

U.S. National Clean Hydrogen Strategy Opening Remarks

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U.S. Energy Landscape and Key Goals



Total = 100.4 guadrillion Total = 13.1 guadrillion Btu British thermal units (Btu) Geothermal, 2% Solar, 14% Natural Gas, 33% Coal, 10% Hydroelectric, 18% Wind, 29% Renewables, 13% Petroleum, 36% Nuclear, 8% Biomass, 37%

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

Carbon Dioxide Emissions by Sector



Source: National Clean Hydrogen Strategy and Roadmap based on Annual Energy Outlook 2021

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 H₂ value chain from production through end use
- H₂ 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 H₂ pipeline • World's largest H₂ storage cavern



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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)

U.S. National Clean Hydrogen Strategy and Roadmap



U.S. National Clean Hydrogen Strategy and Roadmap - Bing video



Clean Hydrogen Use Scenarios

- Catalyze clean H₂ 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, highimpact uses

Range of Potential Demand for Clean Hydrogen by 2050



• Core range: ~ 18–36 MMT H₂

Higher range: ~ 36–56 MMT H₂

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 DDE 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

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

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HYDROGEN AND FUEL CELL TECHNOLOGIES OFFICE

DOE Hydrogen Activities across RDD&D – Examples

Deployment and Financing Research and Development Technology Integration, Validation, Demos 1st of a kind demonstrations and systems Basic and applied research through H2 Hubs, loan guarantee program, individual projects and consortia integration to de-risk deployments workforce development Searthshots | Hydrogen Examples: Consortia Examples Example: Core Team: National Labs \$8 billion for at HydroGEN least 4 hubs: FOA Renewables. University 8 National H₂NEW Industry Non-Profit fossil w/CCS, Lab nuclear; multiple end-uses Clean-H₂ Renewables and nuclear to H_2 , 15 delivery **CELL TRUCK** trucks in disadvantaged area, 3 Super Truck projects, data center, fueling for passenger Basic science user facilities, theory, modeling ferry, energy storage, H₂ for steel

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



Hydrogen Education



2 new loan guarantee projects (\$1.5B total) on pyrolysis and large-scale electrolysis, H₂ energy storage and power generation









Hydrogen

Hydrogen Energy Earthshot

"Hydrogen Shot"

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

All pathways included: Electrolysis, Thermal Conversion, Advanced Pathways

How to reduce cost? Examples across multiple pathways

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

H₂ from Electrolysis



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

Thermal Conversion



Example: Natural Gas Conversion + CCUS

 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

Collaboration

Energy and Environmental Justice

Diversity, Equity, Inclusion, and Accessibility

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



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

H₂ 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

Early Career Network With >40 countries

GLASGOW BREAKTHROUGHS

Breakthrough Agenda in collaboration with other partnerships is mapping activities across global H₂ initiatives to identify gaps, focus areas, and prioritized workstreams

Landscape Coordination	Hydrogen Knowliken op de gesternikje et in het inderhen indere							
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Call to Action: Join the Center for Hydrogen Safety!



www.aiche.org/CHS

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

Composed of 7 fundamental hydrogen safety e-courses,

including:

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

Resources and Opportunities for Engagement



RONALD REAGAN INT. TRADE CENTER WASHINGTON D.C.

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





Join Monthly H2IQ Hour Webinars

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Thank you

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

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