

Safety, Codes & Standards Program Area Plenary Poster

Laura Hill, Project Manager – Fuel Cells Technology Office

2018 Annual Merit Review and Peer Evaluation Meeting

June 13-15, 2018 – Washington DC



Safety, Codes & Standards Goals & Objectives

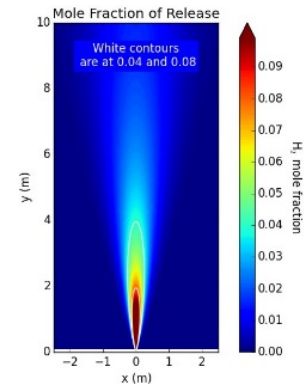
Funding R&D needed to develop science-based codes and standards, thereby enabling the safe deployment of H₂ and fuel cell technologies

Codes & Standards

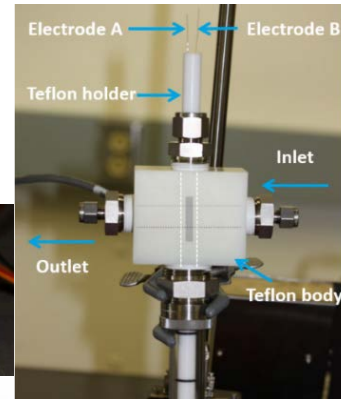
- Conduct **R&D to provide critical data** and information needed to define requirements in developing codes and standards.
- Support and facilitate development of **essential codes and standards to enable widespread deployment** of hydrogen and fuel cell technologies and completion of essential regulations, codes and standards (RCS).

Safety

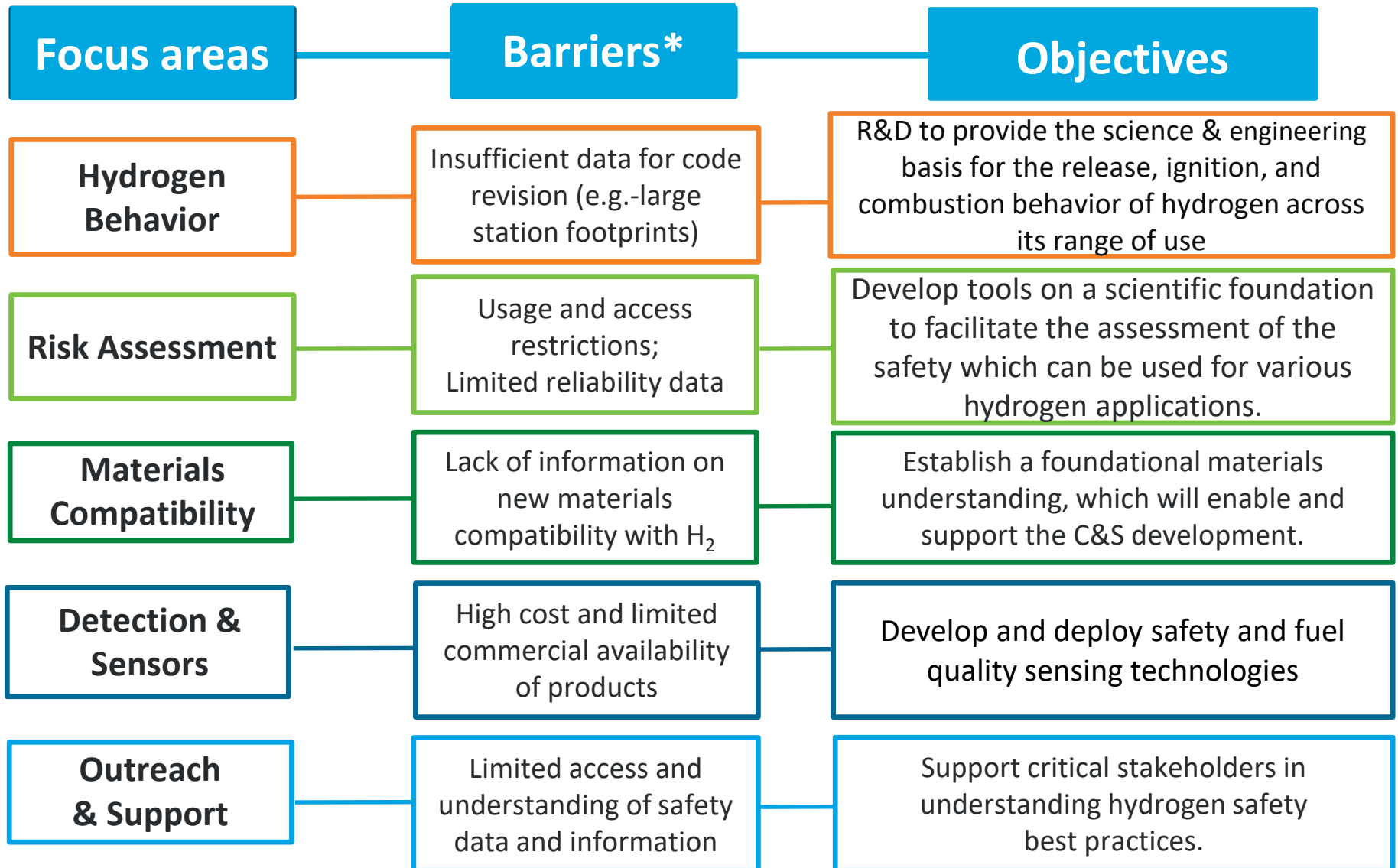
- Ensure that **best safety practices** underlie activities supported through DOE-funded projects.
- Enable **widespread sharing of safety-related information resources** and lessons learned with key stakeholders.



614g 100 cycles



Current Strategy and Barriers

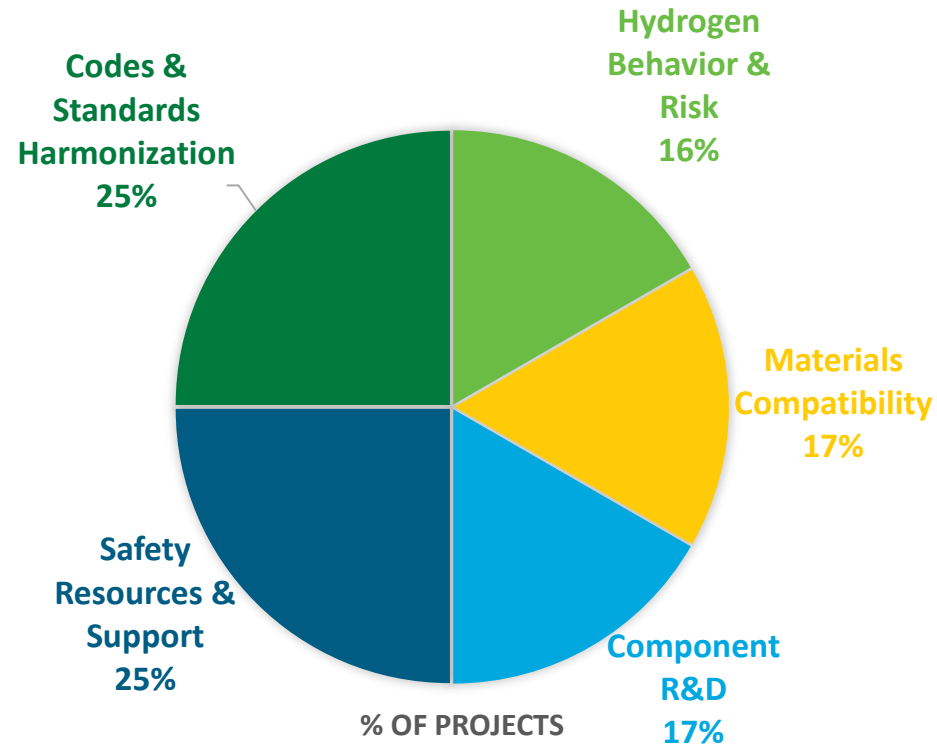
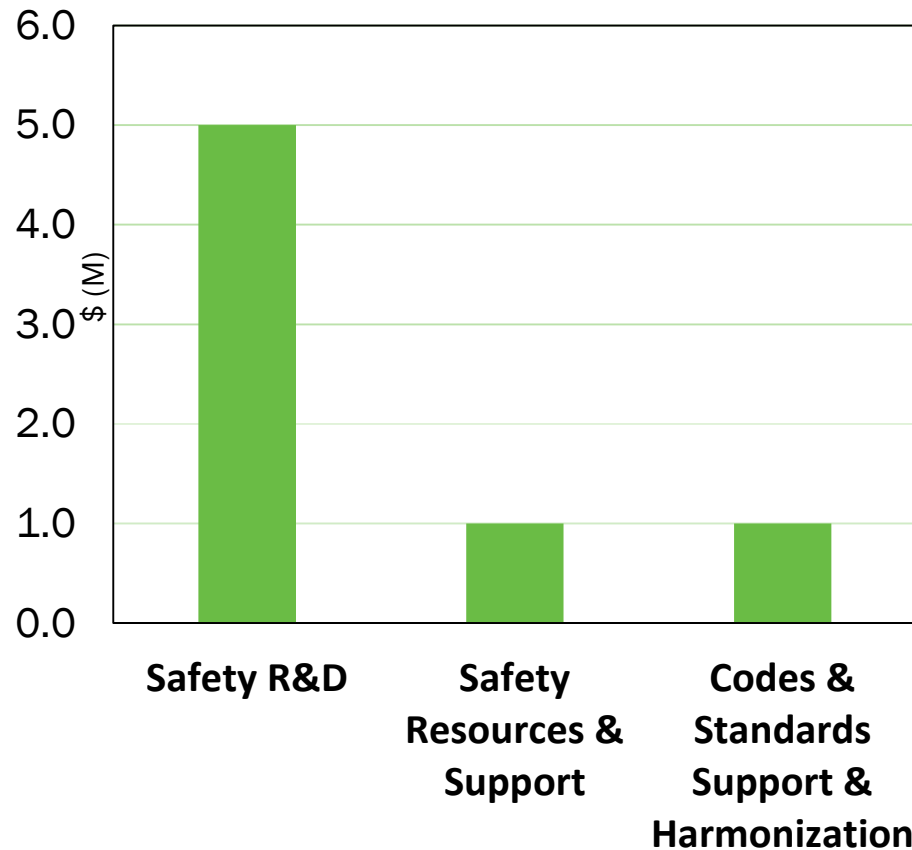


* From Safety, Codes and Standards MYRD&D (June 2015)

Budget

FY 2018 Appropriation = \$ 7M

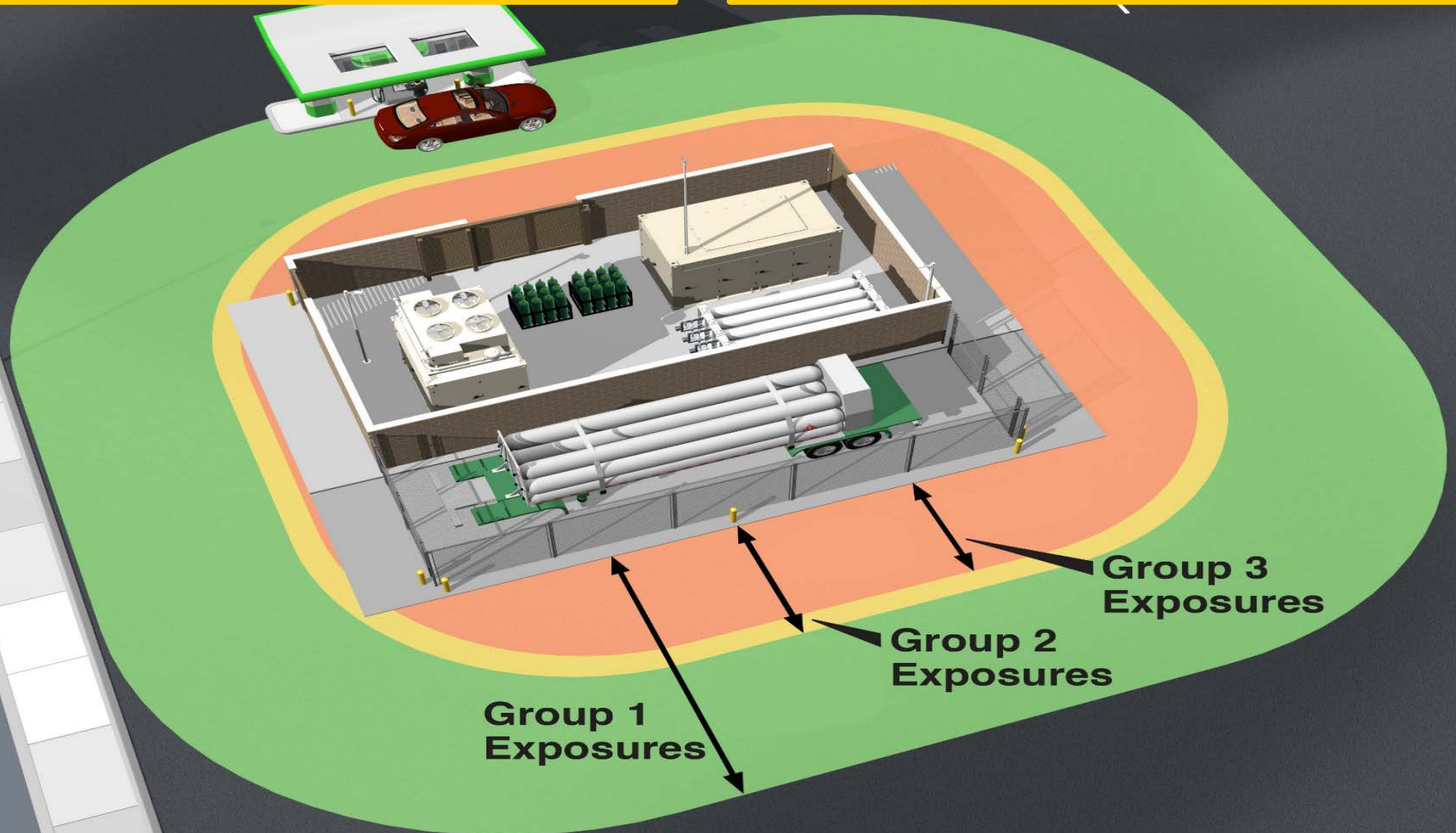
Emphasis: R&D to enable science-based codes & standards and to support H₂ safety best practices



Barrier: LH2 Separation Distances

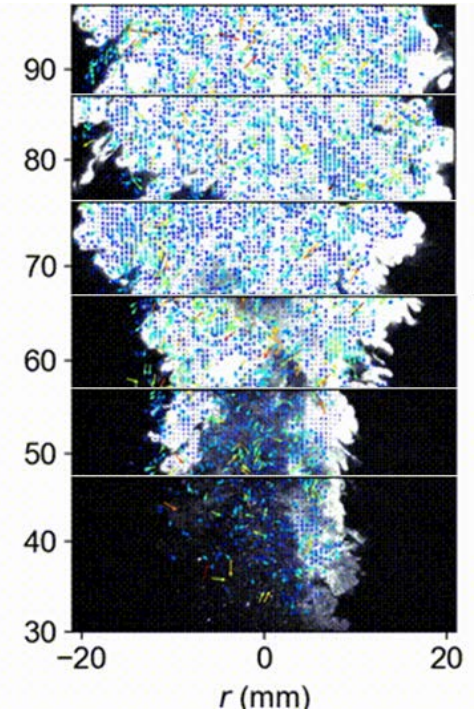
Barrier: Insufficient data for code revision (large LH2 station footprints)

Barrier: Usage and access restrictions;
Limited reliability data

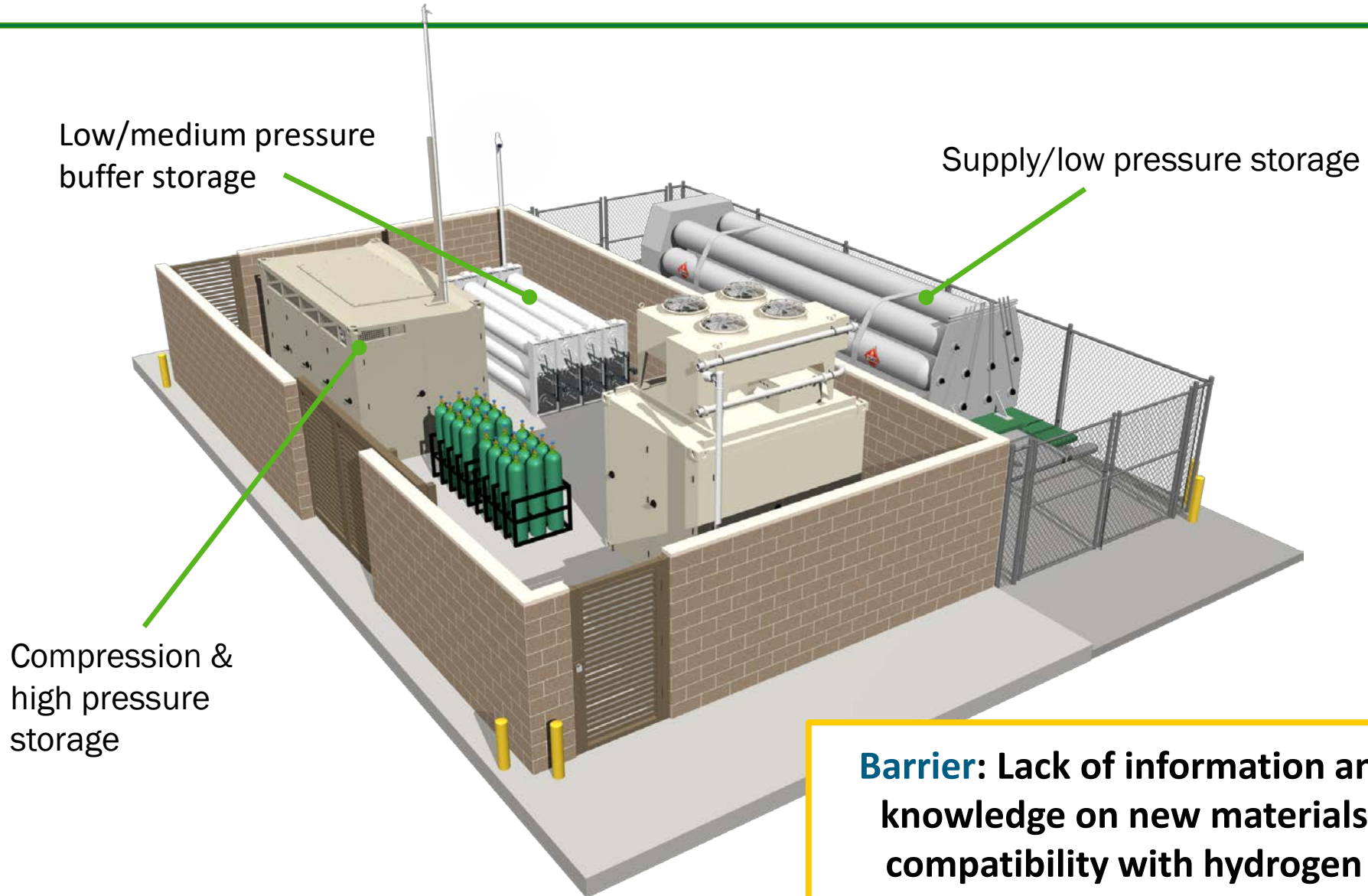


R&D Accomplishment: Separation Distances

- **Hydrogen Behavior (SCS010)**
 - Completed the first ever nearfield measurement and validation of temperature, concentration and velocity of cryogenic plumes at 50K
- **Quantitative Risk Assessment (SCS011):**
 - Converted backend HyRAM code to increase model efficiency and future enhancements
 - Identified and prioritized four areas of risk relating to hydrogen materials based on level of resources required and potential impact to the field
- **Enable Hydrogen Infrastructure through Science-based Codes and Standards (SCS025)**
 - Initiated CRADA to employ HyRAM (Hydrogen Risk Assessment Models) and other analysis to real-world acceptance of risk-based alternate means for code compliance



Barrier: Hydrogen Compatibility of Materials

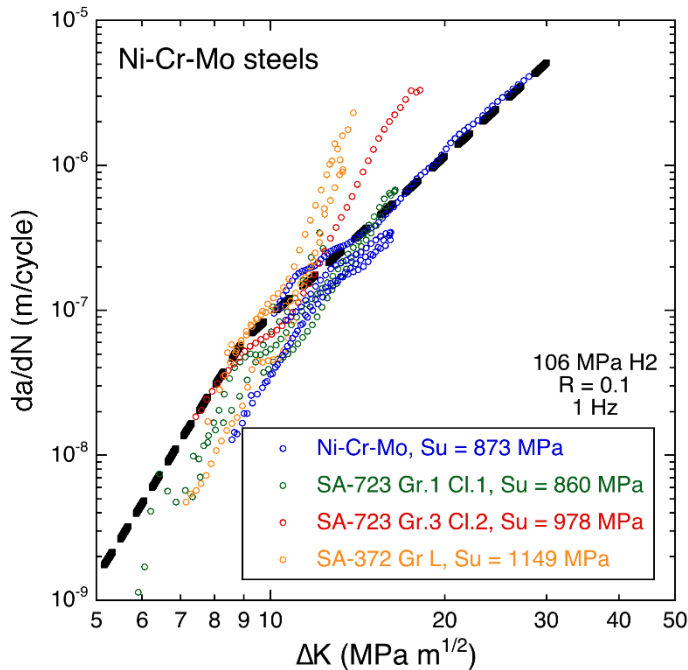


R&D Accomplishment: H₂ Materials Compatibility

Performing critical materials R&D to understand material behavior in high pressure hydrogen, which will enable RCS in support of infrastructure deployment

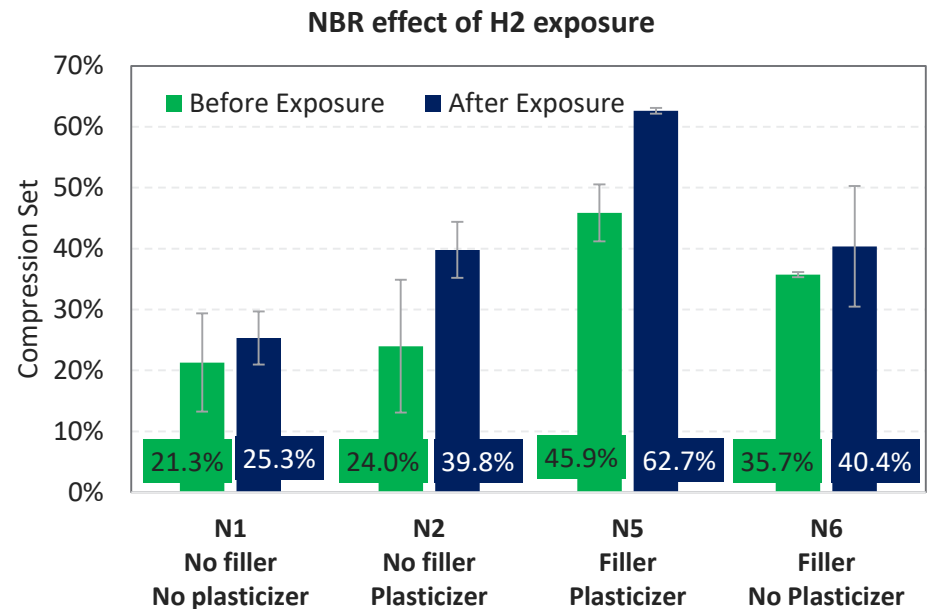
Metallic Materials Compatibility (SCS005)

A universal fatigue crack growth curve was developed to capture the general behavior of pressure vessel steels



Non-Metallic (Polymer) Compatibility (SCS026)

Initiated testing program of model elastomer compounds to understand behaviors of various polymers



Barrier: Safety Sensors

Barrier: High Cost and Limited Commercial Availability of Products

H₂ safety sensors

Tailpipe Analyzer



R&D Accomplishment: Safety Sensors

Comprehensive knowledge on safety sensor behavior is improving safety for FCEVs, infrastructure, and repair garages; all critical components of hydrogen technology.

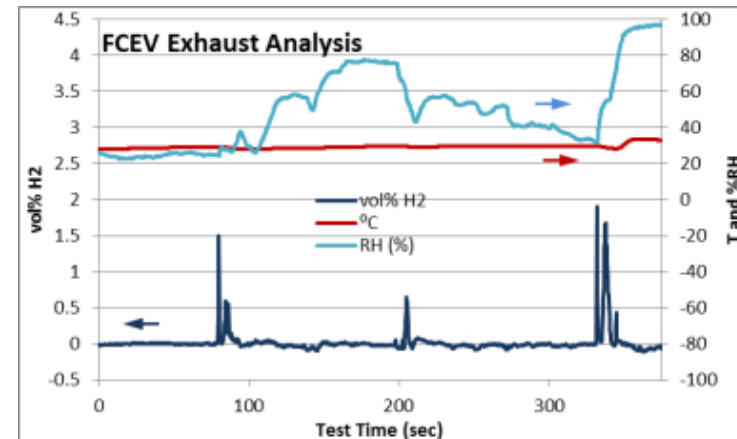
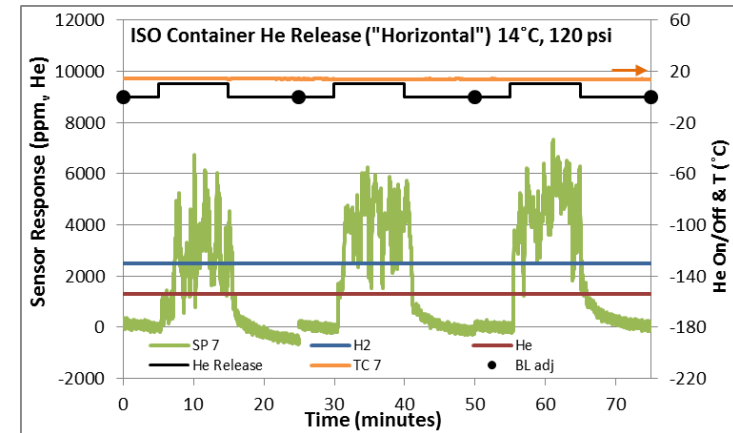
Objective: Develop low cost, low power, durable, and reliable H₂ safety sensor for vehicle and infrastructure applications.

1. Indoor Placement Study: CFD modelling and empirical verification of indoor hydrogen releases

- Empirical verification using the NREL HyWAM
- Good agreement between model and measurement
- Independent CFD verification ongoing

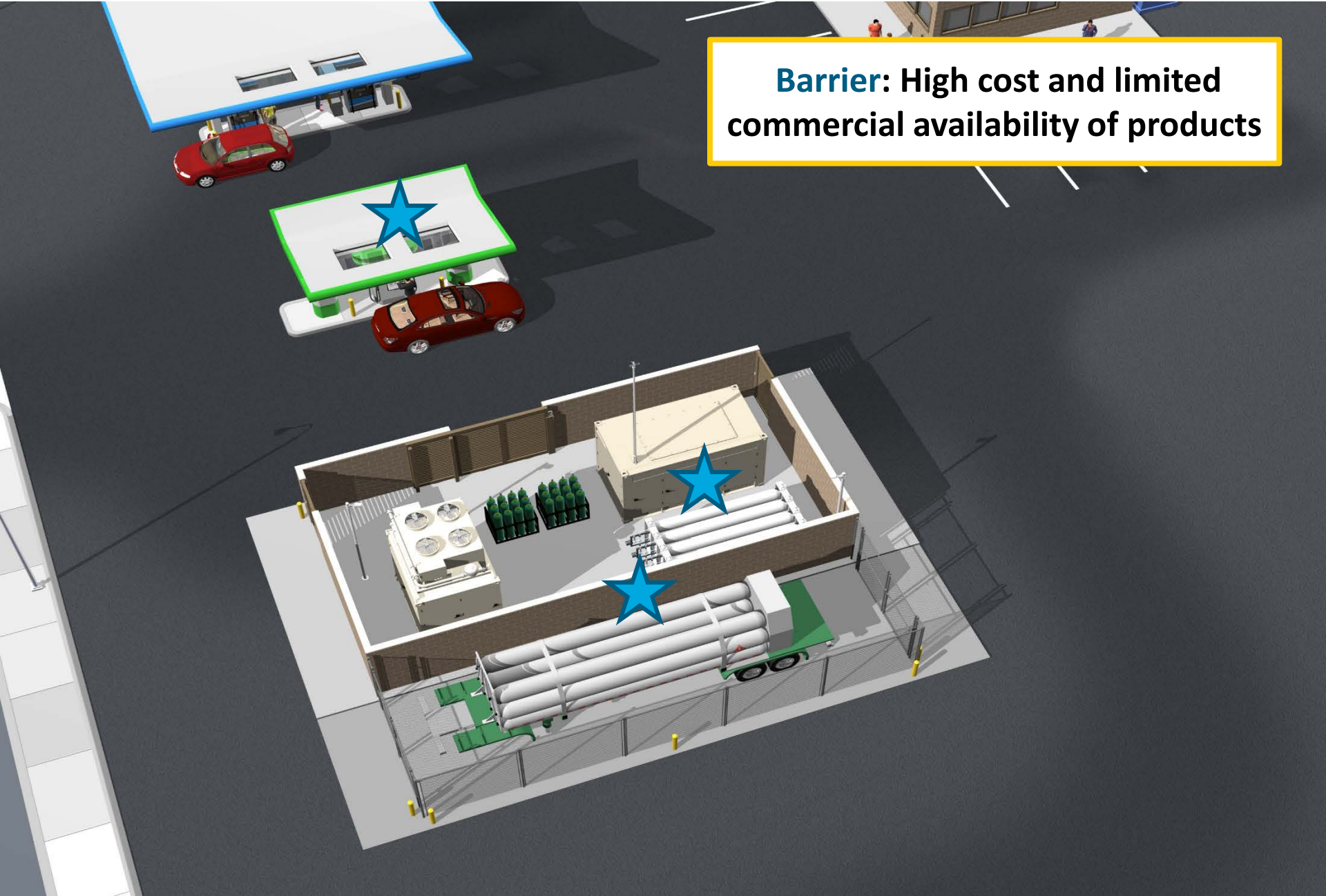
2. Vehicle Tailpipe H₂ Emissions: Collaboration with DOT NHTSA in support of Global Technical Regulation (GTR)

- Developed FCEV Exhaust Analyzer for verification of GTR-13 requirements.
- Performance verified in the laboratory and vehicle; Field tested on FCEV; detected hydrogen successfully



Barrier: Fuel Quality Assurance

Barrier: High cost and limited commercial availability of products

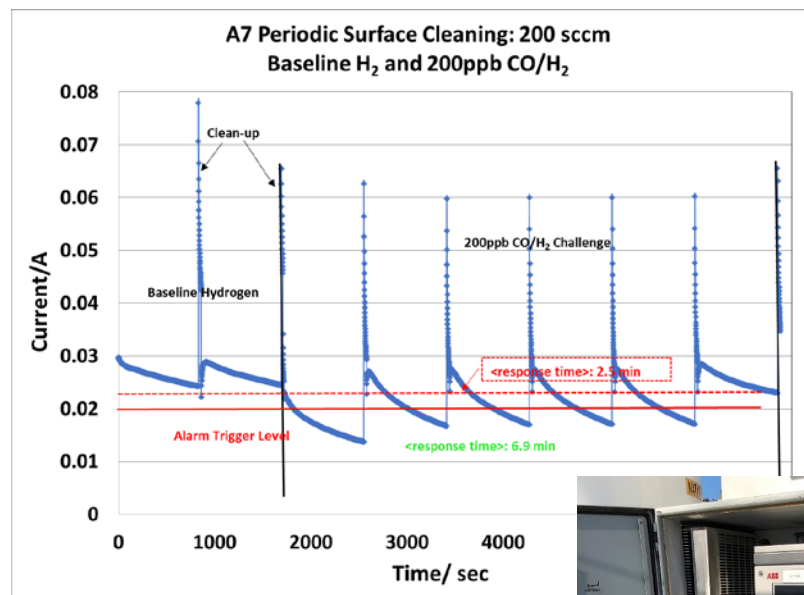


R&D Accomplishment: Fuel Quality and Fuel Quality Assurance

A means of detecting contaminants in the hydrogen fuel stream is vital to ensure quality according to SAE J2719 and prevent damage to the fuel cell.

Hydrogen Fuel Quality (SCS007)

- Initiated fuel testing of in-line hydrogen contaminate detector with improved baseline stability
- Response time goal met for both 100 sccm and 200 sccm hydrogen flows
- **Patent application filed for analyzer prototype.**
- Analyzer installed and field tested
- Will test analyzer response to 1ppm CO/H₂ test gas and calibrate response and verify baseline recovery after cleanup potential is applied

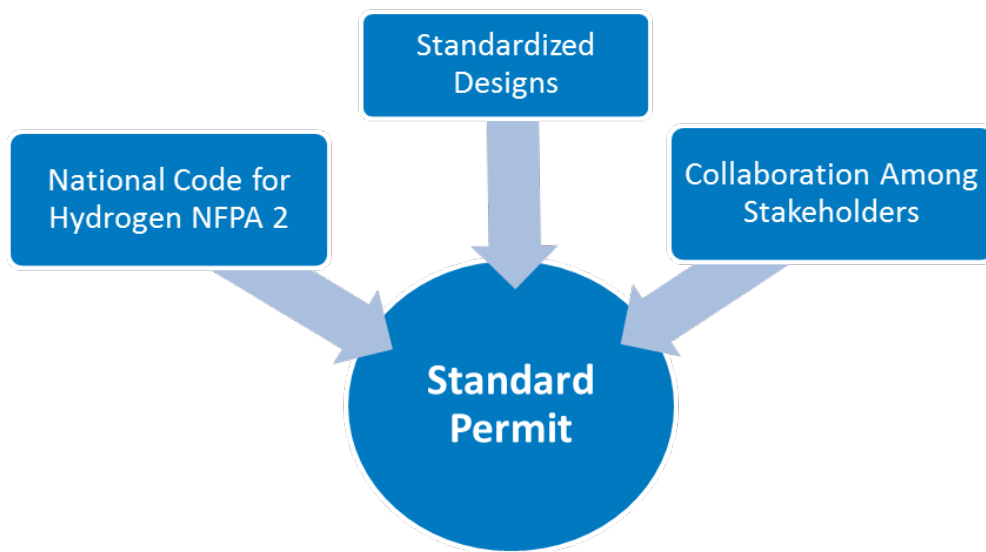


R&D Accomplishment: Developed Standard Permit for Hydrogen Storage

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

Codes and Standards Deployment and Outreach (SCS001):

- Based on industry requests, facilitated development of a Standard Permit for Hydrogen Fueling Stations to enable a more efficient permitting process
- Standard permit for gaseous/liquid HFSs submitted to NFPA 2 to be added to annex text
- Maintained Permitting tools on H2Tools
- Presented Webinar on permitting tools to streamline hydrogen infrastructure permitting and standard permitting



Cross-cutting Effort: Tunnel Safety Evaluation

Barrier: Hydrogen safety risks in tunnels are not well characterized



Cross-cutting Effort: Tunnel Safety Evaluation

Risk analysis and modeling results will be communicated to code officials to assist in their decision-making on allowing FCEVs in tunnels.

Tunnel Safety Evaluation Accomplishments (SCS025):

- Structural epoxy is not impacted by jet flame or heating effects
- Damage to concrete ceiling panels is extremely localized, shallow and conservative
- No structural impact to load bearing structure due to maximum temperature of steel hangers exposed directly to the hydrogen jet flame

t = 1.02 s

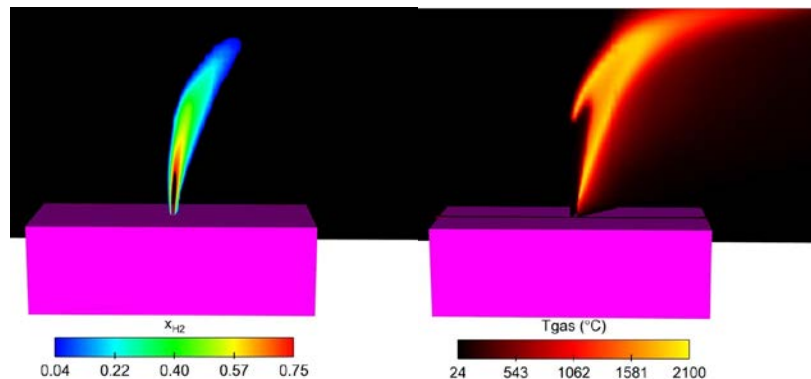
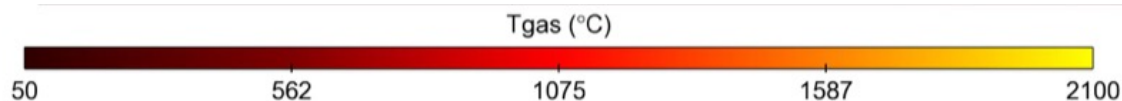
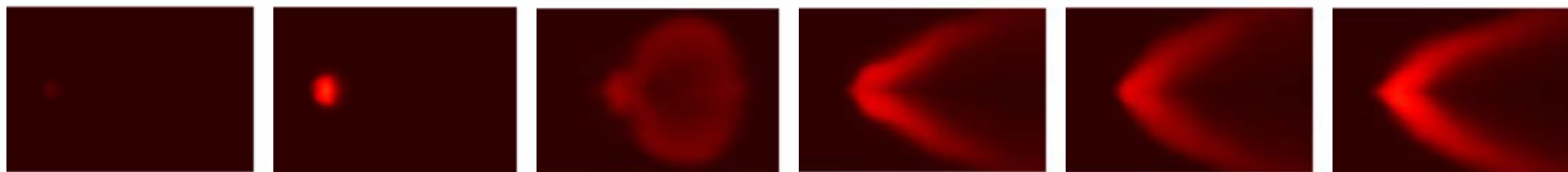
t = 1.12 s

t = 2 s

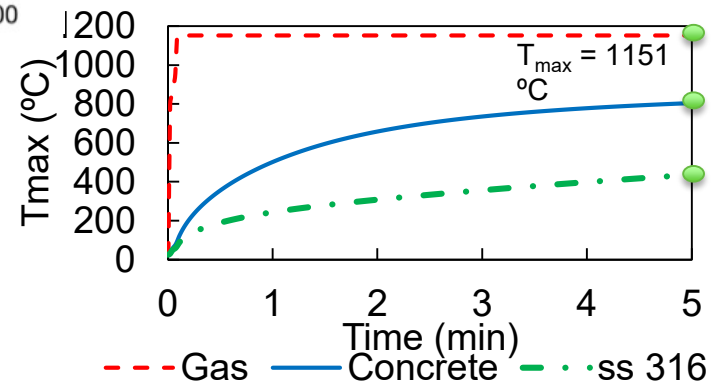
t = 3.05 s

t = 4.08 s

t = 5.88 s



Maximum concrete Temperature vs. Time



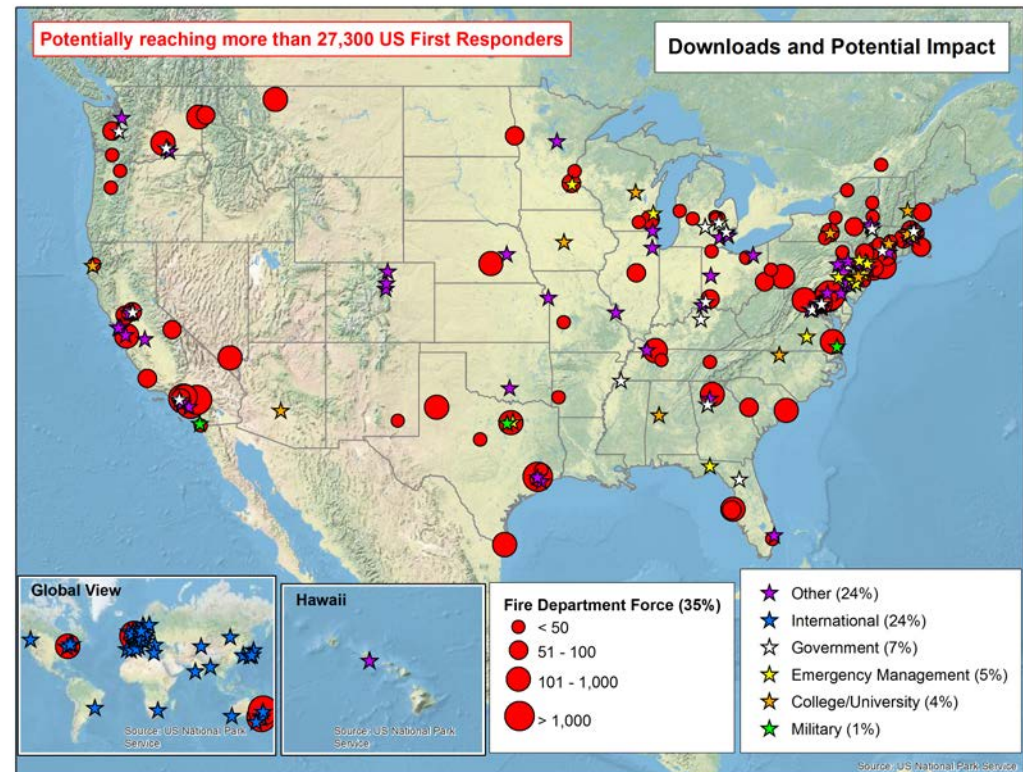
Outreach Resources – Training & Outreach

SCS supports continued code official and first-responder training, both online and in-person, with over 36,000 individuals reached!

*Safety outreach in both California and Northeast in FY18:
Supporting the safe rollout of hydrogen infrastructure (SCS019)*

Accomplishments:

- Substantial update of First Responder training material was completed in February 2018
- Refreshed Online Training in May 2018
- >1,500 attendees at Classroom Training since 2009
- 388 downloads of National Template (+58 in past 12 months)



Enabling Safe Deployment: H2Tools.org

The U.S. is a leader in hydrogen safety; H2Tools.org is a key resource to disseminate safety information

Enable the safe and timely transition to hydrogen and fuel cell technologies through unique and highly impactful safety resources (SCS019)

Site Content

3,629

Total Pages

2,414

Bibliographic References

217

Lessons Learned Pages

142

Best Safety Practices Pages

Usage Stats*

279,678

Total Pageviews

56,951

Sessions

4.91

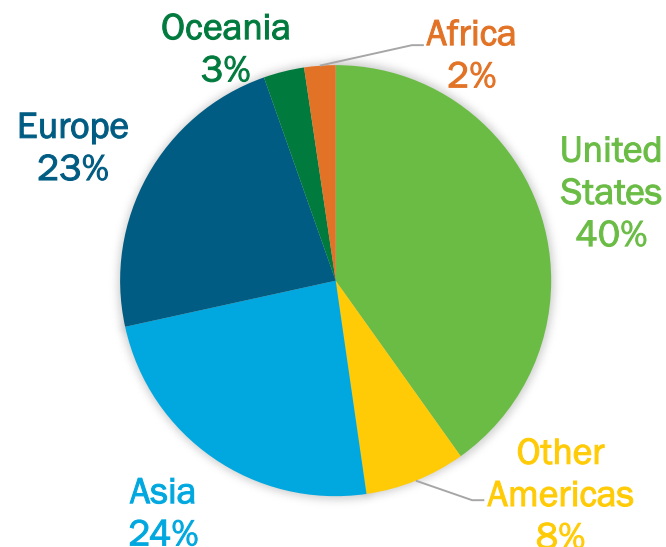
Pages Visited per Session

6:36

Minutes per Session

>100% growth
since 3/2017

H2Tools.org - A Global Resource!



* Nonbounce statistics through March 31, 2018

Enabling Safe Deployment: AIChE Partnership

Partnership will enable broader access to online and in-person training resources

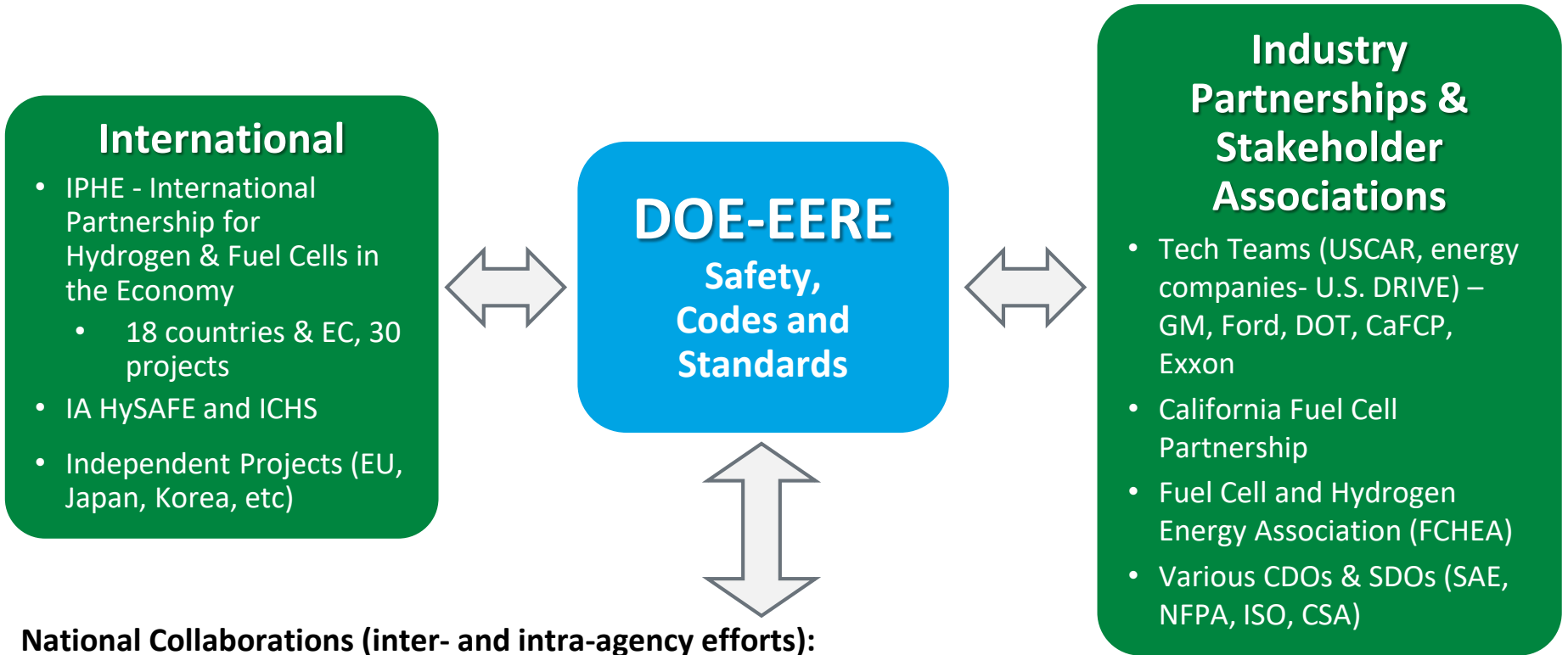
Codes and Standards Deployment and Outreach (SCS001):

AIChE* is planning to establish a Center for Hydrogen Safety. PNNL will partner with AIChE to expand the HSP's access to new customers by:

- Making the HSP more readily available to industry, state, and federal government agencies (national and international)
- Enabling less cumbersome/time-consuming contracting efforts
- Enabling broader access to key safety knowledge resources



Collaborations



National Collaborations (inter- and intra-agency efforts):

State & Regional Partnerships

- California Fuel Cell Partnership
- CT Center for Advanced Technology
- Massachusetts Hydrogen Coalition

National Laboratories

LANL	PNNL
NREL	SNL
ORNL	

Federal Agencies

DOT NASA DOE-FEMP

– Interagency coordination: staff-level Interagency Working Group
Assistant Secretary-level Interagency Task Force mandated by EPACK 2005.

Thank You

Laura Hill

Project Manager

202-287-6223

laura.hill@ee.doe.gov

Chris LaFleur

M&O Contractor

202-287-5371

chris.lafleur@ee.doe.gov

Jay Keller

Consultant

925-519-2043

Jay.keller@zces-inc.com

Salil Deshpande

Contractor

202-586-9731

salil.deshpande@ee.doe.gov