U.S. DEPARTMENT OF ENERGY

U.S. DOE Hydrogen Program and National Clean Hydrogen Strategy Opening Remarks

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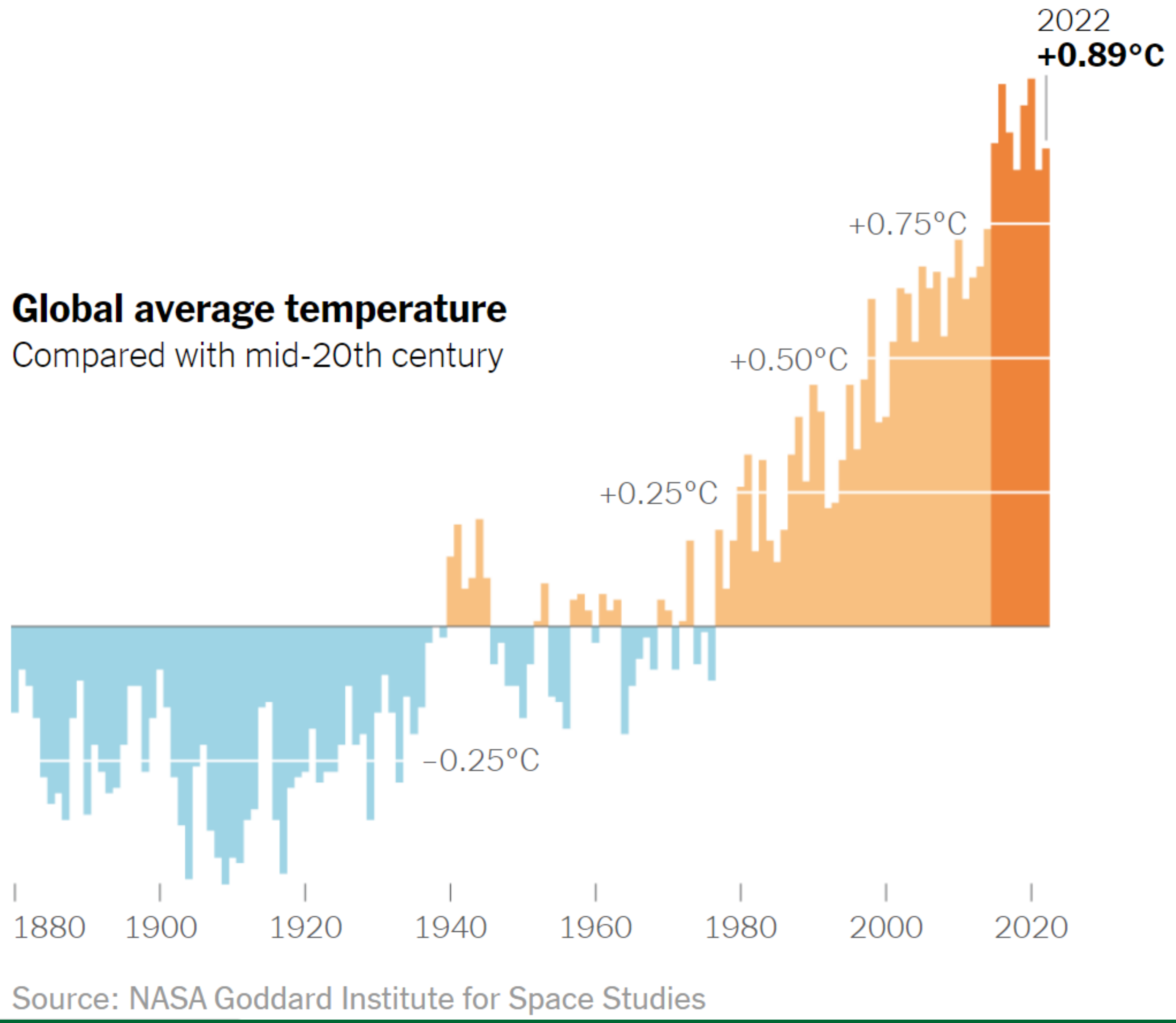
U.S. Department of Energy

International Conference on Green Hydrogen, Delhi, India

July 5, 2023

Introduction – Energy, Market, and Policy Context

The Global Challenge….

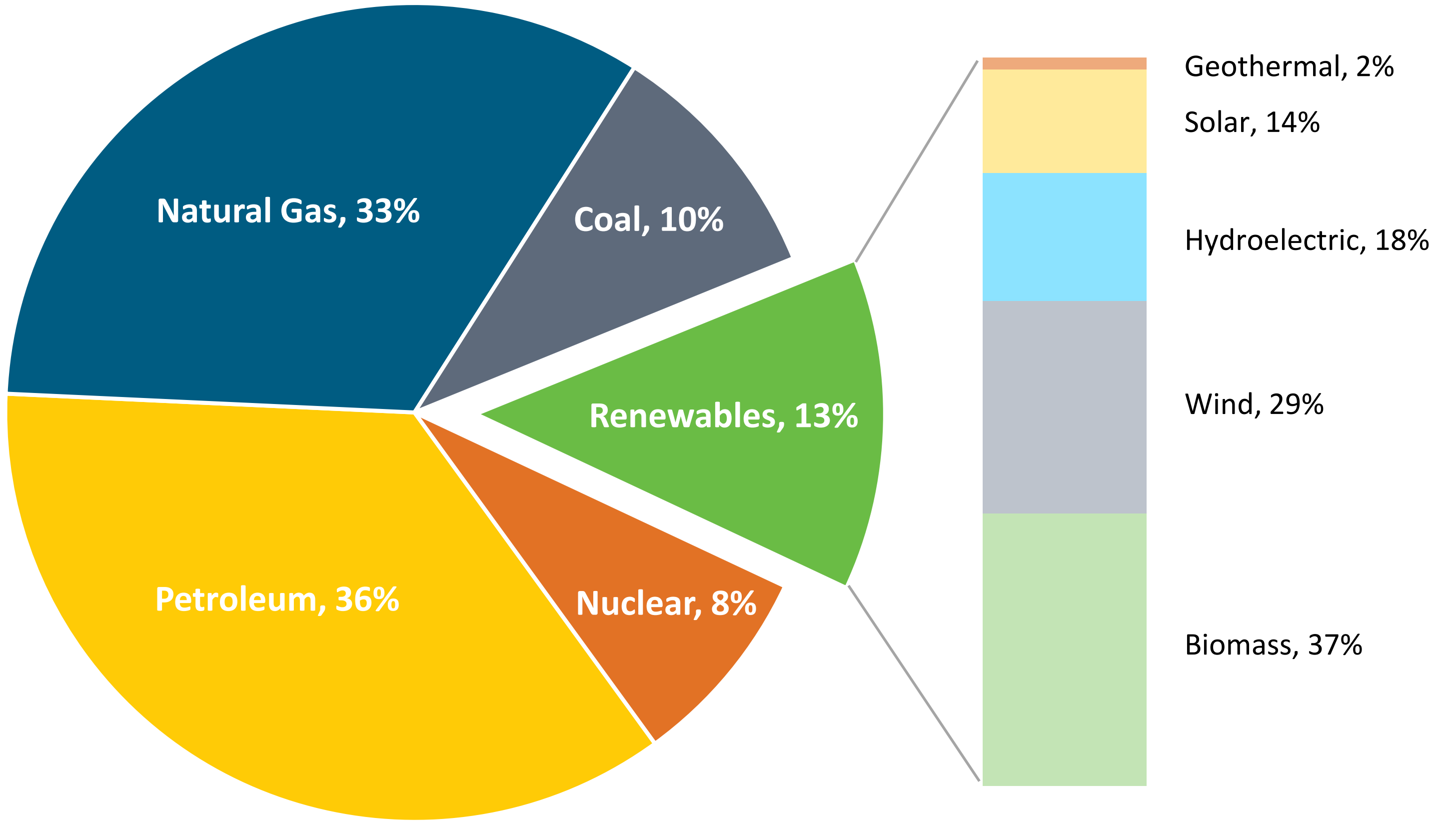


U.S. Energy Landscape and Key Goals

U.S. primary energy consumption by energy source, 2022

Total = 100.4 quadrillion British thermal units (Btu)

Total = 13.1 quadrillion Btu



Note: Sum of components may not equal 100% because of independent rounding
Source: Data collected from U.S. Energy Information Administration, May 2023, *Monthly Energy Review,* preliminary data

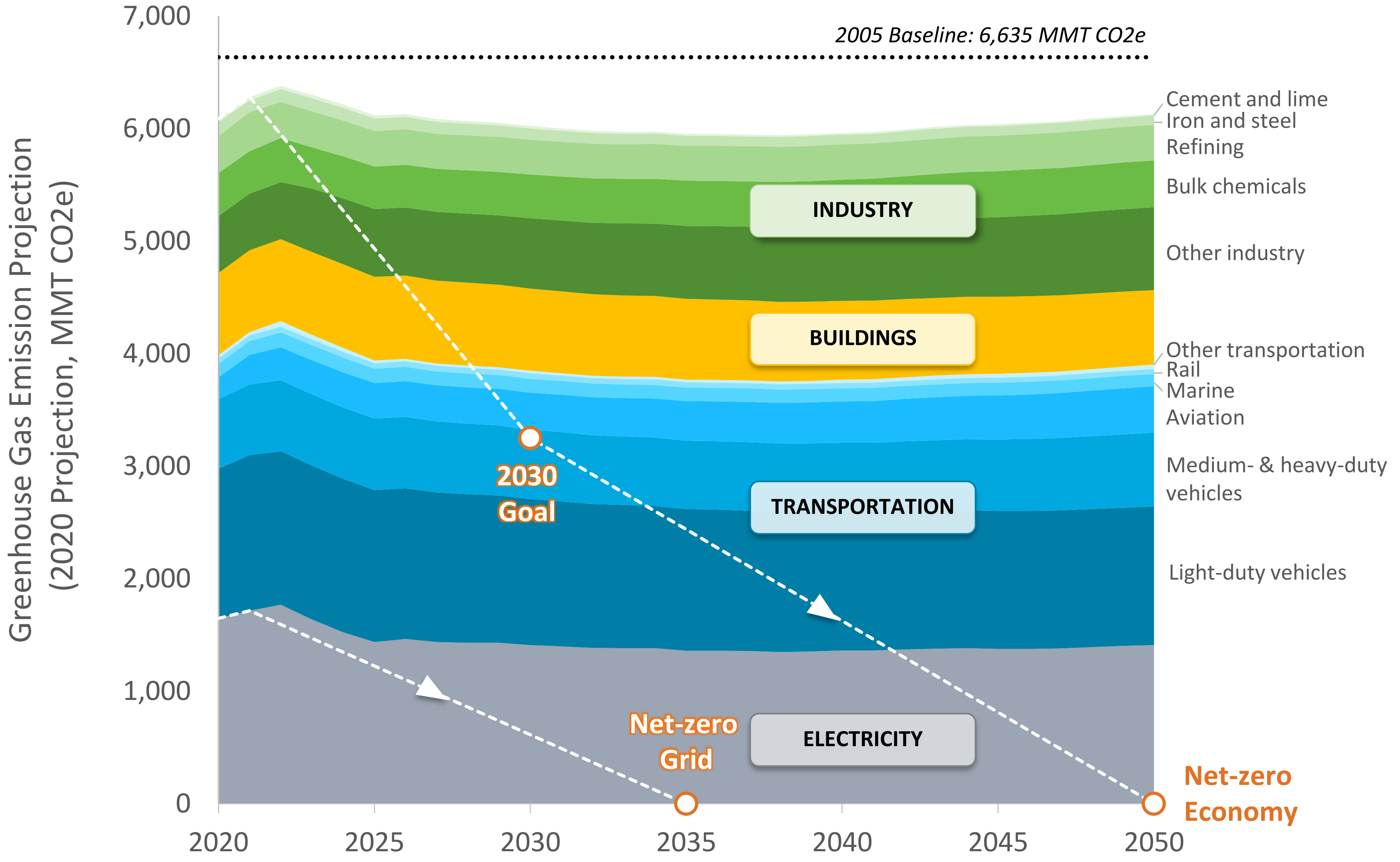
Administration Goals include:

- **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

EJ: Environmental Justice

Carbon Dioxide Emissions by Sector



Source: Annual Energy Outlook 2021, DOE National Clean Hydrogen Strategy and Roadmap

Hydrogen is a key element of a portfolio of solutions to decarbonize the economy.

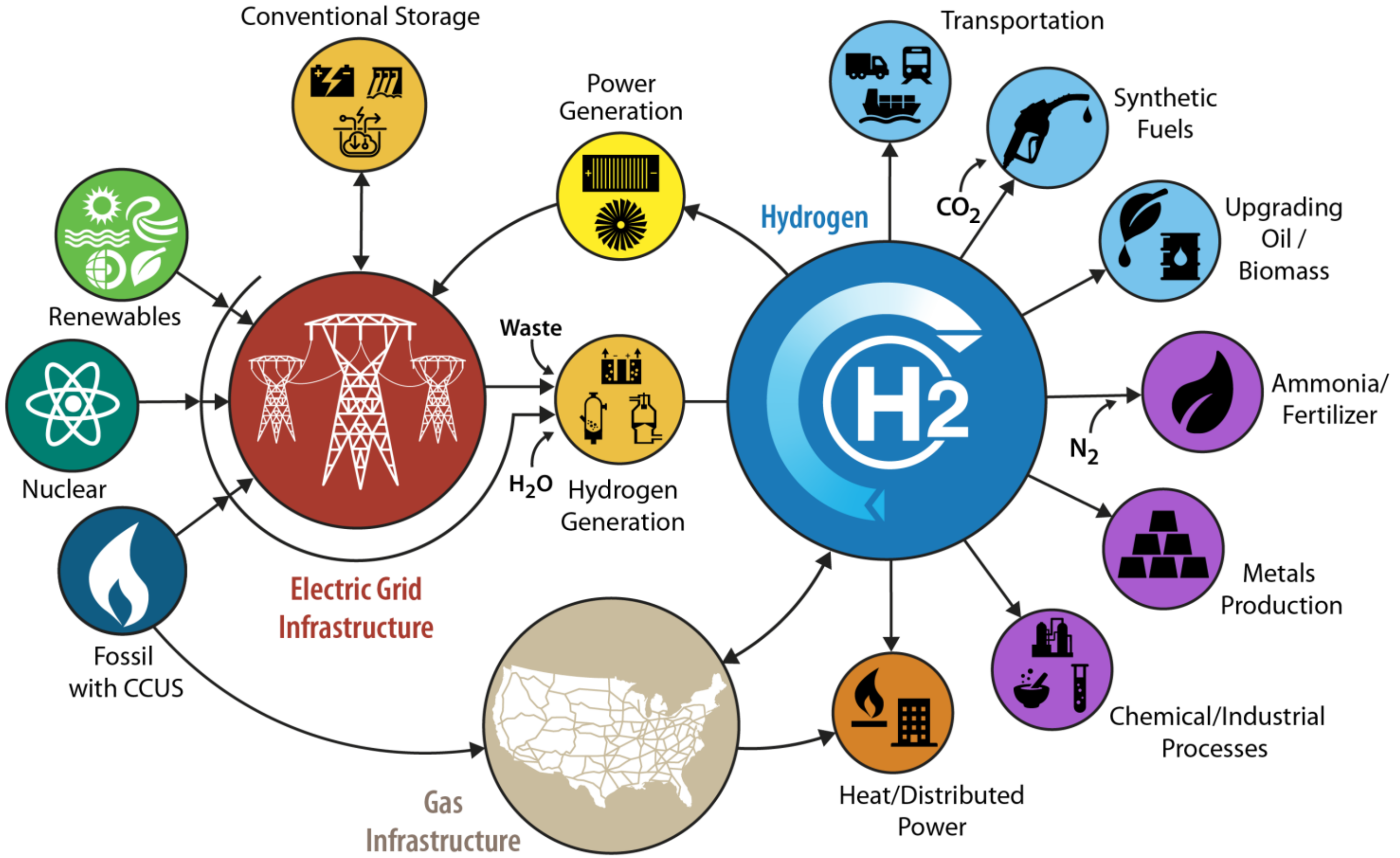
Hydrogen Program

Coordinated across DOE on **research, development, demonstration, and deployment (RDD&D)** to address:

- **The entire H_2 value chain** from production through end use
- **H_2 production from all resources** (renewables, nuclear, and fossil + CCS)

www.hydrogen.energy.gov

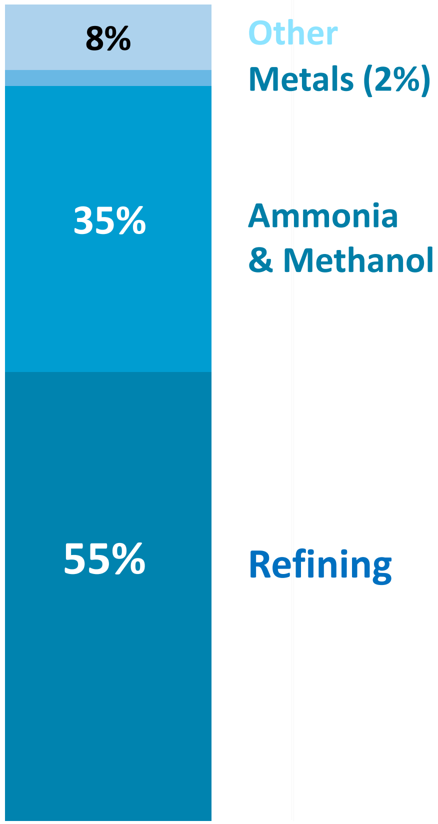
H2@Scale vision: Enables clean-energy pathways across sectors



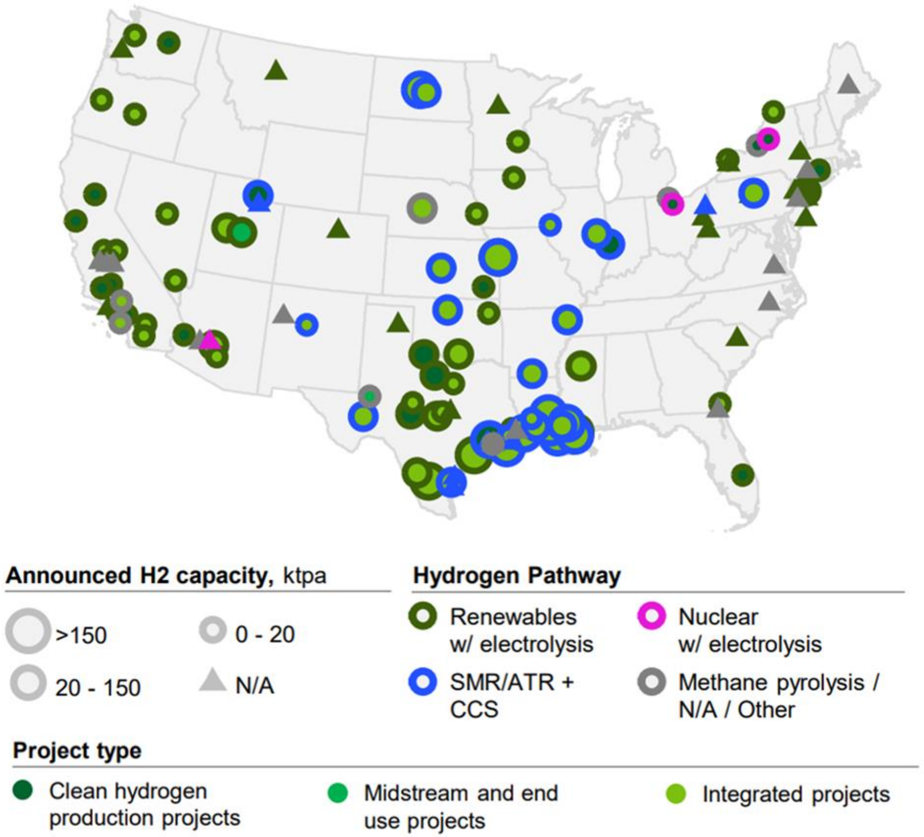
Snapshot of Hydrogen and Fuel Cells in the U.S.

- 10 million metric tons 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



Current publicly announced clean hydrogen production projects*



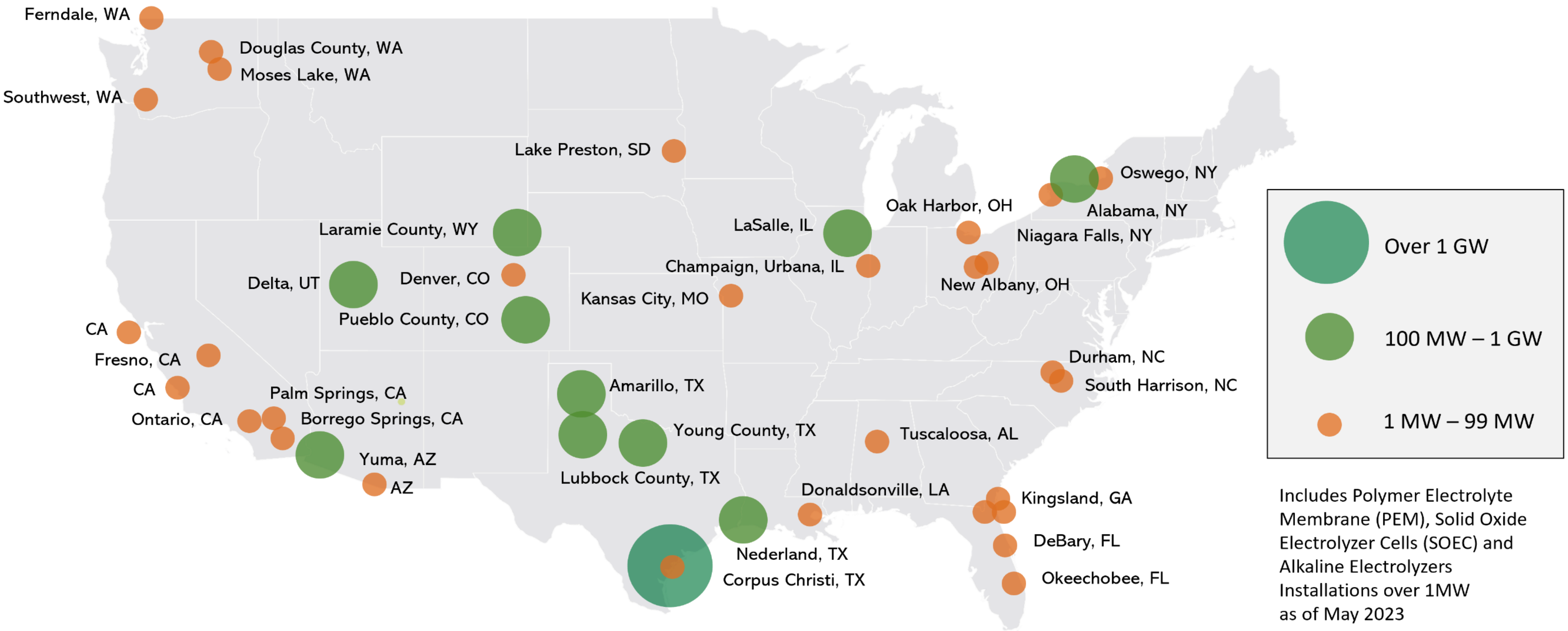
*as of EOY 2022, DOE Commercial Liftoff Report

Examples of Deployments

- **>500 MW** Backup Power
- **>60,000** Forklifts
- **>3.7 GW** Electrolyzers
- **~80 – 150** Fuel Cell Buses
- **~50** H_2 Retail Stations
- **>16,000** Fuel Cell Cars

New Announcement: Planned and Installed Electrolyzer Capacity in the US

Total 3.7 GW in Electrolyzer Capacity
5-fold increase since 2022



Includes Polymer Electrolyte Membrane (PEM), Solid Oxide Electrolyzer Cells (SOEC) and Alkaline Electrolyzers Installations over 1MW as of May 2023

Source: Arjona, DOE Program Record #23003, June 2023

Legislation Highlights: 2021 – 2022

Bipartisan Infrastructure Law

- **Includes $9.5B for clean hydrogen**:
  - $1B for electrolysis
  - $0.5B for manufacturing and recycling
  - $8B for at least four regional clean hydrogen hubs
- **Requires** developing a **National Clean Hydrogen Strategy and Roadmap**

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

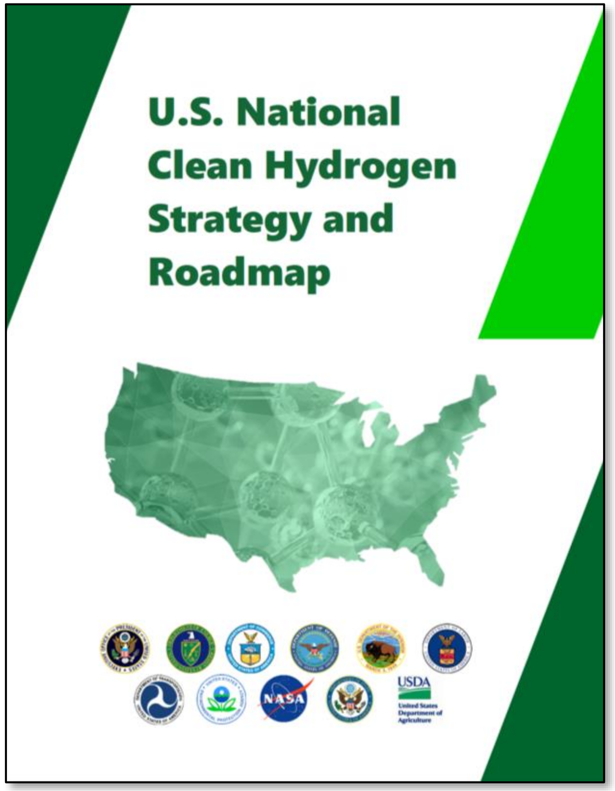
Inflation Reduction Act

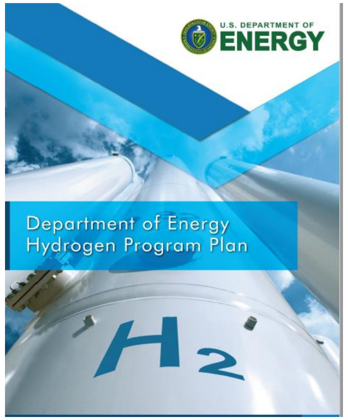
- **Includes significant tax credits** (e.g., up to $3/kg for production of clean hydrogen)

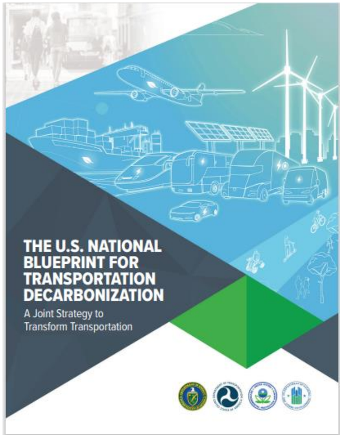
Strategy & Goals

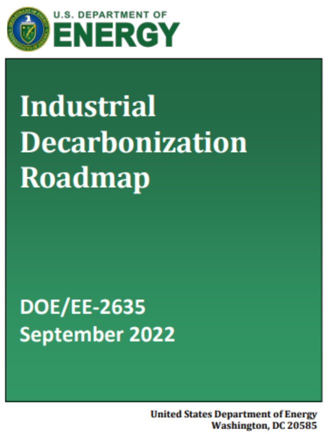
Key Publications

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









www.hydrogen.energy.gov

U.S. National Clean Hydrogen Strategy and Roadmap

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

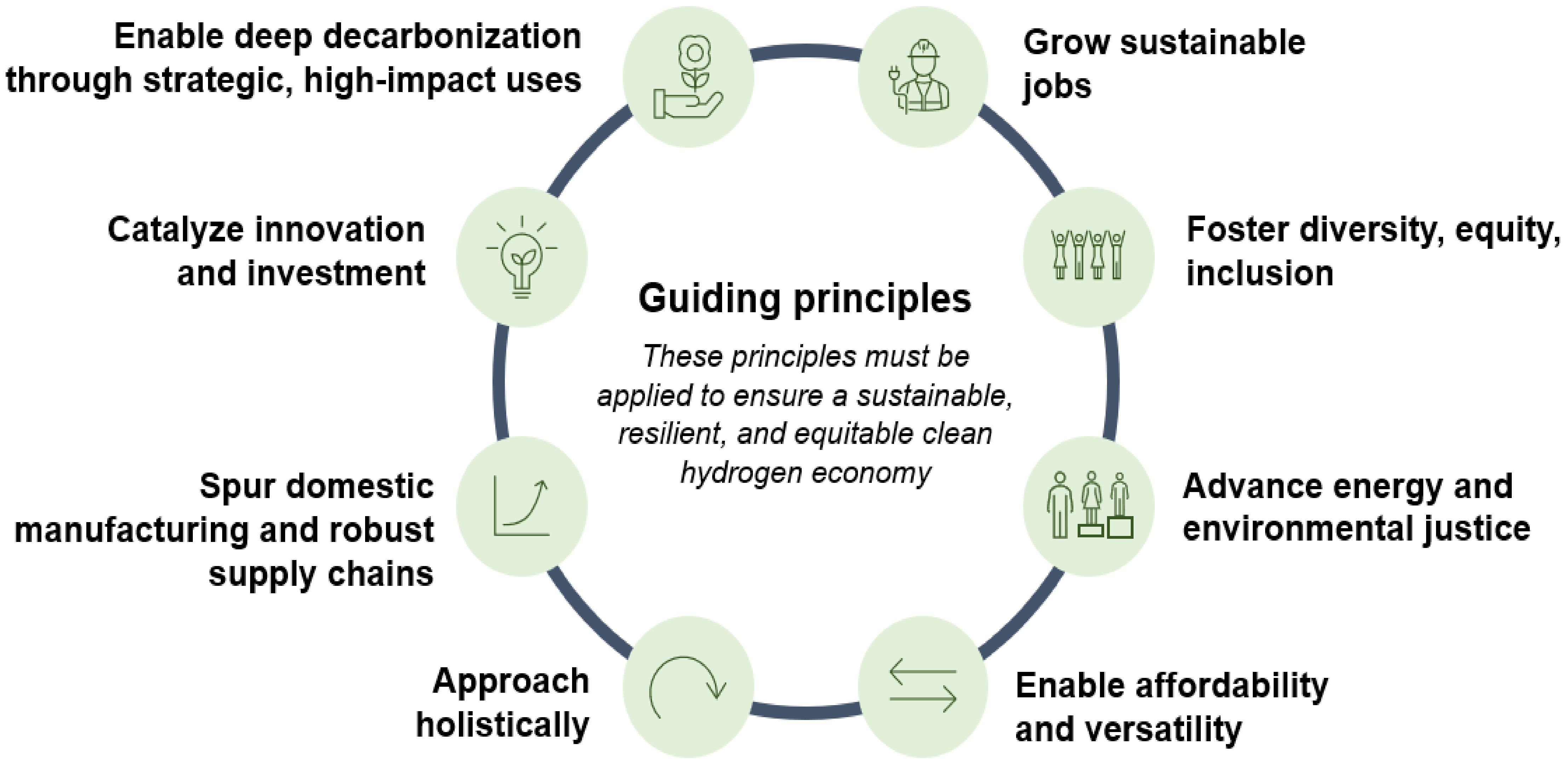
Benefits:
Emissions reduction; job growth; energy security and resilience

Enablers

Work with other agencies to accelerate market lift off

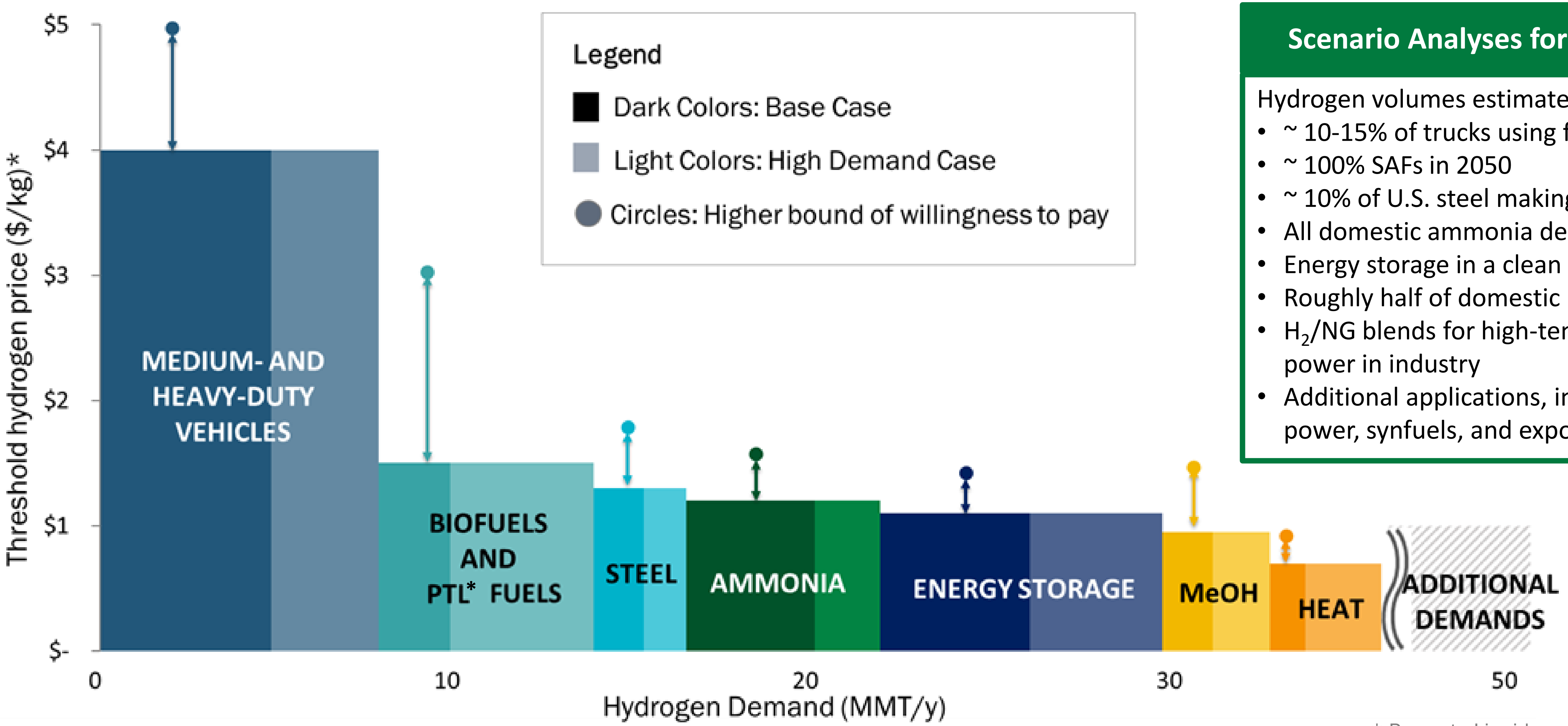
- Good Jobs and Workforce Development
- Safety, codes and standards
- Policies and incentives
- Stimulating private sector investment
- Energy and environmental justice

Guiding Principles



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% SAFs in 2050
- ~ 10% 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 and power in industry
- Additional applications, include stationary power, synfuels, and export potential

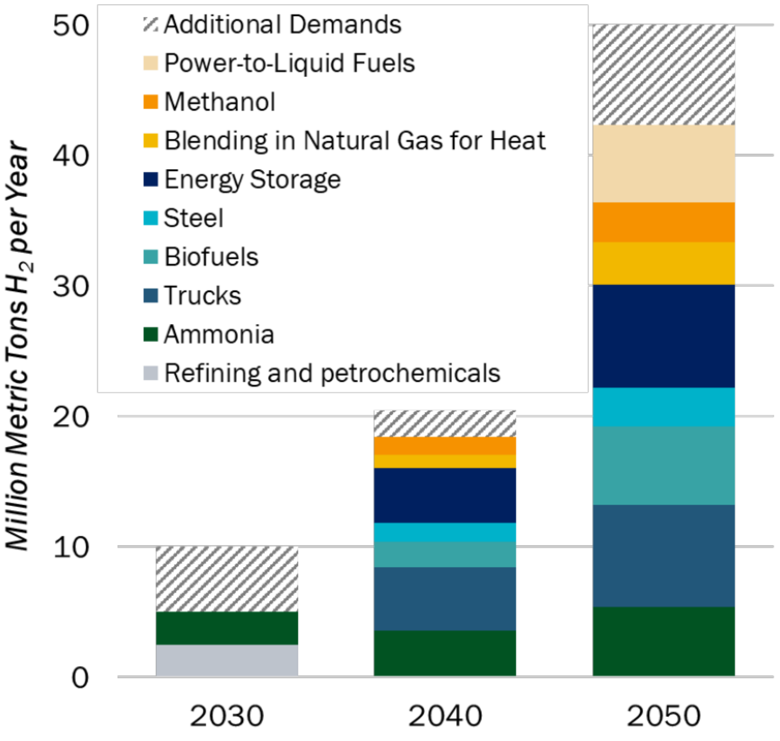
* Power to Liquid

** Volumes dependent on multiple variables

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

Strategy 1: Target High-Impact Uses of Hydrogen

Opportunities for Clean Hydrogen Across Applications

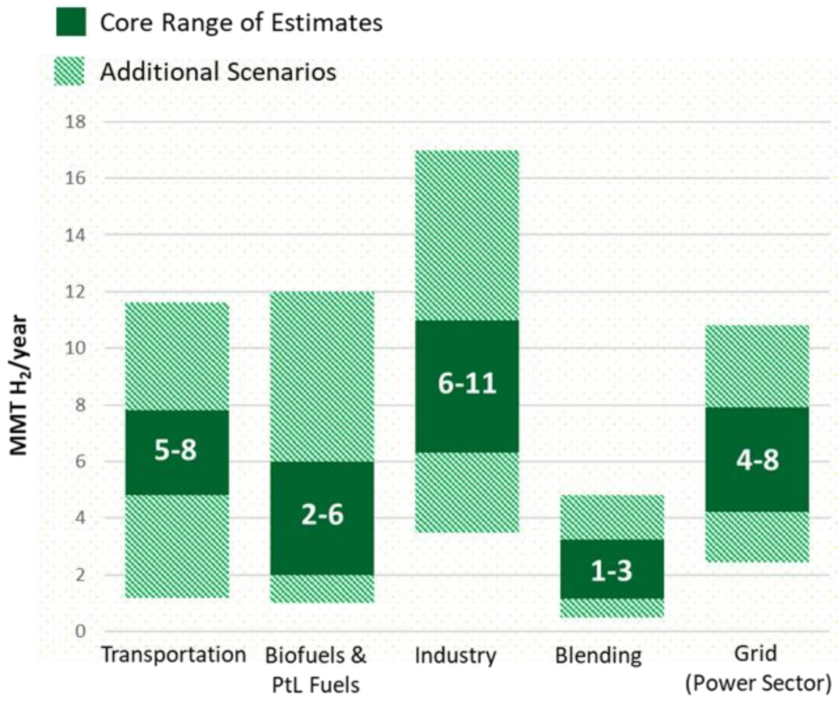


U.S. Opportunity: 10MMT/yr by 2030, 20 MMT/yr by 2040, 50 MMT/yr by 2050. ~10% Emissions Reduction. ~100K Jobs by 2030

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

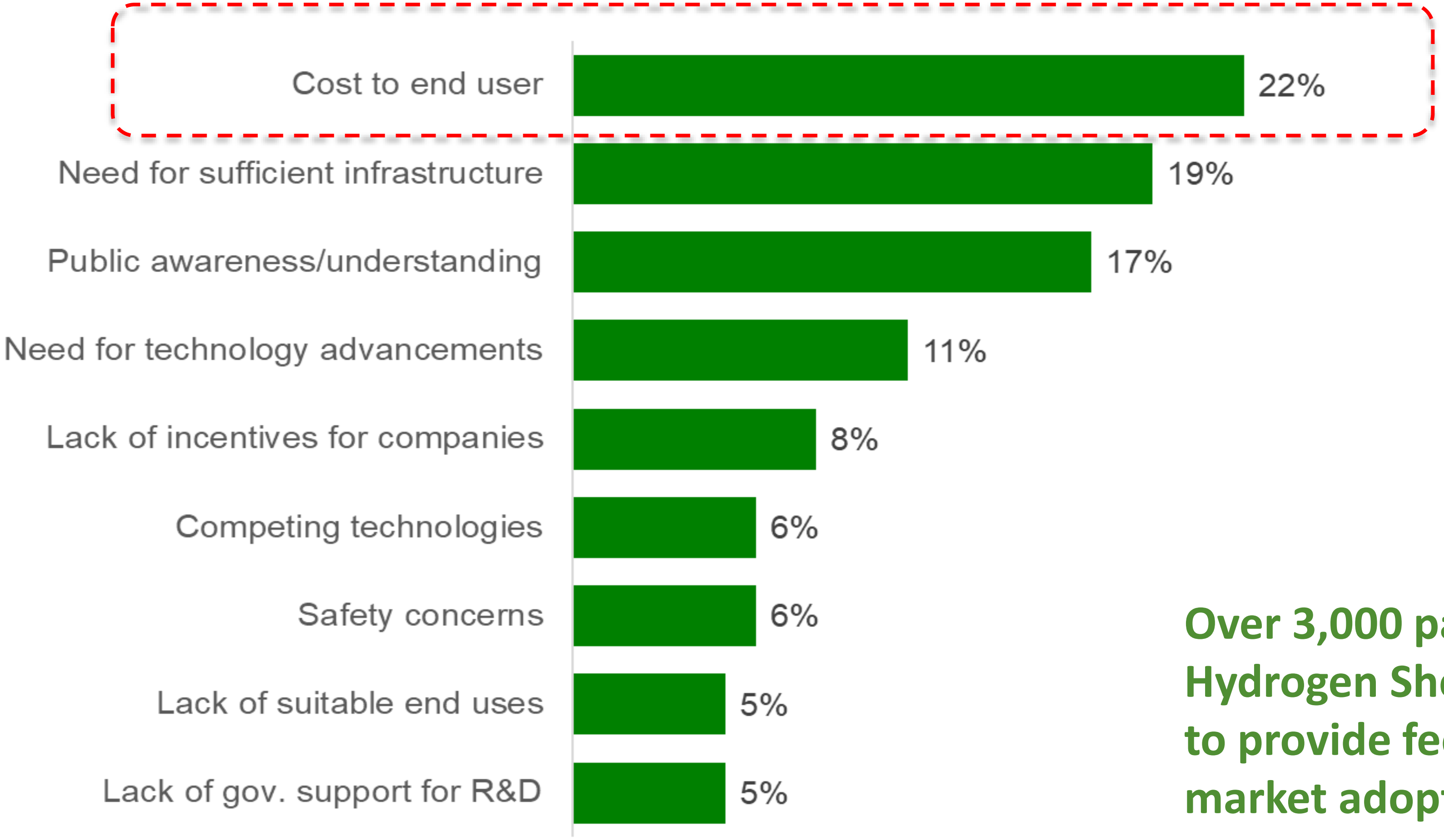


- **Core range: ~ 18–36 MMT H_2**
- **Higher range: ~ 36–56 MMT H_2**

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

Strategy 2: Focus on Cost-Reduction

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

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

Source: Hydrogen Shot Summit, Sept 2021

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen

Hydrogen Energy Earthshot

"Hydrogen Shot"

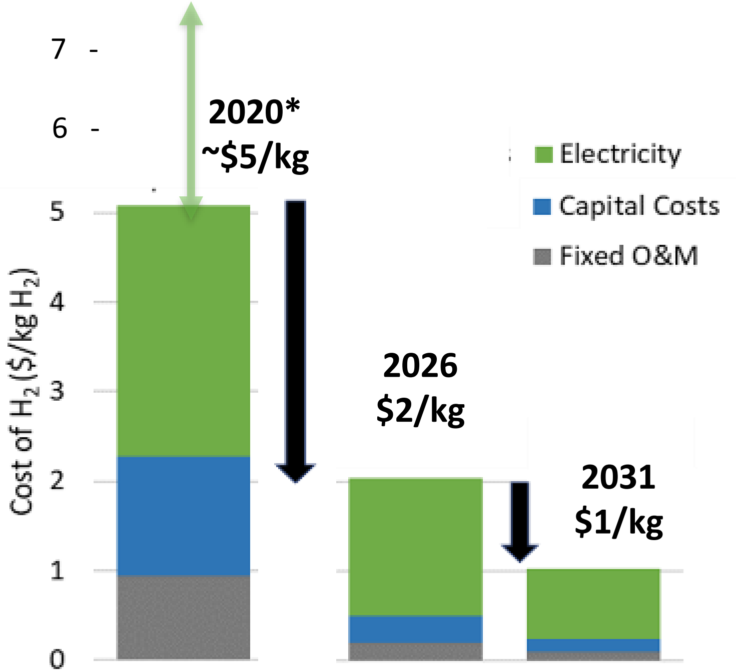
"1 1 1"
$1 for 1 kg clean hydrogen in 1 decade

Launched June 7, 2021

How to reduce cost? Examples across multiple pathways

Strategies and scenarios being developed to reduce cost and emissions across pathways

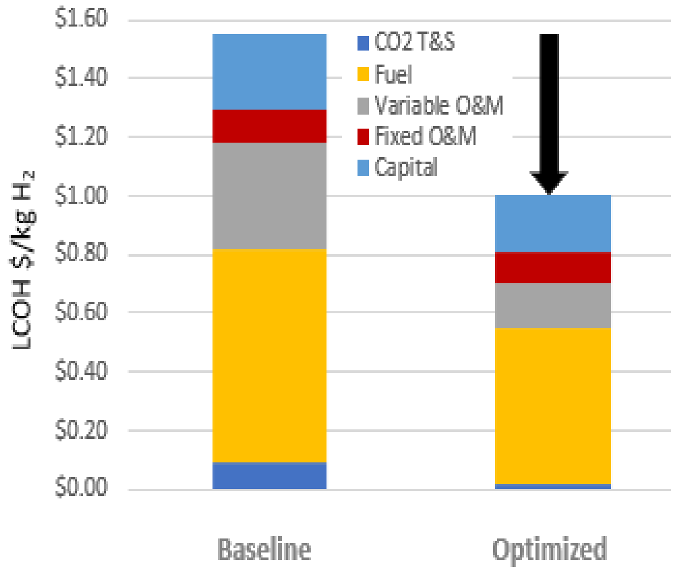
H_2 from Electrolysis



- Reduce electricity cost, improve efficiency and utilization
- Reduce capital cost >80%, operating & maintenance cost >90%

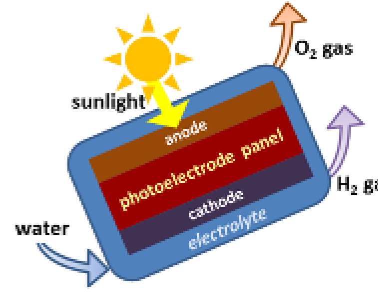
Thermal Conversion

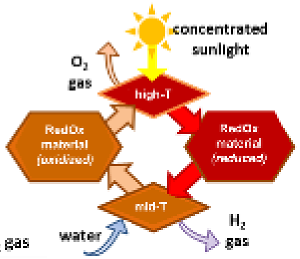
Example: Autothermal Reforming + CCS

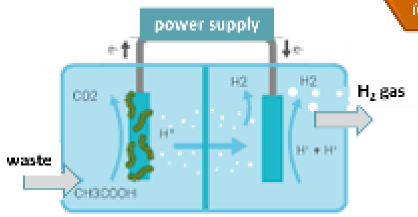


- Reforming; pyrolysis; air separation; catalysts; carbon capture and storage (CCS); upstream emissions

Advanced Pathways





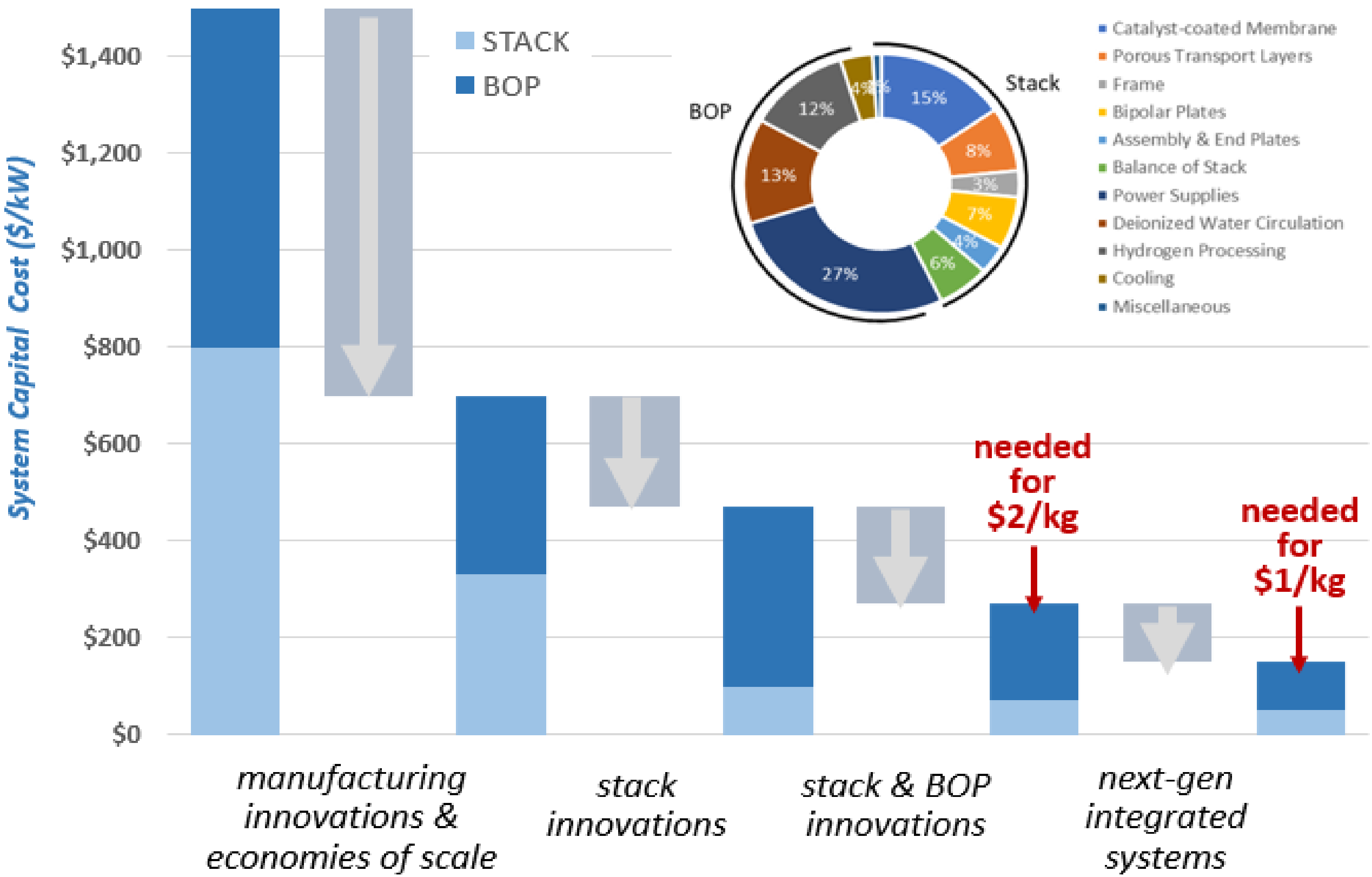


- Photelectrochemical (PEC), thermochemical, biological, etc.

*2020 Baseline: PEM (Polymer Electrolyte Membrane) low volume capital cost ~\$1,500/kW, electricity at \$50/MWh. Pathways to targets include capital cost <\$300/kW by 2025, < \$150/kW by 2030 (at scale). Assumes \$50/MWh in 2020, \$30/MWh in 2025, \$20/MWh in 2030

How to reduce cost? Examples across multiple pathways

Analysis shows pathways to reduce cost require both scale and R&D



DOE Electrolyzer Technical Targets recently updated

DOE Targets for electrolyzer stack and system PEM, Liquid Alkaline (LA) and High Temp Electrolyzers (HTE)

Technical Targets for High Temperature Electrolyzer Stacks and Systems [a,b]

CHARACTERISTIC	UNITS	2022 STATUS[C]	2026 TARGETS	ULTIMATE TARGETS
Stack				
Performance	A/cm^2 @ 1.28 V/cell	0.6	1.2	2.0
Electrical Efficiency [d]	kWh/kg H_2 (% LHV)	34 (98%)	34 (98%)	34 (98%)
Average Degradation Rate [e]	mV/kH (%/1,000 h)	6.4 (0.50)	3.2 (0.25)	1.6 (0.12)
Lifetime [f]	Operation h	20,000	40,000	80,000
Capital Cost [g]	$/kW	300	125	50
System				
Electrical Efficiency	kWh/kg H_2 (% LHV)	38 (88%)	36 (93%)	35 (95%)
Energy Efficiency [h]	kWh/kg H_2 (% LHV)	47 (71%)	44 (76%)	42 (79%)
Uninstalled Capital Cost [g]	$/kW	2,500	500	200
H_2 Production Cost [i]	$/kg H_2	>4	2.00	1.00

Technical Targets for PEM Electrolyzer Stacks and Systems [a,b]

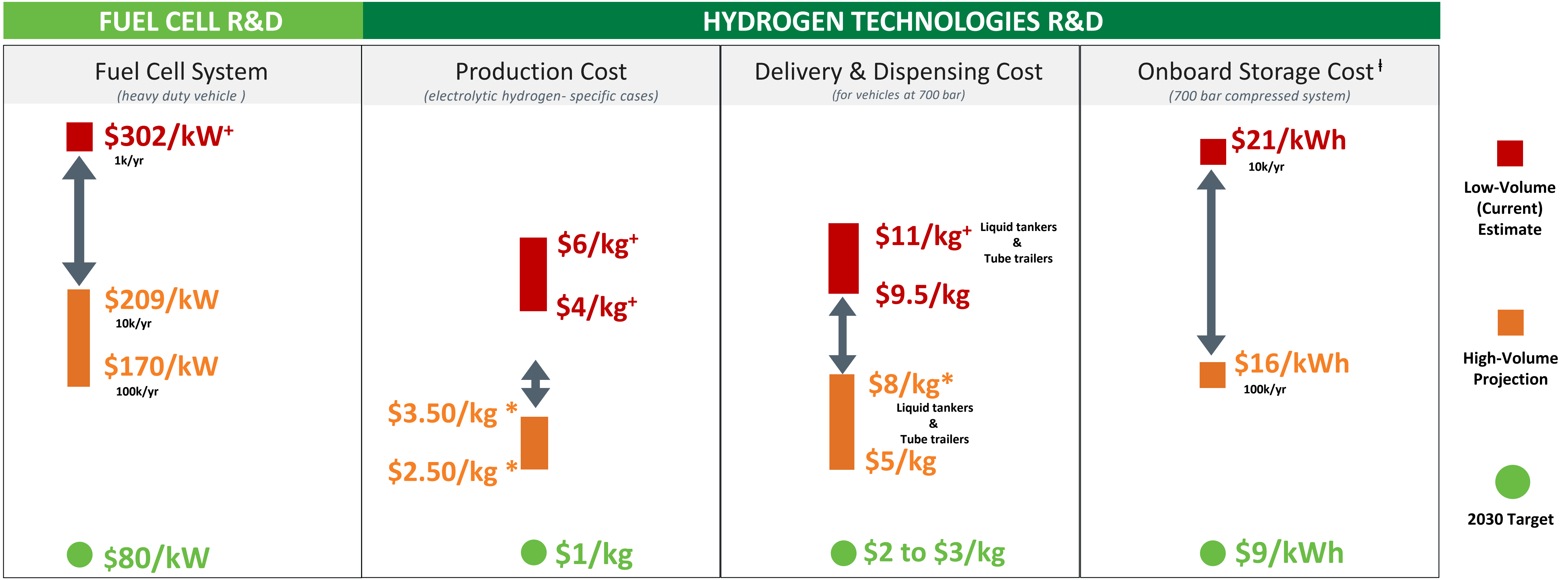
CHARACTERISTIC	UNITS	2022 STATUS[C]	2026 TARGETS	ULTIMATE TARGETS
Stack				
Total Platinum Group Metal Content (both electrodes combined) [d]	mg/cm^2	3.0	0.5	0.125
	g/kW	0.8	0.1	0.03
Performance		2.0 A/cm2 @ 1.9 V/cell	3.0 A/cm2 @ 1.8 V/cell	3.0 A/cm2 @ 1.6 V/cell
Electrical Efficiency [e]	kWh/kg H_2 (% LHV)	51 (65%)	48 (69%)	43 (77%)
Average Degradation Rate [f]	mV/kh (%/1,000 h)	4.8 (0.25)	2.3 (0.13)	2.0 (0.13)
Lifetime [g]	Operation h	40,000	80,000	80,000
Capital Cost [h]	$/kW	450	100	50
System				
Energy Efficiency	kWh/kg H_2 (% LHV)	55 (61%)	51 (65%)	46 (72%)
Uninstalled Capital Cost [h]	$/kW	1,000	250	150
H_2 Production Cost [i]	$/kg H_2	>3	2.00	1.00

https://www.energy.gov/eere/fuelcells/hydrogen-production-related-links#targets

DOE HFTO periodically updates targets as advances are made and data becomes available

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 applications specific targets



†Based on 275 kW Heavy Duty Fuel Cell System Cost Analysis (2022), adjusted to reflect cost of system that meets 25,000 hours durability

+2.5 to 4 cents/kWh, 50% capacity factor, $1000/kW-$1300/kW; See H2 Technologies presentation for details on pending Record.
*2.5 to 4 cents/kWh, 50% capacity factor, $600/kW.

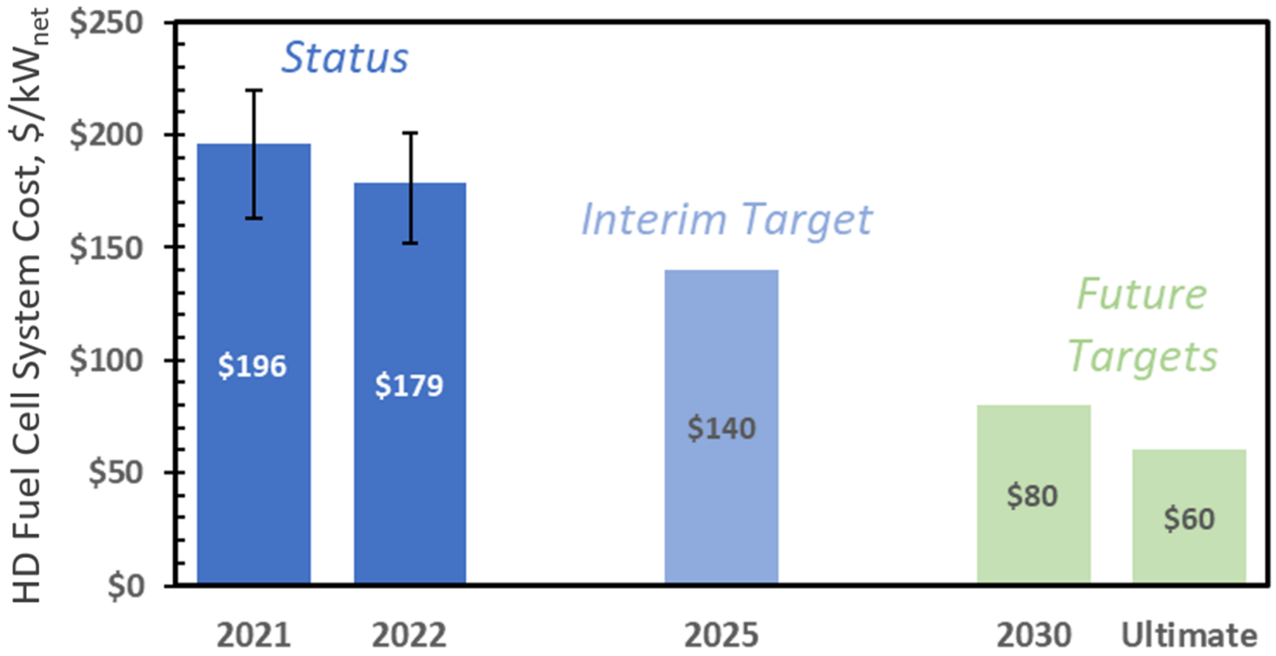
† Delivery and dispensing at today's (2020) stations at ~450 kg/day
*Delivery and dispensing at today's (2020) stations with capacity 450-1,000 kg/day at high volume manufacturing. Note high volatility and market/supply chain factors; current at station H_2 prices as high as ~ $25/kg in some regions

ǂ Storage costs based on 2019 storage cost record

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

Heavy Duty Truck Fuel Cell Durability-Adjusted Costs (for 25,000-hour lifetimes)

Modeled cost of a 275-kWnet HD Truck PEMFC system



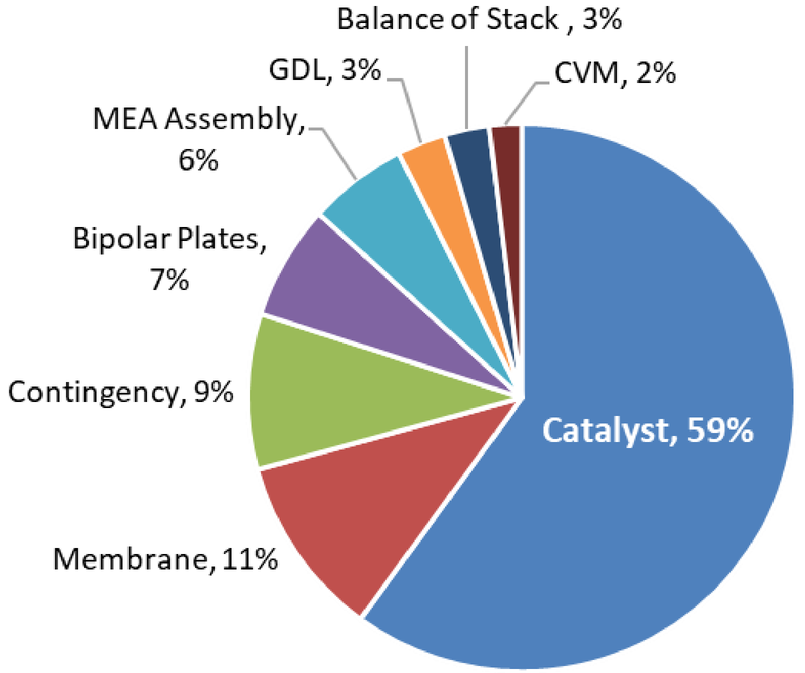
Cost status (2021, 2022) and interim target (2025) for a manufacturing volume of 50,000 systems/yr. Future (2030, ultimate) targets at 100,000 systems/yr; ($302/$kW_{net}$ at 1,000 systems/yr; $179/$kW_{net}$ at 50,000 systems/yr; $170/$kW_{net}$ at 100,000 systems/year

MILLION MILE FUEL CELL TRUCK
U.S. DEPARTMENT OF ENERGY

DOE Million Mile Fuel Cell Truck Consortium with labs, industry, universities to achieve cost, durability, efficiency targets

Stack cost breakdown

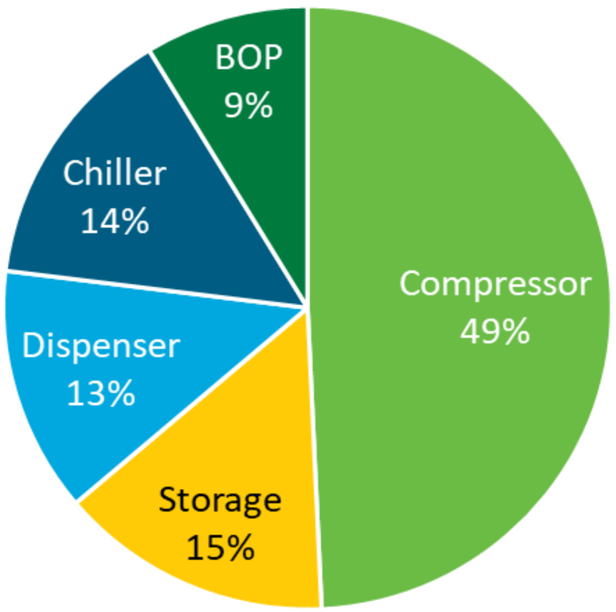
($112/$kW_{net}$ at 50,000 systems/year)



In addition to stack cost and catalysts and MEAs, more work needed on non-PFSA and high T membranes, BOP, and supply chain

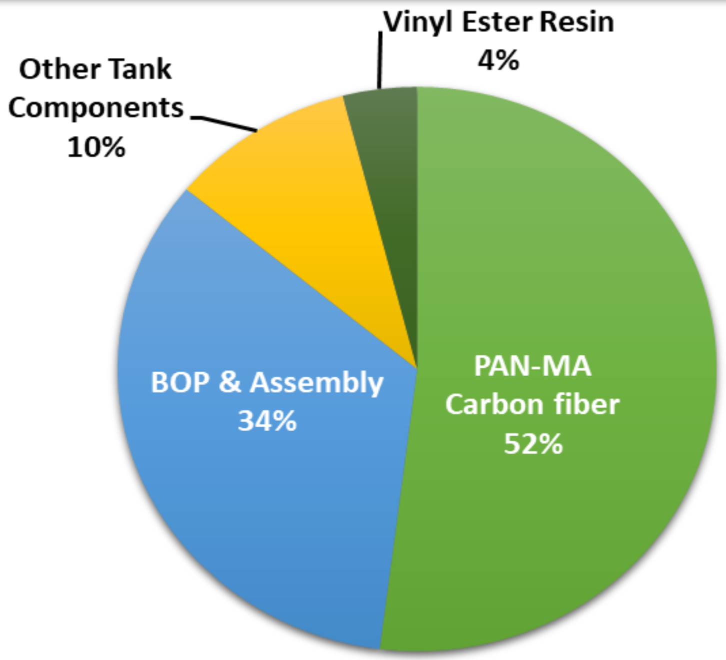
Examples of Cost Drivers and Focus Areas for Hydrogen Technologies

H_2 Infrastructure Cost Drivers:
Compressors, Chiller, Dispenser and Storage



Hydrogen Fueling Station Levelized Cost Example
(700 Bar, 800 kg/day Station)

H_2 Onboard Storage Cost Drivers:
Carbon Fiber Precursors and Processing

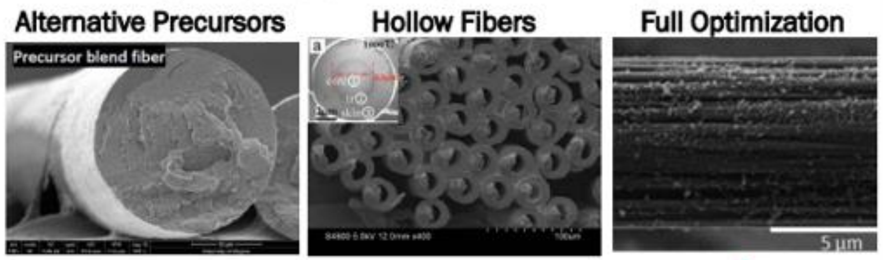


On-board Vehicle Hydrogen Storage Cost Example
(700 bar Type IV, 5.6 kg Hydrogen Storage System)

Additional R&D Needs: Sensors for ppb detection of H_2, infrastructure components (nozzles, dispensers, meters), liquefaction, sub-surface 10-100 tonne storage, and more

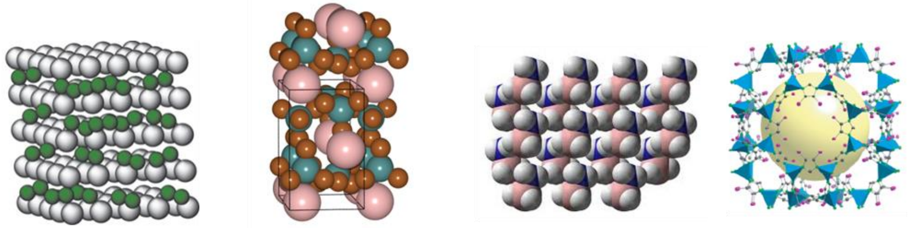
Examples of Hydrogen Storage RD&D Needs

RD&D needed on low-cost carbon fiber precursors



University of Virginia

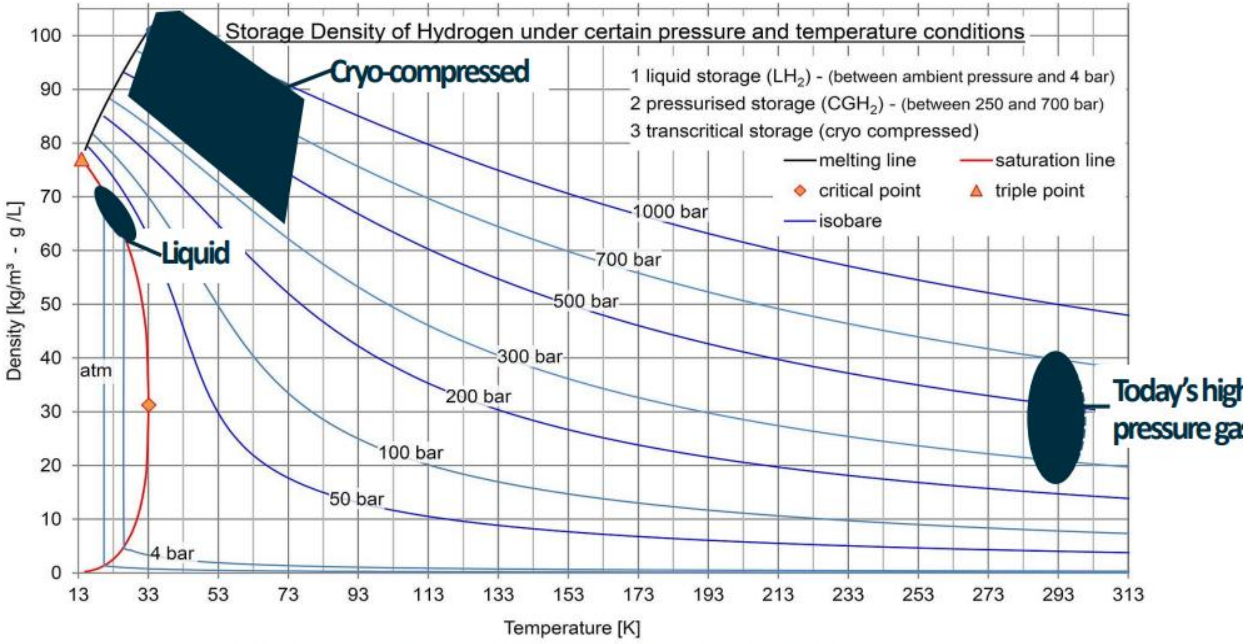
Materials-based storage and chemical carriers R&D continues. Expanding to demonstrations.



interstitial hydrides	complex hydrides	chemical storage	sorbents
~100-150 g H_2/L	~70-150 g H_2/L	~70-150 g H_2/L	≤ 70 g H_2/L

HyMARC

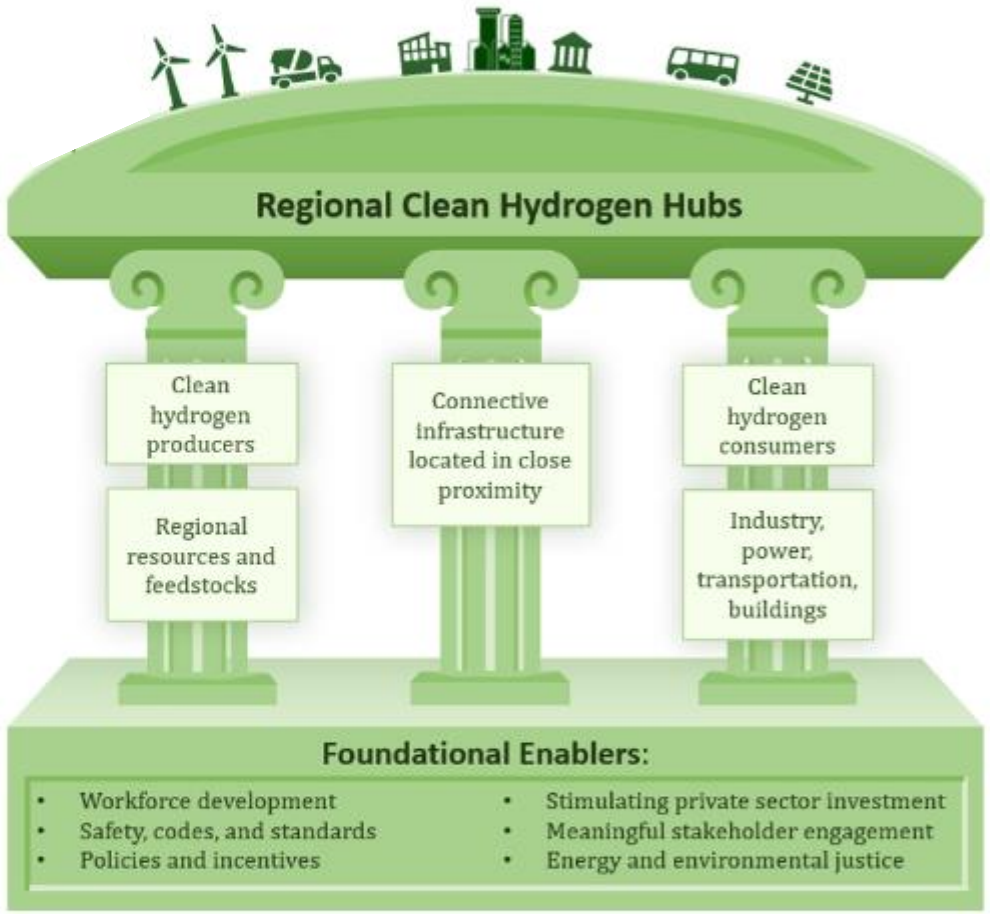
Phase diagram for hydrogen shows regions of high energy density. Insulation and boil off reduction RD&D needed.



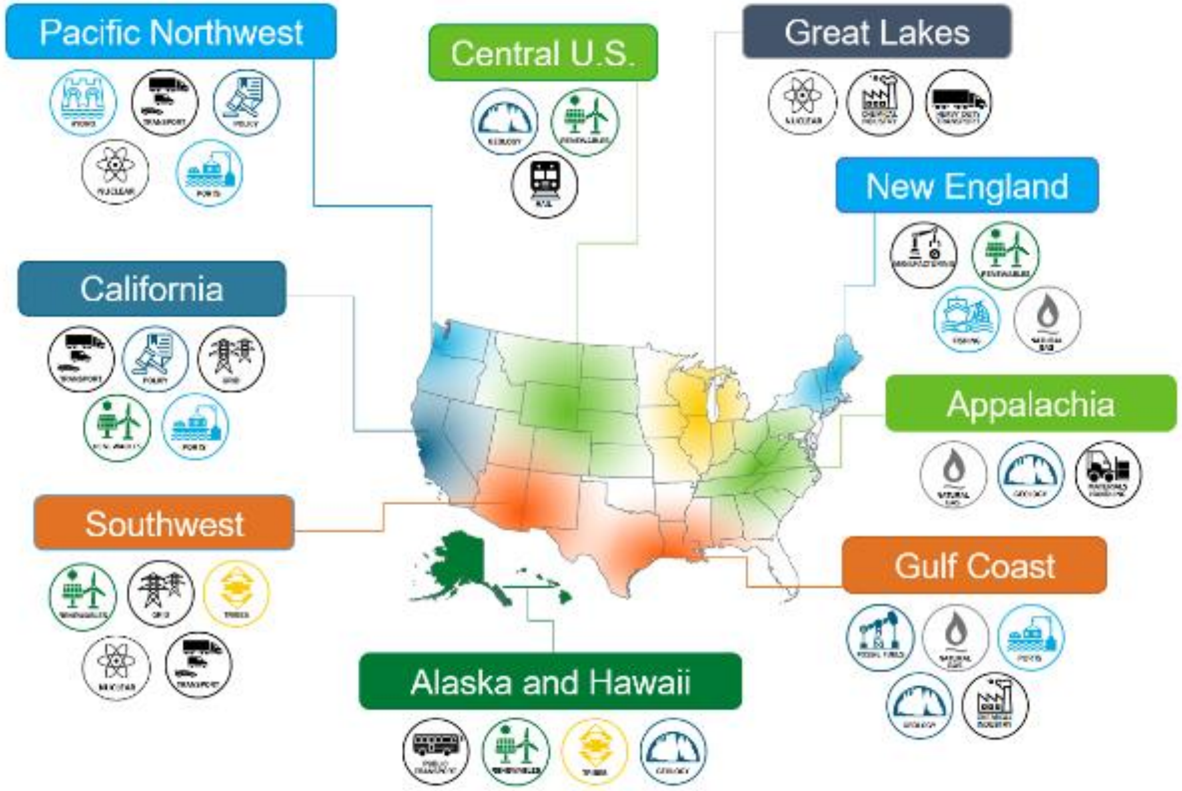
ANL analysis (preliminary) shows potential for:

- 90-200% storage capacity increase
- 25% less cost (at 5,000 units/yr)
- 46% less carbon fiber composite

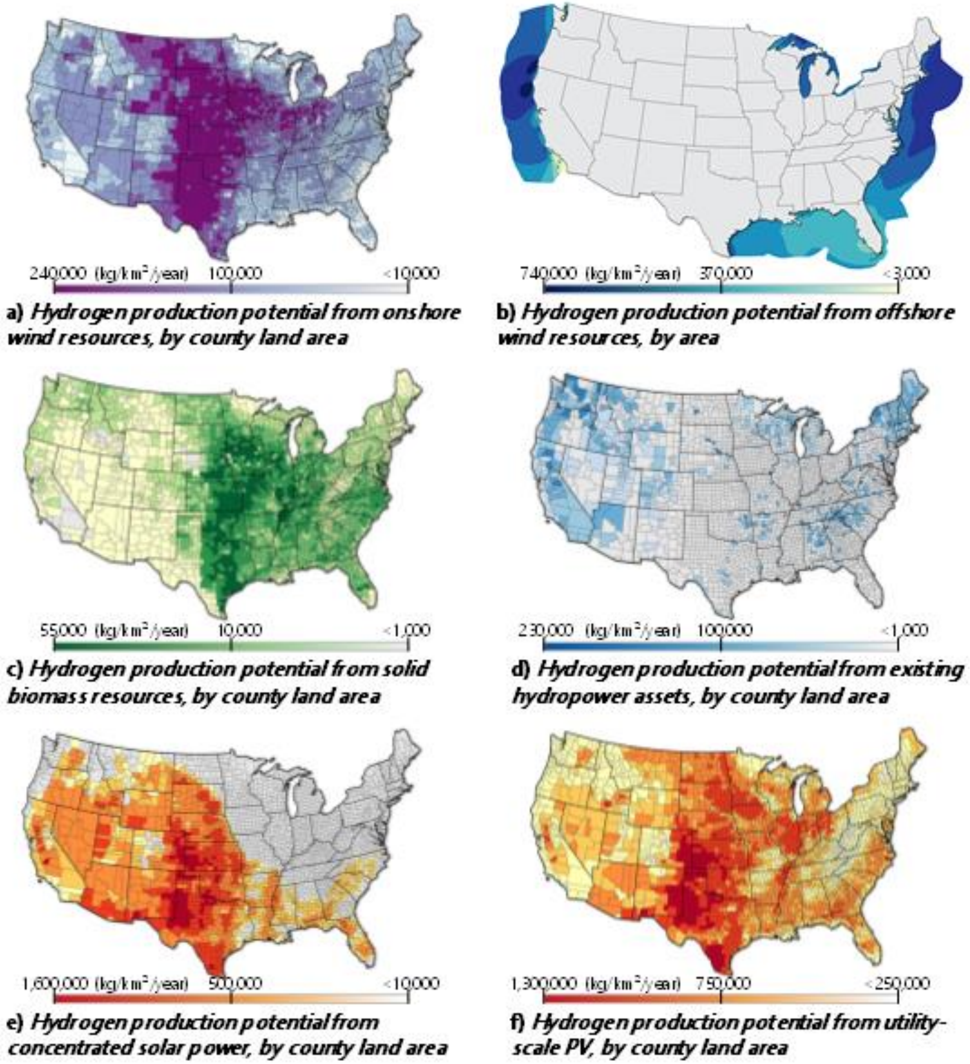
Build Regional Networks through "Clean Hydrogen Hubs"



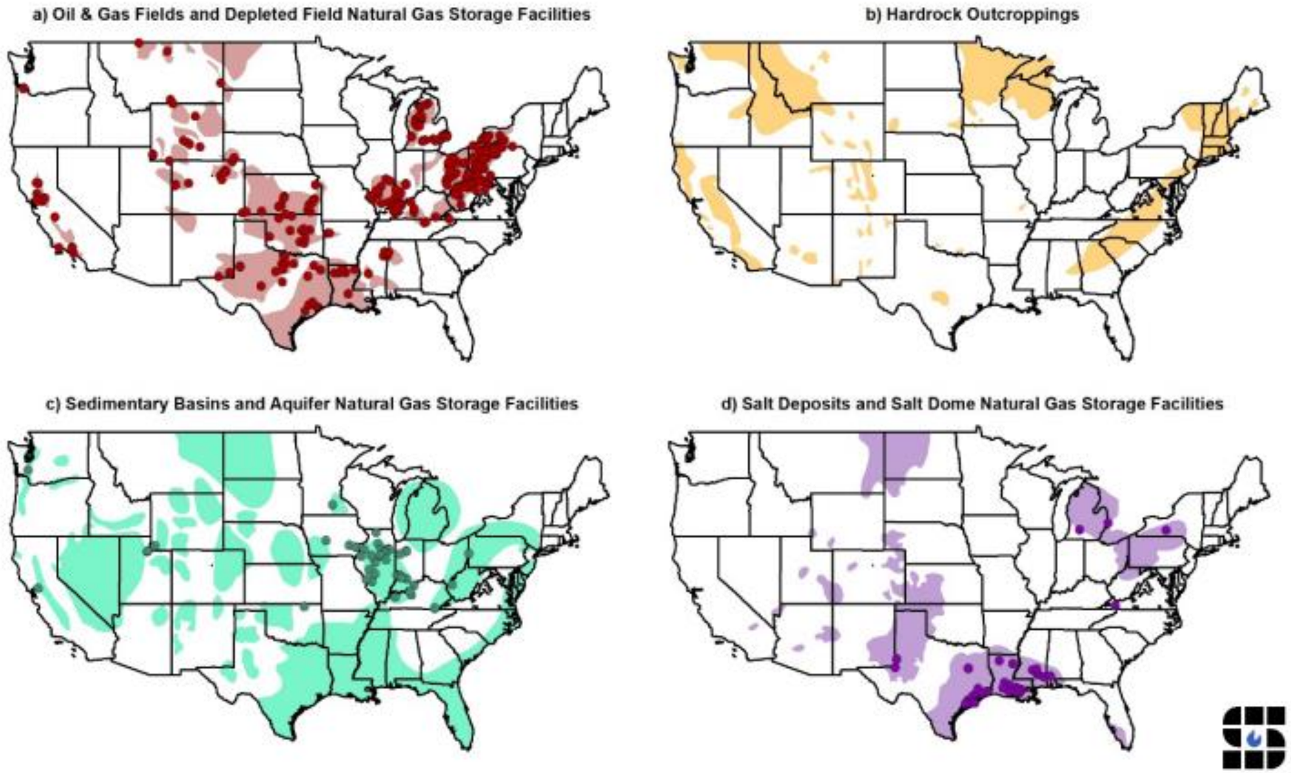
Examples of Stakeholder and RFI Input



Analysis of Potential Supply Resources and Underground Storage



Source: NREL, Lab analysis, National Strategy

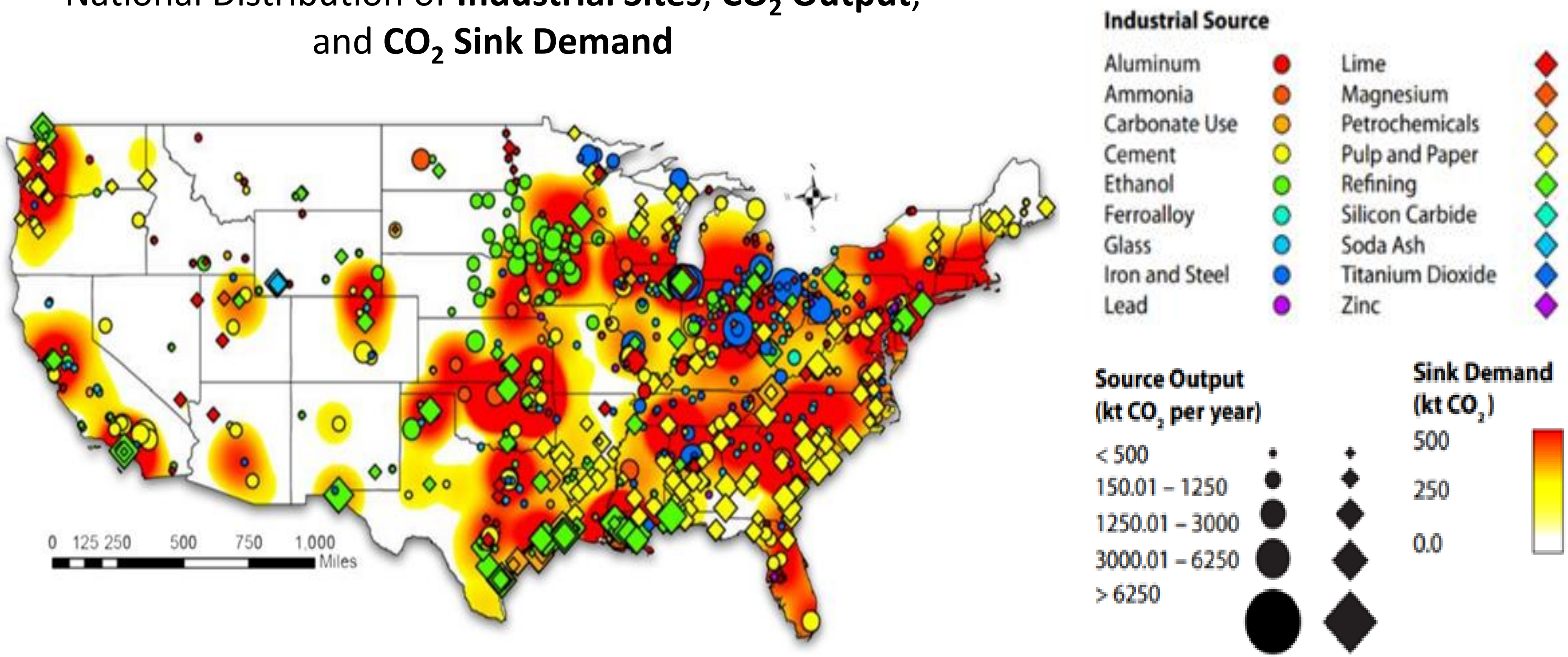


Source: SHASTA, NETL, funded by FECM

Example: Industrial Clusters to Enable Large-Scale Offtakers

Priority deployments for hydrogen in industry include sectors where other decarbonization pathways are challenging, such as high-temperature heat generation, steelmaking, and ammonia production.

National Distribution of **Industrial Sites**, **CO_2 Output**, and **CO_2 Sink Demand**



Mapping industrial sites to CO_2 sources and demands can help identify **industrial clusters for potential decarbonization hubs**

Adapted from Carbon Capture and Utilization in the Industrial Sector | Environmental Science & Technology (acs.org)

Ongoing Work and Accomplishments to Address Key Priorities

Examples of DOE Hydrogen Program Enabled Accomplishments

Innovation

1,306 Patents

in hydrogen and fuel cell technologies through HFTO funding from Labs, Industry and Academia

36% from National Labs

Technology-to-Market

30 Technologies Commercialized

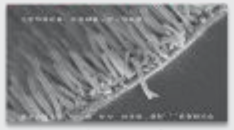
By private industry

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

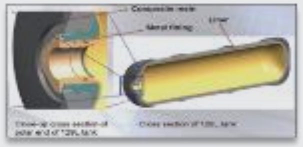
Class-1, -2, and -3 Forklifts
Plug Power (GenDrive FCs)

Electrolyzers

Electrolyzer System
Proton Series

PEM Electrolyzer System
Giner

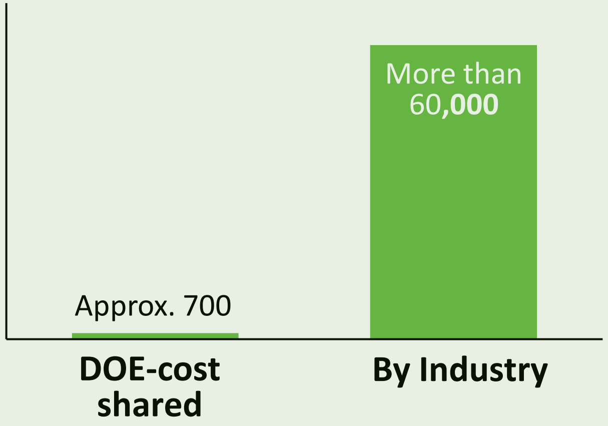
Hydrogen Tanks



Optimized 129L Tank
Quantum Technologies

Market Uptake

Hydrogen fuel cell forklifts in the U.S.



American-made small-scale hydrogen refueler

- Exported to Japan
- Uses electrolysis

DOE Hydrogen Activities across RDD&D – Examples

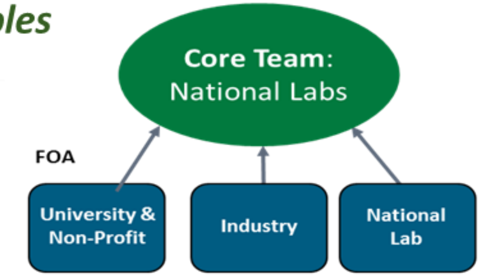
Research and Development

Basic and applied research through individual projects and consortia

Consortia Examples

HydroGEN Advanced Water Splitting Materials

H2NEW U.S. DEPARTMENT OF ENERGY



H-Mat Hydrogen Materials Compatibility Consortium

ElectroCat Electrocatalysis Consortium

HyMARC Hydrogen Materials Advanced Research Consortium

ACT U.S. DEPARTMENT OF ENERGY

MILLION MILE FUEL CELL TRUCK

SHASTA Subsurface Hydrogen Assessment, Storage, and Technology Acceleration

Basic science user facilities, theory, modeling

Technology Integration, Validation, Demos

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

Examples:





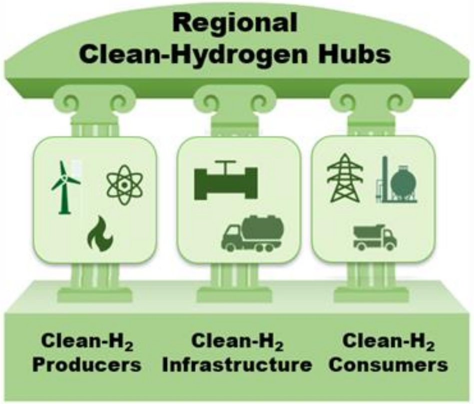

Renewables and nuclear to H_2, 15 delivery trucks in disadvantaged area, 3 Super Truck projects, data center, fueling for passenger ferry, energy storage, H_2 for steel

Deployment and Financing

H2 Hubs, loan guarantee program, workforce development

Example:

$8 billion for at least 4 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

H_2 Matchmaker

Examples of Recent Highlights – Just a Few!

Nation's first integrated (behind the meter) 1.25MW PEM electrolyzer at a nuclear plant (Constellation)

NREL's Heavy-Duty Hydrogen Fast-Flow Research Station

Achieved fast fueling for heavy duty fuel cell trucks

82.3 kg in 6.6 min
12.6 kg/min average
23 kg/min peak

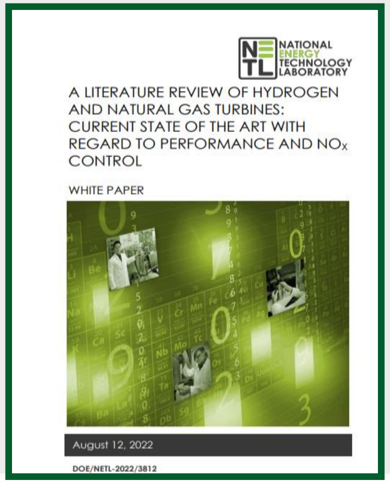
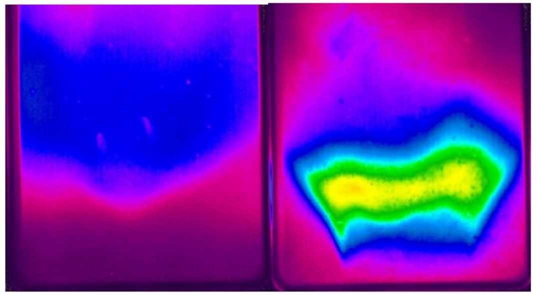


Exhibit 2-1. Chemiluminescence images of flames for natural gas (left) and 80% hydrogen (right)



NETL Review of H_2 and NG turbines

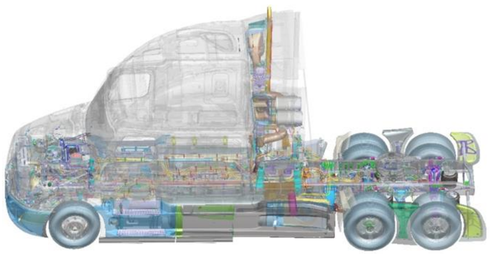
https://netl.doe.gov/sites/default/files/publication/A-Literature-Review-of-Hydrogen-and-Natural-Gas-Turbines-081222.pdf

Hydrogen Fuel Cell Heavy Duty Truck Projects

SuperTruck 3 Demonstrations include H_2 Fuel Cells (>75% GHG Reduction)

DAIMLER

Walmart, Schneider, Linde, MAHLE, Michelin



Argonne National Laboratory, NREL, Oak Ridge National Laboratory, Auburn University, Oregon State University

Goals:
- Demonstrate 2 total (Class 8) HD long-haul fuel cell electric trucks (B-sample & final truck demo)
- 6.0 mi/kg H2 fuel economy
- 600-mile range (onboard LH_2 storage)
- 65,000 pounds GVW

Fleet Operators: Schneider National, Walmart

general motors

Southern Company, nel, Argonne National Laboratory

Goals:
- Demonstrate 8 total (Class 4-6) MD trucks
  - 4 fuel cell & 4 battery electric trucks
- Fuel Cell System Goals:
  - 65% peak efficiency
  - <$80/kW system cost (100K units/yr)
  - 20K-30K hour lifetime
- Demonstrate microgrid w/ electrolyzer & fuel cell (H_2 fueling & fast charging)

Fleet Operators: Southern Co, Metro Delivery

The above image is not final product/visual and is subject to change

Ford Motor Company

Ferguson, Consumers Energy (Count on Us), SoCalGas

FEV, NREL

Goals
- Demonstrate 5 total (Class 4-6) MD vocational trucks
- 300+kW net vehicle power, H_2 PEM FC + Li-Ion battery
- 300-mile range (700 bar H_2 storage)
- 10K/20K pounds payload/tow capacity

Fleet Operators: Consumers Energy, Ferguson, SoCalGas

H2Rescue – “H_2 to the Rescue” for disaster or emergency response

Demonstrating prototype fuel cell emergency relief truck that can deploy to a disaster and power 20+ American homes for 3-days during a grid outage.

U.S. Government Team

U.S. ARMY

Office of Naval Research ONR Science & Technology

DEVCOM GROUND VEHICLE SYSTEMS CENTER

US Army Corps of Engineers

U.S. NAVAL RESEARCH LABORATORY

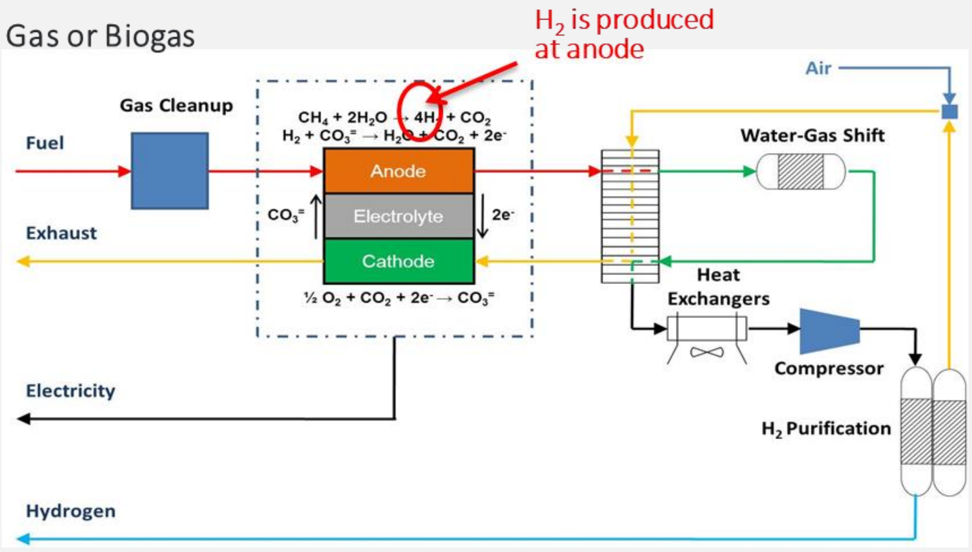
Science and Technology & FEMA

Key Stats

- Kenworth Class 7 Truck
- 176 kg H_2 Onboard (700 Bar)
- 90 kW Fuel Cell System / 155 kWh battery
- 245 kW Tractor Motor
- Range: 180 miles + 72h of export power up to 25 kW
- Road testing & demos ongoing

Example of innovation: Government RD&D to industry scale up

DOE co-funded world's first tri-gen: to co-produce power, heat and hydrogen. Uses biogas from wastewater treatment plant



FuelCell Energy Air Products

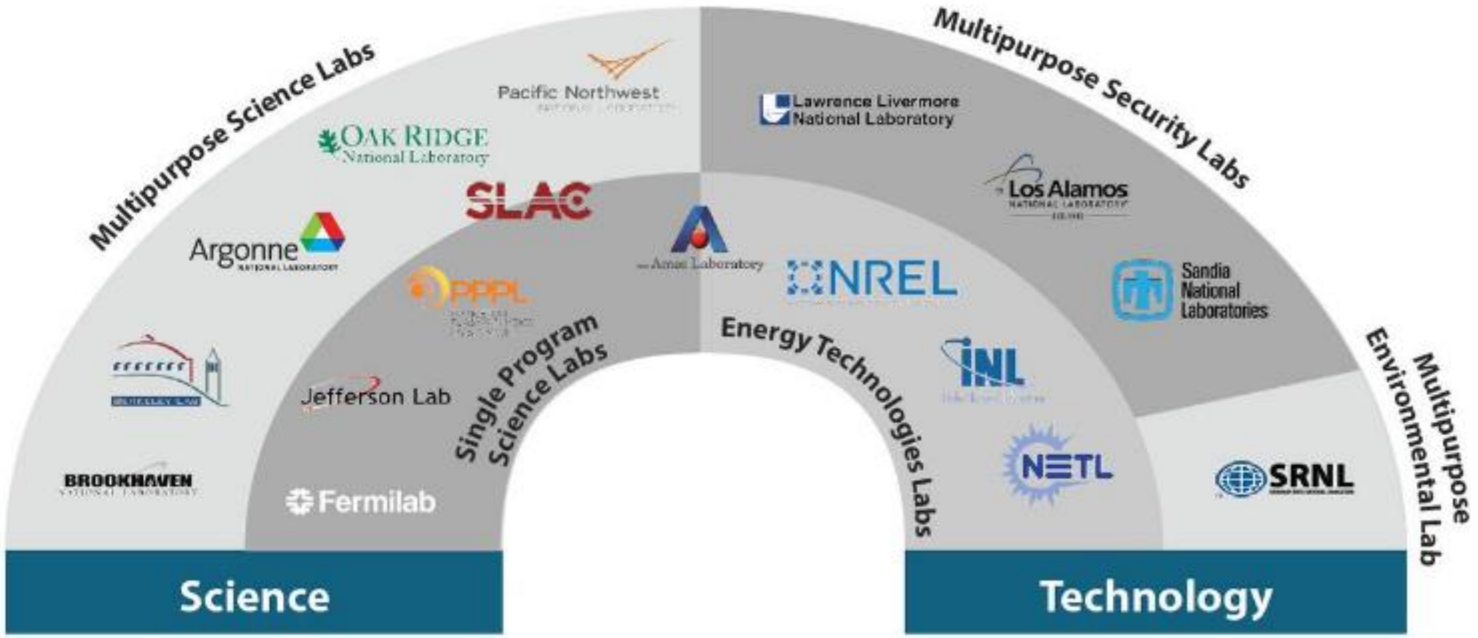
Fountain Valley Demonstration Completed
~250 kW of electricity. ~100 kg/day hydrogen capacity (350 and 700 bar), enough to fuel 25 to 50 vehicles.

Today industry is building a 2.5 MW trigen facility at the Port of Long Beach (Fuelcell Energy, Toyota, and partners)!

https://www.linkedin.com/feed/update/urn:li:activity:7031751541216665600?utm_source=share&utm_medium=member_desktop

DOE National Laboratories

Strategy leverages DOE National Laboratories, partnering with industry and academia



DOE National Laboratories across energy, science, and security:

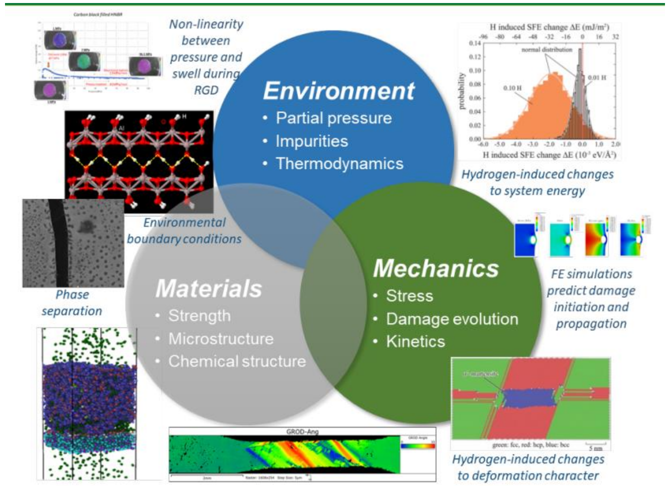
- Support RD&D
- Offer User Facilities and science resources
- Help to de-risk technology adoption, accelerating progress

H-Mat and HyBlend Consortia – labs, industry, and academia

RD&D on materials compatibility and enabling H_2-natural gas blends

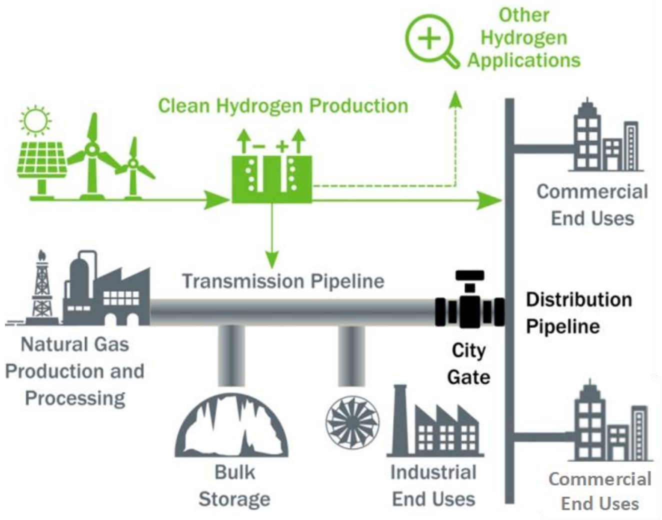
H-Mat Hydrogen Materials Compatibility Consortium

Pacific Northwest



Elucidating mechanisms of H2-materials interactions to inform design of materials with improved resistance to H2 degradation

HyBlend
U.S. DEPARTMENT OF ENERGY

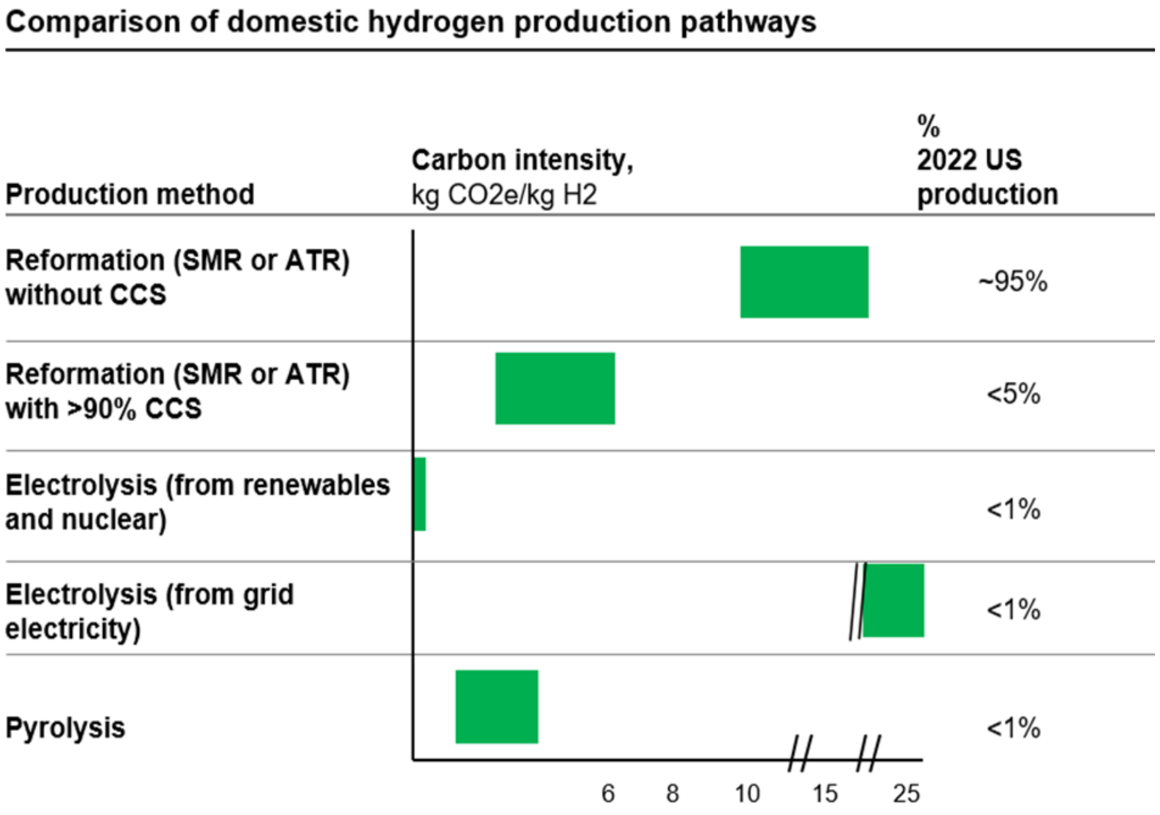


Includes metals and polymer R&D, life cycle analysis, and technoeconomic analysis – to inform and enable H2 blending with NG

https://www.energy.gov/eere/fuelcells/hyblend-opportunities-hydrogen-blending-natural-gas-pipelines

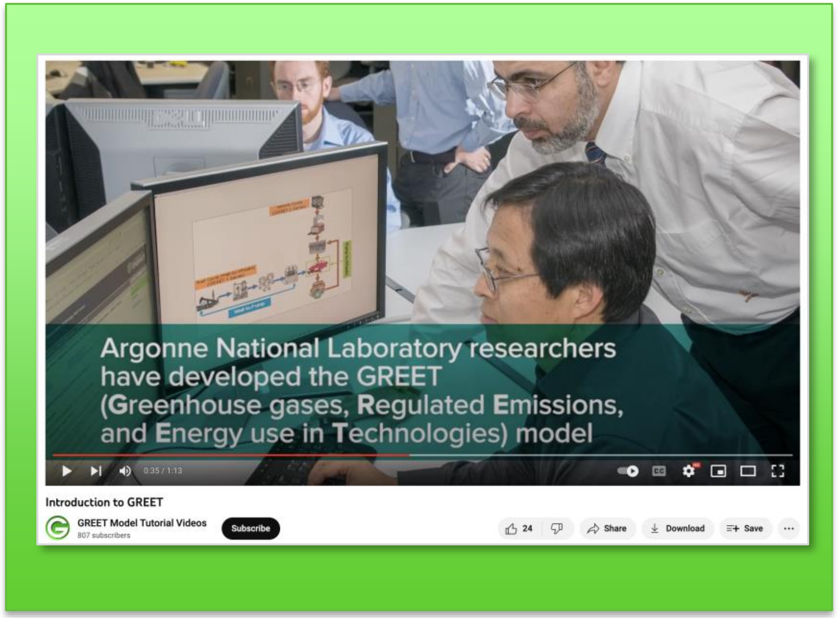
Life Cycle Emissions Analysis

Carbon Intensity Ranges



Well to gate emissions includes upstream emissions
For full life cycle emissions including upstream manufacturing, mining, etc., more data and analysis are needed

Learn how to use GREET Model



GREET Model Tutorial Videos
@greetmodeltutorialvideos5576 812 subscribers 27 videos
More about this channel >
YouTube

www.youtube.com/@greetmodeltutorialvideos5576

Partners include U. MN, GPI

GREET: Greenhouse gases, Regulated Emissions, and Energy use in Technologies

Energy and Environmental Justice

Diversity, Equity, Inclusion, and Accessibility

“No one can whistle a symphony. It takes a whole orchestra to play it.”

- H. Luccock

Example of DOE-funded Project in a Disadvantaged Community

DOE project with CTE for UPS Fuel Cell Delivery Vans in Ontario, CA

UPS truck at hydrogen fueling station

Commercial service in disadvantaged communities!

Key Accomplishments and Status:

- 15 trucks built; validation testing complete on 10
- Training complete. First package delivered!

Project impact per year: Savings of

- 285 metric tons of CO2-eq
- 280,000 grams of criteria pollutants
- 56,000 gallons of diesel

Justice 40 & Disadvantaged Communities

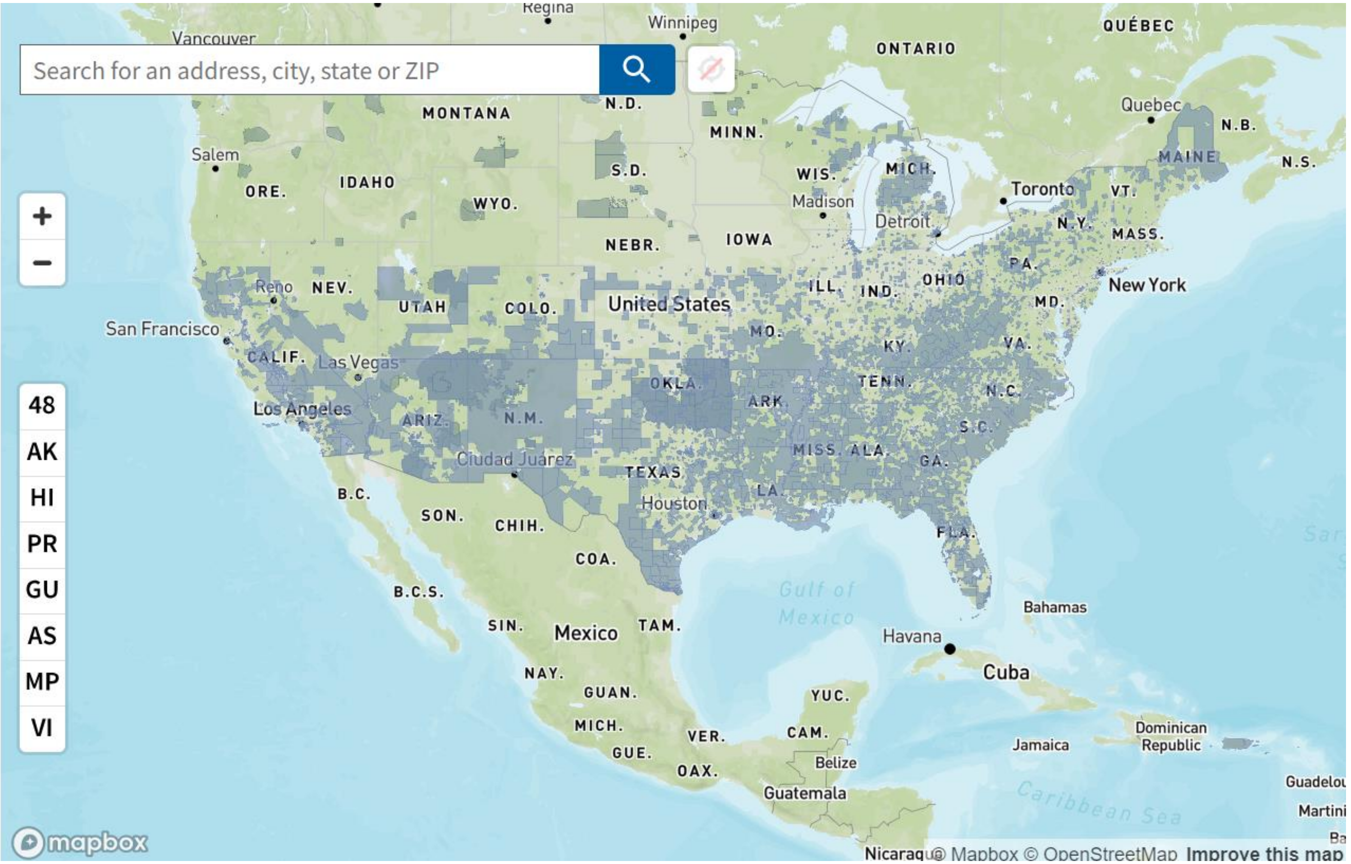
Communities are considered disadvantaged:

•If they are in a census tract or geographically dispersed groups that share a common characteristic and meet the thresholds for at least one of the tool's categories of burden listed below, or
•If they are on land within the boundaries of Federally Recognized Tribes

INDICATORS:

- CLIMATE CHANGE
- ENERGY
- WATER & WASTEWATER
- HEALTH
- HOUSING
- TRANSPORTATION
- LEGACY POLLUTION
- WORKFORCE DEVELOPMENT

Distribution of census tracts identified as DACs



Census tracts that are overburdened and underserved are highlighted as being **disadvantaged** on the map. Federally Recognized Tribes, including Alaska Native Villages, are also considered disadvantaged communities.

[Explore the map - Climate & Economic Justice Screening Tool (geoplatform.gov)](https://screeningtool.geoplatform.gov)

Global Collaboration

Call to Action: Join the Center for Hydrogen Safety!

www.aiche.org/CHS

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

New Hydrogen Safety Credential!

Composed of 7 fundamental hydrogen safety e-courses, including:

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

H2 Twin Cities 2022 Winners Announced!

- **Announced at COP27 on Nov 16** by US DOE Sec. Granholm in collaboration **with UK, Japan and CEM H2I**

- H2 Twin Cities 2023: To be soon and to focus on **Mentor-Mentee partnerships**

Learn more about the winners: www.energy.gov/eere/h2twincities/h2-twin-cities-2022-winners

Examples of International Collaboration

Collaborating through multiple global and bilateral partnerships—key priority is creating coordinated framework to leverage activities, identify gaps, and avoid duplication to accelerate progress

iea

H_2 TWIN CITIES

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

HYDROGEN INITIATIVE
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

Glasgow Breakthroughs @ COP26

MISSION INNOVATION

H_2 CLEAN HYDROGEN MISSION

CENTER FOR Hydrogen SAFETY 水素安全センター
Connecting a Global Community

hySafe

FCH

PRHYDE
Protocol for heavy-duty hydrogen refuelling

PRESLHY

CEM Global Ports Coalition with EC
Numerous Bilaterals on Hydrogen
Hydrogen Council, IRENA, and more

IPHE

The International Partnership for Hydrogen and Fuel Cells in the Economy

Enabling the global adoption of hydrogen and fuel cells in the economy

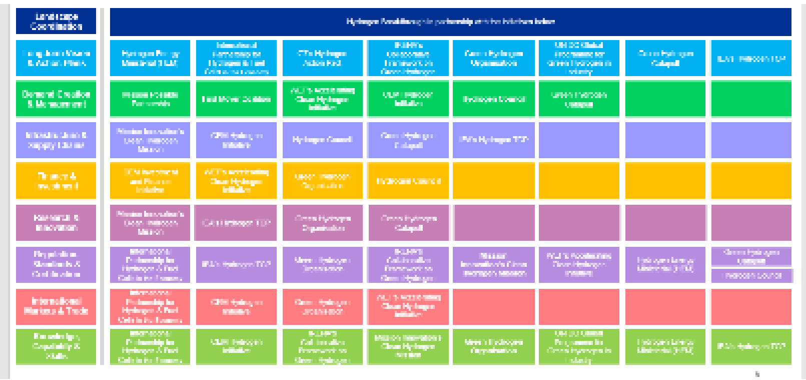
H_2 Production Analysis (H2PA)
To facilitate international trade
Common analytical framework for GHG emissions footprint

Regulations, Codes, Standards, Safety and Education & Outreach Working Groups

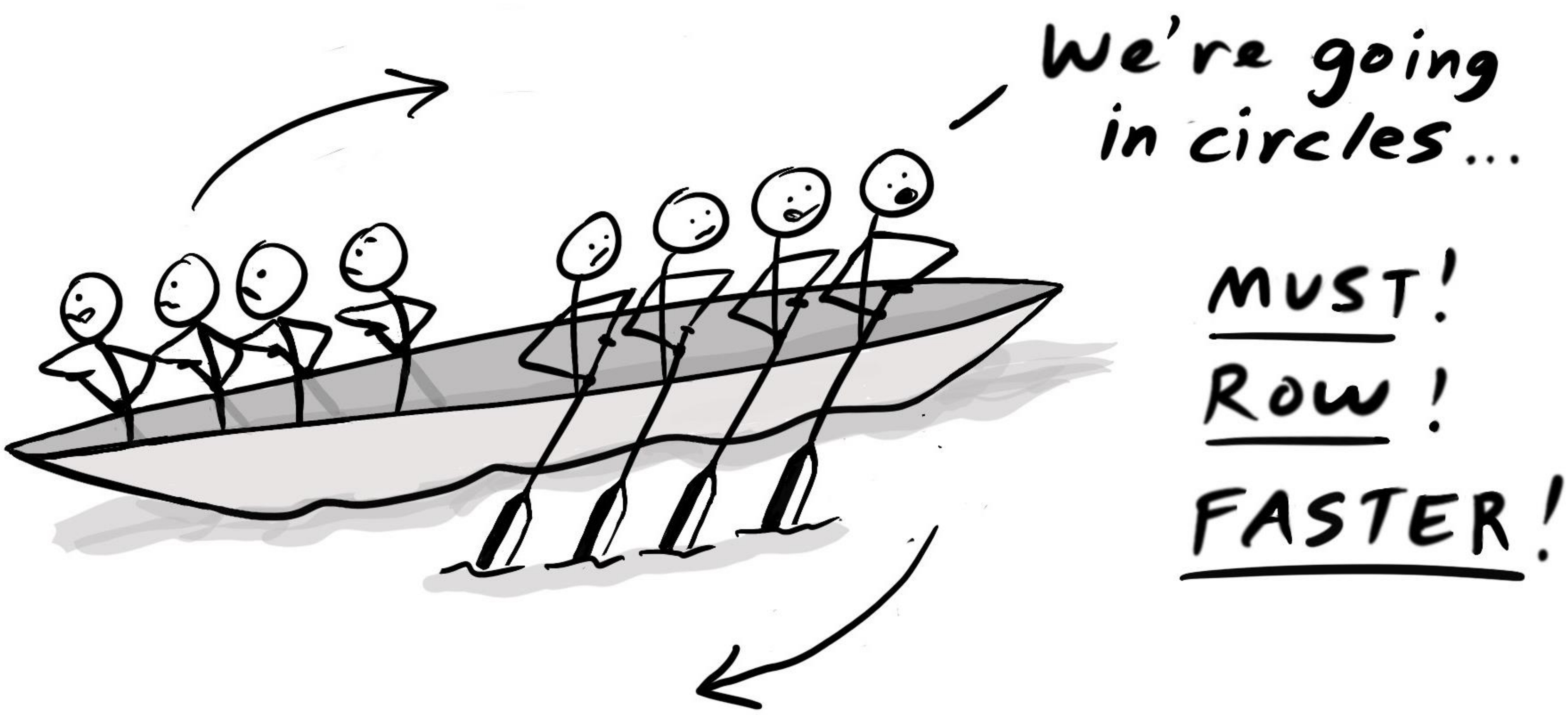
www.iphe.net

GLASGOW BREAKTHROUGHS

Breakthrough Agenda in collaboration with other partnerships is mapping activities across global H_2 initiatives to identify gaps, focus areas, and prioritized workstreams

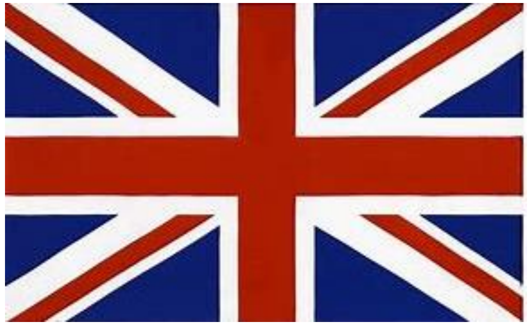


We need to make sure we're rowing together…



And in the same direction!

Congratulations to India on joining co-leadership of Breakthrough Agenda



& More

GLASGOW BREAKTHROUGHS

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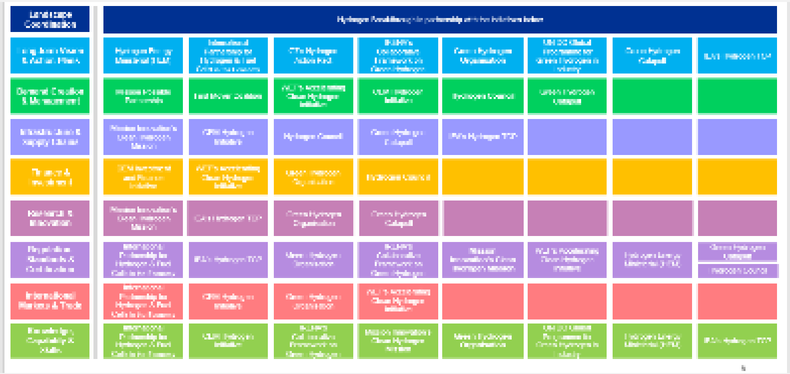

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Mapping of International Hydrogen Initiatives and Priorities

Hydrogen Breakthrough – Overview of the Priority Actions for 2023

BREAKTHROUGH AGENDA

a joint project of CEM & MI

Priority International Action	Coordinating initiative(s) To date
H.1: Standards & Certification Accelerate the development of standards for clean hydrogen	IPHE, IEA's Hydrogen TCP, IRENA's Collaborative Framework on Green Hydrogen
H.2: Demand Creation & Management Coordinate internationally to drive demand for clean hydrogen	First Movers Coalition, Clean Energy Ministerial Hydrogen Initiative, Mission Innovation Clean Hydrogen Mission
H.3: Research & Innovation Expand the number and scope of innovative clean hydrogen projects	Mission Innovation Clean Hydrogen Mission
H.4: Finance & Investment Scale and facilitate access to financial & technical assistance, particularly for developing countries	World Bank & UNIDO
H.5: Landscape Coordination Enhance the coordination and transparency of international collaboration on clean hydrogen	Breakthrough Agenda project team in close partnership with initiatives

Under discussion among partnerships

IPHE Early Career Network

- 350+ members
- 40 countries
- **Students, post-docs**, and **early career professionals** worldwide
- Networking
- Career Development
- Webinars
- Leadership Opportunities

International Partnership for Hydrogen and Fuel Cells in the Economy

Early Career Network

Join IPHE Early Ca LinkedIn Group

www.iphe.net/early-career-chapter

The redwoods are the tallest trees on earth—growing tall and enduring long dry spells—on harsh terrain and despite shallow roots.

They are able to do this through the collective strength of their roots which are an interwoven system, where each tree supports—and is supported by—the trees around it.

Resources and Opportunities for Engagement

Save the date!

2024 DOE Annual Merit Review and Peer Evaluation Meeting
May 6-9, 2024

Hydrogen and Fuel Cells Day
October 8

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

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H
Hydrogen

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hydrogen.energy.gov

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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: Champions #1 for Element #1

Thank you

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

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