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# *Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources*

**NICK BARILO**

**Hydrogen Safety Panel and Resources Project**

Hydrogen Program Annual Merit Review and Peer Evaluation Meeting

Washington, DC

June 7, 2016

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

## Hydrogen Safety Panel and Resources

### Project Timeline

- Project Start Date: March 2003
- Project End Date: September 2016<sup>1</sup>

### Budget

- FY15 DOE Funding: \$968K
- Planned FY16 DOE Funding: \$775K
  - Hydrogen Safety Panel (HSP): \$525K
  - Safety Knowledge Tools: \$125K
  - First Responder (FR) Training: \$125K
- Total Project Funding: \$12,012K

## Barriers addressed<sup>2</sup>

- A. Safety data and information: limited access and availability
- C. Safety is not always treated as a continuous process
- D. Lack of hydrogen knowledge by authorities having jurisdiction (AHJ)
- E. Lack of hydrogen training materials and facilities for emergency responders
- G. Insufficient technical data to revise standards

## Partners

- Panel member organizations
- California Fuel Cell Partnership (CaFCP)
- National Renewable Energy Laboratory (NREL)
- National Fire Protection Association (NFPA)
- National Fire Academy (U.S. Fire Administration)
- California Air Resources Board
- California Energy Commission

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<sup>1</sup> Project continuation and direction determined annually by DOE

<sup>2</sup> Technical Plan – Hydrogen Safety, Codes and Standards, Section 3.7, Multi-Year Research, Development and Demonstration Plan, 2015, pp. 21-22 (updated June 2015)



## HYDROGEN

### Safety Panel

- ▶ Identify safety-related technical data gaps
- ▶ Review safety plans and project designs
- ▶ Perform safety evaluation site visits
- ▶ Provide technical oversight for other program areas



## HYDROGEN

### Tools

- ▶ Hydrogen Lessons Learned
- ▶ Hydrogen Best Practices
- ▶ Hydrogen Tools web portal (<http://h2tools.org>)



## HYDROGEN

### Emergency Response Training Resources

- ▶ Online awareness training
- ▶ Operations-level classroom/hands-on training
- ▶ National hydrogen and fuel cell emergency response training resource

## Hydrogen Safety Panel (HSP)

- ▶ Provide expertise and recommendations to DOE and assist with identifying safety-related technical data gaps, best practices and lessons learned.
- ▶ Help integrate safety planning into funded projects to ensure that all projects address and incorporate hydrogen and related safety practices.

## Safety Knowledge Tools and Dissemination

- ▶ Collect information and share lessons learned from hydrogen incidents and near-misses, with a goal of preventing similar safety events from occurring in the future.
- ▶ Capture vast and growing knowledge base of hydrogen experience and make it publicly available to the “hydrogen community.”

## First Responder Training

- ▶ Implement a national hydrogen emergency response training resource program with downloadable materials that are adaptable to the specific needs of first responders and training organizations
- ▶ Identify enhancements to first responder training content, techniques and delivery

# Approach

## *Priority attention to safety and enhanced visibility*



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### **Hydrogen Safety Panel**

- ▶ Conduct ongoing safety evaluations of projects through design reviews, safety plan reviews and site visits and assess learnings
- ▶ Utilize Panel expertise to develop and maintain safety guidance tools; address technical safety gaps and make recommendations to DOE on safety related topics

### **Safety Knowledge Tools and Dissemination**

- ▶ Identify and develop new tools and methods to support hydrogen and fuel cell commercialization, and disseminate hydrogen safety knowledge through the Hydrogen Tools Portal
- ▶ Bring greater visibility to hydrogen safety and the project's safety knowledge tools through presentations to relevant audiences not familiar with fuel cell technologies

### **First Responder Training**

- ▶ Engage organizations and develop opportunities to provide classroom training and bring visibility to the program's training resources

# PNNL Hydrogen Safety Program Timeline

- ▶ Hydrogen Safety Panel
- ▶ Safety Knowledge Tools
- ▶ First Responder Training

▶ **National FR Template Released**

▶ **First HSP Review of Non-DOE Project**

▶ **Certification Guide Release**

▶ **Transfer Online FR Training**

▶ **Hydrogen Safety Panel Established**

▶ **Classroom and Prop FR Training Available**

▶ **Online FR Course Released**

▶ **HSP ARRA Project Report**

**2016**

▶ **Hydrogen Tools Portal Available**

▶ **Best Practices Online Manual Released**

▶ **Incident Database Released**

▶ **Hydrogen Tools App Available**



**2003**

2003

2005

2007

2009

2011

2013

2015



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# Accomplishments: Hydrogen Safety Panel

# Vision: Hydrogen Safety Panel

*Safety practices, incorporating a wealth of historical experience with new knowledge and insights gained, are in place. Continuous and priority attention is being given to safety in all aspects of hydrogen and fuel cell technologies: research, development and demonstration; design and manufacturing; deployment and operations.*

Name	Affiliation
Nick Barilo, Manager	Pacific Northwest National Laboratory
Richard Kallman, Chair	City of Santa Fe Springs, CA
David Farese	Air Products and Chemicals
Larry Fluer	Fluer, Inc.
Bill Fort	Consultant
Donald Frikken	Becht Engineering
*Livio Gambone	CSA Group
Aaron Harris	Air Liquide
Chris LaFleur	Sandia National Laboratories
Miguel Maes	NASA-JSC White Sands Test Facility
Steve Mathison	Honda Motor Company
Larry Moulthrop	Proton OnSite
Glenn Scheffler	GWS Solutions of Tolland
Steven Weiner	Excelsior Design, Inc.
*Tom Witte	Witte Engineered Gases
Robert Zalosh	Firexplo

\*Indicates a new member







# Identifying gaps... *the lack of listed equipment*

- In the early market, the availability of systems or equipment that are listed, labeled or certified is limited
- Significant cost can be involved since the technology and products are still rapidly changing and each new iteration can require recertification
- When equipment is not listed or available, “approval” by the code official is required before installation occurs



*The scarcity of listed hydrogen equipment places an extraordinary burden on code officials to ensure (approve) that the products employed include the appropriate inherent or automatic safety measures.*

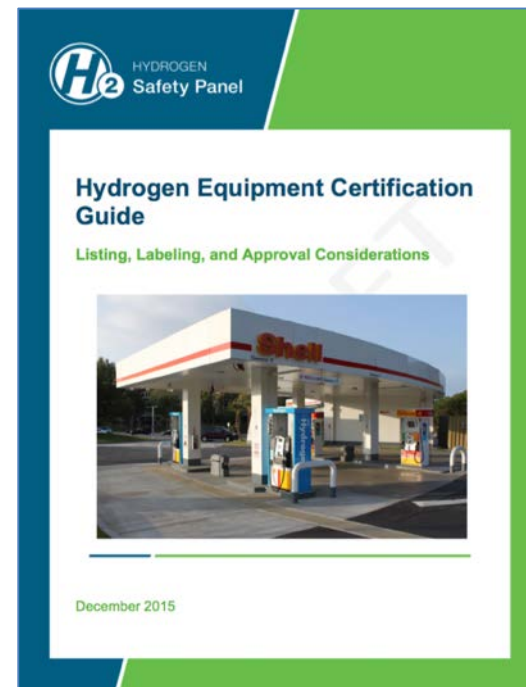


# Accomplishments

## *Finding solutions... development of a certification guide*

A *Guide* has been developed to assist code officials, designers, owners, evaluators and others with the application of the listing and approval requirements pertinent to the design and/or installation of hydrogen equipment as regulated by the model codes.

- ▶ Chapter 1. Introduction – Purpose, Scope and Background
- ▶ Chapter 2. Overview of the Certification Process
- ▶ Chapter 3. Selected Definitions
- ▶ Chapter 4. Guidance and Explanation
- ▶ Appendix A. References
- ▶ Appendix B. The Use of Equivalency, Alternative Materials, Methods and Modifications
- ▶ Appendix C. Typical Permit Process
- ▶ Appendix D. Bibliography



The draft Guide is available at [https://h2tools.org/sites/default/files/Hydrogen\\_Equipment\\_Certification\\_Guide\\_20151210.zip](https://h2tools.org/sites/default/files/Hydrogen_Equipment_Certification_Guide_20151210.zip)

# Accomplishments

## *Benefits from the use of the guide*



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- ▶ Enables designers, users and code officials to better apply the requirements where the use of *listed, labeled, certified or approved* equipment or methods is required and to increase awareness and understanding of what the equipment is expected to do
- ▶ Increased consistency in the application of requirements with the expectation of an expedited permitting process
- ▶ Consistent application of requirements among providers, regardless of hydrogen experience results in a level playing field as the technology emerges



# Accomplishments

## Webinar to introduce the guide...

- ▶ Webinar held on December 10, 2015 introduced the draft Guide and solicited a stakeholder review
- ▶ 130 persons attended the webinar
  - Code officials
  - Standard development organizations
  - Certification/listing agencies
  - Federal agencies
  - State agencies
  - OEMs
  - Universities
- ▶ Questions and comments provided have been addressed
- ▶ The “final” version of the Guide will be made available on the Hydrogen Tools Portal before September 2016

[ENERGY.GOV](http://ENERGY.GOV)  
Office of Energy Efficiency & Renewable Energy

**Fuel Cell Technologies Office**

### Webinar December 10: Hydrogen Equipment Certification Guide

The Fuel Cell Technologies Office will present a live webinar titled "Hydrogen Equipment Certification Guide" on Thursday, December 10, from 1 to 2 p.m. Eastern Standard Time (EST.) The webinar will introduce the Hydrogen Equipment Certification Guide, a document intended to aid in equipment approval until listed equipment are available for the entirety of equipment and components. Additionally, the webinar will begin a public comment phase of the document for soliciting stakeholder feedback in preparation for a September 2016 release. The Guide is intended to be used by (1) authorities having jurisdiction (AHJs) to support their determination of approval where approved equipment is either required or allowed by the codes, and in instances where the code may otherwise require the use of listed or labeled equipment, and (2) by designers, manufacturers, fabricators, installers, operators, distributors, or others for facilities designated for hydrogen fuel storage, distribution, dispensing, and use where compliance with the requirements of the model codes is paramount. Use of the Guide can assist these users in meeting the necessary requirements to ensure the safe use of hydrogen fuel and to obtain the necessary AHJ approvals of facilities, systems, equipment, and services that require approval in the permitting process.

[Register for the webinar.](#)

Update your subscriptions, modify your password or email address, or stop subscriptions at any time on your [subscriber preferences page](#). You will need your email address to log in. If you have questions or problems with the subscription service, contact [support@govdelivery.com](mailto:support@govdelivery.com).

This service is provided to you by the U.S. Department of Energy's [Office of Energy Efficiency and Renewable Energy](#) (EERE).

# Accomplishments

## *Supporting the H-Prize review*

- ▶ HSP assisted in development of the safety criteria and information provided on the competition's website
- ▶ Modified the existing safety guidance document for DOE projects to be tailored for this activity
- ▶ Led a safety planning webinar for competition participants in August 2015
- ▶ Reviewed six H-Prize submittals and safety plans
  - Comments were provided to the judges for consideration
  - Comments were also provided to all applicants (including those that were not chosen by the judges) to provide safety considerations for their future development activities

### The 2014-2016 H-Prize Competition



*The H2 Refuel H-Prize challenges America's innovators to deploy an on-site hydrogen generation system, using electricity or natural gas, to fuel hydrogen vehicles, that can be used in homes, community centers, small businesses, or similar locations. (See <http://www.hydrogenprize.org/> for more information)*



# Accomplishments

## *State support and making the HSP more accessible*

- ▶ FY2016 - HSP is contracted by the California Energy Commission (CEC) to support the construction of new hydrogen fueling stations through the following services:
  - Pre-award safety consultation for applicants
  - Review of hydrogen safety plans with feedback to the CEC
  - Incident fact finding
  - Annual reviews of station deployments
  - Identifying learnings from the review of safety plans and incident
  - Sharing safety plans on the Hydrogen Tools Portal
  
- ▶ FY2016 - Hold three to six meetings in California with hydrogen fueling station builders, the California Energy Commission, code officials, and station owners to discuss safety issues and lessons learned from station construction, system validation, and system operation. Pertinent learnings from the meetings may be added to the Best Practices and Lessons Learned online resources.
  
- ▶ September 2015 HSP performed a review for the California Air Resources Board



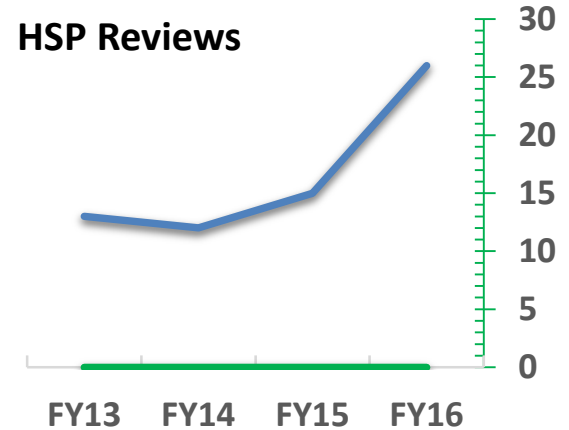
# Accomplishments

## Hydrogen Safety Panel scorecard



Activity	Since the 2015 AMR	Total for the Project Duration
Project Reviews (including safety plans, site visits reviewed, follow-up interviews and design review activities)	26 (includes 6 H-Prize reviews)	438
Panel Meetings	1 (Torrance, CA)	22
White Papers & Recommendations (e.g., Safety of Hydrogen Systems Installed in Outdoor Enclosures)	0	7
Accident Investigations	0	3
Publications, Presentations and Webinars (all tasks combined total)	11	57

### HSP Reviews



### Active HSP Task Groups

- Compatibility of materials
- Certification Guide development
- New application safety/code gaps
- Compressed natural gas incidents
- Disseminating learnings from project reviews
- Safety guidance document update

# Accomplishments

## Responses to 2015 reviewer comments



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- ▶ “Consider working with other federal Departments (particularly DOT) and state agencies (particularly in California) that are funding hydrogen infrastructure/fuel cell vehicle deployment projects to also include language in solicitations that ‘encourages coordination with the HSP for development of Safety Plans’ similar to the DOE FOA’s. This has been very effective for early project involvement for DOE projects.”
- ▶ “Safety is paramount - its the first question we get asked in California when we go into local communities. If anything, we need to figure out how to expand the Safety Panel's reach. The reviews from the Panel have already shown benefit to the state - its a crucial, trusted 3rd party resource.”
  - *We agree with the review comments and have been pursuing opportunities to make the HSP available for supporting non-DOE activities. In September 2015 the HSP performed a safety review of a mobile fuel cell power unit for the California Air Resources Board. Additionally, PNNL is currently working with California to utilize the HSP for reviews of new hydrogen fueling stations through a direct multiyear contract. This important activity will make the HSP available for:*
    - *Pre-award safety consultation for applicants*
    - *Review of hydrogen safety plans with feedback to the CEC*
    - *Incident fact finding*
    - *Annual reviews of station deployments*
    - *Identifying learnings from the review of safety plans and incidents*

*The learnings gathered from these activities can benefit DOE’s Safety, Codes and Standards activities as well as the industry’s future station deployments.*





# **Accomplishments: Safety Knowledge Tools and Dissemination**

# Accomplishments - Hydrogen Tools Portal

## A Transformative Step Towards Hydrogen Adoption

### CENTRALIZED LOCATION

organizes current H<sub>2</sub> resources in one robust location—including **more than 20** existing tools, with plans for adding future content

### FOCUSED CONTENT

tailored to the specialized needs of H<sub>2</sub> user groups

### CUSTOMIZABLE INTERFACE

allows content to display based on the H<sub>2</sub> user's role or interests

### RESPONSIVE DESIGN

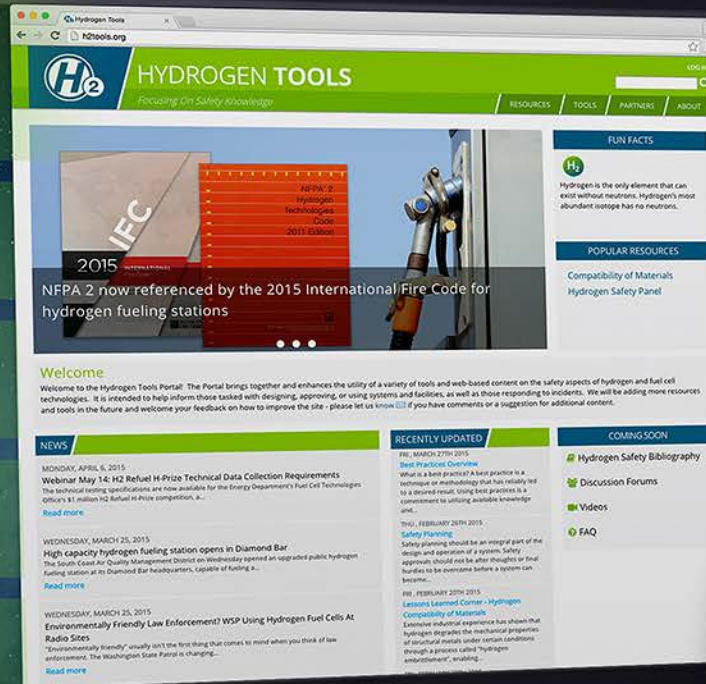
enables H<sub>2</sub> safety work across both desktop and mobile devices

### TRUSTED COMMUNITIES

fostered through social networking around H<sub>2</sub> subject matter expertise

### EXPANDABLE FORMAT

built with frequently requested future feature sets in mind



Online  
June 2015

+ Mobile Friendly



<http://h2tools.org>

➤ **Credible and reliable** safety information from a **trustworthy** source

# Accomplishments

*New methods for publicizing the tools*



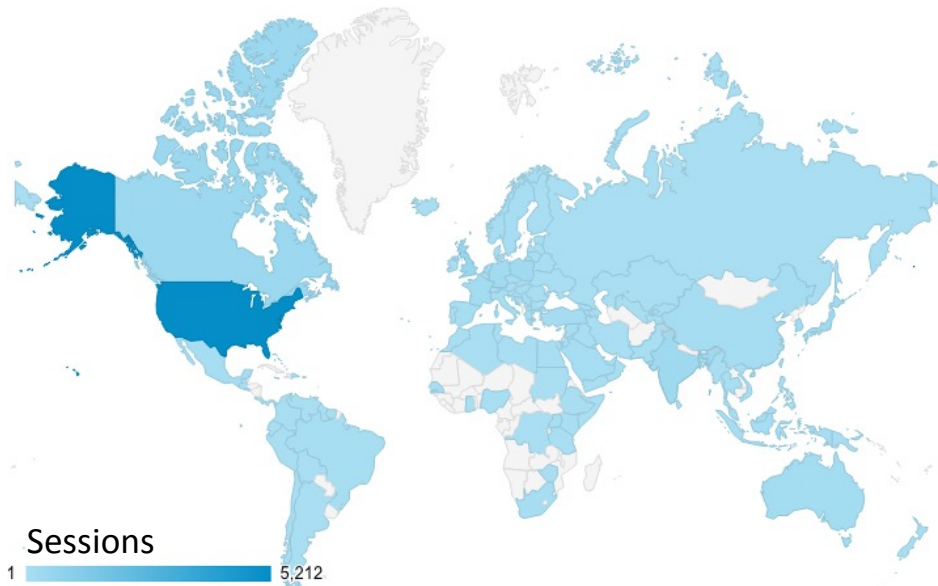
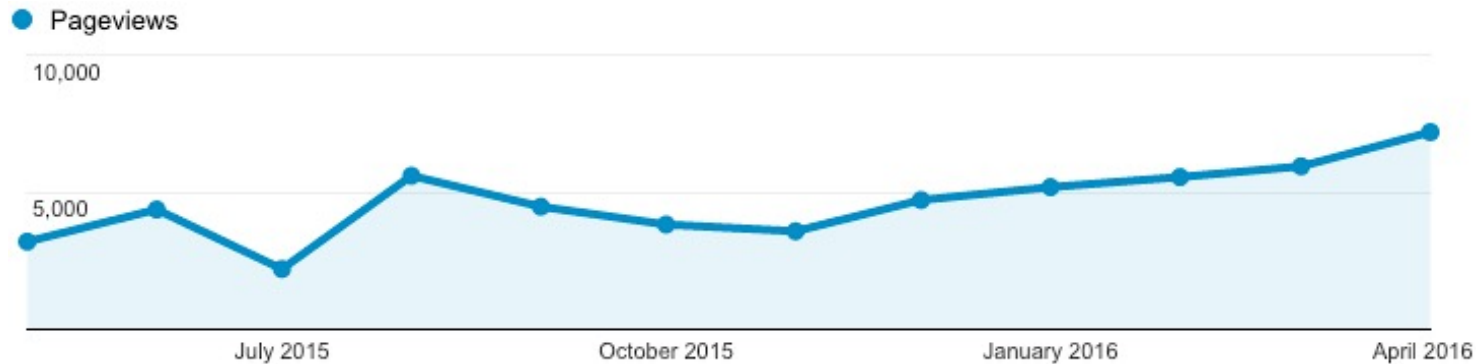
In 2014, the U.S. consumed

**19 Million** barrels of oil

each **day**

# Accomplishments

## Measuring success of the H2Tools Portal



**H2Tools.org - A Global Resource!**

### Resources w/Most Views

1. Best Practices
2. Lessons Learned
3. Training Materials

### Newest Info/Resources

- NREL Codes & Standards
- HyStEP
- H2FIRST
- Vehicle Emergency Response Guides
- *Coming soon...*  
*ICHS Papers*



# Accomplishments

*Disseminating safety knowledge to reach critical audiences*

## International Code Council (ICC) Outreach

- ▶ ICC annual business meeting in September 2015 (PNNL/CaFCP collaboration)
  - Classroom content (PNNL/CaFCP copresenters)
  - Site tour to a fueling station, repair garage and stationary application
  - Expo booth and a ride/drive event
  - Coordinated with H2USA Market Support and Acceleration Working Group
- ▶ Educational session for the ICC Colorado Chapter Educational Institute (March 2016)



## Stakeholder and Code Official Outreach

- ▶ U.S. Fire Administration, National Professional Development Symposium webinar (June 2015)
- ▶ Sacramento Fire Prevention Officers, West Sacramento, CA (August 2015)
- ▶ International Association of Fire Chiefs webinar (September 2015)
- ▶ NY-Boston outreach events with NREL, Toyota and Air Liquide (April 2016)

# Accomplishments

## Responses to 2015 reviewer comments

- ▶ “I am concerned that attempting to bring into the portal the databases of others could rapidly become unyielding from a maintenance perspective. Serious thought should be given to understand how the data bases can be referenced rather than actually porting that into this portal. This would put the burden of maintenance on the “owner” of the data base.”
  - *As configured, the Hydrogen Tools Portal aggregates all information and resources into a central location. The concept of linking to information, as opposed to including those resources directly in the Hydrogen Tools Portal, was given much consideration. From its inception, a primary goal of the Portal has been to integrate resources to facilitate accessibility and display from a single, trustworthy source, thereby increasing their visibility and value. Linked resources require a user to leave the Portal and access information from a third-party site. These sites are sometimes difficult to navigate and lack a consistent look and feel, while others are outdated or use outdated technology. In addition to resolving those issues, aggregating the resources into a single site allows the information to be searched and viewed together in a complimentary manner. Another benefit for consolidating the information is that it aggregates users and increases the value of each application by reducing effort (one-stop-shopping) and increasing the population of potential users the same way a mall does for its stores’ customers. A customer on the way to store C must first pass stores A and B. Customers may not even know store B exists until they walk past on the way to store C (their intended purpose).*
  - *To reduce the maintenance requirements for third-party resources, data/information owners maintain ownership of their resource along with access to update content. To facilitate this approach, the site design utilizes a straightforward content management system and simple interfaces. Guides are also provided for resource owners to help them understand how to make changes. PNNL is committed to maximize the benefits of this impactful tool while minimizing maintenance burdens.*



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# Accomplishments: First Responder Training

# Accomplishments

## *First responder training*



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- ▶ September 2015 - First responder training prop loaned to the CaFCP to support demonstration and training activities
- ▶ December 2015 – National Hydrogen and Fuel Cell Emergency Response Training Resource updated
- ▶ May 2016 – Four U.S. first responders participated in HyResponse training in France
- ▶ September 2016 – Online training will be transferred to the a third-party
- ▶ Fall 2016 – FR training will be conducted in the Northeast



Training prop “on loan” at the CaFCP



# Collaboration with EU HyResponse Project

## May 2016

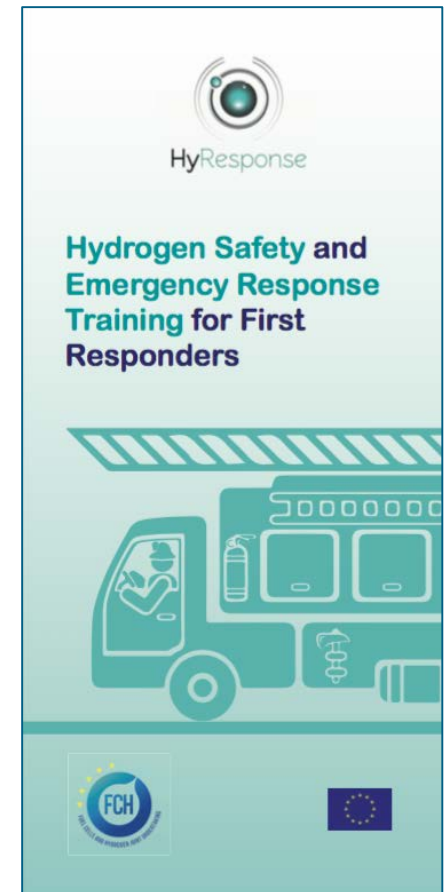
DOE/PNNL sponsored four U.S. fire fighters to attend training at the French Academy for Fire, Rescue and Civil Protection Officers (ENSOSP), Aix-en-Provence, France. Training and accommodations were provided by HyResponse. Participation in this training afforded a number of positive benefits:

- ▶ Equipped first responders with the needed experience and knowledge to train others in their region and support additional U.S. based training outreaches
- ▶ Gained valuable first responder feedback on the training strategies implemented by the HyResponse project in order to consider improvements to PNNL/DOE first responder training activities
- ▶ Discussed opportunities for future collaborations with HyResponse organizations (including participating in the March 2017 Northeast U.S. training event)



### First responder attendees from:

- New York City Fire Department
- Littleton (MA) Fire Department
- Los Angeles County Fire Department
- San Jose Fire Department



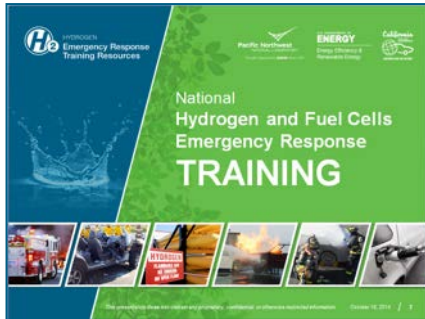
# Accomplishments

## First responder training...by the numbers



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### Online Training

>32,000 visits since 2007

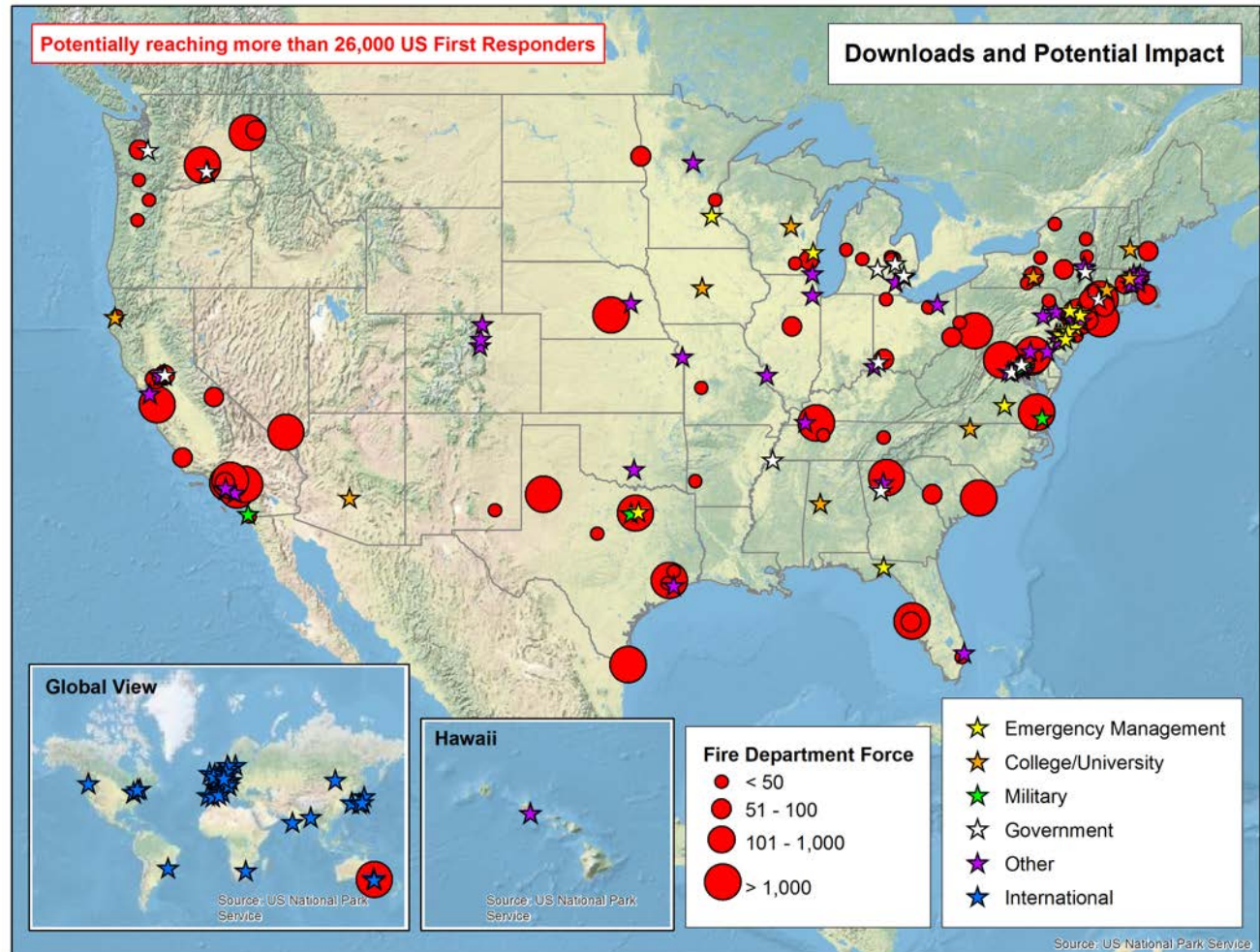
### Classroom Training

>1,100 attendees since 2009

### National Template

>300 downloads since 10/2014

Updated in December 2015



# Future Work

## Expanding the reach of training

- ▶ Transfer of online awareness training to a third-party (e.g. IAFF, NFA, etc.) and subsequent dissemination provides significant benefits.
  - Allows a broader distribution of the materials,
  - Provides better crediting of course completion/CEUs, and
  - Provides a good long-term landing spot for the training
- ▶ PNNL/CaFCP will continue to provide subject matter expertise on the technical content.



**Introduction to Hydrogen Safety for First Responders**

U.S. Department of Energy  
**Hydrogen Program**  
www.hydrogen.energy.gov/firstresponders

COURSE MATERIALS LIBRARY EXIT ▶

Hydrogen Basics  Transport & Storage  Hydrogen Vehicles  Hydrogen Dispensing  Stationary Facilities  Codes & Standards  Emergency Response  Summary & Quiz

### Hydrogen Safety Course Contents

The Course Materials cover the following topics:

- Hydrogen Basics
- Hydrogen Vehicles
- Stationary Facilities
- Emergency Response
- Transport & Storage
- Hydrogen Dispensing
- Codes & Standards

You can view the topic modules in sequence or select them in random order using the top navigation bar.

A short quiz follows at the end of the course.

You can mute the narration by clicking on the mute button in the navigation bar.

[Begin the Course ▶](#)

Slide 1 of 1

**Expected completion date: September 2016**

# Accomplishments

## Responses to 2015 reviewer comments



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- ▶ “The first responder training has matured but continues to provide enormous value to the community as we roll out the hydrogen fueling infrastructure. It is time this activity move to the more mainstream like the National Fire [Academy]– a movement recognized by the PI and in the future plans.”
  - *The initiative to transfer training to a third-party is underway. The goal is to allow a third-party to host and promote the training and PNNL to provide support on the subject matter. Current activities include content updating and reformatting, development of new and conversion of online animations and videos to current standards. It is expected that these activities will be completed before the end of FY2016. When completed the course will have broader visibility and accreditation.*

# Proposed Future Work

## *Remainder of FY 2016*

### **Hydrogen Safety Panel**

- Continue early project engagements and safety plan reviews for DOE funded projects
- Participate in reviews of fueling stations in support the California Energy Commission
- Incorporate comments from stakeholders and complete the initial release of the certification guide
- Participate in review meetings and visit 3-6 completed fueling stations in California to identify learnings

### **Safety Knowledge: Tools and Dissemination**

- Add 600+ papers from the International Conference on Hydrogen Safety to the Hydrogen Tools Portal
- Lead the development of the Safety, Codes and Standards outreach plan to establish a multiyear strategy for reaching code officials, relevant stakeholders and first responders through 2020

### **First Responder Training**

- Complete the transition of online training to a third-party to facilitate broader dissemination and accreditation of the training
- Conduct classroom-only first responder training at multiple locations in the Northeast to support early deployment efforts of hydrogen infrastructure and vehicles
- Begin planning for a significant operations-level training in the Northeast in March 2017 which will include classroom training, prop demonstrations and virtual reality training

### Hydrogen Safety Panel

- Continue to utilize Panel resources to address safety knowledge gaps through white papers, recommendations to DOE, manuscripts, presentations and subject matter expertise for the Hydrogen Tools Portal
- Explore and engage opportunities to directly support states/regional rollout of fuel cell vehicles, stationary applications and supporting infrastructure
- Support the CEC in review of fueling stations and station-related incidents

### Safety Knowledge Tools and Dissemination

- Expand the value and impact of the Hydrogen Tools portal by incorporating new tools and resources from other national laboratories and private organizations
- Develop a codes and standards guide – a drill down, question based tool to provide an outline or checklist of code requirements for a specific application
- Outreach to a variety of stakeholders and organizations in accordance with a formal outreach plan

### First Responder Training

- Bring classroom, props and virtual reality training (in collaboration with CRISE/HyResponse) to the Northeast in April 2017

# Collaborations

## *Hydrogen Safety Panel and Safety Knowledge Tools*

### **Hydrogen Safety Panel**

- ▶ Organizations supporting Hydrogen Safety Panel members

### **Safety Knowledge Tools**

- ▶ NREL to include their H2FIRST and HyStEP information on the Hydrogen Tools Portal
- ▶ NREL, Toyota and Air Liquide – Northeast outreach activities
- ▶ ICC and CaFCP – outreach activities to the ICC
- ▶ U.S. Fire Administration in promoting safety knowledge tools and collaborating on specific outreach events

### **First Responder Training**

- ▶ California Fuel Cell Partnership in updating and publicizing the national template and other first responder training activities
- ▶ Fuel Cells and Hydrogen (FCH) Joint Undertaking (JU) funded HyResponse Project

## Hydrogen Safety Panel

- ▶ The Panel's involvement in a wide variety of early market demonstration projects puts it in a unique position to analyze issues and share what it has learned.
- ▶ The Panel can be an asset for supporting the safe commercial rollout of fuel cell vehicles, stationary applications and infrastructure. Learnings from the Panel's specific project involvement and interaction with code officials, stakeholders and project proponents can benefit the industry and the FCT program more broadly.

## Safety Knowledge Tools

- ▶ The entire hydrogen community benefits if hydrogen safety-related knowledge is openly and broadly shared. The Hydrogen Tools Portal represents a significant opportunity to broadly disseminate safety information and knowledge. Integrating information from DOE and other national laboratories is an opportunity to expand its value and impact, and warrants increased investment.
- ▶ A strong commitment to reaching new stakeholders and users is essential for enabling a safe transition to commercialization of hydrogen and fuel cell technologies.

## First Responder Training

- ▶ The National Training Resource has been well received and provides the best opportunity to support first responder training for hydrogen and broader alternative fuels focused activities. Emphasis will be needed to keep the material and training materials relevant and impactful.



# Thank you

- ▶ U.S. Department of Energy
  - Fuel Cell Technologies Office (Sunita Satyapal, Director; Will James, Safety, Codes and Standards Manager; and Laura Hill, SCS ORISE Fellow)
- ▶ California Fuel Cell Partnership
  - Jennifer Hamilton and Bill Elrick
- ▶ All of my colleagues at Pacific Northwest National Laboratory, the Hydrogen Safety Panel and other collaborators
- ▶ **AMR Reviewers** – your comments and perspectives are important to help us identify areas for improvement and be more impactful



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# Technical Back-up Slides for the FY2015 Merit Review and Peer Evaluation

# Project Review Reports, White Papers and Other Documents Since the 2015 AMR

1. Safety Plan Review – Smart Matrix Development for Direct Carbonate Fuel Cell (revision)I, May 15, 2015.
2. Document Review – Austin Fuel Cell Bus, Hydrogen Purge Failure Analysis Report 1 of 2, May 28, 2015.
3. Design Review – Hydrogen Refueling Trailer (Hawaii Maritime Project), June 1, 2015.
4. Barilo, N.F., “Safety Planning for the 2014-2016 H-Prize Competition,” August 2015, URL – <https://h2tools.org/sites/default/files/Safety-Planning-for-the-2014-2016-H-Prize-Competition.pdf>.
5. Document Review – Fire Protection Engineering Design Brief Template: Hydrogen Refueling Station, September 22, 2015.
6. Design Review – Luxfer-GTM ZeroSet Generator, November 5, 2015.
7. Safety Plan Review – Advanced Catalysts and Membrane Electrode Assemblies (MEAs) for Reversible Alkaline Membrane Fuel Cells (two reviews), November 22, 2016.
8. Barilo, N.F., “Hydrogen Equipment Certification Guide, Listing, Labeling and Approval Considerations,” (Draft), December 2015, URL – [https://h2tools.org/sites/default/files/Hydrogen\\_Equipment\\_Certification\\_Guide\\_20151210.zip](https://h2tools.org/sites/default/files/Hydrogen_Equipment_Certification_Guide_20151210.zip).
9. Safety Plan/Design Review – H-Prize, WSU, December 17, 2016.
10. Safety Plan/Design Review – H-Prize, Simple.Fuel, December 17, 2016.
11. Safety Plan/Design Review – H-Prize, Reactwell, December 17, 2016.
12. Safety Plan/Design Review – H-Prize, Katsu, December 17, 2016.
13. Safety Plan/Design Review – H-Prize, Ion, December 17, 2016.
14. Safety Plan Review – Design and Synthesis of Materials with High Capacities for Hydrogen Physisorption (two reviews), January 4, 2016.
15. Safety Plan Review – Hydrogen Adsorbents with High Volumetric Density: New Materials and System Projections, January 4, 2016.
16. Safety Plan Review/Design Review – H-Prize, Millennium (two reviews), January 11, 2016.
17. Safety Plan Review – High Performance Platinum Group Metal Free Membrane Electrode Assemblies Through Control of Interfacial Processes, January 15, 2016.

# Project Review Reports, White Papers and Other Documents Since the 2015 AMR (cont'd)

18. Safety Plan Review – Tandem Particle-slurry Batch Reactors for Solar Water Splitting (two reviews), January 26, 2016.
19. Barilo, N.F., “Safety Planning for Hydrogen and Fuel Cell Projects,” January 2016, URL – [https://h2tools.org/sites/default/files/Safety\\_Planning\\_for\\_Hydrogen\\_and\\_Fuel\\_Cell\\_Projects\\_-\\_January\\_2016.pdf](https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects_-_January_2016.pdf).
20. Safety Plan Review – Conformable Hydrogen Storage Coil Reservoir, February 12, 2016.
21. Procedure Review – HyStEP (two reviews), February 24, 2016.
22. Safety Plan Review – Wide Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting (revised safety plan), March 23, 2016.

# Publications and Presentations

(since 2012)

1. Kallman, R.A., Barilo, N.F. and Murphy, W.F., “Permitting of a Project Involving Hydrogen – A Code Official’s Perspective,” PNNL-SA-87780, World Hydrogen Energy Conference, Toronto, Ontario, Canada, June 3-7, 2012.
2. Weiner, S.C., Fassbender, L.L., Blake, C., Aceves, S., Somerday, B.P. and Ruiz, A., “Web-Based Resources Enhance Hydrogen Safety Knowledge,” PNNL-SA-82812, International Journal of Hydrogen Energy (manuscript HE10236, <http://dx.doi.org/10.1016/j.ijhydene.2012.07.028>, published online August 2, 2012).
3. Weiner, S.C., “Safety Knowledge Tools Overview and Examples,” PNNL-SA-90919, IEA Hydrogen Implementing Agreement Hydrogen Safety Stakeholders Workshop, Bethesda, MD, October 2-3, 2012.
4. Weiner, S.C., “Advancing the Hydrogen Safety Knowledge Base,” PNNL-SA-91531, International Conference on Hydrogen Safety, Brussels, Belgium, September 9-11, 2013 (abstract submitted October 23, 2012).
5. Weiner, S.C. and Fassbender L.L., “Lessons Learned from Safety Events,” PNNL-SA-86551, International Journal of Hydrogen Energy, Volume 37, Issue 22, November 2012, pp. 17358-17363 (published online <http://dx.doi.org/10.1016/j.ijhydene.2012.03.152>).
6. Kallman, R.A., Barilo, N.F. and Murphy, W.F., “Permitting of a Project Involving Hydrogen – A Code Official’s Perspective,” PNNL-SA-87780, Energy Procedia, Volume 29, November 2012, pp. 265-275 (published online <http://dx.doi.org/10.1016/j.egypro.2012.09.032>).
7. Barilo, N.F., Weiner, S.C. and James, C., “Deployment of Hydrogen Fuel Cells – Safety Considerations and Resources,” PNNL-SA-92552, 2013 NFPA Conference & Expo, June 11, 2013.
8. Barilo, N.F. and Weiner, S.C., “Deploying Fuel Cell Systems: What Have We Learned?” PNNL-SA-94975, International Conference on Hydrogen Safety, Brussels, Belgium, September 9-11, 2013.
9. Weiner, S.C., “Advancing the Hydrogen Safety Knowledge Base,” PNNL-SA-91531, International Conference on Hydrogen Safety, Brussels, Belgium, September 9-11, 2013 (selected for IJHE publication, December 22, 2013).
10. Weiner, S.C., “What Can We Learn from Hydrogen Safety Event Databases? – H2Incidents.org,” Webinar presented at the International Conference on Hydrogen Safety, Brussels, Belgium, September 10, 2013.
11. Barilo, N.F., “The H Factor,” NFPA Journal, May/June 2014, pp. 76-77. ([http://www.nxtbook.com/nxtbooks/nfpa/journal\\_20140506/index.php#/80](http://www.nxtbook.com/nxtbooks/nfpa/journal_20140506/index.php#/80))
12. Barilo, N.F., “Design to Operations: Integrating Safety into Hydrogen and Fuel Cell Projects,” PNNL-SA-102337, 2014 NFPA Conference & Expo, Las Vegas, NV, June 14, 2014. (<http://www.nfpa.org/~media/2B0101A61A9346C595C7BB77A3A74A06.pdf>)

# Publications and Presentations (continued)

13. Weiner, S.C., “First Responder Training – Resources and Future Direction, “ PNNL-SA-104297, International Workshop on Hydrogen Safety for First Responders, French Academy for Fire, Rescue and Civil Protection Officers (ENSOSP), Aix-en-Provence, France, September 3-4, 2014. ([http://hyresponse.eu/files/1st%20Workshop%20presentations/13%20PNNL\\_SWeiner.pdf](http://hyresponse.eu/files/1st%20Workshop%20presentations/13%20PNNL_SWeiner.pdf))
14. Weiner, S.C., “Advancing the Hydrogen Safety Knowledge Base,” International Journal of Hydrogen Energy, Vol. 39, Issue 35, December 2014, pp. 20357-20361.
15. Barilo, N.F., “Hydrogen and Fuel Cells Are Coming...Are You Ready?,” International Code Council Building Safety Journal Online, February 2015.
16. Barilo, N.F. and Rivkin, C. H., “Hydrogen and Fuel Cells...Focusing on Facility Safety Requirements,” submitted for inclusion in the April 2015 International Code Council Building Safety Journal Online.
17. Barilo, N.F. and Weiner, S.C., “Hydrogen and Fuel Cells – Emphasizing Safety to Enable Commercialization,” PNNL-SA-108993, International Conference on Hydrogen Safety, Yokohama, Japan, October 19-21, 2015. (manuscript submitted March 2015)
18. Barilo, N.F., Hamilton, J.J. and Weiner, S.C., “First Responder Training: Supporting Commercialization of Hydrogen and Fuel Cell Technologies,” PNNL-SA-109109, International Conference on Hydrogen Safety, Yokohama, Japan, October 19-21, 2015. (manuscript submitted March 2015)
19. Barilo, Nick, “First Responder Training Resources Essential for Transforming Energy Use,” H2FC Newsletter ([http://h2fc.eu/files/downloads/e-newsletter/H2FC\\_e-journal\\_2-2015\\_interaktiv.pdf](http://h2fc.eu/files/downloads/e-newsletter/H2FC_e-journal_2-2015_interaktiv.pdf)), Issue 2, March 2015.
- 20. Barilo, N.F., “Hydrogen Safety Resources,” Washington State Annual Hazardous Materials Workshop, Richland, WA, April 18-19, 2015.**
- 21. Barilo, N.F., “Hydrogen Safety Resources,” Northwest’s International Association of Fire Fighters Fire Ops 101, Richland, WA, May 14, 2015.**
- 22. Barilo, N.F., “Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources,” Hydrogen Program Annual Merit Review and Peer Evaluation Meeting, Arlington, VA, June 9, 2015.**
- 23. Barilo, N.F., “An Introduction to Hydrogen and Fuel Cell Technologies,” National Professional Development Symposium, Emmitsburg, MD, June 12, 2015.**

Note: Bold font identifies publications and presentations subsequent to the 2015 Annual Merit Review and Peer Evaluation Meeting

# Publications and Presentations (continued)

24. Barilo, N.F., "Overview of the US Program and Safety Resources," European Technical School on Hydrogen and Fuel Cells, Crete, Greece, June 22, 2015.
25. Barilo NF, and D Frikken, "Safety Planning for the H-Prize Competition," "Safety First" Webinar for \$1M H2 Refuel H-Prize, August 6, 2015. PNNL-SA-111763.
26. Barilo NF, "Hydrogen and Fuel Cells are Coming...Are You Ready," United States Fire Administration and International Association of Fire Chiefs, online webinar on September 15, 2015. PNNL-SA-112620.
27. Barilo NF, "Safety Considerations for Hydrogen and Fuel Cell Applications," ICC Annual Business Meeting, Long Beach, CA, on September 29, 2015. PNNL-SA-110843.
28. Barilo NF, JJ Hamilton, and SC Weiner, "First Responder Training: Supporting Commercialization of Hydrogen and Fuel Cell Technologies." 2015 International Conference on Hydrogen Safety, Yokohama, Japan, on October 19, 2015. PNNL-SA-113046.
29. Barilo NF, and SC Weiner, "Overview of the DOE Hydrogen Safety, Codes and Standards Program Part 2: Hydrogen and Fuel Cells - Emphasizing Safety to Enable Commercialization," 2015 International Conference on Hydrogen Safety, Yokohama, Japan, on October 20, 2015. PNNL-SA-113249.
30. Barilo NF, "Hydrogen Equipment Certification Guide Listing, Labeling and Approval Considerations," Pacific Northwest National Laboratory, Richland, WA. PNNL-25053, December 10, 2015 (draft document).

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