U.S. DEPARTMENT OF ENERGY

U.S. DOE Hydrogen Program Annual Merit Review (AMR) Plenary Remarks

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DOE Hydrogen Program Coordinator
U.S. Department of Energy

May 6, 2024

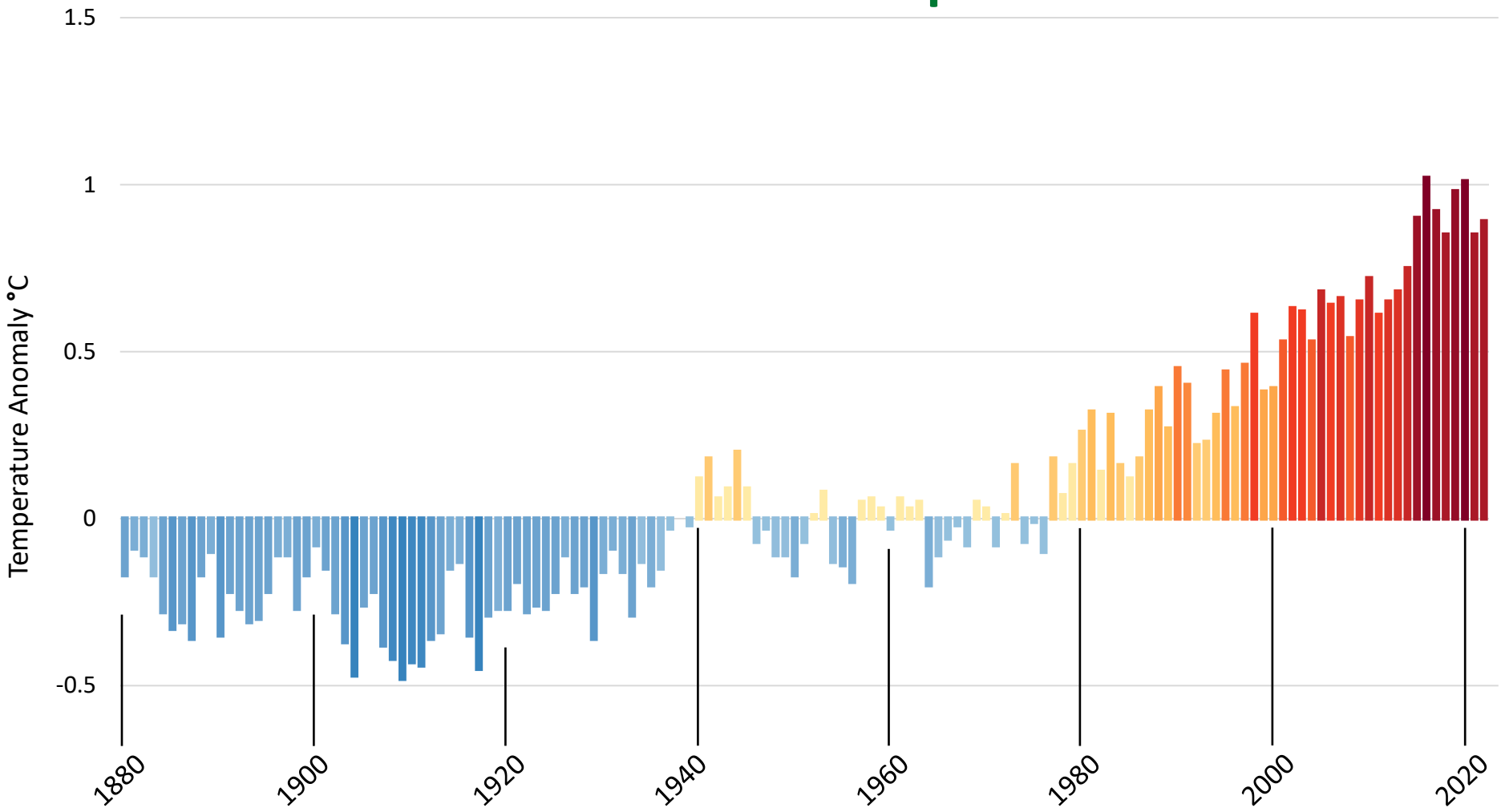
Agenda

1. National Strategy & Goals
2. Program Plans
3. Accomplishments
4. Collaborations

Introduction – Energy, Market, and Policy Context

The Global Challenge….

Global Land-Ocean Temperature Index

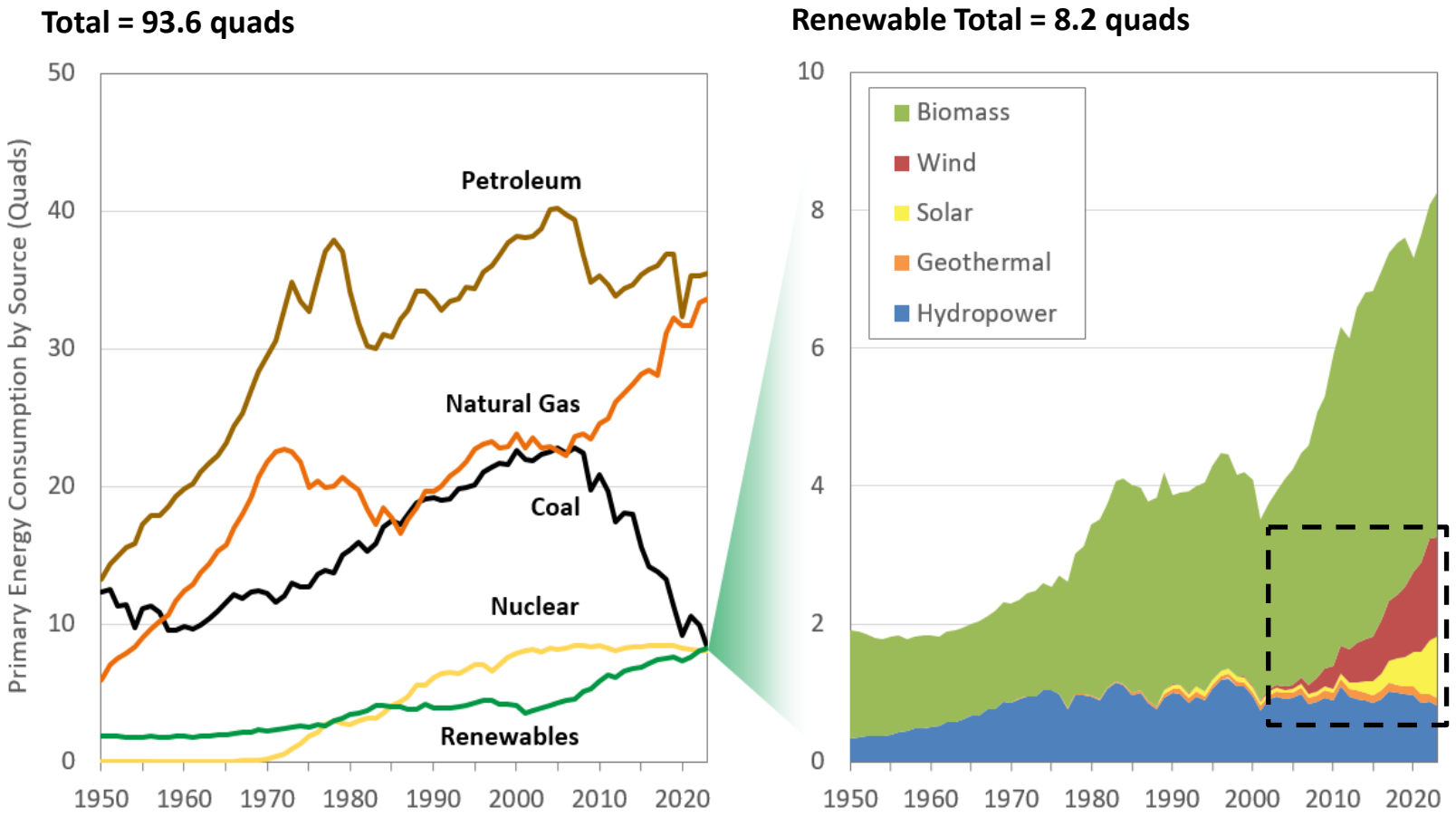


The 10 most recent years were the warmest years on record.

Source: https://climate.nasa.gov/vital-signs/global-temperature/?intent=121 - ;
Chilton, et al, DOE HFTO, based on NASA Goddard Institute for Space Studies reported data

U.S. Energy Landscape and Key Goals

U.S. Primary Energy Consumption by Energy Source



Quad= quadrillion British thermal units (Btu)

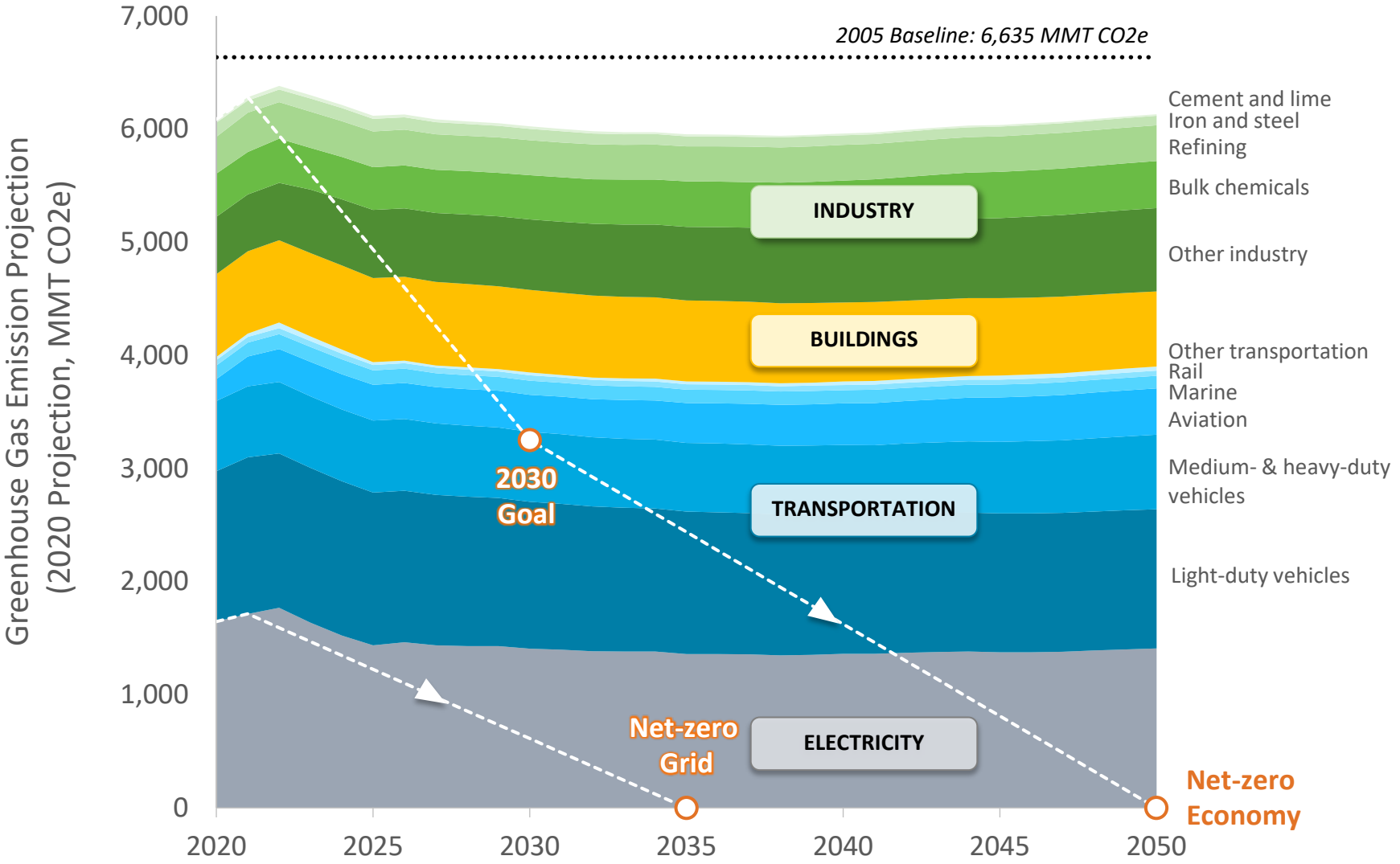
Source: Melaina, Chilton, et al, DOE HFTO, based on data collected from U.S. Energy Information Administration, *Monthly Energy Review,* April 2024, Table 1.3. https://www.eia.gov/totalenergy/data/browser/?tbl=T01.03#/?f=A

Administration Goals include:

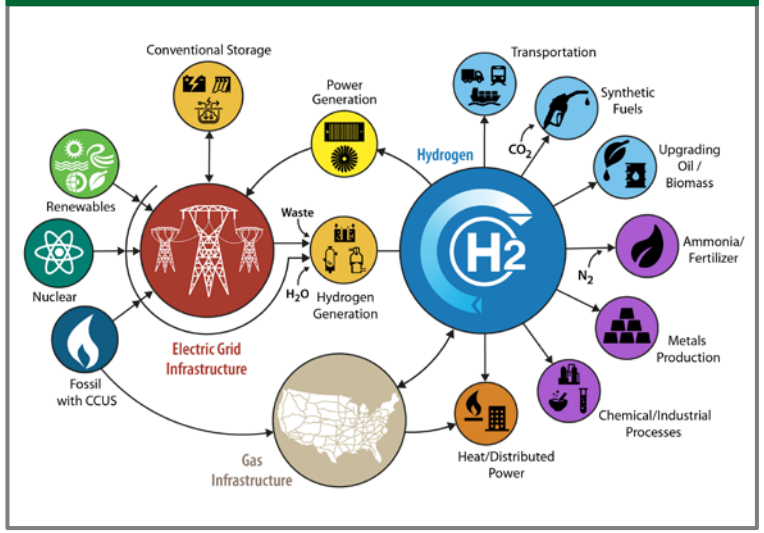
- Net-zero emissions economy by 2050 and 50–52% reduction by 2030
- 100% carbon-pollution-free electric sector by 2035

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

Carbon Dioxide Emissions by Sector



Hydrogen is a key element of a comprehensive portfolio of solutions to enable net zero



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

Bipartisan Infrastructure Law (BIL) provides $9.5B for clean H_2 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

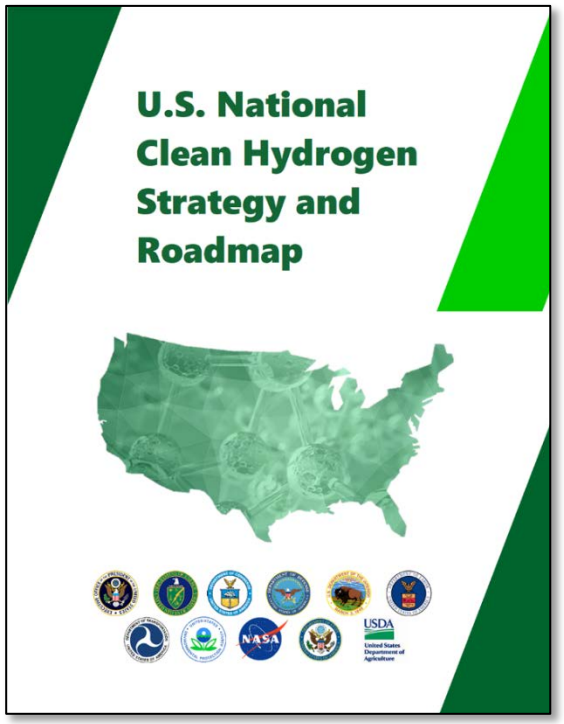
Examples of policies & activities across the H_2 value chain

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]
Manufacturing Tax Credit 48C (Treasury/DOE)	Manufacturing Tax Credit 48C (Treasury/DOE)	Clean Power Rule NPRM (EPA)
H2 Hubs, BIL (DOE)	H2 Hubs, BIL (DOE)	Buy Clean Standards (EOP)
		Agency offtake (DOD, USPS, USDA, DOT, EPA, etc.)
		H2 Hubs (including Demand Side Initiative) BIL (DOE)

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

U.S. National Clean Hydrogen Strategy and Roadmap

U.S. National Clean Hydrogen Strategy and Roadmap



www.hydrogen.gov

Released June 5, 2023

Strategy

1. **Target strategic, high-impact end uses**
   Achieve 10 MMT/year of clean hydrogen by 2030
2. **Reduce the cost of clean hydrogen**
   Enable $2/kg by electrolysis by 2026 and $1/kg H_2 by 2031
3. **Focus on regional networks**
   Deploy regional clean hydrogen hubs and ramp up scale

Vision:
Affordable clean hydrogen for a net-zero carbon future and a sustainable, resilient, and equitable economy

Benefits:
Emissions reduction; job growth; energy security and resilience

Enablers

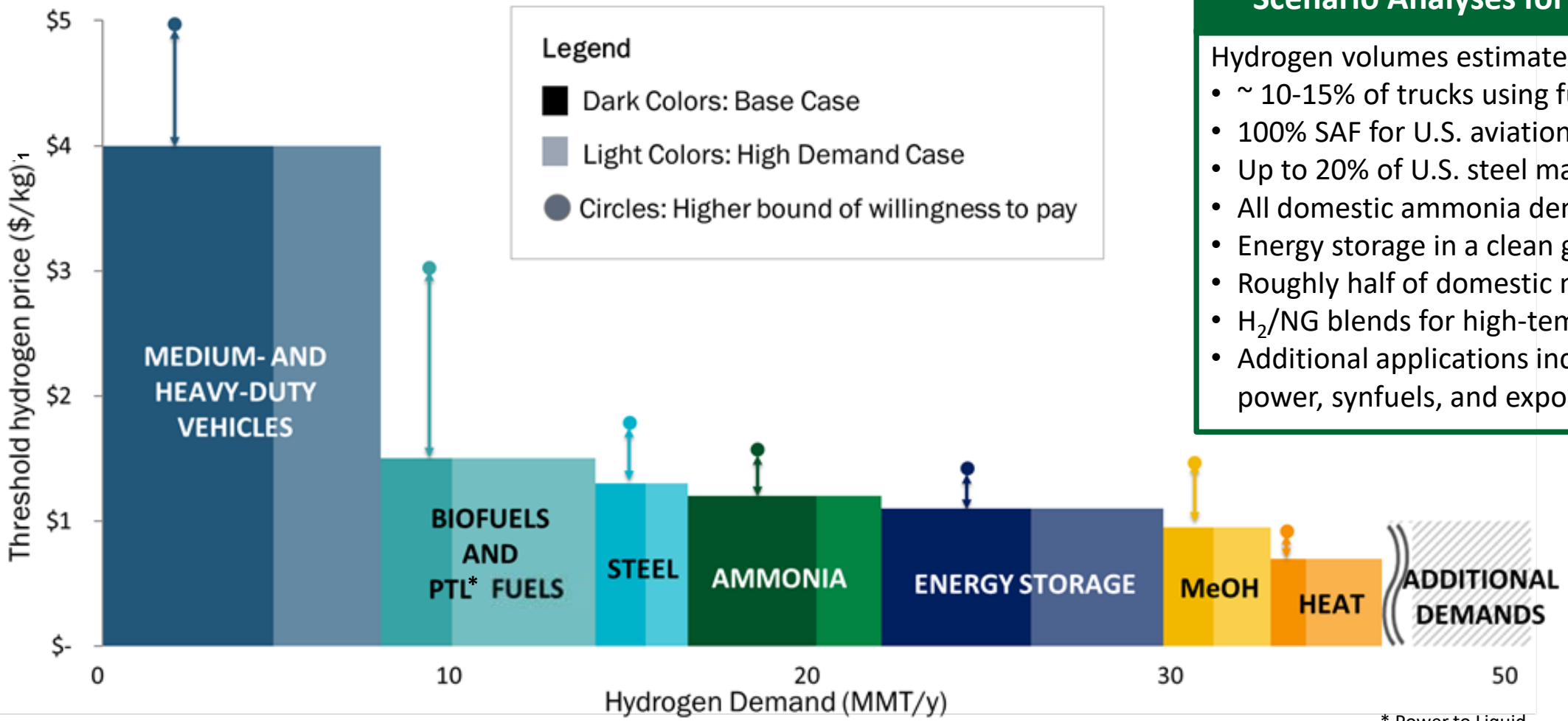
Work with other agencies to accelerate market lift off

- Good Jobs and Workforce Development
- Safety, codes and standards
- Policies and incentives
- Stimulating private sector investment
- Energy and environmental justice

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

Strategy 1: Target High-Impact Uses of Hydrogen

Clean Hydrogen Demand and Costs for Market Penetration



Scenario Analyses for H_2 Demand**

Hydrogen volumes estimated for:

- ~ 10-15% of trucks using fuel cells
- 100% SAF for U.S. aviation (35B gal) in 2050
- Up to 20% of U.S. steel making
- All domestic ammonia demand
- Energy storage in a clean grid
- Roughly half of domestic methanol
- H_2/NG blends for high-temp heat in industry
- Additional applications include stationary power, synfuels, and export potential

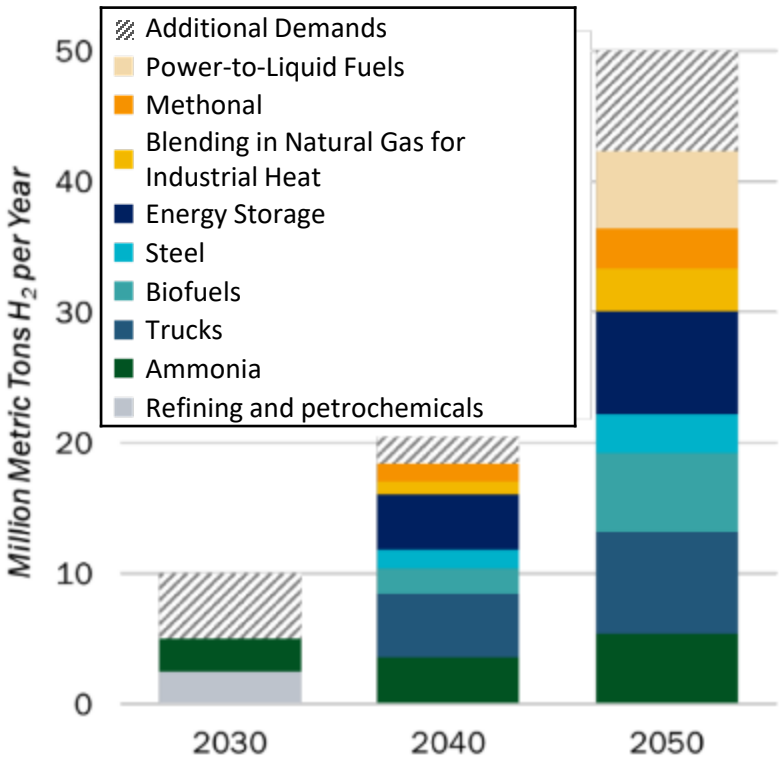
[1]Costs include production, delivery, dispensing to the point of use (e.g., high-pressure fueling for vehicle applications)

* Power to Liquid

** Volumes dependent on multiple variables

Strategy 1: Target High-Impact Uses of Hydrogen

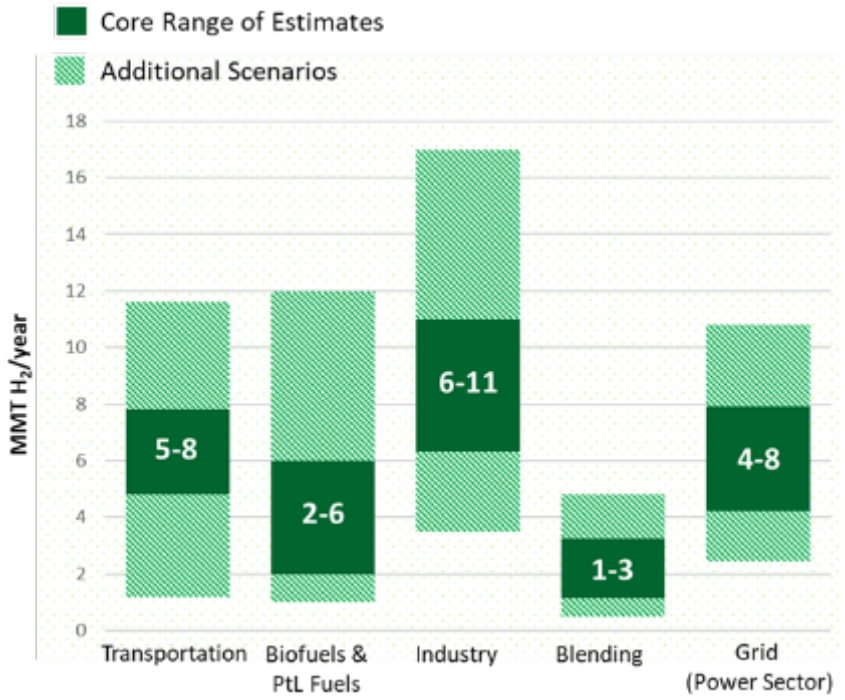
Opportunities for Clean Hydrogen Across Applications



Clean Hydrogen Use Scenarios

- Catalyze clean H_2 use in existing industries (ammonia, refineries), initiate new use (e.g., sustainable aviation fuels [SAFs], steel, potential exports)
- Scale up for heavy-duty transport, industry, and energy storage
- Market expansion across sectors for strategic, high-impact uses

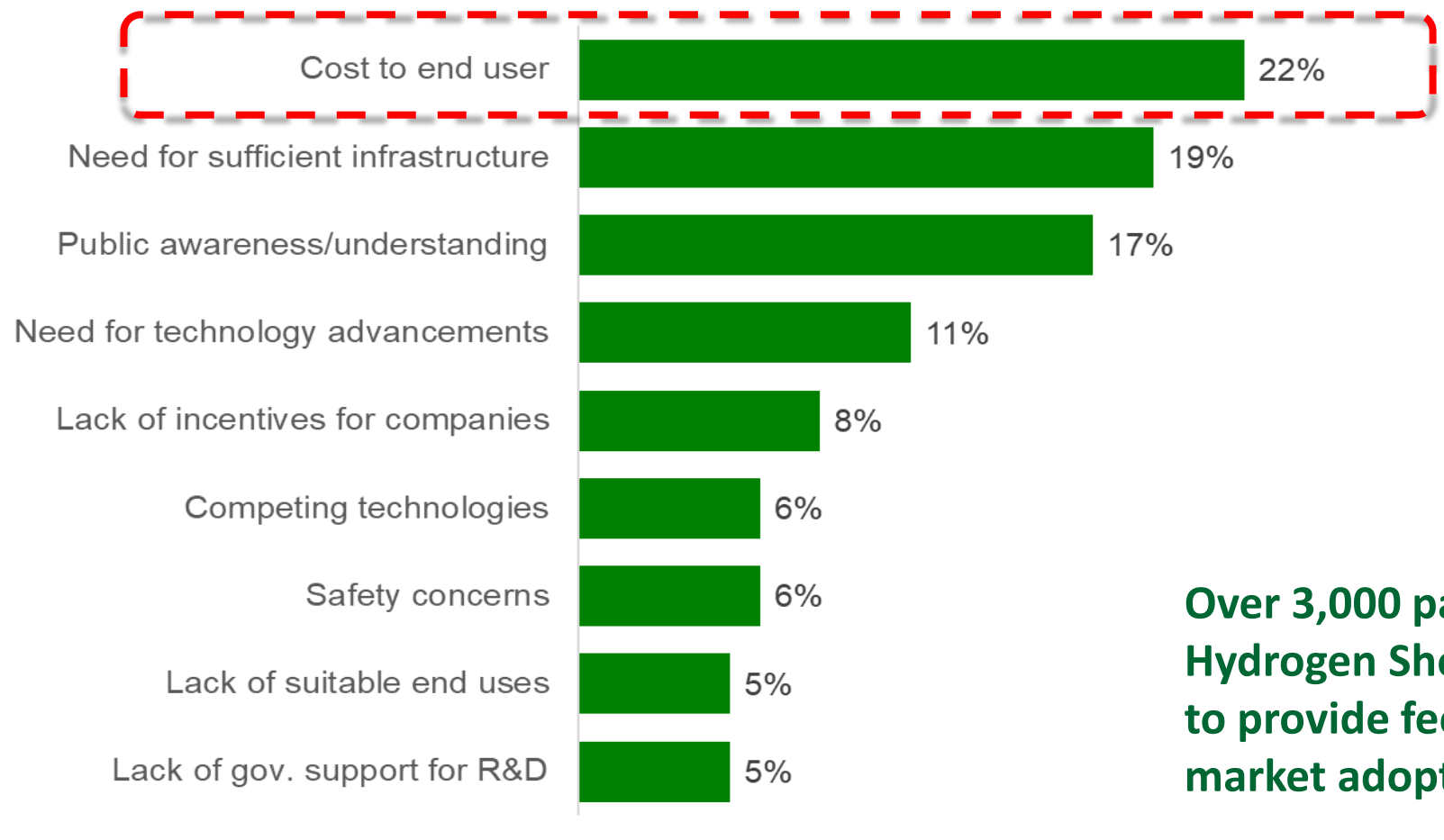
Range of Potential Demand for Clean Hydrogen by 2050



- **Core range: ~ 18–36 MMT H_2**
- **Higher range: ~ 36–56 MMT H_2**

Refs: 1. NREL MDHD analysis using TEMPO model; 2. Analysis of biofuel pathways from NREL; 3. Synfuels analysis based off H2@Scale ; 4. Steel and ammonia demand estimates based off DOE Industrial Decarbonization Roadmap and H2@Scale. Methanol demands based off IRENA and IEA estimates; 5. Preliminary Analysis, NREL 100% Clean Grid Study; 6. DOE Solar Futures Study; 7. Princeton Net Zero America Study

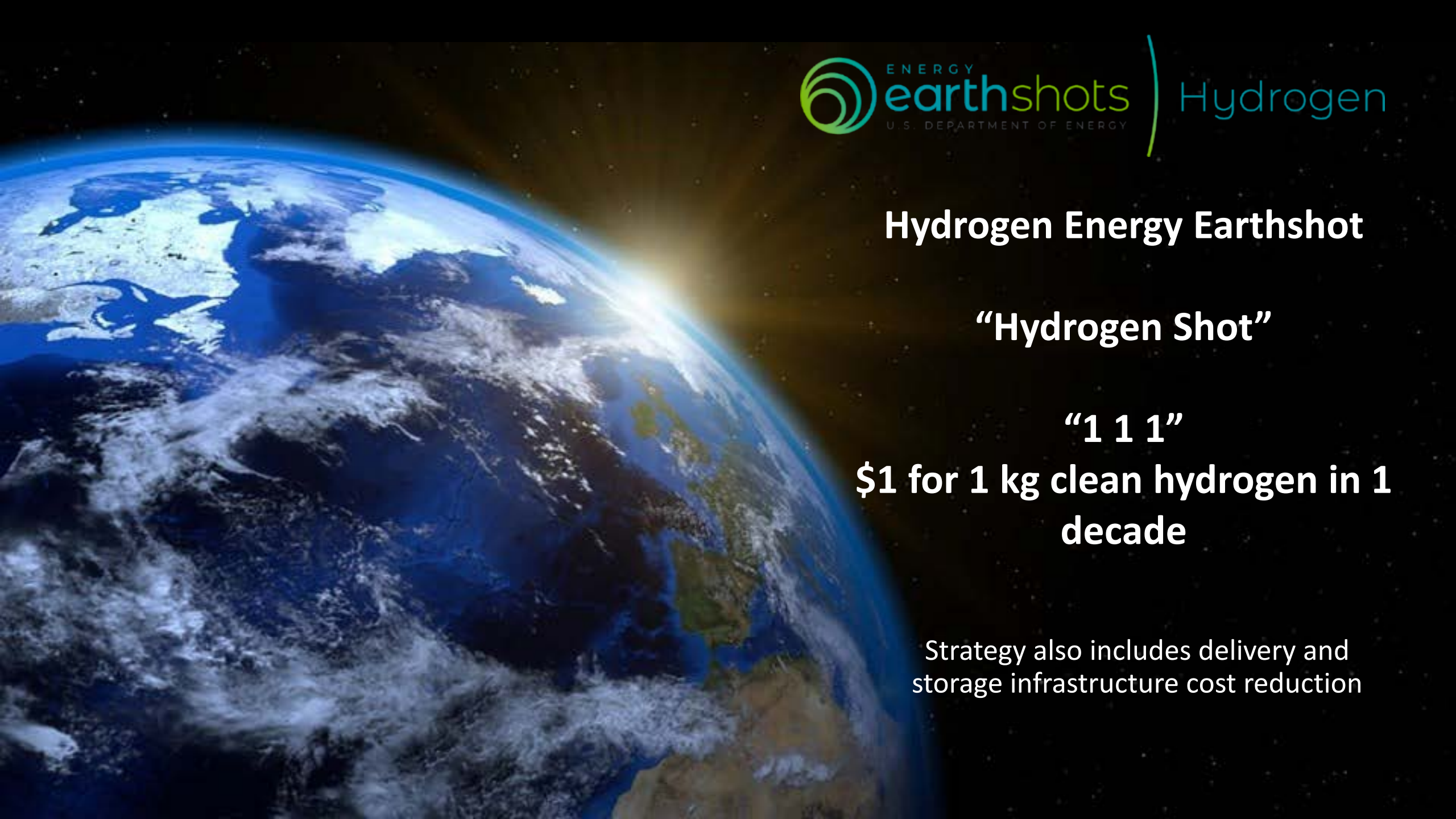
Stakeholder Reported Barriers to Hydrogen Market Adoption



Over 3,000 participants at DOE Hydrogen Shot Summit were requested to provide feedback on key barriers to market adoption of hydrogen

Source: Hydrogen Shot Summit, Sept 2021

https://www.energy.gov/eere/fuelcells/hydrogen-shot-summit



ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen

Hydrogen Energy Earthshot

“Hydrogen Shot”

“1 1 1”
$1 for 1 kg clean hydrogen in 1 decade

Strategy also includes delivery and storage infrastructure cost reduction

Strategy 3: Focus on Regional Networks and Ramp-up Scale

President Biden announces $7B for 7 H2 Hubs, Oct 2023

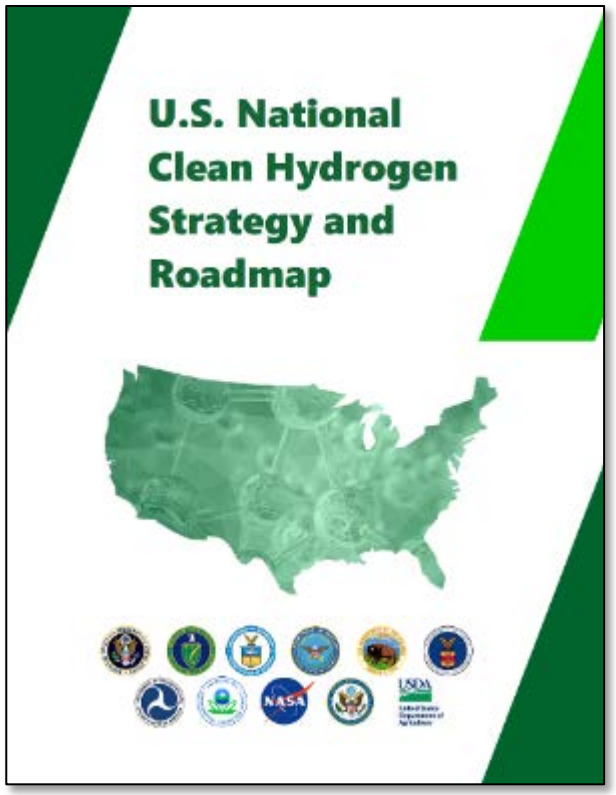
Demand side strategy for Hubs announced

DOE selects consortium to bridge demand for clean H_2 providing market certainty and unlock private capital
Jan 2024

H2 Hubs managed by OCED: See https://www.energy.gov/oced/office-clean-energy-demonstrations

Key Publications

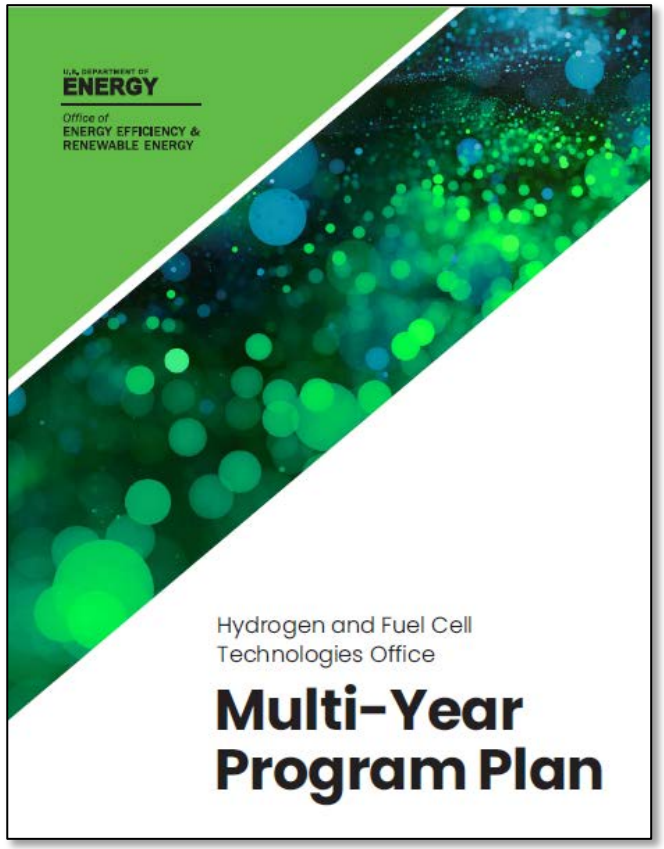
Analysis and guiding documents provide framework for key activities from basic science through deployment



www.hydrogen.energy.gov

Liftoff updates coming soon

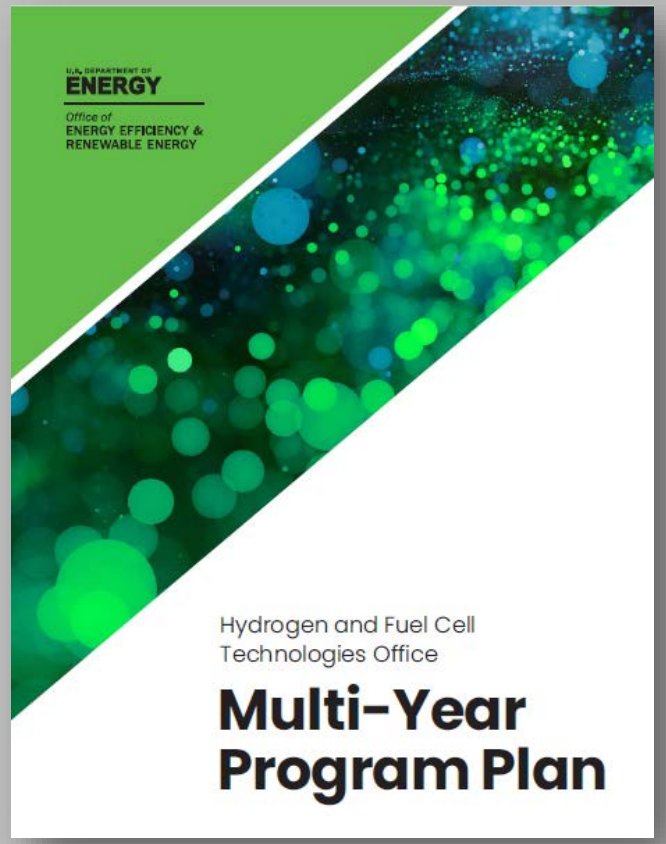
Modal plans underway
Rail, offroad, marine, etc.



Released May 6, 2024

www.energy.gov/eere/fuelcells/mypp

HFTO Multi-Year Program Plan Released Today!



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

HFTO Multi-Year Program Plan (MYPP) Overview

MYPP includes strategic priorities, targets, barriers, and pathways to address them.

Strategic Priorities

Strategic Priorities		Near-Term 2025	Mid-Term 2030	Longer Term
Clean H_2 Production	• **Affordable, efficient, and durable electrolyzers** for **GW-scale** operations • **Innovative approaches to clean H_2 production**, beyond electrolysis			
H_2 Delivery & Storage Infrastructure	• Affordable and reliable components and systems for **H_2 transport and dispensing in heavy-duty applications** • **Advanced H_2 liquefaction and carrier distribution concepts** • **Low-cost vessels** for high-pressure gaseous & cryogenic liquid H2 storage • **Innovative H_2 storage materials** for high-density, low-pressure storage			
Fuel Cell Technologies	• **Efficient, durable, and cost-competitive fuel cells** for heavy-duty applications • **Advanced materials and components** for next-generation fuel cell technologies in diverse applications			
Systems Development & Integration	• **Transportation and H_2 fueling** demonstrations • **Chemical and industrial processes** integrating H_2 technologies, focusing on decarbonization • **Energy storage and power generation** including integrated and resilient hybrid energy systems			
Systems Analysis	• **Tools, modeling and analysis** to prioritize RD&D and inform early-market deployments • **Regional analysis** to support energy transition planning and assess impacts • **Integrated analysis** to inform supply chain expansion and sustainable market growth			
Safety, Codes, & Standards	• **H_2 component technologies safety**, including materials compatibility and environmental modeling, emphasizing near-term dispensing applications • **Safety, codes, and standards** with additional emphasis on bulk storage and large-scale applications of H_2			
Cross-Cutting / Enabling	Collaborations within HFTO, and across offices and other federal agencies, to enable low-cost, high-volume domestic manufacturing and recycling, a robust domestic supply chain, good-paying U.S. jobs, regional clean H_2 networks and address energy and environmental justice and diversity, equity, inclusion, and accessibility.			

Defining Barriers

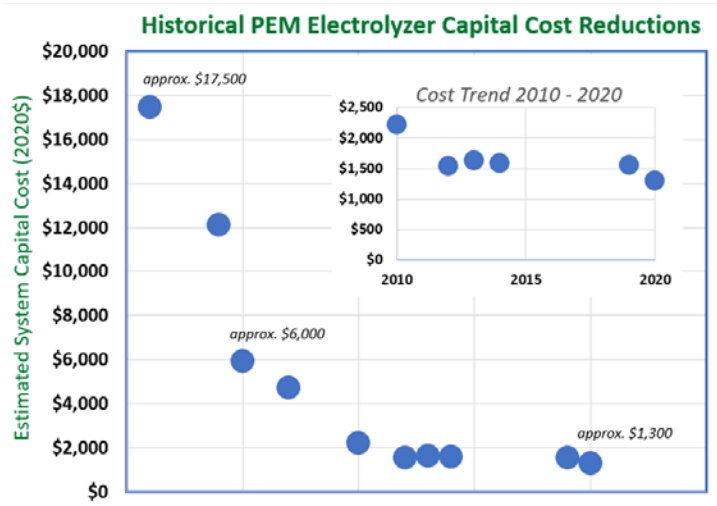
Barrier	Associated Challenges
C: Cost materials, components, systems	Capital costs of materials and components (e.g., catalysts, electrodes, membranes) Installation, operations, maintenance, and replacement costs in H_2 production systems Balance-of-plant capital costs (e.g., feedstock pre-treatment, power electronics, H_2 purification) Feedstock costs (e.g., electricity, water, biomass, waste), including any transport or pre-treatment
D: Durability/ Reliability	Durability of materials, components, and integrated systems System reliability and lifetime under dynamic operating conditions
E: Efficiency/ Performance	H_2 production conversion efficiency H_2 production rates and yield Operational performance, including the ability to dynamically electric power input
LC: Life-Cycle / Sustainability	Life-cycle cost and environmental impacts Cost-effective recycling (e.g., catalysts, membrane electrode a
M: Manufacturing, Scale-Up, and Supply Chain	Materials, components, and systems compatible with high-vol affordable scale-up and large-scale manufacturing Robust domestic supply chain (e.g., electrolyzer PGM catalysts BOP components such as power electronics)
S: Safety	Materials, components, and systems with adequate considera related safety issues

Developing Targets

	Parameter	Units	Low-Temperature PEM Baseline	Low-Temperature PEM 2026 Targets	Low-Temperature PEM Ultimate Targets	High-Temperature O-SOEC Baseline	High-Temperature O-SOEC 2026 Targets	High-Temperature O-SOEC Ultimate Targets
Stack	Total PGM Content	mg/cm² / g/kW	3.0 / 0.8	0.5 / 0.1	0.125 / 0.03	- / -	- / -	- / -
Stack	Performance	A/cm² @V/cell	2.0 A/cm² @1.9 V	3.0 A/cm² @ 1.8 V	3.9 A/cm² @ 1.5 V	0.6 A/cm² @ 1.28 V	1.3 A/cm² @ 1.28 V	
Stack	Electrical Efficiency	kWh/kg H_2	51	48	43	34	34	
Stack	Lifetime	Operation hr	40,000	80,000	80,000	20,000	40,000	
Stack	Degradation Rate	mV/khr	4.8	2.3	2.0	6.4	3.2	
System	Capital Cost	$/kW	450	100	50	300	125	
System	Energy Efficiency	kWh/kg H_2	55	51	46	47	44	
System	Uninstalled Capital Cost	$/kW	1,000	250	150	2,500	500	

Addressing Barriers through RD&D

RD&D Focus Areas	Barriers addressed	Key Milestones
Low Temperature Electrolysis *Proton Exchange Membrane, Liquid Alkaline, Alkaline Exchange Membrane*		
Increase durability, improve performance, and lower cost of membranes, ionomers, catalysts/electrodes, bipolar plates, and porous transport layers in polymer electrolyte membrane (PEM) electrolysis through materials and design innovations	C, D, E	• Develop and implement accelerated stress test (AST) protocols to enable durability improvements (2024)
Develop viable membranes and ionomers for alkaline exchange membrane (AEM) electrolysis as a potential lower-cost alternative to PEM	C, D, E	• Achieve PEM stack cost of $300/kW, with a stack efficiency of 69% lower heating value (LHV) and an 80,000-hr lifetime (2026)
Develop improved cell designs and optimized components for liquid alkaline (LA) electrolysis to enable improved performance and dynamic operation	C, D, E	• Demonstrate AEM electrolyzers operating at 2 A/cm² at 1.8 V with a degradation rate of <4 mV/khr (2026)
Improve kinetic performance and durability in low-platinum group metal (PGM) and PGM-free catalysts	C, D, E	• Develop PEM electrolyzer systems with cost of $250/kW, 65% LHV efficiency, and 80,000-hr durability (2026)
Optimize efficiency and durability of electrolyzer stacks and systems under dynamic operations through innovations in component and systems engineering	C, D, E	• Demonstrate LA electrolyzers operating at 1 A/cm² at 1.8 V with a degradation rate of <2.3 mV/khr and capable of dynamic operation (2026)
Develop optimized balance of plant components, including power electronics, to reduce system costs and increase efficiency	C, E	
Develop low-cost, high-throughput, high-quality		



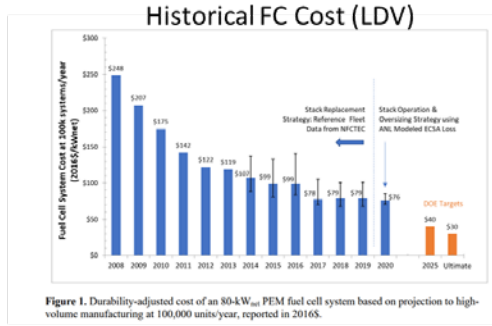
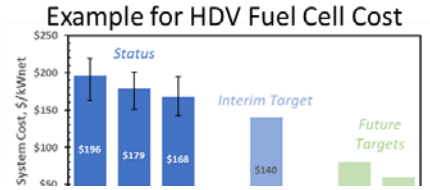
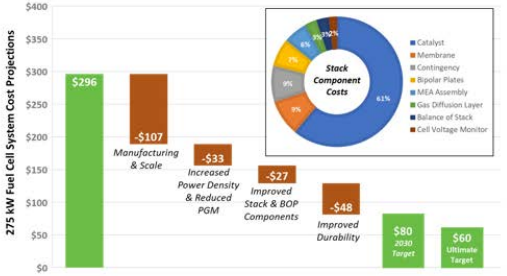
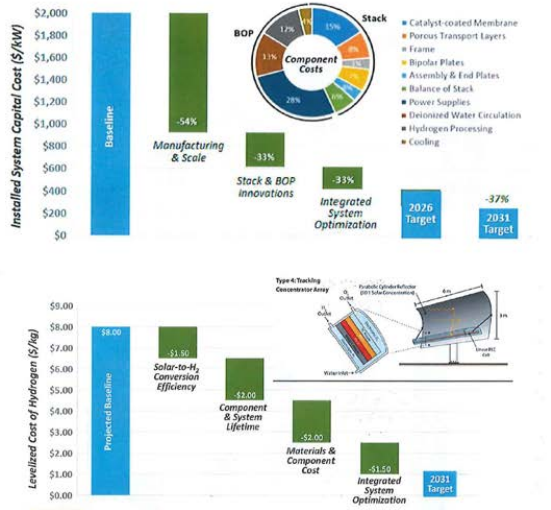


Figure 1. Durability-adjusted cost of an 80-kW_{net} PEM fuel cell system based on projection to high-volume manufacturing at 100,000 units/year, reported in 2016$.





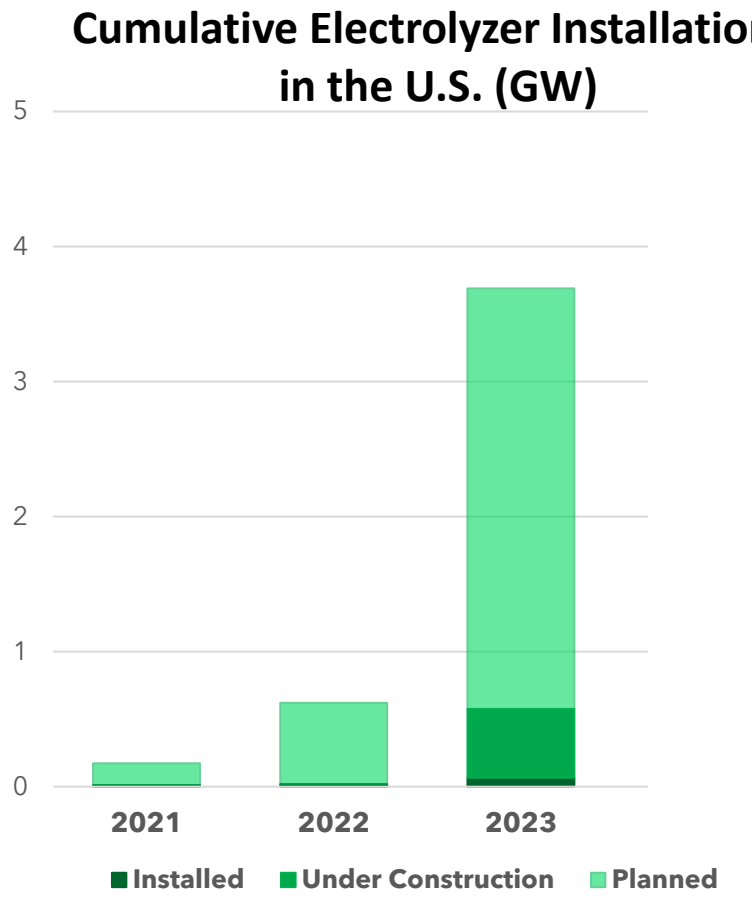


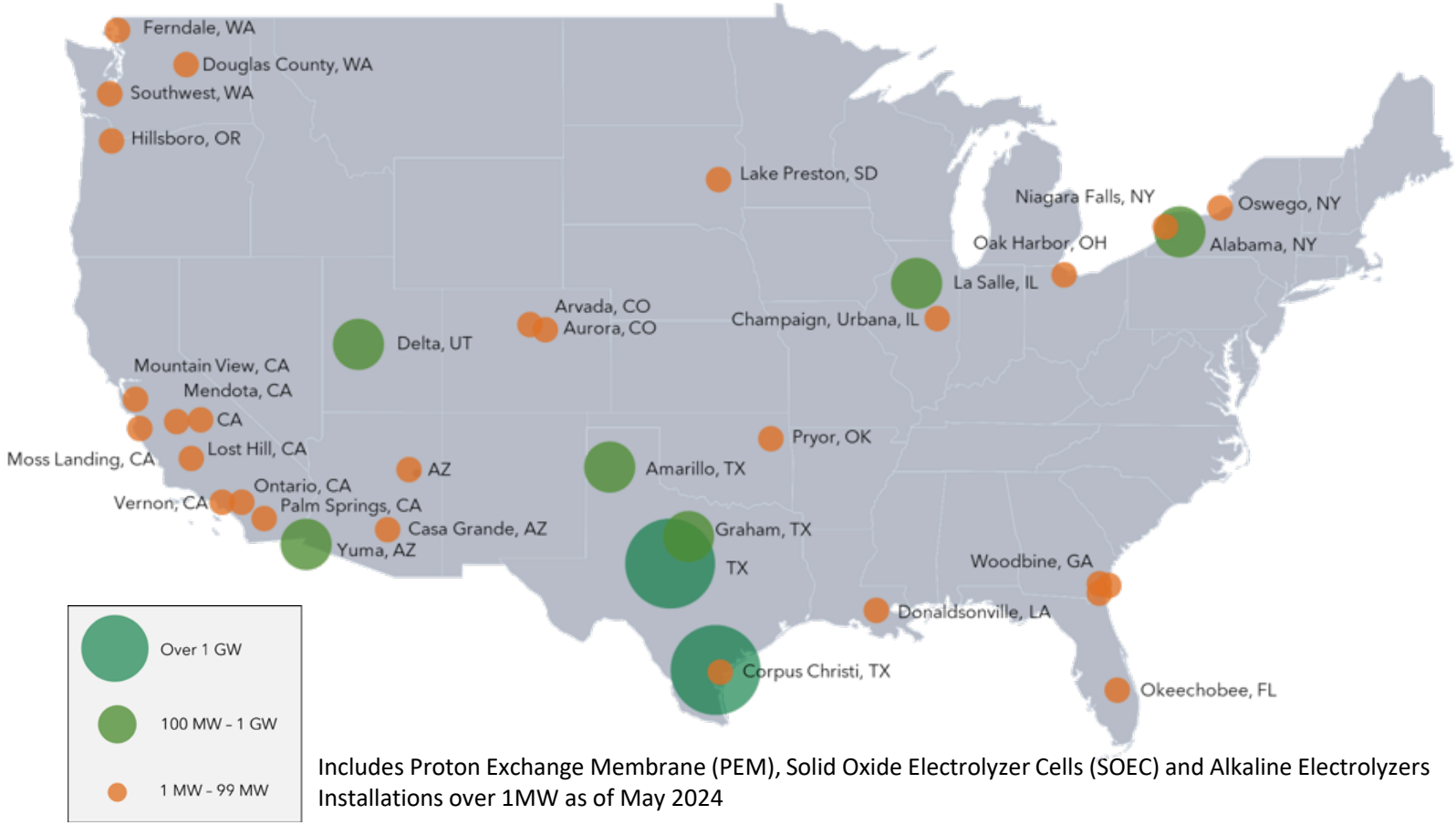
https://www.energy.gov/eere/fuelcells/articles/hydrogen-and-fuel-cell-technologies-office-multi-year-research-development

Snapshot – Today and Recent Progress in the U.S.

Planned and Installed Electrolyzer Capacity in the U.S.

Total 4.5 GW in Electrolyzer Capacity
~1 GW added since 2023 (Up by >20%)



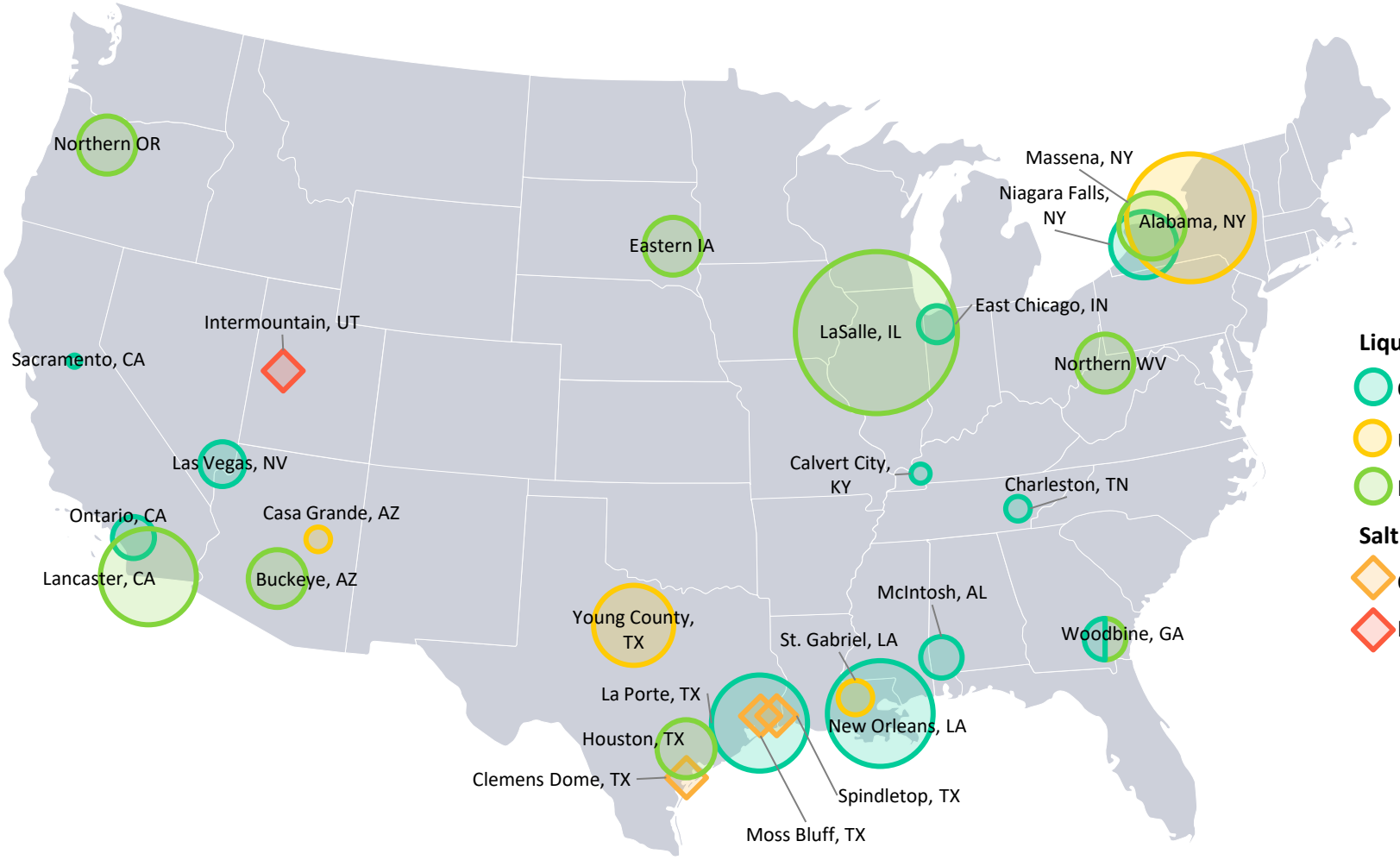


Includes Proton Exchange Membrane (PEM), Solid Oxide Electrolyzer Cells (SOEC) and Alkaline Electrolyzers
Installations over 1MW as of May 2024

Source: Hubert, M., & Arjona, V. (2024). DOE Hydrogen Program Record# 24001
https://www.hydrogen.energy.gov/library/program-records

Existing and Planned Liquefaction and Salt Cavern Storage

~800 Metric Tons per Day (TPD) Liquefaction Capacity
>330 GWh Salt Cavern Storage Currently; 150-300 GWh More Planned



Operating U.S. Hydrogen Liquefaction Plants
14 Operating at 5-32 TPD
304 TPD total capacity

Planned U.S. Hydrogen Liquefaction Plants
4 Under Construction &
9 Planned at 11-90 TPD
490 TPD total capacity

U.S. Hydrogen Storage Caverns
3 Operating, 1 Planned
4 Total
100-150 GWh capacity

Additional liquefaction plants in Canada: 3 operating (~50 TPD) + 1 planned (35 TPD)

Source: Wieliczko, M. (2024). DOE Hydrogen Program Record #24003, https://www.hydrogen.energy.gov/library/program-records, publicly available information, and NREL

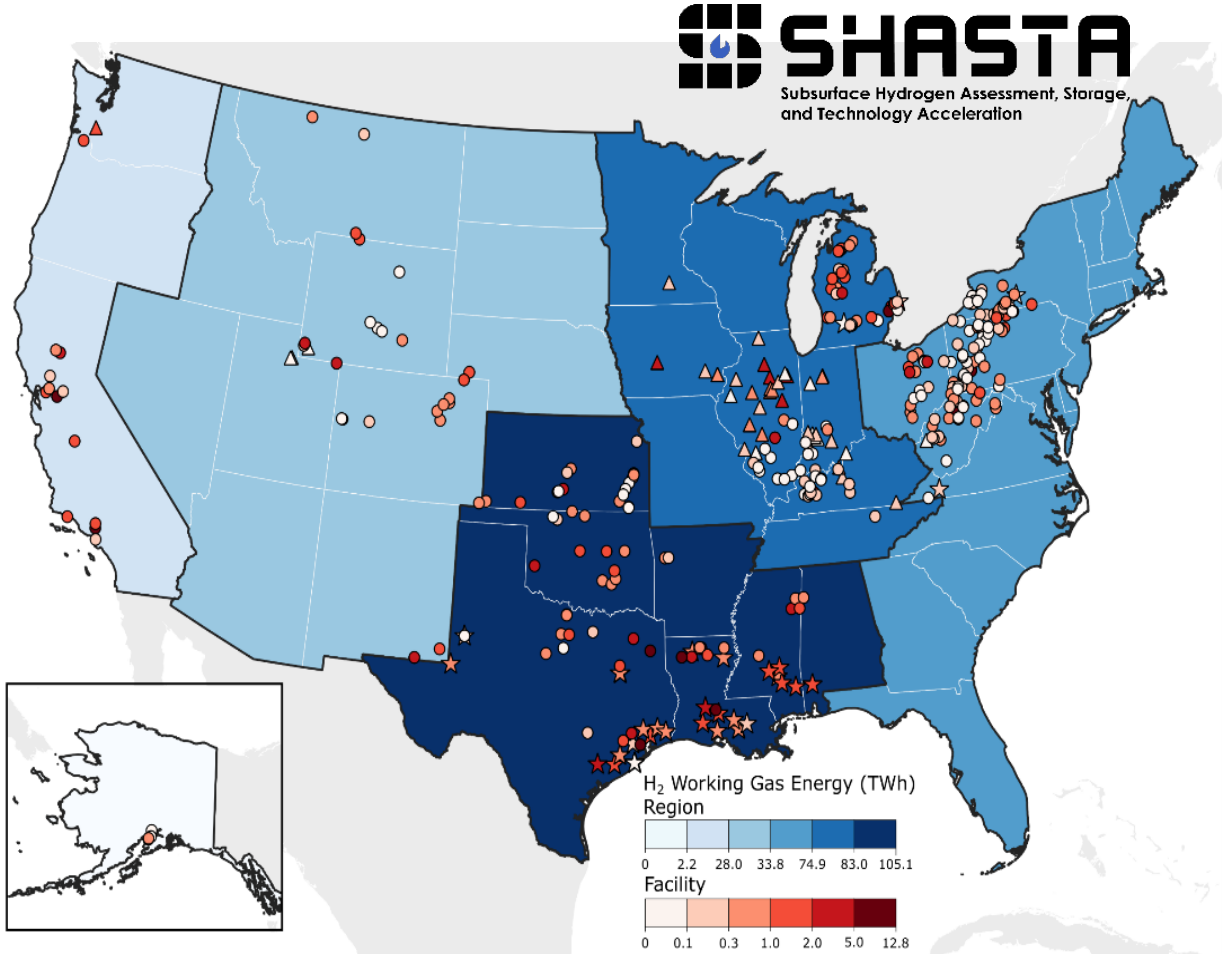
Potential for Large Scale Subsurface Storage

Assessing Potential for Subsurface Storage

- ~ 400 active underground natural gas storage facilities in the U.S. today
  (~12% saline aquifers, 79% depleted reservoirs)
- Conversion to H_2 could store ~ 9.8 MMT H_2 (~330 TWh)

SHASTA goals include:

- Quantify operational risks
- Develop enabling tools, technologies, recommended practices
- Develop a collaborative field-scale test plan in partnership with relevant stakeholders



https://edx.netl.doe.gov/sites/shasta/

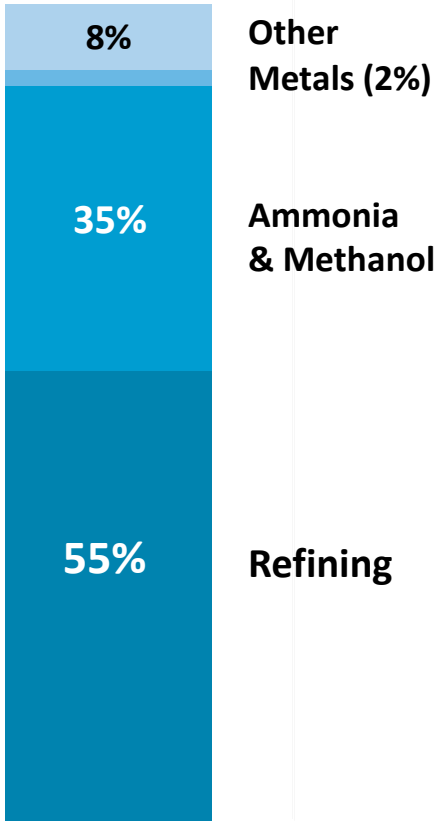
Lackey et al., 2023 (https://doi.org/10.1029/2022GL101420)

U.S. Department of Energy | Fossil Energy and Carbon Management | NETL National Energy Technology Laboratory | Pacific Northwest National Laboratory | Lawrence Livermore National Laboratory | Sandia National Laboratories

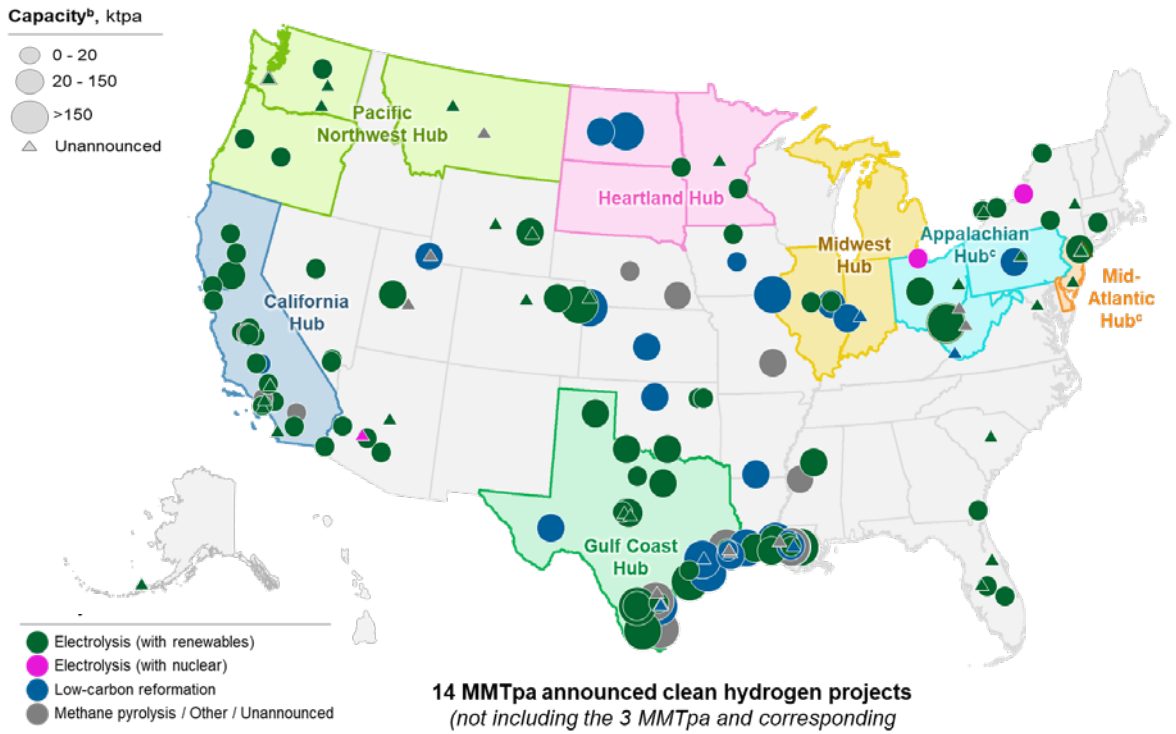
Snapshot of Hydrogen and Fuel Cells in the U.S.

10 million metric tons H_2 produced annually | More than 1,600 miles of H_2 pipeline | World's largest H_2 storage cavern

Use of Hydrogen in the U.S. Today



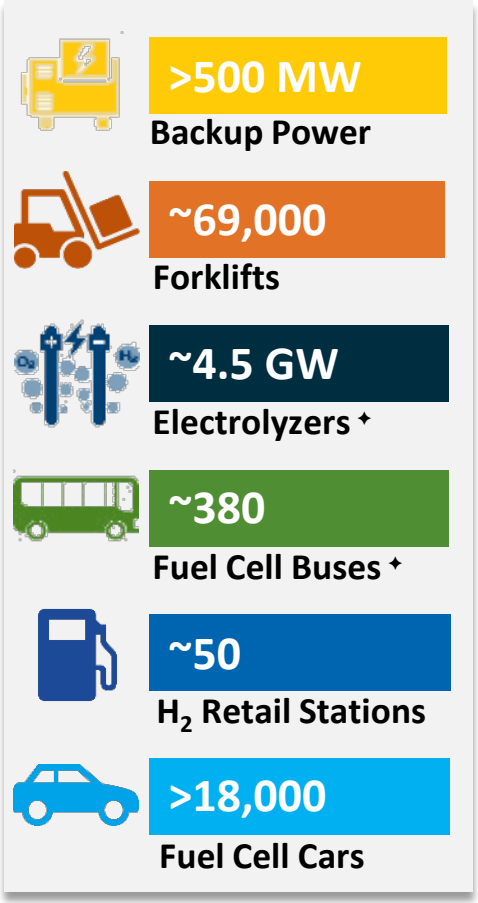
Clean hydrogen production projects announced as of Jan. 2024*



14 MMTpa announced clean hydrogen projects
(not including the 3 MMTpa and corresponding projects associated with DOE H2Hubs)

*DOE Commercial Liftoff Report Updates available soon.

Examples of Deployments



✦Buses and electrolyzers include planned / under construction / deployed

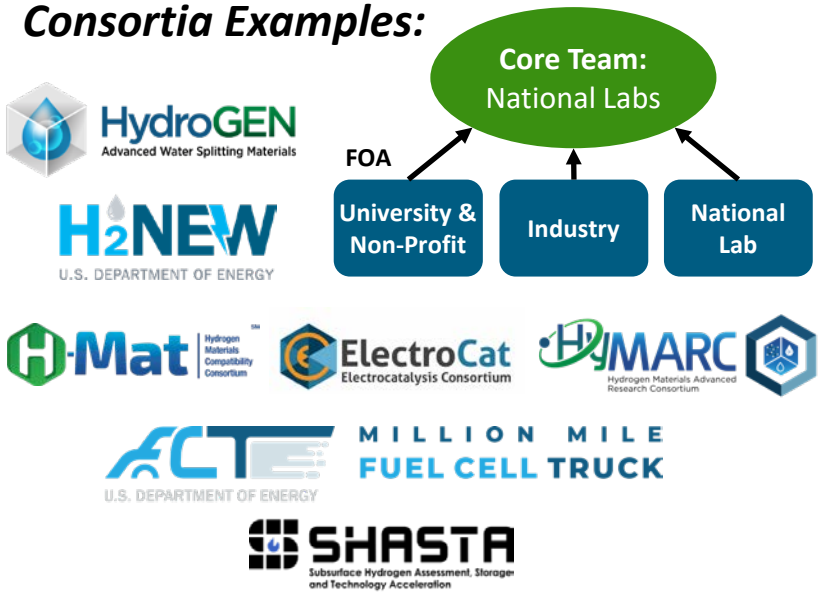
Ongoing Work and Accomplishments to Address Key Priorities

DOE Hydrogen Activities across RDD&D – Examples

Research and Development

Basic and applied research through individual projects and consortia

Consortia Examples:



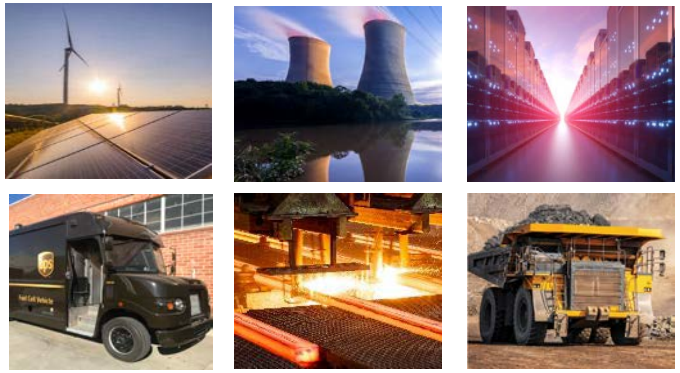
Basic science user facilities, theory, modeling

- New areas include AI/machine learning

Technology Integration, Validation, Demos

1st of a kind demonstrations and systems integration to de-risk deployments

Examples:



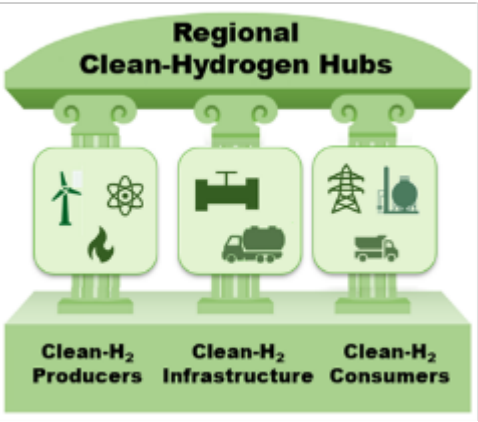
Renewable and nuclear to H_2, 15 delivery trucks in disadvantaged area, 3 Super Truck projects, data center, energy storage, H_2 for steel

Deployment and Financing

H2 Hubs, loan guarantee program, workforce development

Example:

$7 billion for 7 hubs: Renewables, fossil w/ CCS, nuclear; multiple end-uses



2 new loan guarantee projects ($1.5B total) on pyrolysis and large-scale electrolysis, H_2 energy storage and power generation

Enabling Activities

- Analysis and tools
- Safety, codes & standards
- Manufacturing
- Workforce development

H2EDGE Hydrogen Education for a Decarbonized Global Economy

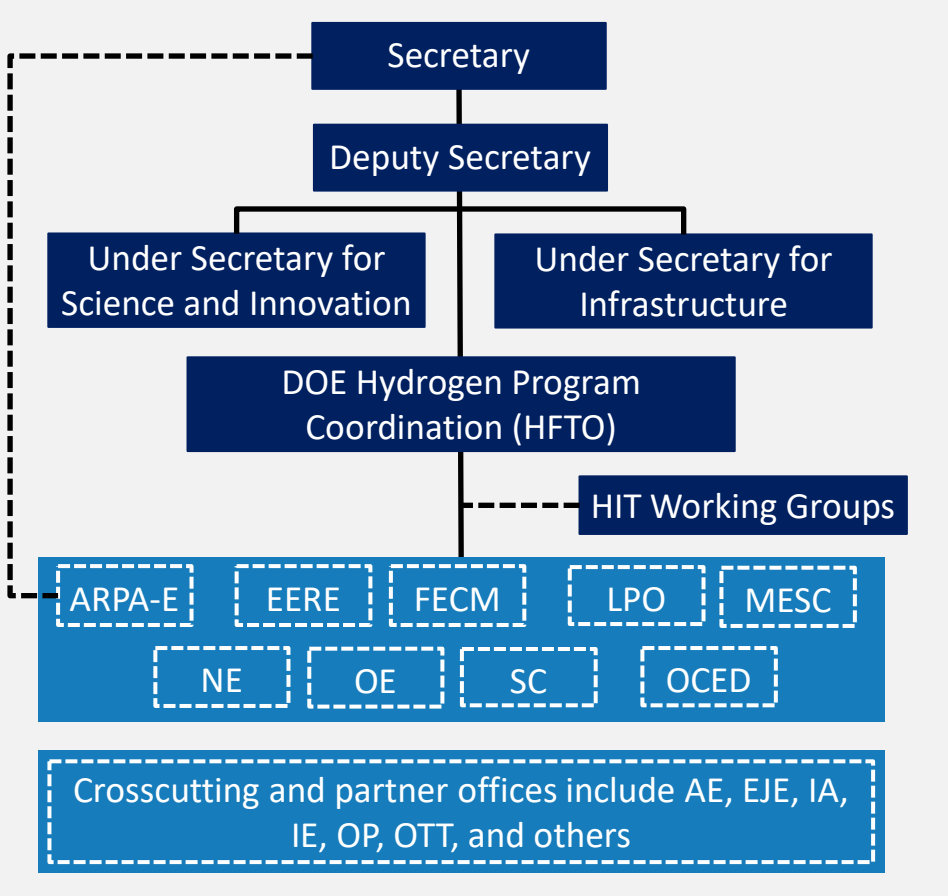
CENTER FOR Hydrogen SAFETY Connecting a Global Community

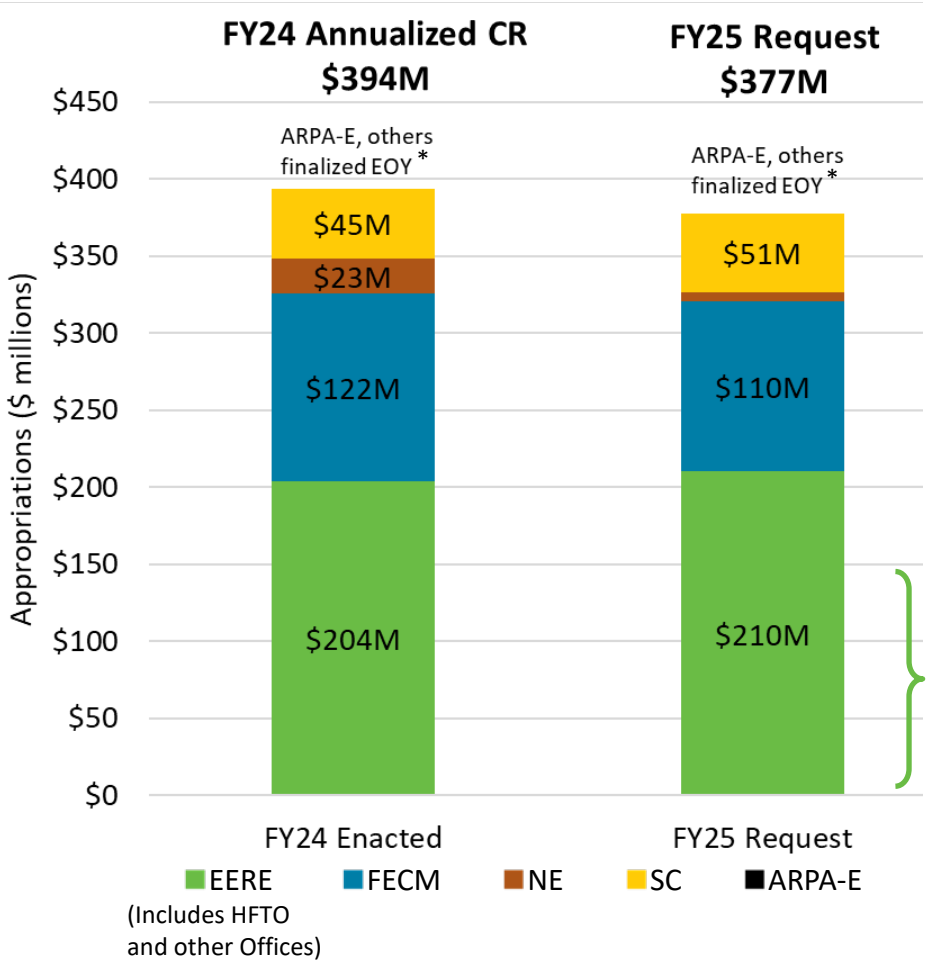
HyBlend U.S. DEPARTMENT OF ENERGY

Energy Justice and Equity Collaborations across programs

The U.S. DOE Hydrogen Program – Coordinated across Offices

Comprehensive, coordinated program across offices with $377M in FY25 Budget Request





Annual Appropriations Budgets

(excludes BIL $9.B funding and LPO)

HFTO

FY24: $170M

FY25 Request: $170M

FY25 Request: Production: $15M; Infrastructure: $52M; Fuel cells: $25M Syst. Dev.Integ:$75M; Analysis: $3M

DOE Hydrogen Program coordinated through HFTO. Source: https://www.energy.gov/sites/default/files/2023-03/doe-fy2024-budget-volume-2-crosscutting-v3.pdf

**Final to be updated by end of year (EOY) , e.g., ARPA-E, SC funding is determined annually based on programs/selections. Annual funding only, excludes BIL funding and new offices (e.g., OCED)*

HFTO Enabled Accomplishments

Innovation

1089 Active Patents

Total since 2004

Due to HFTO funding
Inventors from Labs, Industry and Academia

1361 cumulative patents, including those expired

Technology-to-Market

30 Technologies Commercialized

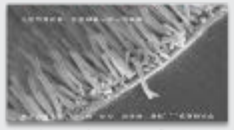
By industry*

65 With Potential to Enter Market

in the next 3-5 years*

Examples of Technologies Enabled

Fuel Cell Catalysts



Catalyst and Supports for PEM Fuel Cells
3M

Hydrogen Tube Trailers

Hydrogen Tube Trailers
Hexagon Lincoln

Forklifts

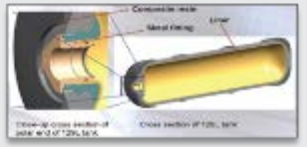
Class-1, -2, and -3 Forklifts
Plug Power (GenDrive FCs)

Electrolyzers

Electrolyzer System
Proton Series

PEM Electrolyzer System
Giner

Hydrogen Tanks

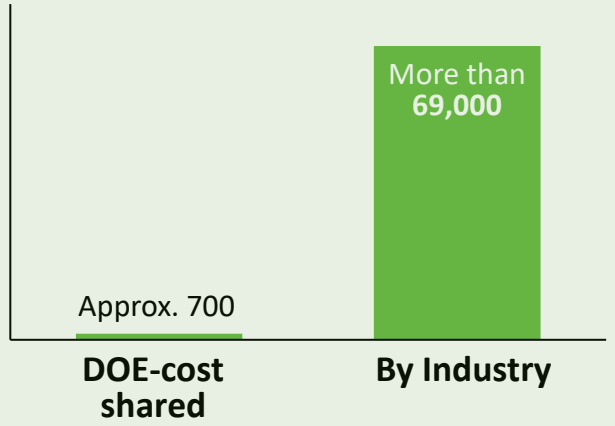


Optimized 129L Tank
Quantum Technologies

* Enabled by HFTO funds. Additional tracking underway and available soon.

Market Uptake

Hydrogen fuel cell forklifts in the U.S.



American-made small-scale hydrogen refueler

- Exported to Japan
- Uses electrolysis

Snapshot of Patents due to HFTO Funding

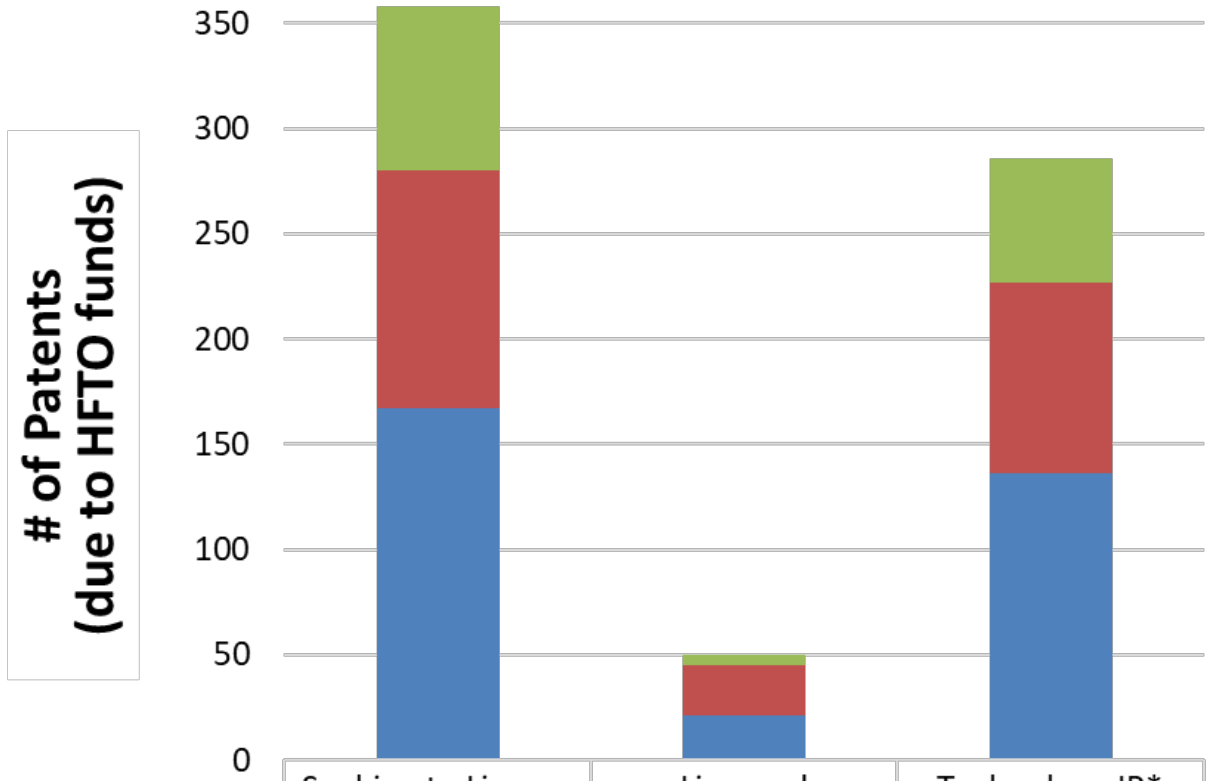
179 organizations received patents due to HFTO funding

~42% of patents across 109 companies
~36% across 14 national labs
~21% across universities

Next Steps

Accelerate tech transfer and connect innovations with investors and manufacturers

Stay tuned at www.hydrogen.energy.gov



	Seeking to License	Licensed	Technology IP*
Infrastructure / Sotrage	78	5	59
Production / Delivery	113	24	91
Fuel Cell	167	21	136
Total	324	228	142

*Technology IP are patents related to commercial or near market-ready technologies (preliminary assessment by PNNL) resulting from HFTO R&D funding
Source: Annual HFTO-funded patent tracking study conducted by PNNL

Key Activities Across DOE Addressing Program Priorities

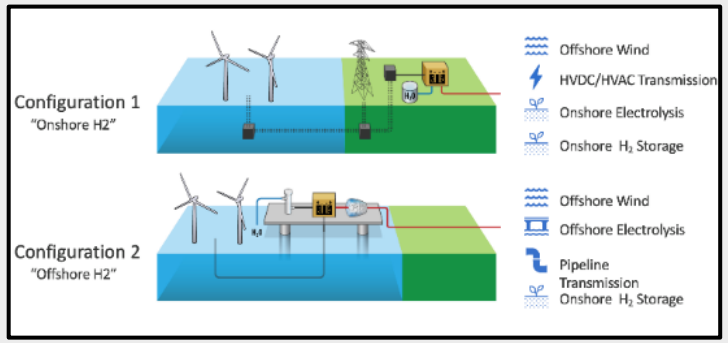
Program Priorities	Key Activities to Address Priorities
1 Low-Cost Clean Hydrogen Production	H2NEW, HydroGEN, ElectroCAT, H2 Shot Incubator Prize, EERCs, EFRCs, ARPA-E NH_3, Pyrolysis, Geologic H_2
2 Safe, Low-Cost Delivery and Storage Infrastructure	H-Mat, HyBlend, HyMARC, SHASTA, C-Fiber, Liquid H_2, H_2 Carriers, HD Dispensing, Sensors
3 Low-Cost, Durable, and Efficient Fuel Cells & Low-NOx Turbines	M2FCT, ElectroCAT, Low-NOx Turbine RD&D, ARPA-E INTEGRATE, EFRCs (*e.g., CABES)*
4 Enable End Use Applications at Scale	H2@Scale Demos, Clean Hydrogen Hubs, NE Integrated Energy Systems, ARPA-E (*e.g., REEACH*)

Examples from multiple offices across DOE

Examples of Highlights Across Applied RD&D Offices

EERE

NREL Flatirons Campus ARIES
H2 System: Commissioned & Operational:
1.25MW electrolyzer, 1MW fuel cell, storage



Offshore Wind and Hydrogen Use Case Studies: ***Cross-Office Collaboration***

FECM

Hydrogen Shot assessment on thermal pathways
(e.g., SMR/ATR with CCS)

National Petroleum Council Study
https://harnessinghydrogen.npc.org/

National Strategy Targets (2024-2028)
9 ppm NOx for 100% H2 turbines
2 ppm with selective catalytic reduction

Co-funding H2 Shot incubator prize Phase 2 with HFTO

https://netl.doe.gov/projects/files/HydrogenShotTechnologyAssessmentThermalConversionApproaches_120523.pdf

NE

Nuclear-powered production of H_2 and syn-fuels, first-of-a-kind demos

Nine Mile Point: 1.25 MWe PEM Started Feb 2023 (Constellation)

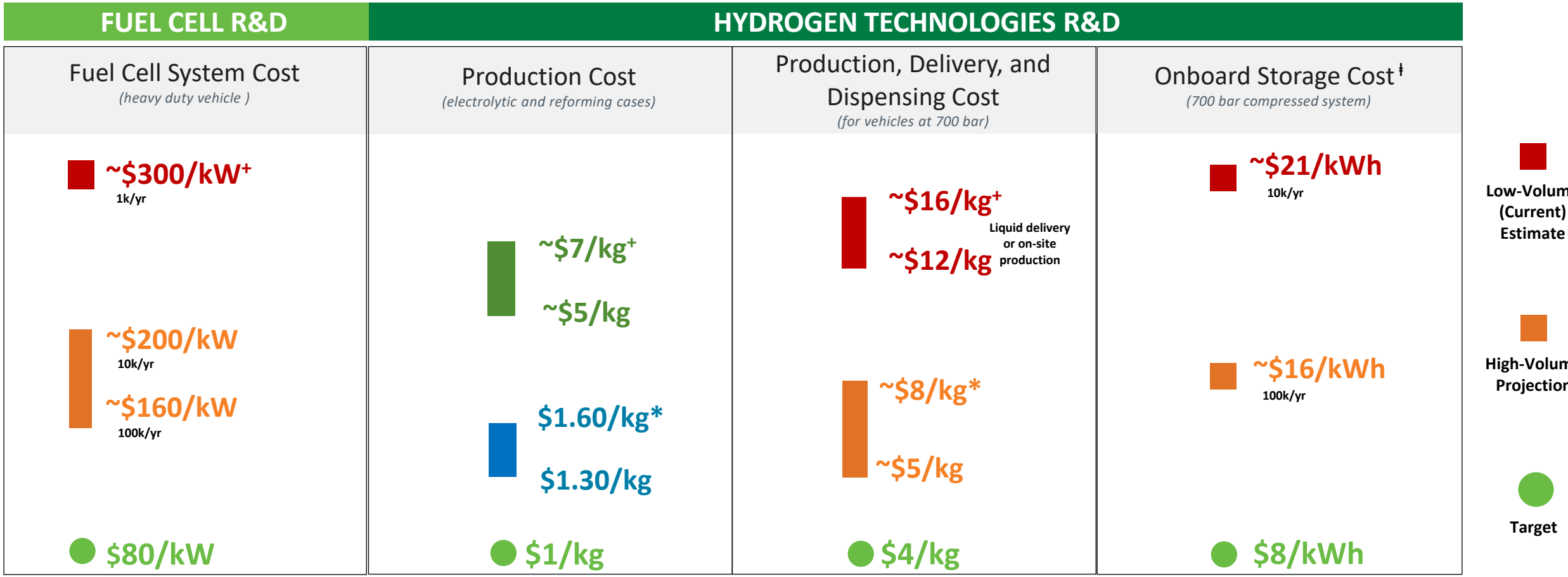
Prairie Island: 150 kWe SOEC H_2 production planned ~July 2024 (Xcel Energy)

Davis-Besse (Vistra): 1-2 MWe

Co-funding with HFTO

Still Need Technology Cost Reductions – Targets guide RD&D

Key Goals: Reduce the cost of fuel cells and hydrogen production, delivery, storage; and meet performance and durability requirements—guided by application-specific targets. Status shows scenario analyses.



†Based on 275 kW Heavy Duty Fuel Cell System Cost Analysis (2023; Program Record #24004), adjusted to reflect cost of system that meets 25,000 hours durability

+ 2022 dollars, electrolysis (PEM) with renewables no tax credits
* Based on NETL analysis including projected modeled cost for SMR/ATR with CCS and technology advances at volume (H2 Shot Assessment Report)

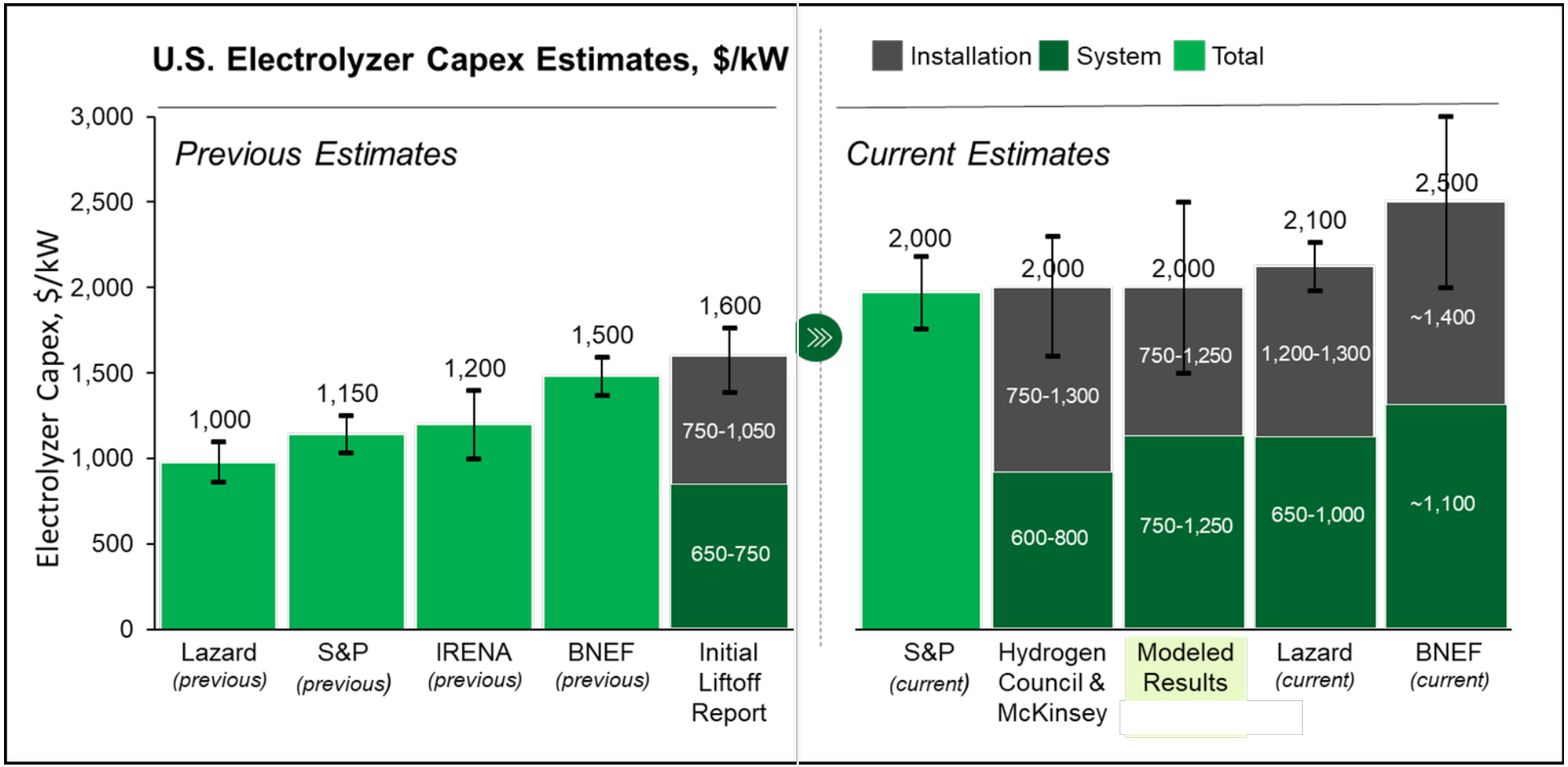
† Early market cost assuming 2 tonnes/day stations with 30% - 50% utilization, liquid delivery or onsite production, and clean hydrogen production cost of $5/kg. Does not include markup.
*Assumes large-scale fueling stations (8 tonnes/day or more) with 50% or higher utilization, supplied by liquid delivery or onsite production, and a cost of production of $1.50/kg.

‡ Storage costs based on 2019 storage cost record 19008

Note: Graph is not to scale. For illustrative purposes only

Tracking Electrolyzer Costs

Updated Electrolyzer Cost Estimates from Multiple Sources: ~ $2,000/kW Including Installation



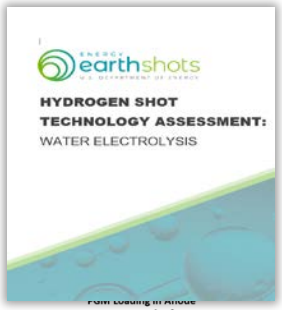
Levelized cost of hydrogen (LCOH) ~$5-$7/kg

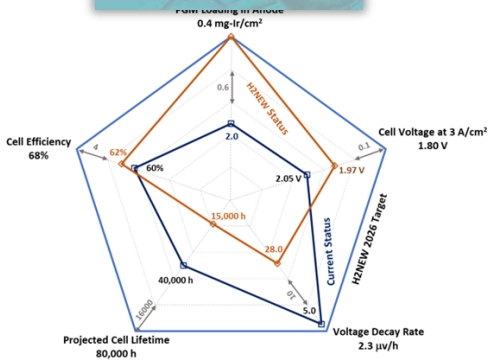
- **Without subsidies**
- **Specific cases using renewables**
- **~$30/MWh and ~50-75% capacity factors**

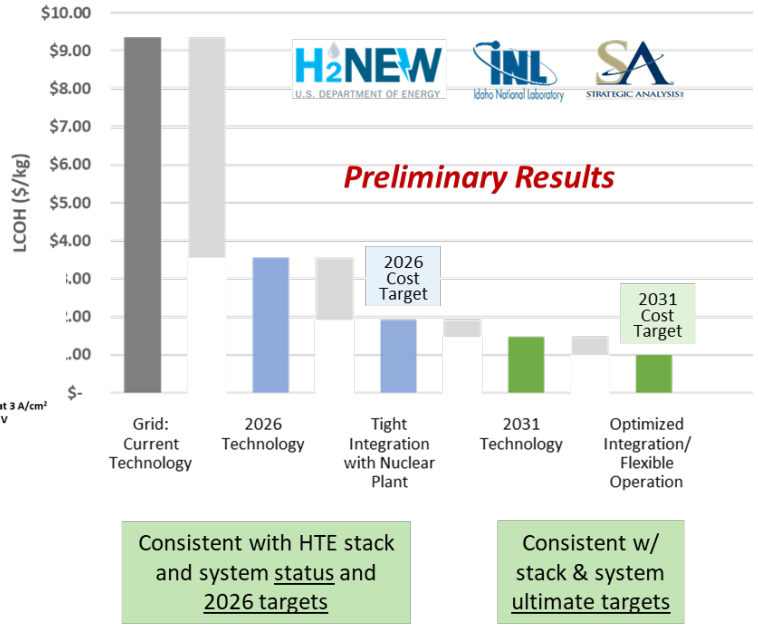
DOE Hydrogen Program Record and Commercial Liftoff report updates coming soon: www.hydrogen.energy.gov and https://www.hydrogen.energy.gov/library/program-records

Recent Highlights – Production

Metrics and Pathways to $2 and $1/kg







Consistent with HTE stack and system status and 2026 targets

Consistent w/ stack & system ultimate targets

- H2NEW developing Figure of Merit to track progress; need cost, performance, durability
- Developed scenarios to achieve $2/kg and $1/kg and Tech assessment reports

Selected new projects: See Bipartisan Infrastructure Law (BIL) new project slides

Incubator Prize, H2LinkSC, and More

HydroGEN
Advanced Water Splitting Materials

ElectroCat
Electrocatalysis Consortium

Advanced Pathways Experts Meeting

New projects on AEMs, hi-T electrolysis, non-PFAS with fuel cell collaboration

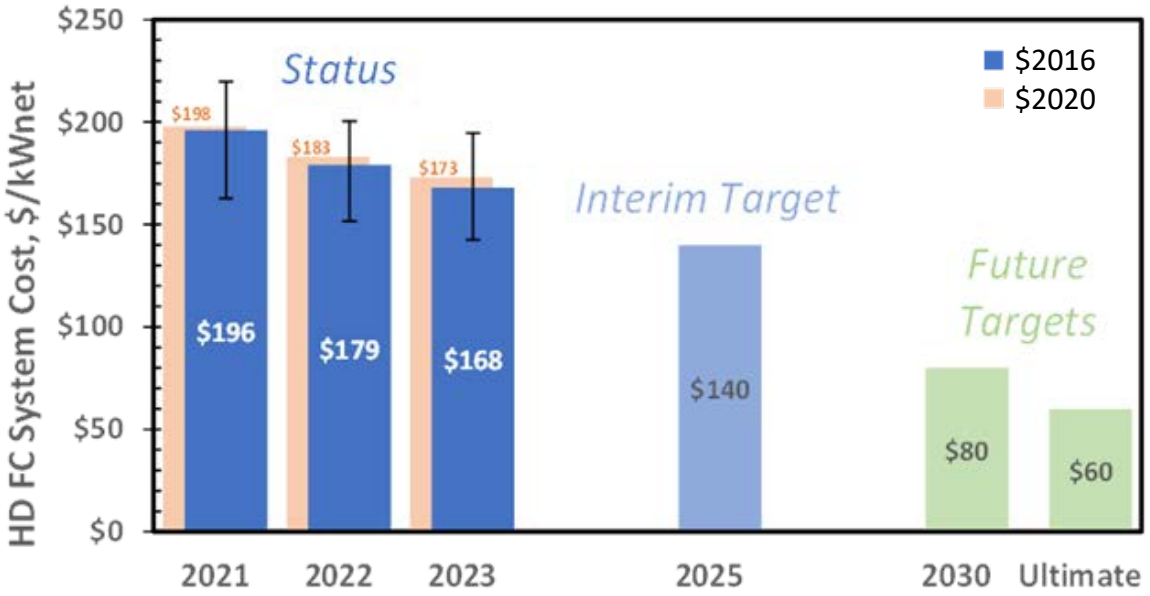
FOA topic on Carbon Negative H_2 (Collaboration w/ FECM; up to $7M)

- Down-selected 4 Hydrogen Shot Incubator Prize projects for Phase2 (off-roadmap concepts)
- Held experts meeting on advanced pathways
- Initiated H2LinkSc pilot; connect to basic science

Hydrogen Shot Incubator Prize: www.herox.com/HydrogenShotPrize

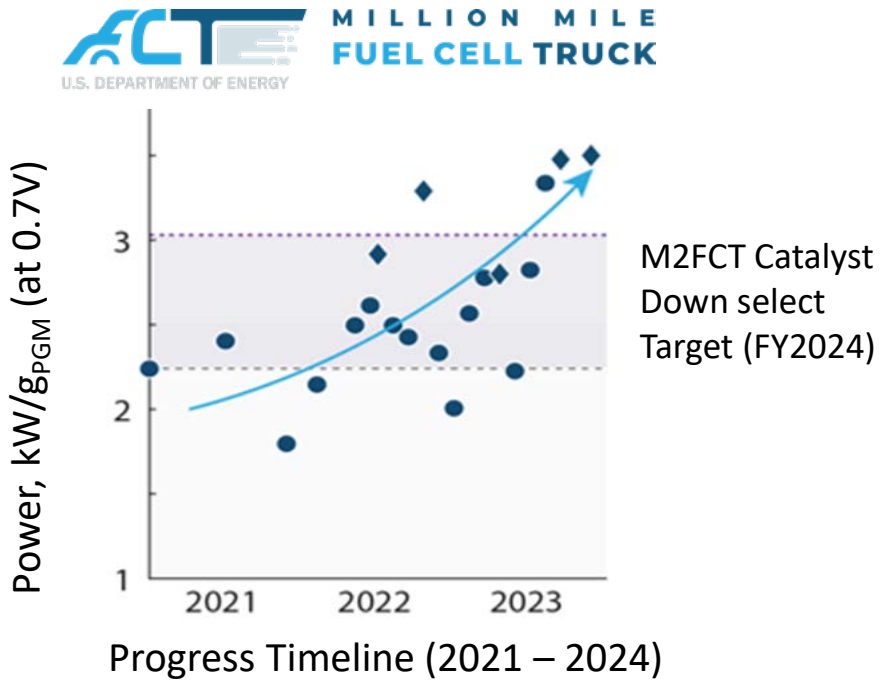
Recent Highlights – Fuel Cells

Heavy-duty (HD) Truck Fuel Cell Cost



- Modeled cost reductions based on technology advances at mid-/high-volume manufacturing
- Stack cost: $105/kW$_{net}$ at 50,000 systems/year

M2FCT Catalyst Progress



Progress Timeline (2021 – 2024)

- Significant progress on catalyst and support development through M2FCT
- Next step is MEA AST testing

Selected new projects: See Bipartisan Infrastructure Law (BIL) new project slides

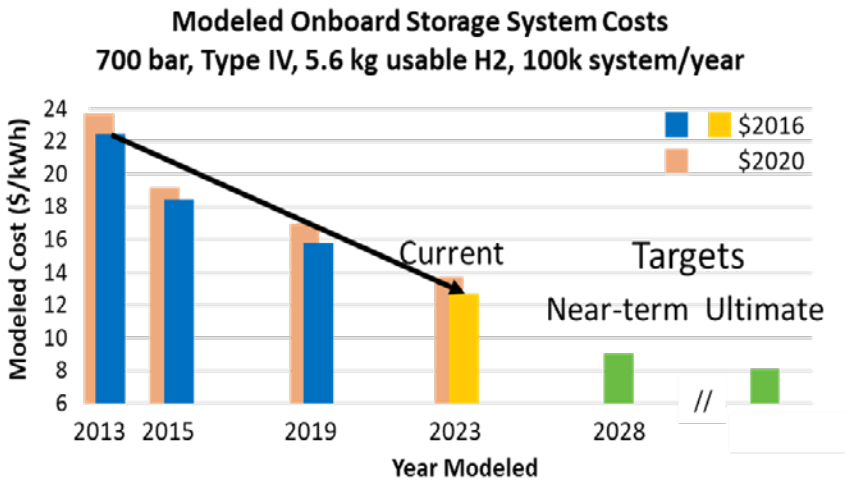
AST – Accelerated Stress Test

Cost status (2021, 2022, 2023) in 2016$ (blue bars) and 2020$ (orange bars) vs. interim target (2025) for a manufacturing volume of 50,000 systems/yr. 2030 and ultimate targets are at 100,000 systems/yr.

Program Record #20004; https://www.hydrogen.energy.gov/library/program-records – available soon

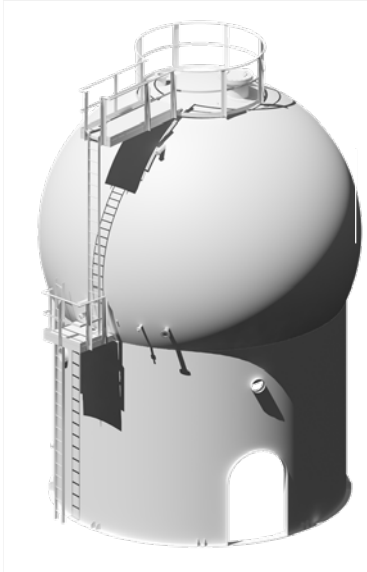
Recent Highlights – Storage

Carbon Fiber Tanks



- Down-selected for Phase II project (Hexagon)
- Targets 50% reduction in carbon fiber contribution to tank costs

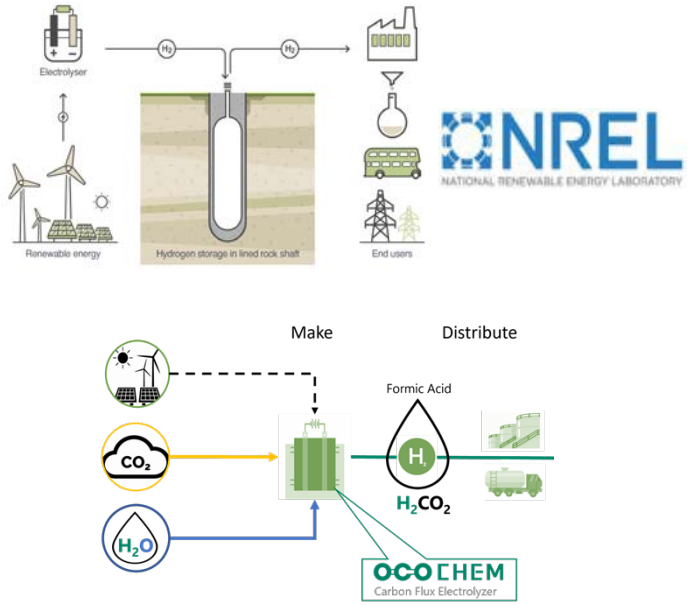
Liquid Hydrogen Tanks



Project will demo 20 m^3 version at NASA Marshall

- First-of-its-kind tank design to enable world's largest, non-vacuum insulation LH2 tank
- 20,000 m^3 – 100,000 m^3 (1420 – 7100 tons)

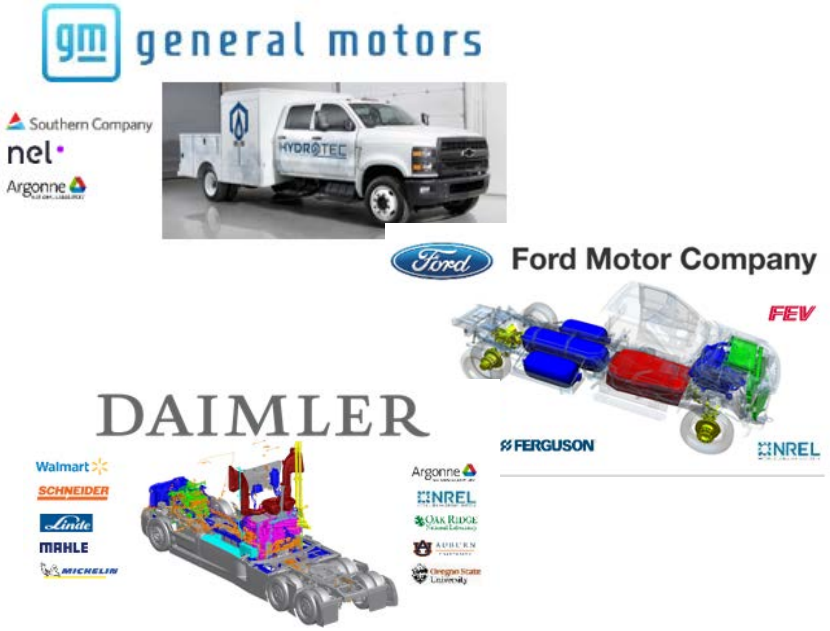
Carriers and Subsurface



- First-of-its-kind engineered subsurface storage at NREL (10 tonnes) for 5+ MW and end uses
- RFP issued – proposals due 5/16
- R&D on DME, formic acid, NH_3

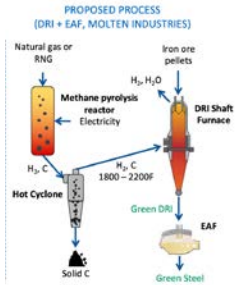
Recent Highlights – Systems Development and Integration, and More

SuperTruck Projects



- Demonstrating class 8 (Daimler) and class 4-6 (GM, Ford) fuel cell trucks
- All have developed and commissioned fuel cell systems

Industrial



New FOA topic: Industrial Pre-FEED Study FOA Topic w/ IEDO

~$1.9B in H_2 for industry projects selected by OCED ($6B Total)*

- New H_2 for steel projects (Hertha Metal; Molten, U. Wisconsin)
- Demonstrated 1 tonne/wk reduction of iron with hydrogen (MS&T)

Enabling Stations & More

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Demonstrated fast fueling for H_2 trucks

New FOA Topics:
Station of the Future ($30M)
Port equipment Topic ($10M)
Fueling Components ($10M)
Siting, Permitting ($6M)

- Supporting station and fueling component development
- First LH2 projects for rail
- Completed 1.5 MW H_2 fuel cell for data center project

*See Backup Slides for OCED IDP projects

Recent Highlights – New Capabilities, Tools, Safety, Codes and Standards

HySCAN
Hydrogen Safety Codes & Standards Applicability Navigator

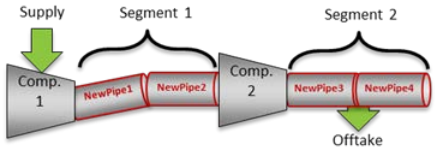
HELPR
Hydrogen Extremely Low Probability of Rupture

HyBlend U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

Hydrogen Extremely Low Probability of Rupture (HELPR) Toolkit

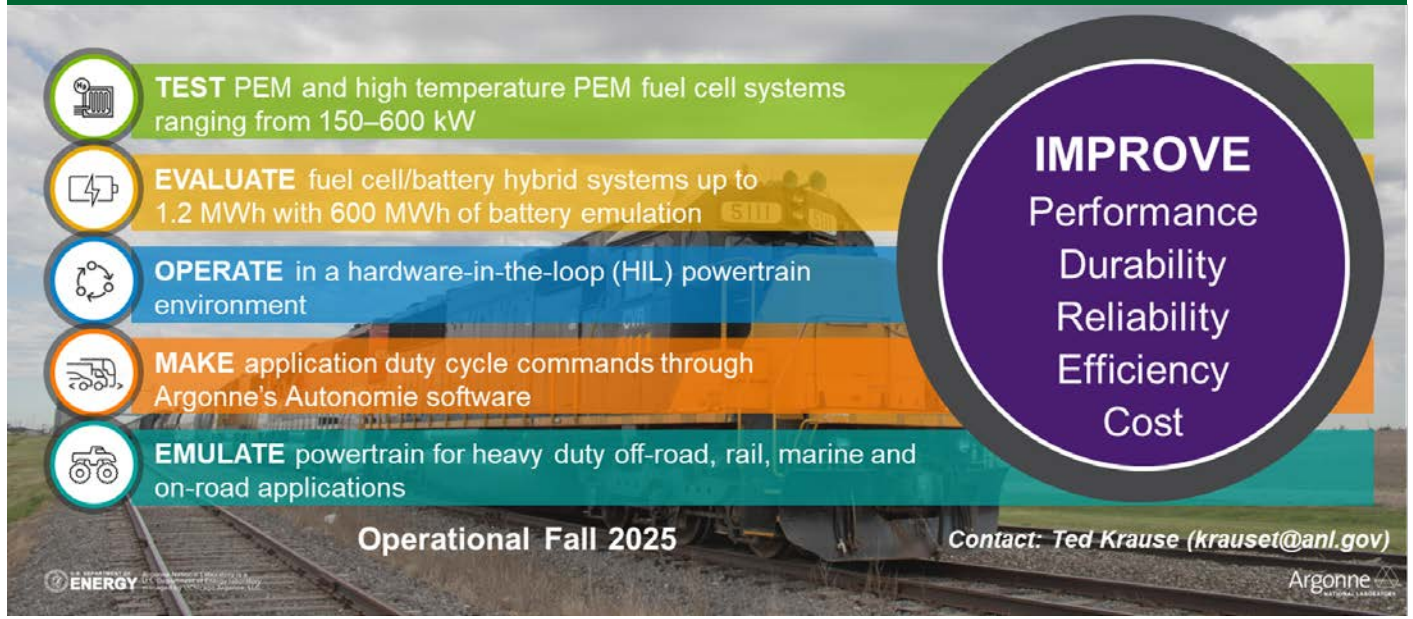
BlendPATH



For blending H_2 in NG pipelines

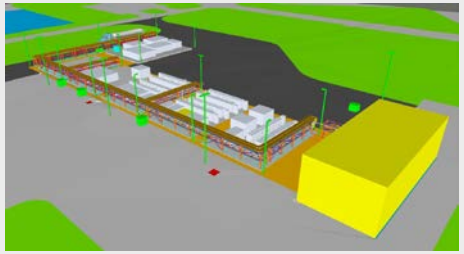
https://github.com/NREL/BlendPATH

Planned HD Fuel Cell Testing (150-600 kW) at ANL

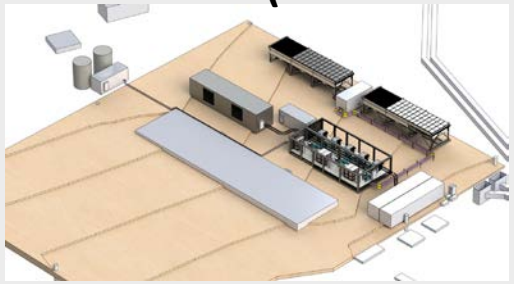


Expansions underway for up to 10 MW electrolyzer testing

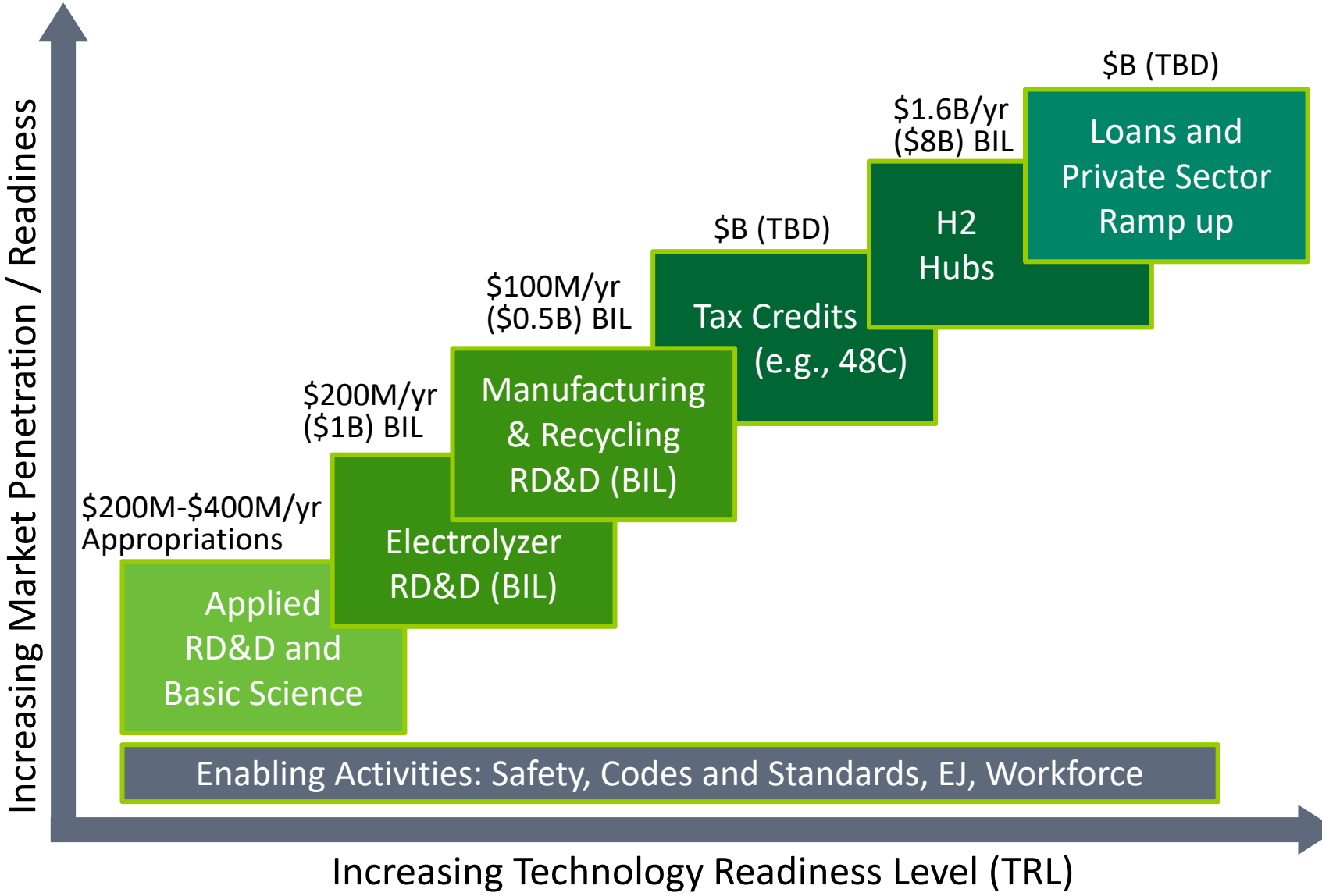
Online in 2025 (INL- High T)



Online in 2026 (NREL- Low T)



Context: DOE Hydrogen Portfolio Activities including BIL



BIL Provisions:

- **$1B for Clean Hydrogen Electrolysis Program (Sec. 816)**
  - $200M/yr (FY22-FY26) to enable $2/kg H_2 by 2026
- **$500M for Clean Hydrogen Manufacturing & Recycling (Sec. 815)**
  - $100M/yr (FY22-FY26) to enable manufacturing and recycling


BIG NEWS!

Major Accomplishment – Announced in March 2024

Department of Energy

Biden-Harris Administration Announces $750 Million to Support America's Growing Hydrogen Industry as Part of Investing in America Agenda

March 13, 2024

52 projects across 24 states to accelerate breakthroughs in clean hydrogen technology, cutting costs and supporting DOE's Hydrogen Hubs and other large-scale deployments.

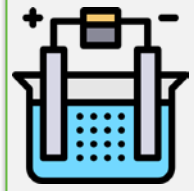
https://www.energy.gov/articles/biden-harris-administration-announces-750-million-support-americas-growing-hydrogen

Impacts of BIL Funding for Electrolysis, Recycling, and Manufacturing

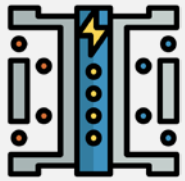
52 Projects

RD&D and manufacturing for domestic supply chain. Enables $2/kg H_2 by 2026 and $80/kW fuel cells by 2030

RD&D for domestic manufacturing and support for H2 Hubs



Electrolysis **10 GW/yr** Supports production of 1.3M metric tons of H_2/year



Fuel Cells **14 GW/yr** Capacity for 100,000 HD fuel cell stacks, corresponding to 50,000 trucks (~15% of annual sales)

$1.6B

Total Project Costs

Including **~$750M** in federal cost share and ~**$850M** in cost share

1,500+

Direct jobs created

Plus, thousands of indirect jobs across the U.S.

24 States

Benefiting 32 disadvantaged communities across the U.S. with initiatives in workforce development, energy equity, and DEIA

BIL Electrolyzer and Fuel Cell FOA Selections Overview

$1.6B Total

$750M DOE Share

$1.2B Total $466M

Stack Manufacturing
13 projects

$225M Total $163M

Supply Chain Components
20 projects

$83M Total $72M

Next Generation Innovations
18 projects

$64M Total $50M

Recovery & Recycling Consortium
15 partners

Includes first-of-its kind consortium to develop domestic recovery and recycling capability for electrolyzers and fuel cells

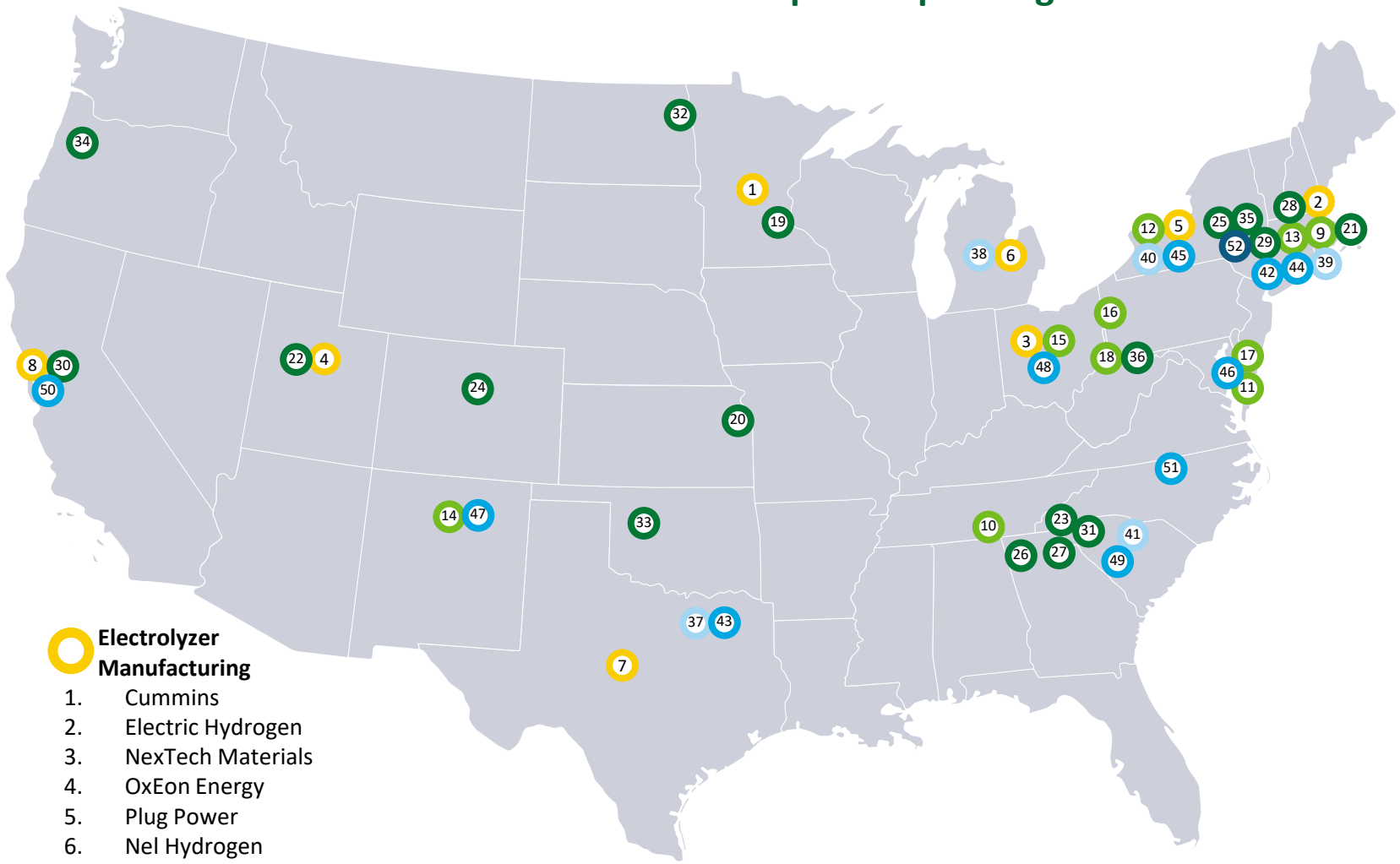
H_2CIRC

Circular Recycling for the H_2 Economy Consortium

- AIChE (PI)
- Chemours
- Cummins
- Delaware State U.
- General Motors
- Heraeus
- Johnson Matthey
- Nel Hydrogen
- Plug Power
- Strategic Analysis Inc.
- U. of Delaware
- U. of Houston
- Worchester Poly
- Labs: ORNL,NREL,LBNL

Anticipated Project Locations and Prime Recipients

Based on selections announcement – to be updated pending final awards



Electrolyzer Manufacturing

1. Cummins
2. Electric Hydrogen
3. NexTech Materials
4. OxEon Energy
5. Plug Power
6. Nel Hydrogen
7. thyssenkrupp nucera
8. Verdagy

Electrolyzer Supply Chain

9. ACS Industries
10. eSpin Technologies
11. HighT-Tech
12. Ionomr Innovations
13. Mott Corporation
14. Pajarito Power
15. Power to Hydrogen
16. PPG Industries
17. The Chemours Company
18. West Virginia University

Electrolyzer Components

19. 3M Company
20. Avium
21. Boston University
22. Chemtronergy
23. Clemson University
24. Colorado School of Mines
25. Ecolectro
26. Georgia Tech
27. Georgia Tech
28. Nel Hydrogen
29. Plug Power
30. Stanford University
31. Tetramer Technologies
32. University of North Dakota
33. University of Oklahoma
34. University of Oregon
35. W. L. Gore & Associates
36. West Virginia University

Fuel Cell Manufacturing

37. Ballard Power Systems
38. General Motors
39. Nuvera Fuel Cells
40. Plug Power
41. Robert Bosch

Fuel Cell Supply Chain

42. AvCarb Material Solutions
43. Ballard Power Systems
44. Cabot Corporation
45. Ionomr Innovations
46. Materic
47. Pajarito Power
48. pH Matter
49. Robert Bosch
50. Robert Bosch
51. Saueressig

Recycling Consortium

52. American Institute of Chemical Engineers and 15 partners

Source: HFTO https://www.energy.gov/eere/fuelcells/bipartisan-infrastructure-law-clean-hydrogen-electrolysis-manufacturing-and-0

Recent News!

Department of Energy

Biden-Harris Administration Announces First Projects Receiving Clean Energy Manufacturing Investments in America's Industrial and Energy Communities

April 19, 2024

President Biden's *Investing in America Agenda* Supports New Projects Building Grid Transformers, Manufacturing EV Chargers and Solar Components, and Processing Critical Minerals, Helping Revitalize Local Economies with Clean Energy Jobs

https://www.energy.gov/articles/biden-harris-administration-announces-first-projects-receiving-clean-energy-manufacturing

Qualifying Advanced Energy Product Credit – 48C – Examples of Self-Reported Recipients and Make It Prize Winners – Examples related to Hydrogen

	Organization Name	Credit Allocation	Project Location
Hydrogen Electrolyzer	Cummins, Inc.	~$10.6M	Fridley, MN
	Electric Hydrogen Co.	~$18.3M	Devens, MA
	John Cockerill Hydrogen North America	~$34.1M	Baytown, TX
	Nel Hydrogen	~$41M	Plymouth Township, MI
	Topsoe SOEC Productions US Inc	$135.9M	Chester, VA
Fuel Cells	Ballard Power Systems	$54M	Rockwall, TX
	Nuvera Fuel Cells, LLC	$14.1M	Billerica, MA
	Total	**~$308M**	

MAKE-IT Prize Clean Hydrogen Awardees

Electrolyzer Manufacturing

BOSCH

Fuel Cell Engine Manufacturing

BALLARD
PUTTING FUEL CELLS TO WORK

Components for Fuel Cell Trucks

BOSTON MATERIALS

Conformable H_2 Tanks

Noble GAS SYSTEMS

H_2 Storage Vessel

Linde

Select voucher recipient case studies:

OCOchem, Independence Hydrogen, Anaheim Fire & Rescue Department, FC Renew

Press Release: https://www.energy.gov/articles/biden-harris-administration-announces-first-projects-receiving-clean-energy-manufacturing -
Applicant Self-Disclosed 48C Projects: https://www.energy.gov/mesc/applicant-self-disclosed-48c-projects -

See MESC for 48C; see OTT for Make It Prize

Qualifying Advanced Energy Project Credit (48C) Program

Department of the Treasury

U.S. Departments of the Treasury and Energy Release Additional Guidance on Inflation Reduction Act Programs to Incentive Manufacturing and Clean Energy Investments in Hard-Hit Coal Communities

April 29, 2024

https://home.treasury.gov/news/press-releases/jy2301?utm_medium=email&utm_source=govdelivery%20- -

Up to **$6 billion** in tax credit allocations for the second round of allocations of the **48C(e) program**.

DOE and Treasury will host a virtual webinar for potential applicants on **Thursday, May 16, 2024, at 12:00 PM (ET).**

48C – Round 2: Concept Paper Applicant Webinar

https://www.energy.gov/infrastructure/qualifying-advanced-energy-project-credit-48c-program -

REGISTER TODAY!

Roll-to-Roll (R2R) Consortium

ROLL TO ROLL CONSORTIUM
U.S. DEPARTMENT OF ENERGY
Hydrogen and Fuel Cell Technologies Office

Advancing efficient, high-throughput, and high-quality manufacturing processes

National Lab Team

Argonne NATIONAL LABORATORY
NREL Transforming ENERGY
BERKELEY LAB Bringing Science Solutions to the World
OAK RIDGE National Laboratory
Sandia National Laboratories

Industry Advisory Board

ASSOCIATION FOR ROLL-TO-ROLL CONVERTERS
gm
pH Matter llc
Chemours™
IONOMR INNOVATIONS
PAJARITO POWDER
DE NORA
nel
plug™

BIL-MNF001, Wed 3:45 in FC Session

Task Areas

- Materials Scale-Up Science
- MEA Fabrication
- Quality Control
- Process Modeling and AI / ML
- Characterization for Mfg Environment
- Technoeconomic Analysis

CRADA Request for Proposals: Open Today!

- Collaborative projects with Industry & Labs
- Up to **$8M** for 5 – 15 awards
- Concept Papers Due **June 3**

CRADA: Cooperative Research and Development Agreement

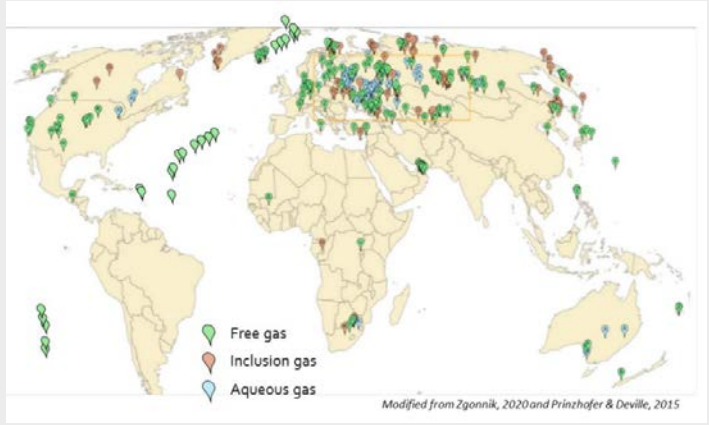
http://www.nrel.gov/hydrogen/r2r-crada-call.html

NEW ACTIVITIES

New Activities: Earth, Sky, and In-Between…

Geologic Hydrogen

What is the potential and where? Estimates range from <20 MMT/yr to trillion?

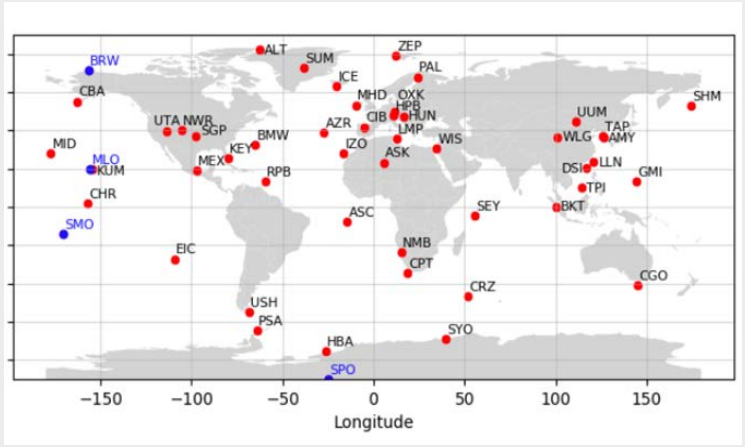


Preliminary estimates of surface observations of hydrogen concentrations greater than 10%

ARPA-E ($24M), USGS, and others

Climate Science

What is the atmospheric H_2 concentration and potential impact? Sources and sinks?



NOAA Global Cooperative Air Sampling Network: Largest H2 measurement network in the world

NOAA, HFTO ($2.2M Interagency Agreement)

Sensors and Monitoring

How to detect ppb-level H_2 and how to monitor and reduce potential releases?

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

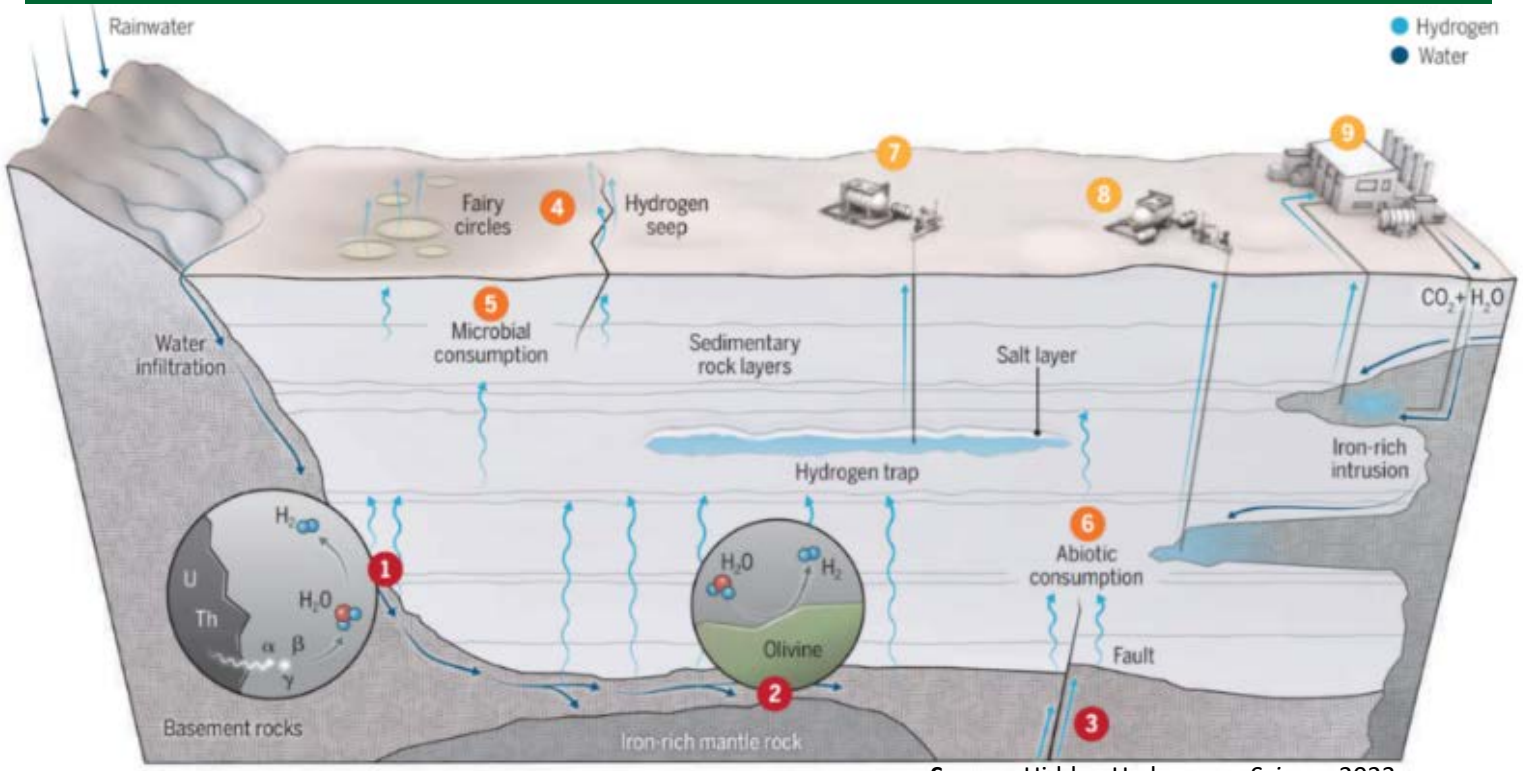
New sensor projects launched by HFTO and new efforts coming soon by ARPA-E!

DOE HFTO (~$8.5M), ARPA-E (NEW- $20M)

New Efforts – Geologic Hydrogen

Need to address many unknowns: focus on the subsurface

Need fundamental understanding, scalable technologies, production models, economic viability



Source: Hidden Hydrogen – *Science* 2023

Mineral Oxidation

Example reaction

$$2Fe^{2+} + 3H_2O \rightleftharpoons 2Fe^{3+} + 3H_2$$

Sources: Doug Wicks, Program Director, ARPA-E; Geoffrey Ellis, Research Geologist, US Geological Survey (USGS); Science 2023

ARPA-E awardees: $24M

Production of Geologic Hydrogen through Stimulated Mineralogical Processes

Berkeley Lab · Los Alamos National Laboratory · Lawrence Livermore National Laboratory · MIT · School of Mines 1874 Colorado · Texas Tech University · NER · Koloma · 89A · Eden

Subsurface Engineering for Reservoir Management

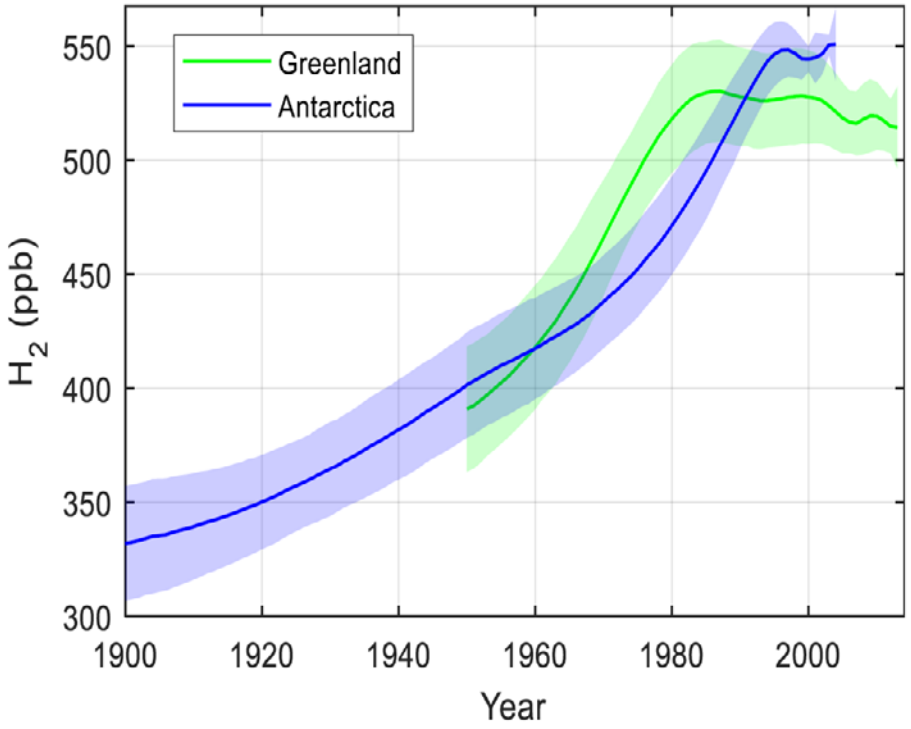
Eden · Berkeley Lab · New Mexico Institute of Mining and Technology · University of Texas at Austin · Penn State · Texas A&M · University of Southern California

Methodology for Life-Cycle Analysis for Geological Hydrogen (GREET)

Argonne National Laboratory

Cutting Edge Work – Understanding Hydrogen Releases and Sinks with NOAA

Atmospheric H_2 levels from Greenland and Antarctica in the last century
Steeper increase in recent years (1-2 ppb/year)

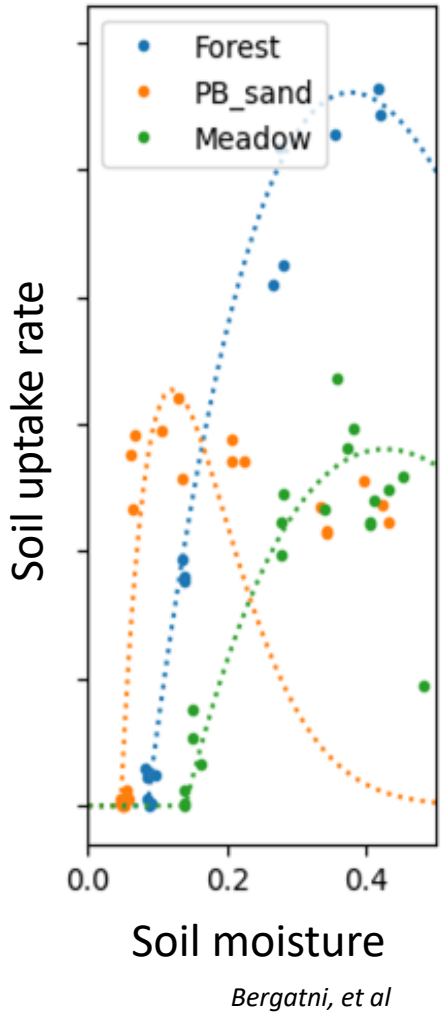


Patterson, et al, https://cp.copernicus.org/articles/19/2535/2023/

Improving our understanding of the H_2 soil sink through observations and modeling

Forests and specific moisture conditions appear to increase H_2 uptake

HFTO funding supports NOAA (~$2.2M) and parters to improve monitoring, analysis, modeling.



Bergatni, et al

Fabien Paulot, Gabrielle Pétron, Andrew M. Crotwell, and Matteo B. Bertagni

New Work – Hydrogen sensors for ppb level detection and emissions data

HFTO is funding new projects on H_2 Sensors for ppb level detection and quantification

Indrio Technologies Inc.; Palo Alto Research Center Inc.; University of Georgia; Iowa State University; University of Missouri; General Electric; Aerodyne Research Inc.; Solve Technology and Research Inc.; Lawrence Livermore National Laboratory

HyCRed
Hydrogen Component Reliability Database

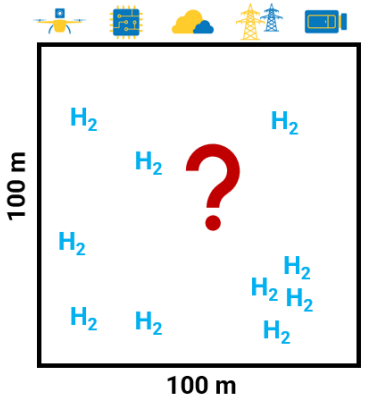
Collects high quality data to improve safety, reduce failure rates and maintenance cost, and inform R&D to enable reduced H2 emissions.

Call to Action: Get Involved!
Share your data with NREL and UMD (w/ NDA). Email hycred@nrel.gov

Sensor efforts include FOA, SBIR, and TCF projects **NDA: Nondisclosure agreement**

NEW FOA – $20M for H2SENSE

arpa·e
CHANGING WHAT'S POSSIBLE



Source: ARPA-E webinar, 4/18/24

Contacts:

Dr. Robert Ledoux
Program Director

Dr. Julia Greenwald
Fellow

Due June 7, 9:30 AM

See FOA (Exploratory topics) & ARPA-E website for most up to date information

https://arpa-e-foa.energy.gov/#FoaId521a7aa4-b255-4c3b-a211-b128d2a4a0e4

Recent News!

Hydrogen and Fuel Cell Technologies Office

Biden-Harris Administration Announces More Than $90 Million for Hydrogen Infrastructure

January 30, 2024

Funding will help build a hydrogen corridor from California to Texas, establish fueling infrastructure along Interstate 25 in Colorado

www.energy.gov/eere/fuelcells/articles/biden-harris-administration-announces-623-million-grants-ev-charging-and

Examples of DOT FHWA and EPA Funding

$90+M from DOT-FHWA Funding for H_2 Stations

North Central Texas Council of Governments
$70M
- 5 MD/HD H_2 fueling stations in TX triangle
- Created H_2 corridor from Southern CA to TX

California's Victor Valley Transit Authority
$12M
- Build a H2 fueling station and 6 DC fast charging stations for fleet and public fueling

California State University, Los Angeles
$7M
- Transform H_2 Research Fueling Facility into high-capacity, multi-modal (light- to heavy-duty) H_2 fueling station

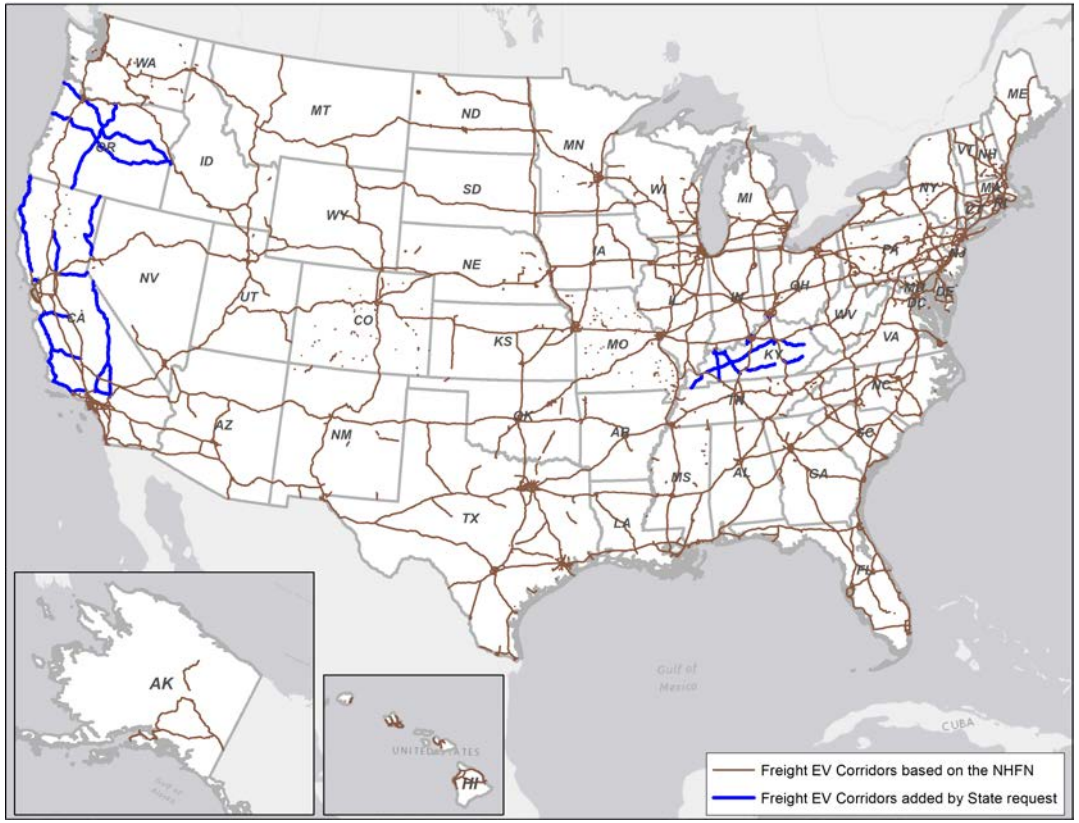
Colorado State University (CSU)
~$9M
- Build 3 public H_2 fueling stations near CSU campuses in Fort Collins, Denver, and Pueblo for truck fleets and potential vehicles along I-25

EPA Clean Ports Program: $3B for Grants

At least 25% ($750M) to be spent in nonattainment areas

Due before May 28

Federal Highway Administration (FHWA) announced the designation of National EV Freight Corridors – includes H2 stations



https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/freight_ev_corridors/

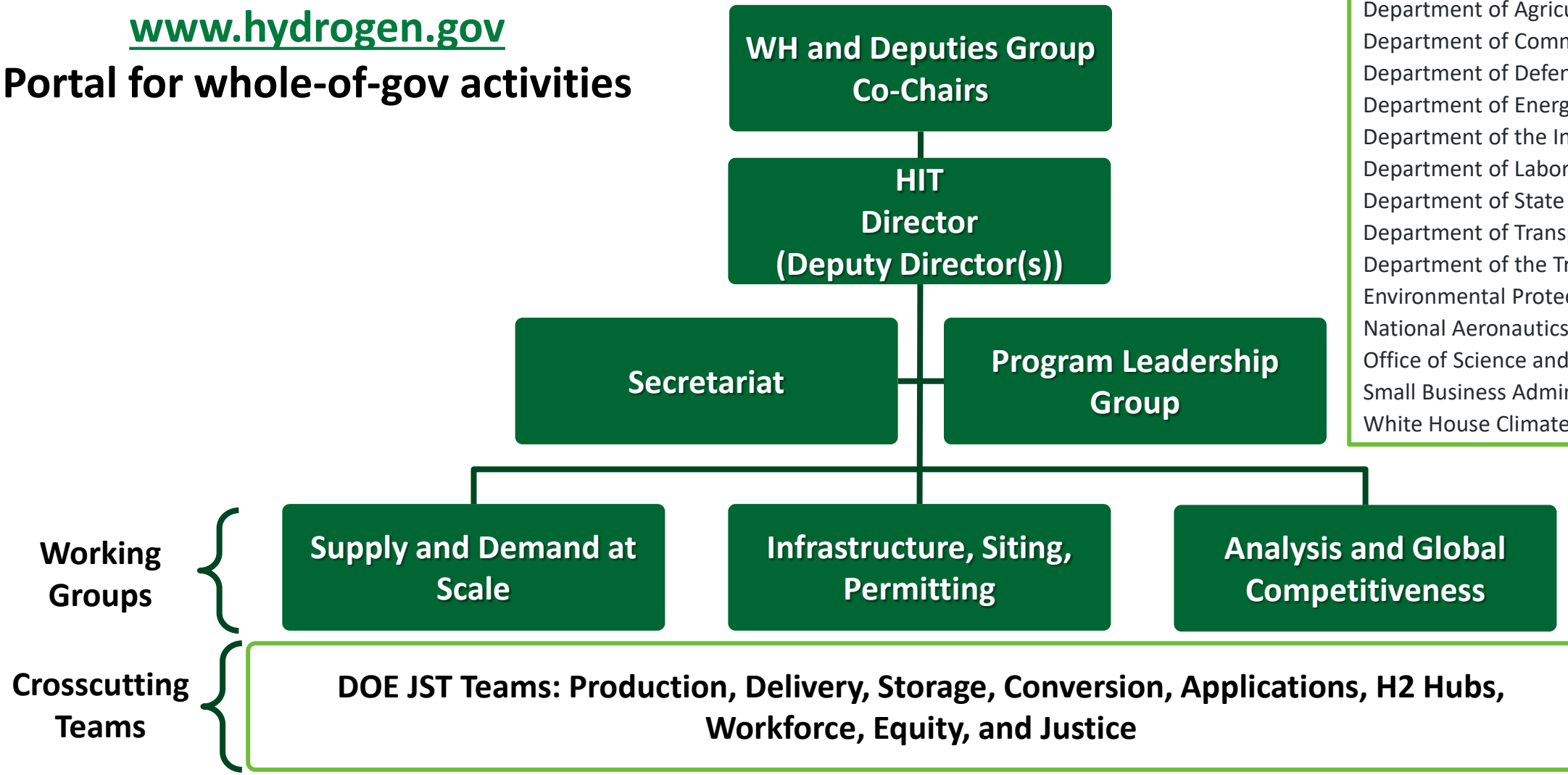
FHWA station & charging in collaboration with Joint Office of DOT, DOE

Whole-of-Government Coordination

And with the private sector, communities, and more

Hydrogen Interagency Task Force (HIT) across Agencies

www.hydrogen.gov
Portal for whole-of-gov activities



Department of Agriculture
Department of Commerce
Department of Defense
Department of Energy (Co-Chair)
Department of the Interior
Department of Labor
Department of State
Department of Transportation
Department of the Treasury
Environmental Protection Agency
National Aeronautics and Space Administration
Office of Science and Technology Policy
Small Business Administration
White House Climate Policy Office (Co-Chair)

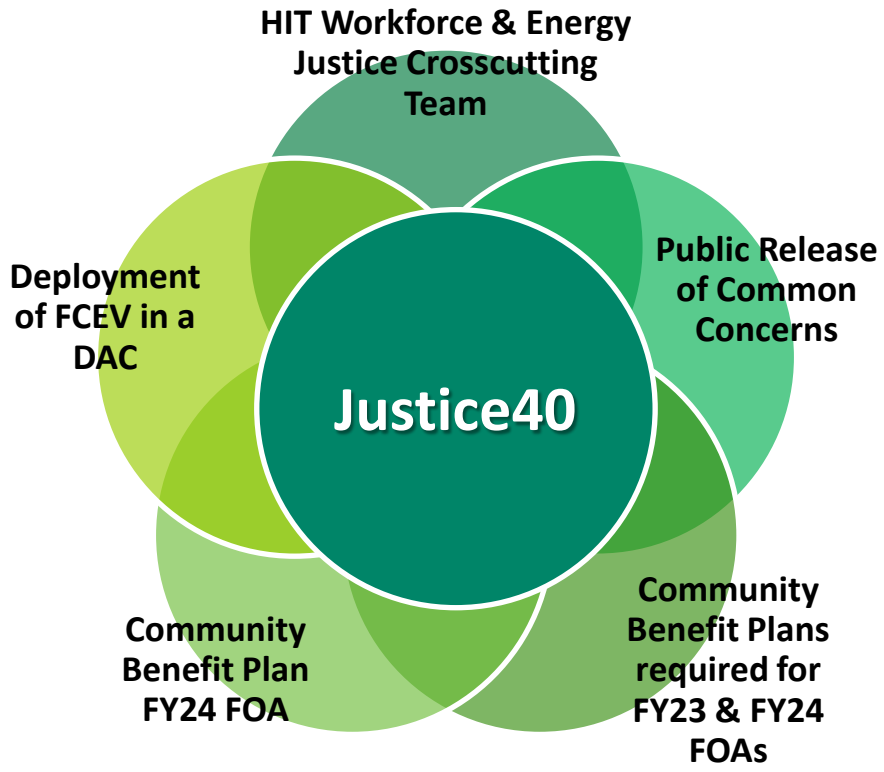
JST: Joint Strategy Team. Equity, Energy and Environmental Justice is a crosscutting priority across WGs.

Energy and Environmental Justice

Diversity, Equity, Inclusion, and Accessibility

Environmental Justice Initiatives

- I. Listening, Engaging & Increasing Transparency
- II. Prioritizing Safety & Positive Impacts
- III. Lowering Barriers
- IV. Diversifying the Clean Hydrogen Workforce
- V. Building Capacity & Skills
- VI. Environmental Justice in Permitting & Siting



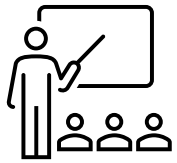
Draft Responses to Frequently Asked Questions and Common Concerns About Clean Hydrogen

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

Examples of H_2 Environmental Justice Activities

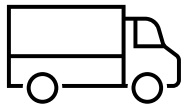
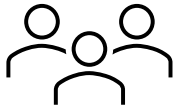
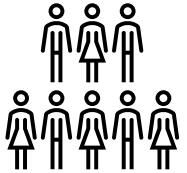
Internal Coordination

- **Community Benefits Plan (CBP) Workshops**
- **Environmental Justice Training at Staff Offsite**
- **EJ Subcommittee** has at least one member from each HFTO subprogram
- **BIL reporting & CBP support**



External Coordination

- **FY24 FOA:** Equitable Hydrogen Technology Community Engagement
- **Harnessing Hydrogen Public Forum**
- **Participation in EJE's Energy Justice to the People Roadshow**
- **Draft *Common Concerns* doc released**
- **Hydrogen Interagency Taskforce Workforce and Energy Justice Crosscutting team**
- **EERE HFTO project with CTE for UPS Fuel Cell Delivery Vans in Disadvantaged Community (DAC)**
- **Planning underway for Eco-H2**

R&D Community Benefits Plan Examples – Three Priorities

Diversity, Equity, Inclusion, and Accessibility

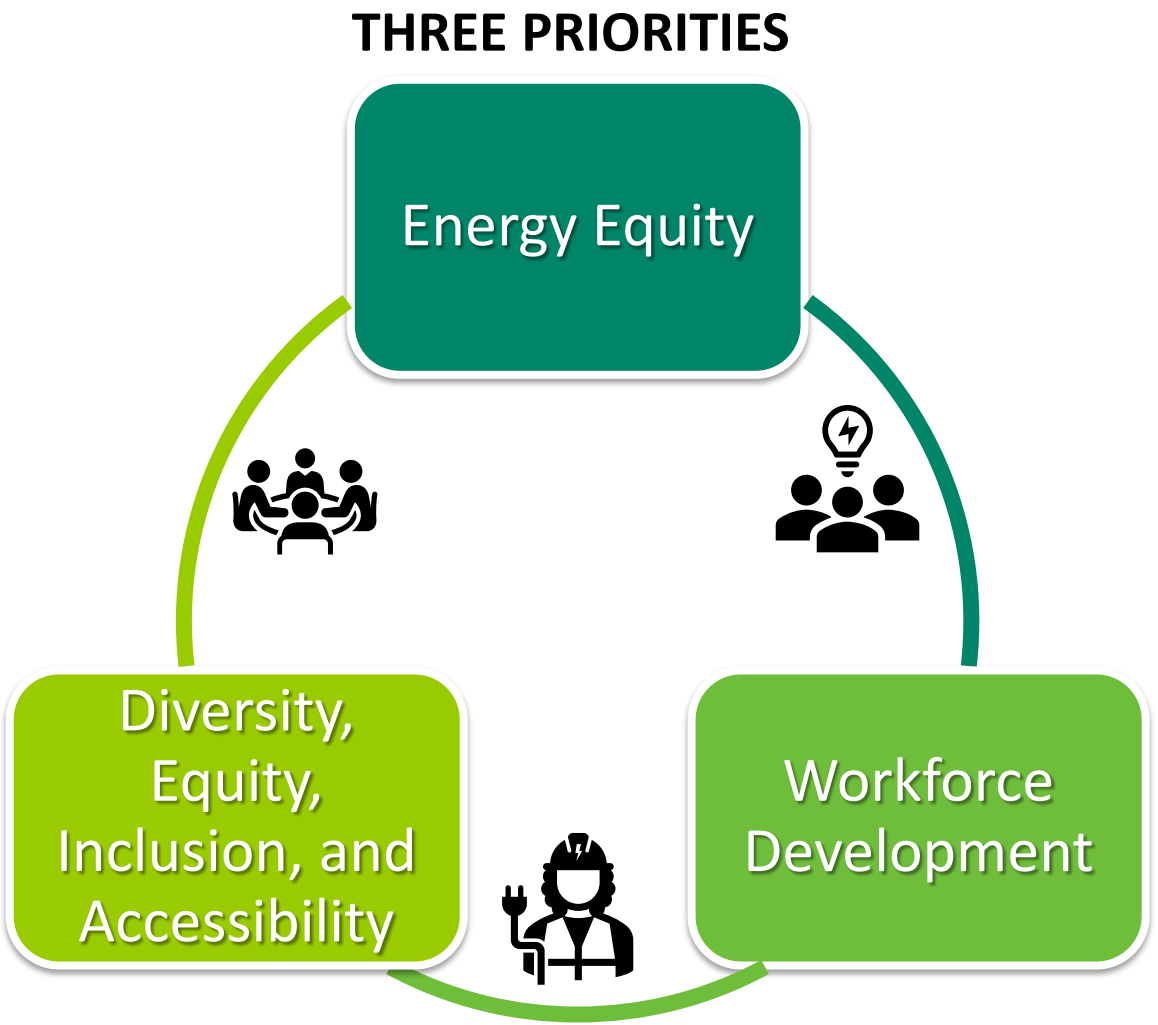
- Equitable access to wealth building opportunities (teaming, access to good jobs, business and contracting opportunities, etc.)

Energy Equity

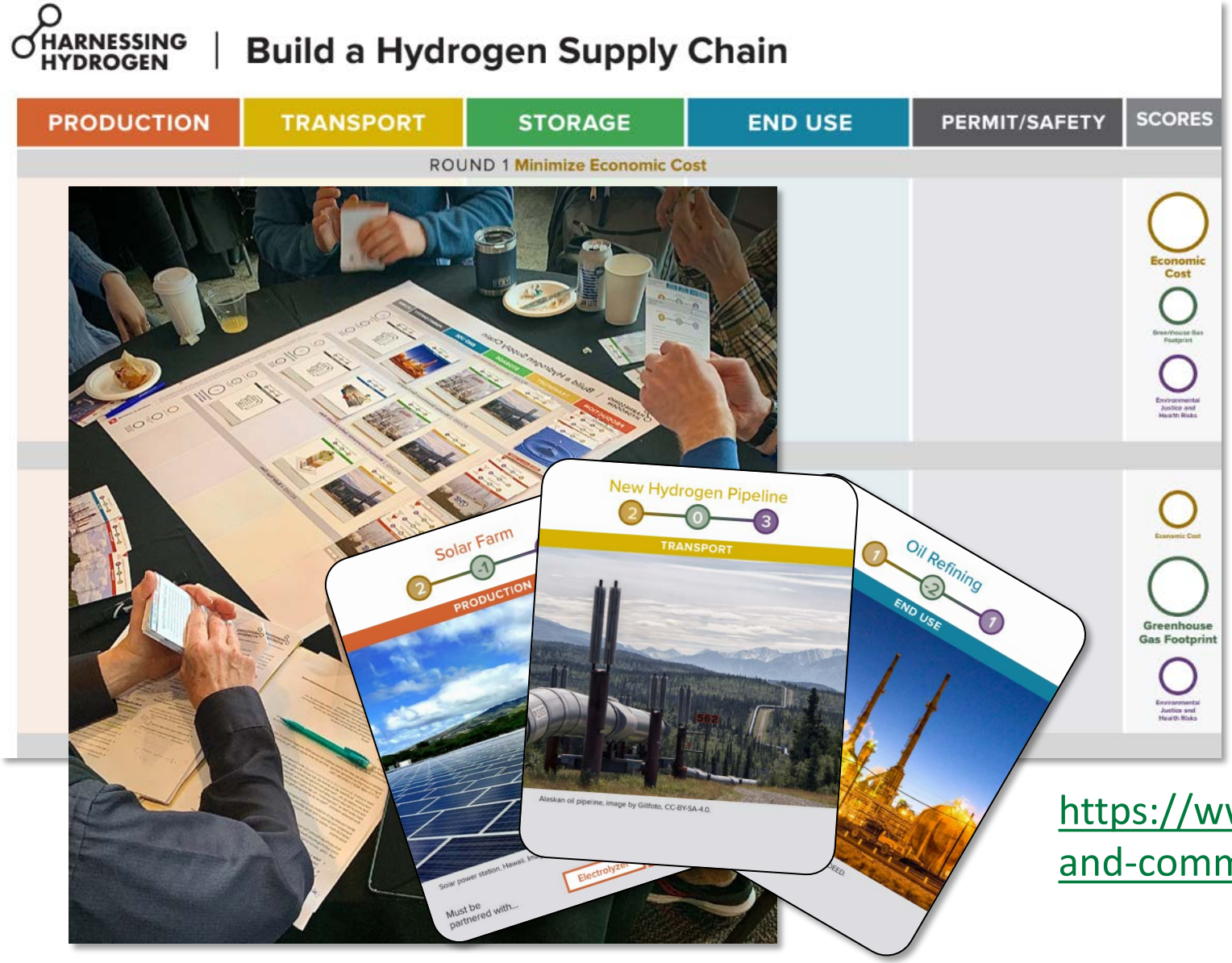
- How research will drive benefits to frontline communities and historically under-resourced groups (DACs)

Workforce Development

- Consideration of long-term workforce impacts and opportunities of research
- Create/retain high-quality jobs
- Attract, train, and retain skilled workers



Harnessing Hydrogen for a Just Transition



HOT OFF THE PRESS

- Forum to learn about H_2 and community benefits
- Unveiled at Boston Museum of Science and National Environmental Justice Conference
- Publicly released April 22nd!
- **Available for free for public use***

https://www.energy.gov/justice/harnessing-hydrogen-and-community-benefits-public-forums -

*Free public use enabled through Creative Commons license

Example of DOE-funded Project in a Disadvantaged Community

HFTO Project with CTE for UPS Fuel Cell Delivery Vans and Shell Station in Ontario, CA


Shell H2 Station in Ontario, CA

Commercial service in disadvantaged communities!

Refueling with commercial infrastructure

Project Ending:

- 15 H2 FC re-powered UPS vans built
- Data collected

Lessons Learned:

- Blueprint for safety and underwriting at depots
- Challenges of re-powered vehicles
- H_2 infrastructure challenges

Special appreciation to Shell
Early 2024
Rapid response to station challenges

CTE received AMR award 2023

New Training and Intern Opportunities!

GREET
Train the Trainer

Contact:
greet_trainer@gpisd.net

LEARN, CO-TEACH, EDUCATE

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

Trainer Commitment

Attend in-person & quarterly online workshops
Provide on-demand training for at least 2 years

>160 hours / year

ANL: Argonne National Lab
GPI: Great Plains Institute

Building off successful Geothermal internship program
(November 2023)

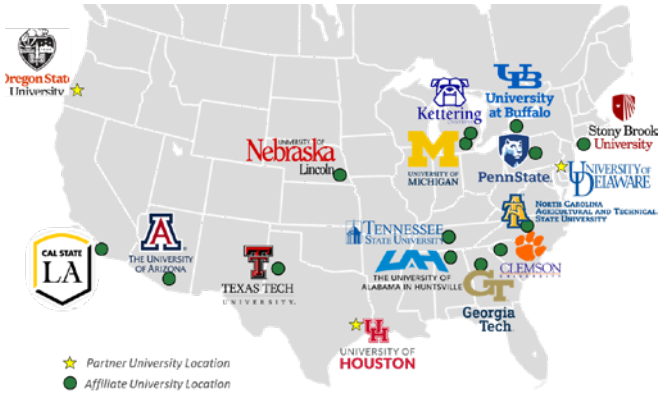
See NSF INTERN at: https://www.nsf.gov/eng/eec/intern.jsp

More Highlights on Education, Diversity, Equity, Inclusion, and Accessibility

H_2 Education

H_2EDGE

Hydrogen Education for a Decarbonized Global Economy



Register for virtual course now!

Email h2edge@epri.com

Tribal Engagement

Navajo Technical University

Turtle Mountain Community College

Los Alamos National Laboratory

Internships, high-tech equipment offer opportunities in H_2 and fuel cell research

https://discover.lanl.gov/news/1130-ntu-collaboration/ -

Global Collaboration

H2-DEIA

Supported launch of H2-DEIA at COP28. New global platform dedicated to advancing DEIA with IPHE and H2 Council

https://h2-deia.org/


Global Collaboration

Mapping of International Hydrogen Initiatives and Collaborations Underway

BREAKTHROUGH AGENDA

Priority Actions for International Collaboration — Coordinated through the Hydrogen Breakthrough

Priority International Actions	Participating Initiatives (to date)*
H.1: Standards & Certification	**Coordinating:** IPHE (with IEA H2-TCP) **Partners include:** IRENA, UNIDO
H.2: Demand Creation & Management	**Coordinating:** CEM Hydrogen Initiative (w/ RMI) **Partners include:** First Movers' Coalition, World Economic Forum, Int'l H2 Trade Forum, MI Clean H2 Mission, H2 Global
H.3: Research & Innovation	**Coordinating:** Mission Innovation Clean Hydrogen Mission **Partners include:** IEA H2 TCP
H.4: Finance & Investment	**Coordinating:** World Bank and UNIDO
H.5: Landscape Coordination	**Coordinating:** H2 Breakthrough Facilitator (hosted by IPHE Secretariat) **Partners:** Open to all globally focused H2 initiatives

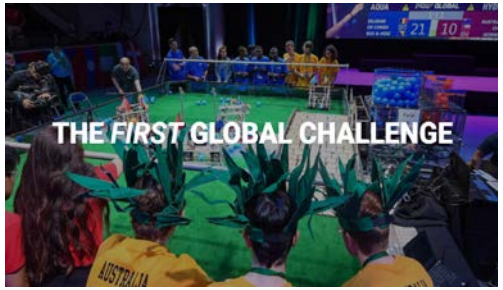
*Examples shown. Updated periodically by BtA.

Global Collaboration – Certification, Outreach, and STEM

COP28 UAE

Declaration of Intent seeks to work toward mutual recognition of clean hydrogen certification schemes and to help facilitate a global market

https://www.energy.gov/articles/cop28-countries-launch-declaration-intent-clean-hydrogen



FIRST GLOBAL

https://first.global/fgc/

Can support local robotics teams through Community Benefits Plans

Students from 190 Countries and Team Hope (refugees) competed in Singapore for Hydrogen Day 2023

Energy Observer H_2 vessel visits DC

Around the world in 7 years!

https://www.energy.gov/eere/fuelcells/articles/hydrogen-fuel-cell-powered-laboratory-vessel-arrives-washington-dc

IPHE Early Career Network

Calling all hydrogen-enthusiast **STUDENTS** (undergraduate & graduate), **POST-DOCS**, and **EARLY CAREER PROFESSIONALS** worldwide!

Connect with peers, mentors, scientific researchers, industry professionals, and policymakers!

Networking ● Career Development ● Webinars
Research ● Policy ● Leadership ● Science

500+ members from 38 countries

www.iphe.net/early-career-chapter

2023–2024 Leadership Team

Call to Action: Join the Center for Hydrogen Safety

H2 Safety Panel – Established 2003

>600 Safety reviews

300+ Global safety presentations

>600 Combined years of experience

>10k First responders trained

Hydrogen tools portal

CENTER FOR Hydrogen SAFETY

Connecting a Global Community

www.aiche.org/CHS

AIChE The Global Home of Chemical Engineers

Hydrogen Council

hySafe INTERNATIONAL ASSOCIATION FOR HYDROGEN SAFETY

IPHE

Pacific Northwest NATIONAL LABORATORY

Over 100 members from industry, government, and academia—and growing!

CENTER FOR Hydrogen SAFETY Connecting a Global Community
FUNDAMENTAL
HYDROGEN SAFETY CREDENTIAL

New Hydrogen Safety Credential!

Based on H_2 safety e-courses, including:

- Properties & Hazards
- Safety Planning
- System Operation
- Inspection & Maintenance

Year in Review Highlights

June 2023

- **$7B to launch the Regional Clean H_2 Hubs**
- **$750M BIL FOA to advance Clean H_2 RD&D**
- **H_2 Twin Cities 2023 announced**
- **National Clean H_2 Strategy & Roadmap**

Aug 2023

- **Hydrogen Interagency Taskforce (HIT) launches**
- **$48M to advance clean H_2 technologies**

Oct 2023

- **IPHE launches H2-DEIA**
- ***FIRST* Global Non-Profit – STEM Opportunity with H_2 Theme for Hydrogen Day – Students from 190 countries competed in Singapore**

- **$7B for America's first Regional Clean H_2 Hubs**

Dec 2023

- **Justice Week 2023**
- **H_2 Earthshot report at COP28**
- **Clean H_2 Production Tax Credit (45V)**

- **$59M to advance National Clean H_2 Strategy**

Feb 2024

- **$10M for H_2 combustion engine innovation**
- **$10M for H_2 direct iron-reduction demonstration**
- **>$90M for H_2 corridor from Texas to California**

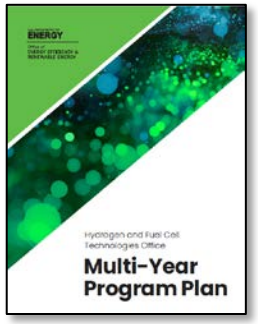
April 2024

- **HBCU Clean Energy Education Prize**
- **$750M for 52 projects to reduce cost of clean H_2**
- **R2R Consortium announced**

- ***Energy Observer* laboratory vessel visits Washington DC**

May 2024

- **Multi-Year Program Plan**



- **Phase II Hydrogen Shot Incubator Prize**

Summary of HIT Key Activities and Next Steps

Completed – 2023

- ✓ Launched *National Strategy*
- ✓ Launched HIT
- ✓ $7B for 7 Hubs
- ✓ NPRMs – Tax Credits (45V), GHGs
- ✓ Demand-side Consortium selection
- ✓ Pipeline Safety R&D Forum
- ✓ Initial USG Demand Mapping
- ✓ Joint Workshops, Annual Merit Review
- ✓ New projects ($8M) – sensors for leakage, initiated climate studies
- ✓ Initial EJ listening sessions
- ✓ New RD&D FOAs across value chain (>$1B)

*Hub selections announced in 2023; final awards to be completed in 2024

Key Activities – 2024

- All Hubs awarded*; Map to potential demand for offtake
- Fueling corridors and ports funding for deployments

- Rule activities; Guidance, final rules, verification strategy. Cost updates, analysis on exports, resource/water use, supply chain
- New manufacturing projects; Recovery & Recycling consortium

- Identify regulatory requirements and responsibilities across local, state, and federal levels and gaps; infrastructure RD&D needs
- New awards for best practices in siting, permitting, safety

- New projects with communities on lessons learned, best practices
- Develop strategies with industry for responsible deployment
- Develop metrics for impacts on EJ communities
- Initiate workforce strategy, assessment of skill gaps

Continue RDD&D priorities as outlined in *National Strategy* and *MYPP*

Resources and Opportunities for Engagement

HYDROGEN AMERICAS 2024 SUMMIT & EXHIBITION

11 – 12 JUNE 2024

RONALD REAGAN INT. TRADE CENTER, WASHINGTON D.C.

Key Publications

www.hydrogen.energy.gov

Hydrogen and Fuel Cells Day October 8

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

1 1.008 H Hydrogen

INCREASE YOUR H2IQ hydrogen.energy.gov

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

Acknowledgements: Hydrogen and Fuel Cell Technologies Office

Hydrogen and Fuel Cell Technologies
Sunita Satyapal, Director

Phyllis Cooper

Chief Scientist
Eric Miller

Deputy Director
Nichole Fitzgerald

Operations Supervisor
Katie Randolph

Operations Manager
Vanessa Arjona

Karen Dandridge
Vacant

Reggie Caradine
Joe Stanford
Christina Walls

Kyle Hlavacek
Gerry Watson
Thomas Chilton

Hydrogen Production Program Manager
David Peterson (Acting)

Electrolysis (BIL Lead)

(David Peterson – DO)
Anne Marie Esposito
McKenzie Hubert
Kim Cierpik-Gold
Elias Pomeroy

Corey Schaffer
David Aguerrebere

Advanced Pathways
James Vickers

Katherine Rinaldi

Leah McGovern

Delivery & Storage Infrastructure Program Manager
Ned Stetson

Zeric Hulvey
Mark Richards
Marika Wieliczko
Kevin Carey

Asha-Dee Celestine
Nikkia McDonald
Zakaria Hsain
Abhi Karkamkar
Josh Farley
Haboon Osmond

Fuel Cell Technologies Program Manager
Dimitrios Papageorgopoulos

William Gibbons
Donna Ho
Greg Kleen
Eric White
Shaylynn Crum-Dacon

Vacant
Vacant

Mike Ulsh
John "Ty" Genard
Joe Troy

Systems Development and Integration Program Manager
Jesse Adams

H2 Hubs Technology
Brian Hunter
Industry and Chemicals
Power Gen & Grid Energy Storage
Michael Hahn
Rebecca Erwin
Tomas Green
Transportation
Pete Devlin
Ben Gould

Vacant

Will Luppino
Tom Jacobs
Ashley Bird

Analysis, Codes & Standards Program Manager
Neha Rustagi

Data, Modeling & Analysis
Jacob Englender
Marc Melaina
Benjamin Zavell
Branden Leonhardt
Theodore Henry
Safety, Codes, Standards & Workforce Development

Laura Hill
Christine Watson
Vacant

Natalie Alvarado
Susan Amodeo Cathey
Emily Loker

DOE Clean Energy Corps Applicant Portal: www.energy.gov/applicant-portal

Thank you

EERE Career Homepage

bit.ly/DOE_EERE

Dr. Sunita Satyapal
Director, Hydrogen and Fuel Cell Technologies Office
Coordinator, DOE Hydrogen Program
U.S. Department of Energy
and
Director, Hydrogen Interagency Taskforce

Also on LinkedIn

EERE Career Newsletter

bit.ly/EERE-career-news

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

Acknowledging our Collaboration Network

Collaboration and coordination to accelerate progress and advance environmental justice

Project Partners

14 National Labs

~190 Companies

>100 Universities

Cross-Office work with Multiple DOE Offices

EERE *(WETO, IEDO, SETO, BETO, AMMTO, WPTO, VTO, BTO;* ***FECM; NE; OCED; SC; ARPA-E; MESC; OTT; LPO; OE; EJE; OIE; IA; and more***

Joint Strategy Team

DOE Crosscutting Initiatives

Transportation, Industrial Decarb., Manufacturing, Clean Fuels & Products, Grid Modernization, Cybersecurity, AI/ML, Critical Materials, EMNs

Interagency Collaboration & Coordination

Including ***DOC, DOD, DOT, DHS, EPA, NASA, NSF, State, Treasury,*** *and more (Hydrogen Interagency Taskforce since 2024)*

International Collaboration

IEA, IPHE, CEM, HEM, MI, IRENA, CH-JU, NALS, Bilaterals, *and many more*

Other External Partners

Regional & National Associations and States FCHEA, NASEO and many more

Labor groups, Tribes, and EJ Communities

Public-private partnerships 21 CTP, USDRIVE, etc.

HFTO Project Partners: Labs, Universities, and Industry

3M Company	*GKN Hydrogen**	*NeoGraf Solutions LLC*	*Treadstone Technologies, Inc.*
Air Products and Chemicals	*Hertha Metals*	*New Jersey Clean Cities Coalition**	*University of Alabama*
Ames Laboratory	*Hexagon R&D LLC*	*Nexceris, LLC*	*University of Buffalo*
Argonne National Laboratory	*Hornblower Energy*	*Nikola Corporation*	*University of California, Irvine*
Arizona State University	*Hy-Performance Materials Testing, LLC*	*North Carolina State University*	*University of California, San Diego*
Army GVSC	*Idaho National Laboratory*	*Northwestern University*	*University of Colorado, Boulder*
Brookhaven National Laboratory	*Indiana University*	*Oak Ridge Institute for Science & Education*	*University of Delaware*
Cal State LA University Auxiliary Services	*Indrio Technologies*	*Oak Ridge National Laboratory*	*University of Florida*
*California Institute of Technology**	*Iowa State University*	*Oak Ridge Associated Universities*	*University of Georgia*
Caterpillar Inc.	*John Hopkins University*	*OCOchem, Inc.**	*University of Hawaii*
Center for Transportation and the Environment	*Komatsu America**	*Oregon State University*	*University of Illinois at Urbana-Champaign*
Clemson University	*Leland Stanford Junior University**	*Orlando Utilities Commission*	*University of Kentucky*
Collaborative Composite Solutions Corporation	*Lawrence Berkeley National Laboratory*	*Pacific Northwest National Laboratory*	*University of Michigan*
Colorado School of Mines	*Lawrence Livermore National Laboratory*	*Palo Alto Research Center, Inc.*	*University of Missouri*
Constellation Corporation	*Linde Engineering North America**	*Pennsylvania State University*	*University of Oregon*
Cummins Inc.	*Los Alamos National Laboratory*	*Plug Power Inc.*	*University of South Carolina*
Daimler Trucks North America	*Louisiana State University*	*Rensselaer Polytechnic Institute*	*University of Southern California*
DOT National Highway Traffic Safety Administration	*MAHLE Powertrain*	*Rice University*	*University of Tennessee-Knoxville*
Eaton Corporation	*Massachusetts Institute of Technology*	*RTX Corporation*	*University of Tennessee, Space Institute*
Electric Power Research Institute Inc	*Missouri University of Science & Technology*	*San Juan College*	*University of Texas, El Paso*
Electricore Inc.	*Molten Industries, Inc.*	*Saint-Gobain Ceramics and Plastics, Inc.*	*University of Toledo*
Ford Motor Company	*Montana State University*	*Sandia National Laboratories*	*University of Virginia*
Frontier Energy, Inc.	*National Aeronautics and Space Administration*	*Savannah River National Laboratory*	*University of Wisconsin**
FuelCell Energy, Inc.	*National Energy Technology Laboratory*	*Shell*	*Washington State University*
Gas Technology Institute	*National Institute of Standards and Technology*	*SLAC National Accelerator Laboratory*	*Washington University in St. Louis*
General Motors LLC	*National Oceanic and Atmospheric Administration*	*Southern Company Services*	*West Virginia University*
General Electric Company	*National Renewable Energy Laboratory*	*Strategic Analysis, Inc.*	*Yale University**
Giner ELX, Inc.	*NEL Hydrogen, Inc.*	*SUNY University at Buffalo**	

**Awards subject to negotiations*

DOE Hydrogen Program and Related FOAs/Lab Calls

	Office	FY	FOA / Lab Call	~Funds $M	Relevant Focus Areas
EERE	HFTO	23	Bipartisan Infrastructure Law: Clean Hydrogen Electrolysis, Manufacturing, and Recycling FOA	$750	Clean H2 Electrolysis Program & Clean H2 Manufacturing & Recycling
EERE	HFTO	23	HFTO FOA in Support of Hydrogen Shot	$47	H2 storage & delivery R&D with LH & carriers; HD fuel cell RD&D
EERE	HFTO	23	Clean Hydrogen Electrolysis Program HFTO Lab Call	$30	Advanced Materials, Components, & Interfaces for Electrolyzers
EERE	HFTO	24	HFTO FOA to Advance the National Clean Hydrogen Strategy	$59	Fueling Components; Station of the Future; Port Demo; Permitting & Safety; Community Engagement
EERE	HFTO	24	HFTO Lab Call for Development of Advanced Materials & Systems for H2 Infrastructure & Fuel Cell Technology	$11	Material-based H2 Carrier Demos w/ Industry; Innovative Concepts in non-PFSA High Temp PEM Fuel Cells for HD Transportation
EERE	HFTO	24	R2R Consortium to Advance Electrolyzer and Fuel Cell Manufacturing	$8	Materials synthesis processes; R2R coating process development; QC technique development; advanced materials characterization; electrochemical testing; advanced computing
EERE	IEDO	23	Industrial Efficiency and Decarbonization Office Multi-Topic FOA	$156	Includes H2 as a low-carbon fuel, and for decarbonizing industrial processes
EERE	IEDO	24	Energy and Emissions Intensive Industries FOA	$83	Includes Integration of Clean H_2 in the Industrial Sector (Pre-Feed Studies)
EERE	SETO	23	Solar-thermal Fuels and Thermal Energy Storage via Concentrated Solar-thermal (CST) Energy FOA	$30	Includes RD&D to enable cost-effective solar fuel production such as hydrogen using CST-generated heat potentially supported by green electricity
JOET, FECM	JOET	24	EV Charging and Alternative Fueling	$623	Includes >$90M for Hydrogen Infrastructure
JOET, FECM	FECM	23	Fossil Energy Based Production, Storage, Transport and Utilization of H_2 Approaching Net-Zero or Net-Negative Carbon Emissions	$32	H2 production, storage, transport, & utilization
JOET, FECM	FECM	24	Carbon Negative Shot Pilots	$100	Pilot-Scale Testing of Advanced CO_2 Removal Technologies; Includes Funding for Projects to Produce Carbon-Negative H_2 from Biomass

DOE Hydrogen Program and Related FOAs/Lab Calls

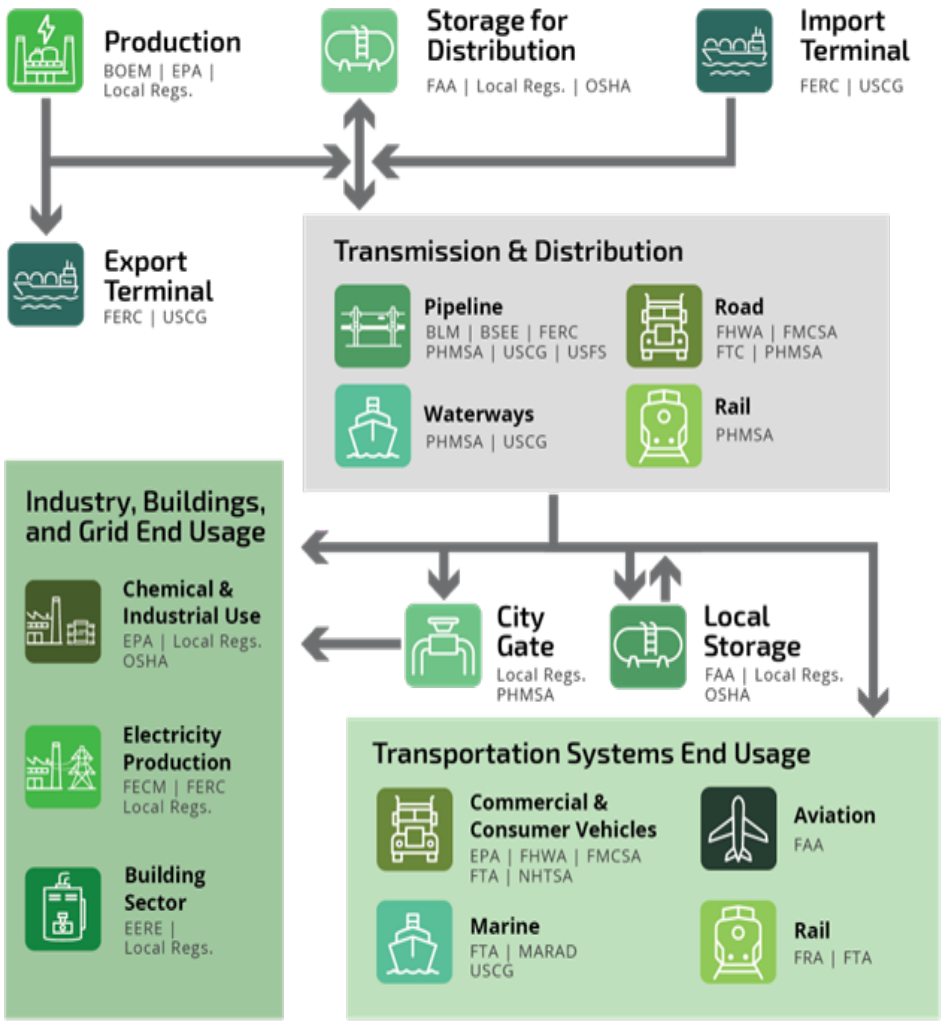
	Office	FY	FOA / Lab Call	~Funds $M	Relevant Focus Areas
OCED, MESC, OTT	OCED, OTT	23	Bipartisan Infrastructure Law TCF: Collaborative Alignment for Critical Technology Industries Lab Call	$8	Topics on clean H2 and long duration energy storage
	OCED, MESC, IEDO	23	Industrial Decarbonization and Emissions Reduction Demonstration-to-Deployment FOA	$6,000	Installations and retrofit demonstrations including H2-based industrial decarbonization
	OCED, OTT	24	The Manufacture of Advanced Key Energy Infrastructure Technologies (MAKE IT) Prize	$30	Includes a track to establish a domestic supply chain for components deemed critical for the commercialization of clean energy technologies, including components related to hydrogen
	OTT w/ OCED, FECM, EERE	24	Voucher Program through Technology Commercialization Fund	$32	Provides commercialization support to organizations that have a role in bringing innovative energy technologies, such as hydrogen and fuel cell technologies, to market nation-wide
	MESC	23	Bipartisan Infrastructure Law: Advanced Energy Manufacturing and Recycling Grant Program FOA	$350	New or expanded facilities, including for H2 & fuel cell components
	MESC	23	Modeling, Mapping, and Analysis Consortium (MMAC)	$2	Includes $300K for Electrolyzer Analysis
SC ARPA-E	SC/BES	23	Science Foundations for Energy Earthshots FOA	$150	Supporting Energy Earthshot goals including H2 Shot
	SC/BES	23	Energy Earthshot Research Centers Lab Call	$200	Supporting Energy Earthshot goals including H2 Shot
	ARPA-E	24	Production of Geologic Hydrogen Through Stimulated Mineralogical Processes	$20	Technologies that stimulate H_2 production from mineral deposits found in the subsurface, including understanding of H_2 geochemical reactions and how to enhance or control the rate of H_2 production

Hydrogen Related IDP FOA Selections- New from OCED $6B Selections!

	Project Title	Lead Organization	Federal Cost Share
Iron & Steel 	**H_2-Ready Electric Melting Furnace Iron and Steel Retrofit**	Cleveland-Cliffs Steel Corporation	$500M
	H_2-Fueled Zero Emissions Steel Making	SSAB	$500M
Chemicals & Refining 	**Novel CO_2 Utilization for Electric Vehicle Battery Chemical Production**	The Dow Chemical Company	$95M
	Star e-Methanol	Orsted P2X US Holding LLC	$100M
	Sustainable Ethylene from CO_2 Utilization with Renewable Energy (SECURE)	T.EN Stone & Webster Process Technology, Inc.	$200M
	Baytown Olefins Plant Carbon Reduction Project	Exxon Mobile Corporation	$332M
Aluminum & Metals 	**Low Carbon SmartMelt Furnace Conversion**	Constellium Rolled Products, Ravenswood	$75M
	Nextcase-Next Generation Aluminum Mini Mill	Golden Aluminum Inc.	$22M
	Zero Waste Advanced Aluminum Recycling	Real Alloy Recycling, LLC	$67M
		TOTAL	**~$1.9B**

Chilton, et al, HFTO; adapted from OCED IDP announcements
https://www.energy.gov/articles/biden-harris-administration-announces-6-billion-transform-americas-industrial-sector -

Key USG Focus Areas for Cross-Agency Collaboration and Coordination



Enable National Goals: 10 MMT/yr supply and use by 2030, 20 MMT/yr by 2040, 50 MMT/yr by 2050

Supply and Demand at Scale

- Enabling large scale production and demand creation
- Financing, incentives, and compliance tools for commercial scale up
- Metrics for deployment and USG as offtaker
- Supply chains and resiliency (critical materials, strategic reserve)
- R&D to accelerate cost reductions and end use commercialization (JST interface)

Infrastructure, Siting, Permitting

- Siting, permitting, pipelines, storage, and infrastructure
- Harmonized codes and standards
- Interoperability and global standardization
- Safety, emissions (including secondary), sensors, risk mitigation, environmental impact
- Environmental review and best practices (NEPA, etc.)
- Pipeline and blending test facilities

Analysis and Global Competitiveness

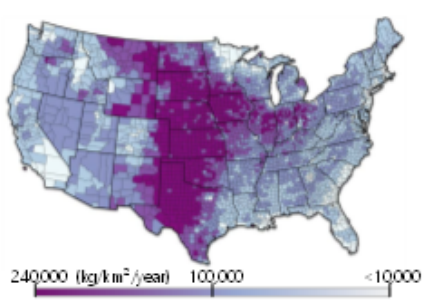
- National strategy and commercial liftoff analysis
- Impacts and gap assessments (technoeconomic analysis, incentives, resource/water availability, emissions, jobs, manufacturing, etc.)
- Intellectual property and global landscape assessment
- Export market analysis
- Systems integration and optimization

Clean Hydrogen Production, Delivery, Storage, Conversion, Applications, H2 Hubs

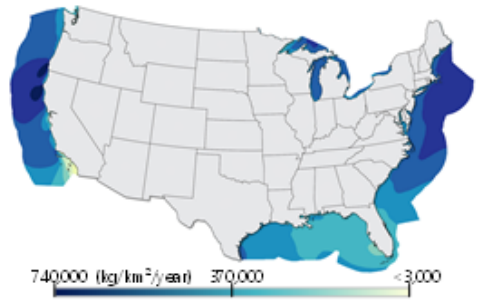
Workforce, Equity, and Justice

National Clean Hydrogen Strategy and Roadmap

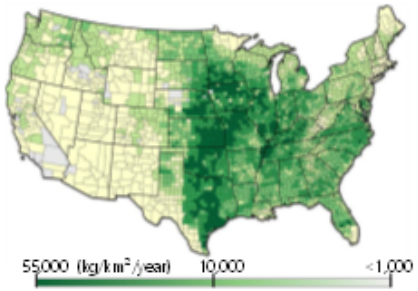
Potential Supply Resources and Underground Storage



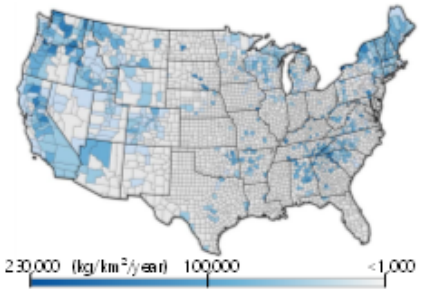
a) *Hydrogen production potential from onshore wind resources, by county land area*



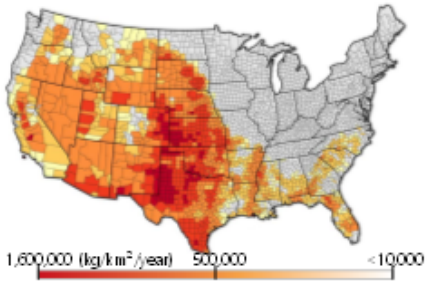
b) *Hydrogen production potential from offshore wind resources, by area*



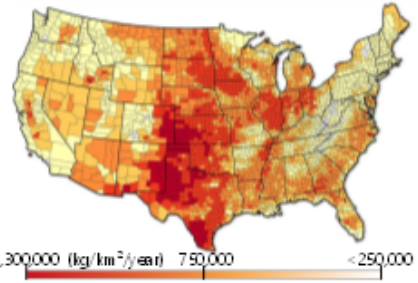
c) *Hydrogen production potential from solid biomass resources, by county land area*



d) *Hydrogen production potential from existing hydropower assets, by county land area*



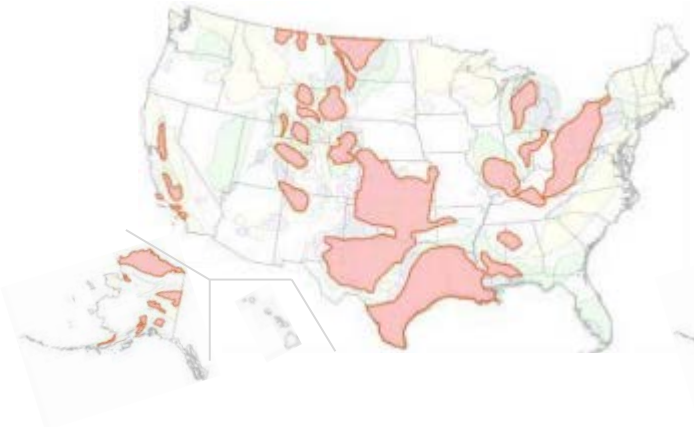
e) *Hydrogen production potential from concentrated solar power, by county land area*



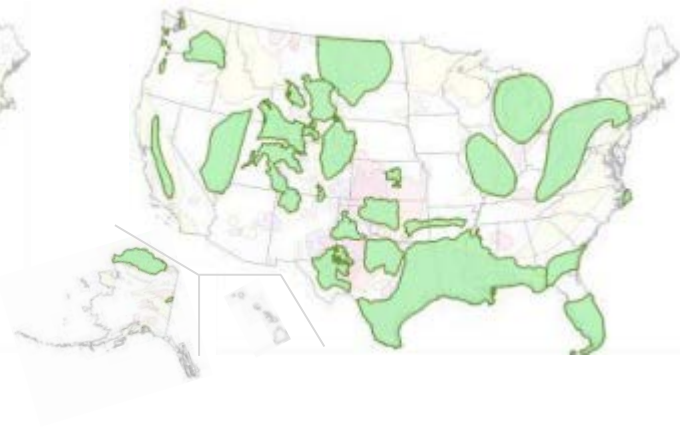
f) *Hydrogen production potential from utility-scale PV, by county land area*

Source: NREL, Lab analysis, National Strategy

Oil and Gas Fields in the United States



Sedimentary Basins in the United States

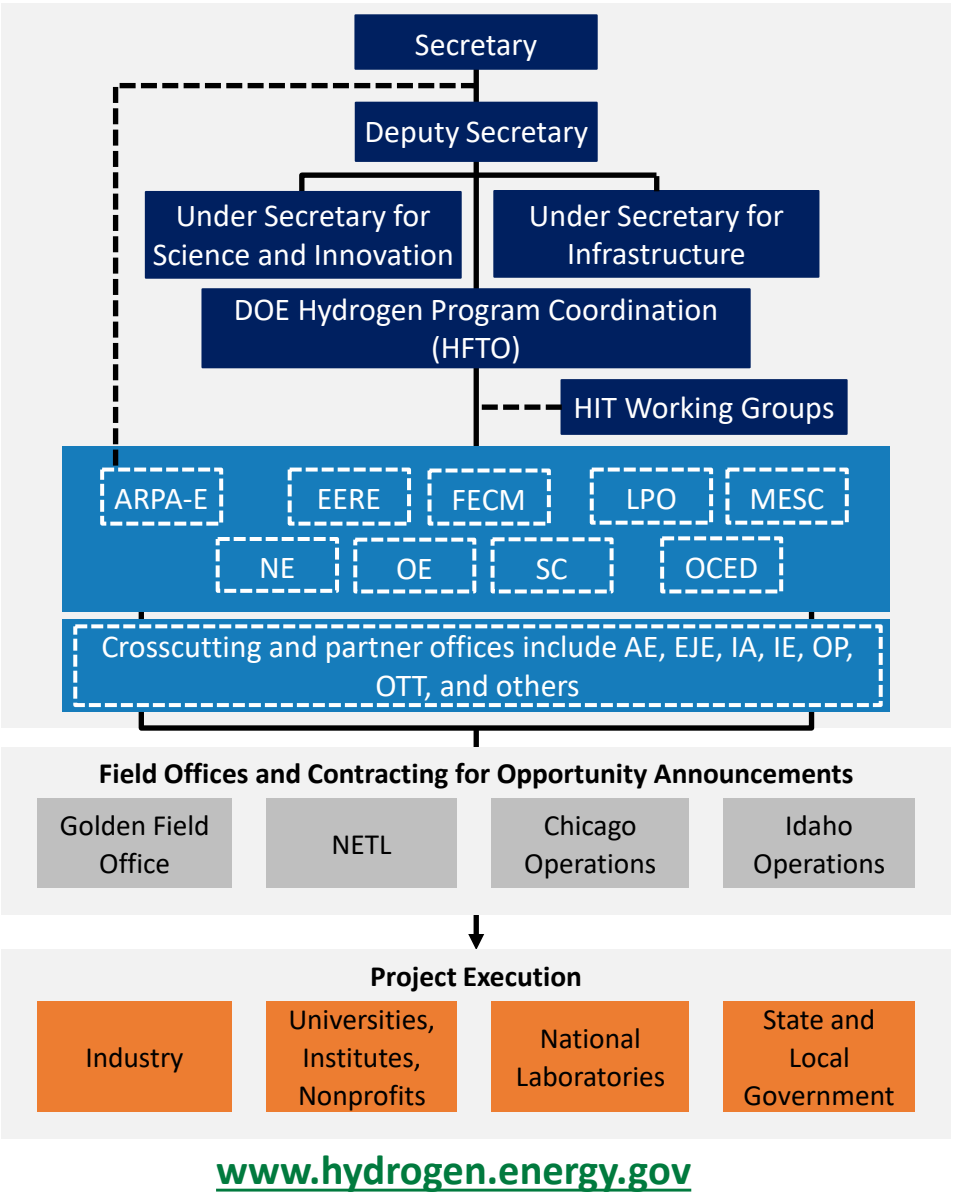


Hardrock Outcrops in the United States

Salt Deposits in the United States

Source: SHASTA, NETL, funded by FECM

The U.S. DOE Hydrogen Program – Coordinated across Offices



www.hydrogen.energy.gov

EERE Hydrogen

Feedstocks:
- Renewables and Water

Technologies:
- Electrolysis – Low- and High-Temperature
- Advanced Water Splitting – Solar / High-Temp Thermochemical, Photoelectrochemical
- Biological Approaches

FECM Hydrogen

Feedstocks:
- Fossil Fuels – Coal* and Natural Gas

Technologies:
- Gasification, Reforming, Pyrolysis
- Advanced Approaches – Co-firing and Modular Systems
- Natural Gas to Solid Carbon plus Hydrogen

*Waste coal, other waste

Areas of Collaboration

Reversible Fuel Cells, Biomass, Municipal Solid Waste, Plastics Polygeneration including Co-Gasification with Biomass

High-Temperature Electrolysis, System Integration

NE Hydrogen

Feedstocks:
- Nuclear Fuels and Water

Technologies:
- Risk Assessment & Licensing, Thermal Delivery
- Advanced Nuclear Reactors
- System Integration and Controls – LWRs and Advanced Reactors

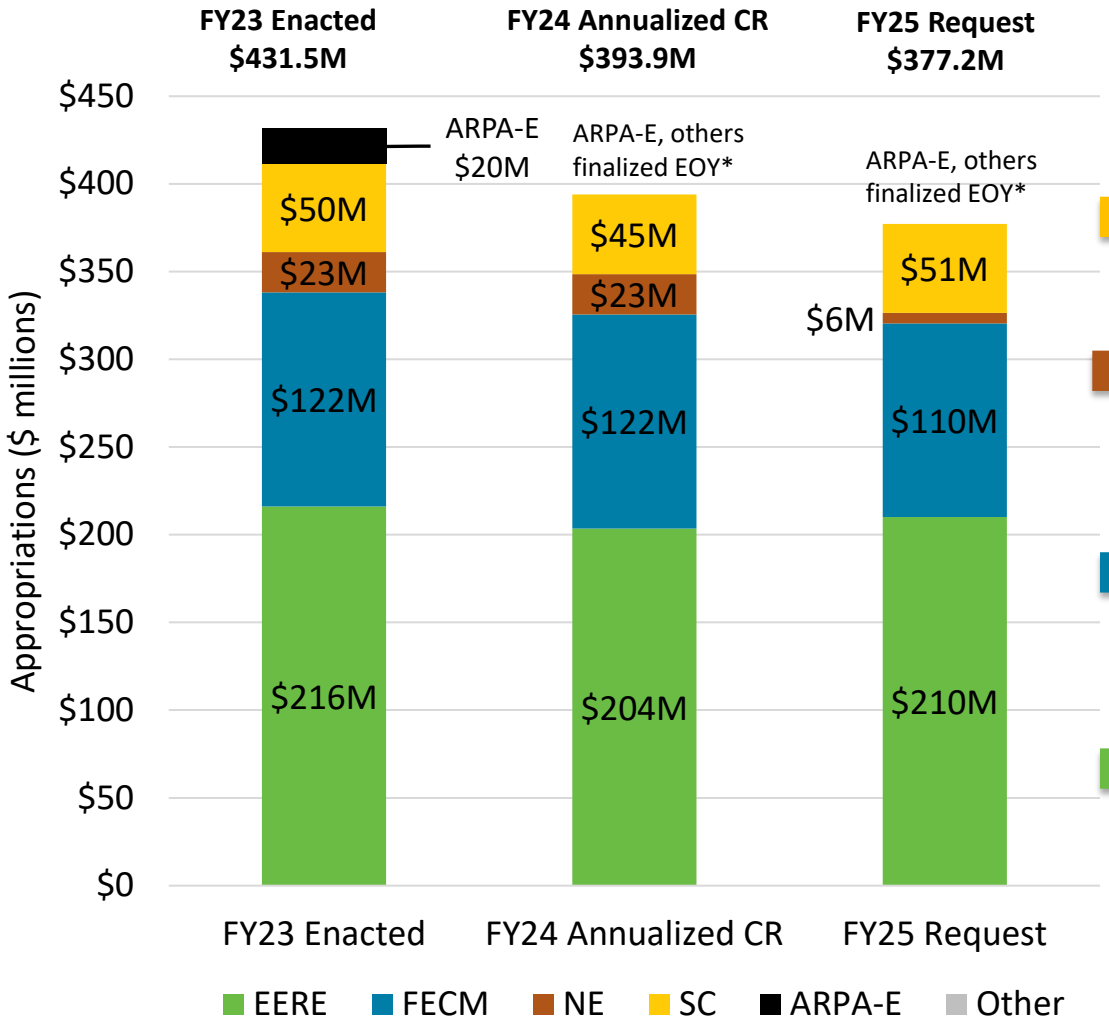
Crosscutting R&D Offices: Office of Science (SC) and ARPA-E

Fundamental Science and Advanced Innovative Concepts

Foundational research and innovation; user facilities and tools, materials and chemical processes (e.g., catalysis, separations), artificial intelligence/machine learning, databases and validation, high risk – high impact R&D, and other crosscutting activities.

OCED (H2 Hubs), MESC, OTT, LPO, OP, EJE, IE, IA, and more

DOE Hydrogen Program Fiscal Year (FY) Funding across Offices

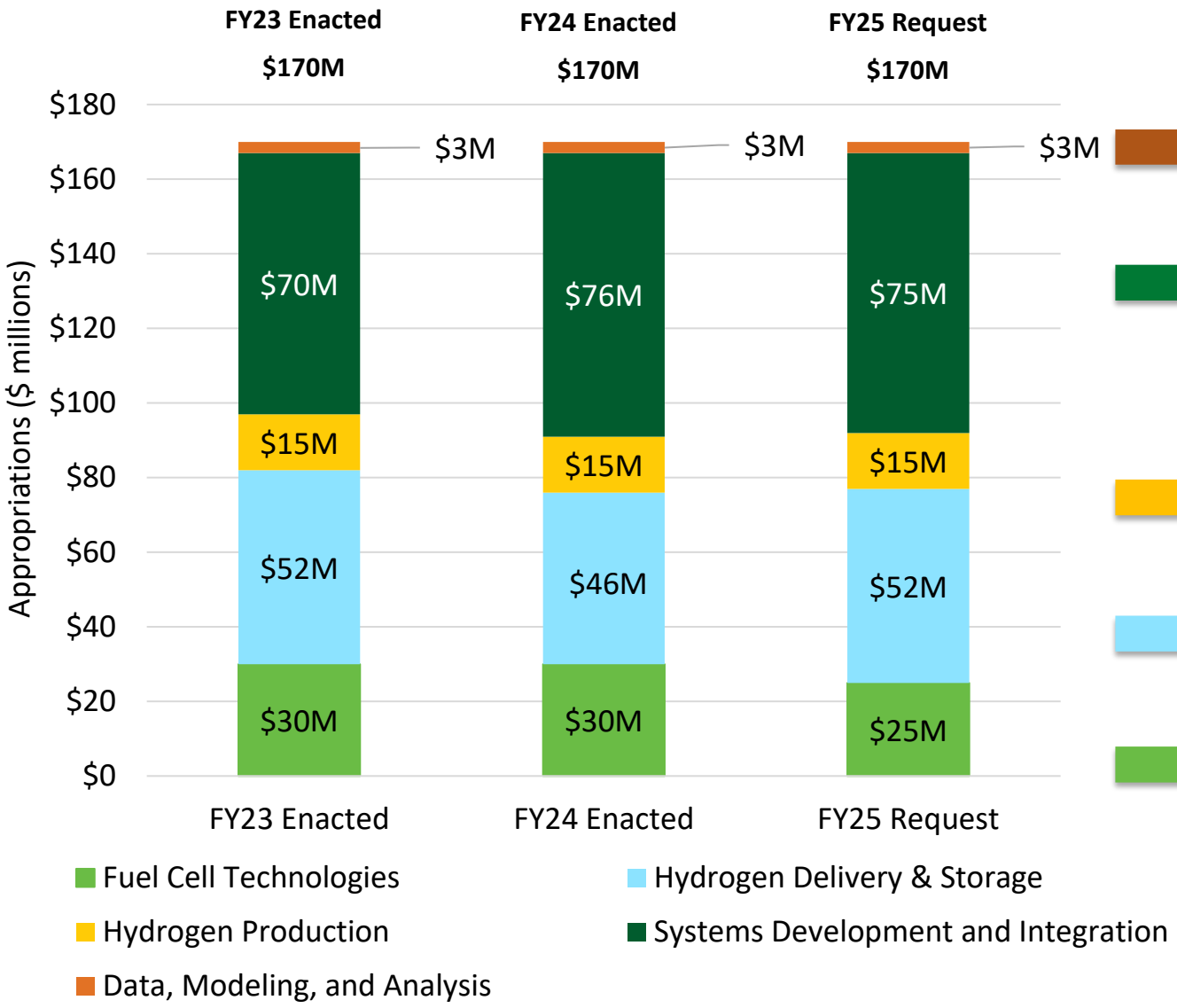


Focus Areas

- Foundational knowledge and state-of-the-art capabilities supporting clean H_2 including EERCs
- Nuclear-powered production of H_2 and syn-fuels, including first-of-a-kind demos with thermal integration
- Co-gasification of wastes with CCS; combustion of H_2 and blends; SOFC for data-center backup power
- Production, storage, delivery, conversion, end use of clean H_2 across sectors; focus on infrastructure for integration with renewables

DOE Hydrogen Program coordinated through HFTO. Source: https://www.energy.gov/sites/default/files/2023-03/doe-fy2024-budget-volume-2-crosscutting-v3.pdf
**Final to be updated end of year (EOY) , e.g., ARPA-E, SC funding is determined annually based on programs/selections. Annual funding only, excludes BIL funding and new offices (e.g., OCED)*

Hydrogen and Fuel Cell Technologies Office Budget



Focus Areas

- Guide and strengthen portfolio through rigorous analysis
- Validate first-of-a-kind systems across applications, de-risk technologies; includes safety, codes and standards, workforce development
- Production RD&D supplemented with BIL funding (including $1B)
- Increase bulk storage, liquid, and delivery focus (e.g., carriers)
- Continue heavy-duty fuel cell RD&D, including supply chain (Note: HFTO funds fuel cells; VTO funds H_2 internal combustion engine work)

New activities to strengthen connections with SC—e.g., H2LinkSC to link lab projects with SC; HFTO part-time assignment to SC

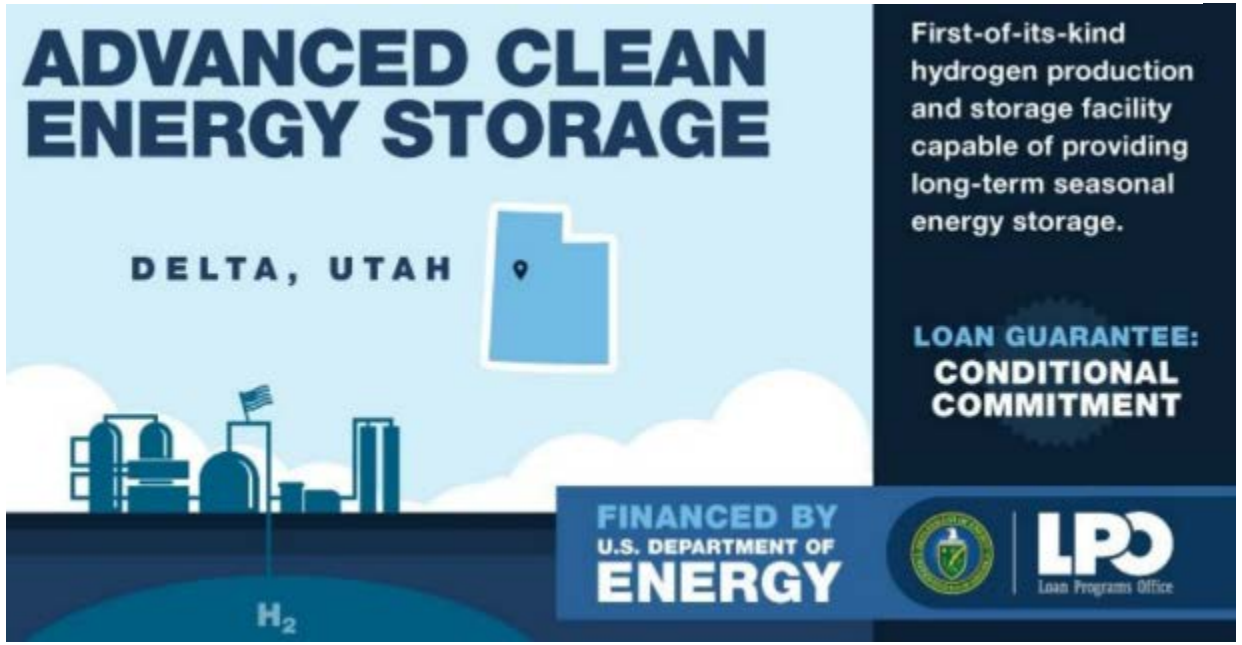
Note: Appropriations reflect Congressional direction

Financing to Enable Deployment at Scale – H_2 Examples

Loan Programs Office (LPO) Builds The Bridge to Bankability & Market Catalyzation

LPO announced loan guarantee conditional commitments for 2 clean hydrogen projects

$1.04B for the first-ever commercial-scale project to deploy methane pyrolysis technology. Will enable 1,000 construction jobs and 75 operations jobs.
(December 2021)



$504.4M for large-scale hydrogen energy storage, 220 MW electrolysis and turbine. Will enable up to 400 construction jobs and 25 operations jobs.
(April 2022)

Let's talk about your project. Call or email for a no-cost pre-application consultation: (202) 287-5900 or LPO@hq.doe.gov

Examples of Tax Credits and Notices of Proposed Rulemakings

Clean Hydrogen Production Tax Credit 45V

EPA announced the MDHD rule for Zero Emissions Vehicles

More **protective emissions standards** for criteria pollutants and greenhouse gases for light-duty **and Class 2B and 3 medium-duty vehicles** that will phase-in between 2027-2032 which **includes FCEVs**.

EPA Clean Air Act Section 111 Carbon Pollution Standards for Power Plants

Emissions Guidelines for existing coal fired boilers
Emissions Standards for new combustion turbines

- https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-multi-pollutant-emissions-standards-model
- https://www.epa.gov/system/files/documents/2024-04/cps-presentation-final-rule-4-24-2024.pdf

Examples of Additional Tax Credits

30C – Fueling Infrastructure
30D & 45W – Vehicles
45Y/48E – Clean Electricity Production
40B – Biofuel Production
45Z – Clean Fuel Production
48C – Manufacturing Tax Credit

NHTSA announced NPRM

Proposes the establishment of two new **Federal Motor Vehicle Safety Standards** for vehicles that use **hydrogen as a fuel source**

NPRM: Notice for Proposed Rulemaking

- https://www.nhtsa.gov/document/nprm-fuel-system-integrity-hydrogen-vehicles -

View more at: https://www.federalregister.gov/documents/2023/12/26/2023-28359/section-45v-credit-for-production-of-clean-hydrogen-section-48a15-election-to-treat-clean-hydrogen -