Charting the Future: The Intersection of Hydrogen and CCS Technologies

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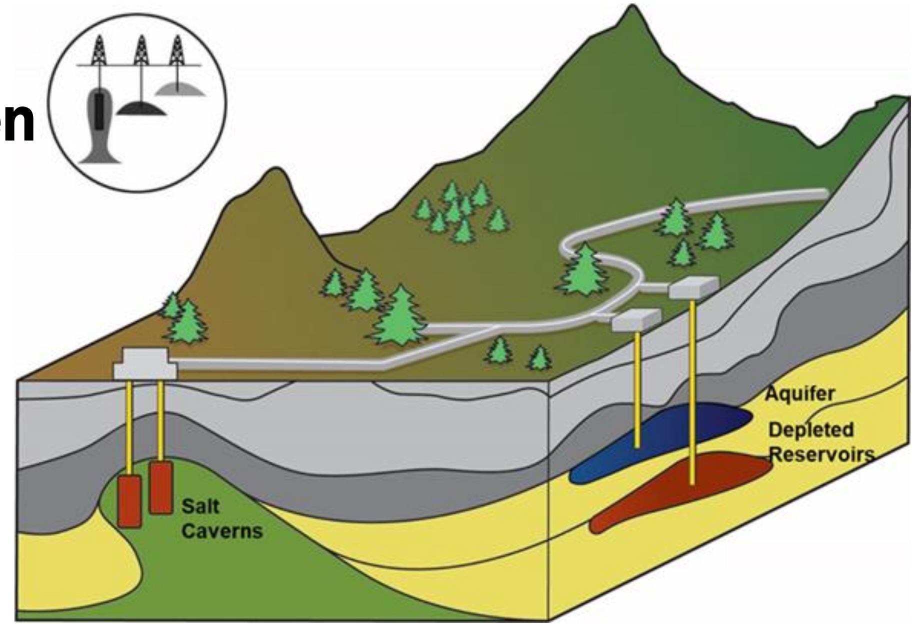
Bureau of Economic Geology

GeoH2

Conduct geoscience, reservoir engineering, & economic research to facilitate and advance the development of a hydrogen economy *at scale*

- **Geological Storage**
- **Techno-economics and Value Chain Analysis**
- **Novel Concepts: in situ generation, native hydrogen**



Participating Companies and Organizations

Shell, Repsol, bp, SINOPEC Smart Energy Better Life, ExxonMobil, OMV, equinor, CGG, saudi aramco أرامكو السعودية, EDF Environmental Defense Fund Finding the ways that work, U.S. Department of Energy, State of Texas Advanced Oil and Gas Resource Recovery STARR, The University of Texas at Austin Center for Subsurface Energy and the Environment Cockrell School of Engineering

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UT has about 80 researchers working across the entire field of hydrogen production, storage, transmission, and use

Providing information to industry and government supporting prudent decisions to guide the growth of the hydrogen economy

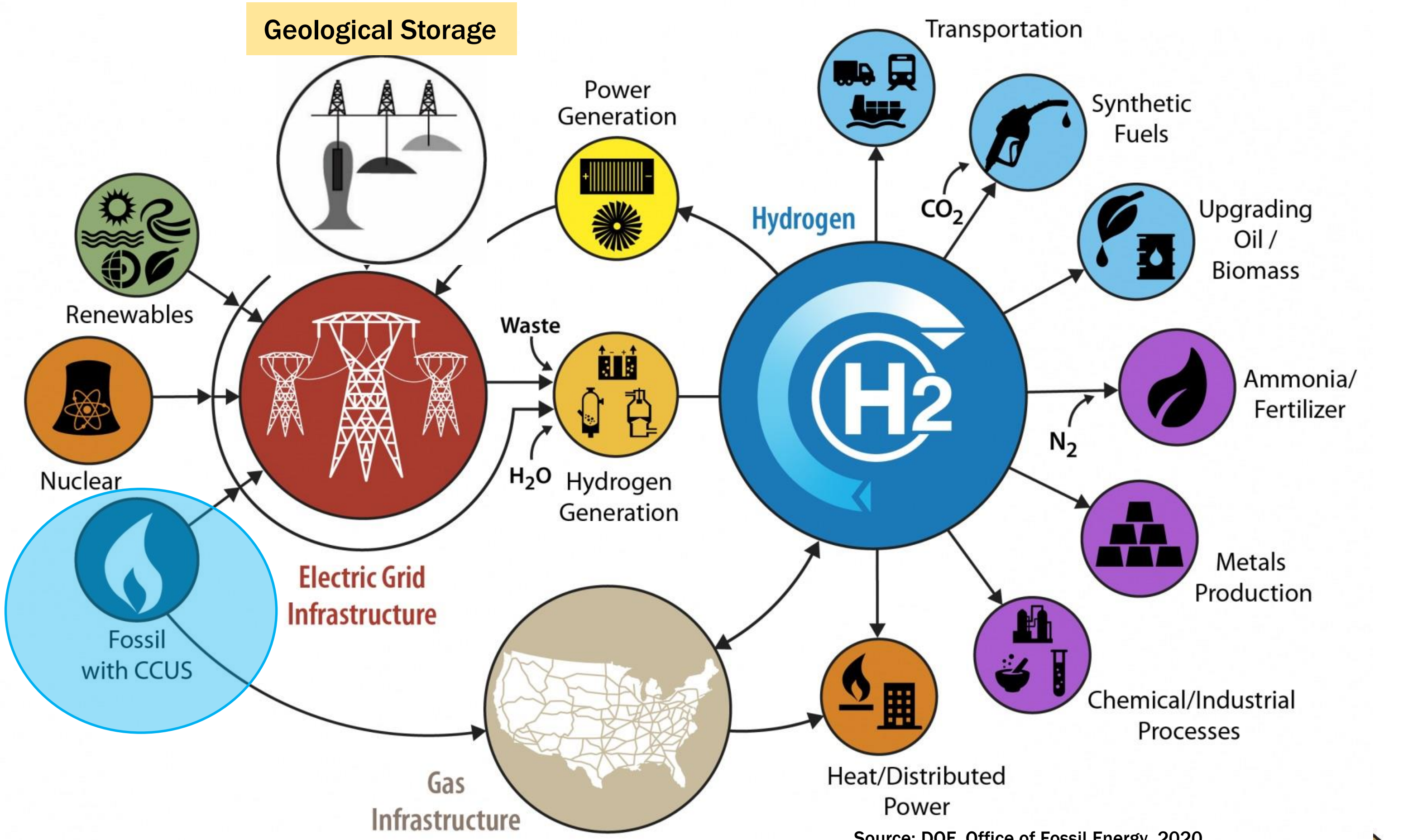
Educating students who will lead future hydrogen growth

- **Hydrogen-related research in the Permian Basin, collaborated the Center of Electromechanics (CEM)**
- **The HyVelocity Hub application in 2022, led by UT Energy Institute**

1. Introduction

Hydrogen Could Be A Flexible Low Carbon Solution

- Low carbon emissions
  - From electrolysis (hydro, solar, wind, nuclear, geothermal) without CO_2
  - From fossil fuels combined with carbon captu and storage (CCS)
- Transportable
  - Pipeline gas
  - Liquified
  - Compounds (e.g. ammonia)
- Store-able
  - Large capacity (geological)
  - Indefinite storage duration
- Multiple sources
  - Electrolysis
  - Natural gas reforming
  - Coal gasification
- Multiple Uses
  - Transportation
  - Industrial
  - Power (back-up/balancing)



Source: DOE, Office of Fossil Energy, 2020

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Production Pathways - The Color Spectrum of Hydrogen Supply

Higher H_2 Production Cost

$5.60 – 13.00/kg H_2

Lower H_2 Production Cost

$1.35 – 2.30/kg H_2

Renewable* (electrolysis)	Nuclear* (electrolysis)	"Grid" (electrolysis)	Natural Gas (pyrolysis)	Fossil Fuels/ Natural Gas (w/ CCS)	Natural Gas (steam reforming w/o CCS)	Coal (coal gasification w/o CCS)
Green	Pink	Yellow	Turquoise	Blue	Grey	Brown
No direct CO_2 emissions		Grid level emission factor	Solid carbon	Low CO_2	CO_2 emissions	

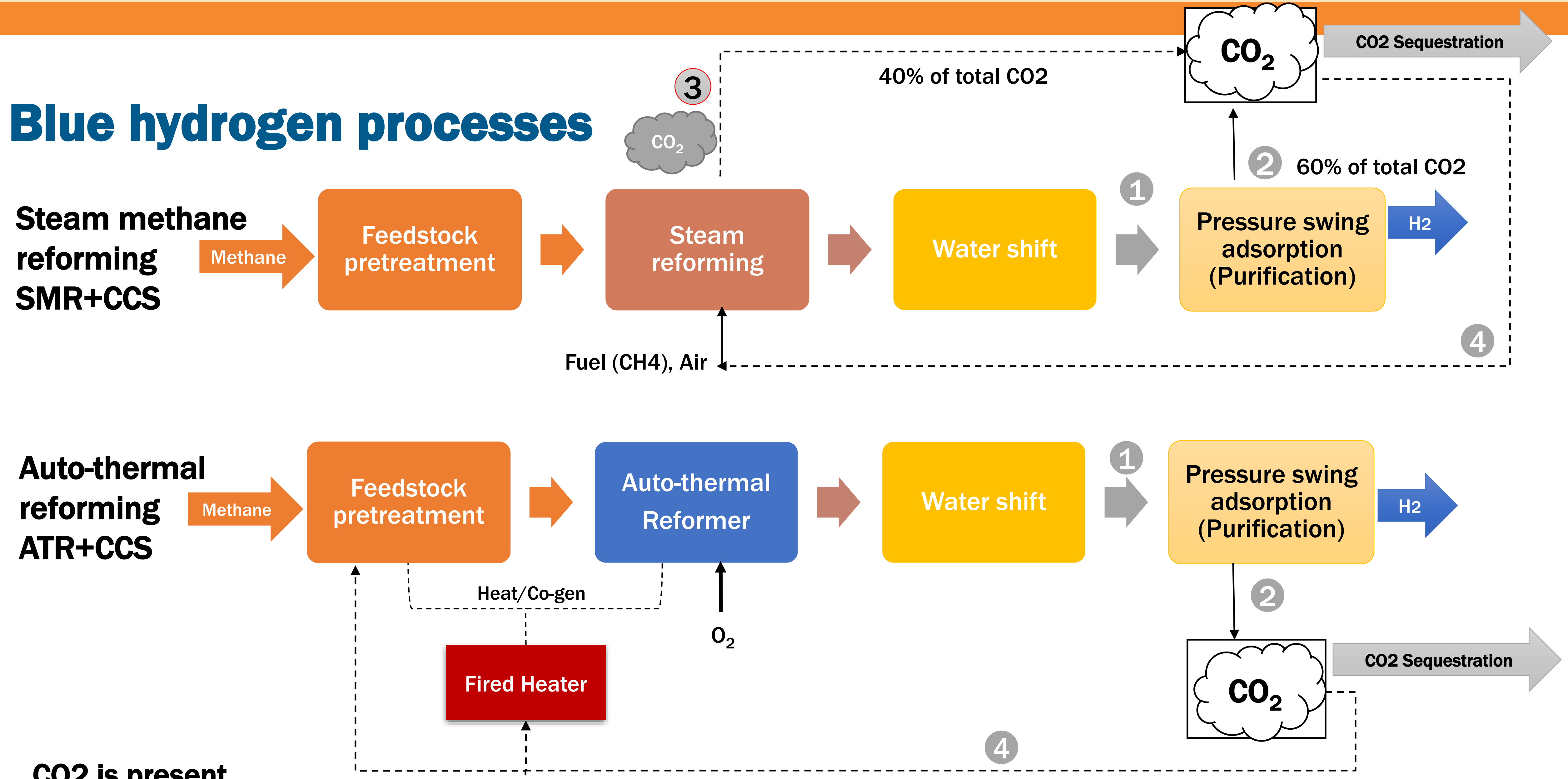
*

Biomass Gasification ~ $1.90/kg
Nuclear thermolysis ~$2.40/kg

Source: Production & cost data from DOE, Office of Fossil Energy, 2020

https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf

Blue hydrogen processes



CO2 is present

1 Shifted syngas
2 PSA tail gas (Off gas)
3 flue gas (CO_2, N_2), only present in SMR
4 Vent gas (Low CO_2, some H_2, CH_4. For SMR, there is also N_2)

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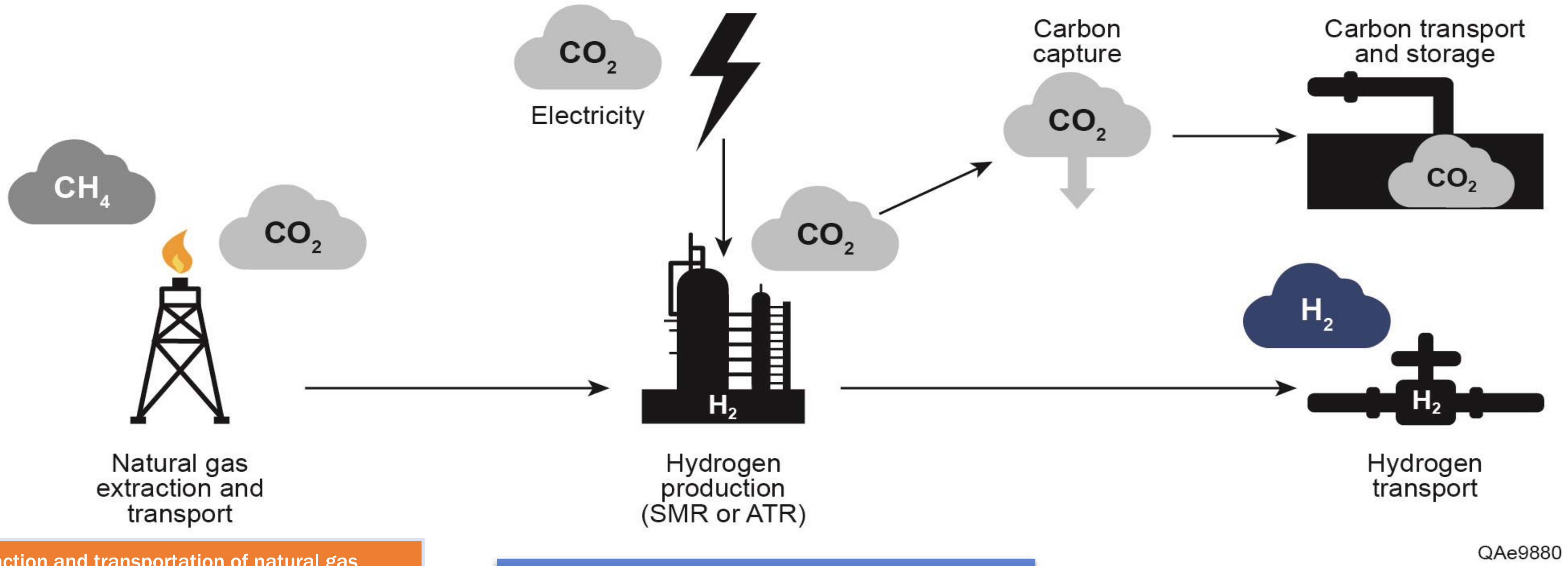
Life cycle emission of natural gas based hydrogen with CCS

Emission of the electric grid



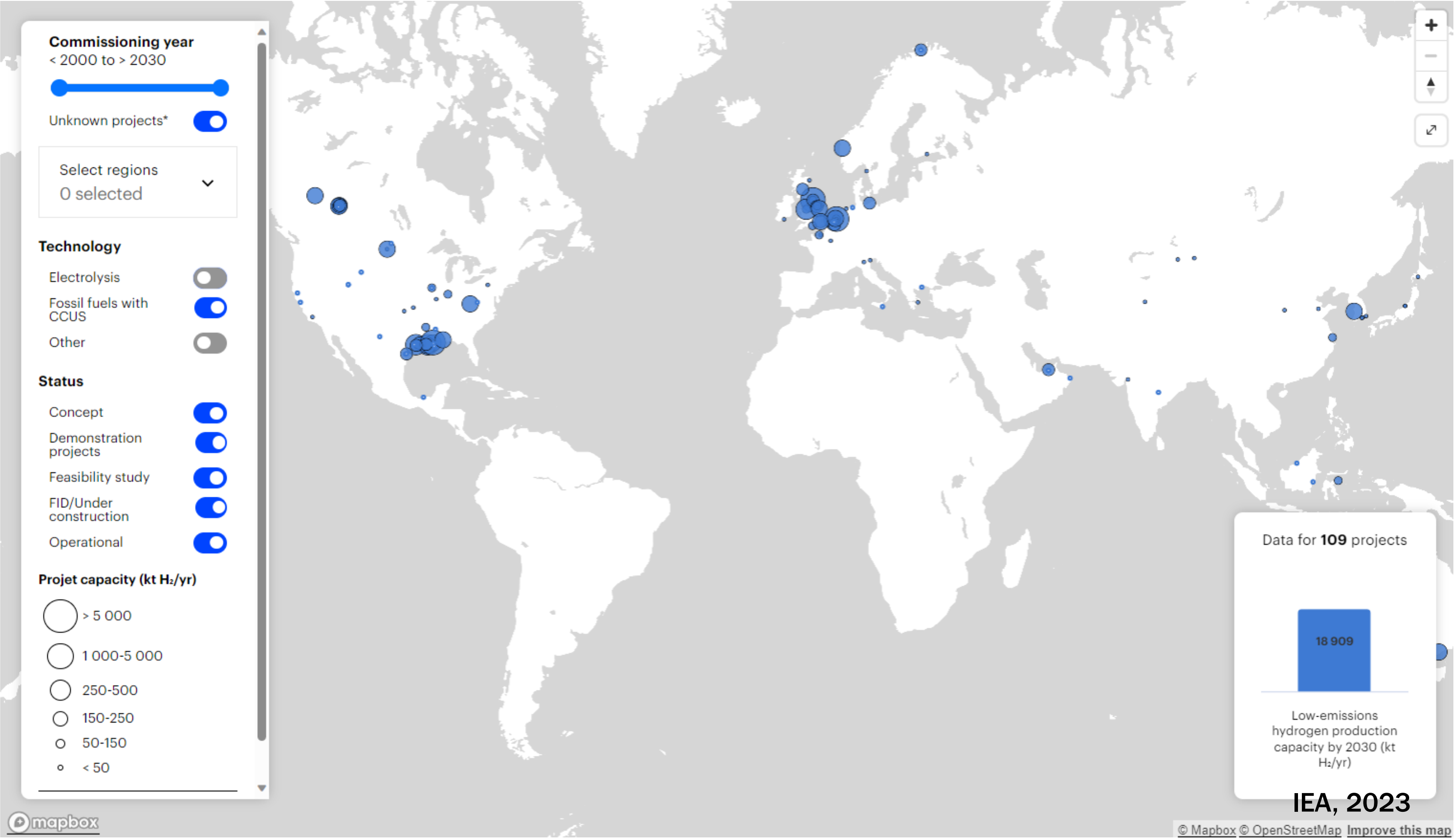
- the extraction and transportation of natural gas (upstream emissions)

the construction and decommissioning of facilities for hydrogen production and carbon capture

the hydrogen production process

2. Understanding Global and U.S. Trends in Hydrogen Development

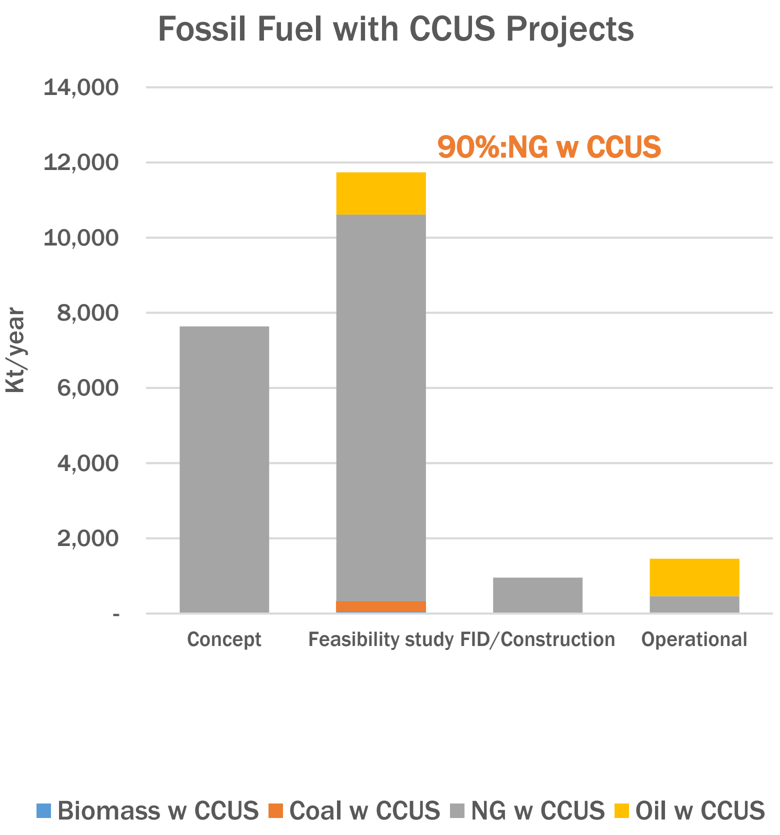
Global Low Carbon Intensity Hydrogen Production Since 2000

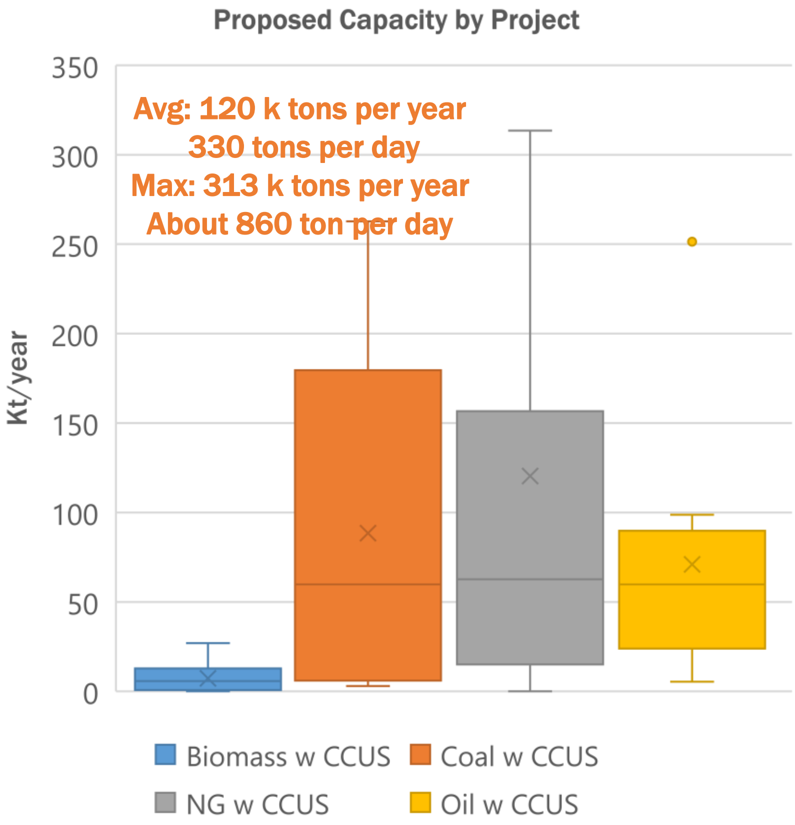


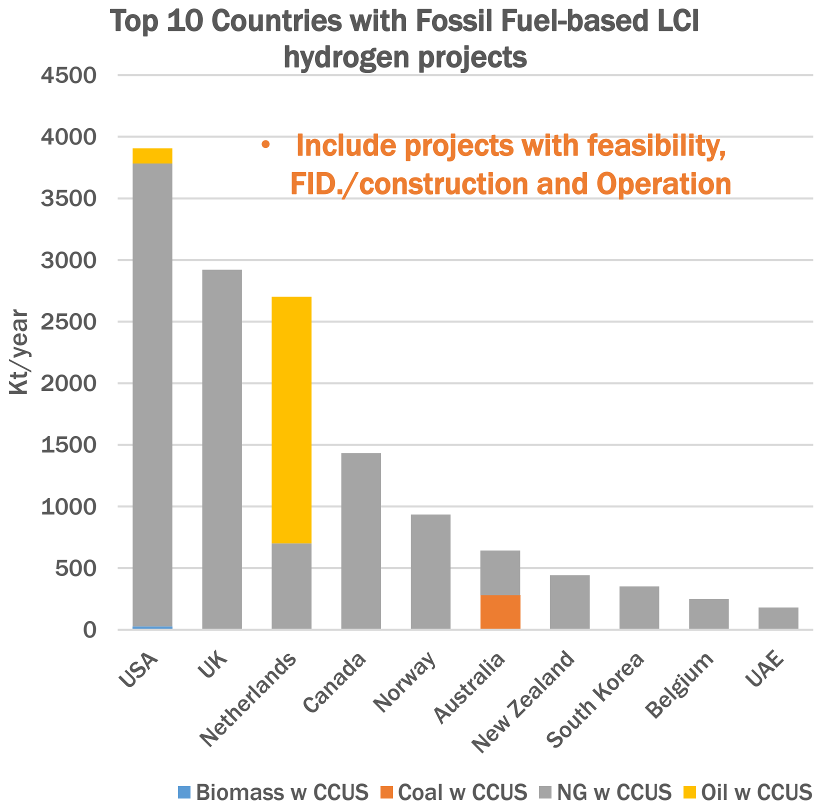
IEA, 2023

- The potential is huge as annual production of LCI H2 could reach 38 MT in 2030 if all are realized
- **10 MT, about 23% is fossil fuel with CCS. =>**
-
- This implies ~80 MT of carbon needs to be captured and sequestrated, almost 30% of the currently announced commercial CO2 projects in 2023 (Global CCS Institute, 2023; IEA 2023)

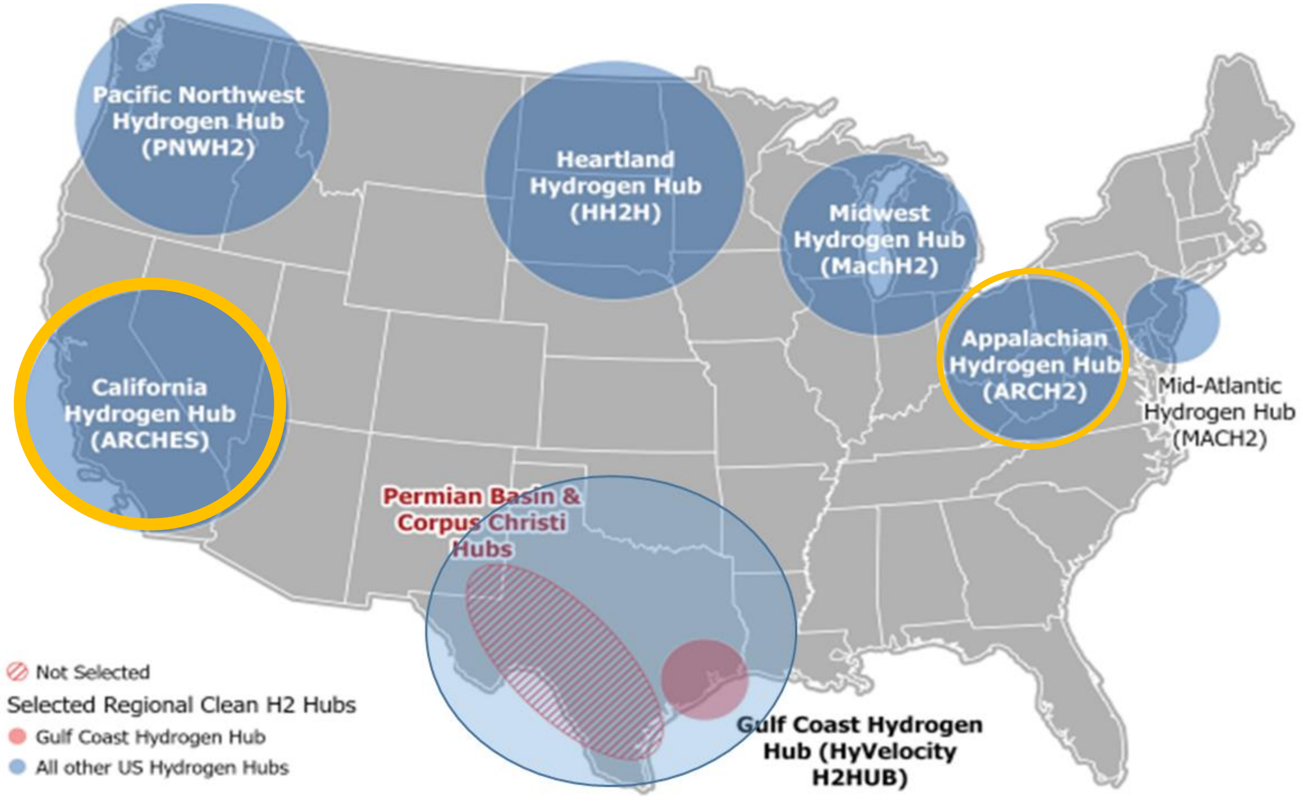
Fossil Fuel-Based LCI Hydrogen Projects







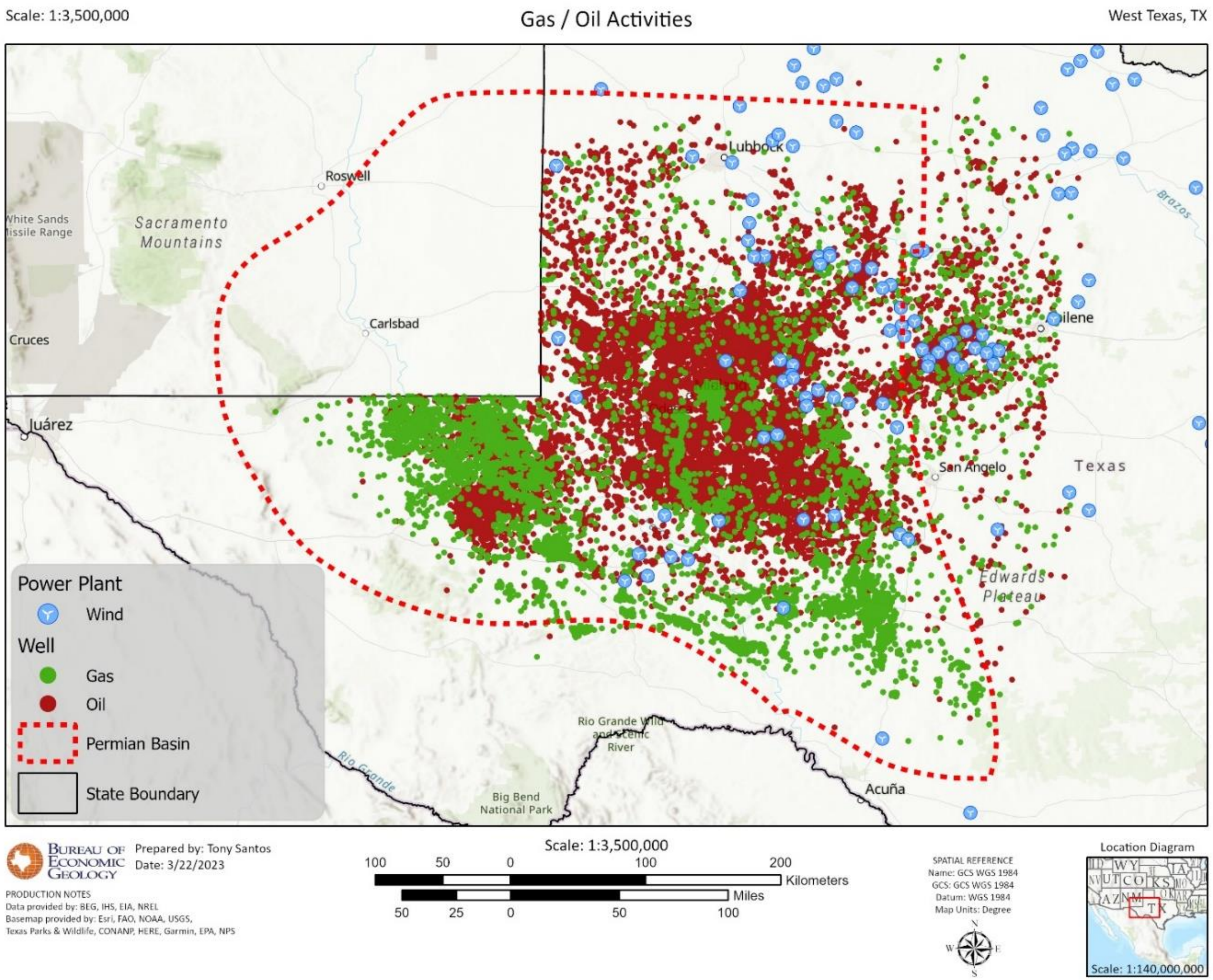
DOE Selected Regional Hydrogen Hubs

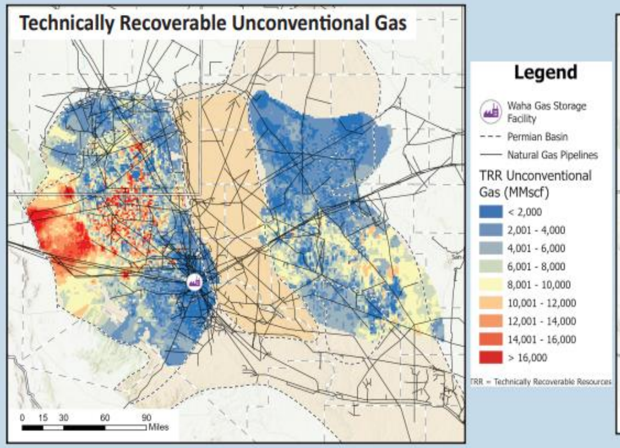


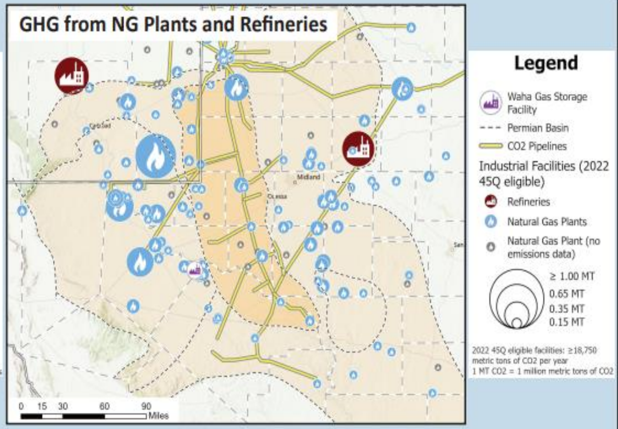
Implication on CCS needs:

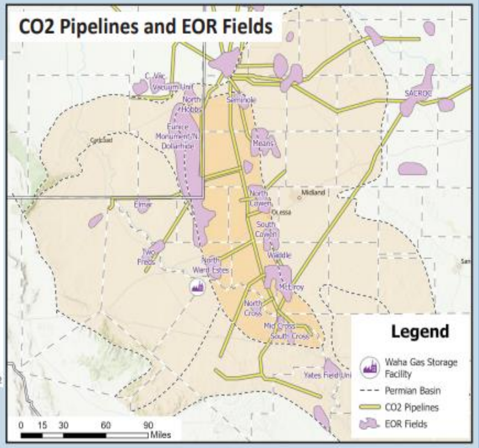
- **Appalachian and Gulf Coast** hydrogen hubs include significant natural gas-based hydrogen production projects
- **California hub** has bio-methane-based hydrogen projects as well.
- **West Texas** can play a role in the Gulf Coast hydrogen hub, which is one of the seven hubs supported by DOE.

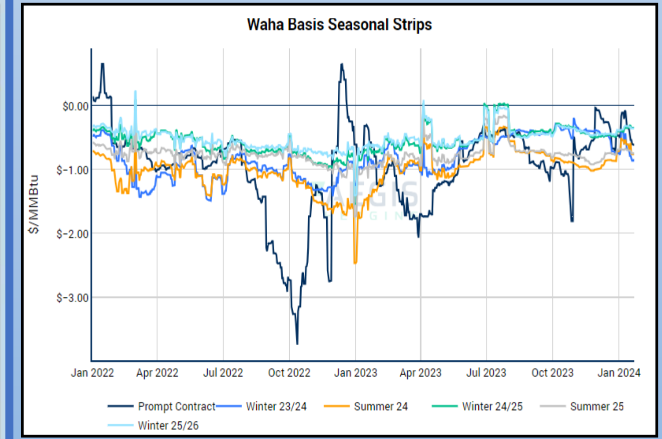
3. Hydrogen Production and CCS in A Case Study – Permian Basin

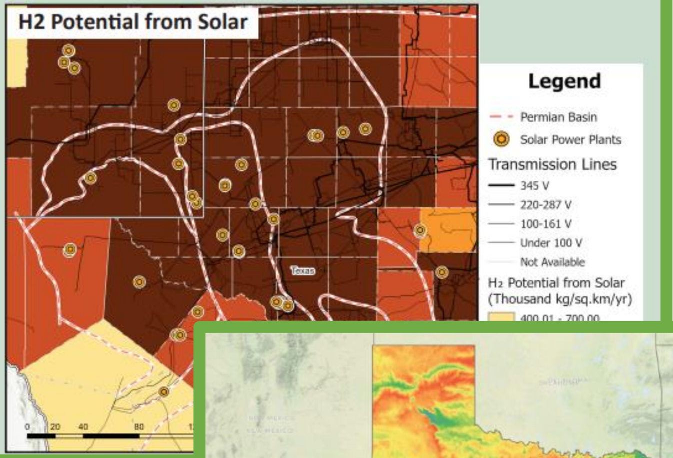


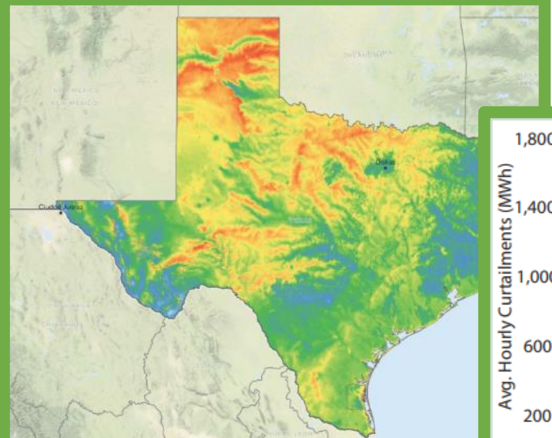




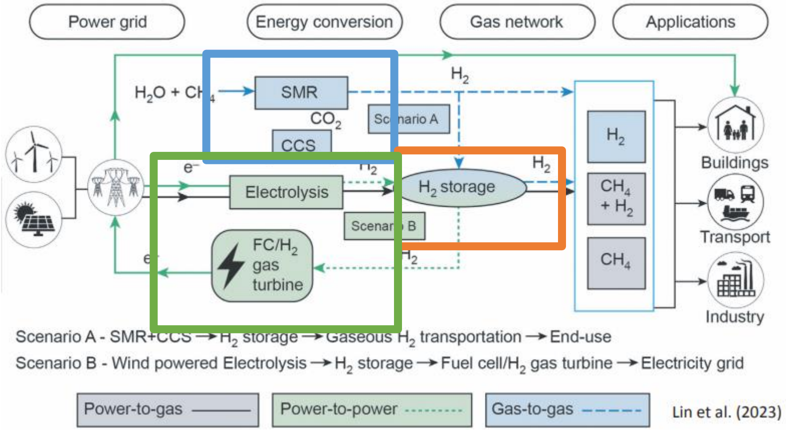


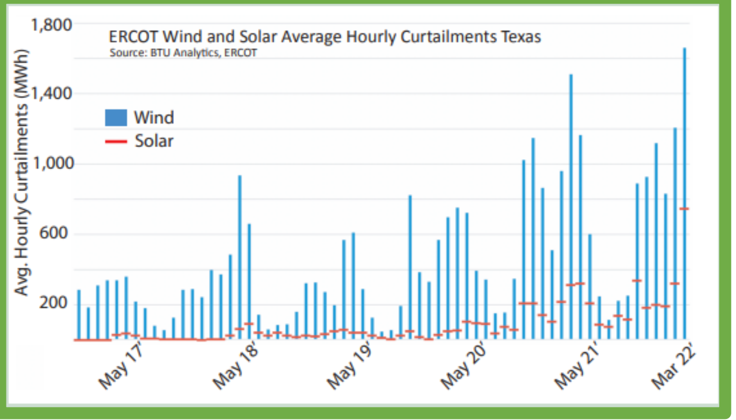


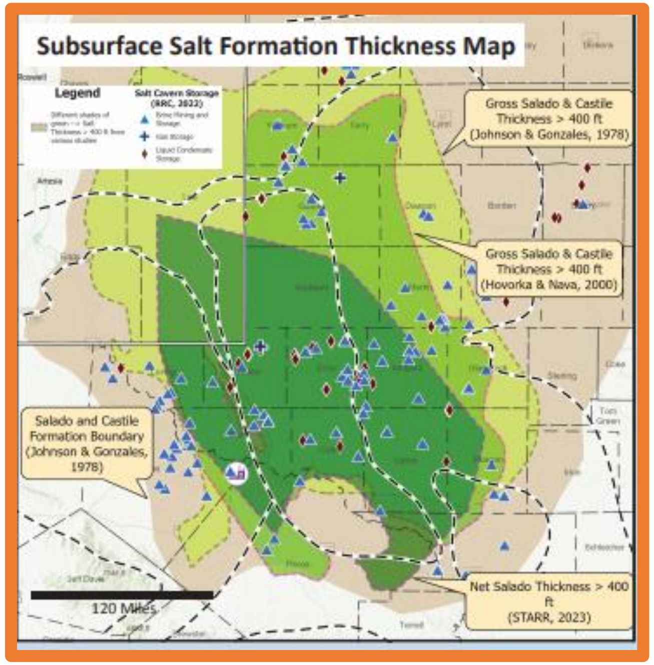




H2 potential from wind







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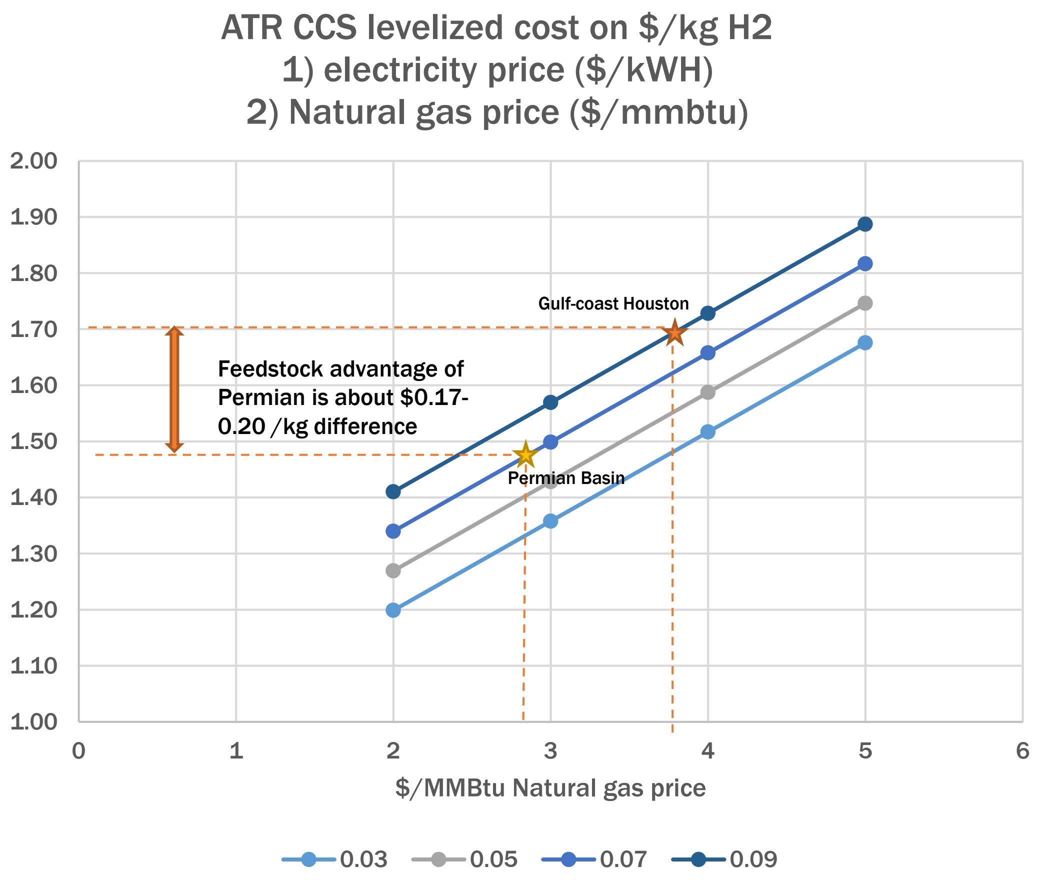
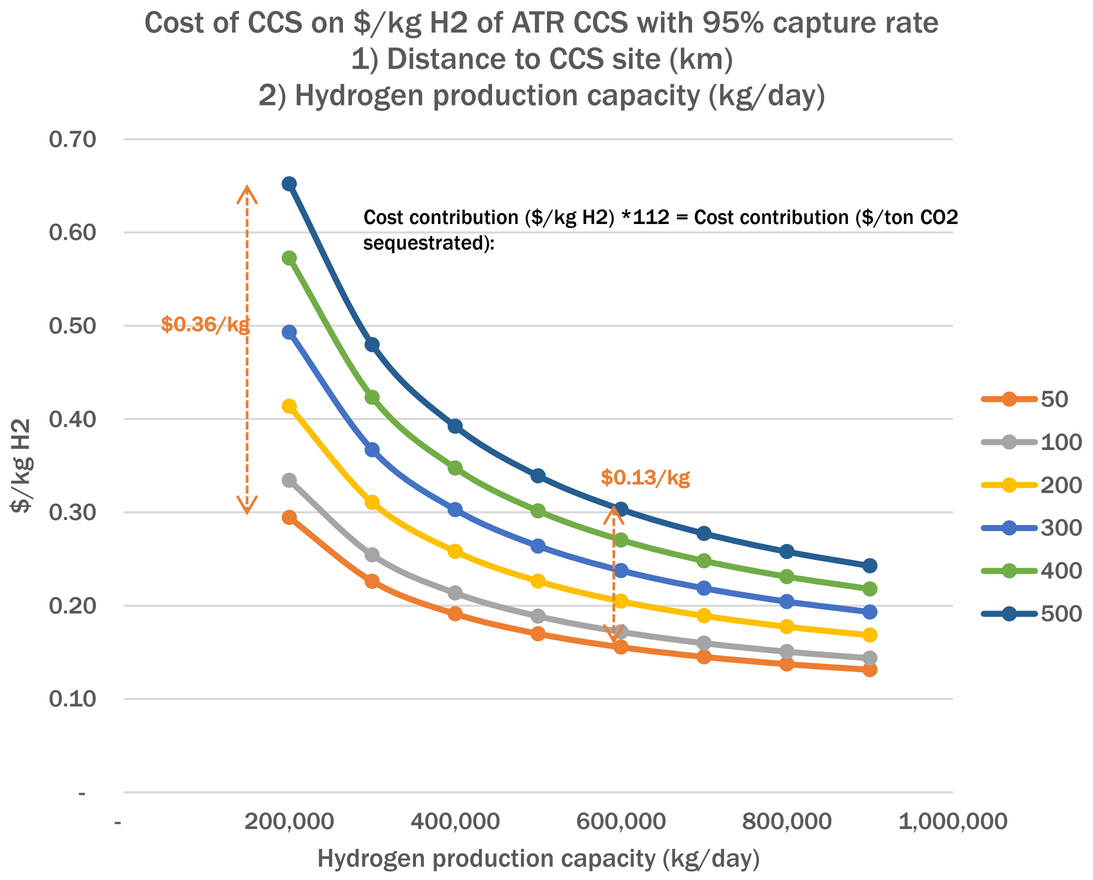
Levelized cost of ATR+CCS





CCS cost (transportation and storage) could have an impact on hydrogen production cost, that offset some locational basis difference

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Overview of 45Q vs. 45V

2008: the Energy Improvement and Extension Act.

75 **million metric tons of CO_2** cap

at least 500,000 metric tons of CO_2

$20**/ton **$CO_2$ sequestered in secure geological storage and $10/ton **for CO_2 for enhanced oil recovery** (**EOR**)

Inflation adjusted and 12 year duration

February 2018: Bipartisan Budget Act

More **biologic sequestration methods** and first inclusion of DAC (Direct Air Capture).

a planned linear increase to $50/ton **by 2026, for permanently geological storage, and $35/ton by 2026** for EOR.

removed the **75 million metric tons** cap

2021: New Legislation

$85/ton for CO_2 captured and stored in saline geologic formations, $65/ton for EOR.

Life Cycle Emissions (kg CO_2e/kgH2)	PTC Value (2022$/kgH2)
4 – 2.5	0.60
2.5 – 1.5	0.75
1.5 – 0.45	1.00
0.45 - 0	3.00

- The Inflation Reduction Act of 2022 (IRA)
- Clean Hydrogen Production Tax Credit (PTC), as a 10 year tax credit.
- Agnostic of production method, PTC credits depending on life cycle emissions (kg CO_2e/kgH2)

Hydrogen projects need to choose between 45Q and 45V and cannot use both.

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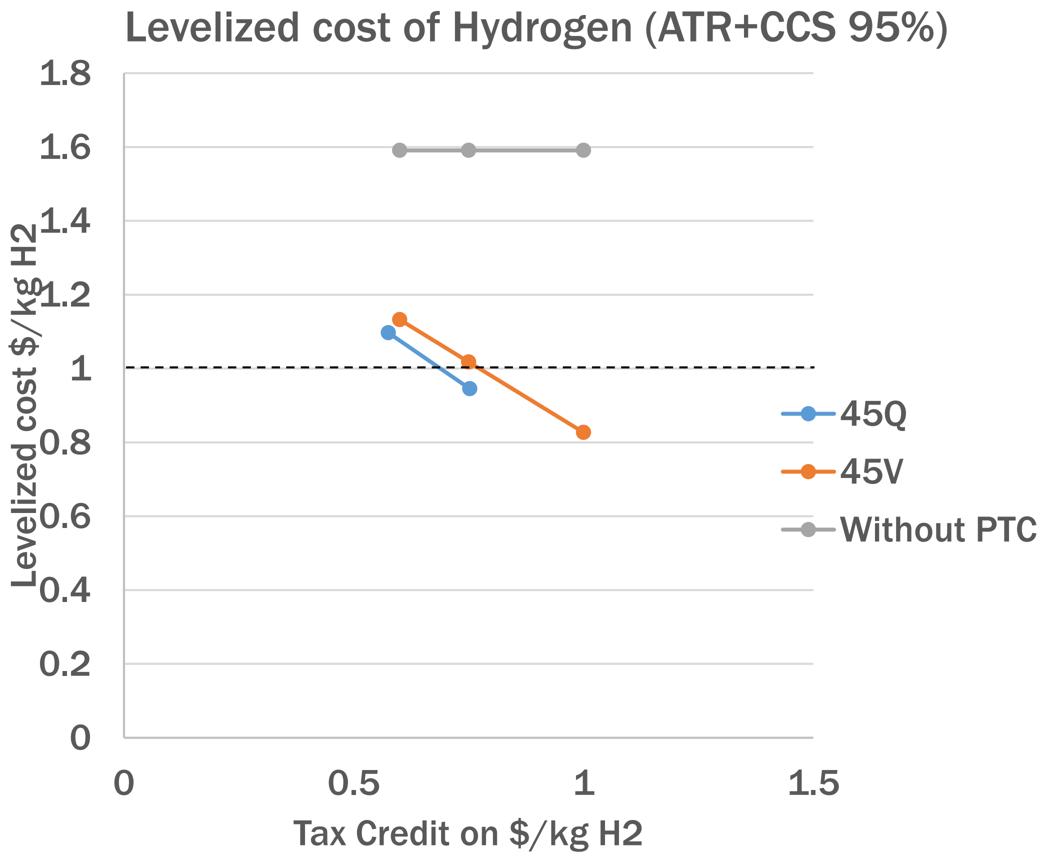
CCS Policy impact on Hydrogen Cost



- The subsidies both effectively bring hydrogen cost with CCS below $1/kg for both Permian and Houston.
- The impact of 45Q with CCS is slightly more competitive than 45V.
- 45Q can be a preferred option for tax credit for gas based hydrogen projects

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Concluding slide – Opportunities and Strategic Decisions

Key takeaways:

- About 25% of the low carbon intensity hydrogen projects globally have CCS needs, which translates up to 80 million tons of CCS
- CCS can be a differentiating factor to blue hydrogen costs, along with feedstock and electricity. This needs to be considered when designing a hydrogen network.

Low Carbon Intensity Hydrogen

Potential research topics:

- Optimizing hydrogen production with integrated CCS in gas production regions like Permian or Appalachian
- Considering the CCS (transportation and storage) component in shaping the hydrogen hub

Carbon Capture and Storage