ECONOMICS OF CARBON CAPTURE, UTILIZATION, & STORAGE

CEEPR Fall Research Workshop

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Overview

Policy Context of CCUS*

Instrument Choice & Federal 45Q Tax Credit

Air Pollution Co-benefits of CCUS

* I am not going to focus on Direct Air Capture or BECCS

SOURCE: Shell

Why Economics of CCUS?

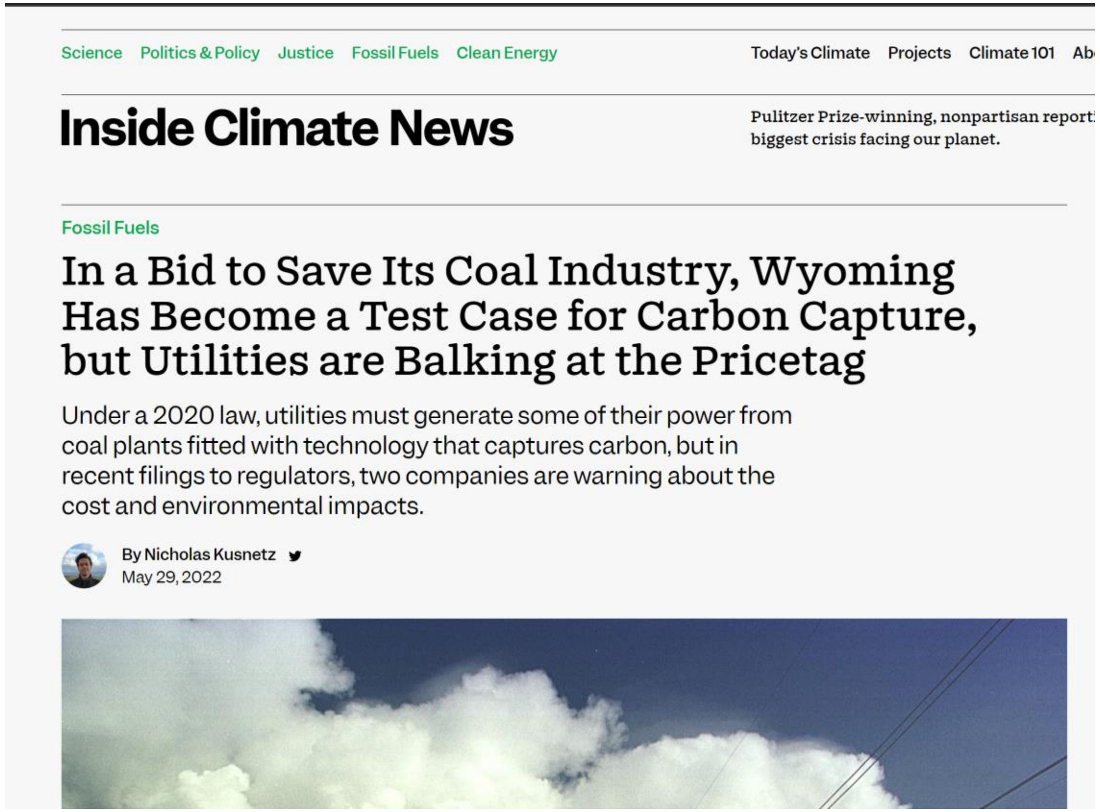
IEA's *WEO* Sustainable Development Scenario 2050 CCUS 9% of CO_2 ↓

IPCC AR5: excluding CCUS would double costs of avoiding 2ºC ↑

A key component of Biden's 2035 net zero carbon electricity sector goals

Much work in engineering about how to do CCUS and cost estimates

Relatively little work in Economics on CCUS



Science Politics & Policy Justice Fossil Fuels Clean Energy Today's Climate Projects Climate 101

Inside Climate News

Pulitzer Prize-winning, nonpartisan report
biggest crisis facing our planet.

Fossil Fuels

In a Bid to Save Its Coal Industry, Wyoming Has Become a Test Case for Carbon Capture, but Utilities are Balking at the Pricetag

Under a 2020 law, utilities must generate some of their power from coal plants fitted with technology that captures carbon, but in recent filings to regulators, two companies are warning about the cost and environmental impacts.

By Nicholas Kusnetz
May 29, 2022

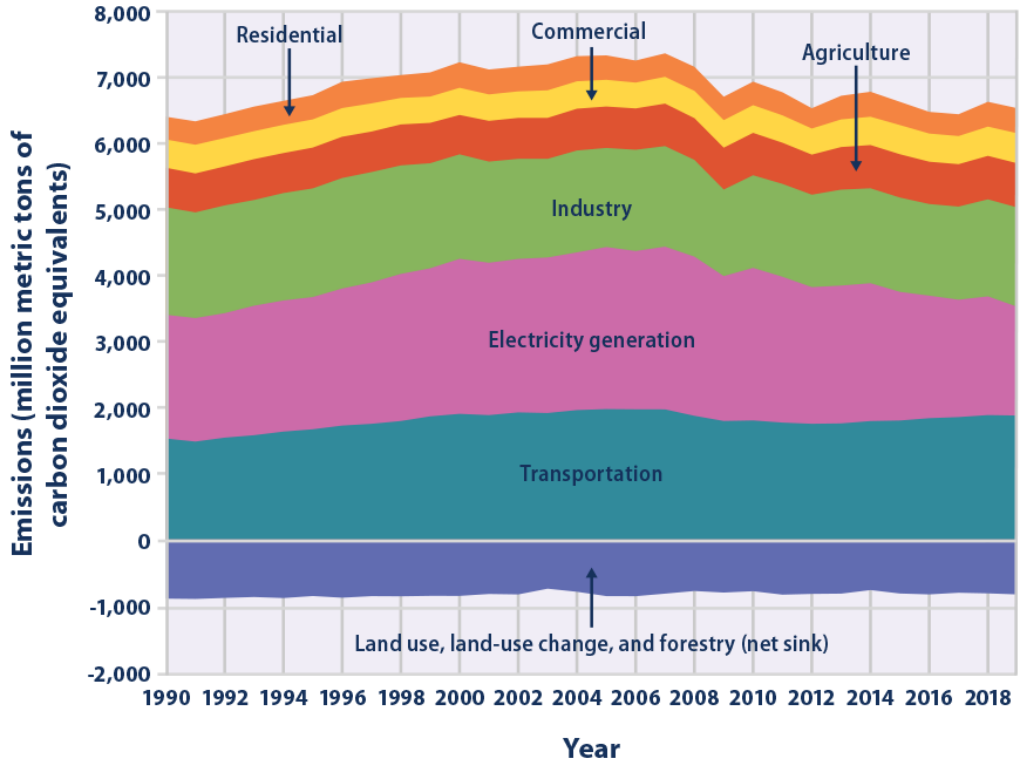
Source: https://insideclimatenews.org/news/29052022/coal-carbon-capture-wyoming/

Where to put CCUS?

Technological constraints: capture is very, very expensive → only economical for large pure CO_2 sources

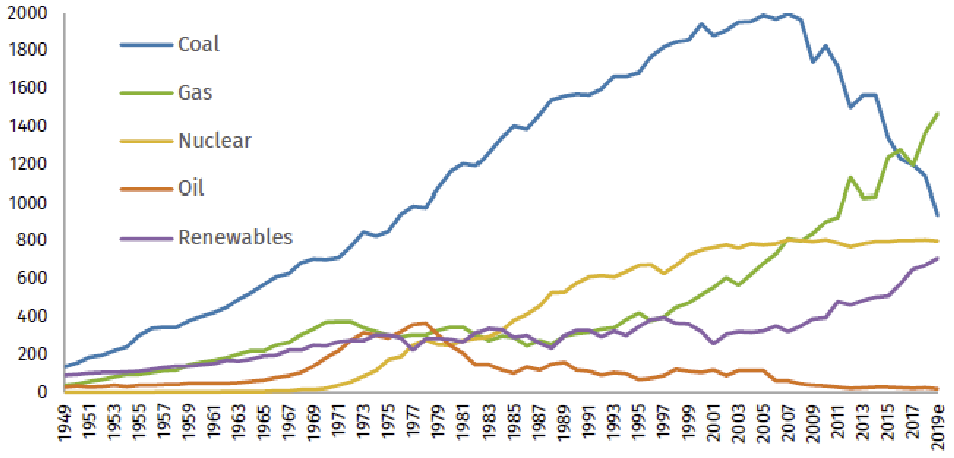
CCUS-coal or –natural gas could be justified as a bridge until full renewables/storage is feasible

Case for CCUS for industrial emissions is more compelling: few feasible low-carbon technological alternatives for near-term



US power generation by energy source

Billion kWh, electric power sector only, does not included distributed generation



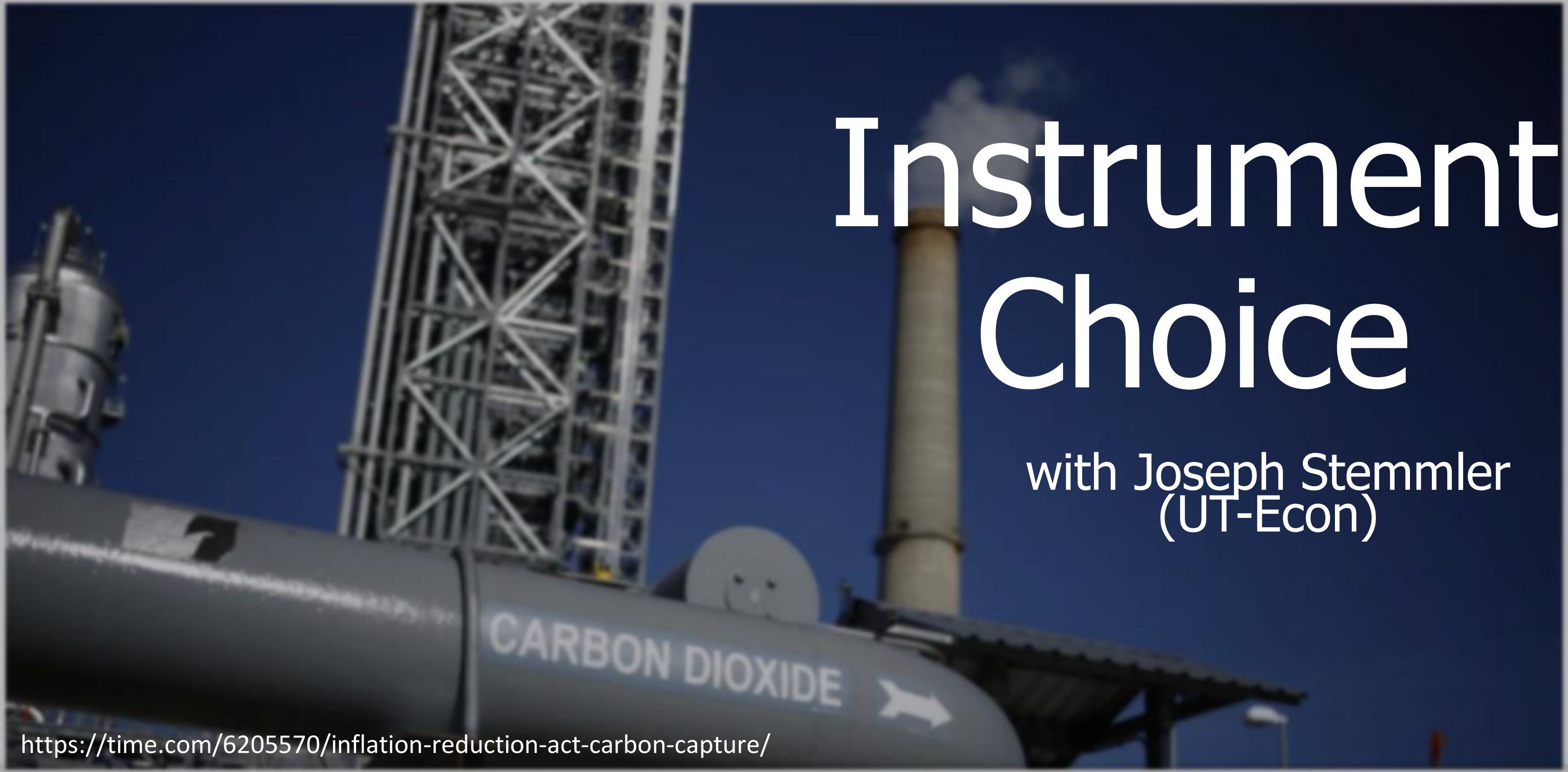
Source: Rhodium Climate Service

Sources: https://www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions, https://rhg.com/research/preliminary-us-emissions-2019/

TIME SPOTLIGHT STORY DONALD TRUMP ENTERS THE ARENA AGAIN SIGN IN

CLIMATE • POLICY

The Inflation Reduction Act Includes a Bonanza for the Carbon Capture Industry



Instrument Choice

with Joseph Stemmler
(UT-Econ)

https://time.com/6205570/inflation-reduction-act-carbon-capture/

2022 IRA & 45Q CCUS CO2 Production Tax Credit

- Increased all credits, also DAC
- Direct pay
- Zommence construction window extended seven years to January 1, 2033
- Transferability of tax credit
- Lowers CO_2 threshold (18,750 mmtpa EGU, 12,500 mmtpa industrial)
- Wage/Apprenticeship Req's

End Use	**Current Amount**	**Base credit** (not meeting Wage and Apprenticeship Requirements)	**Increased amount** (meeting Wage and Apprenticeship Requirements)
Traditional Carbon Capture: Carbon Oxide *Used or Utilized*	$35	$12	$60
Traditional Carbon Capture: Carbon Oxide *Sequestered*	$50	$17	**$85**
Direct Air Capture: Carbon Oxide *Used or Utilized*	$35	$26	$130
Direct Air Capture: Carbon Oxide *Sequestered*	$50	$36	**$180**

ource: White & Case, LLP; Sidley Austin LLP (Data Updated August 17, 2022)

How does 45Q compare to alternative policies?

Carbon tax & social cost of carbon (SCC)

R&D subsidies & positive externalities

Clean energy standards

45Q: Subsidy per ton of CO_2 stored, subsidy lasts 12 years

- A firm that was not profitable under a $85/ton carbon tax will be under 45Q
- A firm with 2 plants: high CO_2 & low CO_2 → Incentivized to use high CO_2 plant
- Compared to Renewable Energy Subsidies→ subsidizing a polluting sector
- Does CCUS industry need to be subsidized forever to be profitable without a carbon tax?

Air Pollution Co-Benefits of CCUS

with HR Huber-Rodriguez & Sheila Olmstead

https://www.nrdc.org/experts/david-doniger/epa-launches-multi-pollutant-power-plant-pollution-strategy

Key Questions

- Potential climate co-benefit/costs (local air pollution) of CO_2 ↓ via carbon capture, utilization and storage (CCUS)?
- Policy “Counterfactual”: Damages if existing CCUS incentives result in current technology investments?
- How are the co-benefits/costs distributed across affected populations?

Co-benefits

"co-benefits account for about 46 percent of the monetized benefits on average across all RIA" – Aldy, et al., 2021, NBER

More than direct CO_2 benefits (Buonocore, et al., 2016; Fullerton & Karney, 2018; Burtraw, et al., 2014)

Scope of Analysis

1. Retrofit on Gulf Region industrial facilities (as in prior work) where economically & technically feasible (Waxman, et al., 2021 *EP*)
2. Comparison to Gulf Fossil Fuel Power Plants
3. Other non-Gulf US generation & industrial facilities (still underway)

Data

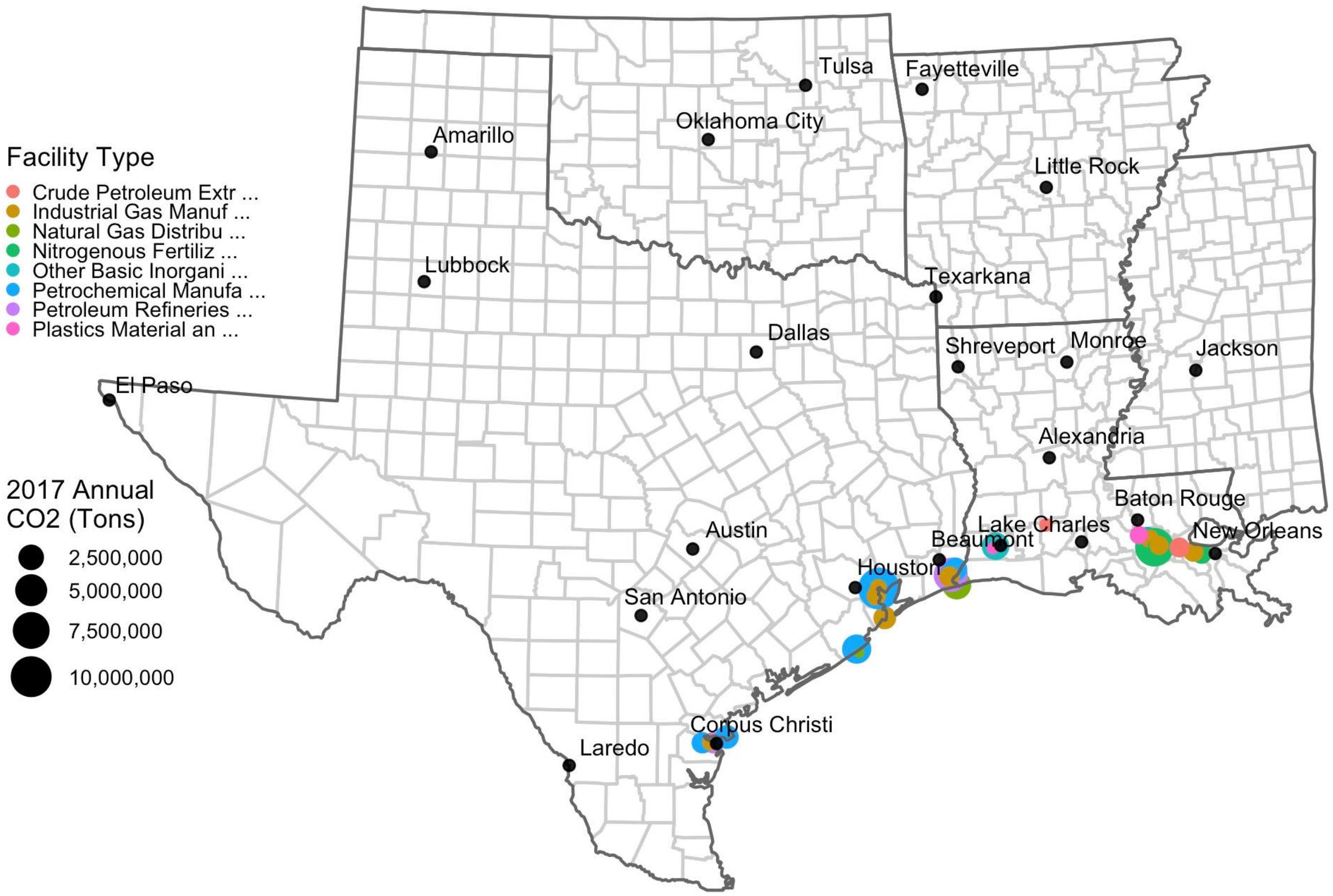
Facility locations & emissions: EPA National Emissions Inventory (NEI) & Constant Emissions Monitoring System (CEMS)

Source-receptor pollution dispersion model estimates (Latimer, 1995)

NOAA weather data

US Census American Community Survey, American Housing Survey

Industrial Facilities in our Sample

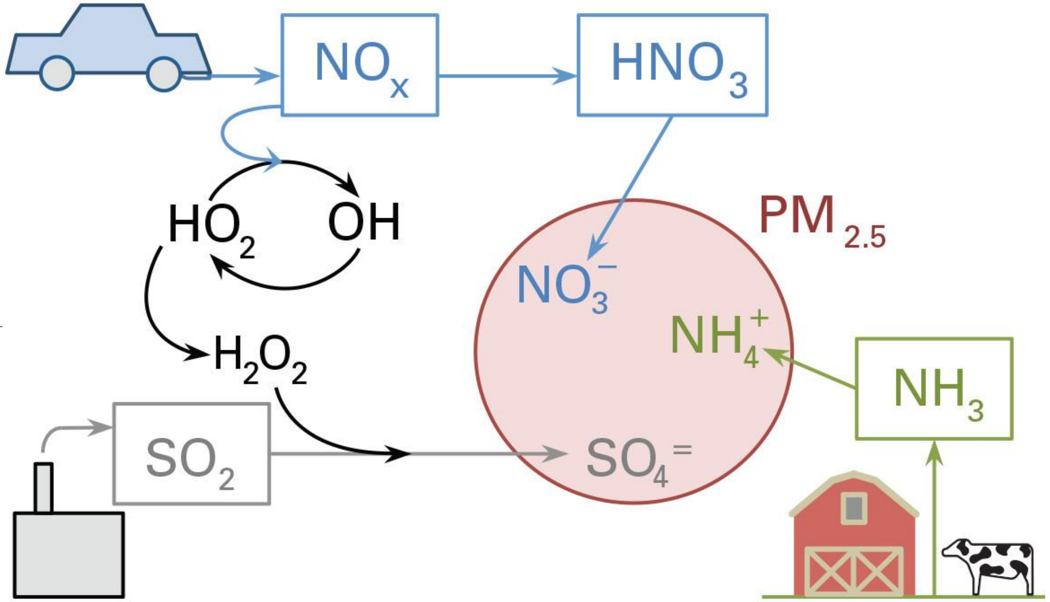


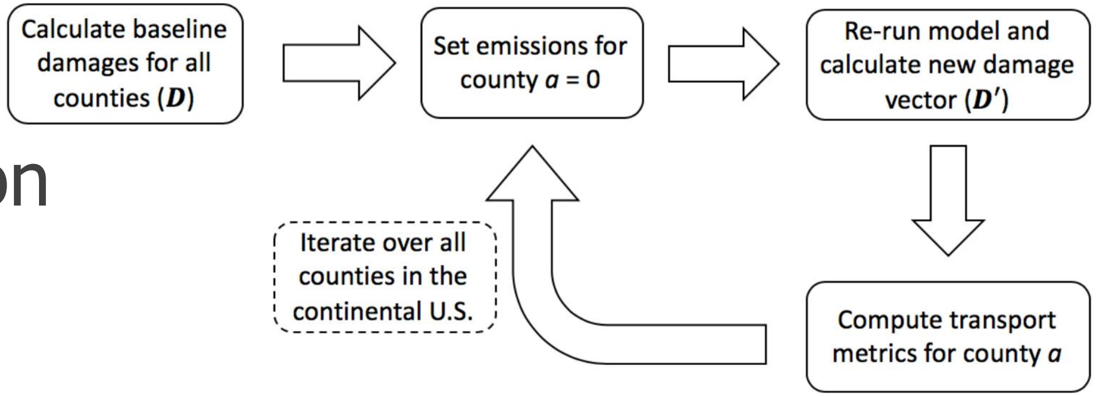
Translating Emissions into Concentrations

Gaussian plume model from Climatological Reginal Dispersion Model (Latimer, 1996)

Accounts for wind, weather, vertical dispersion, deposition and distances and heights of emission sources and concentrations

Accounts for **primary** pollutant production & **secondary** via photochemical interactions between pollutants ($PM_{2.5}$, NOx, ammonia, $SO_{2)}$





Methodology

Data on baseline facility emissions EPA NEI, CEMS

Hypothetical CCUS emissions to calculated emissions change: Δe_i from engineering literature

Aggregate emissions to county level combining w/ other point & non-point emissions EPA NEI

Source-Receptor Model (AP3): county level emissions → pollution concentrations w/ wind dispersion model w/in & across counties

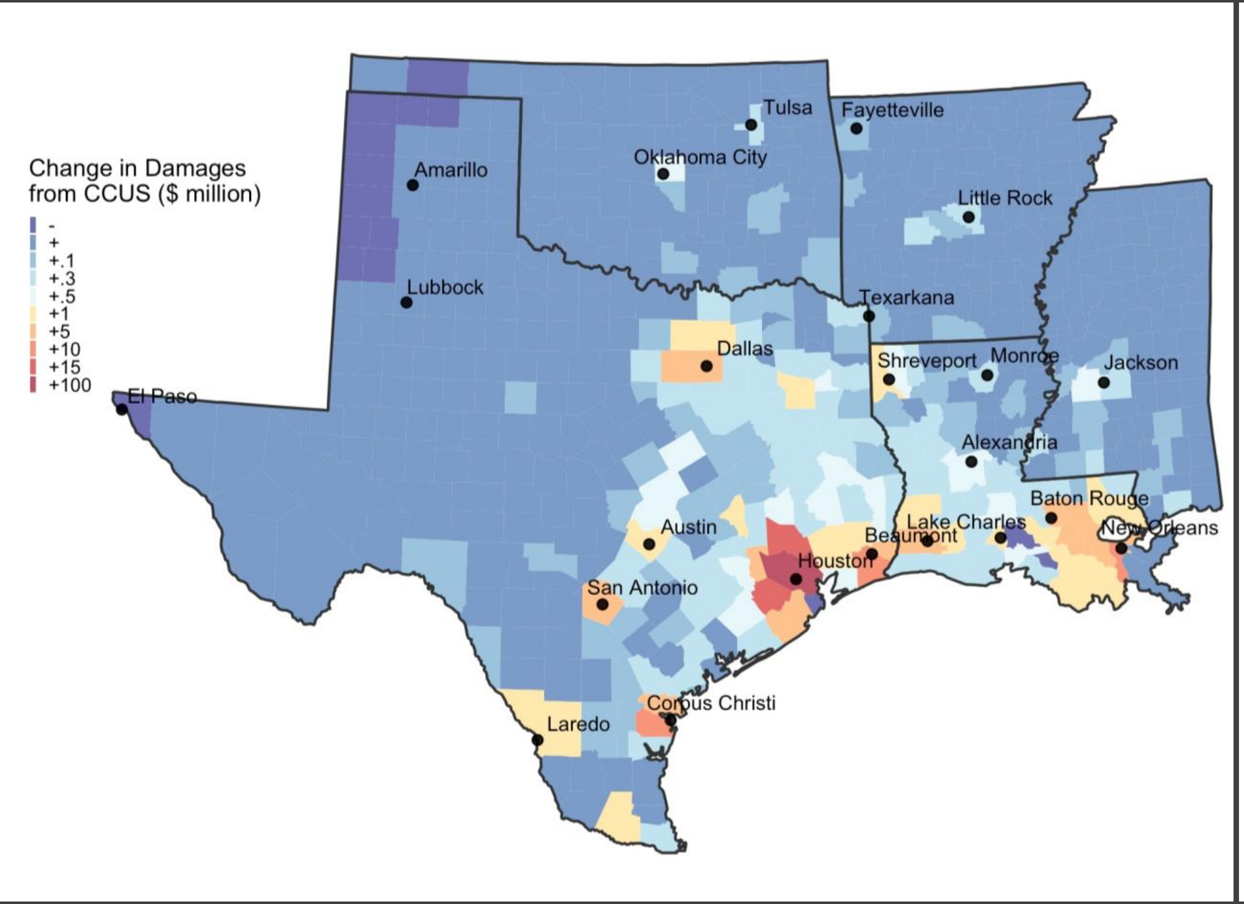
Calculate mortality impacts population, baseline mortality & concentration response function → Value mortality impacts using EPA Value of a Statistical Life (VSL)

Preliminary Results

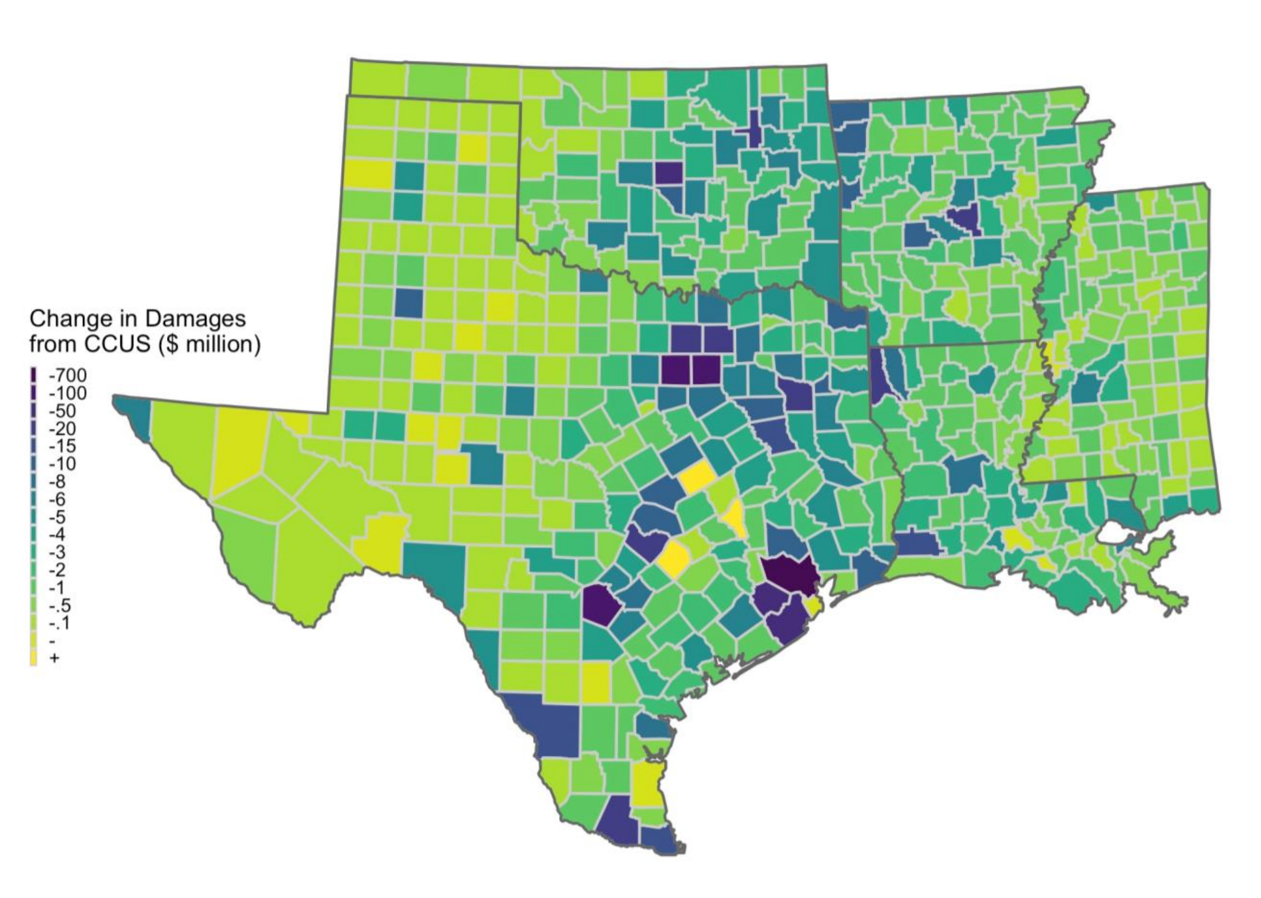
Lost Cabin Gas CCUS Plant, WY *Source:* https://rbnenergy.com/way-down-in-the-hole-part-6-carbon-capture-projects-still-hold-promise-but-hurdles-remain

Damages from all 5 pollutants

Industrial



EGUs



	Type	Facilities	Total	Mean	St. Dev.	Min.	Max.
Annual CCUS Air Pollution Damages ($ mil.)	Industrial	35	290.6	8.3	15.8	0.1	92.4
	EGU	92	-5,700	-62.0	215.5	-1,531	40.8
	All	127	-5,409	-42.6	186.0	-1,531	92.4

		2% SCC	3% SCC	5% SCC
Total CO_2 Reduction Benefits	Industrial	4,825.5	3,225.5	914.1
	EGU	20,516	13,713	3,886
	All	25,341	16,939	4,800
Co-Benefit Ratio (Air Pollution/CO_2)	Industrial	2.0	3.0	10.5
	EGU	-8.2	-12.2	-43.1
	All	-6.2	-9.3	-32.7

Environmental Justice Implications

Correlation: ΔDamage pc & Economic Variables

From InMAP model, observations are Census Block Groups, demographics from ACS, EJ indicators EPA EJScreen

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	EGU	Ind.	EGU	Ind.	EGU	Ind.	EGU	Ind.	EGU	Ind.	EGU	Ind.
Tot. Block Group Popul.	4.60***	-0.008										
	(3.471)	(-0.554)										
Popul. Density			0.298**	-0.003								
			(2.139)	(-1.110)								
Med. HH Inc.					0.042**	0.000						
					(2.182)	(0.497)						
% below poverty line							-35.101	-1.994*				
							(-0.622)	(-1.900)				
% in metro area									10^5***	1,695***		
									(3.560)	(3.664)		
Unemployment Rate											-285.8	-3.25**
											(-1.554)	(-2.072)

Correlation: ΔDamage pc & Demographic Variables

From InMAP model, observations are Census Block Groups, demographics from ACS, EJ indicators EPA EJScreen

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	EGU	**Ind.**	**EGU**	**Ind.**	**EGU**	**Ind.**	**EGU**	**Ind.**	**EGU**	**Ind.**	**EGU**	**Ind.**
% Black	-67.920	0.799										
	(-1.026)	(0.581)										
% Hispanic			5.945**	0.015								
			(2.483)	(0.366)								
% Asian					171***	-0.391						
					(2.776)	(-0.227)						
% white							-8.181	0.447				
							(-0.174)	(0.578)				
% housing pre-1960									-7,018*	-209.36**		
									(-1.919)	(-2.384)		
Traffic Proximity											0.604	-0.013
											(1.542)	(-1.099)

Correlation: ΔDamage pc & Pollution Variables

From InMAP model, observations are Census Block Groups, demographics from ACS, EJ indicators EPA EJScreen

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	EGU	Ind.	EGU	Ind.	EGU	Ind.	EGU	Ind.	EGU	Ind.
Wastewater Discharge Index	29.828	-0.308								
	(1.447)	(-0.962)								
Superfund Proximity			5,791	-105.22						
			(0.962)	(-1.606)						
RMP Proximity					510.478	9.654				
					(1.042)	(0.578)				
Hazardous Waste Proximity							1,100	21.83		
							(1.638)	(1.029)		
Underground Storage Tanks									215.6	1.660
									(0.854)	(0.318)

Conclusions

Illinois Industrial CCUS Project. *Source:* https://www.carbonbrief.org/around-the-world-in-22-carbon-capture-projects/

Summary of Results

Post-combustion CCUS for CCNG and PC likely to increase NH_3 emissions, lower other criteria pollutants/precursors (especially SO_2 for coal)

Using source-receptor matrices, secondary PM formation results in net decreases, with large damage reduction near power plants

Correlated for EGUs with income & some race/ethnicity, not correlated with pre-existing pollution exposure measures

Thank You