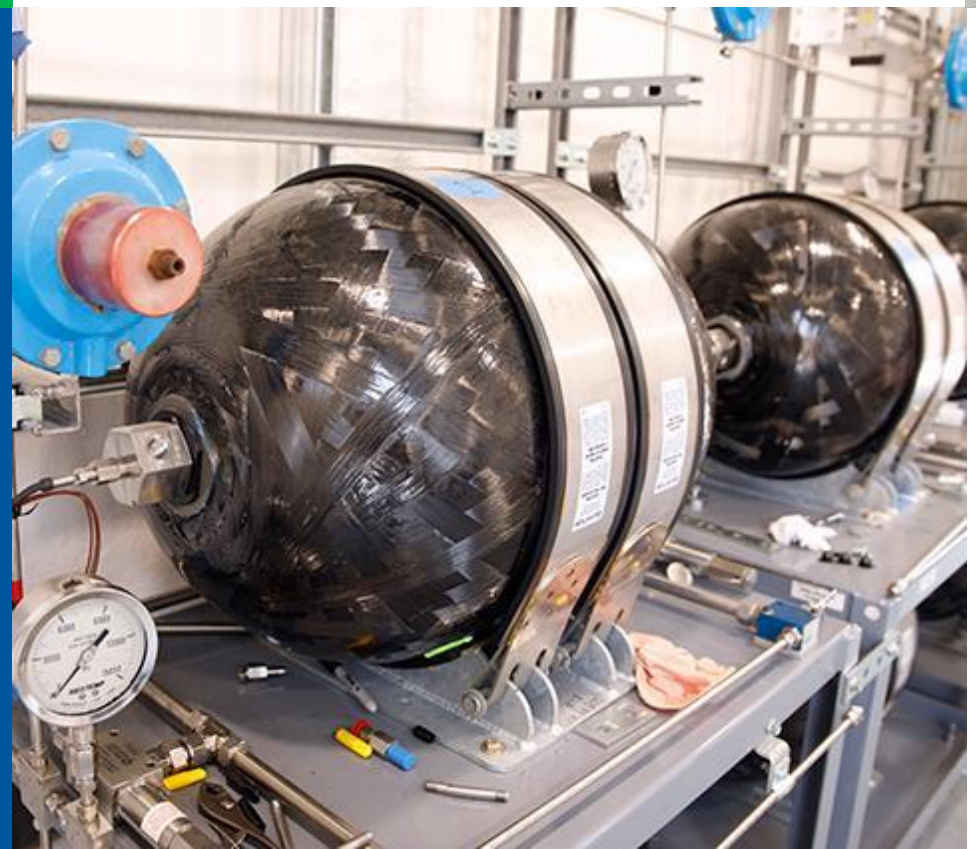
GTI ENERGY

solutions that transform



Hydrogen Hubs

Bart Sowa, *R&D Manager*

2023 Green Drives | May 18, 2023

GTI ENERGY

solutions that transform

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

We develop, scale and deploy solutions in the transition to low-carbon, low-cost energy systems

GTI ENERGY

SOURCE MAKE MOVE STORE USE

We work collaboratively to address critical energy challenges impacting gases, liquids, efficiency and infrastructure

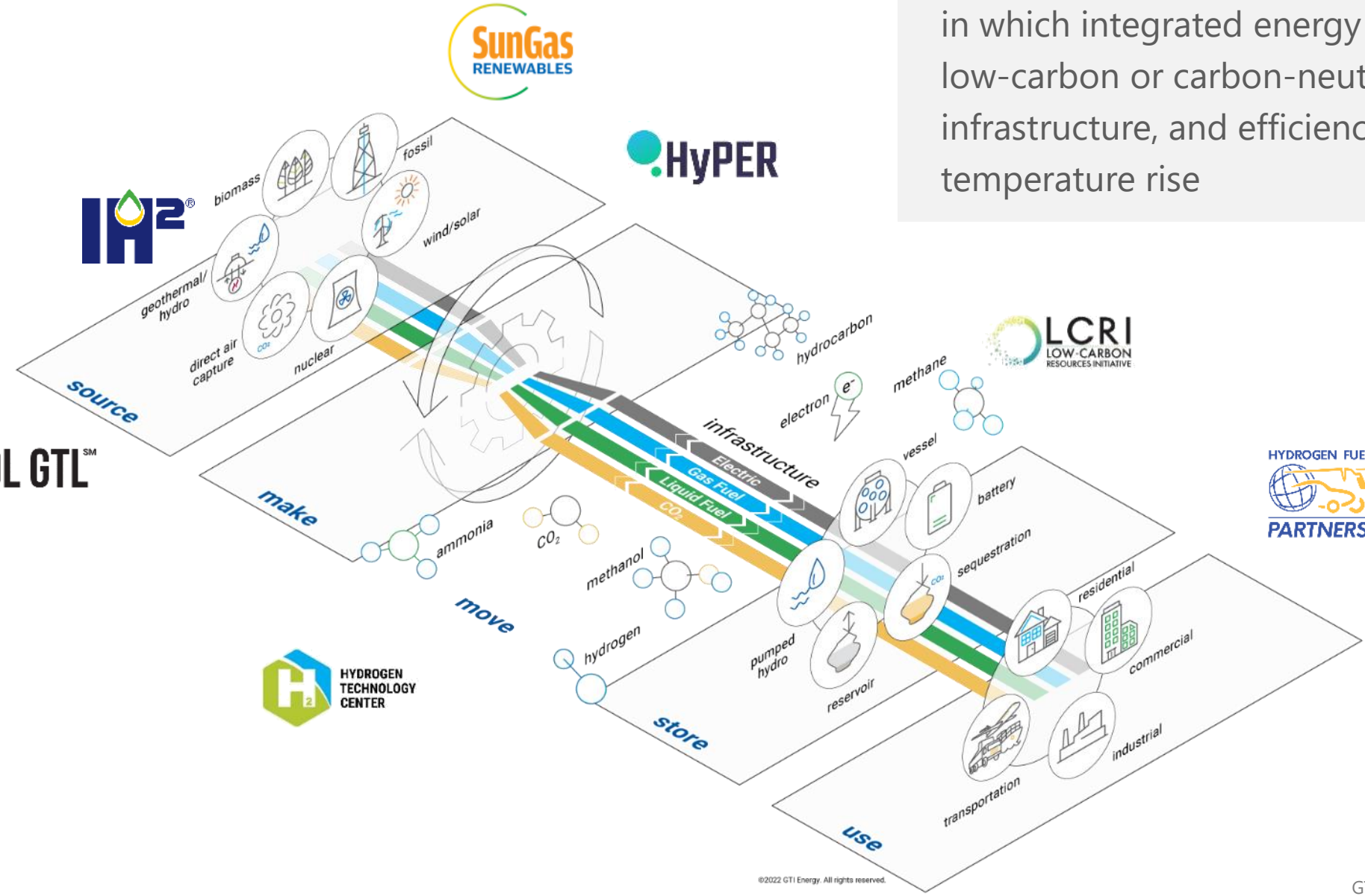
OTD Operations Technology Development

UTD Utilization Technology Development

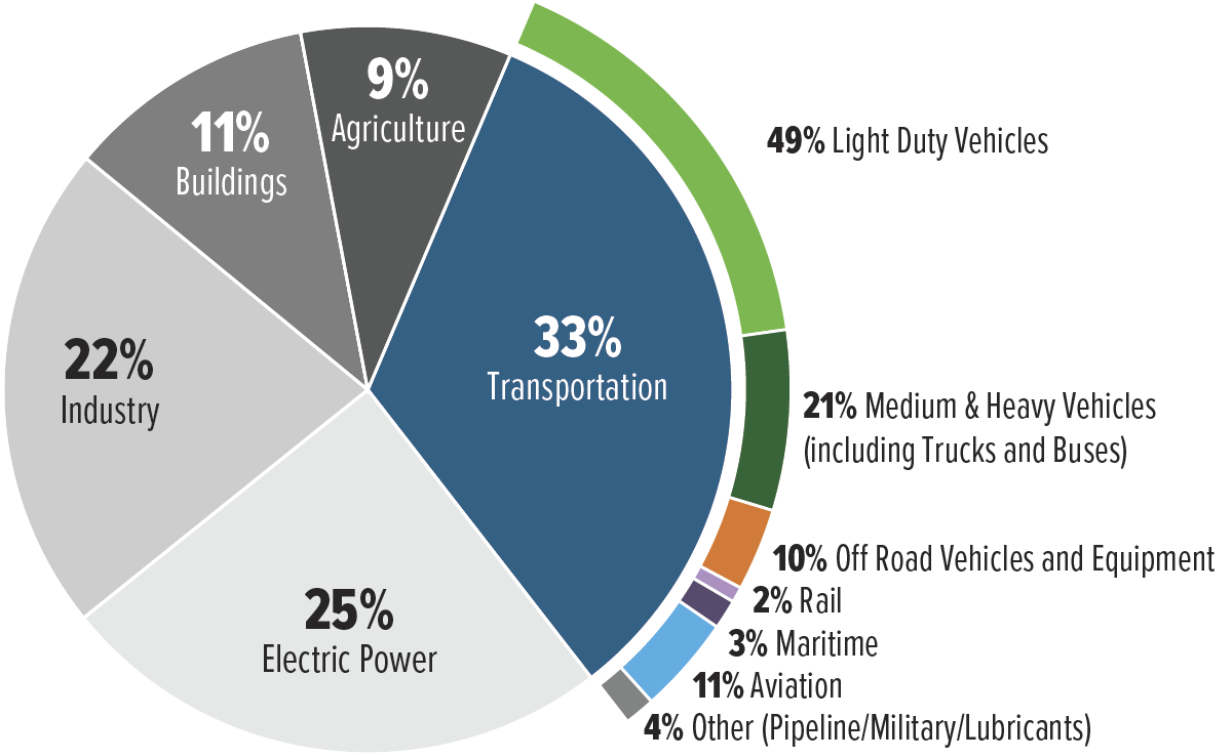
ETP Emerging Technology Program

LCRI LOW-CARBON RESOURCES INITIATIVE

GTI Energy envisions a carbon-managed future in which integrated energy systems using low-carbon or carbon-neutral fuels, gases, infrastructure, and efficiency to limit global temperature rise

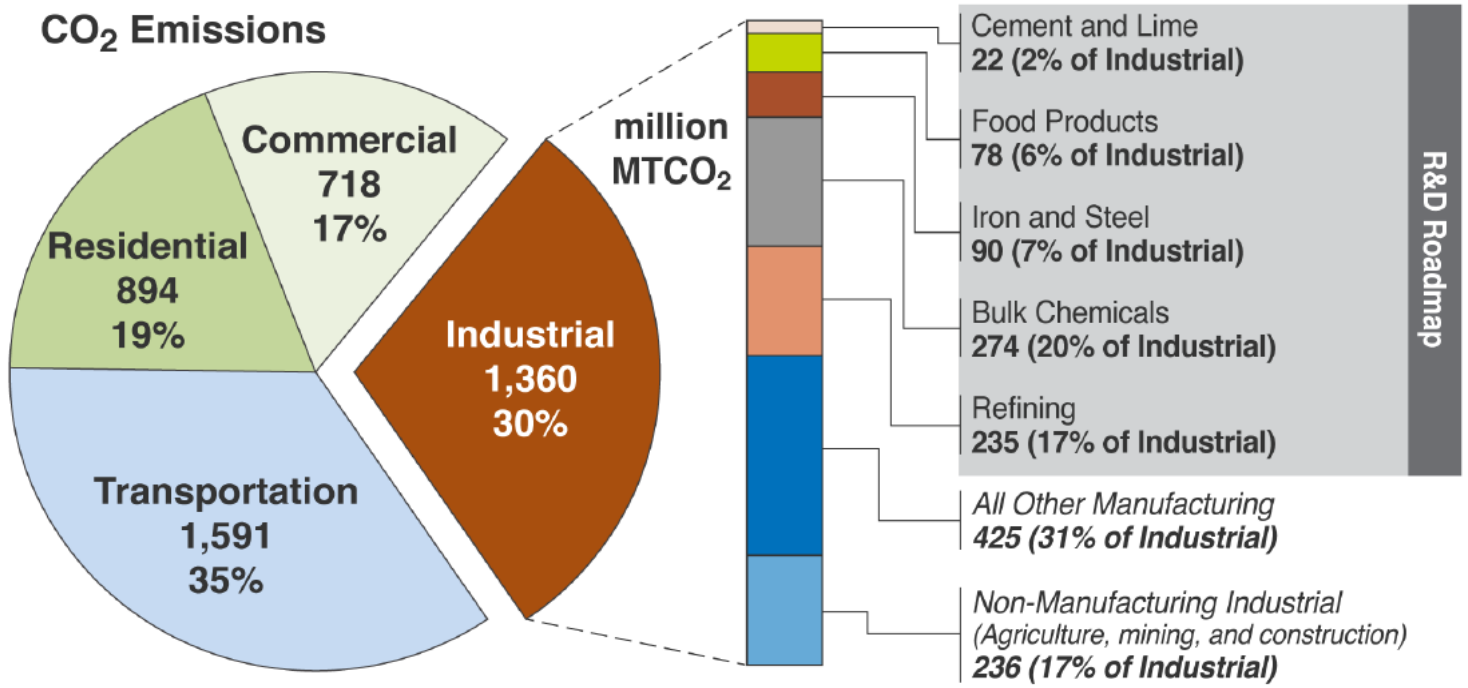


Decarbonization Will Not Be Simple



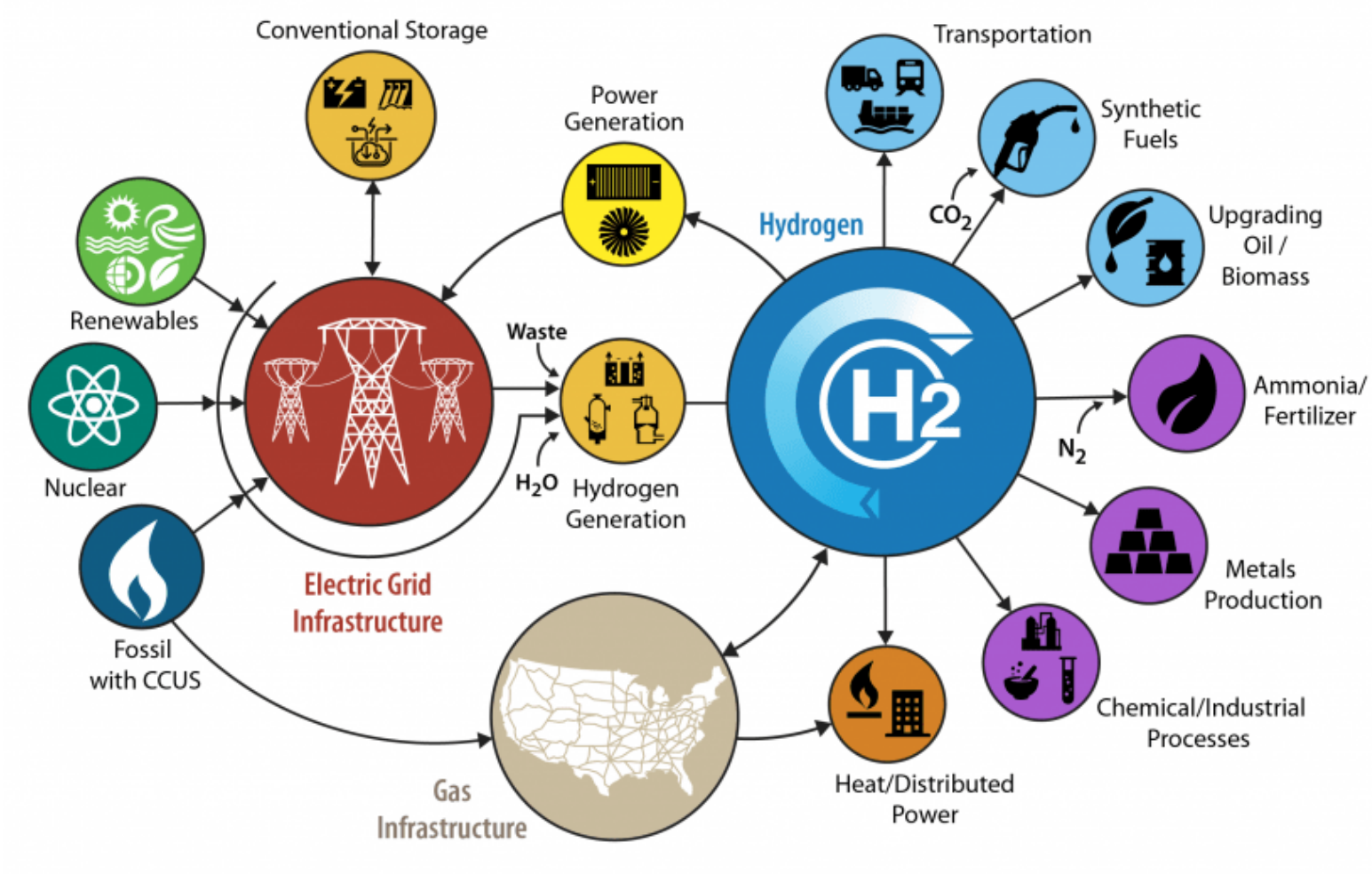
Total 2019 U.S. GHG emissions with transportation and mobile sources breakdown. Data derived from the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks. 2019 used as a baseline since impacts due to COVID-19 complicate the use of later data.

Decarbonization Will Not Be Simple

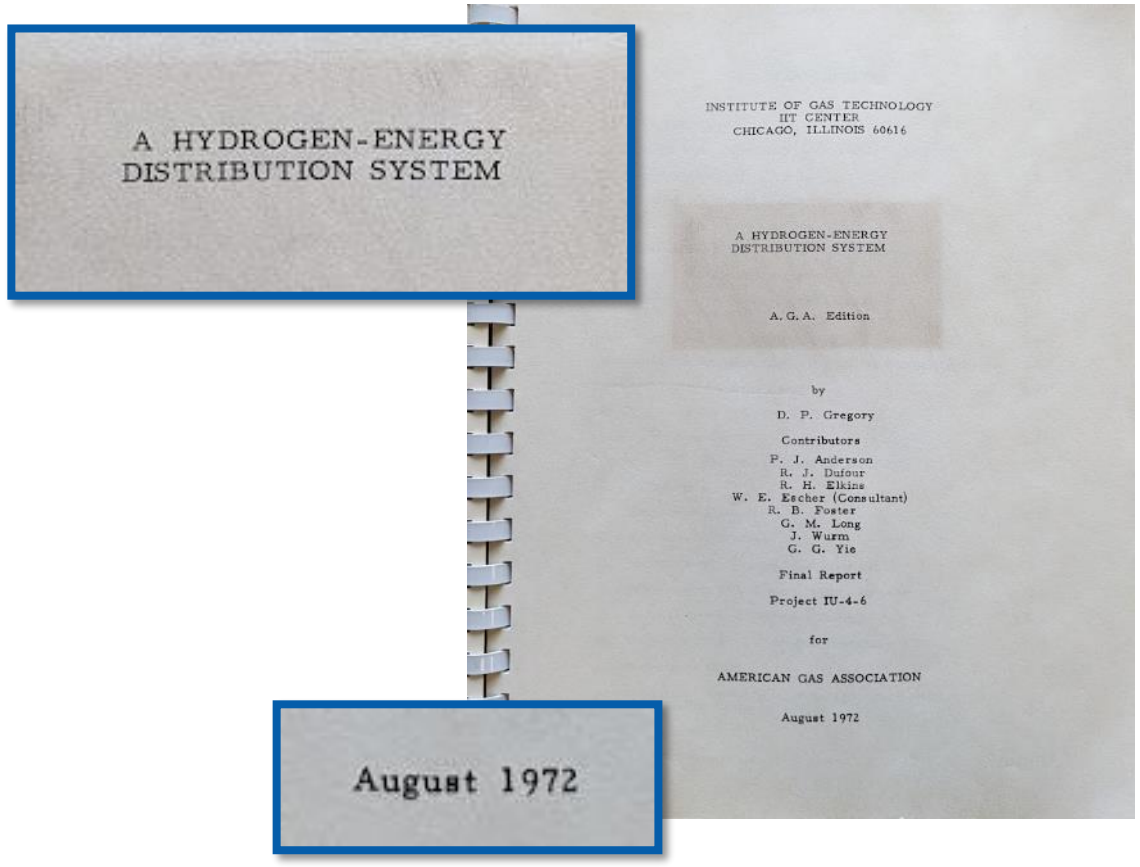


The U.S. industrial sector accounted for 30% of U.S. energy-related CO2 emissions in 2020, with the five focus subsectors responsible for over half of the industrial contribution.

Why Hydrogen?

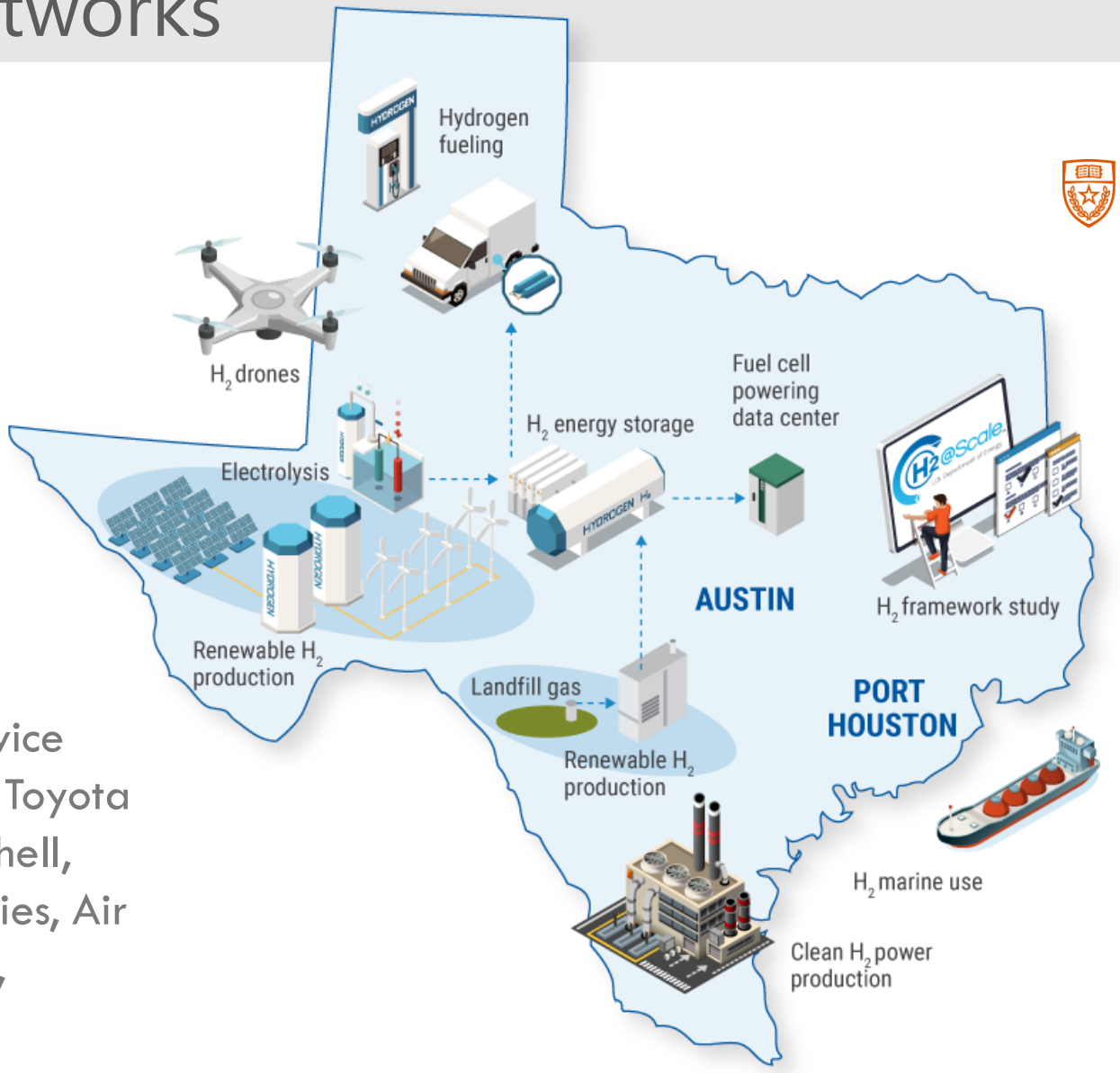


Hydrogen Is Not New



2020: Demonstration and Strategic Planning for Hydrogen Networks

H2@Scale Project – Hydrogen for Texas "…and Beyond"



Project Partners

ONEH2, Texas Gas Service (ONE Gas), SoCal Gas, Toyota Motor North America, Shell, Mitsubishi Heavy Industries, Air Liquide, Chart Industries, Waste Management

2021: Hydrogen Shot

ENERGY earthshots | Hydrogen
U.S. DEPARTMENT OF ENERGY

1 Dollar

1 Kilogram

1 Decade

Production And Demand Studies

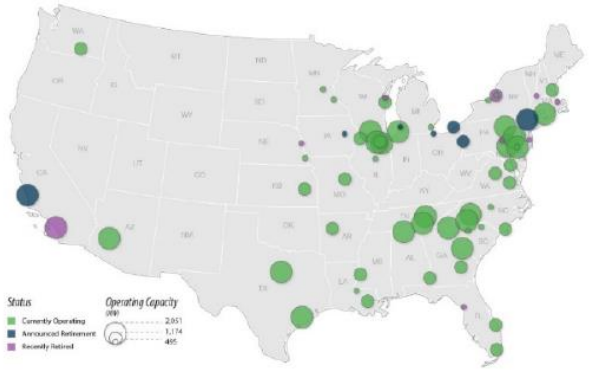


Figure 8. The locations of nuclear power plants in the United States[34]

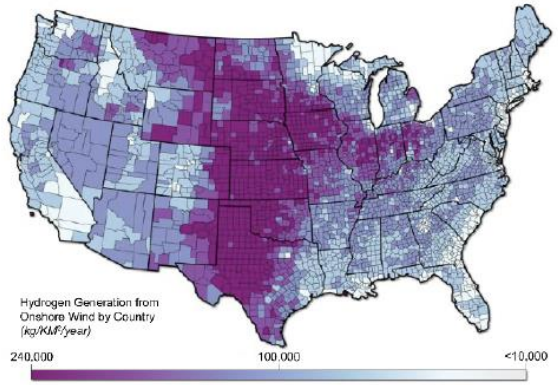


Figure 9. Hydrogen production potential from onshore wind resources, by county land area[35]

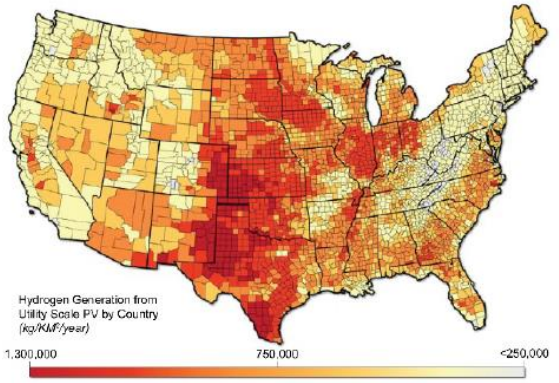


Figure 10. Hydrogen production potential from utility-scale PV, by county land area[36]

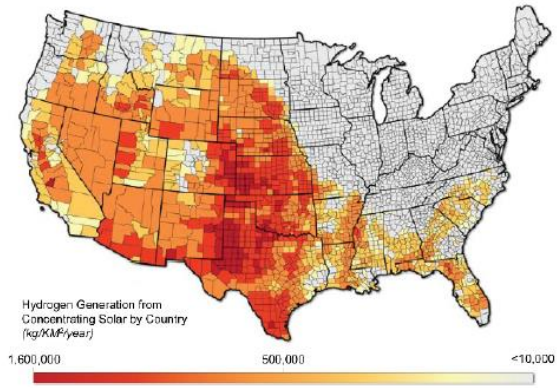


Figure 11. Hydrogen production potential from concentrated solar power, by county land area[37]

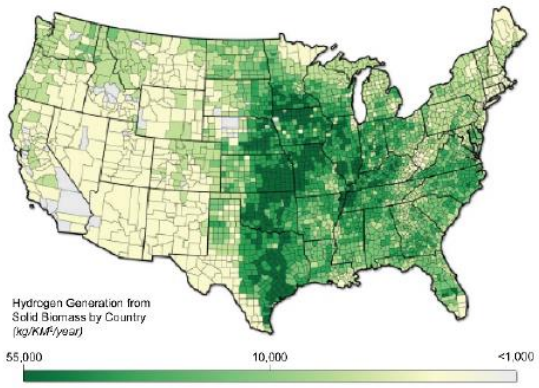


Figure 12. Hydrogen production potential from solid biomass resources, by county land area[38]

Production And Demand Studies

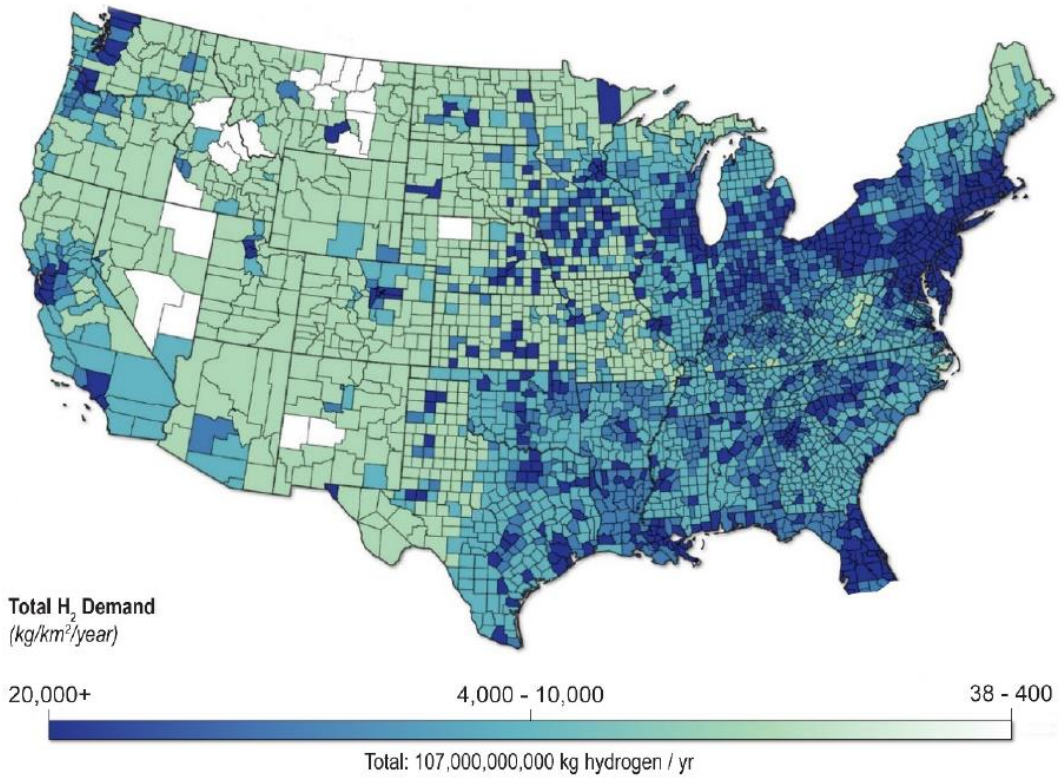


Figure 14. Serviceable consumption potential for hydrogen in the industrial and transportation sectors, natural gas, and storage[41]

2021: Hydrogen Hubs

Hydrogen Hub

a network of hydrogen producers and consumers, and the connective infrastructure located in close proximity.

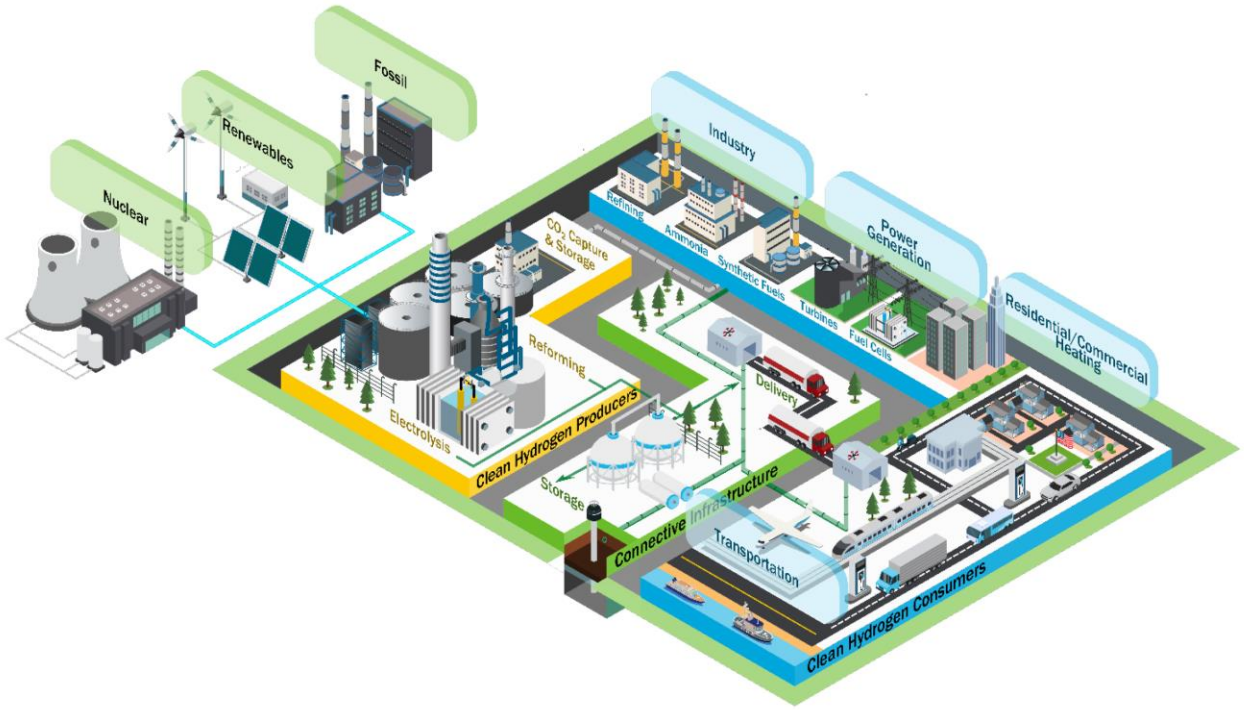
- Produce clean hydrogen from multiple energy resources
- Demonstrate diverse end uses
- Create training/employment opportunities
- Cover different regions of the United States

Administration Goals

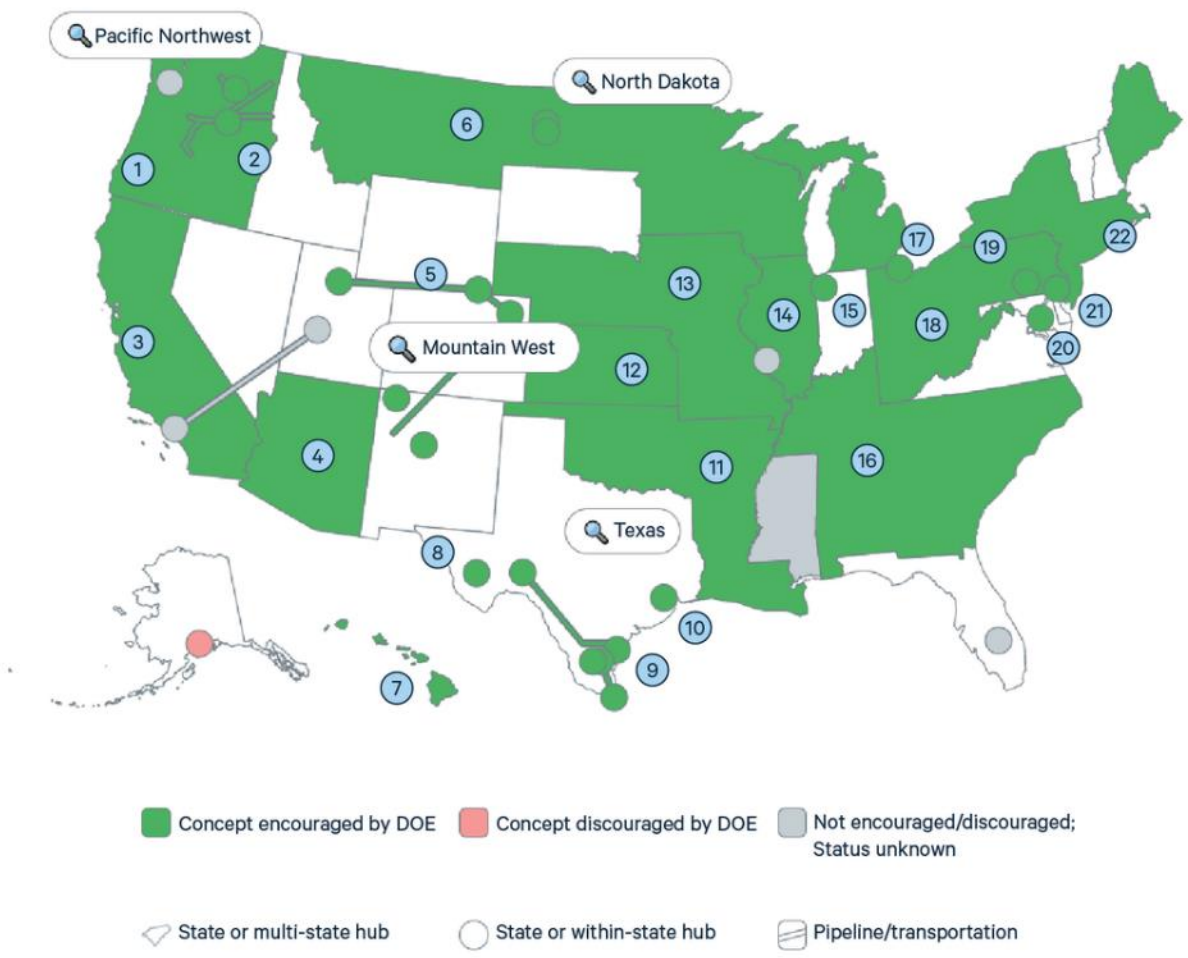
- 100% clean electrical grid by 2035
- net-zero carbon emissions by 2050

2021: Hydrogen Hubs

- $8B allocated for H2Hubs via Infrastructure Investment and Jobs Act (Nov 2021)
- 6-8 hubs expected
- Max $1.25B per hub + 50% cost share
- 79 concepts submitted (Nov 2022)
- $200B combined investment ($60B + $140B)
- 33 passed to next phase
- Est. 20-25 applied (Apr 2023)
- Awards in Fall 2023



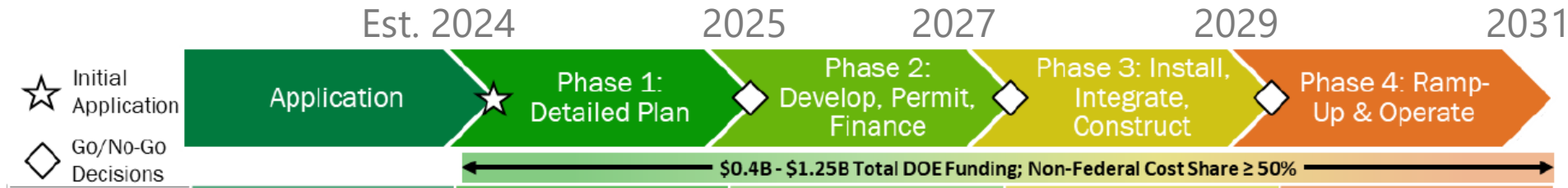
Hydrogen Hub Applicants



1. Pacific Northwest Hydrogen Hub
2. Obsidian Pacific Northwest Hydrogen Hub
3. Alliance for Renewable Clean Energy Systems (ARCHES)
4. Southwest Clean Hydrogen Innovation Network (SHINe)
5. Western Interstate Hydrogen Hub (WIH2)
6. Heartland Hydrogen Hub
7. Hawai'i Pacific Hydrogen Hub
8. Trans Permian Hydrogen Hub
9. Horizons Clean Hydrogen Hub
10. HyVelocity Hydrogen Hub
11. HALO Hydrogen Hub
12. HARVEST Hydrogen Hubs Coalition
13. Mid-Continent Hydrogen Hub
14. Midwest Alliance for Clean Hydrogen (MachH2)
15. Northwest Indiana Hydrogen Hub
16. Southeast Hydrogen Hub
17. Great Lakes Clean Hydrogen Hub
18. Appalachian Regional Clean Hydrogen Hub (ARCH2)
19. Decarbonization Network of Appalachia
20. Mid-Atlantic Hydrogen Hub (MAAH)
21. Mid-Atlantic Clean Hydrogen Hub
22. Northeast Hydrogen Hub

Source: RFF's Hydrogen Hub Explorer data tool, resources.org

Hydrogen Hub: 8-12 Year Project

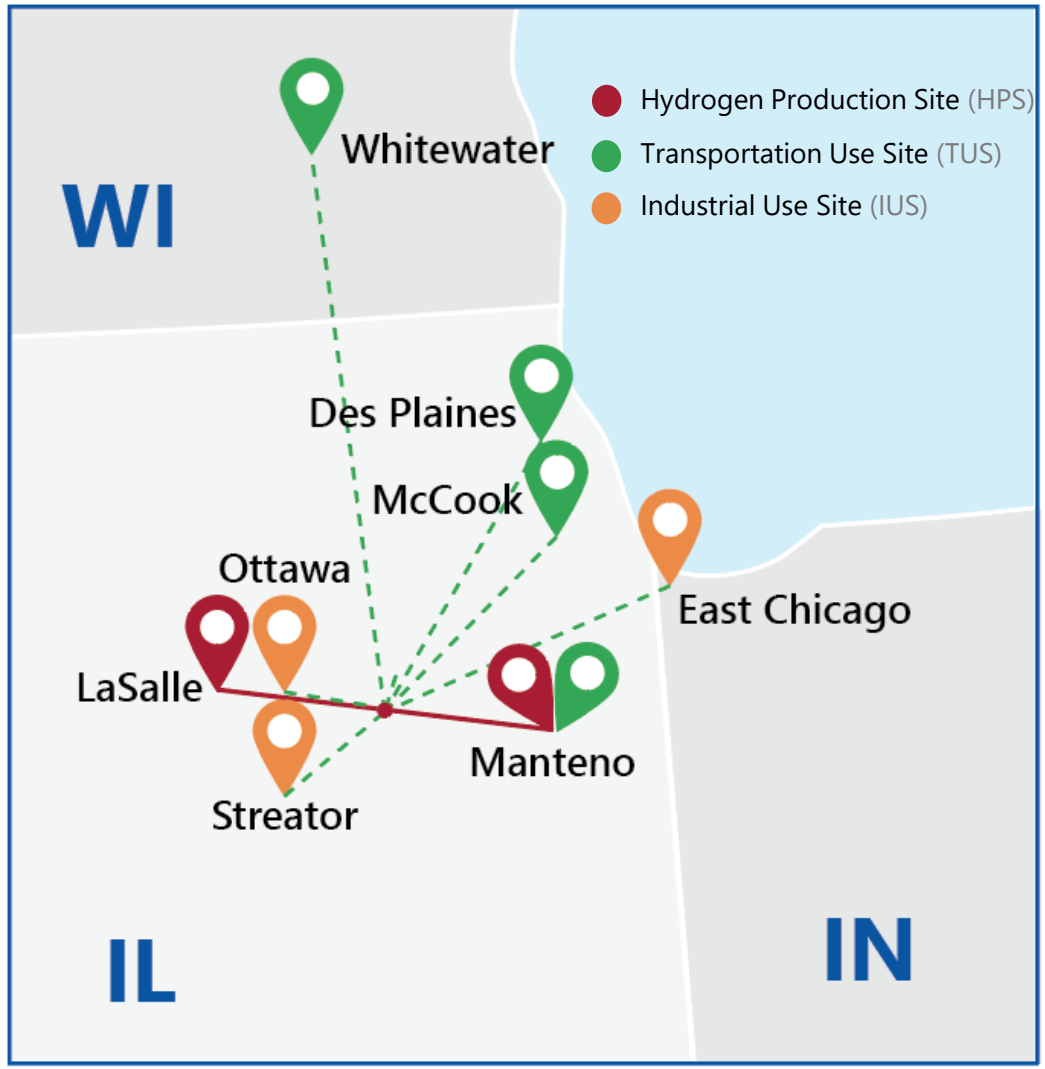


	Pre - DOE funding	Up to $20M DOE Funding, ~12-18 Months	Up to 15% of Total DOE Funding, ~2-3 Years	DOE Funding To Be Negotiated, ~2-4 Years	DOE Funding To Be Negotiated, 2-4 Years
Business Development & Management	• H2Hub Summary • Business Plan (BP), including preliminary site selection • Management Plan (MP) • Financial Plan (FP)	• Market, feedstock, & offtake letters of commitment • Final site selection • Financial model • Updated BP, MP, FP	• Teaming, offtake, & feedstock agreements • Site access secured • Confirmed project financing • Updated BP, MP, FP • Labor agreements	• Regular progress/status reporting for all agreements • Regular financial status reports • Other reporting per terms & conditions (T/Cs) • Updated BP, MP, FP covering Phases 3-4	• Financial model updated with offtake & production data • Revised growth plan & projections • Updated BP, MP, FP covering ramp-up & steady state operations
Engineering, Procurement, Construction, & Operations	Technical Volume • Engineering concept (~5%) • Technology Readiness Level (TRL) descriptions • Integrated Project Schedule (IPS): Full Project - L1; Phase 1 - L2 • Class 4 Total Project Cost (TPC) estimate • Operating & disposition concepts	• Engineering & Design (~30%) & related documents • Performance model • TRL analysis & uncertainties • IPS: Full Project - L2; Phase 2 - L3 • Class 3 TPC estimate	• Engineering & Design (~90%) & related documents • TRL updates • IPS: Full Project - L3 • Class 1 TPC estimate • Standard project management tool in use • Updated Operating Plan • Updated Disposition & Decommissioning (D&D) Plan	• Progress execution reporting • Integrated project completion testing	• Regular operations status reporting • Performance ramp verification & validation (V&V) • Validated performance model • Final TPC accounting

MachH2 Hub – Project SWITCH

MIDWEST ALLIANCE FOR CLEAN HYDROGEN

- Over 70 partners
- Solutions Working *to transform* Industry and Transportation to Clean Hydrogen (SWITCH)



Other H2 Hubs

- GTI Leading or participating in three hydrogen hub teams
  - Texas/Gulf Coast (HyVelocity)
  - Midwest (MachH2)
  - West Virginia (ARCH2)

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solutions that transform

Thank you

Bart Sowa, bsowa@gti.energy