REPORT

The Carbon Capture Mirage

Carbon capture and storage (CCS) is a technology that promises to capture carbon dioxide (CO_2) either from smokestacks or the air and then permanently keep it from entering the atmosphere. Unlike a transition to renewable energy, storage, and electrification — which would entail a re-ordering of the energy system and an end to the fossil fuel industry — CCS promises to preserve a "clean fossil fuel" industry forever. By promising compatibility with the current fossil fuel energy system, CCS enables continued fossil fuel investment and a delay of climate action even as the CCS install dates recede into the future.

At best, CCS burns money on speculative tech to pretend that there is an escape hatch for fossil fuel investments. At worst, funding CCS supports a business model that generates CO_2 just to later capture it, subsidizing fossil fuel production for the sake of pollution. In practice, CCS currently functions as a back door for subsidizing existing fossil fuel infrastructure. Despite the enduring political appeal of CCS, for the most part the technology remains permanently stuck in the project announcement phase. Carbon capture advocates continue to suggest that widespread adoption is just around the corner if only they could get higher subsidies, a few more grants, and reprieve from burdensome regulation.

This report finds:

- Continued failure of CCS to live up to promises
- Ongoing re-branding of current fossil fuel industry activities to create the illusion of progress on CCS
- An increasingly lax CCS subsidy and regulatory regime needed to keep the illusion afloat
- Dangerous pay-to-pollute incentives that this subsidy system creates
- A glimpse into the future of CCS and how it supports dead-end industries with no hope of full decarbonization.

Carbon Capture Has Been Hyped and Subsidized for Decades

From clean coal to carbon capture: CCS emerges as the fossil fuel industry's preferred alternative to renewable energy

CCS grew out of federal "clean coal" efforts, which received $2.6 billion from the program's inception in 1984 through 1990, producing few commercially viable technologies.[1] In 2003, President George W. Bush revived clean coal with a $1 billion coal power plant focused on capturing carbon emissions under the FutureGen program.[2] During the Bush administration, Congress established the Clean Coal Power Initiative, providing $2 billion to fund private sector coal demonstration projects such as CCS.[3]

The 2005 Energy Policy Act created $1.65 billion in tax credits for clean coal facilities.[4] In 2006, the Bush administration announced that $1 billion of the credits would go to nine clean coal facilities.[5] However, by 2008, "new market realities" forced the U.S. Department of Energy (DOE) to restructure the program into up to three smaller demonstration projects.[6] These projects were

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touted as a way to boost oil production by supplementing the supply of naturally occurring CO_2 that oil producers injected into older oil reservoirs to increase production, a process known as enhanced oil recovery (EOR).[7]

During the 2008 presidential election, the coal industry made a deal with then-candidate Barack Obama, running ads on his behalf touting the magic of clean coal CCS as a climate solution (while others in the Democratic party, such as Al Gore, were calling for 100 percent renewable electricity by 2018).[8] At the time, industry groups were very optimistic about the technology. In 2009, the International Energy Agency (IEA) released a roadmap for CCS predicting 121 million metric tons of CO_2 capture per year by 2020 in North America.[9] A year earlier, a vice president from the clean coal industry group the American Coalition for Clean Coal Electricity said that CCS technology existed and that, "With the current research being done, we think we can get the technology up and running within 10 to 15 years."[10]

The Obama administration delivers for the CCS industry, but the projects fail to pan out

CCS proponents were set to get far more federal investment in the technology than "current research." In 2009, the American Recovery and Reinvestment Act (ARRA) offered $3.4 billion for the research and development of CCS projects (with nearly $1 billion going unspent).[11] With billions flowing to CCS, in early 2010 President Obama claimed that, "Rapid commercial development and deployment of clean coal technologies, particularly carbon capture and storage, will help position the United States as a leader in the global clean energy race."[12] Later that year, the DOE supplemented the claim with a roadmap highlighting DOE-supported CCS projects with a combined 16.8 million tons per year of capacity that would be operational by 2016.[13]

Much like earlier attempts to make CCS viable, during this period CCS underperformed spectacularly.[14] Out of 11 large-scale demonstration projects selected by the DOE, 9 were funded by the ARRA and only 3 remained operational as of mid-2025.[15] Of the five commercial power plant projects, only one (Petra Nova) ever reached operation, and it faced serious challenges, forcing the plant to close after fewer than four years.[16] An MIT database of carbon capture projects through September 2016 recorded 15 cancelled carbon capture projects, but that list is not exhaustive; more than 30 coal plants announced in the mid 2000s considered carbon capture.[17] The DOE roadmap admitted that this generation of carbon capture projects would use much of the CO_2 for oil extraction.[18]

The flagship CCS boondoggle of the Obama era

Southern Company's notorious power plant project in Kemper, Mississippi appeared in the DOE's 2010 roadmap for its Clean Coal Power Initiative program.[19] The project aimed to build a "clean coal" plant and use the captured emissions for EOR.[20] In 2012, the Global CCS Institute claimed that, "The next key event for the advance of pre-combustion capture technology will be the integrated operation of the first [integrated gasification combined cycle, or IGCC] plant with capture at the Kemper County IGCC plant in Mississippi in 2014."[21]

Even before it was completed, the Kemper project served as crucial evidence for those advocating that an "all of the above" energy policy could address climate change.[22] Advocates claimed that it would provide a viable way to continue using coal.[23] Referring to the Kemper plant as proof of CCS viability, in 2014 a Clean Air Task Force (CATF) representative said, "It would be pretty hard to argue that this technology does not exist when it is standing there on 55 acres and many many storeys towering above you."[24]

The Kemper plant aimed to capture 2 million metric tons of CO_2 per year — 65 percent of its total emissions.[25] The project was awarded at least $680 million in federal grants and tax credits, (nearly 25 percent more than the infamous loan to Solyndra)[26], including millions that Southern Company managed to redirect from another failed clean coal project in Orlando, Florida.[27] Set to open in 2013, Kemper pushed back its opening day for years.[28] By 2015, the project's overall budget had ballooned from $1.8 billion to $6.2 billion.[29] Critical parts of the plant were torn down and rebuilt due to construction challenges, such as a misunderstanding of chemical reactions that led to the replacement of 1,500 feet of pipe.[30] In 2015, Southern Company claimed that the project was "98 percent or so complete"[31] By 2017, fed up with delays and overruns, regulators forced the Kemper plant to abandon its clean coal plans completely.[32]

CCS supporters continue to make outlandish predictions.

In 2022, the Princeton University-affiliated REPEAT Project predicted that passage of the Inflation Reduction Act (IRA) would result in more than 50 million metric tons per year of additional CCS in the U.S. for "transport and geologic storage" by 2024.[33] REPEAT would later claim that the law would encourage primarily geologic sequestration, rather than the use of captured CO_2 to produce more oil.[34] As a result, the REPEAT model predicted that oil and gas production would decline as a result of the IRA.[35] As with other components of the REPEAT model, this prediction was proved wrong almost immediately. In 2024, oil and gas production was up 6.8 percent from 2022, making the U.S. the all-time largest producer of crude oil in the world.[36]

This carbon capture vision failed to materialize. In July 2023, the REPEAT project released an updated report showing almost no additional CCS in 2024 but a large jump in 2025, to the roughly 50 million metric ton level.[37] While originally bullish on the possibility of CCS installation at coal- and gas-fired power plants (90 million tons of capture annually by 2030), even in the updated "optimistic" scenario, virtually no power plants are projected to use CCS through 2035.[38]

In REPEAT's May 2025 report, the organization further pushed back the start date for a power plant CCS boom, but continued to claim that around 100 million tons of CO_2 would be captured by power plants in 2035 if the 45Q tax credit (which provides money for CO_2 injected underground) remained intact.[39] REPEAT's earlier prediction that gas production would decline is surprising, as carbon capture significantly increases fuel use at power plants to cover the energy needs of the capture equipment.[40] Less surprisingly, the American Gas Association has seized on the REPEAT modeling to celebrate the supposed role for fracked gas in reducing long-term emissions.[41]

In 2011, the Global CCS Institute (GCCI) claimed that around 150 million tons per year of carbon capture projects were in operation, construction, or development globally.[42] However, the vast majority of this CCS capacity was in the "development" categories. By the GCCI's own count, in 2023 this translated to less than 50 million tons per year of operational global CCS capacity.[43] Given the current state of CCS, it is unlikely that the GCCI's 2010 prediction of 2,000 gigatons of CO_2 captured per year by 2030 will materialize.[44]

The GCCI now touts the number of project announcements, even though it admits that "relatively few have yet advanced to operation."[45] In the 2023 GCCI report, the first chart actually excludes operational CCS, showing a massive growth of CCS projects in "development and construction."[46]

Evaluating the predictions: CCS continues to disappoint

The CCS buildout has not lived up to expectations. A December 2023 U.S. Congressional Budget Office (CBO) report estimated 22.3 million metric tons of annual U.S. CCS capacity.[47] This closely matches the IEA's CCS tracker estimates of 21.8 million metric tons.[48] These capacities are an overestimate of captured carbon because many projects are not operating at capacity due to persistent operational and economical challenges.[49] According to the U.S. Environmental Protection Agency (EPA), in 2023 only 16.1 million metric tons of CO_2 were captured, down nearly 28 percent from the 2019 peak.[50] As of September 2023, total U.S. CCS capacity — if run at maximum capacity — could capture only 0.4 percent of all U.S. emissions; all announced projects, if built, would capture only 3 percent.[51]

On the other hand, renewables are booming. Net generation from wind and solar power grew nearly eight-fold from 2010 to 2024, accounting for 17.5 percent of all electricity generated in the U.S. in 2024.[52] In contrast to CCS, 81 percent of solar projects were on or ahead of schedule in 2023, and among the delayed projects most only suffered a delay of one to six months.[53] Battery storage capacity grew from 1.6 gigawatts (GW) in 2020 to 26 GW by the end of 2024. From 2021 to 2024, more than two-thirds of U.S. planned battery storage capacity was built.[54]

The EOR "runway" myth

Much like the roundly debunked "bridge fuel" prediction that natural gas would pave the way for a transition from coal to renewable energy,[55] CCS proponents claimed that using CO_2 for oil production (a technique referred to as enhanced oil recovery or EOR) would help scale up carbon capture in the short term and improve the viability of pure sequestration in the long term.[56] In 2008, the environmental organization Natural Resources Defense Council (NRDC) promoted EOR as a great way to increase oil production.[57] In 2011, groups including CATF and NRDC, , along with corporations such as Archer Daniels Midland and Arch Coal, participated in the National Enhanced Oil Recovery Initiative (NEORI).[58]

NEORI argued that EOR deployment would lead to CCS cost reductions and create a national infrastructure that could be used beyond oilfields.[59] During the Obama administration, these groups promoted the idea that EOR could develop CCS technology and ultimately pave the way for CCS that does not involve oil production.[60]

According to a December 2023 CBO report, nearly 95 percent of CCS capacity operating as of September 2023 provides CO_2 to oil producers for use in EOR.[61] Only 11 percent of all produced and captured CO_2 in the U.S. in 2022 went to non-EOR applications, primarily food and beverage applications in which CO_2 is re-emitted to the atmosphere.[62] Even as the transition to non-EOR CCS failed to emerge, CATF continued to claim that future projects may not follow the same trend.[63]

To the extent that carbon capture has managed to scrape marginal amounts of the CO_2 from the waste streams of industrial facilities, it has served to prop up oil production and supplement natural sources of CO_2. In the last few years, traditional "domes" where naturally occurring CO_2 is mined for EOR have experienced contamination, production declines, and in one case near-total depletion.[64] Carbon capture also enables oil fields that lack pipelines to CO_2 domes to use EOR, further increasingly oil production.[65]

The Next Generation of Carbon Capture Is Following the Same Pattern of Failure

NET Power seems unlikely to revolutionize natural gas power plants

Gas-fired power plants have proven even more challenging ground for CCS than coal because of the highly diluted CO_2 exhaust stream.[66] A Food & Water Watch (FWW) analysis found that the increased methane emissions from producing additional natural gas to meet the high energy requirements for capturing CO_2 from natural gas combustion undermines the benefit of capturing those emissions. In fact, equipping fracked gas power plants with 90 percent effective carbon capture would lower their life-cycle emissions by only 18 percent, even assuming that the captured carbon emissions remain underground, which is dubious as best.[67]

One proposed, theoretical, unproven technology is oxyfuel gas plants that use pure oxygen and natural gas as fuel. In theory, recirculating the CO_2-laden exhaust back into the system would raise the concentration of CO_2 in the eventual waste stream, reducing the typically significant amount of power required to purify the CO_2 for capture.[68] However, there is a chasm between the promises and track record of this technology. In 2013, the company NET Power announced plans to build a 50-megawatt pilot plant that would demonstrate the technology by 2015.[69] NET Power later claimed that the plant would be fully commissioned in 2017, but the pilot plant did not achieve grid synchronization until 2021.[70]

By the end of 2023, NET Power's demonstration plant still faced significant technological hurdles, which the company disclosed to the U.S. Securities and Exchange Commission (SEC). "The NET Power Cycle has yet to be integrated with a combustion system and turbine operating coincidentally at target temperature and pressure," the company disclosed, while including references to a new, custom-ordered part necessary to achieve the plant's goals.[71] Even more damning is the revelation that, "Our Demonstration Plant successfully generated electric power while synchronized to the grid, but it has not yet overcome all facility auxiliary power loads (pumps, compressors, etc.) to provide net positive power delivery to the commercial grid during its operation."[72] In other words, the plant

remained incapable of providing more power than it burned operating with its carbon capture technology.

In addition, the plant appears to be significantly over budget. When construction started, NET Power said that the pilot plant was a "$140 million program," but in a 2023 interview, the CEO described spending "a couple of hundred million dollars" on the project.[73] During the two years following grid synchronization, NET Power bragged of "over 1,500 hours of total facility runtime time," but that is less than 10 percent of time over those two years.[74]

NET Power's announcement in May 2023 of a commercial-scale oxyfuel gas plant by 2026[75] is already behind schedule and over budget, with current cost estimates double what the company said in 2018 that a new plant would cost.[76] The plant's technology is also significantly less efficient than was described in early media promises.[77] The CEO of NET Power concedes that even after reaching mass production, these plants will be 2.5 to 3.3 times as expensive as traditional gas plants.[78] Both wind and solar have comparable or lower lifetime costs to non-CCS natural gas power plants.[79] NET Power's plant may have one dubious advantage over wind and solar: the company brags that when the plant works, the CO_2 is ready to be used for EOR without further compression.[80]

Occidental's renewed embrace of CCS mirrors an earlier failed bet on the technology

Occidental Petroleum has engaged in a public relations onslaught to define itself as a "net zero oil company," including a branding deal to become the "preferred carbon removal partner" for the NFL football team the Texans.[81] Occidental claims that it will build and operate 70 carbon capture facilities by 2035.[82] While pitching itself as special among oil companies, Occidental remained clear that its views and positions were "generally consistent" with groups like the American Petroleum Institute and the U.S. Chamber of Commerce.[83] The company simply supports CCS because it sees CCS as a way to keep burning oil and gas forever.[84]

Central to Occidental's climate-friendly image is a billion-dollar investment in the "world's largest" direct air capture project, originally slated to be open in late 2024.[85] Although this project promises to capture 500,000 metric tons of CO_2 per year when built, eventually scaling up to 1 million tons, this is only 0.02 percent of U.S. CO_2 emissions.[86] As of August 2024, the project's budget increased 30 percent from original estimates, and its opening had been pushed back to "mid 2025."[87]

This is not the first time Occidental has bet on CCS. The company's Century natural gas processing plant was central to claims about the bright future for CCS. In 2010, Occidental's business partner SandRidge bragged that the Century facility would be North America's largest industrial CCS facility.[88] Built to supply Occidental with an additional source of CO_2, Occidental anticipated a large boost in oil production as a result of the new EOR.[89]

Slated to open in late 2010,[90] the facility did not open until September 2012.[91] From the beginning, SandRidge failed to make sufficient contractually obligated CO_2 deliveries to Occidental, resulting in penalties.[92] By 2015, Occidental had written down most of the plant's value in SEC filings.[93] The facility never recovered from this rough start. In 2022, Occidental sold the facility for less than the cost of building it, having never operated it at more than one-third of capacity.[94]

The quest to build the "world's largest" carbon capture project continues

In September 2022, CarbonCapture Inc. and Frontier Carbon Solutions announced "Project Bison," a Wyoming direct air capture CCS facility that they claimed would be operational by late 2023 and capture 5 million metric tons of CO_2 from the air each year by 2030.[95] Just like Occidental, Project Bison could have become the "world's largest" carbon capture facility of its type.[96] By June 2023, the company still had no employees in Wyoming.[97] Despite the mounting delays, CarbonCapture Inc. managed to attract an equity investment from Amazon.[98]

Correspondence between CarbonCapture Inc. and the DOE obtained from a Freedom of Information Act (FOIA) request revealed that Project Bison relied heavily on additional speculative and expensive technologies such as small modular nuclear reactors, conversion of CO_2 to jet fuel, and blockchain tracking of emissions.[99] In addition to millions in DOE funding for engineering studies, the company sought funding through the separate carbon capture hub program.[100] However, less than two years after announcing the facility, CarbonCapture Inc. pulled the plug, citing an inability to source electricity amid competition from data centers and cryptocurrency miners.[101]

Clean coal projects continue to be unsuccessful

In New Mexico, a CCS project at the San Juan Generating Station was yet another failed attempt to build a "world's largest" CCS project.[102] Founded by an analyst and investor fired in 2012 for mooning his bosses,[103] the project's backer Enchant Energy claimed that the project would become a model for other CCS projects across the western U.S.[104] Originally pitched in 2019 with a $1.3 billion price tag,[105] the carbon capture system was supposed to be operational in 2023.[106] The project never made it past planning stages, and in late 2024 the plant was demolished.[107]

One reason projects like this fail is that proposed CCS systems practically double the water needs of original coal plants.[108] While the company and the DOE spent $29 million to study the feasibility of converting the plant to CCS,[109] miners and plant workers received only $20 million in severance from the closing of the coal plant.[110]

The Fossil Fuel Industry Does Not Need CCS to Work – It Just Needs to Keep the Idea Alive

Even if CCS technology remains permanently stuck in the research, development, pilot, and announcement phases, it still serves an important function for corporate balance sheets heavy with dirty investments. In order to keep global temperature rise within 1.5 degrees Celsius, around 97 percent of global coal reserves, 81 percent of natural gas reserves, and 71 percent of oil reserves would need to remain unburned.[111] Fossil fuel infrastructure such as power plants and pipelines (expensive investments with long lifetimes) would also have to be closed early, erasing the value of the assets.[112] Carbon capture reassures investors and enables continued investment in fossil fuels without risking a sudden repricing of dirty assets.[113]

Carbon capture promises to save these investments from the threat of climate policy by resurrecting the "clean coal" narrative, painting them as "clean fossil fuels" that can be burned forever.[114] According to Occidental's CEO, "If it's produced in the way that I'm talking about, there's no reason not to produce oil and gas forever."[115] One oil driller claimed that direct air capture was like "draining

the ocean with a straw," but praised the public relations benefit of the technology, saying, "let's go run out there and build all these plants we can build to shut up whoever we need to shut up."[116]

The promise of CCS also lets utility corporations claim that they are on track to meet commitments to achieving net zero greenhouse gas emissions while continuing to open new gas-fired power plants.[117] Industry associations like the American Gas Association (AGA) say that carbon capture equipment can be used on existing emitting infrastructure,[118] cutting emissions without sacrificing current investments. The AGA highlights the promise of CCS to allow "the grid to lean even more on natural gas than it already does while continuing to lower emissions."[119]

The fossil fuel industry and its allies are clear that any requirements to cut emissions must be accompanied with massive subsidies for CCS.[120] While publicly touting its company's investment in carbon capture as proof of a commitment to addressing climate change, behind the closed doors of an oil and gas industry conference, an ExxonMobil lobbyist emphasized that carbon capture was about profit, not the environment.[121] Chevron emphasizes that achieving net zero emissions is "not possible" without CCS and says that it can use carbon capture to reduce the carbon intensity of its current infrastructure.[122]

CCS growth numbers are being juiced by rebranding fossil fuel infrastructure

While the fossil fuel industry has largely failed to develop large-scale carbon capture for facilities such as electric power plants, it has found growth for "CCS" by reclassifying existing activities as carbon capture with minimal physical changes. The EPA's data reporting on CCS has enabled this deception, tricking observers by creating the appearance of a booming industry amid continued failure and stagnation. At the center of this deception is the following paradox: According to the EPA, between 2016 and 2023 annual carbon sequestration grew from 3.09 million metric tons to 16.3 million metric tons; however, carbon capture from industrial facilities declined over the same period from 17.2 million metric tons to 16.1 million metric tons.[123]

One of the largest and oldest facilities often referred to as a carbon capture facility is ExxonMobil's Shute Creek processing plant, which was built to refine natural gas, not reduce CO_2 emissions.[124] A closer examination of EPA-permitted CCS projects shows that many of the largest "carbon capture" projects are just redefined fossil fuel facilities.[125] Between 2016 and 2023, the number of Subpart UU facilities (a class of waste injection well) declined by 24 while the number of Subpart RR facilities (the EPA's "sequestration" category) increased by 19. Over the same period, underground injection of CO_2 under Subpart UU declined by 17.4 million metric tons, more than the increase in Subpart RR "sequestration" during the same period.[126] Our analysis reveals that many of these "new" "sequestration" facilities simply changed their reporting classification.

A quirk in the EPA's well permitting system creates the appearance of new sequestration at acid gas injection facilities

If someone only learned about CCS through industry hype, they would not know that most of the CO_2 that enters the CO_2 supply chain comes from underground, naturally occurring CO_2 reservoirs (as opposed to CO_2 released from combustion or industrial reactions).[127] Historically, oil and gas companies bought CO_2 for EOR from wells drilled into underground "domes" that contained nearly pure CO_2.[128] These domes still account for the majority of CO_2 sourced in the U.S., but the

subsidization of CCS has incentivized sourcing underground CO_2 from reservoirs that also contain fossil fuels.[129]

In the U.S., some natural gas is pumped to the surface during extraction alongside impurities such as CO_2 and hydrogen sulfide (H_2S).[130] Natural gas processing plants remove the valuable hydrocarbons from this mixture, creating an "acid gas" waste stream consisting primarily of H_2S and CO_2, but with other impurities such as water, nitrogen, and light hydrocarbons.[131] H_2S is regulated as a sulfur dioxide precursor and is frequently disposed of in underground injection wells alongside significant quantities of CO_2.[132] As early as 2005, 20 of these sites injected acid gas for H_2S disposal.[133] In 2022, the natural gas processing sector disposed of or released 64 million pounds of H_2S.[134] These processing plants are not "capturing carbon" in the conventional sense; they are removing hydrocarbons from a naturally occurring mix of chemicals that they brought to the surface while extracting natural gas, some of which includes CO_2.

Natural gas processing plants can access the 45Q tax credit, which rewards CCS for each metric ton of CO_2 "sequestered" underground, potentially by "converting" existing acid gas injection (AGI) wells to "Subpart RR and 45Q."[135] (The Subpart RR reporting category, for wells covered by the EPA's Underground Injection Control portion of the Safe Drinking Water Act regulations, has become significant in the administration of tax credits for CCS.[136]) For example, the Lucid Red Hills gas plant in the Permian Basin injects acid gas from natural gas processing and was originally built in 2012-2013.[137] The facility processes natural gas from Lea and Eddy counties in New Mexico.[138] Under the new permitting category, the Red Hills plant could count CO_2 injected into an existing well as "geologically sequestered," and is also drilling a new CO_2 well.[139] Lucid claims that it applied for this rebrand in order to qualify for the 45Q tax credit.[140]

Defining natural gas processing as "CCS" carries unique risks

The "natural" versus "captured" carbon distinction is further muddled when considering reinjected CO_2 for oil and gas production. For example, at Occidental's Denver unit, when natural gas and natural gas liquids (NGLs) are coproduced with CO_2 and H_2S, the CO_2 is recycled back into the EOR process. In that case, the recycled CO_2 counts against the amount stored.[141] However, if Occidental were to acquire CO_2 sourced from a non-EOR natural gas reservoir (such as the gas processed by the nearby Century Natural Gas Processing CCS plant that Occidental built in 2010 and owned until 2022), the coproduced "fresh" CO_2 would count as "geologically sequestered" (Subpart RR) upon injection.[142]

The potential for double counting is further complicated by the use of CO_2 for enhanced natural gas recovery,[143] as well as when methane (and CO_2) is produced from reservoirs that previously underwent EOR.[144] In cases where CO_2 from nearby sources is reinjected for further gas or oil recovery, it may not be possible to distinguish between freshly extracted CO_2 and previously injected CO_2 because, at the molecular level, they have the same isotopic signatures (the primary way of tracking CO_2 leaks in CCS).[145] Generally, these isotope compositions correspond to the type of CO_2 source (combustion of oil versus steam methane reforming for hydrogen) rather than the specific well.[146] Researchers found that in Texas, the isotopic composition of CO_2 used in EOR and extracted at natural gas processing facilities is in the same range.[147] Practically speaking, all of this CO_2 started underground and was only brought to the surface because corporations drilled into it.

These natural gas processing facilities are often located in fossil fuel-producing areas. At Lucid's Red Hills processing plant, at the time of the CCS application, there were six active oil wells within one mile of Lucid's injection wells.[148] While monitoring plans aim to prevent the migration of CO_2 from injection sites to avoid re-extraction of injected CO_2,[149] by counting co-produced CO_2 as CCS, the possibility remains that the same molecule of CO_2 is extracted, re-injected, and later produced to be counted multiple times for 45Q tax credits.

The EPA's reporting system also sows confusion about EOR, the main use of CO_2

As carbon capture has largely failed to progress from the "stepping stone" of enhanced oil recovery, CCS proponents and the EPA have begun to describe CO_2 used to extract oil as "geologically sequestered."[150] Rather than advancing CCS technology or applying it to new settings, EOR has become another way to claim that CCS is growing by redefining a fossil fuel industry activity as CCS. Sequestration is a term that was historically distinct from EOR,[151] but fossil fuel advocates sought to muddy the terminology by including EOR under the umbrella of "utilization," and trying to use a new acronym that includes this (CCUS or carbon capture, utilization and storage).[152]

In an October 2023 update, the EPA's website proudly reported that in 2022, 7.95 million metric tons of CO_2 were "geologically sequestered"; however, the EPA did not make it clear that this includes EOR (and naturally occurring CO_2 received from CO_2 production wells).[153] While it lists EOR as a separate line in the same table, the table reflects two separate but overlapping data sets.[154] The EPA's current overview of CCS features a map that labels enhanced recovery and geologic sequestration separately, even though the "sequestration" in question is enhanced recovery.[155] As a result, a 2023 *Washington Post* article linking to the page claimed that only 60 percent of CO_2 captured from industrial facilities was used for EOR.[156]

Part of the unrealistically low estimates of the portion of CCS dedicated to EOR arises from the misleading inclusion of the "food and beverage" category in the denominator.[157] These industries use CO_2 for refrigeration, stunning animals before killing them, and carbonation of beverages, among other uses.[158] CO_2 used for these purposes is emitted to the atmosphere,[159] and as a result these uses were specifically not considered to be part of CCS by early industry proponents.[160]

Another problem is that the EPA bases these data on self-reporting of end uses from capture facilities in cases where an end use "is known."[161] As a result, 25 percent of captured CO_2 is reported as having an "other" use, which the EPA says includes sequestration, EOR, and unknown.[162] In fact, of the 16 million metric tons of CO_2 reported as "sequestered," 92 percent is used in enhanced recovery wells, and less than 5 percent is injected in dedicated storage facilities (the rest is injected in Class 2 disposal wells).[163] However, these data are also a flawed picture of the state of CCS, as they may include CO_2 that was produced rather than captured and later "sequestered."[164]

In 2022, the two largest facilities in Subpart RR — misleadingly labeled "geological sequestration of carbon dioxide" by the EPA — were Occidental Petroleum facilities located in the heart of the Permian Basin.[165] Occidental's CEO described pure sequestration as "a waste of a valuable product."[166] The largest of these facilities, Occidental's West Texas "Denver Unit," uses CO_2 for

EOR in the Permian oil fields.[167] According to Occidental, the Denver unit had already "stored" 128.8 million metric tons of CO_2 from 1983 to 2013, before the monitoring, reporting, and verification (MRV) plan allowed a re-brand into a "Subpart RR" facility (the EPA requires facilities to submit information on geology, leak detection, and facility information in an MRV plan in order for a well to be permitted under Subpart RR).[168] That is nearly triple the total CO_2 reported across all years of the Subpart RR reporting nationally (46.75 million metric tons).[169] In fact, annual CO_2 "storage" at the facility appears to have peaked in the 1990s and has since declined.[170]

The Main Tax Credit for CCS Is Ill-Equipped to Prevent Fraud and Ensure Long Term Storage

Congress has doubled down on 45Q, a tax credit with a terrible track record

The main tax credit for CCS is 45Q, which rewards corporations for each ton of CO_2 they inject underground. This program has a history of fraud and abuse, and there is limited publicly available information on the total value of the 45Q tax credit and on whether specific facilities can claim the credit.[171] A 2020 Treasury Department Inspector General investigation found that nearly $1 billion in 45Q credits had been improperly claimed without meeting the EPA's requirements for storage and monitoring. In other words, corporations claimed the credits without proof that the CO_2 was effectively stored.[172]

In the years since this investigation, Congress increased the value of the 45Q credit from $50 to $85 per metric ton of geologic sequestration, and from $35 to $60 per metric ton used in EOR. It also added a direct pay option, allowing companies to receive the 45Q "credit" without corresponding tax liability.[173] The "Big Ugly Bill" of July 2025 erased the distinction between EOR and sequestration, raising the value of CO_2 used in EOR to $85 per ton.[174] Agencies have also weakened some of the requirements to qualify for the credit.[175] The Internal Revenue Service (IRS) now only requires that companies pay back 45Q credits on CO_2 leaks occurring within three years after they claim the credit.[176] While the CO_2 would need to remain stored for thousands of years to have a climate benefit, corporations can keep 45Q credits for carbon that only stays in the ground for four years.[177]

No single government organization has full access to the data used to oversee the 45Q program. The EPA does not implement 45Q and has no access to taxpayer data.[178] However, the IRS relies on the EPA by requiring capturing companies to submit their Greenhouse Gas Reporting Program identification numbers and the volumes of CO_2 injected by their operations.[179] Corporations can then self-certify volumes of CO_2 reported for 45Q that they also report to the EPA under Subpart RR.[180] Alternatively, companies can instead choose to avoid the EPA entirely by claiming 45Q through a separate (ANSI) certification process.[181]

While the EPA certification process is vulnerable to fraud and abuse, allowing CCS operators to sidestep the EPA and use the ANSI certification process is a recipe for disaster.[182] This process allows companies to hire their own experts without approval from the EPA and with no oversight from regulators.[183] The EPA requires reporting of CO_2 covered this way, but it does not approve these plans or cooperate with the IRS to verify the 45Q credit.[184] During an audit, the IRS, not the EPA, would review these third-party materials.[185]

Fossil fuel corporations have already succeeded in removing key guardrails from the 45Q program

The "date of construction" rule highlights how fossil fuel corporations leverage an army of lawyers, lobbyists, and accountants to secure counter-intuitive but lucrative interpretations of tax laws. Theoretically, values for the 45Q tax credit are tied to the date that the capture equipment was built, with capture equipment constructed before 2023 ineligible for the increased value of the credit, and facilities placed into service before February 8, 2018 no longer eligible.[186] (According to the U.S. Tax Code, pre-2018 facilities cannot claim 45Q after a total of 75 million metric tons of credits are claimed [a cap reached in 2022] or January 1, 2023, whichever comes first.)[187] In addition to ensuring that old carbon capture equipment does not receive a windfall from the new credits, they are tied to labor standards that older construction may not have met.[188]

However, the IRS 80/20 rule creates a pathway for old facilities to claim that their carbon capture equipment entered service more recently.[189] Old facilities can move up their official start date so long as the "fair market value" of their used carbon capture components is not more than 20 percent of the total value of all carbon capture equipment (even including related infrastructure such as pipelines).[190] The use of fair market value means that the new investment can be a lower dollar value than the original investment,[191] and it could also be the case that the market value of the original property is contingent on whether it qualifies for the 45Q tax credit.

According to reporting by E&E News, the Petra Nova CCS coal plant restarted in 2023 partly due to higher 45Q credits.[192] Petra Nova's construction was completed in 2017,[193] but the project was such a failure that in 2022, NRG Energy sold its 50 percent stake for $3.6 million, down from the $1 billion spent to build the project (including an $190 million grant from the DOE).[194] At this valuation, Petra Nova would require only $28.8 million in new investment to move up its construction date and potentially qualify for 45Q credits worth $63 million per year.[195]

New converts to "carbon capture" are also under the impression that their old facilities qualify for 45Q credits. The passage of the IRA and promulgation of IRS rules that allow companies to self-certify volumes of CO_2 covered by the EPA's Subpart RR program likely led to a surge in applications for approval of new MRV plans to access 45Q credits.[196] Applications rose significantly in the wake of these new rules and the increase in the value of the tax credit.[197] Many of these are natural gas processing plants that are engaged in acid gas disposal.[198] The IRS has previously ruled that these acid gas removal systems (acid gas is the carbon component of natural gas processing) count as carbon capture equipment for purposes of construction year, even if the carbon was emitted to the atmosphere.[199]

Many of these facilities were built before 2018. For example, Lucid's Red Hills acid gas injection system, built in 2012-2013, submitted MRV documents with the goal of accessing 45Q credits.[200] Scout Energy submitted an MRV for EOR in Colorado to obtain 45Q credits despite using CO_2 from ExxonMobil's Shute Creek facility, one of the oldest CCS facilities in

the country.[201] Scout Energy bought these oil fields from Chevron, which had been doing EOR there since the 1980s.[202] Another corporation, Frontier, also aims to get 45Q credits from acid gas injection at two older natural gas processing plants.[203]

45Q relies on the IRS for environmental oversight despite inadequate resources

Confidentiality rules limit cross-agency collaboration and verification.[204] While the IRS has broader access to confidential taxpayer information, it does not have the same expertise in environmental compliance as the EPA, while the EPA does not coordinate with the IRS in verification of 45Q claims.[205] The EPA says that greenhouse gas reporting data were never designed or accumulated for use in taxes.[206]

This gap is evident in the tracking of CO_2 for 45Q. While companies can self-certify the volumes of CO_2 that they report in Subpart RR, Subpart RR does not distinguish between 45Q qualified sources of CO_2 (captured from eligible industrial facilities) and other sources (recycled from EOR, produced from natural reservoirs).[207] Oil companies are asking the IRS to further loosen the rules and clarify that CO_2 should be treated as fungible, not tracked from source to disposal.[208] This would mean that so long as a capture facility was hooked up to the same pipeline as a sequestration well, it could contract to claim 45Q credits even if the actual injected CO_2 was from a pure CO_2 well.[209]

Well-resourced fossil fuel corporations are up against a weakened IRS. While the IRS received an influx of funding during the Biden administration from the IRA, the agency is firmly in the crosshairs of the Trump administration, as Trump's pick to lead the IRS co-sponsored legislation to abolish the IRS.[210] One of the administration's first executive orders was to institute a federal hiring freeze, which is temporary for all agencies except for the IRS, where the freeze is indefinite.[211] The IRS hiring freeze is exacerbated by Trump's threats to fire IRS workers and reverse the IRA funding while also attempting to re-assign IRS employees to immigration enforcement.[212] Even at current funding levels, the IRS fails to collect $696 billion per year in unpaid taxes.[213]

Paying to Pollute: 45Q Rewards Corporations for Finding New Sources of CO_2 to Capture

Corporations are cashing in on naturally occurring CO_2

Providing money for emissions capture creates a perverse incentive. Corporations might get into the pollution creation business just to bank tax credits when they capture that new pollution. For this reason, the 45Q program as initially promulgated was supposed to exclude "a facility that produces CO_2 from CO_2 production wells at natural CO_2-bearing formations."[214] The goal was to limit tax credits to CO_2 "that, absent capture and disposal, would otherwise be released into the atmosphere."[215] However, as this report shows, a large portion of CCS, including some of the largest operational CCS facilities, violate or exist in the gray area of these provisions.

As early as 2010, natural gas processing facilities, capturing essentially natural CO_2, claimed that they qualified for CCS tax credits.[216] While the EPA and IRS often refer to these facilities as "industrial carbon capture," a category that meets 45Q requirements,[217] even CCS advocacy

organizations sometimes describe these facilities as capturing "naturally occurring CO_2."[218] Following pressure to erase the distinction between natural and anthropogenic CO_2, in 2021 the IRS ruled that the prohibition on natural CO_2 applied only to wells that extract more than 90 percent CO_2 by volume.[219] The IRS also created an exception allowing facilities that "capture" naturally occurring CO_2 from reservoirs that are above 90 percent CO_2 so long as there is also a commercially viable non-CO_2 product present in the reservoir and the project is not dependent on credits for viability.[220] For reservoirs that are less than 90 percent CO_2 by volume, 45Q credits can be the primary motivation for extraction.[221]

In this context, one concern is that CO_2 could migrate underground and be produced by neighboring wells that do not monitor the total mass of CO_2 in their reservoirs.[222] The IRS forbids double claiming 45Q on re-extracted CO_2 used for EOR,[223] but if the CO_2 migrates to a nearby reservoir with a similar isotopic carbon signature and noble gas composition (perhaps because the nearby reservoir is the original source of the CO_2), tracing techniques could fail to distinguish previously and newly produced CO_2.[224] Moreover, IRS provisions for repayment of tax credits on CO_2 apply only to CO_2 that is deliberately extracted or escapes to the atmosphere, not CO_2 that migrates.[225]

ExxonMobil's Shute Creek facility highlights a potentially lucrative business strategy

In 2021, ExxonMobil touted its Shute Creek facility in Wyoming as the largest carbon capture facility in the world.[226] Built in 1986 and expanded by adding an acid gas injection well in 2005, the facility's 2005 10-K filing does not mention CCS, describing the natural gas processing plant as merely another gas processing and acid gas injection project.[227] The facility began acid gas injection in 2005, incidentally injecting CO_2 because the facility processes gas that is 66 percent CO_2 and only 21 percent methane.[228] However, ExxonMobil had to remove the naturally occurring CO_2 in order to market the natural gas, and by 2009 the company provided around 4 to 5 million metric tons of CO_2 annually for EOR.[229] As of 2018, ExxonMobil still sold most of the CO_2 to nearby oilfields for EOR.[230] The company only injects some of the naturally produced CO_2 — injecting gas that has a significantly higher H_2S concentration than the extracted gas — and sells or emits the rest.[231] The acid gas is injected into the same geologic formation that natural gas is produced from, albeit at a different location.[232]

Reinjecting produced CO_2 for tax credits creates the risk that companies begin producing otherwise unprofitable CO_2-rich gas, injecting only a portion and emitting the rest. At ExxonMobil's Shute Creek facility, every cubic foot of methane is extracted alongside 3.14 cubic feet of CO_2.[233] At 2024 prices, one cubic foot of natural gas sold at the main natural gas market was worth $0.0023, while each cubic foot of CO_2 used for EOR at a new CCS project is worth $.0044 per cubic foot.[234] A newly built facility that extracted a similar ratio of CO_2 to natural gas as Shute Creek and injected CO_2 for EOR would make 6.1 times as much money from the CO_2 tax credits as from selling natural gas.[235] A 2014 DOE report explicitly analyzed this reservoir as a naturally occurring source of CO_2, finding that 52 trillion cubic feet (2.7 billion metric tons) of CO_2 could be profitably produced if sold for $20 per ton, a fraction of the gas's value if injected to get 45Q tax credits.[236]

Providing 45Q for enhanced oil recovery is a fossil fuel subsidy

According to an industry consultant, in 2022 EOR was used to produce an additional 88.2 million barrels of oil.[237] The EPA says that 36.7 million metric tons of CO_2 were "used" in EOR (although only 19 percent of that CO_2 met the EPA's "sequestration" criteria).[238] That means that every ton of CO_2 injected for EOR produces 2.4 barrels of oil, which when burned emits more CO_2 than was injected.[239] In recent years, oil production per metric ton of CO_2 used in EOR has increased.[240] A U.S. Geological Survey study of future EOR potential found that an average of 3.5 barrels of oil is produced per metric ton of CO_2 "stored"; if burned, this oil would emit 1.5 tons of CO_2 for every ton injected.[241]

45Q heavily subsidizes this process. At 2022 rates of CO_2 use per barrel of oil produced, 45Q would be worth around 37 percent of the average sale price of a barrel of oil.[242] This oil also contains potentially valuable CO_2. A single barrel of oil when burned emits 0.43 metric tons of CO_2.[243] If captured, this CO_2 would be worth $36.55 in 45Q credits — 48 percent of the cost of the oil sold on the market.[244] Now that EOR receives the same value as sequestration,[245] fossil fuel lobbyists get their wish and can ensure that CO_2 is not diverted to sequestration.[246]

Subsidizing CCS creates a risk that corporations will burn fossil fuels just to capture the new CO_2 that they create

While the IRS nominally restricts the extraction of purely naturally occurring CO_2 for CCS, it does nothing to limit another natural source of CO_2 ripe for extraction: the carbon bound up in fossil fuels. Just as 45Q incentivizes corporations to extract extra naturally occurring CO_2, the credit also subsidizes overproduction of other fossil fuels in order to harvest their lucrative carbon emissions (assuming they manage to get failed carbon capture technology to work).

In 2024, coal-fired power plants paid an average of $2.55 per million Btu of coal.[247] That much coal, when burned, will emit CO_2 worth up to $8.14 if captured.[248] In other words, carbon capture plants could buy coal just to burn it, capture half of their emissions, and make a profit. Additionally, regional coal prices can be as low as $0.81 per million per Btu, leading to an even stronger incentive for some carbon capture operations.[249] Some electricity markets feature marginal price dispatch, which means that power plants turn on in the order of their cost to operate.[250] Sufficient subsidies can push the cost to operate toward the negative side, meaning that CCS-equipped coal plants could potentially displace renewable energy even when there is abundant wind and sun.[251] Of course, this assumes that the CCS plant is not facing technical problems that plague carbon capture equipment.[252]

The 45Q tax credit also creates the possibility of this effect in natural gas markets. In 2024, natural gas-fired power plants paid $3.03 per million Btu of natural gas.[253] If burned, this gas contains carbon worth up to $4.50 in 45Q credits.[254] However, this is a national average, including the costs that power plants must pay for transportation to locations far from the wellhead. Henry Hub (the primary U.S. spot market for natural gas) prices in 2024 averaged $2.19 per million Btu, low enough to support an "extract to recapture" business model.[255]

Utility corporations are already choosing coal with CCS over renewables

A 2020 report commissioned by the Wyoming governor found that the 45Q tax credit incentivized replacing wind, solar, and battery storage with coal carbon capture, even though those coal plants would not capture all of their emissions.[256] Whether or not these cost projections pan out, 45Q is partially responsible for leading Wyoming to pursue costly carbon capture mandates in lieu of renewables.[257] Western utilities in Utah and Wyoming (near the cheapest coal sources) have already begun cutting back on planned renewables and storage in favor of CCS.[258]

Enchant Energy's failed plan to re-open and CCS retrofit the San Juan Generating Station coal plant in New Mexico projected receiving up to twice as much revenue from 45Q credits as from electricity sales.[259] After including revenue from selling CO_2 for oil production, Enchant projected receiving between 1.4 and 3.3 times its electricity revenue from CO_2.[260] In fact, Enchant bragged that it could pay for the capture project with the tax credits and CO_2 revenue.[261] That means Enchant wouldn't even rely on actually selling electricity. While nearly one-third of the electricity from the plant would go to running the power-hungry carbon capture equipment, Enchant characterized the carbon capture system as an "anchor customer."[262] For Enchant, this project represented a "model" for the CCS industry.[263]

Failures like Enchant's reflect that carbon capture is significantly more likely at totally new facilities, despite messaging about the value of CCS retrofits. Old power plants tend to inefficiently convert fuel to power, which means increasing fuel use substantially to run the capture system, and the site may not have room.[264] Adding carbon capture to older plants approaches the cost of building power plants from scratch.[265] That means that CCS facilities primarily compete with wind, solar, and batteries — the newly built forms of electricity capacity (comprising 94 percent of new capacity in 2024).[266]

Direct air capture creates more emissions than it captures

Even the "purest" forms of CCS face a similar, if more diffuse, form of perverse incentive. Occidental's plans for a million metric ton per year direct air capture plant would capture carbon extracted from the earth and released into the air from combustion.[267] However, generating electricity required to run direct air capture equipment would create more greenhouse gas emissions than the CO_2 captured by the equipment. According to calculations by FWW, capturing one ton of CO_2 from the atmosphere using electricity from fossil fuels would create greenhouse gas emissions equivalent to 3.5 tons of CO_2. Using enough electricity from the U.S. grid to capture one ton of CO_2 from the air would be responsible for the equivalent of 2.2 tons of CO_2 emissions.[268]

While using electricity from renewable energy could theoretically avoid this problem, that would involve building out a massive amount of clean energy just to support continuing to extract and burn fossil fuels. It is far more advantageous to simply shift our grid from fossil fuels to renewable energy. For instance, replacing natural gas with renewables in the electrical grid avoids three times the amount of greenhouse gas emissions than could be captured by a direct air capture facility powered by renewable electricity.[269]

CCS Also Benefits From Lax Regulation and Easy Access to Government Support

The light regulatory touch of the 45Q program is not atypical for CCS. As the technological development of CCS has stalled, proponents have continued to ask for yet more exemptions and regulatory favors that are supposedly necessary to let the technology flourish.

Only a fraction of CCS activities fall under EPA regulation

The EPA only regulates carbon sequestration through the Underground Injection Control (UIC) program of the Safe Drinking Water Act (SDWA).[270] The SDWA UIC program is concerned with protecting underground sources of drinking water and preventing contamination. [271] Other laws primarily regulate hazardous waste. For example, the Resource Conservation and Recovery Act (RCRA) regulates hazardous waste across transport, treatment, and disposal, applying a cradle-to-grave framework that tracks waste from source through every phase of management.[272] CO_2, when injected into a Class VI well permitted under the SDWA UIC program, is exempt from RCRA.[273] Releases from UIC program-permitted wells are typically exempt from other forms of regulation such as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which would otherwise apply to releases of hazardous substances and community notification and emergency planning regulations.[274]

Even on its own terms, SDWA regulation of carbon sequestration has numerous flaws, particularly in the identification and management of pre-existing wells. For example, monitoring wells for testing carbon leakage have no associated federal permitting regime and in many cases are drilled without any state permitting structure.[275] Abandoned, unpermitted test wells are more likely to go unnoticed when evaluating storage areas for leakage risks, as permitting databases are an important source of information for finding abandoned wells.[276] In some cases, MRV plans allow the reclassification of existing wells as carbon sequestration wells without any modifications to the materials or construction of the well.[277]

Identifying old wells and using CO_2-specific materials in construction is necessary to avoid CO_2 leaks. Since many storage locations are in and around fossil fuel reservoirs, abandoned oil and gas wellbores provide a pathway for CO_2 leaking to the surface.[278] Any old, unsealed, or defectively sealed wells are essentially pipelines to the surface.[279] CO_2 can also slowly escape along well linings and has been shown to corrode materials used in well casings and seals.[280]

The EPA has also delegated authority (known as granting primacy) over the regulation of Class VI wells (wells used for geologic sequestration of CO_2) to fossil fuel-producing states such as Louisiana, North Dakota, and Wyoming, to the cheers of the fossil fuel industry.[281] Primacy involves turning over to states the day-to-day responsibility for granting permits, monitoring compliance, and leading enforcement.[282] In this context, granting primacy to industry-friendly states is a fundamentally deregulatory measure, carrying risks like lower environmental penalties and lax enforcement responsibilities in an attempt to appease industry groups and attract investment.[283] CCS proponents and the fossil fuel industry are pushing for the EPA to approval additional state primacy requests.[284]

Poor oversight of pipeline construction is a recipe for disaster

The other key area of CCS regulation is pipelines. According to some projections, a CCS buildout could involve 65,000 miles of carbon pipelines, but the regulatory framework for pipelines is grossly inadequate.[285] Carbon pipelines are regulated federally by the Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA).[286] Following the 2020 carbon pipeline rupture in Sartartia, Mississippi, the PHMSA committed to issuing regulations that covered the specific dangers of CO_2 pipelines. But the Biden administration's DOT delayed the rulemaking, proposing the rules only four days before Trump assumed office — far too late to shield the rules from withdrawal and rollback.[287]

The PHMSA sets standards for the construction of pipelines, but companies are allowed to start construction without agency approval.[288] Pipeline construction is almost entirely overseen by private inspectors hired by the pipeline developer.[289] Developers frequently ignore safety warnings identified by inspectors, who can be fired for rocking the boat.[290] The PHMSA primarily relies on corporations to oversee pipeline operation and self-report data.[291]

Even when inspectors do report concerns to the PHMSA, the administration does not always adequately investigate or follow up on safety problems.[292] The PHMSA prefers to encourage companies to make repairs rather than fining companies upon discovery of unsafe pipelines.[293] The PHMSA assessed just $12.6 million in fines in 2023, a fraction of the $6.5 billion worth of natural gas pipelines currently under construction.[294] This process is theoretically overseen by the PHMSA, but the agency has a tiny number of inspectors, incapable of adequately monitoring a massive buildout of CO_2 pipelines.[295] The PHMSA routinely struggles to hire inspectors, as they must compete with the higher-paying private sector for employees.[296]

Department of Energy CCS grants have a long history of embarrassing scandals

The façade of a future carbon capture economy is propped up by ever increasing research and development funding, touting impressive-sounding projects that invariably fail to pan out. Between 2011 and 2023, the federal government spent $16.9 billion on research and development of CCS.[297] From 2022 to 2024, the DOE spent more than $7.3 billion on CCS.[298]

Unfortunately, the size of this federal largess has not been matched by oversight or proper procedures at the DOE. Government Accountability Office (GAO) reports on the DOE's handling of CCS dating back to the George W. Bush administration detail basic math errors, not requiring congressionally mandated cost-sharing, and continuing to fund projects even after they missed targets and violated DOE agreements.[299] A 2024 GAO investigation found that the DOE's risk management and selection processes for carbon capture funding were inconsistent and did not always meet the basic thresholds set by the agency.[300] Despite previous GAO reports documenting serious mishandling of CCS funding, years later the DOE has still not fully implemented recommendations.[301]

The Trump administration's moves to dismantle the administrative state will make adequate oversight even less likely. Despite promises to combat fraud and waste, the administration has instead fired internal government watchdogs responsible for investigating agency misconduct.[302]

The Trump administration has also cut about 25 percent of the DOE staff responsible for overseeing loans to energy projects.[303]

The carbon capture industry wants even more deregulation and public funding

Despite the extensive regulatory leeway granted to the CCS industry, CCS boosters are asking for even more support.[304] According to CCS advocates, the current regulatory framework is insufficiently supportive of CCS and will not allow CCS to be deployed fast enough to meet their goals.[305] They also want to increase spending on CCS, claiming that products made from captured carbon cannot compete without additional subsidies.[306]

CCS proponents admit that CCS facilities will not continue to operate after the 12 years of 45Q eligibility are up; in order to keep these facilities open, the 45Q tax credit will need to be made permanent.[307] In addition, proponents have supported redefining existing waste injection wells as "CCS" and want the EPA to provide explicit guidance for the reclassification of Class II wells (wells used for EOR or waste disposal) to Class VI wells.[308] Congress did the industry an even bigger favor and simply raised the value of 45Q used in EOR to the sequestration value.[309] Despite this change, the industry continues to complain that the 45Q tax credit is insufficiently generous.[310]

CCS proponents are also interested in yet more "permitting reform" for CCS.[311] Rather than strengthening PHMSA enforcement and inspection, permitting reform in Congress is focused on speeding up the approval of pipelines.[312] The pro-CCS Nature Conservancy supports opening federal lands to carbon injection, granting primacy to states for Class VI wells, and avoiding "permitting delays" to ensure rapid development of CCS.[313]

Despite claims that they are committed to long-term secure storage, the CCS industry does not want to be on the hook for long-term liability associated with their facilities. For example, the Carbon Free Technology Institute (CFTI) wants the federal government to assume long-term liability for closed carbon storage facilities.[314] Even the Global CCS Institute acknowledges that the kind of liability immunity demanded by storage facilities is "exceedingly rare" in the treatment of industrial liability.[315] However, some CCS advocates want states to assume responsibility for all leakage liability immediately after the injection ends.[316]

What's Next for CCS: Support for Dirty, Dead-End Industries with Easy Alternatives

CCS is poorly suited for genuinely "hard-to-abate" emissions

While CCS proponents tend to emphasize the importance of CCS for "hard-to-abate" industries,[317] in practice, the future of carbon capture is primarily in dirty, dead-end industries with easy alternatives.[318] Other, more speculative proposals lean on CCS in an attempt to paper over serious problems with other flawed technologies such as biofuels and cryptocurrency. Some definitions of "hard to abate" include a huge range of sectors, even mentioning electric power and refining.[319]

Generally, it is harder to capture CO_2 that is less concentrated in lower-pressure exhaust streams, a central challenge for genuinely hard-to-abate industries.[320] Steel, cement, and iron have very diluted carbon emission streams, making carbon capture challenging.[321] While carbon-free steel production methods need new research and development, some methods show promise. In 2013, researchers

at the Massachusetts Institute of Technology laid the groundwork for an affordable, entirely electrified, carbon emission-free steel production technique.[322] Another method uses renewably produced hydrogen to produce steel from iron.[323]

Carbon capture in the cement industry faces unique challenges, with carbon capture technologies that are capable of reducing emissions by more than 64 percent still at the prototype stage.[324] Alternative cement production methods and products are still undergoing research, but several carbon-free options appear viable.[325]

Natural gas processing remains a likely industry of interest for CCS

Natural gas processing facilities are poised to continue benefiting from CCS subsidies. There are additional acid gas injection wells and natural gas processing facilities that have not yet made the permitting rebrand to CCS.[326] It is likely that this industry will attempt to access 45Q given that it is possible to do so with almost no commitment of new infrastructure.[327]

Natural gas processing is a dead-end industry. The major uses of natural gas are for energy in buildings (easily electrified), generation of electricity (easily replaced with renewables and storage), and industrial use.[328] Natural gas is used by industrial facilities both as a heat source and as a feedstock.[329] Several technologies allow electricity to directly generate process heat, and natural gas's primary use as a feedstock is through the creation of hydrogen, which can be replaced by electrolysis.[330]

Dirty hydrogen production will continue to funnel money to the oil industry

Another sector that will likely see new carbon capture investment is facilities that produce hydrogen from natural gas (called "blue hydrogen" when paired with CCS).[331] The leading uses of hydrogen are for oil refining (68 percent) and for producing nitrogen fertilizers (21 percent).[332] Hydrogen is used at oil refineries to change the composition of fuel (primarily by removing sulfur), so any CCS subsidy for blue hydrogen would likely directly fund an existing oil industry activity.[333]

Carbon capture providers justify blue hydrogen at oil refineries by saying that oil refining is a "hard-to-abate" sector and thus needs fossil fuels.[334] However, producing hydrogen from electricity and water is a well-established technology.[335] The actual appeal of blue hydrogen is that the process emissions from steam methane reformation contain a high concentration of CO_2 that is comparatively cheaper to capture than other CO_2 emissions.[336] However, these process emissions account for only around two-thirds of emissions, the rest of which are much harder to capture and are simply emitted at "blue hydrogen" facilities.[337]

Some blue hydrogen CCS facilities do not even capture all the process emissions, pushing the facility capture rate below 50 percent.[338] Even if blue hydrogen facilities did manage to capture the energy emissions at steam methane reformation facilities, the natural gas used at these facilities has persistent upstream methane emissions that almost fully offset the emissions reductions from carbon capture.[339]

It is also not clear that there is any need to decarbonize oil refineries by incorporating any form of hydrogen. The vast majority of output at oil refineries is fuel for surface transportation.[340] Since battery electric vehicles are well equipped to replace this use entirely, the best decarbonization pathway for refineries is likely closure.[341]

Among the speculative hydrogen CCS applications are proposals to create synthetic fuels, potentially using a combination of captured CO_2 and blue hydrogen.[342] Of particular interest is methanol, a toxic gas that CCS boosters hope to use for shipping fuel.[343] Theoretically, hydrogen producers could create methanol by combining captured CO_2 with hydrogen made from natural gas.[344] Methanol has been a favorite alternative fuel of D.C. lobbyists and insiders dating back to the 1980s.[345]

Plans are in the works to revive a previously failed carbon capture equipped methanol production factory at Lake Charles, Louisiana.[346] Originally proposed in 2007, the project has, according to local media, "had at least five or six name changes."[347] In 2009, Louisiana Senator J. Bennet Johnson described the facility as "shovel ready."[348] The project planned to use the CO_2 for EOR, and despite receiving $12.7 million from the DOE, backers cancelled it in 2015.[349] In 2016, a new iteration of Lake Charles methanol production secured $2 billion in conditional loan guarantees from the DOE, promising commercial operation by 2019.[350]

In February 2024, Lake Charles Methanol II LLC and the Louisiana Economic Development office issued a press release announcing a "new" $3.2 billion methanol plant in the same location.[351] The press release touted the millions in tax handouts that the project would receive from the state.[352] In May 2025, the Lake Charles Methanol II website claimed that the project would begin construction in 2025, with a $5 billion price tag.[353] By September of 2025 the company's website claimed that the project would start construction in the second quarter of 2026 and cost an unspecified billions of dollars.[354]

In addition to the problems faced by using carbon capture for hydrogen production, methanol is energy intensive and expensive to produce.[355] It still releases pollution when burned, such as a relatively high level of formaldehyde.[356]

Ethanol refineries can cash in big on small CCS investments

Ethanol refineries continue to be among the most rapid adopters of CCS.[357] Highly concentrated ethanol fermentation emissions represent lower-hanging fruit for capture, which many ethanol plants were capturing long before rebranding it "CCS."[358] The capture systems at these refineries dehydrate and compress a stream of 99 percent pure CO_2 that is a byproduct of fermenting corn ethanol.[359]

However, the typical ethanol refinery only captures the emissions that are a byproduct of the fermentation process, leaving a wide range of uncaptured emissions from ethanol production.[360] And this is an even smaller portion of the overall emissions[361] from a fuel that, when burned, will emit CO_2.[362] Even ethanol producers admit that the technology to capture these other emissions "doesn't exist."[363]

When assessing the fuel's climate impact, refining ethanol only accounts for a fraction of overall emissions.[364] Fuel and feedstock transport, agricultural emissions, and land use change all contribute to the lifecycle greenhouse gas footprint.[365] Accounting for land use changes, ethanol has lifecycle emissions that are likely at least 24 percent higher than fossil fuel-derived gasoline.[366] Ethanol also increases the overall supply of gasoline available to burn, leading to increased consumption and leaving oil that can still be burned later.[367]

Heavy adoption of biofuels with or without CCS would have serious consequences.[368] Deriving less than 10 percent of global energy from the most efficient biofuel sources would require between 11 and 14 percent of arable land and 18 to 25 percent of current human water consumption.[369] Heavy use of biofuels could require up to 80 percent of current cropland.[370] As a result, biofuels raise food prices.[371]

Sustainable aviation fuel will likely augment demand for ethanol CCS

Another greenwashing effort that aims to incorporate CCS is called "sustainable aviation fuel" (SAF).[372] The airline industry association the International Air Transport Association (IATA) is counting on SAF for the bulk of the aviation industry's emission cuts.[373] The IRA created a credit worth between $1.25 and 1.75 per gallon for SAF that successfully claims a greenhouse gas footprint at least 50 percent lower than conventional jet fuel.[374] The Biden administration's energy policy targeted producing a minimum of 3 billion gallons of SAF per year by 2030 and 35 billion gallons per year by 2050.[375] In tax credits, that could be worth nearly eight times the U.S. airline industry's 2023 post-tax profits.[376]

The IATA claims that SAF will not be generated from food crops or produced on newly cultivated farmland.[377] Americans for Clean Aviation Fuels — a group that includes BP, Exxon, Delta, and the Iowa Soybean Association — advocates for "feedstock neutral" policies that will raise corn income.[378] Ethanol refiners are itching to tap into this lucrative market, producing SAF from conventional corn ethanol with a splash of CCS.[379] IRS rules governing the distribution of IRA credits allow ethanol to qualify.[380]

Promises of CCS in press releases are useful for greenwashing datacenters

Growing demand for data centers to train artificial intelligence is projected to massively increase U.S. emissions.[381] This data center boom has led utilities to double down on new gas infrastructure and delay retirements.[382] It is also generating renewed interest in CCS as a way to square the new electricity demand with earlier climate pledges.[383] Many technology corporations are investing in highly speculative CCS ventures.[384] For example, Google backed a start-up that plans to link with data centers to capture 500 tons of CO_2 annually.[385]

Data centers are also drawing in other corporations who want to cash in on CCS. ExxonMobil and Chevron have both announced plans to build natural gas power plants with CCS to supply electricity to data centers.[386] In its press release, ExxonMobil is excited to emphasize that CCS will let the company decarbonize a broad swath of the economy, making Exxon a climate champion for its development of technology.[387] Chevron's planned natural gas plants will not initially use CCS, merely leaving space to later add the technology.[388]

Direct air capture is an attractive fantasy that is unlikely to go away

Direct air capture (DAC) holds a unique status among CCS technologies due its promise to turn the clock back on bad climate decisions. However, DAC is unlikely up to this lofty role. Beyond the prohibitive energy requirements, DAC has proven to be very expensive.[389] While corporations are undoubtedly eager to reduce costs, existing facilities have not succeeded in producing substantially cheaper DAC.[390] An existing DAC facility run by Climeworks sells carbon removal credits for $1,500 a ton.[391] Even at new facilities, Climeworks says costs for capturing CO_2 are closer to $1,000 than

$100 per ton, but it is aiming to reduce these to $300 to $350 per ton by 2030 (meaning that it would still cost $2.67 to $3.11 to capture the carbon emitted by a gallon of gasoline).[392]

High costs have coincided with delays in deploying DAC at larger scales. As of May 7, 2024, the biggest DAC facility is Climeworks's Mammoth facility that the company claims captures 36,000 tons of carbon per year — 0.00000712 percent of 2022 U.S. CO_2 emissions.[393] As discussed earlier, Occidental's planned DAC plant has delayed its opening and raised cost projections multiple times.[394]

Conclusion

While the declarations of a bright future for carbon capture echo past waves of hype, carbon capture dreams remain as elusive now as they were at the height of clean coal enthusiasm. The inherent energy costs and technological barriers to widespread CCS adoption will likely preclude the use of CCS in all but a few niche, dirty industries. However, CCS provides cover for continued fossil fuel investment and an excuse to funnel yet more public money to the oil and gas industry. The time has come to take CCS off the table as a climate solution by ending subsidies, banning the building of CCS infrastructure, and transitioning to a 100 percent renewable energy system.

Endnotes

1 Behrens, Carl E. Congressional Research Service (CRS). "The Clean Coal Technology Program: Current Prospects." RS20877. April 6, 2001 at 1; Folger, Peter. CRS. "Carbon Capture and Sequestration (CCS)." CRS Report for Congress. RL33801. June 19, 2009 at summary, 2, 23, and 24.

2 Folger (2009) at 23.

3 CRS. "Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions." RL33302. March 8, 2006 at 34 and 35.

4 *Ibid.* at 91.

5 U.S. Department of Energy (DOE). "Fact Sheet: Clean Coal Technology Ushers in New Era in Energy." November 30, 2006 at 1. Available at https://2001-2009.state.gov/g/oes/rls/or/2006/77196.htm. Accessed July 2025.

6 Folger (2009) at 23.

7 DOE. National Energy Technology Laboratory (NETL). "Carbon Sequestration Through Enhanced Oil Recovery." April 2008 at 2 and 3.

8 Whitten, Daniel. "Clean-coal debate pits Al Gore's group against Obama, Peabody." *Bloomberg.* February 4, 2009.

9 International Energy Agency (IEA). "Technology Roadmap Carbon Capture and Storage." 2009 at 17 and 20.

10 Stone, Daniel. "Going after clean-coal technology." *Newsweek.* December 8, 2008.

11 Lawson, Ashley J. CRS. "Carbon Capture Versus Direct Air Capture." November 16, 2021 at 2.

12 DOE. "DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap." December 2010 at 2.

13 *Ibid.* at Table 1-2 at 14 and Table 1-3 at 15.

14 For a full account of these projects see: Shelton-Thomas, Oakley. Food & Water Watch (FWW). "Carbon Capture: Billions of Federal Dollars Poured Into Failure." September 27, 2022. Available at https://www.foodandwaterwatch.org/2022/09/27/carbon-capture-failures.

15 U.S. Government Accountability Office (GAO). "Advanced Fossil Energy: Information on DOE-Provided Funding for Research and Development Projects Started From Fiscal Years 2010 Through 2017." GAO-18-619. September 2018 at Highlights, 10 and 11; GAO. "Carbon Capture and Storage: Actions Needed to Improve DOE Management of Demonstration Projects." GAO-22-105111. December 2021 at 4.

16 Congressional Budget Office (CBO). "Federal Efforts to Reduce the Cost of Capturing and Storing Carbon Dioxide." June 2012 at 4; Anchondo, Carlos and Edward Klump. "Petra Nova is closed: What it means for carbon capture." *Energywire.* September 22, 2020.

17 Massachusetts Institute of Technology. "CCS Project Database: Power Plant Carbon Dioxide Capture and Storage Projects." Available at http://sequestration.mit.edu/tools/projects/index_capture.html. Accessed June 2022; Samuelsohn, Darren. "Billions over budget. Two years after deadline. What's gone wrong for the 'clean coal' project that's supposed to save an industry." *Politico.* May 26, 2015.
18 DOE (December 2010) at 46.
19 *Ibid.*; Samuelsohn (2015).
20 Urbina, Ian. "Piles of dirty secrets behind a model 'clean coal' project." *New York Times.* July 5, 2016.
21 Global CCS Institute. "CO2 Capture Technologies." January 2012 at 10.
22 Banerjee, Neela. "In Mississippi, a power plant is designed to shape the future of coal." *Los Angeles Times.* March 16, 2014.
23 *Ibid.*
24 Goldenberg, Suzanne. "Can Kemper become the first US power plant to use 'clean coal'?" *Guardian.* March 12, 2014.
25 DOE (December 2010) at 14 and 15; Samuelsohn (2015).
26 Ferris, David and Saqib Rahim. "Solyndra vs. SunEdison: 2 bankruptcies show how solar has changed." *E&E News.* April 28, 2016.
27 Samuelsohn (2015).
28 *Ibid.*
29 *Ibid.*
30 *Ibid.*
31 *Ibid.*
32 Swartz, Kristi E. "The Kemper project just collapsed. What it signifies for CCS." *E&E News.* October 26, 2021.
33 Jenkins, Jesse et al. REPEAT. "Preliminary Report: The Climate and Energy Impacts of the Inflation Reduction Act of 2022." August 2022 at 13.
34 Jenkins, Jesse et al. REPEAT. "Climate Progress and the 117th Congress: The Impacts of the Inflation Reduction Act and Infrastructure Investment and Jobs Act." July 2023 at 92.
35 *Ibid.* at 64 and 65.
36 U.S. Energy Information Administration (EIA). "United States produces more crude oil than any country, ever." March 11, 2024; EIA. "Monthly Energy Review June 2025." June 2025 at 5.
37 Jenkins et al. (2023) at 91.
38 *Ibid.;* Jenkins et al. (2022) at 13.
39 Jenkins, Jesse et al. REPEAT. "A Fork in the Road: Impacts of Federal Policy Repeal on the U.S. Energy Transition." May 2025 at 40 and 45.
40 FWW. "The Case Against Carbon Capture: False Claims and New Pollution." March 2020 at 3. Available at https://foodandwaterwatch.org/wp-content/uploads/2021/04/ib_2003_carboncapture-web.pdf.
41 Kay, Adam. American Gas Association (AGA). "Faster Natural Gas Growth Means Faster Emissions Reductions According to Princeton University." October 24, 2024.
42 Global CCS Institute. "Global Status of Large-Scale Integrated CCS Projects." June 2011 at 10.
43 Global CCS Institute. "Global Status of CCS 2023 Scaling Up Through 2030." 2023 at 10.
44 Kannellos, Michael. "How to make money in carbon capture: Will the long dormant industry finally spring to life? Let's hope." *Greentech Media.* January 22, 2010.
45 Global CCS Institute. "198 New Facilities." Available at https://status23.globalccsinstitute.com/new-facilities. Accessed July 2024.
46 Global CCS Institute (2023) at 6.
47 CBO. "Carbon Capture and Storage in the United States." December 2023 at 9.
48 FWW analysis of IEA data. CCUS projects database. Last updated March 2024. Available at https://www.iea.org/data-and-statistics/data-product/ccus-projects-database. Accessed May 2024.
49 White, Natasha et al. "An oil giant quietly ditched the world's biggest carbon capture plant." *Bloomberg.* October 23, 2024; For additional examples see Shelton-Thomas (2022).
50 U.S. Environmental Protection Agency (EPA). "Supply, Underground Injection, and Geologic Sequestration of Carbon Dioxide." January 14, 2025. Available at https://www.epa.gov/ghgreporting/supply-underground-injection-and-geologic-sequestration-carbon-dioxide. Accessed February 2025.
51 CBO (2023) at 3.
52 FWW analysis of EIA data. Electric Power Monthly. "Net Generation for All Sectors." Available at https://www.eia.gov/electricity/data.php. Accessed February 2025.
53 EIA. "U.S. electric power sector reported fewer delays for new solar capacity projects in 2023." May 8, 2024.

54 EIA. "Electric Power Monthly." March 2021 at Table 6.1 at 143; EIA. "Electric Power Monthly." March 2022 at Table 6.1 at 143; EIA. "Electric Power Monthly." March 2023 at Table 6.1 at 143; EIA. "Electric Power Monthly." March 2024 at Table 6.1 at 143; EIA. "U.S. battery storage capacity expected to nearly double in 2024." January 9, 2024; EIA. "Electric Power Monthly." February 2025 at Table 6.1 at 142.

55 See FWW. "Fracking's Bridge to Climate Chaos Exposing the Fossil Fuel Industry's Deadly Spin." January 2020 at 3 to 5.

56 Gardner, Timothy. DOE. "Using oil to reduce carbon emissions." Reuters. December 11, 2011; Dooley, J.J. et al. "CO2-driven Enhanced Oil Recovery as a Stepping Stone to What?" July 2010 at 3 and 4.

57 Natural Resources Defense Council (NRDC). "Tapping into stranded domestic oil: Enhanced oil recovery with carbon dioxide is a win-win-win." July 2008 at 1.

58 National Enhanced Oil Recovery Initiative (NEORI) "Carbon Dioxide Enhanced Oil Recovery: A Critical Domestic Energy, Economic, and Environmental Opportunity." February 2012 at i; NEORI. "NEORI Participant List." Available at https://web.archive.org/web/20130806043335/http://neori.org/about/participants and on file at FWW.

59 NEORI (2012) at 2.

60 Guerin, Emily. "Can more oil extraction cut CO2 emissions from power plants?" *High Country News.* December 9, 2013; Mordick, Briana. NRDC. "Enhanced oil recovery is a step toward large-scale carbon capture and sequestration — if done right." October 28, 2011; Waltzer, Kurt. Clean Air Task Force. "Enhanced Oil Recovery Takes a Big Step Forward." March 3, 2012.

61 CBO (2023) at 9.

62 EPA. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022." EPA 430-R-24-004. April 2024 at 4-96 to 4-98.

63 Waltzer (2012) at 5; Osaka, Shannon. "Companies capture a lot of CO2. Most of it is going into new oil." *Washington Post*. October 25, 2023; Guerin, Emily. "Can more oil extraction cut CO2 emissions from power plants?" High Country News. December 9, 2013.

64 Clouse, Thomas. "Contaminated CO2 from Mississippi volcano pressures local brewers." *Spokane (WA) Spokesman Review.* September 22, 2022; Advanced Resources International (ARI). "The U.S. CO2 Enhanced Oil Recovery Survey." February 2024 at 3; FWW analysis of Mississippi Oil and Gas Board data. CO2 Production and Fate. Available at https://www.ogb.state.ms.us. Accessed May 2025.

65 ARI (2024) at 6 and 7; Kuuskraa, Vello and Matt Wallace. ARI. "CO2-EOR set for growth as new CO2 supplies emerge." *Oil & Gas Journal.* May 5, 2014.

66 Dods, Matthew N. et al. "Deep CCS: Moving beyond 90% carbon dioxide capture." *Environmental Science & Technology.* Vol. 55. June 2021 at 8526.

67 FWW (2020) at 3.

68 Dabbs, Brian et al. "The complete guide to CCS and the EPA power plant rule." *E&E News.* May 10, 2023.

69 Allam, Rodney, J. "NET Power's CO2 cycle: The breakthrough that CCS needs." *Modern Power Systems.* July 10, 2013; Dabbs et al. (2023); NET Power Inc. U.S. Securities and Exchange Commission (SEC) Form 10-Q. Quarter ended June 30, 2023 at 11.

70 NET Power Inc. [Press Release]. "NET Power Breaks Ground on Demonstration Plant for World's First Emissions-Free, Low-Cost Fossil Fuel Power Technology." March 9, 2016; NET Power Inc. (2023) at 11.

71 NET Power Inc. SEC Form 10-K. Fiscal Year ended December 31, 2023 at 21.

72 *Ibid. at* 26.

73 Trendafilova, Petya. "'Net Power brings the world clean, cost effective, reliable, and dispatchable utility-scale energy' — CEO Ron DeGregorio.'" *Carbon Herald.* February 8, 2023; NET Power Inc. (2016).

74 NET Power Inc. (2023) at 46.

75 Dabbs et al. (2023).

76 Powers, Mary B. and Debra K. Rubin. "Developer NET Power delays $1B Texas net-zero power plant start." *Engineering News-Record.* November 18, 2023; Marshall, Christa. "'Revolutionary' pilot uses CO2 to drive turbines." *E&E News.* January 1, 2018.

77 Allam (2013); NET Power Inc. (2023) at 30.

78 Dabbs et al. (2023).

79 Lazard. "Lazard's Levelized Cost of Energy+ — Version 18.0." June 2025 at 8.

80 Williams Sale Partnership (WSP). "NET Power demonstration plant." Available at https://www.wsp.com/en-ca/projects/net-power-demonstration-plant. Accessed May 2025.

81 Occidental Petroleum Corporation. [Press Release]. "Occidental, SK Trading International sign first agreement for net-zero oil created from captured atmospheric carbon dioxide." March 22, 2022; Occidental Petroleum Corporation. "Climate Report 2023: Leading the Way in Carbon Management." 2023 at 14 and 28; Crowley, Kevin. "NFL's Texans to buy carbon offsets from oil giant Occidental." *Bloomberg.* January 6, 2023.

82 Takahashi, Paul. "Occidental plans 70 plants to capture carbon from air by 2035." *Bloomberg.* March 23, 2022.

83 Occidental Petroleum Corporation (2023) at 14 to 19.

84 Domonoske, Camila. "This oil company invests in pulling CO2 out of the sky — so it can keep selling crude." December 27, 2023.

85 Takahashi (2022); Occidental Petroleum Corporation. [Press Release]. "Occidental, 1PointFive to Begin Construction of World's Largest Direct Air Capture Plant in the Texas Permian Basin." August 25, 2022.
86 EPA (April 2024) at ES-5; Occidental (2022).
87 Webb, Shelby. "Occidental updates plan for world's largest CO2 trap." *E&E News*. August 9, 2024; Takahashi, Paul. "Occidental plans 70 plants to capture carbon from air by 2035." *Bloomberg.* March 23, 2022.
88 SandRidge. [Presentation]. "2010 Annual Meeting." June 4, 2010 at 21.
89 " West Texas carbon dioxide plant starts up." *Oil & Gas Journal.* November 8, 2010.
90 Occidental Petroleum Corporation. [Press Release]. "Occidental Petroleum Details Plans to Sustain Long-Term Growth and Profitability." May 19, 2010.
91 LeBlanc, Eddie M. SandRidge Energy, Inc. Letter to Mr. H. Roger Schwall, Assistant Director Division of Corporation Finance. SEC. "Re: SandRidge Energy, Inc. File No. 001-33784." November 19, 2014 at 5.
92 *Ibid*.
93 Occidental Petroleum Corporation. SEC Form 10-K. Commission File No. 1-9210. Fiscal Year ended December 31, 2015 at 22 and 49; McEwen, Mella. "SandRidge, Oxy team up to build CO2 extraction plant." *Midland Reporter-Telegram.* July 12, 2008.
94 White et al. (2024).
95 Anchondo, Carlos. "Companies unveil plans for massive Wyo. CO2 capture project." *E&E News.* September 9, 2022.
96 *Ibid*.
97 Hiar, Corbin. "Project Bison, a large carbon removal proposal, faces delays." *E&E News.* June 1, 2023.
98 Hiar, Corbin. "Amazon vaults into carbon removal race." *E&E News.* September 12, 2023.
99 Hiar, Corbin. "DOE docs: Carbon removal proposal bets on rare nuclear reactors." *E&E News.* January 3, 2024.
100 *Ibid*.
101 Hiar, Corbin. "Project Bison fails. What's next for the carbon removal megaproject?" *E&E News.* September 5, 2024.
102 Klump, Edward. "World's largest CCS plant in N.M. — plan or pipe dream?" *E&E News.* July 19, 2019.
103 *Ibid*.
104 "Carbon capture CEO sees 'model' in N.M." *E&E News.* July 29, 2020.
105 Klump (2019).
106 E&E News (2020).
107 Burke, Adam. "A coal power plant demolition serves as a poignant historical moment for the Navajo." *KSJD.* October 22, 2024.
108 Fitzpatrick, Tim. "Carbon-capture company comes close but can't close contracts." *Salt Lake Tribune*. January 18, 2023.
109 Enchant Energy. "Enchant Energy City of Farmington San Juan Generating Station Carbon Capture Project." Presented at the 26th Annual CO2 Conference, Midland, Texas. December 9, 2020 at 23.
110 Clark, Kevin. "Smokestacks demolished at New Mexico's San Juan plant." *Power Engineering.* August 26, 2024.
111 Pellegrini, Lorenzo et al. "The atlas of unburnable oil for supply-side climate policies." *Nature Communications.* Vol. 15. March 2024 at abstract.
112 Firdaus, Nur and Akihisa Mori. "Stranded assets and sustainable energy transition: A systematic and critical review of incumbents' response." *Energy for Sustainable Development*. Vol. 73. April 2023 at 76 and 77.
113 *Ibid.* at 79 and 81.
114 *Ibid*.
115 Domonoske (2023).
116 *Ibid*.
117 Klump, Edward. "Natural gas and net zero: Can they coexist?" *E&E News.* October 13, 2021.
118 McGrath, Maren. AGA. "Decarbonizing Through Carbon Capture." October 4, 2023.
119 Kay (2024).
120 Butler, Desmond. "Exxon lobbyist questions urgency of climate's catastrophic risks." *Washington Post.* November 24, 2021.
121 *Ibid.*
122 Chevron. "Chevron new energies accelerating carbon capture, utilization, and storage solutions." April 2023.
123 EPA. "Supply, Underground Injection, and Geologic Sequestration of Carbon Dioxide." November 5, 2024. Available at https://www.epa.gov/ghgreporting/supply-underground-injection-and-geologic-sequestration-carbon-dioxide. Accessed November 2024.
124 CBO (2023) at 9;ExxonMobil Corporation. SEC Form 10-K Commission File Number 1-2256. Fiscal Year ended December 31, 2005 at 13.
125 *Ibid.*
126 Miller, Melinda et al. "United States greenhouse gas reporting framework for CCS." *17th International Conference on Greenhouse Gas Control Technologies, GHGT-17.* October 2024 at 7; EPA (January 2025).

127 EPA (January 2025).
128 EPA (April 2024) at 4-96 to 4-98.
129 EPA (April 2024) at 4-96; Targa Resources Corp. "Red Hills Processing Plant AGIs & MRV Plan." June 2023 at 3; EPA (January 2025).
130 Klewicki, J. Kenneth et al. "Acid Gas Injection in the United States." Fifth Annual Conference on Carbon Capture and Sequestration DOE/NETL. May 8-11, 2006 at 2.
131 *Ibid.*
132 *Ibid.*
133 *Ibid.* at 6.
134 FWW analysis of EPA data. Toxic Release Inventory. NAICS 211 — Natural Gas Processing 2022. Available at https://enviro.epa.gov. Accessed May 2024.
135 Targa Resources Corp. (2023) at 3; CRS. "The Section 45Q Tax Credit for Carbon Sequestration." August 25, 2023 at 2.
136 CRS. "CO2 Underground Injection Regulations: Selected Differences for Enhanced Oil Recovery and Geologic Sequestration." June 16, 2020 at 1 and 2.
137 EPA. "Technical Review of Subpart RR MRV Plan for the Lucid Red Hills Gas Plant." December 2021 at 2; Lucid Energy Delaware, LLC. "Monitoring, Reporting, and Verification Plan Red Hills AGI #1 And AGI #2." Version 3.0. September 2021 at 4.
138 Lucid Energy Delaware, LLC (2021) at 32.
139 EPA (December 2021) at 2, 3, 4, 13, and 14.
140 Lucid Energy Delaware, LLC (2021) at 4.
141 Occidental Petroleum Corporation. "Oxy Denver Unit CO2 Subpart RR Monitoring, Reporting and Verification (MRV) Plan Final Version." December 2015 at 24, 25, 36 to 40 and 42.
142 *Ibid.*; White et al. (2024).
143 Occidental Petroleum Corporation. "Permian Basin Overview." 2014 at 4. Available at https://www.nmlegis.gov/handouts/ALESC%20092214%20Item%208%20Occidental%20Petroleum%20Company.pdf. Accessed January 2025.
144 Györe, Domokos et al. "Tracking the interaction between injected CO2 and reservoir fluids using noble gas isotopes in an analogue of large-scale carbon capture and storage." *Applied Geochemistry.* Vol. 78, 2017 at 117.
145 *Ibid.* at 116 to 117.
146 Mayer, B. et al. "Assessing the usefulness of the isotopic composition of CO2 for leakage monitoring at CO2 storage sites: A review." *International Journal of Greenhouse Gas Control.* Vol. 37. June 2015 at 51.
147 *Ibid.* at 51.
148 Lucid Energy Delaware, LLC (2021) at 11.
149 *Ibid.* at 11 and 49 to 51.
150 CBO (2023) at 9; Gardner (2011); Dooley (2010) at 3 and 4.
151 Dooley (2010) at 3.
152 Greenwald, Judith. Center for Climate and Energy Solutions. "Putting the 'U' in CCUS." May 3, 2012. Available at https://c2es.org/2012/05/putting-the-u-in-ccus. Accessed November 2024.
153 40 CFR § 98.446(d)(1); Miller et al. (2024) at 3.
154 EPA. "Supply, Underground Injection, and Geologic Sequestration of Carbon Dioxide." October 5, 2023. Available at https://www.epa.gov/ghgreporting/supply-underground-injection-and-geologic-sequestration-carbon-dioxide. Accessed May 2024.
155 EPA (November 2024); CRS (June 2020) at 1 and 2.
156 Osaka (2023).
157 EPA (November 2024).
158 Newman, Jesse. "Food, beverage companies race to keep plants running during wide CO2 shortage." *Wall Street Journal.* August 26, 2022.
159 EPA (April 2024) at 4-96.
160 Carbon Sequestration Leadership Forum. "What Is Carbon Utilization?" 2011 at 2.
161 EPA. "Suppliers of Carbon Dioxide Subpart PP, Greenhouse Gas Reporting Program." July 2024 at 3.
162 EPA (November 2024).
163 *Ibid.*
164 40 CFR § 98.446(d)(1).
165 FWW analysis of EPA data. "Greenhouse Gas Reporting Program for 2022." Available at https://www.epa.gov/ghgreporting/data-sets. Accessed May 2024.
166 White et al. (2024).

167 FWW analysis of EPA data. "Greenhouse Gas Reporting Program for 2022." Available at https://www.epa.gov/ghgreporting/data-sets. Accessed May 2024; Occidental Petroleum Corporation (December 2015) at 4.
168 FWW analysis of EPA data. "Greenhouse Gas Reporting Program for 2022." Available at https://www.epa.gov/ghgreporting/data-sets. Accessed May 2024; Occidental Petroleum Corporation (December 2015) at 6 and 13.
169 EPA (October 2023).
170 Occidental Petroleum Corporation (December 2015) at 6; FWW analysis of EPA data. "Greenhouse Gas Reporting Program." Available at https://www.epa.gov/ghgreporting/data-sets. Accessed August 2025.
171 Webb, Shelby. "How oil companies could tap the climate law to pump more crude." *E&E News*. September 4, 2024.
172 Menendez, Robert. [Press Release]. "Menendez releases Inspector General investigation finding fossil fuel companies improperly claimed nearly $1B in clean air tax credits." April 30, 2020; George, Russel. U.S. Treasury Inspector General for Tax Administration. Letter to Senator Robert Menendez. April 15, 2020 at 1 and 2. On file with FWW.
173 CRS (August 2023) at 2.
174 Plumer, Brad. "A bill that's big for fossil fuels, not so beautiful for clean energy." *New York Times.* July 3, 2025; Dabbs, Brian and Christa Marshall. "How the megabill shakes up fossil fuels, renewables." *E&E News.* July 2, 2025.
175 Internal Revenue Service. "Credit for Carbon Dioxide Sequestration Under Section 45Q." Notice 2009-83. 2009 at 4; 86 Fed. Reg. 4738 to 4739. January 15, 2021.
176 86 Fed. Reg. 4749 to 4750. January 15, 2021.
177 *Ibid.*
178 EPA. "Subpart RR — Geologic Sequestration of Carbon Dioxide." Available at https://www.epa.gov/ghgreporting/subpart-rr-geologic-sequestration-carbon-dioxide. Accessed May 2024.
179 86 Fed. Reg. 4764. January 15, 2021.
180 86 Fed. Reg. 4740 to 4742. January 15, 2021.
181 *Ibid.*
182 *Ibid.*
183 Peridas, George. Lawrence Livermore National Laboratory. "Permitting Carbon Capture & Storage Projects in California." LLNL-TR-817425. February 2021 at 33.
184 EPA. "Geologic Sequestration of Carbon Dioxide With Enhanced Oil Recovery Subpart VV, Greenhouse Gas Reporting Program." July 2024 at 1; EPA. "Subpart RR — Geologic Sequestration of Carbon Dioxide." Available at https://www.epa.gov/ghgreporting/subpart-rr-geologic-sequestration-carbon-dioxide. Accessed May 2024; Miller et al. (2024) at 6.
185 Peridas (2021) at 33.
186 CRS (August 2023) at 2.
187 *Ibid.*; 26 U.S.C. § 45Q (g) (2023).
188 CRS (August 2023) at 2.
189 Girouard, Chris and Tim Glasgow. "Section 45Q tax credits for carbon capture, utilization, and storage projects." *Wyoming Law Review.* Vol. 24, No. 2. 2024 at 434.
190 *Ibid.*
191 KPMG. "KPMG report: Section 450 credit for carbon oxide sequestration; considerations for equipment upgrades and the 80/20 Rule." No. 2022-019. January 13, 2022 at 1 to 3.
192 Webb (September 2024).
193 Anchondo and Klump (September 2020).
194 "Japan's Eneos to buy out operator of U.S. CO2 capture project Petra Nova." *Reuters.* September 14, 2022; Buckley, Kyra. "NRG sells stake in Petra Nova carbon capture project to Japanese company for $3.6 million." *Reuters.* September 20, 2022; Gardner, Timothy. "Restart delayed at Texas coal unit linked to Petra Nova CCS project." *Reuters.* August 2, 2023.
195 Girouard and Glasgow (2024) at 434; CRS (August 2023) at 2; Gardner (2023).
196 EPA. "Subpart RR — Geologic Sequestration of Carbon Dioxide." https://www.epa.gov/ghgreporting/subpart-rr-geologic-sequestration-carbon-dioxide. Accessed December 2024. For example: Pinon Midstream, LLC. "Monitoring, Reporting, and Verification Plan Independence Agi #1 And #2 Wells Pinon Midstream, LLC." Version 5.0. February 2024 at 1.
197 Anchondo, Carlos. "Climate law's CCS windfall is almost 2 years old. Is it working." *E&E News*. July 29, 2024; CRS (August 2023) at 2.
198 Anchondo (July 2024).
199 Girouard and Glasgow (2024) at 435.
200 EPA (December 2021) at 2; Lucid Energy Delaware, LLC (2021) at 4.

201 Scout Energy Management, LLC. "Rangely Field Subpart RR Monitoring, Reporting and Verification (MRV) Plan." March 2024 at 3; CBO (2023) at 9.
202 Scout Energy Management, LLC (2024) at 3 and 13; Turner, Lucas. "Chevron sells Rangely oil field." *Meeker (CO) Herald Times.* December 15, 2021.
203 Frontier Field Services, LLC. "Monitoring, Reporting, and Verification Plan Frontier Field Services, LLC (Frontier) Acid Gas Injection Facility Metropolis, Maljamar AGI #1 and Maljamar AGI #2 Wells." May 2024 at 2 and 98.
204 Webb (September 2024).
205 EPA. "Subpart RR — Geologic Sequestration of Carbon Dioxide." Available at https://www.epa.gov/ghgreporting/subpart-rr-geologic-sequestration-carbon-dioxide. Accessed May 2024.
206 Webb (September 2024).
207 86 Fed. Reg. 4740 to 4742. January 15, 2021; 40 CFR § 98.446(d)(1); Scout Energy Management, LLC. (March 2024) at 3.
208 American Carbon Alliance et al. Letter to Acting Assistant Secretary, Tax Policy U.S. Department of Treasury Aviva Aron-Dine. "Comments with respect to the credit for carbon oxide sequestration Internal Revenue Code Section 45Q." July 31, 2024 at 2 and 3.
209 *Ibid.*
210 Duehren, Andrew. "How a consulting firm and Trump's I.R.S. pick pushed a problematic tax credit." *New York Times.* December 24, 2024; H.R. 25. 115th Cong. (2017).
211 White House. [Press Release]. "Hiring Freeze." January 20, 2025.
212 Erb, Kelly Phillips. "Hiring freeze at IRS is already being felt as job offers are rescinded." *Forbes.* January 27, 2025; Hussein, Fatima. "Republicans once railed against armed IRS agents. Now they want them for immigration enforcement." *Associated Press.* February 11, 2025.
213 Treasury Inspector General for Tax Administration. "Major Management Challenges Facing the IRS in 2025." October 15, 2024 at 12.
214 IRS (2009) at 4.
215 *Ibid.* at 3.
216 SandRidge (2010) at 20.
217 86 Fed. Reg. 4738 to 4739. January 15, 2021; EPA. "Carbon Dioxide Capture and Sequestration: Overview." Available at https://19january2017snapshot.epa.gov/climatechange/carbon-dioxide-capture-and-sequestration-overview_.html. Accessed May 2025.
218 Oil Gas Climate Initiative. Global CCS Institute. Haliburton. International Association of Oil & Gas Producers. "CO2 Storage Resource Catalogue Cycle 4 Report." July 2024 at 89.
219 86 Fed. Reg. 4738 to 4739, 4766. January 15, 2021.
220 86 Fed. Reg. 4738 to 4739. January 15, 2021.
221 86 Fed. Reg. 4738 to 4739, 4766. January 15, 2021.
222 Occidental Petroleum Corporation (December 2015) at 26.
223 86 Fed. Reg. 4733. January 15, 2021.
224 Mayer et al. (2015) at abstract.
225 86 Fed. Reg. 4749. January 15, 2021.
226 CBO (2023) at 9; ExxonMobil. [Press Release]. "ExxonMobil plans to increase carbon capture at LaBarge, Wyoming facility." October 21, 2021.
227 ExxonMobil Corporation. SEC Form 10-K Commission File Number 1-2256. Fiscal Year ended December 31, 2005 at 13.
228 ExxonMobil Corporation. "ExxonMobil Shute Creek Treating Facility Subpart RR Monitoring, Reporting and Verification Plan." February 2018 at 2 and 11.
229 Parker, Michael E. et al. "CO2 Management at ExxonMobil's LaBarge Field, Wyoming, USA." *Energy Procedia.* Vol. 4. 2011 at 5455, 5458, and 5470.
230 ExxonMobil Corporation (February 2018) at 11.
231 *Ibid.* at 11 and 14.
232 *Ibid.* at 14.
233 *Ibid.* at 11.
234 EIA. "Henry Hub Natural Gas Spot Price." August 13, 2025; EIA. "Monthly Energy Review: Appendix A British Thermal Unit Conversion Factors." May 2024 at 229; Congressional Research Service. "The Section 45Q Tax Credit for Carbon Sequestration." August 25, 2023 at 2; National Institutes of Health. National Library of Medicine. "Compound Summary: Carbon Dioxide." Last Modified June 1, 2024.
235 *Ibid*.
236 DOE. "Subsurface Sources of CO2 in the Contiguous United States Volume 1: Discovered Reservoirs." DOE/NETL-2014/1637 Working Paper. March 2014 at 1.
237 Wallace, Matt. Advanced Resources International, Inc. "U.S. CO2 EOR Survey Updated to End-of-Year 2022." March 13, 2024 at 8.

238 EPA (November 2024).
239 EPA. "Greenhouse Gas Equivalencies Calculator — Calculations and References." Available at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-calculations-and-references. Accessed February 2025.
240 Wallace (2024) at 15.
241 Warwick, Peter D. et al. United States Geological Survey (USGS). "National Assessment of Carbon Dioxide Enhanced Oil Recovery and Associated Carbon Dioxide Retention Resources — Results." 2022 at 1; EPA. "Greenhouse Gas Equivalencies Calculator — Calculations and References." Available at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-calculations-and-references. Accessed February 2025.
242 CRS. "The Section 45Q Tax Credit for Carbon Sequestration." August 25, 2023 at 2; EIA "Spot Prices (Crude Oil in Dollars per Barrel, Products in Dollars per Gallon)." February 12, 2025. Available at https://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm. Accessed February 2025.
243 EPA. "Greenhouse Gas Equivalencies Calculator — Calculations and References." Available at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-calculations-and-references. Accessed February 2025.
244 CRS (August 2023) at 2; EIA. "Spot Prices (Crude Oil in Dollars per Barrel, Products in Dollars per Gallon)." February 12, 2025. Available at https://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm. Accessed February 2025.
245 Plumer (2025); Dabbs and Marshall (2025).
246 Webb (September 2024).
247 EIA. "Electric Power Monthly February 2025." February 28, 2025 at Table 4.2 at 100.
248 FWW analysis of EIA data. CO2 emissions coefficients. Available at https://www.eia.gov/environment/emissions/xls/CO2_coeffs_detailed.xls. Accessed February 2025. See: EIA. "Monthly Energy Review January 2025." January 28, 2025 at 225.
249 EIA. "Average weekly coal commodity spot prices." February 18, 2025. Available at https://www.eia.gov/coal/markets/#tabs-prices-2. Accessed February 2025.
250 Seel, Joachim et al. "Plentiful electricity turns wholesale prices negative." *Advances in Applied Energy.* Vol. 4. November 2021 at 1; ISO New England. "How resources are selected and prices are set in the wholesale energy markets." Available at https://www.iso-ne.com/about/what-we-do/how-resources-are-selected-and-prices-are-set. Accessed June 2025.
251 *Ibid.*
252 Leonardo Technologies, Inc. Prepared for U.S. Department of Energy Office of Fossil Energy. "Wyoming Carbon Capture, Utilization, and Storage (CCUS) Study." August 2020 at 1, 61, and 64; White et al. (2024). For additional examples see Shelton-Thomas (2022).
253 EIA. "Electric Power Monthly February 2025." February 28, 2025 at Table 4.2 at 101.
254 FWW analysis of EIA data. CO2 emissions coefficients. Available at https://www.eia.gov/environment/emissions/xls/CO2_coeffs_detailed.xls. Accessed February 2025. See: EIA. "Monthly Energy Review January 2025." January 28, 2025 at 225.
255 EIA. "Natural Gas Spot and Futures Prices." February 12, 2025. Available at https://www.eia.gov/dnav/ng/ng_pri_fut_s1_a.htm. Accessed February 2025.
256 Leonardo Technologies, Inc. (2020) at 1 and 61.
257 Mason, Greg. "Wyoming senate OKs carbon capture mandate deadline extension." *NewsData.* March 1, 2024; Tan, Caitlin. "'Make carbon dioxide great again' bill appears to be dead, along with carbon capture mandate repeal." *Wyoming Public Media.* February 4, 2025.
258 Plautz, Jason and Carlos Anchondo. "PacifiCorp weighs hiring CCS company with ties to its CEO." *E&E News.* June 10, 2024.
259 Enchant Energy (2020) at 15; E&E News (2020).
260 Enchant Energy (2020) at 15.
261 Mandelstam, Peter. Enchant Energy. [Presentation]. "In Partnership With City of Farmington, NM Carbon Capture Utilization & Storage Project Summary." December 17, 2019 at 11.
262 *Ibid.*
263 E&E News (2020).
264 Folger, Peter. CRS. "Carbon Capture: A Technology Assessment." R41325. November 5, 2013 at 19.
265 *Ibid.*
266 EIA. "Solar and battery storage to make up 81% of new U.S. electric-generating capacity in 2024." December 26, 2024.
267 Crowley, Kevin and Akshat Rathi. "Occidental to strip carbon from the air and use it to pump crude." Bloomberg. January 13, 2021; Webb (August 2024).
268 Calculation uses methodology from: FWW. "Direct Air Capture: The Dire Climate Consequences of Capturing Carbon From the Atmosphere." January 2023.
269 *Ibid.*

270 Ombudstvedt, Ingvild et al. "Regulatory donut holes in the CCS Underground Injection Control Program; a blessing or a curse?" *16th International Conference on Greenhouse Gas Control Technologies, GHGT-16.* October 2022 at 1.
271 Jones, Angela. CRS. "Class VI Carbon Sequestration Wells: Permitting and State Program Primacy." R48033. April 16, 2024 at 2.
272 CRS. "Environmental Laws: Summaries of Major Statutes Administered by the Environmental Protection Agency." December 2013 at 49 and 50.
273 Jones, Angela. CRS. "Injection and Geologic Sequestration of Carbon Dioxide: Federal Role and Issues for Congress." R46192. September 2022 at 16 and 17.
274 *Ibid.*
275 Ombudstvedt et al. (2022) at 6.
276 *Ibid*. at 14.
277 EPA (December 2021) at 2, 3, 13, and 14.
278 Jahediesfanjani, Hossein et al. "Estimating the pressure-limited CO2 injection and storage capacity of the United States saline formations: Effect of the presence of hydrocarbon reservoirs." *International Journal of Greenhousse Gas Control.* Vol. 79. December 2018 at 14; Ajayi, Temitope et al. "A review of CO2 storage in geological formations emphasizing modeling, monitoring and capacity estimation approaches." *Petroleum Science.* Vol. 16, Iss. 5. October 2019 at 1029 and 1030; Carey, J. William. NETL. "Probability Distributions for Effective Permeability of Potentially Leaking Wells at CO2 Sequestration Sites." NRAP-TRS-III-021-2017. April 27, 2017 at 19.
279 Carey (2017) at 19.
280 Qafoku, Nikolla P. et al. "Review of the impacts of leaking CO2 gas and brine on groundwater quality." *Earth-Science Reviews.* Vol. 169. June 2017 at 69; Ideker, J. H. et al. NETL. "Experimental and Numerical Modeling Approach to Elucidating Damage Mechanisms in Cement — Well Casing — Host Rock Settings for Underground Storage of CO2." NETL-TRS-4-2018. March 1, 2018 at 1.
281 Jones (2024) at 10; Obermueller, Pete. Petroleum Association of Wyoming. "OPINION: Petroleum Association of Wyoming Applauds Wyoming Primacy Over Class VI Injection Wells." September 4, 2020. See: https://www.eia.gov/beta/states/rankings.
282 Jones (2024) at 1.
283 Atlas, Mark. "Enforcement principles and environmental agencies: Principal-agent relationships in a delegated environmental program." *Law & Society Review.* Vol. 41, Iss. 4. December 2007 at 939 and 942.
284 Anchondo, Carlos. "Senators praise states' CO2-well permitting." *E&E News.* February 13, 2025.
285 Soraghan, Mike. "Inspector: Weak pipeline rules put 'profit over safety.'" *E&E News.* December 3, 2024.
286 CRS. "DOT's Federal Pipeline Safety Program: Background and Key Issues for Congress." R44201. March 29, 2019 at 1.
287 Bogardus, Kevin and Hannah Northey. "Trump's regs freeze trips up Biden's green rules." *E&E News.* January 22, 2025; CRS. "Carbon Dioxide (CO2) Pipeline Development: Federal Initiatives." IN12169. June 2, 2023 at 1; U.S. Department of Transportation. [Press Release]. "USDOT Proposes New Rule to Strengthen Safety Requirements for Carbon Dioxide Pipelines." Available at https://www.transportation.gov/briefing-room/usdot-proposes-new-rule-strengthen-safety-requirements-carbon-dioxide-pipelines. Accessed February 2025.
288 Soraghan, Mike. "Whistleblowers say 'bad seeds' undermine pipeline safety." *E&E News.* July 15, 2021.
289 Soroghan, Mike. "'Everything's on fire': Inside the US failure to safeguard pipelines." *E&E News.* May 2, 2024.
290 *Ibid.*
291 GAO. "Gas Pipeline Safety: Better Data and Planning Would Improve Implementation of Regulatory Changes." GAO-24-106690. April 3, 2024 at 4 and 5.
292 Soraghan (2021).
293 Soraghan, Mike. "Inspector: Weak pipeline rules put 'profit over safety.'" *E&E News.* December 3, 2024.
294 *Ibid.*; EIA. "Natural Gas Pipeline Projects." April 2025. Available at https://www.eia.gov/naturalgas/pipelines/EIA-NaturalGasPipelineProjects_Apr2025.xlsx. Accessed June 2025.
295 Soraghan (2024).
296 CRS. "DOT's Federal Pipeline Safety Program: Background and Key Issues for Congress." R44201. March 29, 2019 at 1 and 21.
297 CBO (2023) at 1.
298 CRS. "DOE's Carbon Capture and Storage (CCS) and Carbon Removal Programs." IF11861. November 29, 2024.
299 GAO (September 2018) at Highlights, 10, and 11; GAO (December 2021) at 4; GAO (February 2009) at Highlights, 2, and 4.
300 GAO. "Opportunities Exist to Improve the Department of Energy's Management of Risks to Carbon Capture Projects." GAO-24-106489. May 2024 at summary.
301 *Ibid.* at 2.
302 Raju, Manu et al. "Trump fires inspectors general from more than a dozen federal agencies." *CNN.* January 25, 2025.
303 Patterson, Scott. "Clean-energy program fueled by Biden takes deep staff cuts under Trump." *Wall Street Journal.* February 16, 2025.

304 Carbon Free Technology Initiative (CFTI). "CFTI CCUS Workgroup Recommendation Compilation Proposed 118th Congress Priorities." Available at https://www.carbonfreetech.org. Accessed February 2025.
305 Carbon Capture Coalition. "Federal Policy Blueprint." April 2023 at 11.
306 *Ibid.* at 22, 25, and 36.
307 CFTI. "CFTI CCUS Workgroup Recommendation Compilation Proposed 118th Congress Priorities." Available at https://www.carbonfreetech.org. Accessed February 2025.
308 *Ibid.*
309 Plumer (2025); Dabbs and Marshall (2025).
310 Carbon Capture Coalition. [Press Release]. "Senate Passes Budget Reconciliation Package, Retains Mission-Critical Elements of Federal Section 45Q Tax Credit." July 1, 2025.
311 CFTI. "CFTI CCUS Workgroup Recommendation Compilation Proposed 118th Congress Priorities." Available at https://www.carbonfreetech.org. Accessed February 2025.
312 Soraghan (2021); Staines, Killian. "CERAWEEK: Gas pipeline groups see glimmers of hope for permitting reform in 2026." *S&P Global.* March 14, 2025.
313 Nature Conservancy. "Improving the Environmental Permitting Process for Clean Energy Infrastructure." 2024 at 11, 41, 42, and 59.
314 CFTI. "CFTI CCUS Workgroup Recommendation Compilation Proposed 118th Congress Priorities." Available at https://www.carbonfreetech.org. Accessed February 2025.
315 Havercroft, Ian and Chiara Trabucchi. Global CCS Institute. Fiori LLC. "Long-Term Stewardship and Liability." September 2024 at 2.
316 Texans for Lawsuit Reform Foundation. "Liability Protection for Carbon Dioxide Sequestration in Texas." 2022 at 1, 26, and 27.
317 Global CCS Institute. [Press Release]. "Understanding the true value of carbon capture and storage: New paper highlights strong case for technology investment and deployment." May 13, 2020.
318 CBO (2023) at 7 and 19.
319 Chevron. "Explainer: What do we mean by hard-to-abate industries?" Available at https://www.chevron.com/newsroom/2024/q2/explainer-what-do-we-mean-by-hard-to-abate-industries. Accessed February 2025.
320 CBO (2023) at 7.
321 Zitelman, Kiera et al. National Association of Regulatory Utility Commissioners. "Carbon Capture, Utilization, and Sequestration: Technology and Policy Status and Opportunities." November 5, 2018 at 28 and 30.
322 Allanore, Antoine et al. "A new anode material for oxygen evolution in molten oxide electrolysis." *Nature.* Vol. 497. May 2013 at 353; Cavaliere, P. (2019). *Clean Ironmaking and Steelmaking Processes.* Switzerland: Springer Nature at 555 and 574.
323 Bataille, Chris et al. "A review of technology and policy deep decarbonization pathway options." *Journal of Cleaner Production.* Vol. 187. June 2018 at 11.
324 Voldsund, Mari et al. "Comparison of technologies for CO2 capture from cement production — Part 1: Technical evaluation." *Energies.* Vol. 12, Iss. 3, No. 559. February 2019 at 22 and 27.
325 Bataille et al. (2018) at 12 and 13.
326 Miller et al. (2024) at 7; EPA (January 2025).
327 EPA (December 2021) at 2, 3, 13, and 14; Lucid Energy Delaware, LLC (2021) at 4.
328 EIA. "Natural Gas Consumption by End Use." January 31, 2025. Available at https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_m.htm. Accessed February 2025; Dombrovski, Kelsea. National Renewable Energy Laboratory (NREL). "Overview of Building Electrification Technologies and Market Opportunities." November 2024 at 39; Al-Shetwi, Ali Q. et al. "Feasibility of future transition to 100% renewable energy: Recent progress,
policies, challenges, and perspetives." *Journal of Cleaner Production.* Vol. 478. November 2024 at 1, 5, and 7.
329 Mallapragada, Dharik S. et al. "Decarbonization of the chemical industry through electrification: Barriers and opportunities." *Joule.* Vol. 7. January 2023 at 30.
330 *Ibid.* at 27 to 30 and 32; Thiel, Gregory P. and Addison K. Stark "To decarbonize industry, we must decarbonize heat." *Joule.* Vol. 5. March 2021 at 542.
331 Marshall, Christa. "'Green' hydrogen 'on life support' as major projects canceled." *E&E News.* February 26, 2025.
332 EIA. "U.S. refiners and chemical manufacturers lead hydrogen production and consumption." April 8, 2024.
333 Ruth, Mark F. et al. NREL. "The Technical and Economic Potential of the H2@Scale Concept Within the United States." NREL/TP-6A20-77610. October 2020 at 7.

334 Honeywell. "The Role of Carbon Capture Technologies in Decarbonizing Hard-to-Abate Sectors." Available at http://ess.honeywell.com/us/en/about-ess/newsroom/featured-stories/the-role-of-carbon-capture-technologies-in-decarbonizing-hard-to-abate-sectors. Accessed February 2025.

335 Smolinka, Tom et al. "The history of water electrolysis from its beginnings to the present." In Smolinka, Tom and Jurgen Garche (Eds.). (2021). *Hydrogen Production by Water Electrolysis*. New Delhi: Elsevier at 83.

336 CBO (2023) at 7 and 19; Longden, Thomas et al. "'Clean' hydrogen? Comparing the emissions and costs of fossil fuel versus renewable electricity-based hydrogen." *Applied Energy.* Vol. 306, No. 118145. January 2022 at 4.

337 Longden et al. (2022) at 4.

338 EPA. 2020 Greenhouse Gas Emissions From Large Facilities: Air Products Port Arthur Facility. FLIGHT Tool. Available at ghgdata.epa.gov/ghgp/main.do. Accessed June 2022; Air Products and Chemicals. "Large-scale Carbon Capture, Use and Storage." Available at airproducts.com/company/innovation/carbon-capture. Accessed August 2022.

339 Longden et al. (2022) at 1 and 4.

340 EIA. "Oil and petroleum products explained." June 20, 2024. Available at https://www.eia.gov/energyexplained/oil-and-petroleum-products/refining-crude-oil-inputs-and-outputs.php. Accessed 2025.

341 Ramshankar, Arjun Thangaraj et al. "Sustainability analysis of overhead cable line powered freight trucks: A life cycle impact and techno-economic assessment toward transport electrification." *Environmental Research Infrastructure Sustainability.* Vol 3. March 2023 at 2; Zhu, Feiqin et al. "Does the battery swapping energy supply mode have better economic potential for electric heavy-duty trucks?" *eTransportation.* Vol. 15. January 2023 at Abstract.

342 Jiang, Yuan et al. Pacific Northwest National Laboratory. "Emerging Technologies Review: Carbon Capture and Conversion to Methane and Methanol." PNNL-35588. January 2024 at ii, 2.7, and 2.8.

343 EPA. "Methanol Hazard Summary." January 2000 at 1; Martin, Jonathan A. et al. "Temperature−pressure swing process for reactive carbon capture and conversion to methanol: Techno-economic analysis and life cycle assessment." *Environmental Science & Technology.* Vol. 58. July 2024 at 13738.

344 Jiang et al. (2024) at ii, 2.7, and 2.8.

345 McGrory, Mary. "Step on the methanol." *Washington Post.* May 3, 1989.

346 Schmidt, Theresa. "Public hearing Thursday on plan to convert petroleum coke to methanol." *7KPLC.* February 23, 2022.

347 *Ibid.*

348 *Ibid.*

349 GAO. "Carbon Capture and Storage: Actions Needed to Improve DOE Management of Demonstration Projects." GAO-22-105111. December 2021 at 11 and 12.

350 Davis, Carolyn. "Lake Charles Methanol Secures DOE Backing for World's First Carbon Capture, Petcoke Facility." *Natural Gas Intelligence.* December 23, 2016; Daigle, Adam. "Work halted on $1.3B methanol plant in Lake Charles that would have employed 150." *Acadiana (LA) Advocate.* April 10, 2024.

351 Louisiana Economic Development. [Press Release]. "Lake Charles Methanol Announces Plan for New $3.2 Billion Manufacturing Plant in Southwest Louisiana." February 14, 2024.

352 *Ibid.*

353 Lake Charles Methanol II. "Frequently Asked Questions." Available at https://www.lakecharlesmethanol.com. Accessed May 2025.

354 Lake Charles Methanol II. "Frequently Asked Questions." Available at https://www.lakecharlesmethanol.com. Accessed September 2025.

355 Jiang et al. (2024) at 6.3.

356 Liu, Fangjie et al. "Mechanism of methanol and formaldehyde emissions from methanol-fueled engines." *Fuel Processing Technology.* Vol. 268. April 2025 at 1.

357 Bryan, Tom. "The CO2 Report." *Ethanol Producer Magazine.* October 11, 2024.

358 *Ibid.*

359 DOE. "Archer Daniels Midland Company: CO2 Capture From Biofuels Production and Storage Into the Mt. Simon Sandstone." FE0001547. April 2022 at 2.

360 Gollakota, Sai and Scott McDonald. "Commercial-Scale CCS project in Decatur, Illinois — Construction Status and Operational Plans for Demonstration." *Energy Procedia.* Vol. 63. 2014 at 5988 and 5989; Scully, Melissa et al. "Carbon intensity of corn ethanol in the United States: State of the science." *Environmental Research Letters.* Vol. 16. March 2021 at 11, 14, and 15.

361 Edwards, Ryan W. J. and Michael A. Celia. "Infrastructure to enable deployment of carbon capture, utilization, and storage in the United States." *PNAS.* Vol. 155, No. 38. 2018 at E8815 and E8816; Scully et al. (2021) at 11, 14, and 15.

362 Dias de Oliveira, Marcelo E. et al. "Ethanol as Fuel: Energy, Carbon Dioxide Balances, and Ecological Footprint." *BioScience.* Vol. 55, No. 7. July 2005 at 596.
363 Archer Daniels Midlands (ADM). "Carbon Reduction Feasibility Study." R001. March 30, 2020 at 10.
364 Scully et al. (2021) at 14.
365 *Ibid.*
366 Lark, Tyler J. et al. "Environmental outcomes of the US Renewable Fuel Standard." *PNAS.* Vol. 119, No. 9. February 2022 at 1.
367 Hill, Jason et al. "Climate consequences of low-carbon fuels: The United States Renewable Fuel Standard." *Energy Policy.* Vol. 97. August 2016 at 351 and 352.
368 Fajardy, Mathilde et al. Imperial College London. "BECCS Deployment: A Reality Check." Briefing paper No 28. January 2019 at 3.
369 Holmatov, B. et al. "Land, water and carbon footprints of circular bioenergy production systems." *Renewable and Sustainable Energy Reviews.* Vol. 111. September 2019 at 224 and 233.
370 Fajardy et al. (2019) at 3.
371 Kocak, Emrah et al. "Is ethanol production responsible for the increase in corn prices?" *Renewable Energy.* Vol. 199. November 2022 at abstract.
372 CRS. "Sustainable Aviation Fuel (SAF): An Overview of Current Laws and Legislation Introduced in the 118th Congress." December 12, 2024 at 1; ADM. "Sustainable Aviation Fuel (SAF) & Carbon Capture and Storage (CCS)." Available at https://www.adm.com/globalassets/standalone-pages/carbon-capture-and-storage/ccs-saf-fact-sheet.pdf. Accessed February 2025.
373 International Air Transport Association (IATA). "Net zero 2050: Sustainable aviation fuels." December 2024 at 1.
374 CRS (December 2024) at 1 and 2.
375 Brennan, Eamonn. "Biden administration unveils updated SAF tax credit model, provides ethanol clarity." *S&P Global.* April 30, 2024.
376 Bureau of Transportation Statistics. "US Airlines gain $7.8 billion in 2023, an increase over 2022." May 15, 2024; CRS (December 2024) at 1; CRS. "The Section 45Z Clean Fuel Production Credit." February 18, 2025 at 1.
377 IATA (2024) at 1.
378 Americans for Clean Aviation Fuels. "Learn More." Available at https://www.americansforcleanaviationfuels.com/newpage#FoundersCAFsInitiatives. Accessed February 2025.
379 ADM. "Sustainable Aviation Fuel (SAF) & Carbon Capture and Storage (CCS)." Available at https://www.adm.com/globalassets/standalone-pages/carbon-capture-and-storage/ccs-saf-fact-sheet.pdf. Accessed February 2025.
380 Brennan (2024); CRS. "The Section 45Z Clean Fuel Production Credit." IF12502. February 18, 2025 at 1 and 2.
381 "Global data center industry to emit 2.5 billion tons of CO2 through 2030, Morgan Stanley says." *Reuters.* September 3, 2024.
382 Khan, Shariq and Shashwat Awasthi. "Big Oil eyes powering Big Tech's data center demand." *Reuters.* December 11, 2024.
383 Reuters (September 2024).
384 Ma, Michelle. "Sergey Brin-backed carbon removal startup nears firing up its new plant." *Bloomberg.* April 29, 2024.
385 *Ibid.*
386 Khan and Awasthi (2024).
387 ExxonMobil. [Press Release]. "Steel, ammonia and AI? Oh my! What can't our CCS help decarbonize?" December 11, 2024.
388 Elliott, Rebecca F. "Chevron Joins Race to Generate Power for A.I." *New York Times.* January 28, 2025.
389 Fuss, Sabine et al. "Negative emissions — Part 2: Costs, potentials and side effects." *Environmental Research Letters.* Vol. 13. May 2018 at 18; Sabatino, Francesco et al. "Evaluation of a direct air capture process combining wet scrubbing and bipolar membrane electrodialysis." *Industrial & Engineering Chemistry Research.* Vol. 59, Iss. 15. January 2020 at 7007.
390 Al Yafiee, Omnya et al. "Direct air capture (DAC) vs. Direct ocean capture (DOC) — A perspective on scale-up demonstrations and environmental relevance to sustain decarbonization." *Chemical Engineering Journal*. Vol. 497. October 2024 at 2.
391 Rivero, Nicolás. "The world's largest carbon-capture plant just switched on." *Washington Post.* May 9, 2024.
392 Paddison, Laura. "The 'world's largest' vacuum to suck climate pollution out of the air just opened. Here's how it works." *CNN.* May 8, 2024; EPA. "Greenhouse Gas Equivalencies Calculator — Calculations and References." April 24, 2025.
393 Hiar, Corbin. "New direct air capture plant poised for record removals." *E&E News.* May 7, 2024; EPA (April 2024) at ES-5.
394 Valle, Sabrina and Ruhi Soni. "Occidental's project to capture CO2 takes a hit from inflation." *Reuters.* November 9, 2022; Webb (August 2024); Takahashi (2022); Occidental Petroleum Corporation. [Press Release]. "Occidental, 1PointFive to Begin Construction of World's Largest Direct Air Capture Plant in the Texas Permian Basin." August 25, 2022.