Hydrogen
Why Central Texas?

SOUTHWEST RESEARCH INSTITUTE®

Ryan Williams

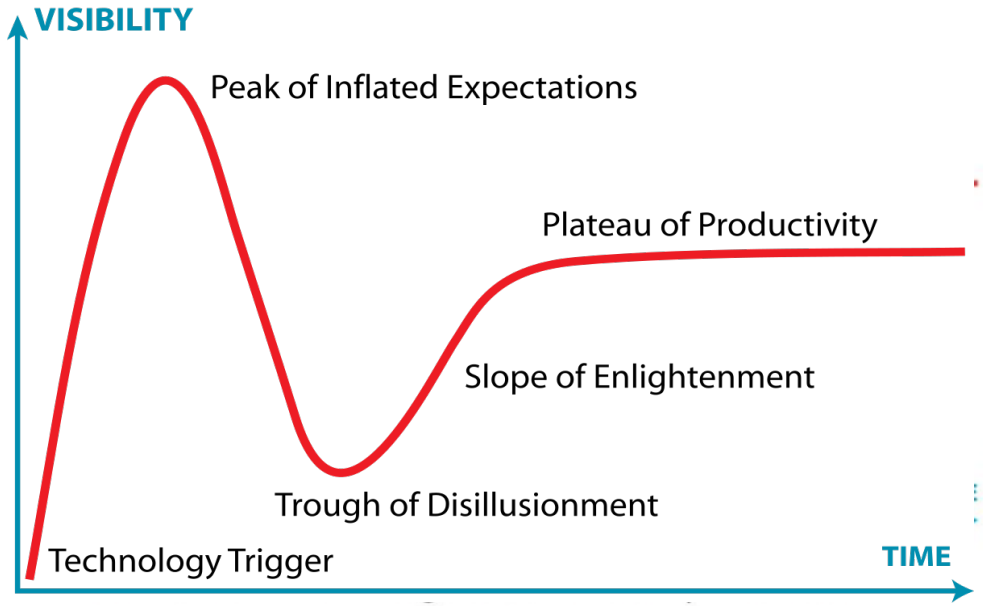
Texas Hydrogen Workshop

October 1st, 2025

The Hype Cycle

- **The innovation trigger** starts when an event, like a technological breakthrough or a product launch, gets people talking.
- **The peak of inflated expectations** is when product usage increases, but there's still more hype than proof that the innovation can deliver what you need.
- **The trough of disillusionment** happens when the original excitement wears off and early adopters report performance issues and low ROI.
- **The slope of enlightenment** occurs when early adopters see initial benefits and others start to understand how to adapt the innovation to their organizations.
- **The plateau of productivity** marks the point at which more users see real-world benefits and the innovation goes mainstream.

The Position of Hydrogen Market Segments on Gartner's Hype Cycle Curve



Gartner Inc.

Note: Not an exhaustive list.

Texas Energy Landscape

QUICK FACTS

- 43% of US crude oil production
- 28% of natural gas extraction
- 6.3 million barrels/day → 33% of total US refining capacity.
- 28% of the total US wind power generation
- 13% of the U.S. total electricity generation
- 25% of total US industrial energy consumption

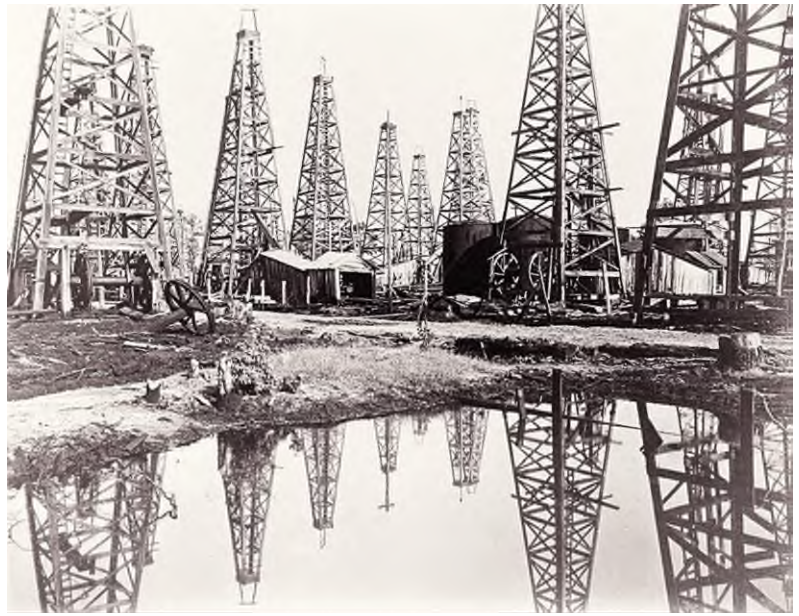


Image courtesy The Dolph Briscoe Center for American History at The University of Texas at Austin

GABRIEL CRISTÓVER PÉREZ / KUT

Texas Hydrogen Landscape

Energy Assets

- Broad base of industrial energy customers across multiple demand segments
- 33% of U.S. hydrogen production capacity
- Large concentration of industry-driven energy innovation: major research universities and an innovation campus
- Welcoming environment for infrastructure development
- Highly skilled energy workforce (11% of U.S. energy jobs)
- Largest energy manufacturing cluster (7,000+ establishments)

Production capacity

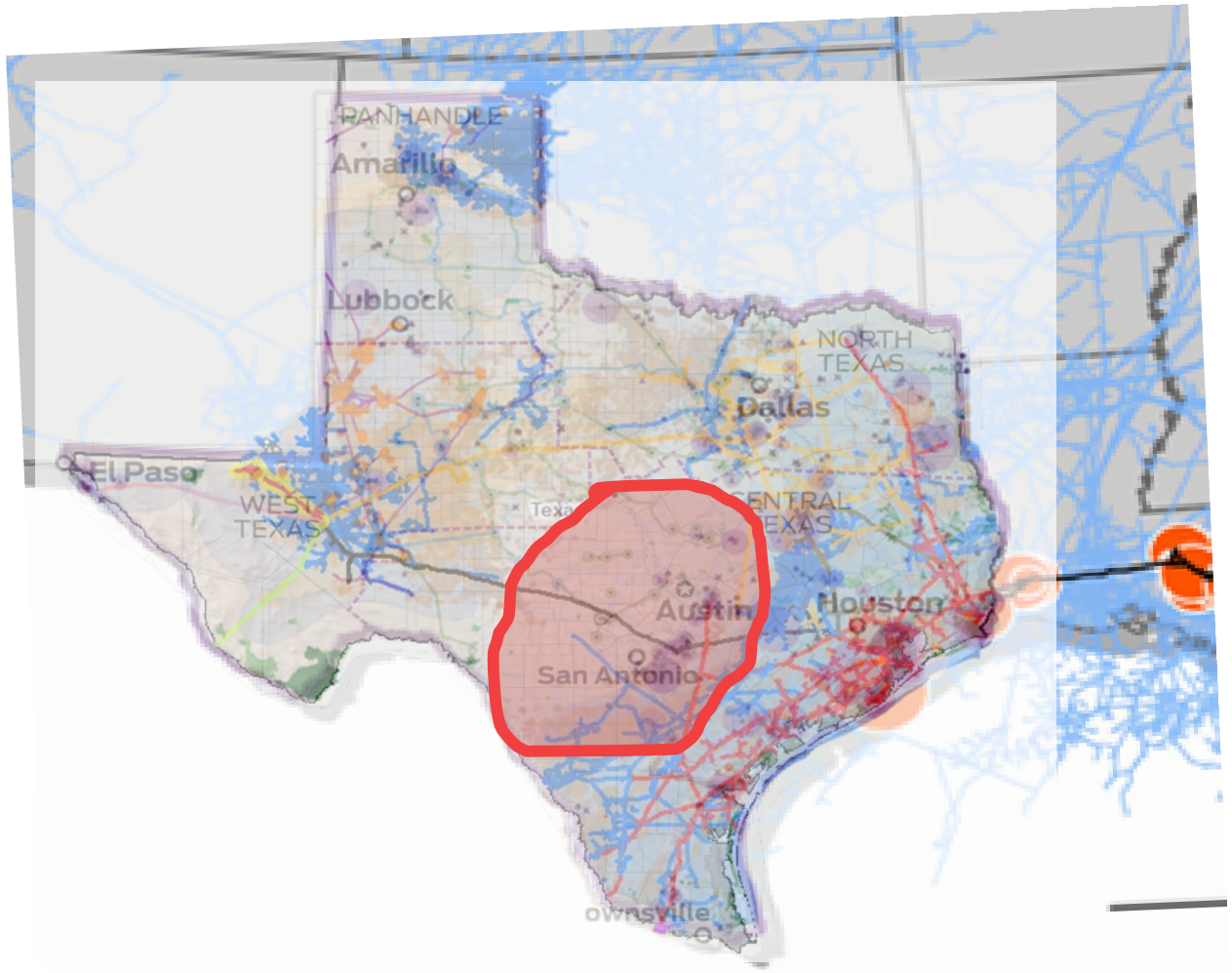
- Billions of tons of CO_2 storage capacity
- Access to abundant low-cost natural gas (11.2 Tcf natural gas produced in 2022)

Transportation & storage

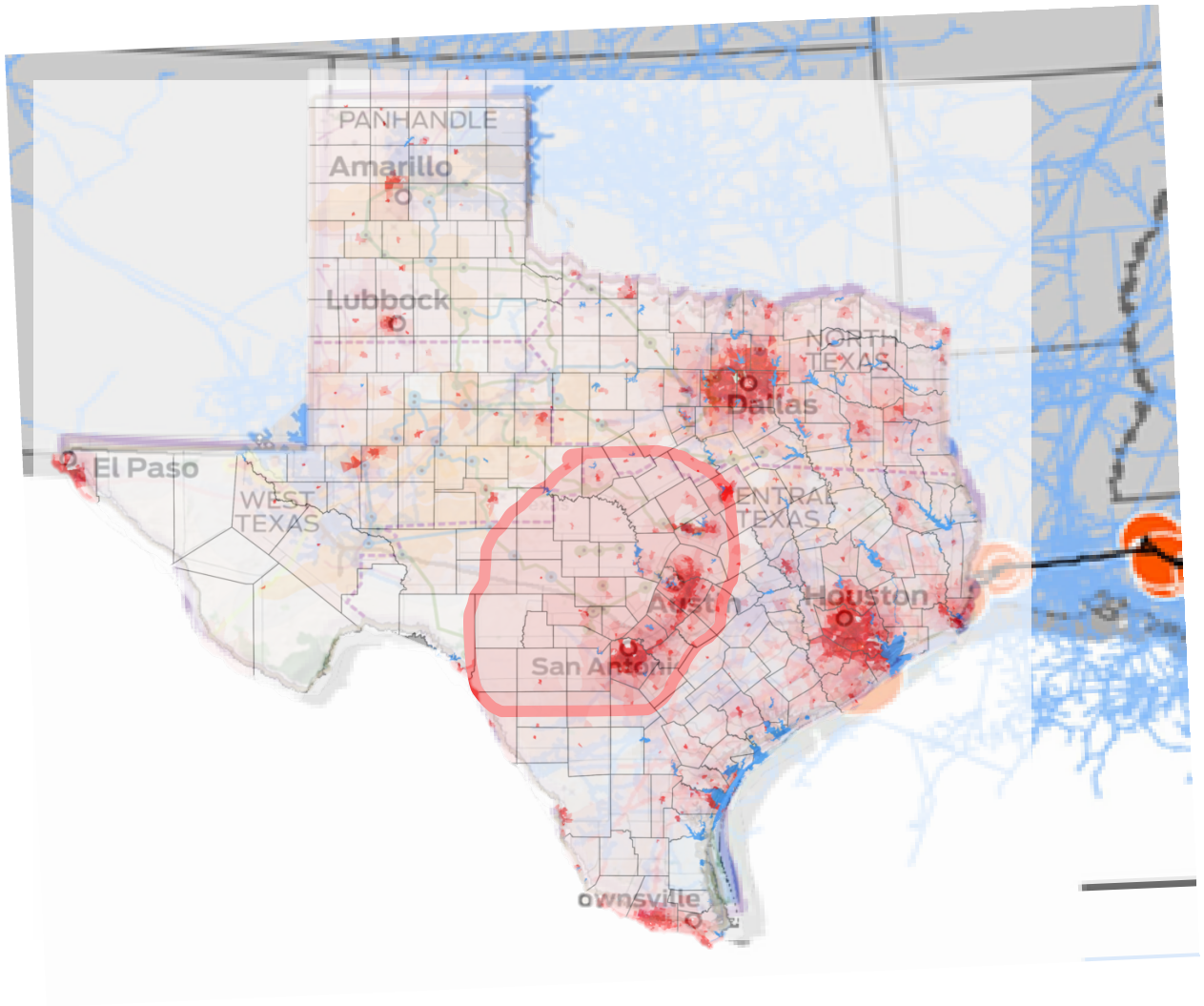
- Thousands of miles of hydrogen pipeline – largest networks in the nation
- 3 of the 6 hydrogen storage caverns in the world

Source: McKinsey and CHF Gulf Coast Hydrogen Roadmap , 2022 US DOE Energy and Employment Report

Location Matters: Central Texas Energy Landscape



Location Matters: Hill Country Assets



KENS5 News Weather Sports KENS5+

City leaders prepare for massive growth from San Antonio to Austin

Over 8 million people are expected to live in the metros combined by 2050.

Central Texas Hydrogen Landscape: Energy Powerhouses

Energy Assets

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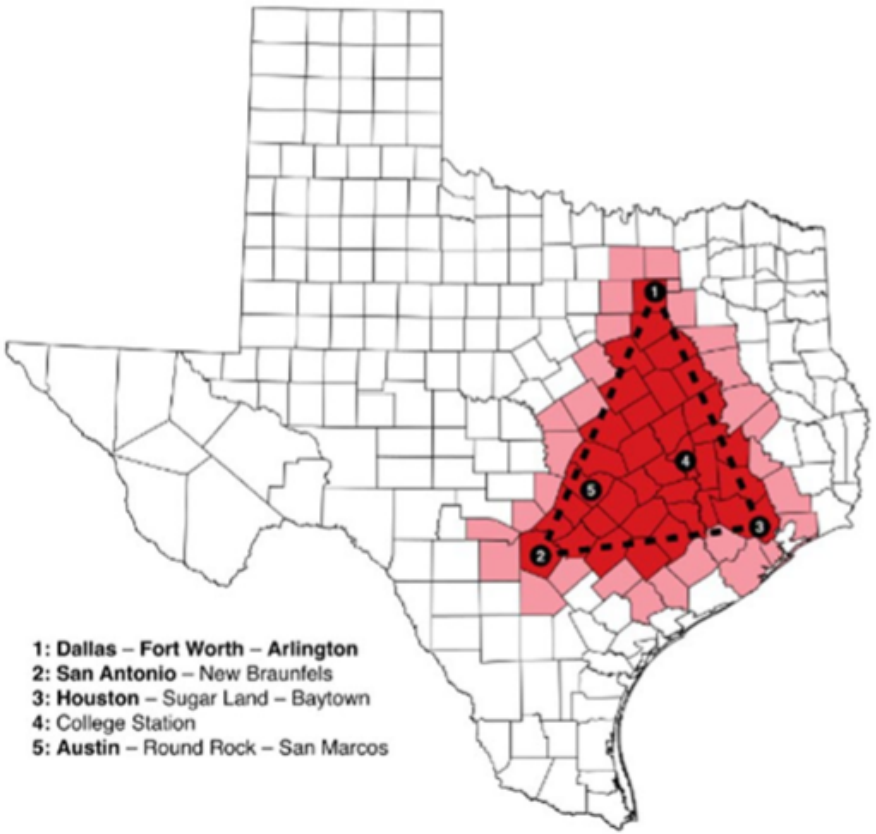
POWERTRAIN ENGINEERING

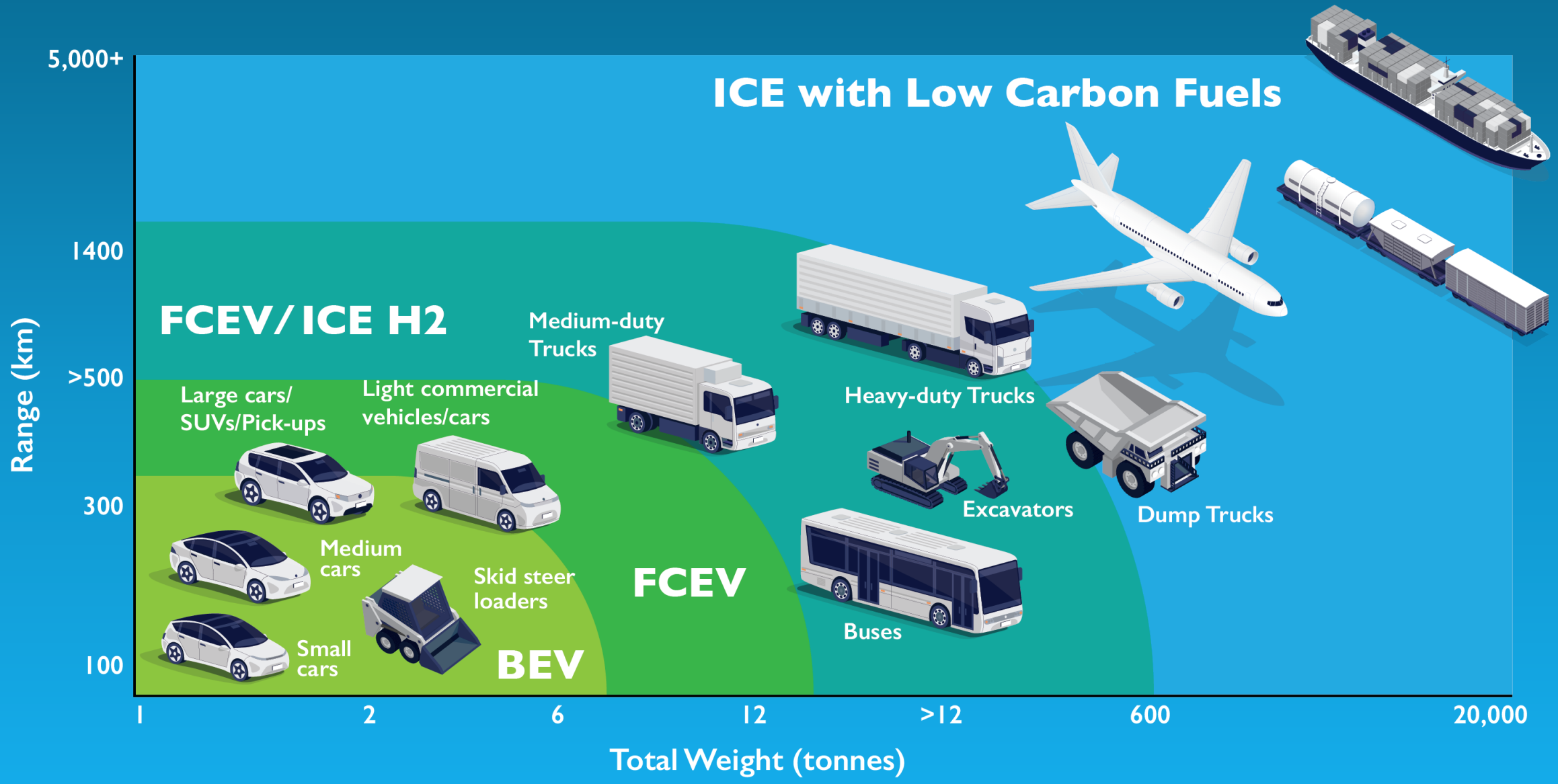
Completing the Texas Triangle: Mobility is Key



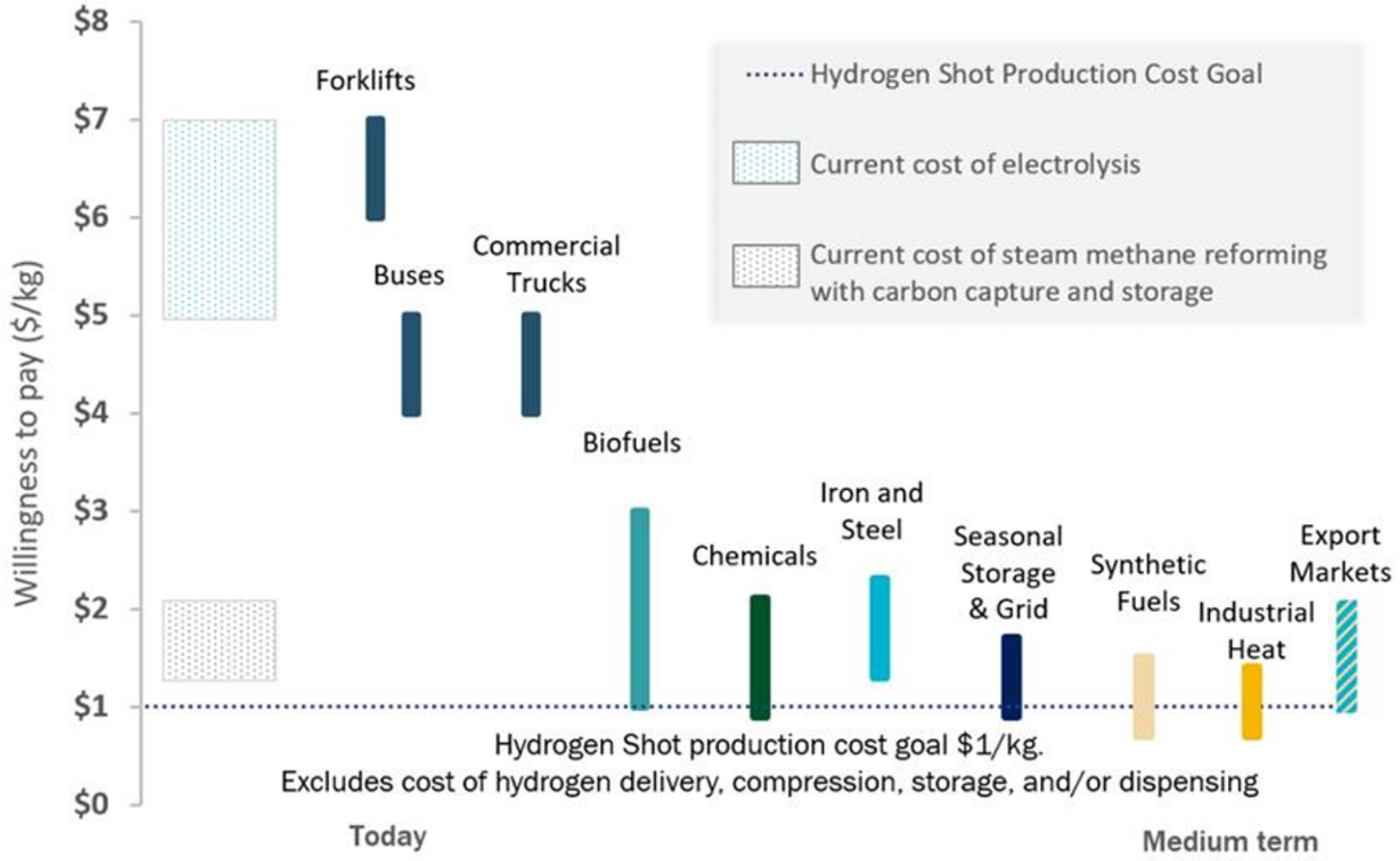
Texas Triangle Megaregion encompasses:

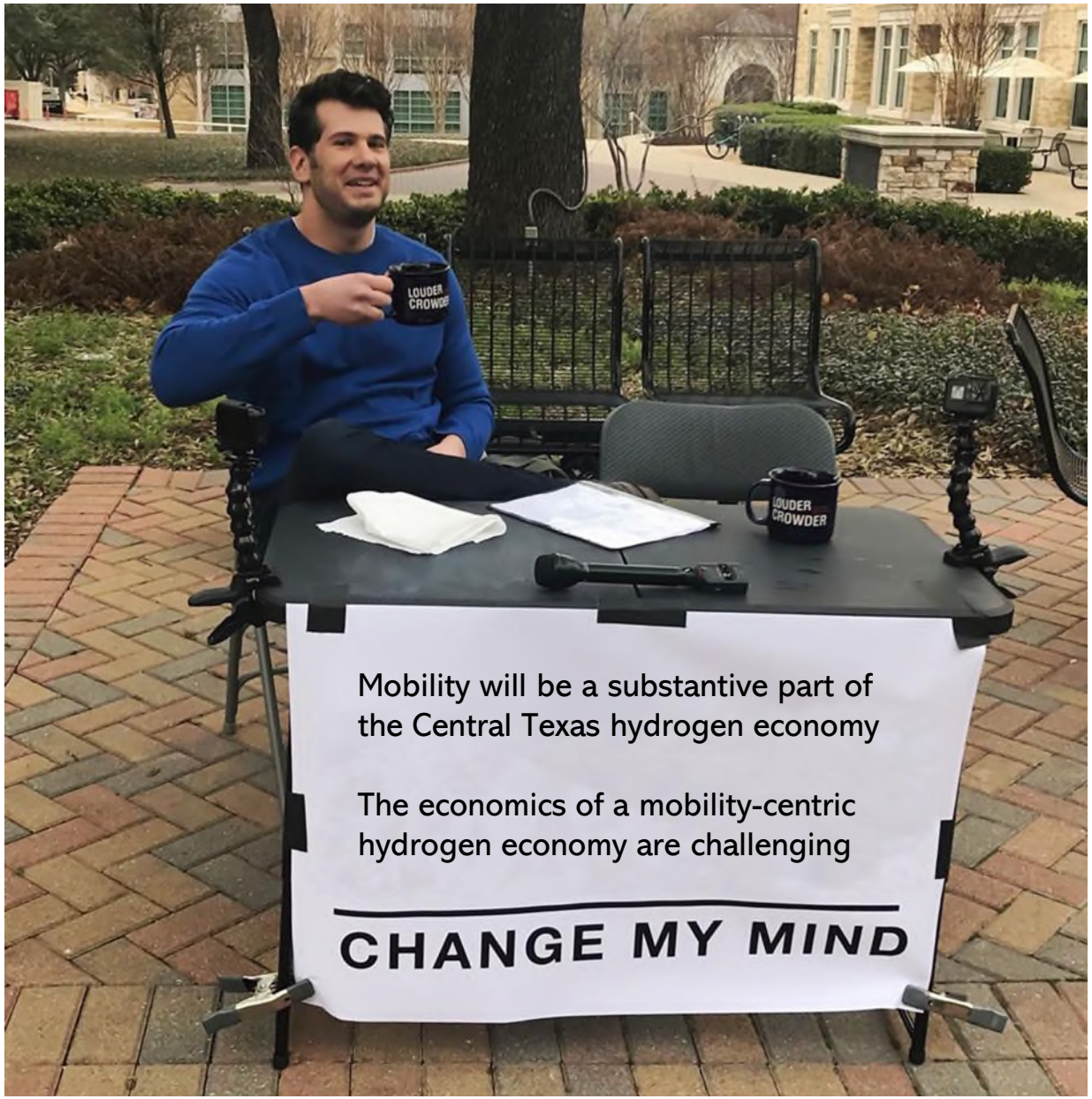
- 5 of the largest 20 U.S. cities and is home to more than 70% of Texans, nearly 21 million people
- 5.3% of the total U.S. truck freight through an average of 35.7k miles of daily commercial VMT
- I-10 freight corridor from San Antonio to Los Angeles, adds 2.1%

Hydrogen & Mobility



Hydrogen & Mobility





Carlos Beltran

Modern Hydrogen

ModernHydrogen

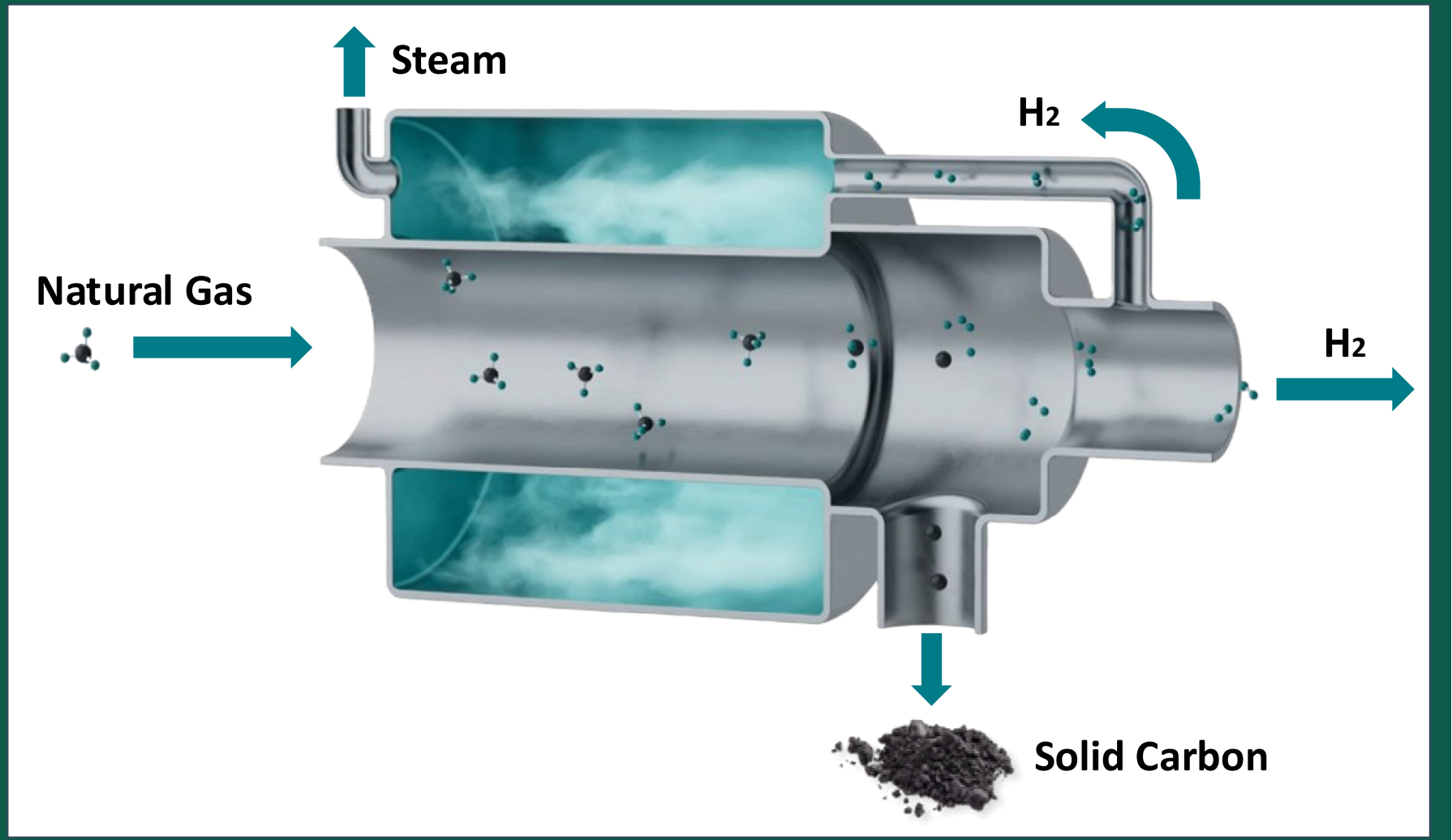
About Modern Hydrogen

- We decarbonize natural gas into clean hydrogen at the point of use…
- …and sell the captured solid carbon as a clean specialty material in asphalt
- Backed by top investors and customers including Bill Gates, NextEra Energy, TC Energy, National Grid, CPS Energy, and NW Natural. ~40 patents issued + pending.

Modern's Methane Pyrolysis

Same Pipes, Zero Emissions

Upvalue Existing Gas Infrastructure
No H_2 Transportation Cost
No CO_2



Paid H_2 Projects Underway with U.S. Utilities

Portland, Oregon
– for blending

Miami, Florida
– for powergen

San Antonio, Texas
– for powergen

Distributed Clean Power

Mobility Refueling

Solid Carbon for Asphalt

Our solid carbon is a superior asphalt binder

Asphalt companies using our carbon as a “binder extender” to make better asphalt:

1. **Improve performance**
2. **Reduce embodied CO_2**
3. **Buy less traditional bitumen**

Asphalt companies pay us for carbon so they can put it in the ground to make roads, sequestering it forever.

“Modern’s Carbon sequestering asphalt outperforms TXDOT (Texas Department of Transportation) spec.”

–Bexar County (San Antonio) Dept of Public Works

Modern Carbon in asphalt in Miami

Pothole repair in Texas public roads with our Modern Carbon

Mike Lewis

Center for Electromechanics – UT Austin

The University of Texas at Austin
Cockrell School of Engineering

THE HYDROGEN PROTOHUB

A PROVING GROUND AND EDUCATIONAL RESOURCE FOR THE ADVANCEMENT OF HYDROGEN TECHNOLOGIES

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Cockrell School of Engineering

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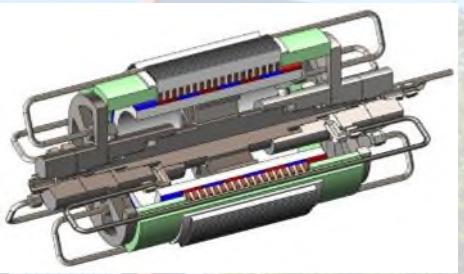
Center for Electromechanics at UT-Austin

- **CEM is an Organized Research Unit (ORU) within the Cockrell School of Engineering at The University of Texas at Austin**
- **Operate under Sponsored Research Agreements with Government and Industry**
  - Often using industry funding/support as cost share to federal funding
  - Past and current programs with DOD, DOE, and DOT
- **Full-time research staff (engineers/scientist and technicians) with traditionally no faculty appointments**
  - Approximately 35 staff members + faculty and staff



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Research at CEM

Mission: To transition Power and Energy Solutions into Products and Students into Leaders by using expertise in modeling, prototyping, and testing of electric machines, energy storage, grid solutions and controls, and hydrogen energy systems.

Vision: To provide a collaborative R&D environment where academia, government, and industry can come together to develop system-level power and energy solutions that address societal electrification challenges and change the world.

Success includes:

1. Research and Development
2. Education
3. Technology Transfer

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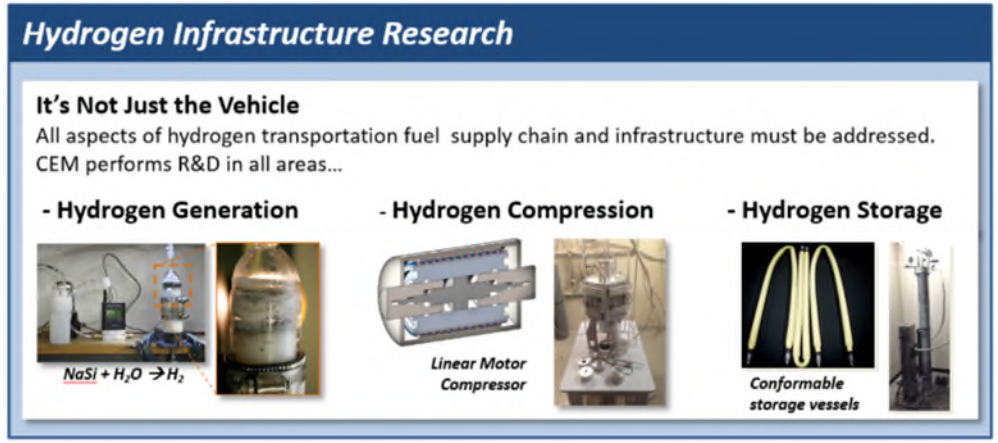
Hydrogen Research

- **Began hydrogen research in 2006 with the first and only hydrogen fueling station and commercial fuel cell vehicle in Texas.**
  - **Leveraging expertise in hybrid vehicle powertrains**
- **National Fuel Cell Bus Program demos**
- **Prototype fuel cell vehicle demos**
  - **Ultra light-duty to heavy-duty**
- **Other hydrogen infrastructure technologies**



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H2@Scale Hydrogen ProtoHub R&D Facility at UT Austin

First-of-its-kind hydrogen R&D facility with multiple forms of hydrogen generation and use cases

Part of the DOE HFTO H2@Scale program. DOE project demonstration to continue through end of 2025.

Future work and vision is to be a training site and proving ground for new H2 technologies

protoH$_2$ub

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H2@Scale Project Partners and Timelines

Project Partners:

- Air Liquide
- CenterPoint
- Chart Industries
- Chevron
- ConocoPhillips
- Frontier Energy
- GTI Energy
- Hitachi Energy
- Low-Carbon Resources Initiative
- McDermott
- Mitsubishi Heavy Industries
- OneH2
- ONE Gas
- ONEOK
- Shell
- SoCalGas
- Texas Commission on Environmental Quality
- Toyota
- University of Texas at Austin Center for Electromechanics
- US DOE
- WM

Support Partners:

- Center for Houston's Future
- IdeaSmiths
- Rice University's Baker Institute for Public Policy

Timeline	Key milestones & deliverables
Budget Period 1 (8/1/20-1/31/22)	• Demonstration site planning and construction • Technoeconomic H2@Scale models in Texas
Budget Period 2 (2/1/22-7/31/23)	• Complete construction and begin demonstration • Complete framework for H2@Scale in Texas
Budget Period 3 (8/1/23-12/31/25)	• Conduct demonstration, document performance, and assess H_2 cost-effectiveness

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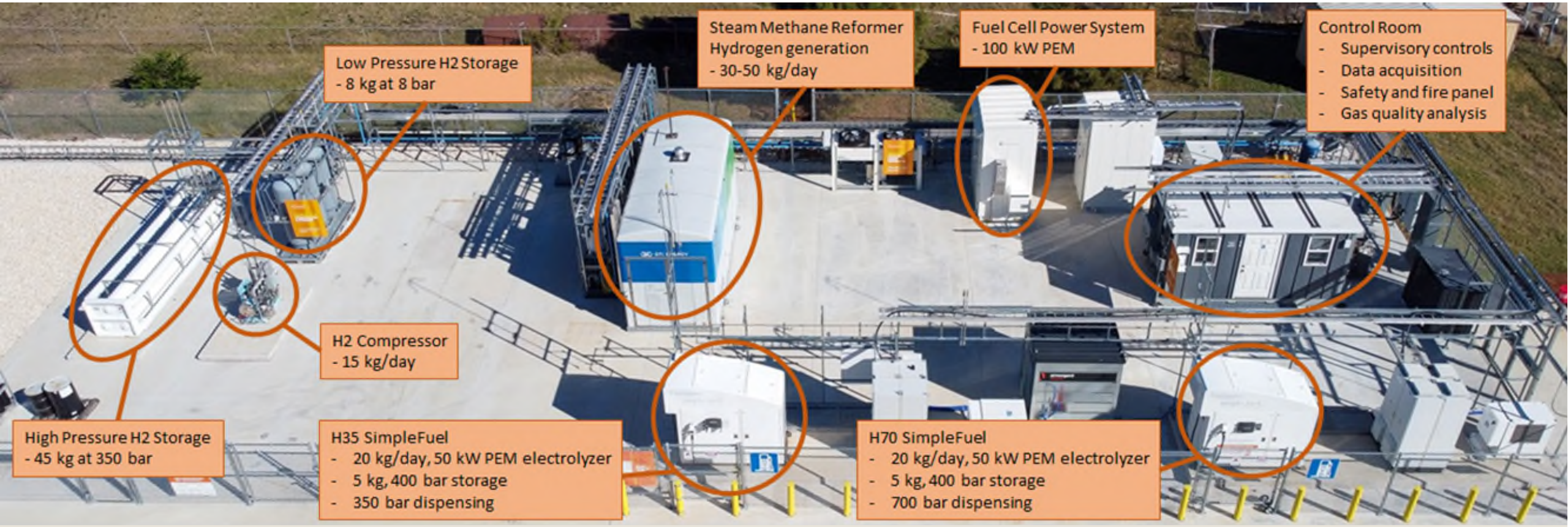
Hydrogen ProtoHub Facility Overview

protoH2ub



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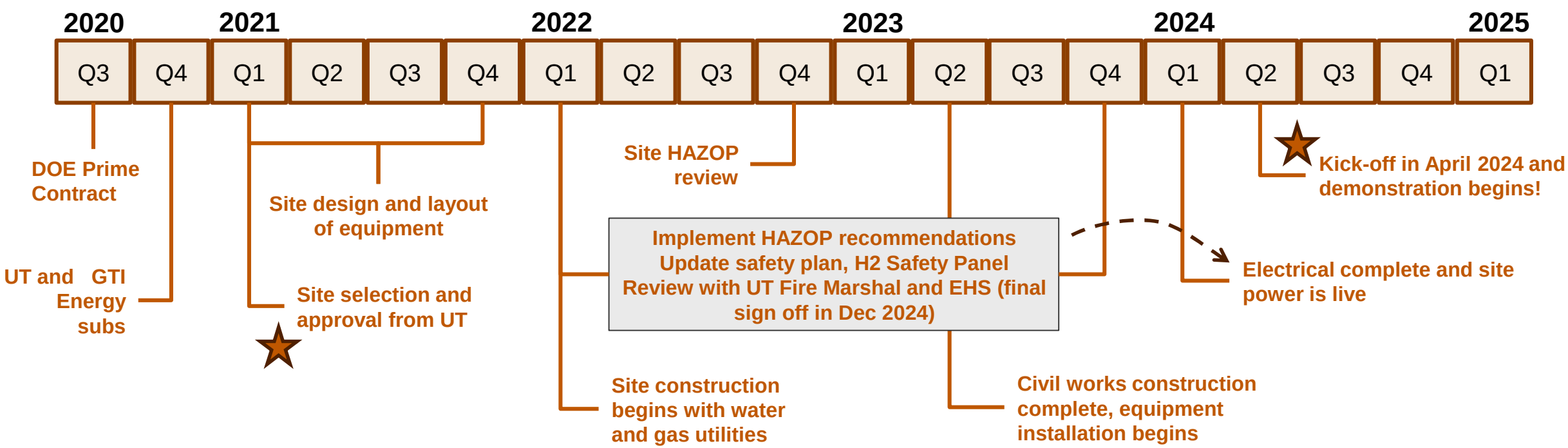
Project Implementation and Lessons Learned



- Schedule delays, supply chains, and inflation post-COVID were a challenge
- UT safety approval resulted in delays between civil and electrical work (6+ mos)
- EHS team imposed additional requirements late in the build

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Site Construction and Integration Photos

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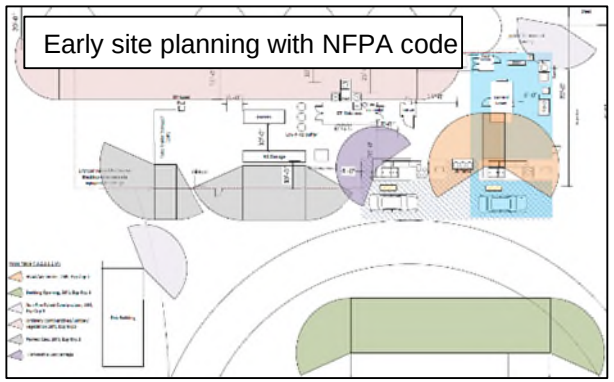
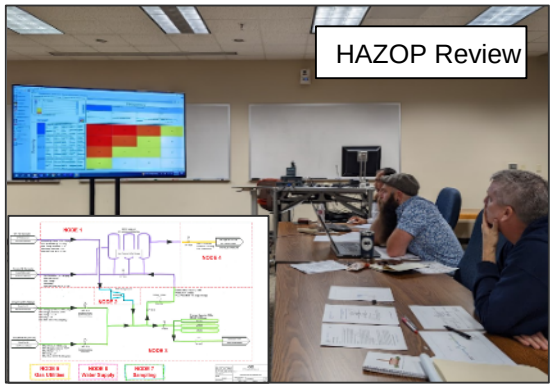
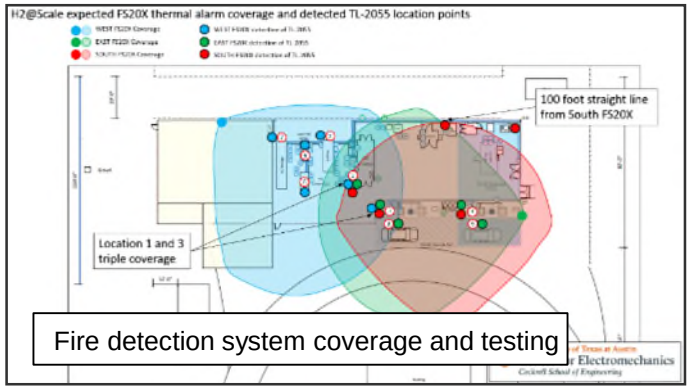
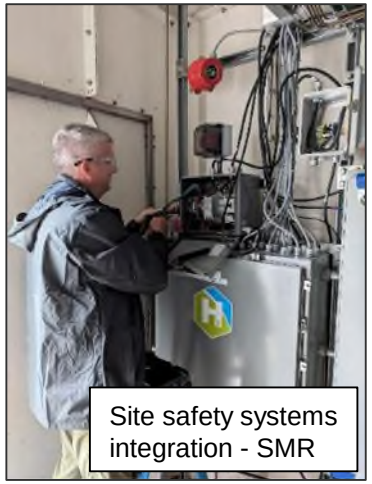
Safety Planning and Implementation

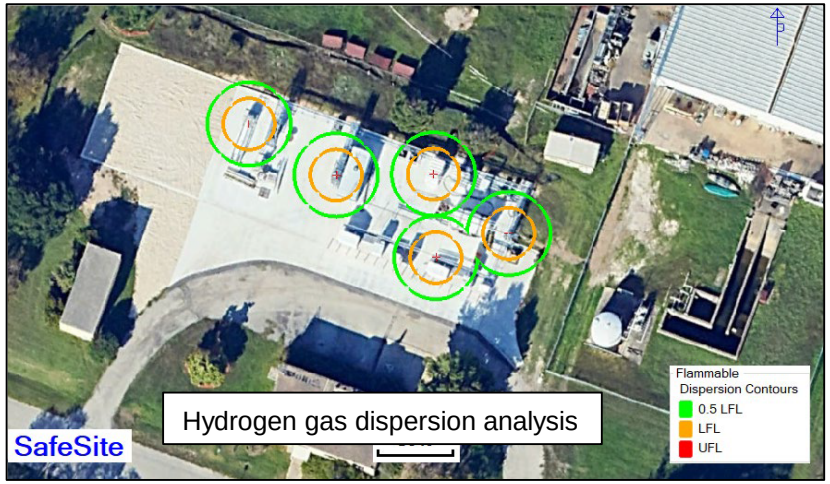

Early site planning with NFPA code


HAZOP Review

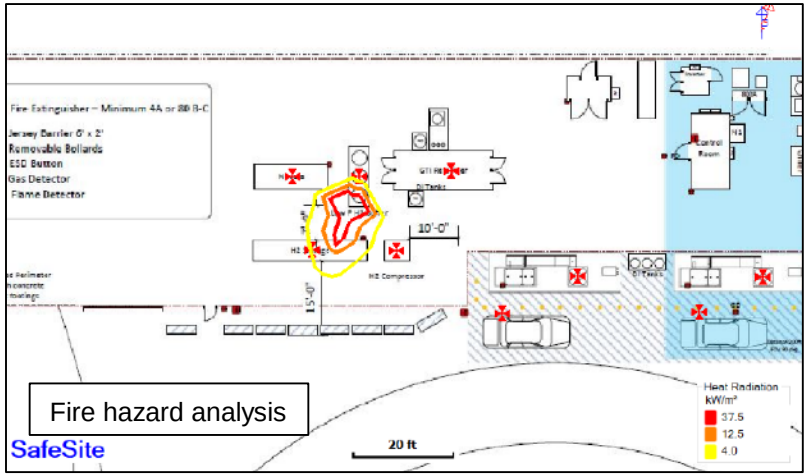


Fire detection system coverage and testing


Site safety systems integration - SMR



Hydrogen gas dispersion analysis



Fire hazard analysis


Sie Fire Panel

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Hydrogen Electrolysis, Compression, Storage, and Fueling System Implementation

PDC commissioning


Toyota fueling protocol testing

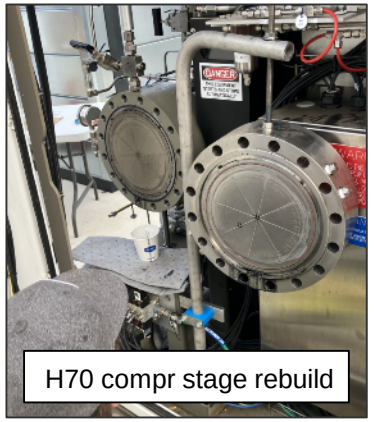

Hitachi Energy PQ testing


H70 electrolyzer freeze

Early vehicle refueling!

Early vehicle refueling!

H70 with signage



H70 compr stage rebuild

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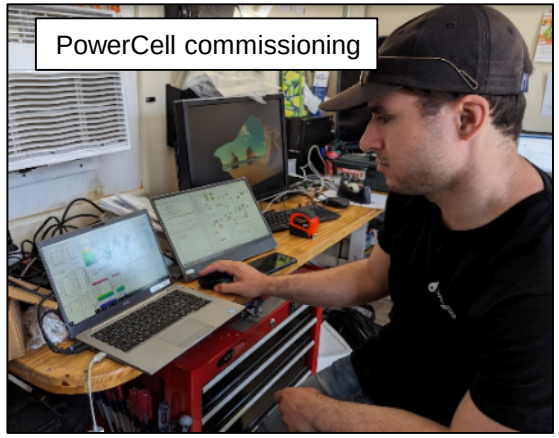
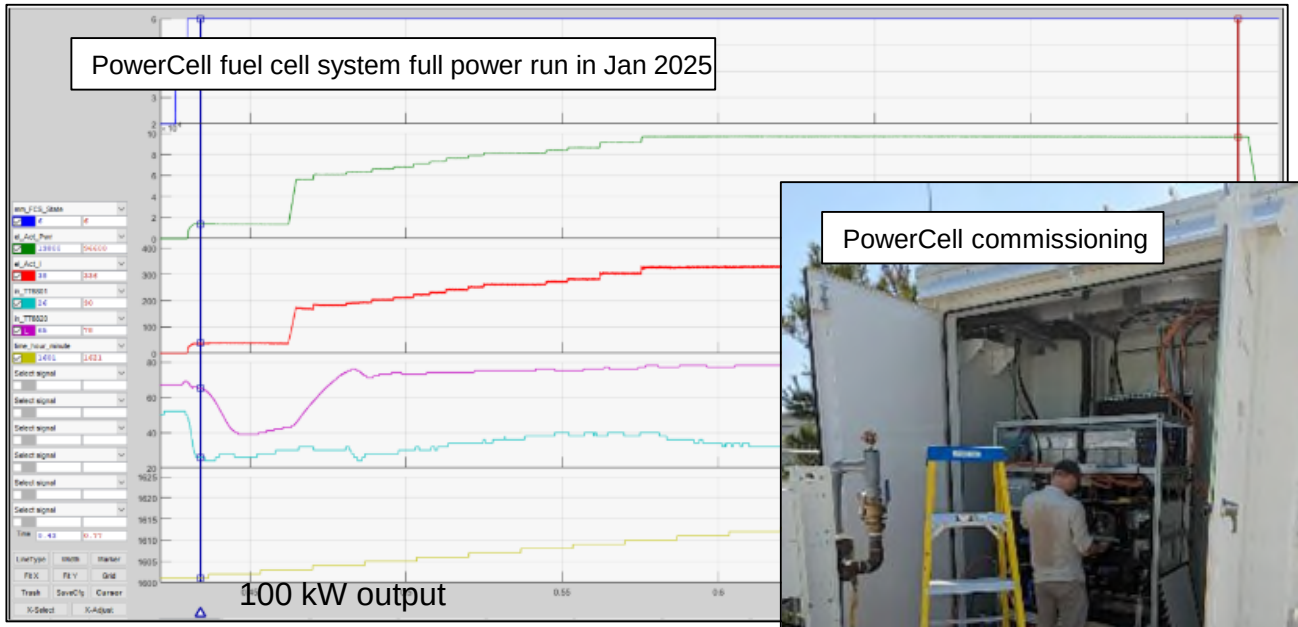
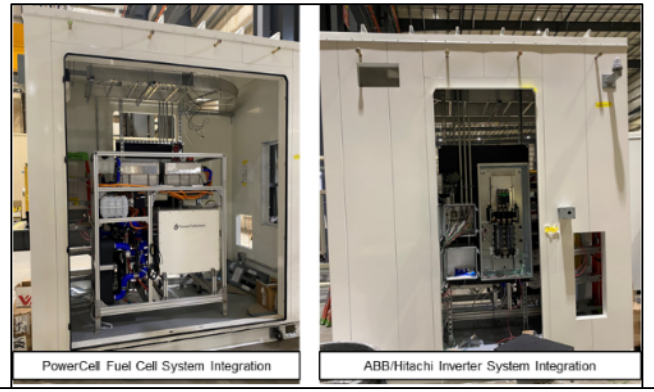
Fuel Cell and Inverter System Implementation


Power feed install


PowerCell commissioning



PowerCell commissioning




Replacing DC/DC converter

Fuel cell system (left) and inverter (right) integration at GPC

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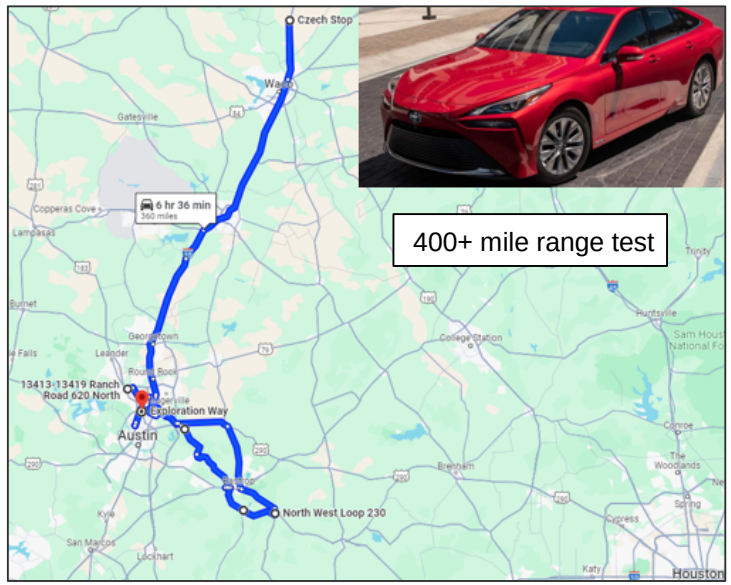
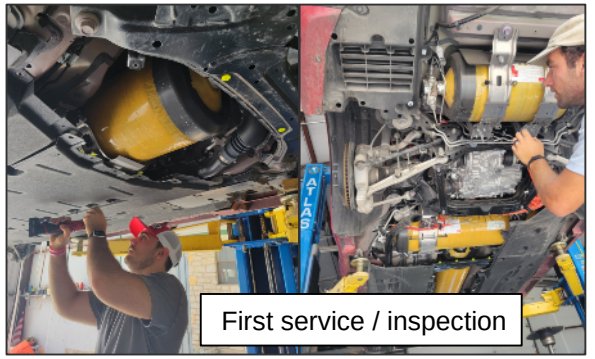
Fuel Cell Vehicle Demonstration

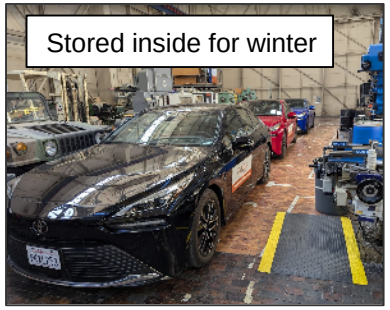


400+ mile range test

UT H2 Day

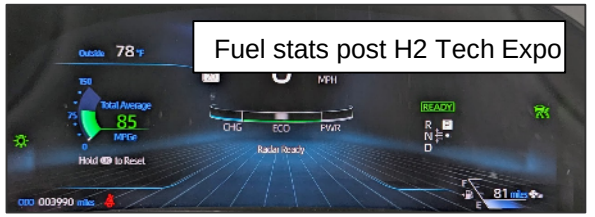


First service / inspection



Stored inside for winter

Trailering for Houston events



Fuel stats post H2 Tech Expo

Event at Texas State Capitol

First public fueling

After H2 Tech Expo roundtrip

Houston road trip pit-stop no fuel needed!

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ProtoHub Lessons Learned

Deploying hydrogen technology can be a challenge, even for commercial systems

Fundamental technologies and solutions are sound, but System Integration and BOP remain a challenge

- Communication and controls between different pieces of equipment
- Documentation and instructions for the equipment
- Different vendors working together for first time
- Early-stage commercial products with unproven BOP components
- Redundancy of systems improved uptime and operation (especially for vehicles)

Interpretation of codes and standards varies across the spectrum

- UT Fire Marshal and EHS review and approval requirements evolved over time as their knowledge of the site and hydrogen grew
- Ever changing goal posts resulted in delays and additional costs
- Vendor interpretation of codes varied, also leading to delays and acceptance of equipment

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protoH2ub Poised for Future H2 R&D and Education

- Purpose of the Hydrogen ProtoHub
  - Hardware and technology showcase and testing facility
    - Hydrogen generation, storage, distribution, use, emissions detection, etc.
  - Training facility for industry, academia, workforce, and AHJ's
  - Maintain fueling site for hydrogen vehicles

- Hydrogen ProtoHub Program Areas
  - Hydrogen Networks / Digital Modeling
  - Clean Hydrogen Production
  - Hydrogen Delivery Systems
  - Training
  - Mobility and Fueling Infrastructure
  - Hydrogen Emissions Test Facility

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Hydrogen ProtoHub / UT-PRC Site Advantages

- World-known and publicly accessible research campus with local/state support.
  - 475 acres, 10 miles north of downtown Austin
- Multiple research units and facilities with numerous end-use applications.
  - Texas Advanced Computing Center
  - UT-CEM MW-level microgrid facility
  - Chilling plants and boilers
  - Dedicated, university-owned gas distribution system
- On-site hydrogen production, storage, with permitted facilities in place at the Hydrogen ProtoHub site.
- Energy expertise and technicians on-site.
- UT and GTI have over 15+ years partnership in H2.

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Thank You !

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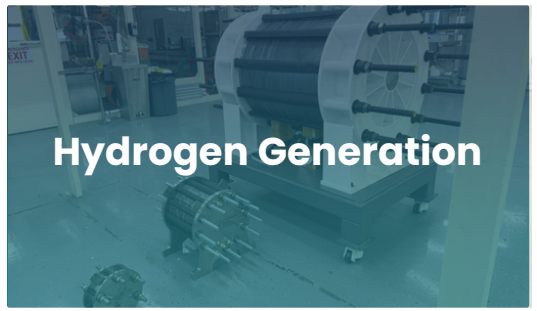
Bobby Hunt

Total Hydrogen Solutions

total hydrogen solutions
A DIVISION OF PNEUMATIC AND HYDRAULIC COMPANY, LLC

We offer distribution, design, and system integration across most any part of the hydrogen value chain



Selected Projects in Hydrogen

Battery/Fuel Cell Clean Backup Generator for Large Bank

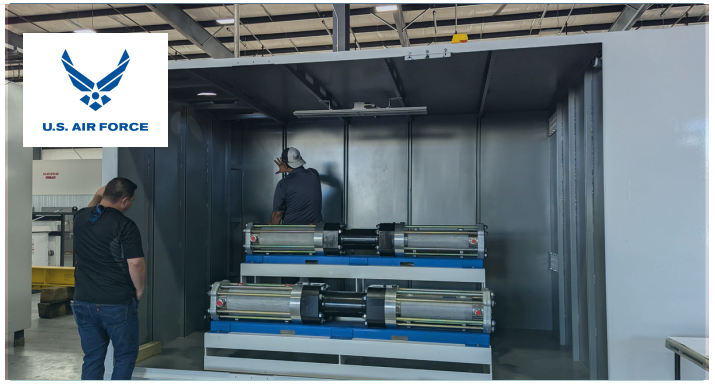
Full System Design, Integration, Sourcing, Fabrication

Hydrogen Generation and Refueling System for a hydrogen technology company

System Design, Integration, Fabrication, and Testing

Mobile Drone Refueling for a DOD Contract

Compression System Design and Integration



Hydrogen Microgrid for Air Force Research Laboratory

System Design and integration for Hydrogen Generation (Alkaline Electrolysis), Compression, Storage, and Dispensing

total hydrogen solutions
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Selected Projects in Hydrogen

Oxygen Compression Unit for Fisheries From Alkaline Electorlyzer

Full System Design, Integration, Fabrication

Hydrogen Compression for Refuse Trucks

System Design, Integration, Fabrication, and Testing

Stationary and Mobile Hydrogen Dispensers for H35, H70, and Tube Trailer Refueling

System Design, Integration, Testing and Fabrication

500kg/day Hydrogen Production, Compression and Refueling

Site Prep, Design, Integration of Compression, Storage and Dispensing for Heavy Duty Trucks and Tube Trailers

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Selected Projects in Hydrogen

950 Bar Cascade Storage and Refueling System

System Design, Integration, Frame Fabrication

120kW Fuel Cell Backup Generator

System Design, Integration, Fabrication, and Testing

Mobile Hydrogen Refueling Stations with Compression for H35 and H70 Refueling

System Design, Integration, Testing and Fabrication

4-9kW Fuel Cell / Supercap System

System Design, Integration, and Testing

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Project Detail

Large Refilling Trailer

For Buses and Heavy Duty Trucks and Cars - 350 bar and 700 bar - gaseous hydrogen delivery

Full refueling unit

Power Distribution for easy site or generator connection and all chilling/HVAC on trailer

Compression on Trailer up to 700 bar

Touch Screen Operation and Dispensing on Back of Trailer

Car Refilling

Expandable High pressure storage for cascade filling

Operational Concept

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Project Detail

Compact Hydrogen Production and Refueling System

5 kg/24 hrs, 700 bar refilling for Toyota Mirai Cars

System Pictures

99.999% Fuel Cell Grade Hydrogen

- In line Purity sensor optional

Remote contols and monitoring via mobile and desktop app

Site needs:

Tap water

220v, 3 phase, 50 amps

Easy Transport

Compression

Manual Controls

Push button controls

Handle-held nozzle

total hydrogen solutions

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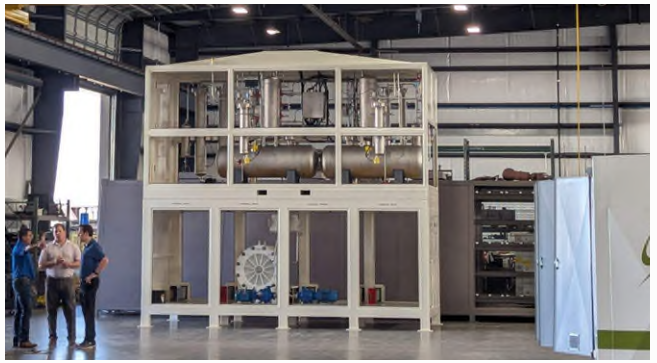
Project Detail

500kg/day electrolyzer, compression and refueling station
For Heavy Duty Trucks and bulk transport trailers - up to 700


New Site


1.25MW

Bulk storage at 200 bar


High pressure storage


Dispensing

Compression to 1000 bar


Rectifier
s


Transformers

Not pictured: switchgear, chilling

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