

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Overview of DOE Activities Addressing Hydrogen Emissions

Christine Watson– Safety, Codes & Standards Subprogram

Hydrogen Emissions and Environmental Impacts Workshop

September 16-17, 2024, Irvine, CA



U.S. Primary Energy Consumption by Energy Source

Renewable Total = 8.2 guads

Total = 93.6 quads



Administration Goals include:

- Net-zero emissions economy by 2050 and 50–52% reduction by 2030
- 100% carbon-pollution-free electric sector by 2035

Priorities: Ensure benefits to all Americans, focus on jobs, Justice40: 40% of benefits in disadvantaged communities

Quad= quadrillion British thermal units (Btu)

Source: Melaina, Chilton, et al, DOE HFTO, based on data collected from U.S. Energy Information Administration, *Monthly Energy Review*, April 2024, Table 1.3. <u>https://www.eia.gov/totalenergy/data/browser/?tbl=T01.03#/?f=A</u>

President Biden Signs Key Bills into Law – Examples of Policies and Activities

Bipartisan Infrastructure Law (BIL) provides \$9.5B for clean H₂ and Inflation Reduction Act (IRA) includes significant tax credits



President Biden Signs the Bipartisan Infrastructure Bill into law on November 15, 2021. Photo Credit: Kenny Holston/Getty Images

BIL Required National Clean Hydrogen Strategy and Roadmap

Examples of policies & activities across the H ₂ value chain				
Supply	Midstream	End Use Demand		
Production Tax Credit 45V, 45Q (Treasury)	Fueling Corridor Grants (DOT/JO)	Vehicle Tax Credits, Clean Fuels Credits, 48C (Treasury)		
Electrolyzer RD&D BIL (DOE)	Bipartisan PIPES Act NPRM (DOT PHMSA)	State Policies (ZEV Mandates, H2 PTC) ¹		
		Clean Power Rule NPRM (EPA)		
Manufacturing Tax Credit	Manufacturing Tax Credit 48C (Treasury/DOE)	Buy Clean Standards (EOP)		
40C (Treasury/DOE)		Agency offtake (DOD, USPS,		
H2 Hubs, BIL (DOE)	H2 Hubs, BIL (DOE)	H2 Hubs. BIL (DOE)		

JO: Joint Office of Energy and Transportation; EOP: Executive Office of the President, NPRM: Notice of proposed rulemaking 1: ZEV Mandates see: <u>https://www.c2es.org/document/us-state-clean-vehicle-policies-and-incentives/</u>. State example <u>https://leg.colorado.gov/bills/hb23-1281</u>.

U.S. National Clean Hydrogen Strategy and Roadmap



U.S. Opportunity: 10MMT/yr by 2030, 20 MMT/yr by 2040, 50 MMT/yr by 2050. ~10% Emissions Reduction. ~100K Jobs by 2030.

Environmental Justice Initiatives



Draft Responses to Frequently Asked Questions and Common Concerns About Clean Hydrogen

https://www.energy.gov/eere/fuelcells/draft-responses-frequently-asked-questions-and-common-concerns-about-clean-hydrogen

HFTO Safety, Codes, and Standards Subprogram



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

Enabling the Safe Deployment of Hydrogen and Fuel Cell Technologies

- Conduct RD&D to provide scientific basis needed to define requirements in developing and revising codes and standards.
- Enable improvements to permitting process.
- Support best safety practices for hydrogen and fuel cell deployments.
- Develop and enable widespread sharing of safety-related information resources and lessons learned.
- Conduct **workforce development** activities with an emphasis on safety practices and culture.

Background

- Hydrogen emissions indirectly contribute to global warming
- Multiple research groups have highlighted that these indirect effects can be substantial and must be better understood.
- In March 2022, the European Commission and HFTO co-led a workshop on current status and R&D needs regarding the Global Warming Potential (GWP) of hydrogen
 - ~150 global experts invited from HFTO, FECM, Sandia, NREL, NOAA, NASA, DOT, EPA, NIST, environmental groups, and industry
 - Highlighted need for more data on atmospheric behavior of hydrogen and quantification of hydrogen losses to fully model these effects



JRC TECHNICAL REPORT

Hydrogen emissions from a hydrogen economy and their potential global warming impact



Summary report of the Clean Hydrogen Joint Undertaking Expert Workshop on the Environmental Impacts of Hydrogen

Arrigoni, A., Bravo Diaz, L

2022



HFTO and NOAA Interagency Agreement

\$2.2M over 3 years to develop a more robust understanding of the H2 biogeochemical cycle, including its sensitivity to anthropogenic emissions and climate change

Improve best practices for H₂ air ALT measurements MID **Analysis & modeling of atmospheric** ASC SMO NMB behavior of H₂ EIC CPT CRZ USH SYO HBA R&D on soil removal of H₂ and sensitivity -150100 -100-5050 150 to climate change and land use Longitude NOAA Global Cooperative Air Sampling Network: Largest H₂ measurement network in the world Fabien Paulot, Gabrielle Pétron, Andrew M. Crotwell, and Matteo B. Bertagni

Activities to Detect and Quantify Hydrogen Releases

National Lab R&D

\$8.6M in FOA Projects to Develop ppb – Level Sensors

> SBIR Phase I on Quantification

TCF to Develop ppb – Level Sensor

CRADA

- NREL: sensors and advanced leak detectionSandia: hydrogen and blends release behavior
- Iowa State University
- Palo Alto Research Center Incorporated
- University of Georgia
- Indrio Technologies Inc.
- University of Missouri
- General Electric Company
- Aerodyne Research Inc.Solve Technology and Research Inc.

• LLNL

• NREL: hydrogen wide area monitoring



Safety Sensor Testing Apparatus (SSTA) at NREL upgraded for ppb level detection

ARPA-E H2SENSE Program

Metric	FOA Target	Context
Emission Rate	10 kg/hr	Across 100 m x 100 m
Accuracy	+/- 20% accuracy, within 24 hrs	Under variable conditions
Detection Probability	90% detection, 1% false positive	Must alert on emission of > 10 kg/hr
Localization	+/- 10 m	May employ different technology to quantify v. localize leak
Cost	≤\$10,000	Total survey cost

Optional Target: Estimate an H₂ leak rate as low as 1 kg/hr with accuracy error \leq 50%, probability of detection \geq 90%, and false positive rate of < 1%.



Exploratory Topics DE-FOA-0002784 App. M. Exploratory Topics SBIR/STTR DE-FOA-0002785 App. M

10

Successful approaches will integrate three components



H2SENSE Selections



Name	Project Title	City, State
GE Vernova Advanced Research Center	H2-LOCATE: H2 Leak LOCAlization and QuanTification Using Physics-Enhanced Analytics and Fence-Line Monitoring	Niskayuna, NY
Colorado State University	Hydrogen Emissions Monitoring System Based on Trace Gas PARS Sensor	Fort Collins, CO
National Energy Technology Laboratory	Novel Fiber Optic Sensor Systems and Al-driven Methods for Hydrogen Pipeline Emission Quantification	Pittsburgh, PA
University of Wisconsin- Madison	Large-Survey-Area H2 Leak Detector based on a Quadcopter-Mounted Laser Imager	Madison, WI
Serinus Labs, Inc.	Parts Per Billion Hydrogen Plume Emissions Reporting System (ppb-HyPERS)	Berkeley, CA
Northeastern University	Wireless Hydrogen Integrated Sensing via PiezoElectric Resonators and Switches (WHISPERS)	Boston, MA
Princeton University	HydroNet: Integrated Photonic System for Hydrogen Leak Localization, Quantification and Monitoring	Princeton, NJ
Aerodyne Research, Inc.	Autonomous Method to Quantify and Localize Hydrogen Facility Emissions	Billerica, MA
2Witech Solutions	Hybridized High-Q Plasmonic Hydrogen Sensor	Andover, MA

Activities to Mitigate Intentional Releases

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Office of ENERGY EFFICIENCY & RENEWABLE ENERGY Hydrogen Infrastructure Priorities to Enable Deployment in the High-Impact Transportation Sector

- Boil-off mitigation critical to reducing economic losses
- R&D investment is required to minimize losses at all transfer points
- Redesign tanks
- Rethink standard hydrogen management practices
- Optimize trailer delivery processes
- Re-use vented hydrogen for power
- Improve the methods used to determine the location and quantity of releases
- Develop monitoring tools and methods

HFTO Projects Addressing Boil-Off

Colorado School of Mines, "Solid State Based Hydrogen Loss Recovery During LH2 Transfer", \$6M

LBNL, "High Energy Density H2 for Freight Rail through Novel Adsorption Systems Integrated with Liquid Hydrogen as Fuel", \$2M

FY24 Station of the Future FOA Projects: development and demonstration of a lowcost, standardized, and replicable advanced "hydrogen fueling station of the future" for commercial-scale MD/HD truck fueling, including mitigation of hydrogen releases

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MISSION INNOVATION **Mission Innovation Offroad Working Group:**

Reference Guide for Vented H2 Recovery

HYDROGEN AND FUEL CELL TECHNOLOGIES OFFICE

Opportunities for Involvement

Hz

Industry Collaboration Opportunity: HyCReD

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.

INPUT

Failed components, component life, system description, O&M data, industry engagement, failure modes

HyCReD

OUTPUT



NREL's National Fuel Cell Technology Evaluation Center



Failed component taxonomy, hazard classification, leak rates, component reliability, QRA, PHM

Industry Collaboration Opportunity: HyCReD



*Data shown from public sources

Industry Collaboration Opportunity: HyCReD

Initial data from 4 public sources

- NREL's Hydrogen Infrastructure Testing and Research Facility (HITRF)
 - Research station(s)
- KHK Database (Japan)
 - High Pressure Gas Safety Institute of Japan
 - Incidents involving high pressure gases, including hydrogen

HIAD

- European Joint Research Commission
- Public H2 incident reporting and lessons learned
- H2Tools Lessons Learned
 - Pacific Northwest National Lab
 - Public H2 incident reporting and lessons learned

Call to Action: Get

Involved!

- Share your data with NREL and UMD through a standard NDA
- 3 NDAs executed
- 4 NDAs in progress

Email hycred@nrel.gov

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Hydrogen

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: <u>www.zintellect.com</u> Keyword: Hydrogen Shot

Call to Action: Join the Center for Hydrogen Safety



Resources and Opportunities for Engagement



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

Thank You

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

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