Carbon Capture:

The PR and the Realities

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by

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Briefing for the League of Women Voters

Carbon Capture:
We hear that it's a "climate solution"

We hear:

*** It's "unproven" but very promising**
*** It's expensive**
*** It needs gov't investment to bring costs down**

What we *don't* hear:

*** It <u>is</u> proven. It has so far proven not to work.**
*** The public has been** (mainly) **paying for it already.**

The PR We Hear

The Problem We Face

The Realities of Carbon Capture

What *Could* Work

The PR

Advocates & promoters of carbon capture have crafted the vocabulary and thereby controlled the conversation.

- **Carbon “capture”** Sounds good.
- **Capture “technology”** Sounds high-tech & clean.
- **“Net zero”** Sounds great.
- **“Carbon management”** Sounds professional.
- **“Carbon recycling”** Sounds fabulous.

Does carbon capture "work"?

To answer, define the problem and the need.

- The problem:

  Excess concentration of CO_2 in the atmosphere.

- The need:

  Reduce the level of CO_2 in the atmosphere.

- The 'carbon capture' solutions:

  1. Capture emissions at sources.
  2. Pull CO2 out of the air – "direct air capture".

  I.e., We do not need to stop burning fossil fuels.

But neither "solution" is correcting the problem.

And #1 does not even address it.

The problem

that needs to be solved:

The *excess* CO_2 that is in the atmosphere.

(and other GHG's, but today we're only talking about *carbon* capture).

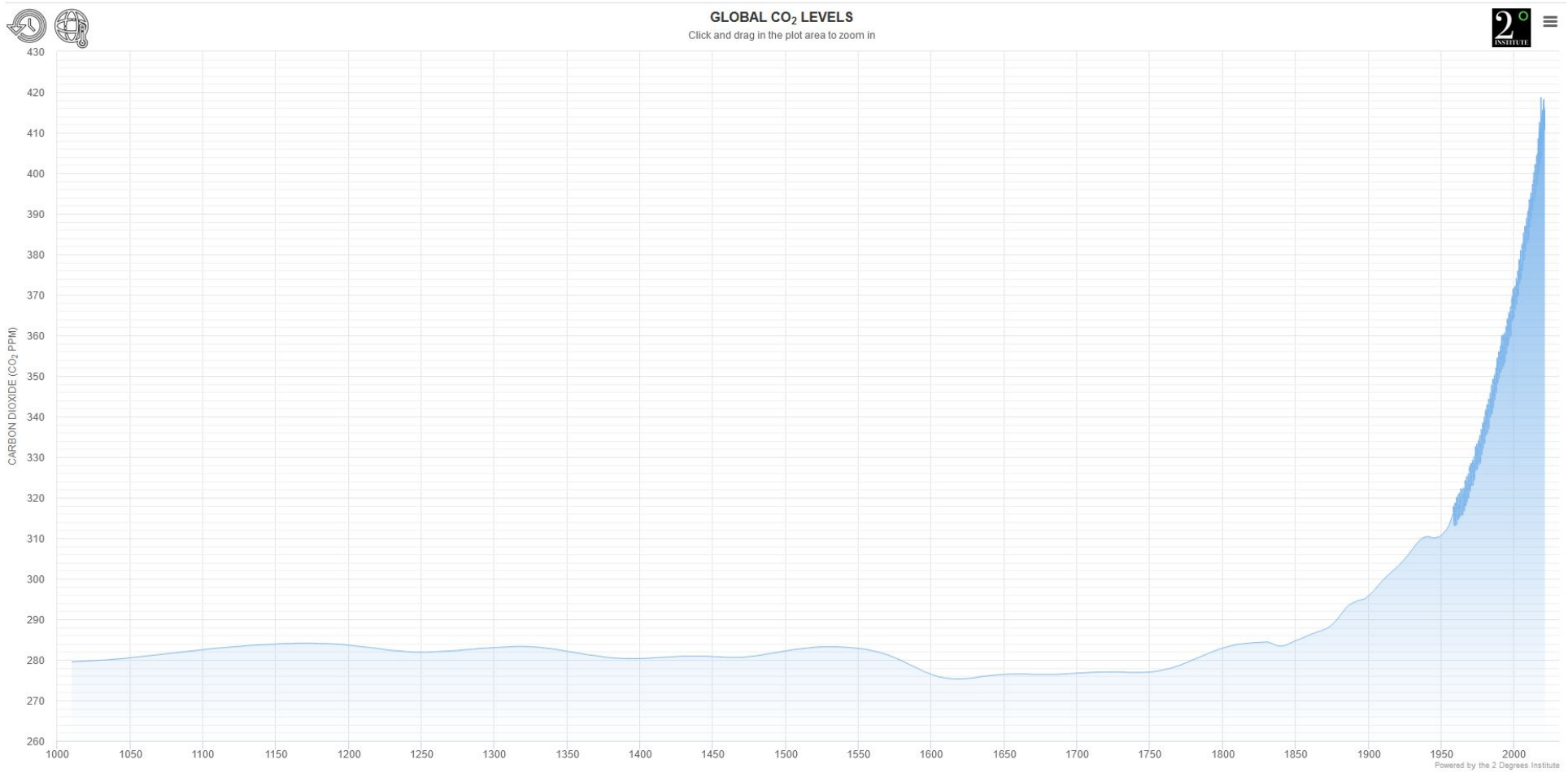
CO_2 level in the atmosphere—

280 ppm for 6,000 years of human civilization,

until the Industrial Revolution, mid-1700's.

Now at 420 ppm.

CO_2 level in the atmosphere (since 1000).
Carbon cycle kept balance for 1000's of years.



source: https://www.co2levels.org/

1000 2021

Carbon Capture / Sequestration

2 Approaches:

- Mechanical methods

- Biological methods

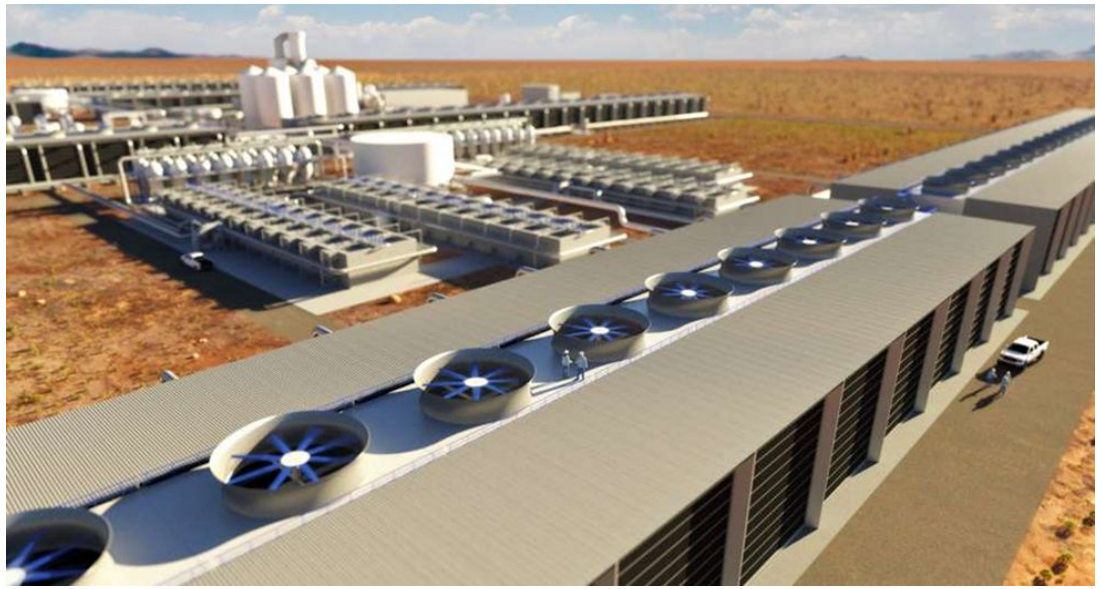
The Two Mechanical Methods

Trap Emissions

"Point-Source capture"
('CCS' and 'CCUS')

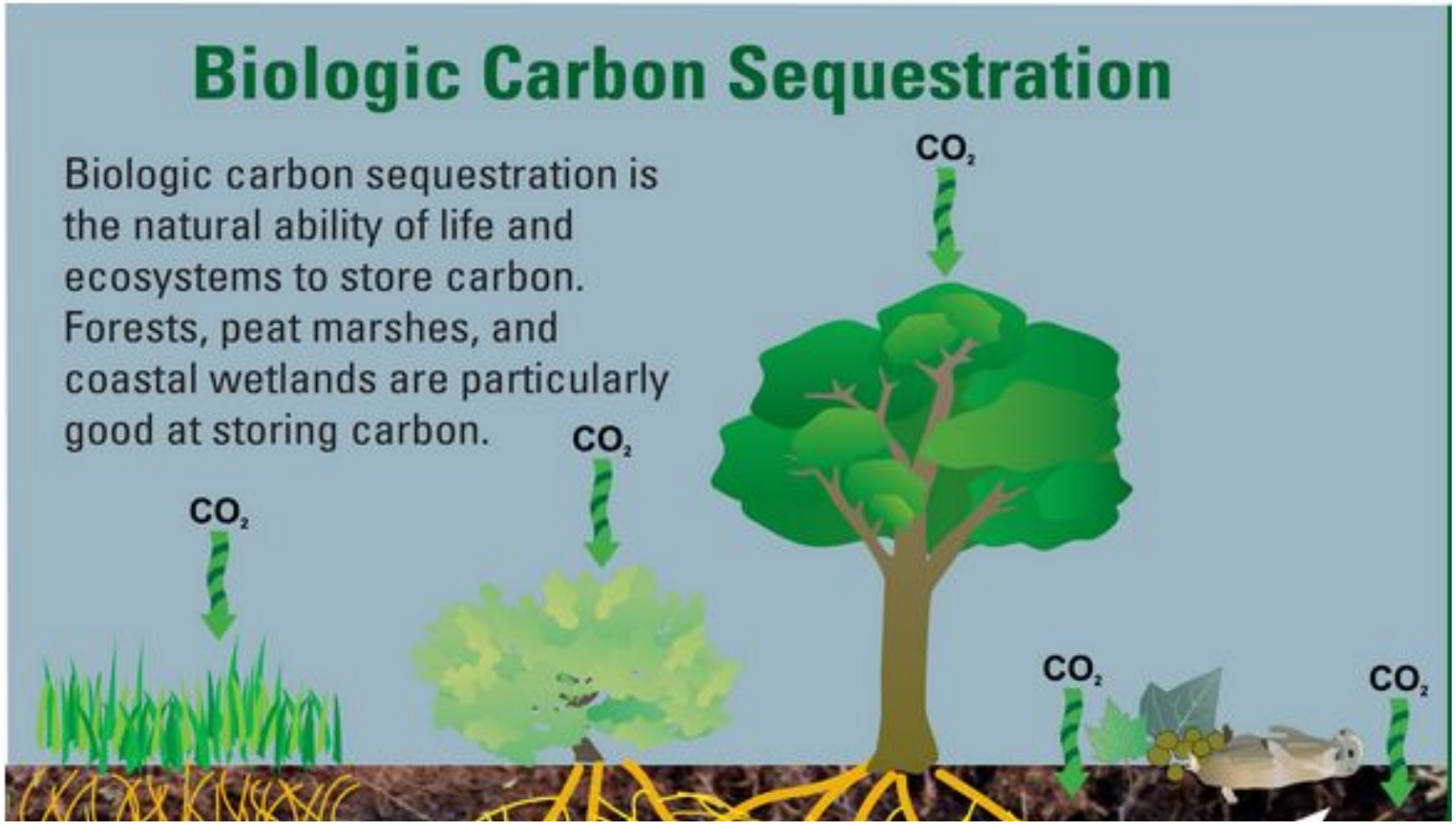
Pull CO_2 from Air

"Direct Air Capture"
(DAC - 'direct air capture').



Industrial machinery **traps flue gasses or sucks in air.**
Chemicals **separate out CO_2**

Biological Methods



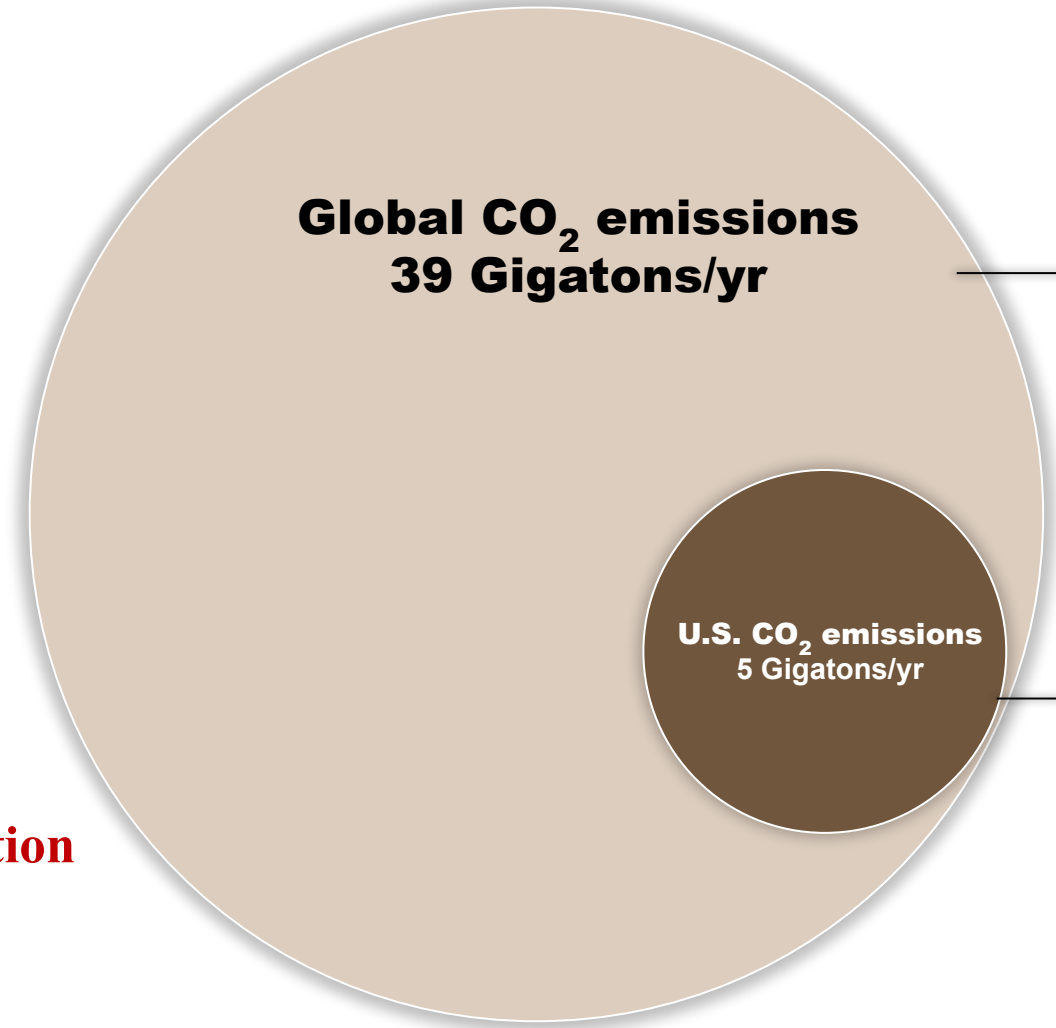
Source: U.S. Geological Survey

What are we doing now?

in terms of CO_2 emissions and carbon capture

First, the context…

Anthropogenic CO_2 emissions/yr



Causes:

- **Fossil fuel combustion**
- **Eco-system destruction**

Global CO_2 emissions per year:

39 Gt[1]

36 Gt fossil fuel combustion

3 Gt ecosystem destruction

U.S. CO_2 emissions per year:

5 Gt

1 Gt is one billion tons

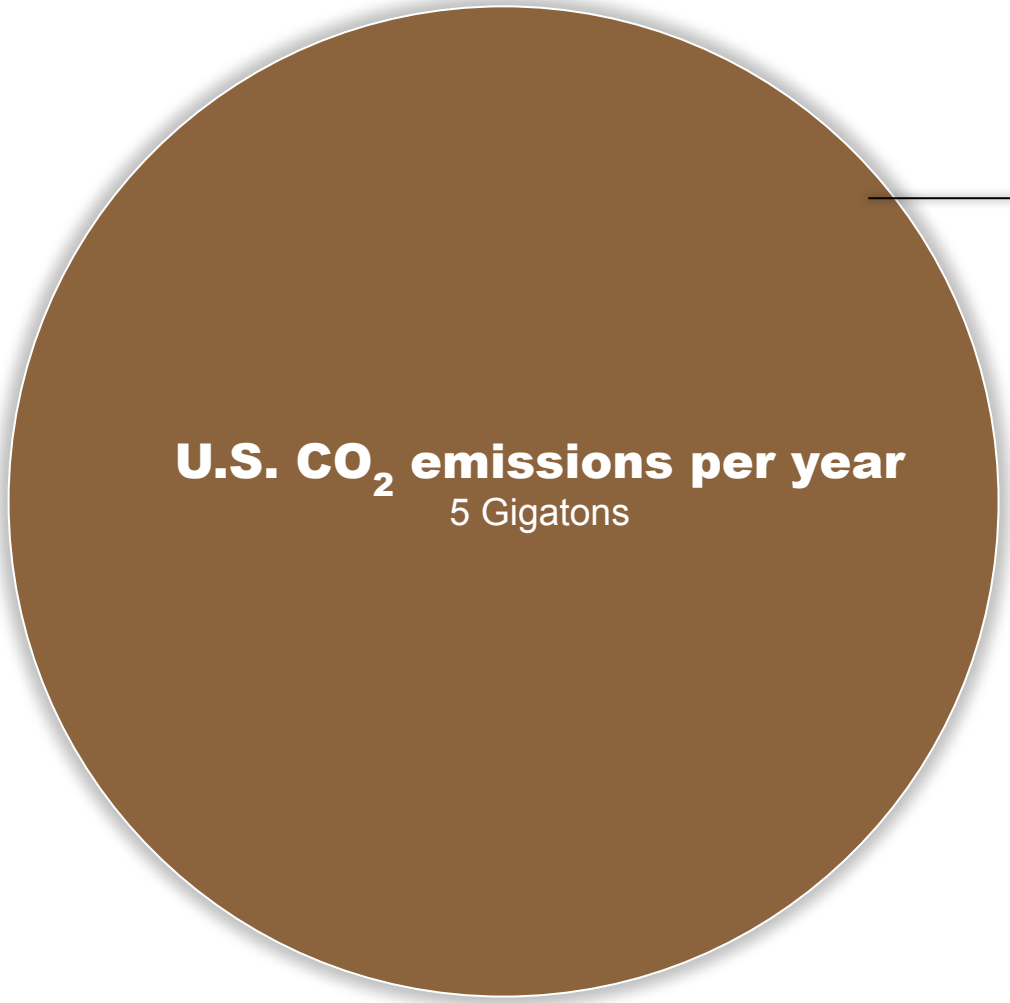
U.S. anthropogenic CO_2 emissions/yr

U.S. CO_2 emissions per year:
5 Gt[1]

1 Gt is one billion tons

CO_2 removed from the atmosphere now by **mechanical carbon capture:**

~0



U.S. CO_2 emissions per year:
5 Gt[1]

Mechanical carbon capture:
Amount of CO_2 emissions captured – *gross*[2]*; not net*: 0.02 Gt/yr

Amount of CO_2 being *removed* from the atmosphere: ~0

1. Gt: gigaton. 1 Gt is one billion tons

2. Amt. CO_2 captured per year from Global CCS Institute 2021 report. Note: this excludes emissions from the CCS process itself and from EOR production and the oil transport, refining and combustion of that oil. Also note, all U.S. commercial capture is source capture: no CO_2 is being removed from the atmosphere.

Amount of CO_2 being removed globally 0.000004 Gt/yr

Mechanical methods are removing ~nothing as of now.

But…

Scientists say* we'd need to get to **6-10** Gt (*billions* of tons) *per year* removal from the atmosphere by 2050.

From 0 now to 6 billion by 2050?

* IPCC and U.S. National Academies of Sciences

IPCC Report:

- **<u>Carbon Capture</u> – "direct air carbon capture and storage" -- fails now and remains ineffective through mid-century.**

Global CO_2 Removal/yr by DAC

Method	Global GtCO2/yr by 2030	Global GtCO2/yr by 2050	Global GtCO2/yr by 2100
DACCS	0	0.02	1.02

Source: IPCC 2022 *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Page 1265.

IPCC Report

Global CO_2 Removal/yr: Biological methods and DAC

Method	Global GtCO2/yr by 2030	Global GtCO2/yr by 2050	Global GtCO2/yr by 2100
Annual net CO2 removal, biological sequestration ("managed land")	0.86	2.98	4.19
DACCS	0	0.02	1.02

IPCC defines "managed land" to mean primarily reforestation, afforestation, improved forest management and ecosystem conservation.

Data source: IPCC 2022 *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Page 12-40.

What is “carbon capture” and “storage”?

Mechanical-chemical carbon capture. (Not biological sequestration).

It’s a multi-stage, mechanical / chemical / industrial process.

1. **Capture the CO_2.**
2. **Transport the CO_2.**
3. **Do something with the CO_2.**

“Capture”

Mechanical-chemical carbon capture. (*Not* biological sequestration.)

- **2 types of carbon capture**

The Two Mechanical-Chemical Approaches

Trap Emissions

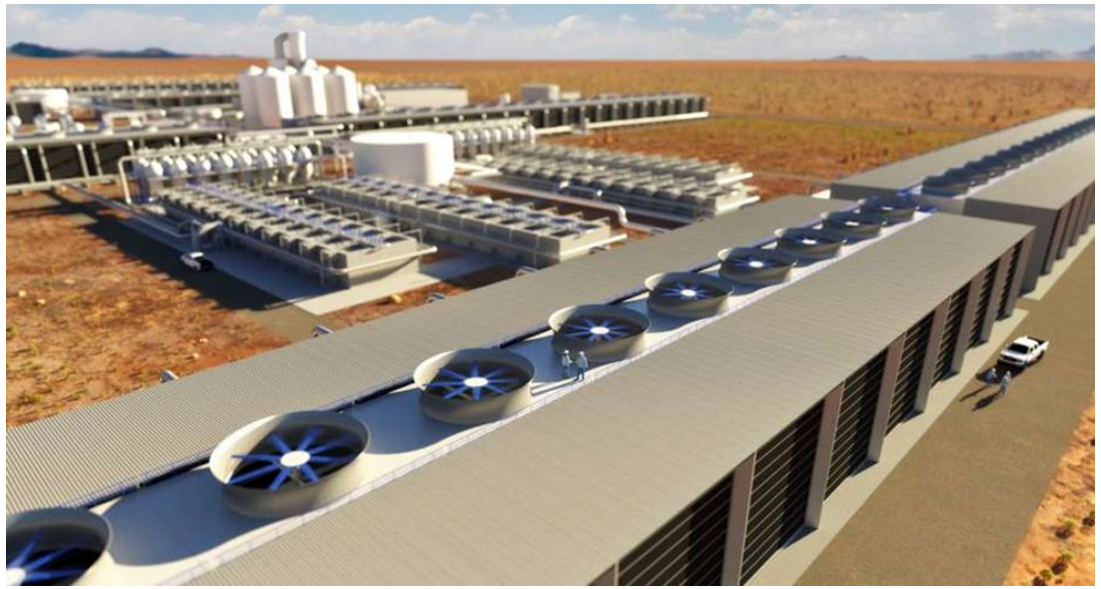
"Point-Source capture"

('CCS' and 'CCUS')

Pull CO_2 from Air

"Direct Air Capture"

(DAC - 'direct air capture').



Industrial machinery **traps flue gasses or sucks in air.**
Chemicals **separate out CO_2**

Chemicals used *in* carbon capture…

Chemicals used as sorbents and solvents, or used or produced in their manufacture:

- Potassium hydroxide (**caustic potash**). DAC. Swallowing can cause severe burns of mouth, throat and stomach.
- Sodium hydroxide (**lye**). DAC. Contact can cause severe burns and blindness.
- **Monoethanolamine** (MEA). CCS, DAC. **Flammable** and vapor is highly toxic.
- **Ethylene oxide**, used in production of MEA. **Flammable/explosive**; can be carcinogenic, neurotoxic

All are toxic and pose dangers to communities.

(Not all carbon capture processes use these chemicals; e.g., ethanol CCS).

13 U.S. Carbon Capture sites

in **commercial** operation.

Facility Title	Location	Owner or Oil Partner	Start Date	Industry	Storage Type	Max Capture Capacity Mt/yr
Terrell Natural Gas Processing Plant	Val Verde, Texas	Pennzoil and Altura	1972	Natural gas processing	**EOR**	.5
Enid Fertilizer	Enid, Oklahoma	Koch Fertilizer Daylight Petroleum	1982	Fertilizer production	**EOR**	.2
Shute Creek Gas Processing Plant	Kemmerer, Wyoming	Owned by ExxonMobil	1986	Natural gas processing	**EOR**	7
Great Plains Synfuels Plant and Weyburn-Midale	Beulah, North Dakota	Cenovus, and Apache Energy	2000	Synthetic natural gas (coal gasification ?)	**EOR**	3
Core Energy CO_2-EOR	Otsego County, Michigan	Core Energy	2003	Natural gas processing	**EOR**	.35
Arkalon CO_2 Compression Facility	Liberal, Kansas	Chaparral Energy	2009	Ethanol production	**EOR**	.29
Century Plant	Fort Stockton, Texas	Owned by Occidental Petroleum	2010	Natural gas processing	**EOR**	5
Bonanza BioEnergy CCUS EOR (formerly Conestoga Energy Partners)	Garden City, Kansas	PetroSantander Inc.	2012	Ethanol production	**EOR**	.1
PCS Nitrogen	Geismar, Louisiana	Denbury	2013	Fertilizer production	**EOR**	.3
Coffeyville Gasification Plant	Coffeyville, Kansas	Chaparral Energy, and Blue Source	2013	Fertilizer production	**EOR**	.9
Air Products Steam Methane Reformer	Port Arthur, Texas	Denbury	2013	Hydrogen production	**EOR**	1
Illinois Industrial Carbon Capture and Storage	Decatur, Illinois	ADM	2017	Ethanol production	**geolog storage**	1
Red Trail Energy CCS	Richardton, ND		2022	Ethanol production	**geolog storage**	.18
Total - million metric tons/yr.						19.82

Data source: “Global Status of CCS 2022”, Global CCS Institute

All are enabled by taxpayer subsidies.

None remove CO_2 from the atmosphere.

None is at an electric power plant.

94% of captured CO_2 is used to pump out more oil (EOR).

All carbon capture projects at U.S. power plants have failed.

After $2 billion in public subsidies.

U.S. power-plant CCS projects – all were withdrawn or failed after starting. All received federal $:

- FutureGen (IL) CCS plan cancelled (2015)
- Summit (TX) Cancelled (2017)
- Kemper (Miss) Cancelled 2017
- American Elec. Power (W VA) Withdrawn (2011)
- Antelope Valley (ND) Withdrawn (2012)
- Southern Company (AL) Withdrawn (2010)
- Petra Nova (TX) "Shuttered" (2020)

The only operating CCS power plant in the world (Canada) – caused the price of electricity to double.

‘Carbon capture’ –

capture at emissions sources (CCS) –

fails to reduce

the level of CO2 in the atmosphere:

Source Capture

CCS
does *not* remove
CO_2 from the atmosphere

In some cases, it can *increase* the amount of CO_2 in the atmosphere

CCS with ‘enhanced oil recovery’
Coal-fired power plants.
Emits 3.4 to 4.7 tons/ CO_2 for each ton removed

direct air capture (DAC)

DAC in the U.S.
largest plant now planned (TX)

Occidental Petroleum and Carbon Engineering

- **Powered mainly by fossil fuel (natural gas)**
- **Business plan relies on gov't subsidies**
- **Captured CO_2 will be used for oil extraction (EOR)**

Aims to capture 1 million tons/yr (**0.001 gigaton/yr)**

Fossil fuel-powered DAC is counterproductive

DAC fossil-fuel-powered

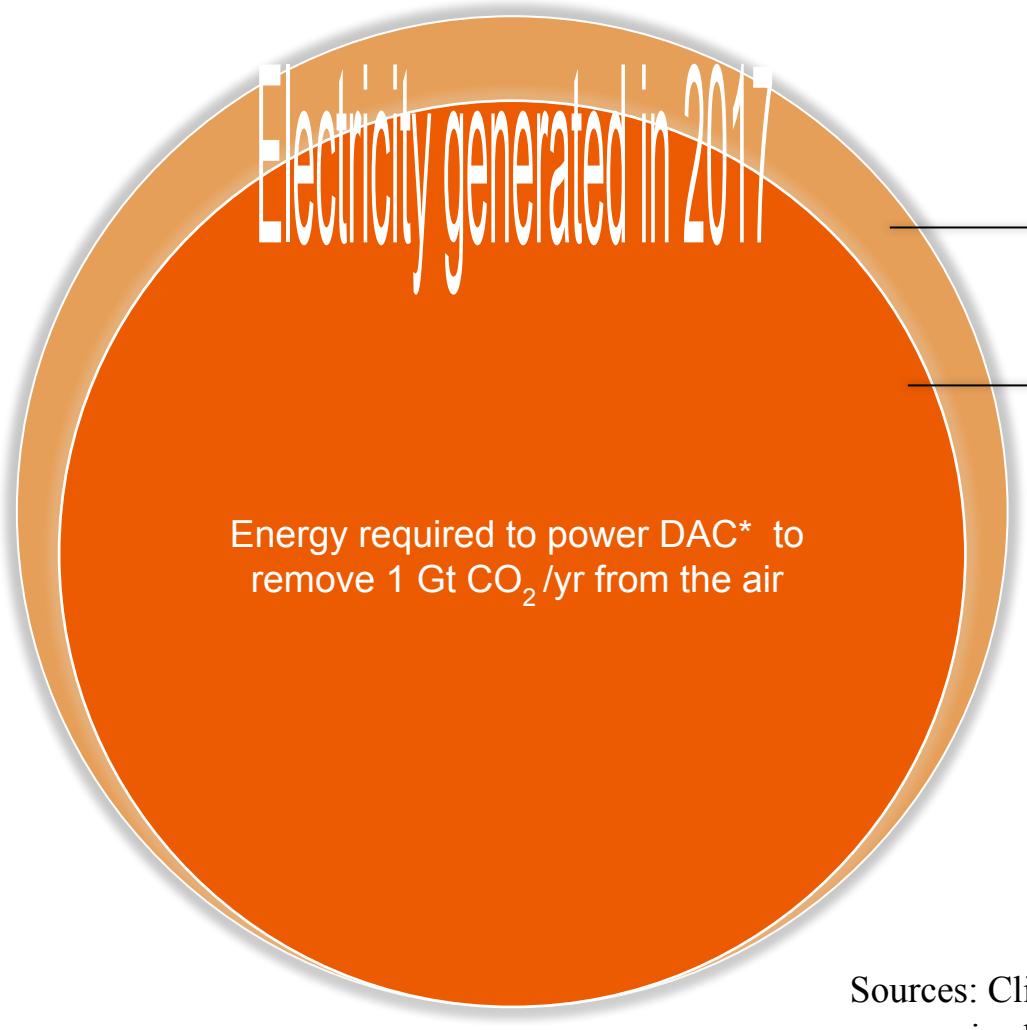
Emits 1.5 to 3.4 tons/CO_2 for each ton captured

Not counting the EOR

Project Bison - DAC plant just announced (Wyoming).
Will likely be powered by natural gas, at least initially.
Relies on 45Q tax credit.

DAC Energy usage to remove 1 Gt CO_2

Electricity Generated in the US vs Energy Required to Power DAC* for 1 Gt Capture



Electricity generated in the US in 2017:
4,091 TWh

Energy required by DAC to remove* 1 Gt of CO_2/yr:
3,417 TWh

* DAC "liquid solvent" process.
Does not include energy consumption for manufacturing and transporting the millions of tons of solvent/sorbent chemicals required for capture.

Sources: Climate Advisers (2018), Smith et al (2016), House et al (2011), summarized in Sekera & Lichtenberger (2020).

Largest DAC plant in operation now.

Climeworks ‘Orca’ plant, in Iceland

“In a year, it’ll capture just 3 seconds' worth of humanity’s CO_2 emissions.”

Climate scientist Peter Kalmus, quoted in *Business Insider* 2021

0.000004 Gt removal/yr

to get to 1 gigaton/yr capture would take 250,000 of these plants

the Process, cont'd

Mechanical-chemical carbon capture. ***Not*** **biological sequestration.**

Transport the CO_2 , by pipelines, to a location to use it or bury it.

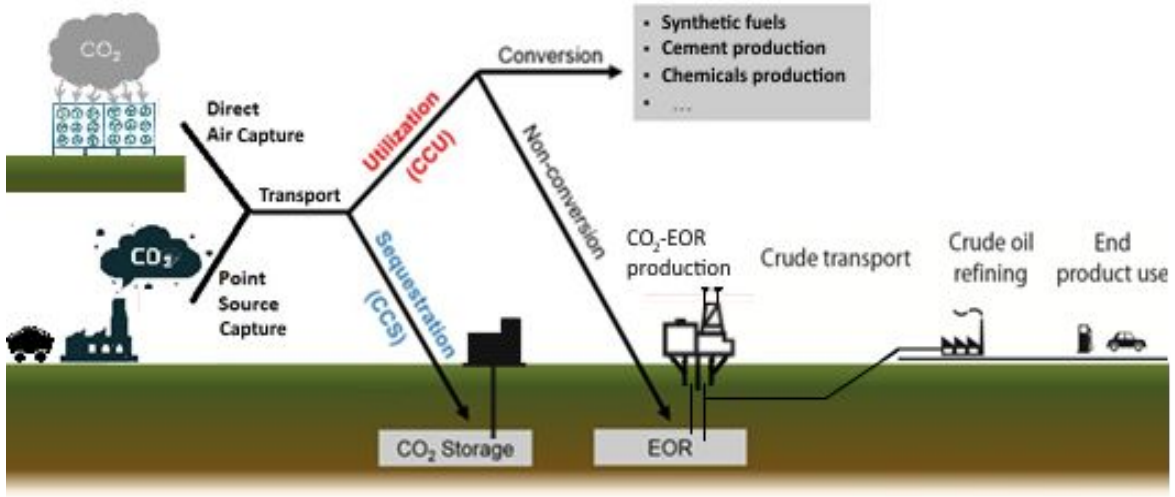
What to do with the CO_2 ?

3 choices

1) Inject it underground for ‘storage’

2) Sell as chemical feedstock

3) Sell it for oil extraction

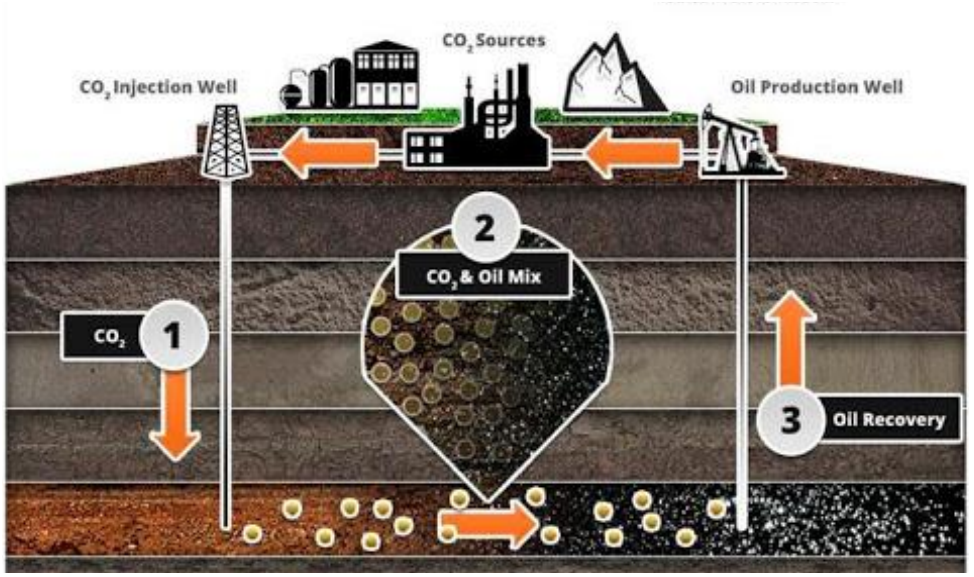


What <u>is</u> done with the CO_2 in the US:

Of the 12 CCS projects:

- 11 oil extraction
- 1 geological storage

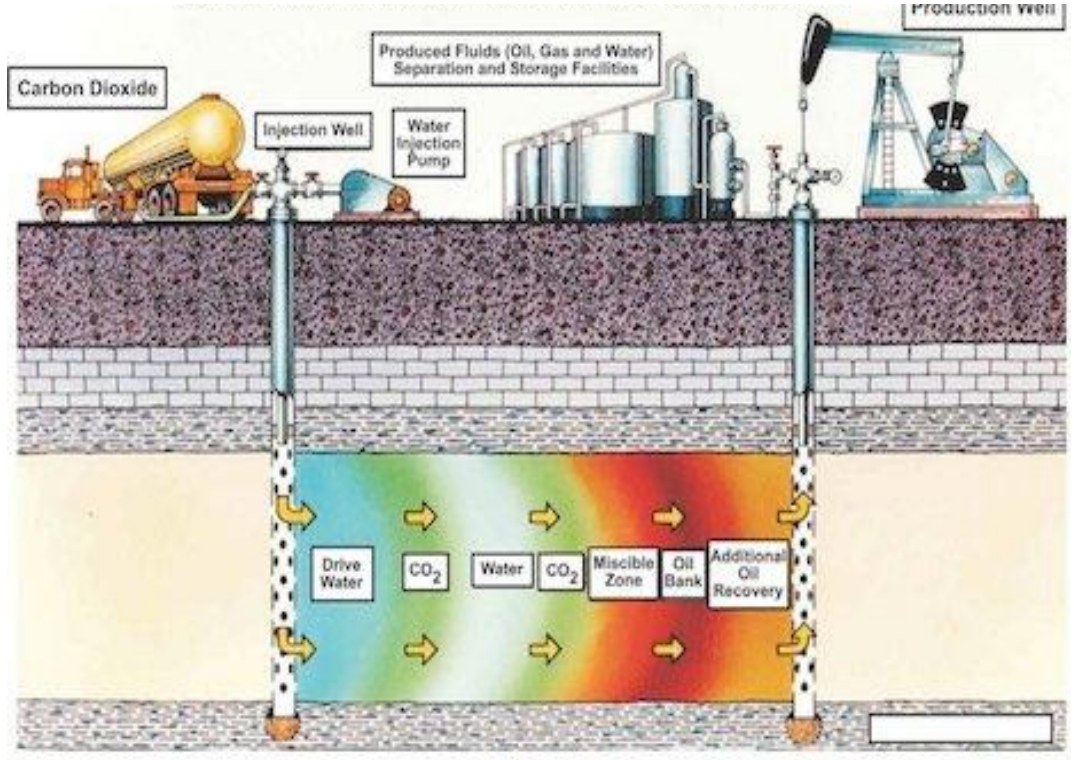
(this facility continues to emit 8x as much CO2 as it stores)



94% of captured CO_2 is used for EOR *(U.S)*

(Enabled by taxpayer subsidies)

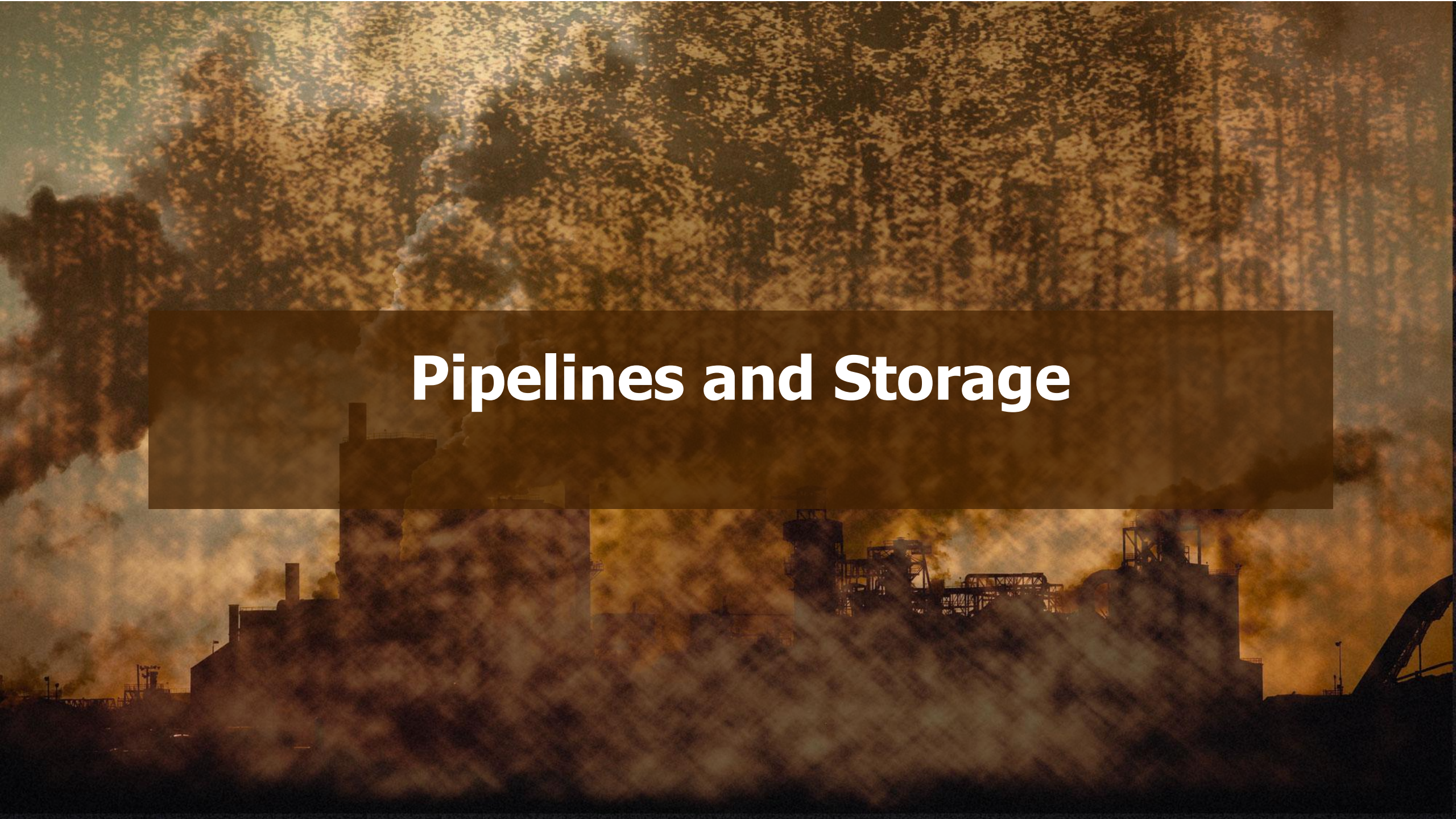
Enhanced Oil Recovery (EOR)
“injecting CO2 to emit CO2” *



injects carbon dioxide into existing oil wells

to flush out remaining, hard-to-pump oil

* IEEFA “Carbon Capture Crux” 2022



Pipelines and Storage

Pipelines

Compression

Inter -stage piping in the compressor facility (photo ADM)

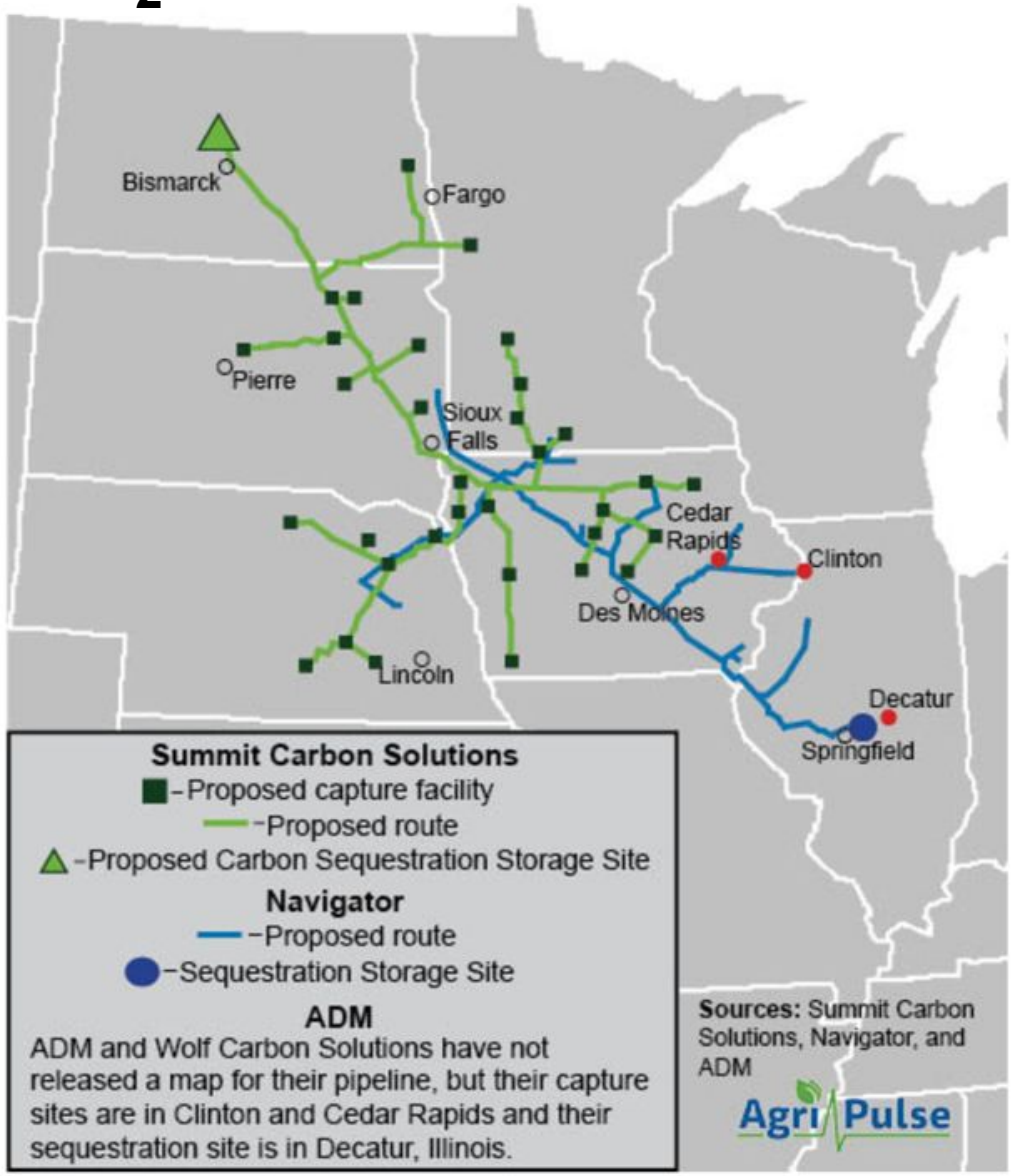
ADM CCS operation at Decatur, Ill ethanol production plant

Compressor “Booster” Stations

Natural gas compressor booster stations

Planned CO_2 Pipelines – Midwest Ethanol Ventures

Iowa
Nebraska
Illinois
Minnesota
South Dakota
North Dakota



Land to be taken by Eminent Domain if landowners don't voluntarily give easements.

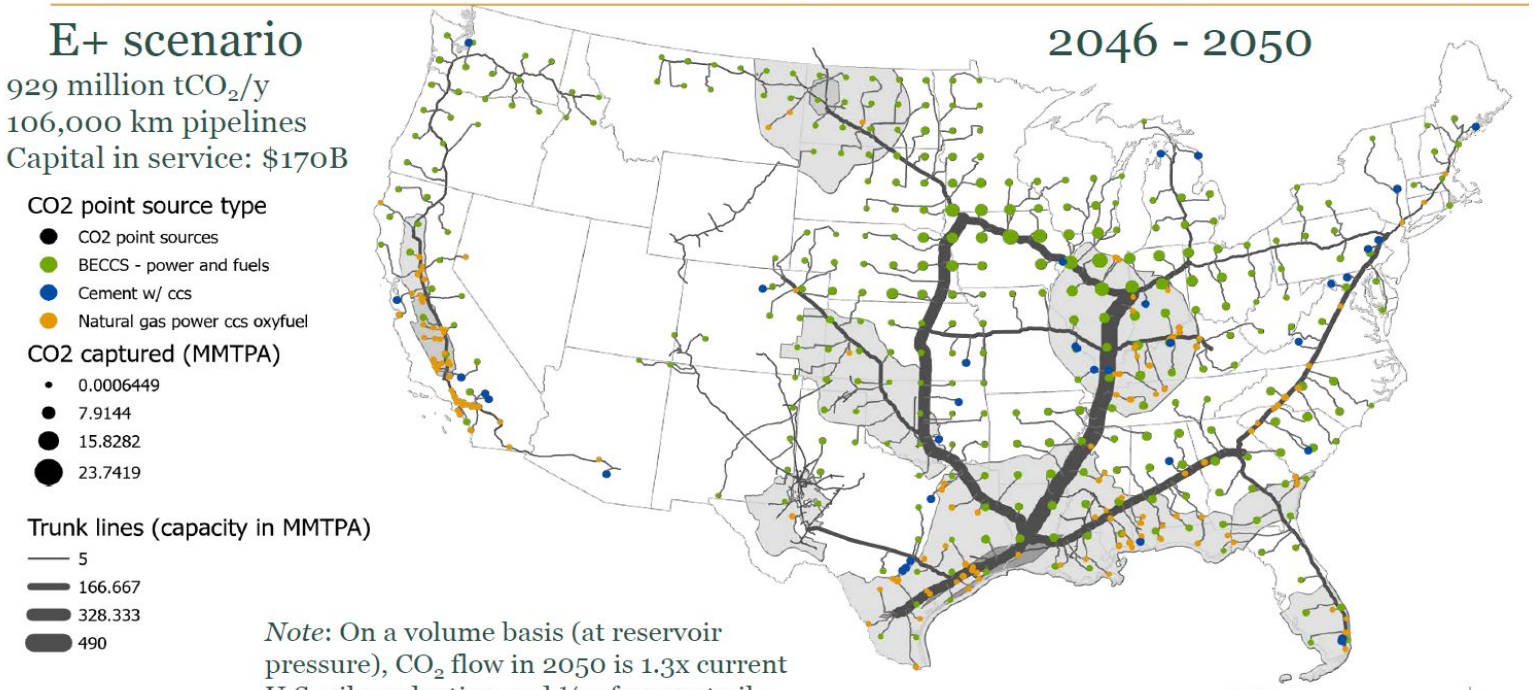
Source: Agrii-Pulse 1-26-22

CO_2 Pipelines

CO_2 pipeline network needed:
66,000 miles of CO_2 pipelines

2050 totals: 21,000 km trunk lines + 85,000 km spur lines
(equivalent to ~22% of US natural gas transmission pipeline total)

E+ scenario
929 million tCO_2/y
106,000 km pipelines
Capital in service: $170B



Note: On a volume basis (at reservoir pressure), CO_2 flow in 2050 is 1.3x current U.S. oil production and ¼ of current oil + gas production.

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High Meadows Environmental Institute

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Princeton “Net Zero America” Report 2021

CO_2 pipeline rupture, Mississippi, 2020

"The Gassing of Satartia"

HuffPost Aug. 2021:

'Foaming at the mouth': First responders describe scene after pipeline rupture, gas leak

Sarah Fowler The Clarion-Ledger

Published 11:23 a.m. CT Feb. 27, 2020

View Comments

Story Highlights

- Approximately 300 people were evacuated and 45 treated at area hospitals after a pipeline rupture.
- The pipeline, which ruptured Saturday in Yazoo County, belonged to Denbury Resources out of Texas.
- The pipleline released CO_2 into the air, making people "act like zombies," said first responder.
- First responder rescued three people before he too was overtaken by the gas.

* Yazoo County, where the population is majority Black; 34% is poverty level; Friends of the Earth, March 18, 2021.

Storage

“It is impossible to guarantee that stored CO_2 will stay underground.”

Institute for Energy Economics and Financial Analysis; “Carbon Capture Crux” 2022

Overview of **Potential Failure Modes and Effects** Associated with CO2 Injection and Storage Operations in Saline Formations

DOE/NETL. December 18, 2020

Exhibit 3-7. Potential failure effect examples from CO_2 storage operations

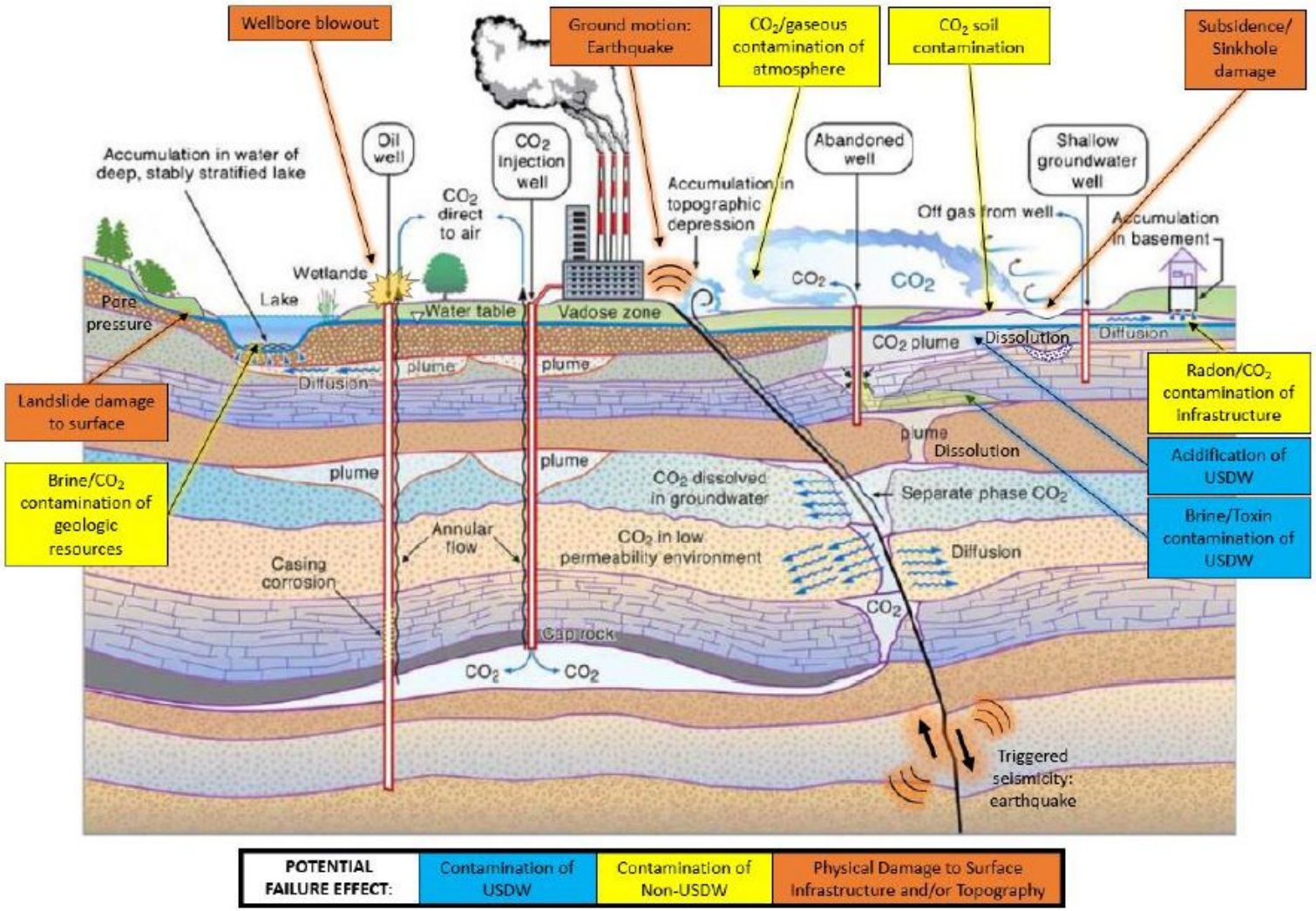


Illustration not to scale (depth scale is condensed for illustrative purposes)

Premise: Underground storage is “safe”

leakage, blowouts

other examples in last decade

- **Blowout** from CO_2 storage site after EOR; CO_2 spew-out 37 days; CO_2 blanketed area; **deer suffocated; workers sent to hospitals**; Mississippi 2011
- **Gas-bubbling creek,** Wyo – due to unpermitted CO_2 release 2012
- Series of **repeated** CO_2 **leaks** from a Wyo oil field that used CO_2 from Exxon for EOR 2004-2016
- **School in Wyo forced to close; houses evacuated** due to leakage of CO_2 from storage (at EOR storage site) 2016

A publicly-financed sewer system for the fossil fuel industry.

What *could* work?

IPCC Report Data Show:

- **Biological sequestration methods are effective now, and grow increasingly effective through mid-century and beyond.**

- **Mechanical capture – "Direct Air Carbon Capture & Storage" - fails now and remains ineffective through mid-century.**

Global CO2 Removal and Sequestration/yr: Biological CDR and DACCS

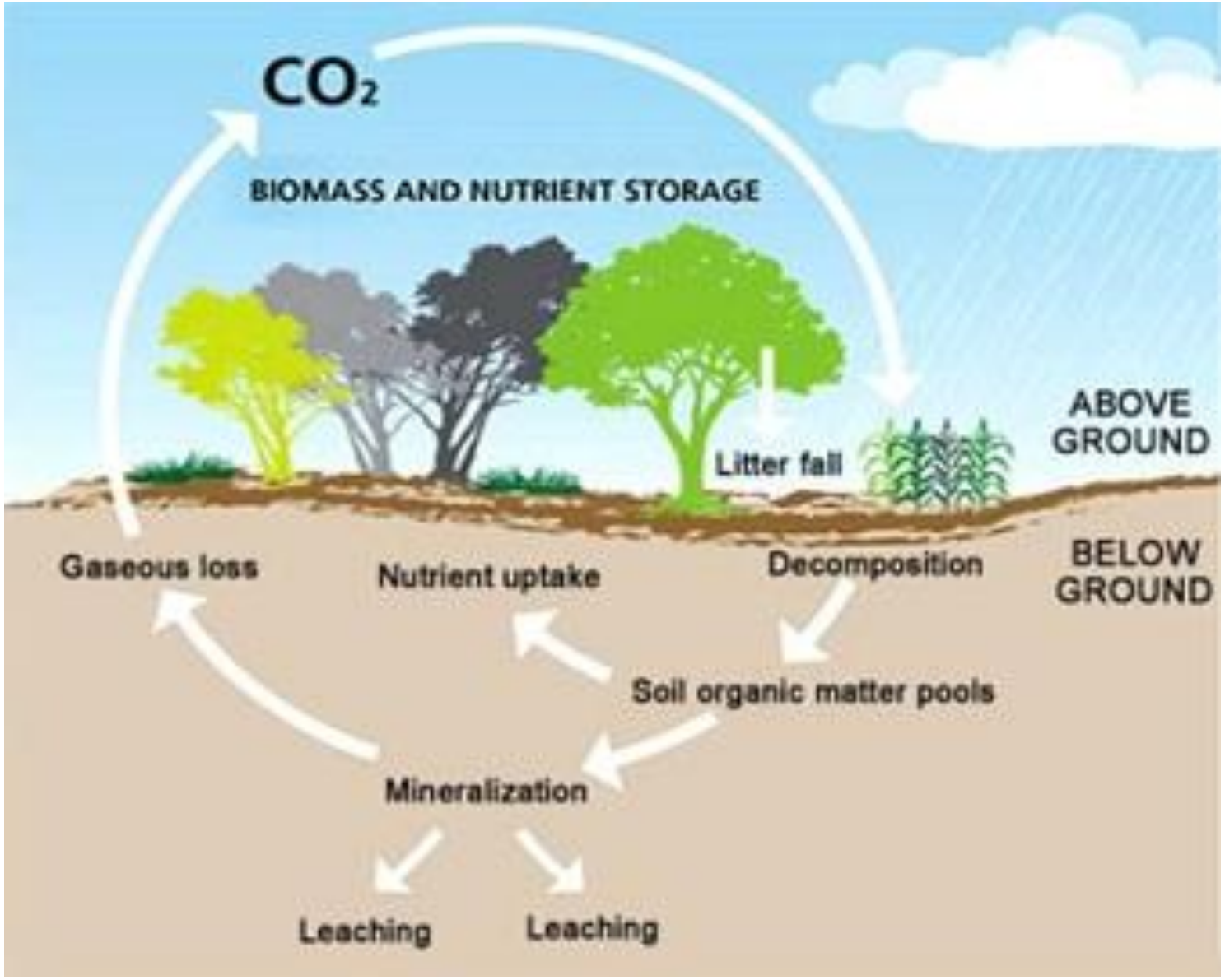
Method	Global GtCO2/yr by 2030	Global GtCO2/yr by 2050	Global GtCO2/yr by 2100
Annual net CO2 removal, biological sequestration ("managed land")	0.86	2.98	4.19
DAC	0	0.02	1.02

IPCC defines "managed land" to mean primarily reforestation, afforestation, improved forest management and ecosystem conservation.

Data source: IPCC 2022 *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Page 12-40.

Biological Systems

- **Forests**
- **Farms**
- **Grasslands**
- **Wetlands**



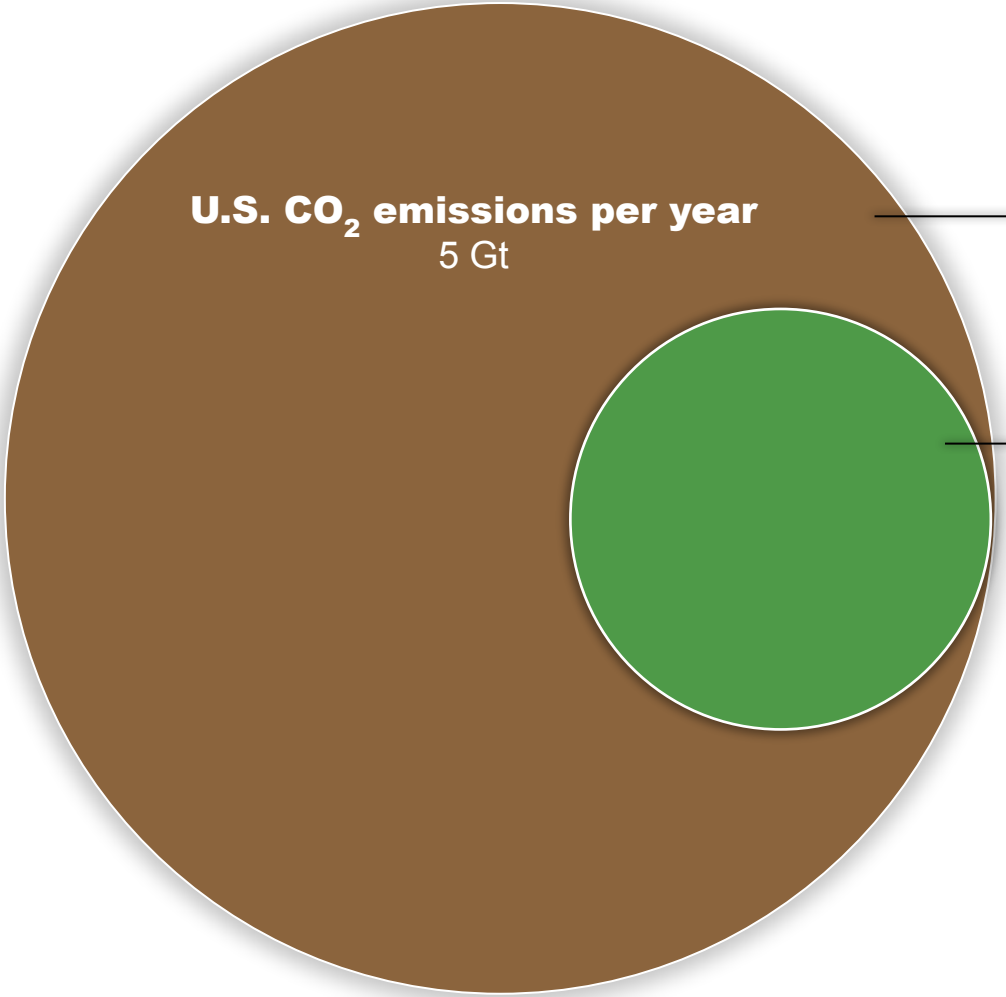
Carbon dioxide removal–What's worth doing? A biophysical and public need perspective

by

June Sekera, Dominique Cagalanan, Amy Swan, Richard Birdsey, Neva Goodwin , Andreas Lichtenberger

PLOS Climate
February 14, 2023

Amount of CO_2 removed from the atmosphere now:
Biological Sequestration vs Mechanical Carbon Capture



U.S. CO_2 emissions per year:
5 Gt

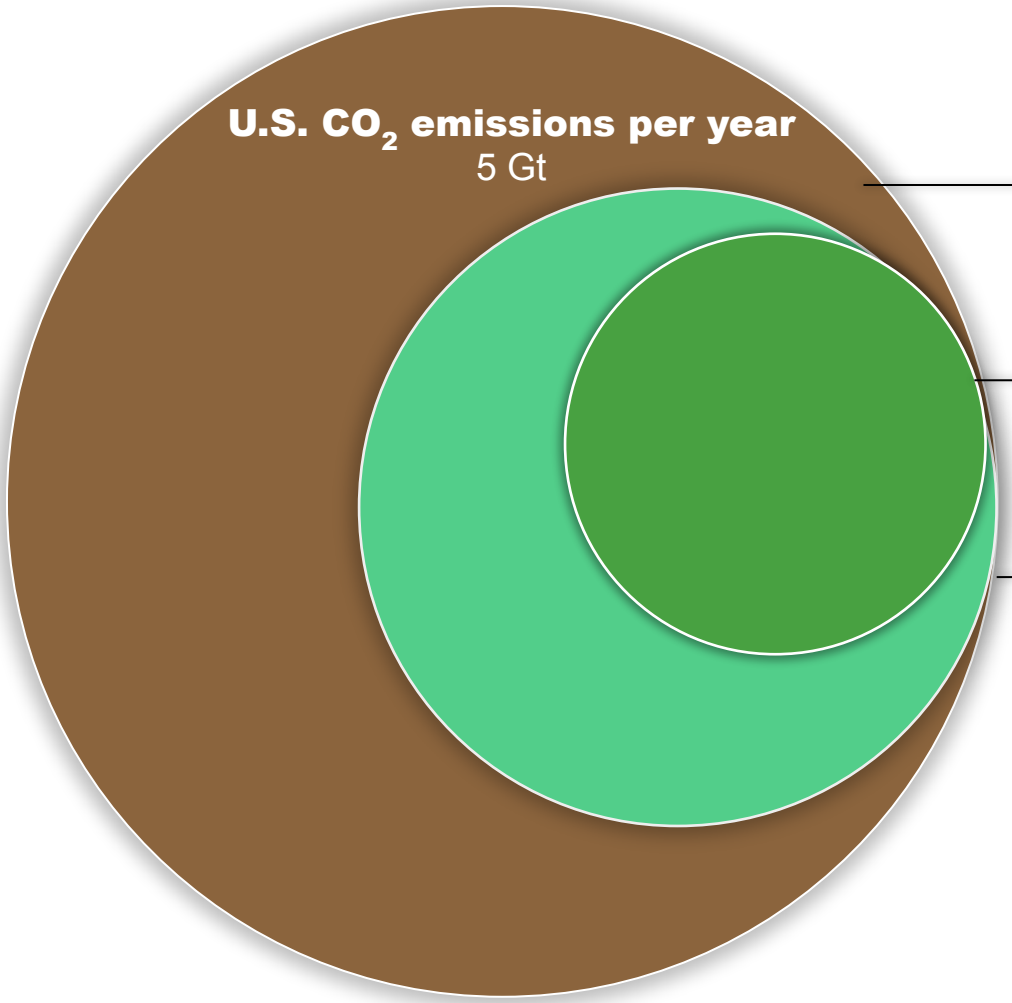
Amount of CO_2 per year:

Biological net sequestration[1] now; U.S.:
.9 Gt
Mechanical CO_2 removal[2] now: 0.0

1. Net sequestration -- i.e., net uptake by plant growth minus emissions from respiration, harvesting fire, etc..
Biological methods included here: forest mgmt.; reforestation; regenerative agriculture; wetlands management & restoration.

2. **There is no significant atmospheric CO_2 removal by mechanical methods**. DAC plants are boutique. And source capture (CCS) does not remove CO_2 from the atmosphere. CCS is likely *increasing* the amount of CO_2 in the atmosphere because emissions likely exceed removals, due to emissions from the capture process itself and from EOR oil production, and oil transport, crude refining and product combustion.

US Potential Biological Sequestration with Improved Practices



U.S. CO_2 emissions per year:
5 Gt

Biological net[1] sequestration now, U.S. :
0.9 Gt

Biological net sequestration with improved practices, U.S.:
2.08 Gt/yr. ~ 40% of U.S. emissions
Not via offsets.

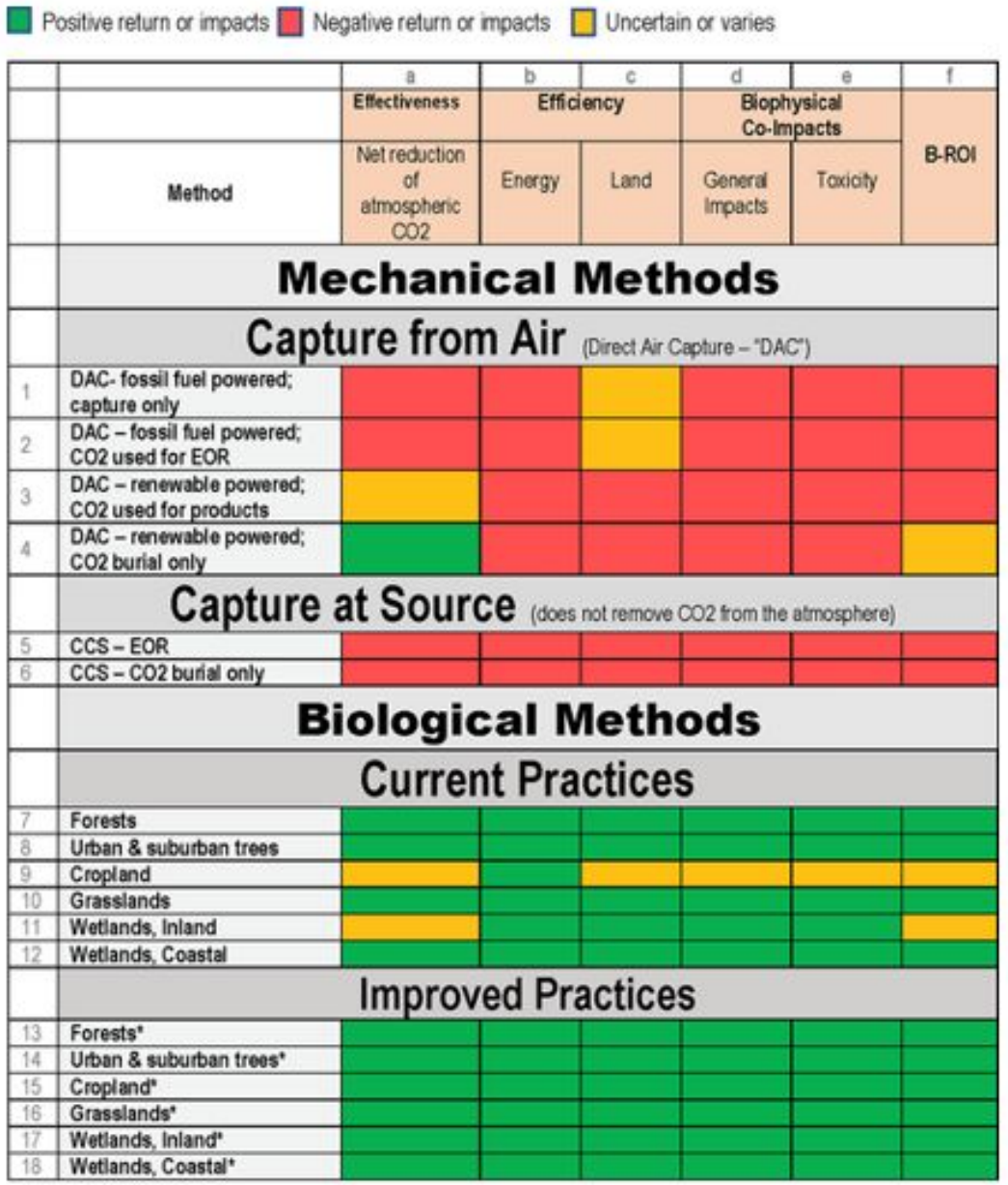
Mechanical carbon removal U.S. now: 0.0

1. *Net* sequestered -- i.e., net uptake by plant growth minus emissions from respiration, harvesting fire, etc.. Natural methods included here = forest mgmt.; reforestation, regenerative agriculture; wetlands management & restoration.

Fig 1. Carbon Accountability Dashboard.

Explanations for each cell are in the Legend.

Note that all designations exclude effects of "carbon offsets" or "carbon credits," which can counteract carbon removal accomplishments.



		a	b	c	d	e	f
		Effectiveness	Efficiency		Biophysical Co-Impacts		
	Method	Net reduction of atmospheric CO2	Energy	Land	General Impacts	Toxicity	B-ROI
	Mechanical Methods						
	Capture from Air (Direct Air Capture – "DAC")						
1	DAC- fossil fuel powered; capture only						
2	DAC – fossil fuel powered; CO2 used for EOR						
3	DAC – renewable powered; CO2 used for products						
4	DAC – renewable powered; CO2 burial only						
	Capture at Source (does not remove CO2 from the atmosphere)						
5	CCS – EOR						
6	CCS – CO2 burial only						
	Biological Methods						
	Current Practices						
7	Forests						
8	Urban & suburban trees						
9	Cropland						
10	Grasslands						
11	Wetlands, Inland						
12	Wetlands, Coastal						
	Improved Practices						
13	Forests*						
14	Urban & suburban trees*						
15	Cropland*						
16	Grasslands*						
17	Wetlands, Inland*						
18	Wetlands, Coastal*						

* For details on improved practices, see S2 Carbon Accountability Dashboard Legend.

Carbon dioxide removal–What's worth doing?
A biophysical and public need perspective
Feb 14, 2023

Instead of subsidies for mechanical carbon capture

Use the $ to pay communities, farmers, indigenous groups, public agencies to:

- Adopt / expand regenerative ag practices.
- Plant trees in urban & rural communities.
- Restore forests.
- Restore grasslands.
- Restore wetlands.

end of slide show

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