U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

DOE Hydrogen Program Overview

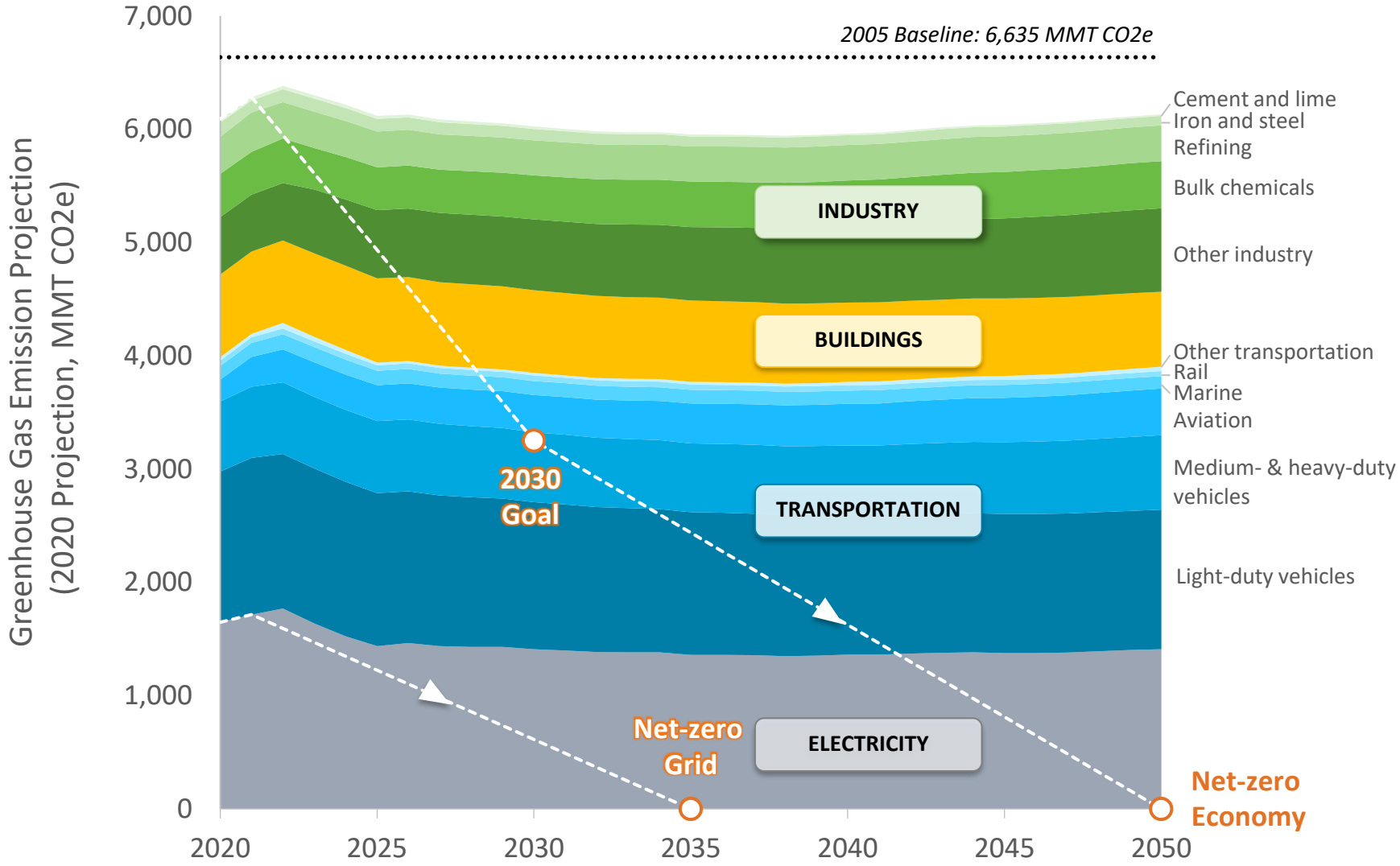
Dr. Zeric Hulvey, Technology Manager

Hydrogen and Fuel Cell Technologies Office

SAMPE Conference and Exhibition, Advanced Materials for Hydrogen Infrastructure Technologies Workshop

May 22, 2024

Carbon Dioxide Emissions by Sector



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

U.S. DOE Hydrogen Program

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

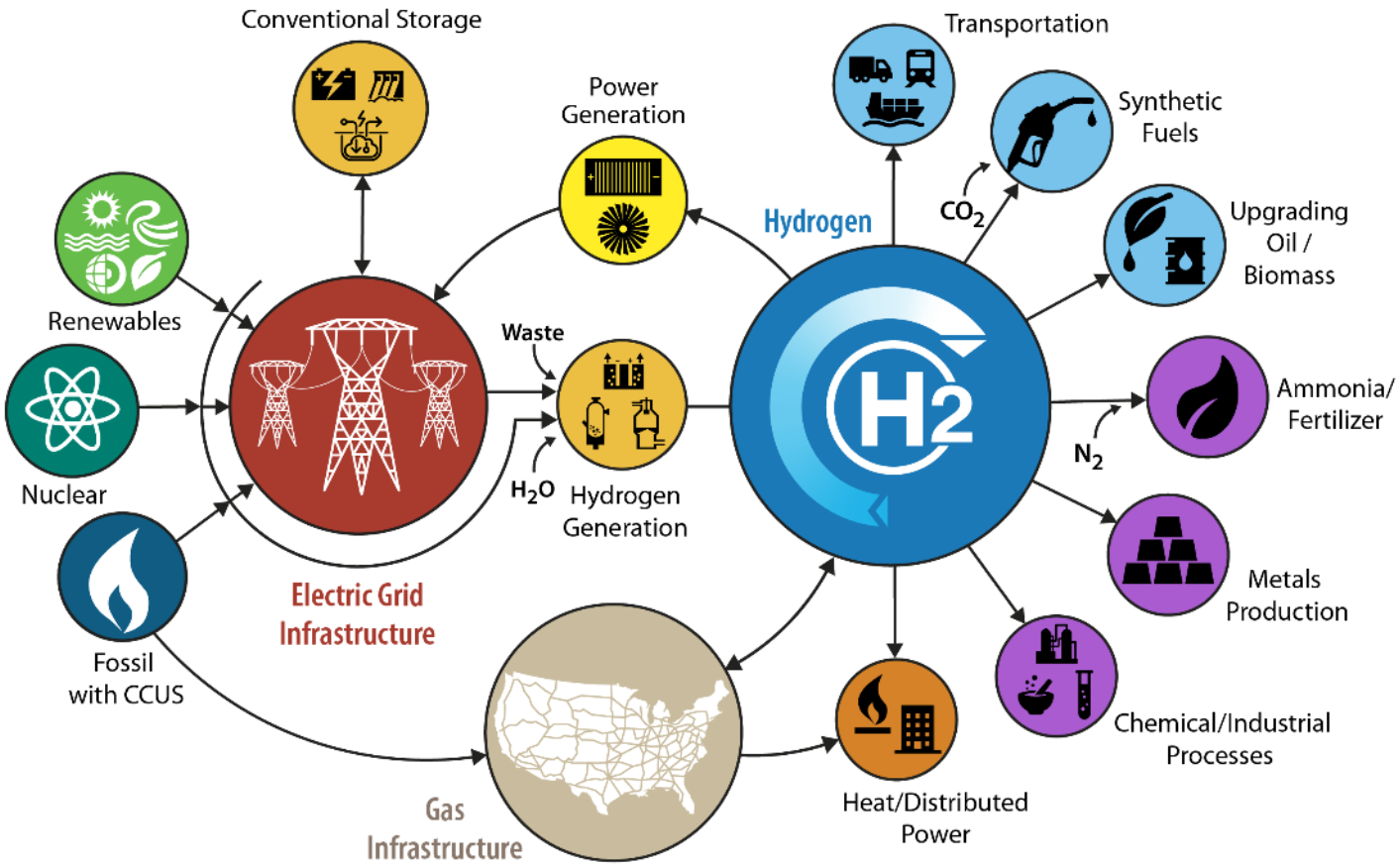
Hydrogen Program

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 <u>all</u> resources** (renewables, nuclear, and fossil + CCS)

www.hydrogen.energy.gov

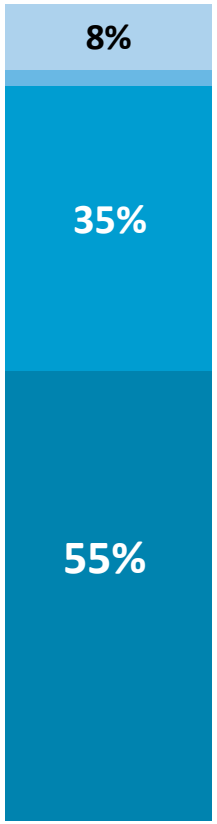
H2@Scale vision: Enables clean-energy pathways across sectors



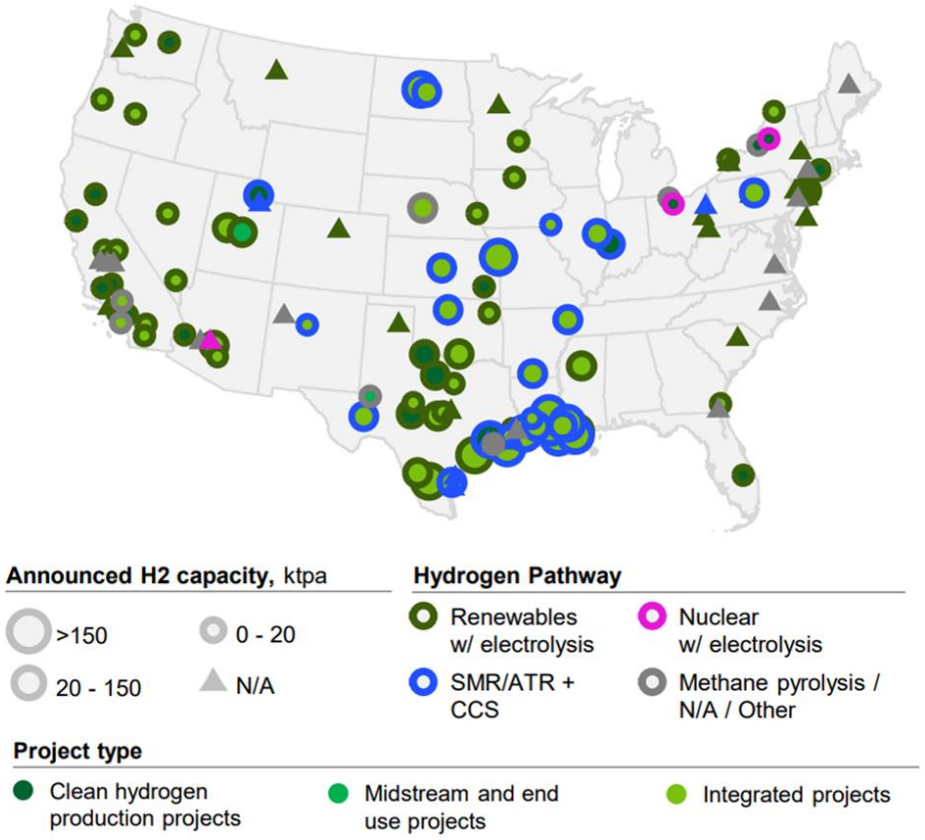
Snapshot of Hydrogen and Fuel Cells in the U.S.

- 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
- >18,000 — Fuel Cell Cars

Legislation Highlights: BIL and IRA

Bipartisan Infrastructure Law

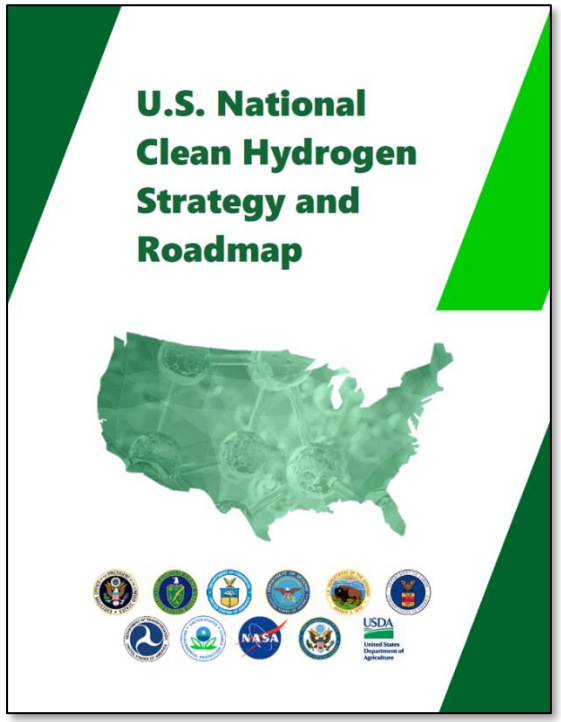
- **Includes $9.5B for clean hydrogen**:
  - $1B for electrolysis
  - $0.5B for manufacturing and recycling
  - $8B for at least four regional clean hydrogen hubs
- **Requires** developing a **National Clean Hydrogen Strategy and Roadmap**

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)

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

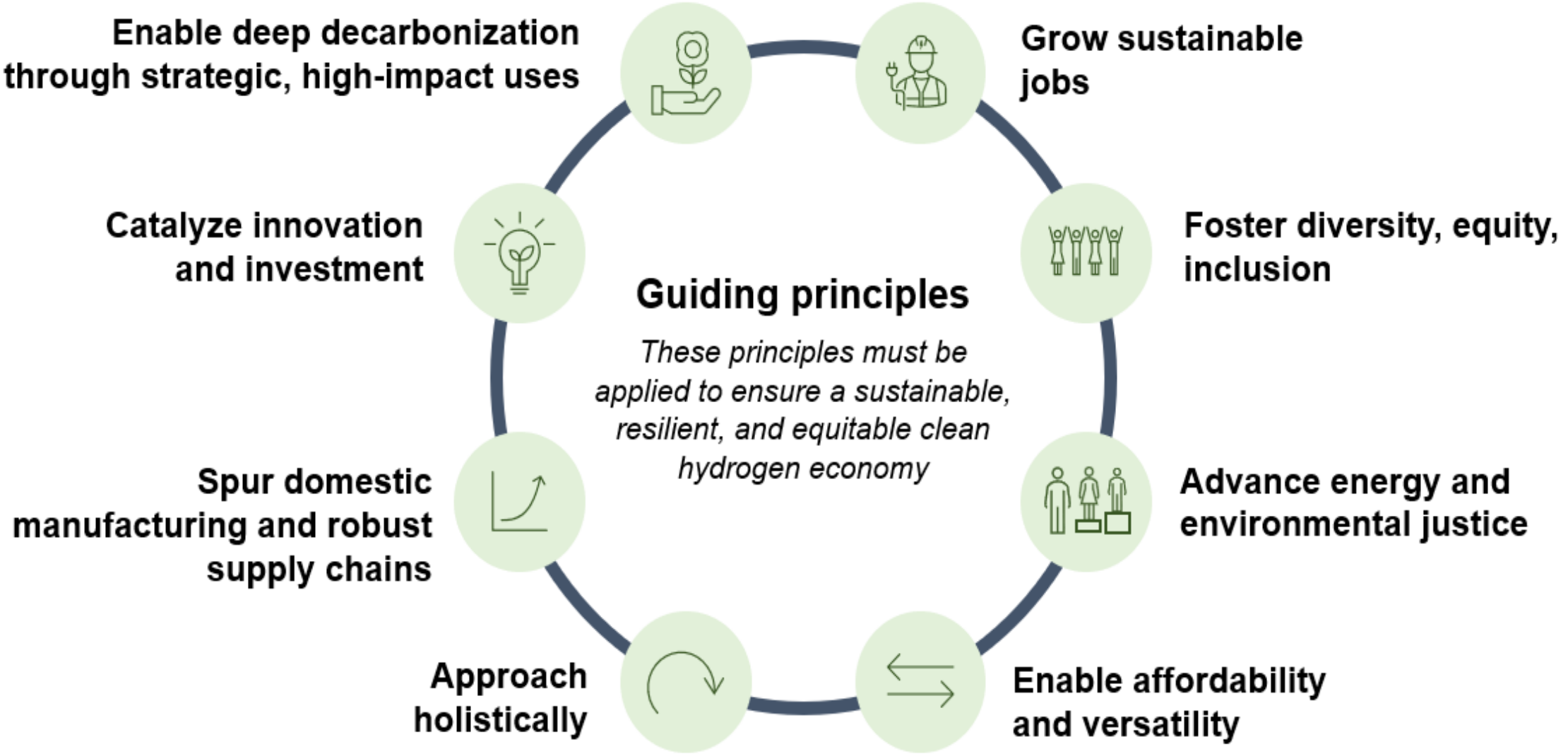
Benefits:
Emissions reduction; job growth; energy security and resilience

Enablers

Work with other agencies to accelerate market lift off

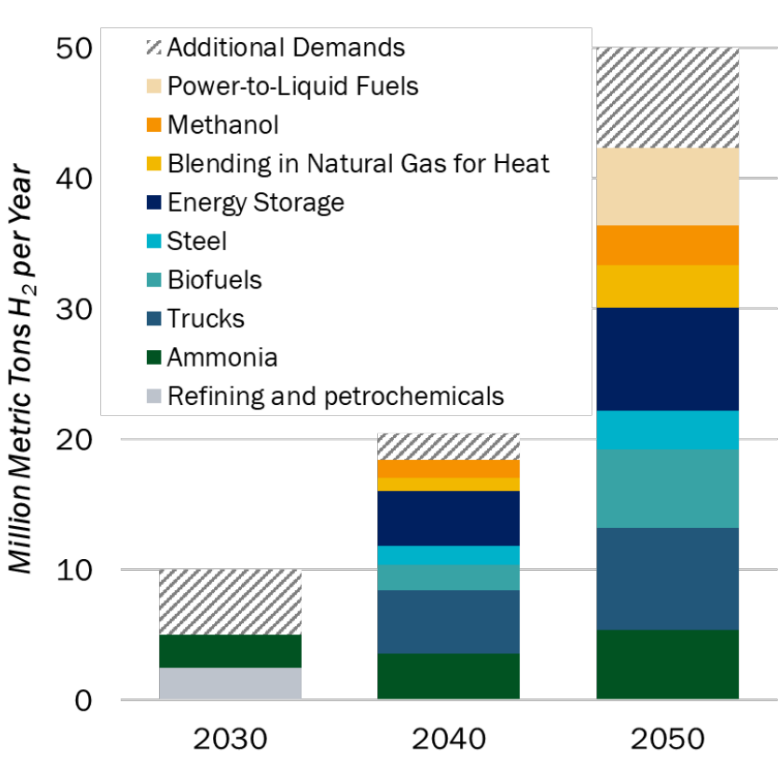
- Good Jobs and Workforce Development
- Safety, codes and standards
- Policies and incentives
- Stimulating private sector investment
- Energy and environmental justice

Guiding Principles



Strategy 1: Target Strategic, High-Impact End Uses

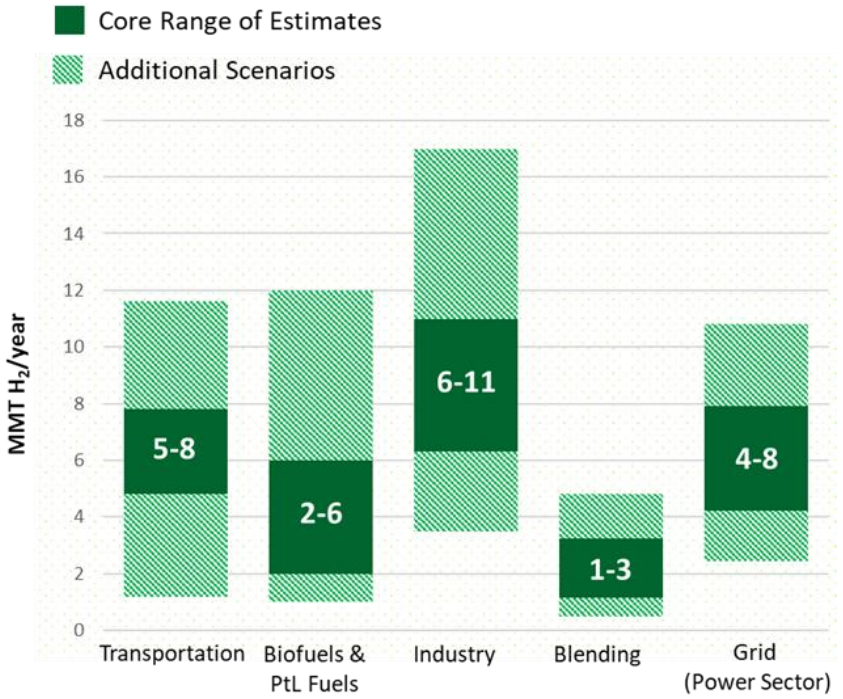
Opportunities for Clean Hydrogen Across Applications



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



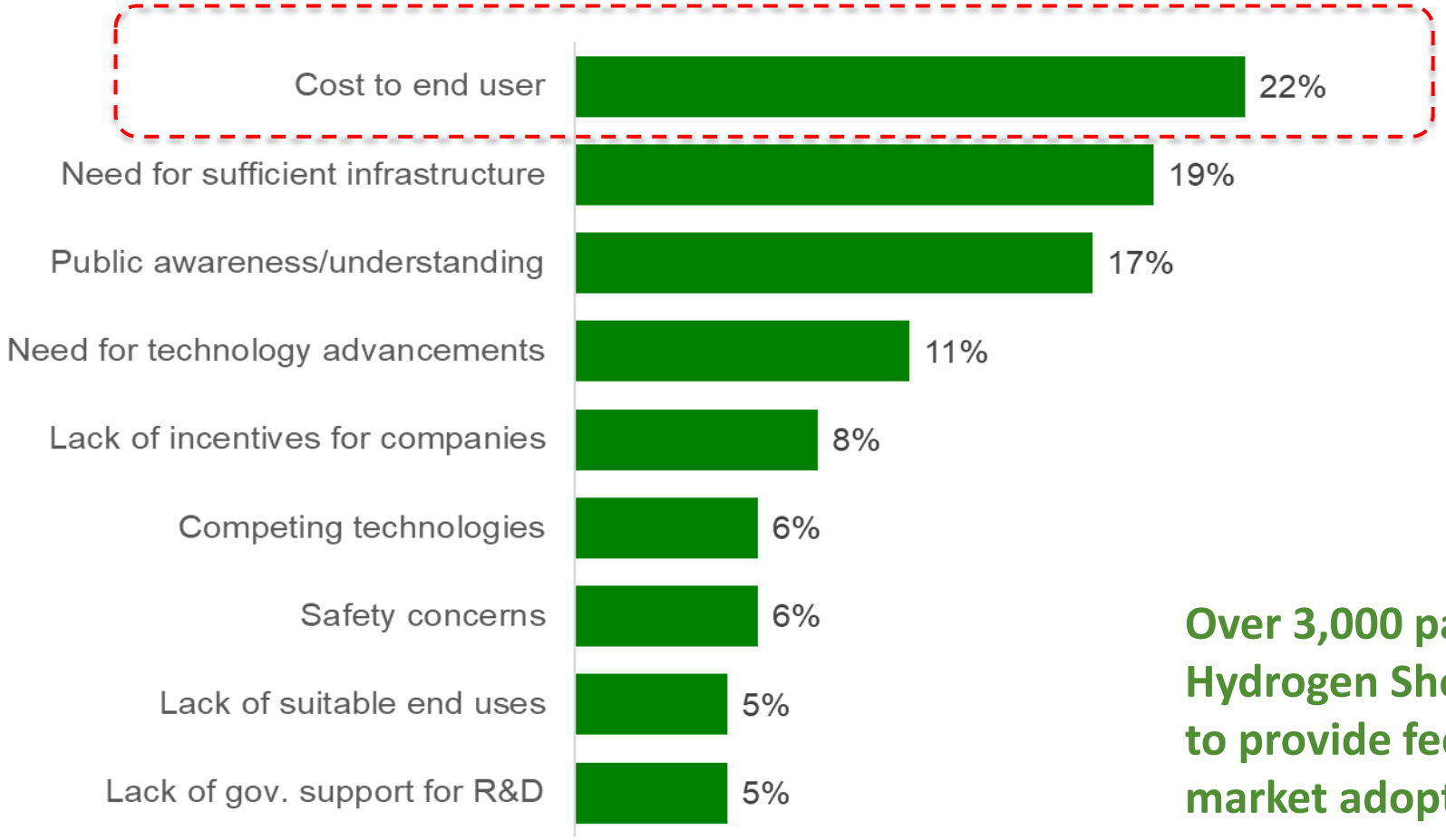
- **Core range: ~ 18–36 MMT H_2**
- **Higher range: ~ 36–56 MMT H_2**

Additional impacts: ~10% emissions reduction ~100K jobs by 2030

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

Source: Hydrogen Shot Summit, Sept 2021

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

ENERGY earthshots | Hydrogen
U.S. DEPARTMENT OF ENERGY

Hydrogen Energy Earthshot

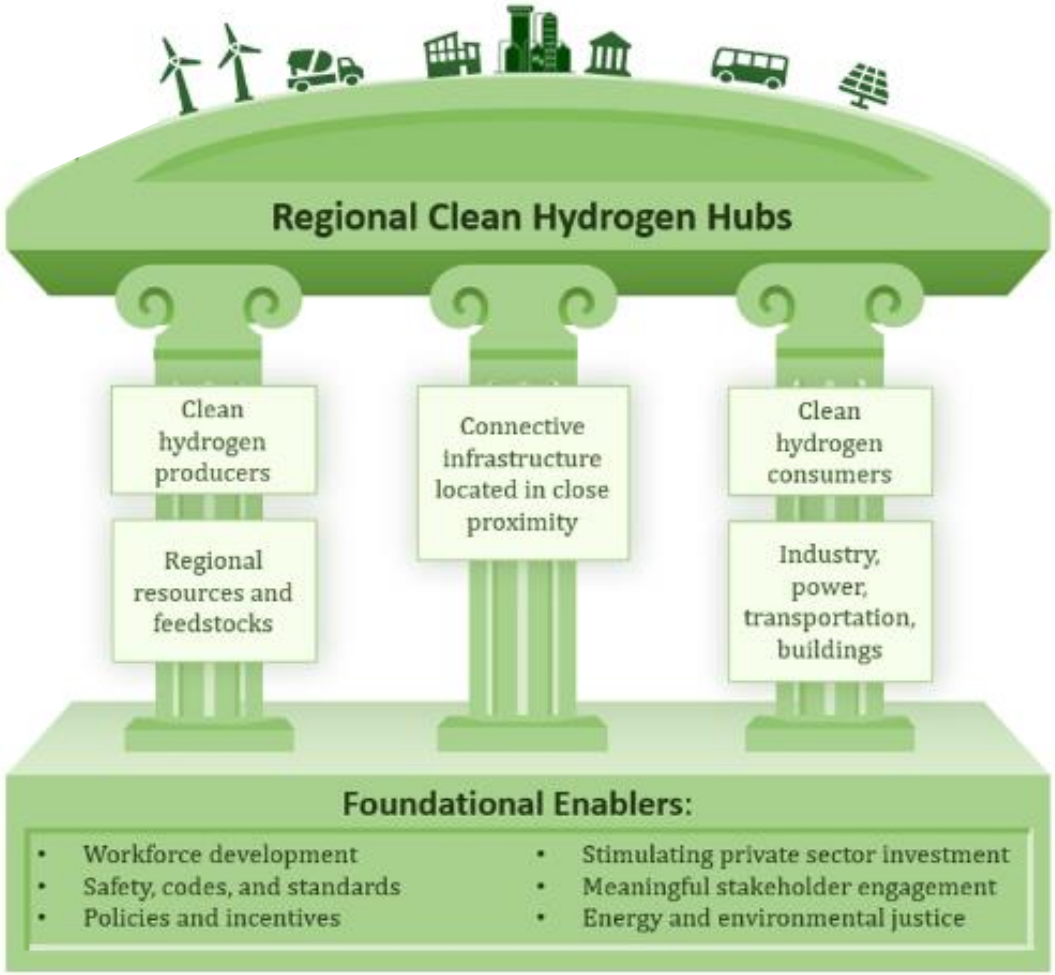
“Hydrogen Shot”

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

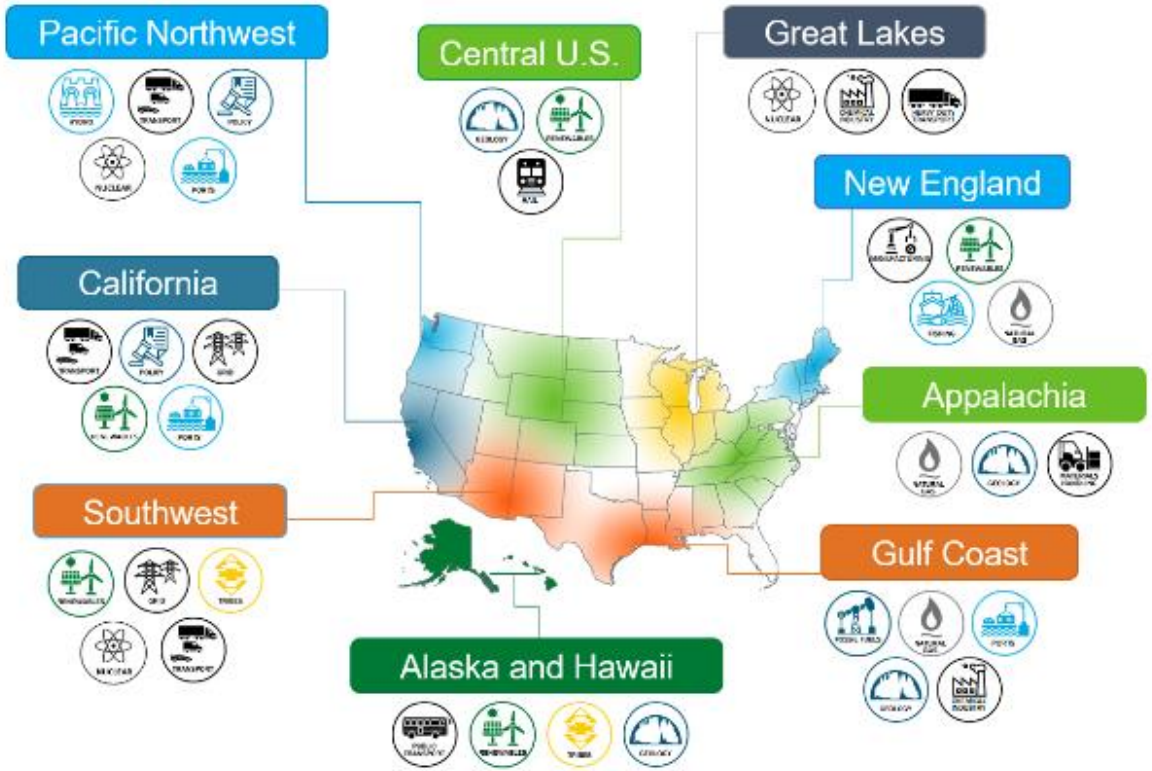
Strategy also includes delivery and storage infrastructure cost reduction

Strategy 3: Focus on Regional Networks and Ramp up Scale

Build Regional Networks through "Clean Hydrogen Hubs"



Examples of Stakeholder and RFI Input



Demand side strategy for Hubs announced

Strategy 3: Focus on Regional Networks

President Biden Announces $7 Billion for 7 H2 Hubs – Oct. 13, 2023

Equity and Environmental Justice Perspectives

I. Listening, Engaging & Increasing Transparency

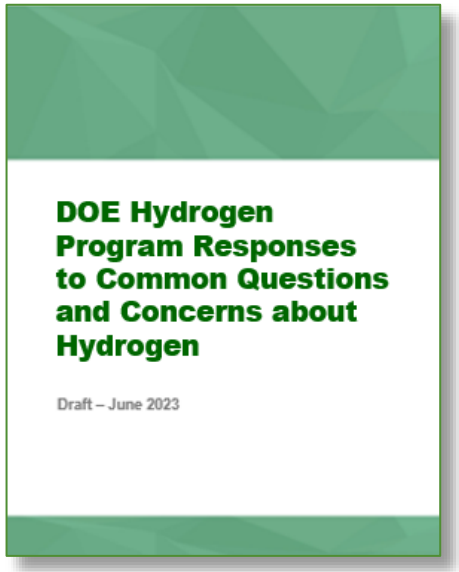
II. Prioritizing Safety and Positive Impacts

III. Lowering Barriers

IV. Diversifying the Clean Hydrogen Workforce

V. Building Capacity & Skills

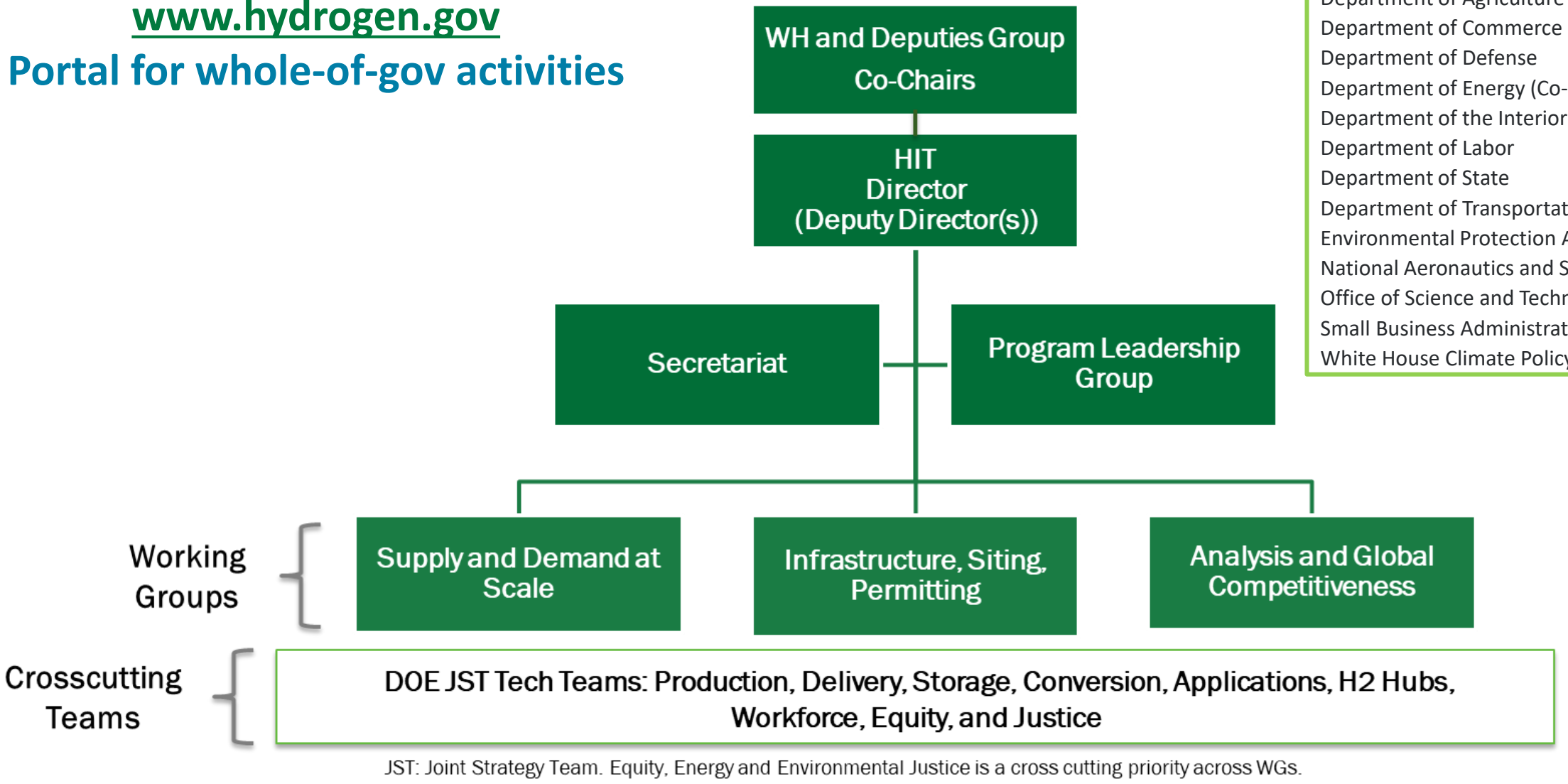
VI. Environmental Justice in Permitting and Siting



Stay tuned for more information on Community Benefits Plans, Mapping Tools, and upcoming activities

Hydrogen Interagency Task Force (HIT) across Agencies

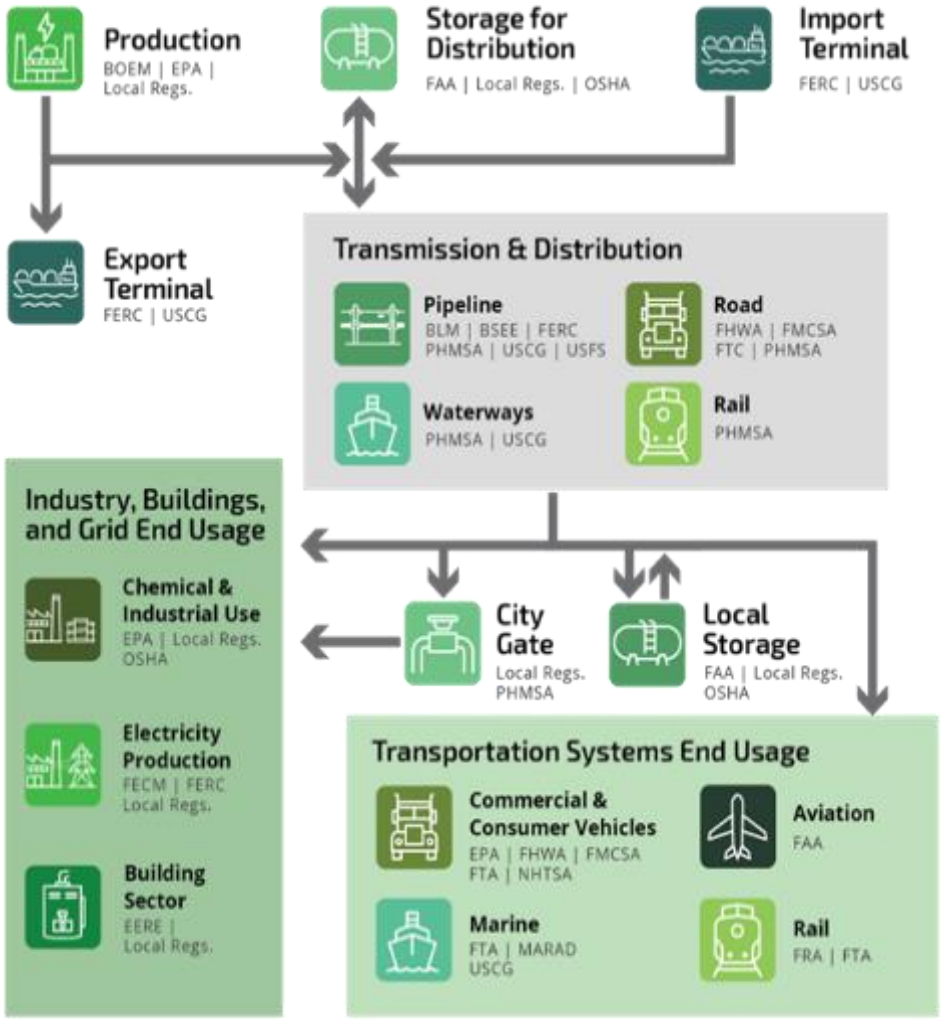
www.hydrogen.gov
Portal for whole-of-gov activities



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

- 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
- Environmental Protection Agency
- National Aeronautics and Space Administration
- Office of Science and Technology Policy
- Small Business Administration
- White House Climate Policy Office (Co-Chair)

Key Focus Areas for Cross-Agency Collaboration and Coordination



National Clean Hydrogen Strategy and Roadmap

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

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
CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together
H2 TWIN CITIES
HYDROGEN INITIATIVE
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL
Glasgow Breakthroughs @ COP26
MISSION INNOVATION
H2 CLEAN HYDROGEN MISSION
CENTER FOR 水素安全センター Hydrogen SAFETY
Connecting a Global Community
hySafe
FCH
PRHYDE
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

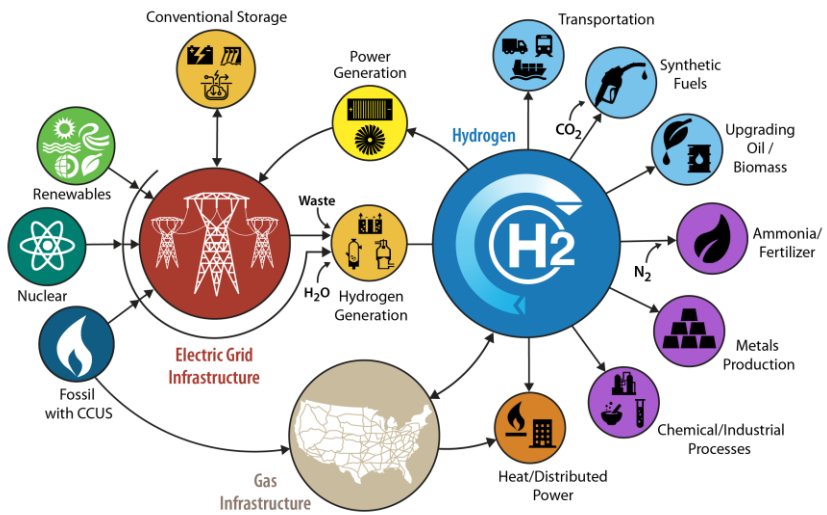
Launched H2-DEIA at COP
https://h2-deia.org/

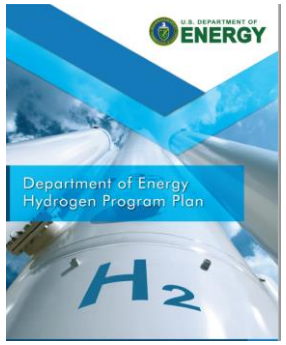
GLASGOW BREAKTHROUGHS

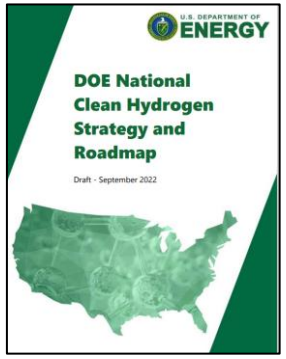
Breakthrough Agenda in collaboration with other partnerships is mapping activities across global H_2 initiatives to identify gaps, focus areas, and prioritized workstreams

Coordination Across DOE

Hydrogen is part of a comprehensive portfolio of activities, coordinated across offices

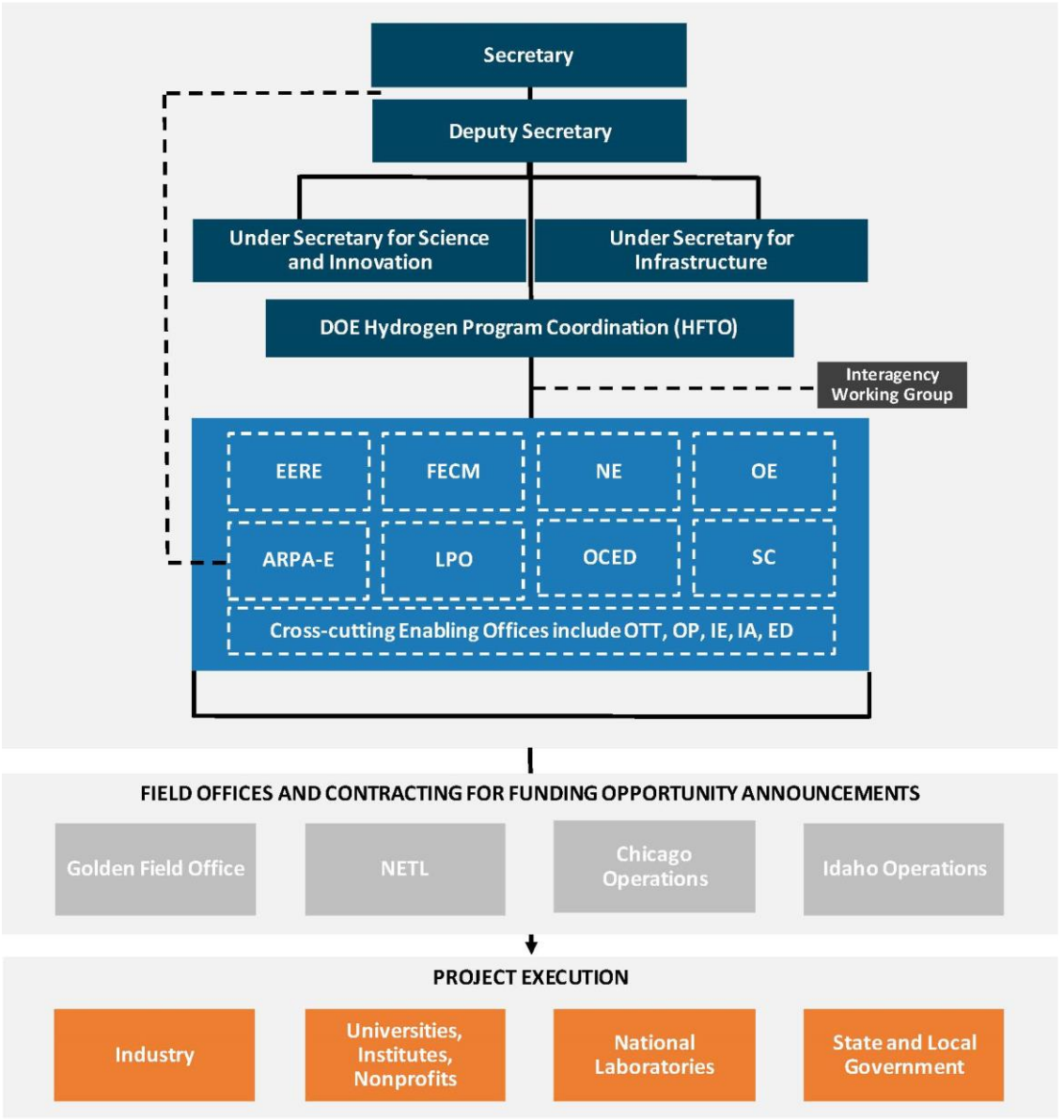






www.hydrogen.energy.gov

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



Hydrogen and Fuel Cell Technologies Office (HFTO)

Mission

Support 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**

Office Sub-Programs

Hydrogen Technologies

- Hydrogen Production
- Hydrogen Infrastructure

Fuel Cell Technologies

- Materials & Components
- Systems

Systems Development & Integration

- Transportation
- Industrial and Chemical Applications
- Grid Energy Storage and Power Generation
- Safety, Codes, and Standards

Data, Modeling, and Analysis

Enabling

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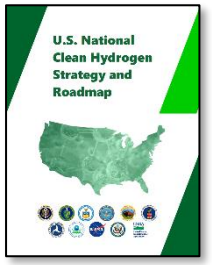
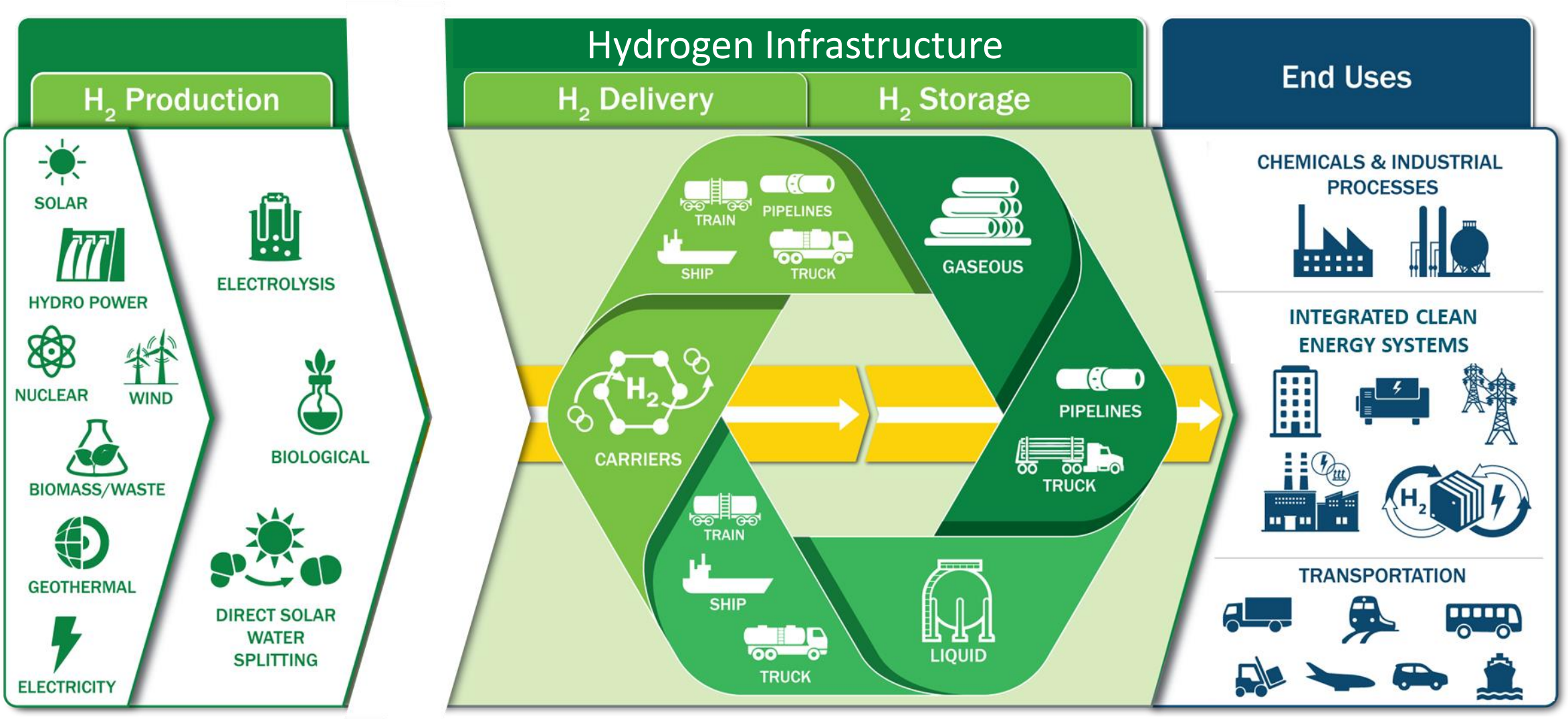
H2@Scale U.S. Department of Energy



Hydrogen Technologies: Production & Infrastructure



From producing hydrogen molecules through dispensing to end-use applications

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

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