U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

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

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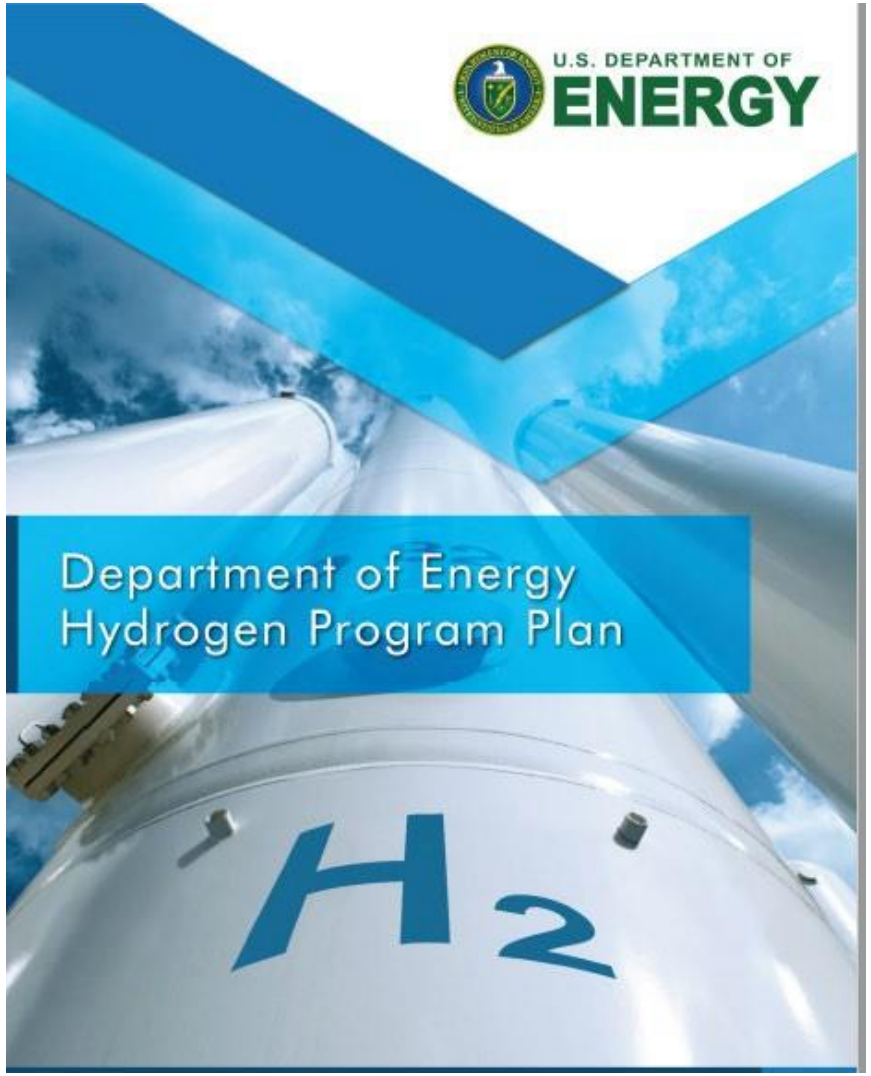
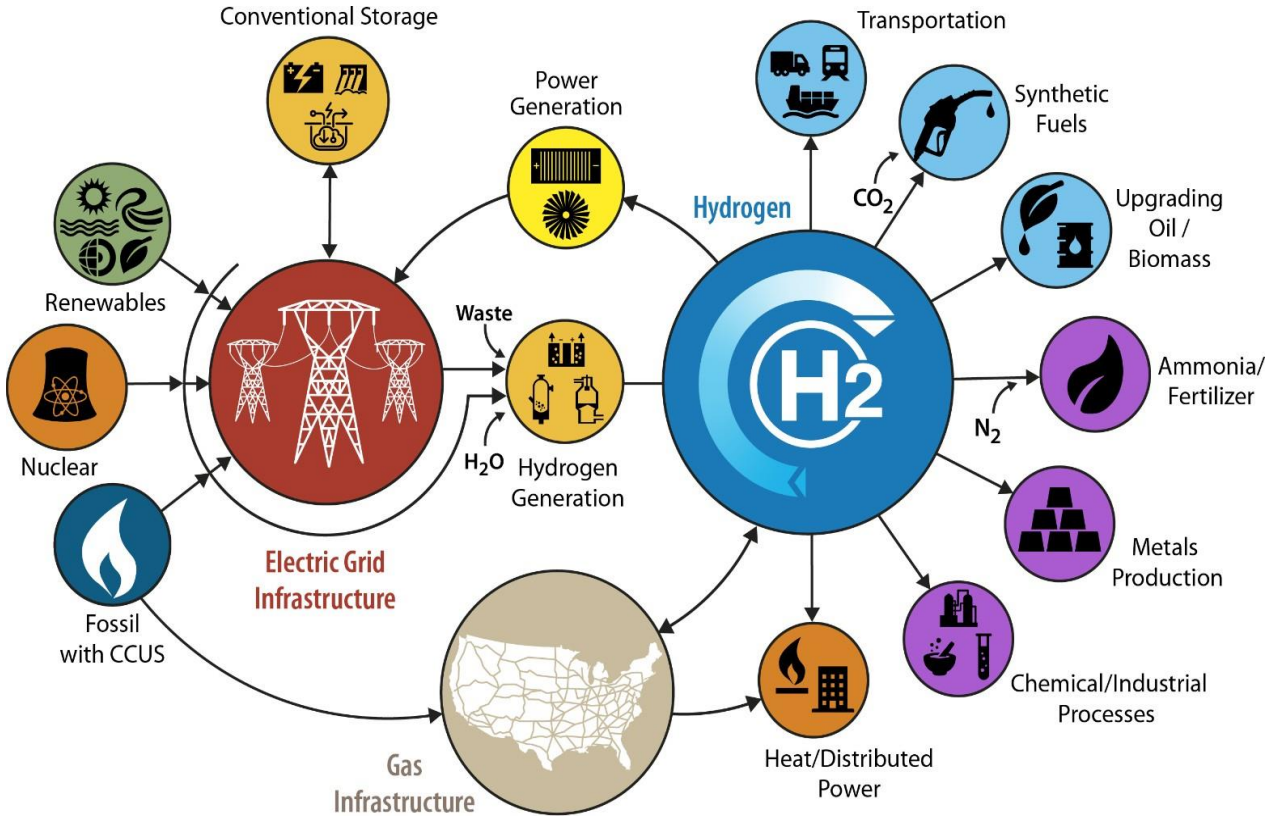
Texas Hydrogen Roundtable – January 12, 2021

US DOE Integrated Hydrogen Program



Released November 2020 - www.hydrogen.energy.gov

H2@Scale to enable affordable, reliable, clean and secure energy across sectors
Strategies include: R&D to reduce cost and improve performance, enable scale and end uses across sectors



Examples of DOE-Funded Innovation and Impact

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Impact due to HFTO Funding

Innovation

1,110 H_2 and fuel cell patents **enabled by HFTO funds**

Approx. 35% of H_2 and fuel cell patents **come from National Labs**

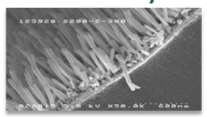
Market Impact

More Than 30 Technologies Commercialized by private industry

And Over 65 with potential to be commercial in the next 3 – 5 years

Can be traced back to HFTO R&D

Fuel Cell Catalysts



Catalyst and Supports for PEM Fuel Cells
3M

Hydrogen Tube Trailers

Hydrogen Tube Trailers
Hexagon Lincoln

Forklifts

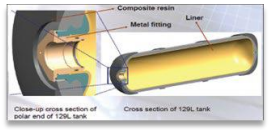
Class-1, -2, and -3 Forklifts
Plug Power (GenDrive FCs)

Electrolyzers

Electrolyzer System
Proton Series

PEM Electrolyzer System
Giner

Hydrogen Tanks



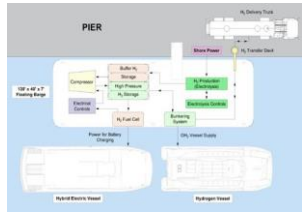
Optimized 129L Tank
Quantum Technologies

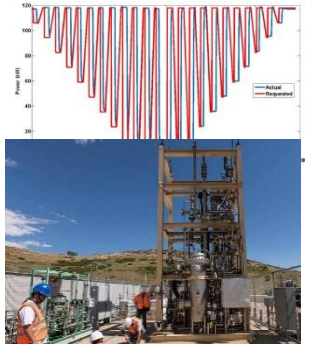
- Small scale H_2 fueler now available
- 5 to 20 kg unit, 700 bar fueling

$1M H-Prize H2Refuel Winner: SimpleFuel

First-of-a-Kind Demonstrations

- Marine application- ½ton H_2 fueling for vessel
- Data center- 1.5 MW
- First ground support equipment
- Parcel delivery vans (2x range vs BEVs)
- Mobile H_2 fueler
- First nuclear to H_2 demos
- First tri-gen system
- Dynamic response of electrolyzers and systems integration
- First H_2+CO_2 to renewable methane demo
- H_2/NG blending





Example: American Recovery Act co-funded few hundred fuel cell forklifts and backup power units for cell phone towers

Today ~ 40,000 systems commercially deployed at major companies, millions of H_2 fuelings to date

Snapshot of Hydrogen and Fuel Cell Applications in the U.S.

Examples of Applications

- **>500MW** Backup Power
- **>35,000** Forklifts
- **>14 MW** PEM* Electrolyzers
- **>60** Fuel Cell Buses
- **>45** H_2 Retail Stations
- **>9,000** Fuel Cell Cars

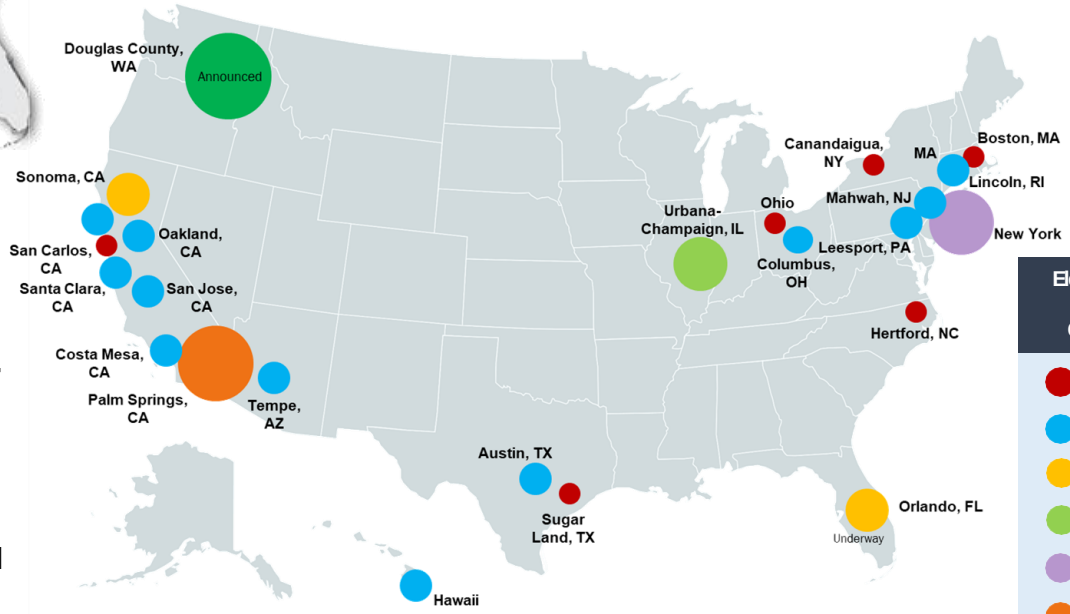
Hydrogen Production Across the U.S.

0 – 50
50 – 100
100 – 200
200 – 400
400 – 800

Hydrogen Production Units
Gaseous Metric Tons/Day

- 10 million metric tons produced annually
- More than 1,600 miles of H_2 pipeline
- World's largest H_2 storage cavern

PEM Electrolyzer Deployment Across the U.S.



* Polymer electrolyte membrane

Hydrogen Stations Plans Across States

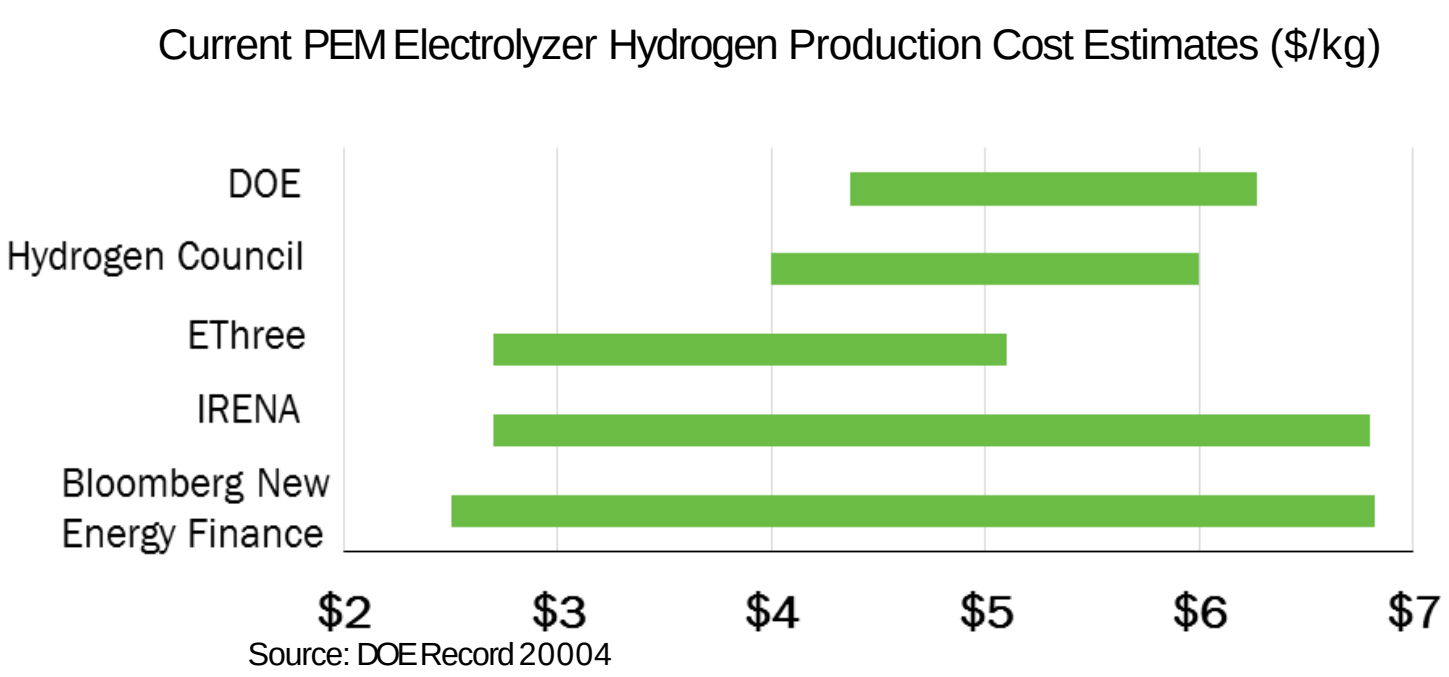
California
200 Stations Planned
CAFCP Goal

Northeast
12 – 20
Stations Planned

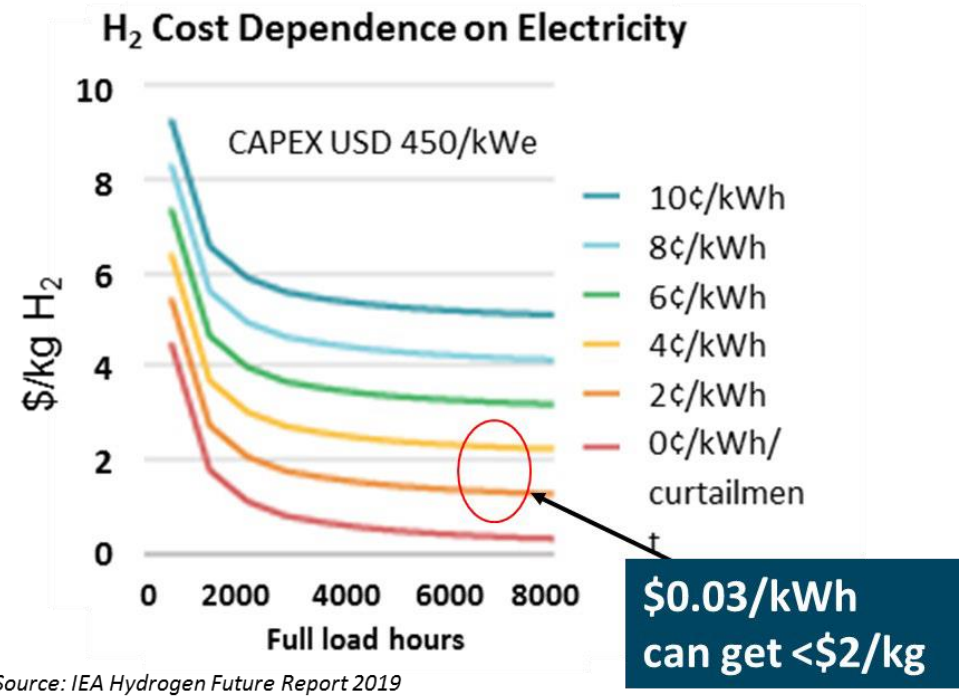
HI, OH, SC, NY, CT, MA, CO, UT, TX, MI
And Others

Cost of Hydrogen from PEM Electrolysis - Example

Multiple studies show H_2 from PEM electrolysis can be much less than $7/kg. Example - $5 to $6/kg at $0.05 to $.07/kWh



Source: DOE Record 20004



Source: IEA Hydrogen Future Report 2019

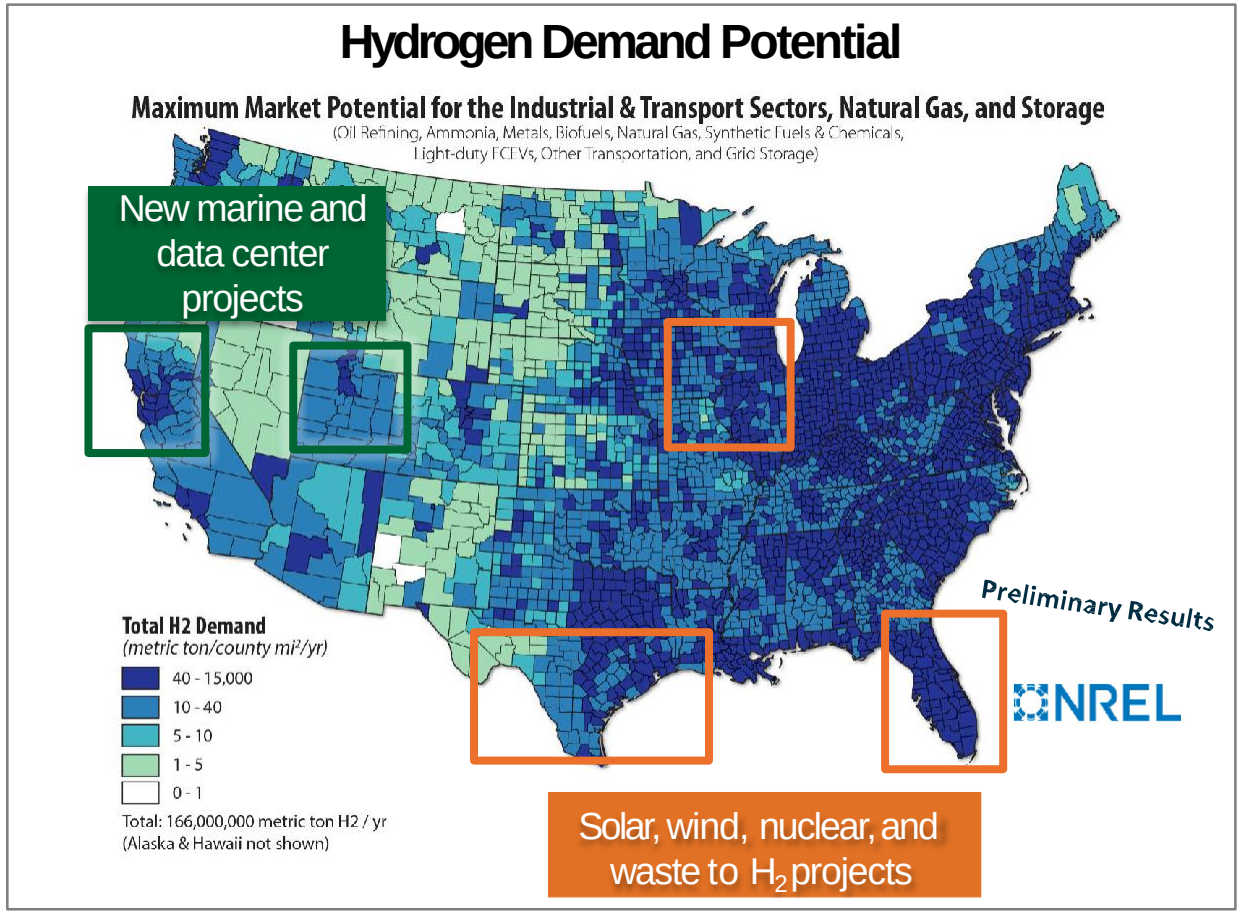
Example to achieve <$2/kg

Strategy

- **Launch H2NEW consortium on electrolysis to achieve <$2/kg ($100/kW stack target)**
- **De-risk deployment through systems integration (e.g. labs, ARIES)**
- **Ramp up scale through demonstrations – co-locate production and end use**

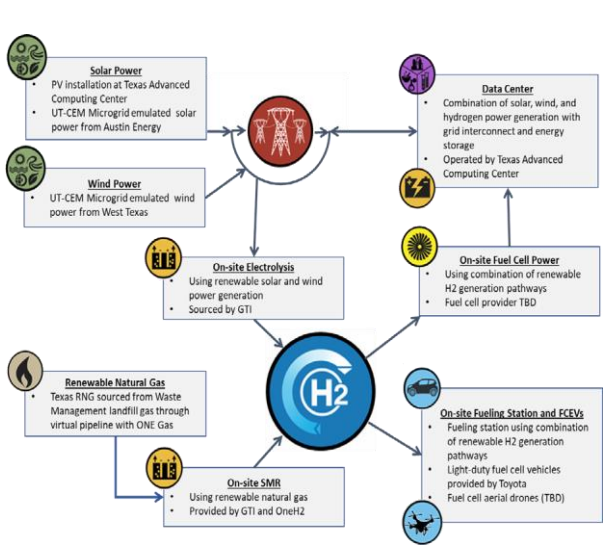
Examples of DOE H2@Scale Demonstration Projects

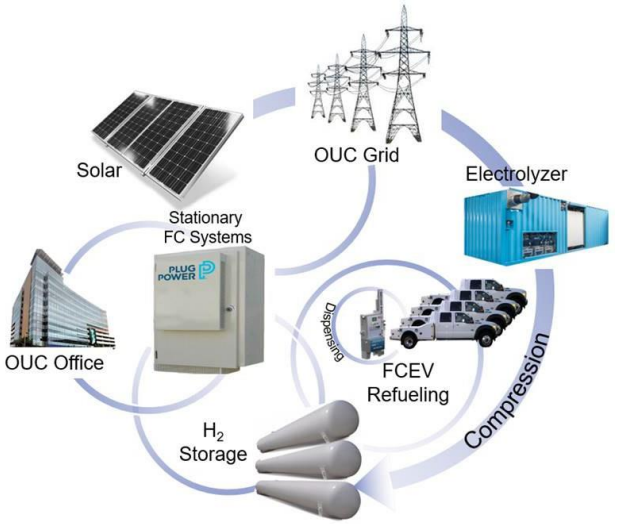
New H2@Scale demonstration projects cover range of applications and regions



H2@Scale clean H_2 production, end uses and integration demonstrations (~$ 70M)

- Sites include: TX, FL, CA, UT, OH*, MN*
- H_2 from: Wind, solar, renewable NG/waste, and nuclear
- Stationary and transportation uses include: Data centers, vehicles, maritime applications, and enabling H_2 for steel manufacturing





*** Nuclear project in collaboration with Office of Nuclear Energy**

Examples of DOE HFTO Activities in Texas

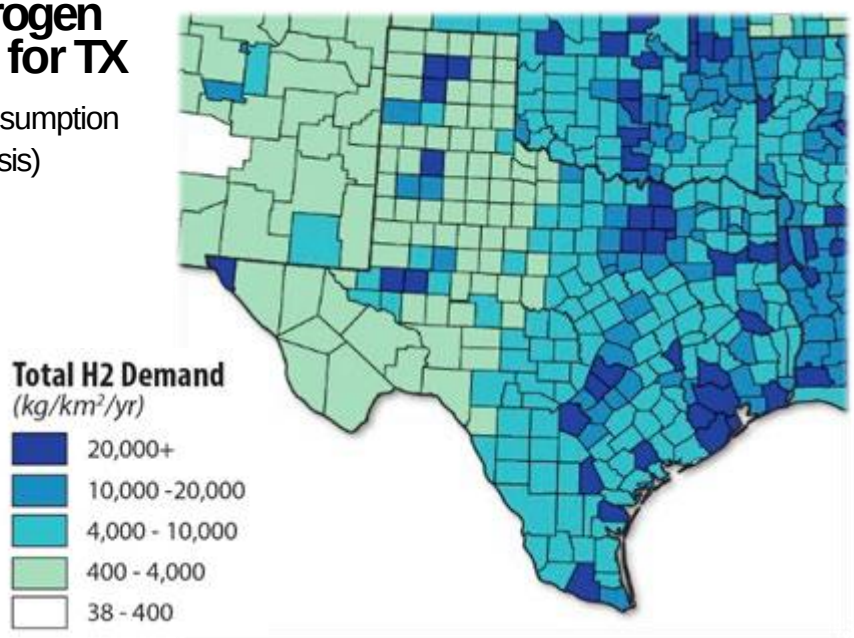
DOE-funded projects include a wide range of technologies

- Solar water-splitting for hydrogen production
- Composite ionomers for high current densities
- Linear motor reciprocating compressors
- Durable high-power membrane electrode assemblies
- H2@Scale demonstration and framework projects

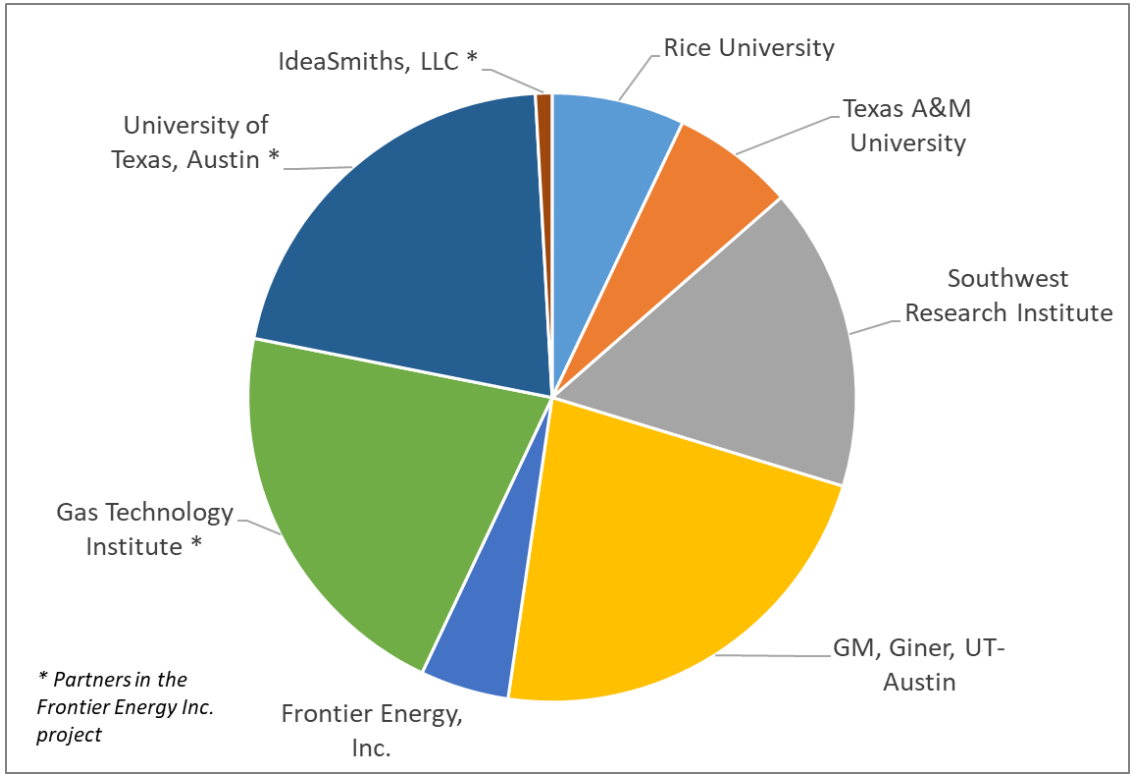
Scenario for hydrogen demand potential for TX

(H2@Scale Serviceable Consumption Potential, NREL analysis)

- Ammonia
- Metals
- Biofuels
- Natura Gas
- Synthetic Hydrocarbons
- Refineries
- Fuel cell vehicles
- Grid storage



DOE HFTO has provided $11.3 million in funding for hydrogen projects in Texas (2014-2020)



Opportunities exist for large-scale hydrogen infrastructure projects

Summary of ways to engage with DOE HFTO

Lab-Based Consortia

HydroGEN
Advanced Water Splitting Materials

HyMARC
Hydrogen Materials Advanced Research Consortium

ElectroCat
Electrocatalysis Consortium

New Consortia

Being launched now:

- H2NEW: Electrolyzer Consortium
- Million Mile Fuel Cell Truck Consortium

Lab - Industry Bridge

- H2@Scale Consortium
- CRADAs
- Strategic Partnerships
- L'Innovator
- Technology Commercialization Fund
- Center for H_2 Safety

Private Sector

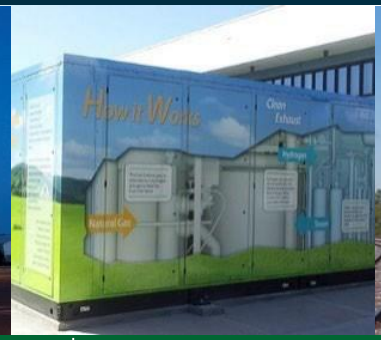
- FOA Projects
- SBIRs
- Prizes
- State Funding
- Demos & Deployments
- Partnerships
- Loan Guarantees

H-Mat™ Hydrogen Materials Compatibility Consortium

H_2 materials R&D, enable codes & standards, reduce regulatory barriers

Safety – Lessons learned, best practices, enable safe infrastructure across sectors



Thank You

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Looking for more info?

#H2IQ

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