U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Analysis, Codes & Standards Overview

Neha Rustagi, HFTO – Program Manager

2024 Annual Merit Review and Peer Evaluation Meeting

May 7, 2024 – Arlington, VA

The Hydrogen and Fuel Cell Technologies Office (HFTO)

Mission

Research, development, and demonstration (RD&D) of hydrogen and fuel cell technologies to advance:

- Clean Energy and Emissions Reduction Across Sectors
- Job Creation and a Sustainable and Equitable Energy Future

HFTO Subprograms

Hydrogen Technologies

- Hydrogen Production
- Hydrogen Infrastructure

Fuel Cell Technologies

- Materials & Components
- Systems

Systems Development & Integration

- Transportation
- Chemical & Industrial Processes
- Energy Storage & Power Generation

Systems Analysis

Safety, Codes & Standards

Crosscutting / Enabling: manufacturing, supply chain, workforce, regional clean H_2 networks

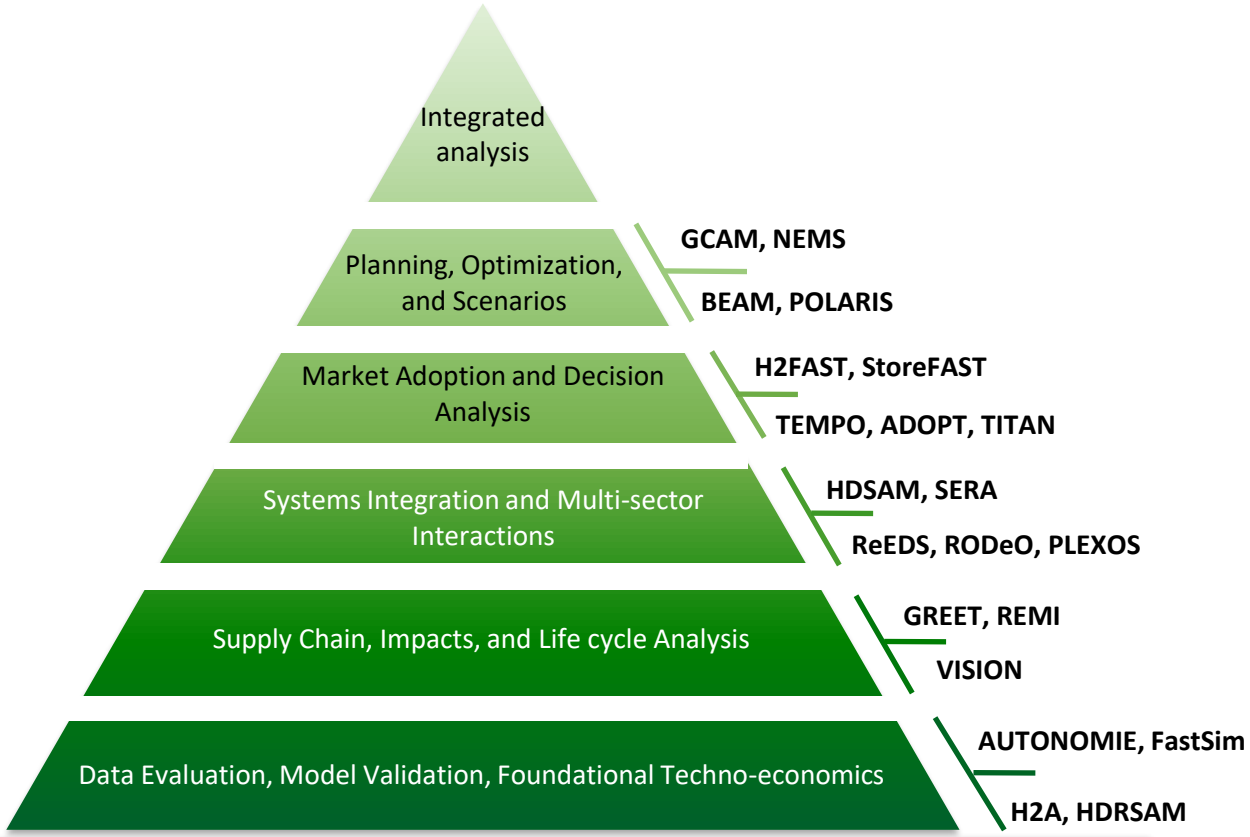
Enabling

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen

H2@Scale U.S. Department of Energy

Analysis, Codes & Standards Program

Enabling activities to inform research, development, demonstrations and deployments



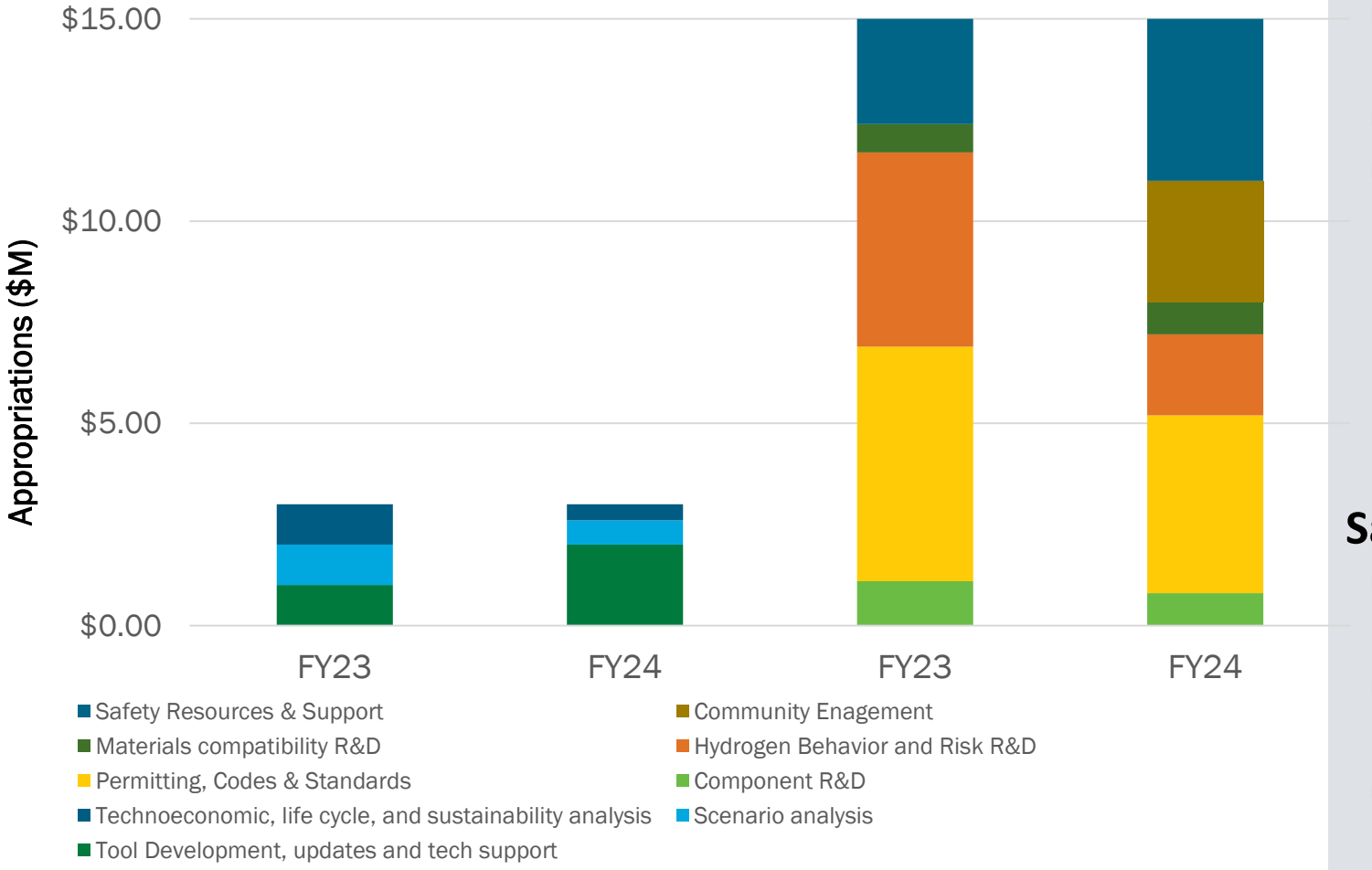
Systems Analysis identifies priority markets for hydrogen technologies and assesses impacts

Safety, Codes, & Standards informs safe design and operation of technologies, and addresses regulatory and permitting challenges.

Systems Analysis & SCS: Budgets

Systems Analysis
$3M FY23, $3M FY24

SCS
$15M FY23, $15M FY24



Program Direction

Systems Analysis (SA)

- User-friendly tools to characterize cost and emissions
- Cost, emissions and sustainability analyses of
- Inclusion of hydrogen in energy market models to include H_2 demand scenarios in strategic sectors
  to enable net zero by 2050

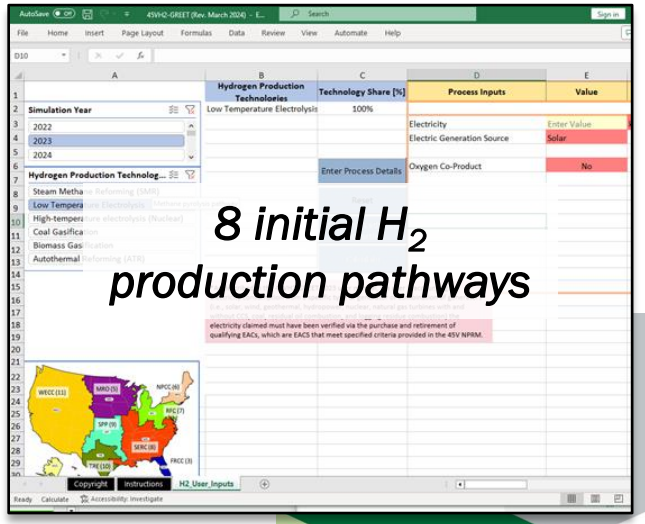
FY25 Request : $3 million

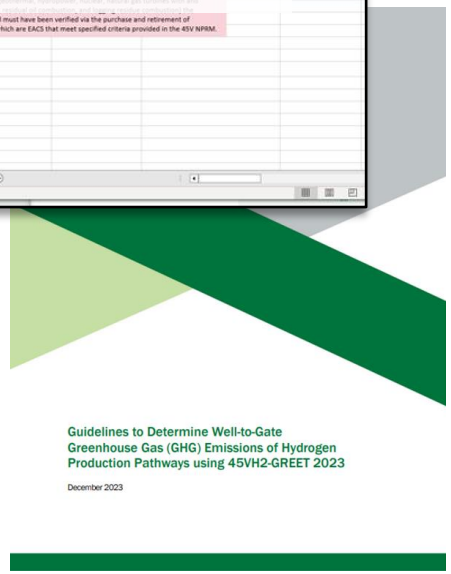
Safety, Codes, & Standards (SCS)

- Increased focus on approaches to streamline permitting
- R&D to inform codes & standards R&D (release behavior, materials compatibility)
- Component R&D (e.g. sensors)

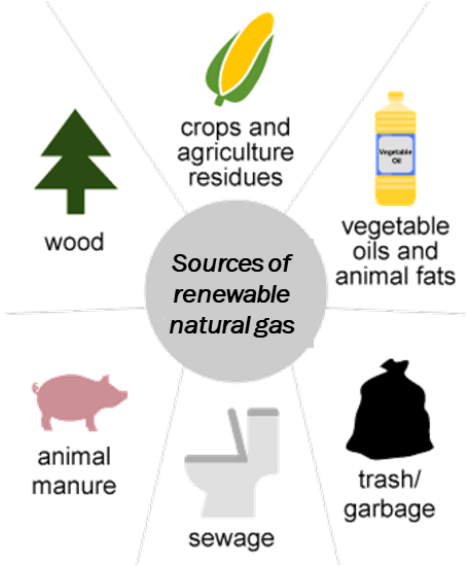
FY25 Request: $10 million

Key Life Cycle Analysis Activities

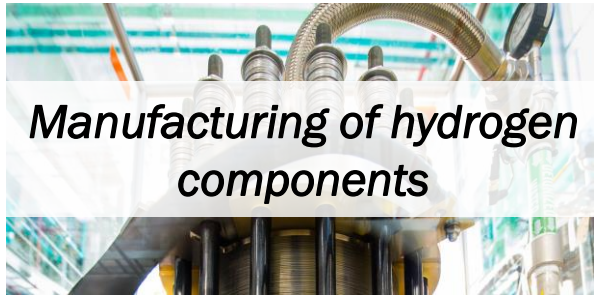




Release of 45VH2-GREET model, in support of 45V tax credit



Evaluating additional H_2 production pathways, in coordination with DOE Offices



Addressing additional drivers of emissions

GREET Train the Trainer Program

01 LEARN

ANL and GPI will train individuals (trainers) with previous Life Cycle Assessment (LCA) experience, excellent verbal communication skills, and specific applications in carbon accounting

02 CO-TEACH

Through interactive training sessions, these trainers will learn the key functionalities, model structure, simulation steps and workflows, data management, and unique modeling features of the GREET model

Broader Users

Analysts

03 EDUCATE

The trainers will increase the accessibility of the GREET model by providing on-demand training, leading workshops in their communities, and staying current on the next generation of the model by attending periodic Argonne online workshops

Interested? Reach out here!
greet_trainer@gpisd.net

Technoeconomic Analysis of Early Markets

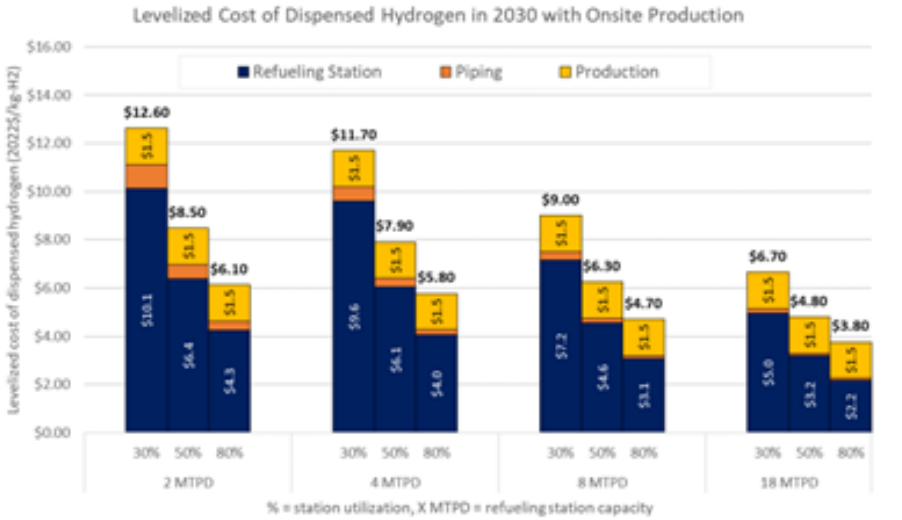


Figure 6.2. Potential total LCOH dispensed at 2, 4, 8, and 18 MTPD fueling stations with various fueling station lifetime utilization rates. Assumes an on-site production facility with 0.1 km (0.062 miles) of piping connecting production and fueling station.

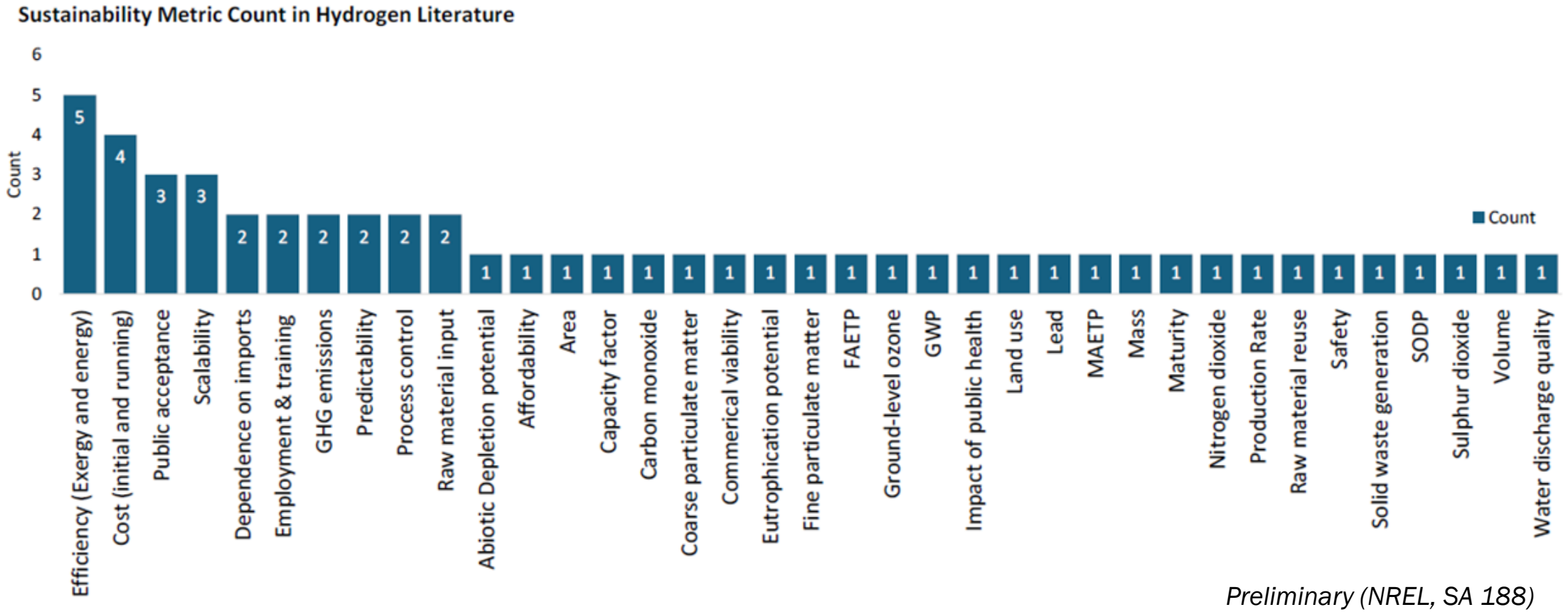
Note: the dispensed LCOH values do not include additional markup that could affect the price of hydrogen fuel to the customer.

NREL/ANL analysis characterizing cost under varying utilization rates and station sizes

- **Analysis identified potential early market cost of clean fuel at ~$12-16/kg[1]**
- **Update to Annual Technology Baseline (ATB) for Transportation to include cost of driving medium- and heavy-duty trucks**
- **Potential focuses of future work:**
  - Update ATB to reflect emissions implications of specific fuel pathways
  - Identify future cost scenarios for hydrogen production, delivery, and dispensing.

1. Assumes 2 tpd station, 30-50% utilization, and ~$5/kg for cost of clean fuel.

Sustainability Assessments to Guide Real-World Deployments

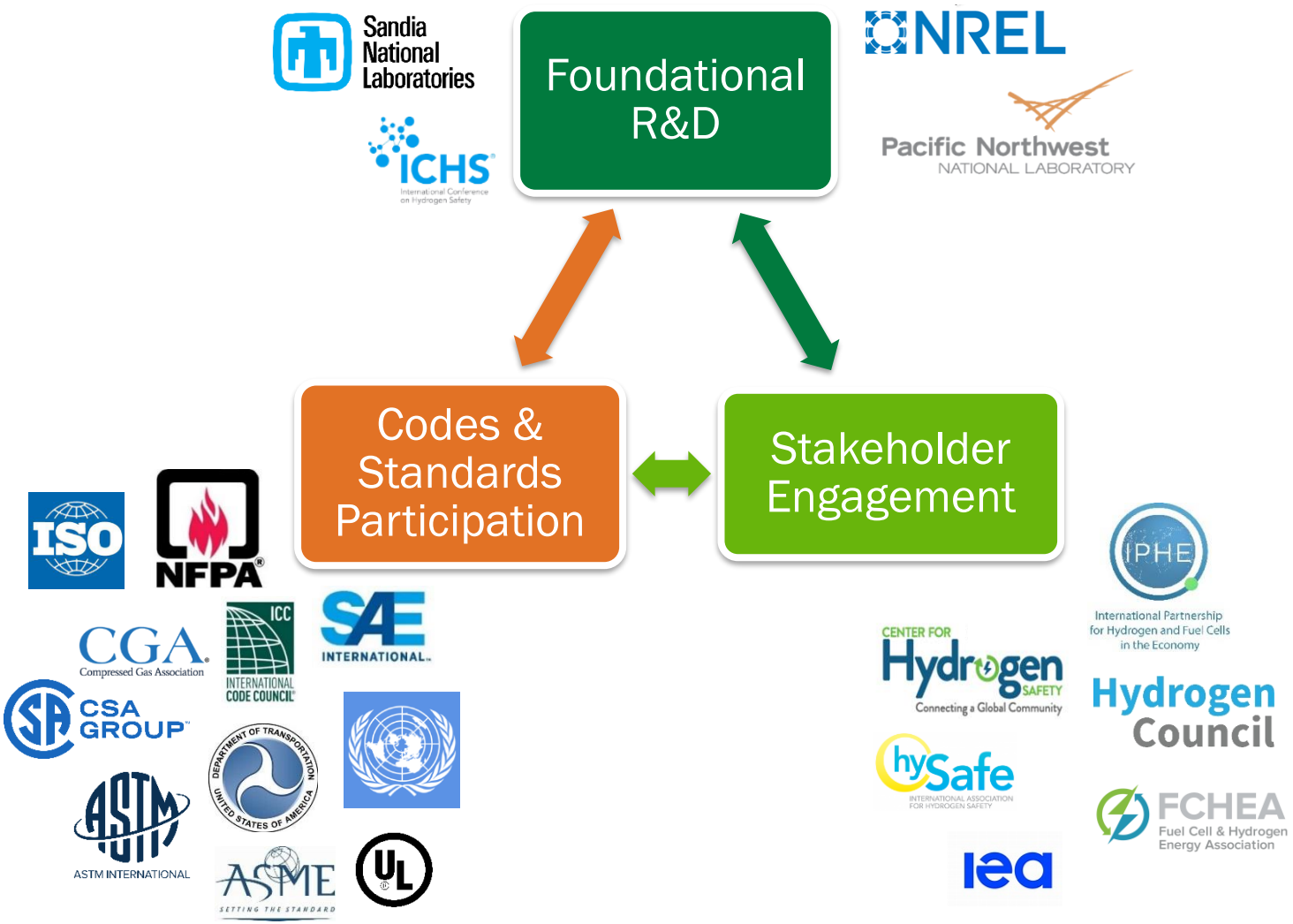


Preliminary (NREL, SA 188)

New projects are focused on developing sustainability criteria for hydrogen deployments, identifying best practices, and addressing key challenges

Safety, Codes, and Standards Focus Areas

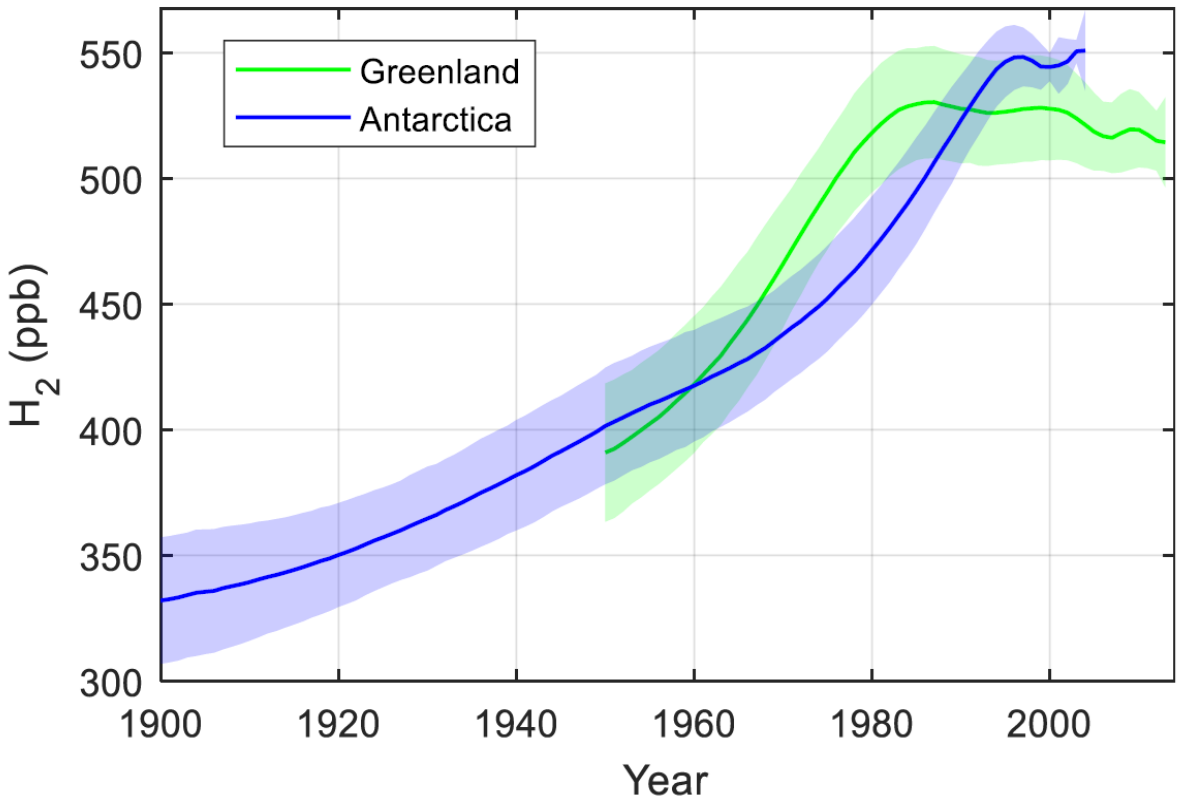
Collaborative Ecosystem



Activities Focused on Cross-Cutting Challenges

- Identifying and addressing permitting challenges
- Harmonization of codes & standards
- Advancement of sensor technologies
- Risk & Behavior R&D
- Materials compatibility R&D
- Safety Resources & Support

Understanding and Addressing Indirect Impacts of Hydrogen Releases



Atmospheric levels of H_2 over the past century based on air measurements using ice samples from Greenland and Antarctica

Patterson et al. https://cp.copernicus.org/articles/19/2535/2023/

$11.4M+ over 3 Years on H_2 Emissions

- R&D with NOAA to model atmospheric levels of H_2, understand soil uptake, and inform estimates of the GWP of H_2
- 9 NEW PROJECTS developing ppb-level sensors and quantification technologies
- Continuing national lab R&D on detection, leak rates, and release behavior

ARPA-E Open funding opportunity on detection of hydrogen releases due June 7, 2024:

Collaborative Approach to Address Hydrogen Emissions

The **Hydrogen Component Reliability Database (HyCReD)** collects high quality data to improve safety, reduce failure rates and maintenance cost, and inform component R&D to enable reduced hydrogen emissions.

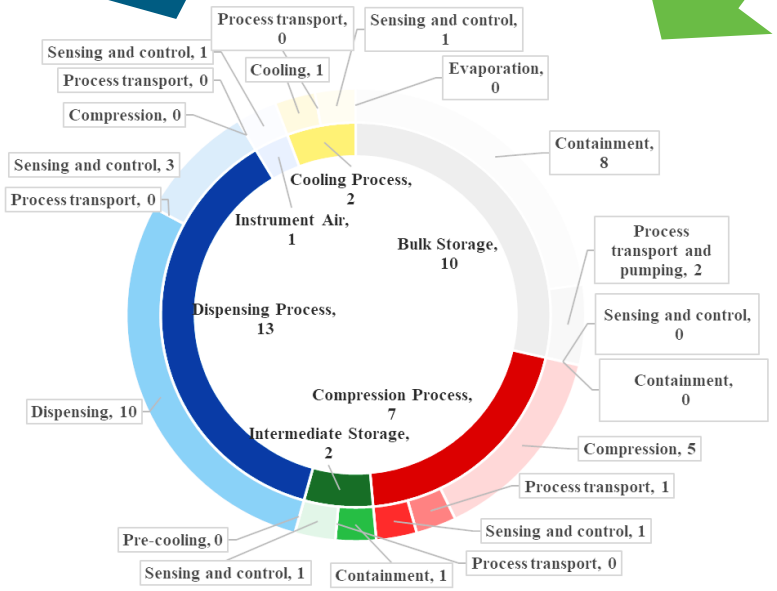
Maintain secure and anonymous data

Increase Transparency

Increase safety and reliability

Enable reduced hydrogen emissions

Reduce maintenance cost



**Data shown from public sources*

Call to Action: Get Involved!

- Share your data with NREL and UMD through a standard NDA
- **Email hycred@nrel.gov**

SYRRA

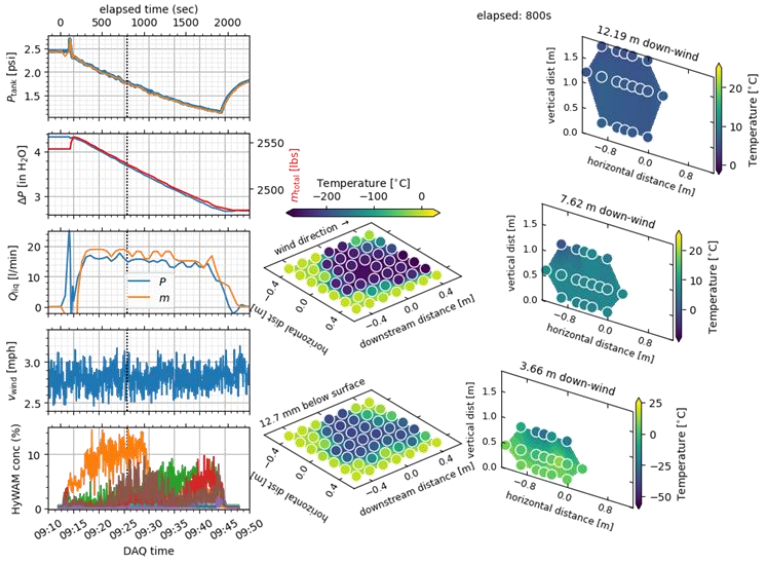
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL's National Fuel Cell Technology Evaluation Center

LH2 Pooling Experiments Enable Model Development & Validation

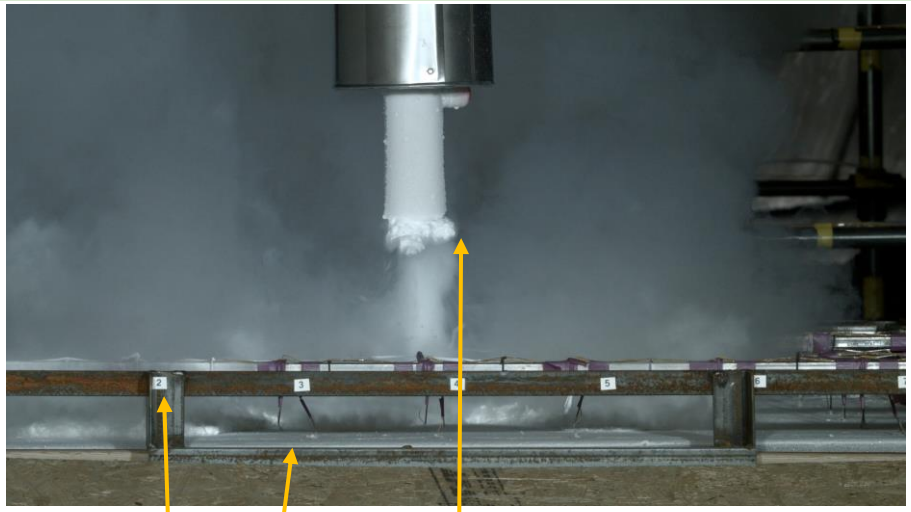
Unique LH2 pooling experiment enables validated models to justify needed safety requirements without unnecessary restrictions for larger liquid hydrogen systems in emerging technologies

- **16 tests** over **4 days**
- Variations in wind speed, substrate, LH2 release rate
- Utilized **IR and Visible cameras** coupled with temperature and concentration sensors
- **NREL** 's Hydrogen Wide Area Monitor (**HyWAM)** monitored hydrogen concentrations, correlated with temperature



Sandia National Laboratories

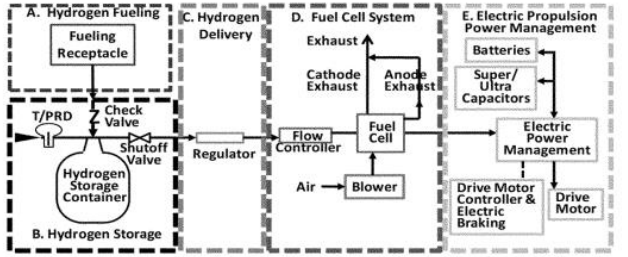
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

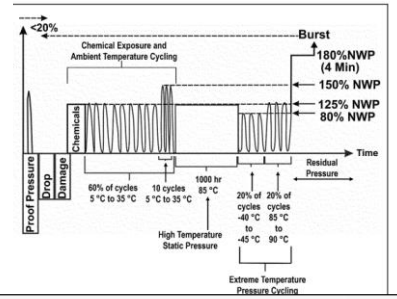


Proposed New Federal Motor Vehicle Safety Standard for Hydrogen

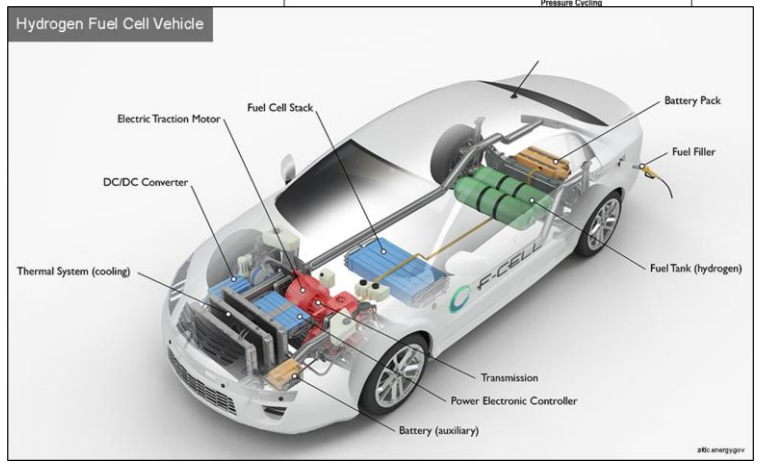
Notice of Proposed Rulemaking by DOT NHTSA for Hydrogen Fuel Systems and Hydrogen Containers

- **Based on the Global Technical Regulation No. 13, developed with support from HFTO**
- Applicable to Light and Heavy Vehicles
- Compressed Hydrogen Storage System
  - Container durability
  - Expected on-road performance
  - End-of-life container strength
  - Closure device (TPRD, valve) performance
  - Fire exposure safety performance
- Vehicle Fuel System
  - Post crash hydrogen leakage limits - light vehicles and school buses
  - Hydrogen discharge direction and concentration limits
  - Hydrogen detection & warning system





View the NPRM at Federal Register pg. 27502-27561 or here:



SCS Technical Assistance Program

Lab Technical Assistance for Small U.S. Projects where Timely Support is Essential

Projects that integrate information sharing and inform near-term deployment activities encouraged

Pacific Northwest NATIONAL LABORATORY

- Assist incident investigations
- Support questions from AHJs
- Inform & review safety materials
- Provide virtual training
- FY24: supported root cause analysis

Please contact:
hsp@h2tools.org
For ongoing support in safety topics, please explore the Center for Hydrogen Safety

Sandia National Laboratories

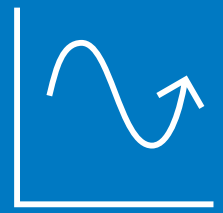
- Conduct risk assessments
- Develop models and diagnostics for hydrogen release and flame behavior
- Answer questions on hydrogen-metal interactions
- FY24: supported upgrading a custom gas-phase permeation system to evaluate surface barrier coatings

Please contact:
H2_SCS_Technical_Assistance@sandia.gov

NREL NATIONAL RENEWABLE ENERGY LABORATORY

- Evaluate hydrogen sensors
  - Metrological performance
  - Use in pure hydrogen and natural gas blends
- Support performance testing of hydrogen contaminant detectors
- FY24: supported assessment of detection for safety, process monitoring, fuel quality, emissions monitoring

Please contact:
HSRD@groups.nrel.gov



Hydrogen Safety Codes and Standards Applicability Navigator (HySCAN)

- Enable **new hydrogen stakeholders** to identify current codes and standards to move quickly and safely into the hydrogen market
- Current focus on NFPA 2 and ASME B31.12

HySCAN
Hydrogen Safety Codes & Standards Applicability Navigator

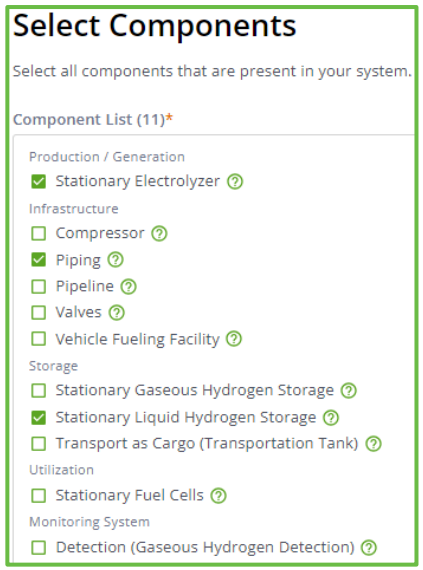
Pacific Northwest NATIONAL LABORATORY

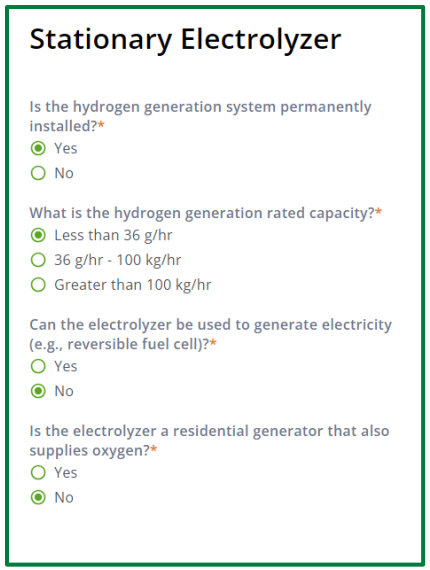
Sandia National Laboratories

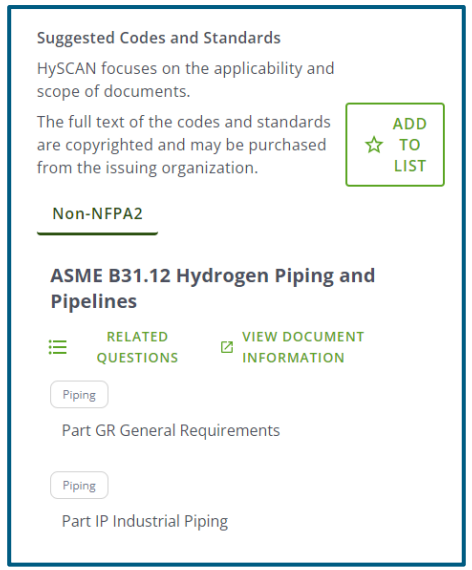
NREL NATIONAL RENEWABLE ENERGY LABORATORY

How It Works:

Select Components → Answer Questions → Relevant Codes & Standards





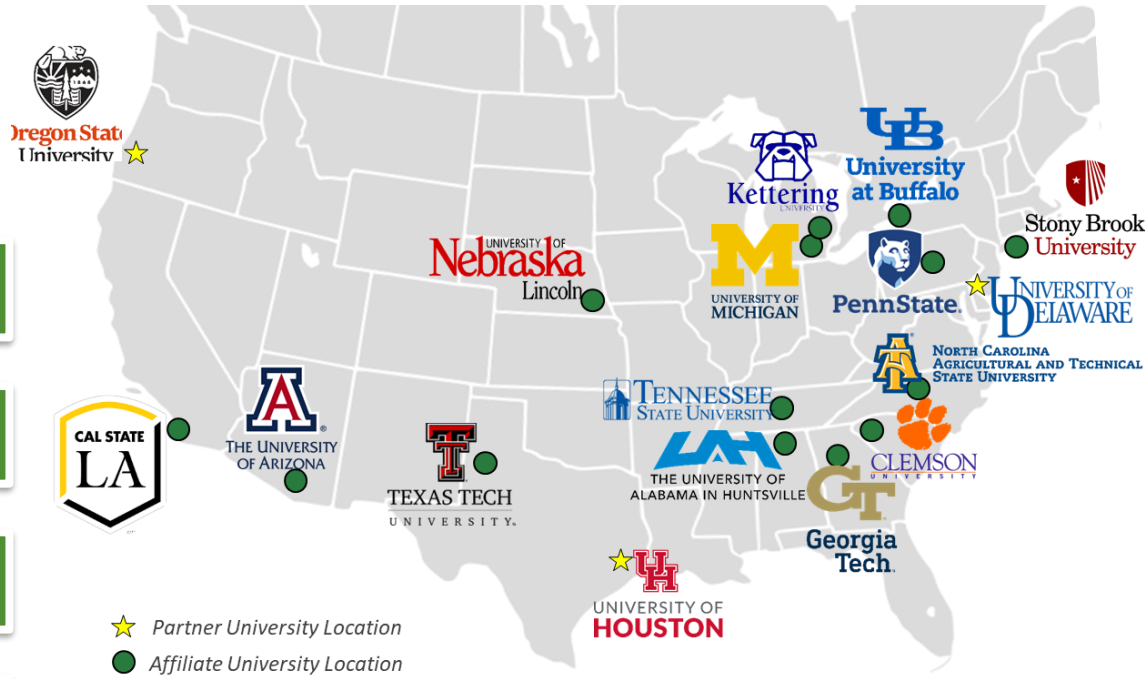


Visit now at https://h2tools.org/hyscan

H2EDGE – Hydrogen Education for a Decarbonized Global Economy

Training engineering professionals and university students for career opportunities in hydrogen

- 21 industry partners guiding curriculum development
- 16 partner and affiliate universities
- >400 university students reached to date
- 57 professionals trained in hydrogen across 5 in-person courses
- Basics of Hydrogen Science Virtual Course May 29-30
- In-person workshop July 16-17 to inform future curriculum development



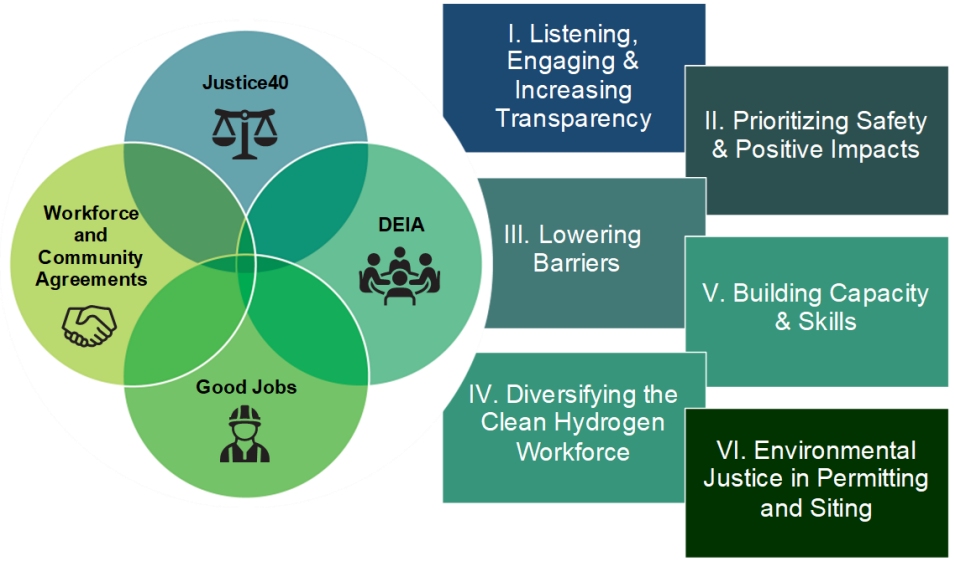
Register for virtual course now!

Email h2edge@epri.com for more information!

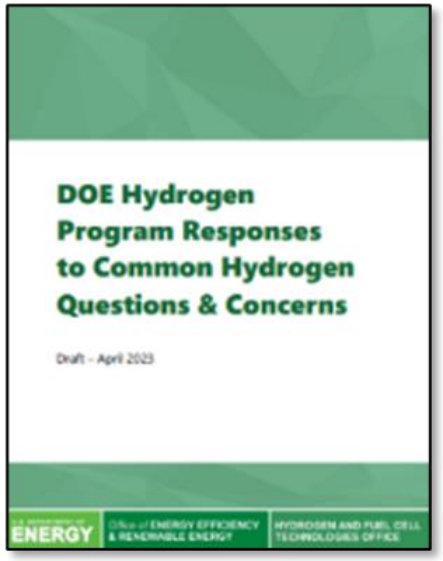
Cross-cutting Environmental Justice and Workforce Activities

FY24 Priorities Included…

- Release of DOE responses to common concerns around hydrogen
- Launch of the Harnessing Hydrogen Public Forum to improve awareness of hydrogen technologies and tradeoffs
  - **Contact hydrogen-engagement@hq.doe.gov for more information on how to host!**
- Release of HFTO's first solicitation to develop community engagement best practices
- Identifying gaps associated with education and training programs
  - **Contact info@h2educate.org to submit an educational program to HFTO's inventory**




Public Forum at Boston Museum of Science



Examples of International Collaborations

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

IEA

HYDROGEN INITIATIVE
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

hySafe
INTERNATIONAL ASSOCIATION FOR HYDROGEN SAFETY

MISSION INNOVATION

CENTER FOR Hydrogen SAFETY
Connecting a Global Community

CLEAN HYDROGEN MISSION

FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

PRHYDE
Protocol for heavy-duty Hydrogen refuelling

PRESLHY

IPHE
The International Partnership for Hydrogen and Fuel Cells in the Economy
Enabling the global adoption of hydrogen and fuel cells in the economy

www.iphe.net

Regulations, Codes, Standards, and Safety Working Group Task Forces:

- **Bulk Storage:** Risk, gaps and deployment barriers – new report published!
- **Permitting:** Identifying permitting processes and lessons learned – newly launched!
- **Maritime:** Gaps and risk analysis underway

Hydrogen Shot Fellowship

The U.S. Department of Energy (DOE) is looking for talented, bright, early career professionals to partner with DOE Hydrogen Program Managers working to achieve the Hydrogen Energy Earthshot goal of $1 per 1 kilogram in 1 decade ("1 1 1").

Are you graduating soon or just starting your career in hydrogen?

Do you want to help make clean hydrogen affordable for all?

The Hydrogen Shot Fellowship might be the opportunity you're looking for!

Apply today at: www.zintellect.com Keyword: Hydrogen Shot

Join Our Clean Energy Workforce Today

Stop by the table outside Independence Ballroom at lunch today to learn more!

EERE is driving the clean energy revolution by funding the innovation that's building the technologies that will forever change the way energy is generated and consumed. So now is a great time to become a **Clean Energy Champion** by joining EERE today!

Together we strive to:

- **Build the clean energy economy in a way that benefits all Americans.**
- **Create good paying jobs for the American people.**
- **Overcome the technological, economic, and institutional barriers to the development of hydrogen and fuel cells.**
- **Make renewable energy cost-competitive with traditional sources of energy.**
- **Increase access to domestic, clean transportation fuels.**
- **Reduce the carbon footprint of buildings.**
- **And so much more.**

EERE is committed to building a clean energy workforce with skilled professionals from diverse backgrounds. If interested in learning more about **becoming a Clean Energy Champion & joining the Clean Energy Revolution, stop by our booth to speak with our EERE Talent Acquisition representatives today!**

EERE CAREER HOME PAGE

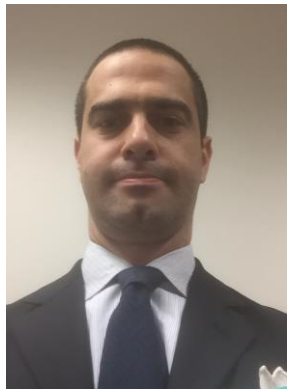
bit.ly/DOE_EERE

EERE Career News Letter

bit.ly/EERE-career-news

The Dream Team!

Systems Analysis Sub-Program



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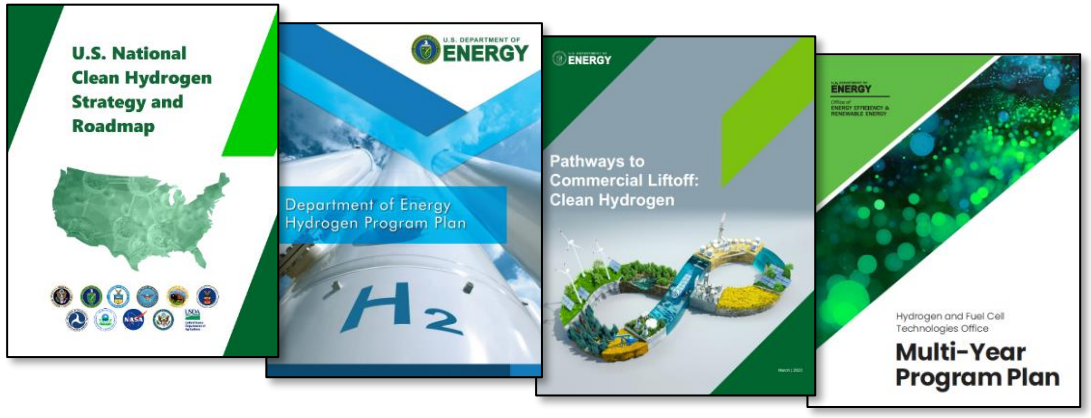
Resources and Opportunities for Engagement

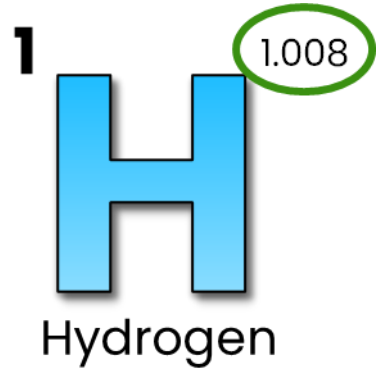
Key Publications

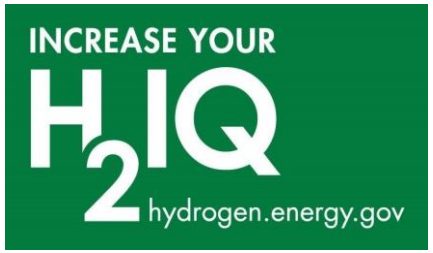


www.hydrogen.energy.gov

Hydrogen and Fuel Cells Day October 8

- Held on hydrogen's very own atomic weight-day





Join Monthly
H2IQ Hour Webinars

Download
H2IQ For Free

Visit H2tools.Org For Hydrogen Safety And Lessons Learned

https://h2tools.org/

CENTER FOR Hydrogen SAFETY
Connecting a Global Community

www.aiche.org/CHS

Sign up to receive hydrogen and fuel cell updates

www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

Learn more at: energy.gov/eere/fuelcells AND www.hydrogen.energy.gov

Session Logistics

General Information

- This meeting is a review, not a conference
  - **Questions will be taken first from reviewers**, and then from other audience members as time allows
  - Remote reviewers are reminded to enter their questions in CHAT
  - Remote general attendees can enter questions or comments into Q&A
- The schedule will be strictly followed so that reviewers can move between sessions
- Presentations are 20 minutes followed by 10 minutes Q&A

Thank You, Reviewers!

Your input on our Program and subprograms helps guide our decisions.

Thank you for your thoughtful, objective, and timely feedback!

Thank you!

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U.S. Department of Energy

www.energy.gov/fuelcells
www.hydrogen.energy.gov