PNNL-23704

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

# Electronic Safety Resource Tools – Supporting Hydrogen and Fuel Cell Commercialization

NF Barilo

September 2014

Pacific Northwest
NATIONAL LABORATORY

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Pacific Northwest National Laboratory
Richland, Washington 99352

# Executive Summary

The Pacific Northwest National Laboratory (PNNL) Hydrogen Safety Program conducted a planning session in Los Angeles, CA on April 1, 2014 to consider what electronic safety tools would significantly benefit the next phase of hydrogen and fuel cell commercialization. A diverse, 20-person team led by an experienced facilitator considered the question as it applied to the eight most relevant user groups. The results and subsequent evaluation activities revealed several possible resource tools that could greatly benefit users.

The tool identified as having the greatest potential for impact is a hydrogen safety portal, which can be the central location for integrating and disseminating safety information (including most of the tools identified in this report). Such a tool can provide credible and reliable information from a trustworthy source. Other impactful tools identified include a codes and standards wizard to guide users through a series of questions relating to application and specific features of the requirements; a scenario-based virtual reality training for first responders; peer networking tools to bring users from focused groups together to discuss and collaborate on hydrogen safety issues; and a tool for training inspectors. Table ES.1 provides results of the planning session, including proposed new tools and changes to existing tools.

**Table ES.1**. Results of the Planning Session

| Priority | New Tools | Update of Existing Tools |
|---|---|---|
| High | Hydrogen safety portal | Update URL and name for Hydrogen Incident and Lessons Learned Database |
| | Codes and standards wizard | Update training content from Adobe Flash to HTML5<br>• Intro to Hydrogen Safety for First Responders<br>• Intro to Hydrogen for Code Officials<br>• Hydrogen Safety Training for Researchers |
| | Scenario-based training for first responders | Update content of Permitting Hydrogen Faculties |
| | Peer networking tools | Update Hydrogen Safety Bibliographic Database |
| | Training for inspectors | Update Regulation, Codes, and Standards Template for national application |
| | Modeling/QRA tools[(a)] | Simplify Technical Reference for Hydrogen Compatibility of Materials for non-expert use |
| | Risk assessment tools[(a)] | Hydrogen Analysis Resource Center (HARC): Hydrogen Conversion Calculator |
| | Third party certification guide[(a)] | Evaluate HARC: Basic Hydrogen Properties to include additional content |
| | Equipment and project performance data | Update Hydrogen Safety Snapshot |
| | Response hotline | Convert Hydrogen Safety Best Practices to a database driven format |
| | Training for maintenance and operations personnel | |
| Low | General safety tools | |

(a) Tools already under development. These will need to be integrated with a web based resource or the hydrogen safety portal.

Ultimately, the new tools in Table ES.1 could help bring safety information to a broader audience in a more relevant manner. These tools can help remove barriers to project development and approval, and support a safer implementation of a hydrogen infrastructure. The U.S. Department of Energy, H2USA, and other interested parties should consider collaborations to develop and promote these tools.

# Acronyms and Abbreviations

| | |
|---|---|
| AHJ | authority having jurisdiction |
| DOE | U.S. Department of Energy |
| ESRT | electronic safety resource tool |
| O&M | operations and maintenance |
| OEM | original equipment manufacturer |
| PNNL | Pacific Northwest National Laboratory |
| QRA | quality risk assessment |

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# 1.0 Introduction

The Pacific Northwest National Laboratory (PNNL) Hydrogen Safety Program conducted a planning session in Los Angeles, CA on April 1, 2014 to consider what electronic safety tools would significantly benefit the next phase of hydrogen and fuel cell commercialization. A diverse, 20-person team led by an experienced facilitator considered the question as it applied to the eight most relevant user groups. This report describes the results of the meeting and subsequent evaluation activities, including descriptions of several possible resource tools that could greatly benefit users.

## 1.1 Background and Need

One goal of the U.S. Department of Energy (DOE) Fuel Cell Technologies Office is to provide comprehensive safety data, information, and knowledge resources to a broad range of stakeholders. As stated in the *Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan* (DOE 2013), "the widespread availability and communication of safety-related information are crucial to ensure the safe operation of future hydrogen and fuel cell technology systems. The entire hydrogen community benefits if hydrogen safety-related knowledge is openly and broadly shared." While a variety of electronic safety resource tools (ESRTs) are available to support this goal (see Appendix A), now is an appropriate time to ask if we have the right tools to support this next phase toward hydrogen and fuel cell commercialization.

To answer that question and best leverage DOE's investment in these tools, a planning session was held to support the development of an overall electronic resource strategy so that key audiences get the information they need in the most efficient manner. The session brought together individuals and organizations responsible for the existing resources and additional stakeholders to identify redundancy in tools, needs to update content, and gaps that need to be addressed to meet the needs of our target audiences.

**Organizations Represented at the Planning Session**

- Air Products
- Air Liquide
- Orange County Fire Authority
- Daimler
- Santa Monica Fire Department
- Santa Fe Springs Department of Fire-Rescue
- NASA
- California Fuel Cell Partnership
- Hydrogen Frontier
- California Office of the State Fire Marshal
- Toyota
- DOE
- NREL
- Sandia
- PNNL

## 1.2 Attendees, Format, and Data Analysis

Twenty individuals representing a variety of user groups and owners of the existing resource tools participated in the meeting, which held was at the City of Santa Fe Springs Department of Fire-Rescue, located southeast of Los Angeles, CA (a list of attendees can be found in Appendix B). The location was chosen due to its proximity to stakeholders, authorities having jurisdiction (AHJs), project proponents, and original equipment manufacturers (OEMs) with experience in recent hydrogen fueling station and deployment activities.

### 1.2.1 Agreement on User Group Designations

Prior to the planning session, potential user groups of ESRTs were identified. This helped focus the planning session and ensure that the

results could be manageable and useful in understanding gaps and future needs. Initially, seven user groups were identified:

- Authorities Having Jurisdiction (AHJ) – includes code officials, inspectors, and those have approval authority for a project
- First Responders/Second Responders (FR/SR) – fire departments, law enforcement, emergency medical personnel, and secondary responders such as wrecking crews
- Operations & Maintenance (OM) – those responsible for operating and maintaining equipment after it is in service
- The Public (PUB) – general public
- Project Proponents (PP) – gas providers, engineers, architects, etc.
- Research & Development (RD) – individuals responsible for development activities
- Stakeholders (STK) – investors and those interested in the outcome of a project

Attendees were asked to rank user groups before the meeting to verify that the right groups were included and assign their priority. The results (Figure 1) show that the AHJ and FR groups were felt to have the greatest need.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total | Average Ranking |
|---|---|---|---|---|---|---|---|---|---|
| **AHJ - Authorities having jurisdiction** | **18.18%** 2 | **63.64%** 7 | **0.00%** 0 | **9.09%** 1 | **9.09%** 1 | **0.00%** 0 | **0.00%** 0 | 11 | 5.73 |
| **FR - First responders (fire, law enforcement, and emergency medical personnel)** | **27.27%** 3 | **27.27%** 3 | **36.36%** 4 | **0.00%** 0 | **9.09%** 1 | **0.00%** 0 | **0.00%** 0 | 11 | 5.64 |
| **OM - Operations and maintenance personnel** | **18.18%** 2 | **0.00%** 0 | **18.18%** 2 | **27.27%** 3 | **9.09%** 1 | **18.18%** 2 | **9.09%** 1 | 11 | 4.00 |
| **PB - The public** | **0.00%** 0 | **0.00%** 0 | **0.00%** 0 | **9.09%** 1 | **9.09%** 1 | **36.36%** 4 | **45.45%** 5 | 11 | 1.82 |
| **PP - Project proponents** | **9.09%** 1 | **9.09%** 1 | **18.18%** 2 | **18.18%** 2 | **18.18%** 2 | **9.09%** 1 | **18.18%** 2 | 11 | 3.73 |
| **RD - Researchers, scientists, engineers** | **9.09%** 1 | **0.00%** 0 | **18.18%** 2 | **18.18%** 2 | **36.36%** 4 | **18.18%** 2 | **0.00%** 0 | 11 | 3.73 |
| **STK - Stakeholders having an interest in the successful completion of a project** | **18.18%** 2 | **0.00%** 0 | **9.09%** 1 | **18.18%** 2 | **9.09%** 1 | **18.18%** 2 | **27.27%** 3 | 11 | 3.36 |

**Figure 1**. Ranking of the User Group

An eighth group, Insurers and Risk Managers (INS), was added to the above list at the start of the meeting on April 1 as a result of input from attendees of the session. The Stakeholder group was also renamed Investors (INV) at this time.

### 1.2.2 Brainstorming

The brainstorming portion of the meeting focused on soliciting unconstrained ideas (referred to as "tickets") from attendees for each user group identified in section 1.2.1. The activity yielded 136 ideas, or tickets. These tickets were assigned to a specific user group or multiple user groups where appropriate. Next, tickets with common themes were organized by session participants into stories (a term to describe what an end user or user of a system does or needs to do as part of his or her job function, based on themes of individual tickets). Stories were only developed for the four highest priority user groups (identified in Figure 1) due to time constraints. Stories for the other four user groups were analyzed by Pacific Northwest National Laboratory (PNNL) in the weeks following the meeting.

### 1.2.3 Binning of the Tickets

The tickets were entered into a database and categorized based on their initial user group assignment. A few tickets were not included with user group information and were assigned an "UNGRP" designation to track the tickets while maintaining integrity of the meeting results.

The tickets were then binned and evaluated for commonality and purpose. The evaluation was a multi-step process that began with tickets being arranged by user group. During the first binning, tickets were arranged into the following categories within each user group:

- Distance training
- Hands-on training
- Codes and standards
- Design/risk
- Certification
- On scene
- Interactive
- Networking
- General information
- Uncategorized

During the next phase, tickets with a common category were moved from user groups and placed together (i.e., into a "category" bin). The final phase focused on arranging tickets within these categories together based on a common functionality (tools). Twenty-two potential tools were identified. These tools are not necessarily meant to be unique products but represent a focus on common functionality. An example of the final binning can be seen in Figure 2. All tickets and their grouped functionality can be found in Appendix C.

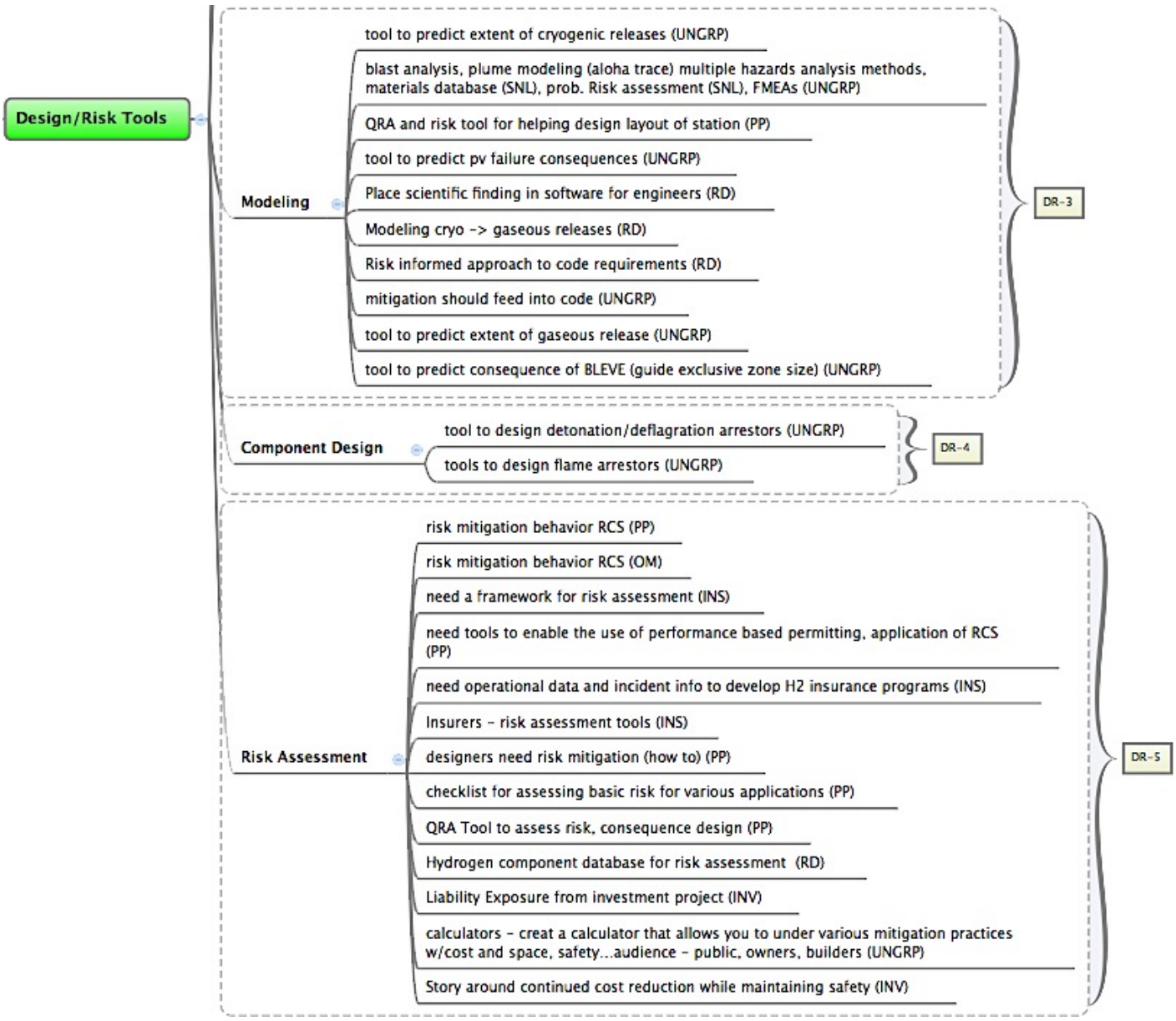


**Figure 2**. Example of Final Binning of Tickets

# 2.0 Session Results

The planning session revealed areas where the user groups could benefit from a new approach to safety knowledge resources (see Appendix D). The following sections discuss new resources based on meeting results as well as the existing tools. Recommendations for implementing new tools and updating existing tools are also provided.

## 2.1 New Tools

The new tools were divided into six groups:

- Cross-cutting tools
- Codes and standards tools
- Design tools (modeling tools, risk assessment tools, design tools, etc.)
- Information tools (general safety, vehicle information, etc.)
- Social tools (networking and hotlines)
- Training tools

The recommendations for implementing new tools are summarized in section 2.3. The recommendations are subdivided by potential impact based on overall value and need. High impact items are considered those that have immediate benefit and/or benefit across a large number of user groups. Medium impact is designated for items recognized as having substantial impact but at a high cost and time needed for development. Low impact is designated for an item that is more directed at niche needs. Items that have very low ranking numbers or that do not fit well as a DOE ESRT are identified in Table 1 as not requiring development. These tools could be developed by other organizations as needed. Finally, the planning session confirmed the need for three tools already under development.

### 2.1.1 Cross-cutting Tools

Hydrogen Safety Portal – A Nexus for Safety Information and Professional Networking (GI-1)

Participants in the planning session suggested that a hydrogen safety web portal, serving as a single source for credible and reliable safety information, would be very beneficial. DOE has a variety of electronic hydrogen safety resources and tools that are spread across government, national laboratory, and support organization's web sites. These are sometimes difficult to navigate to (via Google search) and lack a consistent look and feel. Others are outdated or use outdated technology. A portal could integrate these existing resources to facilitate accessibility (and display) from a single, *trustworthy* source, thereby increasing their visibility and value.

**The Value of Combining Resources**

The value of a network (or service/site, e.g., Twitter) is proportional to the square of the number of users (Metcalfe's law, http://en.wikipedia.org/wiki/Metcalfe%27s_law). Aggregating information and tools into a central location aggregates its 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). In addition to hosting existing tools, the portal could contain wikis, discussion forums, knowledge bases, FAQs, searchable articles, and a variety of other tools designed to facilitate peer networking and the development of a safety community.

The viral or exponential growth possible as the number of users is increased is the way social networks tend to grow (users tend to invite others) (Reed's law, http://en.wikipedia.org/wiki/Reed%27s_law). Increased value through aggregated tools and information combined with the increase in users has the potential for rapid growth much more than individual, disparate, decentralized strategies do. This approach also provides the opportunity to reduce support costs by leveraging one infrastructure, technology, etc.

Table 1 summarizes potential benefits and features. A concept of a portal that includes these benefits and features is provided in Figure 3.

**Potential Impact:** High

**Table 1**. Benefits and Potential Features of a Hydrogen Safety Portal

| | |
|---|---|
| Centralized Location | Organizing current hydrogen resources into one robust location – including more than 20 existing tools and capability for easily adding future content |
| Focused Content | Tailored to the specialized needs of hydrogen user groups |
| Customizable Interface | Allowing content to display based on the user's role or interests |
| Responsive Design | Enabling hydrogen safety work across both desktop and mobile devices (eliminating the need for a separate IOS app) |
| Trusted Communities | Fostered through social networking around hydrogen subject matter expertise |
| Expandable Format | Built with frequently requested future feature sets in mind |

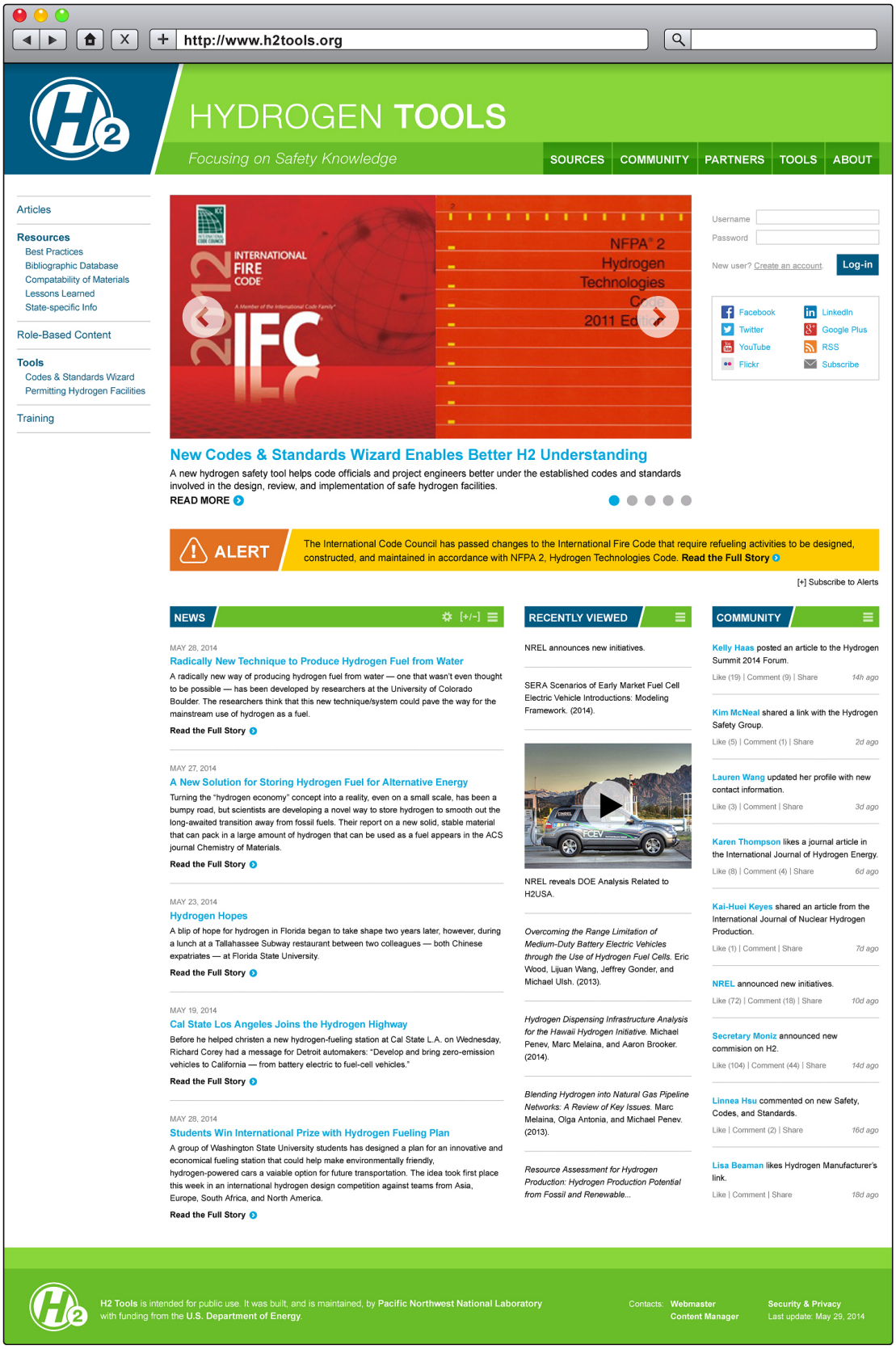


**Figure 3**. Hydrogen Safety Portal Concept

### 2.1.2 Codes and Standards Tools

Codes and Standards Wizard/Guide (CS-1)

There are many codes, standards, regulations and other criteria (ICC, NFPA, ASTM, ASME, UL, CSA, etc.) that govern the design, construction, installation, commissioning, operations and maintenance of hydrogen and fuel cell technologies. It is extremely difficult for an AHJ or project proponent to understand all applicable criteria and then determine which provisions apply to the installation and its component parts. Without experienced personnel, the best case scenario is simply lost time in getting an installation approved and permitted and the worst case is finding out too late that substantial revisions are required.

The topic of codes and standards was the most ticketed and discussed idea at the planning session and highlighted the need for a resource tool. Session participants shared a need for an overview of requirements; simplified code application; an outline of code requirements; a list of applicable codes and standards; help to understand codes and standards and applicable requirements. There are a few code and standard electronic resources currently available, such as http://www.fuelcellstandards.com/ and the National Renewable Energy Laboratory's *Regulations, Codes, and Standards (RCS) Template for California Hydrogen Dispensing Stations*. However, these may not meet the deeper need for a more systematic and intuitive tool.

The concept of a drill-down, question-based tool (similar to Intuit's TurboTax® tool) surfaced as being an ideal solution. Such a tool would guide the user through a series of questions relating to application, topics, and subtopics to help them identify the applicable requirements in a timely manner. More technically speaking, this could be an interactive relational database-driven web app based on codes, standards, and regulations applicable to hydrogen and fuel cell technologies. In addition to identifying applicable requirements, it is recommended that programmers consult with the Building Smart Alliance at the National Institute of Building Sciences to explore how the database could be applied to Building Information Modeling (BIM) related software. Such an effort could facilitate the creation of plans and specifications and automatic checking of those plans and specifications for compliance with applicable building regulations as represented by the database. This approach is being used by both technology proponents and regulators to help ensure a common and accurate understanding of the building regulations applicable to a proposed installation, more timely review and approval of what is proposed, and more timely completion and operation of the installation.

Integrating this tool with the hydrogen safety portal discussed in the previous section would open up significant opportunities to bring additional information to help the user understand how to apply the requirements. For example, once the user is systematically led through the wizard to a particular set of requirements, the portal could also display information such as best practices (from h2bestpractices.org), related lessons learned, instructional videos and wikis, and community discussion or feedback on related topics. A flowchart of how this might work is provided in Figure 4.

**Potential Impact:** High

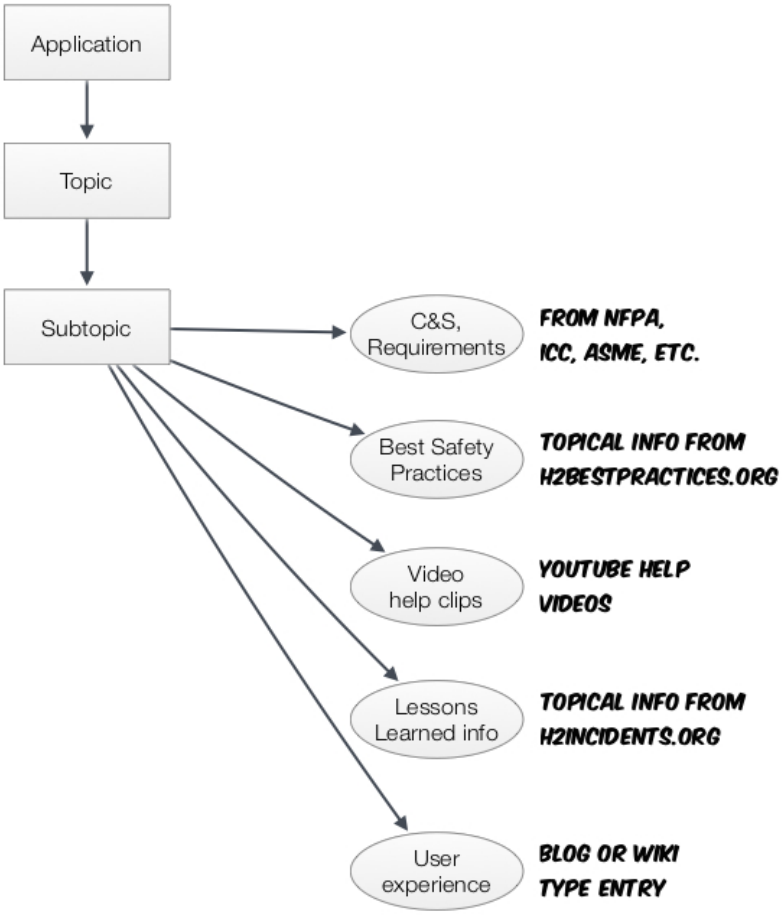


**Figure 4**. Codes and Standards Wizard

### 2.1.3 Design Tools

Design tools discussed during the planning session include the following:

- Modeling/quality risk assessment (QRA) tools
- Risk assessment tools
- Station location and design tools
- Equipment and project performance data
- Third party certification guide

These tools and data should be made readily available through an online resource such as the hydrogen safety portal.

Modeling/QRA Tools (DR-3)

This includes modeling tools to predict consequences of cryogenic releases, pressure valve failure, cryogenic to gas releases, gaseous releases, BLEVEs, etc., to support fueling station designs and risk

informed changes to regulation, codes, and standards. These tools are already under development by Sandia National Laboratories.

**Potential Impact:** Already being developed

Risk Assessment Tools (DR-5)

This includes tools to enable risk assessments and provide options for risk mitigation and support performance-based analysis. It could include checklists for basic risk; component databases; calculators; and cost-benefit features. These tools are already under development by Sandia National Laboratories.

**Potential Impact:** Already being developed

Station Location and Design Tools (DR-1)

This includes design tools to help identify station locations (mapping), options for station configurations, standardized plan formats, and obstacles to project deployments. The evaluation group (April 2 and Hydrogen Safety Panel members) felt this tool would not provide significant impact and that station providers have enough existing resources to address this need.

**Potential Impact:** No further effort by DOE is needed.

Equipment and Project Performance Data (DR-2)

This includes data on equipment and project performance including failure rate data, mean time between failures, incident data, real-time system performance, and "denominator" information for frequency of incidents. While some of this information is available through the NREL secure database, much more work is needed in this area. These tools could have a significant impact but will take much industry support and time to develop.

**Potential Impact:** Medium

Third Party Certification Guide (CI-1)

A guide for project certification by third party is needed and should be based on a tool/methodology that the AHJ can trust, and may include a component certification checklist. This activity is similar to work being performed by the Hydrogen Safety Panel task group on certification. That work is expected to produce a document that could be made available electronically in support of this effort.

**Potential Impact:** Already being developed

### 2.1.4 Information Tools

Four types of information tools were identified during the analysis of the tickets and are discussed in this section:

- General safety tools
- Vehicle and equipment safety information

- On-scene vehicle information
- List of listed or approved equipment

General Safety Tools (GI-4)

These tools include general safety information on hydrogen properties and behavior. Some general safety tools already exist, including properties and conversion calculators. Other areas, such as answers to general questions, pressure safety, flame arrestors, vent systems, relief devices, provide opportunity for further development and should be developed as needs arise. The tools could be included with other tools and/or made available through an online resource such as the hydrogen safety portal.

**Potential Impact:** Low

Vehicle and Equipment Safety Information (GI-3)

This includes vehicle and equipment information covering general information, safety features, safe usage parameters, recall notices, and so forth. This information should be developed and deployed by OEMs. H2USA could help ensure the necessary information is made available.

**Potential Impact:** No further effort by DOE is needed.

On-scene Vehicle Information (OS-1)

These tools would provide critical safety information to firefighters and secondary responders (tow and wrecking) when responding to an event and would include details based on vehicle identification number scanning. OEMs should work with secondary responders to identify needs and develop the appropriate tools.

**Potential Impact:** No further effort by DOE is needed.

Tool for Listed or Approved Equipment (CI-2)

This tool would provide information for listed/approved equipment and systems to support review and approval of designs. While there is an obvious need for this information, very few listed components and systems are available due to the relative immaturity of the industry. When listed equipment becomes available, the testing laboratories would be the best resource to make the listing databases available. Until then, pursuing the third party certification guide (CI-1) is a good alternative.

**Potential Impact:** No further effort by DOE is needed.

### 2.1.5 Social Tools

Peer Networking (NW-1/NW-2/NW-3)

This includes tools to help establish connections and discussions among peers within the following user groups: AHJs, inspectors, researchers, OEMs, and project proponents. Interactions with various user groups, feedback at the planning session, and general industry social movement suggest great value in

these types of tools. Connecting inspectors and code officials also has the potential to reduce delays in project approval due to lack of experience. These tools could be standalone products but would likely be more useful if they were integrated with other electronic safety resources and the hydrogen safety portal.

**Potential Impact:** High

Response Hotline (IA-2)

Session attendees suggested that a hotline be developed for responding to incidents and special issues. This could be a standalone phone number or be combined with various social media tools.

**Potential Impact:** Medium

### 2.1.6 Training Tools

Inspectors (TR-2)

A tool to train code official inspectors in support of permitting and approval of hydrogen facilities was deemed valuable by session attendees. This tool could provide an opportunity to help AHJ reduce approval and permitting times. It could be implemented through short instructional videos incorporated into the portal and codes and standards wizard.

**Potential Impact:** High

Operations and Maintenance Personnel (TR-1)

Operations and maintenance personnel could benefit from training on hazards and operating equipment that can provide certification. This tool could help reduce the number and severity of potential events as O&M personnel are unfamiliar with the hazards of working with hydrogen.

**Potential Impact:** Medium

Scenario-Based Training for First Responders (NN-1)

First responders can greatly benefit from hands-on and scenario-based training. Hands-on training currently exists (through PNNL) but its use is limited due to expense (moving props and equipment to training locations) and the limited number of scenarios available for participants (and only vehicle scenarios). Recent collaborations with the European based HyResponse program offer another opportunity in the form of an electronic virtual reality training tool that will allow for an unlimited number and types of scenarios that can be developed for class participants and support remote class participation. Such a tool could build on the current successes of the PNNL program and future activities involving the first responder training template. One could envision an application where fundamental training (current classroom or template training) is given through a webinar followed by remote participation in in virtual reality scenarios.

**Potential Impact:** High

## 2.2 Existing Tools

Recommendations for existing ESRTs are identified in section 2.3. The affected user groups and tickets associated with existing tools are found in Appendices E and F, respectively. Many of the tools need their content updated to remain relevant. The three online training tools also need a technology refresh to move away from outdated Adobe Flash to current HTML 5 format. Doing this will also make the content viewable on mobile platforms. Consolidating these tools to a single website would allow for information sharing across the tools.

## 2.3 Recommendation Summary Tables

The following tables summarize the recommendations for new and existing ESRTs that resulted from the planning session. Table 2 presents the recommendations for new tools and Table 3 presents recommendations for existing tools.

**Table 2**. Recommendations for Implementation of New Tools

| ID# | Title | Affected User Groups | Implementation Format | Comments |
|---|---|---|---|---|
| High Impact Tools | | | | |
| GI-1 | Hydrogen Safety Portal | All | Web site utilizing a content management system (CMS) | This tool could greatly impact all user groups by providing credible and reliable information from a trustworthy source. See Figure 3 for a mockup of the portal. |
| CS-1 | Codes and Standards Wizard/Guide | AHJ,OM,PP, RD,INS | Custom relational database driven web app | This is a critical tool for supporting AHJ review and approval. |
| NN-1 | Scenario-Based Training for First Responders | FR/SR | Virtual training system such as vr-crisis.com | This could be a 3D simulation platform aimed at teaching, training and qualifying response units for increased preparedness for risk and emergency handling. This type of simulator could address the training needs for individuals or teams, scaling the command ladder from first response operators to strategic command personnel. It allows for a wide application of scenarios (vehicles, stationary apps, transportation, maritime, etc.). |
| NW-1<br>NW-2<br>NW-3 | Peer Networking | AHJ<br>AHJ<br>PP,RD | Social network, forum, knowledge base, etc. (examples - Twitter, Google+, LinkedIn, etc.) | Interactions with various user groups, feedback at the planning session and general industry social movement suggest great value in these types of tools. Connecting inspectors and code officials also has the potential to reduce delays in project approval due to lack of experience. |
| TR-2 | Training for Inspectors | AHJ | Massive Open Online Course (MOOC), Wiki, Videos, etc. | This tool could provide an opportunity to help AHJ reduce approval and permitting times. It could be implemented through short instructional videos incorporated into the portal and codes and standards wizard. |
| Medium Impact Tools | | | | |
| DR-2 | Equipment and Project Performance Data | OM,RD,INV,INS | Searchable database available through a web based resource | These tools could have a significant impact but will take much industry support and time to develop. Part of this information is available through the NREL secure database. |
| IA-2 | Response Hotline | AHJ,FR/SR,OM PP,RD | Telephone line and/or social media | This could require significant planning and resources to plan and implement. |

| ID# | Title | Affected User Groups | Implementation Format | Comments |
|---|---|---|---|---|
| TR-1 | Training for Maintenance and Operations Personnel | OM | Custom online course, Wiki, Videos, etc. | This tool could help reduce the number and severity of potential events as OM personnel are unfamiliar with the hazards of working with hydrogen. |
| Low Impact Tools | | | | |
| GI-4 | General Safety Tools | All | Web deployed Wikis, videos and diagrams | Some tools already exist including properties and conversion calculators. Other areas such as answers to general questions, pressure safety, flame arrestors, vent systems, relief devices provide opportunity for further development and should be developed as needs arise. |
| Tools Already Under Development | | | | |
| DR-3 | Modeling/QRA Tools | AHJ,PP,D,INS | Web and desktop tools which are available through a DOE based website by providing an API for accessing these and creating a UI and front-end to interface with the underlying modeling code | Tools are already under development by Sandia. They should be integrated into the portal when completed. |
| DR-5 | Risk Assessment Tools | AHJ,PP,INV,INS | Same as DR-3 | Tools are already under development by Sandia. They should be integrated into the portal when completed. |
| CI-1 | Third Party Certification Guide | AHJ,PP | Document available in Adobe Acrobat format and available through a website | A task group from the Hydrogen Safety Panel is developing the tool. It should be integrated into the portal when completed. |
| Tools Not Requiring Development by DOE | | | | |
| DR-1 | Station Location and Design Tools | PP,RD,INV | A data driven web app with a custom Google Maps frontend | The group did not feel that there would be significant impact from this tool and that they had enough resources to address this need. |
| GI-3 | Vehicle and Equipment Safety Information | AHJ,FR/SR,OM, INS | Wiki, mobile app or web app (a cross platform framework such as Titanium would allow for a write once, deploy everywhere model) | This information should be developed and deployed by OEMs. H2USA could help ensure the necessary information is made available. |

| ID# | Title | Affected User Groups | Implementation Format | Comments |
|---|---|---|---|---|
| OS-1 | On-scene Vehicle Information | FR/SR | Same as GI-3 | OEMs should work with secondary responders to identify needs and develop the appropriate tools. |
| CI-2 | List of Listed or Approved Equipment | AHJ,PP,INS | Database-driven web app | Very few listed components and systems are available due to the relative immaturity of the industry. When listed equipment becomes available, the testing laboratories would be the best resource to make the listing databases available. Until then, pursuing the third party certification guide discussed in CI-2 is a good alternative. |

**Table 3**. Recommendations for Existing Electronic Safety Resource Tools

| ID# | Title | Affected User Groups | Update Needed | Recommendations | Include in Portal? | Portal Inclusion Method |
|---|---|---|---|---|---|---|
| EX-1 | Introduction to Hydrogen Safety for First Responders | FR/SR | Yes | The current tool requires an update to convert it from Adobe Flash to HTML5. Some content may also require updating. | Yes | Embed |
| EX-2 | Hydrogen Incident Reporting and Lessons Learned Database | AHJ,OM,PP,RD, INV,PUB,INS | Yes | Update for name/URL change to hydrogen lessons learned. There may also be benefit in connecting with the NFIRS folks to talk about how to get the word hydrogen added to that reporting system. | Yes | Embed |
| EX-3 | Hydrogen Safety Best Practices | AHJ,OM,PP,RD, INV,PUB,INS | No | Consider converting to database-driven content for future usability. | Yes | Embed |
| EX-4 | Hydrogen Analysis Resource Center (HARC): Hydrogen Conversion Calculator | AHJ,FR/SROM, PP,RD,PUB,INS | Maybe | Evaluate for changes and a format change to HTML5 and update as necessary. | Yes | Embed |
| EX-5 | Hydrogen Safety Bibliographic Database | AHJ,PP,RD | Yes | New methods for farming bibliographic hydrogen safety information should be explored. One interface could be a binomial key style wizard that interviews the user and drills down to give recommendations or explanations. | Yes | API |

| ID# | Title | Affected User Groups | Update Needed | Recommendations | Include in Portal? | Portal Inclusion Method |
|---|---|---|---|---|---|---|
| EX-6 | HARC: Basic Hydrogen Properties | All | Minor | It may be beneficial to include additional properties in this resource. | Yes | Embed |
| EX-7 | Introduction to Hydrogen for Code Officials | AHJ | Yes | The training information is outdated. Also consider template approach similar to first responder training so that this training could be integrated at the USFA or fire department level. Based on one of the tickets, the information should be expanded to consider what is necessary for review performance based designs<br><br>Additionally, the current tool requires an update to convert it from Adobe Flash to HTML5. | Yes | Embed |
| EX-8 | Regulators' Guide to Permitting Hydrogen Technologies | AHJ | ?? | This resource is outdated and may no longer be needed. Consider removing this resource. | No | N/A |
| EX-9 | Permitting Hydrogen Facilities | AHJ,PP | Maybe | Evaluate for changes and update as necessary. | Yes | Embed |
| EX-10 | Hydrogen Tools IOS App | AHJ,OM,PP,RD | Maybe | The need for and function of the App should be reevaluated after the portal is developed. | No | N/A |
| EX-11 | Hydrogen Safety Snapshot | AHJ,OM,PP,RD | Yes | This resource is not current. Two tickets indicated a desire to retain and update this tool. | Yes | Embed |
| EX-12 | Technical Reference for Hydrogen Compatibility of Materials | AHJ,OM,PP,RD INV,INS | No | Results need to be simplified for non-expert users | Yes | API |
| EX-13 | Hydrogen/Fuel Cell Codes and Standards | AHJ,OM,PP INV,INS | N/A | Not a DOE Resource | No | N/A |
| EX-14 | Regulations, Codes, and Standards Template for California Hydrogen Dispensing Stations | AHJ,PP,INV | Maybe | May need updating as new version of codes and standards are adopted. This could also be updated for more states. | Yes | Link |

| ID# | Title | Affected User Groups | Update Needed | Recommendations | Include in Portal? | Portal Inclusion Method |
|---|---|---|---|---|---|---|
| EX-15 | Hydrogen Safety Training for Researchers | RD | Yes | The current tool requires an update to convert it from Adobe Flash to HTML5. | Yes | Embed |
| EX-16 | Hydrogen Safety Tips for First Responders | FR/SR | ?? | DOE resource? | Yes | Link |
| EX-17 | Hydrogen Safety Fact Sheet (NHA) | All | N/A | Not a DOE resource. | Yes | Link |
| EX-18 | National Template: Hydrogen Vehicle and Infrastructure Codes and Standards | AHJ,PP,INV,INS | No | | Yes | Link |
| EX-19 | Hydrogen Vehicle and Infrastructure Codes and Standards Citations | AHJ,OM,PP,INS | No | | Yes | Link |
| EX-20 | Reaching the U.S. Fire Service with Hydrogen Safety Information: A Roadmap | AHJ,FR/SR | N/A | Not a DOE resource | Yes | Link |
| EX-21 | Hydrogen and Fuel Cell Safety | AHJ | No | | Yes | Link or API |

# 3.0 Future Activities

A small group of attendees from the planning session agreed to participate as an advisory group in future activities and the development of new tools. This group is identified in Appendix B (noted with an asterisk). They should be engaged through the design and development process as appropriate.

The planning session proved valuable for identifying opportunities to enhance the dissemination of safety knowledge. It was also valuable at connecting a number of different user groups together at one location/time to enable discussion on other non-session topics. Consideration should be given for future sessions at a two- or three-year frequency.

# 4.0 References

DOE. 2013. *Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan*. July 2013. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Washington, D.C.

# Appendix A

# Existing Hydrogen and Fuel Cell Safety Electronic Resources

# Appendix A

# Existing Hydrogen and Fuel Cell Safety Electronic Resources

Notes: Resources such as NFPA 2/853, safetygrams, and material safety data sheets are shown as examples, recognizing that other codes and standards organizations (e.g., CGA, ICC, SAE, CSA, ASME) and industrial gas suppliers also develop and provide similar resources.

| Resource by Category | URL | DOE-funded (Y/N) | Last Update/Posting |
|---|---|---|---|
| Databases/Websites (Including Regulations, C&S) | | | |
| Hydrogen Incident Reporting and Lessons Learned Database | http://www.h2incidents.org/ | Y | October 31, 2013 |
| Hydrogen Safety Bibliographic Database | http://www.hydrogen.energy.gov/biblio_database.html | Y | August 2008 |
| Hydrogen/Fuel Cell Codes and Standards | http://www.fuelcellstandards.com/ | N | |
| Hydrogen and Fuel Cell Safety | http://www.hydrogenandfuelcellsafety.info/ | Y | |
| 29 CFR 1910.103 Occupational Safety and Health Standards (Hydrogen) | https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9749 | N | |
| Storage and Handling of Gaseous and Liquefied Hydrogen | http://www.michigan.gov/lara/0,4601,7-154-35299_42271_4115_4237-193832--,00.html | N | |
| International Fire Code & International Building Code | http://www.iccsafe.org/Pages/default.aspx | N | 2015 |
| NFPA 1: Fire Code | http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=1 | N | 2015 |
| NFPA 2: Hydrogen Technologies Code | http://www.nfpa.org/2 | N | 2011 |
| NFPA 853: Standard for the Installation of Stationary Fuel Cell Power Systems | http://www.nfpa.org/853 | N | 2010 |
| Manuals | | | |
| Hydrogen Safety Best Practices | http://h2bestpractices.org/ | Y | April 18, 2013 |
| Technical Reference for Hydrogen Compatibility of Materials | http://www.sandia.gov/matlsTechRef/ | Y | May 13, 2013 |
| ANSI/AIAA G-095 - Guide to Safety of Hydrogen and Hydrogen Systems | http://www.aiaa.org/StandardsDetail.aspx?id=3864 [US$100.95] | N | 2004 |
| ISO/TR 15916 - Basic considerations for the safety of hydrogen systems | http://www.iso.org/iso/catalogue_detail?csnumber=29145 [CHF 172,00] | N | 2004 |
| FM Global Property Loss prevention Data Sheets | http://www.fmglobal.com/FMGlobalRegistration/Vshared/FMDS0791.pdf | N | January 2012 |

| Resource by Category | URL | DOE-funded (Y/N) | Last Update/Posting |
|---|---|---|---|
| Fliers, Posters, Newsletters, Reports, Apps, Other Literature | | | |
| Hydrogen Tools | iPhone/iPad app | Y | September 2013 |
| H2 Safety Snapshot | http://www1.eere.energy.gov/hydrogenandfuelcells/codes/snapshot.html | Y | July 2011 |
| Hydrogen Safety Tips for First Responders | http://www.dhses.ny.gov/ofpc/publications/documents/HydrogenPoster_v15.pdf | Y | |
| Fuel Cell and Hydrogen Safety Report (FCHEA) | http://www.hydrogenandfuelcellsafety.info/ | Y | September 2013 |
| Fact Sheet on Hydrogen Safety (FCHEA) | http://fchea.org/core/import/PDFs/factsheets/Hydrogen%20Safety_NEW.pdf | N | |
| Hydrogen Safety Fact Sheet (NHA) | http://www.arhab.org/pdfs/h2_safety_fsheet.pdf | Y | |
| National Template: Hydrogen Vehicle and Infrastructure Codes and Standards | http://www.afdc.energy.gov/pdfs/48609.pdf | Y | July 2010 |
| Hydrogen Vehicle and Infrastructure Codes and Standards Citations | http://www.afdc.energy.gov/pdfs/48608.pdf | Y | October 2013 |
| Regulations, Codes, and Standards Template for California Hydrogen Dispensing Stations | http://www.nrel.gov/docs/fy13osti/56223.pdf | Y | November 2012 |
| Reaching the U.S. Fire Service with Hydrogen Safety Information: A Roadmap | http://www.nfpa.org/~/media/Files/Research/Research%20Foundation/Research%20Foundation%20reports/For%20emergency%20responders/report%20final%20h2fs.pdf | Y | September 2009 |
| Safetygrams | http://www.airproducts.com/company/Sustainability/environment-health-and-safety/product-safety-safetygrams.aspx | N | April 2007 (LH2) February 2011 (GH2) |
| Materials Safety Data Sheets (GH2) | https://apdirect.airproducts.com/msds/DisplayPDF.aspx?docid=63578 | N | April 2006 |
| Materials Safety Data Sheets (LH2) | http://www.hydrogenandfuelcellsafety.info/resources/mdss/Praxair-LH2.pdf | N | September 2004 |
| Training | | | |
| Introduction to Hydrogen Safety for First Responders | http://www.hydrogen.energy.gov/firstresponders.html | Y | February 2009 |
| Introduction to Hydrogen for Code Officials | http://www.hydrogen.energy.gov/training/code_official_training/ | Y | August 2009 |
| Hydrogen Safety Training for Researchers | http://www.h2labsafety.org/ | Y | September 2010 |
| Permitting Hydrogen Facilities | http://www.hydrogen.energy.gov/permitting/ | Y | October 2013 |
| Regulators' Guide to Permitting Hydrogen Technologies | http://www1.eere.energy.gov/hydrogenandfuelcells/codes/permitting_guides.html | Y | October 2011 |
| Identification, Preparation and Dissemination of Hydrogen Safety | http://www.hyfacts.eu/ | N | |

| Resource by Category | URL | DOE-funded (Y/N) | Last Update/Posting |
|---|---|---|---|
| Facts to Regulators and Public Safety Officials (HyFACTS) | | | |
| IAFF HazMat/WMD Training | http://www.iaff.org/et/HW/index.htm | N | |
| | Properties, Calculators | | |
| Hydrogen Analysis Resource Center (HARC): Basic Hydrogen Properties | http://hydrogen.pnl.gov/cocoon/morf/hydrogen/article/701 | Y | July 2008 |
| HARC: Hydrogen Conversions Calculator | http://hydrogen.pnl.gov/cocoon/morf/hydrogen/site_specific/hydrogen_calculator?canprint=false. | Y | January 2012 |

# Appendix B

# Electronic Safety Resources Planning Session Attendees

# Appendix B

## Electronic Safety Resources Planning Session Attendees

**Date:** April 1, 2014
**Location:** Santa Fe Springs, CA Fire Department

| Name | Affiliation | Email | Telephone |
|---|---|---|---|
| Nick Barilo | PNNL | nick.barilo@pnnl.gov | 509/371-7894 |
| Dave Farese | Air Products | faresedj@apci.com | 610/481-4869 |
| Aaron Harris | Air Liquide | aaron.harris@airliquide.com | 713/385-3939 |
| Tim Martin | FS Studio | tim@fsstudio.com | 510/798-6392 |
| Carl Rivkin | NREL | carl.rivkin@nrel.gov | 303/275-3839 |
| Carl Baust | Orange Co. Fire | carlbaust@ocfa.org | 949-724-6391 |
| Tim McGuire | MBZ/SAE | tim.mcguire@daimler.com | 916/340-4824 |
| Eric Binder* | Santa Monica Fire Department | eric.binder@smgov.net | 310/434-2666 |
| Richard Kallman* | Santa Fe Springs Department of Fire-Rescue | richardkallman@santafesprings.net | 562/906-3810 |
| Monte Elmore | PNNL | monte.elmore@pnnl.gov | 509/551-1602 |
| Will James | US DOE | charles.james@ee.doe.gov | 202/287-6223 |
| Jay Keller | H2USA | jay.keller@zces-inc.com | 925/519-2043 |
| Chris San Marchi | Sandia National Lab | cwsanma@sandia.gov | 925/294-4880 |
| Kym Carey | US DOE | kym.carey@ee.doe.gov | 202/287/1775 |
| Stephen Woods | NASA WSTF | stephen.s.woods@nasa.gov | 575/524-5607 |
| Miguel J. Maes* | NASA WSTF | miguel.j.maes@nasa.gov | 575/524-5677 |
| Joe Gagliano* | California Fuel Cell Partnership | jgagliano@cafcp.org | 714/393-2520 |
| Dan Poppe* | Hydrogen Frontier | dpoppe@hydrogenfrontier.com | 951/741-3631 |
| Kevin Reinertson* | Office of the State Fire Marshal | kevin.reinertson@fire.ca.gov | 916/327-4998 |
| Spencer Quong | QAI, representing Toyota | squong@squong.com | 415/230-0140 |
| Jeromy Markwort | PNNL | jeromy@pnl.gov | 509/948-0250 |

*Advisory group member

# Appendix C

# Final Binning of Tickets

# Appendix C

# Final Binning of Tickets

| ID No. | Functionality | Tickets |
|---|---|---|
| OS-1 | Provide critical safety information to firefighters and secondary responders (tow and wrecking) when responding to an event, includes VIN scanning | • VIN scanning app - disposition of vehicle/out points (UNGRP)<br>• As a FR/SR: I need: critical safety information on vehicles and infrastructure when I am responding to an incident so I can safely identify hazards and mitigate incident (FR)<br>• on-scene response guide (FR)<br>• Vehicle ID (FR)<br>• Response guide (FR) |
| NW-1 | Facilitate networking among AHJs | • Email listserver user groups - 1 Los Angeles area Fire Marshals, 2 Southern CA Fire Prev officers, 3 Northern CA Fire Prev officers, 4 CA Building Officials (UNGRP)<br>• List server discussion on H2 safety issues (UNGRP)<br>• AHJ - Network tools to allow various groups to connect (AHJ)<br>• Network of contacts for information (AHJ) |
| NW-2 | Facilitate networking among inspectors | • Independent source to support AHJ as they have questions and looking for previous systems and installations (AHJ)<br>• Network for inspectors who have inspected with permit an H2 system in their jurisdiction (AHJ) |
| NW-3 | Facilitate networking among researchers and OEMs, station builders, etc. | • Network with auto OEMs, stations, builders, etc. to combine resources (reduce redundancy) (RD) |
| NW-4 | Consult with independent experts | • Send out H2safety.ee.doe.gov address (UNGRP)<br>• AHJs - utilize the panel? (UNGRP)<br>• Insurers - task force to develop and work with insurers (INS) |
| TR-1 | Operations and maintenance personnel need training on hazards and operating equipment that can provide certification | • Guidance on how to approach hazards in OM activities (OM)<br>• Provides station owners and operators a level of education to functionally operate the station through a possible certification process similar to USTs (OM)<br>• Operations and maintenance (car manufacturers, dealers, service stations, service personnel) education and understanding (OM)<br>• Operations - general training program for maintenance repair garages (OM) |
| TR-2 | Inspectors (AHJ) need education and training | • Education tools for inspectors (AHJ)<br>• Inspector Training (UNGRP) |
| NN-1 | Scenario-based training for first responders | • Hands on experience (FR)<br>• Event scenarios (FR)<br>• As a FR I need hands-on training for hydrogen emergencies response when I need training cert. so that I can enhance my basic training through real-life, scenario-based training and respond appropriately and safely to hydrogen emergencies (FR)<br>• Remove mystery of H2 fuel and hydrogen firefighting to boots on the ground. Demo and application (FR)<br>• Quickly identify when H2 fires are occurring (FR) |

| ID No. | Functionality | Tickets |
|---|---|---|
| CS-1 | A clear overview of applicable codes and standards using | • Overview of applicable requirements presented in an intelligible format (PP)<br>• Overview of applicable requirements presented in an intelligible format (AHJ)<br>• Provide simplified code application for fire and building officials based on adopted codes and standards (AHJ)<br>• Software for permitting stations. Outlining code requirements (AHJ)<br>• I need the industry to understand the codes and standards when I discuss project proposals with them so that I can assist them in moving their project forward (AHJ)<br>• Station design template w componentry and necessary codes and standards (AHJ)<br>• Plan view with requirement's overlaid of popup (AHJ)<br>• generic application - plan view with requirements overlaid (AHJ)<br>• I need to know the design constraints or considerations for gas enclosures (PP)<br>• As an AHJ, I need current codes and standards when I review and inspect so that I can provide a safe and usable facility (AHJ)<br>• I need the industry to understand the codes and standards when I discuss project proposals with them so that I can assist them in moving their project forward (PP)<br>• Desirable -No AM&Ms - always meet requirements of codes and standards -Concerned parties will propose changes (UNGRP)<br>Understanding of and use of codes and standards (PP)<br>• Need industry to understand the standards to access proposals. Performance based designs (UNGRP)<br>• Inspectors pictures and video of good and bad examples of installations compliant with Code (AHJ)<br>• Separation distance comparison table (AHJ)<br>• Need current codes and standards (UNGRP)<br>• Risk - Clear understanding of applicable laws and regulations (INS)<br>• Operations and maintenance policy guide for practical implementation (i.e., general contractor building hydrogen filling station - what are the building codes) (UNGRP)<br>• I need to know the applicable specifications to ask for to put out for an RFP - tool to outlay applicable C:S and performance specs (OM)<br>• AHJ - Codes and standards to apply (AHJ)<br>• Appreciation of behavior RCS (AHJ)<br>• Developed codes and standards (AHJ)<br>• Process was used to develop C&S (RD)<br>• What is needed R.C.S. (PUB) |

| ID No. | Functionality | Tickets |
|---|---|---|
| DR-1 | Design tools to help identify station locations (mapping), options for station configurations, standardized plan formats, and identify obstacles to project deployments | • PP: I am a BizDev planner. I need a tool when I am identifying locations for H2 fuel. So that I can Biz models and adjust master plans (INV)<br>• PP: I am a BizDev planner. I need a tool when I am identifying locations for H2 fuel. So that I can Biz models and adjust master plans (PP)<br>• Future: What we would like to see: standardized plan formats broken into details demonstrating compliance on referenced sheets and details. (UNGRP)<br>• PP: As a fuel supply engineer, I need an approved and vetted tool when I am putting in stations, H2 install. So that I can increase options for station design (PP)<br>• GIS systems to allow planners to visualize locations and implications (INV)<br>• Researchers - need understanding of obstacles to project deployment (RD)<br>• Public permits, govs office, reduce roadblocks (PUB) |
| DR-2 | Data on equipment and project performance including failure rate data, MTBF, incident data, real-time system performance and "denominator" information for frequency of incidents | • Denominator for frequency of incidents-#incidents/#demands (INS)<br>• Denominator for frequency of incidents-#incidents/#demands (RD)<br>• Denominator for frequency of incidents-#incidents/#demands (INV)<br>• Data on project performance (INV)<br>• Corp Risk Manager - big data/data fusion API service that allows various stakeholders to report H2 incidents and provide analysis (INS)<br>• Database of component evaluation MTBF (OM)<br>• Insurers - need operational data incident info to develop H2 insurance programs (INS)<br>• Station performance protocol and H2 quality verification (OM)<br>• Real-time system status database (OM)<br>• PR tool-big data/NLP to monitor H2 in public space and assessing general positive or general behavior (OM) |
| DR-3 | Modeling tools to predict consequences of cryogenic releases, pv failure, cryogenic to gas releases, gaseous releases, BLEVEs, etc., to support station layout and risk informed changes to regulation, codes and standards | • Tool to predict extent of cryogenic releases (UNGRP)<br>• Blast analysis, plume modeling (aloha trace) multiple hazards analysis methods, materials database (SNL), prob. Risk assessment (SNL), FMEAs (UNGRP)<br>• QRA and risk tool for helping design layout of station (PP)<br>• Tool to predict pv failure consequences (UNGRP)<br>• Place scientific finding in software for engineers (RD)<br>• Modeling cryo -> gaseous releases (RD)<br>• Risk informed approach to code requirements (RD)<br>• Mitigation should feed into code (UNGRP)<br>• Tool to predict extent of gaseous release (UNGRP)<br>• Tool to predict consequence of BLEVE (guide exclusive zone size) (UNGRP) |

| ID No. | Functionality | Tickets |
|---|---|---|
| DR-4 | Design detonation/deflagration arrestors | • Tool to design detonation/deflagration arrestors (UNGRP)<br>• Tools to design flame arrestors (UNGRP) |
| DR-5 | Enable the performance of risk assessments and provide options for risk mitigation, support performance-based analysis, include checklist functionality for basic risk, component databases, calculators and cost-benefit features | • Risk mitigation behavior RCS (PP)<br>• Risk mitigation behavior RCS (OM)<br>• Need a framework for risk assessment (INS)<br>• Need tools to enable the use of performance based permitting, application of RCS (PP)<br>• Need operational data and incident info to develop H2 insurance programs (INS)<br>• Insurers - risk assessment tools (INS)<br>• Designers need risk mitigation (how to) (PP)<br>• Checklist for assessing basic risk for various applications (PP)<br>• QRA Tool to assess risk, consequence design (PP)<br>• Hydrogen component database for risk assessment (RD)<br>• Liability Exposure from investment project (INV)<br>• Calculators - create a calculator that allows you to under various mitigation practices w/cost and space, safety…audience - public, owners, builders (UNGRP)<br>• Story around continued cost reduction while maintaining safety (INV) |
| GI-1 | Hydrogen safety portal as a credible and reliable and one stop shop for safety information | • H2 safety portal (UNGRP)<br>• One stop shop website (UNGRP)<br>• I am an Engineer and a C+S comm. I need results from a trustworthy source when I am proposing code changes so that I can win acceptance of my proposed changes (RD)<br>• Web Portal, a clearinghouse of all things H2 with links to appropriate resources and sites. (UNGRP)<br>• One stop shop reference about hydrogen (AHJ) |
| GI-2 | Public outreach utilizing television, radio, internet, etc., to address incidents, public concerns and education as well as provide detailed information on vehicles and stations | • "Nova" type prog? (UNGRP)<br>• Get a Hollywood star to front? Jack? (UNGRP)<br>• Broad dissemination of information regarding the timely events. i.e. radio (PUB)<br>• How to address public concerns (PUB)<br>• Outreach and Education (PUB)<br>• Benefits of H2 tech (PUB)<br>• General public confidence, H2 is safe (PUB)<br>• Videos for public to show its safe (UNGRP)<br>• High pressure vehicles in use (PUB)<br>• Infrastructure locations; i.e. filling stations safety locations/the fire stations (PUB)<br>• What is being done today? Not used for permitting in public. Used internally or was used to develop code SME reliance. (PP) |

| ID No. | Functionality | Tickets |
|---|---|---|
| GI-3 | Vehicle and equipment information covering general information, safety features, safe usage parameters, recall notices, etc. | • Permit Officials - Need to understand properties of H2 and Equipment to assess projects (AHJ)<br>• Equipment definitions and safe usage parameters (AHJ)<br>• 3 + 2 equipment definitions and safe usage parameters (FR)<br>• Very general appropriate info on H2 vehicles (FR)<br>• How is this technology different in terms of safety (INS)<br>• Need education of H2 cars to provide coverage (INS)<br>• Retail Operators - need safety data on equip & H2 to ensure safe operation (OM)<br>• Need safety data on equipment and H2 to ensure safe operations (OM)<br>• Project proponents car manufactures; want a utility to indicate safety info for FR, i.e., web service that provides updates for recall notifications and recall info (PP) |
| GI-4 | General safety information on properties of hydrogen and its behavior, including a Wiki and videos and diagrams showing important safety features, pressure safety, flame arrestors, vent systems and relief devices | • Permit Officials - Need to understand properties of H2 and Equipment to assess projects (AHJ)<br>• As a FR I need internet resources (Wiki) when I have general questions on hydrogen behavior so I can have access to appropriate current info (FR)<br>• H2 Behavior (OM)<br>• Wiki (RD)<br>• Wiki (PP)<br>• Wiki (OM)<br>• Wiki (INV)<br>• Wiki (INS)<br>• Wiki (FR)<br>• Wiki (AHJ)<br>• Videos and Diagrams showing important safety features (AHJ)<br>• H2 Behavior (FR)<br>• As a FR I need internet resources (Wiki) when I have general questions on hydrogen behavior so I can have access to appropriate current info (FR)<br>• Pressure safety for compressible fluids (OM)<br>• Operations - Pressure safety of compressed fluids (OM)<br>• Provide guides on specific topics, flame arrestors, vent systems, relief devices, etc. (PP) |
| CI-1 | Guide for project certification by third party based on a tool/methodology that the AHJ can trust, may include a component certification checklist | • Component certification checklist (PP)<br>• Qualified 3rd party reviewers (AHJ)<br>• 3rd party vs fire dept expertise (AHJ)<br>• AHJ needs access to this tool to develop trust in the product from the designer (PP)<br>• Guide for project certification (PP) |

| ID No. | Functionality | Tickets |
|---|---|---|
| CI-2 | List of listed/approved equipment and systems to support review and approval of designs | • Coded and labeled systems (PP)<br>• List of tools/products from labs (UNGRP)<br>• I need to know if this designed safely and appropriately without prohibiting/penalizing design (AHJ)<br>• As an AHJ I need products that have been listed and approved (By UL, FM) when I review and inspect so that I can approve project more effectively (AHJ)<br>• Meeting the code stay w/in the box keeping uniform and using listed/approved products/design per standards or guidelines (PUB) |
| IA-1 | Interactive tool to manage public opinion and response | • Broad dissemination of information regarding the timely events. i.e. radio (PUB)<br>• Outreach and Education (PUB)<br>• Monitor media and social media and respond with proactive radio response team (UNGRP) |
| IA-2 | Hotlines for responding to incidents and special issues | • ERG Database and Hotline (FR)<br>• Currently: Rely on SME to inform me (PP)<br>• Database hotline (FR)<br>• How to handle special issues (AHJ)<br>• SME (RD)<br>• Q&A Hotline (AHJ) |

# Appendix D

# Affected User Groups for New Functional Tools

# Appendix D

# Affected User Groups for New Functional Tools

| | | Affected User Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ID # | Functionality | AHJ | FR/SR | OM | PP | RD | INV | PUB | INS |
| GI-4 | General safety information on properties of hydrogen and its behavior, including a Wiki and videos and diagrams showing important safety features, pressure safety, flame arrestors, vent systems and relief devices | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GI-1 | Hydrogen safety portal as a credible and reliable and one stop shop for safety information | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CS-1 | A clear overview of applicable codes and standards using | ✓ | | ✓ | ✓ | ✓ | | | ✓ |
| DR-3 | Modeling tools to predict consequences of cryogenic releases, pv failure, cryogenic to gas releases, gaseous releases, BLEVEs, etc., to support station layout and risk informed changes to regulation, codes and standards | ✓ | | | ✓ | ✓ | | | ✓ |
| DR-5 | Enable the performance of risk assessments and provide options for risk mitigation, support performance-based analysis, include checklist functionality for basic risk, component databases, calculators and cost-benefit features | ✓ | | | ✓ | | ✓ | | ✓ |
| IA-2 | Hotlines for responding to incidents and special issues | ✓ | ✓ | ✓ | ✓ | ✓ | | | |
| NW-1 | Facilitate networking among AHJs | ✓ | | | | | | | |
| NW-2 | Facilitate networking among inspectors | ✓ | | | | | | | |
| CI-1 | Guide for project certification by third party based on a tool/methodology that the AHJ can trust, may include a component certification checklist | ✓ | | | ✓ | | | | |
| GI-3 | Vehicle and equipment information covering general information, safety features, safe usage parameters, recall notices, etc. | ✓ | ✓ | ✓ | | | | | ✓ |
| TR-2 | Inspectors (AHJ) need education and training | ✓ | | | | | | | |
| DR-2 | Data on equipment and project performance including failure rate data, MTBF, incident data, real-time system performance and "denominator" information for frequency of incidents | | | ✓ | | ✓ | ✓ | | ✓ |
| OS-1 | Provide critical safety information to firefighters and secondary responders (tow and wrecking) when responding to an event, includes VIN scanning | | ✓ | | | | | | |

| | | Affected User Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ID # | Functionality | AHJ | FR/SR | OM | PP | RD | INV | PUB | INS |
| DR-1 | Design tools to help identify station locations (mapping), options for station configurations, standardized plan formats, and identify obstacles to project deployments | | | | ✓ | ✓ | ✓ | | |
| CI-2 | List of listed/approved equipment and systems to support review and approval of designs | ✓ | | | ✓ | | | | ✓ |
| NW-3 | Facilitate networking among researchers and OEMs, station builders, etc. | | | | ✓ | ✓ | | | |
| TR-1 | Operations and maintenance personnel need training on hazards and operating equipment that can provide certification | | | ✓ | | | | | |
| NN-1 | Scenario-based training for first responders | | ✓ | | | | | | |
| NW-4* | Consult with independent experts | ✓ | | | | | | | ✓ |
| GI-2* | Public outreach utilizing television, radio, internet, etc., to address incidents, public concerns and education as well as provide detailed information on vehicles and stations | | | | | | | ✓ | |
| IA-1* | Interactive tool to manage public opinion and response | | | | | | | ✓ | |
| DR-4* | Design detonation/deflagration arrestors | | | | ✓ | | | | |

* Discussion of this item is not included in the main body of the report as the item is not a safety and/or electronic resource need.

# Appendix E

# Affected User Groups for Existing Electronic Safety Resource Tools (DOE & Non-DOE)

# Appendix E

# Affected User Groups for Existing Electronic Safety Resource Tools (DOE & Non-DOE)

| | | Affected User Groups | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID # | Title | AHJ | FR/SR | OM | PP | RD | INV | PUB | INS | Last Updated | Needs Updating? |
| EX-17 | Hydrogen Safety Fact Sheet (NHA) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | No |
| EX-6 | HARC: Basic Hydrogen Properties | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 2008 | Maybe |
| EX-2 | Hydrogen Incident Reporting and Lessons Learned Database | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | 2014 | Yes |
| EX-4 | Hydrogen Analysis Resource Center (HARC): Hydrogen Conversion Calculator | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | 2012 | Maybe |
| EX-3 | Hydrogen Safety Best Practices | ✓ | | ✓ | ✓ | ✓ | | ✓ | ✓ | 2013 | No |
| EX-13 | Hydrogen/Fuel Cell Codes and Standards | ✓ | | ✓ | ✓ | | ✓ | | ✓ | 2014 | |
| EX-12 | Technical Reference for Hydrogen Compatibility of Materials | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | 2013 | |
| EX-19 | Hydrogen Vehicle and Infrastructure Codes and Standards Citations | ✓ | | ✓ | ✓ | | | | ✓ | 2013 | No |
| EX-5 | Hydrogen Safety Bibliographic Database | ✓ | | | ✓ | ✓ | | | | 2008 | Yes |
| EX-18 | National Template: Hydrogen Vehicle and Infrastructure Codes and Standards | ✓ | | | ✓ | | ✓ | | ✓ | 2010 | Maybe |
| EX-14 | Regulations, Codes, and Standards Template for California Hydrogen Dispensing Stations | ✓ | | | ✓ | | ✓ | | | 2012 | |
| EX-10 | Hydrogen Tools IOS App | ✓ | | ✓ | ✓ | ✓ | | | | 2014 | |
| EX-16 | Hydrogen Safety Tips for First Responders | | ✓ | | | | | | | ? | No |

| | | Affected User Groups | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID # | Title | AHJ | FR/SR | OM | PP | RD | INV | PUB | INS | Last Updated | Needs Updating? |
| EX-20 | Reaching the U.S. Fire Service with Hydrogen Safety Information: A Roadmap | ✓ | ✓ | | | | | | | 2010 | No |
| EX-11 | Hydrogen Safety Snapshot | ✓ | | ✓ | ✓ | ✓ | | | | 2011 | |
| EX-9 | Permitting Hydrogen Facilities | ✓ | | | ✓ | | | | | 2013 | |
| EX-21 | Hydrogen and Fuel Cell Safety | ✓ | | | | | | | | 2014 | No |
| EX-1 | Introduction to Hydrogen Safety for First Responders | | ✓ | | | | | | | 2009 | Yes |
| EX-15 | Hydrogen Safety Training for Researchers | | | | | ✓ | | | | 2010 | Yes |
| EX-7 | Introduction to Hydrogen for Code Officials | ✓ | | | | | | | | 2009 | Yes |
| EX-8 | Regulators' Guide to Permitting Hydrogen Technologies | ✓ | | | | | | | | 2011 | |

# Appendix F

# Tickets Associated with Existing Tools

# Appendix F

# Tickets Associated with Existing Tools

| ID No. | Functionality | Tickets |
|---|---|---|
| EX-1 | Introduction to Hydrogen Safety for First Responders | • Uniform and current training (FR)<br>• Quickly identify when H2 fires are occurring (FR)<br>• Training tools data/database understanding of... (FR)<br>• Up to date training as tech evolves (FR)<br>• Simple, easy to remember training on H2 safety issues (FR)<br>• FR - Up-to-date training materials as technology evolves (FR)<br>• Event scenarios (FR) |
| EX-2 | Hydrogen Incident Reporting and Lessons Learned Database | • H2 Fire incident reporting (PP)<br>• Lessons learned (PP)<br>• Does the incidents db need freq disclaimer (EXST)<br>• H2 Fire incident reporting (AHJ) |
| EX-3 | Hydrogen Safety Best Practices | • Best practices (INV) |
| EX-4 | Hydrogen Analysis Resource Center (HARC): Hydrogen Conversion Calculator | • Basic tools for H2 properties calculators etc. - all audiences (PP) |
| EX-5 | Hydrogen Safety Bibliographic Database | • History of past R&D efforts, easy access to info to preserve institutional knowledge (RD) |
| EX-6 | HARC: Basic Hydrogen Properties | • Basic tools for H2 properties calculators etc. - all audiences (PP) |
| EX-7<br>EX-8 | Introduction to Hydrogen for Code Officials<br>Regulators' Guide to Permitting Hydrogen Technologies | • Consistent training of hydrogen standards cross all AHJs (to attempt standardization) (AHJ)<br>• AHJ - Codes, standards, training, development (AHJ)<br>• As an AHJ I need training for when I plan review and inspect so that safety, uniformity, and reduced cost (AHJ)<br>• Permit Officials - Need to understand properties of H2 and Equipment to assess projects (AHJ)<br>• AHJ - Understanding codes, consequence, mitigation methods (AHJ)<br>• I as an AHJ need to have trained and resources when I address/review projects that are performance base designs (AHJ) |
| EX-9 | Permitting Hydrogen Facilities | None |
| EX-10 | Hydrogen Tools IOS App | None |
| EX-11 | Hydrogen Safety Snapshot | • Tool: database/outreach with a monthly quarterly newsletter like CCPS Beacon (UNGRP)<br>• Coffee break training - one page summary on all topics (UNGRP) |

| ID No. | Functionality | Tickets |
|---|---|---|
| EX-12 | Technical Reference for Hydrogen Compatibility of Materials | None |
| EX-13 | Hydrogen/Fuel Cell Codes and Standards | None |
| EX-14 | Regulations, Codes, and Standards Template for California Hydrogen Dispensing Stations | None |
| EX-15 | Hydrogen Safety Training for Researchers | None |
| EX-16 | Hydrogen Safety Tips for First Responders | None |
| EX-17 | Hydrogen Safety Fact Sheet (NHA) | None |
| EX-18 | National Template: Hydrogen Vehicle and Infrastructure Codes and Standards | None |
| EX-19 | Hydrogen Vehicle and Infrastructure Codes and Standards Citations | None |
| EX-20 | Reaching the U.S. Fire Service with Hydrogen Safety Information: A Roadmap | None |
| EX-21 | Hydrogen and Fuel Cell Safety | None |

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NATIONAL LABORATORY

U.S. DEPARTMENT OF
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