

The Entangled Roles of Policy and Economics in CCUS



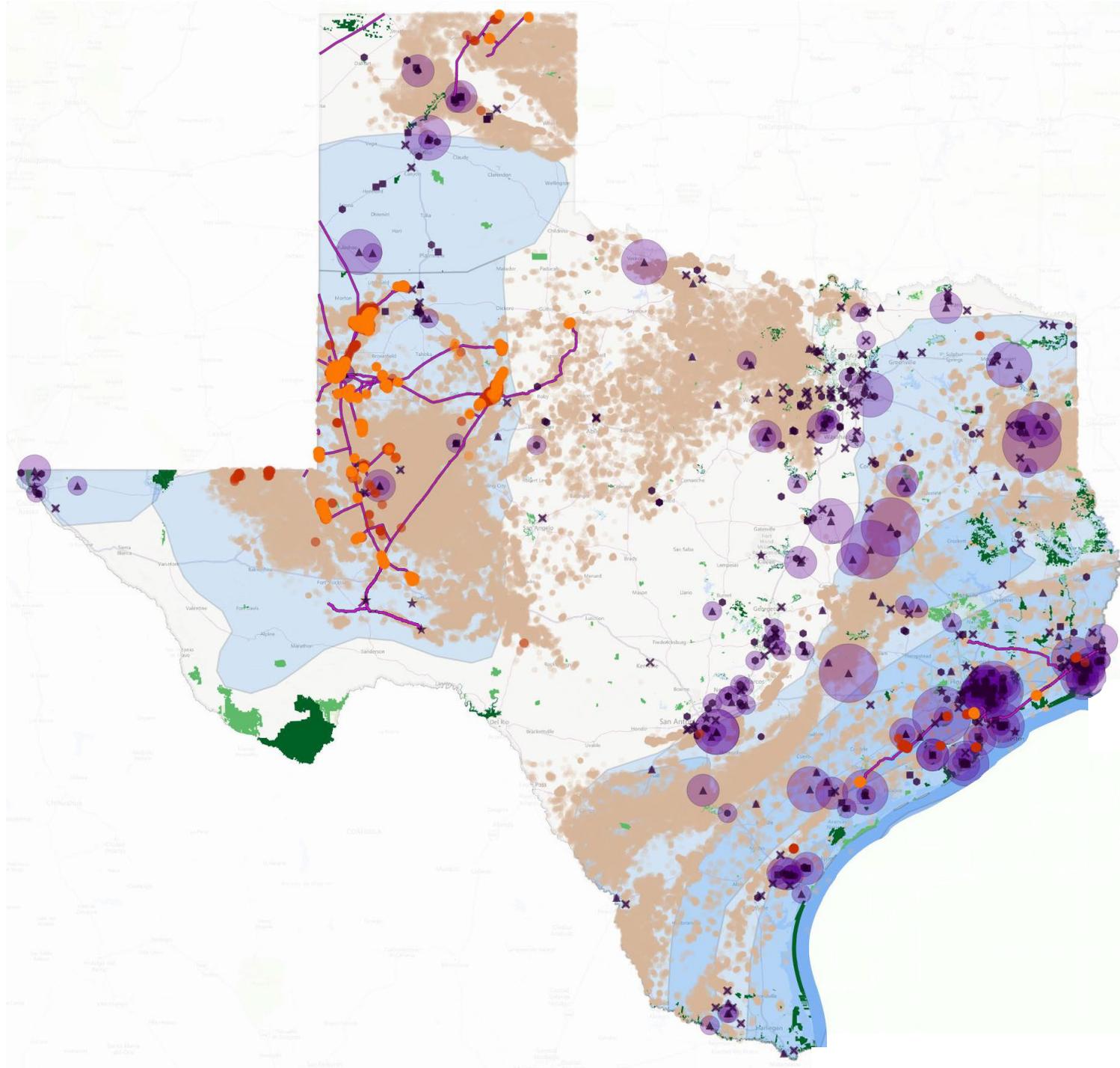
Kenneth B Medlock III, PhD

**James A Baker III and Susan G Baker Fellow in Energy and Resource Economics, and Senior Director
Center for Energy Studies, Baker Institute for Public Policy, Rice University**

November 14, 2022

Carbon Capture

**An Example of Evaluating Regional Opportunities with Distinct
Comparative Advantages: The Case of Texas**



Legend

CO2 injection wells

- Active CO2 injection wells
- Non active CO2 injection wells

CO2 direct emitters (excl. oil and gas extraction and natural gas pipelines and distribution)

- Chemical manufacturing
- ▲ Electric power generation, transmission, and distribution
- ★ Others
- Other manufacturing
- Petroleum refineries
- × Waste treatment and disposal

CO2 direct emitters: 2018 emissions in tons (same exclusion as above)

- 0 - 513,078
- 513,078 - 1,590,215
- 1,590,215 - 3,476,313
- 3,476,313 - 7,180,671
- 7,180,671 - 14,870,599

CO2 pipelines

State vs Federal lands

- State
- Federal
- Active oil and gas wells
- Saline formation

Legend

CO2 injection wells

- Active CO2 injection wells
- Non active CO2 injection wells

CO2 direct emitters (excl. oil and gas extraction and natural gas pipelines and distribution)

- Chemical manufacturing
- ▲ Electric power generation, transmission, and distribution
- ★ Others
- Other manufacturing
- Petroleum refineries
- × Waste treatment and disposal

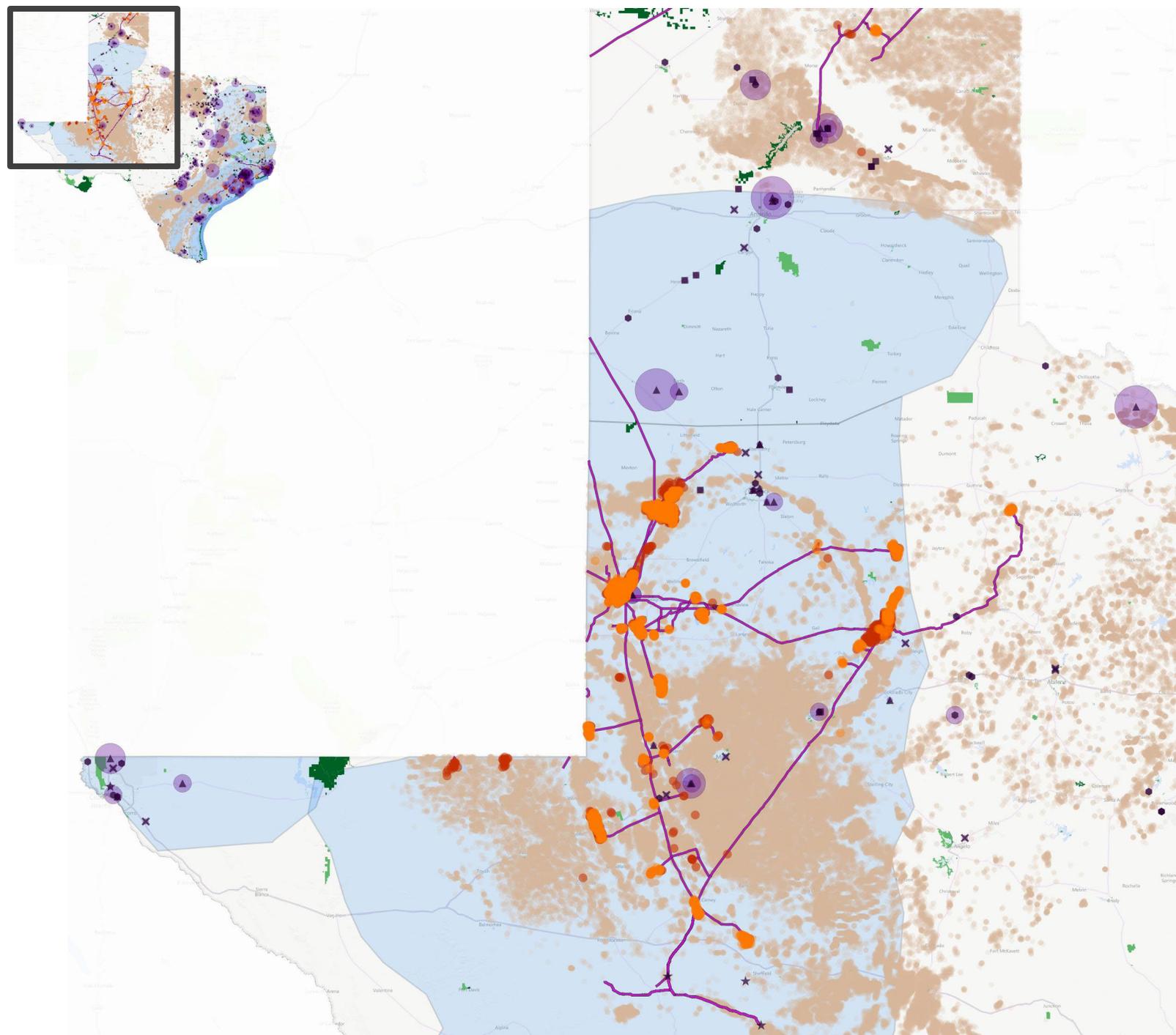
CO2 direct emitters: 2018 emissions in tons (same exclusion as above)

- 0 - 513,078
- 513,078 - 1,590,215
- 1,590,215 - 3,476,313
- 3,476,313 - 7,180,671
- 7,180,671 - 14,870,599

CO2 pipelines

State vs Federal lands

- State
- Federal
- Active oil and gas wells
- Saline formation



Legend

CO2 injection wells

- Active CO2 injection wells
- Non active CO2 injection wells

CO2 direct emitters (excl. oil and gas extraction and natural gas pipelines and distribution)

- Chemical manufacturing
- ▲ Electric power generation, transmission, and distribution
- ★ Others
- Other manufacturing
- Petroleum refineries
- × Waste treatment and disposal

CO2 direct emitters: 2018 emissions in tons (same exclusion as above)

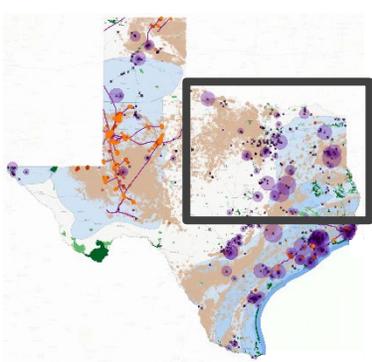
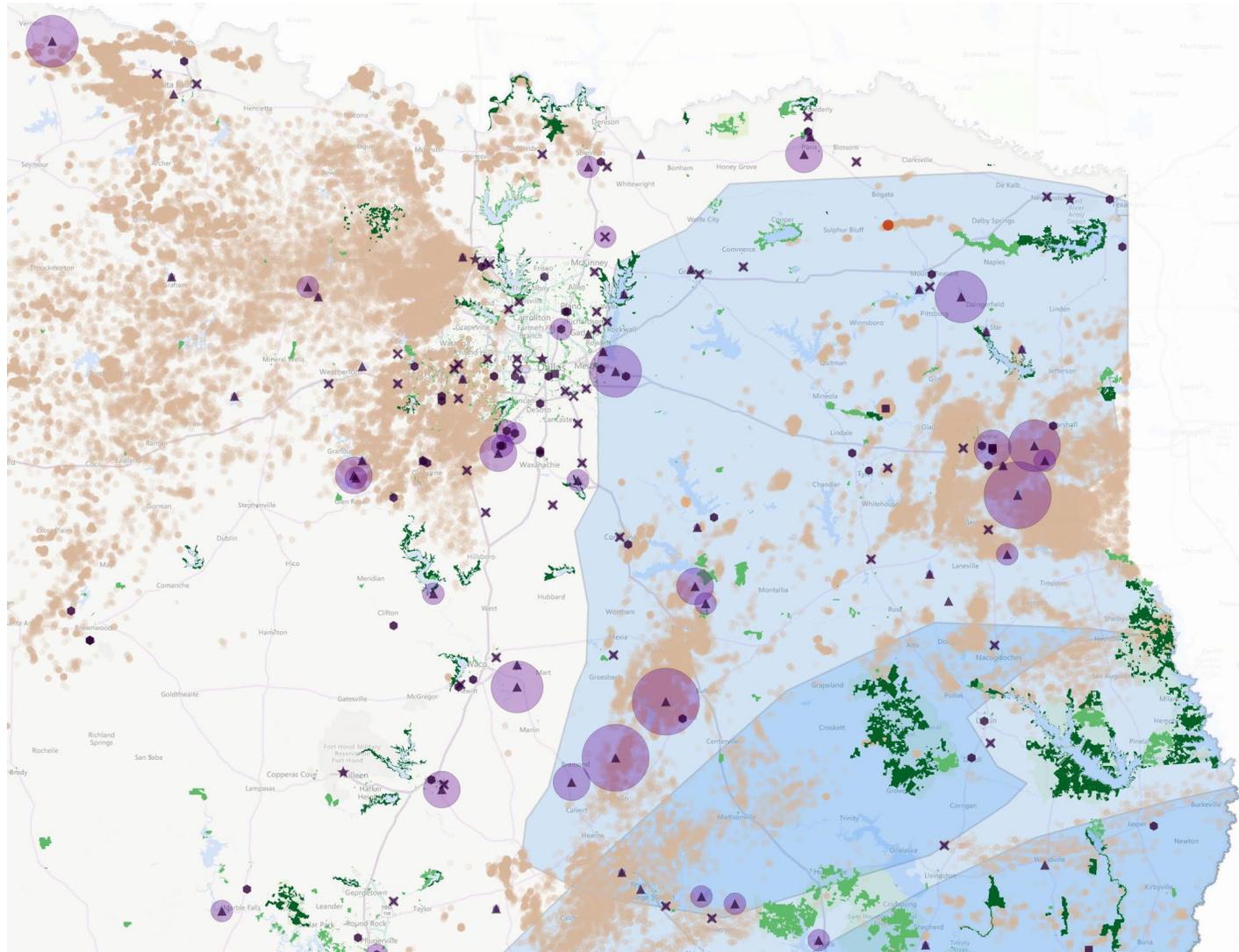
- 0 - 513,078
- 513,078 - 1,590,215
- 1,590,215 - 3,476,313
- 3,476,313 - 7,180,671
- 7,180,671 - 14,870,599

CO2 pipelines

- CO2 pipelines

State vs Federal lands

- State
- Federal
- Active oil and gas wells
- Saline formation



Legend

CO2 injection wells

- Active CO2 injection wells
- Non active CO2 injection wells

CO2 direct emitters (excl. oil and gas extraction and natural gas pipelines and distribution)

- Chemical manufacturing
- ▲ Electric power generation, transmission, and distribution
- ★ Others
- Other manufacturing
- Petroleum refineries
- × Waste treatment and disposal

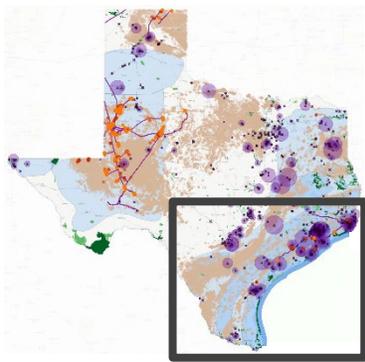
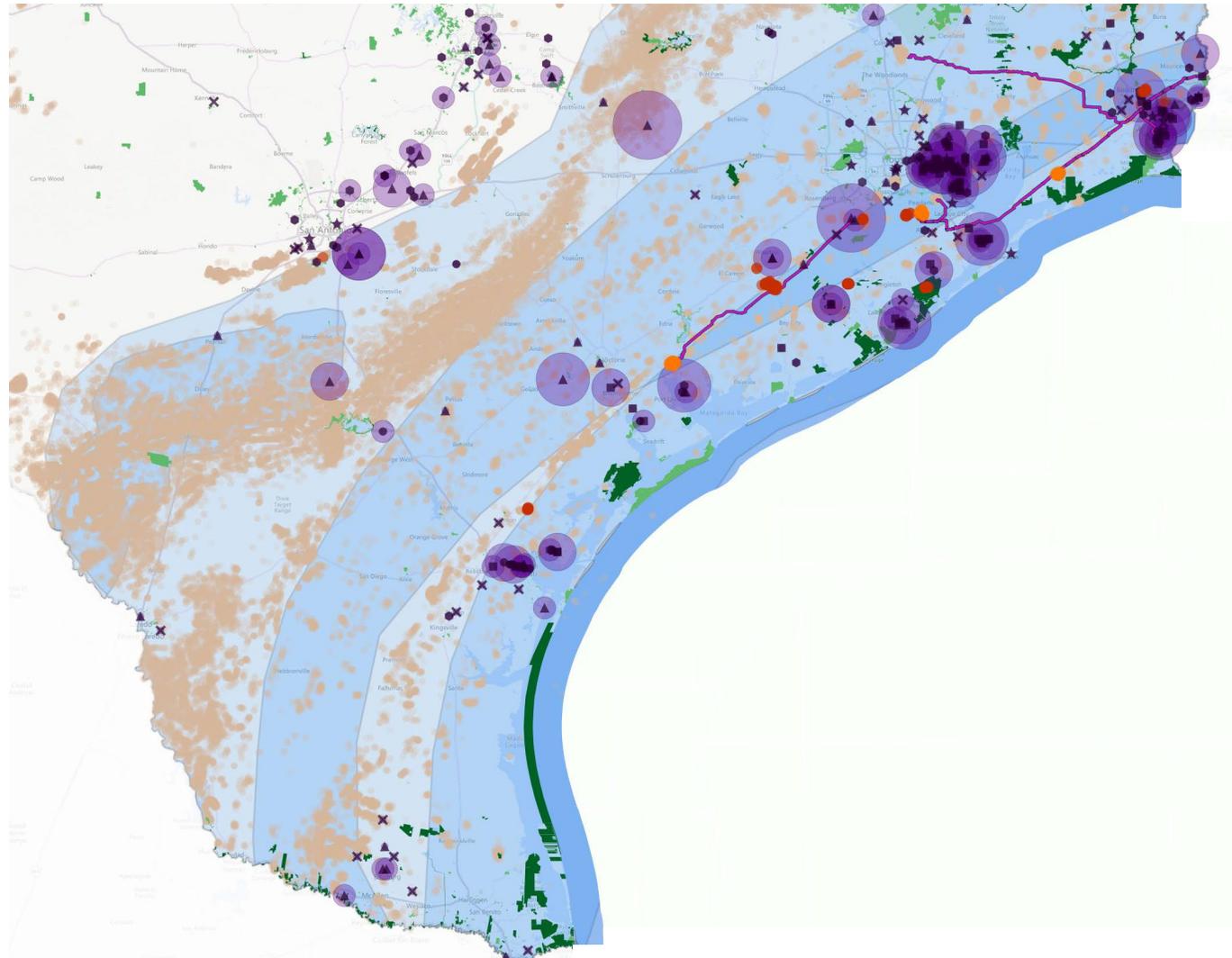
CO2 direct emitters: 2018 emissions in tons (same exclusion as above)

- 0 - 513,078
- 513,078 - 1,590,215
- 1,590,215 - 3,476,313
- 3,476,313 - 7,180,671
- 7,180,671 - 14,870,599

CO2 pipelines

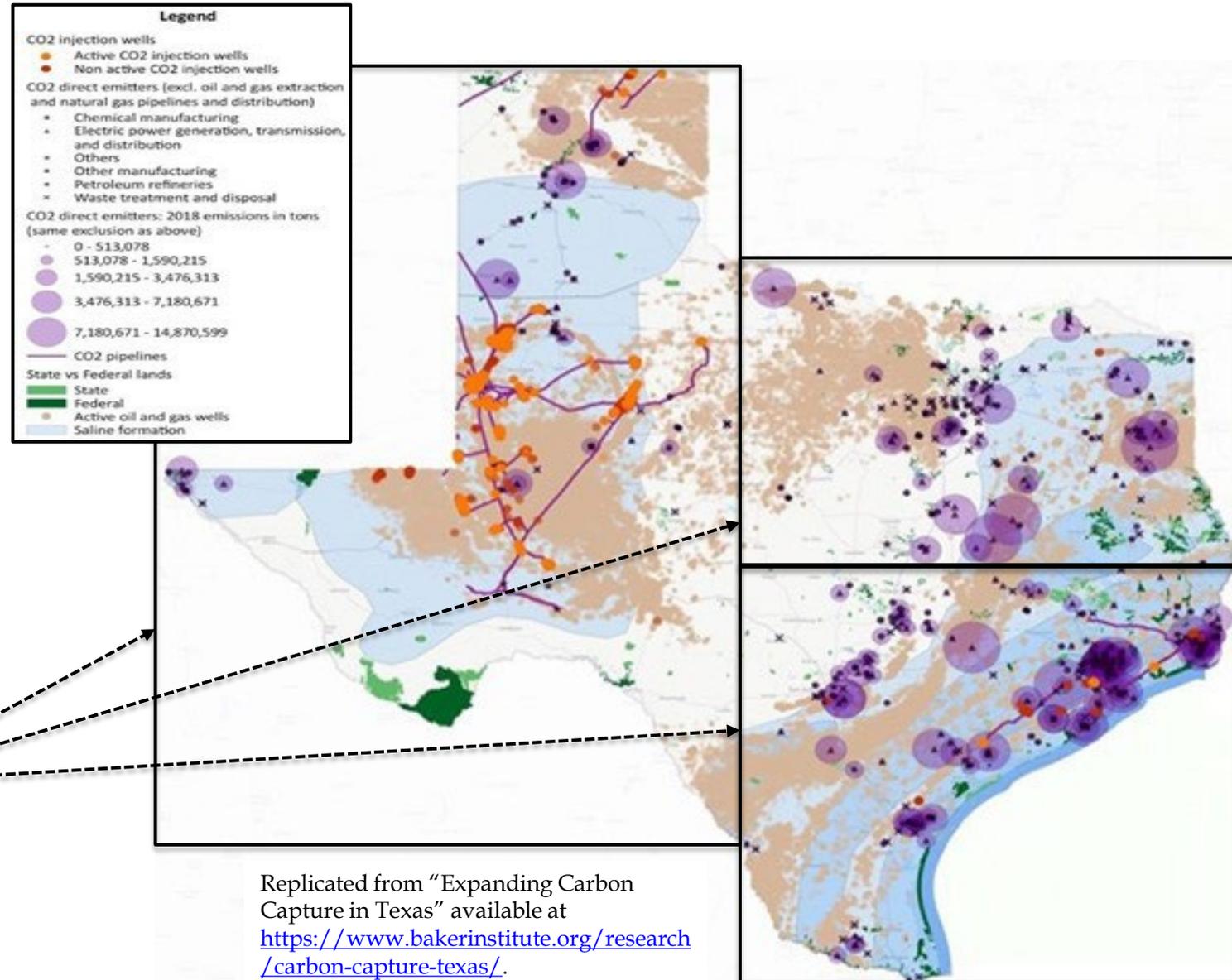
State vs Federal lands

- State
- Federal
- Active oil and gas wells
- Saline formation



Carbon capture matters, and the opportunity is different everywhere... again, consider Texas.

- Texas a leader in carbon capture?
- Significant industrial and power generation CO₂ emissions
 - 24% of US energy-related emissions from industry
 - 12% of US energy-related emissions from power generation
- Comparative advantages:
 - Large CO₂ footprint
 - Supply chain logistics and management expertise
 - Engineering and subsurface expertise
 - Geologic endowment
 - Business-friendly
- Regionally distinct differences. There are challenges, but the opportunities are multifaceted.



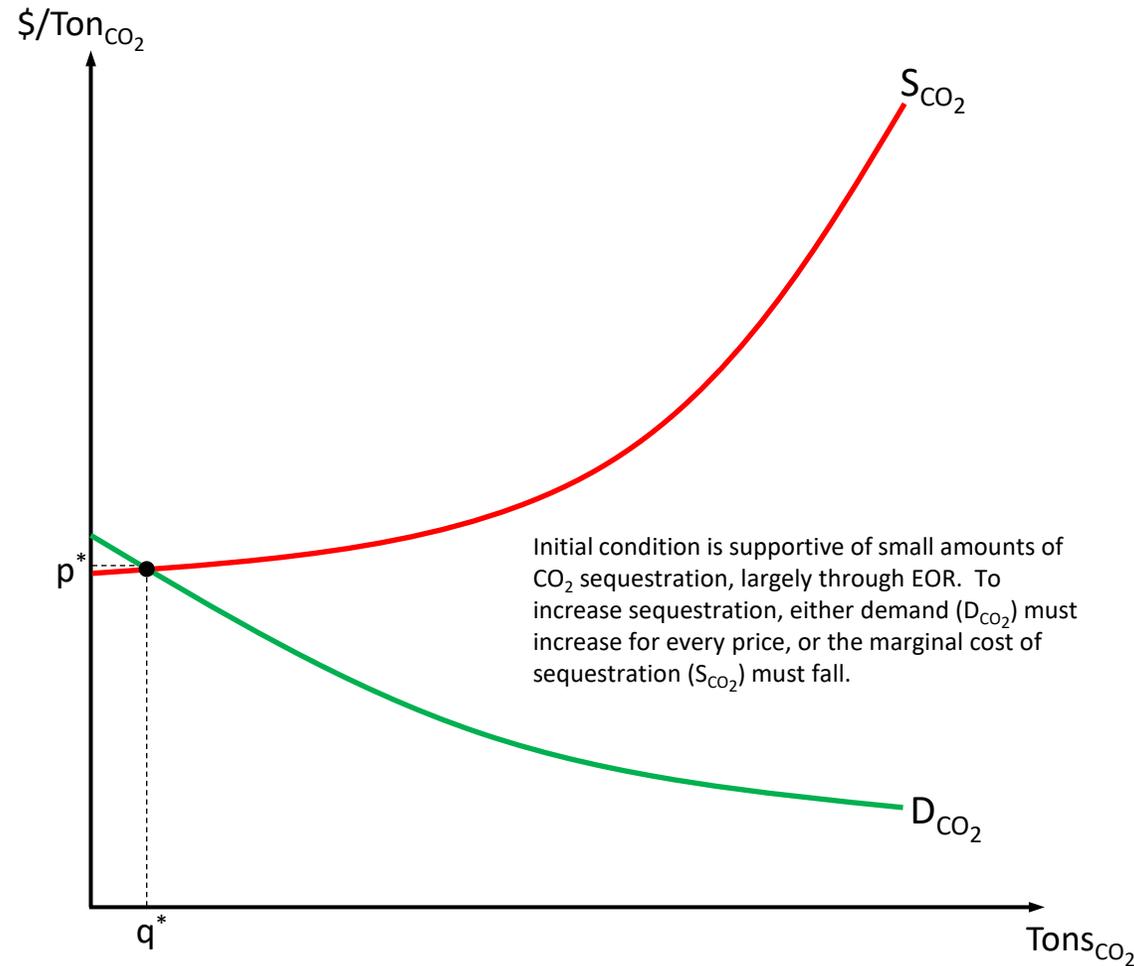
Replicated from "Expanding Carbon Capture in Texas" available at <https://www.bakerinstitute.org/research/carbon-capture-texas/>.

From Mapping the Landscape to a Conceptual Framework:

What Matters and Why?

Supply and demand for CO₂ sequestration

Status quo



Supply shifters

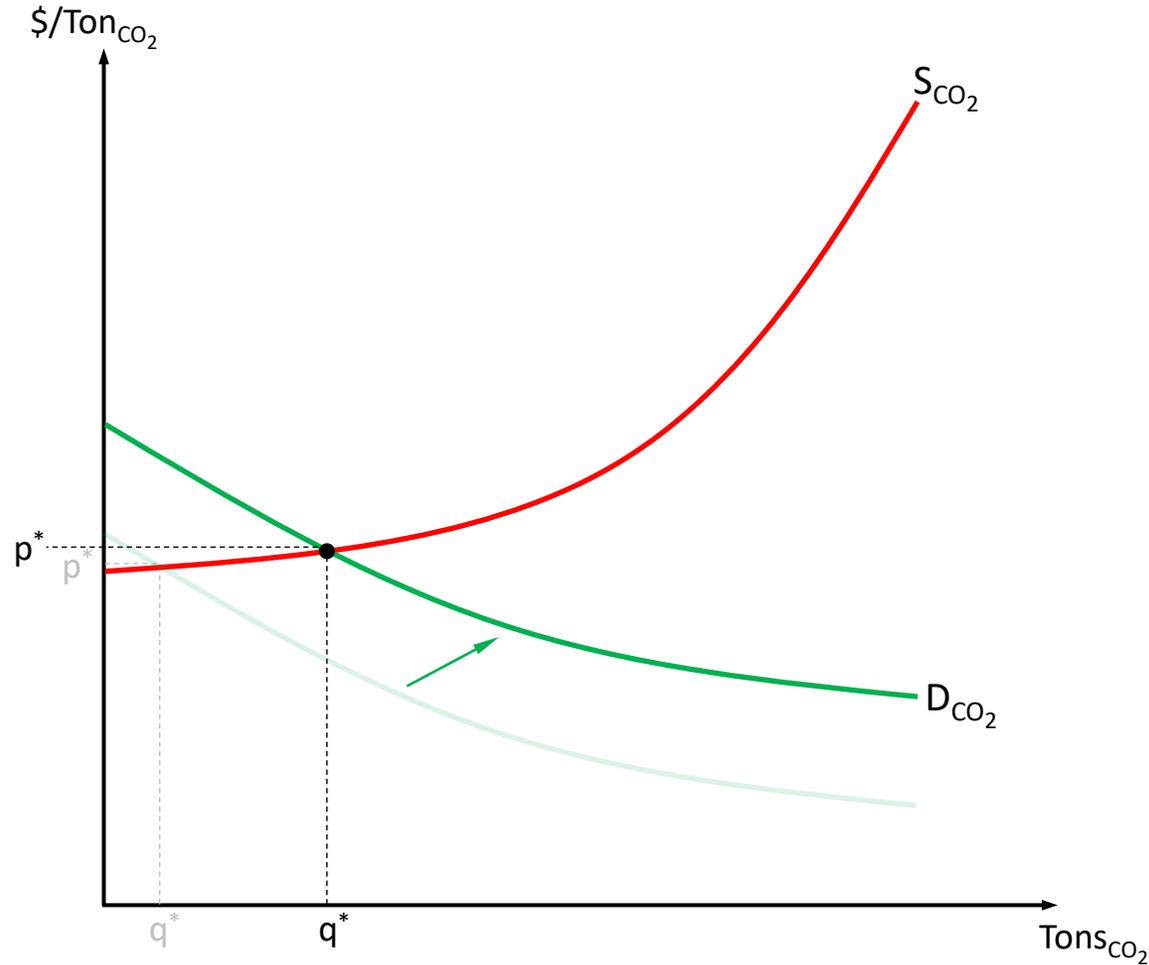
- Innovation, new technologies, new products (carbon-to-value)
- Tax/fiscal policy that lowers infrastructure and project fixed/operating costs (45Q, of course, but local measures matter too)
- Removing permitting/access restrictions or legal barriers
- Market risk and barriers to entry

Demand shifters

- Consumer preference and ESG investor sentiment focused on lower corporate net carbon footprints
- Direct government regulation of emissions
- CO₂ tax

Supply and demand for CO₂ sequestration

Adding demand-side drivers



Supply shifters

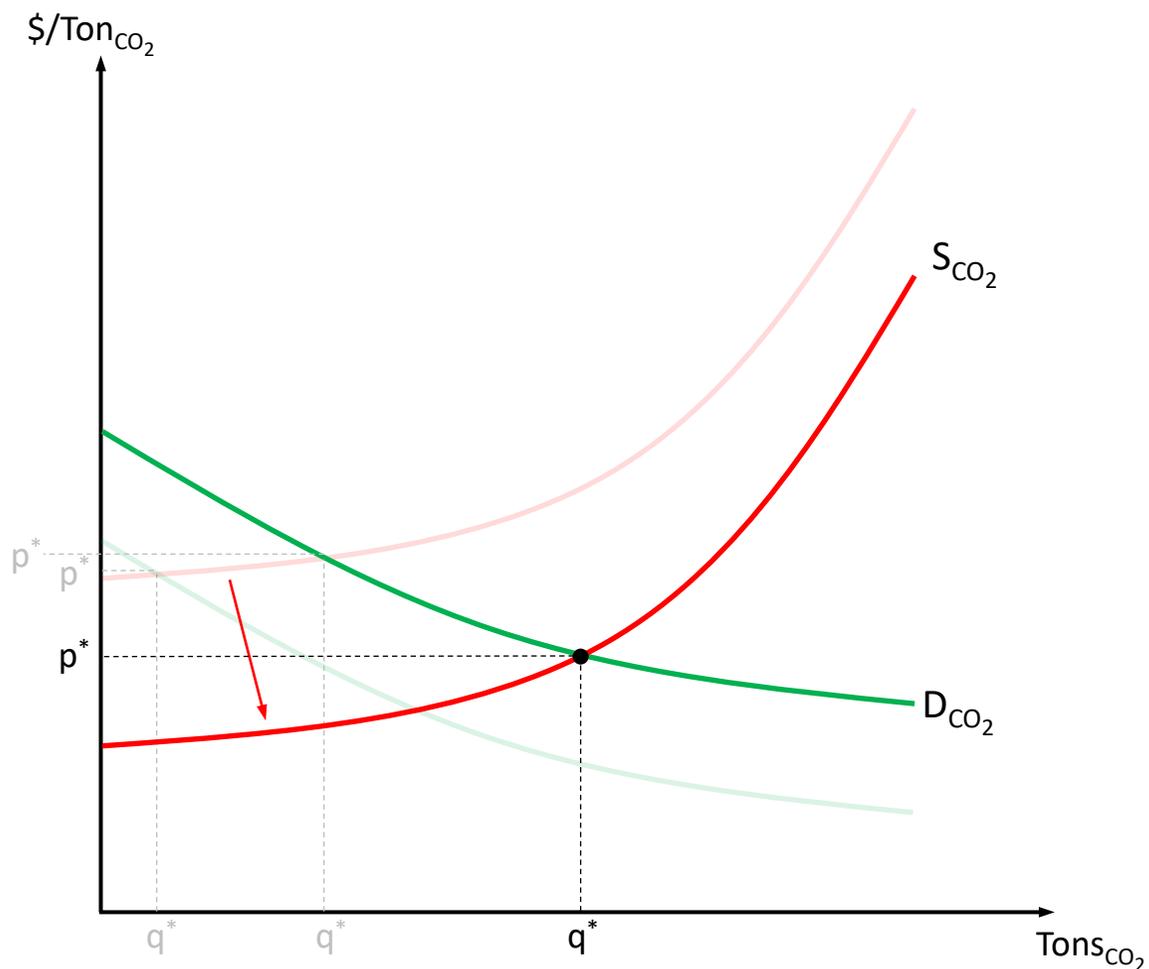
- Innovation, new technologies, new products (carbon-to-value)
- Tax/fiscal policy that lowers infrastructure and project fixed/operating costs (45Q, of course, but local measures matter too)
- Removing permitting/access restrictions or legal barriers
- Market risk and barriers to entry

Demand shifters

- Consumer preference and ESG investor sentiment focused on lower corporate net carbon footprints
- Direct government regulation of emissions
- CO₂ tax

Supply and demand for CO₂ sequestration

Layering in supply-side drivers



Supply shifters

- Innovation, new technologies, new products (**carbon-to-value**)
- Tax/fiscal policy that lowers infrastructure and project fixed/operating costs (**45Q, of course, but local measures matter too**)
- Removing permitting/access restrictions or legal barriers
- Market risk and barriers to entry

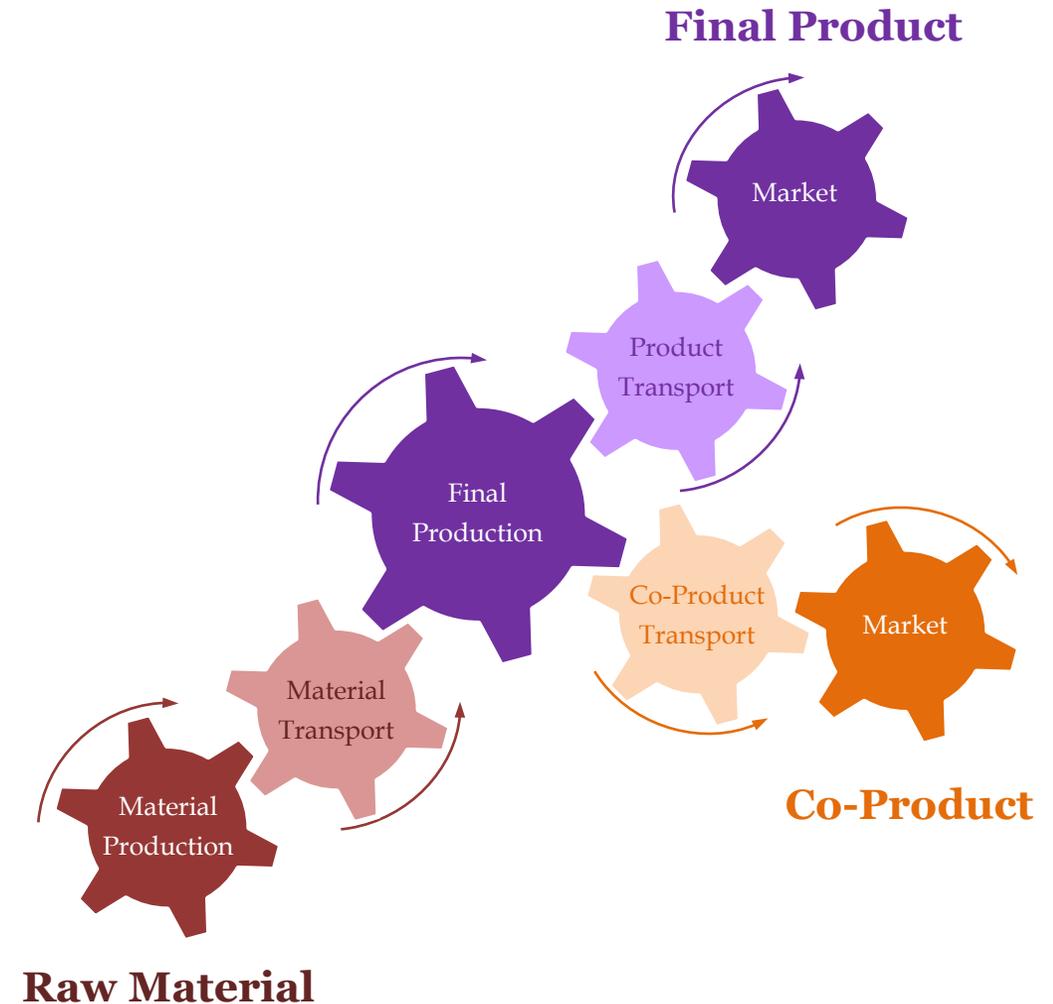
Demand shifters

- Consumer preference and ESG investor sentiment focused on lower corporate net carbon footprints
- Direct government regulation of emissions
- CO₂ tax

Coordination Theory: A Critical Concept

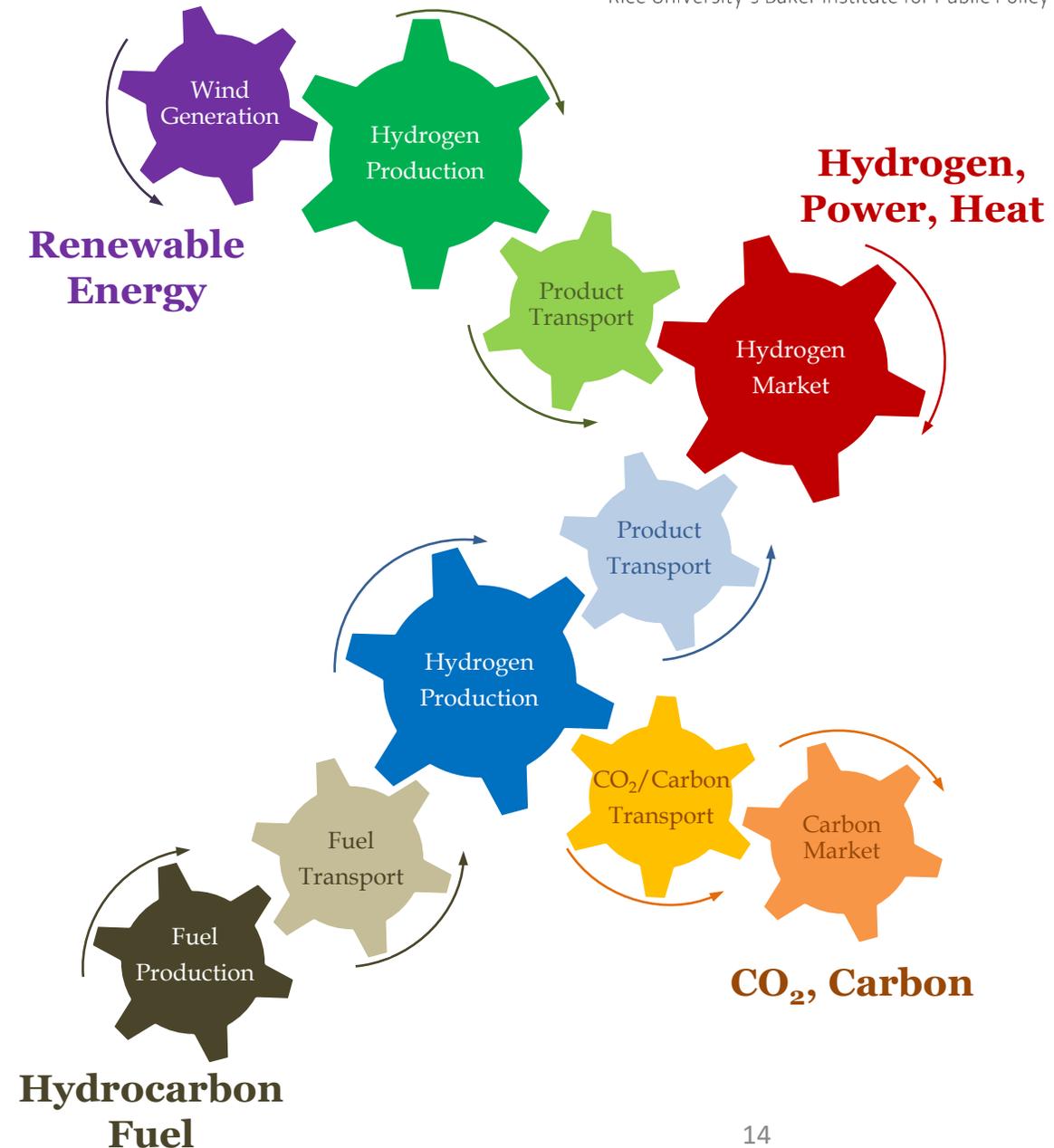
Coordination and the Valley of Death

- Every production process involves a value chain associated with raw material inputs that are used in a production process to deliver a final product and potentially a co-product.
- Thus, coordination theory plays a central role.
 - The simplest example of coordination theory is the prisoner's dilemma.
- If any part of the value chain breaks down, coordination failure ensues. Hence, it is critical that actors along the value chain coordinate development.
- Raw materials must be produced and transported to a user. The user must have an ability to ship the final product plus any co-products to a viable marketable outlet. If any part of this complex set of interactions breaks down, the commercial viability of investments at any point is compromised.
- Note, these complexities can lead to the “valley of death” for new energy technologies.



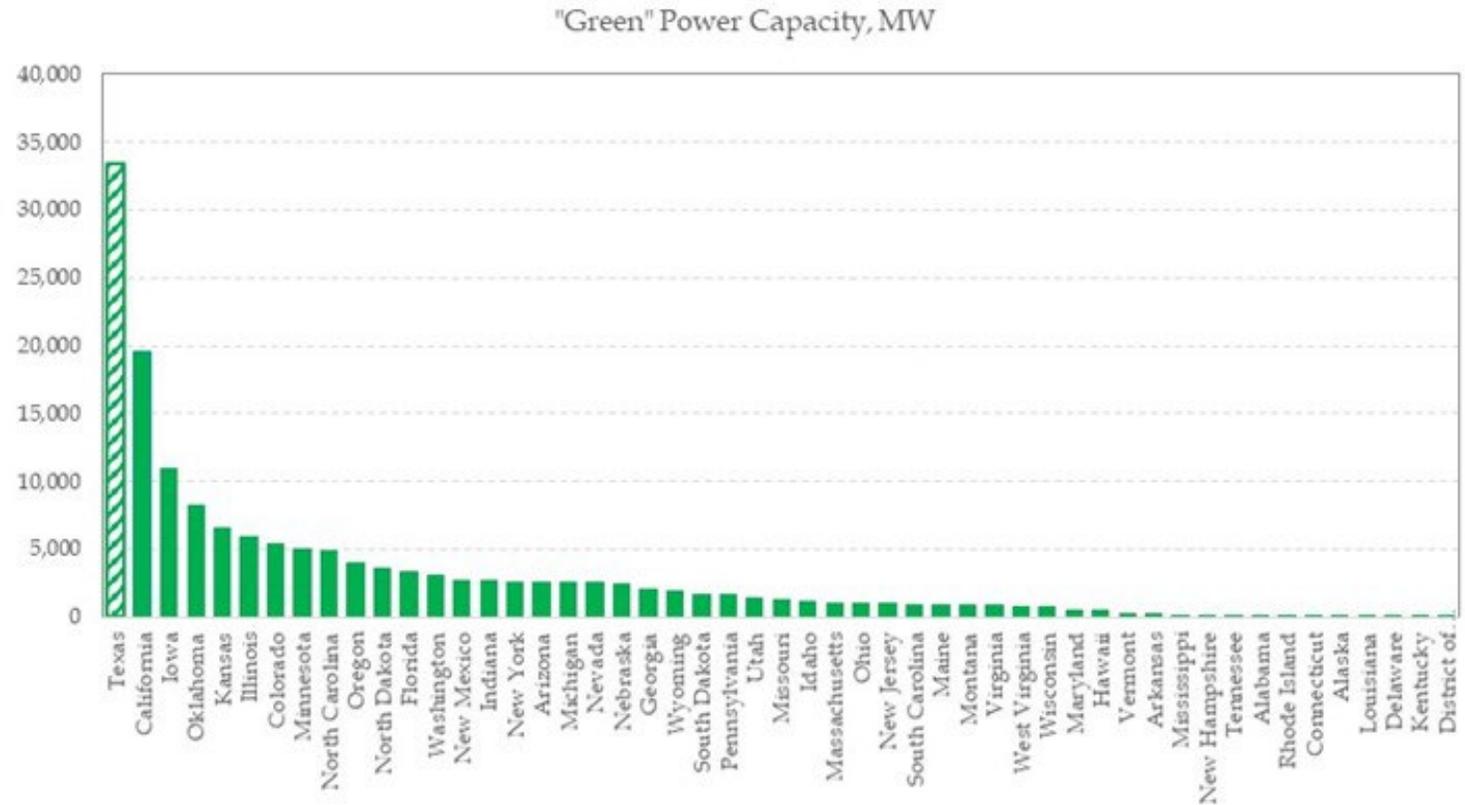
Coordination, Hydrogen with CCUS, and Hubs

- With limited market participation, deals to support investments along the value chain must be bilateral, thus requiring identification of specific counterparty with a specific requirement. Thus, investments are highly conditional on counterparty identification.
- In the presence of a hub, investments along the value chain are de-risked because direct counterparty interaction is not needed. This facilitates investment from all players.
- In the absence of a hub, investments are limited to parties with sufficient risk tolerance, thereby diminishing the scale of the activity.
- One can think of this through the lens of real options. Investing in infrastructure is a real option. One only exercises the option when profitable. In the absence of market liquidity, a liquidity premium exists that renders the option value lower, thus reducing investment. Liquidity increases scale.



Coordination Theory at Work

- Texas power generation market. #1 in wind capacity (26% of US), #2 in battery capacity (10% of US), and #3 in solar capacity (10% of US). Total MWs of installed “green” capacity → #1 in the US.
 - Senate Bill 7 (1999), tax incentives at the Federal, State and local levels, all matter.
 - But, growth did not occur until investment in the Competitive Renewable Energy Zones (CREZ) happened.
- Coordination theory at work. The CREZ was a \$7 billion investment approved by the Texas PUC and completed in 2013. Costs are rolled into wholesale rates.
- The CREZ provided transmission, which allowed access to a liquid market, i.e.- hubs. This de-risked investment in renewable capacity and supported significant expansion, with a lot more coming.
- Hydrogen and carbon capture will follow suit with market liquidity.



center for
**ENERGY
STUDIES**
Rice University's Baker Institute

Stay connected...

Web: www.bakerinstitute.org/center/center-energy-studies

Bio: www.bakerinstitute.org/expert/kenneth-b-medlock-iii

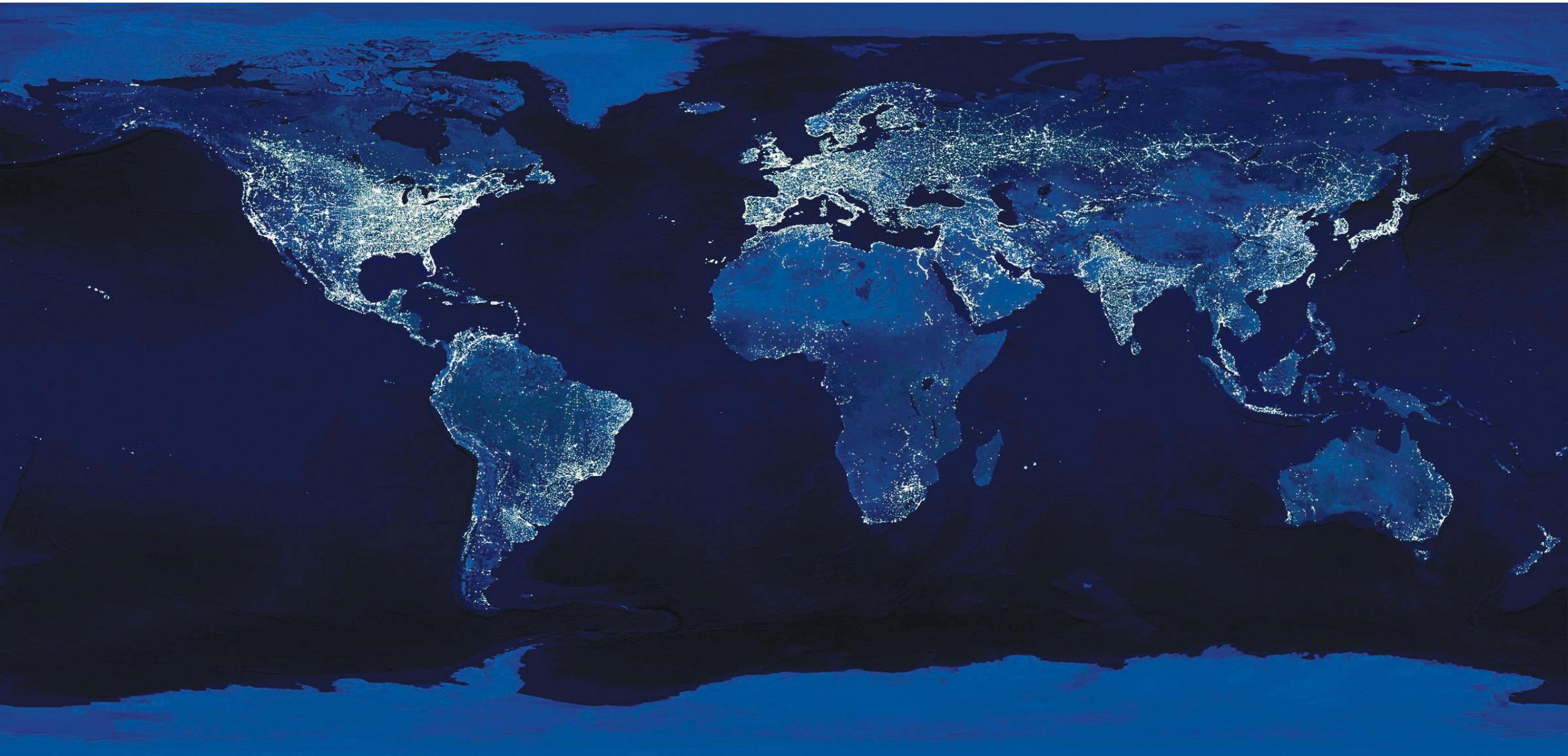
Email: medlock@rice.edu

BONUS MATERIAL

Why CCUS?

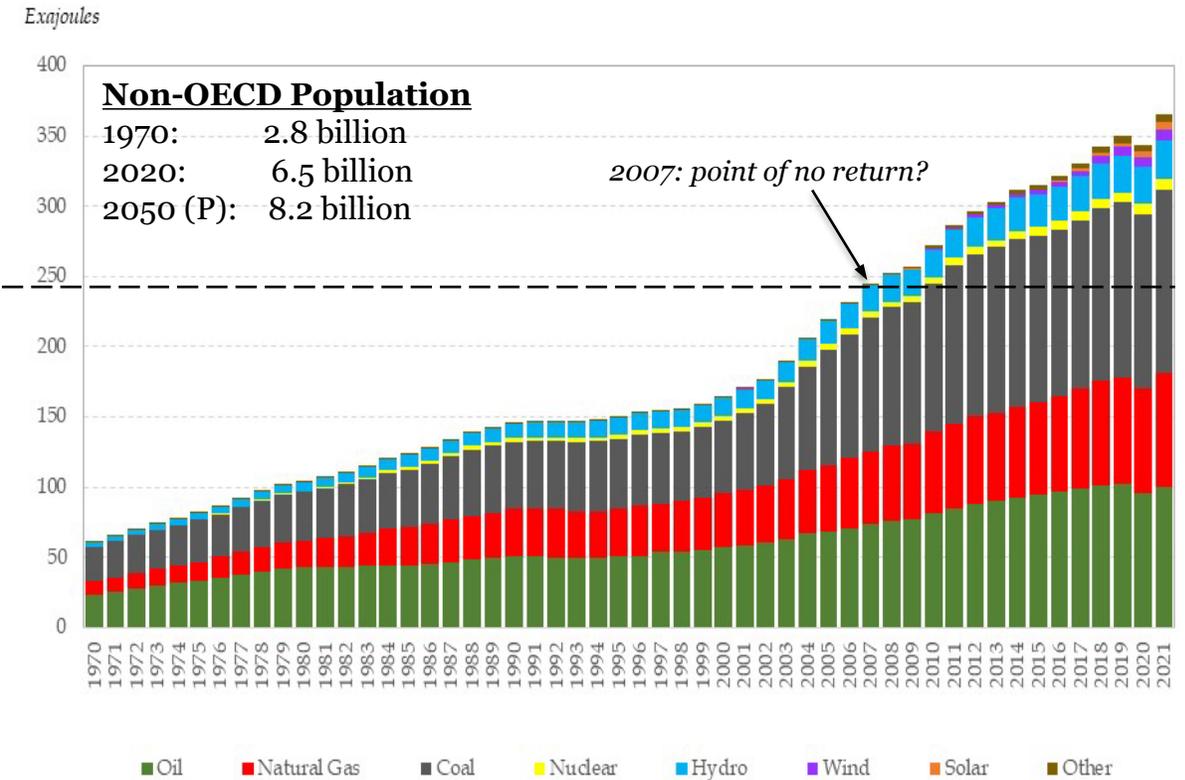
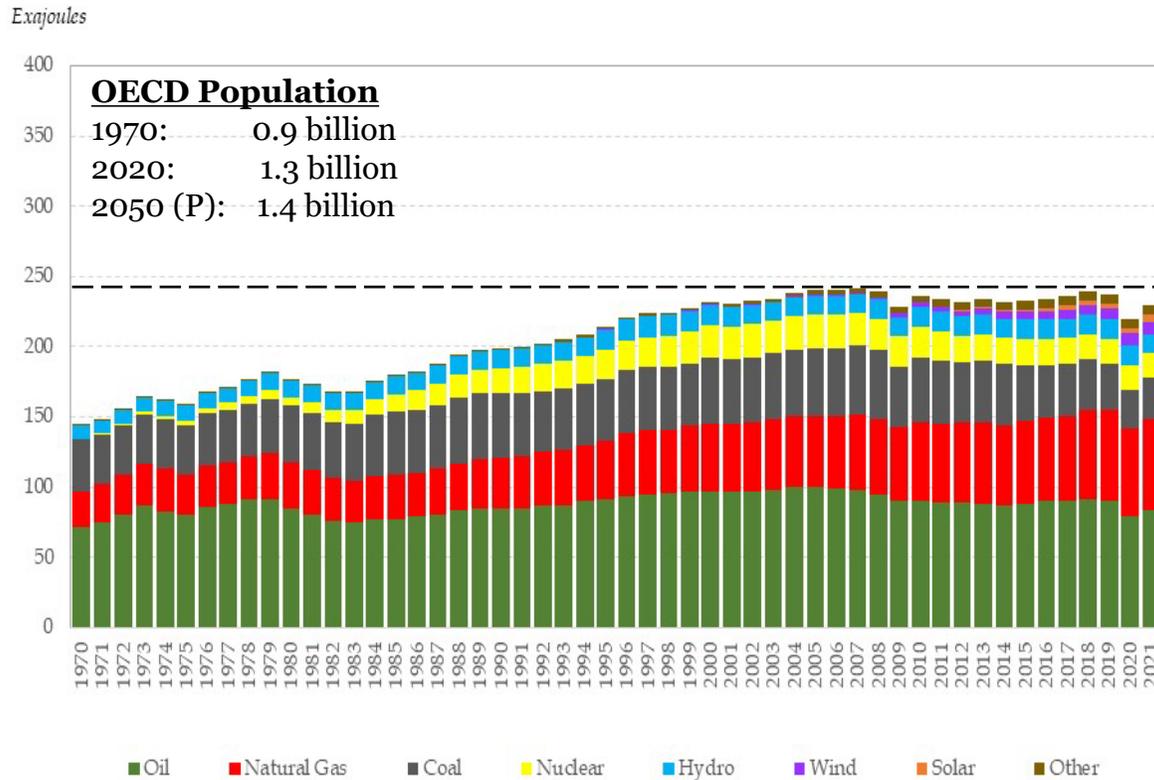
A Look at the Global Scale of Energy and the Challenge of Decarbonization

Energy is about the legacy and scale of existing infrastructure, and the technology embodied in it...



The evolving energy landscape is a developing nation story

- Energy demand is rising fastest in the developing world, largely driven by hydrocarbon fuels.
 - EU is 11.8% of global demand; N. America is 20.0% of global demand; developing Asia is 36.9% of global demand.
- Projections for population and economic growth indicate this trend will likely continue.



The global energy landscape, the reality of “scale”

- Even with double-digit year-on-year percentage increases for wind and solar over the last 20 years, they are still a small proportion of the total energy mix, 2.5% and 1.4%, respectively, in 2020.
- Demand continues to grow.
- Electricity is about 43% of total energy. Zero-carbon generation sources: nuclear at 10%, hydro at 16%, and wind+solar at 13%... of electricity.
- Hydrocarbons account for 61% of power generation, 99% of all non-electric energy, and 82% of all energy.
- Decarbonization will require multiple solutions, and must include *net* decarbonization of incumbent supply chains. This is the reality of scale.
- The paths will look different everywhere, and will hinge on “resource” endowments – nature, minerals, energy, human capital, etc.

