



# A Vision for a Houston's Low Carbon Energy Future

September 2021

# About the Center for Houston's Future

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



# Vision for the Houston Energy Transition Initiative

Leverage Houston's energy leadership to accelerate global solutions for a low-carbon future.

## Tenets of the Vision:

### **Drive sustainable and equitable economic growth in the Greater Houston region**

through a portfolio of technology, policy, and market initiatives that embrace and create value from the world's transition to low-carbon energy systems.

Delivering on this vision requires us to **build upon our history of leadership in the energy and chemical industries, provide new opportunities to our people, and leverage our assets and existing expertise, while creating conditions to attract new and innovative talent and capital.**

A successful effort would result in **economic growth and positive impact on the environment, thereby placing Houston as the leading hub of energy and clean tech innovation.**






# Houston Has Many Distinctive Assets To Capture The Opportunity

Benchmarking Houston  
with other cities identified  
5 core strengths:

- ⊕ Large **engineering workforce** and vast energy experience
- ⊕ Existing large scale **energy and industrial infrastructure**
- ⊕ Significant **renewable generation capacity**
- ⊕ Business friendly ecosystem that provides the **right environment for startups to scale**
- ⊕ Largest US **port with global shipping connections**



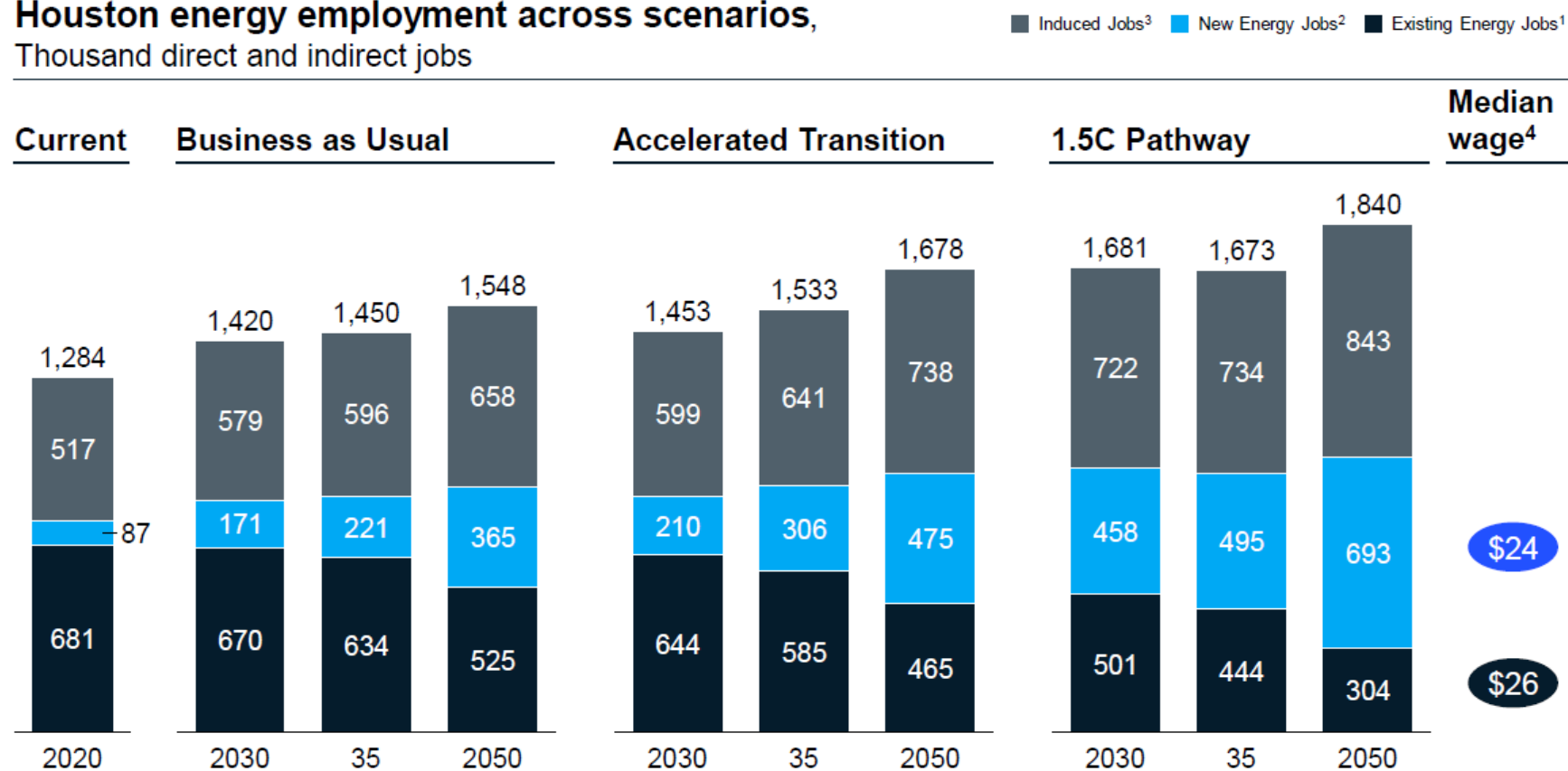
# Action Is Planned Across Value Chains In Three Domains

1.	Jumpstart emerging sectors where Houston has a distinct advantage		CCUS Hydrogen Circular economy – plastics Battery manufacturing and energy storage solutions								
2.	Attract and support companies in established “new energy” industries		Renewables (Solar and Wind) Renewable natural gas Low-carbon LNG Biofuels								
3.	Deploy cross-cutting initiatives to attract and grow companies in <i>all</i> Energy value-chains		<table><tr><td>Energy efficiency</td><td>Electric &amp; fuel cell vehicles</td></tr><tr><td>Natural Gas and Oil</td><td>Nature-based solutions</td></tr><tr><td>Petrochemicals</td><td>Advanced materials</td></tr><tr><td>Carbon trading</td><td>Geothermal, and others</td></tr></table>	Energy efficiency	Electric & fuel cell vehicles	Natural Gas and Oil	Nature-based solutions	Petrochemicals	Advanced materials	Carbon trading	Geothermal, and others
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Natural Gas and Oil	Nature-based solutions										
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Carbon trading	Geothermal, and others										



# With decisive action to lead in the energy transition, Houston could gain 600k additional jobs

**Houston energy employment across scenarios,**  
Thousand direct and indirect jobs



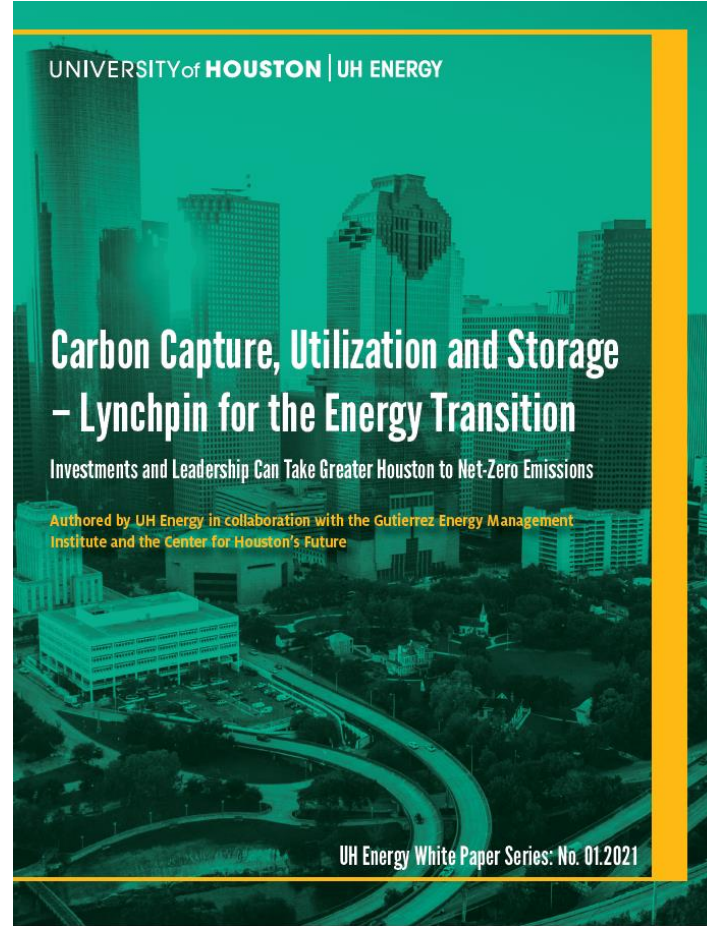
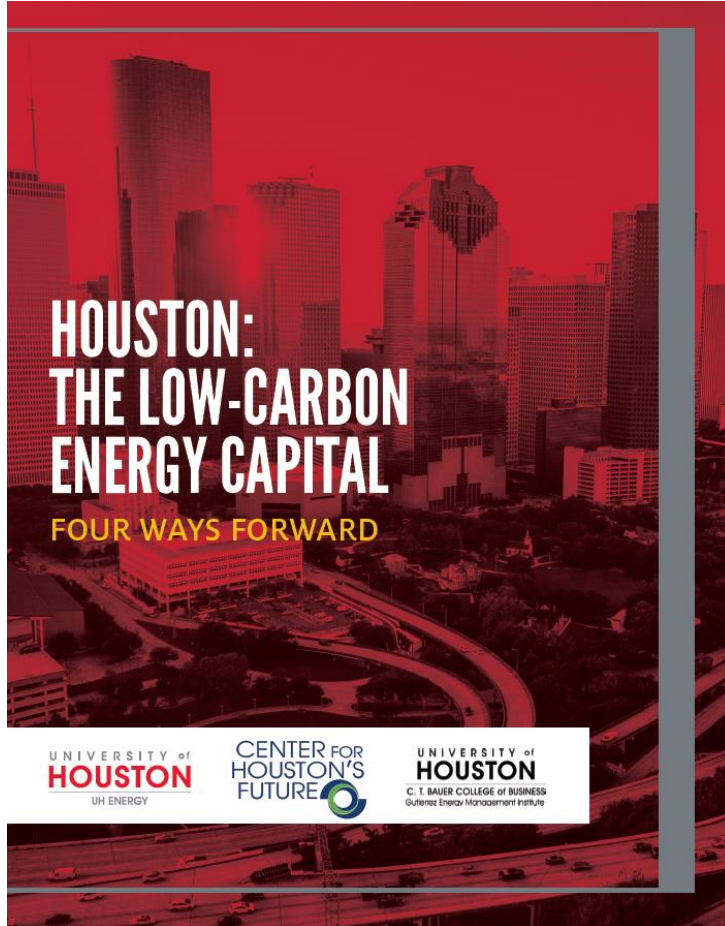
Total **GDP gains** could amount to **\$70 – 160Bn** by 2050<sup>5</sup> with a concerted effort to attract high-paying new energy jobs with wages that are, on average, **28% higher than Texas median wage**

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 Solar, Wind, Hydrogen, CCUS, Biofuels, Energy Efficiency, Energy Storage and Electric vehicles sectors
3. Includes direct and indirect jobs in Solar, Wind, Hydrogen, CCUS, Biofuels, Energy Efficiency, Energy Storage and Electric vehicles
4. 2019 median wage, USD/hr
5. 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 new energy jobs





# CHF Low Carbon Energy White Papers



## CENTER FOR HOUSTON'S FUTURE

### Houston Region: Becoming a Global Hydrogen Hub

#### Hydrogen industry growth can drive diversification needed to sustain Houston's economic advantage.

In 2019, the Center for Houston's Future (CHF) released an economic viability study that assessed Houston's long-term economic outlook given the close ties between the oil and gas (O&G) sector and the region's economic success.

The study found that Houston had outperformed economically versus peer cities, and that this growth was driven primarily by the O&G sector. Looking at the impact of the 2014 oil price crash, the study found that 80,000 O&G related jobs lost in the fallout of the 2014 oil price decline were:

- high-multiplier jobs, or jobs that spur additional economic activity in the region, resulting in higher economic impact than other jobs.
- not replaced with commensurate jobs once the region's job growth rebounded. (see Figures 1 and 2 below).

As a result, the study found that Houston's growth story had shifted: Houston's economy has since been growing slower than peer cities as new jobs added after the oil price rebound had lower multipliers, whereby resulting in slower GDP growth. . Examples included temporary roles and construction jobs driven by Hurricane Harvey recovery, and hotel, restaurant and retail industry expansion resulting from the earlier high economic-growth period. As shown in Figures 1 and 2, the jobs lost during this time period had a 2.9x multiplier (meaning that they created 2.9x additional jobs) and the jobs gained had only a 1.66x multiplier.



# Recent Media Coverage of CHF H2 Work



## OPINION

HOUSTON CHRONICLE • SUNDAY, APRIL 11, 2021 • PAGE A16 ★★

EDITORIAL

### Our future in five atoms

Hydrogen's potential for the region is to give new life to existing infrastructure.

★★ Houston Chronicle | HoustonChronicle.com | Sunday, September 19, 2021 | A19

## OUTLOOK

### Houston can lead 'Earthshot' to hydrogen

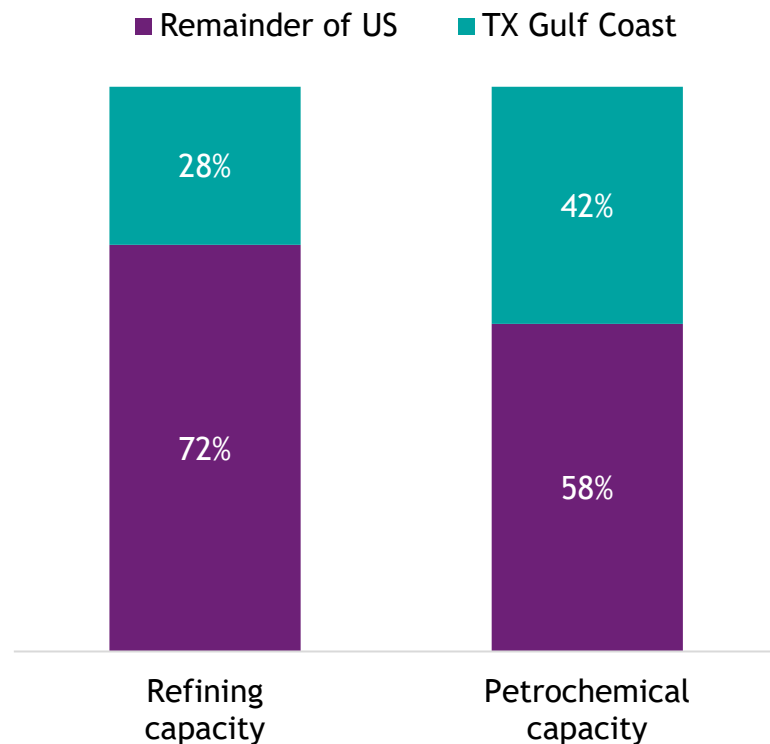
An "Earthshot" that will allow us to conquer climate change and lead the world in creating new markets can also allow us to claim a new title as the "Low-Carbon Energy Capital of the World."



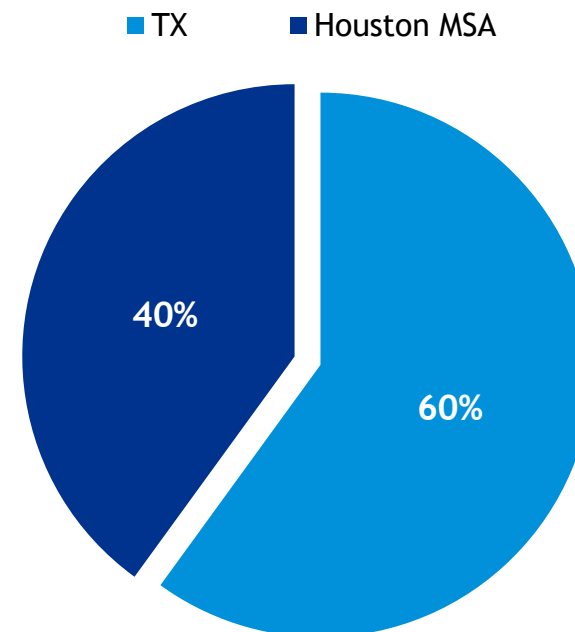


# Reducing GHG emissions resulting from Houston's vast industrial processes is a vast undertaking

TX Gulf Coast vs. US refining and petchem capacity<sup>1</sup>



Houston MSA vs. TX industrial emissions



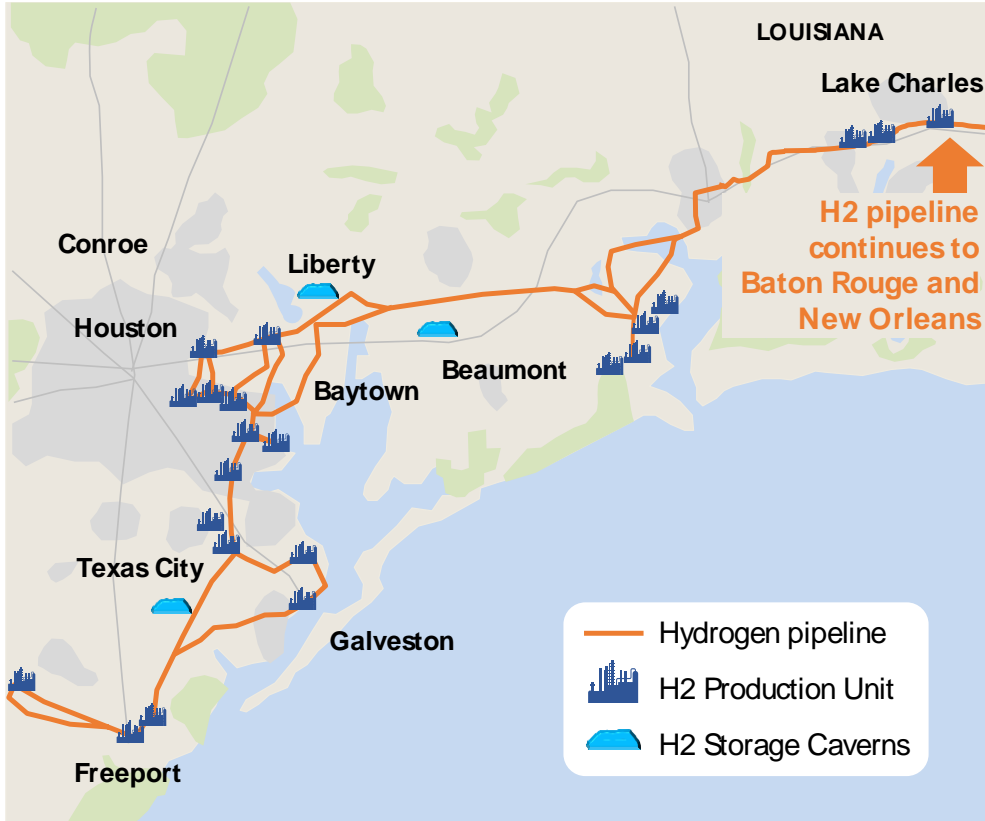
Notes: (1) Texas Gulf Coast refers to Houston area

Source: EIA, Barclays Research



# 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<sup>1,2,3</sup>



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

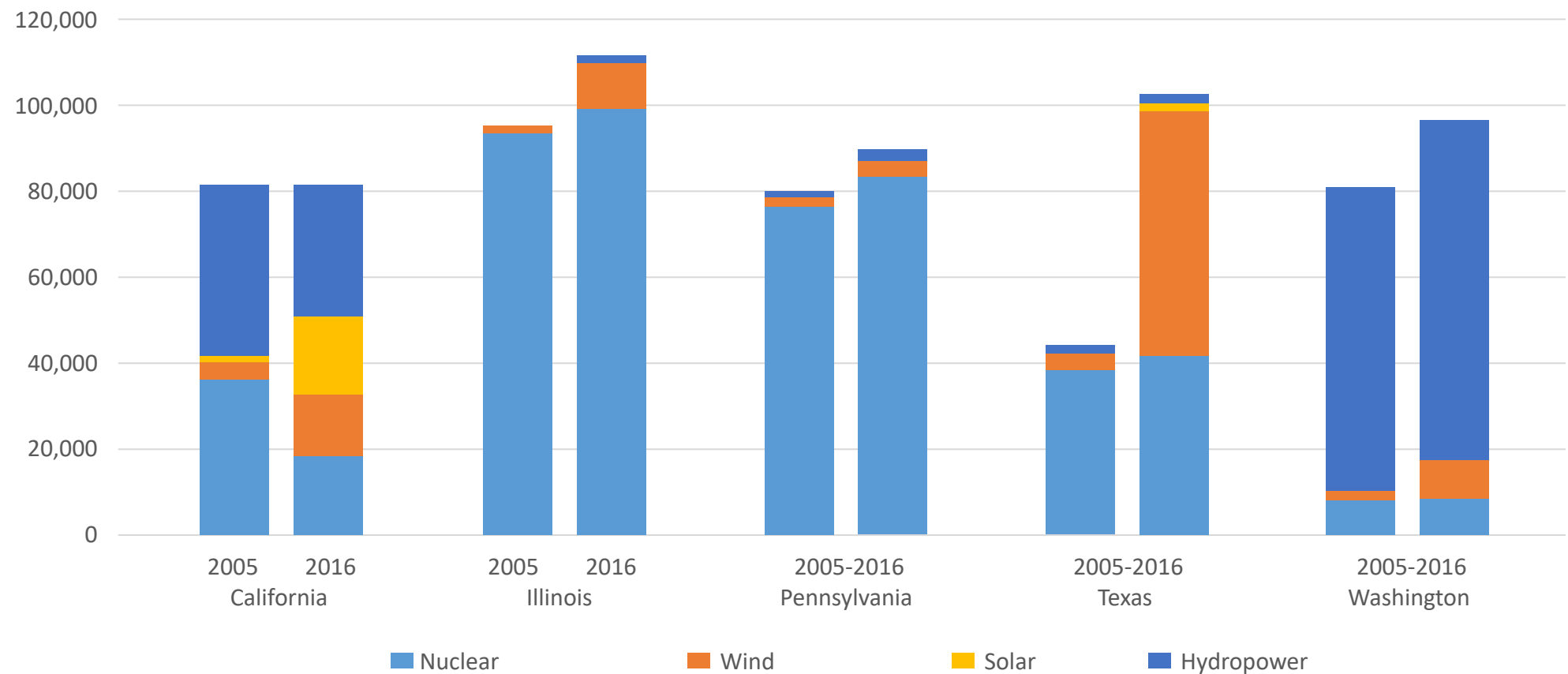
Notes: (1) Houston MSA defined Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery and Waller counties; (2) TX Gulf Coast includes a region from Corpus Christi, TX to Lake Charles, LA; (3) Number of global H2 plants estimated by dividing global H2 production by US avg. production 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



# ERCOT Leads in Non-Carbon Electricity Generation

Non-Carbon Electric Power Sector Generation  
Billion KWh

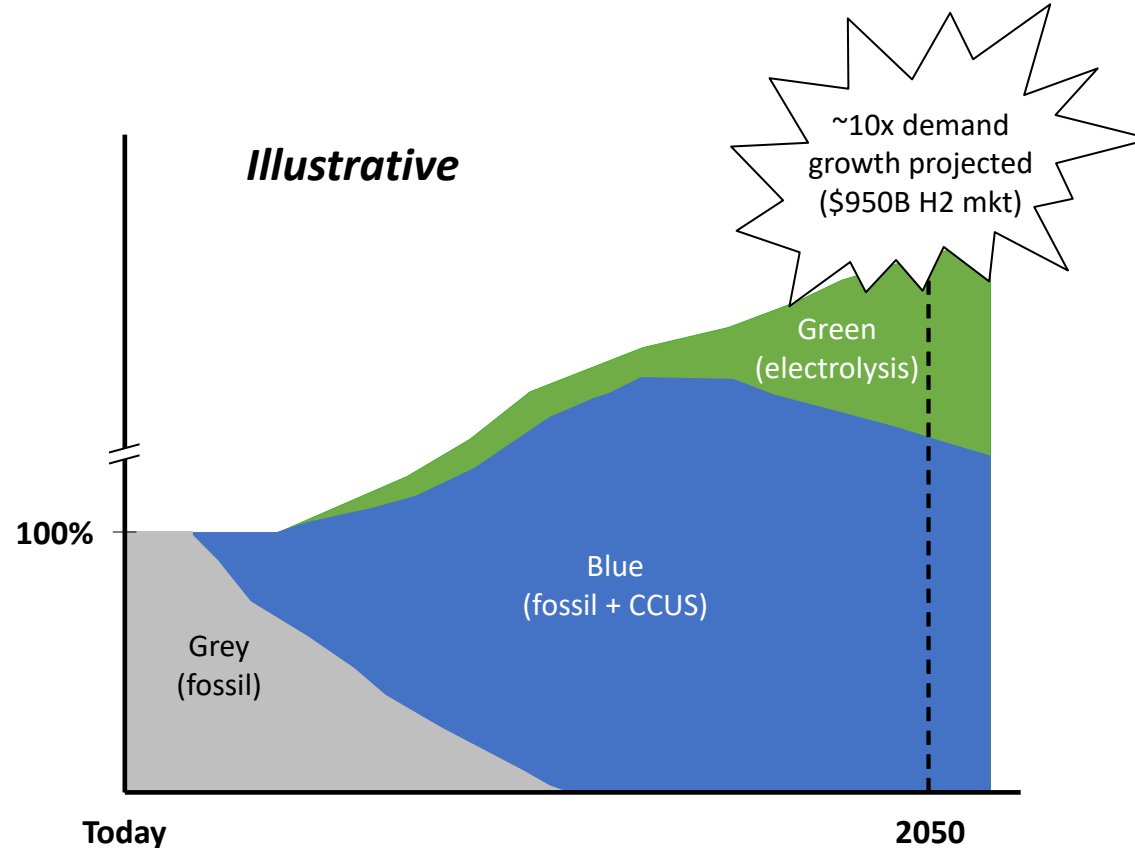


Source: EIA, State Energy Data Systems and EIA calculations made for this analysis



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

Hydrogen demand and mix over time



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

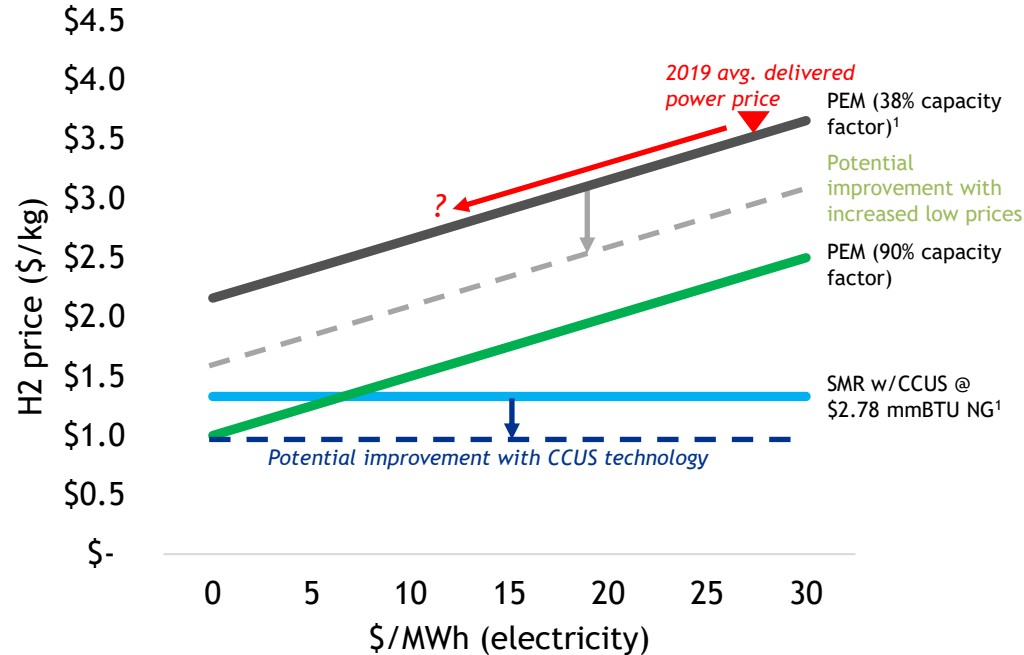
## Cross cutting Enablers

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



## B Cost and technology advances expected for blue and green, though greater gains required for green to be competitive

Current Houston blue and green H2 production costs



\*\*Costs exclude transportation, storage, and dispensing station

Notes: (1) Capacity factor of 38% represents extent of 2019 “low price” hours in Houston

Sources: S&P Platts

### Potential improvements for blue

- Continued improvements in CCUS cost and technology
- Policy instituted to support CCUS adoption
- Retaining low methane cost

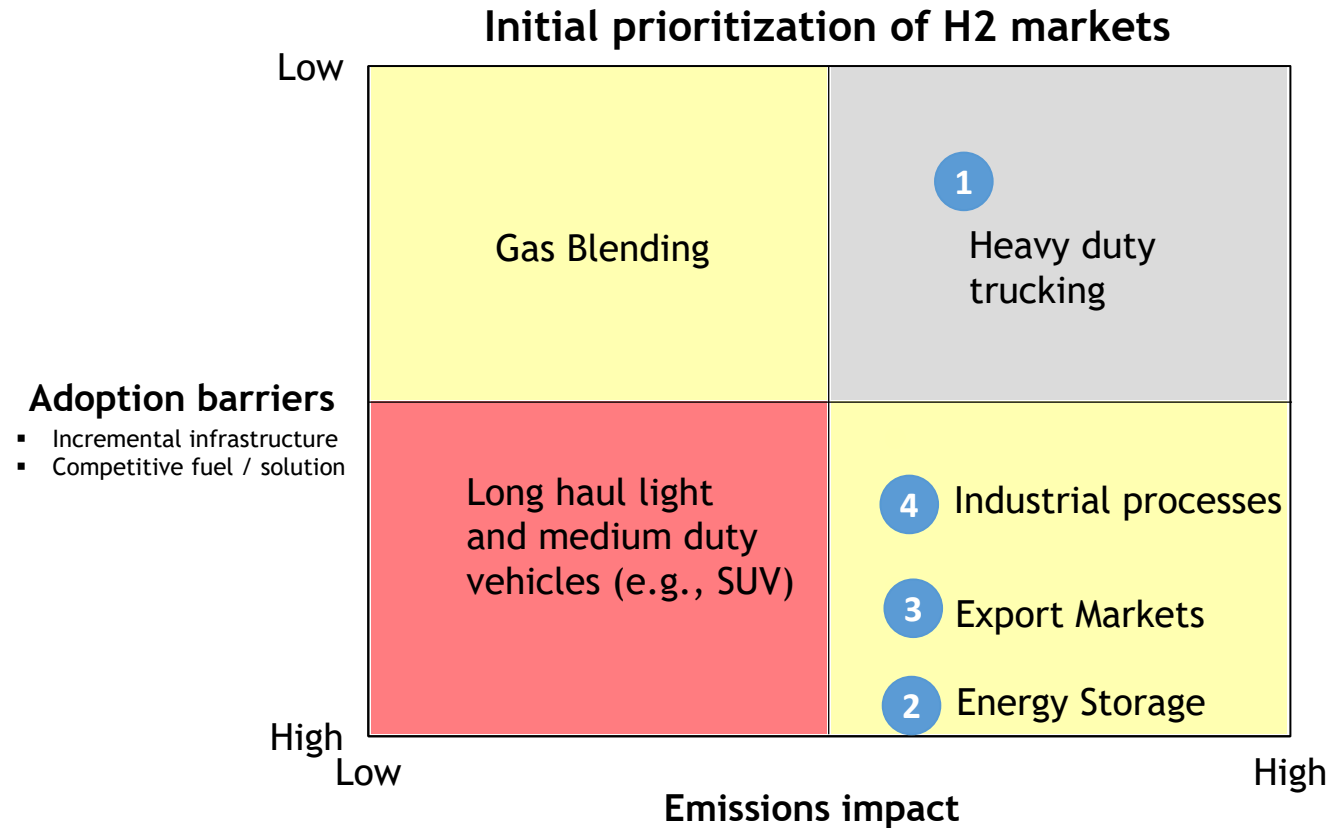
### Potential improvements for green

- Electrolyzer cost and technology materially improve
- Substantial renewables penetration drives ubiquitous low price power
- Policy and investor sentiment favor green H2





# New markets were prioritized based on relative adoption barriers (or advantages) and emissions impacts



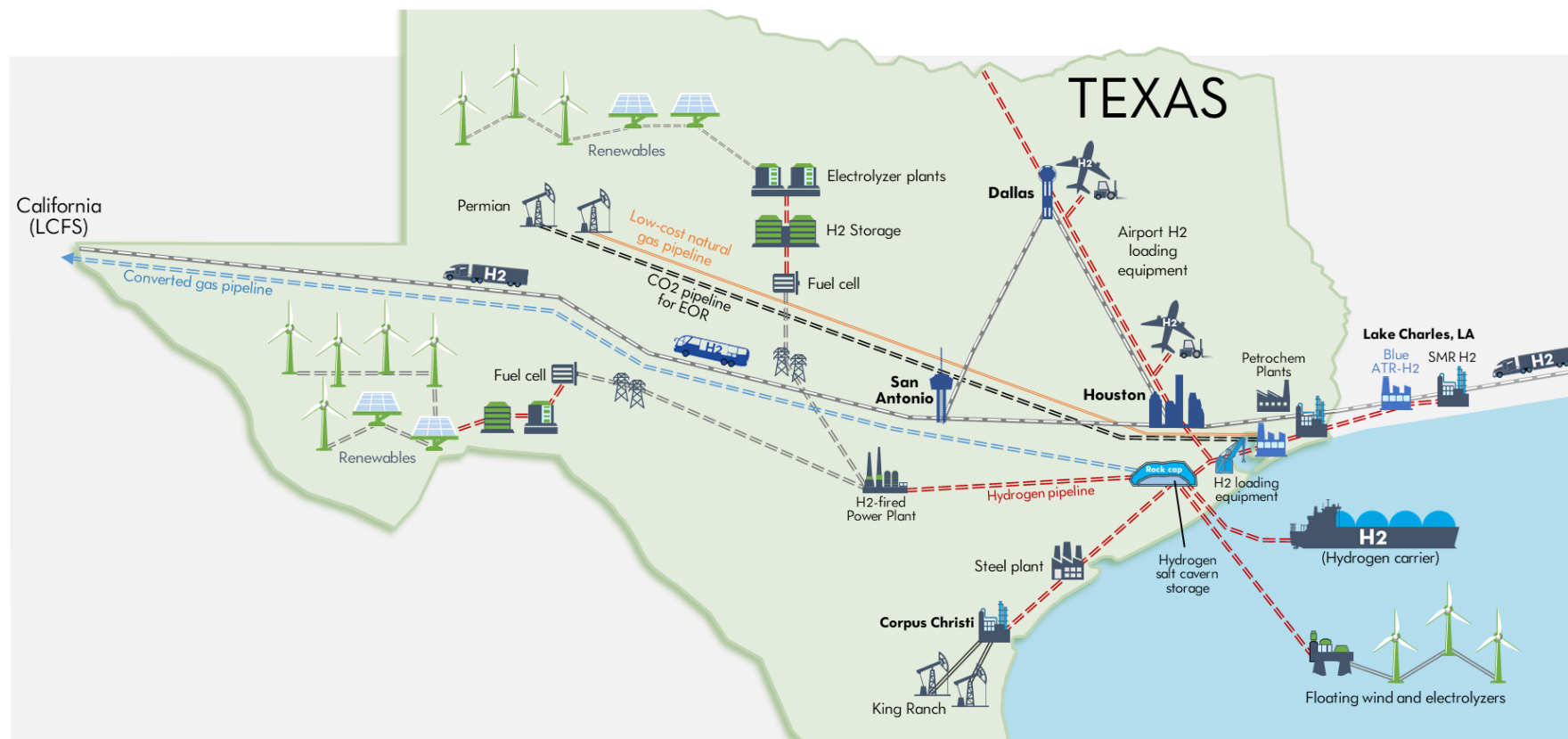
*"We see heavy hauling of freight as kind of like an anchor tenant in the hydrogen shopping mall."*

- Program Lead,  
Canadian Energy Systems Initiative

Notes: (1) Access to CA Transportation / LCFS via addressed in Expand phase; (2) Seasonal / long duration storage addressed as part of green H2 chain  
Sources: S&P Platts



# Introducing ... H2Houston Hub – A Global Hydrogen Hub



## Vision for a Global H2 Hub

- Anchor local and national heavy transportation markets
- Exporter, market maker
- Decarbonize industrial process heat and power
- Leverage captured CO2 for EOR

- Focuses carbon intensity for all sources of hydrogen
- Seeks to lower H2 production costs and build massive scale at an accelerated pace (2030 time frame)
- Creates opportunities for early deployment for low carbon hydrogen applications through pilot projects
- Integrates the innovation energy ecosystem to create new innovation opportunities and establishes a test bed for new applications
- Develops a new industry base that leverages Houston's existing assets and skills

