IX.1 Hydrogen Codes and Standards

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- National Fire Protection Foundation, Quincy, MA
- University of South Carolina Research Foundation, Columbia, SC
- Hawaii Natural Energy Institute at the University of Hawaii, Honolulu, HI
- Smart Chemistry, Sacramento, CA
- Sloane Solutions, Oxford, MI

Project Start Date: 1995
Project End Date: Project continuation and direction determined annually by DOE

Objectives

- Conduct research and development (R&D) needed to establish sound technical requirements for alternative fuel vehicle codes and standards.
- Support code development for the safe use of alternative fuels in transportation applications.
- Advance safety, code development, and market transformation issues through collaborations with appropriate stakeholders.
- Facilitate the safe deployment of alternative fuel technologies.

Technical Barriers

(A) **Limited Government Influence on Model Codes**
The code development process is voluntary, so the government can affect its progression, but ultimately it is up to the code development organizations (CDOs).

(B) **Competition among Standards Development Organizations (SDOs) and CDOs**
The competition between various organizations may hinder the creation of consistent vehicle codes and standards.

(C) **Limited State Funds for New Codes**
Budget shortfalls in many states and local jurisdictions impact the adoption of codes and standards because they do not always have the funds for training building and fire officials.

(D) **Large Number of Local Government Jurisdictions (approximately 44,000)**
The large number of jurisdictions hinders the universal adoption of codes and standards.

(E) **Lack of Consistency in Training of Officials**
The training of code officials is not mandated and varies significantly. The large number of jurisdictions leads to variation in training facilities and requirements.

(F) **Limited DOE Role in the Development of International Standards**
Governments can participate and influence the development of codes and standards, but they cannot direct the development of international standards.

(G) **Inadequate Representation at International Forums**
Participation in international forums and meetings is voluntary and, to date, has been limited by budgetary constraints.

(H) **International Competitiveness**
Economic competition complicates the development of international standards.

(I) **Conflicts between Domestic and International Standards**
National positions can complicate the harmonization of domestic and international standards.

(J) **Lack of National Consensus on Codes and Standards**
Competitive issues hinder consensus.

(K) **Lack of Sustained Domestic Industry Support at International Technical Committees**
Cost, time and availability of domestic experts have limited consistent support of the activities conducted within the international technical committees.

(L) **Competition in Sales of Published Standards**
The development and licensing of codes and standards is a business. The competition among CDOs and SDOs for sales of codes and standards inhibits harmonization of requirements adopted by local jurisdictions.

(M) **Insufficient Technical Data to Revise Standards**
Research activities are underway to develop and verify the technical data needed to support codes and standards development but are not yet completed.

(N) **Affordable Insurance is not Available**
New technologies, not yet recognized in codes and standards, will have difficulty in obtaining reasonable insurance.

(O) **Large Footprint Requirements for Hydrogen Refueling Stations**
The existing set-back distances for siting fueling equipment and other safety requirements result in large footprints.

(P) **Parking and Other Access Restrictions**
Complete access to parking, tunnels and other travel areas has not yet been secured. Appropriate codes and standards need to be developed to provide safe access to these areas.

Contribution to Achievement of DOE Safety, Codes & Standards Milestones

This project will contribute to achievement of the following Hydrogen Codes and Standards milestone from the DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 21** – Completion of necessary codes and standards needed for the early commercialization and market entry of hydrogen energy technologies. (4Q 2012)

Accomplishments

NREL has accomplished the following in support of the Safety, Codes and Standards section (3.7) of the DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- Vehicle codes and standards gap analysis: Performed an analysis of codes and standards for all six alternative fuel vehicle fuels. The analysis gave background information on the history of fuel usage, the existing codes and standards structure, gaps in the existing codes and standards structure, and research projects or other work needed to fill these codes and standards gaps.
- Chemical sensor testing and validation: Began collaborations with key stakeholders; worked on a formal agreement with the European Commission's Joint Research Centre laboratory for testing hydrogen safety sensors; started testing commercially available sensors; participated on International Organization for Standardization (ISO) TC197 WG13 to develop a hydrogen sensor standard.
- Component testing: Conducted validation testing of high-pressure onboard hydrogen storage systems; tested hydrogen fueling station breakaways, fittings, nozzles, and hoses; began work on hydrogen pressure release device (HPRD) testing. This work has been used to develop a HPRD standard by CSA America.
- Fuel quality specification: Worked with ISO on technical specification 14687-2; conducted validation testing of particulate measurement methodology; coordinated testing and modeling to understand the effects of contaminants on fuel cell performance.
- Modeling/simulation of leak scenarios in residential garages: Completed validation testing at NREL's Thermal Test Facility on full-scale garage model; worked with computational fluid dynamics (CFD) group to develop a modeling/test validation protocol. Published paper in International Journal of Hydrogen Energy describing project and modeling validation.
- Codes and standards development: Worked with CDOs and SDOs to develop codes, identify gaps, and provide R&D support; participated on National Hydrogen and Fuel Cell Codes and Standards Coordinating Committee, DOE Codes and Standards Technical Team, and Hydrogen Industry Panel on Codes; assisted DOE Golden Field Office in moving responsibilities for subcontract support to CDOs and SDOs.
- Codes and standards workshops: Expanded codes and standards workshops from Fiscal Year 2008 to cover more locations and subject matter. Presented seven workshops in FY 2009 partnering with local fire departments and government organizations.
- Web-based information compendium: Released Web-based information compendium as a reference for codes and standards workshop participants and the public; expanding compendium to include other vehicle fuels.

Introduction

It is essential to develop and promulgate codes and standards in order to provide for the safe use of vehicle technologies. With the help of key stakeholders, the DOE Vehicle Technologies Program and NREL are coordinating a collaborative national effort to prepare, review, and promulgate codes and standards for all alternative fuel vehicle technologies.

Approach

The Vehicles Program recognizes that domestic and international codes and standards must be established to enable the timely commercialization and safe use of alternative vehicle fuels. The lack of codes and

standards applicable to vehicle technologies is an institutional barrier to deploying vehicle technologies. It is in the national interest to eliminate this potential barrier. As such, the subprogram works with domestic and international SDOs to facilitate the development of performance-based and presecriptive codes and standards. These standards are then referenced by building and other codes to expedite regulatory approval of vehicle technologies. This approach ensures that U.S. consumers can purchase products that are safe and reliable, regardless of their country of origin, and that U.S. companies can compete internationally.

Results

DOE has identified the 2012 targets for hydrogen safety sensor performance. NREL is testing both commercially available and near-term developmental sensors to identify performance variables relative to the DOE targets. NREL will make their data on sensor testing available through publications or Web access. Fuel quality work at NREL has helped produce a draft ISO fuel quality standard.

NREL has published results of a CFD study on leak scenarios in residential garages. Full-scale experimental validation of the CFD model has been done in NREL's Thermal Test Facility.

To help manage the vehicle safety codes and standards development process, NREL is working directly with key technical committees and at the coordinating committee level. Coordinating Committees include the National Hydrogen and Fuel Cell Codes and Standards Coordinating Committee and DOE's Codes and Standards Technical Team. NREL is also contributing to both national and international standards committees, such as National Fire Protection Association 2, the SAE Fuel Cell Safety Group, and ISO TC 197. With DOE's Golden Field Office, NREL provides support and monitors the progress of work by CDOs and SDOs that is coordinated by Regulatory Logic, LLC.

Facilitating the codes and standards to implement vehicle technologies is a high priority for the program. NREL is continuing work on a DOE initiative to address this need by organizing workshops that include fueling station developers, state and local code officials, and other interested parties. These workshops are targeting regions in which there is project activity. Further work includes developing web based training and educational materials for all six alternative vehicle fuels.

Conclusions and Future Directions

NREL will continue to support the development of codes and standards by:

- Working with DOE and Regulatory Logic to implement a national template for vehicle codes and standards development.
- Continuing R&D support of the key technologies required to close the gaps identified in the codes and standards development process.
- Continuing R&D collaborations with national and international stakeholders on vehicle codes and standards activities.
- Building on coordinating committee efforts to further consolidate and coordinate domestic and international codes and standards activities.

FY 2009 Publications/Presentations

1. C. Rivkin, "US hydrogen Fueling stations: Case Studies" University of Ulster short course in hydrogen safety, 2009.

2. C. Rivkin, C. Blake, R. Burgess, W. Buttner, and M. Post, "Code Compliance Analysis for Indoor Hydrogen Fueling", published in the proceedings of the 2009 National Hydrogen Association meeting.

3. W. Buttner, C. Blake, R. Burgess, M. Post and C.Rivkin. "Development and Compliance to Hydrogen Sensor Codes and Standards the NREL Hydrogen Sensor Testing Laboratory" published in the proceedings of the 2009 National Hydrogen Association meeting.

4. C. Rivkin, C. Blake, R. Burgess, W. Buttner, and M. Post, "CA National Set of Hydrogen Codes and Standards for the US", published in the proceedings of the 2009 International Conference on Hydrogen Safety meeting.

5. W. Buttner, C. Blake, R. Burgess, M. Post and C.Rivkin. "An Overview of Hydrogen Safety Sensors and Requirements"published in the proceedings of the 2009 International Conference on Hydrogen Safety meeting.

6. W. Buttner, R. Burgess, M. Post and C. Rivkin "Hydrogen Sensor Codes and Standards–The NREL Hydrogen Sensor Testing Laboratory," International Energy Association, Experts Meeting Task 19 (invited talk), April 21–24, 2009.

7. W. Buttner, R. Burgess, M. Post and C. Rivkin "An Overview of Hydrogen Sensors and Requirements"IEEE Stationary Battery Meeting (invited talk), June 7–11, 2009.