



# Fuel Cell & Hydrogen Energy Association Codes and Standards Support

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DOE Project Award #: DE-AC05-00OR22725

Subcontract number: 4000193697

June 5-8, 2023

DOE Hydrogen Program

2023 Annual Merit Review and Peer Evaluation Meeting

AMR Project ID #

SCS022

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# Project Goal

**Project Goal:** Facilitate wide-scale adoption of fuel cells and hydrogen energy systems through the development of consistent safety codes and standards that incorporate industry best practices.

To achieve this goal, we engage industry in the process of developing technical requirements, work to ensure requirements are consistent, and develop and enable widespread sharing of safety-related information resources and lessons learned with first responders, authorities having jurisdiction (AHJs), and other key stakeholders.

# Overview

## Timeline

- Project start date: 05/05/21
  - Project end date: 01/31/23\*
- \* Project continuation determined annually by DOE

## Budget

- FY22 DOE Funding: \$252K
- FY23 Planned DOE Funding: \$183K\*
- Total DOE Funds Received to Date\*\*:  
\$672,503

\* Contract ended 31 January 2022. Negotiations underway for follow-on.

\*\* Since the project started

## Barriers

- F. Enabling National and International Markets Requires Consistent RCS
- H. Insufficient Synchronization of National Codes and Standards
- J Limited Participation of Business in the Code Development Process

## Partners

- Project Lead: FCHEA
- Interactions/ collaborations: FCHEA Members; CDOs & SDOs through NHFCCSCC, PNNL, and direct participation
- ORNL- Prime Contract

# Potential Impact

- **Enabling National and International Markets Requires Consistent RCS (Barrier F)**
  - Lack of consistency limits international trade and markets.
    - FCHEA Board Priorities for our RCS efforts focuses on efforts to advocate for removal of regulatory and policy barriers; as well as efforts to harmonize codes, standards, and regulations
    - Our technical working groups engage in document review and provide input to facilitate consistent requirements
    - Conducting the monthly NHFCCSCC calls facilitates harmonization
  - FCHEA staff participates directly in the key national and international codes and standards technical committees to provide consistency – ensuring the industry is engaged and requirements are harmonized with industry best practices.
- **Insufficient Synchronization of National Codes and Standards (Barrier H)**
  - The codes and standards development and revision cycles established by SDOs vary and are difficult to coordinate or synchronize even under a consensus national agenda.
    - FCHEA facilitates the monthly meetings of the NHFCCSCC, where CDOs/SDOs can share information about timing and issues. Organizations that report out during the calls include: DOE, DOT, IEC, NFPA, ICC, CSA, SAE, ASTM, ASME, IEEE, and NIST.

# Potential Impact Cont'd

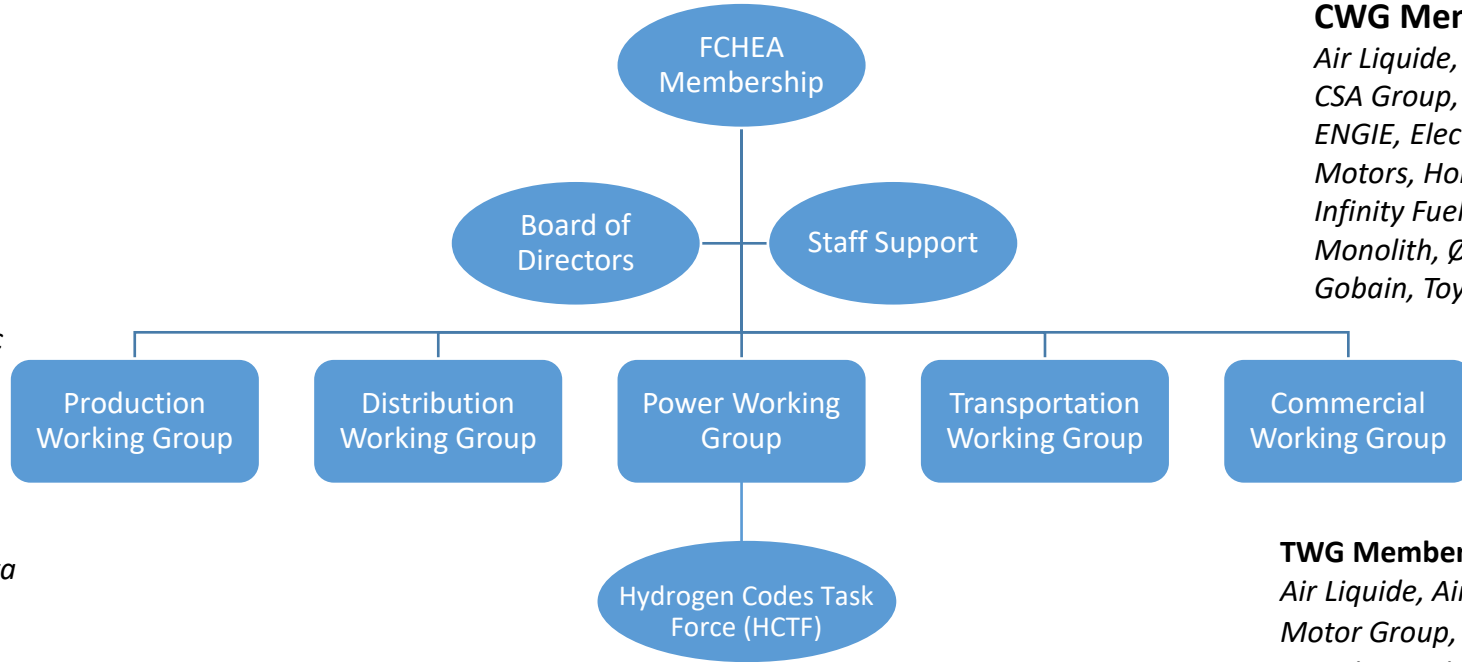
- **Limited Participation of Business in the Code Development Process (Barrier J)**
  - Businesses, particularly small businesses, do not always have the resources to participate fully in the codes and standards development process.
    - Participation in FCHEA RCS Working Groups allows these businesses opportunities to be briefed on the RCS efforts of interest; to weigh in on issues that arise; and to review documents in order to develop a FCHEA comment or position, and know when the time is right for their organization to engage directly.
      - Recent example – Outreach to Stationary Power WG members on upcoming changes to IEEE interconnection standards led to interest from member experts to engage directly in those activities
      - Recent example – Outreach to Stationary Power Working Group members on a new revision to ASME BPVC – Boiler and Pressure Vessel Code proposal to cover requirements for cell stack assemblies led to interest from member experts to engage directly in those activities
    - The Hydrogen and Fuel Cell Safety Report, the FCHEA Regulatory Matrix, and the codes and standards database at H2Tools.org provide quick overview information, making it easier for organizations to track and engage in key efforts.

# Approach to Resolve Technical Challenges

- **Challenge: Development and Harmonization of Regulations, Codes and Standards**
  - Facilitate the development of clear and comprehensive codes and standards to ensure consistency and facilitate deployment of hydrogen and fuel cell technologies
  - **APPROACH:** FCHEA Working Groups provide regular opportunities to engage industry in developing RCS, assess RCS priorities and needs, and identify opportunities to harmonize requirements. NHFCCSCC provides a forum to identify issues and discuss progress and needs in developing RCS; open dialog between CDOs/SDOs, government and research organizations, industry and users; FCHEA facilitates direct participation in RCS-development activities; and information dissemination and outreach to develop consensus requirements to ensure consistency.
- **Challenge: Dissemination of Data, Safety Knowledge, and Information**
  - General lack of understanding of hydrogen and fuel cell safety needs among local government officials, fire marshals, and the public. Failure to comprehensively consider the properties and behavior of hydrogen may lead to overly restrictive policies that preclude or delay deployment of hydrogen and fuel cell technologies.
  - **APPROACH:** FCHEA works with stakeholders to disseminate FCV and infrastructure-deployment activities. FCHEA publishes, maintains, and disseminates key safety information through the *Hydrogen and Fuel Cell Safety Report* website at [www.hydrogenandfuelcellsafety.info](http://www.hydrogenandfuelcellsafety.info), and [www.H2Tools.org](http://www.H2Tools.org), enhancing access to codes, standards, and regulations worldwide.
- **Milestones: Monthly summaries, bi-monthly Safety Report**
  - Aligned with the Go/No-Go Decisions in DOE's current plans. Provides regular mechanism to identify and address industry priorities.

*\* All members are encouraged to participate in RCS activities appropriate to their business. Outside experts are invited as needed to address topics of interest to industry.*

# Approach - FCHEA RCS Working Groups



## CWG Membership

*Air Liquide, Air Products, Basal, Bosch, CF Industries, CSA Group, Compressed Gas Association, Cummins, ENGIE, Electric Hydrogen, FuelCell Energy, General Motors, Honeywell, Hy Stor Energy, IHI Turbo, Inc., Infinity Fuel Cell and Hydrogen, Ionomr, John Cockerill, Monolith, Ørsted, Phillips66, Proteum Energy, Saint-Gobain, Toyota, and Twelve,*

## TWG Membership

*Air Liquide, Air Products, Amazon, Anglo American, BMW Motor Group, Ballard Power Systems, BayoTech, Black & Veatch, Bosch, CSA Group, California Fuel Cell Partnership, Clean Energy Fuels, Compressed Gas Association, Cummins, ENGIE North America, First Element Fuel, First Mode, Forvia Faurecia, FuelCell Energy, FuelCell Energy, Garrett Advancing Motion, General Motors, HORIBA, Hexagon, Honda, Hy Stor Energy, Hyundai, Hyzon Motors, IHI Turbo America, Inc., Infinity Fuel and Hydrogen, Intelligent Energy, Ionomr, Kaizen Clean Energy, Loop Energy, Nel Hydrogen, Nikola Motor Company, Nuvera, PDC Machines, Phillips66, Plug Power, PowerCell Group, Proteum Energy, Saint-Gobain, Toyota, and ZeroAvia*

## Production WG Membership

*Air Liquide, Basal, Bosch, CF Industries, CSA Group, Chart Industries, Clean Energy Fuels, Compressed Gas Association, Electric Hydrogen, FRIEM, FuelCell Energy, Honda, Hy Stor Energy, IHI Turbo, John Cockerill, Monolith, Nebraska Public Power District, Nel Hydrogen, Phillips66, Proteum Energy, Saint-Gobain, Terrestrial Energy, and Toyota*

## DWG Membership

*Air Liquide, Bosch, Chart Industries, Clean Energy Fuels, Compressed Gas Association, Electric Hydrogen, FMGL, Forvia Faurecia, FuelCell Energy, General Motors, Hexagon, Honda, Hy Stor Energy, IHI Turbo, Phillips66, Proteum Energy, Saint-Gobain, and Toyota*

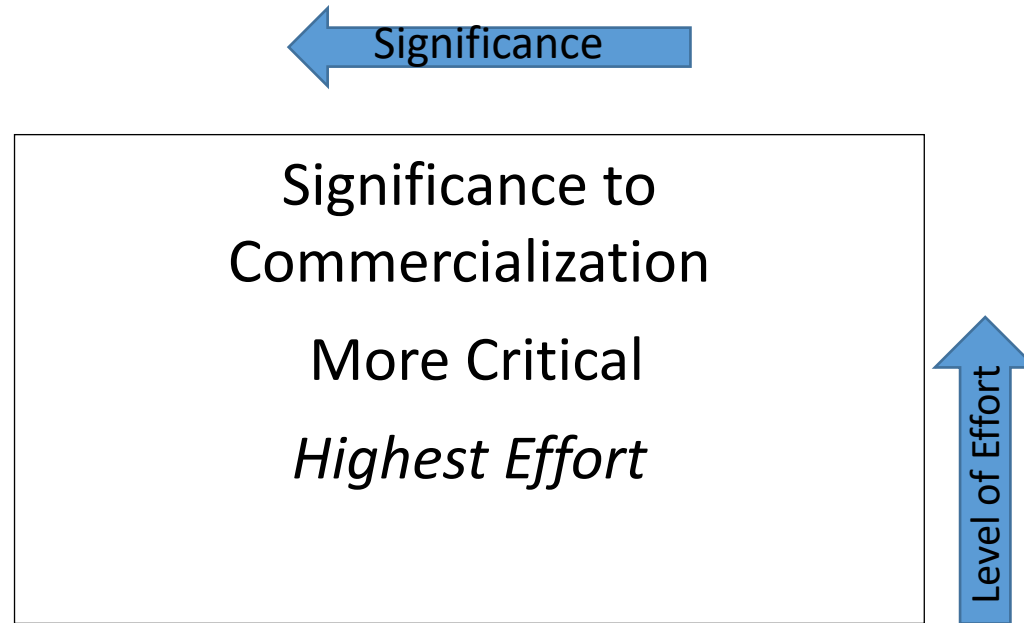
## HCTF Membership

*Bloom Energy, California Fuel Cell Partnership, CSA Group, Hexagon, and HyAxiom- Doosan Fuel Cell America*

## Power WG Membership

*Advent, Air Liquide, Aris Renewable Energy, Avantus, Ballard, Bloom Energy, Basal, Bosch, CSA Group, Clean Energy Fuels, Compressed Gas Association, Cummins, Electric Hydrogen, Forvia Faurecia, FuelCell Energy, GenCell, General Motors, Honda, Hy Stor Energy, HyAxiom –Doosan Fuel Cell America, IHI Turbo, Inc., Infinity Fuel Cell and Hydrogen, Intelligent Energy, Ionomr, Kaizen Clean Energy, Nebraska Public Power District, Nel Hydrogen, Nikola, Nuvera, Parker Hannifin, Phillips66, Plug Power, PowerCell Group, Proteum Energy, Renewable Innovations, Saint-Gobain, and Toyota*

# Approach - FCHEA Regulatory Matrix updated Quarterly



Through the use of “Track Changes” software, users can quickly identify what has changed during the past quarter. The “track changes” version is reviewed by our WGs and the NHFCCSCC, and provided to ORNL each quarter. Clean copies are available upon request and archived, and form the basis of the next quarters mark-up.



# Approach: Coordination and Outreach

## NHFCCSCC (monthly)

- Forum for effective communication and collaboration
- Facilitates the development of the consensus-based C&S
- Identifies critical gaps and makes recommendations to address them.

## Safety Report (bi-monthly)

- Central source of RCS information
- Improves coordination and information transfer
- Meetings of the NHFCCSCC
- Summarizes key domestic and international RCS issues
- List key upcoming events and issues

Note – this is NOT an incident report

## H2Tools.org (monthly)

- Database of Regulations, Codes and Standards
- Ability to drill for detailed information
- Central source of RCS information
- Improves coordination and information transfer

January / February 2023

January/February 2023 Hydrogen and Fuel Cell Safety Report

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# Accomplishments and Progress: Working Groups

- **Transportation WG:** All applications of hydrogen and fuel cells in transportation across land, sea, and air. Administers Hydrogen Codes Task Force to review and develop public input for NFPA 2. Continued participation in NFPA to track code change proposals and decisions taken in most recent revision cycle for 2023 editions of NFPA 2 and NFPA 55 model codes. Also engaged in SAE/EuroCAE efforts to develop standards for use of hydrogen and fuel cells in the aviation sector.
  - Served in task group to review AS6858 Installation of Fuel Cell Systems in Large Civil Aircraft.
  - Hydrogen Codes Task Force developed six harmonized public inputs for the 2023 editions of the NFPA 2 model code. The public inputs were solicited from business and experts with operational experience and focus on harmonizing requirements with other industry-accepted standards and codes.
- **Power WG:** The confluence of hydrogen, fuel cells, and power markets both as a production vector and end-use market. Reviewed and provided feedback on draft documents, including New Work Item Proposals and National Deviations for International Standards. Activities include domestic and international standards development, with a focus on ensuring consistency of requirements.
  - Significance: Supports Objective from MYRDD – Provides consistent RCS and synchronization of national codes and standards.
  - **Take Home Message: FCHEA WGs and TFs work collaboratively with others to effectively make changes to developing RCS**

# Accomplishments and Progress: Working Groups, Cont'd.

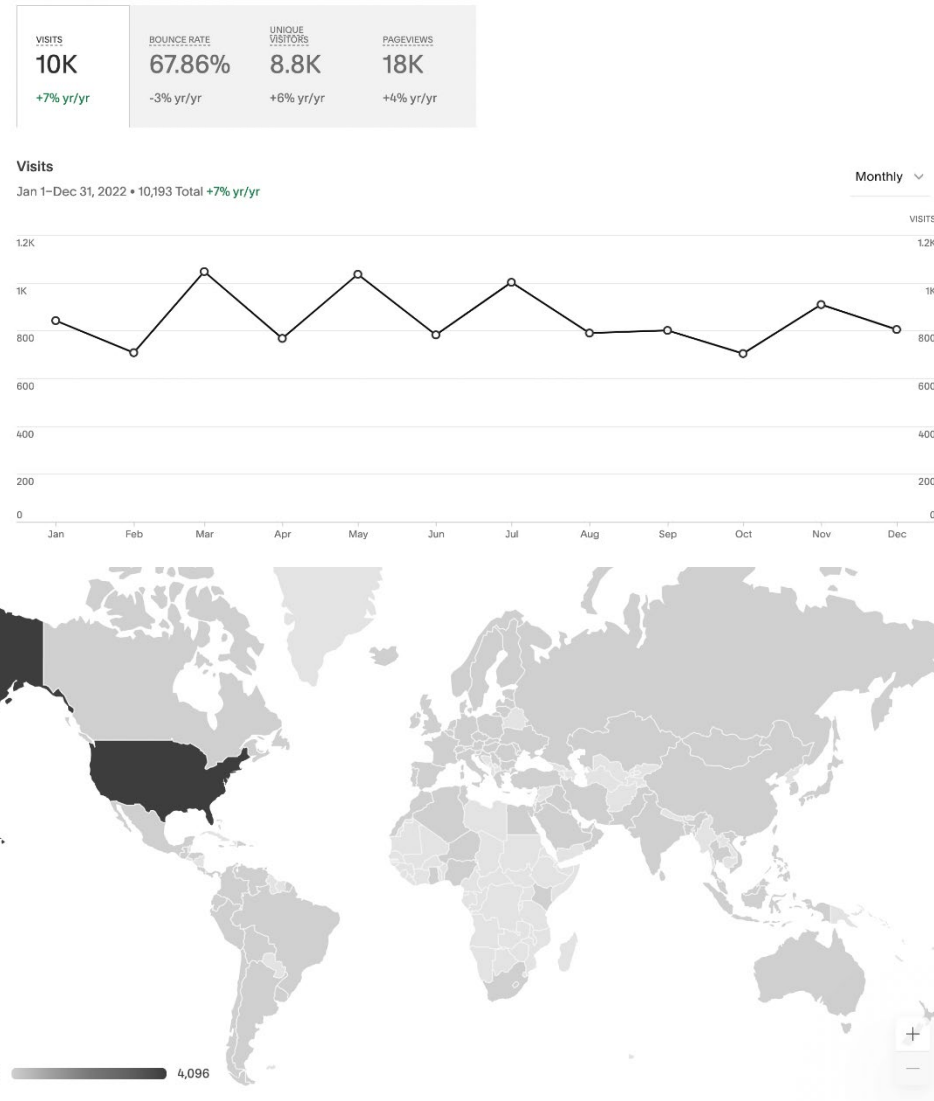
- **Production WG:** The diversity of clean hydrogen production pathways, both from traditional and renewable sources. Recent activity includes direct participation in the myriad efforts on electrolyzers to ensure harmonized requirements. Participated in CSA-led effort to adopt ISO 22734 as an ANSI standard.
- **Distribution WG:** The spectrum of infrastructure including distribution, compression, storage and dispensing. Recent activity includes convening ISO/TC 197 WG 21 to develop standard for compressors, working closely with CSA to facilitate harmonization.
- **Commercial WG:** The intersection of hydrogen and emerging markets for commercial processes like steel and cement production, use of hydrogen as a chemical feedstock such as ammonia, hydrogen for heating, and other uses. Our newest WG is bringing stakeholders who are new to hydrogen energy to the table to discuss priorities and novel applications.
- **Significance:** Supports Objective from MYRDD - Enabling National and International Markets Requires Consistent RCS by ensuring national and international standards are harmonized, then adopted in appropriate codes and Regulations.
  - **Take Home Message:** Regular dialog in FCHEA WGs and consistent messaging and participation in relevant RCS forums can result in consistent RCS.

# Accomplishments and Progress: Coordination

- **Coordination** (Note: The following tools are open and available to any interested party.)
  - **NHFCCSCC** – Monthly facilitated discussion of key topics of broad interest, such as “Facilitating Deployment”, and “Legal Metrology Standards Hydrogen Fuel”. Progress in the development of RCS is reported and captured for the FCHEA Regulatory Matrix, providing an up-to-date overview of current industry priorities and recent progress in RCS. Recent examples: In early 2023, ICC has launched a project to update hydrogen requirements across the I-Codes, and presented their plans at the NHFCCSCC meetings. FCHEA has set up a group under our HCTF, and staff has joined the ICC effort. More under Future Work.
  - **Hydrogen & Fuel Cell Safety Report** – Published every two months, keeping readers informed of the progress and issues encountered in the development of RCS. Has introduced industry to the many new WGs in ISO/TC 197 and the call for participation in U.S. standards committees. Calendar of events aids in planning and scheduling.
  - **H2Tools.org Codes & Standards Database** - This website tracks the world-wide development of about 400 hydrogen and fuel cell standards, and its matrix can be searched. FCHEA works closely with PNNL to make information available for H2Tools in a format more appropriate for policy-makers and decision-makers. Content transfer from [www.FuelCellStandards.com](http://www.FuelCellStandards.com) was completed in late 2021. Current efforts are focused on keeping the information up to date and identifying ways to improve functionality to meet user needs.
- **Significance:** Contributes to DOE goal to develop and enable widespread sharing of safety-related information resources and lessons learned with first responders, authorities having jurisdiction (AHJs), and other key stakeholders. Increases participation of stakeholders in development of harmonized RCS.
- **Take-Home Message:** FCHEA makes useful, informative resources available to all interested stakeholders in order to ensure consistency in RCS and facilitate deployment of hydrogen and fuel cell technologies.

# Accomplishments and Progress: Hydrogen and Fuel Cell Safety Report

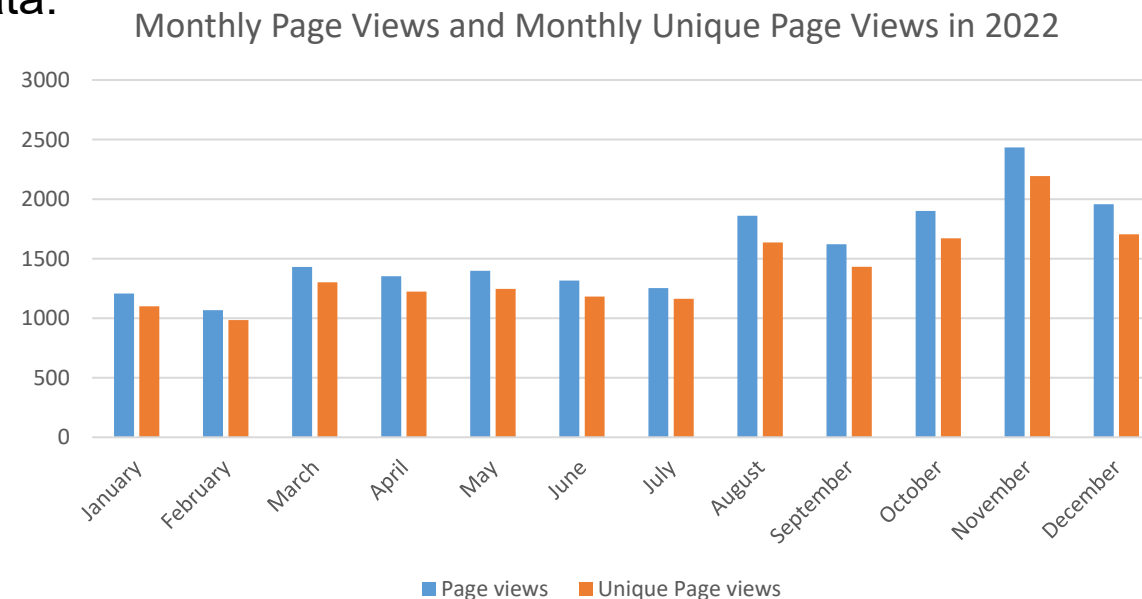
- Develop and enable widespread sharing of safety-related information resources and lessons learned with first responders, authorities having jurisdiction (AHJs), and other key stakeholders.
- *The Hydrogen and Fuel Cell Safety Report* is read by thousands of interested parties all over the world.
- 10,000 people, including AHJs and first responders, visited the website in 2022. This represents a 7% increase over last year.
- Top geographies of our visitors in 2022 are from the United States, Canada, Germany, United Kingdom, India, and France.



# Accomplishments and Progress– Cont'd

## Codes and Standards database in H2Tools

- FCHEA updates the codes and standards database on H2Tools.org, managed by PNNL. This database tracks the world-wide development of hundreds of industry standards.
- Launched in October 2021 to facilitate integration of the data previously maintained on [www.FuelCellStandards.com](http://www.FuelCellStandards.com) into the toolset at H2Tools.
- The site receives more than 2,000 unique visitors to the site every month.
- In 2022, the database was viewed in five continents: Africa, Americas, Asia, Europe, and Oceania.
- The site received over 18,800 page views and 16,838 unique page views in 2022, showing users are diving deeper into the data.



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# Accomplishments and Progress - Responses to Previous Year Reviewers' Comments

- 2021 AMR Reviewer Comments were addressed in our 2022 poster presentation. Updates to those responses, where applicable, are provided here.
- Probably reprofiling or re-orienting working groups more on international activities will bring a bigger benefit to members and DOE.
  - **Response:** We have put this comment to action by realigning our working groups to recognize of the rapid expansion and momentum of the hydrogen and fuel cell industry into new markets and utilization pathways. Realignment of FCHEA's working group structure better fits the needs of our growing and diverse membership and the industry at large.
- The project should consider including or linking the FCHEA efforts with H2Tools, where relevant.
  - **Response:** We have completed integration of our <http://www.fuelcellstandards.com> data into the H2Tools website. In late 2021, we migrated all activity to the H2Tools website, and no longer maintain two separate sites. A search for [www.FuelCellStandards.com](http://www.FuelCellStandards.com) will redirect to the Codes & Standards database at H2Tools.org. We now maintain the data on a single site.

# Collaboration and Coordination

- FCHEA performs this work under subcontract to ORNL.
- FCHEA members represent the full global supply chain, including universities, government laboratories and agencies, trade associations, fuel cell materials, components and systems manufacturers, hydrogen producers and fuel distributors, utilities and other end users. Members direct our activities, provide input to RCS through FCHEA involvement in RCS development; review and prioritize our efforts.
- FCHEA works with CDOs/SDOs through direct participation on RCS activities, participation in the NHFCCSCC, and participation in appropriate FCHEA Working Groups and Task Forces. This facilitates information-sharing and synchronization.
  - Reporting organizations include ASME, ASTM, NIST, SAE, CSA Group, CGA, NFPA, and others.
- FCHEA works with the full range of stakeholders, including industry, state and local officials, and others to address RCS and outreach needs and facilitate deployment.
  - Non-SDOs engaged in the NHFCCSCC include the Center for Hydrogen Safety, and the California Fuel Cell Partnership.
- FCHEA works closely with PNNL to make RCS data available for H2Tools and The Center for Hydrogen Safety.
- FCHEA works closely with DOE to facilitate productive dialog on industry priorities, R&D needs, and deployment barriers; as well as to promulgate R&D results and information and data resources available through DOE-funded projects.



# Remaining Challenges and Barriers

- The four objectives supported by this project are ongoing and tied to DOE Goals.
- International standards need to develop in a coordinated fashion to ensure they reflect the needs of industry and consistency with accepted practices.
- Significant progress: ISO/TC 197 WGs on hydrogen fueling stations and components. Remaining challenges include completion and publication of ISO 19880-4 (Compressors), ISO 19880-5 (hoses), and ISO 19880-6 (Fittings). Once published, efforts to harmonize with U.S. standards on similar topics will get underway.
- Published standards being updated to reflect advances and learnings. Ex: Dispensing hoses for gaseous hydrogen fueling stations, valves and fittings for high-pressure hydrogen uses. CSA HGV 4.2 recently revised their document to harmonize where appropriate with ISO 19880-5 for gaseous hydrogen fueling station hoses. Now ISO 19880-5 is being revised, and is working to harmonize with HGV 4.2 as much as practicable. The resulting revision will then be made available to CSA for consideration of national adoption.
- Ensuring hydrogen experts contribute to development of RCS in new areas. Example: Hydrogen and fuel cell experts are briefed and provided many opportunities to contribute to standards for newer applications for hydrogen and fuel cells. EUROCAE/SAE is developing standards for gaseous and liquid hydrogen fueled aircraft. FCHEA is helping to bring hydrogen experts to the table. Similar challenges in areas such as railway, maritime, etc.
- U.S. adoption (with national deviations) for published International Standards. FCHEA participated in recent efforts to ensure technical harmonization between national and international requirements. Ex: CSA C22.2 No. 22734 Subcommittee completed the adoption of ISO 22734:2019 for North America. FCHEA staff and members participate in these efforts to ensure technical requirements are consistent and reflect industry best practices and lessons learned. As standards are published, FCHEA will continue to coordinate member participation and input to ensure technical consistency.
- Codes and standards are modified every 3-5 years. FCHEA works to keep members informed of technical issues and provides opportunities to contribute to ensure harmonization of technical requirements.

# Proposed Future Work

- **Power WG:** Complete revision of three standards in IEC/TC 105 WG 302 (formerly WG 8). Coordinate with ASME on activity to provide mandatory language for cell stack assemblies. Participate in revision of IEEE 1547 for grid interconnection.
- **Transportation WG:** Continue to address RCS and R&D needs for medium/heavy-duty vehicles, aircraft, railway applications, maritime applications, and others.
- **Production WG:** Continue to review international standards and U.S. as well as state regulations to ensure consistency with accepted U.S. requirements and best practices.
- **Distribution WG:** Work with ICC to ensure infrastructure requirement harmonization with NFPA 2.
- **Commercial WG:** Identify RCS needs and priorities for commercial applications.
- **Hydrogen Codes Task Force:** Lead FCHEA member participation in the International Code Council's newly formed hydrogen working group, which will be updating all the I-codes for hydrogen technologies for the 2027 edition.
- **Coordination**
  - **NHFCCSCC** – continue to administer, identify key issues, and document discussions and outcomes.
  - **Safety Report** – continue to report on the developing RCS to improve coordination of activities and improve information transfer to facilitate industry engagement in RCS.
  - Maintain data and improve functionality of **H2Tools.org** – continue to ensure data on all relevant codes and standards is current and readily available to stakeholders.

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

# Summary

## **Relevance:**

- FCHEA project contributes directly to achievement of four of the seven objectives outlined in the Fuel Cell Technologies Office Multi-Year Research, Development and Demonstration Plan. Project facilitates industry participation in essential codes and standards to meet DOE goals.

## **Approach:**

- Multi-tiered approach: forums to identify issues and discuss progress and needs in developing RCS; facilitating open dialog; participating directly in national and international RCS-development activities to address industry needs; information dissemination & outreach tools.

## **Technical Accomplishments:**

- Significant progress in conducting information exchange and data transfer to improve harmonization in domestic and international RCS; maintained central point of information for RCS activities; identified and communicated needs in RCS, R&D, and outreach.
- Success in engaging industry to participate in codes and standards development process. Some participate directly, while others take the opportunity to review draft codes and standards when out for review. FCHEA staff then represents these comments and concerns on the Technical Committees of CSA, SAE, ISO/TC 197, IEC/TC 105, ICC, IEEE, NFPA, and others as appropriate. Participated in U.S. adoption of ISO standard on electrolyzers.

## **Proposed Future Work:**

- Complete drafting of documents where FCHEA staff holds convenorship and facilitate national adoption. Continued focus on harmonization of requirements to facilitate deployment; ensure international standards are consistent with U.S. practices; continue building relationships with key stakeholders, including outside associations; continue dialog with industry to facilitate deployment of hydrogen vehicles infrastructure; identify I-code inputs for 2027 code revision cycle. Determine RCS priorities and needs for the next round of code revisions. Continue to address new and emerging energy applications.