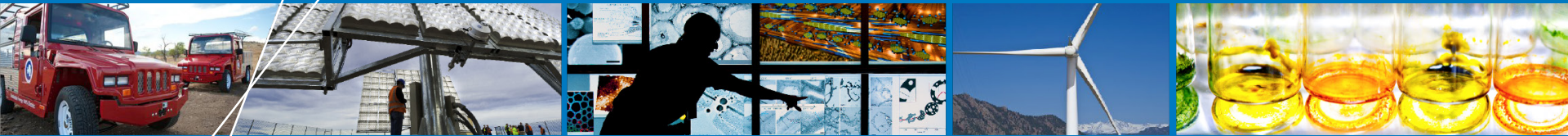


National Codes and Standards Deployment and Outreach



Carl Rivkin
National Renewable Energy Laboratory
7 June 2016

Project ID SCS001

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Overview

Timeline

- **Project start date:** October 1, 2002
- **Project end date*:** September 30, 2016

*Project continuation and direction determined annually by DOE

Budget

- **FY15 planned DOE funding:** \$275,000
 - Training and Outreach – \$150,000
 - Continuous Codes and Standards Improvement – \$125,000
- **FY16 planned DOE funding:** \$300,000
 - Training and Outreach – \$175,000
 - Continuous Codes and Standards Improvement – \$125,000
- **Total DOE funds received to date:** \$1,000,000

Barriers

- **G. Insufficient Technical Data to Revise Standards**
- **F. Enabling National and International Markets Requires Consistent RCS**
- **A. Safety Data and Information: Limited Access and Availability**

Partners

- **Regional fire departments such as Orange County Fire Authority**
- **DOE national labs**
- **Regional hydrogen associations such as California Fuel Cell Partnership**
- **Industrial gas industry- Linde, Air Products, Praxair, and Air Products, and Air Liquide**
- **Standards development organizations**

Relevance

- **Objectives: Both projects further the deployment of hydrogen fuel cell technologies with particular focus on the infrastructure required to support fuel cell electric vehicles (FCEVs).**
- **Project impact:**
 - The Continuous Codes and Standards Improvement (CCSI) project supports technology deployment by modifying codes and standards to remove barriers to their effective application.
 - The Codes and Standards Outreach and Training project supports technology deployment by providing codes and standards information to project developers and code officials, making project permitting smoother and faster.
 - These impacts directly address DOE barriers to deployment (consistent codes and standards and having information readily available to users).
 - These projects have proven to be effective over the last year with furthering hydrogen fueling station deployment and addressing key code issues such as hydrogen storage setback distances.

Approach

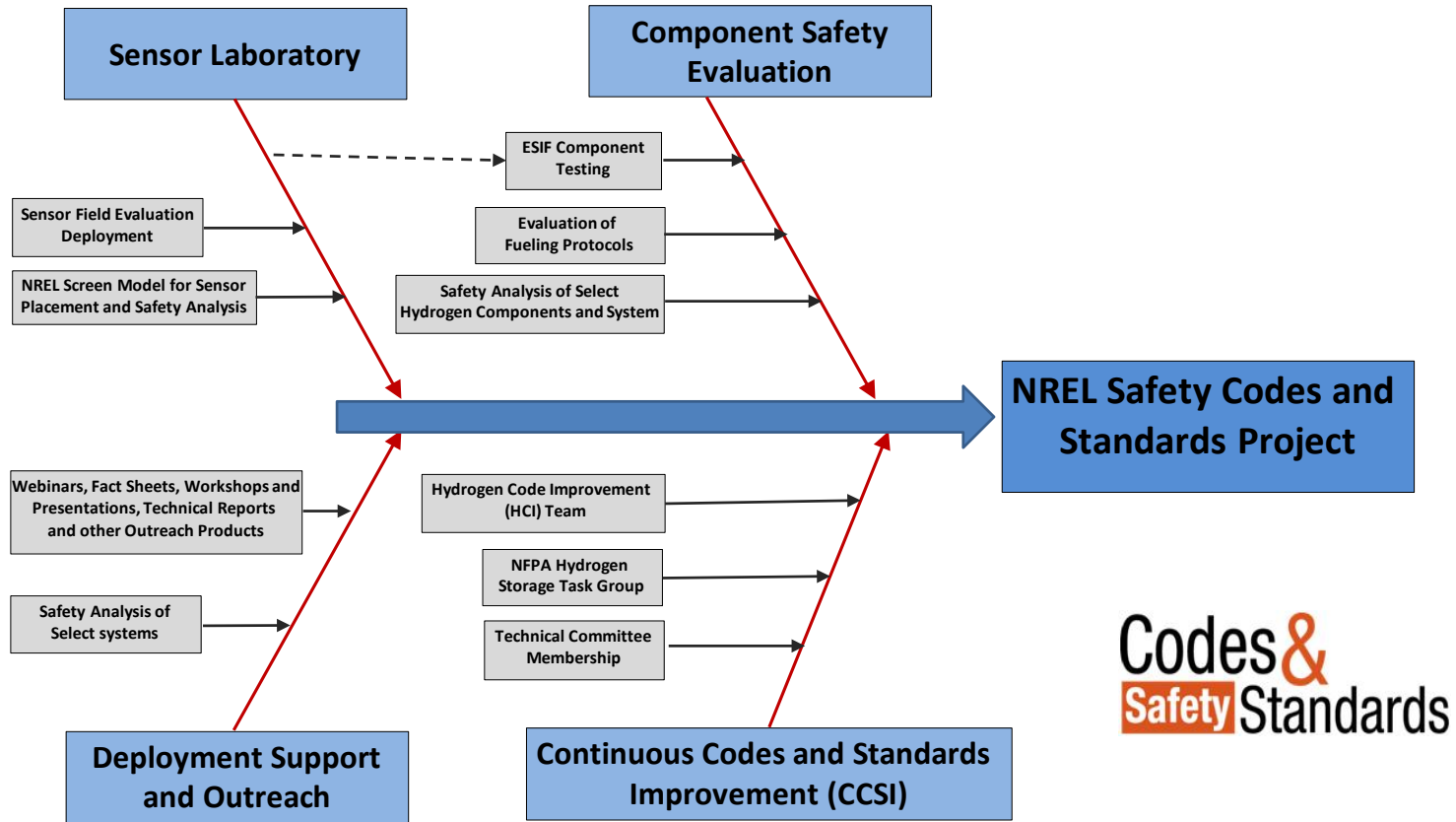
- **Outreach and Training:**

- Identify the users' needs at this stage of technology deployment, particularly code officials and project developers, and develop tools to make their jobs easier.
- Use extensive collaborations with interested parties to ensure information is effectively distributed to users.

- **CCSI:**

- Use NREL participation in Regulations, Codes, and Standards (RCS) technical committees (including ISO committees), H2USA, H2FIRST, and review of NREL field data to identify key RCS issues requiring action.
- Identify research needs based code issues defined through CCSI
- Use a process that complements the ANSI process that all North American standards development organizations (SDOs) follow.
- Foster collaborations with industry, national laboratories, SDOs, project developers and other interested parties to identify code improvement issues.

Integrated Approach: NREL Safety Codes and Standards Project Structure



H2Tools Permitting Web Page

- **Objective**-reduce difficulty of permit development and review for hydrogen infrastructure projects
- Permit tools web page will provide information such as technology overviews and codes and standards summaries that will reduce work required to develop and review permits
- Permit tools form an integrated package to address different learning venues (video, technical report, and on line learning) and levels of detail
- Permitting will be faster and more efficient through easily accessible information

Permit Tool	Description
"Permitting Hydrogen Fueling Station Stations"	Video format. Video giving basic background on hydrogen technologies followed by a description of the permitting process done through the Orange County Fire Authority in Irvine, CA. Contains interviews with code officials, emergency responders, and technical experts as well as footage of hydrogen stations. (available early 2016)
Code Official Training Course	Online interactive format. This online training is divided into the following modules: <ol style="list-style-type: none"> 1. Module 1 Hydrogen & Fuel Cell Basics 2. Module 2 Hydrogen & Fuel Cell Applications 3. Module 3 Hydrogen Fueling Stations 4. Module 4 Fuel Cell Facilities <p>The course includes questions at the end of each module to confirm the student has learned the basic points of the module. Currently online http://www.hydrogen.energy.gov/code_official_training.html. (Update available early 2016.)</p>
National Permit Guide for Hydrogen Fueling Stations	PDF Format. Complete update of the 2004 document including updated references to the 2016 edition of NFPA 2 Hydrogen Technologies Code (available early 2016)
Permitting Web Site	PDF format. This interactive web site provides code citations for hydrogen fueling stations and stationary fuel cells. These citations can be downloaded in PDF format. The code citations are based on applying nationally recognized model codes and standards. Requirements at specific sites will vary based on codes and standards in effect at that location. Accessible at http://www.hydrogen.energy.gov/permitting/ . (Updated 2014)
Hydrogen Technologies Safety Guide	PDF Format. This guide provides basic information on hydrogen technologies and safety. The primary objective of this guide is give users who are unfamiliar with hydrogen technologies basic background information on the technologies, safety issues of concern, and safety requirements intended to address these safety issues. <p>The information in the guide includes:</p> <ul style="list-style-type: none"> -history of hydrogen technologies -basic properties of hydrogen -regulations, codes and standards that apply to hydrogen technologies <p>http://www.nrel.gov/docs/fy15osti/60948.pdf</p>

Outreach and Training Accomplishments and Progress: Permitting Hydrogen Fueling Stations Video Complete

Project Impact

- **Objective-** Reduce difficulty of permit development and review for hydrogen fueling stations
- Permit video will provide information that will reduce work required to develop and review permits from a fire protection authority
- Easy to use and can be revisited as needed
- Code officials will get to key code requirements quickly & confidentially

Video Covers



- Why there is an interest in FCEVs
- Technology basics
- Agencies and their roles in the approval process
- Codes and Standards including key requirements of NFPA 2 Hydrogen Technologies Code
- Maintenance and inspection

Guide to Permitting Hydrogen Motor Fuel Dispensing Facilities

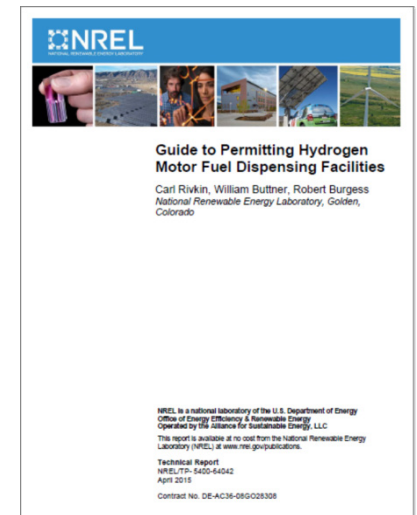
Published April 2016

Project Impact

- **Objective:** Reduce difficulty of permit development and review for hydrogen fueling stations
- Permit guidance document will provide information that will reduce work required to develop and review permits
- Guide covers different station configurations and codes and standards in detail
- Permitting will be faster and more efficient due to focused and detailed information on hydrogen fueling stations

Table of contents

- 1.0 Introduction
- 2.0 Hydrogen Motor Fuel Dispensing Facility Basics
- 3.0 Hydrogen Motor Fuel Dispensing Facility Requirements
- 4.0 Codes and Standards Affecting Design, Installation, and Operation of a Hydrogen Motor Fuel Dispensing Facility
- 5.0 Case Study
- 6.0 Hydrogen Properties



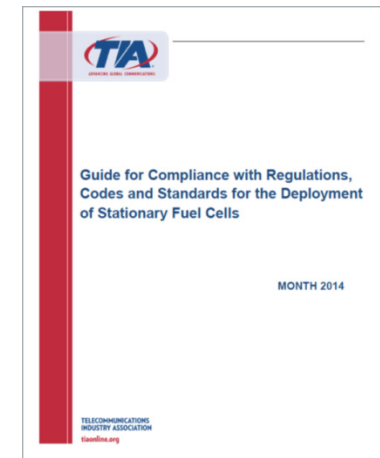
Outreach and Training Accomplishments and Progress: Telecommunications Industry Association (TIA) Documents

Project Impact

- Objective: Reduce difficulty of permit development and review for stationary fuel cells
- Permit guidance documents will provide information that will reduce work required to develop and review permits for stationary fuel cells
- Information includes overview of fuel cell technology, siting issues, and codes and standards summaries
- Developed by industry experts focused on needs of industry
- Permitting will be faster and more efficient due to focused accessible information on stationary fuel cells

Stationary Fuel Cell Guides

- Guide for Deployment of Stationary Fuel Cells (background information)-published June 2016
- Guide for Compliance with Regulations, Codes and Standards for the Deployment of Stationary Fuel Cells - published FY2016
- They are similar to maps that guide the developer through the existing RCS and provide background information on fuel cell technologies



Outreach and Training Accomplishments and Progress: Codes and Standards In Person Outreach

Project Impact

- **Objective:** Reduce difficulty of permit development and review for hydrogen infrastructure
- Training will provide information that will reduce work required to develop and review permits
- Information includes overview of hydrogen technologies, hydrogen properties, information resources, and codes and standards summaries
- Code officials will be able to quickly locate key codes and standards
- Permitting will be faster and more efficient due to increased communication with code and safety experts

Outreach presentations

4 August 2015 Norwalk, CA in collaboration with CAFCP

20 August 2015 in collaboration with PNNL, Massachusetts Fire Service, and the Massachusetts Hydrogen Coalition

18-21 April 2016 with PNNL, Massachusetts Hydrogen Coalition, New York City Department of Administrative Services, Air Liquide, and Toyota Motor Sales*

Total number of attendees over duration of project exceeds 700

*Used training package developed with PNNL and SNL that can be used for additional hydrogen codes and standards outreach events

Standardized Outreach Codes and Standards Materials

Project Impact

- **Objective-** develop outreach materials that will provide basic safety and codes and standards information on Fuel Cell Electric Vehicles (FCEVs) and the infrastructure required to support these vehicles
- Standardized materials are publicly available on H2Tools
<https://h2tools.org/content/national-labs-and-industry-safety-outreach-northeast>
- Collaborative effort utilized SNL's expertise in materials science, PNNL's expertise in information distribution, and NREL's expertise in code development
- Developing standardized presentation materials in collaboration with SNL and PNNL produced strong technical package and will greatly increase information leverage

Draft Agenda for Model Outreach Activity

<i>Time</i>	<i>Description</i>	<i>Host/Presenter</i>
8:30-9:00	<i>Sign in and Introductions</i>	
9:00- 9:15	Why is there an interest in Fuel Cell Electric Vehicles (FCEVs) (and the infrastructure required to support these vehicles)	Carl Rivkin
9:15 – 9:30	What is a Hydrogen fueling station	Nick Barilo
9:30 – 9:45	Basic Code requirements for Hydrogen Fueling Stations	Carl Rivkin
<i>Break 9:45-10:00</i>	<i>Break</i>	
10:00-10:30	<i>Hydrogen Fueling Station Incidents and Impacts</i>	Chris LaFleur
10:30 – 10:45 pm	<i>Information Resources</i>	Nick Barilo
10:45- 12:00	Open Discussion	Group



Outreach and Training Accomplishments and Progress: H2USA /Maryland Plan

Project Impact

- **Objective**-allow FCEVs to use Baltimore tunnels
- Currently FCEVs not directly allowed to use Baltimore tunnels
- Developed Plan to Modify Maryland regulation to allow FCEVs to transit Baltimore harbor tunnels
 - Identified key regulations
 - Determined process for modifying regulations
 - Developed technical justification for modifications
 - Will submit proposal to change regulations in FY16

Maryland Tunnel Restrictions

- **Maryland Regulation:** Regulations that address the use of alternative fueled vehicles in MDOT's tunnels are located at 11.07.01.03.
- <http://www.dsd.state.md.us/comar/getfile.aspx?file=11.07.01.03.htm>
- .03 Alternative-Fuel Vehicles.
 - **A.** Alternative-fuel vehicles powered by liquefied petroleum gas (LPG), liquefied natural gas (LNG), or compressed natural gas (CNG) shall be permitted to use the Baltimore Harbor Tunnel and the Fort McHenry Tunnel, if the:

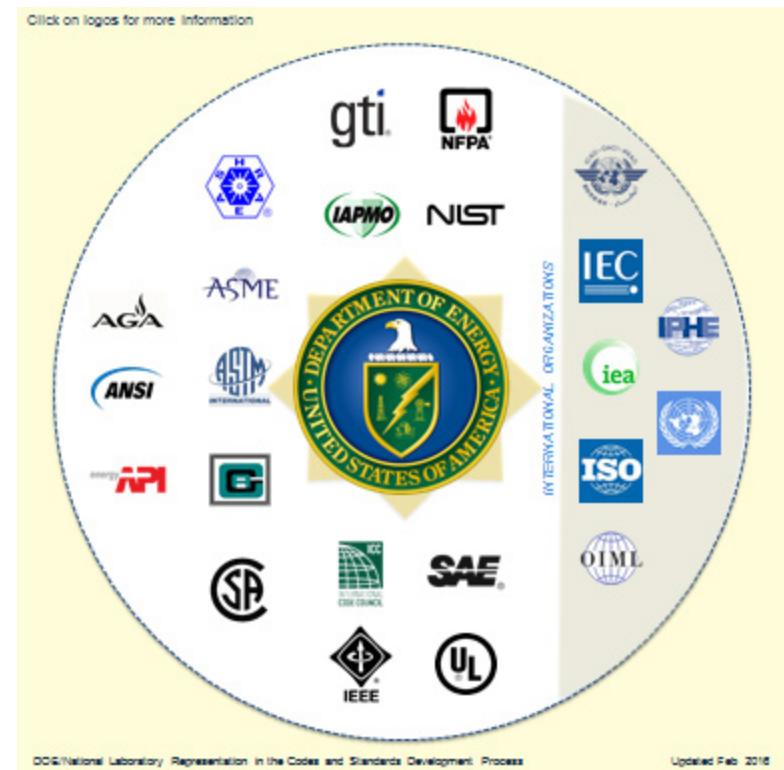


Interactive Codes and Standards Tool

Project Impact

- **Objective-** make code information easily accessible
- Current code information may be difficult to access
- Graphical interface has live links to codes and standards summary information for all standards development organizations (SDOs)
- Each SDO web page has links to the committee web page for the codes and standards projects to provide the user with the most current information

Graphical interface for easy use

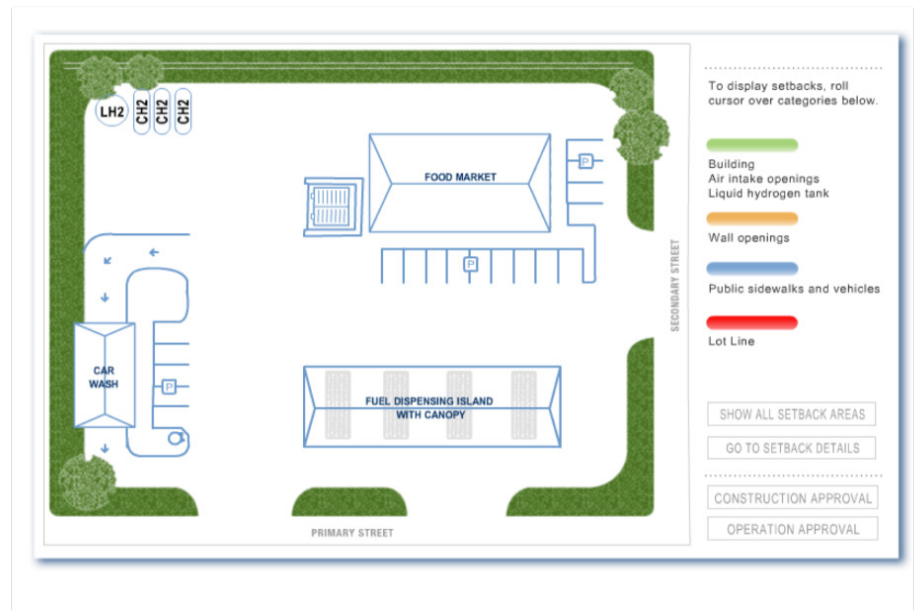


Online Code Official Training Update

Project Impact

- **Objective**-make code training easily accessible
- Will give code officials a tool that can be used anytime and anyplace
- Compliments permitting video and guide
- Modules cover:
 - Module 1 Hydrogen & Fuel Cell Basics
 - Module 2 Hydrogen & Fuel Cell Applications
 - Module 3 Hydrogen Fueling Stations
 - Module 4 Fuel Cell Facilities
- Updates include:
 - Code citations
 - Photos of active installations
 - Interactive station schematic with links to code citations
- Will be complete in FY2106
- [Code officials \(and others\) can be trained anytime and anyplace](#)

Update interactive schematic



Links from equipment to code citations and other data

Hydrogen Awareness Training

Project Impact

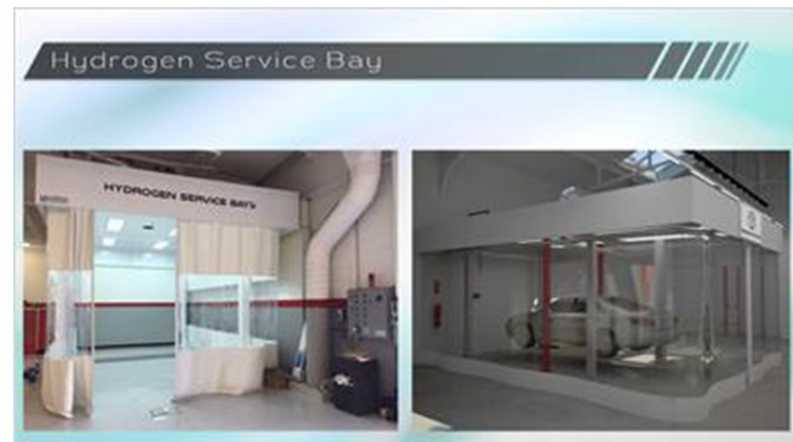
- **Objective-** orient workers who need basic information on hydrogen safety
- Focused on vehicle repair facilities
- NREL, CAFCP, KPA and Toyota developed short hydrogen safety orientation video to achieve this objective
- Workers will know enough to stay safe and make the correct decision in the event of an emergency

Video Addresses FCEV Repairs

1.1 Intro



1.11 Hydrogen Service Bay

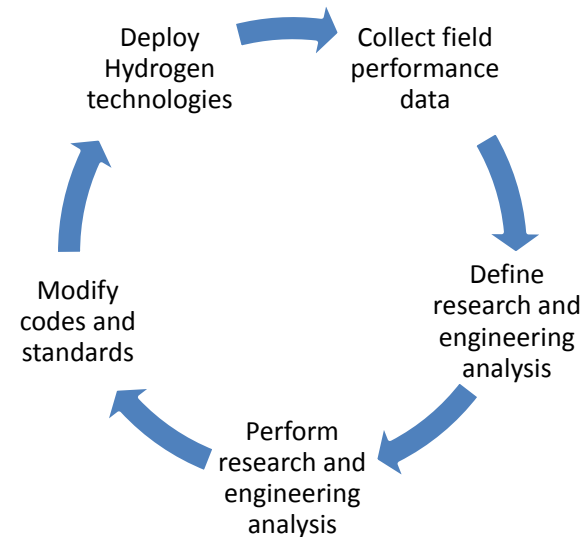


Accomplishments and Progress: Continuous Codes and Standards Improvement (CCSI) Project

CCSI projects

- **Objective**-integrate new information to improve codes
- CCSI being implemented through:
 - NFPA Hydrogen Storage Task Group
 - Hydrogen Code Improvement (HCI) Team
 - Member of several codes and standards technical committees
 - Principal Member of NFPA Industrial and Medical Gases Technical Committee
 - CGA Hydrogen Technology Committee
 - CSA Technical Subcommittee on Compressed Natural Gas (NGV) and Compressed Hydrogen Vehicle Fuel
 - Chair, NFPA 2 Hydrogen Technologies
 - SAE Fuel Cell Committee
 - ASME piping standards
 - Review of ISO standards as a member of ISO T/C 197 WG 21, 22, and 23
- Lessons learned from deployment integrated into Codes and Standards development to improve codes

The CCSI process



Connecting deployment and codes

Research Integration into CCSI

Project Impact

CCSI Incorporates and Defines Research

- **Objective**-effectively integrate research into code development
- Research output is used as technical material to justify code changes
- Information on code application to projects in the field helps identify code gaps that define research needs
- NREL performed evaluation of research needs in key codes and standards
- Key integration needs include:
 - Liquid hydrogen dispersion behavior into NFPA 2
 - PRD performance into NFPA 2 and ASME
 - Component performance data into various component standards
 - Sensor placement guidance into fire codes
 - Hydrogen fueling maintenance data into fire codes
- Research and code development can be more effectively aligned

NREL report identifies Research needs for Code development

Hydrogen Component Research Integration into Codes and Standards

December 2015

C. Rivkin, W. Buttner, and R. Burgess



NFPA Hydrogen Storage Task Group

Project Impact

- **Objective-** develop safety setback distances with a documented technical basis
- Hydrogen storage setback distances can be a critical parameter in determining whether a site can be utilized for hydrogen dispensing
- Bulk liquefied hydrogen storage requirements had resided in NFPA codes for decades without any documented technical basis
- Bulk gaseous requirements reviewed based on experience with deployment (CCSI process) and proposal developed for less restrictive distances
- Task group will produce safe, technically documented, requirements that allow increased flexibility in system siting

Progress

- Task group formed with wide industry, research, and safety participation
- Close collaboration between DOE laboratories
- Directed integration of research into code development
- Risk analysis on representative bulk liquefied hydrogen system complete
- Nine key release scenarios identified and modeling analysis initiated
- Review of bulk gaseous work done in 2007-2009 timeframe
- Proposal to revise bulk gaseous setback distances developed



NFPA Hydrogen Task Group

Project Impact

Proposal to Modify Setback Distances for Bulk Gaseous Storage Will Increase Siting Options

- Existing distances in Brackets
- Group 1 Exposures are
- Critical in siting hydrogen storage and include :
 - (a) Lot line
 - (b) Air intakes
 - (c) Operable opening in buildings and structures
 - (d) Ignition sources

Harm Criteria	Table 3. Separation Distance in feet with 1.5 safety factor			
	>0.10 to 1.72 MPa (>15 to 250 psig)	>1.72 to 20.68 MPa (>250 to 3000 psig)	>20.68 to 51.71 MPa (>3000 to 7500 psig)	>51.71 to 103.43 MPa (>7500 to 15000 psig)
Group 1 Exposures	17 (40)	20 (46)	12 (29)	15 (34)
Group 2 Exposures	15 (20)	18 (24)	10 (13)	13 (16)
Group 3 exposures	14 (17)	17 (19)	10 (12)	12 (14)

Justification published

GCPS 2016



Siting Bulk Hydrogen Storage Systems: Advances in Risk-Informed Siting Procedures in NFPA Codes

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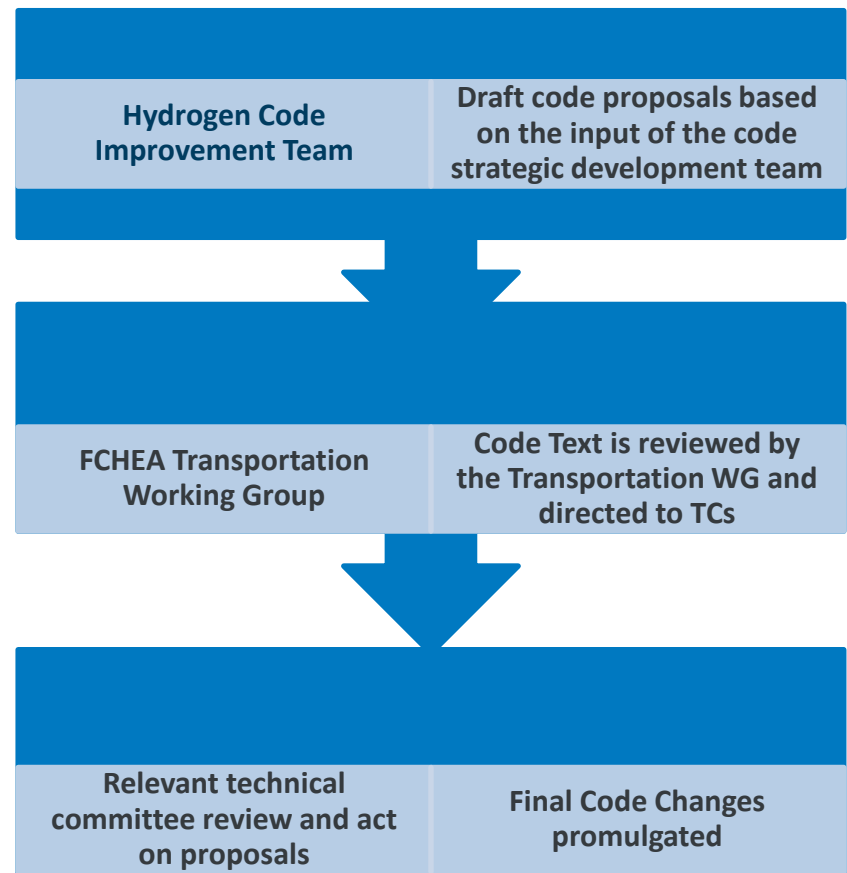
Alice Muna
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Albuquerque, NM 87185
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CCSI Accomplishments and Progress: Support of Hydrogen Code Improvement (HCI) Team

Project impact

- **Objective-** ensure building and fire code coordination does not hinder deployment
- Building and fire codes determine what is allowed to be built
- Coordination of code requirements between the primary building and fire codes in the US is critical to infrastructure deployment to prevent redundant or conflicting requirements
- NREL supported the development of an HCI team to eliminate conflicts in these codes and support continued coordination
- The HCI team has been effective in developing code proposals that have eliminated several conflicts between International Code Council documents and NFPA documents

HCI is Part of FCHEA Process



NFPA 2 Task Groups: NREL Directed Code Activities

Project impact

Objective-Improve code in key areas of deployment through focused task groups

Active Task Groups

- Enclosures- evaluate requirements for hydrogen equipment enclosures
- Repair Garages –requirements for modifying repair garages to work on FCEVs
- Joint NFPA 30A/2 Multi-fuel Station Task Group
- Chapter 10 Hydrogen Fueling Stations- increase ease of use for fueling station projects

Hydrogen Fueling Stations

- Initial hydrogen fueling station requirements developed with little data available
- Bulk of hydrogen fueling station specific requirements are found in Chapter 10 of NFPA 2
- Overall goal is move hydrogen fueling station requirements closer to those for commercially deployed technology
- The recommended code changes should reflect the fueling station deployment information



Accomplishments and Progress:

Responses to Previous Year Reviewers' Comments

- How specifically is NREL supporting code development by participating on technical committees?
- NREL's support for code development includes chairing committees, directing task group activities, monitoring activities to determine consistency with the complete matrix of codes and standards, such as their participation on the CGA Hydrogen Technical Committee, and providing technical information to code development projects to support code changes. Additionally, NREL plans on increasing the involvement of their engineering research staff (many of whom are not working in the SCS project) in code development activities to strengthen the CCSI process and more effectively leverage research in code development work.

Collaborations: Outreach and Training Project

- **NREL collaborators:**

- Pacific Northwest National Laboratory – joint in-person training and co-authored outreach materials
- Sandia National Laboratories and Los Alamos National Laboratory – co-authored paper on history of codes and standards
- California Fuel Cell Partnership – joint in-person training
- Orange County Fire Authority – collaborated on hydrogen “Fueling Station Permitting” video
- Massachusetts Hydrogen Coalition – collaborated on H2USA outreach
- Colorado Hydrogen Coalition – collaborated on plan to support hydrogen deployment in Colorado
- Several fire departments including the fire departments in the Los Angeles metropolitan area and the Denver Fire Department collaborated on training –
- H2USA Market Acceleration Working Group – collaborated on development of outreach materials
- Western Governors Association – presented on resources available to support hydrogen infrastructure deployment
- National Conference of State Legislators – presented on resources available to support hydrogen infrastructure deployment
- Fuel Cell and Hydrogen Energy Association (FCHEA) – collaborated on webinar on listing hydrogen fueling system components
- Codes and standards development organizations such as the International Code Council – collaborated on in-person training and webinar on listing hydrogen fueling system components
- Hydrogen fueling station developers – supported hydrogen fueling station developers (such as First Element) by answering questions on compliance issues
- Industrial gas companies including Air Products, Linde, Praxair, and Air Liquide
- Car companies including Toyota Motor Sales

Collaborations: CCSI Project

- **NREL collaborators:**

- Sandia National Laboratories
- Pacific Northwest National Laboratory
- Standards development organizations including the following:
 - International Code Council, National Fire Protection Association, CSA, CGA, SAE, ISO, ASME, ASTM, UL
- H2USA
- H2FIRST
- DOE Codes and Standards Tech Team
- DOE Hydrogen Safety Panel
- Hydrogen fueling project developers – First Element
- Industrial gas industry – NFPA Hydrogen Storage Task Group
- Regional Fire Departments- Santa Clara County Fire Department
- Other AHJs such as Michigan Department of Environmental Quality

Remaining Challenges and Barriers

CCSI

- Coordinating requirements in building and fire codes with hydrogen-specific codes and standards
- Implementing the analytical tools required to make technically substantiated code changes
- Obtaining data on component failure and leak frequency for liquid systems
- Validating test requirements in component listing standards
- Addressing regional infrastructure code issues

Training and Outreach

- Continuing to identify and reach out to key groups on both a regional and national basis
- Reducing large amounts of information into clear, intelligible training materials
- Identifying codes and standards and permitting issues that are creating difficulties for users
- Keeping outreach tools current as code and technology develops
- Conveying the current state of hydrogen infrastructure

Proposed Future Work

CCSI

- Develop engineering-based setback distances for liquid hydrogen
- Broadly integrate research activities in code development projects
- Codify mitigation measures to reduce setback distances for both liquid and gaseous hydrogen
- Address key coordination issues in building and fire codes
- Support component standard development and validation
- Make codes reflect the state of technology commercialization

Training and Outreach

- Continue to support H2USA outreach efforts with more geographic focus
- Continue to populate H2Tools Permitting web page with new tools
- Support the use of video “Permitting Hydrogen Fueling Stations”
- Continue focused in-person training in key geographic locations
- Develop short focused videos on key topics hydrogen infrastructure topics such maintenance at hydrogen fueling stations

Summary

CCSI

- The NFPA Task Group has a solid plan to revise liquid hydrogen setback distances and has submitted a proposal to the next edition of NFPA 55/2 to reduce bulk gaseous hydrogen setback distances
- A Hydrogen Code Improvement (HCI) team has been formed that has translated codes and standards issues into high quality code and standards proposals.
- A plan to integrate research into code development has been implemented

Training and Outreach

- Outreach tailored to extent of deployment and users needs
- The hydrogen permitting video will be an effective tool to further infrastructure deployment.
- Permitting and safety documents will complement the permitting video.
- In-person training will get information to key geographical audiences.
- H2USA outreach will get information to key groups across the United States, support code development, and address infrastructure hurdles