NREL
NATIONAL RENEWABLE ENERGY LABORATORY





National Codes and Standards Deployment and Outreach

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National Renewable Energy Laboratory
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Project ID SCS001

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Overview

Timeline and Budget

- **Project start date:** October 1, 2002
- **Project end date*:** September 30, 2017
- **FY16 DOE funding: $275,000**
  - Outreach and Training – $150,000
  - Continuous Codes and Standards Improvement – $125,000
- **FY17 planned DOE funding: $330,000**
  - Outreach and Training – $60,000
  - Continuous Codes and Standards Improvement – $270,000
- **Total DOE funds received to date: $1,300,000**

*Project continuation and direction determined annually by DOE

Barriers

- G. Insufficient Technical Data to Revise Standards
- F. Enabling National and International Markets Requires Consistent RCS
- A. Safety Data and Information: Limited Access and Availability

Partners

- Regional fire departments such as Orange County Fire Authority
- DOE national labs
- Regional hydrogen associations such as California Fuel Cell Partnership
- Industrial gas industry
- Standards development organizations

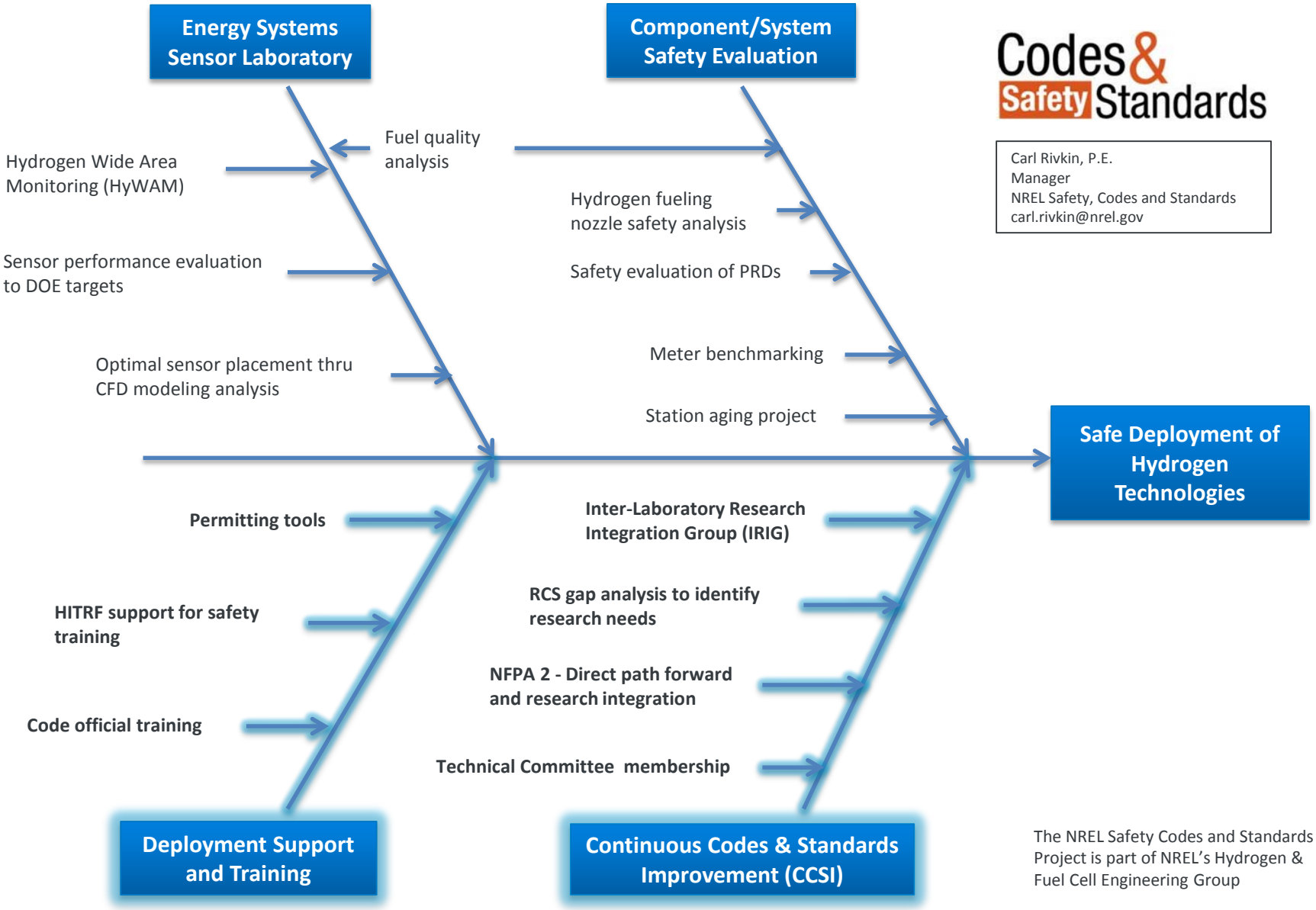
Relevance

- Objectives: Both projects further enable the safe deployment of hydrogen fuel cell technologies by developing required codes with particular focus on the infrastructure required to support fuel cell electric vehicles (FCEVs).
- Project impact:
  - The Continuous Codes and Standards Improvement (CCSI) project supports technology deployment by integrating research into codes and standards to make more effective documents.
  - The Codes and Standards Outreach and Training project supports technology deployment by providing 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 technologies by integrating research into the code development process.

Approach

- CCSI:
  - Use NREL participation in Regulations, Codes, and Standards (RCS) technical committees (including ISO committees), H2USA, H2FIRST, and review of NREL field data to identify key RCS issues requiring action.
  - Identify research needs through deployment feedback.
  - Use a process that complements the ANSI process that all North American standards development organizations (SDOs) follow.
  - Foster collaborations with industry, national laboratories, SDOs, project developers, and other interested parties to identify code improvement issues.
- Outreach and Training:
  - Identify the needs of users—particularly code officials and project developers— at this stage of technology deployment, develop tools to make their jobs easier, and present information in a format that meets users' needs.
  - Use extensive collaborations with interested parties to ensure information is effectively distributed to users.

Integrated Approach:
NREL Safety Codes and Standards Project Structure



Codes & Safety Standards

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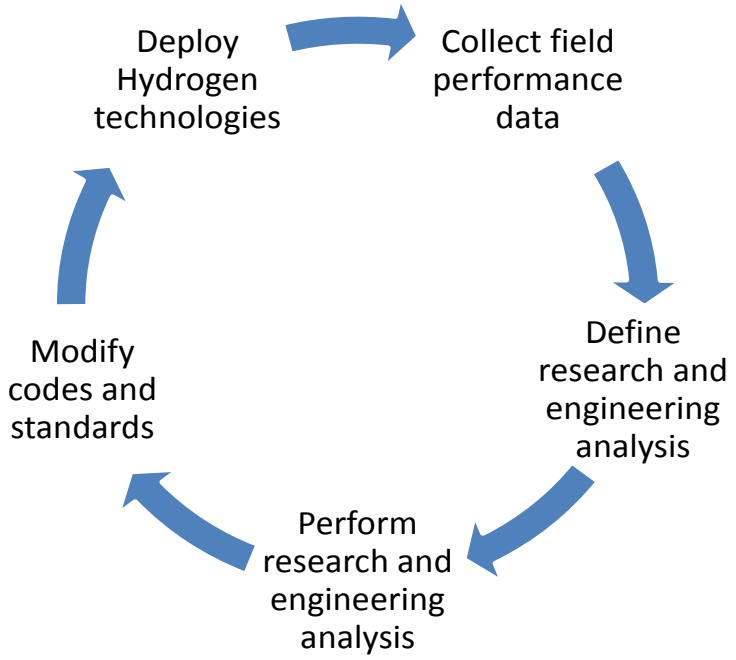
The NREL Safety Codes and Standards Project is part of NREL's Hydrogen & Fuel Cell Engineering Group

Accomplishments and Progress: CCSI

CSSI Key Projects

- Codes and standards gap analysis
- Inter-Laboratory Research Integration Group – utilize DOE research
- NFPA 2 and Task Groups
- Multi-fuel station analysis
- Large-scale grid projects
- Station aging
- International coordination between ISO and North American codes and standards

CCSI Process



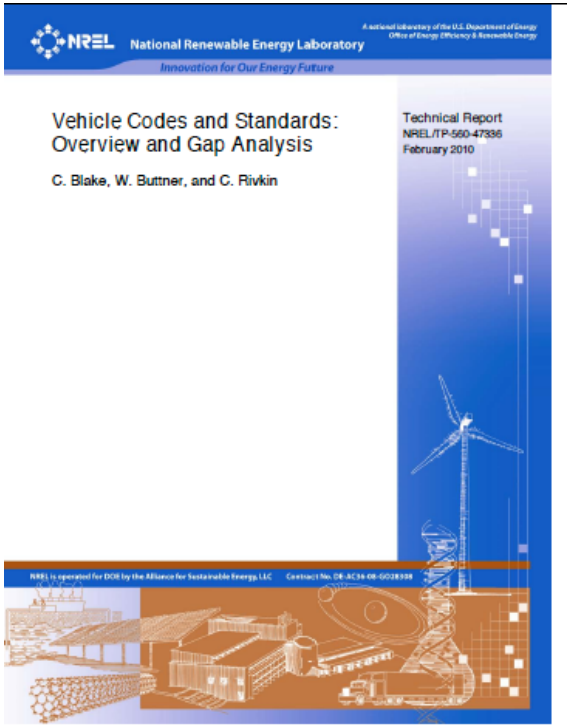
Impact: Better codes integrate current technology and enable safer, faster deployment of hydrogen

Accomplishments and Progress: RCS Gap Analysis

Codes and Standards Gap Analysis

- Analyze six key alternative fuels as defined by DOE
- Based on interviews with experts in all six fuels
- Identify and prioritize gaps
- Inform DOE research activities to support code development
- Draft in progress – publication September 2017

Updating 2010 Gap Analysis



Impact: Report will provide a prioritized list of code gaps and research required to fill these gaps.

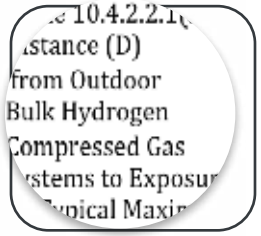
Accomplishments and Progress: Created Inter-Laboratory Research Integration Group (IRIG)

IRIG Process

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

DOE-funded hydrogen technology and alternative fuel research projects conducted at DOE and other laboratories

Existing work product:
Improved technology performance and reduced technology costs



+ New IRIG work product:
Increased public safety and reduced permitting and deployment costs

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

Impact: Leveraging DOE research, particularly stranded R&D assets, can support major code proposals and enable advances in public safety.

Accomplishments and Progress:
Created Inter-Laboratory Research Integration Group (IRIG

IRIG Objectives

1. Enable research and development to positively impact public safety by writing code proposals based on research
2. Leverage existing research projects to support code development
3. Identify areas of research that are needed to support code development based on deployment priorities

- Achieve these objectives through a structured process that utilizes DOE laboratory work
- Implement the (CCSI) process

IRIG Team/FY17 Objectives

- DOE Group members-NREL, PNNL, SNL, and LANL
- Submit at least three high impact proposals
  - NFPA 502 –proposal on FCEVs in tunnels
  - NFPA 2 Safe venting for hydrogen stack discharges
  - Component safety, likely hose safety requirements
  - Multi-fuel stations
  - H2@Scale

Los Alamos NATIONAL LABORATORY EST 1943

Sandia National Laboratories

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

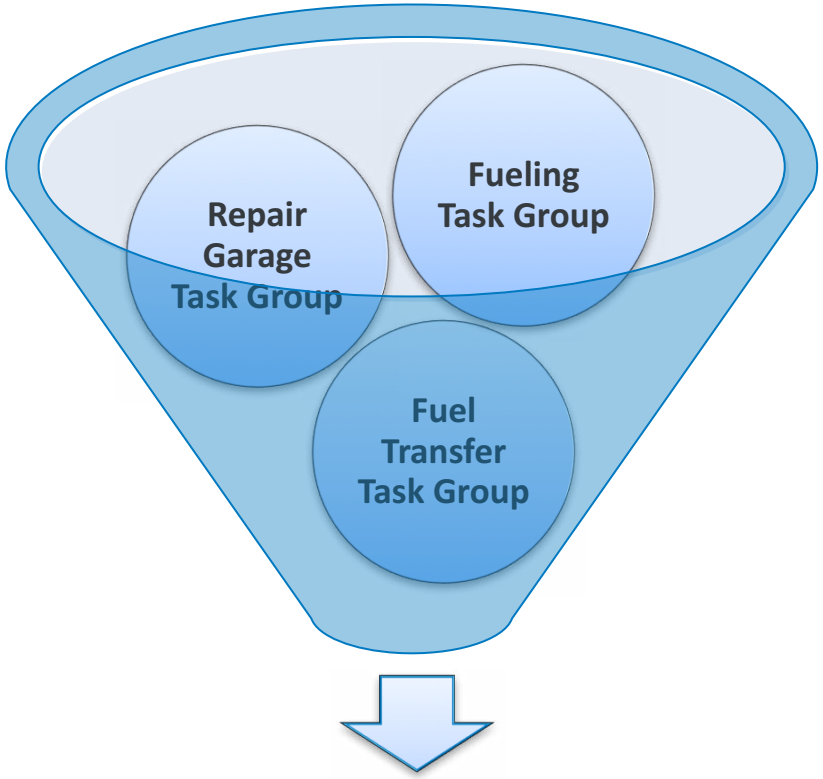
Impact: Leveraging DOE research through a formal IRIG structure will increase research and development impact on public safety

Accomplishments and Progress: NFPA 2 2020 Edition

Task Groups

NREL directed and organized Task Groups to develop:

1. Controls over unconventional fueling
2. FCEV repair garages
3. Coordination between fire codes
4. Increased flexibility for siting bulk liquid and gaseous hydrogen storage
5. Safer vent stack configurations



NFPA 2020 edition will include major improvements and advances in coverage

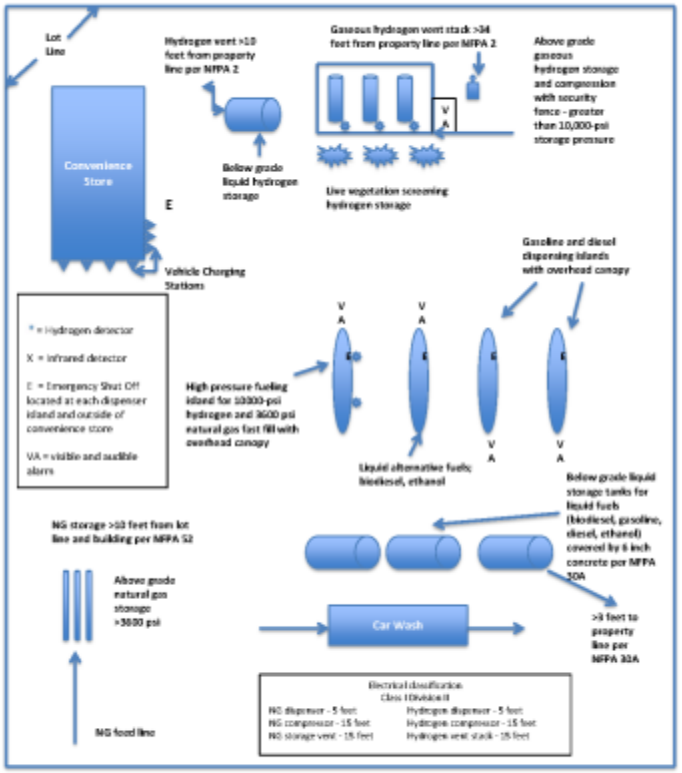
Impact: The NFPA 2 has effectively become the National Code that facilitates deployment. Advances in technology will be reflected in the 2020 edition through incorporation of the task group work and public inputs. NREL has directed this activity.

Accomplishments and Progress: Multi-Fuel Station Analysis

Key Issues with Multi-Fuel Stations

- NREL will publish a paper on multi-fuel stations at the 2017 International Conference on Hydrogen Safety (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



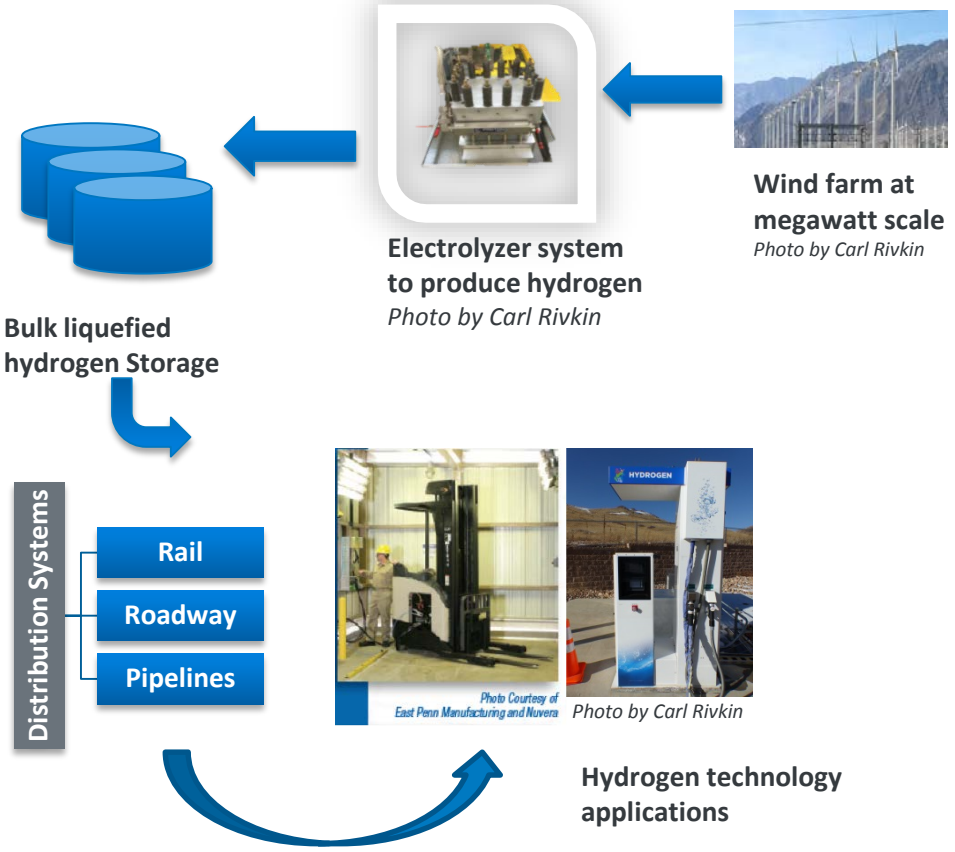
Impact: This analysis will facilitate hydrogen dispensing at existing fueling stations by addressing code integration.

Accomplishments and Progress: H2@ Scale RCS Analysis

NREL will publish an ICHS paper analyzing RCS and permitting for large-scale hydrogen systems.

Analysis includes:

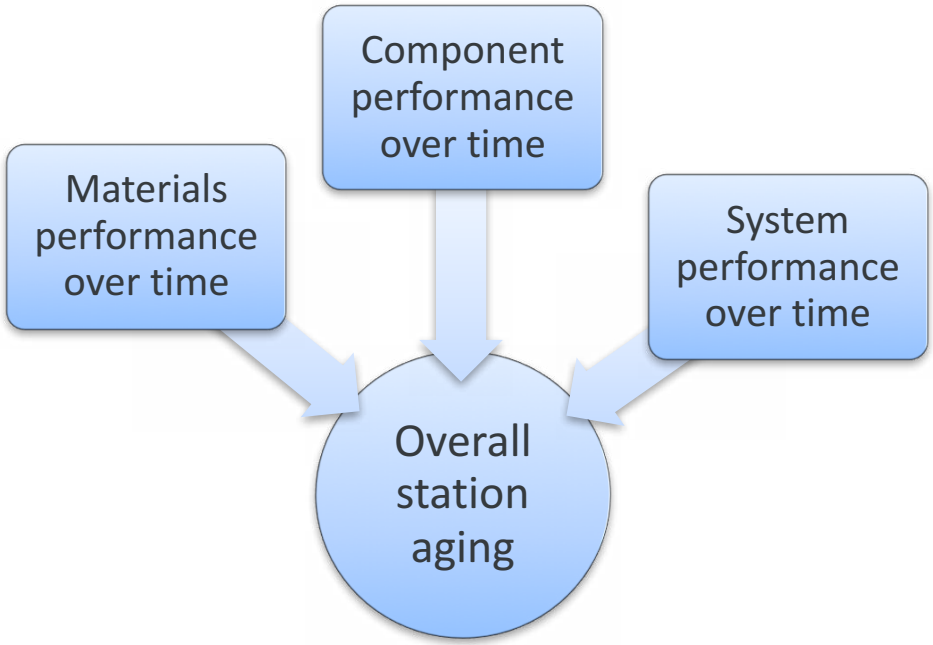
- Existing regulations, codes, and standards for hydrogen production, storage, and distribution
- Permitting options, including performance-based code compliance
- Gaps in regulations, codes, and standards.



Impact: NREL ICHS paper will define a codes and standards and permitting path for large scale systems. This pathway will include an analysis of the permitting process for large or unconventional installations such as large-scale storage systems.

Accomplishments and Progress: Station Aging Project

- NREL collaboration with Zhejiang University initiated FY17, completed FY18
- NREL will direct project, provide data, and perform analyses in collaboration with Zhejiang University
- The project will:
  - Identify failure timelines at all three levels of station structure (materials, components, and system operations)
  - Make recommendations about corrective actions
  - Optimize station performance
  - Identify required changes to RCS
  - Directly support the NREL CCSI process project

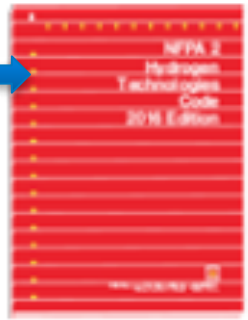


Impact: Station aging analysis will improve station safety and potentially reduce costs by identifying problems before they become failures.

Accomplishments and Progress: International Coordination

North American code coordination process between NREL and BNQ/ISO established 2017

NREL participates in and supports international component coordination work



NFPA 2: Hydrogen Technologies Code

CSA Seed Documents → ISO Standards → Coordinated ISO/North American Standards

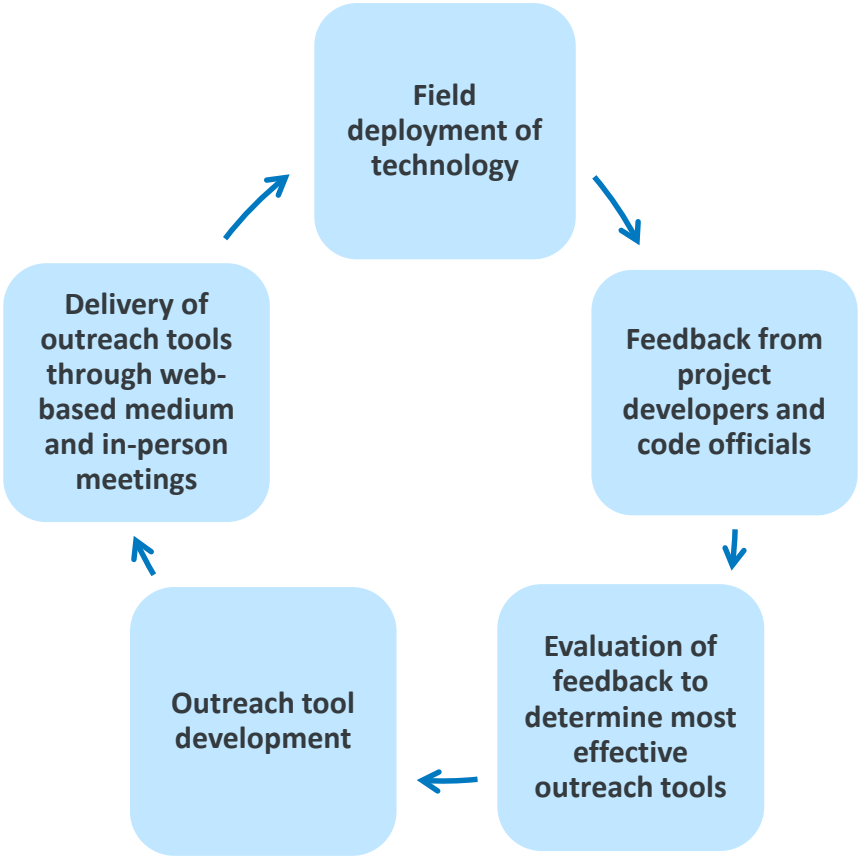
Impact: Coordinated standards increase safety by making product certification easier and requirements consistent.

Accomplishments and Progress: Outreach

Outreach Key Projects

- Permitting tools @ H2Tools
  - Permitting video
  - Telecommunications Industry Association guidance docs
  - NREL technical reports
  - Code Official Training update
- Code official support – National Association of State Fire Marshals (NASFM)
- Regional deployment support – Colorado Hydrogen Coalition

Outreach Process



Impact: Readily understood codes will lead to safer deployment

Accomplishments and Progress: H2 Tools Permitting Resources

Permitting Tools Streamline Process

- Permitting video – easiest access
- Code Official Training – online
- NREL technical reports providing detailed codes and standards citations

Located at https://h2tools.org/content/codes-standards-permitting-tools

Permitting Tools

Permit Tool	Description
"Permitting Hydrogen Fueling Station Stations"	Video format. Video giving basic background on hydrogen technologies followed by a description of the permitting process done through the Orange County Fire Authority in Irvine, CA. Contains interviews with code officials, emergency responders, and technical experts as well as footage of hydrogen stations.
Code Official Training Course	Online interactive format. This online training is divided into the following modules: 1. Module 1 Hydrogen & Fuel Cell Basics 2. Module 2 Hydrogen & Fuel Cell Applications 3. Module 3 Hydrogen Fueling Stations 4. Module 4 Fuel Cell Facilities The course includes questions at the end of each module to confirm the student has learned the basic points of the module. Currently online http://www.hydrogen.energy.gov/code_official_training.html. (Will be updated early 2017.)
National Permit Guide for Hydrogen Fueling Stations	PDF Format. Complete update of the 2004 document including updated references to the 2016 edition of NFPA 2 Hydrogen Technologies Code (Publish date November 2016)
Permitting Web Site	PDF format. This interactive web site provides code citations for hydrogen fueling stations and stationary fuel cells. These citations can be downloaded in PDF format. The code citations are based on applying nationally recognized model codes and standards. Requirements at specific sites will vary based on codes and standards in effect at that location. Accessible at http://www.hydrogen.energy.gov/permitting/. (Updated 2014)
Hydrogen Safety Guide	Provides basic safety information on hydrogen technologies including properties, codes, and applications
Telecommunications Industry Guide	Provides an overview of Regulations, Codes, and Standards for siting stationary fuel cells as well as a description of the fuel cell technologies

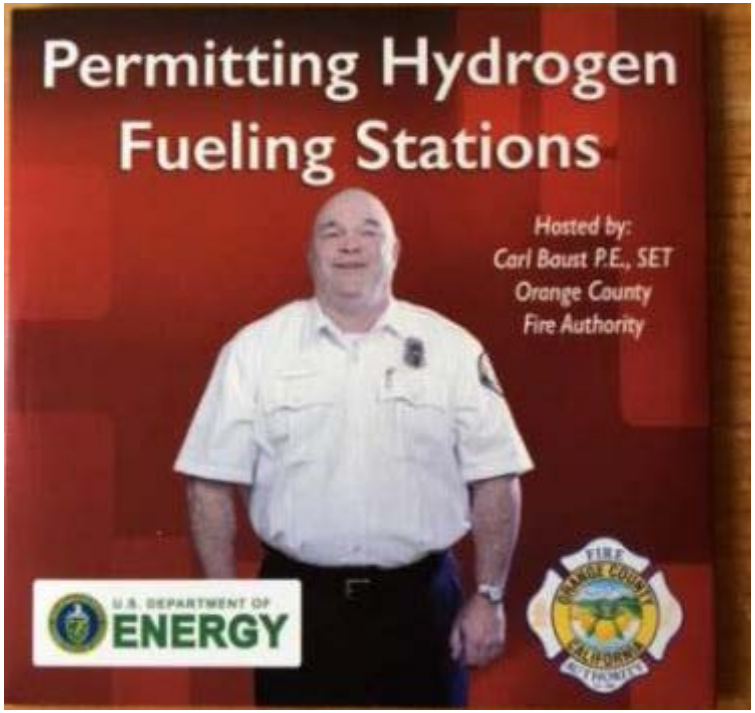
Impact: NREL permitting products provide guidance for both the infrequent user needing to get quickly oriented and the experienced user needing detailed information.

Accomplishments and Progress: Orange County Fire Authority Permitting Video

Key Topics Addressed in Video

- Why there is an interest in fuel cell electric vehicles (FCEVs)
- Basics of hydrogen technologies
- Planning and building considerations
- Fire department regulations
- Annual station inspections
- Available at: https://h2tools.org/content/codes-standards-permitting-tools

NREL Collaboration with OCFA

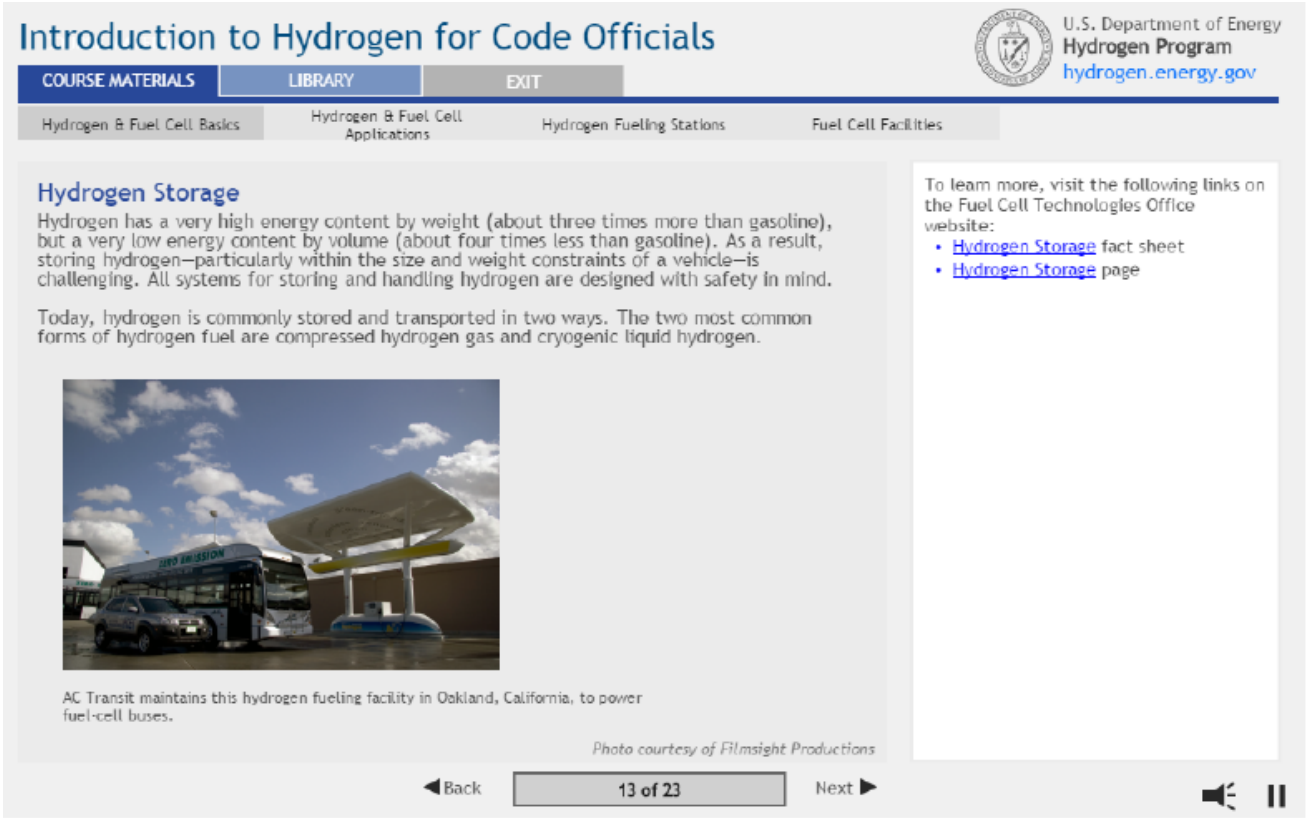


Impact: Video will get AHJs and project developers quickly oriented on hydrogen technologies and code requirements effectively streamlining the permitting process.

Accomplishments and Progress: Code Official Training Course Update

Format:

Interactive with multiple embedded files, links, audio, photos and schematics, and learning evaluation tool



Impact: Easy access, online training allows code officials and other parties quick orientation

Accomplishments and Progress: Fuel Cell Guide

- NREL chaired Telecommunications Industry Association Fuel Cell Focus Group – guide published April 2017

Background for market newcomer

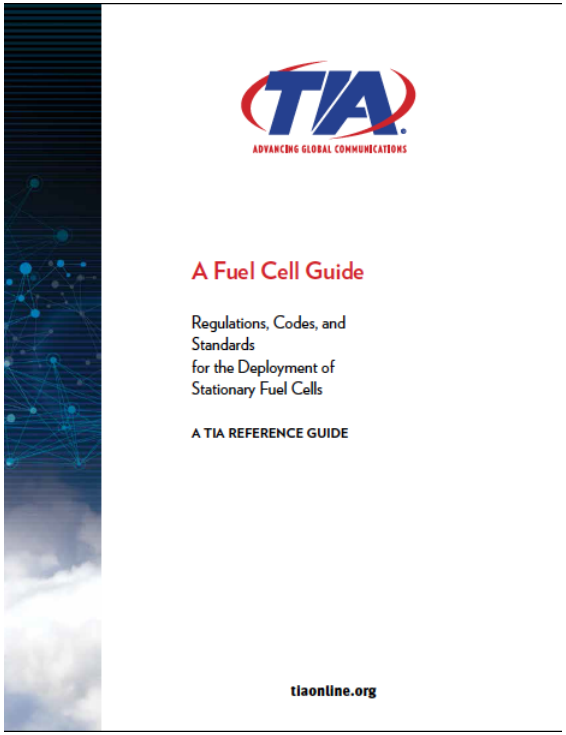
Generally Applicable Codes and Standard

Needed to expand fuel cell market

Fuel Supply Considerations

Clarify and speed up process

The Permitting process



Impact: Guide will get more fuel cells built faster and safer and expand more reliable infrastructure

Accomplishments and Progress: Regional Deployment Support

NREL presented at NASFM Annual Meeting

NREL provided input to Colorado hydrogen regulations

Colorado H_2 Hydrogen Coalition

NREL provided Washington, DC Fire Service Training

Impact: NREL support accelerates project deployment and jurisdictions' technology readiness.

Accomplishments and Progress:
Responses to Previous Year Reviewers' Comments

- Reviewer comment:
  "The code process is one of continuous development and improvement accomplished through periodic revisit, review, and code modifications. It is not clear what is new and novel about this concept."

- Response:
  The CCSI concept is not new or novel. The objective of the CCSI process is to be effective, not new or novel, in incorporating research into the code development process. This means that a DOE process that mirrors the code development process can be an effective tool to identify code gaps, identify research needs, and incorporate research into new code requirements.

Collaborations

Collaborator	Project Impact
Industrial gas companies	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	Major contributors to NFPA 2
SDOs including NFPA, CGA, SAE, CSA, UL, ISO, BNQ, ICC, ASME, and ASTM	NREL has served on multiple SDO technical committees
Orange County Fire Authority (OCFA)	NREL collaborated with OCFA to produce video "Permitting Hydrogen Fueling Stations"
Regional Fire and Building Officials including New York City Fire Department 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

Remaining Challenges and Barriers

Challenges	Path Forward
Data not readily available for using risk-informed code development in the CCSI process	Working with industry and interested parties may produce data to support code development projects
Code compliance process can be complicated leading to noncompliance	Implement the CCSI process to develop code requirements that reflect information derived from actual deployment
Code users may be infrequent or new users	Develop tools in the most effective format to get users quickly oriented to the applicable requirements
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

Proposed Future Work

Future Project Area	Example Work Product
Develop IRIG proposals on tunnels, components, system maintenance, and venting systems	Public inputs to NFPA codes and components standards
Complete codes and standards gap analysis	Prioritized list of code gaps and required research to fill gaps
Update permitting tools	Code Official Training
Complete station aging analysis	Timeline of preventative maintenance actions to avoid component and system failures

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

Summary

- 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 for their needs.
  - Performing all of these activities with the widest collaboration with all interested parties.