

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

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Pacific Northwest National Laboratory

Hydrogen Program Annual Merit Review
and Peer Evaluation Meeting
June 8, 2023

Overview

HYDROGEN SAFETY PANEL, SAFETY KNOWLEDGE TOOLS, AND FIRST RESPONDER TRAINING RESOURCES

Project Timeline

- ▶ Project start date: March 2003
- ▶ Project end date: September 2023¹

Budget

- ▶ FY22 DOE funding: \$1,075K
- ▶ FY23 DOE funding received a/o March: \$0K
- ▶ Planned FY23 DOE funding: \$450K

Partners

- ▶ Panel member organizations
- ▶ California Energy Commission (CEC)
- ▶ AIChE Center for Hydrogen Safety (CHS)

Barriers

- ▶ Safety is not always treated as a continuous process
- ▶ Safety data and information — limited access and availability
- ▶ Lack of hydrogen knowledge by AHJs

¹ Project continuation and direction determined annually by DOE.

Why Focus on Hydrogen Safety

Safety issues can be a 'deal breaker' and must be addressed for successful hydrogen technology acceptance and deployment

Its Use as a Fuel is New to Many

- ▶ Users may lack experience or expertise for its safe use
- ▶ Some users have misconceptions... and may not know that they don't know



Stable Foundation

- ▶ Hydrogen can be used safely... It has been for nearly a century by industry
- ▶ Safety knowledge and best practices exist

Dangerous Assumptions

- ▶ "We already know how to use hydrogen safety" (apathy - established users)
- ▶ "Hydrogen is like any other flammable gas" (misconceptions - new players)
- ▶ "Hydrogen is too dangerous" (fear - general public/AHJs)

Failing to address the knowledge gaps can result in impactful incidents and industry setbacks

Goals

Enable the safe and timely transition to hydrogen and fuel cell technologies by:

- **HSP:** sharing the benefit of extensive experience and providing suggestions and recommendations pertaining to the safe use and handling of hydrogen, and
- **H2Tools Portal:** supporting the implementation of the practices and procedures that will ensure safety in the handling and use of hydrogen in a variety of fuel cell applications.

***Embracing a culture of safety
will be vital to realize the
potential of hydrogen and its
widescale adoption***

Relevance

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

Barrier from SCS MYRDD ³	PNNL Objectives (impacts are provided on later slides)
C. Safety is not always treated as a continuous process G. Insufficient technical data to revise standards	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
A. Safety data and information — limited access and availability D. Lack of hydrogen knowledge by AHJs	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 Participate in key outreach opportunities to share HSP learnings and safety information with AHJs and code officials

³ Technical Plan – Hydrogen Safety, Codes and Standards, Section 3.7, Multi-Year Research, Development and Demonstration Plan, 2015, pp. 21-22 (updated June 2015), https://www.energy.gov/sites/prod/files/2015/06/f23/fcto_myrrdd_safety_codes.pdf.

Approach

Priority attention to safety and enhanced visibility



HYDROGEN

Safety Panel

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



HYDROGEN

Tools

- ▶ Identify and expand tools and methods to support hydrogen and fuel cell commercialization and disseminate hydrogen safety knowledge through the Hydrogen Tools Portal (<http://h2tools.org>)
- ▶ Bring greater visibility to hydrogen safety and the project's safety knowledge tools through presentations and webinars to relevant audiences not familiar with fuel cell technologies

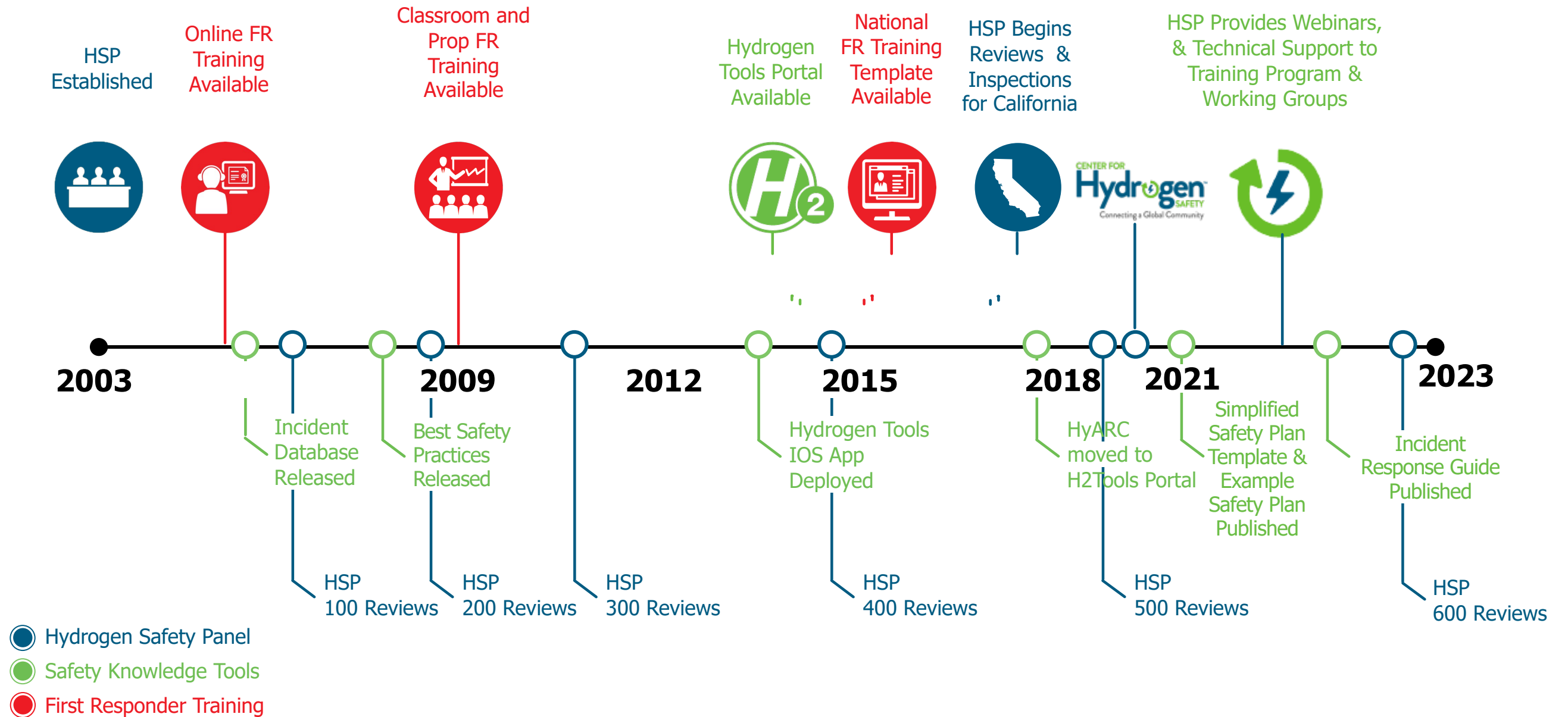


HYDROGEN

Emergency Response Training Resources

- ▶ Transitioned to the Center for Hydrogen Safety (CHS) in FY2020

Hydrogen Safety Program Timeline



Celebrating 20 Years of Advancing the Safe Use of Hydrogen

- ▶ 609 safety reviews covering 437 projects
- ▶ 300+ US and global hydrogen safety presentations
- ▶ 15 hydrogen safety guides
- ▶ A global hydrogen safety information portal
 - 3,467 pages of information
 - 2,385 bibliographic references
 - 222 lessons learned records
 - 100 best safety practices
 - 449 records in the hydrogen codes and standards database
 - 37K user sessions per month
- ▶ Applied learning resources on hydrogen safety
 - 22 eLearning courses/training webinars
 - A first-of-its-kind fundamental hydrogen safety credential
 - 2,267 webinar attendees (from 7 webinars led by HSP members)
 - 10,000+ first responders trained
 - A national first responder training template
 - More than 2,000 fundamental hydrogen safety trainings provided
- ▶ Creation of an international community for applied hydrogen safety
 - CHS: Created in 2019 now with more than 100 members from 14 countries





Hydrogen Safety Panel (HSP)

Hydrogen Safety Panel Membership

The HSP is a multidisciplinary team of engineers, code officials, safety professionals, equipment providers, and testing and certification experts that provides guidance for hydrogen projects and facilities, through design and process safety reviews, hazard analysis support, inspections, and training.



HSP 2023 Panel Meeting at Kennedy Space Center

Name	Affiliation
Nick Barilo, Manager	Pacific Northwest National Laboratory
Rick Tedeschi, Chair	Tedeschi Consulting Solutions, LLC
Harold Beeson	WHA International, Inc
Ken Boyce	UL, LLC
Bud Bucci	Tradewind Services, LLC
*Tom Drube	Chart Industries
David Farese	Durham Consulting, LLC
Donald Frikken	Becht Engineering
Livio Gambone	Nikola Motors
Aaron Harris	Air Liquide
Brian Ladds	Calgary Fire Department
Chris LaFleur	Sandia National Laboratories
Miguel Maes	NASA-JSC White Sands Test Facility
*David Moore	AcuTech-Consulting
Larry Moulthrop	Proton Onsite (ret.)
Dani Murphy	WHA International, Inc.
*Annemarie Purmer	OCI Global
Spencer Quong	Quong & Associates
Ilse Reyes	NASA-JSC White Sands Test Facility
Brian Somerday	Somerday Consulting, LLC
Gary Stottler	Stottler Development, LLC
Kelly Thomas	Baker Engineering and Risk Consultants, Inc.
Tom Witte	Witte Engineered Gases & Cryogenics
Robert Zalosh	Firexplo

* New Panel Member

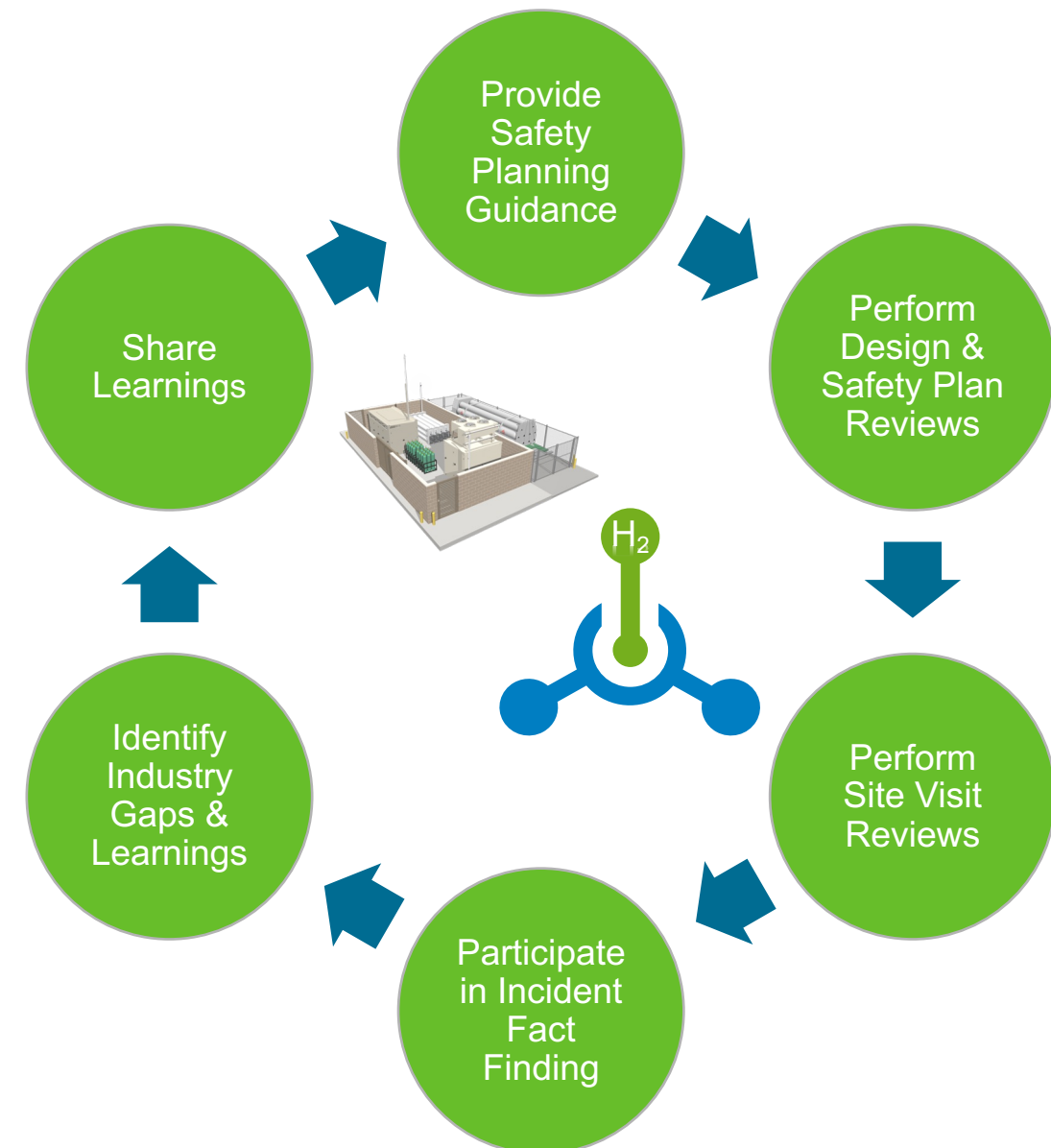
Relevance

HSP's overall purpose and objectives

Purpose: Share the benefits of extensive experience by providing suggestions and recommendations pertaining to the safe handling and use of hydrogen.

Objective: Enable the safe and timely transition to hydrogen technologies by:

- ▶ Participating in hydrogen projects to ensure safety is adequately considered
- ▶ Providing expertise and recommendations to stakeholders and assisting with identifying safety-related gaps, best practices, and lessons learned
- ▶ Supporting the safe deployment of hydrogen hubs



Hydrogen Safety Panel Results



THE HSP PROMOTES SAFE OPERATION, HANDLING, AND USE OF HYDROGEN

Background

- ▶ Formed in 2003
- ▶ 24 members with 700+ yrs combined experience
- ▶ Hydrogen safety reviews – hydrogen fueling, auxiliary power, backup power, CHP, portable power, and lab R&D
- ▶ White papers, reports, and guides
- ▶ Provides support on the application of hydrogen codes and standards
- ▶ H₂ safety knowledge shared through the H₂ Tools Portal (h2tools.org)

20 Years

609 Reviews

437 Projects

300+ Presentations

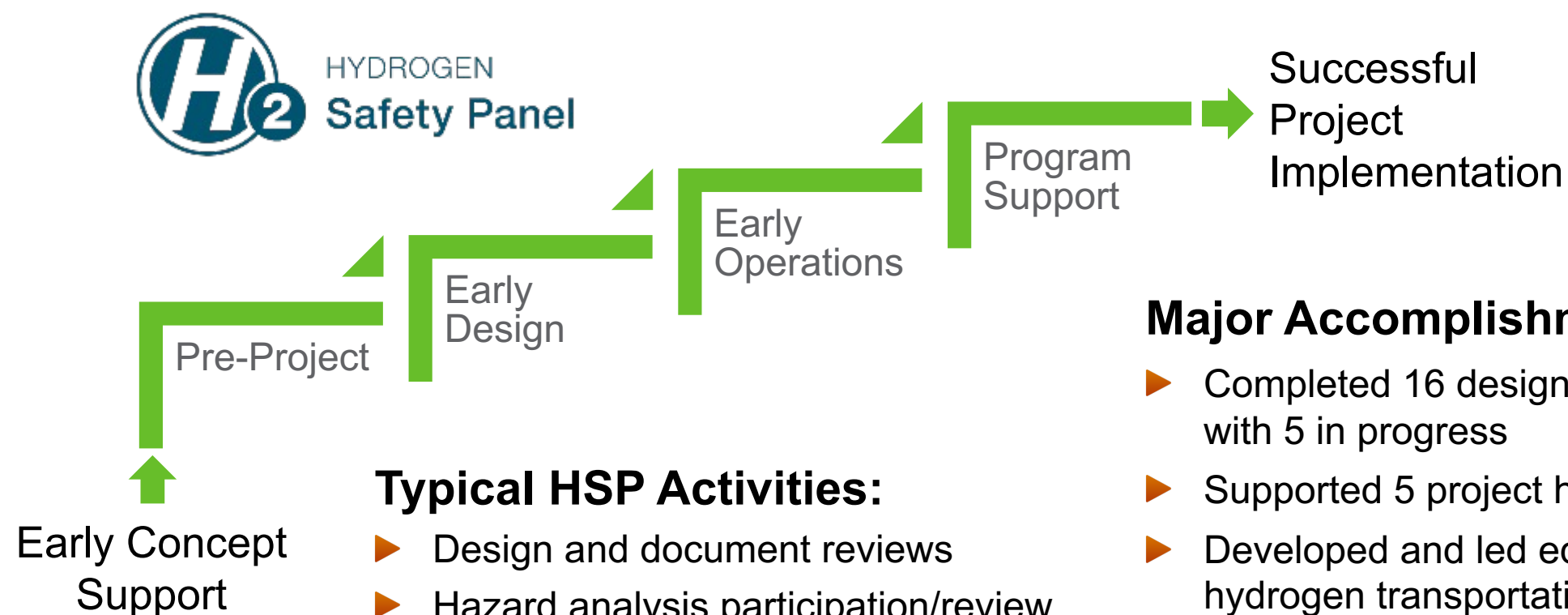
15 Guides

Impact

- ▶ Non-regulatory, objective, and neutral
- ▶ Helps reduce costs
 - Costs from over-engineering
 - Delayed approvals
 - Missed safety considerations/features
- ▶ Provides a balanced solution to questions and problems
- ▶ Helps projects avoid safety incidents
- ▶ Helps establish stakeholder and public confidence

Accomplishments

Extending the Reach of the HSP



Typical HSP Activities:

- ▶ Design and document reviews
- ▶ Hazard analysis participation/review
- ▶ Site safety evaluations
- ▶ Safety training and webinars
- ▶ Outreach
- ▶ Incident investigation

Major Accomplishments Since Last AMR:

- ▶ Completed 16 design/safety plan project reviews with 5 in progress
- ▶ Supported 5 project hazard analysis reviews
- ▶ Developed and led educational safety webinars on hydrogen transportation, hazard analysis, material compatibility, and liquid hydrogen
- ▶ Published multiple international magazine articles
- ▶ Presented at CHS Americas Conference
- ▶ Developed laboratory hydrogen safety training course
- ▶ Developed an Incident Management Guide

Accomplishments

Adapting to Growing Industry Safety Needs

Historical Focus

- ▶ Primarily DOE-project safety plan reviews
- ▶ Added California light-duty fueling station and production plant design reviews (CRADA)
- ▶ Development of information tools for laboratory/research



Current and Future Focus

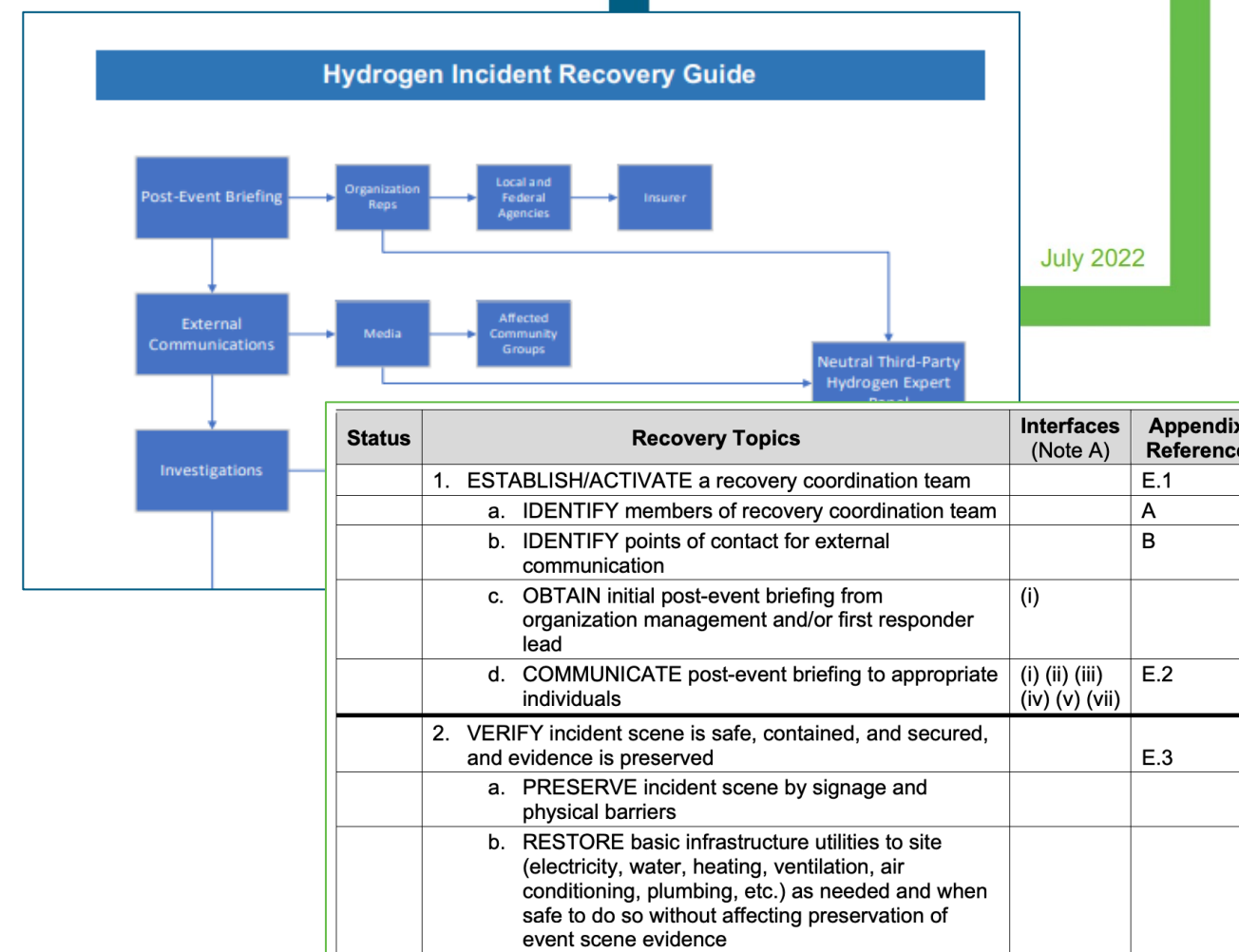
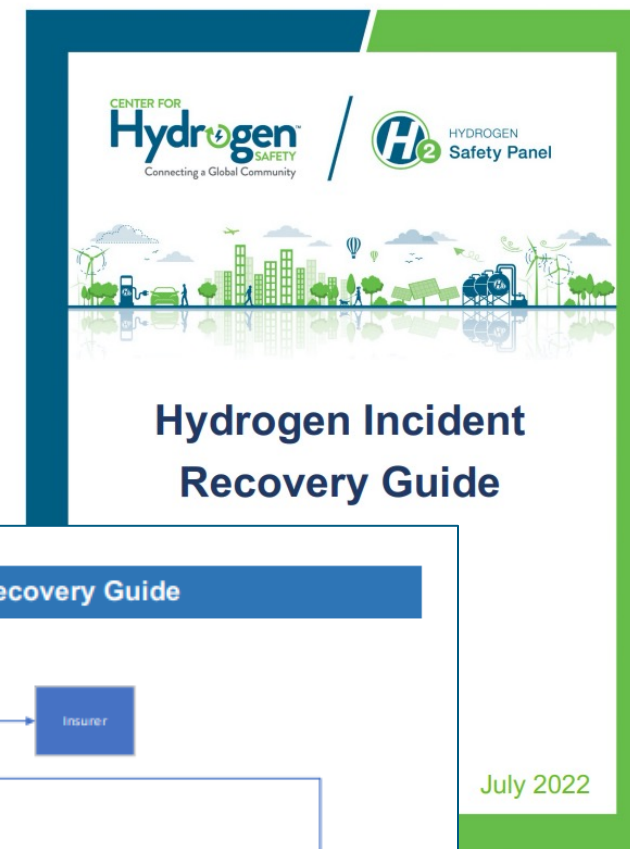
- ▶ DOE and non-DOE safety plan reviews
- ▶ Design reviews for diverse project phases and varied projects resulting in complex interactions
- ▶ Increasing hazard and risk analysis support
- ▶ Increasing code and standards feedback for organizations new to the hydrogen industry
- ▶ Expansion of information tools for safety culture improvement

Accomplishments

New HSP Document

Hydrogen Incident Recovery Guide

- ▶ Published July 2022
- ▶ Provides practical guidance with a checklist to help an organization recover from a hydrogen incident and return to normal operations
- ▶ Applies to the post-event recovery phase after the event scene has been stabilized and returned to the organization by the incident commander
- ▶ Depending on the severity of the incident, this guidance can be tailored to meet the specific needs of the organization



Other Accomplishments

Cooperative Research and Development Agreements (CRADA)

California Energy Commission (CEC) CY19-28

****EXTENDED END DATE FROM 2023 to 2028****

Activities to support the California hydrogen fueling infrastructure, including renewable hydrogen production facilities

- ▶ Provide safety reviews of designs, plans, and facilities
- ▶ Provide outreach to code officials, stakeholders, and first responders
- ▶ Review hydrogen incidents
- ▶ Support hazard analyses
- ▶ Reviews expanded to cover medium and heavy-duty fueling infrastructure
- ▶ The HSP is recognized as an impactful resource with companies new to the industry rather than just a “check-the-box” interaction



Artist's View of GTI/Sierra Northern Proposed H₂-powered Switcher
(Courtesy GTI.energy.com)

Learnings from these activities are brought back to California, DOE, and the hydrogen community

Other Accomplishments

Cooperative Research and Development Agreements (CRADA)

American Institute of Chemical Engineers (AIChE) CY23-25

This CRADA will synergize PNNL and AIChE capabilities and technical expertise to develop and broadly share hydrogen safety knowledge

Goals

- ▶ Ensure impactful hydrogen safety resources have broad industry development support, acceptance, and use
- ▶ Facilitate continuity in PNNL's participation in and DOE's influence on the development of important hydrogen safety resources until they are fully transitioned to industry

Tasks

- ▶ Hydrogen Safety Education Material Development
- ▶ Technical Coordination to Support Incident Fact-Finding and Other Hydrogen Safety Data Collection
- ▶ Hydrogen Safety Communication and Outreach
- ▶ Build the Future-Generation HSP Expert Pipeline Review
- ▶ Hydrogen Safety Panel Reviews

The successful partnership between AIChE and PNNL under this CRADA will:

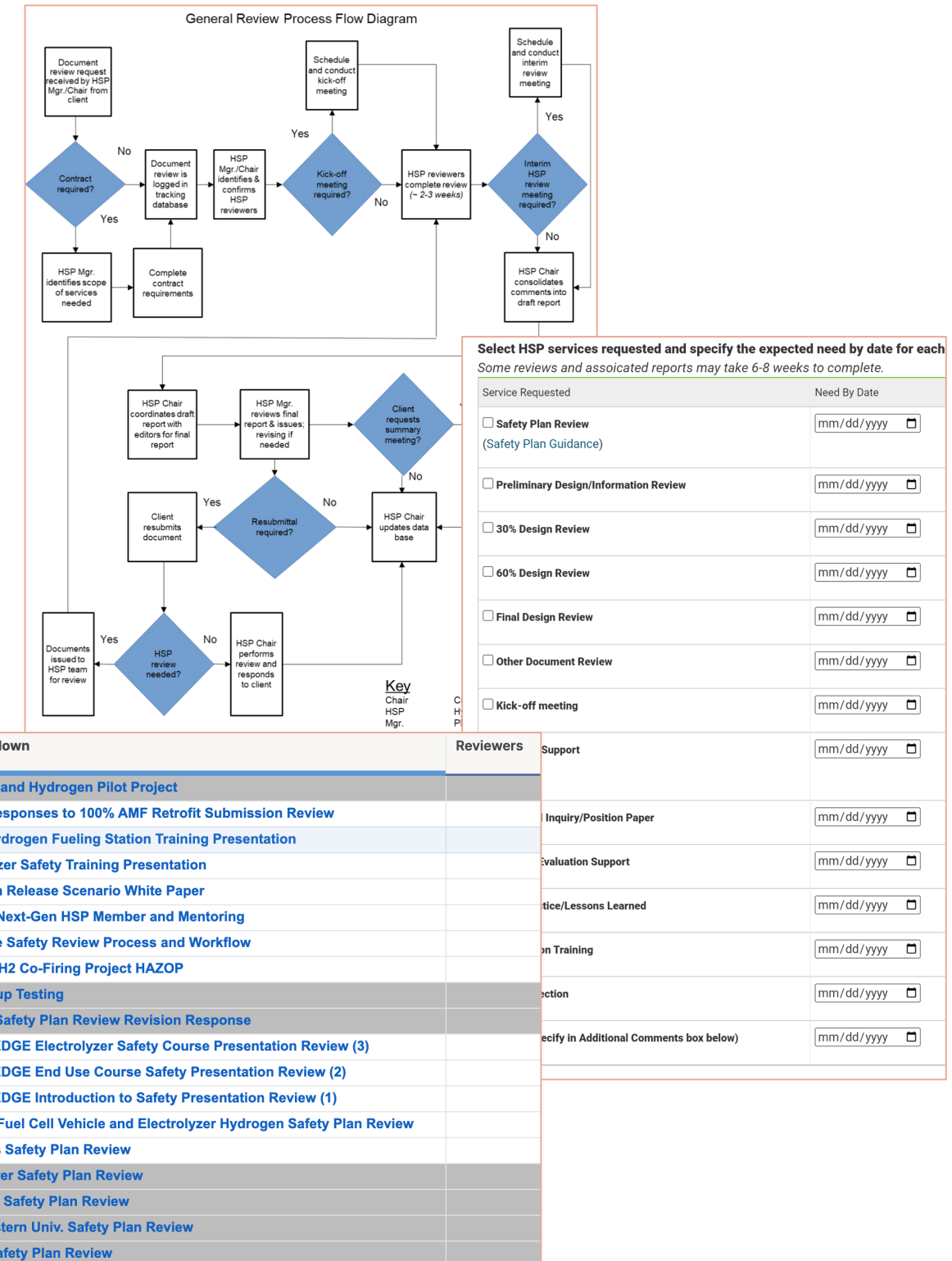
- Further amplify the impact of the hydrogen safety resources of both organizations,
- Help make the resources and the industry-wide focus on safety more sustainable, and
- Assist in transitioning the leadership of safety awareness and responsibilities from the government to the industry as the industry continues to grow and mature.

Accomplishment

HSP Review Process Streamlined

To accommodate the increasing demand for safety-related expertise, the PNNL has identified and implemented an integrated approach to enhancing its workflow toward greater operational efficiency and timeliness.

- ▶ Workflow standardization with identification of operating procedures, roles, and responsibilities
- ▶ Implementation of a web-based review request form that allows users to submit a safety review request to h2tools.org directly
- ▶ Implementation of web-based task tracking to capture, track, and update task progress
- ▶ Refined roles and strategic redundancy for task management to offload administrative actions from the HSP leadership to mitigate the risk of having a single point of failure on the team



Moving Forward

Continuing and Developing Depth of HSP Expertise

Building the HSP expertise pipeline

- ▶ Expanding hydrogen technologies and advanced applications requires growing safety technology expertise
- ▶ 2022 featured success in recruiting three new HSP members with a wide range of experience, including a new international member (Netherlands)
- ▶ A mentoring guide is being developed, and several potential candidates have been identified
- ▶ Interface with CHS provides excellent opportunities for collaboration and identification of potential new members and mentees

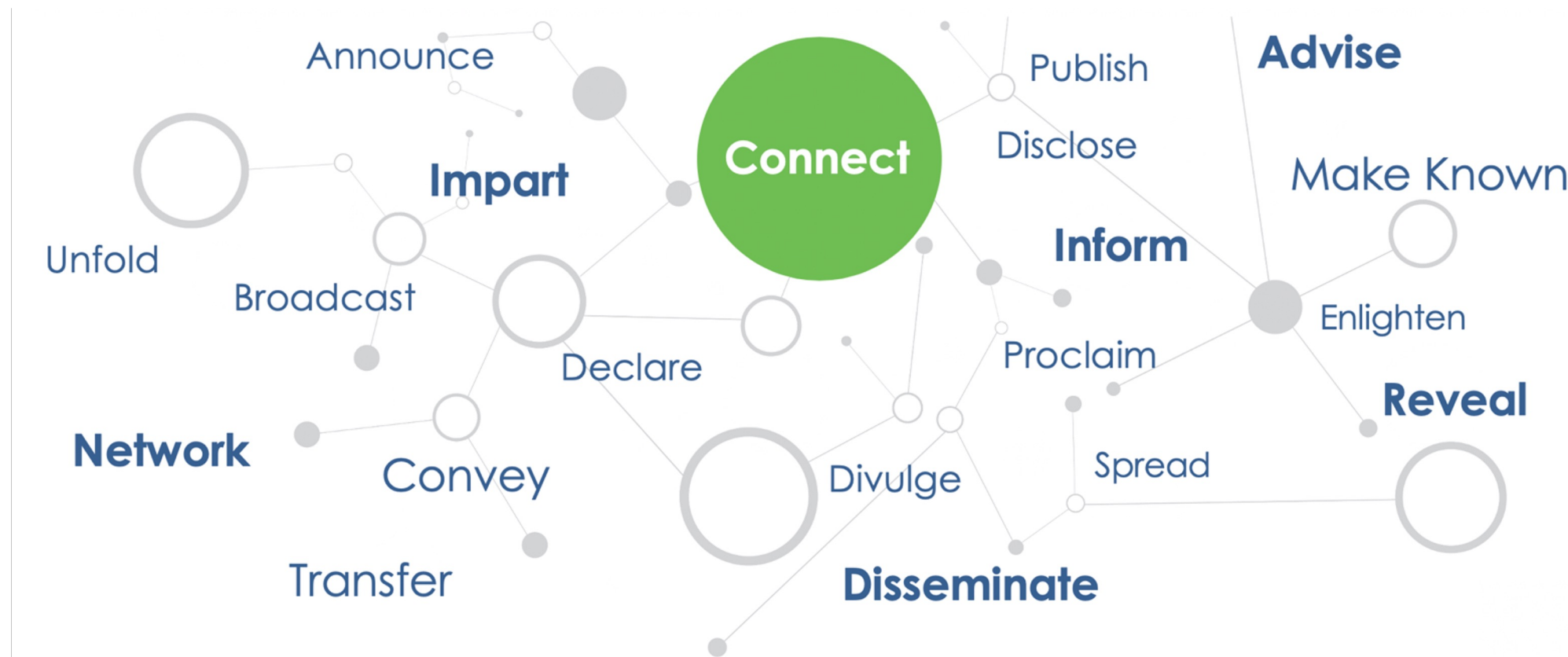


Dublin, Ireland, Trinity Library

Safety Knowledge Tools and Information Dissemination

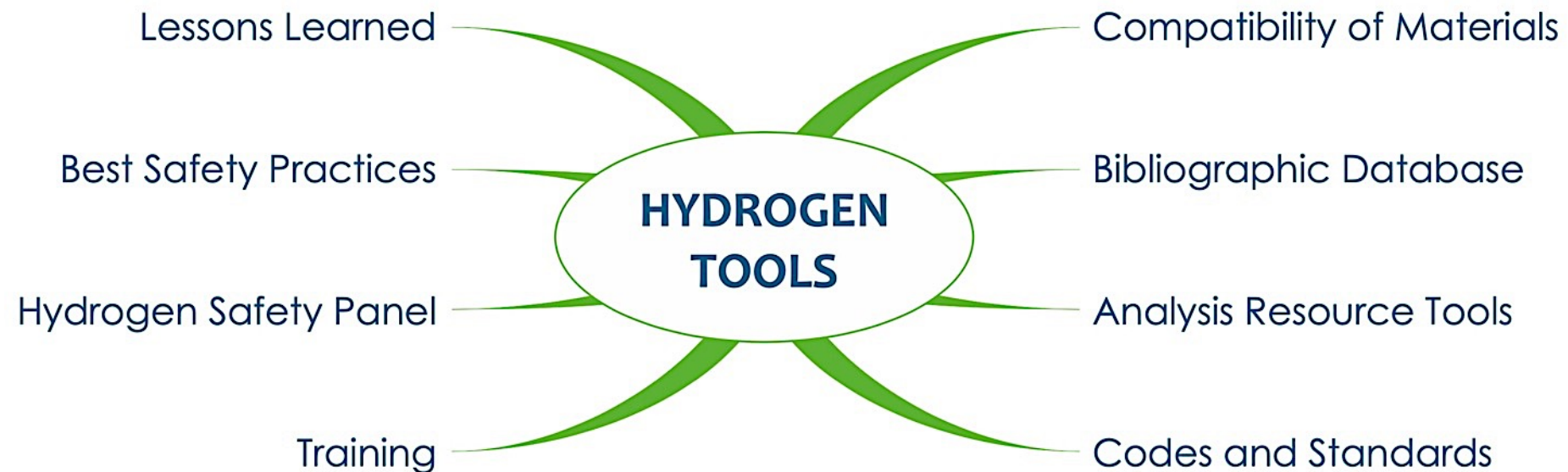
Connecting People to Safety Knowledge

- **Communication of hydrogen specific safety guidance** will be critical to the success of hydrogen as a part of the global energy transition
- Establishing and communicating best practices **from a trusted, independent safety resource** is a valuable part of the hydrogen safety ecosystem



Hydrogen Tools Portal – *h2tools.org*

Significant hydrogen safety resources in one location



- ▶ Supports implementation of the safe handling practices and procedures
- ▶ Brings together a variety of tools and web-based content on the safety of hydrogen
- ▶ Informs designers, stakeholders, and first responders

Accomplishments

Hydrogen Tools website stats

Site Content

3,467	Total pages
2,385	Bibliographic references
222	Lessons learned pages
100	Best safety practices pages
449	Hydrogen/Fuel Cell Codes & Standards

Usage Stats*

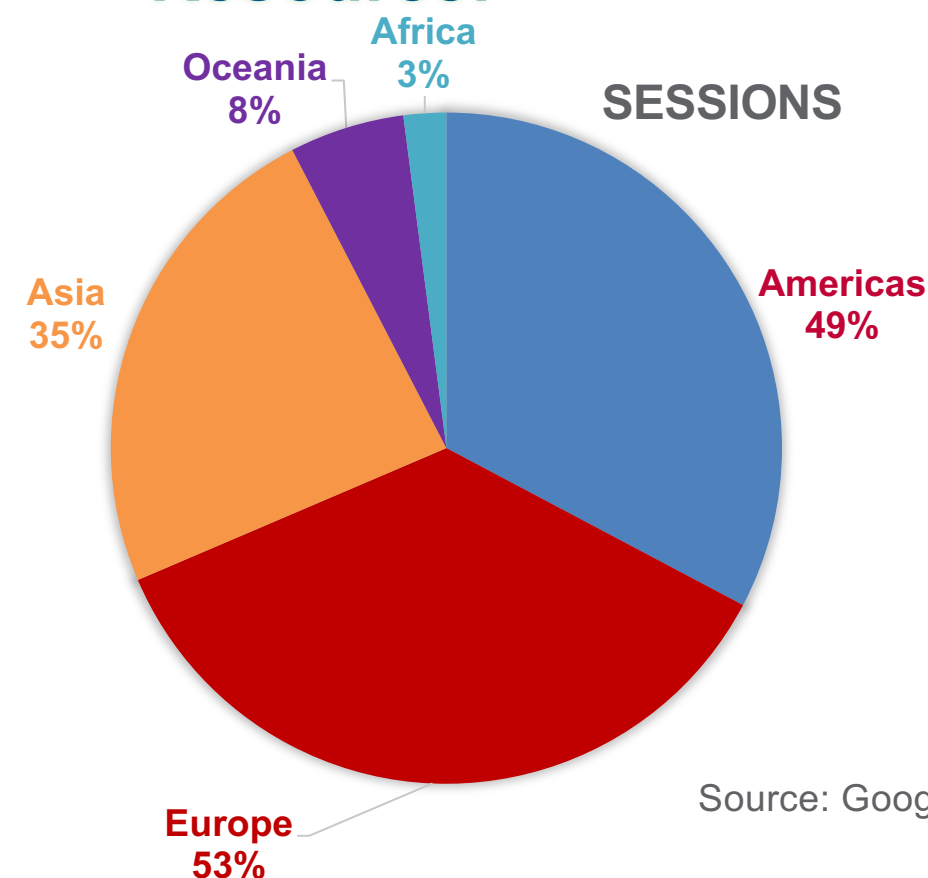
44,416	Maximum pageviews in one month
36,944	Average pageviews/month
4.62	Avg. Pages visited per session
06:54	Minutes per session

* Nonbounce statistics through December 31, 2022



HydrogenTools

A Global Resource!



Accomplishments

H2Tools Improvements and Published Articles

Hydrogen Tools Portal Improvements

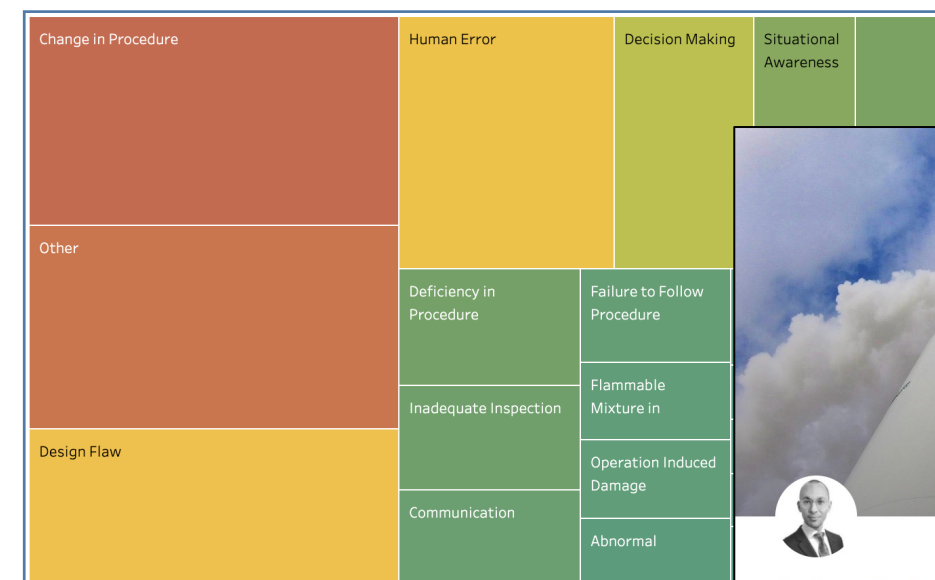
- ▶ Added charting capabilities for the lessons learned database
- ▶ Incorporated the Hydrogen Incident and Accident Database (HIAD) alongside the existing Lessons Learned database
- ▶ Developed a private repository for technical inquiries answered by the HSP (103 current records)

Published Articles

- ▶ Four articles for Hydrogen Tech World global online magazine (authored by CHS and the HSP)
 - The Promise of Safety Comes with the Responsibility of Safety (April 2022)
 - Safety Through Collaboration (August 2022)
 - Safety for Hydrogen Vent Systems (December 2022)
 - Compatibility of Metals with Hydrogen Gas (April 2022)

Total Records Contributing Factors Plot

To view a breakdown of total cases by different metrics use the filters above.



Lessons Learned Database
Plot Example

FEATURED ARTICLE





Safety for hydrogen vent systems

Hydrogen vent systems play an essential role in ensuring hydrogen safety. For many applications, it is common practice to connect all normal hydrogen piping vent points, including relief valves, to a vent system. Evaluating this system during the facility hazard review is essential. This evaluation is often missed, and there have been numerous incidents in which improper vent stack design or operation caused injuries and property damage. This article addresses critical safety issues in vent system design and operation for liquefied (LH2) and gaseous (GH2) hydrogen.

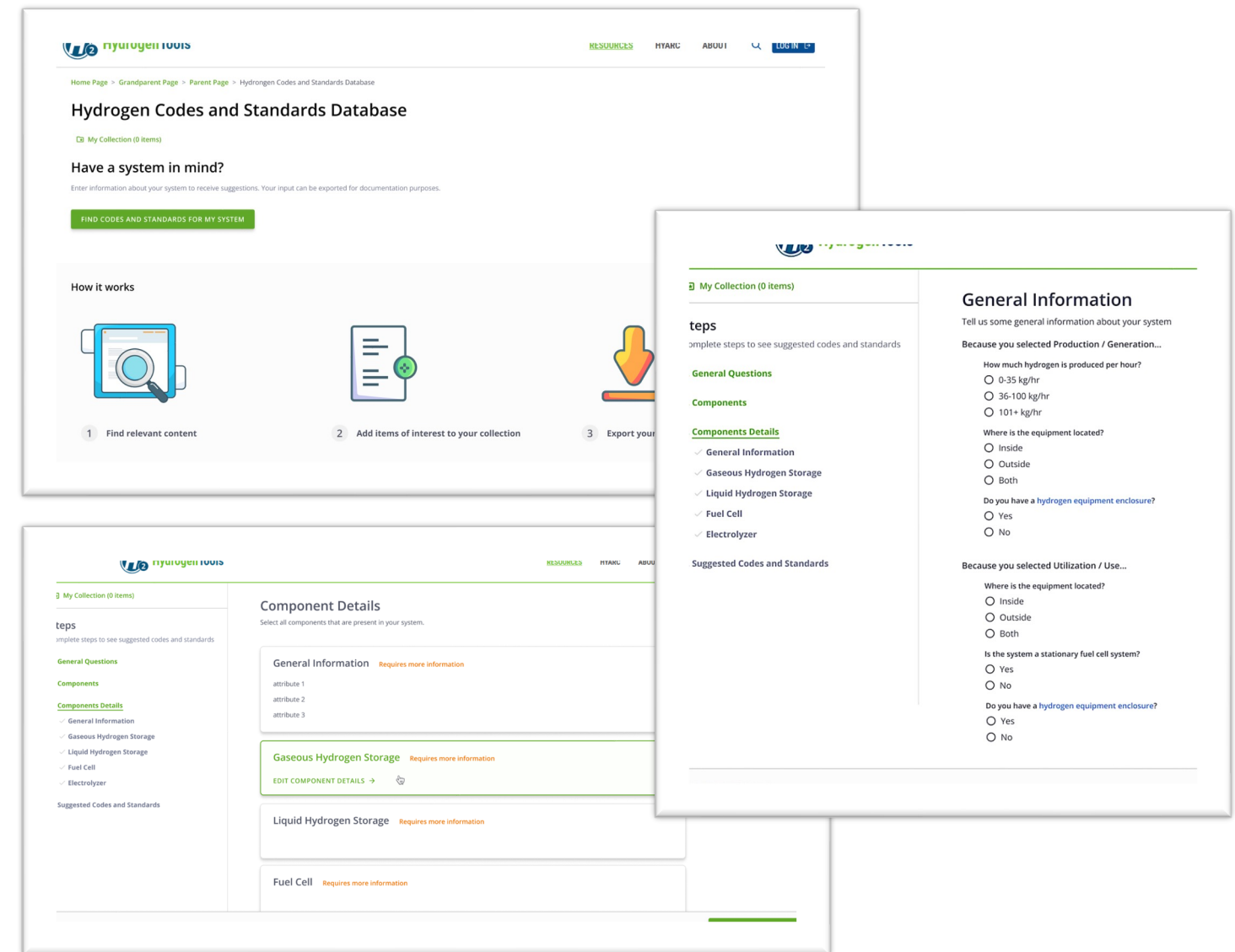
READ ARTICLE

February 2, 2023

Example of Hydrogen Tech
World Article

HySCAN Tool Development

- ▶ Interactive tool similar to TurboTax that directs users to applicable codes and standards for a given hydrogen system or subsystem
- ▶ Collaboration among NREL, SNL and PNNL
 - Code logic provided by NREL and SNL
 - UI/UX design and software development by PNNL
- ▶ Current design focuses on gaseous and liquid hydrogen storage, fuel cell, and electrolyzer
- ▶ Initial release scheduled for September 2023



The HySCAN tool interface is designed to help users find applicable codes and standards for their hydrogen system. It features a 'Hydrogen Codes and Standards Database' section with a search bar and a 'Find Codes and Standards for My System' button. A 'How it works' flowchart shows three steps: 1. Find relevant content, 2. Add items of interest to your collection, and 3. Export your collection. The interface also includes a 'My Collection' section with a list of items and a 'General Information' section with various questions and checkboxes.

Hydrogen Codes and Standards Database

Home Page > Grandparent Page > Parent Page > Hydrogen Codes and Standards Database

My Collection (0 items)

Have a system in mind?
Enter information about your system to receive suggestions. Your input can be exported for documentation purposes.

FIND CODES AND STANDARDS FOR MY SYSTEM

How it works

1 Find relevant content 2 Add items of interest to your collection 3 Export your collection

My Collection (0 items)

General Information

Tell us some general information about your system

Because you selected Production / Generation...

How much hydrogen is produced per hour?

☐ 0-35 kg/hr
☐ 36-100 kg/hr
☐ 101+ kg/hr

Where is the equipment located?

☐ Inside
☐ Outside
☐ Both

Do you have a hydrogen equipment enclosure?

☐ Yes
☐ No

Because you selected Utilization / Use...

Where is the equipment located?

☐ Inside
☐ Outside
☐ Both

Is the system a stationary fuel cell system?

☐ Yes
☐ No

Do you have a hydrogen equipment enclosure?

☐ Yes
☐ No

Component Details

Select all components that are present in your system.

General Information Requires more information

attribute 1
attribute 2
attribute 3

Gaseous Hydrogen Storage Requires more information

EDIT COMPONENT DETAILS →

Liquid Hydrogen Storage Requires more information

Fuel Cell Requires more information

Update on Activities for the Center for Hydrogen Safety (CHS)

A Safety Partnership



*Streamlined
access to
the HSP*



PNNL has partnered with the American Institute of Chemical Engineers (AIChE) to establish a Center for Hydrogen Safety (CHS). CHS expands access to the HSP by:

- ▶ **Making the HSP more readily available to industry and government agencies in the US and internationally**
- ▶ **Enabling less cumbersome/time-consuming contracting efforts**

PNNL transferred its first responder hydrogen safety training resources to AIChE to enable broader access to online and in-person training resources

Center for Hydrogen Safety

A global non-profit community dedicated to promoting hydrogen safety and best practices worldwide

100+ member organizations and 14 strategic partners

Mission

- ▶ Support and promote the safe handling and use of hydrogen across industrial/commercial uses and applications in the energy transition
- ▶ Provide a common communication platform with a global scope to ensure safety information, guidance and expertise is available to all stakeholders

Rich in Resources

Strong in Collaboration

Focused on Impact

- ✓ Best Practices
- ✓ Lessons Learned
- ✓ Expert Reviews
- ✓ Education & Training
- ✓ Conferences
- ✓ Webinars & Workshops
- ✓ Incident Coordination
- ✓ Working Groups

CHS Member Organizations



CHS Training



*Technical content developed by HSP and courses designed by CHS/Xpan (designers)

**HSP presented content

[All courses available at AIChE Academy](#)

*Fundamental Hydrogen Safety E-Courses

- Hydrogen as an Energy Carrier
- Properties and Hazards
- Safety Planning
- Facility Design
- Equipment and Components
- Liquid Systems
- Material Compatibility
- System Operation
- Inspection & Maintenance

New Free eLearning Course

- Hydrogen Laboratory Safety

First Responder Hydrogen Safety E-Courses

- Introduction to Hydrogen Safety for First Responders
- First Responders Micro Training Learning Plan
- Introduction to Hydrogen Fuel Cell Vehicles for Incident Response
- Fire Response & Extrication of a Hydrogen Fuel Cell Vehicle
- Transport of Hydrogen Fuel
- Hydrogen Fueling Station Incident Response

**Other Training Resources

Recorded webinars:

- Safety of Water Electrolysis
- Global Hydrogen Safety Codes and Standards
- Ventilation Considerations for Hydrogen Safety
- Material Compatibility Considerations for Hydrogen
- Overview of Hazard Analysis for Hydrogen Applications
- Safety for the Transportation and Delivery of Hydrogen
- Liquid Hydrogen: Safety and Design Considerations

CHS Webinars and Formal & Technical Training

Hydrogen Safety Webinar Series

- ▶ Started in April 2021
- ▶ Intermediate and advanced topics
- ▶ Speakers from CHS membership and other invited experts
- ▶ Live presentations are free to all, and recorded presentations are available for purchase (free to CHS members)
- ▶ Panel members have provided several webinars: electrolyzers, ventilation, hydrogen transportation, and liquid hydrogen



University of Houston Training

- ▶ Participated as a guest speaker in the Summer of 2021 in the University of Houston's Silver Belt program
- ▶ The session included presentations on hydrogen safety, a discussion of incidents and learnings, and hydrogen safety resources
- ▶ Repeated in 2022 and recorded for future presentations with live Q&A starting in March 2023

Hydrogen Hub

- ▶ Continue to provide safety presentations and safety information to multiple hub consortia

Update on CHS Working Groups (WG)

Facilitating collaboration around topics of shared needs and interest

▶ **Introducing H2 into Natural Gas Infrastructure**

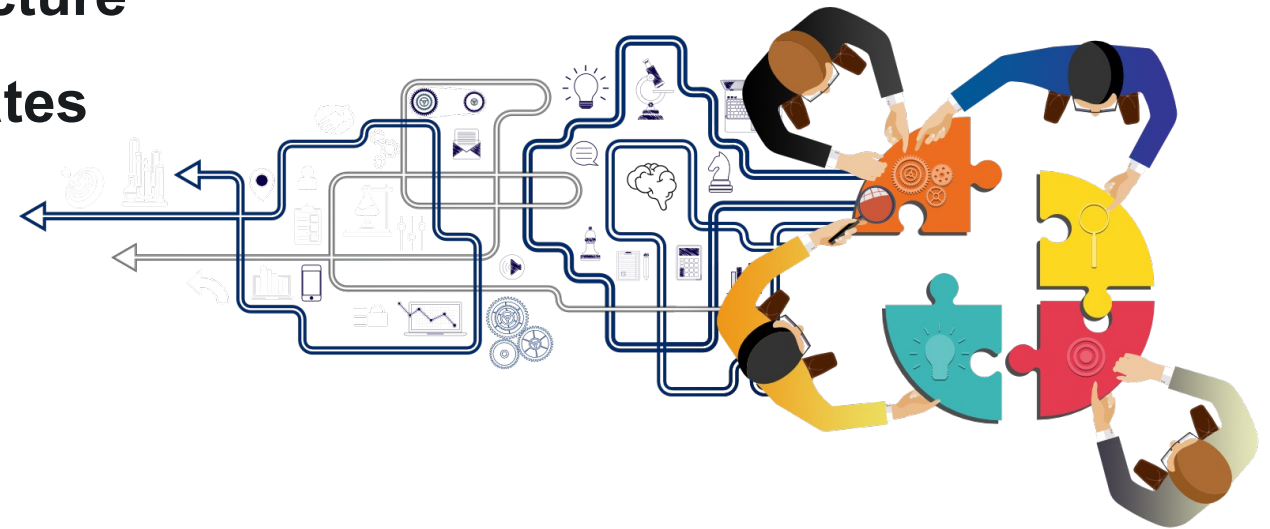
▶ **H2 Equipment and Component Failure Rates**

▶ **New Working Group – Academia**

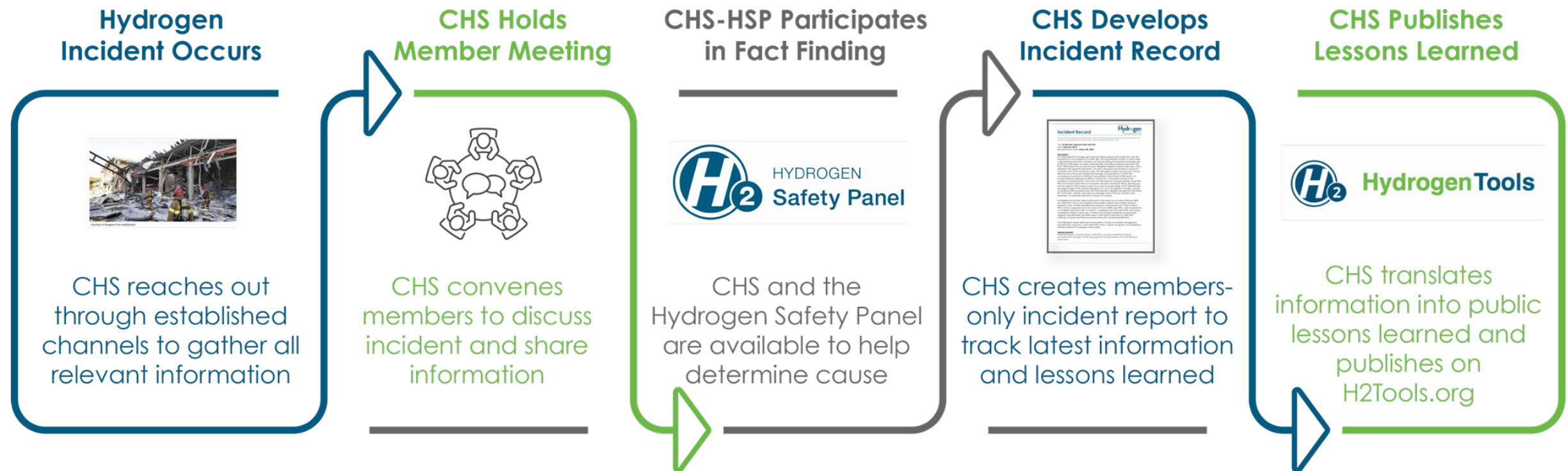
- Aimed at universities and research needs and issues that affect them

▶ **New Working Group – Safety Culture**

- Best safety culture practice will ensure consistency and help create trust in the ability of the hydrogen energy industry to deliver safe, reliable, and high-quality products and services. This working group also supports the Hydrogen Council and an International Energy Agency (IEA) hydrogen safety task

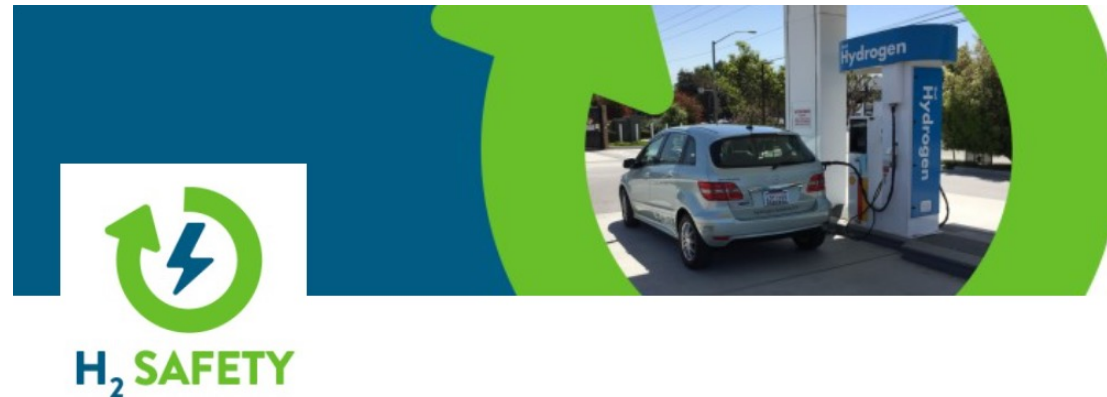


PNNL-CHS Collaboration on Hydrogen Incidents



Other resources CHS may use for responding to an incident

- ▶ Education Materials – new courses, revised course content
- ▶ Technical Bulletins – members-only and public safety bulletins developed and disseminated
- ▶ Working Groups – addressing specific safety issues, developing material for communities and industry
- ▶ Conferences & Workshops – sharing incident information and learnings
- ▶ Incident Management Guide (New – published July 2022 PNNL-32947)



CHS Held Two LinkedIn Live Sessions

- November 2022 - "Hydrogen: The Importance of Collaboration for a Safe and Sustainable Future"
- June 2022 - "Hydrogen: Safety Moving Toward Our Next Fuel Source"

Center for Hydrogen Safety

Connecting a global community to enable the safe and timely transition to hydrogen and fuel cell technologies.

Public Safety · New York, New York · 2,264 followers

- ▶ Follow us at www.linkedin.com/showcase/center-for-hydrogen-safety/
- ▶ Posts will include member highlights and news, h2tools resources, upcoming events, conference promotion and snapshots, among others



Proposed Future Work, Collaborations, and Presentation Summary

Remaining Challenges

- ▶ Applications using hydrogen will grow in volume and diversity
- ▶ Because hydrogen as a fuel is still new, the best methods of handling, storage, transport, and use may not be well understood by new participants
- ▶ Safe practices for the production, storage, distribution, and use of hydrogen are essential
- ▶ Awareness of and availability of safety data and information remains limited
- ▶ Activities with Hydrogen Hubs provides great opportunities to share best practices and technical expertise



Den Helder Sunset by [Klaas Heiligenberg](#)

Proposed Future Work

Remainder of FY 2023



Hydrogen Safety Panel

- ▶ Continue safety reviews for DOE-funded projects
- ▶ Continue to support the CEC hydrogen fueling station deployment and renewable production facility activities
- ▶ Continue to support AIChE-CHS CRADA for design/safety plan reviews, and learning activities
- ▶ Support project safety and advancement of Hydrogen Earthshot and Hydrogen Hubs through technical teams, working meetings, design reviews, and addressing technical queries

Safety Knowledge: Tools and Dissemination

- ▶ Maintain Hydrogen Tools Portal
- ▶ Work with AIChE/CRADA to deploy hydrogen safety training courses
- ▶ Develop new best safety practice topics for the Portal
- ▶ Support additional CHS webinars and LinkedIn Live Sessions

Proposed Future Work

Hydrogen Safety Panel

- ▶ Review project safety plans, and design and reengage site visits in support of the DOE fuel cell, Hydrogen Earthshot, and Hydrogen Hubs programs
- ▶ 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
- ▶ Continue to support California's hydrogen fueling station deployment and renewable production facility activities
- ▶ Continue to support projects and activities for AIChE-CHS CRADA

Safety Knowledge Tools and Dissemination

- ▶ Provide outreach to stakeholders in California in support of CRADA activities
- ▶ Deploy additional best practices on new and uncovered topics

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

Collaborations

Hydrogen Safety Panel and Safety Knowledge Tools

- ▶ Organizations supporting HSP members
- ▶ CEC in support of safe infrastructure deployment and safety learnings
- ▶ AIChE-CHS through CRADA for resources and activities, training, and credential and improvements to the Hydrogen Tools Best Safety Practices website
- ▶ National Laboratories (NREL, PNNL, INL, SNL) reviewing development projects
- ▶ DOE, NREL and SNL in support of HySCAN implementation



Summary

Hydrogen Safety Panel

- ▶ The Panel's involvement in a wide variety of early market demonstration projects and commercialization activities puts it in a unique position to analyze issues, identify gaps, share its learnings, and advance safety culture in the hydrogen industry.
- ▶ 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 also feeds back to the Hydrogen and Fuel Cell Technologies Office's research and development efforts.

The HSP's availability and accessibility as a resource for these applications are expanded to a broader industry and stakeholder community through the CEC and AIChE CRADAs.

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 disseminate safety information and knowledge broadly.



Thank you!

U.S. Department of Energy Hydrogen and Fuel Cell Technologies Office (Sunita Satyapal, Director, Laura Hill, Safety, Codes, and Standards Manager, and Christine Watson, Fellow)

AICHE staff supporting the AICHE-CHS CRADA

AMR Reviewers – your comments and perspectives are important to help us identify areas for improvement and be more impactful

Technical Backup and Additional Information for the 2023 Annual Merit Review and Peer Evaluation

Technology Transfer Activities

- ▶ No related patent, licensing, or potential licensing information
- ▶ No related plans for technology-to-market or technology transfer plans
- ▶ No plans for future funding from alternative sources

Response to Select 2021 AMR Reviewer Comments

“The number and range of hydrogen projects are expected to grow significantly with increased rollout of policies for clean energy technologies. It would be good to see the project address how it may handle the significantly increased number of projects to review and the increased need for specialized training of unique stakeholders. Online training courses can reach more stakeholders, yet in-person training workshops can be more tailored to individual stakeholder needs. It is not clear how the project will be able to be responsive to a significantly increased need for project reviews, training, etc., as well as how PNNL, through the CHS, will support development and deployment of courses offered through the AIChE.”

- *Thanks for the comment. PNNL has been focusing on increasing its resources and strengthening its collaboration with the Center for Hydrogen Safety in ways that will address these issues. The HSP is now at 24 members, up from 16 just a few years ago. Also, as shown on Slide 18, PNNL has streamlined its HSP review process to increase efficiency and reduce review time. The HSP is also collaborating with CHS to develop online training courses. Ten courses have been published, and two are being developed (see slide 30). In-depth teaching webinars are provided by CHS four times per year, with the HSP being involved in most. PNNL also supports CHS’ in-person training and conferences, yet there have been no requests for such in-person training (probably due to COVID). We are confident that we have the resources needed to support these activities.*

When asked what review process was in place to approve fact sheets or other materials for general distribution, no formal review process was articulated. PNNL and the CHS need to do a better job at reviewing the technical content of all products produced and released for general distribution. This project is the voice of the hydrogen safety community, so its products must be technically correct without ambiguity adhering to the current state of the art in hydrogen safety. PNNL and the CHS should create a formal review process, drawing experts from both inside and outside the organization, before approving anything for general distribution.

- PNNL formalized a process for review a wide variety of documents and materials (see slide 18). The process includes an online request form available at <https://h2tools.org/form/request-for-hydrogen-safety-pane>. The process was utilized by National Grid and resulted in the FAQ sheet available at <https://www.nationalgrid.com/document/148951/download>.

Completed HSP Reviews since Prior AMR

#	Organization	Project Title
1	Plug Power	Autonomous Hydrogen Fueling Station
2	Frontier Energy/GTI	Demonstration and Framework for H2@Scale in Texas and Beyond
3	First Element/True Zero	Hydrogen Station Safety Plan
4	Foothill Transit - Clean Energy Fuels	New Station Design and Installation
5	ZEMU - Mott-MacDonald	AMF 30% Design Review
6	Cummins	PEM Fuel Cell System for Heavy Duty Applications
7	First Element Fuel	TrueZero NorCalZERO Liquid Hydrogen Fueling Station at East Bay Municipal Utility District (EBMUD)
8	Xcel Energy	Prairie Island Hydrogen Pilot Project
9	NCTD & Trillium	North County Transit District (NCTD) LH2 Storage and Use for Bus Operations
10	First Element/True Zero	Hydrogen Station Design Review
11	ZEMU Mott-McDonald	AMF 100% Design Review
12	Caterpillar Inc.	Flexible Natural Gas/Hydrogen Combined Heat and Power System
13	Ford	Ford FC truck and Facilities
14	Neograf and Ballard	Development of Low Cost, Thin Flexible Graphite Bipolar Plates for Heavy Duty Fuel Cell Applications
15	GTI Sierra Northern - H2RAM	Hydrogen Locomotive
16	Plug Power & UTK	Hydrogen Fuel Cell Test Facility