U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

DOE Hydrogen and Fuel Cell Remarks

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

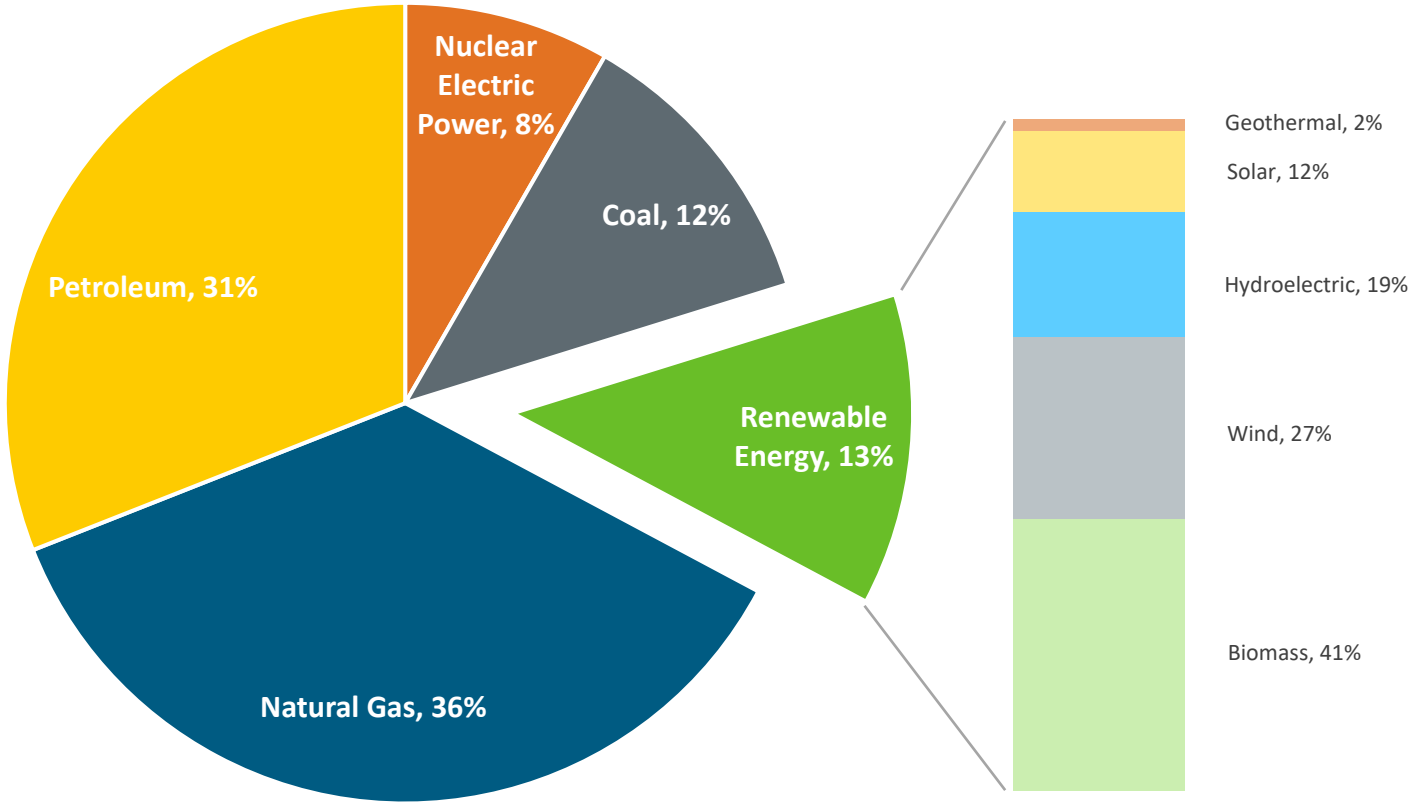
3rd American Hydrogen Forum

March 15, 2023

U.S. Energy Landscape and Key Goals

U.S. primary energy consumption by energy source, 2021

Total = 97.8 quadrillion British thermal units (Btu)



Note: Sum of components may not equal 100% because of independent rounding
Source: Data collected from U.S. Energy Information Administration, April 2022, *Monthly Energy Review,* preliminary data

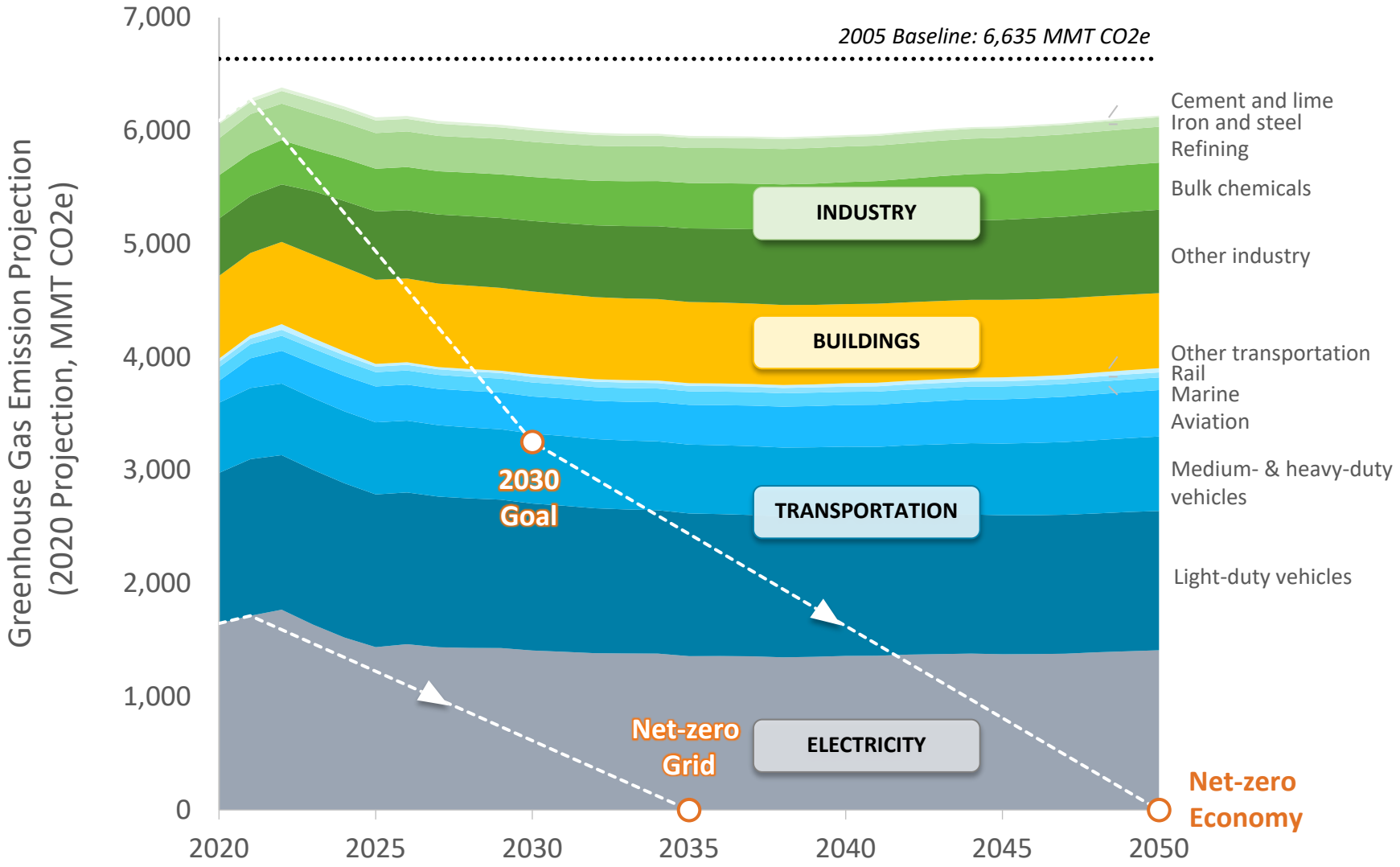
Administration Goals include:

- 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

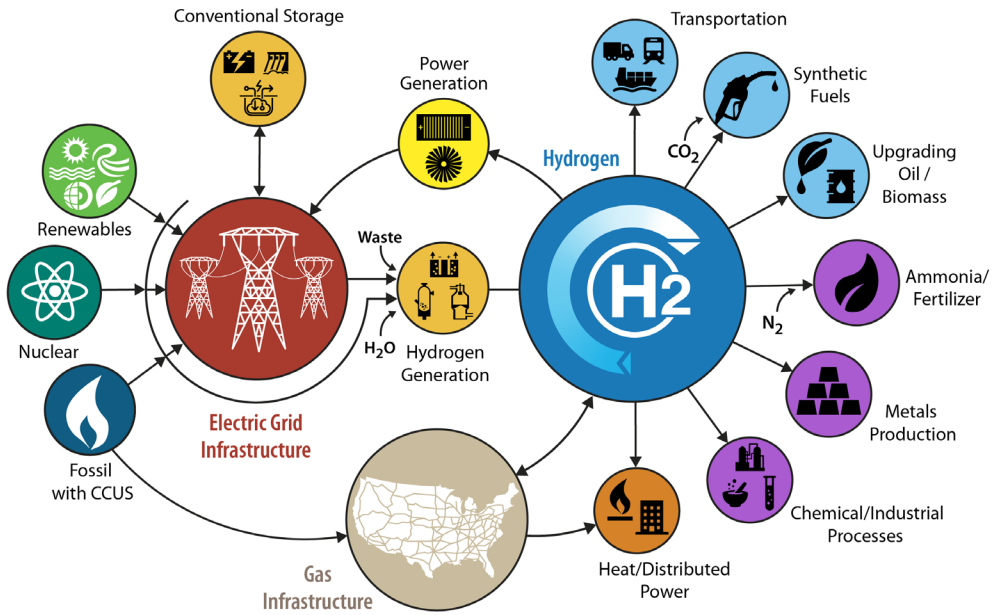
Carbon Dioxide Emissions by Sector

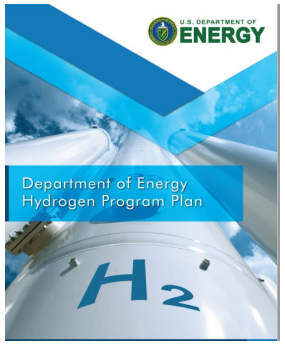


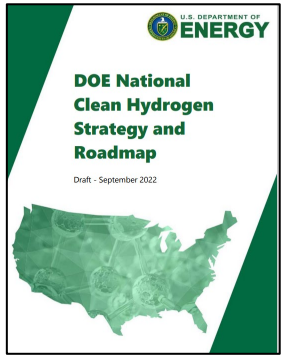
Source: Annual Energy Outlook 2021, DOE National Clean Hydrogen Strategy and Roadmap

U.S. DOE Hydrogen Program

Hydrogen is one part of a broad portfolio of activities Includes multiple offices and the entire RDD&D value chain from production through end use

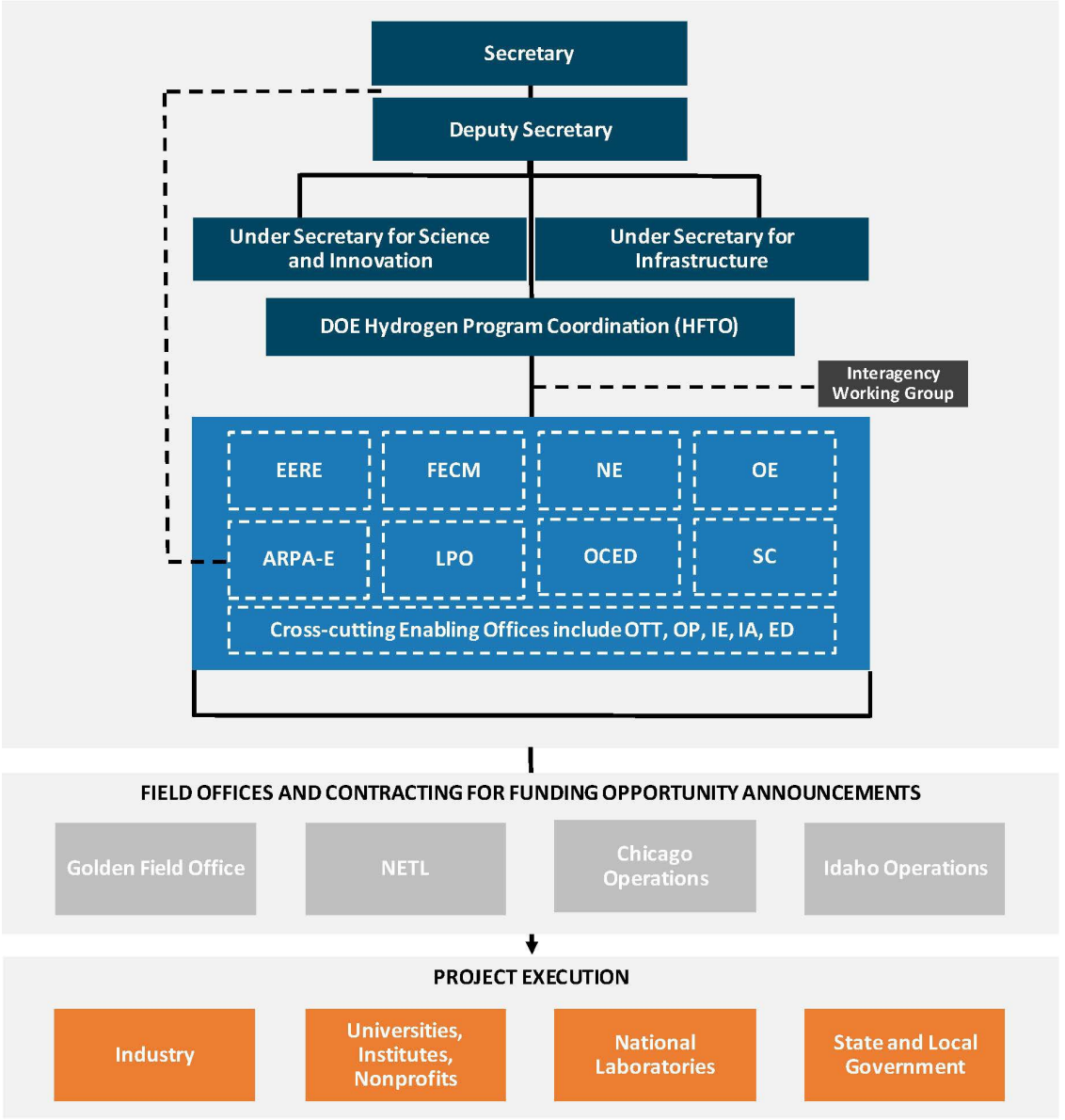






www.hydrogen.energy.gov

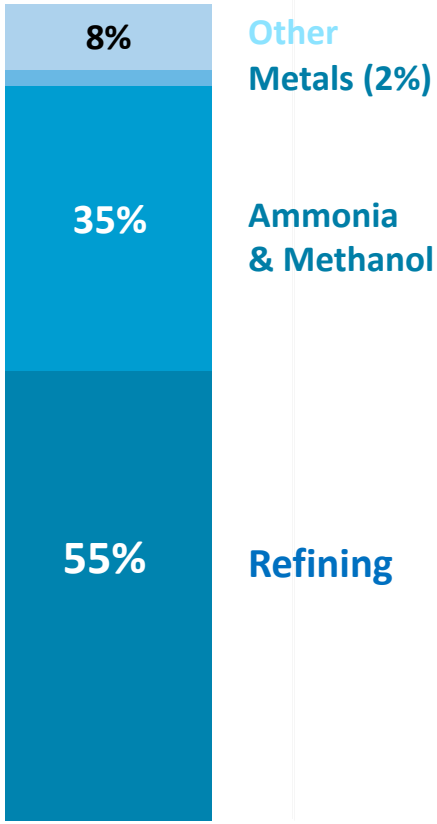
Coordinated across Offices by DOE Hydrogen and Fuel Cell Technologies Office (HFTO)



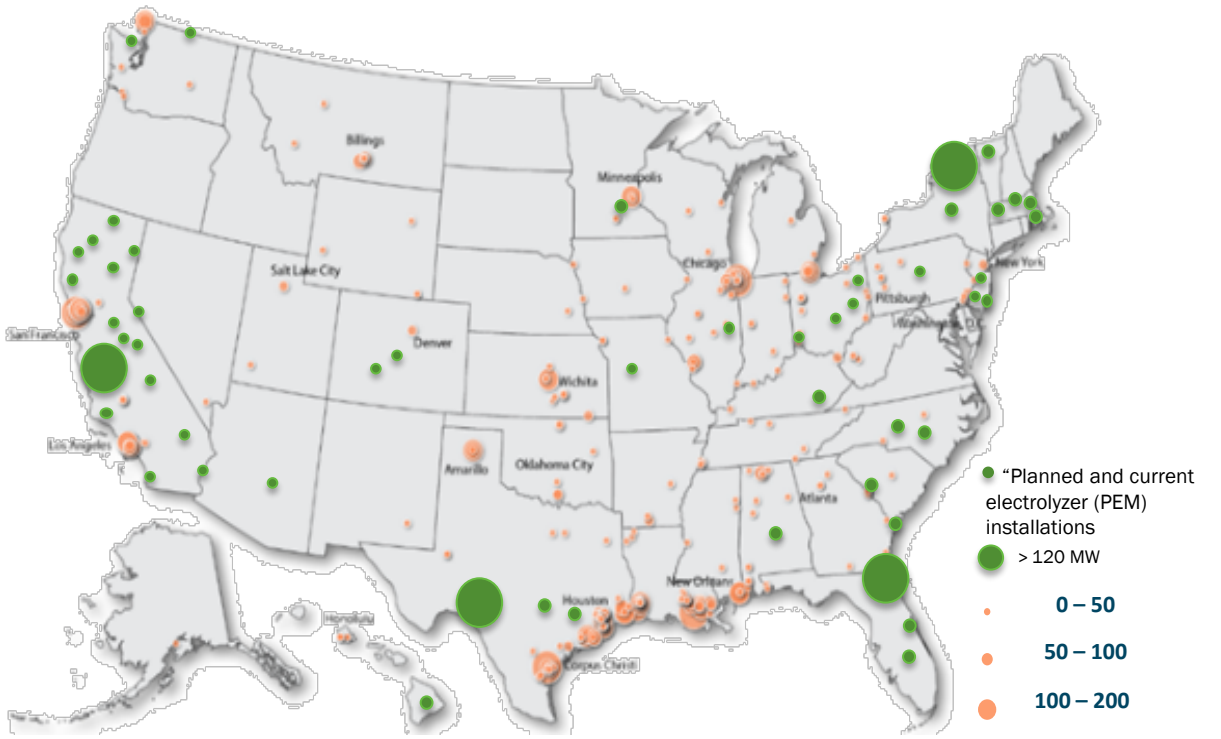
Snapshot of Hydrogen and Fuel Cells in the U.S.

- 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



Examples of Hydrogen Production Locations



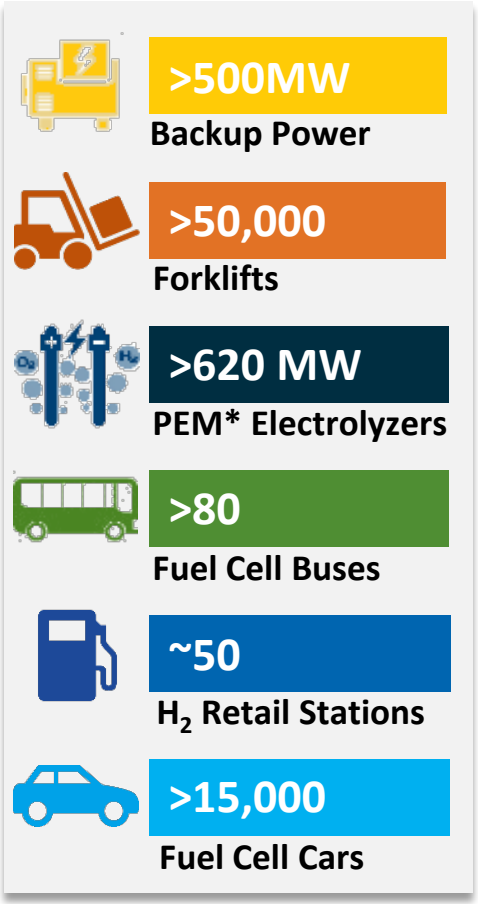
"Planned and current electrolyzer (PEM) installations

- > 120 MW
- 0 – 50
- 50 – 100
- 100 – 200
- 200 – 400
- 400 – 800

Hydrogen Production Units using natural gas Gaseous Metric Tons/Day

>620 MW of PEM* electrolysis in the U.S.
>3X increase since 2021

Examples of Deployments



*Proton exchange membrane

Accomplishments enabled by DOE Hydrogen and Fuel Cell Technologies Office (HFTO) Funding

Innovation

1,256 Patents

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

35% from National Labs

Technology-to-Market

30 Technologies Commercialized

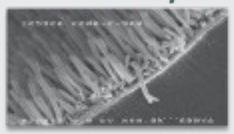
By private industry

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

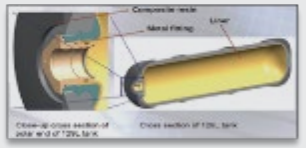
Class-1, -2, and -3 Forklifts
Plug Power (GenDrive FCs)

Electrolyzers

Electrolyzer System
Proton Series

PEM Electrolyzer System
Giner

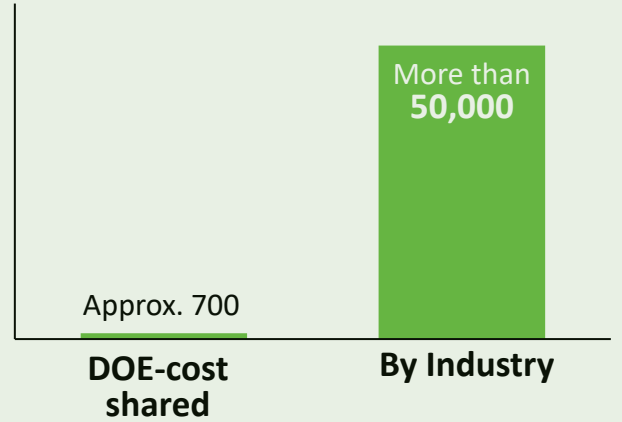
Hydrogen Tanks



Optimized 129L Tank
Quantum Technologies

Market Uptake

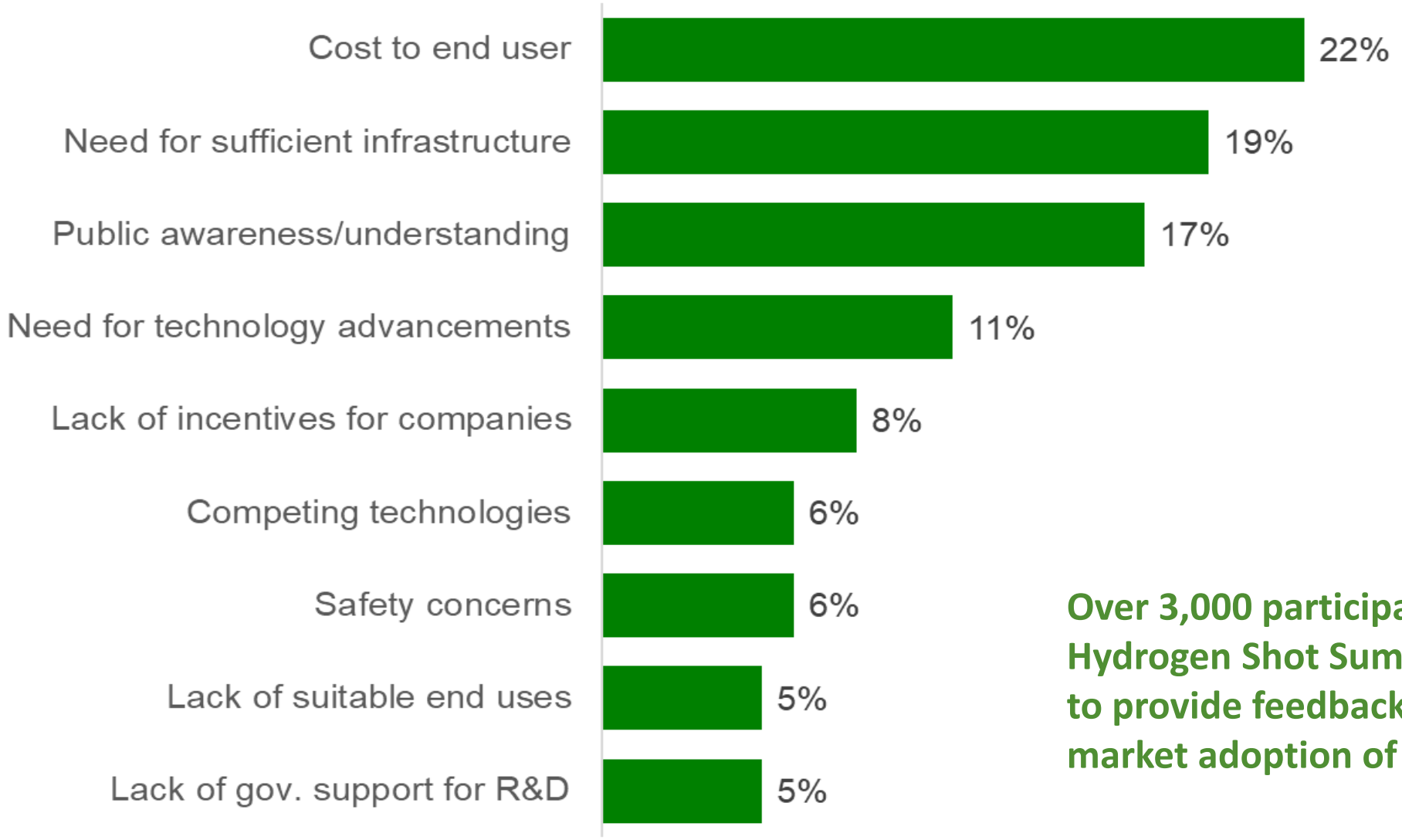
Hydrogen fuel cell forklifts in the U.S.



American-made small-scale hydrogen refueler

- Exported to Japan
- Uses electrolysis

There are Still Significant Challenges: 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: DOE Hydrogen Shot Summit, Sept 2021

Hydrogen Energy Earthshot

“Hydrogen Shot”

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

Recent Legislation Highlights

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)

Inflation Reduction Act (IRA) – Examples of H_2 and Fuel Cell Incentives

Clean Hydrogen Production Tax Credit (45V) up to $3/kg

Carbon Intensity (kg CO_2 per kg H_2)	Max Tax Credit ($/kg H_2)*
4–2.5	$0.60
2.5–1.5	$0.75
1.5–0.45	$1.00
0.45–0	$3.00

Qualified Commercial Clean Vehicles Credit (45W)

Creates a **new 30% credit** for commercial fuel cell electric vehicles through 2032, capped at **$40,000**:

- Class 1–3 vehicles: **$7,500 tax credit** for purchase of qualified clean vehicles
- Class 4 and above: **$40,000 tax credit**

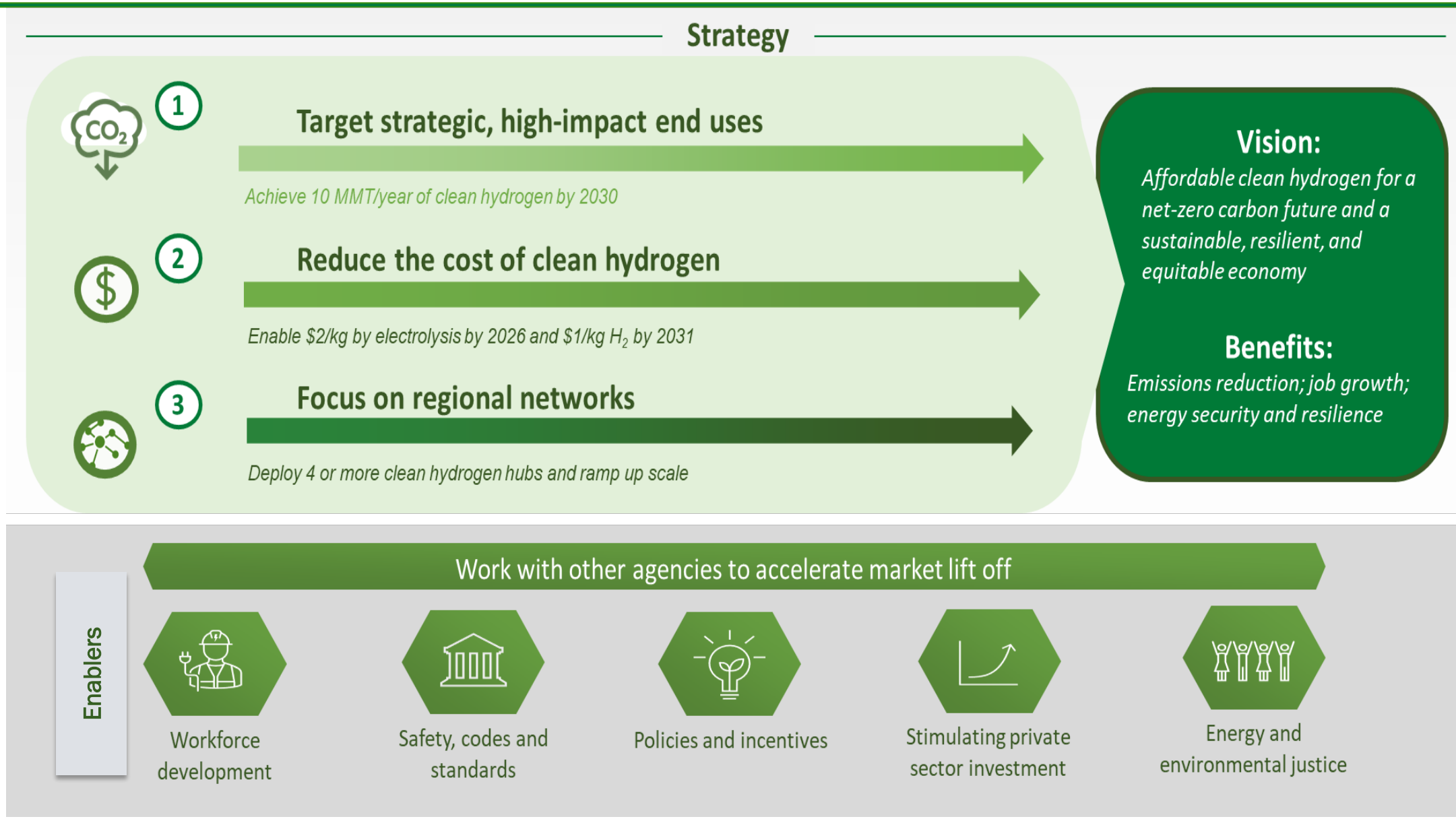
Alternative Fuel Refueling Property Credit (30C)

Tax credit up to 30% of the cost of alternative fuel refueling property up to **$100,000**

View more at: www.energy.gov/eere/fuelcells/financial-incentives-hydrogen-and-fuel-cell-projects

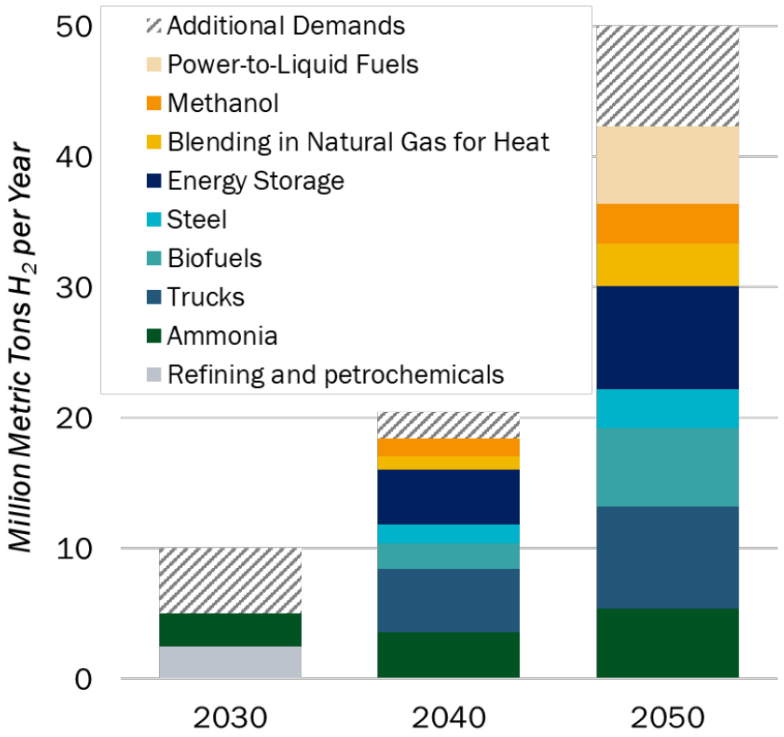
* Well to gate, using GREET

National Clean Hydrogen Strategy and Roadmap for Public Comment



National Clean Hydrogen Strategy – The Opportunity for Clean Hydrogen

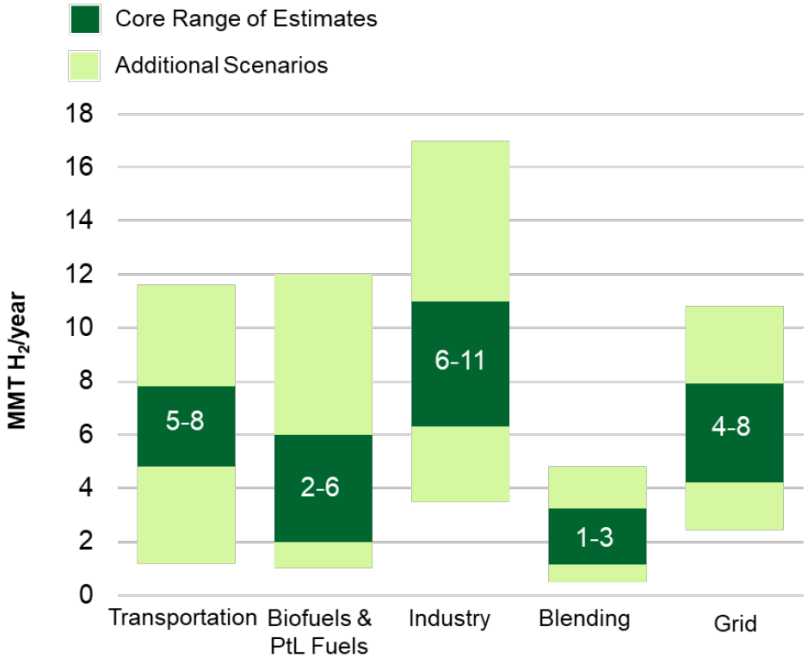
Opportunities for Clean Hydrogen Across Applications



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**

U.S. Opportunity:
10MMT/yr by 2030, 20 MMT/yr by 2040, 50 MMT/yr by 2050

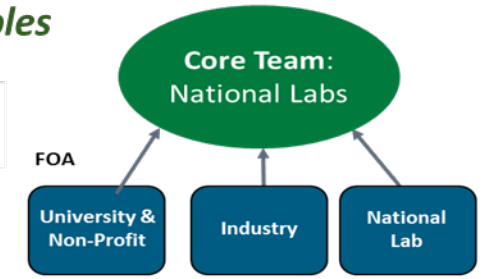
Refs: 1. NREL MDHD analysis using TEMPO model; 2. Analysis of biofuel pathways from NREL; 3. Synfuels analysis based off H2@Scale ; 4. Steel and ammonia demand estimates based off DOE Industrial Decarbonization Roadmap and H2@Scale. Methanol demands based off IRENA and IEA estimates; 5. Preliminary Analysis,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

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

MILLION MILE FUEL CELL TRUCK

U.S. DEPARTMENT OF ENERGY

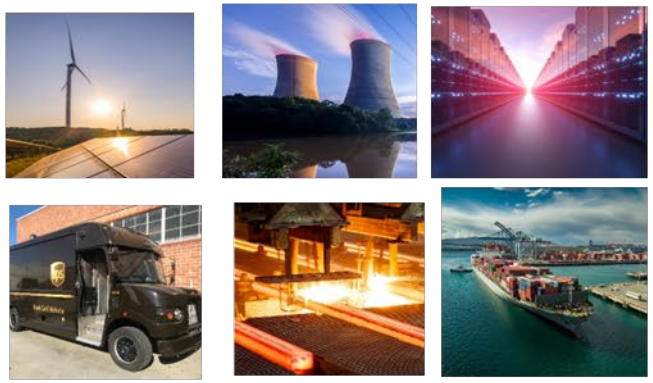
SHASTA Subsurface Hydrogen Assessment, Storage, and Technology Acceleration

Basic science user facilities, theory, modeling

Technology Integration, Validation, Demos

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

Examples:



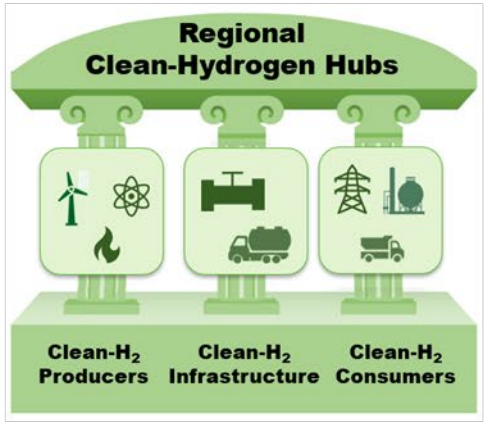
Renewables and nuclear to H_2, 15 delivery trucks in disadvantaged area, 3 Super Truck projects, data center, fueling for passenger ferry, energy storage, H_2 for steel

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

H2 Matchmaker

Current & Upcoming DOE Funding Opportunities – Examples

Bipartisan Infrastructure Law Includes

- $1B for electrolysis RD&D
- $0.5B for manufacturing and recycling R&D
- $8B for at least four regional clean hydrogen hubs

Notice of Intent (NOI) Announced

- **$750 million covers Electrolysis, Fuel Cells, Manufacturing, and Recycling**
- **Stay tuned for funding opportunity details**

Sign up to receive DOE hydrogen and fuel cell updates

www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

Funding Opportunity Announcement (FOA)

- **$47 million from HFTO**

Topics Areas Include:

  - **Hydrogen Carriers**
  - **Onboard Storage Systems for Liquid Hydrogen**
  - **Liquid Hydrogen Transfer/Fueling Components and Systems**
  - **Membrane Electrode Assemblies for Medium and Heavy-Duty Applications as part of Million Mile Fuel Cell Truck Consortium**

- Concept papers due **February 24, 2023**
- Learn more at: www.energy.gov/articles/biden-harris-administration-announces-47-million-develop-affordable-clean-hydrogen

Collaboration
Diversity, Equity, Inclusion, and Accessibility

Examples Promoting DEIA, bridging academia, labs and industry

Tommy Rockward, Scientist, Los Alamos National Lab (LANL) Advancing Diversity, Equity, Inclusion, & Accessibility (DEIA)

Lead for Minority Serving Institution Partnership Program (MSIPP) at LANL.
Has mentored over 100 minority students, enabling fuel cell jobs

INCREASE YOUR H2IQ hydrogen.energy.gov

Stay tuned for this month's HFTO Spotlight featuring Tommy and others in celebration of Black History Month!
And view Oct 6, 2022, webinar for more.

Funding for MSIs and Historically Black Colleges and Universities (HBCUs) to join HFTO consortia

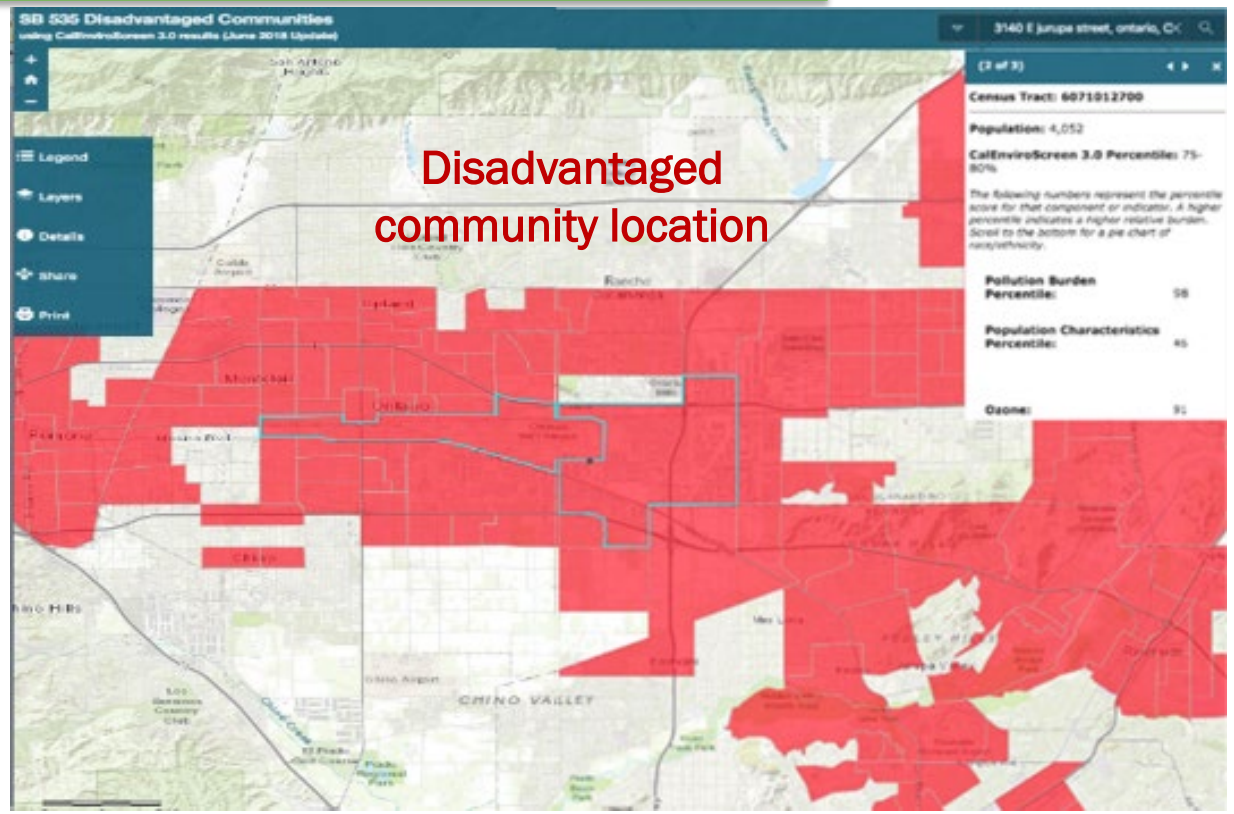
DOE Announces $1.5 Million to Train the Next-Generation Hydrogen Workforce | Department of Energy

LANL and Pajarito Powder Establish Collaboration with Minority Serving Institutions (MSIs)

Pajarito Powder and LANL host Industry day

Example of DOE-funded Project in Disadvantaged Community

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



Key Accomplishments and Status:

- 15 trucks built with validation testing complete on 10.
- Third party inspection soon to be completed on remaining trucks
- Operations have begun in disadvantaged community out of UPS Service center in CA. Vehicle deployment is beginning soon.

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

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 **launched early 2023** and to focus on **Mentor-Mentee partnerships**

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

Examples of Global Collaboration in Hydrogen and Fuel Cells

Collaborating through multiple partnerships – prioritization of gaps and key activities underway

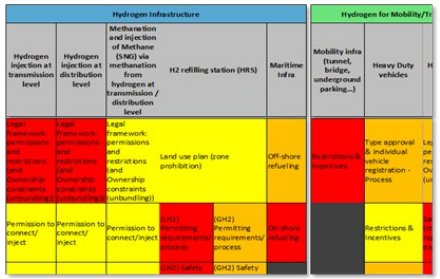
CEM Global Ports Coalition with EC
Numerous Bilaterals on Hydrogen
Hydrogen Council, IRENA, G7, UNIDO, and more

The International Partnership for Hydrogen and Fuel Cells in the Economy

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

Common analytical framework for GHG emissions footprint and facilitating international trade

Regulations, codes, standards, harmonization gap analysis

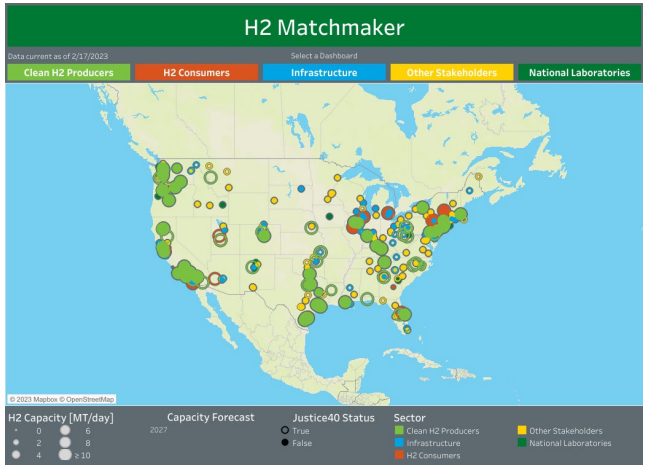


www.iphe.net

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

Resources and Opportunities for Engagement

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen



Save the date!

2023 DOE Annual Merit Review and Peer Evaluation Meeting
June 5-8, 2023

Hydrogen and Fuel Cells Day
October 8

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

1 1.008 H Hydrogen

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Thank You

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