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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 8, 2017

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

SCS019

PNNL-SA-125384

Overview

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HYDROGEN SAFETY PANEL AND RESOURCES

Project Timeline

- Project Start Date: March 2003
- Project End Date: September 2017[1]

Barriers Addressed[2]

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

Budget

- FY16 DOE Funding: $895K
- Planned FY17 DOE Funding: $775K
  - Hydrogen Safety Panel (HSP): $525K
  - Safety Knowledge Tools: $125K
  - First Responder (FR) Training: $125K

Partners

- Panel member organizations
- California Fuel Cell Partnership (CaFCP)
- National Renewable Energy Laboratory (NREL)
- Sandia National Laboratories (SNL)
- California Energy Commission

[1] Project continuation and direction determined annually by DOE

[2] 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 Resources

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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

Objectives

Primary Objective: Enable the safe and timely transition to hydrogen and fuel cell technologies through unique and highly impactful safety resources

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; assess learnings from evaluations
- Utilize Panel expertise to develop and maintain safety guidance tools, address technical safety gaps and make recommendations 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 outreach opportunities to share online and classroom training for first responders and bring visibility to the program's safety resources

PNNL Hydrogen Safety Program Timeline

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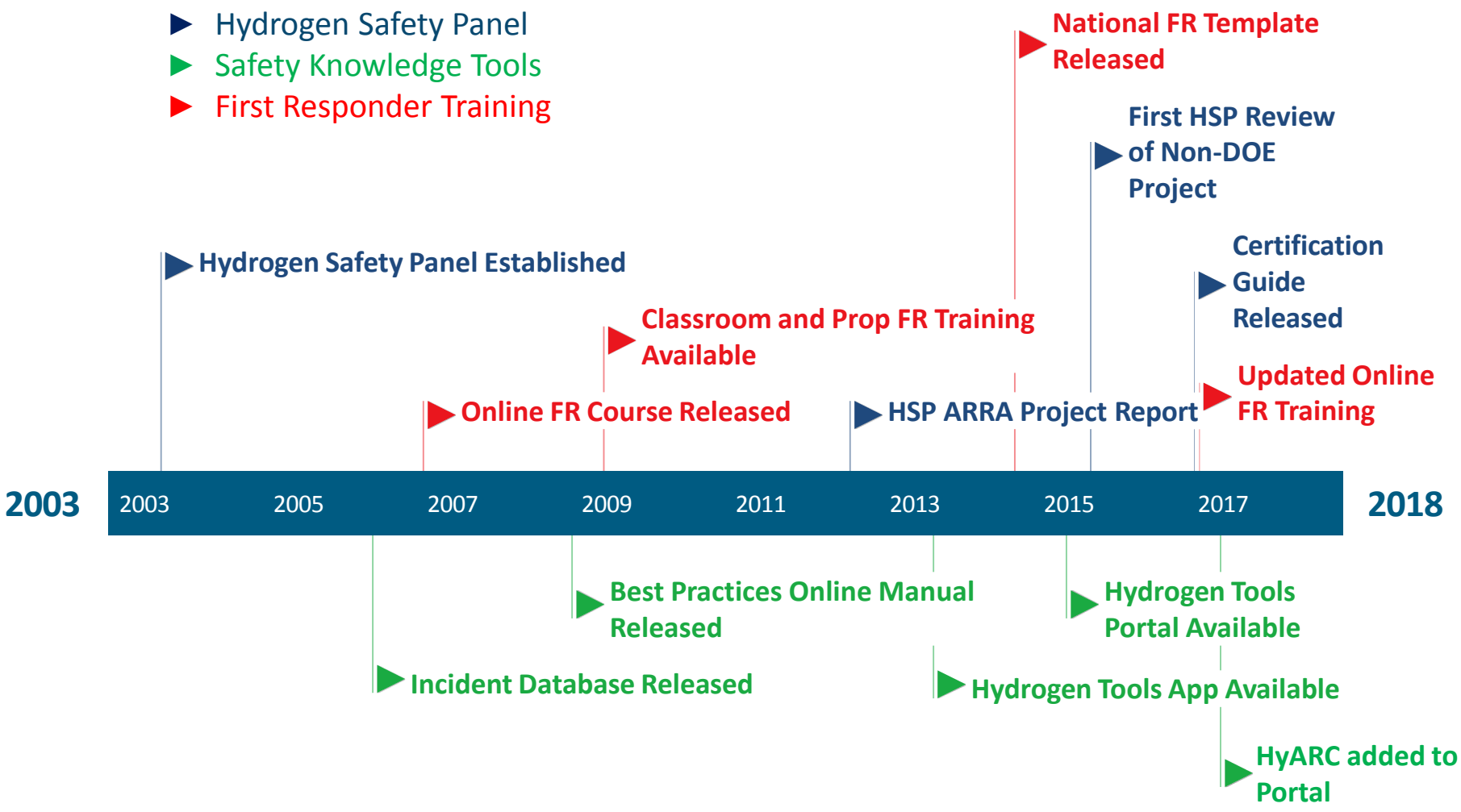

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Accomplishments: Hydrogen Safety Panel

Hydrogen Safety Panel

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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; and deployment and operations.

Name	Affiliation
Nick Barilo, Manager	Pacific Northwest National Laboratory
Richard Kallman, Chair	City of Santa Fe Springs Fire Dept.
*Eric Binder	Santa Monica Fire Department
*Ken Boyce	UL
David Farese	Air Products and Chemicals
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 (retired)
Glenn Scheffler	GWS Solutions of Tolland
Tom Witte	Witte Engineered Gases
Robert Zalosh	Firexplo

*Indicates a new member since 2016 AMR

Accomplishments

Finding solutions… Hydrogen Equipment Certification Guide

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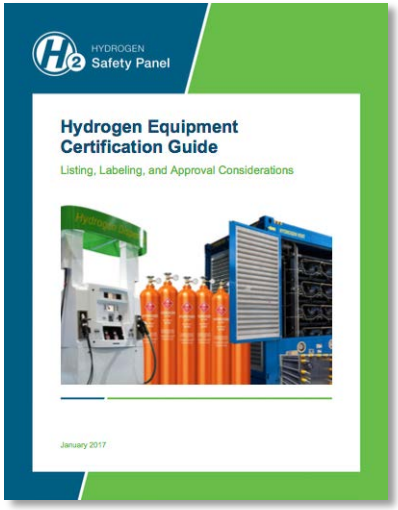
A *Hydrogen Equipment Certification Guide* has been released to assist code officials, designers, owners, evaluators, and others with the application of the listing and approval requirements pertinent to the design and/or installation of hydrogen equipment as regulated by the model codes.

Gaps Addressed

- In the early market, the availability of systems or equipment that are listed, labeled, or certified is limited
- When equipment is not listed or available, "approval" by the code official is required before installation occurs

Benefits Provided

- Enables code users 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



The *Guide* is available at https://h2tools.org/system/files/Hydrogen%20Equipment%20Certification%20Guide_Jan2017.pdf.

Accomplishments

Supporting the safe rollout of California infrastructure

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- Contracted by the California Energy Commission (CEC) to support the construction of new hydrogen fueling stations through the following services
  - Provided guidance for preparing safety plans
  - Participated in pre-award safety consultation for applicants
  - Reviewed safety plans submitted by 12 applicants to California's GFO-605 and provided comments to the CEC in support of award decisions
  - Additional support to be provided until funded stations have been complete for three years
- March 2017 — Held meetings at 7 California locations with hydrogen fueling station builders, code officials, and other state officials and stakeholders to discuss safety issues and lessons learned from recent station deployments
  - Pertinent learnings from the meetings may be added to the Best Safety Practices online resource

Accomplishments
Other Highlights

- 23rd HSP Meeting in Washington, DC — Participation included representatives from the Department of Transportation and Department of Defense, and included discussion of timely topics on transportation issues (mobile applications, tank issues, etc.) and unique DOD fuel cell applications
- H-Prize site visit (SimpleFuel) in support of the final prize award
- Participated in a hydrogen incident fact finding visit at a major university
- To measure the HSP's impact, submittal of safety review comments now include a request for feedback from principal investigator
  - ✓ *Was the interaction helpful?*
  - ✓ *What did the HSP do well?*
  - ✓ *What could the HSP do better?*

"I cannot emphasize enough how vital & timely the HSP involvement was during this [H-Prize] competition – appropriately informing our product safety architecture, and enabling us to galvanize our appliance design."
Darryl Pollica, IVYS Energy Solutions

Accomplishments

HTAC Event Response Subcommittee Report

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A subcommittee of the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) members worked together beginning in January 2016 to review and assess current resources such as safety plans; event response plans; current federal, state, and local requirements; and case studies to identify gaps and recommend actions to address current and projected needs.

Recommendation #1 - Maximize the Role of the Hydrogen Safety Panel

DOE should develop a strategic plan that positions the HSP as a trusted resource on hydrogen safety, invests in marketing to make the HSP more visible, and provides resources to enable the HSP to develop relationships with safety officials at the local, state, and national levels. While state and privately funded projects should also budget for HSP involvement, DOE should enable federal funding to support non-DOE funded projects with the goal of broadly advancing hydrogen FCEVs. The recommendation identifies four objectives:

- Raise awareness of the HSP and H2Tools targeting project developers and state/local officials
- Establish working relations (MOUs, etc.) with key state and local organizations for incident response
- Identify methods to facilitate outside organizations paying for HSP services
- Identify types of projects that would benefit from HSP involvement

The strategic plan is currently being drafted by PNNL.

Note: Any proposed future work is subject to change based on funding levels.

Accomplishments

Hydrogen Safety Panel scorecard

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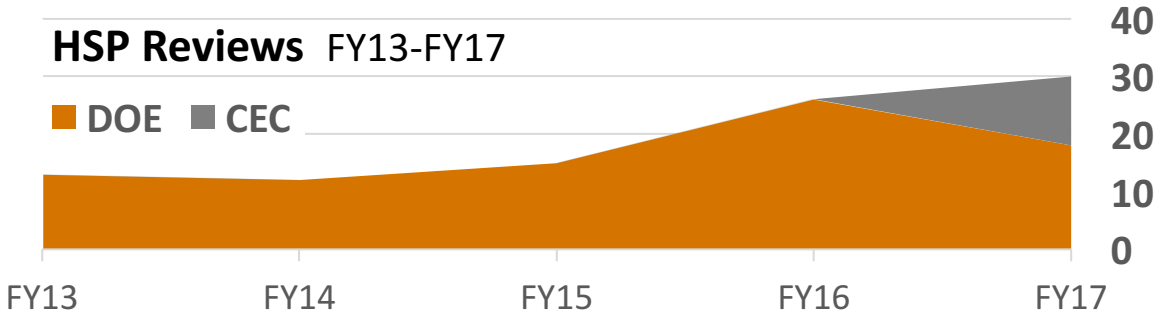
The past two years have seen expanded use of the HSP reviewing federal and state projects



Activity	Since the 2016 AMR	Total for the Project Duration
Project Reviews (including safety plans, site visits reviewed, follow-up interviews and design review activities)	30*	468
Panel Meetings	1	23
White Papers, Recommendations, etc.	1	8
Accident Investigations	1	4
Publications, Presentations, and Webinars (all tasks combined total)	9	66

* (includes 12 California fueling station submittals under contract with the CEC)

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Accomplishments: Safety Knowledge Tools and Dissemination

Hydrogen Tools Portal

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A Transformative Step Towards Hydrogen Adoption

CENTRALIZED LOCATION organizes current H_2 resources in one robust location—including **more than 20** existing tools, with plans for adding future content

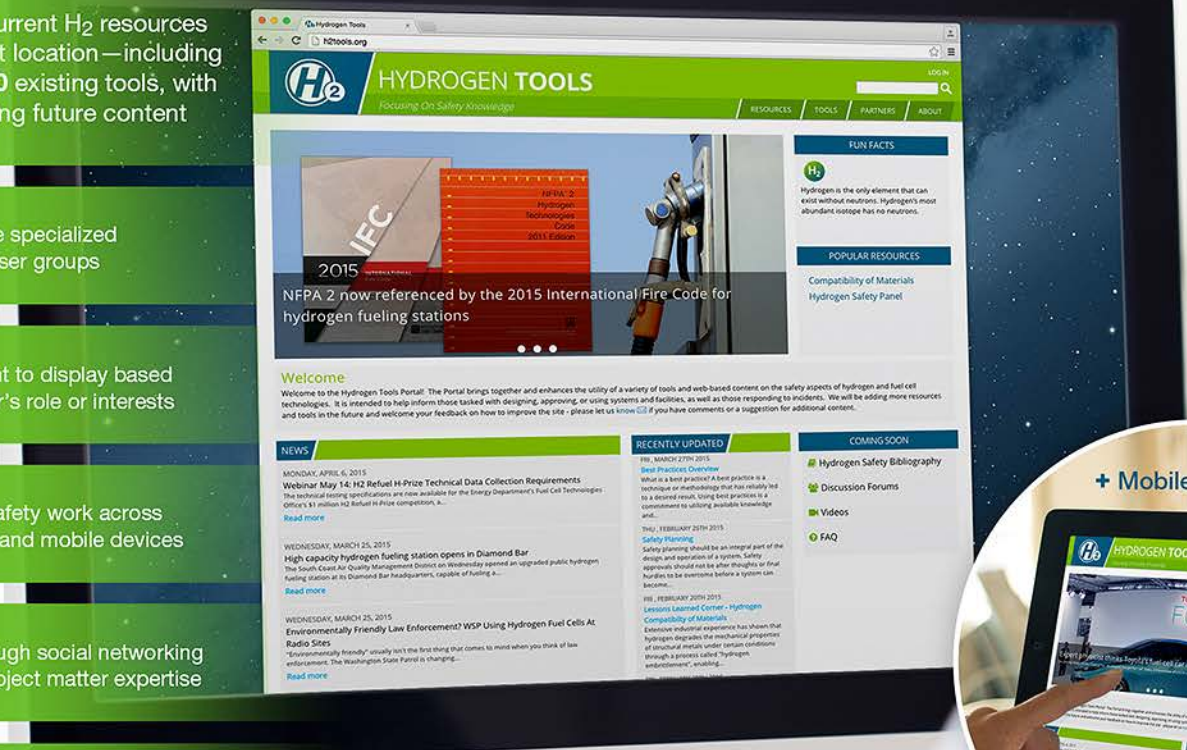
FOCUSED CONTENT tailored to the specialized needs of H_2 user groups

CUSTOMIZABLE INTERFACE allows content to display based on the H_2 user's role or interests

RESPONSIVE DESIGN enables H_2 safety work across both desktop and mobile devices

TRUSTED COMMUNITIES fostered through social networking around H_2 subject matter expertise

EXPANDABLE FORMAT built with frequently requested future feature sets in mind



http://h2tools.org

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

Accomplishments

Enriching the content of the Hydrogen Tools portal

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Completed

- 633 papers (with searchable content) from the International Conference on Hydrogen Safety added to the Hydrogen Tools portal (https://h2tools.org/ichs)
- HyRAM discussion forum (https://h2tools.org/forums/hyram)
- Permitting Hydrogen Fueling Station videos (https://h2tools.org/videos)

In-Progress

- Relocation of the Hydrogen Analysis Resource Center (HyARC) to the Portal (HyARC provides well-documented, reliable data for use in evaluating hydrogen-related technologies)
- Updates to and new content provided for the Best Safety Practices resources, including short topic-related videos from HSP members
- HyRAM resource information page and download link
- Hydrogen Equipment Certification Guide information pages

ICHS International Conference on Hydrogen Safety

HyRAM HYDROGEN RISK ASSESSMENT MODELS

Accomplishments

Hydrogen Tools Portal Stats

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Site Content

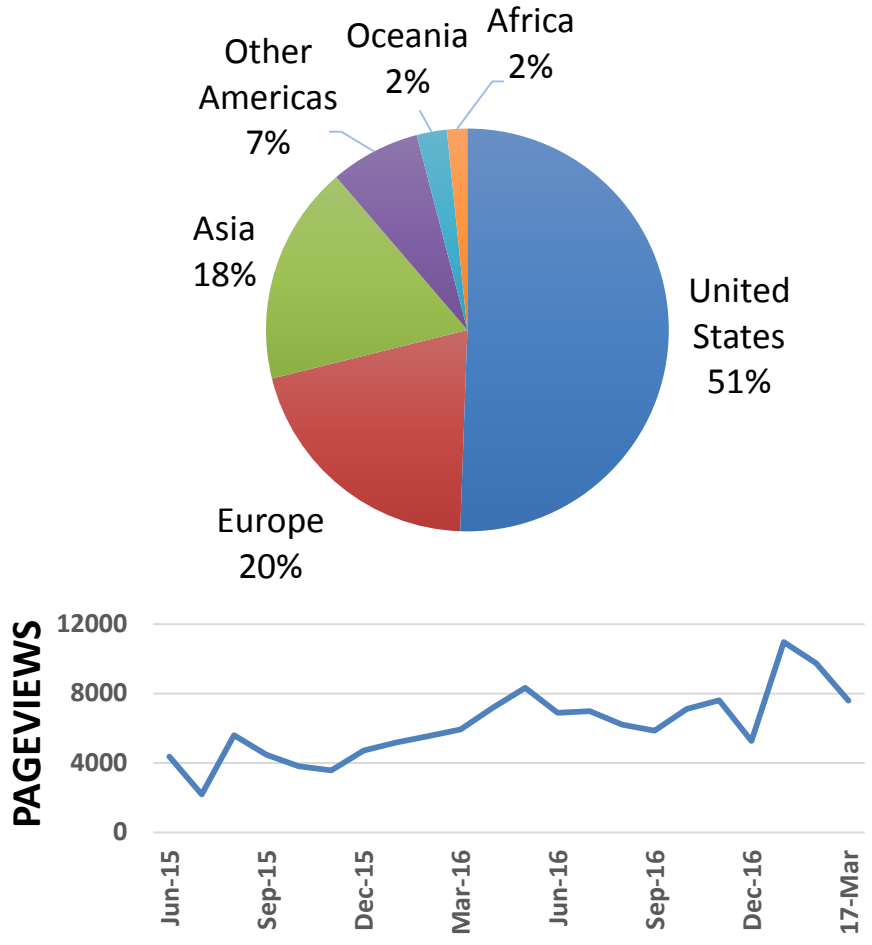
- **3,581** Total Pages
- **2,414** Bibliographic References
- **217** Lessons Learned Pages
- **142** Best Safety Practices Pages

Usage Stats*

- **135,160** Total Pageviews
- **23,805** Sessions
- **5.68** Pages Visited per Session
- **7:26** Minutes per Session

*Nonbounce statistics through March 31, 2017

H2Tools.org - A Global Resource!



Accomplishments

Disseminating safety knowledge to reach critical audiences

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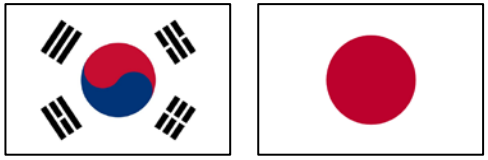
International Collaboration

- PNNL worked with Hydrogen South Africa, hySafe, and the U.K.'s Health and Safety Laboratory to provide an online hydrogen safety awareness webinar/panel discussion for code officials and stakeholders in South Africa in October 2016
- PNNL presented "Safety Resources for Hydrogen and Fuel Cell Applications" to Korean and Japanese Delegations in January 2017

HySA Infrastructure
Hydrogen South Africa



U.S. Stakeholder Outreach

- NFPA Conference and Expo (June 2017)
- Maryland Tunnel Authorities (February 2017)
- Boston, MA, Tunnel Authorities and First Responders (October 2016)
- Washington State Energy Employees (July 2016)

"Many thanks for your presentations yesterday, and making time available over the last couple of months in preparation for yesterday. I think the event went really well. So again thanks for an excellent job, I really do appreciate your dedication to knowledge dissemination on the subject of Hydrogen safety. We could maybe consider replicating an event like this in other cities, such as Johannesburg or Polokwane, where there are talks of Hydrogen buses roll-out." - Brian North, Clean Energy Tech. at CSIR, South Africa

Accomplishments

Establishing long term goals – Multi-lab Outreach Plan

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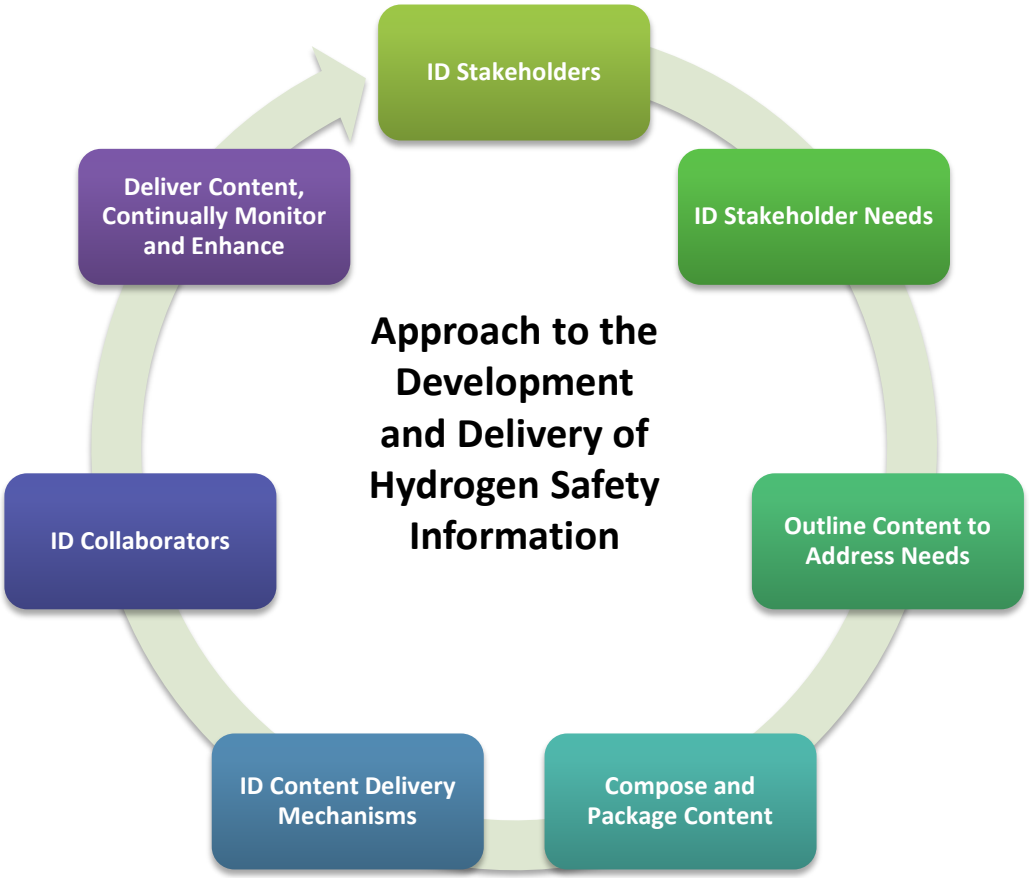
Outreach Plan Goal: Proactively reaching stakeholders to ensure a safe transition to hydrogen and fuel cell technologies

- Recent outreach activities have identified the need for a more formal systematic approach to reach stakeholders
- The outreach plan helps ensure that important stakeholder organizations have necessary knowledge to ensure the safe and timely deployment of this technology
- The plan is expected to include participation by PNNL, NREL, and SNL, with support from DOE FCTO



Accomplishments

Federal Energy Management Program (FEMP) Outreach

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- Goal: Provide agencies and organizations with the information, tools, and assistance they need to deploy clean energy technologies
- A key challenge is educating early adopters and other stakeholders on FCEVs as fleet vehicles and the operation of associated hydrogen infrastructure
- PNNL and NREL will collaborate to develop training material and train agencies over a 5 year effort, transitioning in a strategic, coordinated way as FCEVs become more widely available in federal fleets

Anticipated PNNL Funding

FY17
FEMP - $40K
FCTO - $40K

FY18
FEMP - $40K
FCTO - $25K

FY19-FY21
FEMP - $55K/year
FCTO - $20K/year

Note: Any proposed future work is subject to change based on funding levels.

Accomplishments/Future Work

Federal Energy Management Program (FEMP) Outreach

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FY17

- Incorporate introductory hydrogen information into FEMP training and outreach material
  - PNNL will present at the August 2017 Energy Exchange

FY18

- Develop a follow-on FEMP training webinar
- Training and/or workshops will be expanded to three additional federal agencies and include a module on fleets

FY19

- Develop a third FEMP training webinar as a follow-on to the FEMP training webinar
  - Materials will be prepared for FEMP's certificate series and deploy it on the FEMP training website
- Training and/or workshops will be expanded to five additional federal agencies

FY20

- Update technical and training tools and create train the trainer and virtual training material to reach a broader group of stakeholders

FY21

- Update the train-the-trainer training to include not just light duty vehicles but other applicable vehicles such as medium and heavy-duty vehicles
- Training and/or workshops will expand to an additional five federal agencies

Note: Any proposed future work is subject to change based on funding levels.

Opportunities for New Resources

Proposed Online Code Verification Tool

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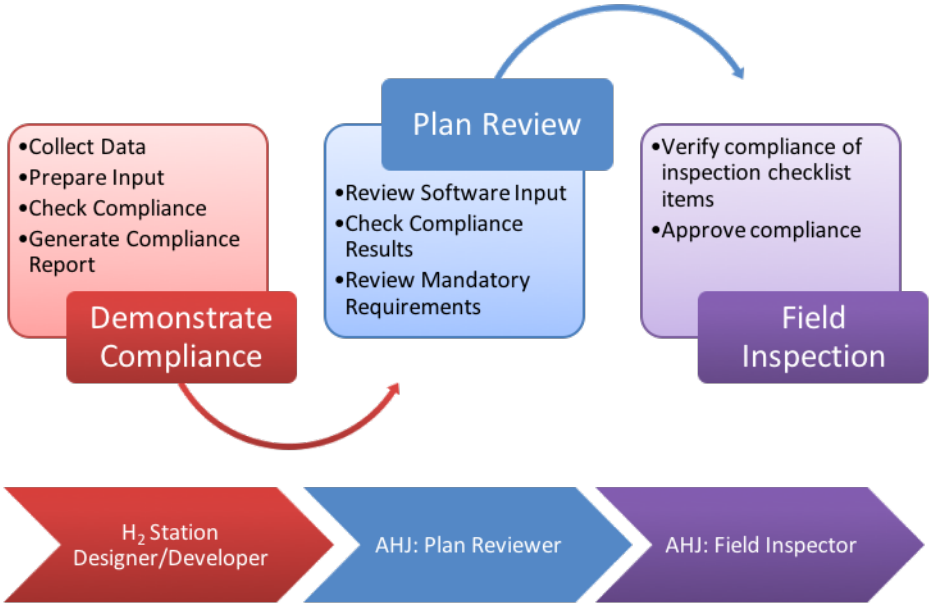
Enabling those with limited experience… An online tool to make it fast and easy for builders, designers, and contractors to determine whether their proposed hydrogen fueling stations meets the requirements of NFPA 2 (Hydrogen Technologies Code) and the International Fire Code (IFC), and simplify efforts of building and fire officials, plan checkers, and inspectors responsible for verification of compliance with those requirements by allowing them to quickly identify the requirements for a specific installation and apply them to their code enforcement tasks.

Potential Impact

- Decrease the time and costs needed for preparing and reviewing plans and issuing permits
- Ensure accuracy and consistency in the application of NFPA 2 and the IFC
- Enable paperless plan checks and code studies (green)
- Speed up the transfer of information



Note: Any proposed future work is subject to change based on funding levels.

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Accomplishments:
First Responder Training

Accomplishments

First Responder Outreach – Northeast U.S.

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Supporting the Rollout of Infrastructure and Vehicles

- Fall 2016 – **more than 250 Attendees**
  - Hempstead, NY
  - Stow, MA
  - Hartford, CT
- Fall 2017 Proposed Activities
  - Classroom training
  - Prop demonstration
  - Virtual reality exercises

Activity Partners

TOWN OF HEMPSTEAD, N.Y. FOUNDED 1644 NASSAU COUNTY

AIR LIQUIDE

TOYOTA

Accomplishments

First responder training…by the numbers

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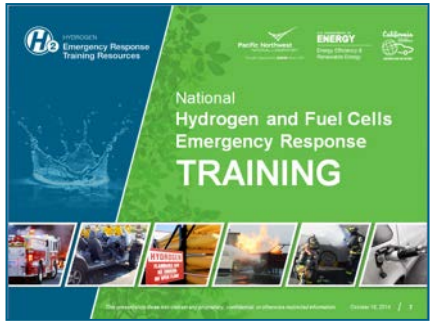


Online Training

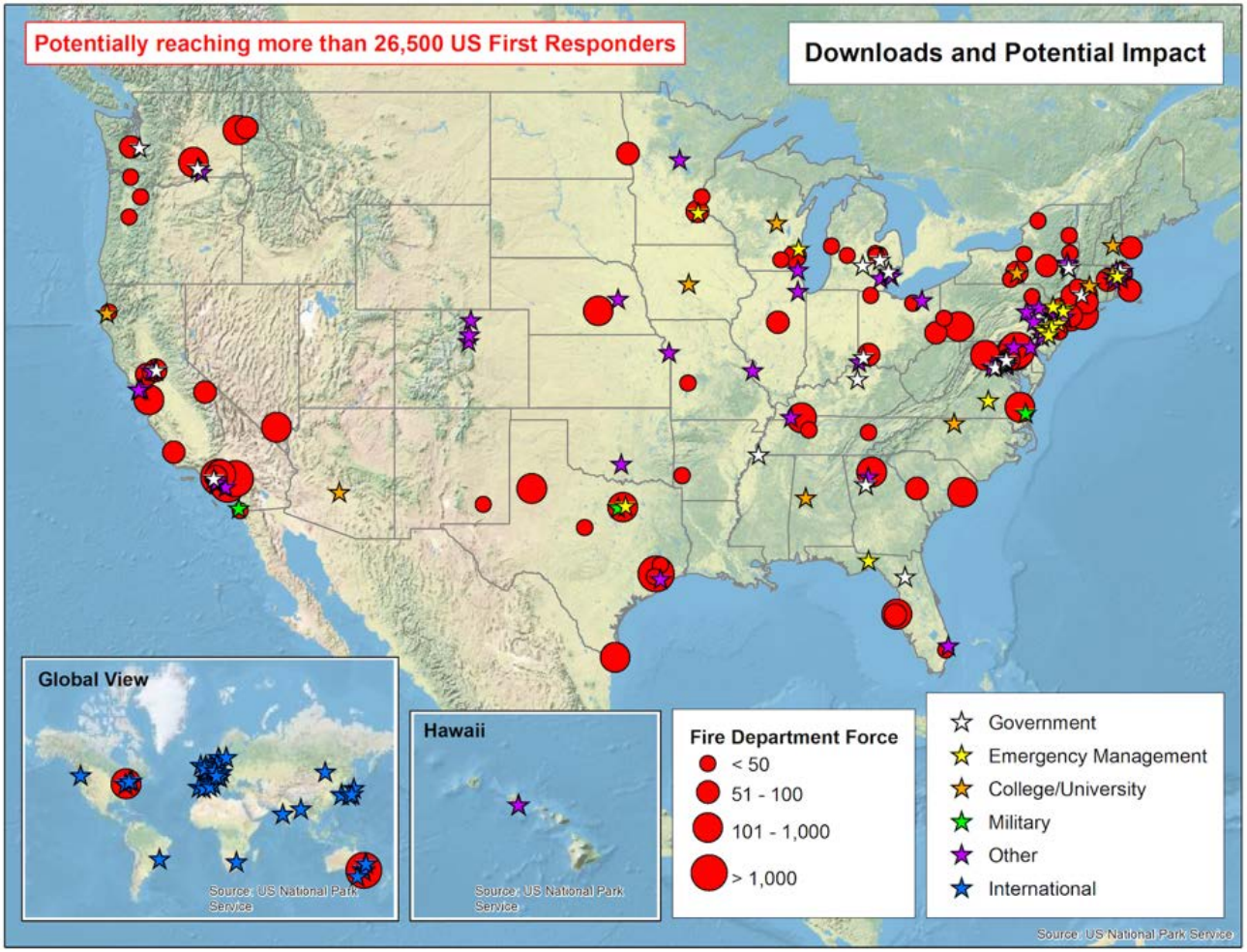
>Refreshed in February 2017

Classroom Training

>1,350 attendees since 2009

National Template

>330 downloads since 2014



National Template - downloads and potential impact

Accomplishments/Future Work

What's coming next… enriching training content

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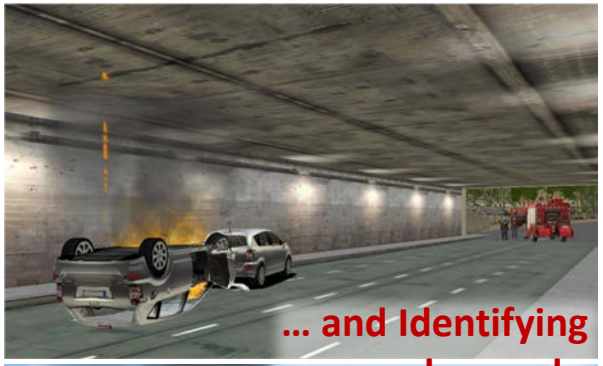
PNNL is now utilizing 3D simulation software for picture and video content

- Training First Responders
  - Scenario development
  - Attack strategies
  - Visualize results of modeling (code officials, tunnel engineers, etc.)

Video clips & pictures for visualizing scenarios…



… and Identifying approaches and attack strategies

Flame impingement on tunnel ceiling

TPRD release

Content for outreach meetings and reports

Examples of beneficial uses

Proposed Future Work, Collaborations and Presentation Summary

Proposed Future Work

Remainder of FY 2017

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Hydrogen Safety Panel

- Continue early project engagements and safety reviews for DOE funded projects
- Continue to support the California Energy Commission hydrogen fueling station deployment activities
- Finalize the HSP strategic plan
- Conduct the 24th Hydrogen Safety Panel meeting in Quincy, MA
- Present on "Safety Planning for Light Duty Hydrogen Vehicle Fueling Infrastructure," at the International Conference on Hydrogen Safety, September 11-13, 2017, in Hamburg, Germany

Safety Knowledge: Tools and Dissemination

- Update and incorporate new content into the Best Safety Practices resource
- Present on "Hydrogen and Fuel Cells - Emerging Technologies and Safety Related Issues," at the 2017 NFPA Conference and Expo, June 5, 2017, in Boston, MA
- Finish relocation of the HyARC and HyRAM resources to the Hydrogen Tools portal

First Responder Training

- Revise training materials based on learnings from recent trainings in the Northeast (Fall 2016)
- Continue planning for a significant operations-level training in the Northeast in the Fall 2017 which will include classroom training, prop demonstrations and may also include virtual reality training

Note: Any proposed future work is subject to change based on funding levels.

Proposed Future Work

FY 2018

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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
- Implement the HSP strategic plan and explore/engage opportunities to directly support states/regional rollout of fuel cell vehicles, stationary applications and supporting infrastructure
- Support California's hydrogen fueling station deployment activities

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 (if funding is made available)
- Outreach to a variety of stakeholders and organizations in accordance with the formal outreach plan

First Responder Training

- Bring classroom, props and virtual reality training (in collaboration with CRISE/HyResponse) to the Northeast in April 2017
- Incorporate 3D simulation software outputs into all training resources (online, classroom and the downloadable National Hydrogen and Fuel Cell Emergency Response Training Resource)

Note: Any proposed future work is subject to change based on funding levels.

Collaborations

Hydrogen Safety Panel and Safety Knowledge Tools

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- Organizations supporting Hydrogen Safety Panel members
- NREL on NFPA 2 liquid hydrogen task group, safety outreach and code development activities
- SNL on California hydrogen station safety plan reviews and safety outreach activities
- Toyota and Air Liquide – first responder training activities
- California Fuel Cell Partnership in support of first responder training activities
- Council for Scientific and Industrial Research, South Africa in support of outreach activities
- CEC in support of safe infrastructure deployment and safety learnings
- FEMP in support of outreach activities

Summary

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, identify gaps, 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. Dissemination of learnings from the Panel's specific project involvement and interaction with code officials, stakeholders and project proponents not only broadly benefits the industry, but feeds back to FCTO's research and development efforts.

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.

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Responses to Select 2016 AMR Reviewer Comments

Accomplishments

Responses to 2016 reviewer comments

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- "There are some concerns regarding the H2Tools portal part of the task. The first concern is in regard to the response of a 2015 reviewer comment pertaining to data maintenance. Although it makes sense to have the owners keep this information updated, this may not happen for a number of possible reasons. Such updating requires resources. There is no clear commitment or plans to provide such resources. There is a risk that the data will not be maintained or that such maintenance may end up needing to be performed by project participants. The second concern has to do with the home page of the H2Tools website, which looks like the Fuel Cell & Hydrogen Energy Association (FCHEA) Hydrogen and Fuel Cell Safety Report, with articles pertaining to codes, standards and regulations—several of which have recently been featured in the FCHEA publication. There are also several articles featured that are unrelated to safety. The home page has the look and feel of a trade association or advocacy group rather than a site to aggregate hydrogen tools focused on safety."
  - *Thanks for the comments. The goal of the portal is to bring together and enhance the utility of a variety of tools and web-based content on the safety aspects of hydrogen and fuel cell technologies. It is was recognized early in the planning stages that the benefit of the portal would be best realized by bringing content into the site (making it searchable and relatable), rather than just providing links to outside resources. To address the risk of the information becoming outdated, the project works with contributors to ensure that the content is current. If a resource is deemed outdated or no longer beneficial, PNNL will remove from the Portal.*

(Response continued on next slide)

Accomplishments

Responses to 2016 reviewer comments

(Continued Response)

- *Regarding the second concern, which appears directed at the news articles linked on the home page… The approach for providing relevant news articles (safety or non-safety related) is aimed at enhancing visibility and drawing attention to the site in order to introduce the site's resources to those who have may have not been aware of them. Additionally, the portal was named "Hydrogen Tools," as it was anticipated that the Portal may include other non-safety resources that would be beneficial and/or impactful for users.*

- "It is time for more attention to be given to the Northeast, with outreach and possibly more direct interaction with the HSP. To provide more resources for the outreach, training, and portal work, maybe a different funding model for the HSP should be considered. Possibly a user-funded model would help—for example, the financial burden of a safety review could be put on the project that is being reviewed, dividing up the financial responsibility among the projects that benefit from that review."

  - *PNNL agrees with that there could be significant benefit realized from additional Northeast interaction with the HSP. The HSP's recent interaction with the California Energy Commission demonstrated that it can be contracted directly. This approach can be used for other federal and state agencies and industry. A strategy plan is being prepared to bring visibility to the HSP's resources in response to a recommendation in the Hydrogen Technical Advisory Committee communications report. This recommendation includes the need to investigate funding mechanisms for non-DOE projects.*

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Thank You!

- U.S. Department of Energy
  - Fuel Cell Technologies Office (Sunita Satyapal, Director; Will James, Safety, Codes, and Standards Manager; and Laura Hill)
- 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 2017 Annual Merit Review and Peer Evaluation

Project Review Reports, White Papers, and Other Documents Since the 2016 AMR

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1. Safety Plan Review – Integrated Insulation System for Cryogenic Automotive Tanks (iCAT) , April 10, 2017.
2. Safety Plan Review – Novel Ionomers and Electrode Structures for Improved PEMFC Electrode Performance at Low PGM Loadings, March 24, 2017.
3. Design Review – Advanced Hydrogen Mobile Fueler, February 7, 2017.
4. Safety Plan Review – Development of Magnesium Boride Etherates as Hydrogen Storage Materials, February 1, 2017.
5. Safety Plan Review – Advanced Electrochemical Hydrogen Compressor (2 reviews), January 31, 2017.
6. Safety Plan Review – Metal Hydride Compressor for High Pressure Hydrogen Delivery, January 4, 2017.
7. Safety Plan Review – Multi-Scale Ordered Cell Structure for Cost Effective Production of Hydrogen by HTWS, January 3, 2017.
8. Safety Plan Review – Applicants to the California GFO-605 for hydrogen fueling stations (12 applications, each with multiple safety plans), December 20, 2016.
9. Design Review – Fuel Cell Hybrid Electric Delivery Van, December 14, 2016.
10. Site Visit – CHEF HAZOP/Safety Plan, November 29, 2016.
11. Safety Plan – Highly Active, Durable, and Ultra-Low PGM NSTF Thin Film ORR Catalysts and Supports, September 26, 2016.
12. H-Prize - Simple.Fuel Site Visit, September 19, 2016.
13. Site Visit – Washington State University Hydrogen Incident Fact Finding, September 1, 2016.
14. Safety Plan Review – Linear Motor Reciprocating Compressor (LMRC) for Forecourt Hydrogen Compression (Updated Safety Plan), August 12, 2016.
15. Safety Plan – Biohydrogen production and bench-scale hydrogen-producing reactors, July 13, 2016.
16. Site Visit – Brentwood Hydrogen Fueling Station, June 27. 2016.
17. Design Review – NREL H2 Station Reconfiguration, June 24, 2016.

Publications and Presentations (since 2012)

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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)
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)

Note: Bold font identifies publications and presentations subsequent to the 2016 Annual Merit Review and Peer Evaluation Meeting

Publications and Presentations (continued)

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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)
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), 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.

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Publications and Presentations (continued)

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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).
31. 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.” Article submitted for publication in the International Journal of Hydrogen Energy, February 2016.
32. Barilo NF, JJ Hamilton, and SC Weiner. “First Responder Training: Supporting Commercialization of Hydrogen and Fuel Cell Technologies.” Article submitted for publication in the International Journal of Hydrogen Energy, February 2016.
33. Barilo NF. “Safety Planning for Hydrogen and Fuel Cell Projects.” PNNL-25279, Pacific Northwest National Laboratory, Richland, WA. Available at https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects-March_2016.pdf, March 2016.
34. Barilo NF. "Hydrogen and Fuel Cell Applications." Presented at 2016 Colorado Chapter Educational Institute (ICC), Denver, CO, on March 3, 2016. PNNL-SA-116090.

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Publications and Presentations (continued)

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35. Barilo NF, "Hydrogen Safety Information Resources." Presented at the Northeast outreach events in New York and Massachusetts, on April 18-21, 2016. PNNL-SA-117224.

36. Barilo NF, "Safety Planning for Hydrogen and Fuel Cell Projects." Presented at a California Energy Commission Webinar, on May 3, 2016. PNNL-SA-117758.

37. Barilo, NF, "Hydrogen and Fuel Cells -- Emerging Technology and Safety-Related Issues," NFPA Conference & Expo, Boston, MA, June 5, 2017 (abstract approved December 2017).

38. Barilo NF, "Hydrogen Equipment Certification Guide Listing, Labeling and Approval Considerations," Pacific Northwest National Laboratory, Richland, WA. PNNL-25053, January 2017.

39. Barilo, NF and Gambone, LR., "Safety Planning for Light Duty Hydrogen Vehicle Fueling Infrastructure," International Conference on Hydrogen Safety, Hamburg, Germany, September 13-15, 2017 (abstract approved February 2017).

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