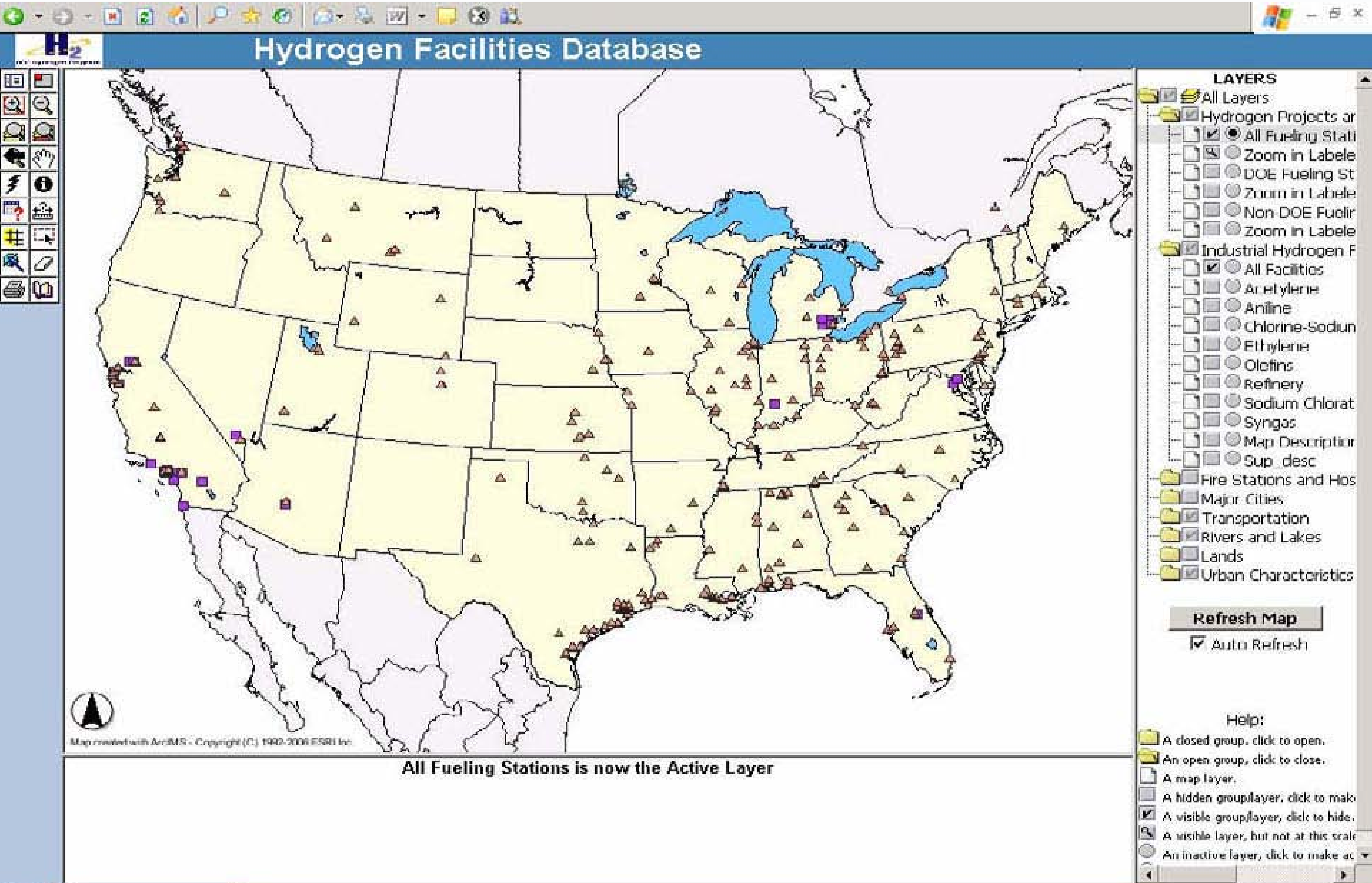
Technical Accomplishments/Progress: Fuel Quality – 5-year R&D/Testing Plan Defined

Topic of Investigation	2006	2007	2008	2009	2010
I. Consensus Testing Strategy					
A. Fuel cell-OEMs/fuel providers select n critical species from Table 1 based on key technical/economic drivers					
B. Develop R&D/test plan with WG12					
C. Coordinate activities, revise plan annually					
D. Derive optimal balance bet. fuel cell performance and fuel cost					
II. Fuel Cell Tests ('standard' MEA)					
A. Conduct failure mechanism tests w/re concn. at const. load, RH, T & P with critical constituents (CO, H2S, etc.)	Determine mechanism	Identify regeneration alternatives	Alternate materials		
B. Conduct long-term tests (const. physical conditions) and const. & variable loads with critical constituents (CO, H2S, etc.)	Aging/const load	Aging/variable load	Aging w/regen		
C. Conduct tests with selected combinations of critical constituents (CO, H2S, etc.) and concentrations	Determine mechanisms	Identify regeneration alternatives	Alternative materials use (low cat. loading, etc.)	Commercial Materials	
D. Conduct "Simulated Drive Cycle" tests with H_2 + critical constituents as fuel		Operations with limited contaminants and limits on conditions (load,SD/SU)	Operations with 'H2 Fuel' & typical conditions		
E. Investigate performance/cost trade offs re: critical constituents					
III. H2 Fuel Provider Integration					
A. Define H_2 fuel quality variations based on current cleanup procedures (relative to critical constituent limits)					
B. Define contaminant species/ concentration variations as a function of planned H_2 sources					
C. Investigate H_2 cleanup alternatives commensurate with fuel cell tests					
D. Conduct cost trade-offs re: critical constituents					
IV. Analytical Protocol/Instrumentation					
A. Evaluate adequacy of Table 1 info., set priorities based on IA					
B. Modify ASTM standards to measure critical constituents as needed	Determine variations to current practice	Investigate and incorporate required alternatives to SOP			
C. Validate test methodology and requirements for critical constituents	Identify key species required to be monitored		Finalize species and concns to be monitored		
D. Assess cost trade-offs, esp. in-line measurement					
V. OEM Engine/Vehicle Tests					
A. H2 Fuel with Priority Constituents		Correlate small scale fuel cell tests with large scale	Assemble and evaluate demo and fleet vehicle operations with H_2 fuel quality	Test and demonstrate vehicle/engine dyno tests with	
VI. Advance Storage Materials					
A. Track Development of Adv. Materials					

Technical Accomplishments/Progress: Safety Bibliographic Database



Technical Accomplishments/Progress: Hydrogen Facilities Database



Future Work

- Fuel Quality (FY06-07)
  - coordinate R&D and testing in parallel with preparation of international standard
  - focus R&D/testing on critical constituents identified as cost and technology drivers by consensus of fuel providers and fuel cell and automobile OEMs
    - cell testing
    - fuel cell system performance and durability trade-offs
    - fuel production, purification, delivery, options and cost trade-offs
    - sampling, analytic methodology, and instrumentation needs
  - develop consensus on critical analytical methods and procedures needed to verify recommended maximum levels of contaminants
  - integrate findings, results with DOE H2 Quality Working Group
- Component Testing and Validation (FY06-07)
  - harmonize performance-based test protocols and validation of technical requirements in domestic and international hydrogen standards, codes, and regulations
    - streamline testing/validation through computer-aided engineering (CAE), Design of Experiments, and other statistical techniques
- Sensor Testing and Validation (FY07)
  - sensitivity, accuracy, selectivity, durability in laboratory and field
  - develop criteria, test procedures relevant to integrated engineering and design approach
  - measure performance dependence on temperature, humidity, exposure to outdoor air

Summary

• Strengthened consensus codes and standards agenda through National H2-FC C&S Coordinating Committee

  - contracts with all key SDO/MCO to develop essential standards and model codes under significant budget constraints

• Established and coordinated North American team of experts to help prepare and submit draft ISO Technical Specification for hydrogen fuel quality for PEMFC road vehicles

  - high priority for FreedomCAR- Fuel Partnership C&S Tech Team

• Created online hydrogen safety bibliographic database for DOE

  - fulfills NAS recommendation

• Created online Geographic Information System (GIS) hydrogen facility database

  - enables timely and informed response to hydrogen incidents

• Applying risk assessment techniques to develop better risk-informed codes and standards (with SNL)

  - linked to IEA Annex 19 (Hydrogen Safety)

Supplemental Slides

The following slides are for the purposes of the reviewers only.

Responses to Previous Year Reviewers' Comments

- "Accelerate efforts on hydrogen quality specifications;" "focus on fuel quality, data collection, and underlying R&D"
  - final draft of ISO specification submitted, ISO requirements harmonized with SAE
  - fuel quality incorporated in R&D Roadmap, designated as high priority by Codes and Standards Tech Team
  - the North American team has developed 5-year and 1-year R&D plans for testing, data collection

Responses to Previous Year Reviewers' Comments

- "Move more budgets toward codes and standards R&D and decrease general contributions made to trade organizations"

- significant R&D budgets planned for integrated safety engineering, component testing and validation, sensor testing and validation eliminated due to funding reductions
- R&D focus placed on fuel quality testing
- less than 10% of budget going to an industry association (provided 20% cost-share) to support codes and standards coordination and provide central communication for C&S issues

Responses to Previous Year Reviewers' Comments

- "More attention to residential and commercial systems is desirable"

  - supporting revision of ICC model codes relevant to residential and commercial buildings
  - supporting revision of NFPA model codes and standards for fueling stations
  - supporting R&D to establish scientific foundation for setbacks for hydrogen and fuel cell applications in telecommunication facilities

Publications and Presentations

Patents:

Two submitted for hydrogen safety sensor, prospective patents licensed to industrial firm

Papers:

- Overview Paper, Hydrogen Energy Cycle, MRS Symposium on Hydrogen; Cambridge, MA
- Risk Assessment for Hydrogen Codes and Standards, 1st International Conference on Hydrogen Safety; Pisa, Italy
- DOE Hydrogen Codes and Standards Program, SAE Congress; Detroit, MI

Presentations:

- Fuel quality R&D and Testing, ISO TC197 WG12; Palm Springs, CA
- DOE Hydrogen Codes and Standards Program, SAE Congress; Detroit, MI
- Hydrogen Fuel Quality R&D Needs, Codes and Standards Tech Team; Washington, D.C.
- North American Consensus for Fuel Quality Requirements, ISO TC197 WG12; Kyoto, Japan
- Fuel Quality R&D Plan, Fuel Cell Tech Team; Detroit, MI
- Hydrogen Fuel Quality, National H2/FC C&S CC and US TAGs; Detroit, MI

Critical Assumptions

- Synchronization of Codes and Standards Development with R&D
  - better synchronization of codes and standards development with the R&D will establish a sound technical and scientific basis for requirements incorporated in codes and standards
  - scientific and technical basis requirements difficult to trace at times; SDOs and MDOs devoting significant efforts to update requirements using the results of R&D supported by DOE and industry
- Performance-Based preferred over Design-Based, or Prescriptive, Standards
  - specifies tests component, subsystem, or system must pass without regard to materials made of or how designed
  - requirements for stationary applications will most probably remain prescriptive, requirements for vehicular applications should, to extent possible, be performance-based
- Coordinating National and International Codes and Standards Development
  - many major stakeholders involved in codes and standards operate in global markets and clearly recognize need for close coordination and integration of national codes and standards development and international efforts to protect U.S. economic interests
  - DOE will facilitate harmonization of requirements, including uniform application of results from R&D efforts in formulating safety requirements, and minimize duplications of effort

Technical Accomplishments/Progress: National Template for Vehicle Systems and Refueling Facilities

Vehicles

Controlling Authority:
DOT/NHTSA (Crashworthiness)
EPA (Emissions)

Standards Development:
General FC Vehicle Safety: SAE
Fuel Cell Vehicle Systems: SAE
Fuel System Components: CSA
Containers: SAE
Reformers: SAE
Emissions: SAE
Recycling SAE
Service/Repair: SAE

Interface

Fuel Specs: SAE ASTM, API
Analytical Methods: ASTM
Wts/Measures:NIST, API, ASME
Fueling: SAE, CSA
Sensors/Detectors: UL, NFPA, SAE, CSA
Connectors: SAE, CSA
Communications : SAE UL, CSA, API, IEEE

Fuel Delivery, Storage

Controlling Authority:
DOT/PHMSA: (Over-road Transport**,** Pipeline Safety)

Standards Development:
Composite Containers: ASME CSA, CGA, NFPA
Pipelines: ASME, API, CGA, AGA
Equipment: ASME, API, CGA, AGA
Fuel Transfer: NFPA, API

Fueling, Service

Parking Facility

Controlling Authority: State, Local Govt.
Zoning, Building Permits

Standards Development:
Storage Tanks: ASME**,** CSA, CGA, NFPA, API
Piping: ASME**,** CSA, CGA, NFPA
Dispensers: CSA, UL, NFPA**,**
On-site H2 Production: CSA, UL, CGA, API
Codes for the Environment: ICC, NFPA

Lead SDO underlined

Technical Accomplishments/Progress: National Template for Stationary and Portable Systems

Controlling Authority:
OSHA, Emissions – EPA
Pipeline: DOT/PHMSA
State, Local Government Zoning, Building Permits

Standards Development:
Electrolyzers: UL, CSA
Reformers: UL, CSA, API
Performance Test Procedures: ASME, CSA
Chemical Hydrides: UL, CSA, NFPA

Hydrogen Generator

Installation Piping: ASME, CSA, CGA, NFPA, ICC
Storage: ASME, CGA, CSA, API, NFPA
Compressors Safety Certification: CSA, UL
Compressor Design, Performance & Safety: API
Sensors/Detectors: UL, CSA, NFPA
Fuel specifications: CGA, SAE, API, ASTM
Weights/Measures: NIST, API, ASME
Dispensers: NFPA, SAE**,** CSA, UL, API
Non-vehicle Dispensing: CGA
Codes for Built Environment: ICC, NFPA, CGA, ASHRAE
Interconnection: IEEE , UL, NFPA

Interface

Controlling Authority:
OSHA,
State, Local Government Zoning, Building Permits

Standards Development:
H2 ICEs: UL, CSA
H2 Fueled Turbines: API**,** CSA, UL, ASME
FC Systems: CSA, ASME, UL
FC Installation: NFPA
FC Performance Test Procedures: ASME, CSA, NHA-GTI

Stationary Fuel Cells

Controlling Authority: CPSC, DOT/PHMSA, OSHA, EPA (Methanol), State, Local Govt. (Zoning, Building Permits)

Standards Development:
Handheld Systems: UL, CSA
Portable Systems: CSA, UL, CGA
Handheld Fuel Containers: UL, CSA, CGA
Portable Fuel Containers: CGA, CSA, ASME
H2 Fuel Specifications: CGA, SAE
Performance Test Procedures: NHA-GTI**,** ASME, CSA

Portable Fuel Cells

Leads will change depending on type of environment.

Technical Accomplishments/Progress: Fuel Quality – North American Team Established

- Bhaskar Balasubramanian, John Lemen, Chevron (C&STT, HPTT)
- Bob Boyd, BOC Gases (ASTM, SAE)
- Bill Collins, UTC Fuel Cells (ISO/TC197 WG12, USFCC, SAE)
- Raul Dominguez, SCAQMD (ASTM D03)
- Tony Estrada, PG&E (ASTM, SAE, ISO/TC197 WG12)
- Karen Hall, NHA (ISO TC197 and WG12)
- J.P. Hsu, Smart Chemistry (ASTM)
- Tom Joseph, Air Products (CGA, NFPA, ISO TC197)
- Jim Ohi, NREL (DOE HFCIT, C&STT)
- Rick Rocheleau, University of Hawaii (ISO/TC197 WG12, DOD)
- Leon Rubinstein, Patrick Kilough, Shell Hydrogen (HPTT, SAE, ASTM D03)
- Jesse Schneider, Daimler-Chrysler (C&STT, SAE, ISO/TC197 WG12)
- Joe Schwartz, Praxair (CGA, NFPA)
- Jim Simnick, BP (ASTM, HPTT)
- Mike Steele, Fred Wagner, GM (C&STT, FCTT, SAE)
- Tommy Rockward, Francisco Uribe, LANL (FCTT, USFCC/SCTRR)
- Spenser Quong, Quong and Associates (ASTM, CaFCP)
- Gerald Voecks, consultant to NREL (ISO/TC197 WG12)
- Silvia Wessel, Ballard Power Systems (ISO/TC197 WG12, CaFCP, USFCC)
- Doug Wheeler, consultant to University of Hawaii (ISO/TC197 WG12)
- Robert Wichert, USFCC (ISO and TC197 WG12, IEC)