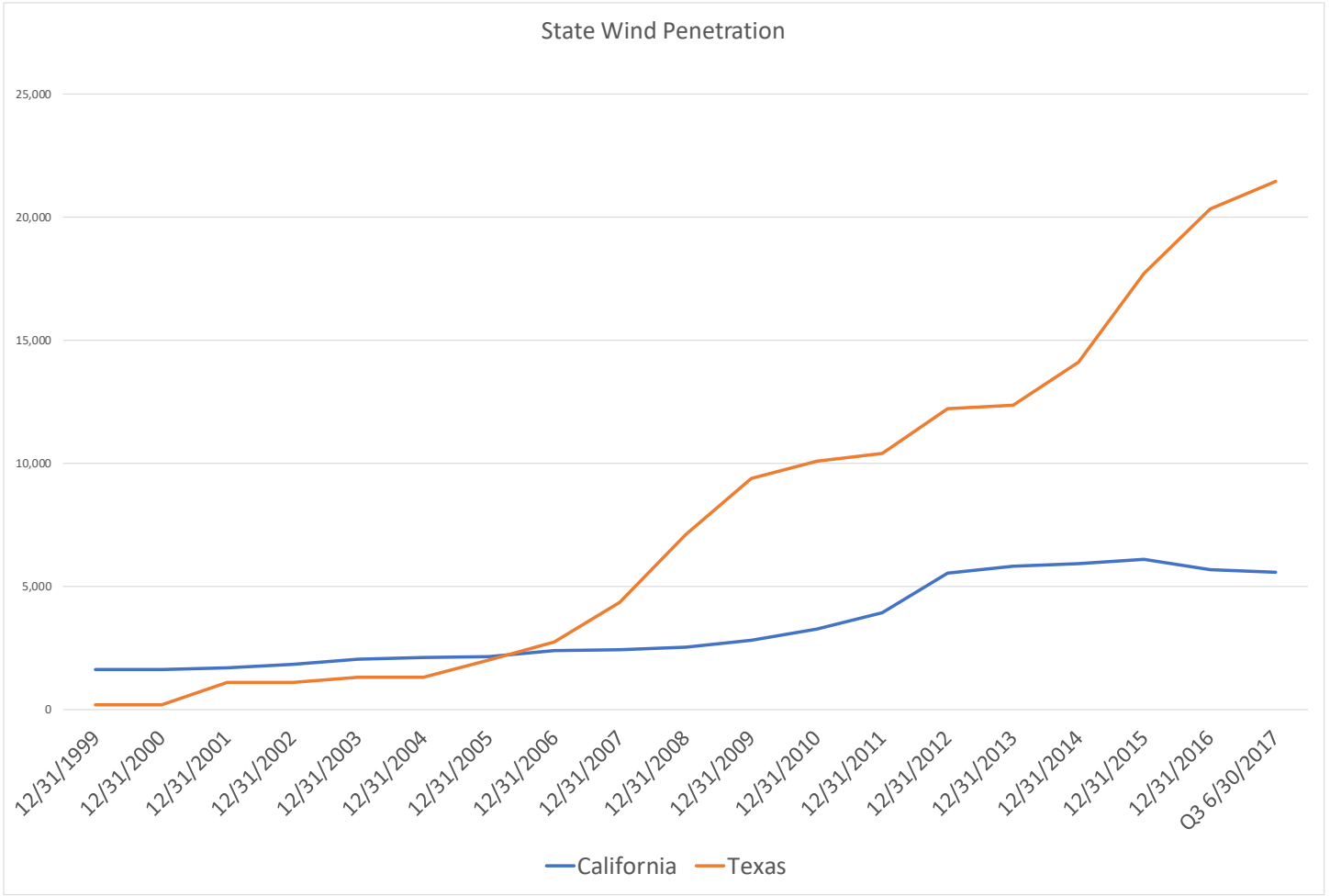
# Why Houston Will Be the Capital of a Low Carbon Energy World

UNIVERSITY of HOUSTON
UH ENERGY

UNIVERSITY of HOUSTON
C. T. BAUER COLLEGE of BUSINESS
Gutierrez Energy Management Institute

CENTER FOR HOUSTON'S FUTURE

# “Its Like Deja Vu All Over Again” –Yogi Berra



# Overview

- The University of Houston and the Center for Houston's Future are launching a project to create a vision for what Houston's Low Carbon Energy future might look like and what would be required to achieve it.
- We plan to examine four critical Low Carbon Energy technologies: Carbon Capture Utilization and Storage (CCUS), Hydrogen, Massive Electrification and the Circular Economy, since we believe that Texas, and the Houston region in particular, has unique strengths and capabilities in these areas.
- The study will look at the size of the potential opportunity, timing and the barriers that must be overcome to accomplish this goal.
- This presentation contains an overview of the Houston region's potential for CCUS and blue hydrogen.

# Two Areas for Catalyzing Houston's Role in a Low Carbon Energy Future

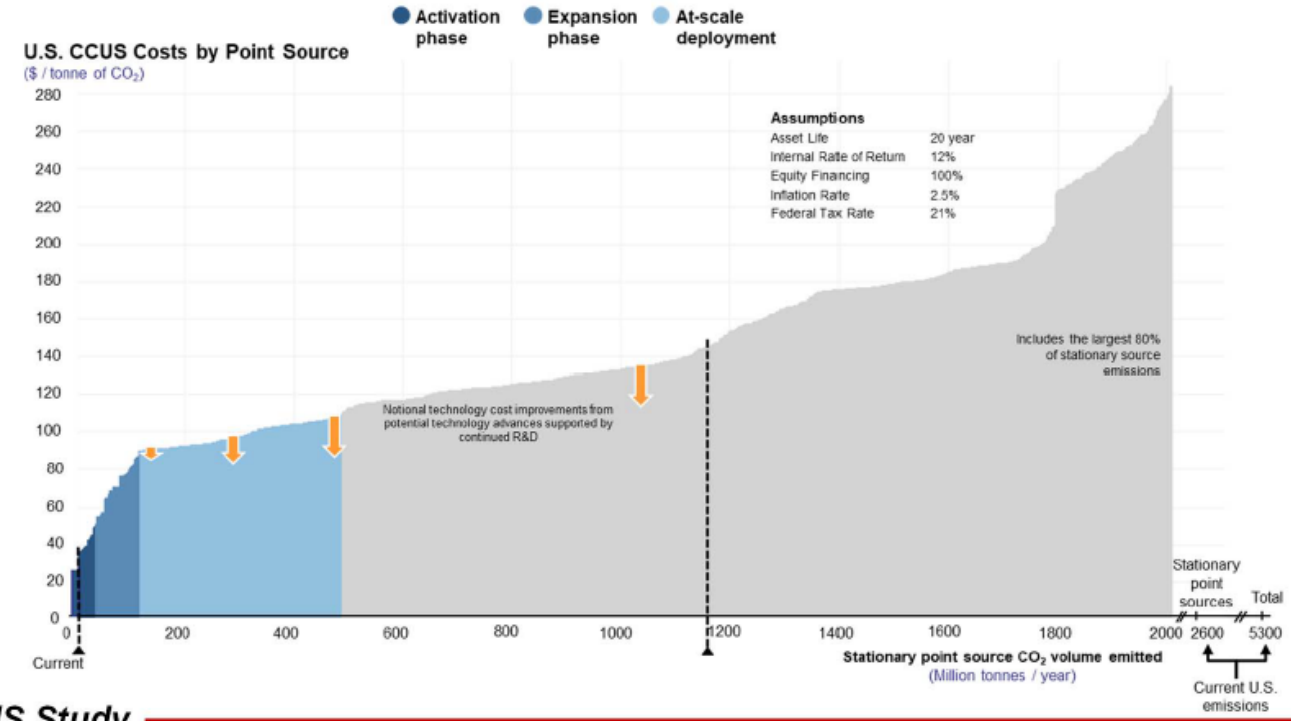
1. CCUS: Houston can become an "early adopter" for deploying CCUS technologies.
   - The Houston Ship Channel has significant of large, centralized and concentrated sources of CO2 from power and plants and industrial facilities
   - The Gulf Coast region has many large locations (deleted hydrocarbon reservoirs, salt domes) for CO2 sequestration and/or storage
   - Opportunities exist to manufacture new products from captured CO2 (including some currently derived from hydrocarbons) which can be integrated into existing chemical industry infrastructure

2. Hydrogen: Houston has most aspects of the supply chain required to produce both significant amounts of blue and green hydrogen.
   - "Blue Hydrogen" production will be driven by the large base of existing steam reforming plants with carbon capture added
   - "Green Hydrogen" production can be created from new electrolysis plants fueled by low cost renewable energy
   - Houston already has a hydrogen pipeline network that can provide hydrogen for high temperature process heat in refining, petrochemicals, ammonia, steel and cement plants
   - Export facilities for ammonia, methanol and liquid organic hydrogen carriers can be developed at the Port

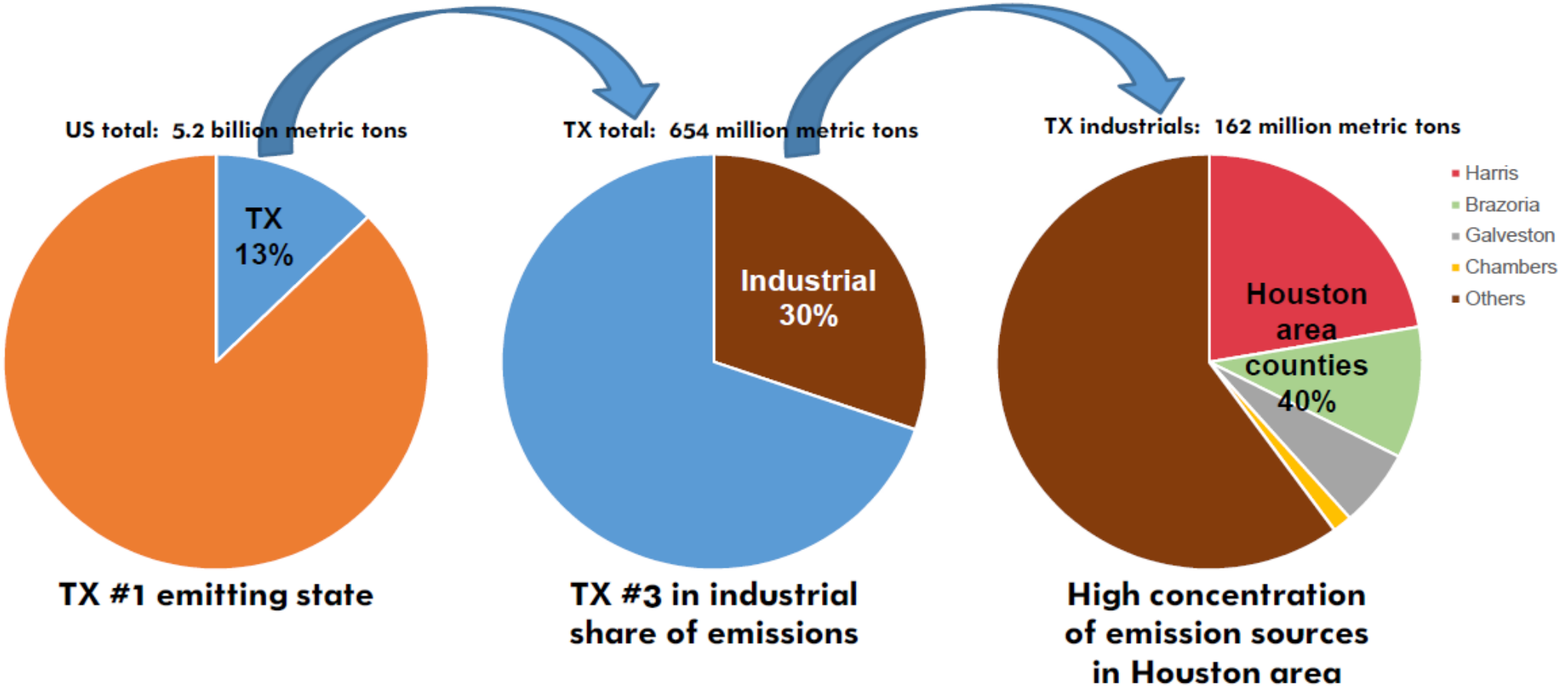
# NPC Study -- Phases of Implementation

Study lays out a three phases – Activation, Expansion and At-Scale:

- Prioritized based on economics and ease of implementation
- Specific recommendations
- Economic benefits – GDP and jobs

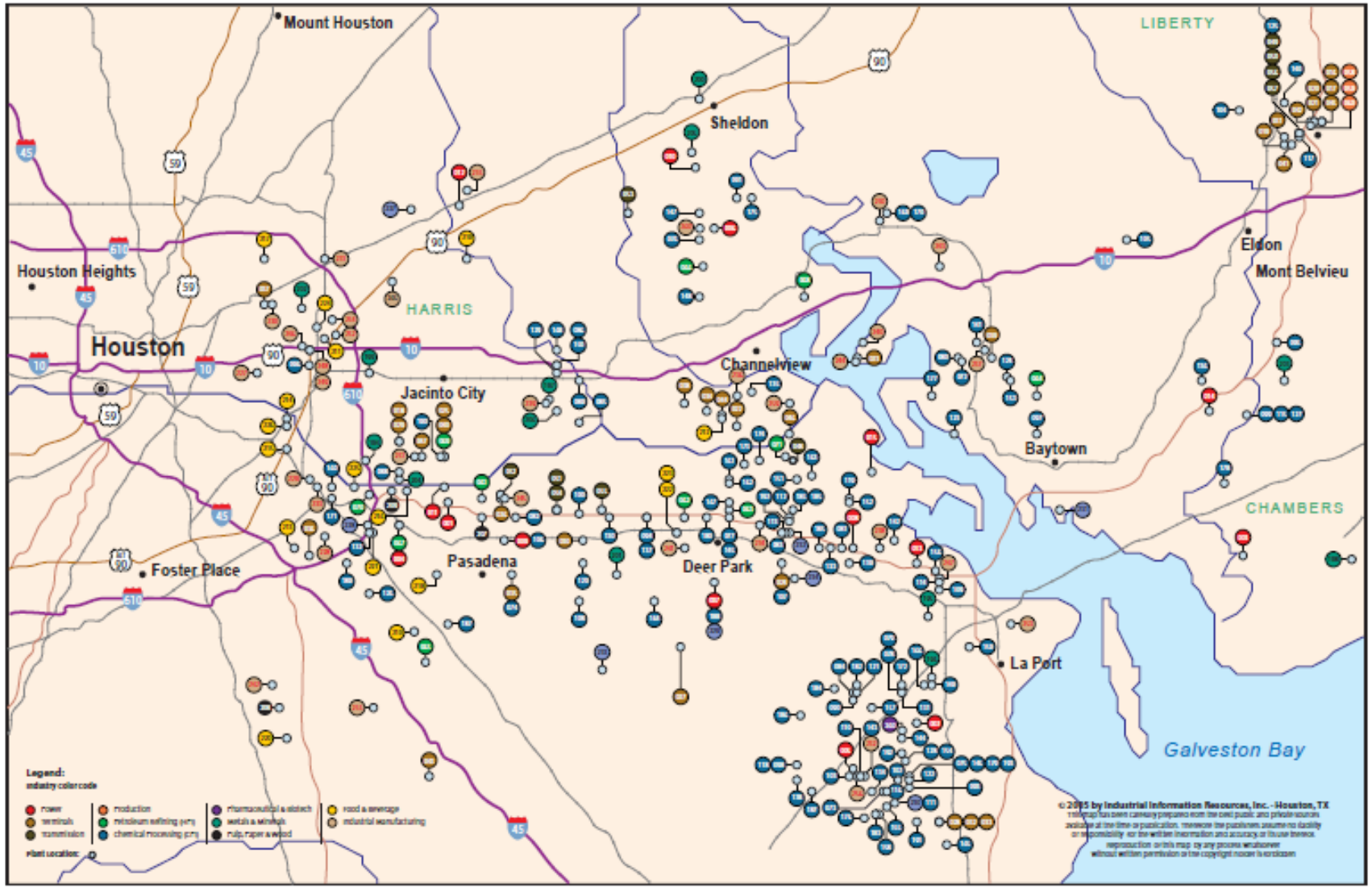


# Houston Industrial Sector



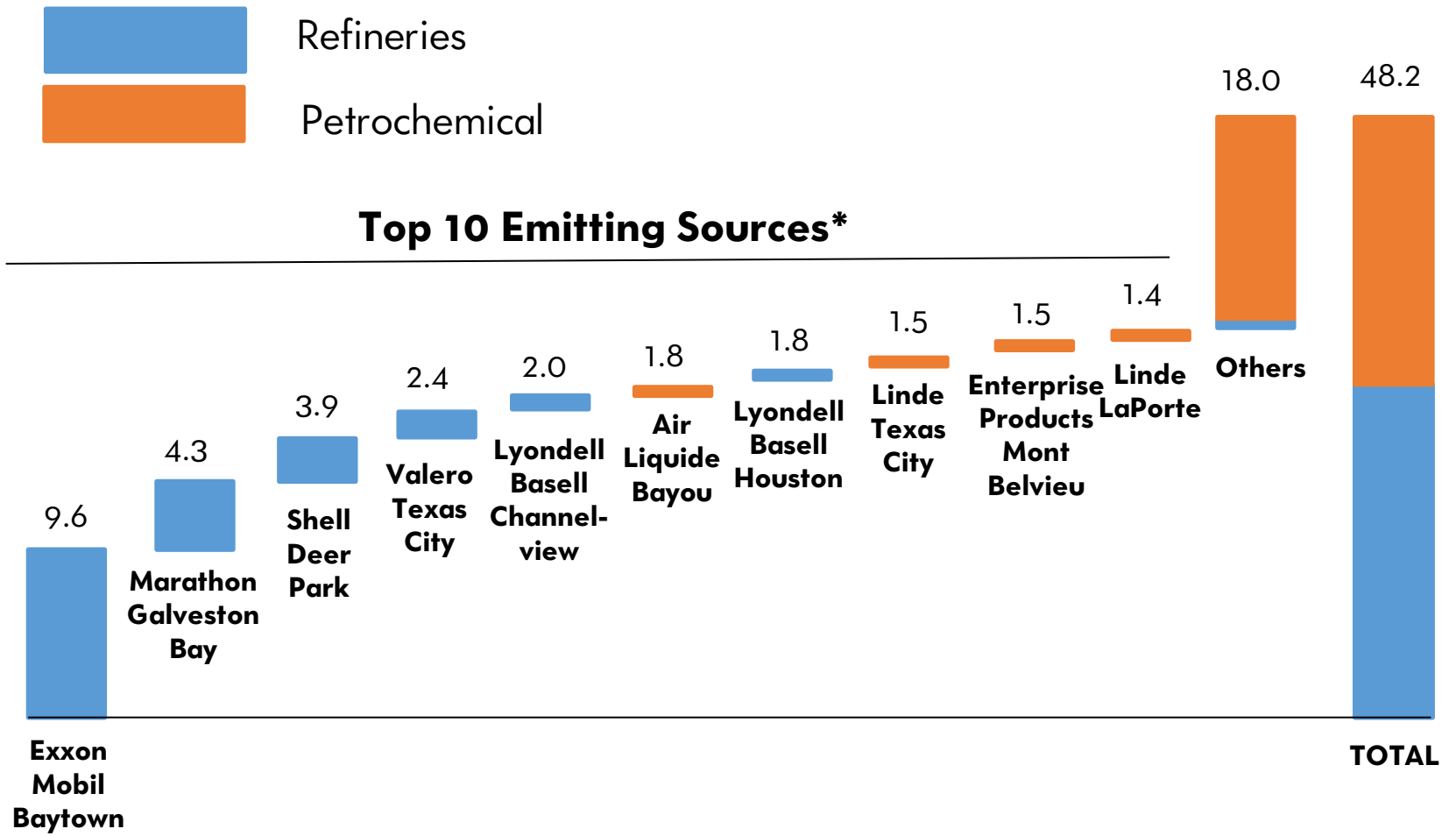

Note: discrepancies in estimated emissions due to different data sources used

# Industrial Facilities on Houston Ship Channel



# 2017 Houston Industrial $CO_2$ Emissions Footprint*

Million metric tons $CO_2$ equivalent




~100 major facilities: 48.2 million tons $CO_2$/year (~1% of US total emissions)

#1 emitter: ExxonMobil Baytown (9.6 million tons/year)

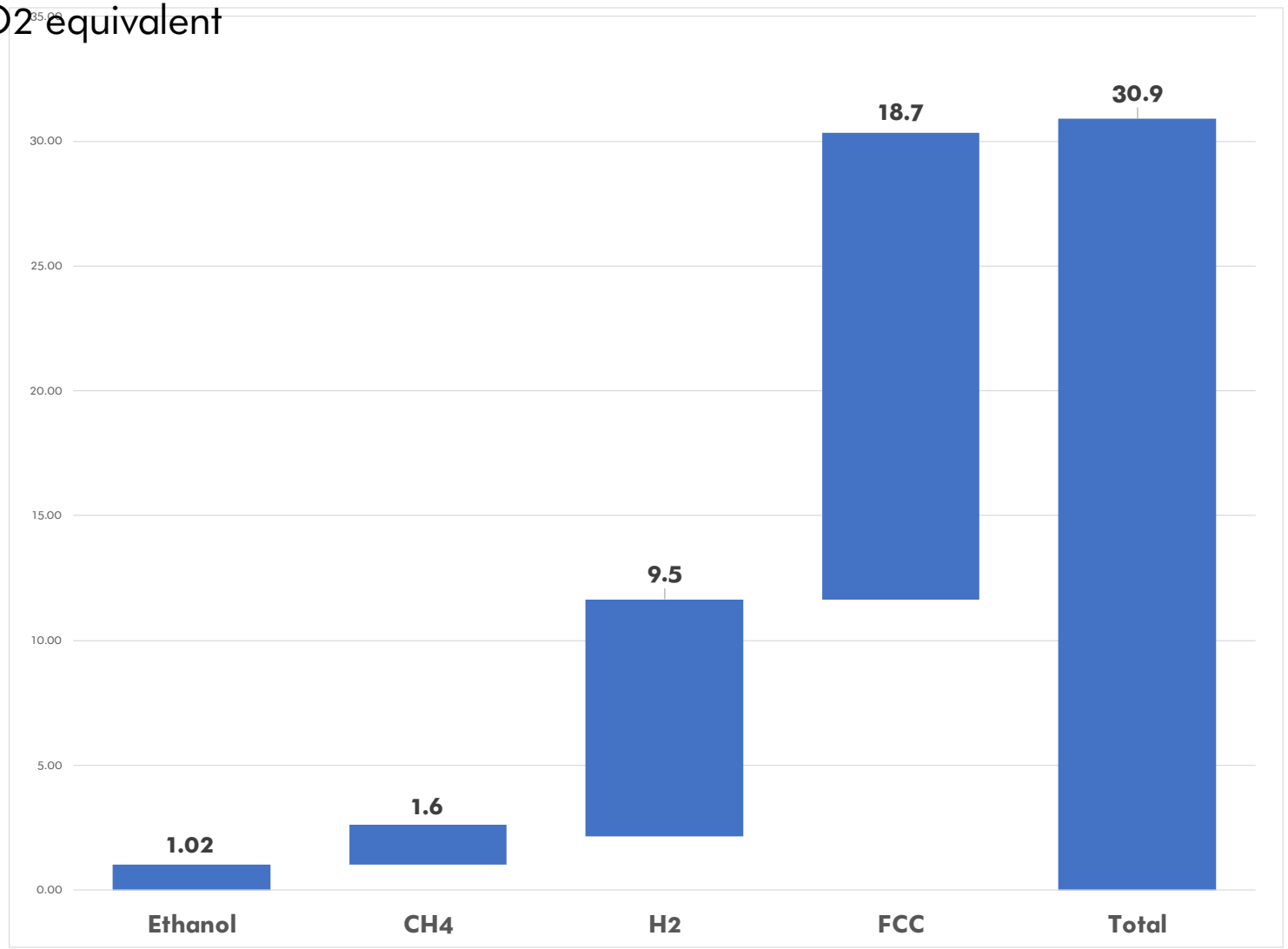
Top 10 sources: 63% of emissions

Refining: 53% of emissions (79% of Top 10)

* Sources in Harris, Chambers and Galveston Counties (excluding power generation), US EPA Greenhouse Gas Reporting Program (GHGRP)

# Gulf Coast CCUS Potential

Million metric tons $CO_2$ equivalent




Source: Great Plains Institute

# Key Interview Findings

- The basis for the deep decarbonization discussion amongst Houston's industrial community is improving, as more parties begin to recognize the value at stake
  - Most uptake amongst global supermajors domiciled in Europe, where social license to operate is more pressing
  - However, still lots of skepticism, passivity and non-collaboration among certain players (especially those that are US-focused and play only a narrow role in the value chain, like pure independent E&Ps and refiners)
- No way for Houston's industrial sector to deeply decarbonize without CCUS (and a CO2 network) – and Houston is well-suited for CCUS
  - Good local geologic conditions for storage (offshore GOM)
  - Proximity to Permian (for EOR)
  - Low gathering costs due to number/size/intensity of sources within small geographic area
- As technology improves and costs fall, increasing activity to analyze and potentially pursue CCUS in Houston
  - 45Q is making some marginal projects viable (Carbon Capture Coalition continuing to advocate policy)
  - OGCI is making Gulf of Mexico its primary US focus, facilitating collaboration among emitters to pursue joint solutions with better economics

# What's Changed as a Result of the Oil Price Shock…

- Major energy companies and investors have re-affirmed their commitment to moving forward with not only Scope 1 and Scope 2 but also Scope 3 emissions
- Re-starting the economy may provide opportunities to jumpstart clean energy and low carbon energy projects
- Economics of projects are likely to become more challenging. Low oil prices could prompt some interest in EOR to wane and make pure geological storage of carbon dioxide a more attractive option

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# Houston has unique assets and capabilities, which position Houston as a potential leader in advancing the hydrogen economy

**Hydrogen value chain**

**Areas in which Houston has competitive advantages**

| Production | Storage | Transport | Customers |
|---|---|---|---|
| ▪ Among the world's largest source of hydrogen production (eg, refining and chemical production)<br>▪ Access to methane production and depleted reservoirs / CCUS sites<br>▪ 2nd largest state producer of renewable energy today (potential source via electrolysis of water) | ▪ Established network of hydrogen pipelines to service US Gulf Coast refining and related industrial area<br>▪ Storage that may be currently available or readily converted to hydrogen storage<br>▪ Largest foreign trade port and second largest tonnage port in US | | ▪ 2nd largest US manufacturing area<br>– Established base of hydrogen feedstock customers<br>– Multiple potential industrial users of hydrogen based heat<br>▪ Mature gas grid with numerous residential & business customers |

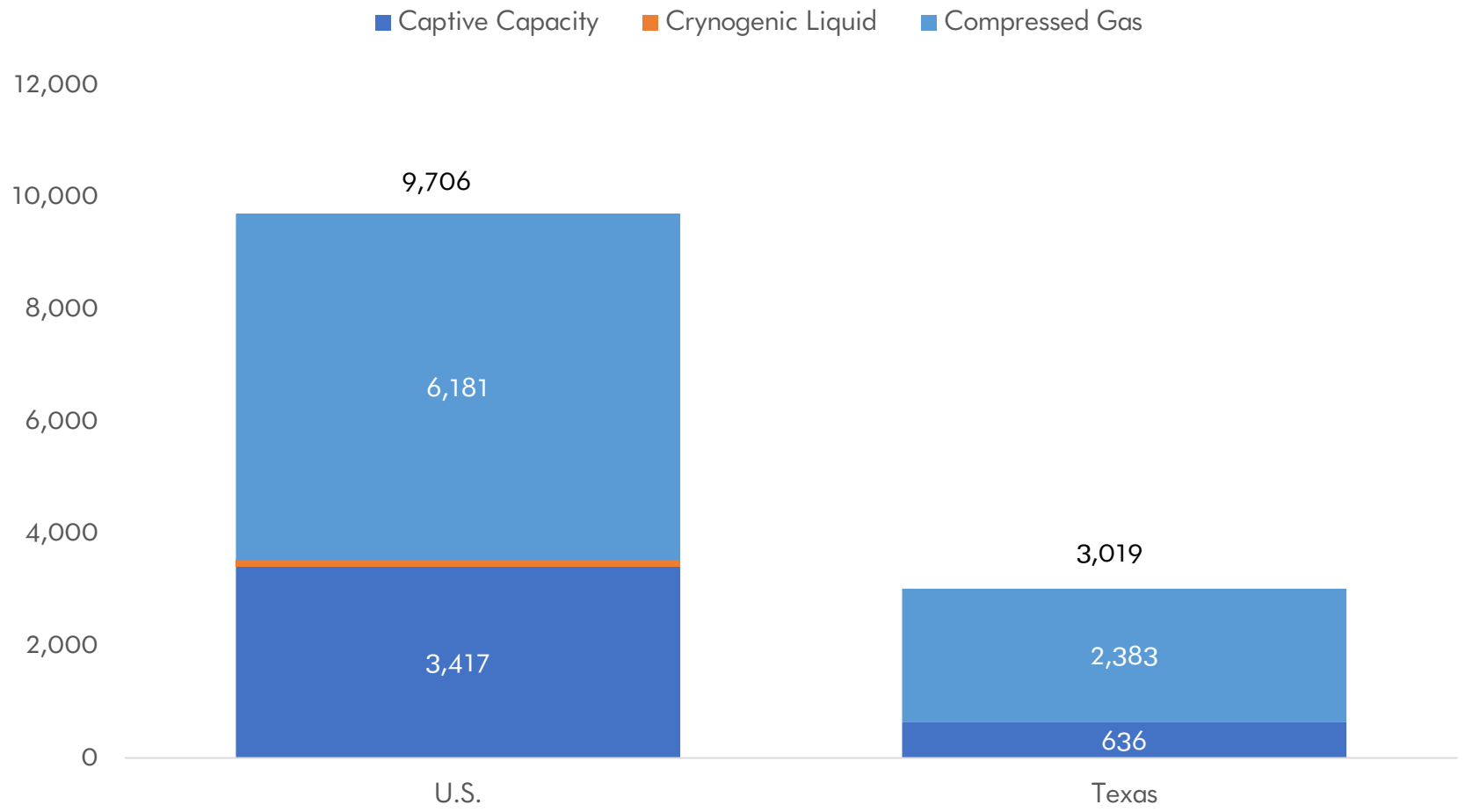
**Development support**

- Deep experience with steam methane reformation hydrogen production technology
- Multiple global energy leaders with CCUS and hydrogen technical capabilities, including global hydrogen leader (Air Liquide) with Houston presence
- Civic leadership, commitment to clean transportation

Source: KPMG

# U.S. and Gulf Coast Hydrogen Production

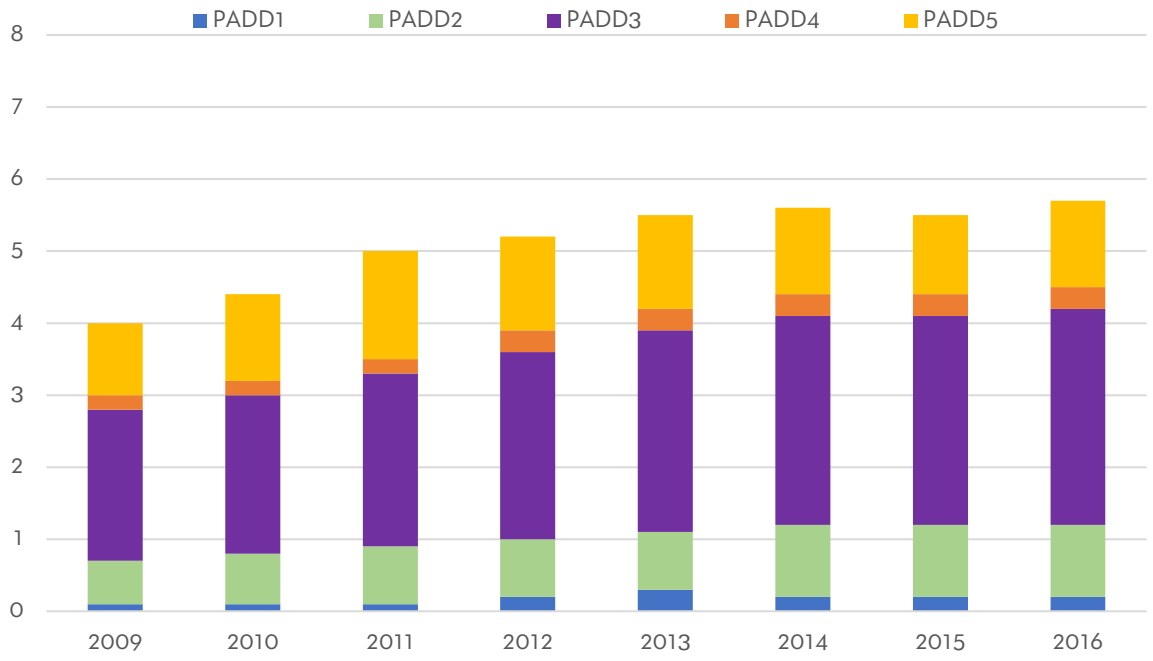
**Production capacity** (MMSCFD or million standard cubic feet per day)




https://h2tools.org/hyarc/hydrogen-delivery

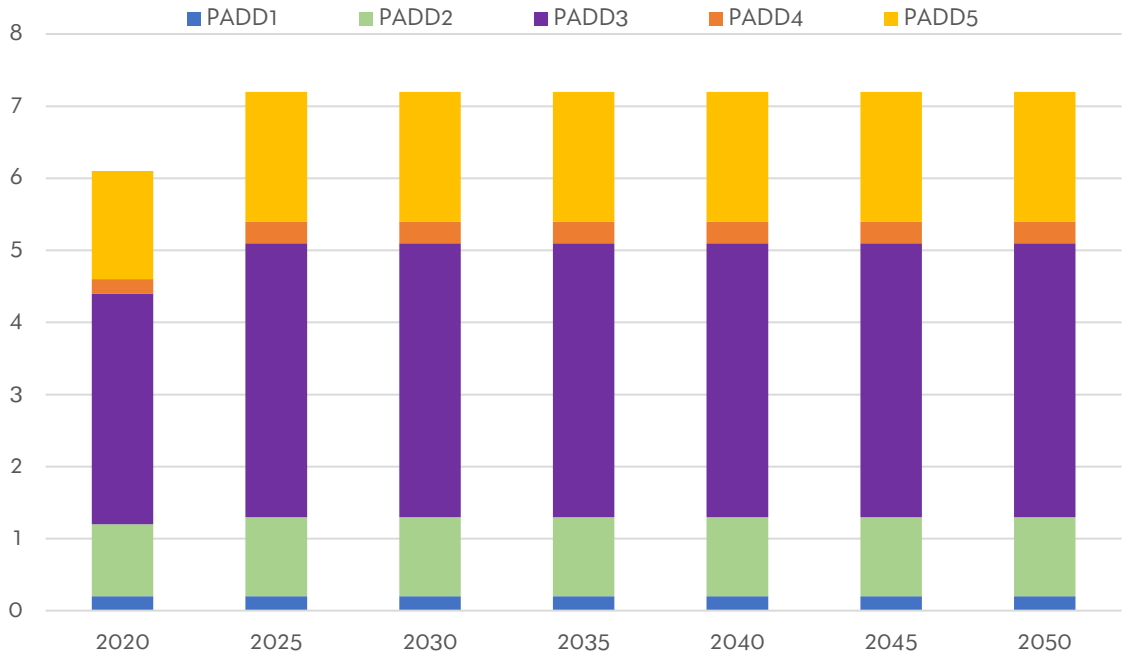
# Hydrogen Demand

**Hydrogen demand for U.S. refineries**
Million metric tons per year (2009-2016)




EIA

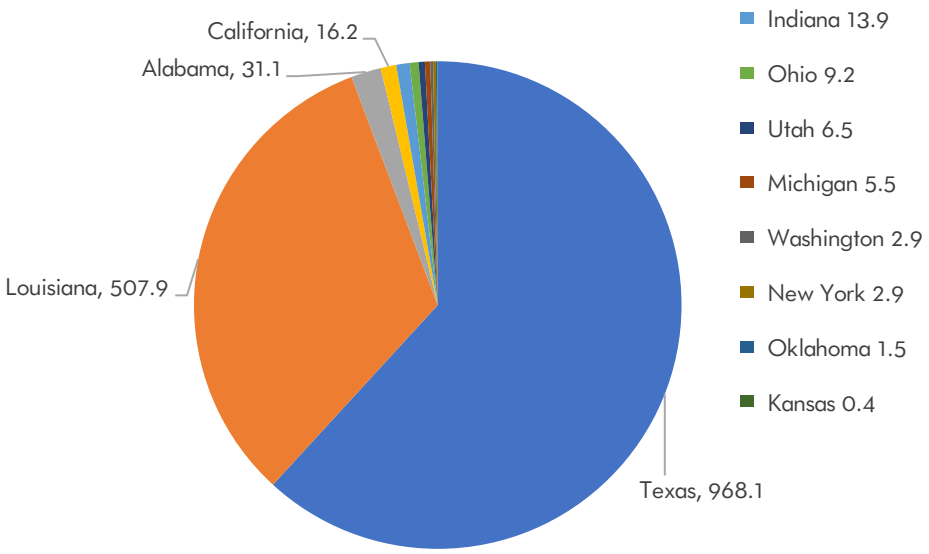
**Estimated Hydrogen demand for U.S. refineries**
Million metric tons per year (2020-2050)




Argonne National Lab

# U.S. Hydrogen Pipeline Network

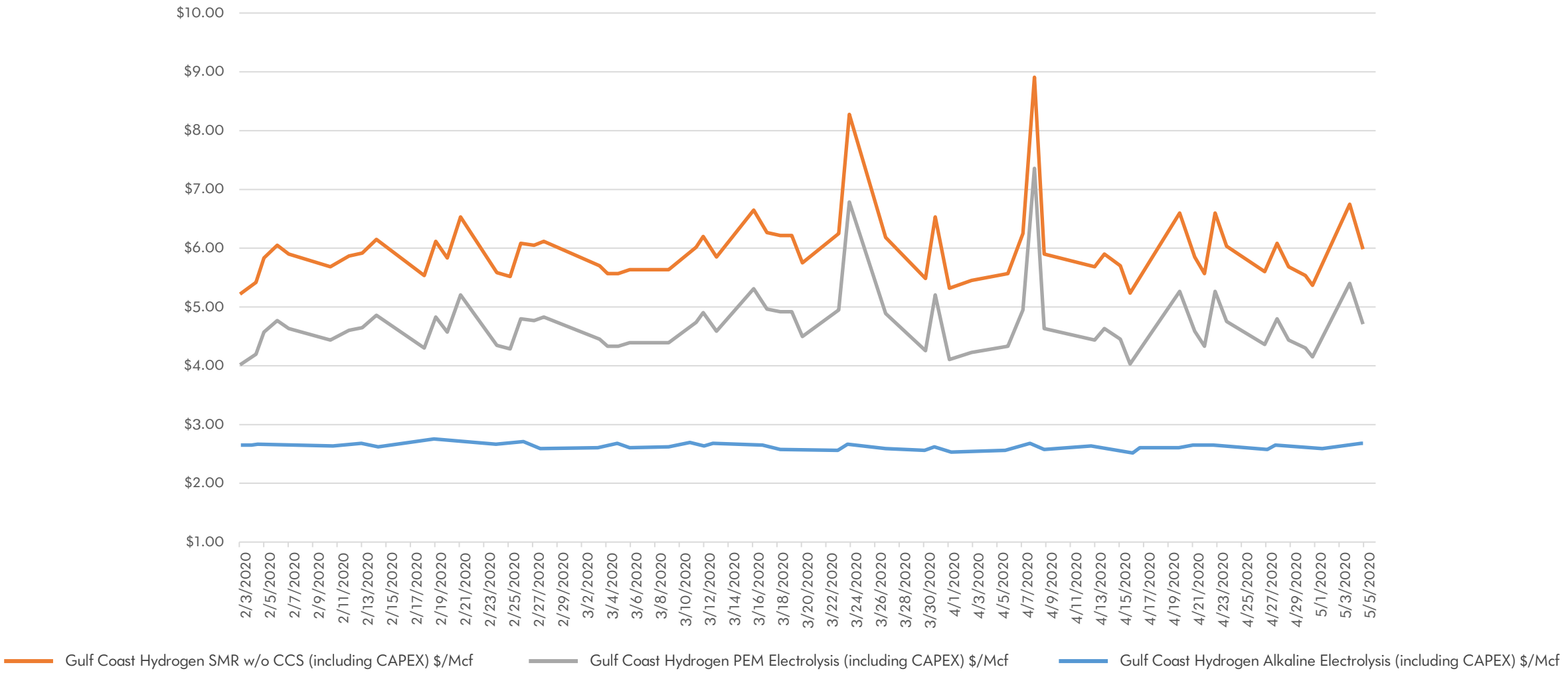
Pipeline Miles





Source: U.S. Pipeline and Hazardous Materials Safety Administration

# Hydrogen Prices




Platts

# Comparing Gulf Coast Hydrogen Prices with NA Prices

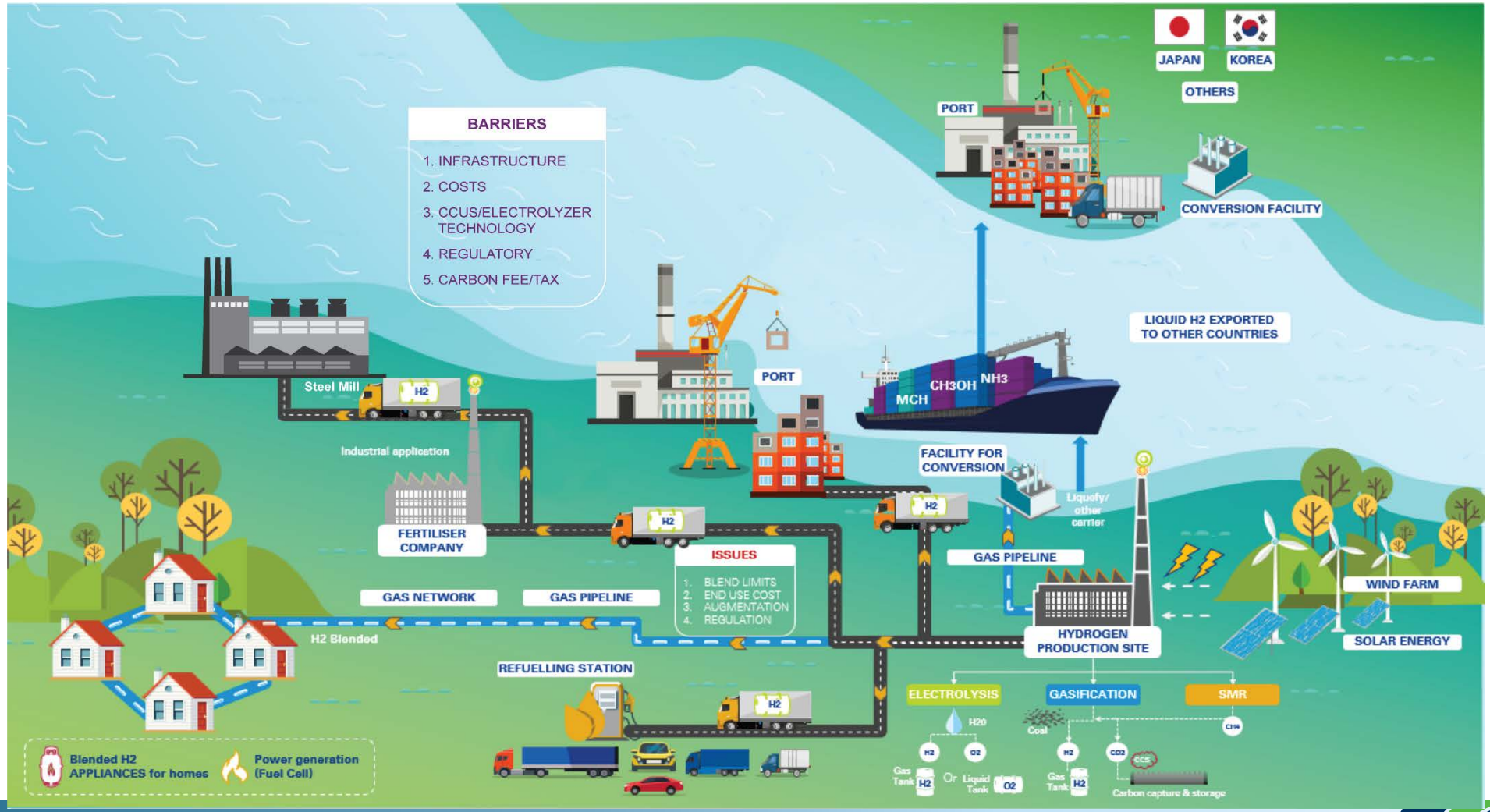
**NORTH AMERICA HYDROGEN ASSESSMENTS, APRIL 21***

| Production Pathway | Excluding Capex $/kg | Excluding Capex Change | Including Capex $/kg | Including Capex Change |
|---|---|---|---|---|
| **Alberta (C$/kg)** | | | | |
| SMR w/o CCS | 0.36 | +0.03 | | |
| Alkaline Electrolysis | 1.46 | -0.13 | | |
| PEM Electrolysis | 1.64 | -0.14 | | |
| **Appalachia** | | | | |
| SMR w/o CCS | 0.29 | +0.02 | | |
| Alkaline Electrolysis | 0.87 | -0.08 | | |
| PEM Electrolysis | 0.98 | -0.08 | 2.43 | |
| **Gulf Coast** | | | | |
| SMR w/o CCS | 0.32 | +0.03 | 1.16 | +0.03 |
| Alkaline Electrolysis | 1.04 | -0.28 | 2.00 | -0.28 |
| PEM Electrolysis | 1.17 | -0.31 | 2.54 | -0.31 |
| **Midcontinent** | | | | |
| SMR w/o CCS | 0.26 | +0.01 | 1.15 | +0.01 |
| Alkaline Electrolysis | 0.90 | -0.09 | 1.88 | -0.09 |
| PEM Electrolysis | 1.01 | -0.10 | 2.41 | -0.10 |
| **Northeast** | | | | |
| SMR w/o CCS | 0.33 | +0.04 | 1.39 | +0.04 |
| Alkaline Electrolysis | 0.86 | -0.04 | 1.89 | -0.04 |
| PEM Electrolysis | 0.96 | -0.05 | 2.45 | -0.05 |
| **Northern California** | | | | |
| SMR w/o CCS | 0.54 | +0.01 | 1.76 | +0.01 |
| Alkaline Electrolysis | 0.91 | -0.15 | 2.04 | -0.15 |
| PEM Electrolysis | 1.02 | -0.16 | 2.64 | -0.16 |
| **Northwest** | | | | |
| SMR w/o CCS | 0.26 | +0.01 | 1.39 | +0.07 |
| Alkaline Electrolysis | 0.74 | -0.32 | 1.77 | -0.32 |
| PEM Electrolysis | 0.83 | -0.36 | 2.30 | -0.36 |
| **Rockies** | | | | |
| SMR w/o CCS | 0.25 | +0.02 | 1.18 | +0.02 |
| Alkaline Electrolysis | 0.92 | +0.03 | 1.91 | +0.03 |
| PEM Electrolysis | 1.03 | +0.04 | 2.46 | +0.04 |
| **Southeast** | | | | |
| SMR w/o CCS | 0.32 | +0.03 | 1.19 | +0.03 |
| Alkaline Electrolysis | 0.93 | 0.00 | 1.91 | 0.00 |
| PEM Electrolysis | 1.04 | 0.00 | 2.44 | 0.00 |
| **Southern California** | | | | |
| SMR w/o CCS | 0.41 | +0.01 | 1.58 | +0.01 |
| Alkaline Electrolysis | 0.64 | -0.26 | 1.74 | -0.26 |
| PEM Electrolysis | 0.72 | -0.29 | 2.31 | -0.29 |
| **Upper Midwest** | | | | |
| SMR w/o CCS | 0.31 | +0.02 | 1.26 | +0.02 |
| Alkaline Electrolysis | 1.03 | +0.06 | 2.07 | +0.06 |
| PEM Electrolysis | 1.15 | +0.06 | 2.65 | +0.06 |

*Assessed previous day

**Gulf Coast SMR Has Lowest U.S. Costs**

# KPMG Australia H2 City Study shows that Hydrogen's versatility not only spans current uses largely in refining and ammonia but also provides disruptive potential as clean energy, under the right economic conditions




Potential hydrogen usage could include extending its current uses largely in refining and ammonia and providing clean energy for power generation, transportation fuel, and industrial applications