U.S. DEPARTMENT OF ENERGY

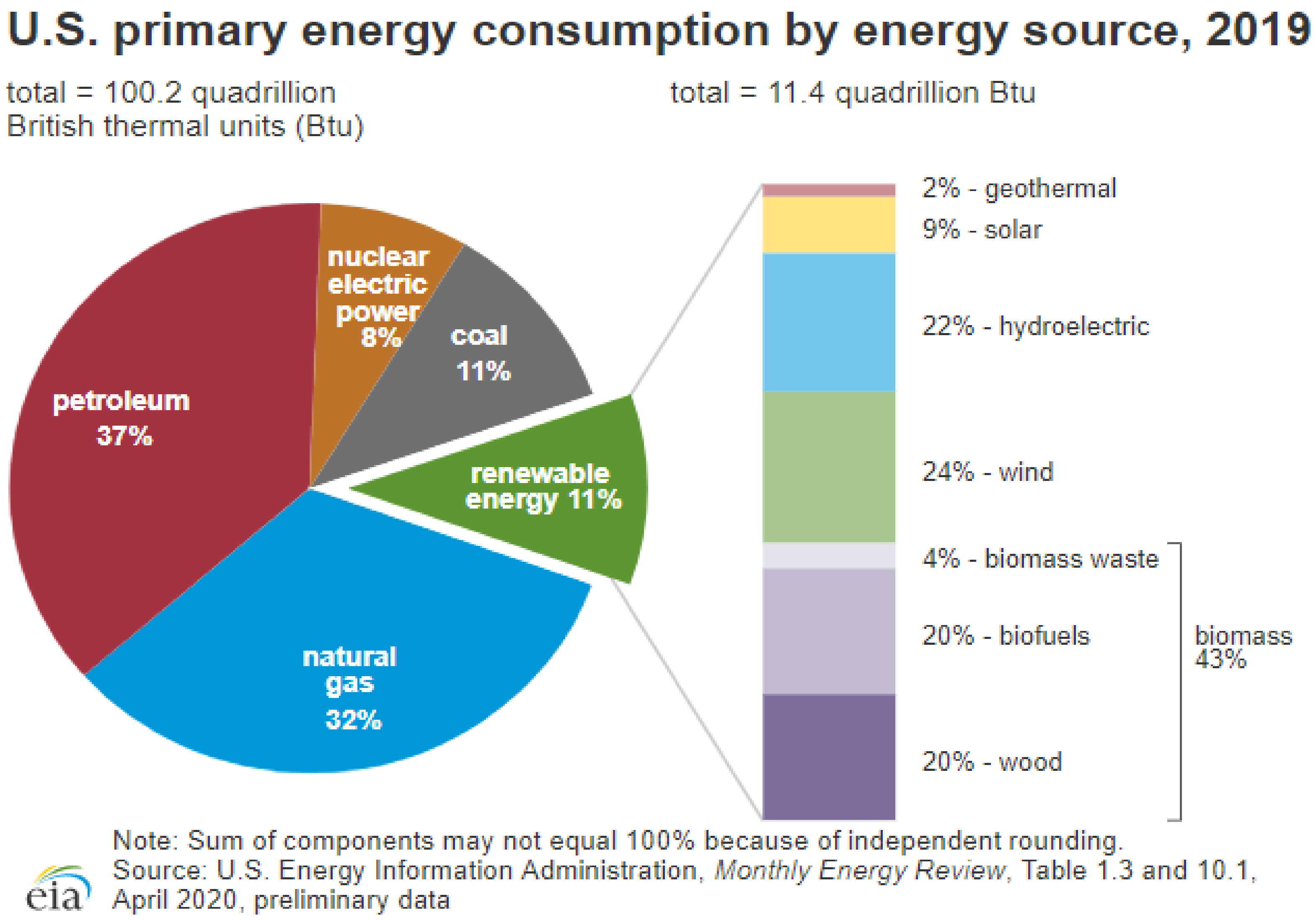
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

U.S. Department of Energy Hydrogen Activities and Hydrogen Shot Overview

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

March 2022

U.S. Energy Landscape and Key Goals



Administration Goals include:

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

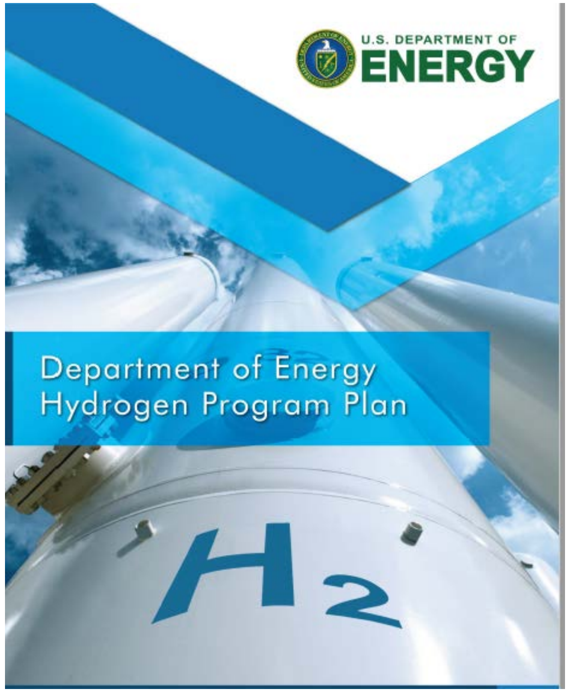
Priorities: Ensure benefits to all Americans, focus on jobs, EJ40: 40% of benefits in disadvantaged communities

EJ: Environmental Justice

The U.S. DOE Hydrogen Program

Key DOE Hydrogen Authorizations in Energy Policy Act (2005, 2020) and Infrastructure Investment and Jobs Act (2021)

Hydrogen is one part of a broad portfolio of activities



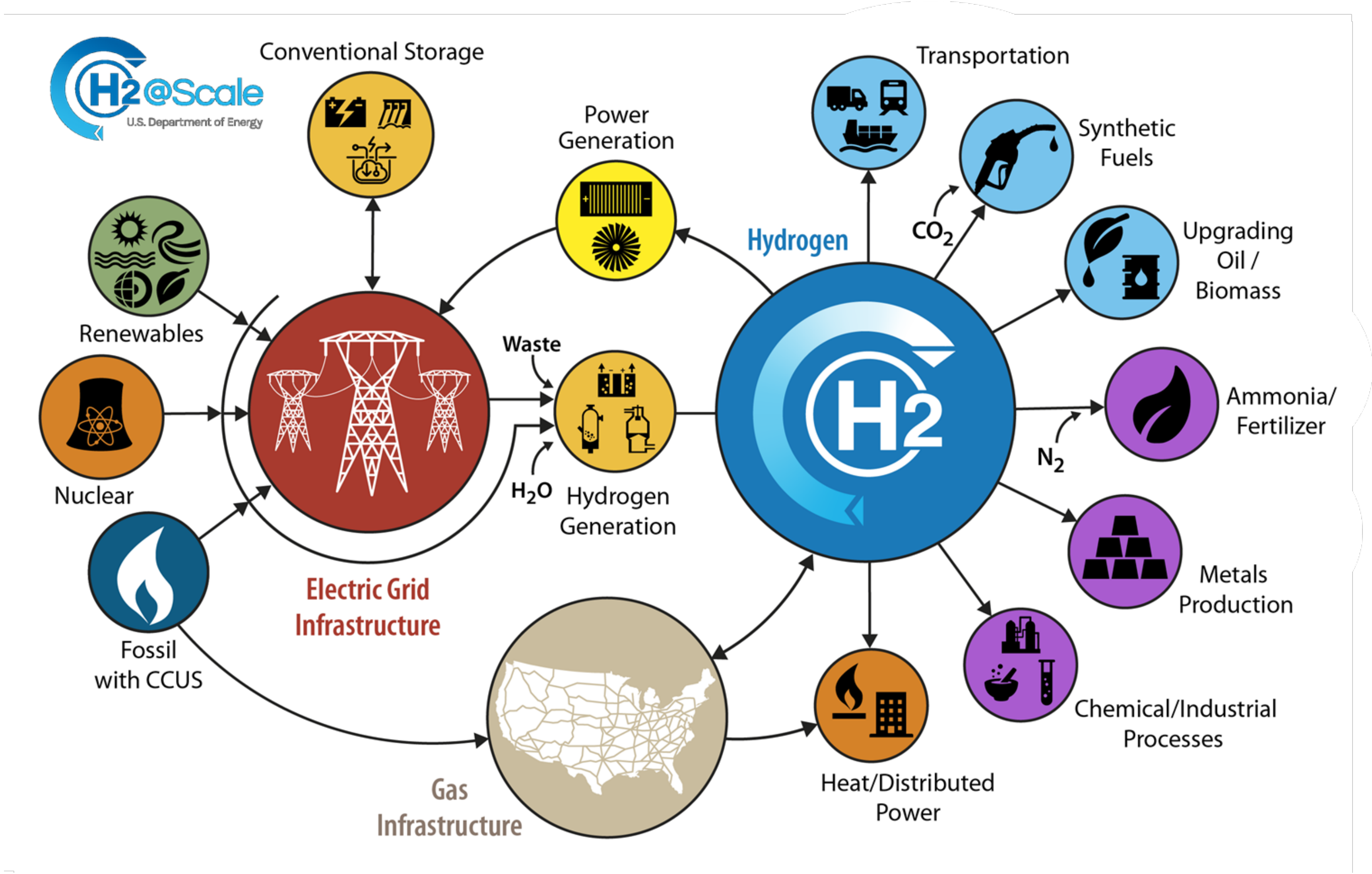
www.hydrogen.energy.gov

Priorities

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

Workforce development, safety, codes, standards, and Environmental Justice priorities

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



Key Opportunities

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

U.S. Snapshot

- 10 MMT of H_2/yr produced today with scenarios for 2-5X growth.
- +10 MMT H_2 would ~ double today's solar or wind deployment
- Potential for 700K jobs, $140B by 2030

Hydrogen Program Areas of Focus Across Multiple Offices

	NEAR-TERM	LONGER-TERM
Production	Electrolysis (low-temperature, high-temperature) Advanced fossil and biomass reforming/conversion/pyrolysis Gasification of biomass, legacy coal waste, and other wastes with carbon capture, utilization, and storage	Advanced thermo/photoelectro-chemical H_2O splitting Advanced biological/microbial conversion
Delivery	Distribution from on-site production Tube trailers (gaseous H_2) Cryogenic trucks (liquid H_2)	Chemical H_2 carriers Widespread pipeline transmission and distribution
Storage	Pressurized tanks (gaseous H_2) Cryogenic vessels (liquid H_2)	Geologic H_2 storage (e.g., caverns, depleted oil/gas reservoirs) Cryo-compressed Chemical H_2 carriers Materials-based H_2 storage
Conversion	Turbine combustion Fuel cells	Advanced combustion Next generation fuel cells Fuel cell/combustion hybrids Reversible fuel cells
Applications	Fuel refining Space applications Portable power Blending in natural gas pipelines Distributed stationary power Transportation Industrial and chemical processes Defense, security, and logistics applications	Distributed CHP Utility systems Integrated energy systems

DOE Program Implementation across RDD&D

New: $100M/5yrs

H2NEW U.S. DEPARTMENT OF ENERGY

Focused Consortia with labs, industry, universities

R&D

Core Team: National Labs

FOA

University & Non-Profit | Industry | National Lab

HyMARC

HydroGEN Advanced Water Splitting Materials

ElectroCat Electrocatalysis Consortium

21CTP / FCTE U.S. DEPARTMENT OF ENERGY

MILLION MILE FUEL CELL TRUCK

2016 — 2018 — 2020

D&D

Trucks, GSE

Infrastructure

CO_2+H_2

Renewables to H_2

Data Center

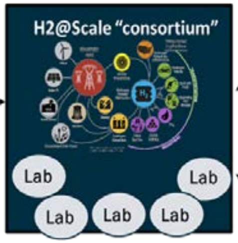
Nuclear to H_2

Ammonia (ARPA-E)

New Super Truck projects

Enablers

Government Funding



CRADAs

SPPs

Comprehensive analysis, tools and models to accelerate progress

Safety, codes, standards, workforce development

Systems integration and validation

H2EDGE Hydrogen Education for a Decarbonized Global Economy

H-Mat Hydrogen Materials Compatibility Consortium

Center for Hydrogen Safety Connecting a Global Community

HyBlend U.S. DEPARTMENT OF ENERGY

Key 2030 Targets

Clean Hydrogen
- $1/kg production
- $2/kg delivery
- $9/kWh storage

Electrolyzers
- $150/kW
- 73% efficiency
- 80Khr durability

Fuel Cells
- $80/kW
- 25Khr durability

Enable EJ40 Priorities, DEI

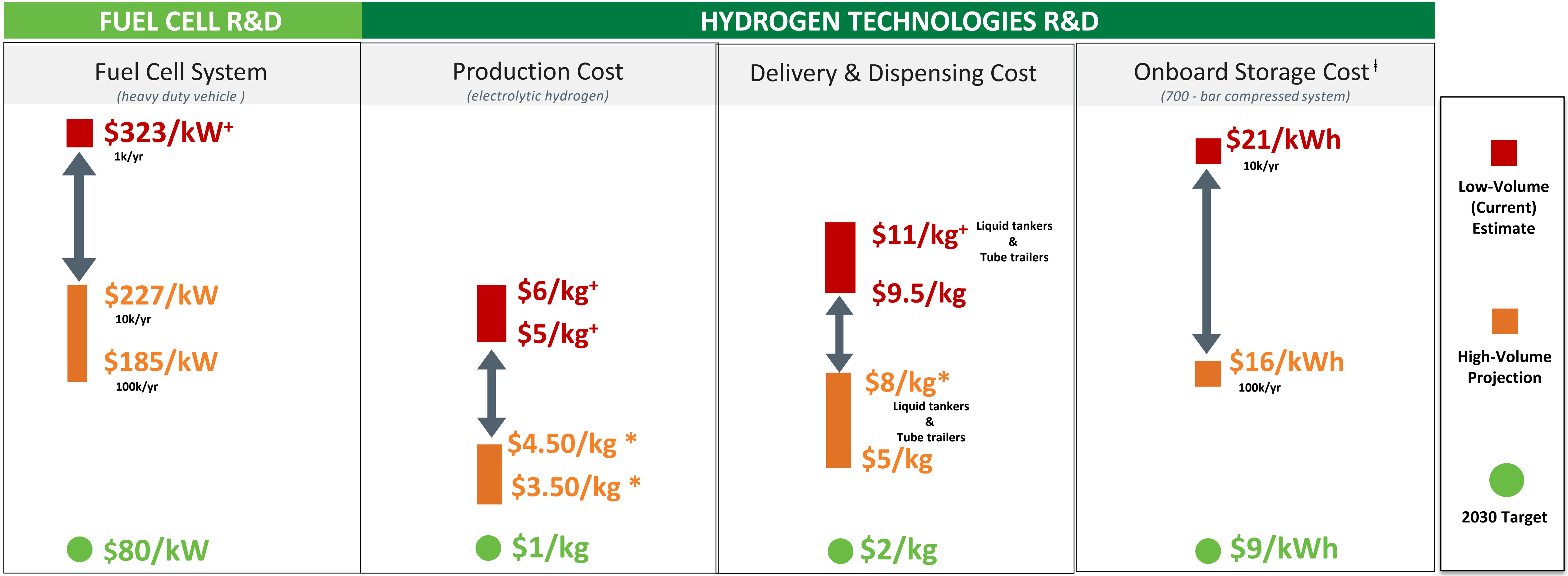
Deployment in collaboration with Loan Program Office

Examples shown, not exhaustive. Over 190 companies, 109 universities, 16 national labs in the last decade; CRADAs are Cooperative Research And Development Agreements

Research and Development

Technology Targets Guide Research and Development Activities

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 (2021), adjusted to reflect cost of system that meets 25,000 hours durability

ǂ5 to 7 cents/kWh, 90% capacity factor at $1500/kW
*5 to 7 cents/kWh, 90% capacity factor at $460/kW

†For range: Delivery and dispensing at today's (2020) stations with capacity ~450 kg/day
*For range: Delivery and dispensing at today's (2020) stations with capacity 450-1,000 kg/day at high volume manufacturing

ǂStorage costs based on 2019 storage cost record

All costs based on $2016

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

Million Mile Fuel Cell Truck Consortium (M2FCT)

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

"Team-of-teams" approach that allows for rapid feedback, idea development, and information exchange, resulting in an effort that is more than the sum of its parts

HD MEA Projects

Carnegie Mellon University, gm, NIKOLA

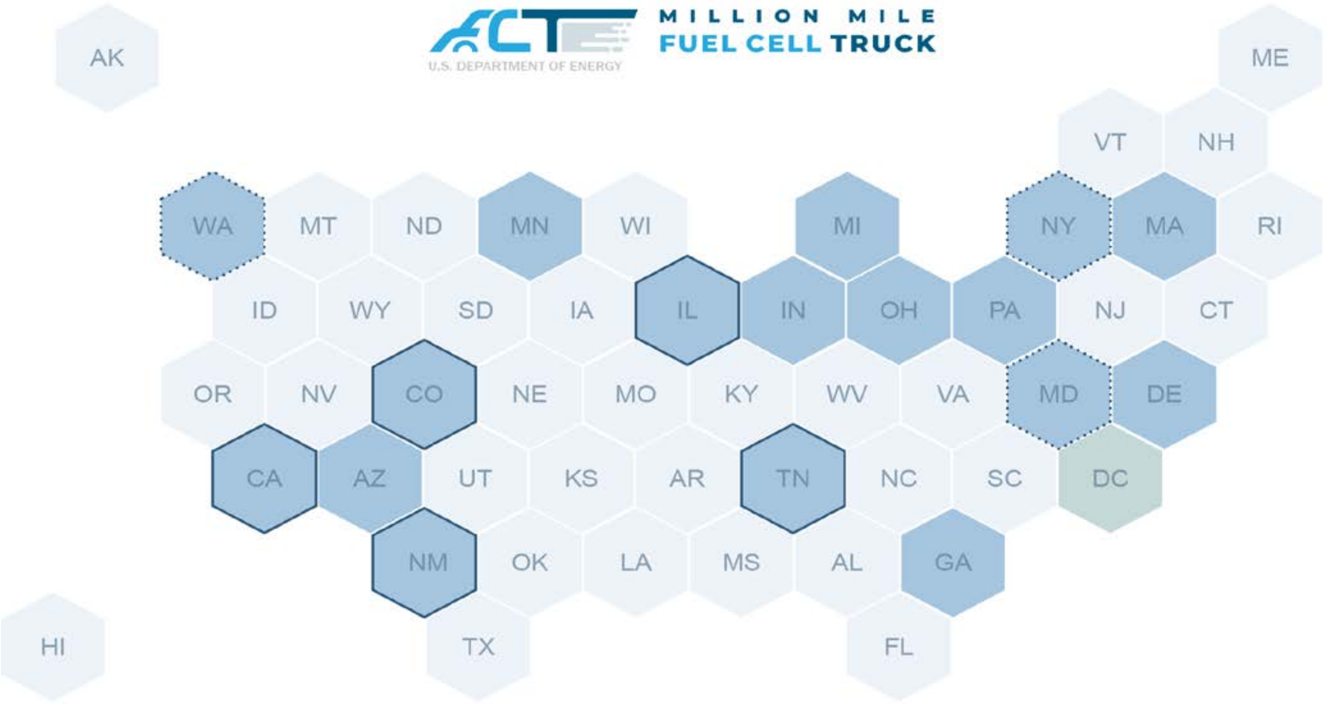
HD Membrane Projects

Lubrizol, 3M, NIKOLA

HD Stack Projects

Cummins, PLUG POWER

To add FOA bipolar plate and air management projects in FY21



Primary Labs	Partners Labs	Partners Academia	Partners Industry	
LBNL	PNNL	Cornell	3M Company	Kodak
LANL	BNL	Carneige Mellon Univ.	Akron Polymer Products	Lubrizol
ANL	NIST	Colorado School of Mines	Ballard	Nikola Motors
NREL		GeorgiaTech	Chemours	Pajarito Powder
ORNL		Northeastern	Cummins	Plug Power
		University of Tennessee	General Motors	

Main Laboratories

Los Alamos NATIONAL LABORATORY

BERKELEY LAB

OAK RIDGE National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Argonne NATIONAL LABORATORY

Affiliate Laboratories

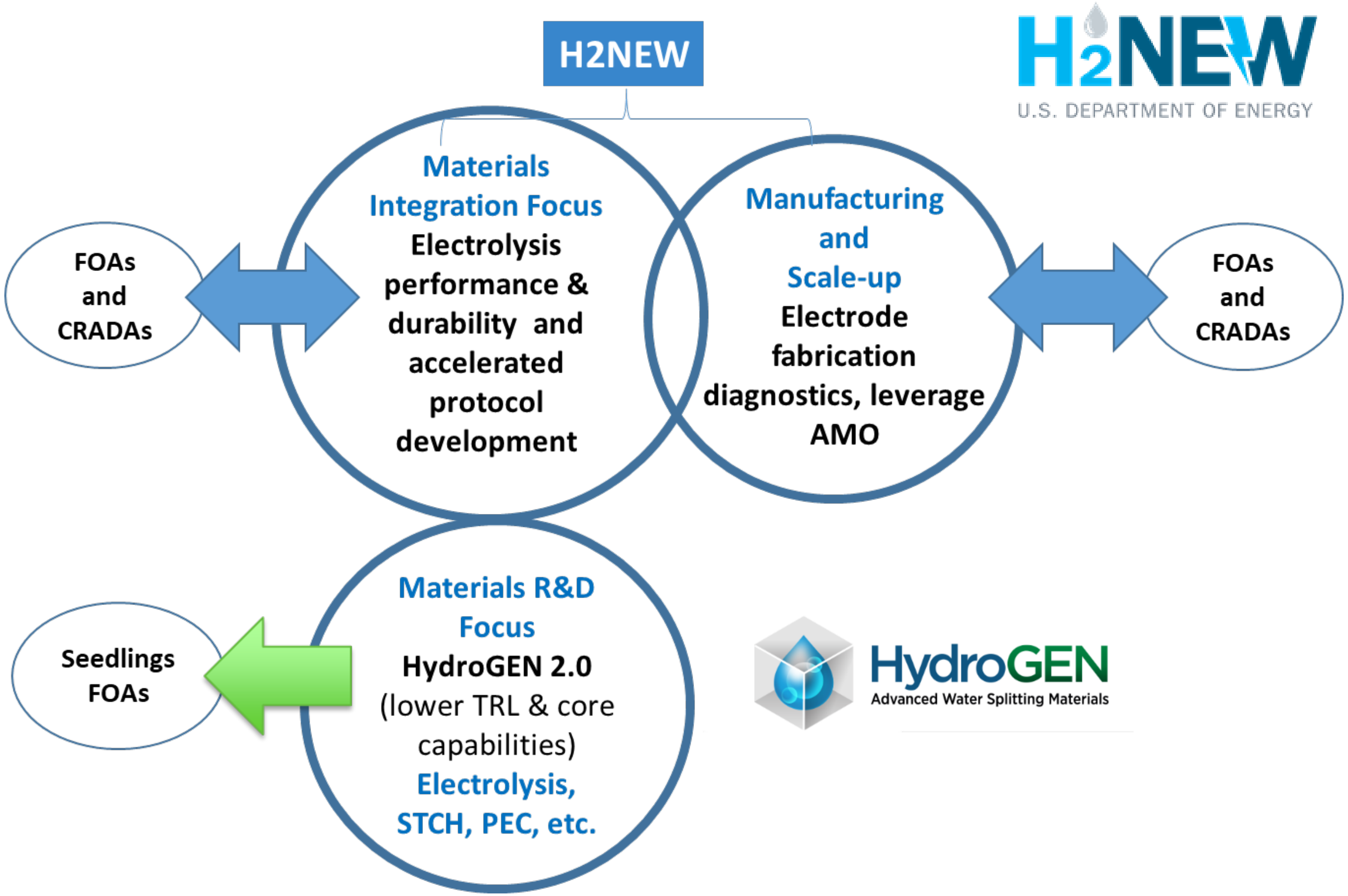
Pacific Northwest NATIONAL LABORATORY

BROOKHAVEN NATIONAL LABORATORY

NIST National Institute of Standards and Technology

H2NEW Consortium to accelerate progress in Electrolyzers

H2 from the Next-generation of Electrolyzers of Water



National Lab Consortium Team

NREL National Renewable Energy Laboratory
INL Idaho National Laboratory
Argonne National Laboratory
Berkeley Lab
Pacific Northwest National Laboratory
Los Alamos National Laboratory
Lawrence Livermore National Laboratory
Oak Ridge National Laboratory
National Energy Technology Laboratory

Clear, well-defined stack metrics

Electrolyzer Stack Goals by 2025		
	LTE PEM	HTE
Capital Cost	\$100/kW	\$100/kW
Elect. Efficiency (LHV)	70% at 3 A/cm^2	98% at 1.5 A/cm^2
Lifetime	80,000 hr	60,000 hr

Demonstration and Deployment

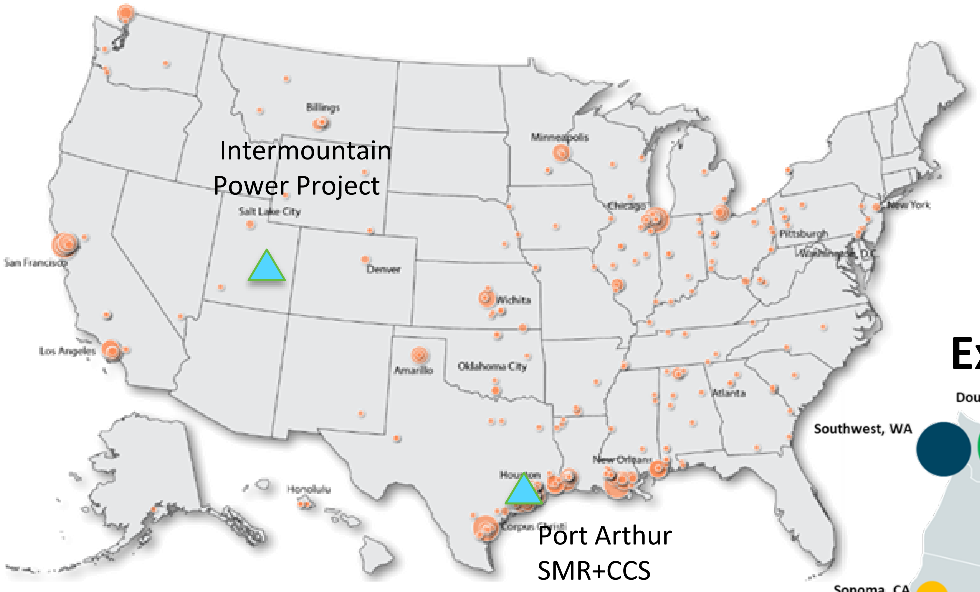
Snapshot of Hydrogen and Fuel Cells in the U.S.

Deployment Examples

- **>550MW** Backup Power
- **>50,000** Forklifts
- **>172 MW** PEM* Electrolyzers
- **~70** Fuel Cell Buses
- **~50** H_2 Retail Stations
- **>12,000** Fuel Cell Cars

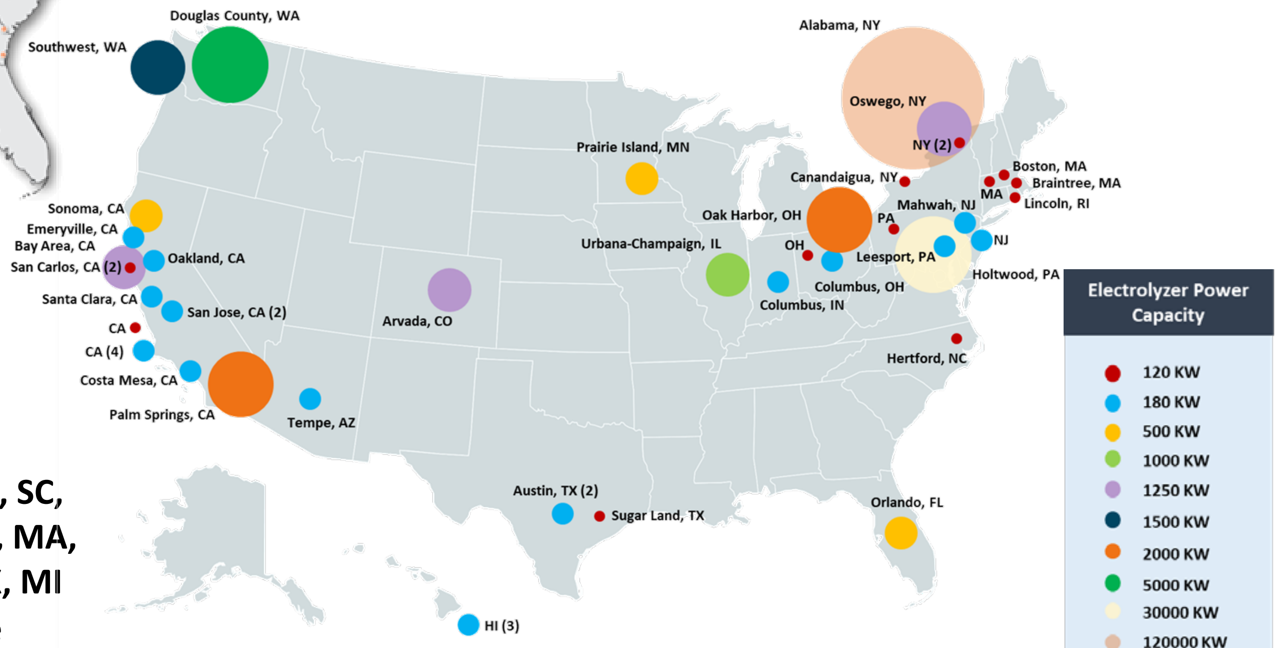
* PEM: Polymer electrolyte membrane

Examples of Hydrogen Production Locations



- **10 million metric tons (MMT) H_2/yr**
- **Over 1,600 miles of H_2 pipelines**
- **World's largest H_2 storage cavern**

Examples of PEM Electrolyzer Installations



Current and under construction installations over 120 kW as of Jun. 2021

** Source: Arjona, et al, DOE HFTO Program Record, June 2021*

Examples of Hydrogen Station Plans

California	Northeast	AZ, HI, OH, SC, NJ, NY, CT, MA, CO, UT, TX, MI
200 Stations Planned California Fuel Cell Partnership Goal	12 – 20 Stations Planned	And more

Examples of H2@Scale Projects: Demonstrations and Workforce Training

Different regions, hydrogen sources, end uses & educational opportunities

H_2 for Marine Application

California

1st-of-its-kind maritime H_2 refueling on floating barge - up to ½ ton H_2/day

H_2 from Renewables

Texas

Integrates wind, solar, RNG from waste with onsite electrolysis and multiple end-uses

H_2 for Data Center

Washington

Integrates a 1.5MW fuel cell with a data center to provide reliable and resilient power

H_2 for Steel Production

Missouri

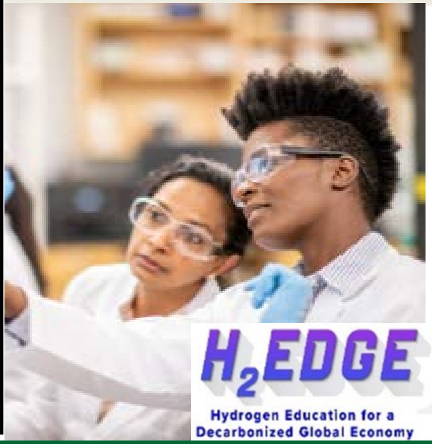
Reduction of 30% in energy and 40% emissions vs. conventional processes

H_2 from Nuclear

New York

Demonstrates a MW electrolyzer with a nuclear plant (collaboration with Nuclear Energy Office)

Workforce Development



Multi-state

A Training, education and recruiting program to build skills needed in the H_2 industry

Examples of DOE Hydrogen Demonstration Projects

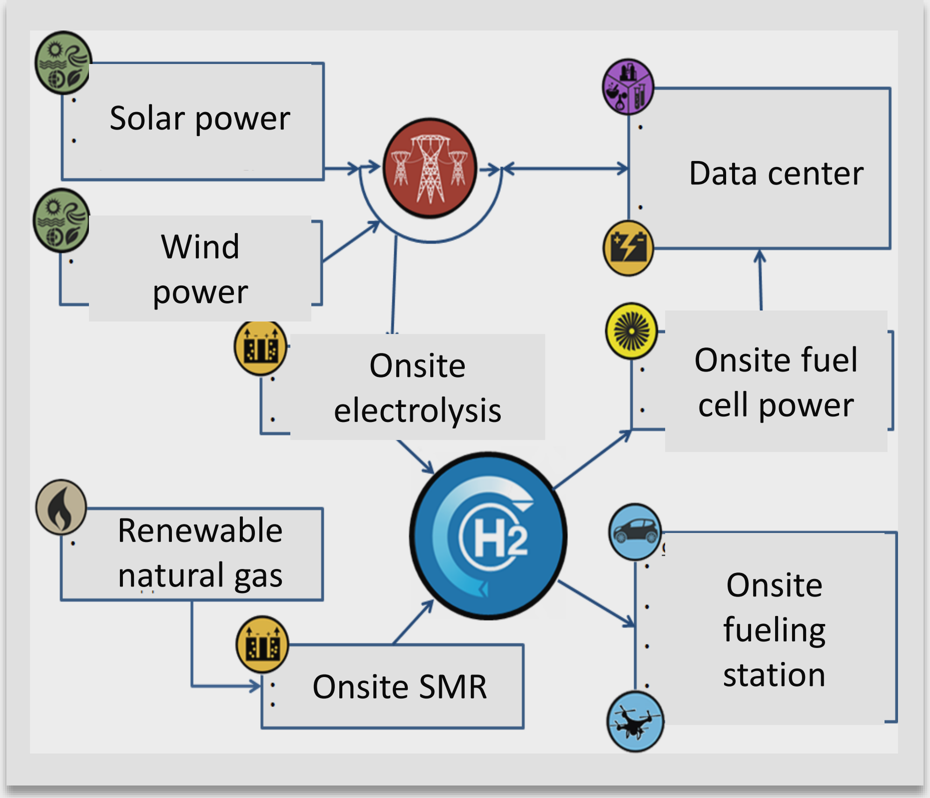
U.S. DEPARTMENT OF ENERGY

Nuclear

- Integrates a light water reactor with a 2 megawatt (MW) electrolyzer (low-temp.)
- Davis-Besse nuclear power plant in Ohio
- Budget: $11.5M total

Office of Nuclear Energy

Renewables



- Integrates wind, solar, RNG from waste with onsite electrolysis to power a data center
- Will explore H_2 use at Port of Houston
- Budget: $10.8M

Office of Energy Efficiency and Renewable Energy

Fossil + CCS

- Integrates hydrogen production from Steam Methane Reformers (SMR) with carbon capture
- Hydrogen plant at Valero Refinery in Port Arthur, Texas
- Budget: $431M
- Ongoing operations since 2013

Office of Fossil Energy and Carbon Management

Financing to Enable Deployment at Scale

$40 Billion in Available Debt Capital

LPO offers project financing across energy sectors through three distinct loan programs.

Includes Clean Hydrogen

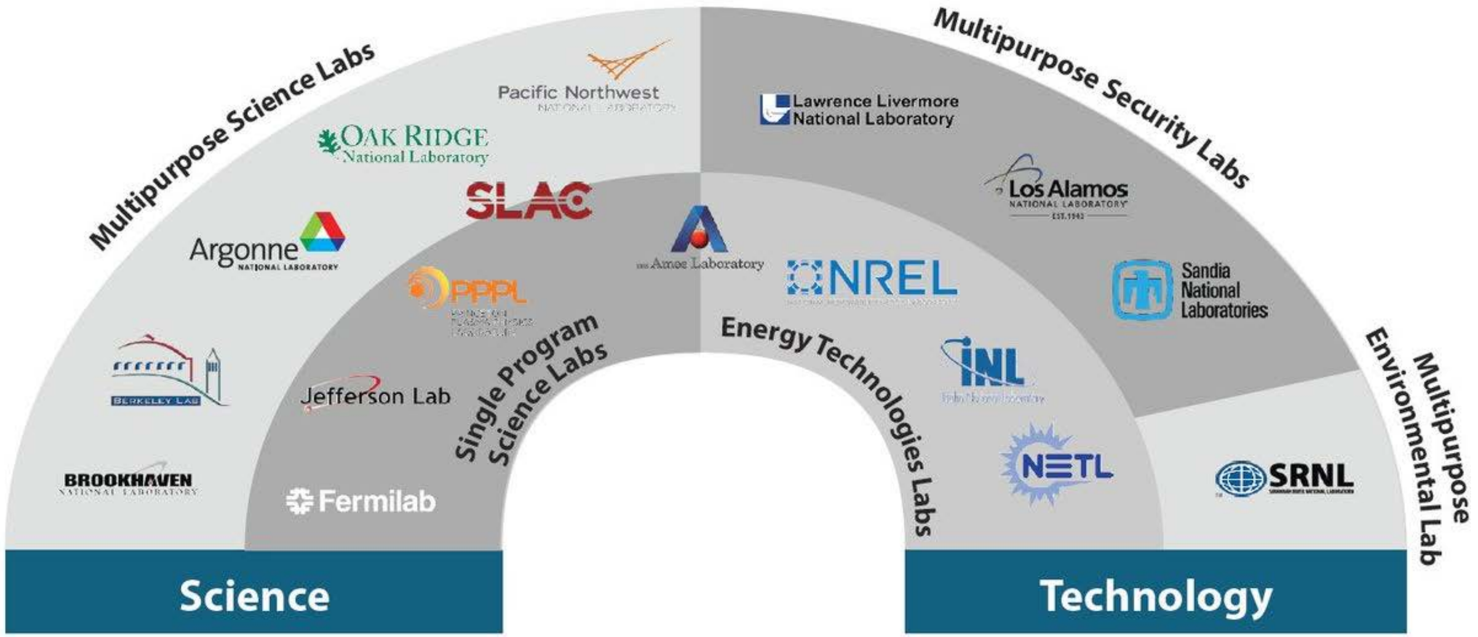
LPO Loan Programs

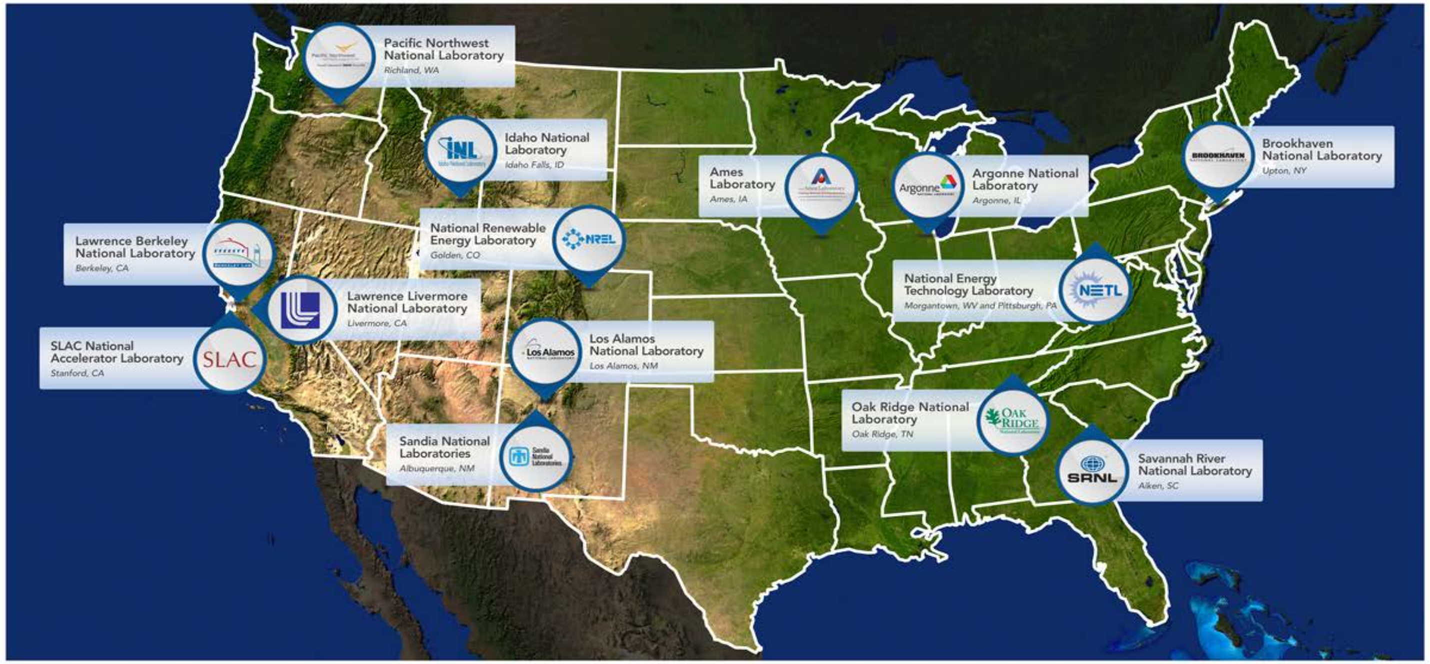
Program	Sector	Available
TITLE 17 Loan Guarantees	Renewable Energy and Efficient Energy	$3 Billion Available
	Advanced Nuclear Energy	$10.9 Billion Available
ATVM Direct Loans	Advanced Technology Vehicles Manufacturing	$17.7 Billion Available
TELGP Partial Loan Guarantees	Tribal Energy Projects	Up to $2 Billion Available

Enabling Activities

DOE National Laboratories

U.S. DOE Hydrogen Program funds RD&D across National Laboratories





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.

HyBlend and H-Mat Consortia

To assess and enhance compatibility of key materials with hydrogen, and to accelerate the use of hydrogen in multiple applications (including in natural gas blending)

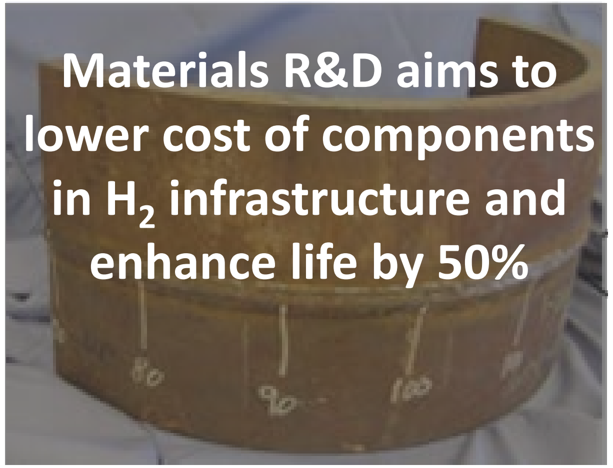
H-Mat Hydrogen Materials Compatibility Consortium[SM]

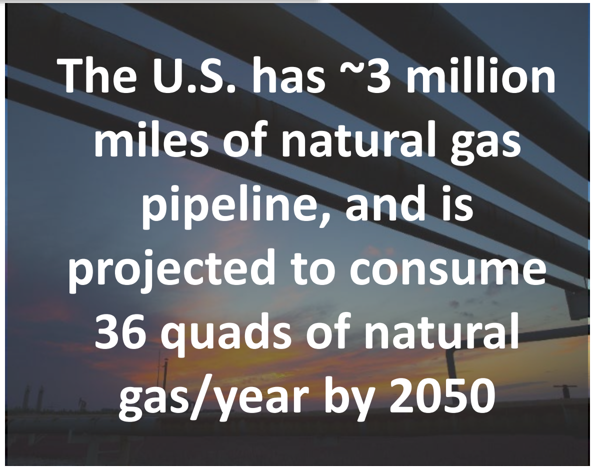
National lab consortium to assess and improve performance and reliability of materials in hydrogen, reduce costs, and inform codes & standards.

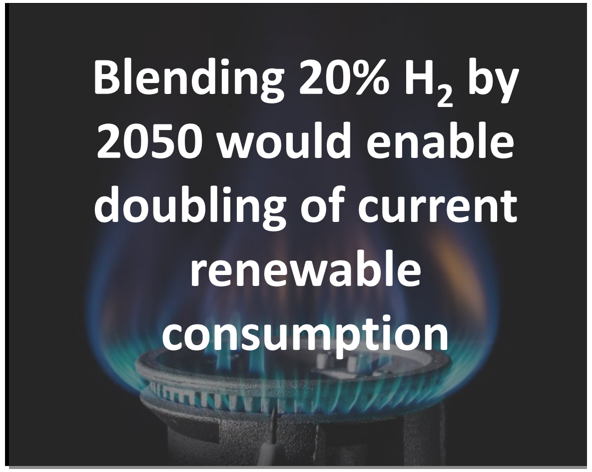
HyBlend U.S. DEPARTMENT OF ENERGY

Pipeline materials compatibility R&D, technoeconomic analysis, and life cycle analysis to assess the feasibility of hydrogen blending in the US natural gas pipeline infrastructure.

Over 40 partners



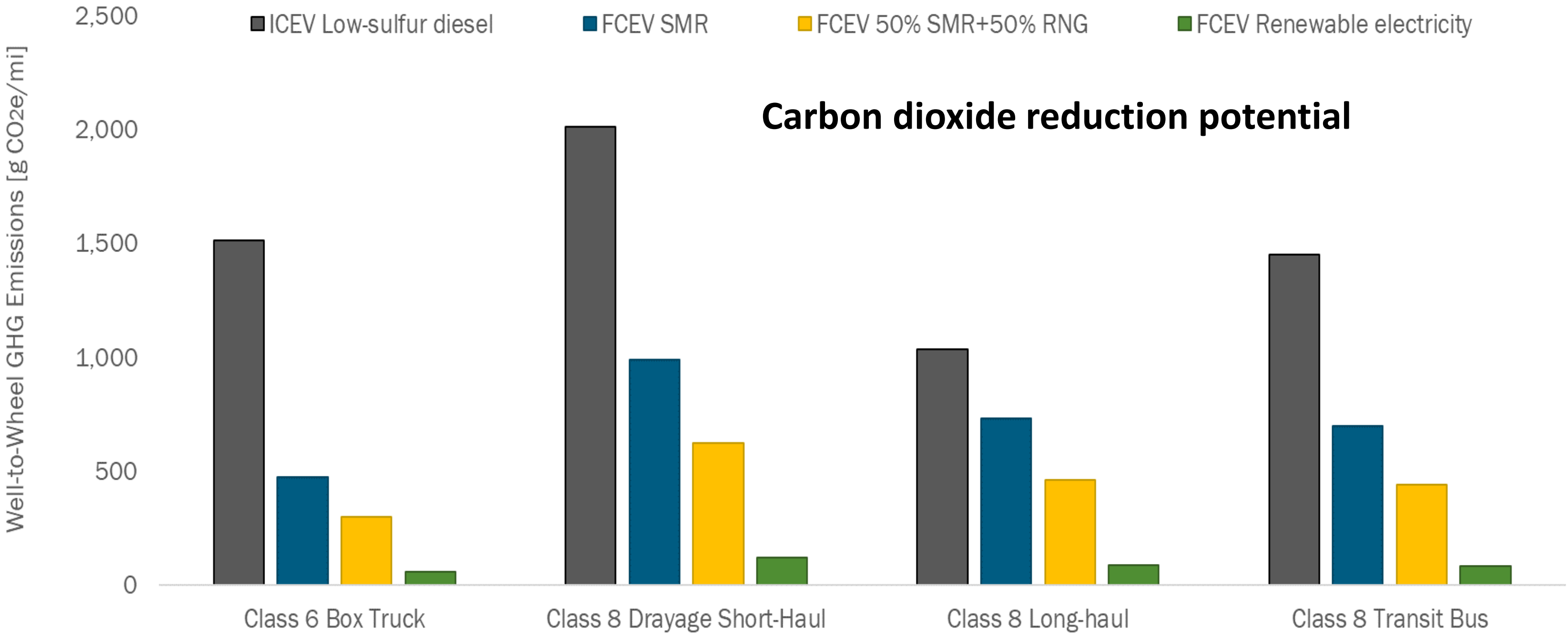


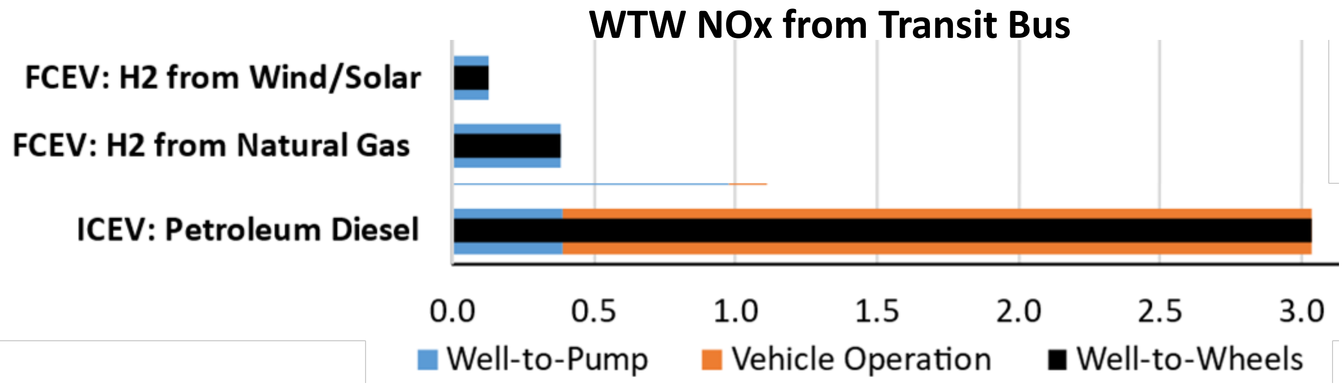


Labs | Sandia National Laboratories, PNNL, SRNL, Oak Ridge National Laboratory, Argonne National Laboratory

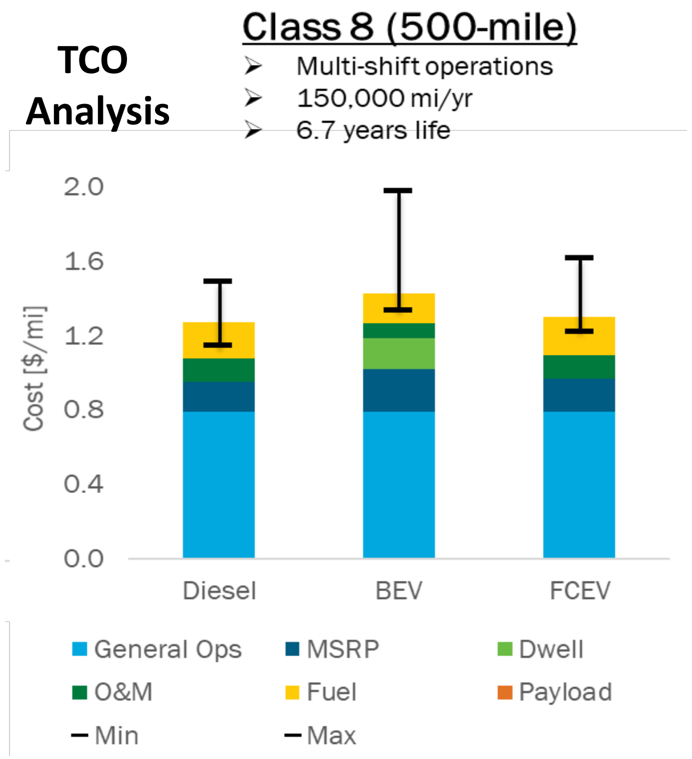
Labs | NREL National Renewable Energy Laboratory, Sandia National Laboratories, PNNL, Oak Ridge National Laboratory, Argonne National Laboratory, NETL

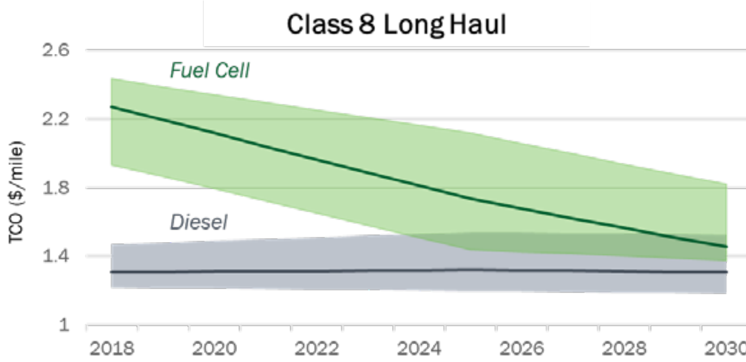
Enabler: Analysis Guides Portfolio, Decision Making, and Impact





Source: Elgowainy, et. al. (ANL), 2021



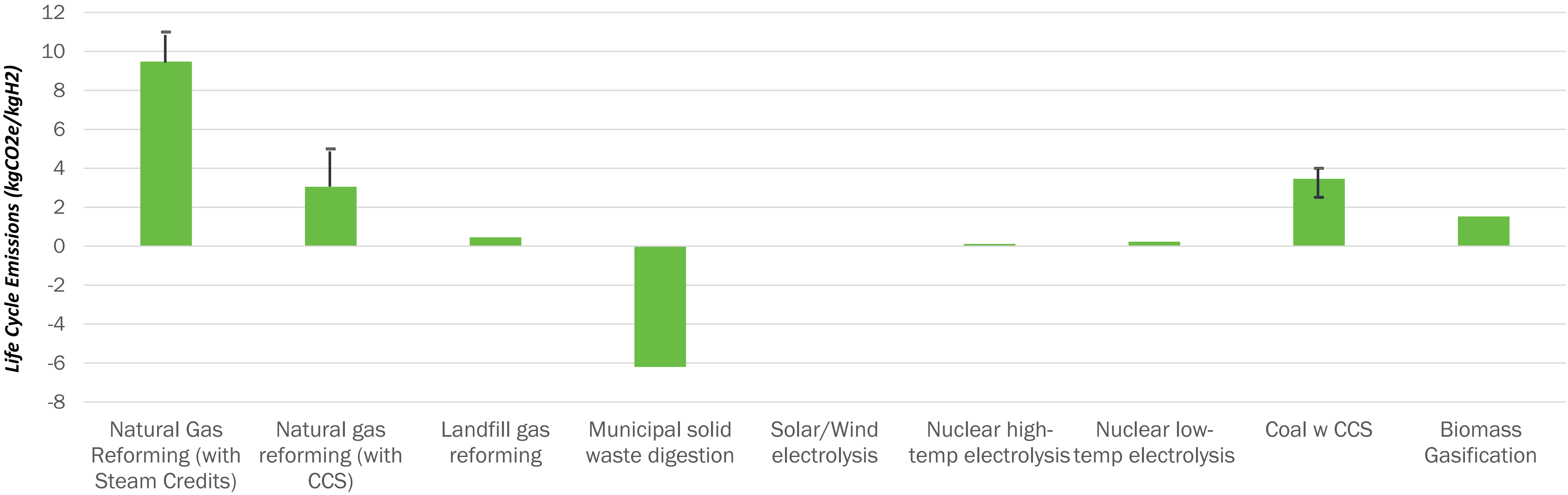


Preliminary analysis

Source: Hunter, et al, NREL, 2021

GREET GHG Emissions Analysis Tool

Identifies life cycle GHG emission from multiple hydrogen pathways



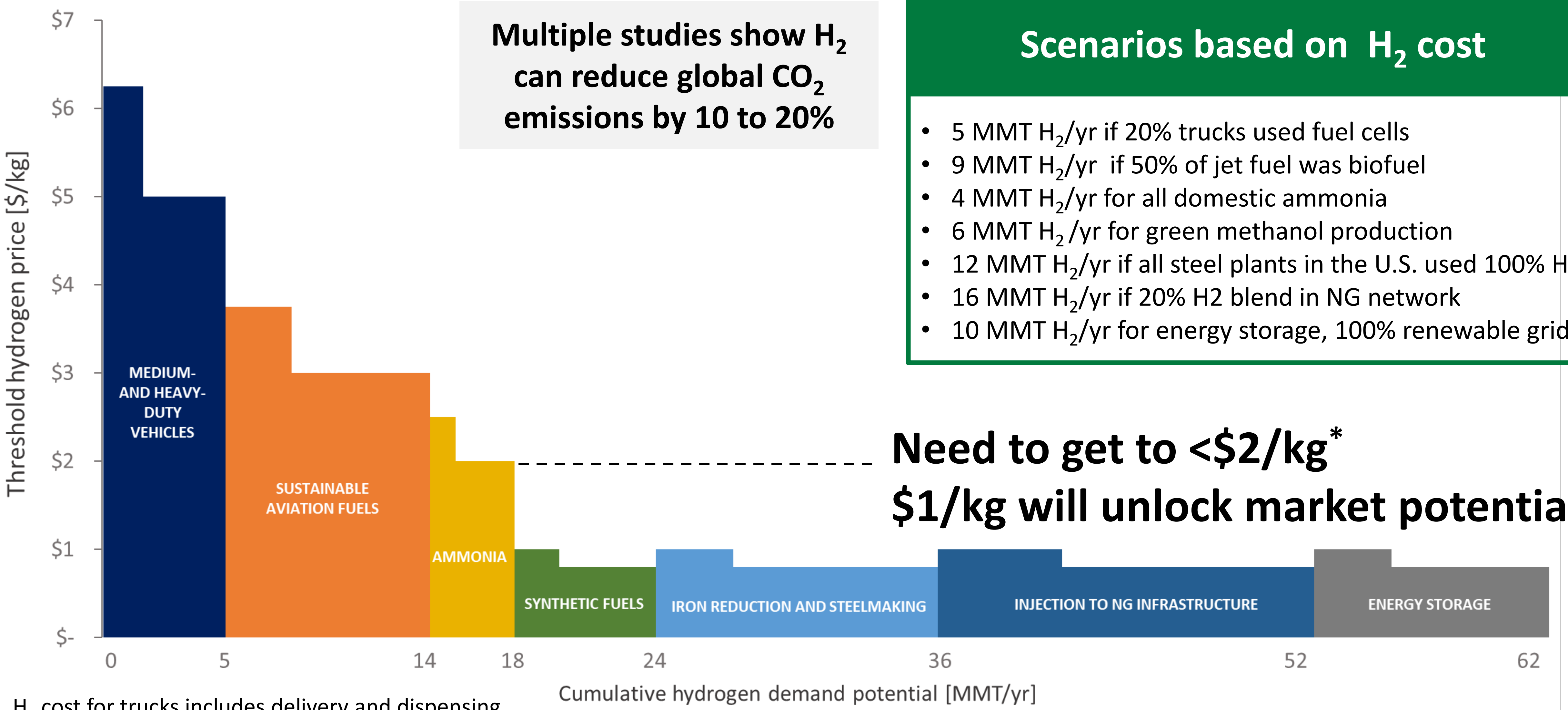
Ranges shown reflect potential variability in upstream leak rates, CCS efficiency, and capture rates. Baseline assumes 90% capture.

Source: Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model 2021, https://greet.es.anl.gov/

For more information, see GREET documentation or the October H2IQHr: https://www.energy.gov/eere/fuelcells/2021-hydrogen-and-fuel-cell-technologies-office-webinar-archives#date10282021

CCS: Carbon Capture and Sequestration
GHG: Greenhouse Gas
GREET: Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model

Analysis Determines Market Potential Scenarios



Multiple studies show H_2 can reduce global CO_2 emissions by 10 to 20%

Scenarios based on H_2 cost

- 5 MMT H_2/yr if 20% trucks used fuel cells
- 9 MMT H_2/yr if 50% of jet fuel was biofuel
- 4 MMT H_2/yr for all domestic ammonia
- 6 MMT H_2 /yr for green methanol production
- 12 MMT H_2/yr if all steel plants in the U.S. used 100% H_2
- 16 MMT H_2/yr if 20% H2 blend in NG network
- 10 MMT H_2/yr for energy storage, 100% renewable grid

Need to get to <$2/kg*
$1/kg will unlock market potential

H_2 cost for trucks includes delivery and dispensing

* H_2 could compete at $1 to $2/kg higher cost with a carbon price

Results based on preliminary analysis

President Biden and Energy Secretary Granholm at Climate Summit

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

President Joseph R. Biden
April 23, 2021

Launch of Hydrogen Energy Earthshot
First of the Energy Earthshots
June 7, 2021
at DOE Hydrogen Program Annual Merit Review

Secretary Jennifer Granholm
June 7, 2021

Hydrogen Energy Earthshot

“Hydrogen Shot”

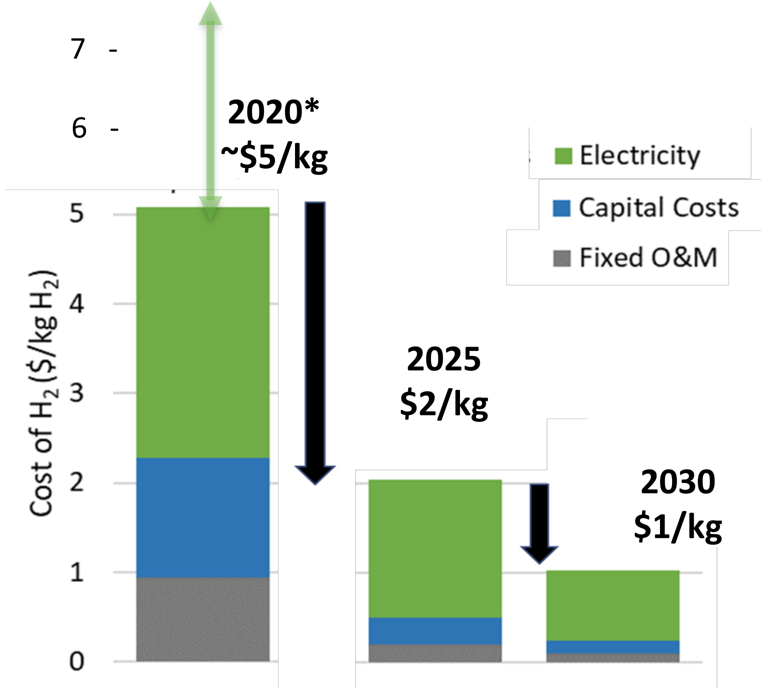
“1 1 1”
$1 for 1 kg clean hydrogen in 1 decade

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

How to reduce cost? Examples across pathways:

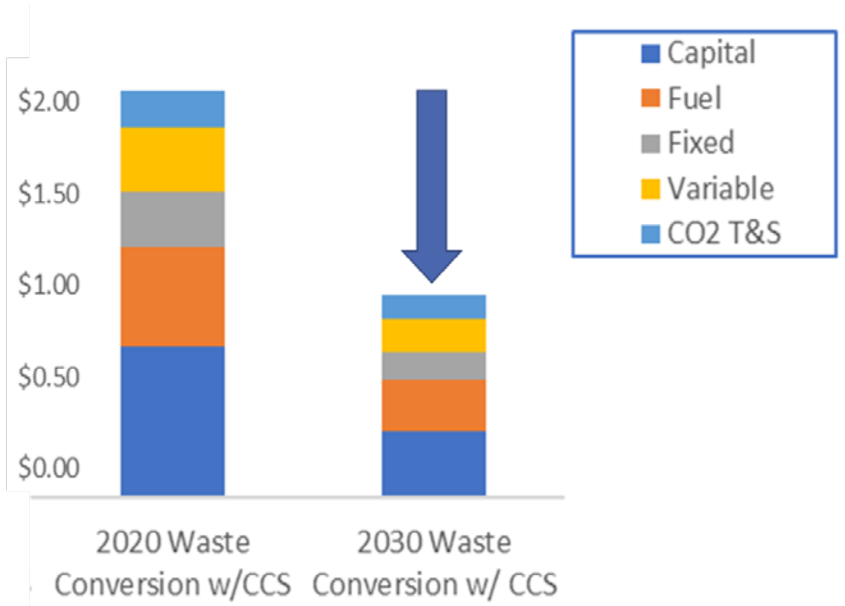
Hydrogen Shot Summit (Aug 2021): 3,200+ stakeholders discussed potential hydrogen pathways to enable "1 1 1"

H_2 from Electrolysis



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

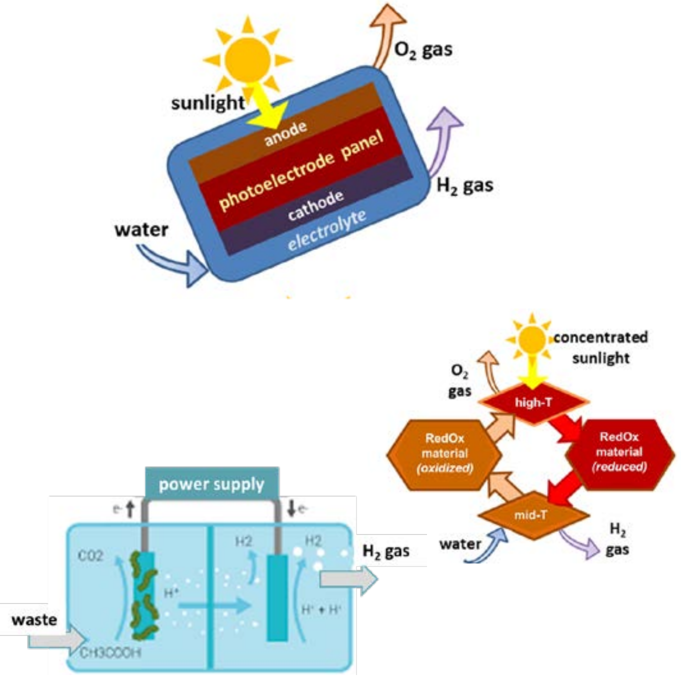
H_2 from Waste Conversion + CCS



* Waste coal, plastics, biomass residuals, municipal solid waste (MSW), and biogas

- Reforming, pyrolysis, air separation, catalysts, Carbon Capture and Storage (CCS), upstream emissions

Advanced Pathways

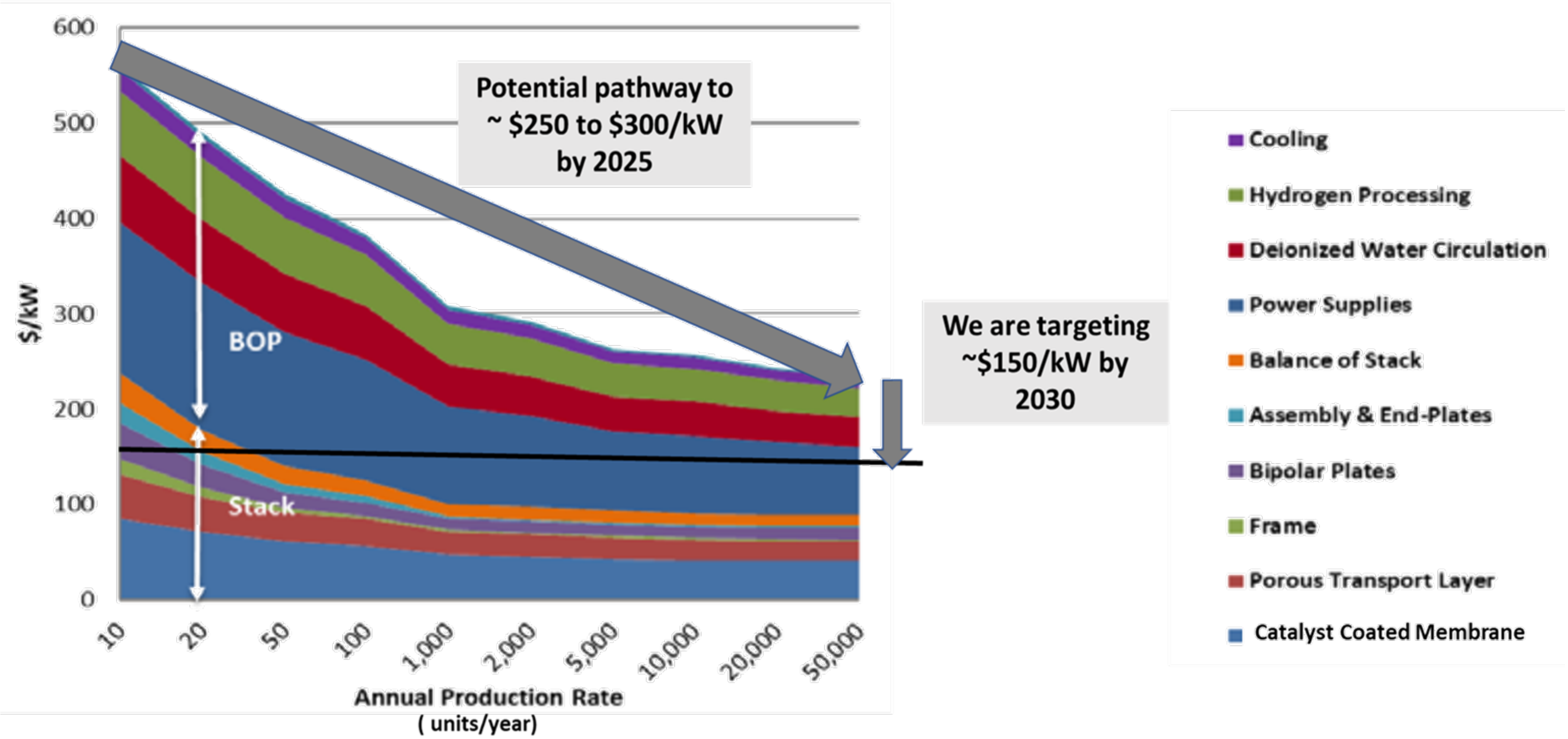


- Photoelectrochemical (PEC), thermochemical, biological, etc.

*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

Analysis guides RD&D and cost reduction strategies

Electrolyzer System Cost Reduction Needs – cost reductions needed for stack and balance of plant (BOP) components



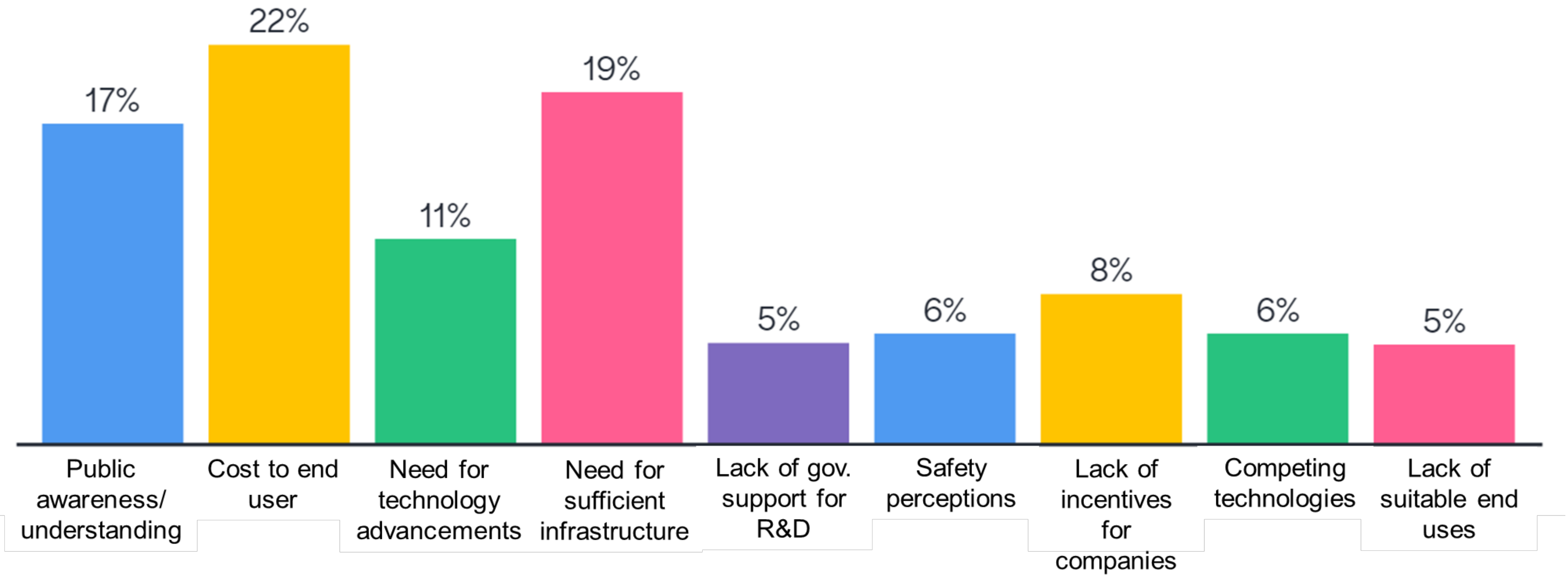
Example for proton exchange membrane (PEM) electrolyzers, NREL, ongoing analysis underway
Economies of scale projections for 1 MW per unit

DOE Hydrogen Shot Summit Stakeholder Feedback

4,900+ total registrants, 3,200+ participants in Plenary, 33 countries + USA

Speakers included:
- **Secretary Granholm, DOE Leadership across offices**
- **Sec. John Kerry**
- **Bill Gates**
- Industry CEOs, VPs Congressional Members, Labs, Research and Academic Experts

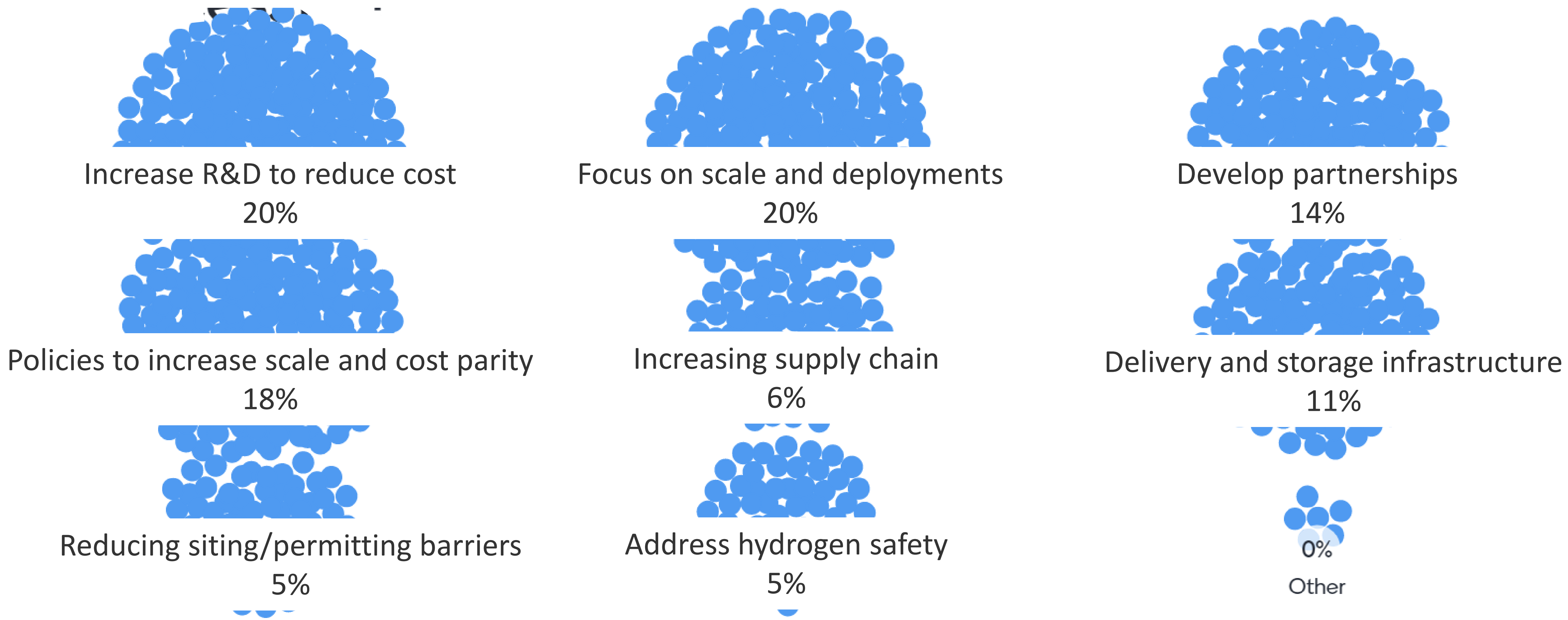
Responses to: What are the greatest barriers preventing public acceptance of widespread H_2 in the US?



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

Hydrogen Shot Summit Responses to: How Can We Succeed?

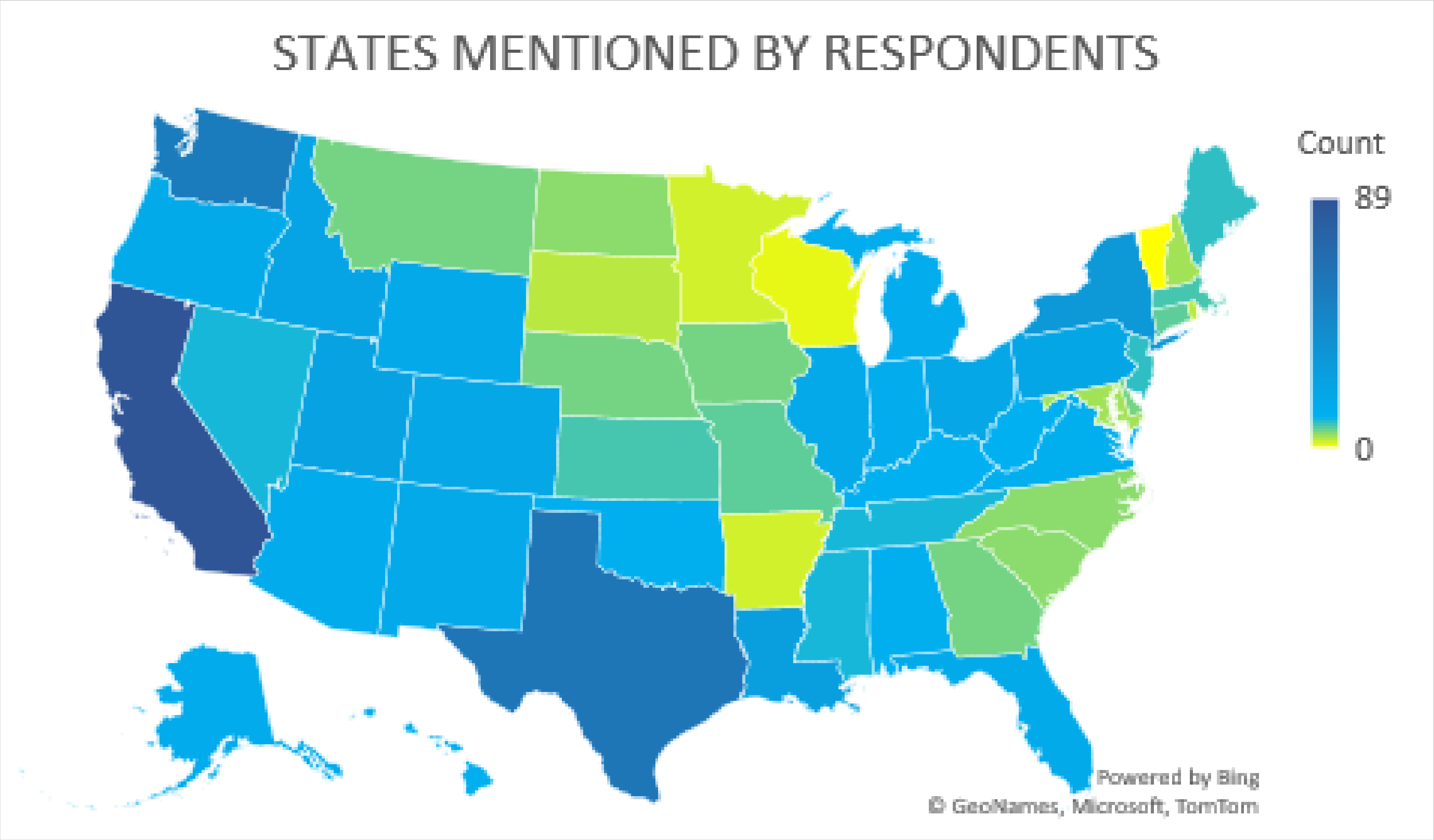
What are your top 3 priorities for Hydrogen Shot to be successful?



Source: Wieliczko, et al, DOE HFTO

Request for Information (RFI) collected stakeholder feedback

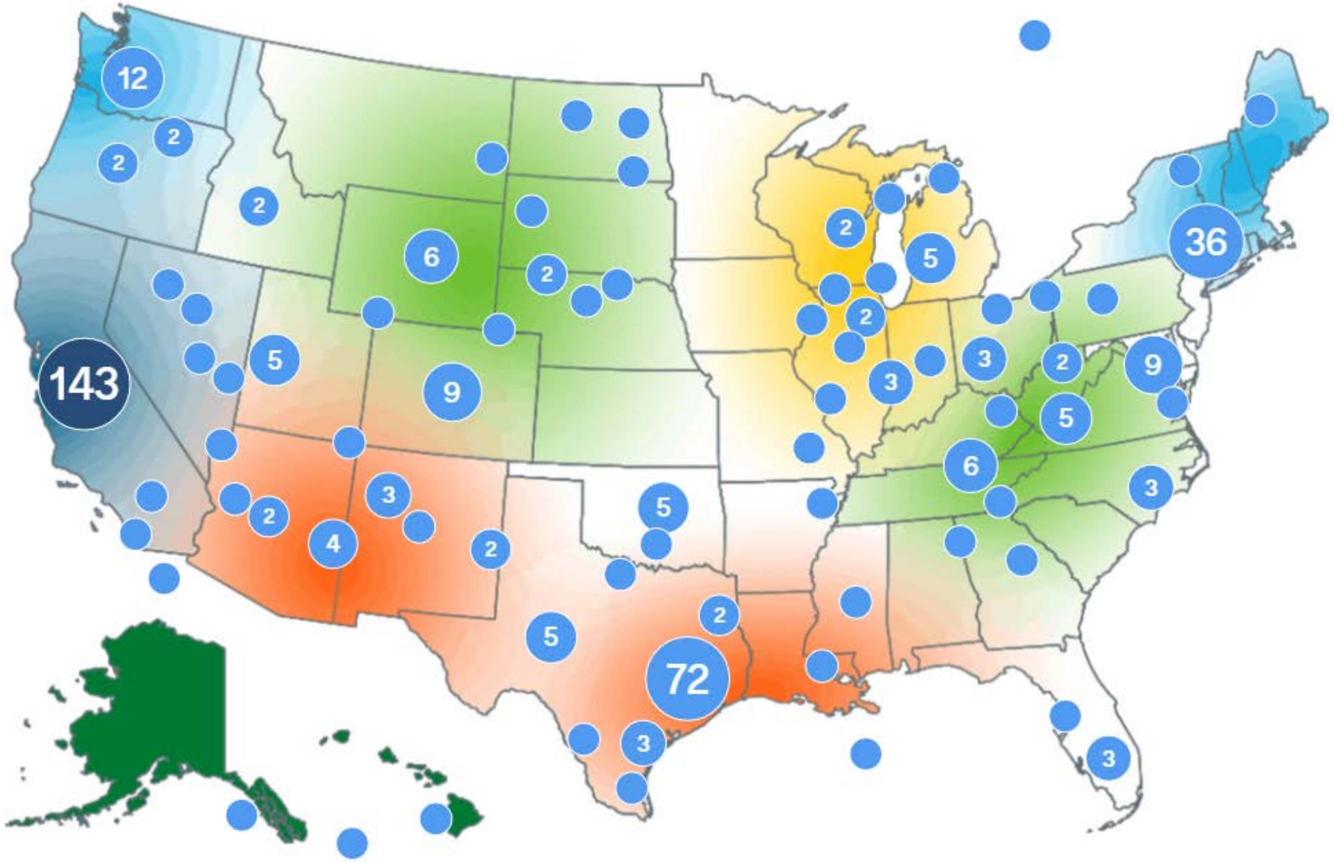
Includes regional, EJ, tribal, investor, and industry perspectives



Over 200 RFI responses described diverse resources, end-uses and impact potential in various regions

Potential Locations for Hydrogen Demonstrations

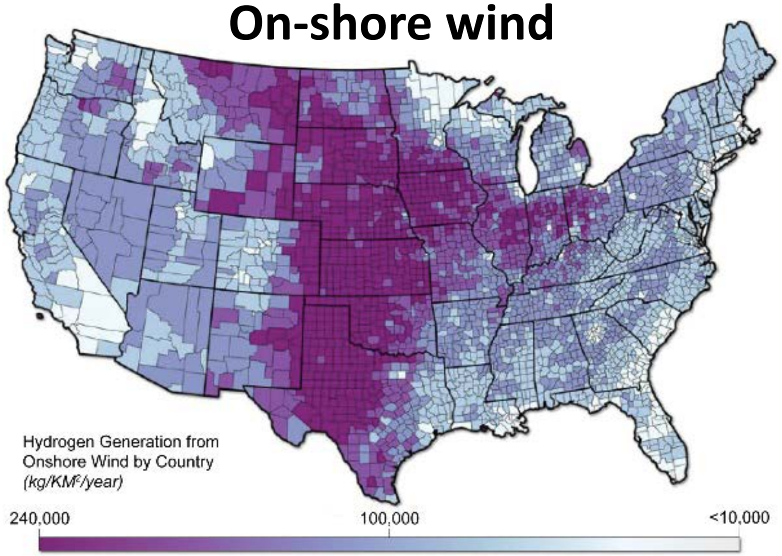
Response to Question: Please select the region that you believe is most ready for a large-scale hydrogen demonstration.



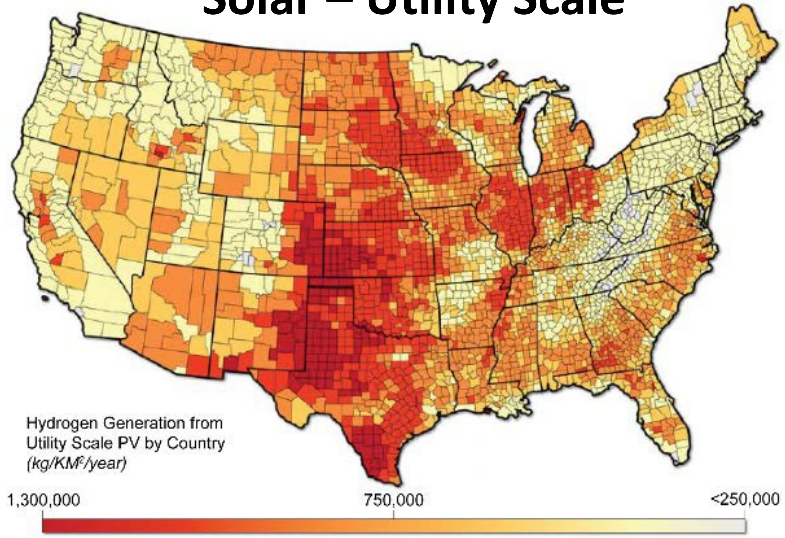
Source: Wieliczko, Harting, et al, DOE HFTO

Examples of Resource Analysis Across the United States

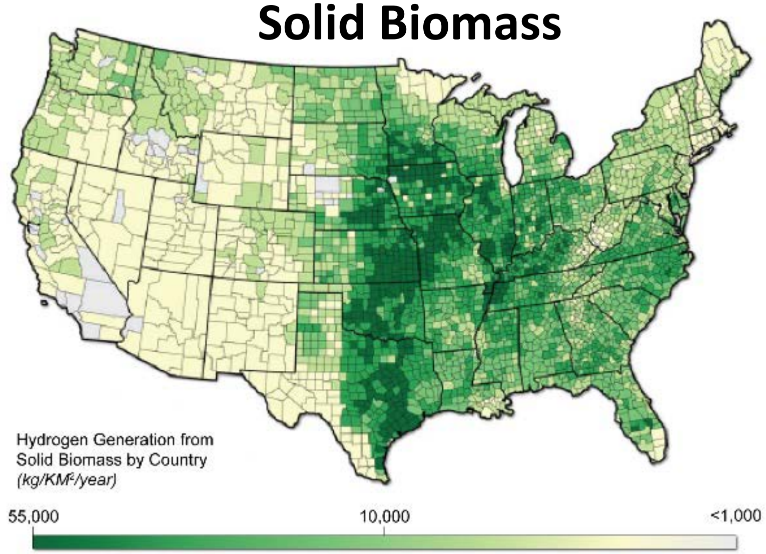
On-shore wind



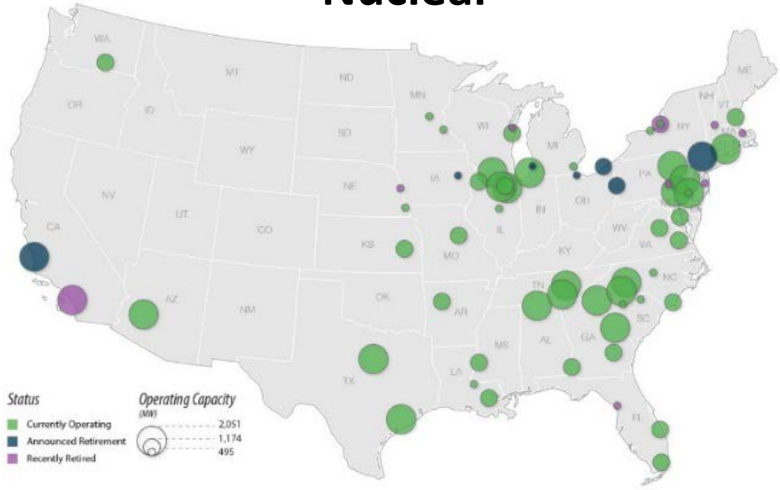
Solar – Utility Scale



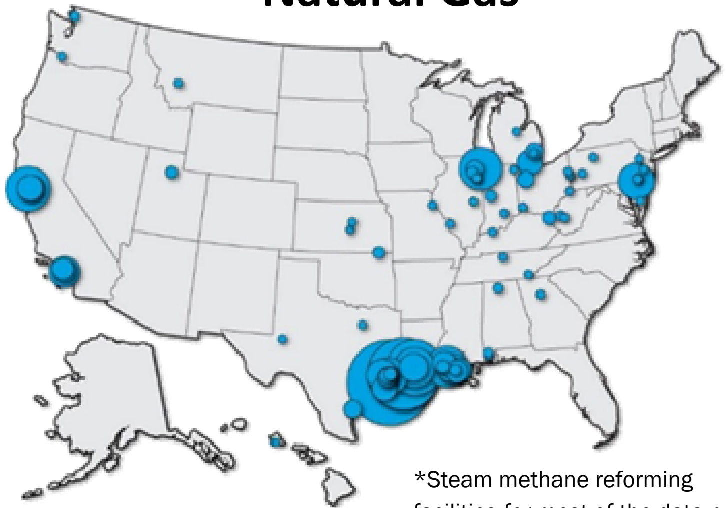
Solid Biomass



Nuclear

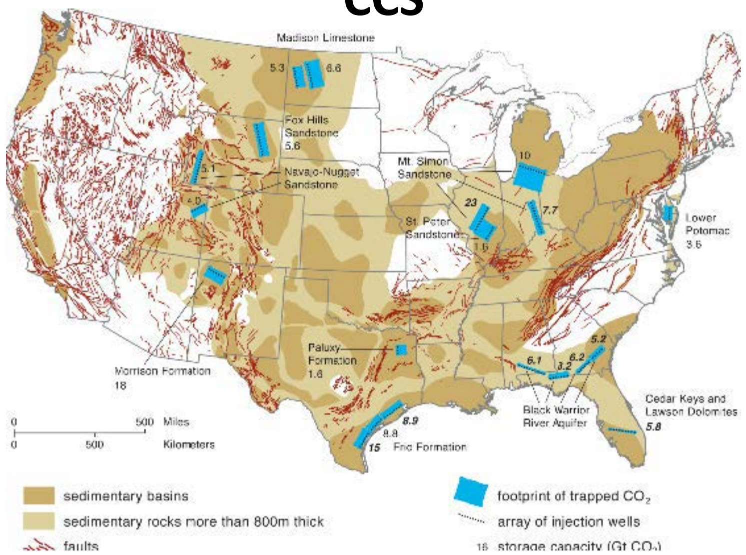


Natural Gas*



*Steam methane reforming facilities for most of the data points.

CCS



RFI findings: Regional clusters and geographic factors

Pacific Northwest

- *Port communities*
- *Tribal communities*
- *Extensive renewables*
- *8 jobs per $1M invested in H_2*

California

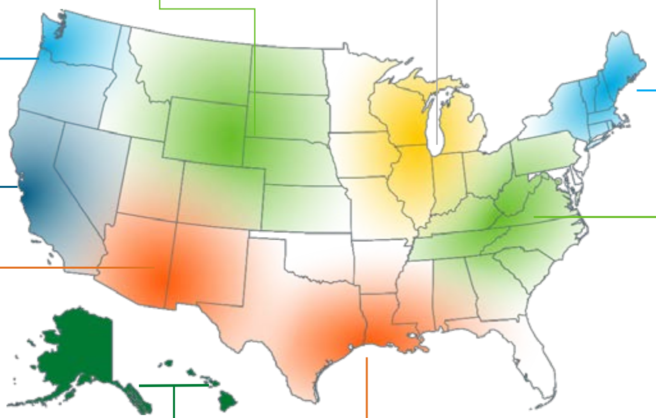
- *Diverse populations*
- *Extensive infrastructure*
- *Emissions regulations*
- *40,000+ jobs*

Southwest

- *Tribal and Hispanic communities*
- *Underutilized solar*
- *Nuclear power*
- *Up to 2B tonnes/yr emission reduction potential*

Central U.S.

- *Ample wind*
- *Geological storage*
- *Railway transport*
- *Nuclear resources*
- *>630,000 tonnes/yr CO_2 reduction*



Alaska and Hawaii

- *Extensive renewables – geothermal, solar, ocean*
- *Backup power*
- *Isolated communities*
- *86,000 tonnes/yr emission reduction*

Great Lakes

- *Major national corridors* • *Nuclear power* • *60,000+ jobs*

New England

- *Offshore wind*
- *Fishing communities*
- *Backup power and winter heating*
- *~120K tons CO_2/year reduction*

Appalachia

- *Retiring fossil plants*
- *Mining, refining transferable skills*
- *Carbon capture and sequestration*
- *70,000 tons/yr H_2 production*

Gulf Coast

- *Existing infrastructure*
- *Multiple opportunity zones*
- *Renewable resources*
- *1,000s of jobs*
- *Chemical industry*

Bipartisan Infrastructure Law (BIL)

(Infrastructure Investment and Jobs Act)

Bipartisan Infrastructure Law - Hydrogen Highlights

U.S. DEPARTMENT OF ENERGY

- **Includes $9.5B for clean hydrogen**:
  - $1B for electrolysis research, development and demonstration
  - $500M for clean hydrogen technology manufacturing and recycling R&D
  - $8B for at least four regional clean hydrogen hubs

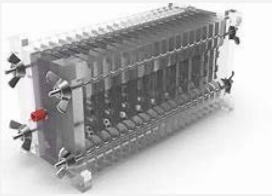
President Biden Signs the Bipartisan Infrastructure Bill into law on November 15, 2021. Photo Credit: Kenny Holston/Getty Images

- **Aligns with Hydrogen Shot priorities by directing work to reduce the cost of clean hydrogen to $2 per kilogram by 2026**

- **Requires developing a National Hydrogen Strategy and Roadmap**

Key BIL Sec. 40314 Hydrogen Provisions – Overview

U.S. DEPARTMENT OF ENERGY



“Clean H_2 Electrolysis Program”: BIL Includes research, development, demonstration and deployment (RDD&D) across multiple electrolysis technologies, compression, storage, drying, integrated systems, etc. Directly supports Hydrogen Shot

Sec. 40314 (EPACT Sec 816): Clean Hydrogen Electrolysis Program; **$1 Billion over 5 years. Goal $2/kg by 2026**

“Clean Hydrogen Manufacturing and Recycling”

Raw Materials → Processed Materials → Subcomponents → End Product

Focus on manufacturing and end of life/recycling RD&D

Sec. 40314 (EPACT Sec 815): Clean Hydrogen Manufacturing & Recycling **$0.5 Billion over 5 years**

Regional Clean H_2 Hubs: At least 4 Hubs, geographic diversity, includes renewables, fossil + CCS, nuclear, for clean hydrogen production, multiple end use applications.

Sec. 40314 (EPACT Sec 813): Regional Clean Hydrogen Hubs; **$8 Billion over 5 years**

National Hydrogen Strategy and Roadmap: Includes working with EPA to develop an initial clean hydrogen production standard per Sec. 822 $\leq$ 2 kg CO_2e/kg H_2

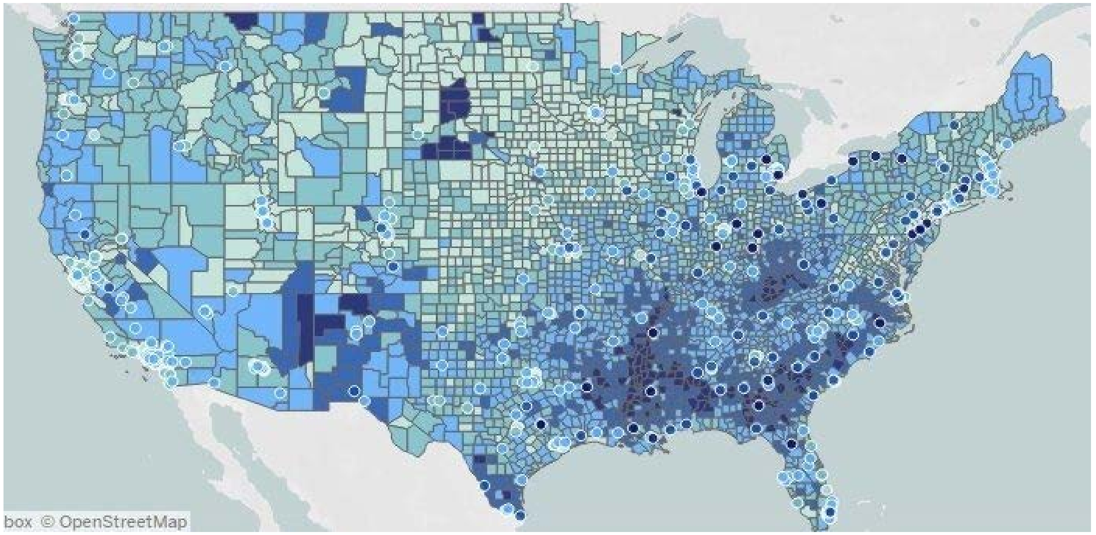
Sec. 40314 (EPACT Sec 814: Strategy & Roadmap and **Sec. 40315 (EPACT Sec 822)**: Clean Hydrogen Production Qualifications)


Collaboration &
Diversity, Equity, Inclusion

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

- H. Luccock

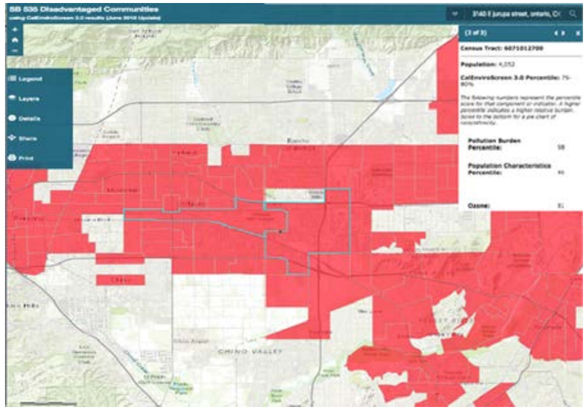
Emphasis is on Benefits in Underserved & Disadvantaged Communities



[New index ranks America's 100 most disadvantaged communities | University of Michigan News (umich.edu)]

Funding Opportunities will encourage broader engagement, demonstrating benefits, including DEI (minorities, gender equity, etc.)

Example: DOE project with CTE for UPS Fuel Cell Delivery Vans



Trucks will be demonstrated in Ontario, CA- disadvantaged community

Goal: Demonstrate 15 fuel cell trucks (up to 125-mile range)

Project impact per year: Savings of

- **285 metric tons of CO_{2e}**
- **280,000 grams of criteria pollutants**
- **56,000 gallons of diesel**

Examples of International Collaborations

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

HYDROGEN INITIATIVE
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

MISSION INNOVATION

CLEAN HYDROGEN MISSION

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

hySafe INTERNATIONAL ASSOCIATION FOR HYDROGEN SAFETY

PRHYDE Protocol for heavy-duty Hydrogen refuelling

PRESLHY

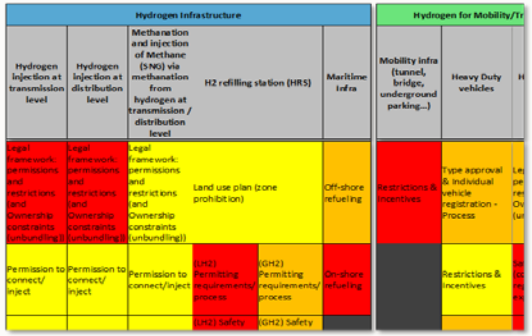
The International Partnership for Hydrogen and Fuel Cells in the Economy

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

www.iphe.net

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

RCS&S Compendium

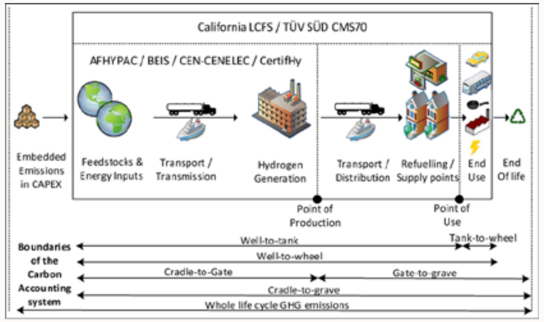


- Reports, workshops, safety sharing
- Assessing gaps
- Education, student engagement, compiling country info

Task Force to facilitate international trade of H_2

H_2 Production Analysis (H2PA)

- Developing a common analytical framework to determine emissions footprint for H_2
- Harmonizing approach across countries and pathways



(Source: Abad et al., Energy policy 138 (2020) 111300)

Example of Collaboration: Global Center for H_2 Safety (CHS)

CHS includes over 70 partners from industry, government, and academia

Access to >110 countries, 60,000 members

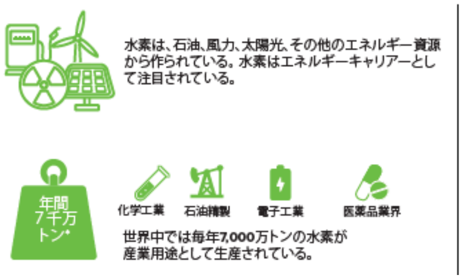
CENTER FOR Hydrogen SAFETY
Connecting a Global Community

HYDROGEN Safety Panel

HYDROGEN Emergency Response Training Resources

Information to be available in multiple languages

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


水素は、石油、風力、太陽光、その他のエネルギー資源から作られている。水素はエネルギーキャリアーとして注目されている。

年間 7千万トン*

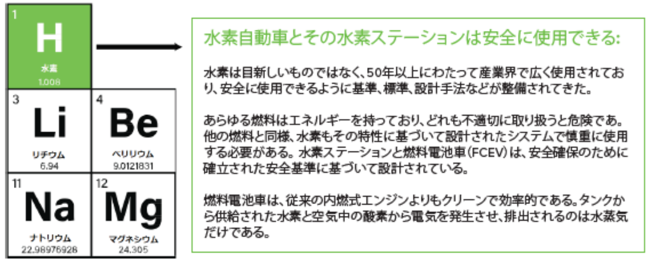
化学工業 石油精製 電子工業 医薬品業界

世界中では毎年7,000万トンの水素が産業用途として生産されている。

輸送分野の水素利用:

汚染物質、炭素排出量、騒音の削減手段として、トラックや船舶にゼロエミッションの燃料電池活用への関心が急速に高まっている。

60 輌 燃料電池電車


水素自動車とその水素ステーションは安全に使用できる:

水素は目新しいものではなく、50年以上にわたって産業界で広く使用されており、安全に使用できるように基準、標準、設計手法などが整備されてきた。

あらゆる燃料はエネルギーを持っており、どれも不適切に取り扱うと危険である。他の燃料と同様、水素もその特性に基づいて設計されたシステムで慎重に使用する必要がある。水素ステーションと燃料電池車(FCEV)は、安全確保のために確立された安全基準に基づいて設計されている。

燃料電池車は、従来の内燃式エンジンよりもクリーンで効率的である。タンクから供給された水素と空気中の酸素から電気を発生させ、排出されるのは水蒸気だけである。

水素は、石油、風力、太陽光、その他のエネルギー資源から作られている。水素はエネルギーキャリアーとして注目されている。

年間 7千万トン*

化学工業 石油精製 電子工業 医薬品業界

産業用途として生産されている。

1,991 億米ドル
2023年見込みの売上規模

58万台
2023年見込み台数

輸送分野の水素利用:

汚染物質、炭素排出量、騒音の削減手段として、トラックや船舶にゼロエミッションの燃料電池活用への関心が急速に高まっている。

60 輌 燃料電池電車

11,000 台
公道上の水素自動車台数
2018年実績

20,000 台
水素燃料のフォークリフト
2018年実績

www.aiche.org/CHS

H2 Twin Cities Initiative Launched at COP26

Connecting Communities Around the World to Deploy Clean Hydrogen Solutions

Phase 1: November 10 – December 29, 2021
Applicants self-identify and self-pair on the H2 Twin Cities website

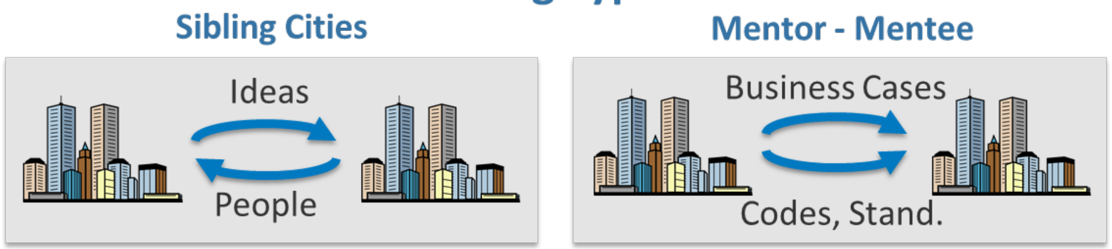
Phase 2: January 3 – March 18, 2022
A single, joint application is prepared
Open submission until March 18

Selections WG will evaluate proposals
Announce winners in early spring 2022

H2 TWIN CITIES

OFFICIAL APPLICATION GUIDELINES
H2 Twin Cities 2021

Pairing Types



Share and learn more: www.energy.gov/eere/twincities

IPHE Early Career Network

Chair
Christine Watson (USA)

Co-Chair
Regional Director of Asia, Middle East, USA
Gaurav Shukla (India)

Co-Chair
Kendall Parker (USA)

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Regional Director of Europe
Thilo Krechlak
(Germany)

Regional Director of Africa
Faan Du Preez
(South Africa)

Education & Outreach Directors
Qingwang Yuan (USA)
Bikram Roy Chowdhury (USA)

Communications & Social Media Director
Yangwei Liu
(USA)

Community Manager
Ander Martinez Alonso
(Belgium)

IPHE Comm. Liaison
Ted Kwon
(Korea)

Summary and Next Steps

Timeline for Key Hydrogen Provisions in Bipartisan Infrastructure Law

2022	2023	2024	2025	2026
National Strategy and Roadmap	Ongoing analysis: supply, demand, emissions, jobs, infrastructure, policies, investments, etc.		Update National Strategy & Roadmap	Continue to refine and iterate
Clean Hydrogen Standard	DOE, in consultation with EPA, to assess Clean Hydrogen Production Qualifications and update Standard within five years of enactment			
Hydrogen Hubs Solicitation	Select at least 4 regional clean hydrogen hubs within 1 year of proposal submissions and execute. Total $8B from FY22 through FY26			
Electrolysis RD&D	Additional electrolysis and related RD&D. Total $1B from FY22 through FY26			Meet $2/kg H_2 from electrolysis
Manufacturing & Recycling RD&D	Additional Manufacturing & Recycling RD&D. Total $0.5B from FY22 through FY26			

Stakeholder Engagement and Enablers

Stakeholder Engagement

- Webinars, Listening Sessions, Workshops
- Interagency & State Coordination
- EJ, Tribal, DEI Engagement

Tools and Enablers

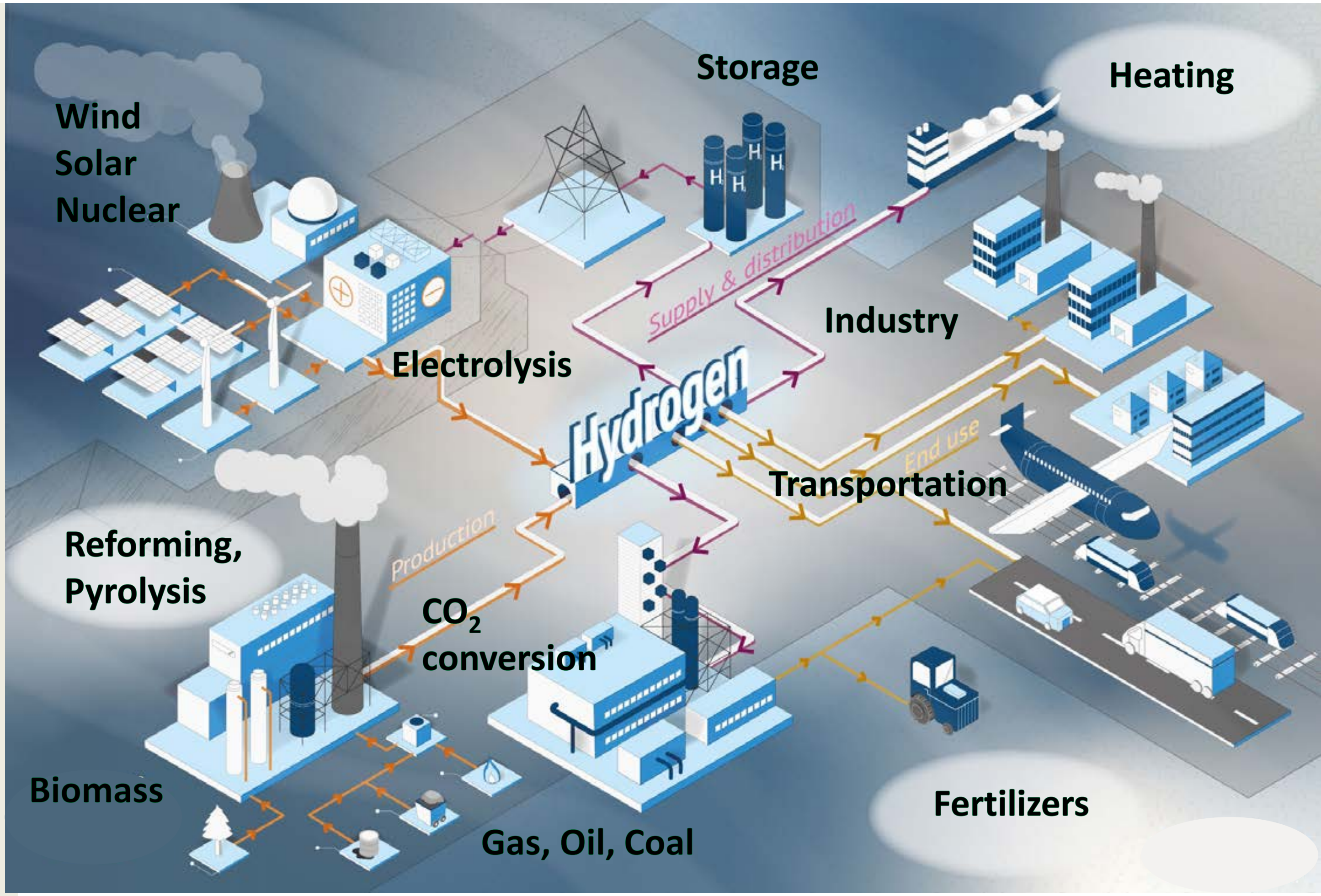
- Tech Assistance
- Analyses and Tools
- H2 Matchmaker
- RFI and Feedback from Community

Plan for Deliverables

- National Strategy and Roadmap including Targets
- Hydrogen Hubs Solicitation
- Document on Clean Hydrogen Standard

Summary: Strategy and Next Steps

1) Accelerate RD&D to reduce cost
2) Ramp up replicable and sustainable demonstrations and deployments across the H_2 value chain & leverage private sector
3) Enable benefits: Disadvantaged communities, emissions reduction, jobs, air quality improvement, and more.



Upcoming Opportunities for Engagement

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen

DOE Annual Merit Review and Peer Evaluation Meeting June 6-8, 2022

Hydrogen and Fuel Cells Day October 8

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

1 H 1.008
Hydrogen

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www.aiche.org/CHS

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

Thank you

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