



H2@Scale “in Texas and Beyond” Proto-Hub + Regional Clean Hydrogen Hubs

Brian Weeks, P.E.
bweeks@gti.energy
281.235.7993

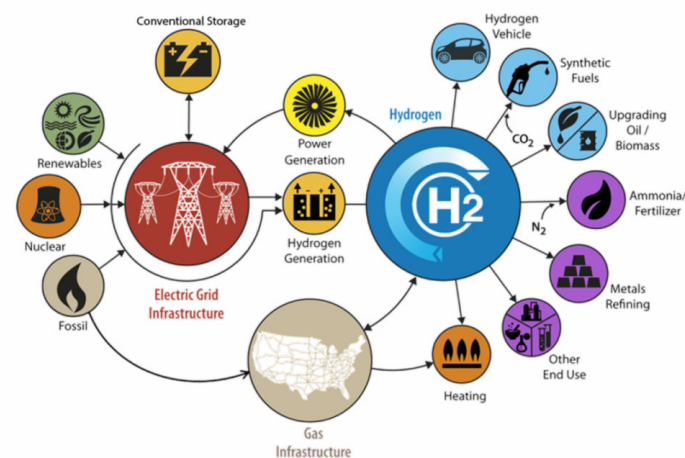
November 2022

DOE's Hydrogen at Scale Vision



Hydrogen can **Fuel a Sustainable Energy Transition** by enabling U.S. energy security, resiliency and decarbonize the energy sector

- Hydrogen can be produced from diverse domestic resources for use in multiple sectors, or for export.
- Hydrogen has the highest energy content by weight of all known fuels – 3X higher than gasoline – and is a critical feedstock for the entire chemicals industry, including liquid fuels.
- Hydrogen and fuel cells can enable zero or near zero emissions in transportation, stationary or remote power, and portable power applications.
- Hydrogen can be used as a “responsive load” on the grid to enable grid stability and gigawatt-hour energy storage, and increase utilization of power generators, including nuclear, coal, natural gas, and renewables.
- Hydrogen can enable innovations in domestic industries (such as steel manufacturing and energy storage) and in transportation (e.g. in vehicles, rail, aviation, and marine applications) and iron making.

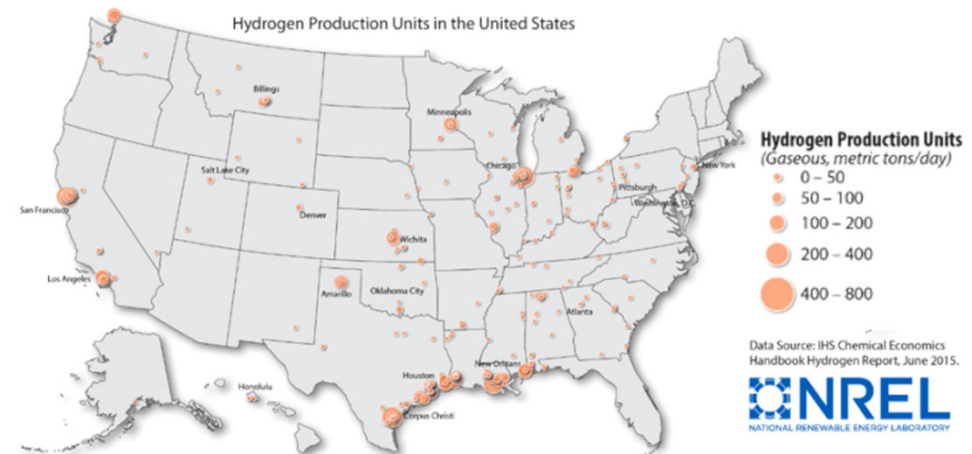
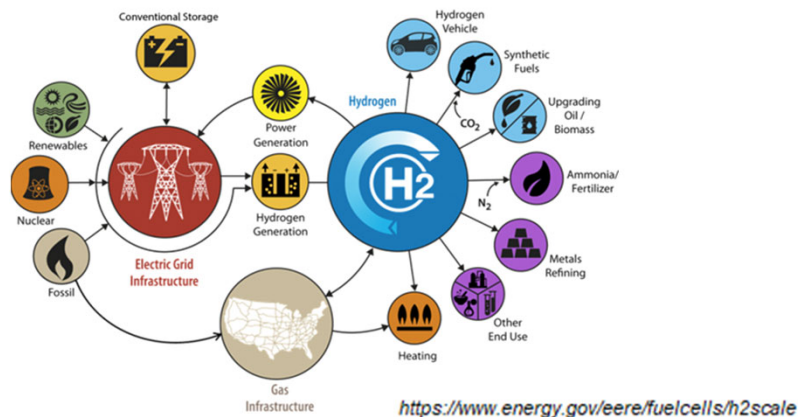


<https://www.energy.gov/eere/fuelcells/h2scale>

H2@Scale relevant for Texas

Texas ideal to lead H₂ production for a sustainable energy system

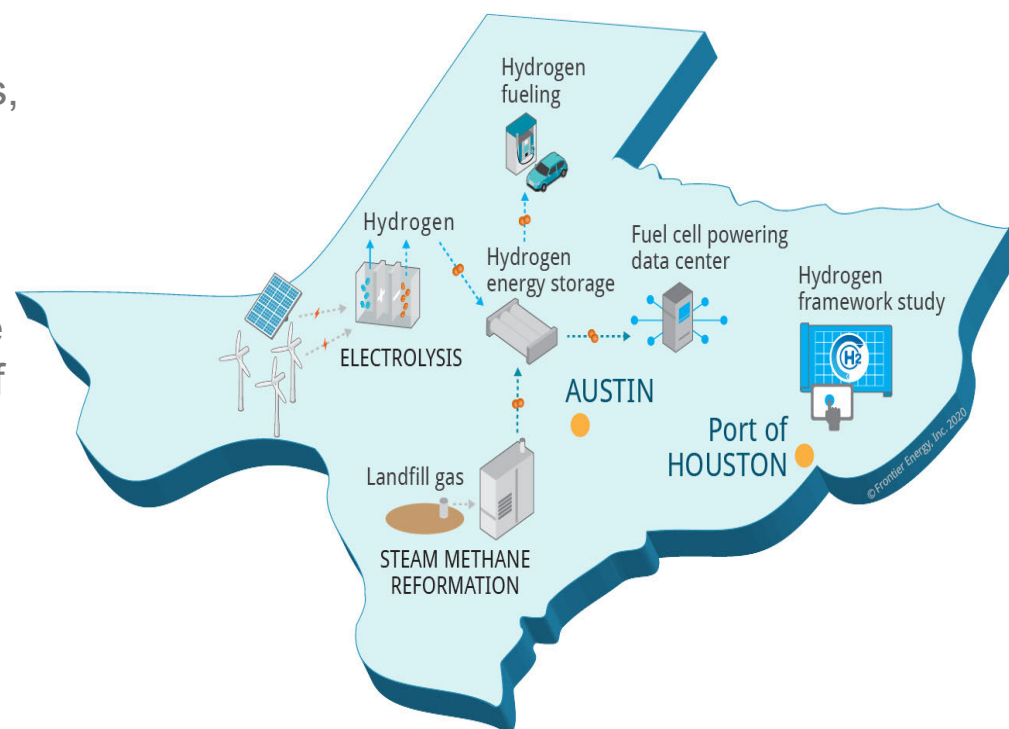
- Excellent resources of natural gas, solar and wind for RH₂
- Largest H₂ producer in the nation
- Major industry leaders on Hydrogen Council have significant presence in Texas



Approach

Show H2@Scale benefits

1. Demonstrate multiple RH_2 generation options, co-located with vehicle fueling and a large base load consumer to enable cost-effective H_2 energy solutions
2. Develop framework for actionable H2@Scale pilot plans in Texas, Port of Houston and Gulf Coast region, including energy storage



Demonstration activities at UT (*Track 1*)



~100% renewable H₂ generation

- 75 kg/d SMR: GTI, OneH2, ONE Gas, WM
 - RNG credits from landfill in Texas
- 40 kg/d from 2 PEM electrolyzers in H70 & H35 SimpleFuel units: MHI, SoCalGas, TACC, TCEQ
 - Solar power and emulated wind power through UT CEM microgrid

Large scale, industry H₂ user

- 100 kW fuel cell powering Texas Advanced Computing Center

Vehicle refueling

- Published SAE J2601-4 fueling of 7-10 Toyota Mirai's (Gen 1)
- Hydrogen powered drones

Port of Houston H₂ Framework (*Track 2*)



- Identify policy and regulatory barriers
- Define use and implementation plans leveraging existing industry resources
- Develop actionable plan for H2@Scale and FCEV rollout in region
- Partnering with other synergistic activities currently underway in Texas



Image courtesy Port of Houston

Project Sponsorship



Sponsors

- Air Liquide
- CenterPoint
- Chart Industries
- Chevron
- ConocoPhillips
- Frontier Energy
- Gas Technology Institute
- LCRI
- McDermott
- Mitsubishi Heavy Industries
- OneH2
- ONE Gas
- ONEOK
- Shell
- SoCalGas
- Toyota
- University of Texas at Austin
- US DOE
- WM

Support partner

- Center for Houston's Future
- IdeaSmiths
- Rice University

H2@Scale in TX Study Projects



White Deer Wind Farm Study

- Partner: MHI
- Contributors: GTI and UT
- Scope: Assess H2 potential at wind farm facility. Use wind farm data for demonstration.



Demonstration and Framework for H2@Scale in Texas and Beyond

- Partners: Air Liquide, CenterPoint, Chart, Chevron, ConocoPhillips, Frontier Energy, GTI, LCRI, McDermott, MHIA, ONE Gas, OneH2, ONEOK, Shell, SoCalGas, Toyota, UT Austin, US DOE, Waste Management
- Scope: H2@Scale TX -



FCEVs in Texas Study

- Partner: OneGas
- Contributors: GTI, UT, Frontier, Lone Star Clean Fuels Alliance
- Scope: Assess use of fuel cell electric vehicles in Austin, TX and necessary hydrogen infrastructure.

Hydrogen Modeling / ESG Study

- Partner: CenterPoint
- Contributors: GTI, CHF, Rice
- Scope: Mapping social, health, and carbon intensity impacts.



H2 Drone Fueling Assessment

- Partner: SoCalGas
- Contributors: GTI, DMI
- Scope: Assess refueling of hydrogen powered drones. Support demonstrations.



H2 Liquefaction Study

- Partner: Chart
- Contributor: GTI
- Scope: Assess H2 liquefaction opportunities in Texas



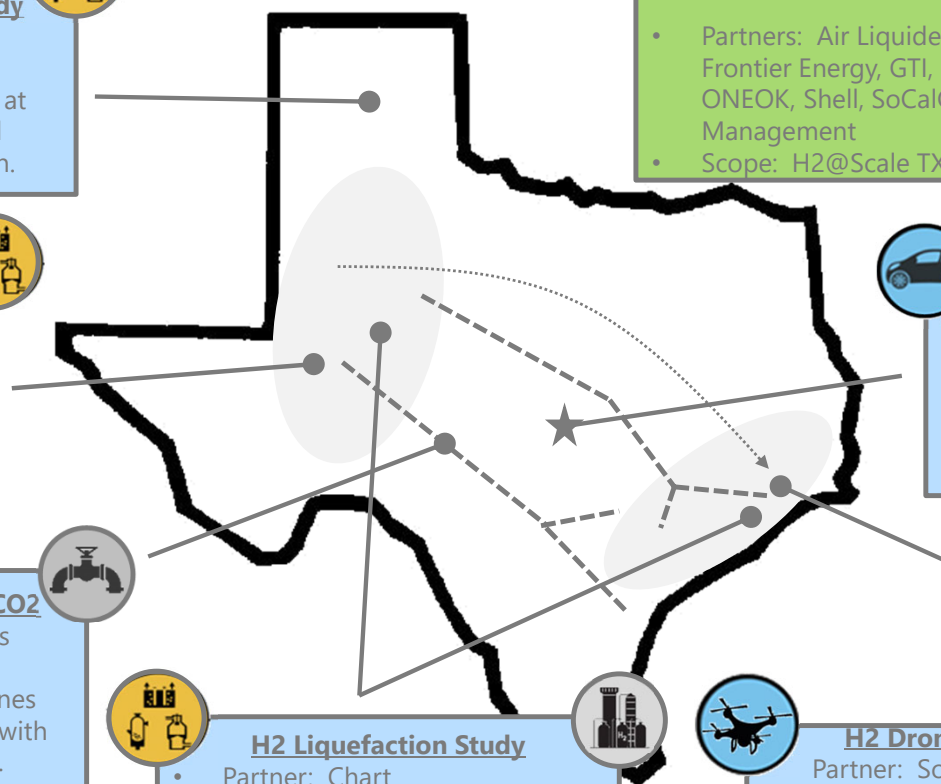
Pipeline Study – NG +H2, CO2

- Partners: ONEOK, ONE Gas
- Contributor: GTI
- Scope: Assess Texas pipelines suitability for blending H2 with natural gas, as well as CO2.

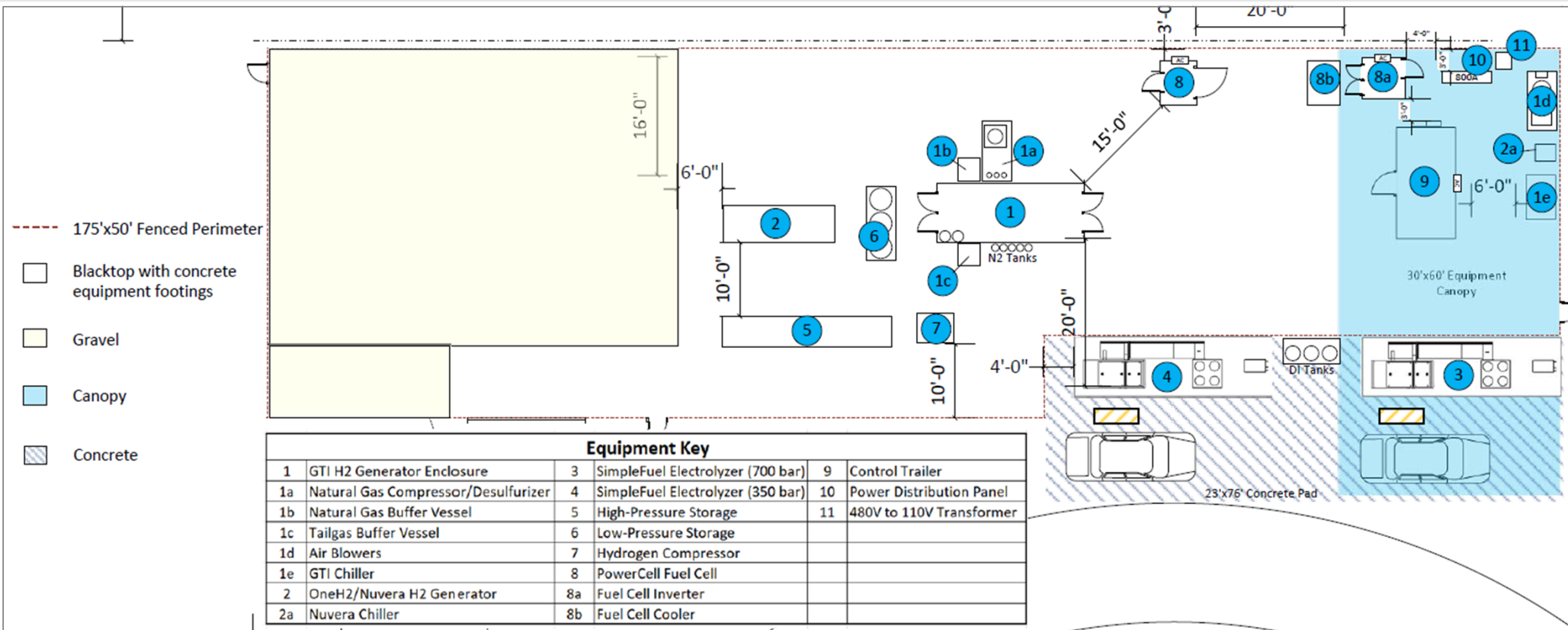


Permian Basin H2 Study

- Partner: ConocoPhillips
- Contributor: UT
- Scope: Assess H2 potential and pathways from Permian Basin to Gulf Coast (blue, green, ammonia).



Current site layout

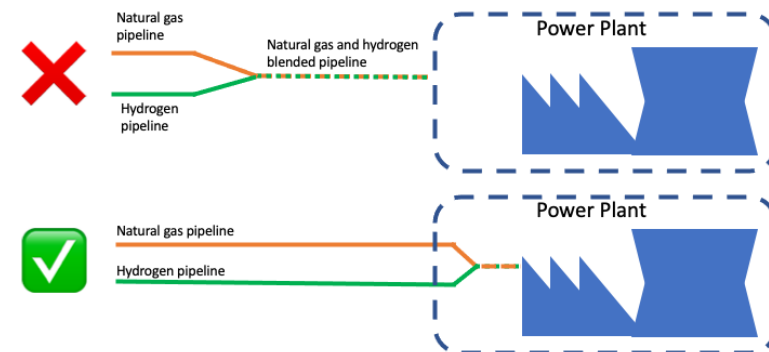
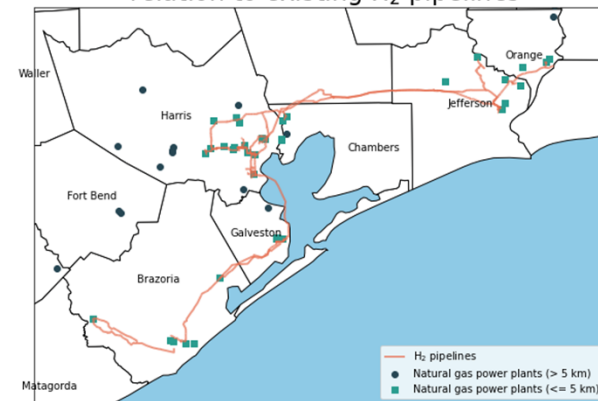


Port of Houston H2 Framework

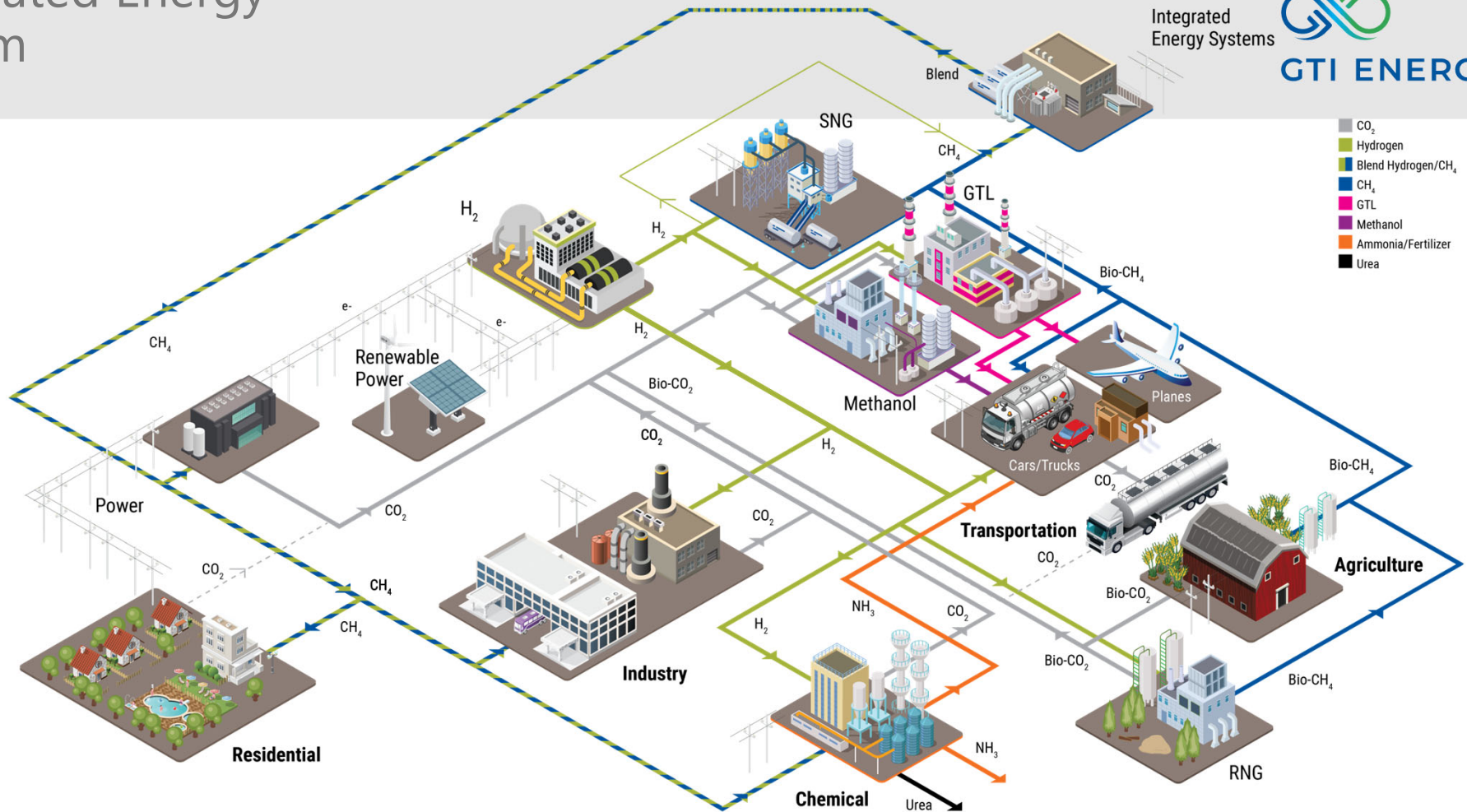
- Current status:
 - Preliminary pathway to \$4/kg modeling complete
 - Held workshop to focus on HD trucking and fueling to guide completion of pathway analysis
 - Organizing path forward on Strategic Plan and developing draft document
- White papers :
 - Electrolysis within ERCOT
 - Pipelines vs electrical transmission from West Texas
 - **Hydrogen Power Turbines at Power Plants**
 - Available at:

<https://sites.utexas.edu/h2/featured-publications/>

Texas Gulf Coast natural gas power plants in relation to existing H₂ pipelines

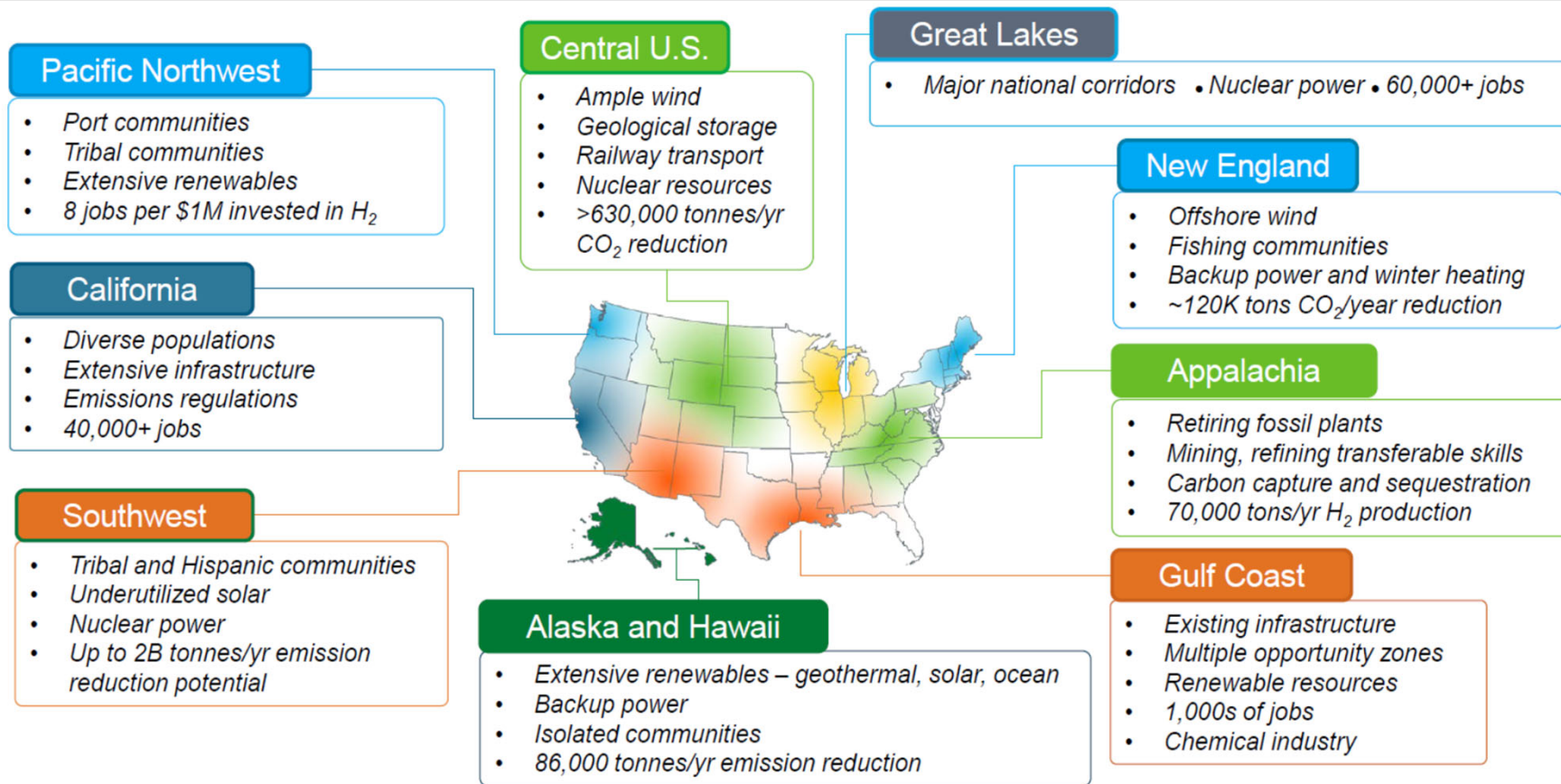


Integrated Energy System



Expand, Modify, Repurpose, Leverage Existing Infrastructure

DOE Hub Concept



By the Numbers



The Hydrogen

$\leq 2\text{kg CO}_{2e} / \text{kg H}_2$

Carbon intensity

<\$2/kg by 2026

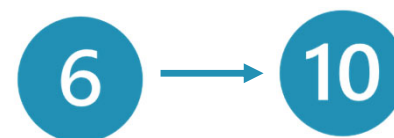
<\$1/kg in the next decade

Cost of produced hydrogen

50 – 100 mtons/day minimum

Minimum amount

The Hub



hubs on initial launch

\$400M - 500M

↓ per hub
\$1B - \$1.25B

50% Cost Share

Hydrogen Hub White Paper – Vision and Roadmap for creating a global H2 ecosystem



SUPPLY

Production

Natural-Gas based pathways – competitive advantage in natural gas and leader in CCUS technology

Electrolysis based pathways – top-quartile renewables costs

INFRASTRUCTURE

Transmission & Distribution

H₂ pipelines – largest network in US

Trucking – home to a major trade corridor

Shipping – established port infrastructure for potential H₂ exports

Storage

Salt caverns – access to formations including Spindletop and Clemmons Dome with demonstrated H₂ storage capacity

Depleted gas reservoirs – expansive former O&G operations sites present potential storage opportunities

Storage tanks – presence of equipment manufacturers throughout state

Hydrogen Hub

TRADING & MARKETPLACE

A digital marketplace for hydrogen leveraging existing commodities trading platforms

DEMAND

Refinery & Petrochemicals

Proximity to industrial demand centers, including the nation's largest network petrochemical producers with the potential for near-term switching

Ammonia (incl. Exports)

Home to leading ammonia and fertilizer producers proximal to agricultural operations in TX; ammonia is a cost-competitive hydrogen carrier for export

Mobility

Maritime vessels, intrastate heavy-duty trucks, drayage to and from four major seaports; major airports like IAH present high-visibility opportunities for global recognition

Power & Heat

Largest renewables capacity with top-quartile costs (especially in West TX), H₂ presents opportunities in energy storage and variation in power supply management

Other industrial heating and feedstock

High-grade heat applications which are used primarily by concentration of iron, steel, and cement producers along the Gulf

Potential opportunity by 2050

21MT

of clean hydrogen production in Texas, including 11MT local demand, 10MT export

220MT

global CO₂ abatement potential from 21MT of hydrogen, i.e., 4x Houston's 2019 emissions

30-60%

projects located in communities most impacted by environmental justice

180k

potential direct, indirect, and induced jobs to be created in the hydrogen economy

\$100b

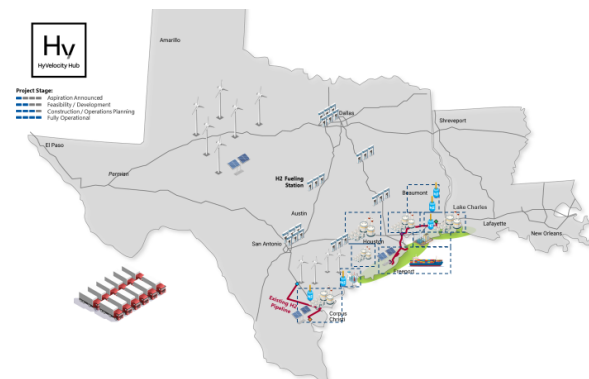
potential addition to Texas' GDP, i.e., 6% of Texas' 2019 GDP

Source: McKinsey Internal Study, US DOE H₂@Scale RFI Summary of Results

Gulf Coast Hydrogen Consortium Goals



- Position Texas Triangle and Gulf Coast Region (Corpus Christi – SW Louisiana and Port Houston to Permian) as “Regional Clean Hydrogen Hub”
- Commercially focused
- Address DOE priorities for clean hydrogen hub (policies and programming on EEEJ & benefit metrics, workforce development, hub connectivity)
- Establish financial and administrative structure that can facilitate federal grant application and administration
- <https://www.hyvelocityhub.us/>



Summary

- ONE Gas, GTI Energy, and The University of Texas at Austin are collaborating on decarbonization:
 - Discussed Today
 - H2@Scale Project in Texas and Beyond
 - DOE Regional Clean Hydrogen Hub www.hyvelocity.us
 - Not Discussed Today
 - HyBlend – NREL, Sandia, Argonne, GTI Energy, ONE Gas, 30+ co-sponsors
 - DOE CRADA to perform materials research and lifecycle analysis on hydrogen blending in gas pipelines
 - Methane Emissions Mitigation R&D
 - Examples: Free piston linear drive compressor, methane atmospheric research, sensor and leak detection, etc.



GTI Energy develops innovative solutions that transform lives, economies, and the environment

Brian Weeks, P.E.

Sr. Director, Business Development, Research Operations

bweeks@gti.energy

281.235.7993