TAXPAYERS for COMMON SENSE

REPORT

May 2023

Pricey and Problematic: Carbon Capture and Storage Remains Elusive Despite Decades of Taxpayer Subsidies

Executive Summary

Carbon Capture and Storage (or Sequestration, also known as CCS) is an integrated suite of technologies used to capture carbon dioxide (CO_2) emitted during power generation and industrial processes instead of releasing it into the atmosphere. CCS is more recently referred to as Carbon Capture, Utilization and Storage (CCUS), with the recognition of captured CO_2 uses in manufactured goods and other industrial processes.

The U.S. federal government subsidizes the CCS industry at every step—from federal funding of research, development, and demonstration (RD&D), financing of CCS commercial projects and infrastructure, to the carbon capture and sequestration tax credit (also referred to as 45Q) for when CCS facilities go into operation. From FY2010 to FY2023, Congress provided over $2.8 billion (in nominal dollars) in annual appropriations for CCS RD&D at the Department of Energy (DOE). The American Recovery and Reinvestment Act (ARRA) provided an additional $3.4 billion specifically for CCS demonstration projects until the end of FY2015. In 2008 the 45Q tax credit was created to provide support for CCS facilities once they began capturing carbon. Most recently the credit was expanded in the Inflation Reduction Act (IRA, P.L. 117-169). The 45Q tax

credit provides additional subsidy for CCS facilities and has cost taxpayers $1.2 billion from FY2011 to FY2021, according to Joint Committee on Taxation (JCT) estimates.[1]

Despite the layers of financial assistance, federal management of existing CCS programs and subsidies has had a poor track record, wasting hundreds of millions of taxpayer dollars. Most federally subsidized CCS demonstration projects have either failed or been withdrawn because they are economically unviable and/or failed to find private investors. In 2021, the Government Accountability Office (GAO) reported that DOE funded coal CCS demonstration projects that were "unlikely to succeed."[2] Massive fraud involving 45Q tax credits totaling over $1 billion came to light in 2020, as nearly 90% of all credits claimed for sequestered carbon were not in compliance with Environmental Protection Agency (EPA) monitoring, reporting and verification requirements.

The failure of DOE's CCS programs and rampant noncompliance with reporting standards for 45Q tax credits has not stopped Congress from continuing to increase funding and support for CCS. They have proposed and enacted CCS legislation increasing funding for RD&D, and expanded the 45Q tax credit, and increased financing for CCS infrastructure. According to the Congressional Research Service (CRS), more than 55 bills were introduced in the 116th Congress with CCS provisions, some of which were included in the Energy Act of 2020 and passed as part of the FY2021 Omnibus spending bill (Consolidated Appropriations Act of 2021). Not even a year later, the Infrastructure Investment and Jobs Act (IIJA) increased the authorization level for almost all CCS programs established by 2020 legislation and created new programs like CCS transportation infrastructure finance and innovation, regional direct air capture hubs, etc. The IIJA provided $12.1 billion for these programs over the next five years.

Most recently the IRA extended the availability of the 45Q tax credit and expanded the scope of eligible projects. At the same time the tax credit's annual capture requirements for qualifying facilities were greatly reduced. The JCT estimates the expansion and extension of 45Q tax credits will cost $3.2 billion from FY2022 to FY2031.[3]

Despite massive taxpayer subsidies, CCS has been challenging to deploy because it remains prohibitively expensive, especially compared to other climate mitigation strategies. Beyond the outright cost and complexity of implementing on a broad scale, CCS may offer less climate benefit as it is currently used primarily to extend the life of oil and gas wells and potentially

[1] Joint Committee on Taxation (JCT), "Estimated Budget Effects of The Tax Provisions Contained In An Amendment In The Nature Of A Substitute To H.R. 1424", JCX-78-08
[2] Government Accountability Office (GAO), Carbon Capture and Storage: Actions Needed to Improve DOE Management of Demonstration Projects, GAO-22-105111. Published: Dec 20, 2021. Publicly Released: Dec 20, 2021. https://www.gao.gov/products/gao-22-105111
[3] Congressional Budget Office (CBO), "Estimated Budgetary Effects of Public Law 117-169," https://www.cbo.gov/system/files/2022-09/PL117-169_9-7-22.pdf

other carbon intensive industries which may increase overall carbon emissions.[4] The net benefits of CCS are difficult to predict, but we do know it is going to be an expensive and difficult option for reducing greenhouse gases.

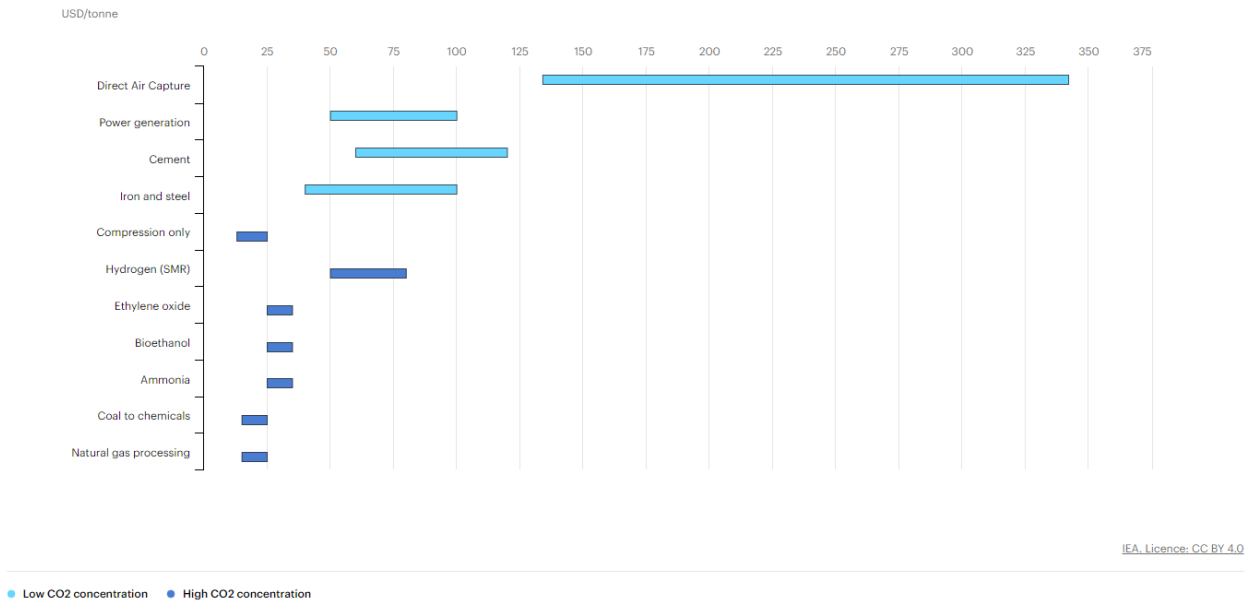
How Does CCS Work (or Not)?

CCS technologies entail three major steps: capture, transportation, and storage (and more recently, utilization). Each area can be costly and onerous to implement on its own but face even greater hurdles when considered together.

Carbon Capture

Carbon capture is a technologically challenging and expensive step in CCS. First, CO_2 is captured at the source (e.g., power plant stack) and separated from other gases using chemical solvents or other methods. Extracting, pumping, and compressing CO_2 requires a considerable amount of energy. A power plant using CCS technology produces 20% less electricity than the same plant

Figure 1. Cost of CO_2 Capture by Sector and Initial CO_2 Concentration



Source: IEA, Levelized cost of CO2 capture by sector and initial CO2 concentration. Sectors ranked from the lowest to highest initial CO2 concentration. 2019, IEA, Paris https://www.iea.org/data-and-statistics/charts/levelised-cost-of-co2-capture-by-sector-and-initial-co2-concentration-2019, IEA. License: CC BY 4.0

[4] National Academics Sciences Engineering Medicine. Renewable Fuel Standard Potential Economic and Environmental Effects of U.S. Biofuel Policy (2011) https://nap.nationalacademies.org/catalog/13105/renewable-fuel-standard-potential-economic-and-environmental-effects-of-us

without CCS, known as its energy penalty or parasitic load.[5] Building capture equipment is capital intensive. According to the International Energy Agency (IEA), the cost of carbon capture can vary greatly by capture source. Capturing CO_2 from dilute gas streams in cement production and power generation can cost $40-120 per ton of CO_2.[6] The Global CCS Institute, a think tank advocating for global CCS deployment, estimates installation of first-of-a-kind CCS equipment at a power plant increases the levelized cost of electricity[7] by 60-70%.[8]

Carbon Transport

After CO_2 is captured, it is compressed into a fluid and transported to a storage site. Pipelines are the most common method of transportation, although other methods like ships and rail cars can be used. Transportation of CO_2 is costly, as significant energy is required to maintain high pressure and low temperature throughout pipelines to carry condensed CO_2. To achieve this, specially designed pipelines for CO_2 have to be employed instead of existing pipelines for oil and gas.[9] Currently, there are about 5,339 miles of pipelines for transporting CO_2 in the U.S.[10] Most of these existing pipelines carry CO_2 where it is used for enhanced oil recovery (EOR).[11] But transportation infrastructure needed for large-scale deployment of CCS does not currently exist. The Global CCS Institute estimated that CO_2 transportation infrastructure necessary for global deployment of CCS would need to increase 100-fold over the next 30 to 40 years.[12]

Carbon Storage

To securely store and sequester CO_2, it is injected into a deep, underground porous rock formation that holds or previously held fluids. This is necessary to ensure enough pressure to keep the CO_2 in a supercritical state so it does not leak out.[13] Three main types of geological formations being considered for underground storage are former oil and gas reservoirs, deep saline formations, and unmineable coal beds. Injecting CO_2 into depleted oil and gas reservoirs to boost oil production, a method known as EOR, has been used by the oil and gas industry for decades. While EOR mostly uses CO_2 from naturally occurring geological formations, EOR is the

[5] Congressional Research Service (CRS), Carbon Capture and Sequestration (CCS) in the United States. October 2022. https://sgp.fas.org/crs/misc/R44902.pdf
[6] International Energy Agency (IEA), Is Carbon Capture Too Expensive? https://www.iea.org/commentaries/is-carbon-capture-too-expensive
[7] The levelized cost of electricity (LCOE) is a measure of the average net present cost of electricity generation for a generator over its lifetime.
[8] Global CCS Institute, Global Costs of Carbon Capture and Storage, https://www.globalccsinstitute.com/archive/hub/publications/201688/global-ccs-cost-updatev4.pdf
[9] Resources for the Future (RFF), Carbon Capture and Storage 101, https://www.rff.org/publications/explainers/carbon-capture-and-storage-101/
[10] Pipeline and Hazardous Materials Safety Administration, "Annual Report Mileage for Hazardous Liquid or Carbon Dioxide Systems," https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-hazardous-liquid-or-carbon-dioxide-systems
[11] CRS, Carbon Capture and Sequestration (CCS) in the United States. October 2022. https://sgp.fas.org/crs/misc/R44902.pdf
[12] Global CCS Institute, Transporting CO_2, https://www.globalccsinstitute.com/wp-content/uploads/2018/12/Global-CCS-Institute-Fact-Sheet_Transporting-CO2-1.pdf
[13] CRS, Carbon Capture and Sequestration (CCS) in the United States. October 2022. https://sgp.fas.org/crs/misc/R44902.pdf

main (and only) commercially available market for captured carbon, as the revenue from oil and gas production is needed to offset the cost of carbon capture. Of the 13 operating CCS facilities in the U.S., 11 capture CO_2 for EOR.[14]

Carbon Utilization

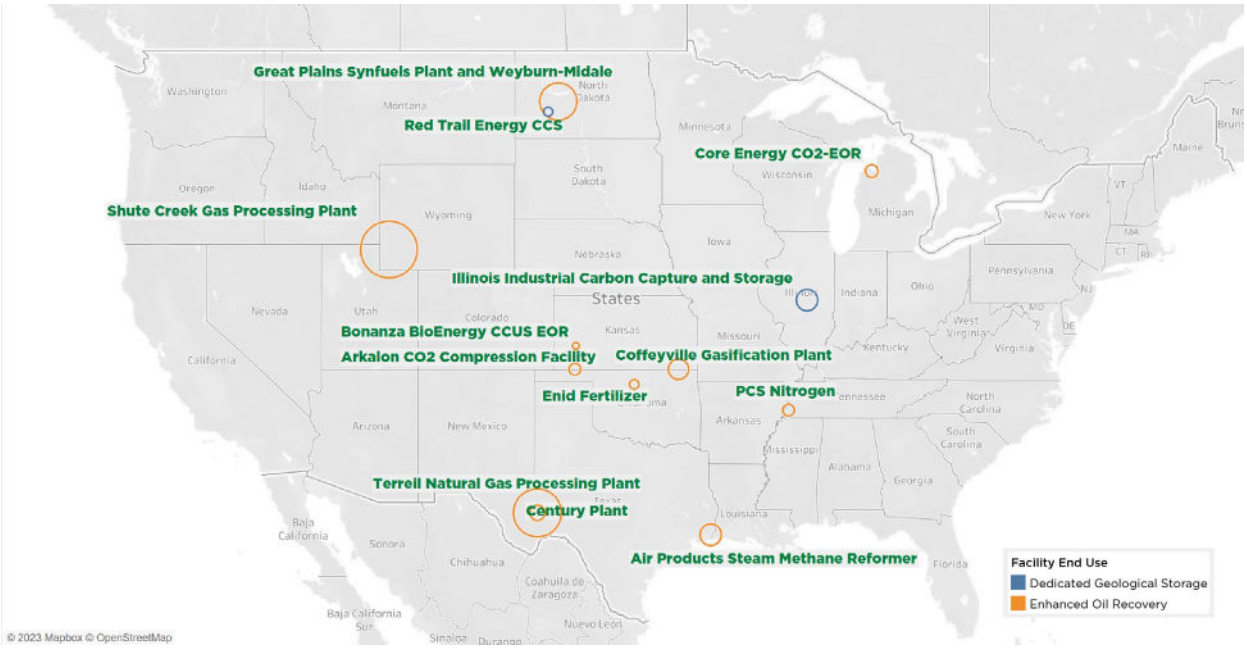
Similar to EOR, using captured CO_2 to manufacture goods or in other industrial processes could have the potential to offset the massive cost of carbon capture. However, carbon utilization faces the same challenge as carbon capture – the significant amount of energy needed to make CO_2 react because it is relatively inert. Other potential utilization pathways include the fixation of carbon oxide through photosynthesis or chemosynthesis to produce biomass, chemical conversion of carbon oxide to material or chemical compounds like fuels or chemicals like plastic, and mineralization of carbon oxide into carbonates like cement and aggregate materials.[15] But all of these utilization technologies are still in the early stages, meaning EOR will likely continue to dominate the commercial market for captured carbon for some time.

Direct Air Capture

Direct air capture (DAC) is a related technology that removes CO_2 directly from the atmosphere, as opposed to the emission source. CO_2 can be separated from the air using two methods: liquid and solid. Liquid systems use chemical solutions to remove the CO_2 from ambient air. The CO_2 is then removed from the chemical by applying heat. Solid DAC technology uses solid sorbent filters that bind with CO_2 chemically. A vacuum is used to capture CO_2 as it is released when the filters are heated.[16] However, because the concentration of CO_2 in the air is much lower (just 0.04% of air is CO_2) than that at a source of emission, the cost of DAC is even higher than other carbon capture methods. A company that launched a DAC pilot project assessed that the project cost was $94-232 per metric ton of carbon.[17] By comparison, the Global CCS Institute estimates costs for conventional coal-fired power plants of $74-83 for every metric ton of carbon avoided.[18]

[14] Global CCS Institute, Global Status Report 2022, https://www.globalccsinstitute.com/resources/global-status-of-ccs-2022/
[15] CRS, Carbon Capture and Sequestration (CCS) in the United States. October 2022. https://sgp.fas.org/crs/misc/R44902.pdf
[16] International Energy Agency (IEA), Direct Air Capture Tracking Report, November 2021. https://www.iea.org/reports/direct-air-capture
[17] Robert F. Service, "Cost Plunges for Capturing Carbon Dioxide from the Air," Science, June 7, 2018, at http://www.sciencemag.org/news/2018/06/cost-plunges-capturing-carbon-dioxide-air.
[18] Lawrence Irlam, Global cost of Carbon Capture and Storage-2017 Update, Global CCS Institute, June 2017, p. 1, at https://www.globalccsinstitute.com/archive/hub/publications/201688/global-ccs-cost-updatev4.pdf

Figure 2. CCS Commercial Facilities in the U.S.



Source: TCS using Global CCS Institute data. CCS Status Report 2022. https://public.tableau.com/views/CCSFacilitiesintheU_S_2023_16837472705770/Sheet1?:language=en-US&publish=yes&:display_count=n&:origin=viz_share_link

Taxpayer Subsidies for CCS

For decades the federal government has provided billions of dollars of direct and indirect subsidies in support of CCS technology and projects. These subsidies have run the gamut from RD&D and financing of CCS commercial projects and infrastructure, to lucrative tax credits. Over the years some of these subsidies have gone to projects that have stopped and started only to eventually collapse under their own weight and controversy (e.g. FutureGen, Kemper, etc.). Even the more recent 45Q tax credit, which has grown significantly in both size and scope, is already mired in fraud and waste.

RD&D at the Department of Energy

CCS was developed from federal clean coal efforts, first started in 1984 as the Clean Coal Technology (CCT) program under a now defunct government corporation established to help develop new domestic fuel sources. According to the CRS, Congress provide approximately $2.6 billion for the program by 1990. However, as the potential for clean coal technology adoption

diminished, the DOE recommended against further funding of the program in 1994.[19] Then in 1997, the DOE officially started funding RD&D through the Office of Fossil Energy, now known as the Office of Fossil Energy and Carbon Management (FECM).[20] To accelerate the deployment of CCS, the Bush Administration's FY2002 budget outlined over $2 billion of spending over 10 years on a restructured CCT program, known as the Clean Coal Power Initiative (CCPI). The CCPI was initiated in 2002 to provide direct subsidies to demonstration projects through cost-sharing agreements between DOE and industry. There was a total of three rounds of funding through the CCPI:

- Round 1 (2003) – for "advanced coal-based power generation and efficiency, environmental and economic improvements"
- Round 2 (2004) – for "focused on gasification, mercury (Hg) control and carbon dioxide (CO_2) sequestration."
- Round 3 (2009) – for "CO2 capture and sequestration/beneficial reuse (CO_2 EOR)"

In 2003, the Bush Administration announced plans to construct the world's first clean coal power plant using CCS technologies—FutureGen. The plant was supposed to be managed through a public-private partnership between DOE and the FutureGen Industrial Alliance, a coalition of power producers from around the world formed in support of the project. DOE would cover 76% of the cost while the FutureGen alliance would provide 24%. Congress provided FutureGen with $174 million from FY2004 to FY2008. DOE spent $42 million on the project between FY2005 and FY2010.[21] In 2008, DOE cancelled the funds for FutureGen due to rising costs of construction, effectively cancelling the whole project. In 2010, the Obama Administration revived the project and reintroduced it as FutureGen 2.0, which would consist of two demonstration projects—a power plant and a pipeline and storage project.

CCPI, FutureGen 2,0, and Industrial Carbon Capture and Storage projects (ICCS) were the three main CCS programs funded by DOE by late 2000s. ICCS supported CCS projects demonstration in non-power plant industrial sector. In 2009, Congress passed ARRA, also known as the stimulus bill. Almost $3.4 billion of stimulus funds was targeted specifically for DOE-supported CCS demonstration projects:

- $850 million for Round 3 of CCPI, awarded to six projects.
- $1.52 billion for ICCS program, part of which funded three ICCS demonstrations in 2010
- $1 billion for two FutureGen 2.0 demonstration projects

[19] Congressional Research Service (CRS). The Clean Coal Technology Program: Current Prospects. Carl Behrens. https://www.everycrsreport.com/files/20010406_RS20877_94e7ef7a309fd41b42318963535e17d26edaba24.pdf
[20] Congressional Research Service (CRS). Carbon Capture and Sequestration (CCS) in the United States. October 2022. https://sgp.fas.org/crs/misc/R44902.pdf
[21] Congressional Research Service (CRS). The FutureGen Carbon Capture and Sequestration Project: A Brief History and Issues for Congress. Peter Folger. February 2014. https://sgp.fas.org/crs/misc/R43028.pdf

Authority to spend ARRA funds expired on September 30, 2015. DOE spent around $2 billion of the $3.4 billion allocated for CCS by the deadline. The rest of the stimulus funding—around $1.4 billion went unspent either because recipients withdrew, or DOE terminated the project. The largest portion of the unspent funds, $795 million, was intended for FutureGen 2.0, which was suspended in February 2015 by DOE due to ballooning construction costs.[22]

Figure 3. CCS Demonstration Projects Selected by DOE Under ARRA

	Project	DOE original award amount ($, million)	Funded Thru
Coal	American Electric Power	334	(CCPI 3)
	Basin Electric	100	(CCPI 3)
	FutureGen 2.0 Power Plant	1,000	(ARRA)
	FutureGen 2.0 Pipeline and Storage		(ARRA)
	Hydrogen Energy California	408	(CCPI 3)
	Petra Nova	167	(CCPI 3)
	Southern Company Services (Plant Barry)	295	(CCPI 3)
	Summit Texas Clean Energy	450	(CCPI 3)
Coal CCS Total		2,754	
Industrial	Air Products and Chemicals	284	(ARRA)
	Archer Daniels Midland	141	(ARRA)
	Leucadia Lake Charles	261	(ARRA)
Industrial CCS Total		**686**	
CCS Demonstration Project Total		**3,440**	

Aside from the ARRA stimulus fund, Congress provided roughly $9 billion (in nominal dollars) in annual appropriations for DOE's FECM from FY2010 to FY2023, over $2.8 billion of which was specifically directed towards CCS line items.

[22] Congressional Research Service (CRS). The FutureGen Carbon Capture and Sequestration Project: A Brief History and Issues for Congress. Peter Folger. February 2014. https://sgp.fas.org/crs/misc/R43028.pdf

Figure 4. Annual Appropriations for DOE FECM Program Areas

FY2010-FY2022 (nominal, $ thousands)

FECM Program Areas	Program	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
CCUS and Power Systems	Carbon Capture	-	58,703	66,986	63,725	92,000	88,000	101,000	101,000	100,671	100,671	117,800	86,300	99,000	135,000
	Carbon Dioxide Removal	-	-	-	-	-	-	-	-	-	-	-	40,000	49,000	70,000
	Carbon Utilization	-	-	-	-	-	-	-	-	-	-	-	23,000	29,000	50,000
	Carbon Storage	-	120,912	112,208	106,745	108,766	100,000	106,000	95,300	98,096	98,096	100,000	79,000	97,000	110,000
	Advanced Energy and Hydrogen Systems	-	168,627	97,169	93,438	99,500	103,000	105,000	105,000	113,000	129,683	150,000	168,700	94,000	
	Cross-Cutting Research	-	41,116	47,946	45,618	42,925	49,000	50,000	45,500	58,350	56,350	56,000	32,900	33,000	
	Mineral Sustainability	-	-	-	-	-	-	-	-	-	-	-	53,000	53,000	54,000
	Supercritical CO2 Technology	-	-	-	-	-	10,000	15,000	24,000	24,000	22,430	16,000	14,500	15,000	95,000
	NETL Coal R&D	-		35,011	33,338	50,011	50,000	53,000	53,000	53,000	54,000	61,000	0		
	Transformational Coal Pilots	-	-	-	-	-	-	-	50,000	35,000	75,000	70,000	10,000	0	
Subtotal CCUS and Power Systems		393,485	389,688	359,320	341,864	392,207	400,000	430,000	473,800	481,117	486,230	490,800	446,800	469,000	514,000
Other FECM		266,285	195,361	161,751	156,851	178,229	171,000	202,000	208,200	245,700	253,770	259,200	303,200	356,000	376,000
Total FECM		659,770	434,052	337,071	498,715	570,431	571,000	632,000	668,000	726,817	740,000	750,000	750,000	825,000	890,000

Recently enacted legislation also greatly expanded RD&D programs. The Energy Act of 2020, which was included in the Consolidated Appropriations Act, 2021 (Division Z) authorized $6.34 billion for RD&D programs for FY2021-FY2025, including the following:

- $2.6 billion for six commercial-scale demonstrations (natural gas, coal, industrial)
- $1 billion for large-scale pilot projects
- $910 million for DOE R&D program
- $200 million for front-end engineering and design program for CCUS
- $800 million for a large-scale carbon storage validation and testing
- $100 million for carbon capture test centers
- $283 million for carbon utilization program
- $450 million for carbon removal

The Infrastructure and Investment Act (IIJA), passed in November 2021, further increased the authorization levels of CCS programs established in the Energy Act of 2020 and created new programs as well:

- $2.537 billion for CCS demonstration projects
- $100 million for front-end engineering and design program for CCUS transport infrastructure
- $2.5 billion for carbon storage validation and testing
- $2.1 billion for carbon dioxide transportation infrastructure financing and innovation
- $937 million for large-scale CCS pilot projects
- $310 million for carbon utilization
- $3.5 billion for regional direct air capture (DAC) hubs under the carbon removal program
- $115 million for carbon removal prize competition

In total, the Energy Act of 2020 and the IIJA authorized nearly $13.6 billion for RD&D for FY2022 - FY2026, $12.1 billion of which has already been appropriated.

Debt Capital Financing for CCS Commercial Projects and CCS Infrastructure

In addition to directly funding RD&D programs, the DOE supports early commercialization of advanced technologies like renewables, nuclear, and advanced fossil fuels through a variety of loan guarantee programs with hundreds of billions in lending authority. Loan guarantees, as the name suggests, means the federal government will guarantee to pay back loans to lenders if the borrowers default. To date, DOE has made one conditional agreement with one CCS facility but has not finalized a loan guarantee, yet.

The Loan Programs Office at DOE has $8.5 billion in loan guarantee authority specifically for advanced fossil energy projects like CCS under the Title XVII Innovative Loan Guarantee Program created by the Energy Policy Act of 2005. In 2016, DOE offered a conditional commitment to a loan guarantee of up to $2 billion for Lake Charles Methanol, [23] a petcoke-to-methanol facility that sell its captured carbon for EOR, the same project that was selected as one of DOE's industrial CCS demonstration projects but withdrew in 2015 because the gasification facility on which the CCS technology was to be built was canceled. DOE has not finalized a loan guarantee to any CCS facility, yet.

On top of the existing loan authority, the IRA provides an additional $40 billion of loan authority for Title XVII projects, to remain available through the end of FY2026, and it appropriated $3.6 billion in credit subsidy to support the cost of those loans and administrative expenses. When a loan guarantee is issued, the loan guarantee recipient, or the borrower must pay a credit subsidy cost, which is an estimate of the long-term cost to the federal government of guaranteeing a loan for the entire period the loan is outstanding. It includes the costs of covering interest subsidies, loan defaults, and loan delinquencies.[24] The size of the credit subsidy cost corresponds to the size and riskiness of the loan.

The IRA also created a new, time-limited $250 billion Title XVII loan authority—Section 1706, Energy Infrastructure Reinvestment Financing—for projects that:

(1) retool, repower, repurpose, or replace energy infrastructure that has ceased operations; or

[23] DOE, Energy Department Offers Conditional Commitment for First Advanced Fossil Energy Loan Guarantee. https://www.energy.gov/articles/energy-department-offers-conditional-commitment-first-advanced-fossil-energy-loan#:~:text=WASHINGTON%20%E2%80%94%20The%20U.S.%20Department%20of,technology%20in%20Lake%20Charles%2C%20Louisiana.
[24] GAO, DOE Loan Guarantees: Further Actions Are Needed to Improve Tracking and Review of Applications. GAO-12-157. https://www.gao.gov/assets/gao-12-157.pdf

(2) enable operating energy infrastructure to avoid, reduce, utilize, or sequester air pollutants or anthropogenic emissions of greenhouse gases.

Potential projects could include repurposing shuttered fossil energy facilities for clean energy production, updating operating energy infrastructure with emissions control technologies, including CCUS. The IRA appropriated $5 billion in credit subsidy to support the cost of those loans and administrative expenses.

The IIJA also created a new CO_2 transportation infrastructure financing and innovation program (CIFIA) to provide federal credit instruments like a loan guarantee, a secured loan, or a grant to CCS infrastructure projects. CIFIA will be managed by the Loan Programs Office under FECM, the same office that manages CCS loan guarantees. Congress appropriated $2.1 billion for the program for FY2022 through FY2026 to support the construction of infrastructure (e.g. pipeline, shipping, rail, etc.) to transport CO_2 from capture sites to storage or utilization locations.

Carbon Capture and Sequestration Tax Credit (45Q)

The carbon capture and sequestration credit – often referred to as 45Q – can be claimed by qualified taxpayers for every metric ton of carbon oxide they capture and sequester. Congress created the credit in 2008 to encourage the adoption of CCS technologies. At the time, the JCT estimated it would cost taxpayers $1.12 billion in lost revenue.[25] In the Bipartisan Budget Act of 2018 (BBA), Congress greatly expanded and extended the 45Q credit. Carbon oxides captured by equipment placed in service after enactment of the BBA and before the start of 2024 can claim the credit for 12 years. In December 2020,[26] Congress extended the deadline for qualifying facilities to begin construction by two years to the start of 2026.

The IRA then expanded and extended the CCS tax credit again, pushing the eligibility date back to 2033. The IRA also made credits transferable, and it allows certain taxpayers to elect to receive 45Q credits as a direct payment rather than as a credit against their federal income tax liabilities – which means companies can benefit from the lucrative credit regardless of tax liability.

Figure 5. 45Q Credit for Qualifying Equipment

	Equipment in Service 10/3/2008 – 2/9/18	Equipment in Service 2/9/18 – 12/31/22	Equipment in Service 12/31/22 – Construction Begins Before 1/1/33
Claim Period	Till Jan 1, 2023*	12 years	12 years
Credit Amount**			
Geologically Sequestered CO_2	$20	$17	$17 ($36 DAC***)

[25] JCX-78-08
[26] Division EE of the Consolidated Appropriations Act of 2021 (P.L. 116 – 260)

Geologically Sequestered CO_2 with Enhanced Oil Recovery	$10	$12	$12 ($26 DAC)
Other Qualified Use of CO_2	$10	$12	$12 ($26 DAC)
Credit Amount if prevailing wage & apprenticeship requirements are satisfied (multiply by 5)			
Geologically Sequestered CO_2	N/A	$85	$85 ($180 DAC)
Geologically Sequestered CO_2 with Enhanced Oil Recovery	N/A	$60	$60 ($130 DAC)
Other Qualified Use of CO_2	N/A	$60	$60 ($130 DAC)
Annual Capture Requirements	Capture ≥ 500,000 metric tons	*Facilities that emit ≤ 500,000 metric tons per year:* ≥ 25,000 metric tons. *Power plants that emit > 500,000 metric tons*: ≥ 500,000 metric tons. *DAC and other capture facilities:* ≥ 100,000 metric tons.	**Construction begins before 8/16/22:** Previous annual capture requirements apply. **Construction begins after 8/16/22:** *Power Plants*: ≥ 18,750 metric tons AND ≥ 75% baseline carbon oxide production. *Other Facilities:* ≥ 12,500 metric tons. *Direct Air Capture:* ≥ 1,000 metric tons.

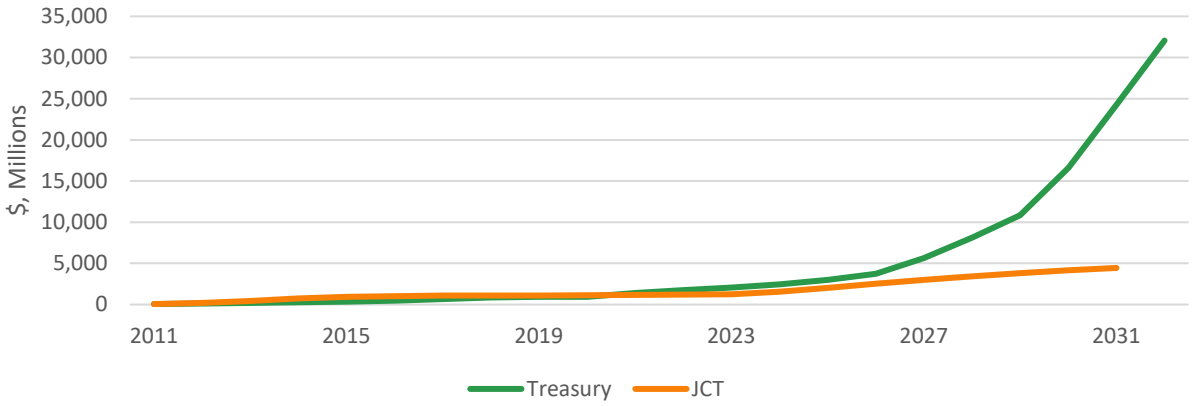
Source: TCS, Hot Air and High Costs: The Carbon Capture and Sequestration 45Q Credit. https://www.taxpayer.net/energy-natural-resources/hot-air-and-high-costs-the-carbon-capture-and-sequestration-credit-45q/

When the BBA removed the 75-million-ton cap and expanded the 45Q credit, JCT estimated the expansion would cost an additional $680 million over 10 years, from FY2018 to FY2027. When Congress extended the deadline for qualifying facilities to begin construction by two more years in the Consolidated Appropriations Act of 2021, JCT estimated that the extension would cost $641 million from FY2021 to FY2030. JCT estimates the latest IRA expansion will cost taxpayers an additional $3.2 billion over the next decade.[27] However, because facilities can claim credits for years after the period covered in JCT's cost estimate, so long as *construction* begins before 2033, the actual costs will be much higher.

[27] Congressional Budget Office (CBO), "Estimated Budgetary Effects of Public Law 117-169," https://www.cbo.gov/system/files/2022-09/PL117-169_9-7-22.pdf

Meanwhile, the Treasury Department produced drastically different cost estimates of the 45Q credit, reflecting the wildly different assumptions about the industry's readiness to take advantage of these credits and the commercial viability of CCS technologies. In 2021, after the 45Q credit was extended for two more years, Treasury put the estimated cost of the credit at $20.1 billion from FY2021-FY2031[28] – more than double Treasury's previous estimate[29] and far higher than the JCT estimate of $641 million for FY2021-FY2030. And just one year later, in 2022, the Treasury Department's estimate jumped to $30.6 billion.[30] This cost estimate does not even include the most recent expansion of the credit by IRA.

Figure 6. Cumulative Estimated Cost of 45Q



Failure, Fraud and Fruitless Results

Poor Management, Cost Overrun and the Lack of Investor Interest - CCS Demonstration Projects

Despite decades of extensive federal investment in CCS, including an array of programs offering loan guarantees and tax credits for every stage of development, the results so far have been uniformly disappointing. The GAO recently examined 11 CCS demonstrations projects funded through Round 3 of CCPI and ARRA and found that only 3 of the 11 projects were completed, partially due to DOE mismanagement of the program. Coal demonstration projects were less successful—only 1 out of 8 was built and went into operation, only to shut down in May 2020

[28] U.S. Treasury Department, "Tax Expenditures – FY23," https://home.treasury.gov/system/files/131/Tax-Expenditures-FY2023.pdf
[29] U.S. Treasury Department, "Tax Expenditures – FY22," https://home.treasury.gov/system/files/131/Tax-Expenditures-FY2022.pdf
[30] U.S. Treasury Department, "Tax Expenditures – FY24," https://home.treasury.gov/system/files/131/Tax-Expenditures-FY2024-update.pdf

due to low oil prices. Industrial CCS demonstration projects yielded better results—2 of the 3 selected projects were completed and remained operational.

Figure 7. Status of CCS Demonstration Projects Funded by DOE

CCS Program	Project	Project outcome	Final phase entered	DOE funding totals ($)
Coal	American Electric Power	Withdrawn	Definition	16,880,268
	Basin Electric	Withdrawn	None	0
	FutureGen 2.0 Power Plant	Terminated	Design	116,666,759
	FutureGen 2.0 Pipeline and Storage	Terminated	Design	83,857,100
	Hydrogen Energy California	Terminated	Definition	153,428,898
	Petra Nova	Completed (Shut down in 2020)	Operations	195,132,425
	Southern Company Services (Plant Barry)	Withdrawn	None	0
	Summit Texas Clean Energy	Terminated	Definition	117,876,707
Coal CCS Total				**683,842,157**
Industrial	Air Products and Chemicals	Completed	Operations	284,012,496
	Archer Daniels Midland	Completed	Operations	141,405,945
	Leucadia Lake Charles	Withdrawn	Design	12,758,649
Industrial CCS Total				**438,177,090**
CCS Demonstration Project Total				**1,122,019,247**

Source: GAO-22-105111. Table 1 and 2

The GAO found DOE failed to award coal CCS projects selectively and negotiated funding agreements on an expedited schedule, resulting in significant waste of taxpayer funds. The expedited negotiation resulted in conditional cooperative agreements limiting DOE's ability to enforce certain actions, such as procurement contracts. GAO found DOE had violated the agency's own risk mitigation measure in funding four unsuccessful coal CCS demonstrations: the two FutureGen 2.0 projects, the Hydrogen Energy California project, and the Summit Texas Clean Energy project. When these four projects were unable to meet established milestones, instead of terminating funding agreement, DOE reduced the awardee cost share portion established in the original agreements and shifted funds earmarked for later phases of development and sped up

disbursement of ARRA funds. As a result, DOE wasted an additional $300 million for projects that were never built.

FutureGen

Originally proposed by the Bush Administration in 2003, FutureGen was a large-scale, multibillion dollar initiative of the DOE to build and operate the world's first coal-fueled, zero emissions power plant in Mattoon, IL. The mega-plant was intended to produce hydrogen and electricity from coal, while capturing and storing CO_2 emissions underground using CCS. In 2010, the DOE abandoned this plan, announced it would no longer finance the construction of the new plant due to cost overruns.

Instead, DOE awarded $1 billion to retrofit a 64-year-old oil-burning plant in Meredosia, IL. The redesigned plan called for the use of "advanced oxy-combustion" technology and pumping the emissions consisting of pure carbon dioxide through a 150-mile underground pipeline back to Mattoon for storage. The underground pipeline would span over 400 acres of Coles County farmland. The project, now labeled "FutureGen 2.0," is intended to transport and store more than 1.3 million tons of carbon dioxide annually. The $1 billion DOE award provided by the Recovery Act of 2009 will be used to finance the estimated $1.4 billion project. In 2011, the Chicago Tribune reported the power company Ameren was pulling out of the FutureGen project and shutting down their power plant in Meredosia.

Meanwhile, local landowners expressed concerns about the vicinity of the sequestration site to residential homes and local farmland, citing unknown changes in property values and compensation—if contamination occurred. This local opposition had already driven Coles County, the original sequestration site, to refuse development plans in their county.

FutureGen 2.0 was eventually abandoned because the designated power plant was unable to complete necessary procurement and construction negotiations or secure private funding. DOE spent more than $200 million on the project.

The GAO recommended Congress require regular DOE reporting on project status and funding to ensure greater oversight and accountability of CCS program expenditures. Nevertheless, Congress did not require any additional oversight of these funds, even as it appropriated an additional $12.1 billion in IIJA for a variety of RD&D and demonstration projects. DOE has already announced multiple funding opportunities under IIJA.

Petra Nova

In 2017, the Petra Nova–W.A. Parish Generating Station became the first industrial-scale coal-fired power plant with CCS to operate in the United States. The plant began capturing CO2 per day from its 240-megawatt slipstream. The captured CO2 is transported via an 82-mile pipeline to the West Ranch oil field, where it is injected for EOR, increasing the field's oil production from 300 to 15,000 barrels per day.

NRG Energy Inc., and JX Nippon Oil & Gas Exploration Corporation, the joint owners of the Petra Nova project, announced in May 2020, that Petro Nova would stop operating the CCS equipment, citing unfavorable economic conditions due to low crude oil prices.

DOE provided Petra Nova with more than $160 million in funding a part of the ARRA. Petra Nova is the only CCPI Round 3 project that expended its ARRA funding and began operating. The three other CCPI Round 3 demonstration projects funded using ARRA appropriations have been withdrawn, canceled, or suspended.

Risky Loan Guarantees

The track record for DOE loan guarantees is not pretty, either. In the past, the Title XVII loan guarantee program has been used to provide debt financing for large-scale, capital-intensive, and highly risky projects, often without sufficient safeguards for federal taxpayers.

In one noteworthy project, the Title XVII program guaranteed up to $12 billion for the Vogtle Reactors 3 & 4, a nuclear plant more than 6 years behind schedule and $14 billion over budget.[31] During the construction of the project, financial rating agencies downgraded credit ratings for the partners involved in the project.[32] Westinghouse, one of the partner companies of the project went bankrupt in 2017, largely because of Vogtle 3 & 4.[33] Despite these risk factors, DOE's estimate of the credit subsidy costs for the loan guarantee was $0, meaning DOE considered these loans – for a nuclear power plant – to be risk-free. If this project goes bankrupt, taxpayers will be on the hook for these loans.

[31] Taxpayers for Common Sense, Fact Sheet, DOE Loan Guarantee Program: Vogtle Reactors 3 & 4. March 2019. https://www.taxpayer.net/energy-natural-resources/doe-loan-guarantee-program-vogtle-reactors-3-4-2/

[32] Fitch Ratings. "FITCH RATES GEORGIA DEV AUTH'S (OGLETHORPE POWER CORP) $212.76MM PCRS 2013A 'A'; OUTLOOK TO NEGATIVE." April 5, 2013. http://opc.com/oracle_cons/groups/public/@opc-web/documents/webcontent/ct_000403.pdf. Moody's. https://www.moodys.com/research/Moodys-changes-Georgia-Power-outlook-to-negative-affirms-Southern-with–PR_363495

[33] Reuters, Huge nuclear cost overruns push Toshiba's Westinghouse into bankruptcy. March 28, 2017. http://www.reuters.com/article/us-toshiba-accounting-board-idUSKBN17006K

The latest subsidy for carbon infrastructure, the CIFIA program will similarly guarantee loans for large-scale, capital-intensive, and highly risky projects. And the new loan authority granted by the IRA will further increase the risk exposure for federal taxpayers. As we learned with projects like FutureGen, Petra Nova, etc., CCS facilities are troubled and we need to protect any taxpayer investments tied to them.

Fraudulent Past and Questionable Future of 45Q

In addition to the mismanagement and obvious risks of CCS funding and loan programs, the 45Q tax credit has also been abused. In 2020, the Treasury Department's Inspector General for Tax Administration found that 10 taxpayers claimed over $1 billion under 45Q from 2010 to 2019, or 99 percent of total credits claimed.

Figure 8. 45Q Tax Credit Claimants and Credit Amount - Tax Year 2010-2019

Range of Total Credits Claimed	Number of Claimants	Percent of Claimants	Credits Claimed	Percent of Credits Claimed
$0 - $1000	592	88.10%	$39,656	0.00%
$1,000 - $10,000	56	8.33%	$212,749	0.02%
$10,000 - $1 million	14	2.08%	$1,213,397	0.12%
Over $1 million	10	1.49%	$1,024,900,044	99.86%
Total	**672**	**100.00%**	**$1,026,365,846**	**100.00%**

Source: Treasury Department audit using IRS Business Returns Transaction File data as of February 13, 2020. https://www.menendez.senate.gov/imo/media/doc/TIGTA%20IRC%2045Q%20Response%20Letter%20FINAL%2004-15-2020.pdf

The Internal Revenue Service (IRS) audited the 10 companies who claimed over $100 million each in credits and found that $894 million worth of the credits claimed by these companies did not comply with Environmental Protection Agency (EPA) monitoring, reporting and verification requirements for sequestered carbon.[34] The companies had insufficiently documented whether the carbon for which they were claiming credits remained underground. The IRS has reported on their examination of 68% of these cases and has subsequently disallowed 59% of the noncompliant credits, worth approximately $531 million. No further update has been released since April 2020. In the audit, the IRS stated that "a campaign or special project"[35] examining every claimant of the 45Q credit would be needed to ensure all claimants are in compliance with EPA's requirements.

Nevertheless, as with other risky CCS subsidies, Congress expanded and extended the 45Q tax credit in the IRA without any provisions or funding for oversight. As more commercial CCS

[34] Treasury Department's Inspector General for Tax Administration (TIGTA) Audit of 45Q https://www.menendez.senate.gov/imo/media/doc/TIGTA%20IRC%2045Q%20Response%20Letter%20FINAL%2004-15-2020.pdf
[35] Ibid.

facilities are expected to take advantage of the 45Q in the coming years, EPA and IRS will not be able to effectively monitor and oversee 45Q tax credit claims and reporting compliance without sufficient resources or antifraud safeguards, once again exposing taxpayers to increased risks of corporate tax fraud.

The IRA allows certain claimants of 45Q (among other tax credits) to receive a direct payment rather than a credit against their federal income tax liabilities. This allows companies to receive a direct cash payment if the credit exceeds their tax liabilities, meaning the U.S. Treasury cuts a check to the company. This is especially advantageous to oil and gas companies, which already employ a laundry list of tax subsidies to lower their effective tax rate.[36]

The IRA also allows the transfer of eligible credits from eligible claimants to an unrelated third party, allowing an investor with no formal ties to an underlying CCS project to claim all or some portion of the available 45Q credit. This will make oversight more complicated, especially when credits must be reclaimed due to noncompliance or carbon leakage into the atmosphere.

Finally, the IRS issued a final rule[37] in 2021 setting a three-year recapture period for 45Q credit, during which the Secretary of Treasury can claw back benefits of the 45Q credit if stored or injected carbon is leaked. As a result, facilities claiming the 45Q credit need only to retain data on stored or injected carbon for three years. A three-year limit on monitoring and verification utterly fails to address any long-term liability issues associated with CO_2 leakage and will not ensure that the 45Q tax credit has enduring benefits to greenhouse gas emissions reduction and the climate, despite the high price tag for taxpayers.

Mad Dash to Reap in Subsidies

Given the recent expansion of the whole suite of CSS subsidies, it is unsurprising that fossil fuels companies are taking advantage of taxpayer dollars on the table. In May 2022, BP Plc. and industrial gas supplier Linde Plc. announced a new CCS project that would capture CO2 from Linde's hydrogen gas plant near Houston, Texas.[38] In that same month, Chevron announced that it would launch a CCS project at its cogeneration plant in Kern County, California.[39] In October 2022, ExxonMobil, partnered with CF Industries, announced a CCS project at CF Industries' blue ammonia production plant in Louisiana.[40]

Various CCS pipeline projects have also been announced since the passage of IIJA and IRA. POET, the largest ethanol producer in the world, announced plans for a $3 billion CCS pipeline

[36] TCS, Effective Tax Rate. https://www.taxpayer.net/wp-content/uploads/ported/images/downloads/TCS_ETR-Report.pdf
[37] Docket Number: TD9944
[38] https://www.reuters.com/markets/carbon/bp-linde-plan-carbon-capture-project-near-houston-2022-05-17/
[39] https://www.chevron.com/newsroom/2022/q2/chevron-launches-carbon-capture-and-storage-project-in-san-joaquin-valley
[40] https://gov.louisiana.gov/index.cfm/newsroom/detail/3858

partnering with Navigator CO2.[41] The pipelines will transport captured CO2 from 18 poet plants in Iowa, Nebraska and South Dakota to Illinois for storage. Summit Agriculture Group, a subsidiary of a private equity company is planning to build a 2000-mile pipeline transporting captured carbon from 31 ethanol plans in 5 states to be eventually sequestered underground in North Dakota.[42] Wolf Carbon Solutions is also building a 350-mile pipeline transporting 12 million tons of CO2, which will be stored at Archer Daniels Midland's sequestration site in Decatur, Illinois.[43]

The oil and gas and ethanol industry stands to receive billions appropriated in IIJA in the form of subsidized demonstration project as well as DOE debt capital financing. When the projects eventually reach commercialization, these companies will be eligible to receive another billions of dollars' worth of 45Q tax credits.

Dubious Climate Claims

CCS has failed to deliver on its climate reduction promises, even after decades of taxpayer subsidies. Deployment of CCS at scale still faces incredible challenges in feasibility and expense, and yet, its efficacy in reducing greenhouse gases is only speculative.

Foremost, the only existing market for captured carbon is increasing oil and gas production through EOR. Globally 91% of captured carbon is being used for EOR;[44] in the US, 11 out of 13 (85%) CCS facilities capturing carbon to sell it to oil and gas companies for EOR. It is still unknown if using captured carbon oxides for EOR results in a net reduction in emissions. According to the IEA, between 300 and 600 kg of CO2 is injected in EOR processes to produce one barrel of oil in the United States, which releases around 400 kg of CO2 when combusted, and another 100 kg of CO2 on average during the production, refining and transportation of the oil.[45] Recent papers also suggest that most EOR projects using captured CO_2 initially have a negative carbon footprint (net emissions reduction) because a high portion of the CO_2 pumped underground becomes trapped. But as projects continue, increasingly less CO_2 is trapped underground, and the carbon footprint becomes positive (no net emission reduction).[46] This

[41] https://www.desmoinesregister.com/story/money/agriculture/2022/06/07/poet-iowa-ethanol-plant-navigator-co-2-carbon-pipeline-project/7543718001/
[42] https://www.motherjones.com/environment/2022/05/midwest-carbon-express-summit-bruce-rastetter/
[43] https://investors.adm.com/news/news-details/2022/Wolf-Carbon-Solutions-ADM-Announce-Partnership-to-Advance-Decarbonization-of-Ethanol-Production/default.aspx
[44] K. Novak Mavar, N. Gaurina-Medimurec, L. Hrnčević, Significance of Enhanced Oil Recovery in Carbon Dioxide Emission Reduction, 13(4) Sustainability 1, 3 (Table 1) (2021)
[45] IEA, Can CO2-EOR really provide carbon-negative oil? https://www.iea.org/commentaries/can-co2-eor-really-provide-carbon-negative-oil
[46] Núñez-López and Moskal, "Potential of CO2-EOR for Near-Term Decarbonization," Frontiers in Climate., Sept 27, 2019. https://doi.org/10.3389/fclim.2019.00005; Sekera, J. & Lichtenberger, A. (2020) Assessing Carbon Capture: Public Policy, Science, and Societal Need: A Review of the Literature on Industrial Carbon Removal. Biophysical Economics and Sustainability. Available: https://link.springer.com/article/10.1007/s41247-020-00080-5

raises serious questions about the efficacy of handing out billions of dollars in 45Q credits for carbon captured and used for EOR.

Meanwhile, the pipelines required to transport liquified carbon oxides are expensive to build and energy intensive. They must be specifically designed for carrying high pressure CO_2 and impurities in the CO_2 stream, like water, can damage pipelines and lead to dangerous leaks and explosions as the compressed fluid rapidly expands to a gas. The exceedingly cold temperatures of transported CO_2 can cause pipes and equipment to become brittle. In 2022, a CO2 pipeline ruptured in Mississippi, leading to the evacuation of 200 residents.[47]

Finally, each source of CO_2 must be connected to an appropriate storage site via pipeline, which may be hundreds of miles away.[48] Safe, permanent, and verifiable storage of CO2 is difficult to guarantee. Liabilities associated with leakage have not been addressed in law or regulation. [49] And, like other climate liabilities, the financial and liability risks associated with carbon transportation and storage may ultimately fall on the taxpayers, especially with federally backed loan guarantees programs and subsidized programs for CCS infrastructure buildout.

The unproven scalability of CCS technologies and their prohibitive costs mean they cannot play a significant role in the rapid emissions reduction required to address climate change. Despite the existence of the technology for decades and billions of dollars in government subsidies to date, deployment of CCS at scale still faces insurmountable challenges of feasibility, effectiveness, and expense. CCS pilot projects have been overpromised and underdelivered time and time again. The Petra Nova carbon capture facility illustrates the failure of CCS to deliver meaningful emissions reductions—during its operation, the CCS system only captured 7 percent of the power plant's total CO2 emissions, well below the company's promises to reduce CO2 emissions by 90 percent.[50]

CCUS is also being touted as a climate solution alongside the use of biomass for energy. This concept is known as BECCS, or bioenergy with carbon, capture, and storage. While the use of BECCS to date has been limited, the industry is looking to expand in the US Midwest. But the proposed carbon pipelines have not yet been built due to opposition from landowners, farmers, environmental groups, and others. Other forms of biomass offered as potential climate solutions include using forest resources or other feedstocks for use with CCS, but no commercial projects are operating in the US thus far. Despite this, BECCS has been offered as an emissions reduction

[47] Des Moines Register, A carbon dioxide pipeline burst in Mississippi. Here's what happened next. https://www.desmoinesregister.com/story/money/agriculture/2022/09/11/here-minute-details-2020-mississippi-co-2-pipeline-leak-rupture-denbury-gulf-coast/8015510001/
[48] CRS, Carbon Storage Requirements in the 45Q Tax Credit. https://crsreports.congress.gov/product/pdf/IF/IF11639
[49] Ibid.
[50]Energy and Policy Institute, Petra Nova carbon capture project stalls with cheap oil. https://www.energyandpolicy.org/petra-nova

option, including within the 2016 United States Mid-Century Strategy for Deep Decarbonization, released by the White House.

Conclusion

Often touted as a climate solution, CCS has reaped tens of billions of dollars in federal taxpayer tax credits and subsidies without any appreciable reductions in greenhouse gas emissions. Taxpayers have already spent billions of dollars subsidizing every step of the CCS process, and the results have been disastrous. The record is littered with failure, waste, fraud, and abuse. Efforts to tackle the serious need for oversight and accountability have been too far and few between. Congress has nonetheless doubled down on CCS, providing tens of billions in new funding for loan guarantees, tax credits, and other subsidies. If CCS is to be a part of addressing carbon emissions and climate change there must be an overhaul of the current suite of taxpayer subsidies on the table. The status quo is pricey and problematic.