CENTER FOR HOUSTON'S FUTURE

Houston's New Moonshot: Building Our Clean Energy Future

Marsh Annual Energy Symposium

January 12, 2022

About the Center for Houston's Future

We bring business, government, and community stakeholders together to engage in fact-based strategic planning, collaboration and action on issues of great importance to the Houston region.

Our Areas of Focus:

- **Strategic Initiatives**
- **Community Engagement**
- **Leadership**

The 60th Anniversary of JFK's Moonshot Speech at Rice Stadium in Houston

"We choose to go to the moon in this decade, and do the other things, not because they are easy, but because they are hard ..."

President John F. Kennedy, September 12, 1962

"Throughout the United States there is a hunger today for another 'Moonshot,' some shared national endeavor that will transcend partisan politics. If Kennedy put men on the moon why can't we eradicate cancer, or feed the hungry or wipe out poverty or halt climate change?"

American Moonshot: John F. Kennedy and the Great Space Race by Rice Historian Douglas Brinkley

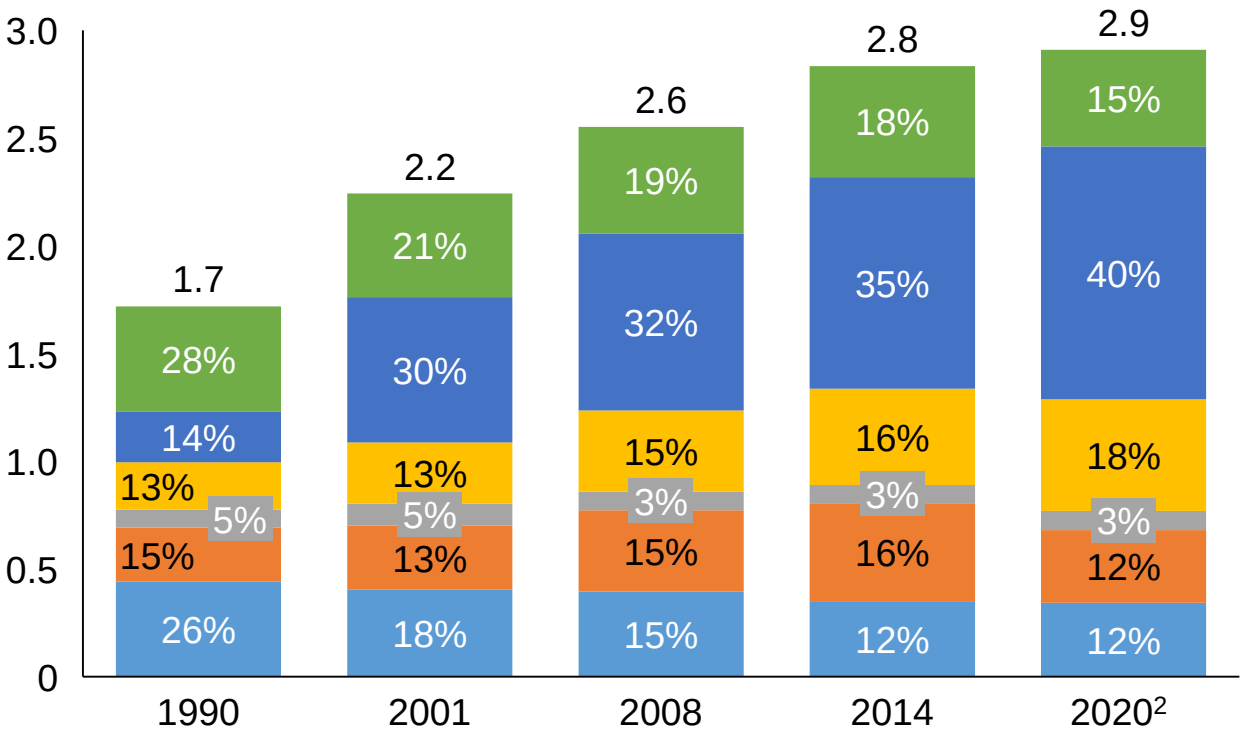
Today’s Discussion

- **How can Houston Lead in the Energy Transition**
- Clean Hydrogen as a Case Study in the Energy Transition
- Role of Insurance Industry in Facilitating the Energy Transition

The Energy Sector Remains Houston's Primary Economic Engine

Preliminary, Work in progress

Houston MSA[1] non-farm employment by sector
Number of jobs, millions



Portion of other sector employment that is induced from Hydrocarbon sectors (i.e., jobs that are created through household spending)

Other sectors
All other non-farm Houston employment sectors (e.g., education, retail, accom-modation & food services, entertainment, real estate, construction, logistics)

Health Care & Life Sciences
Hospitals, ambulatory services, medical equipment manufacturing, pharmaceutical manufacturing, research and development in the Physical, Engineering, and Life Sciences, and employment from sector-related purchases of goods and services in the community[3]

Power & Utilities
Electric power generation, transmission & distribution, natural gas distribution, and employment from sector-related purchase of goods and services in the community[3]

Refining & Petrochemicals
Petroleum products manufacturing, chemical manufacturing, and employment from sector-related purchases of goods and services in the community[3] (e.g., Refining & Petrochemicals-related financial, legal, engineering, and construction services)

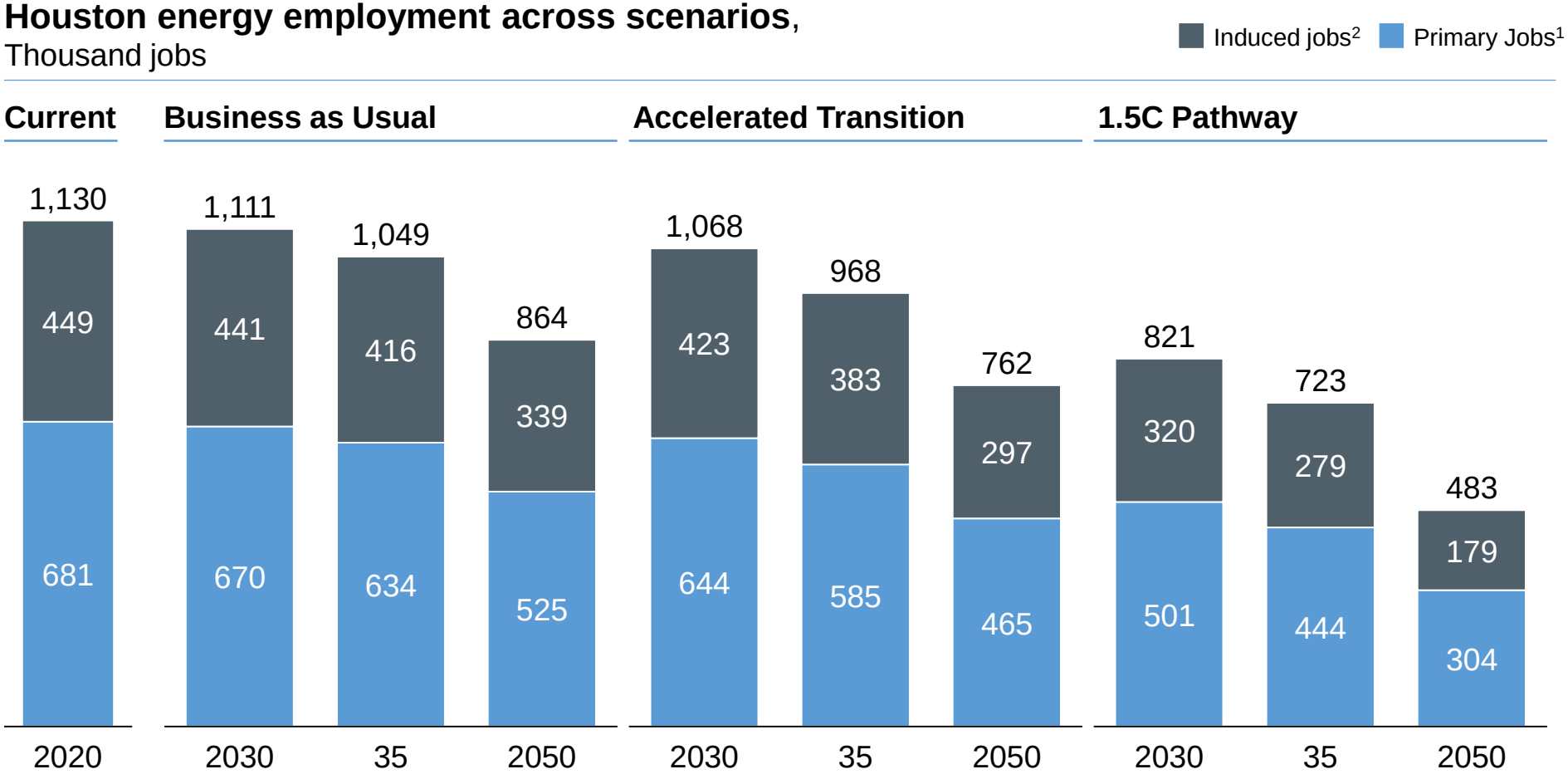
Upstream & Midstream
Oil & Gas extraction, pipeline transportation, machinery manufacturing, and employment from sector-related purchases of goods and services in the community[3] (e.g., Upstream & Midstream-related financial, legal, engineering, and construction services)

1. Metropolitan Statistical Area (Houston-The Woodlands-Sugarland, TX)
2. Data as of Q2 2020
3. Estimated using indirect job multipliers from IMPLAN and Economic Policy Institute

Source: IMPLAN; Economic Policy Institute; U.S. Bureau of Labor Statistics (BLS): Current Employment Statistics (CES), Quarterly Census of Employment and Wages (QCEW); Center for Houston's Future

Houston could lose up to 650K jobs if no actions are taken to respond to changing energy landscape

Houston energy employment across scenarios,
Thousand jobs



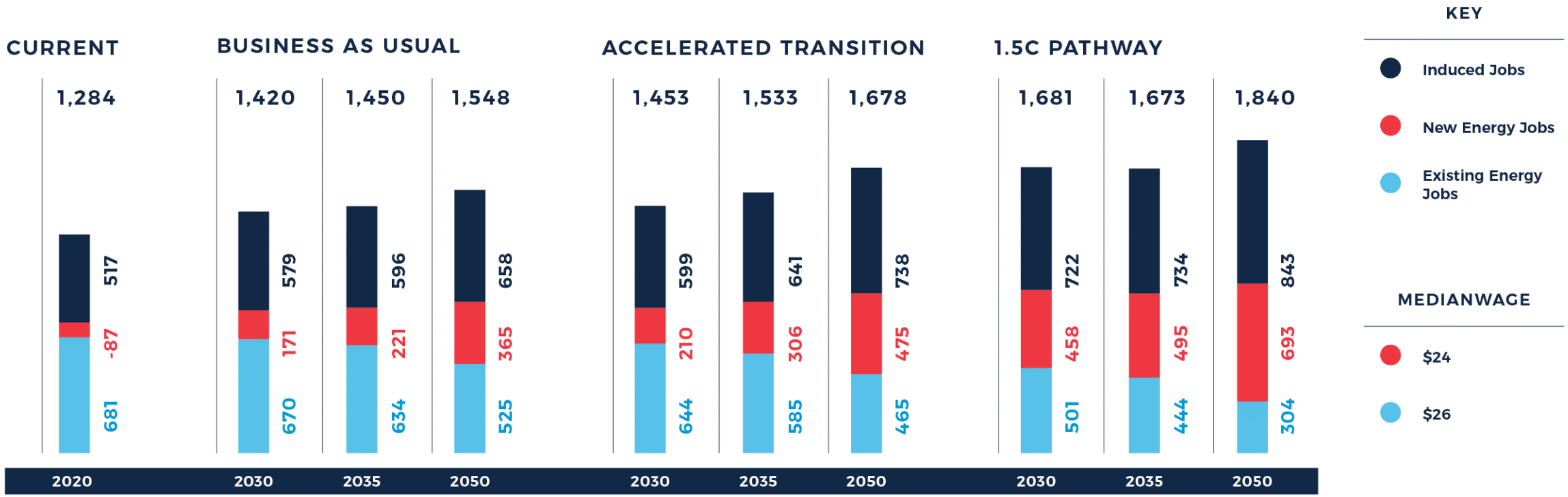
Total **GDP losses could amount to $35 – 85Bn** by 2050[3] on current trajectory, potentially compounded by loss of high paying hydrocarbon jobs with wages that are, on average, **36% higher than national median wage**

1. Includes direct and indirect jobs hydrocarbon (e.g., oil and gas extraction, petroleum refining and petrochemicals) jobs using IMPLAN and EPI multipliers (e.g., supplier jobs, legal and financial service jobs)
2. Includes jobs induced from the hydrocarbon sector
3. 2050 dollars (assumes average inflation of 2%); assumes real GDP per capita remains stable at approximately 72.5k USD (2019 dollars); impact from direct, indirect, and induced jobs in hydrocarbons

Source: McKinsey analysis; E2 “Clean Jobs, Better Jobs” report (October 2020)

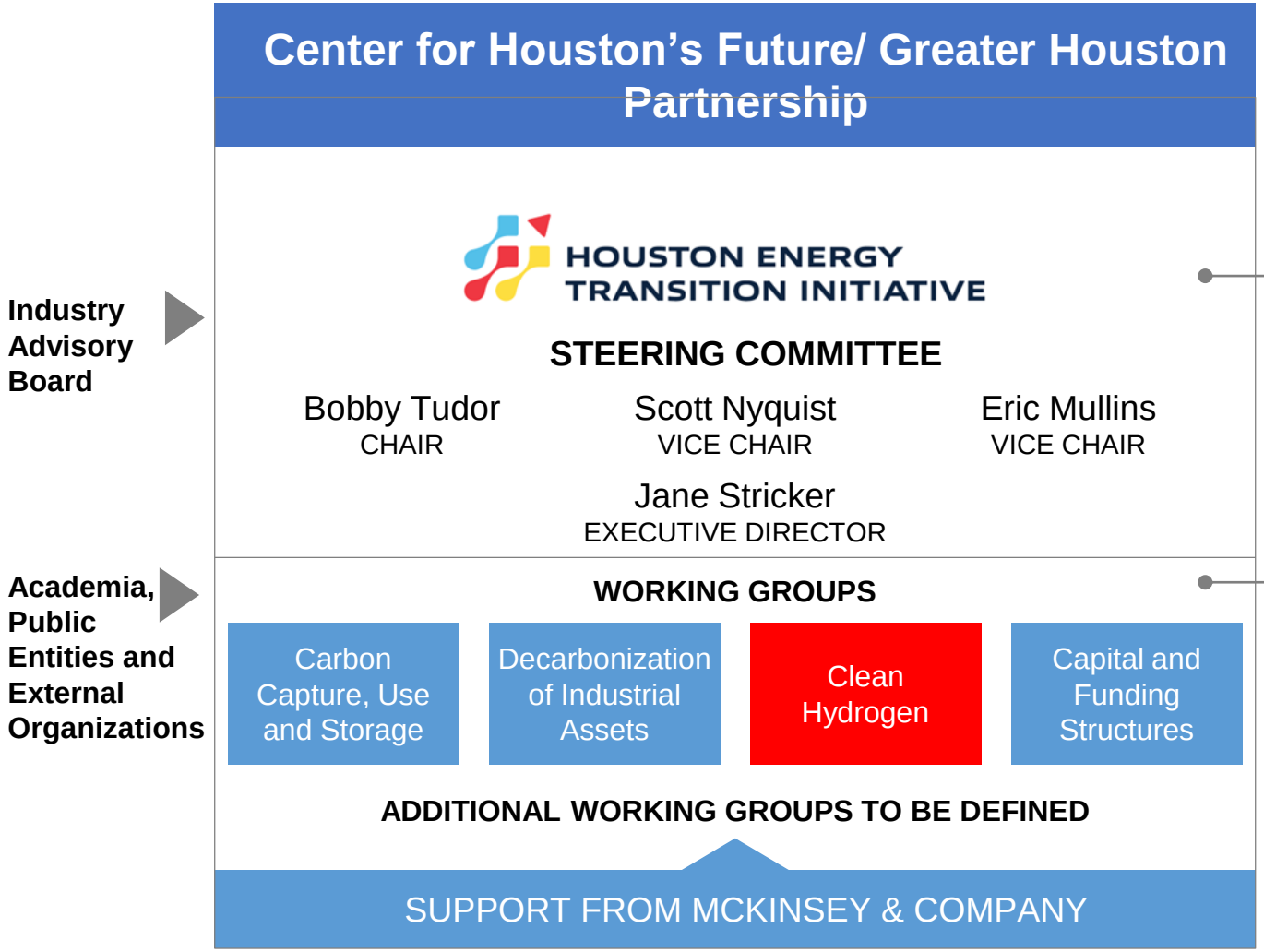
With Decisive Action, Houston Could Gain 560,000 Jobs

Houston Energy Employment Across Scenarios (Thousand Direct and Indirect Jobs)



Source: McKinsey analysis; E2 "Clean Jobs, Better Jobs" report (October 2020)

Houston Energy Transition Initiative



HETI STEERING COMMITTEE FOUNDING MEMBERS

- Baker Hughes
- Bechtel Energy
- BP
- Calpine
- CenterPoint Energy
- Chevron
- ConocoPhillips
- Dow
- ExxonMobil
- Hess
- LyondellBassell
- NRG Energy
- Oxy
- Plains All American Pipeline
- Schlumberger
- Shell
- Sunnova
- TC Energy
- Wood Group

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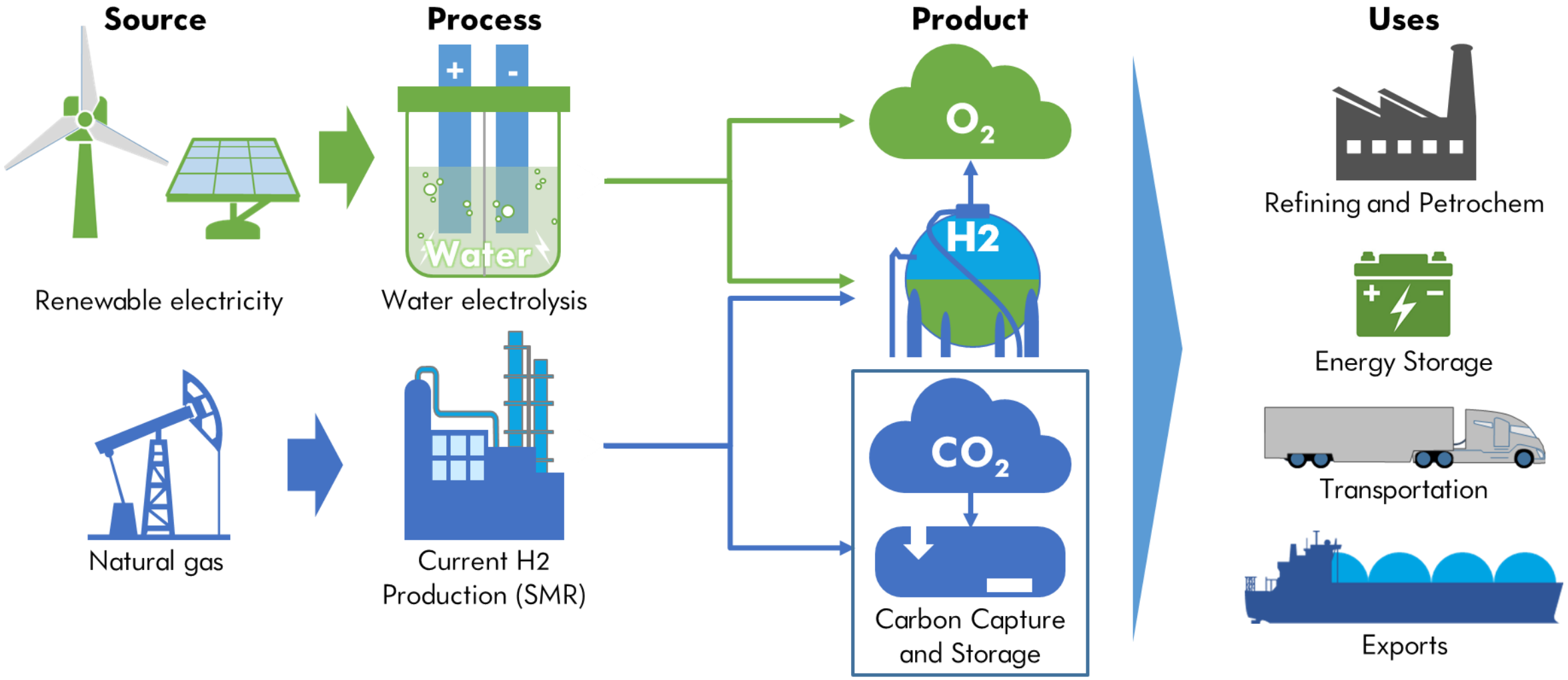
- **Clean Hydrogen as a Case Study in the Energy Transition**
- Role of Insurance Industry in Facilitating the Energy Transition

Typical Hydrogen Production Options



Texas enjoys many advantages in scaling up hydrogen production

General

- Proximity to demand favorable to driving early adoption
- Welcoming environment for infrastructure development
- Existing hydrogen capacity and expertise
- Environmental justice impact
- Concentration of academic and industry-driven innovation
- Highly skilled workforce

Production capacity & cost

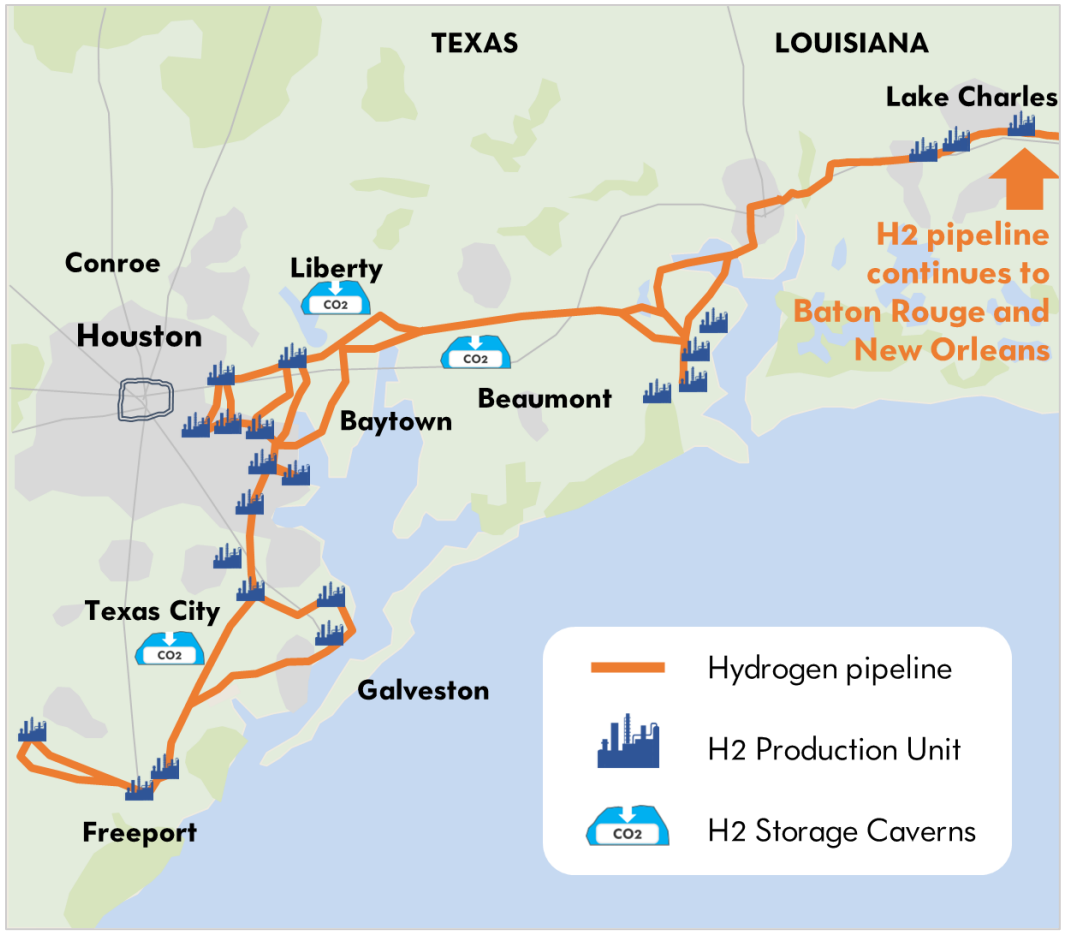
- Access to low-cost renewable energy capacity
- Access to CO_2 storage locations
- Access to low-cost natural gas

Transportation & storage

- Largest network of hydrogen pipelines in the US
- Access to geologic formations for seasonal storage

The Houston area holds an anchor position in a world class H2 system, enabling rapid, scale access to new markets

Existing hydrogen system in the Gulf Coast area



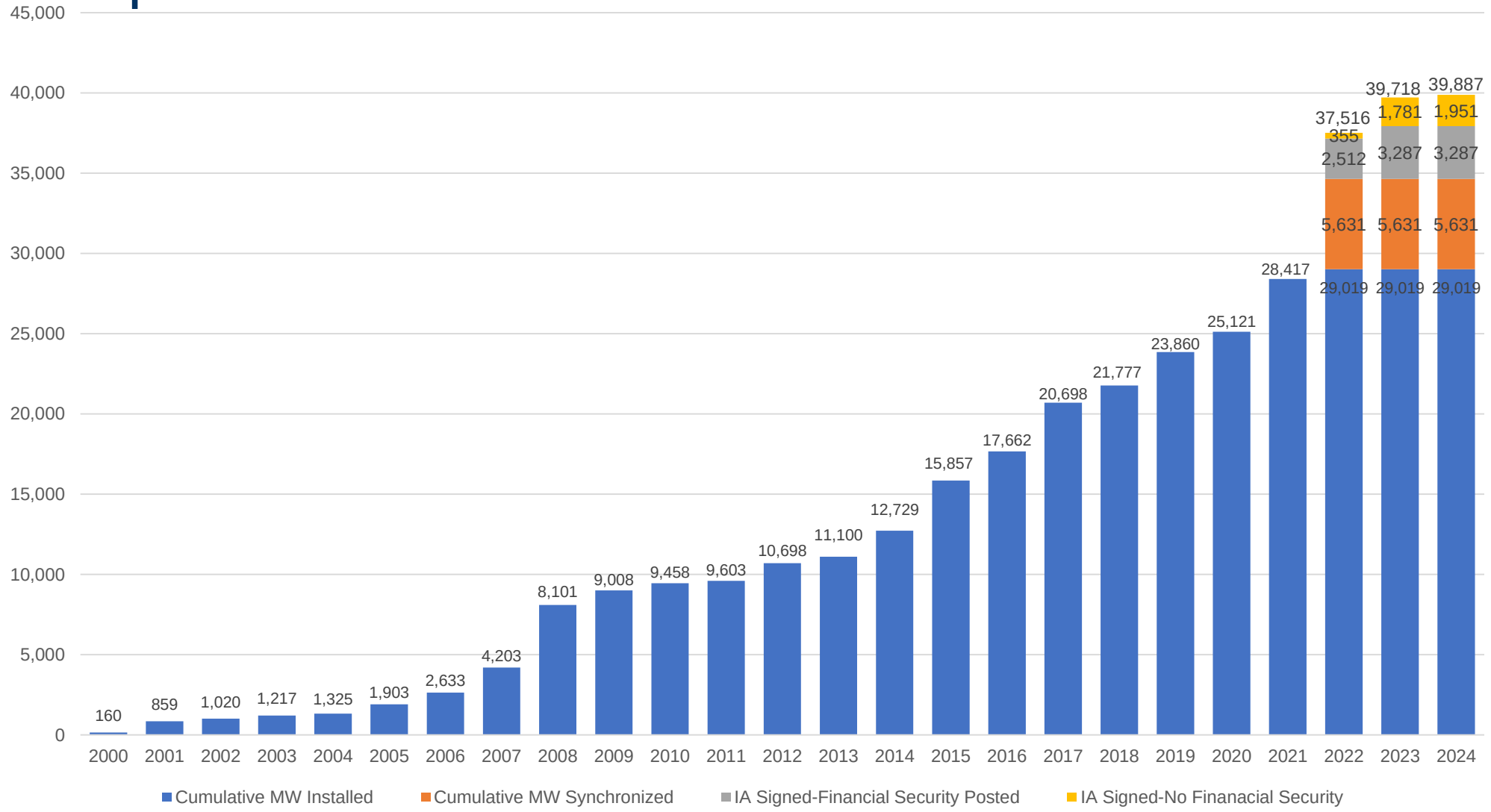
TX Gulf Coast H2 system advantages[1,2,3]

- Over 900 miles H2 pipelines (56% of US; 32% of global)
- ~3.4MMt of H2 produced annually largely through steam methane reformation (34% of US; 8.5x Rotterdam)
- 48 H2 production plants
- World's largest storage caverns for H2; adjacent to H2 network

** Existing H2 system could leverage in-place CCUS assets (e.g., Denbury pipeline) to readily add and scale CCUS to convert grey to blue H2.

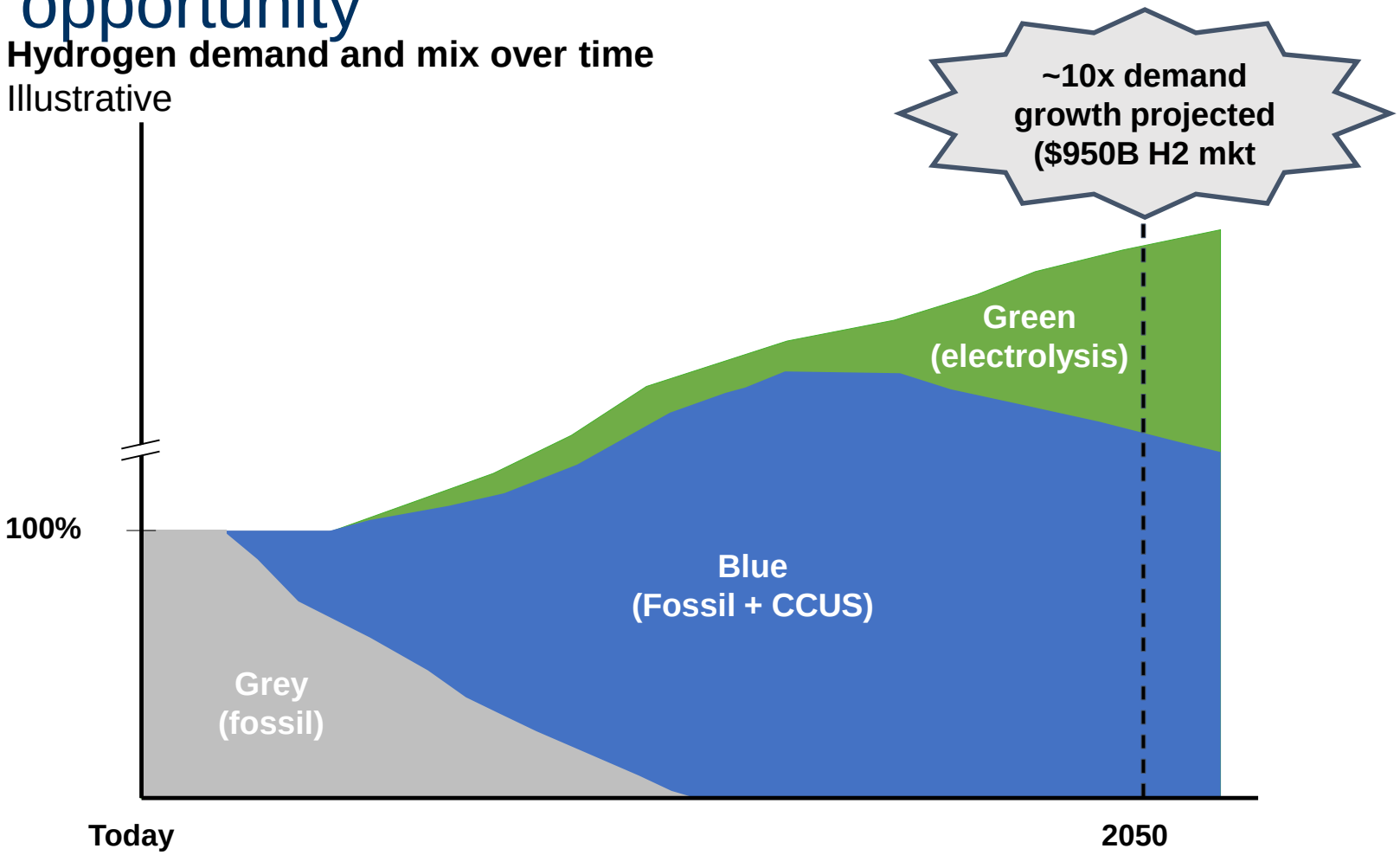
Notes: (1) Houston MSA defined Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery and Waller counties; (2) TX Gulf Coast includes a region from Corpus Christi, TX to Lake Charles, LA; (3) Number of global H2 plants estimated by dividing global H2 production by US avg. production per H2 plant (52k tons H2 / year). Source: H2Tools; USDOT PHMSA - National Pipeline Mapping System; Seeking Alpha; Office of US Energy Efficiency & Renewable Energy; Hydrogen Europe

Texas Wind Market Could Support Clean Hydrogen Development



Decarbonization is catalyzing rapid H2 market expansion, and strategies are emerging to capture the opportunity

Hydrogen demand and mix over time
Illustrative



Source: Barclays, HSBC, Hydrogen Council

Localized Drivers

- Goals: 2050 net zero or similar
- Funding: Carbon fees or other
- Leverageable assets (blue)
  - H2 system
  - At-scale CCUS hub
- Leverageable assets (green)
  - Geologic storage
  - Low power prices

Cross cutting Enablers

- Cost and supply chain improvements
  - Electrolyzers
  - Renewables
- H2 and renewable synergies

Vision For Texas As A Hydrogen Hub – 2050 Snapshot

No.1 Global leader in hydrogen production, use, innovation, and talent development

21MT of clean hydrogen production in Texas, including 12MT local demand, 9MT export; 4% of global hydrogen production in 2050 (540MT)

170k 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

220MT CO2 abatement potential from 21MT of hydrogen, i.e., 4x Houston's 2019 emissions

Sources: U.S. Bureau of Economic Analysis

Phase 1 Completed: Houston 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

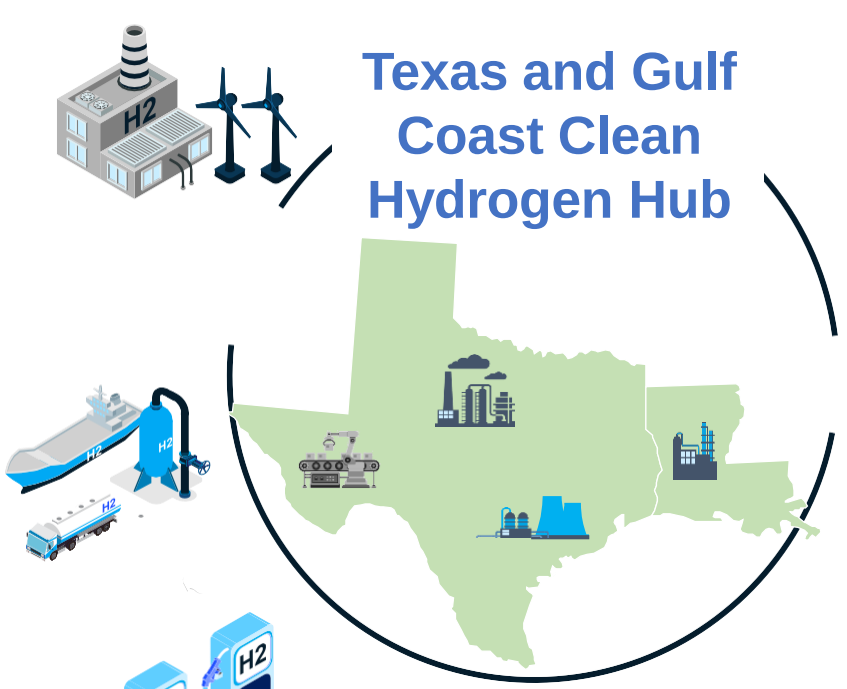
Trucking – home to a major trade corridor

Shipping – established port infrastructure for potential H_2 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



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

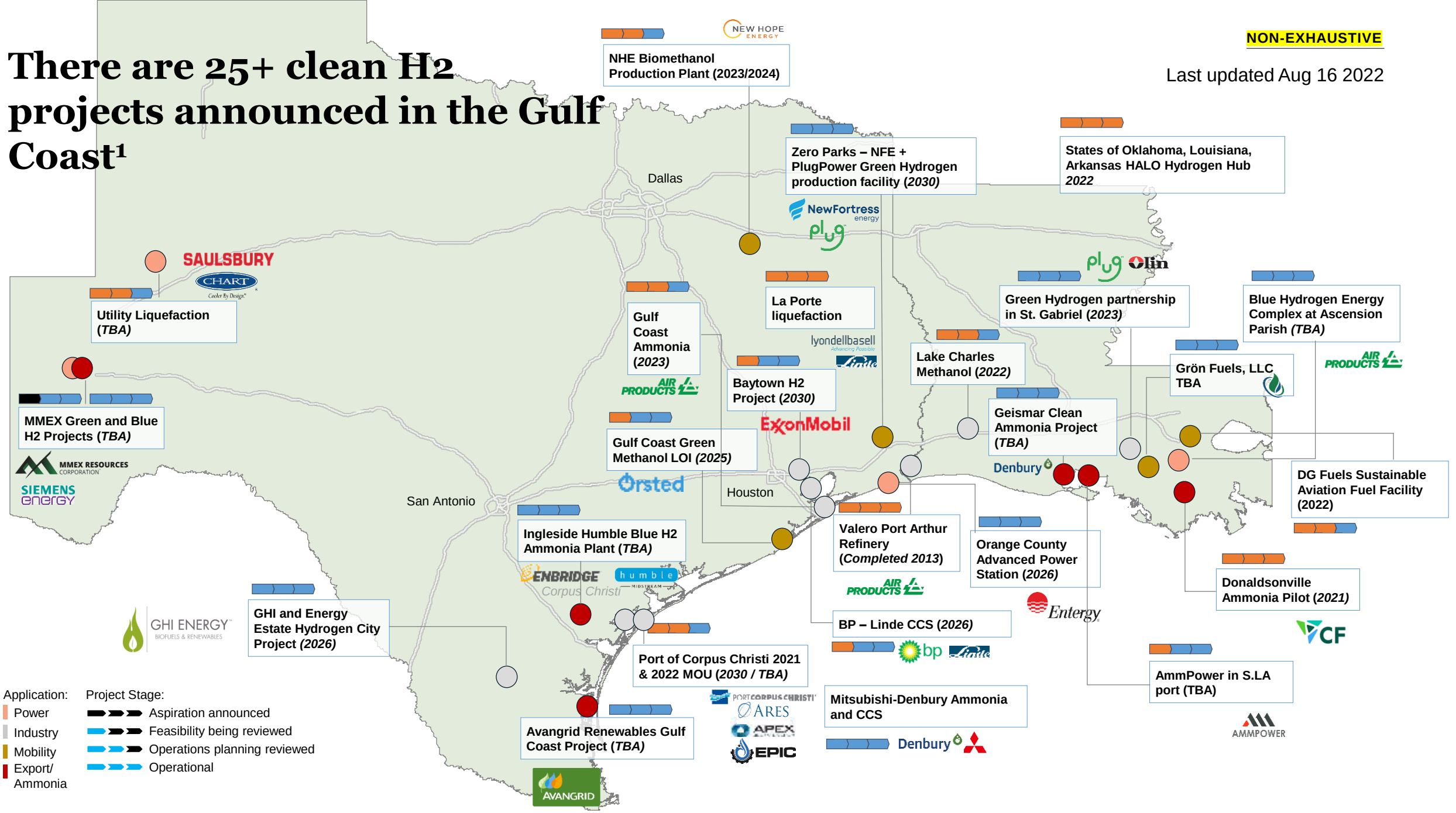
Other industrial heating and feedstock
High-grade heat applications which are used primarily by concentration of iron, steel, and cement producers along the Gulf

Source: McKinsey Internal Study, US DOE H_2@Scale RFI Summary of Results

There are 25+ clean H2 projects announced in the Gulf Coast[1]

NON-EXHAUSTIVE

Last updated Aug 16 2022



Application:
- Power
- Industry
- Mobility
- Export/ Ammonia

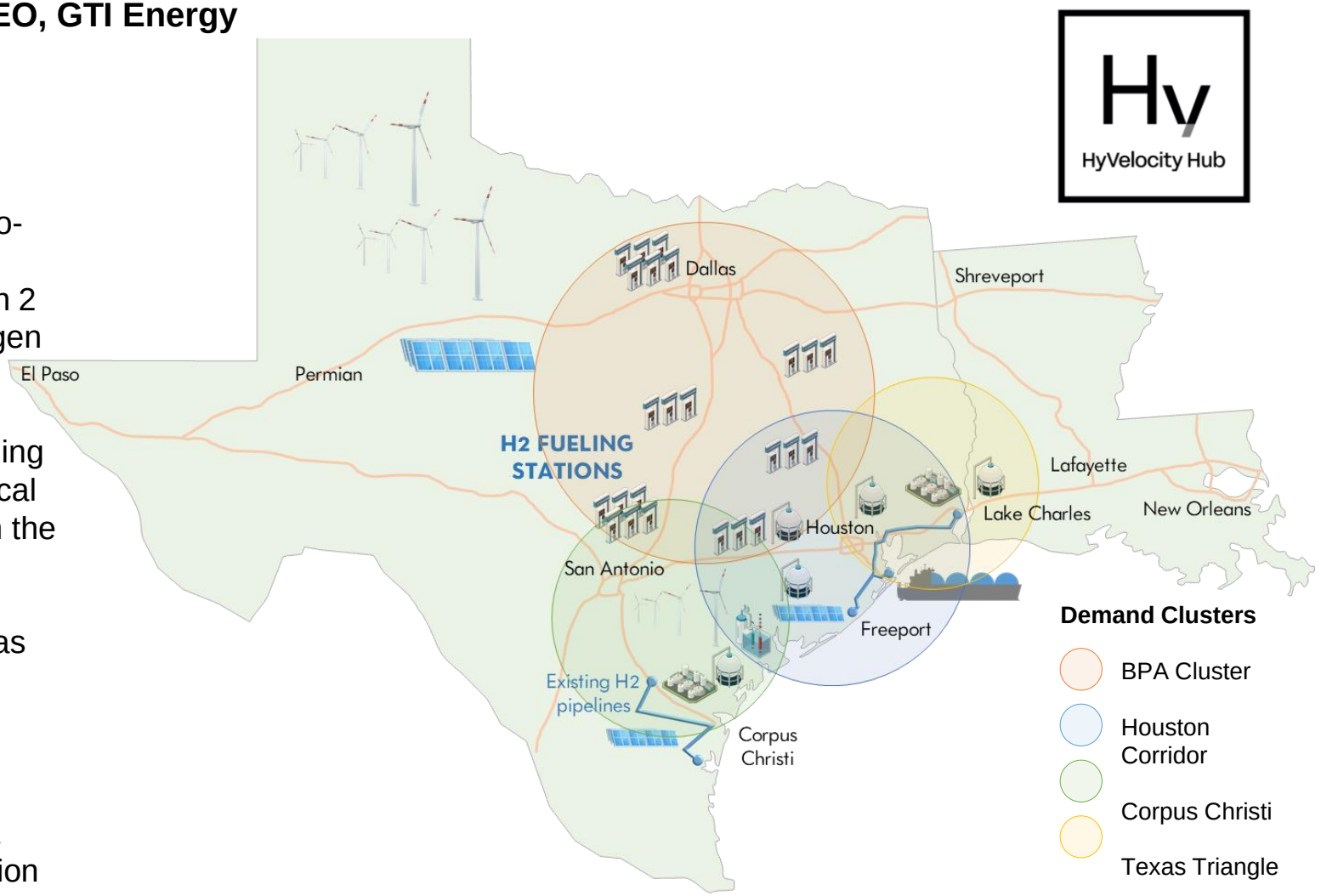
Project Stage:
- Aspiration announced
- Feasibility being reviewed
- Operations planning reviewed
- Operational

1. Focus on TX and LA states. For TX: 19 projects and ~1.5-4.5MTPA capacity announced

HyVelocity Hub Vision

"The name 'HyVelocity' conveys the idea that we have a tremendous opportunity to accelerate the creation of a clean hydrogen market at the pace needed to meet aggressive decarbonization goals for communities in our nation and around the globe," said **Paula A. Gant, PhD, President and CEO, GTI Energy**

- **Vision:** To create the nation's largest clean hydrogen hub along the Gulf Coast
- **Core principles:**
  - Rapidly scale clean hydrogen supply and demand that leads to a market-based, end-to-end innovation ecosystem
  - Decrease carbon emissions to not more than 2 kilograms of carbon per 1 kilogram of hydrogen produced: Reduce cost of clean hydrogen by 80% to $1 per 1 kilogram in 1 decade
  - Serve disadvantaged communities by providing jobs and higher labor standards, reducing local pollution, and supporting and complying with the Justice40 initiative
- **Participants:**
  - Organizers: CHF, GTI Energy, Univ. of Texas
  - Project Sponsors: Air Liquide, Chevron, Energy Transfer, Exxon, Orstead, Sempra, Shell and others
  - Supporters: Over 60 organizations
- **H2 Produced and Consumed:** Over 3 MTPA (9,055 mtpd); Likely the largest DOE submission



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Role of Insurance in Clean Hydrogen Projects