U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Hydrogen and Pipeline Transportation

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Pipeline Transportation: Hydrogen and Emerging Fuels R&D Public Meeting and Forum

30 November 2021

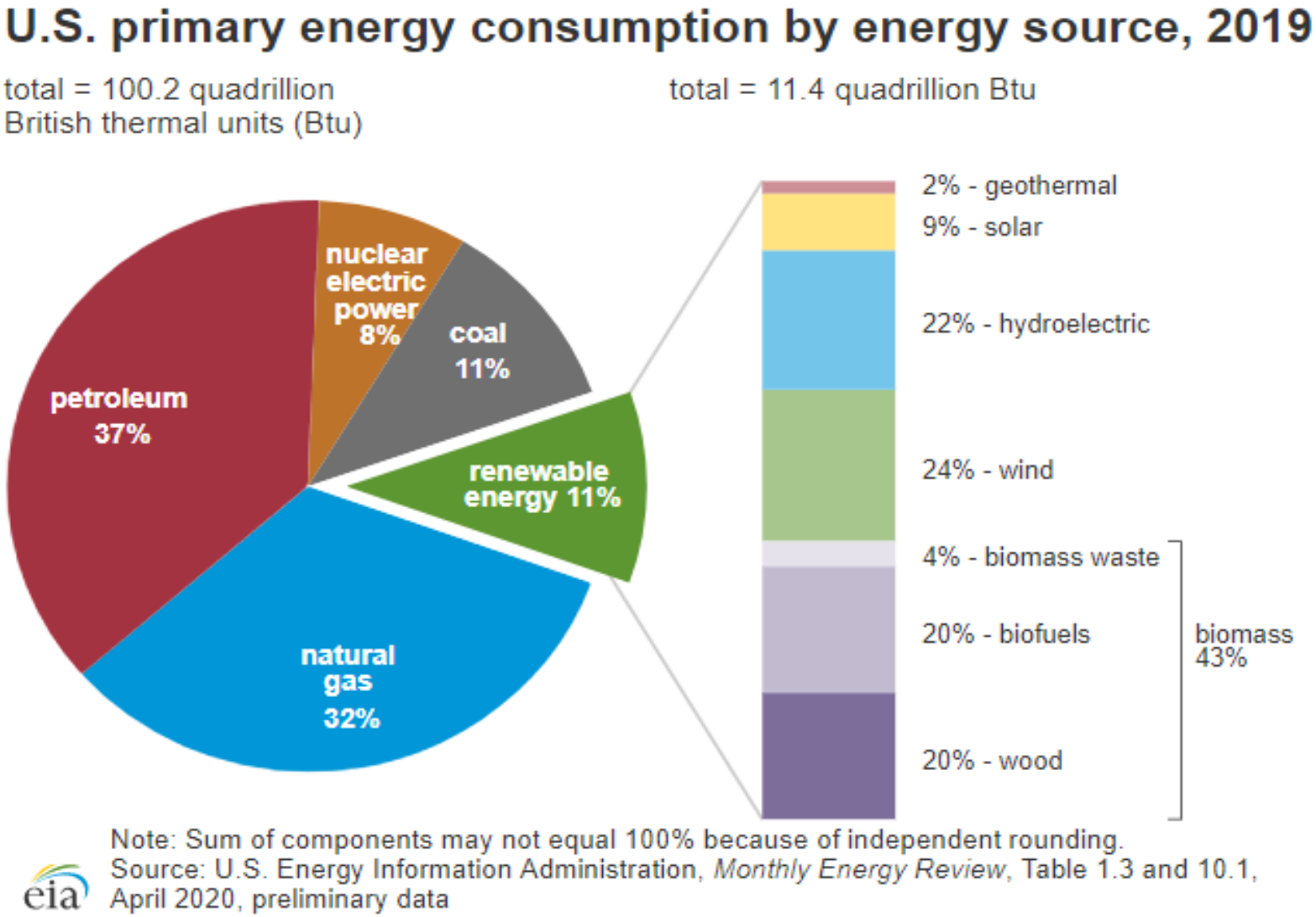
Office of Energy Efficiency & Renewable Energy (EERE)

"…I've asked the Secretary of Energy to speed the development of critical technologies to tackle the climate crisis. No single technology is the answer on its own because every sector requires innovation to meet this moment."

President Joseph R. Biden, April 23, 2021

EERE's mission is to accelerate the research, development, demonstration, and deployment of technologies and solutions to equitably transition America to **net-zero greenhouse gas emissions economy-wide by no later than 2050**, and ensure the clean energy economy benefits all Americans, creating good paying jobs for the American people—especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution.

U.S. Energy Landscape and Key Goals



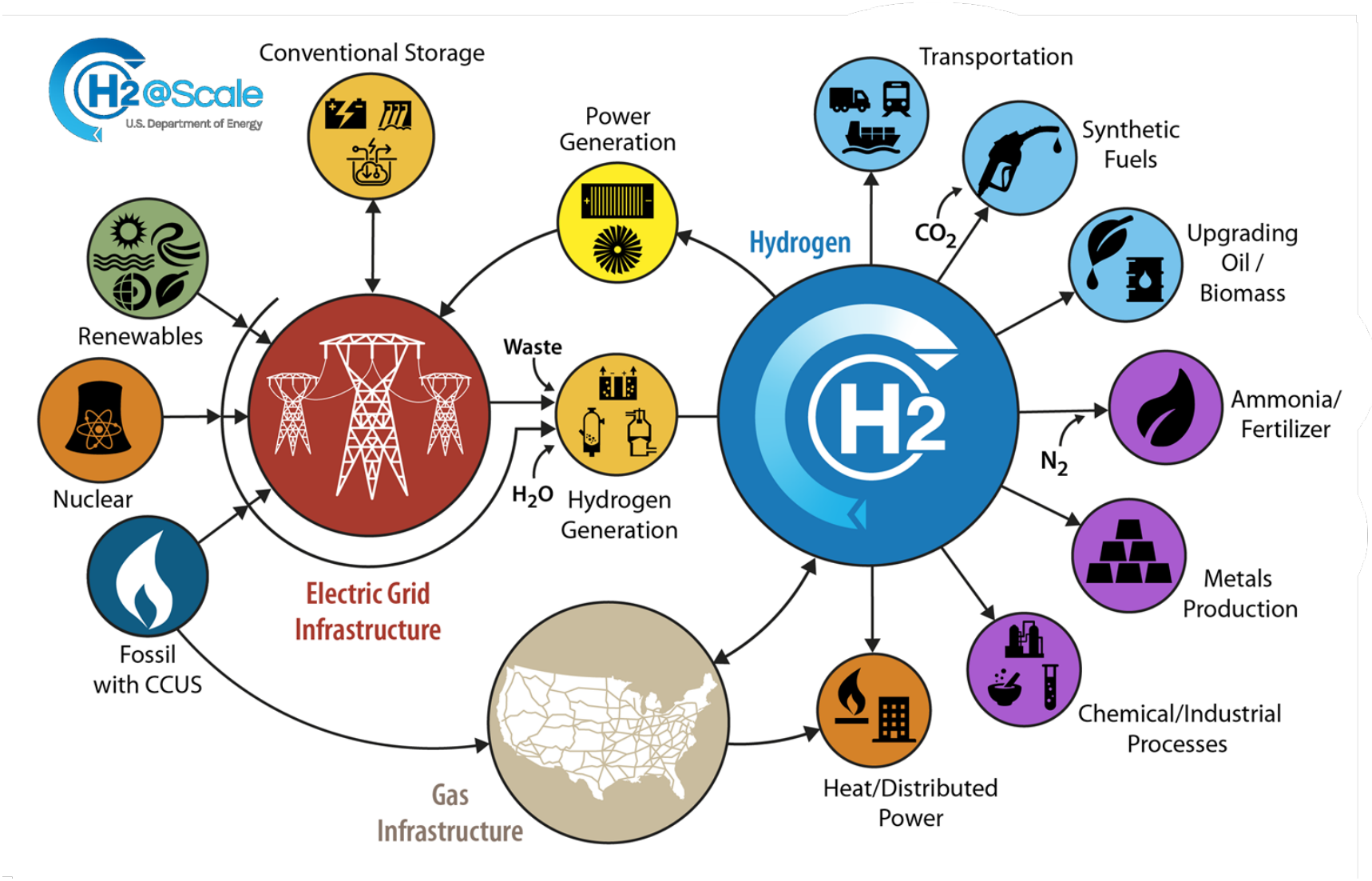
Administration Goals include:

- Net zero emissions economy by 2050
- 100% carbon-pollution-free electric sector by 2035

Priorities: Ensure benefits to all Americans, focus on jobs, EJ40: 40% of benefits in disadvantaged communities

EJ: Environmental Justice

H2@Scale: Enabler for Deep Decarbonization across Sectors and Jobs



Key Opportunities

- **Industry and Chemicals**
  Steel, ammonia, cement, syn fuels (e.g., aviation), exports
- **Transportation**
  Trucks, marine, buses, etc.
- **Power and Energy Storage**
  Long duration storage, NG blending, turbines, fuel cells

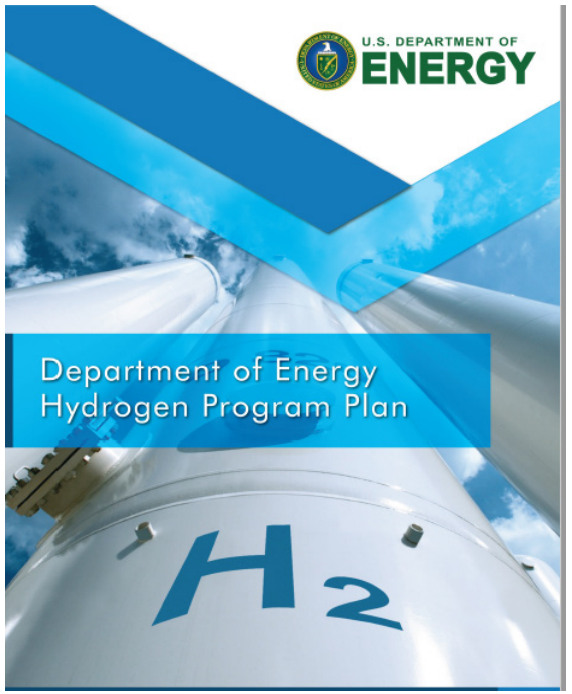
U.S. Snapshot

- 10 MMT of H_2/yr produced today, with scenarios for 2-5X growth
  - Added 10 MMT H_2 could require about doubling today's solar and wind capacity
- Potential for 700K jobs, $140B by 2030

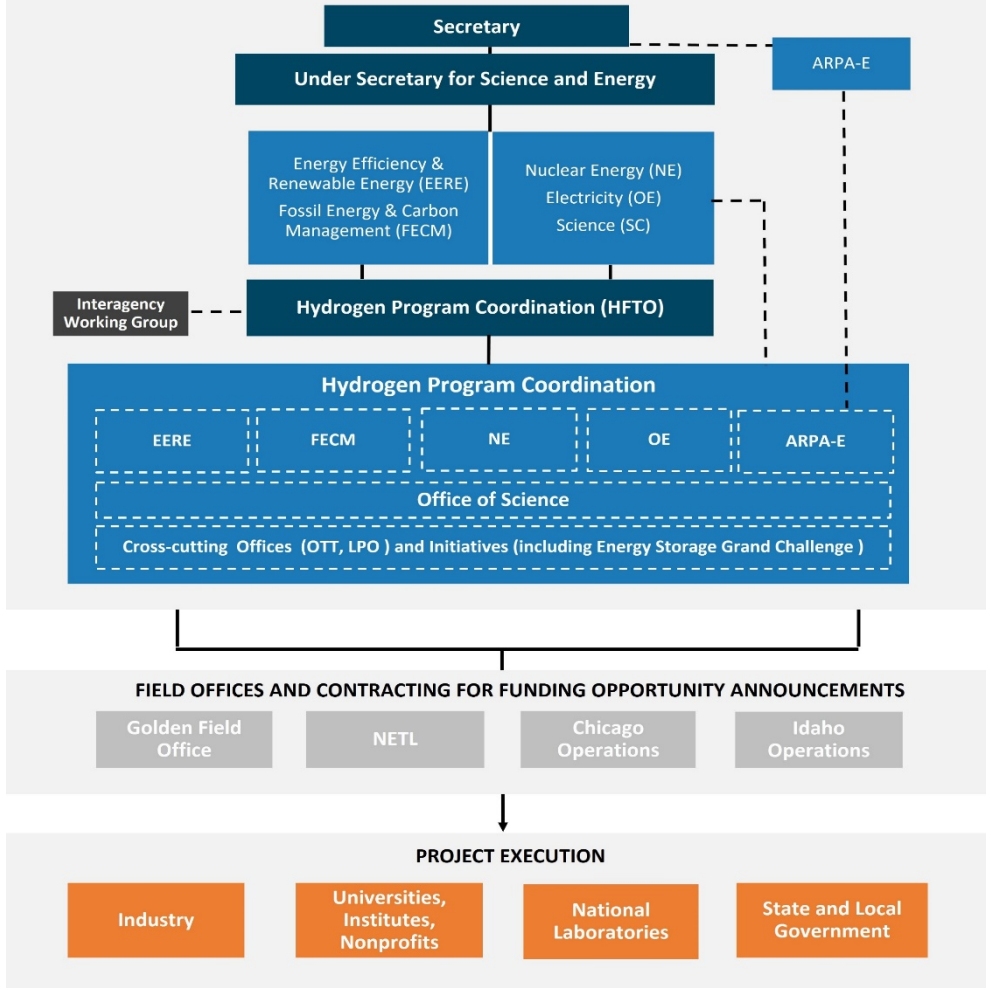
The U.S. DOE Hydrogen Program

The Energy Policy Act (2005) Title VIII and Energy Policy Act of 2020 provide key authorization, coordinated across DOE Offices

Hydrogen is one part of a broad portfolio of activities



www.hydrogen.energy.gov



Priorities

1. **Low cost, clean hydrogen**
2. **Low cost, efficient, safe hydrogen delivery and storage**
3. **Enable end use applications at scale for impact**

Workforce development, safety, codes, standards, and environmental justice priorities

ENERGY earthshots | Hydrogen
U.S. DEPARTMENT OF ENERGY

Hydrogen Energy Earthshot

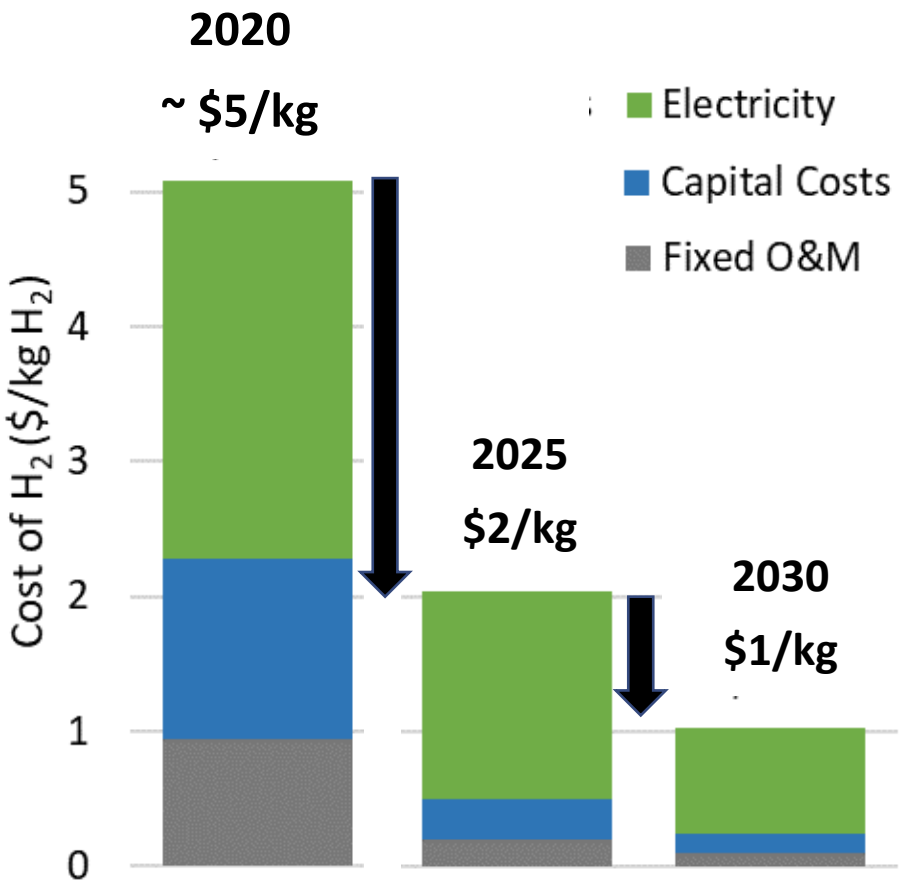
"Hydrogen Shot"

"1 1 1"
$1 for 1 kg clean hydrogen in 1 decade

Launched June 7, 2021
Summit Aug 31-Sept 1, 2021

Pathways to Reduce the Cost of Electrolytic H2

Cost Reduction of Clean Electrolytic H_2



Key enablers for lower cost electrolytic H_2:

- Low-cost electricity
- **High electrical efficiency**
- **Low-cost capital expense**
- **Increased durability/lifetime**
- **Low-cost manufacturing processes**
- **Manufacturing at MW-scale**

Electrolyzer goals for 2025	Unit	PEM	SOEC
Higher electrical efficiency	% (LHV)	≥ 70	≥ 98
Lower stack costs	$/kW	≤ 100	≤ 100
Increased durability	hours	80,000	60,000
Lower system CAPEX	$/kW	≤ 250	≤ 300

HyBlend: Assessing Feasibility of Hydrogen Blending in Natural Gas Pipelines

HyBlend
U.S. DEPARTMENT OF ENERGY

Blending can reduce emissions from heating and power generation

- 30% blend = 10% ↓ CO_2 emissions[1]
- Blend percentages vary greatly by region/country, from <1% to 30%.
  - Up to 15% may be feasible without significant changes to infrastructure.[2]

1. Source: IEA 2. Source: Melaina, et. al., NREL, 2010

Over 30 Stakeholders and 6 National Labs

Labs: NREL, SNL, PNNL, ANL,ORNL, NETL

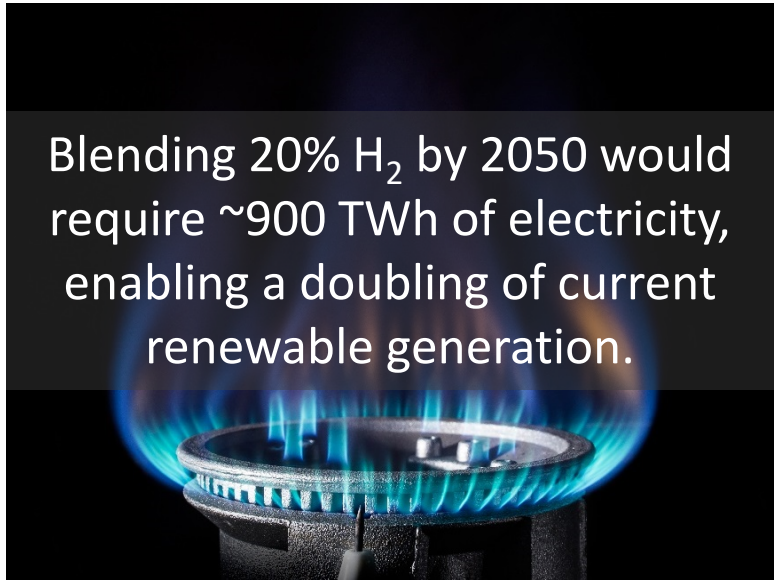
Stakeholders: Air Liquide, Chevron, DNV GL, Enbridge, EPRI, GTI, HI Gas, National Grid, NJNG, OneGas, OTD, PRCI, SMUD, Southern Company Gas, Stony Brook University, SWRI, Tenaris, and more

HyBlend Tasks

Test materials in varying blends (pressure, temperature, composition)

Develop public model of pipeline integrity to inform operating conditions

Technoeconomic and life cycle analysis of blending relative to renewable natural gas.



Prior Accomplishments of Lead Labs

- Materials testing that informed revisions to ASME Code for Hydrogen Piping and Pipelines (SNL)
- Development of the GREET life cycle analysis model, with >40,000 users worldwide (ANL)
- Performance validation of grid-integrated electrolyzers and technoeconomic analysis of H2@Scale (NREL)

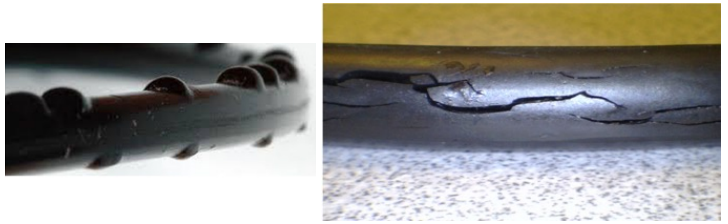
H-Mat (Hydrogen Materials Compatibility) Consortium

H-Mat℠ Hydrogen Materials Compatibility Consortium

Materials Development to Enable 50% Increase in Life of Materials in Hydrogen Environments

- Damage in materials used in fueling stations commonly due to pressure cycling in H_2
- Storage is the second most expensive component at fueling stations; commonly replaced in <5 years due to limited life in H_2

H_2 can diffuse into materials and reduce their durability. Effects are exacerbated in materials that experience pressure cycles.



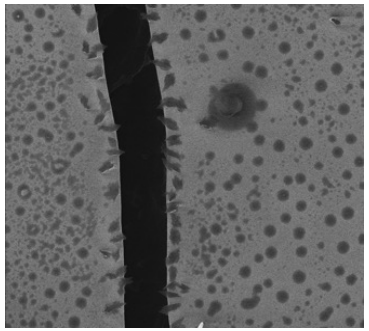
World-Class Materials R&D Capabilities

- Mechanical testing in high-pressure, temperature-controlled hydrogen environments, advanced imaging, and computational modeling tools
- National laboratory expertise developed through decades of R&D that informed hydrogen codes & standards and component design
- Two online portals for metals and polymers, to enable data sharing with global community

H-Mat Focus Areas

- **Polymers:** Improve life of seal materials in H_2 by 50%
- **Metals:** Increase life of storage vessels in hydrogen by 50%
- **Pipelines:** Characterize life of metal and polymer pipe materials in hydrogen blends
- **Cross-cutting:** Support industry and academia in development of novel low-cost materials for H_2 service

R&D can identify operating conditions and materials engineering techniques that increase component life.



More info at https://h-mat.org

Collaboration between 5 national labs & teams from industry and academia

- Partners engaged through FOAs, SBIRs, and CRADAs
- International MOUs and "Affiliate Memberships" to enable coordination and collaboration with world leaders in the field.
- Online data portal to share information with R&D community worldwide

Sandia National Laboratories · PNNL · Oak Ridge National Laboratory · SRNL · Argonne National Laboratory

Gaps and Collaboration Opportunities

- Detection
  - Sufficiency of traditional odorants
  - Detection technologies and specificity
  - Real-time compositional measurement
  - Detector calibration
- Flammability
  - Changes to LFL/UFL and ignition energy (MIE) with blending level
- Material Compatibility
  - Material compatibility of natural gas pipelines at different blend levels
  - Corrosion mechanisms at different blend levels or operating conditions
- Operational
  - Pipeline and system purging/venting requirements
  - Increased static risk with venting lines
  - Effectiveness of witt (bag) stops or PE squeezes relative to blended systems
  - In-service metallic welding impact at different blend levels (UFL changes)
  - PE fusing impact at different blend levels (plastic equivalent of in-service welding)

Thank You

HFTO website: https://www.energy.gov/eere/fuelcells/hydrogen-and-fuel-cell-technologies-office

Annual Merit Review: https://www.hydrogen.energy.gov/annual_review.html

HFTO Newsletter: https://www.energy.gov/eere/fuelcells/subscribe-hydrogen-and-fuel-cells-news

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