NREL
NATIONAL RENEWABLE ENERGY LABORATORY

National Codes and Standards Deployment and Outreach

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National Renewable Energy Laboratory
June 15, 2018

DOE Hydrogen and Fuel Cells Program
2018 Annual Merit Review and Peer Evaluation Meeting

Project ID # SCS001

Overview

Timeline and Budget

- **Project start date:** October 1, 2002
- **Project end date*:** September 30, 2018
- **FY17 DOE funding: $330,000**
  - Outreach and Training – $60,000
  - Continuous Codes and Standards Improvement – $270,000
- **FY18 planned DOE funding: $300,000**
  - Outreach and Training – $50,000
  - Continuous Codes and Standards Improvement – $250,000
- **Total DOE funds received to date: $1,600,000**

*Project continuation and direction determined annually by DOE

Barriers

- G. Insufficient Technical Data to Revise Standards
- F. Enabling Markets Requires Consistent Regulations, Codes, and Standards (RCS)
- A. Limited Safety Data Access

Partners

- Regional fire departments and energy policy associations
- DOE national labs
- Industrial gas industry
- Standards development organizations

Relevance

- Objectives: Both projects further enable the safe deployment of hydrogen fuel cell technologies by informing the development of required codes with a particular focus on Hydrogen at Scale (H2@Scale)
- Project impact:
  - The Continuous Codes and Standards Improvement (CCSI) project supports technology deployment by enabling the integration of research into codes and standards to make more effective documents
  - The Codes and Standards Outreach and Training project supports technology deployment by informing the development of codes and standards information to project developers and code officials, making project permitting smoother and faster
  - These impacts directly address DOE barriers to deployment (consistent, science-based codes and standards; having information readily available to users)
  - These projects have proven to be effective with furthering hydrogen

Integrating research into safety codes for safe infrastructure deployment

Approach

Strategy: Safe Deployment of Hydrogen Technologies

Collaborate with all interested parties
Includes industry, safety community, research laboratories, standards development organizations, regional planning organizations

Leverage existing resources
For example, research projects that have a safety component that can be used to support development of safety codes

Develop safety requirements
Based on research and safety tools to inform safety code users

Fiscal Year 2018 Deliverables: Safety R&D Integration

Integrate the safety research done on FCEV releases in tunnels into the relevant safety documents.

Analyze safety research needs to support the safe use of hydrogen technologies with a focus on H2@Scale project work.

The Inter-Laboratory Research Integration Group (IRIG) met to identify key safety research needs and how to effectively integrate research into safety documents.

Document safety research required to support H2@Scale including current status of safety issues and key safety research to move H2@Scale forward.

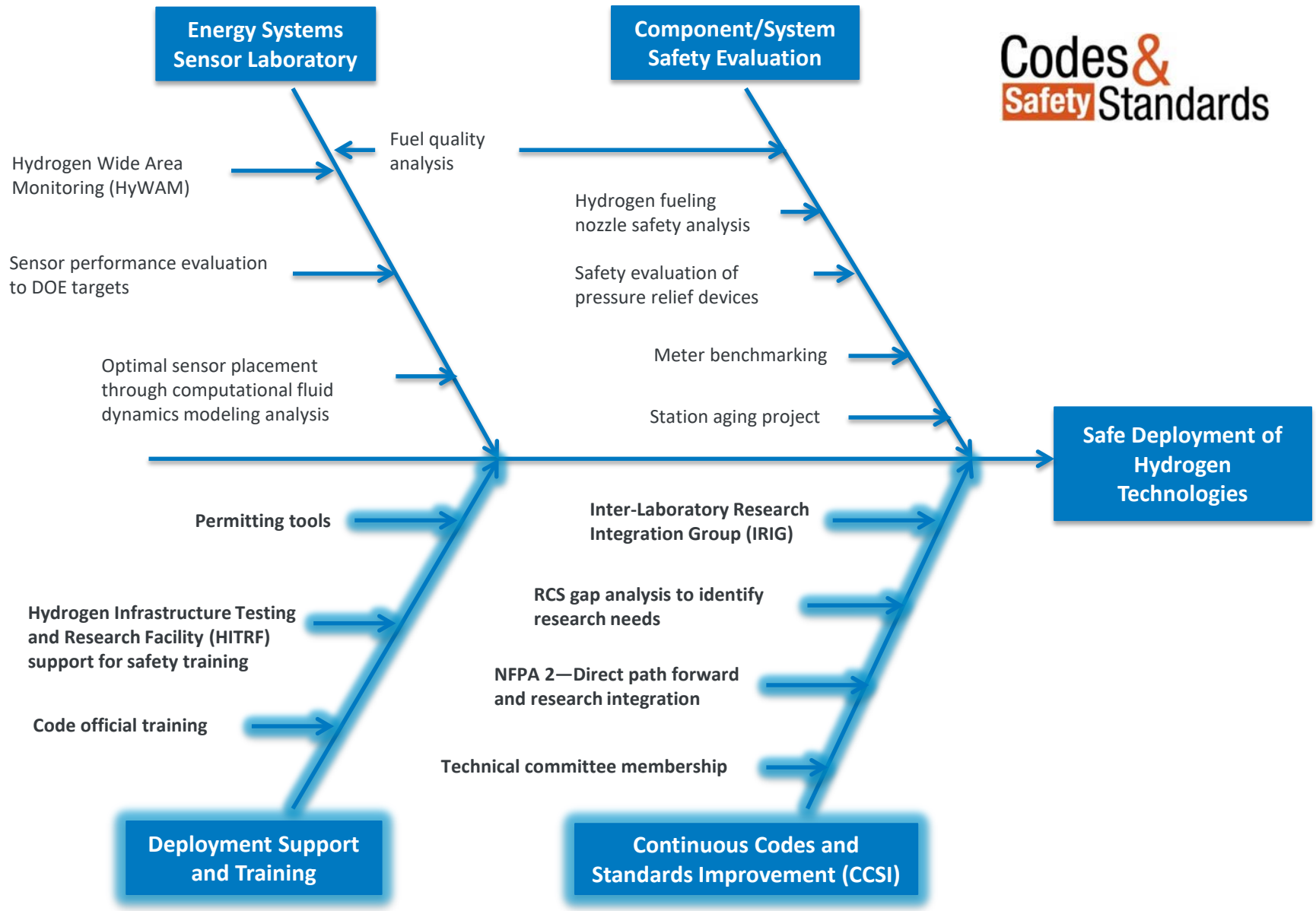
This documentation will be in the form of an NREL technical report.

Integrate key research findings from the NFPA task groups into safety codes.

These research findings include revised requirements for both bulk gaseous and liquid hydrogen storage systems.

Collaborate with key stakeholders and leverage existing research to achieve safe deployment of hydrogen technologies

Approach: Integrated Safety Research

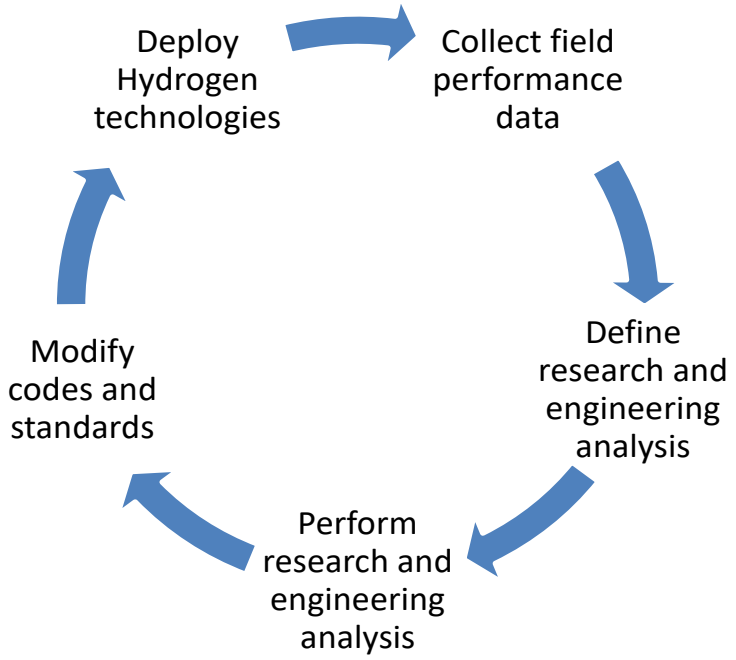


Approach: CCSI

CCSI Key Projects

- Through the Inter-Laboratory Research Integration Group (IRIG), utilize DOE research to develop defensible documented safety requirements
- Direct NFPA 2 Task Groups to develop 2020 edition of NFPA 2 that addresses key code gaps that must be filled to allow for smooth deployment
- Perform H2@Scale code analysis that identifies actions required to address code gaps

CCSI Process

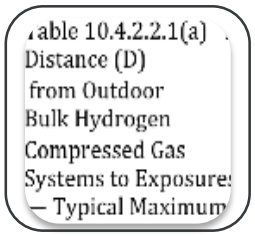


Impact: Codes that integrate current technology enable safer, faster deployment of hydrogen technologies

Approach: IRIG

DOE Office of Energy Efficiency and Renewable Energy

DOE-funded hydrogen technology and alternative fuel research projects conducted at DOE and other laboratories +
Existing DOE supported research that could benefit public safety



Safety requirements that produce Increased public safety and reduced permitting and deployment costs

IRIG/CCSI process:
Research and testing needs defined from the code development committees/project deployment

Leveraging DOE research, particularly stranded R&D assets, can support major code proposals that will have beneficial impact on public safety

Accomplishments: IRIG Ranked Safety Projects and Defined Actions

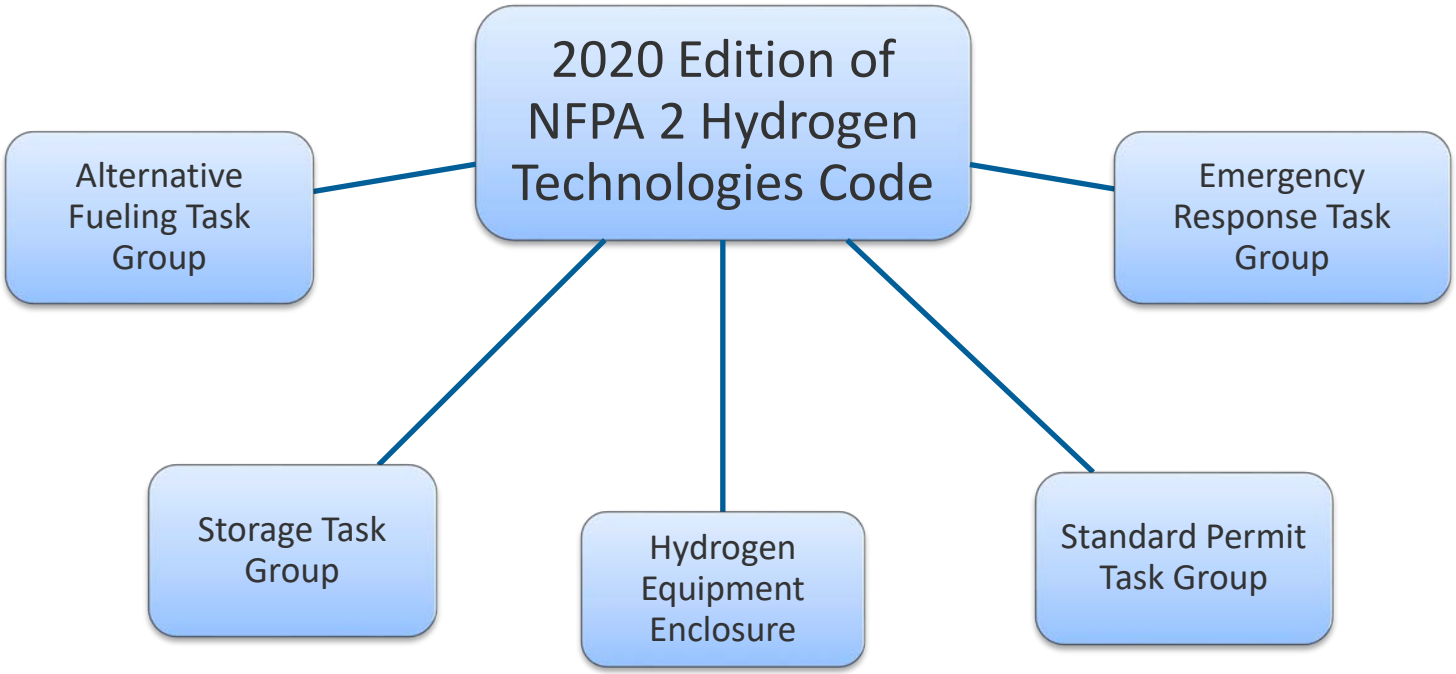
IRIG project safety ranking and actions

Project	Action
Project 1. Annex material on hydrogen fueling station (HFS) system alarms, the information they convey, and appropriate actions	Emergency Response Task Group to develop material for both the 2020 edition and 2024 edition of NFPA 2
Project 2. Addition of material on hydrogen releases in tunnels	NREL successfully submitted material to NFPA 502 committee 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways to allow for fuel cell vehicle usage in tunnels (utilized Sandia National Laboratories safety analysis)
Project 3. Guidance for HFS maintenance to avoid particulate accrual in the hydrogen piping system by enhanced cleaning after tube cutting operations	NREL submitted Public comment submitted to NFPA 2 for current revision cycle based on research conducted at NREL by D.Terlip and team.
Project 4. Electrolyzer chapter requires updating to accommodate larger scale production	Work has begun on this effort by meeting with NREL staff conducting research on electrolyzers and well as a complete review of the chapter. Revisions will be submitted for the next edition of NFPA 2.
Project 5. Additional guidance on approval versus listing/certification for systems and components	This area is being addressed through the NREL led Standard Permit for HFSs that employ both gaseous and liquid hydrogen storage. There will be reference to the guidance material developed by the Hydrogen Safety Panel in Chapter 10 of NFPA 2.

DOE national laboratory safety representatives evaluated and ranked projects to define path forward, which included project actions. NREL acted on directives.

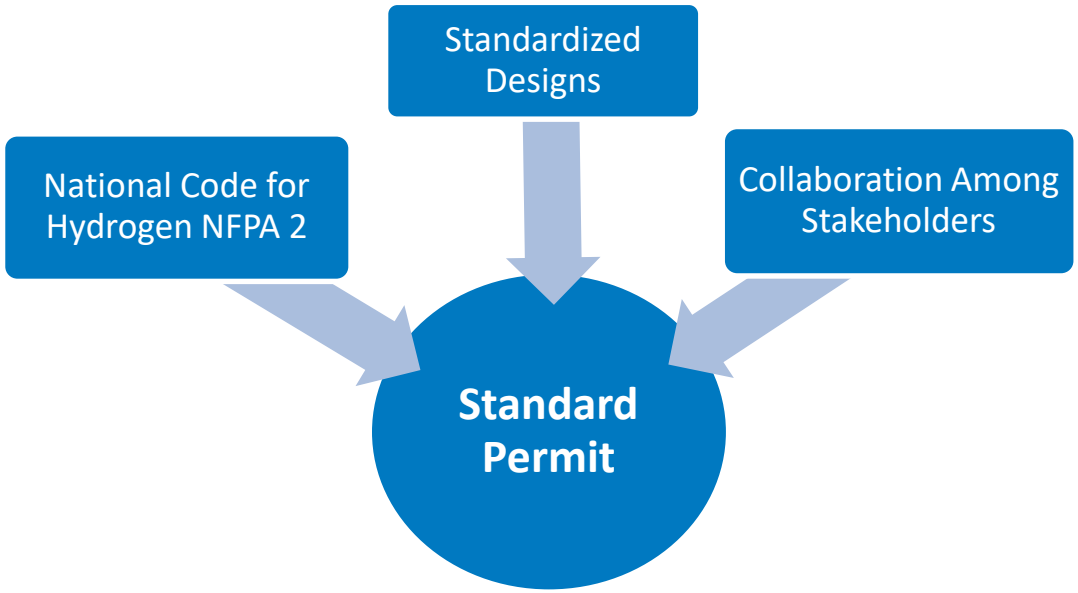
Accomplishments: Directed NFPA 2 Task Groups in Production of 2020 Hydrogen Technologies Code

NREL chaired the NFPA Hydrogen Technologies Technical Committee to direct the production of the 2020 edition of the NFPA 2 Hydrogen Technologies Code, including directing the task groups



Impact: Chaired NFPA Hydrogen Technologies Technical Committee to direct the production of the 2020 edition of NFPA 2 Hydrogen Technologies Code including directing the task groups to make changes closing code gaps

Accomplishments: Developed Standard Permit for Hydrogen Storage with Reduced Setbacks

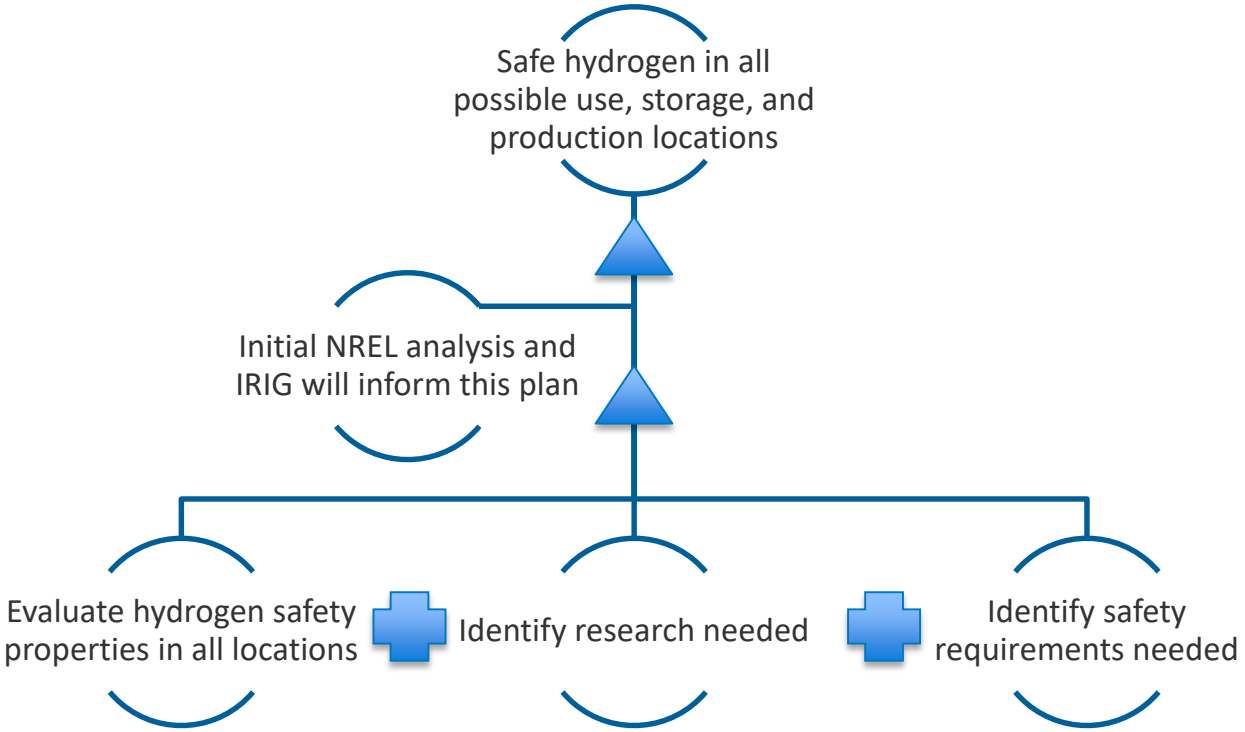


Standard permits will accelerate infrastructure deployment without reducing public safety

- NREL formed NFPA 2 Standard Permit Task Group January 2018
- Key permit identified as hydrogen station with gaseous/liquid storage
- Standard permit for gaseous/liquid HFSs submitted to NFPA 2 to be added to annex text
- Group will continue to develop standard permits based on industry and safety needs

NREL led NFPA 2 Standard Permit Task Group developed standard permit for station with gaseous/liquid storage that allows for relaxation of safety setback distances

Accomplishments: Initiated H2@Scale Code Action Plan



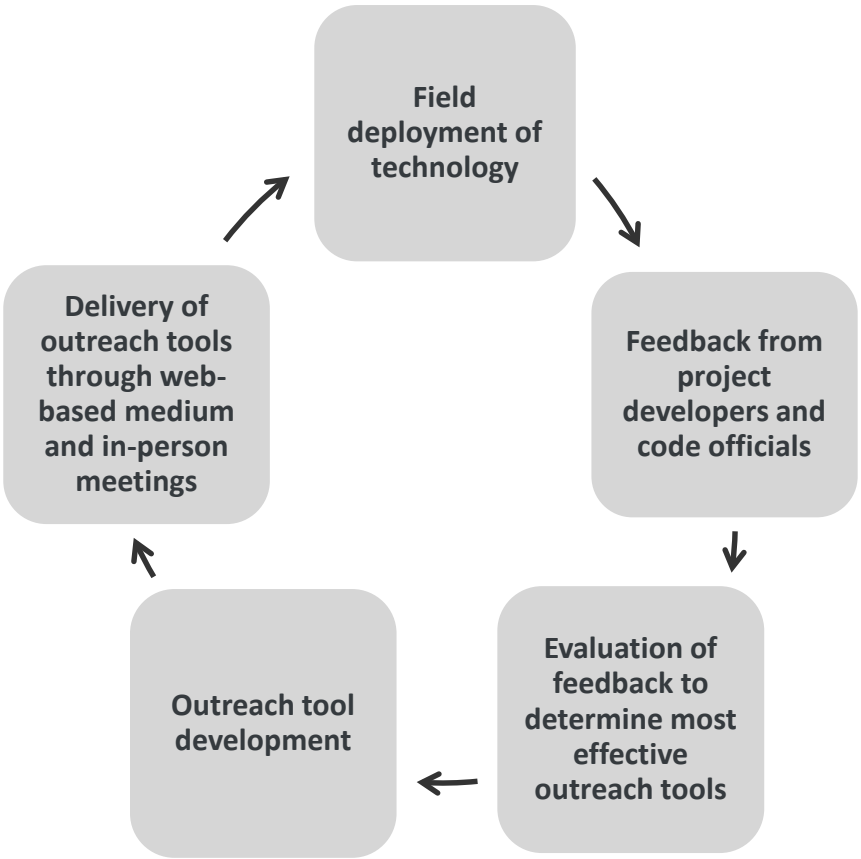
Create action plan that identifies research needs and safety requirements for H2@Scale (to be complete FY18)

Accomplishments and Progress: Delivered Outreach Tools and Guidance

Outreach Key Projects

- Maintained permitting tools at H2Tools
  - Permitting video
  - Telecommunications Industry Association guidance docs
  - NREL technical reports
  - Code Official Training update
- Presented permitting webinar August 22
- Published papers, reports, and articles:
  - American Society of Safety Engineers publication **Hydrogen Safety Guidance for the Safety Professional (draft)**
  - *Firehouse* magazine article*
  - Two papers at the International Conference on Hydrogen Safety (ICHS), September 2017
  - NFPA 2 Hydrogen Technologies Code Handbook for 2020 edition

Outreach Process



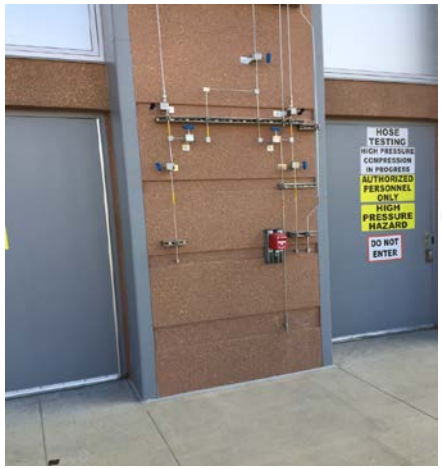
Impact: Readily understood codes will lead to safer and faster deployment

*http://www.firehouse.com/article/12385113/hydrogen-fuel-cell-vehicles-what-first-responders-need-to-know-firehouse

Accomplishments and Progress: American Society of Safety Engineers Paper

Hydrogen venting from experiments involving multiple fuelings has migrated into nearby work areas where it was not expected to accumulate

NREL will document its unique experience with hydrogen safety issues resulting from accelerated testing and other research activities to spread safety knowledge

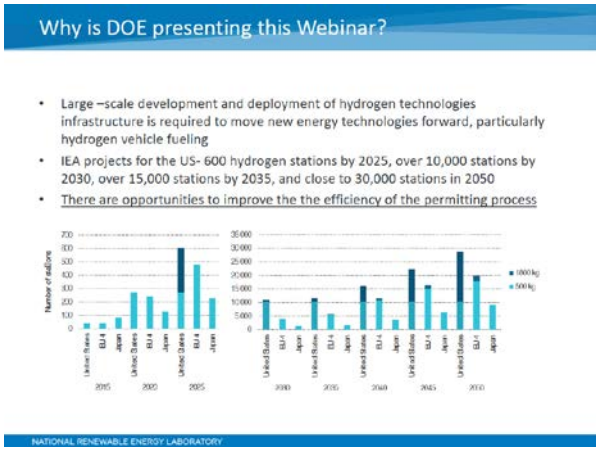


Hydrogen vented from indoor test bays into stacks serving multiple sources has been driven back into work spaces

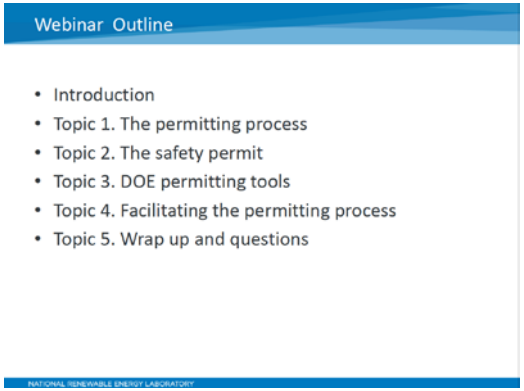
As hydrogen applications expand, NREL will share extensive hydrogen project experience with safety professionals. Information will also be added to H2Tools

Accomplishments and Progress: Permitting Webinar

Webinar presented information on permitting tools to streamline hydrogen infrastructure permitting and use standard permitting



Fuel Cell Technologies Office permitting webinar to reduce barriers to hydrogen technologies deployment to support H2@Scale



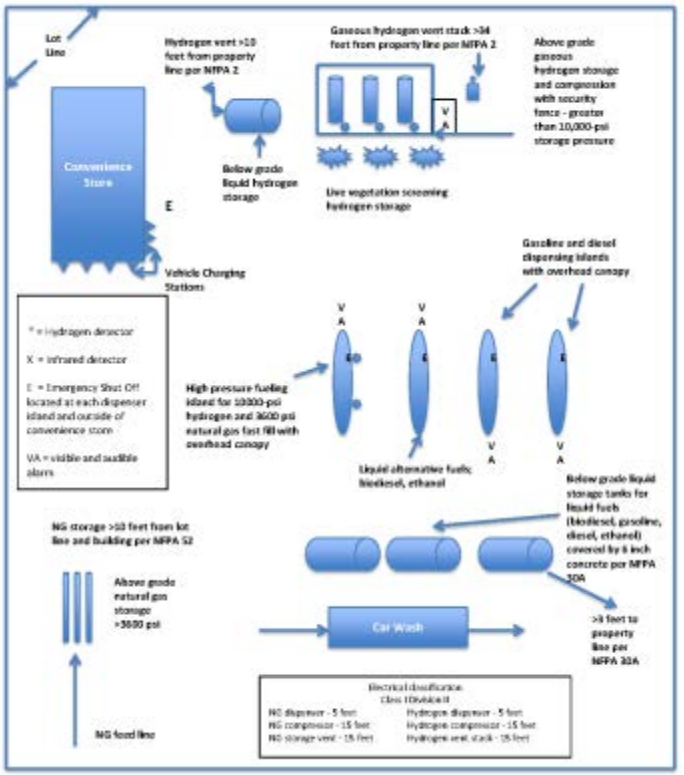
Improved infrastructure permitting is required for widespread hydrogen technologies deployment

Accomplishments and Progress: Multi-Fuel Station Analysis

Key Issues with Multi-Fuel Stations

- NREL presented a paper on multi-fuel stations at the 2017 ICHS
- Issues identified include:
  - Need for integrated sensor, alarm, and emergency shut-off systems
  - Multiple requirements for setback distances can create impinging fuel storage systems
  - Sensing systems must function in a multi-fuel environment
  - Venting and electrical zones cannot impinge.

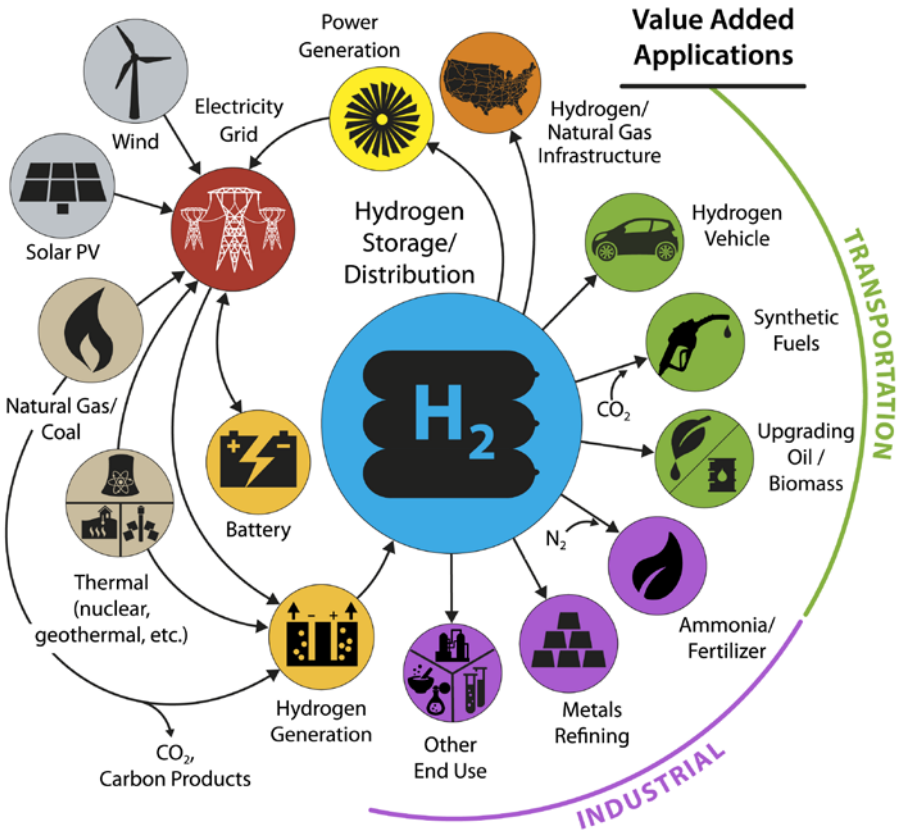
Representative Multi-Fuel Station



Impact: This analysis facilitates hydrogen dispensing at existing fueling stations by addressing code integration. Forms basis for code Proposals.

Accomplishments and Progress: H2@Scale RCS Analysis

- NREL presented a paper at the 2017 ICHS analyzing RCS and permitting for large-scale hydrogen systems
- Analysis includes:
  - Existing regulations, codes, and standards for hydrogen production, storage, and distribution
  - Permitting options, including performance-based code compliance
  - Gaps in regulations, codes, and standards such as large liquid systems and geologic storage.



Impact: NREL's paper defines a codes and standards and permitting path for large-scale systems that will include an analysis of the permitting process for large or unconventional installations such as large bulk liquid hydrogen storage systems

Accomplishments and Progress: Responses to Previous Year Reviewers' Comments

- **Comment:** It is not clear why this project is not better connected to other Program activities. Lack of collaboration with other SCS sub-program projects is a major barrier to accomplishment.
- **Response:** NREL would welcome any opportunities for additional collaboration and identification of specific programs that should be connected to this work. Although it was not clear which program activities this project should be connected to, the major activity in this project, integrating safety research into safety standards, is conducted through the Inter-Laboratory Research Integration Group (IRIG) which is composed of multiple DOE laboratories involved in safety research. Additionally, the NREL safety work will support H2@scale by identifying code gaps required for H2@Scale projects and actions to address these gaps.

Collaboration and Coordination

Collaborator	Project Impact
Industrial gas companies	These companies are major contributors to NFPA Hydrogen Storage Task Group and NFPA 2, 2020 edition
Station installers/developers including First Element, Linde, Air Products, and Air Liquide	These collaborators are major contributors to NFPA 2
Standards development organizations (SDOs) including NFPA, CGA, SAE, CSA, UL, ISO, BNQ, ICC, ASME, and ASTM	NREL has served on multiple SDO technical committees and worked to integrate NREL research into codes and standards
DOE national laboratories	Sandia National Laboratories, Pacific Northwest National Laboratory, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory are part of IRIG and NFPA Task Groups
Regional fire and building officials including California Fire Marshal's Office and Massachusetts Fire Marshal's Office	NREL provided information and outreach events to support project activity in jurisdictions where hydrogen technologies are being deployed
Regional hydrogen advocacy groups including Colorado Hydrogen Coalition and California Fuel Cell Partnership	NREL provided input on the development of state regulations

NREL has worked with all stakeholders to achieve the maximum impact on hydrogen technologies safety

Remaining Challenges and Barriers

Challenges	Path Forward
Hydrogen safety issues identified in the range of applications dictated by H2@Scale	Evaluate hydrogen safety issues and identify actions required to address these issues
The code compliance process can be complicated, leading to noncompliance	Develop standard permits for common project configurations
Code users may be infrequent or new users	Develop tools in the most effective format to get users quickly oriented to the applicable requirements, including placing support material in Annex of NFPA 2 and H2Tools website (where it will be readily seen), and developing NFPA 2 Code Handbook
Different jurisdictions may use different codes or different code editions	Support the national and international application of commonly adopted documents such as NFPA 2 Hydrogen Technologies Code so that requirements are standardized across jurisdictions

Proposed Future Work

- Address key safety issues to enable H2@Scale hydrogen deployment including the following:
  - Determine hydrogen dispersion patterns in representative deployment locations such as large storage systems to inform safety requirements
  - Structure safety requirements to better match infrastructure projects
  - Develop handbook to accompany NFPA 2 Hydrogen Technologies Code
  - Continue to integrate safety research into code requirements to ensure that codes are based on engineering analysis; for example, revising the safety setback distances for liquefied hydrogen storage systems to address H2@Scale projects
  - Continue to identify the needs of safety information users and provide information to meet those needs in the most accessible and intelligible form possible.

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

Summary

- NREL's CCSI and safety outreach activities advance hydrogen technologies safety by:
  - Integrating research and development activities into codes and standards development
  - Transferring lessons learned from the field into the code development process to improve codes and identify research needs
  - Identifying gaps in codes and standards based on feedback from all interested parties and producing plans to fill these code gaps including research needs
  - Distributing information on codes and standards and project permitting to interested parties in a format and level of detail most suited to their needs
  - Performing all of these activities with the widest collaboration with all interested parties.

NREL integrates research into safety requirements to safely advance hydrogen technologies in all applications

Thank You

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Publication Number

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Technical Back-Up Slides

Accomplishments—NFPA 2 Task Groups

Task Group	Accomplishments
NREL led hydrogen Storage Task Group	1. Reduced setback distances for bulk gaseous storage systems 2. Active safety measures to reduce bulk liquid system setback distances
NREL Multi-Fuel Task Group	Coordinated requirements between NFPA 30A and NFPA 2 for stations dispensing hydrogen and other vehicle fuels
Emergency Response task Group	Simple clear guidance posted at facility for emergency responders to make good decisions quickly