U.S. Department of Energy Hydrogen and Fuel Cell Perspectives

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Power-to-Gas Webinar

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Hydrogen – One Part of a Comprehensive Energy Strategy

H₂ can be produced from diverse domestic sources

Many applications rely on or could benefit from H₂

Clean, sustainable, versatile, and efficient energy carrier

High energy content by mass
Nearly 3x more than conventional fuels

Low energy content by volume
Snapshot of Hydrogen and Fuel Cells Applications in the U.S.

Examples of Applications

- **Stationary Power**: >500MW
- **Forklifts**: >33,000
- **Fuel Cell Buses**: >30
- **H₂ Retail Stations**: >45
- **Fuel Cell Cars**: >8,500

Hydrogen Production Across the U.S.

- 10 million metric tons produced annually
- More than 1,600 miles of H₂ pipeline
- World’s largest H₂ storage cavern

Hydrogen Stations: Examples of Plans Across States

- **California**: 200 stations planned - CAFCP goal
- **Northeast**: 12 – 20 stations planned
- **HI, OH, SC, NY, CT, MA, CO, UT, TX, MI, and others**
H₂@Scale: Enabling affordable, reliable, clean, and secure energy across sectors
Electricity Mix Landscape is Changing

Example: Installed Capacity in Texas

The price of solar and wind has dropped dramatically.
Hydrogen costs can be less than $5/kg.

Source: ERCOT, DOE H2@Scale Workshop, TX
Additional Value of Hydrogen: Grid Services and Resiliency

Flexibility will be needed to address grid challenges: high ramp rates and demand fluctuations

Predicted 2025 California EV Charging Load Profile (Weekday) shows impact of demand profiles on the grid

DOE national lab tests show dynamic response potential of electrolysers

Expected increase of ~ 500 MW from 4pm to 7pm


Idaho National Lab & National Renewable Energy Lab results Direct fast charger impact project underway 2020-2021
Commercial Hydrogen and Fuel Cell Technologies Now Available across Sectors

Over 1/3 Million Stationary Fuel Cells, More Than 15,000 Fuel Cell Vehicles, 400 Stations Worldwide
1 GW Fuel Cells Shipped in 2019
Examples of U.S. Activities to Enable H2@Scale

Assessing resource availability. Most regions have sufficient resources.

Hydrogen Availability

Hydrogen Potential From Photovoltaic and Onshore Wind Resources Minus Maximum Market Potential for the Industrial & Transport Sectors, Natural Gas and Storage

Net Hydrogen (metric ton/county mi²/yr)

- 2,000 - 4,000
- 1,000 - 2,000
- 350 - 1,000
- 0 - 350
- <8,000 - 0

Nuclear Energy Plants

- Currently Operating
- Announced Retirement
- Recently Retired

Red: Only regions where projected industrial & transportation demand exceeds supply.

Hydrogen Demand Potential

Maximum Market Potential for the Industrial & Transport Sectors, Natural Gas, and Storage

Total H2 Demand (metric ton/county mi²/yr)

- 40 - 15,000
- 10 - 40
- 5 - 10
- 3 - 5
- 1 - 2
- 0 - 1

Total: 166,000,000 metric ton H2 / yr
(Alaska & Hawaii not shown)

3* new H2@scale demonstration projects in Texas, Florida and Midwest.

*Includes 1 project by Office of Nuclear Energy
Example of H2@Scale Project: Demonstration and Framework for H2@Scale in Texas and Beyond

Integration Concepts Being Considered

**Solar Power**
- PV Installation at Texas Advanced Computing Center
- UT-CEM Microgrid emulated solar power from Austin Energy

**Wind Power**
- UT-CEM Microgrid emulated wind power from West Texas

**Renewable Natural Gas**
- Texas RNG sourced from Waste Management landfill gas through virtual pipeline with OneGas

**On-site Electrolysis**
- Using renewable solar and wind power generation
- Sourced by GTI

**On-site SMR**
- Using renewable natural gas
- Provided by GTI and OneH2

**On-site Fuel Cell Power**
- Using combination of renewable H2 generation pathways
- Fuel cell provided by Hydrogenics

**On-site Fueling Station and FCEVs**
- Using combination of renewable H2 generation pathways
- Fueling station provided by Air Liquide
- Light-duty fuel cell vehicles provided by Toyota
- Fuel cell aerial drones provided by Guinn Partners / DMI

**Data Center**
- Combination of solar, wind, and hydrogen power generation with grid interconnect and battery energy storage
- Operated by Texas Advanced Computing Center

**Partners include:**
- Frontier Energy
- University of Texas at Austin
- GTI
- Toyota
- Waste Management
- OneH2

**Duration**
- 36 Months

**Total budget**
- $12.7M

Note: Based on original submission. To be updated based on project finalization.
Example of H2@Scale Project: Integrated Hydrogen Production and Consumption for Improved Utility Operations – Orlando, FL

Partners
- Giner ELX Inc
- Orlando Utilities Commission
- General Motors
- OneH2
- UCF-FSEC

Duration
- 36 Months

Total budget
- ~$8.5M
Example of H2@Scale Project: Electrolyzer Operation at Nuclear Plant and In-House Hydrogen Supply

Partners

Exelon & Nel Hydrogen
INL
NREL
ANL

Duration
36 months

Total budget
$7.2M
First Ever Carbon-Free, “Power-to-Gas” System in U.S.

Flagship Power-to-gas Project
Funded By DOE EERE In Partnership With Southern California Gas Company (SoCalGas)

• Utilizes H₂+ CO₂ to generate pipeline quality natural gas (> 97% CH₄)

• Biocatalyst used in the process - Methanothermobacter thermautotrophicus

Biomethanation Process:
CO₂ + 4H₂ → CH₄ + 2H₂O

• Industry and lab partners: Southern California Gas Company, NREL and Electrochaea

Press Release

See: Kevin Harrison presentation later in the webinar

- Approx. $2.5 million funded through EERE’s Solar, Hydrogen and Fuel Cells, and Bioenergy Offices along with cost share by SoCalGas

- Process uses a low-temperature water electrolyzer to produce hydrogen from renewable power, then feeds the hydrogen and carbon dioxide into a bioreactor where methanogens produce methane and water

- With minor filtration, the product gas from the bioreactor will meet pipeline quality, allowing it to be injected into the existing natural gas infrastructure
20% hydrogen blends could enable a doubling\(^1\) of U.S. renewables consumption and can enable:

- Cross-sectoral emissions reductions
- Grid resiliency
- Terawatt hours of energy storage

  20% hydrogen blend in the U.S. by volume = 16 MMT/year, which would require ~750 TWh of electricity if produced via electrolysis. (Source: Elgowainy, et al. 2020)
Global Center for Hydrogen Safety Launched 2019

Promotes safe operation, handling and use of hydrogen across all applications.
Provides training and resources, includes industry, government, access to 110 countries.

Includes over 40 partners from industry, government and academia.
Access to >110 countries, 60,000 members.

www.aiche.org/CHS
In addition to DOE Technology Offices: DOE Office of Indian Energy

- IE offers **competitive grants, technical assistance, and education and capacity building** to assist Indian Tribes, including Alaska Native Villages to overcome regulatory and economic challenges to developing their vast energy resources
- IE invested nearly $85 million in more than 180 tribal energy projects valued at over $180 million (2010-2019)
- Tribal Energy Atlas – First-of-its-kind interactive geospatial application for tribes to conduct analyses of installed energy projects and resource potential on tribal lands

www.energy.gov/indianenergy/office-indian-energy-policy-and-programs
Resources and Announcements

Save the Date

June 8-10, 2021 Annual Merit Review and Peer Evaluation Meeting for the Hydrogen and Fuel Cells Program in Arlington, VA

Oct 8 - Hydrogen and Fuel Cells Day
(Held on its very own atomic weight-day)

Resources

Download H2IQ For Free
energy.gov/eere/fuelcells/downloads/increase-your-h2iq-training-resource

Join Monthly H2IQ Hour Webinars
energy.gov/eere/fuelcells/fuel-cell-technologies-office-webinars

Visit H2tools.Org For Hydrogen Safety And Lessons Learned
https://h2tools.org/

Sign up to receive hydrogen and fuel cell updates
www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

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

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Looking for more info?
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